User's Manual

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V850ES/JG3-H, V850ES/JH3-H

User's Manual: Hardware

RENESAS MCU
V850ES/Jx3-H Microcontrollers

V850ES/JG3-H	V850ES/JH3-H
μPD70F3760	μPD70F3765
μPD70F3761	μPD70F3766
μPD70F3762	μPD70F3767
μPD70F3770	μPD70F3771

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(2012.4)

NOTES FOR CMOS DEVICES

① VOLTAGE APPLICATION WAVEFORM AT INPUT PIN

Waveform distortion due to input noise or a reflected wave may cause malfunction. If the input of the CMOS device stays in the area between V_{IL} (MAX) and V_{IH} (MIN) due to noise, etc., the device may malfunction. Take care to prevent chattering noise from entering the device when the input level is fixed, and also in the transition period when the input level passes through the area between V_{IL} (MAX) and V_{IH} (MIN).

② HANDLING OF UNUSED INPUT PINS

Unconnected CMOS device inputs can be cause of malfunction. If an input pin is unconnected, it is possible that an internal input level may be generated due to noise, etc., causing malfunction. CMOS devices behave differently than Bipolar or NMOS devices. Input levels of CMOS devices must be fixed high or low by using pull-up or pull-down circuitry. Each unused pin should be connected to V_{DD} or GND via a resistor if there is a possibility that it will be an output pin. All handling related to unused pins must be judged separately for each device and according to related specifications governing the device.

③ PRECAUTION AGAINST ESD

A strong electric field, when exposed to a MOS device, can cause destruction of the gate oxide and ultimately degrade the device operation. Steps must be taken to stop generation of static electricity as much as possible, and quickly dissipate it when it has occurred. Environmental control must be adequate. When it is dry, a humidifier should be used. It is recommended to avoid using insulators that easily build up static electricity. Semiconductor devices must be stored and transported in an anti-static container, static shielding bag or conductive material. All test and measurement tools including work benches and floors should be grounded. The operator should be grounded using a wrist strap. Semiconductor devices must not be touched with bare hands. Similar precautions need to be taken for PW boards with mounted semiconductor devices.

④ STATUS BEFORE INITIALIZATION

Power-on does not necessarily define the initial status of a MOS device. Immediately after the power source is turned ON, devices with reset functions have not yet been initialized. Hence, power-on does not guarantee output pin levels, I/O settings or contents of registers. A device is not initialized until the reset signal is received. A reset operation must be executed immediately after power-on for devices with reset functions.

⑤ POWER ON/OFF SEQUENCE

In the case of a device that uses different power supplies for the internal operation and external interface, as a rule, switch on the external power supply after switching on the internal power supply. When switching the power supply off, as a rule, switch off the external power supply and then the internal power supply. Use of the reverse power on/off sequences may result in the application of an overvoltage to the internal elements of the device, causing malfunction and degradation of internal elements due to the passage of an abnormal current.

The correct power on/off sequence must be judged separately for each device and according to related specifications governing the device.

⑥ INPUT OF SIGNAL DURING POWER OFF STATE

Do not input signals or an I/O pull-up power supply while the device is not powered. The current injection that results from input of such a signal or I/O pull-up power supply may cause malfunction and the abnormal current that passes in the device at this time may cause degradation of internal elements.

Input of signals during the power off state must be judged separately for each device and according to related specifications governing the device.

How to Use This Manual

Readers

This manual is intended for users who wish to understand the functions of the V850ES/JG3-H and V850ES/JH3-H and design application systems using the V850ES/JG3-H and V850ES/JH3-H.

Purpose

This manual is intended to give users an understanding of the hardware functions of the V850ES/JG3-H and V850ES/JH3-H shown in the **Organization** below.

Organization

The manual of these products is divided into two volumes: Hardware (this volume) and Architecture (**V850ES Architecture User's Manual**).

Hardware	Architecture
• Pin functions	• Data types
• CPU function	• Register set
• On-chip peripheral functions	• Instruction format and instruction set
• Flash memory programming	• Interrupts and exceptions
• Electrical specifications	• Pipeline operation

How to Read This Manual

It is assumed that the readers of this manual have general knowledge in the fields of electrical engineering, logic circuits, and microcontrollers.

To understand the overall functions of the V850ES/JG3-H and V850ES/JH3-H
→Read this manual according to the **CONTENTS**.

To find the details of a register where the name is known
→Use **APPENDIX C REGISTER INDEX**.

Register format
→The name of the bit whose number is in angle brackets (<>) in the figure of the register format of each register is defined as a reserved word in the device file.

To understand the details of an instruction function
→Refer to the **V850ES Architecture User's Manual** available separately.

To know the electrical specifications of the V850ES/JG3-H and V850ES/JH3-H
→Refer to the **CHAPTER 33 ELECTRICAL SPECIFICATIONS**.

The "yyy bit of the xxx register" is described as the "xxx.yyy bit" in this manual. Note with caution that if "xxx.yyy" is described as is in a program, however, the compiler/assembler cannot recognize it correctly.

The mark <R> shows major revised points. The revised points can be easily searched by copying an "<R>" in the PDF file and specifying it in the "Find what: " field.

Conventions	Data significance:	Higher digits on the left and lower digits on the right
	Active low representation:	$\overline{xxx}$ (overscore over pin or signal name)
	Memory map address:	Higher addresses on the top and lower addresses on the bottom
	Note:	Footnote for item marked with **Note** in the text
	Caution:	Information requiring particular attention
	Remark:	Supplementary information
	Numeric representation:	Binary ... xxxx or xxxxB Decimal ... xxxx Hexadecimal ... xxxxH
	Prefix indicating power of 2 (address space, memory capacity):	K (kilo): $2^{10} = 1,024$ M (mega): $2^{20} = 1,024^2$ G (giga): $2^{30} = 1,024^3$

Related Documents

The related documents indicated in this publication may include preliminary versions. However, preliminary versions are not marked as such.

Documents related to V850ES/JG3-H and V850ES/JH3-H

Document Name	Document No.
V850ES Architecture User's Manual	U15943E
V850ES/JG3-H, V850ES/JH3-H Hardware User's Manual	This manual

Documents related to development tools

Document Name		Document No.
QB-V850ESJX3H In-Circuit Emulator		U19170J
QB-V850MINI On-Chip Debug Emulator		U17638E
QB-MINI2 On-Chip Debug Emulator with Programming Function		U18371E
CA850 Ver. 3.20 C Compiler Package	Operation	U18512E
	C Language	U18513E
	Assembly Language	U18514E
	Link Directives	U18515E
PM+ Ver. 6.30 Project Manager		U18416E
ID850QB Ver. 3.40 Integrated Debugger	Operation	U18604E
SM850 Ver. 2.50 System Simulator	Operation	U16218E
SM850 Ver. 2.00 or Later System Simulator	External Part User Open Interface Specification	U14873E
SM+ System Simulator	Operation	U18601E
	User Open Interface	U18212E
RX850 Ver. 3.20 Real-Time OS	Basics	U13430E
	Installation	U17419E
	Technical	U13431E
	Task Debugger	U17420E
RX850 Pro Ver. 3.21 Real-Time OS	Basics	U18165E
	Installation	U17421E
	Task Debugger	U17422E
AZ850 Ver. 3.30 System Performance Analyzer		U17423E
PG-FP5 Flash Memory Programmer		U18865E

Caution: This product uses SuperFlash® technology licensed from Silicon Storage Technology, Inc.

Table of Contents

CHAPTER 1 INTRODUCTION

The V850ES/JG3-H and V850ES/JH3-H are products in the low-power series of Renesas Electronics' V850 single-chip microcontrollers designed for real-time control applications.

1.1 General

The V850ES/JG3-H and V850ES/JH3-H are 32-bit single-chip microcontrollers that use the V850ES CPU core and incorporate peripheral functions such as ROM/RAM, a timer/counter, serial interfaces, an A/D converter, a D/A converter, a DMA controller, CAN, and a USB function controller.

In addition to high real-time response characteristics and 1-clock-pitch basic instructions, the V850ES/JG3-H and V850ES/JH3-H feature multiply instructions realized by a hardware multiplier, saturated operation instructions, and bit manipulation instructions.

Table 1-1 lists the products of the V850ES/JG3-H, and Table 1-2 lists the products of the V850ES/JH3-H.

Table 1-1. V850ES/JG3-H Product List

Generic Name			V850ES/JG3-H			
Part Number			μPD70F3760	μPD70F3761	μPD70F3762	μPD70F3770
Internal memory	Flash memory		256 KB	384 KB	512 KB	256 KB
	RAM[Note 1]		40 KB	48 KB	56 KB	40 KB
Memory space	Logical space		64 MB			
	External memory area		64 KB			
External bus interface			Address data bus: 16 Multiplexed bus			
General-purpose register			32 bits × 32 registers			
Clock	Main clock		(PLL mode: f_X = 3 to 6 MHz, f_{XX} = 24 to 48 MHz (multiplied by 8) Clock through mode: f_X = 3 to 6 MHz (internal: f_{XX} = 3 to 6 MHz)			
	Subclock		f_{XT} = 32.768 kHz			
	Internal oscillator		f_R = 220 kHz (TYP.)			
	Minimum instruction execution time		20.8 ns (main clock (f_{XX}) = 48 MHz)			
I/O port (5 V tolerant)			I/O: 77 (22)			
Timer	16-bit TAA		6 channels (including 1 channel used only for interval function)			
	16-bit TAB		2 channels			
	16-bit TMM		4 channels			
	16-bit TMT		1 channel			
	Motor control		1 channel (functions with combination of TAA and TAB; includes Hi-Z output control function)			
	Watch timer		1 channel (RTC)			
	WDT		1 channel			
Real-time output function			6 bits × 1 channel			
10-bit A/D converter			12 channels			
8-bit D/A converter			2 channels			
Serial interface	CSIF/UARTC		2 channels	2 channels	2 channels	2 channels
	CSIF/UARTC/I^2C		1 channel	1 channel	1 channel	1 channel
	CSIF		2 channels	2 channels	2 channels	2 channels
	UARTC/I^2C		2 channels	2 channels	2 channels	1 channel
	UARTC/I^2C/CAN		–	–	–	1 channel
	USB function		1 channel	1 channel	1 channel	1 channel
DMA controller			4 channels (transfer target: on-chip peripheral I/O, internal RAM, external memory)			
Interrupt source	External[Notes 2, 3]		17 (17)	17 (17)	17 (17)	17 (17)
	Internal		69	69	69	73
Power save function			HALT/IDLE1/IDLE2/STOP/subclock/sub-IDLE mode			
Reset source			$\overline{\text{RESET}}$ pin input, watchdog timer 2 (WDT2), clock monitor (CLM), low-voltage detector (LVI)			
On-chip debugging			MINICUBE®, MINICUBE2 supported			
Operating power supply voltage			2.85 to 3.6 V			
Operating ambient temperature			−40 to +85°C			
Package			100-pin plastic LQFP (fine pitch) (14 × 14 mm)			

Notes 1. Including 8 KB of data-only RAM area.

2. The figures in parentheses indicate the number of external interrupts that can release STOP mode.

3. Including NMI.

Table 1-2. V850ES/JH3-H Product List

Generic Name			V850ES/JH3-H			
Part Number			μPD70F3765	μPD70F3766	μPD70F3767	μPD70F3771
Internal memory	Flash memory		256 KB	384 KB	512 KB	256 KB
	RAM[Note 1]		40 KB	48 KB	56 KB	40 KB
Memory space	Logical space		64 MB			
	External memory area		13 MB			
External bus interface			Address bus: 24 Address data bus: 16 Separate bus output function/Multiplexed bus			
General-purpose register			32 bits × 32 registers			
Clock	Main clock		(PLL mode: f_X = 3 to 6 MHz, f_{XX} = 24 to 48 MHz (multiplied by 8) Clock through mode: f_X = 3 to 6 MHz (internal: f_{XX} = 3 to 6 MHz)			
	Subclock		f_{XT} = 32.768 kHz			
	Internal oscillator		f_R = 220 kHz (TYP.)			
	Minimum instruction execution time		20.8 ns (main clock (f_{XX}) = 48 MHz)			
I/O port (5 V tolerant)			I/O: 96 (25)			
Timer	16-bit TAA		6 channels (including 1 channel used only for interval function)			
	16-bit TAB		2 channels			
	16-bit TMM		4 channels			
	16-bit TMT		1 channel			
	Motor control		1 channel (functions with combination of TAA and TAB; includes Hi-Z output control function)			
	Watch timer		1 channel (RTC)			
	WDT		1 channel			
Real-time output function			6 bits × 1 channel			
10-bit A/D converter			12 channels			
8-bit D/A converter			2 channels			
Serial interface	CSIF/UARTC		2 channels	2 channels	2 channels	2 channels
	CSIF/UARTC/I^2C		1 channel	1 channel	1 channel	1 channel
	CSIF		2 channels	2 channels	2 channels	2 channels
	UARTC/I^2C		2 channels	2 channels	2 channels	1 channel
	UARTC/I^2C/CAN		–	–	–	1 channel
	USB function		1 channel	1 channel	1 channel	1 channel
DMA controller			4 channels (transfer target: on-chip peripheral I/O, internal RAM, external memory)			
Interrupt source	External[Notes 2, 3]		20 (20)			
	Internal		69	69	69	73
Power save function			HALT/IDLE1/IDLE2/STOP/subclock/sub-IDLE mode			
Reset source			$\overline{\text{RESET}}$ pin input, watchdog timer 2 (WDT2), clock monitor (CLM), low-voltage detector (LVI)			
On-chip debugging			MINICUBE, MINICUBE2 supported			
Operating power supply voltage			2.85 to 3.6 V			
Operating ambient temperature			–40 to +85°C			
Package			128-pin plastic LQFP (fine pitch) (14 × 20 mm)			

Notes 1. Including 8 KB of data-only RAM area.

2. The figures in parentheses indicate the number of external interrupts that can release STOP mode.

3. Including NMI.

1.2 Features

- Minimum instruction execution time: 20.8 ns (main clock (f_{XX}) = 48 MHz: V_{DD} = 2.85 to 3.6 V)
  30.5 μs (subclock (f_{XT}) = 32.768 kHz)
- General-purpose registers: 32 bits × 32 registers
- CPU features: Signed multiplication (16 × 16 → 32): 1 or 2 clocks
  Signed multiplication (32 × 32 → 64): 1 to 5 clocks
  Saturated operations (overflow and underflow detection functions included)
  32-bit shift instruction: 1 clock
  Bit manipulation instructions
  Load/store instructions with long/short format
- Memory space: 64 MB of linear address space (for programs and data)
  External expansion: Up to 16 MB (including 1 MB used as internal ROM/RAM space)
  - Internal memory: RAM: 40/48/56 KB (see **Table 1-1** and **Table 1-2**)
    Flash memory: 256/384/512 KB (see **Table 1-1** and **Table 1-2**)
  - External bus interface: Separate bus output function/multiplexed bus output selectable
    (Only a multiplexed bus is available in the V850ES/JG3-H)
    8/16-bit data bus sizing function
    Wait function
    • Programmable wait function
    • External wait function
    Idle state function
    Bus hold function
- Interrupts and exceptions:

		Internal			External		
		Non-maskable	Maskable	Total	Non-maskable	Maskable	Total
V850ES/JG3-H	μPD70F3760	1	68	69	1	16	17
	μPD70F3761	1	68	69	1	16	17
	μPD70F3762	1	68	69	1	16	17
	μPD70F3770	1	72	73	1	16	17
V850ES/JH3-H	μPD70F3765	1	68	69	1	19	20
	μPD70F3766	1	68	69	1	19	20
	μPD70F3767	1	68	69	1	19	20
	μPD70F3771	1	72	73	1	19	20

  Software exceptions: 32 sources
  Exception trap: 2 sources
- I/O lines: I/O ports: 77 (V850ES/JG3-H)
  96 (V850ES/JH3-H)
- Timer function: 16-bit interval timer M (TMM): 4 channels
  16-bit timer/event counter AA (TAA): 6 channels
  16-bit timer/event counter AB (TAB): 2 channels
  16-bit timer/event counter T (TMT): 1 channel
  Motor control function (timers used: TAB1, TAA4)
  6-phase PWM function with dead-time function of 16-bit accuracy
  High-impedance output control function
  A/D trigger generation by timer-tuned operation function
  Arbitrary cycle setting function
  Arbitrary dead-time setting function
  Real-time counter (RTC): 1 channel

Watchdog timer: 1 channel

- Real-time output port: 6 bits × 1 channel
- Serial interface: Asynchronous serial interface C (UARTC)
  3-wire variable-length serial interface F (CSIF)
  I^2C bus interface (I^2C)
  CAN interface
  USB function interface
  - UARTC/CSIF: 2 channels
  - UARTC/CSIF/I^2C: 1 channel
  - UARTC/I^2C[Note]: 2 channels
  - CSIF: 2 channels
  - USB function: 1 channel

Note In the μPD70F3770 and 70F3771, one channel is shared with CAN.

- A/D converter: 10-bit resolution: 12 channels
- D/A converter: 8-bit resolution: 2 channels
- DMA controller: 4 channels
- DCU (debug control unit): JTAG interface
- Clock generator: Main clock or subclock operation:
  7-level CPU clock (f_{XX}, $f_{XX}/2$, $f_{XX}/4$, $f_{XX}/8$, $f_{XX}/16$, $f_{XX}/32$, f_{XT})
  Clock-through mode/PLL mode selectable
- Internal oscillation clock: 220 kHz (TYP.)
- Power-save functions: HALT/IDLE1/IDLE2/STOP/subclock/sub-IDLE mode
- Package: 100-pin plastic LQFP (fine pitch) (14 × 14) (V850ES/JG3-H)
  128-pin plastic LQFP (fine pitch) (14 × 20) (V850ES/JH3-H)

1.3 Application Fields

Equipment requiring a USB interface such as home audio systems, printers, and scanners.

1.4 Ordering Information

- V850ES/JG3-H

Part Number	Package	Internal Flash Memory
μPD70F3760GC-UEU-AX	100-pin plastic LQFP (fine pitch) (14 × 14)	256 KB
μPD70F3761GC-UEU-AX	100-pin plastic LQFP (fine pitch) (14 × 14)	384 KB
μPD70F3762GC-UEU-AX	100-pin plastic LQFP (fine pitch) (14 × 14)	512 KB
μPD70F3770GC-UEU-AX	100-pin plastic LQFP (fine pitch) (14 × 14)	256 KB

- V850ES/JH3-H

Part Number	Package	Internal Flash Memory
μPD70F3765GF-GAT-AX	128-pin plastic LQFP (fine pitch) (14 × 20)	256 KB
μPD70F3766GF-GAT-AX	128-pin plastic LQFP (fine pitch) (14 × 20)	384 KB
μPD70F3767GF-GAT-AX	128-pin plastic LQFP (fine pitch) (14 × 20)	512 KB
μPD70F3771GC-GAT-AX	100-pin plastic LQFP (fine pitch) (14 × 20)	256 KB

Remark The V850ES/JG3-H and V850ES/JH3-H are lead-free products.

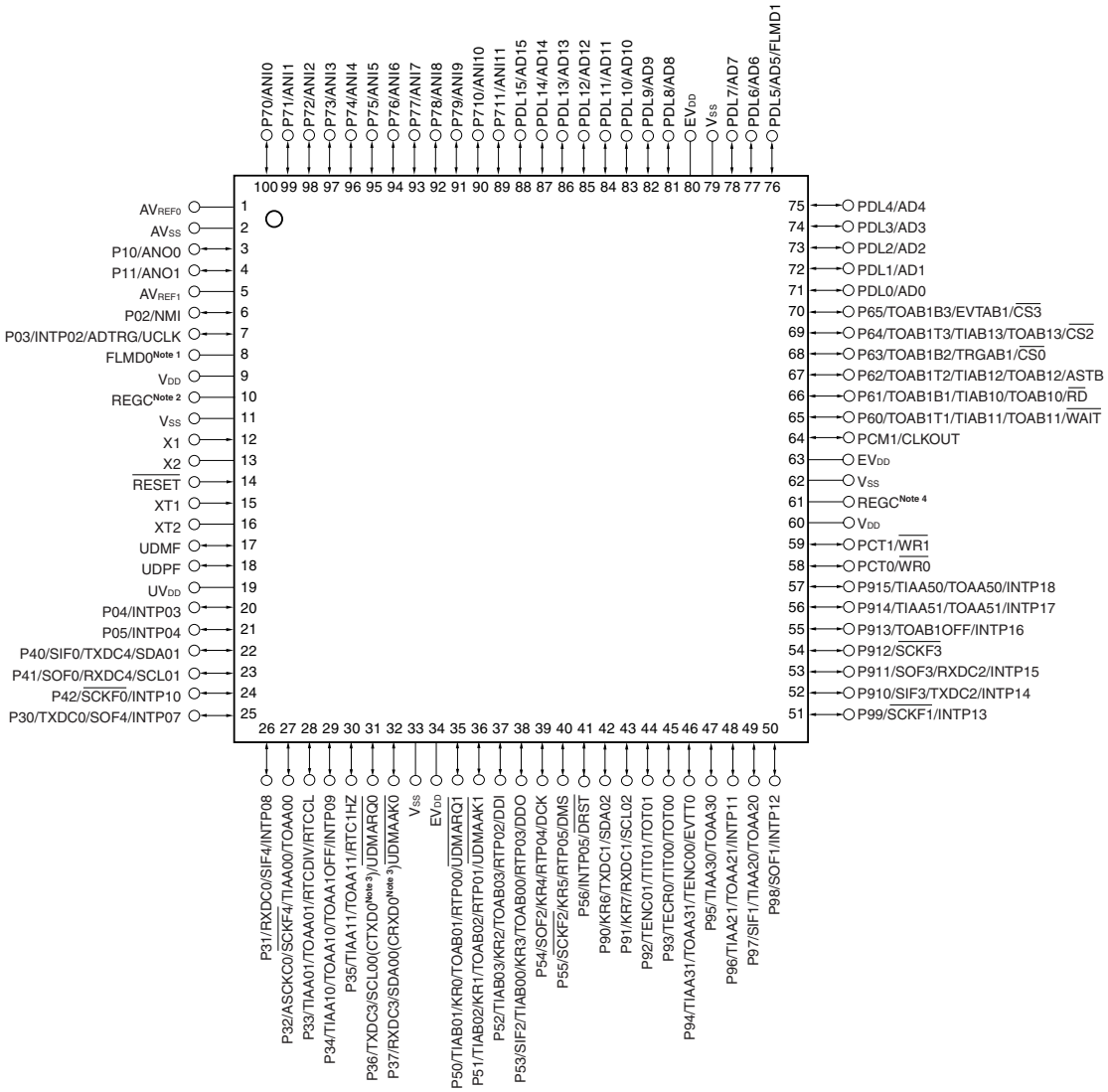
1.5 Pin Configuration (Top View)

- V850ES/JH3-H

  100-pin plastic LQFP (fine pitch) (14 × 14)

  μPD70F3760GC-UEU-AX μPD70F3761GC-UEU-AX μPD70F3762GC-UEU-AX

  μPD70F3770GC-UEU-AX



Notes 1. Connect this pin to VSS in the normal mode.

2. Connect the REGC pin to VSS via a 4.7 μF (recommended value) capacitor.

3. μPD703770 only

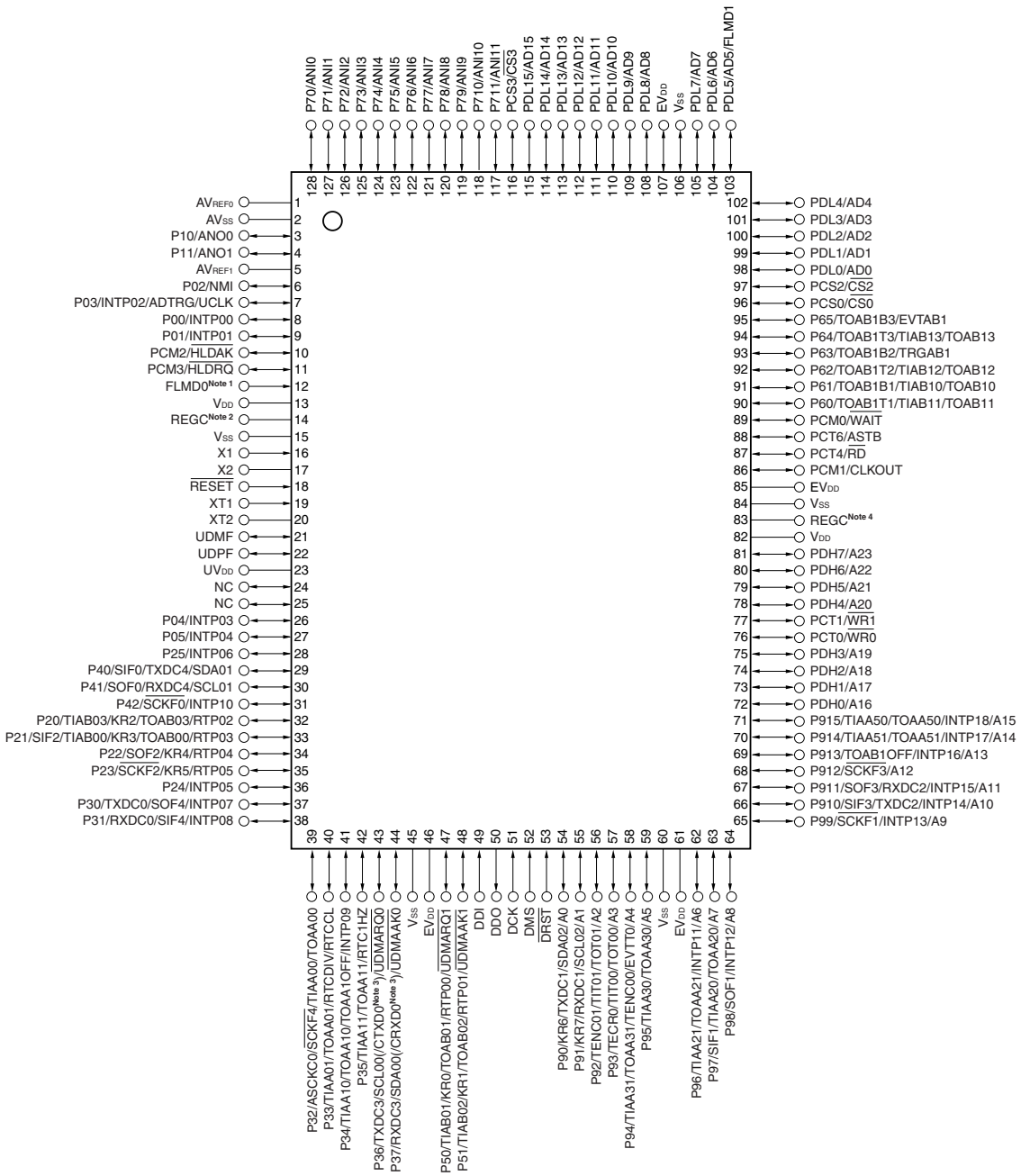
4. Connect the REGC pin to VSS via a 4.7 μF (recommended value) capacitor.

- V850ES/JH3-H

  128-pin plastic LQFP (fine pitch) (14 × 20)

  μPD70F3765GF-GAT-AX μPD70F3766GF-GAT-AX μPD70F3767GF-GAT-AX

  μPD70F3771GF-GAT-AX



Notes 1. Connect this pin to VSS in the normal mode.

2. Connect the REGC pin to VSS via a 4.7 μF (recommended value) capacitor.

3. μPD703770 only

4. Connect the REGC pin to VSS via a 4.7 μF (recommended value) capacitor.

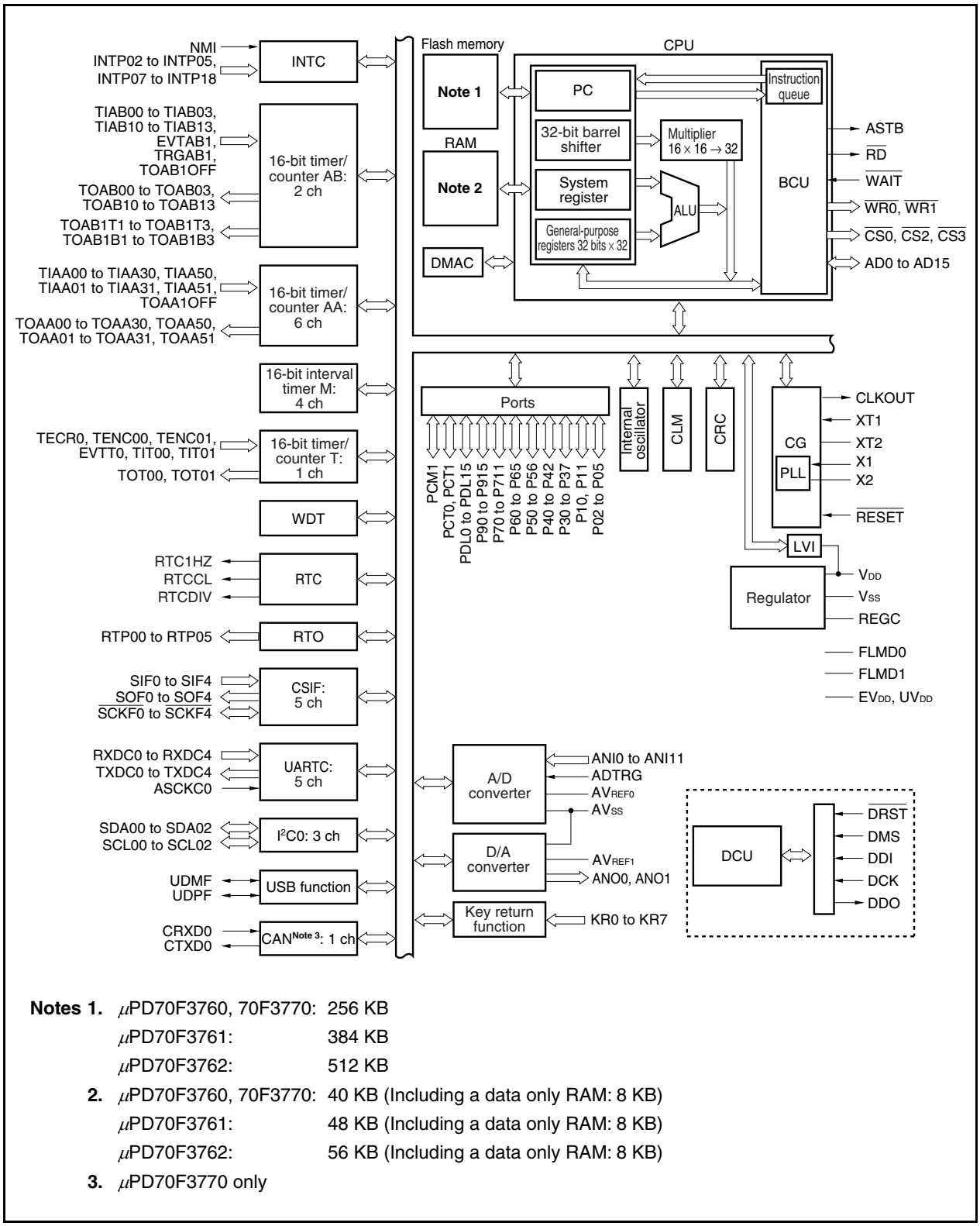
Pin names

A0 to A23:	Address bus
AD0 to AD15:	Address/data bus
ADTRG:	A/D trigger input
ANI0 to ANI11:	Analog input
ANO0, ANO1:	Analog output
ASCKC0:	Asynchronous serial clock
ASTB:	Address strobe
AV_{REF0}, AV_{REF1}:	Analog reference voltage
AV_{SS}:	Grand for analog pin
CLKOUT:	Clock output
CRXD0:	CAN receive data
$\overline{CS0}$, $\overline{CS2}$, $\overline{CS3}$:	Chip select
CTXD0:	CAN transmit data
DCK:	Debug clock
DDI:	Debug data input
DDO:	Debug data output
DMS:	Debug mode select
$\overline{DRST}$:	Debug reset
EV_{DD}:	Power supply for external pin
EVTT0, EVTAB1:	Timer event count input
FLMD0, FLMD1:	Flash programming mode
$\overline{HLDAK}$:	Hold acknowledge
$\overline{HLDRQ}$:	Hold request
INTP00 to INTP18:	External interrupt input
KR0 to KR7:	Key return
NMI:	Non-maskable interrupt request
NC:	Non-connection
P00 to P05:	Port 0
P10, P11:	Port 1
P20 to P25:	Port 2
P30 to P37:	Port 3
P40 to P42:	Port 4
P50 to P56:	Port 5
P60 to P65	Port 6
P70 to P711:	Port 7
P90 to P915:	Port 9
PCM0 to PCM3:	Port CM
PCS0, PCS2, PCS3:	Port CS
PCT0, PCT1, PCT4, PCT6:	Port CT
PDH0 to PDH7:	Port DH
PDL0 to PDL15:	Port DL
$\overline{RD}$:	Read strobe
REGC:	Regulator control
$\overline{RESET}$:	Reset
RTC1HZ, RTCCL, RTCDIV:	Real-time counter clock output
RTP00 to RTP05:	Real-time output port
RXDC0 to RXDC4:	Receive data
$\overline{SCKF0}$ to $\overline{SCKF4}$:	Serial clock
SCL00 to SCL02:	Serial clock
SDA00 to SDA02:	Serial data
SIF0 to SIB4:	Serial input
SOF0 to SOF4:	Serial output
TECR0:	Timer encoder clear input
TENC00, TENC01:	Timer encoder input
TIAA00, TIAA01, TIAA10, TIAA11, TIAA20, TIAA21, TIAA30, TIAA31, TIAA50, TIAA51, TIAB00 to TIAB03, TIAB10, TIAB13, TIT00, TIT01:	Timer input
TOAA00, TOAA01, TOAA10, TOAA11, TOAA20, TOAA21, TOAA30, TOAA31, TOAA50 to TOAA51, TOAB00 to TOAB03, TOAB10 to TOAB13, TOAB1B1 to TOAB1B3, TOAB1T1 to TOAB1T3, TOT00, TOT01:	Timer output
TOAA1OFF, TOAB1OFF:	Timer output off
TRGAB1:	Timer trigger input
TXDC0 to TXDC4:	Transmit data
UCLK:	USB clock
$\overline{UDMAAK0}$, $\overline{UDMAAK1}$:	DMA acknowledge for external USB
$\overline{UDMARQ0}$, $\overline{UDMARQ1}$:	DMA request for external USB
UDMF:	USB data I/O (–) function
UDPF:	USB data I/O (+) function
UV_{DD}:	Power supply for external USB
V_{DD}:	Power supply
V_{SS}:	Ground
$\overline{WAIT}$:	External wait input
$\overline{WR0}$:	Lower byte write strobe
$\overline{WR1}$:	Upper byte write strobe
X1, X2:	Crystal for main clock
XT1, XT2:	Crystal for subclock

1.6 Function Block Configuration

1.6.1 Internal block diagram

- V850ES/JG3-H

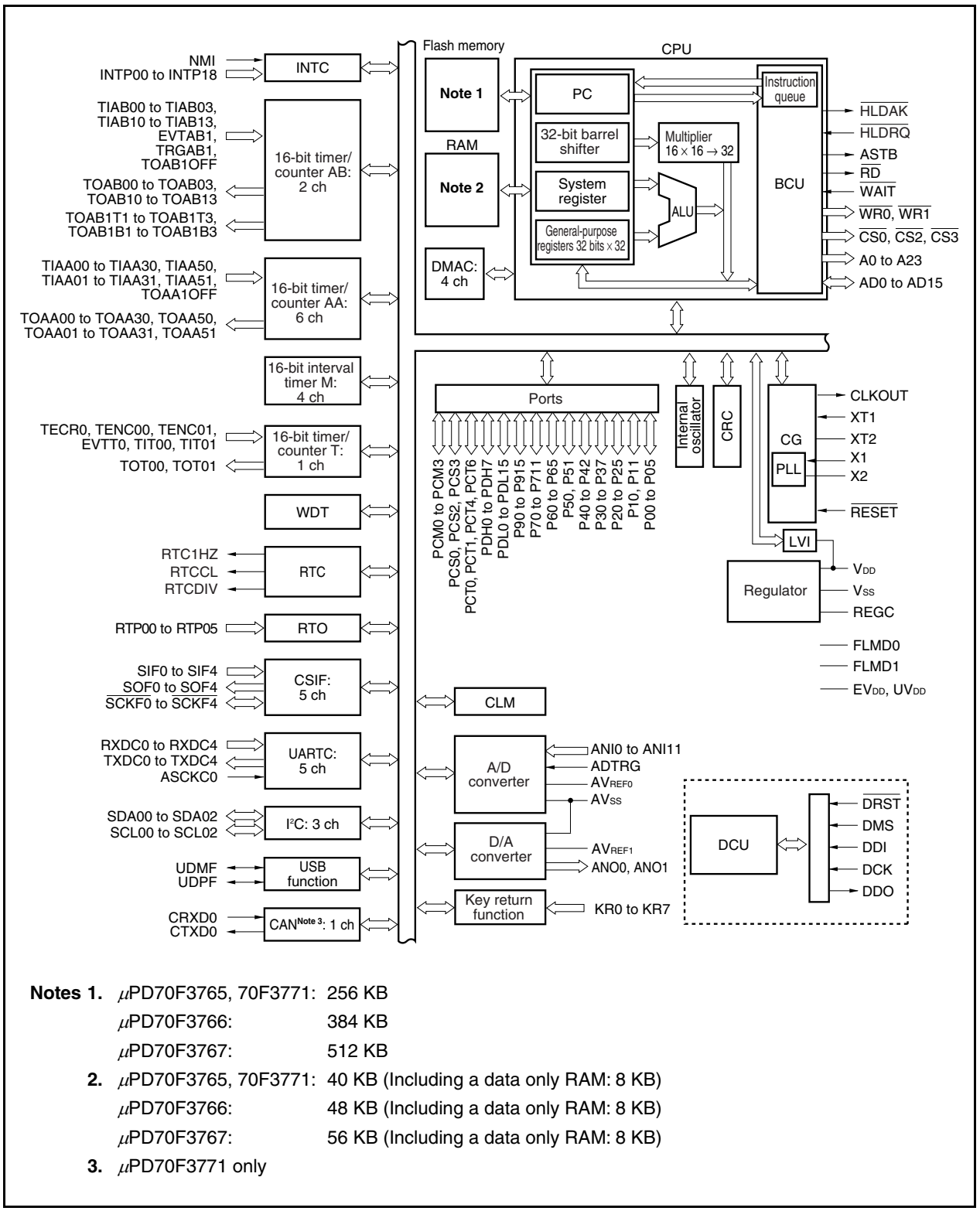


Notes 1. μPD70F3760, 70F3770: 256 KB
μPD70F3761: 384 KB
μPD70F3762: 512 KB

2. μPD70F3760, 70F3770: 40 KB (Including a data only RAM: 8 KB)
μPD70F3761: 48 KB (Including a data only RAM: 8 KB)
μPD70F3762: 56 KB (Including a data only RAM: 8 KB)

3. μPD70F3770 only

• V850ES/JH3-H



Notes 1. μPD70F3765, 70F3771: 256 KB
μPD70F3766: 384 KB
μPD70F3767: 512 KB

2. μPD70F3765, 70F3771: 40 KB (Including a data only RAM: 8 KB)
μPD70F3766: 48 KB (Including a data only RAM: 8 KB)
μPD70F3767: 56 KB (Including a data only RAM: 8 KB)

3. μPD70F3771 only

1.6.2 Internal units

(1) CPU

The CPU uses five-stage pipeline control to enable single-clock execution of address calculations, arithmetic logic operations, data transfers, and almost all other instruction processing.

Other dedicated on-chip hardware, such as a multiplier (16 bits × 16 bits → 32 bits) and a barrel shifter (32 bits) contribute to faster complex processing.

(2) Bus control unit (BCU)

The BCU starts a required external bus cycle based on the physical address obtained by the CPU. When an instruction is fetched from external memory space and the CPU does not send a bus cycle start request, the BCU generates a prefetch address and prefetches the instruction code. The prefetched instruction code is stored in an instruction queue.

(3) Flash memory (ROM)

This is a 512/384/256 KB flash memory mapped to addresses 0000000H to 007FFFFH/0000000H to 005FFFFH/0000000H to 003FFFFH. It can be accessed from the CPU in one clock during instruction fetch.

(4) RAM

This is a 48/40/32 KB RAM mapped to addresses 3FF3000H to 3FFEFFFH/3FF5000H to 3FFEFFFH/3FF7000H to 3FFEFFFH. It can be accessed from the CPU in one clock during data access. An 8 KB data-only RAM is incorporated at addresses 00280000H to 002FFFFFH.

(5) Interrupt controller (INTC)

This controller handles hardware interrupt requests (NMI, INTP0 to INTP18) from on-chip peripheral hardware and external hardware. Eight levels of interrupt priorities can be specified for these interrupt requests, and multiplexed servicing control can be performed.

(6) Clock generator (CG)

A main clock oscillator and subclock oscillator are provided and generate the main clock oscillation frequency (f_X) and subclock frequency (f_{XT}), respectively. There are two modes: In the clock-through mode, f_X is used as the main clock frequency (f_{XX}) as is. In the PLL mode, f_X is used multiplied by 8.

The CPU clock frequency (f_{CPU}) can be selected from among f_{XX}, $f_{XX}/2$, $f_{XX}/4$, $f_{XX}/8$, $f_{XX}/16$, $f_{XX}/32$, and f_{XT}.

(7) Internal oscillator

An internal oscillator is provided on chip. The oscillation frequency is 220 kHz (TYP). The internal oscillator supplies the clock for watchdog timer 2 and timer M.

(8) Timer/counter

Six-channel 16-bit timer/event counter AA (TAA), two-channel 16-bit timer/event counter AB (TAB), one-channel 16-bit timer/event counter T (TMT), and four-channel 16-bit interval timer M (TMM) are provided on chip. The motor control function can be realized using TAB1 and TAA4 in combination.

(9) Real-time counter (for watch)

The real-time counter counts the reference time (one second) for watch counting based on the subclock (32.768 kHz) or main clock. This can simultaneously be used as the interval timer based on the main clock. Hardware counters dedicated to year, month, day of week, day, hour, minute, and second are provided, and can count up to 99 years.

(10) Watchdog timer 2

A watchdog timer is provided on chip to detect inadvertent program loops, system abnormalities, etc.
The internal oscillation clock, the main clock, or the subclock can be selected as the source clock.
Watchdog timer 2 generates a non-maskable interrupt request signal (INTWDT2) or a system reset signal (WDT2RES) after an overflow occurs.

(11) Serial interface

The V850ES/JG3-H and V850ES/JH3-H include three kinds of serial interfaces (asynchronous serial interface C (UARTC), 3-wire variable-length serial interface F (CSIF), and an I^2C bus interface (I^2C)), a CAN controller (CAN)[Note], and a USB function controller (USBF).
UARTC transfers data via the TXDC0 to TXDC2 pins and RXDC0 to RXDC2 pins.
CSIF transfers data via the SOF0 to SOF4 pins, SIF0 to SIF4 pins, and $\overline{\text{SCKF0}}$ to $\overline{\text{SCKF4}}$ pins.
In the case of I^2C, data is transferred via the SDA00 to SDA02 and SCL00 to SCL02 pins.
CAN[Note] transfers data via the CRXD0[Note] and CTXD0[Note] pins.
USBF transfers data via the UDMF and UDPF pins.

Note μPD70F3770, 70F3771 only

(12) A/D converter

This 10-bit A/D converter includes 12 analog input pins. Conversion is performed using the successive approximation method.

(13) D/A converter

A two-channel, 8-bit-resolution D/A converter that uses the R-2R ladder method is provided on chip.

(14) DMA controller

A 4-channel DMA controller is provided on chip. This controller transfers data between the internal RAM, on-chip peripheral I/O devices, and external memory in response to interrupt requests sent by on-chip peripheral I/O devices.

(15) Key interrupt function

A key interrupt request signal (INTKR) can be generated by inputting a falling edge to the key input pins (8 channels).

(16) Real-time output function

The real-time output function transfers preset 6-bit data to output latches upon the occurrence of a timer compare register match signal.

(17) CRC function

A CRC operation circuit that generates a 16-bit CRC (Cyclic Redundancy Check) code upon setting of 8-bit data is provided on-chip.

(18) DCU (debug control unit)

An on-chip debug function that uses the JTAG (Joint Test Action Group) communication specifications is provided. Switching between the normal port function and on-chip debugging function is done with the control pin input level and the OCDM register.

(19) Ports

The following general-purpose port functions and control pin functions are available.

• V850ES/JG3-H

Port	I/O	Alternate Function
P0	4-bit I/O	NMI, external interrupt, A/D converter trigger, serial interface
P1	2-bit I/O	D/A converter analog output
P3	10-bit I/O	External interrupt, real-time counter, serial interface, timer I/O
P4	3-bit I/O	Serial interface, external interrupt
P5	7-bit I/O	Timer I/O, serial interface, real-time output, key interrupt input, debug I/O
P6	6-bit I/O	External bus control signal, timer I/O, external bus control signal
P7	12-bit I/O	A/D converter analog input
P9	16-bit I/O	Serial interface, key interrupt input, timer I/O, external interrupt
PCM	1-bit I/O	External bus control signal
PCT	2-bit I/O	External bus control signal
PDL	16-bit I/O	External address/data bus

• V850ES/JH3-H

Port	I/O	Alternate Function
P0	6-bit I/O	NMI, external interrupt, A/D converter trigger, serial interface
P1	2-bit I/O	D/A converter analog output
P2	6-bit I/O	Timer I/O, real-time output, key interrupt input, serial interface
P3	10-bit I/O	External interrupt, real-time counter, serial interface, timer I/O
P4	3-bit I/O	Serial interface, external interrupt
P5	2-bit I/O	Timer I/O, real-time output, key interrupt input
P6	6-bit I/O	External bus control signal, timer I/O
P7	12-bit I/O	A/D converter analog input
P9	16-bit I/O	External address bus, serial interface, key interrupt input, timer I/O, external interrupt
PCM	4-bit I/O	External bus control signal
PCS	3-bit I/O	External bus control signal
PCT	4-bit I/O	External bus control signal
PDH	8-bit I/O	External address bus
PDL	16-bit I/O	External address/data bus

CHAPTER 2 PIN FUNCTIONS

2.1 List of Pin Functions

The names and functions of the pins of the V850ES/JG3-H and V850ES/JH3-H are described below.

There are four types of pin I/O buffer power supplies: AV_{REF0}, AV_{REF1}, EV_{DD}, and UV_{DD}. The relationship between these power supplies and the pins is described below.

Table 2-1. Pin I/O Buffer Power Supplies

Power Supply	Corresponding Pins	
	V850ES/JG3-H	V850ES/JH3-H
AV_{REF0}	Port 7	Port 7
AV_{REF1}	Port 1	Port 1
EV_{DD}	$\overline{\text{RESET}}$, ports 0, 3 to 6, 9, CM, CT, DL	$\overline{\text{RESET}}$, ports 0, 2 to 6, 9, CM, CS, CT, DH, DL
UV_{DD}	UDPF, UDMF	UDPF, UDMF

<R> **(1) Port pins**

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Pin Name	I/O	Function	Alternate Function	Pin No.	
				JG3-H	JH3-H
P00	I/O	Port 0 6-bit I/O port (V850ES/JH3-H) 4-bit I/O port (V850ES/JG3-H) Input/output can be specified in 1-bit units. 5 V tolerant.	INTP00	–	8
P01			INTP01	–	9
P02			NMI	6	6
P03			INTP02/ADTRG/UCLK	7	7
P04			INTP03	20	26
P05			INTP04	21	27
P10	I/O	Port 1 2-bit I/O port Input/output can be specified in 1-bit units.	ANO0	3	3
P11			ANO1	4	4
P20	I/O	Port 2 6-bit I/O port Input/output can be specified in 1-bit units. 5 V tolerant.	TIAB03/KR2/TOAB03/RTP02	–	32
P21			SIF2/TIAB00/KR3/TOAB00/RTP03	–	33
P22			SOF2/KR4/RTP04	–	34
P23			$\overline{\text{SCKF2}}$/KR5/RTP05	–	35
P24			INTP05	–	36
P25			INTP06	–	28
P30	I/O	Port 3 8-bit I/O port Input/output can be specified in 1-bit units. 5 V tolerant.	TXDC0/SOF4/INTP07	25	37
P31			RXDC0/SIF4/INTP08	26	38
P32			ASCKC0/$\overline{\text{SCKF4}}$/TIAA00/TOAA00	27	39
P33			TIAA01/TOAA01/RTCDIV/RTCCL	28	40
P34			TIAA10/TOAA10/TOAA1OFF/INTP09	29	41
P35			TIAA11/TOAA11/RTC1HZ	30	42
P36			TXDC3/SCL00/CTXD0[Note]/$\overline{\text{UDMARQ0}}$	31	43
P37			RXDC3/SDA00/CRXD0[Note]/$\overline{\text{UDMAAK0}}$	32	44
P40	I/O	Port 4 3-bit I/O port Input/output can be specified in 1-bit units. 5 V tolerant.	SIF0/TXDC4/SDA01	22	29
P41			SOF0/RXDC4/SCL01	23	30
P42			$\overline{\text{SCKF0}}$/INTP10	24	31
P50	I/O	Port 5 2-bit I/O port (V850ES/JH3-H) 7-bit I/O port (V850ES/JG3-H) Input/output can be specified in 1-bit units. 5 V tolerant.	TIAB01/KR0/TOAB01/RTP00 /$\overline{\text{UDMARQ1}}$	35	47
P51			TIAB02/KR1/TOAB02/RTP01 /$\overline{\text{UDMAAK1}}$	36	48
P52			TIAB03/KR2/TOAB03/RTP02/DDI	37	–
P53			SIF2/TIAB00/KR3/TOAB00 /RTP03/DDO	38	–
P54			SOF2/KR4/RTP04/DCK	39	–
P55			$\overline{\text{SCKF2}}$/KR5/RTP05/DMS	40	–
P56			INTP05/$\overline{\text{DRST}}$	41	–

Note μPD70F3770, 70F3771 only

Remark JG3-H: V850ES/JG3-H, JH3-H: V850ES/JH3-H

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Pin Name	I/O	Function	Alternate Function	Pin No.	
				JG3-H	JH3-H
P60	I/O	Port 6 6-bit I/O port Input/output can be specified in 1-bit units.	TOAB1T1/TOAB11/TIAB11/$\overline{\text{WAIT}}$	65	–
			TOAB1T1/TOAB11/TIAB11	–	90
P61			TOAB1B1/TIAB10/TOAB10/$\overline{\text{RD}}$	66	–
			TOAB1B1/TIAB10/TOAB10	–	91
P62			TOAB1T2/TOAB12/TIAB12/ASTB	67	–
			TOAB1T2/TOAB12/TIAB12	–	92
P63			TOAB1B2/TRGAB1/$\overline{\text{CS0}}$	68	–
			TOAB1B2/TRGAB1	–	93
P64			TOAB1T3/TOAB13/TIAB13/$\overline{\text{CS2}}$	69	–
			TOAB1T3/TOAB13/TIAB13	–	94
P65			TOAB1B3/EVTAB1/$\overline{\text{CS3}}$	70	–
			TOAB1B3/EVTAB1	–	95
P70	I/O	Port 7 12-bit I/O port Input/output can be specified in 1-bit units.	ANI0	100	128
P71			ANI1	99	127
P72			ANI2	98	126
P73			ANI3	97	125
P74			ANI4	96	124
P75			ANI5	95	123
P76			ANI6	94	122
P77			ANI7	93	121
P78			ANI8	92	120
P79			ANI9	91	119
P710			ANI10	90	118
P711			ANI11	89	117
P90	I/O	Port 9 16-bit I/O port Input/output can be specified in 1-bit units.	KR6/TXDC1/SDA02	42	–
			KR6/TXDC1/SDA02/A0	–	54
P91			KR7/RXDC1/SCL02	43	–
			KR7/RXDC1/SCL02/A1	–	55
P92			TENC01/TIT01/TOT01	44	–
			TENC01/TIT01/TOT01/A2	–	56
P93			TECR0/TIT00/TOT00	45	–
			TECR0/TIT00/TOT00/A3	–	57
P94			TIAA31/TOAA31/TENC00/EVTT0	46	–
			TIAA31/TOAA31/TENC00/EVTT0/A4	–	58
P95			TIAA30/TOAA30	47	–
			TIAA30/TOAA30/A5	–	59
P96			TIAA21/TOAA21/INTP11	48	–
			TIAA21/TOAA21/INTP11/A6	–	62
P97			SIF1/TIAA20/TOAA20	49	–
			SIF1/TIAA20/TOAA20/A7	–	63

Remark JG3-H: V850ES/JG3-H, JH3-H: V850ES/JH3-H

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Pin Name	I/O	Function	Alternate Function	Pin No.	
				JG3-H	JH3-H
P98	I/O	Port 9 16-bit I/O port Input/output can be specified in 1-bit units.	SOF1/INTP12	50	–
			SOF1/INTP12/A8	–	64
P99			$\overline{\text{SCKF1}}$/INTP13	51	–
			$\overline{\text{SCKF1}}$/INTP13/A9	–	65
P910			SIF3/TXDC2/INTP14	52	–
			SIF3/TXDC2/INTP14/A10	–	66
P911			SOF3/RXDC2/INTP15	53	–
			SOF3/RXDC2/INTP15/A11	–	67
P912			$\overline{\text{SCKF3}}$	54	–
			$\overline{\text{SCKF3}}$/A12	–	68
P913			TOAB1OFF/INTP16	55	–
			TOAB1OFF/INTP16/A13	–	69
P914			TIAA51/TOAA51/INTP17	56	–
			TIAA51/TOAA51/INTP17/A14	–	70
P915			TIAA50/TOAA50/INTP18	57	–
			TIAA50/TOAA50/INTP18/A15	–	71
PCM0	I/O	Port CM 4-bit I/O port (V850ES/JH3-H) 1-bit I/O port (V850ES/JG3-H) Input/output can be specified in 1-bit units.	$\overline{\text{WAIT}}$	–	89
PCM1			CLKOUT	64	86
PCM2			$\overline{\text{HLDAK}}$	–	10
PCM3			$\overline{\text{HLDRQ}}$	–	11
PCS0	I/O	Port CS 3-bit I/O port Input/output can be specified in 1-bit units.	$\overline{\text{CS0}}$	–	96
PCS2			$\overline{\text{CS2}}$	–	97
PCS3			$\overline{\text{CS3}}$	–	116
PCT0	I/O	Port CT 4-bit I/O port (V850ES/JH3-H) 2-bit I/O port (V850ES/JG3-H) Input/output can be specified in 1-bit units.	$\overline{\text{WR0}}$	58	76
PCT1			$\overline{\text{WR1}}$	59	77
PCT4			$\overline{\text{RD}}$	–	87
PCT6			ASTB	–	88
PDH0	I/O	Port DH 8-bit I/O port Input/output can be specified in 1-bit units.	A16	–	72
PDH1			A17	–	73
PDH2			A18	–	74
PDH3			A19	–	75
PDH4			A20	–	78
PDH5			A21	–	79
PDH6			A22	–	80
PDH7			A23	–	81

Remark JG3-H: V850ES/JG3-H, JH3-H: V850ES/JH3-H

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Pin Name	I/O	Function	Alternate Function	Pin No.	
				JG3-H	JH3-H
PDL0	I/O	Port DL 16-bit I/O port Input/output can be specified in 1-bit units.	AD0	71	98
PDL1			AD1	72	99
PDL2			AD2	73	100
PDL3			AD3	74	101
PDL4			AD4	75	102
PDL5			AD5/FLMD1	76	103
PDL6			AD6	77	104
PDL7			AD7	78	105
PDL8			AD8	81	108
PDL9			AD9	82	109
PDL10			AD10	83	110
PDL11			AD11	84	111
PDL12			AD12	85	112
PDL13			AD13	86	113
PDL14			AD14	87	114
PDL15			AD15	88	115

Remark JG3-H: V850ES/JG3-H, JH3-H: V850ES/JH3-H

<R> **(2) Non-port Pins**

(1/9)

Pin Name	I/O	Function	Alternate Function	Pin No.	
				JG3-H	JH3-H
A0	Output	Address bus for external memory (when using separate bus output function)	P90/KR6/TXDC1/SDA02	–	54
A1			P91/KR7/RXDC1/SCL02	–	55
A2			P92/TENC01/TIT01/TOT01	–	56
A3			P93/TECR00/TIT00/TOT00	–	57
A4			P94/TIAA31/TOAA31/TENC0/EVTT0	–	58
A5			P95/TIAA30/TOAA30	–	59
A6			P96/TIAA21/TOAA21/INTP11	–	62
A7			P97/SIF1/TIAA20/TOAA20	–	63
A8			P98/SOF1/INTP12	–	64
A9			P99/$\overline{\text{SCKF1}}$/INTP13	–	65
A10			P910/SIF3/TXDC2/INTP14	–	66
A11			P911/SOF3/RXDC2/INTP15	–	67
A12			P912/$\overline{\text{SCKF3}}$	–	68
A13			P913/TOAB1OFF/INTP16	–	69
A14			P914/TIAA51/TOAA51/INTP17	–	70
A15			P915/TIAA50/TOAA50/INTP18	–	71
A16			PDH0	–	72
A17			PDH1	–	73
A18			PDH2	–	74
A19			PDH3	–	75
A20			PDH4	–	78
A21			PDH5	–	79
A22			PDH6	–	80
A23			PDH7	–	81
AD0	I/O	Address/data bus for external memory	PDL0	71	98
AD1			PDL1	72	99
AD2			PDL2	73	100
AD3			PDL3	74	101
AD4			PDL4	75	102
AD5			PDL5/FLMD1	76	103
AD6			PDL6	77	104
AD7			PDL7	78	105
AD8			PDL8	81	108
AD9			PDL9	82	109
AD10			PDL10	83	110
AD11			PDL11	84	111
AD12			PDL12	85	112
AD13			PDL13	86	113
AD14			PDL14	87	114
AD15			PDL15	88	115
ADTRG	Input	External trigger input for A/D converter	P03/INTP02/UCLK	7	7

Remark JG3-H: V850ES/JG3-H, JH3-H: V850ES/JH3-H

(2/9)

Pin Name	I/O	Function	Alternate Function	Pin No.	
				JG3-H	JH3-H
ANI0	Input	Analog voltage input for A/D converter	P70	100	128
ANI1			P71	99	127
ANI2			P72	98	126
ANI3			P73	97	125
ANI4			P74	96	124
ANI5			P75	95	123
ANI6			P76	94	122
ANI7			P77	93	121
ANI8			P78	92	120
ANI9			P79	91	119
ANI10			P710	90	118
ANI11			P711	89	117
ANO0	Output	Analog voltage output for D/A converter	P10	3	3
ANO1			P11	4	4
ASCKC0	Input	UARTC0 baud rate clock input. 5 V tolerant.	P32/$\overline{\text{SCKF4}}$/TIAA00/TOAA00	27	39
ASTB	Output	Address strobe signal for external memory	P62/TOAB1T2/TIAB12/TOAB12	67	–
			PCT6	–	88
AV_{REF0}	–	Reference voltage input for A/D converter/positive power supply for port 7	–	1	1
AV_{REF1}	–	Reference voltage input for D/A converter/positive power supply for port 1	–	5	5
AV_{SS}	–	Ground potential for A/D and D/A converters	–	2	2
CLKOUT	Output	Internal system clock output	PCM1	64	86
CRXD0[Note]	Input	CAN receive data input. 5 V tolerant.	P37/RXDC3/SDA00/$\overline{\text{UDMAAK0}}$	32	44
$\overline{\text{CS0}}$	Output	Chip select output	P63/TOAB1B2/TRGAB1	68	–
			PCS0	–	96
$\overline{\text{CS2}}$	Output	Chip select output	P64/TOAB1T3/TIAB13/TOAB13	69	–
			PCS2	–	97
$\overline{\text{CS3}}$	Output	Chip select output	P65/TOAB1B3/EVTAB1	70	–
			PCS3	–	116
CTXD0[Note]	Output	CAN transmit data output. 5 V tolerant.	P36/TXDC3/SCL00/$\overline{\text{UDMARQ0}}$	31	43
DCK	Input	Clock input for on-chip debugging 5 V tolerant	P54/SOF2/KR4/RTP04	39	–
			–	–	51
DDI	Input	Data input for on-chip debugging 5 V tolerant	P52/TIAB03/KR2/TOAB03/RTP02	37	–
			–	–	49
DDO	Output	Data output for on-chip debugging In the on-chip debug mode, high-level output is forcibly set. 5 V tolerant.	P53/SIF2/TIAB00/KR3/TOAB00/RTP03	38	–
			–	–	50
DMS	Input	Mode select signal input for on-chip debugging 5 V tolerant	P55/$\overline{\text{SCKF2}}$/KR5/RTP05	40	–
			–	–	52
$\overline{\text{DRST}}$	Input	Reset signal input for on-chip debugging 5 V tolerant	P56/INTP05	41	–
			–	–	53

Note μPD70F3770, 70F3771 only

Remark JG3-H: V850ES/JG3-H, JH3-H: V850ES/JH3-H

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Pin Name	I/O	Function	Alternate Function	Pin No.	
				JG3-H	JH3-H
EV_{DD}	–	Positive power supply for external devices (same potential as V_{DD})	–	34, 63, 80	46, 61, 85,107
EVTT0	Input	External event count input of TMT0	P94/TIAA31/TOAA31/TENC00	46	–
			P94/TIAA31/TOAA31/TENC00/A4	–	58
EVTAB1	Input	External event count input of TAB1	P65/TOAB1B3/$\overline{CS3}$	70	–
			P65/TOAB1B3	–	95
FLMD0	Input	Flash memory programming mode setting pin	–	8	12
FLMD1	Input		PDL5/AD5	76	103
$\overline{HLDAK}$	Output	Bus hold acknowledge output	PCM2	–	10
$\overline{HLDRQ}$	Input	Bus hold request input	PCM3	–	11
INTP00	Input	External interrupt request input (maskable, analog noise elimination) Analog noise elimination or digital noise elimination selectable for INTP02 pin 5 V tolerant (INTP00 to INTP05, INTP07 to INTP10)	P00	–	8
INTP01			P01	–	9
INTP02			P03/ADTRG/UCLK	7	7
INTP03			P04	20	26
INTP04			P05	21	27
INTP05			P56/$\overline{DRST}$	41	–
			P24	–	36
INTP06			P25	–	28
INTP07			P30/TXDC0/SOF4	25	37
INTP08			P31/RXDC0/SIF4	26	38
INTP09			P34/TIAA10/TOAA10/TOAA1OFF	29	41
INTP10			P42/$\overline{SCKF0}$	24	31
INTP11			P96/TIAA21/TOAA21/A6	–	62
			P96/TIAA21/TOAA21	48	–
INTP12			P98/SOF1	50	–
			P98/SOF1/A8	–	64
INTP13			P99/$\overline{SCKF1}$	51	–
			P99/$\overline{SCKF1}$/A9	–	65
INTP14			P910/SIF3/TXDC2	52	–
			P910/SIF3/TXDC2/A10	–	66
INTP15			P911/SOF3/RXDC2	53	–
			P911/SOF3/RXDC2/A11	–	67
INTP16			P913/TOAB1OFF	55	–
			P913/TOAB1OFF/A13	–	69
INTP17			P914/TIAA51/TOAA51	56	–
			P914/TIAA51/TOAA51/A14	–	70
INTP18			P915/TIAA50/TOAA50	57	–
			P915/TIAA50/TOAA50/A15	–	71

Remark JG3-H: V850ES/JG3-H, JH3-H: V850ES/JH3-H

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Pin Name	I/O	Function	Alternate Function	Pin No.	
				JG3-H	JH3-H
KR0	Input	Key interrupt input. (on-chip analog noise eliminator)	P50/TIAB01/TOAB01/RTP00 /$\overline{\text{UDMARQ1}}$	35	47
KR1		5 V tolerant (KR0 to KR5)	P51/TIAB02/TOAB02/RTP01 /$\overline{\text{UDMARQ1}}$	36	48
KR2			P52/TIAB03/TOAB03/RTP02/DDI	37	–
			P20/TIAB03/TOAB03/RTP02	–	32
KR3			P53/SIF2/TIAB00/TOAB00/RTP03/DDO	38	–
			P21/SIF2/TIAB00/TOAB00/RTP03	–	33
KR4			P54/SOF2/RTP04/DCK	39	–
			P22/SOF2/RTP04	–	34
KR5			P55/$\overline{\text{SCKF2}}$/RTP05/DMS	40	–
			P23/$\overline{\text{SCKF2}}$/RTP05	–	35
KR6			P90/TXDC1/SDA02	42	–
			P90/TXDC1/SDA02/A0	–	54
KR7			P91/RXDC1/SCL02	43	–
			P91/RXDC1/SCL02/A1	–	55
NMI	Input	External interrupt input. (non-maskable, analog noise elimination) 5 V tolerant	P02	6	6
NC	–	Non-Connection (Leave open.)	–	–	24, 25
$\overline{\text{RD}}$	Output	Read strobe signal output for external memory	P61/TOAB1B1/TIAB10/TOAB10	66	–
			PCT4	–	87
REGC	–	Connection of regulator output stabilization capacitance (4.7 μF: recommended value)	–	10, 61	14, 83
$\overline{\text{RESET}}$	Input	System reset input	–	14	18
RTC1HZ	Output	Real-time counter correction clock (1 Hz) output. 5 V tolerant.	P35/TIAA11/TOAA11	30	42
RTCCL	Output	Real-time counter clock (32 kHz primary oscillation) output. 5 V tolerant.	P33/TIAA01/TOAA01/RTCDIV	28	40
RTCDIV	Output	Real-time counter clock (32 kHz division) output. 5 V tolerant.	P33/TIAA01/TOAA01/RTCCL	28	40
RTP00	Output	Real-time output port N-ch open-drain output selectable 5 V tolerant	P50/TIAB01/KR0/TOAB01/$\overline{\text{UDMARQ1}}$	35	47
RTP01			P51/TIAB02/KR1/TOAB02/$\overline{\text{UDMAAK1}}$	36	48
RTP02			P52/TIAB03/KR2/TOAB03/DDI	37	–
			P20/TIAB03/KR2/TOAB03	–	32
RTP03			P53/SIF2/TIAB00/KR3/TOAB00/DDO	38	–
			P21/SIF2/TIAB00/KR3/TOAB00	–	33
RTP04			P54/SOF2/KR4/DCK	39	–
			P22/SOF2/KR4	–	34
RTP05			P55/$\overline{\text{SCKF2}}$/KR5/DMS	40	–
			P23/$\overline{\text{SCKF2}}$/KR5	–	35

Remark JG3-H: V850ES/JG3-H, JH3-H: V850ES/JH3-H

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Pin Name	I/O	Function	Alternate Function	Pin No.	
				JG3-H	JH3-H
RXDC0	Input	Serial receive data input (UARTC0 to UARTC4)	P31/SIF4/INTP08	26	38
RXDC1		5 V tolerant	P91/KR7/SCL02	43	–
			P91/KR7/SCL02/A1	–	55
RXDC2			P911/SOF3/INTP15	53	–
			P911/SOF3/INTP15/A11	–	67
RXDC3			P37/SDA00/CRXD0[Note]/$\overline{\text{UDMAAK0}}$	32	44
RXDC4			P41/SOF0/SCL01	23	30
$\overline{\text{SCKF0}}$	I/O	Serial clock I/O (CSIF0 to CSIF4)	P42/INTP10	24	31
$\overline{\text{SCKF1}}$		N-ch open-drain output selectable	P99/INTP13	51	–
		5 V tolerant ($\overline{\text{SCKF0}}$, $\overline{\text{SCKF2}}$, $\overline{\text{SCKF4}}$)	P99/INTP13/A9	–	65
$\overline{\text{SCKF2}}$			P55/KR5/RTP05/DMS	40	–
			P23/KR5/RTP05	–	35
$\overline{\text{SCKF3}}$			P912	54	–
			P912/A12	–	68
$\overline{\text{SCKF4}}$			P32/ASCKC0/TIAA00/TOAA00	27	39
SCL00	I/O	Serial clock I/O (I^2C00 to I^2C02)	P36/TXDC3/CTXD0[Note]/$\overline{\text{UDMARQ0}}$	31	43
SCL01		N-ch open-drain output selectable	P41/SOF0/RXDC4	23	30
SCL02		5 V tolerant (SCL00, SCL01)	P91/KR7/RXDC1	43	–
			P91/KR7/RXDC1/A1	–	55
SDA00	I/O	Serial transmit/receive data I/O (I^2C00 to I^2C02)	P37/RXDC3/CRXD0[Note]/$\overline{\text{UDMAAK0}}$	32	44
SDA01		N-ch open-drain output selectable	P40/SIF0/TXDC4	22	29
SDA02		5 V tolerant (SDA00, SDA01)	P90/KR6/TXDC1	42	–
			P90/KR6/TXDC1/A0	–	54
SIF0	Input	Serial receive data input (CSIF0 to CSIF4)	P40/TXDC4/SDA01	22	29
SIF1		5 V tolerant (SIF0, SIF2, SIF4)	P97/TIAA20/TOAA20	49	–
			P97/TIAA20/TOAA20/A7	–	63
SIF2			P53/TIAB00/KR3/TOAB00/RTP03/DDO	38	–
			P21/TIAB00/KR3/TOAB00/RTP03	–	33
SIF3			P910/TXDC2/INTP14	52	–
			P910/TXDC2/INTP14/A10	–	66
SIF4			P31/RXDC0/INTP08	26	38
SOF0	Output	Serial transmit data output (CSIF0 to CSIF4)	P41/RXDC4/SCL01	23	30
SOF1		N-ch open-drain output selectable	P98/INTP12	50	–
		5 V tolerant (SOF0, SOF2, SOF4)	P98/INTP12/A8	–	64
SOF2			P54/KR4/RTP04/DCK	39	–
			P22/KR4/RTP04	–	34
SOF3			P911/RXDC2/INTP15	53	–
			P911/RXDC2/INTP15/A11	–	67
SOF4			P30/TXDC0/INTP07	25	37

Note μPD70F3770, 70F3771 only

Remark JG3-H: V850ES/JG3-H, JH3-H: V850ES/JH3-H

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Pin Name	I/O	Function	Alternate Function	Pin No.	
				JG3-H	JH3-H
TECR0	Input	TMT0 encoder clear input	P93/TIT00/TOT00	45	–
			P93/TIT00/TOT00/A3	–	57
TENC00		TMT0 encoder input	P94/TIAA31/TOAA31/EVTT0	46	–
			P94/TIAA31/TOAA31/EVTT0/A4	–	58
TENC01			P92/TIT01/TOT01	44	–
			P92/TIT01/TOT01/A2	–	56
TIAA00	Input	External event count input/capture trigger input/external trigger input (TAA0). 5 V tolerant	P32/ASCKC0/$\overline{\text{SCKF4}}$/TOAA00	27	39
TIAA01		Capture trigger input (TAA0). 5 V tolerant.	P33/TOAA01/RTCDIV/RTCCL	28	40
TIAA10		External event count input/capture trigger input/external trigger input (TAA1). 5 V tolerant.	P34/TOAA10/TOAA1OFF/INTP09	29	41
TIAA11		Capture trigger input (TAA1). 5 V tolerant.	P35/TOAA11/RTC1HZ	30	42
TIAA20		External event count input/capture trigger input/external trigger input (TAA2)	P97/SIF1/TOAA20	49	–
			P97/SIF1/TOAA20/A7	–	63
TIAA21		Capture trigger input (TAA2)	P96/TOAA21/INTP11	48	–
			P96/TOAA21/INTP11/A6	–	62
TIAA30		External event count input/capture trigger input/external trigger input (TAA3)	P95/TOAA30	47	–
			P95/TOAA30/A5	–	59
TIAA31		Capture trigger input (TAA3)	P94/TOAA31/TENC00/EVTT0	46	–
			P94/TOAA31/TENC00/EVTT0/A4	–	58
TIAA50		External event count input/capture trigger input/external trigger input (TAA5)	P915/TOAA50/INTP18	57	–
			P915/TOAA50/INTP18/A15	–	71
TIAA51		Capture trigger input (TAA5)	P914/TOAA51/INTP17	56	–
			P914/TOAA51/INTP17/A14	–	70
TIAB00	Input	External event count input/capture trigger input/external trigger input (TAB0). 5 V tolerant.	P53/SIF2/KR3/TOAB00/RTP03/DDO	38	–
			P21/SIF2/KR3/TOAB00/RTP03	–	33
TIAB01		Capture trigger input (TAB0) 5 V tolerant	P50/KR0/TOAB01/RTP00/$\overline{\text{UDMARQ1}}$	35	47
TIAB02			P51/KR1/TOAB02/RTP01/$\overline{\text{UDMAAK1}}$	36	48
TIAB03			P52/KR2/TOAB03/RTP02/DDI	37	–
			P20/KR2/TOAB03/RTP02	–	32
TIAB10	Input	Capture trigger input (TAB1) 5 V tolerant	P61/TOAB1B1/TOAB10/$\overline{\text{RD}}$	66	–
			P61/TOAB1B1/TOAB10	–	91
TIAB11			P60/TOAB1T1/TOAB11/$\overline{\text{WAIT}}$	65	–
			P60/TOAB1T1/TOAB11	–	90
TIAB12			P62/TOAB1T2/TOAB12/ASTB	67	–
			P62/TOAB1T2/TOAB12	–	92
TIAB13			P64/TOAB1T3/TOAB13/$\overline{\text{CS2}}$	69	–
			P64/TOAB1T3/TOAB13	–	94

Remark JG3-H: V850ES/JG3-H, JH3-H: V850ES/JH3-H

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Pin Name	I/O	Function	Alternate Function	Pin No.	
				JG3-H	JH3-H
TIT00	Input	TMT0 external trigger input/capture trigger input	P93/TECR0/TOT00	45	–
			P93/TECR0/TOT00/A3	–	57
TIT01	Input	TMT0 capture trigger input	P92/TENC01/TOT01	44	–
			P92/TENC01/TOT01/A2	–	56
TOAA00	Output	Timer output (TAA0) N-ch open-drain output selectable 5 V tolerant.	P32/ASCKC0/$\overline{\text{SCKF4}}$/TIAA00	27	39
TOAA01			P33/TIAA01/RTCDIV/RTCCL	28	40
TOAA10		Timer output (TAA1) N-ch open-drain output selectable 5 V tolerant.	P34/TIAA10/TOAA1OFF/INTP09	29	41
TOAA11			P35/TIAA11/RTC1HZ	30	42
TOAA1OFF	Input	TAA1 high-impedance output control signal input 5 V tolerant.	P34/TIAA10/TOAA10/INTP09	29	41
TOAA20	Output	Timer output (TAA2) N-ch open-drain output selectable	P97/SIF1/TIAA20	49	–
			P97/SIF1/TIAA20/A7	–	63
TOAA21			P96/TIAA21/INTP11	48	–
			P96/TIAA21/INTP11/A6	–	62
TOAA30		Timer output (TAA3) N-ch open-drain output selectable	P95/TIAA30	47	–
			P95/TIAA30/A5	–	59
TOAA31			P94/TIAA31/TENC00/EVTT0	46	–
			P94/TIAA31/TENC00/EVTT0/A4	–	58
TOAA50		Timer output (TAA5) N-ch open-drain output selectable	P915/TIAA50/INTP18	57	–
			P915/TIAA50/INTP18/A15	–	71
TOAA51			P914/TIAA51/INTP17	56	–
			P914/TIAA51/INTP17/A14	–	70
TOAB00	Output	Timer output (TAB0) N-ch open-drain output selectable 5 V tolerant.	P53/SIF2/TIAB00/KR3/RTP03/DDO	38	–
			P21/SIF2/TIAB00/KR3/RTP03	–	33
TOAB01			P50/TIAB01/KR0/RTP00/$\overline{\text{UDMARQ1}}$	35	47
TOAB02			P51/TIAB02/KR1/RTP01/$\overline{\text{UDMAAK1}}$	36	48
TOAB03			P52/TIAB03/KR2/RTP02/DDI	37	–
			P20/TIAB03/KR2/RTP02	–	32
TOAB1OFF	Input	TAB1 high-impedance output control signal input 5 V tolerant.	P913/INTP16	55	–
			P913/INTP16/A13	–	69
TOAB10	Output	Timer output (TAB1) N-ch open-drain output selectable 5 V tolerant.	P61/TOAB1B1/TIAB10/$\overline{\text{RD}}$	66	–
			P61/TOAB1B1/TIAB10	–	91
TOAB11			P60/TOAB1T1/TIAB11/$\overline{\text{WAIT}}$	65	–
			P60/TOAB1T1/TIAB11	–	90
TOAB12			P62/TOAB1T2/TIAB12/ASTB	67	–
			P62/TOAB1T2/TIAB12	–	92
TOAB13			P64/TOAB1T3/TIAB13/$\overline{\text{CS2}}$	69	–
			P64/TOAB1T3/TIAB13	–	94

Remark JG3-H: V850ES/JG3-H, JH3-H: V850ES/JH3-H

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Pin Name	I/O	Function	Alternate Function	Pin No.	
				JG3-H	JH3-H
TOAB1B1	Output	Pulse signal output for 6-phase PWM low-arm of TAB1	P61/TIAB10/TOAB10/$\overline{RD}$	66	–
			P61/TIAB10/TOAB10	–	91
TOAB1B2			P63/TRGAB1/$\overline{CS0}$	68	–
			P63/TRGAB1	–	93
TOAB1B3			P65/EVTAB1/$\overline{CS3}$	70	–
			P65/EVTAB1	–	95
TOAB1T1	Output	Pulse signal output for 6-phase PWM high-arm of TAB1	P60/TOAB11/TIAB11/$\overline{WAIT}$	65	–
			P60/TIAB11/TOAB11	–	90
TOAB1T2			P62/TIAB12/TOAB12/ASTB	67	–
			P62/TIAB12/TOAB12	–	92
TOAB1T3			P64/TOAB13/TIAB13/$\overline{CS2}$	69	–
			P64/TIAB13/TOAB13	–	94
TOT00	Output	TMT0 timer output	P93/TECR0/TIT00	45	–
			P93/TECR0/TIT00/A3	–	57
TOT01			P92/TENC01/TIT01	44	–
			P92/TENC01/TIT01/A2	–	56
TRGAB1	Input	External trigger input of TAB1	P63/TOAB1B2/$\overline{CS0}$	68	–
			P63/TOAB1B2	–	93
TXDC0	Output	Serial transmit data output (UARTC0 to UARTC4) N-ch open-drain output selectable 5 V tolerant (TXDC0, TXDC3, TXDC4)	P30/SOF4/INTP07	25	37
TXDC1			P90/KR6/SDA02	42	
			P90/KR6/SDA02/A0	–	54
TXDC2			P910/SIF3/INTP14	52	–
			P910/SIF3/INTP14/A10	–	66
TXDC3			P36/SCL00/CTXD0[Note]/$\overline{UDMARQ0}$	31	43
TXDC4			P40/SIF0/SDA01	22	29
UCLK	Input	USB clock signal input. 5 V tolerant.	P03/INTP02/ADTRG	7	7
$\overline{UDMAAK0}$	Output	DMA acknowledge for USB. 5 V tolerant.	P37/RXDC3/SDA00/CRXD0[Note]	32	44
$\overline{UDMAAK1}$		DMA acknowledge for USB. 5 V tolerant.	P51/TIAB02/KR1/TOAB02/RTP01	36	48
$\overline{UDMARQ0}$	Input	DMA request for USB. 5 V tolerant.	P36/TXDC3/SCL00/CTXD0[Note]	31	43
$\overline{UDMARQ1}$		DMA request for USB. 5 V tolerant.	P50/TIAB01/KR0/TOAB01/RTP00	35	47
UDMF	I/O	USB data I/O (–) function	–	17	21
UDPF		USB data I/O (+) function	–	18	22
UV_{DD}	–	3.3 V Positive power supply for USB	–	19	23
V_{DD}	–	Positive power supply pin for internal unit	–	9, 60	13, 82
V_{SS}	–	Ground potential for internal unit	–	11, 33 62, 79	15, 45 60, 84 106

Note μPD70F3770, 70F3771 only

Remark JG3-H: V850ES/JG3-H, JH3-H: V850ES/JH3-H

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Pin Name	I/O	Function	Alternate Function	Pin No.	
				JG3-H	JH3-H
$\overline{\text{WAIT}}$	Input	External wait input	P60/TOAB1T1/TIAB11/TOAB11	65	–
			PCM0	–	89
$\overline{\text{WR0}}$	Output	Write strobe for external memory (lower 8 bits)	PCT0	58	76
$\overline{\text{WR1}}$		Write strove for external memory (higher 8 bits)	PCT1	59	77
X1	Input	Connection of resonator for main clock	–	12	16
X2	–		–	13	17
XT1	Input	Connection of resonator for subclock	–	15	19
XT2	–		–	16	20

Remark JG3-H: V850ES/JG3-H, JH3-H: V850ES/JH3-H

2.2 Pin States

The operation states of pins in the various operation modes are described below.

Table 2-2. Pin Operation States in Various Modes

Pin Name	When Power Is Turned On[Note 1]	During Reset (Other than When Power Is Turned On)	HALT Mode[Note 2]	IDLE1, IDLE2, Sub-IDLE Mode[Note 2]	STOP Mode[Note 2]	Idle State[Note 3]	Bus Hold
$\overline{\text{DRST}}$	Pull down	Pull down[Note 4]	Held	Held	Held	Held	Held
P10/ANO0, P11/ANO1	Undefined	Hi-Z	Held	Held	Hi-Z	Held	Held
AD0 to AD15	Hi-Z[Note 5]	Hi-Z[Note 5]	**Notes 6, 7**	Hi-Z	Hi-Z	Held	Hi-Z
A0 to A15			Undefined[Notes 6, 8]				
A16 to A21			Undefined[Note 6]				
$\overline{\text{WAIT}}$			–	–	–	–	–
CLKOUT			Operating	L	L	Operating	Operating
$\overline{\text{WR0}}$, $\overline{\text{WR1}}$			H[Note 6]	H	H	H	Hi-Z
$\overline{\text{RD}}$							
ASTB							
$\overline{\text{HLDAK}}$			Operating[Note 6]				L
$\overline{\text{HLDRQ}}$				–	–	–	Operating
Other port pins	Hi-Z	Hi-Z	Held	Held	Held	Held	Held

Notes 1. Duration until 1 ms elapses after the supply voltage reaches the operating supply voltage range (lower limit) when the power is turned on.

2. Operates while alternate functions are operating.

3. The state of the pins in the idle state inserted after the T3 state is shown.

4. Pulled down during external reset. During internal reset by the watchdog timer or clock monitor, etc., the state of this pin differs according to the OCDM.OCDM0 bit setting.

5. The bus control pins function alternately as port pins, so they are initialized to the input mode (port mode).

6. Operates even in the HALT mode, during DMA operation.

7. In separate bus output function: Hi-Z
In multiplexed bus mode: Undefined

8. In separate bus output function

Remark Hi-Z: High impedance
Held: The state during the immediately preceding external bus cycle is held.
L: Low-level output
H: High-level output
–: Input without sampling (not acknowledged)

2.3 Pin I/O Circuit Types, I/O Buffer Power Supplies and Connection of Unused Pins

Table 2-3. Pin I/O Circuit Types, I/O Buffer Power Supplies and Connection of Unused Pins (1/4)

Pin Name	Alternate Function	I/O Circuit Type	Recommended Connection	JG3-H	JH3-H
P00	INTP00	10-D	Input: Independently connect to EV_{DD} or V_{SS} via a resistor. Output: Leave open.	–	√
P01	INTP01			–	√
P02	NMI			√	√
P03	INTP02/ADTRG/UCLK			√	√
P04	INTP03			√	√
P05	INTP04			√	√
P10	ANO0	12-D	Input: Independently connect to AV_{REF1} or AV_{SS} via a resistor. Output: Leave open.	√	√
P11	ANO1			√	√
P20	TIAB03/KR2/TOAB03/RTP02	10-D	Input: Independently connect to EV_{DD} or V_{SS} via a resistor. Output: Leave open.	–	√
P21	SIF2/TIAB00/KR3/TOAB00/RTP03			–	√
P22	SOF2/KR4/RTP04			–	√
P23	$\overline{\text{SCKF2}}$/KR5/RTP05			–	√
P24	INTP05			–	√
P25	INTP06			–	√
P30	TXDC0/SOF4/INTP07	10-D	Input: Independently connect to EV_{DD} or V_{SS} via a resistor. Output: Leave open.	√	√
P31	RXDC0/SIF4/INTP08			√	√
P32	ASCKC0/$\overline{\text{SCKF4}}$/TIAA00/TOAA00			√	√
P33	TIAA01/TOAA01/RTCDIV/RTCCL			√	√
P34	TIAA10/TOAA10/TOAA1OFF/INTP09			√	√
P35	TIAA11/TOAA11/RTC1HZ			√	√
P36	TXDC3/SCL00/CTXD0[Note]/$\overline{\text{UDMARQ0}}$			√	√
P37	RXDC3/SDA00/CRXD0[Note]/$\overline{\text{UDMAAK0}}$			√	√
P40	SIF0/TXDC4/SDA01	10-D	Input: Independently connect to EV_{DD} or V_{SS} via a resistor. Output: Leave open.	√	√
P41	SOF0/RXDC4/SCL01			√	√
P42	$\overline{\text{SCKF0}}$/INTP10			√	√
P50	TIAB01/KR0/TOAB01/RTP00/$\overline{\text{UDMARQ1}}$	10-D	Input: Independently connect to EV_{DD} or V_{SS} via a resistor. Output: Leave open.	√	√
P51	TIAB02/KR1/TOAB02/RTP01/$\overline{\text{UDMAAK1}}$			√	√
P52	TIAB03/KR2/TOAB03/RTP02/DDI			√	–
P53	SIF2/TIAB00/KR3/TOAB00/RTP03/DDO			√	–
P54	SOF2/KR4/RTP04/DCK			√	–
P55	$\overline{\text{SCKF2}}$/KR5/RTP05/DMS			√	–
P56	INTP05/$\overline{\text{DRST}}$	10-N	Input: Independently connect to V_{SS} via a resistor. Fixing to V_{DD} level is prohibited. Output: Leave open. Internally pull-down after reset by $\overline{\text{RESET}}$ pin.	√	–

Note μPD70F3770, 70F3771 only

Remark JG3-H: V850ES/JG3-H, JH3-H: V850ES/JH3-H

Table 2-3. Pin I/O Circuit Types, I/O Buffer Power Supplies and Connection of Unused Pins (2/4)

Pin Name	Alternate Function	I/O Circuit Type	Recommended Connection	JG3-H	JH3-H
P60	TOAB1T1/TIAB11/TOAB11/$\overline{\text{WAIT}}$	10-D	Input: Independently connect to EV_{DD} or V_{SS} via a resistor. Output: Leave open.	√	–
	TOAB1T1/TIAB11/TOAB11			–	√
P61	TOAB1B1/TIAB10/TOAB10/$\overline{\text{RD}}$			√	–
	TOAB1B1/TIAB10/TOAB10			–	√
P62	TOAB1T2/TIAB12/TOAB12/ASTB			√	–
	TOAB1T2/TIAB12/TOAB12			–	√
P63	TOAB1B2/TRGAB1/$\overline{\text{CS0}}$			√	–
	TOAB1B2/TRGAB1			–	√
P64	TOAB1T3/TIAB13/TOAB13/$\overline{\text{CS2}}$			√	–
	TOAB1T3/TIAB13/TOAB13			–	√
P65	TOAB1B3/EVTAB1/$\overline{\text{CS3}}$			√	–
	TOAB1B3/EVTAB1			–	√
P70 to P711	ANI0 to ANI11	11-G	Input: Independently connect to AV_{REF0} or AV_{SS} via a resistor. Output: Leave open.	√	√
P90	KR6/TXDC1/SDA02	10-D	Input: Independently connect to EV_{DD} or V_{SS} via a resistor. Output: Leave open.	√	–
	KR6/TXDC1/SDA02/A0			–	√
P91	KR7/RXDC1/SCL02			√	–
	KR7/RXDC1/SCL02/A1			–	√
P92	TENC01/TIT01/TOT01			√	–
	TENC01/TIT01/TOT01/A2			–	√
P93	TECR0/TIT00/TOT00			√	–
	TECR0/TIT00/TOT00/A3			–	√
P94	TIAA31/TOAA31/TENC00/EVTT0			√	–
	TIAA31/TOAA31/TENC00/EVTT0/A4			–	√
P95	TIAA30/TOAA30			√	–
	TIAA30/TOAA30/A5			–	√
P96	TIAA21/TOAA21/INTP11			√	–
	TIAA21/TOAA21/INTP11/A6			–	√
P97	SIF1/TIAA20/TOAA20			√	–
	SIF1/TIAA20/TOAA20/A7			–	√
P98	SOF1/INTP12			√	–
	SOF1/INTP12/A8			–	√
P99	$\overline{\text{SCKF1}}$/INTP13			√	–
	$\overline{\text{SCKF1}}$/INTP13/A9			–	√
P910	SIF3/TXDC2/INTP14			√	–
	SIF3/TXDC2/INTP14/A10			–	√
P911	SOF3/RXDC2/INTP15			√	–
	SOF3/RXDC2/INTP15/A11			–	√
P912	$\overline{\text{SCKF3}}$			√	–
	$\overline{\text{SCKF3}}$/A12			–	√

Remark JG3-H: V850ES/JG3-H, JH3-H: V850ES/JH3-H

Table 2-3. Pin I/O Circuit Types, I/O Buffer Power Supplies and Connection of Unused Pins (3/4)

Pin Name	Alternate Function	I/O Circuit Type	Recommended Connection	JG3-H	JH3-H
P913	TOAB1OFF/INTP16	10-D	Input: Independently connect to EV_{DD} or V_{SS} via a resistor. Output: Leave open.	√	–
	TOAB1OFF/INTP16/A13			–	√
P914	TIAA51/TOAA51/INTP17			√	–
	TIAA51/TOAA51/INTP17/A14			–	√
P915	TIAA50/TOAA50/INTP18			√	–
	TIAA50/TOAA50/INTP18/A15			–	√
PCM0	$\overline{WAIT}$	5	Input: Independently connect to EV_{DD} or V_{SS} via a resistor. Output: Leave open.	–	√
PCM1	CLKOUT			√	√
PCM2	$\overline{HLDAK}$			–	√
PCM3	$\overline{HLDRQ}$			–	√
PCS0	$\overline{CS0}$	5	Input: Independently connect to EV_{DD} or V_{SS} via a resistor. Output: Leave open.	–	√
PCS2	$\overline{CS2}$			–	√
PCS3	$\overline{CS3}$			–	√
PCT0	$\overline{WR0}$	5	Input: Independently connect to EV_{DD} or V_{SS} via a resistor. Output: Leave open.	√	√
PCT1	$\overline{WR1}$			√	√
PCT4	$\overline{RD}$			–	√
PCT6	ASTB			–	√
PDH0 to PDH7	A16 to A23	5	Input: Independently connect to EV_{DD} or V_{SS} via a resistor. Output: Leave open.	–	√
PDL0 to PDL4	AD0 to AD4	5	Input: Independently connect to EV_{DD} or V_{SS} via a resistor. Output: Leave open.	√	√
PDL5	AD5/FLMD1			√	√
PDL6 to PDL15	AD6 to AD15			√	√
AV_{REF0}	–	–	Always connect to power supply. (The same applies during standby.)	√	√
AV_{REF1}	–	–		√	√
AV_{SS}	–	–	Always directly connect to ground. (The same applies during standby.)	√	√
DCK	–	–	Always connect to power supply. (The same applies during standby.)	–	√
DDI	–	–		–	√
DDO	–	–	Leave open.	–	√
DMS	–	–	Always connect to power supply. (The same applies during standby.)	–	√
$\overline{DRST}$	–	–	Always directly connect to ground. (The same applies during standby.)	–	√
EV_{DD}	–	–	Always connect to power supply. (The same applies during standby.)	√	√
FLMD0	–	–	Directly connect to V_{SS} in other than flash mode.	√	√

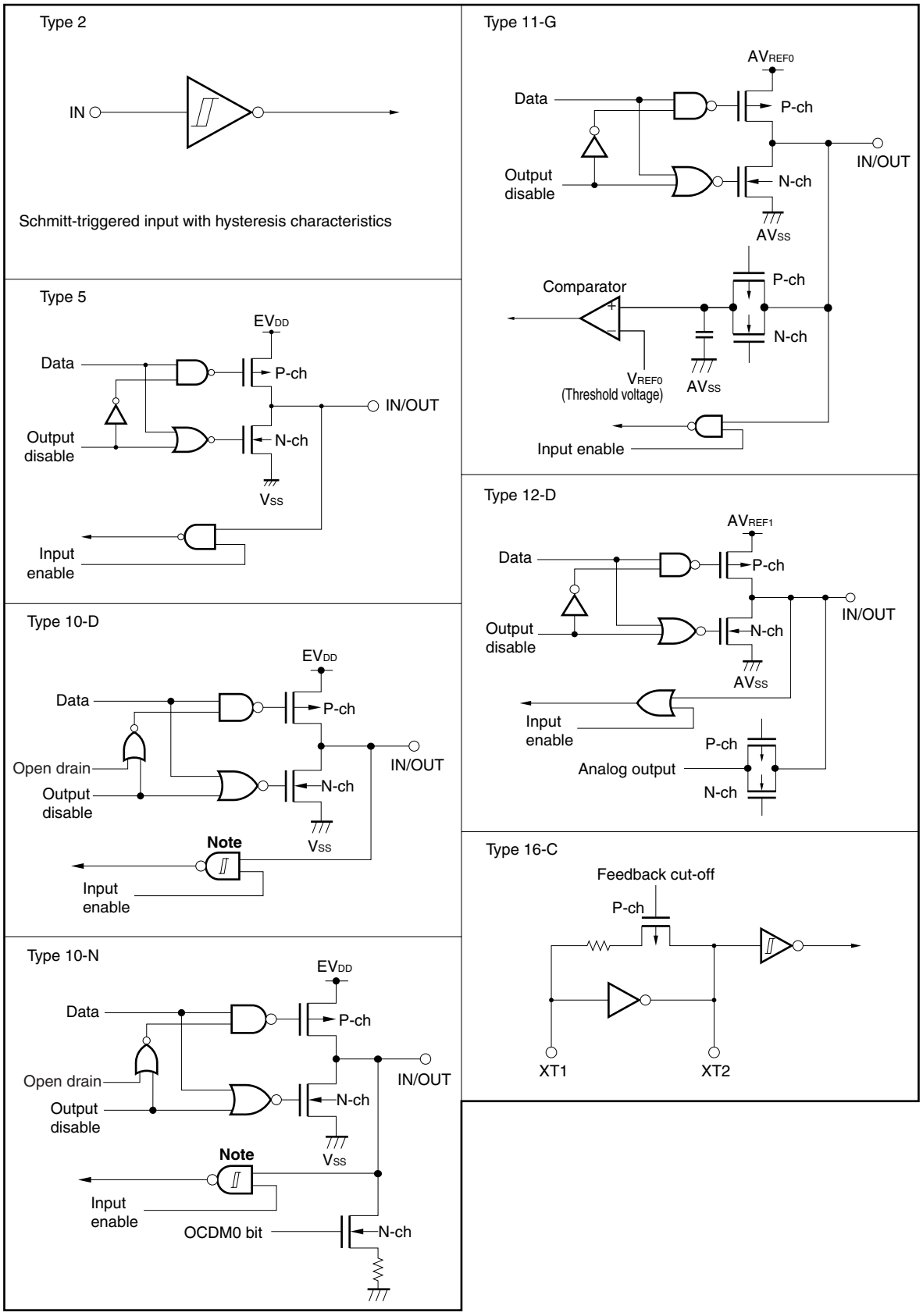
Remark JG3-H: V850ES/JG3-H, JH3-H: V850ES/JH3-H

Table 2-3. Pin I/O Circuit Types, I/O Buffer Power Supplies and Connection of Unused Pins (4/4)

Pin Name	Alternate Function	I/O Circuit Type	Recommended Connection	JG3-H	JH3-H
REGC	–	–	Connect to regulator output stabilization capacitor.	√	√
$\overline{\text{RESET}}$	–	2	–	√	√
UDMF	–	–	Always directly connect to ground via a resistor.	√	√
UDPF	–	–	Always directly connect to ground. (The same applies during standby.)	√	√
UV_{DD}	–	–	Always connect to power supply. (The same applies during standby.)	√	√
V_{DD}	–	–	Always connect to power supply. (The same applies during standby.)	√	√
V_{SS}	–	–	Always directly connect to ground. (The same applies during standby.)	√	√
X1	–	–	–	√	√
X2	–	–	–	√	√
XT1	–	16-C	Connect to V_{SS} via a resistor.	√	√
XT2	–	16-C	Leave open.	√	√
NC	–	–	Leave open.	–	√

Remark JG3-H: V850ES/JG3-H, JH3-H: V850ES/JH3-H

Figure 2-1. Pin I/O Circuits



Note Hysteresis characteristics are not available in port mode.

2.4 Cautions

When the power is turned on, the following pins may output an undefined level temporarily even during reset.

- P10/ANO0 pin
- P11/ANO1 pin
- DDO pin (V850ES/JH3-H only)
- P53/SIF2/TIAB00/KR3/TOAB00/RTP03/DDO pin (V850ES/JG3-H only)

CHAPTER 3 CPU FUNCTION

The CPU of the V850ES/JG3-H and V850ES/JH3-H is based on RISC architecture and executes almost all instructions with one clock by using a 5-stage pipeline.

3.1 Features

- ○ Minimum instruction execution time: 20.8 ns (operating with main clock (f_{XX}) of 48 MHz: V_{DD} = 2.85 to 3.6 V)
  30.5 μs (operating with subclock (f_{XT}) of 32.768 kHz)
- ○ Memory space Program (physical address) space: 64 MB linear
  Data (logical address) space: 4 GB linear
- ○ General-purpose registers: 32 bits × 32 registers
- ○ Internal 32-bit architecture
- ○ 5-stage pipeline control
- ○ Multiplication/division instruction
- ○ Saturation operation instruction
- ○ 32-bit shift instruction: 1 clock
- ○ Load/store instruction with long/short format
- ○ Four types of bit manipulation instructions
  - SET1
  - CLR1
  - NOT1
  - TST1

3.2 CPU Register Set

The registers of the V850ES/JG3-H and V850ES/JH3-H can be classified into two types: general-purpose program registers and dedicated system registers. All the registers are 32 bits wide.

For details, refer to the **V850ES Architecture User's Manual**.

(1) Program register set

31		0
r0	(Zero register)	
r1	(Assembler-reserved register)	
r2		
r3	(Stack pointer (SP))	
r4	(Global pointer (GP))	
r5	(Text pointer (TP))	
r6		
r7		
r8		
r9		
r10		
r11		
r12		
r13		
r14		
r15		
r16		
r17		
r18		
r19		
r20		
r21		
r22		
r23		
r24		
r25		
r26		
r27		
r28		
r29		
r30	(Element pointer (EP))	
r31	(Link pointer (LP))	

31		0
PC	(Program counter)	

(2) System register set

31		0
EIPC	(Interrupt status saving register)	
EIPSW	(Interrupt status saving register)	

FEPC	(NMI status saving register)
FEPSW	(NMI status saving register)

ECR	(Interrupt source register)

PSW	(Program status word)

CTPC	(CALLT execution status saving register)
CTPSW	(CALLT execution status saving register)

DBPC	(Exception/debug trap status saving register)
DBPSW	(Exception/debug trap status saving register)

CTBP	(CALLT base pointer)

3.2.1 Program register set

The program registers include general-purpose registers and a program counter.

(1) General-purpose registers (r0 to r31)

Thirty-two general-purpose registers, r0 to r31, are available. Any of these registers can be used to store a data variable or an address variable.

However, r0 and r30 are implicitly used by instructions and care must be exercised when these registers are used. r0 always holds 0 and is used for an operation that uses 0 or addressing of offset 0. r30 is used by the SLD and SST instructions as a base pointer when these instructions access the memory. r1, r3 to r5, and r31 are implicitly used by the assembler and C compiler. When using these registers, save their contents for protection, and then restore the contents after using the registers. r2 is sometimes used by the real-time OS. If the real-time OS does not use r2, it can be used as a register for variables.

Table 3-1. Program Registers

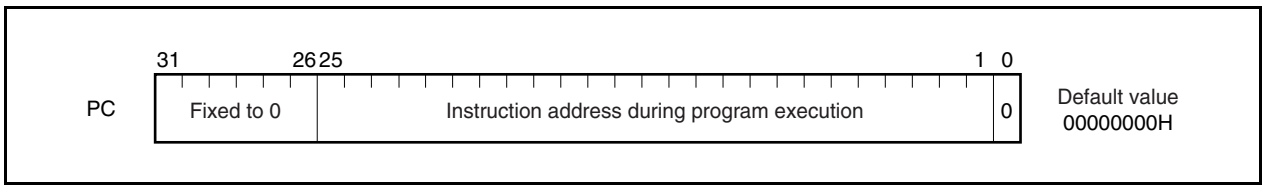
Name	Usage	Operation
r0	Zero register	Always holds 0.
r1	Assembler-reserved register	Used as working register to create 32-bit immediate data
r2	Register for address/data variable (if real-time OS does not use r2)	
r3	Stack pointer	Used to create a stack frame when a function is called
r4	Global pointer	Used to access a global variable in the data area
r5	Text pointer	Used as register that indicates the beginning of a text area (area where program codes are located)
r6 to r29	Register for address/data variable	
r30	Element pointer	Used as base pointer to access memory
r31	Link pointer	Used when the compiler calls a function
PC	Program counter	Holds the instruction address during program execution

Remark For further details on the r1, r3 to r5, and r31 that are used in the assembler and C compiler, refer to the **CA850 (C Compiler Package) Assembly Language User's Manual**.

(2) Program counter (PC)

The program counter holds the instruction address during program execution. The lower 32 bits of this register are valid. Bits 31 to 26 are fixed to 0. A carry from bit 25 to 26 is ignored even if it occurs.

Bit 0 is fixed to 0. This means that execution cannot branch to an odd address.



3.2.2 System register set

The system registers control the status of the CPU and hold interrupt information.

These registers can be read or written by using system register load/store instructions (LDSR and STSR), using the system register numbers listed below.

Table 3-2. System Register Numbers

System Register Number	System Register Name	Operand Specification	
		LDSR Instruction	STSR Instruction
0	Interrupt status saving register (EIPC)Note 1	√	√
1	Interrupt status saving register (EIPSW)Note 1	√	√
2	NMI status saving register (FEPC)Note 1	√	√
3	NMI status saving register (FEPSW)Note 1	√	√
4	Interrupt source register (ECR)	×	√
5	Program status word (PSW)	√	√
6 to 15	Reserved for future function expansion (operation is not guaranteed if these registers are accessed)	×	×
16	CALLT execution status saving register (CTPC)	√	√
17	CALLT execution status saving register (CTPSW)	√	√
18	Exception/debug trap status saving register (DBPC)	√Note 2	√Note 2
19	Exception/debug trap status saving register (DBPSW)	√Note 2	√Note 2
20	CALLT base pointer (CTBP)	√	√
21 to 31	Reserved for future function expansion (operation is not guaranteed if these registers are accessed)	×	×

Notes 1. Because only one set of these registers is available, the contents of these registers must be saved by program if multiple interrupts are enabled.

2. These registers can be accessed only during the interval between the execution of the DBTRAP instruction or illegal opcode and DBRET instruction execution.

Caution Even if EIPC or FEPC, or bit 0 of CTPC is set to 1 by the LDSR instruction, bit 0 is ignored when execution is returned to the main routine by the RETI instruction after interrupt servicing (this is because bit 0 of the PC is fixed to 0). Set an even value to EIPC, FEPC, and CTPC (bit 0 = 0).

Remark √: Can be accessed
×: Access prohibited

(1) Interrupt status saving registers (EIPC and EIPSW)

EIPC and EIPSW are used to save the status when an interrupt occurs.

If a software exception or a maskable interrupt occurs, the contents of the program counter (PC) are saved to EIPC, and the contents of the program status word (PSW) are saved to EIPSW (these contents are saved to the NMI status saving registers (FEPC and FEPSW) if a non-maskable interrupt occurs).

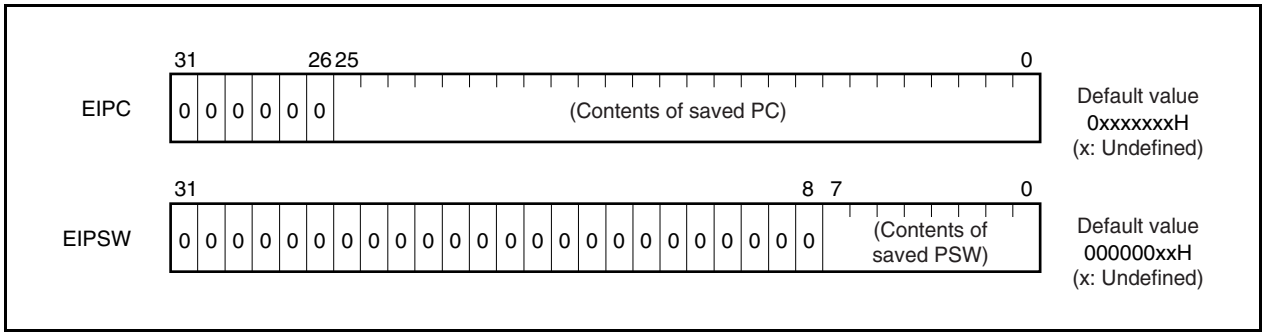
The address of the instruction next to the instruction under execution, except some instructions (see **23.8 Periods in Which Interrupts Are Not Acknowledged by CPU**), is saved to EIPC when a software exception or a maskable interrupt occurs.

The current contents of the PSW are saved to EIPSW.

Because only one set of interrupt status saving registers is available, the contents of these registers must be saved by program when multiple interrupts are enabled.

Bits 31 to 26 of EIPC and bits 31 to 8 of EIPSW are reserved for future function expansion (these bits are always fixed to 0).

The value of EIPC is restored to the PC and the value of EIPSW to the PSW by the RETI instruction.



(2) NMI status saving registers (FEPC and FEPSW)

FEPC and FEPSW are used to save the status when a non-maskable interrupt (NMI) occurs.

If an NMI occurs, the contents of the program counter (PC) are saved to FEPC, and those of the program status word (PSW) are saved to FEPSW.

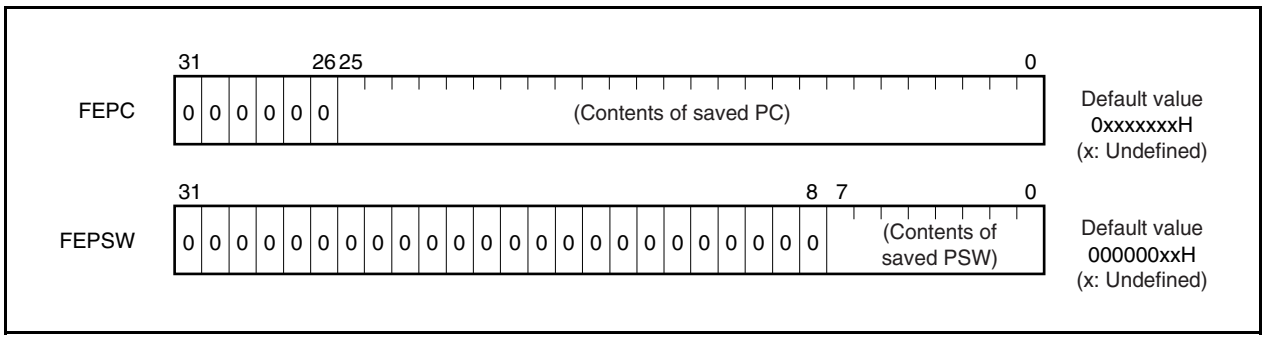
The address of the instruction next to the one of the instruction under execution, except some instructions, is saved to FEPC when an NMI occurs.

The current contents of the PSW are saved to FEPSW.

Because only one set of NMI status saving registers is available, the contents of these registers must be saved by program when multiple interrupts are enabled.

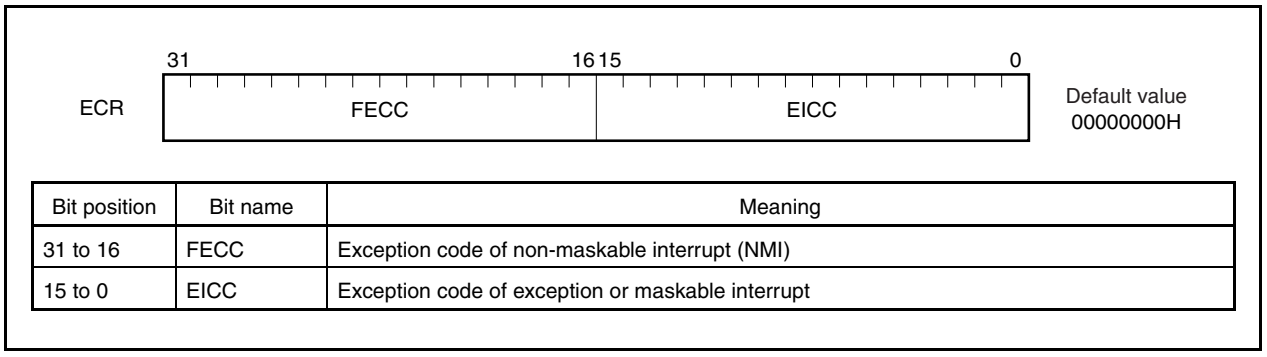
Bits 31 to 26 of FEPC and bits 31 to 8 of FEPSW are reserved for future function expansion (these bits are always fixed to 0).

The value of FEPC is restored to the PC and the value of FEPSW to the PSW by the RETI instruction.



(3) Interrupt source register (ECR)

The interrupt source register (ECR) holds the source of an exception or interrupt if an exception or interrupt occurs. This register holds the exception code of each interrupt source. Because this register is a read-only register, data cannot be written to this register using the LDSR instruction.



Bit position	Bit name	Meaning
31 to 16	FECC	Exception code of non-maskable interrupt (NMI)
15 to 0	EICC	Exception code of exception or maskable interrupt

(4) Program status word (PSW)

The program status word (PSW) is a collection of flags that indicate the status of the program (result of instruction execution) and the status of the CPU.

If the contents of a bit of this register are changed by using the LDSR instruction, the new contents are validated immediately after completion of LDSR instruction execution. However if the ID flag is set to 1, interrupt requests will not be acknowledged while the LDSR instruction is being executed.

Bits 31 to 8 of this register are reserved for future function expansion (these bits are fixed to 0).

(1/2)

Bit position	Flag name	Meaning
31 to 8	RFU	Reserved field. Fixed to 0.
7	NP	Indicates that a non-maskable interrupt (NMI) is being serviced. This bit is set to 1 when an NMI request is acknowledged, disabling multiple interrupts. 0: NMI is not being serviced. 1: NMI is being serviced.
6	EP	Indicates that an exception is being processed. This bit is set to 1 when an exception occurs. Even if this bit is set, interrupt requests are acknowledged. 0: Exception is not being processed. 1: Exception is being processed.
5	ID	Indicates whether a maskable interrupt can be acknowledged. 0: Interrupt enabled 1: Interrupt disabled
4	SAT[Note]	Indicates that the result of a saturation operation has overflowed and is saturated. Because this is a cumulative flag, it is set to 1 when the result of a saturation operation instruction is saturated, and is not cleared to 0 even if the subsequent operation result is not saturated. Use the LDSR instruction to clear this bit. This flag is neither set to 1 nor cleared to 0 by execution of an arithmetic operation instruction. 0: Not saturated 1: Saturated
3	CY	Indicates whether a carry or a borrow occurs as a result of an operation. 0: Carry or borrow does not occur. 1: Carry or borrow occurs.
2	OV[Note]	Indicates whether an overflow occurs during operation. 0: Overflow does not occur. 1: Overflow occurs.
1	S[Note]	Indicates whether the result of an operation is negative. 0: The result is positive or 0. 1: The result is negative.
0	Z	Indicates whether the result of an operation is 0. 0: The result is not 0. 1: The result is 0.

Remark Also read **Note** on the next page.

(2/2)

Note The result of the operation that has performed saturation processing is determined by the contents of the OV and S flags. The SAT flag is set to 1 only when the OV flag is set to 1 when a saturation operation is performed.

Status of Operation Result	Flag Status			Result of Operation of Saturation Processing
	SAT	OV	S	
Maximum positive value is exceeded	1	1	0	7FFFFFFFH
Maximum negative value is exceeded	1	1	1	80000000H
Positive (maximum value is not exceeded)	Holds value before operation	0	0	Operation result itself
Negative (maximum value is not exceeded)			1	

(5) CALLT execution status saving registers (CTPC and CTPSW)

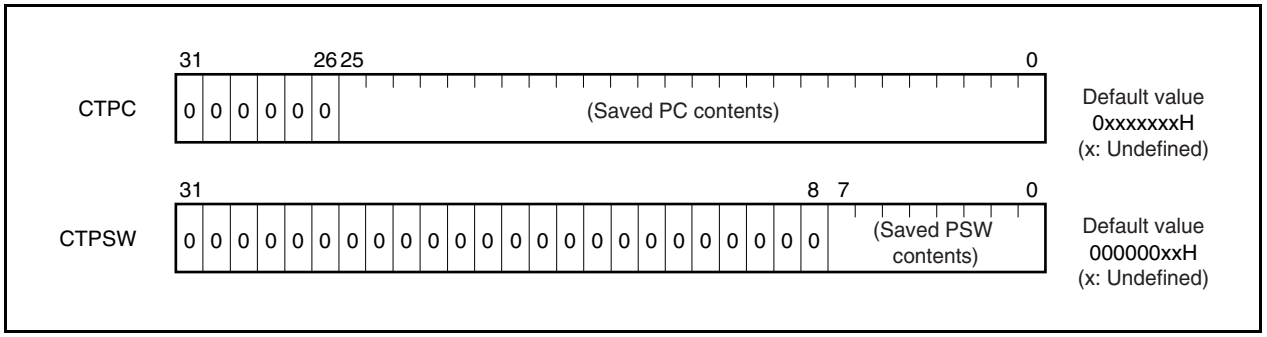
CTPC and CTPSW are CALLT execution status saving registers.

When the CALLT instruction is executed, the contents of the program counter (PC) are saved to CTPC, and those of the program status word (PSW) are saved to CTPSW.

The contents saved to CTPC are the address of the instruction next to CALLT.

The current contents of the PSW are saved to CTPSW.

Bits 31 to 26 of CTPC and bits 31 to 8 of CTPSW are reserved for future function expansion (fixed to 0).



(6) Exception/debug trap status saving registers (DBPC and DBPSW)

DBPC and DBPSW are exception/debug trap status registers.

If an exception trap or debug trap occurs, the contents of the program counter (PC) are saved to DBPC, and those of the program status word (PSW) are saved to DBPSW.

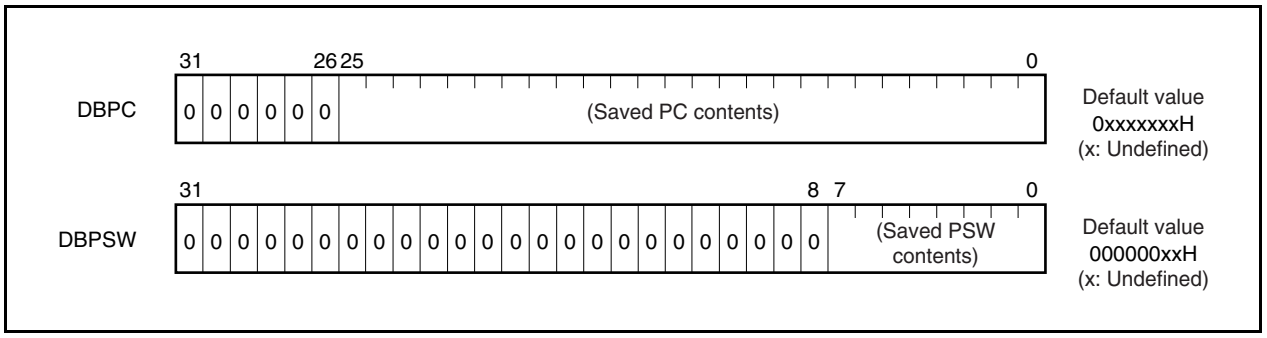
The contents to be saved to DBPC are the address of the instruction next to the one that is being executed when an exception trap or debug trap occurs.

The current contents of the PSW are saved to DBPSW.

This register can be read or written only during the interval between the execution of the DBTRAP instruction or illegal opcode and the DBRET instruction.

Bits 31 to 26 of DBPC and bits 31 to 8 of DBPSW are reserved for future function expansion (fixed to 0).

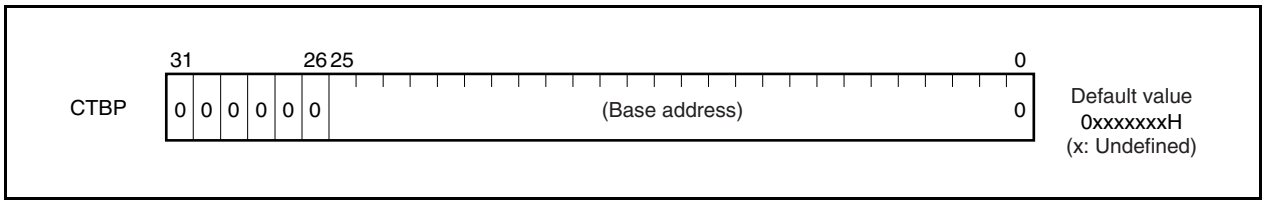
The value of DBPC is restored to the PC and the value of DBPSW to the PSW by the DBRET instruction.



(7) CALLT base pointer (CTBP)

The CALLT base pointer (CTBP) is used to specify a table address or generate a target address (bit 0 is fixed to 0).

Bits 31 to 26 of this register are reserved for future function expansion (fixed to 0).



3.3 Operation Modes

The V850ES/JG3-H and V850ES/JH3-H have the following operation modes.

(1) Normal operation mode

In this mode, each pin related to the bus interface is set to the port mode after system reset has been released. Execution branches to the reset entry address of the internal ROM, and then instruction processing is started.

(2) Flash memory programming mode

In this mode, the internal flash memory can be programmed by using a flash programmer.

(3) On-chip debug mode

The V850ES/JG3-H and V850ES/JH3-H are provided with an on-chip debug function that employs the JTAG (Joint Test Action Group) communication specifications.

For details, see **CHAPTER 32 ON-CHIP DEBUG FUNCTION**.

3.3.1 Specifying operation mode

Specify the operation mode by using the FLMD0 and FLMD1 pins.

In the normal mode, make sure that a low level is input to the FLMD0 pin when reset is released.

In the flash memory programming mode, a high level is input to the FLMD0 pin from the flash programmer if a flash programmer is connected, but it must be input from an external circuit in the self-programming mode.

Operation When Reset Is Released		Operation Mode After Reset
FLMD0	FLMD1	
L	×	Normal operation mode
H	L	Flash memory programming mode
H	H	Setting prohibited

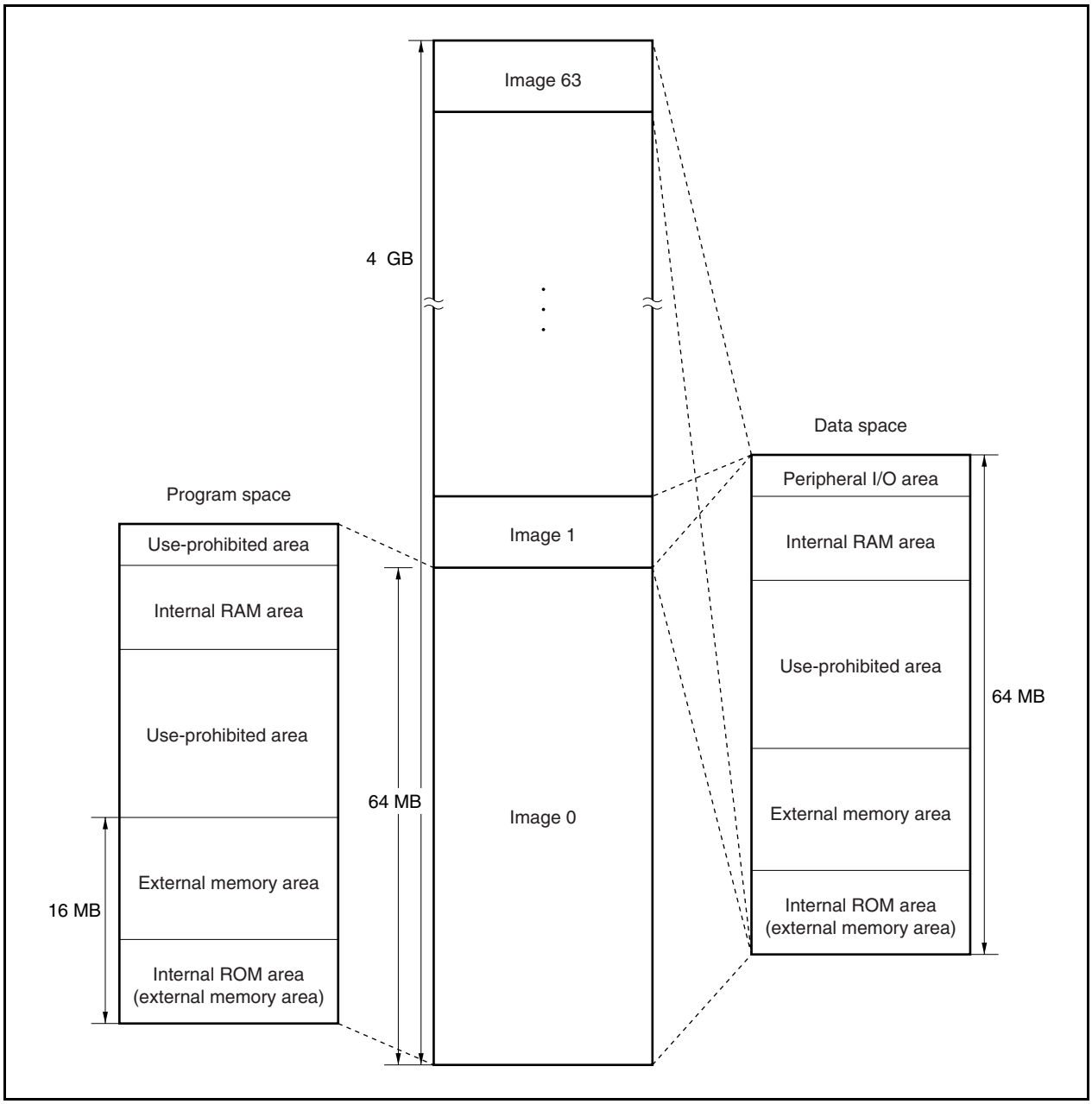
Remark L: Low-level input
H: High-level input
×: Don't care

3.4 Address Space

3.4.1 CPU address space

For instruction addressing, up to a combined total of 16 MB of external memory area and internal ROM area, plus an internal RAM area, are supported in a linear address space (program space) of up to 64 MB. For operand addressing (data access), up to 4 GB of a linear address space (data space) is supported. The 4 GB address space, however, is viewed as 64 images of a 64 MB physical address space. This means that the same 64 MB physical address space is accessed regardless of the value of bits 31 to 26.

Figure 3-1. Image on Address Space



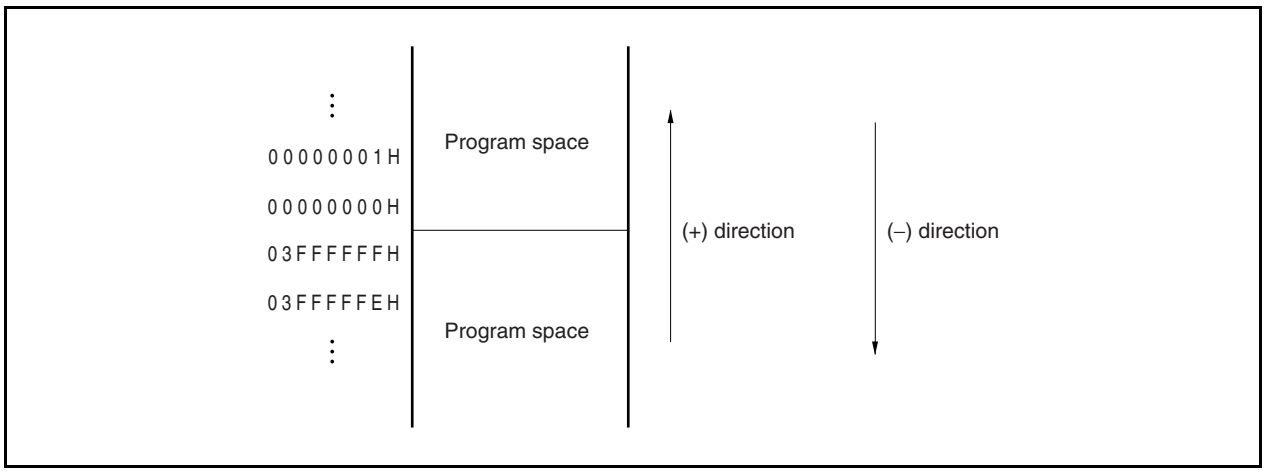
3.4.2 Wraparound of CPU address space

(1) Program space

Of the 32 bits of the PC (program counter), the higher 6 bits are fixed to 0 and only the lower 26 bits are valid. The higher 6 bits ignore a carry or borrow from bit 25 to 26 during branch address calculation.

Therefore, the highest address of the program space, 03FFFFFFH, and the lowest address, 00000000H, are contiguous addresses. That the highest address and the lowest address of the program space are contiguous in this way is called wraparound.

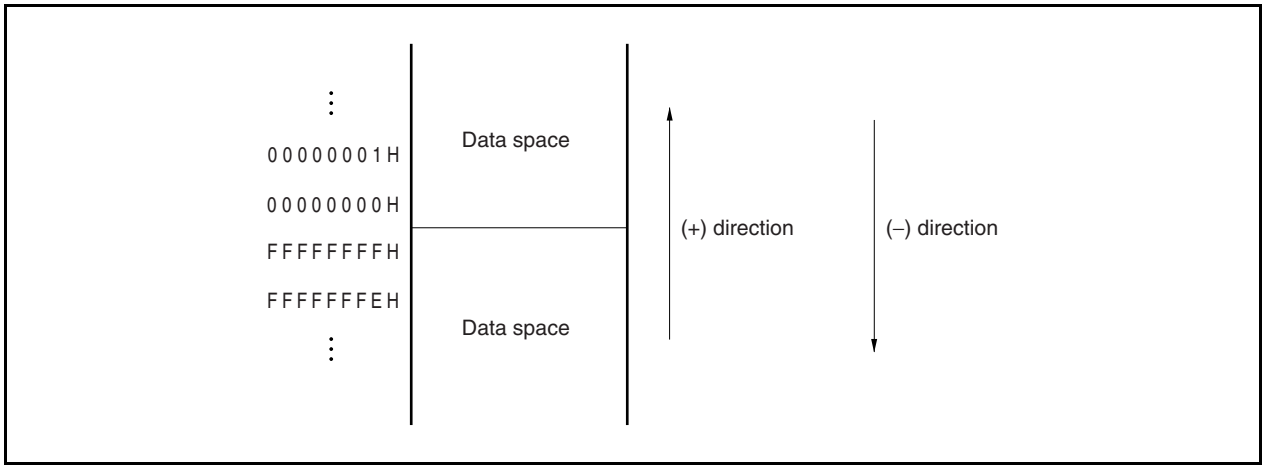
Caution Because the 4 KB area of addresses 03FFF000H to 03FFFFFFH is an on-chip peripheral I/O area, instructions cannot be fetched from this area. Therefore, do not execute an operation in which the result of a branch address calculation affects this area.



(2) Data space

The result of an operand address calculation operation that exceeds 32 bits is ignored.

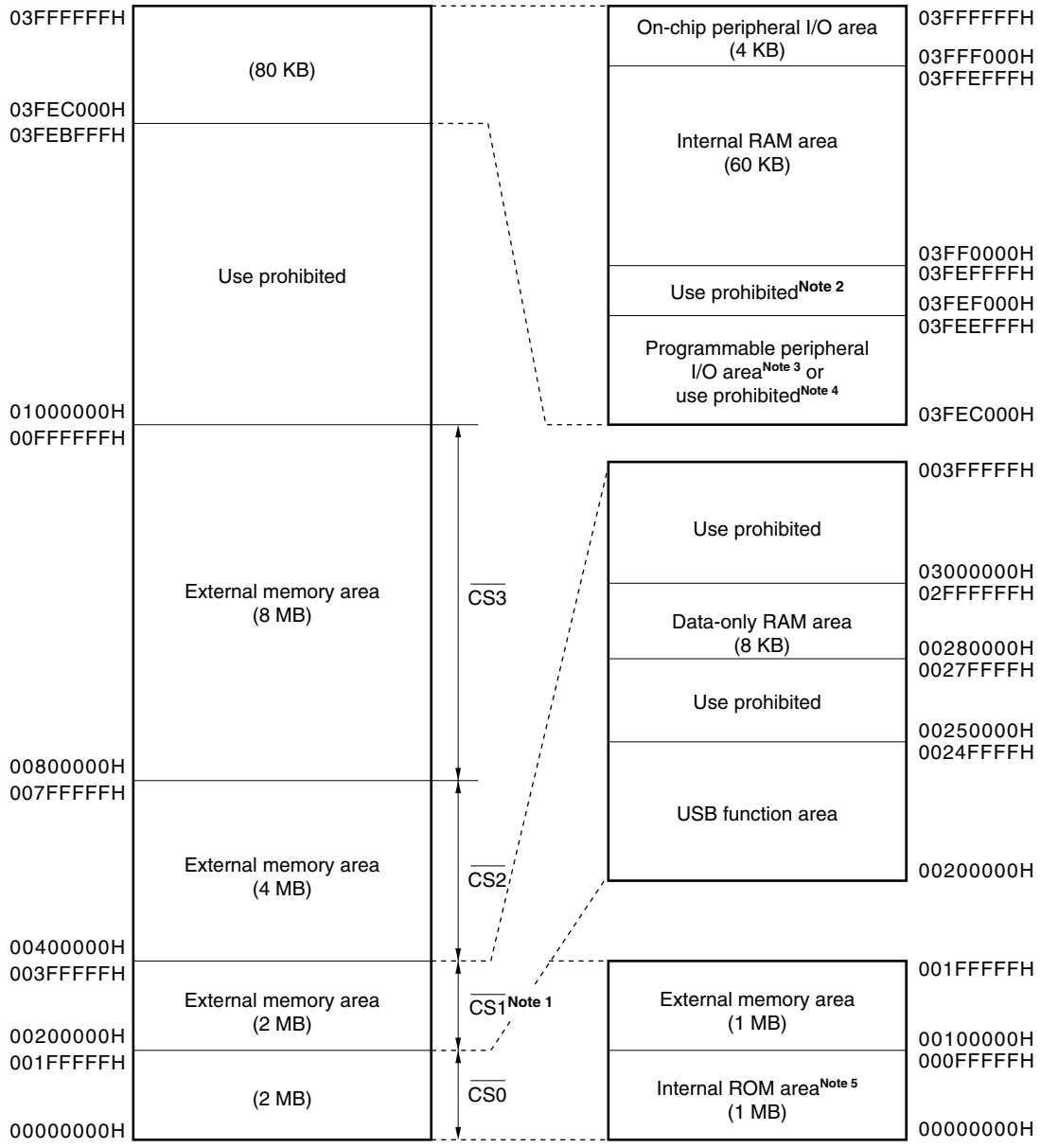
Therefore, the highest address of the data space, FFFFFFFFH, and the lowest address, 00000000H, are contiguous, and wraparound occurs at the boundary of these addresses.



3.4.3 Memory map

The areas shown below are reserved in the V850ES/JG3-H and V850ES/JH3-H.

Figure 3-2. Data Memory Map (Physical Addresses)



Notes 1. CS1 is not provided as an external signal of the V850ES/Jx3-H; it is used internally as a chip select signal for the USB.

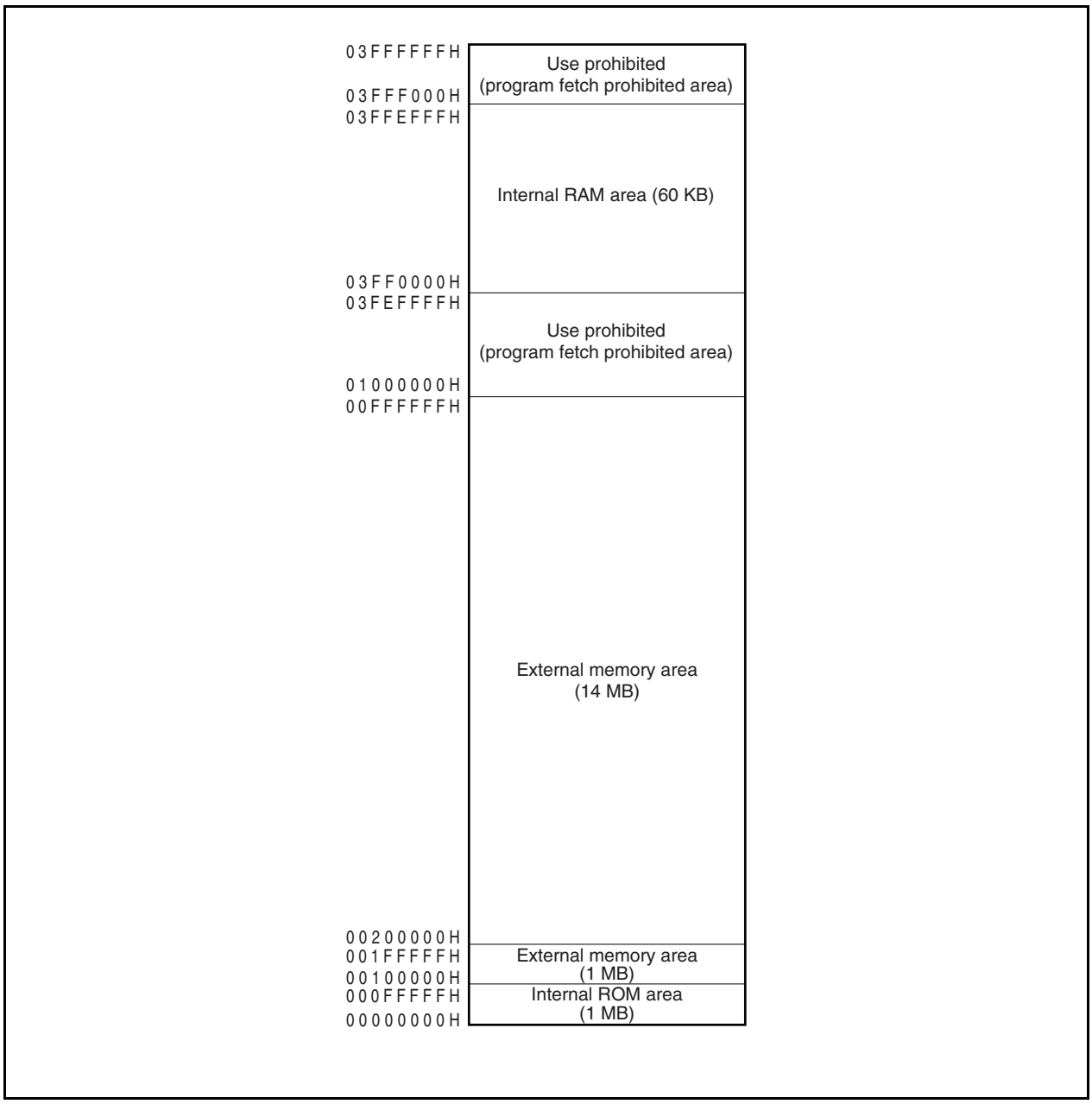
2. Use of addresses 03FEF000H to 03FEFFFFH is prohibited because they overlap an on-chip peripheral I/O area.

3. The programmable peripheral I/O area is seen as 256 MB areas in the 4 GB address space.

4. In on-chip CAN controller products, addresses 03FEC000H to 03FEEFFFH are assigned to addresses 03FEC000H to 03FECBFFH as a programmable peripheral I/O area. In other products, use of this area is prohibited.

5. This area is used as an external memory area when data write access to this area is executed.

Figure 3-3. Program Memory Map



3.4.4 Areas

(1) Internal ROM area

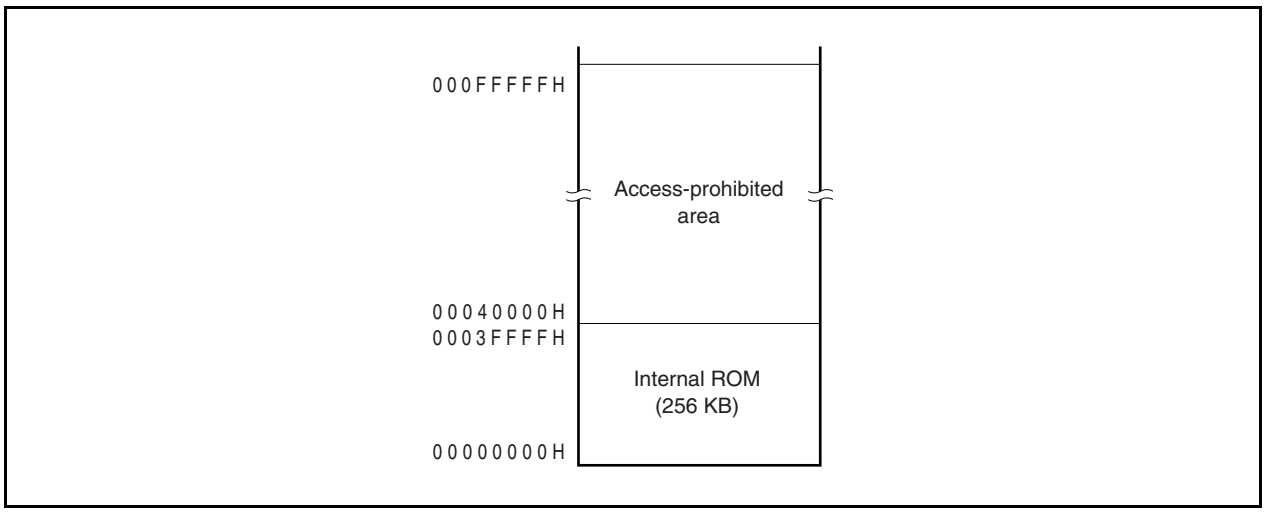
Up to 1 MB is reserved as an internal ROM area.

(a) Internal ROM (256 KB)

256 KB are allocated to addresses 00000000H to 0003FFFFH in the following products.
Accessing addresses 00040000H to 000FFFFFH is prohibited.

- μPD70F3760, 70F3770, 70F3765, 70F3771

Figure 3-4. Internal ROM Area (256 KB)

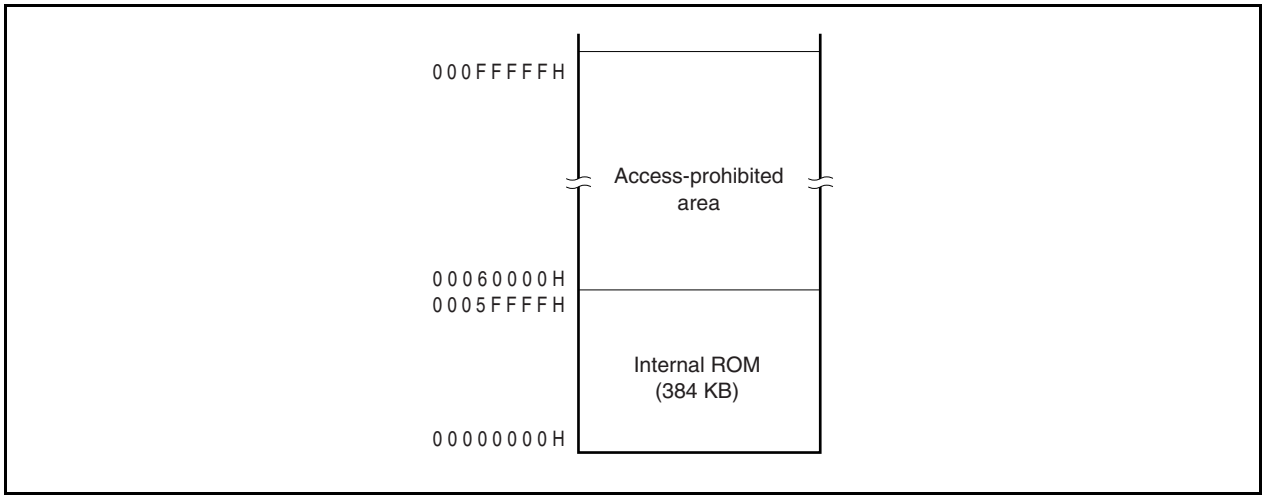


(b) Internal ROM (384 KB)

384 KB are allocated to addresses 00000000H to 0005FFFFH in the following products.
Accessing addresses 00060000H to 000FFFFFH is prohibited.

- μPD70F3761, 70F3766

Figure 3-5. Internal ROM Area (384 KB)

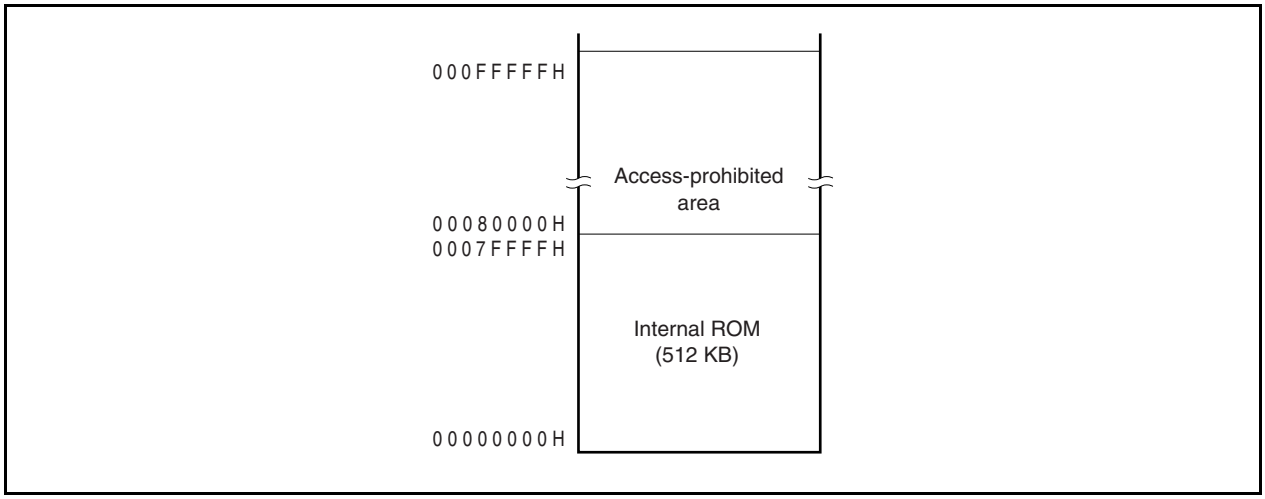


(c) Internal ROM (512 KB)

512 KB are allocated to addresses 00000000H to 0007FFFFH in the following products.
Accessing addresses 00080000H to 000FFFFFH is prohibited.

- μPD70F3762, 70F3767

Figure 3-6. Internal ROM Area (512 KB)



(2) Internal RAM area

Up to 60 KB are reserved as the internal RAM area.

The V850ES/JG3-H and V850ES/JH3-H include a data-only RAM of 8 KB in addition to the internal RAM.

The RAM capacity of V850ES/JG3-H and V850ES/JH3-H is as follows.

Table 3-3 RAM area

Generic Name	Product Name	Internal RAM	Data-only RAM	Total RAM
V850ES/JG3-H	μPD70F3760, 70F3770	32 KB	8 KB	40 KB
	μPD70F3761	40 KB		48 KB
	μPD70F3762	48 KB		56 KB
V850ES/JH3-H	μPD70F3765, 70F3771	32 KB		40 KB
	μPD70F3766	40 KB		48 KB
	μPD70F3767	48 KB		56KB

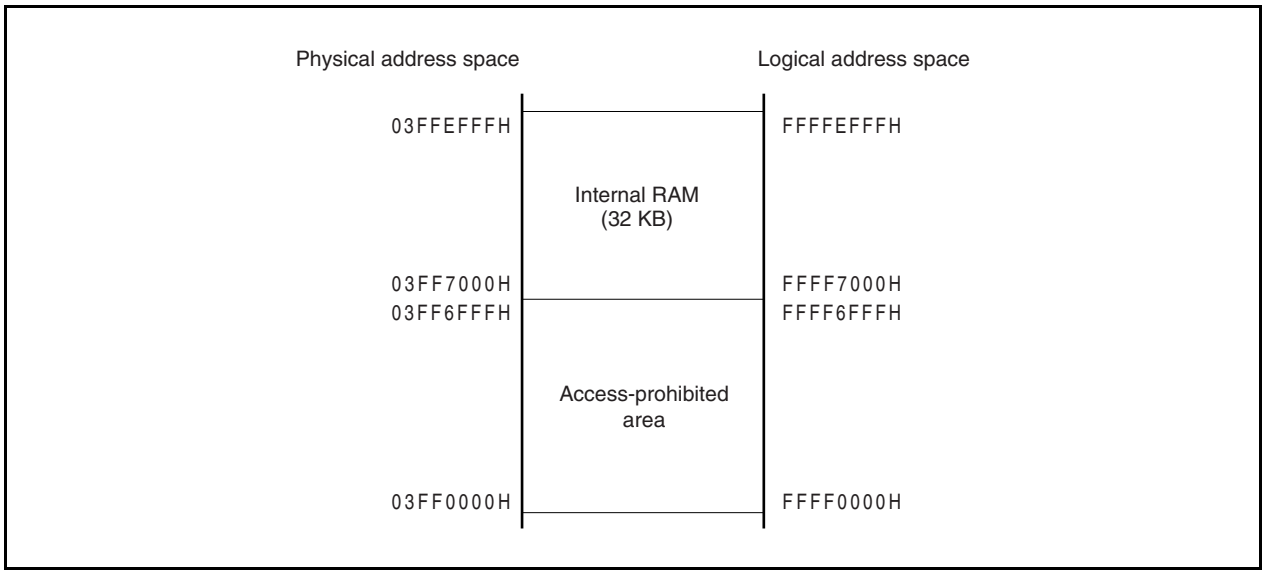
(a) Internal RAM (32 KB)

32 KB are allocated to addresses 03FF7000H to 03FFEFFFH in the following products.

Accessing addresses 03FF0000H to 03FF6FFFH is prohibited.

- μPD70F3760, 70F3770, 70F3765, 70F3771

Figure 3-7. Internal RAM Area (32 KB)

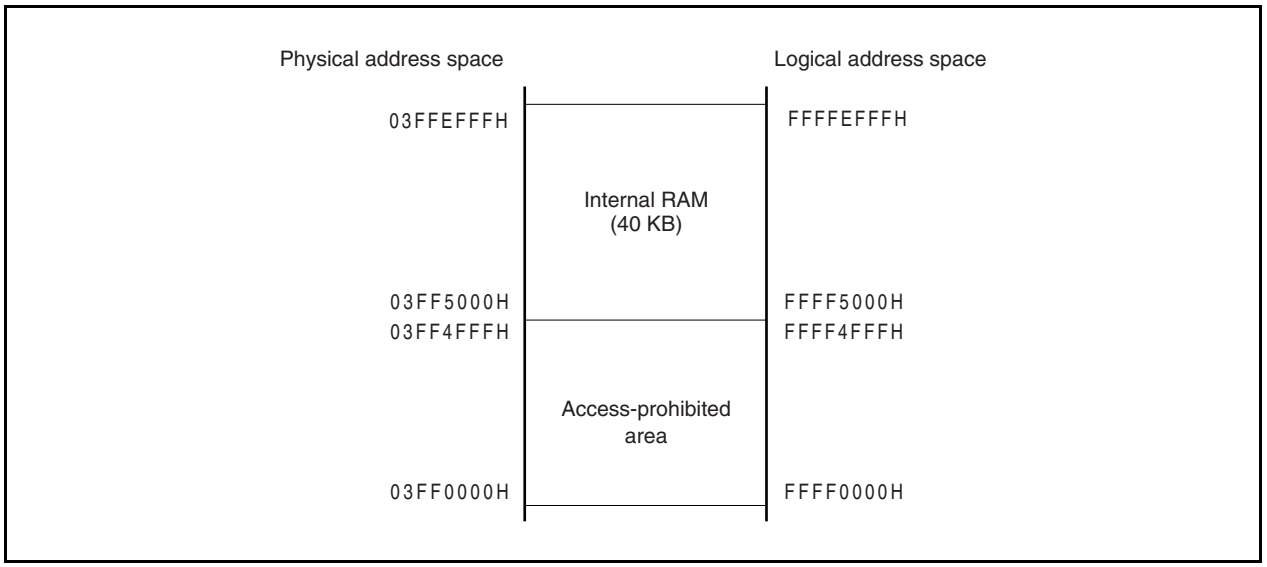


(b) Internal RAM (40 KB)

40 KB are allocated to addresses 03FF5000H to 03FFEFFFH in the following products.
Accessing addresses 03FF0000H to 03FF4FFFH is prohibited.

- μPD70F3761, 70F3766

Figure 3-8. Internal RAM Area (40 KB)

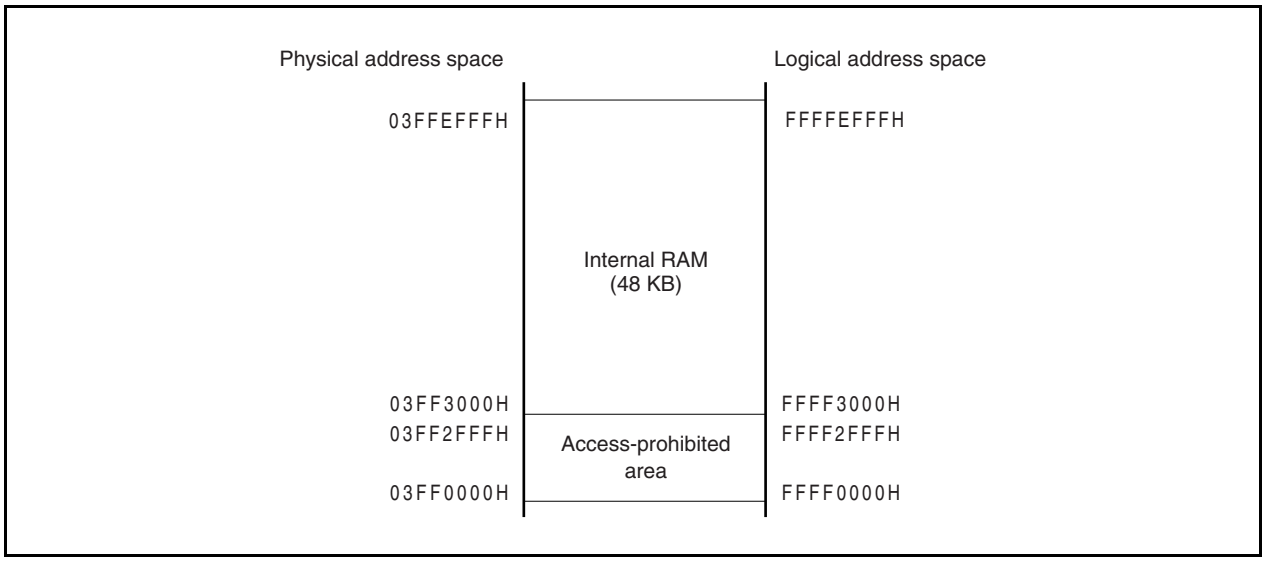


(c) Internal RAM (48 KB)

48 KB are allocated to addresses 03FF3000H to 03FFEFFFH in the following products.
Accessing addresses 03FF0000H to 03FF2FFFH is prohibited.

- μPD70F3762, 70F3767

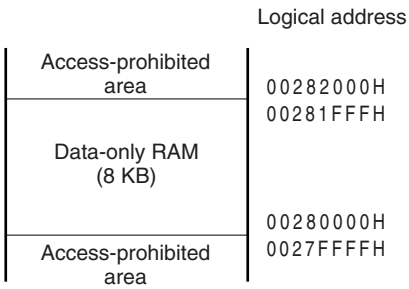
Figure 3-9. Internal RAM Area (48 KB)



(d) Data-only RAM (8 KB)

A data-only RAM of 8 KB is allocated to addresses 00280000H to 00281FFFH in the V850ES/JG3-H and V850ES/JH3-H.

Figure 3-10. Data-Only RAM Area (8 KB)



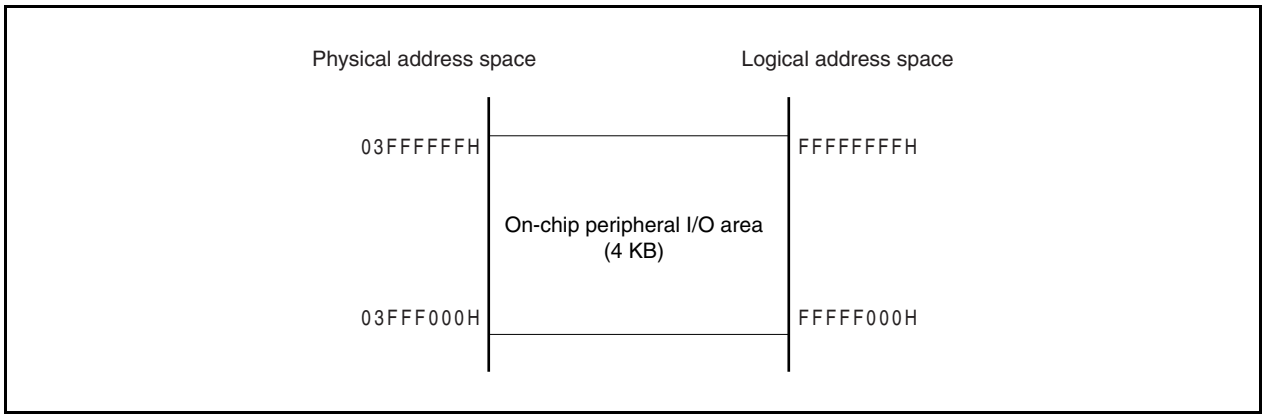
Caution If using the data-only RAM area, the following two register setting are needed.

- **Select the clock that be possible to supply the data-only RAM in the USB clock select register (UCKSEL) (refer to 21.6.1(1))**
- **Set the data-only RAM operation to be enable in the USB function select register (UHCKMSK) (refer to 21.6.1(3)) (UHCKMSK.UHMSK bit = 0)**

(3) On-chip peripheral I/O area

4 KB of addresses 03FFF000H to 03FFFFFFH are reserved as the on-chip peripheral I/O area.

Figure 3-11. On-Chip Peripheral I/O Area



Peripheral I/O registers that have functions to specify the operation mode for and monitor the status of the on-chip peripheral I/O are mapped to the on-chip peripheral I/O area. Program cannot be fetched from this area.

Cautions 1. When a register is accessed in word units, a word area is accessed twice in halfword units in the order of lower area and higher area, with the lower 2 bits of the address ignored.

2. If a register that can be accessed in byte units is accessed in halfword units, the higher 8 bits are undefined when the register is read, and data is written to the lower 8 bits.

3. Addresses not defined as registers are reserved for future expansion. The operation is undefined and not guaranteed when these addresses are accessed.

4. The internal ROM/RAM area and on-chip peripheral I/O area are assigned to successive addresses.

When accessing the internal ROM/RAM area by incrementing or decrementing addresses using a pointer operation or such, be careful not to access the on-chip peripheral I/O area by mistakenly extending over the internal ROM/RAM area boundary.

(4) External memory area

13 MB (00100000H to 001FFFFFH, 00400000H to 00FFFFFFH) are allocated as the external memory area. For details, see **CHAPTER 5 BUS CONTROL FUNCTION**.

3.4.5 Recommended use of address space

The architecture of the V850ES/JG3-H and V850ES/JH3-H requires that a register that serves as a pointer be secured for address generation when operand data in the data space is accessed. The address stored in this pointer ±32 KB can be directly accessed by an instruction for operand data. Because the number of general-purpose registers that can be used as a pointer is limited, however, by keeping the performance from dropping during address calculation when a pointer value is changed, as many general-purpose registers as possible can be secured for variables, and the program size can be reduced.

(1) Program space

Of the 32 bits of the PC (program counter), the higher 6 bits are fixed to 0, and only the lower 26 bits are valid. Regarding the program space, therefore, a 64 MB space of contiguous addresses starting from 00000000H unconditionally corresponds to the memory map.

To use the internal RAM area as the program space, access the following addresses.

Caution If a branch instruction is at the upper limit of the internal RAM area, a prefetch operation (invalid fetch) straddling the on-chip peripheral I/O area does not occur.

RAM Size	Access Address
48 KB	03FF3000H to 03FFEFFFH
40 KB	03FF5000H to 03FFEFFFH
32 KB	03FF7000H to 03FFEFFFH

(2) Data space

With the V850ES/JG3-H and V850ES/JH3-H, it seems that there are sixty-four 64 MB address spaces on the 4 GB CPU address space. Therefore, the least significant bit (bit 25) of a 26-bit address is sign-extended to 32 bits and allocated as an address.

(a) Application example of wraparound

If R = r0 (zero register) is specified for the LD/ST disp16 [R] instruction, a range of addresses 00000000H ±32 KB can be addressed by sign-extended disp16. All the resources, including the internal hardware, can be addressed by one pointer.

The zero register (r0) is a register fixed to 0 by hardware, and practically eliminates the need for registers dedicated to pointers.

Example: μPD70F3767

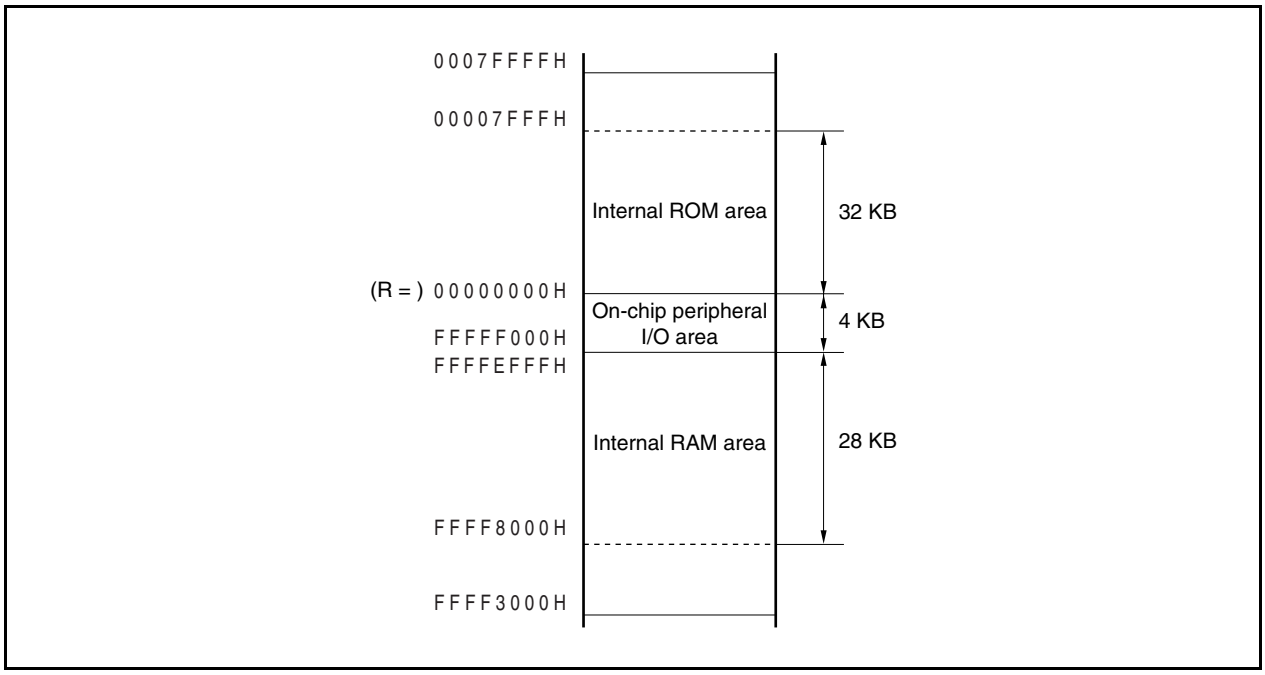
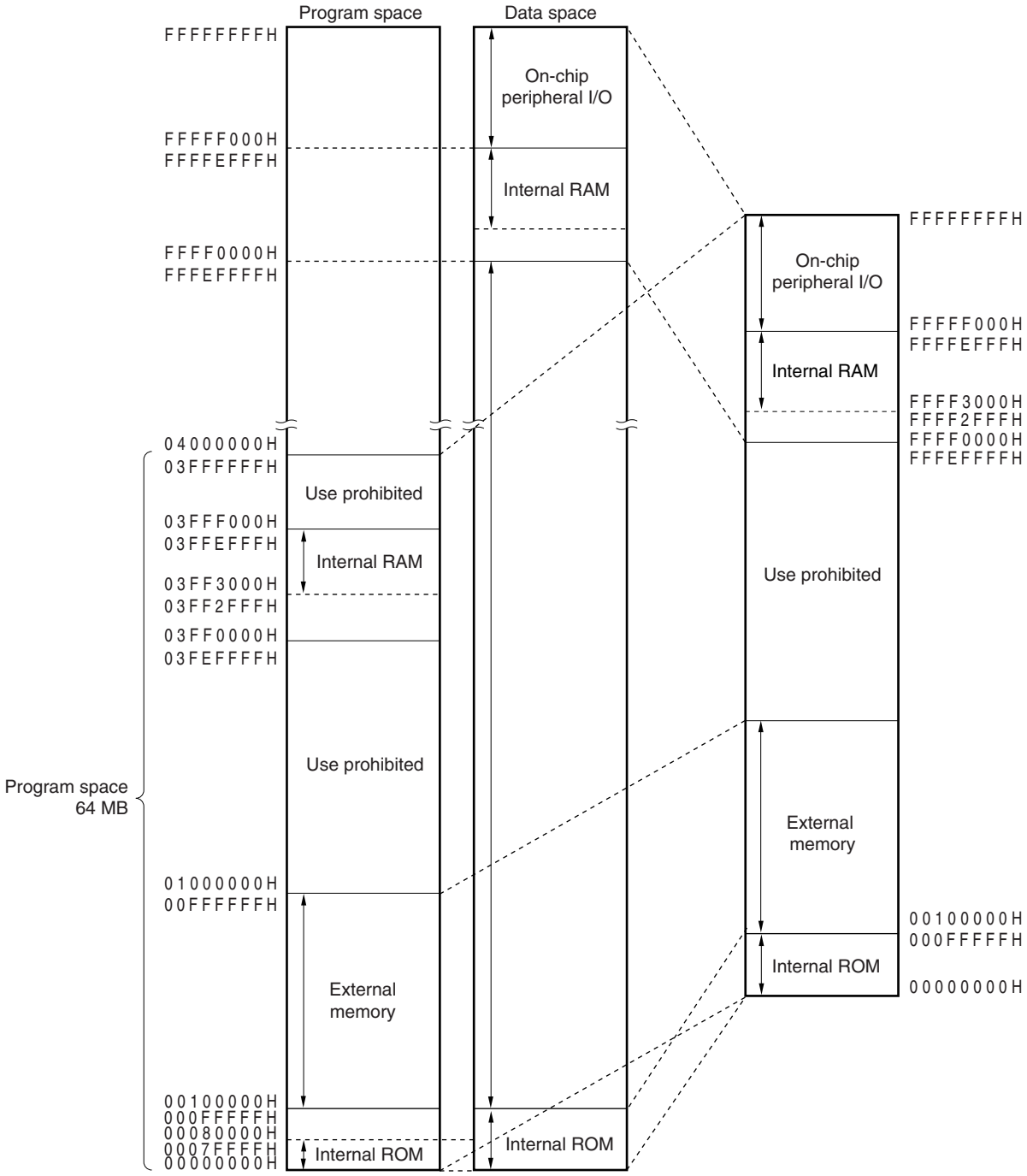


Figure 3-12. Recommended Memory Map



Remarks 1. ↕ indicates the recommended area.

2. This figure is the recommended memory map of the μPD70F3767.

3.4.6 Peripheral I/O registers

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Address	Function Register Name	Symbol	R/W	Manipulatable Bits			Default Value
				1	8	16	
FFFFF004H	Port DL register	PDL	R/W			√	0000H[Note 1]
FFFFF004H	Port DL register L	PDLL		√	√		00H[Note 1]
FFFFF005H	Port DL register H	PDLH		√	√		00H[Note 1]
FFFFF006H	Port DH register[Note 2]	PDH[Note 2]		√	√		00H[Note 1]
FFFFF008H	Port CS register[Note 2]	PCS[Note 2]		√	√		00H[Note 1]
FFFFF00AH	Port CT register	PCT		√	√		00H[Note 1]
FFFFF00CH	Port CM register	PCM		√	√		00H[Note 1]
FFFFF024H	Port DL mode register	PMDL				√	FFFFH
FFFFF024H	Port DL mode register L	PMDLL		√	√		FFH
FFFFF025H	Port DL mode register H	PMDLH		√	√		FFH
FFFFF026H	Port DH mode register[Note 2]	PMDH[Note 2]		√	√		FFH
FFFFF028H	Port CS mode register[Note 2]	PMCS[Note 2]		√	√		FFH
FFFFF02AH	Port CT mode register	PMCT		√	√		FFH
FFFFF02CH	Port CM mode register	PMCM		√	√		FFH
FFFFF044H	Port DL mode control register	PMCDL				√	0000H
FFFFF044H	Port DL mode control register L	PMCDLL		√	√		00H
FFFFF045H	Port DL mode control register H	PMCDLH		√	√		00H
FFFFF046H	Port DH mode control register[Note 2]	PMCDH[Note 2]		√	√		00H
FFFFF048H	Port CS mode control register[Note 2]	PMCCS[Note 2]		√	√		00H
FFFFF04AH	Port CT mode control register	PMCCT		√	√		00H
FFFFF04CH	Port CM mode control register	PMCCM		√	√		00H
FFFFF064H	Peripheral I/O area select control register[Note 3]	BPC[Note 3]				√	0000H
FFFFF066H	Bus size configuration register	BSC				√	5555H
FFFFF06EH	System wait control register	VSWC			√		77H
FFFFF080H	DMA source address register 0L	DSA0L				√	Undefined
FFFFF082H	DMA source address register 0H	DSA0H				√	Undefined
FFFFF084H	DMA destination address register 0L	DDA0L				√	Undefined
FFFFF086H	DMA destination address register 0H	DDA0H				√	Undefined
FFFFF088H	DMA source address register 1L	DSA1L				√	Undefined
FFFFF08AH	DMA source address register 1H	DSA1H				√	Undefined
FFFFF08CH	DMA destination address register 1L	DDA1L				√	Undefined
FFFFF08EH	DMA destination address register 1H	DDA1H				√	Undefined
FFFFF090H	DMA source address register 2L	DSA2L				√	Undefined
FFFFF092H	DMA source address register 2H	DSA2H				√	Undefined
FFFFF094H	DMA destination address register 2L	DDA2L				√	Undefined
FFFFF096H	DMA destination address register 2H	DDA2H				√	Undefined
FFFFF098H	DMA source address register 3L	DSA3L				√	Undefined
FFFFF09AH	DMA source address register 3H	DSA3H				√	Undefined
FFFFF09CH	DMA destination address register 3L	DDA3L				√	Undefined

Notes 1 The output latch is 00H or 0000H. When these registers are in the input mode, the pin statuses are read.

2. V850ES/JH3-H only

3. μPD70F3770, 70F3771 only

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Address	Function Register Name	Symbol	R/W	Manipulatable Bits			Default Value
				1	8	16	
FFFFF09EH	DMA destination address register 3H	DDA3H	R/W			√	Undefined
FFFFF0C0H	DMA transfer count register 0	DBC0				√	Undefined
FFFFF0C2H	DMA transfer count register 1	DBC1				√	Undefined
FFFFF0C4H	DMA transfer count register 2	DBC2				√	Undefined
FFFFF0C6H	DMA transfer count register 3	DBC3				√	Undefined
FFFFF0D0H	DMA addressing control register 0	DADC0				√	0000H
FFFFF0D2H	DMA addressing control register 1	DADC1				√	0000H
FFFFF0D4H	DMA addressing control register 2	DADC2				√	0000H
FFFFF0D6H	DMA addressing control register 3	DADC3				√	0000H
FFFFF0E0H	DMA channel control register 0	DCHC0		√	√		00H
FFFFF0E2H	DMA channel control register 1	DCHC1		√	√		00H
FFFFF0E4H	DMA channel control register 2	DCHC2		√	√		00H
FFFFF0E6H	DMA channel control register 3	DCHC3		√	√		00H
FFFFF100H	Interrupt mask register 0	IMR0				√	FFFFH
FFFFF100H	Interrupt mask register 0L	IMR0L		√	√		FFH
FFFFF101H	Interrupt mask register 0H	IMR0H		√	√		FFH
FFFFF102H	Interrupt mask register 1	IMR1				√	FFFFH
FFFFF102H	Interrupt mask register 1L	IMR1L		√	√		FFH
FFFFF103H	Interrupt mask register 1H	IMR1H		√	√		FFH
FFFFF104H	Interrupt mask register 2	IMR2				√	FFFFH
FFFFF104H	Interrupt mask register 2L	IMR2L		√	√		FFH
FFFFF105H	Interrupt mask register 2H	IMR2H		√	√		FFH
FFFFF106H	Interrupt mask register 3	IMR3				√	FFFFH
FFFFF106H	Interrupt mask register 3L	IMR3L		√	√		FFH
FFFFF107H	Interrupt mask register 3H	IMR3H		√	√		FFH
FFFFF108H	Interrupt mask register 4	IMR4				√	FFFFH
FFFFF108H	Interrupt mask register 4L	IMR4L		√	√		FFH
FFFFF109H	Interrupt mask register 4H	IMR4H		√	√		FFH
FFFFF10AH	Interrupt mask register 5	IMR5				√	FFFFH
FFFFF10AH	Interrupt mask register 5L	IMR5L		√	√		FFH
FFFFF10BH	Interrupt mask register 5H	IMR5H		√	√		FFH
FFFFF110H	Interrupt control register	LVIIC		√	√		47H
FFFFF112H	Interrupt control register	PIC00		√	√		47H
FFFFF114H	Interrupt control register	PIC01		√	√		47H
FFFFF116H	Interrupt control register	PIC02		√	√		47H
FFFFF118H	Interrupt control register	PIC03		√	√		47H
FFFFF11AH	Interrupt control register	PIC04		√	√		47H
FFFFF11CH	Interrupt control register	PIC05		√	√		47H
FFFFF11EH	Interrupt control register	PIC06		√	√		47H
FFFFF120H	Interrupt control register	PIC07		√	√		47H
FFFFF122H	Interrupt control register	PIC08		√	√		47H
FFFFF124H	Interrupt control register	PIC09		√	√		47H

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Address	Function Register Name	Symbol	R/W	Manipulatable Bits			Default Value
				1	8	16	
FFFFF126H	Interrupt control register	PIC10	R/W	√	√		47H
FFFFF128H	Interrupt control register	PIC11		√	√		47H
FFFFF12AH	Interrupt control register	PIC12		√	√		47H
FFFFF12CH	Interrupt control register	PIC13		√	√		47H
FFFFF12EH	Interrupt control register	PIC14		√	√		47H
FFFFF130H	Interrupt control register	PIC15		√	√		47H
FFFFF132H	Interrupt control register	PIC16		√	√		47H
FFFFF134H	Interrupt control register	PIC17		√	√		47H
FFFFF136H	Interrupt control register	PIC18		√	√		47H
FFFFF138H	Interrupt control register	TAB0OVIC		√	√		47H
FFFFF13AH	Interrupt control register	TAB0CCIC0		√	√		47H
FFFFF13CH	Interrupt control register	TAB0CCIC1		√	√		47H
FFFFF13EH	Interrupt control register	TAB0CCIC2		√	√		47H
FFFFF140H	Interrupt control register	TAB0CCIC3		√	√		47H
FFFFF142H	Interrupt control register	TAB1OVIC		√	√		47H
FFFFF144H	Interrupt control register	TAB1CCIC0		√	√		47H
FFFFF146H	Interrupt control register	TAB1CCIC1		√	√		47H
FFFFF148H	Interrupt control register	TAB1CCIC2		√	√		47H
FFFFF14AH	Interrupt control register	TAB1CCIC3		√	√		47H
FFFFF14CH	Interrupt control register	TT0OVIC		√	√		47H
FFFFF14EH	Interrupt control register	TT0CCIC0		√	√		47H
FFFFF150H	Interrupt control register	TT0CCIC1		√	√		47H
FFFFF152H	Interrupt control register	TT0IECIC		√	√		47H
FFFFF154H	Interrupt control register	TAA0OVIC		√	√		47H
FFFFF156H	Interrupt control register	TAA0CCIC0		√	√		47H
FFFFF158H	Interrupt control register	TAA0CCIC1		√	√		47H
FFFFF15AH	Interrupt control register	TAA1OVIC		√	√		47H
FFFFF15CH	Interrupt control register	TAA1CCIC0		√	√		47H
FFFFF15EH	Interrupt control register	TAA1CCIC1		√	√		47H
FFFFF160H	Interrupt control register	TAA2OVIC		√	√		47H
FFFFF162H	Interrupt control register	TAA2CCIC0		√	√		47H
FFFFF164H	Interrupt control register	TAA2CCIC1		√	√		47H
FFFFF166H	Interrupt control register	TAA3OVIC		√	√		47H
FFFFF168H	Interrupt control register	TAA3CCIC0		√	√		47H
FFFFF16AH	Interrupt control register	TAA3CCIC1		√	√		47H
FFFFF16CH	Interrupt control register	TAA4OVIC		√	√		47H
FFFFF16EH	Interrupt control register	TAA4CCIC0		√	√		47H
FFFFF170H	Interrupt control register	TAA4CCIC1		√	√		47H
FFFFF172H	Interrupt control register	TAA5OVIC		√	√		47H
FFFFF174H	Interrupt control register	TAA5CCIC0		√	√		47H
FFFFF176H	Interrupt control register	TAA5CCIC1		√	√		47H
FFFFF178H	Interrupt control register	TM0EQIC0		√	√		47H
FFFFF17AH	Interrupt control register	TM1EQIC0		√	√		47H

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Address	Function Register Name	Symbol	R/W	Manipulatable Bits			Default Value
				1	8	16	
FFFFF17CH	Interrupt control register	TM2EQIC0	R/W	√	√		47H
FFFFF17EH	Interrupt control register	TM3EQIC0		√	√		47H
FFFFF180H	Interrupt control register	CF0RIC/IICIC1		√	√		47H
FFFFF182H	Interrupt control register	CF0TIC		√	√		47H
FFFFF184H	Interrupt control register	CF1RIC		√	√		47H
FFFFF186H	Interrupt control register	CF1TIC		√	√		47H
FFFFF188H	Interrupt control register	CF2RIC		√	√		47H
FFFFF18AH	Interrupt control register	CF2TIC		√	√		47H
FFFFF18CH	Interrupt control register	CF3RIC		√	√		47H
FFFFF18EH	Interrupt control register	CF3TIC		√	√		47H
FFFFF190H	Interrupt control register	CF4RIC		√	√		47H
FFFFF192H	Interrupt control register	CF4TIC		√	√		47H
FFFFF194H	Interrupt control register	UC0RIC		√	√		47H
FFFFF196H	Interrupt control register	UC0TIC		√	√		47H
FFFFF198H	Interrupt control register	UC1RIC/IICIC2		√	√		47H
FFFFF19AH	Interrupt control register	UC1TIC		√	√		47H
FFFFF19CH	Interrupt control register	UC2RIC		√	√		47H
FFFFF19EH	Interrupt control register	UC2TIC		√	√		47H
FFFFF1A0H	Interrupt control register	UC3RIC/IICIC0		√	√		47H
FFFFF1A2H	Interrupt control register	UC3TIC		√	√		47H
FFFFF1A4H	Interrupt control register	UC4RIC		√	√		47H
FFFFF1A6H	Interrupt control register	UC4TIC		√	√		47H
FFFFF1A8H	Interrupt control register	ADIC		√	√		47H
FFFFF1AAH	Interrupt control register	DMAIC0		√	√		47H
FFFFF1ACH	Interrupt control register	DMAIC1		√	√		47H
FFFFF1AEH	Interrupt control register	DMAIC2		√	√		47H
FFFFF1B0H	Interrupt control register	DMAIC3		√	√		47H
FFFFF1B2H	Interrupt control register	KRIC		√	√		47H
FFFFF1B4H	Interrupt control register	RTC0IC		√	√		47H
FFFFF1B6H	Interrupt control register	RTC1IC		√	√		47H
FFFFF1B8H	Interrupt control register	RTC2IC		√	√		47H
FFFFF1BAH	Interrupt control register	ERRIC0n[Note]		√	√		47H
FFFFF1BCH	Interrupt control register	WUPIC0[Note]		√	√		47H
FFFFF1BEH	Interrupt control register	RECIC0[Note]		√	√		47H
FFFFF1C0H	Interrupt control register	TRXIC0[Note]		√	√		47H
FFFFF1C8H	Interrupt control register	UFIC0		√	√		47H
FFFFF1CAH	Interrupt control register	UFIC1		√	√		47H
FFFFF1FAH	In-service priority register	ISPR	R	√	√		00H
FFFFF1FCH	Command register	PRCMD	W		√		Undefined
FFFFF1FEH	Power save control register	PSC	R/W	√	√		00H
FFFFF200H	A/D converter mode register 0	ADA0M0		√	√		00H
FFFFF201H	A/D converter mode register 1	ADA0M1		√	√		00H

Note μPD70F3770, 70F3771 only

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Address	Function Register Name	Symbol	R/W	Manipulatable Bits			Default Value
				1	8	16	
FFFFF202H	A/D converter channel specification register	ADA0S	R/W	√	√		00H
FFFFF203H	A/D converter mode register 2	ADA0M2		√	√		00H
FFFFF204H	Power-fail compare mode register	ADA0PFM		√	√		00H
FFFFF205H	Power-fail compare threshold value register	ADA0PFT		√	√		00H
FFFFF210H	A/D conversion result register 0	ADA0CR0	R			√	Undefined
FFFFF211H	A/D conversion result register 0H	ADA0CR0H			√		Undefined
FFFFF212H	A/D conversion result register 1	ADA0CR1				√	Undefined
FFFFF213H	A/D conversion result register 1H	ADA0CR1H			√		Undefined
FFFFF214H	A/D conversion result register 2	ADA0CR2				√	Undefined
FFFFF215H	A/D conversion result register 2H	ADA0CR2H			√		Undefined
FFFFF216H	A/D conversion result register 3	ADA0CR3				√	Undefined
FFFFF217H	A/D conversion result register 3H	ADA0CR3H			√		Undefined
FFFFF218H	A/D conversion result register 4	ADA0CR4				√	Undefined
FFFFF219H	A/D conversion result register 4H	ADA0CR4H			√		Undefined
FFFFF21AH	A/D conversion result register 5	ADA0CR5				√	Undefined
FFFFF21BH	A/D conversion result register 5H	ADA0CR5H			√		Undefined
FFFFF21CH	A/D conversion result register 6	ADA0CR6				√	Undefined
FFFFF21DH	A/D conversion result register 6H	ADA0CR6H			√		Undefined
FFFFF21EH	A/D conversion result register 7	ADA0CR7				√	Undefined
FFFFF21FH	A/D conversion result register 7H	ADA0CR7H			√		Undefined
FFFFF220H	A/D conversion result register 8	ADA0CR8				√	Undefined
FFFFF221H	A/D conversion result register 8H	ADA0CR8H			√		Undefined
FFFFF222H	A/D conversion result register 9	ADA0CR9				√	Undefined
FFFFF223H	A/D conversion result register 9H	ADA0CR9H			√		Undefined
FFFFF224H	A/D conversion result register 10	ADA0CR10				√	Undefined
FFFFF225H	A/D conversion result register 10H	ADA0CR10H			√		Undefined
FFFFF226H	A/D conversion result register 11	ADA0CR11				√	Undefined
FFFFF227H	A/D conversion result register 11H	ADA0CR11H			√		Undefined
FFFFF280H	D/A conversion value setting register 0	DA0CS0	R/W		√		00H
FFFFF281H	D/A conversion value setting register 1	DA0CS1			√		00H
FFFFF282H	D/A converter mode register	DA0M		√	√		00H
FFFFF300H	Key return mode register	KRM		√	√		00H
FFFFF308H	Selector operation control register 0	SELCNT0		√	√		00H
FFFFF310H	CRC input register	CRCIN			√		00H
FFFFF312H	CRC data register	CRCD				√	0000H
FFFFF320H	Prescaler mode register 1	PRSM1		√	√		00H
FFFFF321H	Prescaler compare register 1	PRSCM1			√		00H
FFFFF324H	Prescaler mode register 2	PRSM2		√	√		00H
FFFFF325H	Prescaler compare register 2	PRSCM2			√		00H
FFFFF328H	Prescaler mode register 3	PRSM3		√	√		00H
FFFFF329H	Prescaler compare register 3	PRSCM3			√		00H
FFFFF340H	IIC division clock select register 0	OCKS0			√		00H
FFFFF344H	IIC division clock select register 1	OCKS1			√		00H

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Address	Function Register Name	Symbol	R/W	Manipulatable Bits			Default Value
				1	8	16	
FFFFF400H	Port 0 register	P0	R/W	√	√		00H[Note 1]
FFFFF402H	Port 1 register	P1		√	√		00H[Note 1]
FFFFF404H	Port 2 register[Note 2]	P2[Note 2]		√	√		00H[Note 1]
FFFFF406H	Port 3 register	P3		√	√		00H[Note 1]
FFFFF408H	Port 4 register	P4		√	√		00H[Note 1]
FFFFF40AH	Port 5 register	P5		√	√		00H[Note 1]
FFFFF40CH	Port 6 register	P6		√	√		00H[Note 1]
FFFFF40EH	Port 7 register L	P7L		√	√		00H[Note 1]
FFFFF40FH	Port 7 register H	P7H		√	√		00H[Note 1]
FFFFF412H	Port 9 register	P9				√	0000H[Note 1]
FFFFF412H	Port 9 register L	P9L		√	√		00H[Note 1]
FFFFF413H	Port 9 register H	P9H		√	√		00H[Note 1]
FFFFF420H	Port 0 mode register	PM0		√	√		FFH
FFFFF422H	Port 1 mode register	PM1		√	√		FFH
FFFFF424H	Port 2 mode register[Note 2]	PM2[Note 2]		√	√		FFH
FFFFF426H	Port 3 mode register	PM3		√	√		FFH
FFFFF428H	Port 4 mode register	PM4		√	√		FFH
FFFFF42AH	Port 5 mode register	PM5		√	√		FFH
FFFFF42CH	Port 6 mode register	PM6		√	√		FFH
FFFFF42EH	Port 7 mode register L	PM7L		√	√		FFH
FFFFF42FH	Port 7 mode register H	PM7H		√	√		FFH
FFFFF432H	Port 9 mode register	PM9				√	FFFFH
FFFFF432H	Port 9 mode register L	PM9L		√	√		FFH
FFFFF433H	Port 9 mode register H	PM9H		√	√		FFH
FFFFF440H	Port 0 mode control register	PMC0		√	√		00H
FFFFF444H	Port 2 mode control register[Note 2]	PMC2[Note 2]		√	√		00H
FFFFF446H	Port 3 mode control register	PMC3		√	√		00H
FFFFF448H	Port 4 mode control register	PMC4		√	√		00H
FFFFF44AH	Port 5 mode control register	PMC5		√	√		00H
FFFFF44CH	Port 6 mode control register	PMC6		√	√		00H
FFFFF452H	Port 9 mode control register	PMC9				√	0000H
FFFFF452H	Port 9 mode control register L	PMC9L		√	√		00H
FFFFF453H	Port 9 mode control register H	PMC9H		√	√		00H
FFFFF460H	Port 0 function control register	PFC0		√	√		00H
FFFFF464H	Port 2 function control register[Note 2]	PFC2[Note 2]		√	√		00H
FFFFF466H	Port 3 function control register	PFC3		√	√		00H
FFFFF468H	Port 4 function control register	PFC4		√	√		00H
FFFFF46AH	Port 5 function control register	PFC5		√	√		00H
FFFFF46CH	Port 6 function control register	PFC6		√	√		00H

Notes 1 The output latch is 00H or 0000H. When these registers are input, the pin statuses are read.

2. V850ES/JH3-H only

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Address	Function Register Name	Symbol	R/W	Manipulatable Bits			Default Value
				1	8	16	
FFFFF472H	Port 9 function control register	PFC9	R/W			√	0000H
FFFFF472H	Port 9 function control register L	PFC9L		√	√		00H
FFFFF473H	Port 9 function control register H	PFC9H		√	√		00H
FFFFF484H	Data wait control register 0	DWC0				√	7777H
FFFFF488H	Address wait control register	AWC				√	FFFFH
FFFFF48AH	Bus cycle control register	BCC				√	AAAAH
FFFFF540H	TAB0 control register 0	TAB0CTL0		√	√		00H
FFFFF541H	TAB0 control register 1	TAB0CTL1		√	√		00H
FFFFF542H	TAB0 I/O control register 0	TAB0IOC0		√	√		00H
FFFFF543H	TAB0 I/O control register 1	TAB0IOC1		√	√		00H
FFFFF544H	TAB0 I/O control register 2	TAB0IOC2		√	√		00H
FFFFF545H	TAB0 option register 0	TAB0OPT0		√	√		00H
FFFFF546H	TAB0 capture/compare register 0	TAB0CCR0				√	0000H
FFFFF548H	TAB0 capture/compare register 1	TAB0CCR1				√	0000H
FFFFF54AH	TAB0 capture/compare register 2	TAB0CCR2				√	0000H
FFFFF54CH	TAB0 capture/compare register 3	TAB0CCR3				√	0000H
FFFFF54EH	TAB0 counter read buffer register	TAB0CNT	R			√	0000H
FFFFF550H	TAB0 I/O control register 4	TAB0IOC4	R/W	√	√		00H
FFFFF560H	TAB1 control register 0	TAB1CTL0		√	√		00H
FFFFF561H	TAB1 control register 1	TAB1CTL1		√	√		00H
FFFFF562H	TAB1 I/O control register 0	TAB1IOC0		√	√		00H
FFFFF563H	TAB1 I/O control register 1	TAB1IOC1		√	√		00H
FFFFF564H	TAB1 I/O control register 2	TAB1IOC2		√	√		00H
FFFFF565H	TAB1 option register 0	TAB1OPT0		√	√		00H
FFFFF566H	TAB1 capture/compare register 0	TAB1CCR0				√	0000H
FFFFF568H	TAB1 capture/compare register 1	TAB1CCR1				√	0000H
FFFFF56AH	TAB1 capture/compare register 2	TAB1CCR2				√	0000H
FFFFF56CH	TAB1 capture/compare register 3	TAB1CCR3				√	0000H
FFFFF56EH	TAB1 counter read buffer register	TAB1CNT	R			√	0000H
FFFFF570H	TAB1 I/O control register 4	TAB1IOC4	R/W	√	√		00H
FFFFF580H	TAB1 option register 1	TAB1OPT1		√	√		00H
FFFFF581H	TAB1 option register 2	TAB1OPT2		√	√		00H
FFFFF582H	TAB1 I/O control register 3	TAB1IOC3		√	√		A8H
FFFFF584H	TAB1 dead time compare register 1	TAB1DTC				√	0000H
FFFFF590H	High impedance output control register 0	HZACTL0		√	√		00H
FFFFF591H	High impedance output control register 1	HZACTL1		√	√		00H
FFFFF600H	TMT0 control register 0	TT0CTL0		√	√		00H
FFFFF601H	TMT0 control register 1	TT0CTL1		√	√		00H
FFFFF602H	TMT0 control register 2	TT0CTL2		√	√		00H
FFFFF603H	TMT0I/O control register 0	TT0IOC0		√	√		00H
FFFFF604H	TMT0I/O control register 1	TT0IOC1		√	√		00H
FFFFF605H	TMT0I/O control register 2	TT0IOC2		√	√		00H
FFFFF606H	TMT0I/O control register 3	TT0IOC3		√	√		00H

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Address	Function Register Name	Symbol	R/W	Manipulatable Bits			Default Value
				1	8	16	
FFFFF607H	TMT0 option register 0	TT0OPT0	R/W	√	√		00H
FFFFF608H	TMT0 option register 1	TT0OPT1		√	√		00H
FFFFF609H	TMT0 option register 2	TT0OPT2		√	√		00H
FFFFF60AH	TMT0 capture/compare register 0	TT0CCR0				√	0000H
FFFFF60CH	TMT0 capture/compare register 1	TT0CCR1				√	0000H
FFFFF60EH	TMT0 counter read buffer register	TT0CNT	R			√	0000H
FFFFF610H	TMT0 counter write register	TT0TCW	R/W			√	0000H
FFFFF630H	TAA0 control register 0	TAA0CTL0		√	√		00H
FFFFF631H	TAA0 control register 1	TAA0CTL1		√	√		00H
FFFFF632H	TAA0 I/O control register 0	TAA0IOC0		√	√		00H
FFFFF633H	TAA0 I/O control register 1	TAA0IOC1		√	√		00H
FFFFF634H	TAA0 I/O control register 2	TAA0IOC2		√	√		00H
FFFFF635H	TAA0 option register 0	TAA0OPT0		√	√		00H
FFFFF636H	TAA0 capture/compare register 0	TAA0CCR0				√	0000H
FFFFF638H	TAA0 capture/compare register 1	TAA0CCR1				√	0000H
FFFFF63AH	TAA0 counter read buffer register	TAA0CNT	R			√	0000H
FFFFF63CH	TAA0 I/O control register 4	TAA0IOC4	R/W	√	√		00H
FFFFF63DH	TAA0 option register 1	TAA0OPT1		√	√		00H
FFFFF640H	TAA1 control register 0	TAA1CTL0		√	√		00H
FFFFF641H	TAA1 control register 1	TAA1CTL1		√	√		00H
FFFFF642H	TAA1 I/O control register 0	TAA1IOC0		√	√		00H
FFFFF643H	TAA1 I/O control register 1	TAA1IOC1		√	√		00H
FFFFF644H	TAA1 I/O control register 2	TAA1IOC2		√	√		00H
FFFFF645H	TAA1 option register 0	TAA1OPT0		√	√		00H
FFFFF646H	TAA1 capture/compare register 0	TAA1CCR0				√	0000H
FFFFF648H	TAA1 capture/compare register 1	TAA1CCR1				√	0000H
FFFFF64AH	TAA1 counter read buffer register	TAA1CNT	R			√	0000H
FFFFF64CH	TAA1 I/O control register 4	TAA1IOC4	R/W	√	√		00H
FFFFF650H	TAA2 control register 0	TAA2CTL0		√	√		00H
FFFFF651H	TAA2 control register 1	TAA2CTL1		√	√		00H
FFFFF652H	TAA2 I/O control register 0	TAA2IOC0		√	√		00H
FFFFF653H	TAA2 I/O control register 1	TAA2IOC1		√	√		00H
FFFFF654H	TAA2 I/O control register 2	TAA2IOC2		√	√		00H
FFFFF655H	TAA2 option register 0	TAA2OPT0		√	√		00H
FFFFF656H	TAA2 capture/compare register 0	TAA2CCR0				√	0000H
FFFFF658H	TAA2 capture/compare register 1	TAA2CCR1				√	0000H
FFFFF65AH	TAA2 counter read buffer register	TAA2CNT	R			√	0000H
FFFFF65CH	TAA2 I/O control register 4	TAA2IOC4	R/W	√	√		00H
FFFFF65DH	TAA2 option register 1	TAA2OPT1		√	√		00H
FFFFF660H	TAA3 control register 0	TAA3CTL0		√	√		00H
FFFFF661H	TAA3 control register 1	TAA3CTL1		√	√		00H
FFFFF662H	TAA3 I/O control register 0	TAA3IOC0		√	√		00H
FFFFF663H	TAA3 I/O control register 1	TAA3IOC1		√	√		00H

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Address	Function Register Name	Symbol	R/W	Manipulatable Bits			Default Value
				1	8	16	
FFFFF664H	TAA3 I/O control register 2	TAA3IOC2	R/W	√	√		00H
FFFFF665H	TAA3 option register 0	TAA3OPT0		√	√		00H
FFFFF666H	TAA3 capture/compare register 0	TAA3CCR0				√	0000H
FFFFF668H	TAA3 capture/compare register 1	TAA3CCR1				√	0000H
FFFFF66AH	TAA3 counter read buffer register	TAA3CNT	R			√	0000H
FFFFF66CH	TAA3 I/O control register4	TAA3IOC4	R/W	√	√		00H
FFFFF670H	TAA4 control register 0	TAA4CTL0		√	√		00H
FFFFF671H	TAA4 control register 1	TAA4CTL1		√	√		00H
FFFFF676H	TAA4 capture compare register 0	TAA4CCR0				√	0000H
FFFFF678H	TAA4 capture compare register 1	TAA4CCR1				√	0000H
FFFFF67AH	TAA4 counter read buffer register	TAA4CNT	R			√	0000H
FFFFF680H	TAA5 control register 0	TAA5CTL0	R/W	√	√		00H
FFFFF681H	TAA5 control register 1	TAA5CTL1		√	√		00H
FFFFF682H	TAA5 I/O control register 0	TAA5IOC0		√	√		00H
FFFFF683H	TAA5 I/O control register 1	TAA5IOC1		√	√		00H
FFFFF684H	TAA5 I/O control register 2	TAA5IOC2		√	√		00H
FFFFF685H	TAA5 option register 0	TAA5OPT0		√	√		00H
FFFFF686H	TAA5 capture/compare register 0	TAA5CCR0				√	0000H
FFFFF688H	TAA5 capture/compare register 1	TAA5CCR1				√	0000H
FFFFF68AH	TAA5 counter read buffer register	TAA5CNT	R			√	0000H
FFFFF68CH	TAA5 I/O control register 4	TAA5IOC4	R/W	√	√		00H
FFFFF6C0H	Oscillation stabilization time select register	OSTS			√		06H
FFFFF6C1H	PLL lockup time specification register	PLLS			√		03H
FFFFF6D0H	Watchdog timer mode register 2	WDTM2			√		67H
FFFFF6D1H	Watchdog timer enable register	WDTE			√		9AH
FFFFF6E0H	Real-time output buffer register 0L	RTBL0		√	√		00H
FFFFF6E2H	Real-time output buffer register 0H	RTBH0		√	√		00H
FFFFF6E4H	Real-time output port mode register 0	RTPM0		√	√		00H
FFFFF6E5H	Real-time output port control register 0	RTPC0		√	√		00H
FFFFF700H	Port 0 function control expansion register	PFCE0		√	√		00H
FFFFF704H	Port 2 function control expansion register[Note]	PFCE2[Note]		√	√		00H
FFFFF706H	Port 3 function control expansion register	PFCE3		√	√		00H
FFFFF708H	Port 4 function control expansion register	PFCE4		√	√		00H
FFFFF70AH	Port 5 function control expansion register	PFCE5		√	√		00H
FFFFF70CH	Port 6 function control expansion register	PFCE6		√	√		00H
FFFFF712H	Port 9 function control expansion register	PFCE9				√	00H
FFFFF712H	Port 9 function control expansion register L	PFCE9L		√	√		0000H
FFFFF713H	Port 2 function control expansion register H	PFCE9H		√	√		00H
FFFFF724H	TAA noise elimination control register	TANFC		√	√		00H
FFFFF726H	TMT noise elimination control register	TTNFC		√	√		00H
FFFFF728H	Noise elimination control register	INTNFC		√	√		00H
FFFFF802H	System status register	SYS		√	√		00H

Note V850ES/JH3-H only

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Address	Function Register Name	Symbol	R/W	Manipulatable Bits			Default Value
				1	8	16	
FFFFF80CH	Internal oscillation mode register	RCM	R/W	√	√		00H
FFFFF810H	DMA trigger factor register 0	DTFR0		√	√		00H
FFFFF812H	DMA trigger factor register 1	DTFR1		√	√		00H
FFFFF814H	DMA trigger factor register 2	DTFR2		√	√		00H
FFFFF820H	Power save mode register	PSMR		√	√		00H
FFFFF822H	Clock control register	CKC		√	√		0AH
FFFFF824H	Lock register	LOCKR	R	√	√		00H
FFFFF828H	Processor clock control register	PCC	R/W	√	√		03H
FFFFF82CH	PLL control register	PLLCTL		√	√		01H
FFFFF82EH	CPU operation clock status register	CCLS	R	√	√		00H
FFFFF870H	Clock monitor mode register	CLM	R/W	√	√		00H
FFFFF888H	Reset source flag register	RESF		√	√		00H
FFFFF890H	Low-voltage detection register	LVIM		√	√		00H
FFFFF892H	Internal RAM data status register	RAMS		√	√		01H
FFFFF8B0H	Prescaler mode register 0	PRSM0		√	√		00H
FFFFF8B1H	Prescaler compare register 0	PRSCM0			√		00H
FFFFF9FCH	On-chip debug mode register Note	OCDM Note		√	√		01H
FFFFFA00H	UARTC0 control register 0	UC0CTL0		√	√		10H
FFFFFA01H	UARTC0 control register 1	UC0CTL1			√		00H
FFFFFA02H	UARTC0 control register 2	UC0CTL2			√		FFH
FFFFFA03H	UARTC0 option control register 0	UC0OPT0		√	√		14H
FFFFFA04H	UARTC0 status register	UC0STR		√	√		00H
FFFFFA06H	UARTC0 receive data register	UC0RX	R		√	√	01FFH
FFFFFA06H	UARTC0 receive data register L	UC0RXL			√		FFH
FFFFFA08H	UARTC0 transmit data register	UC0TX	R/W			√	01FFH
FFFFFA08H	UARTC0 transmit data register L	UC0TXL			√		FFH
FFFFFA0AH	UARTC0 option control register 1	UC0OPT1		√	√		00H
FFFFFA10H	UARTC1 control register 0	UC1CTL0		√	√		10H
FFFFFA11H	UARTC1 control register 1	UC1CTL1			√		00H
FFFFFA12H	UARTC1 control register 2	UC1CTL2			√		FFH
FFFFFA13H	UARTC1 option control register 0	UC1OPT0		√	√		14H
FFFFFA14H	UARTC1 status register	UC1STR		√	√		00H
FFFFFA16H	UARTC1 receive data register	UC1RX	R			√	01FFH
FFFFFA16H	UARTC1 receive data register L	UC1RXL			√		FFH
FFFFFA18H	UARTC1 transmit data register	UC1TX	R/W			√	01FFH
FFFFFA18H	UARTC1 transmit data register L	UC1TXL			√		FFH
FFFFFA1AH	UARTC1 option control register 1	UC1OPT1		√	√		00H
FFFFFA20H	UARTC2 control register 0	UC2CTL0		√	√		10H
FFFFFA21H	UARTC2 control register 1	UC2CTL1			√		00H
FFFFFA22H	UARTC2 control register 2	UC2CTL2			√		FFH
FFFFFA23H	UARTC2 option control register 0	UC2OPT0		√	√		14H

Note V850ES/JG3-H only

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Address	Function Register Name	Symbol	R/W	Manipulatable Bits			Default Value
				1	8	16	
FFFFFA24H	UARTC2 status register	UC2STR	R/W	√	√		00H
FFFFFA26H	UARTC2 receive data register	UC2RX	R			√	01FFH
FFFFFA26H	UARTC2 receive data register L	UC2RXL			√		FFH
FFFFFA28H	UARTC2 transmit data register	UC2TX	R/W			√	01FFH
FFFFFA28H	UARTC2 transmit data register L	UC2TXL			√		FFH
FFFFFA2AH	UARTC2 option control register 1	UC2OPT1		√	√		00H
FFFFFA30H	UARTC3 control register 0	UC3CTL0		√	√		10H
FFFFFA31H	UARTC3 control register 1	UC3CTL1			√		00H
FFFFFA32H	UARTC3 control register 2	UC3CTL2			√		FFH
FFFFFA33H	UARTC3 option control register 0	UC3OPT0		√	√		14H
FFFFFA34H	UARTC3 status register	UC3STR		√	√		00H
FFFFFA36H	UARTC3 receive data register	UC3RX	R			√	01FFH
FFFFFA36H	UARTC3 receive data register L	UC3RXL			√		FFH
FFFFFA38H	UARTC3 transmit data register	UC3TX	R/W			√	01FFH
FFFFFA38H	UARTC3 transmit data register L	UC3TXL			√		FFH
FFFFFA3AH	UARTC3 option control register 1	UC3OPT1		√	√		00H
FFFFFA40H	UARTC4 control register 0	UC4CTL0		√	√		10H
FFFFFA41H	UARTC4 control register 1	UC4CTL1			√		00H
FFFFFA42H	UARTC4 control register 2	UC4CTL2			√		FFH
FFFFFA43H	UARTC4 option control register 0	UC4OPT0		√	√		14H
FFFFFA44H	UARTC4 status register	UC4STR		√	√		00H
FFFFFA46H	UARTC4 receive data register	UC4RX	R			√	01FFH
FFFFFA46H	UARTC4 receive data register L	UC4RXL			√		FFH
FFFFFA48H	UARTC4 transmit data register	UC4TX	R/W			√	01FFH
FFFFFA48H	UARTC4 transmit data register L	UC4TXL			√		FFH
FFFFFA4AH	UARTC4 option control register 1	UC4OPT1		√	√		00H
FFFFFA80H	TMM0 control register 0	TM0CTL0		√	√		00H
FFFFFA84H	TMM0 compare register 0	TM0CMP0				√	0000H
FFFFFA90H	TMM1 control register 0	TM1CTL0		√	√		00H
FFFFFA94H	TMM1 compare register 0	TM1CMP0				√	0000H
FFFFFAA0H	TMM2 control register 0	TM2CTL0		√	√		00H
FFFFFAA4H	TMM2 compare register 0	TM2CMP0				√	0000H
FFFFFAB0H	TMM3 control register 0	TM3CTL0		√	√		00H
FFFFFAB4H	TMM3 compare register 0	TM3CMP0				√	0000H
FFFFFAD0H	Sub-count register	RC1SUBC	R			√	0000H
FFFFFAD2H	Second count register	RC1SEC	R/W		√		00H
FFFFFAD3H	Minute count register	RC1MIN			√		00H
FFFFFAD4H	Hour count register	RC1HOUR			√		12H
FFFFFAD5H	Week count register	RC1WEEK			√		00H
FFFFFAD6H	Day count register	RC1DAY			√		01H
FFFFFAD7H	Month count register	RC1MONTH			√		01H
FFFFFAD8H	Year count register	RC1YEAR			√		00H
FFFFFAD9H	Time error correction register	RC1SUBU		√	√		00H

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Address	Function Register Name	Symbol	R/W	Manipulatable Bits			Default Value
				1	8	16	
FFFFFADAH	Alarm minute set register	RC1ALM	R/W		√		00H
FFFFFADBH	Alarm time set register	RC1ALH			√		12H
FFFFFADCH	Alarm week set register	RC1ALW		√	√		00H
FFFFFADDH	RTC control register 0	RC1CC0		√	√		00H
FFFFFADEH	RTC control register 1	RC1CC1		√	√		00H
FFFFFADFH	RTC control register 2	RC1CC2		√	√		00H
FFFFFAE0H	RTC control register 3	RC1CC3		√	√		00H
FFFFFC00H	External interrupt falling edge specification register 0	INTF0		√	√		00H
FFFFFC04H	External interrupt falling edge specification register 2Note 1	INTF2Note 1		√	√		00H
FFFFFC06H	External interrupt falling edge specification register 3	INTF3		√	√		00H
FFFFFC08H	External interrupt falling edge specification register 4	INTF4		√	√		00H
FFFFFC0AH	External interrupt falling edge specification register 5Note 2	INTF5Note 2		√	√		00H
FFFFFC12H	External interrupt falling edge specification register 9	INTF9				√	0000H
FFFFFC12H	External interrupt falling edge specification register 9L	INTF9L		√	√		00H
FFFFFC13H	External interrupt falling edge specification register 9H	INTF9H		√	√		00H
FFFFFC20H	External interrupt rising edge specification register 0	INTR0		√	√		00H
FFFFFC24H	External interrupt rising edge specification register 2Note 1	INTR2Note 1		√	√		00H
FFFFFC26H	External interrupt rising edge specification register 3	INTR3		√	√		00H
FFFFFC28H	External interrupt rising edge specification register 4	INTR4		√	√		00H
FFFFFC2AH	External interrupt rising edge specification register 5Note 2	INTR5Note 2		√	√		00H
FFFFFC32H	External interrupt rising edge specification register 9	INTR9				√	0000H
FFFFFC32H	External interrupt rising edge specification register 9H	INTR9H		√	√		00H
FFFFFC33H	External interrupt rising edge specification register 9L	INTR9L		√	√		00H
FFFFFC60H	Port 0 function register	PF0		√	√		00H
FFFFFC64H	Port 2 function registerNote 1	PF2Note 1		√	√		00H
FFFFFC66H	Port 3 function register	PF3		√	√		00H
FFFFFC68H	Port 4 function register	PF4		√	√		00H
FFFFFC6AH	Port 5 function register	PF5		√	√		00H
FFFFFC72H	Port 9 function register L	PF9L		√	√		00H
FFFFFD00H	CSIF0 control register 0	CF0CTL0		√	√		01H
FFFFFD01H	CSIF0 control register 1	CF0CTL1		√	√		00H
FFFFFD02H	CSIF0 control register 2	CF0CTL2			√		00H
FFFFFD03H	CSIF0 status register	CF0STR		√	√		00H
FFFFFD04H	CSIF0 receive data register	CF0RX	R			√	0000H
FFFFFD04H	CSIF0 receive data register L	CF0RXL			√		00H
FFFFFD06H	CSIF0 transmit data register	CF0TX	R/W			√	0000H
FFFFFD06H	CSIF0 transmit data register L	CF0TXL			√		00H
FFFFFD10H	CSIF1 control register 0	CF1CTL0		√	√		01H
FFFFFD11H	CSIF1 control register 1	CF1CTL1		√	√		00H
FFFFFD12H	CSIF1 control register 2	CF1CTL2			√		00H
FFFFFD13H	CSIF1 status register	CF1STR		√	√		00H

Notes 1. V850ES/JH3-H only

2. V850ES/JG3-H only

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Address	Function Register Name	Symbol	R/W	Manipulatable Bits			Default Value
				1	8	16	
FFFFFD14H	CSIF1 receive data register	CF1RX	R			√	0000H
FFFFFD14H	CSIF1 receive data register L	CF1RXL			√		00H
FFFFFD16H	CSIF1 transmit data register	CF1TX	R/W			√	0000H
FFFFFD16H	CSIF1 transmit data register L	CF1TXL			√		00H
FFFFFD20H	CSIF2 control register 0	CF2CTL0		√	√		01H
FFFFFD21H	CSIF2 control register 1	CF2CTL1		√	√		00H
FFFFFD22H	CSIF2 control register 2	CF2CTL2			√		00H
FFFFFD23H	CSIF2 status register	CF2STR		√	√		00H
FFFFFD24H	CSIF2 receive data register	CF2RX	R			√	0000H
FFFFFD24H	CSIF2 receive data register L	CF2RXL			√		00H
FFFFFD26H	CSIF2 transmit data register	CF2TX	R/W			√	0000H
FFFFFD26H	CSIF2 transmit data register L	CF2TXL			√		00H
FFFFFD30H	CSIF3 control register 0	CF3CTL0		√	√		01H
FFFFFD31H	CSIF3 control register 1	CF3CTL1		√	√		00H
FFFFFD32H	CSIF3 control register 2	CF3CTL2			√		00H
FFFFFD33H	CSIF3 status register	CF3STR		√	√		00H
FFFFFD34H	CSIF3 receive data register	CF3RX	R			√	0000H
FFFFFD34H	CSIF3 receive data register L	CF3RXL			√		00H
FFFFFD36H	CSIF3 transmit data register	CF3TX	R/W			√	0000H
FFFFFD36H	CSIF3 transmit data register L	CF3TXL			√		00H
FFFFFD40H	CSIF4 control register 0	CF4CTL0		√	√		01H
FFFFFD41H	CSIF4 control register 1	CF4CTL1		√	√		00H
FFFFFD42H	CSIF4 control register 2	CF4CTL2			√		00H
FFFFFD43H	CSIF4 status register	CF4STR		√	√		00H
FFFFFD44H	CSIF4 receive data register	CF4RX	R			√	0000H
FFFFFD44H	CSIF4 receive data register L	CF4RXL			√		00H
FFFFFD46H	CSIF4 transmit data register	CF4TX	R/W			√	0000H
FFFFFD46H	CSIF4 transmit data register L	CF4TXL			√		00H
FFFFFD80H	IIC shift register 0	IIC0			√		00H
FFFFFD82H	IIC control register 0	IICC0		√	√		00H
FFFFFD83H	Slave address register 0	SVA0			√		00H
FFFFFD84H	IIC clock select register 0	IICCL0		√	√		00H
FFFFFD85H	IIC function expansion register 0	IICX0		√	√		00H
FFFFFD86H	IIC status register 0	IICS0	R	√	√		00H
FFFFFD8AH	IIC flag register 0	IICF0	R/W	√	√		00H
FFFFFD90H	IIC shift register 1	IIC1			√		00H
FFFFFD92H	IIC control register 1	IICC1		√	√		00H
FFFFFD93H	Slave address register 1	SVA1			√		00H
FFFFFD94H	IIC clock select register 1	IICCL1		√	√		00H
FFFFFD95H	IIC function expansion register 1	IICX1		√	√		00H
FFFFFD96H	IIC status register 1	IICS1	R	√	√		00H
FFFFFD9AH	IIC flag register 1	IICF1	R/W	√	√		00H
FFFFFDA0H	IIC shift register 2	IIC2			√		00H

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Address	Function Register Name	Symbol	R/W	Manipulatable Bits			Default Value
				1	8	16	
FFFFFDA2H	IIC control register 2	IICC2	R/W	√	√		00H
FFFFFDA3H	Slave address register 2	SVA2			√		00H
FFFFFDA4H	IIC clock select register 2	IICCL2		√	√		00H
FFFFFDA5H	IIC function expansion register 2	IICX2		√	√		00H
FFFFFDA6H	IIC status register 2	IICS2	R	√	√		00H
FFFFFDAAH	IIC flag register 2	IICF2	R/W	√	√		00H
FFFFFF40H	USB clock selection register	UCKSEL		√	√		00H
FFFFFF41H	USB function control register	UFCKMSK		√	√		03H
FFFFFF42H	USB function selection register	UHCKMSK		√	√		03H
FFFFFF60H	External DMA request enable register	EXDRQEN			√		00H

3.4.7 Programmable peripheral I/O registers

The BPC register is used to select the programmable peripheral I/O register area.

The BPC register is valid only μPD70F3770, 70F3771.

(1) Peripheral I/O area select control register (BPC)

This register can be read or written in 16-bit units.

Reset sets this register to 0000H.

After reset: 0000H R/W Address: FFFFF064H

	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
BPC	PA15	0	PA13	PA12	PA11	PA10	PA09	PA08	PA07	PA06	PA05	PA04	PA03	PA02	PA01	PA00

PA15	Allows/does not allow use of programmable peripheral I/O area.
0	Do not allow use of programmable peripheral I/O area.
1	Allow use of programmable peripheral I/O area.

PA13 to PA00	Set address of programmable peripheral I/O area. (correspond to A27 to A14)

Caution If the PA15 bit is set to 1, be sure to set the BPC register to 8FFBH.
If the PA15 bit is set to 0, be sure to set the BPC register to 0000H.

For the list of programmable peripheral I/O registers, refer to **Table 20-16 Register Access Type**.

3.4.8 Special registers

Special registers are registers that are protected from being written with illegal data due to a program loop. The V850ES/JG3-H and V850ES/JH3-H have the following eight special registers.

- Power save control register (PSC)
- Clock control register (CKC)
- Processor clock control register (PCC)
- Clock monitor mode register (CLM)
- Reset source flag register (RESF)
- Low-voltage detection register (LVIM)
- Internal RAM data status register (RAMS)
- On-chip debug mode register (OCDM) (V850ES/JG3-H only)

In addition, the PRCDM register is provided to protect against a write access to the special registers so that the application system does not inadvertently stop due to a program loop. A write access to the special registers is made in a specific sequence, and an illegal store operation is reported to the SYS register.

(1) Setting data to special registers

Set data to the special registers in the following sequence.

<1> Disable DMA operation.
<2> Prepare data to be set to the special register in a general-purpose register.
<3> Write the data prepared in <2> to the PRCMD register.
<4> Write the setting data to the special register (by using the following instructions).
- Store instruction (ST/SST instruction)
- Bit manipulation instruction (SET1/CLR1/NOT1 instruction)

(<5> to <9> Insert NOP instructions (5 instructions).)Note
<10> Enable DMA operation if necessary.

[Example] With PSC register (setting standby mode)

```
   ST.B r11, PSMR[r0]   ; Set PSMR register (setting IDLE1, IDLE2, and STOP modes).
<1>CLR1 0, DCHCn[r0]    ; Disable DMA operation.  n = 0 to 3
<2>MOV0x02, r10
<3>ST.B r10, PRCMD[r0]  ; Write PRCMD register.
<4>ST.B r10, PSC[r0]    ; Set PSC register.
<5>NOPNote              ; Dummy instruction
<6>NOPNote              ; Dummy instruction
<7>NOPNote              ; Dummy instruction
<8>NOPNote              ; Dummy instruction
<9>NOPNote              ; Dummy instruction
<10>SET1 0, DCHCn[r0]   ; Enable DMA operation.  n = 0 to 3
(next instruction)
```

There is no special sequence to read a special register.

Note Five NOP instructions or more must be inserted immediately after setting the IDLE1 mode, IDLE2 mode, or STOP mode (by setting the PSC.STP bit to 1).

Cautions 1. When a store instruction is executed to store data in the command register, interrupts are not acknowledged. This is because it is assumed that steps <3> and <4> above are performed by successive store instructions. If another instruction is placed between <3> and <4>, and if an interrupt is acknowledged by that instruction, the above sequence may not be established, causing malfunction.

2. Although dummy data is written to the PRCMD register, use the same general-purpose register used to set the special register (<4> in Example) to write data to the PRCMD register (<3> in Example). The same applies when a general-purpose register is used for addressing.

(2) Command register (PRCMD)

The PRCMD register is an 8-bit register that protects the registers that may seriously affect the application system from being written, so that the system does not inadvertently stop due to a program hang-up. The first write access to a special register is valid after data has been written in advance to the PRCMD register. In this way, the value of the special register can be rewritten only in a specific sequence, so as to protect the register from an illegal write access.

The PRCMD register is write-only, in 8-bit units (undefined data is read when this register is read).

After reset: Undefined W Address: FFFFF1FCH

	7	6	5	4	3	2	1	0
PRCMD	REG7	REG6	REG5	REG4	REG3	REG2	REG1	REG0

(3) System status register (SYS)

Status flags that indicate the operation status of the overall system are allocated to this register.

This register can be read or written in 8-bit or 1-bit units.

Reset sets this register to 00H.

After reset: 00H R/W Address: FFFFF802H

	7	6	5	4	3	2	1	<0>
SYS	0	0	0	0	0	0	0	PRERR

PRERR	Detects protection error
0	Protection error did not occur
1	Protection error occurred

The PRERR flag operates under the following conditions.

(a) Set condition (PRERR flag = 1)

(i) When data is written to a special register without writing anything to the PRCMD register (when <4> is executed without executing <3> in **3.4.8 (1) Setting data to special registers**)

(ii) When data is written to an on-chip peripheral I/O register other than a special register (including execution of a bit manipulation instruction) after writing data to the PRCMD register (if <4> in **3.4.8 (1) Setting data to special registers** is not the setting of a special register)

Remark Even if an on-chip peripheral I/O register is read (except by a bit manipulation instruction) between an operation to write the PRCMD register and an operation to write a special register, the PRERR flag is not set, and the set data can be written to the special register.

(b) Clear condition (PRERR flag = 0)

(i) When 0 is written to the PRERR flag

(ii) When the system is reset

Cautions 1. If 0 is written to the PRERR bit of the SYS register, which is not a special register, immediately after a write access to the PRCMD register, the PRERR bit is cleared to 0 (the write access takes precedence).

2. If data is written to the PRCMD register, which is not a special register, immediately after a write access to the PRCMD register, the PRERR bit is set to 1.

3.4.9 Cautions

(1) Registers to be set first

Be sure to set the following registers first when using the V850ES/JG3-H and V850ES/JH3-H.

- System wait control register (VSWC)
- On-chip debug mode register (OCDM) (V850ES/JG3-H only)
- Watchdog timer mode register 2 (WDTM2)

After setting the VSWC, OCDM, and WDTM2 registers, set the other registers as necessary.
When using the external bus, set each pin to the alternate-function bus control pin mode by using the port-related registers after setting the above registers.

(a) System wait control register (VSWC)

The VSWC register controls wait of bus access to the on-chip peripheral I/O registers.
Three clocks are required to access an on-chip peripheral I/O register (without a wait cycle). The V850ES/JG3-H and V850ES/JH3-H require wait cycles according to the operating frequency. Set the following value to the VSWC register in accordance with the frequency used.
The VSWC register can be read or written in 8-bit units.
Reset sets this register to 77H.

After reset: 77H R/W Address: FFFFF06EH

	7	6	5	4	3	2	1	0
VSWC								

Operating Frequency (f_{CPU})	Set Value of VSWC	Number of Waits
f_{CPU} < 16.6 MHz	00H	0 (no waits)
16.6 MHz ≤ f_{CPU} < 25 MHz	01H	1
25 MHz ≤ f_{CPU} < 33.3 MHz	11H	2
33.3 MHz ≤ f_{CPU} ≤ 48 MHz	12H	3

(b) On-chip debug mode register (OCDM) (V850ES/JG3-H only)

For details, see **CHAPTER 32 ON-CHIP DEBUG FUNCTION**.

(c) Watchdog timer mode register 2 (WDTM2)

The WDTM2 register sets the overflow time and the operation clock of watchdog timer 2.
Watchdog timer 2 automatically starts in the reset mode after reset is released. Write the WDTM2 register to activate this operation.
For details, see **CHAPTER 13 FUNCTIONS OF WATCHDOG TIMER 2**.

(2) Accessing specific on-chip peripheral I/O registers

This product has two types of internal system buses.

One is a CPU bus and the other is a peripheral bus that interfaces with low-speed peripheral hardware.

The clock of the CPU bus and the clock of the peripheral bus are asynchronous. If an access to the CPU and an access to the peripheral hardware conflict, therefore, unexpected illegal data may be transferred. If there is a possibility of a conflict, the number of cycles for accessing the CPU changes when the peripheral hardware is accessed, so that correct data is transferred. As a result, the CPU does not start processing of the next instruction but enters the wait status. If this wait status occurs, the number of clocks required to execute an instruction increases by the number of wait clocks shown below.

This must be taken into consideration if real-time processing is required.

When specific on-chip peripheral I/O registers are accessed, more wait states may be required in addition to the wait states set by the VSWC register.

The access conditions and how to calculate the number of wait states to be inserted (number of CPU clocks) at this time are shown below.

(1/2)

Peripheral Function	Register Name	Access	k
16-bit timer/event counter AA (TAA) (n = 0 to 5, m = 0 to 3, 5)	TAAnCNT	Read	1 or 2
	TAAnCCR0, TAAnCCR1	Write	• 1st access: No wait • Continuous write: 0 to 3
		Read	1 or 2
	TAAmIOC4	Write	• 1st access: No wait • Continuous write: 0 to 3
		Read	1 or 2
16-bit timer/event counter AB (TAB) (n = 0, 1)	TABnCNT	Read	1 or 2
	TABnCCR0 to TABnCCR3	Write	• 1st access: No wait • Continuous write: 0 to 3
		Read	1 or 2
	TABnIOC4	Write	• 1st access: No wait • Continuous write: 0 to 3
		Read	1 or 2
Motor control	TAB0OPT1	Write	• 1st access: No wait • Continuous write: 0 to 3
	TAB0DTC	Write	• 1st access: No wait • Continuous write: 0 to 3
TMT	TT0CNT	Read	1 or 2
	TT0TCR0, TT0TCR1	Write	• 1st access: No wait • Continuous write: 0 to 3
		Read	1 or 2
Watchdog timer 2 (WDT2)	WDTM2	Write (when WDT2 operating)	3
Real-time output function (RTO)	RTBL0, RTBH0	Write (RTPC0.RTPOE0 bit = 0)	1
A/D converter	ADA0M0	Read	1 or 2
	ADA0CR0 to ADA0CR11	Read	1 or 2
	ADA0CR0H to ADA0CR11H	Read	1 or 2

(2/2)

Peripheral Function	Register Name	Access	k
I^2C00 to I^2C02	IICS0 to IICS2	Read	1
CRC	CRCD	Write	1
CAN controller (m = 0 to 31, a = 1 to 4)	C0GMABT, C0GMABTD, C0MASKaL, C0MASKaH, C0LEC, C0INFO, C0ERC, C0IE, C0INTS, C0BRP, C0BTR, C0TS	Read/Write	$f_{XX}/f_{CANMOD} + 1) / (2 + j)$ (MIN.)[Note] $(2 \times f_{XX}/f_{CANMOD} + 1) / (2 + j)$ (MAX.)[Note]
	C0GMCTRL, C0GMCS, C0CTRL	Read/Write	$(f_{XX}/f_{CAN} + 1) / (2 + j)$ (MIN.)[Note] $(2 \times f_{XX}/f_{CAN} + 1) / (2 + j)$ (MAX.)[Note]
	C0RGPT, C0TGPT	Write	$(f_{XX}/f_{CANMOD} + 1) / (2 + j)$ (MIN.)[Note] $(2 \times f_{XX}/f_{CANMOD} + 1) / (2 + j)$ (MAX.)[Note]
		Read	$(3 \times f_{XX}/f_{CANMOD} + 1) / (2 + j)$ (MIN.)[Note] $(4 \times f_{XX}/f_{CANMOD} + 1) / (2 + j)$ (MAX.)[Note]
	C0LIPT, C0LOPT	Read	$(3 \times f_{XX}/f_{CANMOD} + 1) / (2 + j)$ (MIN.)[Note] $(4 \times f_{XX}/f_{CANMOD} + 1) / (2 + j)$ (MAX.)[Note]
	C0MCTRLm	Write	$(4 \times f_{XX}/f_{CAN} + 1) / (2 + j)$ (MIN.)[Note] $(5 \times f_{XX}/f_{CAN} + 1) / (2 + j)$ (MAX.)[Note]
		Read	$(3 \times f_{XX}/f_{CAN} + 1) / (2 + j)$ (MIN.)[Note] $(4 \times f_{XX}/f_{CAN} + 1) / (2 + j)$ (MAX.)[Note]
	C0MDATA01m, C0MDATA0m, C0MDATA1m, C0MDATA23m, C0MDATA2m, C0MDATA3m, C0MDATA45m, C0MDATA4m, C0MDATA5m, C0MDATA67m, C0MDATA6m, C0MDATA7m, C0MDLCm, C0MCONFm, C0MIDLm, C0MIDHm	Write (8 bits)	$(4 \times f_{XX}/f_{CANMOD} + 1) / (2 + j)$ (MIN.)[Note] $(5 \times f_{XX}/f_{CANMOD} + 1) / (2 + j)$ (MAX.)[Note]
		Write (16 bits)	$(2 \times f_{XX}/f_{CANMOD} + 1) / (2 + j)$ (MIN.)[Note] $(3 \times f_{XX}/f_{CANMOD} + 1) / (2 + j)$ (MAX.)[Note]
		Read (8/16 bits)	$(3 \times f_{XX}/f_{CANMOD} + 1) / (2 + j)$ (MIN.)[Note] $(4 \times f_{XX}/f_{CANMOD} + 1) / (2 + j)$ (MAX.)[Note]

Number of clocks necessary for access = $3 + i + j + (2 + j) \times k$

Note Digits below the decimal point are rounded up.

Caution Accessing the above registers is prohibited in the following statuses. If a wait cycle is generated, it can only be cleared by a reset.

- **When the CPU operates with the subclock and the main clock oscillation is stopped**
- **When the CPU operates with the internal oscillation clock**

Remark i: Values (0) of higher 4 bits of VSWC register
j: Values (0 or 1) of lower 4 bits of VSWC register

(3) Restriction on conflict between sld instruction and interrupt request

(a) Description

If a conflict occurs between the decode operation of an instruction in <2> immediately before the sld instruction following an instruction in <1> and an interrupt request before the instruction in <1> is complete, the execution result of the instruction in <1> may not be stored in a register.

Instruction <1>

- ld instruction: ld.b, ld.h, ld.w, ld.bu, ld.hu
- sld instruction: sld.b, sld.h, sld.w, sld.bu, sld.hu
- Multiplication instruction: mul, mulh, mulhi, mulu

Instruction <2>

mov reg1, reg2	not reg1, reg2	satsubr reg1, reg2	satsub reg1, reg2
satadd reg1, reg2	satadd imm5, reg2	or reg1, reg2	xor reg1, reg2
and reg1, reg2	tst reg1, reg2	subr reg1, reg2	sub reg1, reg2
add reg1, reg2	add imm5, reg2	cmp reg1, reg2	cmp imm5, reg2
mulh reg1, reg2	shr imm5, reg2	sar imm5, reg2	shl imm5, reg2

<Example>

<i> ld.w [r11], r10
•
•
•
<ii> mov r10, r28
<iii> sld.w 0x28, r10

If the decode operation of the mov instruction <ii> immediately before the sld instruction <iii> and an interrupt request conflict before execution of the ld instruction <i> is complete, the execution result of instruction <i> may not be stored in a register.

(b) Countermeasure

<1> When compiler (CA850) is used

Use CA850 Ver. 2.61 or later because generation of the corresponding instruction sequence can be automatically suppressed.

<2> For assembler

When executing the sld instruction immediately after instruction <ii>, avoid the above operation using either of the following methods.

- Insert a nop instruction immediately before the sld instruction.
- Do not use the same register as the sld instruction destination register in the above instruction <ii> executed immediately before the sld instruction.

CHAPTER 4 PORT FUNCTIONS

4.1 Features

- I/O ports
  - V850ES/JG3-H: 77
    5 V tolerant/N-ch open-drain output selectable: 22
  - V850ES/JH3-H: 96
    5 V tolerant/N-ch open-drain output selectable: 25
- Input/output specifiable in 1-bit units

4.2 Basic Port Configuration

The V850ES/JG3-H features a total of 77 I/O ports consisting of ports 0, 1, 3 to 7, 9, CM, CT, and DL.
The V850ES/JH3-H features a total of 96 I/O ports consisting of ports 0 to 7, 9, CM, CS, CT, DH, and DL.
The port configuration is shown below.

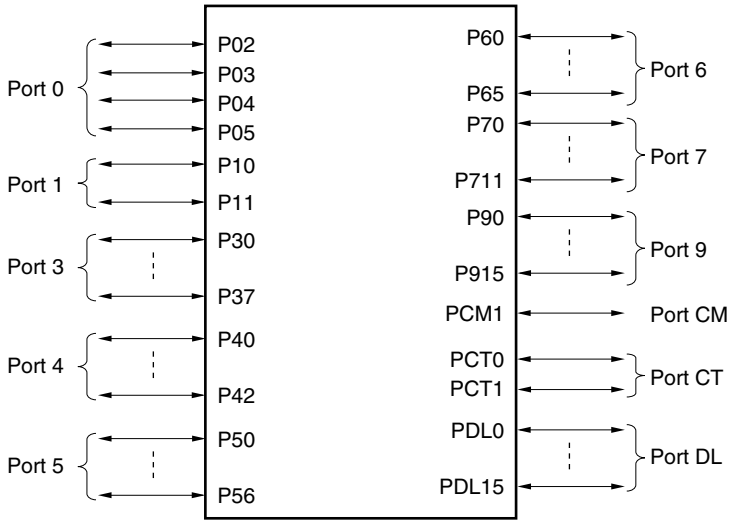
Table 4-1. I/O Buffer Power Supplies for Pins (V850ES/JG3-H)

Power Supply	Corresponding Pins
AV_{REF0}	Port 7
AV_{REF1}	Port 1
EV_{DD}	$\overline{RESET}$, ports 0, 3 to 6, 9, CM, CT, DL

Table 4-2. I/O Buffer Power Supplies for Pins (V850ES/JH3-H)

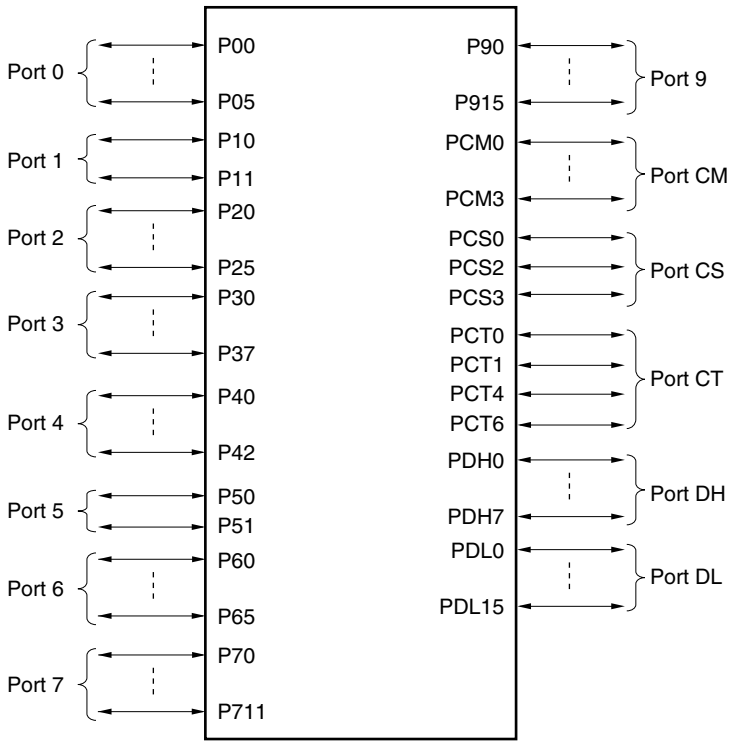
Power Supply	Corresponding Pins
AV_{REF0}	Port 7
AV_{REF1}	Port 1
EV_{DD}	$\overline{RESET}$, ports 0, 2 to 6, 9, CM, CS, CT, DH, DL

Figure 4-1. Port Configuration Diagram (V850ES/JG3-H)



<R> **Caution Ports 0, 3 to 5 are 5 V tolerant.**

Figure 4-2. Port Configuration Diagram (V850ES/JH3-H)



<R> **Caution Ports 0, 2, 3 to 5 are 5 V tolerant.**

4.3 Port Configuration

Table 4-3. Port Configuration (V850ES/JG3-H)

Item	Configuration
Control register	Port n mode register (PMn: n = 0, 1, 3 to 7, 9, CM, CT, DL) Port n mode control register (PMCn: n = 0, 3 to 5, 9, CM, CT, DL) Port n function control register (PFCn: n = 0, 3 to 6, 9) Port n function control expansion register (PFCEn: n = 4 to 6, 9) Port n function register (PFn: n = 0, 3 to 5, 9)
Ports	I/O: 77

Table 4-4. Port Configuration (V850ES/JH3-H)

Item	Configuration
Control register	Port n mode register (PMn: n = 0 to 7, 9, CM, CS, CT, DH, DL) Port n mode control register (PMCn: n = 0, 2 to 6, 9, CM, CS, CT, DH, DL) Port n function control register (PFCn: n = 0, 2 to 6, 9) Port n function control expansion register (PFCEn: n = 4 to 6, 9) Port n function register (PFn: n = 0, 2 to 5, 9)
Ports	I/O: 96

(1) Port n register (Pn)

Data is input from or output to an external device by writing or reading the Pn register.

The Pn register consists of a port latch that holds output data, and a circuit that reads the status of pins.

Each bit of the Pn register corresponds to one pin of port n, and can be read or written in 1-bit units.

After reset: 00H (output latch) R/W

	7	6	5	7	3	2	1	0
Pn	Pn7	Pn6	Pn5	Pn4	Pn3	Pn2	Pn1	Pn0

Pnm	Control of output data (in output mode)
0	Outputs 0.
1	Outputs 1.

Data is written to or read from the Pn register as follows, regardless of the setting of the PMCn register.

Table 4-5. Writing/Reading Pn Register

Setting of PMn Register	Writing to Pn Register	Reading from Pn Register
Output mode (PMnm = 0)	Data is written to the output latch[Note]. In the port mode (PMCn = 0), the contents of the output latch are output from the pins.	The value of the output latch is read.
Input mode (PMnm = 1)	Data is written to the output latch. The pin status is not affected[Note].	The pin status is read.

Note The value written to the output latch is retained until a new value is written to the output latch.

(2) Port n mode register (PMn)

The PMn register specifies the input or output mode of the corresponding port pin.

Each bit of this register corresponds to one pin of port n, and the input or output mode can be specified in 1-bit units.

After reset: FFH R/W

	7	6	5	4	3	2	1	0
PMn	PMn7	PMn6	PMn5	PMn4	PMn3	PMn2	PMn1	PMn0

PMnm	Control of input/output mode
0	Output mode
1	Input mode

(3) Port n mode control register (PMCn)

The PMCn register specifies the port mode or alternate function.

Each bit of this register corresponds to one pin of port n, and the mode of the port can be specified in 1-bit units.

After reset: 00H R/W

	7	6	5	4	3	2	1	0
PMCn	PMCn7	PMCn6	PMCn5	PMCn4	PMCn3	PMCn2	PMCn1	PMCn0

PMCnm	Specification of operation mode
0	Port mode
1	Alternate-function mode

(4) Port n function control register (PFCn)

The PFCn register specifies the alternate function of a port pin to be used if the pin has two alternate functions.

Each bit of this register corresponds to one pin of port n, and the alternate function of a port pin can be specified in 1-bit units.

After reset: 00H R/W

	7	6	5	4	3	2	1	0
PFCn	PFCn7	PFCn6	PFCn5	PFCn4	PFCn3	PFCn2	PFCn1	PFCn0

PFCnm	Specification of alternate function
0	Alternate function 1
1	Alternate function 2

(5) Port n function control expansion register (PFCEn)

The PFCEn register specifies the alternate function of a port pin to be used if the pin has three or more alternate functions.

Each bit of this register corresponds to one pin of port n, and the alternate function of a port pin can be specified in 1-bit units.

After reset: 00H R/W

	7	6	5	4	3	2	1	0
PFCEn	PFCEn7	PFCEn6	PFCEn5	PFCEn4	PFCEn3	PFCEn2	PFCEn1	PFCEn0
PFCn	PFCn7	PFCn6	PFCn5	PFCn4	PFCn3	PFCn2	PFCn1	PFCn0

PFCEnm	PFCnm	Specification of alternate function
0	0	Alternate function 1
0	1	Alternate function 2
1	0	Alternate function 3
1	1	Alternate function 4

(6) Port n function register (PFn)

The PFn register specifies normal output or N-ch open-drain output.

Each bit of this register corresponds to one pin of port n, and the output mode of the port pin can be specified in 1-bit units.

After reset: 00H R/W

	7	6	5	4	3	2	1	0
PFn	PFn7	PFn6	PFn5	PFn4	PFn3	PFn2	PFn1	PFn0

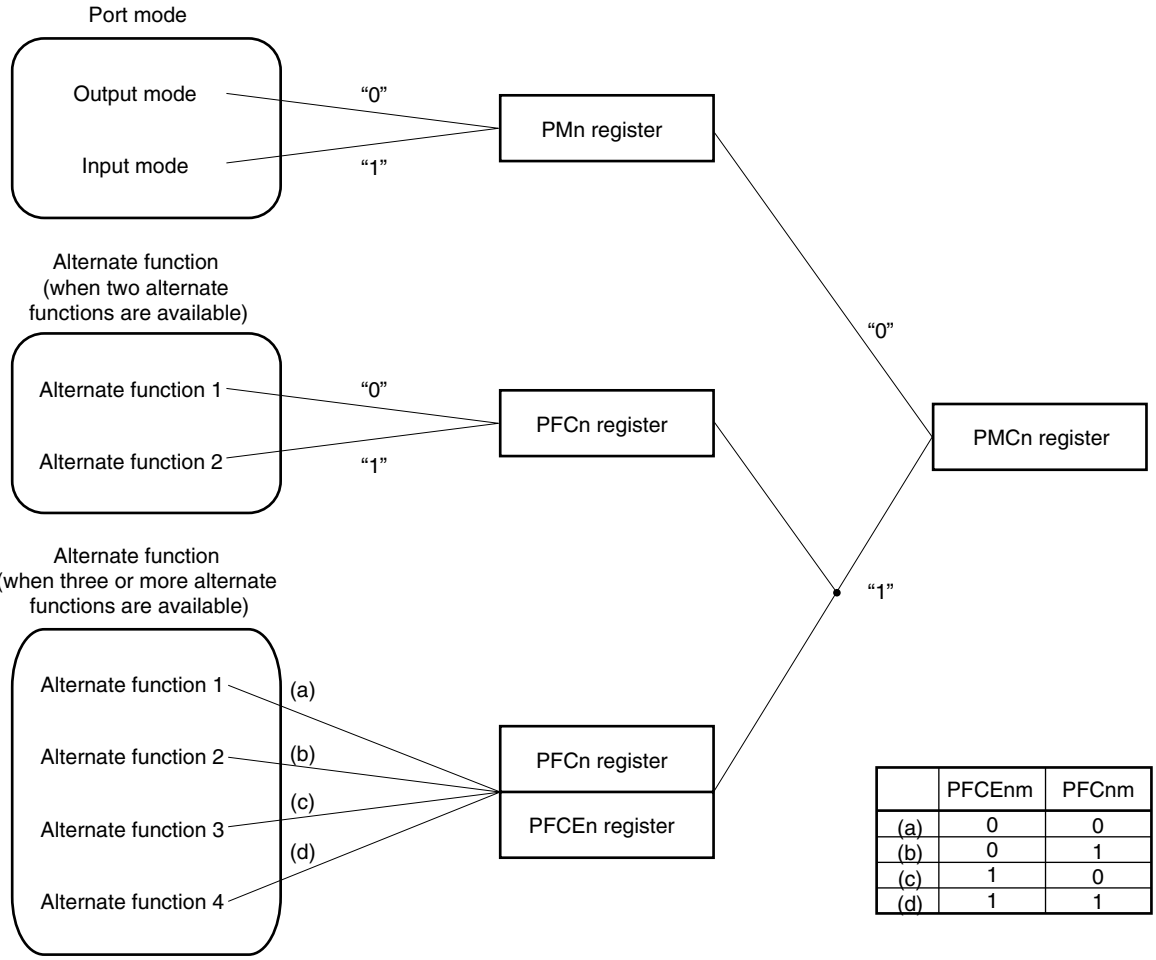
PFnm[Note]	Control of normal output/N-ch open-drain output
0	Normal output (CMOS output)
1	N-ch open-drain output

Note The PFnm bit of the PFn register is valid only when the PMnm bit of the PMn register is 0 (when the output mode is specified) in port mode (PMCnm bit = 0). When the PMnm bit is 1 (when the input mode is specified), the set value of the PFn register is invalid.

(7) Port setting

Set a port as illustrated below.

Figure 4-3. Setting of Each Register and Pin Function



	PFCEnm	PFCnm
(a)	0	0
(b)	0	1
(c)	1	0
(d)	1	1

Remark Set the alternate functions in the following sequence.

<1> Set the PFCn and PFCEn registers.
<2> Set the PMCn register.
<3> Set the INTRn or INTFn register (to specify an external interrupt pin).

If the PMCn register is set first, an unintended function may be set while the PFCn and PFCEn registers are being set.

4.3.1 Port 0

Port 0 is 4-bit (V850ES/JG3-H)/6-bit (V850ES/JH3-H) port for which I/O settings can be controlled in 1-bit units.

Port 0 includes the following alternate-function pins.

Table 4-6. Port 0 Alternate-Function Pins

Pin Name	Pin No.		Alternate-Function Pin Name	I/O	Remark
	V850ES/JG3-H	V850ES/JH3-H			
P00	–	8	INTP00	Input	Selectable as N-ch open-drain output
P01	–	9	INTP01	Input	
P02	6	6	NMI	Input	
P03	7	7	INTP02/ADTRG/UCLK	Input	
P04	20	26	INTP03	Input	
P05	21	27	INTP04	Input	

Caution The P00 to P05 pins have hysteresis characteristics in the input mode of the alternate function, but do not have hysteresis characteristics in the port mode.

(1) Port 0 register (P0)

(a) V850ES/JG3-H

After reset: 00H (output latch) R/W Address: FFFFF400H

	7	6	5	4	3	2	1	0
P0	0	0	P05	P04	P03	P02	0	0

P0n	Output data control (in output mode) (n = 2 to 5)
0	Outputs 0.
1	Outputs 1.

(b) V850ES/JH3-H

After reset: 00H (output latch) R/W Address: FFFFF400H

	7	6	5	4	3	2	1	0
P0	0	0	P05	P04	P03	P02	P01	P00

P0n	Output data control (in output mode) (n = 2 to 5)
0	Outputs 0.
1	Outputs 1.

(2) Port 0 mode register (PM0)

(a) V850ES/JG3-H

After reset: FFH R/W Address: FFFFF420H

	7	6	5	4	3	2	1	0
PM0	1	1	PM05	PM04	PM03	PM02	1	1

PM0n	I/O mode control (n = 2 to 5)
0	Output mode
1	Input mode

(b) V850ES/JH3-H

After reset: FFH R/W Address: FFFFF420H

	7	6	5	4	3	2	1	0
PM0	1	1	PM05	PM04	PM03	PM02	PM01	PM00

PM0n	I/O mode control (n = 0 to 5)
0	Output mode
1	Input mode

(3) Port 0 mode control register (PMC0)

(1/2)

(a) V850ES/JG3-H

After reset: 00H R/W Address: FFFFF440H

	7	6	5	4	3	2	1	0
PMC0	0	0	PMC05	PMC04	PMC03	PMC02	0	0

PMC05	Specification of P05 pin operation mode
0	I/O port
1	INTP04 input

PMC04	Specification of P04 pin operation mode
0	I/O port
1	INTP03 input

PMC03	Specification of P03 pin operation mode
0	I/O port
1	INTP02 input/ADTRG input/UCLK input

PMC02	Specification of P02 pin operation mode
0	I/O port
1	NMI input

(2/2)

(b) V850ES/JH3-H

After reset: 00H R/W Address: FFFFF440H

	7	6	5	4	3	2	1	0
PMC0	0	0	PMC05	PMC04	PMC03	PMC02	PMC01	PMC00

PMC05	Specification of P05 pin operation mode
0	I/O port
1	INTP04 input

PMC04	Specification of P04 pin operation mode
0	I/O port
1	INTP03 input

PMC03	Specification of P03 pin operation mode
0	I/O port
1	INTP02 input/ADTRG input/UCLK input

PMC02	Specification of P02 pin operation mode
0	I/O port
1	NMI input

PMC01	Specification of P01 pin operation mode
0	I/O port
1	INTP01 input

PMC00	Specification of P00 pin operation mode
0	I/O port
1	INTP00 input

(4) Port 0 function control register (PFC0)

After reset: 00H R/W Address: FFFFF460H

	7	6	5	4	3	2	1	0
PFC0	0	0	0	0	PFC03	0	0	0

Remark For details of alternate function specification, see **4.3.1 (6) Port 0 alternate function specifications**.

(5) Port 0 function control expansion register (PFCE0)

After reset: 00H R/W Address: FFFFF700H

	7	6	5	4	3	2	1	0
PFCE0	0	0	0	0	PFCE03	0	0	0

Remark For details of alternate function specification, see **4.3.1 (6) Port 0 alternate function specifications**.

(6) Port 0 alternate function specifications

PFCE03	PFC03	Specification of P03 pin alternate function
0	0	INTP02 input
0	1	ADTRG input
1	0	UCLK input
1	1	Setting prohibited

(7) Port 0 function register (PF0)

(a) V850ES/JG3-H

After reset: 00H R/W Address: FFFFFC60H

	7	6	5	4	3	2	1	0
PF0	0	0	PF05	PF04	PF03	PF02	0	0

PF0n	Control of normal output or N-ch open-drain output (n = 2-5)
0	Normal output
1	N-ch open-drain output

(b) V850ES/JH3-H

After reset: 00H R/W Address: FFFFFC60H

	7	6	5	4	3	2	1	0
PF0	0	0	PF05	PF04	PF03	PF02	PF01	PF00

PF0n	Control of normal output or N-ch open-drain output (n = 0 to 5)
0	Normal output
1	N-ch open-drain output

4.3.2 Port 1

Port 1 is a 2-bit port for which I/O settings can be controlled in 1-bit units.

Port 1 includes the following alternate-function pins.

Table 4-7. Port 1 Alternate-Function Pins

Pin Name	Pin No.		Alternate-Function Pin Name	I/O	Remark
	V850ES/JG3-H	V850ES/JH3-H			
P10	3	3	ANO0	Output	–
P11	4	4	ANO1	Output	

Caution When the power is turned on, the P10 and P11 pins may output an undefined level temporarily even during reset.

(1) Port 1 register (P1)

After reset: 00H (output latch) R/W Address: FFFFF402H

	7	6	5	4	3	2	1	0
P1	0	0	0	0	0	0	P11	P10

P1n	Output data control (in output mode) (n = 0, 1)
0	Outputs 0.
1	Outputs 1.

Caution Do not read or write the P1 register during D/A conversion (see 16.4.3 Cautions).

(2) Port 1 mode register (PM1)

After reset: FFH R/W Address: FFFFF422H

	7	6	5	4	3	2	1	0
PM1	1	1	1	1	1	1	PM11	PM10

PM1n	I/O mode control (n = 0, 1)
0	Output mode
1	Input mode

Cautions 1. When using P1n as the alternate function (ANOn pin output), set the PM1n bit to 1.

2. When using one of the PM10 and PM11 pins as an I/O port and the other as a D/A output pin, do so in an application where the port I/O level does not change during D/A output.

4.3.3 Port 2 (V850ES/JH3-H only)

Port 2 is a 6-bit port for which I/O settings can be controlled in 1-bit units.

Port 2 includes the following alternate-function pins.

Table 4-8. Port 2 Alternate-Function Pins

Pin Name	Pin No.		Alternate-Function Pin Name	I/O	Remark
	V850ES/JG3-H	V850ES/JH3-H			
P20	–	32	TIAB03/KR2/TOAB03/RTP02	I/O	Selectable as N-ch open-drain output
P21	–	33	SIF2/KR3/TIAB00/TOAB00/RTP03	I/O	
P22	–	34	SOF2/KR4/RTP04	I/O	
P23	–	35	SCKF2/KR5/RTP05	I/O	
P24	–	36	INTP05	Input	
P25	–	28	INTP06	Input	

Caution The P20 to P25 pins have hysteresis characteristics in the input mode of the alternate-function pin, but do not have the hysteresis characteristics in the port mode.

(1) Port 2 register (P2)

After reset: 00H (output latch) R/W Address: FFFFF404H

	7	6	5	4	3	2	1	0
P2	0	0	P25	P24	P23	P22	P21	P20

P2n	Output data control (in output mode) (n = 0 to 5)
0	Outputs 0.
1	Outputs 1.

(2) Port 2 mode register (PM2)

After reset: FFH R/W Address: FFFFF424H

	7	6	5	4	3	2	1	0
PM2	1	1	PM25	PM24	PM23	PM22	PM21	PM20

PM2n	I/O mode control (n = 0 to 5)
0	Output mode
1	Input mode

(3) Port 2 mode control register (PMC2)

After reset: 00H R/W Address: FFFFF444H

	7	6	5	4	3	2	1	0
PMC2	0	0	PMC25	PMC24	PMC23	PMC22	PMC21	PMC20

PMC25	Specification of P25 pin operation mode
0	I/O port
1	INTP06 input

PMC24	Specification of P24 pin operation mode
0	I/O port
1	INTP05 input

PMC23	Specification of P23 pin operation mode
0	I/O port
1	$\overline{\text{SCKF2}}$ I/O/KR5 input/RTP05 output

PMC22	Specification of P22 pin operation mode
0	I/O port
1	SOF2 output/KR4 input/RTP04 output

PMC21	Specification of P21 pin operation mode
0	I/O port
1	SIF2 output/KR3 input/TIAB00 input/TOAB00 output/RTP03 output

PMC20	Specification of P20 pin operation mode
0	I/O port
1	TIAB03 input/KR2 input/TOAB03 output/RTP02 output

(4) Port 2 function control register (PFC2)

After reset: 00H R/W Address: FFFFF464H

	7	6	5	4	3	2	1	0
PFC2	0	0	0	0	PFC23	PFC22	PFC21	PFC20

Remark For details of alternate function specification, see **4.3.3 (6) Port 2 alternate function specifications**.

(5) Port 2 function control expansion register (PFCE2)

After reset: 00H R/W Address: FFFFF704H

	7	6	5	4	3	2	1	0
PFCE2	0	0	0	0	PFCE23	PFCE22	PFCE21	PFCE20

Remark For details of alternate function specification, see **4.3.3 (6) Port 2 alternate function specifications**.

(6) Port 2 alternate function specifications

PFCE23	PFC23	Specification of P23 pin alternate function
0	0	$\overline{\text{SCKF2}}$ I/O
0	1	KR5 input
1	0	RTP05 output
1	1	Setting prohibited

PFCE22	PFC22	Specification of P22 pin alternate function
0	0	SOF2 output
0	1	KR4 input
1	0	RTP04 output
1	1	Setting prohibited

PFCE21	PFC21	Specification of P21 pin alternate function
0	0	SIF2 input
0	1	KR3 input/TIAB00 input[Note]
1	0	TOAB00 output
1	1	RTP03 output

Note KR3 and TIAB00 are alternate functions. When using the pin as the TIAB00 pin, disable the KR3 pin key return detection, which is the alternate function (clear the KRM.KRM3 bit to 0). Also, when using the pin as the KRn pin, disable TIAB00 pin edge detection, which is the alternate function (TAB0IOC1.TAB0TIG0, TAB0TIG1 bit = 00 B, TAB0IOC2 register = 00H).

PFCE20	PFC20	Specification of P20 pin alternate function
0	0	TIAB03 input/KR02 input
0	1	KR2 input
1	0	TOAB03 output
1	1	Setting prohibited

(7) Port 2 function register (PF2)

After reset: 00H R/W Address: FFFFFC64H

	7	6	5	4	3	2	1	0
PF2	0	0	PF25	PF24	PF23	PF22	PF21	PF20

PF2n	Control of normal output or N-ch open-drain output (n = 0 to 5)
0	Normal output
1	N-ch open-drain output

4.3.4 Port 3

Port 3 is a 10-bit port that controls I/O in 1-bit units.

Port 3 includes the following alternate-function pins.

Table 4-9. Port 3 Alternate-Function Pins

Pin Name	Pin No.		Alternate-Function Pin Name	I/O	Remark
	V850ES/JG3-H	V850ES/JH3-H			
P30	25	37	TXDC0/SOF4/INTP07	I/O	Selectable as N-ch open-drain output
P31	26	38	RXDC0/SIF4/INTP08	Input	
P32	27	39	ASCKC0/SCKF4/TIAA00/TOAA00	I/O	
P33	28	40	TIAA01/TOAA01/RTCDIV/RTCCL	I/O	
P34	29	41	TIAA10/TOAA10/TOAA1OFF/INTP09	I/O	
P35	30	42	TIAA11/TOAA11/RTC1HZ	I/O	
P36	31	43	TXDC3/SCL00/CTXD0[Note]/$\overline{\text{UDMARQ0}}$	I/O	
P37	32	44	RXDC3/SDA00/CRXD0[Note]/$\overline{\text{UDMAAK0}}$	I/O	

Note μPD70F3770, 70F3771 only

Caution The P30 to P37 pins have hysteresis characteristics in the input mode of the alternate-function pin, but do not have the hysteresis characteristics in the port mode.

(1) Port 3 register (P3)

After reset: 00H (output latch) R/W Address: FFFFF406H

	7	6	5	4	3	2	1	0
P3	P37	P36	P35	P34	P33	P32	P31	P30

P3n	Output data control (in output mode) (n = 0 to 7)
0	Outputs 0.
1	Outputs 1.

(2) Port 3 mode register (PM3)

After reset: FFH R/W Address: FFFFF426H

	7	6	5	4	3	2	1	0
PM3	PM37	PM36	PM35	PM34	PM33	PM32	PM31	PM30

PM3n	I/O mode control (n = 0 to 7)
0	Output mode
1	Input mode

(3) Port 3 mode control register (PMC3)

After reset: 00H R/W Address: FFFFF446H

	7	6	5	4	3	2	1	0
PMC3	PMC37	PMC36	PMC35	PMC34	PMC33	PMC32	PMC31	PMC30

PMC37	Specification of P37 pin operation mode
0	I/O port
1	RXDC3 input/SDA00 I/O/CRXD input[Note]/$\overline{\text{UDMAAK0}}$ output

PMC36	Specification of P36 pin operation mode
0	I/O port
1	TXDC3 output/SCL00 I/O/CTXD0 output[Note]/$\overline{\text{UDMARQ0}}$ input

PMC35	Specification of P35 pin operation mode
0	I/O port
1	TIAA11 input/TOAA11 output/RTC1HZ output

PMC34	Specification of P34 pin operation mode
0	I/O port
1	TIAA10 input/TOAA10 output/TOAA1OFF input/INTP09 input

PMC33	Specification of P33 pin operation mode
0	I/O port
1	TIAA01 input/TOAA01 output/RTCDIV output/RTCCL output

PMC32	Specification of P32 pin operation mode
0	I/O port
1	ASCKA0 input/$\overline{\text{SCKF4}}$ I/O/TIAA00 input/TOAA00 output

PMC31	Specification of P31 pin operation mode
0	I/O port
1	RXDC0 input/SIF4 input/INTP08 input

PMC30	Specification of P30 pin operation mode
0	I/O port
1	TXDC0 output/SOF4 output/INTP07 input

Note μPD70F3770, 70F3771 only

(4) Port 3 function control register (PFC3)

After reset: 00H R/W Address: FFFFF466H

	7	6	5	4	3	2	1	0
PFC3	PFC37	PFC36	PFC35	PFC34	PFC33	PFC32	PFC31	PFC30

Remark For details of alternate function specification, see **4.3.4 (6) Port 3 alternate function specifications**.

(5) Port 3 function control expansion register (PFCE3)

After reset: 00H R/W Address: FFFFF706H

	7	6	5	4	3	2	1	0
PFCE3	PFCE37	PFCE36	PFCE35	PFCE34	PFCE33	PFCE32	PFCE31	PFCE30

Remark For details of alternate function specification, see **4.3.4 (6) Port 3 alternate function specifications**.

(6) Port 3 alternate function specifications

PFCE37	PFC37	Specification of P37 pin alternate function
0	0	RXDC3 input
0	1	SDA00 I/O
1	0	CRXD0 input[Note]
1	1	$\overline{\text{UDMAAK0}}$ output

Note μPD70F3770, 70F3771 only

PFCE36	PFC36	Specification of P36 pin alternate function
0	0	TXDC3 output
0	1	SCL00 I/O
1	0	CTXD0 output[Note]
1	1	$\overline{\text{UDMARQ0}}$ input

Note μPD70F3770, 70F3771 only

PFCE35	PFC35	Specification of P35 pin alternate function
0	0	TIAA11 input
0	1	TOAA11 output
1	0	RTC1HZ output
1	1	Setting prohibited

PFCE34	PFC34	Specification of P34 pin alternate function
0	0	TIAA10 input
0	1	TOAA10 output
1	0	TOAA1OFF input/INTP09 input[Note]
1	1	Setting prohibited

Note TOAA1OFF and INTP09 are alternate functions. When using the pin as the TOAA1OFF pin, disable INTP09 pin edge detection, which is the alternate function. Also, when using the pin as the INTP09 pin, stop the high-impedance output controller.

PFCE33	PFC33	Specification of P33 pin alternate function
0	0	TIAA01 iput
0	1	TOAA01 output
1	0	RTCDIV output
1	1	RTCCL output

PFCE32	PFC32	Specification of P32 pin alternate function
0	0	ASCKC0 input
0	1	$\overline{\text{SCKF4}}$ I/O
1	0	TIAA00 input
1	1	TOAA00 output

PFCE31	PFC31	Specification of P31 pin alternate function
0	0	RXDC0 input
0	1	SIF4 input
1	0	INTP08 input
1	1	Setting prohibited

PFCE30	PFC30	Specification of P30 pin alternate function
0	0	TXDC0 output
0	1	SOF4 output
1	0	INTP07 input
1	1	Setting prohibited

(7) Port 3 function register (PF3)

After reset: 00H R/W Address: FFFFFC66H

	7	6	5	4	3	2	1	0
PF3	PF37	PF36	PF35	PF34	PF33	PF32	PF31	PF30

PF3n	Control of normal output or N-ch open-drain output (n = 0 to 7)
0	Normal output (CMOS output)
1	N-ch open-drain output

4.3.5 Port 4

Port 4 is a 3-bit port that controls I/O in 1-bit units.

Port 4 includes the following alternate-function pins.

Table 4-10. Port 4 Alternate-Function Pins

Pin Name	Pin No.		Alternate-Function Pin Name	I/O	Remark
	V850ES/JG3-H	V850ES/JH3-H			
P40	22	29	SIF0/TXDC4/SDA01	I/O	Selectable as N-ch open-drain output
P41	23	30	SOF0/RXDC4/SCL01	I/O	
P42	24	31	$\overline{\text{SCKF0}}$/INTP10	I/O	

Caution The P40 to P42 pins have hysteresis characteristics in the input mode of the alternate-function pin, but do not have the hysteresis characteristics in the port mode.

(1) Port 4 register (P4)

After reset: 00H (output latch) R/W Address: FFFFF408H

	7	6	5	4	3	2	1	0
P4	0	0	0	0	0	P42	P41	P40

P4n	Output data control (in output mode) (n = 0 to 2)
0	Outputs 0.
1	Outputs 1.

(2) Port 4 mode register (PM4)

After reset: FFH R/W Address: FFFFF428H

	7	6	5	4	3	2	1	0
PM4	1	1	1	1	1	PM42	PM41	PM40

PM4n	I/O mode control (n = 0 to 2)
0	Output mode
1	Input mode

(3) Port 4 mode control register (PMC4)

After reset: 00H R/W Address: FFFFF448H

	7	6	5	4	3	2	1	0
PMC4	0	0	0	0	0	PMC42	PMC41	PMC40

PMC42	Specification of P42 pin operation mode
0	I/O port
1	$\overline{\text{SCKF0}}$ I/O/INTP10 input

PMC41	Specification of P41 pin operation mode
0	I/O port
1	SOF0 output/RXDC4 input/SCL01 I/O

PMC40	Specification of P40 pin operation mode
0	I/O port
1	SIF0 input/TXDC4 output/SDA01 I/O

(4) Port 4 function control register (PFC4)

After reset: 00H R/W Address: FFFFF468H

	7	6	5	4	3	2	1	0
PFC4	0	0	0	0	0	PFC42	PFC41	PFC40

Remark For details of alternate function specification, see **4.3.5 (6) Port 4 alternate function specifications**.

(5) Port 4 function control expansion register (PFCE4)

After reset: 00H R/W Address: FFFFF708H

	7	6	5	4	3	2	1	0
PFCE4	0	0	0	0	0	0	PFCE41	PFCE40

Remark For details of alternate function specification, see **4.3.5 (6) Port 4 alternate function specifications**.

(6) Port 4 alternate function specifications

PFC42	Specification of P42 pin alternate function
0	$\overline{\text{SCKF0}}$ I/O
1	INTP10 input

PFCE41	PFC41	Specification of P41 pin alternate function
0	0	SOF0 output
0	1	RXDC4 input
1	0	SCL01 I/O
1	1	Setting prohibited

PFCE40	PFC40	Specification of P40 pin alternate function
0	0	SIF0 input
0	1	TXDC4 output
1	0	SDA01 I/O
1	1	Setting prohibited

(7) Port 4 function register (PF4)

After reset: 00H R/W Address: FFFFFC68H

	7	6	5	4	3	2	1	0
PF4	0	0	0	0	0	PF42	PF41	PF40

PF4n	Control of normal output or N-ch open-drain output (n = 0 to 2)
0	Normal output (CMOS output)
1	N-ch open-drain output

4.3.6 Port 5

Port 5 is 6-bit (V850ES/JG3-H)/2-bit (V850ES/JH3-H) port that controls I/O in 1-bit units.

Port 5 includes the following alternate-function pins.

Table 4-11. Port 5 Alternate-Function Pins

Pin Name	Pin No.		Alternate-Function Pin Name	I/O	Remark
	V850ES/JG3-H	V850ES/JH3-H			
P50	35	47	TIAB01/KR0/TOAB01/RTP00/$\overline{\text{UDMARQ1}}$	I/O	Selectable as N-ch open-drain output
P51	36	48	TIAB02/KR1/TOAB02/RTP01/$\overline{\text{UDMAAK1}}$	I/O	
P52	37	–	TIAB03/KR2/TOAB13/RTP02/DDI[Note]	I/O	
P53	38	–	SIF2/TIAB00/KR3/TOAB10/RTP03/DDO[Note]	I/O	
P54	39	–	SOF2/KR4/RTP04/DCK[Note]	I/O	
P55	40	–	SCKF2/KR5/RTP05/DMS[Note]	I/O	
P56	41	–	INTP05/$\overline{\text{DRST}}$[Note]	Input	

Note The DDI, DDO, DCK, DMS, and $\overline{\text{DRST}}$ pins are used for on-chip debugging.
If on-chip debugging is not used, fix the P05/INTP02/$\overline{\text{DRST}}$ pin to low level between when the reset by the $\overline{\text{RESET}}$ pin is released and when the OCDM.OCDM0 bit is cleared (0).
For details, see **4.5.3 Cautions on on-chip debug pins**.

Cautions 1. When the power is turned on, the P53 pin may output an undefined level temporarily even during reset.

2. The P50 to P56 pins have hysteresis characteristics in the input mode of the alternate-function pin, but do not have the hysteresis characteristics in the port mode.

(1) Port 5 register (P5)

(a) V850ES/JG3-H

After reset: 00H (output latch) R/W Address: FFFFF40AH

	7	6	5	4	3	2	1	0
P5	0	P56	P55	P54	P53	P52	P51	P50

P5n	Output data control (in output mode) (n = 0 to 6)
0	Outputs 0.
1	Outputs 1.

(b) V850ES/JH3-H

After reset: 00H (output latch) R/W Address: FFFFF40AH

	7	6	5	4	3	2	1	0
P5	0	0	0	0	0	0	P51	P50

P5n	Output data control (in output mode) (n = 0, 1)
0	Outputs 0.
1	Outputs 1.

(2) Port 5 mode register (PM5)

(a) V850ES/JG3-H

After reset: FFH R/W Address: FFFFF42AH

	7	6	5	4	3	2	1	0
PM5	1	PM56	PM55	PM54	PM53	PM52	PM51	PM50

PM5n	I/O mode control (n = 0 to 6)
0	Output mode
1	Input mode

(b) V850ES/JH3-H

After reset: FFH R/W Address: FFFFF42AH

	7	6	5	4	3	2	1	0
PM5	1	1	1	1	1	1	PM51	PM50

PM5n	I/O mode control (n = 0, 1)
0	Output mode
1	Input mode

(3) Port 5 mode control register (PMC5)

(a) V850ES/JG3-H

After reset: 00H R/W Address: FFFFF44AH

	7	6	5	4	3	2	1	0
PMC5	0	PMC56	PMC55	PMC54	PMC53	PMC52	PMC51	PMC50

PMC56	Specification of P56 pin operation mode
0	I/O port
1	INTP05 input

PMC55	Specification of P55 pin operation mode
0	I/O port
1	$\overline{\text{SCKF2}}$ I/O/KR5 input/RTP05 output

PMC54	Specification of P54 pin operation mode
0	I/O port
1	SOF2 output/KR4 input/RTP04 output

PMC53	Specification of P53 pin operation mode
0	I/O port
1	SIF2 input/KR3 input/TIAB00 input/TOAB00 output/RTP03 output

PMC52	Specification of P52 pin operation mode
0	I/O port
1	TIAB03 input/KR2 input/TOAB03 output/RTP02 output

PMC51	Specification of P51 pin operation mode
0	I/O port
1	TIAB02 input/KR1 input/TOAB02 output/RTP01 output/$\overline{\text{UDMAAK1}}$ output

PMC50	Specification of P50 pin operation mode
0	I/O port
1	TIAB01 input/KR0 input/TOAB01 output/RTP00 output/$\overline{\text{UDMARQ1}}$ input

(b) V850ES/JH3-H

After reset: 00H R/W Address: FFFFF44AH

	7	6	5	4	3	2	1	0
PMC5	0	0	0	0	0	0	PMC51	PMC50

PMC51	Specification of P51 pin operation mode
0	I/O port
1	TIAB02 input/KR1 input/TOAB02 output/RTP01 output/$\overline{\text{UDMAAK1}}$ output

PMC50	Specification of P50 pin operation mode
0	I/O port
1	TIAB01 input/KR0 input/TOAB01 output/RTP00 output/$\overline{\text{UDMARQ1}}$ input

(4) Port 5 function control register (PFC5)

(a) V850ES/JG3-H

After reset: 00H R/W Address: FFFFF46AH

	7	6	5	4	3	2	1	0
PFC5	0	0	PFC55	PFC54	PFC53	PFC52	PFC51	PFC50

(b) V850ES/JH3-H

After reset: 00H R/W Address: FFFFF46AH

	7	6	5	4	3	2	1	0
PFC5	0	0	0	0	0	0	PFC51	PFC50

Remark For details of alternate function specification, see **4.3.6 (6) Port 5 alternate function specifications**.

(5) Port 5 function control expansion register (PFCE5)

(a) V850ES/JG3-H

After reset: 00H R/W Address: FFFFF70AH

	7	6	5	4	3	2	1	0
PFCE5	0	0	PFCE55	PFCE54	PFCE53	PFCE52	PFCE51	PFCE50

(b) V850ES/JH3-H

After reset: 00H R/W Address: FFFFF70AH

	7	6	5	4	3	2	1	0
PFCE5	0	0	0	0	0	0	PFCE51	PFCE50

Remark For details of alternate function specification, see **4.3.6 (6) Port 5 alternate function specifications**.

(6) Port 5 alternate function specifications

PFCE55[Note 1]	PFC55[Note 1]	Specification of P55 pin alternate function[Note 1]
0	0	$\overline{\text{SCKF2}}$ I/O
0	1	KR5 input
1	0	RTP05 output
1	1	Setting prohibited

PFCE54[Note 1]	PFC54[Note 1]	Specification of P54 pin alternate function[Note 1]
0	0	SOF2 output
0	1	KR4 input
1	0	RTP04 output
1	1	Setting prohibited

PFCE53[Note 1]	PFC53[Note 1]	Specification of P53 pin alternate function[Note 1]
0	0	SIF2 input
0	1	TIAB00 input/KR3[Note 2] input
1	0	TOAB00 output
1	1	RTP03 output

PFCE52[Note1]	PFC52[Note1]	Specification of P52 pin alternate function[Note 1]
0	0	TIAB03 input/KR2[Note 2] input
0	1	TOAB03 output
1	0	RTP02 output
1	1	Setting prohibited

PFCE51	PFC51	Specification of P51 pin alternate function
0	0	TIAB02 input/KR1[Note 2] input
0	1	TOAB02 output
1	0	RTP01 output
1	1	$\overline{\text{UDMAAK1}}$ output

PFCE50	PFC50	Specification of P50 pin alternate function
0	0	TIAB01 input/KR0[Note 2] input
0	1	TOAB01 output
1	0	RTP00 output
1	1	$\overline{\text{UDMARQ1}}$ input

Notes 1. V850ES/JG3-H only

2. KRn and TIAB0m are alternate functions. When using the pin as the TIAB0m pin, disable KRn pin key return detection, which is the alternate function (clear the KRM.KRMn bit to 0). Also, when using the pin as the KRn pin, disable TIAB0m pin edge detection, which is the alternate function (n = 0 to 3, m = 0 to 3).

Pin Name	Use as TIAB0m Pin	Using as KRn Pin
KR0/TIAB01	KRM.KRM0 bit = 0	TAB0IOC1.TAB0TIG2, TAB0TIG3 bits = 0
KR1/TIAB02	KRM.KRM1 bit = 0	TAB0IOC1.TAB0TIG4, TAB0TIG5 bits = 0
KR2/TIAB03	KRM.KRM2 bit = 0	TAB0IOC1.TAB0TIG6, TAB0TIG7 bits = 0
KR3/TIAB00	KRM.KRM3 bit = 0	TAB0IOC1.TAB0TIG0, TAB0TIG1 bits = 0 TAB0IOC2.TAB0EES0, TAB0EES1 bits = 0 TAB0IOC2.TAB0ETS0, TAB0ETS1 bits = 0

(7) Port 5 function register (PF5)

(a) V850ES/JG3-H

After reset: 00H R/W Address: FFFFFC6AH

	7	6	5	4	3	2	1	0
PF5	0	PF56	PF55	PF54	PF53	PF52	PF51	PF50

PF5n	Control of normal output or N-ch open-drain output (n = 0 to 6)
0	Normal output (CMOS output)
1	N-ch open-drain output

(b) V850ES/JH3-H

After reset: 00H R/W Address: FFFFFC6AH

	7	6	5	4	3	2	1	0
PF5	0	0	0	0	0	0	PF51	PF50

PF5n	Control of normal output or N-ch open-drain output (n = 0, 1)
0	Normal output (CMOS output)
1	N-ch open-drain output

4.3.7 Port 6

Port 6 is a 6-bit port for which I/O settings can be controlled in 1-bit units.

Port 6 includes the following alternate-function pins.

Table 4-12. Port 6 Alternate-Function Pins

Pin Name	Pin No.		Alternate-Function Pin Name	I/O	Remark
	V850ES/JG3-H	V850ES/JH3-H			
P60	65	90	TOAB1T1/TOAB11/TIAB11 /$\overline{\text{WAIT}}$Note	I/O	–
P61	66	91	TOAB1B1/TOAB10/TIAB10 /$\overline{\text{RD}}$Note	I/O	
P62	67	92	TOAB1T2/TOAB12/TIAB12 /ASTBNote	I/O	
P63	68	93	TOAB1B2/TRGAB1/$\overline{\text{CS0}}$Note	I/O	
P64	69	94	TOAB1T3/TOAB13/TIAB13 /$\overline{\text{CS2}}$Note	I/O	
P65	70	95	TOAB1B3/EVTAB1/$\overline{\text{CS3}}$Note	I/O	

Note V850ES/JG3-H only

Caution The P60 to P65 pins have hysteresis characteristics in the input mode of the alternate-function pin, but do not have the hysteresis characteristics in the port mode.

(1) Port 6 register (P6)

After reset: 00H (output latch) R/W Address: FFFFF40CH

	7	6	5	4	3	2	1	0
P6	0	0	P65	P64	P63	P62	P61	P60

P6n	Output data control (in output mode) (n = 0 to 5)
0	Outputs 0.
1	Outputs 1.

(2) Port 6 mode register (PM6)

After reset: FFH R/W Address: FFFFF42CH

	7	6	5	4	3	2	1	0
PM6	1	1	PM65	PM64	PM63	PM62	PM61	PM60

PM6n	Output data control (in output mode) (n = 0 to 5)
0	Output mode
1	Input mode

(3) Port 6 mode control register (PMC6)

After reset: 00H R/W Address: FFFFF44CH

	7	6	5	4	3	2	1	0
PMC6	0	0	PMC65	PMC64	PMC63	PMC62	PMC61	PMC60

PMC65	Specification of P65 pin operation mode
0	I/O port
1	TOAB1B3 output/EVTAB1 input/$\overline{CS3}$ output[Note]

PMC64	Specification of P64 pin operation mode
0	I/O port
1	TOAB1T3 output/TOAB13 output/TIAB13 input/$\overline{CS2}$ output[Note]

PMC63	Specification of P63 pin operation mode
0	I/O port
1	TOAB1B2 output/TRGAB1 input/$\overline{CS0}$ output[Note]

PMC62	Specification of P62 pin operation mode
0	I/O port
1	TOAB1T2 output/TOAB12 output/TIAB12 output/ASTB output[Note]

PMC61	Specification of P61 pin operation mode
0	I/O port
1	TOAB1B1 output/TIAB10 input/TOAB10 output/$\overline{RD}$ output[Note]

PMC60	Specification of P60 pin operation mode
0	I/O port
1	TOAB1T1 output/TOAB11 output/TIAB11 input/$\overline{WAIT}$ output[Note]

Note V850ES/JG3-H only

(4) Port 6 function control register (PFC6)

After reset: 00H R/W Address: FFFFF46CH

	7	6	5	4	3	2	1	0
PFC6	0	0	PFC65	PFC64	PFC63	PFC62	PFC61	PFC60

Remark For details of alternate function specification, see **4.3.7 (6) Port 6 alternate function specifications**.

(5) Port 6 function control expansion register (PFCE6)

(a) V850ES/JG3-H

After reset: 00H R/W Address: FFFFF70CH

	7	6	5	4	3	2	1	0
PFCE6	0	0	PFCE65	PFCE64	PFCE63	PFCE62	PFCE61	PFCE60

(b) V850ES/JH3-H

After reset: 00H R/W Address: FFFFF70CH

	7	6	5	4	3	2	1	0
PFCE6	0	0	0	0	0	0	PFCE61	0

Remark For details of alternate function specification, see **4.3.7 (6) Port 6 alternate function specifications**.

(6) Port 6 alternate function specifications

PFCE65[Note]	PFC65	Specification of P65 pin alternate function
0	0	TOAB1B3 output
0	1	EVTAB1 input
1	0	$\overline{CS3}$ output[Note]
1	1	Setting prohibited[Note]

PFCE64[Note]	PFC64	Specification of P64 pin alternate function
0	0	TOAB1T3 output/TOAB13 output
0	1	TIAB13 input
1	0	$\overline{CS2}$ output[Note]
1	1	Setting prohibited[Note]

PFCE63[Note]	PFC63	Specification of P63 pin alternate function
0	0	TOAB1B2 output
0	1	TRGAB1 input
1	0	$\overline{CS0}$ output[Note]
1	1	Setting prohibited[Note]

PFCE62[Note]	PFC62	Specification of P62 pin alternate function
0	0	TOAB1T2 output/TOAB12 output
0	1	TIAB12 input
1	0	ASTB output[Note]
1	1	Setting prohibited[Note]

PFCE61	PFC61	Specification of P61 pin alternate function
0	0	TOAB1B1 output
0	1	TIAB10 input
1	0	TOAB10 output
1	1	$\overline{RD}$ output (V850ES/JG3-H) Setting prohibited (V850ES/JH3-H)

PFCE60[Note]	PFC60	Specification of P60 pin alternate function
0	0	TOAB1T1 output/TOAB11 output
0	1	TIAB11 input
1	0	$\overline{WAIT}$ output[Note]
1	1	Setting prohibited[Note]

Note V850ES/JG3-H only

4.3.8 Port 7

Port 7 is a 12-bit port for which I/O settings can be controlled in 1-bit units.

Port 7 includes the following alternate-function pins.

Table 4-13. Port 7 Alternate-Function Pins

Pin Name	Pin No.		Alternate-Function Pin Name	I/O	Remark
	V850ES/JG3-H	V850ES/JH3-H			
P70	100	128	ANI0	Input	–
P71	99	127	ANI1	Input	
P72	98	126	ANI2	Input	
P73	97	125	ANI3	Input	
P74	96	124	ANI4	Input	
P77	95	123	ANI5	Input	
P76	94	122	ANI6	Input	
P77	93	121	ANI7	Input	
P78	92	120	ANI8	Input	
P79	91	119	ANI9	Input	
P710	90	118	ANI10	Input	
P711	89	117	ANI11	Input	

(1) Port 7 register H, port 7 register L (P7H, P7L)

After reset: 00H (output latch) R/W Address: P7L FFFFF40EH, P7H FFFFF40FH

	7	6	5	4	3	2	1	0
P7H	0	0	0	0	P711	P710	P79	P78

	7	6	5	4	3	2	1	0
P7L	P77	P76	P75	P74	P73	P72	P71	P70

P7n	Output data control (in output mode) (n = 0 to 11)
0	Outputs 0.
1	Outputs 1.

Caution Do not read or write the P7H and P7L registers during A/D conversion (see 15.6 (4) Alternate I/O).

Remark These registers cannot be accessed in 16-bit units as the P7 register. They can be read or written in 8-bit or 1-bit units as the P7H and P7L registers.

(2) Port 7 mode register H, port 7 mode register L (PM7H, PM7L)

After reset: FFH R/W Address: PM7L FFFFF42EH, PM7H FFFFF42FH

	7	6	5	4	3	2	1	0
PM7H	1	1	1	1	PM711	PM710	PM79	PM78
PM7L	PM77	PM76	PM75	PM74	PM73	PM72	PM71	PM70

PM7n	I/O mode control (n = 0 to 11)
0	Output mode
1	Input mode

Caution When using the P7n pin as its alternate function (ANIn pin), set the PM7n bit to 1.

Remark These registers cannot be accessed in 16-bit units as the PM7 register. They can be read or written in 8-bit or 1-bit units as the PM7H and PM7L registers.

4.3.9 Port 9

Port 9 is a 16-bit port for which I/O settings can be controlled in 1-bit units.

Port 9 includes the following alternate-function pins.

Table 4-14. Port 9 Alternate-Function Pins

Pin Name	Pin No.		Alternate-Function Pin Name	I/O	Remark
	V850ES/JG3-H	V850ES/JH3-H			
P90	42	54	KR6/TXDC1/SDA02/A0Note	I/O	Selectable as N-ch open-drain output
P91	43	55	KR7/RXDC1/SCL02/A1Note	I/O	
P92	44	56	TENC01/TIT01/TOT01/A2Note	I/O	–
P93	45	57	TECR0/TIT00/TOT00/A3Note	I/O	
P94	46	58	TIAA31/TOAA31/TENC00 /EVTT0/A4Note	I/O	
P95	47	59	TIAA30/TOAA30/A5Note	I/O	
P96	48	62	TIAA21/TOAA21/INTP11/A6Note	I/O	
P97	49	63	SIF1/TIAA20/TOAA20/A7Note	I/O	
P98	50	64	SOF1/INTP12/A8Note	I/O	
P99	51	65	$\overline{\text{SCKF1}}$/INTP13/A9Note	I/O	
P910	52	66	SIF3/TXDC2/INTP14/A10Note	I/O	
P911	53	67	SOF3/RXDC2/INTP15/A11Note	I/O	
P912	54	68	$\overline{\text{SCKF3}}$/A12Note	I/O	
P913	55	69	TOAB1OFF/INTP16/A13Note	I/O	
P914	56	70	TIAA51/TOAA51/INTP17/A14Note	I/O	
P915	57	71	TIAA50/TOAA50/INTP18/A15Note	I/O	

Note V850ES/JH3-H only

Caution The P90 to P915 pins have hysteresis characteristics in the input mode of the alternate-function pin, but do not have the hysteresis characteristics in the port mode.

(1) Port 9 register (P9)

After reset: 0000H (output latch) R/W Address: P9 FFFFF412H,
P9L FFFFF412H, P9H FFFFF413H

	15	14	13	12	11	10	9	8
P9 (P9H)	P915	P914	P913	P912	P911	P910	P99	P98

	7	6	5	4	3	2	1	0
(P9L)	P97	P96	P95	P94	P93	P92	P91	P90

P9n	Output data control (in output mode) (n = 0 to 15)
0	Outputs 0.
1	Outputs 1.

Remarks 1. The P9 register can be read or written in 16-bit units.
However, when using the higher 8 bits of the P9 register as the P9H register and the lower 8 bits as the P9L register, they can be read or written in 8-bit or 1-bit units.

2. To read/write bits 8 to 15 of the P9 register in 8-bit or 1-bit units, specify them as bits 0 to 7 of the P9H register.

(2) Port 9 mode register (PM9)

After reset: FFFFH R/W Address: PM9 FFFFF432H,
PM9L FFFFF432H, PM9H FFFFF433H

	15	14	13	12	11	10	9	8
PM9 (PM9H)	PM915	PM914	PM913	PM912	PM911	PM910	PM99	PM98

	7	6	5	4	3	2	1	0
(PM9L)	PM97	PM96	PM95	PM94	PM93	PM92	PM91	PM90

PM9n	I/O mode control (in output mode) (n = 0 to 15)
0	Output mode
1	Input mode

Remarks 1. The PM9 register can be read or written in 16-bit units.
However, when using the higher 8 bits of the PM9 register as the PM9H register and the lower 8 bits as the PM9L register, they can be read or written in 8-bit and 1-bit units.

2. To read/write bits 8 to 15 of the PM9 register in 8-bit or 1-bit units, specify them as bits 0 to 7 of the PM9H register.

(3) Port 9 mode control register (PMC9)

After reset: 0000H R/W Address: PMC9 FFFFF452H,
PMC9L FFFFF452H, PMC9H FFFFF453H

	15	14	13	12	11	10	9	8
PMC9 (PMC9H)	PMC915	PMC914	PMC913	PMC912	PMC911	PMC910	PMC99	PMC98

	7	6	5	4	3	2	1	0
(PMC9L)	PMC97	PMC96	PMC95	PMC94	PMC93	PMC92	PMC91	PMC90

PMC915	Specification of P915 pin operation mode
0	I/O port
1	TIAA50 input/TOAA50 output/INTP18 input/A15 output[Note]

PMC914	Specification of P914 pin operation mode
0	I/O port
1	TIAA51 input/TOAA51 output/INTP17 input/A14 output[Note]

PMC913	Specification of P913 pin operation mode
0	I/O port
1	TOAB1OFF input/INTP16 input/A13 output[Note]

PMC912	Specification of P912 pin operation mode
0	I/O port
1	$\overline{\text{SCKF3}}$ I/O/A12 output[Note]

PMC911	Specification of P911 pin operation mode
0	I/O port
1	SOF3 output/RXDC2 input/INTP15 input/A11 output[Note]

PMC910	Specification of P910 pin operation mode
0	I/O port
1	SIF3 input/TXDC2 output/INTP14 input/A10 output[Note]

PMC99	Specification of P99 pin operation mode
0	I/O port
1	$\overline{\text{SCKF1}}$ I/O/INTP13 input/A9 output[Note]

PMC98	Specification of P98 pin operation mode
0	I/O port
1	SOF1 output/INTP12 input/A8 output[Note]

Note V850ES/JH3-H only

Remarks 1. The PMC9 register can be read or written in 16-bit units.
However, when using the higher 8 bits of the PMC9 register as the PMC9H register and the lower 8 bits as the PMC9L register, they can be read or written in 8-bit or 1-bit units.

2. To read/write bits 8 to 15 of the PMC9 register in 8-bit or 1-bit units, specify them as bits 0 to 7 of the PMC9H register.

(2/2)

PMC97	Specification of P97 pin operation mode
0	I/O port
1	SIF1 input/TIAA20 input/TOAA20 output/A7 output[Note]

PMC96	Specification of P96 pin operation mode
0	I/O port
1	TIAA21 input/TOAA21 output/INTP11 input/A6 output[Note]

PMC95	Specification of P95 pin operation mode
0	I/O port
1	TIAA30 input/TOAA30 output/A5 output[Note]

PMC94	Specification of P94 pin operation mode
0	I/O port
1	TIAA31 input/TOAA31 output/TENC00 input/EVTT0 input/A4 output[Note]

PMC93	Specification of P93 pin operation mode
0	I/O port
1	TECR0 input/TIT00 input/TOT00 output/A3 output[Note]

PMC92	Specification of P92 pin operation mode
0	I/O port
1	TENC01 input/TIT01 input/TOT01 output/A2 output[Note]

PMC91	Specification of P91 pin operation mode
0	I/O port
1	KR7 input/RXDC1 input/SCL02 I/O/A1 output[Note]

PMC90	Specification of P90 pin operation mode
0	I/O port
1	KR6 input/TXDC1 output/SDA02 I/O/A0 output[Note]

Note V850ES/JH3-H only

Caution When using the A0 to A15 pins as the alternate functions of the P90 to P915 pins, be sure to set all 16 bits of the PMC9 register to FFFFH at once (V850ES/JH3-H only).

(4) Port 9 function control register (PFC9)

Caution When performing separate address bus output (A0 to A15), set the PMC9 register to FFFFH for all 16 bits at once after setting the PFC9 register to the FCDFH and PFCE9 register to CFFFH (V850ES/JH3-H only).

(a) V850ES/JG3-H

After reset: 0000H R/W Address: PFC9 FFFFF472H,
PFC9L FFFFF472H, PFC9H FFFFF473H

	15	14	13	12	11	10	9	8
PFC9 (PFC9H)	PFC915	PFC914	0	0	PFC911	PFC910	PFC99	PFC98

	7	6	5	4	3	2	1	0
(PFC9L)	PFC97	PFC96	PFC95	PFC94	PFC93	PFC92	PFC91	PFC90

(b) V850ES/JH3-H

After reset: 0000H R/W Address: PFC9 FFFFF472H,
PFC9L FFFFF472H, PFC9H FFFFF473H

	15	14	13	12	11	10	9	8
PFC9 (PFC9H)	PFC915	PFC914	PFC913	PFC912	PFC911	PFC910	PFC99	PFC98

	7	6	5	4	3	2	1	0
(PFC9L)	PFC97	PFC96	PFC95	PFC94	PFC93	PFC92	PFC91	PFC90

Remarks 1. For details of alternate function specification, see **4.3.9 (6) Port 9 alternate function specifications**.

2. The PFC9 register can be read or written in 16-bit units.
However, when using the higher 8 bits of the PFC9 register as the PFC9H register and the lower 8 bits as the PFC9L register, they can be read or written in 8-bit or 1-bit units.

3. To read/write bits 8 to 15 of the PFC9 register in 8-bit or 1-bit units, specify them as bits 0 to 7 of the PFC9H register.

(5) Port 9 function control expansion register (PFCE9)

Caution When performing separate address bus output (A0 to A15), set the PMC9 register to FFFFH for all 16 bits at once after setting the PFC9 register to FCDFH and the PFCE9 register to CFFFH (V850ES/JH3-H only).

(a) V850ES/JG3-H

After reset: 0000H R/W Address: PFCE9 FFFFF712H,
PFCE9L FFFFF712H, PFCE9H FFFFF713H

	15	14	13	12	11	10	9	8
PFCE9 (PFCE9H)	PFCE915	PFCE914	0	0	PFCE911	PFCE910	0	0

	7	6	5	4	3	2	1	0
(PFCE9L)	PFCE97	PFCE96	0	PFCE94	PFCE93	PFCE92	PFCE91	PFCE90

(b) V850ES/JH3-H

After reset: 0000H R/W Address: PFCE9 FFFFF712H,
PFCE9L FFFFF712H, PFCE9H FFFFF713H

	15	14	13	12	11	10	9	8
PFCE9 (PFCE9H)	PFCE915	PFCE914	0	0	PFCE911	PFCE910	PFCE99	PFCE98

	7	6	5	4	3	2	1	0
(PFCE9L)	PFCE97	PFCE96	PFCE95	PFCE94	PFCE93	PFCE92	PFCE91	PFCE90

Remarks 1. For details of alternate function specification, see **4.3.9 (6) Port 9 alternate function specifications**.

2. The PFCE9 register can be read or written in 16-bit units.
However, when using the higher 8 bits of the PFCE9 register as the PFCE9H register and the lower 8 bits as the PFCE9L register, they can be read or written in 8-bit or 1-bit units.

3. To read/write bits 8 to 15 of the PFCE9 register in 8-bit or 1-bit units, specify them as bits 0 to 7 of the PFCE9H register.

(6) Port 9 alternate function specifications

PFCE915	PFC915	Specification of P915 pin alternate function
0	0	TIAA50 input
0	1	TOAA50 output
1	0	INTP18 input
1	1	Setting prohibited (V850ES/JG3-H) A15 output (V850ES/JH3-H)

PFCE914	PFC914	Specification of P914 pin alternate function
0	0	TIAA51 input
0	1	TOAA51 output
1	0	INTP17 input
1	1	Setting prohibited (V850ES/JG3-H) A14 output (V850ES/JH3-H)

PFC913Note	Specification of P913 pin alternate function
0	TOAB1OFF input/INTP16 input
1	A13 outputNote

PFC912Note	Specification of P912 pin alternate function
0	$\overline{\text{SCKF3}}$ I/O
1	A12 outputNote

PFCE911	PFC911	Specification of P911 pin alternate function
0	0	SOF3 output
0	1	RXDC2 input
1	0	INTP15 input
1	1	Setting prohibited (V850ES/JG3-H) A11 output (V850ES/JH3-H)

PFCE910	PFC910	Specification of P910 pin alternate function
0	0	SIF3 input
0	1	TXDC2 output
1	0	INTP14 input
1	1	Setting prohibited (V850ES/JG3-H) A10 output (V850ES/JH3-H)

PFCE99Note	PFC99	Specification of P99 pin alternate function
0	0	$\overline{\text{SCKF1}}$ I/O
0	1	INTP13 input
1	0	A9 outputNote
1	1	Setting prohibitedNote

PFCE98[Note]	PFC98	Specification of P98 pin alternate function
0	0	SOF1 output
0	1	INTP12 input
1	0	A8 output[Note]
1	1	Setting prohibited[Note]

PFCE97	PFC97	Specification of P97 pin alternate function
0	0	SIF1 input
0	1	TIAA20 input
1	0	TOAA20 output
1	1	Setting prohibited (V850ES/JG3-H) A7 output (V850ES/JH3-H)

PFCE96	PFC96	Specification of P96 pin alternate function
0	0	TIAA21 input
0	1	TOAA21 output
1	0	INTP11 input
1	1	Setting prohibited (V850ES/JG3-H) A6 output (V850ES/JH3-H)

PFCE95[Note]	PFC95	Specification of P95 pin alternate function
0	0	TIAA30 input
0	1	TOAA30 output
1	0	A5 output[Note]
1	1	Setting prohibited[Note]

PFCE94	PFC94	Specification of P94 pin alternate function
0	0	TIAA31 input
0	1	TOAA31 output
1	0	TENC00 input/EVTT0 input
1	1	Setting prohibited (V850ES/JG3-H) A4 output (V850ES/JH3-H)

PFCE93	PFC93	Specification of P93 pin alternate function
0	0	TECR0 input
0	1	TIT00 input
1	0	TOT00 output
1	1	Setting prohibited (V850ES/JG3-H) A3 output (V850ES/JH3-H)

PFCE92	PFC92	Specification of P92 pin alternate function
0	0	TENC01 input
0	1	TIT01 input
1	0	TOT01 output
1	1	Setting prohibited (V850ES/JG3-H) A2 output (V850ES/JH3-H)

PFCE91	PFC91	Specification of P91 pin alternate function
0	0	KR7 input
0	1	RXDC1 input
1	0	SCL02 I/O
1	1	Setting prohibited (V850ES/JG3-H) A1 output (V850ES/JH3-H)

PFCE90	PFC90	Specification of P90 pin alternate function
0	0	KR6 input
0	1	TXDC1 output
1	0	SDA02 I/O
1	1	Setting prohibited (V850ES/JG3-H) A0 output (V850ES/JH3-H)

Note V850ES/JH3-H only

(7) Port 9 function register (PF9)

After reset: 0000H R/W Address: PF9 FFFFFC72H,
PF9L FFFFFC72H

	15	14	13	12	11	10	9	8
PF9	0	0	0	0	0	0	0	0

	7	6	5	4	3	2	1	0
(PF9L)	0	0	0	0	0	0	PF91	PF90

PF9n	Control of normal output or N-ch open-drain output (n = 0, 1)
0	Normal output (CMOS output)
1	N-ch open-drain output

Caution When output pins P90, P91 are pulled up to EV_{DD} or higher, be sure to set the PF9n bit to 1.

Remark The PF9 register can be read or written in 16-bit units.
However, when using the higher 8 bits of the PF9 register as the PF9H register and the lower 8 bits as the PF9L register, they can be read or written in 8-bit or 1-bit units.

4.3.10 Port CM

Port CM is 1-bit (V850ES/JG3-H)/4-bit (V850ES/JH3-H) port for which I/O settings can be controlled in 1-bit units.

Port CM includes the following alternate-function pins.

Table 4-15. Port CM Alternate-Function Pins

Pin Name	Pin No.		Alternate-Function Pin Name	I/O	Remark
	V850ES/JG3-H	V850ES/JH3-H			
PCM0	–	89	$\overline{\text{WAIT}}$	Input	–
PCM1	64	86	CLKOUT	Output	
PCM2	–	10	$\overline{\text{HLDAK}}$	Output	
PCM3	–	11	$\overline{\text{HLDRQ}}$	Input	

(1) Port CM register (PCM)

(a) V850ES/JG3-H

After reset: 00H (output latch) R/W Address: FFFFF00CH

	7	6	5	4	3	2	1	0
PCM	0	0	0	0	0	0	PCM1	0

PCM1	Output data control (in output mode)
0	Outputs 0.
1	Outputs 1.

(b) V850ES/JH3-H

After reset: 00H (output latch) R/W Address: FFFFF00CH

	7	6	5	4	3	2	1	0
PCM	0	0	0	0	PCM3	PCM2	PCM1	PCM0

PCMn	Output data control (in output mode) (n = 0 to 3)
0	Outputs 0.
1	Outputs 1.

(2) Port CM mode register (PMCM)

(a) V850ES/JG3-H

After reset: FFH R/W Address: FFFFF02CH

	7	6	5	4	3	2	1	0
PMCM	1	1	1	1	1	1	PMCM1	1

PMCM1	I/O mode control
0	Output mode
1	Input mode

(b) V850ES/JH3-H

After reset: FFH R/W Address: FFFFF02CH

	7	6	5	4	3	2	1	0
PMCM	1	1	1	1	PMCM3	PMCM2	PMCM1	PMCM0

PMCMn	I/O mode control (n = 0 to 3)
0	Output mode
1	Input mode

(3) Port CM mode control register (PMCCM)

(a) V850ES/JG3-H

After reset: 00H R/W Address: FFFFF04CH

	7	6	5	4	3	2	1	0
PMCCM	0	0	0	0	0	0	PMCCM1	0

PMCCM1	Specification of PCM1 pin operation mode
0	I/O port
1	CLKOUT output

(b) V850ES/JH3-H

After reset: 00H R/W Address: FFFFF04CH

	7	6	5	4	3	2	1	0
PMCCM	0	0	0	0	PMCCM3	PMCCM2	PMCCM1	PMCCM0

PMCCM3	Specification of PCM3 pin operation mode
0	I/O port
1	$\overline{\text{HLDRQ}}$ input

PMCCM2	Specification of PCM2 pin operation mode
0	I/O port
1	$\overline{\text{HLDAK}}$ output

PMCCM1	Specification of PCM1 pin operation mode
0	I/O port
1	CLKOUT output

PMCCM0	Specification of PCM0 pin operation mode
0	I/O port
1	$\overline{\text{WAIT}}$ input

4.3.11 Port CS (V850ES/JH3-H only)

Port CS is a 3-bit port for which I/O settings can be controlled in 1-bit units.

Port CS includes the following alternate-function pins.

Table 4-16. Port CM Alternate-Function Pins

Pin Name	Pin No.		Alternate-Function Pin Name	I/O	Remark
	V850ES/JG3-H	V850ES/JH3-H			
PCS0	–	96	$\overline{CS0}$	Output	–
PCS2	–	97	$\overline{CS2}$	Output	
PCS3	–	116	$\overline{CS3}$	Output	

(1) Port CS register (PCS)

After reset: 00H (output latch) R/W Address: FFFFF008H

	7	6	5	4	3	2	1	0
PCS	0	0	0	0	PCS3	PCS2	0	PCS0

PCSn	Output data control (in output mode) (n = 0, 2, 3)
0	Outputs 0.
1	Outputs 1.

(2) Port CS mode register (PMCS)

After reset: FFH R/W Address: FFFFF028H

	7	6	5	4	3	2	1	0
PMCS	1	1	1	1	PMCS3	PMCS2	1	PMCS0

PMCSn	I/O mode control (n = 0, 2, 3)
0	Output mode
1	Input mode

(3) Port CS mode control register (PMCCS)

After reset: 00H R/W Address: FFFFF048H

	7	6	5	4	3	2	1	0
PMCCS	0	0	0	0	PMCCS3	PMCCS2	0	PMCCS0

PMCCS3	Specification of PCS3 pin operation mode
0	I/O port
1	$\overline{CS3}$ output

PMCCS2	Specification of PCS2 pin operation mode
0	I/O port
1	$\overline{CS2}$ output

PMCCS0	Specification of PCS0 pin operation mode
0	I/O port
1	$\overline{CS0}$ output

4.3.12 Port CT

Port CT is a 2-bit (V850ES/JG3-H)/4-bit (V850ES/JH3-H) port for which I/O settings can be controlled in 1-bit units.

Port CT includes the following alternate-function pins.

Table 4-17. Port CT Alternate-Function Pins

Pin Name	Pin No.		Alternate-Function Pin Name	I/O	Remark
	V850ES/JG3-H	V850ES/JH3-H			
PCT0	58	76	$\overline{WR0}$	Output	–
PCT1	59	77	$\overline{WR1}$	Output	
PCT4	–	87	$\overline{RD}$	Output	
PCT6	–	88	ASTB	Output	

(1) Port CT register (PCT)

(a) V850ES/JG3-H

After reset: 00H (output latch) R/W Address: FFFFF00AH

	7	6	5	4	3	2	1	0
PCT	0	0	0	0	0	0	PCT1	PCT0

PCTn	Output data control (in output mode) (n = 0, 1)
0	Outputs 0.
1	Outputs 1.

(b) V850ES/JH3-H

After reset: 00H (output latch) R/W Address: FFFFF00AH

	7	6	5	4	3	2	1	0
PCT	0	PCT6	0	PCT4	0	0	PCT1	PCT0

PCMn	Output data control (in output mode) (n = 0, 1, 4, 6)
0	Outputs 0.
1	Outputs 1.

(2) Port CT mode register (PMCT)

(a) V850ES/JG3-H

After reset: FFH R/W Address: FFFFF02AH

	7	6	5	4	3	2	1	0
PMCT	1	1	1	1	1	1	PMCT1	PMCT0

PMCTn	I/O mode control (n = 0, 1)
0	Output mode
1	Input mode

(b) V850ES/JH3-H

After reset: FFH R/W Address: FFFFF02AH

	7	6	5	4	3	2	1	0
PMCT	1	PMCT6	1	PMCT4	1	1	PMCT1	PMCT0

PMCTn	I/O mode control (n = 0, 1, 4, 6)
0	Output mode
1	Input mode

(3) Port CT mode control register (PMCCT)

(a) V850ES/JG3-H

After reset: 00H R/W Address: FFFFF04AH

	7	6	5	4	3	2	1	0
PMCCT	0	0	0	0	0	0	PMCCT1	PMCCT0

PMCCT1	Specification of PCT1 pin operation mode
0	I/O port
1	$\overline{WR1}$ output

PMCCT0	Specification of PCT0 pin operation mode
0	I/O port
1	$\overline{WR0}$ output

(b) V850ES/JH3-H

After reset: 00H R/W Address: FFFFF04AH

	7	6	5	4	3	2	1	0
PMCCT	0	PMCCT6	0	PMCCT4	0	0	PMCCT1	PMCCT0

PMCCT6	Specification of PCT6 pin operation mode
0	I/O port
1	ASTB output

PMCCT4	Specification of PCT4 pin operation mode
0	I/O port
1	$\overline{RD}$ output

PMCCT1	Specification of PCT1 pin operation mode
0	I/O port
1	$\overline{WR1}$ output

PMCCT0	Specification of PCT0 pin operation mode
0	I/O port
1	$\overline{WR0}$ output

4.3.13 Port DH (V850ES/JH3-H only)

Port DH is an 8-bit port for which I/O settings can be controlled in 1-bit units.

Port DH includes the following alternate-function pins.

Table 4-18. Port DH Alternate-Function Pins

Pin Name	Pin No.		Alternate-Function Pin Name	I/O	Remark
	V850ES/JG3-H	V850ES/JH3-H			
PDH0	–	72	A16	Output	–
PDH1	–	73	A17	Output	
PDH2	–	74	A18	Output	
PDH3	–	75	A19	Output	
PDH4	–	78	A20	Output	
PDH5	–	79	A21	Output	
PDH6	–	80	A22	Output	
PDH7	–	81	A23	Output	

(1) Port DH register (PDH)

After reset: 00H (output latch) R/W Address: FFFFF006H

	7	6	5	4	3	2	1	0
PDH	PDH7	PDH6	PDH5	PDH4	PDH3	PDH2	PDH1	PDH0

PDHn	Output data control (in output mode) (n = 0 to 7)
0	Outputs 0.
1	Outputs 1.

(2) Port DH mode register (PMDH)

After reset: FFH R/W Address: FFFFF026H

	7	6	5	4	3	2	1	0
PMDH	PMDH7	PMDH6	PMDH5	PMDH4	PMDH3	PMDH2	PMDH1	PMDH0

PMDHn	I/O mode control (n = 0, 7)
0	Output mode
1	Input mode

(3) Port DH mode control register (PMCDH)

After reset: 00H R/W Address: FFFFF046H

	7	6	5	4	3	2	1	0
PMCDH	PMCDH7	PMCDH6	PMCDH5	PMCDH4	PMCDH3	PMCDH2	PMCDH1	PMCDH0

PMCDHn	Specification of PDHn pin operation mode (n = 0 to 7)
0	I/O port
1	Am output (Address bus) (m = 16 to 23)

4.3.14 Port DL

Port DL is a 16-bit port for which I/O settings can be controlled in 1-bit units.

Port DL includes the following alternate-function pins.

Table 4-19. Port DL Alternate-Function Pins

Pin Name	Pin No.		Alternate-Function Pin Name	I/O	Remark
	V850ES/JG3-H	V850ES/JH3-H			
PDL0	71	98	AD0	I/O	–
PDL1	72	99	AD1	I/O	
PDL2	73	100	AD2	I/O	
PDL3	74	101	AD3	I/O	
PDL4	75	102	AD4	I/O	
PDL5	78	103	AD5/FLMD1[Note]	I/O	
PDL6	79	104	AD6	I/O	
PDL7	80	105	AD7	I/O	
PDL8	81	108	AD8	I/O	
PDL9	82	109	AD9	I/O	
PDL10	83	110	AD10	I/O	
PDL11	84	111	AD11	I/O	
PDL12	85	112	AD12	I/O	
PDL13	86	113	AD13	I/O	
PDL14	87	114	AD14	I/O	
PDL15	88	115	AD15	I/O	

Note Since this pin is set in the flash memory programming mode, it does not need to be manipulated with the port control register. For details, see **CHAPTER 31 FLASH MEMORY**.

(1) Port DL register (PDL)

After reset: 0000H (output latch) R/W Address: PDL FFFFF004H,
PDLL FFFFF004H, PDLH FFFFF005H

	15	14	13	12	11	10	9	8
PDL (PDLH)	PDL15	PDL14	PDL13	PDL12	PDL11	PDL10	PDL9	PDL8

	7	6	5	4	3	2	1	0
(PDLL)	PDL7	PDL6	PDL5	PDL4	PDL3	PDL2	PDL1	PDL0

PDLn	Output data control (in output mode) (n = 0 to 15)
0	Outputs 0.
1	Outputs 1.

Remarks 1. The PDL register can be read or written in 16-bit units.
However, when using the higher 8 bits of the PDL register as the PDLH register and the lower 8 bits as the PDLL register, they can be read or written in 8-bit or 1-bit units.

2. To read/write bits 8 to 15 of the PDL register in 8-bit or 1-bit units, specify them as bits 0 to 7 of the PDLH register.

(2) Port DL mode register (PMDL)

After reset: FFFFH R/W Address: PMDL FFFFF024H,
PMDLL FFFFF024H, PMDLH FFFFF025H

	15	14	13	12	11	10	9	8
PMDL (PMDLH)	PMDL15	PMDL14	PMDL13	PMDL12	PMDL11	PMDL10	PMDL9	PMDL8

	7	6	5	4	3	2	1	0
(PMDLL)	PMDL7	PMDL6	PMDL5	PMDL4	PMDL3	PMDL2	PMDL1	PMDL0

PMDLn	I/O mode control (n = 0 to 15)
0	Output mode
1	Input mode

Remarks 1. The PMDL register can be read or written in 16-bit units.
However, when using the higher 8 bits of the PMDL register as the PMDLH register and the lower 8 bits as the PMDLL register, they can be read or written in 8-bit or 1-bit units.

2. To read/write bits 8 to 15 of the PMDL register in 8-bit or 1-bit units, specify them as bits 0 to 7 of the PMDLH register.

(3) Port DL mode control register (PMCDL)

After reset: 0000H R/W Address: PMCDL FFFFF044H,
PMCDLL FFFFF044H, PMCDLH FFFFF045H

	15	14	13	12	11	10	9	8
PMCDL (PMCDLH)	PMCDL15	PMCDL14	PMCDL13	PMCDL12	PMCDL11	PMCDL10	PMCDL9	PMCDL8

	7	6	5	4	3	2	1	0
(PMCDLL)	PMCDL7	PMCDL6	PMCDL5	PMCDL4	PMCDL3	PMCDL2	PMCDL1	PMCDL0

PMCDLn	Specification of PDLn pin operation mode (n = 0 to 15)
0	I/O port
1	ADn I/O (address/data bus I/O)

Remarks 1. The PMCDL register can be read or written in 16-bit units.
However, when using the higher 8 bits of the PMCDL register as the PMCDLH register and the lower 8 bits as the PMCDLL register, they can be read or written in 8-bit or 1-bit units.

2. To read/write bits 8 to 15 of the PMCDL register in 8-bit or 1-bit units, specify them as bits 0 to 7 of the PMCDLH register.

4.4 Port Register Settings When Alternate Function Is Used

Table 4-20 shows the port register settings when each port is used for an alternate function. When using a port pin as an alternate-function pin, refer to the description of each pin.

Table 4-20. Using Port Pin as Alternate-Function Pin (1/10)

Pin Name	Alternate Function		Pnx Bit of Pn Register	PMnx Bit of PMn Register	PMCnx Bit of PMCn Register	PFCEnx Bit of PFCEn Register	PFCnx Bit of PFCn Register	Other Bits (Registers)
	Name	I/O						
P00[Note 1]	INTP00	Input	P00 = Setting not required	PM00 = Setting not required	PMC00 = 1	–	–	
P01[Note 1]	INTP01	Input	P01 = Setting not required	PM01 = Setting not required	PMC01 = 1	–	–	
P02	NMI	Input	P02 = Setting not required	PM02 = Setting not required	PMC02 = 1	–	–	
P03	INTP02	Input	P03 = Setting not required	PM03 = Setting not required	PMC03 = 1	PFCE03 = 0	PFC03 = 0	
	ADTRG	Input	P03 = Setting not required	PM03 = Setting not required	PMC03 = 1	PFCE03 = 0	PFC03 = 1	
	UCLK	Input	P03 = Setting not required	PM03 = Setting not required	PMC03 = 1	PFCE03 = 1	PFC03 = 0	
P04	INTP03	Input	P04 = Setting not required	PM04 = Setting not required	PMC04 = 1	–	–	
P05	INTP04	Input	P05 = Setting not required	PM05 = Setting not required	PMC05 = 1	–	–	
P10	ANO0	Output	P10 = Setting not required	PM10 = 1	–	–	–	
P11	ANO1	Output	P11 = Setting not required	PM11 = 1	–	–	–	
P20[Note 1]	TIAB03	Input	P20 = Setting not required	PM20 = Setting not required	PMC20 = 1	PFCE20 = 0	PFC20 = 0	
	KR2	Input	P20 = Setting not required	PM20 = Setting not required	PMC20 = 1	PFCE20 = 0	PFC20 = 0	
	TOAB03	Output	P20 = Setting not required	PM20 = Setting not required	PMC20 = 1	PFCE20 = 0	PFC20 = 1	
	RTP02	Output	P20 = Setting not required	PM20 = Setting not required	PMC20 = 1	PFCE20 = 1	PFC20 = 0	
P21[Note 1]	SIF2	Input	P21 = Setting not required	PM21 = Setting not required	PMC21= 1	PFCE21 = 0	PFC21 = 0	
	KR3[Note 2]	Input	P21 = Setting not required	PM21 = Setting not required	PMC21= 1	PFCE21 = 0	PFC21 = 1	
	TIAB00[Note 2]	Input	P21 = Setting not required	PM21 = Setting not required	PMC21= 1	PFCE21 = 0	PFC21 = 1	
	TOAB00	Output	P21 = Setting not required	PM21 = Setting not required	PMC21= 1	PFCE21 = 1	PFC21 = 0	
	RTP03	Output	P21 = Setting not required	PM21 = Setting not required	PMC21= 1	PFCE21 = 1	PFC21 = 1	

Notes 1. V850ES/JH3-H only

2. The KR3 pin and TIAB00 pin are alternate-function pins. When using this pin as the TIAB00 pin, do not use the alternate function KR3 pin. Similarly, when using this pin as the KR3 pin, do not use the TIAB00 pin.

Caution When the power is turned on, the P10 and P11 pins may output an undefined level temporarily even during reset.

Table 4-20. Using Port Pin as Alternate-Function Pin (2/10)

Pin Name	Alternate Function		Pnx Bit of Pn Register	PMnx Bit of PMn Register	PMCnx Bit of PMCn Register	PFCEnx Bit of PFCEn Register	PFCnx Bit of PFCn Register	Other Bits (Registers)
	Name	I/O						
P22[Note]	SOF2	Output	P22 = Setting not required	PM22 = Setting not required	PMC22= 1	PFCE22 = 0	PFC22 = 0	
	KR4	Input	P22 = Setting not required	PM22 = Setting not required	PMC22= 1	PFCE22 = 0	PFC22 = 1	
	RTP04	Output	P22 = Setting not required	PM22 = Setting not required	PMC22= 1	PFCE22 = 1	PFC22 = 0	
P23[Note]	$\overline{\text{SCKF2}}$	I/O	P23 = Setting not required	PM23 = Setting not required	PMC23= 1	PFCE23 = 0	PFC23 = 0	
	KR5	Input	P23 = Setting not required	PM23 = Setting not required	PMC23= 1	PFCE23 = 0	PFC23 = 1	
	RTP05	Output	P23 = Setting not required	PM23 = Setting not required	PMC23= 1	PFCE23 = 1	PFC23 = 0	
P24[Note]	INTP05	Input	P24 = Setting not required	PM24 = Setting not required	PMC24= 1	–	–	
P25[Note]	INTP06	Input	P25 = Setting not required	PM25 = Setting not required	PMC25= 1	–	–	
P30	TXDC0	Output	P30 = Setting not required	PM30 = Setting not required	PMC30 = 1	PFCE30 = 0	PFC30 = 0	
	SOF4	Output	P30 = Setting not required	PM30 = Setting not required	PMC30 = 1	PFCE30 = 0	PFC30 = 1	
	INTP07	Input	P30 = Setting not required	PM30 = Setting not required	PMC30 = 1	PFCE30 = 1	PFC30 = 0	
P31	RXDC0	Input	P31 = Setting not required	PM31 = Setting not required	PMC31 = 1	PFCE31 = 0	PFC31 = 0	
	SIF4	Input	P31 = Setting not required	PM31 = Setting not required	PMC31 = 1	PFCE31 = 0	PFC31 = 1	
	INTP08	Input	P31 = Setting not required	PM31 = Setting not required	PMC31 = 1	PFCE31 = 1	PFC31 = 0	
P32	ASCKC0	Input	P32 = Setting not required	PM32 = Setting not required	PMC32 = 1	PFCE32 = 0	PFC32 = 0	
	$\overline{\text{SCKF4}}$	I/O	P32 = Setting not required	PM32 = Setting not required	PMC32 = 1	PFCE32 = 0	PFC32 = 1	
	TIAA00	Input	P32 = Setting not required	PM32 = Setting not required	PMC32 = 1	PFCE32 = 1	PFC32 = 0	
	TOAA00	Output	P32 = Setting not required	PM32 = Setting not required	PMC32 = 1	PFCE32 = 1	PFC32 = 1	
P33	TIAA01	Input	P33 = Setting not required	PM33 = Setting not required	PMC33 = 1	PFCE33 = 0	PFC33 = 0	
	TOAA01	Output	P33 = Setting not required	PM33 = Setting not required	PMC33 = 1	PFCE33 = 0	PFC33 = 1	
	RTCDIV	Output	P33 = Setting not required	PM33 = Setting not required	PMC33 = 1	PFCE33 = 1	PFC33 = 0	
	RTCCL	Output	P33 = Setting not required	PM33 = Setting not required	PMC33 = 1	PFCE33 = 1	PFC33 = 1	

Note V850ES/JH3-H only

Table 4-20. Using Port Pin as Alternate-Function Pin (3/10)

Pin Name	Alternate Function		Pnx Bit of Pn Register	PMnx Bit of PMn Register	PMCnx Bit of PMCn Register	PFCEnx Bit of PFCEn Register	PFCnx Bit of PFCn Register	Other Bits (Registers)
	Name	I/O						
P34	TIAA10	Input	P34 = Setting not required	PM34 = Setting not required	PMC34 = 1	PFCE34 = 0	PFC34 = 0	
	TOAA10	Output	P34 = Setting not required	PM34 = Setting not required	PMC34 = 1	PFCE34 = 0	PFC34 = 1	
	TOAA1OFF[Note 1]	Input	P34 = Setting not required	PM34 = Setting not required	PMC34 = 1	PFCE34 = 1	PFC34 = 0	
	INTP09[Note 1]	Input	P34 = Setting not required	PM34 = Setting not required	PMC34 = 1	PFCE34 = 1	PFC34 = 0	
P35	TIAA11	Input	P35 = Setting not required	PM35 = Setting not required	PMC35 = 1	PFCE35 = 0	PFC35 = 0	
	TOAA11	Output	P35 = Setting not required	PM35 = Setting not required	PMC35 = 1	PFCE35 = 0	PFC35 = 1	
	RTC1HZ	Output	P35 = Setting not required	PM35 = Setting not required	PMC35 = 1	PFCE35 = 1	PFC35 = 0	
P36	TXDC3	Output	P36 = Setting not required	PM36 = Setting not required	PMC36 = 1	PFCE36 = 0	PFC36 = 0	
	SCL00	I/O	P36 = Setting not required	PM36 = Setting not required	PMC36 = 1	PFCE36 = 0	PFC36 = 1	PF36 (PF3) = 1
	CTXD0[Note 2]	Output	P36 = Setting not required	PM36 = Setting not required	PMC36 = 1	PFCE36 = 1	PFC36 = 0	
	$\overline{\text{UDMARQ0}}$	Input	P36 = Setting not required	PM36 = Setting not required	PMC36 = 1	PFCE36 = 1	PFC36 = 1	
P37	RXDC3	Input	P37 = Setting not required	PM37 = Setting not required	PMC37 = 1	PFCE37 = 0	PFC37 = 0	
	SDA00	I/O	P37 = Setting not required	PM37 = Setting not required	PMC37 = 1	PFCE37 = 0	PFC37 = 1	PF37 (PF3) = 1
	CRXD0[Note 2]	Input	P37 = Setting not required	PM37 = Setting not required	PMC37 = 1	PFCE37 = 1	PFC37 = 0	
	$\overline{\text{UDMAAK0}}$	Output	P37 = Setting not required	PM37 = Setting not required	PMC37 = 1	PFCE37 = 1	PFC37 = 1	
P40	SIF0	Input	P40 = Setting not required	PM40 = Setting not required	PMC40 = 1	PFCE40 = 0	PFC40 = 0	
	TXDC4	Output	P40 = Setting not required	PM40 = Setting not required	PMC40 = 1	PFCE40 = 0	PFC40 = 1	
	SDA01	I/O	P40 = Setting not required	PM40 = Setting not required	PMC40 = 1	PFCE40 = 1	PFC40 = 0	PF40 (PF4) = 0
P41	SOF0	Output	P41 = Setting not required	PM41 = Setting not required	PMC41 = 1	PFCE41 = 0	PFC41 = 0	
	RXDC4	Input	P41 = Setting not required	PM41 = Setting not required	PMC41 = 1	PFCE41 = 0	PFC41 = 1	
	SCL01	I/O	P41 = Setting not required	PM41 = Setting not required	PMC41 = 1	PFCE41 = 1	PFC41 = 0	PF41 (PF4) = 0
P42	$\overline{\text{SCKF0}}$	I/O	P42 = Setting not required	PM42 = Setting not required	PMC42 = 1	–	PFC42 = 0	
	INTP10	Input	P42 = Setting not required	PM42 = Setting not required	PMC42 = 1	–	PFC42 = 1	

Notes 1. The TOAA1OFF pin and INTP09 pin are alternate-function pins. When using this pin as the TOAA1OFF pin, disable edge detection of the INTP09 pin, which is the alternate function (set to INTF3.INTF34 = 0, INTR3.INTR34 = 0). Similarly, when using this pin as the INTP09 pin, be sure to stop the high impedance output circuit.

2. μPD70F3770, 70F3771 only

Table 4-20. Using Port Pin as Alternate-Function Pin (4/10)

Pin Name	Alternate Function		Pnx Bit of Pn Register	PMnx Bit of PMn Register	PMCnx Bit of PMCn Register	PFCEnx Bit of PFCEn Register	PFCnx Bit of PFCn Register	Other Bits (Registers)
	Name	I/O						
P50	TIAB01	Input	P50 = Setting not required	PM50 = Setting not required	PMC50 = 1	PFCE50 = 0	PFC50 = 0	KRM0 (KRM)= 0
	KR0	Input	P50 = Setting not required	PM50 = Setting not required	PMC50 = 1	PFCE50 = 0	PFC50 = 0	TAB0TIG2, TAB0TIG3 (TAB0IOC1) = 0
	TOAB01	Output	P50 = Setting not required	PM50 = Setting not required	PMC50 = 1	PFCE50 = 0	PFC50 = 1	
	RTP00	Output	P50 = Setting not required	PM50 = Setting not required	PMC50 = 1	PFCE50 = 1	PFC50 = 0	
	UDMARQ1	Input	P50 = Setting not required	PM50 = Setting not required	PMC50 = 1	PFCE50 = 1	PFC50 = 1	
P51	TIAB02	Input	P51 = Setting not required	PM51 = Setting not required	PMC51 = 1	PFCE51 = 0	PFC51 = 0	KRM1 (KRM) = 0
	KR1	Input	P51 = Setting not required	PM51 = Setting not required	PMC51 = 1	PFCE51 = 0	PFC51 = 0	TAB0TIG4, TAB0TIG5 (TAB0IOC1) = 0
	TOAB02	Output	P51 = Setting not required	PM51 = Setting not required	PMC51 = 1	PFCE51 = 0	PFC51 = 1	
	RTP01	Output	P51 = Setting not required	PM51 = Setting not required	PMC51 = 1	PFCE51 = 1	PFC51 = 0	
	$\overline{\text{UDMAAK1}}$	Output	P51 = Setting not required	PM51 = Setting not required	PMC51 = 1	PFCE51 = 1	PFC51 = 1	
P52[Note]	TIAB03	Input	P52 = Setting not required	PM52 = Setting not required	PMC52 = 1	PFCE52 = 0	PFC52 = 0	KRM2 (KRM) = 0
	KR2	Input	P52 = Setting not required	PM52 = Setting not required	PMC52 = 1	PFCE52 = 0	PFC52 = 0	TAB0TIG6, TAB0TIG7 (TAB0I0C1) = 0
	TOAB03	Output	P52 = Setting not required	PM52 = Setting not required	PMC52 = 1	PFCE52 = 0	PFC52 = 1	
	RTP02	Output	P52 = Setting not required	PM52 = Setting not required	PMC52 = 1	PFCE52 = 1	PFC52 = 0	
P53[Note]	SIF2	Input	P53 = Setting not required	PM53 = Setting not required	PMC53 = 1	PFCE53 = 0	PFC53 = 0	
	TIAB00	Input	P53 = Setting not required	PM53 = Setting not required	PMC53 = 1	PFCE53 = 0	PFC53 = 1	KRM3 (KRM) = 0
	KR3	Input	P53 = Setting not required	PM53 = Setting not required	PMC53 = 1	PFCE53 = 0	PFC53 = 1	TAB0TIG0, TAB0TIG1 (TAB0IOC1) = 0, TAB0EES0, TAB0EES1 (TAB0IOC2) = 0, TAB0ETS0, TAB0ETS1 (TAB0IOC2) = 0
	TOAB00	Output	P53 = Setting not required	PM53 = Setting not required	PMC53 = 1	PFCE53 = 1	PFC53 = 0	
	RTP03	Output	P53 = Setting not required	PM53 = Setting not required	PMC53 = 1	PFCE53 = 1	PFC53 = 1	
P54[Note]	SOF2	Output	P54 = Setting not required	PM54 = Setting not required	PMC54 = 1	PFCE54 = 0	PFC54 = 0	
	KR4	Input	P54 = Setting not required	PM54 = Setting not required	PMC54 = 1	PFCE54 = 0	PFC54 = 1	
	RTP04	Output	P54 = Setting not required	PM54 = Setting not required	PMC54 = 1	PFCE54 = 1	PFC54 = 0	

Note V850ES/JG3-H only

Table 4-20. Using Port Pin as Alternate-Function Pin (5/10)

Pin Name	Alternate Function		Pnx Bit of Pn Register	PMnx Bit of PMn Register	PMCnx Bit of PMCn Register	PFCEnx Bit of PFCEn Register	PFCnx Bit of PFCn Register	Other Bits (Registers)
	Name	I/O						
P55[Note]	$\overline{\text{SCKF2}}$	I/O	P55 = Setting not required	PM55 = Setting not required	PMC55 = 1	PFCE55 = 0	PFC55 = 0	
	KR5	Input	P55 = Setting not required	PM55 = Setting not required	PMC55 = 1	PFCE55 = 0	PFC55 = 1	
	RTP05	Output	P55 = Setting not required	PM55 = Setting not required	PMC55 = 1	PFCE55 = 1	PFC55 = 0	
P60	TOAB1T1	Output	P60 = Setting not required	PM60 = Setting not required	PMC60 = 1	PFCE60 = 0[Note]	PFC60 = 0	
	TOAB11	Output	P60 = Setting not required	PM60 = Setting not required	PMC60 = 1	PFCE60 = 0[Note]	PFC60 = 0	
	TIAB11	Input	P60 = Setting not required	PM60 = Setting not required	PMC60 = 1	PFCE60 = 0[Note]	PFC60 = 1	
	$\overline{\text{WAIT}}$[Note]	Output	P60 = Setting not required	PM60 = Setting not required	PMC60 = 1	PFCE60 = 1[Note]	PFC60 = 0	
P61	TOAB1B1	Output	P61 = Setting not required	PM61 = Setting not required	PMC61 = 1	PFCE61 = 0	PFC61 = 0	
	TIAB10	Input	P61 = Setting not required	PM61 = Setting not required	PMC61 = 1	PFCE61 = 0	PFC61 = 1	
	TOAB10	Output	P61 = Setting not required	PM61 = Setting not required	PMC61 = 1	PFCE61 = 1	PFC61 = 0	
	$\overline{\text{RD}}$[Note]	Output	P61 = Setting not required	PM61 = Setting not required	PMC61 = 1	PFCE61 = 1	PFC61 = 1	
P62	TOAB1T2	Output	P62 = Setting not required	PM62 = Setting not required	PMC62 = 1	PFCE62 = 0[Note]	PFC62 = 0	
	TOAB12	Output	P62 = Setting not required	PM62 = Setting not required	PMC62 = 1	PFCE62 = 0[Note]	PFC62 = 0	
	TIAB12	Input	P62 = Setting not required	PM62 = Setting not required	PMC62 = 1	PFCE62 = 0[Note]	PFC62 = 1	
	ASTB[Note]	Output	P62 = Setting not required	PM62 = Setting not required	PMC62 = 1	PFCE62 = 1[Note]	PFC62 = 0	
P63	TOAB1B2	Output	P63 = Setting not required	PM63 = Setting not required	PMC63 = 1	PFCE63 = 0[Note]	PFC63 = 0	
	TRGAB1	Input	P63 = Setting not required	PM63 = Setting not required	PMC63 = 1	PFCE63 = 0[Note]	PFC63 = 1	
	$\overline{\text{CS0}}$[Note]	Output	P63 = Setting not required	PM63 = Setting not required	PMC63 = 1	PFCE63 = 1[Note]	PFC63 = 0	
P64	TOAB1T3	Output	P64 = Setting not required	PM64 = Setting not required	PMC64 = 1	PFCE64 = 0[Note]	PFC64 = 0	
	TOAB13	Output	P64 = Setting not required	PM64 = Setting not required	PMC64 = 1	PFCE64 = 0[Note]	PFC64 = 0	
	TIAB13	Input	P64 = Setting not required	PM64 = Setting not required	PMC64 = 1	PFCE64 = 0[Note]	PFC64 = 1	
	$\overline{\text{CS2}}$[Note]	Output	P64 = Setting not required	PM64 = Setting not required	PMC64 = 1	PFCE64 = 1[Note]	PFC64 = 0	
P65	TOAB1B3	Output	P65 = Setting not required	PM65 = Setting not required	PMC65 = 1	PFCE65 = 0[Note]	PFC63 = 0	
	EVTAB1	Input	P65 = Setting not required	PM65 = Setting not required	PMC65 = 1	PFCE65 = 0[Note]	PFC65 = 1	
	$\overline{\text{CS3}}$[Note]	Output	P65 = Setting not required	PM65 = Setting not required	PMC65 = 1	PFCE65 = 1[Note]	PFC65 = 0	

Note V850ES/JG3-H only

Table 4-20. Using Port Pin as Alternate-Function Pin (6/10)

Pin Name	Alternate Function		Pnx Bit of Pn Register	PMnx Bit of PMn Register	PMCnx Bit of PMCn Register	PFCEnx Bit of PFCEn Register	PFCnx Bit of PFCn Register	Other Bits (Registers)
	Name	I/O						
P70	ANI0	Input	P70 = Setting not required	PM70 = 1	–	–	–	
P71	ANI1	Input	P71 = Setting not required	PM71 = 1	–	–	–	
P72	ANI2	Input	P72 = Setting not required	PM72 = 1	–	–	–	
P73	ANI3	Input	P73 = Setting not required	PM73 = 1	–	–	–	
P74	ANI4	Input	P74 = Setting not required	PM74 = 1	–	–	–	
P75	ANI5	Input	P75 = Setting not required	PM75 = 1	–	–	–	
P76	ANI6	Input	P76 = Setting not required	PM76 = 1	–	–	–	
P77	ANI7	Input	P77 = Setting not required	PM77 = 1	–	–	–	
P78	ANI8	Input	P78 = Setting not required	PM78 = 1	–	–	–	
P79	ANI9	Input	P79 = Setting not required	PM79 = 1	–	–	–	
P710	ANI10	Input	P710 = Setting not required	PM710 = 1	–	–	–	
P711	ANI11	Input	P711 = Setting not required	PM711 = 1	–	–	–	
P90	KR6	Input	P90 = Setting not required	PM90 = Setting not required	PMC90 = 1	PFCE90 = 0	PFC90 = 0	
	TXDC1	Output	P90 = Setting not required	PM90 = Setting not required	PMC90 = 1	PFCE90 = 0	PFC90 = 1	
	SDA02	I/O	P90 = Setting not required	PM90 = Setting not required	PMC90 = 1	PFCE90 = 1	PFC90 = 0	PF90 (PF9) = 1
	A0[Note 1]	Output	P90 = Setting not required	PM90 = Setting not required	PMC90 = 1	PFCE90 = 1	PFC90 = 1	**Note 2**
P91	KR7	Input	P91 = Setting not required	PM91 = Setting not required	PMC91 = 1	PFCE91 = 0	PFC91 = 0	
	RXDC1	Input	P91 = Setting not required	PM91 = Setting not required	PMC91 = 1	PFCE91 = 0	PFC91 = 1	
	SCL02	I/O	P91 = Setting not required	PM91 = Setting not required	PMC91 = 1	PFCE91 = 1	PFC91 = 0	PF91 (PF9) = 1
	A1[Note 1]	Output	P91 = Setting not required	PM91 = Setting not required	PMC91 = 1	PFCE91 = 1	PFC91 = 1	**Note 2**
P92	TENC01	Input	P92 = Setting not required	PM92 = Setting not required	PMC92 = 1	PFCE92 = 0	PFC92 = 0	
	TIT01	Input	P92 = Setting not required	PM92 = Setting not required	PMC92 = 1	PFCE92 = 0	PFC92 = 1	
	TOT01	Output	P92 = Setting not required	PM92 = Setting not required	PMC92 = 1	PFCE92 = 1	PFC92 = 0	
	A2[Note 1]	Output	P92 = Setting not required	PM92 = Setting not required	PMC92 = 1	PFCE92 = 1	PFC92 = 1	**Note 2**

Notes 1. V850ES/JH3-H only

2. When using as the A0 to A15 pins, be sure to set all 16 bits of the PMC9 register to FFFFH at once.

Table 4-20. Using Port Pin as Alternate-Function Pin (7/10)

Pin Name	Alternate Function		Pnx Bit of Pn Register	PMnx Bit of PMn Register	PMCnx Bit of PMCn Register	PFCEnx Bit of PFCEn Register	PFCnx Bit of PFCn Register	Other Bits (Registers)
	Name	I/O						
P93	TECR0	Input	P93 = Setting not required	PM93 = Setting not required	PMC93 = 1	PFCE93 = 0	PFC93 = 0	
	TIT00	Input	P93 = Setting not required	PM93 = Setting not required	PMC93 = 1	PFCE93 = 0	PFC93 = 1	
	TOT00	Output	P93 = Setting not required	PM93 = Setting not required	PMC93 = 1	PFCE93 = 1	PFC93 = 0	
	A3[Note 1]	Output	P93 = Setting not required	PM93 = Setting not required	PMC93 = 1	PFCE93 = 1	PFC93 = 1	**Note 2**
P94	TIAA31	Input	P94 = Setting not required	PM94 = Setting not required	PMC94 = 1	PFCE94 = 0	PFC94 = 0	
	TOAA31	Output	P94 = Setting not required	PM94 = Setting not required	PMC94 = 1	PFCE94 = 0	PFC94 = 1	
	TENC00	Input	P94 = Setting not required	PM94 = Setting not required	PMC94 = 1	PFCE94 = 1	PFC94 = 0	
	EVTT0	Input	P94 = Setting not required	PM94 = Setting not required	PMC94 = 1	PFCE94 = 1	PFC94 = 0	
	A4[Note 1]	Output	P94 = Setting not required	PM94 = Setting not required	PMC94 = 1	PFCE94 = 1	PFC94 = 1	**Note 2**
P95	TIAA30	Input	P95 = Setting not required	PM95 = Setting not required	PMC95 = 1	PFCE95 = 0	PFC95 = 0	
	TOAA30	Output	P95 = Setting not required	PM95 = Setting not required	PMC95 = 1	PFCE95 = 0	PFC95 = 1	
	A5[Note 1]	Output	P95 = Setting not required	PM95 = Setting not required	PMC95 = 1	PFCE95 = 1	PFC95 = 0	**Note 2**
P96	TIAA21	Input	P96 = Setting not required	PM96 = Setting not required	PMC96 = 1	PFCE96 = 0	PFC96 = 0	
	TOAA21	Output	P96 = Setting not required	PM96 = Setting not required	PMC96 = 1	PFCE96 = 1	PFC96 = 1	
	INTP11	Input	P96 = Setting not required	PM96 = Setting not required	PMC96 = 1	PFCE96 = 1	PFC96 = 0	
	A6[Note 1]	Output	P96 = Setting not required	PM96 = Setting not required	PMC96 = 1	PFCE96 = 1	PFC96 = 1	**Note 2**
P97	SIF1	Input	P97 = Setting not required	PM97 = Setting not required	PMC97 = 1	PFCE97 = 0	PFC97 = 0	
	TIAA20	Input	P97 = Setting not required	PM97 = Setting not required	PMC97 = 1	PFCE97 = 0	PFC97 = 1	
	TOAA20	Output	P97 = Setting not required	PM97 = Setting not required	PMC97 = 1	PFCE97 = 1	PFC97 = 0	
	A7[Note 1]	Output	P97 = Setting not required	PM97 = Setting not required	PMC97 = 1	PFCE97 = 1	PFC97 = 1	**Note 2**
P98	SOF1	Output	P98 = Setting not required	PM98 = Setting not required	PMC98 = 1	PFCE98 = 0	PFC98 = 0	
	INTP12	Input	P98 = Setting not required	PM98 = Setting not required	PMC98 = 1	PFCE98 = 0	PFC98 = 1	
	A8[Note 1]	Output	P98 = Setting not required	PM98 = Setting not required	PMC98 = 1	PFCE98 = 1	PFC98 = 0	**Note 2**

Notes 1. V850ES/JH3-H only

2. When using as the A0 to A15 pins, be sure to set all 16 bits of the PMC9 register to FFFFH at once.

Table 4-20. Using Port Pin as Alternate-Function Pin (8/10)

Pin Name	Alternate Function		Pnx Bit of Pn Register	PMnx Bit of PMn Register	PMCnx Bit of PMCn Register	PFCEnx Bit of PFCEn Register	PFCnx Bit of PFCn Register	Other Bits (Registers)
	Name	I/O						
P99	$\overline{\text{SCKF1}}$	I/O	P99 = Setting not required	PM99 = Setting not required	PMC99 = 1	PFCE99 = 0	PFC99 = 0	
	INTP13	Input	P99 = Setting not required	PM99 = Setting not required	PMC99 = 1	PFCE99 = 0	PFC99 = 1	
	A9[Note 1]	Output	P99 = Setting not required	PM99 = Setting not required	PMC99 = 1	PFCE99 = 1	PFC99 = 0	**Note 2**
P910	SIF3	Input	P910 = Setting not required	PM910 = Setting not required	PMC910 = 1	PFCE910 = 0	PFC910 = 0	
	TXDC2	Output	P910 = Setting not required	PM910 = Setting not required	PMC910 = 1	PFCE910 = 0	PFC910 = 1	
	INTP14	Input	P910 = Setting not required	PM910 = Setting not required	PMC910 = 1	PFCE910 = 1	PFC910 = 0	
	A10[Note 1]	Output	P910 = Setting not required	PM910 = Setting not required	PMC910 = 1	PFCE910 = 1	PFC910 = 1	**Note 2**
P911	SOF3	Output	P911 = Setting not required	PM911 = Setting not required	PMC911 = 1	PFCE911 = 0	PFC911 = 0	
	RXDC2	Input	P911 = Setting not required	PM911 = Setting not required	PMC911 = 1	PFCE911 = 0	PFC911 = 1	
	INTP15	Input	P911 = Setting not required	PM911 = Setting not required	PMC911 = 1	PFCE911 = 1	PFC911 = 0	
	A11[Note 1]	Output	P911 = Setting not required	PM911 = Setting not required	PMC911 = 1	PFCE911 = 1	PFC911 = 1	**Note 2**
P912	$\overline{\text{SCKF3}}$	I/O	P912 = Setting not required	PM912 = Setting not required	PMC912 = 1	–	PFC912 = 0	
	A12[Note 1]	Output	P912 = Setting not required	PM912 = Setting not required	PMC912 = 1	–	PFC912 = 1	**Note 2**
P913	TOAB1OFF	Input	P913 = Setting not required	PM913 = Setting not required	PMC913 = 1	–	PFC913 = 0	
	INTP16	Input	P913 = Setting not required	PM913 = Setting not required	PMC913 = 1	–	PFC913 = 0	
	A13[Note 1]	Output	P913 = Setting not required	PM913 = Setting not required	PMC913 = 1	–	PFC913 = 1	**Note 2**
P914	TIAA51	Input	P914 = Setting not required	PM914 = Setting not required	PMC914 = 1	PFCE914 = 0	PFC914 = 0	
	TOAA51	Output	P914 = Setting not required	PM914 = Setting not required	PMC914 = 1	PFCE914 = 0	PFC914 = 1	
	INTP17	Input	P914 = Setting not required	PM914 = Setting not required	PMC914 = 1	PFCE914 = 1	PFC914 = 0	
	A14[Note 1]	Output	P914 = Setting not required	PM914 = Setting not required	PMC914 = 1	PFCE914 = 1	PFC914 = 1	**Note 2**
P915	TIAA50	Input	P915 = Setting not required	PM915 = Setting not required	PMC915 = 1	PFCE915 = 0	PFC915 = 0	
	TOP50	Output	P915 = Setting not required	PM915 = Setting not required	PMC915 = 1	PFCE915 = 0	PFC915 = 1	
	INTP18	Input	P915 = Setting not required	PM915 = Setting not required	PMC915 = 1	PFCE915 = 1	PFC915 = 0	
	A15[Note 1]	Output	P915 = Setting not required	PM915 = Setting not required	PMC915 = 1	PFCE915 = 1	PFC915 = 1	**Note 2**

Notes 1. V850ES/JH3-H only

2. When using as the A0 to A15 pins, be sure to set all 16 bits of the PMC9 register to FFFFH at once.

Table 4-20. Using Port Pin as Alternate-Function Pin (9/10)

Pin Name	Alternate Function		Pnx Bit of Pn Register	PMnx Bit of PMn Register	PMCnx Bit of PMCn Register	PFCEnx Bit of PFCEn Register	PFCnx Bit of PFCn Register	Other Bits (Registers)
	Name	I/O						
PCM0	$\overline{\text{WAIT}}$Note	Input	PCM0 = Setting not required	PMCM0 = Setting not required	PMCCM0 = 1	–	–	
PCM1	CLKOUT	Output	PCM1 = Setting not required	PMCM1 = Setting not required	PMCCM1 = 1	–	–	
PCM2	$\overline{\text{HLDAK}}$Note	Output	PCM2 = Setting not required	PMCM2 = Setting not required	PMCCM2 = 1	–	–	
PCM3	$\overline{\text{HLDRQ}}$Note	Input	PCM3 = Setting not required	PMCM3 = Setting not required	PMCCM3 = 1	–	–	
PCS0	$\overline{\text{CS0}}$Note	Output	PCS0 = Setting not required	PMCS0 = Setting not required	PMCCS0 = 1	–	–	
PCS2	$\overline{\text{CS2}}$Note	Output	PCS2 = Setting not required	PMCS2 = Setting not required	PMCCS2 = 1	–	–	
PCS3	$\overline{\text{CS3}}$Note	Output	PCS3 = Setting not required	PMCS3 = Setting not required	PMCCS3 = 1	–	–	
PCT0	$\overline{\text{WR0}}$	Output	PCT0 = Setting not required	PMCT0 = Setting not required	PMCCT0 = 1	–	–	
PCT1	$\overline{\text{WR1}}$	Output	PCT1 = Setting not required	PMCT1 = Setting not required	PMCCT1 = 1	–	–	
PCT4	$\overline{\text{RD}}$Note	Output	PCT4 = Setting not required	PMCT4 = Setting not required	PMCCT4 = 1	–	–	
PCT6	ASTBNote	Output	PCT6 = Setting not required	PMCT6 = Setting not required	PMCCT6 = 1	–	–	
PDH0	A16	Output	PDH0 = Setting not required	PMDH0 = Setting not required	PMCDH0 = 1	–	–	
PDH1	A17	Output	PDH1 = Setting not required	PMDH1 = Setting not required	PMCDH1 = 1	–	–	
PDH2	A18	Output	PDH2 = Setting not required	PMDH2 = Setting not required	PMCDH2 = 1	–	–	
PDH3	A19	Output	PDH3 = Setting not required	PMDH3 = Setting not required	PMCDH3 = 1	–	–	
PDH4	A20	Output	PDH4 = Setting not required	PMDH4 = Setting not required	PMCDH4 = 1	–	–	
PDH5	A21	Output	PDH5 = Setting not required	PMDH5 = Setting not required	PMCDH5 = 1	–	–	
PDL0	AD0	I/O	PDL0 = Setting not required	PMDL0 = Setting not required	PMCDL0 = 1	–	–	
PDL1	AD1	I/O	PDL1 = Setting not required	PMDL1 = Setting not required	PMCDL1 = 1	–	–	
PDL2	AD2	I/O	PDL2 = Setting not required	PMDL2 = Setting not required	PMCDL2 = 1	–	–	
PDL3	AD3	I/O	PDL3 = Setting not required	PMDL3 = Setting not required	PMCDL3 = 1	–	–	
PDL4	AD4	I/O	PDL4 = Setting not required	PMDL4 = Setting not required	PMCDL4 = 1	–	–	

Note V850ES/JH3-H only

Table 4-20. Using Port Pin as Alternate-Function Pin (10/10)

Pin Name	Alternate Function		Pnx Bit of Pn Register	PMnx Bit of PMn Register	PMCnx Bit of PMCn Register	PFCEnx Bit of PFCEn Register	PFCnx Bit of PFCn Register	Other Bits (Registers)
	Name	I/O						
PDL5	AD5	I/O	PDL5 = Setting not required	PMDL5 = Setting not required	PMCDL5 = 1	–	–	
	FLMD1[Note]	Input	PDL5 = Setting not required	PMDL5 = Setting not required	PMCDL5 = Setting not required	–	–	
PDL6	AD6	I/O	PDL6 = Setting not required	PMDL6 = Setting not required	PMCDL6 = 1	–	–	
PDL7	AD7	I/O	PDL7 = Setting not required	PMDL7 = Setting not required	PMCDL7 = 1	–	–	
PDL8	AD8	I/O	PDL8 = Setting not required	PMDL8 = Setting not required	PMCDL8 = 1	–	–	
PDL9	AD9	I/O	PDL9 = Setting not required	PMDL9 = Setting not required	PMCDL9 = 1	–	–	
PDL10	AD10	I/O	PDL10 = Setting not required	PMDL10 = Setting not required	PMCDL10 = 1	–	–	
PDL11	AD11	I/O	PDL11 = Setting not required	PMDL11 = Setting not required	PMCDL11 = 1	–	–	
PDL12	AD12	I/O	PDL12 = Setting not required	PMDL12 = Setting not required	PMCDL12 = 1	–	–	
PDL13	AD13	I/O	PDL13 = Setting not required	PMDL13 = Setting not required	PMCDL13 = 1	–	–	
PDL14	AD14	I/O	PDL14 = Setting not required	PMDL14 = Setting not required	PMCDL14 = 1	–	–	
PDL15	AD15	I/O	PDL15 = Setting not required	PMDL15 = Setting not required	PMCDL15 = 1	–	–	

Note Since this pin is set in the flash memory programming mode, it does not need to be manipulated using the port control register. For details, see **CHAPTER 31 FLASH MEMORY**.

4.5 Cautions

4.5.1 Cautions on setting port pins

(1) In the V850ES/JG3-H and V850ES/JH3-H, the general-purpose port functions share pins with several peripheral function I/O pins. Switch between the general-purpose port (port mode) and the peripheral function I/O pin (alternate-function mode) by setting the PMCn register. Note the following cautions with regards to this register setting sequence.

(a) Cautions on switching from port mode to alternate-function mode
Switch from the port mode to alternate-function mode in the following order.

<1> Set the PFn register[Note 1]: N-ch open-drain setting
<2> Set the PFCn and PFCEn registers: Alternate-function selection
<3> Set the corresponding bit of the PMCn register to 1: Switch to alternate-function mode
<4> Set the INTRn and INTFn registers[Note 2]: External interrupt setting

If the PMCn register is set first, note that unexpected operations may occur at that moment or depending on the change of the pin states in accordance with the setting of the PFn, PFCn, and PFCEn registers.
A concrete example is shown in [Example] below.

Notes 1. N-ch open-drain output pin only
2. Only when the external interrupt function is selected

Caution Regardless of the port mode/alternate-function mode, the Pn register is read and written as follows.
- **Pn register read: Read the port output latch value (when PMn.PMnm bit = 0), or read the pin states (PMn.PMnm bit = 1).**
- **Pn register write: Write to the port output latch**

[Example] SCL01 pin setting example
The SCL01 pin is used alternately as the P41/SOF0 pin. Select the valid pin function using the PMC4, PFC4, and PF4 registers.

PMC41 Bit	PFC41 Bit	PF41 Bit	Valid Pin Function
0	don't care	1	P41 (in output port mode, N-ch open-drain output)
1	0	1	SOF0 output (N-ch open-drain output)
	1	1	SCL01 I/O (N-ch open-drain output)

The setting procedure that may cause malfunction on switching from the P41 pin to the SCL01 pin is shown below.

Setting Procedure	Setting Contents	Pin State	Pin Level
<1>	Initial value (PMC41 bit = 0, PFC41 bit = 0, PF41 bit = 0)	Port mode (input)	Hi-Z
<2>	PMC41 bit ← 1	SOF0 output	Low level (high level depending on the CSIF0 setting)
<3>	PFC41 bit ← 1	SCL01 I/O	High level (CMOS output)
<4>	PF41 bit ← 1	SCL01 I/O	Hi-Z (N-ch open-drain output)

In <2>, I^2C communication may be affected since the alternate-function SOF0 output is output to the pin. In the CMOS output period of <2> or <3>, unnecessary current may be generated.

(b) Cautions on alternate-function mode (input)

The signal input to the alternate-function block is low level when the PMCn.PMCnm bit is 0 due to the AND output of the PMCn register set value and the pin level. Thus, depending on the port setting and alternate-function operation enable timing, unexpected operations may occur. Therefore, switch between the port mode and alternate-function mode in the following sequence.

- To switch from port mode to alternate-function mode (input)
  Set the pins to the alternate-function mode using the PMCn register and then enable the alternate-function operation.
- To switch from alternate-function mode (input) to port mode
  Stop the alternate-function operation and then switch the pins to the port mode.

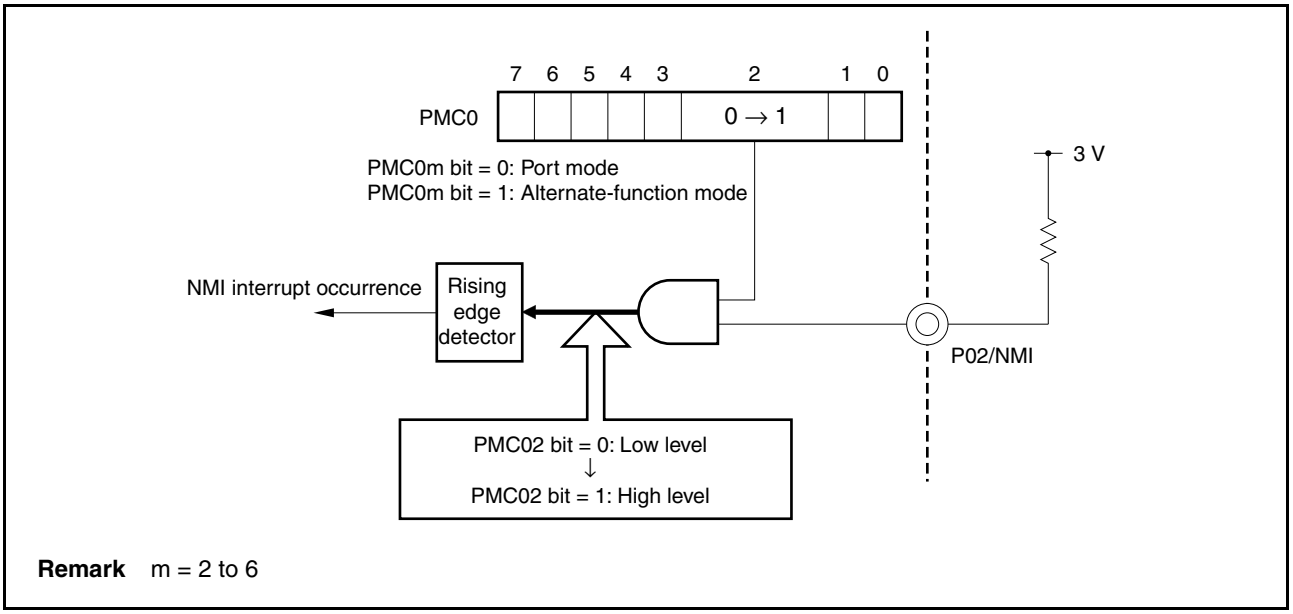
Concrete examples are shown in [Example 1] and [Example 2].

[Example 1] Switching from general-purpose port (P02) to external interrupt pin (NMI)

When the P02/NMI pin is pulled up as shown in Figure 4-4 and the rising edge is specified by the NMI pin edge detection setting, even though a high level is input continuously to the NMI pin when switching from the P02 pin to the an NMI pin (PMC02 bit = 0 → 1), this is detected as a rising edge as if a low level changed to a high level, and an NMI interrupt occurs.

To avoid this, set the NMI pin's valid edge after switching from the P02 pin to the NMI pin.

Figure 4-4. Example of Switching from P02 to NMI (Incorrect)



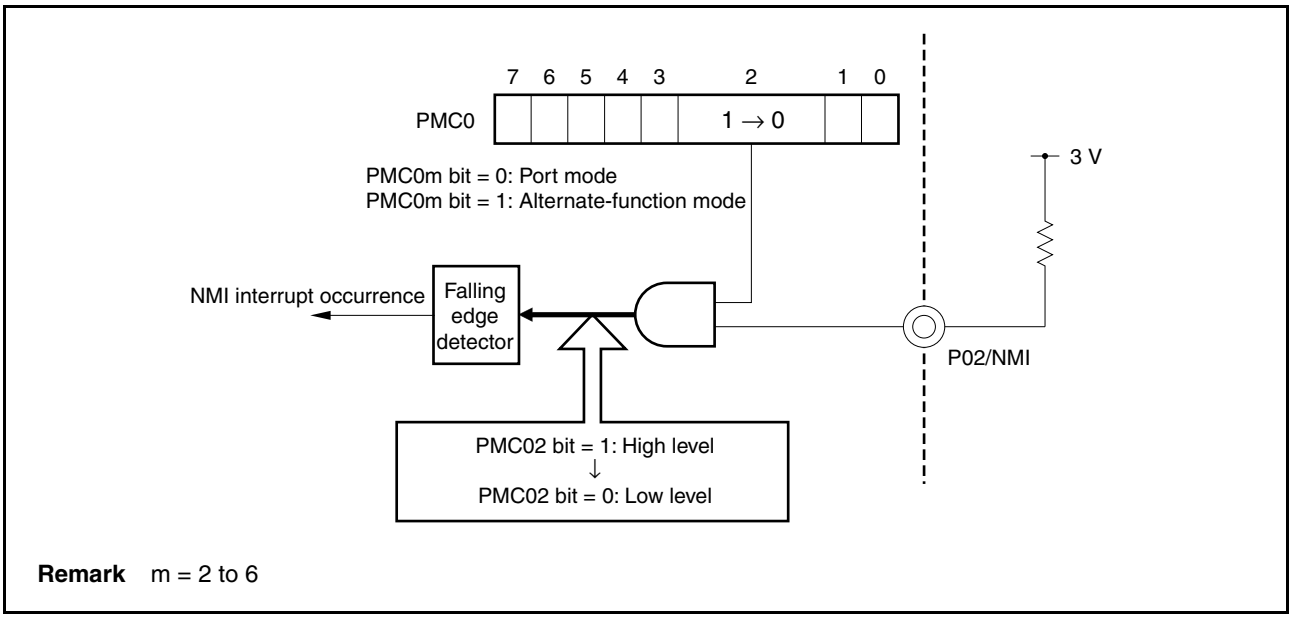
Remark m = 2 to 6

[Example 2] Switching from external pin (NMI) to general-purpose port (P02)

When the P02/NMI pin is pulled up as shown in Figure 4-5 and the falling edge is specified by the NMI pin edge detection setting, even though a high level is input continuously to the NMI pin when switching from the NMI pin to the P02 pin (PMC02 bit = 1 → 0), this is detected as a falling edge as if a high level changed to a low level, and an NMI interrupt occurs.

To avoid this, set the NMI pin edge detection as “No edge detected” before switching to the P02 pin.

Figure 4-5. Example of Switching from NMI to P02 (Incorrect)



Remark m = 2 to 6

(2) In port mode, the PFn.PFnm bit is valid only in the output mode (PMn.PMnm bit = 0). In the input mode (PMnm bit = 1), the value of the PFnm bit is not reflected in the buffer.

4.5.2 Cautions on bit manipulation instruction for port n register (Pn)

When a 1-bit manipulation instruction is executed on a port that provides both input and output functions, the value of the output latch of an input port that is not subject to manipulation may be written in addition to the targeted bit.

Therefore, it is recommended to rewrite the output latch when switching a port from input mode to output mode.

<Example> When the P90 pin is an output port, the P91 to P97 pins are input ports (all pin statuses are high level), and the value of the port latch is 00H, if the output of the P90 pin is changed from low level to high level via a bit manipulation instruction, the value of the port latch is FFH.

Explanation: The targets of writing to and reading from the Pn register of a port whose PMnm bit is 1 are the output latch and pin status, respectively.

A bit manipulation instruction is executed in the following order in the V850ES/JG3-H and V850ES/JH3-H.

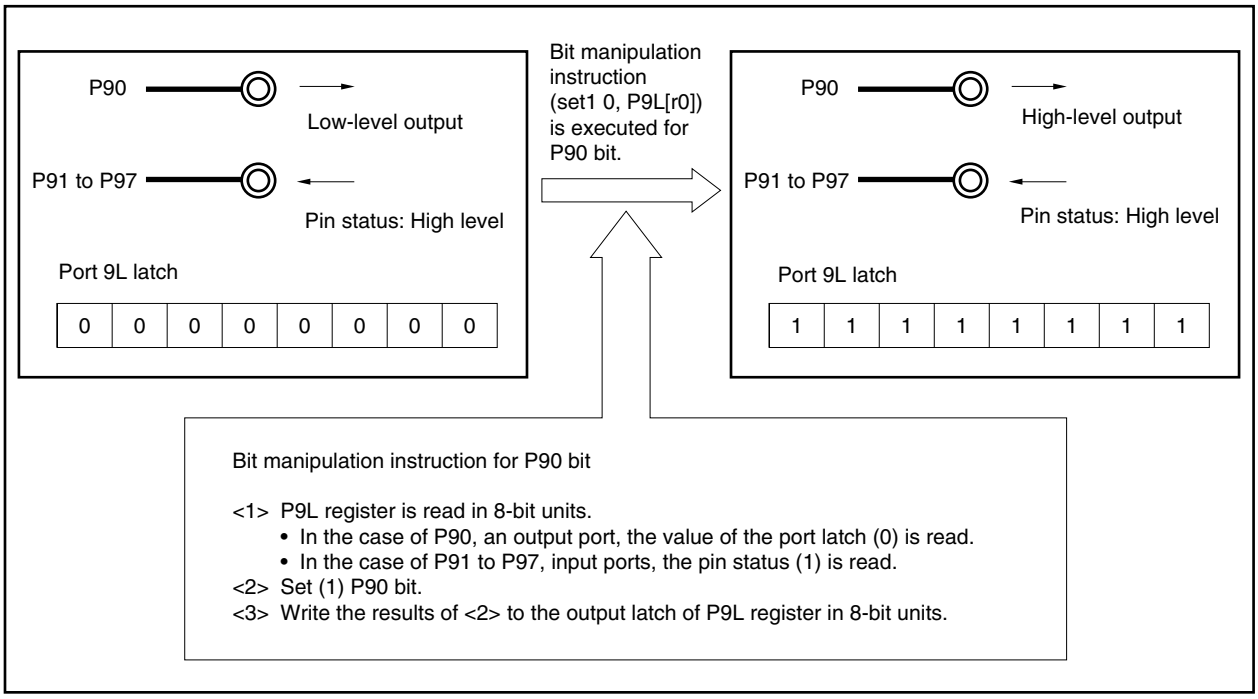
<1> The Pn register is read in 8-bit units.
<2> The targeted bit is manipulated.
<3> The Pn register is written in 8-bit units.

In step <1>, the value of the output latch (0) of the P90 pin, which is an output port, is read, while the pin statuses of the P91 to P97 pins, which are input ports, are read. If the pin statuses of the P91 to P97 pins are high level at this time, the read value is FEH.

The value is changed to FFH by the manipulation in <2>.

FFH is written to the output latch by the manipulation in <3>.

Figure 4-6. Bit Manipulation Instruction (P90 Pin)



4.5.3 Cautions on on-chip debug pins (V850ES/JG3-H only)

The $\overline{\text{DRST}}$, DCK, DMS, DDI, and DDO pins are on-chip debug pins.

After reset by the $\overline{\text{RESET}}$ pin, the P56/INTP05/$\overline{\text{DRST}}$ pin is initialized to function as an on-chip debug pin ($\overline{\text{DRST}}$). If a high level is input to the $\overline{\text{DRST}}$ pin at this time, the on-chip debug mode is set, and the DCK, DMS, DDI, and DDO pins can be used.

The following action must be taken if on-chip debugging is not used.

- Clear the OCDM0 bit of the OCDM register (special register) (0)

At this time, fix the P56/INTP05/$\overline{\text{DRST}}$ pin to low level from when reset by the $\overline{\text{RESET}}$ pin is released until the above action is taken.

If a high level is input to the $\overline{\text{DRST}}$ pin before the above action is taken, it may cause a malfunction (CPU deadlock). Handle the P56 pin with the utmost care.

Caution After reset by the WDT2RES signal, clock monitor (CLM), or low-voltage detector (LVI), the P56/INTP05/$\overline{\text{DRST}}$ pin is not initialized to function as an on-chip debug pin ($\overline{\text{DRST}}$). The OCDM register holds the current value.

4.5.4 Cautions on P56/INTP05/$\overline{\text{DRST}}$ pin

The P56/INTP05/$\overline{\text{DRST}}$ pin has an internal pull-down resistor (30 kΩ TYP.). After a reset by the $\overline{\text{RESET}}$ pin, a pull-down resistor is connected. The pull-down resistor is disconnected when the OCDM0 bit is cleared (0).

4.5.5 Cautions on P10, P11, and P53 pins when power is turned on

When the power is turned on, the following pins may output an undefined level temporarily even during reset.

- P10/ANO0 pin
- P11/ANO1 pin
- P53/SIF2/TIAB00/KR3/TOAB00/RTP03/DDO pin (V850ES/JG3-H only)

4.5.6 Hysteresis characteristics

In port mode, the following port pins do not have hysteresis characteristics.

P00 to P05
P20 to P25
P30 to P37
P40 to P42
P50 to P56
P60 to P65
P90 to P915

CHAPTER 5 BUS CONTROL FUNCTION

The V850ES/JG3-H and V850ES/JH3-H are provided with an external bus interface function by which external memories such as ROM and RAM, and I/O can be connected.

5.1 Features

- ○ Output is selectable from multiplexed bus output with a minimum of 3 bus cycles and separate bus output function (V850ES/JH3-H only; the V850ES/JG3-H only supports the multiplexed bus.)
- ○ 8-bit/16-bit data bus selectable
- ○ Wait function
  - Programmable wait function of up to 7 states
  - External wait function using $\overline{\text{WAIT}}$ pin
- ○ Idle state function
- ○ Bus hold function

5.2 Bus Control Pins

The pins used to connect an external device are listed in the table below.

Table 5-1. V850ES/JH3-H Bus Control Pins (Multiplexed Bus)

Bus Control Pin	Alternate-Function Pin	I/O	Function
AD0 to AD15	PDL0 to PDL15	I/O	Address/data bus
A16 to A23	PDH0 to PDH7	Output	Address bus
$\overline{\text{WAIT}}$	PCM0	Input	External wait control
CLKOUT	PCM1	Output	Internal system clock
$\overline{\text{WR0}}$, $\overline{\text{WR1}}$	PCT0, PCT1	Output	Write strobe signal
$\overline{\text{RD}}$	PCT4	Output	Read strobe signal
ASTB	PCT6	Output	Address strobe signal
$\overline{\text{HLDRQ}}$	PCM3	Input	Bus hold control
$\overline{\text{HLDAK}}$	PCM2	Output	
$\overline{\text{CS0}}$, $\overline{\text{CS2}}$, $\overline{\text{CS3}}$	PCS0, PCS2, PCS3	Output	Chip select

Table 5-2. V850ES/JH3-H Bus Control Pins (Separate Bus Output Function)

Bus Control Pin	Alternate-Function Pin	I/O	Function
AD0 to AD15	PDL0 to PDL15	I/O	Data bus
A0 to A15	P90 to P915	Output	Address bus
A16 to A23	PDH0 to PDH7	Output	Address bus
$\overline{\text{WAIT}}$	PCM0	Input	External wait control
CLKOUT	PCM1	Output	Internal system clock
$\overline{\text{WR0}}$, $\overline{\text{WR1}}$	PCT0, PCT1	Output	Write strobe signal
$\overline{\text{RD}}$	PCT4	Output	Read strobe signal
$\overline{\text{HLDRQ}}$	PCM3	Input	Bus hold control
$\overline{\text{HLDAK}}$	PCM2	Output	
$\overline{\text{CS0}}$, $\overline{\text{CS2}}$, $\overline{\text{CS3}}$	PCS0, PCS2, PCS3	Output	Chip select

Table 5-3. V850ES/JG3-H Bus Control Pins (Multiplexed Bus)

Bus Control Pin	Alternate-Function Pin	I/O	Function
AD0 to AD15	PDL0 to PDL15	I/O	Address/data bus
$\overline{\text{WAIT}}$	PCM0	Input	External wait control
CLKOUT	PCM1	Output	Internal system clock
$\overline{\text{WR0}}$, $\overline{\text{WR1}}$	PCT0, PCT1	Output	Write strobe signal
$\overline{\text{RD}}$	P61	Output	Read strobe signal
ASTB	P62	Output	Address strobe signal
$\overline{\text{CS0}}$, $\overline{\text{CS2}}$, $\overline{\text{CS3}}$	P63, P64, P65	Output	Chip select

5.2.1 Pin status when internal ROM, internal RAM, or on-chip peripheral I/O is accessed

When the internal ROM, internal RAM, or on-chip peripheral I/O are accessed, the status of each pin is as follows.

Table 5-4. Pin Statuses When Internal ROM, Internal RAM, or On-Chip Peripheral I/O Is Accessed

Bus Control Pin	Separate Bus Output Function		Multiplexed Bus Mode	
	Internal ROM/RAM	Peripheral I/O	Internal ROM/RAM	Peripheral I/O
Address/data bus (AD15 to AD0)	Undefined	Undefined	Undefined	Undefined
Address bus (A23 to A16)	Undefined	Undefined (Address output during access)	Undefined	Undefined (Address output during access)
Address bus (A15 to A0)	Undefined	Undefined (Address output during access)	Undefined	Undefined (Address output during access)
Control signal	Inactive	Inactive	Inactive	Inactive

Caution When a write access is performed to the internal ROM area, address, data, and control signals are activated in the same way as access to the external memory area.

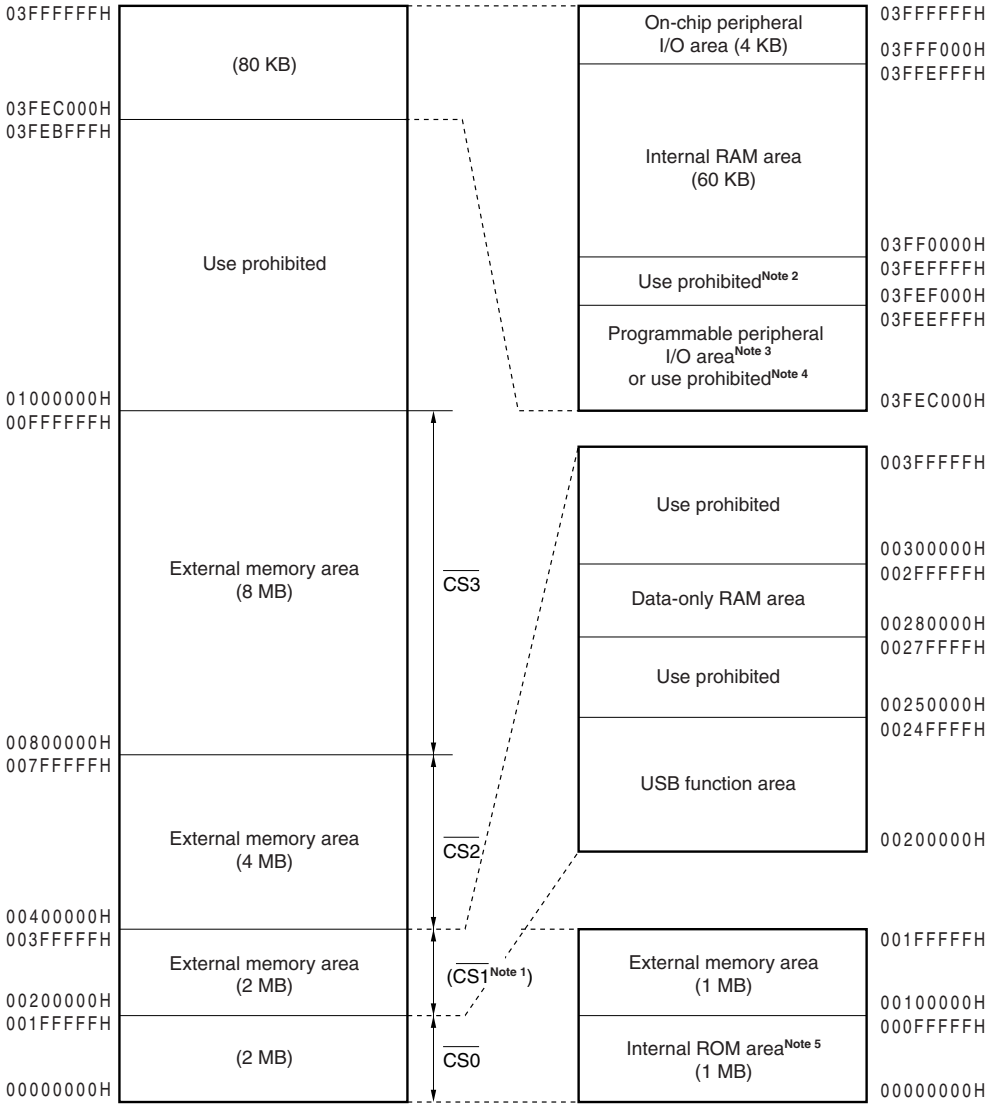
5.2.2 Pin status in each operation mode

For the pin status of the V850ES/JG3-H and V850ES/JH3-H in each operation mode, see **2.2 Pin States**.

5.3 Memory Block Function

The 16 MB external memory space is divided into memory blocks of 2 MB, 4 MB, and 8 MB from the lowest of the memory space. The programmable wait function and bus cycle operation mode for each of these blocks can be independently controlled in one-block units.

Figure 5-1. Data Memory Map: Physical Address



Notes 1. $\overline{CS1}$ is not provided as an external signal of the V850ES/Jx3-H; it is used internally as a chip select signal for the USB.

2. Use of addresses 03FEF000H to 03FEFFFFH is prohibited because these addresses are in the same area as the on-chip peripheral I/O area.

3. Only the programmable peripheral I/O area is seen as images of 256 MB each in the 4 GB address space.

4. In the CAN controller version, addresses 03FEC000H to 03FEEFFFH are assigned as a programmable peripheral I/O area in addresses 03FEC000H to 03FECBFFH. Use of these addresses in a version without a CAN controller is prohibited.

5. This area is an external memory area in the case of a data write access.

5.4 Bus Access

5.4.1 Number of clocks for access

The following table shows the number of basic clocks required for accessing each resource.

Bus Cycle Type \ Area (Bus Width)	Internal ROM (32 Bits)	Internal RAM (32 Bits)	External Memory (16 Bits)	
			Multiplexed	Separate[Note 1]
Instruction fetch (normal access)	1	1[Note 2]	3 + n	
Instruction fetch (branch)	3	2[Note 1]	3 + n	
Operand data access	5	1	3 + n	

Notes 1. V850ES/JH3-H only

2. Increases by 1 if a conflict with a data access occurs.

Remark Unit: Clocks/access

5.4.2 Bus size setting function

Each external memory area selected by memory block $\overline{CSn}$ can be set by using the BSC register. However, the bus size can be set to 8 bits and 16 bits only.

The external memory area of the V850ES/JG3-H and V850ES/JH3-H is selected by memory blocks $\overline{CS0}$, $\overline{CS2}$, and $\overline{CS3}$.

(1) Bus size configuration register (BSC)

The BSC register can be read or written in 16-bit units.

Reset sets this register to 5555H.

Caution Write to the BSC register after reset, and then do not change the set values. Also, do not access an external memory area until the initial settings of the BSC register are complete.

After reset: 5555H R/W Address: FFFFF066H

	15	14	13	12	11	10	9	8
BSC	0	1	0	1	0	1	0	1

7	6	5	4	3	2	1	0
0	BS30	0	BS20	0	1	0	BS00
	$\overline{CS3}$		$\overline{CS2}$				$\overline{CS0}$

BSn0	Data bus width of memory block CSn space (n = 0, 2, 3)
0	8 bits
1	16 bits

Caution Be sure to set bits 14, 12, 10, 8, and 2 to "1", and clear bits 15, 13, 11, 9, 7, 5, 3, and 1 to "0".

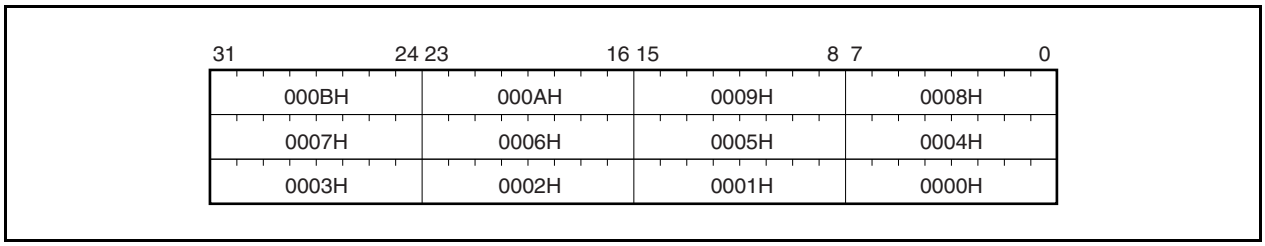
5.4.3 Access by bus size

The V850ES/JG3-H and V850ES/JH3-H access the on-chip peripheral I/O and external memory in 8-bit, 16-bit, or 32-bit units. The bus size is as follows.

- The bus size of the on-chip peripheral I/O is fixed to 16 bits.
- The bus size of the external memory is selectable from 8 bits or 16 bits (by using the BSC register).

The operation when each of the above is accessed is described below. All data is accessed starting from the lower side. The V850ES/JG3-H and V850ES/JH3-H support only the little-endian format.

Figure 5-2. Little-Endian Address in Word



(1) Data space

The V850ES/JG3-H and V850ES/JH3-H have an address misalign function.

With this function, data can be placed at all addresses, regardless of the format of the data (word data or halfword data). However, if the word data or halfword data is not aligned at the boundary, a bus cycle is generated at least twice, causing the bus efficiency to drop.

(a) Halfword-length data access

A byte-length bus cycle is generated twice if the least significant bit of the address is 1.

(b) Word-length data access

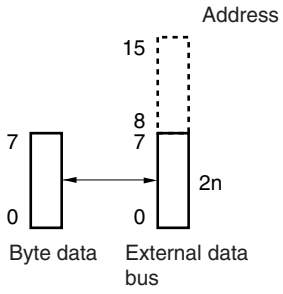
(i) A byte-length bus cycle, halfword-length bus cycle, and byte-length bus cycle are generated in that order if the least significant bit of the address is 1.

(ii) A halfword-length bus cycle is generated twice if the lower 2 bits of the address are 10.

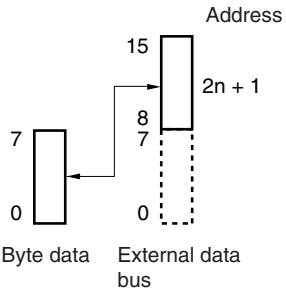
(2) Byte access (8 bits)

(a) 16-bit data bus width

<1> Access to even address (2n)

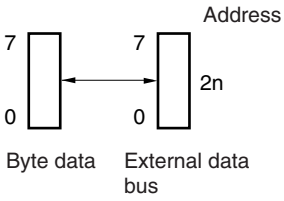


<2> Access to odd address (2n + 1)

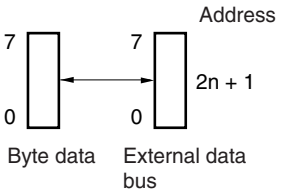


(b) 8-bit data bus width

<1> Access to even address (2n)



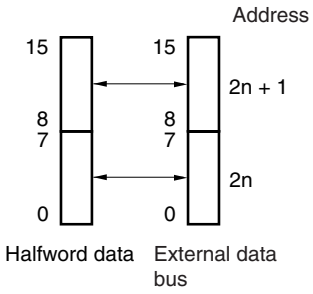
<2> Access to odd address (2n + 1)



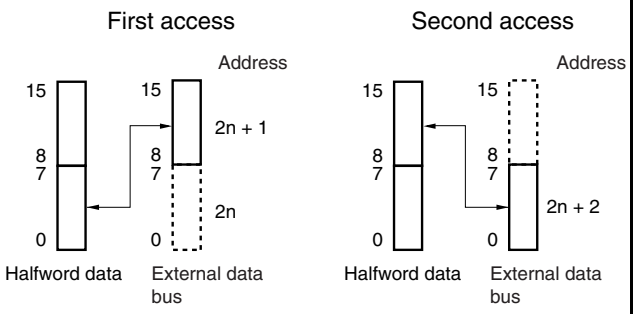
(3) Halfword access (16 bits)

(a) 16-bit data bus width

<1> Access to even address (2n)



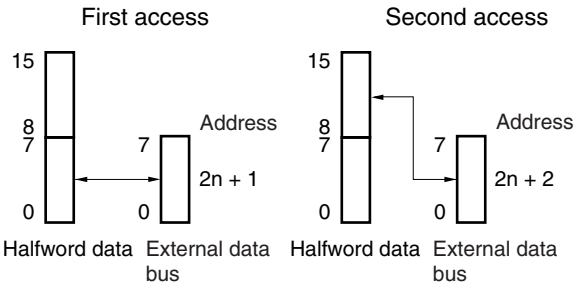
<2> Access to odd address (2n + 1)



(b) 8-bit data bus width

<1> Access to even address (2n)

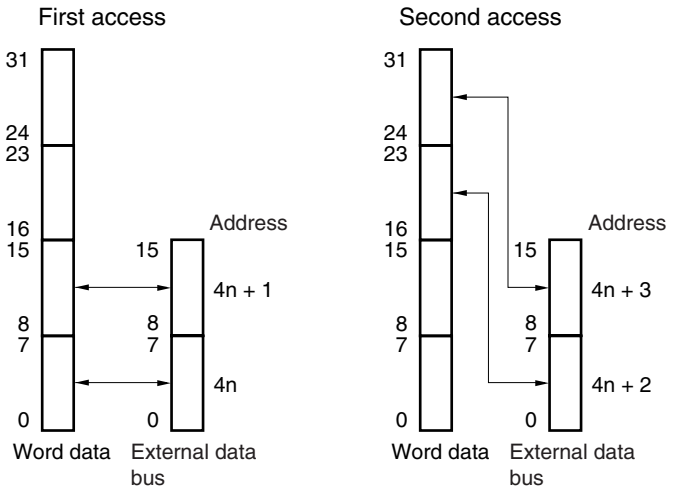
<2> Access to odd address (2n + 1)



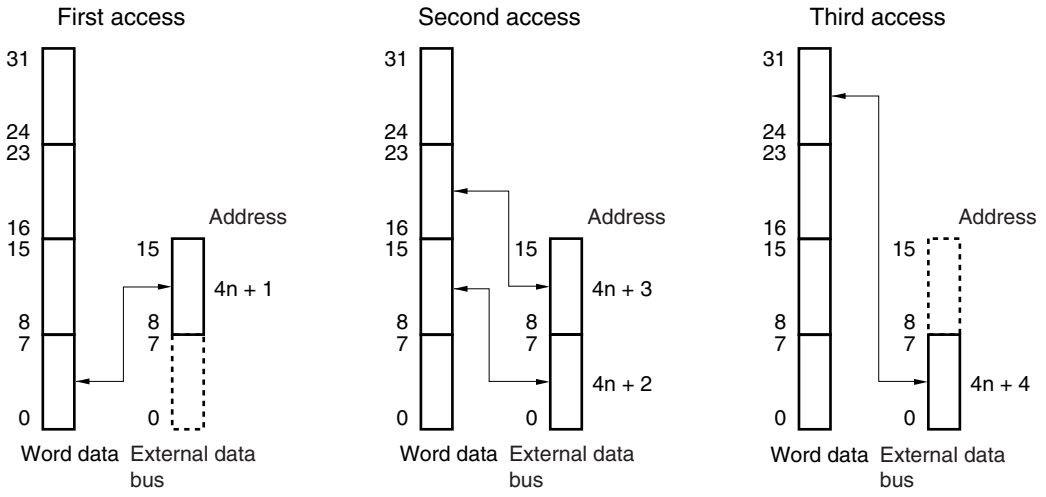
(4) Word access (32 bits)

(a) 16-bit data bus width (1/2)

<1> Access to address (4n)

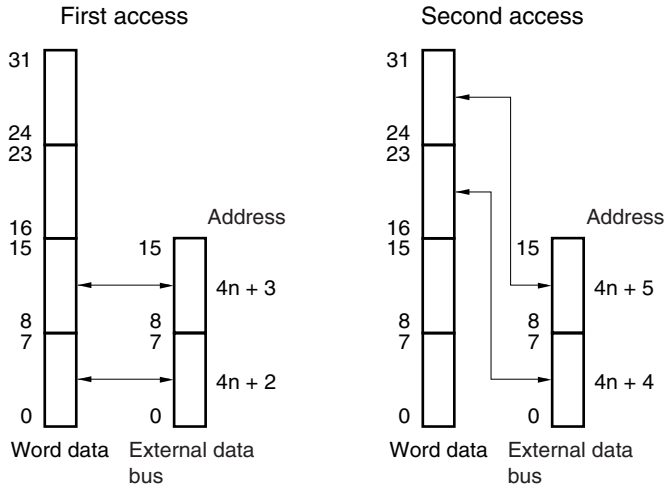


<2> Access to address (4n + 1)

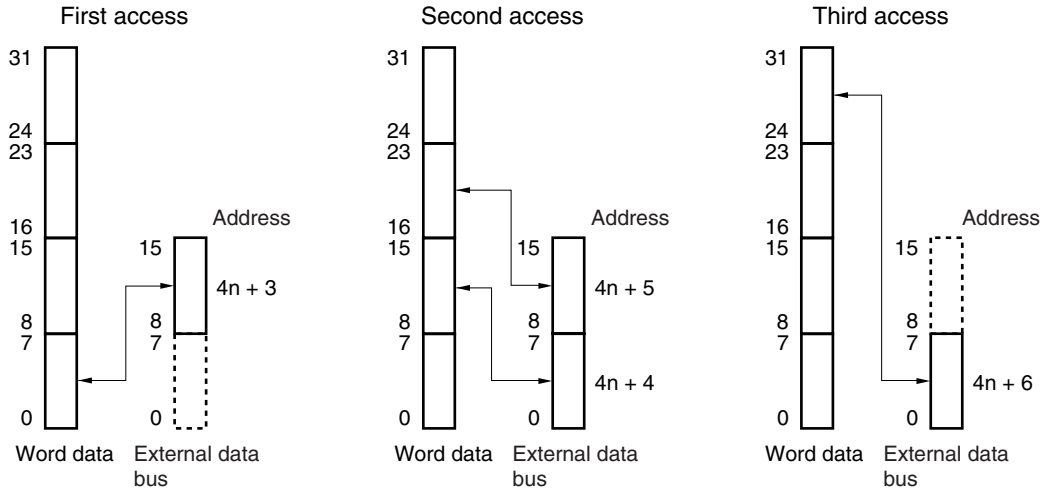


(a) 16-bit data bus width (2/2)

<3> Access to address (4n + 2)

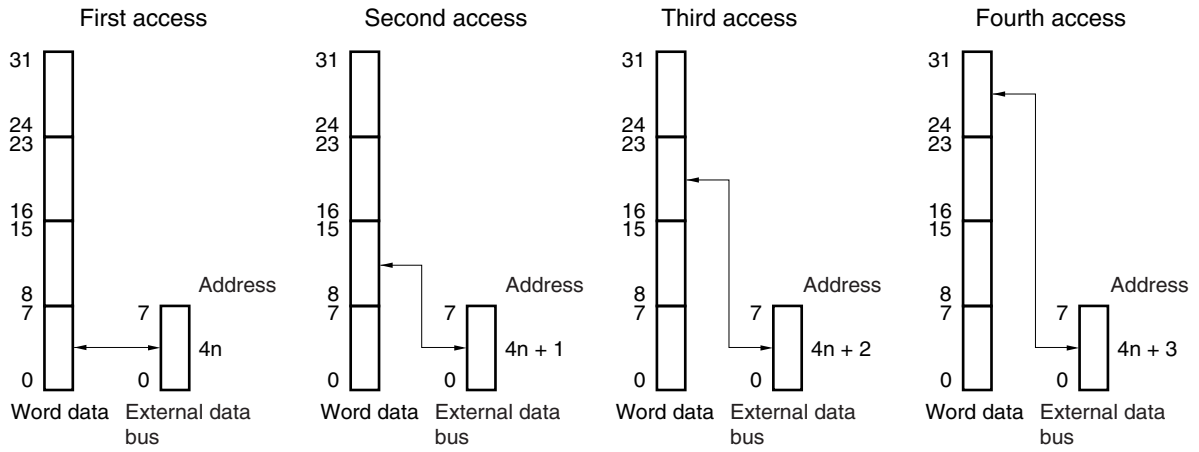


<4> Access to address (4n + 3)

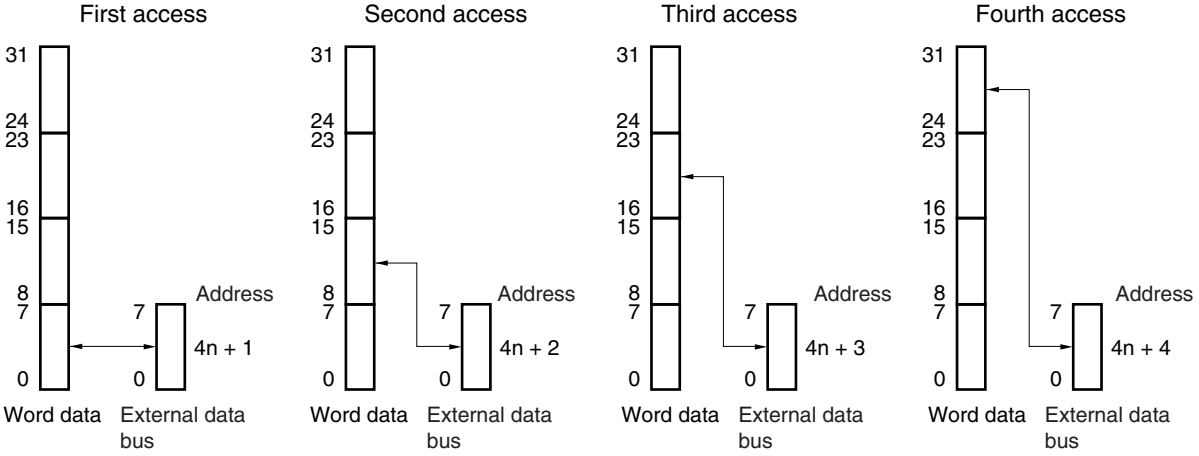


(b) 8-bit data bus width (1/2)

<1> Access to address (4n)

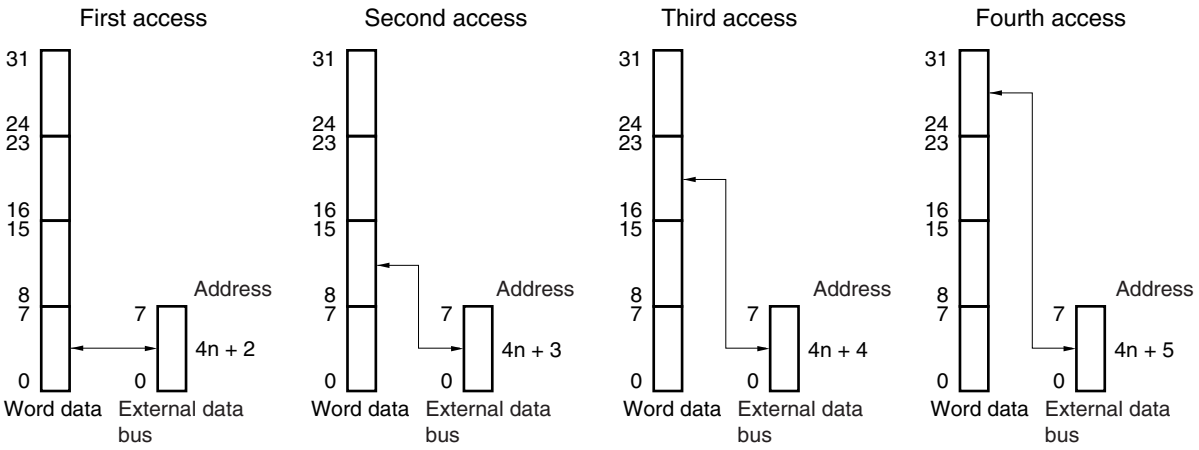


<2> Access to address (4n + 1)

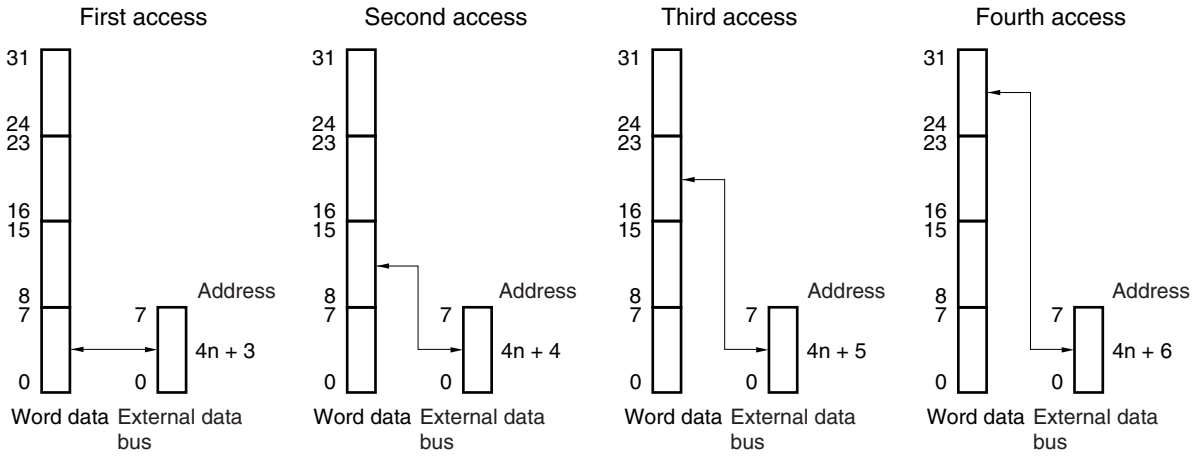


(b) 8-bit data bus width (2/2)

<3> Access to address (4n + 2)



<4> Access to address (4n + 3)



5.5 Wait Function

5.5.1 Programmable wait function

(1) Data wait control register 0 (DWC0)

To realize interfacing with a low-speed memory or I/O, up to seven data wait states can be inserted in the bus cycle that is executed for each CS space.

The number of wait states can be programmed by using the DWC0 register. Immediately after system reset, 7 data wait states are inserted for all the blocks.

The DWC0 register can be read or written in 16-bit units.

Reset sets this register to 7777H.

Cautions 1. The internal ROM and internal RAM areas are not subject to programmable wait, and are always accessed without a wait state. The on-chip peripheral I/O area is also not subject to programmable wait, and only wait control from each peripheral function is performed.

2. Write to the DWC0 register after reset, and then do not change the set values. Also, do not access an external memory area until the initial settings of the DWC0 register are complete.

After reset: 7777H R/W Address: FFFFF484H

	15	14	13	12	11	10	9	8
DWC0	0	DW32	DW31	DW30	0	DW22	DW21	DW20
		$\overline{CS3}$				$\overline{CS2}$		

	7	6	5	4	3	2	1	0
	0	DW12[Note]	DW11[Note]	DW10[Note]	0	DW02	DW01	DW00
						$\overline{CS0}$		

DWn2	DWn1	DWn0	Number of wait states inserted in CSn space (n = 0 to 3)
0	0	0	None
0	0	1	1
0	1	0	2
0	1	1	3
1	0	0	4
1	0	1	5
1	1	0	6
1	1	1	7

Note The DW12 to DW10 bits set wait of access to the USB function area.
It is recommended to set the DW12 to DW10 bits to 001B (1 wait).

Caution Be sure to clear bits 15, 11, 7, and 3 to "0".

5.5.2 External wait function

To synchronize an extremely slow external memory, I/O, or asynchronous system, any number of wait states can be inserted in the bus cycle by using the external wait pin ($\overline{\text{WAIT}}$).

When the P60[Note 1] or PCM0[Note 2] pin is set to its alternate function, the external wait function is enabled.

Access to each area of the internal ROM, internal RAM, and on-chip peripheral I/O is not subject to control by the external wait function, in the same manner as the programmable wait function.

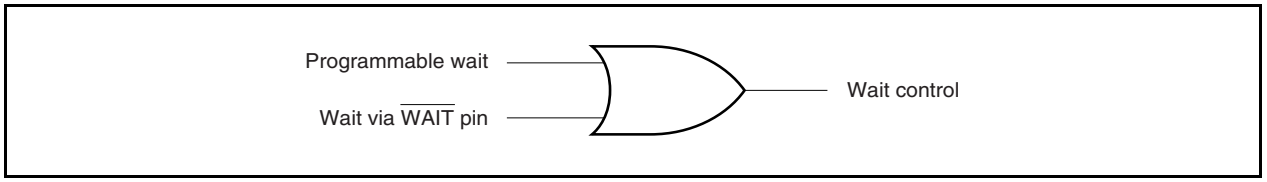
The $\overline{\text{WAIT}}$ signal can be input asynchronously to CLKOUT, and is sampled at the falling edge of the clock in the T2 and TW states of the bus cycle. it is sampled at the rising edge of the clock immediately after the T1 and TW states of the bus cycle. If the setup/hold time of the sampling timing is not satisfied, a wait state is inserted in the next state, or not inserted at all.

Notes 1. V850ES/JG3-H

2. V850ES/JH3-H

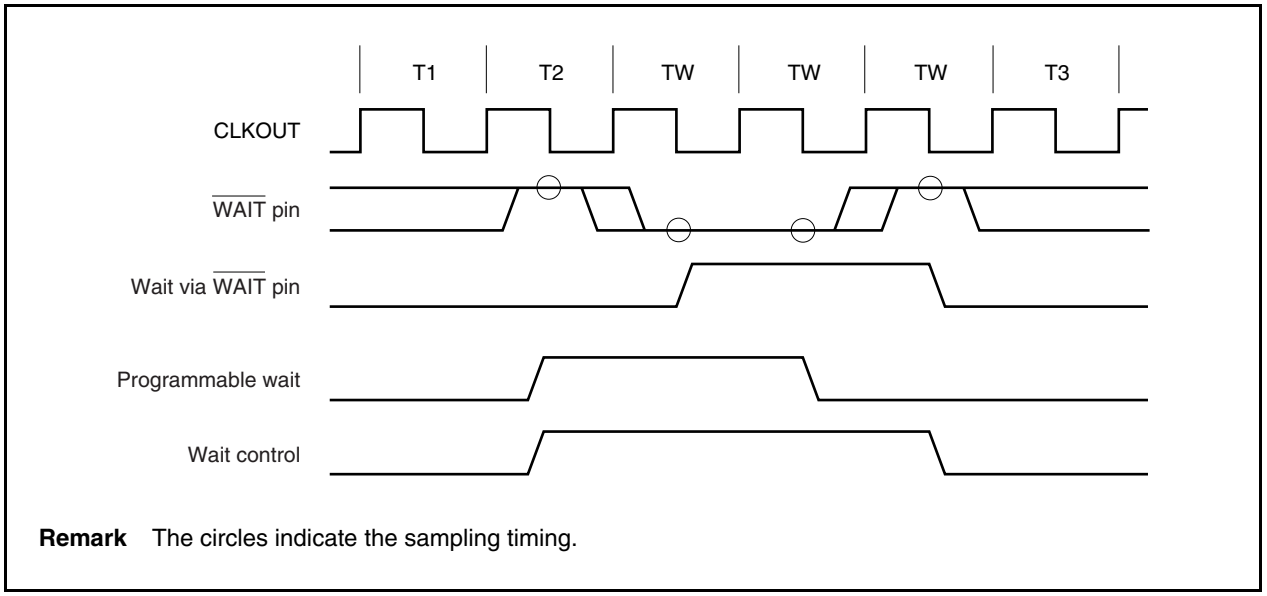
5.5.3 Relationship between programmable wait and external wait

Wait cycles are inserted as the result of an OR operation between the wait cycles specified by the set value of the programmable wait and the wait cycles controlled by the $\overline{\text{WAIT}}$ pin.



For example, if the timing of the programmable wait and the $\overline{\text{WAIT}}$ pin signal is as illustrated below, three wait states will be inserted in the bus cycle.

Figure 5-3. Inserting Wait Example



Remark The circles indicate the sampling timing.

5.5.4 Programmable address wait function

Address-setup or address-hold waits to be inserted in each bus cycle can be set by using the AWC register. Address wait insertion is set for each chip select area ($\overline{CS0}$, $\overline{CS2}$, $\overline{CS3}$).

If an address setup wait is inserted, it seems that the high-clock period of the T1 state is extended by 1 clock. If an address-hold wait is inserted, it seems that the low-clock period of the T1 state is extended by 1 clock.

(1) Address wait control register (AWC)

The AWC register can be read or written in 16-bit units.

Reset sets this register to FFFFH.

Cautions 1. Address-setup wait and address-hold wait cycles are not inserted when the internal ROM area, internal RAM area, and on-chip peripheral I/O areas are accessed.

2. Write to the AWC register after reset, and then do not change the set values. Also, do not access an external memory area until the initial settings of the AWC register are complete.

After reset: FFFFH R/W Address: FFFFF488H

	15	14	13	12	11	10	9	8
AWC	1	1	1	1	1	1	1	1

7	6	5	4	3	2	1	0
AHW3	ASW3	AHW2	ASW2	AHW1Note	ASW1Note	AHW0	ASW0
	$\overline{CS3}$		$\overline{CS2}$				$\overline{CS0}$

AHWn	Specifies insertion of address-hold wait (n = 0 to 3)
0	Not inserted
1	Inserted

ASWn	Specifies insertion of address-setup wait (n = 0 to 3)
0	Not inserted
1	Inserted

Note It is recommended to clear the AHW1 bit and the ASW1 bit to 0.

Caution Be sure to set bits 15 to 8 to "1".

5.6 Idle State Insertion Function

To facilitate interfacing with low-speed memories, one idle state (TI) can be inserted after the T3 state in the bus cycle that is executed for each space selected by the chip select. By inserting an idle state, the data output float delay time of the memory can be secured during read access (an idle state cannot be inserted during write access).

Whether the idle state is to be inserted can be programmed by using the BCC register.

An idle state is inserted for all the areas immediately after system reset.

(1) Bus cycle control register (BCC)

The BCC register can be read or written in 16-bit units.

Reset sets this register to AAAAH.

Cautions 1. The internal ROM, internal RAM, and on-chip peripheral I/O areas are not subject to idle state insertion.

2. Write to the BCC register after reset, and then do not change the set values. Also, do not access an external memory area until the initial settings of the BCC register are complete.

After reset: AAAAH R/W Address: FFFFF48AH

	15	14	13	12	11	10	9	8
BCC	1	0	1	0	1	0	1	0

7	6	5	4	3	2	1	0
BC31	0	BC21	0	BC11[Note]	0	BC01	0
$\overline{CS3}$		$\overline{CS2}$				$\overline{CS0}$	

BCn1	Specifies insertion of idle state (n = 0 to 3)
0	Not inserted
1	Inserted

Note It is recommended to clear the BC11 bit to 0.

Caution Be sure to set bits 15, 13, 11, and 9 to "1", and clear bits 14, 12, 10, 8, 6, 4, 2, and 0 to "0".

5.7 Bus Hold Function (V850ES/JH3-H only)

5.7.1 Functional outline

The $\overline{\text{HLDRQ}}$ and $\overline{\text{HLDAK}}$ functions are valid if the PCM2 and PCM3 pins are set to their alternate function.

When the $\overline{\text{HLDRQ}}$ pin is asserted (low level), indicating that another bus master has requested bus mastership, the external address/data bus goes into a high-impedance state and is released (bus hold status). If the request for the bus mastership is cleared and the $\overline{\text{HLDRQ}}$ pin is deasserted (high level), driving these pins is started again.

During the bus hold period, execution of the program in the internal ROM and internal RAM is continued until an on-chip peripheral I/O register or the external memory is accessed.

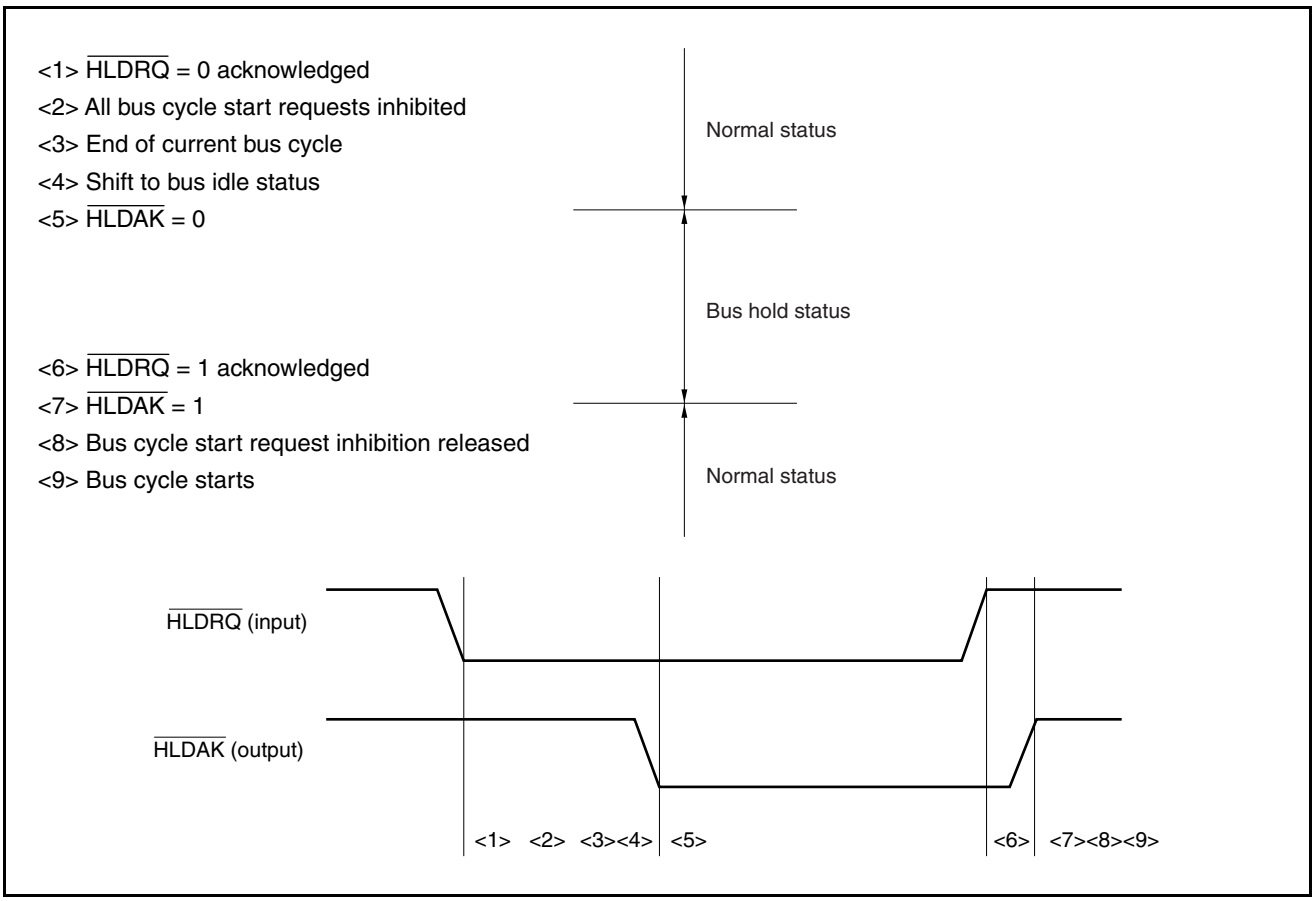
The bus hold status is indicated by assertion of the $\overline{\text{HLDAK}}$ pin (low level). The bus hold function enables the configuration of multi-processor type systems in which two or more bus masters exist.

Note that the bus hold request is not acknowledged during a multiple-access cycle initiated by the bus sizing function or a bit manipulation instruction.

Status	Data Bus Width	Access Type	Timing at Which Bus Hold Request Is Not Acknowledged
CPU bus lock	16 bits	Word access to even address	Between first and second access
		Word access to odd address	Between first and second access
			Between second and third access
		Halfword access to odd address	Between first and second access
	8 bits	Word access	Between first and second access
			Between second and third access
			Between third and fourth access
		Halfword access	Between first and second access
Read-modify-write access of bit manipulation instruction	–	–	Between read access and write access

5.7.2 Bus hold procedure

The bus hold status transition procedure is shown below.



5.7.3 Operation in power save mode

Because the internal system clock is stopped in the STOP, IDLE1, and IDLE2 modes, the bus hold status is not entered even if the $\overline{\text{HLDRQ}}$ pin is asserted.

In the HALT mode, the $\overline{\text{HLDAK}}$ pin is asserted as soon as the $\overline{\text{HLDRQ}}$ pin has been asserted, and the bus hold status is entered. When the $\overline{\text{HLDRQ}}$ pin is later deasserted, the $\overline{\text{HLDAK}}$ pin is also deasserted, and the bus hold status is cleared.

5.8 Bus Priority

Bus hold, DMA transfer, operand data accesses, instruction fetch (branch), and instruction fetch (successive) are executed in the external bus cycle.

Bus hold has the highest priority, followed by DMA transfer, operand data access, instruction fetch (branch), and instruction fetch (successive).

An instruction fetch may be inserted between the read access and write access in a read-modify-write access.

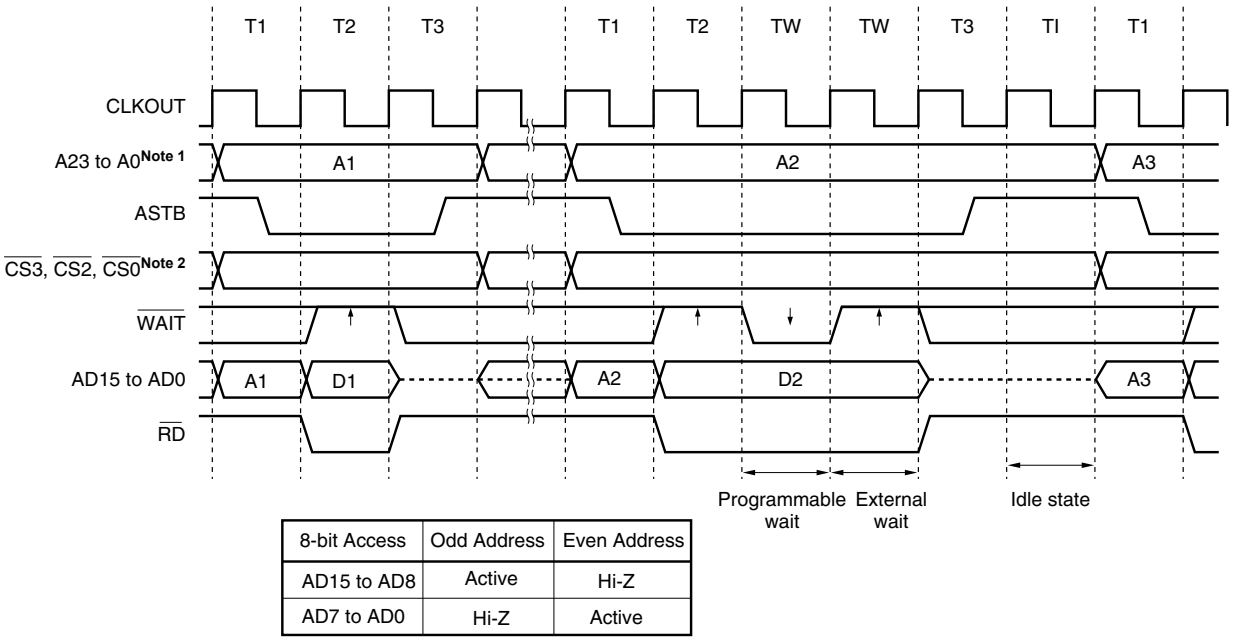
If an instruction is executed for two or more accesses, an instruction fetch and bus hold are not inserted between accesses due to bus size limitations.

Table 5-5. Bus Priority

Priority	External Bus Cycle	Bus Master
High ↕ Low	Bus hold	External device
	DMA transfer	DMAC
	Operand data access	CPU
	Instruction fetch (branch)	CPU
	Instruction fetch (successive)	CPU

5.9 Bus Timing

Figure 5-4. Multiplexed Bus/Separate Bus Output Function Read Timing (Bus Size: 16 Bits, 16-Bit Access)



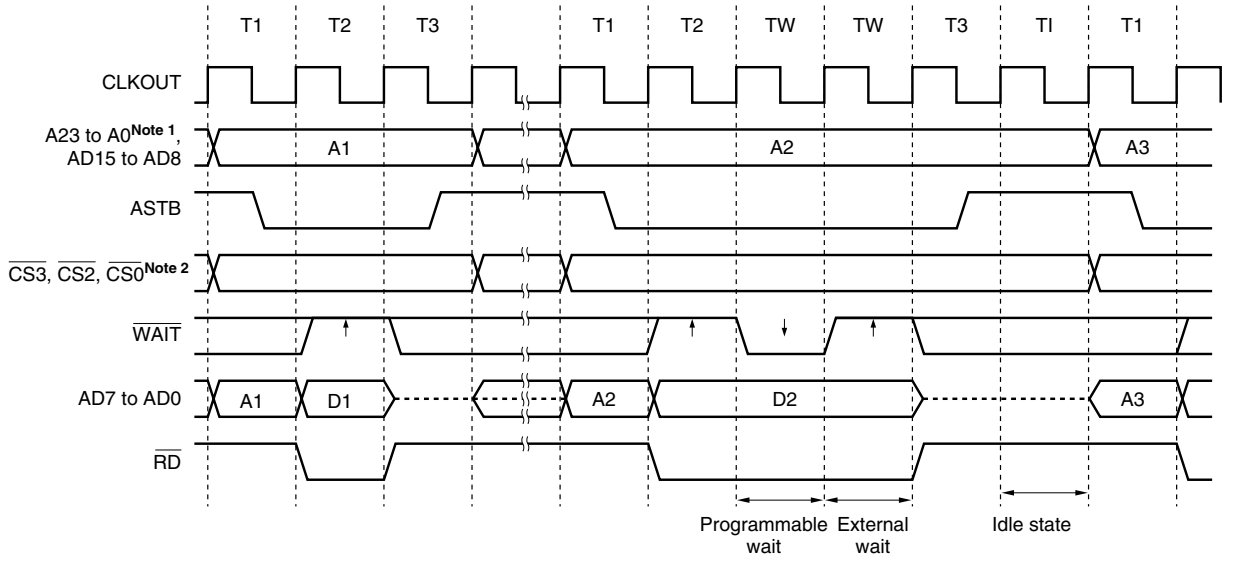
8-bit Access	Odd Address	Even Address
AD15 to AD8	Active	Hi-Z
AD7 to AD0	Hi-Z	Active

Notes 1. V850ES/JH3-H only

2. Only the $\overline{CS}$ space subject to access is active.

Remark The broken lines indicate high impedance.

Figure 5-5. Multiplexed Bus/Separate Bus Output Function Read Timing (Bus Size: 8 Bits)

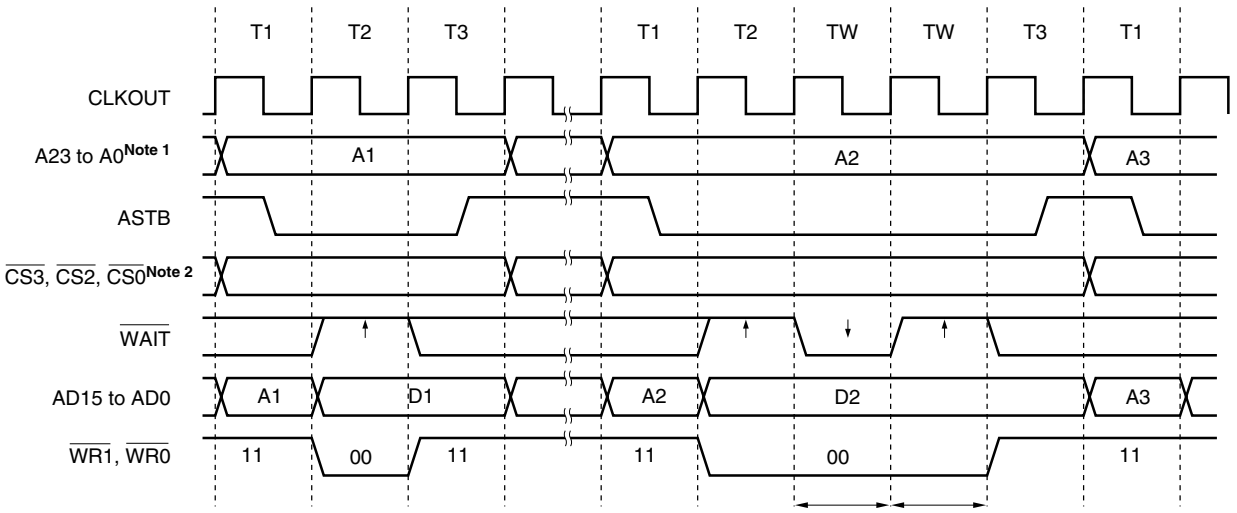


Notes 1. V850ES/JH3-H only

2. Only the $\overline{CS}$ space subject to access is active.

Remark The broken lines indicate high impedance.

Figure 5-6. Multiplexed Bus/Separate Bus Output Function Write Timing (Bus Size: 16 Bits, 16-Bit Access)

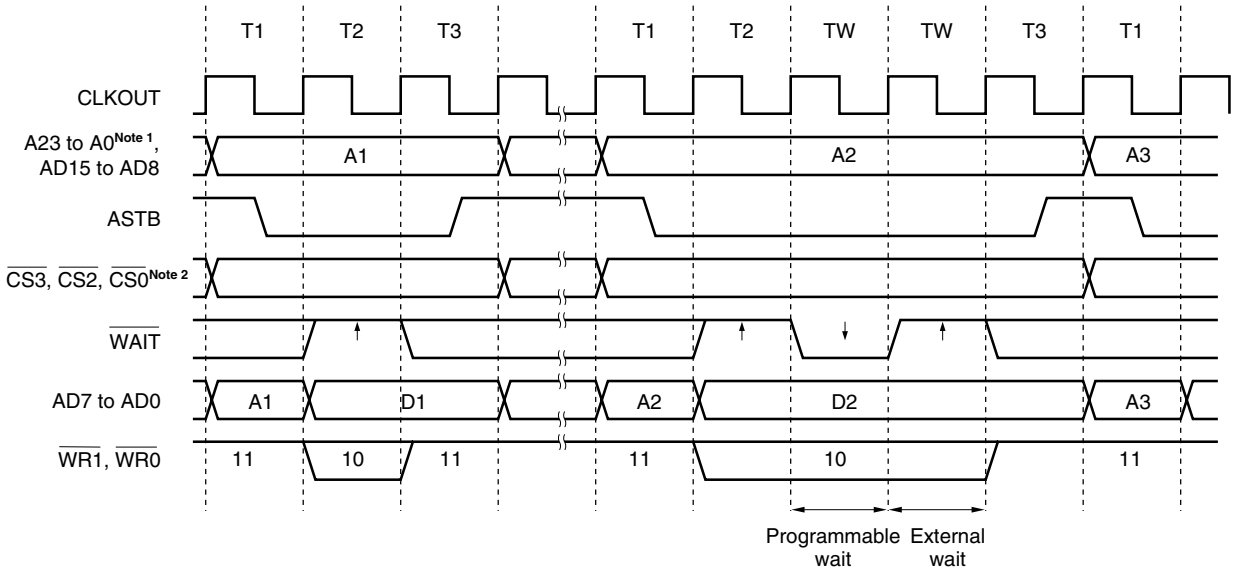


8-bit Access	Odd Address	Even Address
AD15 to AD8	Active	Hi-Z
AD7 to AD0	Undefined	Active
$\overline{WR1}$, $\overline{WR0}$	01	10

Notes 1. V850ES/JH3-H only

2. Only the $\overline{CS}$ space subject to access is active.

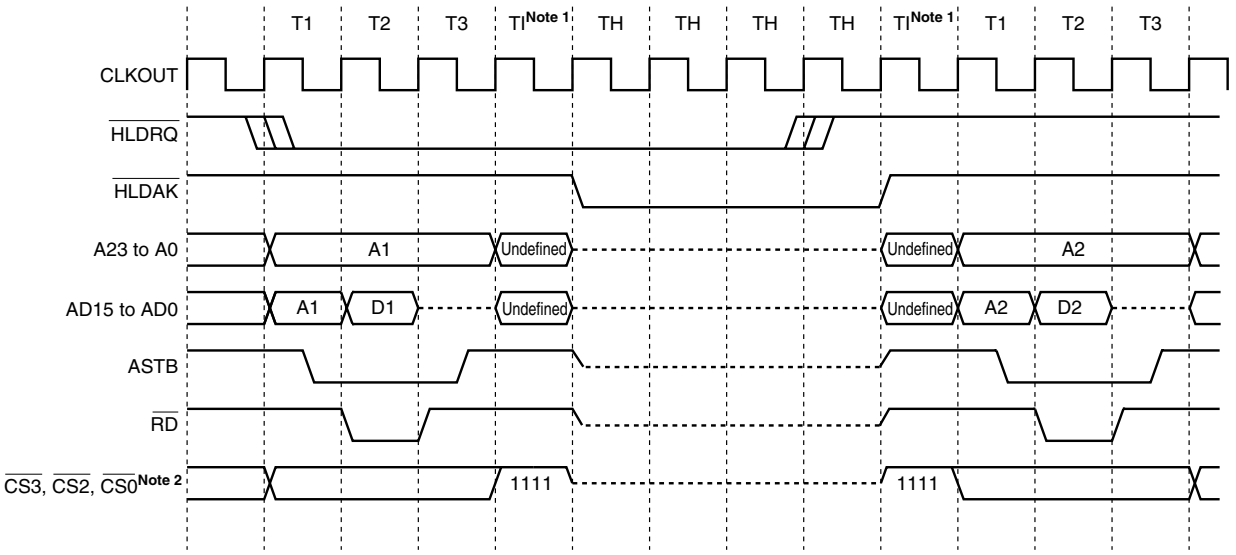
Figure 5-7. Multiplexed Bus/Separate Bus Output Function Write Timing (Bus Size: 8 Bits)



Notes 1. V850ES/JH3-H only

2. Only the $\overline{CS}$ space subject to access is active.

Figure 5-8. Multiplexed Bus/Separate Bus Output Function Hold Timing (Bus Size: 16 Bits, 16-Bit Access) (V850ES/JH3-H only)



Notes 1. This idle state (TI) does not depend on the BCC register settings.

2. Only the $\overline{CS}$ space subject to access is active.

Remarks 1. See **Table 2-2** for the pin statuses in the bus hold mode.

2. The broken lines indicate high impedance.

CHAPTER 6 CLOCK GENERATION FUNCTION

6.1 Overview

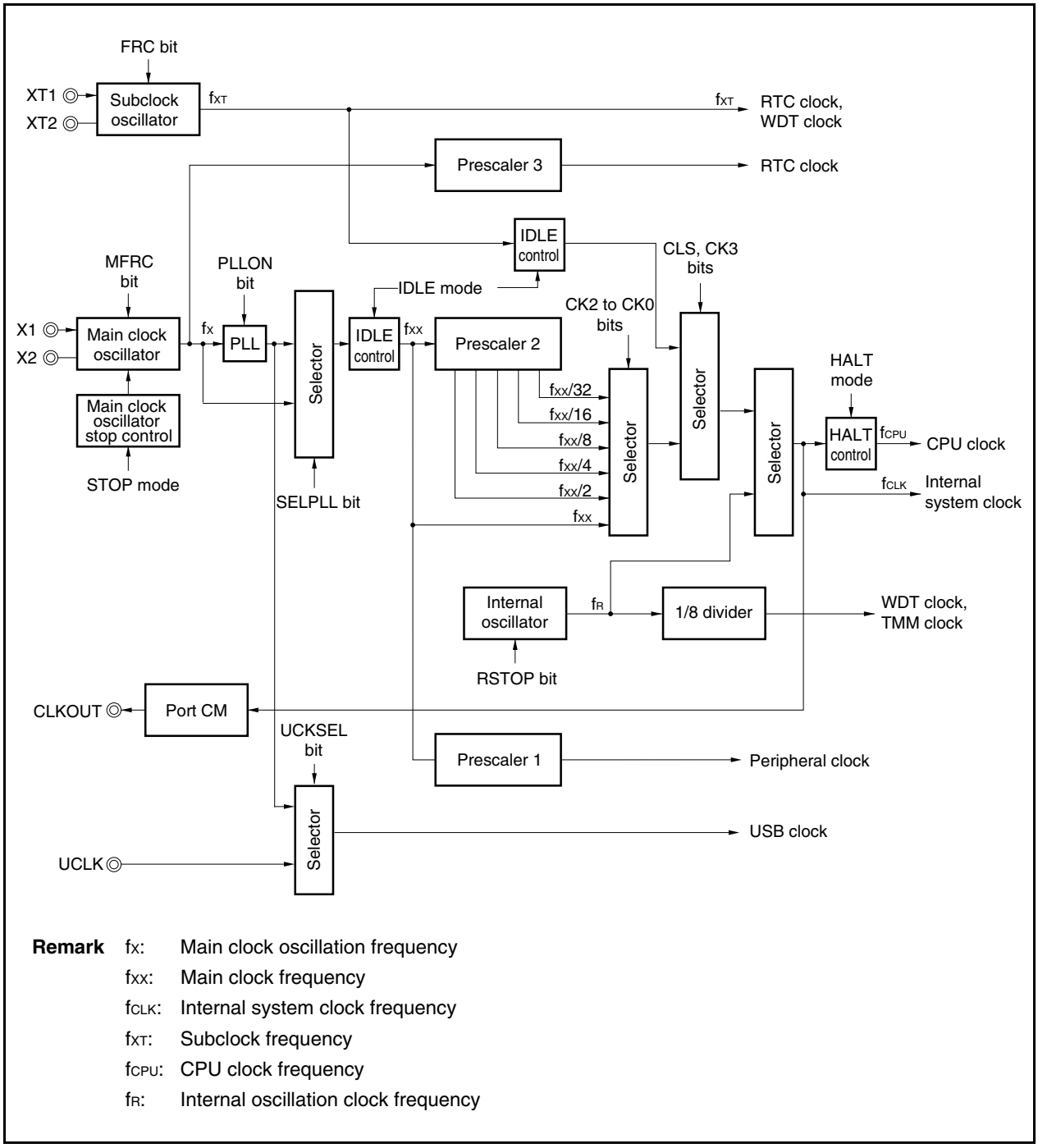
The following clock generation functions are available.

- ○ Main clock oscillator
  - In clock-through mode
    f_X = 3.0 to 6.0 MHz (f_{XX} = 3.0 to 6.0 MHz)
  - In PLL mode
    f_X = 3.0 to 6.0 MHz (×8: f_{XX} = 24 to 48 MHz)
- ○ Subclock oscillator
  - f_{XT} = 32.768 kHz
- ○ Multiply (×8) function by PLL (Phase Locked Loop)
  - Clock-through mode/PLL mode selectable
- ○ Internal oscillator
  - f_R = 220 kHz (TYP.)
- ○ Internal system clock generation
  - 7 steps (f_{XX}, f_{XX}/2, f_{XX}/4, f_{XX}/8, f_{XX}/16, f_{XX}/32, f_{XT})
- ○ Peripheral clock generation
- ○ Clock output function

Remark f_X: Main clock oscillation frequency
f_{XX}: Main clock frequency
f_{XT}: Subclock frequency
f_R: Internal oscillation clock frequency

6.2 Configuration

Figure 6-1. Clock Generator



Remark fx: Main clock oscillation frequency
fxx: Main clock frequency
fCLK: Internal system clock frequency
fXT: Subclock frequency
fCPU: CPU clock frequency
fR: Internal oscillation clock frequency

(1) Main clock oscillator

The main clock oscillator oscillates the following frequencies (f_X).

- In clock-through mode
  f_X = 3.0 to 6.0 MHz
- In PLL mode
  f_X = 3.0 to 6.0 MHz (×8)

(2) Subclock oscillator

The sub-resonator oscillates a frequency of 32.768 kHz (f_{XT}).

(3) Main clock oscillator stop control

This circuit generates a control signal that stops oscillation of the main clock oscillator.
Oscillation of the main clock oscillator is stopped in the STOP mode or when the PCC.MCK bit = 1 (valid only when the PCC.CLS bit = 1).

(4) Internal oscillator

Oscillates a frequency (f_R) of 220 kHz (TYP.).

(5) Prescaler 1

This prescaler generates the clock (f_{XX} to f_{XX}/1,024) to be supplied to the following on-chip peripheral functions: TAA, TAB, TMM, TMT, CSIF, UARTC, I^2C, CAN, ADC, DAC, WDT2

(6) Prescaler 2

This circuit divides the main clock (f_{XX}).
The clock generated by prescaler 2 (f_{XX} to f_{XX}/32) is supplied to the selector that generates the CPU clock (f_{CPU}) and internal system clock (f_{CLK}).
f_{CLK} is the clock supplied to the INTC, ROM, and RAM blocks, and can be output from the CLKOUT pin.

(7) Prescaler 3

This circuit divides the clock generated by the main clock oscillator (f_X) to a specific frequency (32.768 kHz) and supplies that clock to the real-time counter (RTC) block.

(8) PLL

This circuit multiplies the clock generated by the main clock oscillator (f_X) by 8.
It operates in two modes: clock-through mode in which f_X is output as is, and PLL mode in which a multiplied clock is output. These modes can be selected by using the PLLCTL.SELPLL bit.

6.3 Registers

(1) Processor clock control register (PCC)

The PCC register is a special register. Data can be written to this register only in combination of specific sequences (see **3.4.8 Special registers**).

This register can be read or written in 8-bit or 1-bit units.

Reset sets this register to 03H.

After reset: 03H R/W Address: FFFFF828H

	7	<6>	5	<4>	<3>	2	1	0
PCC	FRC	MCK	MFRC	CLS[Note]	CK3	CK2	CK1	CK0

FRC	Use of subclock on-chip feedback resistor
0	Used
1	Not used

MCK	Main clock oscillator control
0	Oscillation enabled
1	Oscillation stopped

- Even if the MCK bit is set (1) while the system is operating with the main clock as the CPU clock, the operation of the main clock does not stop. It stops after the CPU clock has been changed to the subclock.
- Before setting the MCK bit from 0 to 1, stop the on-chip peripheral functions operating with the main clock.
- When the main clock is stopped and the device is operating with the subclock, clear (0) the MCK bit and secure the oscillation stabilization time by software before switching the CPU clock to the main clock or operating the on-chip peripheral functions.

MFRC	Use of main clock on-chip feedback resistor
0	Used
1	Not used

CLS[Note]	Status of CPU clock (f_{CPU})
0	Main clock operation
1	Subclock operation

CK3	CK2	CK1	CK0	Clock selection (f_{CLK}/f_{CPU})
0	0	0	0	f_{XX}
0	0	0	1	$f_{XX}/2$
0	0	1	0	$f_{XX}/4$
0	0	1	1	$f_{XX}/8$
0	1	0	0	$f_{XX}/16$
0	1	0	1	$f_{XX}/32$
0	1	1	×	Setting prohibited
1	×	×	×	f_{XT}

Note The CLS bit is a read-only bit.

Cautions 1. Do not change the CPU clock (by using the CK3 to CK0 bits) while CLKOUT is being output.

2. Use a bit manipulation instruction to manipulate the CK3 bit. When using an 8-bit manipulation instruction, do not change the set values of the CK2 to CK0 bits.

Remark ×: don't care

(a) Example of setting main clock operation → subclock operation

<1> CK3 bit ← 1: Use of a bit manipulation instruction is recommended. Do not change the CK2 to CK0 bits.

<2> Subclock operation: Read the CLS bit to check if subclock operation has started. It takes the following time after the CK3 bit is set until subclock operation is started.

Max.: 1/f_{XT} (1/subclock frequency)

<3> MCK bit ← 1: Set the MCK bit to 1 only when stopping the main clock.

Cautions 1. When stopping the main clock, stop the PLL. Also stop the operations of the on-chip peripheral functions operating with the main clock.

2. If the following conditions are not satisfied, change the CK2 to CK0 bits so that the conditions are satisfied, then change to the subclock operation mode.

Internal system clock (f_{CLK}) > Subclock (f_{XT}: 32.768 kHz) × 4

Remark Internal system clock (f_{CLK}): Clock generated from the main clock (f_{XX}) by setting the CK2 to CK0 bits

[Description example]

```
     _DMA_DISABLE:
     clrl        0, DCHCn[r0]          -- DMA operation disabled.  n = 0 to 3
<1>  _SET_SUB_RUN :
     st.b        r0, PRCMD[r0]
     set1        3, PCC[r0]            -- CK3 bit ← 1
<2>  _CHECK_CLS :
     tst1        4, PCC[r0]            -- Wait until subclock operation starts.
     bz          _CHECK_CLS
<3>  _STOP_MAIN_CLOCK :
     st.b        r0, PRCMD[r0]
     set1        6, PCC[r0]            -- MCK bit ← 1, main clock is stopped.
     _DMA_ENABLE:
     setl        0, DCHCn[r0]          -- DMA operation enabled.  n = 0 to 3
```

Remark The description above is simply an example. Note that in <2> above, the CLS bit is read in a closed loop.

(b) Example of setting subclock operation → main clock operation

<1> MCK bit ← 0: Main clock starts oscillating

<2> Insert waits by the program and wait until the oscillation stabilization time of the main clock elapses.

<3> CK3 bit ← 0: Use of a bit manipulation instruction is recommended. Do not change the CK2 to CK0 bits.

<4> Main clock operation: It takes the following time after the CK3 bit is set until main clock operation is started.

Max.: 1/f_{XT} (1/subclock frequency)

Therefore, insert one NOP instruction immediately after setting the CK3 bit to 0 or read the CLS bit to check if main clock operation has started.

Caution Enable operation of the on-chip peripheral functions operating with the main clock only after the oscillation of the main clock stabilizes. If their operations are enabled before the lapse of the oscillation stabilization time, a malfunction may occur.

[Description example]

```
     _DMA_DISABLE:
     clrl        0, DCHCn[r0]              -- DMA operation disabled.  n = 0 to 3
<1>  _START_MAIN_OSC :
     st.b        r0, PRCMD[r0]             -- Release of protection of special registers
     clr1        6, PCC[r0]                -- Main clock starts oscillating.
<2>  movea       0x55, r0, r11             -- Wait for oscillation stabilization time.
     _WAIT_OST :
     nop
     nop
     nop
     addi        -1, r11, r11
     cmp         r0, r11
     bne                 _WAIT_OST
<3>  st.b        r0, PRCMD[r0]
     clr1        3, PCC[r0]                -- CK3 ← 0
<4>  _CHECK_CLS :
     tst1        4, PCC[r0]                -- Wait until main clock operation starts.
     bnz         _CHECK_CLS
     _DMA_ENABLE:
     setl        0, DCHCn[r0]              -- DMA operation enabled.  n = 0 to 3
```

Remark The description above is simply an example. Note that in <4> above, the CLS bit is read in a closed loop.

(2) Internal oscillation mode register (RCM)

The RCM register is an 8-bit register that sets the operation mode of the internal oscillator.

This register can be read or written in 8-bit or 1-bit units.

Reset sets this register to 00H.

After reset: 00H R/W Address: FFFFF80CH

	7	6	5	4	3	2	1	<0>
RCM	0	0	0	0	0	0	0	RSTOP

RSTOP	Oscillation/stop of internal oscillator
0	Internal oscillator oscillation
1	Internal oscillator stopped

Cautions 1. The internal oscillator cannot be stopped while the CPU is operating on the internal oscillation clock (CCLS.CCLSF bit = 1). Do not set the RSTOP bit to 1.

2. The internal oscillator oscillates if the CCLS.CCLSF bit is set to 1 (when WDT overflow occurs during oscillation stabilization) even when the RSTOP bit is set to 1. At this time, the RSTOP bit remains being set to 1.

(3) CPU operation clock status register (CCLS)

The CCLS register indicates the status of the CPU operation clock.

This register is read-only, in 8-bit or 1-bit units.

Reset sets this register to 00H.

After reset: 00H[Note] R Address: FFFFF82EH

	7	6	5	4	3	2	1	0
CCLS	0	0	0	0	0	0	0	CCLSF

CCLSF	CPU operation clock status
0	Operating on main clock (f_X) or subclock (f_{XT}).
1	Operating on internal oscillation clock (f_R).

Note If WDT overflow occurs during oscillation stabilization after a reset is released, the CCLSF bit is set to 1 and the reset value is 01H.

6.4 Operation

6.4.1 Operation of each clock

The following table shows the operation status of each clock.

Table 6-1. Operation Status of Each Clock

Register Setting and Operation Status / Target Clock	PCC Register								
	CLK Bit = 0, MCK Bit = 0					CLS Bit = 1, MCK Bit = 0		CLS Bit = 1, MCK Bit = 1	
	During Reset	During Oscillation Stabilization Time Count	HALT Mode	IDLE1, IDLE2 Mode	STOP Mode	Subclock Mode	Sub-IDLE Mode	Subclock Mode	Sub-IDLE Mode
Main clock oscillator (f_X)	×	○	○	○	×	○	○	×	×
Subclock oscillator (f_{XT})	○	○	○	○	○	○	○	○	○
CPU clock (f_{CPU})	×	×	×	×	×	○	×	○	×
Internal system clock (f_{CLK})	×	×	○	×	×	○	×	○	×
Main clock (in PLL mode, f_{XX})	×	○Note	○	×	×	○	○	×	×
Peripheral clock (f_{XX} to f_{XX}/1,024)	×	×	○	×	×	○	×	×	×
WT clock (main)	×	○	○	○	×	○	○	×	×
WT clock (sub)	○	○	○	○	○	○	○	○	○
WDT2 clock (internal oscillation)	×	○	○	○	○	○	○	○	○
WDT2 clock (main)	×	×	○	×	×	○	×	×	×
WDT2 clock (sub)	○	○	○	○	○	○	○	○	○

Note Lockup time

Remark ○: Operable
×: Stopped

6.4.2 Clock output function

The clock output function is used to output the internal system clock (f_{CLK}) from the CLKOUT pin.

The internal system clock (f_{CLK}) is selected by using the PCC.CK3 to PCC.CK0 bits.

The CLKOUT pin functions alternately as the PCM1 pin and functions as a clock output pin if so specified by the control register of port CM.

The status of the CLKOUT pin is the same as the internal system clock in Table 6-1 and the pin can output the clock when it is in the operable status. It outputs a low level in the stopped status. However, the CLKOUT pin is in the port mode (PCM1 pin: input mode) after reset and until it is set in the output mode. Therefore, the status of the pin is Hi-Z.

6.5 PLL Function

6.5.1 Overview

In the V850ES/JG3-H and V850ES/JH3-H, an operating clock that is 8 times higher than the oscillation frequency output by the PLL function or the clock-through mode can be selected as the operating clock of the CPU and on-chip peripheral functions.

When PLL function is used (×8): Input clock = 3.0 to 6.0 MHz (output: 24 to 48 MHz)
Clock-through mode: Input clock = 3.0 to 6.0 MHz (output: 3.0 to 6.0 MHz)

6.5.2 Registers

(1) PLL control register (PLLCTL)

The PLLCTL register is an 8-bit register that controls the PLL function.
This register can be read or written in 8-bit or 1-bit units.
Reset sets this register to 01H.

After reset: 01H R/W Address: FFFFF82CH

	7	6	5	4	3	2	<1>	<0>
PLLCTL	0	0	0	0	0	0	SELPLL	PLLON

PLLON	PLL operation stop register
0	PLL stopped
1	PLL operating (After PLL operation starts, a lockup time is required for frequency stabilization)

SELPLL	CPU operation clock selection register
0	Clock-through mode
1	PLL mode

Cautions 1. When the PLLON bit is cleared to 0, the SELPLL bit is automatically cleared to 0 (clock-through mode).

2. The SELPLL bit can be set to 1 only when the PLL clock frequency is stabilized. If not (unlocked), "0" is written to the SELPLL bit if data is written to it.

(2) Clock control register (CKC)

The CKC register is a special register. Data can be written to this register only in a combination of specific sequence (see **3.4.8 Special registers**).

The CKC register controls the internal system clock in the PLL mode.

This register can be read or written in 8-bit or 1-bit units.

Reset sets this register to 0AH.

After reset: 0AH R/W Address: FFFFF822H

	7	6	5	4	3	2	1	0
CKC	0	0	0	0	1	0	1	CKDIV0

CKDIV0	Internal system clock (f_{XX}) in PLL mode
0	Setting prohibited
1	$f_{XX} = 8 \times f_X$ (f_X = 3.0 to 6.0 MHz)

Caution 1. Be sure to set the CKC register to 0BH. When setting this register to a value other than 0BH or leaving it set to its initial value without setting it to 0BH, enabling PLL operation (PLLCTL.SELPLL = 1) is prohibited.

2. Be sure to set bits 3 and 1 to "1" and clear bits 7 to 4 and 2 to "0".

Remark Both the CPU clock and peripheral clock are divided by the CKC register, but only the CPU clock is divided by the PCC register.

(3) Lock register (LOCKR)

Phase lock occurs at a given frequency following power application or immediately after the STOP mode is released, and the time required for stabilization is the lockup time (frequency stabilization time). This state until stabilization is called the lockup status, and the stabilized state is called the locked status.

The LOCKR register includes a LOCK bit that reflects the PLL frequency stabilization status.

This register is read-only, in 8-bit or 1-bit units.

Reset sets this register to 00H.

After reset: 00H R Address: FFFFF824H

	7	6	5	4	3	2	1	<0>
LOCKR	0	0	0	0	0	0	0	LOCK

LOCK	PLL lock status check
0	Locked status
1	Unlocked status

Caution The LOCK register does not reflect the lock status of the PLL in real time. The set/clear conditions are as follows.

[Set conditions]

- Upon system reset[Note]
- In IDLE2 or STOP mode
- Upon setting of PLL stop (clearing of PLLCTL.PLLON bit to 0)
- Upon stopping main clock and using CPU with subclock (setting of PCC.CK3 bit to 1 and setting of PCC.MCK bit to 1)

Note This register is set to 01H by reset and cleared to 00H after the reset has been released and the oscillation stabilization time has elapsed.

[Clear conditions]

- Upon overflow of oscillation stabilization time following reset release (OSTS register default time (see **25.2 (3) Oscillation stabilization time select register (OSTS)**))
- Upon oscillation stabilization timer overflow (time set by OSTS register) following STOP mode release, when the STOP mode was set in the PLL operating status
- Upon PLL lockup time timer overflow (time set by PLLS register) when the PLLCTL.PLLON bit is changed from 0 to 1
- After the setup time inserted upon release of the IDLE2 mode is released (time set by the OSTS register) when the IDLE2 mode is set during PLL operation.

(4) PLL lockup time specification register (PLLS)

The PLLS register is an 8-bit register used to select the PLL lockup time when the PLLCTL.PLLON bit is changed from 0 to 1.

This register can be read or written in 8-bit units.

Reset sets this register to 03H.

After reset: 03H R/W Address: FFFFF6C1H

	7	6	5	4	3	2	1	0
PLLS	0	0	0	0	0	0	PLLS1	PLLS0

PLLS1	PLLS0	Selection of PLL lockup time
0	0	$2^{10}/f_X$
0	1	$2^{11}/f_X$
1	0	$2^{12}/f_X$
1	1	$2^{13}/f_X$ (default value)

Cautions 1. Set so that the lockup time is 800 μs or longer.

2. Do not change the PLLS register setting during the lockup period.

6.5.3 Usage

(1) When PLL is used

- After the reset signal has been released, the PLL operates (PLLCTL.PLLON bit = 1), but because the default mode is the clock-through mode (PLLCTL.SELPLL bit = 0), select the PLL mode (SELPLL bit = 1).
- To enable PLL operation, first set the PLLON bit to 1, and then set the SELPLL bit to 1 after the LOCKR.LOCK bit = 0. To stop the PLL, first select the clock-through mode (SELPLL bit = 0), wait for 8 clocks or more, and then stop the PLL (PLLON bit = 0).
- The PLL stops during transition to the IDLE2 or STOP mode regardless of the setting and is restored from the IDLE2 or STOP mode to the status before transition. The time required for restoration is as follows.

(a) When transiting to the IDLE2 or STOP mode from the clock through mode

- STOP mode: Set the OSTS register so that the oscillation stabilization time is 1 ms (min.) or longer.
- IDLE2 mode: Set the OSTS register so that the setup time is 350 μs (min.) or longer.

(b) When transiting to the IDLE 2 or STOP mode while remaining in the PLL operation mode

- STOP mode: Set the OSTS register so that the oscillation stabilization time is 1 ms (min.) or longer.
- IDLE2 mode: Set the OSTS register so that the setup time is 800 μs (min.) or longer.

When transiting to the IDLE1 mode, the PLL does not stop. Stop the PLL if necessary.

(2) When PLL is not used

- The clock-through mode (SELPLL bit = 0) is selected after the reset signal has been released, but the PLL is operating (PLLON bit = 1) and must therefore be stopped (PLLON bit = 0).

CHAPTER 7 16-BIT TIMER/EVENT COUNTER AA (TAA)

Timer AA (TAA) is 16-bit timer/event counter.
The V850ES/JG3-H and V850ES/JH3-H have TAA0 to TAA5.

7.1 Overview

An overview of TAAn is shown below.

- Clock selection: 8 ways
- Capture/trigger input pins: 2
- External event count input pins[Note]: 1
- External trigger input pin[Note]: 1
- Timer/counter: 1
- Capture/compare registers: 2
  (32-bit capture timer function available by using a cascade connection of TAA0 and TAA1, TAA2 and TAA3.)
- Capture/compare match interrupt request signals: 2
- Timer output pins: 2

Note External event count input pins and external trigger input pins are alternately used as capture/trigger input pins (TIAAm0).

Remark n = 0 to 5, m = 0 to 3, 5

7.2 Functions

TAAn has the following functions.

- Interval timer
- External event counter
- External trigger pulse output
- One-shot pulse output
- PWM output
- Free-running timer
- Pulse width measurement
- Timer-tuned function
- Simultaneous-start function

7.3 Configuration

TAAn includes the following hardware.

Table 7-1. Configuration of TAAn

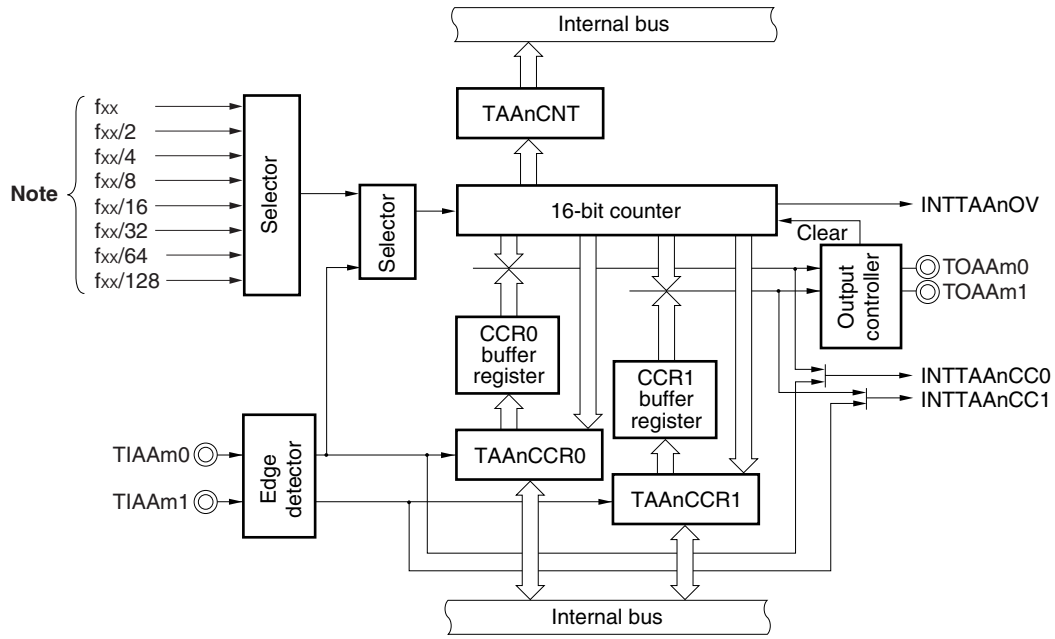
Item	Configuration
Registers	16-bit counter TAAn capture/compare registers 0, 1 (TAAnCCR0, TAAnCCR1) TAAn counter read buffer register (TAAnCNT) CCR0, CCR1 buffer registers TAAn control registers 0, 1 (TAAnCTL0, TAAnCTL1) TAAm I/O control registers 0 to 2, 4 (TAAmIOC0 to TAAmIOC2, TAAmIOC4) TAAm option registers 0, 1 (TAAmOPT0, TAAmOPT1) TAA noise elimination control register (TANFC)
Timer inputs[Note 1]	2 (TIAAm0[Note 2], TIAAm1 pins)
Timer outputs[Note 1]	2 (TOAAm0, TOAAm1 pins)

Notes1. When using the functions of the TIAAm0, TIAAm1, TOAAm0, and TOAAm1 pins, see **Table 4-20 Using Port Pin as Alternate-Function Pin**.

2. The TIAAm0 pin functions alternately as a capture trigger input signal, external event count input signal, and external trigger input signal.

Remark n = 0 to 5, m = 0 to 3, 5

Figure 7-1. Block Diagram of TAAn



Note TAA2, TAA3, TAA5: fxx/2, fxx/4, fxx/8, fxx/16, fxx/64, fxx/256, fxx/512, fxx/1024.

Remark fxx: Main clock frequency
n = 0 to 5, m = 0 to 3, 5

(1) 16-bit counter

This 16-bit counter can count internal clocks or external events.

The count value of this counter can be read by using the TAAnCNT register.

When the TAAnCTL0.TAAnCE bit = 0, the value of the 16-bit counter is FFFFH. If the TAAnCNT register is read at this time, 0000H is read.

Reset sets the TAAnCE bit to 0. Therefore, the 16-bit counter is set to FFFFH.

(2) CCR0 buffer register

This is a 16-bit compare register that compares the count value of the 16-bit counter.

When the TAAnCCR0 register is used as a compare register, the value written to the TAAnCCR0 register is transferred to the CCR0 buffer register. When the count value of the 16-bit counter matches the value of the CCR0 buffer register, a compare match interrupt request signal (INTTAAnCC0) is generated.

The CCR0 buffer register cannot be read or written directly.

Reset clears the TAAnCCR0 register to 0000H. Therefore, the CCR0 buffer register is cleared to 0000H.

(3) CCR1 buffer register

This is a 16-bit compare register that compares the count value of the 16-bit counter.

When the TAAnCCR1 register is used as a compare register, the value written to the TAAnCCR1 register is transferred to the CCR1 buffer register. When the count value of the 16-bit counter matches the value of the CCR1 buffer register, a compare match interrupt request signal (INTTAAnCC1) is generated.

The CCR1 buffer register cannot be read or written directly.

Reset clears the TAAnCCR1 register to 0000H. Therefore, the CCR1 buffer register is cleared to 0000H.

(4) Edge detector

This circuit detects the valid edges input to the TIAAm0 and TIAAm1 pins. No edge, rising edge, falling edge, or both the rising and falling edges can be selected as the valid edge by using the TAAmIOC1 and TAAmIOC2 registers.

(5) Output controller

This circuit controls the output of the TOAAm0 and TOAAm1 pins. The outputs of the TOAAm0 and TOAAm1 pins are controlled by the TAAmIOC0 register.

(6) Selector

This selector selects the count clock for the 16-bit counter. Eight types of internal clocks or an external event can be selected as the count clock.

7.3.1 Pin configuration

The timer inputs and outputs that configure TAAn are shared with the following ports. The port functions must be set when using each pin (see **Table 4-20 When Using Port Pins as Alternate-Function Pins**).

Table 7-2 Pin Configuration

Channel	Port	Timer AA Input	Timer AA Output	Other Alternate Function
TAA0	P32	TIAA00Note 1	TOAA00	ASCK0/$\overline{\text{SCKF4}}$
	P33	TIAA01	TOAA01	RTCDIV/RTCCL
TAA1	P34	TIAA10Note 1	TOAA10	TOAA1OFF/INTP09
	P35	TIAA11	TOAA11	RTC1HZ
TAA2	P97	TIAA20Note 1	TOAA20	SIF1/A7Note 2
	P96	TIAA21	TOAA21	INTP11/A6Note 2
TAA3	P95	TIAA30Note 1	TOAA30	A5Note 2
	P94	TIAA31	TOAA31	TENC00/EVTT0/A4Note 2
TAA4	–	–	–	–
	–	–	–	–
TAA5	P915	TIAA50Note 1	TOAA50	INTP18/A15Note 2
	P914	TIAA51	TOAA51	INTP17/A14Note 2

Notes 1. The TAAm0 pin functions alternately as a capture trigger input function, external event input function, and external trigger input function.

2. V850ES/JH3-H only

Remark TAA4 has neither timer inputs nor outputs. Consequently, only the interval timer function can use TAA4 by itself. However, the 6-phase PWM output function can be achieved by using TAA4 together with TAB1.

7.4 Registers

The registers that control TAAn are as follows.

- TAAn control register 0 (TAAnCTL0)
- TAAn control register 1 (TAAnCTL1)
- TAAn I/O control register 0 (TAAmIOC0)
- TAAn I/O control register 1 (TAAmIOC1)
- TAAn I/O control register 2 (TAAmIOC2)
- TAAn I/O control register 4 (TAAmIOC4)
- TAAn option register 0 (TAAmOPT0)
- TAAn option register 1 (TAAmOPT1)
- TAAn capture/compare register 0 (TAAnCCR0)
- TAAn capture/compare register 1 (TAAnCCR1)
- TAAn counter read buffer register (TAAnCNT)
- TAA noise elimination control register (TANFC)

Remarks 1. When using the functions of the TIAAm0, TIAAm1, TOAAm0, and TOAAm1 pins, see **Table 4-20 Using Port Pin as Alternate-Function Pin**.

2. n = 0 to 5, m = 0 to 3, 5

(1) TAAn control register 0 (TAAnCTL0)

The TAAnCTL0 register is an 8-bit register that controls the operation of TAAn.

This register can be read or written in 8-bit or 1-bit units.

Reset sets this register to 00H.

The same value can always be written to the TAAnCTL0 register by software.

After reset: 00H R/W Address: TAA0CTL0 FFFFF630H, TAA1CTL0 FFFFF640H, TAA2CTL0 FFFFF650H, TAA3CTL0 FFFFF660H, TAA4CTL0 FFFFF670H, TAA5CTL0 FFFFF680H

	7	6	5	4	3	2	1	0
TAAnCTL0 (n = 0 to 5)	TAAnCE	0	0	0	0	TAAnCKS2	TAAnCKS1	TAAnCKS0

TAAnCE	TAAn operation control
0	TAAn operation disabled (TAAn reset asynchronously[Note]).
1	TAAn operation enabled. TAAn operation started.

TAAnCKS2	TAAnCKS1	TAAnCKS0	Internal count clock selection	
			n = 0, 1, 4	n = 2, 3, 5
0	0	0	fxx (20.8 ns)	fxx/2 (41.7 ns)
0	0	1	fxx/2 (41.7 ns)	fxx/4 (83.3 ns)
0	1	0	fxx/4 (83.3 ns)	fxx/8 (166.7 ns)
0	1	1	fxx/8 (166.7 ns)	fxx/16 (333.3 ns)
1	0	0	fxx/16 (333.3 ns)	fxx/64 (1.3333 μs)
1	0	1	fxx/32 (666.7 ns)	fxx/256 (5.3333 μs)
1	1	0	fxx/64 (1.3333 μs)	fxx/512 (10.6667 μs)
1	1	1	fxx/128 (2.6667 μs)	fxx/1024 (21.3333 μs)

Note TAAnOPT0.TAAnOVF bit, 16-bit counter, timer output (TOAAn0, TOAAn1 pins)

Cautions 1. Set the TAAnCKS2 to TAAnCKS0 bits when the TAAnCE bit = 0. When the value of the TAAnCE bit is changed from 0 to 1, the TAAnCKS2 to TAAnCKS0 bits can be set simultaneously.

2. Be sure to set bits 3 to 6 to "0".

Remark fxx: Main clock frequency

The values in parentheses indicate the cycles when fxx = 48 MHz.

(2) TAAn control register 1 (TAAnCTL1)

The TAAnCTL1 register is an 8-bit register that controls the operation of TAAn.

This register can be read or written in 8-bit or 1-bit units.

Reset sets this register to 00H.

(1/2)

After reset: 00H R/W Address: TAA0CTL1 FFFFF631H, TAA1CTL1 FFFFF641H, TAA2CTL1 FFFFF651H, TAA3CTL1 FFFFF661H, TAA4CTL1 FFFFF671H, TAA5CTL1 FFFFF681H

	7	6	5	4	3	2	1	0
TAA0CTL1	TAA0SYE	TAA0EST	TAA0EEE	TAA0SYM	0	TAA0MD2	TAA0MD1	TAA0MD0
TAA1CTL1	0	TAA1EST	TAA1EEE	0	0	TAA1MD2	TAA1MD1	TAA1MD0
TAA2CTL1	TAA2SYE	TAA2EST	TAA2EEE	TAA2SYM	0	TAA2MD2	TAA2MD1	TAA2MD0
TAA3CTL1	0	TAA3EST	TAA3EEE	0	0	TAA3MD2	TAA3MD1	TAA3MD0
TAA4CTL1	TAA4SYE	0	0	TAA4SYM	0	TAA4MD2	TAA4MD1	TAA4MD0
TAA5CTL1	TAA5SYE	TAA5EST	TAA5EEE	TAA5SYM	0	TAA5MD2	TAA5MD1	TAA5MD0

TAAmSYE	TAAmSYM	Tuned operation mode enable control (m = 0, 2, 4, 5)
0	0	Independent operation mode (asynchronous operation mode)
0	1	Setting prohibited
1	0	Tuned-operation function (specification of slave operation)
1	1	Simultaneous-start function (specification of slave timer)

These bits can be set only for the slave timer (setting them for the master timer is prohibited).
The relationship between the master timer and slave timer is as follows.

Master timer	Slave timer
TAA1	TAA0
TAA3	TAA2
TAB0	TAA5
TAB1	TAA4

For the tuned-operation function, see **7.6 Timer-Tuned Operation Function**.
For the simultaneous-start function, see **7.7 Simultaneous-Start Function**.

TAAnEST	Software trigger control (n = 0 to 3, 5)
0	–
1	Generates a valid signal for external trigger input. • In one-shot pulse output mode: A one-shot pulse is output with writing 1 to the TAAnEST bit as the trigger. • In external trigger pulse output mode: A PWM waveform is output with writing 1 to the TAAnEST bit as the trigger.

Cautions 1. The TAAnEST bit is valid only in the external trigger pulse output mode or one-shot pulse output mode. In any other mode, writing 1 to this bit is ignored.

2. Be sure to clear the sections of the TAAnCTL1 register of each channel, where 0 is specified, to 0.

(2/2)

TAAmEEE	Count clock selection
0	Disables operation with external event count input. (Performs counting with the count clock selected by the TAAmCTL0.TAAmCK0 to TAAmCK2 bits.)
1	Enables operation with external event count input. (Performs counting at every valid edge of the external event count input signal.)
The TAAmEEE bit selects whether counting is performed with the internal count clock or the valid edge of the external event count input.	

TAAnMD2	TAAnMD1	TAAnMD0	Timer mode selection
0	0	0	Interval timer mode
0	0	1	External event count mode
0	1	0	External trigger pulse output mode
0	1	1	One-shot pulse output mode
1	0	0	PWM output mode
1	0	1	Free-running timer mode
1	1	0	Pulse width measurement mode
1	1	1	Setting prohibited

Cautions 1. External event count input is selected in the external event count mode regardless of the value of the TAAmEEE bit.

2. Set the TAAmEEE and TAAmMD2 to TAAmMD0 bits when the TAAmCTL0.TAAmCE bit = 0. (The same value can be written when the TAAmCE bit = 1.) The operation is not guaranteed when rewriting is performed with the TAAmCE bit = 1. If rewriting was mistakenly performed, clear the TAAnCE bit to 0 and then set the bits again (m = 0 to 3, 5).

(3) TAAn I/O control register 0 (TAAnIOC0)

The TAAnIOC0 register is an 8-bit register that controls the timer output (TOAAn0, TOAAn1 pins).

This register can be read or written in 8-bit or 1-bit units.

Reset sets this register to 00H.

After reset: 00H R/W Address: TAA0IOC0 FFFFF632H, TAA1IOC0 FFFFF642H, TAA2IOC0 FFFFF652H, TAA3IOC0 FFFFF662H, TAA5IOC0 FFFFF682H

TAAnIOC0 (n = 0 to 3, 5)

7	6	5	4	3	2	1	0
0	0	0	0	TAAnOL1	TAAnOE1	TAAnOL0	TAAnOE0

TAAnOL1	TOAAn1 pin output level setting[Note]
0	TOAAn1 pin output starts at high level
1	TOAAn1 pin output starts at low level

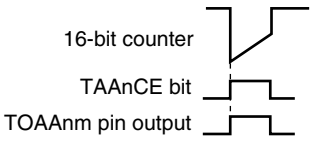
TAAnOE1	TOAAn1 pin output setting
0	Timer output disabled • When TAAnOL1 bit = 0: Low level is output from the TOAAn1 pin • When TAAnOL1 bit = 1: High level is output from the TOAAn1 pin
1	Timer output enabled (a square wave is output from the TOAAn1 pin).

TAAnOL0	TOAAn0 pin output level setting[Note]
0	TOAAn0 pin output starts at high level
1	TOAAn0 pin output starts at low level

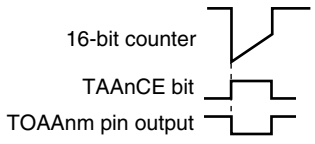
TAAnOE0	TOAAn0 pin output setting
0	Timer output disabled • When TAAnOL0 bit = 0: Low level is output from the TOAAn0 pin • When TAAnOL0 bit = 1: High level is output from the TOAAn0 pin
1	Timer output enabled (a square wave is output from the TOAAn0 pin).

Note The output level of the timer output pin (TOAAnm) specified by the TAAnOLm bit is shown below.

• When TAAnOLm bit = 0



• When TAAnOLm bit = 1



Cautions 1. Rewrite the TAAnOL1, TAAnOE1, TAAnOL0, and TAAnOE0 bits when the TAAnCTL0.TAAnCE bit = 0. (The same value can be written when the TAAnCE bit = 1.) If rewriting was mistakenly performed, clear the TAAnCE bit to 0 and then set the bits again.

2. Even if the TAAnOLm bit is manipulated when the TAAnCE and TAAnOEm bits are 0, the TOAAnm pin output level varies.

Remark m = 0, 1

(4) TAAn I/O control register 1 (TAAnIOC1)

The TAAnIOC1 register is an 8-bit register that controls the valid edge of the capture trigger input signals (TIAAn0, TIAAn1 pins).

This register can be read or written in 8-bit or 1-bit units.

Reset sets this register to 00H.

After reset: 00H R/W Address: TAA0IOC1 FFFFF633H, TAA1IOC1 FFFFF643H, TAA2IOC1 FFFFF653H, TAA3IOC1 FFFFF663H, TAA5IOC1 FFFFF683H

TAAnIOC1 (n = 0 to 3, 5)

7	6	5	4	3	2	1	0
0	0	0	0	TAAnIS3	TAAnIS2	TAAnIS1	TAAnIS0

TAAnIS3	TAAnIS2	Capture trigger input signal (TIAAn1 pin) valid edge setting
0	0	No edge detection (capture operation invalid)
0	1	Detection of rising edge
1	0	Detection of falling edge
1	1	Detection of both edges

TAAnIS1	TAAnIS0	Capture trigger input signal (TIAAn0 pin) valid edge setting
0	0	No edge detection (capture operation invalid)
0	1	Detection of rising edge
1	0	Detection of falling edge
1	1	Detection of both edges

Cautions 1. Rewrite the TAAnIS3 to TAAnIS0 bits when the TAAnCTL0.TAAnCE bit = 0. (The same value can be written when the TAAnCE bit = 1.) If rewriting was mistakenly performed, clear the TAAnCE bit to 0 and then set the bits again.

2. The TAAnIS3 to TAAnIS0 bits are valid only in the free-running timer mode and the pulse width measurement mode. In all other modes, a capture operation is not performed.

(5) TAAn I/O control register 2 (TAAnIOC2)

The TAAnIOC2 register is an 8-bit register that controls the valid edge of the external event count input signal (TIAAn0 pin) and external trigger input signal (TIAAn0 pin).

This register can be read or written in 8-bit or 1-bit units.

Reset sets this register to 00H.

After reset: 00H R/W Address: TAA0IOC2 FFFFF634H, TAA1IOC2 FFFFF644H, TAA2IOC2 FFFFF654H, TAA3IOC2 FFFFF664H. TAA5IOC2 FFFFF684H

TAAnIOC2 (n = 0 to 3, 5)

7	6	5	4	3	2	1	0
0	0	0	0	TAAnEES1	TAAnEES0	TAAnETS1	TAAnETS0

TAAnEES1	TAAnEES0	External event count input signal (TIAAn0 pin) valid edge setting
0	0	No edge detection (external event count invalid)
0	1	Detection of rising edge
1	0	Detection of falling edge
1	1	Detection of both edges

TAAnETS1	TAAnETS0	External trigger input signal (TIAAn0 pin) valid edge setting
0	0	No edge detection (external trigger invalid)
0	1	Detection of rising edge
1	0	Detection of falling edge
1	1	Detection of both edges

Cautions 1. Rewrite the TAAnEES1, TAAnEES0, TAAnETS1, and TAAnETS0 bits when the TAAnCTL0.TAAnCE bit = 0. (The same value can be written when the TAAnCE bit = 1.) If rewriting was mistakenly performed, clear the TAAnCE bit to 0 and then set the bits again.

2. The TAAnEES1 and TAAnEES0 bits are valid only when the TAAnCTL1.TAAnEEE bit = 1 or when the external event count mode (TAAnCTL1.TAAnMD2 to TAAnCTL1.TAAnMD0 bits = 001) has been set.

3. The TAAnETS1 and TAAnETS0 bits are valid only when the external trigger pulse output mode (TAAnCTL1.TAAnMD2 to TAAnCTL1.TAAnMD0 bits = 010) or the one-shot pulse output mode (TAAnCTL1.TAAnMD2 to TAAnCTL1.TAAnMD0 = 011) is set.

(6) TAAn I/O control register 4 (TAAnIOC4)

The TAAnIOC4 register is an 8-bit register that controls the timer output.

This register can be read or written in 8-bit or 1-bit units.

Reset sets this register to 00H. This register is not reset by stopping the timer operation (TAAnCTL0.TAAnCE = 0).

Cautions 1. Accessing the TAAnIOC4 register is prohibited in the following statuses. For details, see 3.4.9 (2) Accessing specific on-chip peripheral I/O registers.

- **When the CPU operates with the subclock and the main clock oscillation is stopped**
- **When the CPU operates with the internal oscillation clock**

2. The TAAnIOC4 register can be set only in the interval timer mode and free-running timer mode. Be sure to set the TAAnIOC4 register to 00H in all other modes (for details of the mode setting, see 7.4 (2) TAAn control register 1 (TAAnCTL1)). The TAAnIOC4 register setting is invalid if the TAAnCCR0 and TAAnCCR1 registers are set to the capture function, even if the free-running timer mode is set.

After reset: 00H R/W Address: TAA0IOC4 FFFFF63CH, TAA1IOC4 FFFFF64CH, TAA2IOC4 FFFFF65CH, TAA3IOC4 FFFFF66CH, TAA5IOC4 FFFFF68CH

	7	6	5	4	3	2	1	0
TAAnIOC4	0	0	0	0	TAAnOS1	TAAnOR1	TAAnOS0	TAAnOR0

(n = 0 to 3, 5)

TAAnOS1	TAAnOR1	Toggle control of TIAAn1 pin
0	0	No request. Normal toggle operation.
0	1	Reset request Fix to inactive level upon next match between value of 16-bit counter and value of TAAnCCR1 register.
1	0	Set request Fix to active level upon next match between value of 16-bit counter and value of TAAnCCR1 register.
1	1	Keep request Keep current output level.

TAAnOS0	TAAnOR0	Toggle control of TIAAn0
0	0	No request. Normal toggle operation.
0	1	Reset request Fix to inactive level upon next match between value of 16-bit counter and value of TAAnCCR0 register.
1	0	Set request Fix to active level upon next match between value of 16-bit counter and value of TAAnCCR0 register.
1	1	Keep request Keep current output level.

(7) TAAn option register 0 (TAAnOPT0)

The TAAnOPT0 register is an 8-bit register used to set the capture/compare operation and detect an overflow.

This register can be read or written in 8-bit or 1-bit units.

Reset sets this register to 00H.

After reset: 00H R/W Address: TAA0OPT0 FFFFF635H, TAA1OPT0 FFFFF645H, TAA2OPT0 FFFFF655H, TAA3OPT0 FFFFF665H, TAA5OPT0 FFFFF685H

	7	6	5	4	3	2	1	0
TAAnOPT0 (n = 0 to 3, 5)	0	0	TAAnCCS1	TAAnCCS0	0	0	0	TAAnOVF

TAAnCCS1	TAAnCCR1 register capture/compare selection
0	Compare register selected
1	Capture register selected
The TAAnCCS1 bit setting is valid only in the free-running timer mode.	

TAAnCCS0	TAAnCCR0 register capture/compare selection
0	Compare register selected
1	Capture register selected
The TAAnCCS0 bit setting is valid only in the free-running timer mode.	

TAAnOVF	TAAn overflow detection flag
Set (1)	Overflow occurred
Reset (0)	0 written to TAAnOVF bit or TAAnCTL0.TAAnCE bit = 0
• The TAAnOVF bit is set to 1 when the 16-bit counter count value overflows from FFFFH to 0000H in the free-running timer mode or the pulse width measurement mode. • An interrupt request signal (INTTAAnOV) is generated at the same time that the TAAnOVF bit is set to 1. The INTTAAnOV signal is not generated in modes other than the free-running timer mode and the pulse width measurement mode. • The TAAnOVF bit is not cleared even when the TAAnOVF bit or the TAAnOPT0 register are read when the TAAnOVF bit = 1. • The TAAnOVF bit can be both read and written, but the TAAnOVF bit cannot be set to 1 by software. Writing 1 has no influence on the operation of TAAn.	

Cautions 1. Rewrite the TAAnCCS1 and TAAnCCS0 bits when the TAAnCE bit = 0. (The same value can be written when the TAAnCE bit = 1.) If rewriting was mistakenly performed, clear the TAAnCE bit to 0 and then set the bits again.

2. Be sure to set bits 1 to 3, 6, and 7 to "0".

(8) TAAn option register 1 (TAAnOPT1)

The TAAnOPT1 register is an 8-bit register that controls the 32-bit capture function realized by a cascade connection.

Rewriting this register is prohibited while the timer is operating (TAAnCTL0.TAAnCE = 1).

This register can be read or written in 8-bit or 1-bit units.

Reset sets this register to 00H.

After reset: 00H R/W Address: TAA0OPT1 FFFFF63DH, TAA2OPT1 FFFFF65DH

	7	6	5	4	3	2	1	0
TAAnOPT1 (n = 0, 2)	TAAnCSE	0	0	0	0	0	0	0

TAAnCSE	Cascade control
0	Individual operation or operation as lower side of cascade function
1	Operation as higher side of cascade function

Cautions 1. Cascade connection and timer-tuned operation cannot be used together. Be sure to set TAAnCTL1.TAAnSYE to 0 for a cascade connection.

2. For a cascade connection, set the free-running timer mode and use the TAAnCCR0 and TAAnCCR1 registers as capture registers.

For details of cascade connection, see 7.8 Cascade Connection.

(9) TAAn capture/compare register 0 (TAAnCCR0)

The TAAnCCR0 register can be used as a capture register or a compare register depending on the mode.

This register can be used as a capture register or a compare register only in the free-running timer mode, depending on the setting of the TAAnOPT0.TAAnCCS0 bit. In the pulse width measurement mode, the TAAnCCR0 register can be used only as a capture register. In any other mode, this register can be used only as a compare register.

The TAAnCCR0 register can be read or written during operation.

This register can be read or written in 16-bit units.

Reset sets this register to 0000H.

Caution Accessing the TAAnCCR0 register is prohibited in the following statuses. For details, see 3.4.9 (2) Accessing specific on-chip peripheral I/O registers.

- **When the CPU operates with the subclock and the main clock oscillation is stopped**
- **When the CPU operates with the internal oscillation clock**

After reset: 0000H R/W Address: TAA0CCR0 FFFFF636H, TAA1CCR0 FFFFF646H,
TAA2CCR0 FFFFF656H, TAA3CCR0 FFFFF666H,
TAA4CCR0 FFFFF676H, TAA5CCR0 FFFFF686H

	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
TAAnCCR0																

(n = 0 to 5)

(a) Function as compare register

The TAAnCCR0 register can be rewritten even when the TAAnCTL0.TAAnCE bit = 1.

The set value of the TAAnCCR0 register is transferred to the CCR0 buffer register. When the value of the 16-bit counter matches the value of the CCR0 buffer register, a compare match interrupt request signal (INTTAAnCC0) is generated. If TOAAn0 pin output is enabled at this time, the output of the TOAAn0 pin is inverted.

When the TAAnCCR0 register is used as a cycle register in the interval timer mode, external event count mode, external trigger pulse output mode, one-shot pulse output mode, or PWM output mode, the value of the 16-bit counter is cleared (0000H) if its count value matches the value of the CCR0 buffer register.

(b) Function as capture register

When the TAAnCCR0 register is used as a capture register in the free-running timer mode, the count value of the 16-bit counter is stored in the TAAnCCR0 register if the valid edge of the capture trigger input pin (TIAAn0 pin) is detected. In the pulse width measurement mode, the count value of the 16-bit counter is stored in the TAAnCCR0 register and the 16-bit counter is cleared (0000H) if the valid edge of the capture trigger input pin (TIAAn0) is detected.

Even if the capture operation and reading the TAAnCCR0 register conflict, the correct value of the TAAnCCR0 register can be read.

The following table shows the functions of the capture/compare register in each mode, and how to write data to the compare register.

Table 7-3. Function of Capture/Compare Register in Each Mode and How to Write Compare Register

Operation Mode	Capture/Compare Register	How to Write Compare Register
Interval timer	Compare register	Anytime write
External event counter	Compare register	Anytime write
External trigger pulse output	Compare register	Batch write
One-shot pulse output	Compare register	Anytime write
PWM output	Compare register	Batch write
Free-running timer	Capture/compare register	Anytime write
Pulse width measurement	Capture register	–

(10) TAAn capture/compare register 1 (TAAnCCR1)

The TAAnCCR1 register can be used as a capture register or a compare register depending on the mode.

This register can be used as a capture register or a compare register only in the free-running timer mode, depending on the setting of the TAAnOPT0.TAAnCCS1 bit. In the pulse width measurement mode, the TAAnCCR1 register can be used only as a capture register. In any other mode, this register can be used only as a compare register.

The TAAnCCR1 register can be read or written during operation.

This register can be read or written in 16-bit units.

Reset sets this register to 0000H.

Caution Accessing the TAAnCCR1 register is prohibited in the following statuses. For details, see 3.4.9 (2) Accessing specific on-chip peripheral I/O registers.

- **When the CPU operates with the subclock and the main clock oscillation is stopped**
- **When the CPU operates with the internal oscillation clock**

After reset: 0000H R/W Address: TAA0CCR1 FFFFF638H, TAA1CCR1 FFFFF648H,
TAA2CCR1 FFFFF658H, TAA3CCR1 FFFFF668H,
TAA4CCR1 FFFFF678H, TAA5CCR1 FFFFF688H

	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
TAAnCCR1																

(n = 0 to 5)

(a) Function as compare register

The TAAnCCR1 register can be rewritten even when the TAAnCTL0.TAAnCE bit = 1.

The set value of the TAAnCCR1 register is transferred to the CCR1 buffer register. When the value of the 16-bit counter matches the value of the CCR1 buffer register, a compare match interrupt request signal (INTTAAnCC1) is generated. If TOAAn1 pin output is enabled at this time, the output of the TOAAn1 pin is inverted.

(b) Function as capture register

When the TAAnCCR1 register is used as a capture register in the free-running timer mode, the count value of the 16-bit counter is stored in the TAAnCCR1 register if the valid edge of the capture trigger input pin (TIAAn1 pin) is detected. In the pulse width measurement mode, the count value of the 16-bit counter is stored in the TAAnCCR1 register and the 16-bit counter is cleared (0000H) if the valid edge of the capture trigger input pin (TIAAn1) is detected.

Even if the capture operation and reading the TAAnCCR1 register conflict, the correct value of the TAAnCCR1 register can be read.

The following table shows the functions of the capture/compare register in each mode, and how to write data to the compare register.

Table 7-4. Function of Capture/Compare Register in Each Mode and How to Write Compare Register

Operation Mode	Capture/Compare Register	How to Write Compare Register
Interval timer	Compare register	Anytime write
External event counter	Compare register	Anytime write
External trigger pulse output	Compare register	Batch write
One-shot pulse output	Compare register	Anytime write
PWM output	Compare register	Batch write
Free-running timer	Capture/compare register	Anytime write
Pulse width measurement	Capture register	–

(11) TAAn counter read buffer register (TAAnCNT)

The TAAnCNT register is a read buffer register that can read the count value of the 16-bit counter.

If this register is read when the TAAnCTL0.TAAnCE bit = 1, the count value of the 16-bit timer can be read.

This register is read-only, in 16-bit units.

The value of the TAAnCNT register is cleared to 0000H when the TAAnCE bit = 0. If the TAAnCNT register is read at this time, the value of the 16-bit counter (FFFFH) is not read, but 0000H is read.

Reset clears the TAAnCE bit to 0. Therefore, the value of the TAAnCNT register is cleared to 0000H.

Caution Accessing the TAAnCNT register is prohibited in the following statuses. For details, see 3.4.9 (2) Accessing specific on-chip peripheral I/O registers.

- **When the CPU operates with the subclock and the main clock oscillation is stopped**
- **When the CPU operates with the internal oscillation clock**

After reset: 0000H R Address: TAA0CNT FFFFF63AH, TAA1CNT FFFFF64AH,
TAA2CNT FFFFF65AH, TAA3CNT FFFFF66AH,
TAA4CNT FFFFF67AH, TAA5CNT FFFFF68AH

	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
TAAnCNT																

(n = 0 to 5)

(12) Noise elimination control register (TANFC)

Digital noise elimination can be selected for the TIAAn0 and TIAAn1 pins. The noise elimination setting is selected using the TANFC register.

When digital noise elimination is selected, the sampling clock for digital sampling can be selected from among fxx and fxx/4. Sampling is performed 3 times.

This register can be read or written in 8-bit units.

Reset sets this register to 00H.

Caution Time equal to the sampling clock × 3 clocks is required until the digital noise eliminator is initialized after the sampling clock has been changed. If the valid edge of TIAAn0 and TIAAn1 is input after the sampling clock has been changed and before the time of the sampling clock × 3 clocks passes, therefore, an interrupt request signal may be generated. Therefore, when using the external trigger function, the external event function, and the capture trigger function of TAA, enable TAA operation after the time of the sampling clock × 3 clocks has elapsed.

Remark n = 0 to 3, 5

After reset: 00H R/W Address: FFFFF724H

	7	6	5	4	3	2	1	0
TANFC	TANFEN	0	0	0	0	0	0	TANFC0

TANFEN	Setting of digital noise elimination
0	Does not perform digital noise elimination
1	Performs digital noise elimination

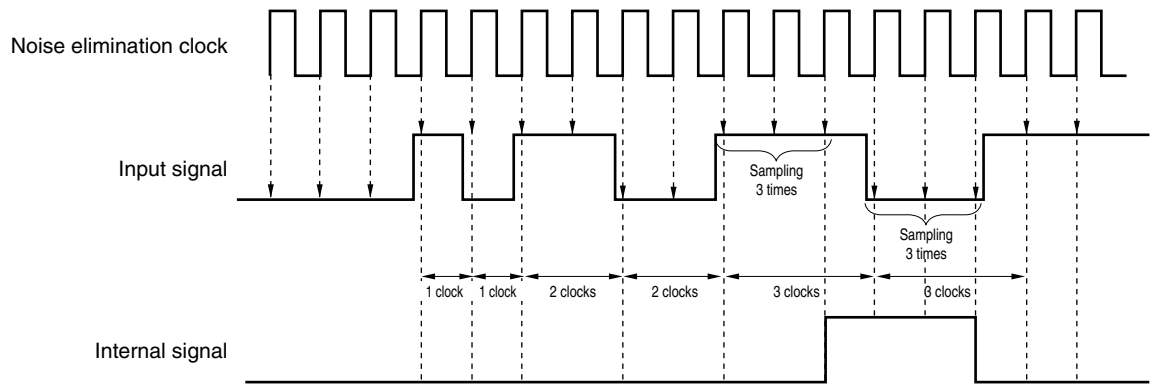
TANFC0	Digital sampling clock
0	fxx
1	fxx/4

Remarks 1. Since sampling is performed 3 times, the noise width for reliably eliminating noise is 2 sampling clocks.

2. In the case of noise with a width smaller than 2 sampling clocks, an interrupt request signal is generated if noise synchronized with the sampling clock is input.

A timing example of noise elimination performed by the timer AA input pin digital filter is shown Figure 7-2.

Figure 7-2. Example of Digital Noise Elimination Timing



Remark If there are two or fewer noise elimination clocks while the TIAAn0 or TIAAn1 input signal is high level (or low level), that input signal is eliminated as noise. If it is sampled three times or more, the edge is detected as a valid input (n = 0 to 3, 5).

7.5 Operation

TAAn can perform the following operations.

Operation	TAAnCTL1.TAAmEST Bit (Software Trigger Bit)	TIAAn0 Pin (External Trigger Input)	Capture/Compare Register Setting	Compare Register Write
Interval timer mode	Invalid	Invalid	Compare only	Anytime write
External event count mode[Note 1]	Invalid	Invalid	Compare only	Anytime write
External trigger pulse output mode[Note 2]	Valid	Valid	Compare only	Batch write
One-shot pulse output mode[Note 2]	Valid	Valid	Compare only	Anytime write
PWM output mode	Invalid	Invalid	Compare only	Batch write
Free-running timer mode	Invalid	Invalid	Switching enabled	Anytime write
Pulse width measurement mode[Note 2]	Invalid	Invalid	Capture only	Not applicable

Notes 1. To use the external event count mode, specify that the valid edge of the TIAAn0 pin capture trigger input is not detected (by clearing the TAAnIOC1.TAAnIS1 and TAAnIOC1.TAAnIS0 bits to “00”).

2. When using the external trigger pulse output mode, one-shot pulse output mode, and pulse width measurement mode, select the internal clock as the count clock (by clearing the TAAnCTL1.TAAnEEE bit to 0).

Remark n = 0 to 3, 5

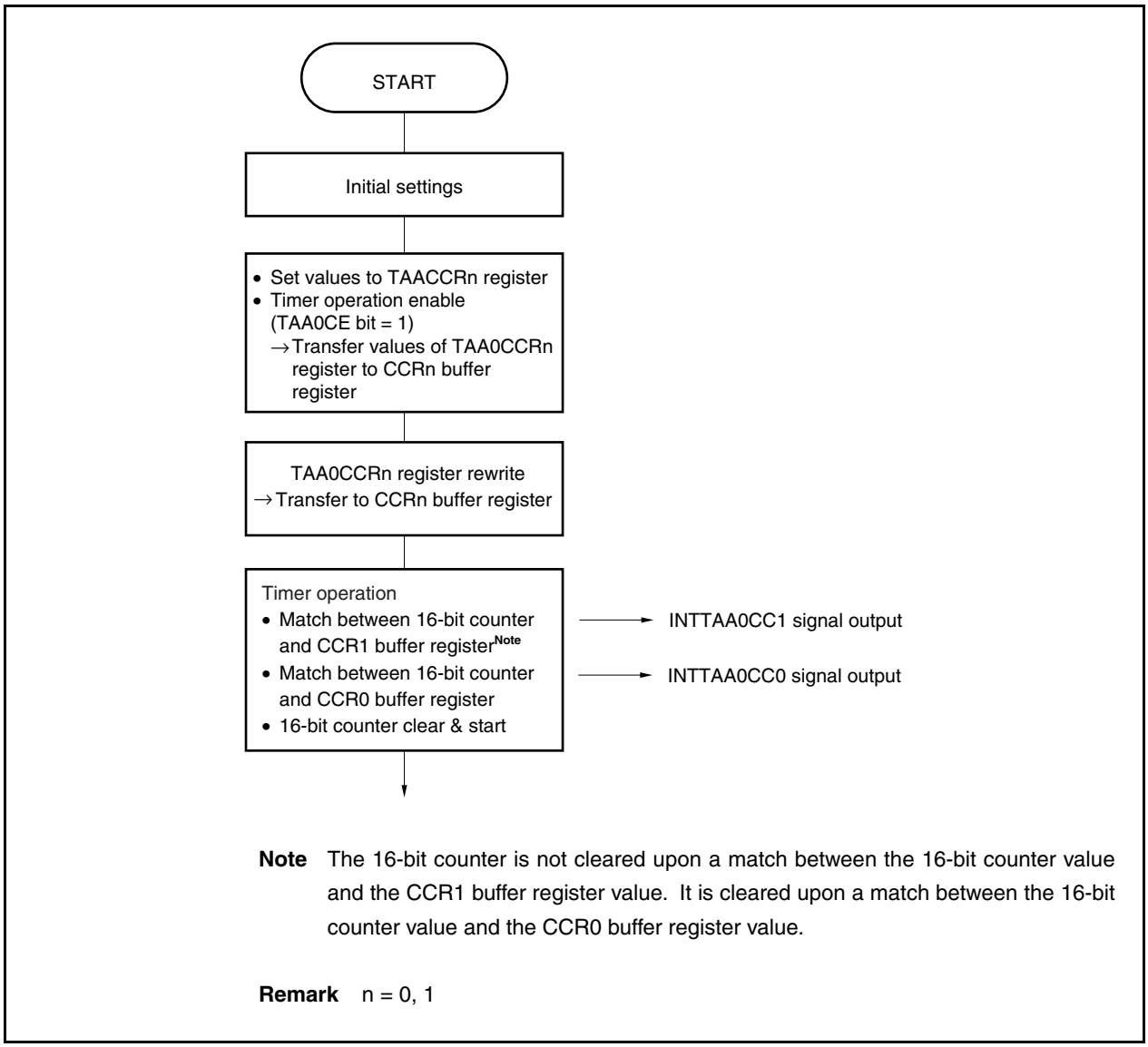
(1) Anytime write and batch write

With TAAn, the TAAnCCR0 and TAAnCCR1 registers can be rewritten during timer operation (TAAnCTL0.TAAnCE bit = 1), but the write method (anytime write, batch write) of the CCR0 and CCR1 buffer registers differs depending on the mode.

(a) Anytime write

In this mode, data is transferred at any time from the TAAnCCR0 and TAAnCCR1 registers to the CCR0 and CCR1 buffer registers during timer operation.

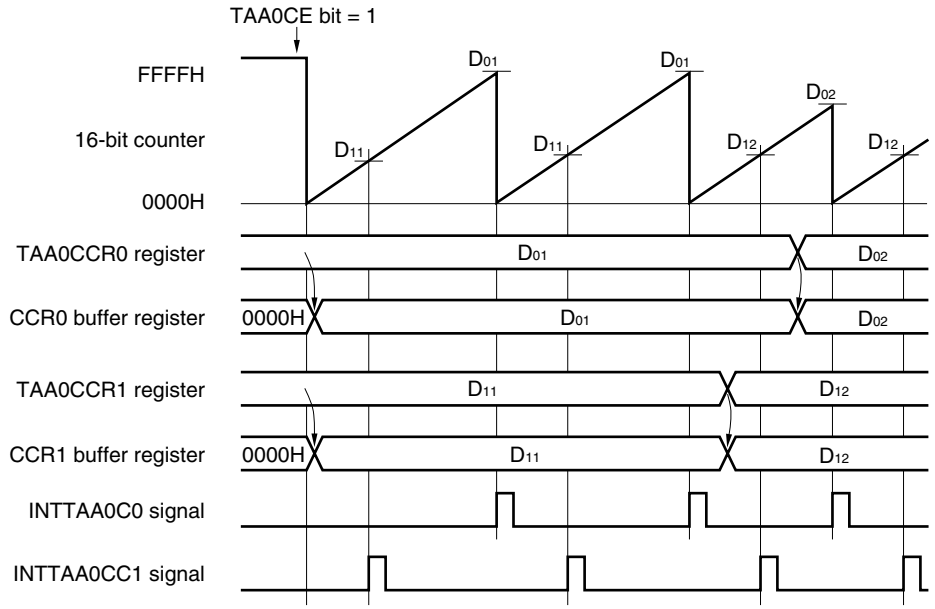
Figure 7-3. Example of Basic Anytime Write Operation Flowchart (Interval Timer Mode of TAA0)



Note The 16-bit counter is not cleared upon a match between the 16-bit counter value and the CCR1 buffer register value. It is cleared upon a match between the 16-bit counter value and the CCR0 buffer register value.

Remark n = 0, 1

Figure 7-4. Example of Anytime Write Timing (Interval Timer Mode of TAA0)



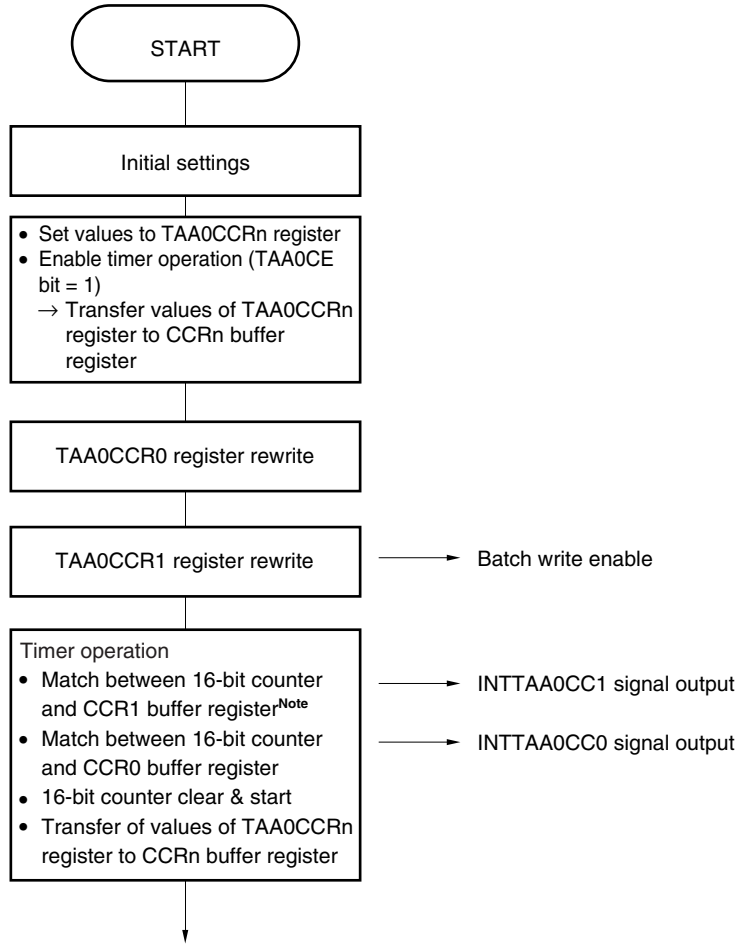
Remark D_{01}, D_{02}: Set values of TAA0CCR0 register
D_{11}, D_{12}: Set values of TAA0CCR1 register

(b) Batch write

In this mode, data is transferred all at once from the TAAnCCR0 and TAAnCCR1 registers to the CCR0 and CCR1 buffer registers during timer operation. This data is transferred upon a match between the value of the CCR0 buffer register and the value of the 16-bit counter. Transfer is enabled by writing to the TAAnCCR1 register. Whether to enable or disable the next transfer timing is controlled by writing or not writing to the TAAnCCR1 register.

In order for the set value when the TAAnCCR0 and TAAnCCR1 registers are rewritten to become the 16-bit counter comparison value (in other words, in order for this value to be transferred to the CCR0 and CCR1 buffer registers), it is necessary to rewrite the TAAnCCR0 register and then write to the TAAnCCR1 register before the 16-bit counter value and the CCR0 buffer register value match. Therefore, the values of the TAAnCCR0 and TAAnCCR1 registers are transferred to the CCR0 and CCR1 buffer registers upon a match between the count value of the 16-bit counter and the value of the CCR0 buffer register. Thus even when wishing only to rewrite the value of the TAAnCCR0 register, also write the same value (same as preset value of the TAAnCCR1 register) to the TAAnCCR1 register.

Figure 7-5. Example of Basic Batch Write Operation Flowchart (PWM Output Mode of TAA0)

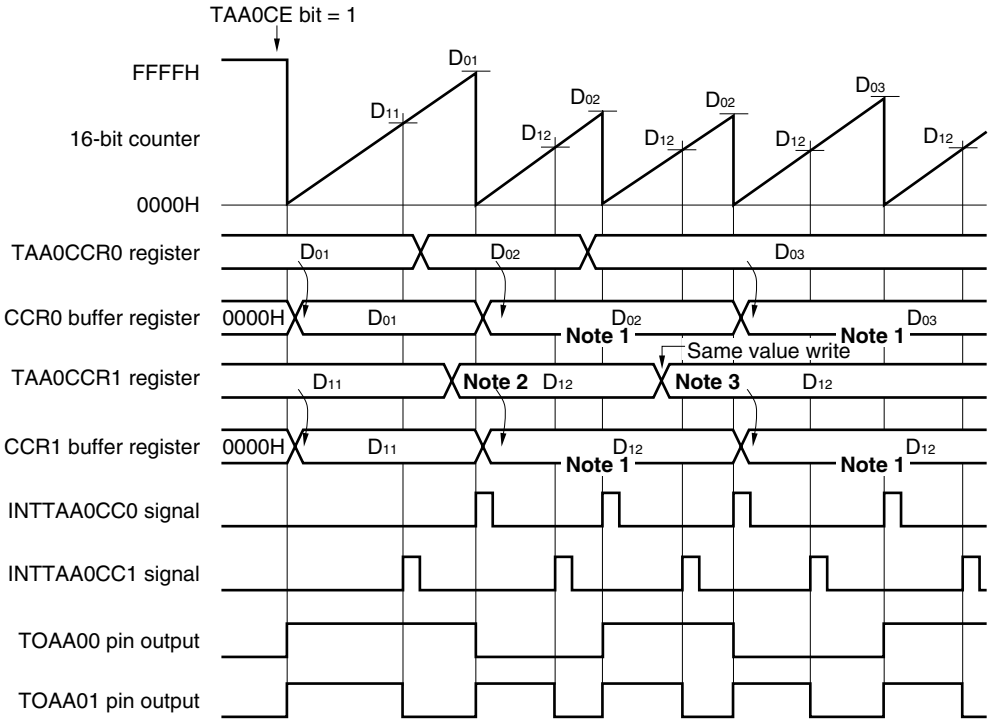


Note The 16-bit counter is not cleared upon a match between the 16-bit counter value and the CCR1 buffer register value. It is cleared upon a match between the 16-bit counter value and the CCR0 buffer register value.

Caution Writing to the TAA0CCR1 register includes enabling of batch write. Thus, rewrite the TAA0CCR1 register after rewriting the TAA0CCR0 register.

Remark n = 0, 1

Figure 7-6. Timing of Batch Write (Interval Timer Mode of TAA0)



Notes 1. Because the TAA0CCR1 register was not rewritten, D_{03} is not transferred.

2. Because the TAA0CCR1 register has been written (D_{12}), data is transferred to the CCR1 buffer register upon a match between the value of the 16-bit counter and the value of the TAA0CCR0 register (D_{01}).

3. Because the TAA0CCR1 register has been written (D_{12}), data is transferred to the CCR1 buffer register upon a match between the value of the 16-bit counter and the value of the TAA0CCR0 register (D_{02}).

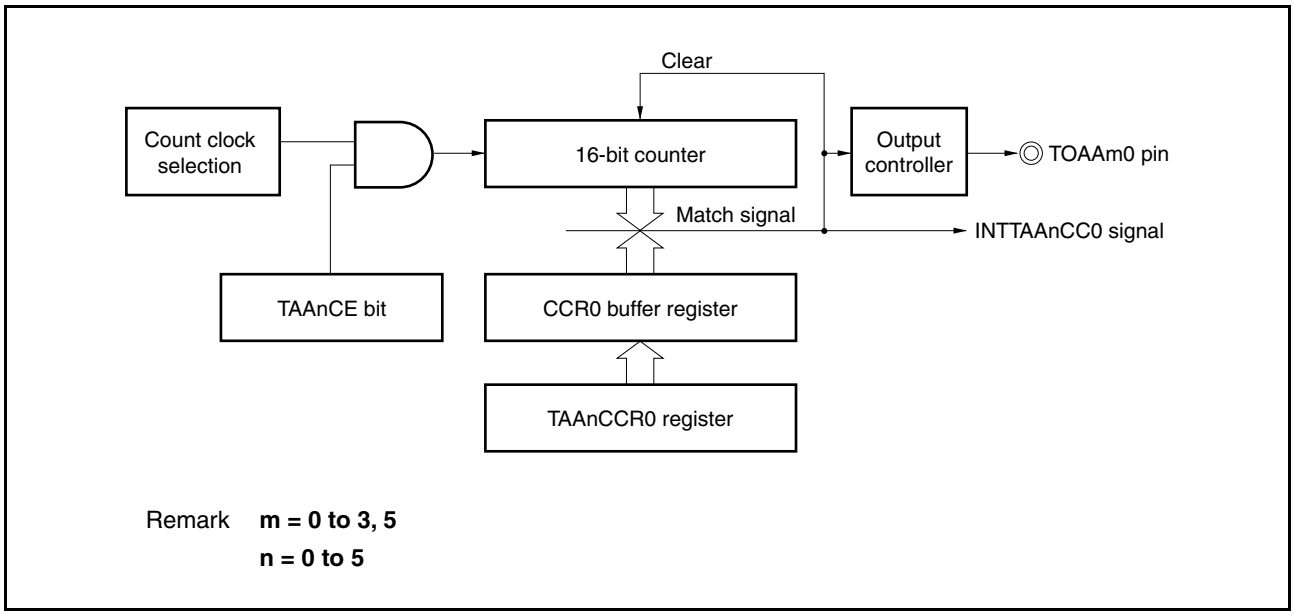
Remark D_{01}, D_{02}, D_{03}: Set values of TAA0CCR0 register
D_{11}, D_{12}: Set values of TAA0CCR1 register

7.5.1 Interval timer mode (TAAmMD2 to TAAmMD0 bits = 000)

In the interval timer mode, an interrupt request signal (INTTAAnCC0) is generated at any interval if the TAAnCTL0.TAAnCE bit is set to 1. A square wave whose half cycle is equal to the interval can be output from the TOAAn0 pin.

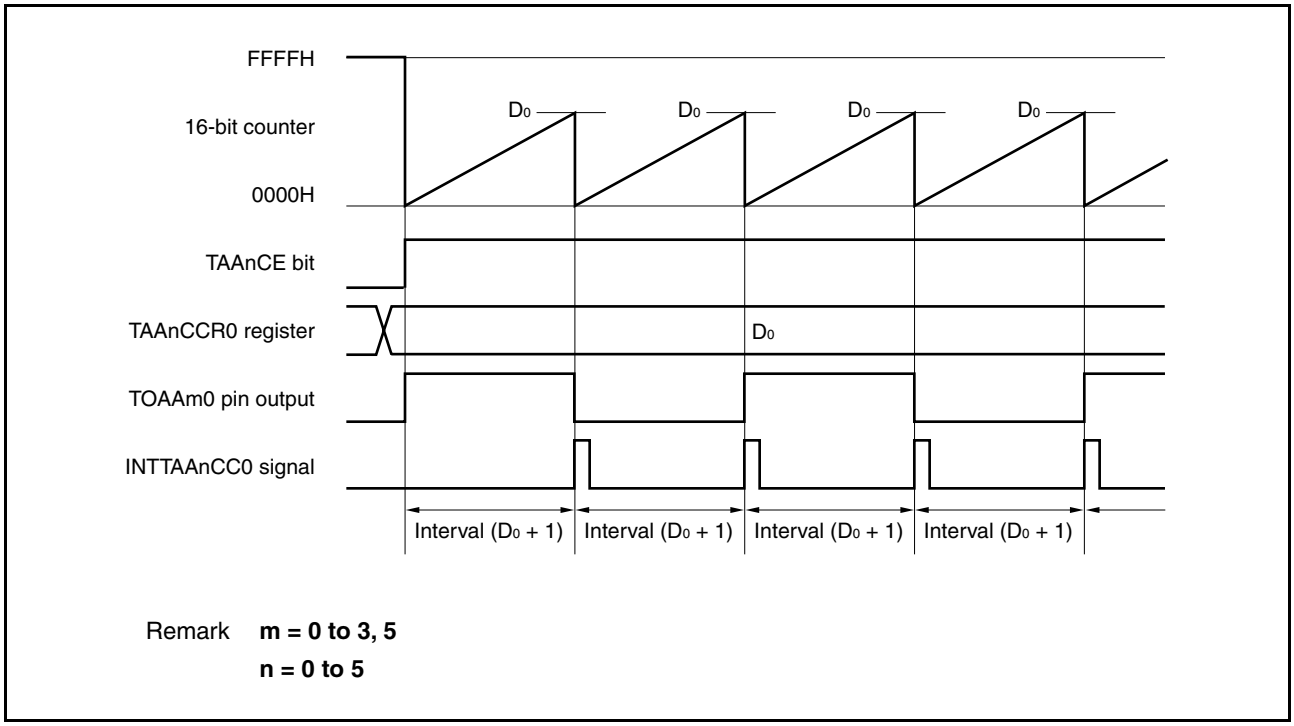
Usually, the TAAnCCR1 register is not used in the interval timer mode.

Figure 7-7. Configuration of Interval Timer



Remark **m = 0 to 3, 5**
n = 0 to 5

Figure 7-8. Basic Timing of Operation in Interval Timer Mode



Remark **m = 0 to 3, 5**
n = 0 to 5

When the TAAnCE bit is set to 1, the value of the 16-bit counter is cleared from FFFFH to 0000H in synchronization with the count clock, and the counter starts counting. At this time, the output of the TOAAn0 pin is inverted. Additionally, the set value of the TAAnCCR0 register is transferred to the CCR0 buffer register.

When the count value of the 16-bit counter matches the value of the CCR0 buffer register, the 16-bit counter is cleared to 0000H, the output of the TOAAn0 pin is inverted, and a compare match interrupt request signal (INTTAAnCC0) is generated.

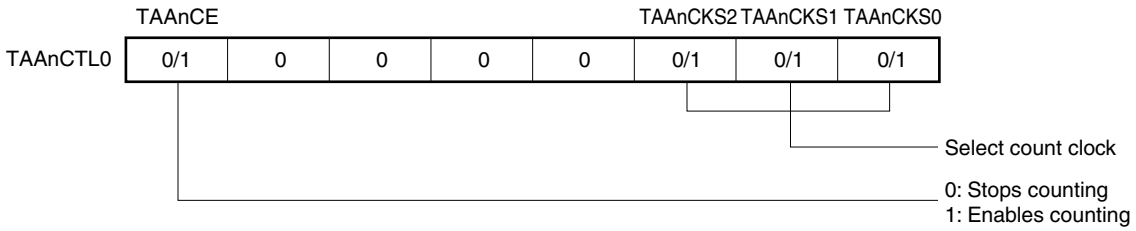
The interval can be calculated by the following expression.

Interval = (Set value of TAAnCCR0 register + 1) × Count clock cycle

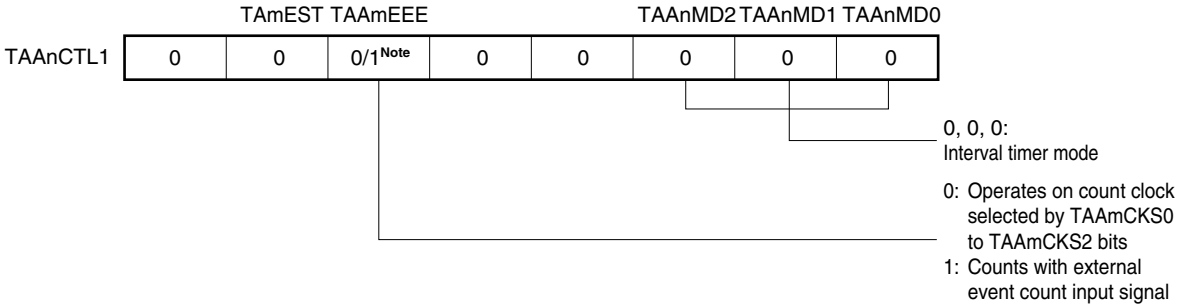
Remark m = 0 to 3, 5
n = 0 to 5

Figure 7-9. Register Settings for Interval Timer Mode Operation (1/2)

(a) TAAn control register 0 (TAAnCTL0)



(b) TAAn control register 1 (TAAnCTL1)

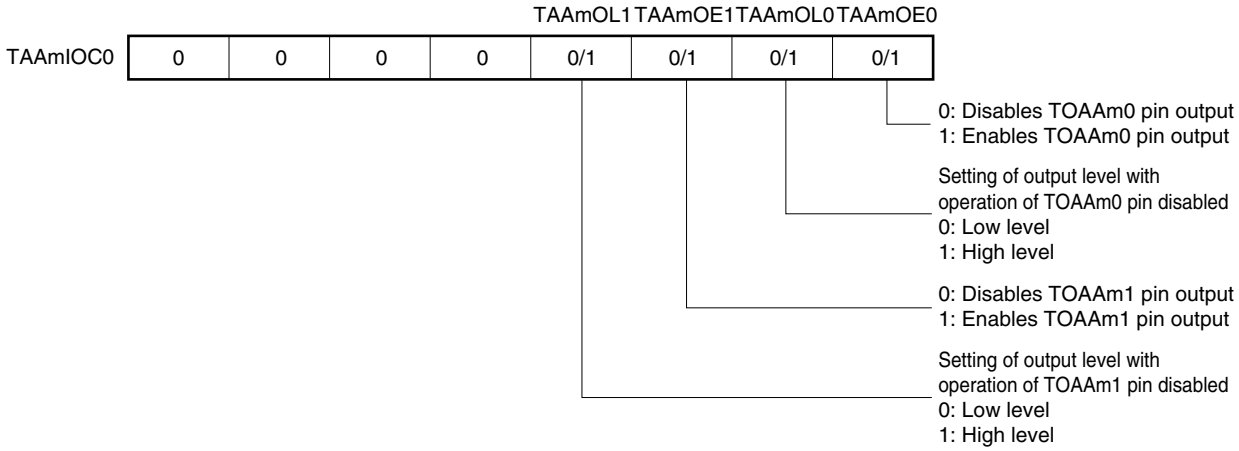


Note **This bit can be set to 1 only when the interrupt request signals (INTTAAmCC0 and INTTAAmCC1) are masked by the interrupt mask flags (TAAmCCMK0 and TAAmCCMK1) and timer output (TOAAm1) is performed. However, set the TAAmCCR0 and TAAmCCR1 registers to the same value (see** 7.5.1 (2) (d) Operation of TAAnCCR1 register**).**

Remark **m = 0 to 3, 5**
n = 0 to 5

Figure 7-9. Register Settings for Interval Timer Mode Operation (2/2)

(c) TAAm I/O control register 0 (TAAmIOC0)



(d) TAAn counter read buffer register (TAAnCNT)

By reading the TAAnCNT register, the count value of the 16-bit counter can be read.

(e) TAAn capture/compare register 0 (TAAnCCR0)

If the TAAnCCR0 register is set to D_0, the interval is as follows.

Interval = (D_0 + 1) × Count clock cycle

(f) TAAn capture/compare register 1 (TAAnCCR1)

Usually, the TAAnCCR1 register is not used in the interval timer mode. However, the set value of the TAAnCCR1 register is transferred to the CCR1 buffer register. A compare match interrupt request signal (INTTAAnCC1) is generated when the count value of the 16-bit counter matches the value of the CCR1 buffer register.

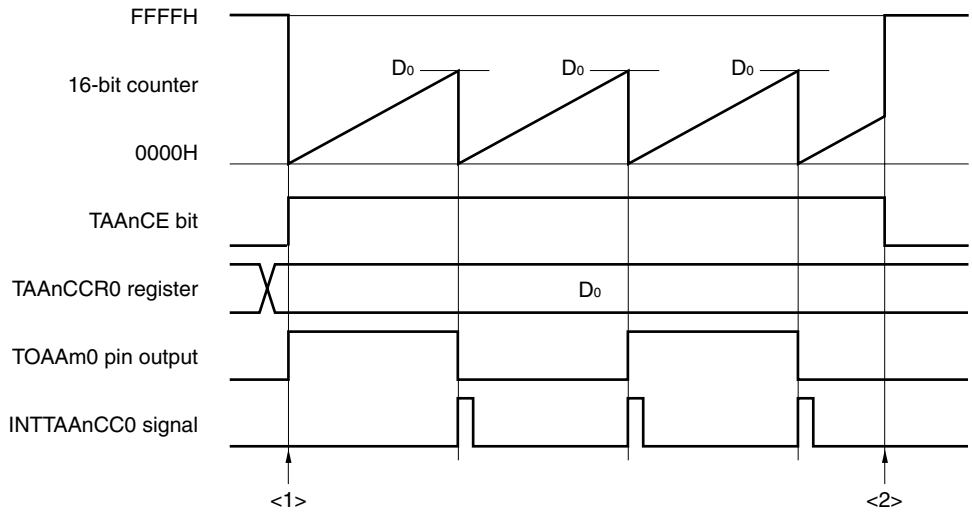
Therefore, mask the interrupt request by using the corresponding interrupt mask flag (TAAnCCMK1).

Remarks 1. **TAAm I/O control register 1 (TAAmIOC1), TAAm I/O control register 2 (TAAmIOC2), and TAAm option register 0 (TAAmOPT0) are not used in the interval timer mode.**

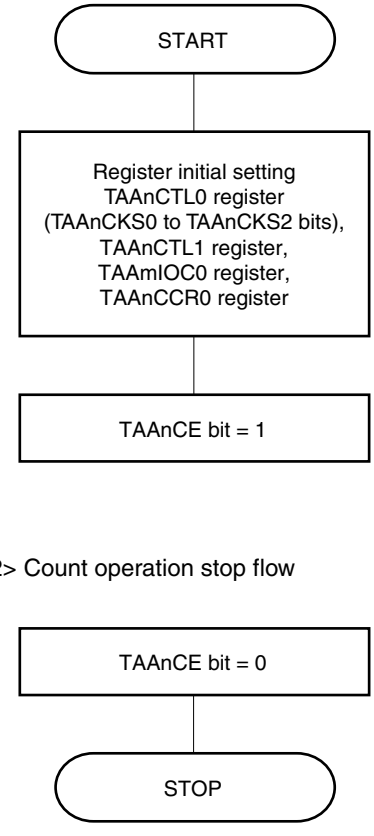
2. **m = 0 to 3, 5**
   n = 0 to 5

(1) Interval timer mode operation flow

Figure 7-10. Software Processing Flow in Interval Timer Mode



<1> Count operation start flow



Initial setting of these registers is performed before setting the TAAnCE bit to 1.

The TAAnCKS0 to TAAnCKS2 bits can be set at the same time when counting has been started (TAAnCE bit = 1).

<2> Count operation stop flow

The counter is initialized and counting is stopped by clearing the TAAnCE bit to 0.

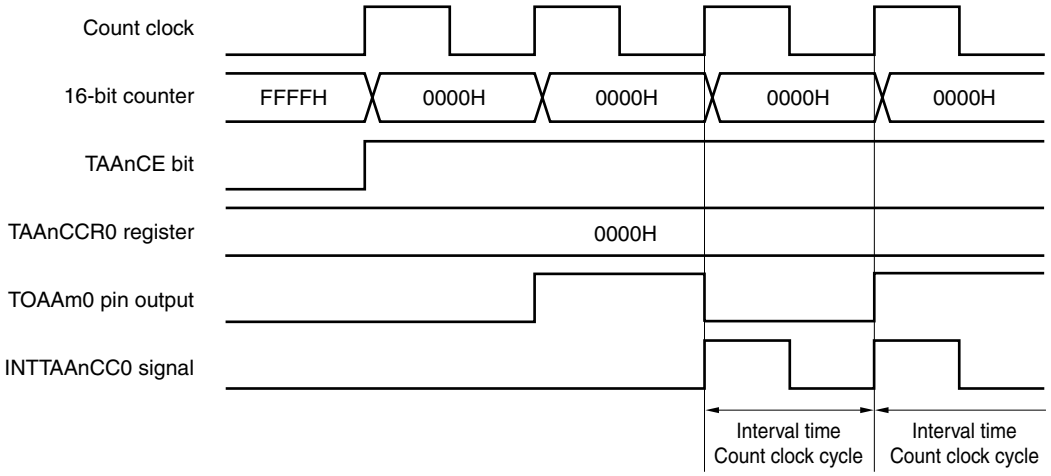
Remark **m = 0 to 3, 5**
n = 0 to 5

(2) Interval timer mode operation timing

(a) Operation if TAAnCCR0 register is set to 0000H

If the TAAnCCR0 register is set to 0000H, the INTTAAnCC0 signal is generated at each count clock subsequent to the first count clock, and the output of the TOAAm0 pin is inverted.

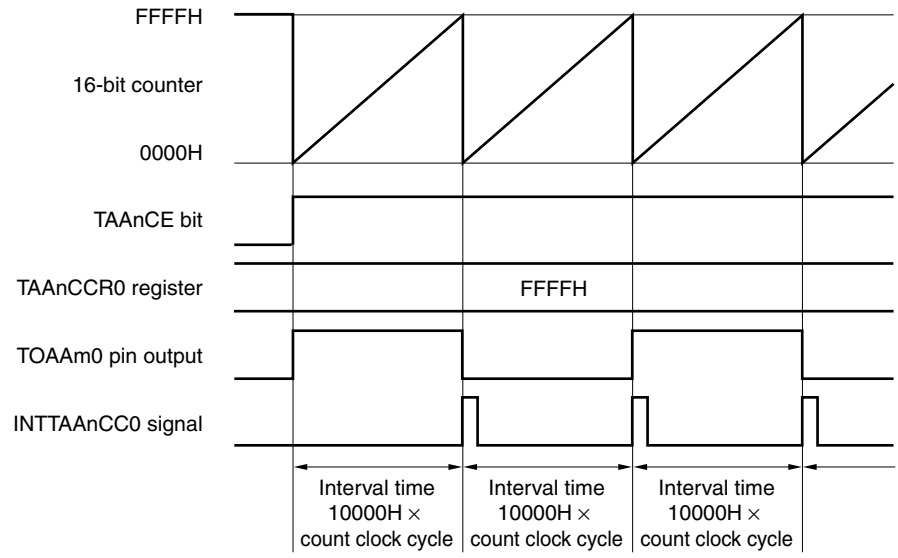
The value of the 16-bit counter is always 0000H.



Remark **m = 0 to 3, 5**
n = 0 to 5

(b) Operation if TAAnCCR0 register is set to FFFFH

If the TAAnCCR0 register is set to FFFFH, the 16-bit counter counts up to FFFFH. The counter is cleared to 0000H in synchronization with the next count-up timing. The INTTAAnCC0 signal is generated and the output of the TOAAm0 pin is inverted. At this time, an overflow interrupt request signal (INTTAAnOV) is not generated, nor is the overflow flag (TAAmOPT0.TAAmOVF bit) set to 1.

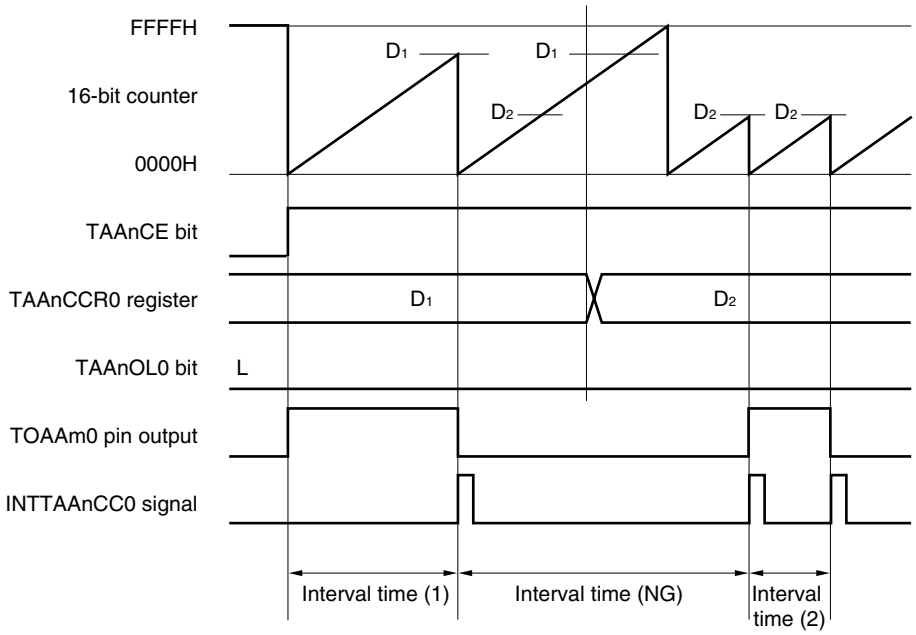


Remark **m = 0 to 3, 5**
n = 0 to 5

(c) Notes on rewriting TAAnCCR0 register

To change the value of the TAAnCCR0 register to a smaller value, stop counting once and then change the set value.

If the value of the TAAnCCR0 register is rewritten to a smaller value during counting, the 16-bit counter may overflow.



Remarks 1. **Interval time (1): $(D_1 + 1) \times$ Count clock cycle**
Interval time (NG): $(10000H + D_2 + 1) \times$ Count clock cycle
Interval time (2): $(D_2 + 1) \times$ Count clock cycle

2. **m = 0 to 3, 5**
n = 0 to 5

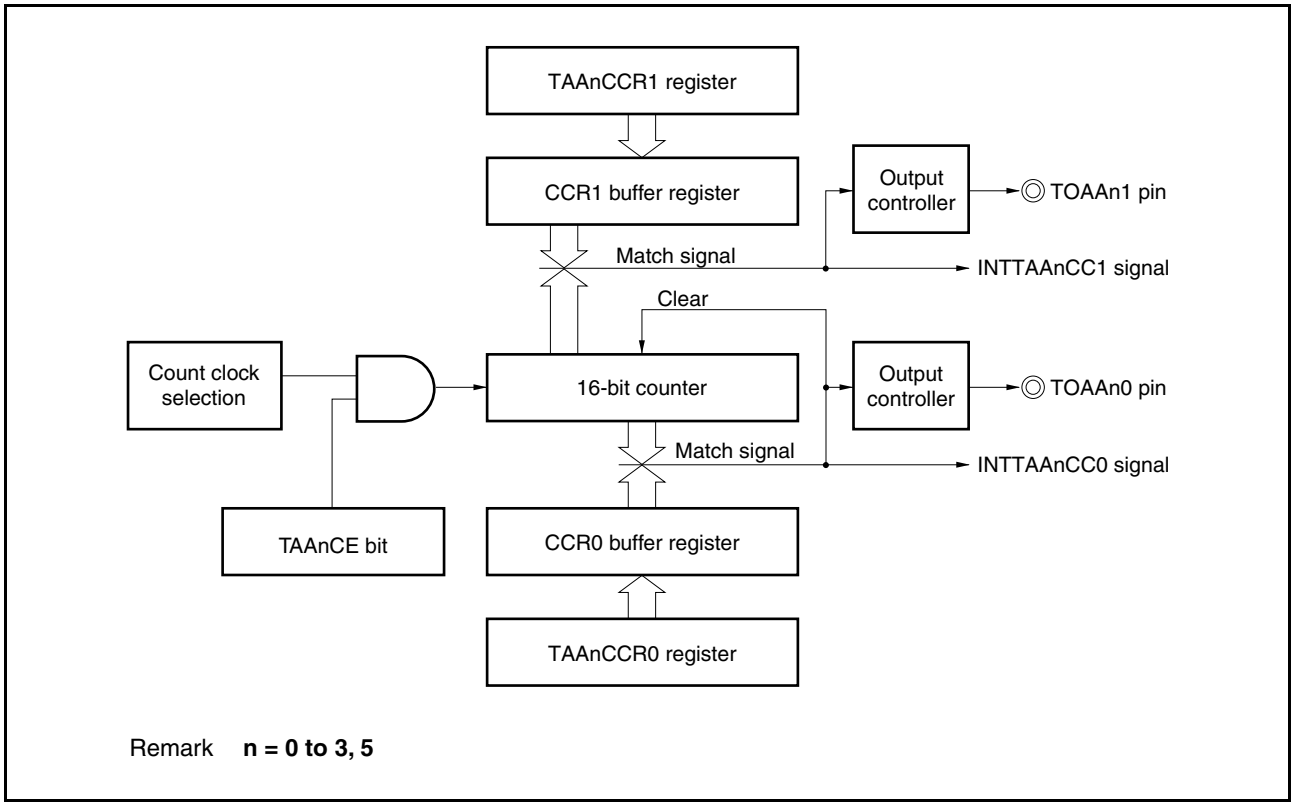
If the value of the TAAnCCR0 register is changed from D_1 to D_2 while the count value is greater than D_2 but less than D_1, the count value is transferred to the CCR0 buffer register as soon as the TAAnCCR0 register has been rewritten. Consequently, the value of the 16-bit counter that is compared is D_2.

Because the count value has already exceeded D_2, however, the 16-bit counter counts up to FFFFH, overflows, and then counts up again from 0000H. When the count value matches D_2, the INTTAAnCC0 signal is generated and the output of the TOAAm0 pin is inverted.

Therefore, the INTTAAnCC0 signal may not be generated at the interval time "$(D_1 + 1) \times$ Count clock cycle" or "$(D_2 + 1) \times$ Count clock cycle" as originally expected, but may be generated at an interval of "$(10000H + D_2 + 1) \times$ Count clock period".

(d) Operation of TAAnCCR1 register

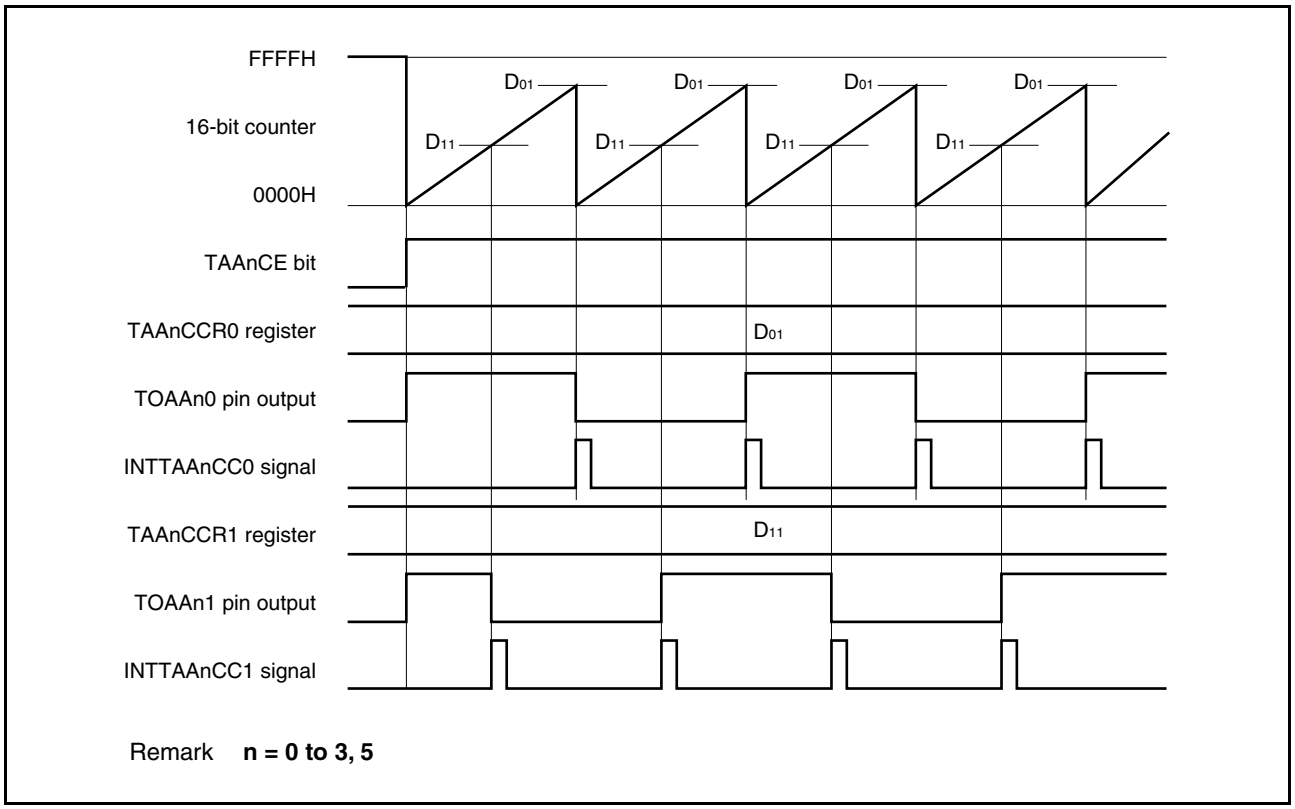
Figure 7-11. Configuration of TAAnCCR1 Register



Remark **n = 0 to 3, 5**

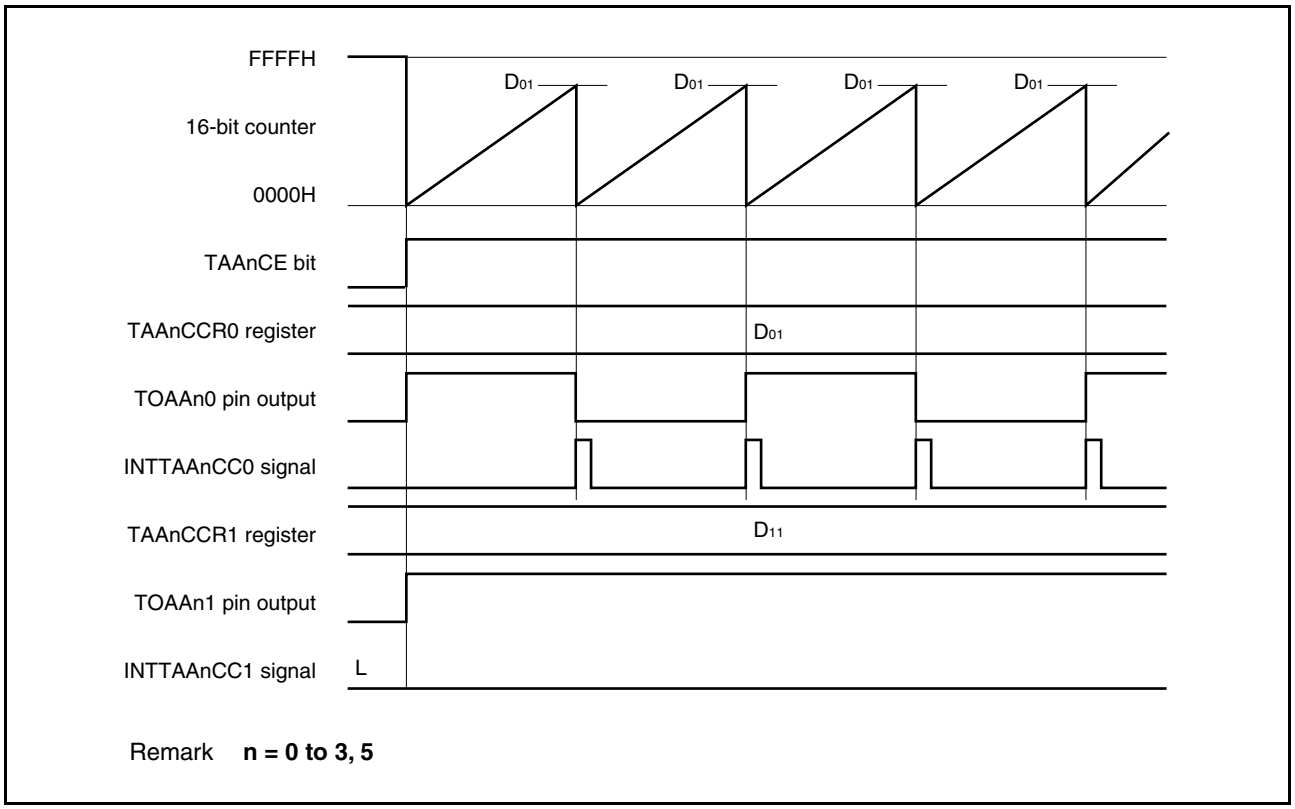
If the set value of the TAAnCCR1 register is less than the set value of the TAAnCCR0 register, the INTTAAnCC1 signal is generated once per cycle. At the same time, the output of the TOAAn1 pin is inverted. The TOAAn1 pin outputs a square wave with the same cycle as that output by the TOAAn0 pin.

Figure 7-12. Timing Chart When $D_{01} \geq D_{11}$



If the set value of the TAAnCCR1 register is greater than the set value of the TAAnCCR0 register, the count value of the 16-bit counter does not match the value of the TAAnCCR1 register. Consequently, the INTTAAnCC1 signal is not generated, nor is the output of the TOAAn1 pin changed.

Figure 7-13. Timing Chart When $D_{01} < D_{11}$



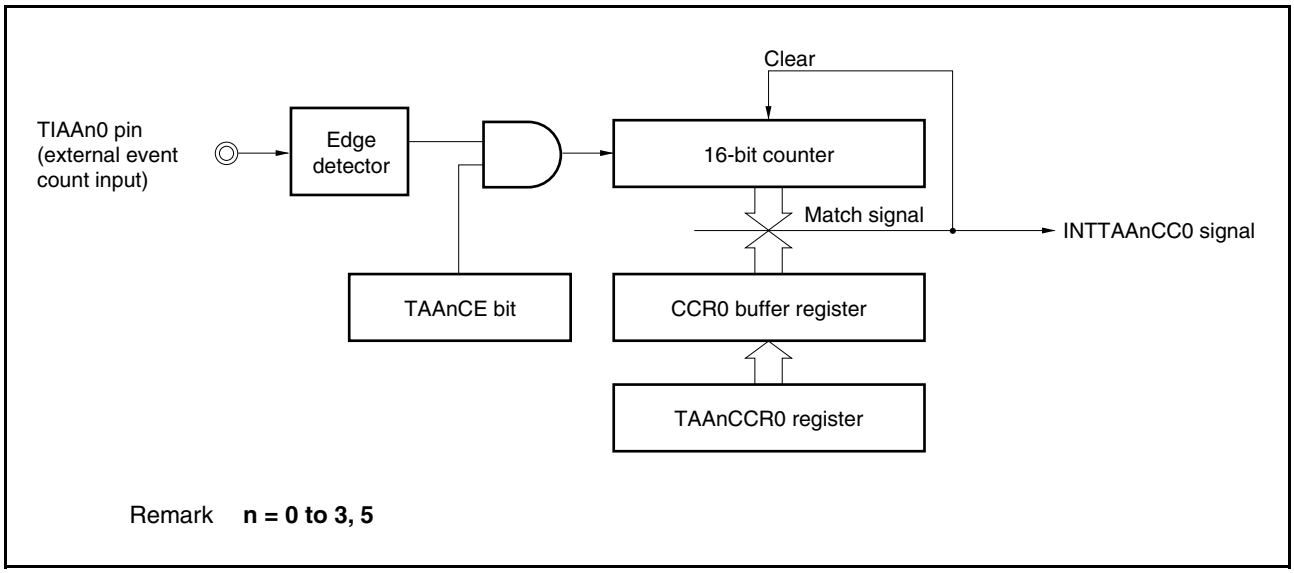
Remark **n = 0 to 3, 5**

7.5.2 External event count mode (TAAnMD2 to TAAnMD0 bits = 001)

In the external event count mode, the valid edge of the external event count input is counted when the TAAnCTL0.TAAnCE bit is set to 1, and an interrupt request signal (INTTAAnCC0) is generated each time the specified number of edges have been counted. The TOAAn0 pin cannot be used.

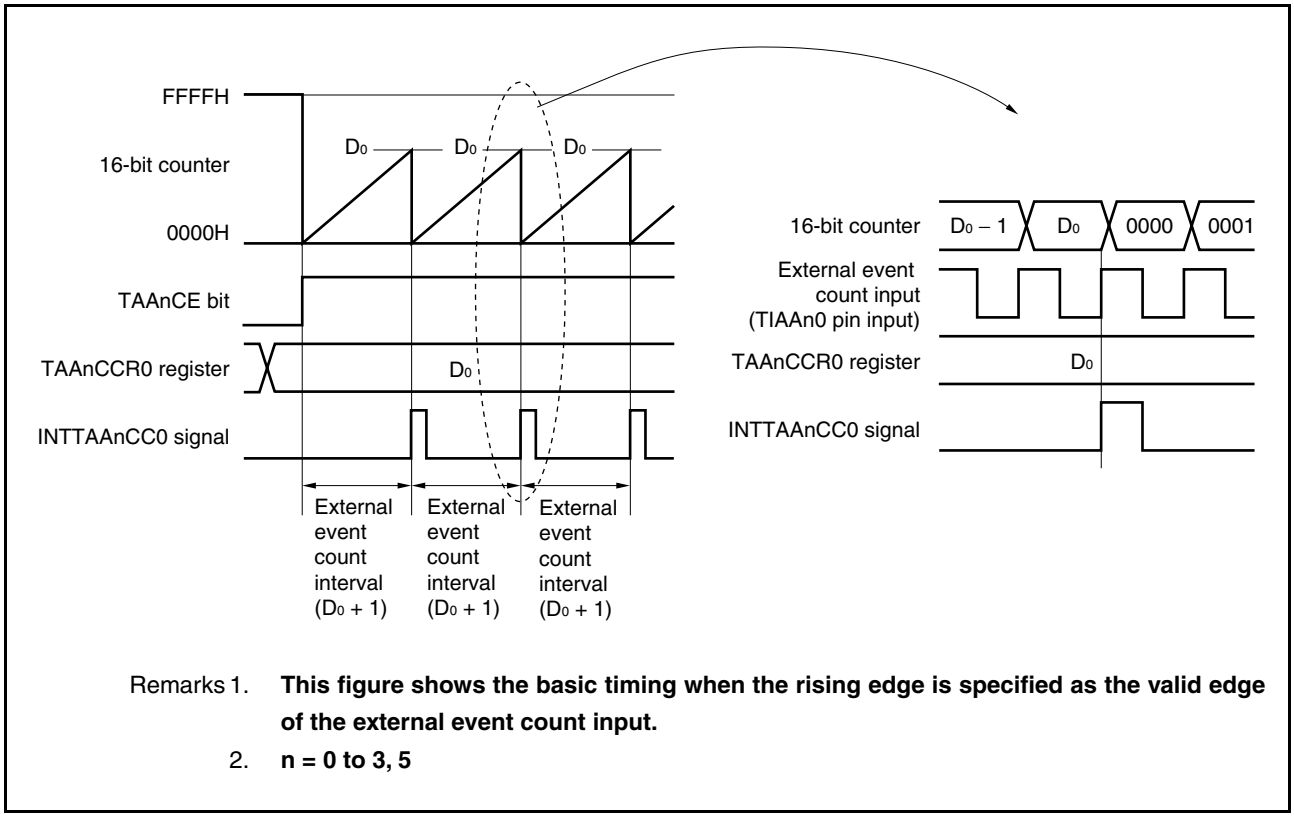
Usually, the TAAnCCR1 register is not used in the external event count mode.

Figure 7-14. Configuration in External Event Count Mode



Remark **n = 0 to 3, 5**

Figure 7-15. Basic Timing in External Event Count Mode



Remarks 1. **This figure shows the basic timing when the rising edge is specified as the valid edge of the external event count input.**

2. **n = 0 to 3, 5**

When the TAAnCE bit is set to 1, the value of the 16-bit counter is cleared from FFFFH to 0000H. The counter counts each time the valid edge of external event count input is detected. Additionally, the set value of the TAAnCCR0 register is transferred to the CCR0 buffer register.

When the count value of the 16-bit counter matches the value of the CCR0 buffer register, the 16-bit counter is cleared to 0000H, and a compare match interrupt request signal (INTTAAnCC0) is generated.

The INTTAAnCC0 signal is generated each time the valid edge of the external event count input has been detected (set value of TAAnCCR0 register + 1) times.

Figure 7-16. Register Setting for Operation in External Event Count Mode (1/2)

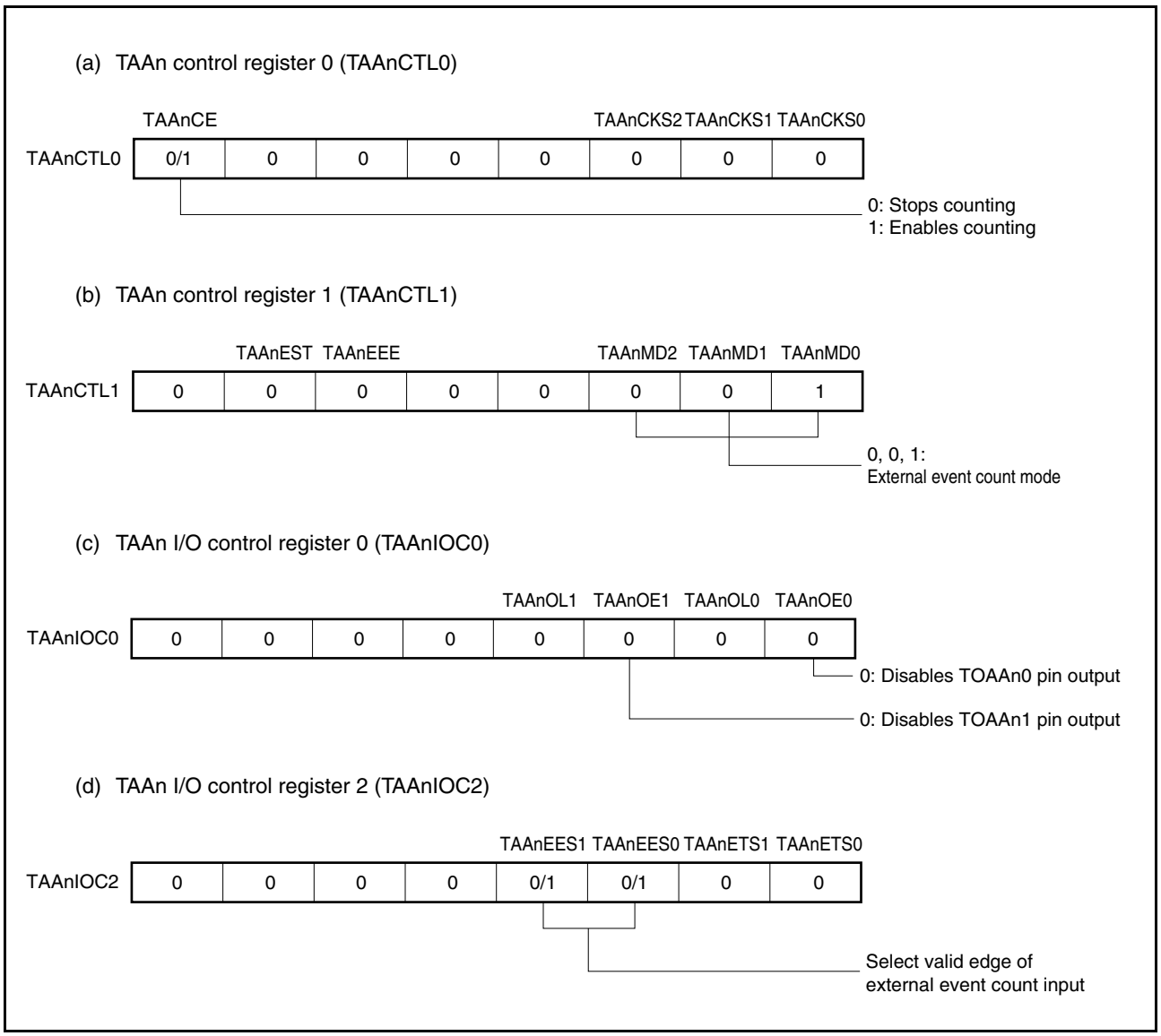


Figure 7-16. Register Setting for Operation in External Event Count Mode (2/2)

(e) TAAn counter read buffer register (TAAnCNT)

The count value of the 16-bit counter can be read by reading the TAAnCNT register.

(f) TAAn capture/compare register 0 (TAAnCCR0)

If D_0 is set to the TAAnCCR0 register, the counter is cleared and a compare match interrupt request signal (INTTAAnCC0) is generated when the number of external event counts reaches (D_0 + 1).

(g) TAAn capture/compare register 1 (TAAnCCR1)

Usually, the TAAnCCR1 register is not used in the external event count mode. However, the set value of the TAAnCCR1 register is transferred to the CCR1 buffer register. When the count value of the 16-bit counter matches the value of the CCR1 buffer register, a compare match interrupt request signal (INTTAAnCC1) is generated.

Therefore, mask the interrupt signal by using the interrupt mask flag (TAAnCCMK1).

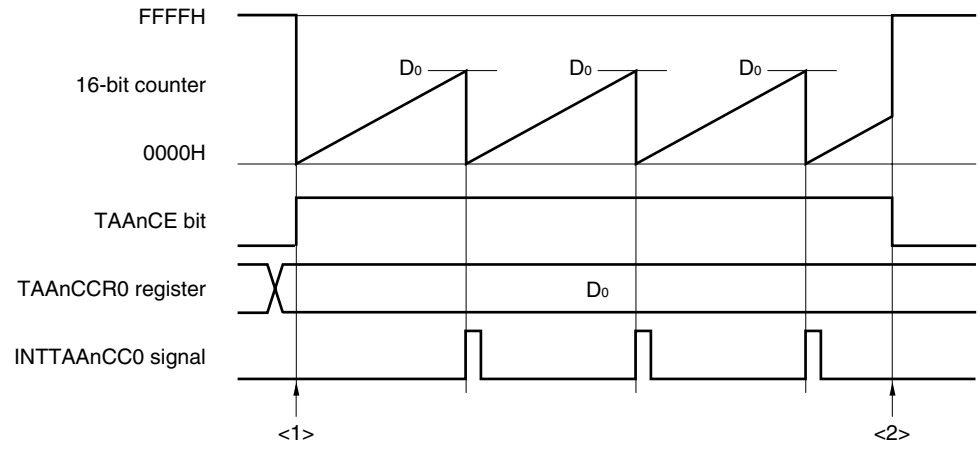
Caution When an external clock is used as the count clock, the external clock can be input only from the TIAAn0 pin. At this time, set the TAAnIOC1.TAAnIS1 and TAAnIOC1.TAAnIS0 bits to 00 (capture trigger input (TIAAn0 pin): no edge detection).

Remarks 1. **TAAn I/O control register 1 (TAAnIOC1) and TAAn option register 0 (TAAnOPT0) are not used in the external event count mode.**

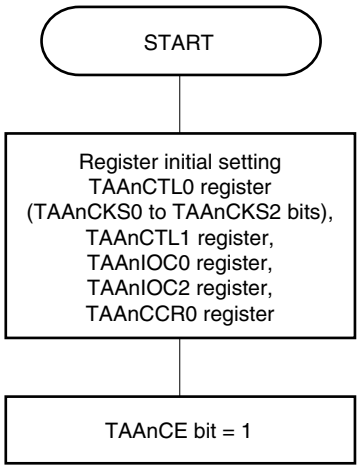
2. **n = 0 to 3, 5**

(1) External event count mode operation flow

Figure 7-17. Flow of Software Processing in External Event Count Mode



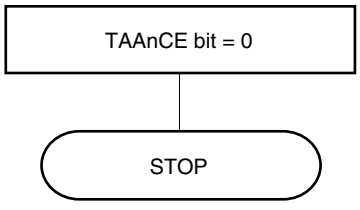
<1> Count operation start flow



Initial setting of these registers is performed before setting the TAAnCE bit to 1.

The TAAnCKS0 to TAAnCKS2 bits can be set at the same time when counting has been started (TAAnCE bit = 1).

<2> Count operation stop flow



The counter is initialized and counting is stopped by clearing the TAAnCE bit to 0.

Remark **n = 0 to 3, 5**

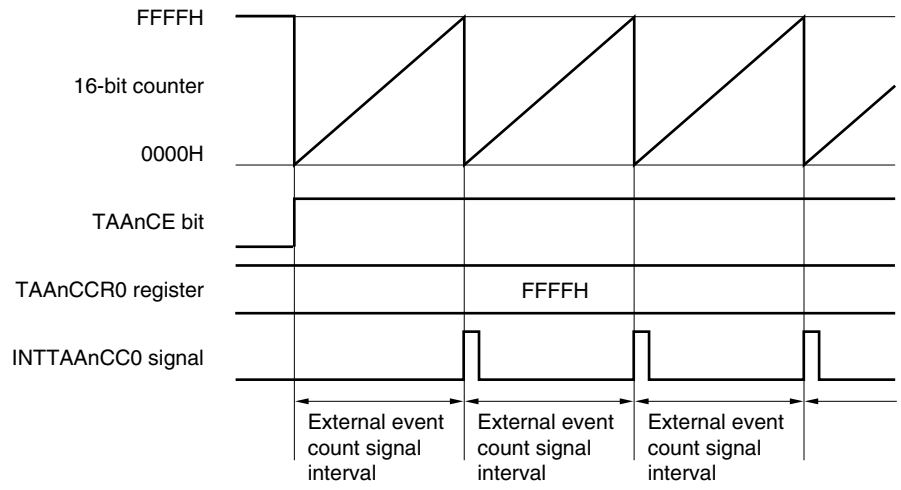
(2) Operation timing in external event count mode

Cautions 1. In the external event count mode, do not set the TAAnCCR0 register to 0000H.

2. In the external event count mode, use of the timer output is disabled. If performing timer output using external event count input, set the interval timer mode, and select the operation of the count clock to be enabled by the external event count input (TAAnCTL1.TAAnMD2 to TAAnCTL1.TAAnMD0 bits = 000, TAAnCTL1.TAAnEEE bit = 1).

(a) Operation if TAAnCCR0 register is set to FFFFH

If the TAAnCCR0 register is set to FFFFH, the 16-bit counter counts to FFFFH each time the valid edge of the external event count signal has been detected. The 16-bit counter is cleared to 0000H in synchronization with the next count-up timing, and the INTTAAnCC0 signal is generated. At this time, the TAAnOPT0.TAAnOVF bit is not set.

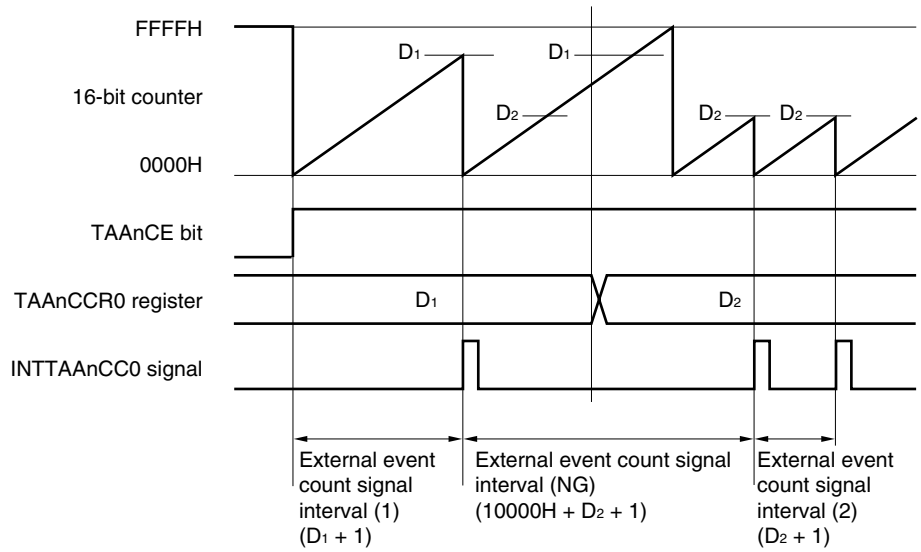


Remark **n = 0 to 3, 5**

(b) Notes on rewriting the TAAnCCR0 register

To change the value of the TAAnCCR0 register to a smaller value, stop counting once and then change the set value.

If the value of the TAAnCCR0 register is rewritten to a smaller value during counting, the 16-bit counter may overflow.



Remark **n = 0 to 3, 5**

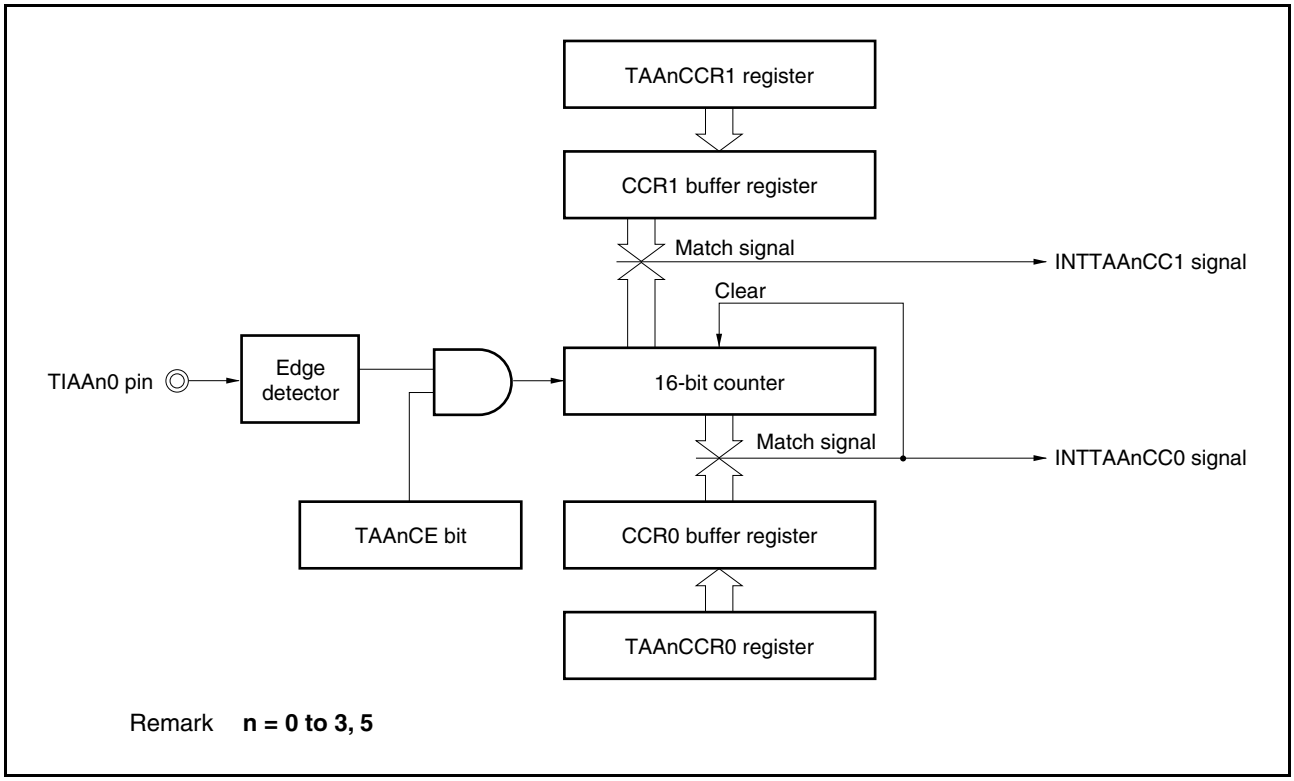
If the value of the TAAnCCR0 register is changed from D_1 to D_2 while the count value is greater than D_2 but less than D_1, the count value is transferred to the CCR0 buffer register as soon as the TAAnCCR0 register has been rewritten. Consequently, the value that is compared with the 16-bit counter is D_2.

Because the count value has already exceeded D_2, however, the 16-bit counter counts up to FFFFH, overflows, and then counts up again from 0000H. When the count value matches D_2, the INTTAAnCC0 signal is generated.

Therefore, the INTTAAnCC0 signal may not be generated at the valid edge count of "(D_1 + 1) times" or "(D_2 + 1) times" as originally expected, but may be generated at the valid edge count of "(10000H + D_2 + 1) times".

(c) Operation of TAAnCCR1 register

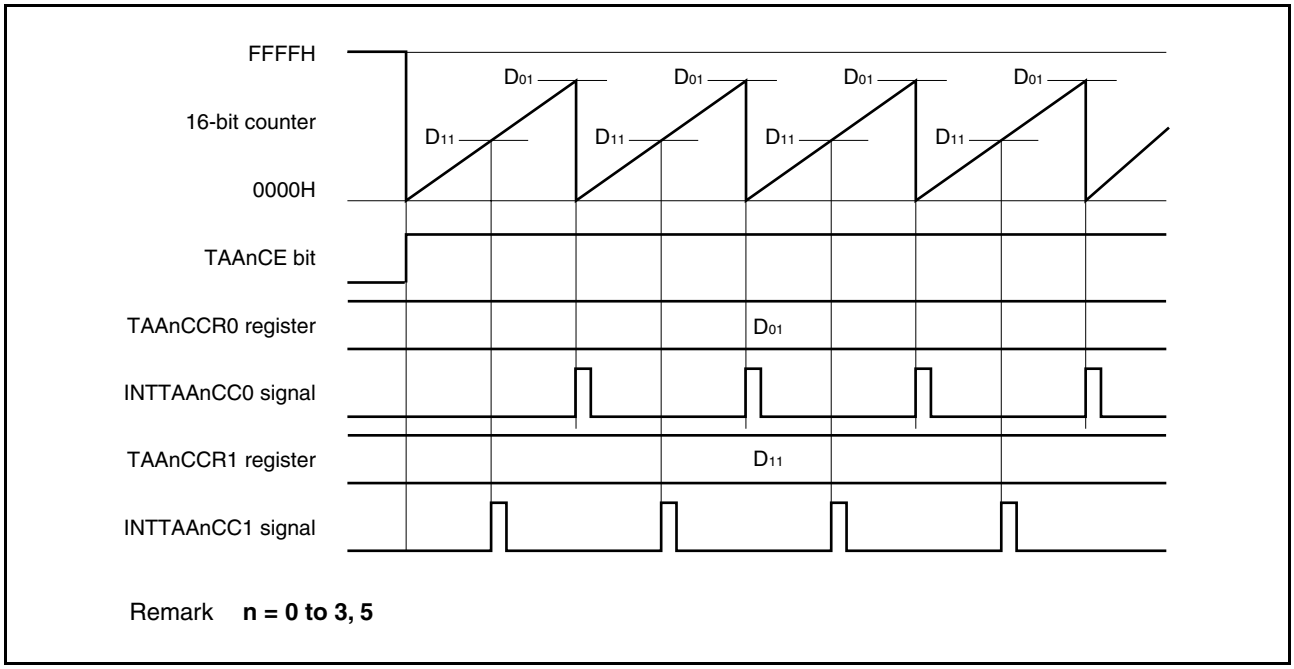
Figure 7-18. Configuration of TAAnCCR1 Register



Remark **n = 0 to 3, 5**

If the set value of the TAAnCCR1 register is smaller than the set value of the TAAnCCR0 register, the INTTAAnCC1 signal is generated once per cycle.

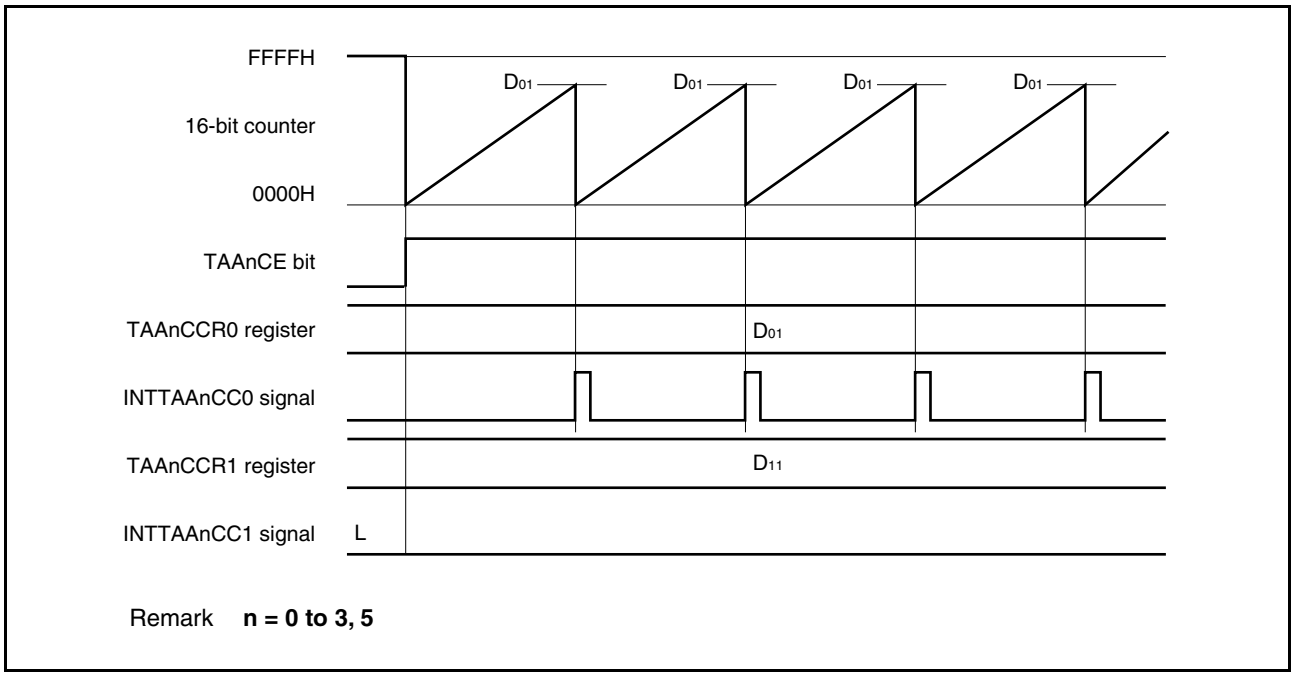
Figure 7-19. Timing Chart When $D_{01} \geq D_{11}$



Remark **n = 0 to 3, 5**

If the set value of the TAAnCCR1 register is greater than the set value of the TAAnCCR0 register, the INTTAAnCC1 signal is not generated because the count value of the 16-bit counter and the value of the TAAnCCR1 register do not match.

Figure 7-20. Timing Chart When $D_{01} < D_{11}$



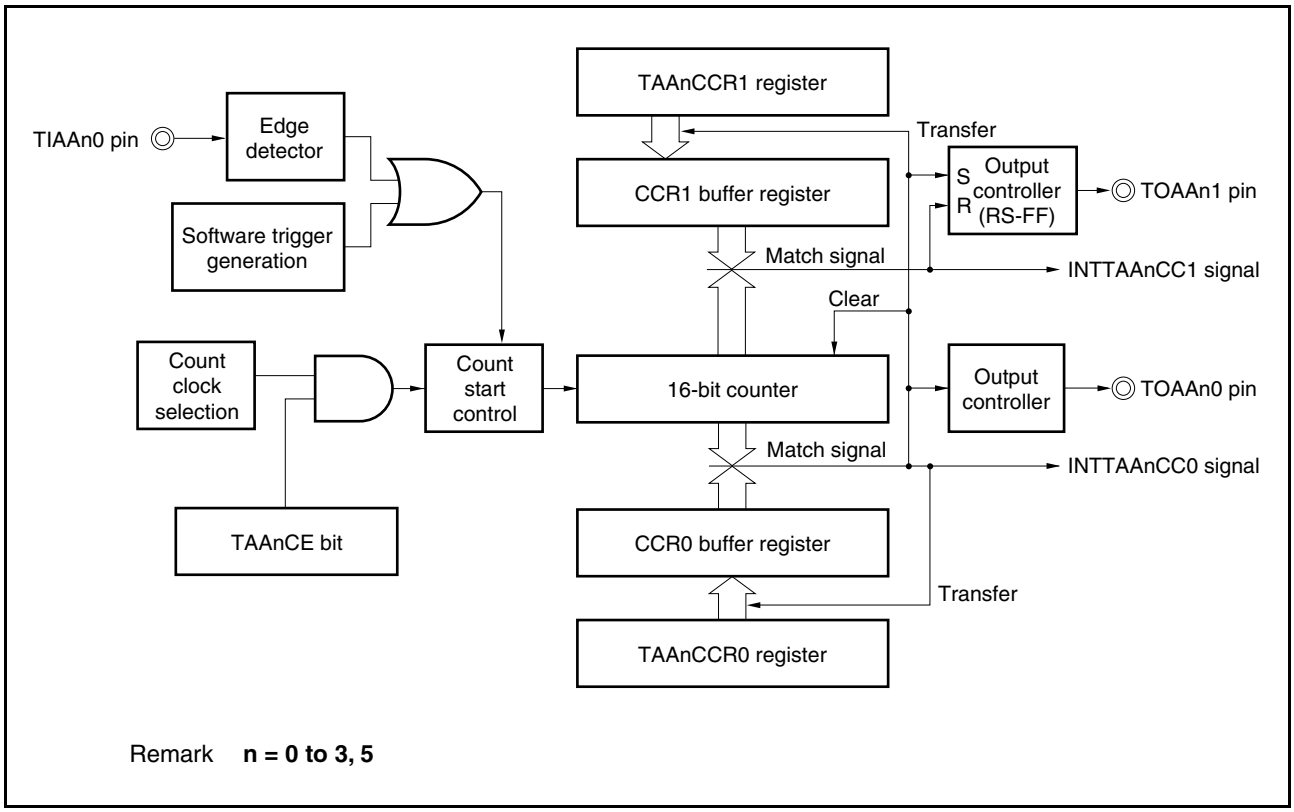
Remark **n = 0 to 3, 5**

7.5.3 External trigger pulse output mode (TAAnMD2 to TAAnMD0 bits = 010)

In the external trigger pulse output mode, 16-bit timer/event counter AA waits for a trigger when the TAAnCTL0.TAAnCE bit is set to 1. When the valid edge of an external trigger input signal is detected, 16-bit timer/event counter AA starts counting, and outputs a PWM waveform from the TOAAn1 pin.

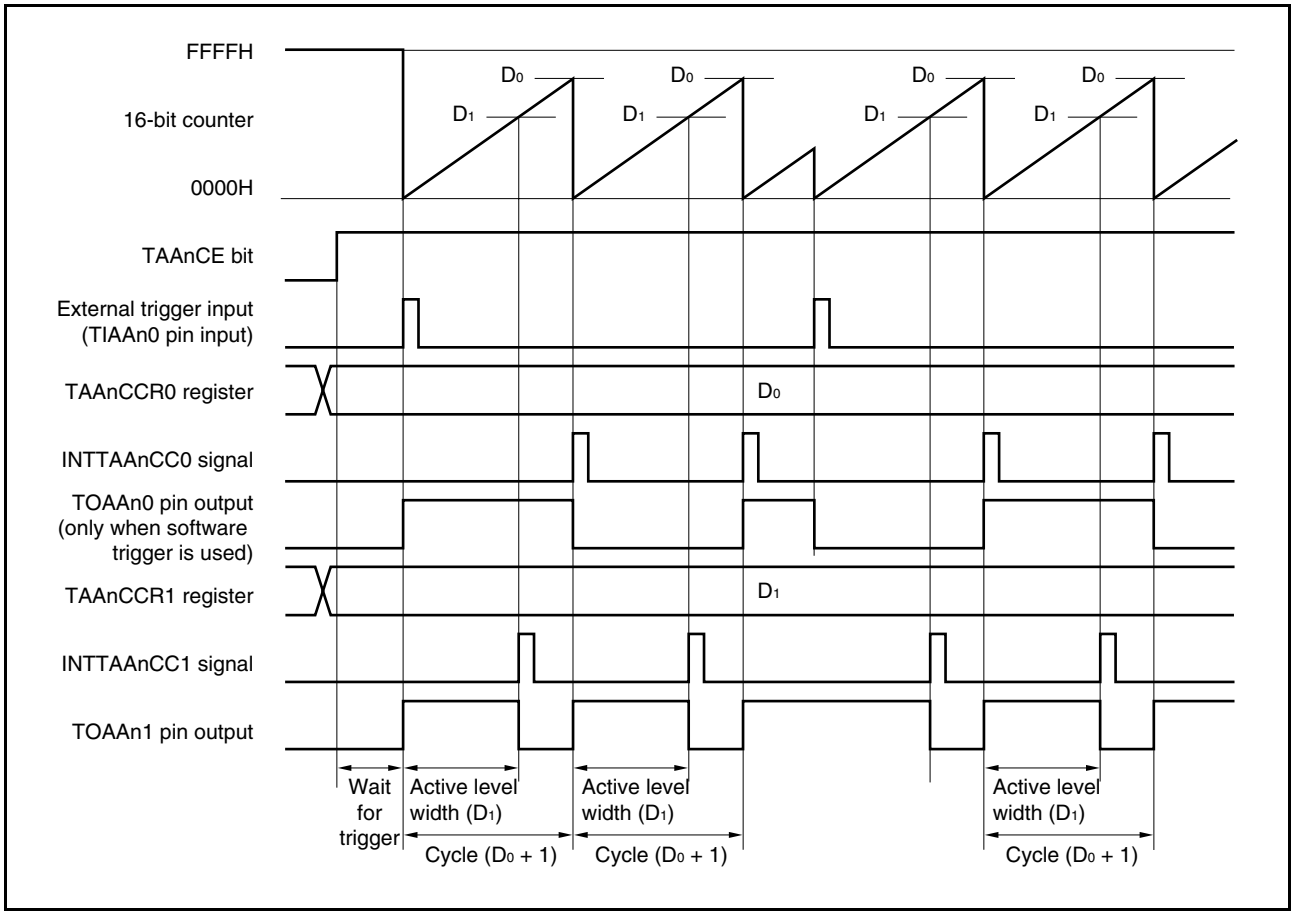
Pulses can also be output by generating a software trigger instead of using the external trigger. When using a software trigger, a square wave that has one cycle of the PWM waveform as half its cycle can also be output from the TOAAn0 pin.

Figure 7-21. Configuration in External Trigger Pulse Output Mode



Remark **n = 0 to 3, 5**

Figure 7-22. Basic Timing in External Trigger Pulse Output Mode



16-bit timer/event counter AA waits for a trigger when the TAAnCE bit is set to 1. When the trigger is generated, the 16-bit counter is cleared from FFFFH to 0000H, starts counting at the same time, and outputs a PWM waveform from the TOAAn1 pin. If the trigger is generated again while the counter is operating, the counter is cleared to 0000H and restarted. (The output of the TOAAn0 pin is inverted. The TOAAn1 pin outputs a high level regardless of the status (high/low) when a trigger occurs.)

The active level width, cycle, and duty factor of the PWM waveform can be calculated as follows.

Active level width = (Set value of TAAnCCR1 register) × Count clock cycle
Cycle = (Set value of TAAnCCR0 register + 1) × Count clock cycle
Duty factor = (Set value of TAAnCCR1 register)/(Set value of TAAnCCR0 register + 1)

The compare match request signal INTTAAnCC0 is generated the next time the 16-bit counter counts after its count value matches the value of the CCR0 buffer register, and the 16-bit counter is cleared to 0000H at the same time. The compare match interrupt request signal INTTAAnCC1 is generated when the count value of the 16-bit counter matches the value of the CCR1 buffer register.

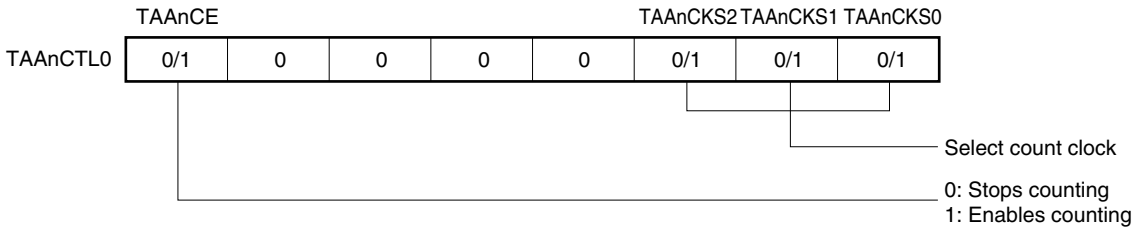
The value set to the TAAnCCRm register is transferred to the CCRm buffer register when the count value of the 16-bit counter matches the value of the CCRm buffer register and the 16-bit counter is cleared to 0000H.

The valid edge of an external trigger input signal, or setting the software trigger (TAAnCTL1.TAAnEST bit) to 1 is used as the trigger.

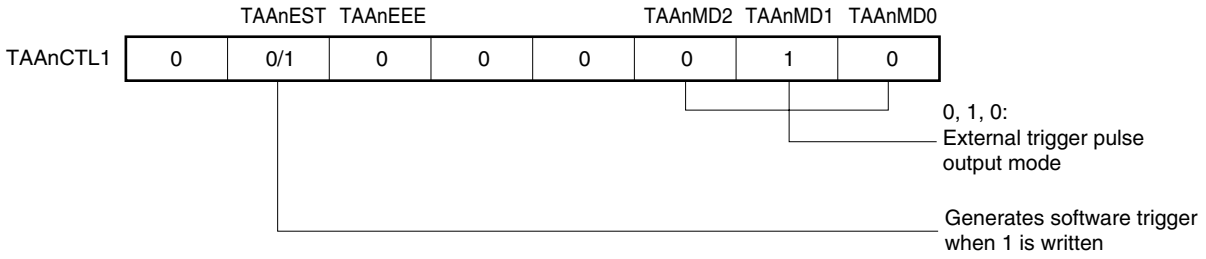
Remark n = 0 to 3, 5
m = 0, 1

Figure 7-23. Setting of Registers in External Trigger Pulse Output Mode (1/2)

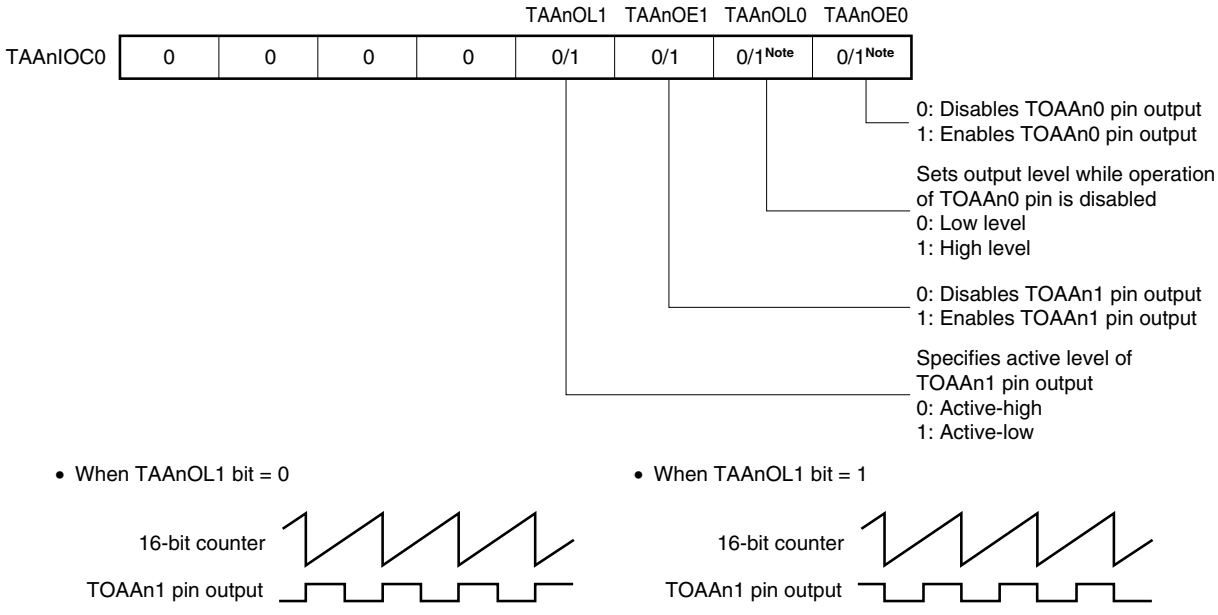
(a) TAAn control register 0 (TAAnCTL0)



(b) TAAn control register 1 (TAAnCTL1)



(c) TAAn I/O control register 0 (TAAnIOC0)



- When TAAnOL1 bit = 0

- When TAAnOL1 bit = 1

Note **Clear this bit to 0 when the TOAAn0 pin is not used in the external trigger pulse output mode.**

Figure 7-23. Setting of Registers in External Trigger Pulse Output Mode (2/2)

(d) TAAn I/O control register 2 (TAAnIOC2)

					TAAnEES1	TAAnEES0	TAAnETS1	TAAnETS0
TAAnIOC2	0	0	0	0	0	0	0/1	0/1

Select valid edge of external trigger input

(e) TAAn counter read buffer register (TAAnCNT)

The value of the 16-bit counter can be read by reading the TAAnCNT register.

(f) TAAn capture/compare registers 0 and 1 (TAAnCCR0 and TAAnCCR1)

If D_0 is set to the TAAnCCR0 register and D_1 to the TAAnCCR1 register, the cycle and active level of the PWM waveform are as follows.

Cycle = (D_0 + 1) × Count clock cycle

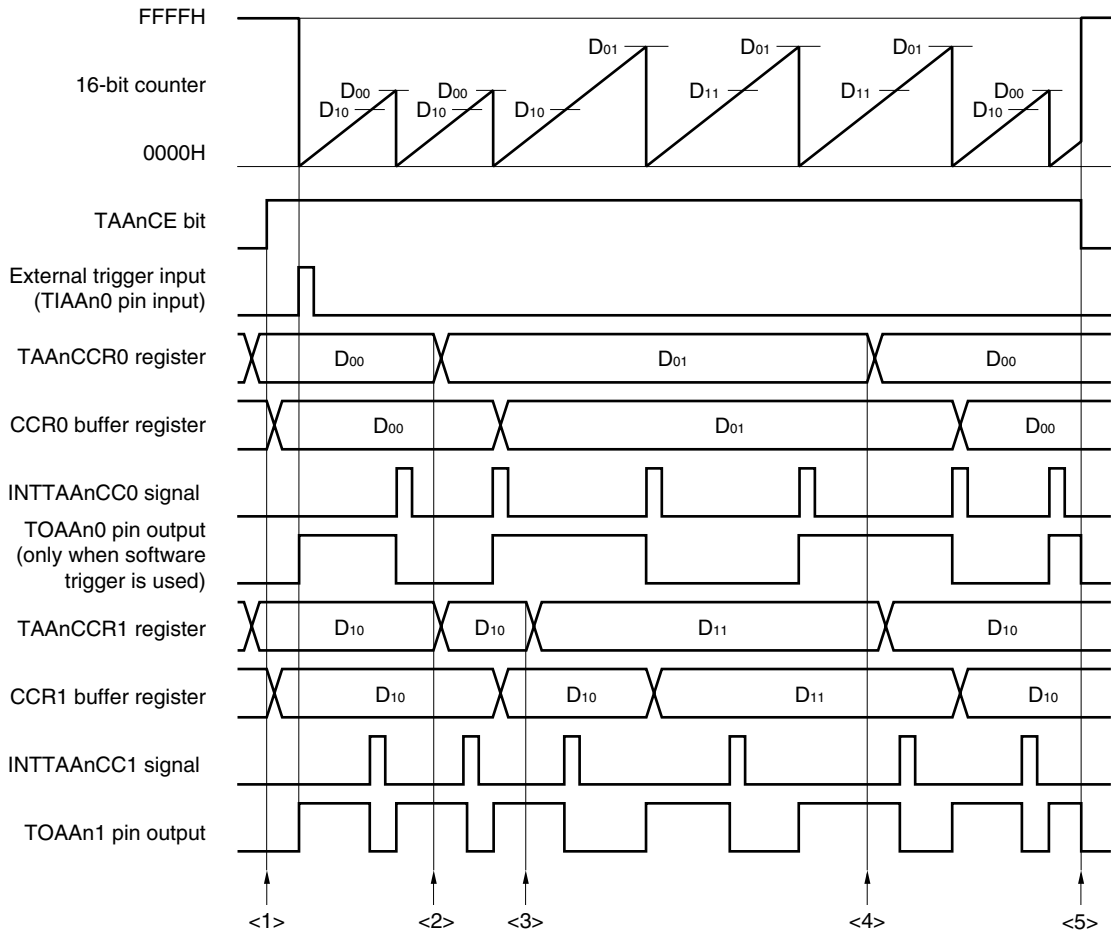
Active level width = D_1 × Count clock cycle

Remarks 1. **TAAn I/O control register 1 (TAAnIOC1) and TAAn option register 0 (TAAnOPT0) are not used in the external trigger pulse output mode.**

2. **n = 0 to 3, 5**

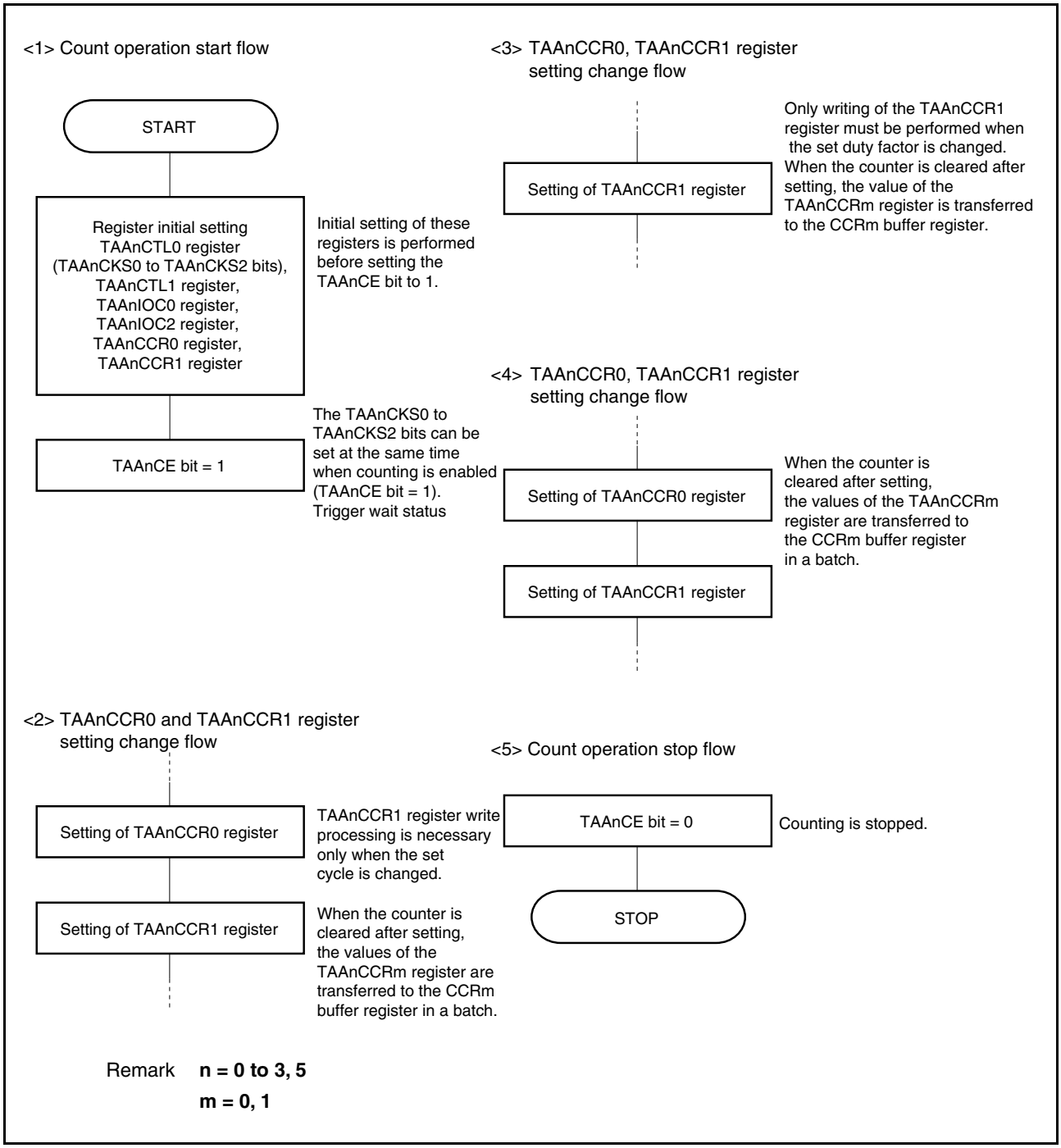
(1) Operation flow in external trigger pulse output mode

Figure 7-24. Software Processing Flow in External Trigger Pulse Output Mode (1/2)



Remark **n = 0 to 3, 5**

Figure 7-24. Software Processing Flow in External Trigger Pulse Output Mode (2/2)



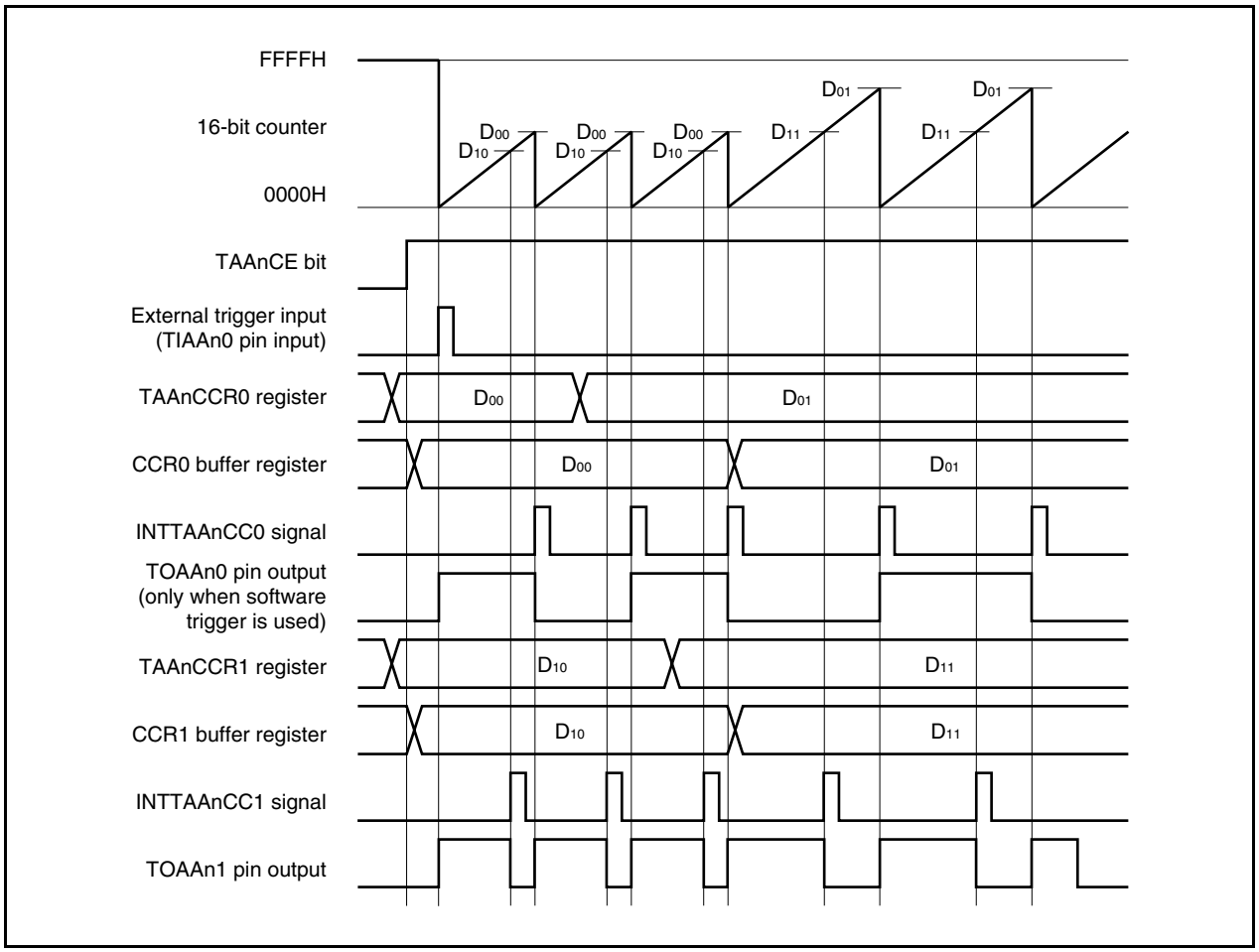
Remark **n = 0 to 3, 5**
m = 0, 1

(2) External trigger pulse output mode operation timing

(a) Note on changing pulse width during operation

To change the PWM waveform while the counter is operating, write the TAAnCCR1 register last.

Rewrite the TAAnCCRm register after writing the TAAnCCR1 register after the INTTAAnCC0 signal is detected.



In order to transfer data from the TAAnCCRm register to the CCRm buffer register, the TAAnCCR1 register must be written.

To change both the cycle and active level width of the PWM waveform at this time, first set the cycle to the TAAnCCR0 register and then set the active level width to the TAAnCCR1 register.

To change only the cycle of the PWM waveform, first set the cycle to the TAAnCCR0 register, and then write the same value to the TAAnCCR1 register.

To change only the active level width (duty factor) of the PWM waveform, only the TAAnCCR1 register has to be set.

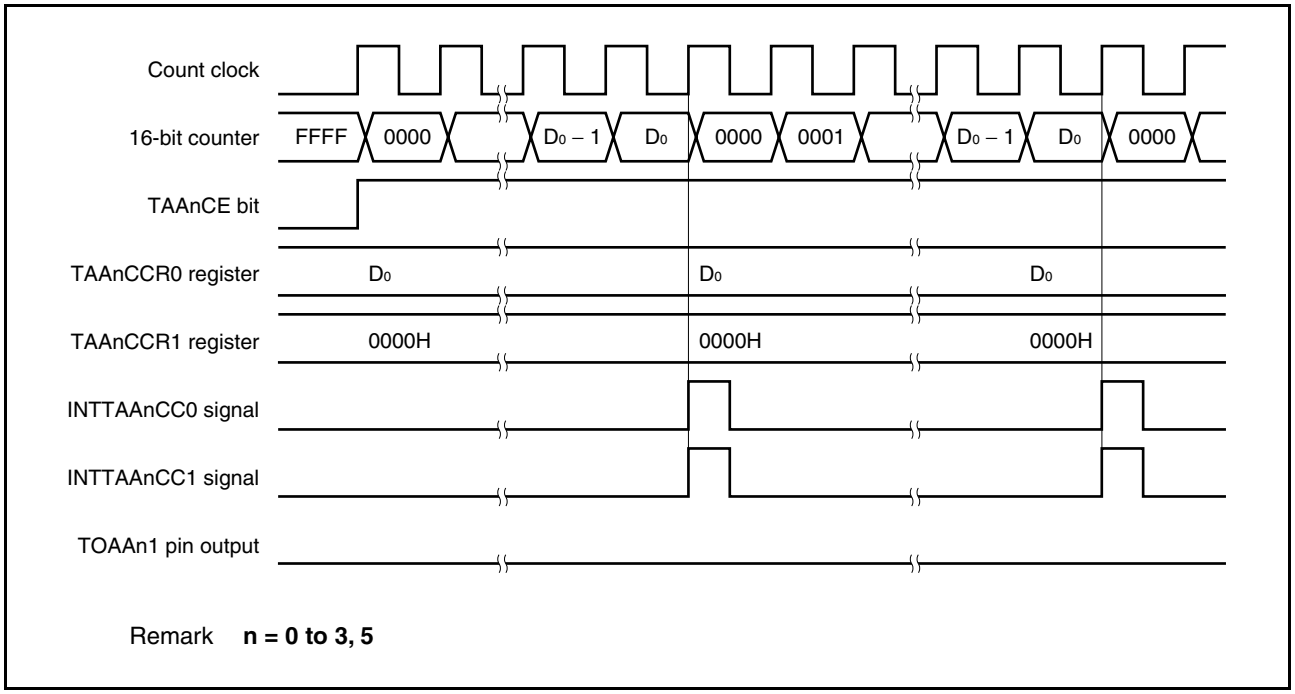
After data is written to the TAAnCCR1 register, the value written to the TAAnCCRm register is transferred to the CCRm buffer register in synchronization with clearing of the 16-bit counter, and is used as the value compared with the 16-bit counter.

To write the TAAnCCR0 or TAAnCCR1 register again after writing the TAAnCCR1 register once, do so after the INTTAAnCC0 signal is generated. Otherwise, the value of the CCRm buffer register may become undefined because the timing of transferring data from the TAAnCCRm register to the CCRm buffer register conflicts with writing the TAAnCCRm register.

Remark n = 0 to 3, 5
m = 0, 1

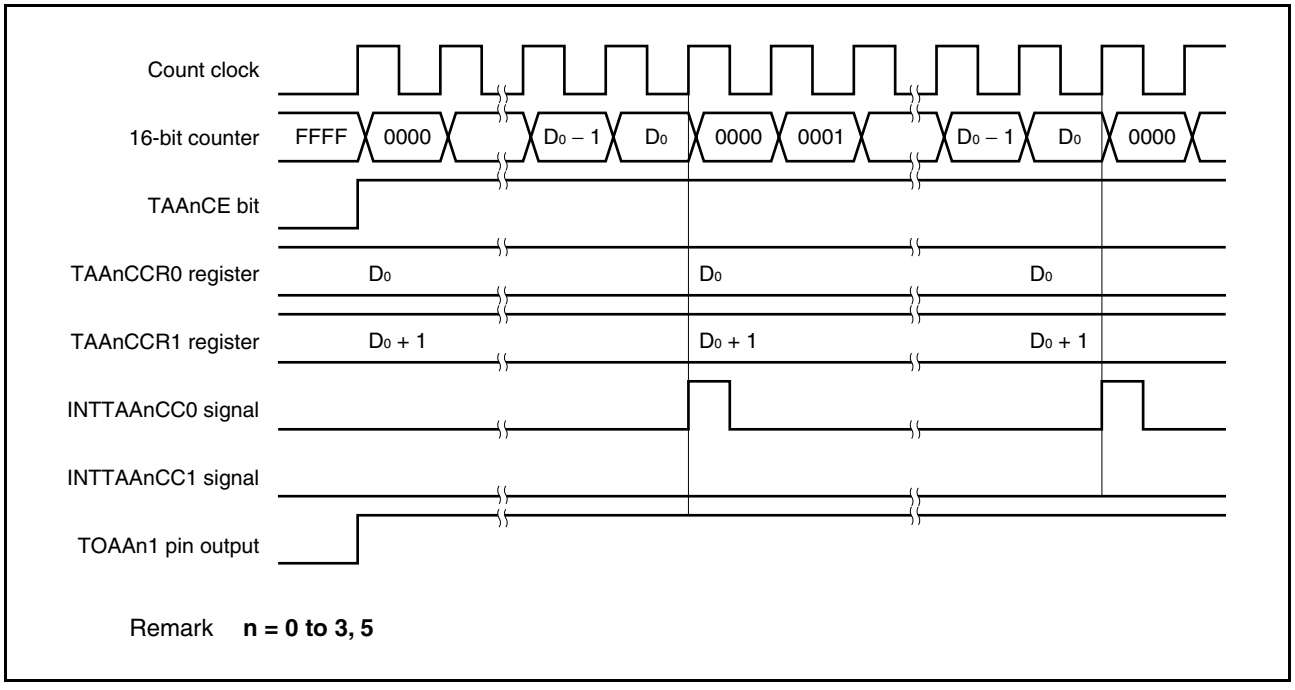
(b) 0%/100% output of PWM waveform

To output a 0% waveform, set the TAAnCCR1 register to 0000H. If the set value of the TAAnCCR0 register is FFFFH, the INTTAAnCC1 signal is generated periodically.



Remark **n = 0 to 3, 5**

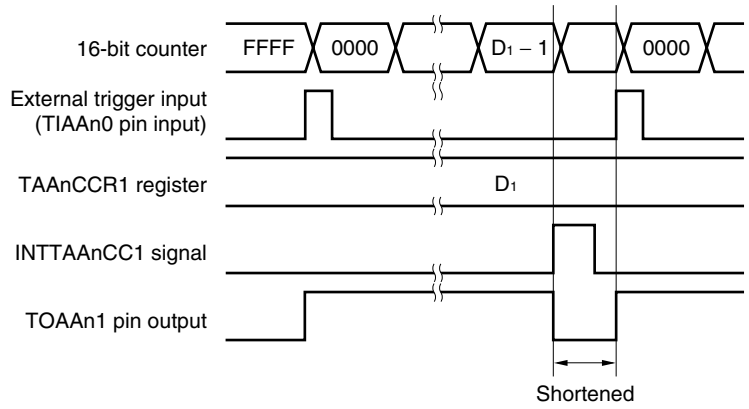
To output a 100% waveform, set a value of (set value of TAAnCCR0 register + 1) to the TAAnCCR1 register. If the set value of the TAAnCCR0 register is FFFFH, 100% output cannot be produced.



Remark **n = 0 to 3, 5**

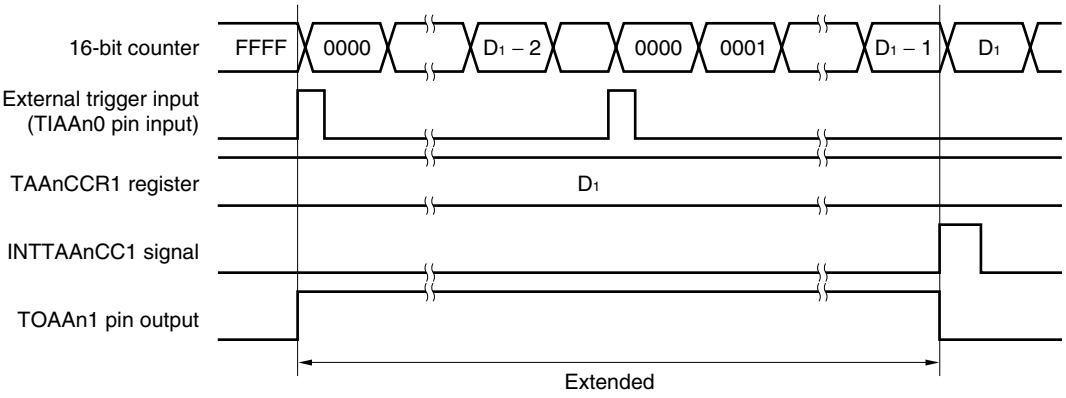
(c) Conflict between trigger detection and match with TAAnCCR1 register

If the trigger is detected immediately after the INTTAAnCC1 signal is generated, the 16-bit counter is cleared to 0000H at the same time, the output signal of the TOAAn1 pin is asserted, and the counter continues counting. Consequently, the inactive period of the PWM waveform is shortened.



Remark **n = 0 to 3, 5**

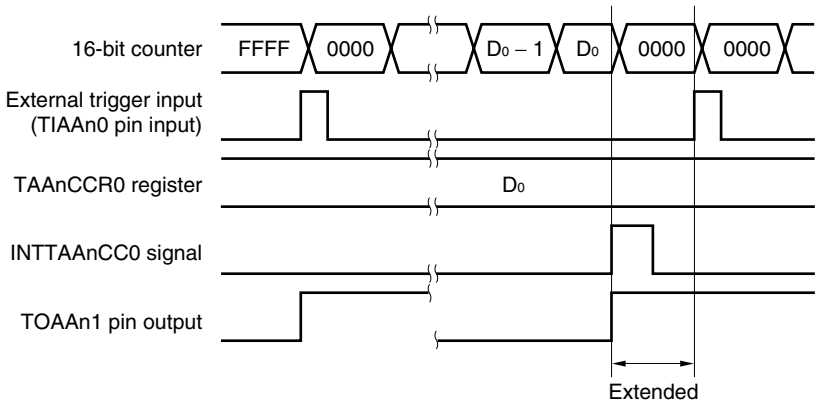
If the trigger is detected immediately before the INTTAAnCC1 signal is generated, the INTTAAnCC1 signal is not generated, and the 16-bit counter is cleared to 0000H and continues counting. The output signal of the TOAAn1 pin remains active. Consequently, the active period of the PWM waveform is extended.



Remark **n = 0 to 3, 5**

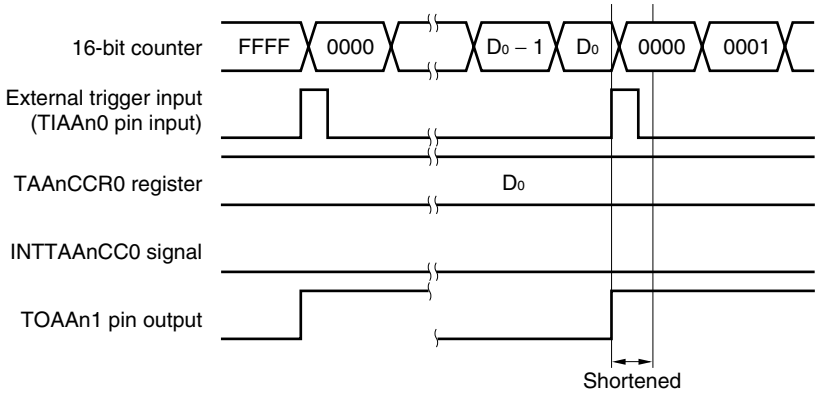
(d) Conflict between trigger detection and match with TAAnCCR0 register

If the trigger is detected immediately after the INTTAAnCC0 signal is generated, the 16-bit counter is cleared to 0000H again and continues counting up. Therefore, the active period of the TOAAn1 pin is extended by the time from generation of the INTTAAnCC0 signal to trigger detection.



Remark **n = 0 to 3, 5**

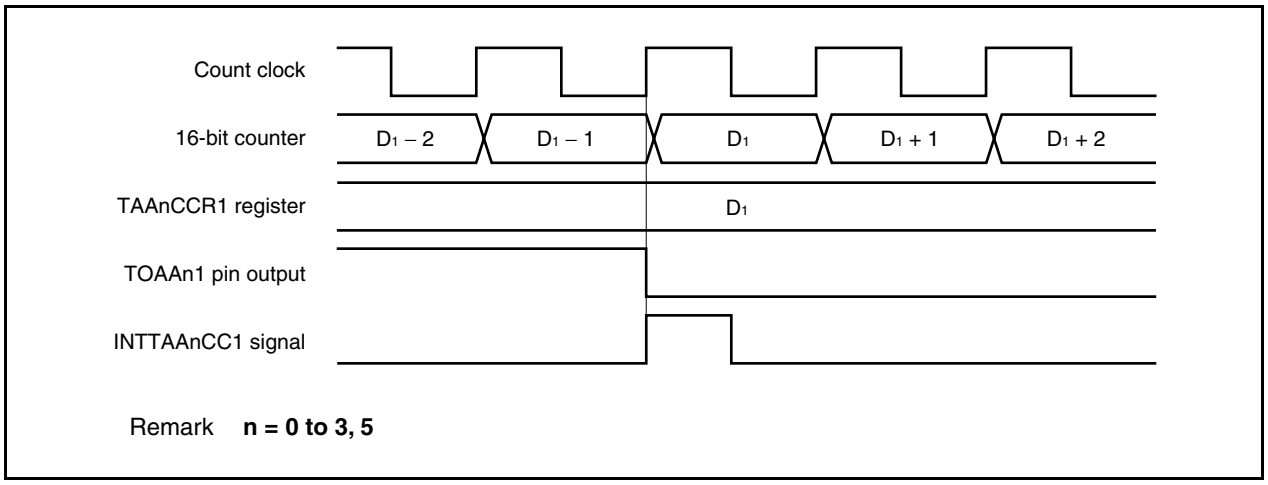
If the trigger is detected immediately before the INTTAAnCC0 signal is generated, the INTTAAnCC0 signal is not generated. The 16-bit counter is cleared to 0000H, the TOAAn1 pin is asserted, and the counter continues counting. Consequently, the inactive period of the PWM waveform is shortened.



Remark **n = 0 to 3, 5**

(e) Generation timing of compare match interrupt request signal (INTTAAnCC1)

The timing of generation of the INTTAAnCC1 signal in the external trigger pulse output mode differs from the timing of other INTTAAnCC1 signals; the INTTAAnCC1 signal in the external trigger pulse output mode is generated when the count value of the 16-bit counter matches the value of the TAAnCCR1 register.



Remark **n = 0 to 3, 5**

Usually, the INTTAAnCC1 signal is generated in synchronization with the next count-up, after the count value of the 16-bit counter matches the value of the TAAnCCR1 register.

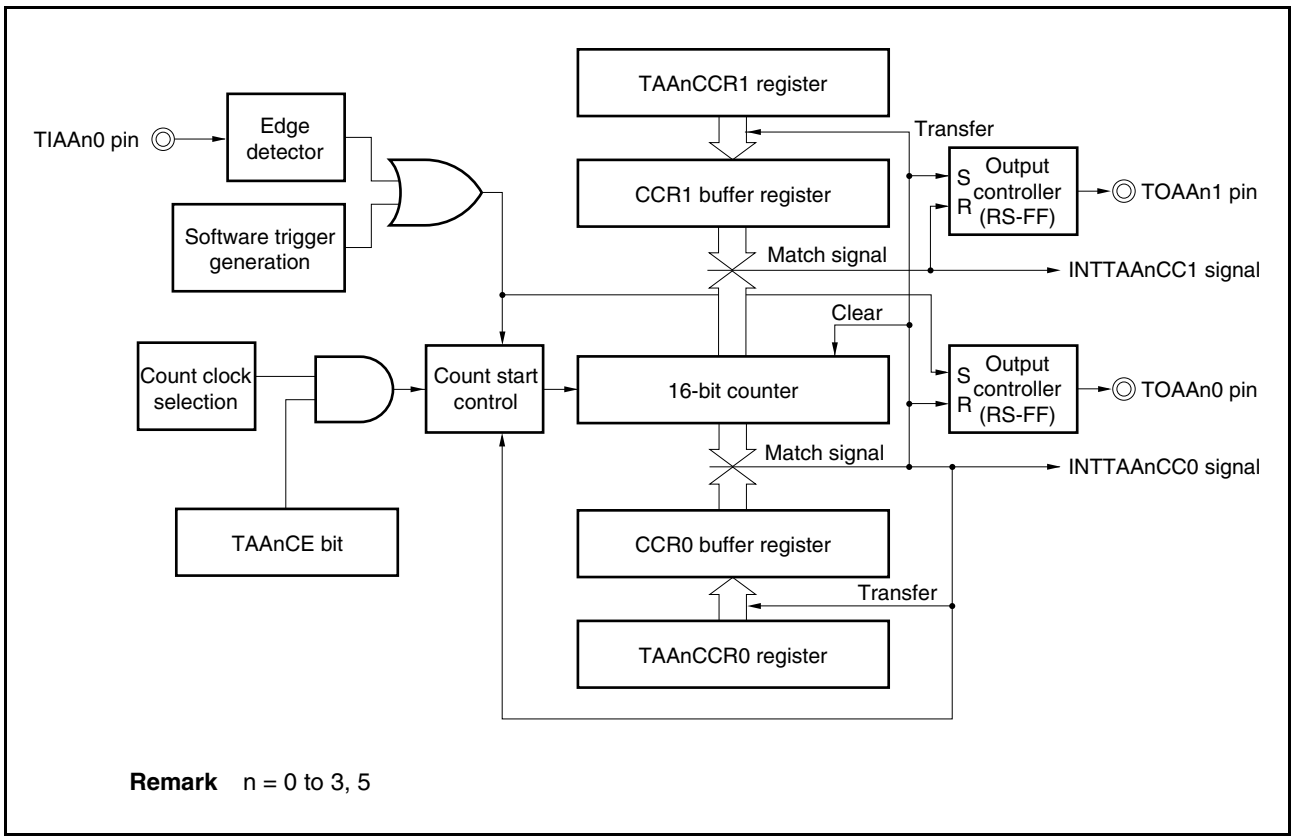
In the external trigger pulse output mode, however, it is generated one clock earlier. This is because the timing is changed to match the timing of changing the output signal of the TOAAn1 pin.

7.5.4 One-shot pulse output mode (TAAnMD2 to TAAnMD0 bits = 011)

In the one-shot pulse output mode, 16-bit timer/event counter AA waits for a trigger when the TAAnCTL0.TAAnCE bit is set to 1. When the valid edge of an external trigger input is detected, 16-bit timer/event counter AA starts counting, and outputs a one-shot pulse from the TOAAn1 pin.

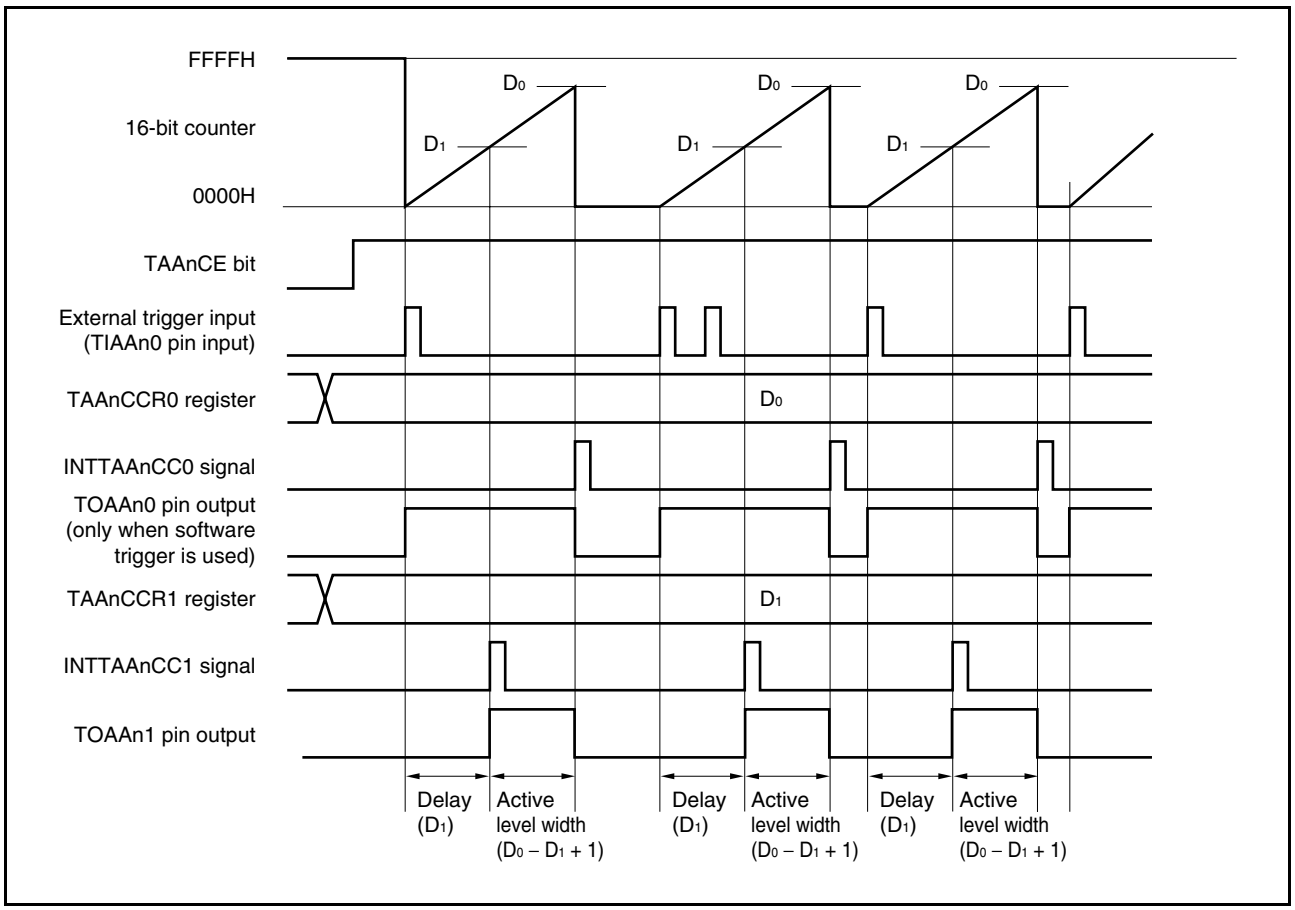
Instead of the external trigger, a software trigger can also be generated to output the pulse. When the software trigger is used, the TOAAn0 pin outputs the active level while the 16-bit counter is counting, and the inactive level when the counter is stopped (waiting for a trigger).

Figure 7-25. Configuration in One-Shot Pulse Output Mode



Remark n = 0 to 3, 5

Figure 7-26. Basic Timing in One-Shot Pulse Output Mode



When the TAAnCE bit is set to 1, 16-bit timer/event counter AA waits for a trigger. When the trigger is generated, the 16-bit counter is cleared from FFFFH to 0000H, starts counting, and outputs a one-shot pulse from the TOAAn1 pin. After the one-shot pulse is output, the 16-bit counter is set to FFFFH, stops counting, and waits for a trigger. If a trigger is generated again while the one-shot pulse is being output, it is ignored.

The output delay period and active level width of the one-shot pulse can be calculated as follows.

Output delay period = (Set value of TAAnCCR1 register) × Count clock cycle

Active level width = (Set value of TAAnCCR0 register − Set value of TAAnCCR1 register + 1) × Count clock cycle

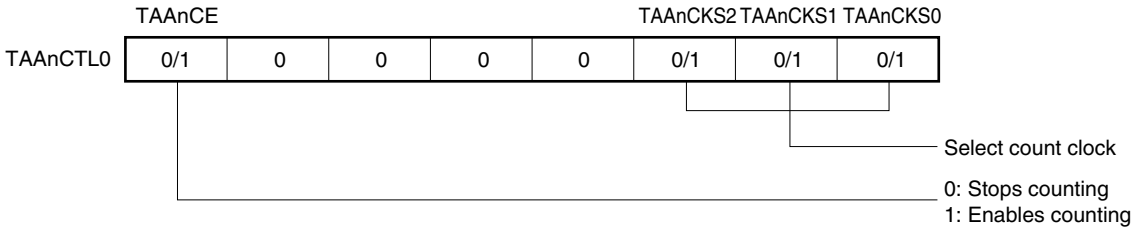
The compare match interrupt request signal INTTAAnCC0 is generated when the 16-bit counter counts after its count value matches the value of the CCR0 buffer register. The compare match interrupt request signal INTTAAnCC1 is generated when the count value of the 16-bit counter matches the value of the CCR1 buffer register.

The valid edge of an external trigger input or setting the software trigger (TAAnCTL1.TAAnEST bit) to 1 is used as the trigger.

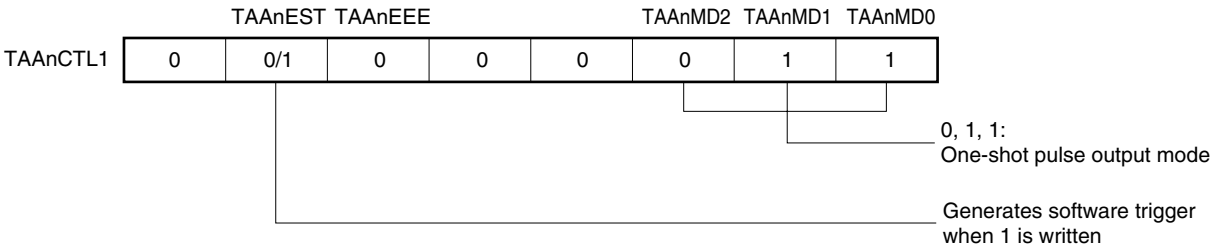
Remark n = 0 to 3, 5

Figure 7-27. Register Setting for Operation in One-Shot Pulse Output Mode (1/2)

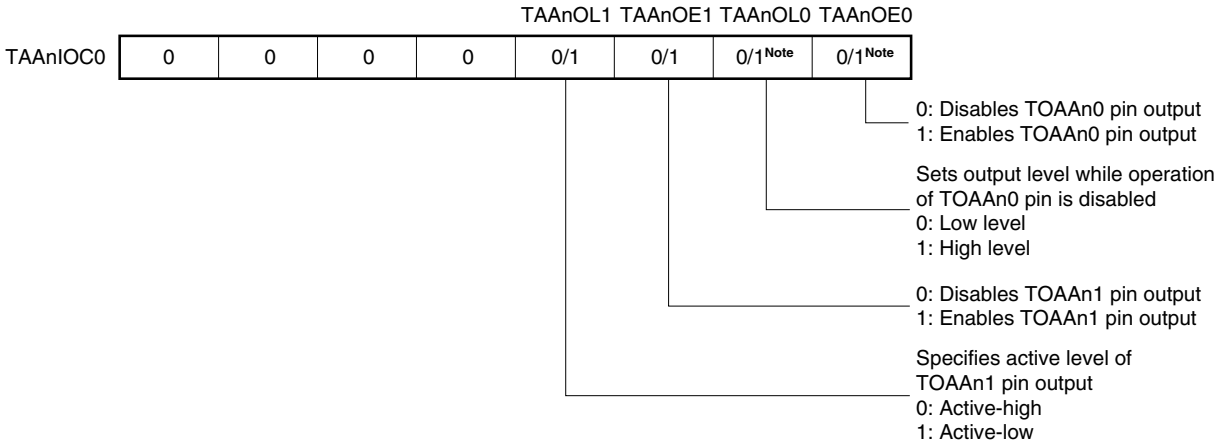
(a) TAAn control register 0 (TAAnCTL0)



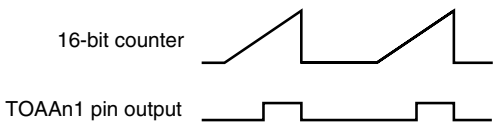
(b) TAAn control register 1 (TAAnCTL1)



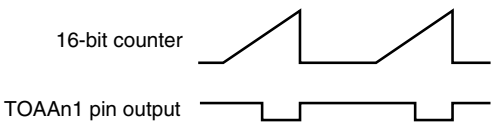
(c) TAAn I/O control register 0 (TAAnIOC0)



• When TAAnOL1 bit = 0



• When TAAnOL1 bit = 1



Note Clear this bit to 0 when the TOAAn0 pin is not used in the one-shot pulse output mode.

Figure 7-27. Register Setting for Operation in One-Shot Pulse Output Mode (2/2)

(d) TAAn I/O control register 2 (TAAnIOC2)

	TAAnEES1	TAAnEES0	TAAnETS1	TAAnETS0
TAAnIOC2	0	0	0/1	0/1

Select valid edge of external trigger input

(e) TAAn counter read buffer register (TAAnCNT)

The value of the 16-bit counter can be read by reading the TAAnCNT register.

(f) TAAn capture/compare registers 0 and 1 (TAAnCCR0 and TAAnCCR1)

If D_0 is set to the TAAnCCR0 register and D_1 to the TAAnCCR1 register, the active level width and output delay period of the one-shot pulse are as follows.

Active level width = $(D_0 - D_1 + 1) \times$ Count clock cycle

Output delay period = $(D_1) \times$ Count clock cycle

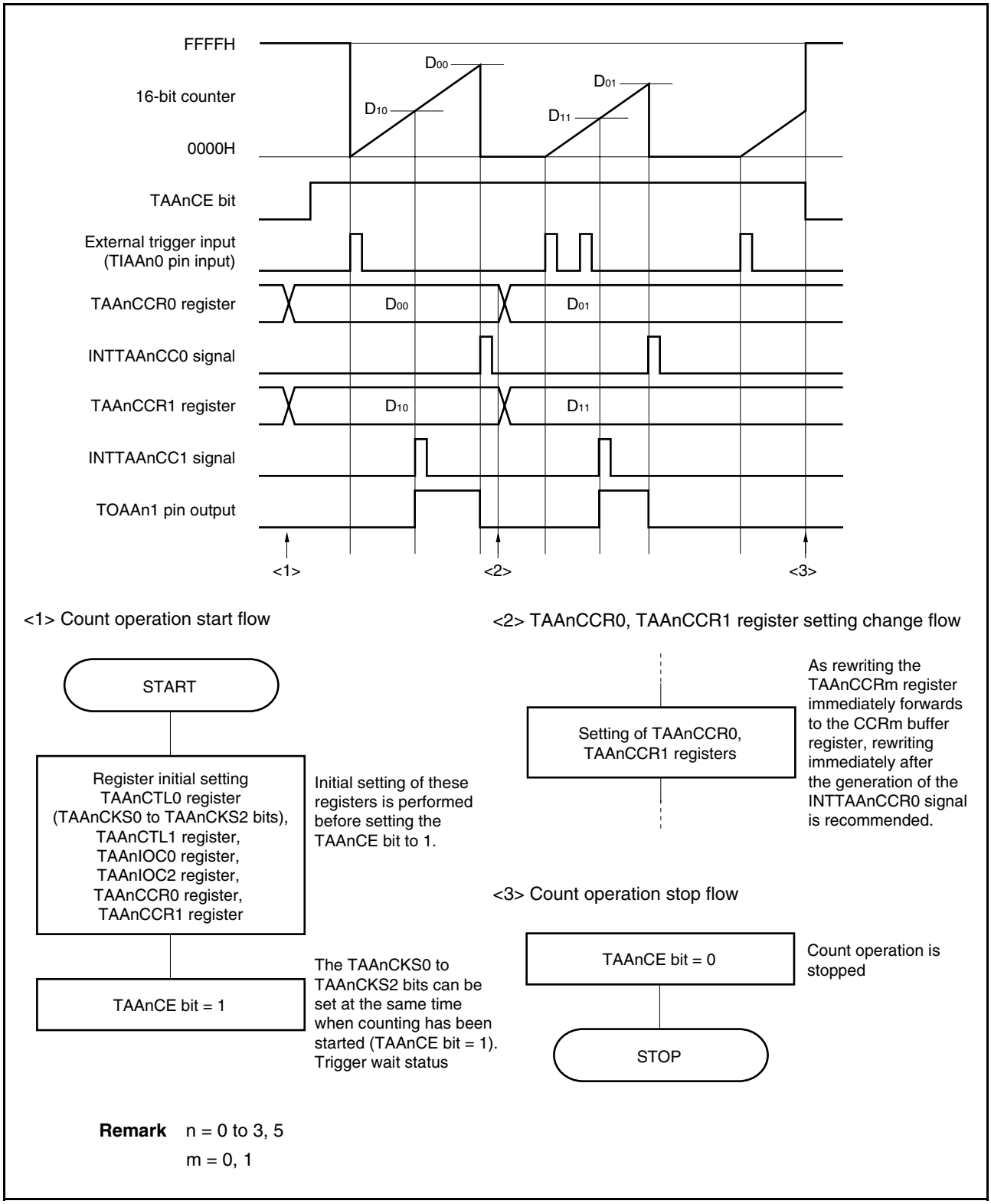
Caution One-shot pulses are not output even in the one-shot pulse output mode, if the set value of the TAAnCCR1 register is greater than the set value of the TAAnCCR0 register.

Remarks 1. TAAn I/O control register 1 (TAAnIOC1) and TAAn option register 0 (TAAnOPT0) are not used in the one-shot pulse output mode.

2. n = 0 to 3, 5

(1) Operation flow in one-shot pulse output mode

Figure 7-28. Software Processing Flow in One-Shot Pulse Output Mode



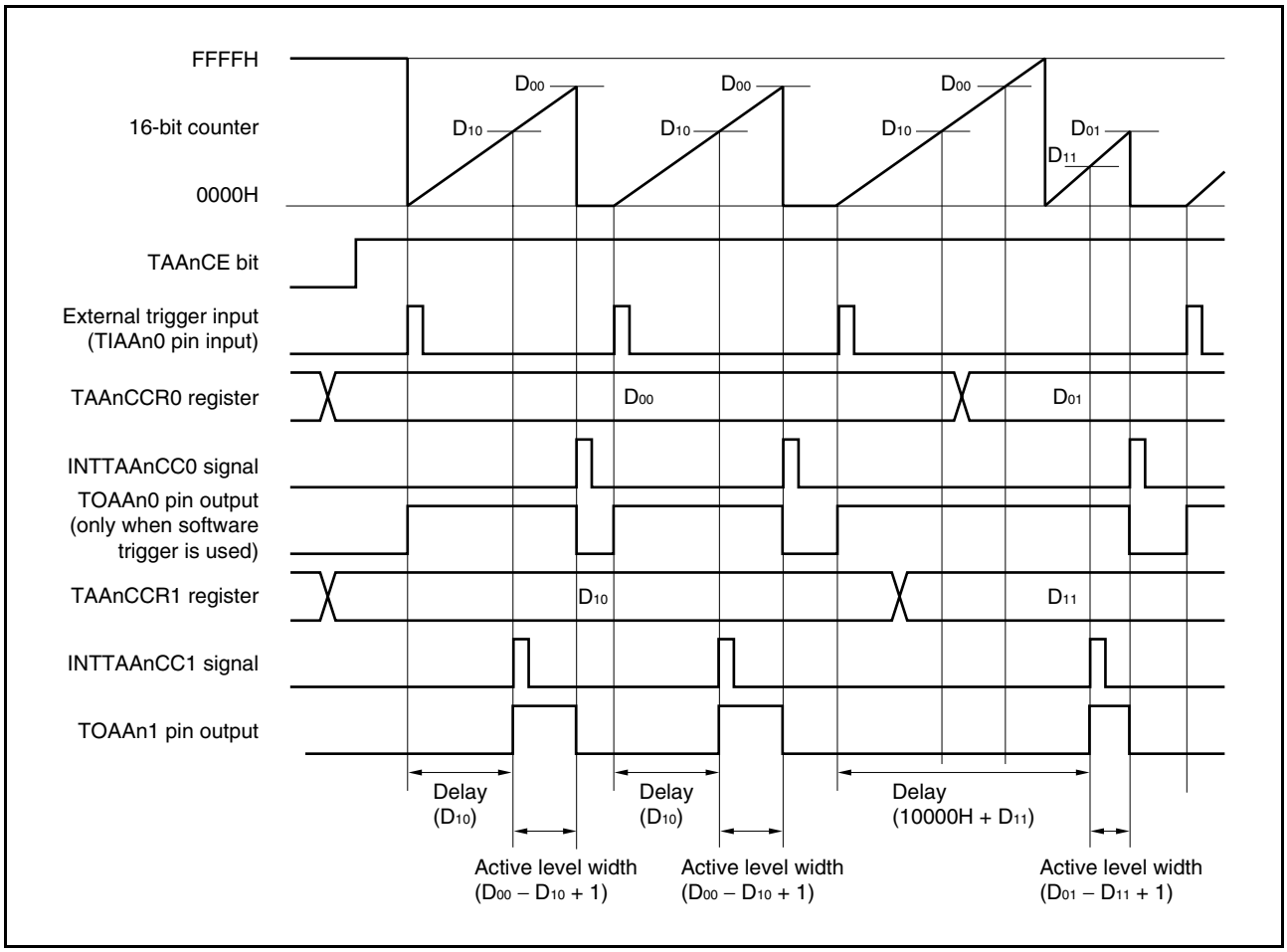
Remark n = 0 to 3, 5
m = 0, 1

(2) Operation timing in one-shot pulse output mode

(a) Note on rewriting TAAnCCRm register

To change the set value of the TAAnCCRm register to a smaller value, stop counting once, and then change the set value.

If the value of the TAAnCCRm register is rewritten to a smaller value during counting, the 16-bit counter may overflow.



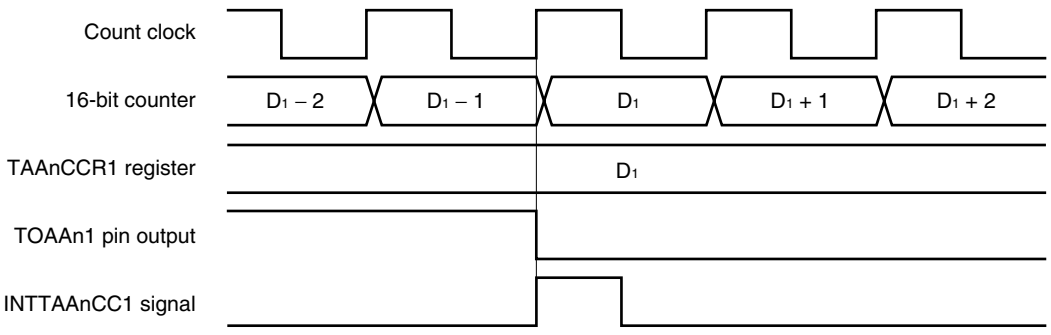
When the TAAnCCR0 register is rewritten from D_{00} to D_{01} and the TAAnCCR1 register from D_{10} to D_{11} where $D_{00} > D_{01}$ and $D_{10} > D_{11}$, if the TAAnCCR1 register is rewritten when the count value of the 16-bit counter is greater than D_{11} and less than D_{10} and if the TAAnCCR0 register is rewritten when the count value is greater than D_{01} and less than D_{00}, each set value is reflected as soon as the register has been rewritten and compared with the count value. The counter counts up to FFFFH and then counts up again from 0000H. When the count value matches D_{11}, the counter generates the INTTAAnCC1 signal and asserts the TOAAn1 pin. When the count value matches D_{01}, the counter generates the INTTAAnCC0 signal, deasserts the TOAAn1 pin, and stops counting.

Therefore, the counter may output a pulse with a delay period or active period different from that of the one-shot pulse that is originally expected.

Remark n = 0 to 3, 5
m = 0, 1

(b) Generation timing of compare match interrupt request signal (INTTAAnCC1)

The generation timing of the INTTAAnCC1 signal in the one-shot pulse output mode is different from other INTTAAnCC1 signals; the INTTAAnCC1 signal in the one-shot pulse output mode is generated when the count value of the 16-bit counter matches the value of the TAAnCCR1 register.



Remark n = 0 to 3, 5

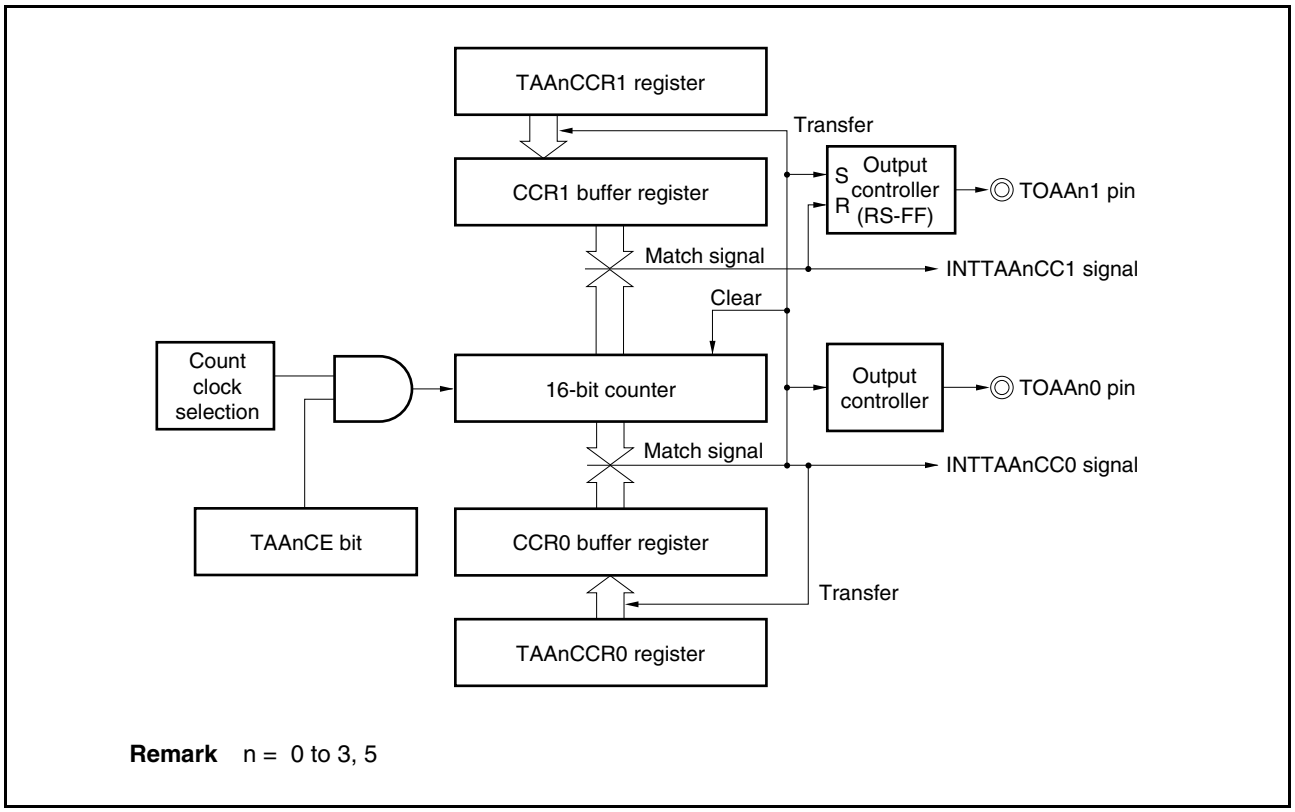
Usually, the INTTAAnCC1 signal is generated the next time the 16-bit counter counts after its count value matches the value of the TAAnCCR1 register.

In the one-shot pulse output mode, however, it is generated one clock earlier. This is because the timing is changed to match the change timing of the TOAAn1 pin.

7.5.5 PWM output mode (TAAnMD2 to TAAnMD0 bits = 100)

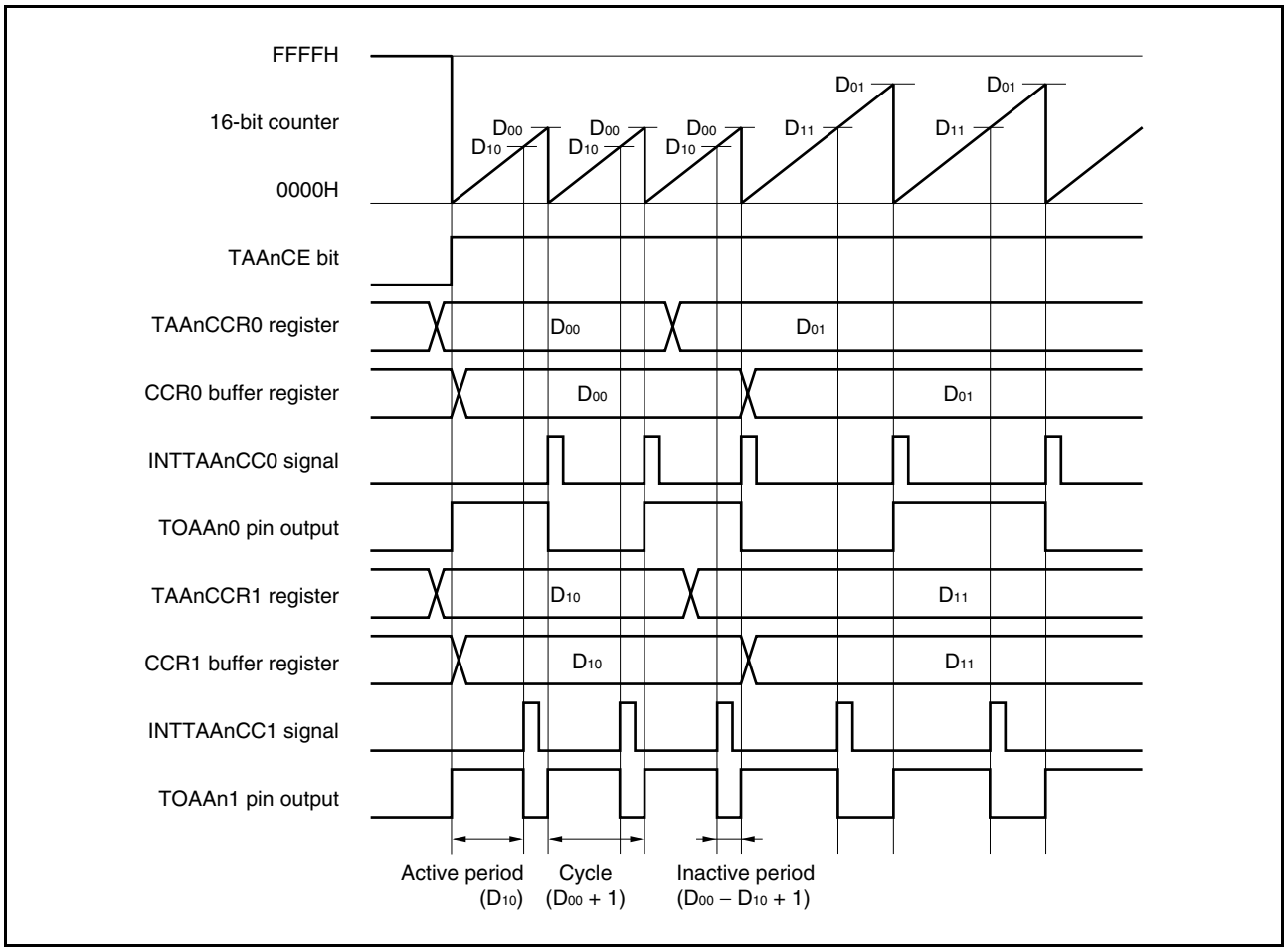
In the PWM output mode, a PWM waveform is output from the TOAAn1 pin when the TAAnCTL0.TAAnCE bit is set to 1. In addition, a pulse with one cycle of the PWM waveform as half its cycle is output from the TOAAn0 pin.

Figure 7-29. Configuration in PWM Output Mode



Remark n = 0 to 3, 5

Figure 7-30. Basic Timing in PWM Output Mode



When the TAAnCE bit is set to 1, the 16-bit counter is cleared from FFFFH to 0000H, starts counting, and outputs a PWM waveform from the TOAAn1 pin.

The active level width, cycle, and duty factor of the PWM waveform can be calculated as follows.

Active level width = (Set value of TAAnCCR1 register) × Count clock cycle
Cycle = (Set value of TAAnCCR0 register + 1) × Count clock cycle
Duty factor = (Set value of TAAnCCR1 register)/(Set value of TAAnCCR0 register + 1)

The PWM waveform can be changed by rewriting the TAAnCCRm register while the counter is operating. The newly written value is reflected when the count value of the 16-bit counter matches the value of the CCR0 buffer register and the 16-bit counter is cleared to 0000H.

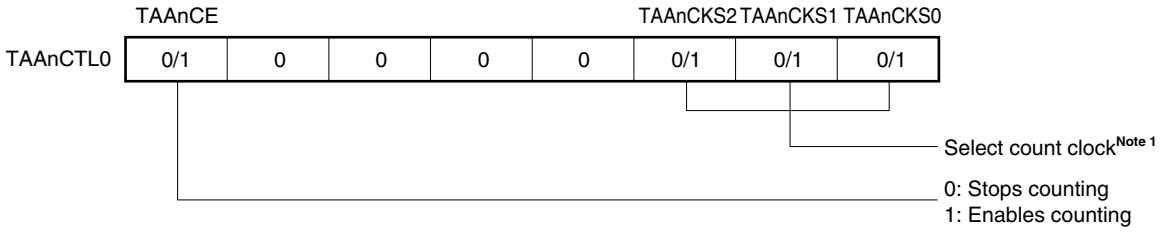
The compare match interrupt request signal INTTAAnCC0 is generated the next time the 16-bit counter counts after its count value matches the value of the CCR0 buffer register, and the 16-bit counter is cleared to 0000H. The compare match interrupt request signal INTTAAnCC1 is generated when the count value of the 16-bit counter matches the value of the CCR1 buffer register.

The value set to the TAAnCCRm register is transferred to the CCRm buffer register when the count value of the 16-bit counter matches the value of the CCRm buffer register and the 16-bit counter is cleared to 0000H.

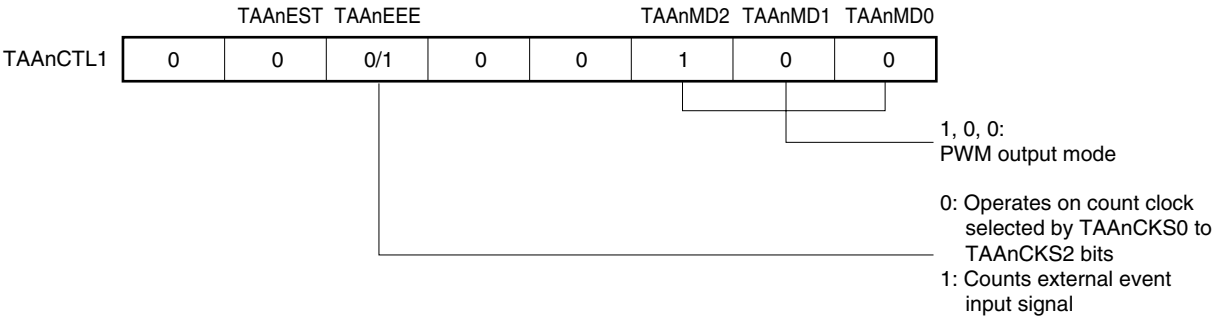
Remark n = 0 to 3, 5
m = 0, 1

Figure 7-31. Setting of Registers in PWM Output Mode (1/2)

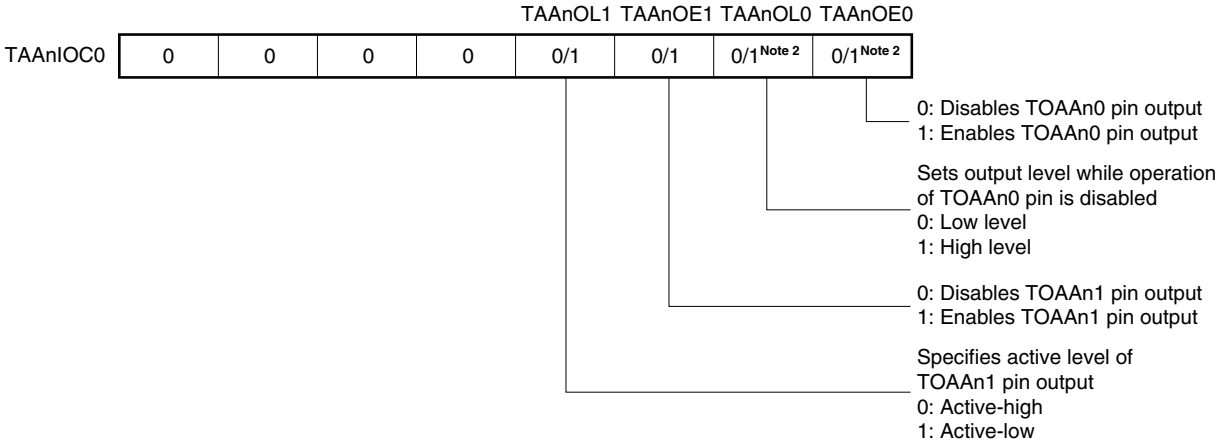
(a) TAAn control register 0 (TAAnCTL0)



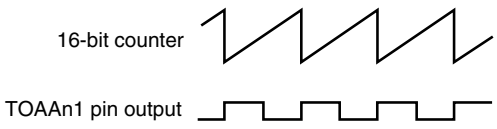
(b) TAAn control register 1 (TAAnCTL1)



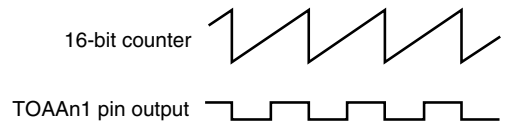
(c) TAAn I/O control register 0 (TAAnIOC0)



- When TAAnOL1 bit = 0



- When TAAnOL1 bit = 1



Notes 1. The setting is invalid when the TAAnCTL1.TAAnEEE bit = 1.

2. Clear this bit to 0 when the TOAAn0 pin is not used in the PWM output mode.

Figure 7-31. Setting of Registers in PWM Output Mode (2/2)

(d) TAAn I/O control register 2 (TAAnIOC2)

	TAAnEES1	TAAnEES0	TAAnETS1	TAAnETS0				
TAAnIOC2	0	0	0	0	0/1	0/1	0	0

Select valid edge of external event count input.

(e) TAAn counter read buffer register (TAAnCNT)

The value of the 16-bit counter can be read by reading the TAAnCNT register.

(f) TAAn capture/compare registers 0 and 1 (TAAnCCR0 and TAAnCCR1)

If D_0 is set to the TAAnCCR0 register and D_1 to the TAAnCCR1 register, the cycle and active level of the PWM waveform are as follows.

Cycle = $(D_0 + 1) \times$ Count clock cycle

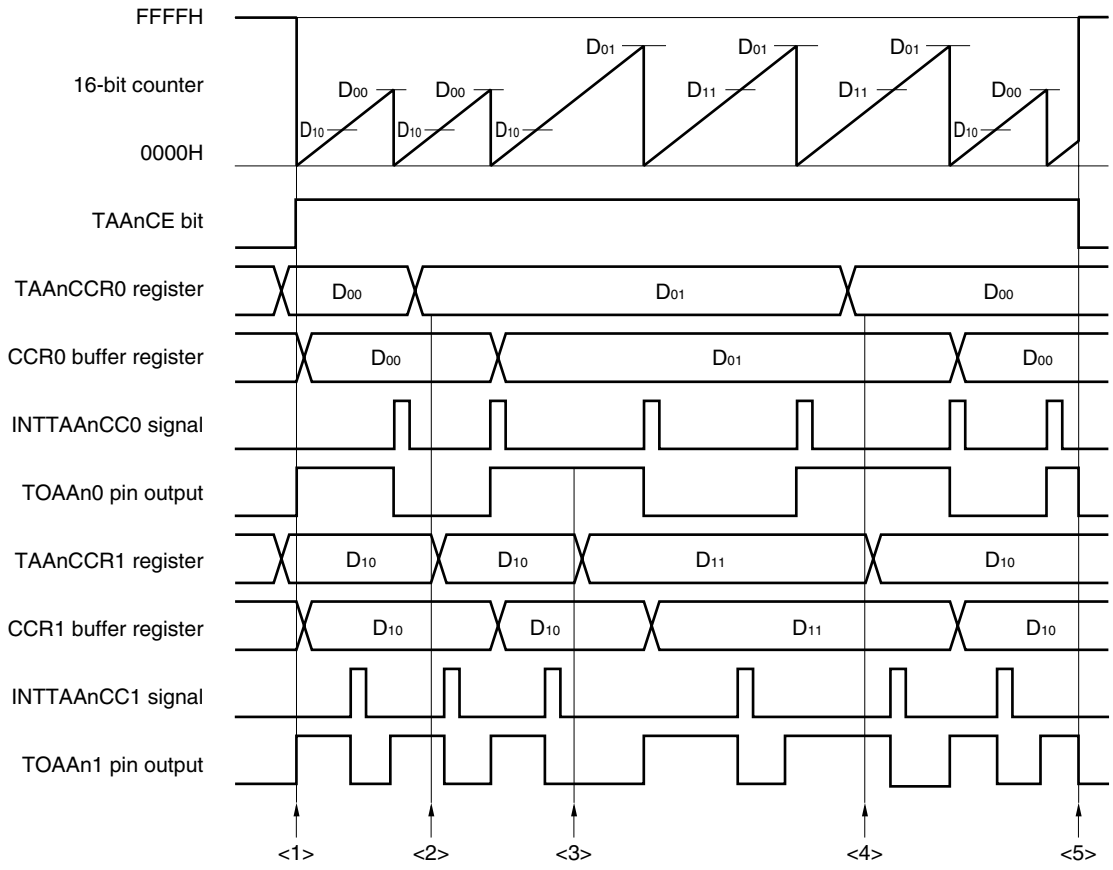
Active level width = $D_1 \times$ Count clock cycle

Remarks 1. TAAn I/O control register 1 (TAAnIOC1) and TAAn option register 0 (TAAnOPT0) are not used in the PWM output mode.

2. n = 0 to 3, 5

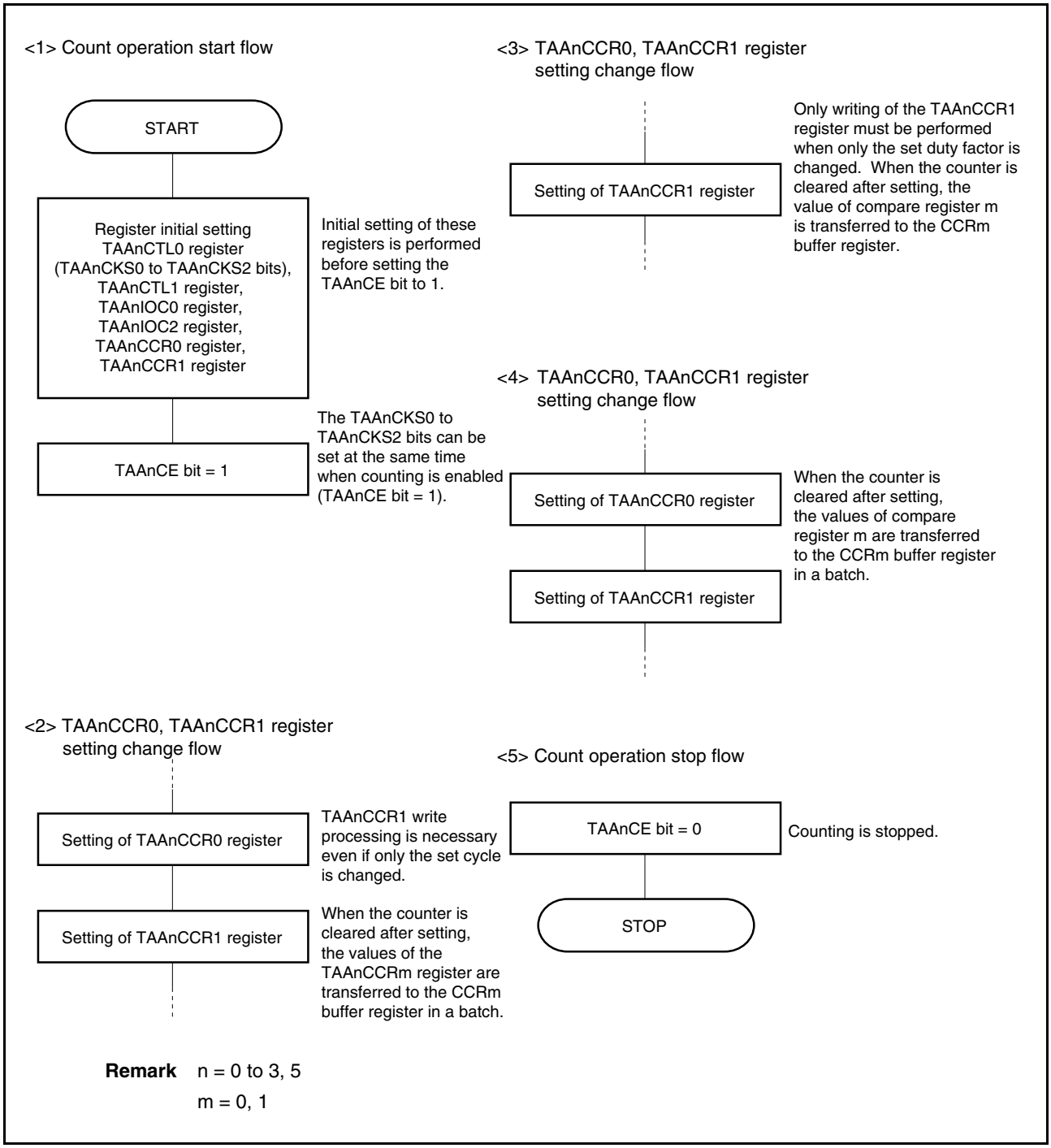
(1) Operation flow in PWM output mode

Figure 7-32. Software Processing Flow in PWM Output Mode (1/2)



Remark n = 0 to 3, 5
m = 0, 1

Figure 7-32. Software Processing Flow in PWM Output Mode (2/2)



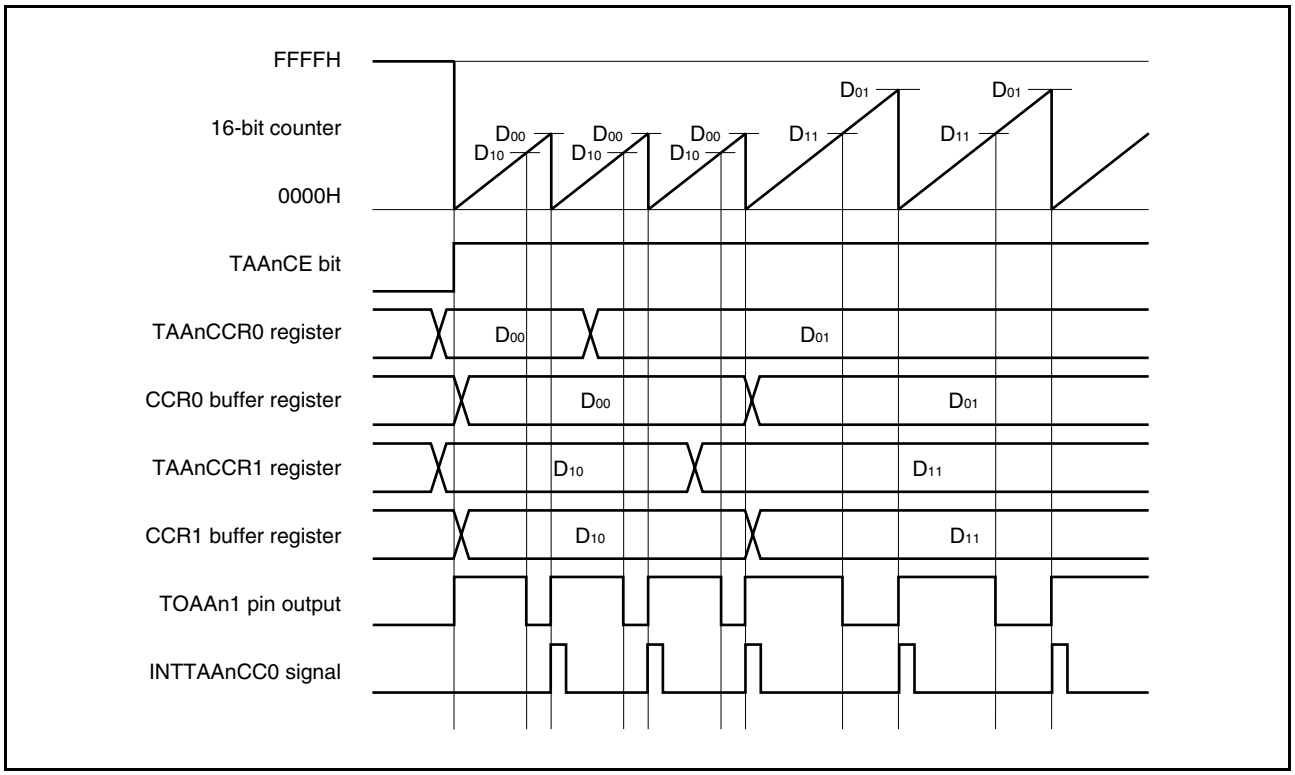
Remark n = 0 to 3, 5
m = 0, 1

(2) PWM output mode operation timing

(a) Changing pulse width during operation

To change the PWM waveform while the counter is operating, write the TAAnCCR1 register last.

Rewrite the TAAnCCRm register after writing the TAAnCCR1 register after the INTTAAnCC1 signal is detected.



To transfer data from the TAAnCCRm register to the CCRm buffer register, the TAAnCCR1 register must be written.

To change both the cycle and active level of the PWM waveform at this time, first set the cycle to the TAAnCCR0 register and then set the active level to the TAAnCCR1 register.

To change only the cycle of the PWM waveform, first set the cycle to the TAAnCCR0 register, and then write the same value to the TAAnCCR1 register.

To change only the active level width (duty factor) of the PWM waveform, only the TAAnCCR1 register has to be set.

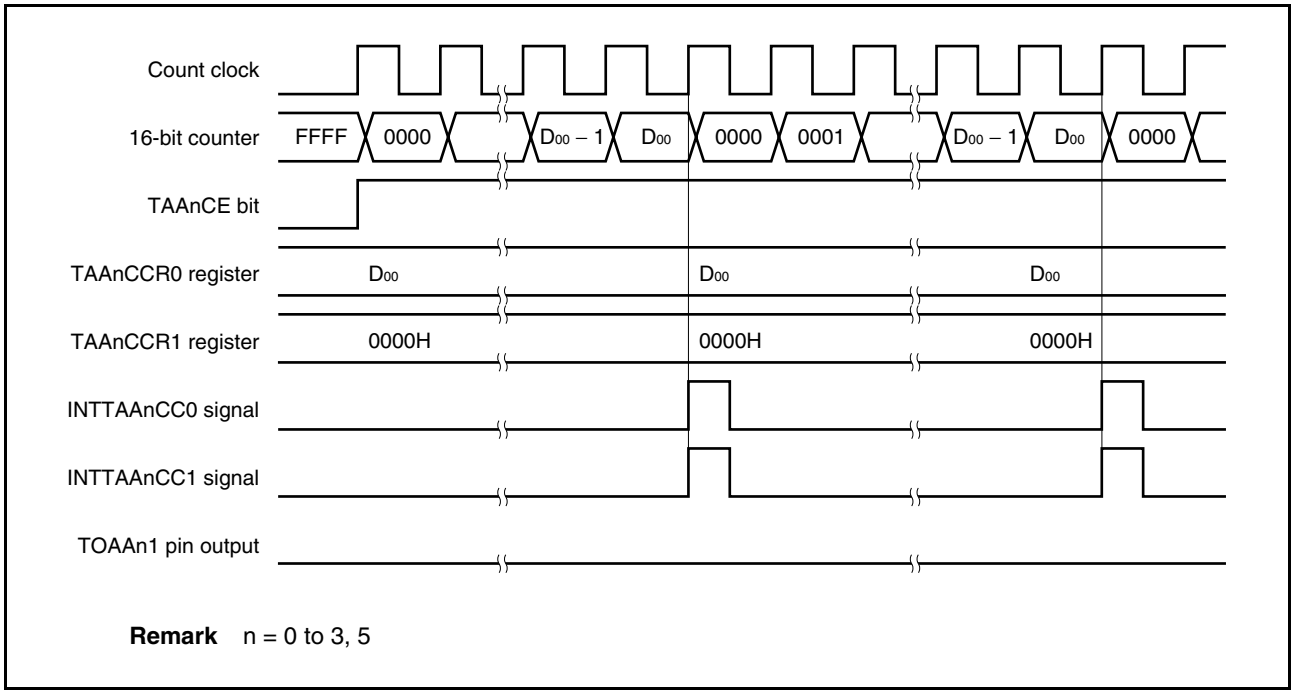
After data is written to the TAAnCCR1 register, the value written to the TAAnCCRm register is transferred to the CCRm buffer register in synchronization with clearing of the 16-bit counter, and is used as the value compared with the 16-bit counter.

To write the TAAnCCR0 or TAAnCCR1 register again after writing the TAAnCCR1 register once, do so after the INTTAAnCC0 signal is generated. Otherwise, the value of the CCRm buffer register may become undefined because the timing of transferring data from the TAAnCCRm register to the CCRm buffer register conflicts with writing the TAAnCCRm register.

Remark n = 0 to 3, 5
m = 0, 1

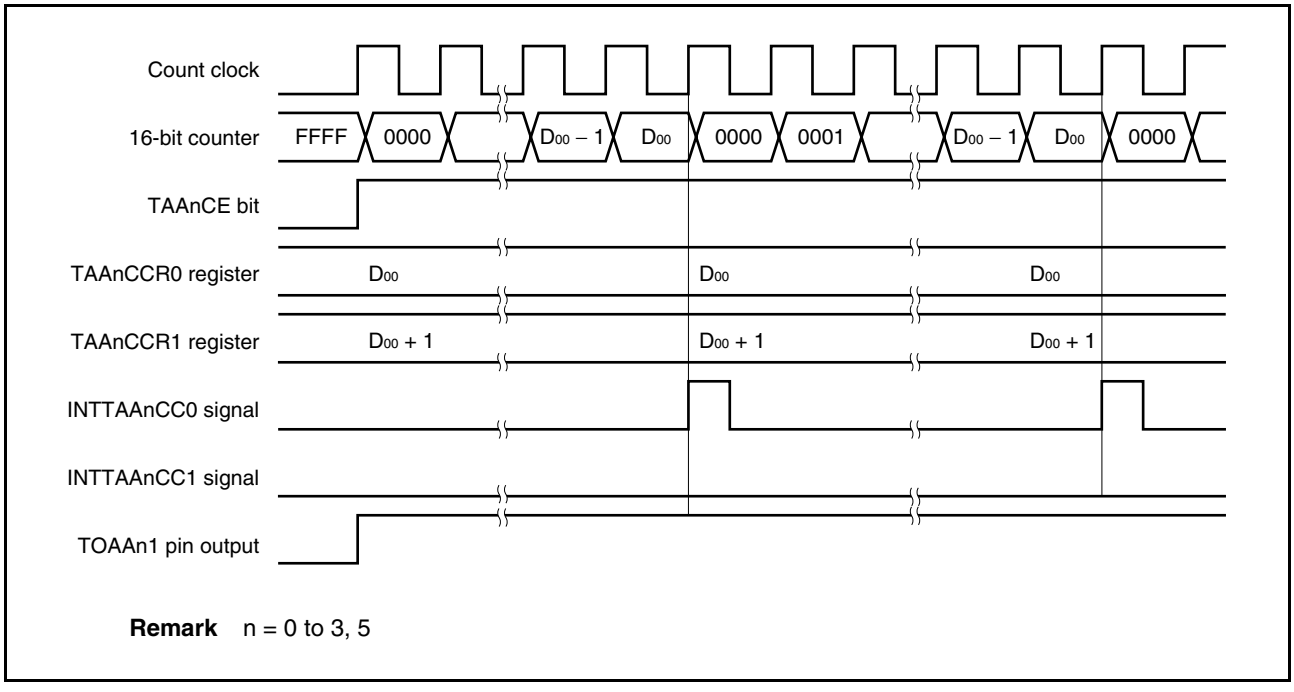
(b) 0%/100% output of PWM waveform

To output a 0% waveform, set the TAAnCCR1 register to 0000H. If the set value of the TAAnCCR0 register is FFFFH, the INTTAAnCC1 signal is generated periodically.



Remark n = 0 to 3, 5

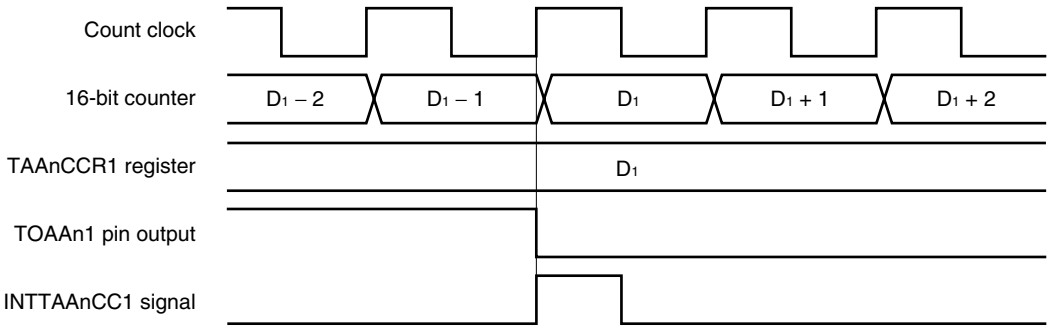
To output a 100% waveform, set a value of (set value of TAAnCCR0 register + 1) to the TAAnCCR1 register. If the set value of the TAAnCCR0 register is FFFFH, 100% output cannot be produced.



Remark n = 0 to 3, 5

(c) Generation timing of compare match interrupt request signal (INTTAAnCC1)

The timing of generation of the INTTAAnCC1 signal in the PWM output mode differs from the timing of other INTTAAnCC1 signals; the INTTAAnCC1 signal in the PWM output mode is generated when the count value of the 16-bit counter matches the value of the TAAnCCR1 register.



Remark n = 0 to 3, 5

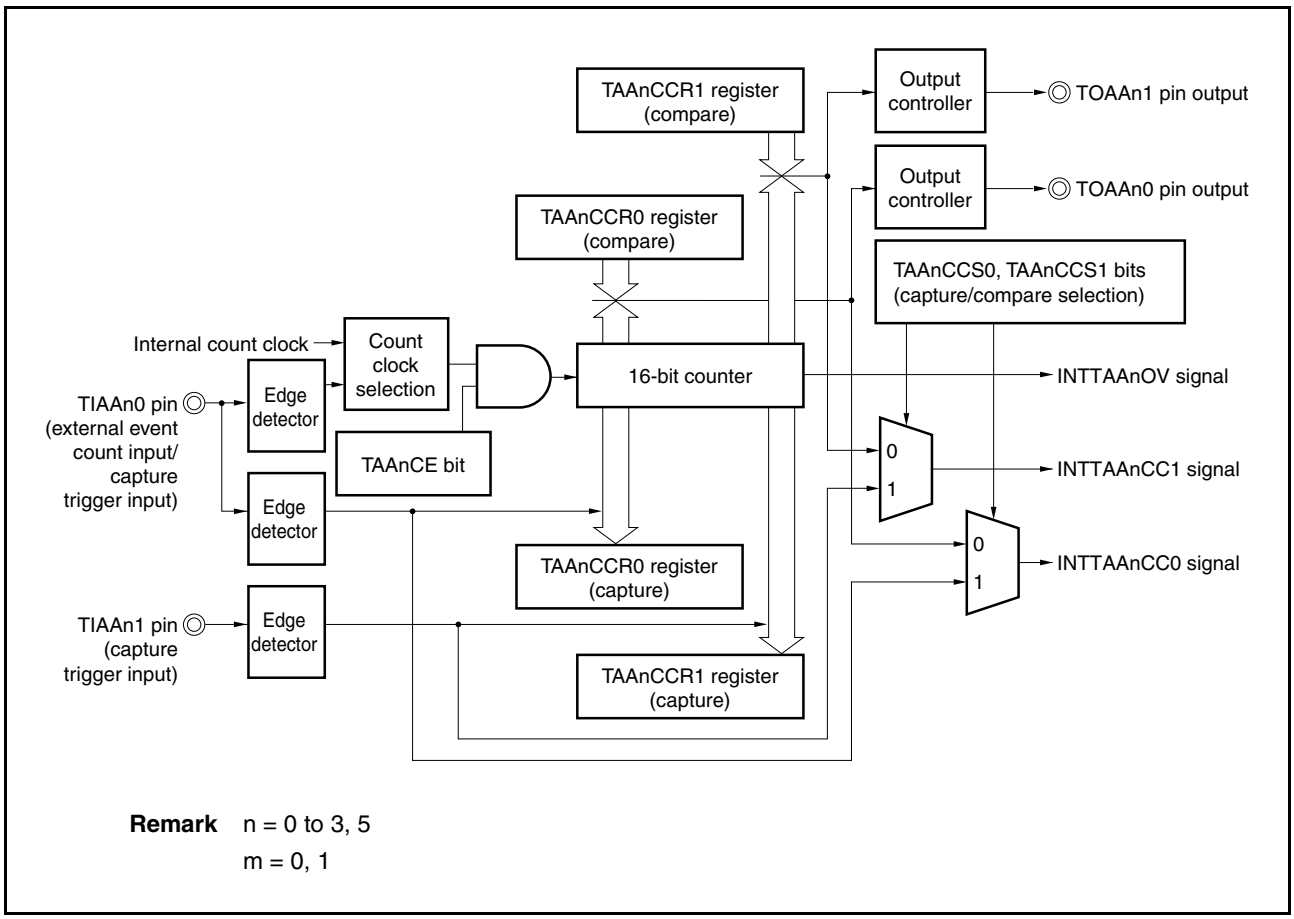
Usually, the INTTAAnCC1 signal is generated in synchronization with the next count-up after the count value of the 16-bit counter matches the value of the TAAnCCR1 register.

In the PWM output mode, however, it is generated one clock earlier. This is because the timing is changed to match the change timing of the output signal of the TOAAn1 pin.

7.5.6 Free-running timer mode (TAAnMD2 to TAAnMD0 bits = 101)

In the free-running timer mode, 16-bit timer/event counter AA starts counting when the TAAnCTL0.TAAnCE bit is set to 1. At this time, the TAAnCCRm register can be used as a compare register or a capture register, depending on the setting of the TAAnOPT0.TAAnCCS0 and TAAnOPT0.TAAnCCS1 bits.

Figure 7-33. Configuration in Free-Running Timer Mode



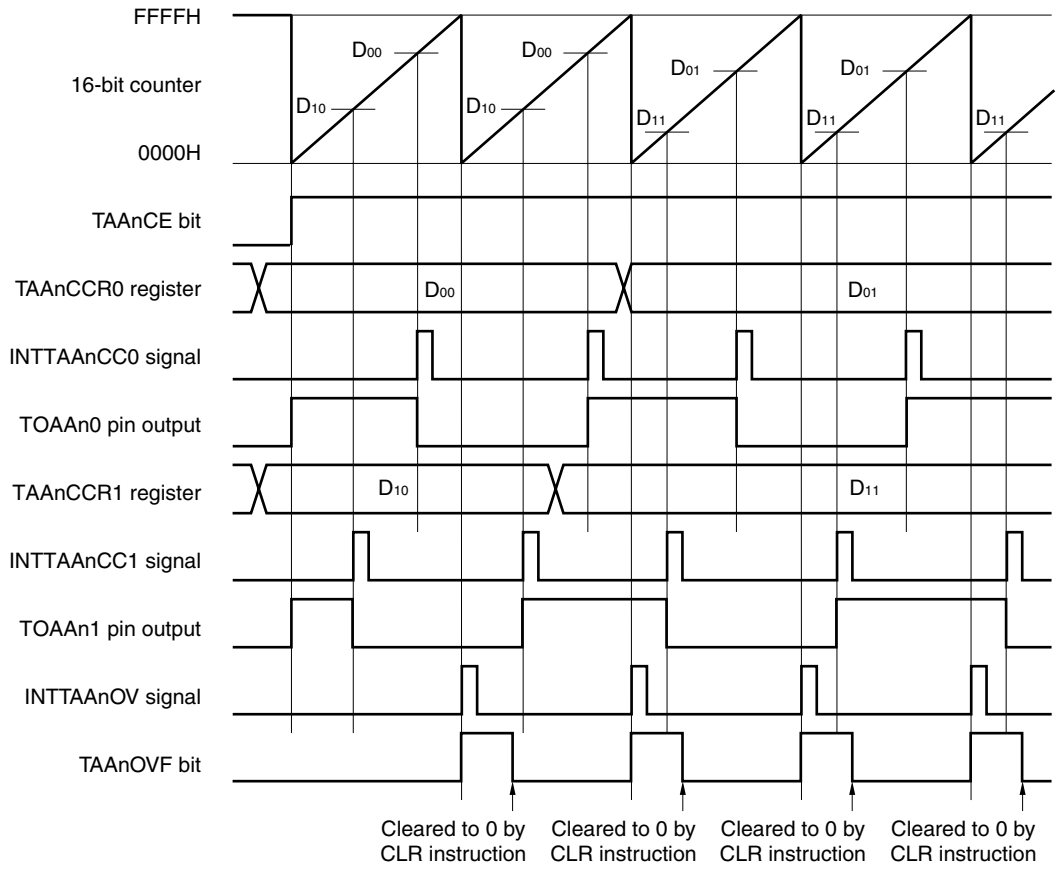
Remark n = 0 to 3, 5
m = 0, 1

When the TAAnCE bit is set to 1, 16-bit timer/event counter AA starts counting, and the output signals of the TOAAn0 and TOAAn1 pins are inverted. When the count value of the 16-bit counter later matches the set value of the TAAnCCRm register, a compare match interrupt request signal (INTTAAnCCm) is generated, and the output signal of the TOAAnm pin is inverted.

The 16-bit counter continues counting in synchronization with the count clock. When it counts up to FFFFH, it generates an overflow interrupt request signal (INTTAAnOV) at the next clock, is cleared to 0000H, and continues counting. At this time, the overflow flag (TAAnOPT0.TAAnOVF bit) is also set to 1. Clear the overflow flag to 0 by executing the CLR instruction by software.

The TAAnCCRm register can be rewritten while the counter is operating. If it is rewritten, the new value is reflected at that time, and compared with the count value.

Figure 7-34. Basic Timing in Free-Running Timer Mode (Compare Function)

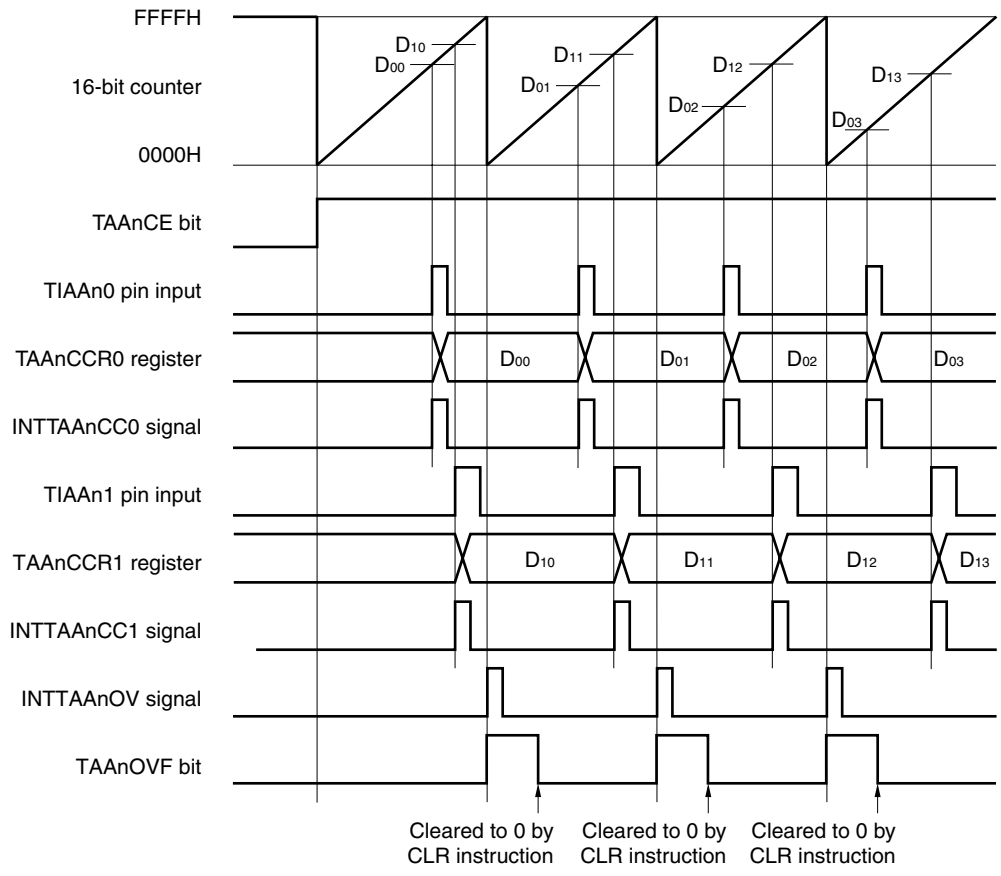


Remark n = 0 to 3, 5
m = 0, 1

When the TAAnCE bit is set to 1, the 16-bit counter starts counting. When the valid edge input to the TIAAnm pin is detected, the count value of the 16-bit counter is stored in the TAAnCCRm register, and a capture interrupt request signal (INTTAAnCCm) is generated.

The 16-bit counter continues counting in synchronization with the count clock. When it counts up to FFFFH, it generates an overflow interrupt request signal (INTTAAnOV) at the next clock, is cleared to 0000H, and continues counting. At this time, the overflow flag (TAAnOPT0.TAAnOVF bit) is also set to 1. Clear the overflow flag to 0 by executing the CLR instruction by software.

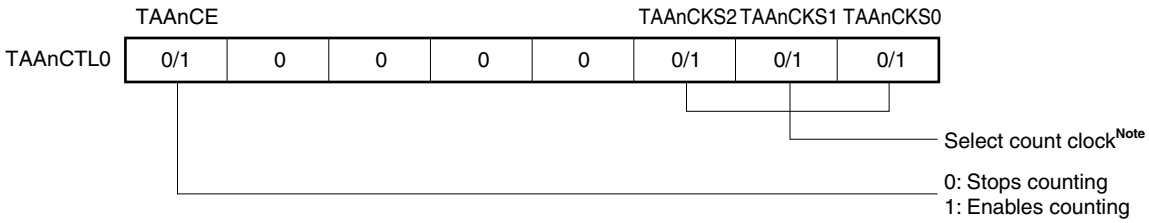
Figure 7-35. Basic Timing in Free-Running Timer Mode (Capture Function)



Remark n = 0 to 3, 5

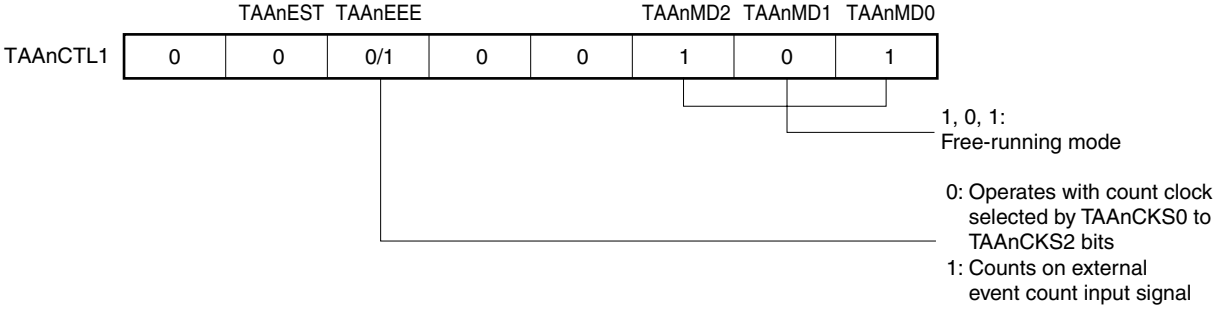
Figure 7-36. Register Setting in Free-Running Timer Mode (1/2)

(a) TAAn control register 0 (TAAnCTL0)



Note The setting is invalid when the TAAnCTL1.TAAnEEE bit = 1

(b) TAAn control register 1 (TAAnCTL1)



(c) TAAn I/O control register 0 (TAAnIOC0)

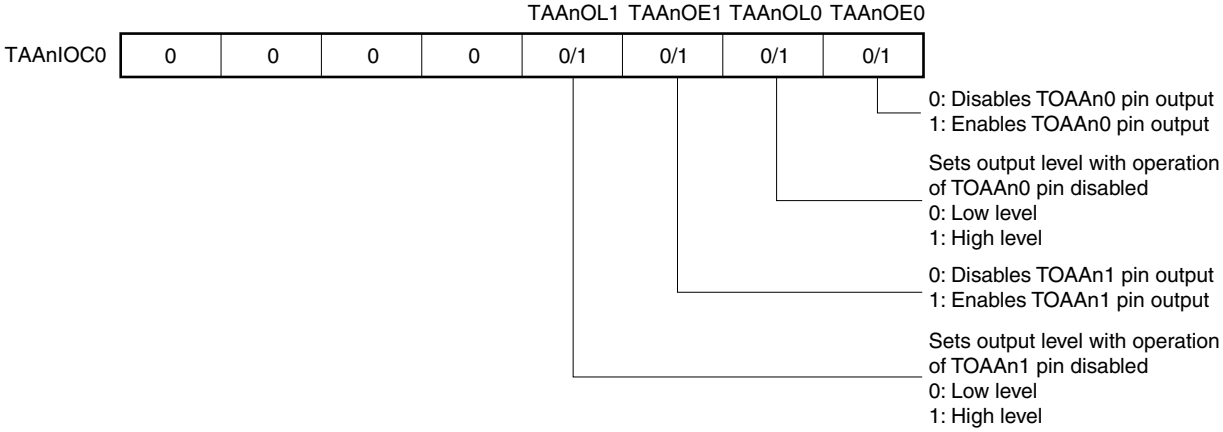
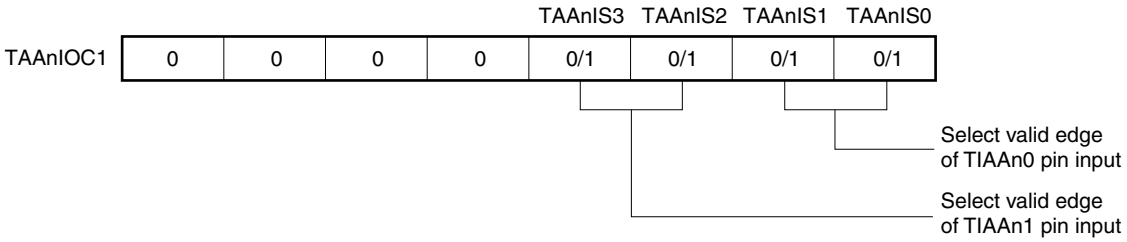
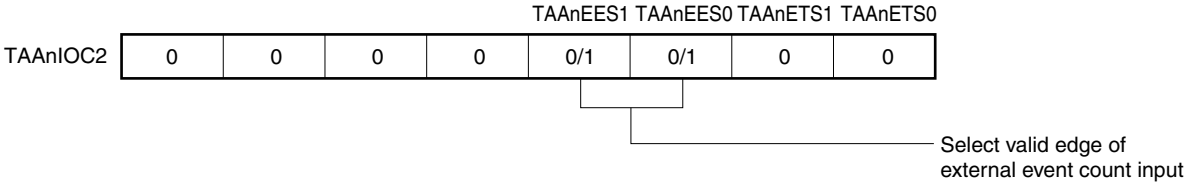


Figure 7-36. Register Setting in Free-Running Timer Mode (2/2)

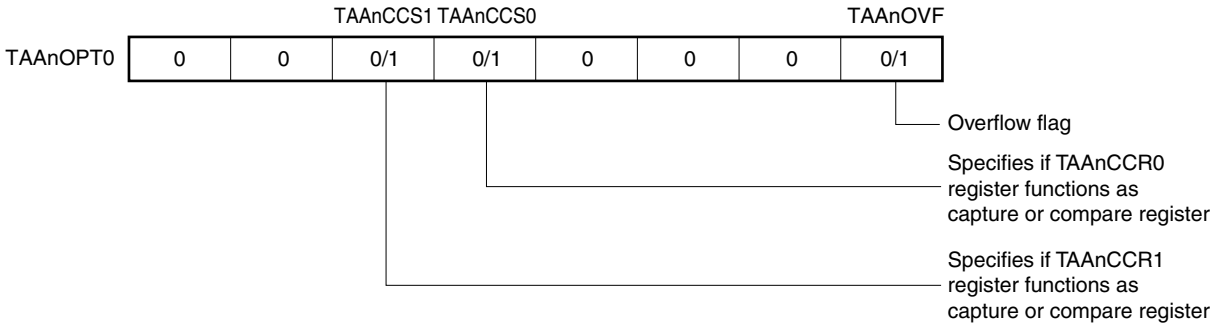
(d) TAAn I/O control register 1 (TAAnIOC1)



(e) TAAn I/O control register 2 (TAAnIOC2)



(f) TAAn option register 0 (TAAnOPT0)



(g) TAAn counter read buffer register (TAAnCNT)

The value of the 16-bit counter can be read by reading the TAAnCNT register.

(h) TAAn capture/compare registers 0 and 1 (TAAnCCR0 and TAAnCCR1)

These registers function as capture registers or compare registers depending on the setting of the TAAnOPT0.TAAnCCSm bit.

When the registers function as capture registers, they store the count value of the 16-bit counter when the valid edge input to the TIAAnm pin is detected.

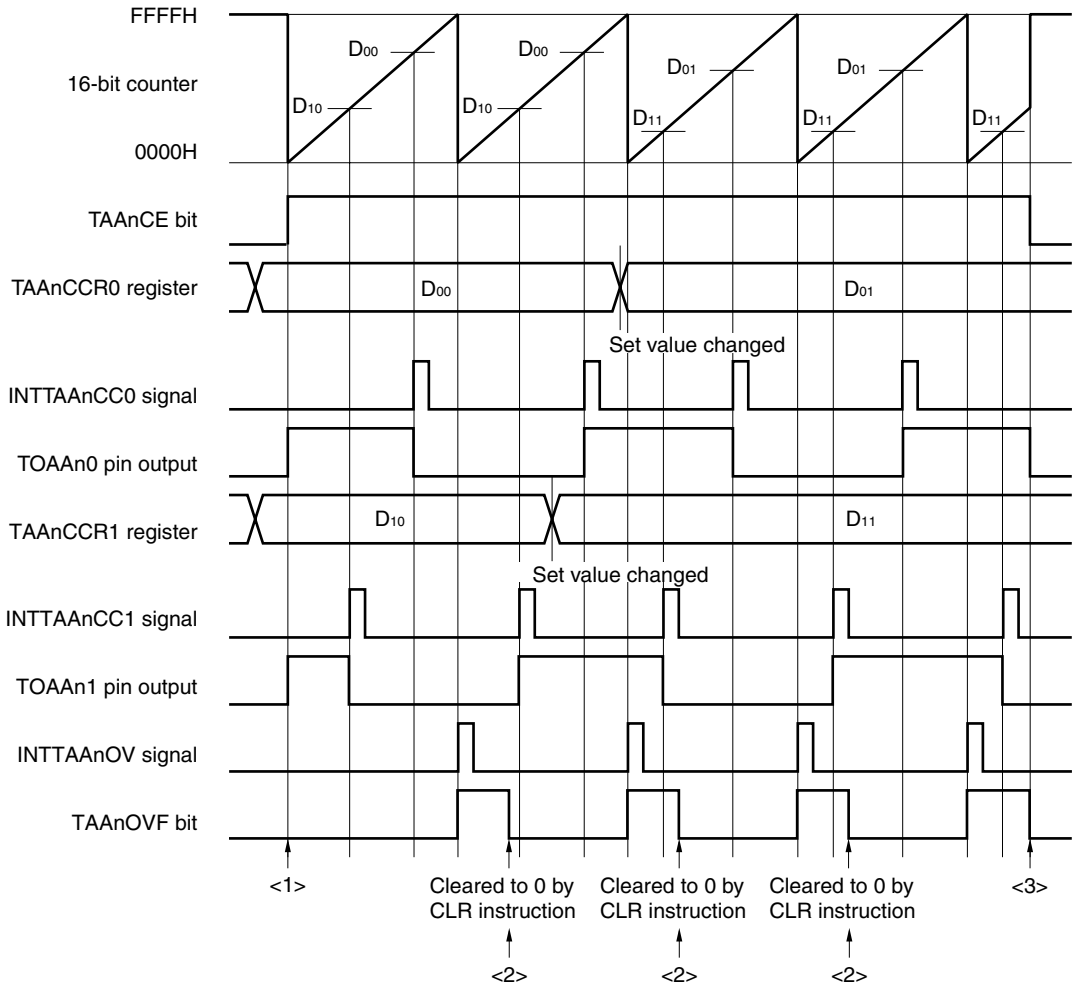
When the registers function as compare registers and when D_m is set to the TAAnCCRm register, the INTTAAnCCm signal is generated when the counter reaches (D_m + 1), and the output signal of the TOAAnm pin is inverted.

Remark n = 0 to 3, 5
m = 0, 1

(1) Operation flow in free-running timer mode

(a) When using capture/compare register as compare register

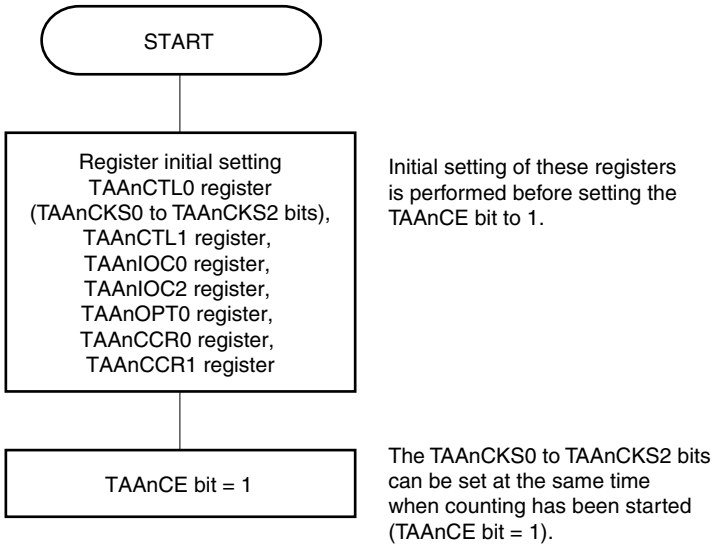
Figure 7-37. Software Processing Flow in Free-Running Timer Mode (Compare Function) (1/2)



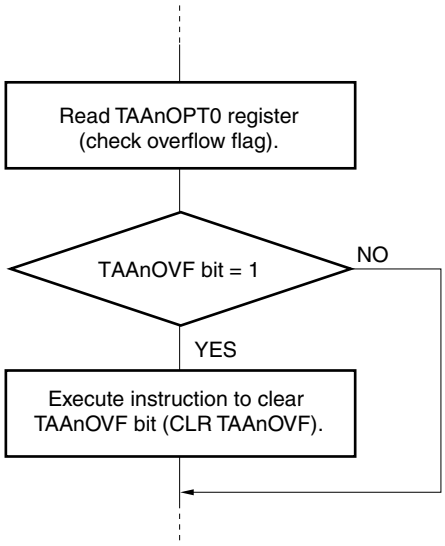
Remark n = 0 to 3, 5

Figure 7-37. Software Processing Flow in Free-Running Timer Mode (Compare Function) (2/2)

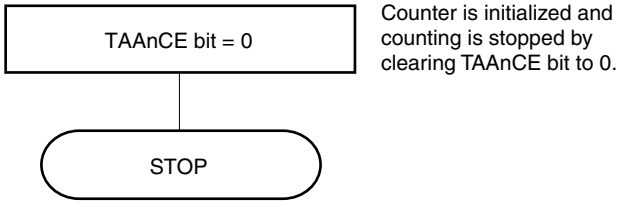
<1> Count operation start flow



<2> Overflow flag clear flow



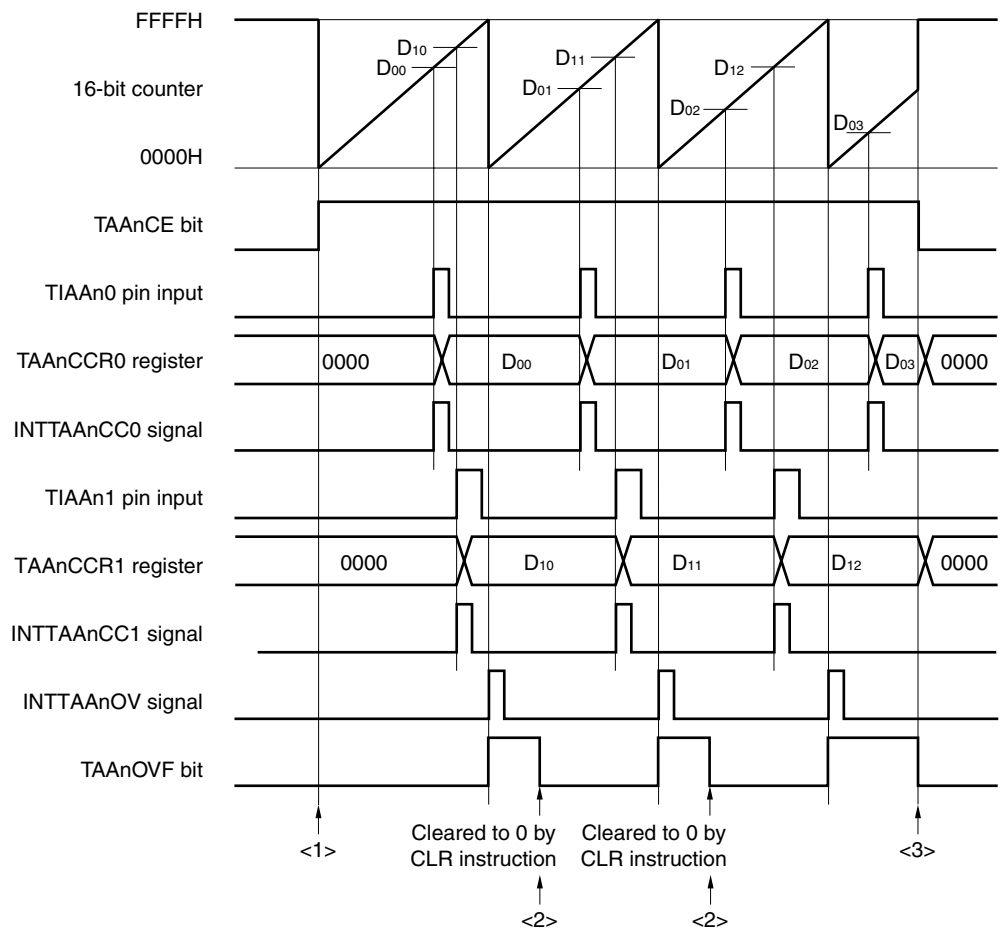
<3> Count operation stop flow



Remark n = 0 to 3, 5

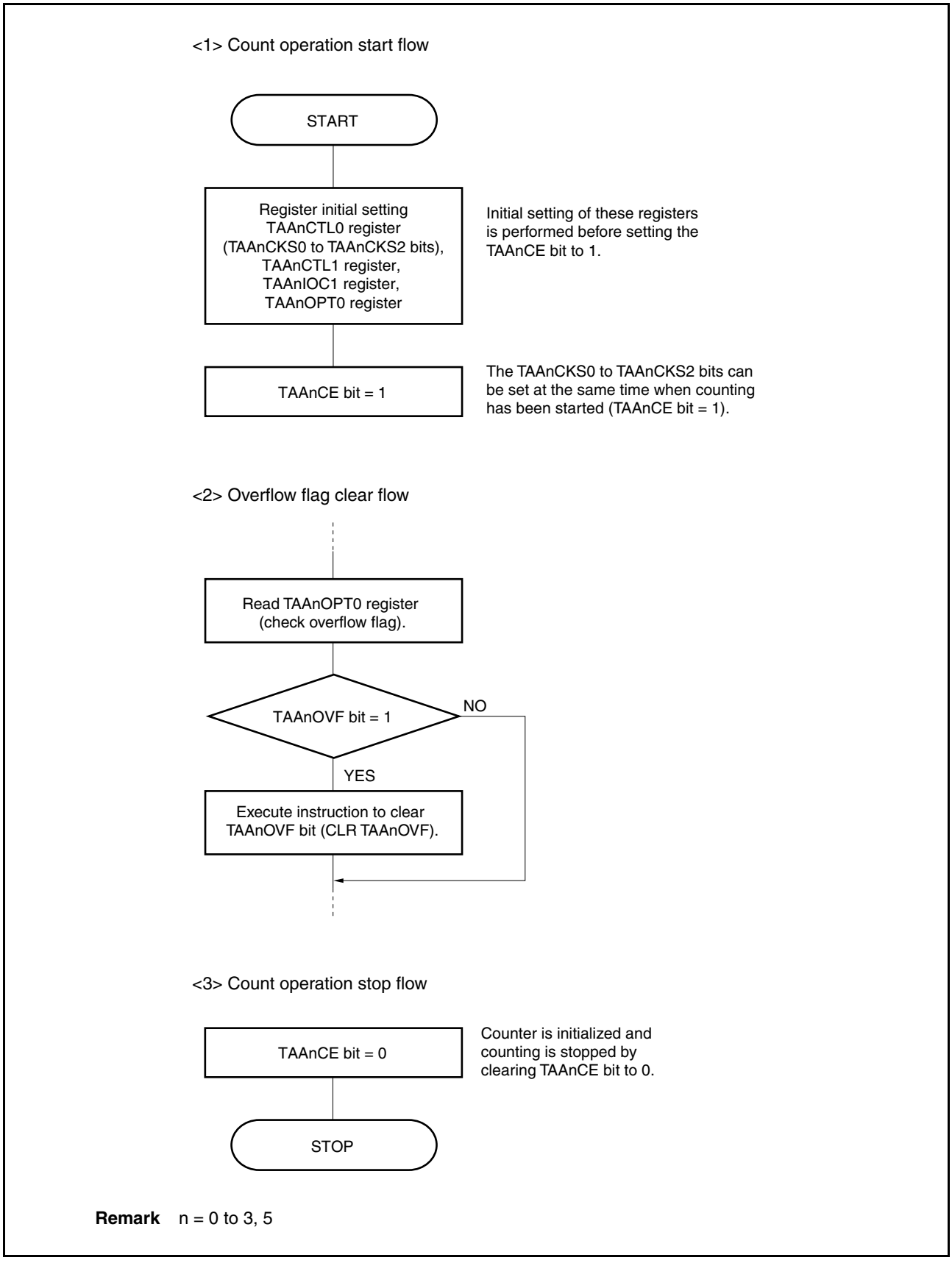
(b) When using capture/compare register as capture register

Figure 7-38. Software Processing Flow in Free-Running Timer Mode (Capture Function) (1/2)



Remark n = 0 to 3, 5

Figure 7-38. Software Processing Flow in Free-Running Timer Mode (Capture Function) (2/2)

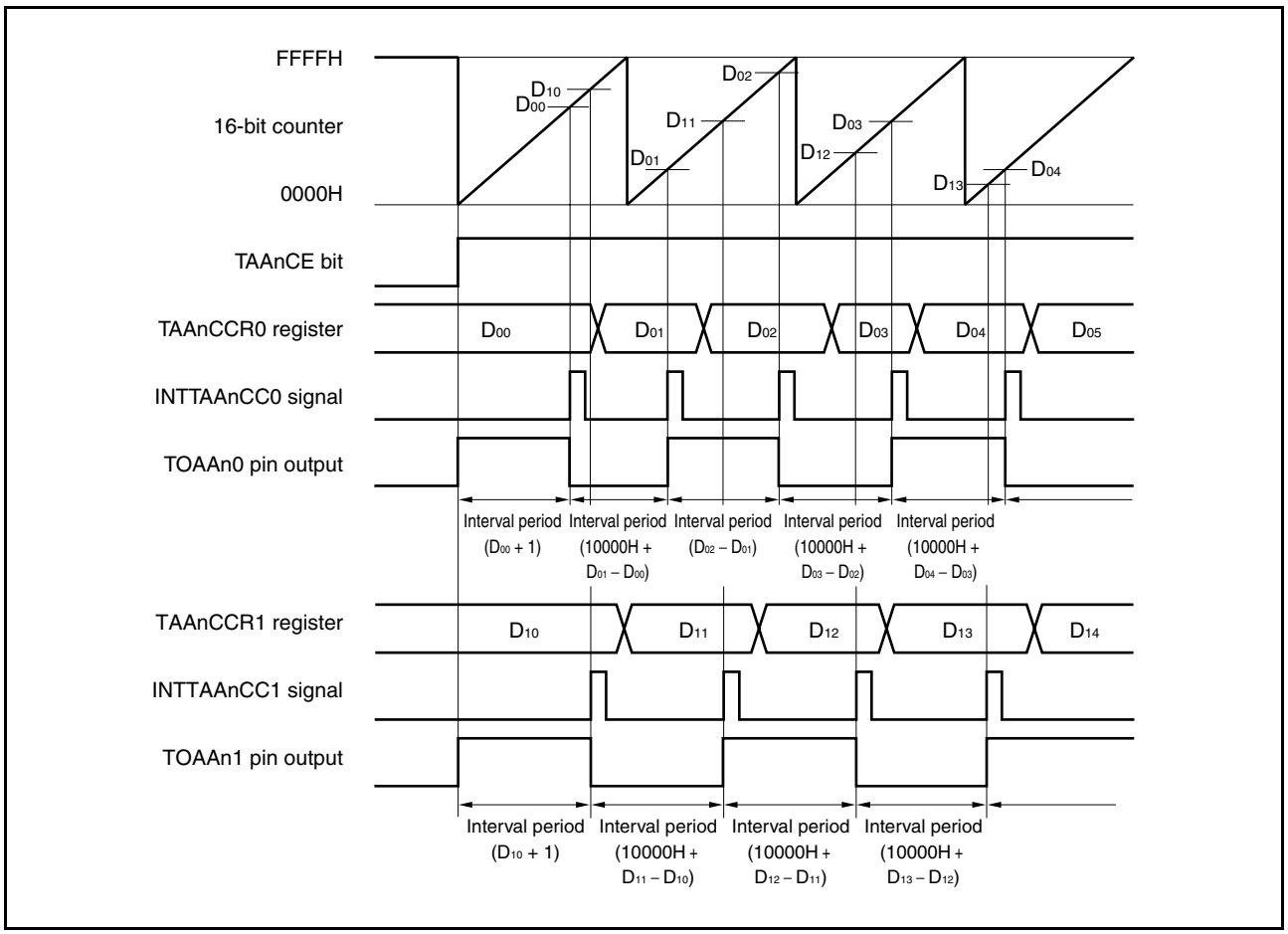


Remark n = 0 to 3, 5

(2) Operation timing in free-running timer mode

(a) Interval operation with TAAnCCRm register used as compare register

When 16-bit timer/event counter AA is used as an interval timer with the TAAnCCRm register used as a compare register, software processing is necessary for setting a comparison value to generate the next interrupt request signal each time the INTTAAnCCm signal has been detected.



When performing an interval operation in the free-running timer mode, two intervals can be set with one channel.

To perform the interval operation, the value of the corresponding TAAnCCRm register must be re-set in the interrupt servicing that is executed when the INTTAAnCCm signal is detected.

The set value for re-setting the TAAnCCRm register can be calculated by the following expression, where "D_m" is the interval period.

Compare register default value: $D_m - 1$

Value set to compare register second and subsequent times: Previous set value + D_m

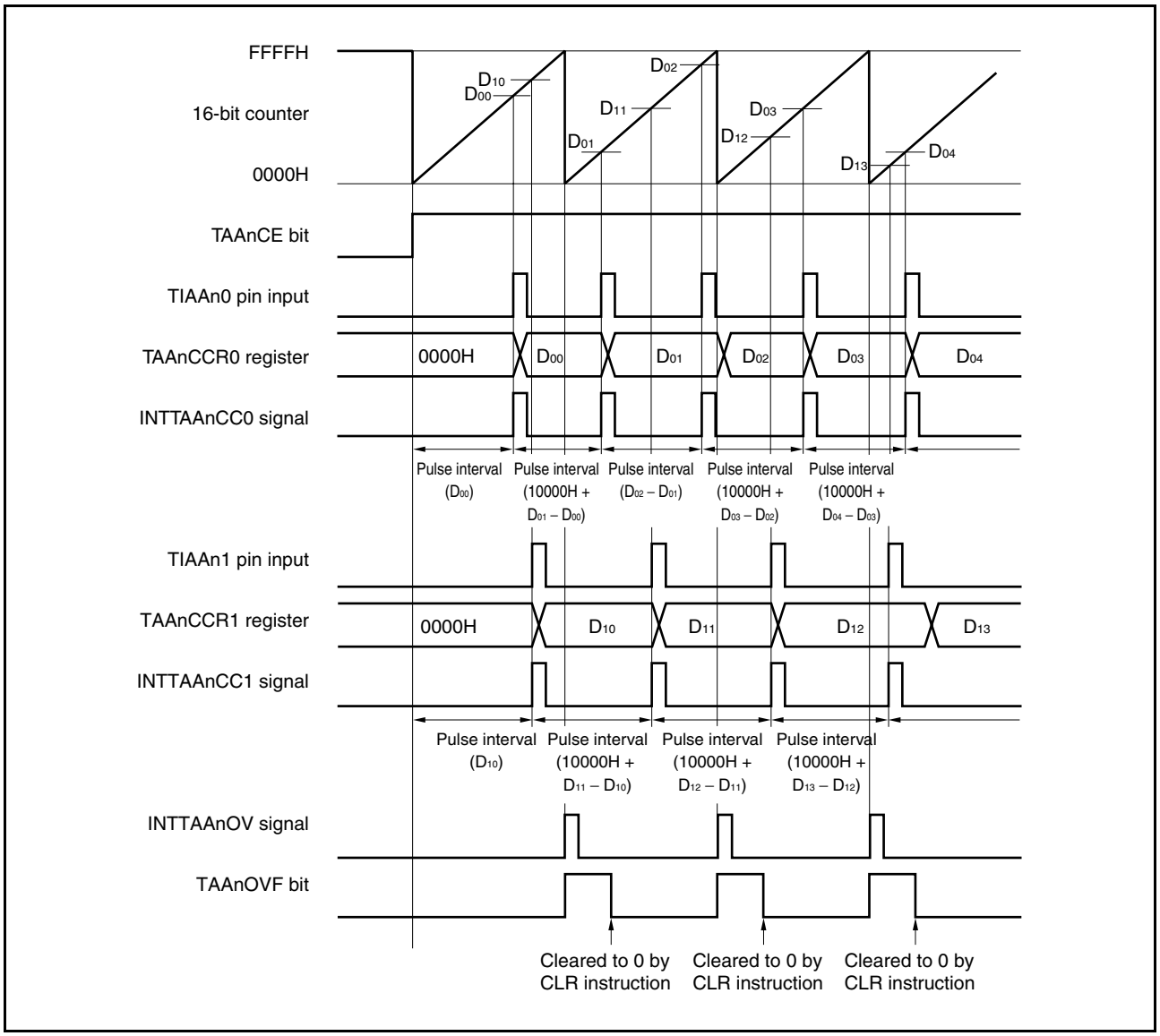
(If the calculation result is greater than FFFFH, subtract 10000H from the result and set this value to the register.)

Remark m = 0, 1

n = 0 to 3, 5

(b) Pulse width measurement with TAAnCCRm used as capture register

When pulse width measurement is performed with the TAAnCCRm register used as a capture register, software processing is necessary for reading the capture register each time the INTTAAnCCm signal has been detected and for calculating the interval.



When executing pulse width measurement in the free-running timer mode, two pulse widths can be measured with one channel.

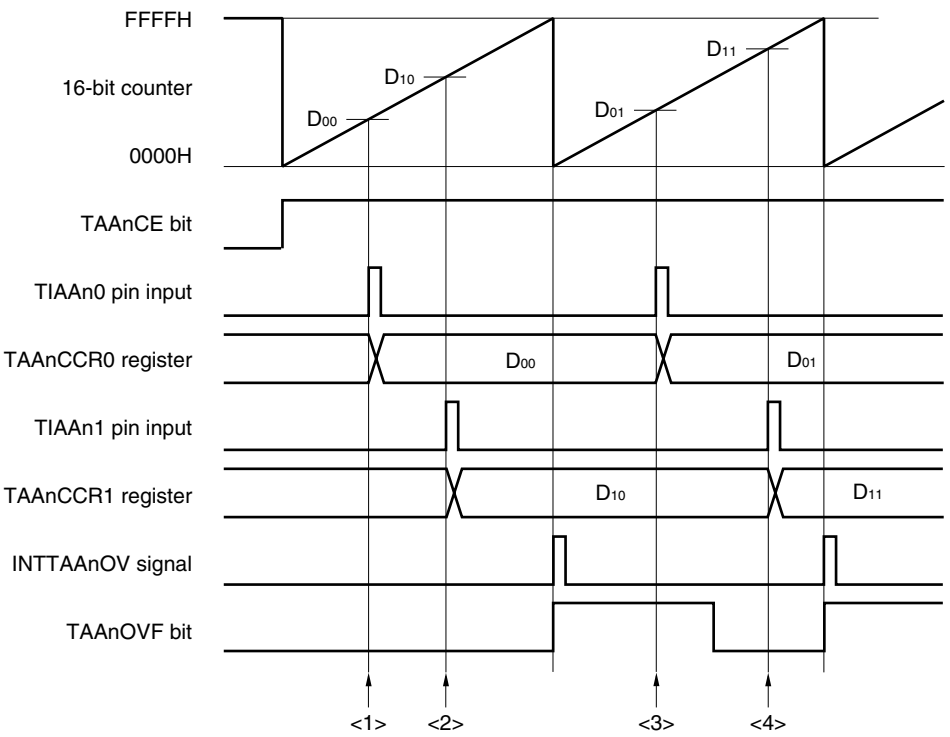
To measure a pulse width, the pulse width can be calculated by reading the value of the TAAnCCRm register in synchronization with the INTTAAnCCm signal, and calculating the difference between the read value and the previously read value.

Remark m = 0, 1
n = 0 to 3, 5

(c) Processing of overflow when two capture registers are used

Care must be exercised in processing the overflow flag when two capture registers are used. First, an example of incorrect processing is shown below.

Example of incorrect processing when two capture registers are used



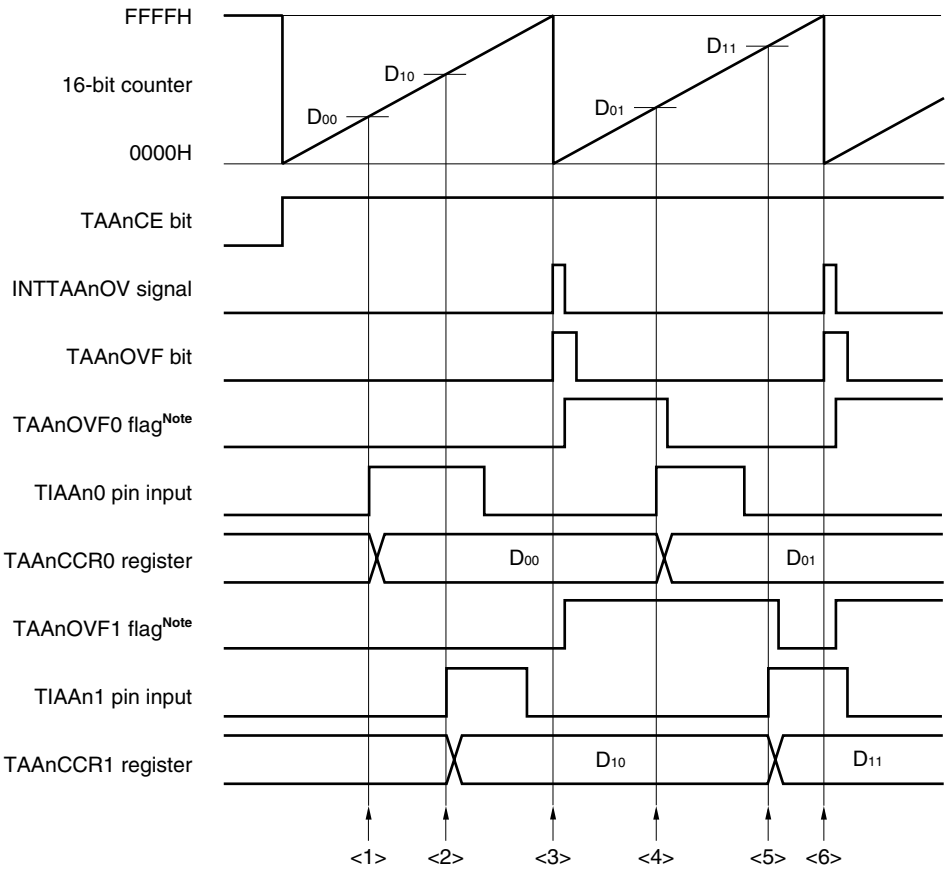
The following problem may occur when two pulse widths are measured in the free-running timer mode.

<1> Read the TAAnCCR0 register (setting of the default value of the TIAAn0 pin input).
<2> Read the TAAnCCR1 register (setting of the default value of the TIAAn1 pin input).
<3> Read the TAAnCCR0 register.
Read the overflow flag. If the overflow flag is 1, clear it to 0.
Because the overflow flag is 1, the pulse width can be calculated by (10000H + D_{01} − D_{00}).
<4> Read the TAAnCCR1 register.
Read the overflow flag. Because the flag is cleared in <3>, 0 is read.
Because the overflow flag is 0, the pulse width can be calculated by (D_{11} − D_{10}) (incorrect).

When two capture registers are used, and if the overflow flag is cleared to 0 by one capture register, the other capture register may not obtain the correct pulse width.
Use software when using two capture registers. An example of how to use software is shown below.

(1/2)

Example when two capture registers are used (using overflow interrupt)



Note The TAAnOVF0 and TAAnOVF1 flags are set on the internal RAM by software.

<1> Read the TAAnCCR0 register (setting of the default value of the TIAAn0 pin input).

<2> Read the TAAnCCR1 register (setting of the default value of the TIAAn1 pin input).

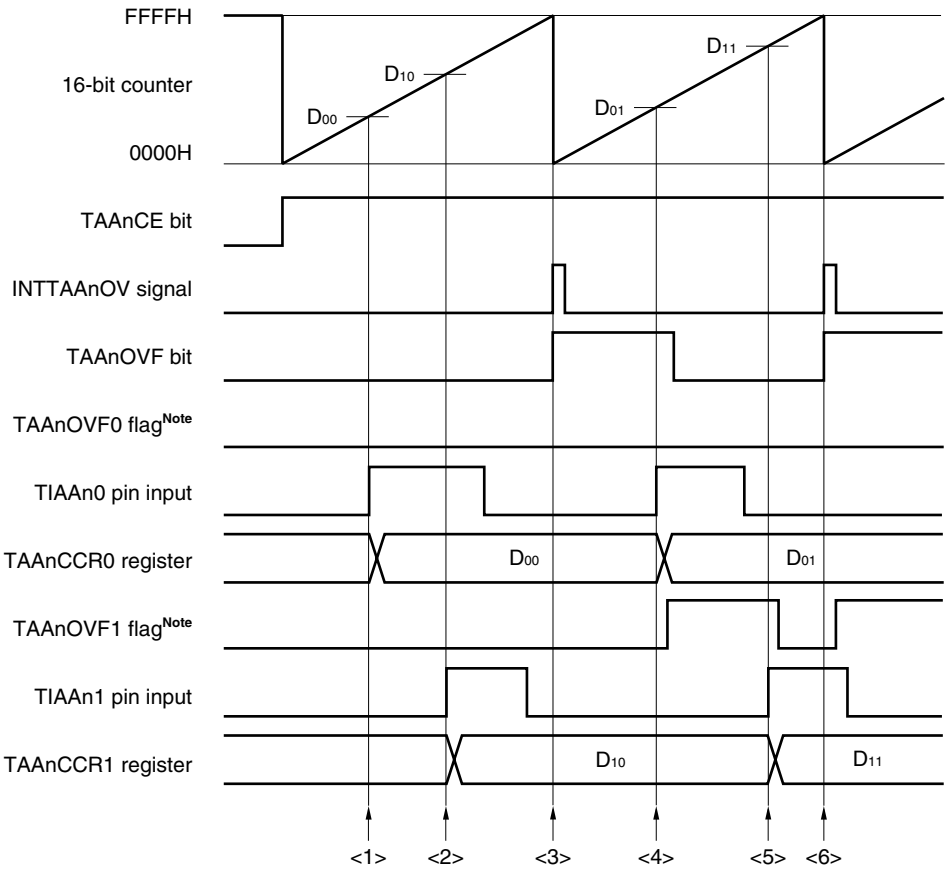
<3> An overflow occurs. Set the TAAnOVF0 and TAAnOVF1 flags to 1 in the overflow interrupt servicing, and clear the overflow flag to 0.

<4> Read the TAAnCCR0 register.
Read the TAAnOVF0 flag. If the TAAnOVF0 flag is 1, clear it to 0.
Because the TAAnOVF0 flag is 1, the pulse width can be calculated by (10000H + D_{01} − D_{00}).

<5> Read the TAAnCCR1 register.
Read the TAAnOVF1 flag. If the TAAnOVF1 flag is 1, clear it to 0 (the TAAnOVF0 flag is cleared in <4>, and the TAAnOVF1 flag remains 1).
Because the TAAnOVF1 flag is 1, the pulse width can be calculated by (10000H + D_{11} − D_{10}) (correct).

<6> Same as <3>

Example when two capture registers are used (without using overflow interrupt)



Note The TAAnOVF0 and TAAnOVF1 flags are set on the internal RAM by software.

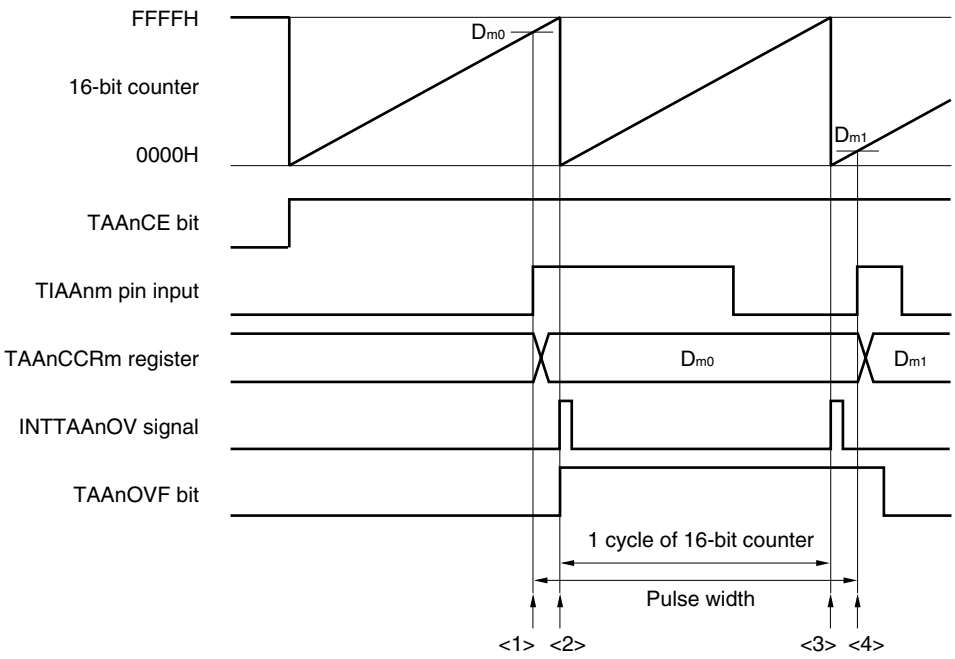
<1> Read the TAAnCCR0 register (setting of the default value of the TIAAn0 pin input).
<2> Read the TAAnCCR1 register (setting of the default value of the TIAAn1 pin input).
<3> An overflow occurs. Nothing is done by software.
<4> Read the TAAnCCR0 register.
Read the overflow flag. If the overflow flag is 1, set only the TAAnOVF1 flag to 1, and clear the overflow flag to 0.
Because the overflow flag is 1, the pulse width can be calculated by (10000H + D_{01} − D_{00}).
<5> Read the TAAnCCR1 register.
Read the overflow flag. Because the overflow flag is cleared in <4>, 0 is read.
Read the TAAnOVF1 flag. If the TAAnOVF1 flag is 1, clear it to 0.
Because the TAAnOVF1 flag is 1, the pulse width can be calculated by (10000H + D_{11} − D_{10}) (correct).
<6> Same as <3>

Remark n = 0 to 3, 5

(d) Processing of overflow if capture trigger interval is long

If the pulse width is greater than one cycle of the 16-bit counter, care must be exercised because an overflow may occur more than once from the first capture trigger to the next. First, an example of incorrect processing is shown below.

Example of incorrect processing when capture trigger interval is long



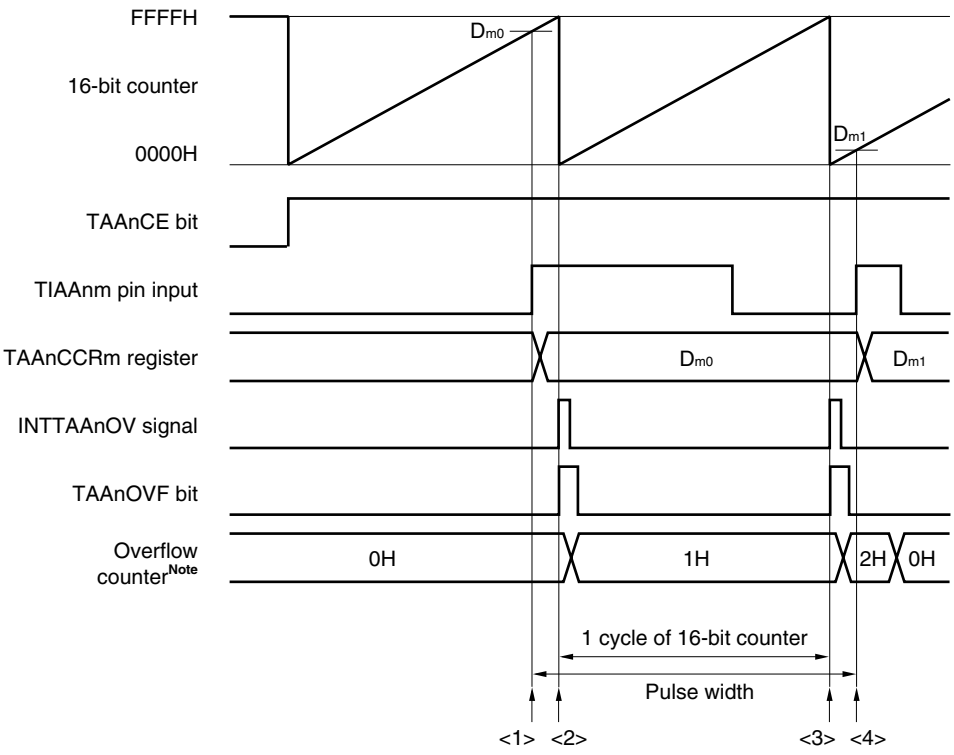
The following problem may occur when a long pulse width is measured in the free-running timer mode.

<1> Read the TAAnCCRm register (setting of the default value of the TIAAnm pin input).
<2> An overflow occurs. Nothing is done by software.
<3> An overflow occurs a second time. Nothing is done by software.
<4> Read the TAAnCCRm register.
Read the overflow flag. If the overflow flag is 1, clear it to 0.
Because the overflow flag is 1, the pulse width can be calculated by (10000H + D_{m1} − D_{m0}) (incorrect).
Actually, the pulse width must be (20000H + D_{m1} − D_{m0}) because an overflow occurs twice.

If an overflow occurs twice or more when the capture trigger interval is long, the correct pulse width may not be obtained.
If the capture trigger interval is long, slow the count clock to lengthen one cycle of the 16-bit counter, or use software. An example of how to use software is shown next.

Remark m = 0, 1
n = 0 to 3, 5

Example when capture trigger interval is long



Note The overflow counter is set arbitrarily by software on the internal RAM.

<1> Read the TAAnCCRm register (setting of the default value of the TIAAnm pin input).

<2> An overflow occurs. Increment the overflow counter and clear the overflow flag to 0 in the overflow interrupt servicing.

<3> An overflow occurs a second time. Increment (+1) the overflow counter and clear the overflow flag to 0 in the overflow interrupt servicing.

<4> Read the TAAnCCRm register.

Read the overflow counter.

→ When the overflow counter is “N”, the pulse width can be calculated by (N × 10000H + D_{m1} – D_{m0}).

In this example, the pulse width is (20000H + D_{m1} – D_{m0}) because an overflow occurs twice.

Clear the overflow counter (0H).

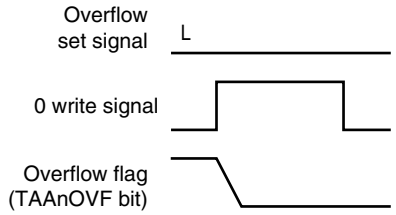
Remark m = 0, 1

n = 0 to 3, 5

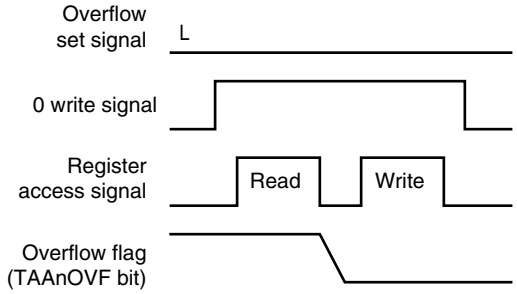
(e) Clearing overflow flag

The overflow flag can be cleared to 0 by clearing the TAAnOVF bit to 0 with the CLR instruction and by writing 8-bit data (bit 0 is 0) to the TAAnOPT0 register. To accurately detect an overflow, read the TAAnOVF bit when it is 1, and then clear the overflow flag by using a bit manipulation instruction.

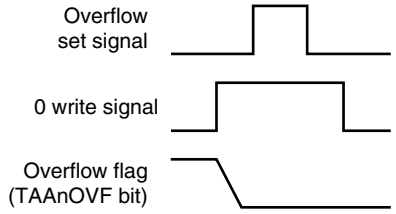
(i) Operation to write 0 (without conflict with setting)



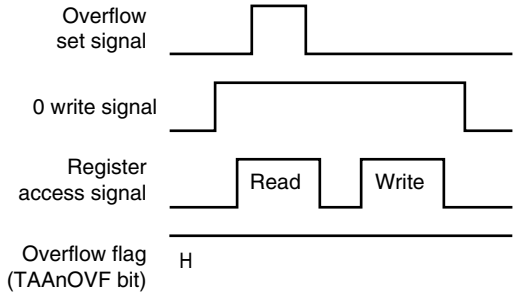
(iii) Operation to clear to 0 (without conflict with setting)



(ii) Operation to write 0 (conflict with setting)



(iv) Operation to clear to 0 (conflict with setting)



Remark n = 0 to 3, 5

To clear the overflow flag to 0, read the overflow flag to check if it is set to 1, and clear it with the CLR instruction. If 0 is written to the overflow flag without checking if the flag is 1, the set information of the overflow may be erased by writing 0 ((ii) in the above chart). Therefore, software may judge that no overflow has occurred even when an overflow has actually occurred.

If execution of the CLR instruction conflicts with occurrence of an overflow when the overflow flag is cleared to 0 with the CLR instruction, the overflow flag remains set (1) even after execution of the clear instruction.

7.5.7 Pulse width measurement mode (TAAnMD2 to TAAnMD0 bits = 110)

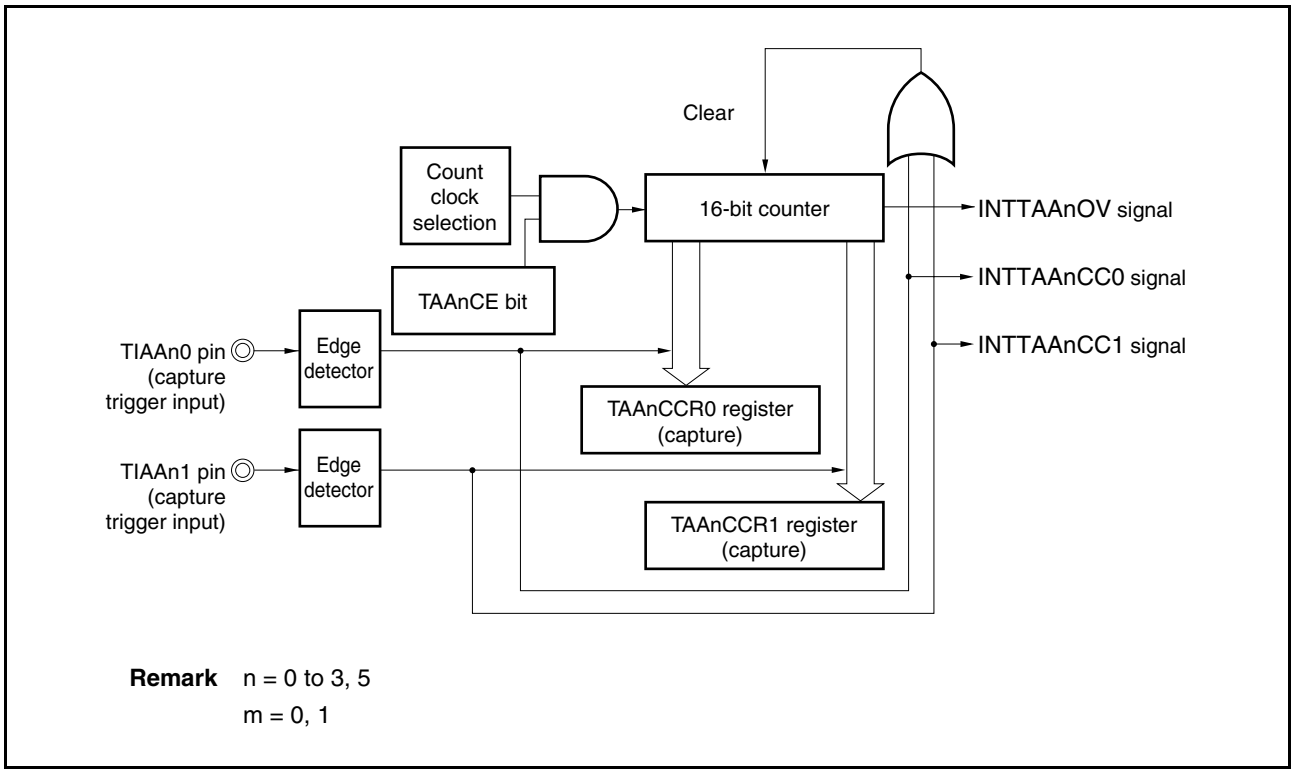
In the pulse width measurement mode, 16-bit timer/event counter AA starts counting when the TAAnCTL0.TAAnCE bit is set to 1. Each time the valid edge input to the TIAAnm pin has been detected, the count value of the 16-bit counter is stored in the TAAnCCRm register, and the 16-bit counter is cleared to 0000H.

The interval of the valid edge can be measured by reading the TAAnCCRm register after a capture interrupt request signal (INTTAAnCCm) occurs.

Select either the TIAAn0 or TIAAn1 pin as the capture trigger input pin. Specify “No edge detection” for the unused pins by using the TAAnIOC1 register.

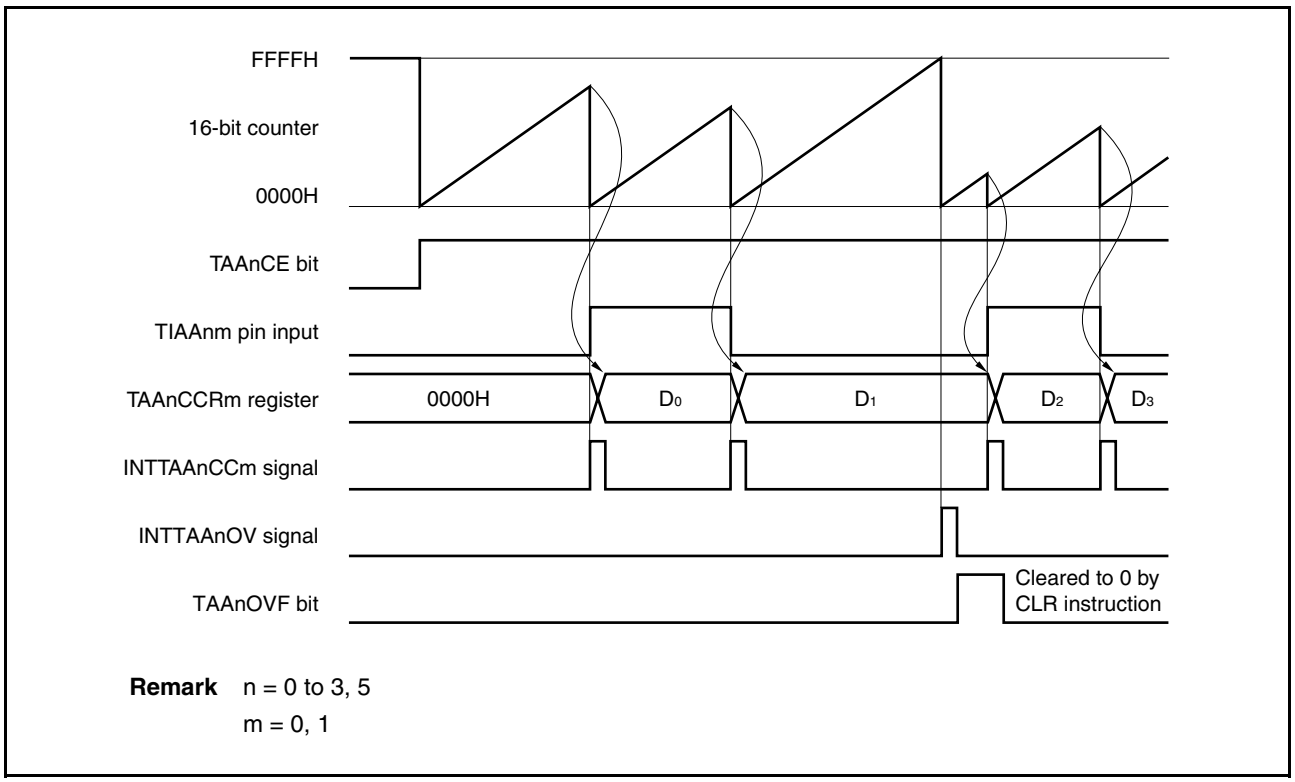
When an external clock is used as the count clock, measure the pulse width of the TIAAn1 pin because the external clock is fixed to the TIAAn0 pin. At this time, clear the TAAnIOC1.TAAnIS1 and TAAnIOC1.TAAnIS0 bits to 00 (capture trigger input (TIAAn0 pin): No edge detection).

Figure 7-39. Configuration in Pulse Width Measurement Mode



Remark n = 0 to 3, 5
m = 0, 1

Figure 7-40. Basic Timing in Pulse Width Measurement Mode



Remark n = 0 to 3, 5
m = 0, 1

When the TAAnCE bit is set to 1, the 16-bit counter starts counting. When the valid edge input to the TIAAnm pin is later detected, the count value of the 16-bit counter is stored in the TAAnCCRm register, the 16-bit counter is cleared to 0000H, and a capture interrupt request signal (INTTAAnCCm) is generated.

The pulse width is calculated as follows.

Pulse width = Captured value × Count clock cycle

If the valid edge is not input to the TIAAnm pin even when the 16-bit counter counted up to FFFFH, an overflow interrupt request signal (INTTAAnOV) is generated at the next count clock, and the counter is cleared to 0000H and continues counting. At this time, the overflow flag (TAAnOPT0.TAAnOVF bit) is also set to 1. Clear the overflow flag to 0 by executing the CLR instruction via software.

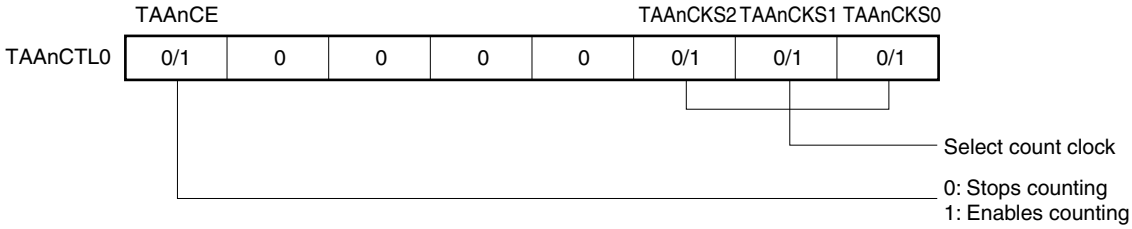
If the overflow flag is set to 1, the pulse width can be calculated as follows.

Pulse width = (10000H × TAAnOVF bit set (1) count + Captured value) × Count clock cycle

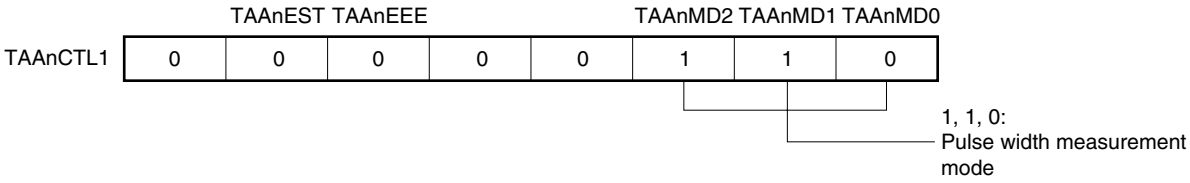
Remark n = 0 to 3, 5
m = 0, 1

Figure 7-41. Register Setting in Pulse Width Measurement Mode

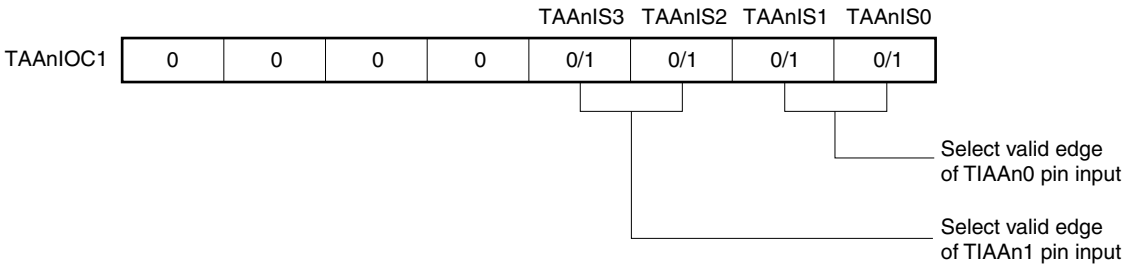
(a) TAAn control register 0 (TAAnCTL0)



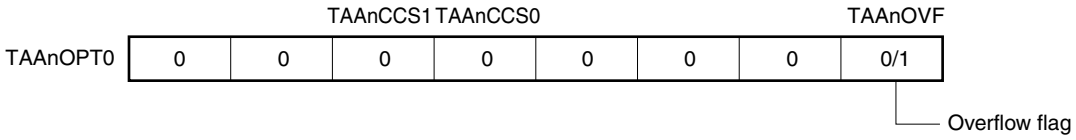
(b) TAAn control register 1 (TAAnCTL1)



(c) TAAn I/O control register 1 (TAAnIOC1)



(d) TAAn option register 0 (TAAnOPT0)



(e) TAAn counter read buffer register (TAAnCNT)

The value of the 16-bit counter can be read by reading the TAAnCNT register.

(f) TAAn capture/compare registers 0 and 1 (TAAnCCR0 and TAAnCCR1)

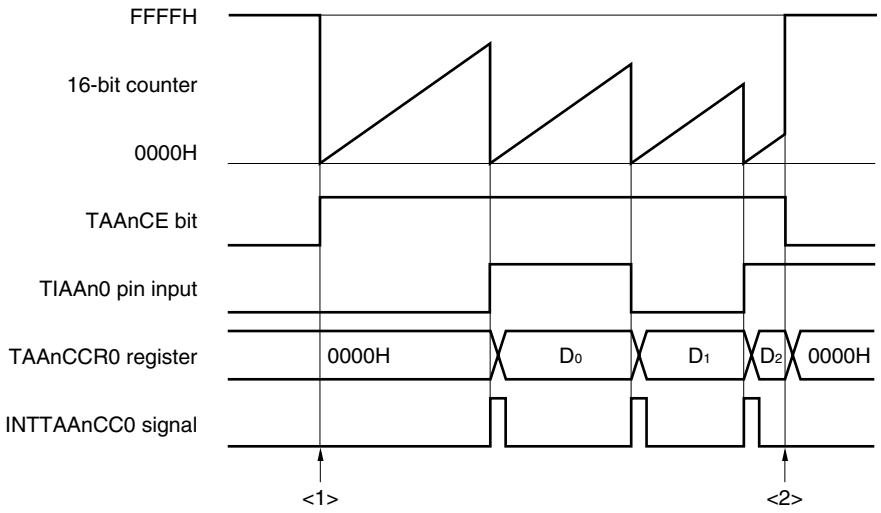
These registers store the count value of the 16-bit counter when the valid edge input to the TIAAnm pin is detected.

Remarks 1. TAAn I/O control register 0 (TAAnIOC0), and TAAn I/O control register 2 (TAAnIOC2) are not used in the pulse width measurement mode.

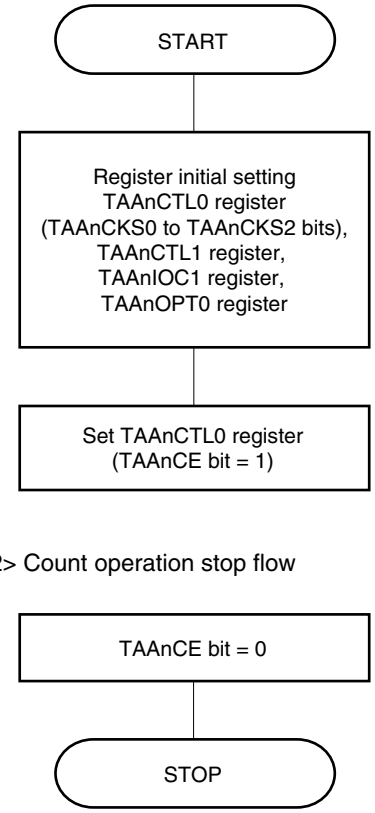
2. m = 0, 1
n = 0 to 3, 5

(1) Operation flow in pulse width measurement mode

Figure 7-42. Software Processing Flow in Pulse Width Measurement Mode



<1> Count operation start flow



Initial setting of these registers is performed before setting the TAAnCE bit to 1.

The TAAnCKS0 to TAAnCKS2 bits can be set at the same time when counting has been started (TAAnCE bit = 1).

<2> Count operation stop flow

The counter is initialized and counting is stopped by clearing the TAAnCE bit to 0.

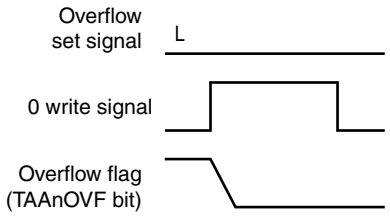
Remark n = 0 to 3, 5

(2) Operation timing in pulse width measurement mode

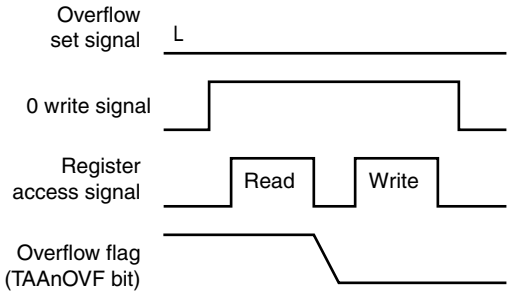
(a) Clearing overflow flag

The overflow flag can be cleared to 0 by clearing the TAAnOVF bit to 0 with the CLR instruction and by writing 8-bit data (bit 0 is 0) to the TAAnOPT0 register. To accurately detect an overflow, read the TAAnOVF bit when it is 1, and then clear the overflow flag by using a bit manipulation instruction.

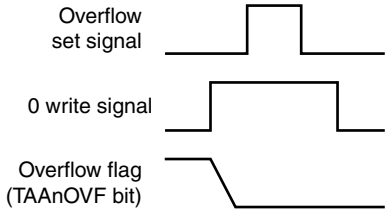
(i) Operation to write 0 (without conflict with setting)



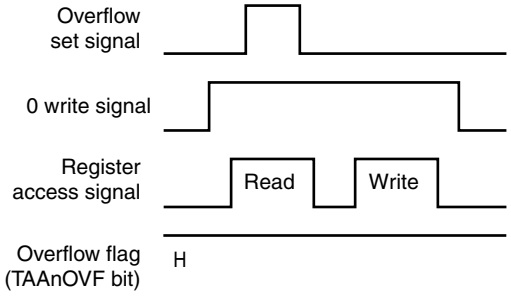
(iii) Operation to clear to 0 (without conflict with setting)



(ii) Operation to write 0 (conflict with setting)



(iv) Operation to clear to 0 (conflict with setting)



Remark n = 0 to 3, 5

To clear the overflow flag to 0, read the overflow flag to check if it is set to 1, and clear it with the CLR instruction. If 0 is written to the overflow flag without checking if the flag is 1, the set information of the overflow may be erased by writing 0 ((ii) in the above chart). Therefore, software may judge that no overflow has occurred even when an overflow has actually occurred.

If execution of the CLR instruction conflicts with occurrence of an overflow when the overflow flag is cleared to 0 with the CLR instruction, the overflow flag remains set (1) even after execution of the clear instruction.

7.5.8 Timer output operations

The following table shows the operations and output levels of the TOAAn0 and TOAAn1 pins.

Table 7-5. Timer Output Control in Each Mode

Operation Mode	TOAAn1 Pin	TOAAn0 Pin
Interval timer mode	Square wave output	
External event count mode	Square wave output	–
External trigger pulse output mode	External trigger pulse output	Square wave output
One-shot pulse output mode	One-shot pulse output	
PWM output mode	PWM output	
Free-running timer mode	Square wave output (only when compare function is used)	
Pulse width measurement mode	–	

Remark n = 0 to 3, 5

Table 7-6. Truth Table of TOAAn0 and TOAAn1 Pins Under Control of Timer Output Control Bits

TAAnIOC0.TAAnOLm Bit	TAAnIOC0.TAAnOEm Bit	TAAnCTL0.TAAnCE Bit	Level of TOAAnm Pin
0	0	×	Low-level output
	1	0	Low-level output
		1	Low level immediately before counting, high level after counting is started
1	0	×	High-level output
	1	0	High-level output
		1	High level immediately before counting, low level after counting is started

Remark n = 0 to 3, 5
m = 0, 1

7.6 Timer-Tuned Operation Function

Timer AA and timer AB have a timer-tuned operation function.

The timer-tuned operation function is used to tune the internal timers of the V850ES/JG3-H and V850ES/JH3-H, so that the number of capture or compare registers of the slave timer (the number of timer outputs and the number of compare match interrupts of the slave timer) can be added to the master timer. The timers that can be tuned are listed in Table 7-7.

Table 7-7. Tuned-Operation Mode of Timers

Master Timer	Slave Timer
TAA1	TAA0
TAA3	TAA2
TAB0	TAA5

The tuned-operation function has the following modes.

- PWM output mode
- Free-running timer mode

Figure 7-43 shows an example where individual operation and tuned operation of TAA0 (as the master timer) and TAA1 (as the slave timer) are performed in PWM output mode.

Figure 7-43. Differences Between Individual Operation and Tuned Operation Using TAA0 and TAA1

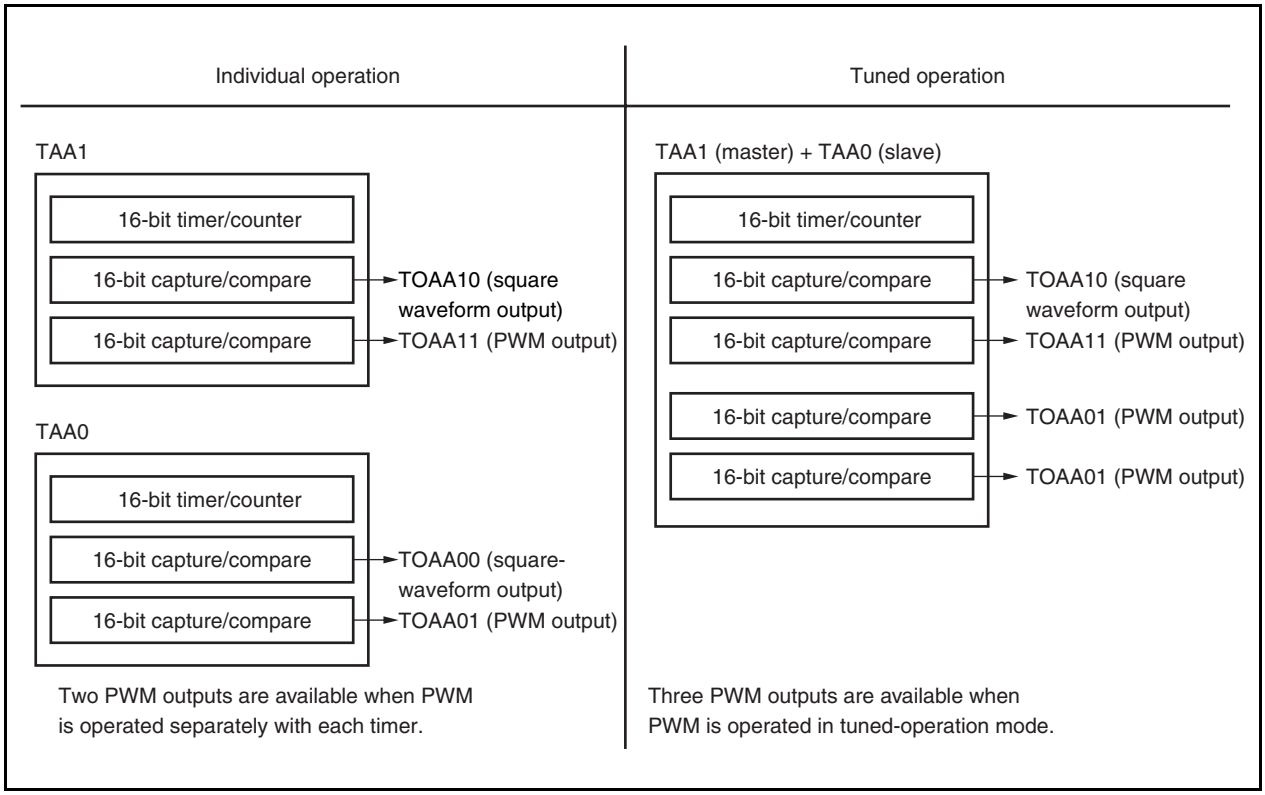


Table 7-8 show the timer modes that can be used in the tuned-operation mode and Table 7-9 shows the differences of the timer output functions between individual operation and tuned operation (√: Settable, ×: Not settable).

Table 7-8. Timer Modes Usable in Tuned-Operation Mode

Master Timer	Slave Timer	Free-Running Timer Mode	PWM Mode
TAA1	TAA0	√	√
TAA3	TAA2	√	√
TAB0	TAA5	√	√

Table 7-9. Timer Output Functions

Tuned Channel	Timer	Pin	Free-Running Timer Mode		PWM Mode	
			Individual Operation	Tuned Operation	Individual Operation	Tuned Operation
Ch0	TAA1 (master)	TOAA10	PPG	←	Toggle	←
		TOAA11	PPG	←	PWM	←
	TAA0 (slave)	TOAA00	PGP	←	Toggle	PWM
		TOAA01	PPG	←	PWM	←
Ch1	TAA3 (master)	TOAA30	PPG	←	Toggle	←
		TOAA31	PPG	←	PWM	←
	TAA2 (slave)	TOAA20	PPG	←	Toggle	PWM
		TOAA21	PPG	←	PWM	←
Ch2	TAB0 (master)	TOAB00	PPG	←	Toggle	←
		TOAB01 to TOAB03	PPG	←	PWM	←
	TAA5 (slave)	TOAA50	PPG	←	Toggle	PWM
		TOAA51	PPG	←	PWM	←

Remark The timing of transmitting data from the compare register of the buffer register is as follows.

- PPG: CPU write timing
- Toggle, PWM, triangular wave PWM: Timing at which timer counter and compare register match TOAAn0 and TOABm0

7.6.1 Free-running timer mode (during timer-tuned operation)

This section explains the free-running timer mode of the timer-tuned operation. For the combination of timer-tuned operations, see **Table 7-7**. In this section, an example of timer-tuned operation using TAA1 and TAA0 is shown.

(i) Selecting capture/compare registers

When the free-running timer mode of the timer-tuned operation is used with TAA1 and TAA0 connected to each other, the two capture/compare registers of TAA1 and two capture/compare registers of TAA0 can be used in combination.

How the capture and compare registers are combined is not restricted and can be selected by using the TAAnCCSn bit of the master or slave timer. When the compare register is selected, the set value of the compare register can be rewritten during operation and the rewriting method is anytime write (n = 0, 1).

(ii) Overflow

If the counter overflows, an overflow interrupt (INTTAA1OV) of the master timer is generated and the overflow flag (TAA1OVF) is set to “1”.

The overflow interrupt (INTTAA0OV) and overflow flag (TAA0OVF) of the slave timer do not operate and are always at the low level.

(1) Settings in free-running timer mode (compare function)

[Initial settings]

Master timer: TAA1CTL0.TAA1CE = 0 (operation disabled)
Slave timer: TAA0CTL0.TAA0CE = 0 (operation disabled)

[Initial settings of master timer (TAA1)]

- TAA1CTL1.TAA1MD2 to TAA1CTL1.TAA1MD0 = 101 (setting of free-running timer mode)
- TAA1OPT0.TAA1CCS1 and TAA1OPT0.TAA1CCS0 = 00 (setting of capture/compare select bit to “compare”.)
- TAA1CTL1.TAA1CKS2 to TAA1CTL1.TAA1CKS0 (setting of count clock (any))
- TAA1CCR1 and TAA1CCR0 registers are set.

[Initial settings of slave timer (TAA0)]

- TAA0CTL1.TAA0SYE = 1 (setting of timer-tuned operation)
- TAA0CTL1.TAA0MD2 to TAA0CTL1.TAA0MD0 = 101 (setting of free-running timer mode)
- TAA0OPT0.TAA0CCS1 and TAA0OPT0.TAA0CCS0 = 00 (setting of capture/compare select bit to “compare”.)
- TAA0CCR0 and TAA0CCR1 registers are set.

Remark The initial settings of the master timer and slave timer may be performed in any order.

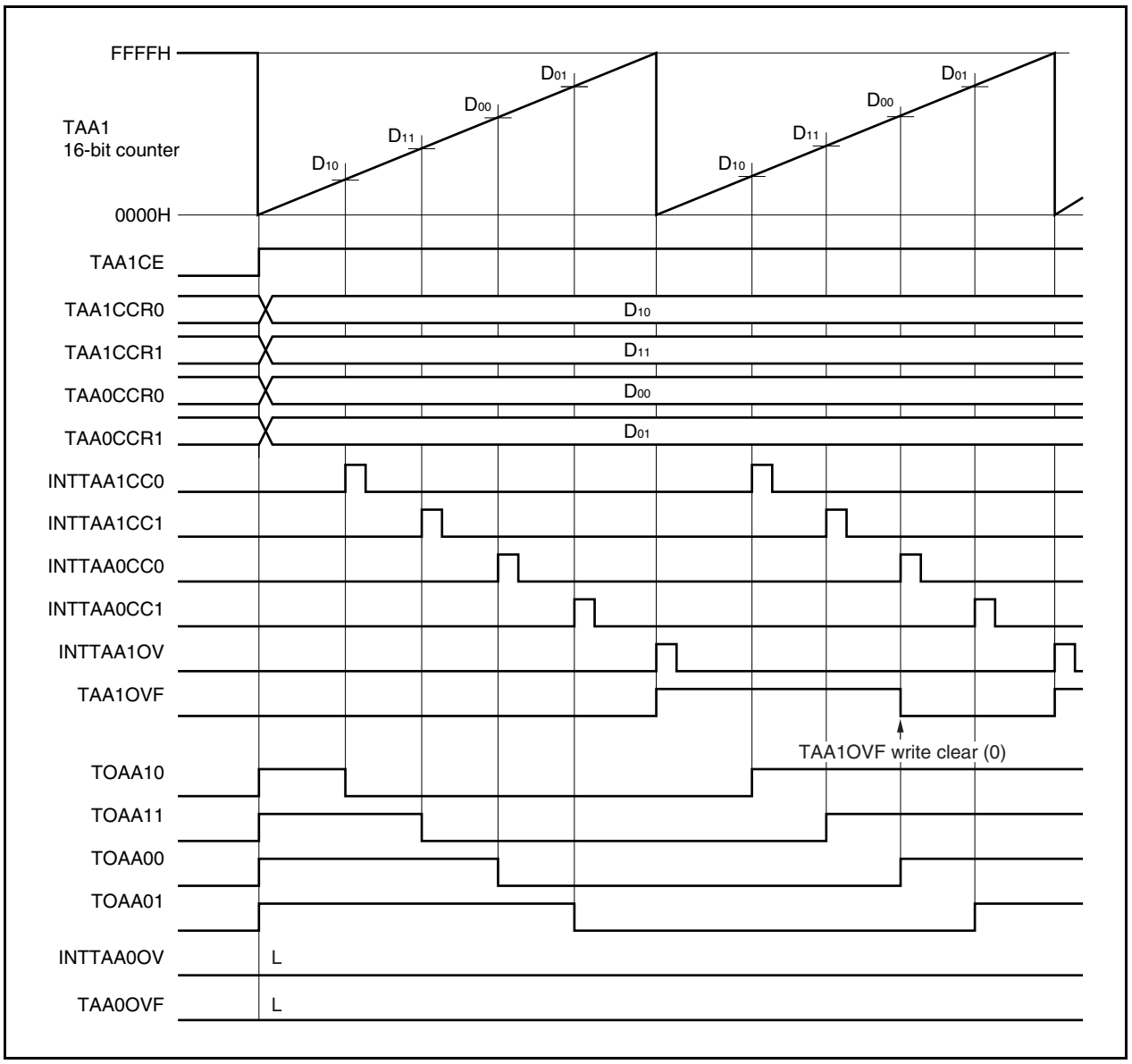
[Starting counting]

<1> Set TAA1CTL0.TAA1CE of the master timer to 1.
<2> Start counting.
<3> Changing the setting of the register during operation
- The compare register can be rewritten (anytime write).

[End condition]

- Set TAA1CTL0.TAA1CE of the master timer to 0.

Figure 7-44. Example of Timing in Free-Running Mode (Compare Function)



(2) Settings in free-running timer mode (capture function)

[Initial settings]

Master timer: TAA1CTL0.TAA1CE = 0 (operation disabled)

Slave timer: TAA0CTL0.TAA0CE = 0 (operation disabled)

[Initial settings of master timer (TAA1)]

- TAA1CTL1.TAA1MD2 to TAA1CTL1.TAA1MD0 = 101 (setting of free-running timer mode)
- TAA1OPT0.TAA1CCS1 and TAA1OPT0.TAA1CCS0 = 11 (setting of capture/compare select bit to “capture”.)
- TAA1CTL1.TAA1CKS2 to TAA1CTL1.TAA1CKS0 (setting of count clock (any))
- TAA1IOC1.TAA1IS3 to TAA1IOC1.TAA1IS0 (specification of valid edge of capture trigger)

[Initial settings of slave timer (TAA0)]

- TAA0CTL1.TAA0SYE = 1 (setting of timer-tuned operation)
- TAA0CTL1.TAA0MD2 to TAA0CTL1.TAA0MD0 = 101 (setting of free-running timer mode)
- TAA0OPT0.TAA0CCS1 and TAA0OPT0.TAA0CCS0 = 11 (setting of capture/compare select bit to “capture”.)
- TAA0IOC1.TAA0IS3 to TAA0IOC1.TAA0IS0 (specification of valid edge of capture trigger)

Remark The initial settings of the master timer and slave timer may be performed in any order.

[Starting counting]

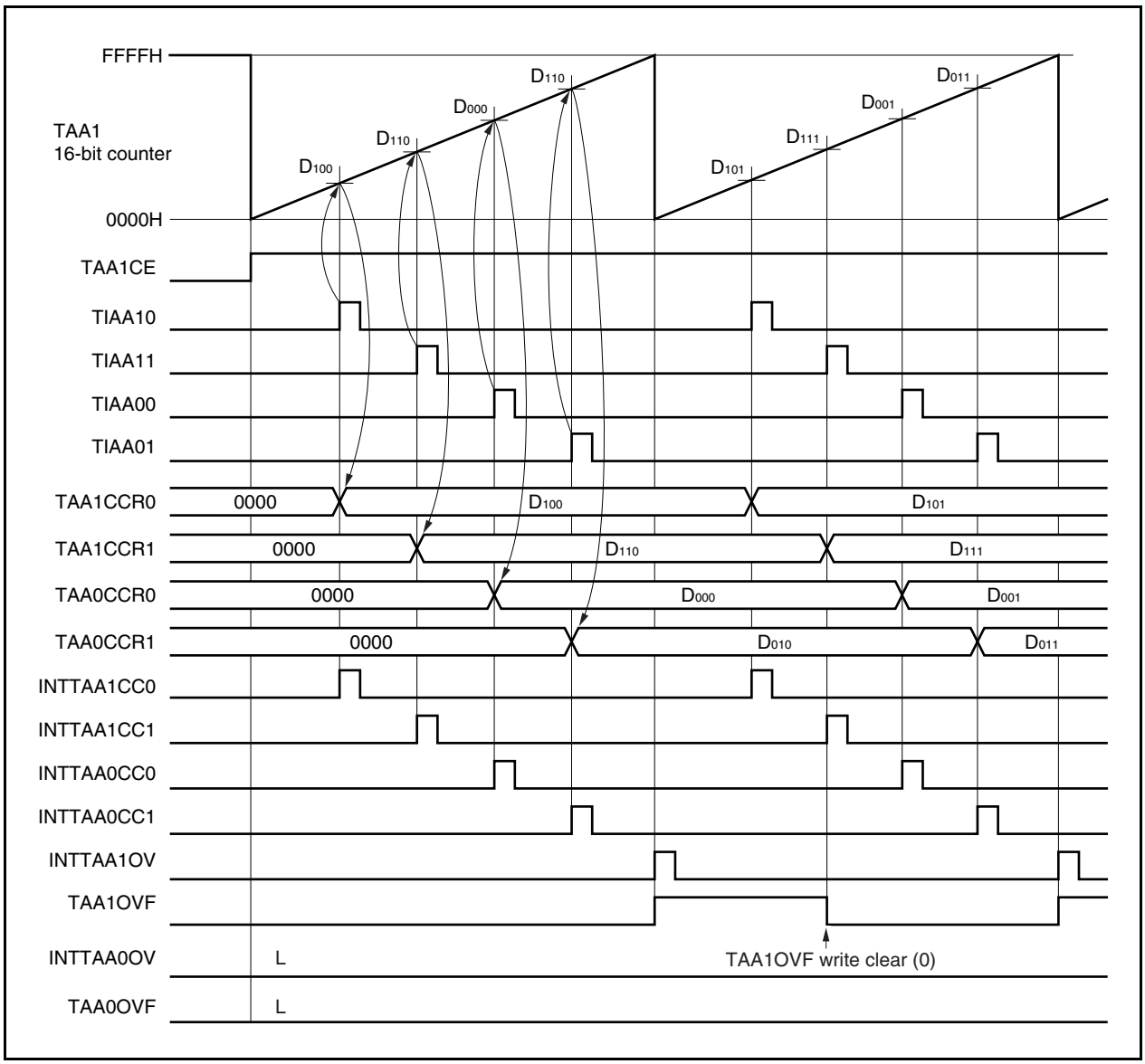
<1> Set TAA1CTL0.TAA1CE of the master timer to 1.

<2> Start counting.

[End condition]

- Set TAA1CTL0.TAA1CE of the master timer to 0.

Figure 7-45. Example of Timing in Free-Running Mode (Capture Function)



(3) Settings in free-running timer mode (capture/compare used together)

An example of using TAA0 as a capture register and TAA1 as a compare register is shown below.

[Initial settings]

Master timer: TAA1CTL0.TAA1CE = 0 (operation disabled)

Slave timer: TAA0CTL0.TAA0CE = 0 (operation disabled)

[Initial settings of master timer (TAA1)]

- TAA1CTL1.TAA1MD2 to TAA1CTL1.TAA1MD0 = 101 (setting of free-running timer mode)
- TAA1OPT0.TAA1CCS1 and TAA1OPT0.TAA1CCS0 = 11 (setting of capture/compare select bit to “capture”.)
- TAA1CTL1.TAA1CKS2 to TAA1CTL1.TAA1CKS0 (setting of count clock (any))
- TAA1.TAA0IS3 to TAA1.TAA1IS0 (specification of valid edge of capture trigger)

[Initial settings of slave timer (TAA0)]

- TAA0CTL1.TAA0SYE = 1 (setting of timer-tuned operation)
- TAA0CTL1.TAA0MD2 to TAA0CTL1.TAA0MD0 = 101 (setting of free-running timer mode)
- TAA0OPT0.TAA0CCS1 and TAA0OPT0.TAA0CCS0 = 00 (setting of capture/compare select bit to “compare”.)
- TAA0CCR0 and TAA0CCR1 registers are set.

Remark The initial settings of the master timer and slave timer may be performed in any order.

[Starting counting]

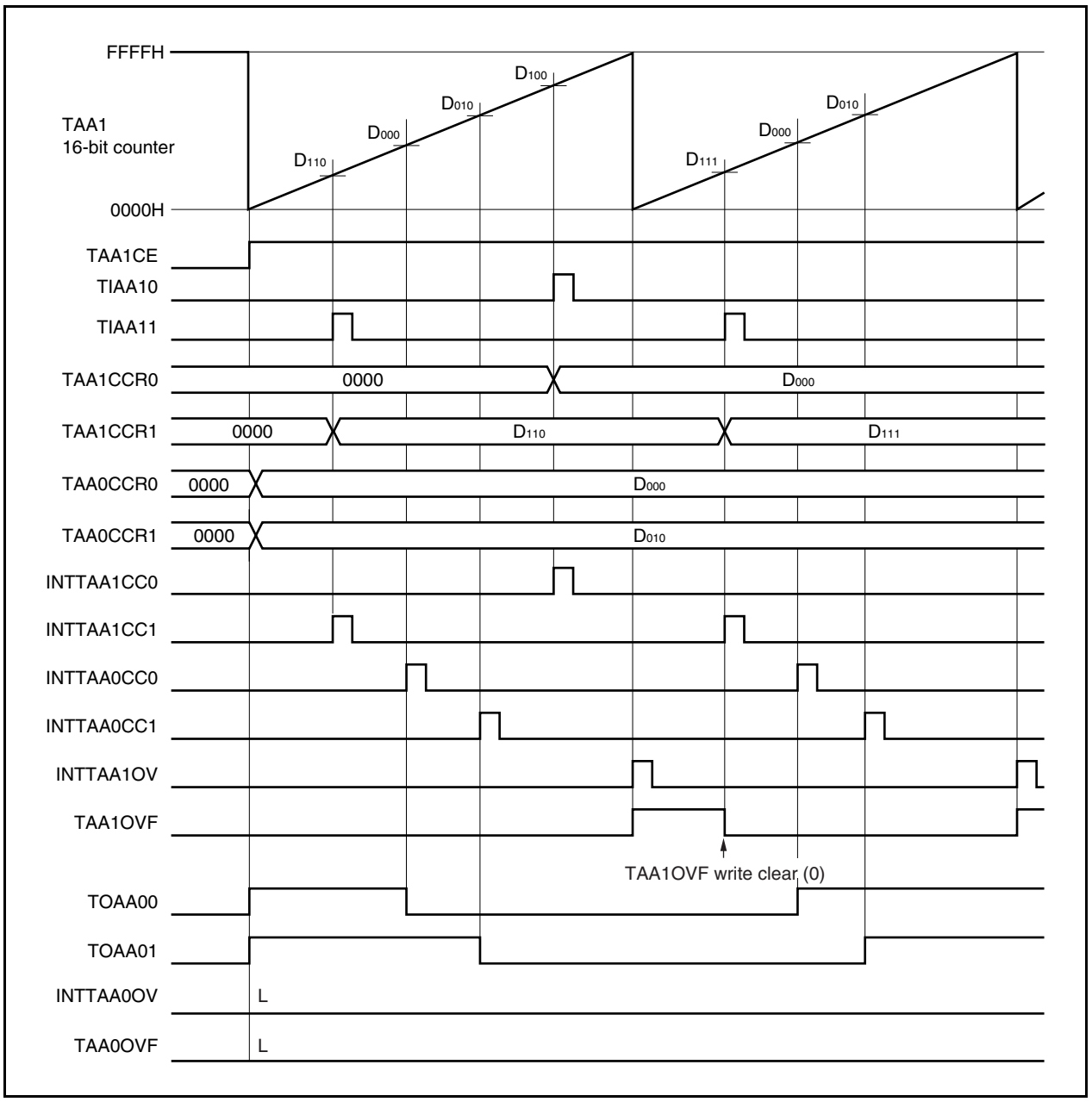
<1> Set TAA1CTL0.TAA1CE of the master timer to 1.

<2> Start counting.

[End condition]

- Set TAA1CTL0.TAA1CE of the master timer to 0.

Figure 7-46. Example of Timing in Free-Running Mode (Capture/Compare Used Together)



7.6.2 PWM output mode (during timer-tuned operation)

This section explains the PWM output mode of timer-tuned operation. For combinations of timer-tuned operations, see **Table 7-7**. This section presents an example of a timer-tuned operation with TAB0 and TAA5.

The TAB0CCR0 register of the master timer (TAB0) is used as a compare register for cycle, and the TAB0CCR1, TAB0CCR2, and TAB0CCR3 registers of the master timer (TAB0) and the TAA5CCR0 and TAA5CCR1 registers of the slave timer (TAA5) are used as compare registers for duty.

The compare registers can be rewritten during operation and the rewriting method is batch writing.

Batch writing is enabled when the TAB0CCR1 register of the master timer (TAB0) is written, and all the compare registers of the master and slave timers are rewritten or the same value is written to them when an interrupt, which is generated if the value of the TAB0CCR0 register of the master timer (TAB0) matches the value of the timer counter, is generated.

(1) Settings in PWM output mode

[Initials setting]

Master timer: TAB0CTL0.TAB0CE = 0 (operation disabled)
Slave timer: TAA5CTL0.TAA5CE = 0 (operation disabled)

[Initial settings of master timer (TAB0)]

- TAB0CTL1.TAB0MD2 to TAB0CTL1.TAB0MD0 = 100 (setting of PWM output mode)
- TAB0OPT0.TAB0CCS3 to TAB0OPT0.TAB0CCS0 = 0000 (setting of capture/compare select bit to “compare”.)
- TAB0CCR0, TAB0CCR1, TAB0CCR2, and TAB0CCR3 registers are set.

[Initial settings of slave timer (TAA5)]

- TAA5CTL1.TAA5SYE = 1 (setting of timer-tuned operation)
- TAA5CTL1.TAA5MD2 to TAA5CTL1.TAA5MD0 = 101 (setting of free-running timer mode)
- TAA5OPT0.TAA5CCS1 and TAA5OPT0.TAA5CCS0 = 00 (setting of capture/compare select bit to “compare”.)
- TAA5CCR0 and TAA5CCR1 registers are set.

Remark The initial settings of the master timer and slave timer may be performed in any order.

[Starting counting]

<1> Set TAB0CTL0.TAB0CE of the master timer to 1.
<2> Start counting.
<3> Changing the setting of the register during operation
- The compare register can be rewritten (batch rewrite).

[End condition]

- Set TAB0CTL0.TAB0CE of the master timer to 0.

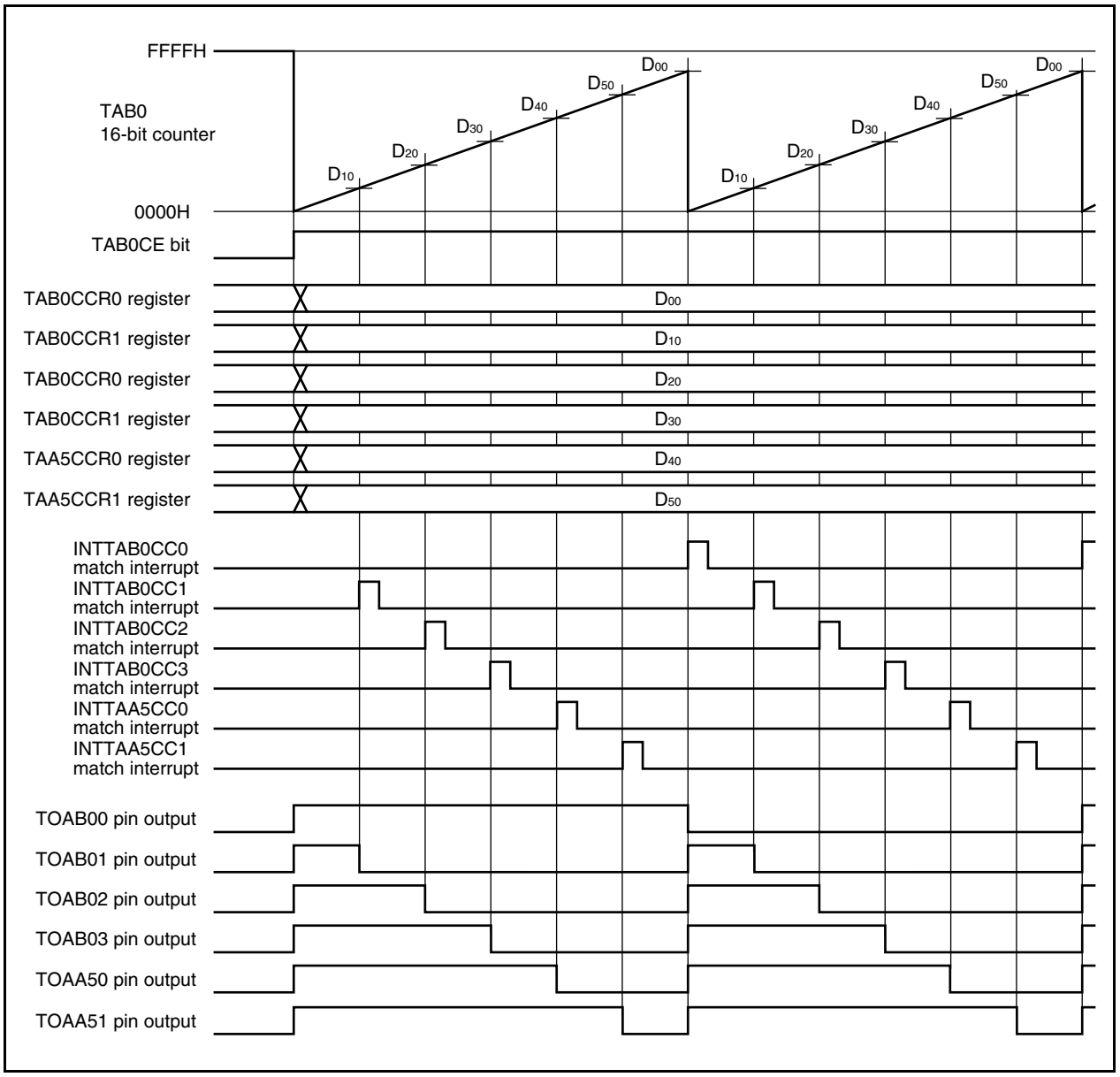
[Batch write]

In the PWM output mode, the next batch write is enabled by writing the TAB0CCR1 register of the master timer (TAB0). After all the compare registers that must be rewritten have been rewritten, therefore, the TAB0CCR1 register of the master timer (TAB0) must be written.

Batch writing is executed when the value of the timer counter matches the value of the compare register for cycle (TAB0CCR0).

If the TAB0CCR1 register of the master timer (TAB0) is not written, batch writing is not enabled even if any other compare register is rewritten. Consequently, the value of the compare registers is not rewritten even when the value of the timer counter matches the value of the compare register for cycle (TAB0CCR0).

Figure 7-47. Timing Example of Tuned PWM Function (TAB0, TAA5)



7.7 Simultaneous-Start Function

Timer AA and timer AB have a timer-tuned operation function.

By using the simultaneous-start function, a timer operation in which the operation start timing and count up timing of the master timer and slave timer are synchronized can be performed.

Only the PWM output mode can be used in the simultaneous-start function.

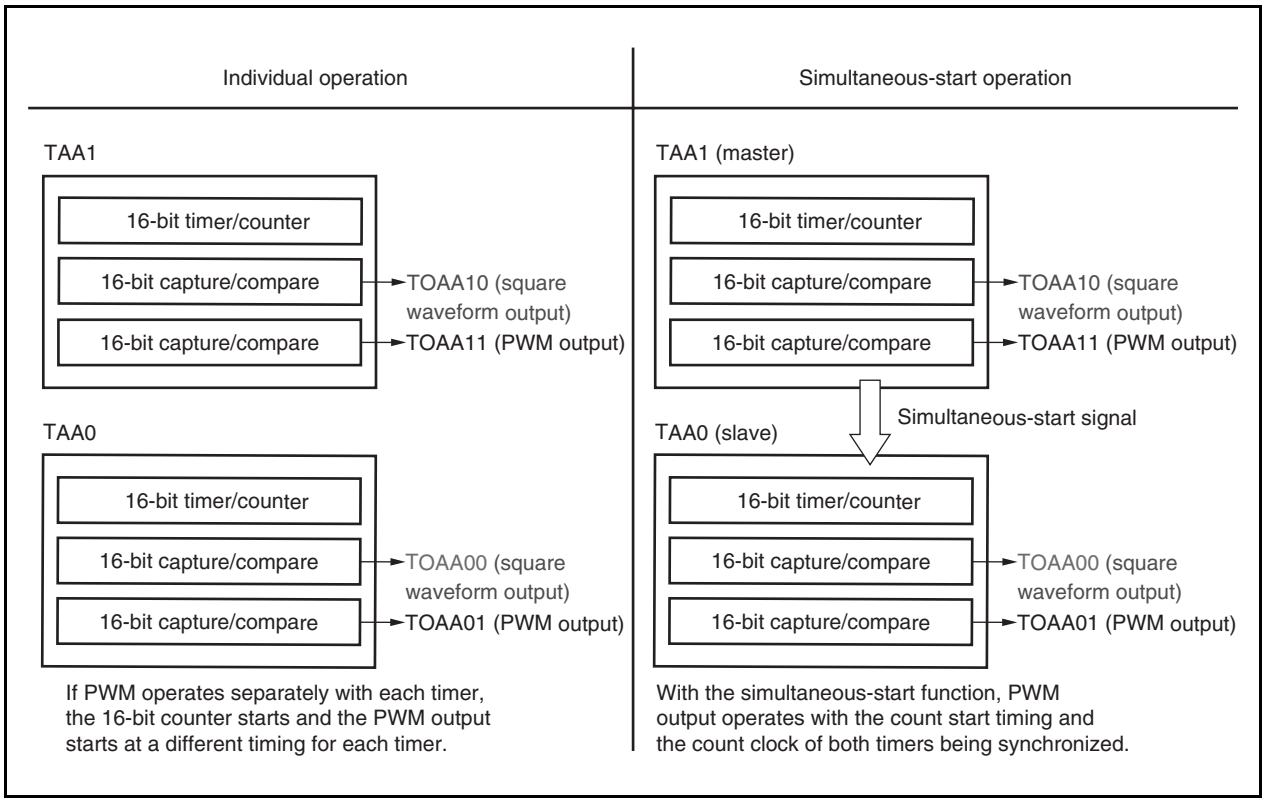
The combinations of timers that can use the simultaneous-start function are listed in Table 7-10.

Table 7-10. Timer Simultaneous-Start Function

Master Timer	Slave Timer
TAA1	TAA0
TAA3	TAA2
TAB0	TAA5

Figure 7-48 shows an example where individual operation and simultaneous-start operation of TAA0 (as the master timer) and TAA1 (as the slave timer) are performed in PWM output mode.

Figure 7-48. Differences Between Individual Operation and Simultaneous-Start Operation Using TAA1 and TAA0



7.7.1 PWM output mode (simultaneous-start operation)

In this section, the operation of the simultaneous-start function is shown, where TAA1 is used as the master timer and TAA0 is used as the slave timer.

The master timer (TAA1) and slave timer (TAA0) start operating at the same time when the TAA1CTL0.TAA0CE bit of master timer is set to 1. The slave timer operates by the count clock supplied from the master timer (TAA1). After the slave timer starts operating, however, the 16-bit counter of the slave timer (TAA0) is not cleared even if the 16-bit counter of the master timer (TAA1) is cleared to 0000H upon a match between the 16-bit counter value of the master timer (TAA1) and the TAA1CCR0 register value, because each timer operates individually.

In the same manner, if the compare register value of the master timer (TAA1) is rewritten by batch writing, the compare register of the slave timer is not affected.

[Initial settings]

Master timer: TAA1CTL0.TAA1CE = 0 (operation disabled)
Slave timer: TAA0CTL0.TAA0CE = 0 (operation disabled)

[Initial settings of master timer (TAA1)]

- TAA1CTL1.TAA1MD2 to TAA1CTL1.TAA1MD0 = 100 (setting of PMW output mode)
- TAA1CTL1.TAA1CKS2 to TAA1CTL1.TAA1CKS0 (setting of count clock (any))
- TAA1CCR1, TAA1CCR0 (specification of valid edge of capture trigger)
- TAA1IOC0 (specification of valid edge of capture trigger)

[Initial settings of slave timer (TAA0)]

- TAA0CTL1.TAA0SYE = 1, TAA0SYM = 1 (simultaneous-start operation)
- TAA0CTL1.TAA0MD2 to TAA0CTL1.TAA0MD0 = 100 (setting of PMW output mode)
- TAA0CCR0, TAA1CCR1 (specification of valid edge of capture trigger)
- TAA0IOC0 (specification of valid edge of capture trigger)

Remark The initial settings of the master timer and slave timer may be performed in any order.

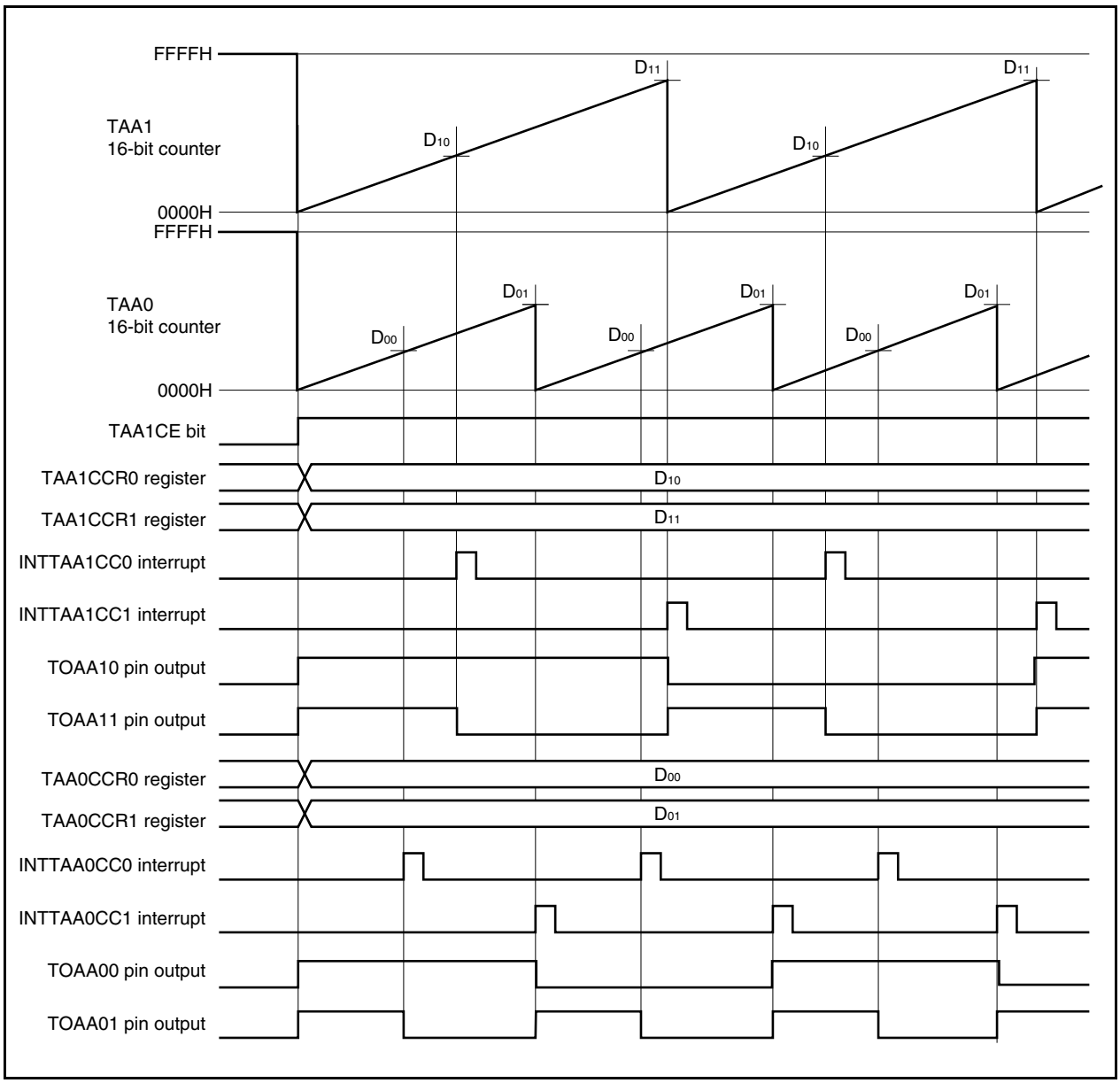
[Starting counting]

<1> Set TAA1CTL0.TAA1CE of the master timer to 1.
<2> Start counting.
<3> Changing the setting of the register during operation
- The compare register can be rewritten (anytime write).

[End condition]

- Set TAA1CTL0.TAA0CE of the master timer to 0.

Figure 7-49. Timing Example of Simultaneous-Start Function (TAA1: Master, TAA0: Slave)



7.8 Cascade Connection

This section explains an operation of connecting two channels of TAA in cascade to form a 32-bit capture timer.

For cascade connection, the free-running timer mode must be set and all the capture/compare registers must be set as capture registers (TAA0CCSn = 1).

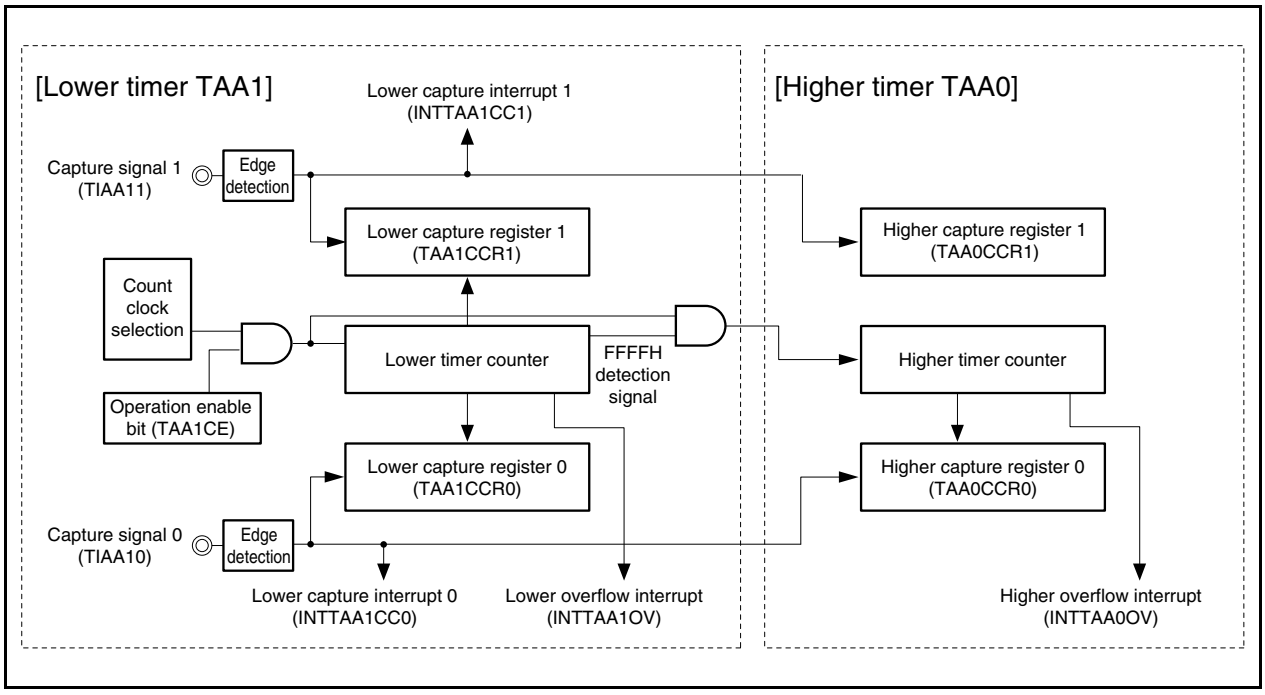
Combinations of TAA channels that can be connected in cascade are shown in the following table.

Table 7-11. Cascade Connection of TAA

Lower Timer (Master Timer)	Higher Timer (Slave Timer)
TAA1	TAA0
TAA3	TAA2

In the following example, TAA1 is used as the lower timer (master timer) and TAA0 is used as the higher timer (slave timer) to use them as a 32-bit capture timer by cascade connection.

Figure 7-50. Cascade Connection Example



The operation of each pin and signal when TAA1 and TAA0 are connected in cascade is shown below.

Table 7-12. Status in Cascade Connection

Name	Higher/Lower	Function	Operation
TIAA10 pin input	Lower	Capture input 0	The value of the lower timer counter is stored in the TAA1CCR0 register and the value of the higher timer counter is stored in the TAA0CCR0 register when the valid edge of this input is detected.
TIAA11 pin input	Lower	Capture input 1	The value of the lower timer counter is stored in the TAA1CCR1 register and the value of the higher timer counter is stored in the TAA0CCR1 register when the valid edge of this input is detected.
INTTAA1CCR0 interrupt signal	Lower	Capture interrupt 0	This interrupt is generated when the valid edge of the TIAA10 pin is detected.
INTTAA1CCR1 interrupt signal	Lower	Capture interrupt 1	This interrupt is generated when the valid edge of the TIAA11 pin is detected.
INTTAA1OV interrupt signal	Lower	Overflow interrupt	This interrupt is generated when an overflow of the lower timer counter is detected.
TIAA00 pin input	Higher	Capture input 0	Does not operate.
TIAA01 pin input	Higher	Capture input 1	Does not operate.
INTTAA0CCR0 interrupt signal	Higher	Capture interrupt 0	Does not operate.
INTTAA0CCR1 interrupt signal	Higher	Capture interrupt 1	Does not operate.
INTTAA0OV interrupt signal	Higher	Overflow interrupt	This interrupt is generated when an overflow of the higher timer counter is detected.

Figure 7-51. Operation Flow in Cascade Connection of TAA1 and TAA0 (1/2)

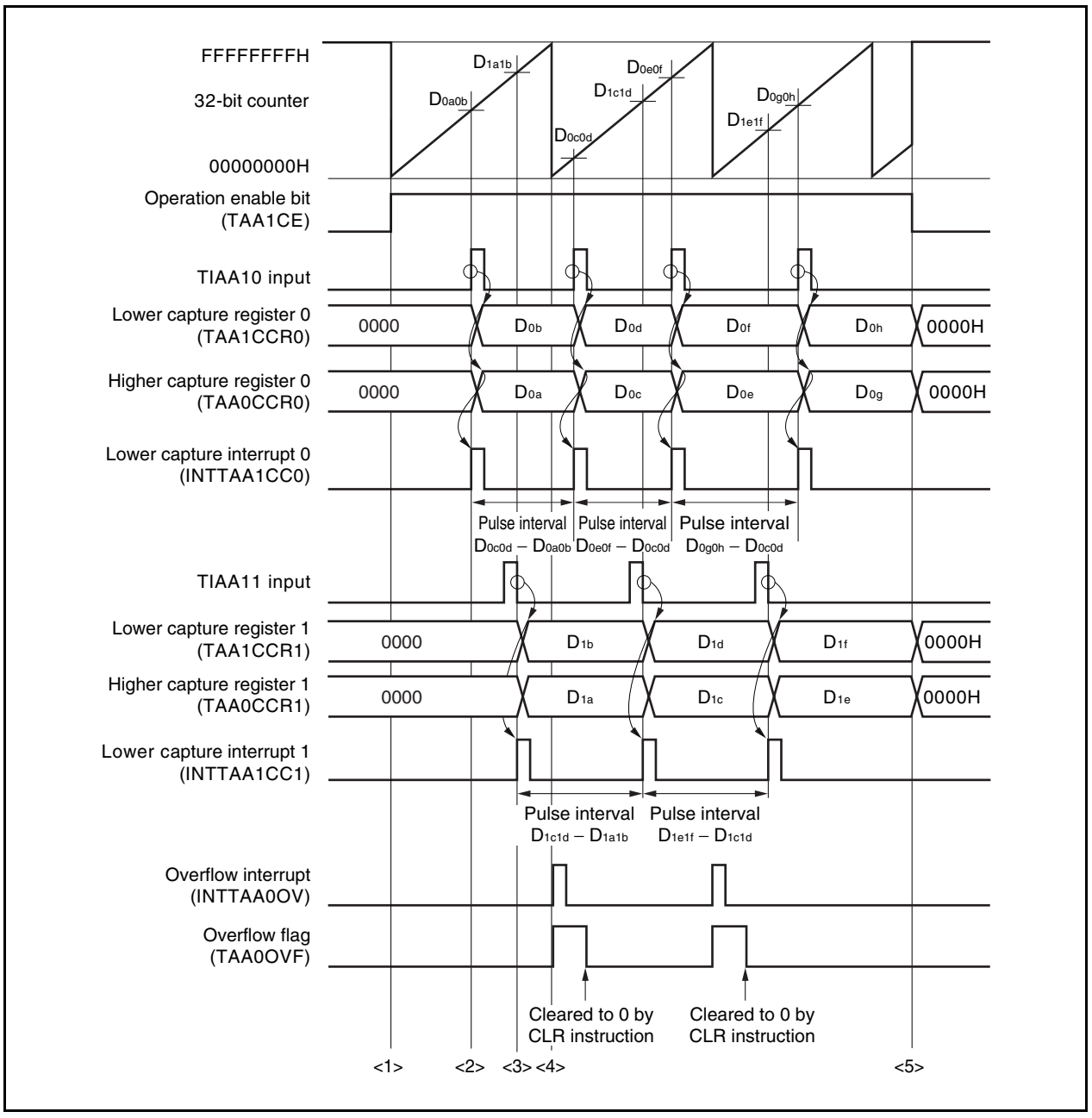


Figure 7-51. Operation Flow in Cascade Connection of TAA1 and TAA0 (2/2)

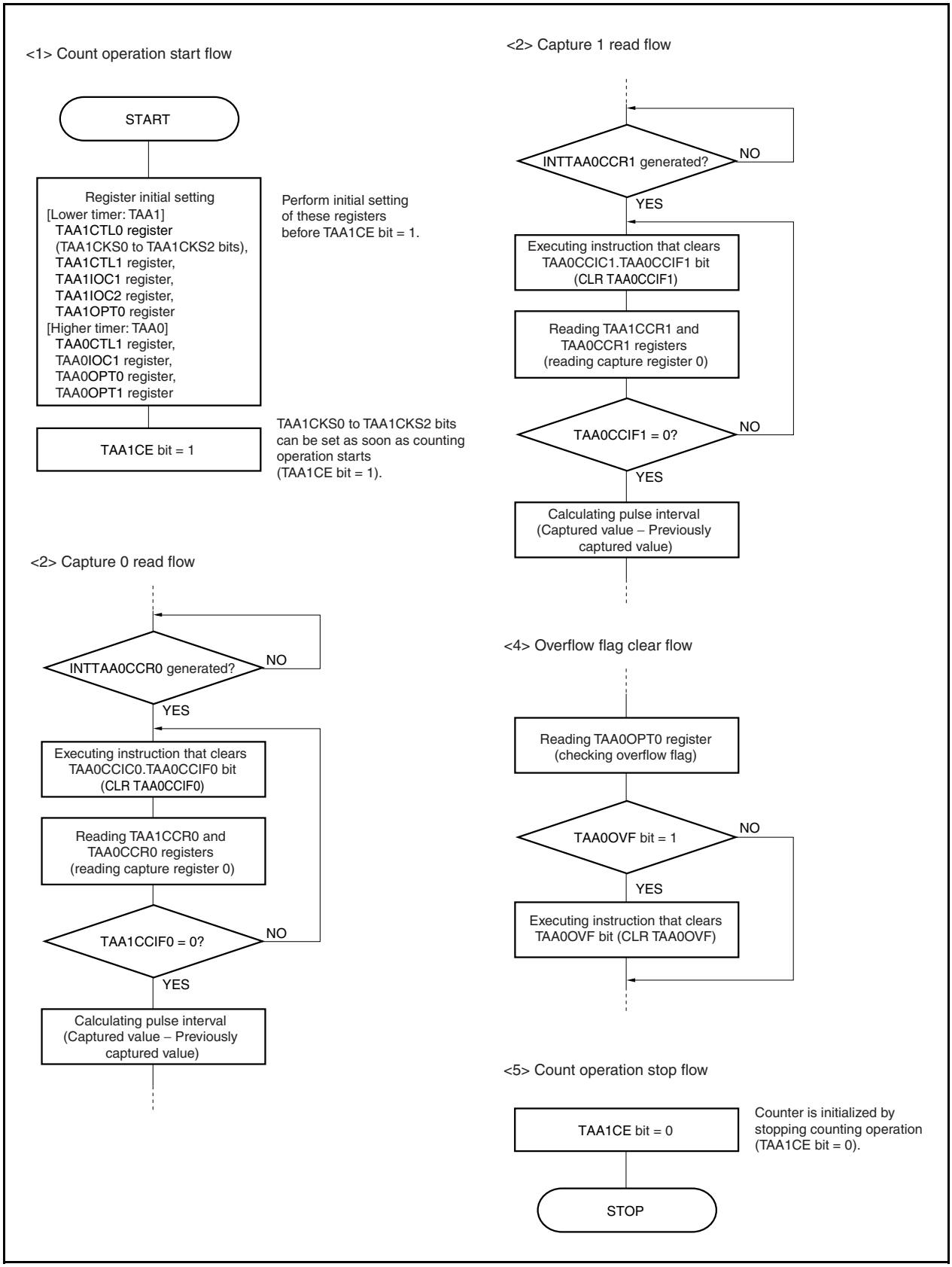
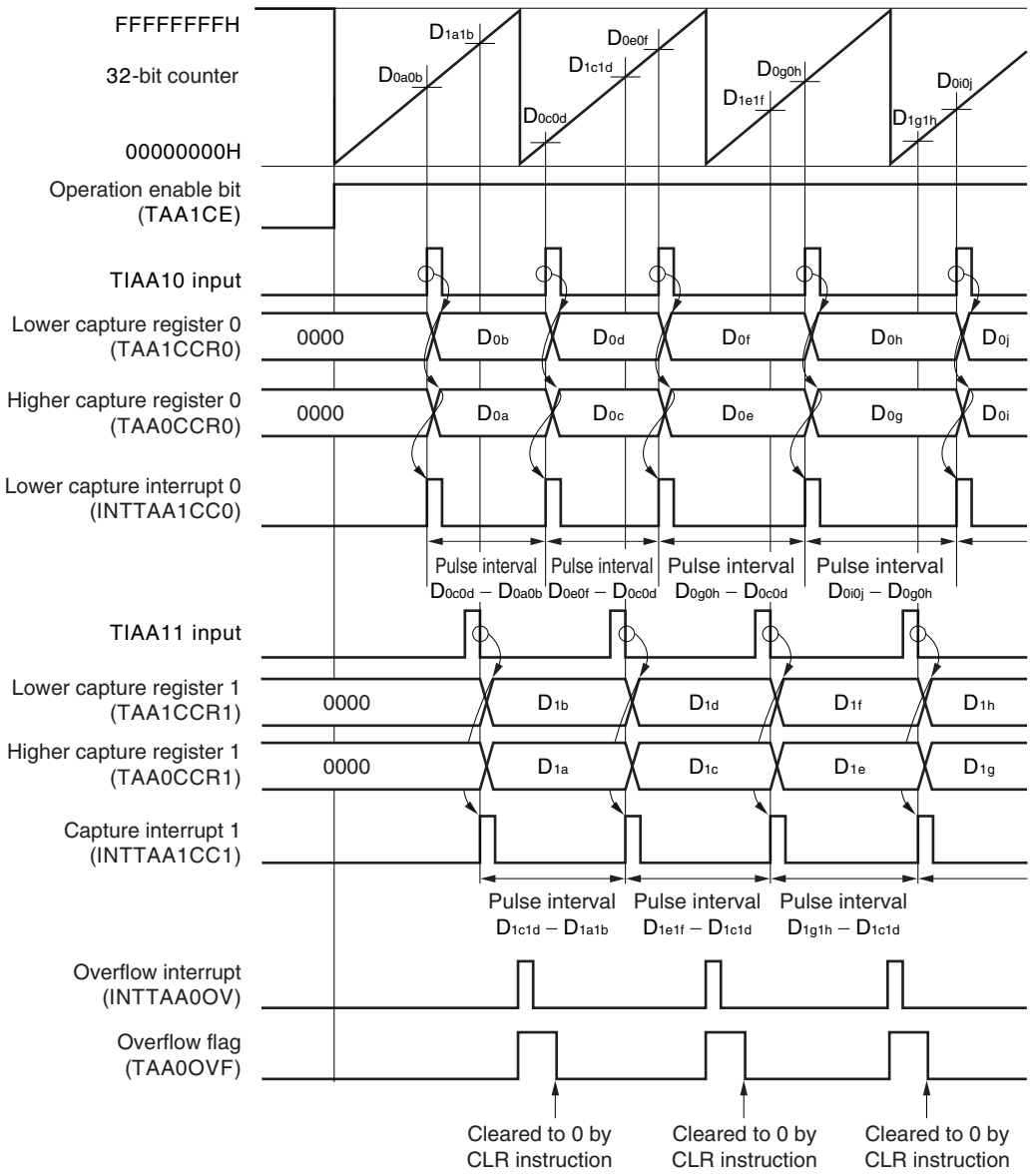


Figure 7-52. Example of Basic Timing When TAA1 and TAA0 Are Connected in Cascade



The counting operation is started when the TAA1CTL.TAA1CE bit is set to 1 and the count clock is supplied. When the valid edge input to the TIAA10 pin is detected, the count value is stored in the capture register 0 (TAA1CCR0 and TAA0CCR0), and capture interrupt 0 signal (INTTAA1CC0) is issued.

The timer counter continues the counting operation in synchronization with the count clock. When it counts up to FFFFFFFFH, the overflow interrupt (INTTAA0OV) is generated at the next clock and the overflow flag (TAA0OVF) is set to 1. The timer counter is cleared to 00000000H and continues counting up.

The overflow flag (TAA0OVF) is cleared by an instruction issued from the CPU that writes “0” to it.

Because the free-running timer mode is set, the timer counter cannot be cleared by detection of the valid edge input to the TIAA10 pin.

Using TOAA10 output is prohibited because it alternately functions as the TIAA10 input.

Capture register 1 (TAA1CCR1 and TAA0CCR1) also operates in the same manner.

If the lower timer counter (TAA1) overflows, an overflow interrupt (TAA1OVF) is generated. However, it is recommended to mask this interrupt because it cannot be used as an overflow interrupt of the 32-bit counter.

7.9 Selector Function

In the V850ES/JG3-H and V850ES/JH3-H, the alternate-function pins of ports or peripheral I/O (TAA1, TAB0, UARTC0, or UARTC1) signals can be selected as the capture trigger input of TAA1 and TAB0.

If the signal input from the UARTCn pin is selected by the selector function when RXDCn is used, baud rate errors of the LIN reception transfer rate of UARTCn can be calculated (n = 0, 1).

(1) Selector operation control register 0 (SELCNT0)

The SELCNT0 register is an 8-bit register that selects the capture trigger for CAN0, TAA1, and TAB0.

This register can be read or written in 8-bit or 1-bit units.

Reset sets this register to 00H.

After reset: 00H R/W Address: FFFFF308H

	7	6	5	4	3	2	1	0
SELCNT0	0	0	0	ISEL4	ISEL3	0	0	ISEL0[Note]

ISEL4	Selection of TIAA11 capture trigger input signal
0	TIAA11 (alternately functions as P35) pin
1	RXDC1 (alternately functions as P91) pin

ISEL3	Selection of TIAA10 capture trigger input signal
0	TIAA10 (alternately functions as P34) pin
1	RXDC0 (alternately functions as P31) pin

ISEL0[Note]	Selection of TIAB02 capture trigger input signal
0	TIAB02 (alternately functions as P51) pin
1	CAN0 TSOUT signal

Note μPD70F3770 and 70F3771 only

Cautions 1. To set the ISEL4, ISEL3, and ISEL0 bits to 1, set the corresponding function pin to the capture input mode.

2. Set the ISEL4, ISEL3, and ISEL0 bits when the operation of TAA1, TAB0, and UARTC0, UARTC1, and CAN0 are stopped.

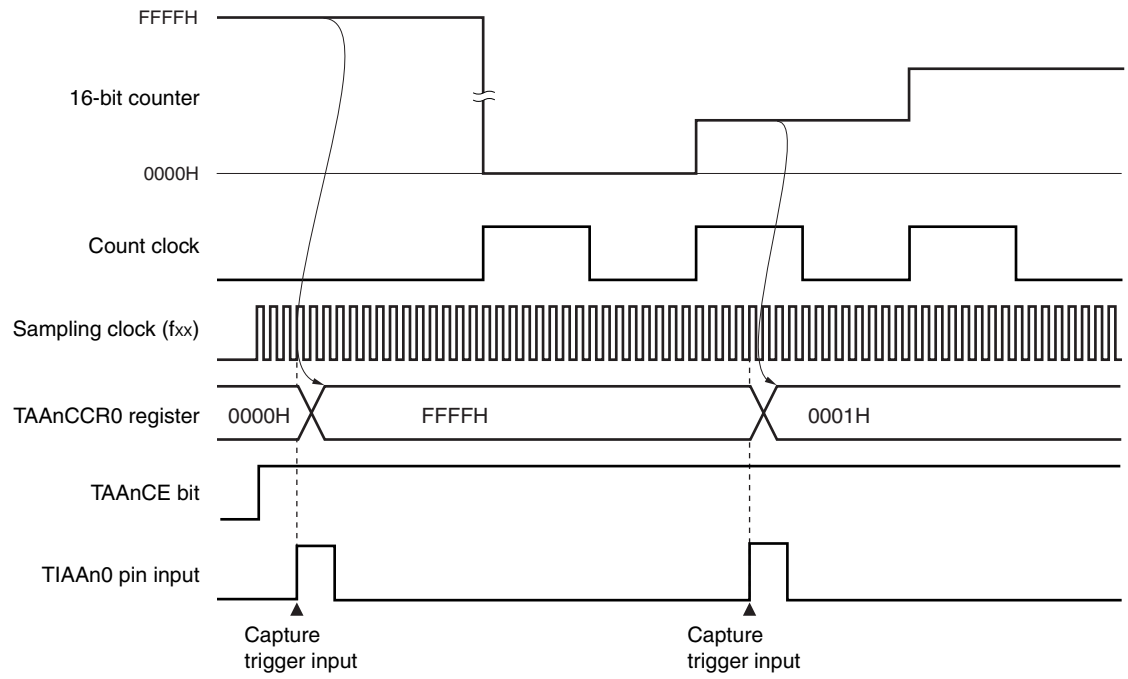
3. Be sure to set bits 7 to 5, 2, and 1 to "0".

7.10 Cautions

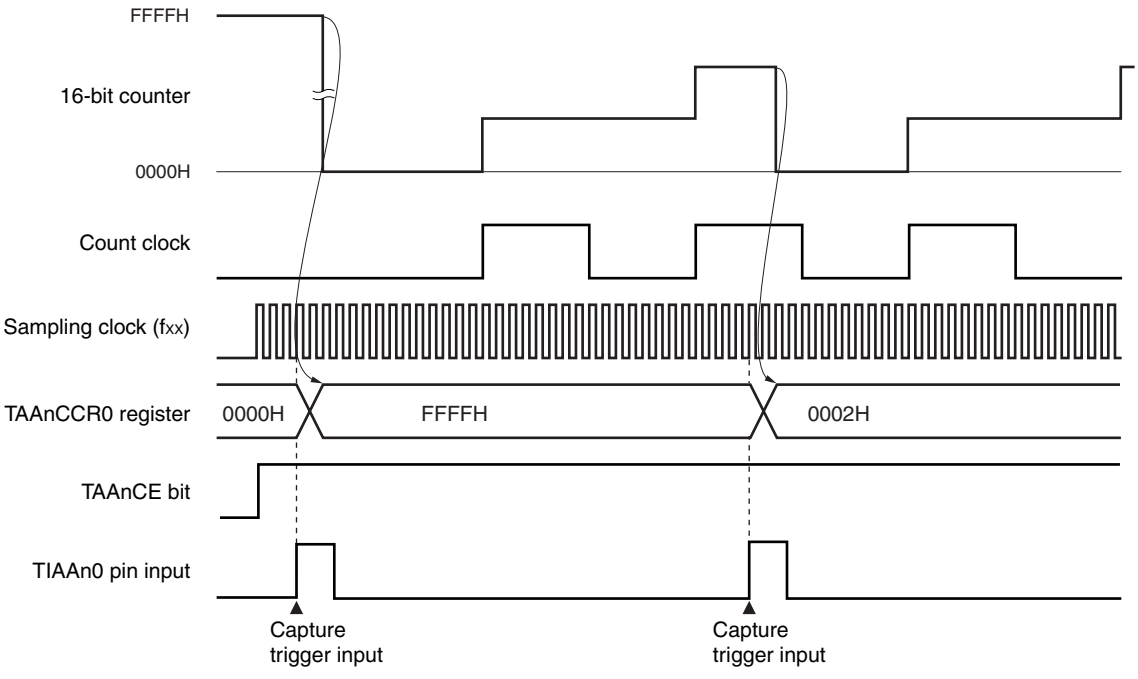
(1) Capture operation

When the capture operation is used and a slow clock is selected as the count clock, FFFFH, not 0000H, may be captured in the TAAnCCR0 and TAAnCCR1 registers if the capture trigger is input immediately after the TAAnCE bit is set to 1.

(a) Free-running timer mode



(b) Pulse width measurement mode



CHAPTER 8 16-BIT TIMER/EVENT COUNTER AB (TAB)

Timer AB (TAB) is a 16-bit timer/event counter.
The V850ES/JG3-H and V850ES/JH3-H have TAB0 and TAB1.

8.1 Overview

An outline of TABn is shown below.

- Clock selection: 8 ways
- Capture/trigger input pins: 4
- External event count input pins: 1
- External trigger input pins: 1
- Timer counters: 1
- Capture/compare registers: 4
- Capture/compare match interrupt request signals: 4
- Timer output pins: 4

Remark n = 0, 1

8.2 Functions

TABn has the following functions.

- Interval timer
- External event counter
- External trigger pulse output
- One-shot pulse output
- PWM output
- Free-running timer
- Pulse width measurement
- Triangular wave PWM output
- Timer-tuned operation function
- Simultaneous-start function

Remark n = 0, 1

8.3 Configuration

TABn includes the following hardware.

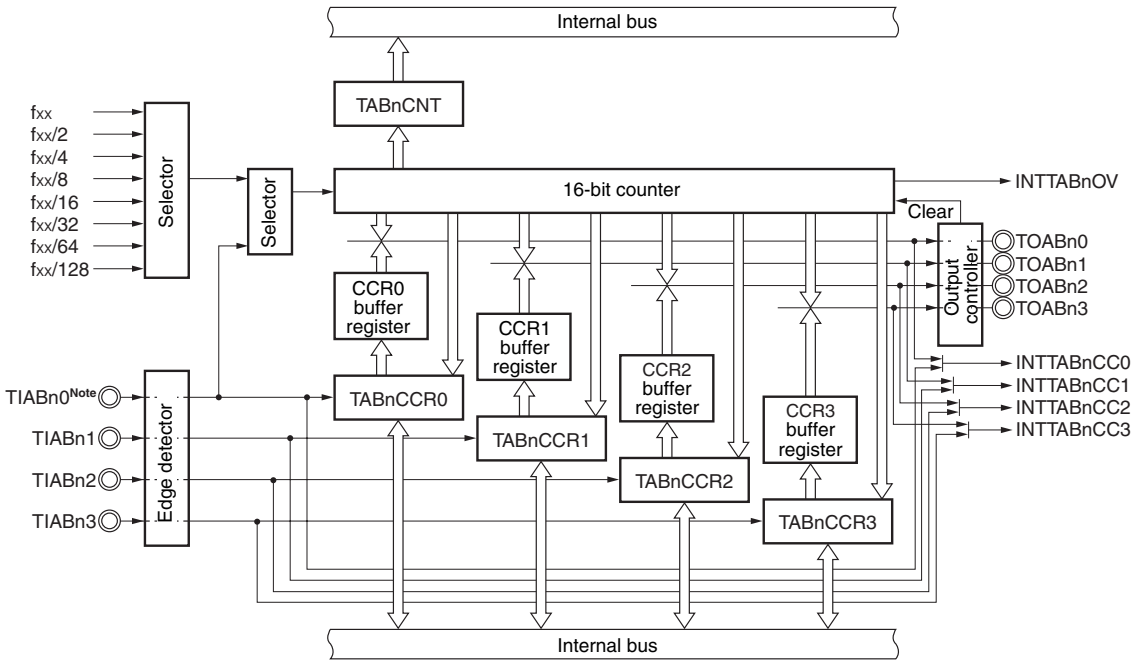
Table 8-1. Configuration of TABn

Item	Configuration
Registers	16-bit counter TABn capture/compare registers 0 to 3 (TABnCCR0 to TABnCCR3) TABn counter read buffer register (TABnCNT) CCR0 to CCR3 buffer registers TABn control registers 0, 1 (TABnCTL0, TABnCTL1) TABn I/O control registers 0 to 2 (TABnIOC0 to TABnIOC2, TABnIOC4) TABn option register 0 (TABnOPT0)
Timer inputs[Note 2]	4 (TIABn0[Note 1] to TIABn3 pins)
Timer outputs[Note 2]	4 (TOABn0 to TOABn3 pins)

Notes 1. When using the functions of the TIABn0 to TIABn3 and TOABn0 to TOABn3 pins, see **Table 4-20 Using Port Pin as Alternate-Function Pin**.

2. The TIAB00 pin functions alternately as a capture trigger input signal, external event count input signal, and external trigger input signal.

Figure 8-1. Block Diagram of TABn



Note TAB1: EVTAB1 pin and TRGAB1 pin

Remarks 1. fxx: Main clock frequency

2. n = 0, 1

(1) 16-bit counter

This 16-bit counter can count internal clocks or external events.

The count value of this counter can be read by using the TABnCNT register.

When the TABnCTL0.TABnCE bit = 0, the value of the 16-bit counter is FFFFH. If the TABnCNT register is read at this time, 0000H is read.

Reset sets the TABnCE bit to 0. Therefore, the 16-bit counter is set to FFFFH.

(2) CCR0 buffer register

This is a 16-bit compare register that compares the count value of the 16-bit counter.

When the TABnCCR0 register is used as a compare register, the value written to the TABnCCR0 register is transferred to the CCR0 buffer register. When the count value of the 16-bit counter matches the value of the CCR0 buffer register, a compare match interrupt request signal (INTTABnCC0) is generated.

The CCR0 buffer register cannot be read or written directly.

The CCR0 buffer register is cleared to 0000H after reset, as the TABnCCR0 register is cleared to 0000H.

(3) CCR1 buffer register

This is a 16-bit compare register that compares the count value of the 16-bit counter.

When the TABnCCR1 register is used as a compare register, the value written to the TABnCCR1 register is transferred to the CCR1 buffer register. When the count value of the 16-bit counter matches the value of the CCR1 buffer register, a compare match interrupt request signal (INTTABnCC1) is generated.

The CCR1 buffer register cannot be read or written directly.

The CCR1 buffer register is cleared to 0000H after reset, as the TABnCCR1 register is cleared to 0000H.

(4) CCR2 buffer register

This is a 16-bit compare register that compares the count value of the 16-bit counter.

When the TABnCCR2 register is used as a compare register, the value written to the TABnCCR2 register is transferred to the CCR2 buffer register. When the count value of the 16-bit counter matches the value of the CCR2 buffer register, a compare match interrupt request signal (INTTABnCC2) is generated.

The CCR2 buffer register cannot be read or written directly.

The CCR2 buffer register is cleared to 0000H after reset, as the TABnCCR2 register is cleared to 0000H.

(5) CCR3 buffer register

This is a 16-bit compare register that compares the count value of the 16-bit counter.

When the TABnCCR3 register is used as a compare register, the value written to the TABnCCR3 register is transferred to the CCR3 buffer register. When the count value of the 16-bit counter matches the value of the CCR3 buffer register, a compare match interrupt request signal (INTTABnCC3) is generated.

The CCR3 buffer register cannot be read or written directly.

The CCR3 buffer register is cleared to 0000H after reset, as the TABnCCR3 register is cleared to 0000H.

(6) Edge detector

This circuit detects the valid edges input to the TIABn0 to TIABn3 pins. No edge, rising edge, falling edge, or both the rising and falling edges can be selected as the valid edge by using the TABnIOC1 and TABnIOC2 registers.

(7) Output controller

This circuit controls the output of the TOABn0 to TOABn3 pins. The output controller is controlled by the TABnIOC0 register.

(8) Selector

This selector selects the count clock for the 16-bit counter. Eight types of internal clocks or an external event can be selected as the count clock.

8.4 Registers

The registers that control TABn are as follows.

- TABn control register 0 (TABnCTL0)
- TABn control register 1 (TABnCTL1)
- TABn I/O control register 0 (TABnIOC0)
- TABn I/O control register 1 (TABnIOC1)
- TABn I/O control register 2 (TABnIOC2)
- TABn I/O control register 4 (TABnIOC4)
- TABn option register 0 (TABnOPT0)
- TABn capture/compare register 0 (TABnCCR0)
- TABn capture/compare register 1 (TABnCCR1)
- TABn capture/compare register 2 (TABnCCR2)
- TABn capture/compare register 3 (TABnCCR3)
- TABn counter read buffer register (TABnCNT)

Remarks 1. When using the functions of the TIABn0 to TIABn3 and TOABn0 to TOABn3 pins, see **Table 4-20 Using Port Pin as Alternate-Function Pin**.

2. n = 0, 1

(1) TABn control register 0 (TABnCTL0)

The TABnCTL0 register is an 8-bit register that controls the operation of TABn.

This register can be read or written in 8-bit or 1-bit units.

Reset sets this register to 00H.

Software can be used to always write the same value to the TABnCTL0 register.

After reset: 00H R/W Address: TAB0CTL0 FFFFF540H, TAB1CTL0 FFFFF560H

	7	6	5	4	3	2	1	0
TABnCTL0 (n = 0, 1)	TABnCE	0	0	0	0	TABnCKS2	TABnCKS1	TABnCKS0

TABnCE	TABn operation control
0	TABn operation disabled (TABn reset asynchronously[Note]).
1	TABn operation enabled. TABn operation started.

TABnCKS2	TABnCKS1	TABnCKS0	Internal count clock selection
0	0	0	f_{XX}
0	0	1	$f_{XX}/2$
0	1	0	$f_{XX}/4$
0	1	1	$f_{XX}/8$
1	0	0	$f_{XX}/16$
1	0	1	$f_{XX}/32$
1	1	0	$f_{XX}/64$
1	1	1	$f_{XX}/128$

Note TABnOPT0.TABnOVF bit, 16-bit counter, timer output (TOABn0 to TOABn3 pins)

Cautions 1. Set the TABnCKS2 to TABnCKS0 bits when the TABnCE bit = 0. When the value of the TABnCE bit is changed from 0 to 1, the TABnCKS2 to TABnCKS0 bits can be set simultaneously.

2. Be sure to set bits 3 to 6 to "0".

Remark f_{XX}: Main clock frequency

(2) TABn control register 1 (TABnCTL1)

The TABnCTL1 register is an 8-bit register that controls the operation of TABn.

This register can be read or written in 8-bit or 1-bit units.

Reset sets this register to 00H.

After reset: 00H R/W Address: TAB0CTL1 FFFFF541H, TAB1CTL1 FFFFF561H

	7	6	5	4	3	2	1	0
TABnCTL1 (n = 0, 1)	0	TABnEST	TABnEEE	0	0	TABnMD2	TABnMD1	TABnMD0

TABnEST	Software trigger control
0	–
1	Generate a valid signal for external trigger input. • In one-shot pulse output mode: A one-shot pulse is output with writing 1 to the TABnEST bit as the trigger. • In external trigger pulse output mode: A PWM waveform is output with writing 1 to the TABnEST bit as the trigger.

TABnEEE	Count clock selection
0	Disable operation with external event count input. (Perform counting with the count clock selected by the TABnCTL0.TABnCK0 to TABnCTL0.TABnCK2 bits.)
1	Enable operation with external event count input. (Perform counting at the valid edge of the external event count input signal.)
The TABnEEE bit selects whether counting is performed with the internal count clock or the valid edge of the external event count input.	

TABnMD2	TABnMD1	TABnMD0	Timer mode selection
0	0	0	Interval timer mode
0	0	1	External event count mode
0	1	0	External trigger pulse output mode
0	1	1	One-shot pulse output mode
1	0	0	PWM output mode
1	0	1	Free-running timer mode
1	1	0	Pulse width measurement mode
1	1	1	Triangular wave PWM mode

Cautions 1. The TABnEST bit is valid only in the external trigger pulse output mode or one-shot pulse output mode. In any other mode, writing 1 to this bit is ignored.

2. Be sure to set bits 3, 4, and 7 to "0".

3. External event count input is selected in the external event count mode regardless of the value of the TABnEEE bit.

4. Set the TABnEEE and TABnMD2 to TABnMD0 bits when the TABnCTL0.TABnCE bit = 0. (The same value can be written when the TABnCE bit = 1.) The operation is not guaranteed when rewriting is performed with the TABnCE bit = 1. If rewriting was mistakenly performed, clear the TABnCE bit to 0 and then set the bits again.

(3) TABn I/O control register 0 (TABnIOC0)

The TABnIOC0 register is an 8-bit register that controls the timer output (TOABn0 to TOABn3 pins).

This register can be read or written in 8-bit or 1-bit units.

Reset sets this register to 00H.

After reset: 00H R/W Address: TAB0IOC0 FFFFF542H, TAB1IOC0 FFFFF562H

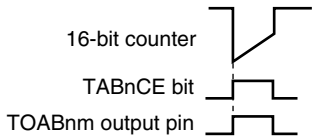
	7	6	5	4	3	2	1	0
TABnIOC0 (n = 0, 1)	TABnOL3	TABnOE3	TABnOL2	TABnOE2	TABnOL1	TABnOE1	TABnOL0	TABnOE0

TABnOLm	TOABnm pin output level setting (m = 0 to 3)[Note]
0	TOABnm pin high level start
1	TOABnm pin low level start

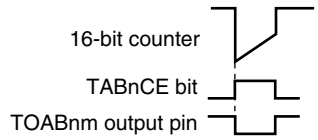
TABnOEm	TOABnm pin output setting (m = 0 to 3)
0	Timer output disabled • When TABnOLm bit = 0: Low level is output from the TOABnm pin • When TABnOLm bit = 1: High level is output from the TOABnm pin
1	Timer output enabled (a square wave is output from the TOABnm pin).

Note The output level of the timer output pin (TOABnm) specified by the TABnOLm bit is shown below.

• When TABnOLm bit = 0



• When TABnOLm bit = 1



Cautions 1. Rewrite the TABnOLm and TABnOEm bits when the TABnCTL0.TABnCE bit = 0. (The same value can be written when the TABnCE bit = 1.) If rewriting was mistakenly performed, clear the TABnCE bit to 0 and then set the bits again.

2. Even if the TABnOLm bit is manipulated when the TABnCE and TABnOEm bits are 0, the TOABnm pin output level varies.

Remark m = 0 to 3

(4) TABn I/O control register 1 (TABnIOC1)

The TABnIOC1 register is an 8-bit register that controls the valid edge of the capture trigger input signals (TIABn0 to TIABn3 pins).

This register can be read or written in 8-bit or 1-bit units.

Reset sets this register to 00H.

After reset: 00H R/W Address: TAB0IOC1 FFFFF543H, TAB1IOC1 FFFFF563H

	7	6	5	4	3	2	1	0
TABnIOC1 (n = 0, 1)	TABnIS7	TABnIS6	TABnIS5	TABnIS4	TABnIS3	TABnIS2	TABnIS1	TABnIS0

TABnIS7	TABnIS6	Capture trigger input signal (TIABn3 pin) valid edge setting
0	0	No edge detection (capture operation invalid)
0	1	Detection of rising edge
1	0	Detection of falling edge
1	1	Detection of both edges

TABnIS5	TABnIS4	Capture trigger input signal (TIABn2 pin) valid edge detection
0	0	No edge detection (capture operation invalid)
0	1	Detection of rising edge
1	0	Detection of falling edge
1	1	Detection of both edges

TABnIS3	TABnIS2	Capture trigger input signal (TIABn1 pin) valid edge setting
0	0	No edge detection (capture operation invalid)
0	1	Detection of rising edge
1	0	Detection of falling edge
1	1	Detection of both edges

TABnIS1	TABnIS0	Capture trigger input signal (TIABn0 pin) valid edge setting
0	0	No edge detection (capture operation invalid)
0	1	Detection of rising edge
1	0	Detection of falling edge
1	1	Detection of both edges

Cautions 1. Rewrite the TABnIS7 to TABnIS0 bits when the TABnCTL0.TABnCE bit = 0. (The same value can be written when the TABnCE bit = 1.) If rewriting was mistakenly performed, clear the TABnCE bit to 0 and then set the bits again.

2. The TABnIS7 to TABnIS0 bits are valid only in the free-running timer mode and the pulse width measurement mode. In all other modes, a capture operation is not possible.

(5) TABn I/O control register 2 (TABnIOC2)

The TABnIOC2 register is an 8-bit register that controls the valid edge of the external event count input signal (TIAB00/EVTAB1 pin) and external trigger input signal (TIAB00/TRGAB1 pin).

This register can be read or written in 8-bit or 1-bit units.

Reset sets this register to 00H.

After reset: 00H R/W Address: TAB0IOC2 FFFFF544H, TAB1IOC2 FFFFF564H

	7	6	5	4	3	2	1	0
TABnIOC2 (n = 0, 1)	0	0	0	0	TABnEES1	TABnEES0	TABnETS1	TABnETS0

TABnEES1	TABnEES0	External event count input signal (TIAB00/EVTAB1 pin) valid edge setting
0	0	No edge detection (external event count invalid)
0	1	Detection of rising edge
1	0	Detection of falling edge
1	1	Detection of both edges

TABnETS1	TABnETS0	External trigger input signal (TIAB00/TRGAB1 pin) valid edge setting
0	0	No edge detection (external trigger invalid)
0	1	Detection of rising edge
1	0	Detection of falling edge
1	1	Detection of both edges

Cautions 1. Rewrite the TABnEES1, TABnEES0, TABnETS1, and TABnETS0 bits when the TABnCTL0.TABnCE bit = 0. (The same value can be written when the TABnCE bit = 1.) If rewriting was mistakenly performed, clear the TABnCE bit to 0 and then set the bits again.

2. The TABnEES1 and TABnEES0 bits are valid only when the TABnCTL1.TABnEEE bit = 1 or when the external event count mode (TABnCTL1.TABnMD2 to TABnCTL1.TABnMD0 bits = 001) has been set.

3. The TABnETS1 and TABnETS0 bits are valid only when the external trigger pulse output mode (TABnCTL1.TABnMD2 to TABnCTL1.TABnMD0 bits = 010) or the one-shot pulse output mode (TABnCTL1.TABnMD2 to TABnCTL1.TABnMD0 = 011) is set.

(6) TABn I/O control register 4 (TABnIOC4)

The TABnIOC4 register is an 8-bit register that controls the timer output.

This register can be read or written in 8-bit or 1-bit units.

Reset sets this register to 00H. This register is not reset by stopping the timer operation (TABnCTL0.TABnCE = 0).

Cautions 1. Accessing the TABnIOC4 register is prohibited in the following statuses. For details, see 3.4.9 (2) Accessing specific on-chip peripheral I/O registers.

- **When the CPU operates on the subclock and the main clock oscillation is stopped**
- **When the CPU operates on the internal oscillation clock**

2. The TABnIOC4 register can be set only in the interval timer mode and free-running timer mode. Be sure to set the TABnIOC4 register to 00H in all other modes (for details of the mode setting, see 8.4 (2) TABn control register 1 (TABnCTL1)). Even in free-running timer mode, if the TABnCCR0 to TABnCCR3 registers are set to the capture function, the setting of the TABnIOC4 register becomes invalid.

After reset: 00H R/W Address: TAB0IOC4 FFFFF550H, TAB1IOC4 FFFFF570H

TABnIOC4 (n = 0, 1)

7	6	5	4	3	2	1	0
TABnOS3	TABnOR3	TABnOS2	TABnOR2	TABnOS1	TABnOR1	TABnOS0	TABnOR0

TABnOSm	TABnORm	Toggle control of TOABnm pin (m = 0 to 3)
0	0	No request. Normal toggle operation.
0	1	Reset request Fix to inactive level upon next match between value of 16-bit counter and value of TAAnCCRm register.
1	0	Set request Fix to active level upon next match between value of 16-bit counter and value of TAAnCCRm register.
1	1	Keep request Keep the current output level.

(7) TABn option register 0 (TABnOPT0)

The TABnOPT0 register is an 8-bit register used to set the capture/compare operation and detect an overflow.

This register can be read or written in 8-bit or 1-bit units.

Reset sets this register to 00H.

After reset: 00H R/W Address: TAB0OPT0 FFFFF545H, TAB1OPT0 FFFFF565H

TABnOPT0 (n = 0, 1)

7	6	5	4	3	2	1	0
TABnCCS3	TABnCCS2	TABnCCS1	TABnCCS0	0	TAB1CMS[Note]	TABnCUF	TABnOVF

TABnCCSm	TABnCCRm register capture/compare selection
0	Compare register selected
1	Capture register selected
The TABnCCSm bit setting is valid only in the free-running timer mode.	

TABnOVF	TABn overflow detection
Set (1)	Overflow occurred
Reset (0)	TABnOVF bit 0 written or TABnCTL0.TABnCE bit = 0
• The TABnOVF bit is set to 1 when the 16-bit counter count value overflows from FFFFH to 0000H in the free-running timer mode or the pulse width measurement mode. • An interrupt request signal (INTTABnOV) is generated at the same time that the TABnOVF bit is set to 1. The INTTABnOV signal is not generated in modes other than the free-running timer mode and the pulse width measurement mode. • The TABnOVF bit is not cleared even when the TABnOVF bit or the TABnOPT0 register are read when the TABnOVF bit = 1. • The TABnOVF bit can be both read and written, but the TABnOVF bit cannot be set to 1 by software. Writing 1 has no effect on the operation of TABn.	

Note The TAB1CMS bit is used for the motor control function. For details, see **CHAPTER 11 MOTOR CONTROL FUNCTION**.

Cautions 1. Rewrite the TABnCCS3 to TABnCCS0 bits when the TABnCTL0.TABnCE bit = 0. (The same value can be written when the TABnCE bit = 1.) If rewriting was mistakenly performed, clear the TABnCE bit to 0 and then set the bits again.

2. Be sure to set bit 3 to "0". When the motor control function is not used, be sure to also set bit 2 to "0".

Remark m = 0 to 3

(8) TABn capture/compare register 0 (TABnCCR0)

The TABnCCR0 register can be used as a capture register or a compare register depending on the mode.

This register can be used as a capture register or a compare register only in the free-running timer mode, according to the setting of the TABnOPT0.TABnCCS0 bit. In the pulse width measurement mode, the TABnCCR0 register can be used only as a capture register. In any other mode, this register can be used only as a compare register.

The TABnCCR0 register can be read or written during operation.

This register can be read or written in 16-bit units.

Reset sets this register to 0000H.

Caution Accessing the TABnCCR0 register is prohibited in the following statuses. For details, see 3.4.9 (2) Accessing specific on-chip peripheral I/O registers.

- **When the CPU operates on the subclock and the main clock oscillation is stopped**
- **When the CPU operates on the internal oscillation clock**

After reset: 0000H R/W Address: TAB0CCR0 FFFFF546H, TAB1CCR0 FFFFF566H

	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
TABnCCR0 (n = 0, 1)																

(a) Function as compare register

The TABnCCR0 register can be rewritten even when the TABnCTL0.TABnCE bit = 1.

The set value of the TABnCCR0 register is transferred to the CCR0 buffer register. When the value of the 16-bit counter matches the value of the CCR0 buffer register, a compare match interrupt request signal (INTTABnCC0) is generated. If TOABn0 pin output is enabled at this time, the output of the TOABn0 pin is inverted.

When the TABnCCR0 register is used as a cycle register in the interval timer mode, external event count mode, external trigger pulse output mode, one-shot pulse output mode, PWM output mode, or triangular wave PWM mode, the value of the 16-bit counter is cleared (0000H) if its count value matches the value of the CCR0 buffer register.

(b) Function as capture register

When the TABnCCR0 register is used as a capture register in the free-running timer mode, the count value of the 16-bit counter is stored in the TABnCCR0 register if the valid edge of the capture trigger input pin (TIABn0 pin) is detected. In the pulse width measurement mode, the count value of the 16-bit counter is stored in the TABnCCR0 register and the 16-bit counter is cleared (0000H) if the valid edge of the capture trigger input pin (TIABn0 pin) is detected.

Even if the capture operation and reading the TABnCCR0 register conflict, the correct value of the TABnCCR0 register can be read.

Remark n = 0, 1

The following table shows the functions of the capture/compare register in each mode, and how to write data to the compare register.

Table 8-2. Function of Capture/Compare Register in Each Mode and How to Write Compare Register

Operation Mode	Capture/Compare Register	How to Write Compare Register
Interval timer	Compare register	Anytime write
External event counter	Compare register	Anytime write
External trigger pulse output	Compare register	Batch write
One-shot pulse output	Compare register	Anytime write
PWM output	Compare register	Batch write
Free-running timer	Capture/compare register	Anytime write
Pulse width measurement	Capture register	–
Triangular wave PWM mode	Compare register	Batch write

(9) TABn capture/compare register 1 (TABnCCR1)

The TABnCCR1 register can be used as a capture register or a compare register depending on the mode.

This register can be used as a capture register or a compare register only in the free-running timer mode, according to the setting of the TABnOPT0.TABnCCS1 bit. In the pulse width measurement mode, the TABnCCR1 register can be used only as a capture register. In any other mode, this register can be used only as a compare register.

The TABnCCR1 register can be read or written during operation.

This register can be read or written in 16-bit units.

Reset sets this register to 0000H.

Caution Accessing the TABnCCR1 register is prohibited in the following statuses. For details, see 3.4.9 (2) Accessing specific on-chip peripheral I/O registers.

- **When the CPU operates on the subclock and the main clock oscillation is stopped**
- **When the CPU operates on the internal oscillation clock**

After reset: 0000H R/W Address: TAB0CCR1 FFFFF548H, TAB1CCR1 FFFFF568H

	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
TABnCCR1 (n = 0, 1)																

(a) Function as compare register

The TABnCCR1 register can be rewritten even when the TABnCTL0.TABnCE bit = 1.

The set value of the TABnCCR1 register is transferred to the CCR1 buffer register. When the value of the 16-bit counter matches the value of the CCR1 buffer register, a compare match interrupt request signal (INTTABnCC1) is generated. If TOABn1 pin output is enabled at this time, the output of the TOABn1 pin is inverted.

(b) Function as capture register

When the TABnCCR1 register is used as a capture register in the free-running timer mode, the count value of the 16-bit counter is stored in the TABnCCR1 register if the valid edge of the capture trigger input pin (TIABn1 pin) is detected. In the pulse width measurement mode, the count value of the 16-bit counter is stored in the TABnCCR1 register and the 16-bit counter is cleared (0000H) if the valid edge of the capture trigger input pin (TIABn1 pin) is detected.

Even if the capture operation and reading the TABnCCR1 register conflict, the correct value of the TABnCCR1 register can be read.

Remark n = 0, 1

The following table shows the functions of the capture/compare register in each mode, and how to write data to the compare register.

Table 8-3. Function of Capture/Compare Register in Each Mode and How to Write Compare Register

Operation Mode	Capture/Compare Register	How to Write Compare Register
Interval timer	Compare register	Anytime write
External event counter	Compare register	Anytime write
External trigger pulse output	Compare register	Batch write
One-shot pulse output	Compare register	Anytime write
PWM output	Compare register	Batch write
Free-running timer	Capture/compare register	Anytime write
Pulse width measurement	Capture register	–
Triangular wave PWM mode	Compare register	Batch write

(10) TABn capture/compare register 2 (TABnCCR2)

The TABnCCR2 register can be used as a capture register or a compare register depending on the mode.

This register can be used as a capture register or a compare register only in the free-running timer mode, according to the setting of the TABnOPT0.TABnCCS2 bit. In the pulse width measurement mode, the TABnCCR2 register can be used only as a capture register. In any other mode, this register can be used only as a compare register.

The TABnCCR2 register can be read or written during operation.

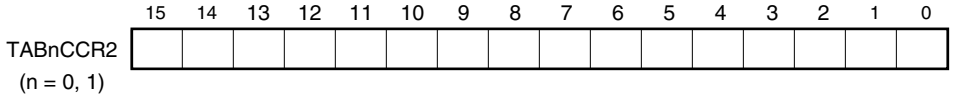
This register can be read or written in 16-bit units.

Reset sets this register to 0000H.

Caution Accessing the TABnCCR2 register is prohibited in the following statuses. For details, see 3.4.9 (2) Accessing specific on-chip peripheral I/O registers.

- **When the CPU operates with the subclock and the main clock oscillation is stopped**
- **When the CPU operates with the internal oscillation clock**

After reset: 0000H R/W Address: TAB0CCR2 FFFFF54AH, TAB1CCR2 FFFFF56AH



(a) Function as compare register

The TABnCCR2 register can be rewritten even when the TABnCTL0.TABnCE bit = 1.

The set value of the TABnCCR2 register is transferred to the CCR2 buffer register. When the value of the 16-bit counter matches the value of the CCR2 buffer register, a compare match interrupt request signal (INTTABnCC2) is generated. If TOABn2 pin output is enabled at this time, the output of the TOABn2 pin is inverted.

(b) Function as capture register

When the TABnCCR2 register is used as a capture register in the free-running timer mode, the count value of the 16-bit counter is stored in the TABnCCR2 register if the valid edge of the capture trigger input pin (TIABn2 pin) is detected. In the pulse width measurement mode, the count value of the 16-bit counter is stored in the TABnCCR2 register and the 16-bit counter is cleared (0000H) if the valid edge of the capture trigger input pin (TIABn2 pin) is detected.

Even if the capture operation and reading the TABnCCR2 register conflict, the correct value of the TABnCCR2 register can be read.

Remark n = 0, 1

The following table shows the functions of the capture/compare register in each mode, and how to write data to the compare register.

Table 8-4. Function of Capture/Compare Register in Each Mode and How to Write Compare Register

Operation Mode	Capture/Compare Register	How to Write Compare Register
Interval timer	Compare register	Anytime write
External event counter	Compare register	Anytime write
External trigger pulse output	Compare register	Batch write
One-shot pulse output	Compare register	Anytime write
PWM output	Compare register	Batch write
Free-running timer	Capture/compare register	Anytime write
Pulse width measurement	Capture register	–
Triangular wave PWM mode	Compare register	Batch write

(11) TABn capture/compare register 3 (TABnCCR3)

The TABnCCR3 register can be used as a capture register or a compare register depending on the mode.

This register can be used as a capture register or a compare register only in the free-running timer mode, according to the setting of the TABnOPT0.TABnCCS3 bit. In the pulse width measurement mode, the TABnCCR3 register can be used only as a capture register. In any other mode, this register can be used only as a compare register.

The TABnCCR3 register can be read or written during operation.

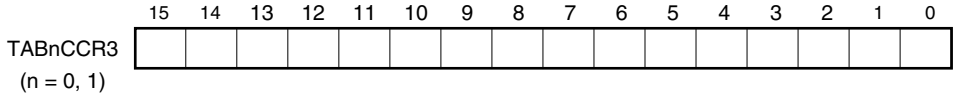
This register can be read or written in 16-bit units.

Reset sets this register to 0000H.

Caution Accessing the TABnCCR3 register is prohibited in the following statuses. For details, see 3.4.9 (2) Accessing specific on-chip peripheral I/O registers.

- **When the CPU operates with the subclock and the main clock oscillation is stopped**
- **When the CPU operates with the internal oscillation clock**

After reset: 0000H R/W Address: TAB0CCR3 FFFFF54CH, TAB1CCR3 FFFFF56CH



(a) Function as compare register

The TABnCCR3 register can be rewritten even when the TABnCTL0.TABnCE bit = 1.

The set value of the TABnCCR3 register is transferred to the CCR3 buffer register. When the value of the 16-bit counter matches the value of the CCR3 buffer register, a compare match interrupt request signal (INTTABnCC3) is generated. If TOABn3 pin output is enabled at this time, the output of the TOABn3 pin is inverted.

(b) Function as capture register

When the TABnCCR3 register is used as a capture register in the free-running timer mode, the count value of the 16-bit counter is stored in the TABnCCR3 register if the valid edge of the capture trigger input pin (TIABn3 pin) is detected. In the pulse width measurement mode, the count value of the 16-bit counter is stored in the TABnCCR3 register and the 16-bit counter is cleared (0000H) if the valid edge of the capture trigger input pin (TIABn3 pin) is detected.

Even if the capture operation and reading the TABnCCR3 register conflict, the correct value of the TABnCCR3 register can be read.

Remark n = 0, 1

The following table shows the functions of the capture/compare register in each mode, and how to write data to the compare register.

Table 8-5. Function of Capture/Compare Register in Each Mode and How to Write Compare Register

Operation Mode	Capture/Compare Register	How to Write Compare Register
Interval timer	Compare register	Anytime write
External event counter	Compare register	Anytime write
External trigger pulse output	Compare register	Batch write
One-shot pulse output	Compare register	Anytime write
PWM output	Compare register	Batch write
Free-running timer	Capture/compare register	Anytime write
Pulse width measurement	Capture register	–
Triangular wave PWM mode	Compare register	Batch write

(12) TABn counter read buffer register (TABnCNT)

The TABnCNT register is a read buffer register that can read the count value of the 16-bit counter.

If this register is read when the TABnCTL0.TABnCE bit = 1, the count value of the 16-bit timer can be read.

This register is read-only in 16-bit units.

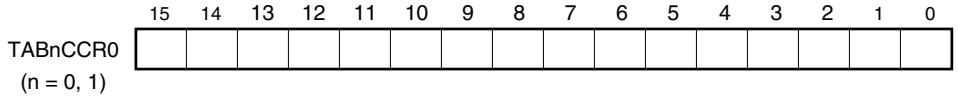
The value of the TABnCNT register is cleared to 0000H when the TABnCE bit = 0. If the TABnCNT register is read at this time, the value of the 16-bit counter (FFFFH) is not read, but 0000H is read.

The value of the TABnCNT register is cleared to 0000H after reset, as the TABnCE bit is cleared to 0.

Caution Accessing the TABnCNT register is prohibited in the following statuses. For details, see 3.4.9 (2) Accessing specific on-chip peripheral I/O registers.

- **When the CPU operates with the subclock and the main clock oscillation is stopped**
- **When the CPU operates with the internal oscillation clock**

After reset: 0000H R/W Address: TAB0CCR0 FFFFF546H, TAB1CCR0 FFFFF566H



TABnCCR0
(n = 0, 1)

8.5 Operation

TABn can perform the following operations.

Operation	TABnCTL1.TABnEST Bit (Software Trigger Bit)	TIABn0 Pin (External Trigger Input)	Capture/Compare Register Setting	Compare Register Write
Interval timer mode	Invalid	Invalid	Compare only	Anytime write
External event count mode[Note 1]	Invalid	Invalid	Compare only	Anytime write
External trigger pulse output mode[Note 2]	Valid	Valid	Compare only	Batch write
One-shot pulse output mode[Note 2]	Valid	Valid	Compare only	Anytime write
PWM output mode	Invalid	Invalid	Compare only	Batch write
Free-running timer mode	Invalid	Invalid	Switching enabled	Anytime write
Pulse width measurement mode[Note 2]	Invalid	Invalid	Capture only	Not applicable
Triangular wave PWM mode	Invalid	Invalid	Compare only	Batch write

Notes 1. To use the external event count mode, specify that the valid edge of the TIABn0 pin capture trigger input is not detected (by clearing the TABnIOC1.TABnIS1 and TABnIOC1.TABnIS0 bits to “00”).

2. When using the external trigger pulse output mode, one-shot pulse output mode, and pulse width measurement mode, select the internal clock as the count clock (by clearing the TABnCTL1.TABnEEE bit to 0).

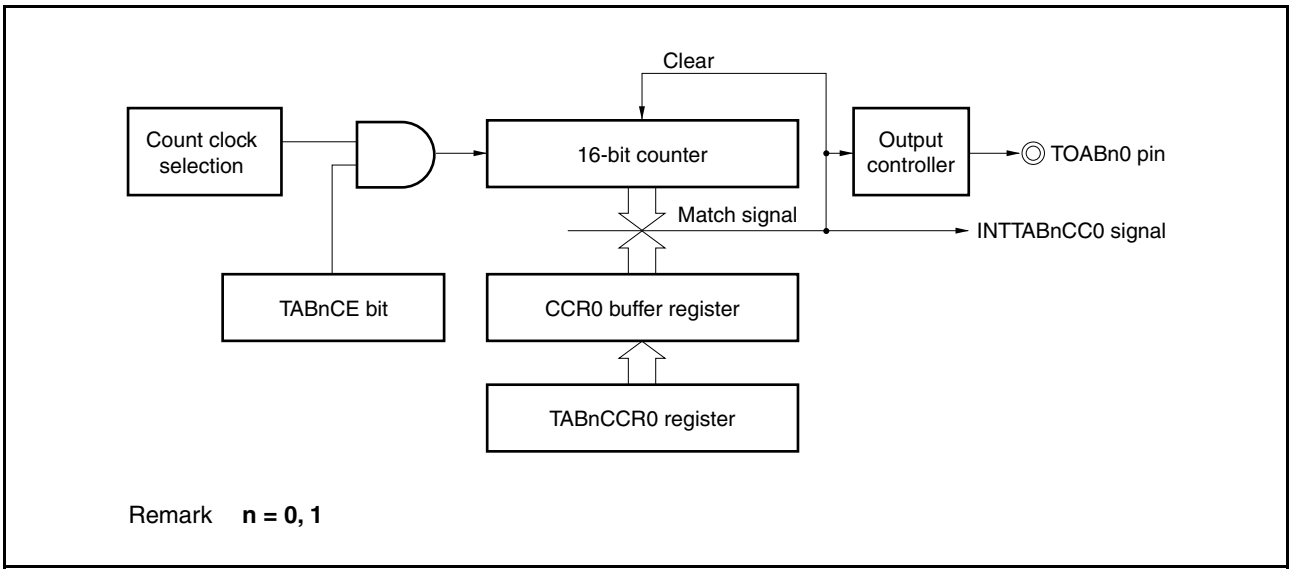
Remark n = 0, 1

8.5.1 Interval timer mode (TABnMD2 to TABnMD0 bits = 000)

In the interval timer mode, an interrupt request signal (INTTABnCC0) is generated at the specified interval if the TABnCTL0.TABnCE bit is set to 1. A square wave whose half cycle is equal to the interval can be output from the TOABn0 pin.

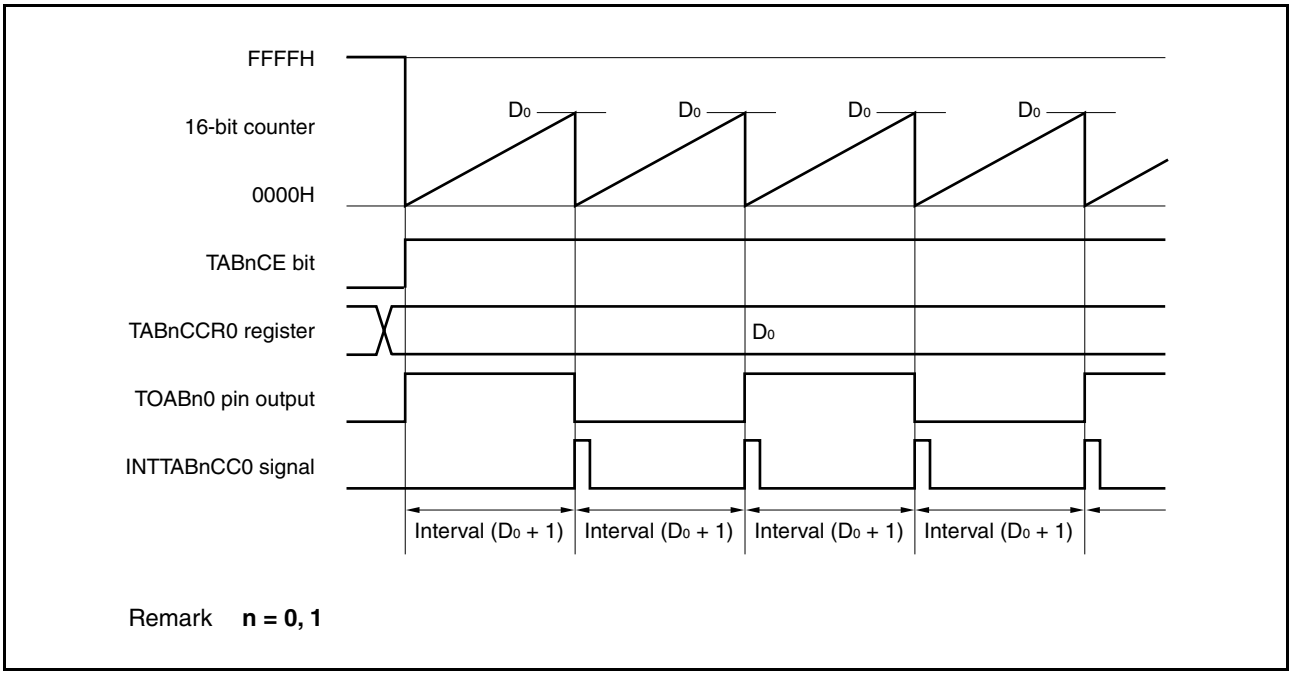
Usually, the TABnCCR1 to TABnCCR3 registers are not used in the interval timer mode.

Figure 8-2. Configuration of Interval Timer



Remark **n = 0, 1**

Figure 8-3. Basic Timing of Operation in Interval Timer Mode



Remark **n = 0, 1**

When the TABnCE bit is set to 1, the value of the 16-bit counter is cleared from FFFFH to 0000H in synchronization with the count clock, and the counter starts counting. At this time, the output of the TOABn0 pin is inverted. Additionally, the set value of the TABnCCR0 register is transferred to the CCR0 buffer register.

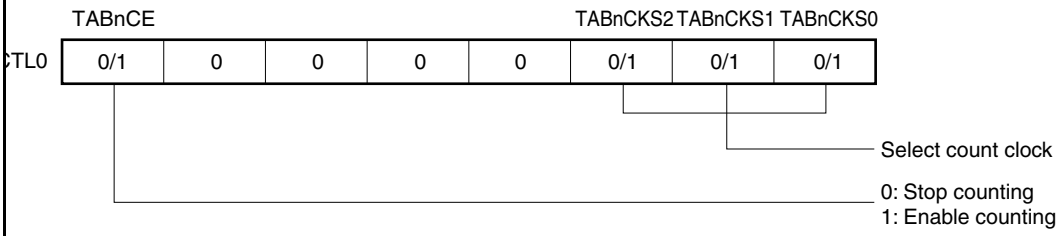
When the count value of the 16-bit counter matches the value of the CCR0 buffer register, the 16-bit counter is cleared to 0000H, the output of the TOABn0 pin is inverted, and a compare match interrupt request signal (INTTABnCC0) is generated.

The interval can be calculated by the following expression.

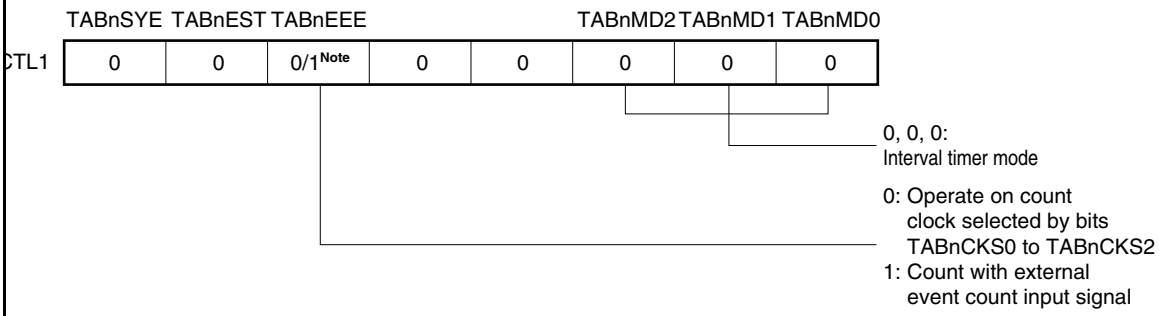
Interval = (Set value of TABnCCR0 register + 1) × Count clock cycle

Figure 8-4. Register Setting for Interval Timer Mode Operation (1/2)

(a) TABn control register 0 (TABnCTL0)



(b) TABn control register 1 (TABnCTL1)

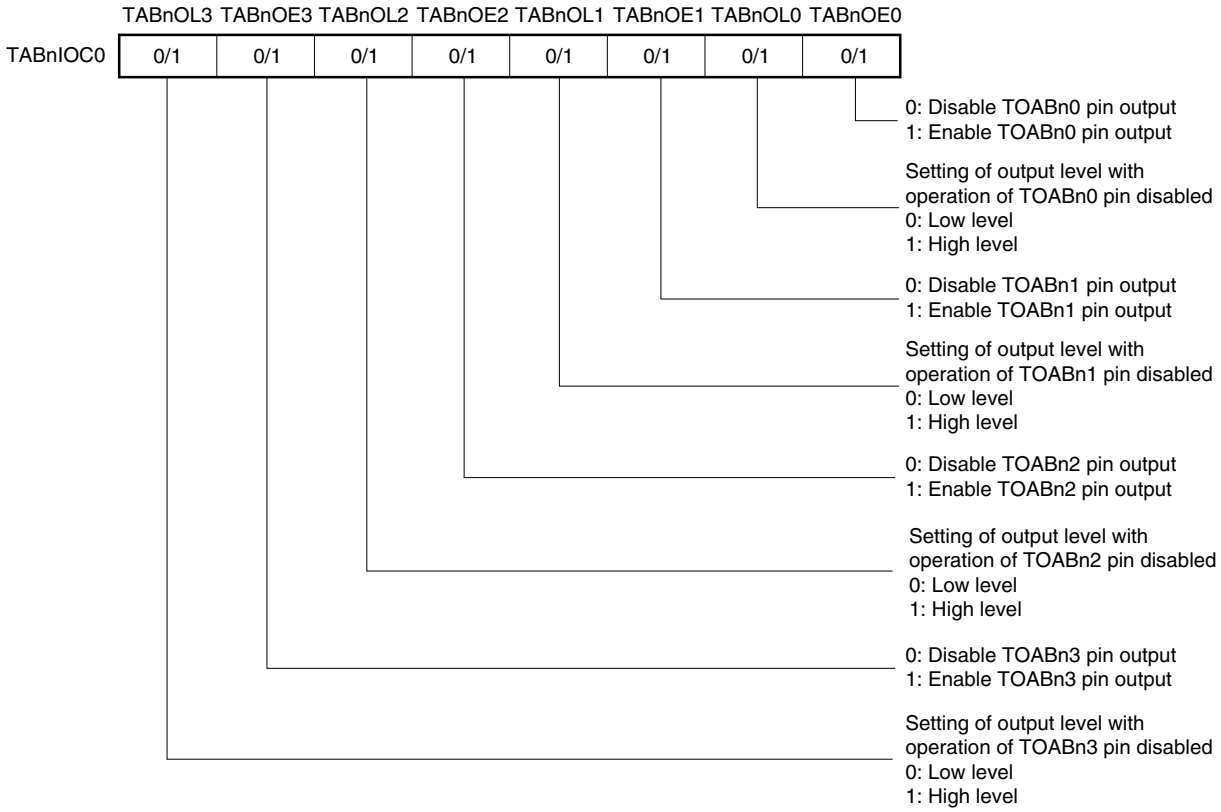


Note **This bit can be set to 1 only when the interrupt request signals (INTTABnCC0 and INTTABnCCk) are masked by the interrupt mask flags (TABnCCMK0 to TABnCCMKk) and the timer output (TOABnk) is performed at the same time. However, the TABnCCR0 and TABnCCRk registers must be set to the same value (see** 8.5.1 (2) (d) Operation of TABnCCR1 to TABnCCR3 registers**) (k = 1 to 3).**

Remark **n = 0, 1**

Figure 8-4. Register Setting for Interval Timer Mode Operation (2/2)

(c) TABn I/O control register 0 (TABnIOC0)



(d) TABn counter read buffer register (TABnCNT)

By reading the TABnCNT register, the count value of the 16-bit counter can be read.

(e) TABn capture/compare register 0 (TABnCCR0)

If the TABnCCR0 register is set to D_0, the interval is as follows.

Interval = (D_0 + 1) × Count clock cycle

(f) TABn capture/compare registers 1 to 3 (TABnCCR1 to TABnCCR3)

Usually, the TABnCCR1 to TABnCCR3 registers are not used in the interval timer mode. However, the set value of the TABnCCR1 to TABnCCR3 registers is transferred to the CCR1 to CCR3 buffer registers. The compare match interrupt request signals (INTTABnCCR1 to INTTABnCCR3) are generated when the count value of the 16-bit counter matches the value of the CCR1 to CCR3 buffer registers.

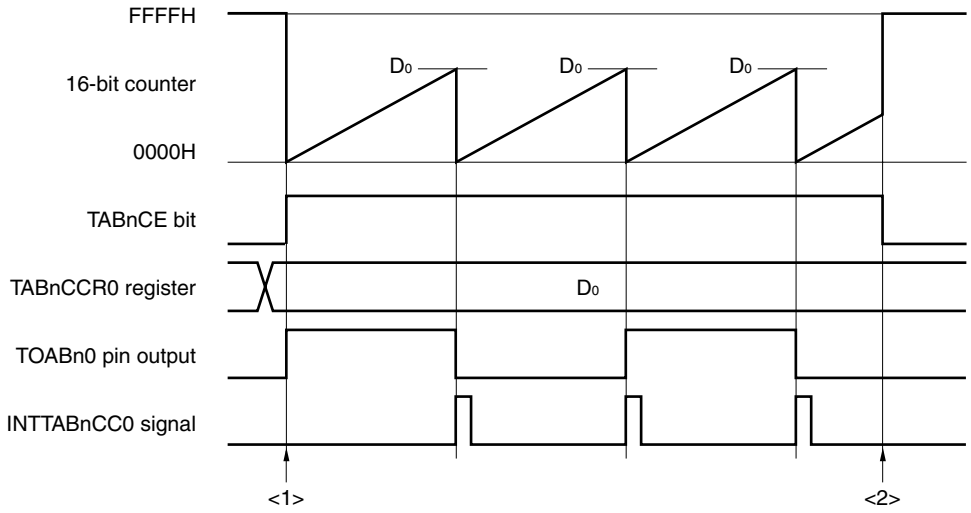
Therefore, mask the interrupt requests by using the corresponding interrupt mask flags (TABnCCMK1 to TABnCCMK3).

Remarks 1. **TABn I/O control register 1 (TABnIOC1), TABn I/O control register 2 (TABnIOC2), and TABn option register 0 (TABnOPT0) are not used in the interval timer mode.**

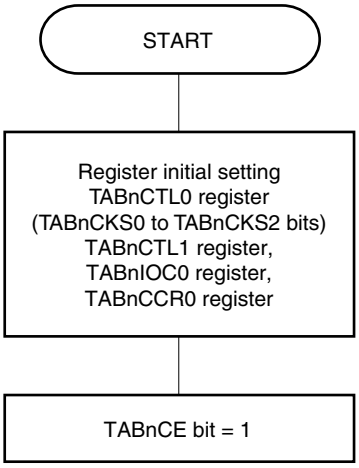
2. **n = 0, 1**

(1) Interval timer mode operation flow

Figure 8-5. Software Processing Flow in Interval Timer Mode



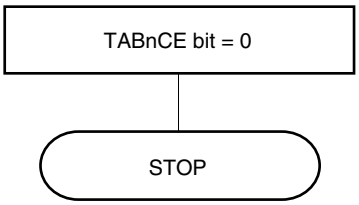
<1> Count operation start flow



The initial setting of these registers is performed before setting the TABnCE bit to 1.

The TABnCKS0 to TABnCKS2 bits can be set at the same time when counting has been started (TABnCE bit = 1).

<2> Count operation stop flow



The counter is initialized and counting is stopped by clearing the TABnCE bit to 0.

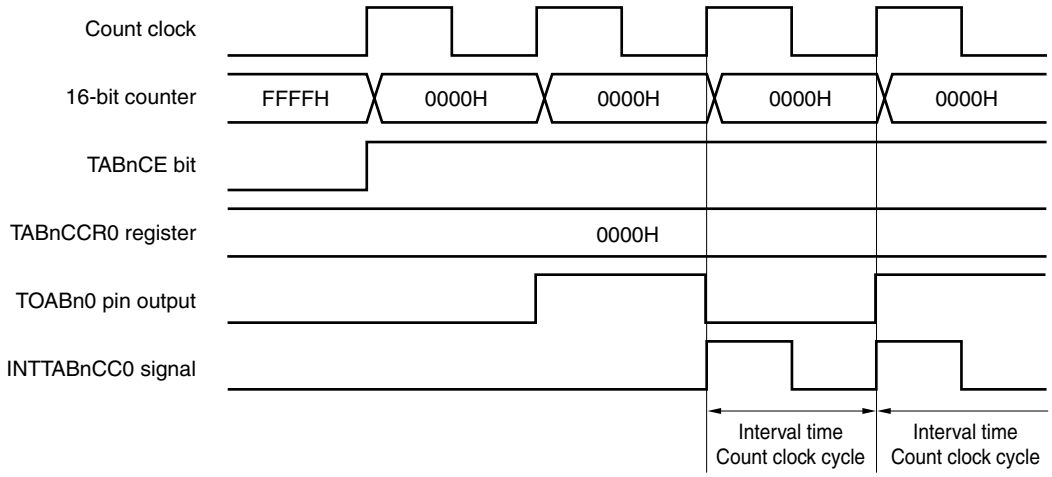
Remark **n = 0, 1**

(2) Interval timer mode operation timing

(a) Operation if TABnCCR0 register is set to 0000H

If the TABnCCR0 register is set to 0000H, the INTTABnCC0 signal is generated at each count clock subsequent to the first count clock, and the output of the TOABn0 pin is inverted.

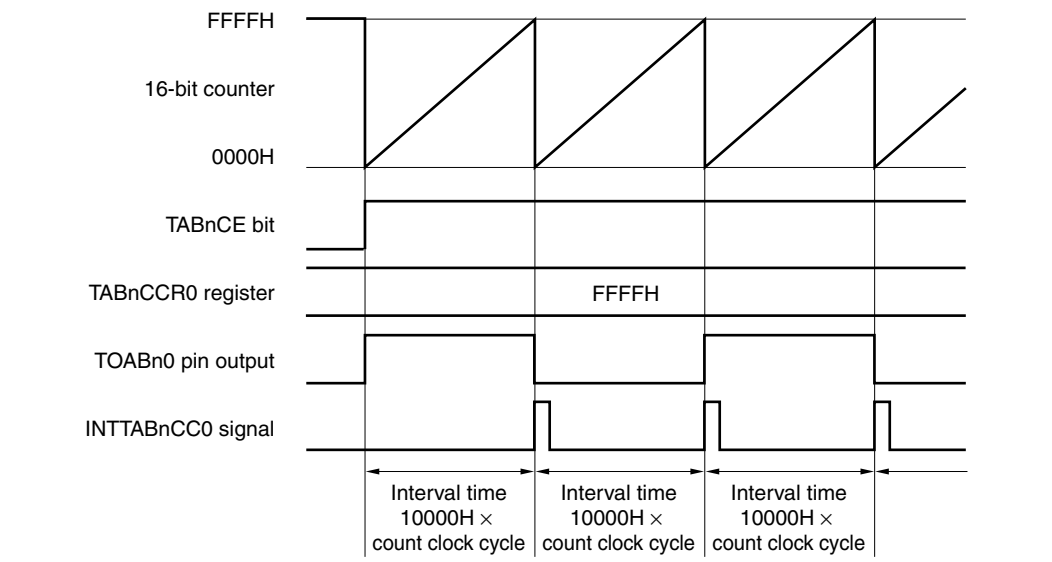
The value of the 16-bit counter is always 0000H.



Remark **n = 0, 1**

(b) Operation if TABnCCR0 register is set to FFFFH

If the TABnCCR0 register is set to FFFFH, the 16-bit counter counts up to FFFFH. The counter is cleared to 0000H in synchronization with the next count-up timing. The INTTABnCC0 signal is generated and the output of the TOABn0 pin is inverted. At this time, an overflow interrupt request signal (INTTABnOV) is not generated, nor is the overflow flag (TABnOPT0.TABnOVF bit) set to 1.

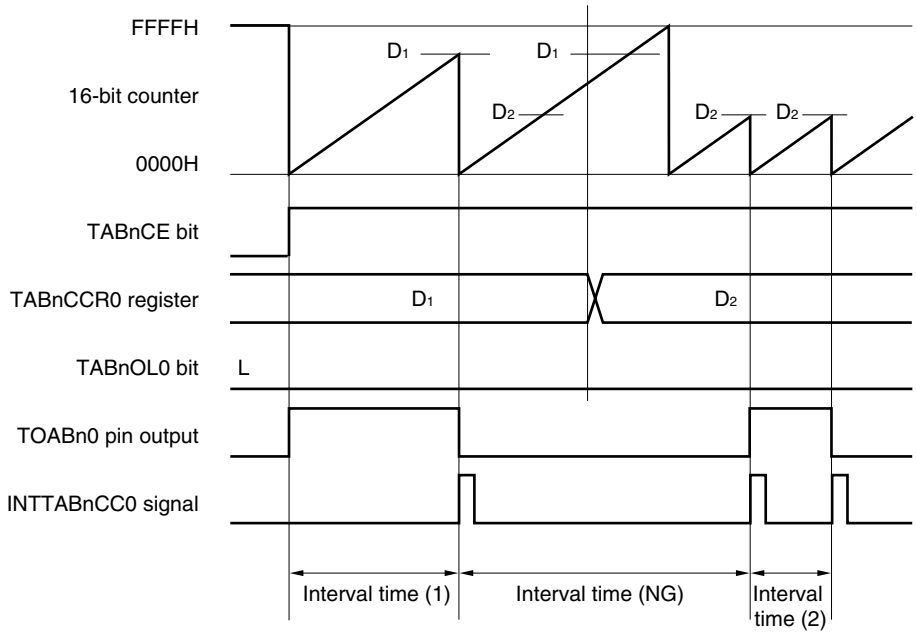


Remark **n = 0, 1**

(c) Notes on rewriting TABnCCR0 register

To change the value of the TABnCCR0 register to a smaller value, stop counting once and then change the set value.

If the value of the TABnCCR0 register is rewritten to a smaller value during counting, the 16-bit counter may overflow.



Remarks 1. **Interval time (1): $(D_1 + 1) \times$ Count clock cycle**

Interval time (NG): $(10000H + D_2 + 1) \times$ Count clock cycle

Interval time (2): $(D_2 + 1) \times$ Count clock cycle

2. **n = 0, 1**

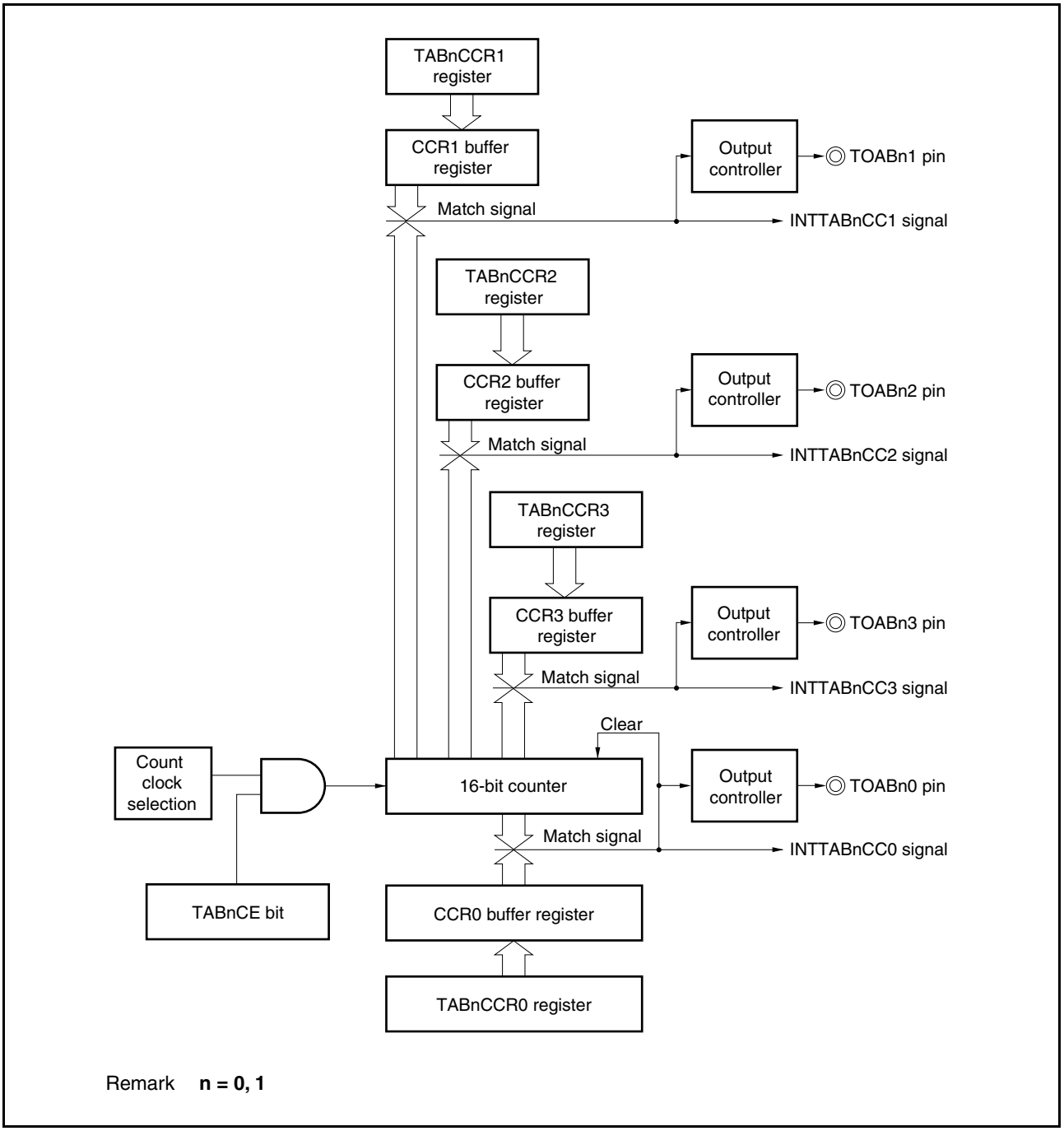
If the value of the TABnCCR0 register is changed from D_1 to D_2 while the count value is greater than D_2 but less than D_1, the count value is transferred to the CCR0 buffer register as soon as the TABnCCR0 register has been rewritten. Consequently, the value of the 16-bit counter that is compared is D_2.

Because the count value has already exceeded D_2, however, the 16-bit counter counts up to FFFFH, overflows, and then counts up again from 0000H. When the count value matches D_2, the INTTABnCC0 signal is generated and the output of the TOABn0 pin is inverted.

Therefore, the INTTABnCC0 signal may not be generated at the interval time "$(D_1 + 1) \times$ Count clock cycle" or "$(D_2 + 1) \times$ Count clock cycle" originally expected, but may be generated at an interval of "$(10000H + D_2 + 1) \times$ Count clock period".

(d) Operation of TABnCCR1 to TABnCCR3 registers

Figure 8-6. Configuration of TABnCCR1 to TABnCCR3 Registers

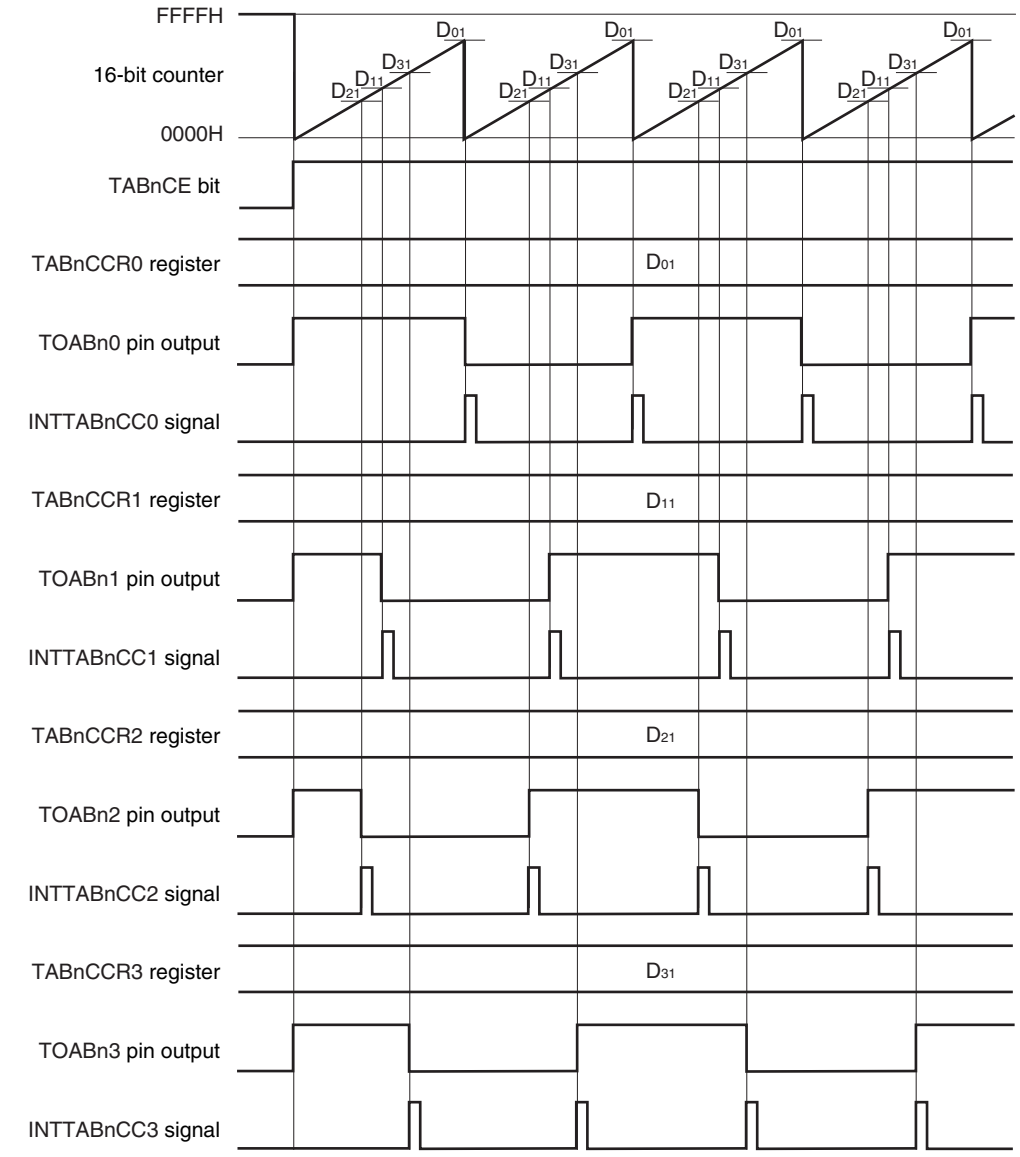


Remark **n = 0, 1**

If the set value of the TABnCCRk register is less than the set value of the TABnCCR0 register, the INTTABnCCk signal is generated once per cycle. At the same time, the output of the TOABnk pin is inverted. The TOABnk pin outputs a square wave with the same cycle as that output by the TOABn0 pin.

Remark k = 1 to 3,
n = 0, 1

Figure 8-7. Timing Chart When $D_{01} \geq D_{k1}$

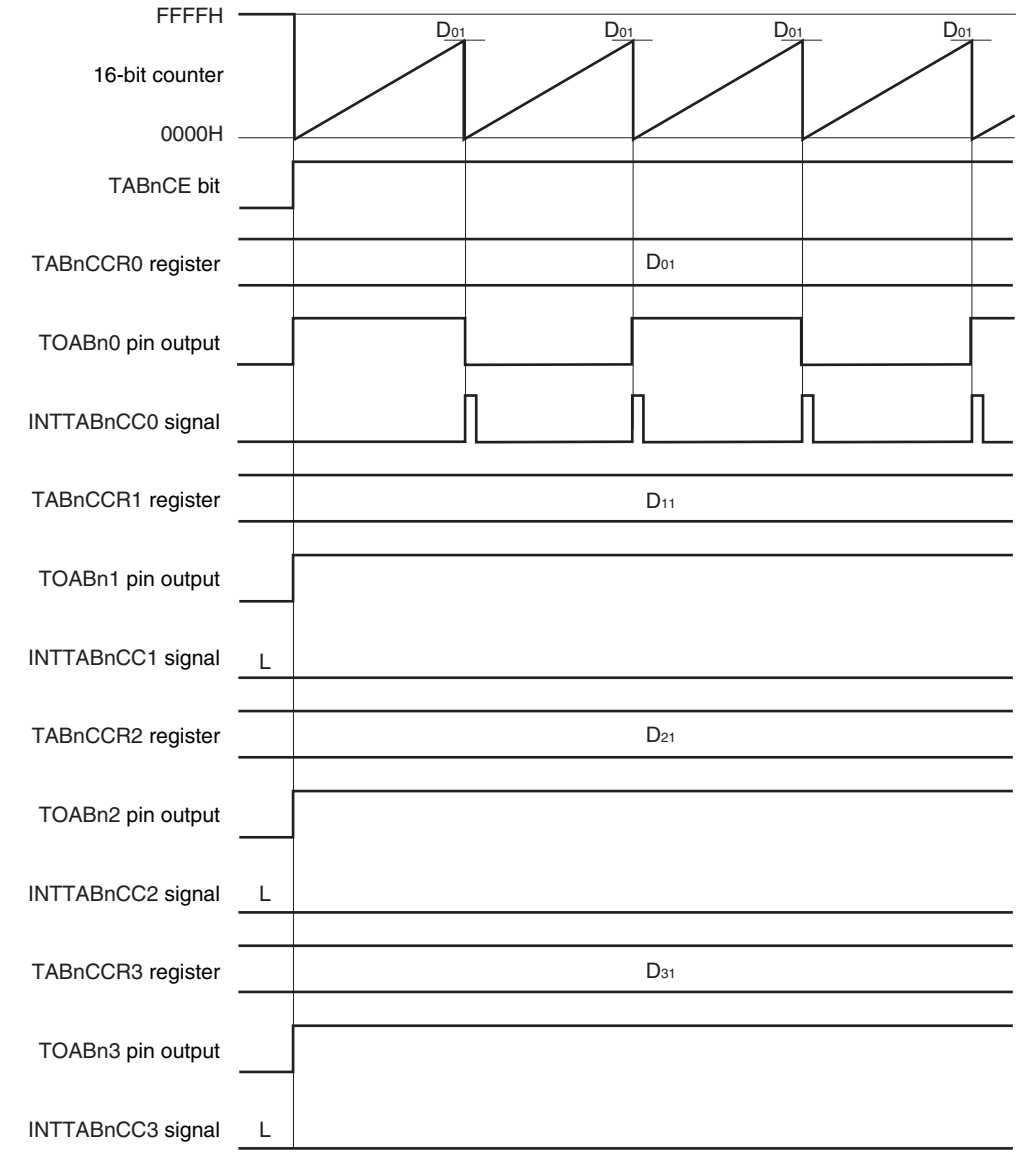


Remark **n = 0, 1**

If the set value of the TABnCCRk register is greater than the set value of the TABnCCR0 register, the count value of the 16-bit counter does not match the value of the TABnCCRk register. Consequently, the INTTABnCCk signal is not generated, nor is the output of the TOABnk pin changed.

Remark k = 1 to 3,
n = 0, 1

Figure 8-8. Timing Chart When $D_{01} < D_{k1}$



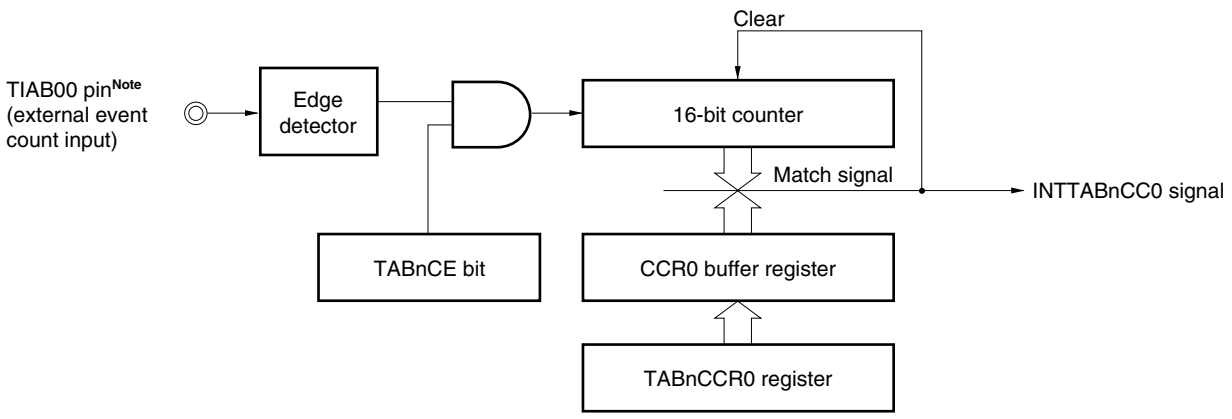
Remark **n = 0, 1**

8.5.2 External event count mode (TABnMD2 to TABnMD0 bits = 001)

In the external event count mode, the valid edge of the external event count input is counted when the TABnCTL0.TABnCE bit is set to 1, and an interrupt request signal (INTTABnCC0) is generated each time the specified number of edges have been counted. The TOABn0 pin cannot be used.

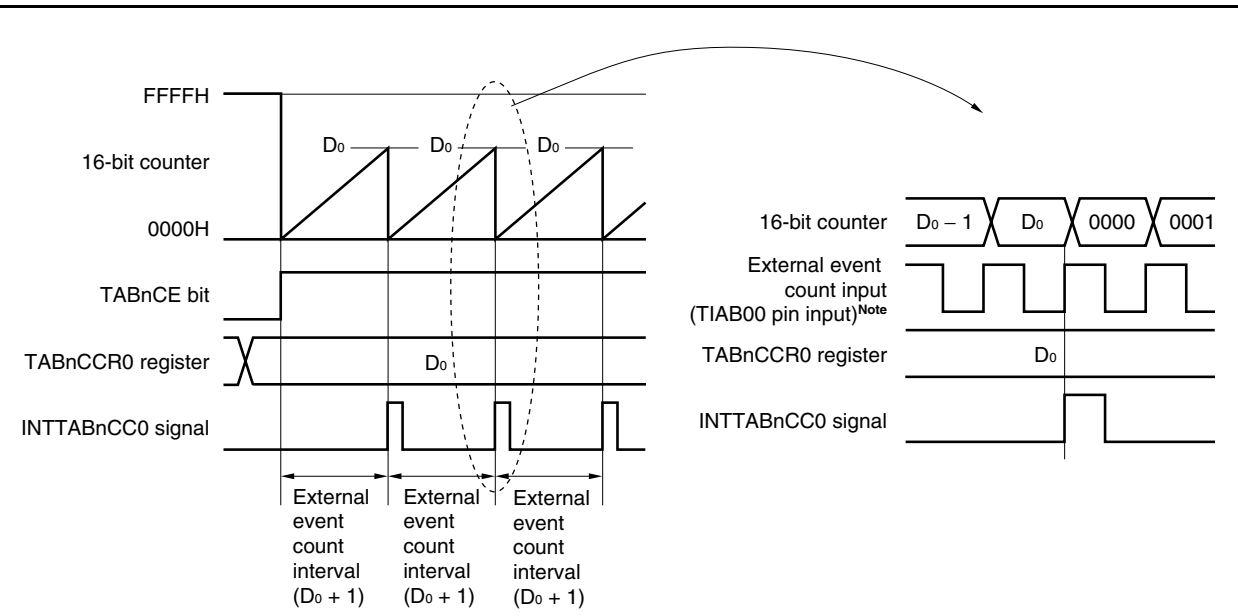
Usually, the TABnCCR1 to TABnCCR3 registers are not used in the external event count mode.

Figure 8-9. Configuration in External Event Count Mode



Note **TAB1: EVTAB1 pin**

Figure 8-10. Basic Timing in External Event Count Mode



Note **TAB1: EVTAB1 pin**

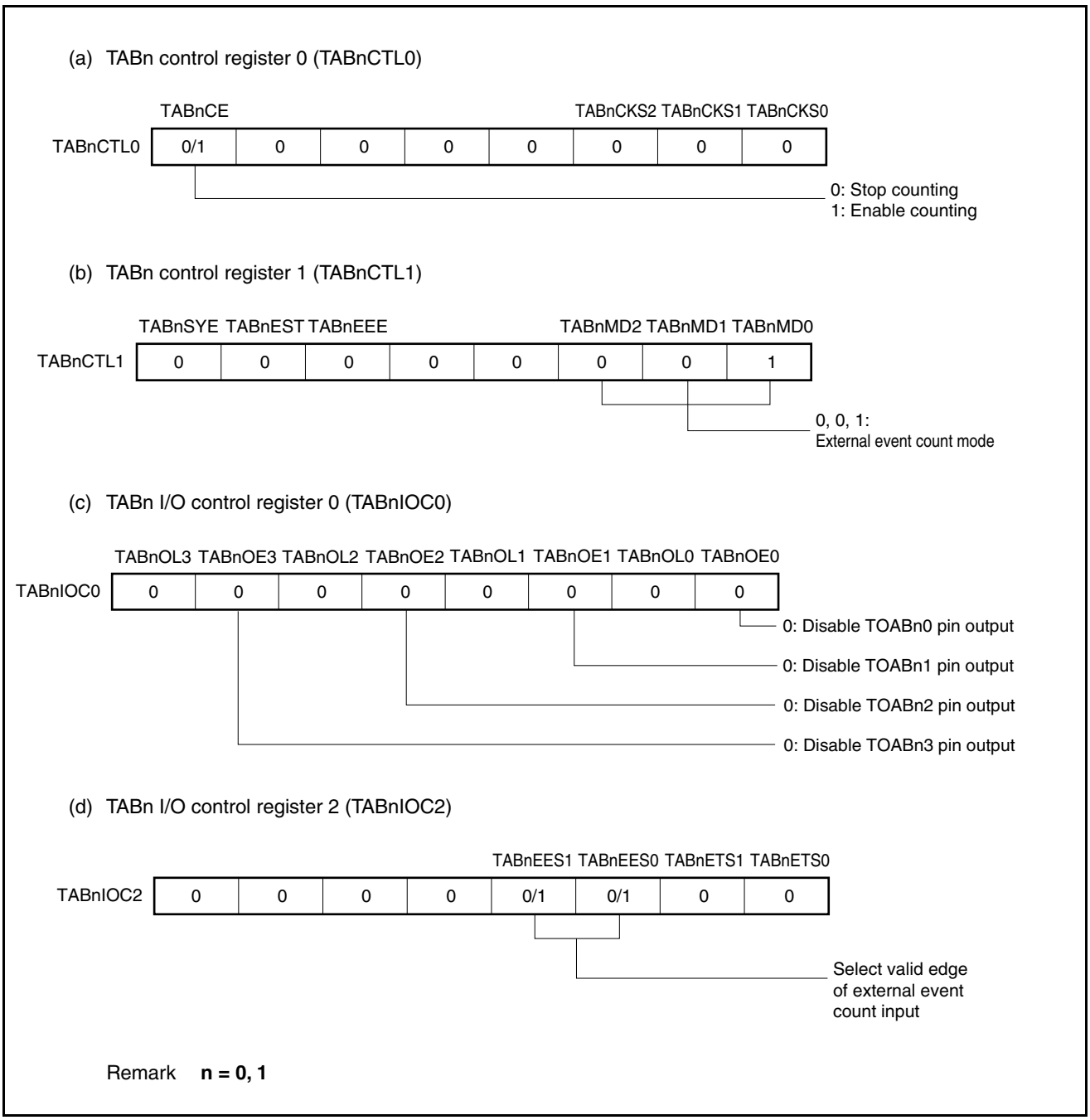
Remark **This figure shows the basic timing when the rising edge is specified as the valid edge of the external event count input.**

When the TABnCE bit is set to 1, the value of the 16-bit counter is cleared from FFFFH to 0000H. The counter counts each time the valid edge of the external event count input is detected. Additionally, the set value of the TABnCCR0 register is transferred to the CCR0 buffer register.

When the count value of the 16-bit counter matches the value of the CCR0 buffer register, the 16-bit counter is cleared to 0000H, and a compare match interrupt request signal (INTTABnCC0) is generated.

The INTTABnCC0 signal is generated each time the valid edge of the external event count input has been detected (set value of TABnCCR0 register + 1) times.

Figure 8-11. Register Setting for Operation in External Event Count Mode (1/2)



Remark **n = 0, 1**

Figure 8-11. Register Setting for Operation in External Event Count Mode (2/2)

(e) TABn counter read buffer register (TABnCNT)

The count value of the 16-bit counter can be read by reading the TABnCNT register.

(f) TABn capture/compare register 0 (TABnCCR0)

If D_0 is set to the TABnCCR0 register, the counter is cleared and a compare match interrupt request signal (INTTABnCC0) is generated when the number of external event counts reaches (D_0 + 1).

(g) TABn capture/compare registers 1 to 3 (TABnCCR1 to TABnCCR3)

Usually, the TABnCCR1 to TABnCCR3 registers are not used in the external event count mode. However, the set value of the TABnCCR1 to TABnCCR3 registers are transferred to the CCR1 to CCR3 buffer registers. When the count value of the 16-bit counter matches the value of the CCR1 to CCR3 buffer registers, compare match interrupt request signals (INTTABnCC1 to INTTABnCC3) are generated.

Therefore, mask the interrupt signals by using the interrupt mask flags (TABnCCMK1 to TABnCCMK3).

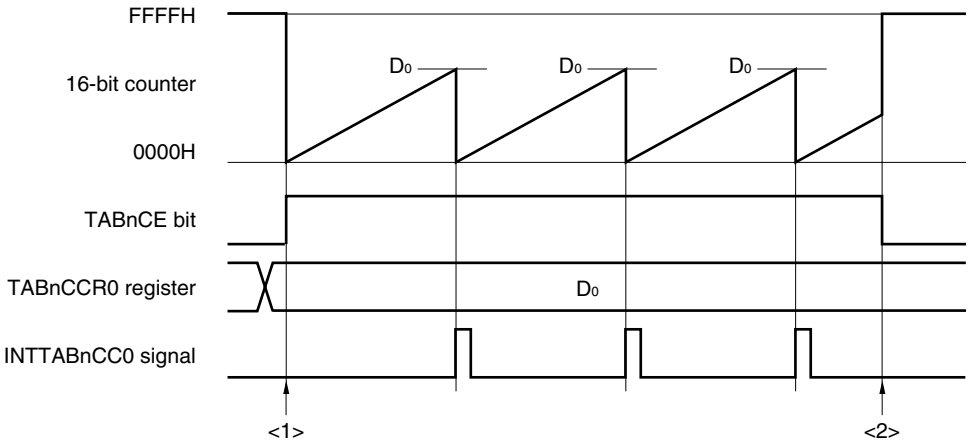
Caution For TAB0, when an external clock is used as the count clock, the external clock can be input only from the TIAB00 pin. At this time, set the TAB0IOC1.TAB0IS1 and TAB0IOC1.TAB0IS0 bits to 00 (capture trigger input (TIAB00 pin): no edge detection).

Remarks 1. **TABn I/O control register 1 (TABnIOC1) and TABn option register 0 (TABnOPT0) are not used in the external event count mode.**

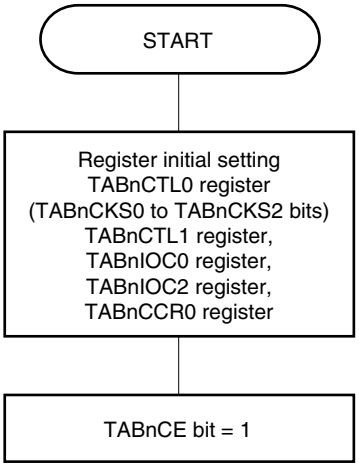
2. **n = 0, 1**

(1) External event count mode operation flow

Figure 8-12. Flow of Software Processing in External Event Count Mode



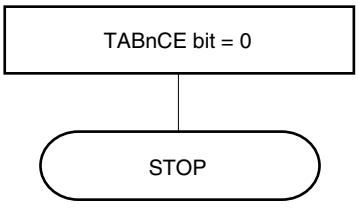
<1> Count operation start flow



The initial setting of these registers is performed before setting the TABnCE bit to 1.

The TABnCKS0 to TABnCKS2 bits can be set at the same time when counting has been started (TABnCE bit = 1).

<2> Count operation stop flow



The counter is initialized and counting is stopped by clearing the TABnCE bit to 0.

Remark **n = 0, 1**

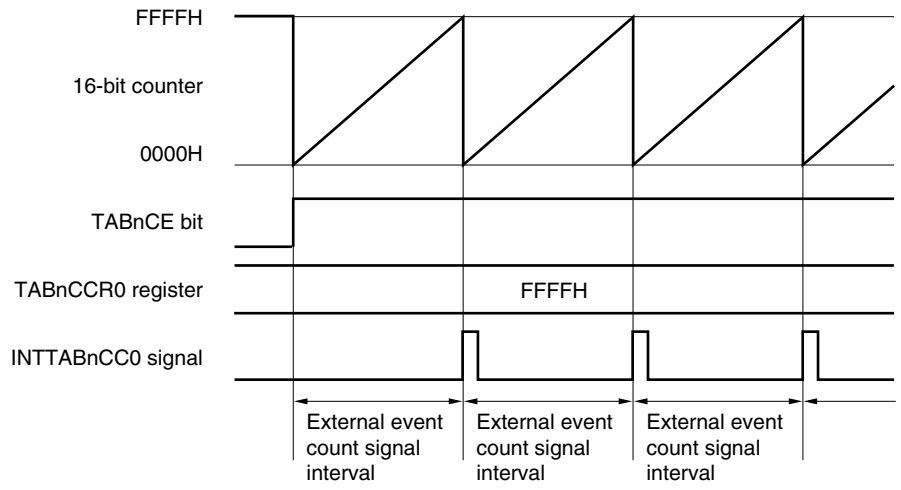
(2) Operation timing in external event count mode

Cautions 1. In the external event count mode, do not set the TABnCCR0 register to 0000H.

2. In the external event count mode, use of the timer output is disabled. If performing timer output using external event count input, set the interval timer mode, and select the operation enabled by the external event count input for the count clock (TABnCTL1.TABnMD2 to TABnCTL1.TABnMD0 bits = 000, TABnCTL1.TABnEEE bit = 1).

(a) Operation if TABnCCR0 register is set to FFFFH

If the TABnCCR0 register is set to FFFFH, the 16-bit counter counts to FFFFH each time the valid edge of the external event count signal has been detected. The 16-bit counter is cleared to 0000H in synchronization with the next count-up timing, and the INTTABnCC0 signal is generated. At this time, the TABnOPT0.TABnOVF bit is not set.

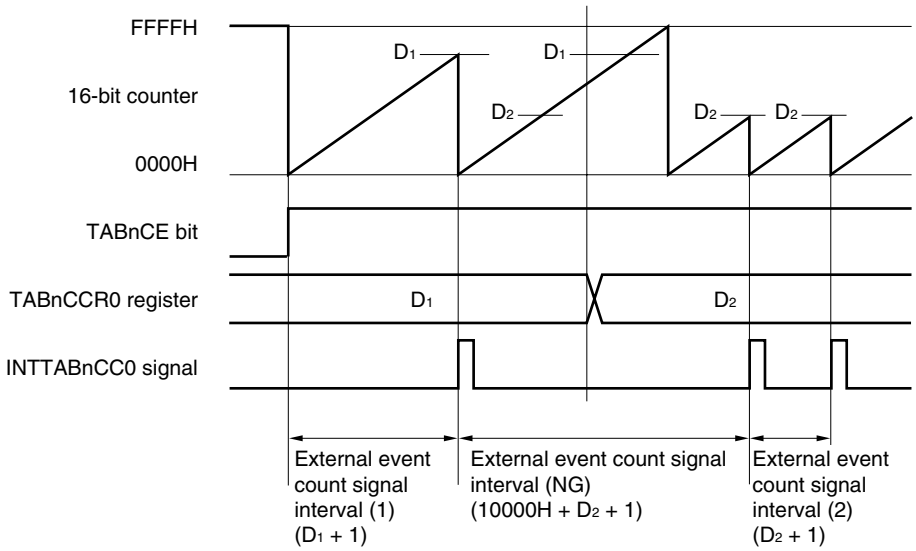


Remark **n = 0, 1**

(b) Notes on rewriting the TABnCCR0 register

To change the value of the TABnCCR0 register to a smaller value, stop counting once and then change the set value.

If the value of the TABnCCR0 register is rewritten to a smaller value during counting, the 16-bit counter may overflow.



Remark **n = 0, 1**

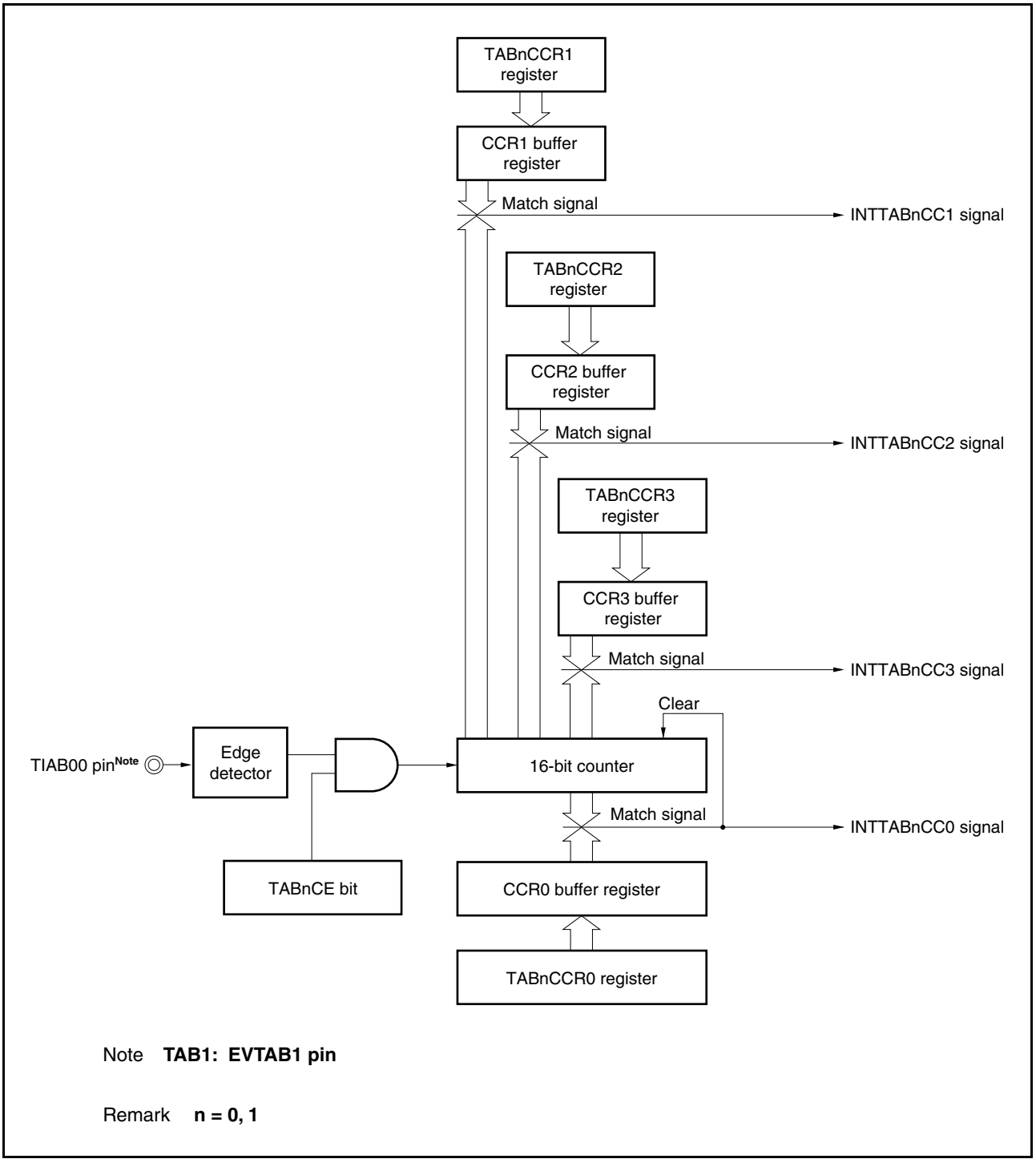
If the value of the TABnCCR0 register is changed from D_1 to D_2 while the count value is greater than D_2 but less than D_1, the count value is transferred to the CCR0 buffer register as soon as the TABnCCR0 register has been rewritten. Consequently, the value that is compared with the 16-bit counter is D_2.

Because the count value has already exceeded D_2, however, the 16-bit counter counts up to FFFFH, overflows, and then counts up again from 0000H. When the count value matches D_2, the INTTABnCC0 signal is generated.

Therefore, the INTTABnCC0 signal may not be generated at the valid edge count of "(D_1 + 1) times" or "(D_2 + 1) times" originally expected, but may be generated at the valid edge count of "(10000H + D_2 + 1) times".

(c) Operation of TABnCCR1 to TABnCCR3 registers

Figure 8-13. Configuration of TABnCCR1 to TABnCCR3 Registers



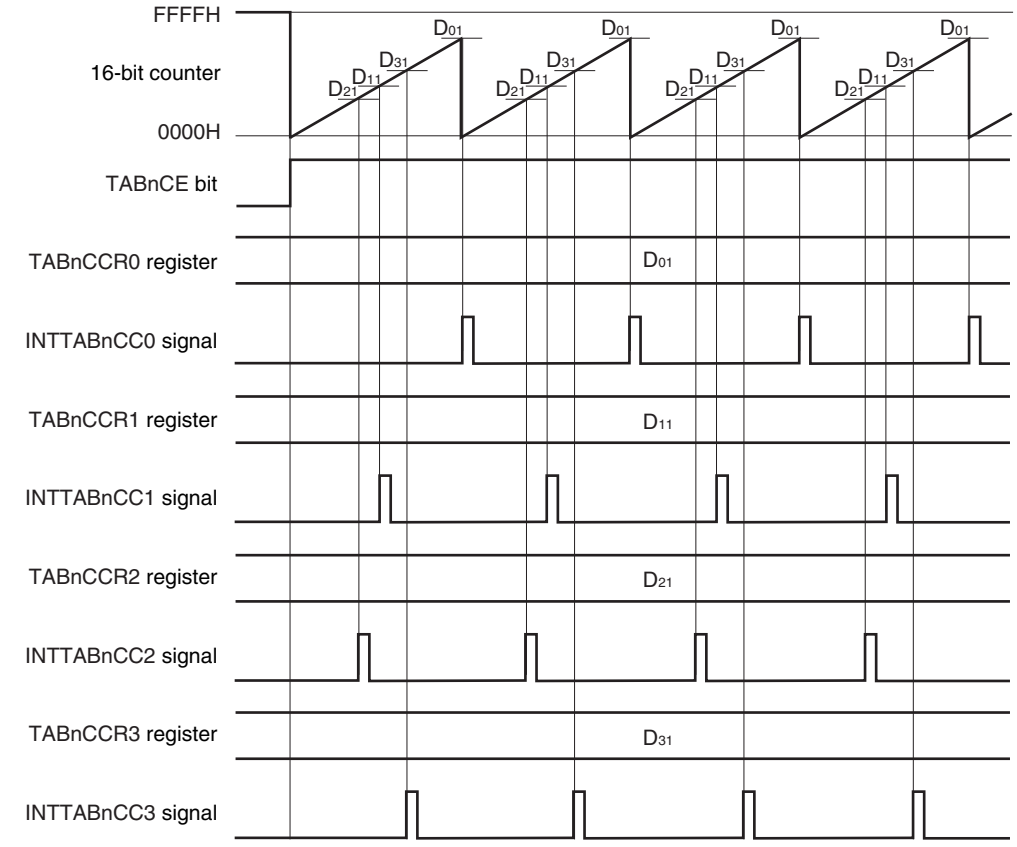
Note **TAB1: EVTAB1 pin**

Remark **n = 0, 1**

If the set value of the TABnCCRk register is smaller than the set value of the TABnCCR0 register, the INTTABnCCk signal is generated once per cycle.

Remark k = 1 to 3,
n = 0, 1

Figure 8-14. Timing Chart When $D_{01} \geq D_{k1}$

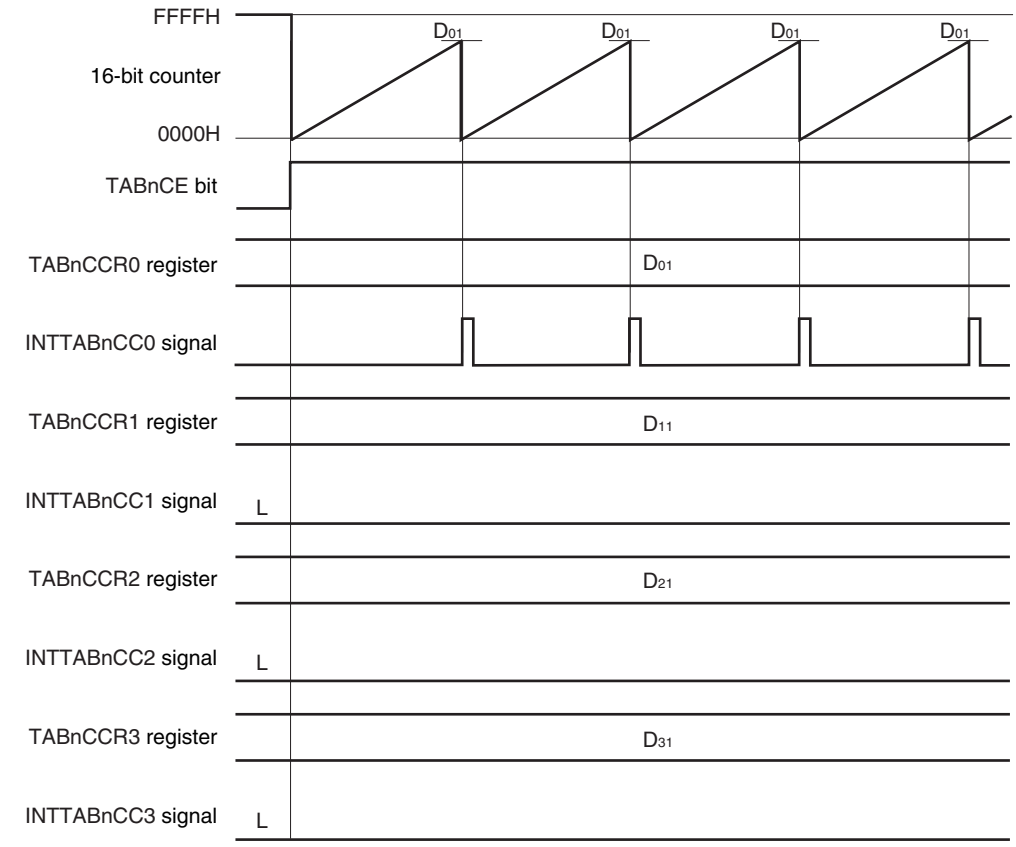


Remark **n = 0, 1**

If the set value of the TABnCCRk register is greater than the set value of the TABnCCR0 register, the INTTABnCCk signal is not generated because the count value of the 16-bit counter and the value of the TABnCCRk register do not match.

Remark k = 1 to 3,
n = 0, 1

Figure 8-15. Timing Chart When $D_{01} < D_{k1}$



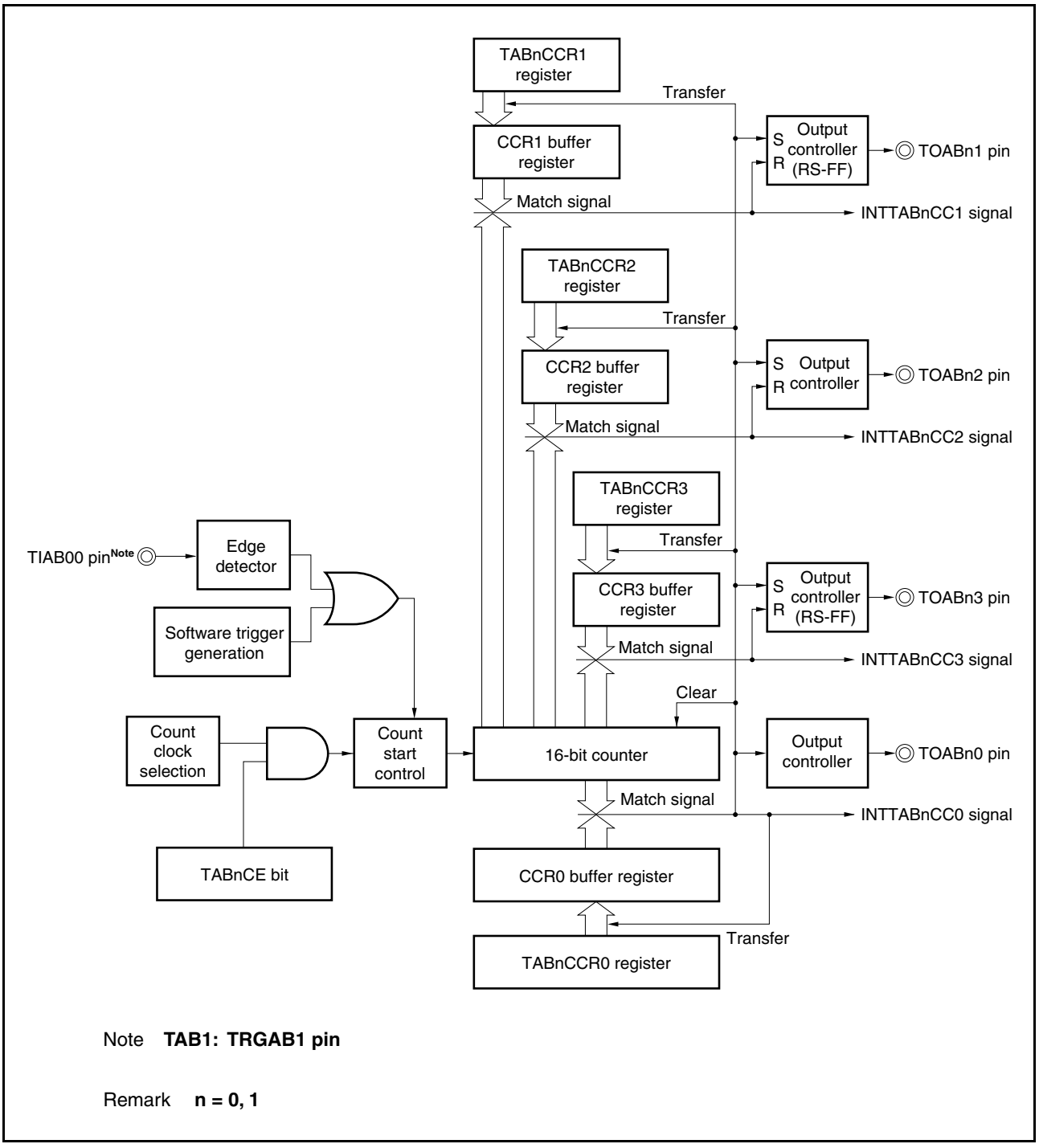
Remark **n = 0, 1**

8.5.3 External trigger pulse output mode (TABnMD2 to TABnMD0 bits = 010)

In the external trigger pulse output mode, TABn waits for a trigger when the TABnCTL0.TABnCE bit is set to 1. When the valid edge of the external trigger input signal is detected, TABn starts counting, and outputs a PWM waveform from the TOABn1 to TOABn3 pins.

Pulses can also be output by generating a software trigger instead of using the external trigger. When using a software trigger, a square wave that has one cycle of the PWM waveform as half its cycle can also be output from the TOABn0 pin.

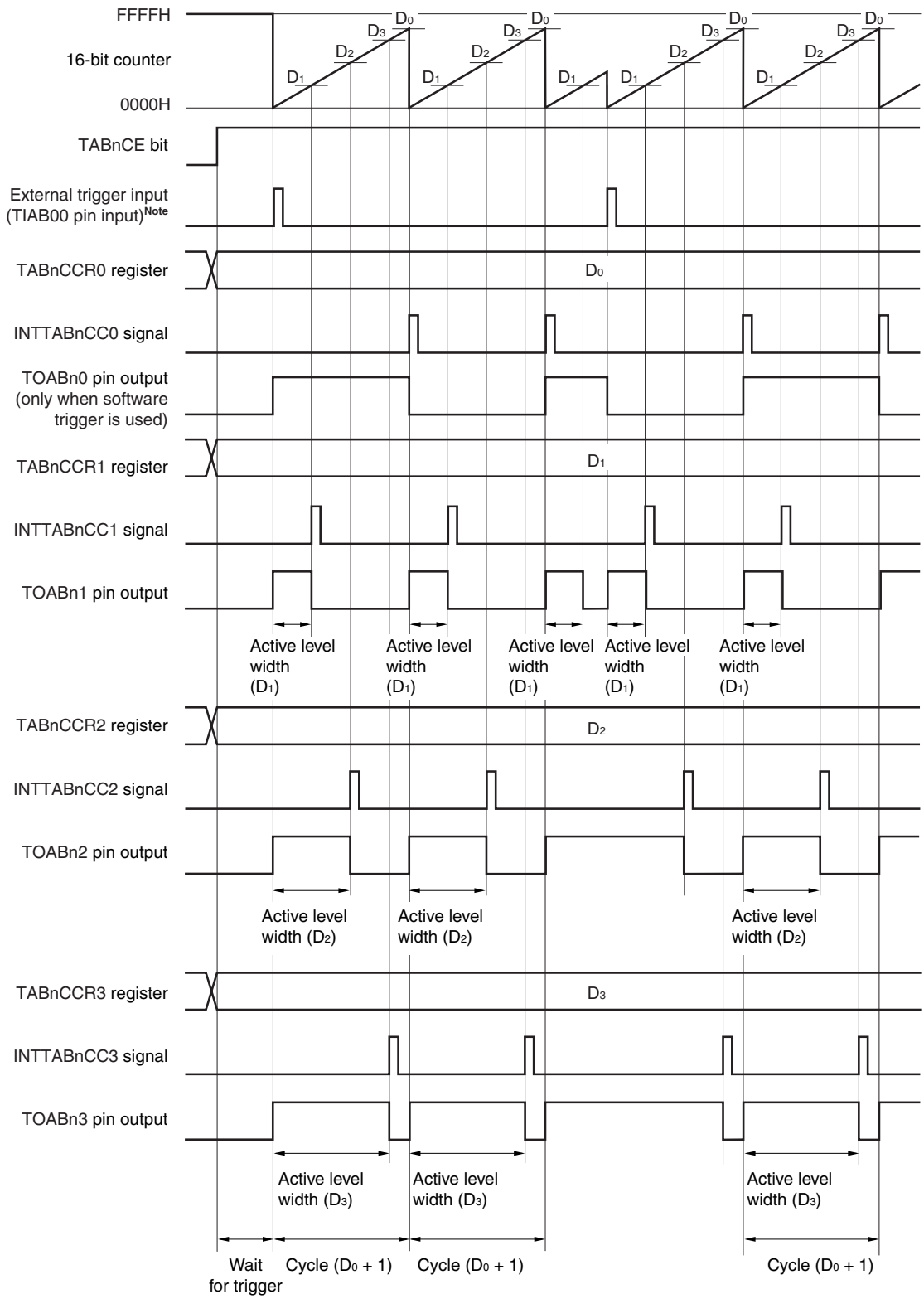
Figure 8-16. Configuration in External Trigger Pulse Output Mode



Note **TAB1: TRGAB1 pin**

Remark **n = 0, 1**

Figure 8-17. Basic Timing in External Trigger Pulse Output Mode



Note **TAB1: TRGAB1 pin**

Remark **n = 0, 1**

TABn waits for a trigger when the TABnCE bit is set to 1. When the trigger is generated, the 16-bit counter is cleared from FFFFH to 0000H, starts counting at the same time, and outputs a PWM waveform from the TOABnk pin. If the trigger is generated again while the counter is operating, the counter is cleared to 0000H and restarted. (The output of the TOABn0 pin is inverted. The TOABnk pin outputs a high level regardless of the status (high/low) when a trigger is generated.)

The active level width, cycle, and duty factor of the PWM waveform can be calculated as follows.

Active level width = (Set value of TABnCCRk register) × Count clock cycle
Cycle = (Set value of TABnCCR0 register + 1) × Count clock cycle
Duty factor = (Set value of TABnCCRk register)/(Set value of TABnCCR0 register + 1)

The compare match request signal (INTTABnCC0) is generated when the 16-bit counter counts up next time after its count value matches the value of the CCR0 buffer register, and the 16-bit counter is cleared to 0000H. The compare match interrupt request signal (INTTABnCCk) is generated when the count value of the 16-bit counter matches the value of the CCRk buffer register.

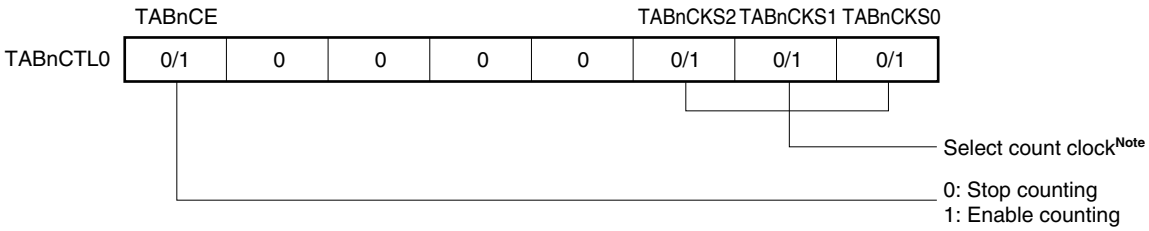
The value set to the TABnCCRm register is transferred to the CCRm buffer register when the count value of the 16-bit counter matches the value of the CCR0 buffer register and the 16-bit counter is cleared to 0000H.

The valid edge of the external trigger input signal or setting the software trigger (TABnCTL1.TABnEST bit) to 1 is used as the trigger.

Remark k = 1 to 3,
m = 0 to 3,
n = 0, 1

Figure 8-18. Setting of Registers in External Trigger Pulse Output Mode (1/3)

(a) TABn control register 0 (TABnCTL0)



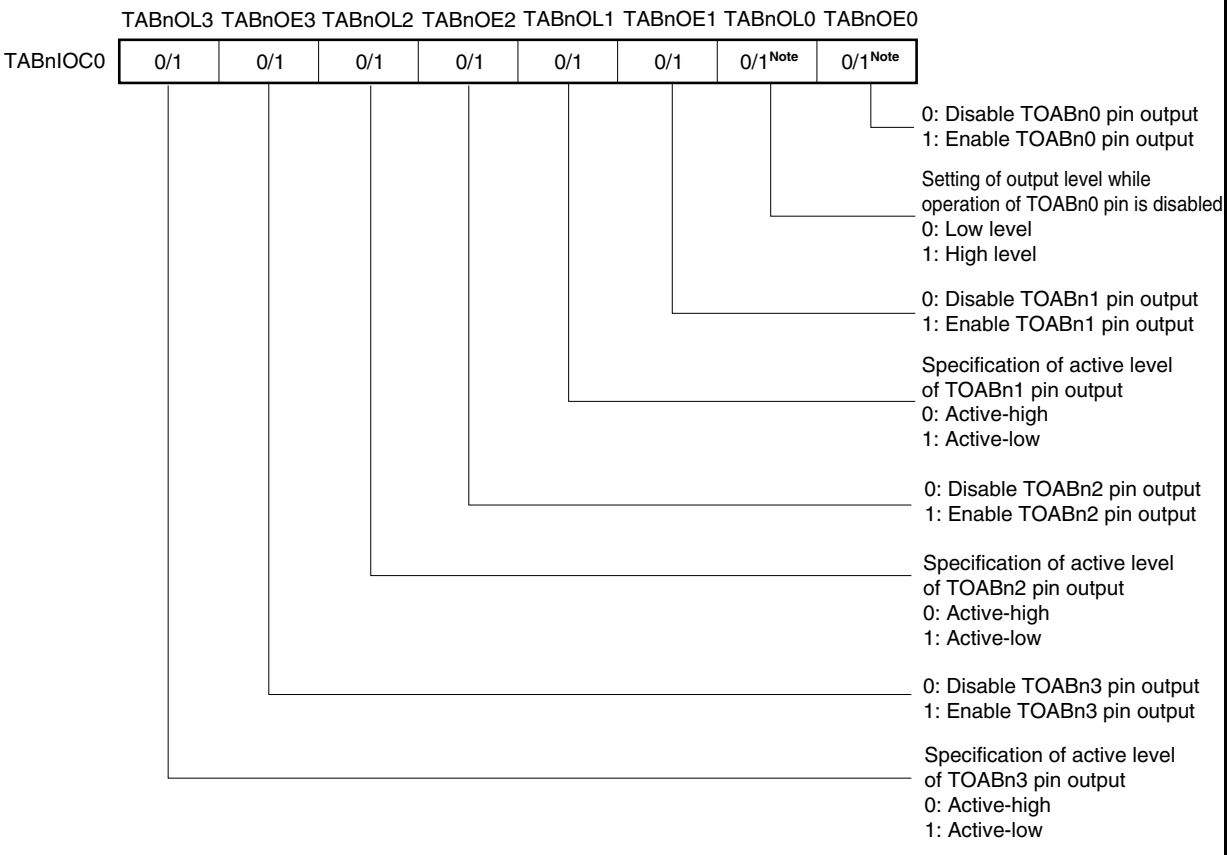
Note **The setting is invalid when the TABnCTL1.TABnEEE bit = 1.**

Remark **n = 0, 1**

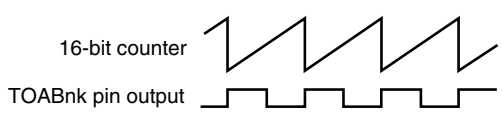
Figure 8-18. Setting of Registers in External Trigger Pulse Output Mode (2/3)

(b) TABn control register 1 (TABnCTL1)

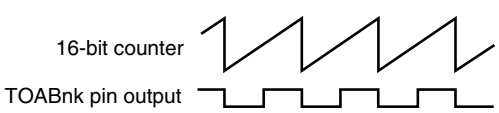
(c) TABn I/O control register 0 (TABnIOC0)



- When TABnOLk bit = 0



- When TABnOLk bit = 1

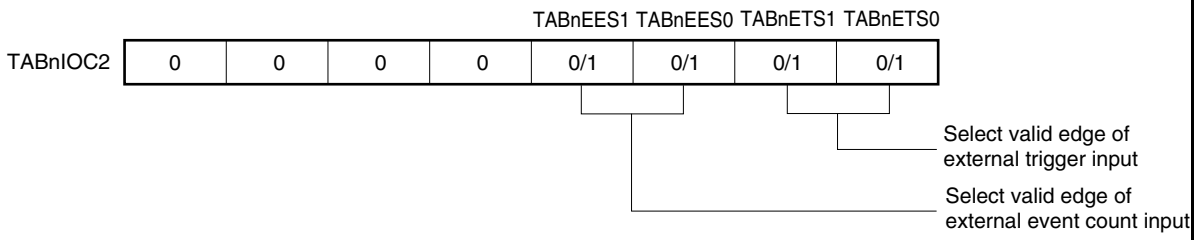


Note **Clear this bit to 0 when the TOABn0 pin is not used in the external trigger pulse output mode.**

Remark **n = 0, 1**

Figure 8-18. Setting of Registers in External Trigger Pulse Output Mode (3/3)

(d) TABn I/O control register 2 (TABnIOC2)



(e) TABn counter read buffer register (TABnCNT)

The value of the 16-bit counter can be read by reading the TABnCNT register.

(f) TABn capture/compare registers 0 to 3 (TABnCCR0 to TABnCCR3)

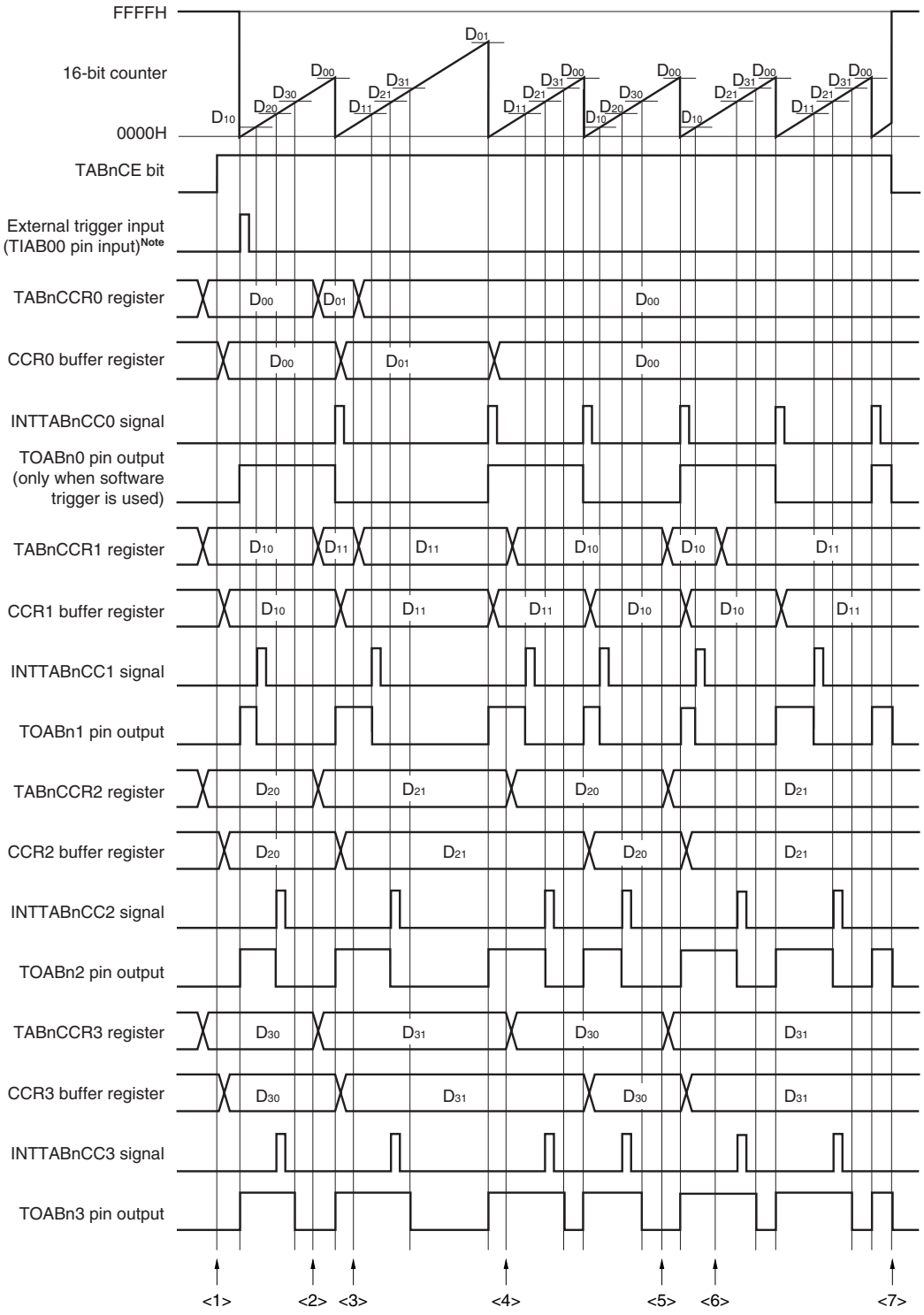
If D_0 is set to the TABnCCR0 register, D_1 to the TABnCCR1 register, D_2 to the TABnCCR2 register, and D_3 to the TABnCCR3 register, the cycle and active level of the PWM waveform are as follows.

Cycle = (D_0 + 1) × Count clock cycle
TOABn1 pin PWM waveform active level width = D_1 × Count clock cycle
TOABn2 pin PWM waveform active level width = D_2 × Count clock cycle
TOABn3 pin PWM waveform active level width = D_3 × Count clock cycle

Remarks 1. **TABn I/O control register 1 (TABnIOC1) and TABn option register 0 (TABnOPT0) are not used in the external trigger pulse output mode.**
2. **Updating TABn capture/compare register 2 (TABnCCR2) and TABn capture/compare register 3 (TABnCCR3) is enabled by writing TABn capture/compare register 1 (TABnCCR1).**
3. **n = 0, 1**

(1) Operation flow in external trigger pulse output mode

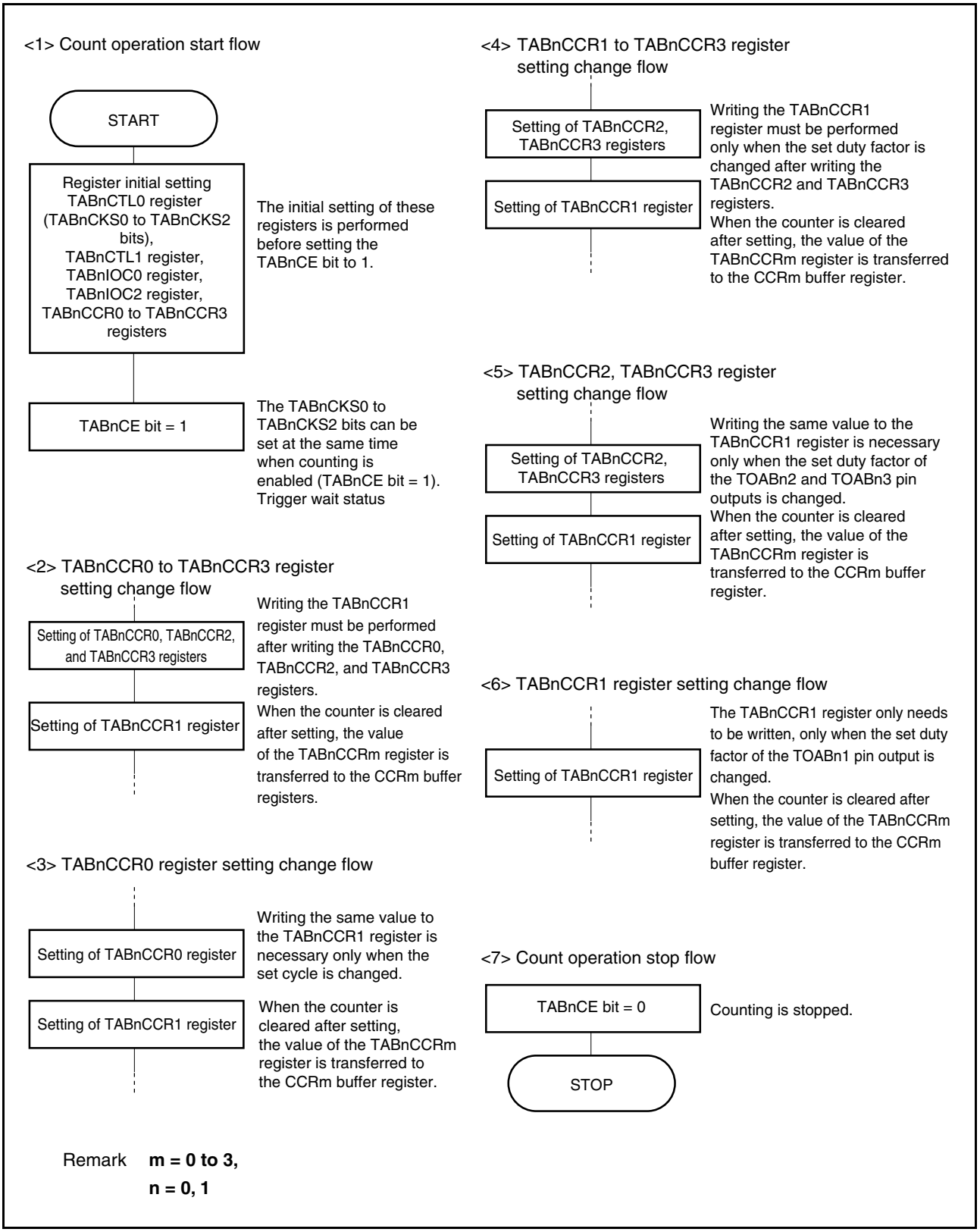
Figure 8-19. Software Processing Flow in External Trigger Pulse Output Mode (1/2)



Note **TAB1: TRGAB1 pin**

Remark **n = 0, 1**

Figure 8-19. Software Processing Flow in External Trigger Pulse Output Mode (2/2)



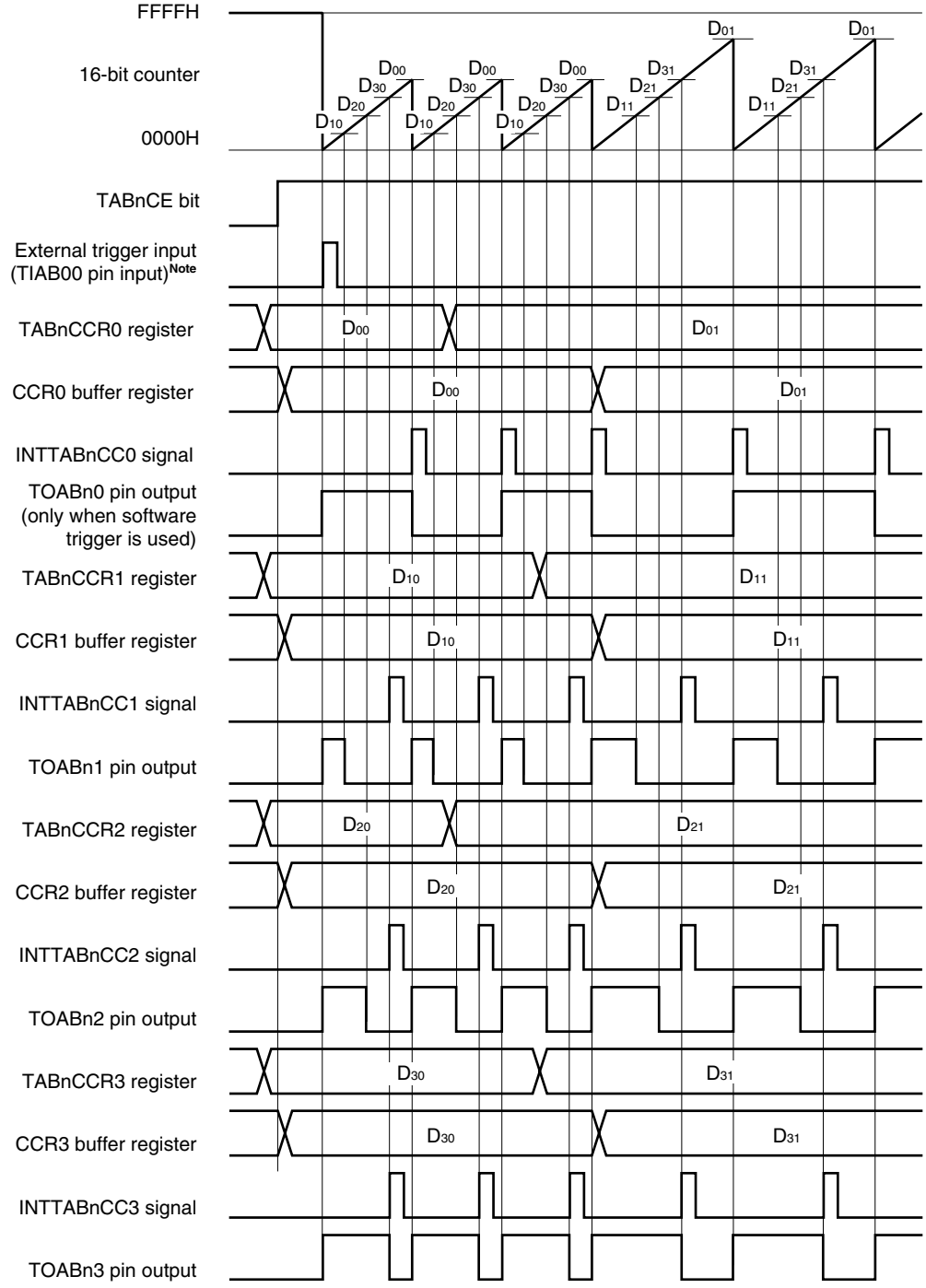
Remark **m = 0 to 3,**
n = 0, 1

(2) External trigger pulse output mode operation timing

(a) Note on changing pulse width during operation

To change the PWM waveform while the counter is operating, write the TABnCCR1 register last.

Rewrite the TABnCCRk register after writing the TABnCCR1 register after the INTTABnCC0 signal is detected.



Note **TAB1: TRGAB1 pin**

Remark **n = 0, 1**

To transfer data from the TABnCCRm register to the CCRm buffer register, the TABnCCR1 register must be written.

To change both the cycle and active level width of the PWM waveform at this time, first set the cycle to the TABnCCR0 register, set the active level width to the TABnCCR2 and TABnCCR3 registers, and then set the active level to the TABnCCR1 register.

To change only the cycle of the PWM waveform, first set the cycle to the TABnCCR0 register, and then write the same value to the TABnCCR1 register.

To change only the active level width (duty factor) of the PWM waveform, first set the active level to the TABnCCR2 and TABnCCR3 registers and then set the active level to the TABnCCR1 register.

To change only the active level width (duty factor) of the PWM waveform output by the TOABn1 pin, only the TABnCCR1 register has to be set.

To change only the active level width (duty factor) of the PWM waveform output by the TOABn2 and TOABn3 pins, first set the active level width to the TABnCCR2 and TABnCCR3 registers, and then write the same value to the TABnCCR1 register.

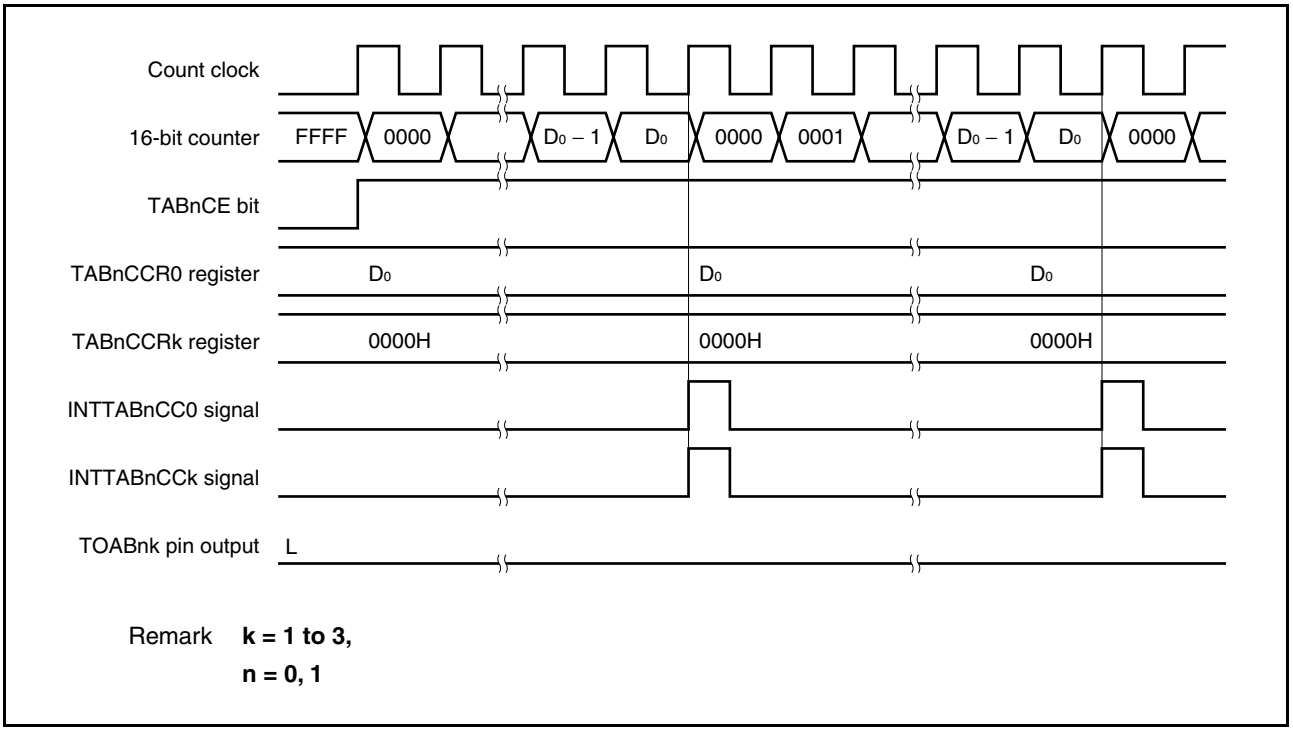
After data is written to the TABnCCR1 register, the value written to the TABnCCRm register is transferred to the CCRm buffer register in synchronization with clearing of the 16-bit counter, and is used as the value to be compared with the 16-bit counter.

To write the TABnCCR0 to TABnCCR3 registers again after writing the TABnCCR1 register once, do so after the INTTABnCC0 signal is generated. Otherwise, the value of the CCRm buffer register may become undefined because the timing of transferring data from the TABnCCRm register to the CCRm buffer register conflicts with writing the TABnCCRm register.

Remark m = 0 to 3,
n = 0, 1

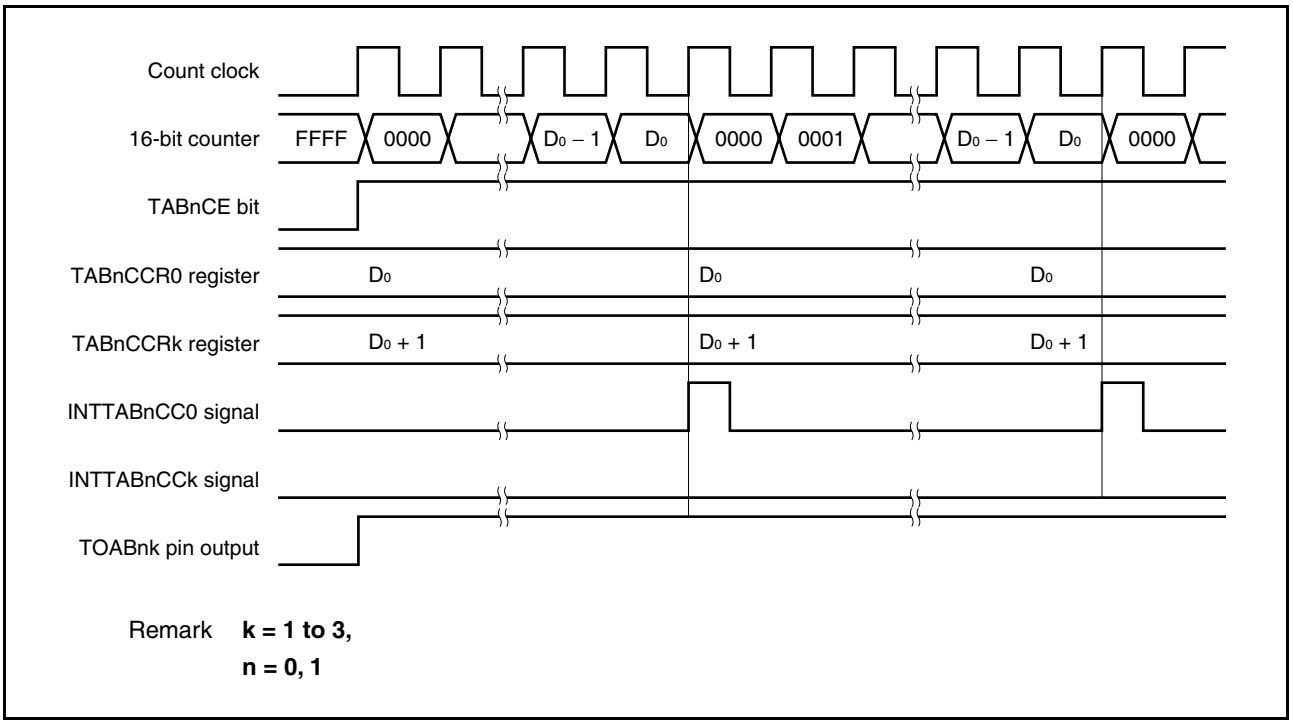
(b) 0%/100% output of PWM waveform

To output a 0% waveform, set the TABnCCRk register to 0000H. If the set value of the TABnCCR0 register is FFFFH, the INTTABnCCk signal is generated periodically.



Remark **k = 1 to 3,**
n = 0, 1

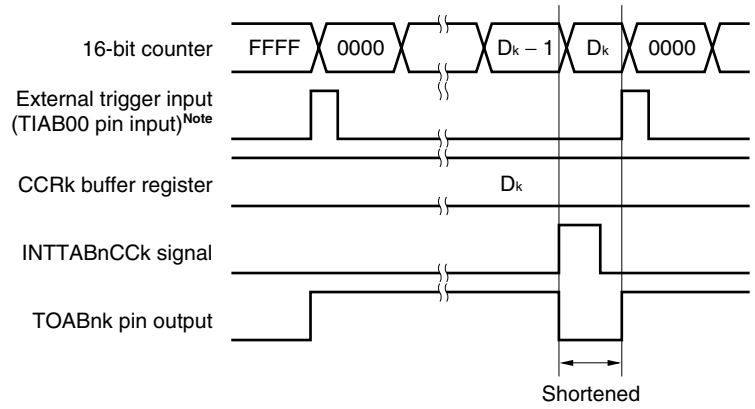
To output a 100% waveform, set a value of “set value of TABnCCR0 register + 1” to the TABnCCRk register. If the set value of the TABnCCR0 register is FFFFH, 100% output cannot be produced.



Remark **k = 1 to 3,**
n = 0, 1

(c) Conflict between trigger detection and match with CCRk buffer register

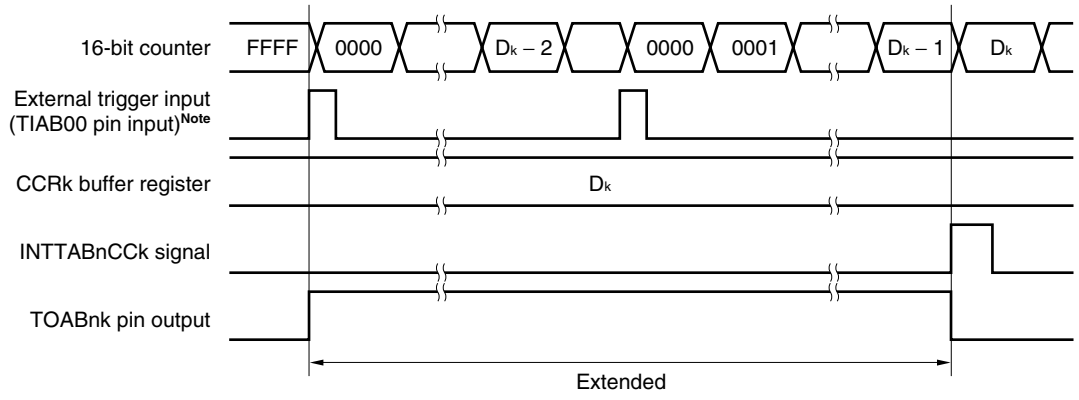
If the trigger is detected immediately after the INTTABnCCk signal is generated, the 16-bit counter is immediately cleared to 0000H, the output signal of the TOABnk pin is asserted, and the counter continues counting. Consequently, the inactive period of the PWM waveform is shortened.



Note **TAB1: TRGAB1 pin**

Remark **k = 1 to 3,**
n = 0, 1

If the trigger is detected immediately before the INTTABnCCk signal is generated, the INTTABnCCk signal is not generated, and the 16-bit counter is cleared to 0000H and continues counting. The output signal of the TOABnk pin remains active. Consequently, the active period of the PWM waveform is extended.

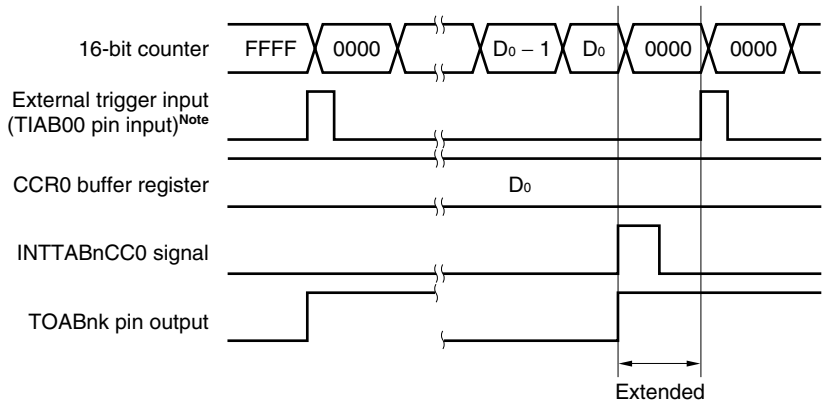


Note **TAB1: TRGAB1 pin**

Remark **k = 1 to 3,**
n = 0, 1

(d) Conflict between trigger detection and match with CCR0 buffer register

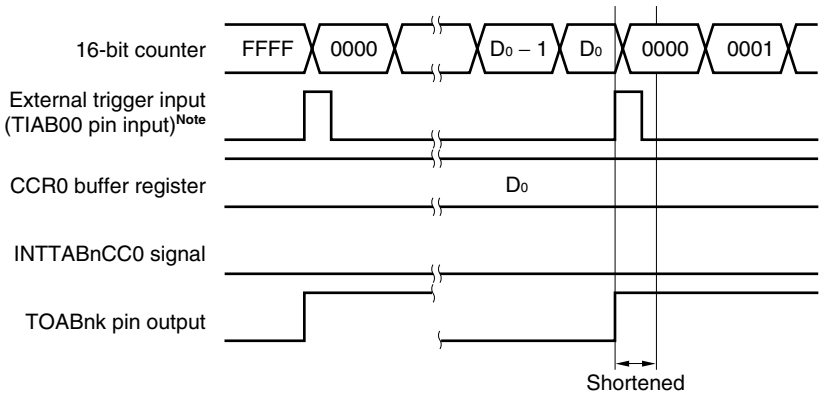
If the trigger is detected immediately after the INTTABnCC0 signal is generated, the 16-bit counter is cleared to 0000H and continues counting up. Therefore, the active period of the TOABnk pin is extended by time from generation of the INTTABnCC0 signal to trigger detection.



Note **TAB1: TRGAB1 pin**

Remark **k = 1 to 3,**
n = 0, 1

If the trigger is detected immediately before the INTTABnCC0 signal is generated, the INTTABnCC0 signal is not generated. The 16-bit counter is cleared to 0000H, the TOABnk pin is asserted, and the counter continues counting. Consequently, the inactive period of the PWM waveform is shortened.

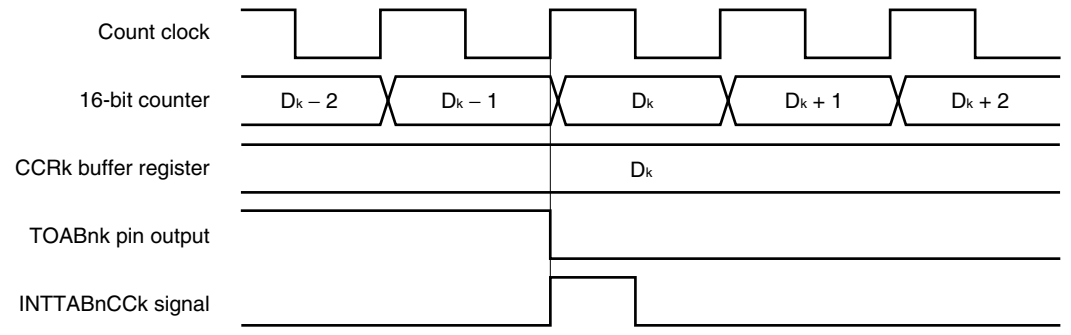


Note **TAB1: TRGAB1 pin**

Remark **k = 1 to 3,**
n = 0, 1

(e) Generation timing of compare match interrupt request signal (INTTABnCCk)

The timing of generation of the INTTABnCCk signal in the external trigger pulse output mode differs from the timing of other INTTABnCCk signals; the INTTABnCCk signal is generated when the count value of the 16-bit counter matches the value of the CCRk buffer register.



Remark **k = 1 to 3,**
n = 0, 1

Usually, the INTTABnCCk signal is generated in synchronization with the next count-up after the count value of the 16-bit counter matches the value of the CCRk buffer register.

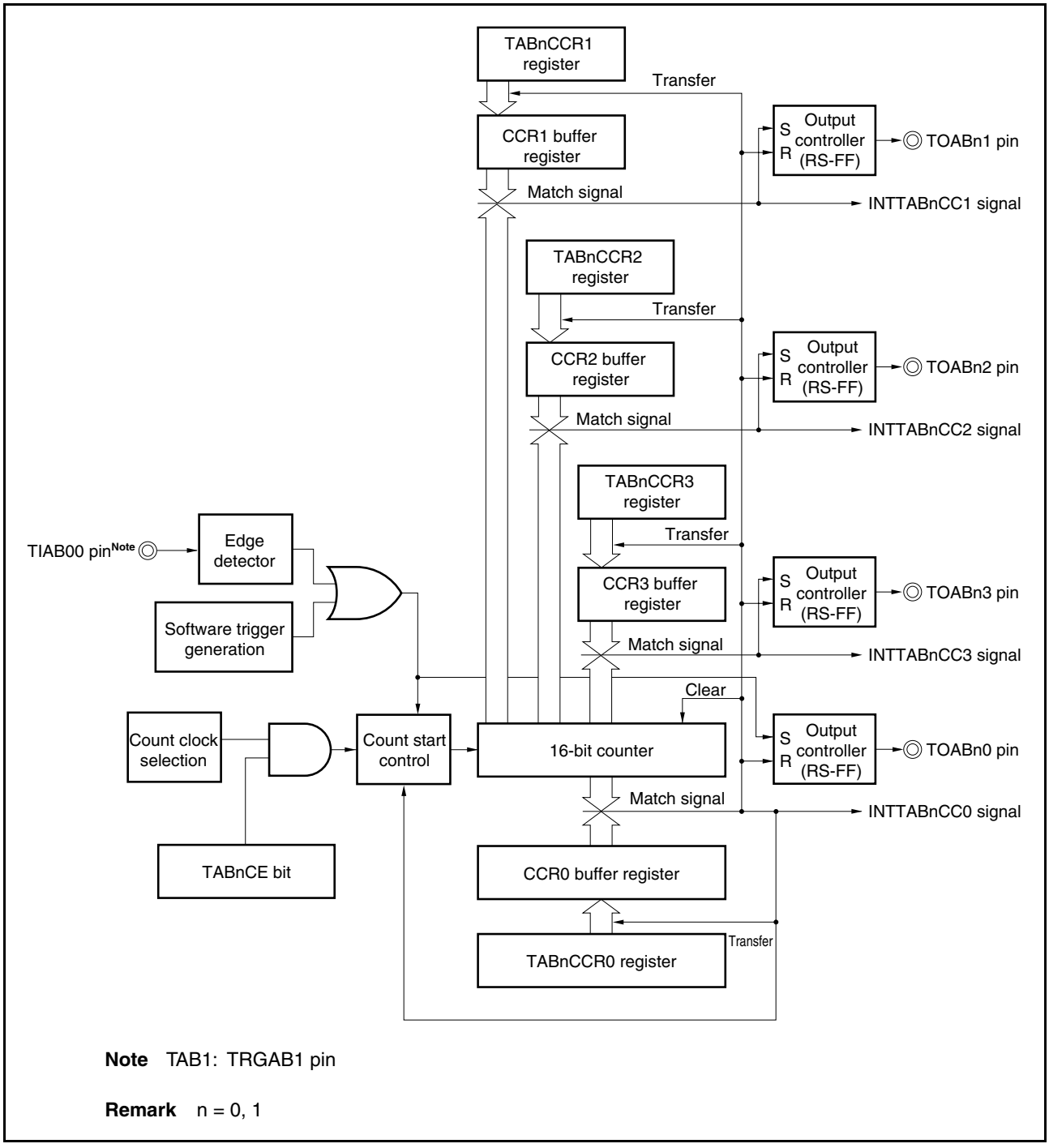
In the external trigger pulse output mode, however, it is generated one clock earlier. This is because the timing is changed to match the timing of changing the output signal of the TOABnk pin.

8.5.4 One-shot pulse output mode (TABnMD2 to TABnMD0 bits = 011)

In the one-shot pulse output mode, TABn waits for a trigger when the TABnCTL0.TABnCE bit is set to 1. When the valid edge of the external trigger input is detected, TABn starts counting, and outputs a one-shot pulse from the TOABn1 to TOABn3 pins.

Instead of the external trigger, a software trigger can also be generated to output the pulse. When the software trigger is used, the TOABn0 pin outputs the active level while the 16-bit counter is counting, and the inactive level when the counter is stopped (waiting for a trigger).

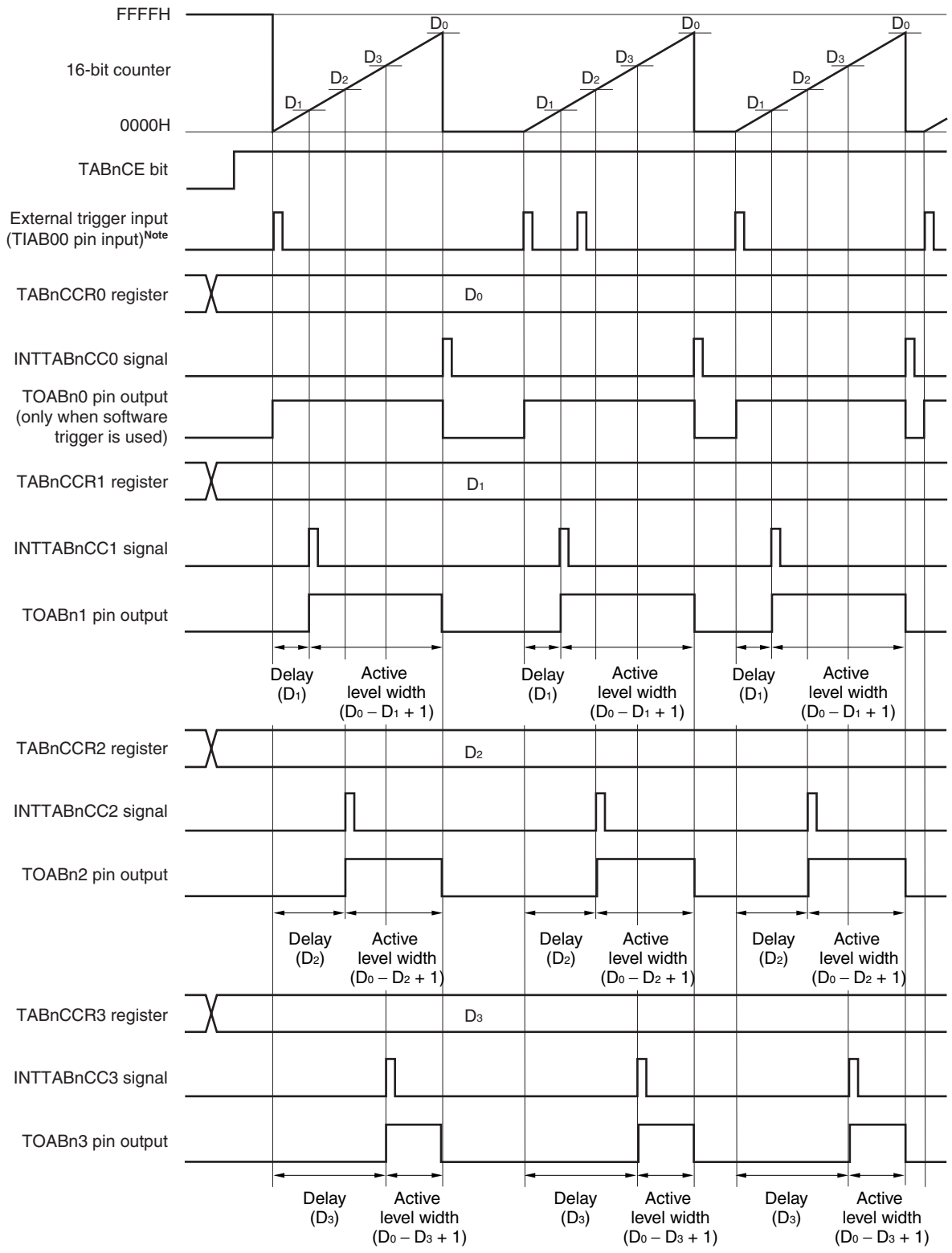
Figure 8-20. Configuration in One-Shot Pulse Output Mode



Note TAB1: TRGAB1 pin

Remark n = 0, 1

Figure 8-21. Basic Timing in One-Shot Pulse Output Mode



Note TAB1: TRGAB1 pin

Remark n = 0, 1

When the TABnCE bit is set to 1, TABn waits for a trigger. When the trigger is generated, the 16-bit counter is cleared from FFFFH to 0000H, starts counting, and outputs a one-shot pulse from the TOABnk pin. After the one-shot pulse is output, the 16-bit counter is set to FFFFH, stops counting, and waits for a trigger. If a trigger is generated again while the one-shot pulse is being output, it is ignored.

The output delay period and active level width of the one-shot pulse can be calculated as follows.

Output delay period = (Set value of TABnCCRk register) × Count clock cycle

Active level width = (Set value of TABnCCR0 register − Set value of TABnCCRk register + 1) × Count clock cycle

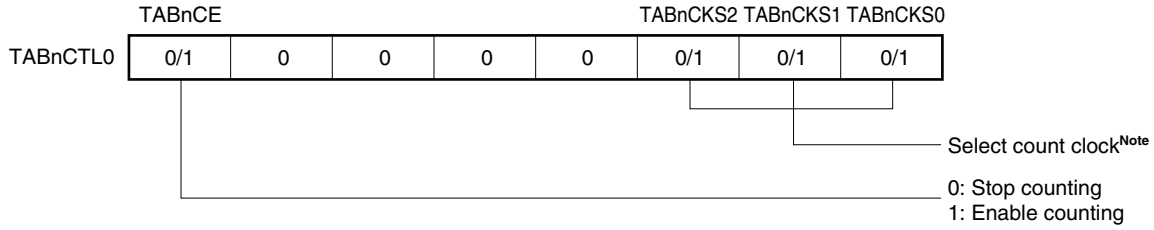
The compare match interrupt request signal INTTABnCC0 is generated when the 16-bit counter counts up after its count value matches the value of the CCR0 buffer register. The compare match interrupt request signal (INTTABnCCk) is generated when the count value of the 16-bit counter matches the value of the CCRk buffer register.

The valid edge of the external trigger input or setting the software trigger (TABnCTL1.TABnEST bit) to 1 is used as the trigger.

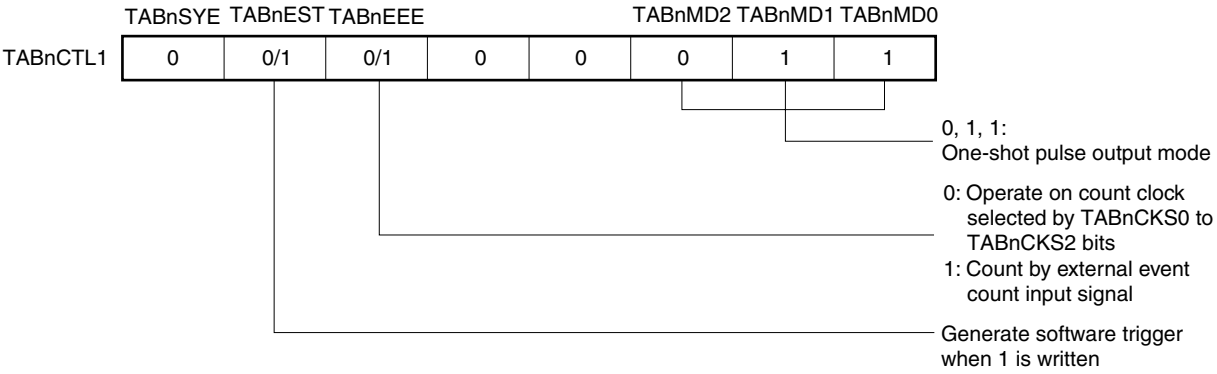
Remark k = 1 to 3,
n = 0, 1

Figure 8-22. Register Setting for Operation in One-Shot Pulse Output Mode (1/3)

(a) TABn control register 0 (TABnCTL0)



(b) TABn control register 1 (TABnCTL1)

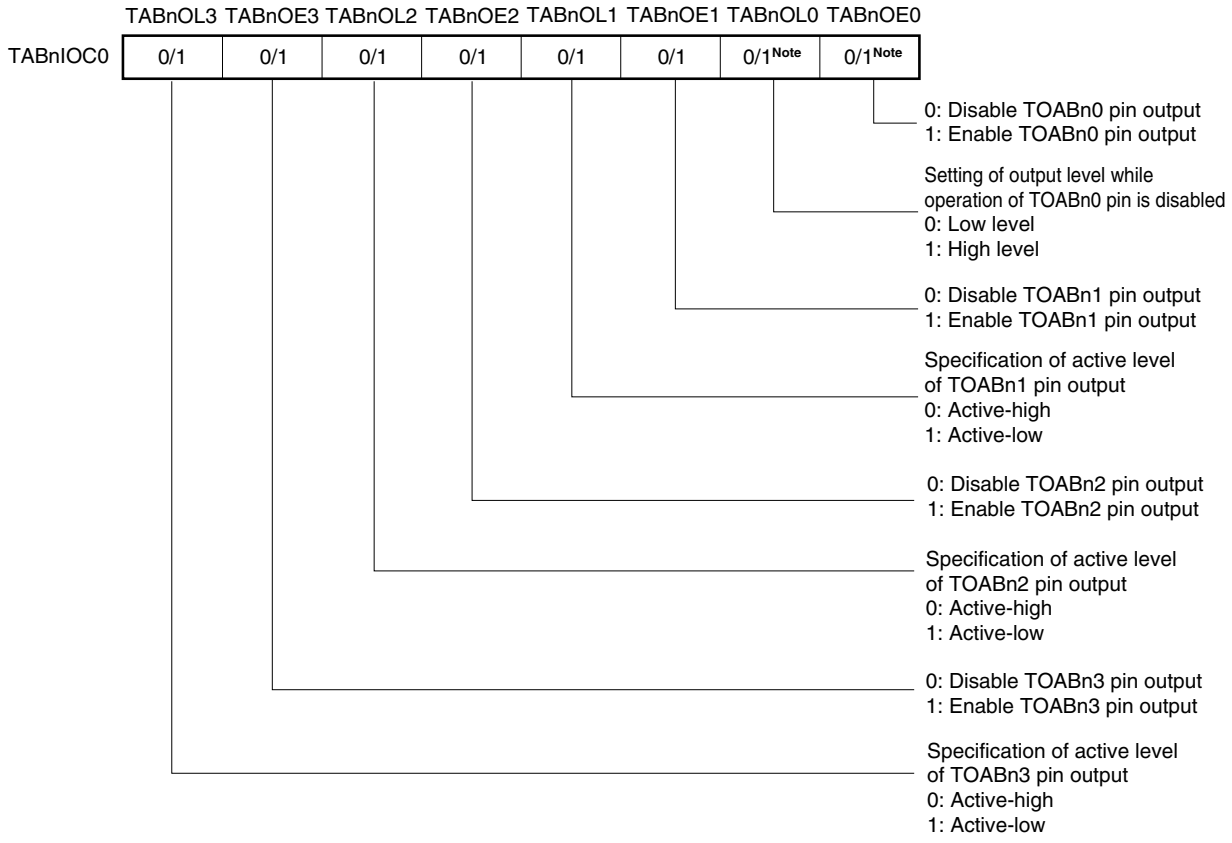


Note The setting is invalid when the TABnCTL1.TABnEEE bit = 1.

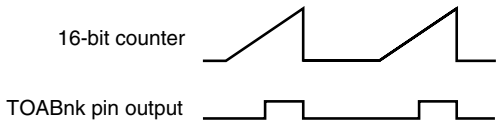
Remark n = 0, 1

Figure 8-22. Register Setting for Operation in One-Shot Pulse Output Mode (2/3)

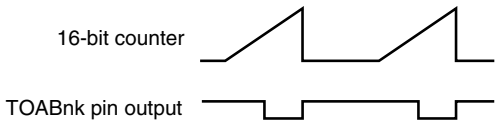
(c) TABn I/O control register 0 (TABnIOC0)



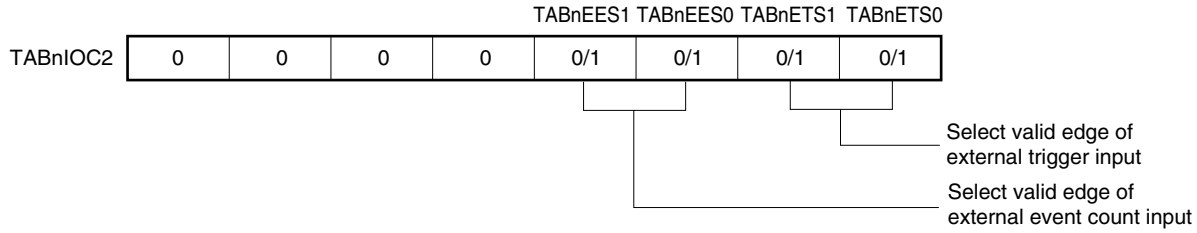
• When TABnOLk bit = 0



• When TABnOLk bit = 1



(d) TABn I/O control register 2 (TABnIOC2)



(e) TABn counter read buffer register (TABnCNT)

The value of the 16-bit counter can be read by reading the TABnCNT register.

Note Clear this bit to 0 when the TOABn0 pin is not used in the one-shot pulse output mode.

Remark n = 0, 1

Figure 8-22. Register Setting for Operation in One-Shot Pulse Output Mode (3/3)

(f) TABn capture/compare registers 0 to 3 (TABnCCR0 to TABnCCR3)

If D_0 is set to the TABnCCR0 register and D_k to the TABnCCRk register, the active level width and output delay period of the one-shot pulse are as follows.

Active level width = $(D_0 - D_k + 1) \times$ Count clock cycle
Output delay period = $(D_k) \times$ Count clock cycle

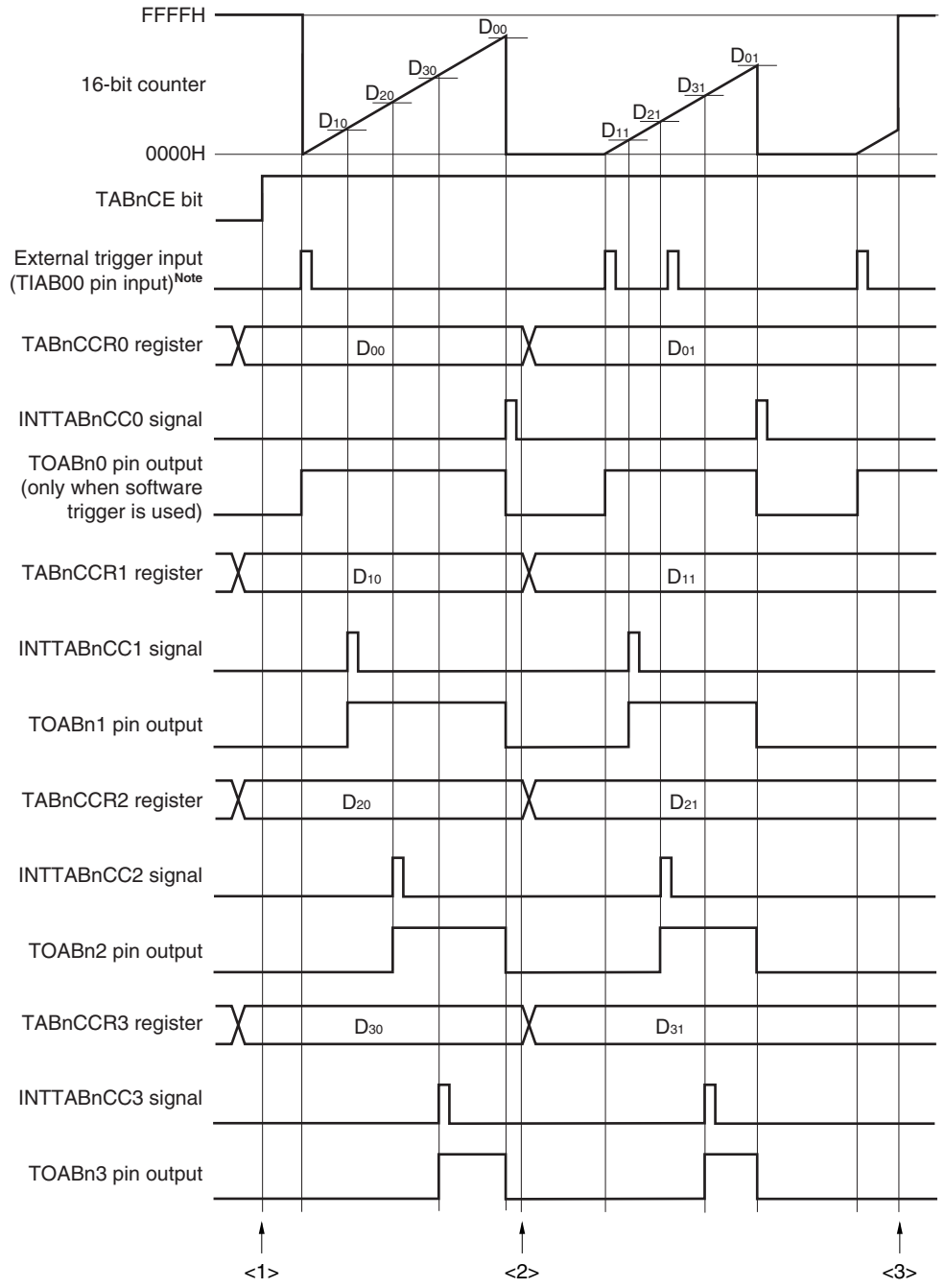
Caution One-shot pulses are not output even in the one-shot pulse output mode, if the set value of the TABnCCRk register is greater than that value of the TABnCCR0 register.

Remarks 1. TABn I/O control register 1 (TABnIOC1) and TABn option register 0 (TABnOPT0) are not used in the one-shot pulse output mode.

2. k = 1 to 3,
n = 0, 1

(1) Operation flow in one-shot pulse output mode

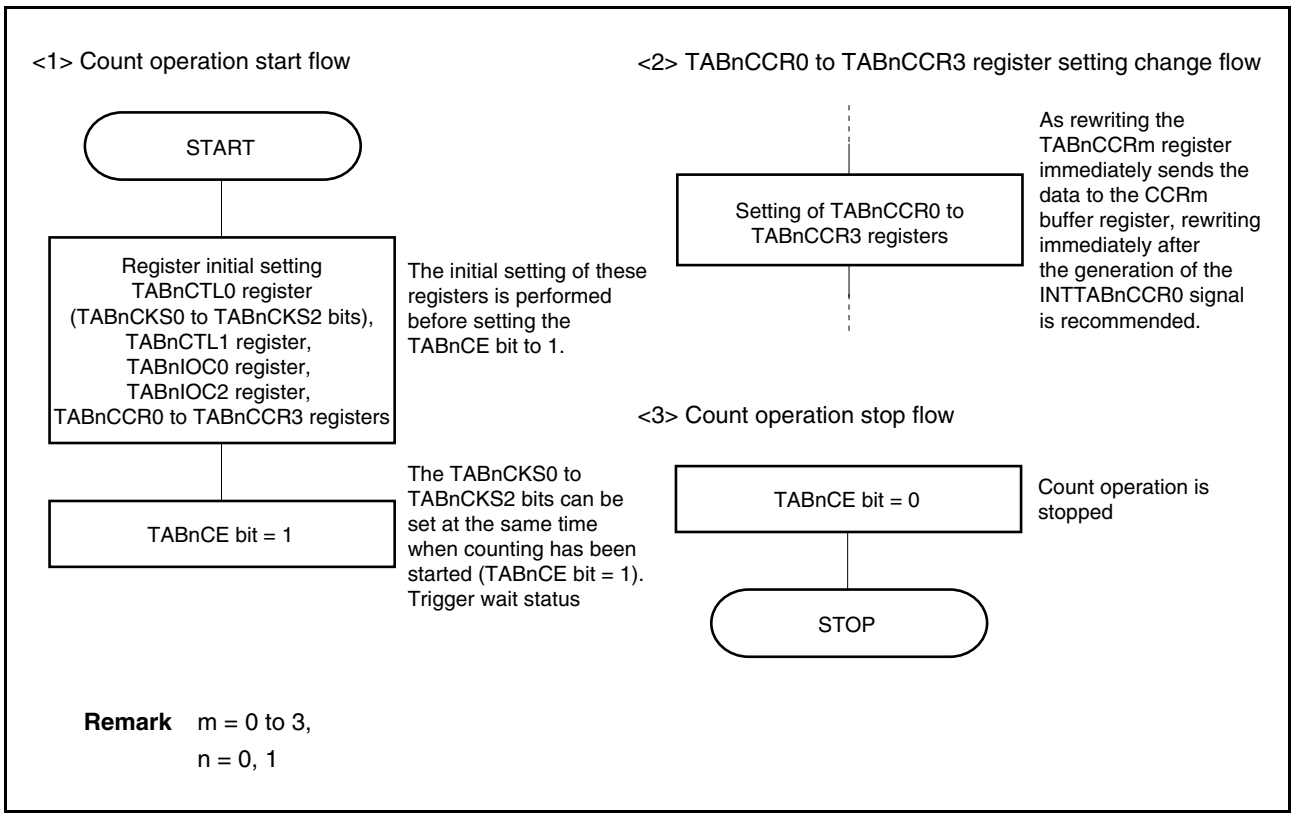
Figure 8-23. Software Processing Flow in One-Shot Pulse Output Mode (1/2)



Note TAB1: TRGAB1 pin

Remark n = 0, 1

Figure 8-23. Software Processing Flow in One-Shot Pulse Output Mode (2/2)



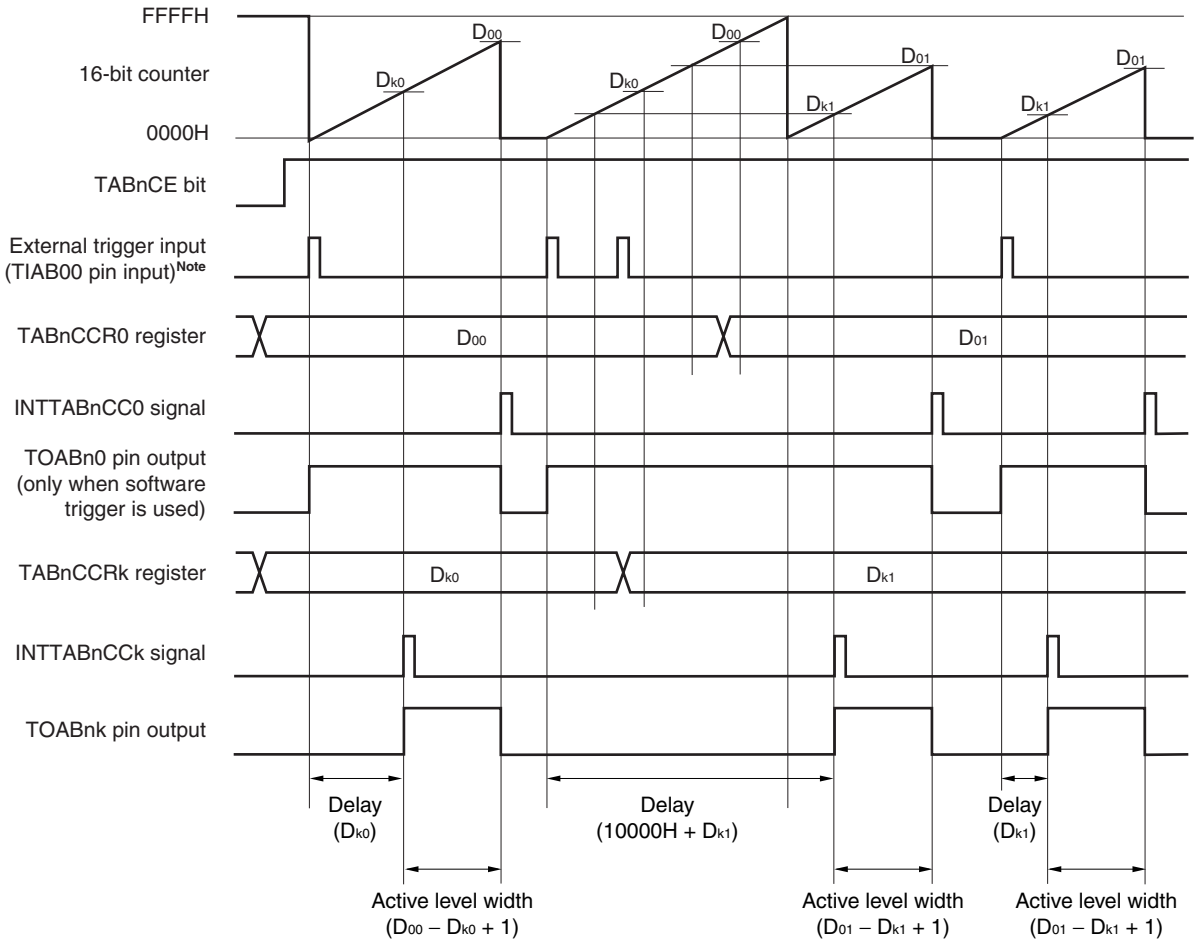
Remark m = 0 to 3,
n = 0, 1

(2) Operation timing in one-shot pulse output mode

(a) Notes on rewriting TABnCCRm register

To change the set value of the TABnCCRm register to a smaller value, stop counting once, and then change the set value.

If the value of the TABnCCR0 register is rewritten to a smaller value during counting, the 16-bit counter may overflow.



Note TAB1: TRGAB1 pin

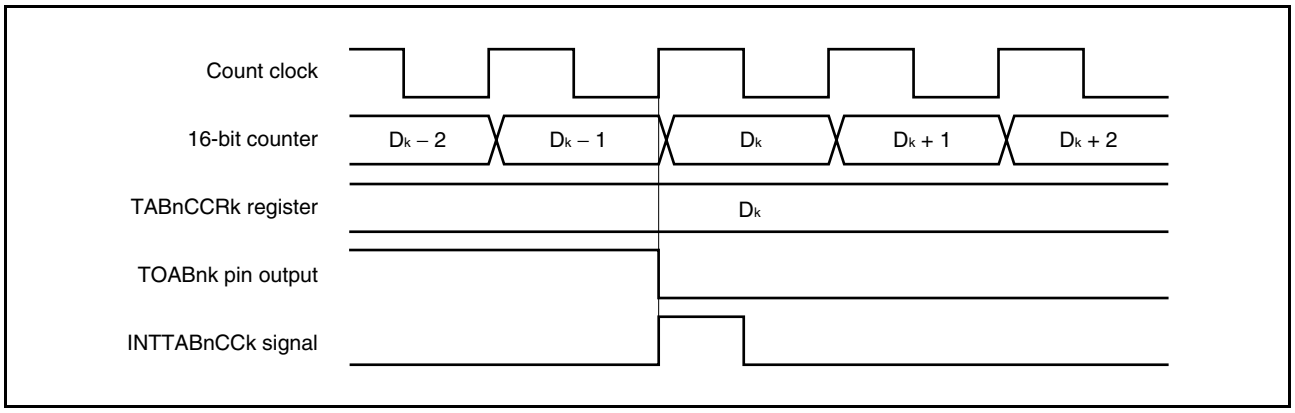
When the TABnCCR0 register is rewritten from D_{00} to D_{01} and the TABnCCRk register from D_{k0} to D_{k1} where $D_{00} > D_{01}$ and $D_{k0} > D_{k1}$, if the TABnCCRk register is rewritten when the count value of the 16-bit counter is greater than D_{k1} and less than D_{k0} and if the TABnCCR0 register is rewritten when the count value is greater than D_{01} and less than D_{00}, each set value is reflected as soon as the register has been rewritten and compared with the count value. The counter counts up to FFFFH and then counts up again from 0000H. When the count value matches D_{k1}, the counter generates the INTTABnCCk signal and asserts the TOABnk pin. When the count value matches D_{01}, the counter generates the INTTABnCC0 signal, deasserts the TOABnk pin, and stops counting.

Therefore, the counter may output a pulse with a delay period or active period different from that of the one-shot pulse that is originally expected.

Remark k = 1 to 3,
n = 0, 1

(b) Generation timing of compare match interrupt request signal (INTTABnCCk)

The generation timing of the INTTABnCCk signal in the one-shot pulse output mode is different from other INTTABnCCk signals; the INTTABnCCk signal is generated when the count value of the 16-bit counter matches the value of the TABnCCRk register.



Usually, the INTTABnCCk signal is generated when the 16-bit counter counts up next time after its count value matches the value of the TABnCCRk register.

In the one-shot pulse output mode, however, it is generated one clock earlier. This is because the timing is changed to match the change timing of the TOABnk pin.

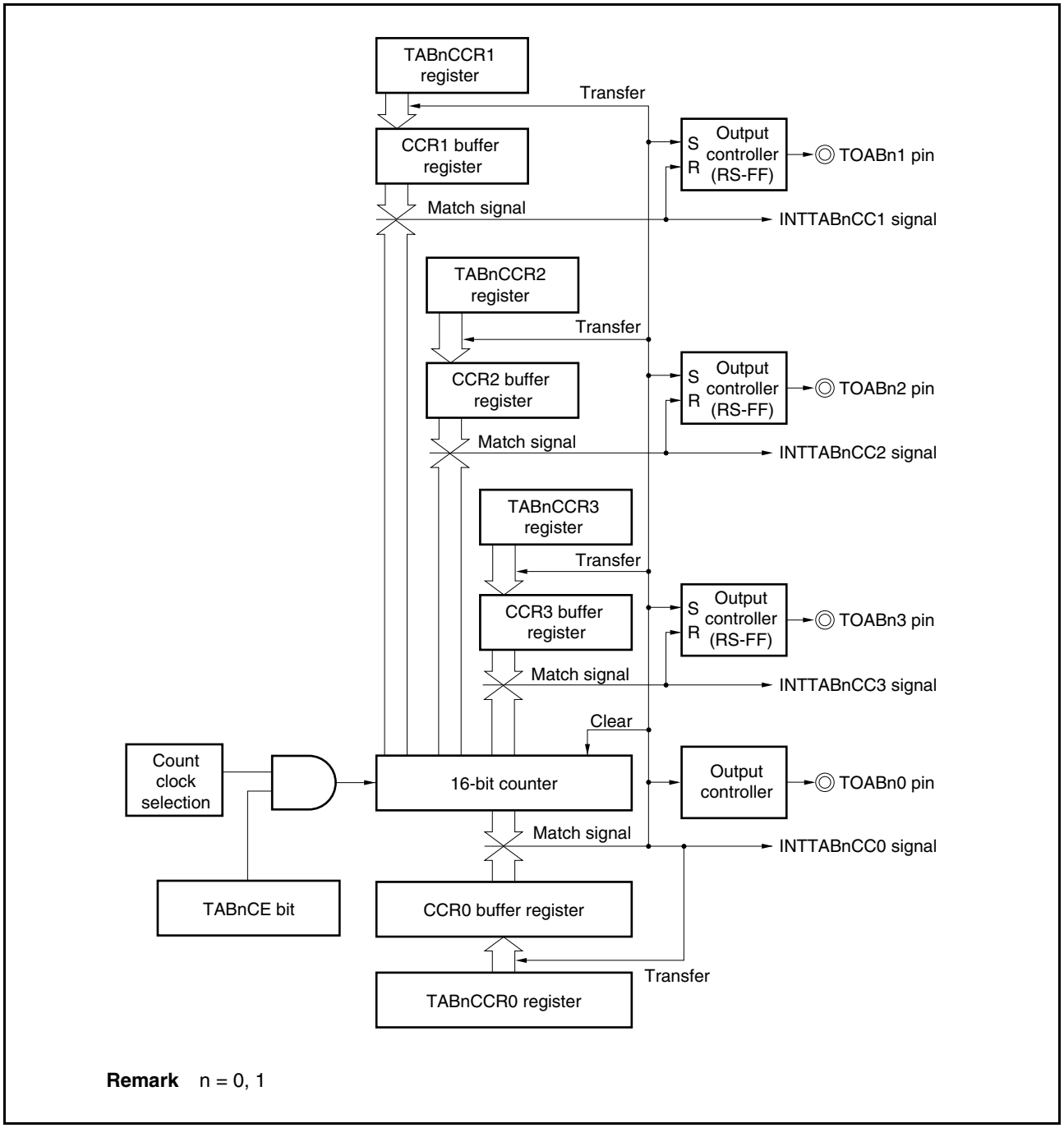
Remark k = 1 to 3,
n = 0, 1

8.5.5 PWM output mode (TABnMD2 to TABnMD0 bits = 100)

In the PWM output mode, a PWM waveform is output from the TOABn1 to TOABn3 pins when the TABnCTL0.TABnCE bit is set to 1.

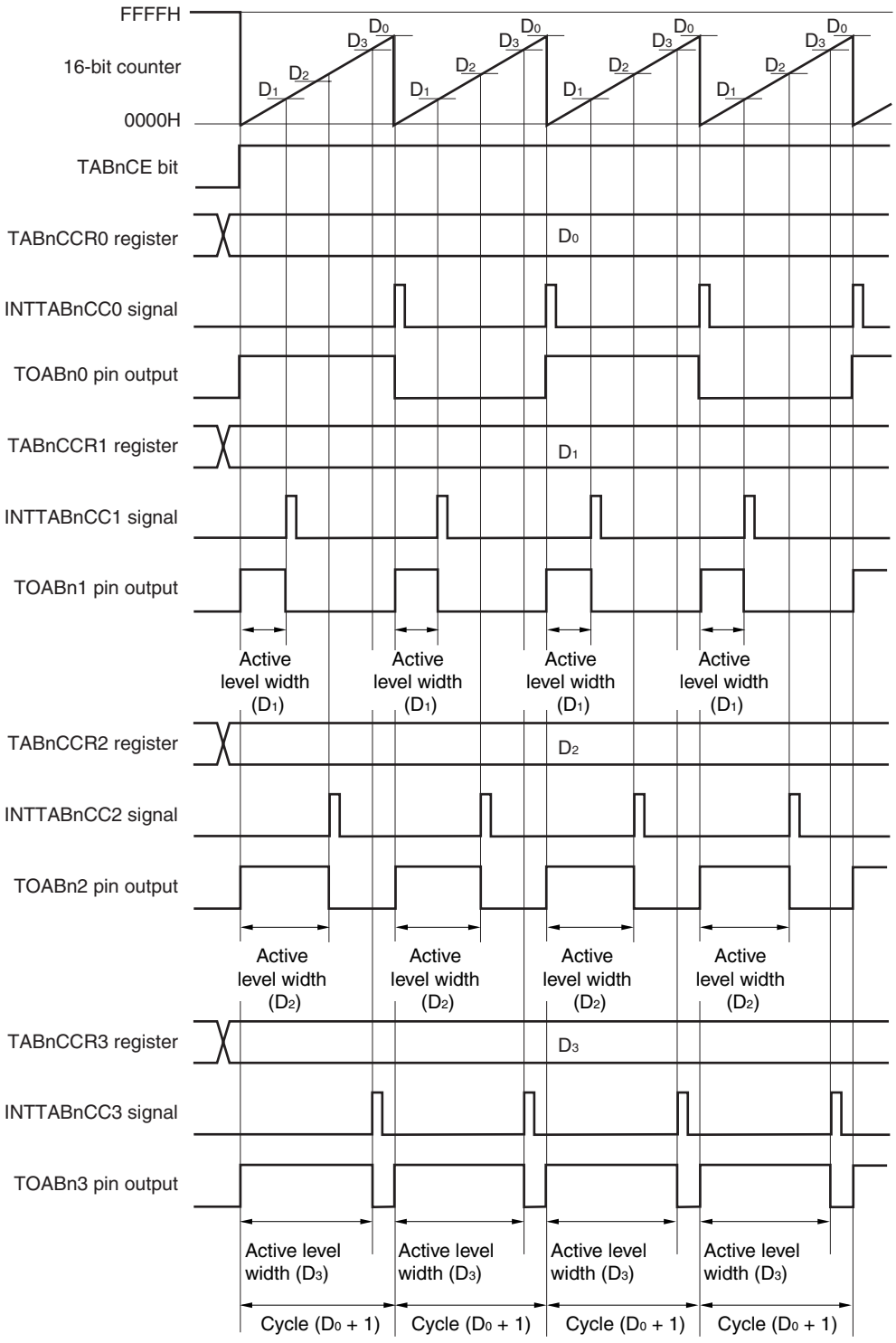
In addition, a pulse with one cycle of the PWM waveform as half its cycle is output from the TOABn0 pin.

Figure 8-24. Configuration in PWM Output Mode



Remark n = 0, 1

Figure 8-25. Basic Timing in PWM Output Mode



Remark n = 0, 1

When the TABnCE bit is set to 1, the 16-bit counter is cleared from FFFFH to 0000H, starts counting, and outputs a PWM waveform from the TOABnk pin.

The active level width, cycle, and duty factor of the PWM waveform can be calculated as follows.

Active level width = (Set value of TABnCCRk register) × Count clock cycle
Cycle = (Set value of TABnCCR0 register + 1) × Count clock cycle
Duty factor = (Set value of TABnCCRk register)/(Set value of TABnCCR0 register + 1)

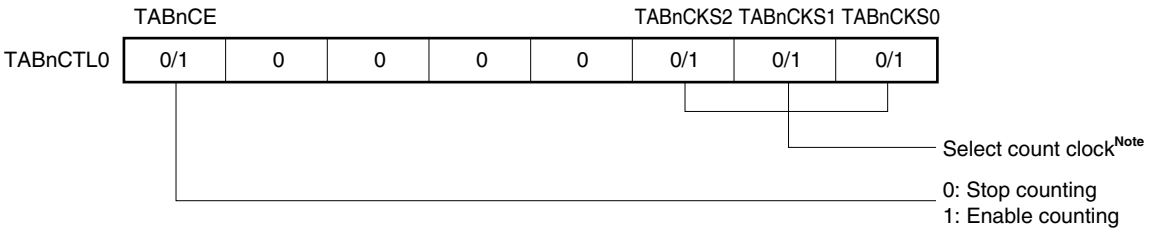
The PWM waveform can be changed by rewriting the TABnCCRm register while the counter is operating. The newly written value is reflected when the count value of the 16-bit counter matches the value of the CCR0 buffer register and the 16-bit counter is cleared to 0000H.

The compare match interrupt request signal (INTTABnCC0) is generated when the 16-bit counter counts up next time after its count value matches the value of the CCR0 buffer register, and the 16-bit counter is cleared to 0000H. The compare match interrupt request signal (INTTABnCCk) is generated when the count value of the 16-bit counter matches the value of the CCRk buffer register.

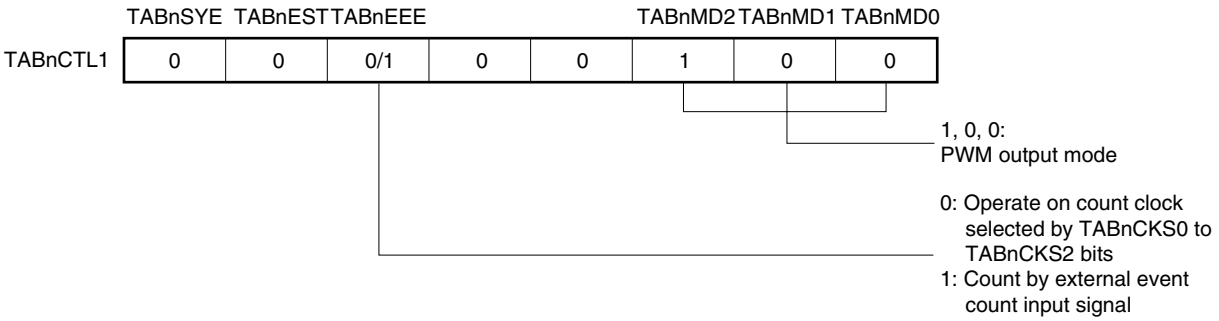
Remark k = 1 to 3,
m = 0 to 3,
n = 0, 1

Figure 8-26. Setting of Registers in PWM Output Mode (1/3)

(a) TABn control register 0 (TABnCTL0)



(b) TABn control register 1 (TABnCTL1)



Note The setting is invalid when the TABnCTL1.TABnEEE bit = 1.

Remark n = 0, 1

Figure 8-26. Setting of Registers in PWM Output Mode (2/3)

(c) TABn I/O control register 0 (TABnIOC0)

	TABnOL3	TABnOE3	TABnOL2	TABnOE2	TABnOL1	TABnOE1	TABnOL0	TABnOE0
TABnIOC0	0/1	0/1	0/1	0/1	0/1	0/1	0/1 Note	0/1 Note

0: Disable TOABn0 pin output
1: Enable TOABn0 pin output

Setting of output level while operation of TOABn0 pin is disabled
0: Low level
1: High level

0: Disable TOABn1 pin output
1: Enable TOABn1 pin output

Specification of active level of TOABn1 pin output
0: Active-high
1: Active-low

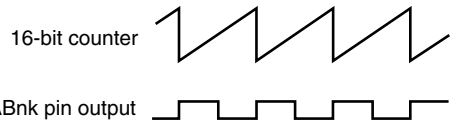
0: Disable TOABn2 pin output
1: Enable TOABn2 pin output

Specification of active level of TOABn2 pin output
0: Active-high
1: Active-low

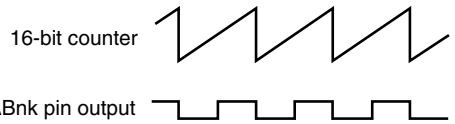
0: Disable TOABn3 pin output
1: Enable TOABn3 pin output

Specification of active level of TOABn3 pin output
0: Active-high
1: Active-low

- When TABnOLk bit = 0



- When TABnOLk bit = 1



(d) TABn I/O control register 2 (TABnIOC2)

	TABnEES1	TABnEES0	TABnETS1	TABnETS0				
TABnIOC2	0	0	0	0	0/1	0/1	0	0

Select valid edge of external event count input.

(e) TABn counter read buffer register (TABnCNT)

The value of the 16-bit counter can be read by reading the TABnCNT register.

Note Clear this bit to 0 when the TOABn0 pin is not used in the PWM output mode.

Remark n = 0, 1

Figure 8-26. Register Setting in PWM Output Mode (3/3)

(f) TABn capture/compare registers 0 to 3 (TABnCCR0 to TABnCCR3)

If D_0 is set to the TABnCCR0 register and D_k to the TABnCCRk register, the cycle and active level of the PWM waveform are as follows.

Cycle = $(D_0 + 1) \times$ Count clock cycle
Active level width = $D_k \times$ Count clock cycle

Remarks 1. TABn I/O control register 1 (TABnIOC1) and TABn option register 0 (TABnOPT0) are not used in the PWM output mode.

2. Updating TABn capture/compare register 2 (TABnCCR2) and TABn capture/compare register 3 (TABnCCR3) is enabled by writing TABn capture/compare register 1 (TABnCCR1).

3. n = 0, 1

(1) Operation flow in PWM output mode

Figure 8-27. Software Processing Flow in PWM Output Mode (1/2)

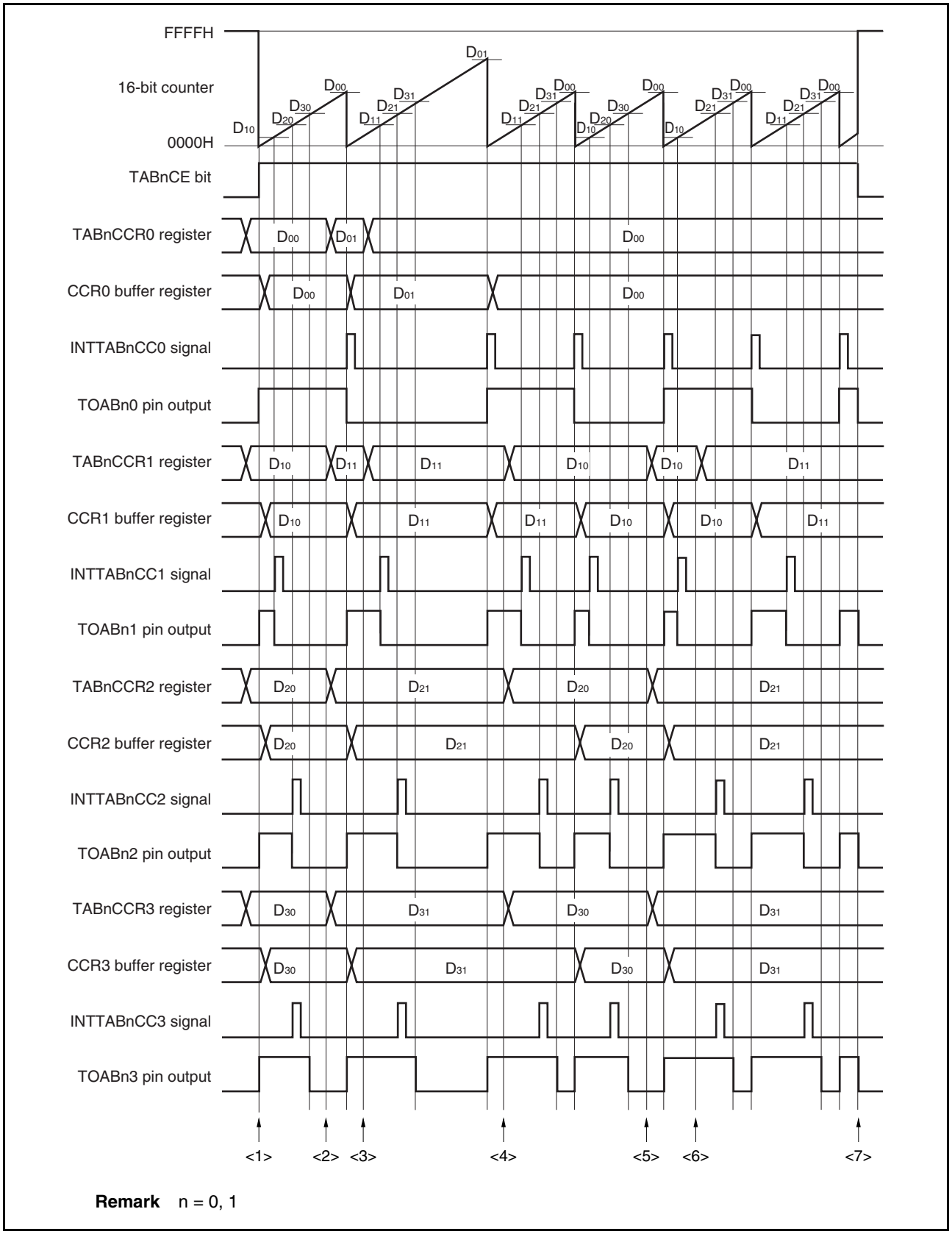
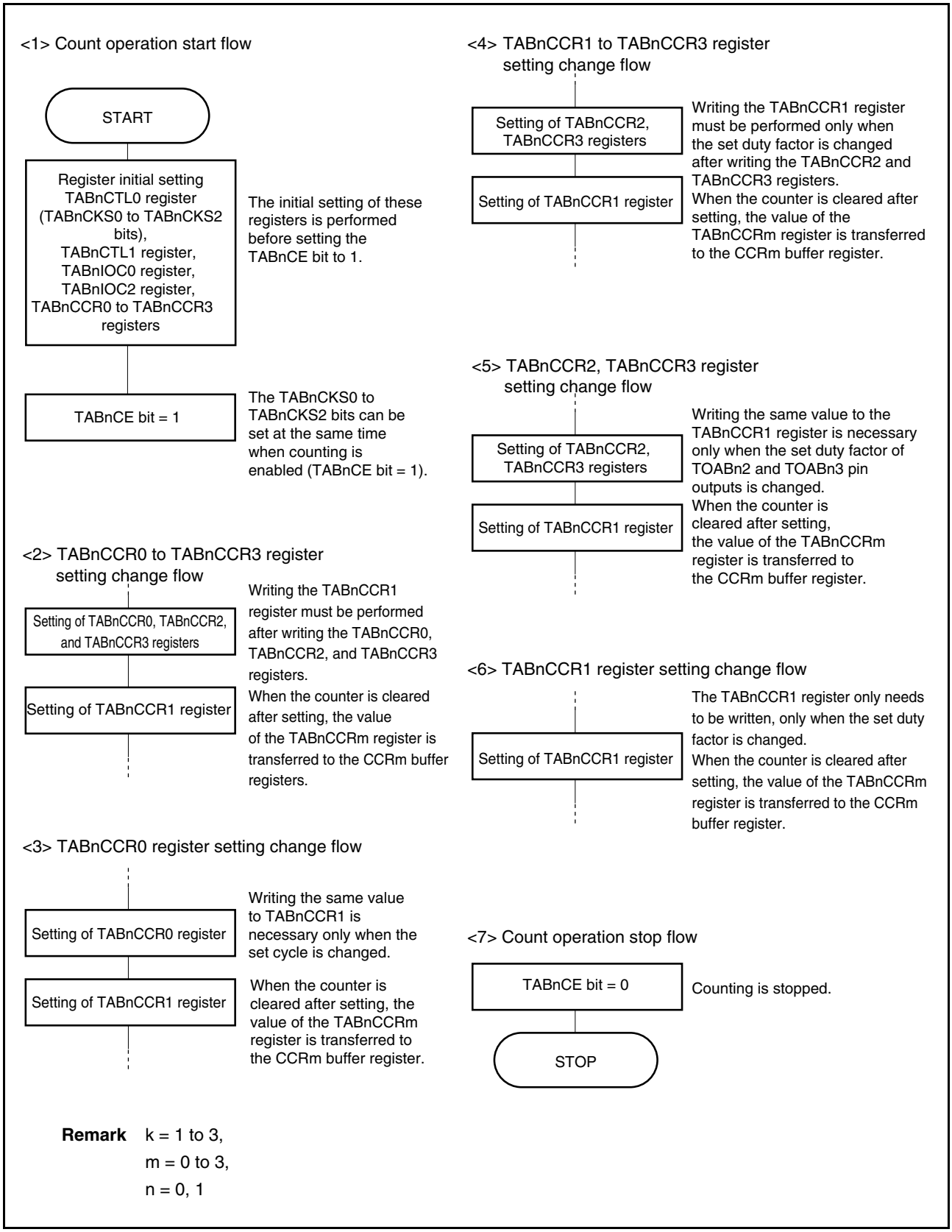


Figure 8-27. Software Processing Flow in PWM Output Mode (2/2)



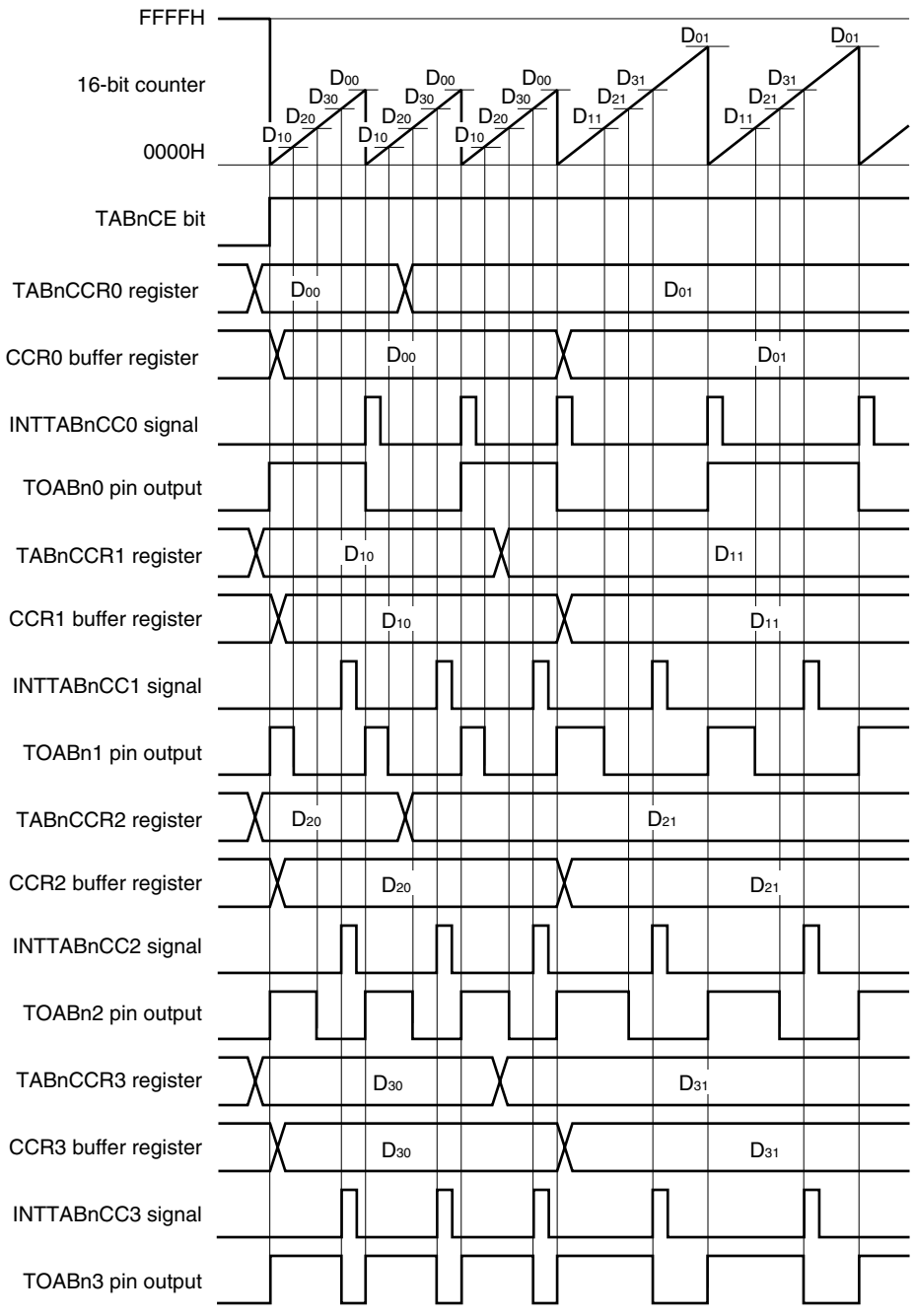
Remark k = 1 to 3,
m = 0 to 3,
n = 0, 1

(2) PWM output mode operation timing

(a) Changing pulse width during operation

To change the PWM waveform while the counter is operating, write the TABnCCR1 register last.

Rewrite the TABnCCRk register after writing the TABnCCR1 register after the INTTABnCC1 signal is detected.



Remark n = 0, 1

To transfer data from the TABnCCRm register to the CCRm buffer register, the TABnCCR1 register must be written.

To change both the cycle and active level of the PWM waveform at this time, first set the cycle to the TABnCCR0 register, set the active level width to the TABnCCR2 and TABnCCR3 registers, and then set the active level width to the TABnCCR1 register.

To change only the cycle of the PWM waveform, first set the cycle to the TABnCCR0 register, and then write the same value to the TABnCCR1 register.

To change only the active level width (duty factor) of the PWM wave, first set the active level to the TABnCCR2 and TABnCCR3 registers, and then set the active level to the TABnCCR1 register.

To change only the active level width (duty factor) of the PWM waveform output by the TOABn1 pin, only the TABnCCR1 register has to be set.

To change only the active level width (duty factor) of the PWM waveform output by the TOABn2 and TOABn3 pins, first set the active level width to the TABnCCR2 and TABnCCR3 registers, and then write the same value to the TABnCCR1 register.

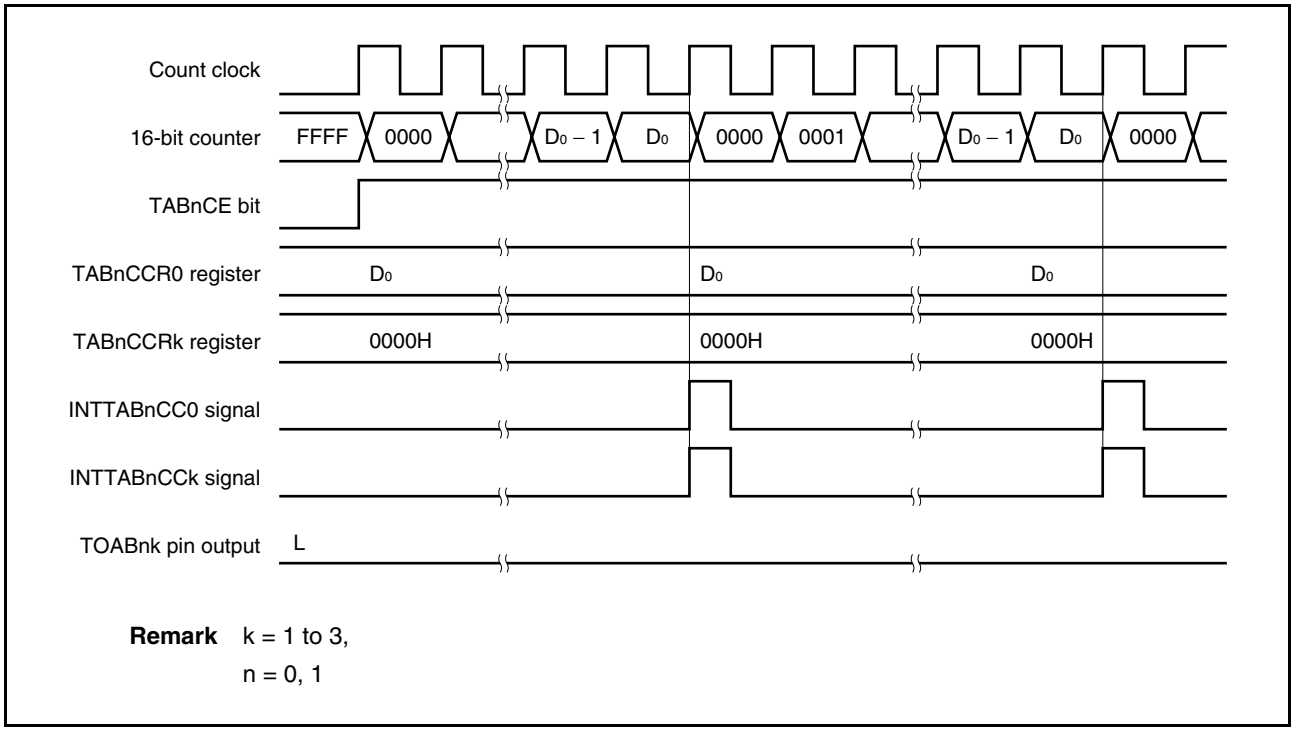
After the TABnCCR1 register is written, the value written to the TABnCCRm register is transferred to the CCRm buffer register in synchronization with the timing of clearing the 16-bit counter, and is used as the value to be compared with the value of the 16-bit counter.

To write the TABnCCR0 to TABnCCR3 registers again after writing the TABnCCR1 register once, do so after the INTTABnCC0 signal is generated. Otherwise, the value of the CCRm buffer register may become undefined because the timing of transferring data from the TABnCCRm register to the CCRm buffer register conflicts with writing the TABnCCRm register.

Remark m = 0 to 3,
n = 0, 1

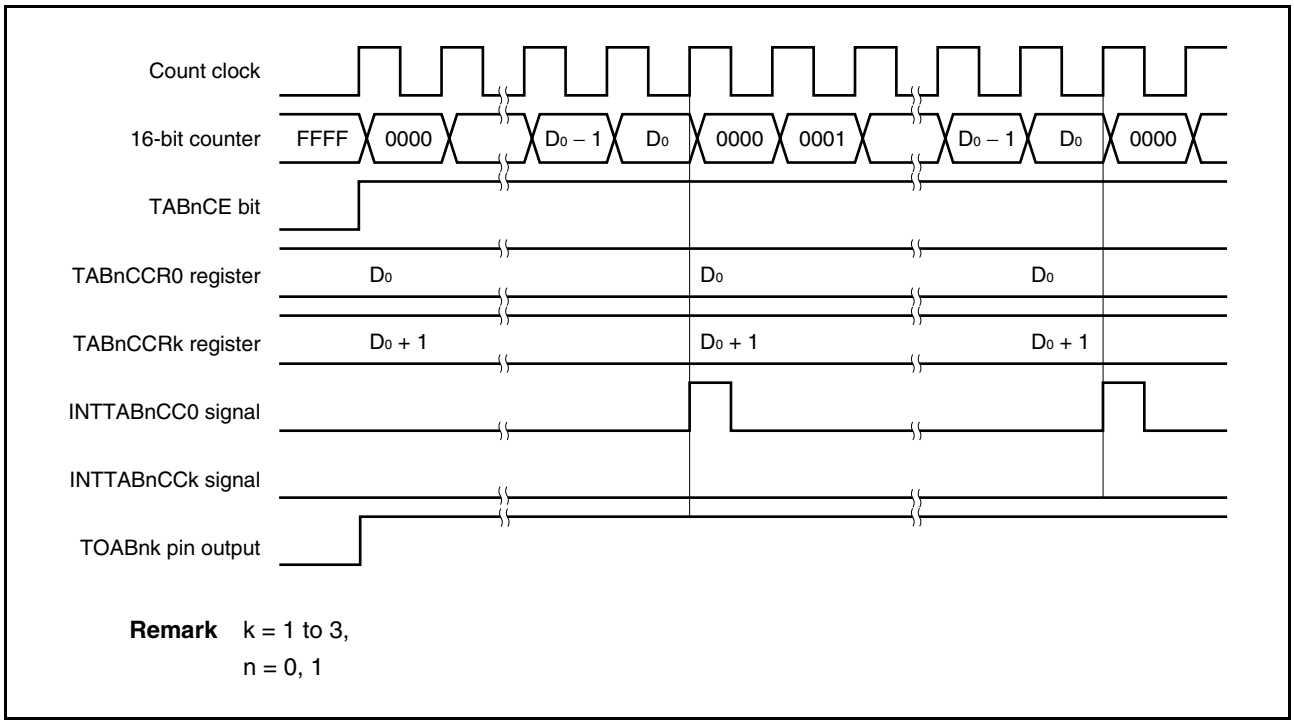
(b) 0%/100% output of PWM waveform

To output a 0% waveform, set the TABnCCRk register to 0000H. If the set value of the TABnCCR0 register is FFFFH, the INTTABnCCk signal is generated periodically.



Remark k = 1 to 3,
n = 0, 1

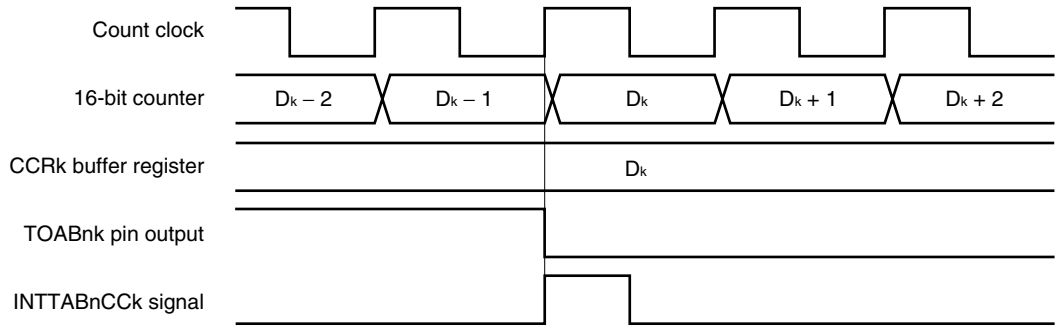
To output a 100% waveform, set a value of “set value of TABnCCR0 register + 1” to the TABnCCRk register. If the set value of the TABnCCR0 register is FFFFH, 100% output cannot be produced.



Remark k = 1 to 3,
n = 0, 1

(c) Generation timing of compare match interrupt request signal (INTTABnCCk)

The timing of generation of the INTTABnCCk signal in the PWM output mode differs from the timing of other INTTABnCCk signals; the INTTABnCCk signal is generated when the count value of the 16-bit counter matches the value of the TABnCCRk register.



Remark k = 1 to 3,
n = 0, 1

Usually, the INTTABnCCk signal is generated in synchronization with the next counting up after the count value of the 16-bit counter matches the value of the TABnCCRk register.

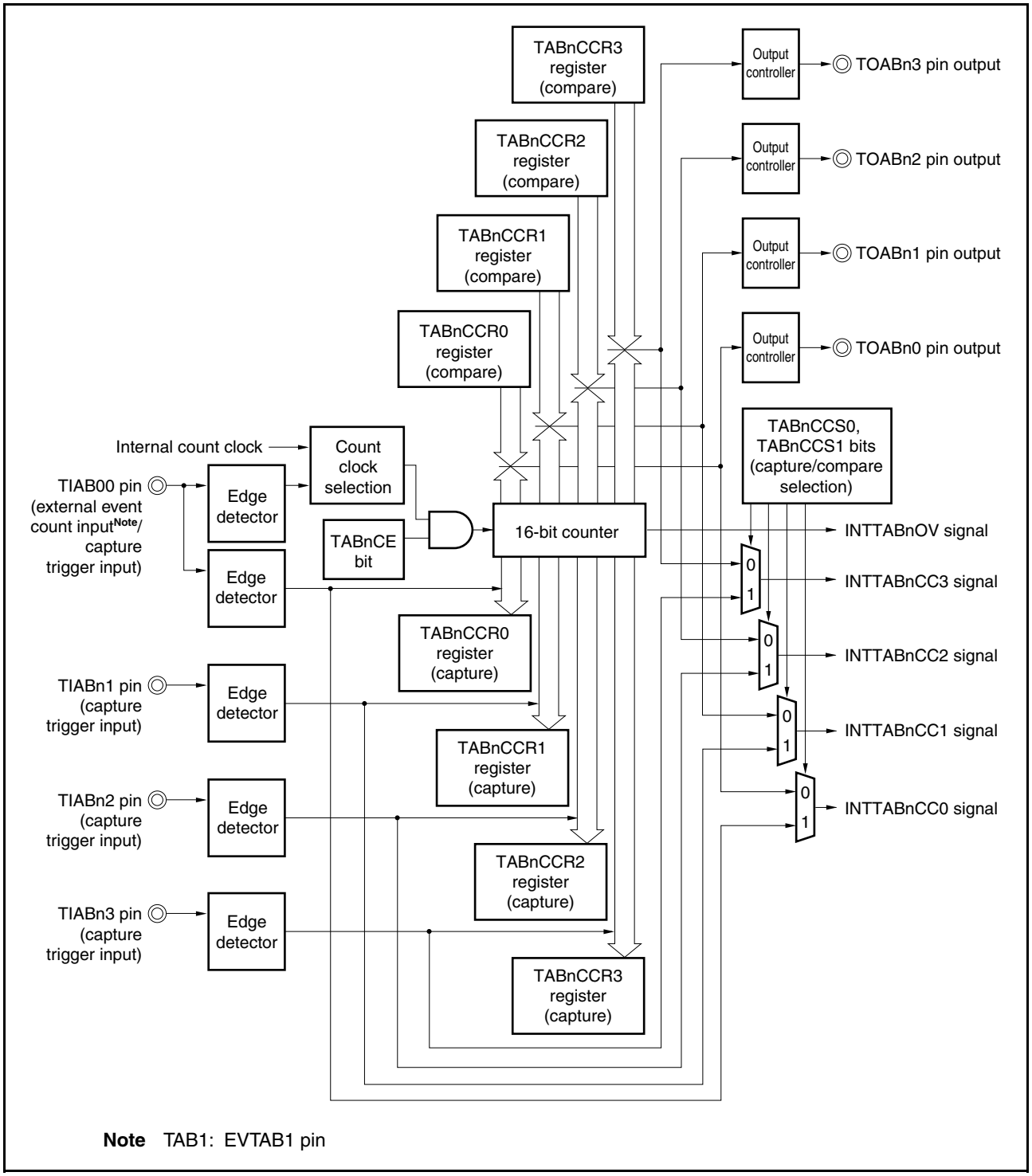
In the PWM output mode, however, it is generated one clock earlier. This is because the timing is changed to match the change timing of the output signal of the TOABnk pin.

8.5.6 Free-running timer mode (TABnMD2 to TABnMD0 bits = 101)

In the free-running timer mode, TABn starts counting when the TABnCTL0.TABnCE bit is set to 1. At this time, the TABnCCRm register can be used as a compare register or a capture register, according to the setting of the TABnOPT0.TABnCCS0 and TABnOPT0.TABnCCS1 bits.

Remark m = 0 to 3,
n = 0, 1

Figure 8-28. Configuration in Free-Running Timer Mode



Note TAB1: EVTAB1 pin

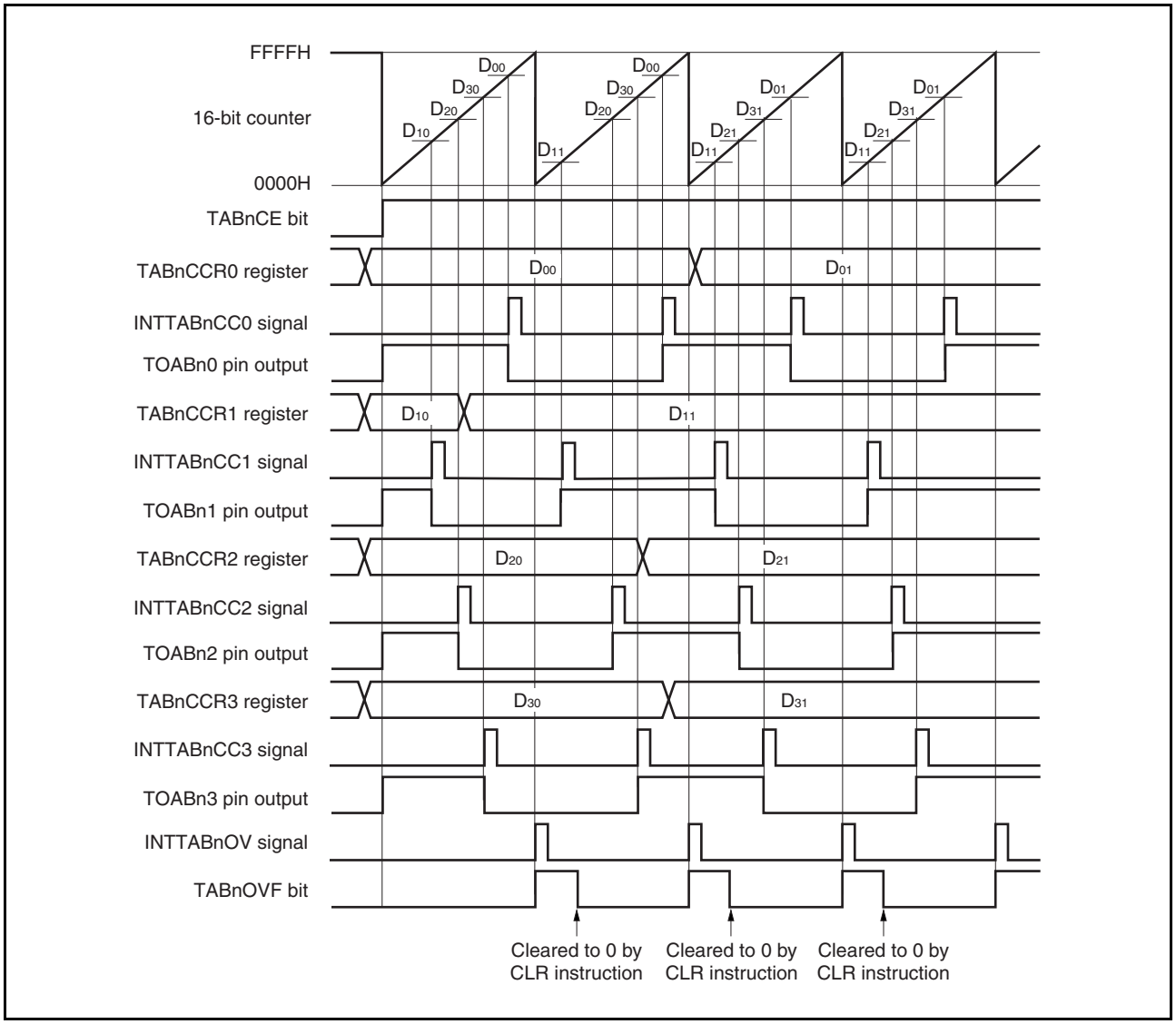
When the TABnCE bit is set to 1, TABn starts counting, and the output signals of the TOABn0 to TOABn3 pins are inverted. When the count value of the 16-bit counter subsequently matches the set value of the TABnCCRm register, a compare match interrupt request signal (INTTABnCCm) is generated, and the output signal of the TOABnm pin is inverted.

The 16-bit counter continues counting in synchronization with the count clock. When it counts up to FFFFH, it generates an overflow interrupt request signal (INTTABnOV) at the next clock, is cleared to 0000H, and continues counting. At this time, the overflow flag (TABnOPT0.TABnOVF bit) is also set to 1. Clear the overflow flag to 0 by executing the CLR instruction by software.

The TABnCCRm register can be rewritten while the counter is operating. If it is rewritten, the new value is reflected at that time, and compared with the count value.

Remark m = 0 to 3,
n = 0, 1

Figure 8-29. Basic Timing in Free-Running Timer Mode (Compare Function)



When the TABnCE bit is set to 1, the 16-bit counter starts counting. When the valid edge input to the TIABnm pin is detected, the count value of the 16-bit counter is stored in the TABnCCRm register, and a capture interrupt request signal (INTTABnCCm) is generated.

The 16-bit counter continues counting in synchronization with the count clock. When it counts up to FFFFH, it generates an overflow interrupt request signal (INTTABnOV) at the next clock, is cleared to 0000H, and continues counting. At this time, the overflow flag (TABnOVF bit) is also set to 1. Clear the overflow flag to 0 by executing the CLR instruction by software.

Remark m = 0 to 3,
n = 0, 1

Figure 8-30. Basic Timing in Free-Running Timer Mode (Capture Function)

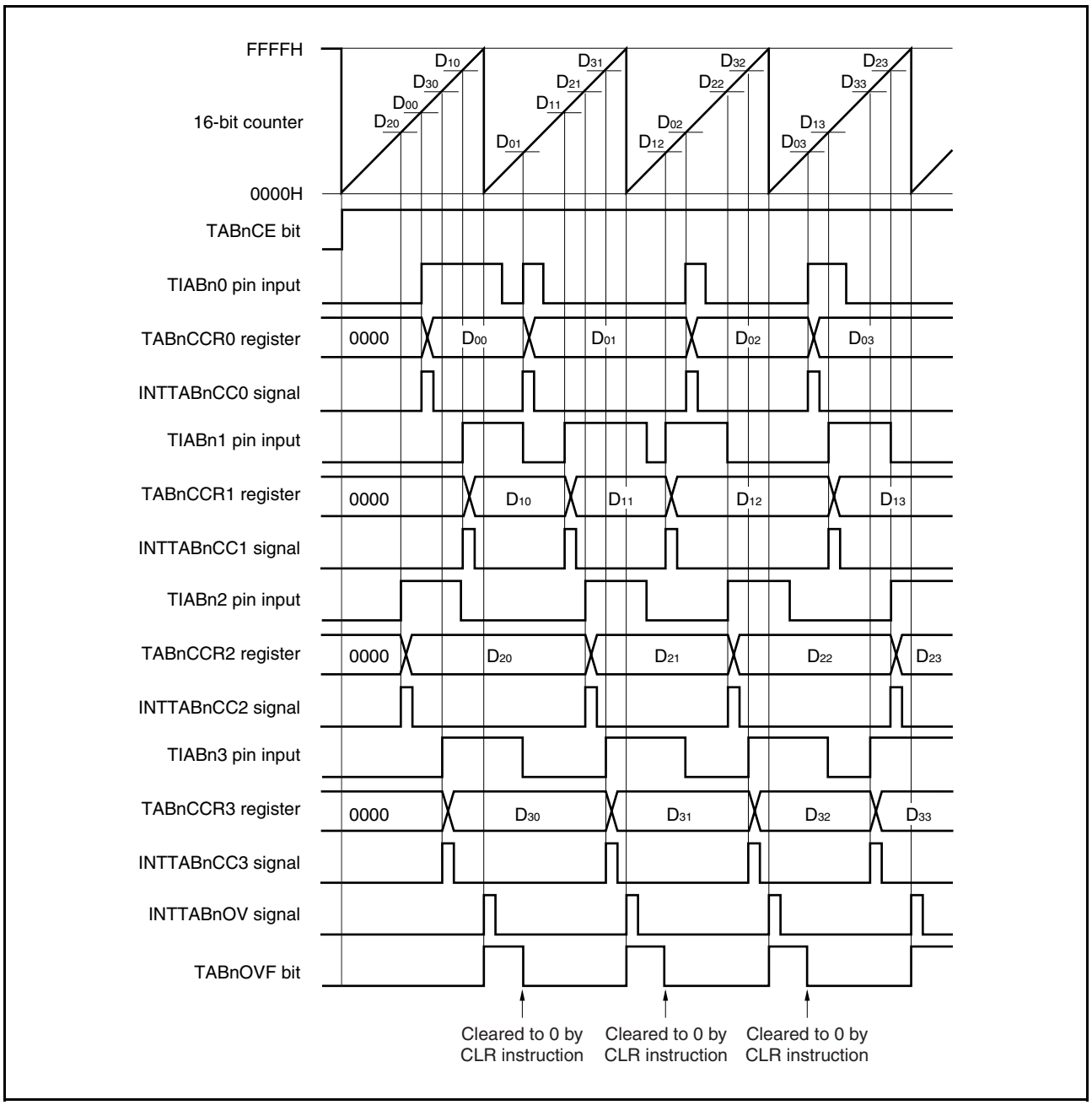
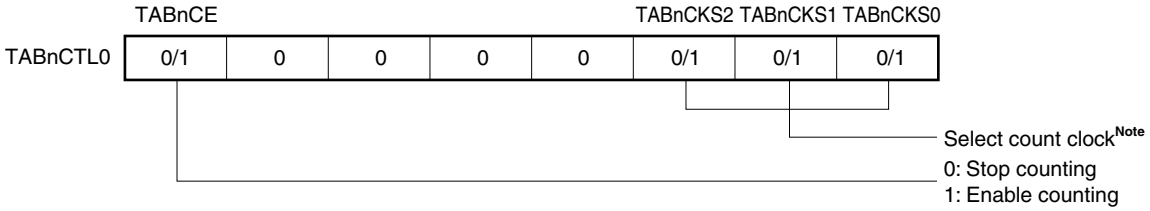


Figure 8-31. Register Setting in Free-Running Timer Mode (1/3)

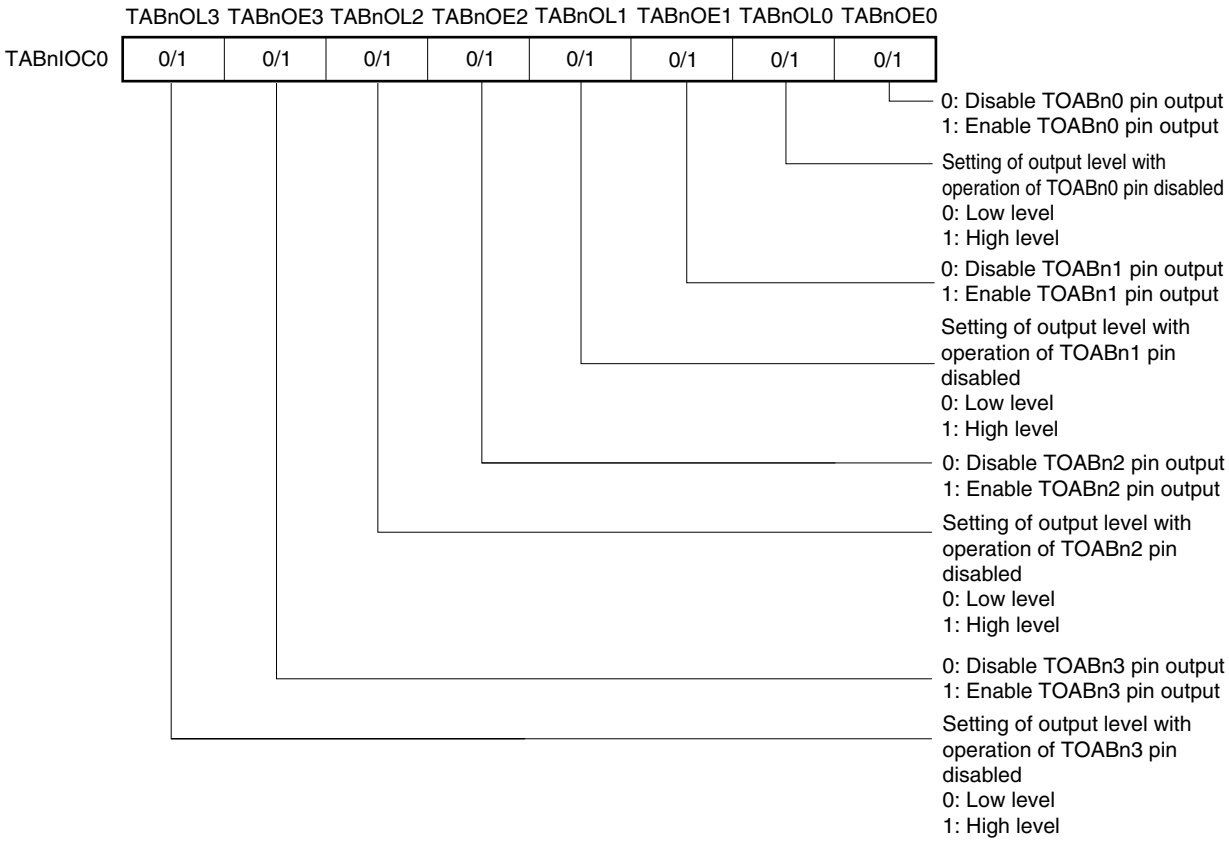
(a) TABn control register 0 (TABnCTL0)



Note The setting is invalid when the TABnCTL1.TABnEEE bit = 1

(b) TABn control register 1 (TABnCTL1)

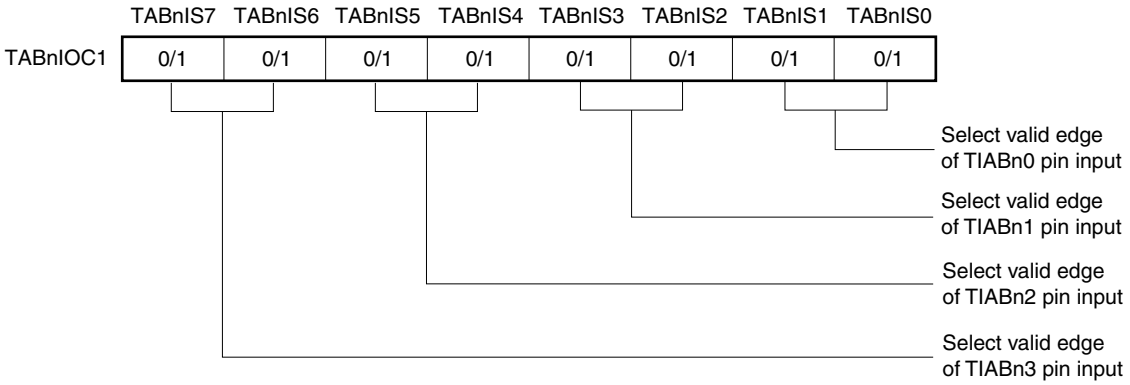
(c) TABn I/O control register 0 (TABnIOC0)



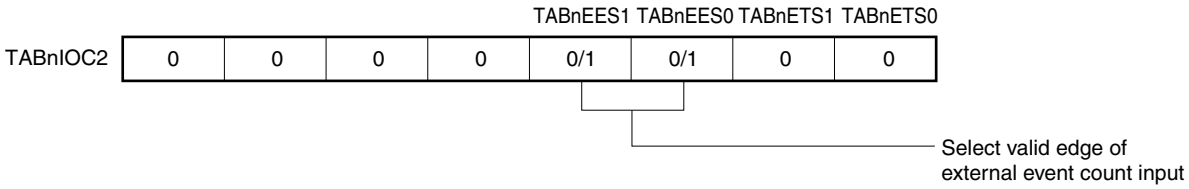
Remark n = 0, 1

Figure 8-31. Register Setting in Free-Running Timer Mode (2/3)

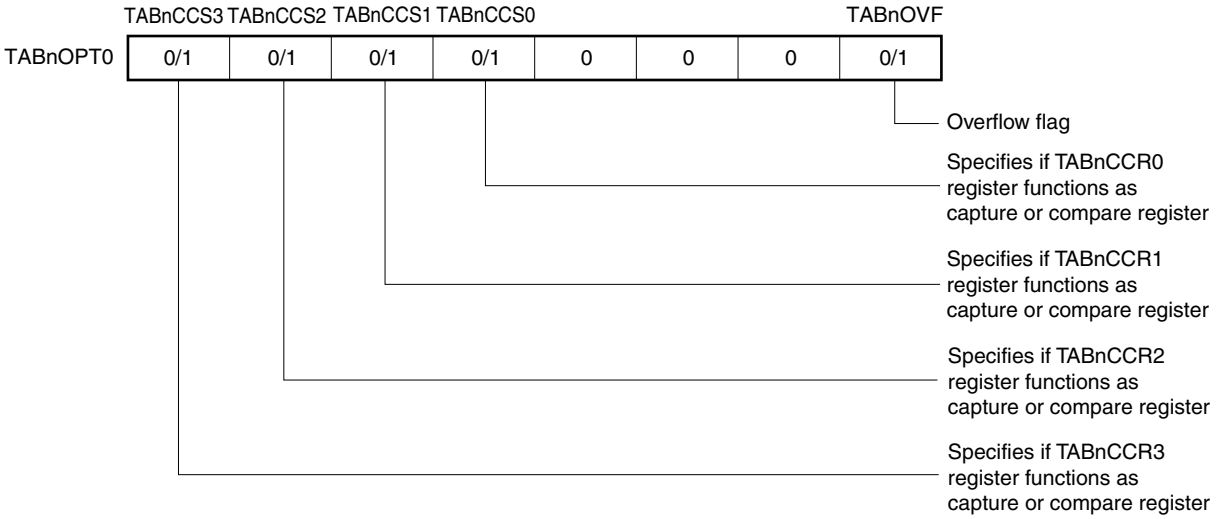
(d) TABn I/O control register 1 (TABnIOC1)



(e) TABn I/O control register 2 (TABnIOC2)



(f) TABn option register 0 (TABnOPT0)



(g) TABn counter read buffer register (TABnCNT)

The value of the 16-bit counter can be read by reading the TABnCNT register.

Remark n = 0, 1

Figure 8-31. Register Setting in Free-Running Timer Mode (3/3)

(h) TABn capture/compare registers 0 to 3 (TABnCCR0 to TABnCCR3)

These registers function as capture registers or compare registers according to the setting of the TABnOPT0.TABnCCSm bit.

When the registers function as capture registers, they store the count value of the 16-bit counter when the valid edge input to the TIABnm pin is detected.

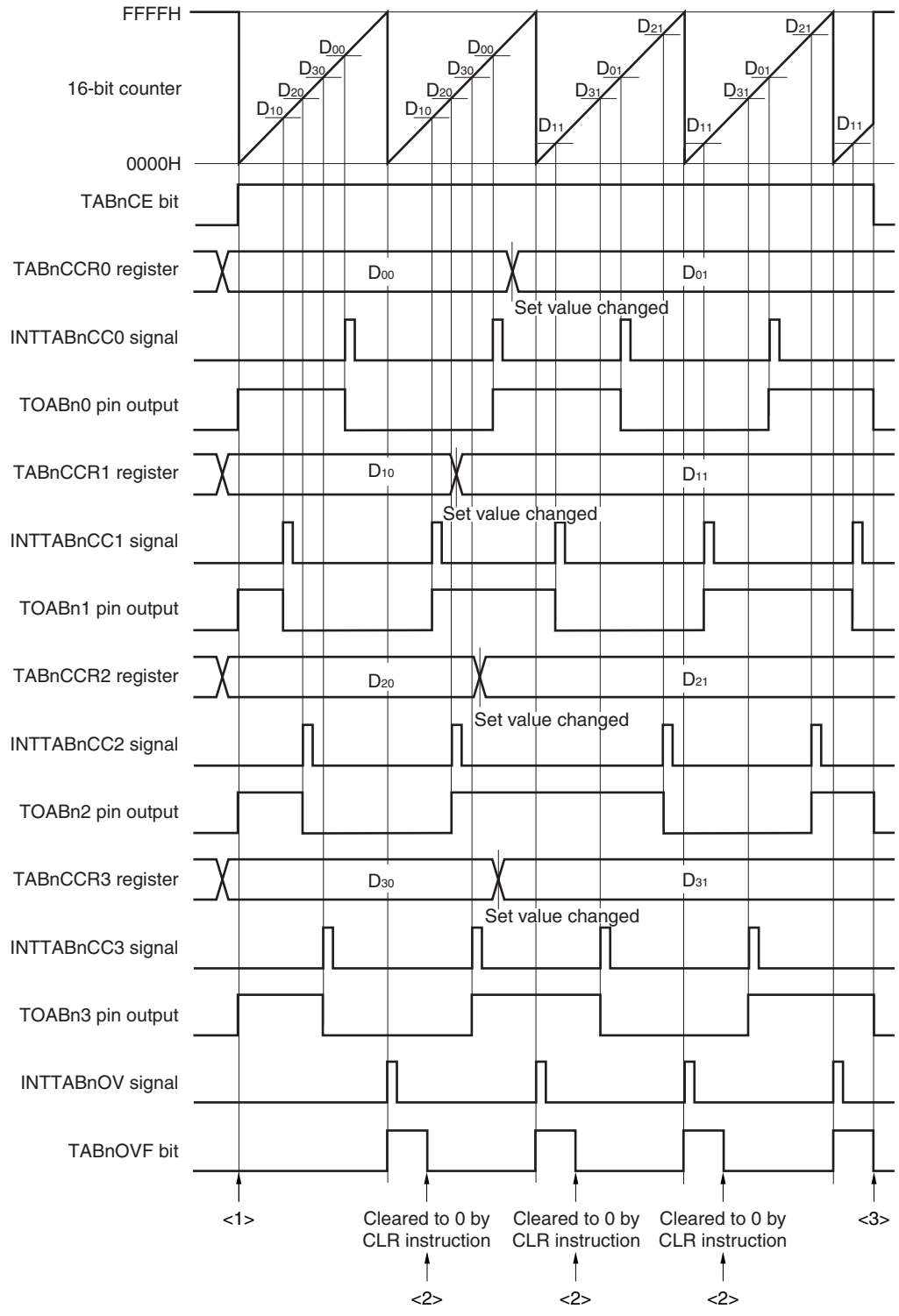
When the registers function as compare registers and when D_m is set to the TABnCCRm register, the INTTABnCCm signal is generated when the counter reaches (D_m + 1), and the output signal of the TOABnm pin is inverted.

Remark m = 0 to 3,
n = 0, 1

(1) Operation flow in free-running timer mode

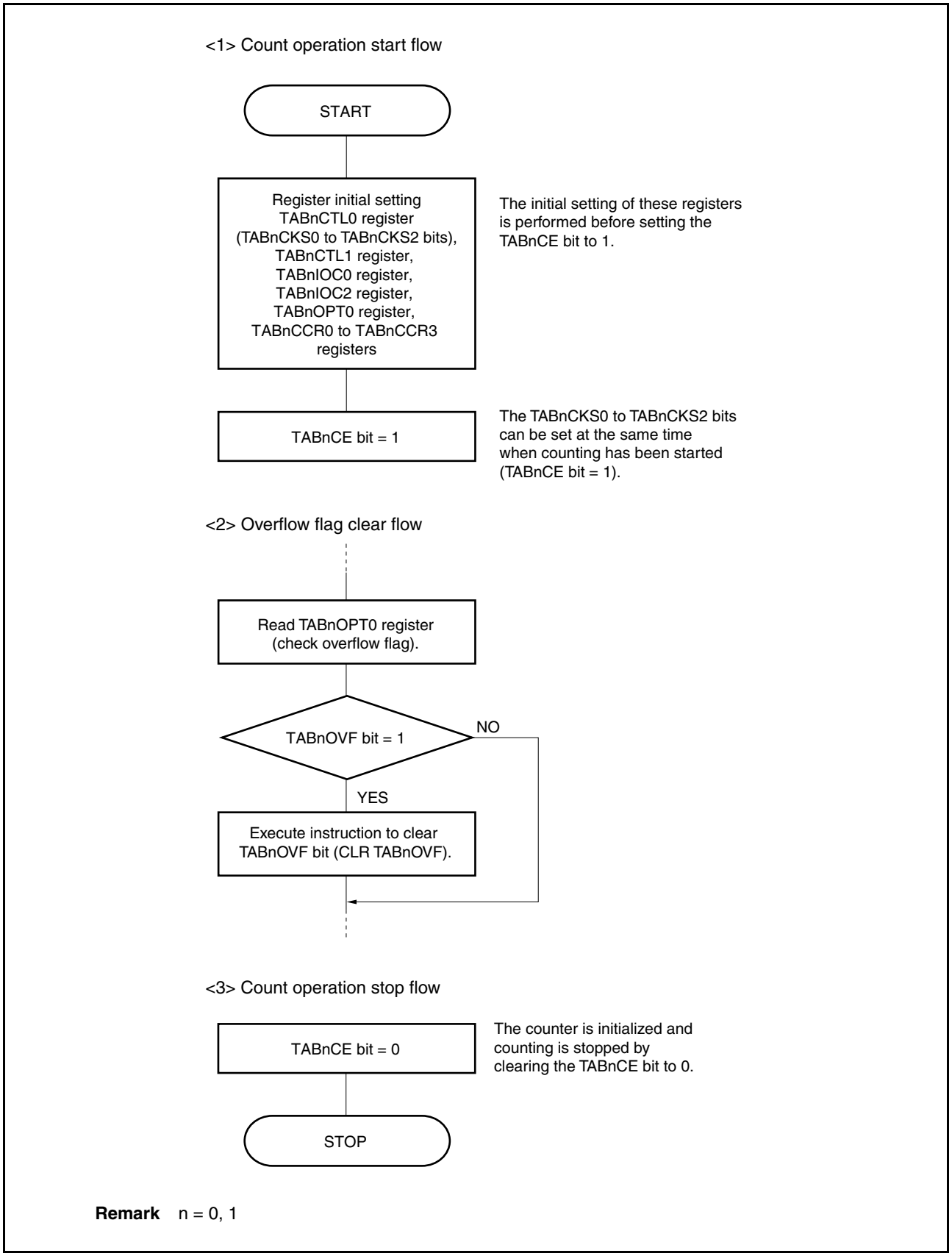
(a) When using capture/compare register as compare register

Figure 8-32. Software Processing Flow in Free-Running Timer Mode (Compare Function) (1/2)



Remark n = 0, 1

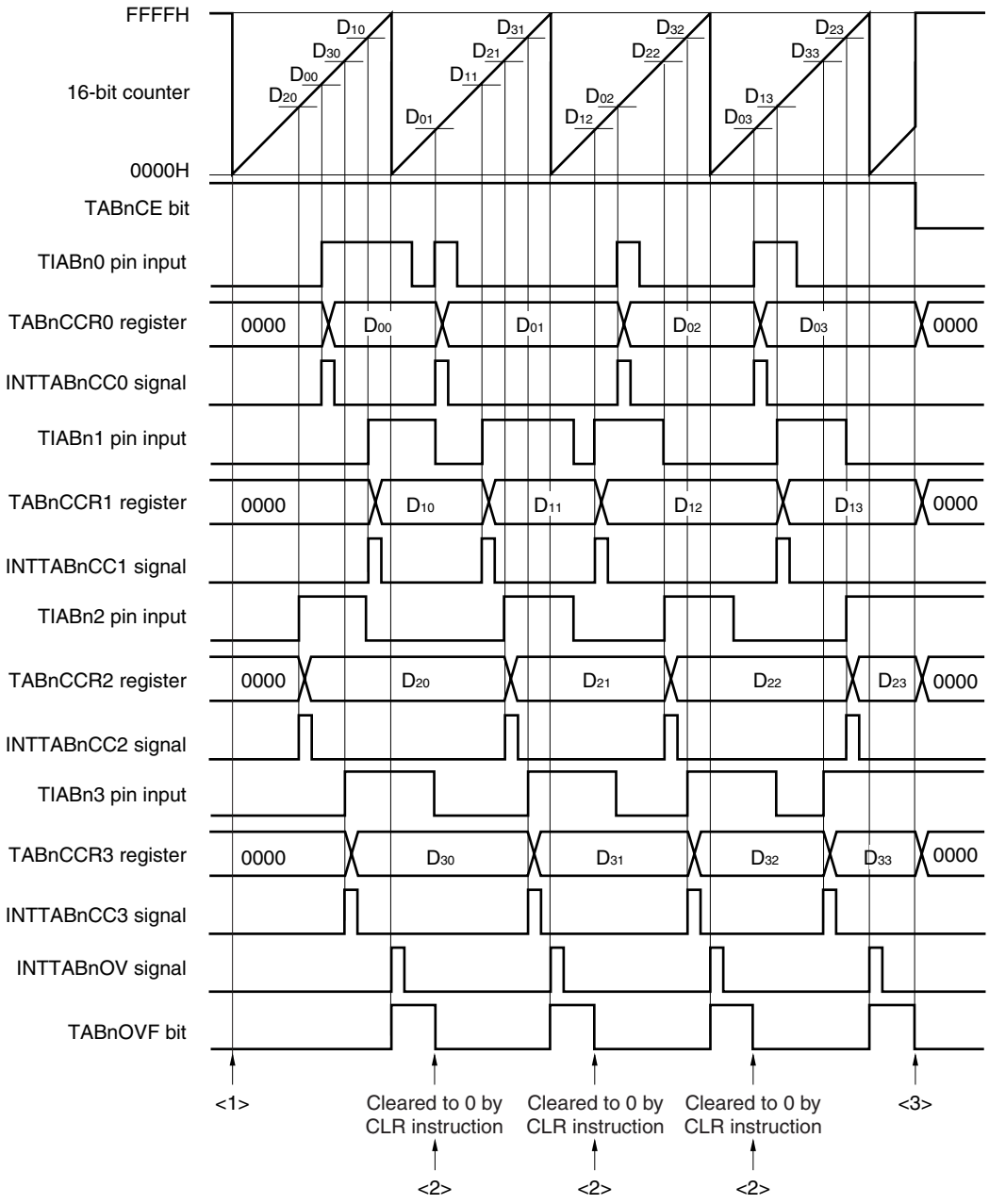
Figure 8-32. Software Processing Flow in Free-Running Timer Mode (Compare Function) (2/2)



Remark n = 0, 1

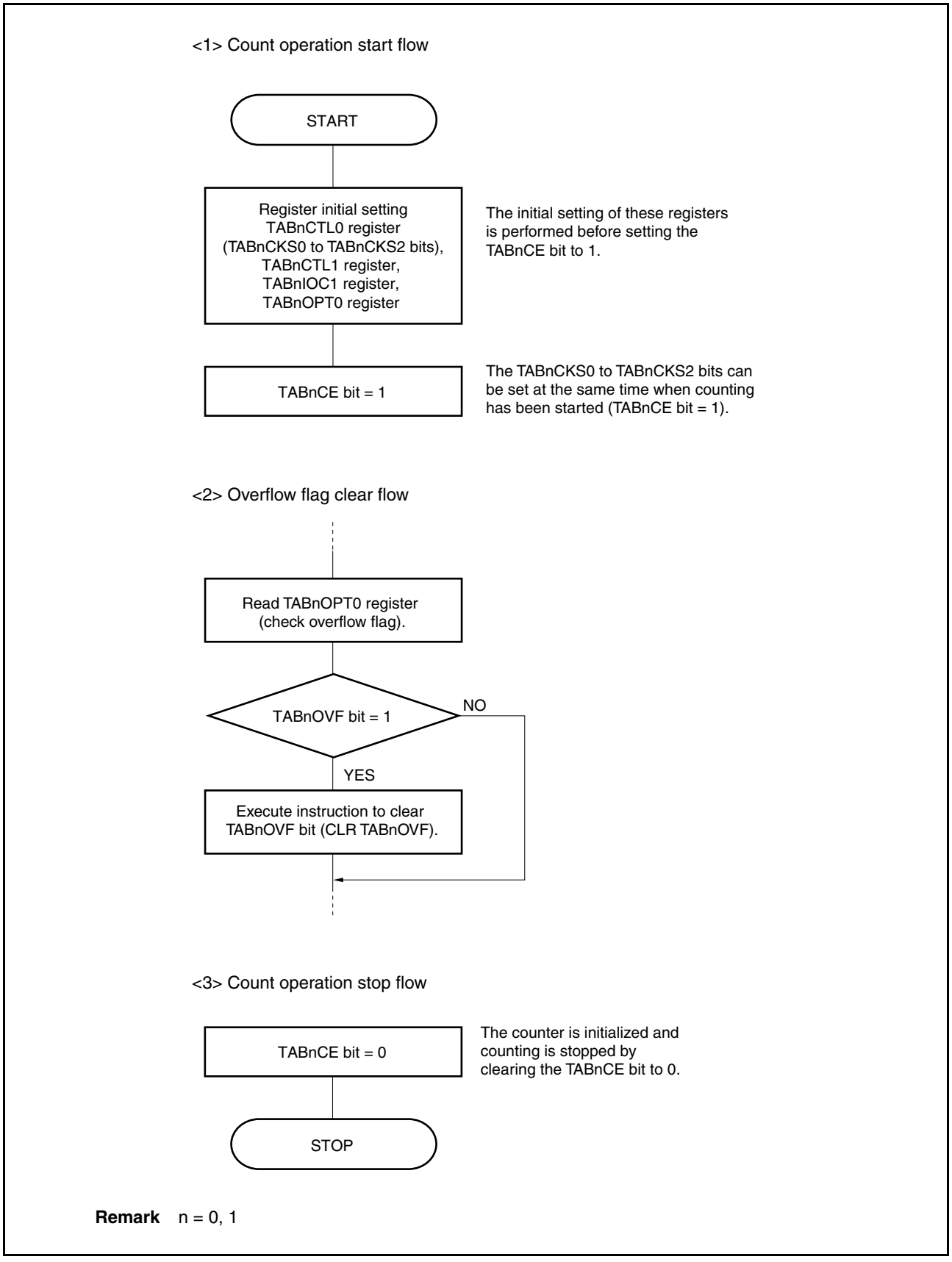
(b) When using capture/compare register as capture register

Figure 8-33. Software Processing Flow in Free-Running Timer Mode (Capture Function) (1/2)



Remark n = 0, 1

Figure 8-33. Software Processing Flow in Free-Running Timer Mode (Capture Function) (2/2)

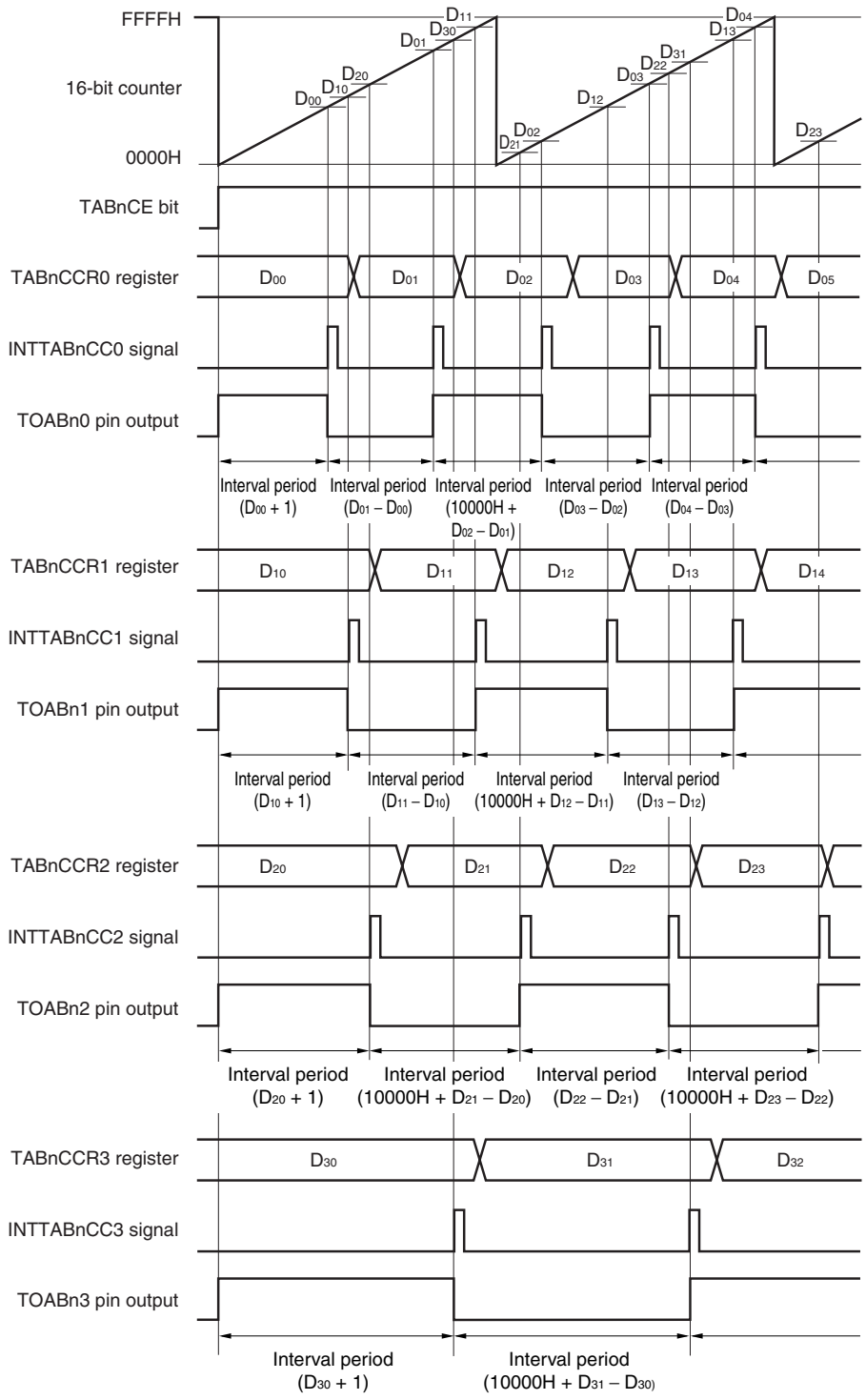


Remark n = 0, 1

(2) Operation timing in free-running timer mode

(a) Interval operation with compare register

When TABn is used as an interval timer with the TABnCCRm register used as a compare register, software processing is necessary for setting a comparison value to generate the next interrupt request signal each time the INTTABnCCm signal has been detected.



Remark n = 0, 1

When performing an interval operation in the free-running timer mode, four intervals can be set with one channel.

To perform the interval operation, the value of the corresponding TABnCCRm register must be re-set in the interrupt servicing that is executed when the INTTABnCCm signal is detected.

The set value for re-setting the TABnCCRm register can be calculated by the following expression, where "D_m" is the interval period.

Compare register default value: $D_m - 1$

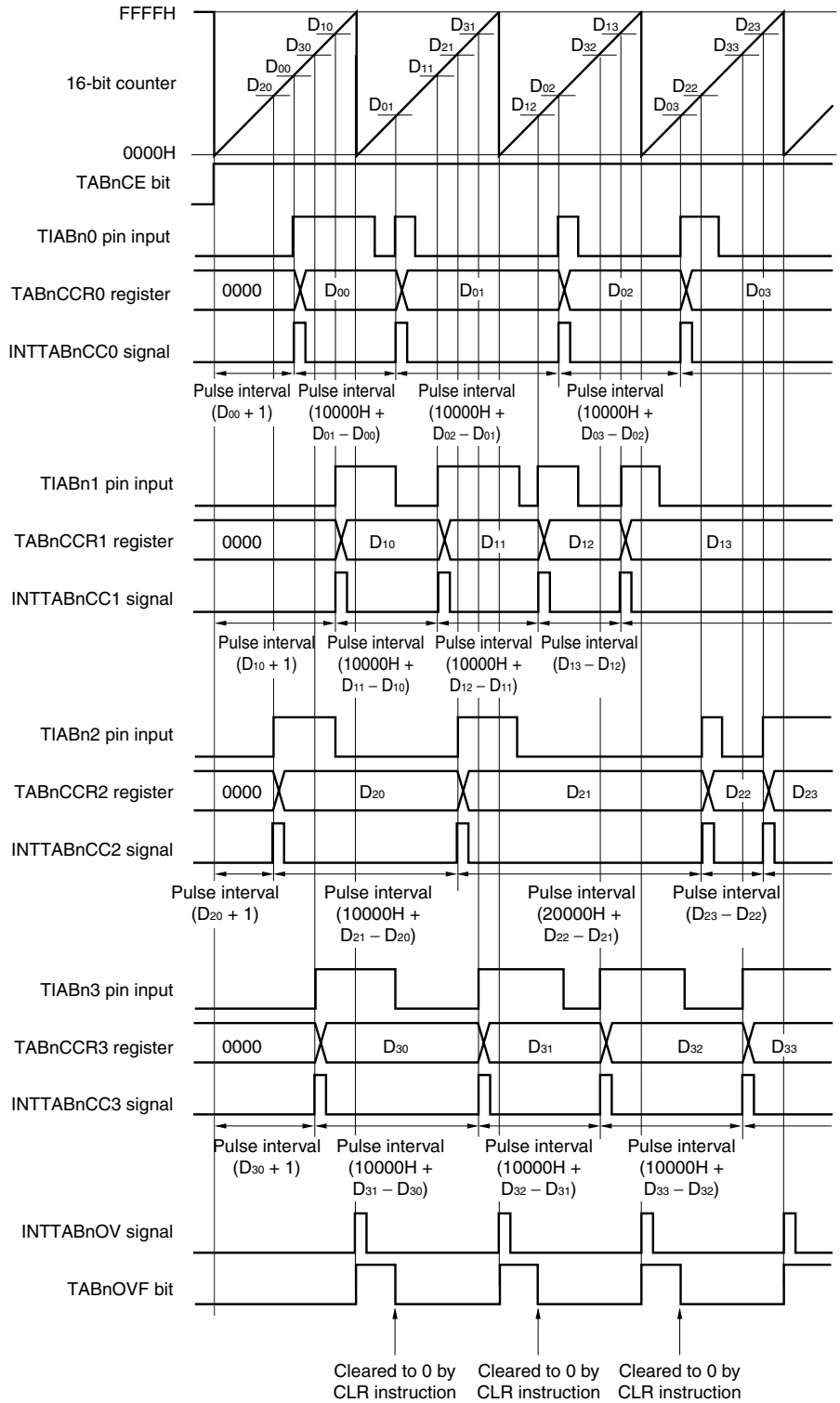
Value set to compare register second and subsequent times: Previous set value + D_m

(If the calculation result is greater than FFFFH, subtract 10000H from the result and set this value to the register.)

Remark m = 0 to 3,
n = 0, 1

(b) Pulse width measurement with capture register

When pulse width measurement is performed with the TABnCCRm register used as a capture register, software processing is necessary for reading the capture register each time the INTTABnCCm signal has been detected and for calculating an interval.



Remark n = 0, 1

When executing pulse width measurement in the free-running timer mode, four pulse widths can be measured with one channel.

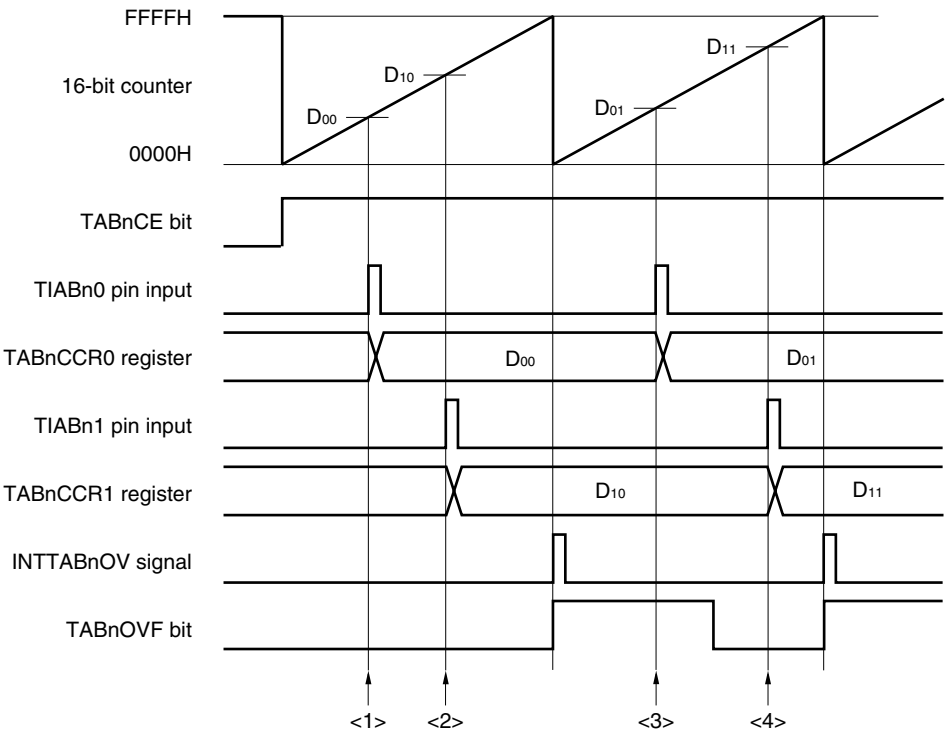
To measure a pulse width, the pulse width can be calculated by reading the value of the TABnCCRm register in synchronization with the INTTABnCCm signal, and calculating the difference between the value read this time and the previously read value.

Remark m = 0 to 3,
n = 0, 1

(c) Processing of overflow when two or more capture registers are used

Care must be exercised in processing the overflow flag when two or more capture registers are used. First, an example of incorrect processing is shown below.

Example of incorrect processing when two or more capture registers are used



The following problem may occur when two pulse widths are measured in the free-running timer mode.

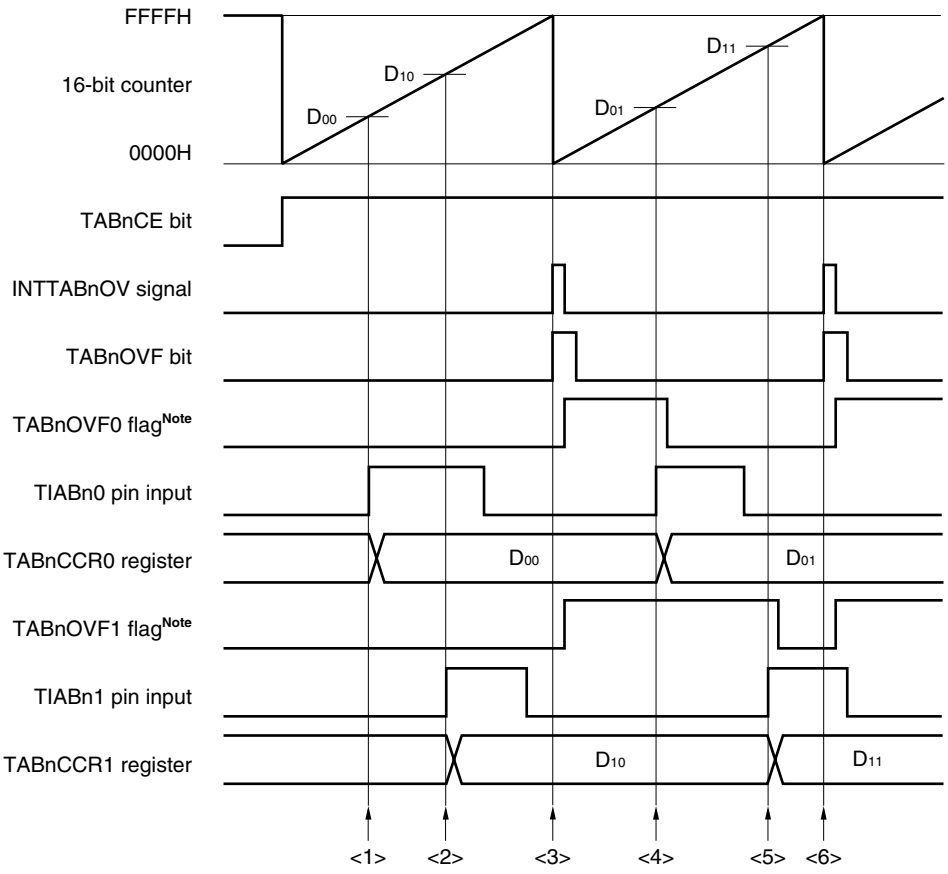
<1> Read the TABnCCR0 register (setting of the default value of the TIABn0 pin input).
<2> Read the TABnCCR1 register (setting of the default value of the TIABn1 pin input).
<3> Read the TABnCCR0 register.
Read the overflow flag. If the overflow flag is 1, clear it to 0.
Because the overflow flag is 1, the pulse width can be calculated by (10000H + D_{01} − D_{00}).
<4> Read the TABnCCR1 register.
Read the overflow flag. Because the flag is cleared in <3>, 0 is read.
Because the overflow flag is 0, the pulse width can be calculated by (D_{11} − D_{10}) (incorrect).

Remark n = 0, 1

When two or more capture registers are used, and if the overflow flag is cleared to 0 by one capture register, the other capture register may not obtain the correct pulse width.
Use software when using two or more capture registers. An example of how to use software is shown below.

(1/2)

Example when two capture registers are used (using overflow interrupt)



Note The TABnOVF0 and TABnOVF1 flags are set in the internal RAM by software.

<1> Read the TABnCCR0 register (setting of the default value of the TIABn0 pin input).

<2> Read the TABnCCR1 register (setting of the default value of the TIABn1 pin input).

<3> An overflow occurs. Set the TABnOVF0 and TABnOVF1 flags to 1 in the overflow interrupt servicing, and clear the overflow flag to 0.

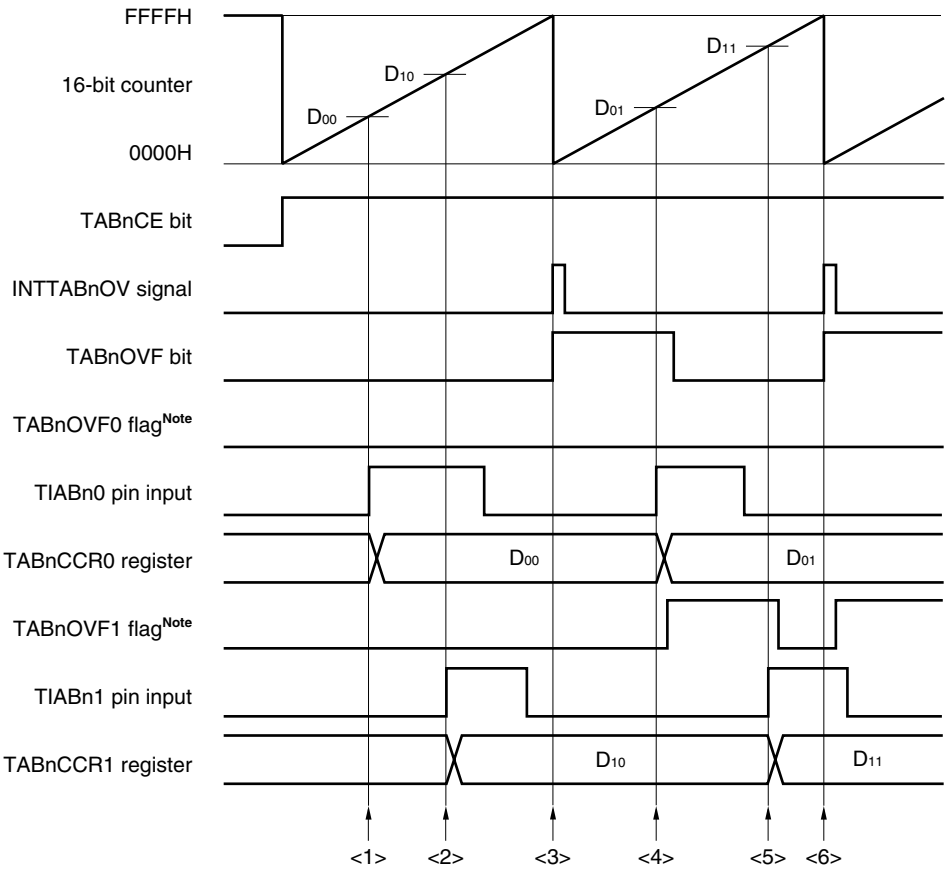
<4> Read the TABnCCR0 register.
Read the TABnOVF0 flag. If the TABnOVF0 flag is 1, clear it to 0.
Because the TABnOVF0 flag is 1, the pulse width can be calculated by (10000H + D_{01} − D_{00}).

<5> Read the TABnCCR1 register.
Read the TABnOVF1 flag. If the TABnOVF1 flag is 1, clear it to 0 (the TABnOVF0 flag is cleared in <4>, and the TABnOVF1 flag remains 1).
Because the TABnOVF1 flag is 1, the pulse width can be calculated by (10000H + D_{11} − D_{10}) (correct).

<6> Same as <3>

(2/2)

Example when two capture registers are used (without using overflow interrupt)



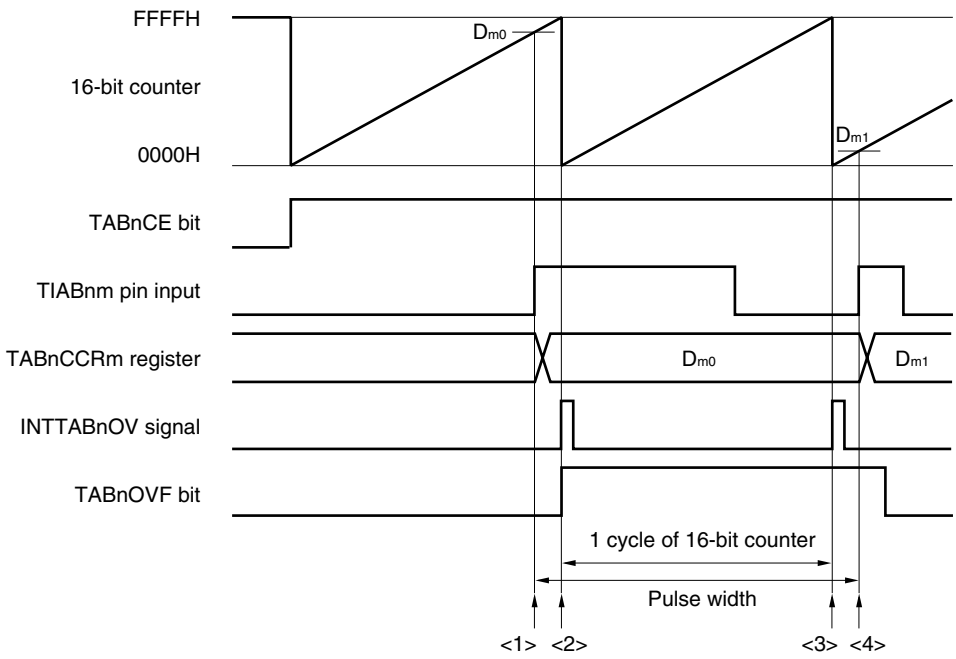
Note The TABnOVF0 and TABnOVF1 flags are set in the internal RAM by software.

<1> Read the TABnCCR0 register (setting of the default value of the TIABn0 pin input).
<2> Read the TABnCCR1 register (setting of the default value of the TIABn1 pin input).
<3> An overflow occurs. Nothing is done by software.
<4> Read the TABnCCR0 register.
Read the overflow flag. If the overflow flag is 1, set only the TABnOVF1 flag to 1, and clear the overflow flag to 0.
Because the overflow flag is 1, the pulse width can be calculated by (10000H + D_{01} − D_{00}).
<5> Read the TABnCCR1 register.
Read the overflow flag. Because the overflow flag is cleared in <4>, 0 is read.
Read the TABnOVF1 flag. If the TABnOVF1 flag is 1, clear it to 0.
Because the TABnOVF1 flag is 1, the pulse width can be calculated by (10000H + D_{11} − D_{10}) (correct).
<6> Same as <3>

(d) Processing of overflow if capture trigger interval is long

If the pulse width is greater than one cycle of the 16-bit counter, care must be exercised because an overflow may occur more than once from the first capture trigger to the next. First, an example of incorrect processing is shown below.

Example of incorrect processing when capture trigger interval is long



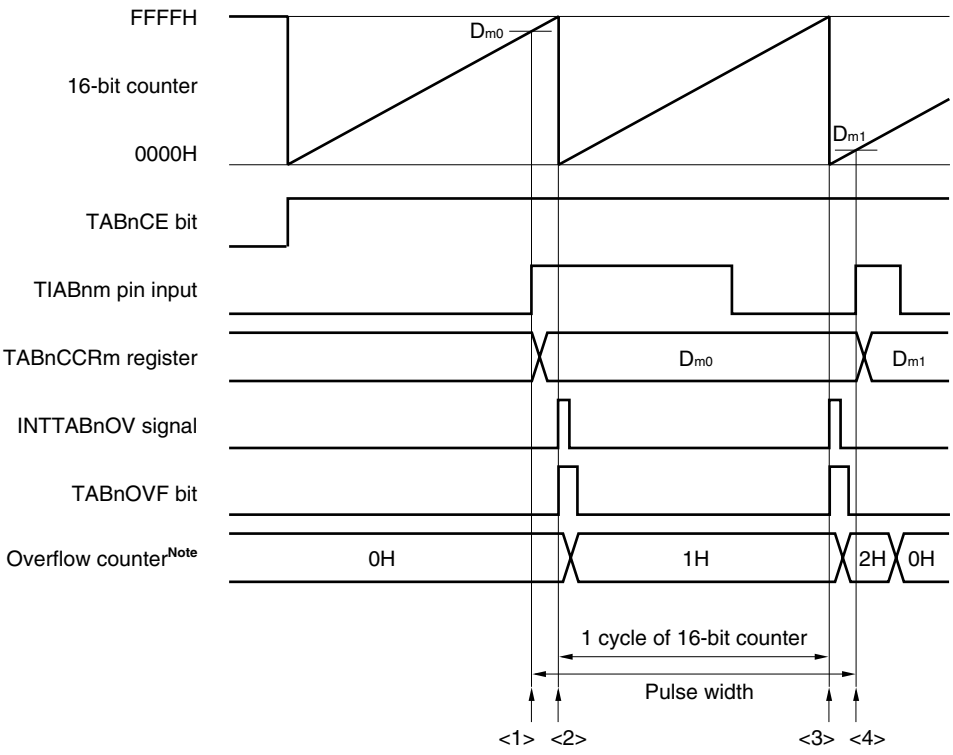
The following problem may occur when a long pulse width is measured in the free-running timer mode.

<1> Read the TABnCCRm register (setting of the default value of the TIABnm pin input).
<2> An overflow occurs. Nothing is done by software.
<3> An overflow occurs a second time. Nothing is done by software.
<4> Read the TABnCCRm register.
Read the overflow flag. If the overflow flag is 1, clear it to 0.
Because the overflow flag is 1, the pulse width can be calculated by (10000H + D_{m1} − D_{m0}) (incorrect).
Actually, the pulse width must be (20000H + D_{m1} − D_{m0}) because an overflow occurs twice.

Remark m = 0 to 3,
n = 0, 1

If an overflow occurs twice or more when the capture trigger interval is long, the correct pulse width may not be obtained.
If the capture trigger interval is long, slow the count clock to lengthen one cycle of the 16-bit counter, or use software. An example of how to use software is shown next.

Example when capture trigger interval is long



Note The overflow counter is set arbitrarily by software in the internal RAM.

<1> Read the TABnCCRm register (setting of the default value of the TIABnm pin input).

<2> An overflow occurs. Increment the overflow counter and clear the overflow flag to 0 in the overflow interrupt servicing.

<3> An overflow occurs a second time. Increment (+1) the overflow counter and clear the overflow flag to 0 in the overflow interrupt servicing.

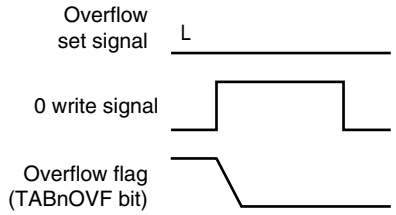
<4> Read the TABnCCRm register.
Read the overflow counter.
When the overflow counter is "N", the pulse width can be calculated by ($N \times 10000H + D_{m1} - D_{m0}$).
In this example, the pulse width is ($20000H + D_{m1} - D_{m0}$) because an overflow occurs twice.
Clear the overflow counter (0H).

Remark m = 0 to 3,
n = 0, 1

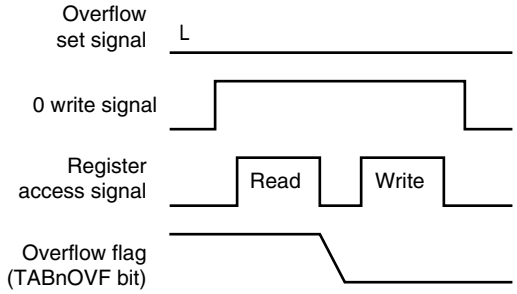
(e) Clearing overflow flag

The overflow flag can be cleared to 0 by clearing the TABnOVF bit to 0 with the CLR instruction and by writing 8-bit data (bit 0 is 0) to the TABnOPT0 register. To accurately detect an overflow, read the TABnOVF bit when it is 1, and then clear the overflow flag by using a bit manipulation instruction.

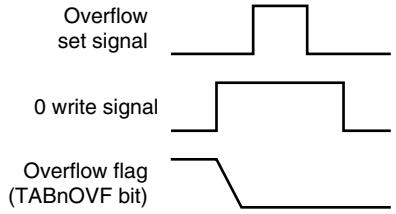
(i) Operation to write 0 (without conflict with setting)



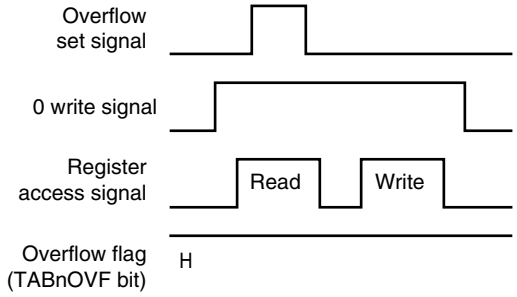
(iii) Operation to clear to 0 (without conflict with setting)



(ii) Operation to write 0 (conflict with setting)



(iv) Operation to clear to 0 (conflict with setting)



Remark n = 0, 1

To clear the overflow flag to 0, read the overflow flag to check if it is set to 1, and clear it with the CLR instruction. If 0 is written to the overflow flag without checking if the flag is 1, the set overflow information may be erased by writing 0 ((ii) in the above chart). Therefore, software may judge that no overflow has occurred even when an overflow actually has occurred.

If execution of the CLR instruction conflicts with occurrence of an overflow when the overflow flag is cleared to 0 with the CLR instruction, the overflow flag remains set even after execution of the CLR instruction.

8.5.7 Pulse width measurement mode (TABnMD2 to TABnMD0 bits = 110)

In the pulse width measurement mode, TABn starts counting when the TABnCTL0.TABnCE bit is set to 1. Each time the valid edge input to the TIABnm pin has been detected, the count value of the 16-bit counter is stored in the TABnCCRm register, and the 16-bit counter is cleared to 0000H.

The interval of the valid edge can be measured by reading the TABnCCRm register after a capture interrupt request signal (INTTABnCCm) occurs.

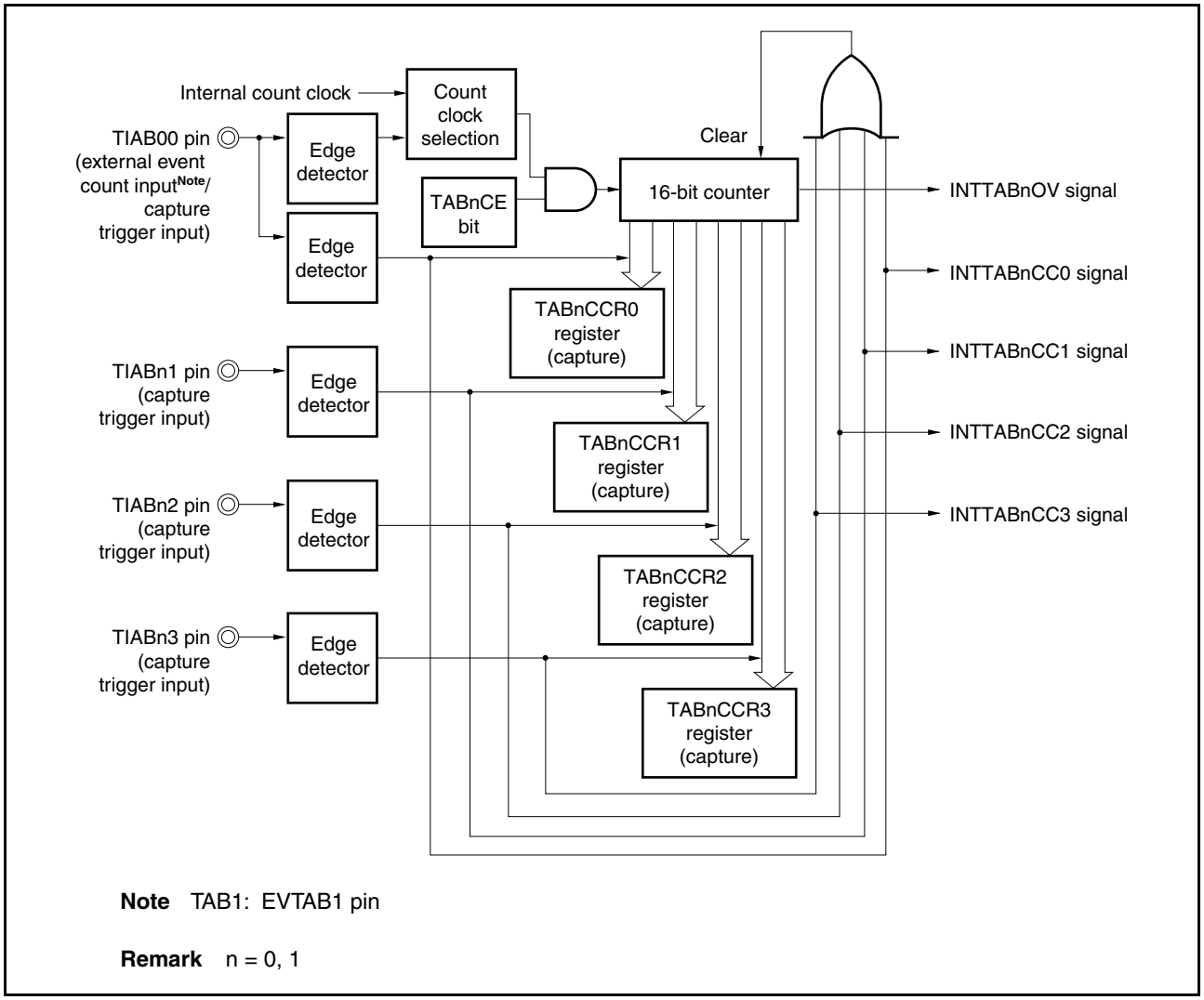
Select one of the TIABn0 to TIABn3 pins as the capture trigger input pin. Specify “No edge detected” for the unused pins by using the TABnIOC1 register.

When an external clock is used as the count clock, measure the pulse width of the TIAB0k pin because the external clock is fixed to the TIAB00 pin. At this time, clear the TAB0IOC1.TAB0IS1 and TAB0IOC1.TAB0IS0 bits to 00 (capture trigger input (TIAB00 pin): No edge detected).

For TAB1, the external clock is input from the EVTAB1 pin, and the pulse width can be measured by using the TIAB10 to TIAB13 pins.

Remark m = 0 to 3,
n = 0, 1
k = 1 to 3

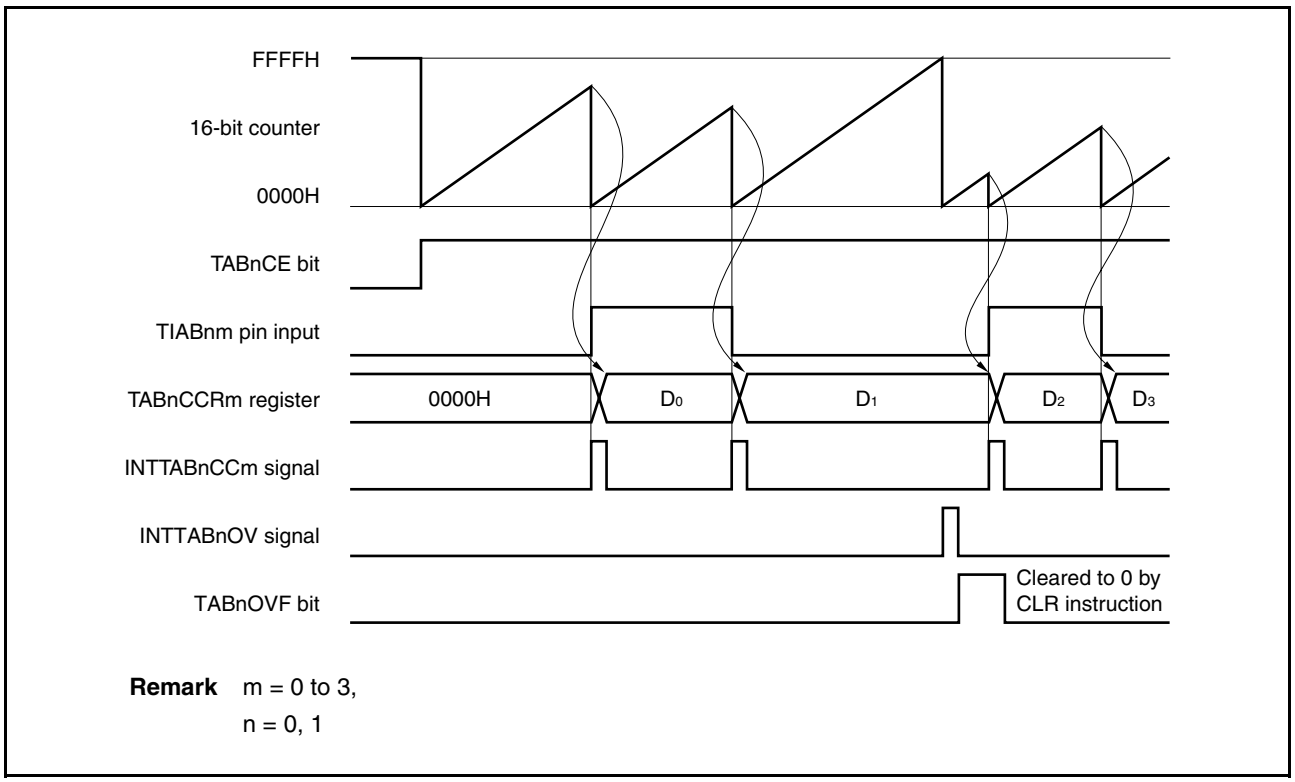
Figure 8-34. Configuration in Pulse Width Measurement Mode



Note TAB1: EVTAB1 pin

Remark n = 0, 1

Figure 8-35. Basic Timing in Pulse Width Measurement Mode



Remark m = 0 to 3,
n = 0, 1

When the TABnCE bit is set to 1, the 16-bit counter starts counting. When the valid edge input to the TIABnm pin is later detected, the count value of the 16-bit counter is stored in the TABnCCRm register, the 16-bit counter is cleared to 0000H, and a capture interrupt request signal (INTTABnCCm) is generated.

The pulse width is calculated as follows.

Pulse width = Captured value × Count clock cycle

If the valid edge is not input to the TIABnm pin even when the 16-bit counter has counted up to FFFFH, an overflow interrupt request signal (INTTABnOV) is generated at the next count clock, and the counter is cleared to 0000H and continues counting. At this time, the overflow flag (TABnOPT0.TABnOVF bit) is also set to 1. Clear the overflow flag to 0 by executing the CLR instruction via software.

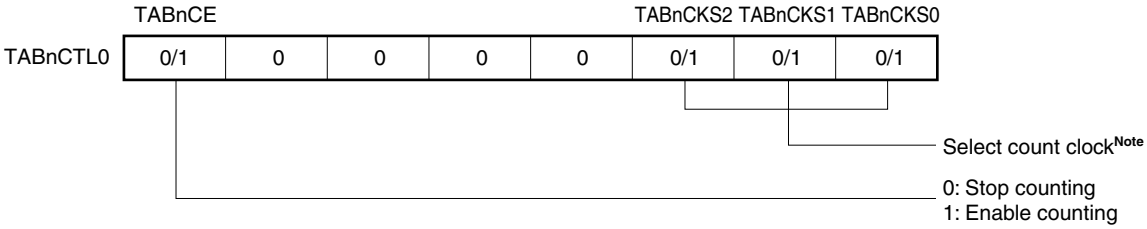
If the overflow flag is set to 1, the pulse width can be calculated as follows.

Pulse width = (10000H × TABnOVF bit setting (1) count + Captured value) × Count clock cycle

Remark m = 0 to 3,
n = 0, 1

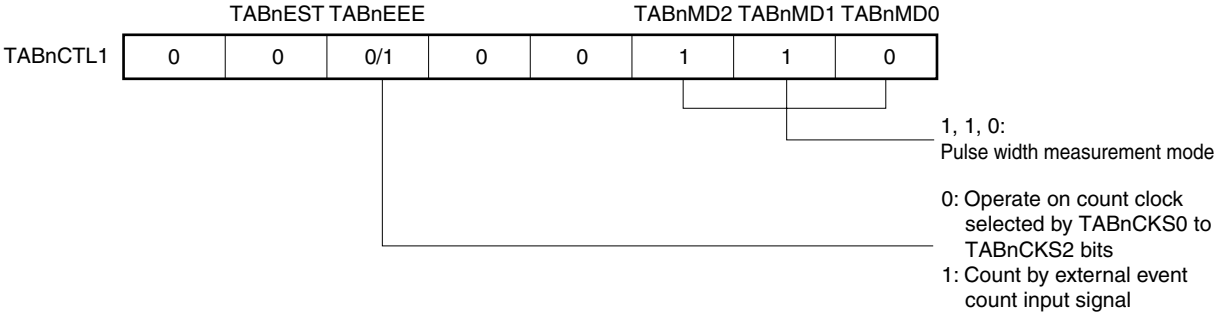
Figure 8-36. Register Setting in Pulse Width Measurement Mode (1/2)

(a) TABn control register 0 (TABnCTL0)

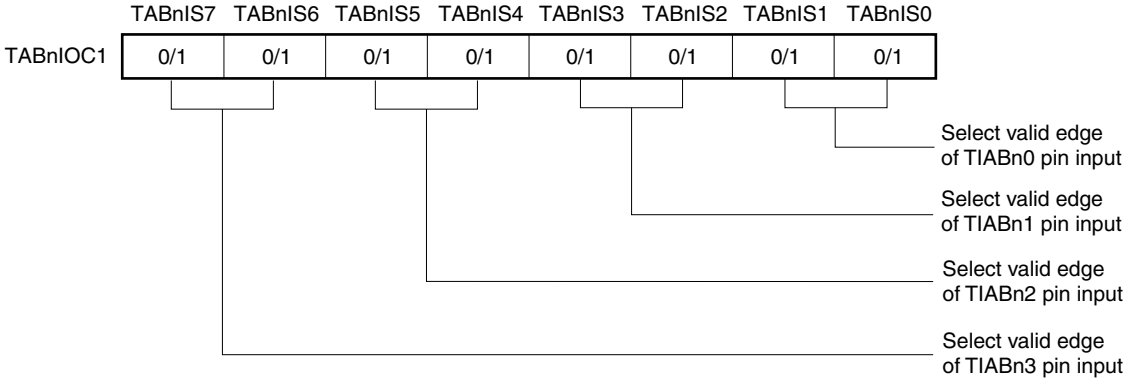


Note The setting is invalid when the TABnEEE bit = 1.

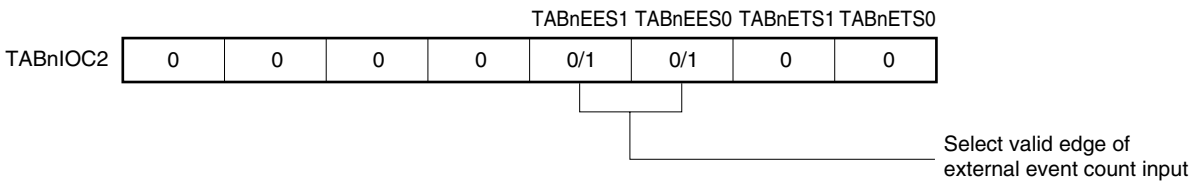
(b) TABn control register 1 (TABnCTL1)



(c) TABn I/O control register 1 (TABnIOC1)



(d) TABn I/O control register 2 (TABnIOC2)



Remark n = 0, 1

Figure 8-36. Register Setting in Pulse Width Measurement Mode (2/2)

(e) TABn option register 0 (TABnOPT0)

	TABnCCS3	TABnCCS2	TABnCCS1	TABnCCS0				TABnOVF
TABnOPT0	0	0	0	0	0	0	0	0/1

Overflow flag

(f) TABn counter read buffer register (TABnCNT)

The value of the 16-bit counter can be read by reading the TABnCNT register.

(g) TABn capture/compare registers 0 to 3 (TABnCCR0 to TABnCCR3)

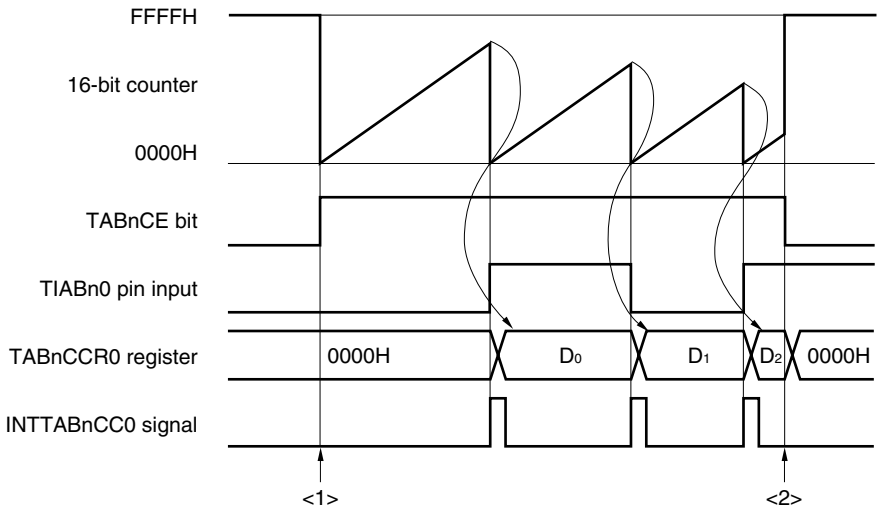
These registers store the count value of the 16-bit counter when the valid edge input to the TIABnm pin is detected.

Remarks 1. TABn I/O control register 0 (TABnIOC0) is not used in the pulse width measurement mode.

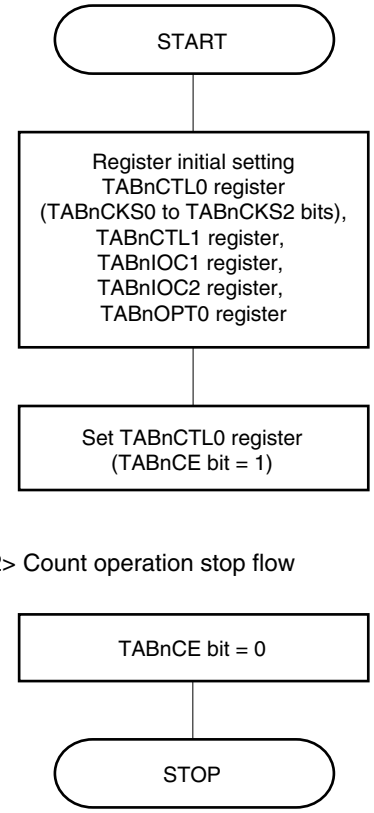
2. m = 0 to 3,
n = 0, 1

(1) Operation flow in pulse width measurement mode

Figure 8-37. Software Processing Flow in Pulse Width Measurement Mode



<1> Count operation start flow



The initial setting of these registers is performed before setting the TABnCE bit to 1.

The TABnCKS0 to TABnCKS2 bits can be set at the same time when counting has been started (TABnCE bit = 1).

<2> Count operation stop flow

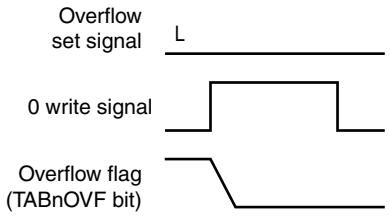
The counter is initialized and counting is stopped by clearing the TABnCE bit to 0.

(2) Operation timing in pulse width measurement mode

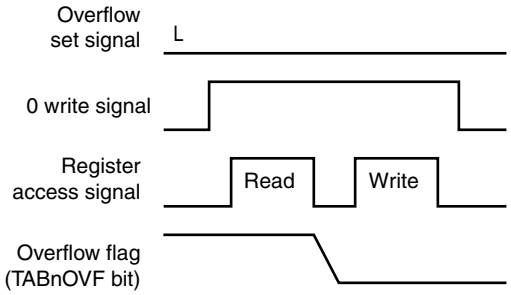
(a) Clearing overflow flag

The overflow flag can be cleared to 0 by clearing the TABnOVF bit to 0 with the CLR instruction and by writing 8-bit data (bit 0 is 0) to the TABnOPT0 register. To accurately detect an overflow, read the TABnOVF bit when it is 1, and then clear the overflow flag by using a bit manipulation instruction.

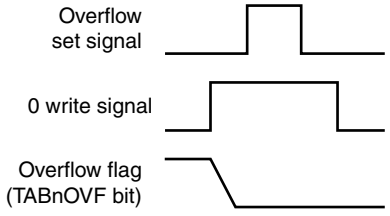
(i) Operation to write 0 (without conflict with setting)



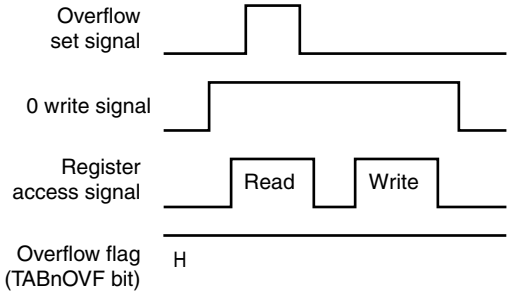
(iii) Operation to clear to 0 (without conflict with setting)



(ii) Operation to write 0 (conflict with setting)



(iv) Operation to clear to 0 (conflict with setting)



Remark n = 0, 1

To clear the overflow flag to 0, read the overflow flag to check if it is set to 1, and clear it with the CLR instruction. If 0 is written to the overflow flag without checking if the flag is 1, the set overflow information may be erased by writing 0 ((ii) in the above chart). Therefore, software may judge that no overflow has occurred even when an overflow actually has occurred.

If execution of the CLR instruction conflicts with occurrence of an overflow when the overflow flag is cleared to 0 with the CLR instruction, the overflow flag remains set even after execution of the CLR instruction.

8.5.8 Triangular wave PWM mode (TABnMD2 to TABnMD0 bits = 111)

In the triangular wave PWM mode, TABn capture/compare register k (TABnCCRk) is used to set the duty factor, and TABn capture/compare register 0 (TABnCCR0) is used to set the cycle.

By using these four registers and operating the timer, triangular wave PWM with a variable cycle is output.

The value of the TABnCCRm register can be rewritten when TABnCE = 1.

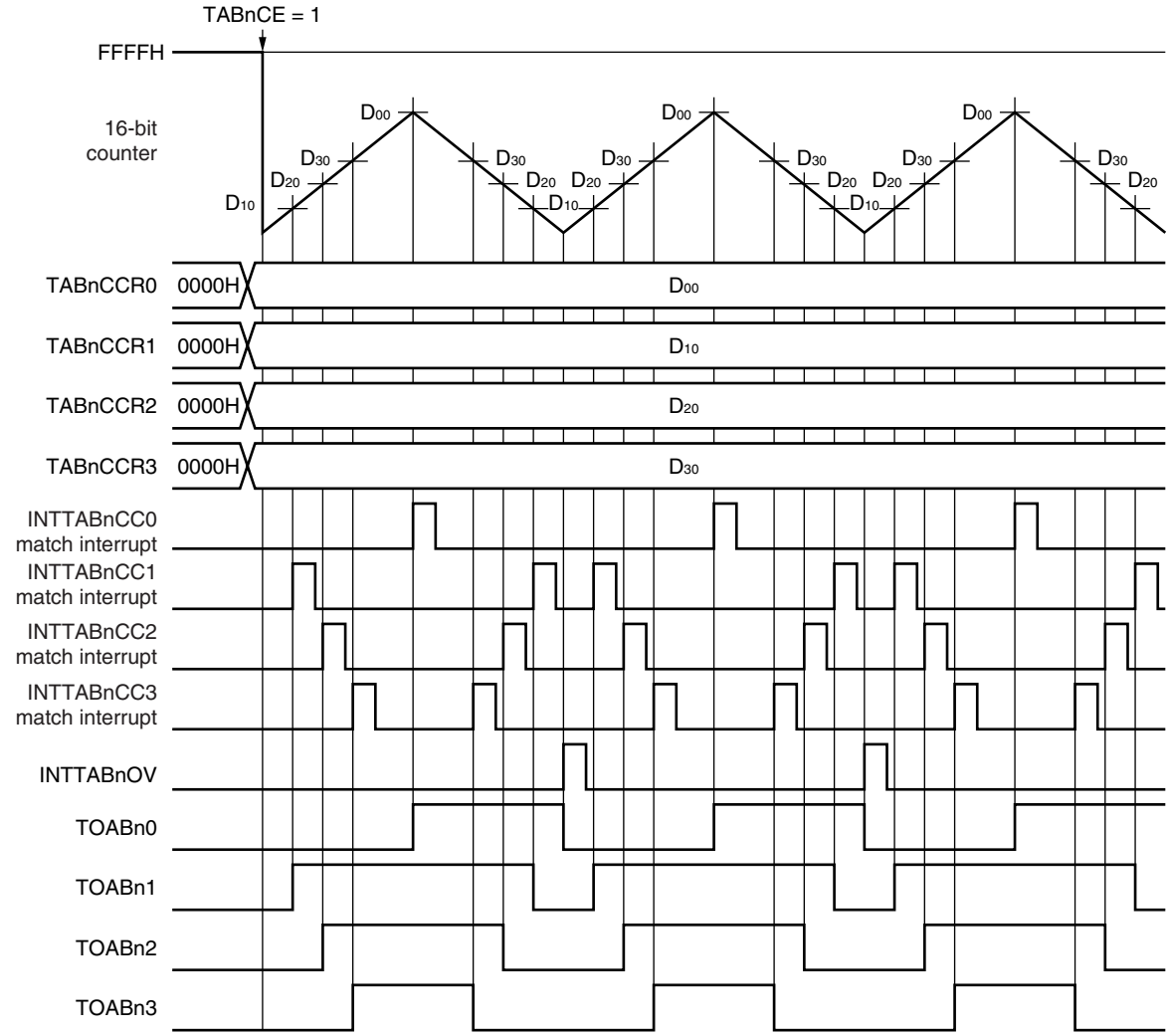
To stop timer AB, clear TABnCE to 0. The PWM waveform is output from the TOABnk pin. The TOABn0 pin produces a toggle output when the value of the 16-bit counter matches the value of the TABnCCR0 register and when the counter underflows.

Caution In the PWM mode, the capture function of the TABnCCRm register cannot be used because this register can be used only as a compare register.

Remark n = 0, 1, m = 0 to 3, k = 1 to 3

Figure 8-38. Timing of Basic Operation in Triangular Wave PWM Mode

(TABnOE0 = 1, TABnOE1 = 1, TABnOE2 = 1, TABnOE3 = 1,
TABnOL0 = 0, TABnOL1 = 0, TABnOL2 = 0, TABnOL3 = 0)



Remark n = 0, 1

8.5.9 Timer output operations

The following table shows the operations and output levels of the TOABn0 to TOABn3 pins.

Table 8-6. Timer Output Control in Each Mode

Operation Mode	TOABn0 Pin	TOABn1 Pin	TOABn2 Pin	TOABn3 Pin
Interval timer mode	Square wave output			
External event count mode	Square wave output	–		
External trigger pulse output mode	Square wave output	External trigger pulse output	External trigger pulse output	External trigger pulse output
One-shot pulse output mode		One-shot pulse output	One-shot pulse output	One-shot pulse output
PWM output mode		PWM output	PWM output	PWM output
Free-running timer mode	Square wave output (only when compare function is used)			
Pulse width measurement mode	–			
Triangular wave PWM output mode	Square wave output	Triangular PWM output	Triangular PWM output	Triangular PWM output

Table 8-7. Truth Table of TOABn0 to TOABn3 Pins Under Control of Timer Output Control Bits

TABnIOC0.TABnOLm Bit	TABnIOC0.TABnOEm Bit	TABnCTL0.TABnCE Bit	Level of TOABnm Pin
0	0	×	Low-level output
	1	0	Low-level output
		1	Low level immediately before counting, high level after counting is started
1	0	×	High-level output
	1	0	High-level output
		1	High level immediately before counting, low level after counting is started

Remark m = 0 to 3,
n = 0, 1

8.6 Timer-Tuned Operation Function/Simultaneous-Start Function

Timer AA and timer AB have a timer-tuned operation function/simultaneous-start function.

The timers that can be synchronized are listed in Table 8-8.

Table 8-8. Timer-Tuned Operation Mode

Master Timer	Slave Timer
TAA1	TAA0
TAA3	TAA2
TAB0	TAA5

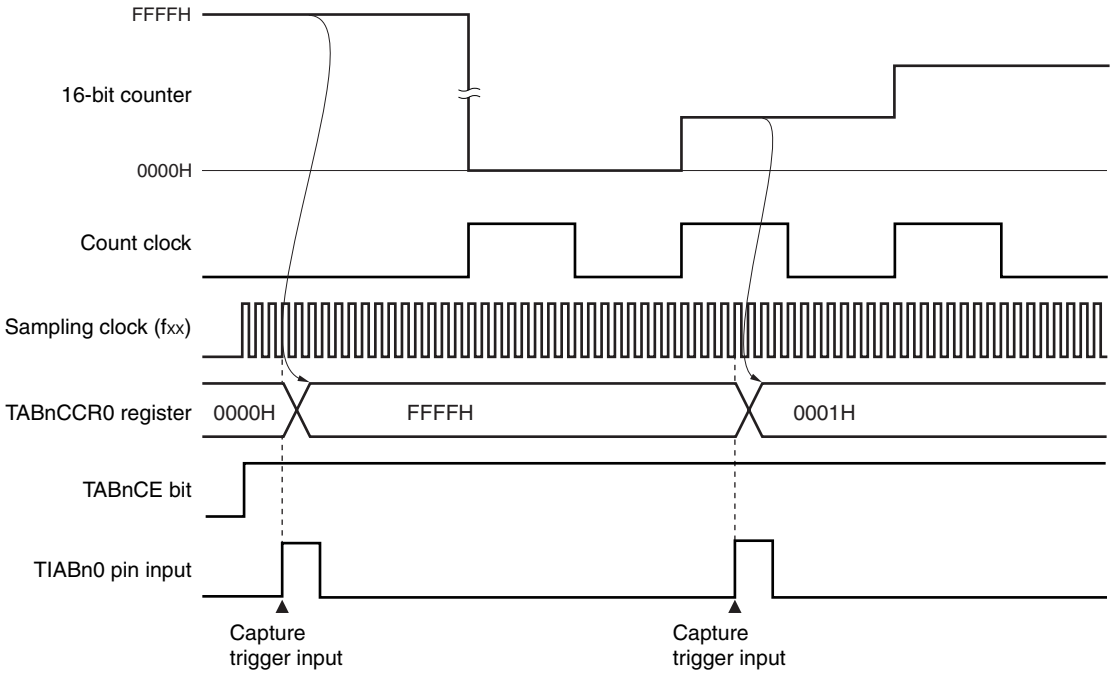
For details of the timer-tuned operation function, see **7.6 Timer-Tuned Operation Function**, and for details of the simultaneous-start function, see **7.7 Simultaneous-Start Function**.

8.7 Cautions

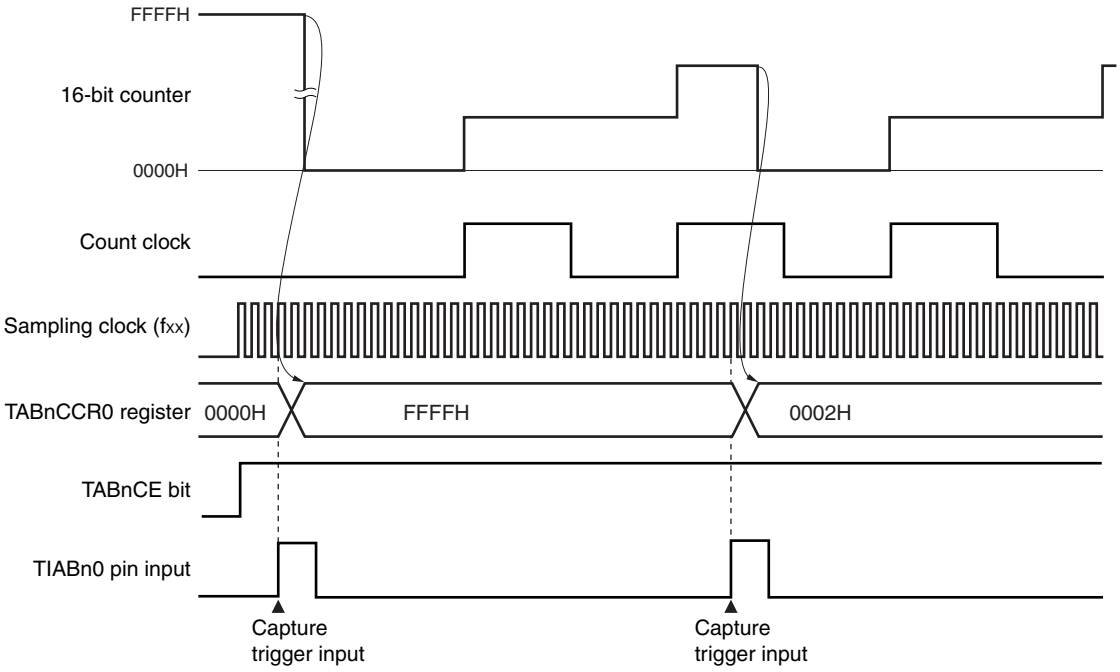
(1) Capture operation

When the capture operation is used and a slow clock is selected as the count clock, FFFFH, not 0000H, may be captured in the TABnCCR0, TABnCCR1, TABnCCR2, and TABnCCR3 registers if the capture trigger is input immediately after the TABnCE bit is set to 1.

(a) Free-running timer mode



(b) Pulse width measurement mode



Remark n = 0, 1

CHAPTER 9 16-BIT TIMER/EVENT COUNTER T (TMT)

Timer T (TMT) is a 16-bit timer/event counter.

An encoder count function and other functions are added to timer AA (TAA). However, TMT does not have a function to operate with an external event count input when it operates in the interval timer mode.

The V850ES/JG3-H and V850ES/JH3-H have one TMT channel.

9.1 Overview

An overview of TMT0 is given below.

- Clock selection: 8 types
- Capture trigger input pins (TIT00, TIT01): 2
- External event count input pin (EVTT0): 1
- Encoder input pins (TENC00, TENC01): 2
- Encoder clear input pin (TECR0): 1
- External trigger input pin[Note]: 1
- Timer counter: 1
- Capture/compare registers: 2
- Capture/compare match interrupt request signals: 2
- Timer output pins: 2

Note The external trigger input pin and external event count input pin (EVTT0) are shared with an encoder input pin (TENC00).

9.2 Functions

The functions of TMT0 are shown below.

- Interval timer
- External event counter
- External trigger pulse output
- One-shot pulse output
- PWM output
- Free-running timer
- Pulse width measurement
- Triangular-wave PWM output
- Encoder count

9.3 Configuration

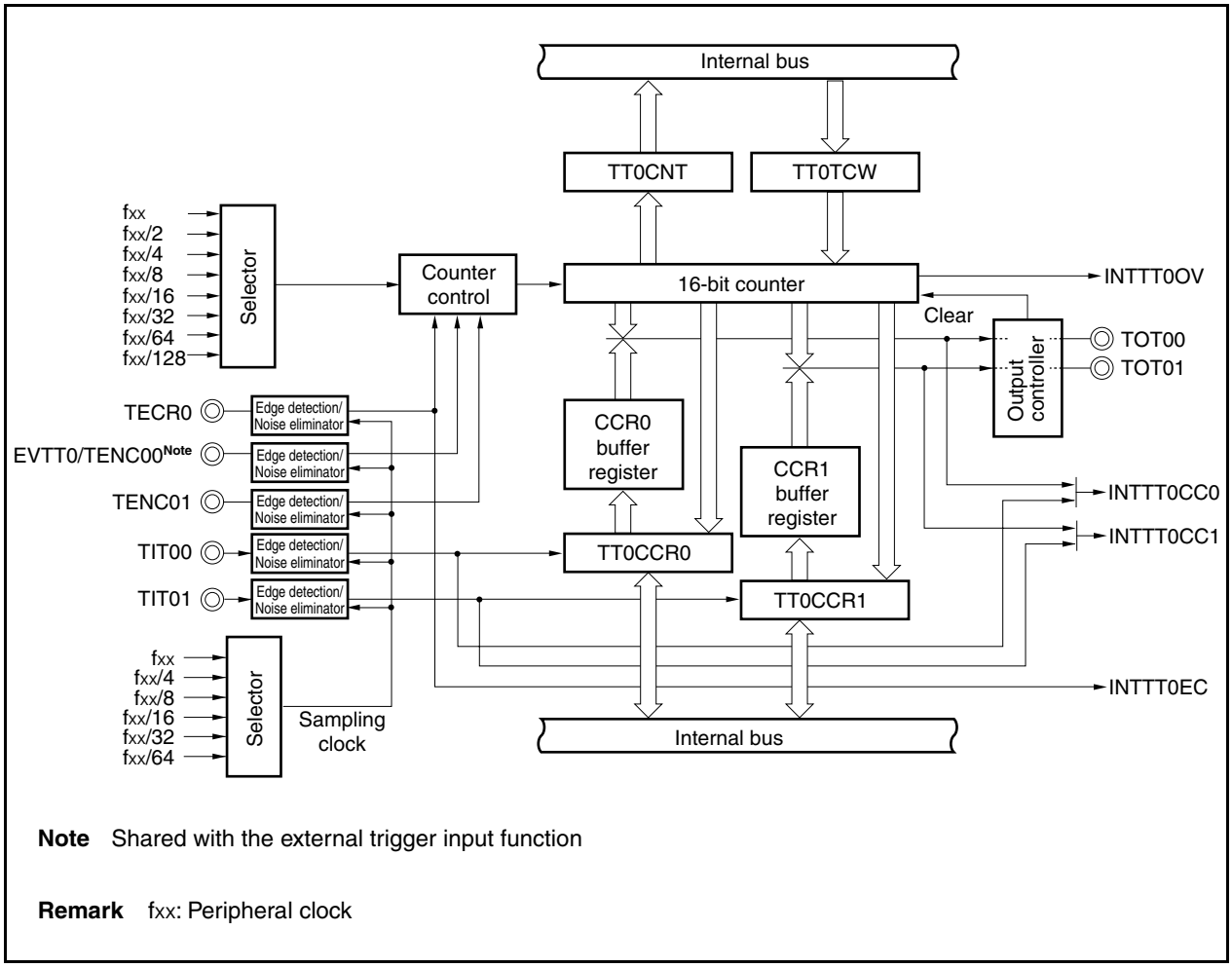
TMT0 includes the following hardware.

Table 9-1. Configuration of TMT0

Item	Configuration
Registers	16-bit counter × 1 TMT0 capture/compare registers 0, 1 (TT0CCR0, TT0CCR1) TMT0 counter read buffer register (TT0CNT) TMT0 counter write register (TT0TCW) CCR0, CCR1 buffer registers TMT0 control registers 0, 1 (TT0CTL0, TT0CTL1) TMT0 control registers 2 (TT0CTL2) TMT0 I/O control registers 0 to 3 (TT0IOC0 to TT0IOC3) TMT0 option register 0 (TT0OPT0) TMT0 option register 1 (TT0OPT1) TMT noise elimination control register (TTNFC)
Timer input	• TIT00, TIT01 (capture trigger input pins) • EVTT0/TENC00 (external event input/encoder 0 input pin)[Note] • TENC01 (encoder 1 input pin) • TENCR0 (encoder clear input pin)
Timer output	TOT00, TOT01

Note Shared with the external trigger input function

Figure 9-1. Block Diagram of TMT0



Note Shared with the external trigger input function

Remark fxx: Peripheral clock

(1) 16-bit counter

This 16-bit counter can count internal clocks or external events.

The count value of this counter can be read by using the TT0CNT register.

When the TT0CTL0.TT0CE bit = 0, the value of the 16-bit counter is FFFFH. If the TT0CNT register is read at this time, 0000H is read.

Reset sets the TT0CE bit to 0.

(2) CCR0 buffer register

This is a 16-bit compare register that compares the count value of the 16-bit counter.

When the TT0CCR0 register is used as a compare register, the value written to the TT0CCR0 register is transferred to the CCR0 buffer register. When the count value of the 16-bit counter matches the value of the CCR0 buffer register, a compare match interrupt request signal (INTTTCC00) is generated.

The CCR0 buffer register cannot be read or written directly.

The CCR0 buffer register is set to 0000H after reset, and the TT0CCR0 register is set to 0000H.

(3) CCR1 buffer register

This is a 16-bit compare register that compares the count value of the 16-bit counter.

When the TT0CCR1 register is used as a compare register, the value written to the TT0CCR1 register is transferred to the CCR1 buffer register. When the count value of the 16-bit counter matches the value of the CCR1 buffer register, a compare match interrupt request signal (INTTTCC01) is generated.

The CCR1 buffer register cannot be read or written directly.

The CCR1 buffer register is set to 0000H after reset, and the TT0CCR1 register is set to 0000H.

(4) Edge detector

This circuit detects the valid edges input to the TIT00, TIT01, EVTT0/TENC00, TENC01, and TECR0 pins. No edge, rising edge, falling edge, or both the rising and falling edges can be selected as the valid edge by using the TT0IOC1, TT0IOC2, and TT0IOC3 registers.

(5) Output controller

This circuit controls the output of the TOT00 and TOT01 pins via the TT0IOC0 register.

(6) Selector

This selector selects the count clock for the 16-bit counter. Eight types of internal clocks or an external event can be selected as the count clock.

(7) Counter control

The count operation is controlled by the timer mode selected by the TT0CTL1 register.

9.3.1 Pin configuration

The timer inputs and outputs that configure TMT0 are shared with the following ports. The port functions must be set when using each pin (see **Table 4-20 Using Port Pin as Alternate-Function Pin**).

Table 9-2. Pin Configuration

Port	Timer Input Pin		Timer Output	Other Alternate Function
P92	TIT01 (capture trigger input 1)	TENC01 (encoder input)	TOT01	A2[Note 1]
P93	TIT00 (capture trigger input 0)	TECR0 (encoder clear input)	TOT00	A3[Note 1]
P94	EVTT0/TENC00[Note 2]	–	–	–

Notes 1. V850ES/JH3-H only

2. The external event count input (EVTT0), encoder input (TENC00), and external trigger input are shared in a state that cannot be controlled by using the port functions. To use each function, set them by using the TT0IOC2 and TT0IOC3 registers after setting their corresponding ports.

9.4 Registers

(1) TMT0 control register 0 (TT0CTL0)

The TT0CTL0 register is an 8-bit register that controls the operation of TMT0.

This register can be read or written in 8-bit or 1-bit units.

Reset sets this register to 00H.

The same value can always be written to the TT0CTL0 register by software.

After reset: 00H R/W Address: FFFF600H

	<7>	6	5	4	3	2	1	0
TT0CTL0	TT0CE	0	0	0	0	TT0CKS2	TT0CKS1	TT0CKS0

TT0CE	TMT0 operation control
0	TMT0 operation disabled (TMT0 reset asynchronously[Note])
1	TMT0 operation enabled. TMT0 operation start

TT0CKS2	TT0CKS1	TT0CKS0	Internal count clock selection
0	0	0	f_{XX}
0	0	1	$f_{XX}/2$
0	1	0	$f_{XX}/4$
0	1	1	$f_{XX}/8$
1	0	0	$f_{XX}/16$
1	0	1	$f_{XX}/32$
1	1	0	$f_{XX}/64$
1	1	1	$f_{XX}/128$

Note The TT0OPT0.TT0OVF bit and 16-bit counter are reset simultaneously. Moreover, timer outputs (TOT00 and TOT01) are reset at the same time as the 16-bit counter.

Cautions 1. Set the TT0CKS2 to TT0CKS0 bits when the TT0CE bit = 0. When the value of the TT0CE bit is changed from 0 to 1, the TT0CKS2 to TT0CKS0 bits can be set simultaneously.

2. Be sure to set bits 3 to 6 to "0".

Remark f_{XX}: Peripheral clock

(2) TMT0 control register 1 (TT0CTL1)

The TT0CTL1 register is an 8-bit register that controls the TMT0 operation.

This register can be read or written in 8-bit or 1-bit units.

Reset sets this register to 00H.

(1/2)

After reset: 00H R/W Address: FFFFF601H

	7	6	5	4	3	2	1	0
TT0CTL1	0	TT0EST	TT0EEE	0	TT0MD3	TT0MD2	TT0MD1	TT0MD0

TT0EST	Software trigger control
0	–
1	Generates a valid signal for external trigger input. • In one-shot pulse output mode: A one-shot pulse is output with writing 1 to the TT0EST bit as the trigger. • In external trigger pulse output mode: A PWM waveform is output with writing 1 to the TT0EST bit as the trigger.
The read value of the TT0EST bit is always 0.	

TT0EEE	Count clock selection
0	Disables operation with external event count input (EVTT0 pin). (Performs counting with the count clock selected by the TT0CTL0.TT0CKS0 to TT0CTL0.TT0CKS2 bits.)
1	Enables operation with external event count input (EVTT0 pin). (Performs counting at every valid edge of the external event count input signal (EVTT0 pin).)
The TT0EEE bit selects whether counting is performed with the internal count clock or the valid edge of the external event count input.	

TT0MD3	TT0MD2	TT0MD1	TT0MD0	Timer mode selection
0	0	0	0	Interval timer mode
0	0	0	1	External event count mode
0	0	1	0	External trigger pulse output mode
0	0	1	1	One-shot pulse output mode
0	1	0	0	PWM output mode
0	1	0	1	Free-running timer mode
0	1	1	0	Pulse width measurement mode
0	1	1	1	Triangular-wave PWM output mode
1	0	0	0	Encoder compare mode
Other than above				Setting prohibited

(2/2)

Cautions 1. The TT0EST bit is valid only in the external trigger pulse output mode or one-shot pulse output mode. In any other mode, writing 1 to this bit is ignored.

2. The TT0EEE bit is valid only in the interval timer mode, external trigger pulse output mode, one-shot pulse output mode, PWM output mode, free-running timer mode, pulse width measurement mode, or triangular-wave PWM output mode. In any other mode, writing 1 to this bit is ignored.

3. External event count input (EVTT0) or encoder inputs (TENC00, TENC01) is selected in the external event count mode or encoder compare mode regardless of the value of the TT0EEE bit.

4. Set the TT0EEE and TT0MD3 to TT0MD0 bits when the TT0CTL0.TT0CE bit = 0. (The same value can be written when the TT0CE bit = 1.) The operation is not guaranteed when rewriting is performed with the TT0CE bit = 1. If rewriting was mistakenly performed, clear the TT0CE bit to 0 and then set the bits again.

5. Be sure to set bits 4 and 7 to "0".

(3) TMT0 control register 2 (TT0CTL2)

The TT0CTL2 register is an 8-bit register that controls the encoder count function operation.

The TT0CTL2 register is valid only in the encoder compare mode.

This register can be read or written in 8-bit or 1-bit units.

Reset sets this register to 00H.

Caution For details of each bit of the TT0CTL2 register, see 9.6.9 (5) Controlling bits of TT0CTL2 register.

(1/2)

After reset: 00H R/W Address: FFFFF602H

	7	6	5	4	3	2	1	0
TT0CTL2	TT0ECC	0	0	TT0LDE	TT0ECM1	TT0ECM0	TT0UDS1	TT0UDS0

TT0ECC	Encoder counter control
0	Normal operation
1	Holds count value of 16-bit counter when TT0CTL0.TT0CE bit = 0.

TT0LDE	Transfer setting to 16-bit counter
0	Disables transfer of set value of TT0CCR0 to 16-bit counter in case of underflow.
1	Enables transfer of set value of TT0CCR0 to 16-bit counter in case of underflow.

TT0ECM1	Control of encoder clear operation 1
0	The 16-bit counter is not cleared to 0000H when its count value matches value of CCR1 register.
1	The 16-bit counter is cleared to 0000H when the count after a match between the 16-bit counter count value and CCR1 register value is a down-count

TT0ECM0	Control of encoder clear operation 0
0	The 16-bit counter is not cleared to 0000H when its count value matches value of CCR0 register.
1	The 16-bit counter is cleared to 0000H when the count after a match between the 16-bit counter count value and CCR0 register value is an up-count

(2/2)

TT0UDS1	TT0UDS0	Up/down count selection
0	0	When valid edge of TENC00 input is detected Counts down when TENC01 = high level. Counts up when TENC01 = low level.
0	1	Counts up when valid edge of TENC00 input is detected. Counts down when valid edge of TENC01 input is detected.
1	0	Counts down when rising edge of TENC00 input is detected. Counts up when falling edge of TENC00 input is detected. However, count operation is performed only when TENC01 = low level.
1	1	Both rising and falling edges of TENC00 and TENC01 are detected. Count operation is automatically identified by combination of edge detection and level detection.

Cautions 1. The TT0ECC bit is valid only in the encoder compare mode. In any other mode, writing "1" to this bit is ignored.
If the TT0CTL0.TT0CE bit is cleared to 0 while the TT0ECC bit = 1, the values of the timer/counter and capture registers (TT0CCR0 and TT0CCR1), and the TT0OPT1, TT0EUF, TT0EOF, and TT0ESF flags are retained.
If the TT0CE bit is set from 0 to 1 when the TT0ECC bit = 1, the value of the TT0TCW register is not transferred to the 16-bit counter.

2. The TT0LDE bit is valid only when the TT0ECM1 and TT0ECM0 bits = 00, 01. Writing "1" to this bit is ignored when the TT0ECM1 and TT0ECM0 bits = 10, 11.

3. The edge detection of the TENC00 and TENC01 inputs specified by the TT0IOC3.TT0EIS1 and TT0IOC3.TT0EIS0 bits is invalid and fixed to both the rising and falling edges when the TT0UDS1 and TT0UDS0 bits = 10, 11.

4. Set the TT0LDE, TT0ECM1, TT0ECM0, TT0UDS1, and TT0UDS0 bits when the TT0CTL0.TT0CE bit = 0 (the same value can be written to these bits when the TT0CE bit = 1). If the value of these bits is changed when the TT0CE bit = 1, the operation cannot be guaranteed. If it is changed by mistake, clear the TT0CE bit and then set the correct value.

5. Be sure to set bits 5 and 6 to "0".

(4) TMT0 I/O control register 0 (TT0IOC0)

The TT0IOC0 register is an 8-bit register that controls the timer output (TOT00, TOT01 pins).

This register can be read or written in 8-bit or 1-bit units.

Reset sets this register to 00H.

After reset: 00H R/W Address: FFFFF603H

	7	6	5	4	3	<2>	1	<0>
TT0IOC0	0	0	0	0	TT0OL1	TT0OE1	TT0OL0	TT0OE0

TT0OL1	TOT01 pin output level setting[Note]
0	TOT01 pin starts output at high level.
1	TOT01 pin starts output at low level.

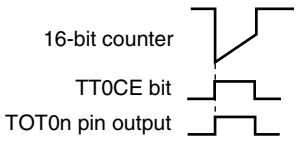
TT0OE1	TOT01 pin output setting
0	Timer output prohibited • Low level is output from the TOT01 pin when the TT0OL1 bit = 0. • High level is output from the TOT01 pin when the TT0OL1 bit = 1.
1	Timer output enabled (A pulse is output from the TOT01 pin.)

TT0OL0	TOT00 pin output level setting[Note]
0	TOT00 pin starts output at high level.
1	TOT00 pin starts output at low level.

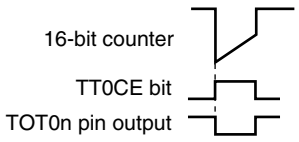
TT0OE0	TOT00 pin output setting
0	Timer output prohibited • Low level is output from the TOT00 pin when the TT0OL0 bit = 0. • High level is output from the TOT00 pin when the TT0OL0 bit = 1.
1	Timer output enabled (A pulse is output from the TOT00 pin.)

Note The output level of the timer output pins (TOT00 and TOT01) specified by the TT0OLn bit is shown below (n = 0, 1).

• When TT0OLn bit = 0



• When TT0OLn bit = 1



Cautions 1. If the setting of the TT0IOC0 register is changed when TOT00 and TOT01 outputs are set for the port mode, the output of the pins change. Set the port in the input mode and make the port go into a high-impedance state, noting changes in the pin status.

2. Rewrite the TT0OL1, TT0OE1, TT0OL0, and TT0OE0 bits when the TT0CTL0.TT0CE bit = 0. (The same value can be written when the TT0CE bit = 1.) If rewriting was mistakenly performed, clear the TT0CE bit to 0 and then set the bits again.

3. Even if the TT0OL0 or TT0OL1 bit is manipulated when the TT0CE, TT0OE0, and TT0OE1 bits are 0, the output level of the TOT00 and TOT01 pins changes.

(5) TMT0 I/O control register 1 (TT0IOC1)

The TT0IOC1 register is an 8-bit register that controls the valid edge for the capture trigger input signals (TIT00, TIT01 pins).

This register can be read or written in 8-bit or 1-bit units.

Reset sets this register to 00H.

After reset: 00H R/W Address: FFFFF604H

	7	6	5	4	3	2	1	0
TT0IOC1	0	0	0	0	TT0IS3	TT0IS2	TT0IS1	TT0IS0

TT0IS3	TT0IS2	Capture trigger input signal (TIT01 pin) valid edge setting
0	0	No edge detection (capture operation invalid)
0	1	Detection of rising edge
1	0	Detection of falling edge
1	1	Detection of both edges

TT0IS1	TT0IS0	Capture trigger input signal (TIT00 pin) valid edge setting
0	0	No edge detection (capture operation invalid)
0	1	Detection of rising edge
1	0	Detection of falling edge
1	1	Detection of both edges

Cautions 1. Rewrite the TT0IS3 to TT0IS0 bits when the TT0CTL0.TT0CE bit = 0. (The same value can be written when the TT0CE bit = 1.) If rewriting was mistakenly performed, clear the TT0CE bit to 0 and then set the bits again.

2. The TT0IS3 and TT0IS2 bits are valid only in the free-running timer mode (only when the TT0OPT0.TT0CCS1 bit = 1) and the pulse width measurement mode. In all other modes, a capture operation is not performed.

The TT0IS1 and TT0IS0 bits are valid only in the free-running timer mode (only when the TT0OPT0. TT0CCS0 bit = 1) and the pulse width measurement mode. In all other modes, a capture operation is not performed.

(6) TMT0 I/O control register 2 (TT0IOC2)

The TT0IOC2 register is an 8-bit register that controls the valid edge for the external event count input signal (EVTT0 pin) and external trigger input signal (EVTT0 pin).

This register can be read or written in 8-bit or 1-bit units.

Reset sets this register to 00H.

After reset: 00H R/W Address: FFFFF605H

	7	6	5	4	3	2	1	0
TT0IOC2	0	0	0	0	TT0EES1	TT0EES0	TT0ETS1	TT0ETS0

TT0EES1	TT0EES0	External event count input signal (EVTT0 pin) valid edge setting
0	0	No edge detection (external event count invalid)
0	1	Detection of rising edge
1	0	Detection of falling edge
1	1	Detection of both edges

TT0ETS1	TT0ETS0	External trigger input signal (EVTT0 pin) valid edge setting
0	0	No edge detection (external trigger invalid)
0	1	Detection of rising edge
1	0	Detection of falling edge
1	1	Detection of both edges

Cautions 1. Rewrite the TT0EES1, TT0EES0, TT0ETS1, and TT0ETS0 bits when the TT0CTL0.TT0CE bit = 0. (The same value can be written when the TT0CE bit = 1.) If rewriting was mistakenly performed, clear the TT0CE bit to 0 and then set the bits again.

2. The TT0EES1 and TT0EES0 bits are valid only when the TT0CTL1.TT0EEE bit = 1 or when the external event count mode (the TT0CTL1.TT0MD3 to TT0CTL1.TT0MD0 bits = 0001) has been set.

3. The TT0ETS1 and TT0ETS0 bits are valid only in the external trigger pulse mode or one-shot pulse output mode.

(7) TMT0 I/O control register 3 (TT0IOC3)

The TT0IOC3 register is an 8-bit register that controls the encoder clear function operation.

The TT0IOC3 register is valid only in the encoder compare mode.

This register can be read or written in 8-bit or 1-bit units.

Reset sets this register to 00H.

(1/2)

After reset: 00H R/W Address: FFFFF606H

	7	6	5	4	3	2	1	0
TT0IOC3	TT0SCE	TT0ZCL	TT0BCL	TT0ACL	TT0ECS1	TT0ECS0	TT0EIS1	TT0EIS0

TT0SCE	Encoder clear selection
0	Clears 16-bit counter on detection of edge of encoder clear signal (TECR0 pin).
1	Clears 16-bit counter on detection of clear level condition of the TENC00, TENC01, and TECR0 pins.
• Clears the 16-bit counter to 0000H when the valid edge of TECR0 pin specified by the TT0ECS1 and TT0ECS0 bits is detected when the TT0SCE bit = 0. • Clears the 16-bit counter to 0000H when the clear level conditions of the TT0ZCL, TT0BCL, and TT0ACL bits match the input levels of the TECR0, TENC01, and TENC00 pins when TT0SCE bit = 1. • Setting of the TT0ZCL, TT0BCL, and TT0ACL bits is valid and that of the TT0ECS1 and TT0ECS0 bits is invalid when the TT0SCE bit = 1. An encoder clear interrupt request signal (INTTTI0EC) is not generated. • Setting of the TT0ZCL, TT0BCL, and TT0ACL bits is invalid and setting of the TT0ECS1 and TT0ECS0 bits is valid when the TT0SCE bit = 0. The INTTTI0EC signal is generated when the valid edge specified by the TT0ECS1 and TT0ECS0 bits is detected. • Be sure to set the TT0CTL2.TT0UDS1 and TT0CTL2.TT0UDS0 bits to 10 or 11 when the TT0SCE bit = 1. Operation is not guaranteed if the TT0UDS1 and TT0UDS0 bits = 00 or 01 and the TT0SCE bit = 1.	

TT0ZCL	Clear level selection of encoder clear signal (TECR0 pin)
0	Clears low level of the TECR0 pin.
1	Clears high level of the TECR0 pin.
Setting of the TT0ZCL bit is valid only when the TT0SCE bit = 1.	

TT0BCL	Clear level selection of encoder input signal (TENC01 pin)
0	Clears low level of the TENC01 pin.
1	Clears high level of the TENC01 pin.
Setting of the TT0BCL bit is valid only when the TT0SCE bit = 1.	

TT0ACL	Clear level selection of encoder input signal (TENC00 pin)
0	Clears low level of the TENC00 pin.
1	Clears high level of the TENC00 pin.
Setting of the TT0ACL bit is valid only when the TT0SCE bit = 1.	

(2/2)

TT0ECS1	TT0ECS0	Valid edge setting of encoder clear signal (TECR0 pin)
0	0	Detects no edge (clearing encoder is invalid).
0	1	Detects rising edge.
1	0	Detects falling edge.
1	1	Detects both edges.

TT0EIS1	TT0EIS0	Valid edge setting of encoder input signals (TENC00, TENC01 pins)
0	0	Detects no edge (inputting encoder is invalid).
0	1	Detects rising edge.
1	0	Detects falling edge.
1	1	Detects both edges.

Cautions 1. Rewrite the TT0SCE, TT0ZCL, TT0BCL, TT0ACL, TT0ECS1, TT0ECS0, TT0EIS1, and TT0EIS0 bits when the TT0CTL0.TT0CE bit = 0. (The same value can be written to these bits when the TT0CE bit = 1.) If rewriting was mistakenly performed, clear the TT0CE bit to 0 and then set these bits again.

2. The TT0ECS1 and TT0ECS0 bits are valid only when the TT0SCE bit = 0 and the encoder compare mode is set.

3. The TT0EIS1 and TT0EIS0 bits are valid only when the TT0CTL2.TT0UDS1 and TT0CTL2.TT0UDS0 bits = 00 or 01.

(8) TMT0 option register 0 (TT0OPT0)

The TT0OPT0 register is an 8-bit register that sets the capture/compare operation and detects overflows.

This register can be read or written in 8-bit or 1-bit units.

Reset sets this register to 00H.

After reset: 00H R/W Address: FFFFF607H

	7	6	5	4	3	2	1	<0>
TT0OPT0	0	0	TT0CCS1	TT0CCS0	0	0	0	TT0OVF

TT0CCS1	TT0CCR1 register capture/compare selection
0	Selected as compare register
1	Selected as capture register (cleared by the TT0CTL0.TT0CE bit = 0)
The TT0CCS1 bit setting is valid only in the free-running timer mode.	

TT0CCS0	TT0CCR0 register capture/compare selection
0	Selected as compare register
1	Selected as capture register (cleared by the TT0CTL0.TT0CE bit = 0)
The TT0CCS0 bit setting is valid only in the free-running timer mode.	

TT0OVF	TMT0 overflow detection flag
Set (1)	Overflow occurred
Reset (0)	0 written to TT0OVF bit or TT0CTL0.TT0CE bit = 0

- The TT0OVF bit is set to 1 when the 16-bit counter value overflows from FFFFH to 0000H in the free-running timer mode or the pulse width measurement mode.
- An overflow interrupt request signal (INTTT0OV) is generated when the TT0OVF bit is set to 1. The INTTT0OV signal is not generated in modes other than the free-running timer mode and the pulse width measurement mode.
- The TT0OVF bit is not cleared to 0 even when the TT0OVF bit or the TT0OPT0 register are read when the TT0OVF bit = 1.
- Before clearing the TT0OVF bit to 0 after generation of the INTTT0OV signal, be sure to confirm (by reading) that the TT0OVF bit is set to 1.
- The TT0OVF bit can be both read and written, but the TT0OVF bit cannot be set to 1 by software. Writing 1 has no effect on the operation of TMT0.

Cautions 1. Rewrite the TT0CCS1 and TT0CCS0 bits when the TT0CE bit = 0. (The same value can be written when the TT0CE bit = 1.) If rewriting was mistakenly performed, clear the TT0CE bit to 0 and then set these bits again.

2. Be sure to set bits 1 to 3, 6, and 7 to "0".

(9) TMT0 option register 1 (TT0OPT1)

The TT0OPT1 register is an 8-bit register that detects overflows, underflows, and count-up/down operations of the encoder count function.

The TT0OPT1 register is valid only in the encoder compare mode.

This register can be read or written in 8-bit or 1-bit units.

Reset sets this register to 00H.

This register can be rewritten even when the TT0CTL0.TT0CE bit = 1.

(1/2)

After reset: 00H R/W Address: FFFFF608H

	7	6	5	4	3	<2>	<1>	<0>
TT0OPT1	0	0	0	0	0	TT0EUF	TT0EOF	TT0ESF

TT0EUF	TMT0 underflow detection flag
Set (1)	Underflow occurs.
Reset (0)	Cleared by writing to TT0EUF bit or when TT0CTL0.TT0CE bit = 0

- The TT0EUF bit is set to 1 when the 16-bit counter underflows from 0000H to FFFFH in the encoder compare mode.
- When the TT0CTL2.TT0LDE bit = 1, the TT0EUF bit is set to 1 when the value of the 16-bit counter is changed from 0000H to the set value of the TT0CCR0 register.
- An overflow interrupt request signal (INTTTOV0) is generated as soon as the TT0EUF bit is set to 1.
- The TT0EUF bit is not cleared to 0 even if the TT0EUF bit or TT0OPT1 register is read when the TT0EUF bit = 1.
- The status of the TT0EUF bit is retained even if the TT0CTL0.TT0CE bit is cleared to 0 when the TT0CTL2.TT0ECC bit = 1.
- Before clearing the TT0EUF bit to 0 after the INTTTOV0 signal is generated, be sure to confirm (read) that the TT0EUF bit is set to 1.
- The TT0EUF bit can be read or written, but it cannot be set to 1 by software. Setting this bit to 1 does not affect the operation of TMT0.

(2/2)

TT0EOF	Overflow detection flag for TMT0 encoder function
Set (1)	Overflow occurs.
Reset (0)	Cleared by writing 0 to the TT0EOF bit or when the TT0CTL0.TT0CE bit = 0

- The TT0EOF bit is set to 1 when the 16-bit counter overflows from FFFFH to 0000H in the encoder compare mode.
- As soon as the TT0EOF bit has been set to 1, an overflow interrupt request signal (INTTTOV0) is generated. At this time, the TT0OPT0.TT0OVF bit is not set to 1.
- The TT0EOF bit is not cleared to 0 even if the TT0EOF bit or TT0OPT1 register is read when the TT0EOF bit = 1.
- The status of the TT0EOF bit is retained even if the TT0CTL0.TT0CE bit is cleared to 0 when the TT0CTL2.TT0ECC bit = 1.
- Before clearing the TT0EOF bit to 0 after the INTTTOV0 signal is generated, be sure to confirm (read) that the TT0EOF bit is set to 1.
- The TT0EOF bit can be read or written, but it cannot be set to 1 by software. Writing 1 to this bit does not affect the operation of TMT0.

TT0ESF	TMT0 count-up/-down operation status detection flag
0	TMT0 is counting up.
1	TMT0 is counting down.

- This bit is cleared to 0 if the TT0CTL0.TT0CE bit = 0 when the TT0CTL2.TT0ECC bit = 0.
- The status of the TT0ESF bit is retained even if the TT0CE bit = 0 when the TT0ECC bit = 1.

Caution Be sure to set bits 3 to 7 to “0”.

(10) TMT0 capture/compare register 0 (TT0CCR0)

The TT0CCR0 register is a 16-bit register that can be used as a capture register or compare register depending on the mode.

This register can be used as a capture register or a compare register only in the free-running timer mode, depending on the setting of the TT0OPT0.TT0CCS0 bit. In the pulse width measurement mode, the TT0CCR0 register can be used only as a capture register. In any other mode, this register can be used only as a compare register.

The TT0CCR0 register can be read or written during operation.

This register can be read or written in 16-bit units.

Reset sets this register to 0000H.

After reset: 0000H R/W Address: FFFFF60AH

	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
TT0CCR0																

(a) Function as compare register

The TT0CCR0 register can be rewritten even when the TT0CTL0.TT0CE bit = 1.

The set value of the TT0CCR0 register is transferred to the CCR0 buffer register. When the value of the 16-bit counter matches the value of the CCR0 buffer register, a compare match interrupt request signal (INTTT0CC0) is generated. If TOT00 pin output is enabled at this time, the output of the TOT00 pin is inverted.

When the TT0CCR0 register is used as a cycle register in the interval timer mode, or when the TT0CCR0 register is used as a cycle register in the external event count mode, external trigger pulse output mode, one-shot pulse output mode, PWM output mode, triangular-wave PWM output mode, or encoder compare mode, the value of the 16-bit counter is cleared (0000H) if its count value matches the value of the CCR0 buffer register.

The compare register is not cleared by setting the TT0CTL0.TT0CE bit to 0.

(b) Function as capture register

In the free-running timer mode (when the TT0CCR0 register is used as a capture register), the count value of the 16-bit counter is stored in the TT0CCR0 register if the valid edge of the capture trigger input pin (TIT00 pin) is detected. In the pulse width measurement mode, the count value of the 16-bit counter is stored in the TT0CCR0 register and the 16-bit counter is cleared (0000H) if the valid edge of the capture trigger input pin (TIT00 pin) is detected.

Even if the capture operation and reading the TT0CCR0 register conflict, the correct value of the TT0CCR0 register can be read.

The capture register is cleared by setting the TT0CTL0.TT0CE bit to 0.

The following table shows the functions of the capture/compare register in each mode, and how to write data to the compare register.

Table 9-3. Function of Capture/Compare Register in Each Mode and How to Write Compare Register

Operation Mode	TT0CCR0 Register	How to Write Compare Register
Interval timer	Compare register	Anytime write
External event counter	Compare register	Anytime write
External trigger pulse output	Compare register	Batch write[Note]
One-shot pulse output	Compare register	Anytime write
PWM output	Compare register	Batch write[Note]
Free-running timer	Capture/compare register	Anytime write
Pulse width measurement	Capture register	None
Triangular-wave WPM output	Compare register	Batch write[Note]
Encoder compare	Compare register	Anytime write

Note Writing to the TT0CCR1 register is the trigger.

Remark For anytime write and batch write, see **9.6 (2) Anytime write and batch write**.

(11) TMT0 capture/compare register 1 (TT0CCR1)

The TT0CCR1 register is a 16-bit register that can be used as a capture register or compare register depending on the mode.

This register can be used as a capture register or a compare register only in the free-running timer mode, depending on the setting of the TT0OPT0.TT0CCS1 bit. In the pulse width measurement mode, the TT0CCR1 register can be used only as a capture register. In any other mode, this register can be used only as a compare register.

The TT0CCR1 register can be read or written during operation.

This register can be read or written in 16-bit units.

Reset sets this register to 0000H.

After reset: 0000H R/W Address: FFFFFF60CH

	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
TT0CCR1																

(a) Function as compare register

The TT0CCR1 register can be rewritten even when the TT0CTL0.TT0CE bit = 1.

The set value of the TT0CCR1 register is transferred to the CCR1 buffer register. When the value of the 16-bit counter matches the value of the CCR1 buffer register, a compare match interrupt request signal (INTTT0CC01) is generated. If TOT01 pin output is enabled at this time, the output of the TOT01 pin is inverted.

The compare register is not cleared by setting the TT0CTL0.TT0CE bit to 0.

(b) Function as capture register

In the free-running timer mode (when the TT0CCR1 register is used as a capture register), the count value of the 16-bit counter is stored in the TT0CCR1 register if the valid edge of the capture trigger input pin (TIT01 pin) is detected. In the pulse width measurement mode, the count value of the 16-bit counter is stored in the TT0CCR1 register and the 16-bit counter is cleared (0000H) if the valid edge of the capture trigger input pin (TIT01 pin) is detected.

Even if the capture operation and reading the TT0CCR1 register conflict, the correct value of the TT0CCR1 register can be read.

The capture register is cleared by setting the TT0CTL0.TT0CE bit to 0.

The following table shows the functions of the capture/compare register in each mode, and how to write data to the compare register.

Table 9-4. Function of Capture/Compare Register in Each Mode and How to Write Compare Register

Operation Mode	TT0CCR1 Register	How to Write Compare Register
Interval timer	Compare register	Anytime write
External event counter	Compare register	Anytime write
External trigger pulse output	Compare register	Batch write[Note]
One-shot pulse output	Compare register	Anytime write
PWM output	Compare register	Batch write[Note]
Free-running timer	Capture/compare register	Anytime write
Pulse width measurement	Capture register	None
Triangular-wave PWM output	Compare register	Batch write[Note]
Encoder compare	Compare register	Anytime write

Note Writing to the TT0CCR1 register is the trigger.

Remark For anytime write and batch write, see **9.6 (2) Anytime write and batch write**.

(12) TMT0 counter write register (TT0TCW)

The TT0TCW register is used to set the initial value of the 16-bit counter.

The TT0TCW register is valid only in the encoder compare mode.

This register can be read or written in 16-bit units.

Rewrite the TT0TCW register when the TT0CTL0.TT0CE bit = 0.

The value of the TT0TCW register is transferred to the 16-bit counter when the TT0CE bit is set (1).

Reset sets this register to 0000H.

After reset: 0000H R/W Address: FFFFF610H

	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
TT0TCW																

(13) TMT0 counter read buffer register (TT0CNT)

The TT0CNT register is a read buffer register that can read the count value of the 16-bit counter.

If this register is read when the TT0CTL0.TT0CE bit = 1, the count value of the 16-bit timer can be read.

This register is read-only, in 16-bit units.

The value of the TT0CNT register is set to 0000H when the TT0CTL2.TT0ECC and TT0CE bits = 0. If the TT0CNT register is read at this time, the value of the 16-bit counter (FFFFH) is not read, but 0000H is read. The TT0CNT register is not set to 0000H but the previous value is read when the TT0ECC bit = 1 and TT0CE bit = 0.

The TT0ECC and TT0CE bits are set to 0 after reset, and the value of the TT0CNT register is set to 0000H.

After reset: 0000H R Address: FFFFFF60EH

	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
TT0CNT																

(14) Noise elimination control register (TTNFC)

Digital noise elimination can be selected for the TIT00, TIT01, TENC01, TECR0, and EVTT00 pins. The noise elimination settings are performed using the TTNFC register.

When digital noise elimination is selected, the sampling clock for digital sampling can be selected from among fxx, fxx/4, fxx/8, fxx/16, fxx/32, and fxx/64. Sampling is performed 3 times.

This register can be read or written in 8-bit units.

Reset sets this register to 00H.

Caution Time equal to the sampling clock × 3 clocks is required until the digital noise eliminator is initialized after the sampling clock has been changed. If the valid edge of the TIT00, TIT01, TENC01, TECR0, and EVTT00 pins is input after the sampling clock has been changed and before the time of the sampling clock × 3 clocks passes, therefore, an interrupt request signal may be generated. Therefore, when using the external trigger function, the external event function, the capture trigger function, and the encoder function of TMT, enable TMT operation after the sampling clock × 3 clocks have elapsed.

After reset: 00H R/W Address: FFFFF726H

	7	6	5	4	3	2	1	0
TTNFC	TTNFEN	0	0	0	0	TTNFC2	TTNFC1	TTNFC0

TTNFEN	Settings of digital noise elimination
0	Digital noise elimination not executed
1	Digital noise elimination executed

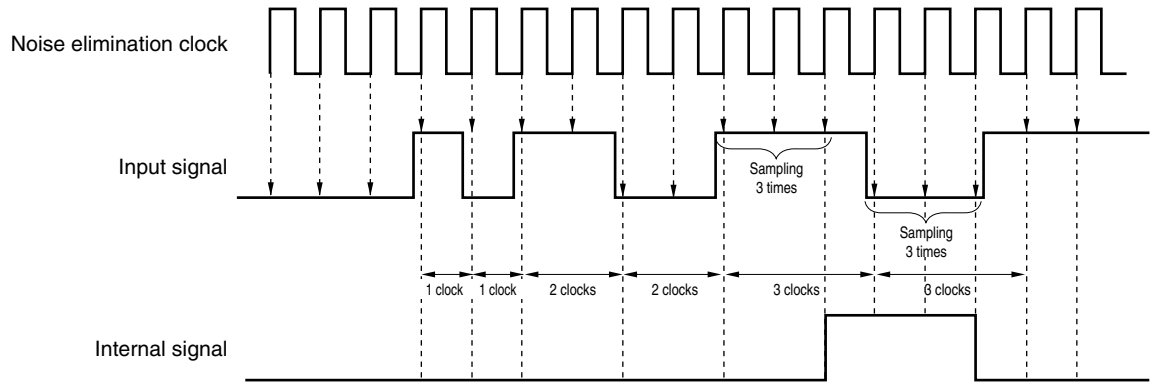
TTNFC2	TTNFC1	TTNFC0	Digital sampling clock
0	0	0	fxx
0	0	1	fxx/4
0	1	0	fxx/8
0	1	1	fxx/16
1	0	0	fxx/32
1	0	1	fxx/64
Other than above			Setting prohibited

Remarks 1. Since sampling is performed three times, the noise width for reliably eliminating noise is 2 sampling clocks.

2. In the case of noise with a width smaller than 2 sampling clocks, an interrupt request signal is generated if noise synchronized with the sampling clock is input.

A timing example of noise elimination performed by the timer T input pin digital filter is shown Figure 9-2.

Figure 9-2. Example of Digital Noise Elimination Timing



Remark If there are two or fewer noise elimination clocks while the TIT00, TIT01, TENC01, TECR0, and EVTT00 input signals are high level (or low level), the input signal is eliminated as noise. If it is sampled three times or more, the edge is detected as a valid input.

9.5 Timer Output Operations

The following table shows the operations and output levels of the TOT00 and TOT01 pins.

Table 9-5. Timer Output Control in Each Mode

Operation Mode	TOT01 Pin	TOT00 Pin
Interval timer mode	Square wave output	
External event count mode	None	
External trigger pulse output mode	External trigger pulse output	Square wave output
One-shot pulse output mode	One-shot pulse output	
PWM output mode	PWM output	
Free-running timer mode	Square wave output (only when compare function is used)	
Pulse width measurement mode	None	
Triangular-wave PWM output mode	Triangular-wave PWM output	
Encoder compare mode	None	

Table 9-6. Truth Table of TOT00 and TOT01 Pins Under Control of Timer Output Control Bits

TT0IOC0.TT0OLn Bit	TT0IOC0.TT0OEn Bit	TT0CTL0.TT0CE Bit	Level of TOT0n Pin
0	0	×	Low-level output
	1	0	Low-level output
		1	Low level immediately before counting, high level after counting is started
1	0	×	High-level output
	1	0	High-level output
		1	High level immediately before counting, low level after counting is started

Remark n = 0, 1

9.6 Operation

The functions of TMT0 that can be implemented differ from one channel to another. The functions of each channel are shown below.

Table 9-7. TMT0 Specifications in Each Mode

Operation	TT0CTL1.TT0EST Bit (Software Trigger Bit)	EVTT0 Pin (External Trigger Input)	Capture/Compare Register Setting	Compare Register Write Method
Interval timer mode	Invalid	Invalid	Compare only	Anytime write
External event count mode	Invalid	Invalid	Compare only	Anytime write
External trigger pulse output mode	Valid	Valid	Compare only	Batch write
One-shot pulse output mode	Valid	Valid	Compare only	Anytime write
PWM output mode	Invalid	Invalid	Compare only	Batch write
Free-running timer mode	Invalid	Invalid	Switchable	Anytime write
Pulse width measurement mode	Invalid	Invalid	Capture only	Not applicable
Triangular-wave PWM output mode	Invalid	Invalid	Compare only	Batch write
Encoder compare mode	Invalid	Invalid	Compare only	Anytime write

(1) Basic counter operation

This section explains the basic operation of the 16-bit counter. For details, refer to the description of the operation in each mode.

(a) Count start operation

- **Encoder compare mode**

  A count operation is controlled by TENC00 and TENC01 phases.

  The 16-bit counter initial setting is performed by transferring the set value of the TT0TCW register to the 16-bit counter and the count operation is started. (When the TT0CTL2.TT0ECC bit = 0, the TT0TCW register set value is transferred to the 16-bit counter at the timing when the TT0CTL0.TT0CE bit changes from 0 to 1.)

- **Triangular-wave PWM mode**

  The 16-bit counter starts counting from the initial value FFFFH.

  It counts up FFFFH, 0000H, 0001H, 0002H, 0003H, and so on.

  Following the count-up operation, the counter counts down upon a match between the 16-bit count value and the CCR0 buffer register.

- **Mode other than above**

  The 16-bit counter starts counting from the initial value FFFFH.

  It counts up FFFFH, 0000H, 0001H, 0002H, 0003H, and so on.

(b) Clear operation

The 16-bit counter is cleared to 0000H when its value matches the value of the compare register, when its value is captured, when the edge of the encoder clear signal is detected, and when the clear level condition of the TENC00, TENC01, and TECR0 pins is detected. The count operation from FFFFH to 0000H that takes place immediately after the counter has started counting or when the counter overflows is not a clear operation. Therefore, the INTTT0CC0 and INTTT0CC1 interrupt signals are not generated.

(c) Overflow operation

The 16-bit counter overflows when it counts up from FFFFH to 0000H in the free-running mode, pulse width measurement mode, and encoder compare mode. If the counter overflows in the free-running mode and pulse width measurement mode, the TT0OPT0.TT0OVF bit is set to 1 and an interrupt request signal (INTTT0OV) is generated.

If the counter overflows in the encoder compare mode, the TT0OPT1.TT0EOF bit is set to 1 and an interrupt request signal (INTTT0OV) is generated.

Note that the INTTT0OV signal is not generated under the following conditions.

- Immediately after a count operation has been started
- If the counter value matches the compare value FFFFH and is cleared
- When FFFFH is captured and cleared to 0000H in the pulse width measurement mode

Caution After the overflow interrupt request signal (INTTT0OV) has been generated, be sure to check that the overflow flag (TT0OVF, TT0EOF bits) is set to 1.

(d) Count value hold operation

The value of the 16-bit counter is held by the TT0CTL2.TT0ECC bit in the encoder compare mode. The value of the 16-bit counter is reset to FFFFH when the TT0ECC bit = 0 and TT0CTL0.TT0CE bit = 0. When the TT0CE bit is next set to 1, the set value of the TT0TCW register is transferred to the 16-bit counter and a count operation is performed.

If the TT0ECC bit = 1 and TT0CE bit = 0, the value of the 16-bit counter is held. When the TT0CE bit is next set to 1, the counter resumes the count operation from the held value.

(e) Counter read operation during count operation

The value of the 16-bit counter of TMT0 can be read by using the TT0CNT register during the count operation.

When the TT0CTL0.TT0CE bit = 1, the value of the 16-bit counter can be read by reading the TT0CNT register.

If the TT0CNT register is read when the TT0CTL2.TT0ECC bit = 0 and TT0CE bit = 0, however, it is 0000H.

The held value of the TT0CNT register is read if the register is read when the TT0ECC bit = 1 and TT0CE bit = 0.

(f) Underflow operation

A 16-bit counter underflow occurs at the timing when the 16-bit counter value changes from 0000H to FFFFH in the encoder compare mode. When an underflow occurs, the TT0OPT1.TT0EUF bit is set to 1 and an interrupt request signal (INTTT0OV) is generated.

(g) Interrupt operation

TMT0 generates the following four types of interrupt request signals.

- INTTT0CC0 interrupt: This signal functions as a match interrupt request signal of the CCR0 buffer register and as a capture interrupt request signal to the TT0CCR0 register.
- INTTT0CC1 interrupt: This signal functions as a match interrupt request signal of the CCR1 buffer register and as a capture interrupt request signal to the TT0CCR1 register.
- INTTT0OV interrupt: This signal functions as an overflow interrupt request signal.
- INTTT0EC interrupt: This signal functions as a valid edge detection interrupt request signal of the encoder clear input (TECR0 pin).

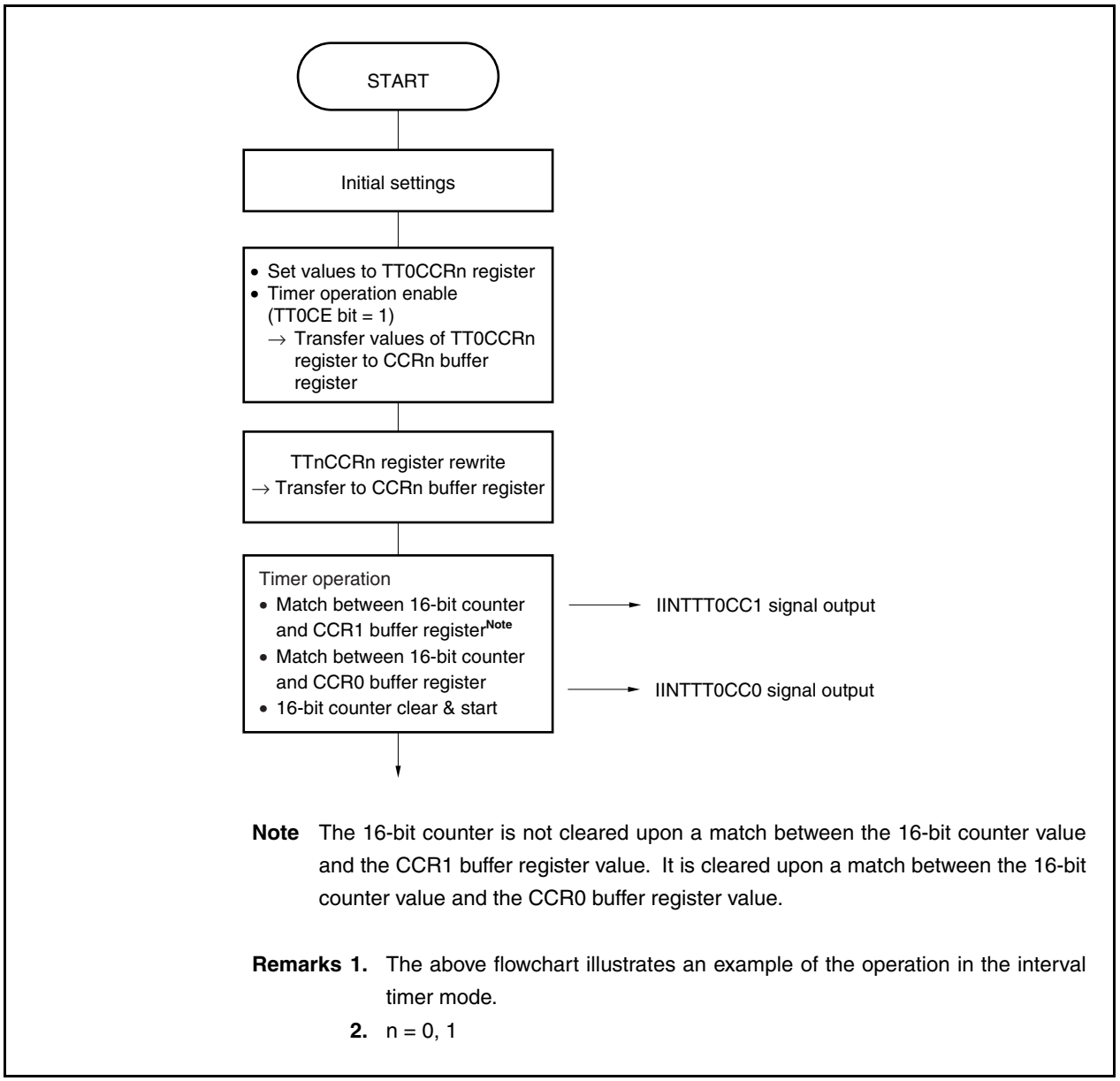
(2) Anytime write and batch write

The TT0CCR0 and TT0CCR1 registers in TMT0 can be rewritten during timer operation (TT0CTL0.TT0CE bit = 1), but the write method (anytime write, batch write) of the CCR0 and CCR1 buffer registers differs depending on the mode.

(a) Anytime write

In this mode, data is transferred at any time from the TT0CCR0 and TT0CCR1 registers to the CCR0 and CCR1 buffer registers during timer operation (n = 0, 1).

Figure 9-3. Flowchart of Basic Operation for Anytime Write

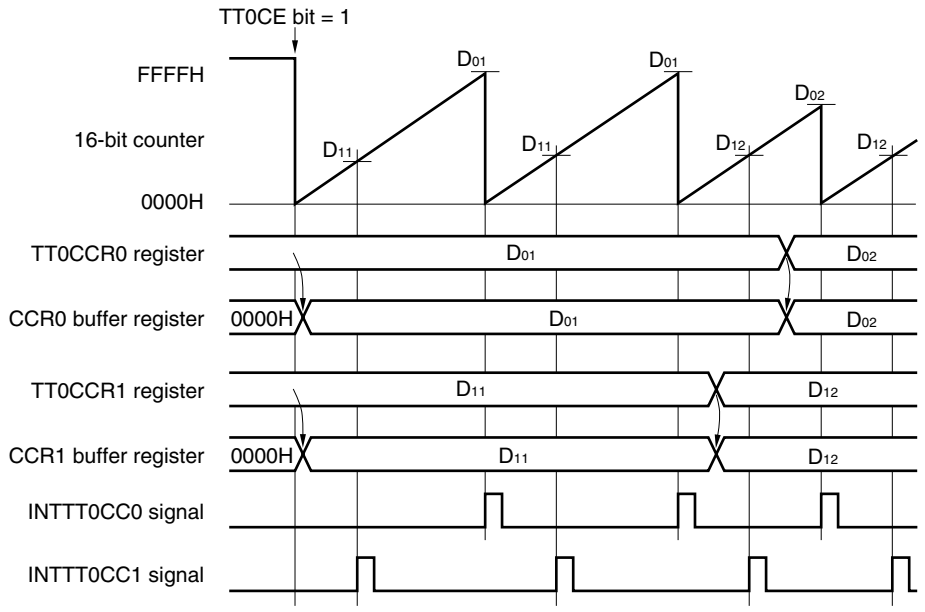


Note The 16-bit counter is not cleared upon a match between the 16-bit counter value and the CCR1 buffer register value. It is cleared upon a match between the 16-bit counter value and the CCR0 buffer register value.

Remarks 1. The above flowchart illustrates an example of the operation in the interval timer mode.

2. n = 0, 1

Figure 9-4. Timing of Anytime Write



Remarks 1. D_{01}, D_{02}: Set values of TT0CCR0 register
D_{11}, D_{12}: Set values of TT0CCR1 register

2. The above timing chart illustrates an example of the operation in the interval timer mode.

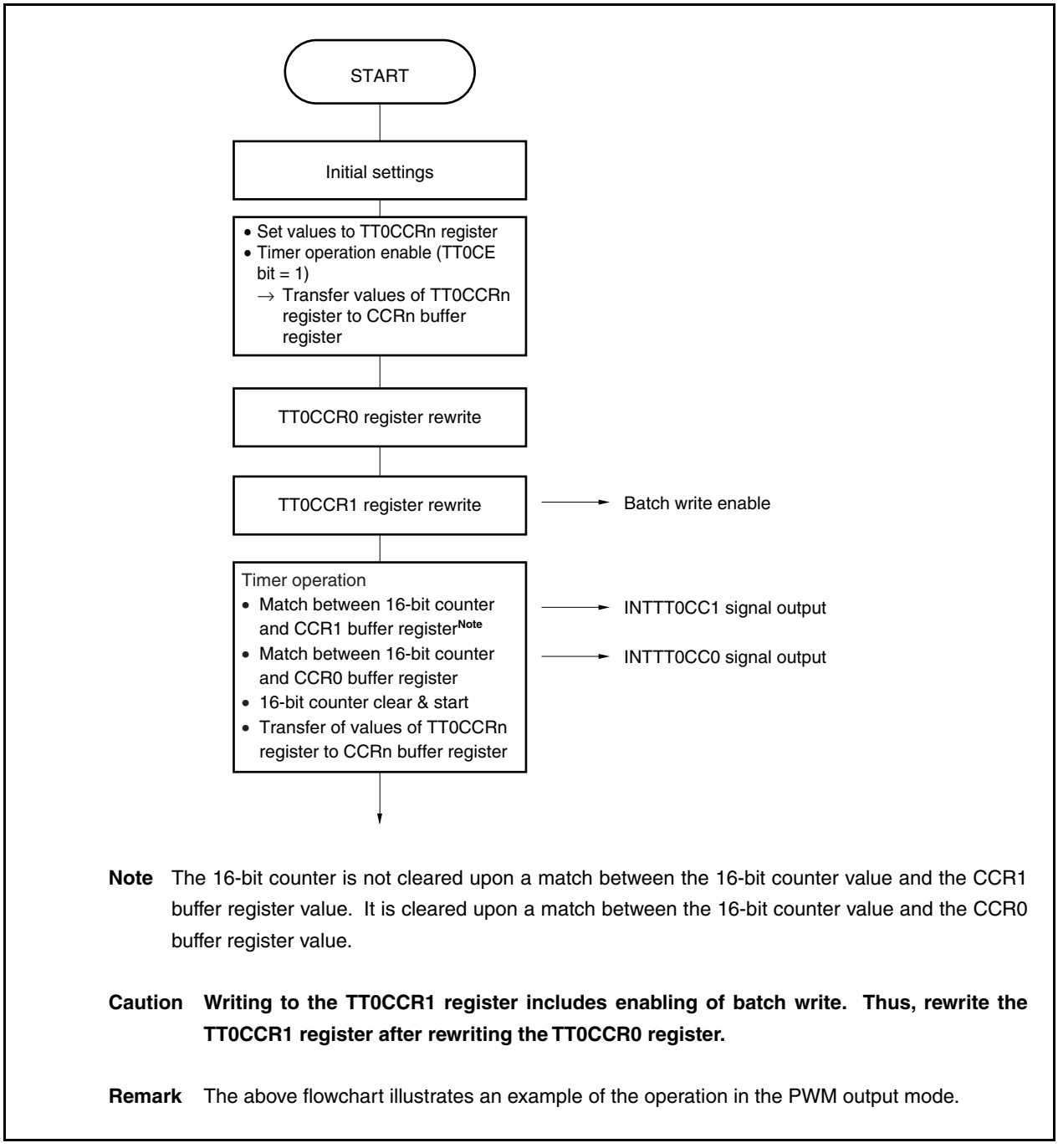
3. n = 0, 1

(b) Batch write

In this mode, data is transferred all at once from the TT0CCR0 and TT0CCR1 registers to the CCR0 and CCR1 buffer registers during timer operation. This data is transferred upon a match between the value of the CCR0 buffer register and the value of the 16-bit counter. Transfer is enabled by writing to the TT0CCR1 register. Whether to enable or disable the next transfer timing is controlled by writing or not writing to the TT0CCR1 register.

In order for the set value when the TT0CCR0 and TT0CCR1 registers are rewritten to become the 16-bit counter comparison value (in other words, in order for this value to be transferred to the CCR0 and CCR1 buffer registers), it is necessary to rewrite the TT0CCR0 register and then write to the TT0CCR1 register before the 16-bit counter value and the CCR0 buffer register value match. Therefore, the values of the TT0CCR0 and TT0CCR1 registers are transferred to the CCR0 and CCR1 buffer registers upon a match between the count value of the 16-bit counter and the value of the CCR0 buffer register. Thus even when wishing only to rewrite the value of the TT0CCR0 register, also write the same value (same as preset value of the TT0CCR1 register) to the TT0CCR1 register.

Figure 9-5. Flowchart of Basic Operation for Batch Write

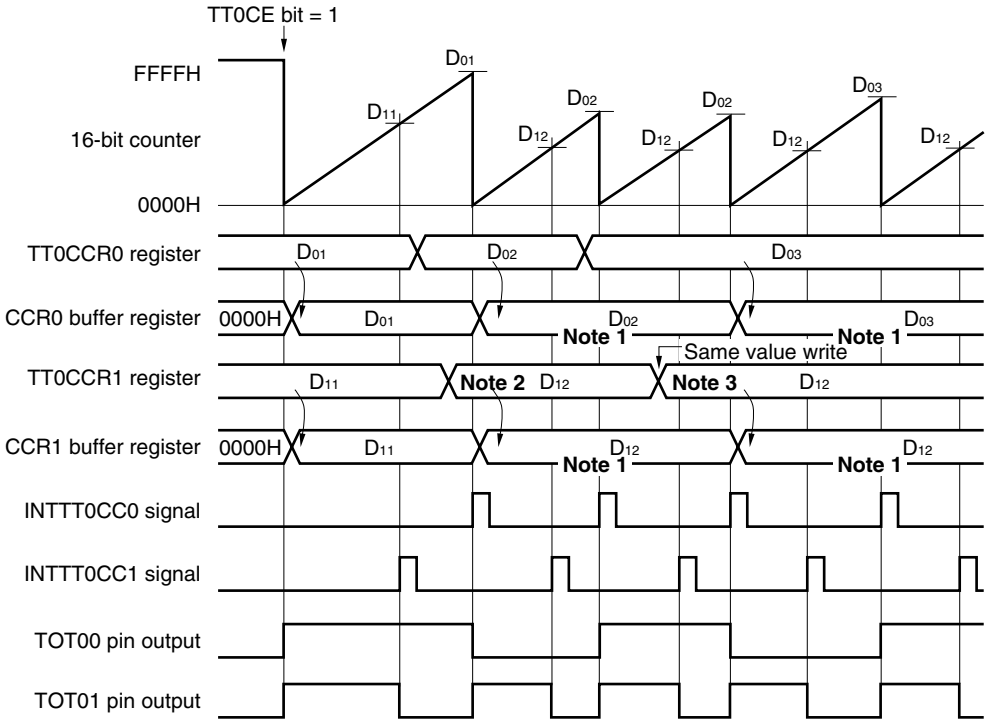


Note The 16-bit counter is not cleared upon a match between the 16-bit counter value and the CCR1 buffer register value. It is cleared upon a match between the 16-bit counter value and the CCR0 buffer register value.

Caution Writing to the TT0CCR1 register includes enabling of batch write. Thus, rewrite the TT0CCR1 register after rewriting the TT0CCR0 register.

Remark The above flowchart illustrates an example of the operation in the PWM output mode.

Figure 9-6. Timing of Batch Write



Notes 1. Because the TT0CCR1 register was not rewritten, D_{03} is not transferred.

2. Because the TT0CCR1 register has been written (D_{12}), data is transferred to the CCR1 buffer register upon a match between the value of the 16-bit counter and the value of the TT0CCR0 register (D_{01}).

3. Because the TT0CCR1 register has been written (D_{12}), data is transferred to the CCR1 buffer register upon a match between the value of the 16-bit counter and the value of the TT0CCR0 register (D_{02}).

Remarks 1. D_{01}, D_{02}, D_{03}: Set values of TT0CCR0 register
D_{11}, D_{12}: Set values of TT0CCR1 register

2. The above timing chart illustrates the operation in the PWM output mode as an example.

9.6.1 Interval timer mode (TT0MD3 to TT0MD0 bits = 0000)

In the interval timer mode, an interrupt request signal (INTTT0CC0) is generated at the interval set by the TT0CCR0 register if the TT0CTL0.TT0CE bit is set to 1. A square wave whose half cycle is equal to the interval can be output from the TOT00 pin.

The TT0CCR1 register is not used in the interval timer mode. However, the set value of the TT0CCR1 register is transferred to the CCR1 buffer register, and when the count value of the 16-bit counter matches the value of the CCR1 buffer register, a compare match interrupt request signal (INTTT0CC1) is generated. In addition, a square wave, which is inverted when the INTTT0CC1 signal is generated, can be output from the TOT01 pin.

The value of the TT0CCR0 and TT0CCR1 registers can be rewritten even while the timer is operating.

Figure 9-7. Configuration of Interval Timer

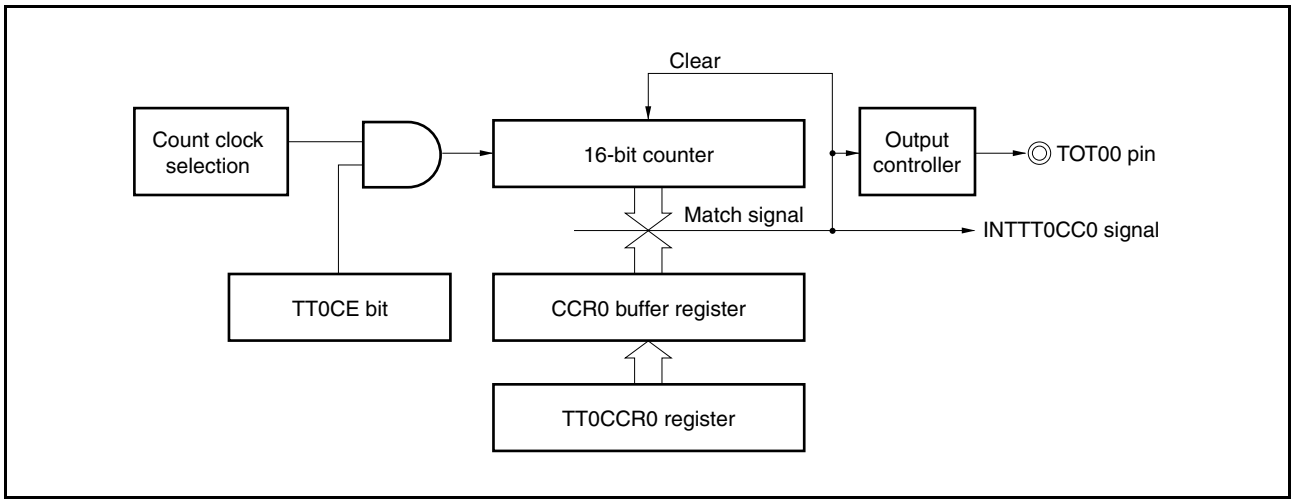
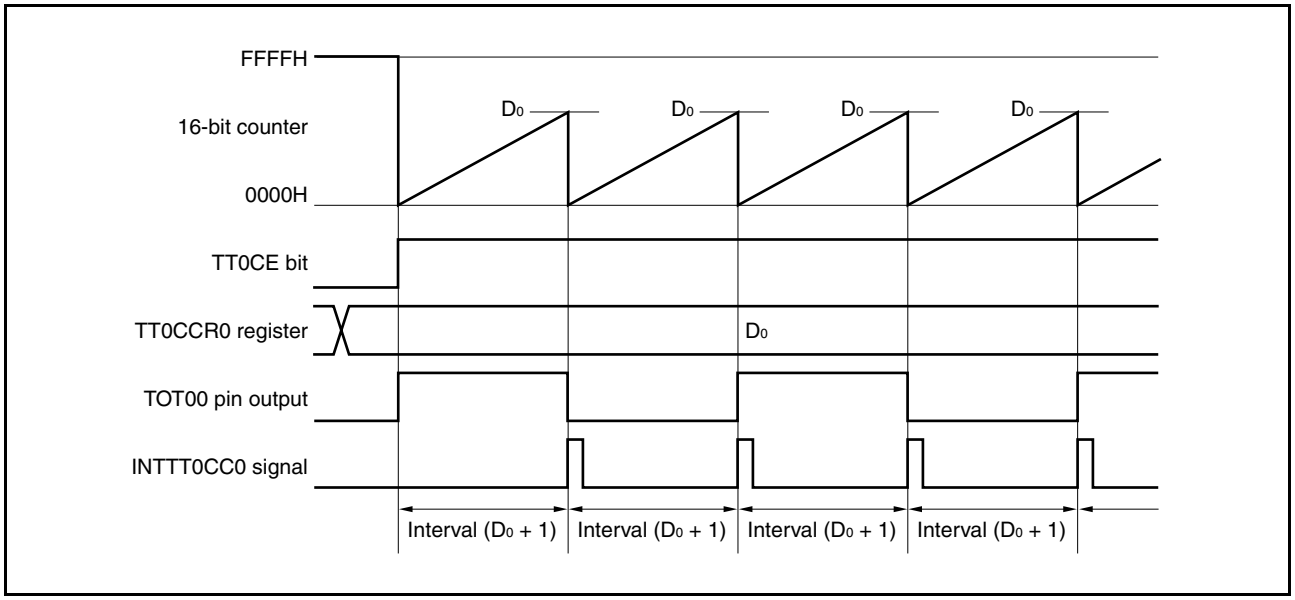


Figure 9-8. Basic Timing of Operation in Interval Timer Mode



When the TT0CE bit is set to 1, the value of the 16-bit counter is cleared from FFFFH to 0000H in synchronization with the count clock, and the counter starts counting. At this time, the output of the TOT00 pin is inverted. Additionally, the set value of the TT0CCR0 register is transferred to the CCR0 buffer register.

When the count value of the 16-bit counter matches the value of the CCR0 buffer register, the 16-bit counter is cleared to 0000H, the output of the TOT00 pin is inverted, and a compare match interrupt request signal (INTTT0CC0) is generated.

The interval can be calculated by the following expression.

Interval = (Set value of TT0CCR0 register + 1) × Count clock cycle

Figure 9-9. Register Setting for Interval Timer Mode Operation (1/2)

(a) TMT0 control register 0 (TT0CTL0)

	TT0CE					TT0CKS2	TT0CKS1	TT0CKS0
TT0CTL0	0/1	0	0	0	0	0/1	0/1	0/1

Select count clock

0: Stops counting
1: Enables counting

(b) TMT0 control register 1 (TT0CTL1)

		TT0EST	TT0EEE			TT0MD3	TT0MD2	TT0MD1	TT0MD0
TT0CTL1	0	0	0	0	0	0	0	0	0

0, 0, 0, 0:
Interval timer mode

(c) TMT0 I/O control register 0 (TT0IOC0)

					TT0OL1	TT0OE1	TT0OL0	TT0OE0
TT0IOC0	0	0	0	0	0/1	0/1	0/1	0/1

0: Disables TOT00 pin output
1: Enables TOT00 pin output

Setting of TOT00 pin output level before count operation
0: Low level
1: High level

0: Disables TOT01 pin output
1: Enables TOT01 pin output

Setting of TOT01 pin output level before count operation
0: Low level
1: High level

Figure 9-9. Register Setting for Interval Timer Mode Operation (2/2)

(d) TMT0 counter read buffer register (TT0CNT)

By reading the TT0CNT register, the count value of the 16-bit counter can be read.

(e) TMT0 capture/compare register 0 (TT0CCR0)

If the TT0CCR0 register is set to D_0, the interval is as follows.

Interval = (D_0 + 1) × Count clock cycle

(f) TMT0 capture/compare register 1 (TT0CCR1)

The TT0CCR1 register is not used in the interval timer mode. However, the set value of the TT0CCR1 register is transferred to the CCR1 buffer register. When the count value of the 16-bit counter matches the value of the CCR1 buffer register, the TOT01 pin output is inverted and a compare match interrupt request signal (INTTT0CC1) is generated.

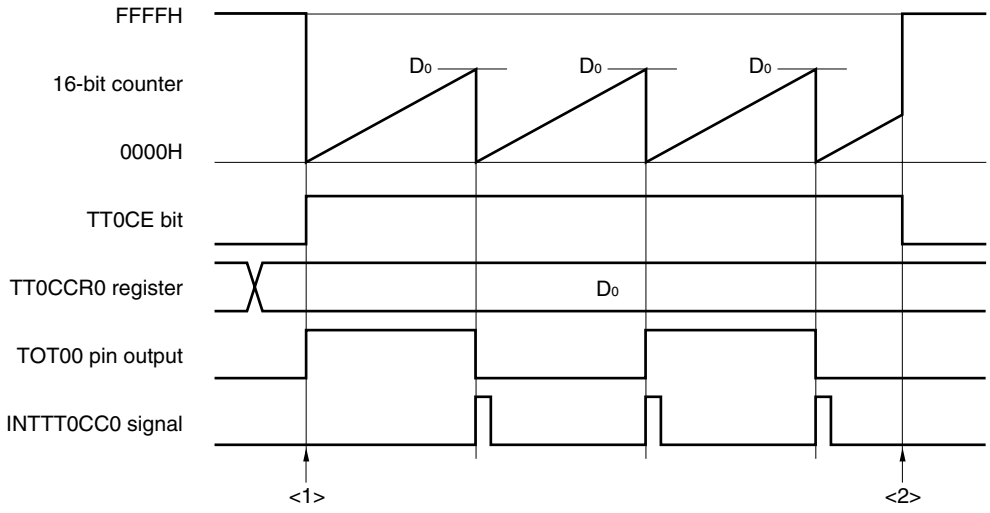
By setting this register to the same value as the value set in the TT0CCR0 register, a square wave with a duty factor of 50% can be output from the TOT01 pin.

When the TT0CCR1 register is not used, it is recommended to set its value to FFFFH. Also mask the register by the interrupt mask flag (TT0CCIC1.TT0CCMK1).

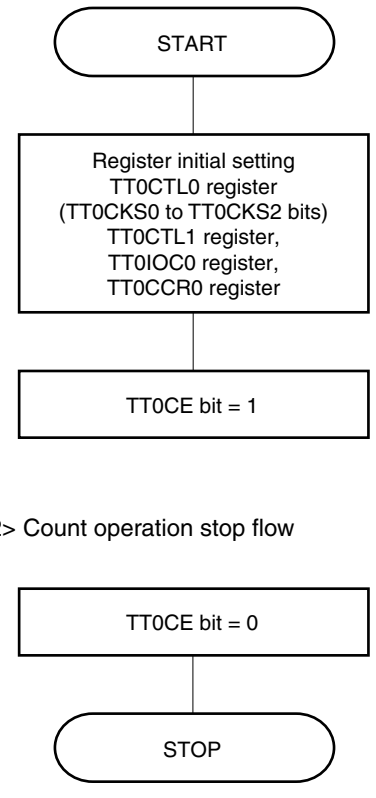
Remark TMT0 control register 2 (TT0CTL2), TMT0 I/O control register 1 (TT0IOC1), TMT0 I/O control register 2 (TT0IOC2), TMT0 I/O control register 3 (TT0IOC3), TMT0 option register 0 (TT0OPT0), TMT0 option register 1 (TT0OPT1), and TMT0 counter write register (TT0TCW) are not used in the interval timer mode.

(1) Interval timer mode operation flow

Figure 9-10. Software Processing Flow in Interval Timer Mode



<1> Count operation start flow



Initial setting of these registers is performed before setting the TT0CE bit to 1.

The TT0CKS0 to TT0CKS2 bits can be set at the same time as when counting starts (TT0CE bit = 1).

<2> Count operation stop flow

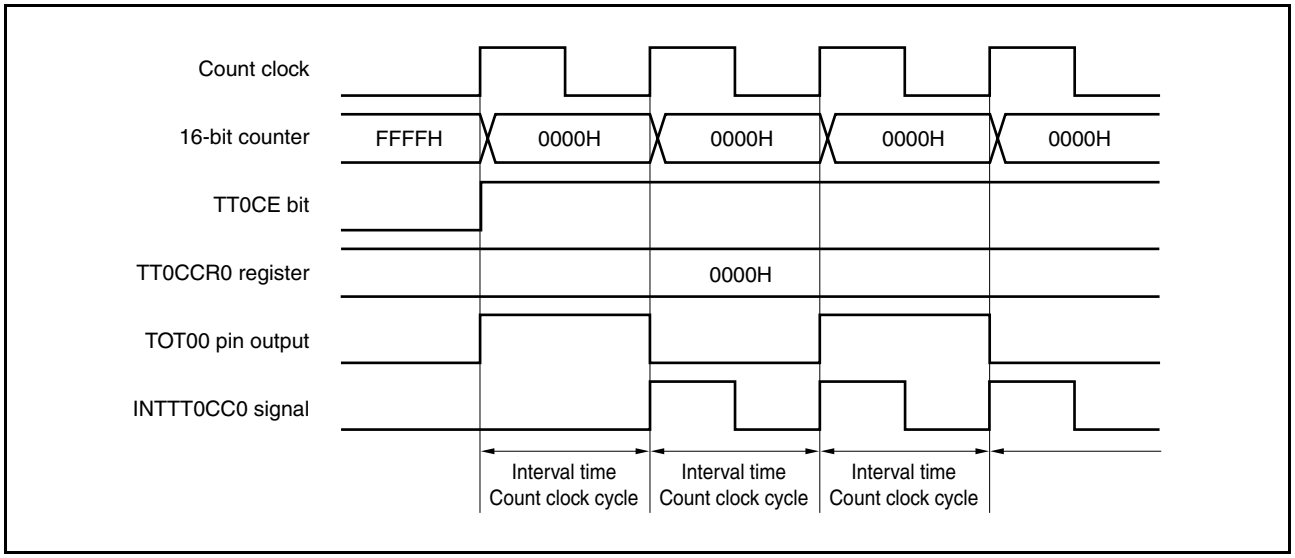
The counter is initialized and counting is stopped by clearing the TT0CE bit to 0. The output level of the TOT00 pin is as specified by the TT0IOC0 register.

(2) Interval timer mode operation timing

(a) Operation if TT0CCR0 register is set to 0000H

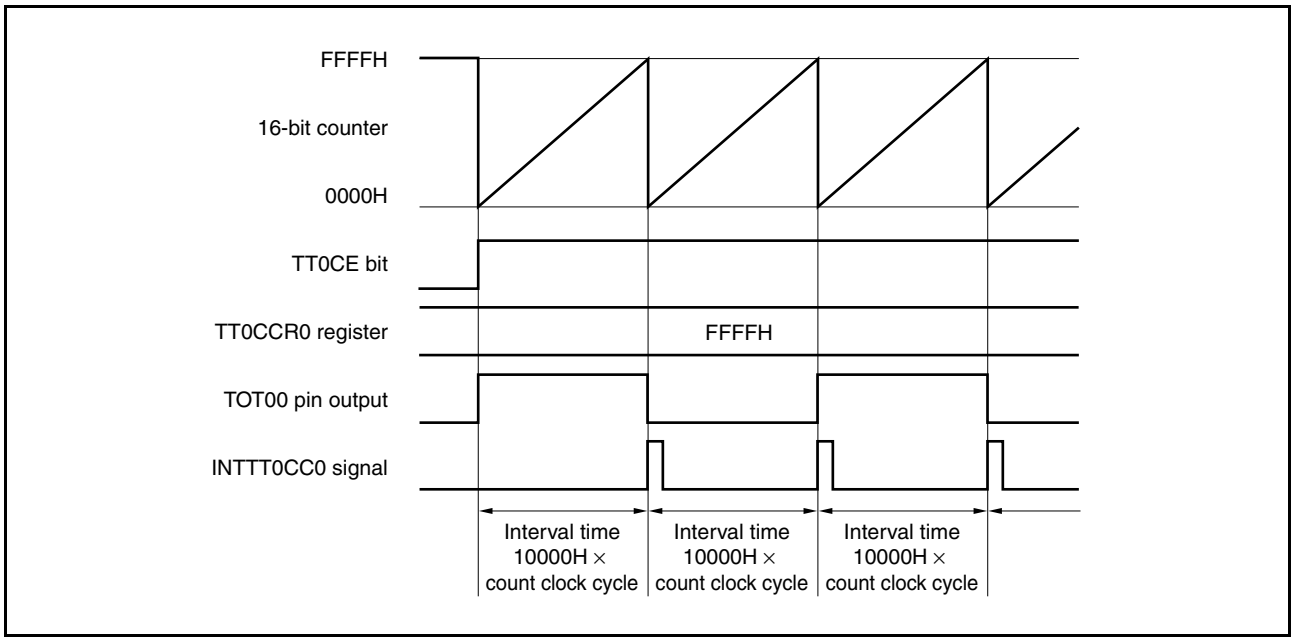
If the TT0CCR0 register is set to 0000H, the INTTT0CC0 signal is generated at each count clock, and the output of the TOT00 pin is inverted.

The value of the 16-bit counter is always 0000H.



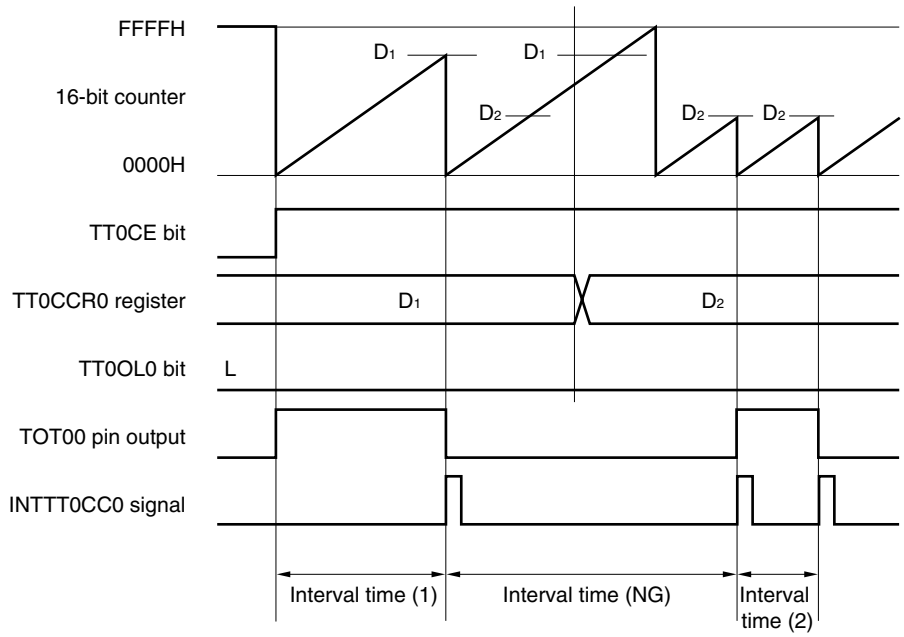
(b) Operation if TT0CCR0 register is set to FFFFH

If the TT0CCR0 register is set to FFFFH, the 16-bit counter counts up to FFFFH. The counter is cleared to 0000H in synchronization with the next count-up timing. The INTTT0CC0 signal is generated and the output of the TOT00 pin is inverted. At this time, an overflow interrupt request signal (INTTT0OV) is not generated, nor is the overflow flag (TT0OPT0.TT0OVF bit) set to 1.



(c) Notes on rewriting TT0CCR0 register

If the value of the TT0CCR0 register is rewritten to a smaller value during counting, the 16-bit counter may overflow. When an overflow may occur, stop counting and then change the set value.



Remark Interval time (1): $(D_1 + 1) \times$ Count clock cycle
Interval time (NG): $(10000H + D_2 + 1) \times$ Count clock cycle
Interval time (2): $(D_2 + 1) \times$ Count clock cycle

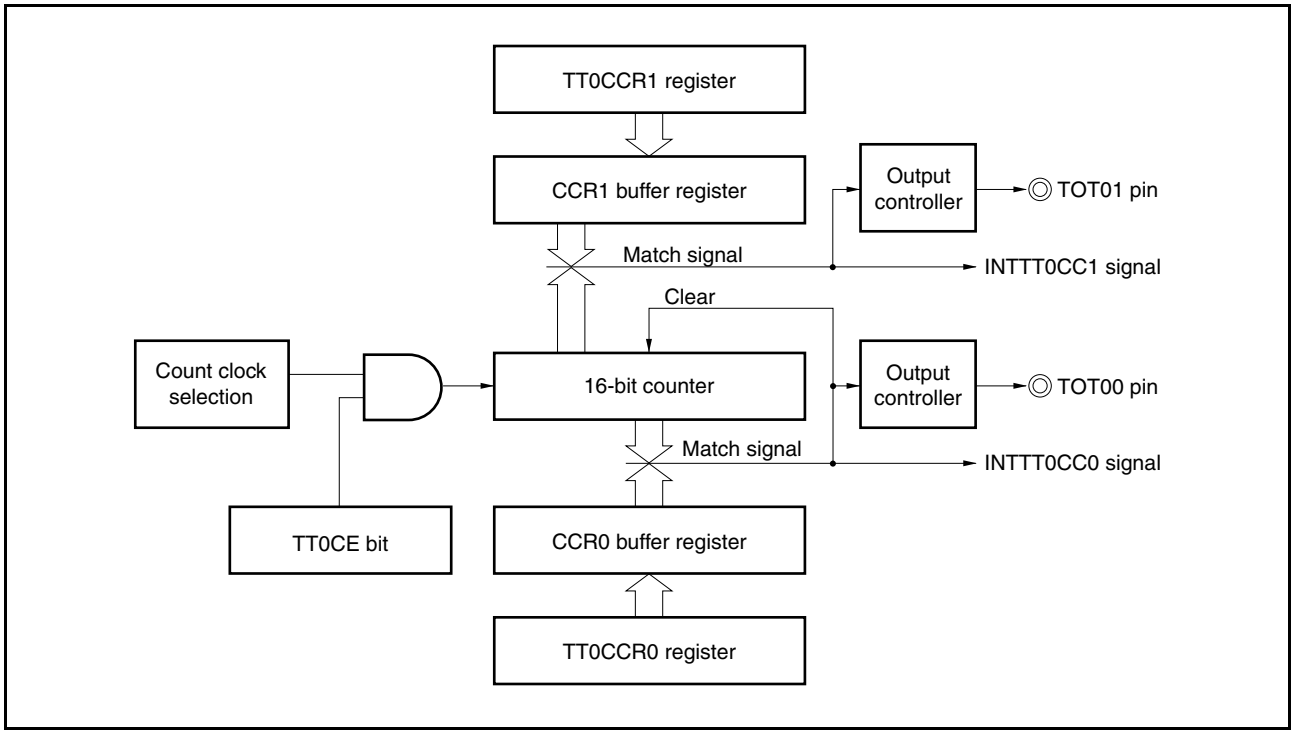
If the value of the TT0CCR0 register is changed from D_1 to D_2 while the count value is greater than D_2 but less than D_1, the count value is transferred to the CCR0 buffer register as soon as the TT0CCR0 register has been rewritten. Consequently, the value of the 16-bit counter that is compared is D_2.

Because the count value has already exceeded D_2, however, the 16-bit counter counts up to FFFFH, overflows, and then counts up again from 0000H. When the count value matches D_2, the INTTT0CC0 signal is generated and the output of the TOT00 pin is inverted.

Therefore, the INTTT0CC0 signal may not be generated at the interval time "$(D_1 + 1) \times$ Count clock cycle" or "$(D_2 + 1) \times$ Count clock cycle" as originally expected, but may be generated at an interval of "$(10000H + D_2 + 1) \times$ Count clock cycle".

(d) Operation of TT0CCR1 register

Figure 9-11. Configuration of TT0CCR1 Register



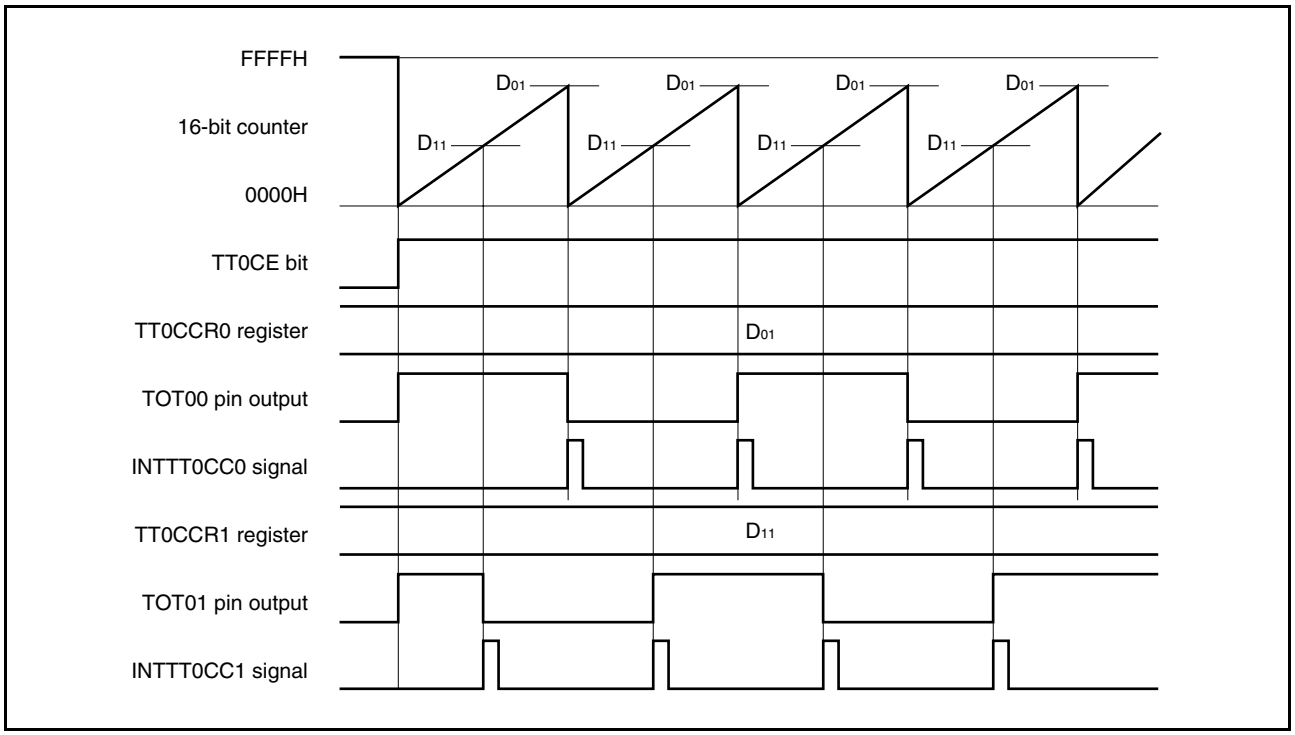
When the TT0CCR1 register is set to the same value as the TT0CCR0 register, the INTTT0CC0 signal is generated at the same timing as the INTTT0CC1 signal and the TOT01 pin output is inverted. In other words, a square wave can be output from the TOT01 pin.

The following shows the operation when the TT0CCR1 register is set to other than the value set in the TT0CCR0 register.

If the set value of the TT0CCR1 register is less than the set value of the TT0CCR0 register, the INTTT0CC1 signal is generated once per cycle. At the same time, the output of the TOT01 pin is inverted.

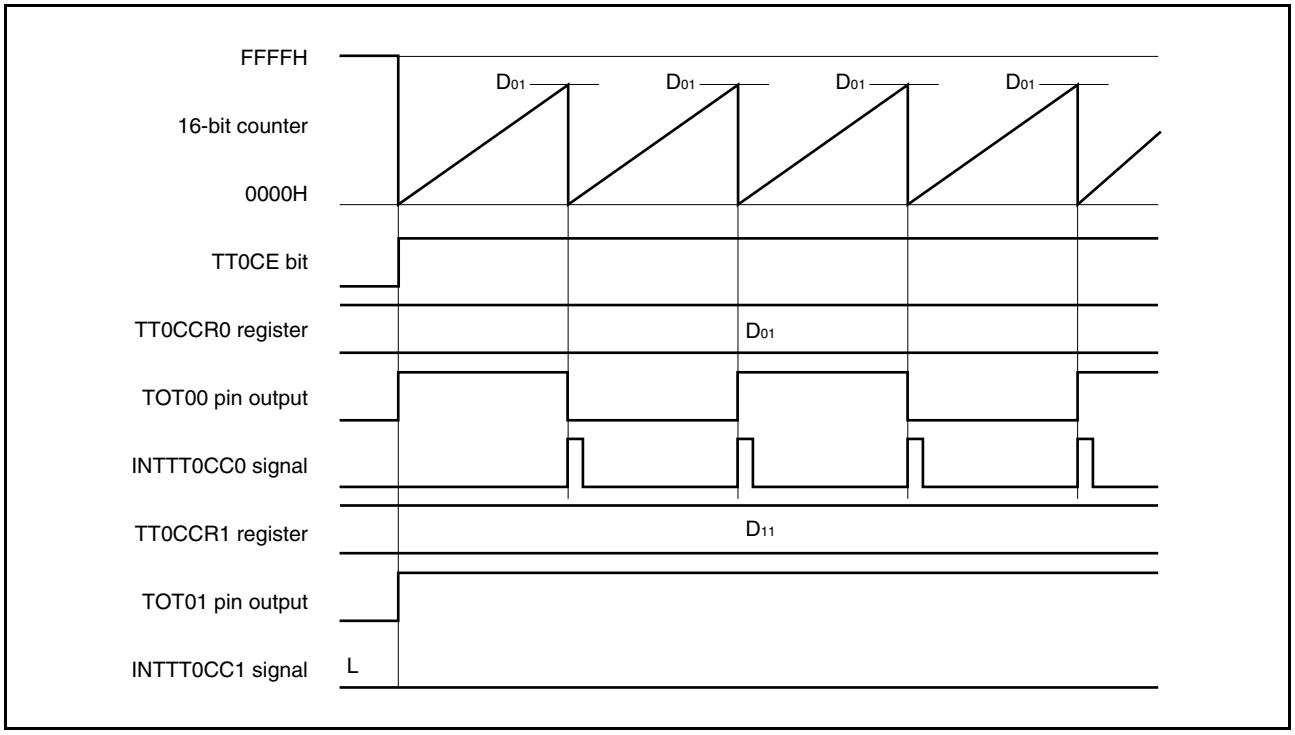
The TOT01 pin outputs a square wave after outputting a short-width pulse.

Figure 9-12. Timing Chart When $D_{01} \geq D_{11}$



If the set value of the TT0CCR1 register is greater than the set value of the TT0CCR0 register, the count value of the 16-bit counter does not match the value of the TT0CCR1 register. Consequently, the INTTT0CC1 signal is not generated, nor is the output of the TOT01 pin changed.
When the TT0CCR1 register is not used, it is recommended to set its value to FFFFH.

Figure 9-13. Timing Chart When $D_{01} < D_{11}$

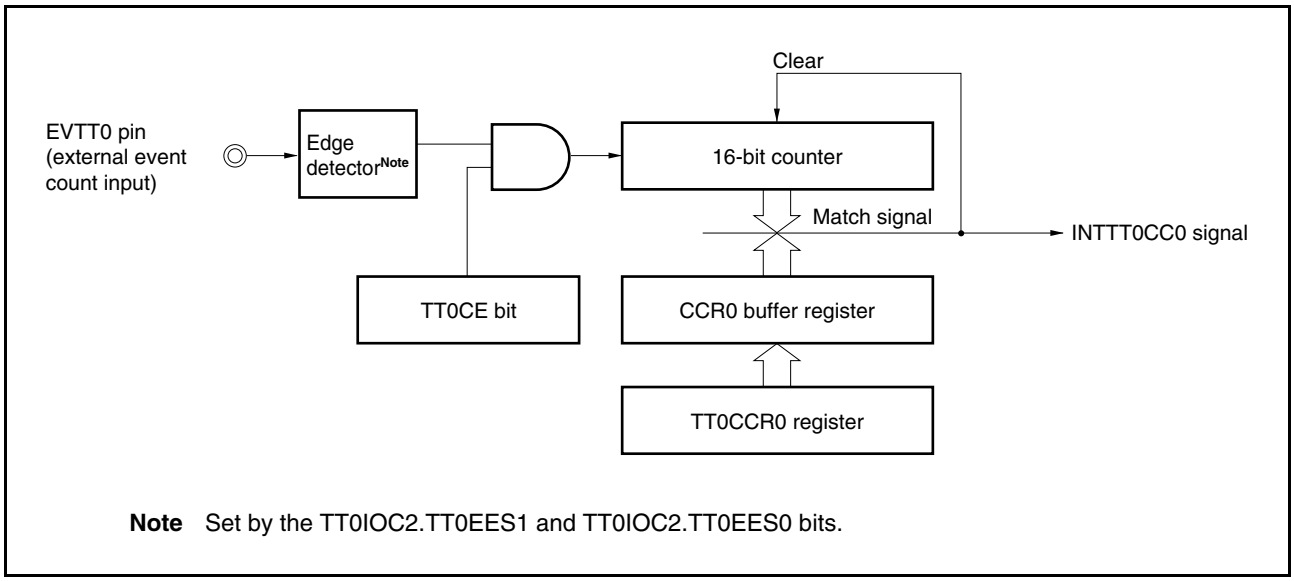


9.6.2 External event count mode (TT0MD3 to TT0MD0 bits = 0001)

In the external event count mode, the valid edge of the external event count input (EVTT0) is counted when the TT0CTL0.TT0CE bit is set to 1, and an interrupt request signal (INTTT0CC0) is generated each time the number of edges set by the TT0CCR0 register have been counted. The TOT00 and TOT01 pins cannot be used.

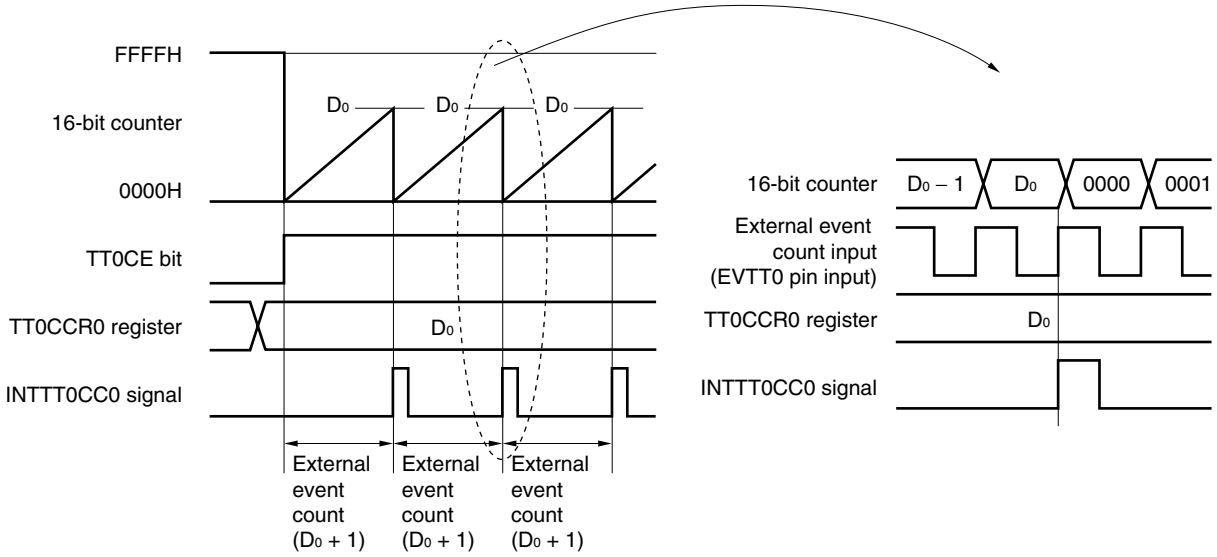
The TT0CCR1 register is not used in the external event count mode.

Figure 9-14. Configuration in External Event Count Mode



Note Set by the TT0IOC2.TT0EES1 and TT0IOC2.TT0EES0 bits.

Figure 9-15. Basic Timing in External Event Count Mode



Remark This figure shows the basic timing when the rising edge is specified as the valid edge of the external event count input.

When the TT0CE bit is set to 1, the value of the 16-bit counter is cleared from FFFFH to 0000H. The counter counts each time the valid edge of external event count input is detected. Additionally, the set value of the TT0CCR0 register is transferred to the CCR0 buffer register.

When the count value of the 16-bit counter matches the value of the CCR0 buffer register, the 16-bit counter is cleared to 0000H, and a compare match interrupt request signal (INTTT0CC0) is generated.

The INTTT0CC0 signal is generated each time the valid edge of the external event count input has been detected "value set to TT0CCR0 register + 1" times.

Figure 9-16. Register Setting for Operation in External Event Count Mode (1/2)

(a) TMT0 control register 0 (TT0CTL0)

	TT0CE					TT0CKS2	TT0CKS1	TT0CKS0
TT0CTL0	0/1	0	0	0	0	0	0	0

0: Stops counting
1: Enables counting

(b) TMT0 control register 1 (TT0CTL1)

		TT0EST	TT0EEE		TT0MD3	TT0MD2	TT0MD1	TT0MD0
TT0CTL1	0	0	0	0	0	0	0	1

0, 0, 0, 1:
External event count mode

(c) TMT0 I/O control register 2 (TT0IOC2)

					TT0EES1	TT0EES0	TT0ETS1	TT0ETS0
TT0IOC2	0	0	0	0	0/1	0/1	0	0

Select valid edge
of external event
count input (EVTT0 pin)

(d) TMT0 counter read buffer register (TT0CNT)

The count value of the 16-bit counter can be read by reading the TT0CNT register.

(e) TMT0 capture/compare register 0 (TT0CCR0)

If the TT0CCR0 register is set to D_0, the count is cleared when the number of external events has reached (D_0 + 1) and the compare match interrupt request signal (INTTT0CC0) is generated.

Figure 9-16. Register Setting for Operation in External Event Count Mode (2/2)

(f) TMT0 capture/compare register 1 (TT0CCR1)

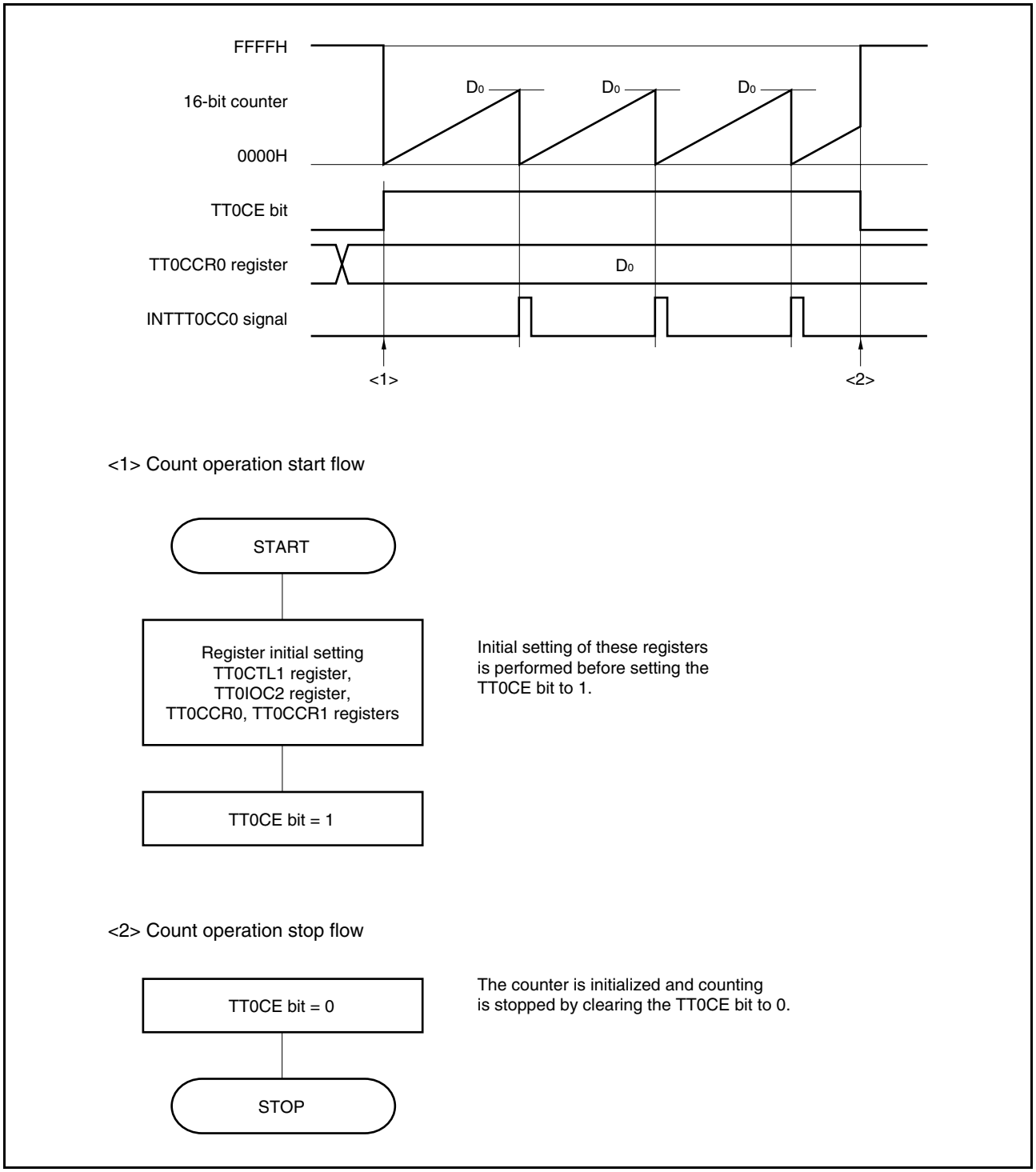
The TT0CCR1 register is not used in the external event count mode. However, the set value of the TT0CCR1 register is transferred to the CCR1 buffer register. When the count value of the 16-bit counter matches the value of the CCR1 buffer register, a compare match interrupt request signal (INTTT0CC1) is generated.

When the TT0CCR1 register is not used, it is recommended to set its value to FFFFH. Also mask the register by the interrupt mask flag (TT0CCIC1.TT0CCMK1).

Remark TMT0 control register 2 (TT0CTL2), TMT0 I/O control register 0 (TT0IOC0), TMT0 I/O control register 1 (TT0IOC1), TMT0 I/O control register 3 (TT0IOC3), TMT0 option register 0 (TT0OPT0), TMT0 option register 1 (TT0OPT1), and TMT0 counter write register (TT0TCW) are not used in the external event count mode.

(1) External event count mode operation flow

Figure 9-17. Software Processing Flow in External Event Count Mode

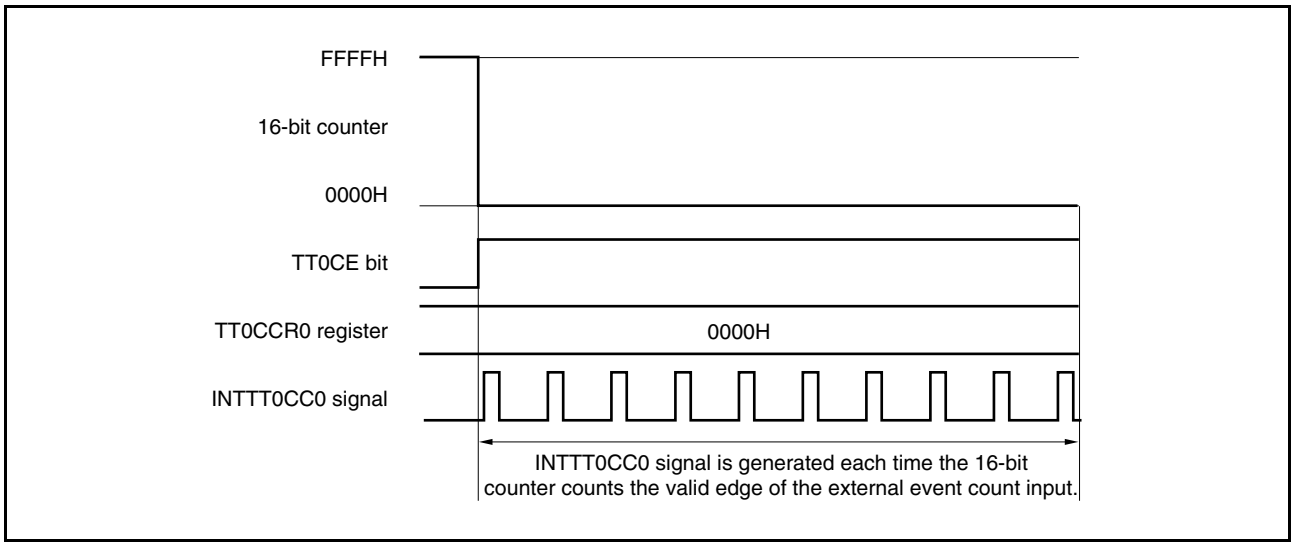


(2) Operation timing in external event count mode

(a) Operation if TT0CCR0 register is set to 0000H

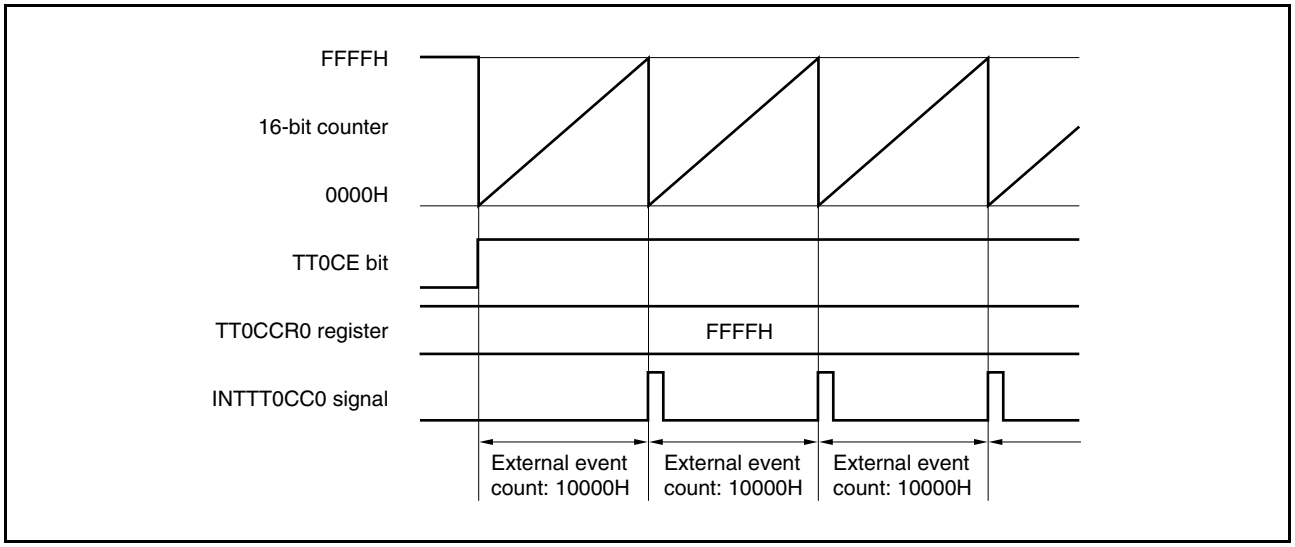
When the TT0CCR0 register is set to 0000H, the 16-bit counter is repeatedly cleared to 0000H and generates the INTTT0CC0 signal each time it has detected the valid edge of the external event count signal and its value has matched that of the CCR0 buffer register.

The value of the 16-bit counter is always 0000H.



(b) Operation if TT0CCR0 register is set to FFFFH

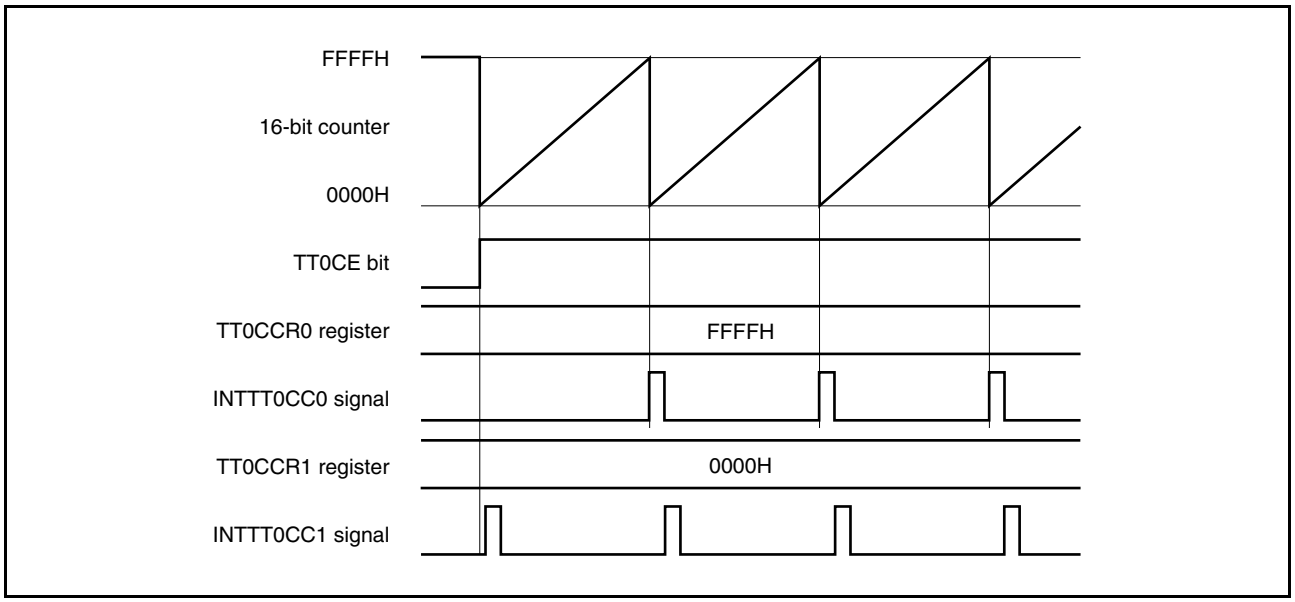
If the TT0CCR0 register is set to FFFFH, the 16-bit counter counts up to FFFFH each time the valid edge of the external event count signal has been detected. The 16-bit counter is cleared to 0000H in synchronization with the next count-up timing, and the INTTT0CC0 signal is generated. At this time, the TT0OPT0.TT0OVF bit is not set.



(c) Operation with TT0CCR0 set to FFFFH and TT0CCR1 register to 0000H

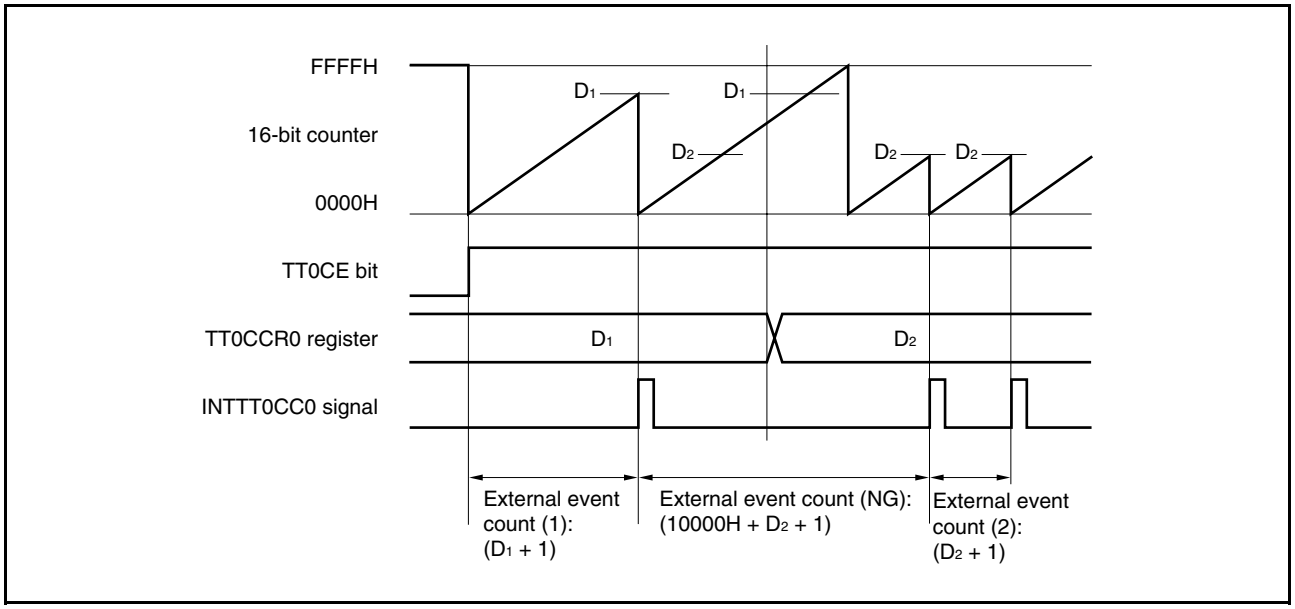
When the TT0CCR0 register is set to FFFFH, the 16-bit counter counts up to FFFFH each time it has detected the valid edge of the external event count signal. The counter is then cleared to 0000H in synchronization with the next count-up timing and the INTTT0CC0 signal is generated. At this time, the TT0OPT0.TT0OVF bit is not set.

If the TT0CCR1 register is set to 0000H, the INTTT0CC1 signal is generated when the 16-bit counter is cleared to 0000H.



(d) Notes on rewriting TT0CCR0 register

If the value of the TT0CCR0 register is rewritten to a smaller value during counting, the 16-bit counter may overflow. When an overflow may occur, stop counting once and then change the set value.

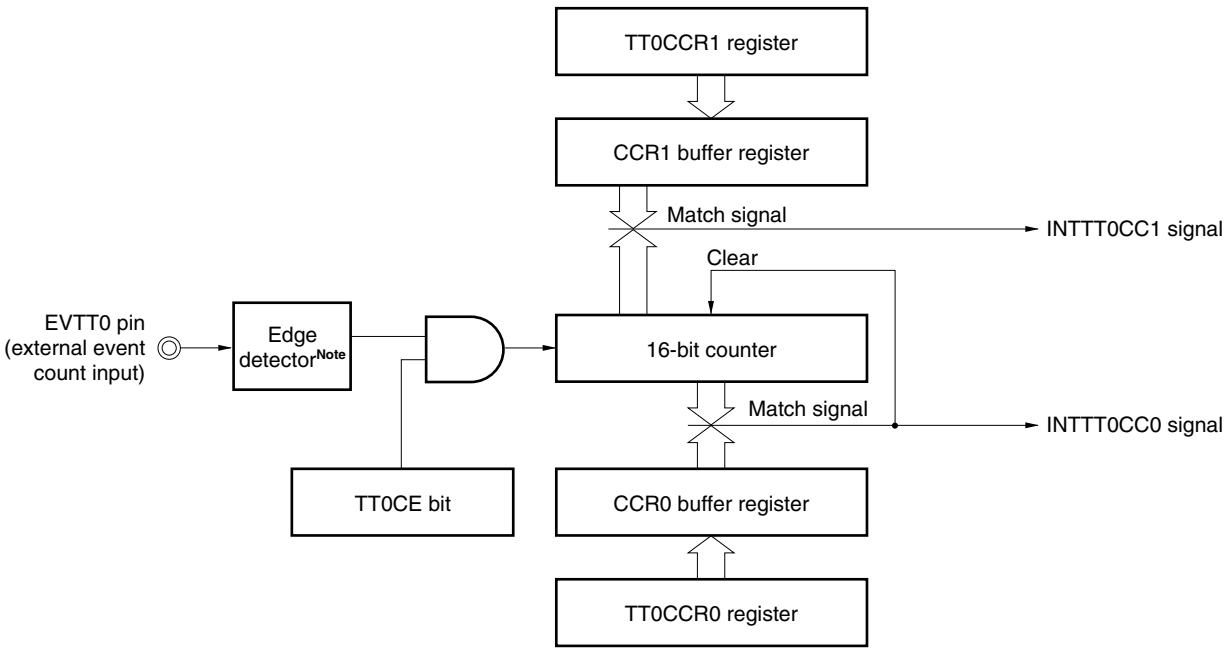


If the value of the TT0CCR0 register is changed from D_1 to D_2 while the count value is greater than D_2 but less than D_1, the count value is transferred to the CCR0 buffer register as soon as the TT0CCR0 register has been rewritten. Consequently, the value that is compared with the 16-bit counter is D_2.

Because the count value has already exceeded D_2, however, the 16-bit counter counts up to FFFFH, overflows, and then counts up again from 0000H. When the count value matches D_2, the INTTT0CC0 signal is generated. Therefore, the INTTT0CC0 signal may not be generated at the valid edge count of "(D_1 + 1) times" or "(D_2 + 1) times" as originally expected, but may be generated at the valid edge count of "(10000H + D_2 + 1) times".

(e) Operation of TT0CCR1 register

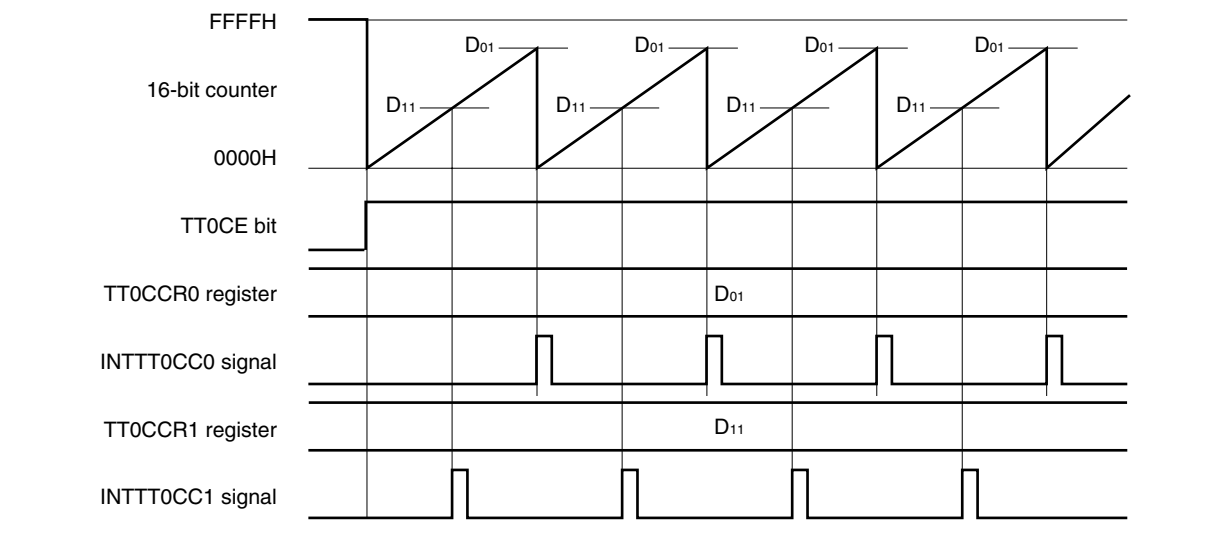
Figure 9-18. Configuration of TT0CCR1 Register



Note Set by the TT0IOC2.TT0EES1 and TT0IOC2.TT0EES0 bits.

If the set value of the TT0CCR1 register is smaller than the set value of the TT0CCR0 register, the INTTT0CC1 signal is generated once per cycle.

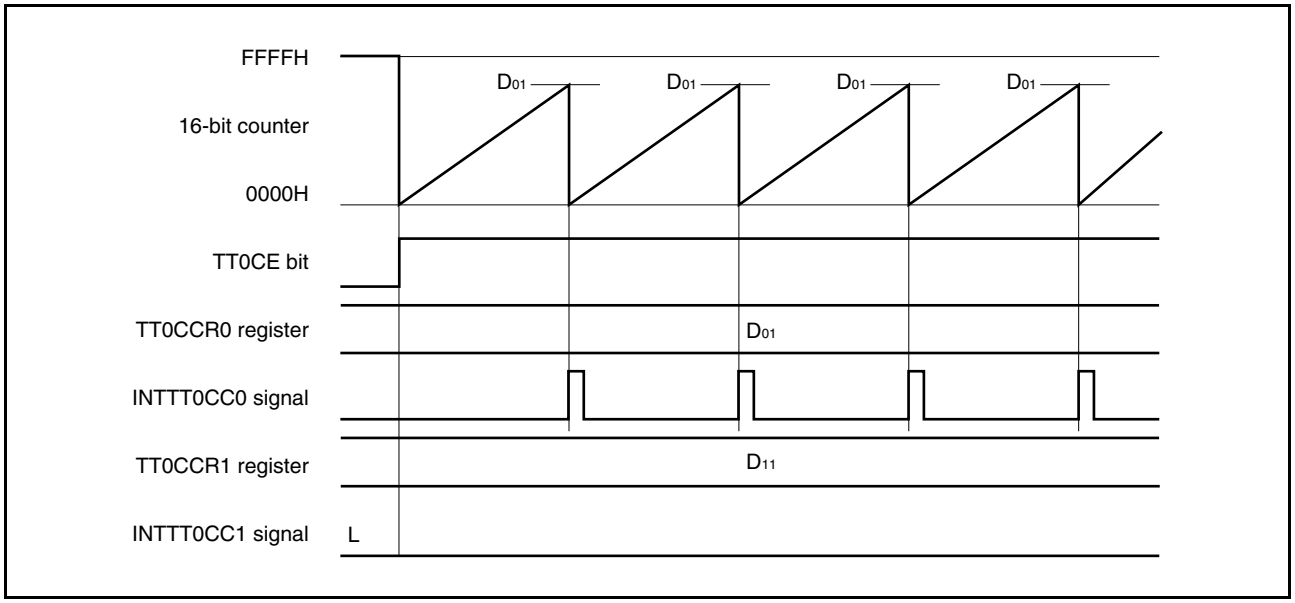
Figure 9-19. Timing Chart When $D_{01} \geq D_{11}$



If the set value of the TT0CCR1 register is greater than the set value of the TT0CCR0 register, the INTTT0CC1 signal is not generated because the count value of the 16-bit counter and the value of the TT0CCR1 register do not match.

When the TT0CCR1 register is not used, it is recommended to set its value to FFFFH.

Figure 9-20. Timing Chart When $D_{01} < D_{11}$

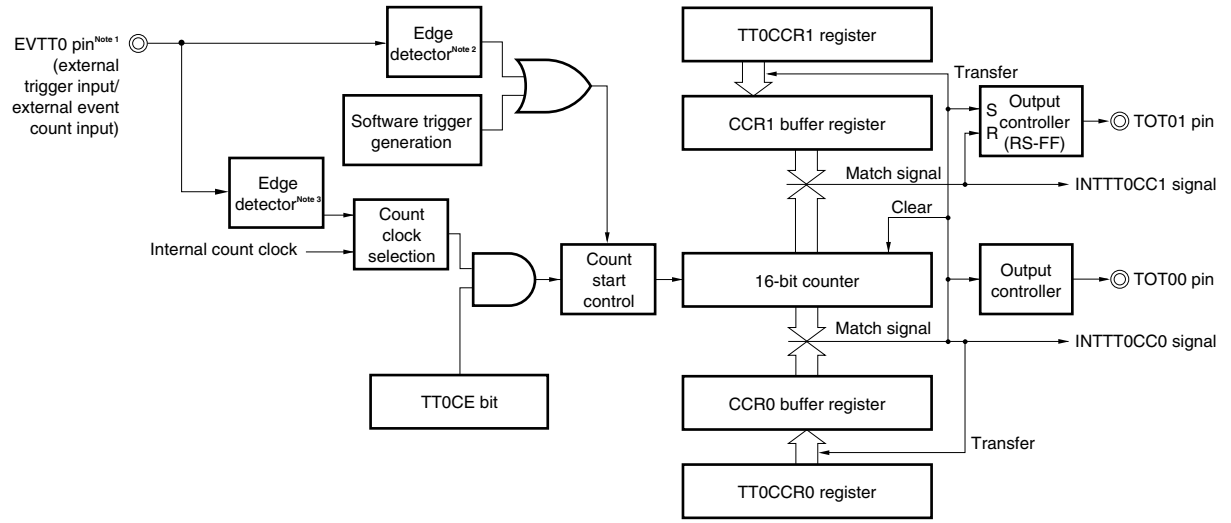


9.6.3 External trigger pulse output mode (TT0MD3 to TT0MD0 bits = 0010)

In the external trigger pulse output mode, 16-bit timer/event counter T waits for a trigger when the TT0CTL0.TT0CE bit is set to 1. When the valid edge of an external trigger input (EVTT0) is detected, 16-bit timer/event counter T starts counting, and outputs a PWM waveform from the TOT01 pin.

Pulses can also be output by generating a software trigger instead of using the external trigger. When using a software trigger, a square wave that has the set value of the TT0CCR0 register + 1 as half its cycle can also be output from the TOT00 pin.

Figure 9-21. Configuration in External Trigger Pulse Output Mode

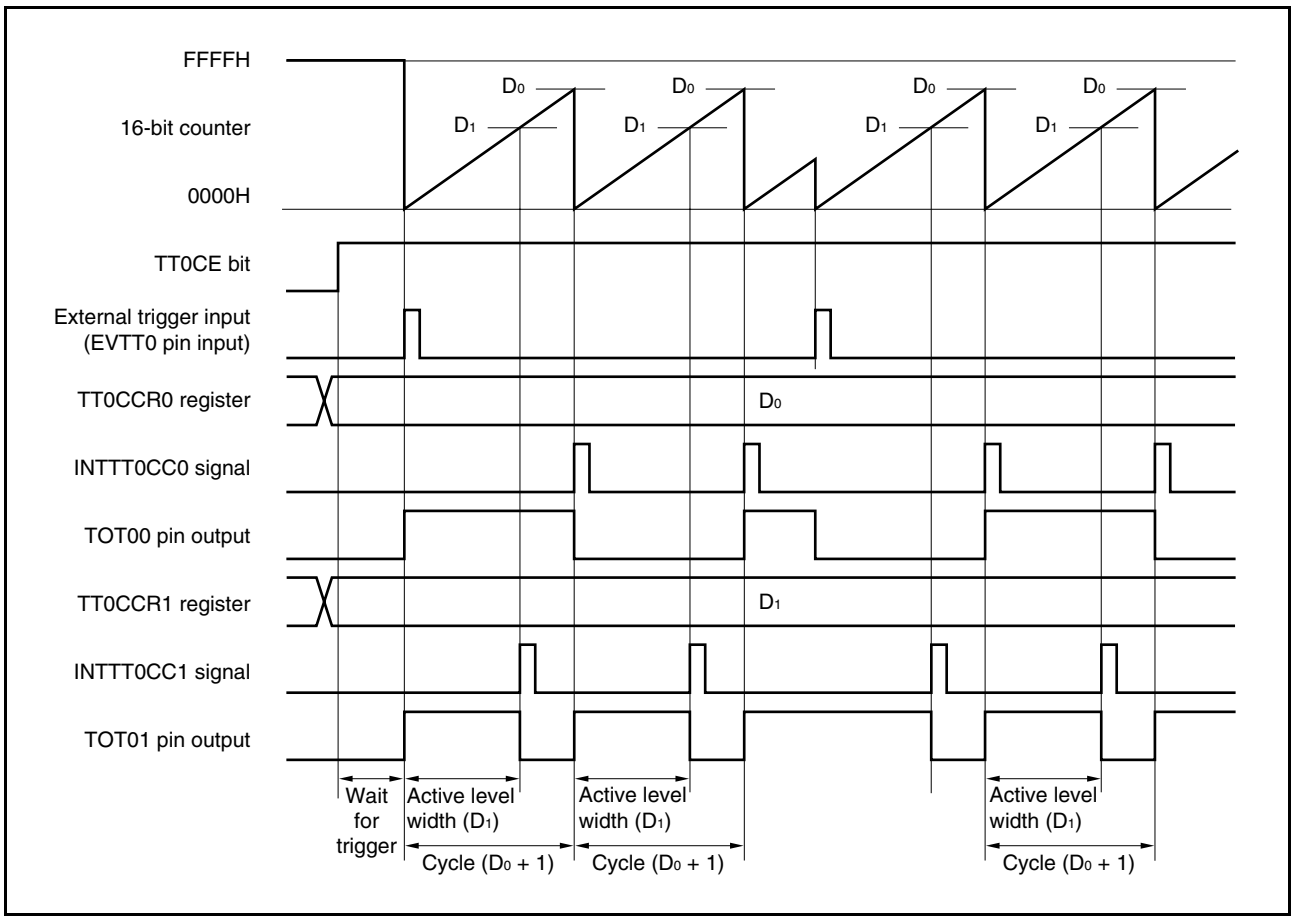


Notes 1. Since the external trigger input pin and external event count input pin are the same alternate-function pin, the external event count input function cannot be used.

2. Edge detector for external trigger input.
Set by the TT0IOC2.TT0ETS1 and TT0IOC2.TT0ETS0 bits.

3. Edge detector for external event count input.
Set by the TT0IOC2.TT0EES1 and TT0IOC2.TT0EES0 bits.

Figure 9-22. Basic Timing in External Trigger Pulse Output Mode



16-bit timer/event counter T waits for a trigger when the TT0CE bit is set to 1. When the trigger is generated, the 16-bit counter is cleared from FFFFH to 0000H, starts counting at the same time, and outputs a PWM waveform from the TOT01 pin. If the trigger is generated again while the counter is operating, the counter is cleared to 0000H and restarted. (The output of the TOT00 pin is inverted. The TOT01 pin outputs a high level regardless of the status (high/low) when a trigger occurs.)

The active level width, cycle, and duty factor of the PWM waveform can be calculated as follows.

Active level width = (Set value of TT0CCR1 register) × Count clock cycle
Cycle = (Set value of TT0CCR0 register + 1) × Count clock cycle
Duty factor = (Set value of TT0CCR1 register)/(Set value of TT0CCR0 register + 1)

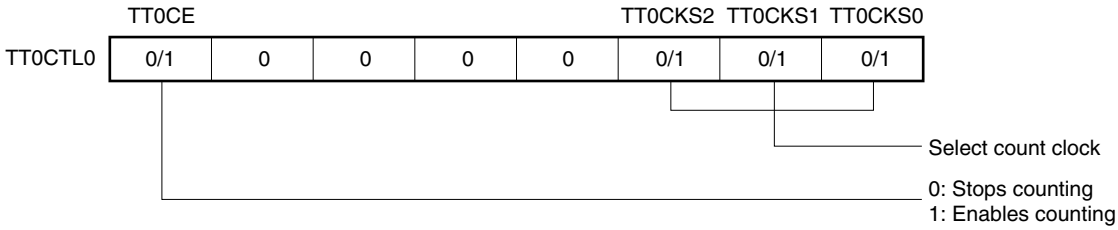
The compare match request signal (INTTT0CC0) is generated the next time the 16-bit counter counts after its count value matches the value of the CCR0 buffer register, and the 16-bit counter is cleared to 0000H. The compare match interrupt request signal (INTTT0CC1) is generated when the count value of the 16-bit counter matches the value of the CCR1 buffer register.

The value set to the TT0CCRn register is transferred to the CCRn buffer register when the count value of the 16-bit counter matches the value of the CCRn buffer register and the 16-bit counter is cleared to 0000H.

The valid edge of an external trigger input (EVTT0), or setting the software trigger (TT0CTL1.TT0EST bit) to 1 is used as the trigger (n = 0, 1).

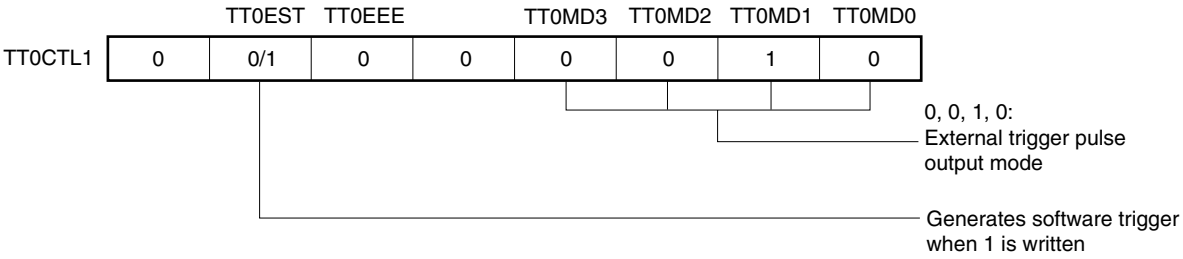
Figure 9-23. Setting of Registers in External Trigger Pulse Output Mode (1/2)

(a) TMT0 control register 0 (TT0CTL0)

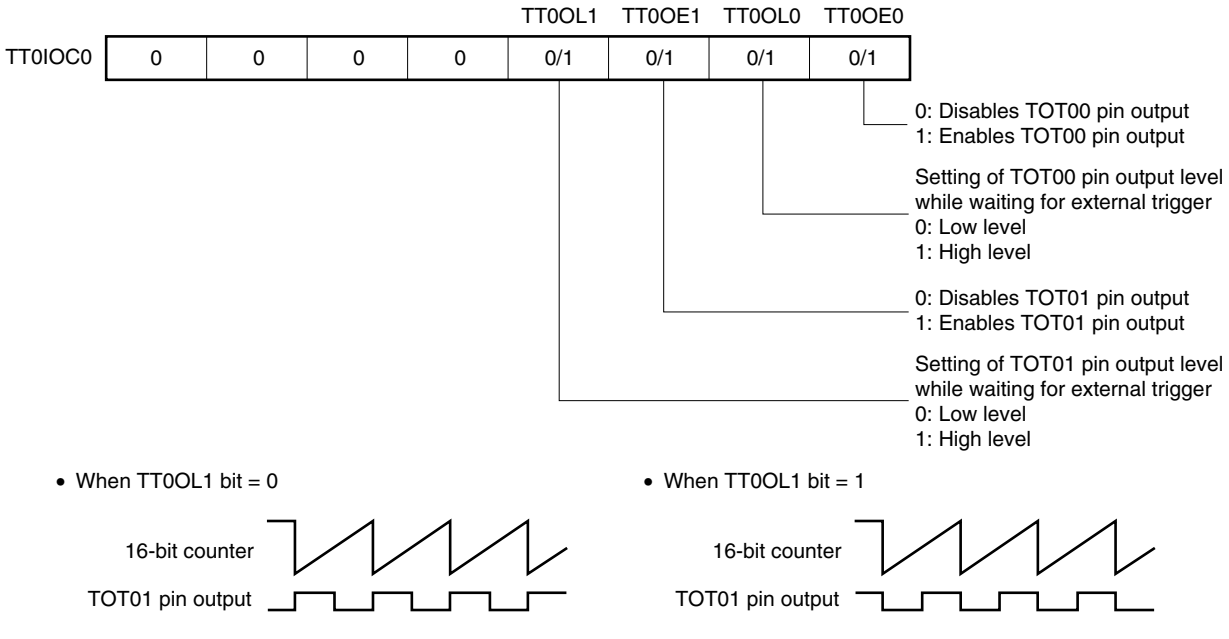


Note The setting is invalid when the TT0CTL1.TT0EEE bit = 1.

(b) TMT0 control register 1 (TT0CTL1)



(c) TMT0 I/O control register 0 (TT0IOC0)

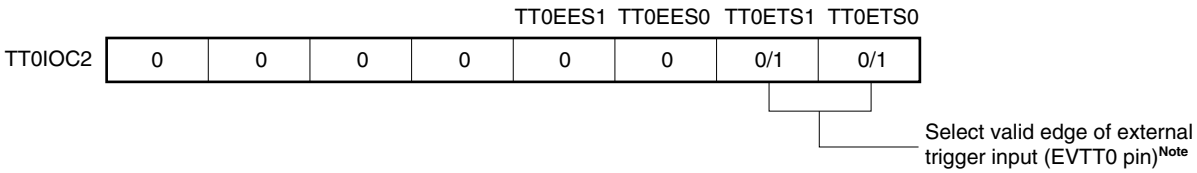


- When TT0OL1 bit = 0

- When TT0OL1 bit = 1

Figure 9-23. Setting of Registers in External Trigger Pulse Output Mode (2/2)

(d) TMT0 I/O control register 2 (TT0IOC2)



Note Set the valid edge selection of the unused alternate external input signals to “No edge detection”.

(e) TMT0 counter read buffer register (TT0CNT)

The value of the 16-bit counter can be read by reading the TT0CNT register.

(f) TMT0 capture/compare registers 0 and 1 (TT0CCR0 and TT0CCR1)

If D_0 is set to the TT0CCR0 register and D_1 to the TT0CCR1 register, the cycle and active level of the PWM waveform are as follows.

Cycle = $(D_0 + 1) \times$ Count clock cycle
Active level width = $D_1 \times$ Count clock cycle

Remark TMT0 control register 2 (TT0CTL2), TMT0 I/O control register 1 (TT0IOC1), TMT0 I/O control register 3 (TT0IOC3), TMT0 option register 0 (TT0OPT0), TMT0 option register 1 (TT0OPT1), and TMT0 counter write register (TT0TCW) are not used in the external trigger pulse output mode.

(1) Operation flow in external trigger pulse output mode

Figure 9-24. Software Processing Flow in External Trigger Pulse Output Mode (1/2)

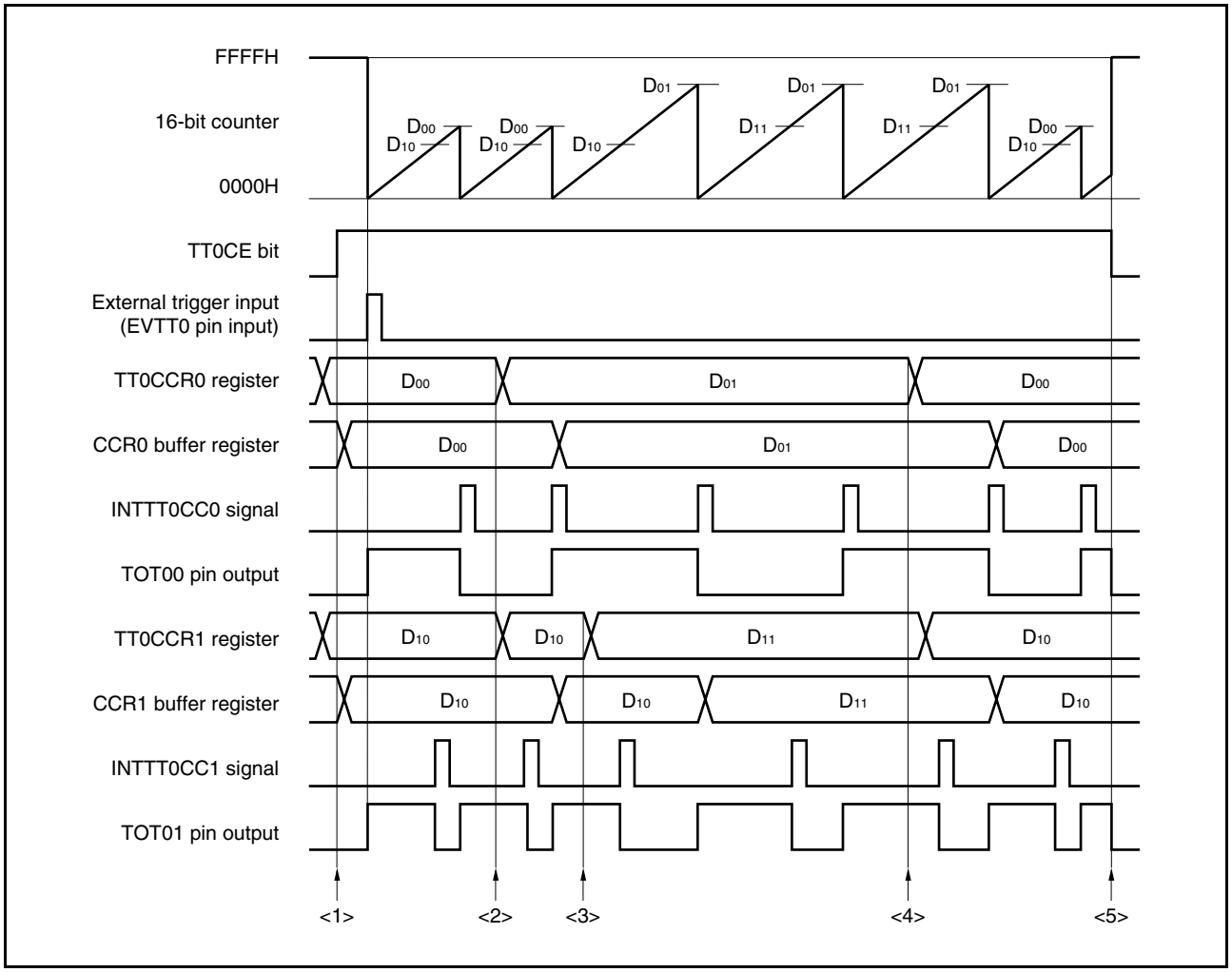
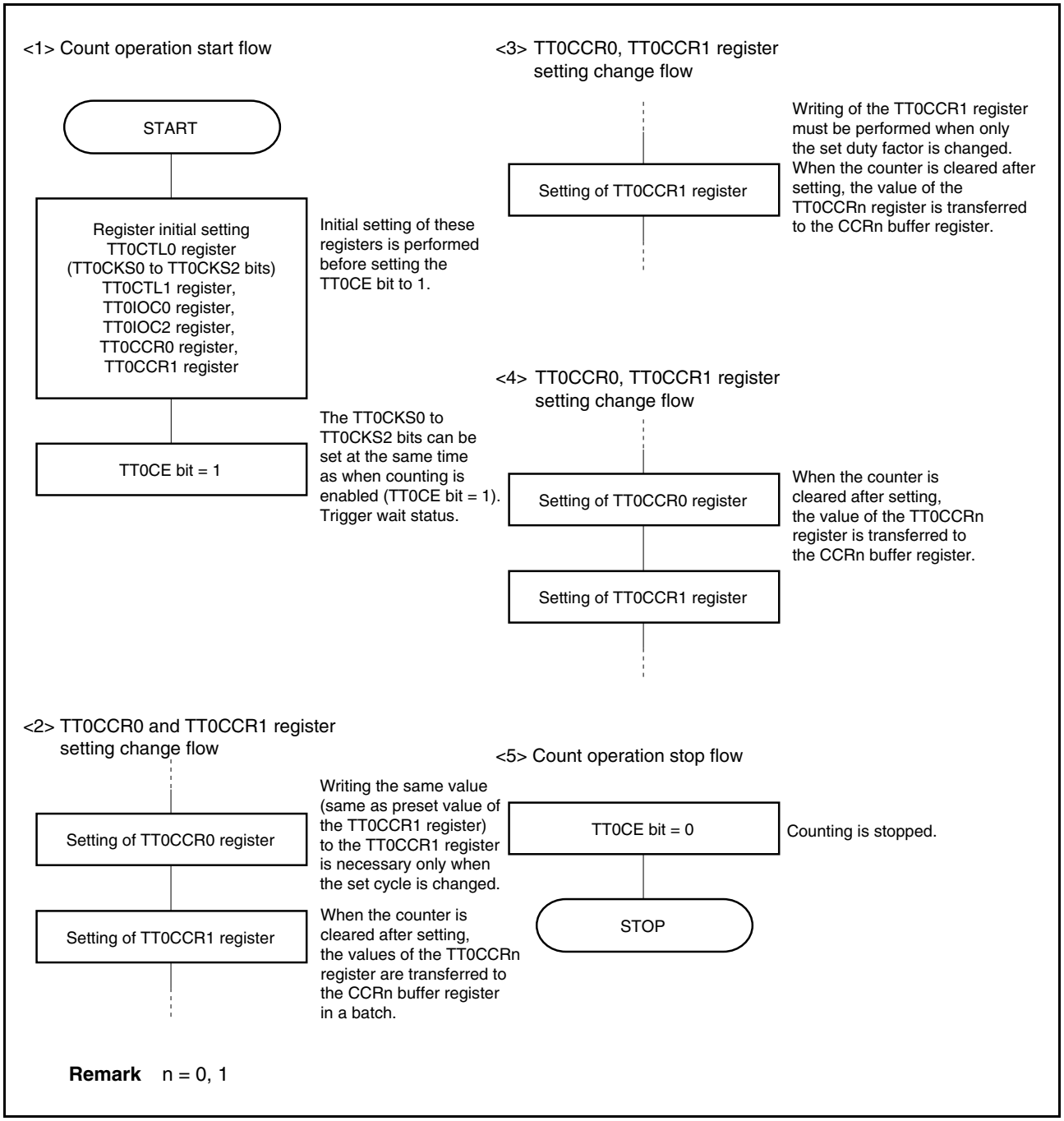


Figure 9-24. Software Processing Flow in External Trigger Pulse Output Mode (2/2)



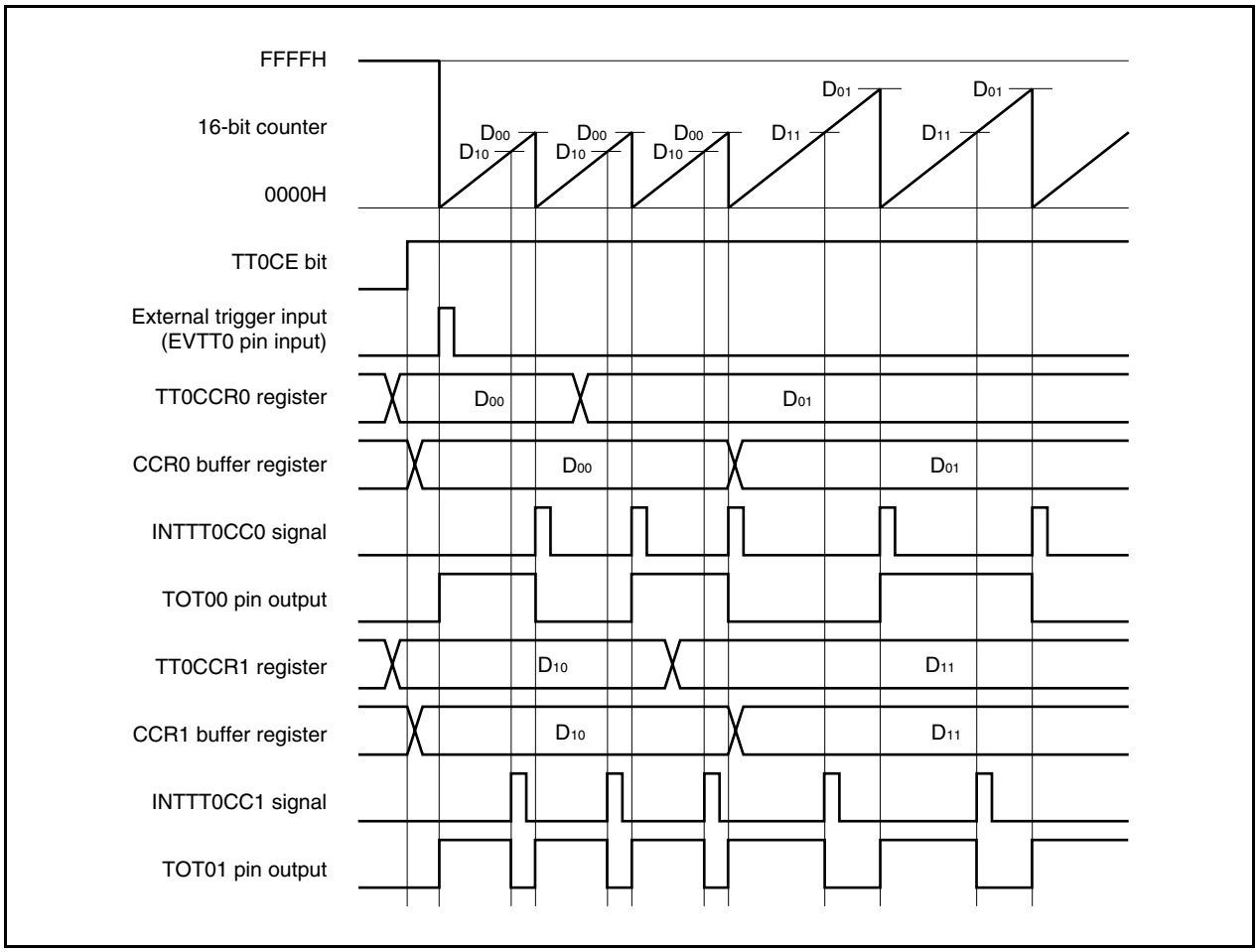
Remark n = 0, 1

(2) External trigger pulse output mode operation timing

(a) Note on changing pulse width during operation

To change the PWM waveform while the counter is operating, write the TT0CCR1 register last.

Rewrite the TT0CCRn register after writing the TT0CCR1 register after the INTTT0CC0 signal is detected.



In order to transfer data from the TT0CCRn register to the CCRn buffer register, the TT0CCR1 register must be written.

To change both the cycle and active level width of the PWM waveform at this time, first set the cycle to the TT0CCR0 register and then set the active level width to the TT0CCR1 register.

To change only the cycle of the PWM waveform, first set the cycle to the TT0CCR0 register, and then write the same value (same as preset value of the TT0CCR1 register) to the TT0CCR1 register.

To change only the active level width (duty factor) of the PWM waveform, only the TT0CCR1 register has to be set.

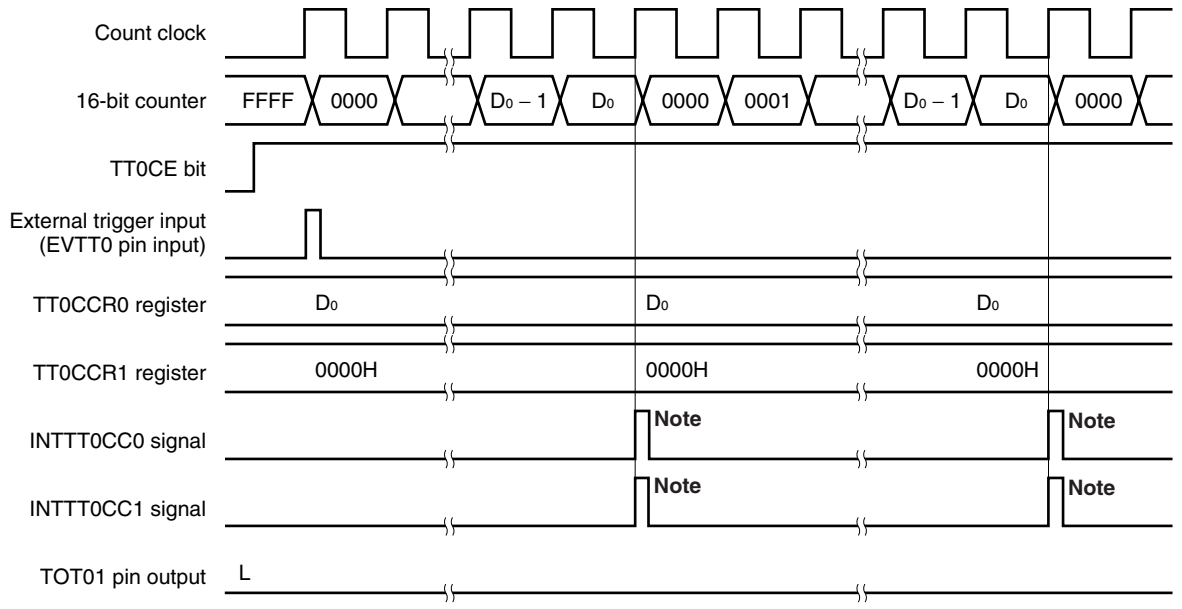
After data is written to the TT0CCR1 register, the value written to the TT0CCRn register is transferred to the CCRn buffer register in synchronization with clearing of the 16-bit counter, and is used as the value compared with the 16-bit counter.

To write the TT0CCR0 or TT0CCR1 register again after writing the TT0CCR1 register once, do so after the INTTT0CC0 signal is generated. Otherwise, the value of the CCRn buffer register may become undefined because the timing of transferring data from the TT0CCRn register to the CCRn buffer register conflicts with writing the TT0CCRn register.

Remark n = 0, 1

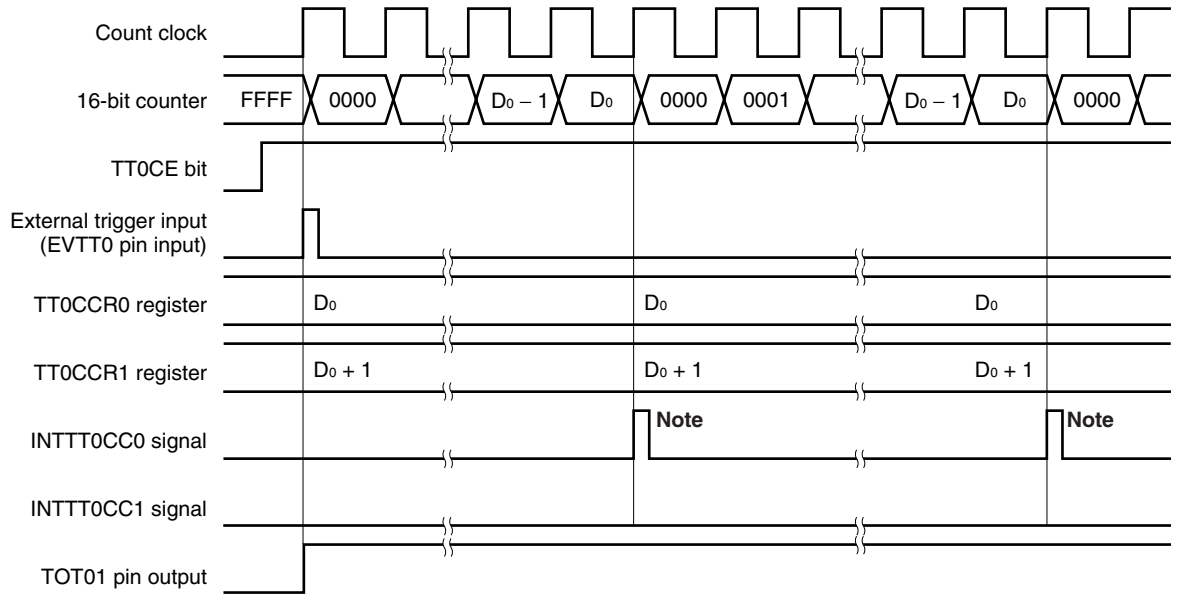
(b) 0%/100% output of PWM waveform

To output a 0% waveform, set the TT0CCR1 register to 0000H. The 16-bit counter is cleared to 0000H and the INTTT0CC0 and INTTT0CC1 signals are generated after a match between the count value of the 16-bit counter and the value of the CCR0 buffer register.



Note The timing is actually delayed by one operating clock (fxx).

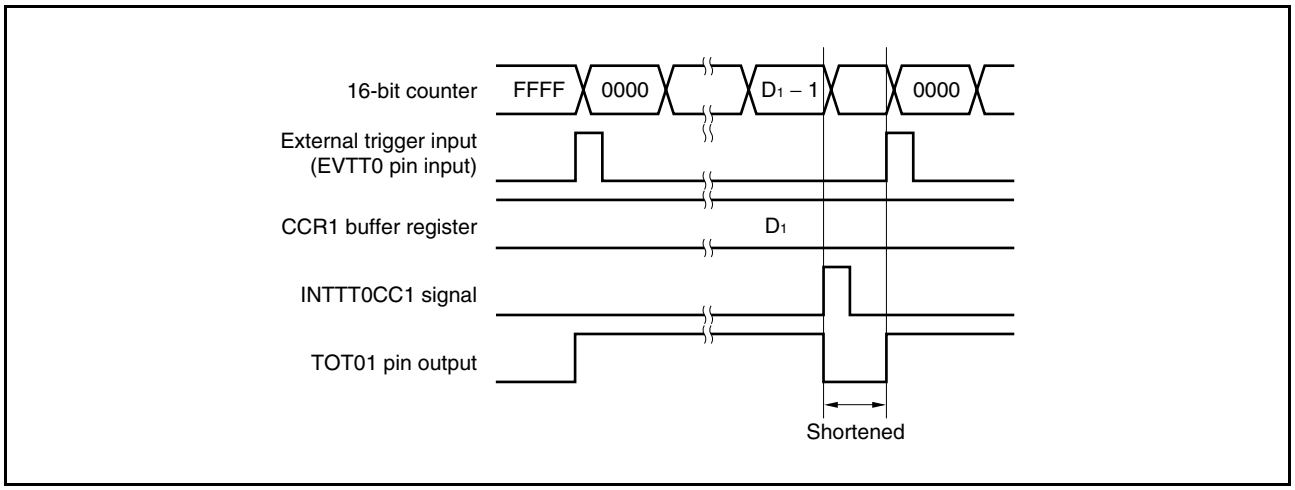
To output a 100% waveform, set a value of (set value of TT0CCR0 register + 1) to the TT0CCR1 register. If the set value of the TT0CCR0 register is FFFFH, 100% output cannot be produced.



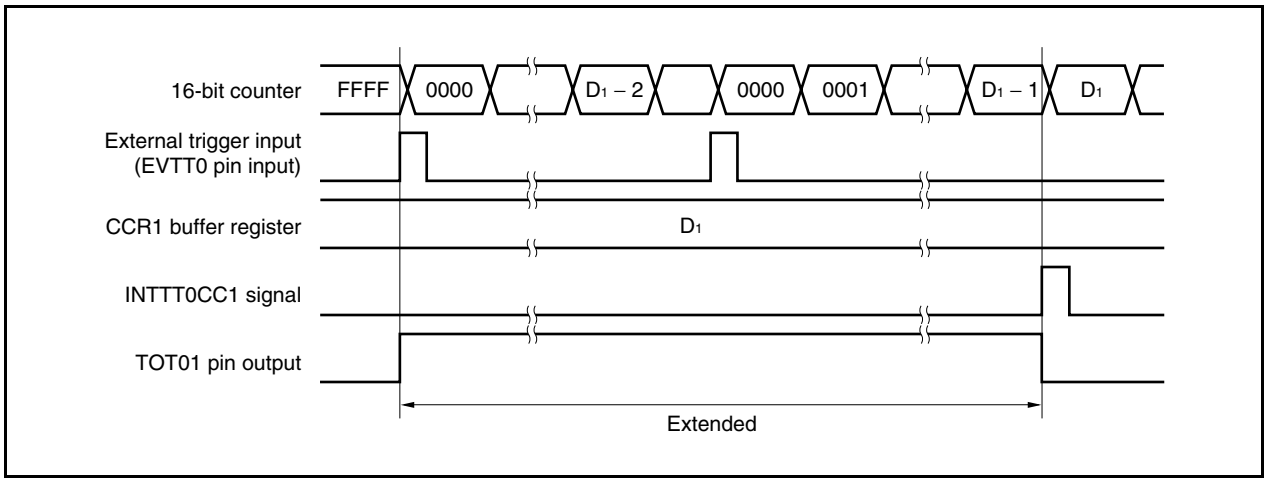
Note The timing is actually delayed by one operating clock (fxx).

(c) Conflict between trigger detection and match with CCR1 buffer register

If the trigger is detected immediately after the INTTT0CC1 signal is generated, the 16-bit counter is immediately cleared to 0000H, the TOT01 pin is asserted, and the counter continues counting. Consequently, the inactive period of the PWM waveform is shortened.

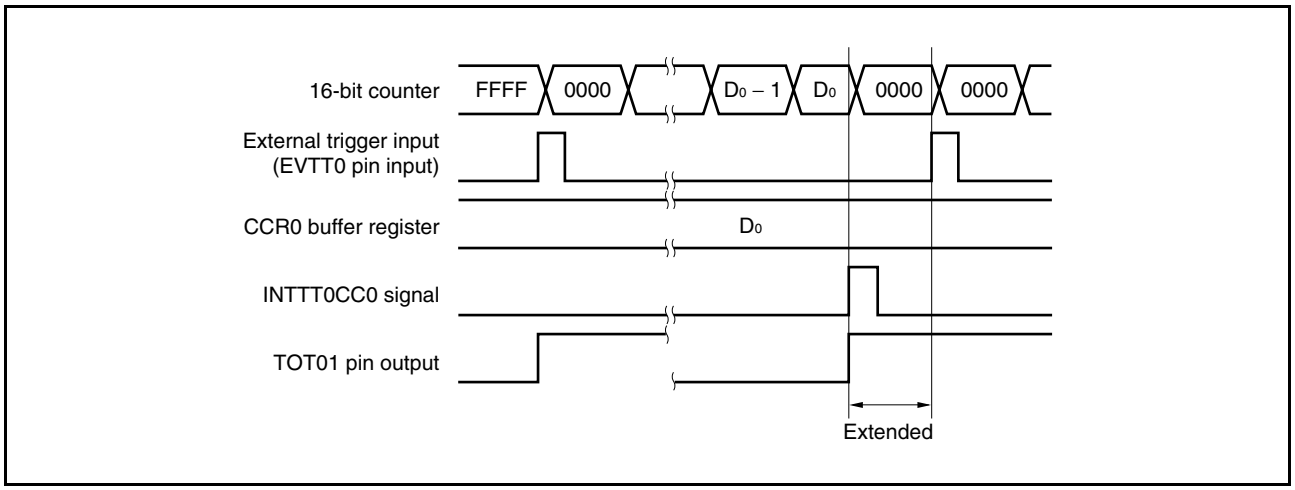


If the trigger is detected immediately before the INTTT0CC1 signal is generated, the INTTT0CC1 signal is not generated, and the 16-bit counter is cleared to 0000H and continues counting. The output signal of the TOT01 pin remains active. Consequently, the active period of the PWM waveform is extended.

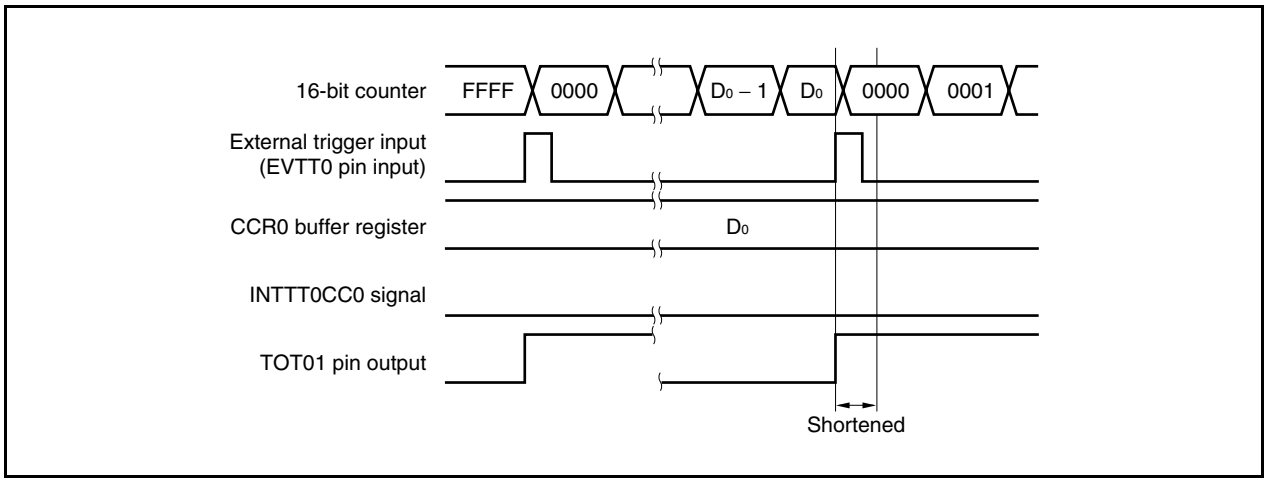


(d) Conflict between trigger detection and match with CCR0 buffer register

If the trigger is detected immediately after the INTTT0CC0 signal is generated, the 16-bit counter is cleared to 0000H and continues counting up again from that point. Therefore, the active period of the TOT01 pin is extended by the time from generation of the INTTT0CC0 signal to trigger detection.

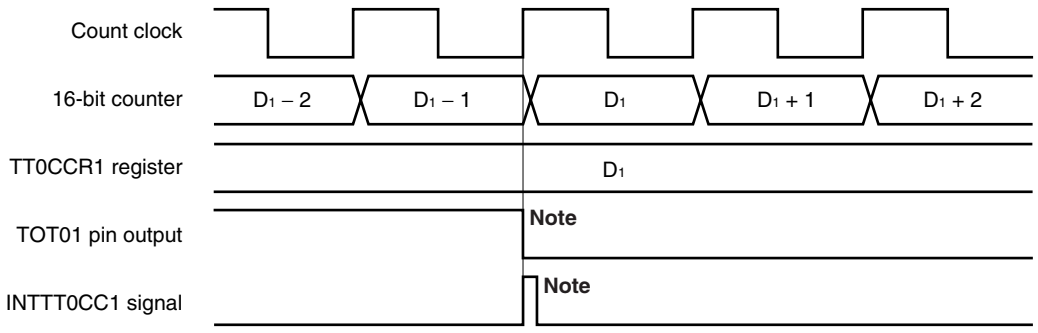


If the trigger is detected immediately before the INTTT0CC0 signal is generated, the INTTT0CC0 signal is not generated. The 16-bit counter is cleared to 0000H, the TOT01 pin is asserted, and the counter continues counting. Consequently, the inactive period of the PWM waveform is shortened.



(e) Generation timing of compare match interrupt request signal (INTTT0CC1)

The timing of generating the INTTT0CC1 signal in the external trigger pulse output mode differs from the timing of generating INTTT0CC1 signals in other modes; the INTTT0CC1 signal is generated when the count value of the 16-bit counter matches the value of the TT0CCR1 register.



Note The timing is actually delayed by one operating clock (fxx).

Usually, the INTTT0CC1 signal is generated in synchronization with the next count-up, after the count value of the 16-bit counter matches the value of the TT0CCR1 register.

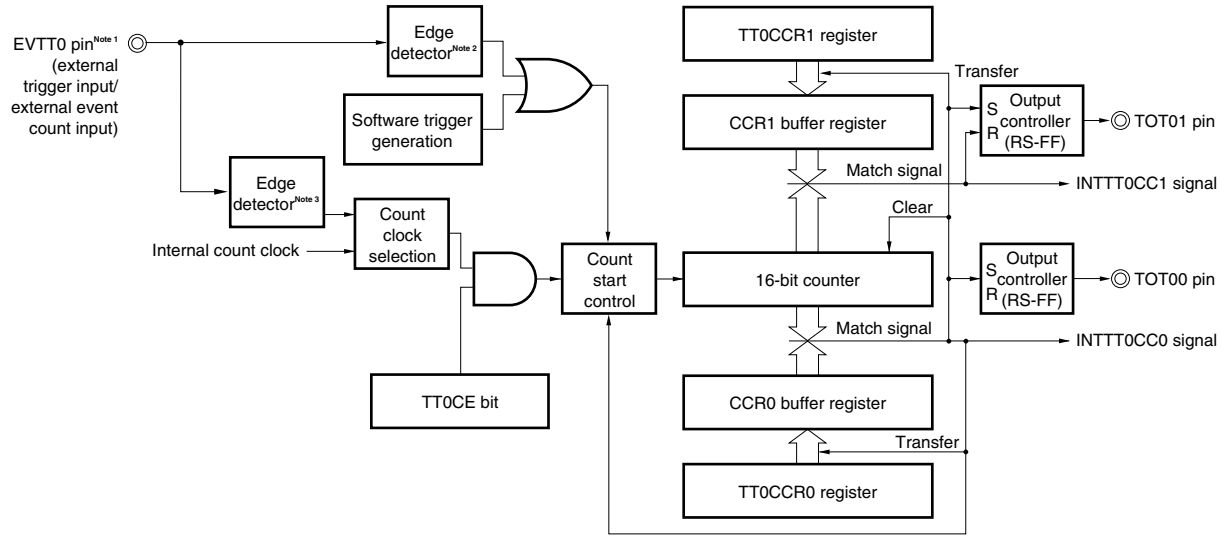
In the external trigger pulse output mode, however, it is generated one clock earlier. This is because the timing is changed to match the timing when the output signal of the TOT01 pin changes.

9.6.4 One-shot pulse output mode (TT0MD3 to TT0MD0 bits = 0011)

In the one-shot pulse output mode, 16-bit timer/event counter T waits for a trigger when the TT0CTL0.TT0CE bit is set to 1. When the valid edge of an external trigger input (EVTT0) is detected, 16-bit timer/event counter T starts counting, and outputs a one-shot pulse from the TOT01 pin.

Instead of the external trigger input (EVTT0), a software trigger can also be generated to output the pulse. When the software trigger is used, the TOT00 pin outputs the active level while the 16-bit counter is counting, and the inactive level when the counter is stopped (waiting for a trigger).

Figure 9-25. Configuration in One-Shot Pulse Output Mode

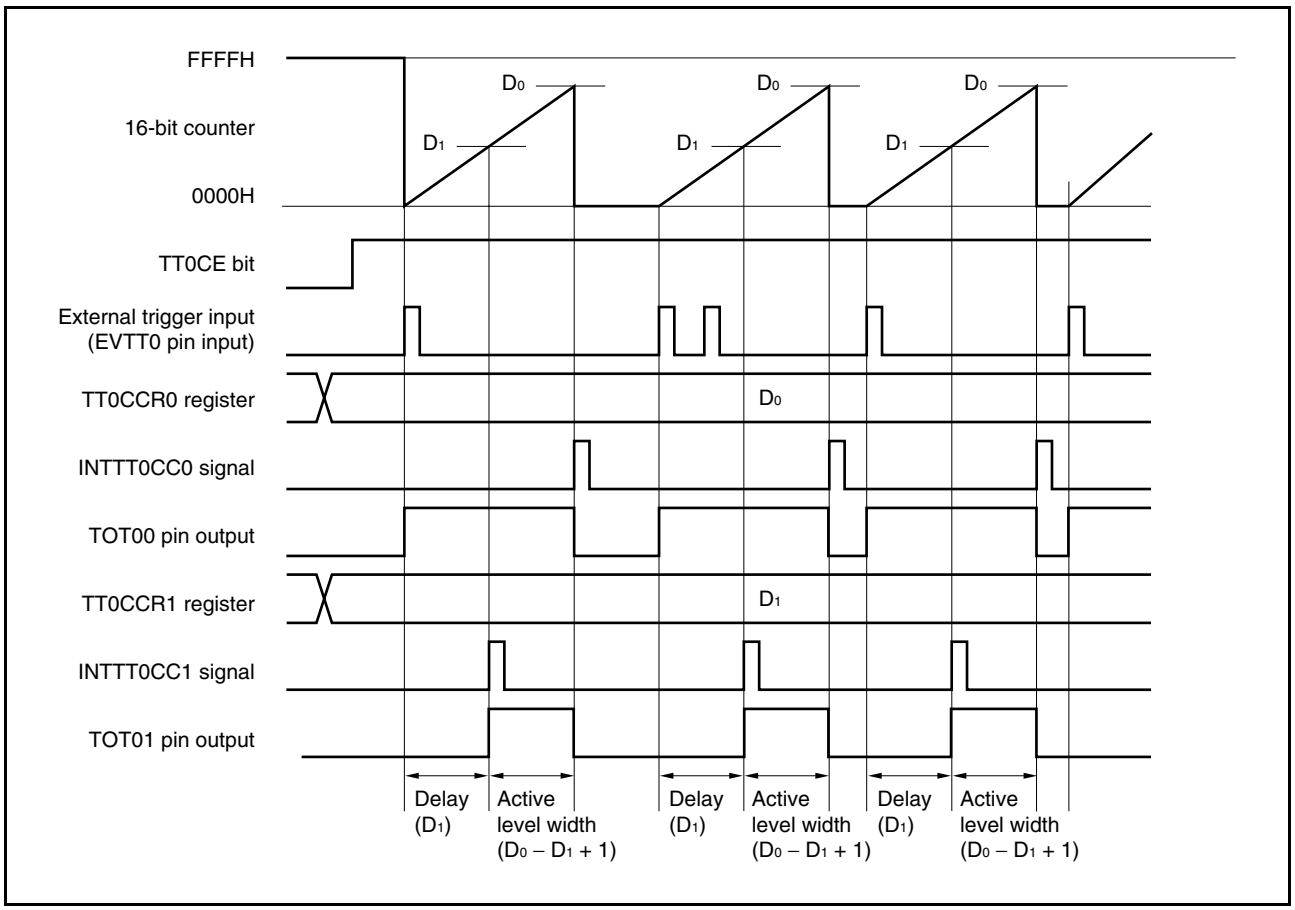


Notes 1. Because the external trigger input pin (EVTT0) and external event count input pin (EVTT0) are the same alternate-function pin, the external trigger input pin (EVTT0) cannot be used.

2. Edge detector for external trigger input.
Set by the TT0IOC2.TT0ETS1 and TT0IOC2.TT0ETS0 bits.

3. Edge detector for external event count input.
Set by the TT0IOC2.TT0EES1 and TT0IOC2.TT0EES0 bits.

Figure 9-26. Basic Timing in One-Shot Pulse Output Mode



When the TT0CE bit is set to 1, 16-bit timer/event counter T waits for a trigger. When the trigger is generated, the 16-bit counter is cleared from FFFFH to 0000H, starts counting, and outputs a one-shot pulse from the TOT01 pin. After the one-shot pulse is output, the 16-bit counter is cleared to 0000H, stops counting, and waits for a trigger. When the trigger is generated again, the 16-bit counter starts counting from 0000H. If a trigger is generated again while the one-shot pulse is being output, it is ignored.

The output delay period and active level width of the one-shot pulse can be calculated as follows.

Output delay period = (Set value of TT0CCR1 register) × Count clock cycle

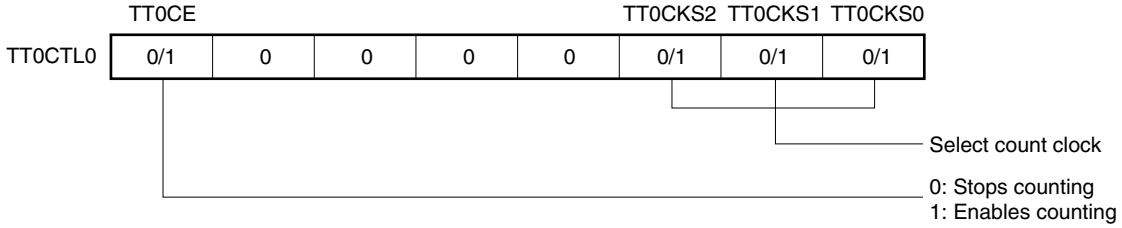
Active level width = (Set value of TT0CCR0 register − Set value of TT0CCR1 register + 1) × Count clock cycle

The compare match interrupt request signal (INTTT0CC0) is generated the next time the 16-bit counter counts after its count value matches the value of the CCR0 buffer register. The compare match interrupt request signal (INTTT0CC1) is generated when the count value of the 16-bit counter matches the value of the CCR1 buffer register.

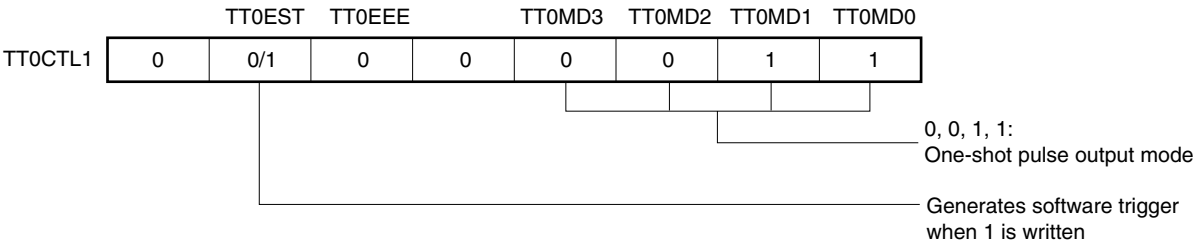
The valid edge of an external trigger input (EVTT0 pin) or setting the software trigger (TT0CTL1.TT0EST bit) to 1 is used as the trigger.

Figure 9-27. Setting of Registers in One-Shot Pulse Output Mode (1/2)

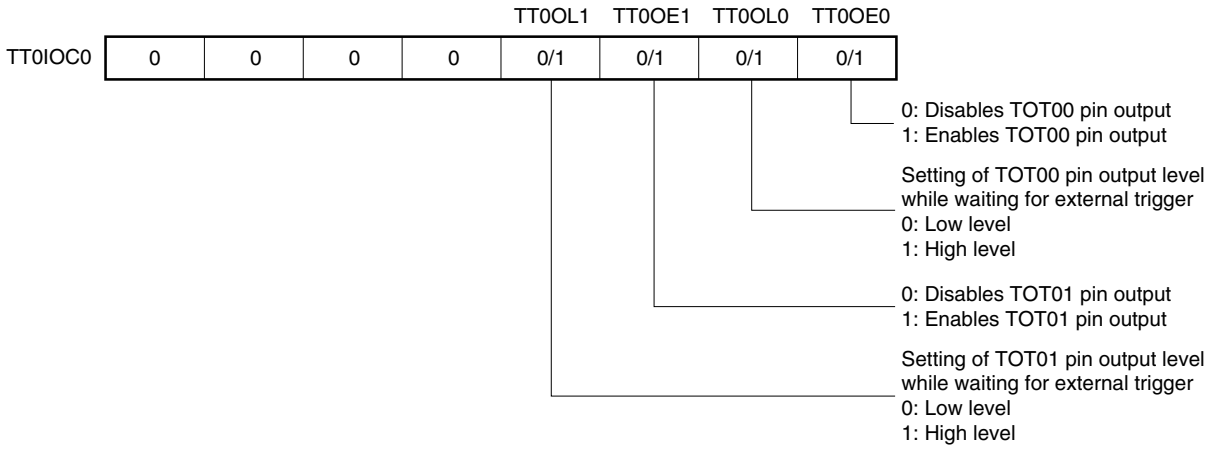
(a) TMT0 control register 0 (TT0CTL0)



(b) TMT0 control register 1 (TT0CTL1)



(c) TMT0 I/O control register 0 (TT0IOC0)



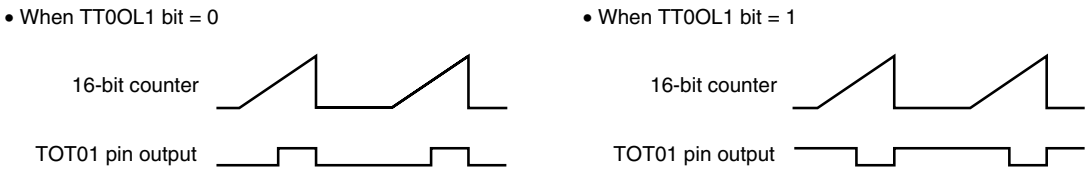
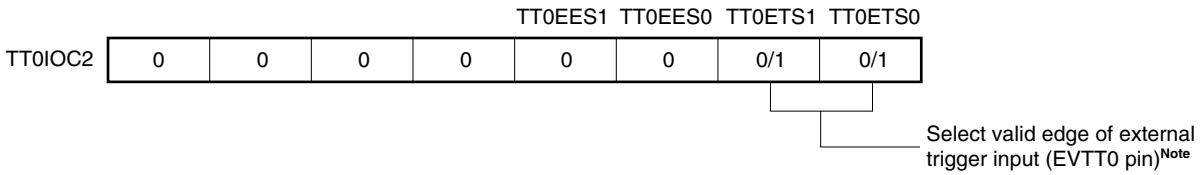


Figure 9-27. Setting of Registers in One-Shot Pulse Output Mode (2/2)

(d) TMT0 I/O control register 2 (TT0IOC2)



Note Set the valid edge selection of the unused alternate external input signals to “No edge detection”.

(e) TMT0 counter read buffer register (TT0CNT)

The value of the 16-bit counter can be read by reading the TT0CNT register.

(f) TMT0 capture/compare registers 0 and 1 (TT0CCR0 and TT0CCR1)

If D_0 is set to the TT0CCR0 register and D_1 to the TT0CCR1 register, the active level width and output delay period of the one-shot pulse are as follows.

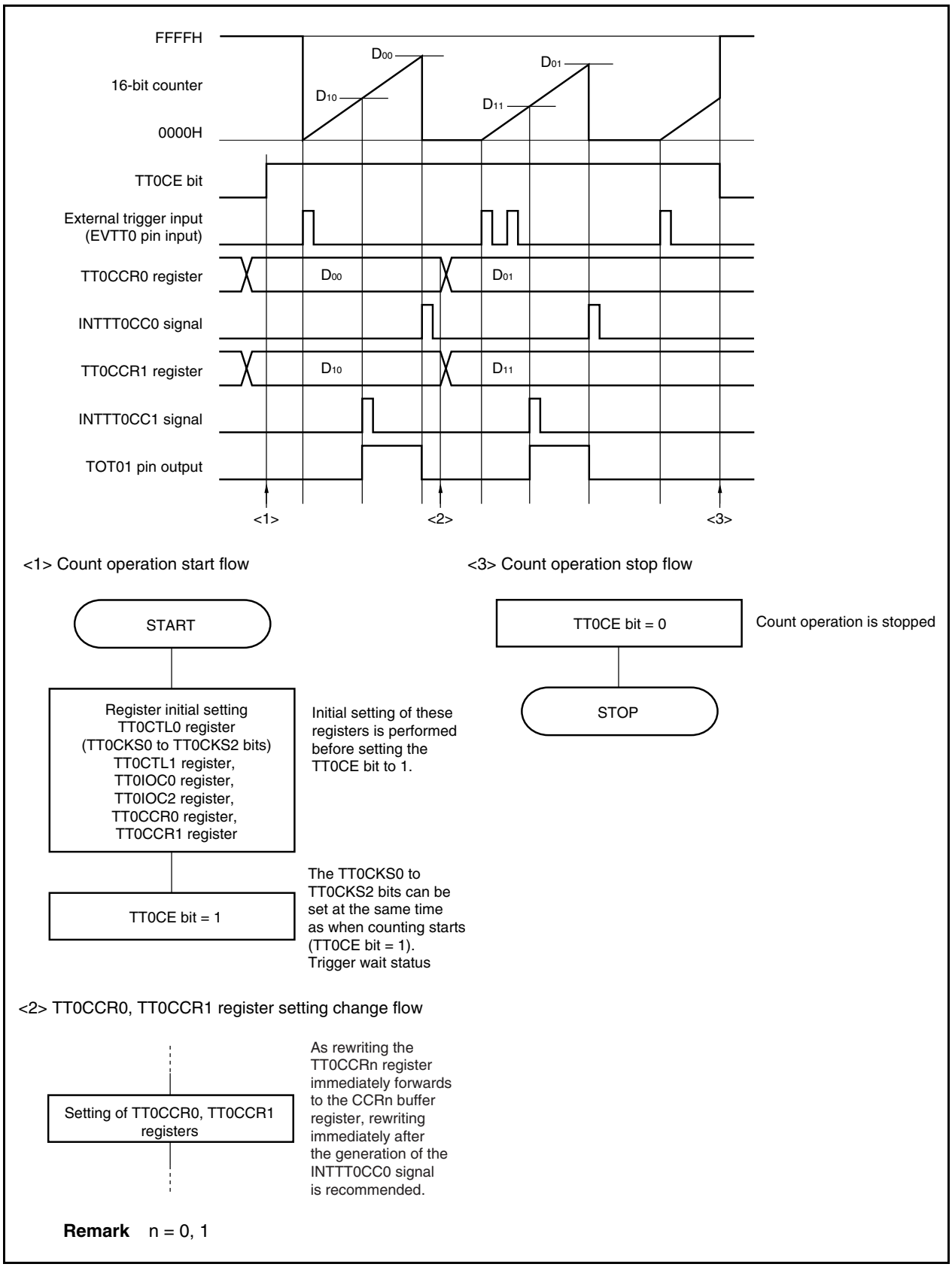
Active level width = $(D_0 - D_1 + 1) \times$ Count clock cycle

Output delay period = $D_1 \times$ Count clock cycle

Remark TMT0 control register 2 (TT0CTL2), TMT0 I/O control register 1 (TT0IOC1), TMT0 I/O control register 3 (TT0IOC3), TMT0 option register 0 (TT0OPT0), TMT0 option register 1 (TT0OPT1), and TMT0 counter write register (TT0TCW) are not used in the one-shot pulse output mode.

(1) Operation flow in one-shot pulse output mode

Figure 9-28. Software Processing Flow in One-Shot Pulse Output Mode



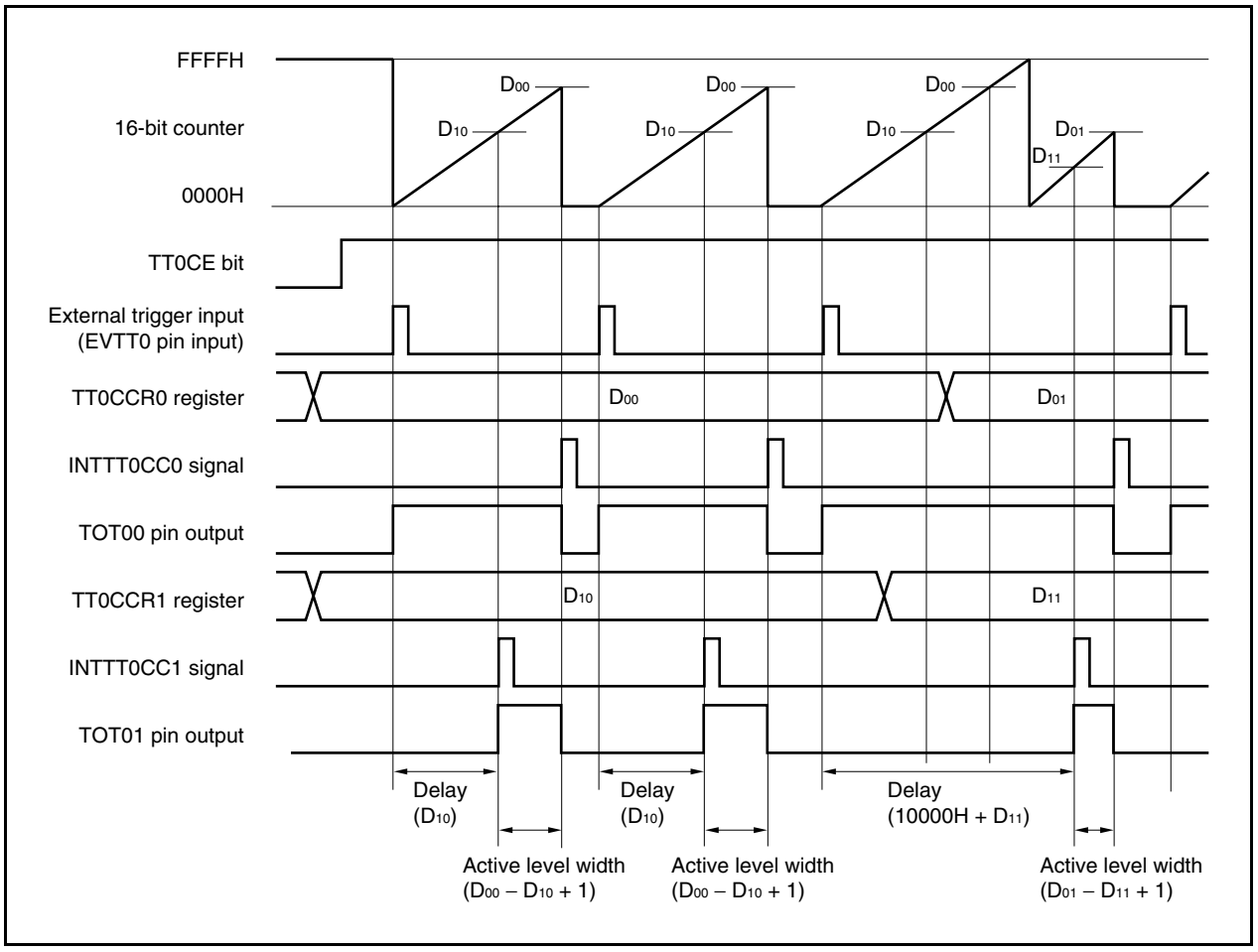
Remark n = 0, 1

(2) Operation timing in one-shot pulse output mode

(a) Note on rewriting TT0CCRn register

If the value of the TT0CCRn register is rewritten to a smaller value during counting, the 16-bit counter may overflow. When an overflow may occur, stop counting and then change the set value.

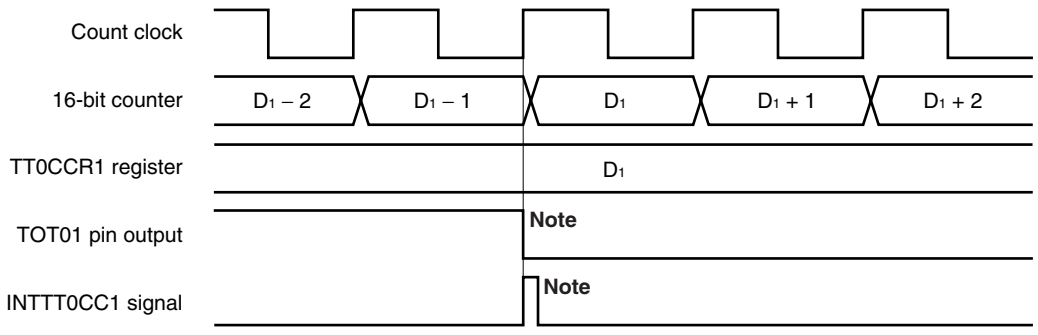
Remark n = 0, 1



When the TT0CCR0 register is rewritten from D_{00} to D_{01} and the TT0CCR1 register from D_{10} to D_{11} where $D_{00} > D_{01}$ and $D_{10} > D_{11}$, if the TT0CCR1 register is rewritten when the count value of the 16-bit counter is greater than D_{11} and less than D_{10} and if the TT0CCR0 register is rewritten when the count value is greater than D_{01} and less than D_{00}, each set value is reflected as soon as the register has been rewritten and compared with the count value. The counter counts up to FFFFH and then counts up again from 0000H. When the count value matches D_{11}, the counter generates the INTTT0CC1 signal and asserts the TOT01 pin. When the count value matches D_{01}, the counter generates the INTTT0CC0 signal, deasserts the TOT01 pin, and stops counting.
Therefore, the counter may output a pulse with a delay period or active period different from that of the one-shot pulse that is originally expected.

(b) Generation timing of compare match interrupt request signal (INTTT0CC1)

The generation timing of the INTTT0CC1 signal in the one-shot pulse output mode is different from INTTT0CC1 signals in other modes; the INTTT0CC1 signal is generated when the count value of the 16-bit counter matches the value of the TT0CCR1 register.



Note The timing is actually delayed by one operating clock (fxx).

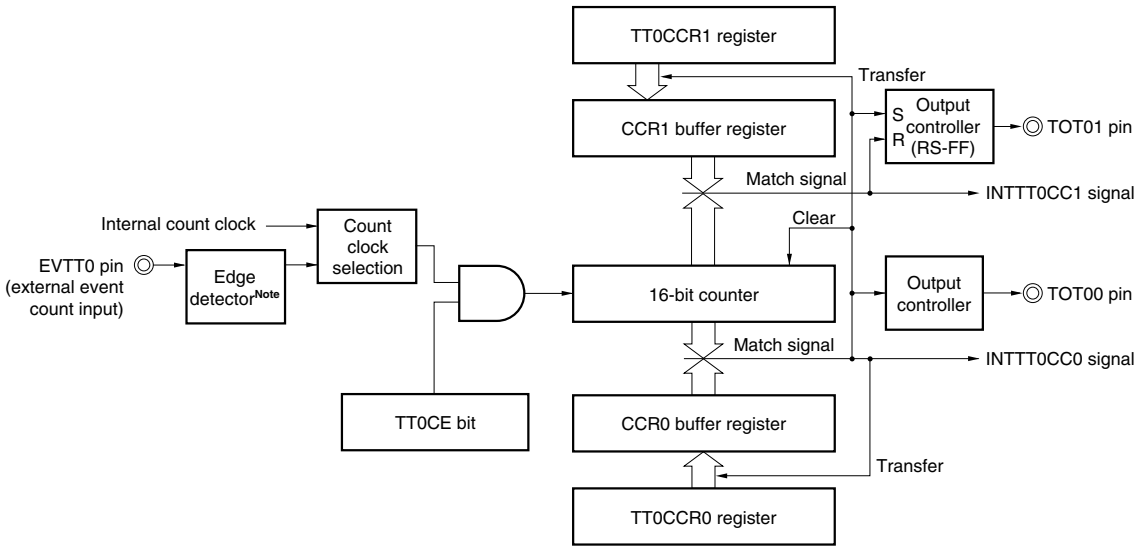
Usually, the INTTT0CC1 signal is generated the next time the 16-bit counter counts up after its count value matches the value of the TT0CCR1 register.

In the one-shot pulse output mode, however, it is generated one clock earlier. This is because the timing is changed to match the timing the output signal of the TOT01 pin changes.

9.6.5 PWM output mode (TT0MD3 to TT0MD0 bits = 0100)

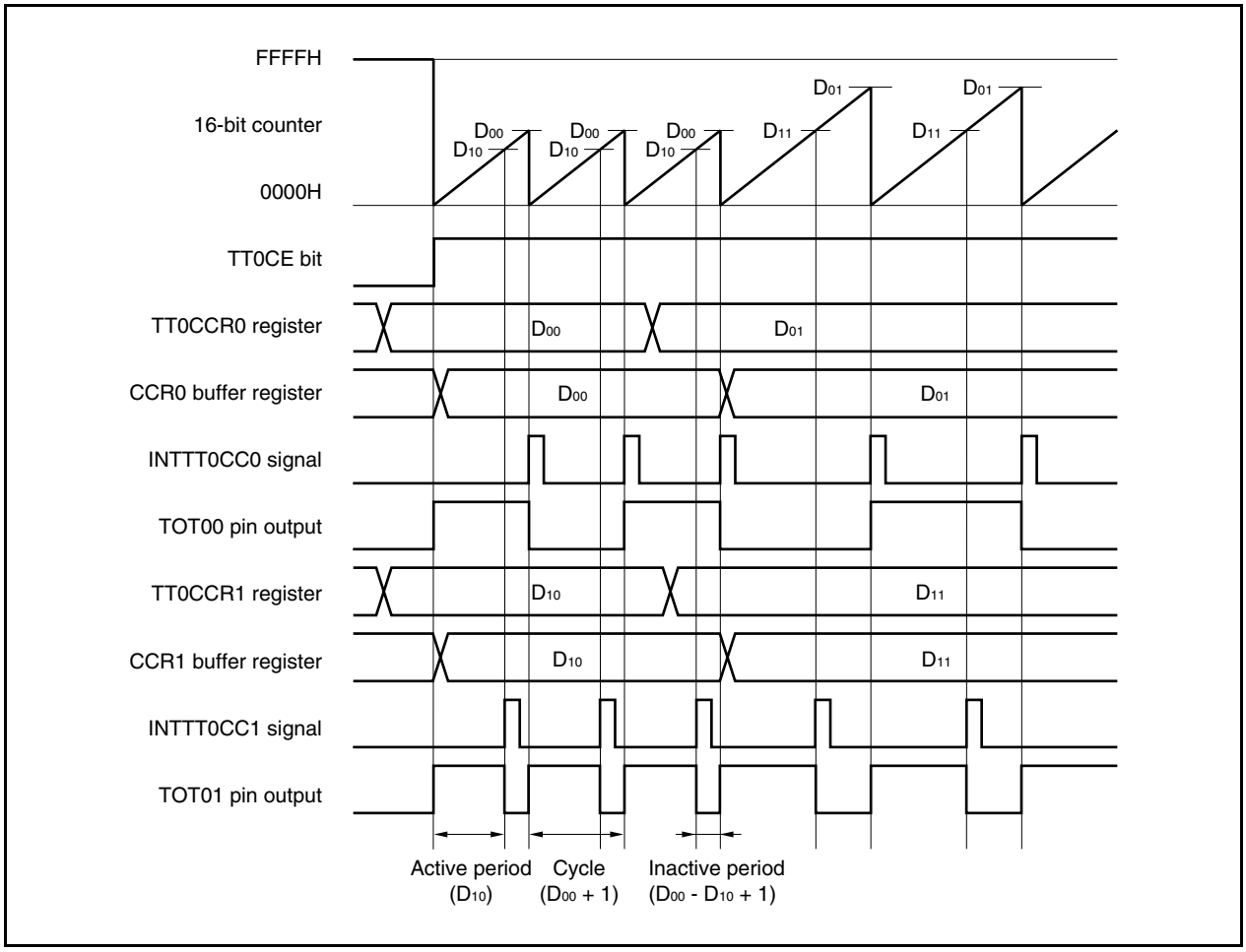
In the PWM output mode, a PWM waveform is output from the TOT01 pin when the TT0CTL0.TT0CE bit is set to 1. In addition, a square wave with the set value of the TT0CCR0 register + 1 as half its cycle is output from the TOT00 pin.

Figure 9-29. Configuration in PWM Output Mode



Note Set by the TT0IOC2.TT0EES1 and TT0IOC2.TT0EES0 bits.

Figure 9-30. Basic Timing in PWM Output Mode



When the TT0CE bit is set to 1, the 16-bit counter is cleared from FFFFH to 0000H, starts counting, and outputs a PWM waveform from the TOT01 pin.

The active level width, cycle, and duty factor of the PWM waveform can be calculated as follows.

Active level width = (Set value of TT0CCR1 register) × Count clock cycle
Cycle = (Set value of TT0CCR0 register + 1) × Count clock cycle
Duty factor = (Set value of TT0CCR1 register)/(Set value of TT0CCR0 register + 1)

The PWM waveform can be changed by rewriting the TT0CCRn register while the counter is operating. The newly written value is reflected when the count value of the 16-bit counter matches the value of the CCR0 buffer register and the 16-bit counter is cleared to 0000H.

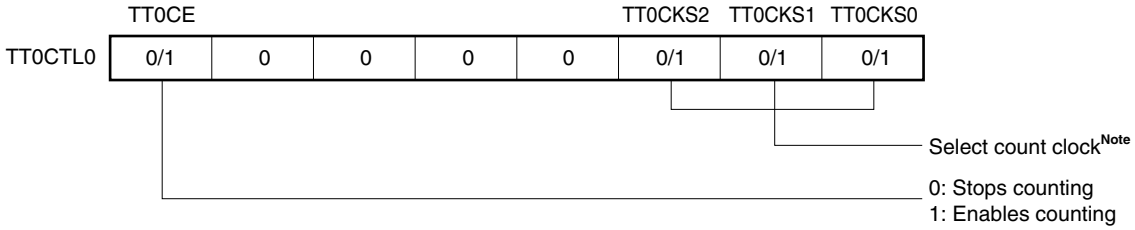
The compare match interrupt request signal (INTTT0CC0) is generated the next time the 16-bit counter counts after its count value matches the value of the CCR0 buffer register, and the 16-bit counter is cleared to 0000H. The compare match interrupt request signal (INTTT0CC1) is generated when the count value of the 16-bit counter matches the value of the CCR1 buffer register.

The value set to the TT0CCRn register is transferred to the CCRn buffer register when the count value of the 16-bit counter matches the value of the CCRn buffer register and the 16-bit counter is cleared to 0000H.

Remark n = 0, 1

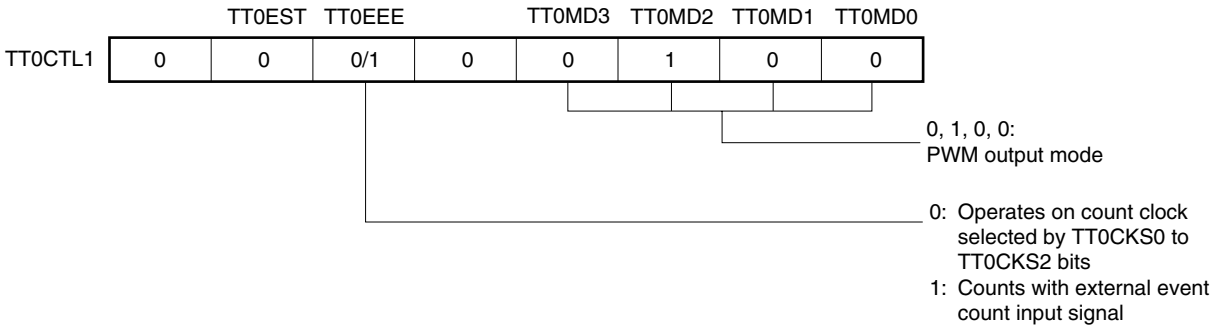
Figure 9-31. Setting of Registers in PWM Output Mode (1/2)

(a) TMT0 control register 0 (TT0CTL0)

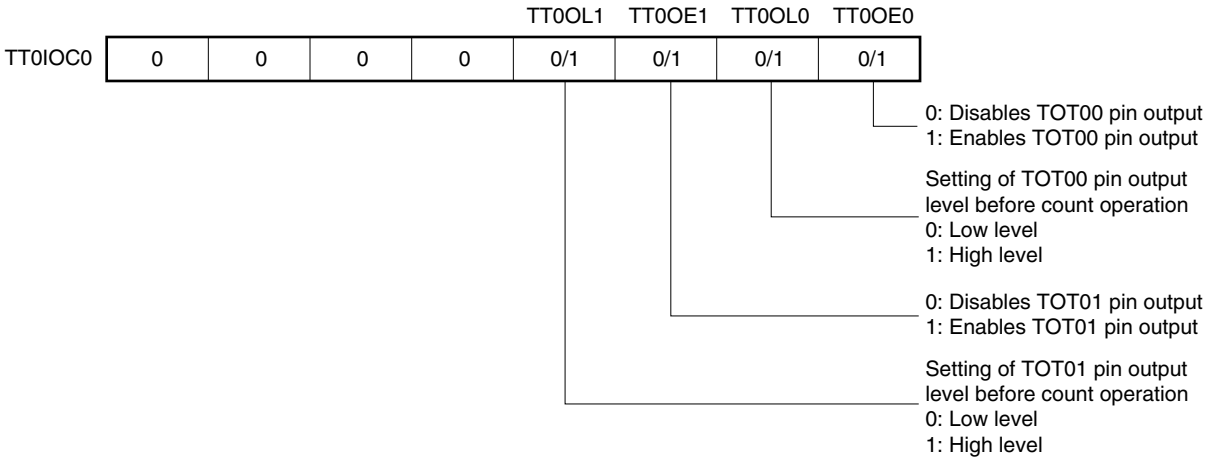


Note The setting is invalid when the TT0CTL1.TT0EEE bit = 1.

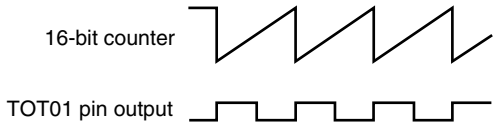
(b) TMT0 control register 1 (TT0CTL1)



(c) TMT0 I/O control register 0 (TT0IOC0)



- When TT0OL1 bit = 0



- When TT0OL1 bit = 1

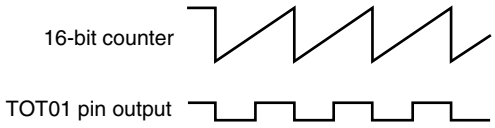
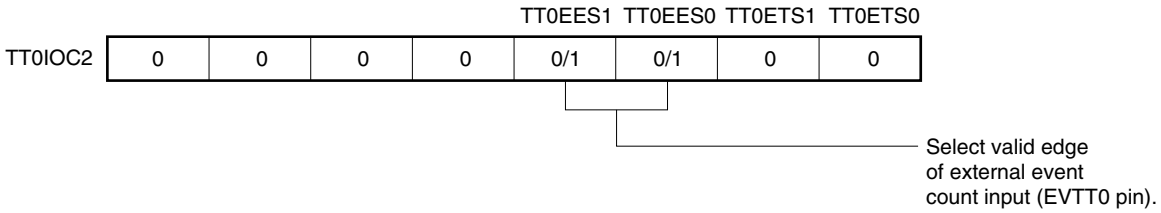


Figure 9-31. Register Setting in PWM Output Mode (2/2)

(d) TMT0 I/O control register 2 (TT0IOC2)



(e) TMT0 counter read buffer register (TT0CNT)

The value of the 16-bit counter can be read by reading the TT0CNT register.

(f) TMT0 capture/compare registers 0 and 1 (TT0CCR0 and TT0CCR1)

If D_0 is set to the TT0CCR0 register and D_1 to the TT0CCR1 register, the cycle and active level of the PWM waveform are as follows.

Cycle = $(D_0 + 1) \times$ Count clock cycle
Active level width = $D_1 \times$ Count clock cycle

Remark TMT0 control register 2 (TT0CTL2), TMT0 I/O control register 1 (TT0IOC1), TMT0 I/O control register 3 (TT0CTL3), TMT0 option register 0 (TT0OPT0), TMT0 option register 1 (TT0OPT1), and TMT0 counter write register (TT0TCW) are not used in the PWM output mode.

(1) Operation flow in PWM output mode

Figure 9-32. Software Processing Flow in PWM Output Mode (1/2)

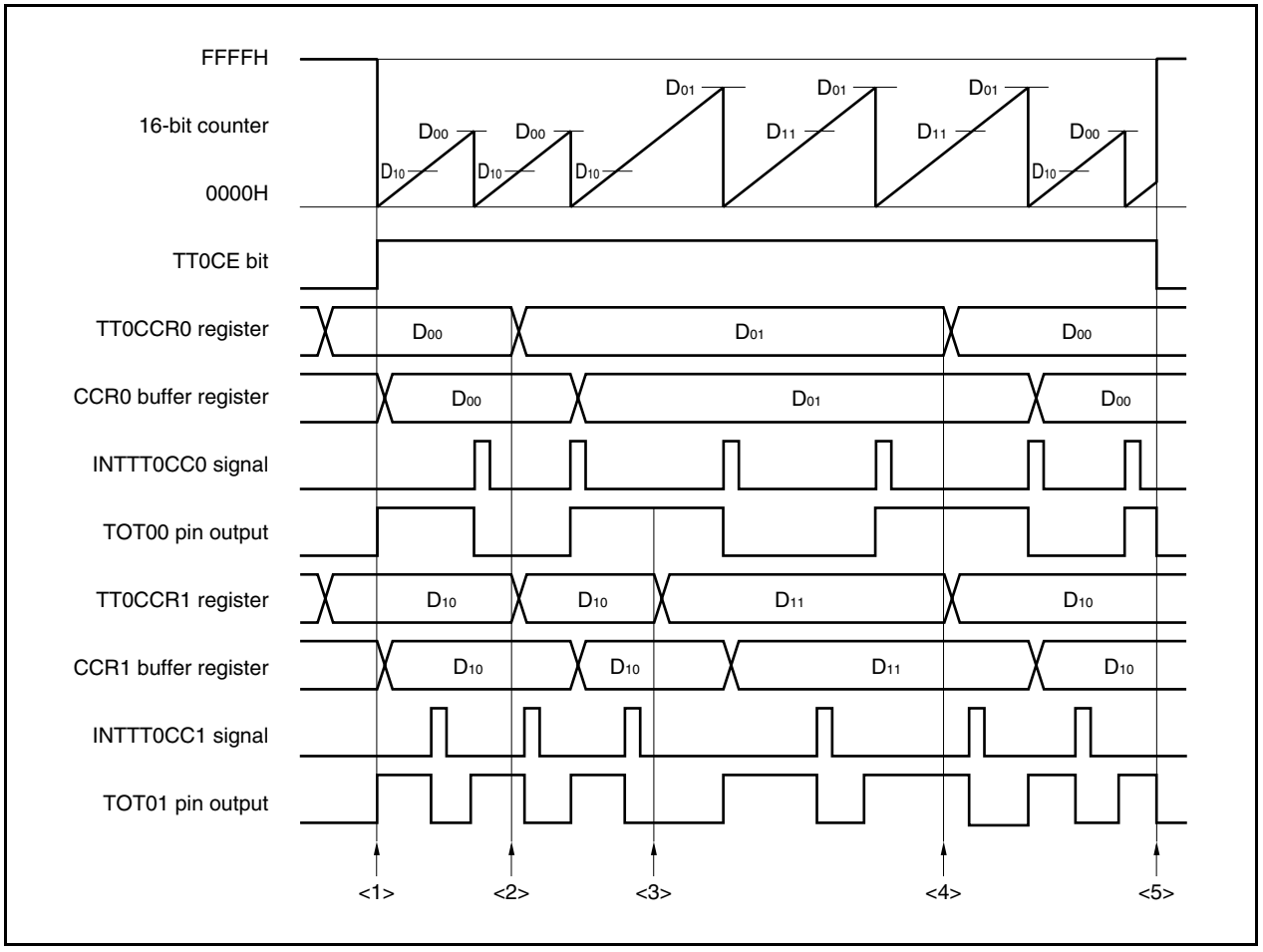
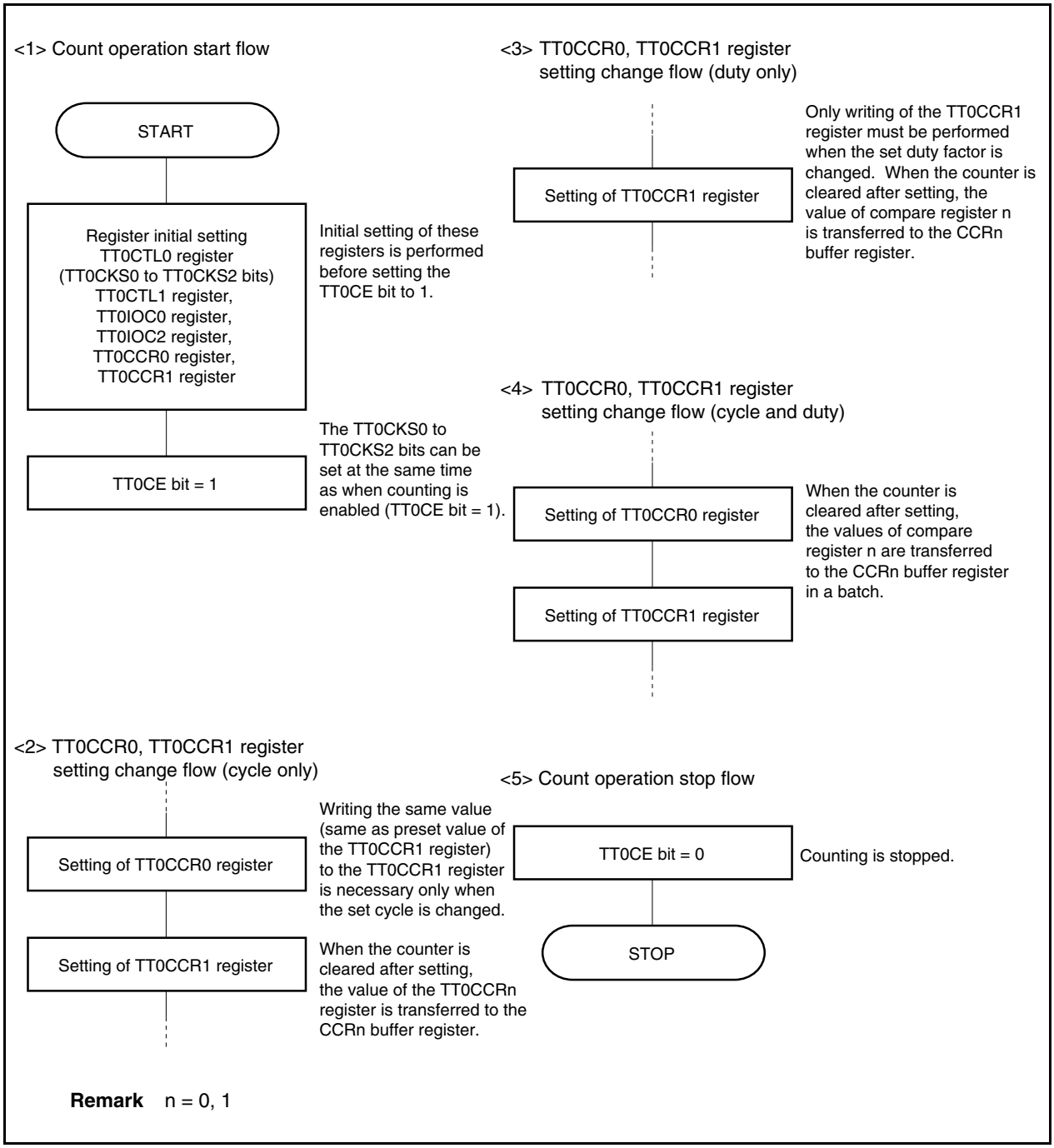


Figure 9-32. Software Processing Flow in PWM Output Mode (2/2)



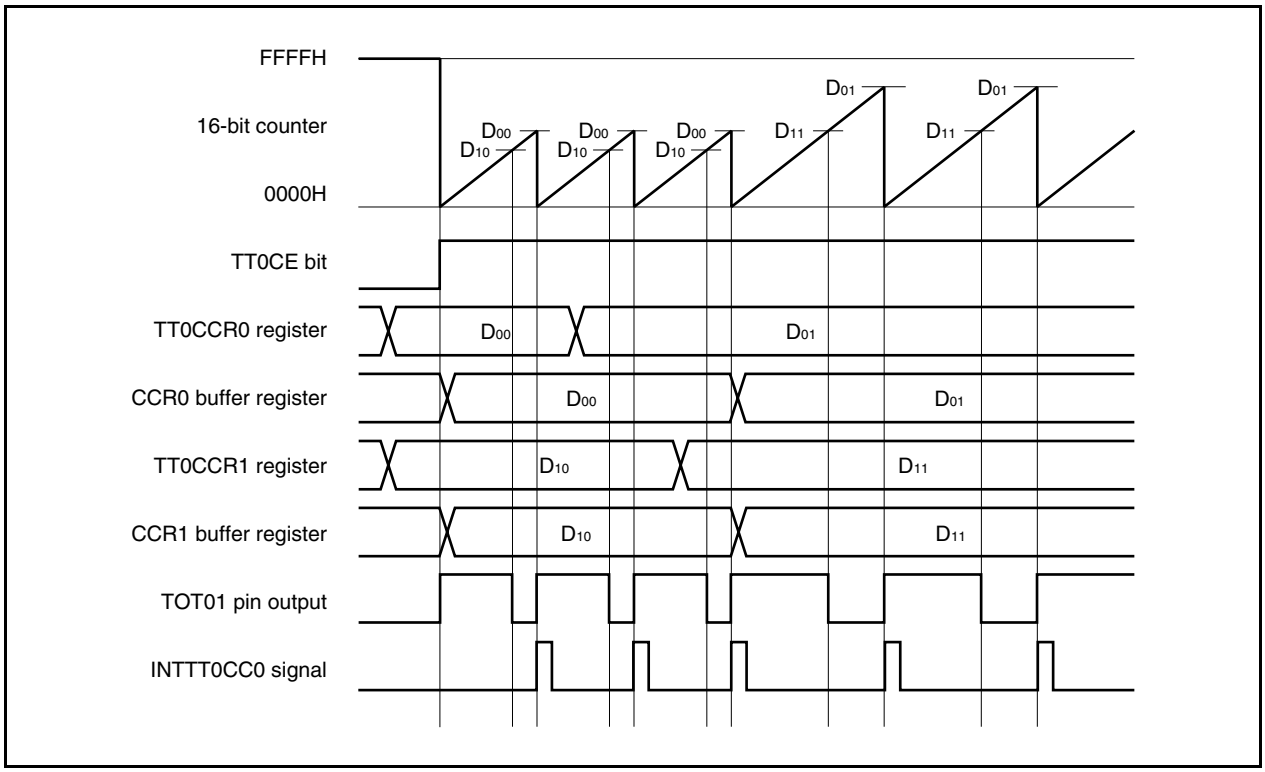
Remark n = 0, 1

(2) PWM output mode operation timing

(a) Changing pulse width during operation

To change the PWM waveform while the counter is operating, write the TT0CCR1 register last.

Rewrite the TT0CCRn register after writing the TT0CCR1 register after the INTTT0CC1 signal is detected.



To transfer data from the TT0CCRn register to the CCRn buffer register, the TT0CCR1 register must be written.

To change both the cycle and active level of the PWM waveform at this time, first set the cycle to the TT0CCR0 register and then set the active level width to the TT0CCR1 register.

To change only the cycle of the PWM waveform, first set the cycle to the TT0CCR0 register, and then write the same value (same as preset value of the TT0CCR1 register) to the TT0CCR1 register.

To change only the active level width (duty factor) of the PWM waveform, only the TT0CCR1 register has to be set.

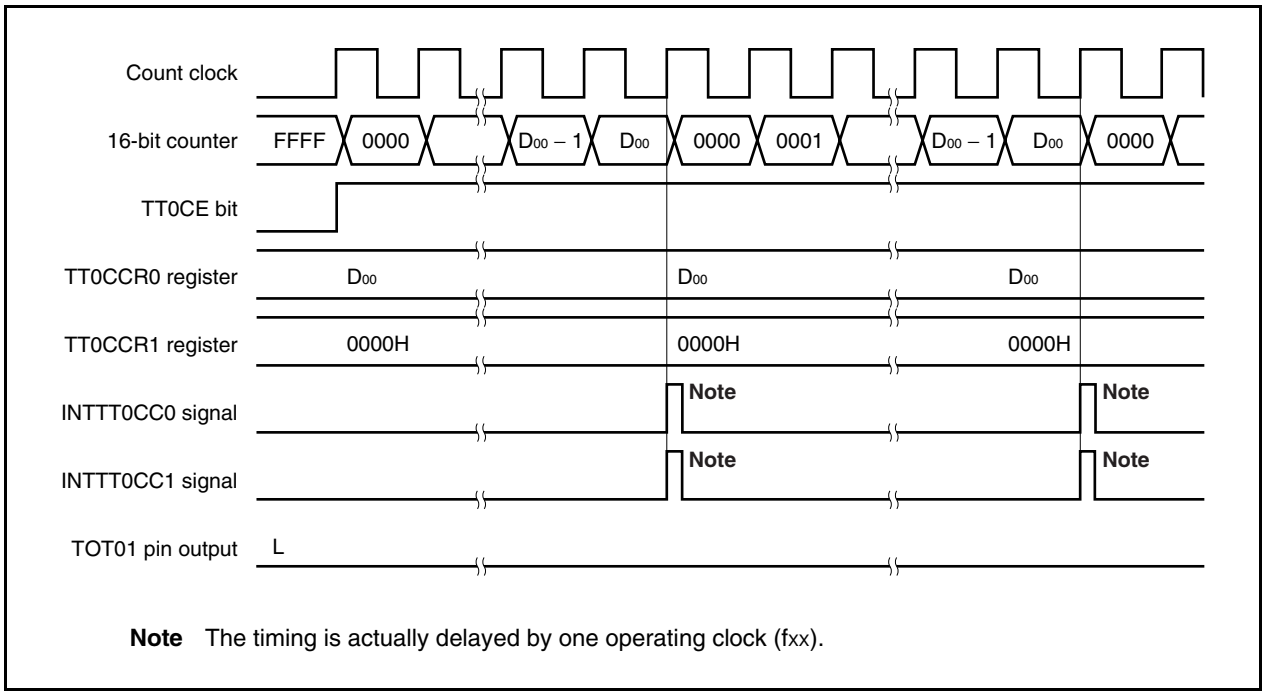
After data is written to the TT0CCR1 register, the value written to the TT0CCRn register is transferred to the CCRn buffer register in synchronization with clearing of the 16-bit counter, and is used as the value compared with the 16-bit counter.

To write the TT0CCR0 or TT0CCR1 register again after writing the TT0CCR1 register once, do so after the INTTT0CC0 signal is generated. Otherwise, the value of the CCRn buffer register may become undefined because the timing of transferring data from the TT0CCRn register to the CCRn buffer register conflicts with writing the TT0CCRn register.

Remark n = 0, 1

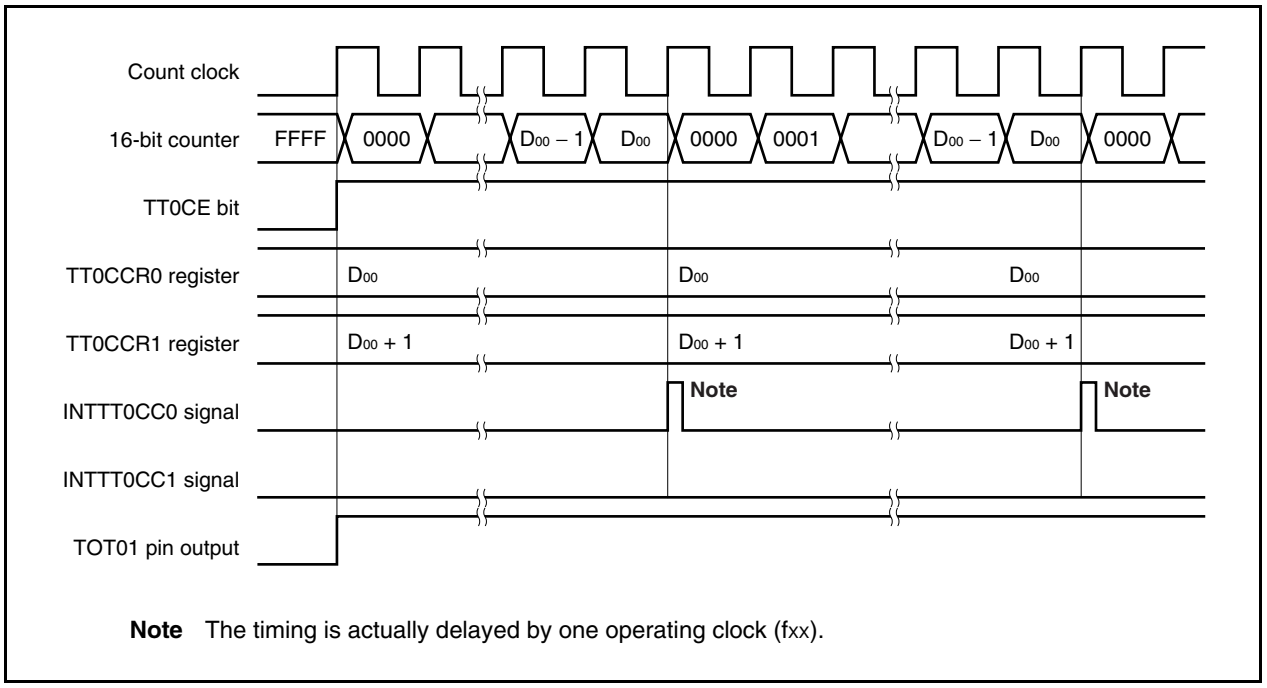
(b) 0%/100% output of PWM waveform

To output a 0% waveform, set the TT0CCR1 register to 0000H. The 16-bit counter is cleared to 0000H and the INTTT0CC0 and INTTT0CC1 signals are generated after a match between the count value of the 16-bit counter and the value of the CCR0 buffer register.



Note The timing is actually delayed by one operating clock (fxx).

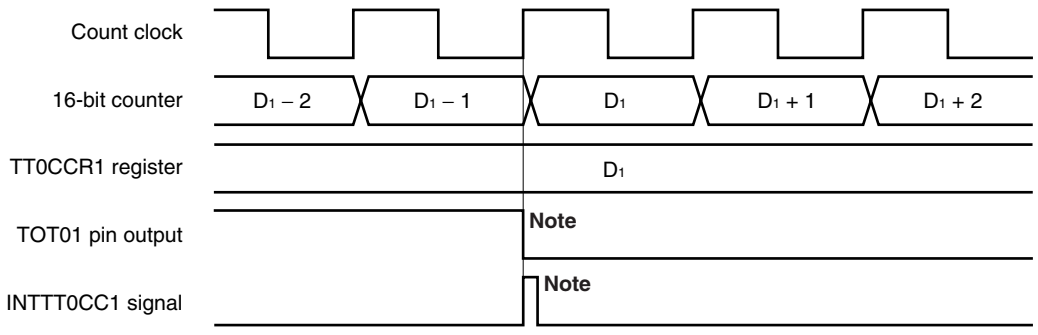
To output a 100% waveform, set a value of (set value of TT0CCR0 register + 1) to the TT0CCR1 register. If the set value of the TT0CCR0 register is FFFFH, 100% output cannot be produced.



Note The timing is actually delayed by one operating clock (fxx).

(c) Generation timing of compare match interrupt request signal (INTTT0CC1)

The timing of generation of the INTTT0CC1 signal in the PWM output mode differs from the timing of INTTT0CC1 signals in other modes; the INTTT0CC1 signal is generated when the count value of the 16-bit counter matches the value of the TT0CCR1 register.



Note The timing is actually delayed by one operating clock (fxx).

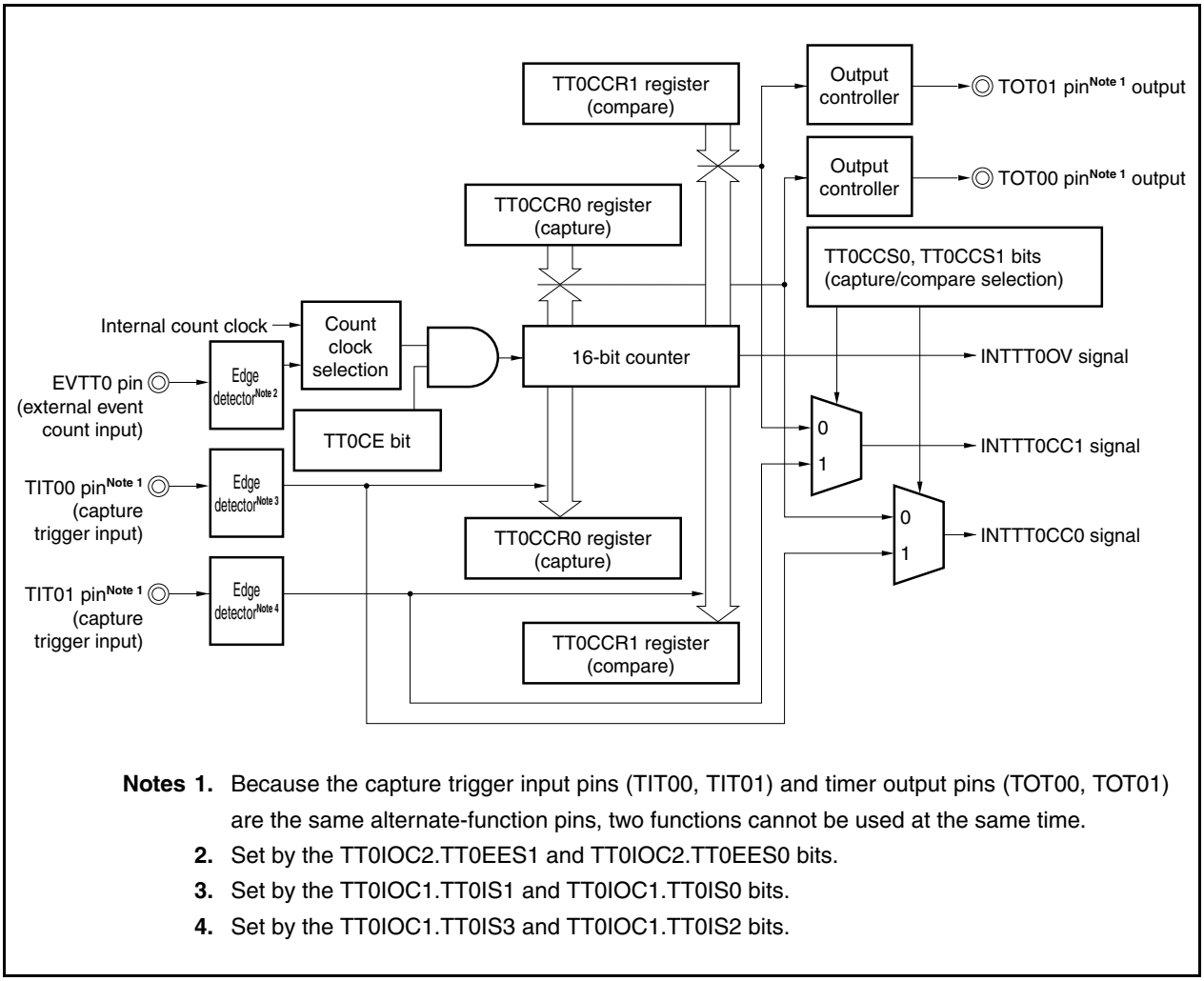
Usually, the INTTT0CC1 signal is generated in synchronization with the next count-up after the count value of the 16-bit counter matches the value of the TT0CCR1 register.

In the PWM output mode, however, it is generated one clock earlier. This is because the timing is changed to match the timing at which the output signal of the TOT01 pin changes.

9.6.6 Free-running timer mode (TT0MD3 to TT0MD0 bits = 0101)

In the free-running timer mode, 16-bit timer/event counter T starts counting when the TT0CTL0.TT0CE bit is set to 1. At this time, the TT0CCR0 and TT0CCR1 registers can be used as compare registers or capture registers, depending on the setting of the TT0OPT0.TT0CCS0 and TT0OPT0.TT0CCS1 bits.

Figure 9-33. Configuration in Free-Running Timer Mode



Notes 1. Because the capture trigger input pins (TIT00, TIT01) and timer output pins (TOT00, TOT01) are the same alternate-function pins, two functions cannot be used at the same time.

2. Set by the TT0IOC2.TT0EES1 and TT0IOC2.TT0EES0 bits.

3. Set by the TT0IOC1.TT0IS1 and TT0IOC1.TT0IS0 bits.

4. Set by the TT0IOC1.TT0IS3 and TT0IOC1.TT0IS2 bits.

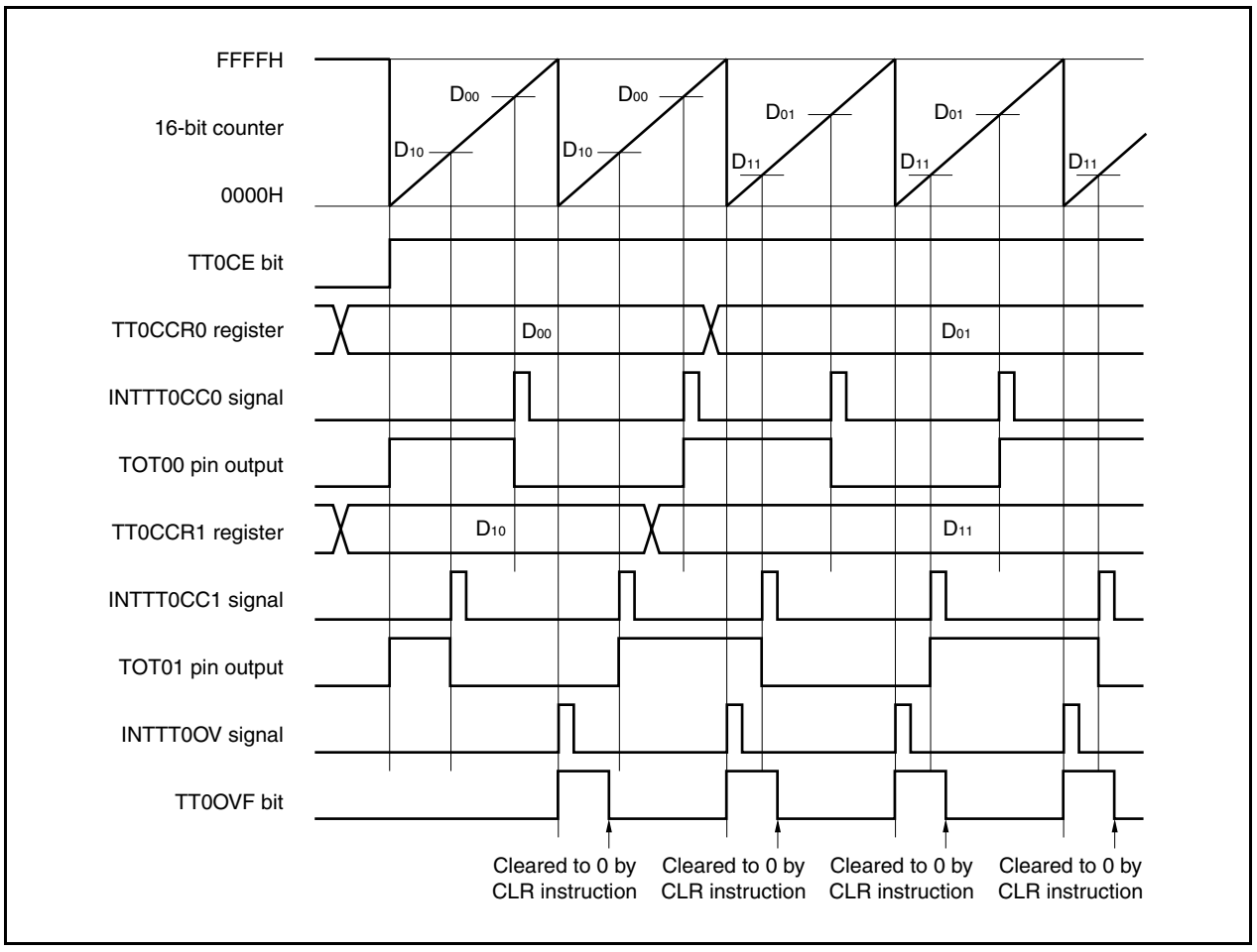
- Compare operation

  When the TT0CE bit is set to 1, 16-bit timer/event counter T starts counting, and the output signal of the TOT0n pin is inverted. When the count value of the 16-bit counter later matches the set value of the TT0CCRn register, a compare match interrupt request signal (INTTT0CCn) is generated, and the output signal of the TOT0n pin is inverted.

  The 16-bit counter continues counting in synchronization with the count clock. When it counts up to FFFFH, it generates an overflow interrupt request signal (INTTT0OV) at the next clock, is cleared to 0000H, and continues counting. At this time, the overflow flag (TT0OPT0.TT0OVF bit) is also set to 1. Confirm that the overflow flag is set to 1 and then clear it to 0 by executing the CLR instruction via software.

  The TT0CCRn register can be rewritten while the counter is operating. If it is rewritten, the new value is reflected at that time by anytime write, and compared with the count value.

Figure 9-34. Basic Timing in Free-Running Timer Mode (Compare Function)



- Capture operation

  When the TT0CE bit is set to 1, the 16-bit counter starts counting. When the valid edge input to the TIT0n pin is detected, the count value of the 16-bit counter is stored in the TT0CCRn register, and a capture interrupt request signal (INTTT0CCn) is generated.

  The 16-bit counter continues counting in synchronization with the count clock. When it counts up to FFFFH, it generates an overflow interrupt request signal (INTTT0OV) at the next clock, is cleared to 0000H, and continues counting. At this time, the overflow flag (TT0OPT0.TT0OVF bit) is also set to 1. Confirm that the overflow flag is set to 1 and then clear it to 0 by executing the CLR instruction via software.

Figure 9-35. Basic Timing in Free-Running Timer Mode (Capture Function)

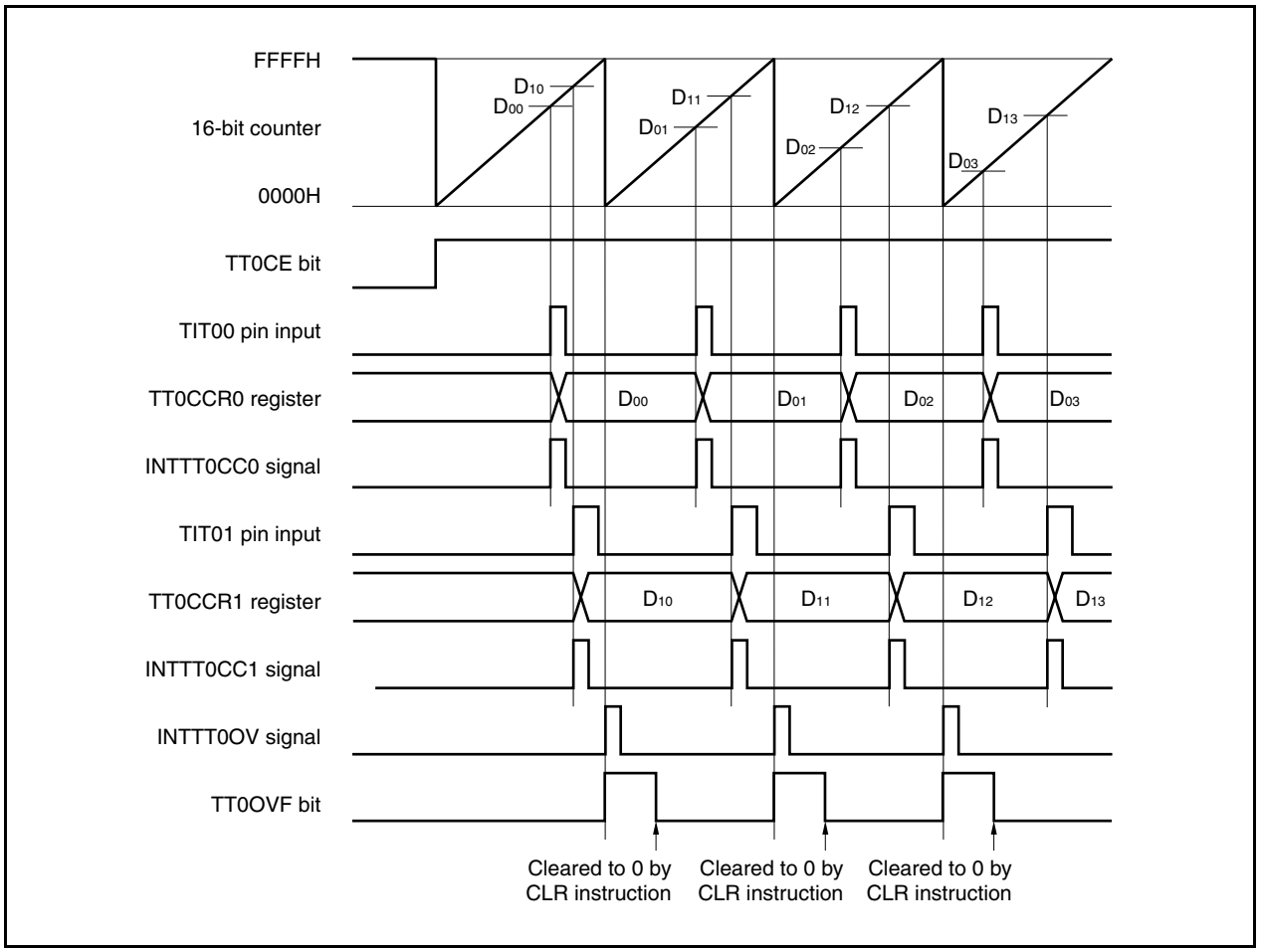
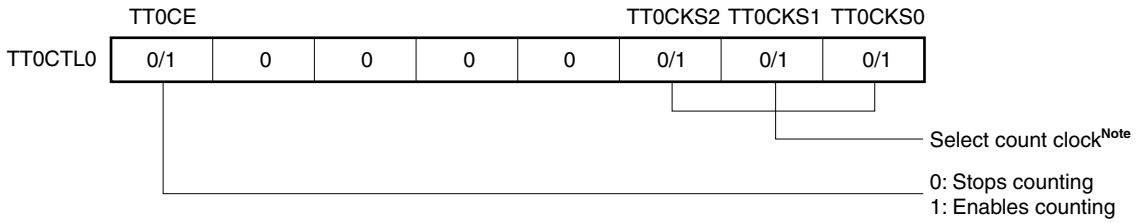


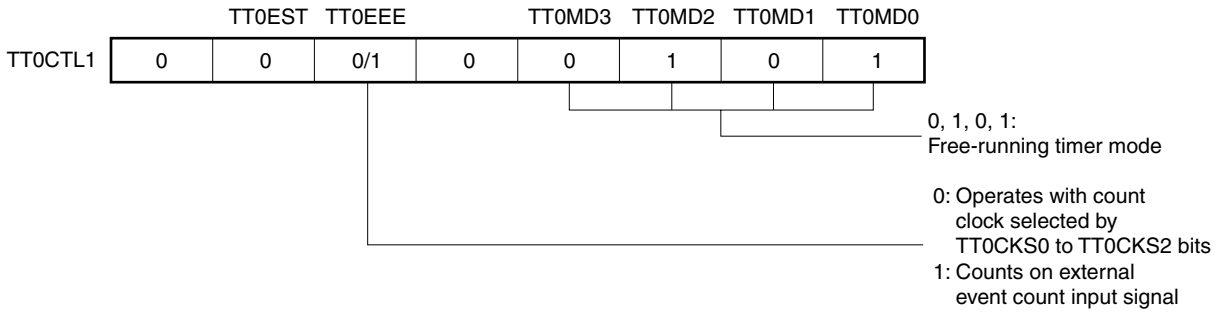
Figure 9-36. Register Setting in Free-Running Timer Mode (1/2)

(a) TMT0 control register 0 (TT0CTL0)

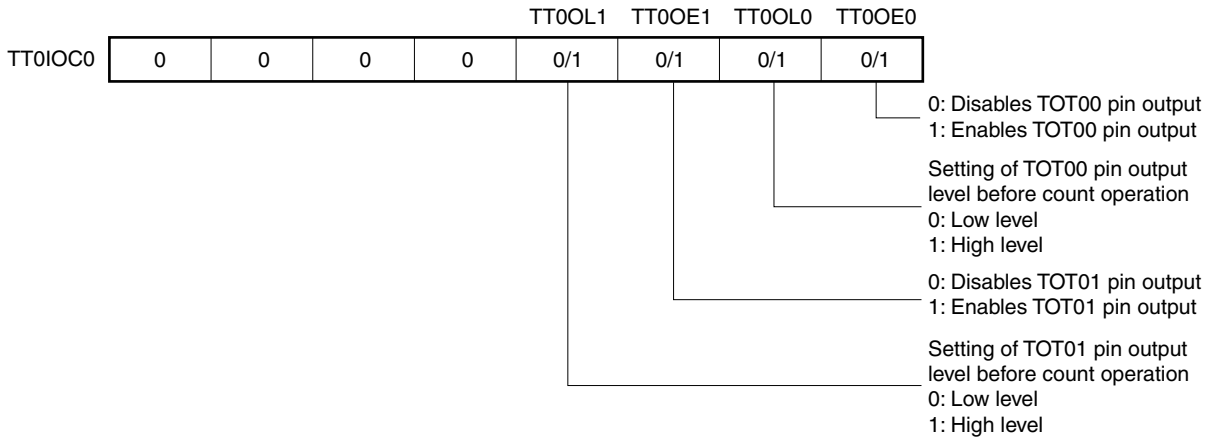


Note The setting is invalid when the TT0CTL1.TT0EEE bit = 1

(b) TMT0 control register 1 (TT0CTL1)



(c) TMT0 I/O control register 0 (TT0IOC0)



(d) TMT0 I/O control register 1 (TT0IOC1)

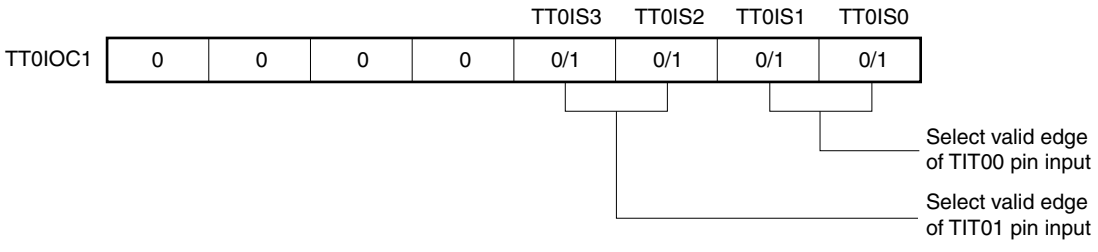
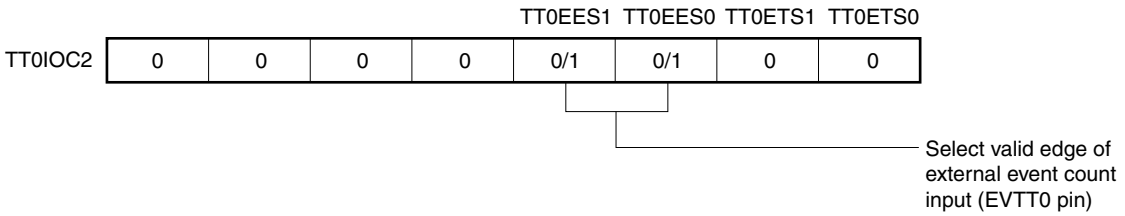
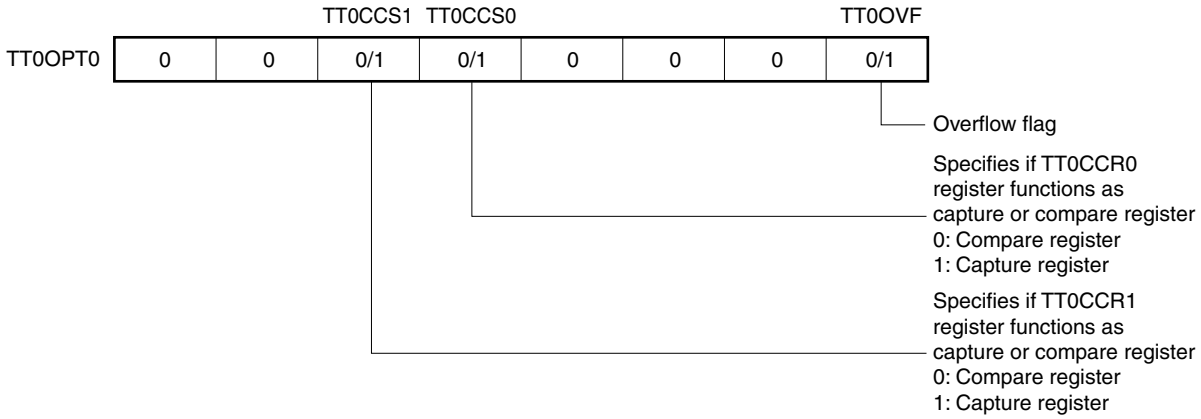


Figure 9-36. Register Setting in Free-Running Timer Mode (2/2)

(e) TMT0 I/O control register 2 (TT0IOC2)



(f) TMT0 option register 0 (TT0OPT0)



(g) TMT0 counter read buffer register (TT0CNT)

The value of the 16-bit counter can be read by reading the TT0CNT register.

(h) TMT0 capture/compare registers 0 and 1 (TT0CCR0 and TT0CCR1)

These registers function as capture registers or compare registers depending on the setting of the TT0OPT0.TT0CCSn bit.

When the registers function as capture registers, they store the count value of the 16-bit counter when the valid edge input to the TIT0n pin is detected.

When the registers function as compare registers and when D_a is set to the TT0CCRn register, the INTTT0CCn signal is generated when the counter reaches (D_a + 1), and the output signals of the TOT00 and TOT01 pins are inverted.

Remark n = 0, 1

(1) Operation flow in free-running timer mode

(a) When using capture/compare register as compare register

Figure 9-37. Software Processing Flow in Free-Running Timer Mode (Compare Function) (1/2)

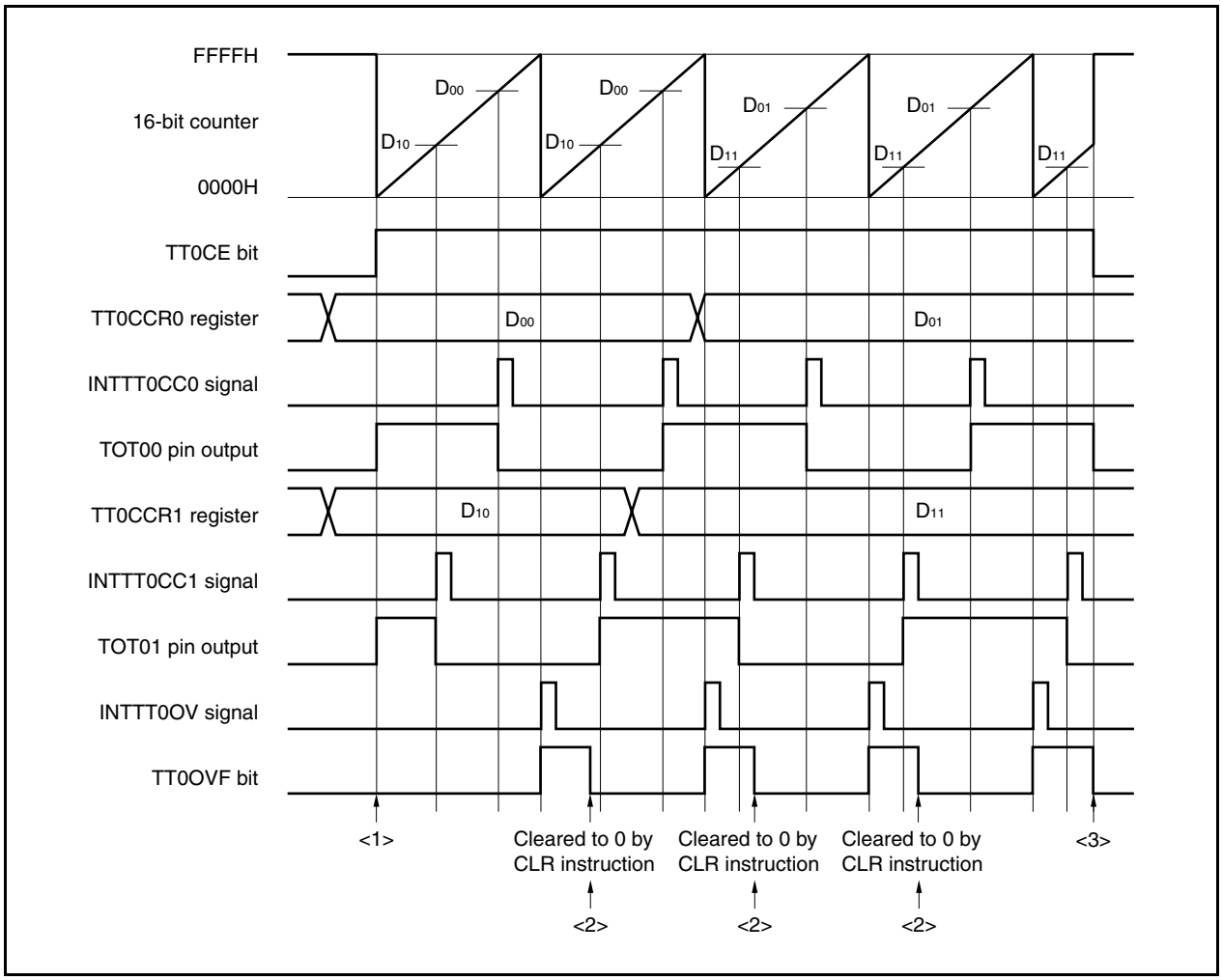
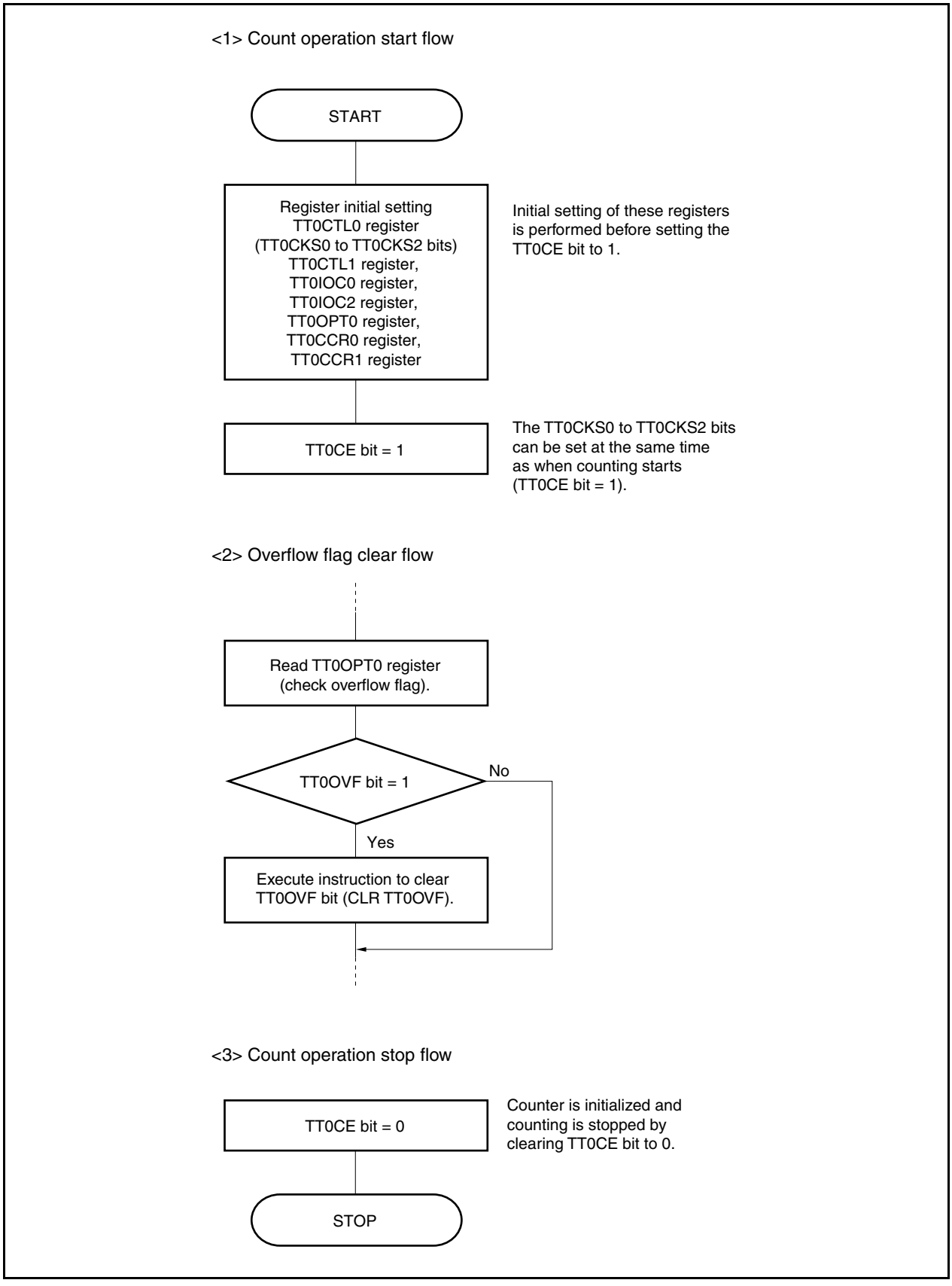


Figure 9-37. Software Processing Flow in Free-Running Timer Mode (Compare Function) (2/2)



(b) When using capture/compare register as capture register

Figure 9-38. Software Processing Flow in Free-Running Timer Mode (Capture Function) (1/2)

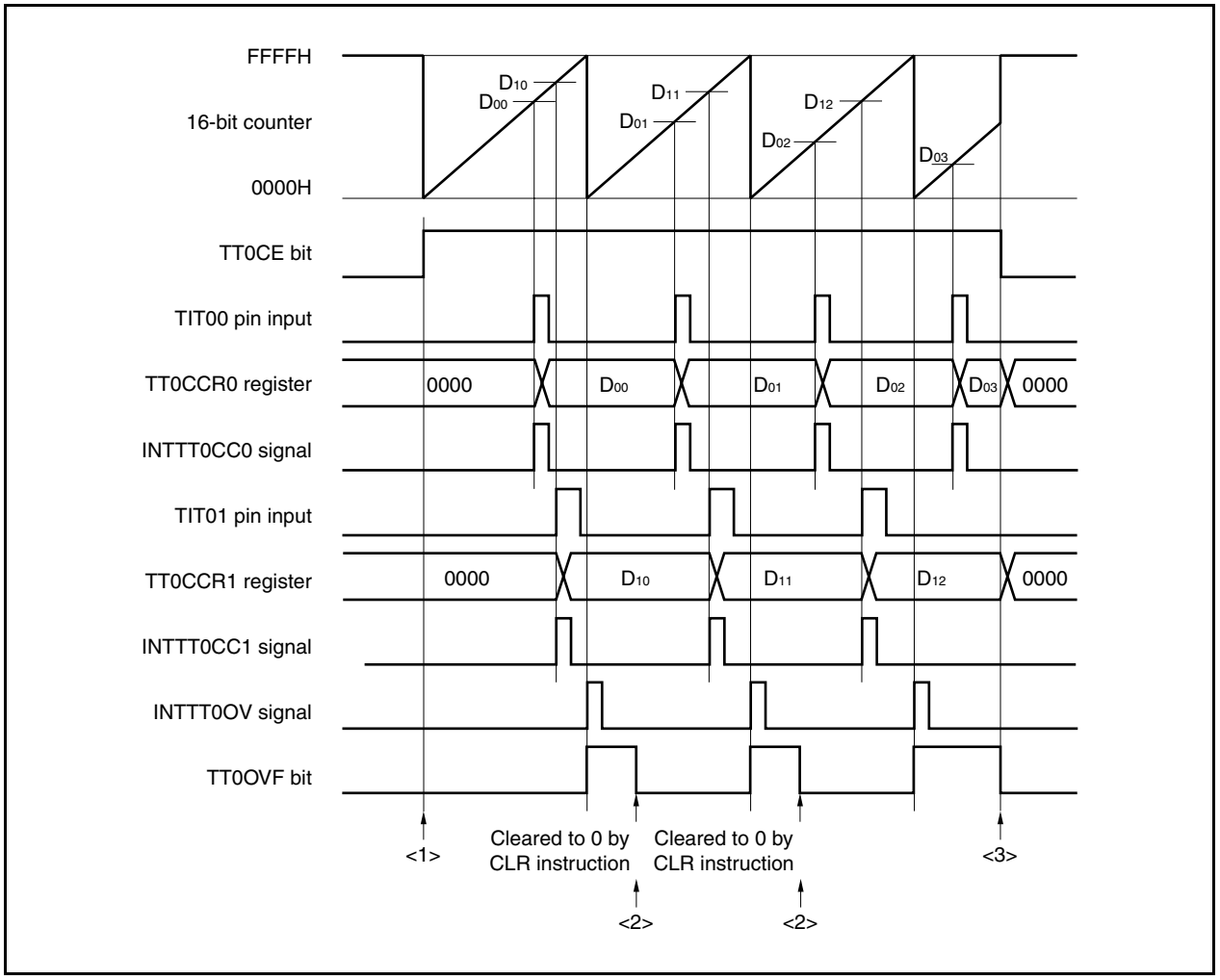
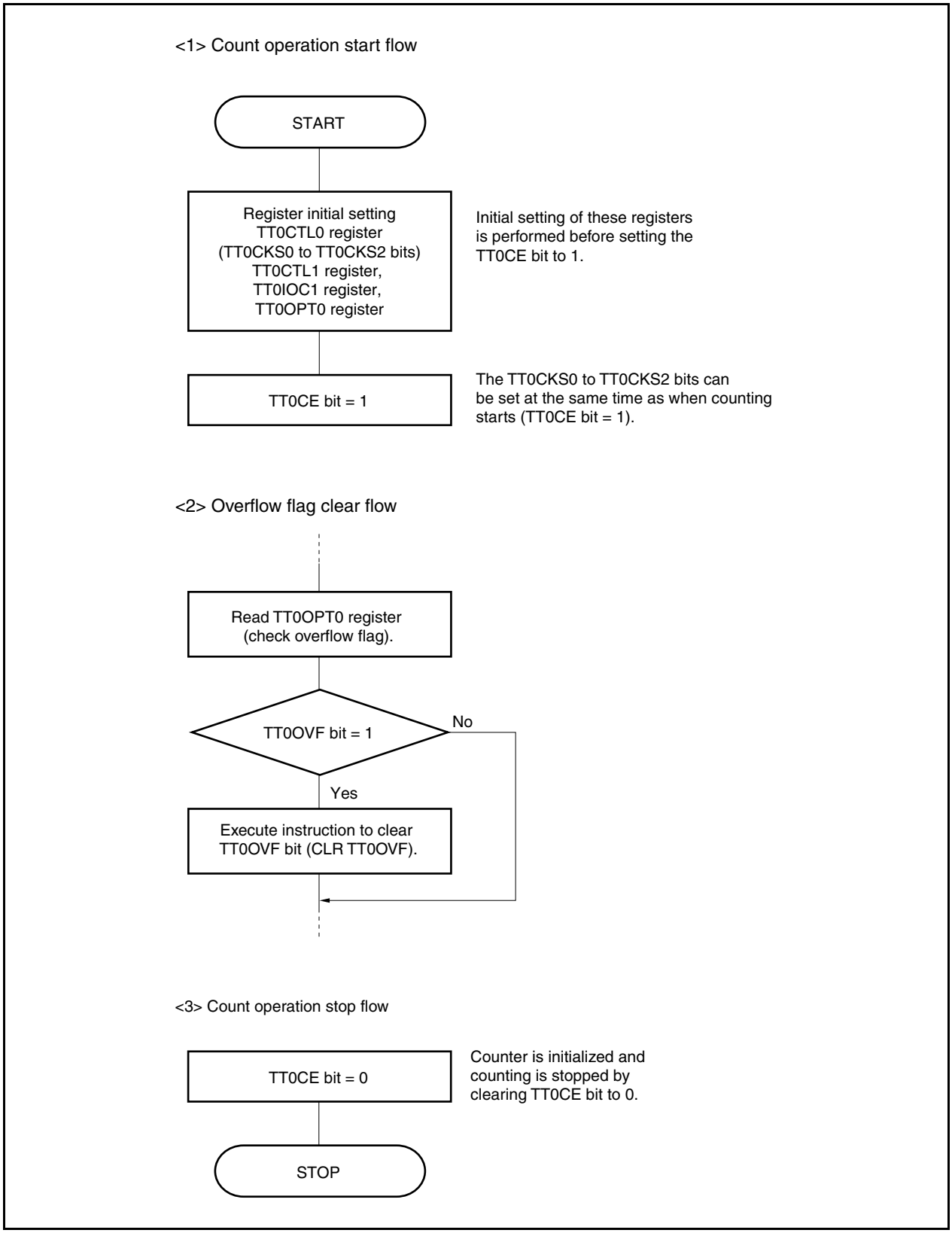


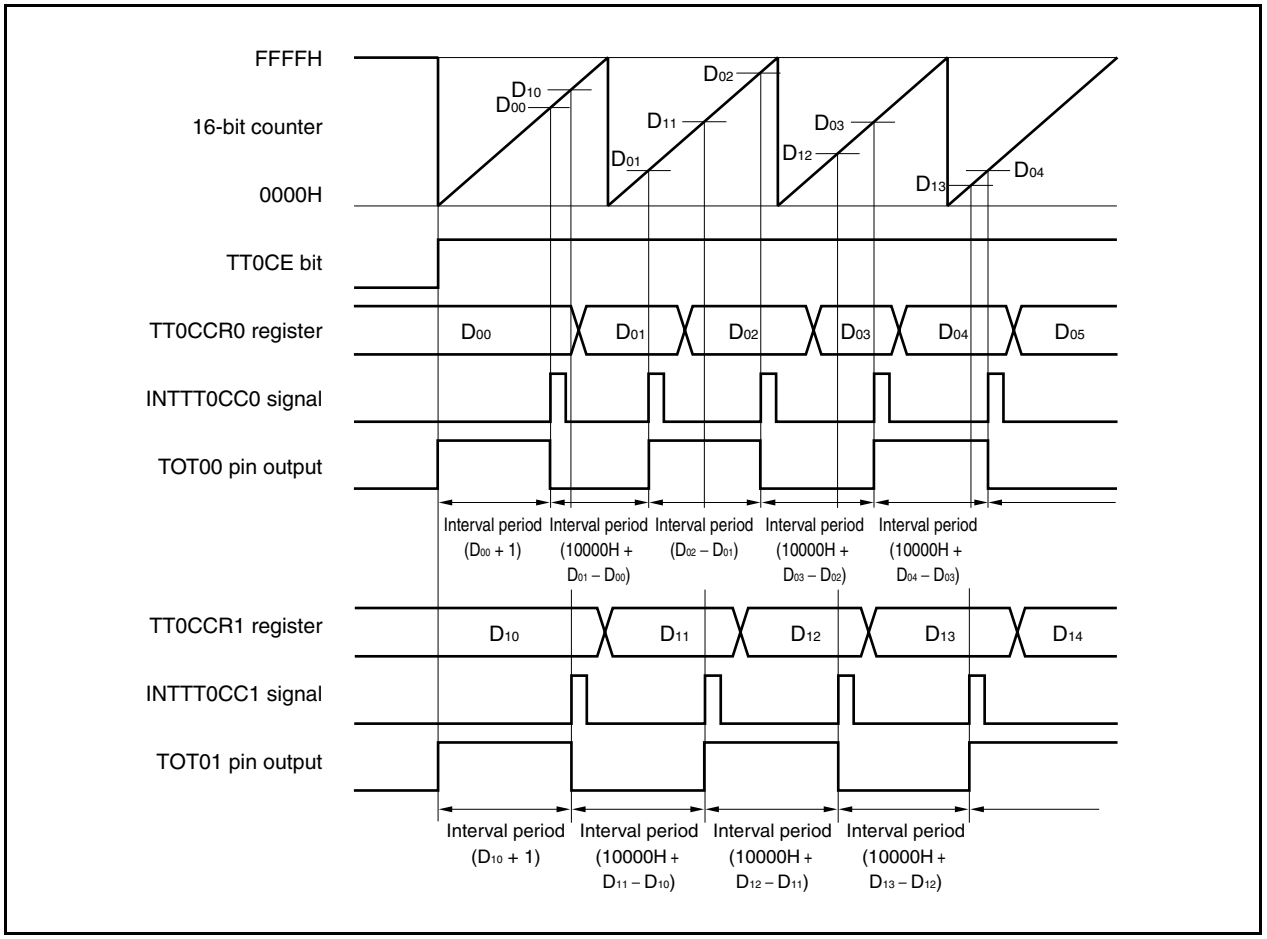
Figure 9-38. Software Processing Flow in Free-Running Timer Mode (Capture Function) (2/2)



(2) Operation timing in free-running timer mode

(a) Interval operation with compare register

When 16-bit timer/event counter T is used as an interval timer with the TT0CCRn register used as a compare register, software processing is necessary for setting a comparison value to generate the next interrupt request signal each time the INTTT0CCn signal has been detected.



When performing an interval operation in the free-running timer mode, two intervals can be set with one channel.

To perform the interval operation, the value of the corresponding TT0CCRn register must be re-set in the interrupt servicing that is executed when the INTTT0CCn signal is detected.

The set value for re-setting the TT0CCRn register can be calculated by the following expression, where "D_a" is the interval period.

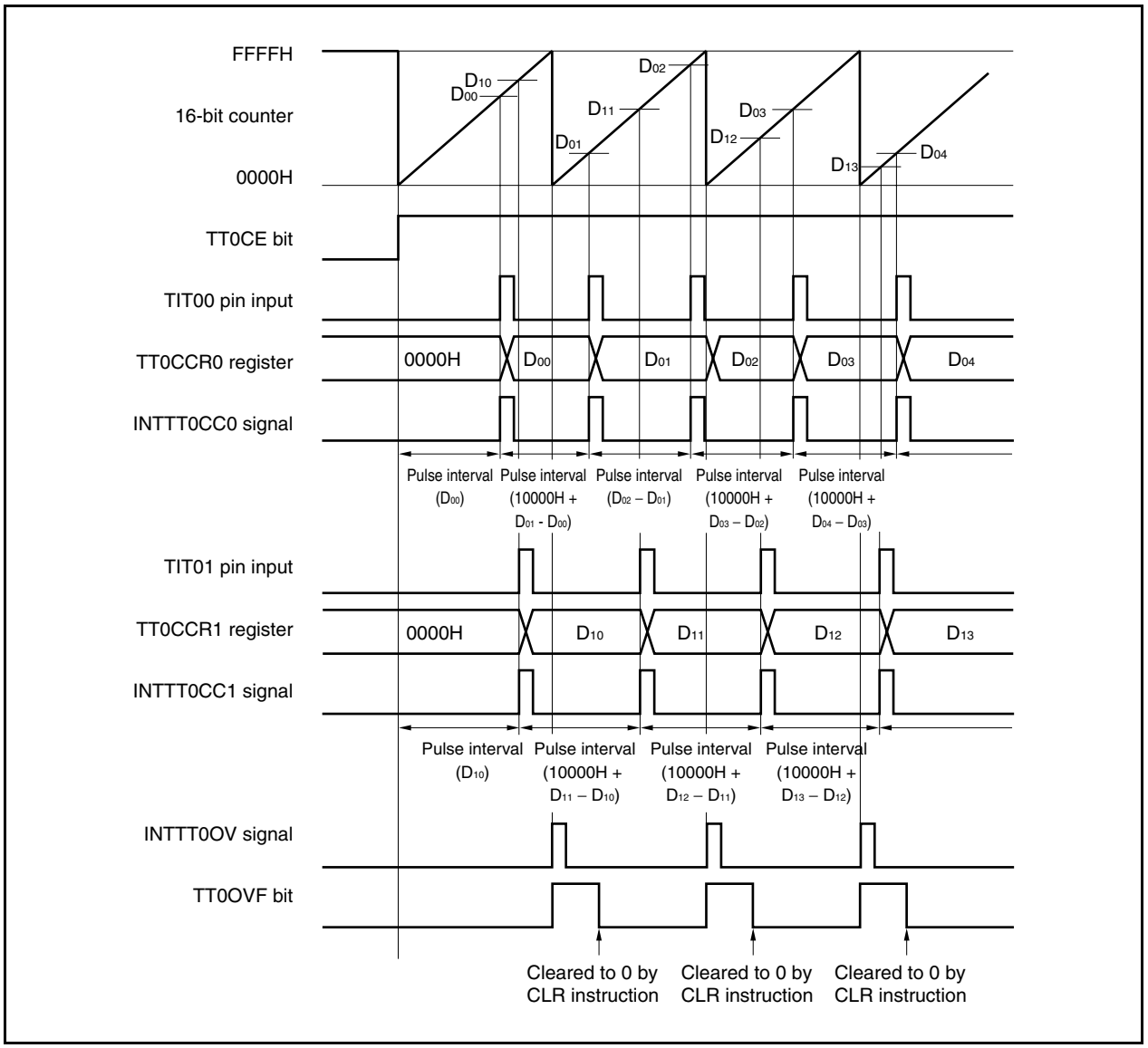
Compare register default value: $D_a - 1$

Value set to compare register second and subsequent time: Previous set value + D_a

(If the calculation result is greater than FFFFH, subtract 10000H from the result and set this value to the register.)

(b) Pulse width measurement with capture register

When pulse width measurement is performed with the TT0CCRn register used as a capture register, software processing is necessary for reading the capture register each time the INTTT0CCn signal has been detected and for calculating an interval.



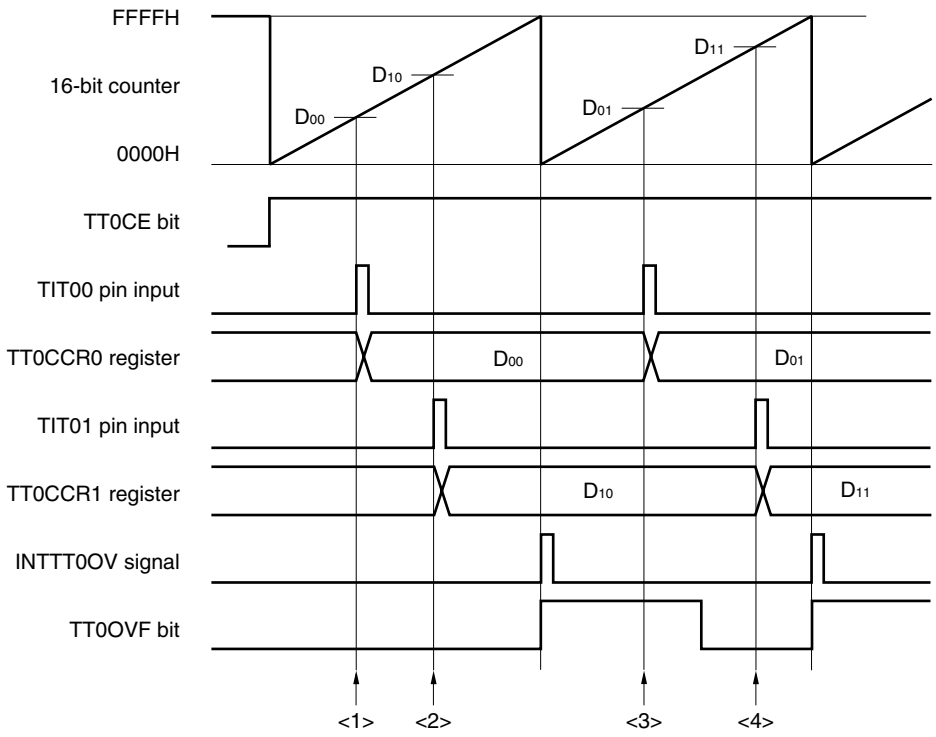
When executing pulse width measurement in the free-running timer mode, two pulse widths can be measured with one channel.

To measure a pulse width, the pulse width can be calculated by reading the value of the TT0CCRn register in synchronization with the INTTT0CCn signal, and calculating the difference between the read value and the previously read value.

(c) Processing of overflow when two capture registers are used

Care must be exercised in processing the overflow flag when two capture registers are used. First, an example of incorrect processing is shown below.

Example of incorrect processing when two capture registers are used



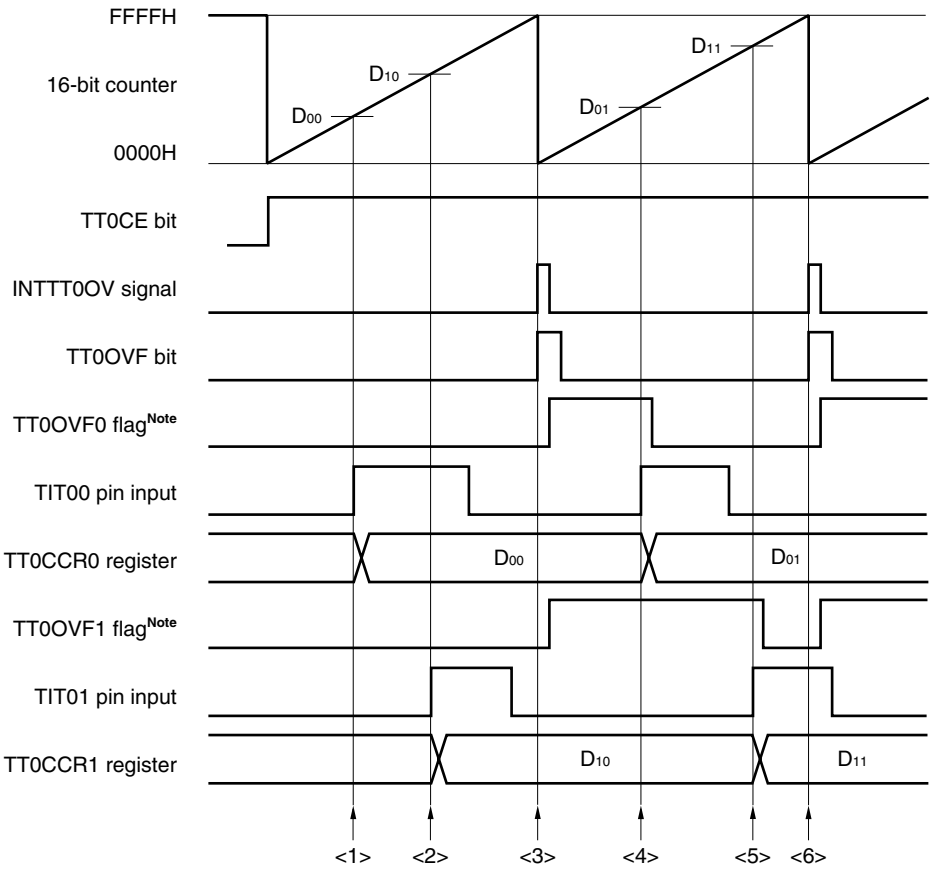
The following problem may occur when two pulse widths are measured in the free-running timer mode.

<1> Read the TT0CCR0 register (setting of the default value of the TIT00 pin input).
<2> Read the TT0CCR1 register (setting of the default value of the TIT01 pin input).
<3> Read the TT0CCR0 register.
Read the overflow flag. If the overflow flag is 1, clear it to 0.
Because the overflow flag is 1, the pulse width can be calculated by (10000H + D_{01} − D_{00}).
<4> Read the TT0CCR1 register.
Read the overflow flag. Because the flag is cleared in <3>, 0 is read.
Because the overflow flag is 0, the pulse width can be calculated by (D_{11} − D_{10}) (incorrect).

When two capture registers are used, and if the overflow flag is cleared to 0 by one capture register, the other capture register may not obtain the correct pulse width.
Use software when using two capture registers. An example of how to use software is shown below.

(1/2)

Example when two capture registers are used (using overflow interrupt)



Note The TT0OVF0 and TT0OVF1 flags are set on the internal RAM by software.

<1> Read the TT0CCR0 register (setting of the default value of the TIT00 pin input).

<2> Read the TT0CCR1 register (setting of the default value of the TIT01 pin input).

<3> An overflow occurs. Set the TT0OVF0 and TT0OVF1 flags to 1 in the overflow interrupt servicing, and clear the overflow flag to 0.

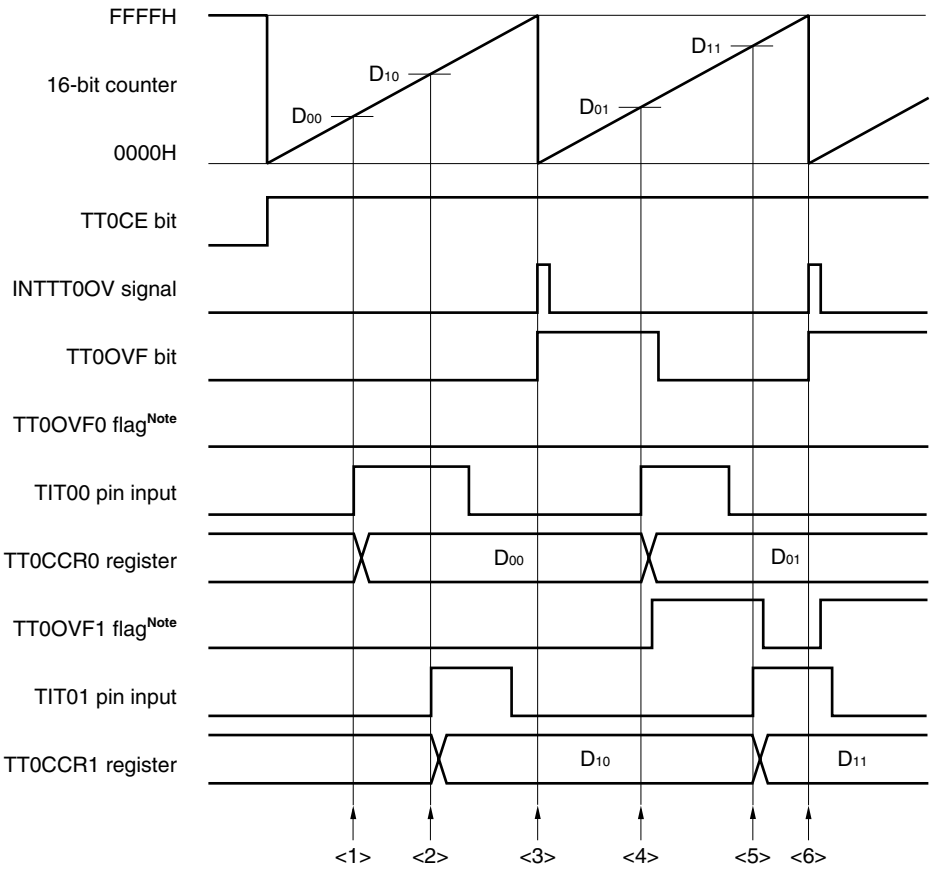
<4> Read the TT0CCR0 register.
Read the TT0OVF0 flag. If the TT0OVF0 flag is 1, clear it to 0.
Because the TT0OVF0 flag is 1, the pulse width can be calculated by (10000H + D_{01} − D_{00}).

<5> Read the TT0CCR1 register.
Read the TT0OVF1 flag. If the TT0OVF1 flag is 1, clear it to 0 (the TT0OVF0 flag is cleared in <4>, and the TT0OVF1 flag remains 1).
Because the TT0OVF1 flag is 1, the pulse width can be calculated by (10000H + D_{11} − D_{10}) (correct).

<6> Same as <3>

(2/2)

Example when two capture registers are used (without using overflow interrupt)



Note The TT0OVF0 and TT0OVF1 flags are set on the internal RAM by software.

<1> Read the TT0CCR0 register (setting of the default value of the TIT00 pin input).

<2> Read the TT0CCR1 register (setting of the default value of the TIT01 pin input).

<3> An overflow occurs. Nothing is done by software.

<4> Read the TT0CCR0 register.

Read the overflow flag. If the overflow flag is 1, set only the TT0OVF1 flag to 1, and clear the overflow flag to 0.

Because the overflow flag is 1, the pulse width can be calculated by (10000H + D_{01} − D_{00}).

<5> Read the TT0CCR1 register.

Read the overflow flag. Because the overflow flag is cleared in <4>, 0 is read.

Read the TT0OVF1 flag. If the TT0OVF1 flag is 1, clear it to 0.

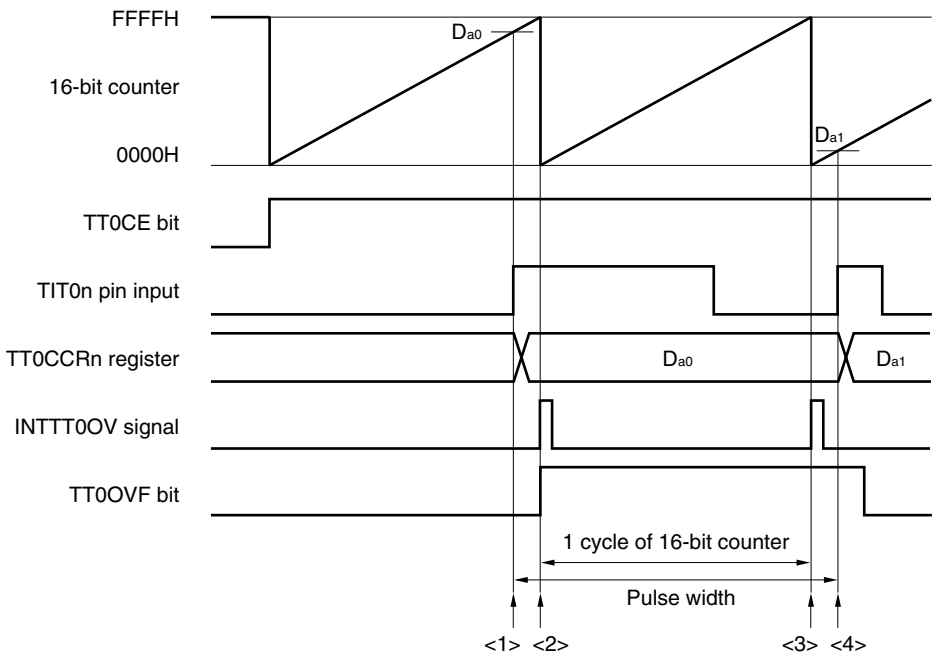
Because the TT0OVF1 flag is 1, the pulse width can be calculated by (10000H + D_{11} − D_{10}) (correct).

<6> Same as <3>

(d) Processing of overflow if capture trigger interval is long

If the pulse width is greater than one cycle of the 16-bit counter, care must be exercised because an overflow may occur more than once from the first capture trigger to the next. First, an example of incorrect processing is shown below.

Example of incorrect processing when capture trigger interval is long



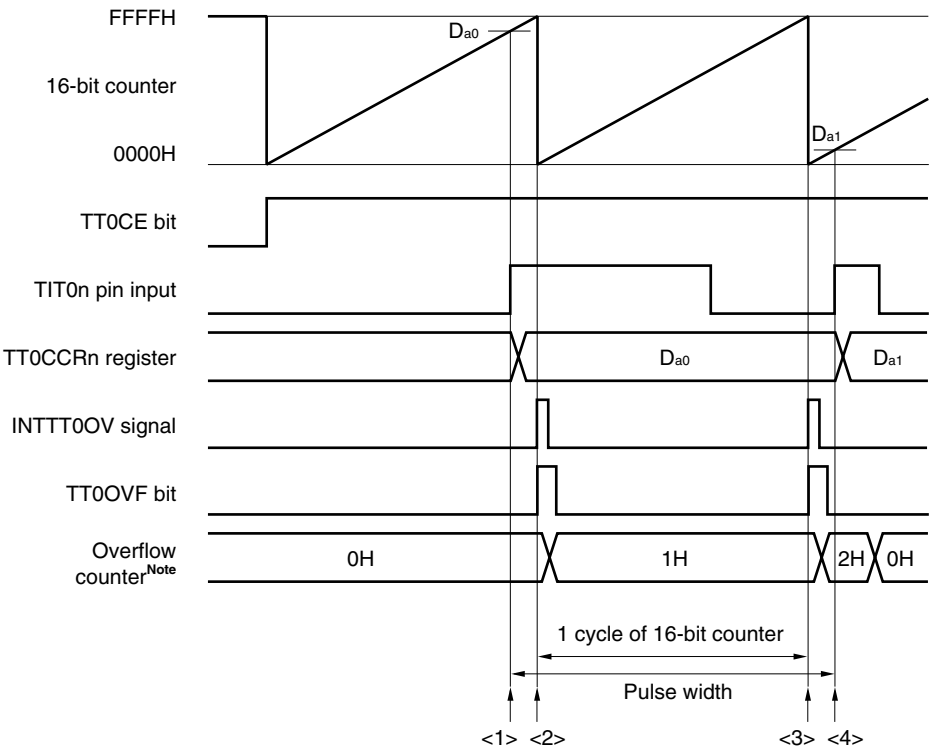
The following problem may occur when long pulse width is measured in the free-running timer mode.

<1> Read the TT0CCRn register (setting of the default value of the TIT0n pin input).
<2> An overflow occurs. Nothing is done by software.
<3> An overflow occurs a second time. Nothing is done by software.
<4> Read the TT0CCRn register.
Read the overflow flag. If the overflow flag is 1, clear it to 0.
Because the overflow flag is 1, the pulse width can be calculated by (10000H + D_{a1} − D_{a0}) (incorrect).
Actually, the pulse width must be (20000H + D_{a1} − D_{a0}) because an overflow occurs twice.

Remark n = 0, 1

If an overflow occurs twice or more when the capture trigger interval is long, the correct pulse width may not be obtained.
If the capture trigger interval is long, slow the count clock to lengthen one cycle of the 16-bit counter, or use software. An example of how to use software is shown next.

Example when capture trigger interval is long



Note The overflow counter is set arbitrarily by software on the internal RAM.

<1> Read the TT0CCRn register (setting of the default value of the TIT0n pin input).

<2> An overflow occurs. Increment the overflow counter and clear the overflow flag to 0 in the overflow interrupt servicing.

<3> An overflow occurs a second time. Increment the overflow counter and clear the overflow flag to 0 in the overflow interrupt servicing.

<4> Read the TT0CCRn register.

Read the overflow counter.

→ When the overflow counter is "N", the pulse width can be calculated by (N × 10000H + D_{a1} – D_{a0}).

In this example, the pulse width is (20000H + D_{a1} – D_{a0}) because an overflow occurs twice.

Clear the overflow counter (0H).

Remark n = 0, 1

(e) Clearing overflow flag

The overflow flag can be cleared to 0 by clearing the TT0OVF bit to 0 with the CLR instruction after reading the TT0OVF bit when it is 1 and by writing 8-bit data (bit 0 is 0) to the TT0OPT0 register after reading the TT0OVF bit when it is 1.

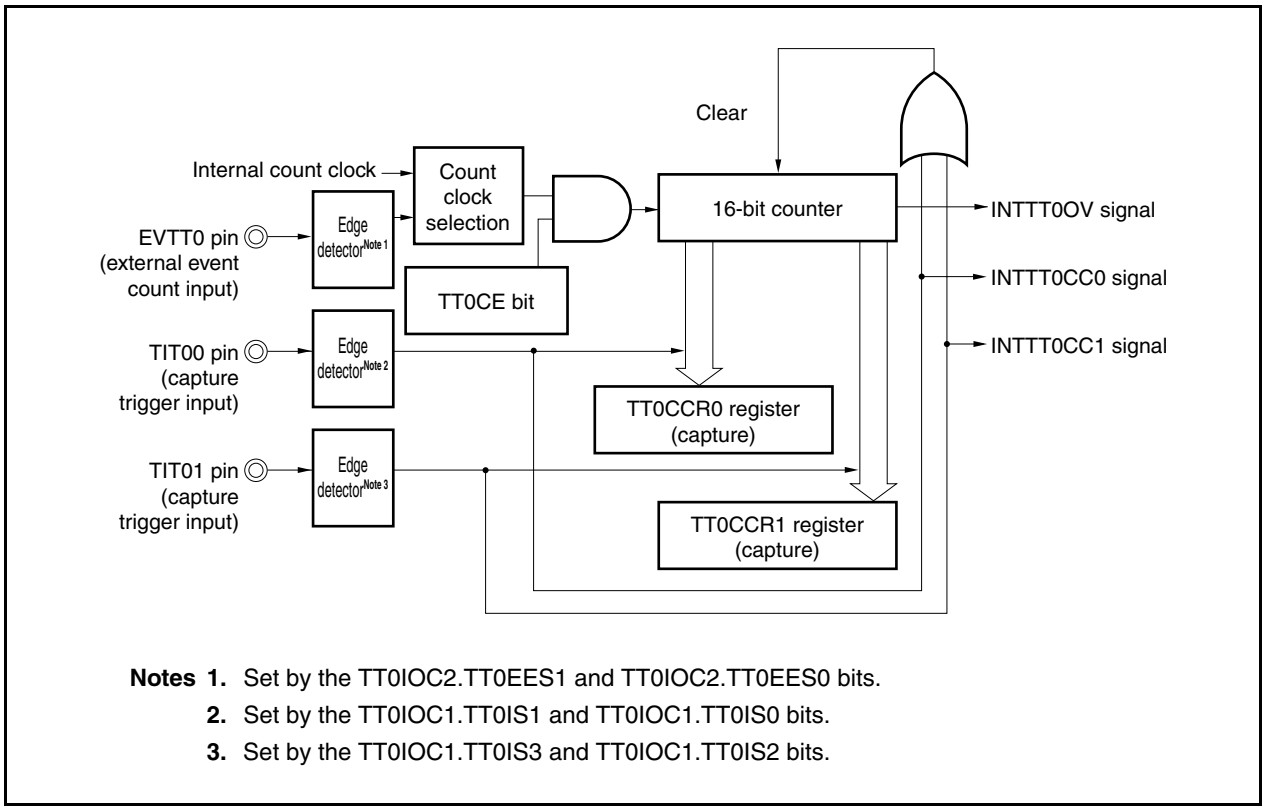
9.6.7 Pulse width measurement mode (TT0MD3 to TT0MD0 bits = 0110)

In the pulse width measurement mode, 16-bit timer/event counter T starts counting when the TT0CTL0.TT0CE bit is set to 1. Each time the valid edge input to the TIT0n pin has been detected, the count value of the 16-bit counter is stored in the TT0CCRn register, and the 16-bit counter is cleared to 0000H.

The interval of the valid edge can be measured by reading the TT0CCRn register after a capture interrupt request signal (INTTT0CCn) occurs.

As shown in Figure 9-39, select either the TIT00 or TIT01 pin as the capture trigger input pin and set the unused pins to “No edge detection” by using the TT0IOC1 register.

Figure 9-39. Configuration in Pulse Width Measurement Mode

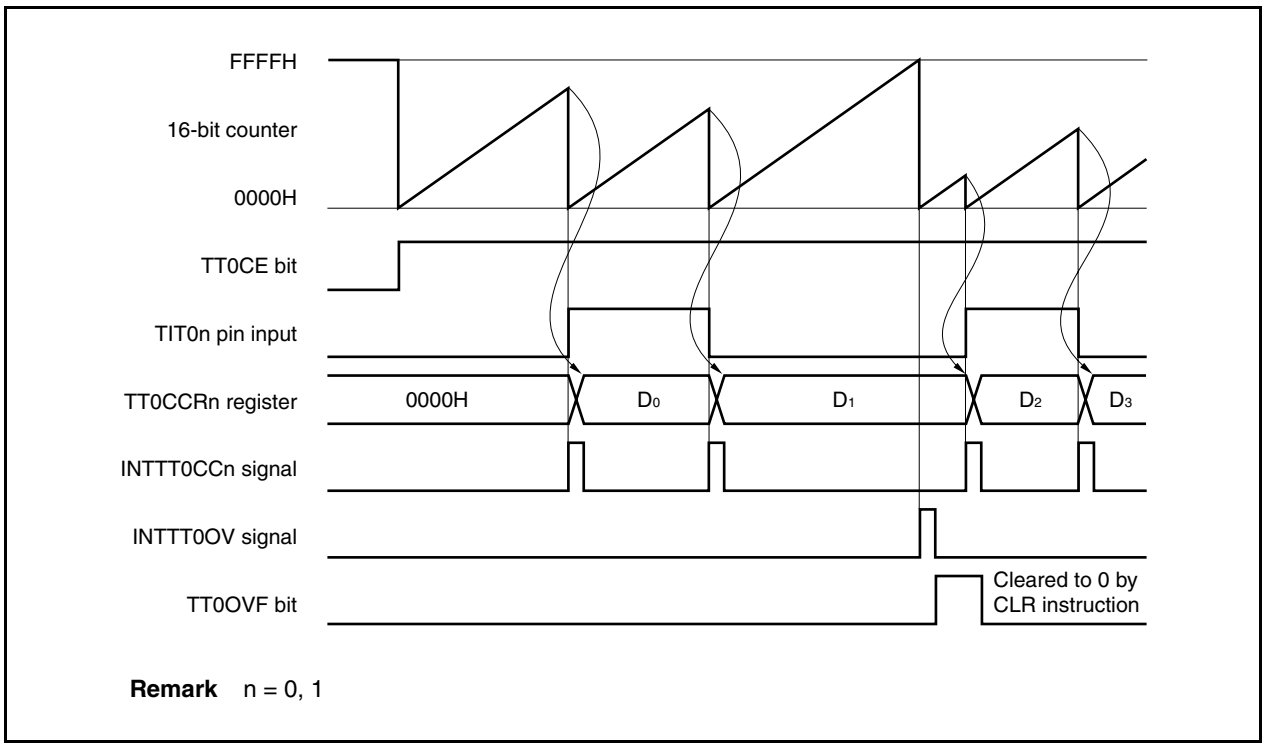


Notes 1. Set by the TT0IOC2.TT0EES1 and TT0IOC2.TT0EES0 bits.

2. Set by the TT0IOC1.TT0IS1 and TT0IOC1.TT0IS0 bits.

3. Set by the TT0IOC1.TT0IS3 and TT0IOC1.TT0IS2 bits.

Figure 9-40. Basic Timing in Pulse Width Measurement Mode



Remark n = 0, 1

When the TT0CE bit is set to 1, the 16-bit counter starts counting. When the valid edge input to the TIT0n pin is later detected, the count value of the 16-bit counter is stored in the TT0CCRn register, the 16-bit counter is cleared to 0000H, and a capture interrupt request signal (INTTT0CCn) is generated.

The pulse width is calculated as follows.

Pulse width = Captured value × Count clock cycle

If the valid edge is not input to the TIT0n pin even when the 16-bit counter counted up to FFFFH, an overflow interrupt request signal (INTTT0OV) is generated at the next count clock, and the counter is cleared to 0000H and continues counting. At this time, the overflow flag (TT0OPT0.TT0OVF bit) is also set to 1. Clear the overflow flag to 0 by executing the CLR instruction via software.

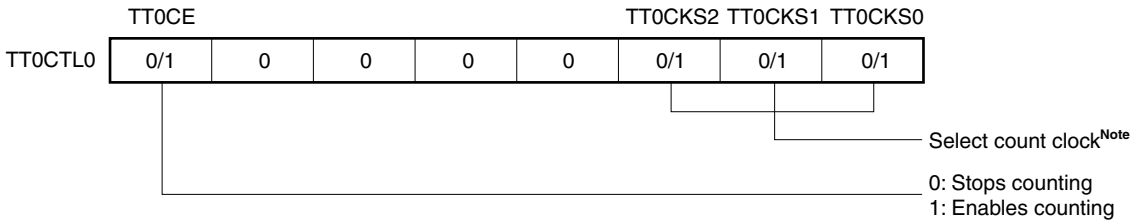
If the overflow flag is set to 1, the pulse width can be calculated as follows.

Pulse width = (10000H × TT0OVF bit set (1) count + Captured value) × Count clock cycle

Remark n = 0, 1

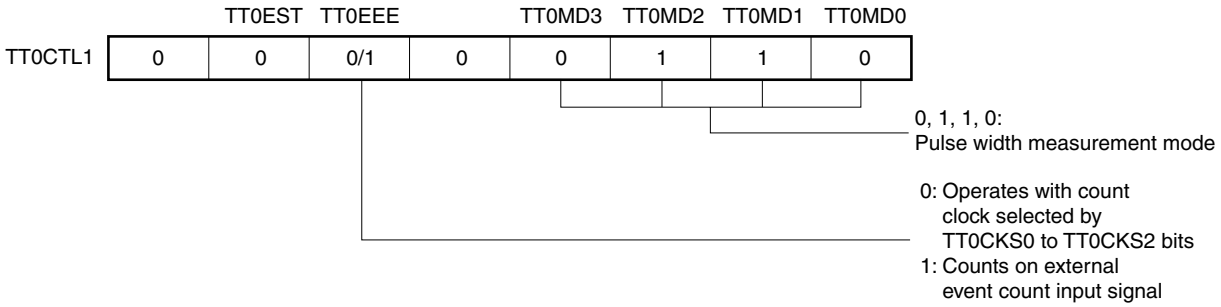
Figure 9-41. Register Setting in Pulse Width Measurement Mode (1/2)

(a) TMT0 control register 0 (TT0CTL0)

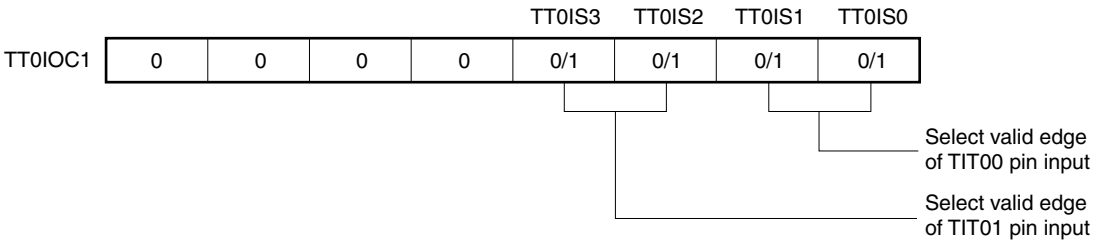


Note Setting is invalid when the TT0CTL1.TT0EEE bit = 1.

(b) TMT0 control register 1 (TT0CTL1)



(c) TMT0 I/O control register 1 (TT0IOC1)



(d) TMT0 I/O control register 2 (TT0IOC2)

Figure 9-41. Register Setting in Pulse Width Measurement Mode (2/2)

(e) TMT0 option register 0 (TT0OPT0)

			TT0CCS1	TT0CCS0				TT0OVF
TT0OPT0	0	0	0	0	0	0	0	0/1

Overflow flag

(f) TMT0 counter read buffer register (TT0CNT)

The value of the 16-bit counter can be read by reading the TT0CNT register.

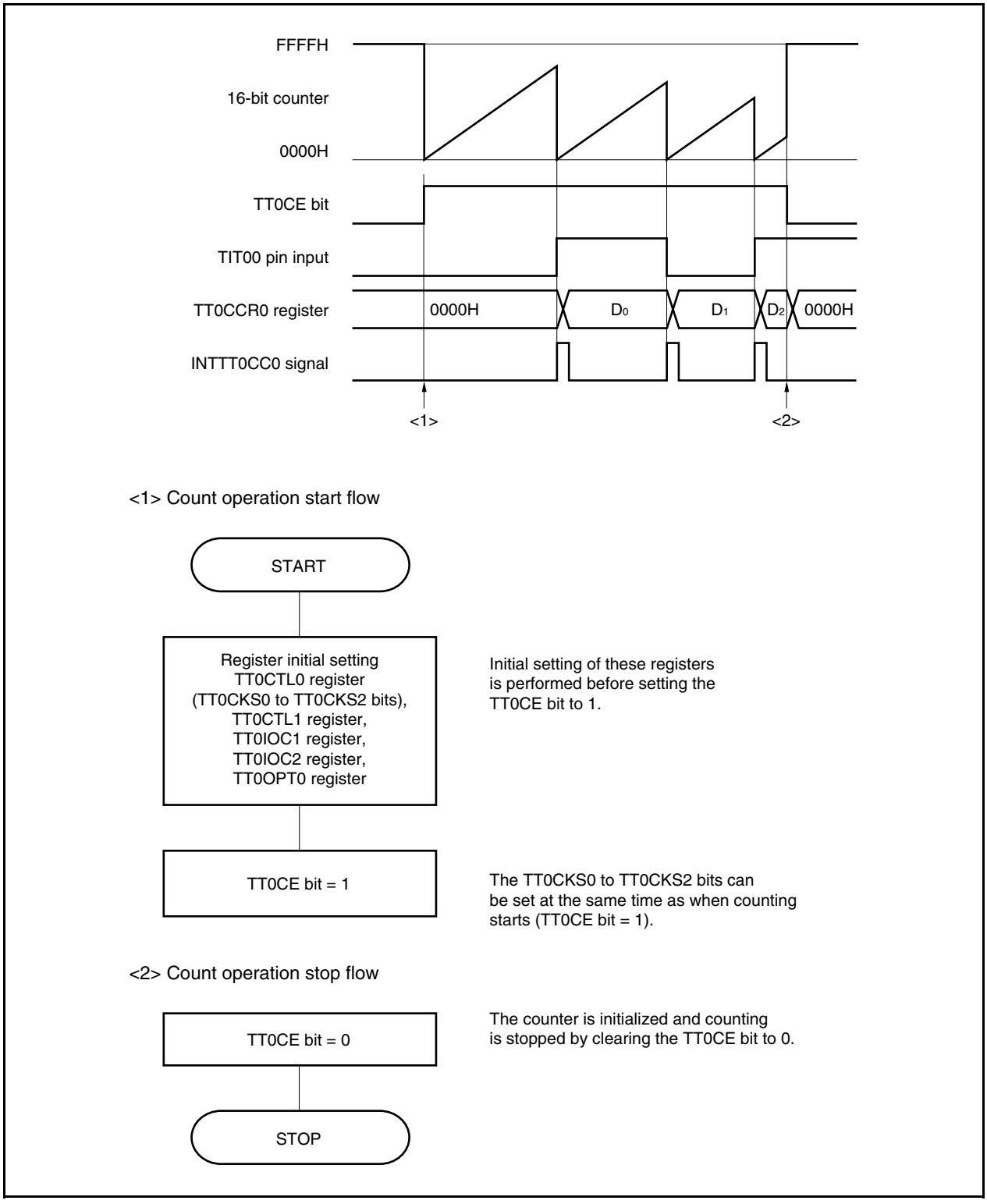
(g) TMT0 capture/compare registers 0 and 1 (TT0CCR0 and TT0CCR1)

These registers store the count value of the 16-bit counter when the valid edge input to the TIT00 and TIT01 pins is detected.

Remark TMT0 control register 2 (TT0CTL2), TMT0 I/O control register 0 (TT0IOC0), TMT0 I/O control register 3 (TT0IOC3), TMT0 option register 1 (TT0OPT1), and TMT0 counter write register (TT0TCW) are not used in the pulse width measurement mode.

(1) Operation flow in pulse width measurement mode

Figure 9-42. Software Processing Flow in Pulse Width Measurement Mode



(2) Operation timing in pulse width measurement mode

(a) Clearing overflow flag

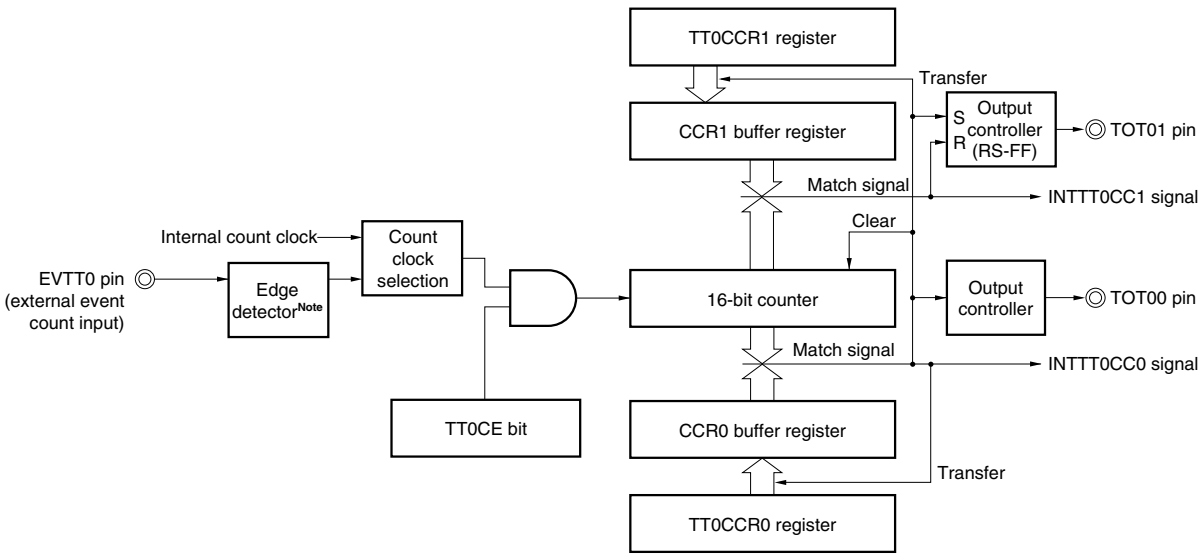
The overflow flag can be cleared to 0 by clearing the TT0OVF bit to 0 with the CLR instruction after reading the TT0OVF bit when it is 1 and by writing 8-bit data (bit 0 is 0) to the TT0OPT0 register after reading the TT0OVF bit when it is 1.

9.6.8 Triangular-wave PWM output mode (TT0MD3 to TT0MD0 bits = 0111)

In the triangular-wave PWM output mode, a triangular-wave PWM waveform is output from the TOT01 pin when the TT0CTL0.TT0CE bit is set to 1.

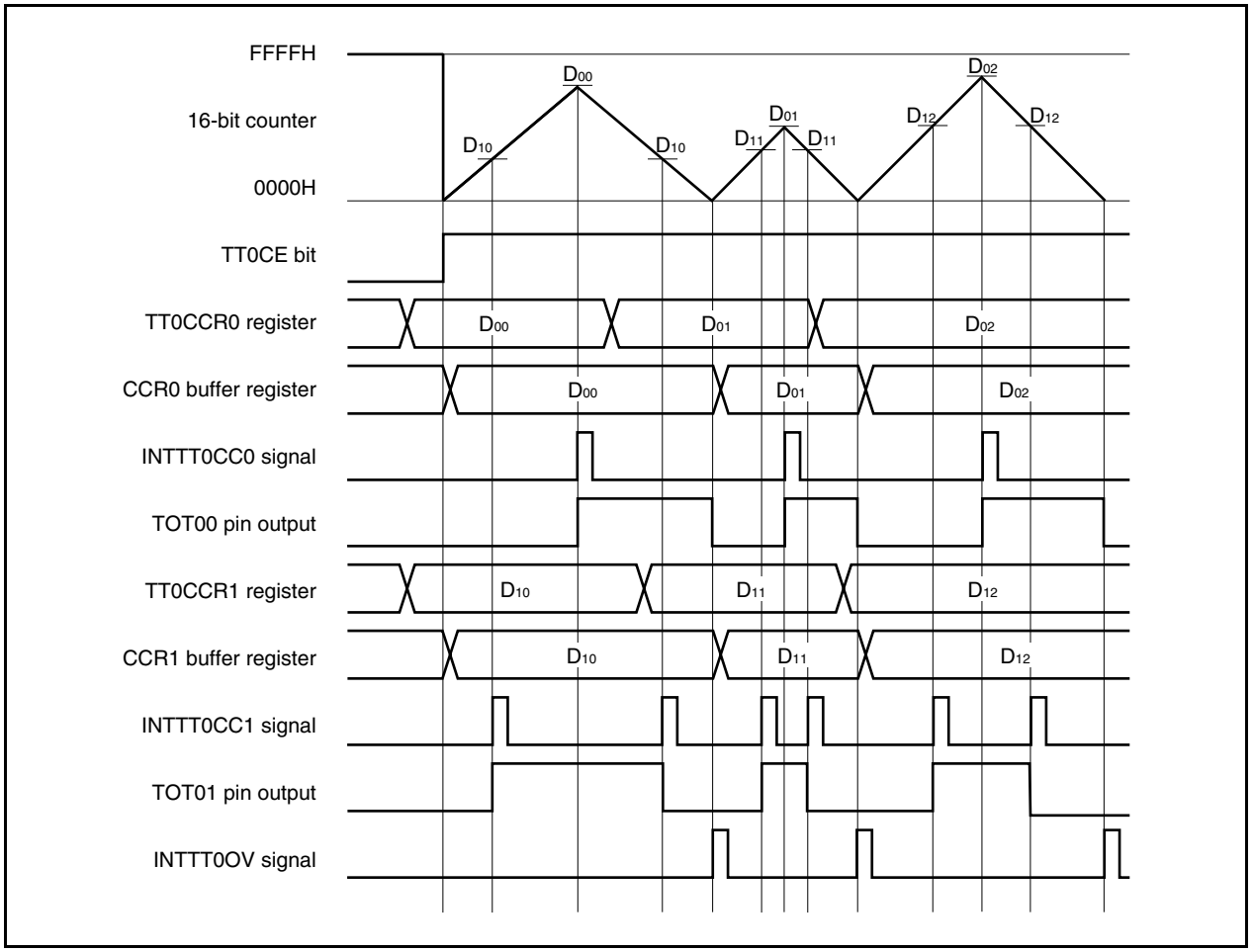
A PWM waveform that is inverted when the count value of the 16-bit counter matches the value of the CCR0 buffer register and when the 16-bit counter is set to 0000H is output from the TOT00 pin.

Figure 9-43. Configuration in Triangular-Wave PWM Output Mode



Note Set by the TT0IOC2.TT0EES1 and TT0IOC2.TT0EES0 bits.

Figure 9-44. Basic Timing in Triangular-Wave PWM Output Mode



The 16-bit counter is cleared from FFFFH and 0000H and starts counting when the TT0CE bit is set to 1. The triangular PWM waveform is output from the TOT01 pin.

In the triangular-wave PWM output mode, the counter counts up or down. When the 16-bit counter reaches 0000H while it is counting down, an overflow interrupt request signal (INTTT0OV) is generated. At this time, the TT0OPT0.TT0OVF bit is not set to 1. If the count value of the 16-bit counter matches the value of the CCR0 buffer register while the counter is counting up, a compare match interrupt request signal (INTTT0CC0) is generated.

The counting direction is changed from up to down when the value of the 16-bit counter matches that of the CCR0 buffer register, and from down to up when the counter is cleared to 0000H.

The PWM waveform can be changed by rewriting the TT0CCRn register during operation. To change the PWM waveform during operation, write the TT0CCR1 register last.

The cycle of the triangular PWM waveform is set by the TT0CCR0 register and its duty factor is set by the TT0CCR1 register. Set a value to the TT0CCR0 register in a range of "0 ≤ TT0CCR0 ≤ FFFEH". The rewritten value is reflected when the 16-bit counter reaches 0000H while it is counting down.

Even when changing only the cycle of the PWM waveform, first set a period to the TT0CCR0 register, and then write the same value (value same as that set to the TT0CCR1 register) to the TT0CCR1 register.

To transfer data from the TT0CCRn register to the CCRn buffer register, the data must be written to the TT0CCR1 register (n = 0, 1).

9.6.9 Encoder count function

The encoder count function includes an encoder compare mode (see **9.6.10 Encoder compare mode (TT0MD3 to TT0MD0 bits = 1000)**).

Mode	TT0CCR0 Register	TT0CCR1 Register
Encoder compare mode	Compare only	Compare only

(1) Count-up/-down control

Counting up or down by the 16-bit counter is controlled by the phase of input encoder signals (TENC00 and TENC01) and settings of the TT0CTL2.TT0UDS1 and TT0CTL2.TT0UDS0 bits.

When the encoder count function is used, the internal count clock and external event count input (EVTT0) cannot be used. Set the TT0CTL0.TT0CKS2 to TT0CTL0.TT0CKS0 bits to 000 and the TT0CTL1.TT0EEE bit to 0.

(2) Setting initial value of 16-bit counter

The initial count value set to the TT0TCW register when the TT0CTL2.TT0ECC bit = 0 is transferred to the 16-bit counter immediately after the counter starts its operation (TT0CTL0.TT0CE bit = 0 → 1), and the counter starts the operation after it detects the valid edge of the encoder input signal (TENC00 or TENC01).

(3) Basic operation

The TT0CCRn register generates a compare match interrupt request signal (INTTT0CCn) when the count value of the 16-bit counter matches the value of the CCRn buffer register.

(4) Clear operation

The 16-bit counter is cleared when the following conditions are satisfied in the encoder compare mode.

- When the value of the 16-bit counter matches the value of the compare register (the TT0CTL2.TT0ECM1 and TT0CTL2.TT0ECM0 bits are set)
- When the edge of the encoder clear input signal (TECR0) is detected (the TT0ECS1 and TT0ECS0 bits are set when the TT0IOC3.TT0SCE bit = 0)
- When the clear level condition of the TENC00, TENC01, and TECR0 pins is detected (the TT0ZCL, TT0BCL, and TT0ACL bits are set when the TT0SCE bit = 1)

Remark n = 0, 1

(5) Controlling bits of TT0CTL2 register

The setting of the TT0CTL2 register in the encoder compare mode is shown below.

Table 9-8. Setting of TT0CTL2 Register

Mode	TT0UDS1, TT0UDS0 Bits (<1>)	TT0ECM1 Bit (<2>)	TT0ECM0 Bit (<2>)	TT0LDE Bit (<3>)	Counter Clear (Target Compare Register)	Transfer to Counter
Encoder compare mode	Can be set to 00, 01, 10, or 11.	0	0	0	–	–
				1		Possible
			1	0	TT0CCR0	–
				1		Possible[Note]
		1	0	Invalid	TT0CCR1	–
			1	Invalid	TT0CCR0, TT0CCR1	–

Note The counter can operate in a range from 0000H to the set value of the TT0CCR0 register.

(a) Outline of each bit

<1> The TT0UDS1 and TT0UDS0 bits identify the counting direction (up or down) of the 16-bit counter by the phase input from the encoder input pin (TENC00 or TENC01).

<2> The TT0ECM1 and TT0ECM0 bits control clearing of the 16-bit counter when its count value matches the value of the CCR0 or CCR1 buffer register.

<3> The TT0LDE bit controls a function to transfer the set value of the TT0CCR0 register to the 16-bit counter when the counter underflows. The TT0LDE bit is valid only when the TT0ECM1 and TT0ECM0 bits are 00 and 01, respectively. It is invalid when these bits are set to any other values.

(b) Detailed explanation of each bit

<1> TT0UDS1 and TT0UDS0 bits: Count-up/-down selection

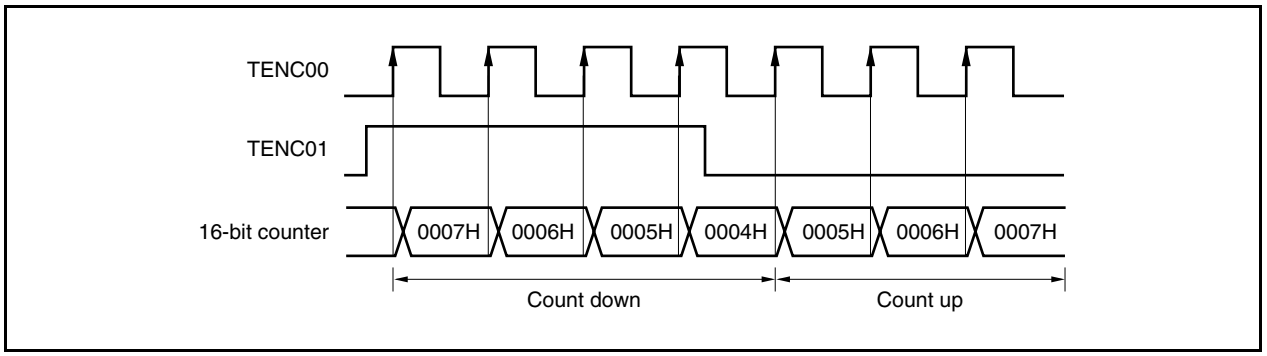
Whether the 16-bit counter is counting up or down is identified by the phase input from the TENC00 or TENC01 pin and depending on the settings of the TT0UDS1 and TT0UDS0 bits. These bits are valid only in the encoder compare mode.

- When TT0UDS1 and TT0UDS0 bits = 00

TENC00 Pin	TENC01 Pin	Count Operation
Rising edge	High level	Count down
Falling edge		
Both edges		
Rising edge	Low level	Count up
Falling edge		
Both edges		

Remark Detecting the edge of the TENC00 pin is specified by the TT0IOC3.TT0EIS1 and TT0EIS0 bits.

Figure 9-45. Operation Example (When Valid Edge of TENC00 Pin Is Specified to Be Rising Edge and No Edge Is Specified as Valid Edge of TENC01 Pin)

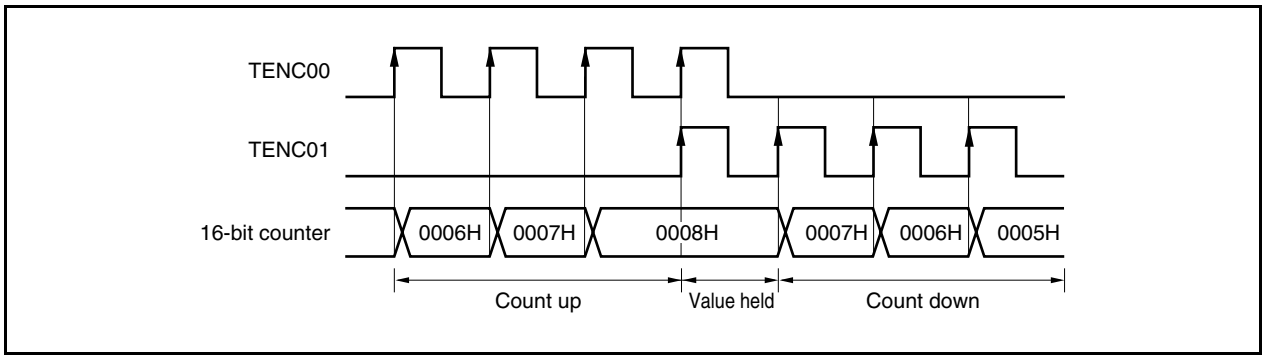


- When TT0UDS1 and TT0UDS0 bits = 01

TENC00 Pin	TENC01 Pin	Count Operation
Low level	Rising edge	Count down
	Falling edge	
	Both edges	
High level	Rising edge	
	Falling edge	
	Both edges	
Rising edge	High level	Count up
Falling edge		
Both edges		
Rising edge	Low level	
Falling edge		
Both edges		
Simultaneous input to TENC00 and TENC01 pins		Counter does not perform count operation but holds value immediately before.

Remark Detecting the edges of the TENC00 and TENC01 pins is specified by the TT0IOC3.TT0EIS1 and TT0IOC3.TT0EIS0 bits.

Figure 9-46. Operation Example (When Rising Edge Is Specified as Valid Edges of TENC00 and TENC01 Pins)



- When TT0UDS1 and TT0UDS0 bits = 10

TENC00 Pin	TENC01 Pin	Count Operation
Low level	Falling edge	Counter does not perform count operation but holds value immediately before.
Rising edge	Low level	Count down
High level	Rising edge	Counter does not perform count operation but holds value immediately before.
Falling edge	High level	
Rising edge		
High level	Falling edge	
Falling edge	Low level	Count up
Low level	Rising edge	Counter does not perform count operation but holds value immediately before.
Rising edge		
Falling edge		
Rising edge	Falling edge	Count down
Falling edge		Count up

Caution Specification of the valid edges of the TENC00 and TENC01 pins is invalid.

Figure 9-47. Operation Example (Count Operation When Valid Edges of TENC00 and TENC01 Pins do not Overlap)

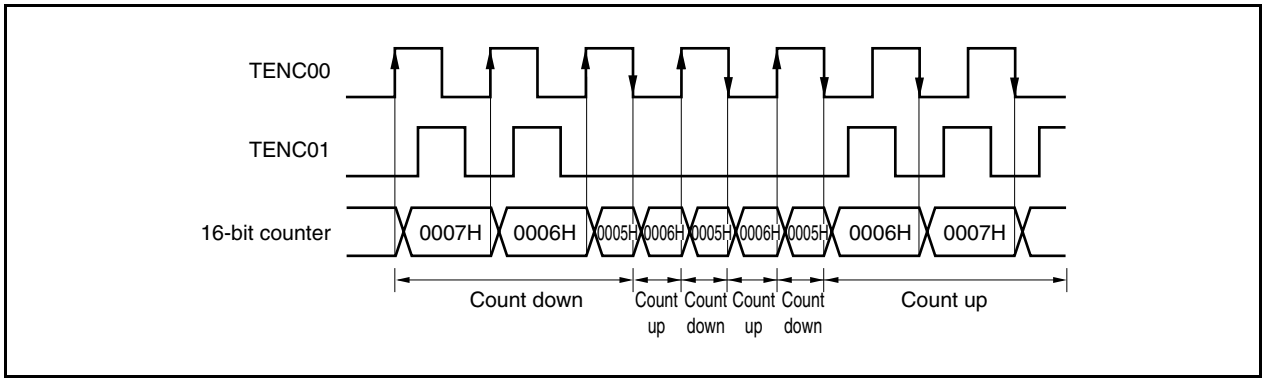
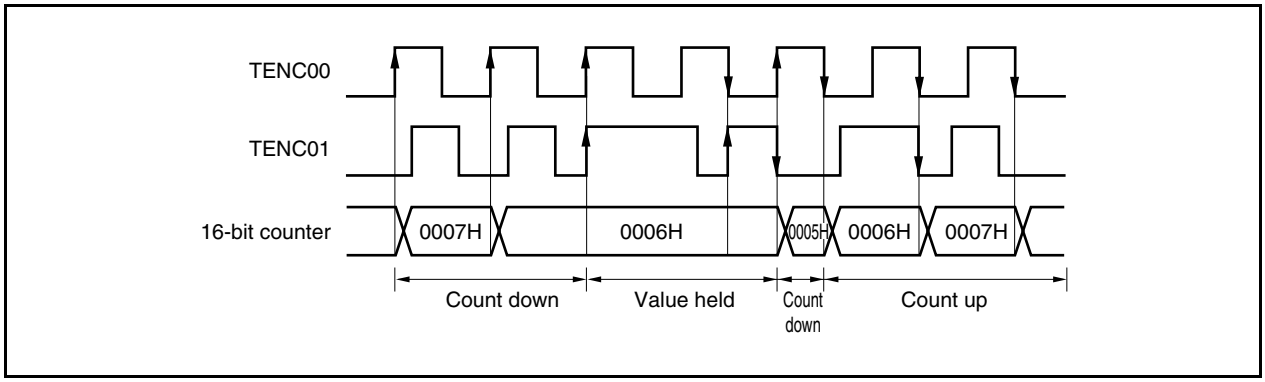


Figure 9-48. Operation Example (Count Operation When Valid Edges of TENC00 and TENC01 Pins Overlap)



- When TT0UDS1 and TT0UDS0 bits = 11

TENC00 Pin	TENC01 Pin	Count Operation
Low level	Falling edge	Count down
Rising edge	Low level	
High level	Rising edge	
Falling edge	High level	
Rising edge		Count up
High level	Falling edge	
Falling edge	Low level	
Low level	Rising edge	
Simultaneous input to TENC00 and TENC01 pins		Counter does not perform count operation but holds value immediately before.

Caution Specification of the valid edges of the TENC00 and TENC01 pins is invalid.

Figure 9-49. Operation Example (Count Operation When Valid Edges of TENC00 and TENC01 Pins do not Overlap)

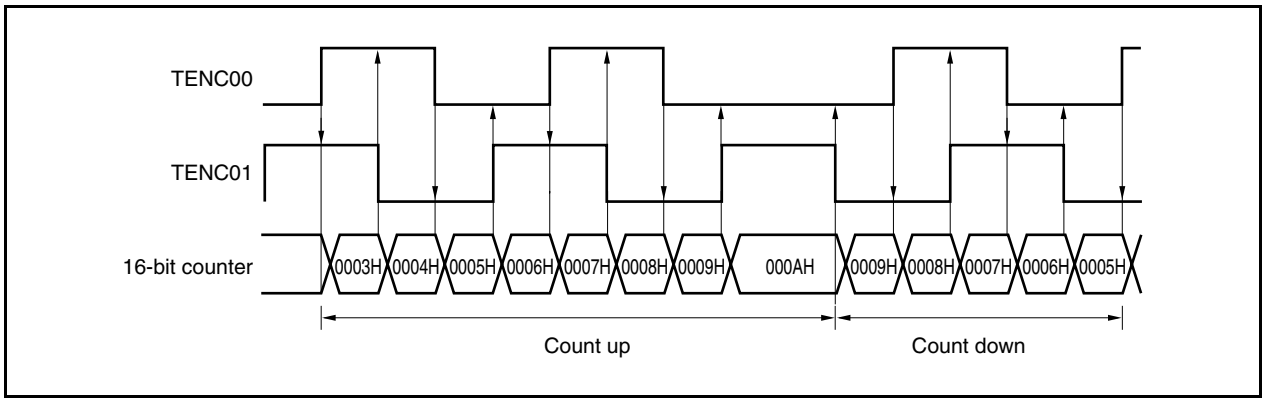
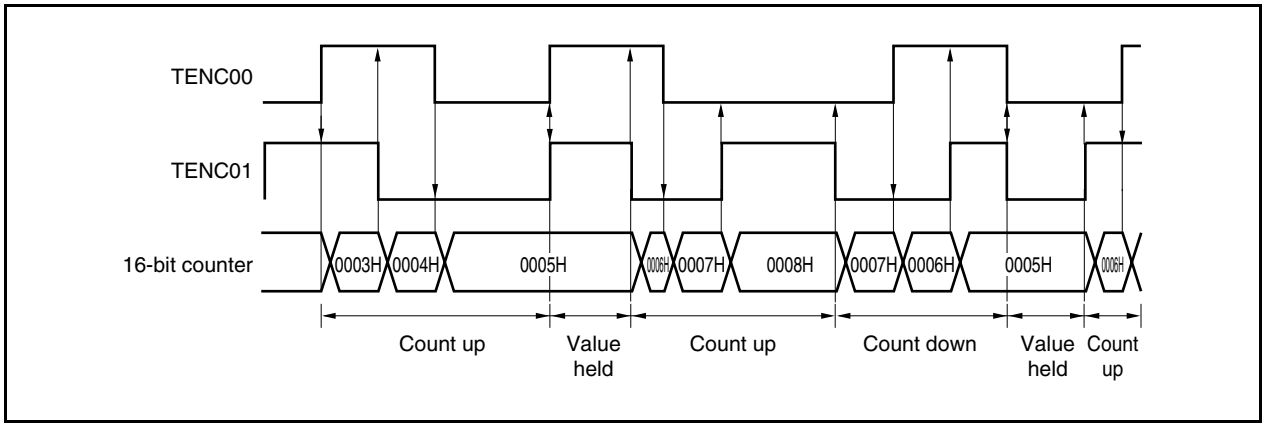


Figure 9-50. Operation Example (Count Operation When Valid Edges of TENC00 and TENC01 Pins Overlap)



<2> TT0ECM1 and TT0ECM0 bits: Timer/counter clear function upon match of the compare register

The 16-bit counter performs its count operation in accordance with the set value of the TT0ECM1 and TT0ECM0 bits when the count value of the counter matches the value of the CCRn buffer register.

- When TT0ECM1 and TT0ECM0 bits = 00

  The 16-bit counter is not cleared when its count value matches the value of the CCRn buffer register.

- When TT0ECM1 and TT0ECM0 bits = 01

  The 16-bit counter performs a count operation under the following condition when its count value matches the value of the CCR0 buffer register.

Next Count Operation	Description
Count up	16-bit counter is cleared to 0000H.
Count down	Count value of 16-bit counter is counted down.

- When TT0ECM1 and TT0ECM0 bits = 10

  The 16-bit counter performs a count operation under the following condition when its count value matches the value of the CCR1 buffer register.

Next Count Operation	Description
Count up	Count value of 16-bit counter is counted up.
Count down	16-bit counter is cleared to 0000H.

- When TT0ECM1 and TT0ECM0 bits = 11

  The 16-bit counter performs a count operation under the following condition when its count value matches the value of the CCR0 buffer register.

Next Count Operation	Description
Count up	16-bit counter is cleared to 0000H.
Count down	Count value of 16-bit counter is counted down.

  The 16-bit counter performs a count operation under the following condition when its count value matches the value of the CCR1 buffer register.

Next Count Operation	Description
Count up	Count value of 16-bit counter is counted up.
Count down	16-bit counter is cleared to 0000H.

<3> TT0LDE bit: Transfer function of the set value of the TT0CCR0 register to the 16-bit counter when the counter underflows

When the TT0LDE bit = 1, the set value of the TT0CCR0 register can be transferred to the 16-bit counter when the counter underflows.

The TT0LDE bit is valid only in the encoder compare mode.

- Count operation in range from 0000H to set value of the TT0CCR0 register

  If the 16-bit counter performs a count operation when the TT0LDE bit = 1 and TT0ECM1 and TT0ECM0 bits = 01, and when the count value of the counter matches the set value of the CCR0 buffer register when the TT0ECM0 bit = 1, the 16-bit counter is cleared to 0000H if the next count operation is counting up.

  If the 16-bit counter underflows when the TT0LDE bit = 1, the set value of the TT0CCR0 register is transferred to the counter.

  Therefore, the counter can operate in a range from 0000H to the set value of the TT0CCR0 register in which the upper-limit count value is the set value of the TT0CCR0 register and the lower-limit value is 0000H.

Figure 9-51. Operation Example (Count Operation in Range from 0000H to Set Value of TT0CCR0 Register)

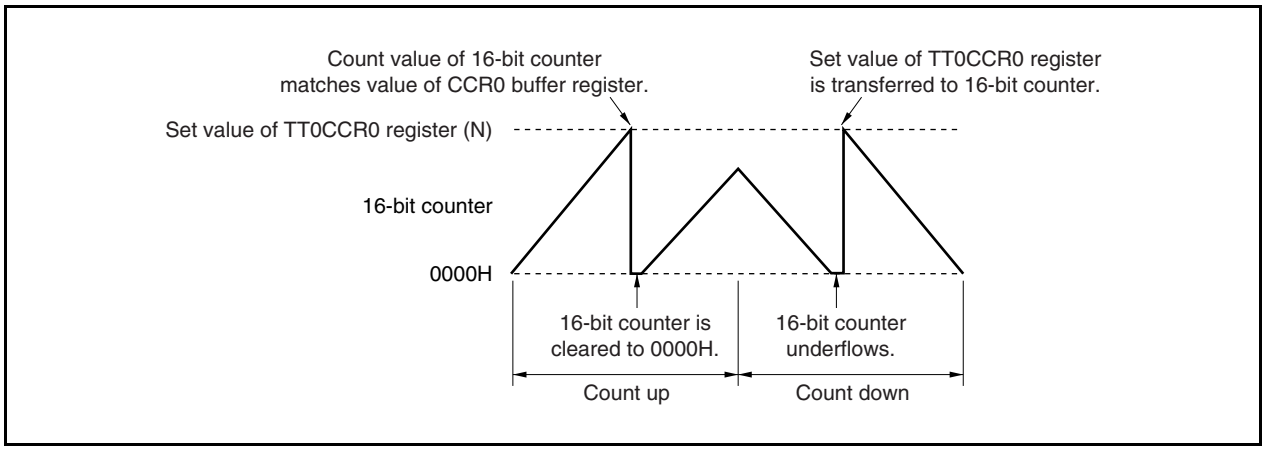
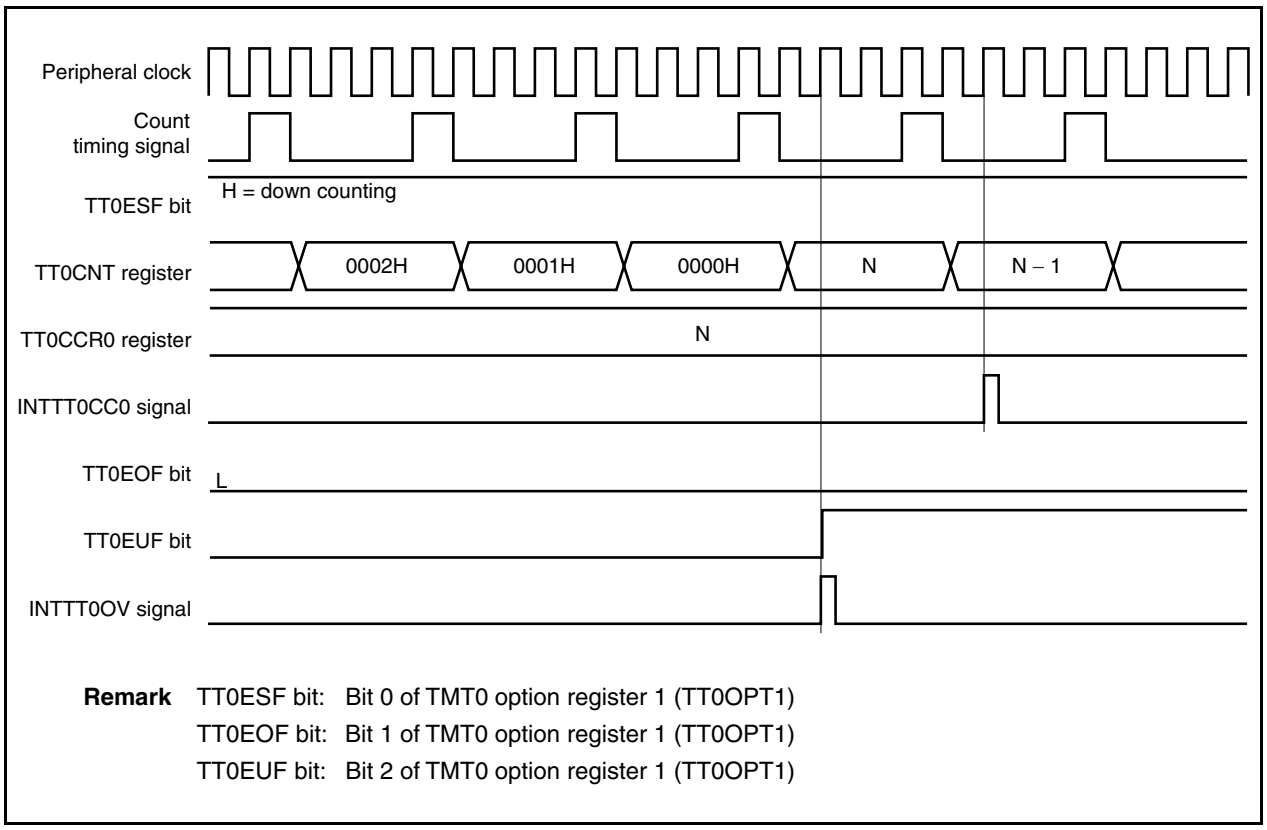


Figure 9-52. Operation Timing (Count Operation in Range from 0000H to Set Value of TT0CCR0 Register)



Remark TT0ESF bit: Bit 0 of TMT0 option register 1 (TT0OPT1)
TT0EOF bit: Bit 1 of TMT0 option register 1 (TT0OPT1)
TT0EUF bit: Bit 2 of TMT0 option register 1 (TT0OPT1)

(6) Function to clear counter to 0000H by encoder clear signal (TECR0 pin)

The 16-bit counter can be cleared to 0000H by the input signal of the TECR0 pin in two ways which are selected by the TT0IOC3.TT0SCE bit. The TT0SCE bit also controls, depending on its setting, the TT0IOC3.TT0ZCL, TT0IOC3.TT0BCL, TT0IOC3.TT0ACL, TT0IOC3.TT0ESC1, and TT0IOC3.TT0ECS0 bits.

The counter can be cleared by the methods described below only in the encoder compare mode.

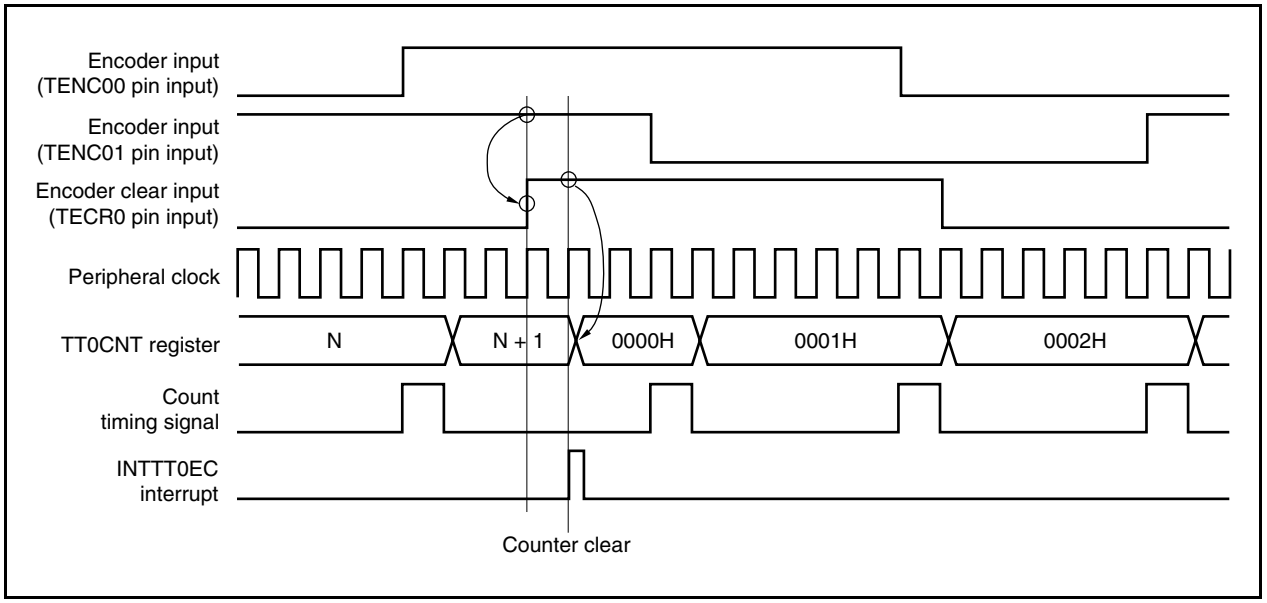
Table 9-9. Relationship Between TT0SCE Bit and TT0ZCL, TT0BCL, TT0ACL, TT0ECS1, and TT0ECS0 Bits

Clearing Method	TT0SCE Bit	TT0ZCL Bit	TT0BCL Bit	TT0ACL Bit	TT0ECS1, TT0ECS0 Bits
<1>	0	Invalid	Invalid	Invalid	Valid
<2>	1	Valid	Valid	Valid	Invalid

(a) Clearing method <1>: By detecting edge of encoder clear signal (TECR0 pin) (TT0SCE bit = 0)

When the TT0SCE bit = 0, the 16-bit counter is cleared to 0000H in synchronization with the peripheral clock if the valid edge of the TECR0 pin specified by the TT0ECS1 and TT0ECS0 bits is detected. At this time, an encoder clear interrupt request signal (INTTT0EC) is generated. When the TT0SCE bit = 0, the settings of the TT0ZCL, TT0BCL, and TT0ACL bits is invalid.

Figure 9-53. Operation Example (When TT0SCE Bit = 0, TT0ECS1 and TT0ECS0 Bits = 01, and TT0UDS1 and TT0UDS0 Bits = 11)



(b) Clearing method <2>: By detecting clear level condition of the TENC00, TENC01, and TECR0 pins (TT0SCE bit = 1)

When the TT0SCE bit = 1, the 16-bit counter is cleared to 0000H if the clear level condition of the TECR0, TENC00, or TENC01 pin specified by the TT0ZCL, TT0BCL, and TT0ACL bits is detected. At this time, the encoder clear interrupt request signal (INTTT0EC) is not generated. The settings of the TT0ECS1 and TT0ECS0 bits is invalid when the TT0SCE bit = 1.

Table 9-10. 16-bit Counter Clearing Condition When TT0SCE Bit = 1

Clear Level Condition Setting			Input Level of Encoder Pin		
TT0ZCL Bit	TT0BCL Bit	TT0ACL Bit	TECR0 Pin	TENC01 Pin	TENC00 Pin
0	0	0	L	L	L
0	0	1	L	L	H
0	1	0	L	H	L
0	1	1	L	H	H
1	0	0	H	L	L
1	0	1	H	L	H
1	1	0	H	H	L
1	1	1	H	H	H

Caution The 16-bit counter is cleared to 0000H when the clear level condition of the TT0ZCL, TT0BCL, and TT0ACL bits match the input level of the TECR0, TENC01, or TENC00 pin.

Figure 9-54. Operation Example (When TT0SCE Bit = 1, TT0ZCL Bit = 1, TT0BCL Bit = 0, TT0ACL Bit = 1, TT0UDS1 and TT0UDS0 Bits = 11, TECR0 = High Level, TENC01 = Low Level, and TENC00 = High Level) (1/3)

(i) If inputting the high level to the TECR0 pin lags behind inputting the low level to the TENC01 pin while the counter is counting up, the counter is cleared after it counts up.

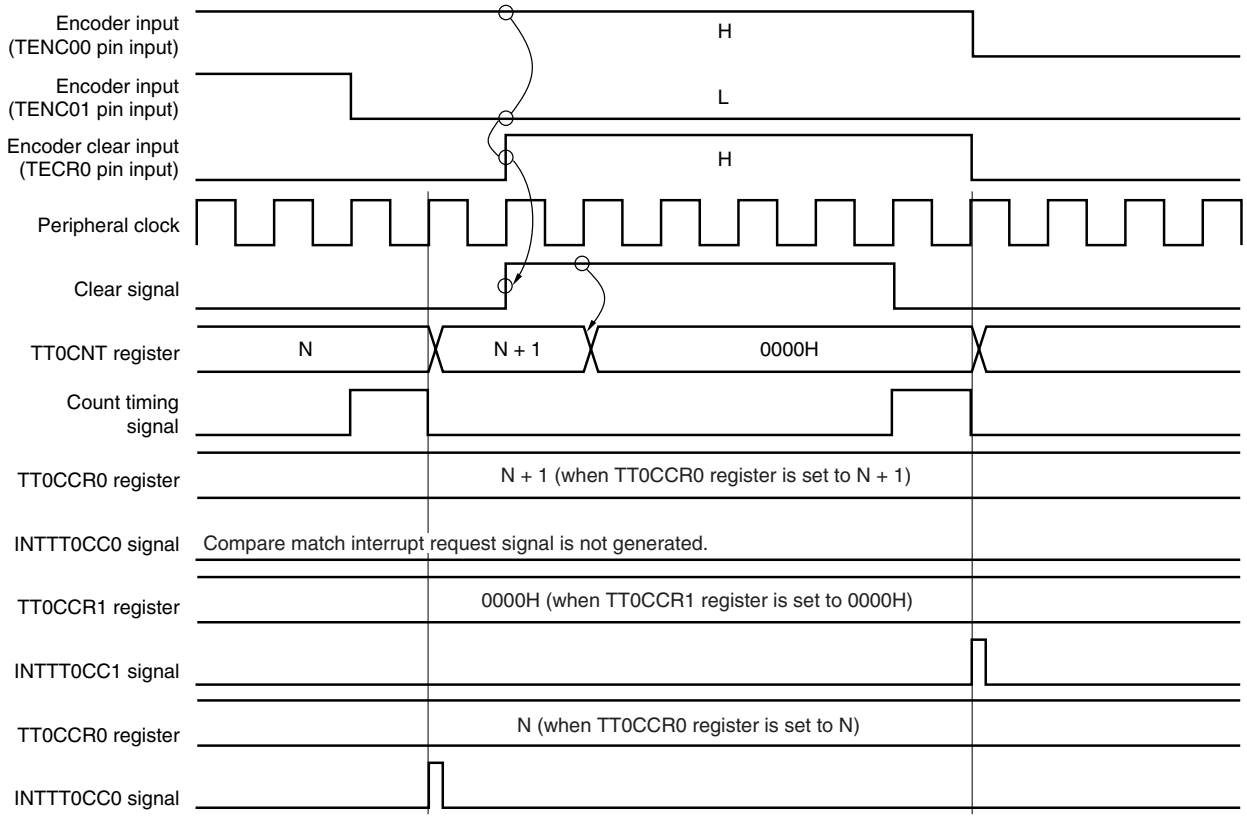
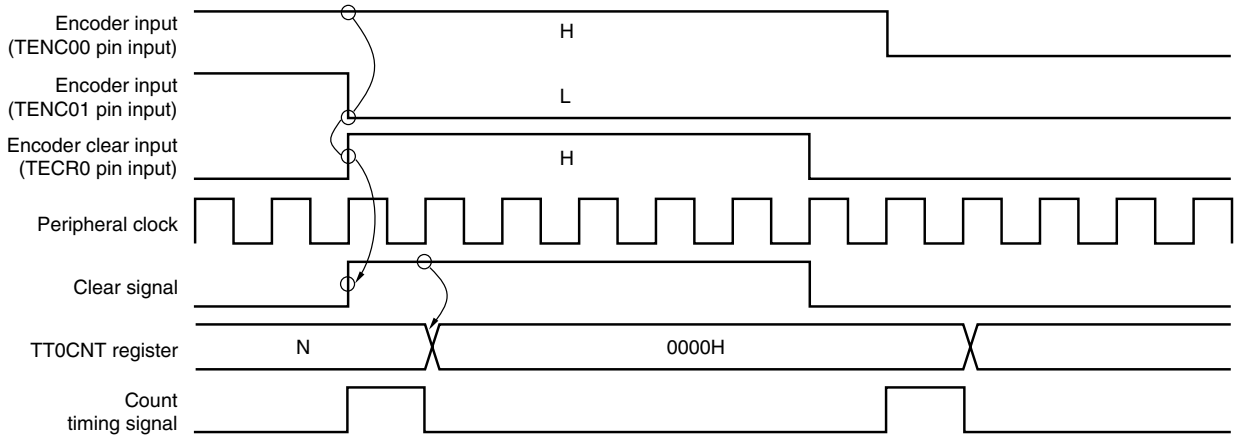


Figure 9-54. Operation Example (When TT0SCE Bit = 1, TT0ZCL Bit = 1, TT0BCL Bit = 0, TT0ACL Bit = 1, TT0UDS1 and TT0UDS0 Bits = 11, TECR0 = High Level, TENC01 = Low Level, and TENC00 = High Level) (2/3)

(ii) If the high level is input to the TECR0 pin at the same time as the low level is input to the TECN01 pin while the counter is counting up, the counter is cleared without counting up.



(iii) If the high level is input to the TECR0 pin earlier than the low level is input to the TENC01 pin while the counter is counting up, the counter is cleared without counting up.

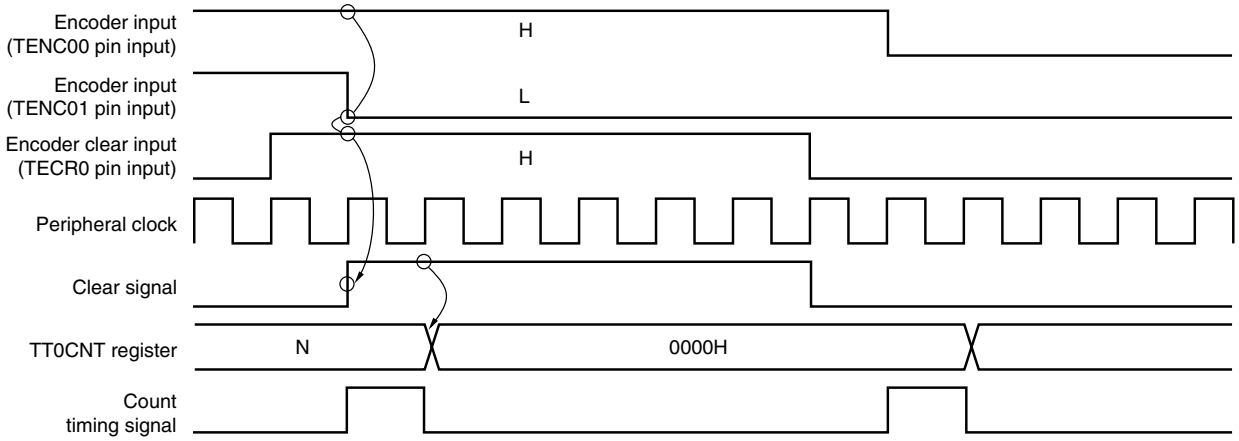
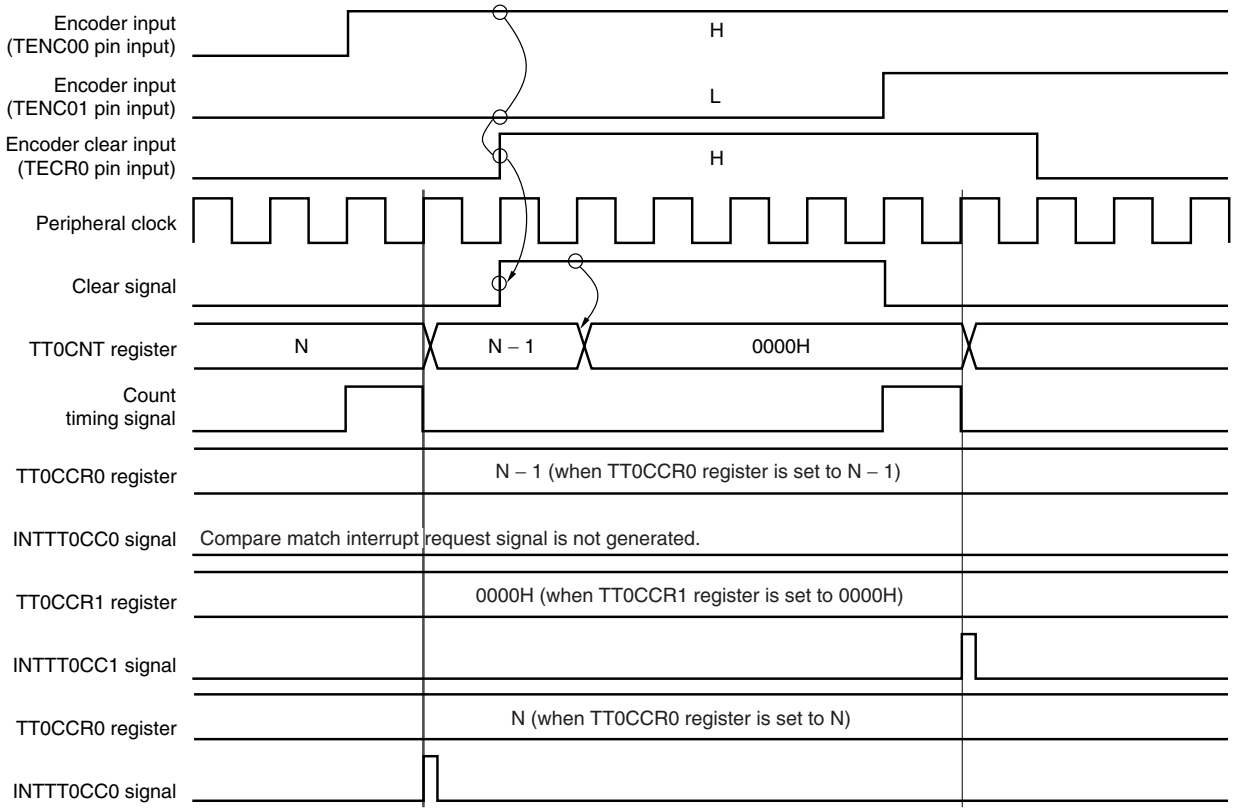


Figure 9-54. Operation Example (When TT0SCE Bit = 1, TT0ZCL Bit = 1, TT0BCL Bit = 0, TT0ACL Bit = 1, TT0UDS1 and TT0UDS0 Bits = 11, TECR0 = High Level, TENC01 = Low Level, and TENC00 = High Level) (3/3)

(iv) If the high level is input to the TECR0 pin later than the low level is input to the TENC01 pin while the counter is counting up, the counter is cleared after it counts up.

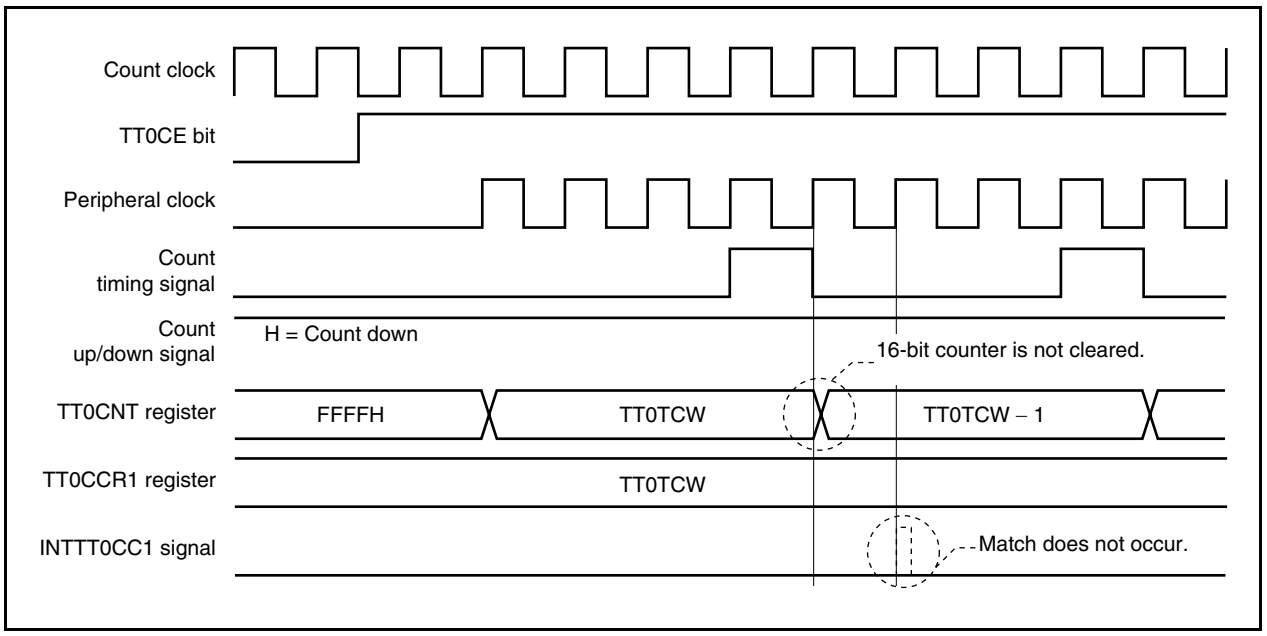


If the counter is cleared in this way, a miscount does not occur even if inputting the signal to the TECR0 pin is late, because the clear level condition of the TECR0, TENC01, and TENC00 pins is set and the 16-bit counter is cleared to 0000H when the clear level condition is detected.

(7) Notes on using encoder count function

(a) If compare match interrupt is not generated immediately after operation is started

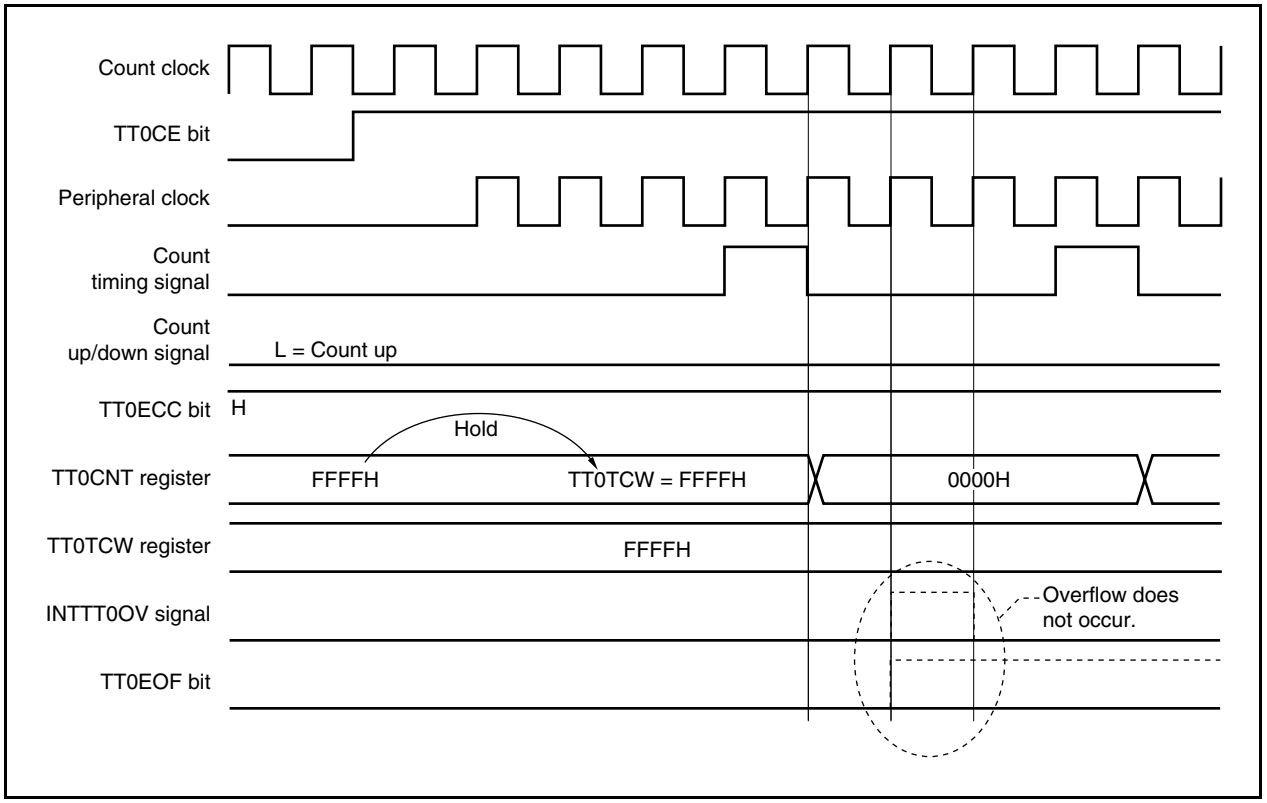
If a value which is the same as that of the TT0TCW register is set to the TT0CCR0 or TT0CCR1 register and the counter operation is started when the TT0CTL2.TT0ECC bit = 0, and if the count value (TT0TCW) of the 16-bit counter matches the value of the CCRn buffer register immediately after the start of the operation, the match is masked and the compare match interrupt request signal (INTTT0CCn) is not generated (n = 0, 1). In addition, the 16-bit counter is not cleared to 0000H by setting the TT0CTL2.TT0ECM1 and TT0CTL2.TT0ECM0 bits.



(b) If overflow does not occur immediately after start of operation

If the count operation is resumed when the TT0CTL2.TT0ECC bit = 1, the 16-bit counter does not overflow if its count value that has been held is FFFFH and if the next count operation is counting up.

After the counter starts operating and counts up from a count value (value of TT0TCW register = FFFFH), the counter overflows from FFFFH to 0000H. However, detection of the overflow is masked, the overflow flag (TT0EOF) is not set, and the overflow interrupt request signal (INTTT0OV) is not generated.



9.6.10 Encoder compare mode (TT0MD3 to TT0MD0 bits = 1000)

In the encoder compare mode, the encoder is controlled by using both the TT0CCR0 and TT0CCR1 registers as compare registers and the input pins for encoder count function (TENC00, TENC01, and TECR0).

In this mode, the 16-bit counter can be cleared to 0000H in three ways: when the count value of the counter matches the value of the CCRn buffer register (compare match interrupt request signal (INTTT0CCn) is generated), when the edge of the encoder clear input (TECR0 pin) is detected, and when the clear level condition of TENC00, TENC01, and TECR0 pins is detected.

When the 16-bit counter underflows, the set value of the TT0CCR0 register can be transferred to the counter.

(1) Encoder compare mode operation flow

Figure 9-55. Encoder Compare Mode Operation Flow

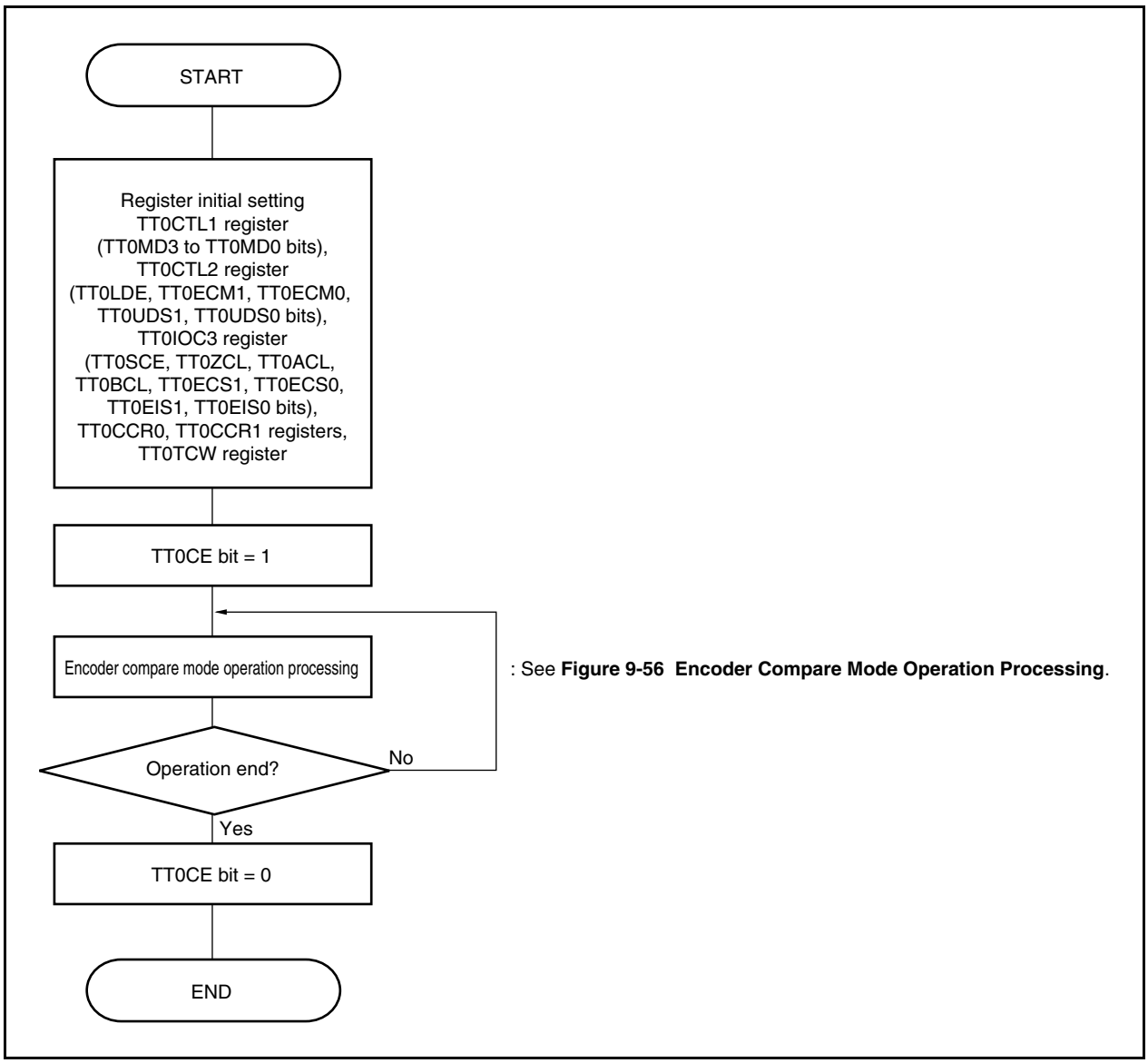
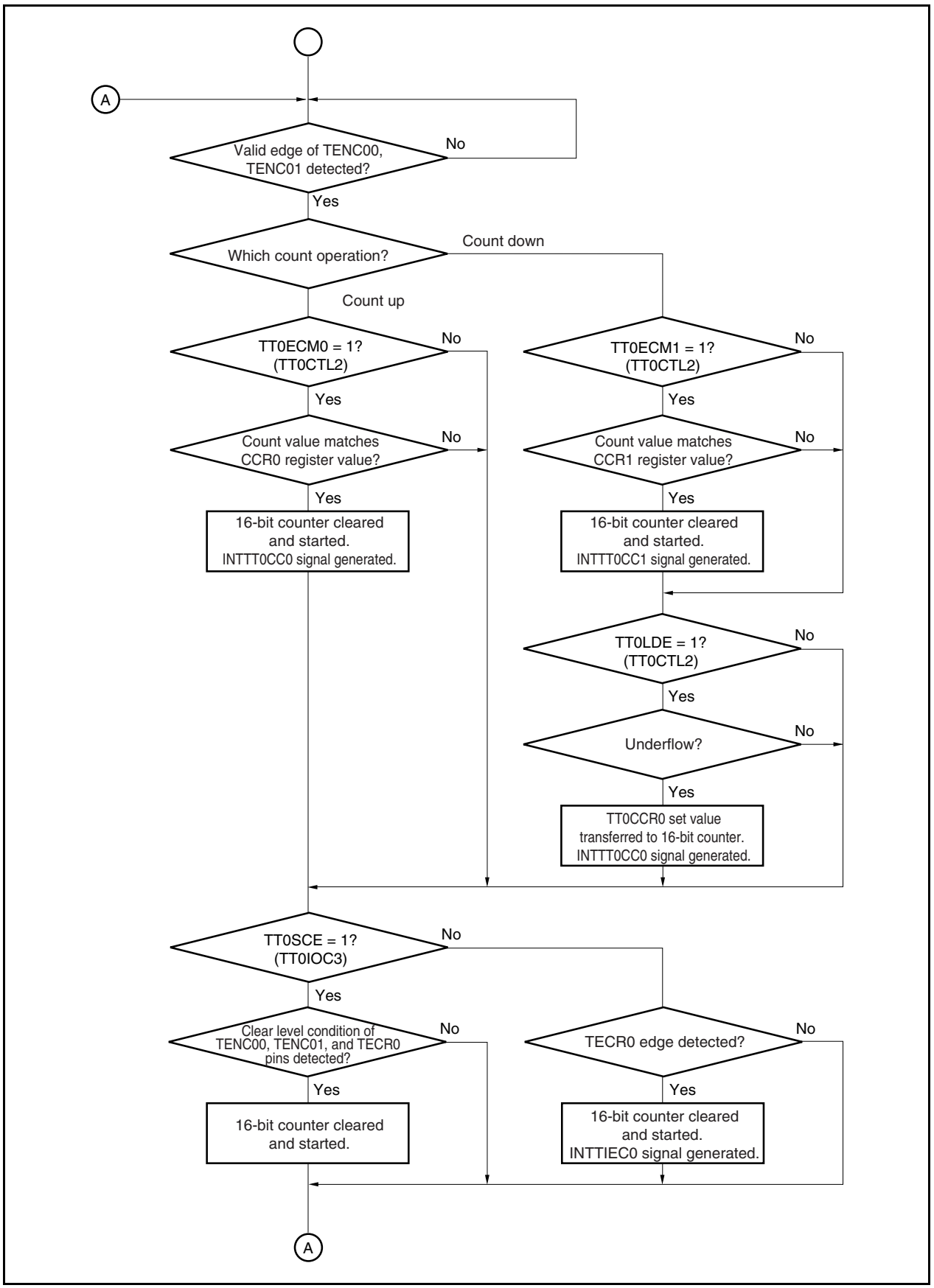


Figure 9-56. Encoder Compare Mode Operation Processing

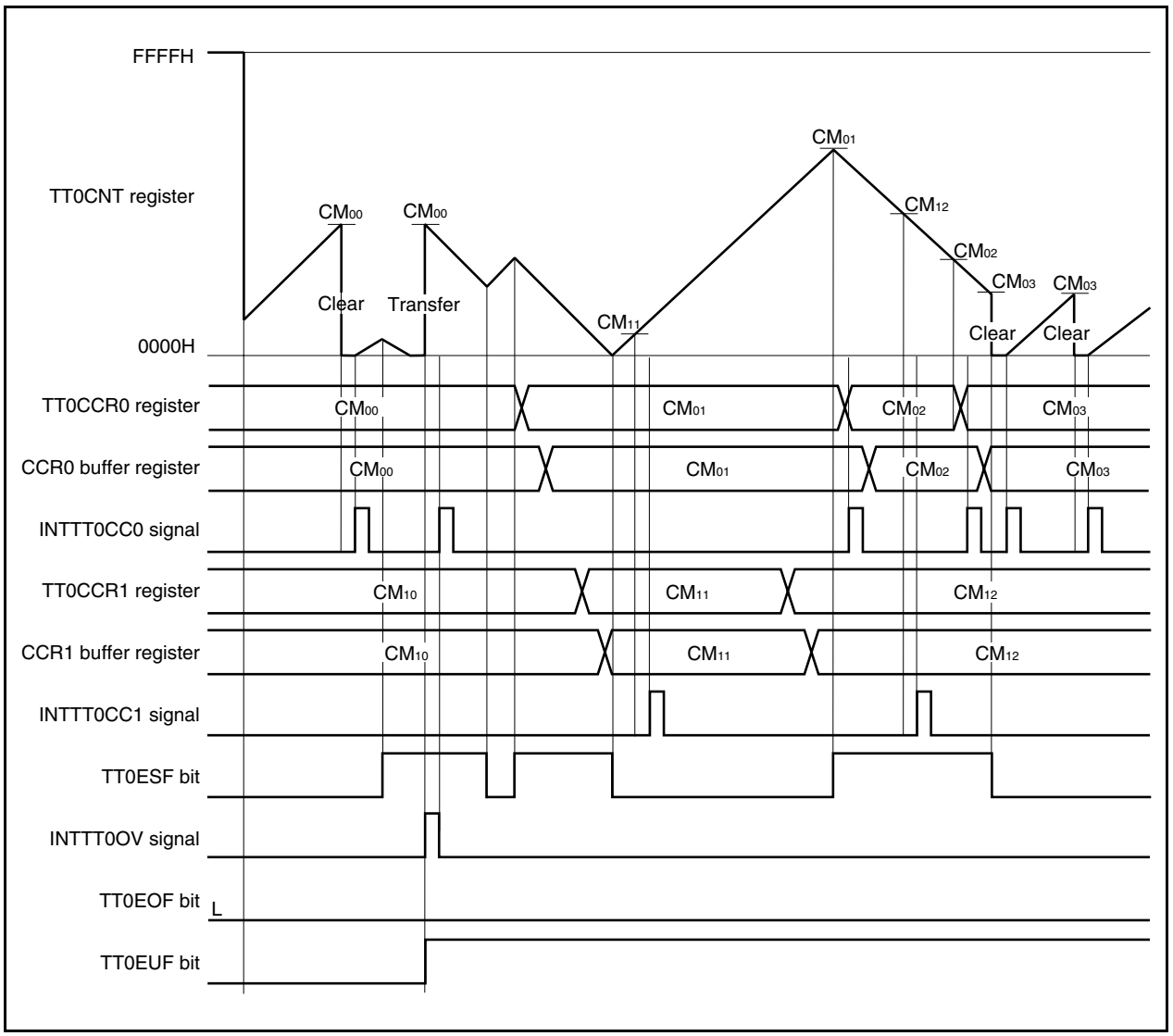


(2) Encoder compare mode operation timing

(a) Basic timing 1

[Register setting conditions]

- TT0CTL2.TT0ECM1 and TT0CTL2.TT0ECM0 bits = 01
  The 16-bit counter is cleared to 0000H when its count value matches the value of the CCR0 buffer register.
- TT0CTL2.TT0LDE bit = 1
  The set value of the TT0CCR0 register is transferred to the 16-bit counter when it overflows.
- TT0IOC3.TT0SCE bit = 0, and TT0IOC3.TT0ECS1 and TT0IOC3.TT0ECS0 bits = 00
  Specification of clearing the 16-bit counter when the edge of the encoder clear input signal (TECR0 pin) is detected (no edge specified)



When the 16-bit counter starts operating (TT0CE bit = 0 → 1), the set value of the TT0TCW register is transferred to the counter and the 16-bit counter starts operating.

When the count value of the counter matches the value of the CCR0 buffer register, the compare match interrupt request signal (INTTT0CC0) is generated. Because the TT0ECM0 bit = 1, the 16-bit counter is cleared to 0000H if the next count operation is counting up.

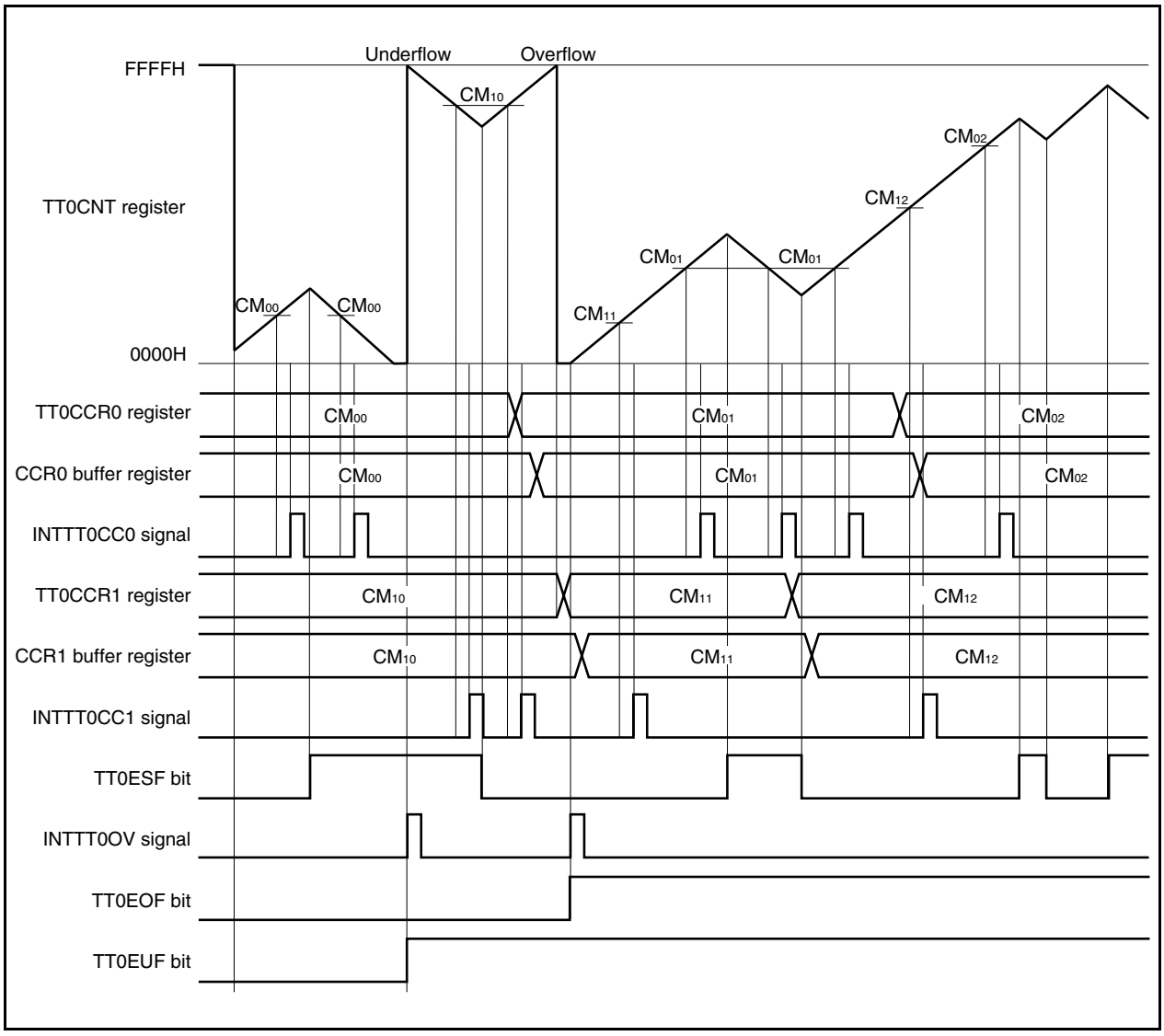
When the count value of the 16-bit counter matches the value of the CCR1 buffer register, the compare match interrupt request signal (INTTT0CC1) is generated. Because the TT0ECM1 bit = 0, the 16-bit counter is not cleared to 0000H when its value matches that of the CCR1 buffer register.

When the TT0LDE bit = 1 and TT0ECM0 bit = 1, the counter can operate in a range from 0000H to the set value of the TT0CCR0 register.

(b) Basic timing 2

[Register setting condition]

- TT0CTL2.TT0ECM1 and TT0CTL2.TT0ECM0 bits = 00
  The 16-bit counter is not cleared even when its count value matches the value of the CCRn buffer register (a = 0, 1).
- TT0CTL2.TT0LDE bit = 0
  The set value of the TT0CCR0 register is not transferred to the 16-bit counter after the counter underflows.
- TT0IOC3.TT0SCE bit = 0, and TT0IOC3.TT0ECS1 and TT0IOC3.TT0ECS0 bits = 00
  Specification of clearing the 16-bit counter when the edge of the encoder clear input signal (TECR0 pin) is detected (no edge specified)



When the 16-bit counter starts operating (TT0CE bit = 0 → 1), the set value of the TT0TCW register is transferred to the 16-bit counter and the counter starts operating.

When the count value of the 16-bit counter matches the value of the CCR0 buffer register, a compare match interrupt request signal (INTTT0CC0) is generated.

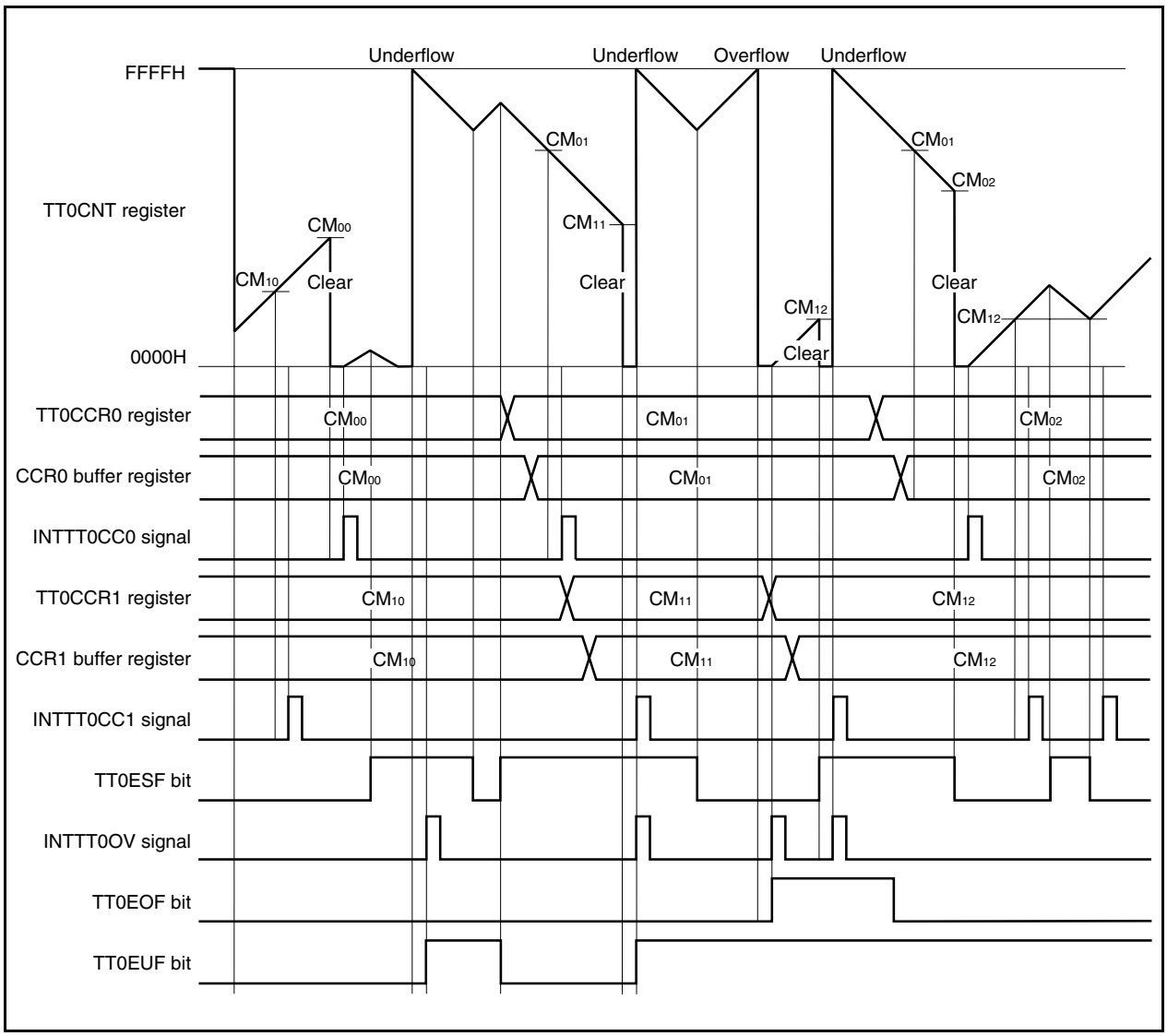
When the count value of the 16-bit counter matches the value of the CCR1 buffer register, a compare match interrupt request signal (INTTT0CC1) is generated.

The 16-bit counter is not cleared to 0000H even when its count value matches the value of the CCRn buffer register because the TT0ECM1 and TT0ECM0 bits = 00 (n = 0, 1).

(c) Basic timing 3

[Register setting condition]

- TT0CTL2.TT0ECM1 and TT0CTL2.TT0ECM0 bits = 11
  The count value of the 16-bit counter is cleared to 0000H when its value matches the value of the CCR0 buffer register.
  The count value of the 16-bit counter is cleared to 0000H when its value matches the value of the CCR1 buffer register.
- Setting of the TT0CTL2.TT0LDE bit is invalid.
- TT0IOC3.TT0SCE bit = 0, and TT0IOC3.TT0ECS1 and TT0IOC3.TT0ECS0 bits = 00
  Specification of clearing the 16-bit counter when the edge of the encoder clear input signal (TECR0 pin) is detected (no edge specified)



When the 16-bit counter starts operating (TT0CE bit = 0 → 1), the set value of the TT0TCW register is transferred to the 16-bit counter and the counter starts operating.

When the count value of the 16-bit counter matches the value of the CCR0 buffer register, a compare match interrupt request signal (INTTT0CC0) is generated. At this time, the 16-bit counter is cleared to 0000H if the next count operation is counting up.

When the count value of the 16-bit counter matches the value of the CCR1 buffer register, a compare match interrupt request signal (INTTT0CC1) is generated. At this time, the 16-bit counter is cleared to 0000H if the next count operation is counting down.

CHAPTER 10 16-BIT INTERVAL TIMER M (TMM)

The V850ES/JG3-H and V850ES/JH3-H have four TMM channels (TMMn).

10.1 Overview

TMMn has the following features.

- Interval function
- 8 clocks selectable
- 16-bit counter × 1
  (The 16-bit counter cannot be read during timer count operation.)
- Compare register × 1
  (The compare register cannot be written during timer counter operation.)
- Compare match interrupt × 1

TMMn supports only the clear & start mode. The free-running timer mode is not supported.

Remark n = 0 to 3

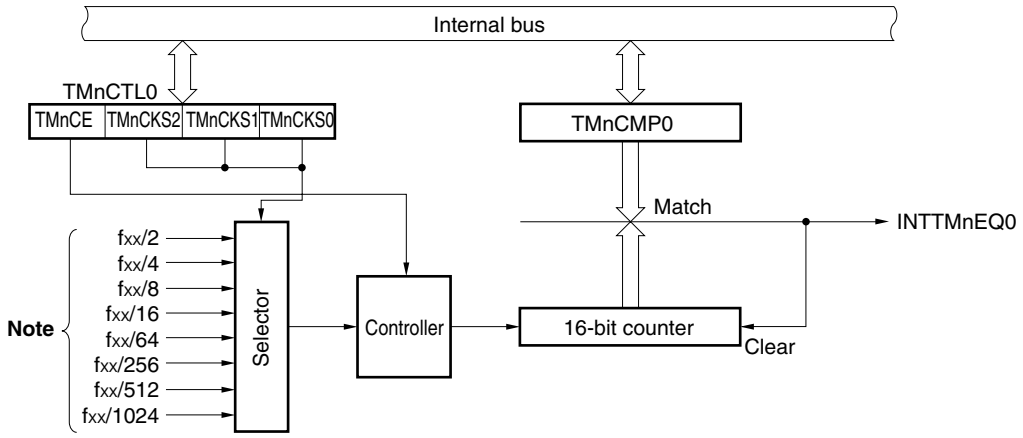
10.2 Configuration

TMMn includes the following hardware.

Table 10-1. Configuration of TMMn

Item	Configuration
Timer register	16-bit counter
Register	TMMn compare register 0 (TMnCMP0)
Control register	TMMn control register 0 (TMnCTL0)

Figure 10-1. Block Diagram of TMMn



Note In TMM0, fxx, fxx/2, fxx/4, fxx/64, fxx/512, fxx/1024, fR, fXT

Remark fXX: Main clock frequency
fR: Internal oscillation clock frequency
fXT: Subclock frequency
n = 0 to 3

(1) 16-bit counter

This is a 16-bit counter that counts the internal clock.

The 16-bit counter cannot be read or written.

(2) TMMn compare register 0 (TMnCMP0)

The TMnCMP0 register is a 16-bit compare register.

This register can be read or written in 16-bit units.

Reset sets this register to 0000H.

Software can be used to always write the same value to the TMnCMP0 register.

Rewriting the TMnCMP0 register is prohibited when the TMnCTL0.TMnCE bit = 1.

After reset: 0000H R/W Address: TM0CMP0 FFFFFA84H, TM1CMP0 FFFFFA94H, TM2CMP0 FFFFFAA4H, TM3CMP0 FFFFFAB4H

	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
TMnCMP0 (n = 0 to 3)																

10.3 Registers

(1) TMMn control register (TMnCTL0)

The TMnCTL0 register is an 8-bit register that controls the TMMn operation.

This register can be read or written in 8-bit or 1-bit units.

Reset sets this register to 00H.

Software can be used to always write the same value to the TMnCTL0 register.

Remark n = 0 to 3

After reset: 00H R/W Address: TM0CTL0 FFFFFA80H, TM1CTL0 FFFFFA90H, TM2CTL0 FFFFFAA0H, TM3CTL0 FFFFFAB0H

TMnCTL0 (n = 0 to 3)

<7>	6	5	4	3	2	1	0
TMnCE	0	0	0	0	TMnCKS2	TMnCKS1	TMnCKS0

TMnCE	Internal clock operation enable/disable specification
0	TMMn operation disabled (16-bit counter reset asynchronously). Operation clock application stopped.
1	TMMn operation enabled. Operation clock application started. TMMn operation started.

Internal clock control and internal circuit reset for TMMn are performed asynchronously using the TMnCE bit. When the TMnCE bit is cleared to 0, the internal clock of TMMn is disabled (fixed to low level) and 16-bit counter is reset asynchronously.

(m = 0)

TMmCKS2	TMmCKS1	TMmCKS0	Count clock selection			
				fxx = 48 MHz	fxx = 32 MHz	fxx = 24 MHz
0	0	0	fxx	20.8 ns	31.3 ns	41.7 ns
0	0	1	fxx/2	41.7 ns	62.5 ns	83.3 ns
0	1	0	fxx/4	83.3 ns	125 ns	167 ns
0	1	1	fxx/64	1.33 μs	2.00 μs	2.67 μs
1	0	0	fxx/512	10.7 μs	16.0 μs	21.3 μs
1	0	1	fxx/1024	21.3 μs	32.0 μs	42.7 μs
1	1	0	fR/8	36.4 μs	36.4 μs	36.4 μs
1	1	1	fXT	30.5 μs	30.5 μs	30.5 μs

(m = 1 to 3)

TMmCKS2	TMmCKS1	TMmCKS0	Count clock selection			
				fxx = 48 MHz	fxx = 32 MHz	fxx = 24 MHz
0	0	0	fxx/2	41.7 ns	62.5 ns	83.3 ns
0	0	1	fxx/4	83.3 ns	125 ns	167 ns
0	1	0	fxx/8	167 ns	250 ns	333 ns
0	1	1	fxx/16	333 ns	500 ns	667 ns
1	0	0	fxx/64	1.33 μs	2.00 μs	2.67 μs
1	0	1	fxx/256	5.33 μs	8.00 μs	10.7 μs
1	1	0	fxx/512	10.7 μs	16.0 μs	21.3 μs
1	1	1	fxx/1024	21.3 μs	32.0 μs	42.7 μs

Cautions 1. Set the TMnCKS2 to TMnCKS0 bits when the TMnCE bit = 0. When changing the value of TMnCE from 0 to 1, it is not possible to set the value of the TMnCKS2 to TMnCKS0 bits simultaneously.

2. Be sure to clear bits 3 to 6 to "0".

Remark fxx: Main clock frequency
fR: Internal oscillation clock frequency
fXT: Subclock frequency

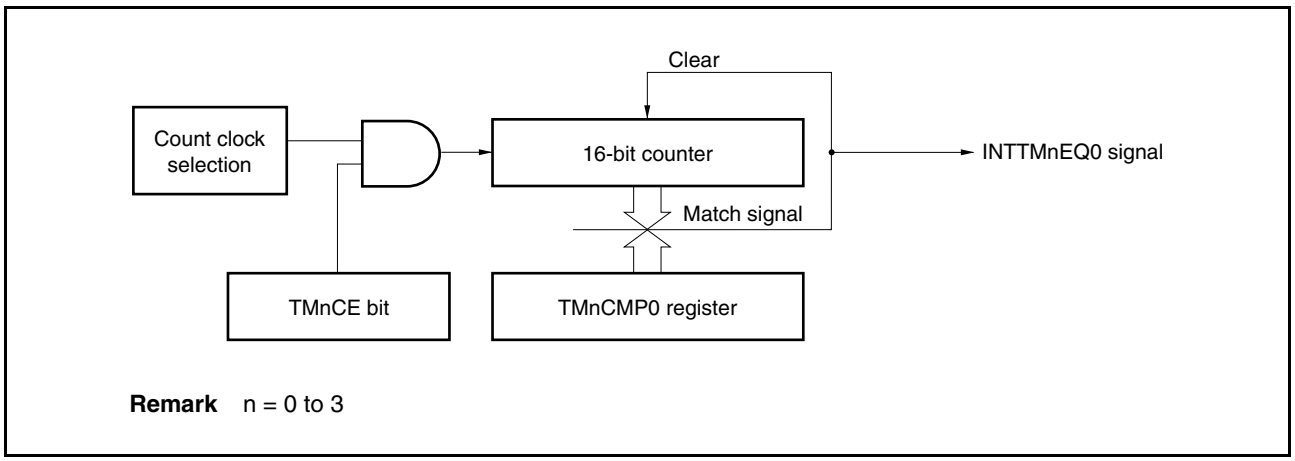
10.4 Operation

Caution Do not set the TMnCMP0 register to FFFFH.

10.4.1 Interval timer mode

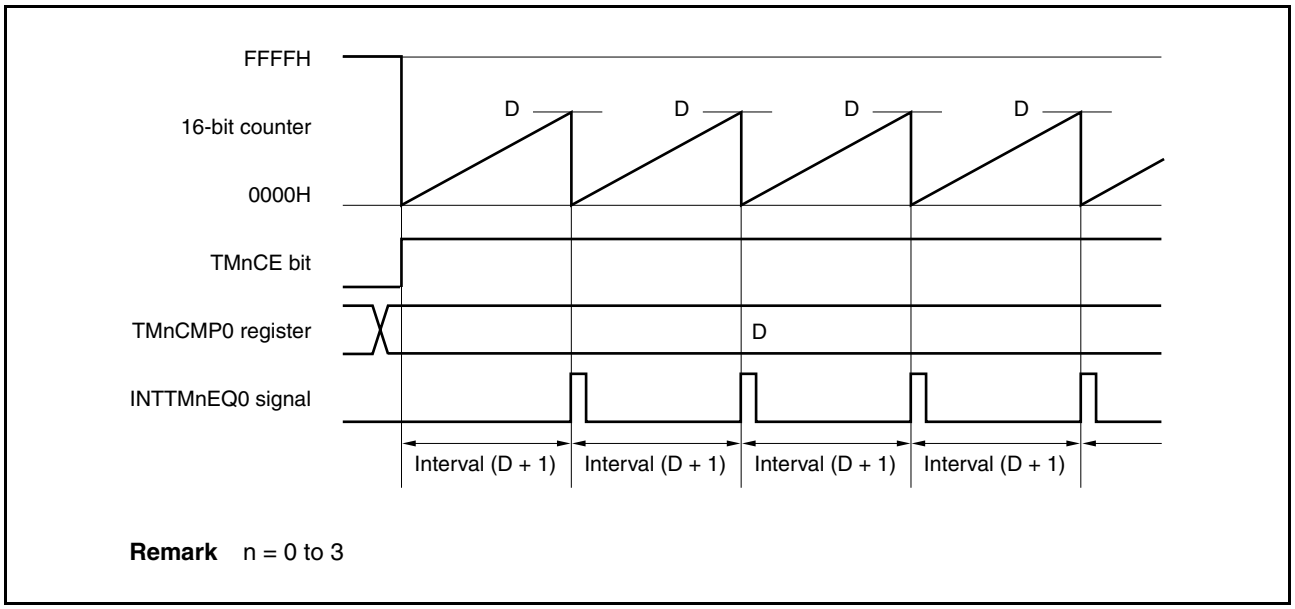
In the interval timer mode, an interrupt request signal (INTTMnEQ0) is generated at the specified interval if the TMnCTL0.TMnCE bit is set to 1.

Figure 10-2. Configuration of Interval Timer



Remark n = 0 to 3

Figure 10-3. Basic Timing of Operation in Interval Timer Mode



Remark n = 0 to 3

When the TMnCE bit is set to 1, the value of the 16-bit counter is cleared from FFFFH to 0000H in synchronization with the count clock, and the counter starts counting.

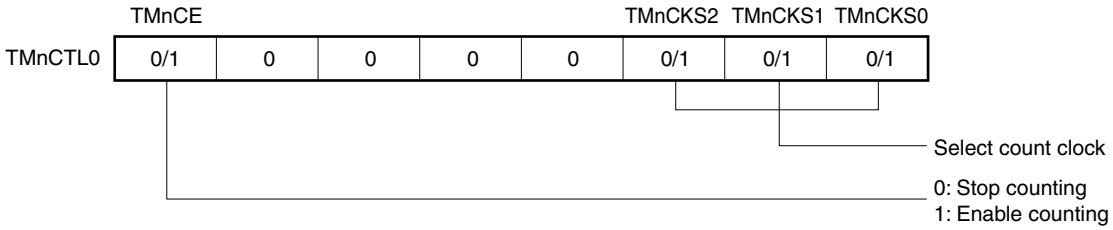
When the count value of the 16-bit counter matches the value of the TMnCMP0 register, the 16-bit counter is cleared to 0000H and a compare match interrupt request signal (INTTMnEQ0) is generated.

The interval can be calculated by the following expression.

Interval = (Set value of TMnCMP0 register + 1) × Count clock cycle

Figure 10-4. Register Setting for Interval Timer Mode Operation

(a) TMMn control register 0 (TMnCTL0)



(b) TMMn compare register 0 (TMnCMP0)

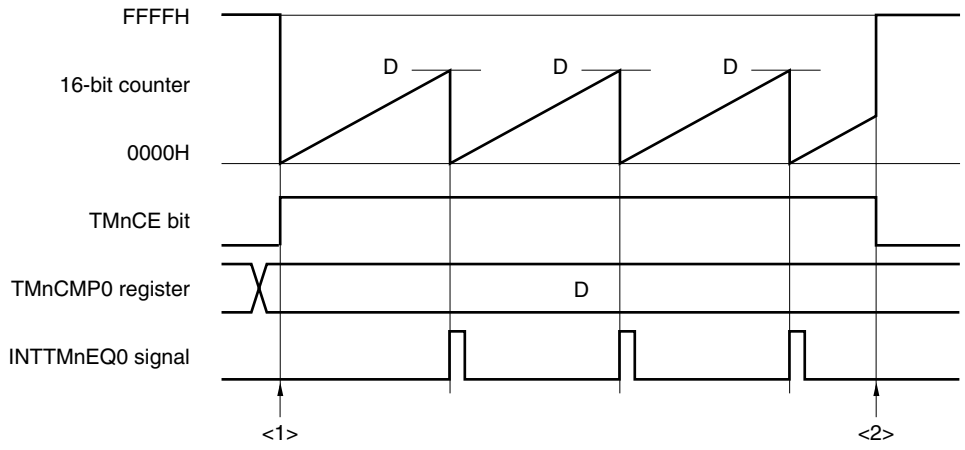
If the TMnCMP0 register is set to D, the interval is as follows.

Interval = (D + 1) × Count clock cycle

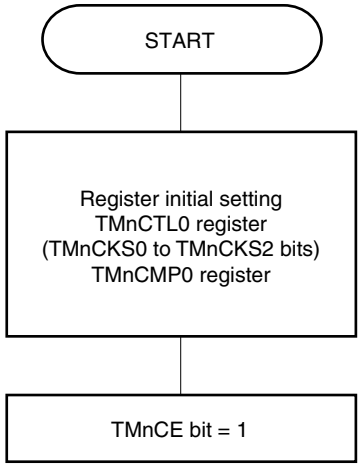
Remark n = 0 to 3

(1) Interval timer mode operation flow

Figure 10-5. Software Processing Flow in Interval Timer Mode



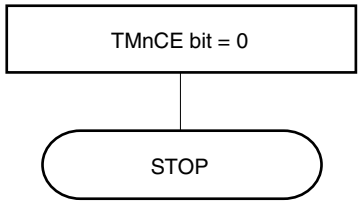
<1> Count operation start flow



The initial setting of these registers is performed before setting the TMnCE bit to 1.

The TMnCKS0 to TMnCKS2 bits cannot be set at the same time when counting has been started (TMnCE bit = 1).

<2> Count operation stop flow



The counter is initialized and counting is stopped by clearing the TMnCE bit to 0.

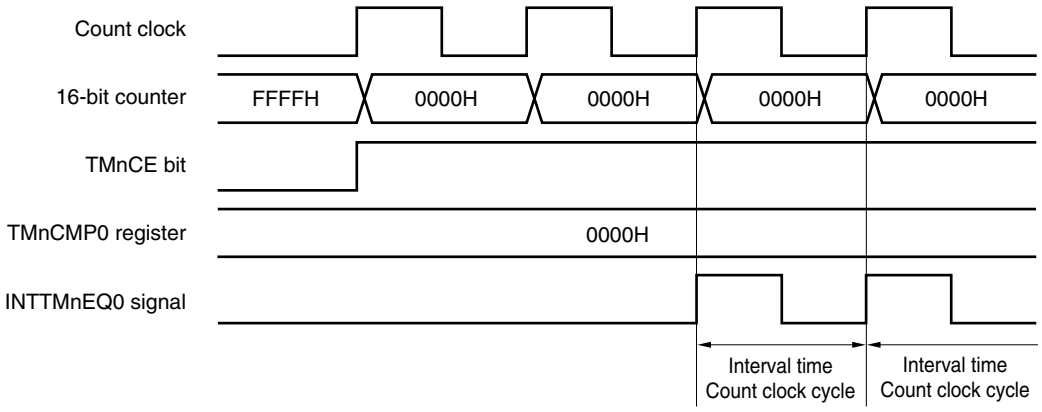
Remark n = 0 to 3

(2) Interval timer mode operation timing

Caution Do not set the TMnCMP0 register to FFFFH.

(a) Operation if TMnCMP0 register is set to 0000H

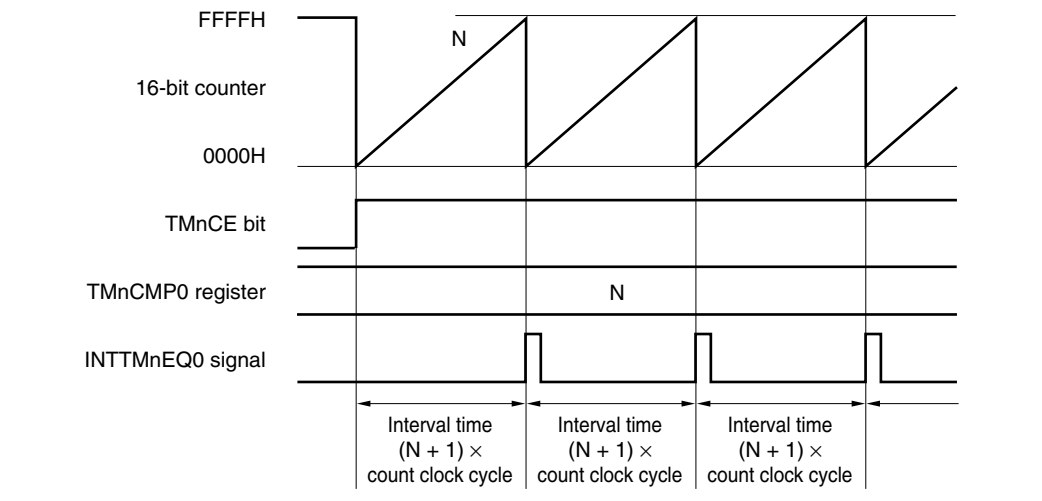
If the TMnCMP0 register is set to 0000H, the INTTMnEQ0 signal is generated at each count clock.
The value of the 16-bit counter is always 0000H.



Remark n = 0 to 3

(b) Operation if TMnCMP0 register is set to N

If the TMnCMP0 register is set to N, the 16-bit counter counts up to N. The counter is cleared to 0000H in synchronization with the next count-up timing and the INTTMnEQ0 signal is generated.



Remark n = 0 to 3

10.4.2 Cautions

(1) It takes the 16-bit counter up to the following time to start counting after the TMnCTL0.TMnCE bit is set to 1, depending on the count clock selected.

(n = 0)

Selected Count Clock	Maximum Time Before Counting Start
f_{XX}	$2/f_{XX}$
$f_{XX}/2$	$3/f_{XX}$
$f_{XX}/4$	$6/f_{XX}$
$f_{XX}/64$	$128/f_{XX}$
$f_{XX}/512$	$1024/f_{XX}$
$f_{XX}/1024$	$2048/f_{XX}$
$f_R/8$	$16/f_R$
f_{XT}	$2/f_{XT}$

(n = 1 to 3)

Selected Count Clock	Maximum Time Before Counting Start
$f_{XX}/2$	$4/f_{XX}$
$f_{XX}/4$	$6/f_{XX}$
$f_{XX}/8$	$12/f_{XX}$
$f_{XX}16$	$32/f_{XX}$
$f_{XX}/64$	$128/f_{XX}$
$f_{XX}/256$	$512/f_{XX}$
$f_{XX}/512$	$1024/f_{XX}$
$f_{XX}/1024$	$2048/f_{XX}$

(2) Rewriting the TMnCMP0 and TMnCTL0 registers is prohibited while TMMn is operating.
If these registers are rewritten while the TMnCE bit is 1, the operation cannot be guaranteed.
If they are rewritten by mistake, clear the TMnCTL0.TMnCE bit to 0, and re-set the registers.

Remark n = 0 to 3

CHAPTER 11 MOTOR CONTROL FUNCTION

11.1 Functional Overview

Timer AB1 (TAB1) and the TMQ0 option (TMQOP0) can be used as an inverter function that controls a motor. It performs a tuning operation with timer AA4 (TAA4) and A/D conversion of the A/D converter can be started when the value of TAB1 matches the value of TAA4. The following operations can be performed as motor control functions.

- 6-phase PWM output function with 16-bit accuracy
- Timer tuning operation function (tunable with TAA4)
- Cycle setting function (cycle can be changed during operation of crest or valley interrupt)
- Compare register rewriting: Anytime rewrite, batch rewrite, or intermittent rewrite (selectable during TAB1 operation)
- Interrupt and transfer culling functions
- Dead-time setting function
- A/D trigger timing function of the A/D converter
- 0% output and 100% output available
- 0% output and 100% output selectable by crest interrupt and valley interrupt
- Forcible output stop function
  - When valid edge detected by external pin input (TOAB1OFF, TOAA1OFF)
  - When main clock oscillation stop detected by clock monitor function

11.2 Configuration

The motor control function consists of the following hardware.

Item	Configuration
Timer register	Dead-time counters
Compare register	TAB1 dead-time compare register (TAB1DTC register)
Control registers	TAB1 option register 1 (TAB1OPT1) TAB1 option register 2 (TAB1OPT2) TAB1 I/O control register 3 (TAB1IOC3) High-impedance output control register 0 (HZA0CTL0) High-impedance output control register 1 (HZA0CTL1)

- 6-phase PWM output can be produced with dead time by using the output of TAB1 (TOAB11, TOAB12, TOAB13).
- The output level of the 6-phase PWM output can be set individually.
- The 16-bit timer/counter of TAB1 counts up/down triangular waves. When the timer/counter underflows and when a cycle match occurs, an interrupt is generated. Interrupt generation, however, can be suppressed up to 31 times.
- TAA4 can execute counting at the same time as TAB1 (timer tuning operation function). TAA4 can be set in three ways as it can generate an A/D trigger source (TABTADT0) and two types of interrupts: a TAB1 underflow interrupt (INTTAB1OV) and a cycle match interrupt (INTTAB1CC0).

Figure 11-1. Block Diagram of Motor Control

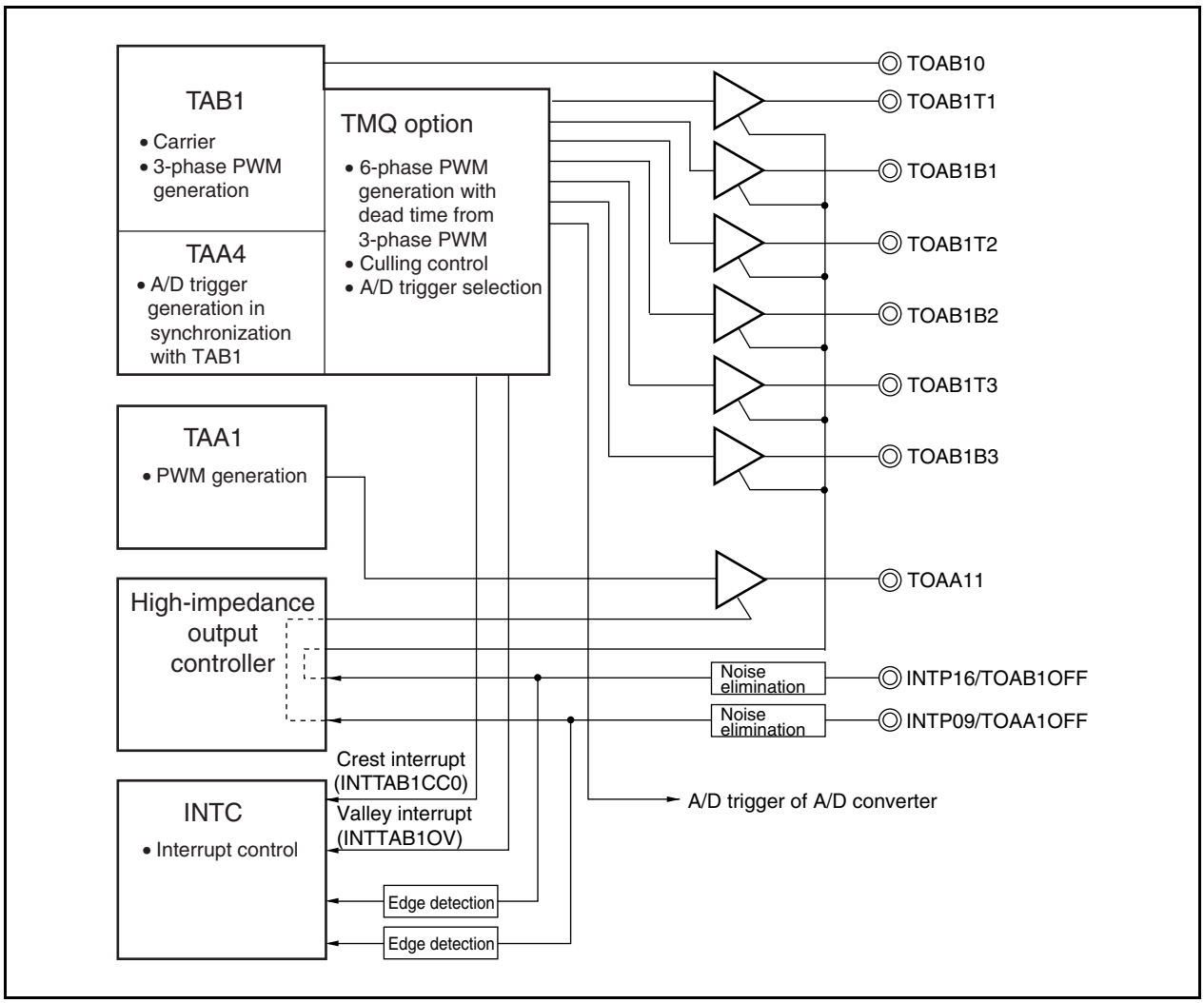
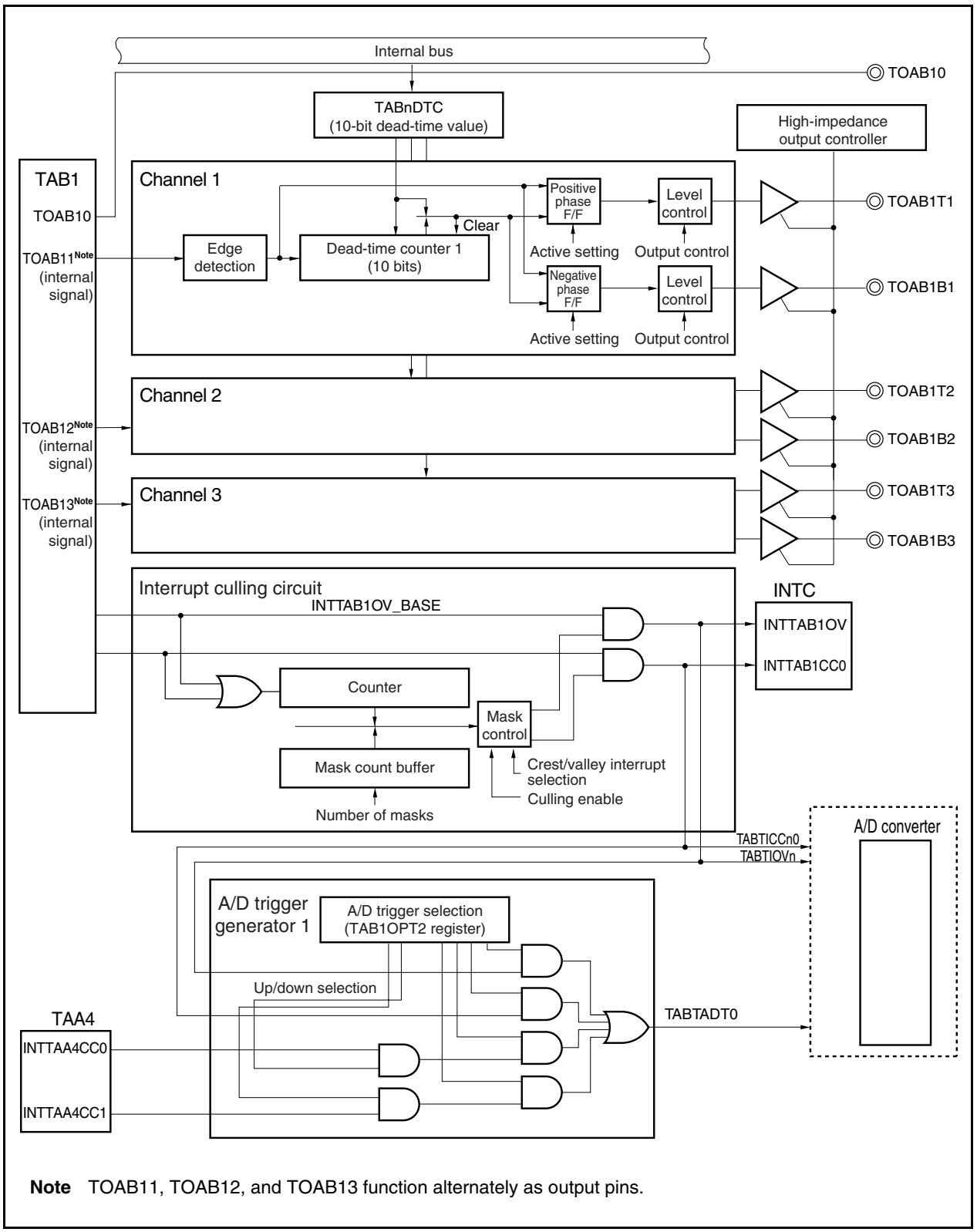


Figure 11-2. TMQ1 Option



Note TOAB11, TOAB12, and TOAB13 function alternately as output pins.

(1) TAB1 dead-time compare register (TAB1DTC)

The TAB1DTC register is a 10-bit compare register that specifies the dead-time value.

Rewriting this register is prohibited when the TAB1CTL0.TAB1CE bit = 1.

This register can be read or written in 16-bit units.

Reset sets this register to 0000H.

Caution When generating a dead-time period, set the TAB1DTC register to 1 or higher.
Note, when the operation is stopped (TAB1CTL0.TAB1CE bit = 0), a dead-time period is not generated, so the output levels of the TOAB1T1 to TOAB1T3 and TOAB1B1 to TOAB1B3 pins are in their default states. Therefore, for the protection of the system, take measures such as making the TOAB1T1 to TOAB1T3 and TOAB1B1 to TOAB1B3 pins go into a high-impedance state before stopping operation, or setting the output levels of the pins before switching port modes.
When a dead-time period is not needed, set the TAB1DTC register to 0.

After reset: 0000H R/W Address: FFFFF584H

	15	10	9	0
TAB1DTC	000000		TAB1DTC9 to TAB1DTC0	

(2) Dead-time counters 1 to 3

The dead-time counters are 10-bit counters that count dead time.

These counters are cleared or count up at the rising or falling edge of the TOAB1m output signal of TAB1, and are cleared or stopped when their count value matches the value of the TAB1DTC register. The count clock of these counters is the same as that set by the TAB1CTL0.TAB1CKS2 to TAB1CTL0.TAB1CKS0 bits of TAB1.

Remarks 1. The operation differs when the TAB1OPT2.TAB1DTM bit = 1. For details, see **11.4.2 (4) Automatic dead-time width narrowing function (TAB1OPT2.TAB1DTM bit = 1)**.

2. m = 1 to 3

11.3 Control Registers

(1) TAB1 option register 1 (TAB1OPT1)

The TAB1OPT1 register is an 8-bit register that controls the interrupt request signal generated by the timer Q option function.

This register can be rewritten when the TAB1CTL0.TAB1CE bit is 1.

Two rewrite modes (batch write mode and anytime write mode) can be selected, depending on the setting of the TAB1OPT0.TAB1CMS bit.

This register can be read or written in 8-bit or 1-bit units.

Reset sets this register to 00H.

After reset: 00H R/W Address: FFFFF580H

	<7>	<6>	5	4	3	2	1	0
TAB1OPT1	TAB1ICE	TAB1IOE	0	TAB1ID4	TAB1ID3	TAB1ID2	TAB1ID1	TAB1ID0

TAB1ICE	Crest interrupt (INTTAB1CC0 signal) enable
0	Do not use INTTAB1CC0 signal (do not use it as count signal for interrupt culling).
1	Use INTTAB1CC0 signal (use it as count signal for interrupt culling).

TAB1IOE	Valley interrupt (INTTAB1OV signal) enable
0	Do not use INTTAB1OV signal (do not use it as count signal for interrupt culling).
1	Use INTTAB1OV signal (use it as count signal for interrupt culling).

TAB1ID4	TAB1ID3	TAB1ID2	TAB1ID1	TAB1ID0	Number of times of interrupt
0	0	0	0	0	Not culled (all interrupts are output)
0	0	0	0	1	1 masked (one of two interrupts is output)
0	0	0	1	0	2 masked (one of three interrupts is output)
0	0	0	1	1	3 masked (one of four interrupts is output)
:	:	:	:	:	:
1	1	1	0	0	28 masked (one of 29 interrupts is output)
1	1	1	0	1	29 masked (one of 30 interrupts is output)
1	1	1	1	0	30 masked (one of 31 interrupts is output)
1	1	1	1	1	31 masked (one of 32 interrupts is output)

(2) TAB1 option register 2 (TAB1OPT2)

The TAB1OPT2 register is an 8-bit register that controls the timer Q option function.

This register can be rewritten when the TAB1CTL0.TAB1CE bit is 1. However, rewriting the TAB1DTM bit is prohibited when the TAB1CE bit is 1. The same value can be rewritten.

This register can be read or written in 8-bit or 1-bit units.

Reset sets this register to 00H.

(1/2)

After reset: 00H R/W Address: FFFFF581H

	<7>	<6>	<5>	<4>	<3>	<2>	<1>	<0>
TAB1OPT2	TAB1RDE	TAB1DTM	TAB1ATM3	TAB1ATM2	TAB1AT3	TAB1AT2	TAB1AT1	TAB1AT0

TAB1RDE	Transfer culling enable
0	Do not cull transfer (transfer timing is generated every time at crest and valley).
1	Cull transfer at the same interval as interrupt culling set by the TAB1OPT1 register.

TAB1DTM	Dead-time counter operation mode selection (m = 1 to 3)
0	The dead-time counter counts up normally and, if TOAB1m output of TAB1 is at a narrow interval (TOAB1m output width < dead-time width), the dead-time counter is cleared and counts up again.
1	The dead-time counter counts up normally and, if TOAB1m output of TAB1 is at a narrow interval (TOAB1m output width < dead-time width), the dead-time counter counts down and the dead-time control width is automatically narrowed.
Rewriting the TAB1DTM bit is disabled during timer operation. If it is rewritten by mistake, stop the timer operation by clearing the TAB1CE bit to 0, and re-set the TAB1DTM bit.	

Cautions 1. When using interrupt culling (the TAB1OPT1.TAB1ID4 to TAB1OPT1.TAB1ID0 bits are set to other than 00000), be sure to set the TAB1RDE bit to 1.

This means that interrupts and transfers are generated at the same timing. Interrupts and transfers, cannot be set separately. If interrupts and transfers are set separately (TAB1RDE bit = 0), transfers are not performed normally.

2. When generating a dead-time period, set the TAB1DTC register to 1 or higher.

Note, when the operation is stopped (TAB1CTL0.TAB1CE bit = 0), a dead-time period is not generated, so the output levels of the TOAB1T1 to TOAB1T3 and TOAB1B1 to TOAB1B3 pins are in their default states. Therefore, for the protection of the system, take measures such as making the TOAB1T1 to TOAB1T3 and TOAB1B1 to TOAB1B3 pins go into a high-impedance state before stopping operation, or setting the output levels of the pins before switching port modes.

When a dead-time period is not needed, set the TAB1DTC register to 0.

(2/2)

TAB1ATM3	TAB1ATM3 mode selection
0	Output A/D trigger signal (TABTADT0) for INTTAA4CC1 interrupt while dead-time counter is counting up.
1	Output A/D trigger signal (TABTADT0) for INTTAA4CC1 interrupt while dead-time counter is counting down.

TAB1ATM2	TAB1ATM2 mode selection
0	Output A/D trigger signal (TABTADT0) for INTTAA4CC0 interrupt while dead-time counter is counting up.
1	Output A/D trigger signal (TABTADT0) for INTTAA4CC0 interrupt while dead-time counter is counting down.

TAB1AT3Note	A/D trigger output control 3
0	Disable output of A/D trigger signal (TABTADT0) for INTTAA4CC1 interrupt.
1	Enable output of A/D trigger signal (TABTADT0) for INTRAA4CC1 interrupt.

TAB1AT2Note	A/D trigger output control 2
0	Disable output of A/D trigger signal (TABTADT0) for INTTAA4CC0 interrupt.
1	Enable output of A/D trigger signal (TABTADT0) for INTTAA4CC0 interrupt.

TAB1AT1Note	A/D trigger output control 1
0	Disable output of A/D trigger signal (TABTADT0) for INTTAB1CC0 (crest interrupt).
1	Enable output of A/D trigger signal (TABTADT0) for INTTAB1CC0 (crest interrupt).

TAB1AT0Note	A/D trigger output control 0
0	Disable output of A/D trigger signal (TABTADT0) for INTTAB1OV (valley interrupt).
1	Enable output of A/D trigger signal (TABTADT0) for INTTAB1OV (valley interrupt).

Note For the setting of the TAB1AT3 to TAB1AT0 bits, see **CHAPTER 15 A/D CONVERTER**.

(3) TAB1 I/O control register 3 (TAB1IOC3)

The TAB1IOC3 register is an 8-bit register that controls the output of the timer Q option function.

To output from the TOAB1Tm pin, set the TAB1IOC0.TAB1OEm bit to 1 and then set the TAB1IOC3 register.

The TAB1IOC3 register can be rewritten only when the TAB1CTL0.TAB1CE bit is 0.

Rewriting each bit of the TAB1IOC3 register is prohibited when the TAB1CTL0.TAB1CE bit is 1; however the same value can be rewritten to each bit of the TAB1IOC3 register when the TAB1CTL0.TAB1CE bit is 1.

This register can be read or written in 8-bit or 1-bit units.

Reset sets this register to A8H.

Caution Set the TAB1IOC3 register to the reset value (A8H) when the timer is used in a mode other than the 6-phase PWM output mode.

Remarks 1. Set the output level of the TOAB1Tm pin by using the TAB1IOC0 register.

2. m = 1 to 3

After reset: A8H R/W Address: FFFFF582H

	<7>	<6>	<5>	<4>	<3>	<2>	1	0
TAB1IOC3	TAB1OLB3	TAB1OEB3	TAB1OLB2	TAB1OEB2	TAB1OLB1	TAB1OEB1	0	0

TAB1OLBm	Setting of TOAB1Bm pin output level (m = 1 to 3)
0	Disable inversion of output of TOAB1Bm pin
1	Enable inversion of output of TOAB1Bm pin

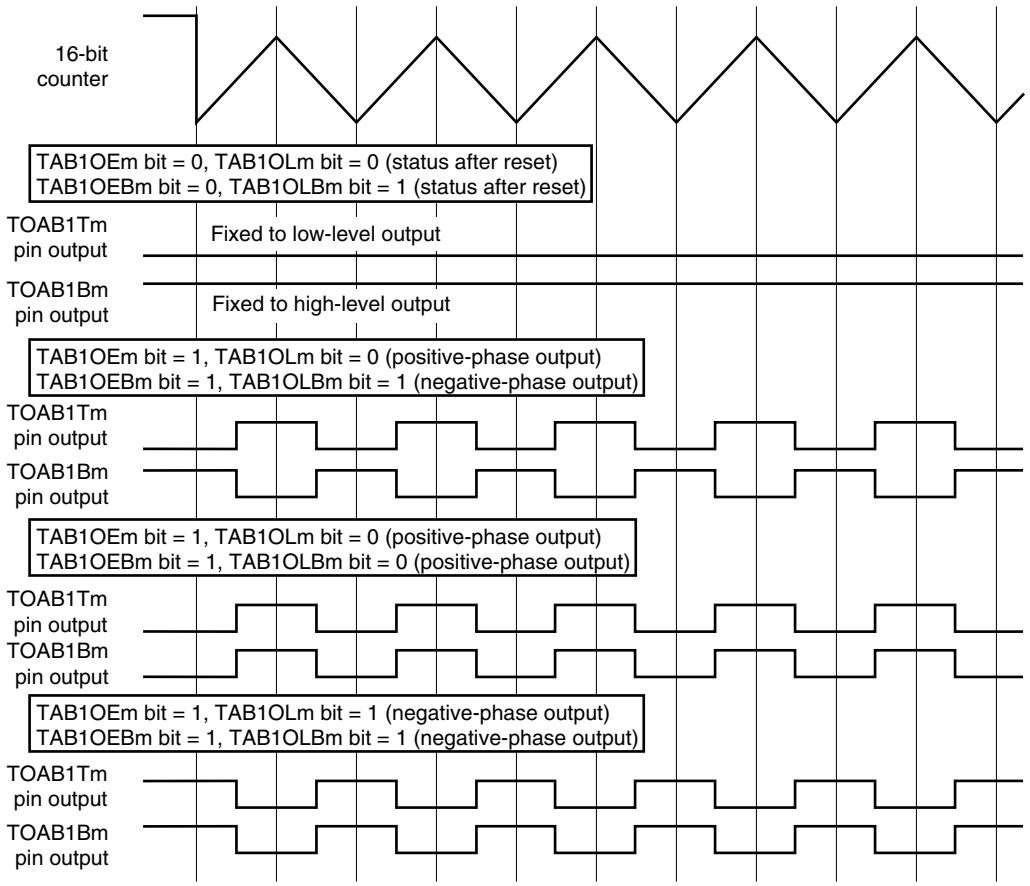
TAB1OEBm	TOAB1Bm pin output (m = 1 to 3)
0	Disable TOAB1Bm pin output. • When TAB1OLBm bit = 0, low level is output from TOAB1Bm pin. • When TAB1OLBm bit = 1, high level is output from TOAB1Bm pin.
1	Enable TOAB1Bm pin output.

(a) Output from TOAB1Tm and TOAB1Bm pins

The TOAB1Tm pin output is controlled by the TAB1IOC0.TAB1OLm and TAB1IOC0.TAB1OEm bits. The TOAB1Bm pin output is controlled by the TAB1IOC3.TAB1OLBm and TAB1IOC3.TAB1OEBm bits.

The timer output with each setting in the 6-phase PWM output mode is shown below.

Figure 11-3. Output Control of TOAB1Tm and TOAB1Bm Pins (Without Dead Time)



Remark m = 1 to 3

Table 11-1. TOAB1Tm Pin Output

TAB1OLm Bit	TAB1OEm Bit	TAB1CE Bit	TOAB1Tm Pin Output
0	0	x	Low-level output
	1	0	Low-level output
		1	TOAB1Tm positive-phase output
1	0	x	High-level output
	1	0	High-level output
		1	TOAB1Tm negative-phase output

Remark m = 1 to 3

Table 11-2. TOAB1Bm Pin Output

TAB1OLBm Bit	TAB1OEBm Bit	TAB1CE Bit	TOAB1Bm Pin Output
0	0	x	Low-level output
	1	0	Low-level output
		1	TOAB1Bm positive-phase output
1	0	x	High-level output
	1	0	High-level output
		1	TOAB1Bm negative-phase output

Remark m = 1 to 3

(6) High-impedance output control registers 0, 1 (HZA0CTL0, HZA0CTL1)

The HZA0CTL0 and HZA0CTL1 registers are 8-bit registers that control the high-impedance state of the output buffer.

These registers can be read or written in 8-bit or 1-bit units. However, the HZA0DCFn bit is a read-only bit and cannot be written.

16-bit access is not possible.

Reset sets these registers to 00H.

Software can be used to always write the same value to the HZA0CTLn register.

The relationship between detection factor and the control registers is shown below.

Pins Subject to High-Impedance Control	High-Impedance Control Factor	Control Register
	External Pin	
When TOAB1T1 to TOAB1T3 are output When TOAB1B1 to TOAB1B3 are output	TOAB1OFF/INTP16	HZA0CTL0
When TOAA11 is output	TOAA1OFF/INTP09	HZA0CTL1

Caution High impedance control is performed only when the target port is specified as a target pin in the above table.

Remark n = 0, 1

(1/2)

After reset: 00H R/W Address: HZA0CTL0 FFFFF590H, HZA0CTL1 FFFFF591H

HZA0CTLn

(n = 0, 1)

<7>	<6>	5	4	<3>	<2>	1	<0>
HZA0DCEn	HZA0DCMn	HZA0DCNn	HZA0DCPn	HZA0DCTn	HZA0DCCn	0	HZA0DCFn

HZA0DCEn	High-impedance output control
0	Disable high-impedance output control operation. Pins can function as output pins.
1	Enable high-impedance output control operation.

HZA0DCMn	Condition of clearing high-impedance state by HZA0DCCn bit
0	Setting of the HZA0DCCn bit is valid regardless of the external pin input.
1	Setting of the HZA0DCCn bit is invalid while the external pin input holds a level detected as abnormal (active level).
Rewrite the HZA0DCMn bit when the HZA0DCEn bit = 0.	

HZA0DCNn	HZA0DCPn	External pin input edge specification
0	0	No valid edge (setting the HZA0DCFn bit by external pin input is prohibited).
0	1	Rising edge of the external pin is valid (abnormality is detected by rising edge input).
1	0	Falling edge of the external pin is valid (abnormality is detected by falling edge input).
1	1	Setting prohibited

- Rewrite the HZA0DCNn and HZA0DCPn bits when the HZA0DCEn bit is 0.
- For the valid edge specification of the interrupts of the INTP09 and INTP16 pins, see **23.6.2 (3) External interrupt falling, rising edge specification register 3 (INTR3, INTF3)** and **(6) External interrupt falling, rising edge specification register 9H (INTR9, INTF9)**.
- For the edge specification of the external pins, begin with the TOAB1OFF and TOAA1OFF pins. Then, perform edge specification for the external pins other than the TOAB1OFF and TOAA1OFF pins. Otherwise, an undefined edge may be detected when the edge for the TOAB1OFF and TOAA1OFF pins is specified.
- High-impedance output control is performed when the valid edge is input after the operation is enabled (by setting HZA0DCEn bit to 1). If the external pin is at the active level when the operation is enabled, therefore, high-impedance output control is not performed.

(2/2)

HZA0DCTn	High-impedance output trigger bit
0	No operation
1	Pins are made to go into a high-impedance state by software and the HZA0DCFn bit is set to 1.

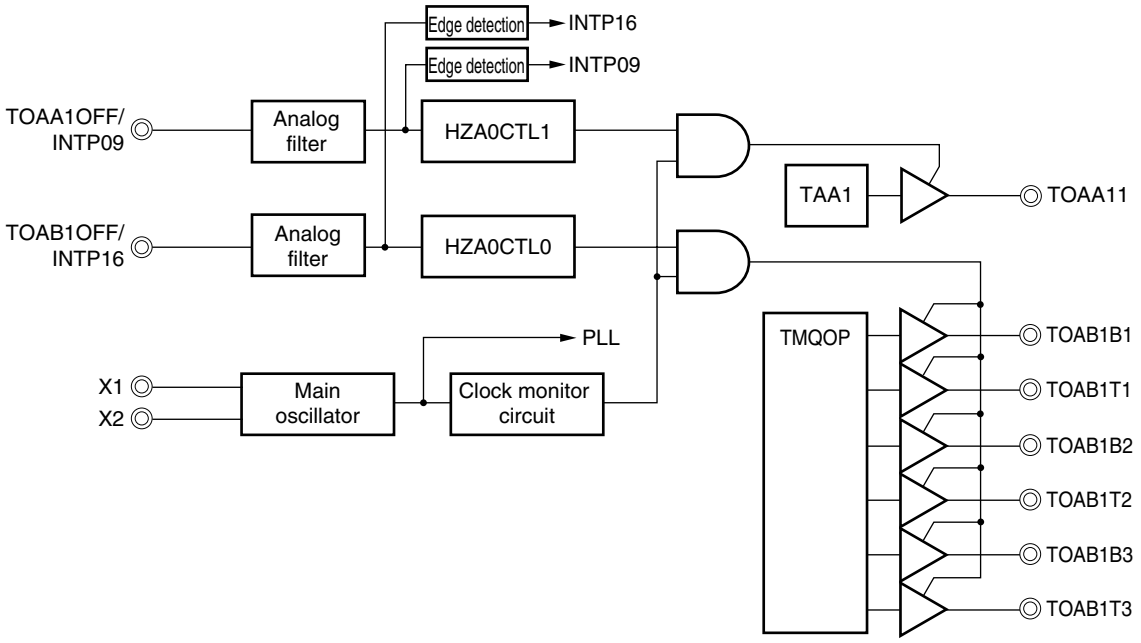
- If an edge indicating abnormality is input to the external pin (which is detected according to the setting of the HZA0DCNn and HZA0DCPn bits), the HZA0DCTn bit is invalid even if it is set to 1.
- The HZA0DCTn bit is always 0 when it is read because it is a software-triggered bit.
- The HZA0DCTn bit is invalid even if it is set to 1 when the HZA0DCEn bit = 0.
- Simultaneously setting the HZA0DCTn and HZA0DCCn bits to 1 is prohibited.

HZA0DCCn	High-impedance output control clear bit
0	No operation
1	Pins that have gone into a high-impedance state are output-enabled by software and the HZA0DCFn bit is cleared to 0.

- Pins can function as output pins when the HZA0DCM bit = 0, regardless of the status of the external pin.
- If an edge indicating abnormality is input to the external pin (which is set by the HZA0DCNn and HZA0DCPn bits) when the HZA0DCM bit = 1, the HZA0DCCn bit is invalid even if it is set to 1.
- The HZA0DCCn bit is always 0 when it is read.
- The HZA0DCCn bit is invalid even if it is set to 1 when the HZA0DCEn bit = 0.
- Simultaneously setting the HZA0DCTn and HZA0DCCn bits to 1 is prohibited.

HZA0DCFn	High-impedance output status flag
Clear (0)	Indicates that output of the pin is enabled. • This bit is cleared to 0 when the HZA0DCEn bit = 0. • This bit is cleared to 0 when the HZA0DCCn bit = 1.
Set (1)	Indicates that the pin goes into a high-impedance state. • This bit is set to 1 when the HZA0DCTn bit = 1. • This bit is set to 1 when an edge indicating abnormality is input to the external pin (which is detected according to the setting of the HZA0DCNn and HZA0DCPn bits).

Figure 11-4. High-Impedance Output Controller Configuration



Remark Also see Figures 11-1 and 11-2.

(a) Setting procedure

(i) Setting of high-impedance control operation

<1> Set the HZA0DCMn, HZA0DCNn, and HZA0DCPn bits.

<2> Set the HZA0DCEn bit to 1 (enable high-impedance control).

(ii) Changing setting after enabling high-impedance control operation

<1> Clear the HZA0DCEn bit to 0 (to stop the high-impedance control operation).

<2> Change the setting of the HZA0DCMn, HZA0DCNn, and HZA0DCPn bits.

<3> Set the HZA0DCEn bit to 1 (to enable the high-impedance control operation again).

(iii) Resuming output when pins are in high-impedance state

If the HZA0DCMn bit is 1, set the HZA0DCCn bit to 1 to clear the high-impedance state after the valid edge of the external pin is detected. However, the high-impedance state cannot be cleared unless this bit is set while the input level of the external pin is inactive.

<1> Set the HZA0DCCn bit to 1 (command signal to clear the high-impedance state).

<2> Read the HZA0DCFn bit and check the flag status.

<3> Return to <1> if the HZA0DCFn bit is 1. The input level of the external pin must be checked.
The pin can function as an output pin if the HZA0DCFn bit is 0.

(iv) Making pin go into high-impedance state by software

The HZA0DCTn bit must be set to 1 by software to make the pin go into a high-impedance state while the input level of the external pin is inactive. The following procedure is an example in which the setting is not dependent upon the setting of the HZA0DCMn bit.

<1> Set the HZA0DCTn bit to 1 (high-impedance output command).

<2> Read the HZA0DCFn bit to check the flag status.

<3> Return to <1> if the HZA0DCFn bit is 0. The input level of the external pin must be checked.
The pin is in a high-impedance state if the HZA0DCFn bit is 1.

However, if the external pin is not used with the HZA0DCPn bit and HZA0DCNn bit cleared to 0, the pin goes into a high-impedance state when the HZA0DCTn bit is set to 1.

Remark n = 0, 1

11.4 Operation

11.4.1 System outline

(1) Outline of 6-phase PWM output

The 6-phase PWM output mode is used to generate a 6-phase PWM output wave, by using the timer AB1 (TAB1) and the TMQ option (TMQOPA) in combination.

The 6-phase PWM output mode is enabled by setting the TAB1CTL1.TAB1MD2 to TAB1CTL1.TAB1MD0 bits of TAB1 to “111”.

One 16-bit counter and four 16-bit compare registers of TAB1 are used to generate a basic 3-phase wave.

The functions of the compare registers are as follows.

TAA4 can perform a tuning operation with TAB1 to generate a conversion trigger source for the A/D converter.

Compare Register	Function	Settable Range
TAB1CCR0 register	Setting of cycle	0002H ≤ m ≤ FFFEH
TAB1CCR1 register	Specifying output width of phase U	0000H ≤ i ≤ m + 1
TAB1CCR2 register	Specifying output width of phase V	0000H ≤ j ≤ m + 1
TAB1CCR3 register	Specifying output width of phase W	0000H ≤ k ≤ m + 1

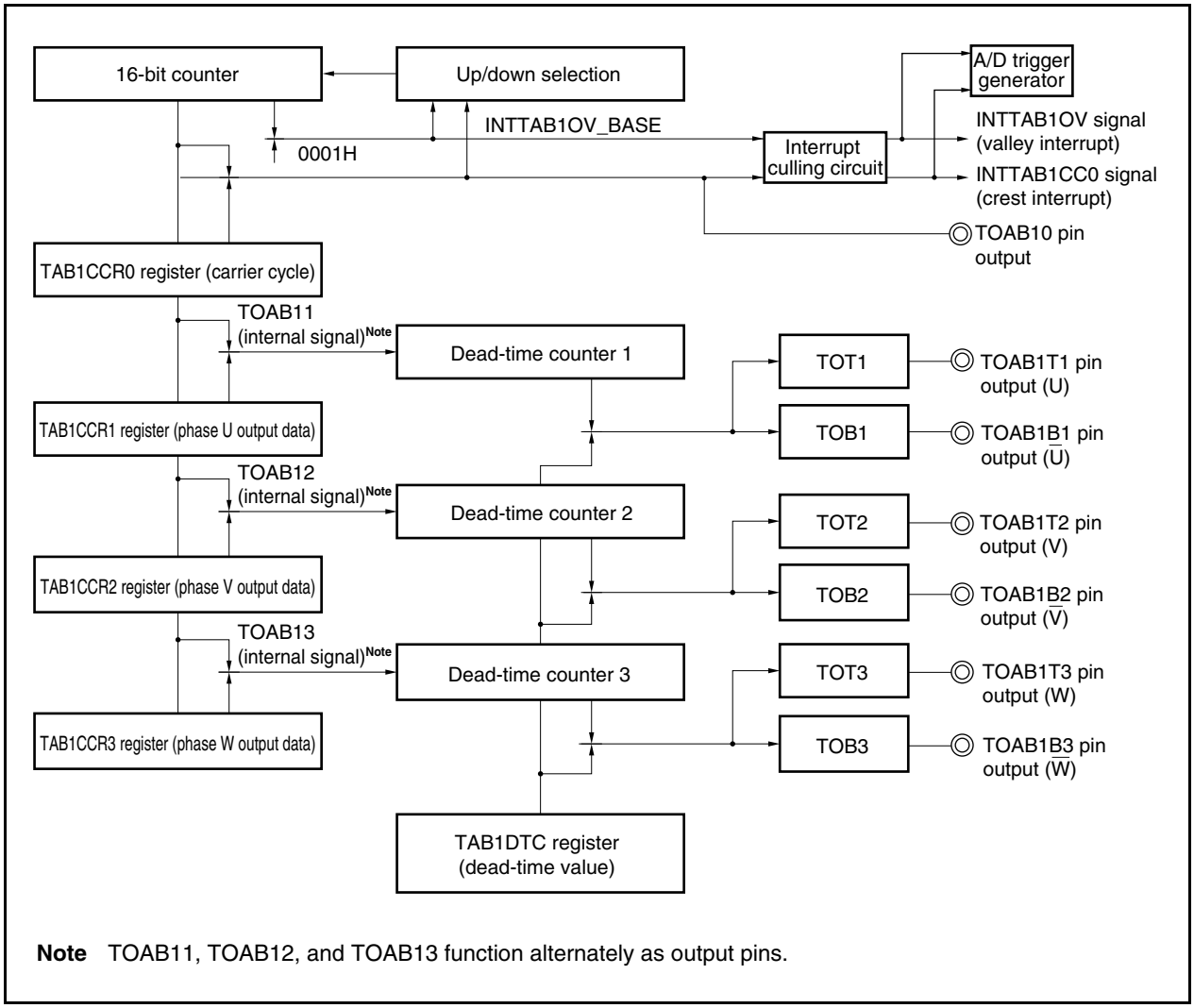
Remark m = Set value of TAB1CCR0 register
i = Set value of TAB1CCR1 register
j = Set value of TAB1CCR2 register
k = Set value of TAB1CCR3 register

A dead-time interval is generated from the basic 3-phase wave generated by using three 10-bit dead-time counters and one compare register to create a wave with a reverse phase to that of the basic 3-phase wave. Then a 6-phase PWM output wave (U, $\overline{U}$, V, $\overline{V}$, W, $\overline{W}$) is generated.

The 16-bit counter for generating the basic 3-phase wave counts up or down. After the operation has been started, this counter counts up. When its count value matches the cycle set to the TAB1CCR0 register, the counter starts counting down. When the count value matches 0001H, the counter counts up again. This means that a value two times higher than the value set to the TAB1CCR0 register + 1 is the carrier cycle.

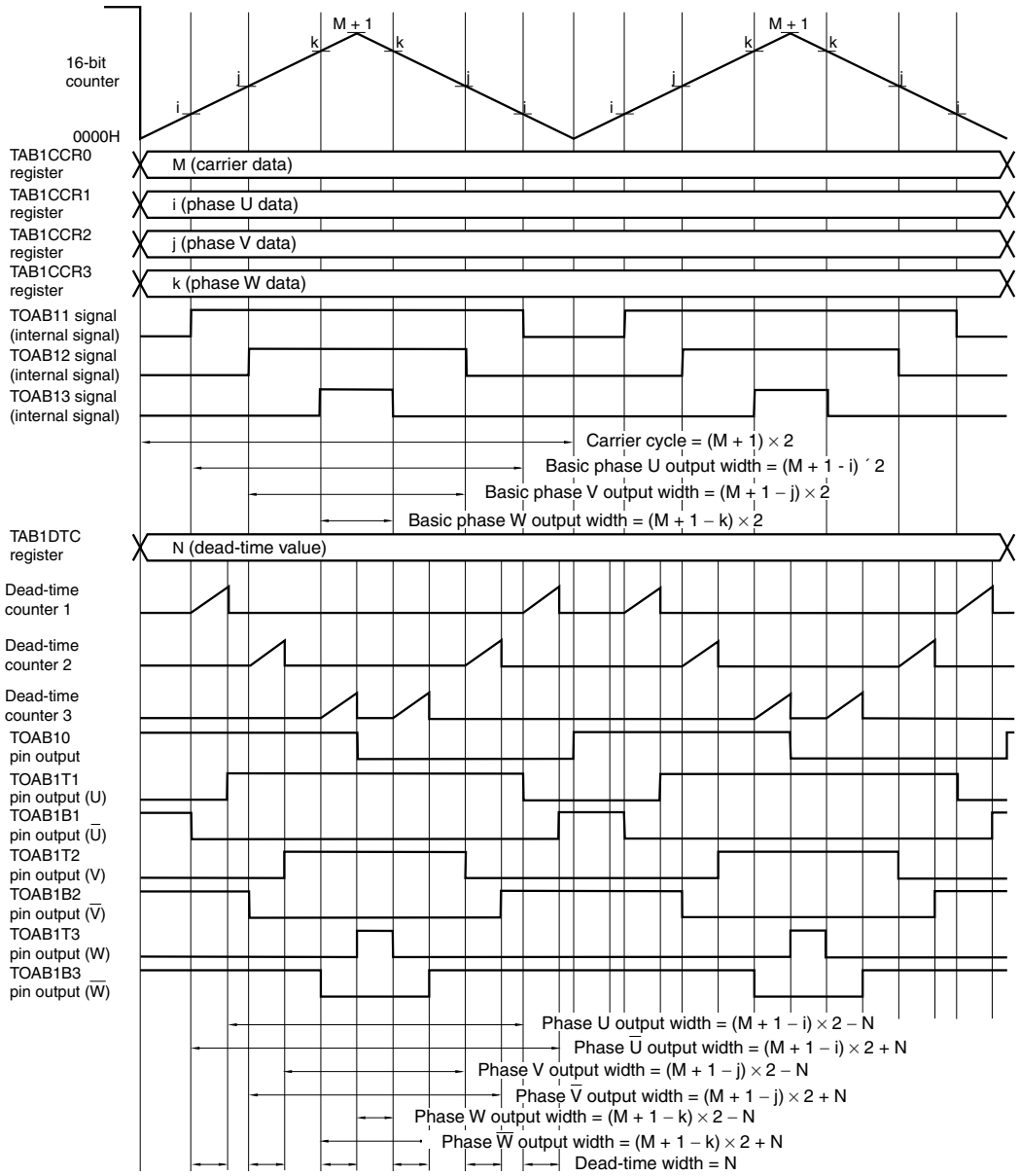
10-bit dead-time counters 1 to 3, which generate the dead-time interval, count up. Therefore, the value set to the TAB1 dead-time compare register (TAB1DTC) is used as a dead-time value as is. Because three counters are used, dead time can be generated independently in phases U, V, and W. However, because there is only one register that specifies a dead-time value (TAB1DTC), the same dead-time value is used in all three phases.

Figure 11-5. Outline of 6-Phase PWM Output Mode



Note TOAB11, TOAB12, and TOAB13 function alternately as output pins.

Figure 11-6. Timing Chart of 6-Phase PWM Output Mode



Cautions 1. Set the value "M" of the TAB1CCR0 register in a range of 0002H ≤ M ≤ FFFEH in the 6-phase PWM output mode.

2. Only a value of up to "M + 1" can be set to the TAB1CCR1, TAB1CCR2, and TAB1CCR3 registers.

3. The output is 100% if "0000H" is set to the TAB1CCR1, TAB1CCR2, and TAB1CCR3 registers. The output is 0% if "M + 1" is set to the TAB1CCR1, TAB1CCR2, and TAB1CCR3 registers.

The output (duty 50%) rises at the crest (M + 1) of the 16-bit counter and falls at the valley (0000H) if "M + 2" or higher is set to the TAB1CCR1, TAB1CCR2, and TAB1CCR3 registers.

4. If the operation value of an equation (such as (M + 1 – i) × 2 – N) of the output width of phases U, V, and W is 0 or lower, it is converged to 0 (100% output). If the operation value is higher than "(M + 1) × 2", it is converged to (M + 1) × 2 (0% output).

(2) Interrupt requests

Two types of interrupt requests are available: the INTTAB1CC0 (crest interrupt) signal and INTTAB1OV (valley interrupt) signal.

The INTTAB1CC0 and INTTAB1OV signals can be culled by using the TAB1OPT1 register.

For details of culling interrupts, see **11.4.3 Interrupt culling function**.

- INTTAB1CC0 (crest interrupt) signal: An interrupt signal indicating a match between the value of the 16-bit counter that counts up and the value of the TAB1CCR0 register
- INTTAB1OV (valley interrupt) signal: An interrupt signal indicating a match between the value of the 16-bit counter that counts down and the value 0001H

(3) Rewriting registers during timer operation

The following registers have a buffer register and can be rewritten in the anytime rewrite mode, batch rewrite mode, or intermittent batch rewrite mode.

Related Unit	Register
Timer AA1	TAA1 capture/compare register 0 (TAA1CCR0) TAA1 capture/compare register 1 (TAA1CCR1)
Timer AB1	TAB1 capture/compare register 0 (TAB1CCR0) TAB1 capture/compare register 1 (TAB1CCR1) TAB1 capture/compare register 2 (TAB1CCR2) TAB1 capture/compare register 3 (TAB1CCR3)
Timer Q1 option	TAB1 option register 1 (TAB1OPT1)

For details of the transfer function of the compare register, see **11.4.4 Operation to rewrite register with transfer function**.

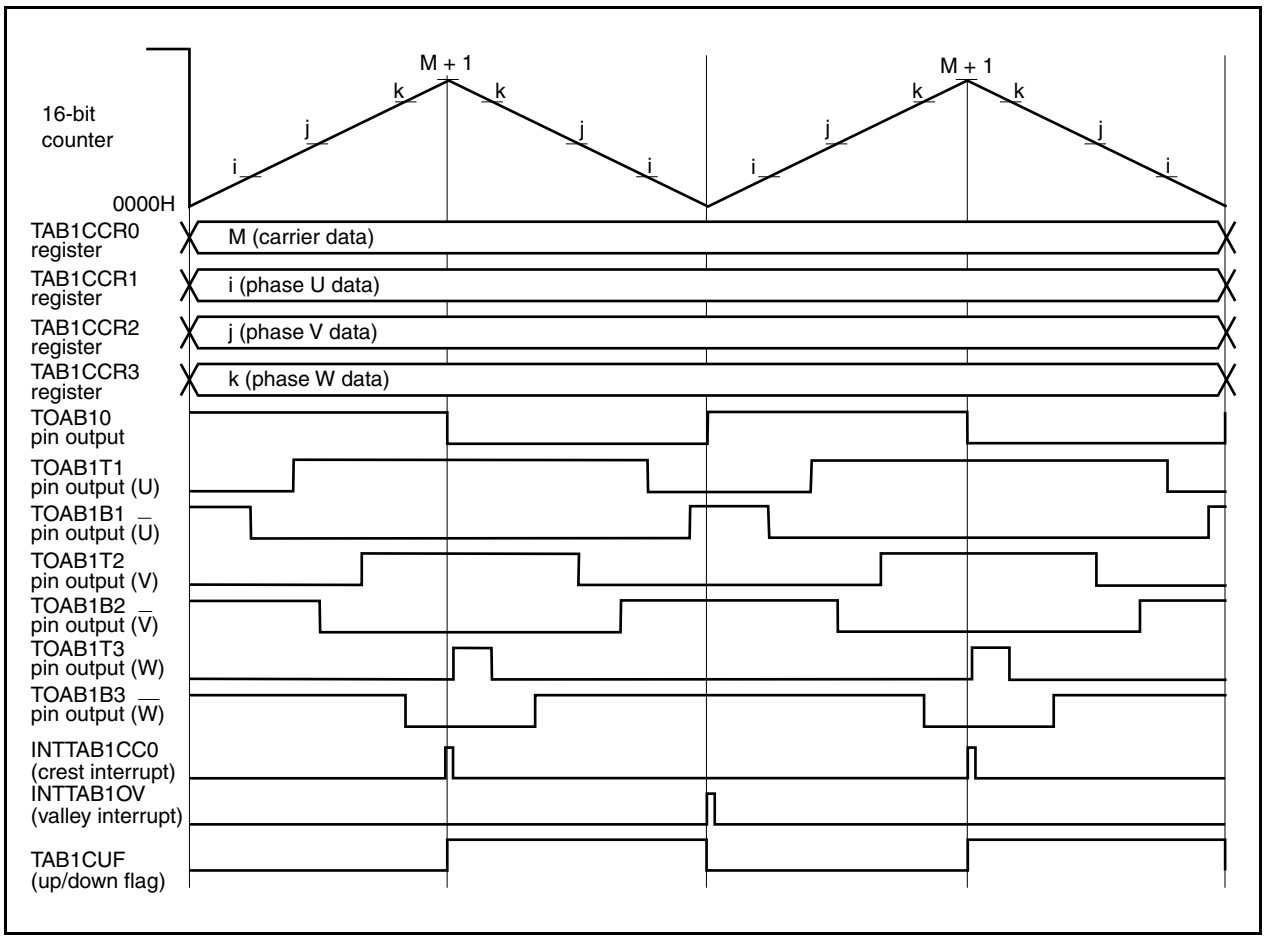
(4) Counting-up/down operation of 16-bit counter

The operation status of the 16-bit counter can be checked by using the TAB1CUF bit of TAB1 option register 0 (TAB1OPT0).

Status of TAB1CUF Bit	Status of 16-Bit Counter	Range of 16-Bit Counter Value
TAB1CUF bit = 0	Counting up	0000H – m
TAB1CUF bit = 1	Counting down	(m + 1) – 0001H

Remark m = Set value of TAB1CCR0 register

Figure 11-7. Interrupt and Up/Down Flag



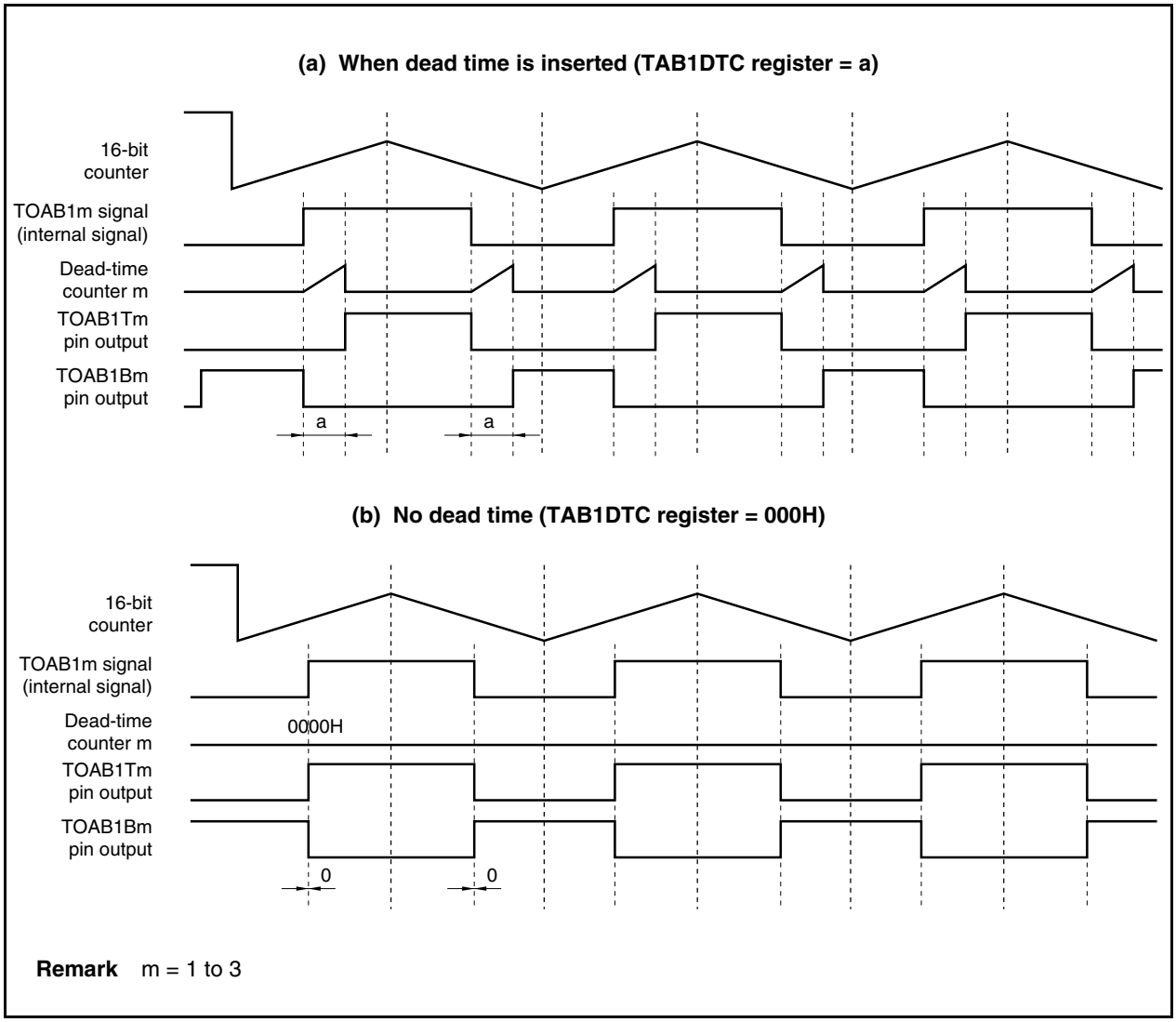
11.4.2 Dead-time control (generation of negative-phase wave signal)

(1) Dead-time control mechanism

In the 6-phase PWM output mode, compare registers 1 to 3 (TAB1CCR1, TAB1CCR2, and TAB1CCR3) are used to set the duty factor, and compare register 0 (TAB1CCR0) is used to set the cycle. By setting these four registers and by starting the operation of TAB1, three types of PWM output waves (basic 3-phase waves) with a variable duty factor are generated. These three PWM output waves are input to the timer Q option unit (TMQOP) and their inverted signal with dead-time is created to generate three sets of (six) PWM waves.

The TMQOP unit consists of three 10-bit counters (dead-time counters 1 to 3) that operate in synchronization with the count clock of TAB1, and a TAB1 dead-time compare register (TAB1DTC) that specifies dead time. If “a” is set to the TAB1DTC register, the dead-time value is “a”, and interval “a” is created between a positive-phase wave and a negative-phase wave.

Figure 11-8. PWM Output Wave with Dead Time (1)



Remark m = 1 to 3

(2) PWM output of 0%/100%

The V850ES/V850ES/JG3-H and V850ES/JH3-H are capable of 0% wave output and 100% wave output for PWM output.

A low level is continuously output from the TOAB1Tm pin as the 0% wave output. A high level is continuously output from the TOAB1Tm pin as the 100% wave output.

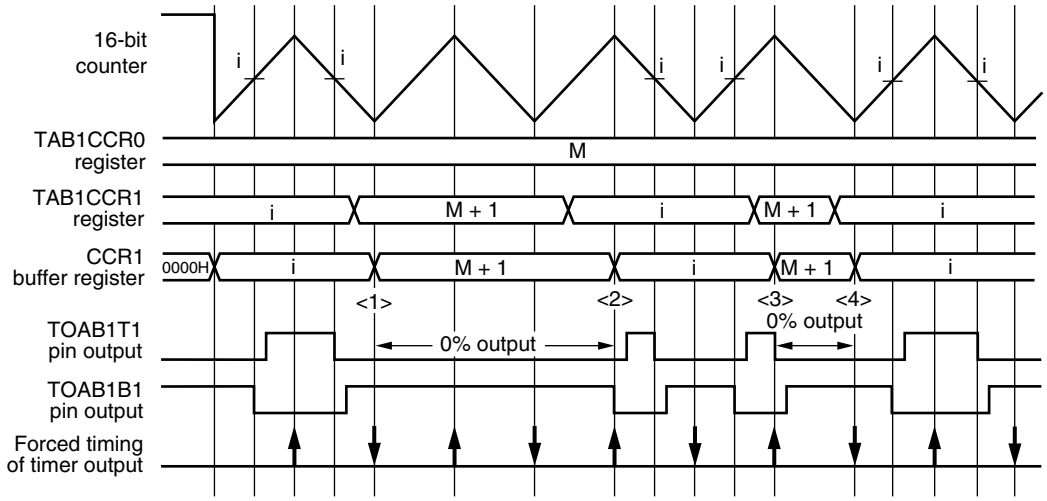
A 0% wave is output by setting the TAB1CCRm register to "M + 1" when the TAB1CCR0 register = M.

A 100% wave is output by setting the TAB1CCRm register to "0000H".

Rewriting the TAB1CCRm register is enabled while the timer is operating, and 0% wave output or 100% wave output can be selected at the point of the crest interrupt (INTTAB1CC0) and valley interrupt (INTTAB1OV).

Remark m = 1 to 3

Figure 11-9. 0% PWM Output Waveform (With Dead Time)



<1> 0% output is selected by the valley interrupt (without a match with the 16-bit counter).
The valley interrupt forcibly lowers the timer output. This produces the 0% output.

<2> 0% output is canceled by the crest interrupt (without a match with the 16-bit counter).
The crest interrupt forcibly raises the timer output. This cancels the 0% output.

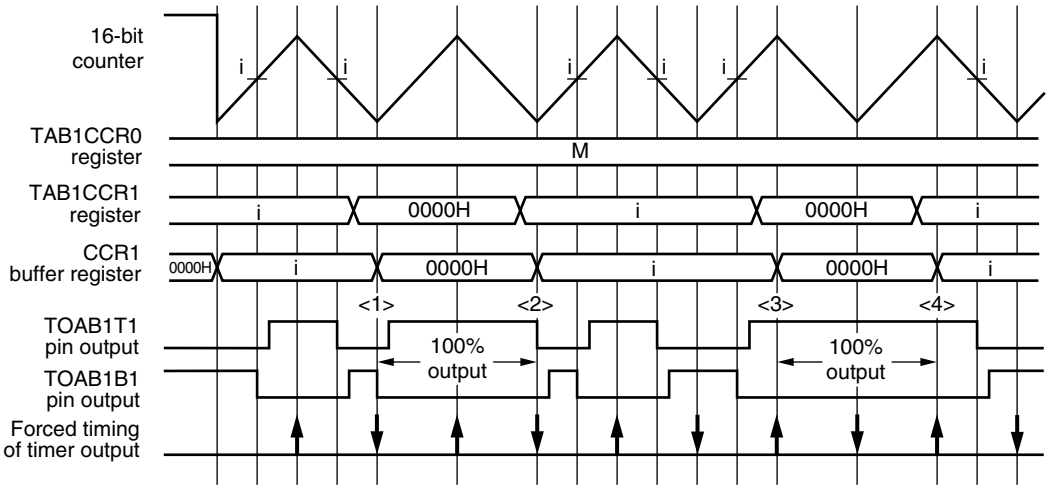
<3> 0% output is selected by the crest interrupt (with a match with the 16-bit counter).
The crest interrupt forcibly raises the timer output, but lowering the timer output takes precedence when the value of the TAB1CCRm register matches the value of the 16-bit counter. As a result, the 0% wave is output.

<4> 0% output is canceled by the valley interrupt (without a match with the 16-bit counter).
The valley interrupt forcibly lowers the timer output. This cancels the 0% output.

Remarks 1. ↑ means forcible raising and ↓ means forcible lowering.

2. m = 1 to 3

Figure 11-10. 100% PWM Output Waveform (With Dead Time)



<1> 100% output is selected by the valley interrupt (with a match with the 16-bit counter).
The valley interrupt forcibly lowers the timer output, but raising the timer output takes precedence when the value of the TAB1CCRm register matches the value of the 16-bit counter. As a result, the 100% output is produced.

<2> 100% output is canceled by the valley interrupt (without a match with the 16-bit counter).
The valley interrupt forcibly lowers the timer output. This cancels the 100% output.

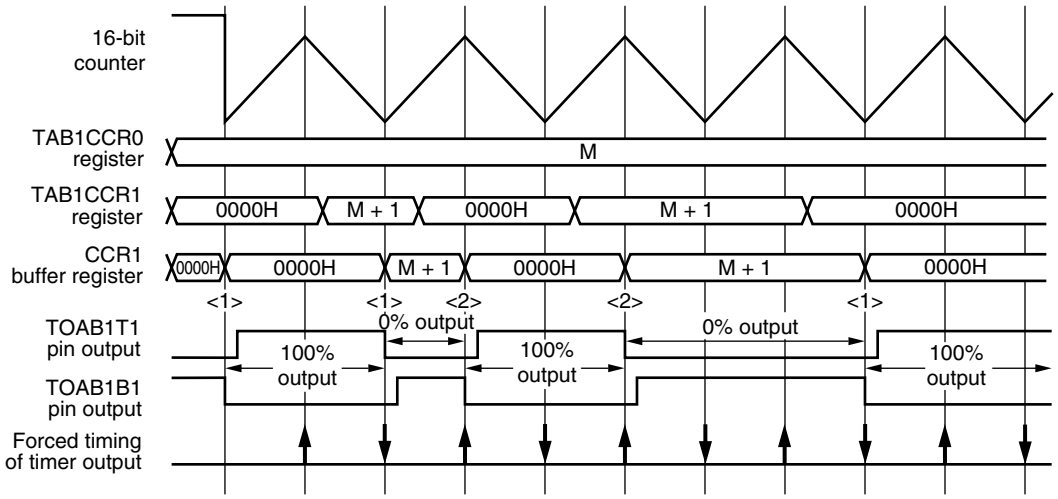
<3> 100% output is selected by the crest interrupt (without a match with the 16-bit counter).
The crest interrupt forcibly raises the timer output. This produces the 100% output.

<4> 100% output is canceled by the crest interrupt (without a match with the 16-bit counter).
The crest interrupt forcibly raises the timer output. This cancels the 100% output.

Remarks 1. ↑ means forcible raising and ↓ means forcible lowering.

2. m = 1 to 3

Figure 11-11. PWM Output Waveform from 0% to 100% and from 100% to 0% (With Dead Time)



<1> The valley interrupt selects 100% ←→ 0% or 0% ←→ 100% output.
Output can be selected from 100% ←→ 0% or 0% ←→ 100% immediately after the timer has been started.

<2> The crest interrupt selects 100% ←→ 0% output.
The crest interrupt selects 100% → 0% output by using the timer output forcible raising function and by a match between the 16-bit counter value and the TAB1CCR0 register value.

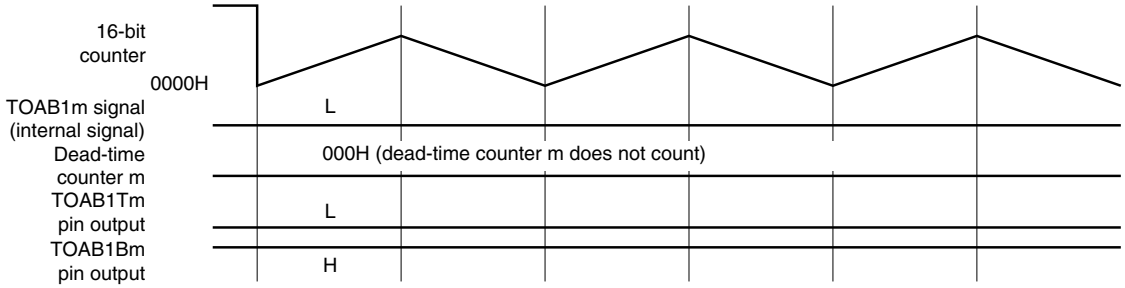
(3) Output waveform in vicinity of 0% and 100% output

If an interrupt is generated because the value of the 16-bit counter matches the value of the compare register while dead time is being counted, the dead-time counter is cleared and starts its count operation again.

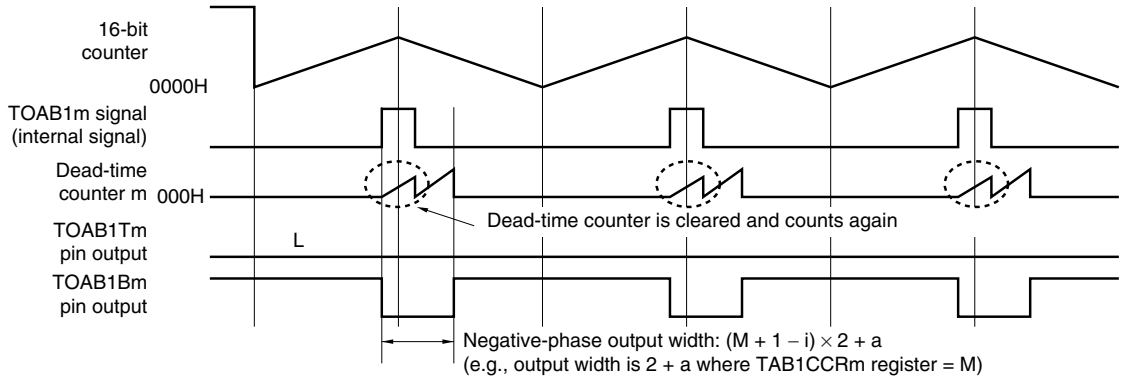
The output waveform of dead-time control in the vicinity of 0% and 100% output is shown below.

Figure 11-12. PWM Output Waveform with Dead Time (2)

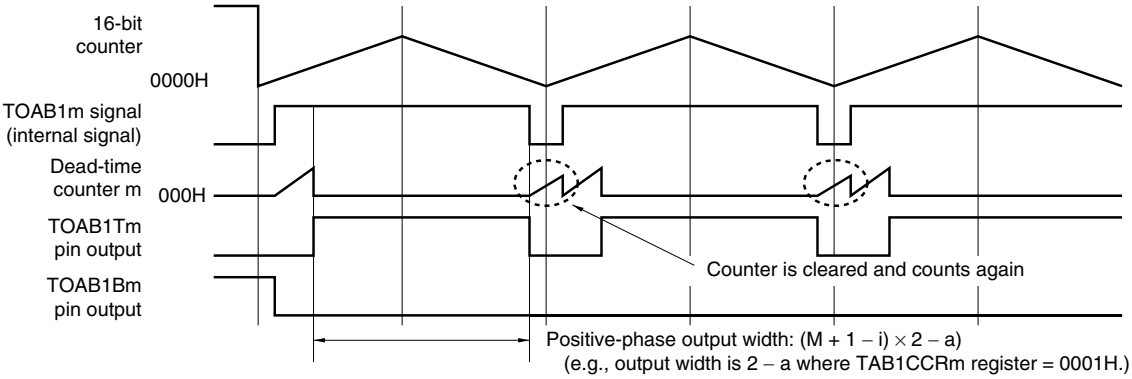
(a) 0% output (TAB1CCRm register = M + 1, TAB1CCR0 register = M, TAB1DTC register = a)



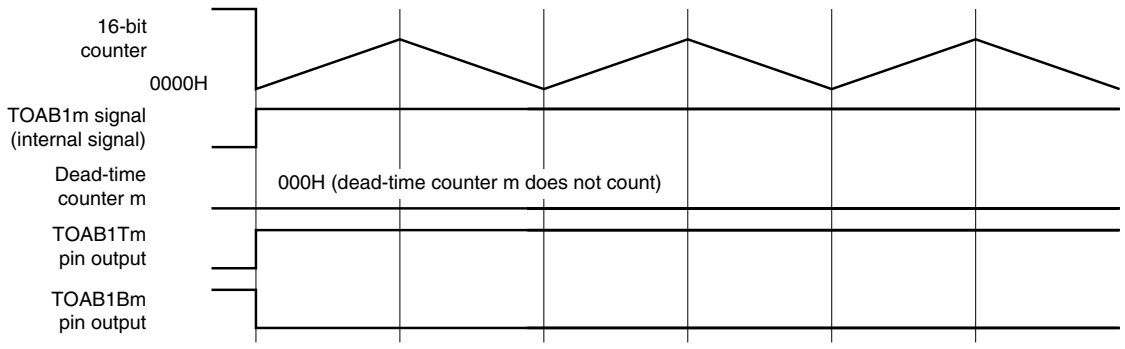
(b) In vicinity of 0% output (TAB1CCRm register = i ≥ M + 1 − a/2, TAB1CCR0 register = M, TAB1DTC register = a)



(c) In vicinity of 100% output (TAB1CCRm register = i ≤ a/2, TAB1CCR0 register = M, TAB1DTC register = a)



(d) 100% output (TAB1CCRm register = 0000H, TAB1CCR0 register = M, TAB1DTC register = a)



Remark m = 1 to 3

(4) Automatic dead-time width narrowing function (TAB1OPT2.TAB1DTM bit = 1)

The dead-time width can be automatically narrowed in the vicinity of 0% output or 100% output by setting the TAB1OPT2.TAB1DTM bit to 1.

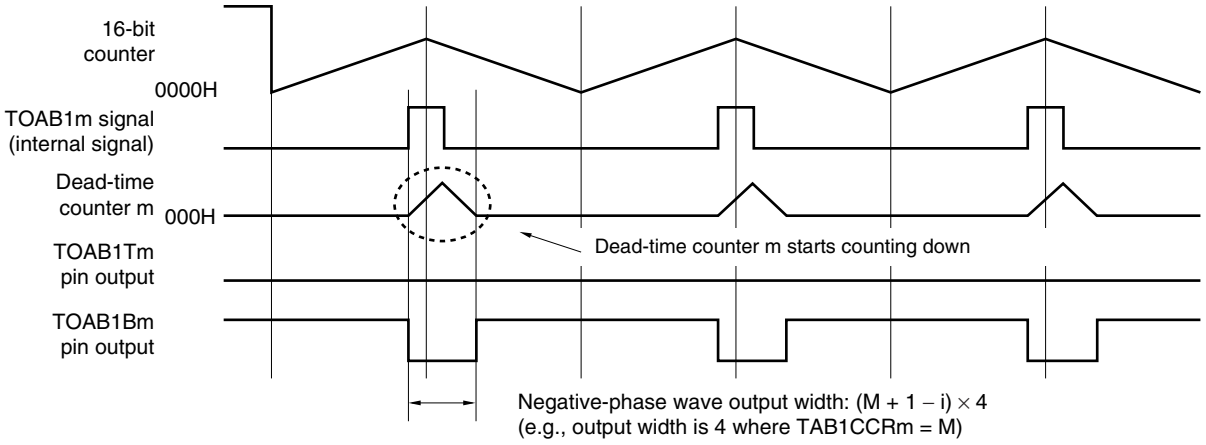
By setting the TAB1DTM bit to 1, the dead-time counter is not cleared, but starts down counting if the TOAB1m (internal signal) output of timer AB changes during dead-time counting.

The following timing chart shows the operation of the dead-time counter when the TAB1DTM bit is set to 1.

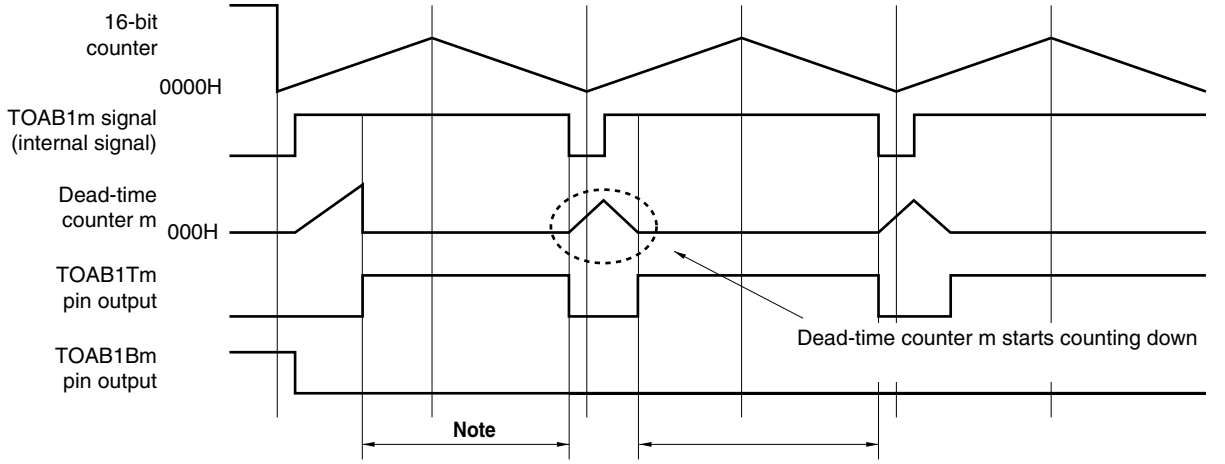
Figure 11-13. Operation of Dead-Time Counter m (1)

(a) In vicinity of 0% output

(TAB1CCRm register = i ≥ M + 1 − a/2, TAB1CCR0 register = M, TAB1DTC register = a)



(b) In vicinity of 100% output (TAB1CCRm register = i ≤ a/2, TAB1CCR0 register = M, TAB1DTC register = a)



Note The output width of the first wave differs from that of the second and subsequent waves immediately after the TAB1CTL0.TAB1CE bit has been set. The first wave is shorter than the second wave because the dead time is fully counted.

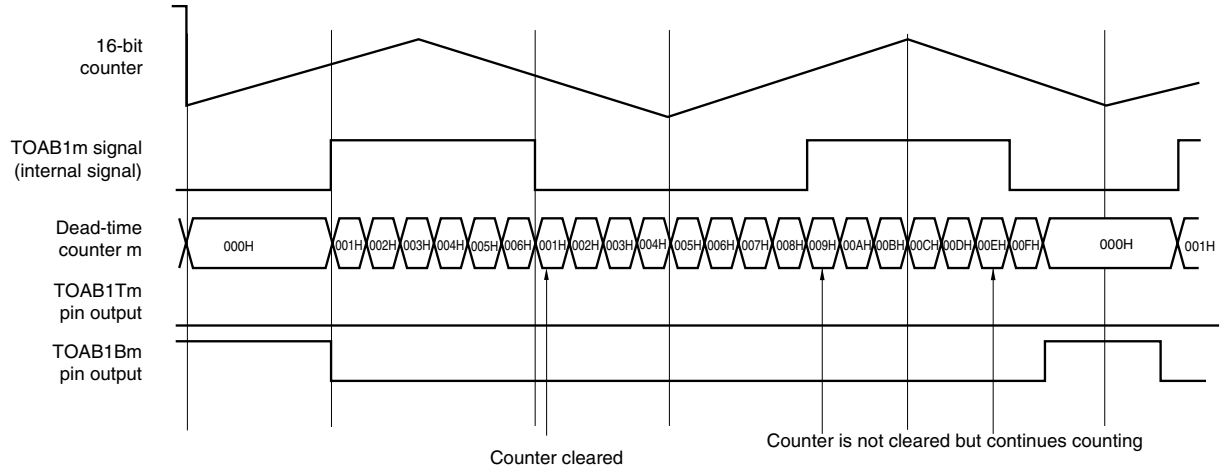
Remark m = 1 to 3

(5) Dead-time control in case of incorrect setting

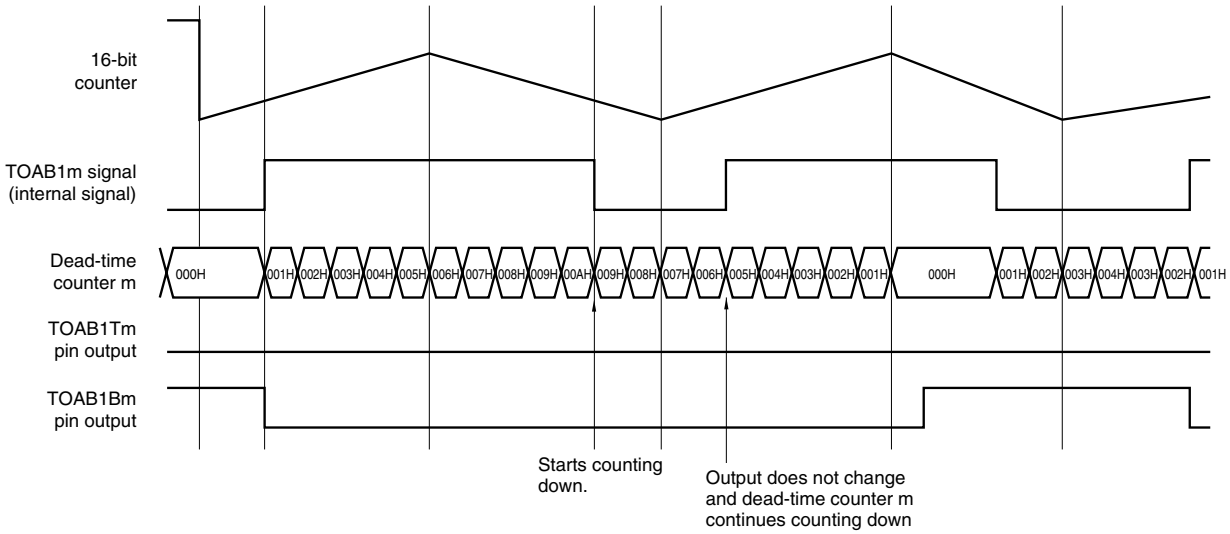
Usually, the TOAB1m (internal signal) output of TAB1 changes only once during dead-time counting, only in the vicinity of 0% and 100% output. This section shows an example where the TAB1CCR0 register (carrier cycle) and TAB1DTC register (dead-time value) are incorrectly set. If these registers are incorrectly set, the TOAB1m (internal signal) output of TAB1 changes twice or three times during dead-time counting. The following flowchart shows the 6-phase PWM output wave in this case.

Figure 11-14. Operation of Dead-Time Counter m (2)

(a) When TAB1OPT2.TAB1DTM bit = 0, TAB1CCR0 register = 0006H, TAB1DTC register = 000FH, TAB1CCRm register = 0004H



(b) When TAB1OPT2.TAB1DTM bit = 1, TAB1CCR0 register = 0006H, TAB1DTC register = 000FH, TAB1CCRm register = 0002H



Remark m = 1 to 3

11.4.3 Interrupt culling function

- The interrupts to be culled are INTTAB1CC0 (crest interrupt) and INTTAB1OV (valley interrupt).
- The TAB1OPT1.TAB1ICE bit is used to enable output of the INTTAB1CC0 interrupt and the number of times the interrupt is to be culled.
- The TAB1OPT1.TAB1IOE bit is used to enable output of the INTTAB1OV interrupt and the number of times the interrupt is to be culled.
- The TAB1OPT1.TAB1ID4 to TAB1OPT1.TAB1ID0 bits are used to specify the number of counts by which a specified interrupt is to be culled. The interrupt is masked for the duration of the specified number of counts and is generated at the next interrupt timing.
- The TAB1OPT2.TAB1RDE bit is used to specify whether transfer is to be culled or not.
  If it is specified that transfer is to be culled, transfer is executed at the same timing as the interrupt output after culling.
  If it is specified that transfer is not to be culled, transfer is executed at the transfer timing after the TAB1CCR1 register has been written.
- The TAB1OPT0.TAB1CMS bit is used to specify whether the registers with a transfer function are batch rewritten or anytime rewritten.
  The values of the registers are updated in synchronization with transfer when the TAB1CMS bit is 0. When the TAB1CMS bit is 1, the values of the registers are immediately updated when a new value is written to the registers.
  Transfer is performed from the TAB1CCRm register to the CCRm buffer register in synchronization with the interrupt culling timing.

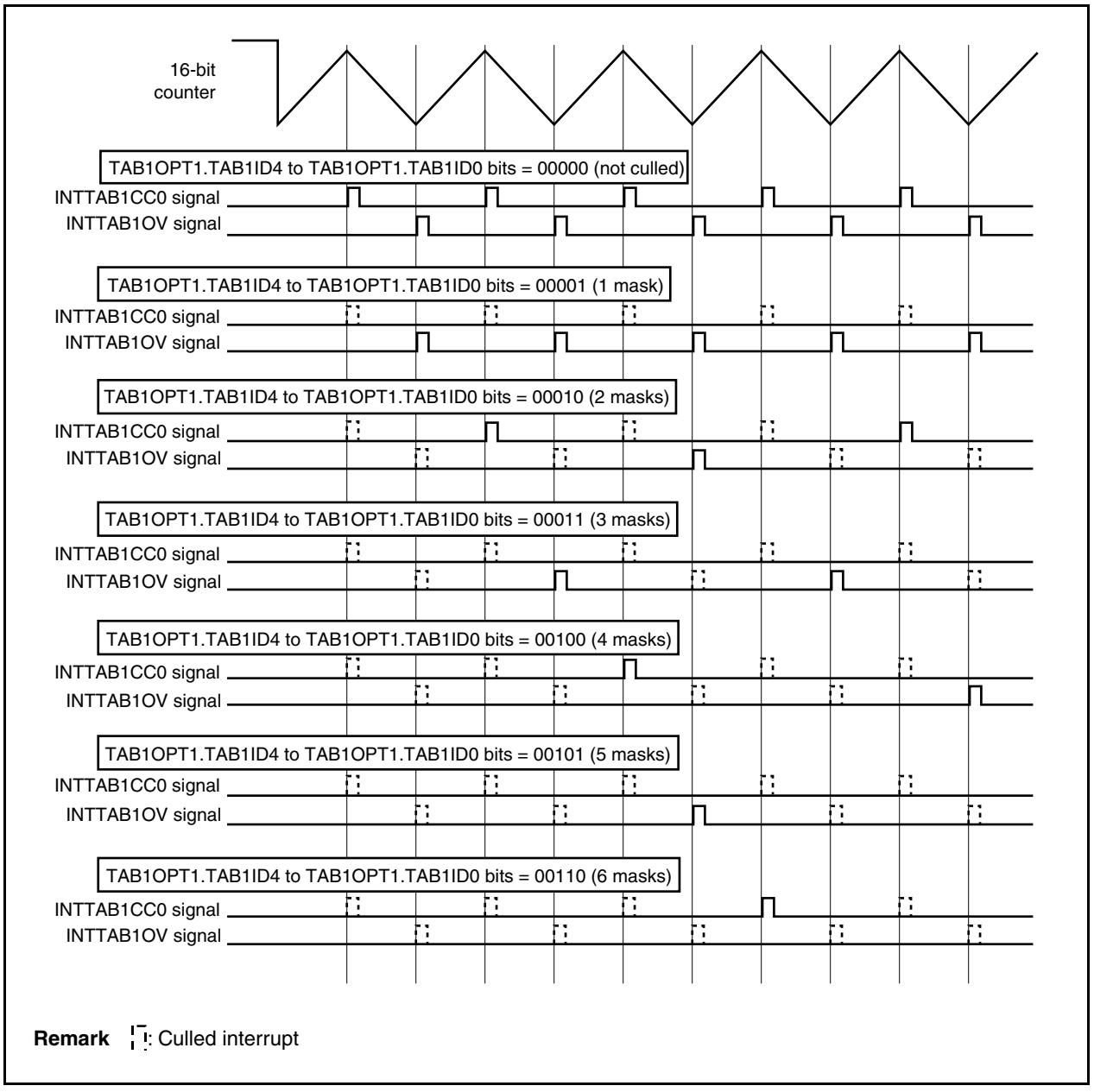
Cautions 1. When using the interrupt culling function in the batch rewrite mode (transfer mode), execute the function in the intermittent batch rewrite mode (transfer culling mode).

2. The interrupt is generated at the timing after culling.

Remark m = 1 to 3

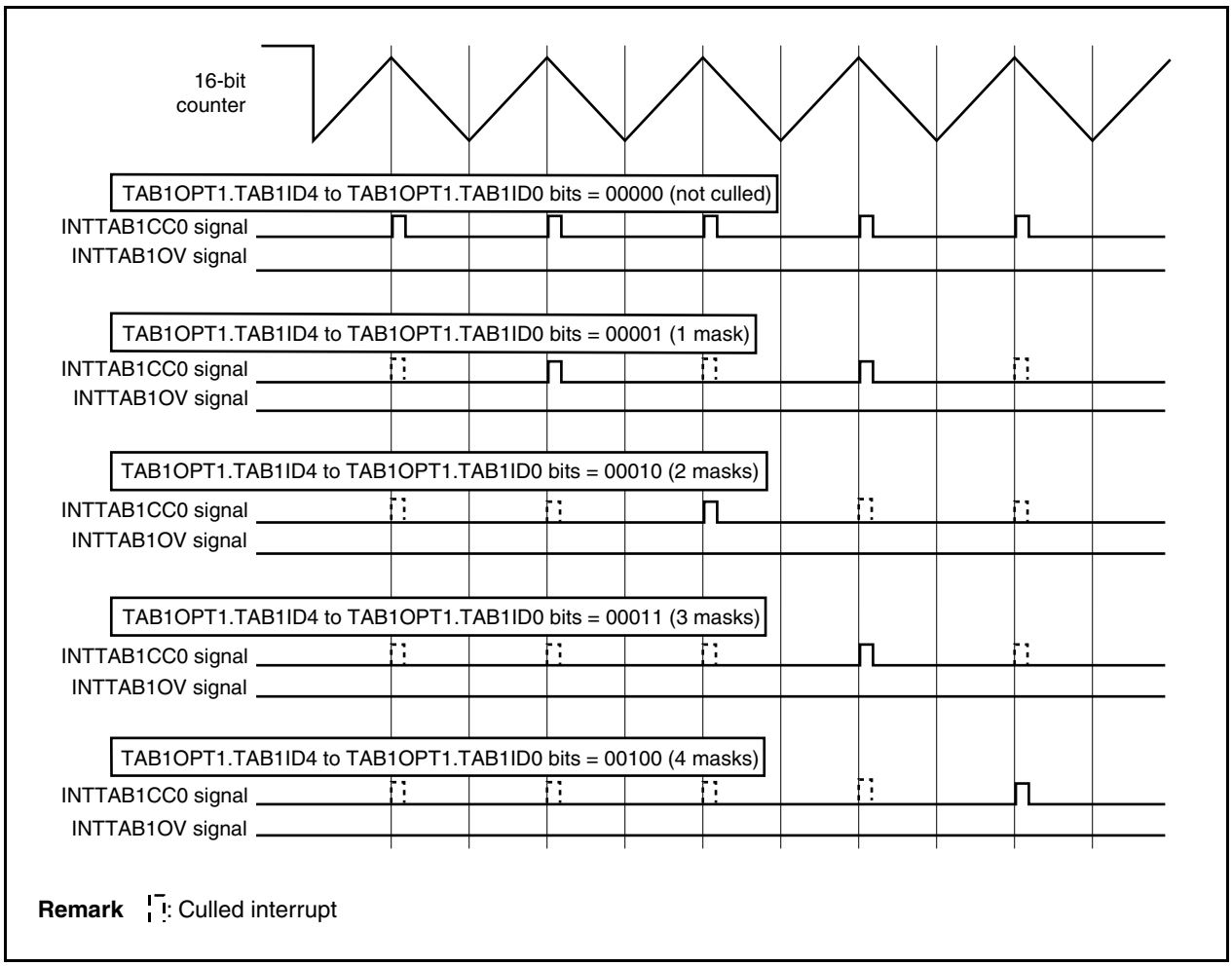
(1) Interrupt culling operation

Figure 11-15. Interrupt Culling Operation When TAB1OPT1.TAB1ICE Bit = 1, TAB1OPT1.TAB1IOE Bit = 1, TAB1OPT2.TAB1RDE Bit = 1 (Crest/Valley Interrupt Output)



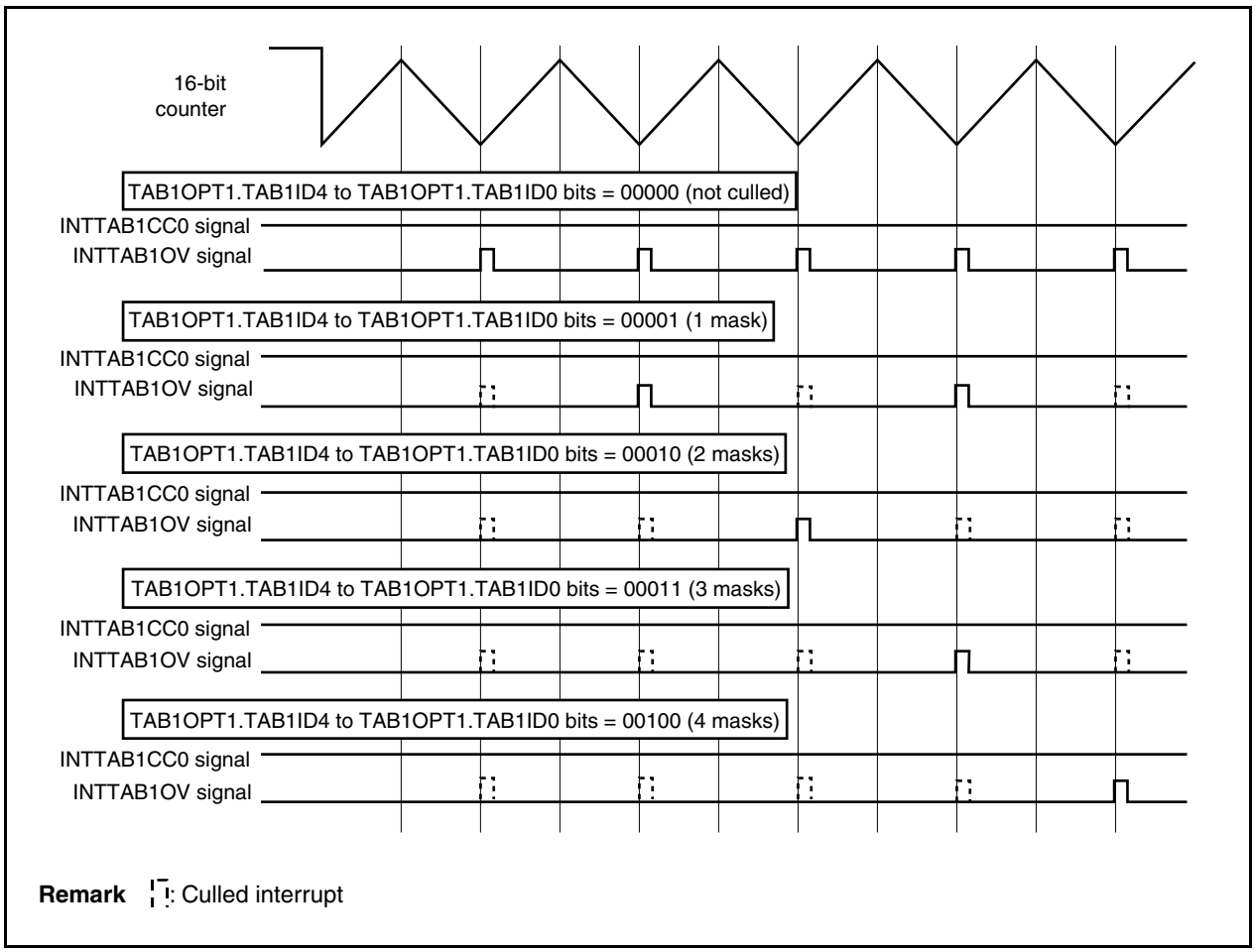
Remark : Culled interrupt

Figure 11-16. Interrupt Culling Operation When TAB1OPT1.TAB1ICE Bit = 1, TAB1OPT1.TAB1IOE Bit = 0, TAB1OPT2.TAB1RDE Bit = 1 (Crest Interrupt Output)



Remark : Culled interrupt

Figure 11-17. Interrupt Culling Operation When TAB1OPT1.TAB1ICE Bit = 0, TAB1OPT1.TAB1IOE Bit = 1, TAB1OPT2.TAB1RDE Bit = 1 (Valley Interrupt Output)



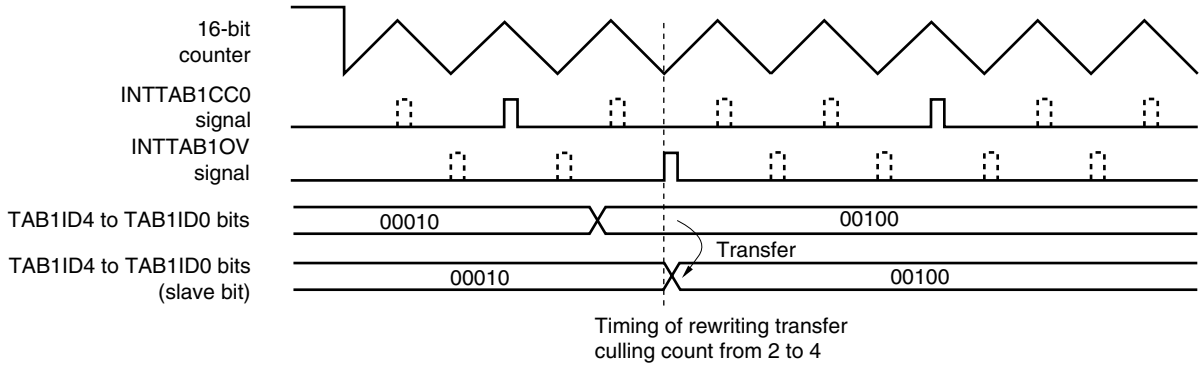
Remark : Culled interrupt

(2) To alternately output crest interrupt (INTTAB1CC0) and valley interrupt (INTTAB1OV)

To alternately output the crest and valley interrupts, set both the TAB1OPT1.TAB1ICE and TAB1OPT1.TAB1IOE bits to 1.

Figure 11-18. Crest/Valley Interrupt Output

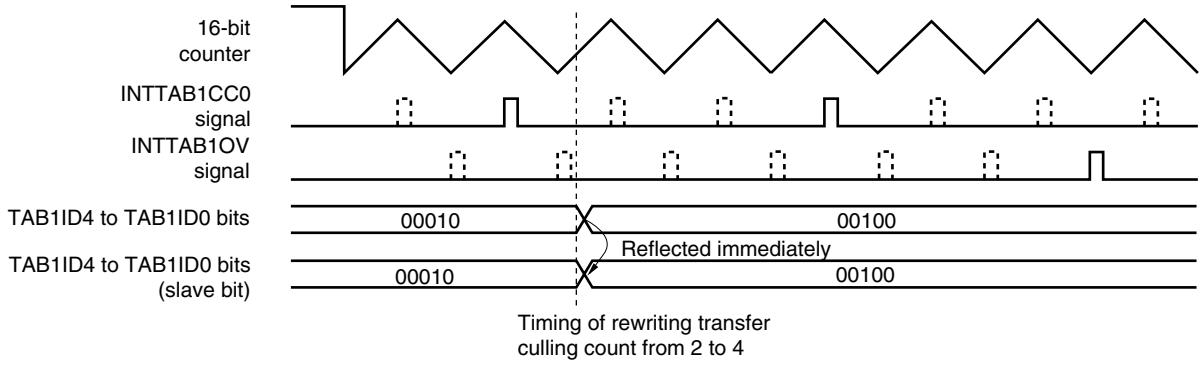
(a) TAB1OPT0.TAB1CMS bit = 0, TAB1OPT2.TAB1RDE bit = 1 (with transfer culling control)



Remarks 1. Transfer is performed at the culled interrupt output timing. The other transfer timing is ignored.

2. : Culled interrupt

(b) TAB1CMS bit = 1, TAB1RDE bit = 0 or 1 (without transfer control)



Remarks 1. Rewriting is reflected immediately. The transfer timing is ignored.

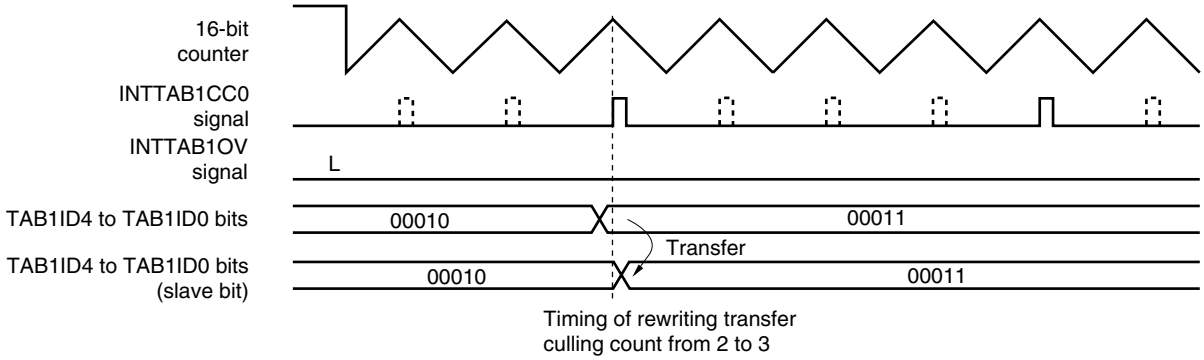
2. : Culled interrupt

(3) To output only crest interrupt (INTTAB1CC0)

Set the TAB1OPT1.TAB1ICE bit to 1 and clear the TAB1OPT1.TAB1IOE bit to 0.

Figure 11-19. Crest Interrupt Output

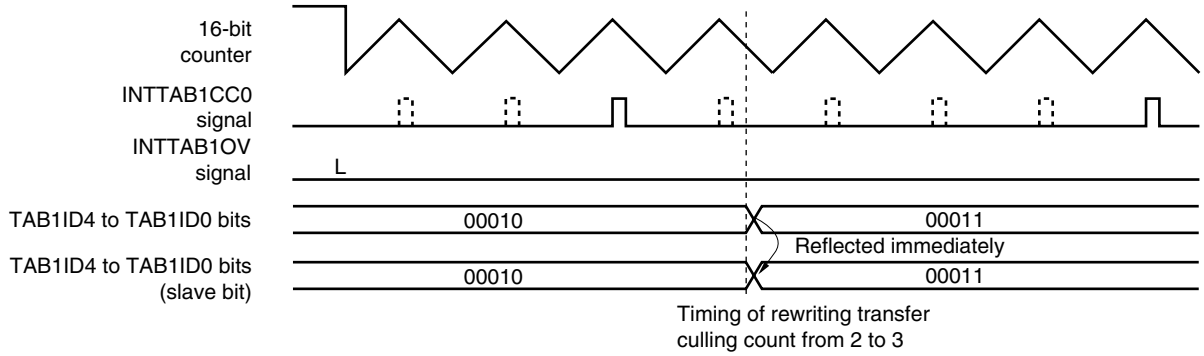
(a) TAB1OPT0.TAB1CMS bit = 0, TAB1OPT2.TAB1RDE bit = 1 (with transfer culling control)



Remarks 1. Transfer is performed at the culled interrupt output timing. The other transfer timing is ignored.

2. : Culled interrupt

(b) TAB1CMS bit = 1, TAB1RDE bit = 0 or 1 (without transfer control)



Remarks 1. Rewriting is reflected immediately. The transfer timing is ignored.

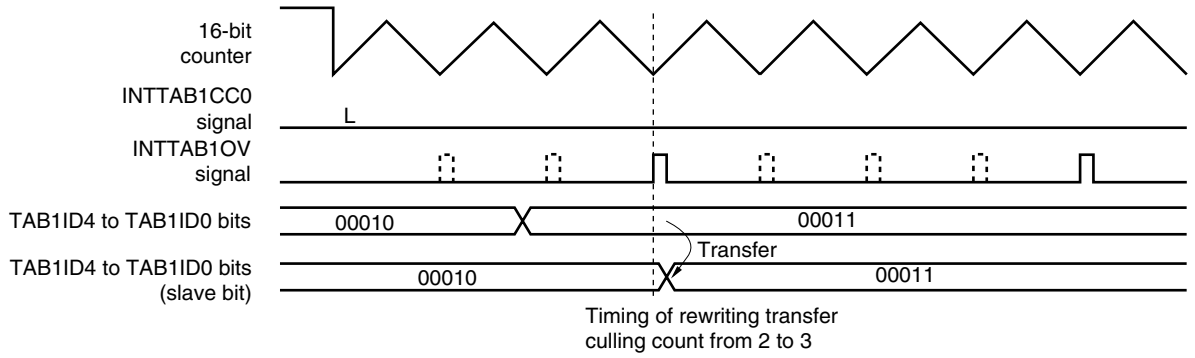
2. : Culled interrupt

(4) To output only valley interrupt (INTTAB1OV)

Clear the TAB1OPT1.TAB1ICE bit to 0 and set the TAB1IOE bit to 1.

Figure 11-20. Valley Interrupt Output

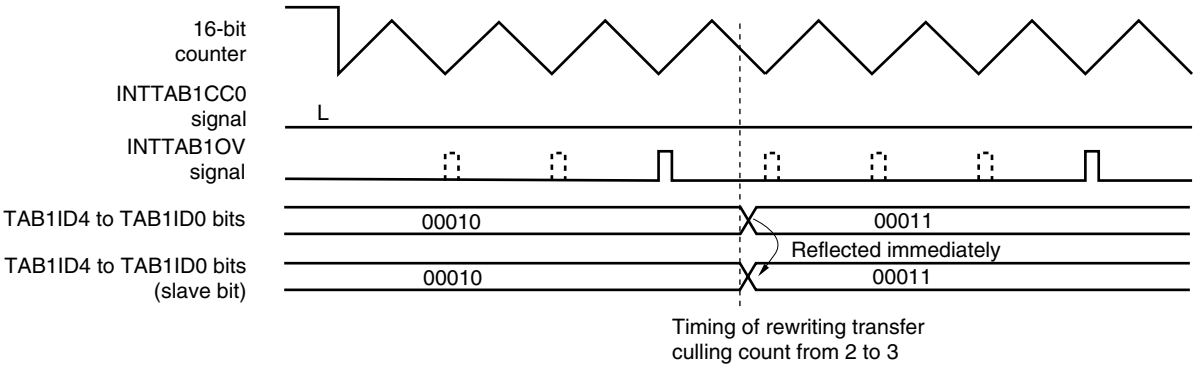
(a) TAB1OPT0.TAB1CMS bit = 0, TAB1OPT2.TAB1RDE bit = 1 (with transfer culling control)



Remarks 1. Transfer is performed at the culled interrupt output timing. The other transfer timing is ignored.

2. : Culled interrupt

(b) TAB1CMS bit = 1, TAB1RDE bit = 0 or 1 (without transfer control)



Remarks 1. Rewriting is reflected immediately. The transfer timing is ignored.

2. : Culled interrupt

11.4.4 Operation to rewrite register with transfer function

The following seven registers are provided with a transfer function and are used to control a motor. Each of the registers has a buffer register.

- TAB1CCR0: Register that specifies the cycle of the 16-bit counter (TAB)
- TAB1CCR1: Register that specifies the duty factor of TOAB1T1 (U) and TOAB1B1 ($\overline{U}$)
- TAB1CCR2: Register that specifies the duty factor of TOAB1T2 (V) and TOAB1B2 ($\overline{V}$)
- TAB1CCR3: Register that specifies the duty factor of TOAB1T3 (W) and TOAB1B3 ($\overline{W}$)
- TAB1OPT1: Register that specifies the culling of interrupts
- TAA4CCR0: Register that specifies the A/D conversion start trigger generation timing (TAA4 during tuning operation)
- TAA4CCR1: Register that specifies the A/D conversion start trigger generation timing (TAA4 during tuning operation)

The following three rewrite modes are provided in the registers with a transfer function.

- Anytime rewrite mode

  This mode is set by setting the TAB1OPT0.TAB1CMS bit to 1. The specification of the TAB1OPT2.TAB1RDE bit is ignored.

  In this mode, each compare register is updated independently, and the value of the compare register is updated as soon as a new value is written to it.

- Batch rewrite mode (transfer mode)

  This mode is set by clearing the TAB1OPT0.TAB1CMS bit to 0, the TAB1OPT1.TAB1ID4 to TAB1OPT1.TAB1ID0 bits to 00000, and the TAB1OPT2.TAB1RDE bit to 0.

  When data is written to the TAB1CCR1 register, data in the seven registers are transferred to the buffer register all at once at the next transfer timing. Unless the TAB1CCR1 register is rewritten, the transfer operation is not performed even if the other six registers are rewritten.

  The transfer timing is the timing of each crest (match between the 16-bit counter value and TAB1CCR0 register value) and valley (match between the 16-bit counter value and 0001H) regardless of the interrupt.

- Intermittent batch rewrite mode (transfer culling mode)

  This mode is set by clearing the TAB1OPT0.TAB1CMS bit to 0 and setting the TAB1OPT2.TAB1RDE bit to 1.

  When data is written to the TAB1CCR1 register, data from the seven registers is transferred to the buffer register all at once at the next transfer timing. Unless the TAB1CCR1 register is rewritten, the transfer operation is not performed even if the other six registers are rewritten.

  If interrupt culling is specified by the TAB1OPT1 register, the transfer timing is also culled as the interrupts are culled, and data from the seven registers is transferred all at once at the culled timing of the crest interrupt (match between the 16-bit counter value and TAB1CCR0 register value) or valley interrupt (match between the 16-bit counter value and 0001H).

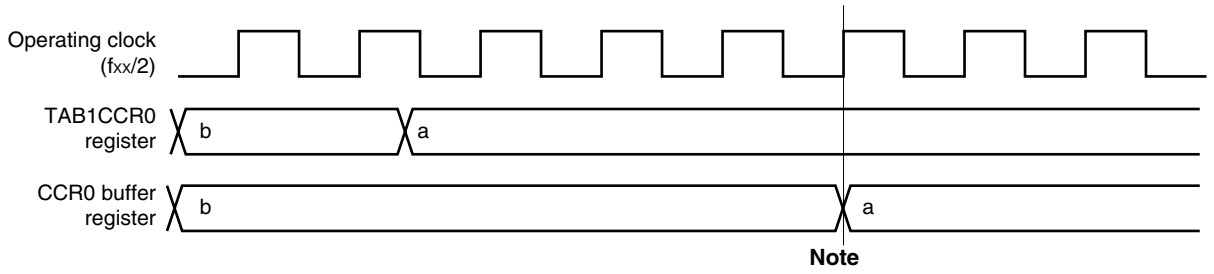
  For details of the interrupt culling function, see **11.4.3 Interrupt culling function**.

(1) Anytime rewrite mode

This mode is set by setting the TAB1OPT0.TAB1CMS bit to 1. The setting of the TAB1OPT2.TAB1RDE bit is ignored.

In this mode, the value written to each register with a transfer function is immediately transferred to an internal buffer register and compared with the value of the counter. If a register with transfer function is rewritten in this mode after the count value of the 16-bit counter matches the value of the TAB1CCRm register, the rewritten value is not reflected because the next match is ignored after the first match has occurred. If the register is rewritten during counting up, the new register value becomes valid after the counter has started counting down.

Figure 11-21. Timing of Reflecting Rewritten Value

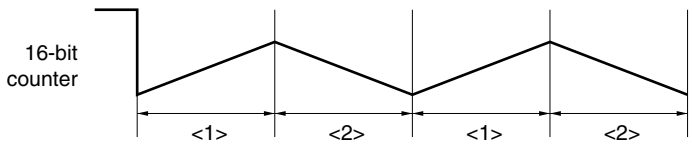


Note After the register (TAB1CCR0, TAB1CCR2, TAB1CCR3, TAB1OPT1, TAA4CCR0, or TAA4CCR1) has been written, the written value is transferred to an internal buffer register after four clocks of the operating clock. However, the value of the TAB1CCR1 register is transferred after 5 clocks.

(a) Rewriting TAB1CCR0 register

Even if the TAB1CCR0 register is rewritten in the anytime rewrite mode, the new value may not be reflected in some cases.

Figure 11-22. Example of Rewriting TAB1CCR0 Register



Rewriting during period <1> (rewriting during counting up)

If the newly rewritten value is greater than the value of the 16-bit counter, there is no problem because it will match the value of the 16-bit counter. If the new value is less than the value of the 16-bit counter, it will not match the value of the counter. As a result, the 16-bit counter overflows and continues counting up from 0000H until it matches the register value again, and the correct PWM waveform is not output.

Rewriting during period <2> (rewriting during counting down)

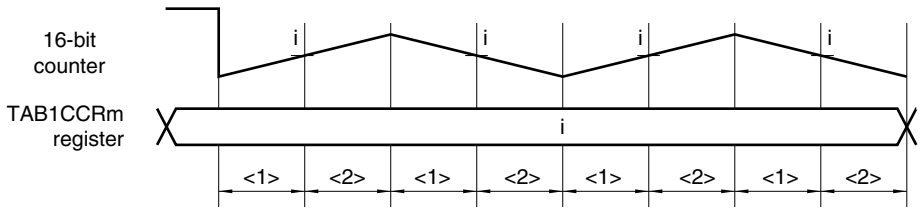
A match with the value of the 16-bit counter is ignored during counting down. Therefore, the rewritten period value is reflected as the match point starting from counting up in the next cycle.

(b) Rewriting TAB1CCRm register

Figure 11-24 shows the timing of rewriting before the value of the 16-bit counter matches the value of the TAB1CCRm register (<1> in Figure 11-23), and Figure 11-25 shows the timing of rewriting after the value of the 16-bit counter matches the value of the TAB1CCRm register (<2> in Figure 11-23).

Figure 11-23. Basic Operation of 16-Bit Counter and TAB1CCRm Register

(a) Basic figure



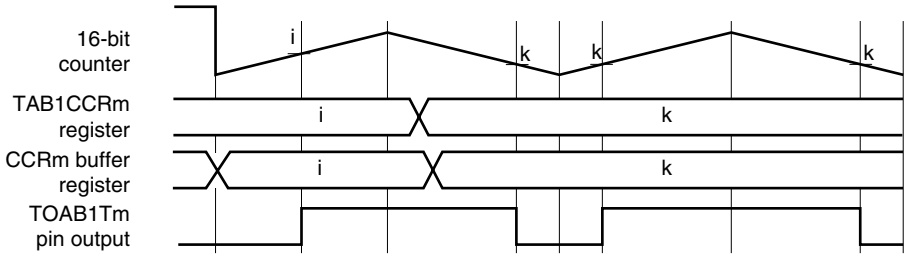
Remarks 1. i = Set value of TAB1CCRm register

2. m = 1 to 3

Figure 11-24. Example of Rewriting TAB1CCR1 to TAB1CCR3 Registers (Rewriting Before Match Occurs)

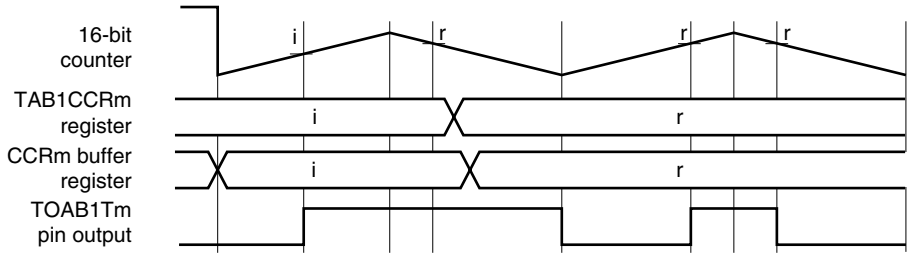
(a)

If the TAB1CCRm register is rewritten before its value matches the value of the 16-bit counter, the register value will match the value of the 16-bit counter after the register has been rewritten. Consequently, the new register value is immediately reflected.



(b)

If a value less than the value of the 16-bit counter (greater if the counter is counting down) is written to the TAB1CCRm register, the output waveform is as follows because the register value does not match the counter value.

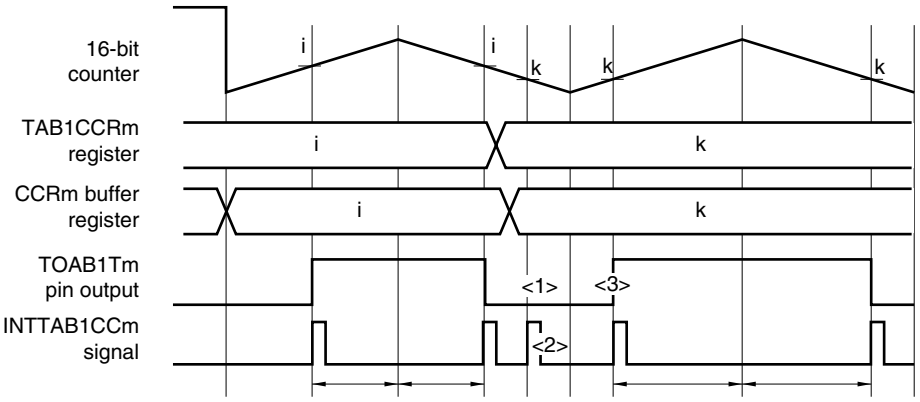


If the register value does not match the counter value, the TOAB1Tm pin output does not change. Even if the value of the 16-bit counter does not match the value of the TAB1CCRm register, the TOAB1Tm pin output always changes to the high level if the crest interrupt occurs and to the low level if the valley interrupt occurs.
This is a function provided for 0% output and 100% output.
For details, see **11.4.2 (2) PWM output of 0%/100%**.

Remarks 1. i, r, k = Set values of TAB1CCRm register

2. m = 1 to 3

Figure 11-25. Example of Rewriting TAB1CCR1 to TAB1CCR3 Registers (Rewriting After Match Occurs)



<1> Matching of the count value of the 16-bit counter and the value of the TAB1CCRm register as a result of rewriting the register is ignored after a match signal has been generated, and the PWM output does not change.

<2> Even if the PWM output does not change, the interrupt generated upon a match between the 16-bit counter value and the TAB1CCRm register value (INTTAB1CCm) is output.

<3> The next match between the 16-bit counter and TAB1CCRm register is valid after the counter has changed its counting direction to up or down, and the PWM output changes.

If the TAB1CCRm register is rewritten after its value matches the value of the 16-bit counter, the next match is ignored after the first match occurs and the rewritten value is not reflected in the TOAB1Tm pin output. If the register is rewritten while the counter is counting down, the match that occurs after the counter starts counting down is valid (the match that occurs after the counter has started counting up is valid if the register is rewritten while the counter is counting up).

Remarks 1. i, r, k = Set value of TAB1CCRm register

2. m = 1 to 3

(c) Rewriting TAB1OPT1 register

The interrupt culling counter is cleared when the TAB1OPT1 register is written. When the interrupt culling counter has been cleared, the measured number of times the interrupt has occurred is discarded. Consequently, the interrupt generation interval is temporarily extended.

To avoid this operation, rewrite the TAB1OPT1 register in the intermittent batch rewrite mode (transfer culling mode).

For details of rewriting the TAB1OPT1 register, see **11.4.3 Interrupt culling function**.

(2) Batch rewrite mode (transfer mode)

This mode is set by clearing the TAB1OPT0.TAB1CMS bit to 0, the TAB1OPT1.TAB1ID4 to TAB1OPT1.TAB1ID0 bits to 00000, and the TAB1OPT2.TAB1RDE bit to 0.

In this mode, the values written to each compare register are transferred to the internal buffer register all at once at the transfer timing and compared with the counter value.

(a) Rewriting procedure

If data is written to the TAB1CCR1 register, the values set to the TAB1CCR0 to TAB1CCR3, TAB1OPT1, TAA4CCR0, and TAA4CCR1 registers are transferred all at once to the internal buffer register at the next transfer timing. Therefore, write to the TAB1CCR1 register last. Writing to the register is prohibited after the TAB1CCR1 register has been written and before the transfer timing is generated (until the crest (match between the 16-bit counter value and TAB1CCR0 register value) or the valley (match between the 16-bit counter value and 0001H)). The operation procedure is as follows.

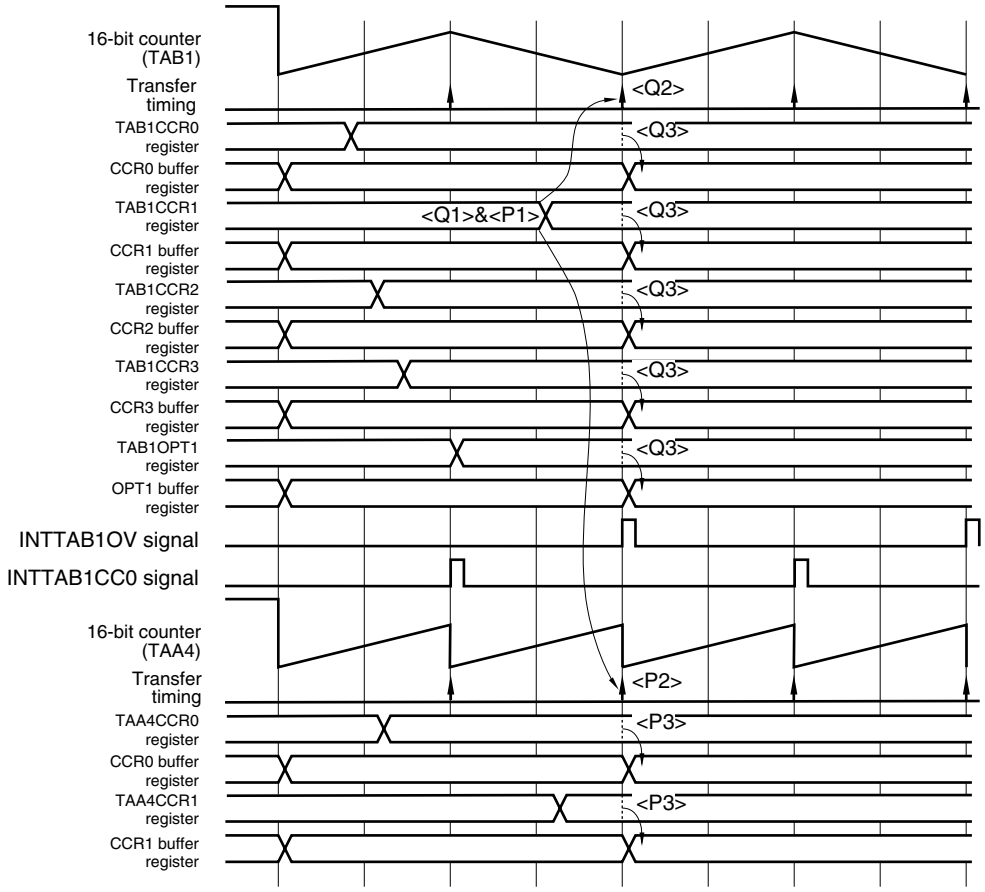
<1> Rewriting the TAB1CCR0, TAB1CCR2, TAB1CCR3, TAB1OPT1, TAA4CCR0, and TAA4CCR1 registers
Do not rewrite registers that do not have to be rewritten.

<2> Rewriting the TAB1CCR1 register
Rewrite the same value to the register even when it is not necessary to rewrite the TAB1CCR1 register.

<3> Holding the next rewriting pending until the transfer timing is generated
Rewrite the register next time after the INTTAB1OV or INTTAB1CC0 interrupt has occurred.

<4> Return to <1>.

Figure 11-26. Basic Operation in Batch Mode



[Operation of TAB1]

<Q1> Write the TAB1CCR1 register

<Q2> The target timing is the first transfer timing after a write to the TAB1CCR1 register.

<Q3> The values are transferred all at once at the transfer timing.

[Operation of TAA4]

<P1> Write the TAB1CCR1 register

<P2> The target timing is the first transfer timing after a write to the TAB1CCR1 register.

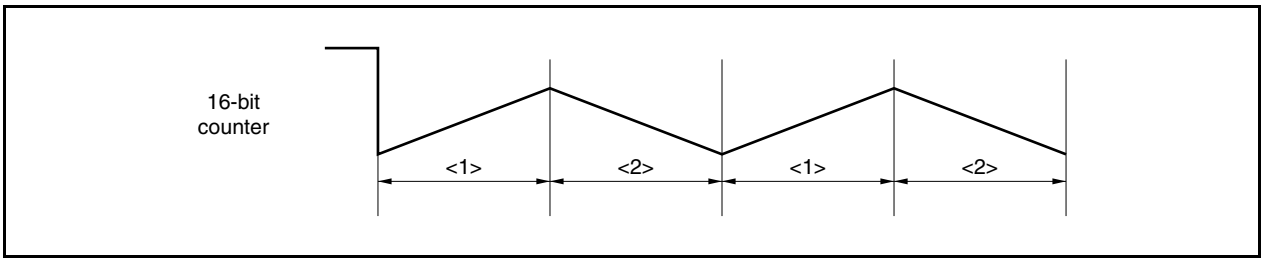
<P3> The values are transferred all at once at the transfer timing.

(b) Rewriting TAB1CCR0 register

When rewriting the TAB1CCR0 register in the batch rewrite mode, the output waveform differs depending on whether transfer occurs at the crest (match between the 16-bit counter value and TAB1CCR0 register value) or at the valley (match between the 16-bit counter value and 0001H). Usually, it is recommended to rewrite the TAB1CCR0 register while the 16-bit counter is counting down, and transfer the register value at the transfer timing of the crest timing.

Figure 11-28 shows an example of rewriting the TAB1CCR0 register while the 16-bit counter is counting up (during period <1> in Figure 11-27). Figure 11-29 shows an example of rewriting the TAB1CCR0 register while the counter is counting down (during period <2> in Figure 11-27).

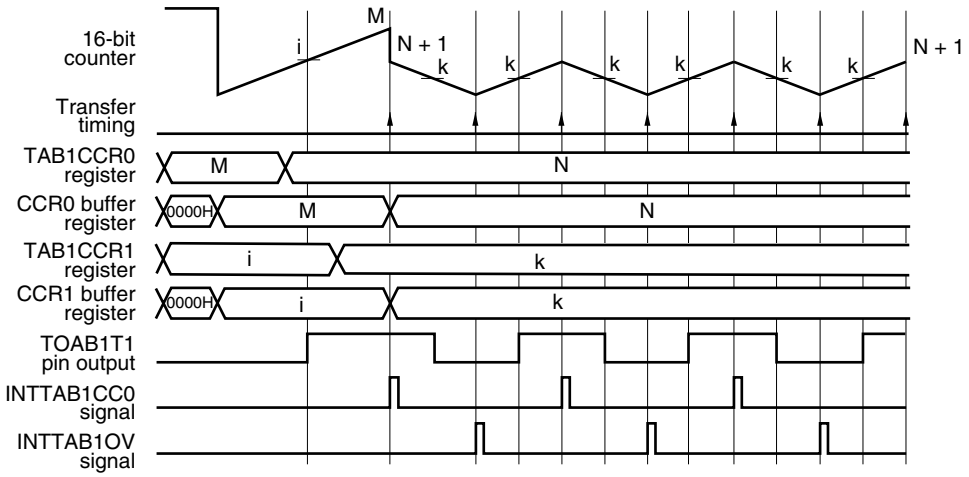
Figure 11-27. Basic Operation of 16-Bit Counter



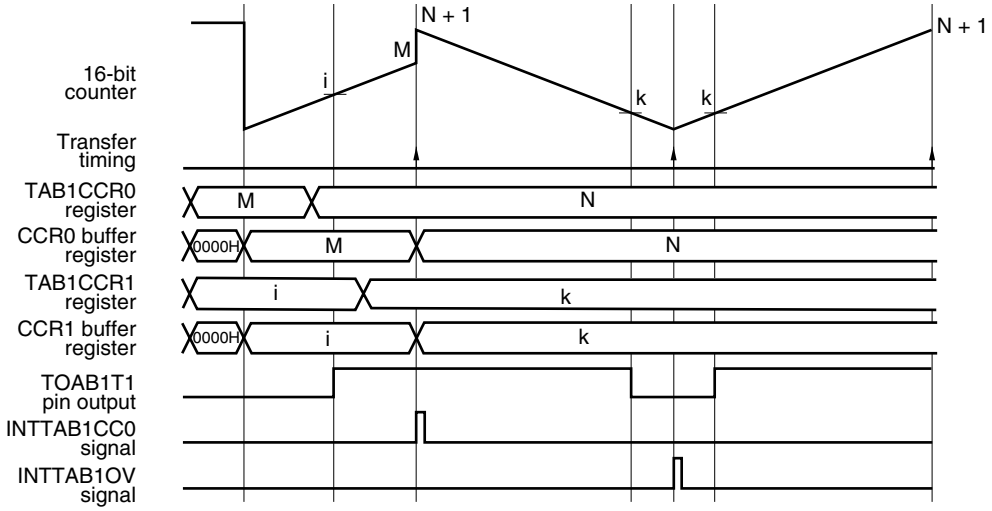
The transfer timing in Figure 11-28 is at the point where the crest timing occurs. While the 16-bit counter is counting down, the cycle changes and an asymmetrical triangular wave is output. Because the cycle changes, rewrite the duty factor (voltage data value).

Figure 11-28. Example of Rewriting TAB1CCR0 Register (During Counting Up)

(a) M > N



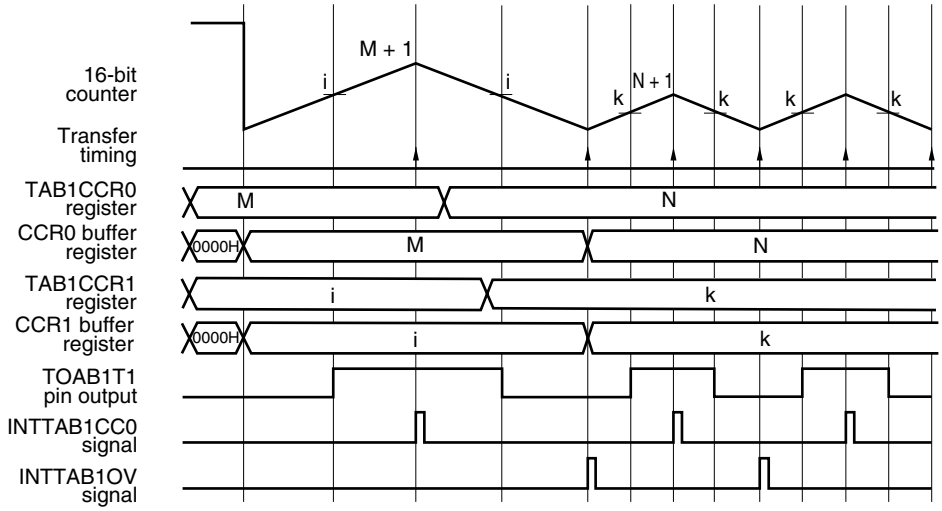
(b) M < N



Remarks 1. If transfer (match between the value of the 16-bit counter and the value of the CCR0 buffer register) occurs in the 6-phase PWM output mode, the value of the TAB1CCR0 register plus 1 is loaded to the 16-bit counter. In this way, the expected wave can be output even if the cycle value is changed at the transfer timing of the crest (match between the 16-bit counter value and the TAB1CCR0 register value) timing.

2. M: Value of CCR0 buffer register before rewriting
N: Value of CCR0 buffer register after rewriting

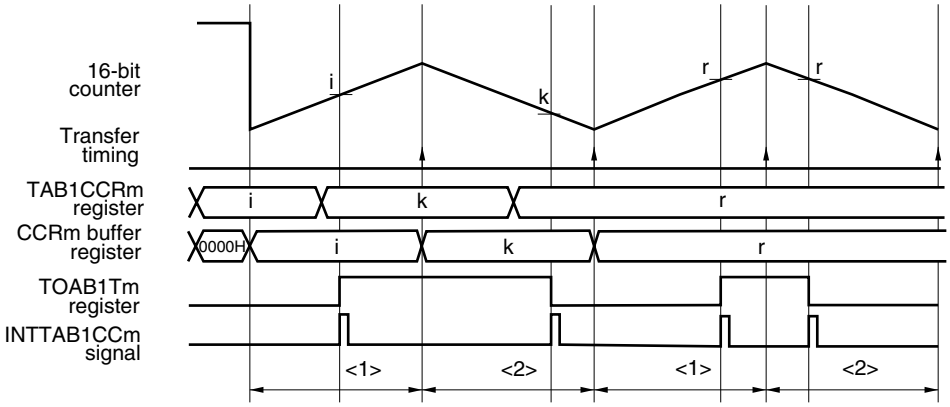
Figure 11-29. Example of Rewriting TAB1CCR0 Register (During Counting Down)



Because the next transfer timing is at the point of the valley (match between the 16-bit counter value and 0001H), the cycle value changes from the next cycle and output of a symmetrical triangular wave is maintained. Because the cycle changes, rewrite the duty value (voltage data value) as required.

(c) Rewriting TAB1CCRm register

Figure 11-30. Example of Rewriting TAB1CCRm Register



Rewriting during period <1> (rewriting during counting up)

Because the TAB1CCRm register value is transferred at the transfer timing of the crest (match between the 16-bit counter value and TAB1CCRm register value), an asymmetrical triangular wave is output.

Rewriting during period <2> (rewriting during counting down)

Because the TAB1CCRm register value is transferred at the transfer timing of the valley (match between the 16-bit counter value and 0001H), a symmetrical triangular wave is output.

Remark m = 1 to 3

(d) Transferring TAB1OPT1 register value

Do not set the TAB1OPT1.TAB1ID4 to TAB1OPT1.TAB1ID0 bits to other than 00000. When using the interrupt culling function, rewrite the TAB1OPT1 register in the intermittent batch rewrite mode (transfer culling mode). For details of rewriting the TAB1OPT1 register, see **11.4.3 Interrupt culling function**.

(3) Intermittent batch rewrite mode (transfer culling mode)

This mode is set by clearing the TAB1OPT0.TAB1CMS bit to 0 and setting the TAB1OPT2.TAB1RDE bit to 1.

In this mode, the values written to each compare register are transferred to the internal buffer register all at once after the culled transfer timing and compared with the counter value. The transfer timing is the timing at which an interrupt is generated (INTTAB1CC0, INTTAB1OV) by interrupt culling.

For details of the interrupt culling function, see **11.4.3 Interrupt culling function**.

(a) Rewriting procedure

If data is written to the TAB1CCR1 register, the data of the TAB1CCR0 to TAB1CCR3, TAB1OPT1, TAA4CCR0, and TAA4CCR1 registers are transferred all at once to the internal buffer register at the next transfer timing. Therefore, write to the TAB1CCR1 register last. Writing to the register is prohibited after the TAB1CCR1 register has been written until the transfer timing is generated (until the INTTAB1OV or INTTAB1CC0 interrupt occurs). The operation procedure is as follows.

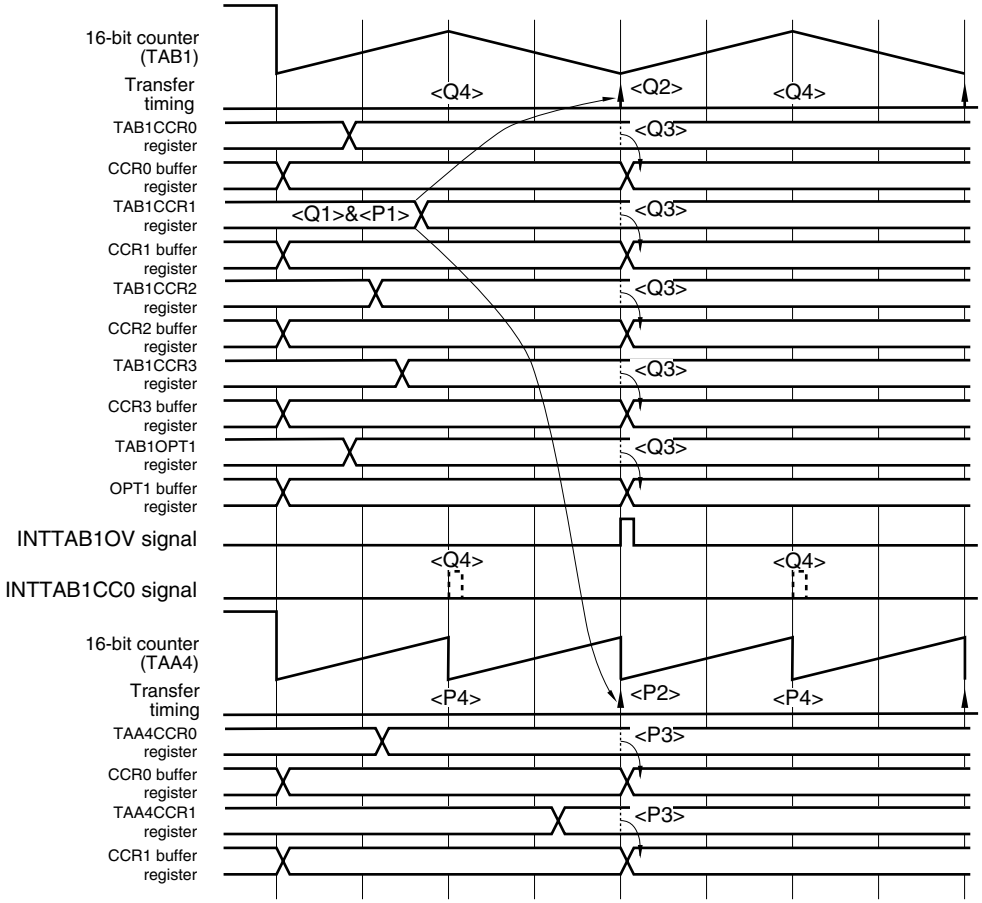
<1> Rewrite the TAB1CCR0, TAB1CCR2, TAB1CCR3, TAB1OPT1, TAA4CCR0, and TAA4CCR1 registers.
Do not rewrite registers that do not have to be rewritten.

<2> Rewrite the TAB1CCR1 register.
Rewrite the same value to the register even when it is not necessary to rewrite the TAB1CCR1 register.

<3> Hold the next rewriting pending until the transfer timing is generated.
Perform the next rewrite after the INTTAB1OV or INTTAB1CC0 interrupt has occurred.

<4> Return to <1>.

Figure 11-31. Basic Operation in Intermittent Batch Rewrite Mode



[TAB1 operation]

<Q1> Write the TAB1CCR1 register.

<Q2> Rewrite the register at the transfer timing that is generated after the TAB1CCR1 register has been rewritten.

<Q3> The registers are transferred all at once at the transfer timing.

<Q4> The transfer timing is also culled as the interrupts are culled.

[TAA4 operation]

<P1> Write the TAB1CCR1 register.

<P2> Rewrite the register at the transfer timing that is generated after the TAB1CCR1 register has been rewritten.

<P3> The registers are transferred all at once at the transfer timing.

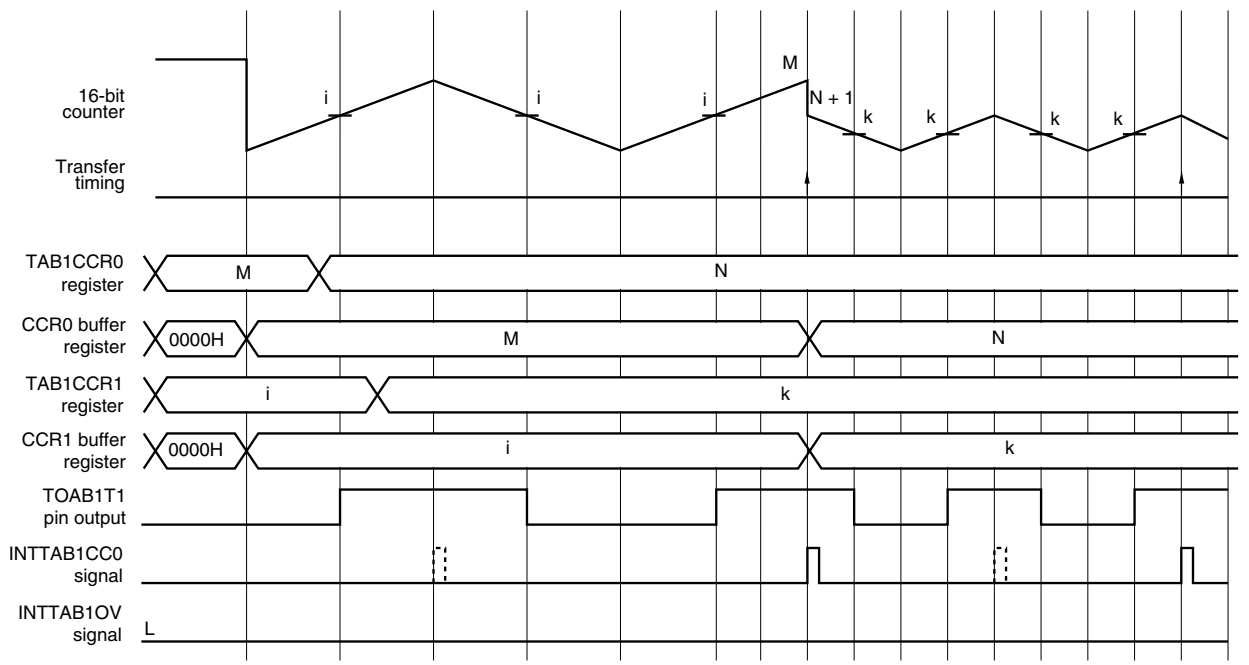
<P4> The transfer timing is also culled as the interrupts are culled.

Remark This is an example of the operation when the TAB1OPT1.TAB1ICE bit = 1, TAB1OPT1.TAB1IOE bit = 1, and TAB1OPT1.TAB1ID4 to TAB1OPT1.TAB1ID0 bits = 00001.

(b) Rewriting TAB1CCR0 register

When rewriting the TAB1CCR0 register in the intermittent batch mode, the output waveform differs depending on where the occurrence of the crest or valley interrupt is specified by the interrupt culling setting. The following figure illustrates the change of the output waveform when interrupts are culled.

Figure 11-32. Rewriting TAB1CCR0 Register (When Crest Interrupt Is Set)

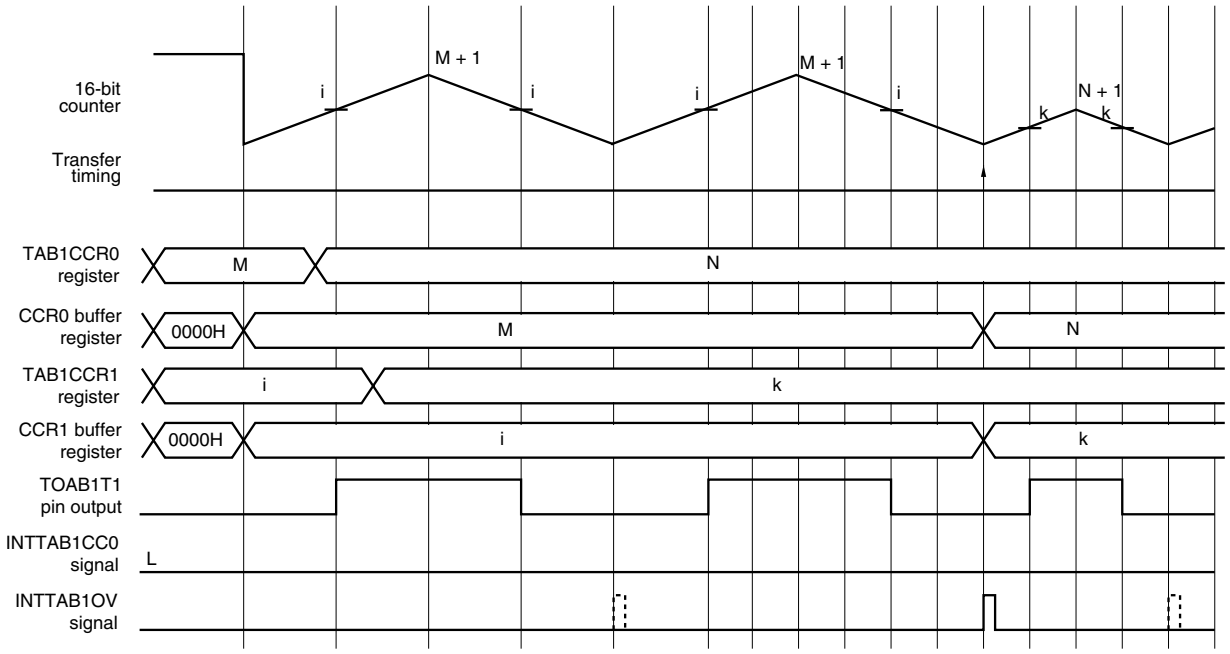


The transfer timing is generated when the crest interrupt occurs, the cycle of counting up and counting down changes, and an asymmetrical triangular wave is output.

Remarks 1. This is an example of the operation when the TAB1OPT1.TAB1ICE bit = 1, TAB1OPT1.TAB1IOE bit = 0, and TAB1OPT1.TAB1ID4 to TAB1OPT1.TAB1ID0 bits = 00001.

2. : Culled interrupt

Figure 11-33. Rewriting TAB1CCR0 Register (When Valley Interrupt Is Set)



The transfer timing is generated when the valley interrupt occurs, the cycle of counting up becomes same as cycle of counting down, and a symmetrical triangular wave is output.

Remarks 1. This is an example of the operation when the TAB1OPT1.TAB1ICE bit = 0, TAB1OPT1.TAB1IOE bit = 1, and TAB1OPT1.TAB1ID4 to TAB1OPT1.TAB1ID0 bits = 00001.

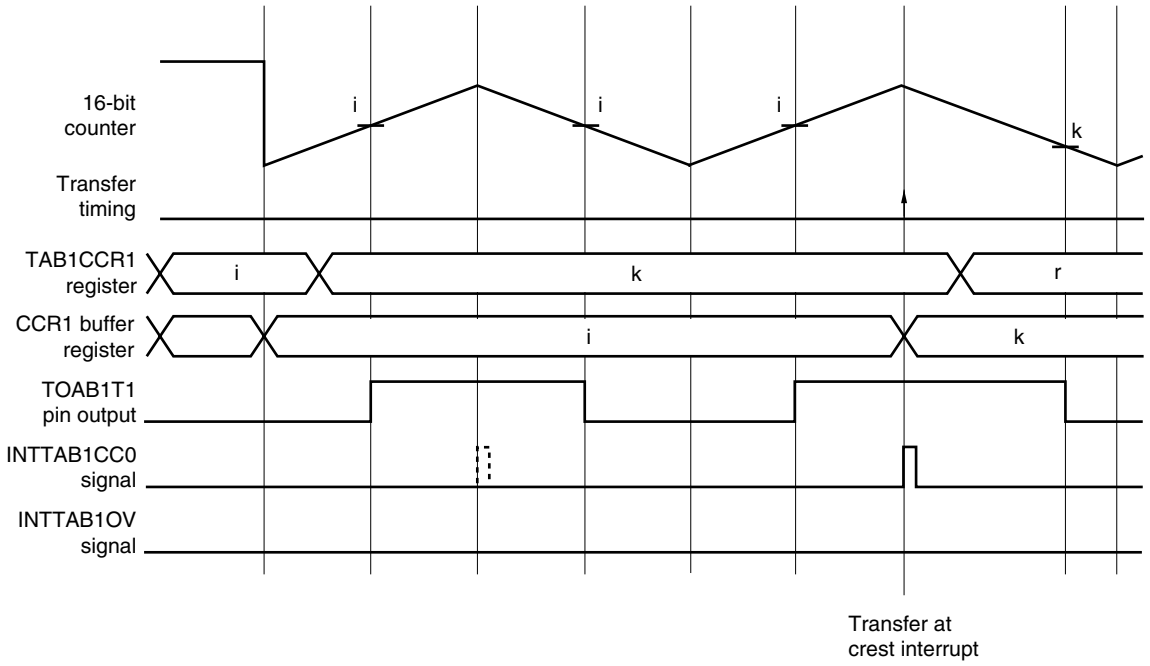
2. : Culled interrupt

(c) Rewriting TAB1CCR1 to TAB1CCR3 registers

- Transfer at crest when crest interrupt is set

  Because the register is transferred at the transfer timing of the crest interrupt, an asymmetrical triangular wave is output.

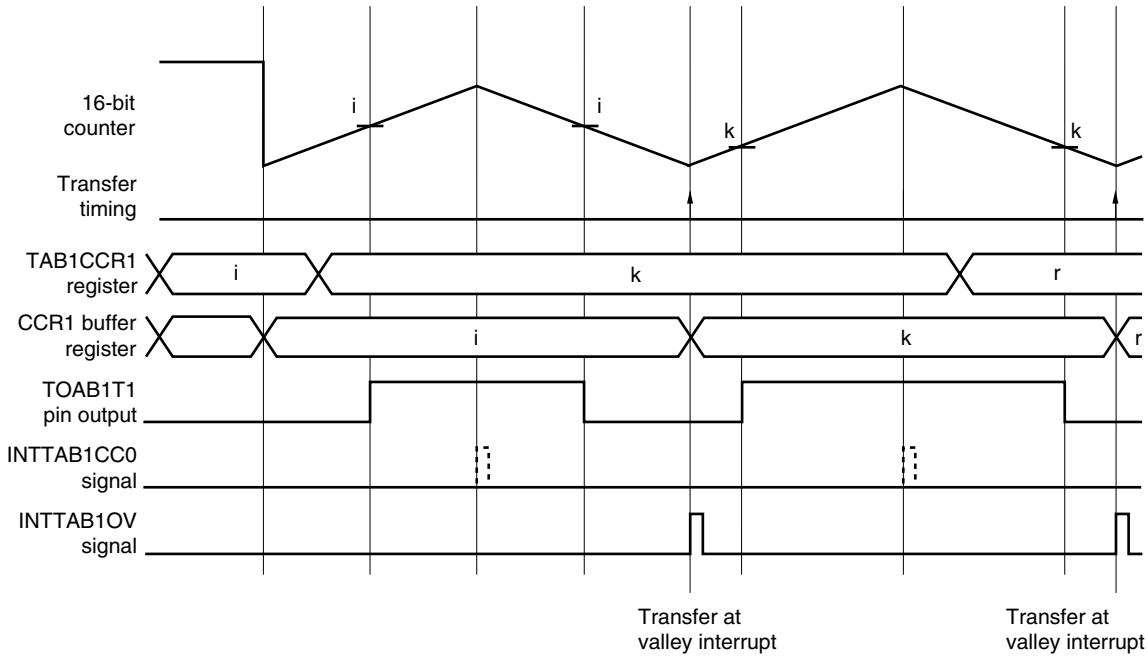
Figure 11-34. Rewriting TAB1CCR1 Register (TAB1OPT1.TAB1ICE Bit = 1, TAB1OPT1.TAB1IOE Bit = 0, TAB1OPT1.TAB1ID4 to TAB1OPT1.TAB1ID0 Bits = 00001)



Remark : Culled interrupt

- Transfer at valley when valley interrupt is set
  Because the register is transferred at the transfer timing of the valley interrupt, a symmetrical triangular wave is output.

Figure 11-35. Rewriting TAB1CCR1 Register (TAB1OPT1.TAB1ICE Bit = 1, TAB1OPT1.TAB1IOE Bit = 1, TAB1OPT1.TAB1ID4 to TAB1OPT1.TAB1ID0 Bits = 00001)



Remark : Culled interrupt

(d) Rewriting TAB1OPT1 register

Because a new interrupt culling value is transferred when the value of the interrupt culling counter matches the value of the 16-bit counter, the next interrupt and those that follow occur at the set interval.

For details of rewriting the TAB1OPT1 register, see **11.4.3 Interrupt culling function**.

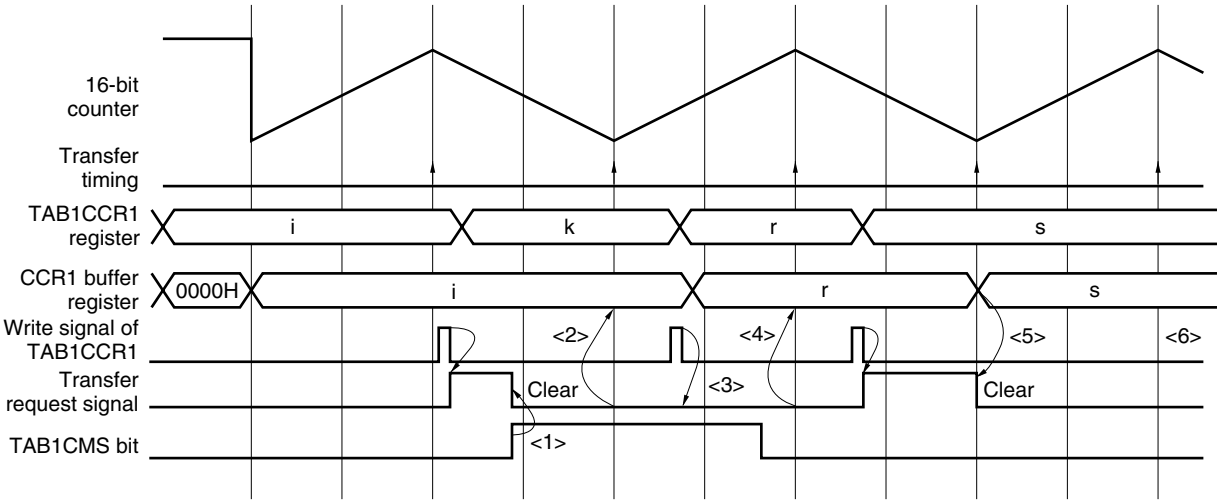
(4) Rewriting TAB1OPT0.TAB1CMS bit

The TAB1CMS bit can select the anytime rewrite mode and batch rewrite mode. This bit can be rewritten during timer operation (when TAB1CTL0.TAB1CE bit = 1). However, the operation and caution illustrated in Figure 11-36 are necessary.

If the TAB1CCR1 register is written when the TAB1CMS bit is cleared to 0, a transfer request signal (internal signal) is set.

When the transfer request signal is set, the register is transferred at the next transfer timing, and the transfer request signal is cleared. This transfer request signal is also cleared when the TAB1CMS bit is set to 1.

Figure 11-36. Rewriting TAB1CMS Bit



<1> If the TAB1CCR1 register is rewritten when the TAB1CMS bit is 0, the transfer request signal is set.
If the TAB1CMS bit is set to 1 in this status, the transfer request signal is cleared.

<2> The register is not transferred because the TAB1CMS bit is set to 1 and the transfer request signal is cleared.

<3> The transfer request signal is not set even if the TAB1CCR1 register is written when the TAB1CMS bit is 1.

<4> The transfer request signal is not set even if the TAB1CCR1 register is written when the TAB1CMS bit is 1, so even if the TAB1CMS bit is cleared to 0, transfer does not occur at the subsequent transfer timing.

<5> The transfer request signal is set if the TAB1CCR1 register is written when the TAB1CMS bit is 0.
Transfer is performed at the subsequent transfer timing and the transfer request signal is cleared.

<6> Once transfer has been performed, the transfer request signal is cleared. Therefore, transfer is not performed at the next transfer timing.

11.4.5 TAA4 tuning operation for A/D conversion start trigger signal output

This section explains the tuning operation of TAA4 and TAB1 in the 6-phase PWM output mode.

In the 6-phase PWM output mode, the tuning operation is performed with TAB1 serving as the master and TAA4 as a slave. The conversion start trigger signal of the A/D converter can be set as the A/D conversion start trigger source by the INTTAA4CC0 and INTTAA4CC1 signals of TAA4 and the INTTAB1OV and INTTAB1CC0 signals of TAB1.

(1) Tuning operation starting procedure

The TAA4 and TAB1 registers should be set using the following procedure to perform the tuning operation.

(a) Setting of TAA4 register (stop the operations of TAB1 and TAA4 (by clearing the TAB1CTL0.TAB1CE bit and TAA4CTL0.TAA4CE bit to 0)).

- Set the TAA4CTL1 register to 85H (set the tuning operation slave mode and free-running timer mode).
- Clear the TAA4OPT0 register to 00H (select the compare register).
- Set an appropriate value to the TAA4CCR0 and TAA4CCR1 registers (set the default value for comparison for starting the operation).

(b) Setting of TAB1 register

- Set the TAB1CTL1 register to 07H (master mode and 6-phase PWM output mode).
- Set an appropriate value to the TAB1IOC0 register (set the output mode of TOAB1T1 to TOAB1T3). However, clear the TAB1OL0 bit to 0 and set the TAB1OE0 bit to 1 (enable positive phase output). Unless this setting is made, the crest interrupt (INTTAB1CC0) and valley interrupt (INTTAB1OV) do not occur. Consequently, the conversion start trigger signal of the A/D converter is not correctly generated.
- Set the TAB1IOC1 and TAB1IOC2 registers to 00H (the TIAB10 to TIAB13, EVTB1, and TRGB1 pins of TAB1 are not used).
- Clear the TAB1OPT0 register to 00H (select the compare register).
- Set an appropriate value to the TAB1CCR0 to TAB1CCR3 registers (set the default value for comparison for starting the operation).
- Set the TAB1CTL0 register to 0xH (clear the TAB1CE bit to 0 and set the operating clock of TAB1).
- The operating clock of TAB1 set by the TAB1CTL0 register is also supplied to TAA4, and the count operation is performed at the same timing. The operating clock of TAA4 set by the TAA4CTL0 register is ignored.

(c) Setting of TMQOP (TMQ option) register

- Set an appropriate value to the TAB1OPT1 and TAB1OPT2 registers.
- Set an appropriate value to the TAB1IOC3 register (set TOAB1B1 to TOAB1B3 in the output mode).
- Set an appropriate value to the TAB1DTC register (set the default value for comparison for starting the operation).

(d) Setting of alternate function

- Set the port to alternate function mode using the port control mode setting.

(e) Set the TAA4CE bit to 1 and set the TAB1CE bit to 1 immediately after that to start the 6-phase PWM output operation

Rewriting the TAB1CTL0, TAB1CTL1, TAB1IOC1, TAB1IOC2, TAA4CTL0, and TAA4CTL1 registers is prohibited during operation. The operation and the PWM output waveform are not guaranteed if any of these registers is rewritten during operation. However, rewriting the TAB1CTL0.TAB1CE bit to clear it is permitted. Manipulating (reading/writing) the other TAB1, TAA4, and TMQ option registers is prohibited until the TAA4CTL0.TAA4CE bit is set to 1 and then the TAB1CE bit is set to 1.

(2) Tuning operation clearing procedure

To clear the tuning operation and exit the 6-phase PWM output mode, set the TAA4 and TAB1 registers using the following procedure.

<1> Clear the TAB1CTL0.TAB1CE bit to 0 and stop the timer operation.
<2> Clear the TAA4CTL0.TAA4CE bit to 0 so that TAA4 can be separated.
<3> Stop the timer output by using the TAB1IOC0 register.
<4> Clear the TAA4CTL1.TAA4SYE bit to 0 to clear the tuning operation.

Caution Manipulating (reading/writing) the other TAB1, TAA4, and TMQ option registers is prohibited until the TAB1CE bit is set to 1 and then the TAA4CE bit is set to 1.

(3) When not tuning TAA4

When the match interrupt signal of TAA4 is not necessary as the conversion trigger source that starts the A/D converter, TAA4 can be used independently as a separate timer without being tuned. In this case, the match interrupt signal of TAA4 cannot be used as a trigger source to start A/D conversion in the 6-phase PWM output mode. Therefore, fix the TAB1OPT2.TAB1AT0 to TAB1OPT2.TAB1AT3 bits to 0.

The other control bits can be used in the same manner as when TAA4 is tuned.

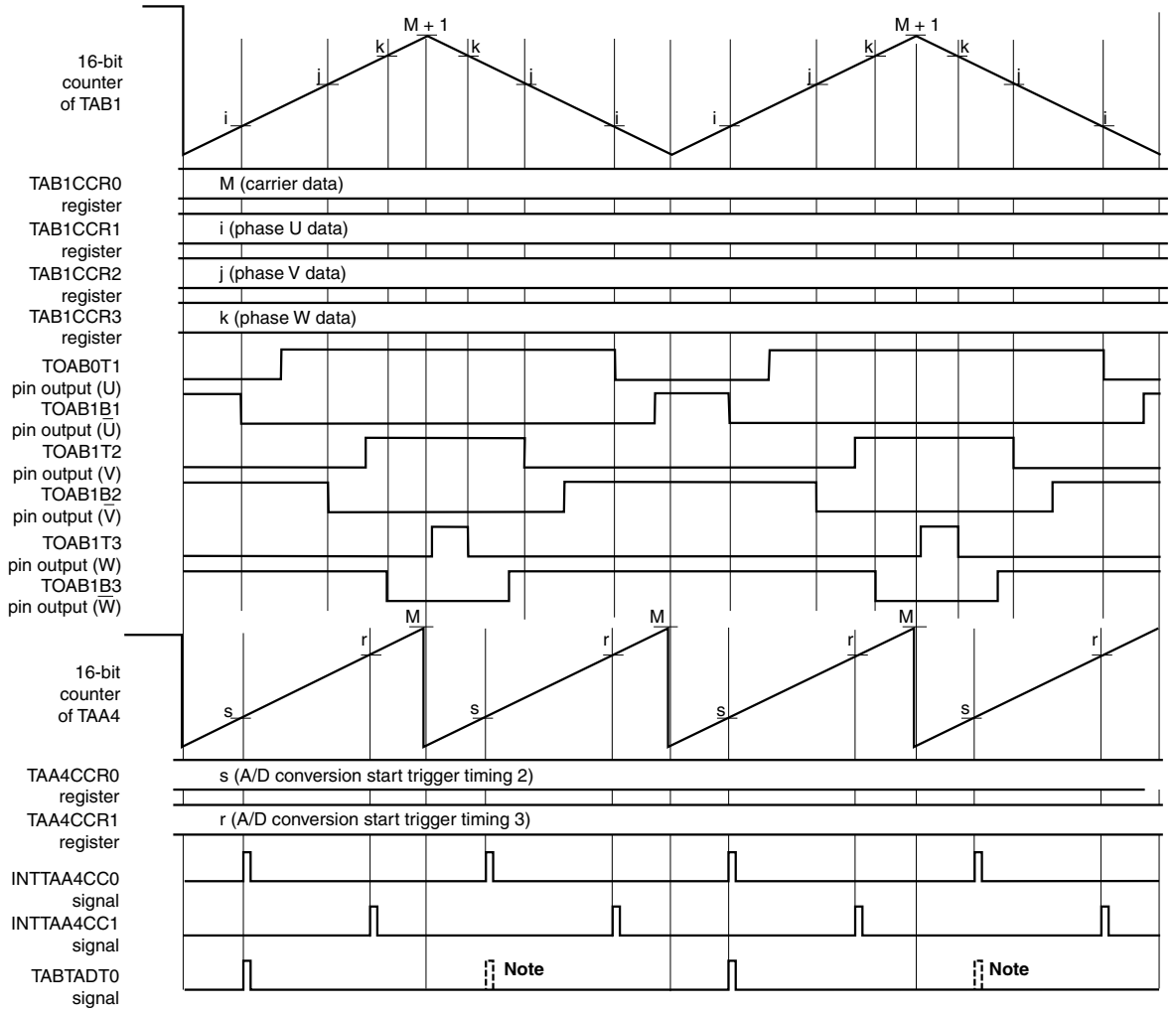
If TAA4 is not tuned, the compare registers (TAA4CCR0 and TAA4CCR1) of TAA4 are not affected by the setting of the TAB1OPT0.TAB1CMS and TAB1OPT2.TAB1RDE bit. For the initialization procedure when TAA4 is not tuned, see (b) to (e) in **11.4.5 (1) Tuning operation starting procedure**. (a) is not necessary because it is a step used to set TAA4 for the tuning operation.

(4) Basic operation of TAA4 during tuning operation

The 16-bit counter of TAA4 only counts up. The 16-bit counter is cleared by the set cycle value of the TAB1CCR0 register and starts counting from 0000H again. The count value of this counter is the same as the value of the 16-bit counter of TAB1 when it counts up. However, it is not the same when the 16-bit counter of TAA4 counts down.

- When TAB1 counts up (same value)
  16-bit counter of TAB1: 0000H → M (counting up)
  16-bit counter of TAA4: 0000H → M (counting up)
- When TAB1 counts down (not same value)
  16-bit counter of TAB1: M + 1 → 0001H (counting down)
  16-bit counter of TAA4: 0000H → M (counting up)

Figure 11-37. TAA4 During Tuning Operation



Note The TABTADT0 signal is masked by the TAB1OPT2.TAB1ATM2 and TAB1OPT2.TAB1ATM3 bits.

11.4.6 A/D conversion start trigger output function

The V850ES/JG3-H and V850ES/JH3-H have a function to select four trigger sources (INTTAB1OV, INTTAB1CC0, INTTAA4CC0, INTTAA4CC1) to generate the A/D conversion start trigger signal (TABTADT0).

The trigger sources are specified by the TAB1OPT2.TAB1AT0 to TAB1OPT2.TAB1AT3 bits.

- TAB1AT0 bit = 1:
  A/D conversion start trigger signal generated when INTTAB1OV (counter underflow) occurs.
- TAB1AT1 bit = 1:
  A/D conversion start trigger signal generated when INTTAB1CC0 (cycle match) occurs.
- TAB1AT2 bit = 1:
  A/D conversion start trigger signal generated when INTTAA4CC0 (match of TAA4CCR0 register of TAA4 during tuning operation) occurs.
- TAB1AT3 bit = 1:
  A/D conversion start trigger signal generated when INTTAA4CC1 (match of TAA4CCR1 register of TAA4 during tuning operation) occurs.

The A/D conversion start trigger signals selected by the TAB1AT0 to TAB1AT3 bits are ORed and output. Therefore, two or more trigger sources can be specified at the same time.

The INTTAB1OV and INTTAB1CC0 signals selected by the TAB1AT0 and TAB1AT1 bits are culled interrupt signals.

Therefore, these signals are output after the interrupts have been culled and, unless interrupt output is enabled (by the TAB1OPT1.TAB1ICE and TAB1OPT1.TAB1IOE bits), the A/D conversion start trigger signal is not output.

The trigger sources (INTTAA4CC0 and INTTAA4CC1) from TAA4 have a function to mask the A/D conversion start trigger signal depending on the count-up/count-down status of the 16-bit counter, if so set by the TAB1AT2 and TAB1AT3 bits.

- TAB1ATM2 bit: Corresponds to the TAB1AT2 bit and controls INTTAA4CC0 (match interrupt signal) of TAA4.
  - TAB1ATM2 bit = 0: The A/D conversion start trigger signal is output when the 16-bit counter counts up (TAB1OPT0.TAB1CUF bit = 0), and the A/D conversion start trigger signal is not output when the 16-bit counter counts down (TAB1OPT0.TAB1CUF bit = 1).
  - TAB1ATM2 bit = 1: The A/D conversion start trigger signal is output when the 16-bit counter counts up (TAB1OPT0.TAB1CUF bit = 1), and the A/D conversion start trigger signal is not output when the 16-bit counter counts down (TAB1OPT0.TAB1CUF bit = 0).

- TAB1ATM3 bit: Corresponds to the TAB1AT3 bit and controls INTTAA4CC1 (match interrupt signal) of TAA4.
  - TAB1ATM3 bit = 0: The A/D conversion start trigger signal is output when the 16-bit counter counts up (TAB1OPT0.TAB1CUF bit = 0), and the A/D conversion start trigger signal is not output when the 16-bit counter counts down (TAB1OPT0.TAB1CUF bit = 1).
  - TAB1ATM3 bit = 1: The A/D conversion start trigger signal is output when the 16-bit counter counts up (TAB1OPT0.TAB1CUF bit = 1), and the A/D conversion start trigger signal is not output when the 16-bit counter counts down (TAB1OPT0.TAB1CUF bit = 0).

The TAB1ATM3, TAB1ATM2, and TAB1AT3 to TAB1AT0 bits can be rewritten while the timer is operating. If the bit that sets the A/D conversion start trigger signal is rewritten while the timer is operating, the new setting is immediately reflected in the output status of the A/D conversion start trigger signal. These control bits do not have a transfer function and can be used only in the anytime rewrite mode.

Cautions 1. The A/D conversion start trigger signal output that is set by the TAB1AT2 and TAB1AT3 bits can be used only when TAA4 is performing a tuning operation as the slave timer of TAB1. If TAB1 and TAA4 are not performing a tuning operation, or if a mode other than the 6-phase PWM output mode is used, the output cannot be guaranteed.

2. The TAB1 signal output is internally used to identify whether the 16-bit counter is counting up or down. Therefore, enable TOAB10 pin output by clearing the TAB1IOC0.TAB1OL0 bit to 0 and setting the TAB1IOC0.TAB1OE0 bit to 1.

Figure 11-38. Example of A/D Conversion Start Trigger (TABTADT0) Signal Output (TAB1OPT1.TAB1ICE Bit = 1, TAB1OPT1.TAB1IOE Bit = 1, TAB1OPT1.TAB1ID4 to TAB1OPT1.TAB1ID0 Bits = 00000: Without Interrupt Culling)

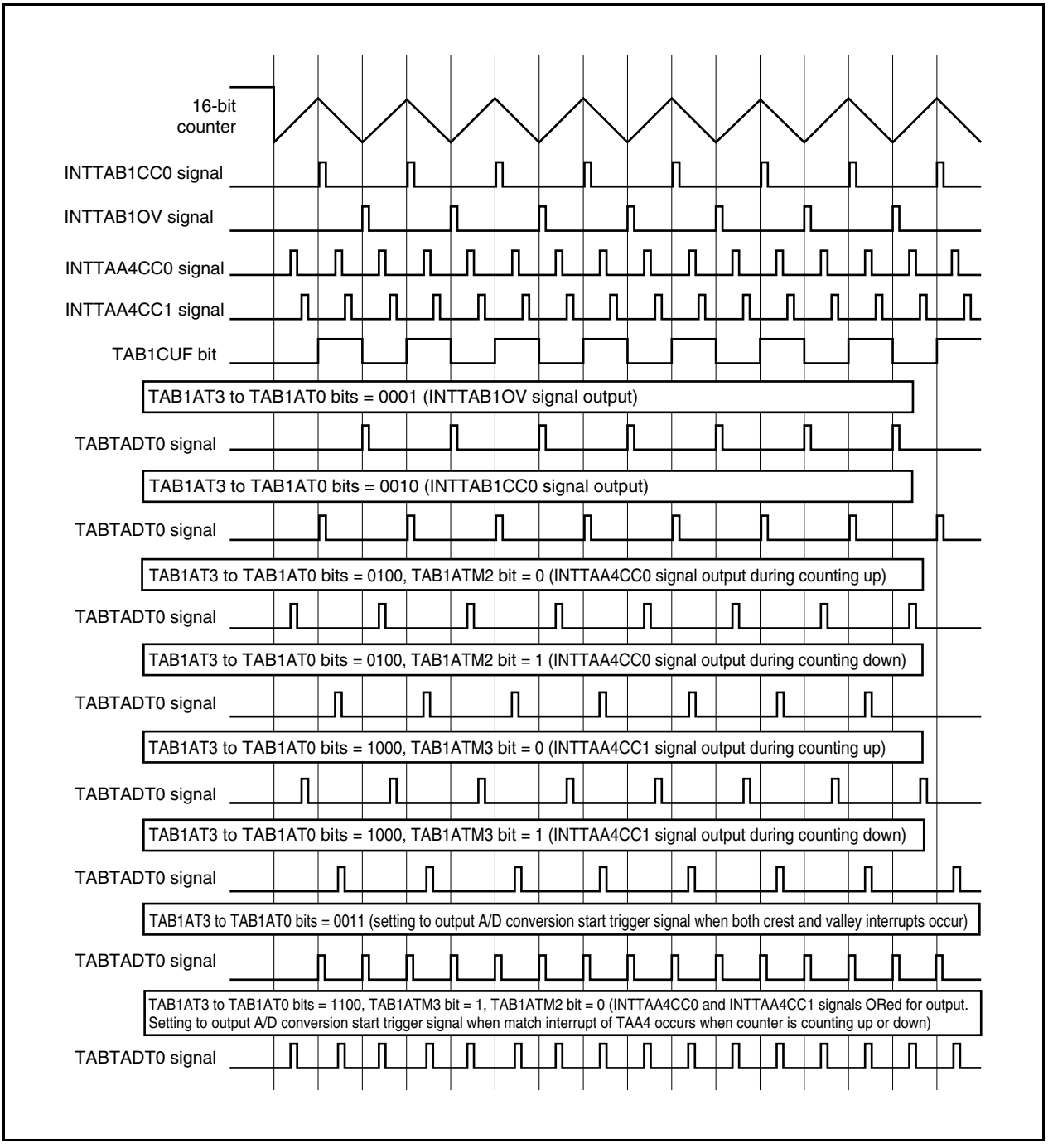
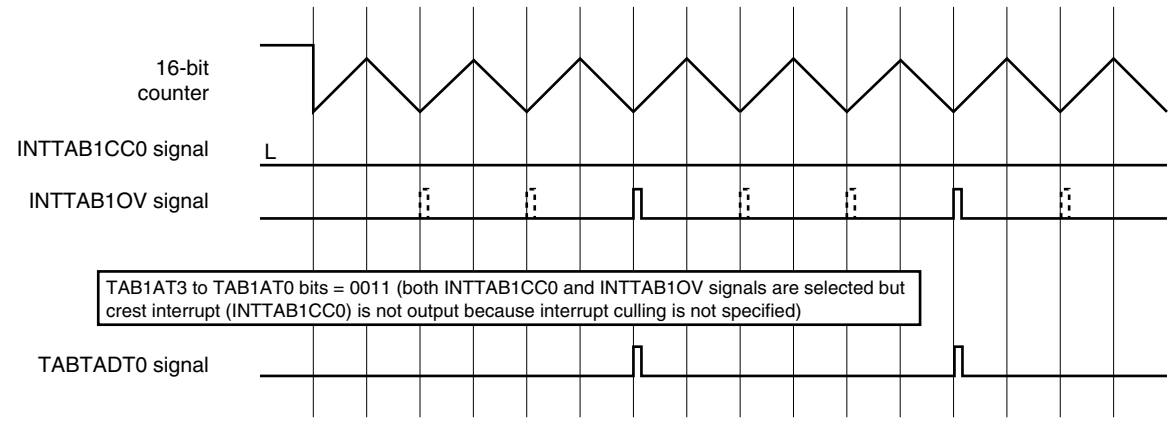
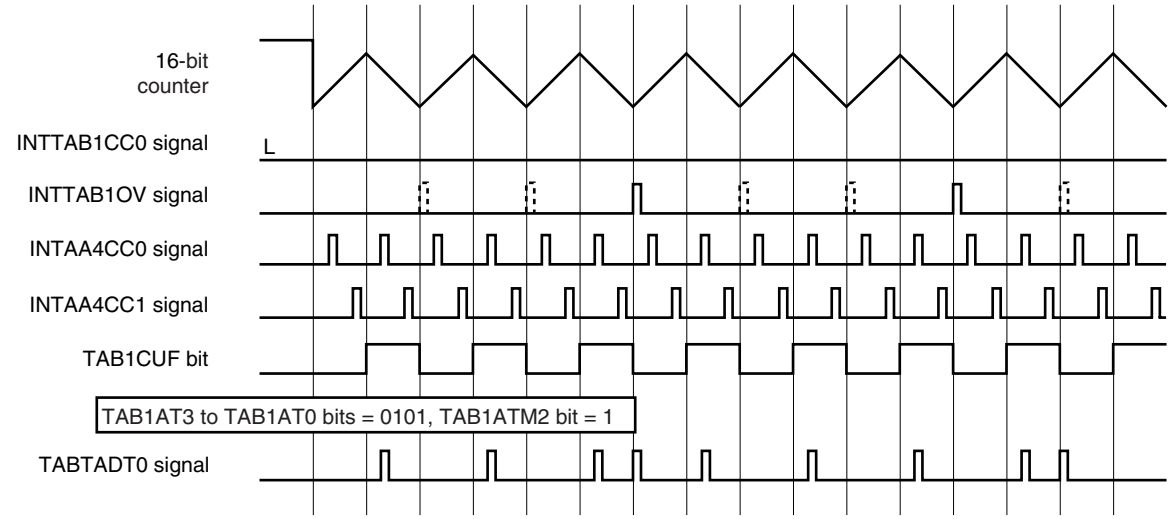


Figure 11-39. Example of A/D Conversion Start Trigger (TABTADT0) Signal Output (TAB1OPT1.TAB1ICE Bit = 0, TAB1OPT1.TAB1IOE Bit = 1, TAB1OPT1.TAB1ID4 to TAB1OPT1.TAB1ID0 Bits = 00010: With Interrupt Culling) (1)



Remark : Culled interrupt

Figure 11-40. Example of A/D Conversion Start Trigger (TABTADT0) Signal Output (TAB1OPT1.TAB1ICE Bit = 0, TAB1OPT1.TAB1IOE Bit = 1, TAB1OPT1.TAB1ID4 to TAB1OPT1.TAB1ID0 Bits = 00010: With Interrupt Culling) (2)



Caution The INTTAB1CC0 signal is culled but the INTTAA4CC0 signal is not.

Remark : Culled interrupt

(1) Operation under boundary condition (operation when 16-bit counter matches INTTAA4CC0 signal)

Table 11-3. Operation When TAB1CCR0 Register = M, TAB1AT2 Bit = 1, TAB1ATM2 Bit = 0 (Counting Up Period Selected)

Value of TAA4CCR0 Register	Value of 16-Bit Counter of TAB1	Value of 16-Bit Counter of TAA4	Status of 16-Bit Counter of TAB1	TABTADT0 Signal Output by INTTAA4CC0 Signal
0000H	0000H	0000H	–	Output
0000H	M + 1	0000H	–	Not output
0001H	0001H	0001H	Count-up	Output
0001H	M	0001H	Count-down	Not output
M	M	M	Count-up	Output
M	0001H	M	Count-down	Not output

Table 11-4. Operation When TAB1CCR0 Register = M, TAB1AT2 Bit = 1, TAB1ATM2 Bit = 1 (Counting Down Period Selected)

Value of TAA4CCR0 Register	Value of 16-Bit Counter of TAB1	Value of 16-Bit Counter of TAA4	Status of 16-Bit Counter of TAB1	TABTADT0 Signal Output by INTTAA4CC0 Signal
0000H	0000H	0000H	–	Not output
0000H	M + 1	0000H	–	Output
0001H	0001H	0001H	Count-up	Not output
0001H	M	0001H	Count-down	Output
M	M	M	Count-up	Not output
M	0001H	M	Count-down	Output

Caution The TAA4CCRm register enables the setting of "0" to "M" when the TAB1CCR0 register = M. Setting a value of "M + 1" or higher is prohibited.
If a value of "M + 1" or higher is set, the 16-bit counter of TAA4 is cleared by "M". Therefore, the TABTADT0 signal is not output.

Remark m = 0, 1

CHAPTER 12 REAL-TIME COUNTER

12.1 Functions

The real-time counter (RTC) has the following features.

- Counting up to 99 years using year, month, day-of-week, day, hour, minute, and second sub-counters provided
- Year, month, day-of-week, day, hour, minute, and second counter display using BCD codes[Note 1]
- Alarm interrupt function
- Constant-period interrupt function (period: 1 month to 0.5 second)
- Interval interrupt function (period: 1.95 ms to 125 ms)
- Pin output function of 1 Hz
- Pin output function of 32.768 kHz
- Pin output function of 512 Hz or 16.384 kHz
- Watch error correction function
- Subclock operation or main clock operation[Note 2] selectable

Notes 1. A BCD (binary coded decimal) code expresses each digit of a decimal number in 4-bit binary format.

2. Use the baud rate generator dedicated to the real-time counter to divide the main clock frequency to 32.768 kHz for use.

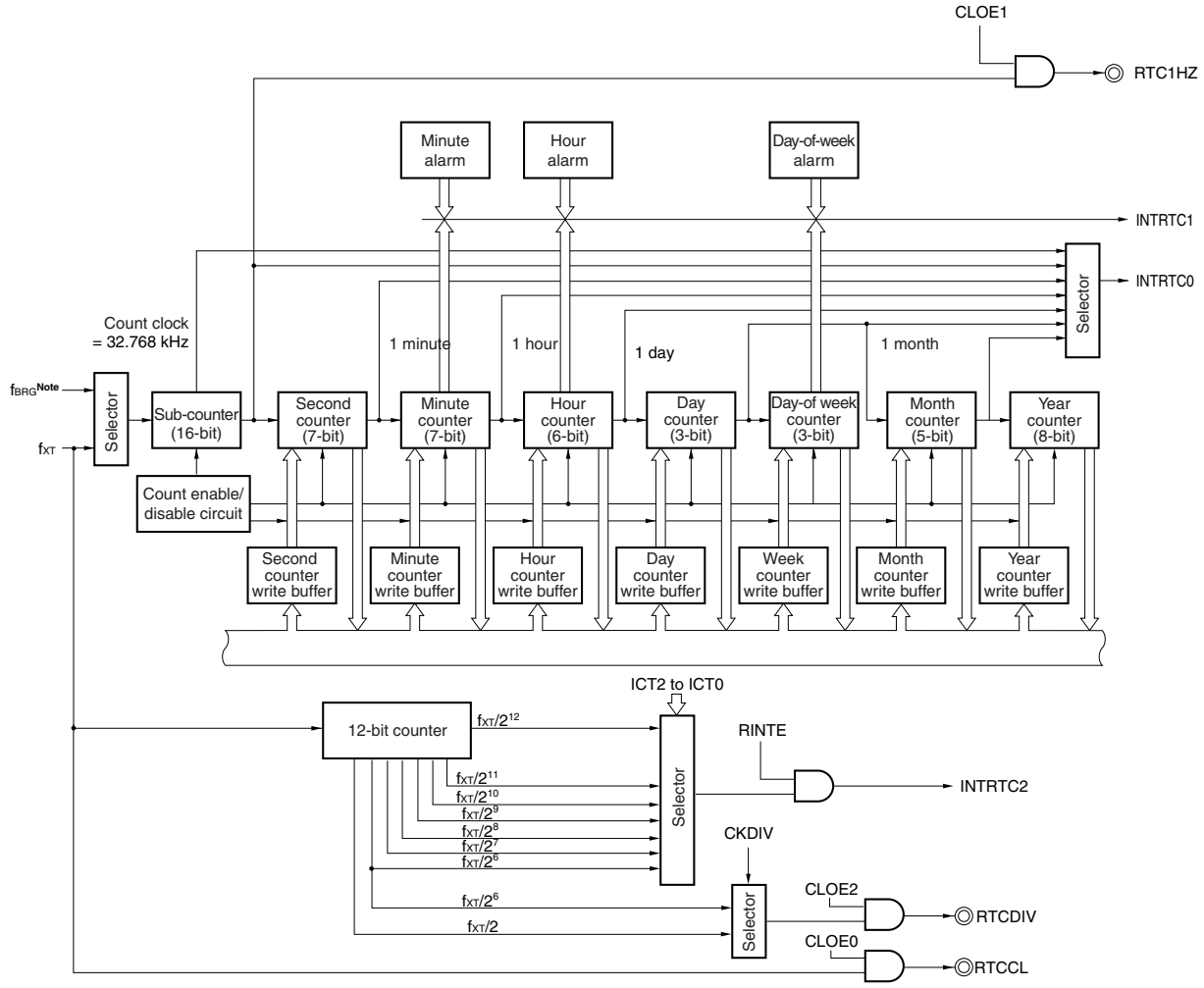
12.2 Configuration

The real-time counter includes the following hardware.

Table 12-1. Configuration of Real-Time Counter

Item	Configuration
Control registers	Real-time counter control register 0 (RC1CC0) Real-time counter control register 1 (RC1CC1) Real-time counter control register 2 (RC1CC2) Real-time counter control register 3 (RC1CC3) Sub-count register (RC1SUBC) Second count register (RC1SEC) Minute count register (RC1MIN) Hour count register (RC1HOUR) Day count register (RC1DAY) Day-of-week count register (RC1WEEK) Month count register (RC1MONTH) Year count register (RC1YEAR) Watch error correction register (RC1SUBU) Alarm minute register (RC1ALM) Alarm hour register (RC1ALH) Alarm week register (RC1ALW) Prescaler mode register 0 (PRSM0) Prescaler compare register 0 (PRSCM0)

Figure 12-1. Block Diagram of Real-Time Counter



Note For detail of f_{BRG}, refer to **12.3 (17) Prescaler mode register 0 (PRSM0)** and **12.3 (18) Prescaler compare register 0 (PRSCM0).**

Remark f_{BRG}: Real-time counter count clock frequency
f_{XT}: Subclock frequency
INTRTC0: Real-time counter fixed-cycle interrupt signal
INTRTC1: Real-time counter alarm match interrupt signal
INTRTC2: Real-time counter interval interrupt signal

12.2.1 Pin configuration

The RTC outputs included in the real-time counter are alternatively used as shown in Table 12-2. The port function must be set when using each pin (see **Table 4-20 Using Port Pin as Alternate-Function Pin**).

Table 12-2. Pin Configuration

Pin Number		Port	RTC Output	Other Alternate Function
V850ES/JG3-H	V850ES/JH3-H			
30	42	P35	RTC1HZ	TIAA11/TOAA11
28	40	P33	RTCDIV	TIAA01/TOAA01/RTCCL
28	40	P33	RTCCL	TIAA01/TOAA01/RTCDIV

12.2.2 Interrupt functions

The RTC includes the following three types of interrupt signals.

(1) INTRTC0

A fixed-cycle interrupt signal is generated every 0.5 second, second, minute, hour, day, or month.

(2) INTRTC1

Alarm interrupt signal

(3) INTRTC2

An interval interrupt signal of a cycle of $f_{XT}/2^6$, $f_{XT}/2^7$, $f_{XT}/2^8$, $f_{XT}/2^9$, $f_{XT}/2^{10}$, $f_{XT}/2^{11}$, or $f_{XT}/2^{12}$ is generated.

12.3 Registers

The real-time counter is controlled by the following 18 registers.

(1) Real-time counter control register 0 (RC1CC0)

The RC1CC0 register selects the real-time counter input clock.

This register can be read or written in 8-bit or 1-bit units.

Reset sets this register to 00H.

After reset: 00H R/W Address: FFFFFADDH

	7	6	5	4	3	2	1	0
RC1CC0	RC1PWR	RC1CKS	0	0	0	0	0	0

RC1PWR	Real-time counter operation control
0	Stops real-time counter operation.
1	Enables real-time counter operation.

RC1CKS	Operation clock selection
0	Selects f_{XT} as operation clock.
1	Selects f_{BRG} as operation clock.

Cautions 1. Follow the description in 12.4.8 Initializing real-time counter when stopping (RC1PWR = 1 → 0) the real-time counter while it is operating.

2. The RC1CKS bit can be rewritten only when the real-time counter is stopped (RC1PWR bit = 0). Furthermore, rewriting the RC1CKS bit at the same time as setting the RC1PWR bit from 0 to 1 is prohibited.

(2) Real-time counter control register 1 (RC1CC1)

The RC1CC1 register is an 8-bit register that starts or stops the real-time counter, controls the RTCCL and RTC1HZ pins, selects the 12-hour or 24-hour system, and sets the fixed-cycle interrupt function.

This register can be read or written in 8-bit or 1-bit units.

Reset sets this register to 00H.

After reset: 00H R/W Address: FFFFFADEH

	7	6	5	4	3	2	1	0
RC1CC1	RTCE	0	CLOE1	CLOE0	AMPM	CT2	CT1	CT0

RCTE	Control of operation of each counter
0	Stops counter operation.
1	Enables counter operation.

CLOE1	RTC1HZ pin output control
0	Disables RTC1HZ pin output (1 Hz)
1	Enables RTC1HZ pin output (1 Hz)

CLOE0	RTCCL pin output control
0	Disables RTCCL pin output (32.768 kHz)
1	Enables RTCCL pin output (32.768 kHz)

AMPM	12-hour system/24-hour system selection
0	12-hour system (a.m. and p.m. are displayed.)
1	24-hour system

CT2	CT1	CT0	Fixed-cycle interrupt (INTRTC0) selection
0	0	0	Does not use fixed-cycle interrupts
0	0	1	Once in 0.5 second (synchronous with second count-up)
0	1	0	Once in 1 second (simultaneous with second count-up)
0	1	1	Once in 1 minute (every minute at 00 seconds)
1	0	0	Once in 1 hour (every hour at 00 minutes 00 seconds)
1	0	1	Once in 1 day (every day at 00 hours 00 minutes 00 seconds)
1	1	×	Once in 1 month (one day every month at 00 hours 00 minutes 00 seconds a.m.)

Cautions 1. Writing 0 to the RTCE bit while the RTCE bit is 1 is prohibited. Clear the RTCE bit by clearing the RC1PWR bit according to 12.4.8 Initializing real-time counter.

2. The RTC1HZ output operates as follows when the CLOE1 bit setting is changed.

- **When changed from 0 to 1: The RTC1HZ output outputs a 1 Hz pulse after two clocks (2 x 32.768 kHz) or less.**
- **When changed from 1 to 0: The RTC1HZ output is stopped (fixed to low level) after two clocks (2 x 32.768 kHz) or less.**

3. See 12.4.1 Initial settings and 12.4.2 Rewriting each counter during the real-time counter operation for setting or changing the AMPM bit. Furthermore, re-set the RC1HOUR register when the AMPM bit is rewritten.

4. See 12.4.4 Changing INTRTC0 interrupt setting during the real-time counter operation when rewriting the CT2 to CT0 bits while the real-time counter operates (RC1PWR bit = 1).

(3) Real-time counter control register 2 (RC1CC2)

The RC1CC2 register is an 8-bit register that controls the alarm interrupt function and waiting of counters.

This register can be read or written in 8-bit or 1-bit units.

Reset sets this register to 00H.

After reset: 00H R/W Address: FFFFFADFH

	7	6	5	4	3	2	1	0
RC1CC2	WALE	0	0	0	0	0	RWST	RWAIT

WALE	Alarm interrupt (INTRTC1) operation control
0	Does not generate interrupt upon alarm match.
1	Generates interrupt upon alarm match.

RWST	Real-time counter wait state
0	Counter operating
1	Counting up of second to year counters stopped (Reading and writing of counter values enabled)
This is a status flag indicating whether the RWAIT bit setting is valid. Read or write counter values after confirming that the RWST bit is 1.	

RWAIT	Real-time counter wait control
0	Sets counter operation.
1	Stops count operation of second to year counters. (Counter value read/write mode)
This bit controls the operation of the counters. Be sure to write 1 to this bit when reading or writing counter values. If the RC1SUBC register overflows while the RWAIT bit is 1, the overflow information is retained internally and the RC1SEC register is counted up after two clocks or less after 0 is written to the RWAIT bit. However, if the second counter value is rewritten while the RWAIT bit is 1, the retained overflow information is discarded.	

Cautions 1. See 12.4.5 Changing INTRTC1 interrupt setting during the real-time counter operation when rewriting the WALE bit while the real-time counter operates (RC1PWR bit = 1).

2. Confirm that the RWST bit is set to 1 when reading or writing each counter value.

3. The RWST bit does not become 0 while each counter is being written, even if the RWAIT bit is set to 0. It becomes 0 when writing to each counter is completed.

(4) Real-time counter control register 3 (RC1CC3)

The RC1CC3 register is an 8-bit register that controls the interval interrupt function and RTCDIV pin.

This register can be read or written in 8-bit or 1-bit units.

Reset sets this register to 00H.

After reset: 00H R/W Address: FFFFFAE0H

	7	6	5	4	3	2	1	0
RC1CC3	RINTE	CLOE2	CKDIV	0	0	ICT2	ICT1	ICT0

RINTE	Interval interrupt (INTRTC2) control
0	Does not generate interval interrupt.
1	Generates interval interrupt.

CLOE2	RTCDIV pin output control
0	Disables RTCDIV pin output.
1	Enables RTCDIV pin output.

CKDIV	RTCDIV pin output frequency selection
0	Outputs 512 Hz (1.95 ms) from RTCDIV pin.
1	Outputs 16.384 kHz (0.061 ms) from RTCDIV pin.

ICT2	ICT1	ICT0	Interval interrupt (INTRTC2) selection
0	0	0	$2^6/f_{XT}$ (1.953125 ms)
0	0	1	$2^7/f_{XT}$ (3.90625 ms)
0	1	0	$2^8/f_{XT}$ (7.8125 ms)
0	1	1	$2^9/f_{XT}$ (15.625 ms)
1	0	0	$2^{10}/f_{XT}$ (31.25 ms)
1	0	1	$2^{11}/f_{XT}$ (62.5 ms)
1	1	×	$2^{12}/f_{XT}$ (125 ms)

Cautions 1. See 12.4.7 Changing INTRTC2 interrupt setting during the real-time counter operation when rewriting the RINTE bit during real-time counter operation (RC1PWR bit = 1).

2. The RTCDIV output operates as follows when the CLOE2 bit setting is changed.

- **When changed from 0 to 1: A pulse set by the CKDIV bit is output after two clocks (2 x 32.768 kHz) or less.**
- **When changed from 1 to 0: Output of the RTCDIV output is stopped after two clocks (2 x 32.768 kHz) or less (fixed to low level).**

3. See 12.4.7 Changing INTRTC2 interrupt setting during the real-time counter operation when rewriting the ICT2 to ICT0 bits while the real-time counter operates (RC1PWR bit = 1).

(5) Sub-count register (RC1SUBC)

The RC1SUBC register is a 16-bit register that counts the reference time of 1 second of the real-time counter.

It takes a value of 0000H to 7FFFH and counts one second with a clock of 32.768 kHz.

This register is read-only, in 16-bit units.

Reset sets this register to 0000H.

Cautions 1. When a correction is made by using the RC1SUBU register, the value may become 8000H or more.

2. This register is also cleared by writing to the second count register.

3. The value read from this register is not guaranteed if it is read during operation, because a changing value is read.

After reset: 0000H R Address: FFFFFAD0H

	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RC1SUBC																

(6) Second count register (RC1SEC)

The RC1SEC register is an 8-bit register that takes a value of 0 to 59 (decimal) and indicates the count value of seconds.

It counts up when the sub-counter overflows.

When data is written to this register, it is written to a buffer and then to the counter up to 2 clocks (2 x 32.768 kHz) later. Set a decimal value of 00 to 59 to this register in BCD code.

This register can be read or written in 8-bit units.

Reset sets this register to 00H.

Caution Setting the RC1SEC register to values other than 00 to 59 is prohibited.

Remark See **12.4.1 Initial settings**, **12.4.2 Rewriting each counter during real-time counter operation**, and **12.4.3 Reading each counter during real-time counter operation** when reading or writing the RC1SEC register.

After reset: 00H R/W Address: FFFFFAD2H

	7	6	5	4	3	2	1	0
RC1SEC	0							

(7) Minute count register (RC1MIN)

The RC1MIN register is an 8-bit register that takes a value of 0 to 59 (decimal) and indicates the count value of minutes.

It counts up when the second counter overflows.

When data is written to this register, it is written to a buffer and then to the counter up to 2 clocks (32.768 kHz) later.

Set a decimal value of 00 to 59 to this register in BCD code.

This register can be read or written 8-bit units.

Reset sets this register to 00H.

Caution Setting a value other than 00 to 59 to the RC1MIN register is prohibited.

Remark See **12.4.1 Initial settings**, **12.4.2 Rewriting each counter during real-time counter operation**, and **12.4.3 Reading each counter during real-time counter operation** when reading or writing the RC1MIN register.

After reset: 00H R/W Address: FFFFFAD3H

	7	6	5	4	3	2	1	0
RC1MIN	0							

(8) Hour count register (RC1HOUR)

The RC1HOUR register is an 8-bit register that takes a value of 0 to 23 or 1 to 12 (decimal) and indicates the count value of hours.

It counts up when the minute counter overflows.

When data is written to this register, it is written to a buffer and then to the counter up to 2 clocks (32.768 kHz) later.

Set a decimal value of 00 to 23, 01 to 12, or 21 to 32 to this register in BCD code.

This register can be read or written 8-bit units.

Reset sets this register to 12H.

However, the value of this register is 00H if the AMPM bit is set to 1 after reset.

Cautions 1. Bit 5 of the RC1HOUR register indicates a.m. (0) or p.m. (1) if AMPM = 0 (if the 12-hour system is selected).

2. Setting a value other than 01 to 12, 21 to 32 (AMPM bit= 0), or 00 to 23 (AMPM bit = 1) to the RC1HOUR register is prohibited.

Remark See **12.4.1 Initial settings**, **12.4.2 Rewriting each counter during real-time counter operation**, and **12.4.3 Reading each counter during real-time counter operation** when reading or writing the RC1HOUR register.

After reset: 12H R/W Address: FFFFFAD4H

	7	6	5	4	3	2	1	0
RC1HOUR	0	0						

Table 12-3 shows the relationship among the AMPM bit setting value, RC1HOUR register value, and time.

Table 12-3. Time Digit Display

12-Hour Display (AMPM Bit = 0)		24-Hour Display (AMPM Bit = 1)	
Time	RC1HOUR Register Value	Time	RC1HOUR Register Value
0:00 a.m.	12 H	0:00	00H
1:00 a.m.	01 H	1:00	01 H
2:00 a.m.	02 H	2:00	02 H
3:00 a.m.	03 H	3:00	03 H
4:00 a.m.	04 H	4:00	04 H
5:00 a.m.	05 H	5:00	05 H
6:00 a.m.	06 H	6:00	06 H
7:00 a.m.	07 H	7:00	07 H
8:00 a.m.	08 H	8:00	08 H
9:00 a.m.	09 H	9:00	09 H
10:00 a.m.	10 H	10:00	10 H
11:00 a.m.	11 H	11:00	11 H
0:00 p.m.	32 H	12:00	12 H
1:00 p.m.	21 H	13:00	13 H
2:00 p.m.	22 H	14:00	14 H
3 :00 p.m.	23 H	15:00	15 H
4:00 p.m.	24 H	16:00	16 H
5:00 p.m.	25 H	17:00	17 H
6:00 p.m.	26 H	18:00	18 H
7:00 p.m.	27 H	19:00	19 H
8:00 p.m.	28 H	20:00	20 H
9:00 p.m.	29 H	21:00	21 H
10:00 p.m.	30 H	22:00	22 H
11:00 p.m.	31 H	23:00	23 H

The RC1HOUR register value is displayed in 12 hour-format if the AMPM bit is 0 and in 24-hour format when the AMPM bit is 1.

In 12-hour display, a.m. or p.m. is indicated by the fifth bit of RCHOUR: 0 indicating before noon (a.m.) and 1 indicating noon or afternoon (p.m.).

(9) Day count register (RC1DAY)

The RC1DAY register is an 8-bit register that takes a value of 1 to 31 (decimal) and indicates the count value of days.

It counts up when the hour counter overflows.

This counter counts as follows.

- 01 to 31 (January, March, May, July, August, October, December)
- 01 to 30 (April, June, September, November)
- 01 to 29 (February in leap year)
- 01 to 28 (February in normal year)

When data is written to this register, it is written to a buffer and then to the counter up to 2 clocks (2 x 32.768 kHz) later. Set a decimal value of 00 to 31 to this register in BCD code.

This register can be read or written in 8-bit units.

Reset sets this register to 01H.

Caution Setting a value other than 01 to 31 to the RC1DAY register is prohibited. Setting a value outside the above-mentioned count range, such as "February 30" is also prohibited.

Remark See **12.4.1 Initial settings**, **12.4.2 Rewriting each counter during the real-time counter operation**, and **12.4.3 Reading each counter during the real-time counter operation** when reading or writing the RC1DAY register.

After reset: 01H R/W Address: FFFFFAD6H

	7	6	5	4	3	2	1	0
RC1DAY	0	0						

(10) Day-of-week count register (RC1WEEK)

The RC1WEEK register is an 8-bit register that takes a value of 0 to 6 (decimal) and indicates the day-of-week count value.

It counts up in synchronization with the day counter.

When data is written to this register, it is written to a buffer and then to the counter up to 2 clocks (2 x 32.768 kHz) later. Set a decimal value of 00 to 06 to this register in BCD code. If a value outside this range is set, the register value returns to the normal value after 1 period.

This register can be read or written in 8-bit units.

Reset sets this register to 00H.

After reset: 00H R/W Address: FFFFFAD5H

	7	6	5	4	3	2	1	0
RC1WEEK	0	0	0	0	0			

Cautions 1. Setting a value other than 00 to 06 to the RC1WEEK register is prohibited.

2. Values corresponding to the month count register and day count register are not automatically stored to the day-of-week register.

Be sure to set as follows after rest release.

Day of Week	RC1WEEK
Sunday	00H
Monday	01H
Tuesday	02H
Wednesday	03H
Thursday	04H
Friday	05H
Saturday	06H

Remark See **12.4.1 Initial settings**, **12.4.2 Rewriting each counter during real-time counter operation**, and **12.4.3 Reading each counter during real-time counter operation** when reading or writing the RC1WEEK register.

(11) Month count register (RC1MONTH)

The RC1MONTH register is an 8-bit register that takes a value of 1 to 12 (decimal) and indicates the count value of months.

It counts up when the day counter overflows.

When data is written to this register, it is written to a buffer and then to the counter up to 2 clocks (2 x 32.768 kHz) later. Set a decimal value of 01 to 12 to this register in BCD code.

This register can be read or written in 8-bit units.

Reset sets this register to 01H.

Caution Setting a value other than 01 to 12 to the RC1MONTH register is prohibited.

Remark See **12.4.1 Initial settings**, **12.4.2 Rewriting each counter during the real-time counter operation**, and **12.4.3 Reading each counter during the real-time counter operation** when reading or writing the RC1MONTH register.

After reset: 01H R/W Address: FFFFFAD7H

	7	6	5	4	3	2	1	0
RC1MONTH	0	0	0					

(12) Year count register (RC1YEAR)

The RC1YEAR register is an 8-bit register that takes a value of 0 to 99 (decimal) and indicates the count value of years.

It counts up when the month counter overflows.

Values 00, 04, 08, …, 92, and 96 indicate a leap year.

When data is written to this register, it is written to a buffer and then to the counter up to 2 clocks (2 x 32.768 kHz) later. Set a decimal value of 00 to 99 to this register in BCD code.

This register can be read or written in 8-bit units.

Reset sets this register to 00H.

Caution Setting a value other than 00 to 99 to the RC1YEAR register is prohibited.

Remark See **12.4.1 Initial settings**, **12.4.2 Rewriting each counter during the real-time counter operation**, and **12.4.3 Reading each counter during the real-time counter operation** when reading or writing the RC1YEAR register.

After reset: 00H R/W Address: FFFFFAD8H

	7	6	5	4	3	2	1	0
RC1YEAR								

(13) Watch error correction register (RC1SUBU)

The RC1SUBU register (8-bit) can be used to correct the watch with high accuracy when the watch is early or late, by changing the value (reference value: 7FFFH) overflowing from the sub-count register (RSUBC) to the second counter register.

This register can be read or written in 8-bit or 1-bit units.

Reset sets this register to 00H.

Remarks 1. The RC1SUBU register can be rewritten only when the real-time counter is set to its initial values. Be sure to see **12.4.1 Initial settings**.

2. See **12.4.9 Watch error correction example of real-time counter** for details of watch error correction.

After reset: 00H R/W Address: FFFFFAD9H

	7	6	5	4	3	2	1	0
RC1SUBU	DEV	F6	F5	F4	F3	F2	F1	F0

DEV	Setting of watch error correction timing
0	Corrects watch errors when RC1SEC (second counter) is at 00, 20, or 40 seconds (every 20 seconds).
1	Corrects watch errors when RC1SEC (second counter) is at 00 seconds (every 60 seconds).

F6	Setting of watch error correction value
0	Increments the RC1SUBC count value by the value set using the F5 to F0 bits (positive correction). Expression for calculating increment value: (Setting value of F5 to F0 bits − 1) × 2
1	Decrements the RC1SUBC count value by the value set using the F5 to F0 bits (negative correction). Expression for calculating decrement value: (Inverted value of setting value of F5 to F0 bits + 1) × 2
If the F6 to F0 bit values are {1/0, 0, 0, 0, 0, 0, 1/0}, watch error correction is not performed.	

(14) Alarm minute setting register (RC1ALM)

The RC1ALM register (8-bit) is used to set minutes of alarm.

This register can be read or written in 8-bit units.

Reset sets this register to 00H.

Caution Set a decimal value of 00 to 59 to this register in BCD code. If a value outside the range is set, the alarm is not detected.

After reset: 00H R/W Address: FFFFFADAH

	7	6	5	4	3	2	1	0
RC1ALM	0							

(15) Alarm hour setting register (RC1ALH)

The RC1ALH register (8-bit) is used to set hours of alarm.

This register can be read or written in 8-bit units.

Reset sets this register to 12H.

Cautions 1. Set a decimal value of 00 to 23, 01 to 12, or 21 to 32 to this register in BCD code. If a value outside the range is set, the alarm is not detected.

2. Bit 5 of the RC1ALH register indicates a.m. (0) or p.m. (1) if the AMPM bit = 0 (12-hour system) is selected.

After reset: 12H R/W Address: FFFFFADBH

	7	6	5	4	3	2	1	0
RC1ALH	0	0						

(16) Alarm day-of-week setting register (RC1ALW)

The RC1ALW register is used to set the day-of-week of the alarm.

This register can be read or written in 8-bit units.

Reset sets this register to 00H.

Caution See 12.4.5 Changing INTRTC1 interrupt setting during the real-time counter operation when rewriting the RC1ALW register while the real-time counter operates (RC1PWR bit = 1).

After apply power to RV_{DD}: 00H R/W Address: FFFFFADCH

	7	6	5	4	3	2	1	0
RC1ALW	0	RC1ALW6	RC1ALW5	RC1ALW4	RC1ALW3	RC1ALW2	RC1ALW1	RC1ALW0

RC1ALWn	Alarm interrupt day-of-week bit (n = 0 to 6)
0	Does not generate alarm interrupt if RC1WEEK = nH.
1	Generates an alarm interrupt if the time specified by using the RC1ALM and RC1ALH registers is reached while RC1WEEK is set to nH.

Remark The relationship between the day-of-week and the RC1WEEK register is described below.

Day of Week	RC1WEEK
Sunday	00H
Monday	01H
Tuesday	02H
Wednesday	03H
Thursday	04H
Friday	05H
Saturday	06H

(a) Alarm interrupt setting examples (RC1ALM, RC1ALH, and RC1ALW setting examples)

Tables 12-4 and 12-5 show setting examples if Sunday is RC1WEEK = 00, Monday is RC1WEEK = 01, Tuesday is RC1WEEK = 02, ···, and Saturday is RC1WEEK = 06.

Table 12-4. Alarm Setting Example if AMPM = 0 (RC1HOUR Register 12-Hour Display)

Register / Alarm Setting Time	RC1ALW	RC1ALH	RC1ALM
Sunday, 7:00 a.m.	01H	07H	00H
Sunday/Monday, 00:15 p.m.	03H	32H	15H
Monday/Tuesday/Friday, 5:30 p.m.	26H	25H	30H
Everyday, 10:45 p.m.	7FH	30H	45H

Table 12-5. Alarm Setting Example if AMPM = 1 (RC1HOUR Register 24-Hour Display)

Register / Alarm Setting Time	RC1ALW	RC1ALH	RC1ALM
Sunday, 7:00	01H	07H	00H
Sunday/Monday, 12:15	03H	12H	15H
Monday/Tuesday/Friday, 17:30	26H	17H	30H
Everyday, 22:45	7FH	22H	45H

(17) Prescaler mode register 0 (PRSM0)

The PRSM0 register (8-bit) controls the generation of the real time counter count clock (f_{BRG}).

This register can be read or written in 8-bit or 1-bit units.

Reset sets this register to 00H.

After reset : 00H R/W Address : FFFFF8B0H

	7	6	5	<4>	3	2	1	0
PRSM0	0	0	0	BGCE0	0	0	BGCS01	BGCS00

BGCE0	Main clock operation enable
0	Disabled
1	Enabled

BGCS01	BGCS00	Selection of real time counter source clock(f_{BGCS})		
			5 MHz	4 MHz
0	0	fx	200 ns	250 ns
0	1	fx/2	400 ns	500 ns
1	0	fx/4	800 ns	1 µs
1	1	fx/8	1.6 µs	2 µs

Cautions 1. Do not change the values of the BGCS00 and BGCS01 bits during real time counteroperation.

2. Set the PRSM0 register before setting the BGCE0 bit to 1.

3. Set the PRSM0 and PRSCM0 registers according to the main clock frequency that is used so as to obtain an f_{BRG} frequency of 32.768 kHz.

(18) Prescaler compare register 0 (PRSCM0)

The PRSCM0 register is an 8-bit compare register.

This register can be read or written in 8-bit units.

Reset sets this register to 00H.

After reset: 00H R/W Address: FFFFF8B1H

	7	6	5	4	3	2	1	0
PRSCM0	PRSCM07	PRSCM06	PRSCM05	PRSCM04	PRSCM03	PRSCM02	PRSCM01	PRSCM00

Cautions 1. Do not rewrite the PRSCM0 register during real time counter operation.

2. Set the PRSCM0 register before setting the PRSM0.BGCE0 bit to 1.

3. Set the PRSM0 and PRSCM0 registers according to the main clock frequency that is used so as to obtain an fBRG frequency of 32.768 kHz.

The calculation for f_{BRG} is shown below.

$f_{BRG} = f_{BGCS}/2N$

Remark f_{BGCS}: Watch timer source clock set by the PRSM0 register

N: Set value of the PRSCM0 register = 1 to 256

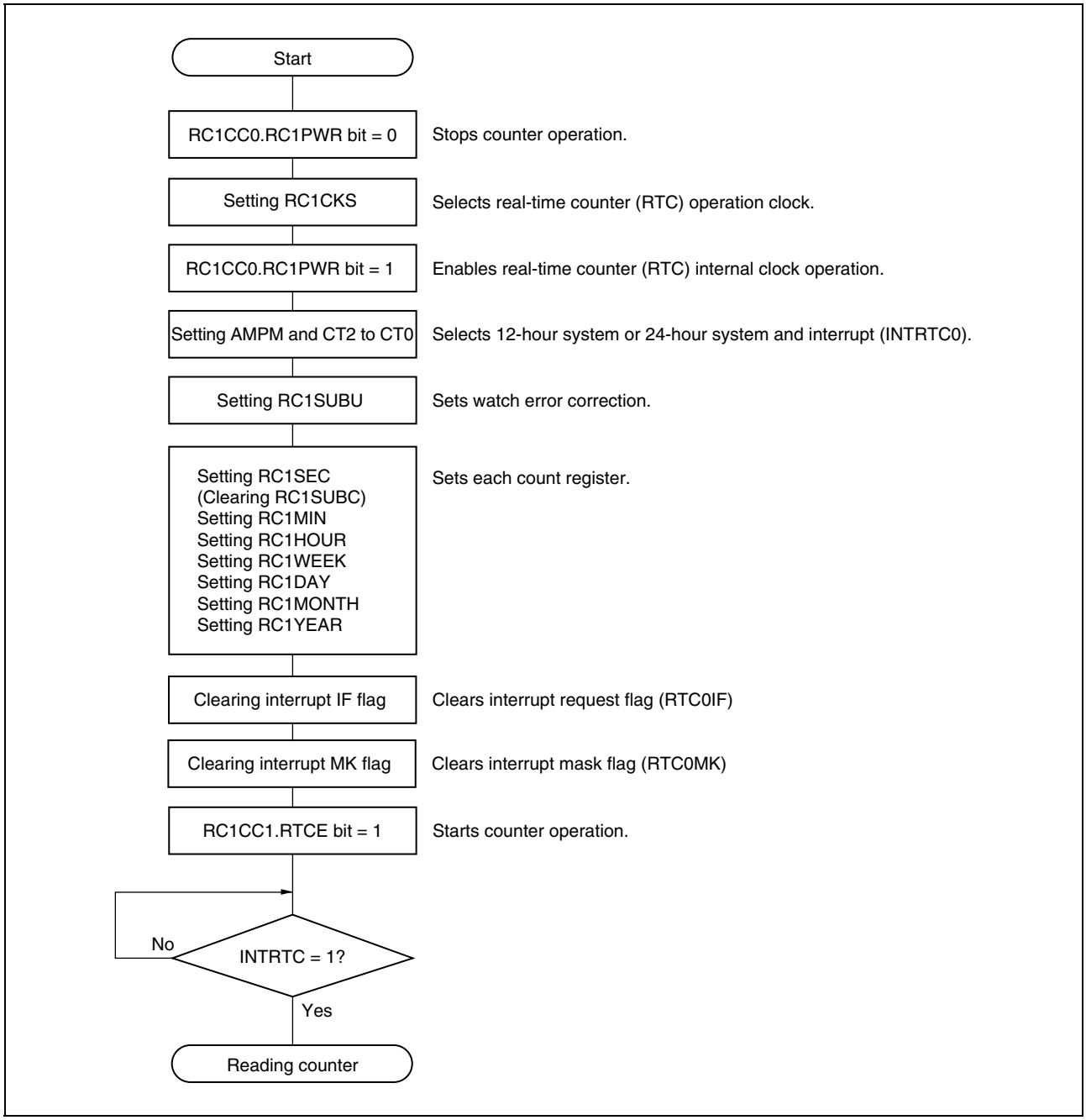
However, N = 256 when the PRSCM0 register is set to 00H.

12.4 Operation

12.4.1 Initial settings

The initial settings are set when operating the watch function and performing a fixed-cycle interrupt operation.

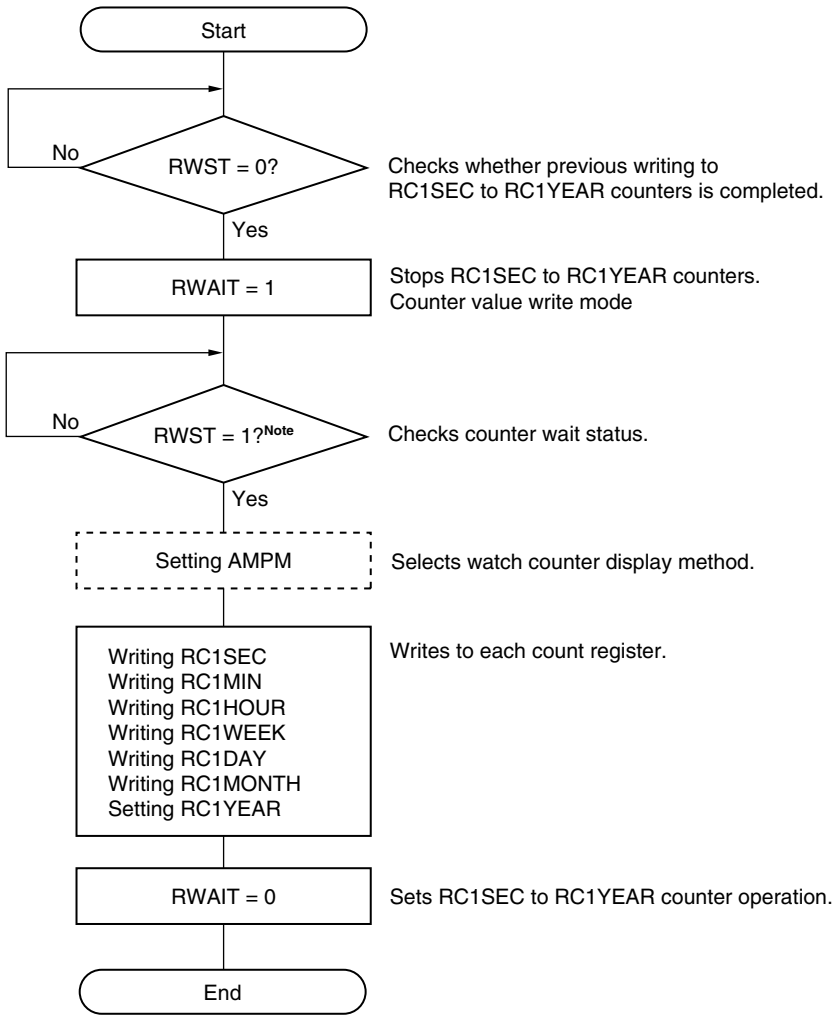
Figure 12-2. Initial Setting Procedure



12.4.2 Rewriting each counter during the real-time counter operation

Set as follows when rewriting each counter (RC1SEC, RC1MIN, RC1HOUR, RC1WEEK, RC1DAY, RC1MONTH, RC1YEAR) during the real-time counter operation (RC1PWR = 1, RTCE = 1).

Figure 12-3. Rewriting Each Counter During The real-time counter Operation



Note Be sure to confirm that RWST = 0 before setting STOP mode.

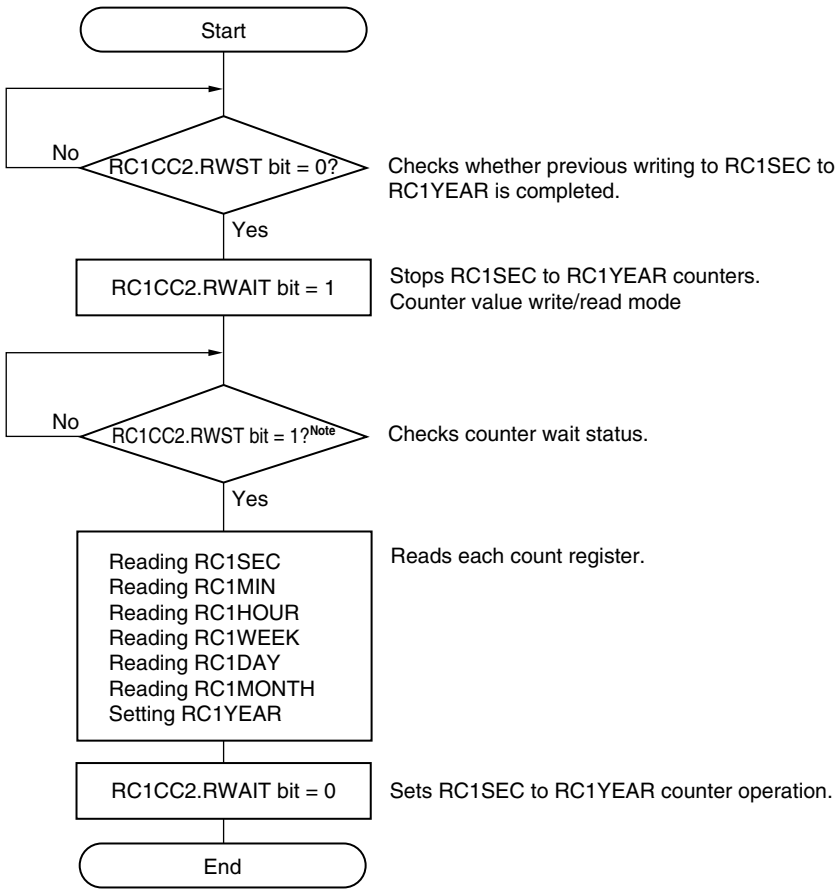
Caution Complete the series of operations for setting RWAIT to 1 to clearing RWAIT to 0 within 1 second.
If RWAIT = 1 is set, the operation of RC1SEC to RC1YEAR is stopped. If a carry occurs from RC1SUBC while RWAIT = 1, one carry can be internally retained. However, if two or more carries occur, the number of carries cannot be retained.

Remark RC1SEC, RC1MIN, RC1HOUR, RC1WEEK, RC1DAY, RC1MONTH, and RC1YEAR may berewrite in any sequence.
All the registers do not have to be set and only some registers may be read.

12.4.3 Reading each counter during the real-time counter operation

Set as follows when reading each counter (RC1SEC, RC1MIN, RC1HOUR, RC1WEEK, RC1DAY, RC1MONTH, RC1YEAR) during real-time counter operation (RC1PWR = 1).

Figure 12-4. Reading Each Counter During The real-time counter Operation



Note Be sure to confirm that RWST = 0 before setting STOP mode.

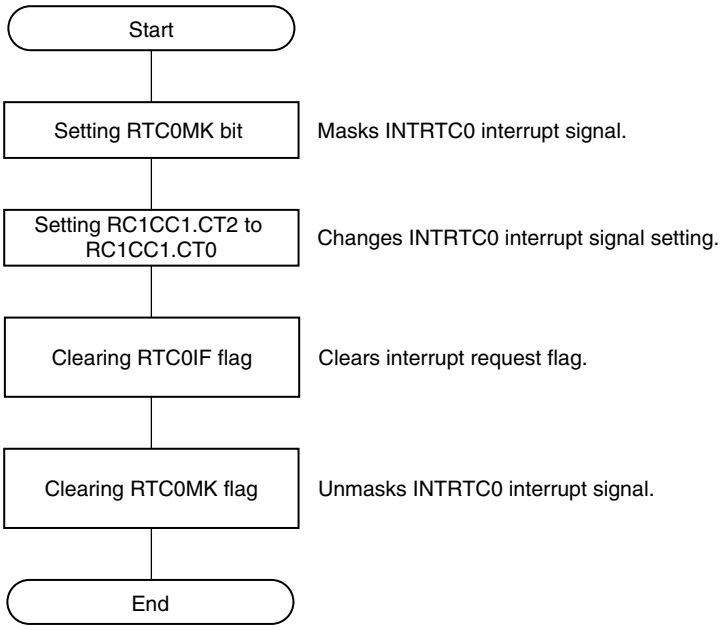
Caution **Complete the series of operations for setting RWAIT to 1 to clearing RWAIT to 0 within 1 second.**
If RWAIT = 1 is set, the operation of RC1SEC to RC1YEAR is stopped. If a carry occurs from RC1SUBC while RWAIT = 1, one carry can be internally retained. However, if two or more carries occur, the number of carries cannot be retained.

Remark RC1SEC, RC1MIN, RC1HOUR, RC1WEEK, RC1DAY, RC1MONTH, and RC1YEAR may be read in any sequence.
All the registers do not have to be set and only some registers may be read.

12.4.4 Changing INTRTC0 interrupt setting during the real-time counter operation

If the setting of the INTRTC0 interrupt (fixed-cycle interrupt) signal is changed while the real-time counter clock operates (PC1PWR = 1), the INTRCT0 interrupt waveform may include whiskers and unintended signals may be output. Set as follows when changing the setting of the INTRTC0 interrupt signal during the real-time counter operation (RC1PWR = 1, RTCE = 1), in order to mask the whiskers.

Figure 12-5. Changing INTRTC0 Interrupt Setting During The real-time counter Operation

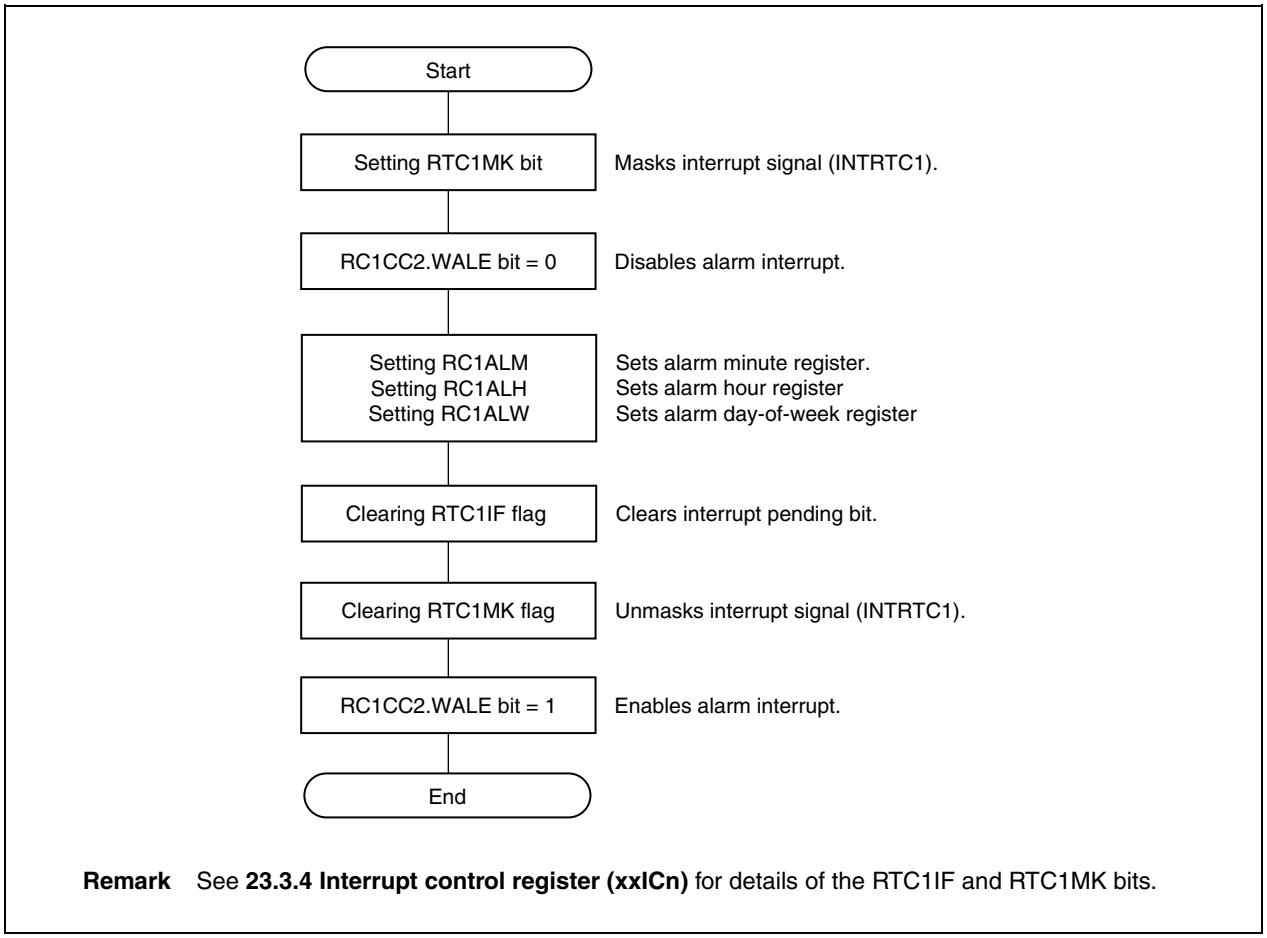


Remark See **23.3.4 Interrupt control register (xxICn)** for details of the RTC0IF and RTC0MK bits.

12.4.5 Changing INTRTC1 interrupt setting during the real-time counter operation

If the setting of the INTRTC1 interrupt (alarm interrupt) signal is changed while the real-time counter clock operates (RC1PWR = 1), the INTRCT1 interrupt waveform may include whiskers and unintended signals may be output. Set as follows when changing the setting of the INTRTC1 interrupt signal during the real-time counter operation (PC1PWR = 1, RTCE = 1), in order to mask the whiskers.

Figure 12-6. Changing INTRTC1 Interrupt Setting During The real-time counter Operation

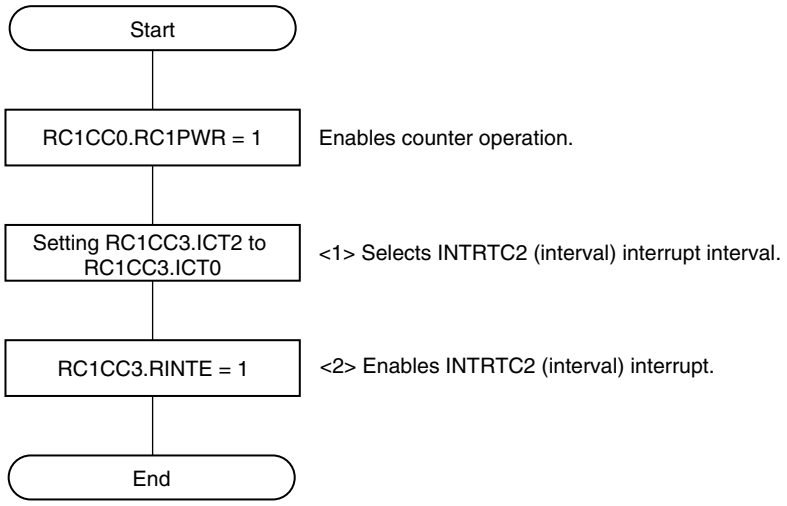


Remark See **23.3.4 Interrupt control register (xxICn)** for details of the RTC1IF and RTC1MK bits.

12.4.6 Initial INTRTC2 interrupt settings

Set as follows to set the INTRTC1 interrupt (interval interrupt).

Figure 12-7. INTRTC2 Interrupt Setting

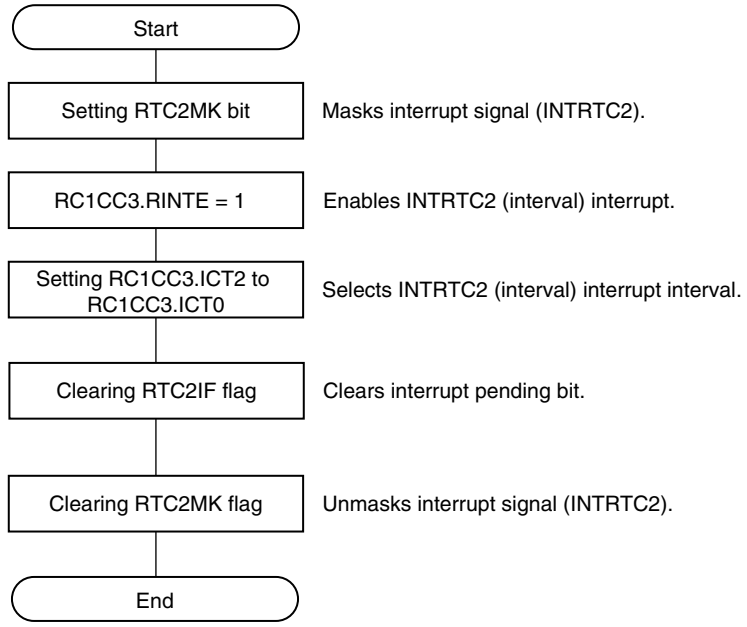


Caution Set <1> and <2> simultaneously or set <1> first. Unintended waveform interrupts may occur if <2> is set first.

12.4.7 Changing INTRTC2 interrupt setting during the real-time counter operation

If the setting of the INTRTC2 interrupt (interval interrupt) is changed while the real-time counter clock operates (PC1PWR = 1), the INTRCT2 interrupt waveform may include whiskers and unintended signals may be output. Set as follows when changing the setting of the INTRTC2 interrupt signal during the real-time counter operation (PC1PWR = 1, RTCE = 1), in order to mask the whiskers.

Figure 12-8. Changing INTRTC2 Interrupt Setting During The real-time counter Operation

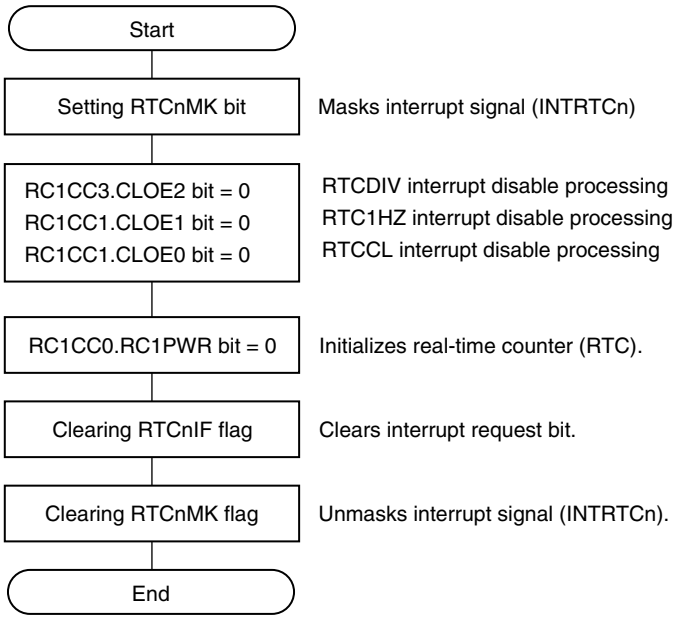


Remark See **23.3.4 Interrupt control register (xxICn)** for details of the RTC2IF and RTC2MK bits.

12.4.8 Initializing real-time counter

The procedure for initializing the real-time counter is shown below.

Figure 12-9. Initializing Real-Time Counter



Remarks 1. See **23.3.4 Interrupt control register (xxICn)** for details of the RTCnIF and RTCnMK bits.

2. n = 0 to 2

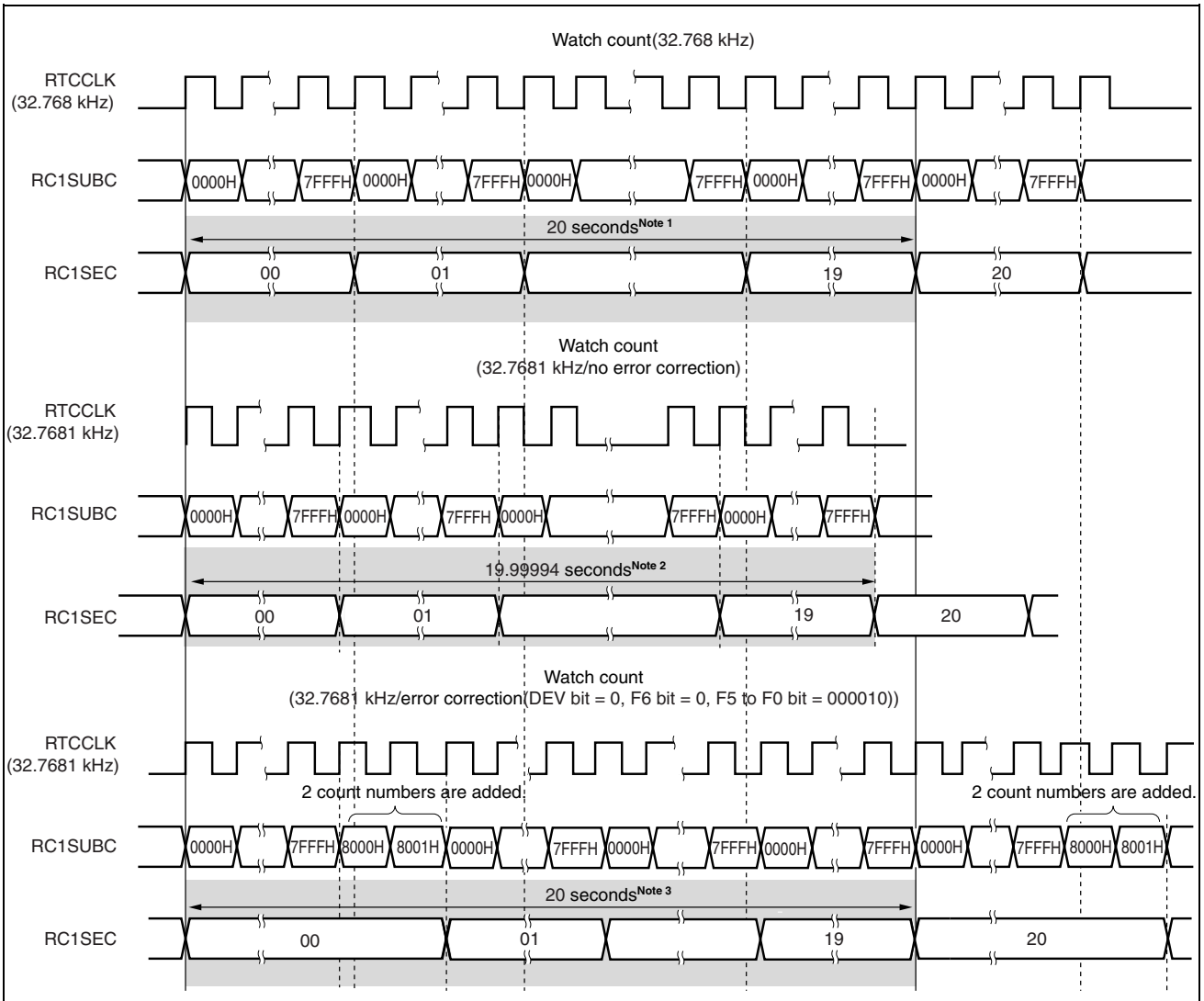
12.4.9 Watch error correction example of real-time counter

The watch error correction function corrects deviation in the oscillation frequency of a resonator connected to the V850ES/Jx3-H.

Deviation, here, refers to steady-state deviation, which is deviation in the frequency when the resonator is designed.

Next, the timing chart when an error has occurred in the input clock intended to be 32.768 kHz but a 32.7681 kHz resonator has been connected when designing the system, and the RC1SUBC and RC1SEC count operations to correct the error are shown below.

Figure 12-10. Watch Error Correction Example



Notes 1. The RC1SEC counter counts 20 seconds every 32,768 cycles (0000H to 7FFFH) of the 32.768 kHz clock.

2. When 32,768 cycles (0000H to 7FFFH) of the 32.7681 kHz clock are input, the time counted by the RC1SEC counter is calculated as follows: 32,768/3,268.1 ≅ 0.999997 seconds
If this counting continues 20 times, the time is calculated as follows: (32,768/32,768.1) x 20 ≅ 19.99994 seconds, which causes an error of 0.00006 seconds.

3. To precisely count 20 seconds by using a 32.7681 kHz clock, clear the DEV and F6 bits to 0 and set the F5 to F0 bits to 2H (000010B) in the RC1SUBU register. As a result, two additional cycles are counted every 20 seconds (when the RC1SEC counter count is 00, 20, and 40 seconds), so that the number of cycles counted at these points is not 32,768, but 32,770 (0000H to 8001H), which is exactly 20 seconds.

As shown in Figure 12-10, the watch can be accurately counted by incrementing the RC1SUBC count value, if a positive error faster than 32.768 kHz occurs at the resonator. Similarly, if a negative error slower than 32.768 kHz occurs at the resonator, the watch can be accurately counted by decrementing the RC1SUBC count value.

The RC1SUBC correction value is determined by using the RC1SUBU.F6 to RC1SUBU.F0 bits.

The F6 bit is used to determine whether to increment or decrement RC1SUBC and the F5 to F0 bits to determine the RC1SUBC value.

(1) Incrementing the RC1SUBC count value

The RC1SUBC count value is incremented by the value set using the F5 to F0 bits, by setting the F6 bit to 0.

Expression for calculating the increment value: (F5 to F0 bit value − 1) × 2

[Example of incrementing the RC1SUBC count value: F6 bit = 0]

If 15H (010101B) is set to the F5 to F0 bits

(15H − 1) × 2 = 40 (increments the RC1SUBC count value by 40)

RC1SUBC count value = 32,768 + 40 = 32,808

(2) Decrementing the RC1SUBC count value

The RC1SUBC count value is decremented by an inverted value of the value set using the F5 to F0 bits, by setting the F6 bit to 1.

Expression for calculating the decrement value: (Inverted value of F5 to F0 bit value + 1) × 2

[Example of decrementing the RC1SUBC count value: F6 bit = 1]

If 15H (010101B) is set to the F5 to F0 bits

Inverted data of 15H (010101B) = 2AH (101010B)

(2AH + 1) × 2 = 86 (decrements the RC1SUBC count value by 86)

RC1SUBC count value = 32,768 − 86 = 32,682

(3) DEV bit

The DEV bit determines when the setting by the F6 to F0 bits is enabled.

The value set by the F6 to F0 bits is reflected upon the next timing, but not to the RC1SUBC count value every time.

Table 12-6. DVE Bit Setting

DEV Bit Value	Timing of Reflecting Value to RC1SUBC
0	When RC1SEC is 00, 20, or 40 seconds.
1	When RC1SEC is 00 seconds.

[Example when 0010101B is set to F6 to F0 bits]

- If the DEV bit is 0

  The RC1SUBC count value is 32,808 at 00, 20, or 40 seconds.

  Otherwise, it is 32,768.

- IF DEV bit is 1

  The RC1SUBC count value is 32,808 at 00 seconds.

  Otherwise, it is 32,768.

As described above, the RC1SUBC count value is corrected every 20 seconds or 60 seconds, instead of every second, in order to match the RC1SUBC count value with the deviation width of the resonator.

The range in which the resonator frequency can be actually corrected is shown below.

- If the DEV bit is 0: 32.76180000 kHz to 32.77420000 kHz
- If the DEV bit is 1: 32.76593333 kHz to 32.77006667 kHz

The range in which the frequency can be corrected when the DEV bit is 0 is three times wider than when the DEV bit is 1.

However, the accuracy of setting the frequency when the DEV bit is 1 is three times that when the DEV bit is 0.

Tables 12-7 and 12-8 show the setting values of the DEV, and F6 to F0 bits, and the corresponding frequencies that can be corrected.

Table 12-7. Range of Frequencies That Can Be Corrected When DEV Bit = 0

F6	F5 to F0	RC1SUBC Correction Value	Frequency of Connected Clock (Including Steady-State Deviation)
0	000000	No correction	–
0	000001	No correction	–
0	000010	Increments RC1SUBC count value by 2 once every 20 seconds	32.76810000 kHz
0	000011	Increments RC1SUBC count value by 4 once every 20 seconds	32.76820000 kHz
0	000100	Increments RC1SUBC count value by 6 once every 20 seconds	32.76830000 kHz
		⋮	
0	111011	Increments RC1SUBC count value by 120 once every 20 seconds	32.77400000 kHz
0	111110	Increments RC1SUBC count value by 122 once every 20 seconds	32.77410000 kHz
0	111111	Increments RC1SUBC count value by 124 once every 20 seconds	32.77420000 kHz (upper limit)
1	000000	No correction	–
1	000001	No correction	–
1	000010	Decrements RC1SUBC count value by 124 once every 20 seconds	32.76180000 kHz (lower limit)
1	000011	Decrements RC1SUBC count value by 122 once every 20 seconds	32.76190000 kHz
1	000100	Decrements RC1SUBC count value by 120 once every 20 seconds	32.76200000 kHz
		⋮	
1	11011	Decrements RC1SUBC count value by 6 once every 20 seconds	32.76770000 kHz
1	11110	Decrements RC1SUBC count value by 4 once every 20 seconds	32.76780000 kHz
1	11111	Decrements RC1SUBC count value by 2 once every 20 seconds	32.76790000 kHz

Table 12-8. Range of Frequencies That Can Be Corrected When DEV Bit = 1

F6	F5 to F0	RC1SUBC Correction Value	Frequency of Connected Clock (Including Steady-State Deviation)
0	000000	No correction	–
0	000001	No correction	–
0	000010	Increments RC1SUBC count value by 2 once every 60 seconds	32.76803333 kHz
0	000011	Increments RC1SUBC count value by 4 once every 60 seconds	32.76806667 kHz
0	000100	Increments RC1SUBC count value by 6 once every 60 seconds	32.76810000 kHz
		⋮	
0	111011	Increments RC1SUBC count value by 120 once every 60 seconds	32.77000000 kHz
0	111110	Increments RC1SUBC count value by 122 once every 60 seconds	32.77003333 kHz
0	111111	Increments RC1SUBC count value by 124 once every 60 seconds	32.77006667 kHz (upper limit)
1	000000	No correction	–
1	000001	No correction	–
1	000010	Decrements RC1SUBC count value by 124 once every 60 seconds	32.76593333 kHz (lower limit)
1	000011	Decrements RC1SUBC count value by 122 once every 60 seconds	32.76596667 kHz
1	000100	Decrements RC1SUBC count value by 120 once every 60 seconds	32.76600000 kHz
		⋮	
1	11011	Decrements RC1SUBC count value by 6 once every 60 seconds	32.76790000 kHz
1	11110	Decrements RC1SUBC count value by 4 once every 60 seconds	32.76793333 kHz
1	11111	Decrements RC1SUBC count value by 2 once every 60 seconds	32.76796667 kHz

CHAPTER 13 FUNCTIONS OF WATCHDOG TIMER 2

13.1 Functions

Watchdog timer 2 has the following functions.

- Default-start watchdog timer[Note 1]
  → Reset mode: Reset operation upon overflow of watchdog timer 2 (generation of WDT2RES signal)
  → Non-maskable interrupt request mode: NMI operation upon overflow of watchdog timer 2 (generation of INTWDT2 signal)[Note 2]
- Input from main clock, internal oscillation clock, and subclock selectable as the source clock

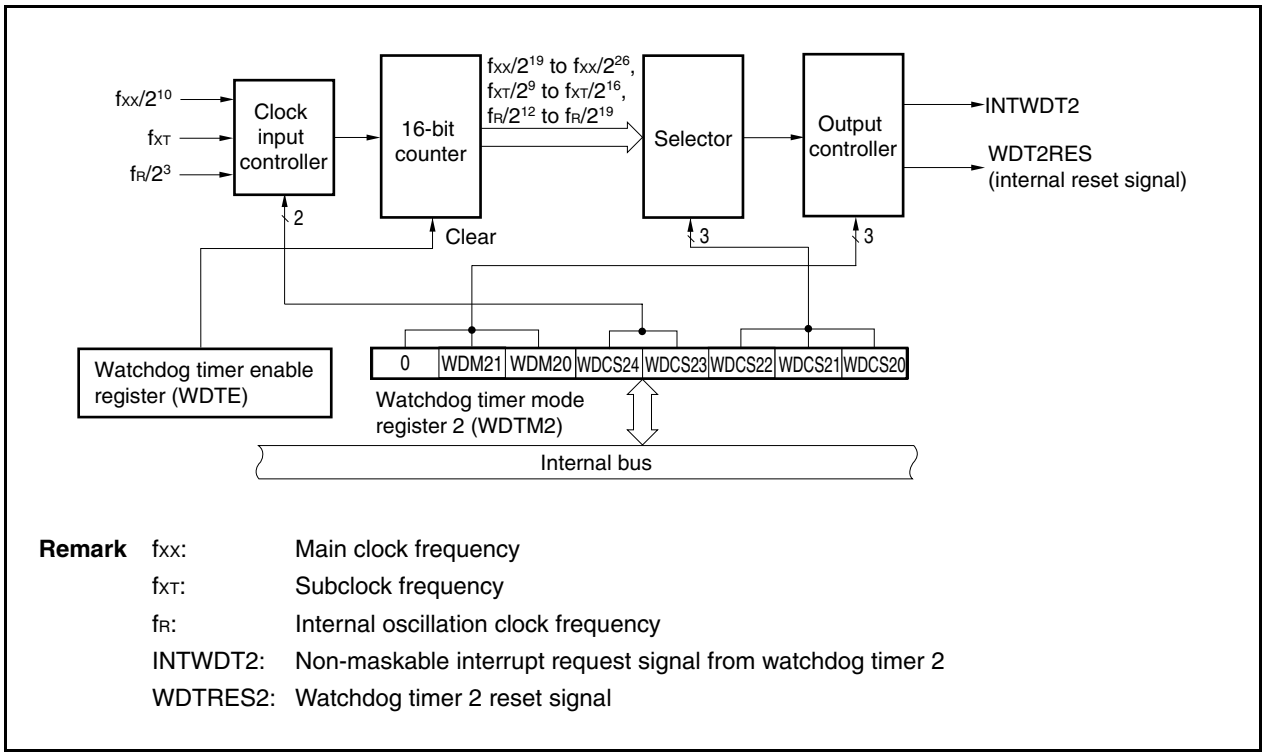
Notes 1. Watchdog timer 2 automatically starts in the reset mode following reset release.
When watchdog timer 2 is not used, either stop its operation before reset is executed via this function, or clear watchdog timer 2 once and stop it within the next interval time.
Also, write to the WDTM2 register for verification purposes once, even if the default settings (reset mode, interval time: $f_R/2^{19}$) do not need to be changed.

2. For the non-maskable interrupt servicing due to a non-maskable interrupt request signal (INTWDT2), see **23.2.2 (2) From INTWDT2 signal**.

13.2 Configuration

The following shows the block diagram of watchdog timer 2.

Figure 13-1. Block Diagram of Watchdog Timer 2



Remark fXX: Main clock frequency
fXT: Subclock frequency
fR: Internal oscillation clock frequency
INTWDT2: Non-maskable interrupt request signal from watchdog timer 2
WDTRES2: Watchdog timer 2 reset signal

Watchdog timer 2 includes the following hardware.

Table 13-1. Configuration of Watchdog Timer 2

Item	Configuration
Control registers	Watchdog timer mode register 2 (WDTM2) Watchdog timer enable register (WDTE)

13.3 Registers

(1) Watchdog timer mode register 2 (WDTM2)

The WDTM2 register sets the overflow time and operation clock of watchdog timer 2.

This register can be read or written in 8-bit units. This register can be read any number of times, but it can be written only once following reset release.

Reset sets this register to 67H.

Caution Accessing the WDTM2 register is prohibited in the following statuses. For details, see 3.4.9 (2) Accessing specific on-chip peripheral I/O registers.

- **When the CPU operates on the subclock and the main clock oscillation is stopped**
- **When the CPU operates on the internal oscillation clock**

After reset: 67H R/W Address: FFFFF6D0H

	7	6	5	4	3	2	1	0
WDTM2	0	WDM21	WDM20	WDCS24	WDCS23	WDCS22	WDCS21	WDCS20

WDM21	WDM20	Selection of operation mode of watchdog timer 2
0	0	Stops operation
0	1	Non-maskable interrupt request mode (generation of INTWDT2 signal)
1	–	Reset mode (generation of WDT2RES signal)

Cautions 1. For details of the WDCS20 to WDCS24 bits, see Table 13-2 Watchdog Timer 2 Clock Selection.

2. Although watchdog timer 2 can be stopped just by stopping operation of the internal oscillator, clear the WDTM2 register to 00H to securely stop the timer (to avoid selection of the main clock or subclock due to an erroneous write operation).

3. If the WDTM2 register is rewritten twice after reset, an overflow signal is forcibly generated and the counter is reset.

4. To intentionally generate an overflow signal, write data to the WDTM2 register twice, or write a value other than "ACH" to the WDTE register once.
However, when the operation of watchdog timer 2 is set to be stopped, an overflow signal is not generated even if data is written to the WDTM2 register twice, or a value other than "ACH" is written to the WDTE register once.

5. To stop the operation of watchdog timer 2, set the RCM.RSTOP bit to 1 (to stop the internal oscillator) and write 00H in the WDTM2 register. If the RCM.RSTOP bit cannot be set to 1, set the WDCS23 bit to 1 (2^n/fxx is selected and the clock can be stopped in the IDLE1, IDLW2, sub-IDLE, and subclock operation modes).

Table 13-2. Watchdog Timer 2 Clock Selection

WDCS24	WDCS23	WDCS22	WDCS21	WDCS20	Selected Clock	100 kHz (MIN.)	220 kHz (TYP.)	400 kHz (MAX.)
0	0	0	0	0	$2^{12}/f_R$	41.0 ms	18.6 ms	10.2 ms
0	0	0	0	1	$2^{13}/f_R$	81.9 ms	37.2 ms	20.5 ms
0	0	0	1	0	$2^{14}/f_R$	163.8 ms	74.5 ms	41.0 ms
0	0	0	1	1	$2^{15}/f_R$	327.7 ms	148.9 ms	81.9 ms
0	0	1	0	0	$2^{16}/f_R$	655.4 ms	297.9 ms	163.8 ms
0	0	1	0	1	$2^{17}/f_R$	1,310.7 ms	595.8 ms	327.7 ms
0	0	1	1	0	$2^{18}/f_R$	2,621.4 ms	1191.6 ms	655.4 ms
0	0	1	1	1	$2^{19}/f_R$ (Default value)	5,242.9 ms	2383.1 ms	1,310.7 ms
						f_{XX} = 24 MHz	f_{XX} = 32 MHz	f_{XX} = 48 MHz
0	1	0	0	0	$2^{19}/f_{XX}$	21.8 ms	16.4 ms	10.9 ms
0	1	0	0	1	$2^{20}/f_{XX}$	43.7 ms	32.8 ms	21.8 ms
0	1	0	1	0	$2^{21}/f_{XX}$	87.4 ms	65.5 ms	43.7 ms
0	1	0	1	1	$2^{22}/f_{XX}$	174.8 ms	131.1 ms	87.4 ms
0	1	1	0	0	$2^{23}/f_{XX}$	349.5 ms	262.1 ms	174.8 ms
0	1	1	0	1	$2^{24}/f_{XX}$	699.1 ms	524.3 ms	349.5 ms
0	1	1	1	0	$2^{25}/f_{XX}$	1398.1 ms	1048.6 ms	699.1 ms
0	1	1	1	1	$2^{26}/f_{XX}$	2796.2 ms	2097.2 ms	1398.1 ms
						f_{XT} = 32.768 kHz		
1	×	0	0	0	$2^9/f_{XT}$	15.625 ms		
1	×	0	0	1	$2^{10}/f_{XT}$	31.25 ms		
1	×	0	1	0	$2^{11}/f_{XT}$	62.5 ms		
1	×	0	1	1	$2^{12}/f_{XT}$	125 ms		
1	×	1	0	0	$2^{13}/f_{XT}$	250 ms		
1	×	1	0	1	$2^{14}/f_{XT}$	500 ms		
1	×	1	1	0	$2^{15}/f_{XT}$	1,000 ms		
1	×	1	1	1	$2^{16}/f_{XT}$	2,000 ms		

(2) Watchdog timer enable register (WDTE)

The counter of watchdog timer 2 is cleared and counting restarted by writing “ACH” to the WDTE register.

The WDTE register can be read or written in 8-bit units.

Reset sets this register to 9AH.

After reset: 9AH R/W Address: FFFFF6D1H

	7	6	5	4	3	2	1	0
WDTE								

Cautions 1. When a value other than “ACH” is written to the WDTE register, an overflow signal is forcibly output.

2. When a 1-bit memory manipulation instruction is executed for the WDTE register, an overflow signal is forcibly output.

3. To intentionally generate an overflow signal, write a value other than “ACH” to the WDTE register once, or write data to the WDTM2 register twice.
However, when the operation of watchdog timer 2 is set to be stopped, an overflow signal is not generated even if data is written to the WDTM2 register twice, or a value other than “ACH” is written to the WDTE register once.

4. The read value of the WDTE register is “9AH” (which differs from written value “ACH”).

13.4 Operation

Watchdog timer 2 automatically starts in the reset mode following reset release.

The WDTM2 register can be written to only once following reset using byte access. To use watchdog timer 2, write the operation mode and the interval time to the WDTM2 register using an 8-bit memory manipulation instruction. After this, the operation of watchdog timer 2 cannot be stopped.

The WDTM2.WDCS24 to WDTM2.WDCS20 bits are used to select the watchdog timer 2 loop detection time interval.

Writing ACH to the WDTE register clears the counter of watchdog timer 2 and starts the count operation again. After the count operation has started, write ACH to WDTE within the loop detection time interval.

If the time interval expires without ACH being written to the WDTE register, a reset signal (WDT2RES) or a non-maskable interrupt request signal (INTWDT2) is generated, depending on the set values of the WDTM2.WDM21 and WDTM2.WDM20 bits.

When the WDTM2.WDM21 bit is set to 1 (reset mode), if a WDT overflow occurs during oscillation stabilization after a reset or standby is released, no internal reset will occur and the CPU clock will switch to the internal oscillation clock.

To not use watchdog timer 2, write 00H to the WDTM2 register.

For the non-maskable interrupt servicing while the non-maskable interrupt request mode is set, see **23.2.2 (2) From INTWDT2 signal**.

CHAPTER 14 REAL-TIME OUTPUT FUNCTION (RTO)

14.1 Function

The real-time output function transfers the data preset to the RTBL0 and RTBH0 registers to the output latches via hardware and outputs the data to an external device, at the same time as a timer interrupt occurs. The pins through which the data is output to an external device constitute a port called the real-time output (RTO) port.

Because signals without jitter can be output by using RTO, it is suitable for controlling a stepper motor.

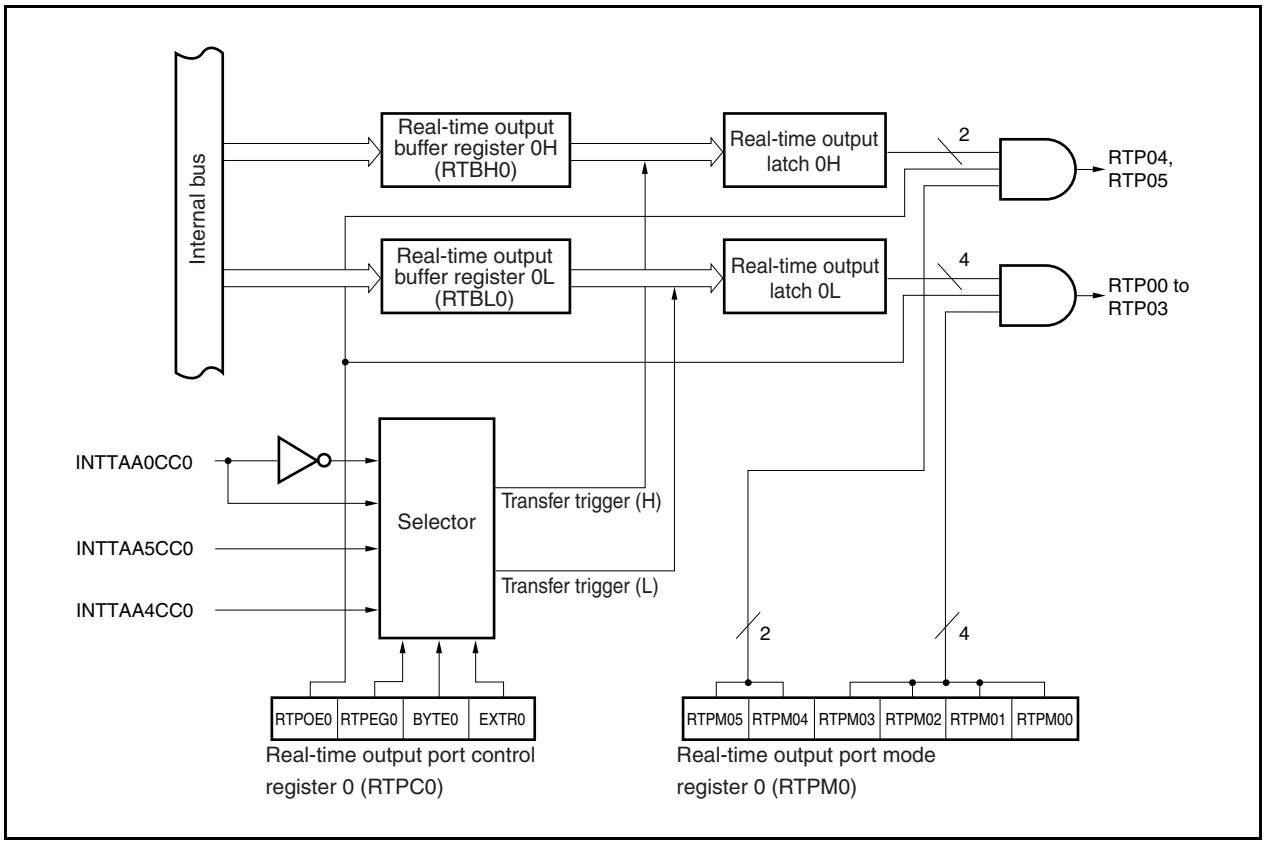
In the V850ES/JG3-H and V850ES/JH3-H, one 6-bit real-time output port channel is provided.

The real-time output port can be set to the port mode or real-time output port mode in 1-bit units.

14.2 Configuration

The block diagram of RTO is shown below.

Figure 14-1. Block Diagram of RTO



RTO includes the following hardware.

Table 14-1. Configuration of RTO

Item	Configuration
Registers	Real-time output buffer registers 0L, 0H (RTBL0, RTBH0)
Control registers	Real-time output port mode register 0 (RTPM0) Real-time output port control register 0 (RTPC0)

(1) Real-time output buffer registers 0L, 0H (RTBL0, RTBH0)

The RTBL0 and RTBH0 registers are 4-bit registers that hold output data in advance.

These registers are each mapped to independent addresses in the peripheral I/O register area.

These registers can be read or written in 8-bit or 1-bit units.

Reset sets these registers to 00H.

If an operation mode of 4 bits × 1 channel or 2 bits × 1 channel is specified (RTPC0.BYTE0 bit = 0), data can be individually set to the RTBL0 and RTBH0 registers. The data of both these registers can be read at once by specifying the address of either of these registers.

If an operation mode of 6 bits × 1 channel is specified (BYTE0 bit = 1), 8-bit data can be set to both the RTBL0 and RTBH0 registers by writing the data to either of these registers. Moreover, the data of both these registers can be read at once by specifying the address of either of these registers.

Table 14-2 shows the operation when the RTBL0 and RTBH0 registers are manipulated.

After reset: 00H R/W Address: RTBL0 FFFFF6E0H, RTBH0 FFFFF6E2H

	7	6	5	4	3	2	1	0
RTBL0					RTBL03	RTBL02	RTBL01	RTBL00
RTBH0	0	0	RTBH05	RTBH04				

Cautions 1. When writing to bits 6 and 7 of the RTBH0 register, always set 0.

2. Accessing the RTBL0 and RTBH0 registers is prohibited in the following statuses. For details, see 3.4.9 (2) Accessing specific on-chip peripheral I/O registers.

- **When the CPU operates on the subclock and the main clock oscillation is stopped**
- **When the CPU operates on the internal oscillation clock**

Table 14-2. Operation During Manipulation of RTBL0 and RTBH0 Registers

Operation Mode	Register to Be Manipulated	Read		Write[Note]	
		Higher 4 Bits	Lower 4 Bits	Higher 4 Bits	Lower 4 Bits
4 bits × 1 channel, 2 bits × 1 channel	RTBL0	RTBH0	RTBL0	Invalid	RTBL0
	RTBH0	RTBH0	RTBL0	RTBH0	Invalid
6 bits × 1 channel	RTBL0	RTBH0	RTBL0	RTBH0	RTBL0
	RTBH0	RTBH0	RTBL0	RTBH0	RTBL0

Note After setting the real-time output port, set output data to the RTBL0 and RTBH0 registers by the time a real-time output trigger is generated.

14.3 Registers

RTO is controlled using the following two registers.

- Real-time output port mode register 0 (RTPM0)
- Real-time output port control register 0 (RTPC0)

(1) Real-time output port mode register 0 (RTPM0)

The RTPM0 register selects the real-time output port mode or port mode in 1-bit units.

This register can be read or written in 8-bit or 1-bit units.

Reset sets this register to 00H.

After reset: 00H R/W Address: RTPM0 FFFFF6E4H

	7	6	5	4	3	2	1	0
RTPM0	0	0	RTPM05	RTPM04	RTPM03	RTPM02	RTPM01	RTPM00

RTPM0m	Control of real-time output port (m = 0 to 5)
0	Real-time output disabled
1	Real-time output enabled

Cautions 1. By enabling the real-time output operation (RTPC0.RTPOE0 bit = 1), the bits enabled for real-time output among the RTP00 to RTP05 signals perform real-time output, and the bits set to port mode output 0.

2. If real-time output is disabled (RTPOE0 bit = 0), the real-time output pins (RTP00 to RTP05) all output 0, regardless of the RTPM0 register setting.

3. In order to use this register for the real-time output pins (RTP00 to RTP05), set these pins as real-time output port pins using the PMC and PFC registers.

(2) Real-time output port control register 0 (RTPC0)

The RTPC0 register is a register that sets the operation mode and output trigger of the real-time output port.

The relationship between the operation mode and output trigger of the real-time output port is as shown in Table 14-3.

This register can be read or written in 8-bit or 1-bit units.

Reset sets this register to 00H.

After reset: 00H R/W Address: FFFFF6E5H

	<7>	6	5	4	3	2	1	0
RTPC0	RTPOE0	RTPEG0	BYTE0	EXTR0	0	0	0	0

RTPOE0	Control of real-time output operation
0	Disables operation[Note 1]
1	Enables operation

RTPEG0	Valid edge of INTTP0CC0 signal
0	Falling edge[Note 2]
1	Rising edge

BYTE0	Specification of channel configuration for real-time output
0	4 bits × 1 channels, 2 bits × 1 channels
1	6 bits × 1 channels

Notes 1. When the real-time output operation is disabled (RTPOE0 bit = 0), all real-time output pins (RTP00 to RTP05) output "0".

2. The INTTAA0CC0 signal is output for 1 clock of the count clock selected by TAA0.

Caution Set the RTPEG0, BYTE0, and EXTR0 bits only when the RTPOE0 bit = 0.

Table 14-3. Operation Modes and Output Triggers of Real-Time Output Port

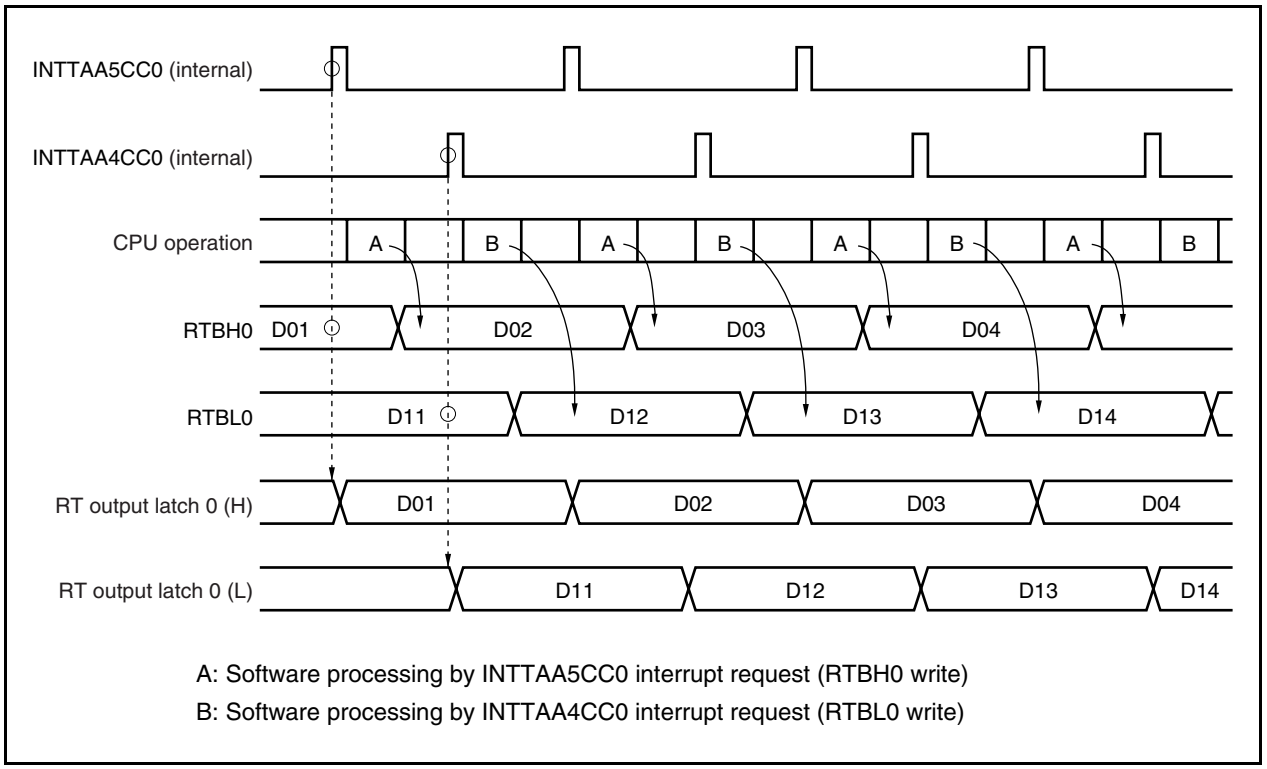
BYTE0	EXTR0	Operation Mode	RTBH0 (RTP04, RTP05)	RTBL0 (RTP00 to RTP03)
0	0	4 bits × 1 channel, 2 bits × 1 channel	INTTAA5CC0	INTTAA4CC0
	1		INTTAA4CC0	INTTAA0CC0
1	0	6 bits × 1 channel	INTTAA4CC0	
	1		INTTAA0CC0	

14.4 Operation

If the real-time output operation is enabled by setting the RTPC0.RTPOE0 bit to 1, the data of the RTBH0 and RTBL0 registers is transferred to the real-time output latch in synchronization with the generation of the selected transfer trigger (set by the RTPC0.EXTR0 and RTPC0.BYTE0 bits). Of the transferred data, only the data of the bits for which real-time output is enabled by the RTPM0 register is output from the RTP00 to RTP05 bits. The bits for which real-time output is disabled by the RTPM0 register output 0.

If the real-time output operation is disabled by clearing the RTPOE0 bit to 0, the RTP00 to RTP05 signals output 0 regardless of the setting of the RTPM0 register.

Figure 14-2. Example of Operation Timing of RTO0 (When EXTR0 Bit = 0, BYTE0 Bit = 0)



Remark For the operation during standby, see **CHAPTER 25 STANDBY FUNCTION**.

14.5 Usage

(1) Disable real-time output.
Clear the RTPC0.RTPOE0 bit to 0.

(2) Perform initialization as follows.
- Set the alternate-function pins of port 2 or port 5
  After setting the PFC2.PFC2m bit and PFCE2.PFCE2m bit to the RTO pin, set the PMC2.PMC2m bit to 1 (m = 0 to 3).
  After setting the PFC5.PFC5m bit and PFCE5.PFCE5m bit to the RTO pin, set the PMC5.PMC5m bit to 1 (m = 0 to 5).
- Specify the real-time output port mode or port mode in 1-bit units.
  Set the RTPM0 register.
- Channel configuration: Select the trigger and valid edge.
  Set the RTPC0.EXTR0, RTPC0.BYTE0, and RTPC0.RTPEG0 bits.
- Set the initial values to the RTBH0 and RTBL0 registers[Note 1].

(3) Enable real-time output.
Set the RTPOE0 bit = 1.

(4) Set the next output value to the RTBH0 and RTBL0 registers by the time the selected transfer trigger is generated[Note 2].

(5) Sequentially set the next real-time output value to the RTBH0 and RTBL0 registers via interrupt servicing corresponding to the selected trigger.

Notes 1. If the RTBH0 and RTBL0 registers are written when the RTPOE0 bit = 0, that value is transferred to real-time output latches 0H and 0L.

2. Even if the RTBH0 and RTBL0 registers are written when the RTPOE0 bit = 1, data is not transferred to real-time output latches 0H and 0L.

14.6 Cautions

(1) Prevent the following conflicts by software.

- Conflict between real-time output disable/enable switching (RTPOE0 bit) and the selected real-time output trigger.
- Conflict between writing to the RTBH0 and RTBL0 registers in the real-time output enabled status and the selected real-time output trigger.

(2) Before performing initialization, disable real-time output (RTPOE0 bit = 0).

(3) Once real-time output has been disabled (RTPOE0 bit = 0), be sure to initialize the RTBH0 and RTBL0 registers before enabling real-time output again (RTPOE0 bit = 0 → 1).

CHAPTER 15 A/D CONVERTER

15.1 Overview

The A/D converter converts analog input signals into digital values, has a resolution of 10 bits, and can handle 12 analog input signal channels (ANI0 to ANI11).

The A/D converter has the following features.

- 10-bit resolution
- 12 channels
- Successive approximation method
- Operating voltage: AV_{REF0} = 3.0 to 3.6 V
- Analog input voltage: 0 V to AV_{REF0}
- The following functions are provided as operation modes.
  - Continuous select mode
  - Continuous scan mode
  - One-shot select mode
  - One-shot scan mode
- The following functions are provided as trigger modes.
  - Software trigger mode
  - External trigger mode (external, 1)
  - Timer trigger mode
- Power-fail monitor function (conversion result compare function)

15.2 Functions

(1) 10-bit resolution A/D conversion

An analog input channel is selected from ANI0 to ANI11, and an A/D conversion operation is repeated at a resolution of 10 bits. Each time A/D conversion has been completed, an interrupt request signal (INTAD) is generated.

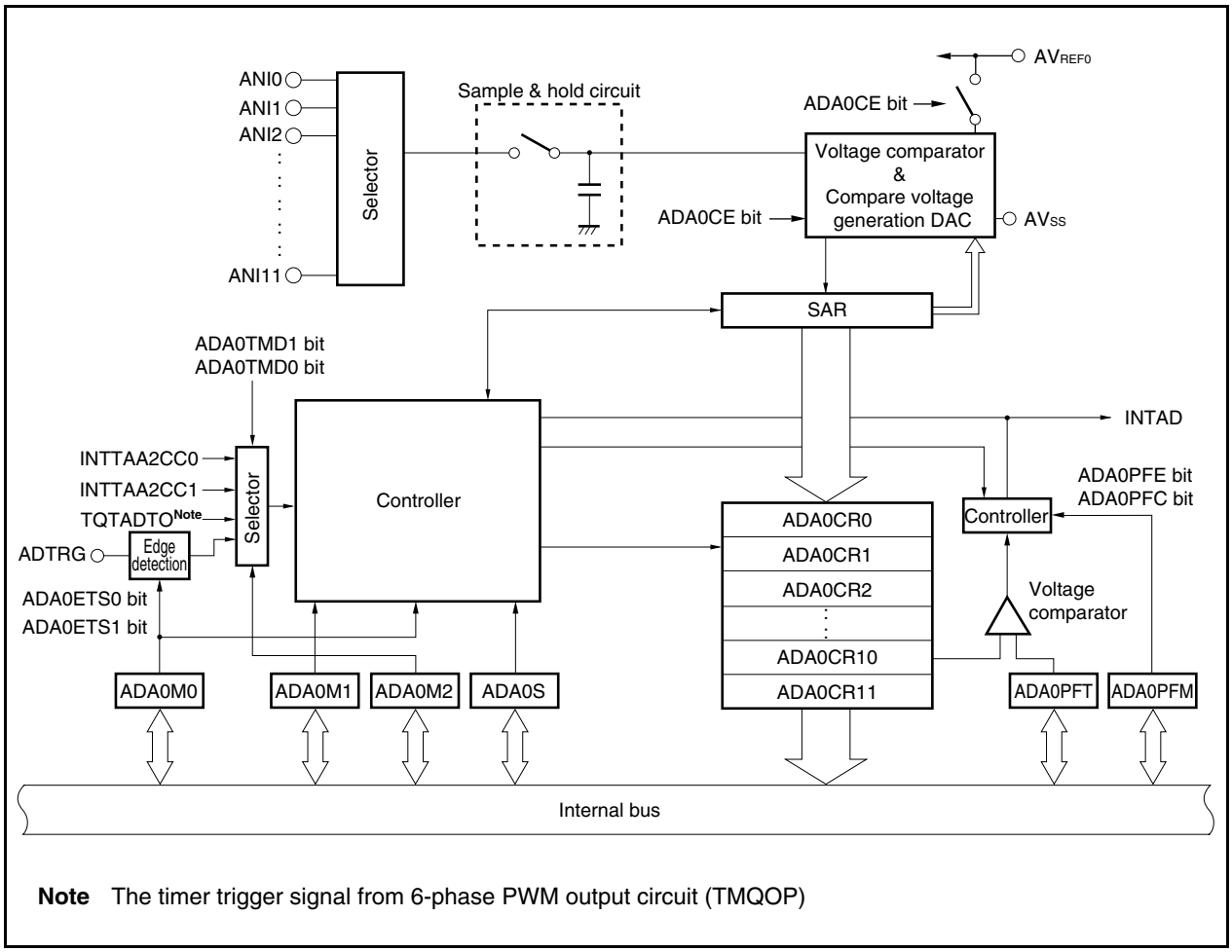
(2) Power-fail detection function

This function is used to detect a drop in the battery voltage. The result of A/D conversion (the value of the ADA0CRnH register) is compared with the value of the ADA0PFT register, and the INTAD signal is generated only when a specified comparison condition is satisfied (n = 0 to 11).

15.3 Configuration

The block diagram of the A/D converter is shown below.

Figure 15-1. Block Diagram of A/D Converter



Note The timer trigger signal from 6-phase PWM output circuit (TMQOP)

The A/D converter includes the following hardware.

Table 15-1. Configuration of A/D Converter

Item	Configuration
Analog inputs	12 channels (ANI0 to ANI11 pins)
Registers	Successive approximation register (SAR) A/D conversion result registers 0 to 11 (ADA0CR0 to ADA0CR11) A/D conversion result registers 0H to 11H (ADCR0H to ADCR11H): Only higher 8 bits can be read
Control registers	A/D converter mode registers 0 to 2 (ADA0M0 to ADA0M2) A/D converter channel specification register 0 (ADA0S) Power fail compare mode register (ADA0PFM) Power fail compare threshold value register (ADA0PFT)

(1) Successive approximation register (SAR)

The SAR compares the voltage value of the analog input signal with the output voltage of the compare voltage generation DAC (compare voltage), and holds the comparison result starting from the most significant bit (MSB).

When the comparison result has been held down to the least significant bit (LSB) (i.e., when A/D conversion is complete), the contents of the SAR are transferred to the ADA0CRn register.

Remark n = 0 to 11

(2) A/D conversion result register n (ADA0CRn), A/D conversion result register nH (ADA0CRnH)

The ADA0CRn register is a 16-bit register that stores the A/D conversion result. ADA0ARn consist of 12 registers and the A/D conversion result is stored in the 10 higher bits of the AD0CRn register corresponding to analog input. (The lower 6 bits are fixed to 0.)

(3) A/D converter mode register 0 (ADA0M0)

This register specifies the operation mode and controls the conversion operation by the A/D converter.

(4) A/D converter mode register 1 (ADA0M1)

This register sets the conversion time of the analog input signal to be converted.

(5) A/D converter mode register 2 (ADA0M2)

This register sets the hardware trigger mode.

(6) A/D converter channel specification register (ADA0S)

This register sets the input port that inputs the analog voltage to be converted.

(7) Power-fail compare mode register (ADA0PFM)

This register sets the power-fail monitor mode.

(8) Power-fail compare threshold value register (ADA0PFT)

The ADA0PFT register sets the threshold value that is compared with the value of A/D conversion result register nH (ADA0CRnH).

The 8-bit data set to the ADA0PFT register is compared with the higher 8 bits of the A/D conversion result register (ADA0CRnH).

(9) Controller

The controller compares the result of the A/D conversion (the value of the ADA0CRnH register) with the value of the ADA0PFT register when A/D conversion is completed or when the power-fail detection function is used, and generates the INTAD signal only when a specified comparison condition is satisfied.

(10) Sample & hold circuit

The sample & hold circuit samples each of the analog input signals selected by the input circuit and sends the sampled data to the voltage comparator. This circuit also holds the sampled analog input signal voltage during A/D conversion.

(11) Voltage comparator

The voltage comparator compares a voltage value that has been sampled and held with the output voltage of the compare voltage generation DAC.

(12) Compare voltage generation DAC

This compare voltage generation DAC is connected between AV_{REF0} and AV_{SS} and generates a voltage for comparison with the analog input signal.

(13) ANI0 to ANI11 pins

These are analog input pins for the 12 A/D converter channels and are used to input analog signals to be converted into digital signals. Pins other than the one selected as the analog input by the ADA0S register can be used as input port pins.

Caution Make sure that the voltages input to the ANI0 to ANI11 pins do not exceed the rated values. In particular if a voltage of AV_{REF0} or higher is input to a channel, the conversion value of that channel becomes undefined, and the conversion values of the other channels may also be affected.

(14) AV_{REF0} pin

This is the pin used to input the reference voltage of the A/D converter. Always make the potential at this pin the same as that at the V_{DD} pin even when the A/D converter is not used.

The signals input to the ANI0 to ANI11 pins are converted to digital signals based on the voltage applied between the AV_{REF0} and AV_{SS} pins.

(15) AV_{SS} pin

This is the ground potential pin of the A/D converter. Always make the potential at this pin the same as that at the V_{SS} pin even when the A/D converter is not used.

15.4 Registers

The A/D converter is controlled by the following registers.

- A/D converter mode registers 0, 1, 2 (ADA0M0, ADA0M1, ADA0M2)
- A/D converter channel specification register 0 (ADA0S)
- Power-fail compare mode register (ADA0PFM)

The following registers are also used.

- A/D conversion result register n (ADA0CRn)
- A/D conversion result register nH (ADA0CRnH)
- Power-fail compare threshold value register (ADA0PFT)

(1) A/D converter mode register 0 (ADA0M0)

The ADA0M0 register is an 8-bit register that specifies the operation mode and controls conversion operations.

This register can be read or written in 8-bit or 1-bit units. However, the ADA0EF bit is read-only.

Reset sets this register to 00H.

After reset: 00H R/W Address: FFFFF200H

	<7>	6	5	4	3	2	1	<0>
ADA0M0	ADA0CE	0	ADA0MD1	ADA0MD0	ADA0ETS1	ADA0ETS0	ADA0TMD	ADA0EF

ADA0CE	A/D conversion control
0	Stops A/D conversion
1	Enables A/D conversion

ADA0MD1	ADA0MD0	Specification of A/D converter operation mode
0	0	Continuous select mode
0	1	Continuous scan mode
1	0	One-shot select mode
1	1	One-shot scan mode

ADA0ETS1	ADA0ETS0	Specification of external trigger (ADTRG pin) input valid edge
0	0	No edge detection
0	1	Falling edge detection
1	0	Rising edge detection
1	1	Detection of both rising and falling edges

(2/2)

ADA0TMD	Trigger mode specification
0	Software trigger mode
1	External trigger mode/timer trigger mode

ADA0EF	A/D converter status display
0	A/D conversion stopped
1	A/D conversion in progress

Cautions 1. Accessing the ADA0M0 register is prohibited in the following statuses. For details, see 3.4.9 (2) Accessing specific on-chip peripheral I/O registers.

- **When the CPU operates on the subclock and the main clock oscillation is stopped**
- **When the CPU operates on the internal oscillation clock**

2. A write operation to bit 0 is ignored.

3. Changing the ADA0M1.ADA0FR2 to ADA0M1.ADA0FR0 bits is prohibited while A/D conversion is enabled (ADA0CE bit = 1).

4. In the following modes, write data to the ADA0M0, ADA0M2, ADA0S, ADA0PFM, or ADA0PFT registers while A/D conversion is stopped (ADA0CE bit = 0), and then enable the A/D conversion operation (ADA0CE bit = 1).

- **Normal conversion mode**
- **One-shot select mode/one-shot scan mode in high-speed conversion mode**

If the ADA0M0, ADA0M2, ADA0S, ADA0PFM, and ADA0PFT registers are written in other modes during A/D conversion (ADA0EF bit = 1), the following will be performed according to the mode.

- **In software trigger mode**
  A/D conversion is stopped and started again from the beginning.
- **In hardware trigger mode**
  A/D conversion is stopped, and the trigger standby status is set.

5. To select the external trigger mode/timer trigger mode (ADA0TMD bit = 1), set the high-speed conversion mode (ADA0M1.ADA0HS1 bit = 1). Do not input a trigger during stabilization time that is inserted once after the A/D conversion operation is enabled (ADA0CE bit = 1).

6. When not using the A/D converter, stop the operation by setting the ADA0CE bit to 0 to reduce the power consumption.

(2) A/D converter mode register 1 (ADA0M1)

The ADA0M1 register is an 8-bit register that specifies the conversion time.

This register can be read or written in 8-bit or 1-bit units.

Reset sets this bit to 00H.

After reset: 00H R/W Address: FFFFF201H

	7	6	5	4	3	2	1	0
ADA0M1	ADA0HS1	0	0	0	ADA0FR3	ADA0FR2	ADA0FR1	ADA0FR0

ADA0HS1	Specification of normal conversion mode/high-speed mode (A/D conversion time)
0	Normal conversion mode
1	High-speed conversion mode

Cautions 1. Changing the ADA0M1 register is prohibited while A/D conversion is enabled (ADA0M0.ADA0CE bit = 1).

2. To select the external trigger mode/timer trigger mode (ADA0M0.ADA0TMD bit = 1), set the high-speed conversion mode (ADA0HS1 bit = 1). Do not input a trigger during the stabilization time that is inserted once after the A/D conversion operation is enabled (ADA0CE bit = 1).

3. Be sure to clear bits 6 to 4 to "0".

Remark For A/D conversion time setting examples, see **Tables 15-2** and **15-3**.

Table 15-2. Conversion Time Selection in Normal Conversion Mode (ADA0HS1 Bit = 0)

ADA0FR3 to ADA0FR0 Bits	A/D Conversion Time			
	Stabilization Time + Conversion Time + Wait Time	48 MHz	32 MHz	24 MHz
0000	26/fxx + 52/fxx + 54/fxx	Setting prohibited	Setting prohibited	5.50 μs
0001	52/fxx + 104/fxx + 106/fxx	5.46 μs	8.19 μs	Setting prohibited
0010	78/fxx + 156/fxx + 158/fxx	8.17 μs	Setting prohibited	Setting prohibited
0011	100/fxx + 208/fxx + 210/fxx	Setting prohibited	Setting prohibited	Setting prohibited
0100	100/fxx + 260/fxx + 262/fxx	Setting prohibited	Setting prohibited	Setting prohibited
0101	100/fxx + 312/fxx + 314/fxx	Setting prohibited	Setting prohibited	Setting prohibited
0110	100/fxx + 364/fxx + 366/fxx	Setting prohibited	Setting prohibited	Setting prohibited
0111	100/fxx + 416/fxx + 418/fxx	Setting prohibited	Setting prohibited	Setting prohibited
1000	100/fxx + 468/fxx + 470/fxx	Setting prohibited	Setting prohibited	Setting prohibited
1001	100/fxx + 520/fxx + 522/fxx	Setting prohibited	Setting prohibited	Setting prohibited
1010	100/fxx + 572/fxx + 574/fxx	Setting prohibited	Setting prohibited	Setting prohibited
1011	100/fxx + 624/fxx + 626/fxx	Setting prohibited	Setting prohibited	Setting prohibited
1100	100/fxx + 676/fxx + 678/fxx	Setting prohibited	Setting prohibited	Setting prohibited
1101	100/fxx + 728/fxx + 730/fxx	Setting prohibited	Setting prohibited	Setting prohibited
1110	100/fxx + 780/fxx + 782/fxx	Setting prohibited	Setting prohibited	Setting prohibited
1111	100/fxx + 832/fxx + 834/fxx	Setting prohibited	Setting prohibited	Setting prohibited
Other than above	Setting prohibited			

Remark Stabilization time: A/D converter setup time (1 μs or longer)
Conversion time: Actual A/D conversion time (2.17 to 9.75 μs)
Wait time: Wait time inserted before the next conversion
fxx: Main clock frequency

In the normal conversion mode, the conversion is started after the stabilization time elapses after the ADA0M0.ADA0CE bit is set to 1, and A/D conversion is performed only during the conversion time (2.17 to 9.75 μs). Operation is stopped after the conversion ends and the A/D conversion end interrupt request signal (INTAD) is generated after the wait time elapses.
Because the conversion operation is stopped during the wait time, operating current can be reduced.

Cautions 1. Set as 2.17 μs ≤ conversion time ≤ 9.75 μs.

2. During A/D conversion, if the ADA0M0, ADA0M2, ADA0S, ADA0PFM, and ADA0PFT registers are written or a trigger is input, reconversion is carried out. However, if the stabilization time end timing conflicts with writing to these registers, or if the stabilization time end timing conflicts with the trigger input, a stabilization time of 64 clocks is reinserted.

If a conflict occurs again with the reinserted stabilization time end timing, the stabilization time is reinserted. Therefore do not set the trigger input interval and control register write interval to 64 clocks or lower.

Table 15-3. Conversion Time Selection in High-Speed Conversion Mode (ADA0HS1 Bit = 1)

ADA0FR3 to ADA0FR0 Bits	A/D Conversion Time			
	Conversion Time (+ Stabilization Time)	48 MHz	32 MHz	24 MHz
0000	52/fxx (+26/fxx)	Setting prohibited	Setting prohibited	2.17 μs
0001	104/fxx (+52/fxx)	2.17 μs	3.25 μs	4.33 μs
0010	156/fxx (+78/fxx)	3.25 μs	4.88 μs	6.50 μs
0011	208/fxx (+100/fxx)	4.33 μs	6.50 μs	8.67 μs
0100	260/fxx (+100/fxx)	5.42 μs	8.13 μs	Setting prohibited
0101	312/fxx (+100/fxx)	6.50 μs	9.75 μs	Setting prohibited
0110	364/fxx (+100/fxx)	7.58 μs	Setting prohibited	Setting prohibited
0111	416/fxx (+100/fxx)	8.67 μs	Setting prohibited	Setting prohibited
1000	468/fxx (+100/fxx)	9.75 μs	Setting prohibited	Setting prohibited
1001	520/fxx (+100/fxx)	Setting prohibited	Setting prohibited	Setting prohibited
1010	572/fxx (+100/fxx)	Setting prohibited	Setting prohibited	Setting prohibited
1011	624/fxx (+100/fxx)	Setting prohibited	Setting prohibited	Setting prohibited
1100	676/fxx (+100/fxx)	Setting prohibited	Setting prohibited	Setting prohibited
1101	728/fxx (+100/fxx)	Setting prohibited	Setting prohibited	Setting prohibited
1110	780/fxx (+100/fxx)	Setting prohibited	Setting prohibited	Setting prohibited
1111	832/fxx (+100/fxx)	Setting prohibited	Setting prohibited	Setting prohibited
Other than above	Setting prohibited			

Remark Stabilization time: A/D converter setup time (1 μs or longer)
Conversion time: Actual A/D conversion time (2.17 to 9.75 μs)
fxx: Main clock frequency

In the high-speed conversion mode, the conversion is started after the stabilization time elapses after the ADA0M0.ADA0CE bit is set to 1, and A/D conversion is performed only during the conversion time (2.17 to 9.75 μs). The A/D conversion end interrupt request signal (INTAD) is generated immediately after the conversion ends.

In continuous conversion mode, the stabilization time is inserted only before the first conversion, and not inserted after the second conversion (the A/D converter remains running).

Cautions 1. Set as 2.17 μs ≤ conversion time ≤ 9.75 μs.

2. In the high-speed conversion mode, rewriting of the ADA0M0, ADA0M2, ADA0S, ADA0PFM, and ADA0PFT registers and trigger input are prohibited during the stabilization time.

(3) A/D converter mode register 2 (ADA0M2)

The ADA0M2 register specifies the hardware trigger mode.

This register can be read or written in 8-bit or 1-bit units.

Reset sets this register to 00H.

After reset: 00H R/W Address: FFFFF203H

	7	6	5	4	3	2	1	0
ADA0M2	0	0	0	0	0	0	ADA0TMD1	ADA0TMD0

ADA0TMD1	ADA0TMD0	Specification of hardware trigger mode
0	0	External trigger mode (when ADTRG pin valid edge is detected)
0	1	Timer trigger mode 0 (when INTTAA2CC0 interrupt request is generated)
1	0	Timer trigger mode 1 (when INTTAA2CC1 interrupt request is generated)
1	1	Timer trigger mode 2 (TQTADT0 signal)

Cautions 1. In the following modes, write data to the ADA0M2 register while A/D conversion is stopped (ADA0M0.ADA0CE bit = 0), and then enable the A/D conversion operation (ADA0CE bit = 1).

- **Normal conversion mode**
- **One-shot select mode/one-shot scan mode in high-speed conversion mode**

2. Be sure to clear bits 7 to 2 to "0".

(4) Analog input channel specification register 0 (ADA0S)

The ADA0S register specifies the pin that inputs the analog voltage to be converted into a digital signal.

This register can be read or written in 8-bit or 1-bit units.

Reset sets this register to 00H.

After reset: 00H R/W Address: FFFFF202H

	7	6	5	4	3	2	1	0
ADA0S	0	0	0	0	ADA0S3	ADA0S2	ADA0S1	ADA0S0

ADA0S3	ADA0S2	ADA0S1	ADA0S0	Select mode	Scan mode
0	0	0	0	ANI0	ANI0
0	0	0	1	ANI1	ANI0, ANI1
0	0	1	0	ANI2	ANI0 to ANI2
0	0	1	1	ANI3	ANI0 to ANI3
0	1	0	0	ANI4	ANI0 to ANI4
0	1	0	1	ANI5	ANI0 to ANI5
0	1	1	0	ANI6	ANI0 to ANI6
0	1	1	1	ANI7	ANI0 to ANI7
1	0	0	0	ANI8	ANI0 to ANI8
1	0	0	1	ANI9	ANI0 to ANI9
1	0	1	0	ANI10	ANI0 to ANI10
1	0	1	1	ANI11	ANI0 to ANI11

Cautions 1. In the following modes, write data to the ADA0S register while A/D conversion is stopped (ADA0M0.ADA0CE bit = 0), and then enable the A/D conversion operation (ADA0CE bit = 1).

- **Normal conversion mode**
- **One-shot select mode/one-shot scan mode in high-speed conversion mode**

2. Be sure to clear bits 7 to 4 to "0".

(5) A/D conversion result registers n, nH (ADA0CRn, ADA0CRnH)

The ADA0CRn and ADA0CRnH registers store the A/D conversion results.

These registers are read-only, in 16-bit or 8-bit units. However, the ADA0CRn register is used for 16-bit access and the ADA0CRnH register for 8-bit access. The 10 bits of the conversion result are read to the higher 10 bits of the ADA0CRn register, and 0 is read to the lower 6 bits. The higher 8 bits of the conversion result are read to the ADA0CRnH register.

Caution Accessing the ADA0CRn and ADA0CRnH registers is prohibited in the following statuses. For details, see 3.4.9 (2) Accessing specific on-chip peripheral I/O registers.

- **When the CPU operates on the subclock and the main clock oscillation is stopped**
- **When the CPU operates on the internal oscillation clock**

After reset: Undefined R Address: ADA0CR0 FFFFF210H, ADA0CR1 FFFFF212H, ADA0CR2 FFFFF214H, ADA0CR3 FFFFF216H, ADA0CR4 FFFFF218H, ADA0CR5 FFFFF21AH, ADA0CR6 FFFFF21CH, ADA0CR7 FFFFF21EH, ADA0CR8 FFFFF220H, ADA0CR9 FFFFF222H, ADA0CR10 FFFFF224H, ADA0CR11 FFFFF226H

ADA0CRn (n = 0 to 11)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
AD9	AD8	AD7	AD6	AD5	AD4	AD3	AD2	AD1	AD0	0	0	0	0	0	0

After reset: Undefined R Address: ADA0CR0H FFFFF211H, ADA0CR1H FFFFF213H, ADA0CR2H FFFFF215H, ADA0CR3H FFFFF217H, ADA0CR4H FFFFF219H, ADA0CR5H FFFFF21BH, ADA0CR6H FFFFF21DH, ADA0CR7H FFFFF21FH, ADA0CR8H FFFFF221H, ADA0CR9H FFFFF223H, ADA0CR10H FFFFF225H, ADA0CR11H FFFFF227H

ADA0CRnH (n = 0 to 11)

7	6	5	4	3	2	1	0
AD9	AD8	AD7	AD6	AD5	AD4	AD3	AD2

Caution A write operation to the ADA0M0 and ADA0S registers may cause the contents of the ADA0CRn register to become undefined. After the conversion, read the conversion result before writing to the ADA0M0 and ADA0S registers. Correct conversion results may not be read at a timing other than the above.

The relationship between the analog voltage input to the analog input pins (ANI0 to ANI11) and the A/D conversion result (ADA0CRn register) is as follows.

$$SAR = INT\left(\frac{V_{IN}}{AV_{REF0}} \times 1{,}024 + 0.5\right)$$

$$ADA0CR^{Note} = SAR \times 64$$

Or,

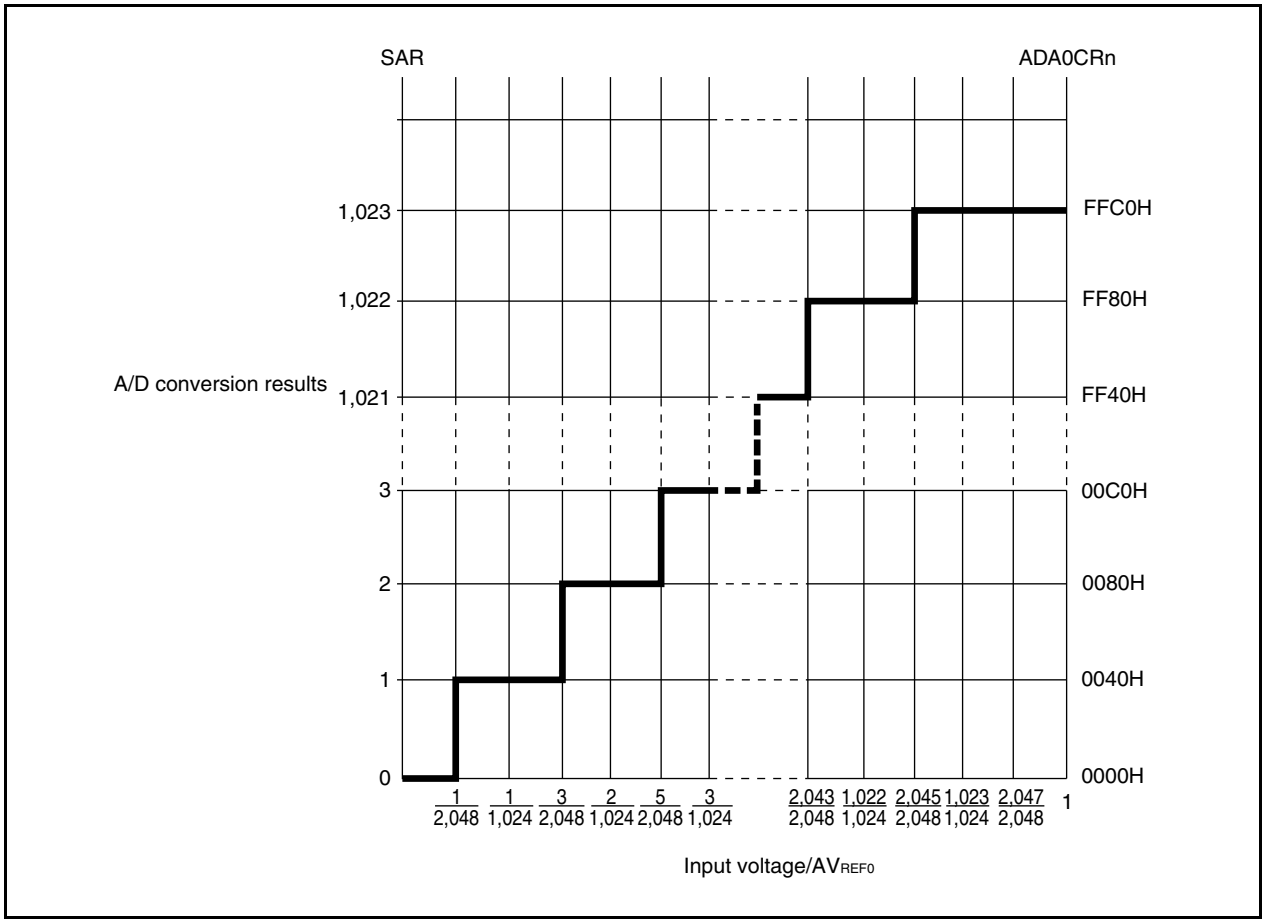
$$(SAR - 0.5) \times \frac{AV_{REF0}}{1{,}024} \leq V_{IN} < (SAR + 0.5) \times \frac{AV_{REF0}}{1{,}024}$$

INT( ): Function that returns the integer of the value in ( )
V_{IN}: Analog input voltage
AV_{REF0}: AV_{REF0} pin voltage
ADA0CR: Value of ADA0CRn register

Note The lower 6 bits of the ADA0CRn register are fixed to 0.

The following shows the relationship between the analog input voltage and the A/D conversion results.

Figure 15-2. Relationship Between Analog Input Voltage and A/D Conversion Results



(6) Power-fail compare mode register (ADA0PFM)

The ADA0PFM register is an 8-bit register that sets the power-fail compare mode.

This register can be read or written in 8-bit or 1-bit units.

Reset sets this register to 00H.

After reset: 00H R/W Address: FFFFF204H

	<7>	6	5	4	3	2	1	0
ADA0PFM	ADA0PFE	ADA0PFC	0	0	0	0	0	0

ADA0PFE	Selection of power-fail compare enable/disable
0	Power-fail compare disabled
1	Power-fail compare enabled

ADA0PFC	Selection of power-fail compare mode
0	Generates an interrupt request signal (INTAD) when ADA0CRnH ≥ ADA0PFT
1	Generates an interrupt request signal (INTAD) when ADA0CRnH < ADA0PFT

Cautions 1. In the select mode, the 8-bit data set to the ADA0PFT register is compared with the value of the ADA0CRnH register specified by the ADA0S register. If the result matches the condition specified by the ADA0PFC bit, the conversion result is stored in the ADA0CRn register and the INTAD signal is generated. If it does not match, however, the interrupt signal is not generated.

2. In the scan mode, the 8-bit data set to the ADA0PFT register is compared with the contents of the ADA0CR0H register. If the result matches the condition specified by the ADA0PFC bit, the conversion result is stored in the ADA0CR0 register and the INTAD signal is generated. If it does not match, however, the INTAD signal is not generated. Regardless of the comparison result, the scan operation is continued and the conversion result is stored in the ADA0CRn register until the scan operation is completed. However, the INTAD signal is not generated after the scan operation has been completed.

3. In the following modes, write data to the ADA0PFM register while A/D conversion is stopped (ADA0M0.ADA0CE bit = 0), and then enable the A/D conversion operation (ADA0CE bit = 1).

- **Normal conversion mode**
- **One-shot select mode/one-shot scan mode in high-speed conversion mode**

(7) Power-fail compare threshold value register (ADA0PFT)

The ADA0PFT register sets the compare value in the power-fail compare mode.

This register can be read or written in 8-bit or 1-bit units.

Reset sets this register to 00H.

After reset: 00H R/W Address: FFFFF205H

	7	6	5	4	3	2	1	0
ADA0PFT								

Caution In the following modes, write data to the ADA0PFT register while A/D conversion is stopped (ADA0M0.ADA0CE bit = 0), and then enable the A/D conversion operation (ADA0CE bit = 1).

- **Normal conversion mode**
- **One-shot select mode/one-shot scan mode in high-speed conversion mode**

15.5 Operation

15.5.1 Basic operation

<1> Set the operation mode, trigger mode, and conversion time for executing A/D conversion by using the ADA0M0, ADA0M1, ADA0M2, and ADA0S registers. When the ADA0CE bit of the ADA0M0 register is set, conversion is started in the software trigger mode and the A/D converter waits for a trigger in the external or timer trigger mode.

<2> When A/D conversion is started, the voltage input to the selected analog input channel is sampled by the sample & hold circuit.

<3> When the sample & hold circuit samples the input channel for a specific time, it enters the hold status, and holds the input analog voltage until A/D conversion is complete.

<4> Set bit 9 of the successive approximation register (SAR), and set the compare voltage generation DAC to (1/2) AV_{REF0}.

<5> The voltage difference between the voltage of the compare voltage generation DAC and the analog input voltage is compared by the voltage comparator. If the analog input voltage is higher than (1/2) AV_{REF0}, the MSB of the SAR remains set. If it is lower than (1/2) AV_{REF0}, the MSB is reset.

<6> Next, bit 8 of the SAR is automatically set and the next comparison is started. Depending on the value of bit 9, to which a result has been already set, the compare voltage generation DAC is selected as follows.

- Bit 9 = 1: (3/4) AV_{REF0}
- Bit 9 = 0: (1/4) AV_{REF0}

This compare voltage and the analog input voltage are compared and, depending on the result, bit 8 is manipulated as follows.

Analog input voltage ≥ Compare voltage: Bit 8 = 1

Analog input voltage ≤ Compare voltage: Bit 8 = 0

<7> This comparison is continued to bit 0 of the SAR.

<8> When comparison of the 10 bits is complete, the valid digital result remains in the SAR, and is then transferred to and stored in the ADA0CRn register. After that, an A/D conversion end interrupt request signal (INTAD) is generated.

<9> In one-shot select mode, conversion is stopped[Note]. In one-shot scan mode, conversion is stopped after scanning once[Note]. In continuous select mode, repeat steps <2> to <8> until the ADA0M0.ADA0CE bit is cleared to 0. In continuous scan mode, repeat steps <2> to <8> for each channel.

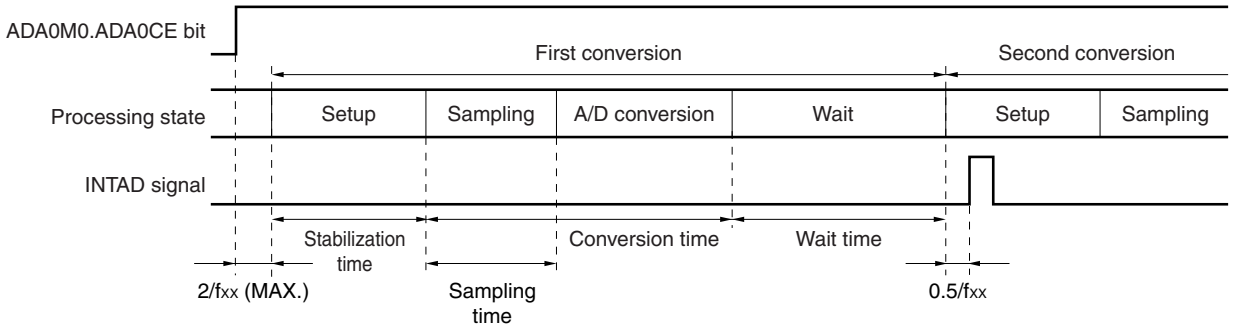
Note In the external trigger mode, timer trigger mode 0, or timer trigger mode 1, the trigger standby status is entered.

Remark The trigger standby status means the status after the stabilization time has elapsed.

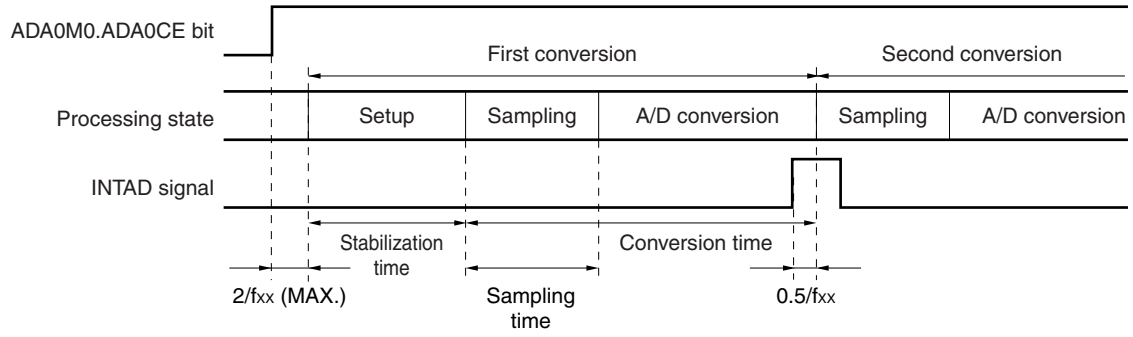
15.5.2 Conversion operation timing

Figure 15-3. Conversion Operation Timing (Continuous Conversion)

(1) Operation in normal conversion mode (ADA0HS1 bit = 0)



(2) Operation in high-speed conversion mode (ADA0HS1 bit = 1)



Remark The above timings are applicable when a trigger is generated within the stabilization time. If a trigger is generated after the stabilization time has elapsed, a trigger response time is inserted.

15.5.3 Trigger mode

The timing of starting the conversion operation is specified by setting the trigger mode. The trigger mode includes the software trigger mode and hardware trigger modes. The hardware trigger modes include timer trigger modes 0 and 1, and external trigger mode. The ADA0M0.ADA0TMD bit is used to set the trigger mode. The hardware trigger modes are set by the ADA0M2.ADA0TMD1 and ADA0M2.ADA0TMD0 bits.

(1) Software trigger mode

When the ADA0M0.ADA0CE bit is set to 1, the signal of the analog input pin (ANI0 to ANI11 pin) specified by the ADA0S register is converted. When conversion is complete, the result is stored in the ADA0CRn register. At the same time, the A/D conversion end interrupt request signal (INTAD) is generated.

If the operation mode specified by the ADA0M0.ADA0MD1 and ADA0M0.ADA0MD0 bits is the continuous select/scan mode, the next conversion is repeated, unless the ADA0CE bit is cleared to 0 after completion of the conversion. Conversion is performed once and ends if the operation mode is the one-shot select/scan mode.

When conversion is started, the ADA0M0.ADA0EF bit is set to 1 (indicating that conversion is in progress).

If the ADA0M0, ADA0M2, ADA0S, ADA0PFM, or ADA0PFT register is written during conversion, the conversion is aborted and started again from the beginning. However, writing to these registers is prohibited in the normal conversion mode and one-shot select mode/one-shot scan mode in the high-speed conversion mode.

(2) External trigger mode

In this mode, converting the signal of the analog input pin (ANI0 to ANI11) specified by the ADA0S register is started when an external trigger is input (to the ADTRG pin). Which edge of the external trigger is to be detected (i.e., the rising edge, falling edge, or both rising and falling edges) can be specified by using the ADA0M0.ADA0ETS1 and ADA0M0.ATA0ETS0 bits. When the ADA0CE bit is set to 1, the A/D converter waits for the trigger, and starts conversion after the external trigger has been input.

When conversion is completed, the result of conversion is stored in the ADA0CRn register, regardless of whether the continuous select, continuous scan, one-shot select, or one-shot scan mode is set as the operation mode by the ADA0MD1 and ADA0MD0 bits. At the same time, the INTAD signal is generated, and the A/D converter waits for the trigger again.

When conversion is started, the ADA0EF bit is set to 1 (indicating that conversion is in progress). While the A/D converter is waiting for the trigger, however, the ADA0EF bit is cleared to 0 (indicating that conversion is stopped).

If the valid trigger is input during the conversion operation, the conversion is aborted and started again from the beginning.

If the ADA0M0, ADA0M2, ADA0S, ADA0PFM, or ADA0PFT register is written during the conversion operation, the conversion is aborted, and the A/D converter waits for the trigger again. However, writing to these registers is prohibited in the one-shot select mode/one-shot scan mode.

Caution To select the external trigger mode, set the high-speed conversion mode. Do not input a trigger during the stabilization time that is inserted once after the A/D conversion operation is enabled (ADA0M0.ADA0CE bit = 1).

Remark The trigger standby status means the status after the stabilization time has elapsed.

(3) Timer trigger mode

In this mode, converting the signal of the analog input pin (ANI0 to ANI11) specified by the ADA0S register is started by the compare match interrupt request signal (INTTAA2CC0 or INTTAA2CC1) of the capture/compare register connected to the timer. The INTTAA2CC0 or INTTAA2CC1 signal is selected by the ADA0TMD1 and ADA0TMD0 bits, and conversion is started at the rising edge of the specified compare match interrupt request signal. When the ADA0CE bit is set to 1, the A/D converter waits for a trigger, and starts conversion when the compare match interrupt request signal of the timer is input.

When conversion is completed, regardless of whether the continuous select, continuous scan, one-shot select, or one-shot scan mode is set as the operation mode by the ADA0MD1 and ADA0MD0 bits, the result of the conversion is stored in the ADA0CRn register. At the same time, the INTAD signal is generated, and the A/D converter waits for the trigger again.

When conversion is started, the ADA0EF bit is set to 1 (indicating that conversion is in progress). While the A/D converter is waiting for the trigger, however, the ADA0EF bit is cleared to 0 (indicating that conversion is stopped). If the valid trigger is input during the conversion operation, the conversion is aborted and started again from the beginning.

If the ADA0M0, ADA0M2, ADA0S, ADA0PFM, or ADA0PFT register is written during conversion, the conversion is stopped and the A/D converter waits for the trigger again. However, writing to these registers is prohibited in the one-shot select mode/one-shot scan mode.

Caution To select the timer trigger mode, set the high-speed conversion mode. Do not input a trigger during the stabilization time that is inserted once after the A/D conversion operation is enabled (ADA0M0.ADA0CE bit = 1).

Remark The trigger standby status means the status after the stabilization time has elapsed.

15.5.4 Operation mode

Four operation modes are available as the modes in which to set the ANI0 to ANI11 pins: continuous select mode, continuous scan mode, one-shot select mode, and one-shot scan mode.

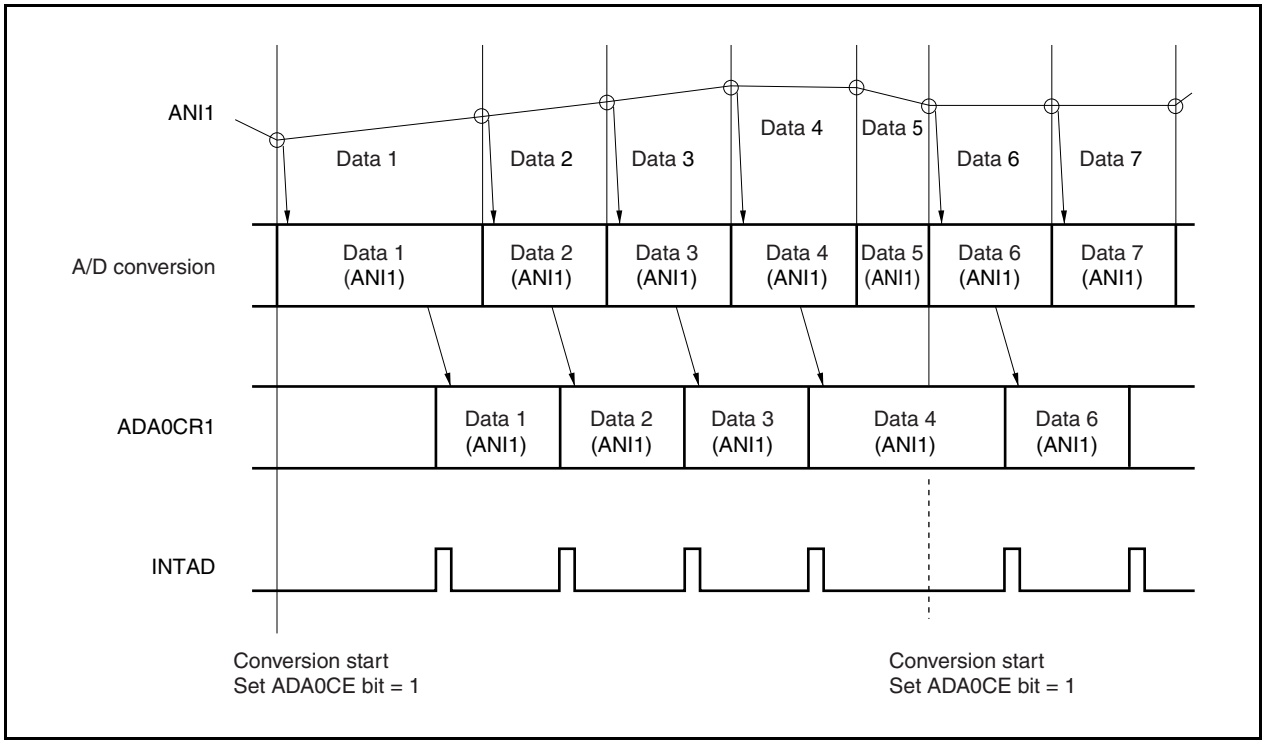
The operation mode is selected by the ADA0M0.ADA0MD1 and ADA0M0.ADA0MD0 bits.

(1) Continuous select mode

In this mode, the voltage of one analog input pin selected by the ADA0S register is continuously converted into a digital value.

The conversion result is stored in the ADA0CRn register corresponding to the analog input pin. In this mode, an analog input pin corresponds to an ADA0CRn register on a one-to-one basis. Each time A/D conversion is completed, the A/D conversion end interrupt request signal (INTAD) is generated. After completion of conversion, the next conversion is started, unless the ADA0M0.ADA0CE bit is cleared to 0 (n = 0 to 11).

Figure 15-4. Timing Example of Continuous Select Mode Operation (ADA0S Register = 01H)



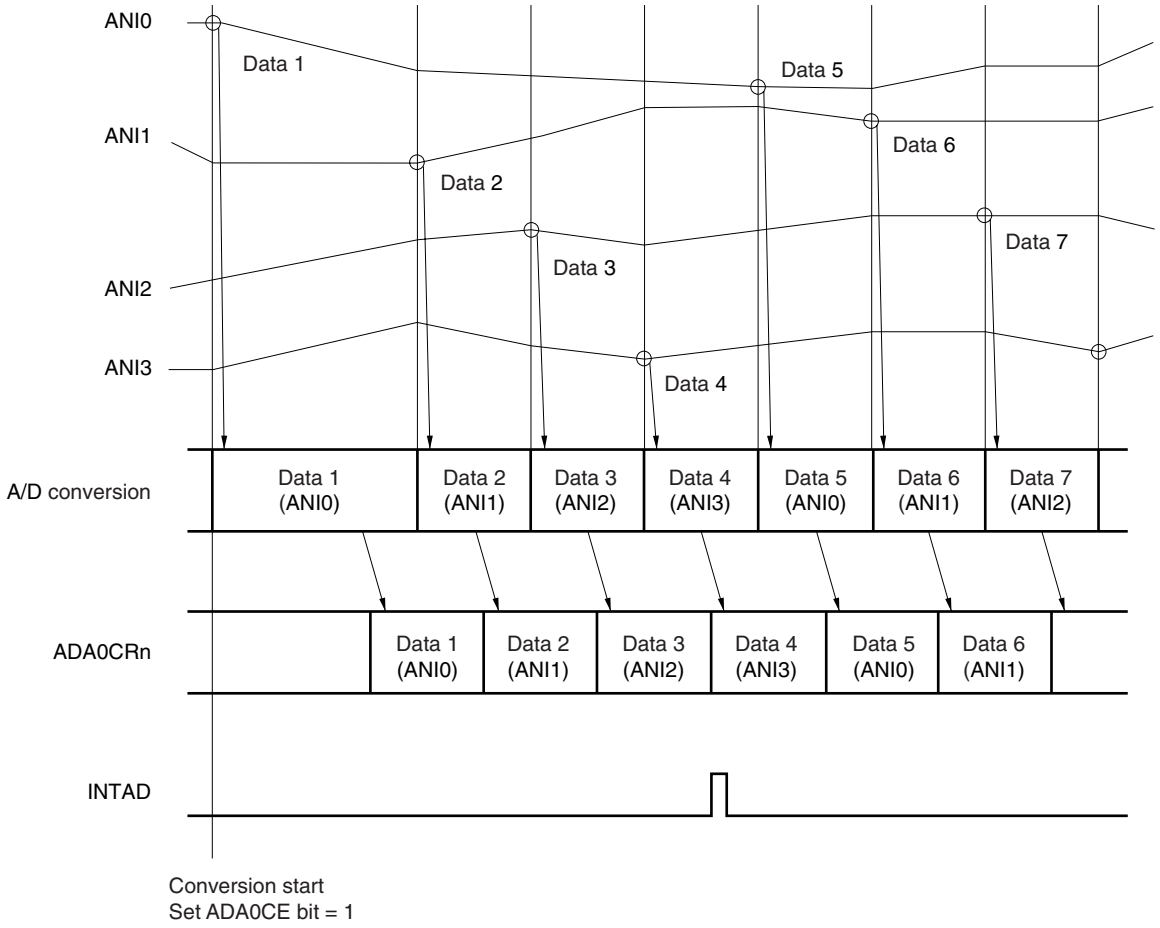
(2) Continuous scan mode

In this mode, analog input pins are sequentially selected, from the ANI0 pin to the pin specified by the ADA0S register, and their values are continuously converted into digital values.

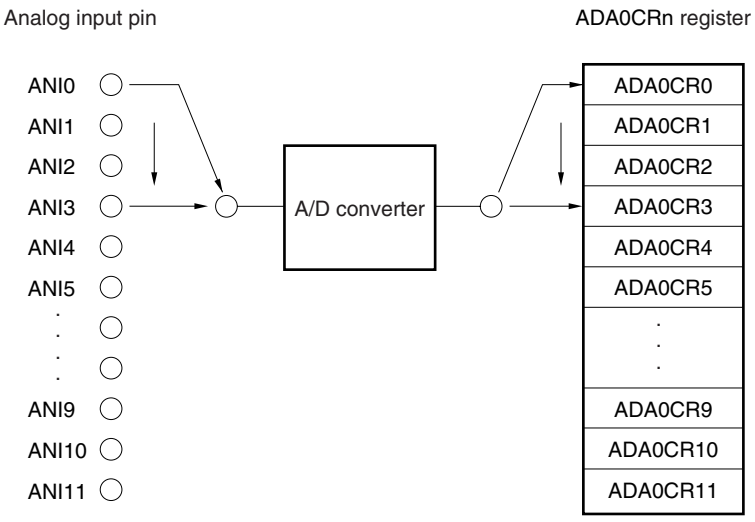
The result of each conversion is stored in the ADA0CRn register corresponding to the analog input pin. When conversion of the analog input pin specified by the ADA0S register is complete, the INTAD signal is generated, and A/D conversion is started again from the ANI0 pin, unless the ADA0CE bit is cleared to 0 (n = 0 to 11).

Figure 15-5. Timing Example of Continuous Scan Mode Operation (ADA0S Register = 03H)

(a) Timing example



(b) Block diagram

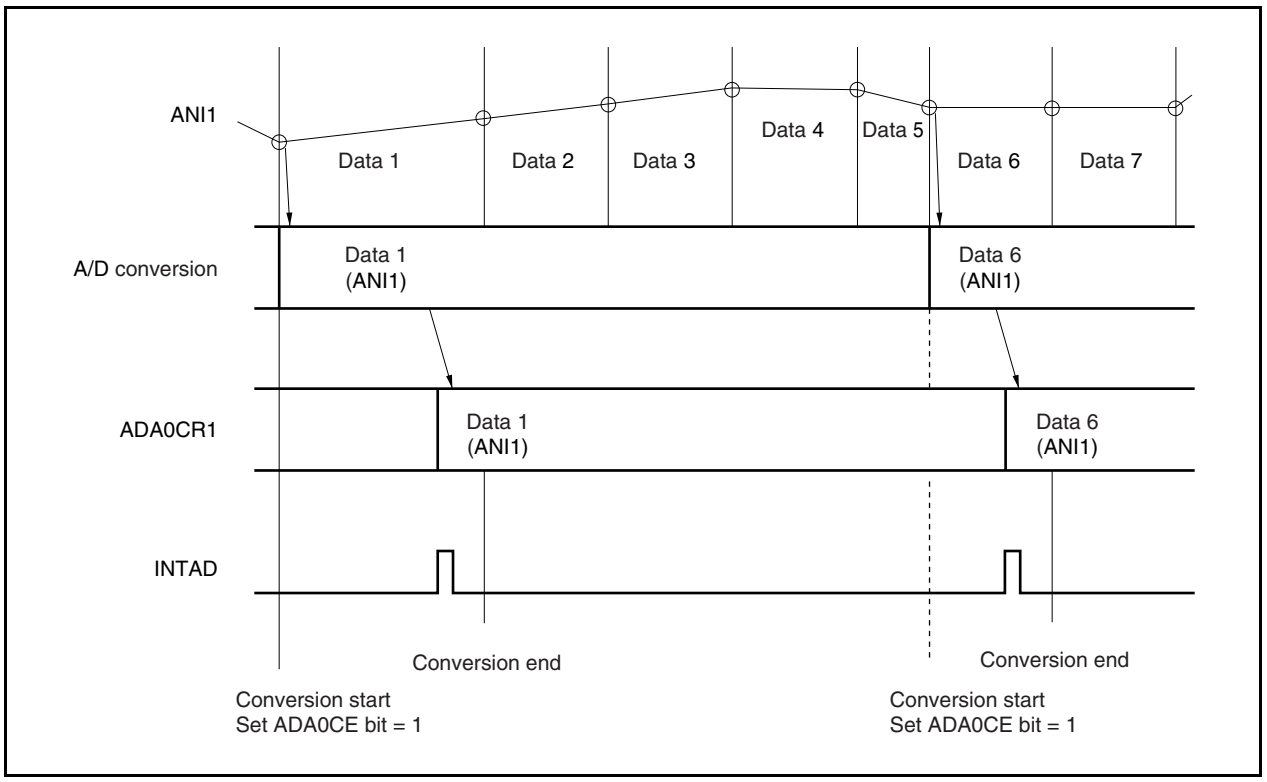


(3) One-shot select mode

In this mode, the voltage of one analog input pin specified by the ADA0S register is converted into a digital value only once.

The conversion result is stored in the ADA0CRn register corresponding to the analog input pin. In this mode, an analog input pin and an ADA0CRn register correspond on a one-to-one basis. When A/D conversion has been completed once, the INTAD signal is generated. The A/D conversion operation is stopped after it has been completed (n = 0 to 11).

Figure 15-6. Timing Example of One-Shot Select Mode Operation (ADA0S Register = 01H)



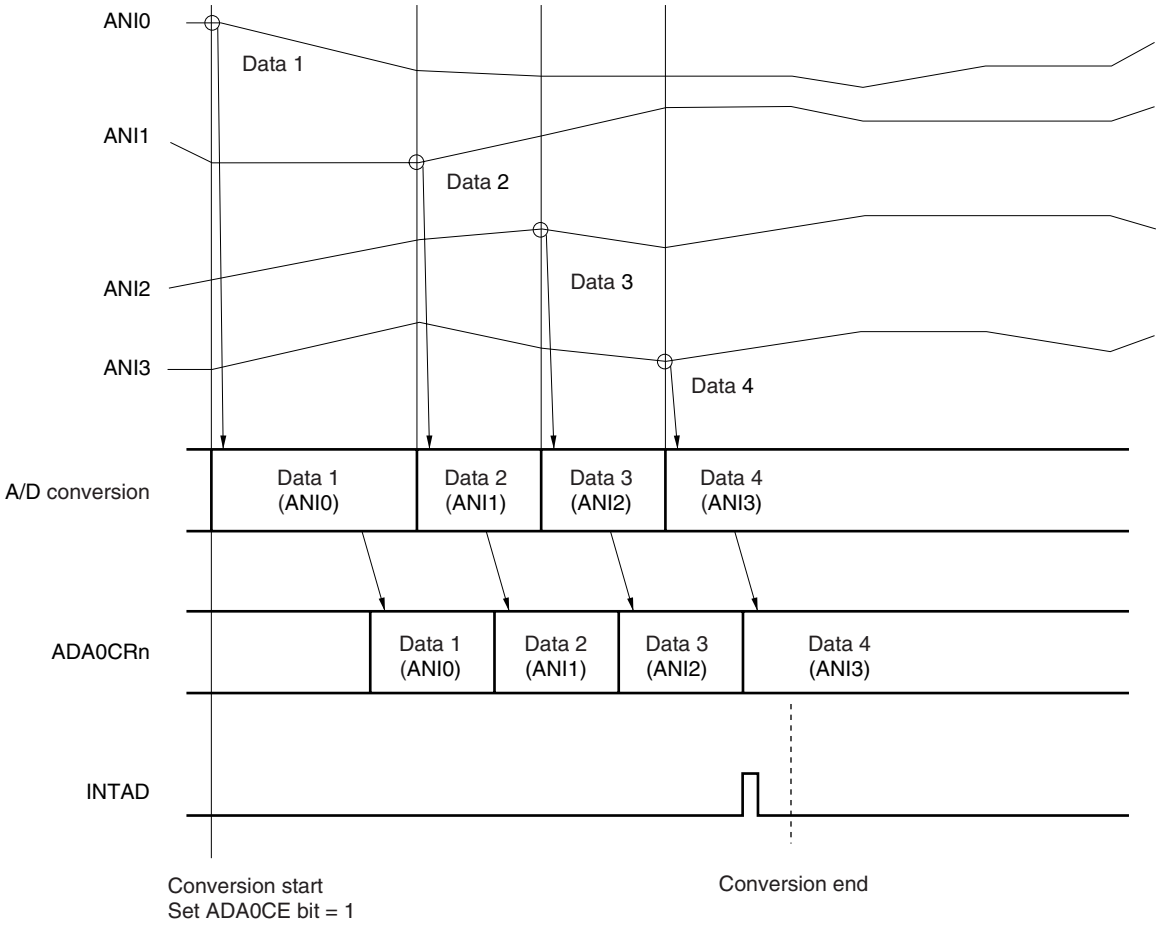
(4) One-shot scan mode

In this mode, analog input pins are sequentially selected, from the ANI0 pin to the pin specified by the ADA0S register, and their values are converted into digital values .

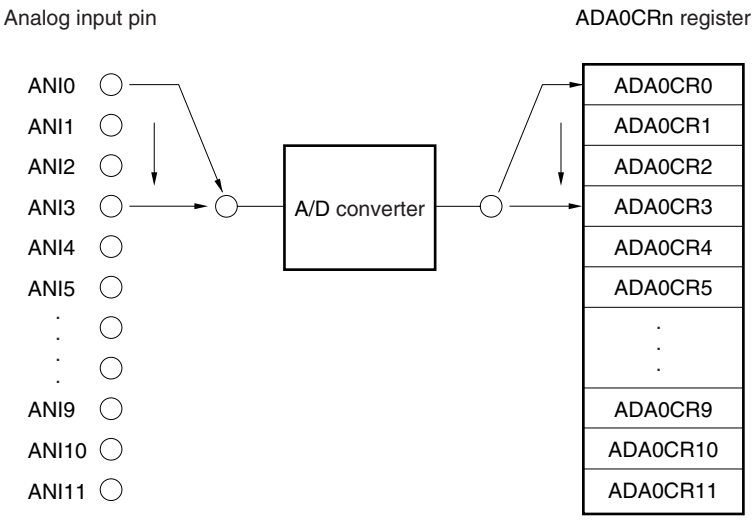
Each conversion result is stored in the ADA0CRn register corresponding to the analog input pin. When conversion of the analog input pin specified by the ADA0S register is complete, the INTAD signal is generated. A/D conversion is stopped after it has been completed (n = 0 to 11).

Figure 15-7. Timing Example of One-Shot Scan Mode Operation (ADA0S Register = 03H)

(a) Timing example



(b) Block diagram



15.5.5 Power-fail compare mode

The A/D conversion end interrupt request signal (INTAD) can be controlled as follows by the ADA0PFM and ADA0PFT registers.

- When the ADA0PFM.ADA0PFE bit = 0, the INTAD signal is generated each time conversion is completed (normal use of the A/D converter).
- When the ADA0PFE bit = 1 and when the ADA0PFM.ADA0PFC bit = 0, the value of the ADA0CRnH register is compared with the value of the ADA0PFT register when conversion is completed, and the INTAD signal is generated only if ADA0CRnH ≥ ADA0PFT.
- When the ADA0PFE bit = 1 and when the ADA0PFC bit = 1, the value of the ADA0CRnH register is compared with the value of the ADA0PFT register when conversion is completed, and the INTAD signal is generated only if ADA0CRnH < ADA0PFT.

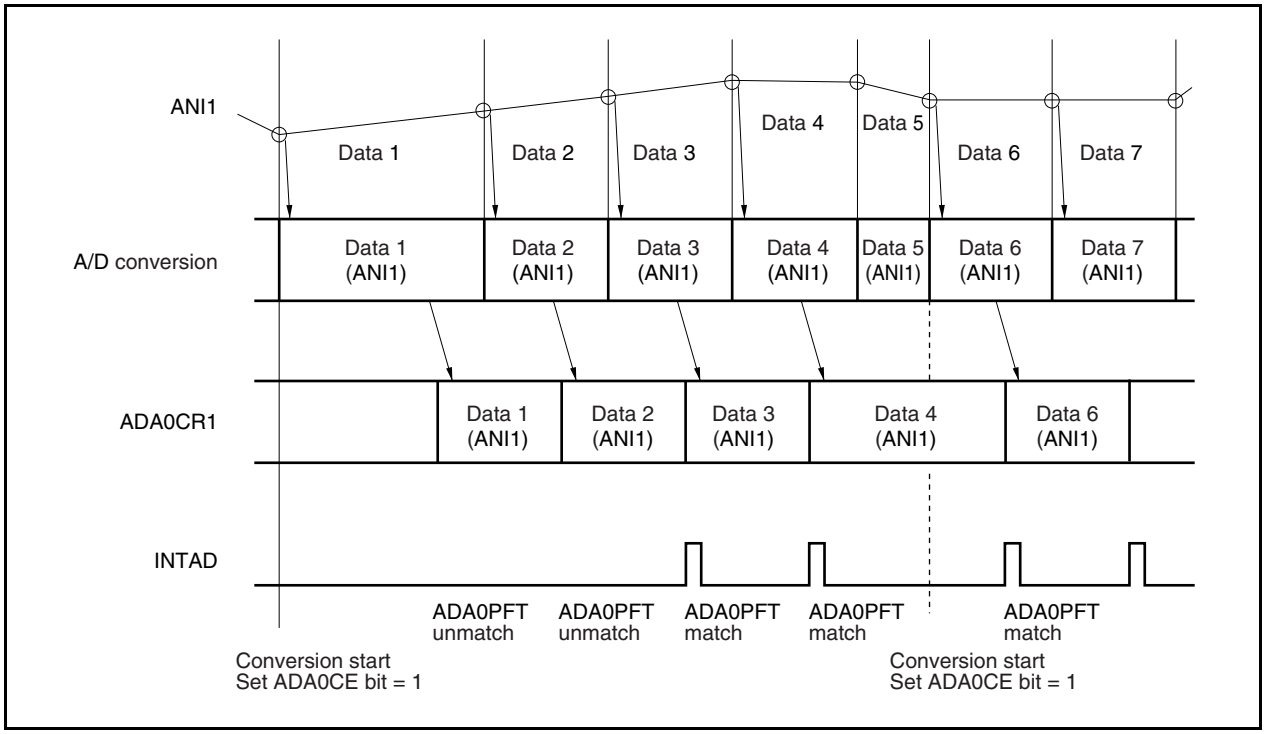
Remark n = 0 to 11

In the power-fail compare mode, four modes are available as modes in which to set the ANI0 to ANI11 pins: continuous select mode, continuous scan mode, one-shot select mode, and one-shot scan mode.

(1) Continuous select mode

In this mode, the result of converting the voltage of the analog input pin specified by the ADA0S register is compared with the set value of the ADA0PFT register. If the result of power-fail comparison matches the condition set by the ADA0PFC bit, the conversion result is stored in the ADA0CRn register, and the INTAD signal is generated. If it does not match, the conversion result is stored in the ADA0CRn register, and the INTAD signal is not generated. After completion of the first conversion, the next conversion is started, unless the ADA0M0.ADA0CE bit is cleared to 0 (n = 0 to 11).

Figure 15-8. Timing Example of Continuous Select Mode Operation (When Power-Fail Comparison Is Made: ADA0S Register = 01H)



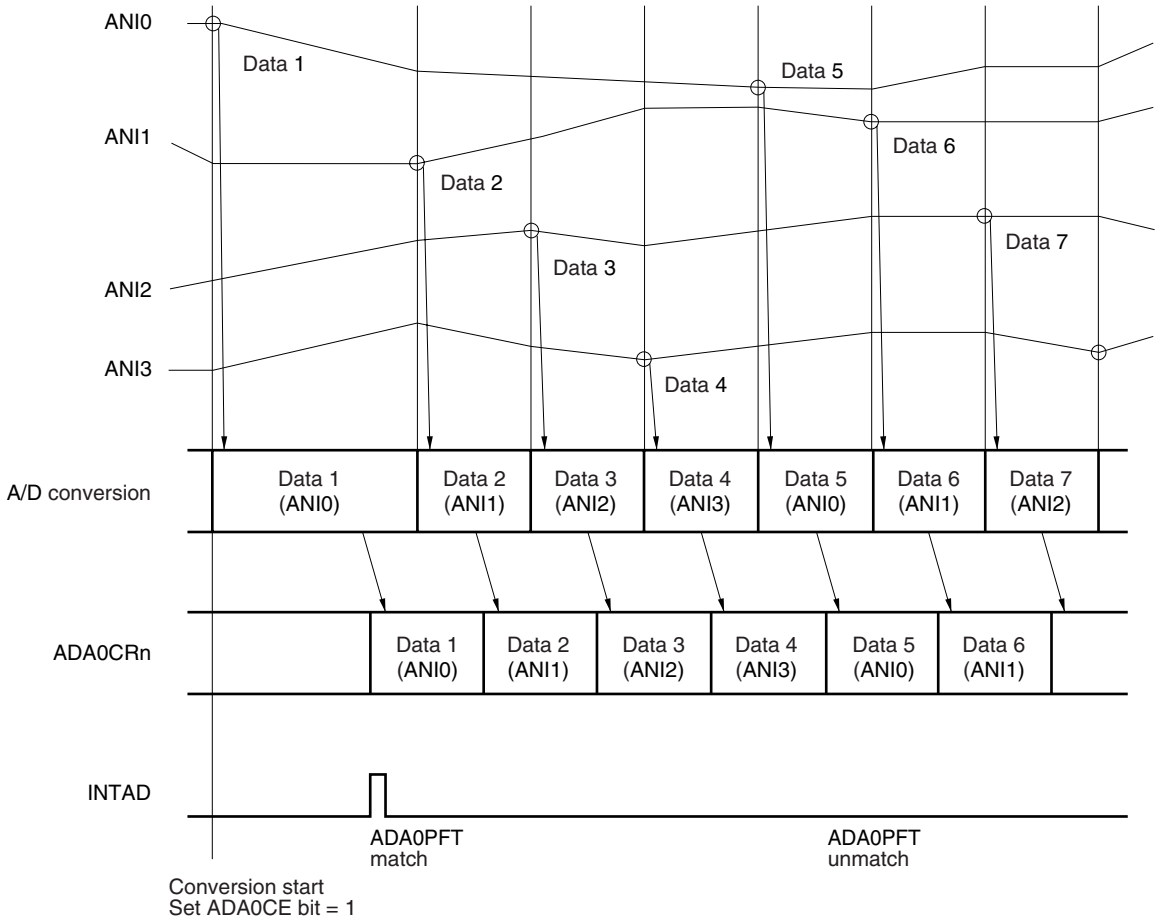
(2) Continuous scan mode

In this mode, the results of converting the voltages of the analog input pins sequentially selected from the ANI0 pin to the pin specified by the ADA0S register are stored, and the set value of the ADA0CR0H register of channel 0 is compared with the value of the ADA0PFT register. If the result of power-fail comparison matches the condition set by the ADA0PFC bit, the conversion result is stored in the ADA0CR0 register, and the INTAD signal is generated. If it does not match, the conversion result is stored in the ADA0CR0 register, and the INTAD signal is not generated.

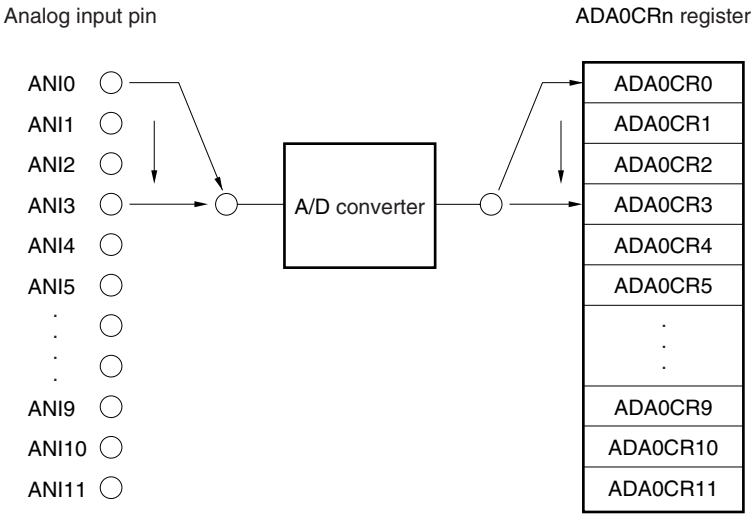
After the result of the first conversion has been stored in the ADA0CR0 register, the results of sequentially converting the voltages on the analog input pins up to the pin specified by the ADA0S register are continuously stored. After completion of conversion, the next conversion is started from the ANI0 pin again, unless the ADA0CE bit is cleared to 0.

Figure 15-9. Timing Example of Continuous Scan Mode Operation (When Power-Fail Comparison Is Made: ADA0S Register = 03H)

(a) Timing example



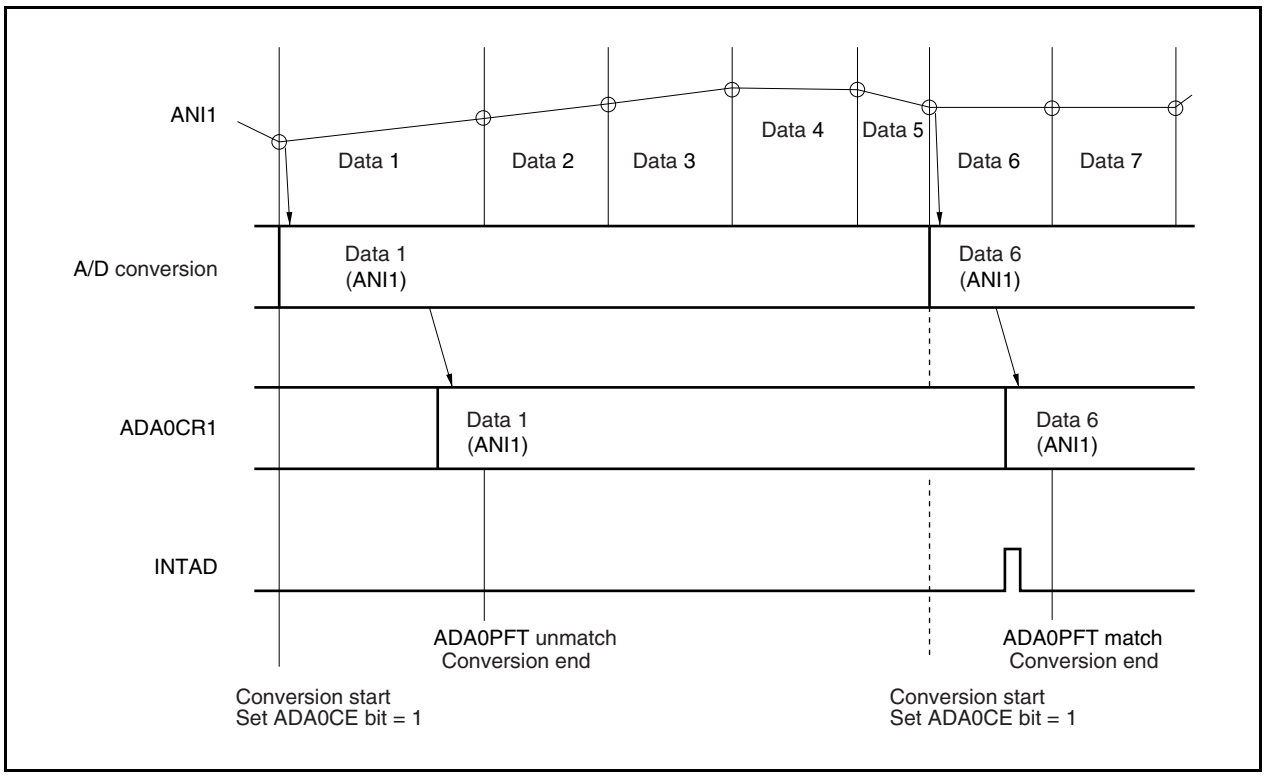
(b) Block diagram



(3) One-shot select mode

In this mode, the result of converting the voltage of the analog input pin specified by the ADA0S register is compared with the set value of the ADA0PFT register. If the result of power-fail comparison matches the condition set by the ADA0PFC bit, the conversion result is stored in the ADA0CRn register, and the INTAD signal is generated. If it does not match, the conversion result is stored in the ADA0CRn register, and the INTAD signal is not generated. Conversion is stopped after it has been completed.

Figure 15-10. Timing Example of One-Shot Select Mode Operation (When Power-Fail Comparison Is Made: ADA0S Register = 01H)

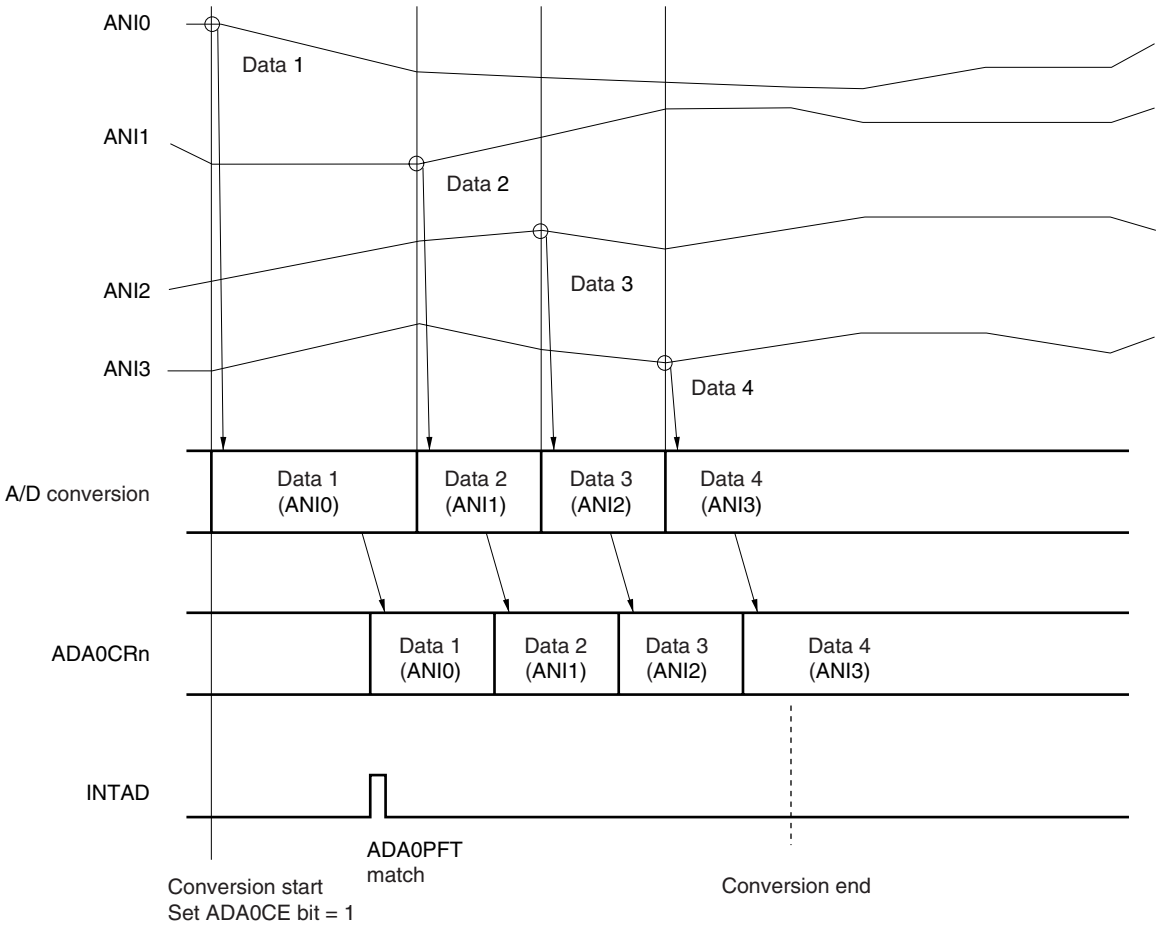


(4) One-shot scan mode

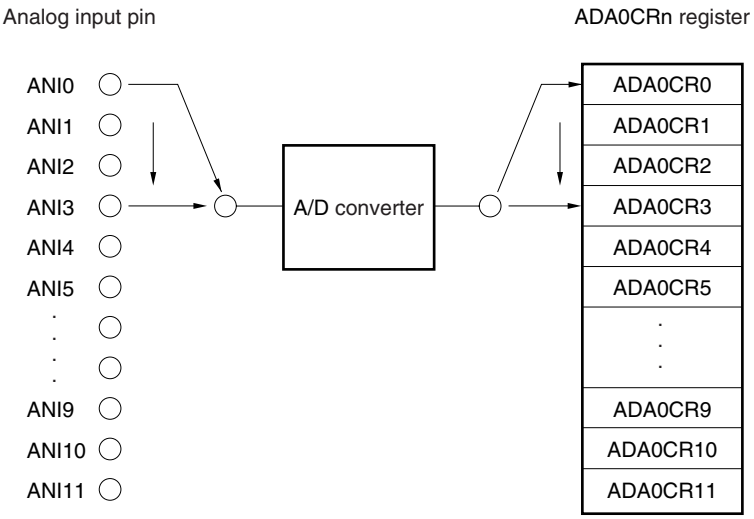
In this mode, the results of converting the voltages of the analog input pins sequentially selected from the ANI0 pin to the pin specified by the ADA0S register are stored, and the set value of the ADA0CR0H register of channel 0 is compared with the set value of the ADA0PFT register. If the result of power-fail comparison matches the condition set by the ADA0PFC bit, the conversion result is stored in the ADA0CR0 register and the INTAD signal is generated. If it does not match, the conversion result is stored in the ADA0CR0 register, and the INTAD0 signal is not generated. After the result of the first conversion has been stored in the ADA0CR0 register, the results of converting the signals on the analog input pins specified by the ADA0S register are sequentially stored. The conversion is stopped after it has been completed.

Figure 15-11. Timing Example of One-Shot Scan Mode Operation (When Power-Fail Comparison Is Made: ADA0S Register = 03H)

(a) Timing example



(b) Block diagram



15.6 Cautions

(1) When A/D converter is not used

When the A/D converter is not used, the power consumption can be reduced by clearing the ADA0M0.ADA0CE bit to 0.

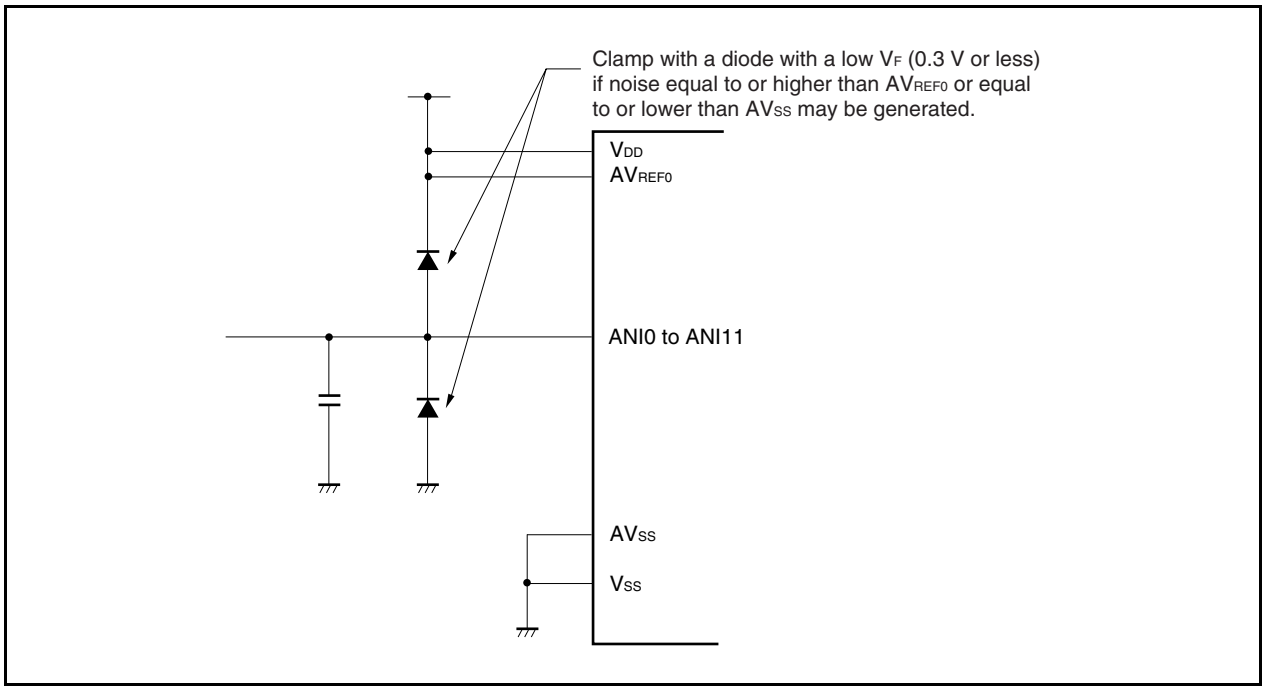
(2) Input range of ANI0 to ANI11 pins

Input the voltage within the specified range to the ANI0 to ANI11 pins. If a voltage equal to or higher than AV_{REF0} or equal to or lower than AV_{SS} (even within the range of the absolute maximum ratings) is input to any of these pins, the conversion value of that channel is undefined, and the conversion value of the other channels may also be affected.

(3) Countermeasures against noise

To maintain the 10-bit resolution, the ANI0 to ANI11 pins must be effectively protected from noise. The effect of noise increases as the output impedance of the analog input source becomes higher. To lower the noise, connecting an external capacitor as shown in Figure 15-12 is recommended.

Figure 15-12. Processing of Analog Input Pin



(4) Alternate I/O

The analog input pins (ANI0 to ANI11) function alternately as port pins. When selecting one of the ANI0 to ANI11 pins to execute A/D conversion, do not execute an instruction to read an input port or write to an output port during conversion as the conversion resolution may drop.

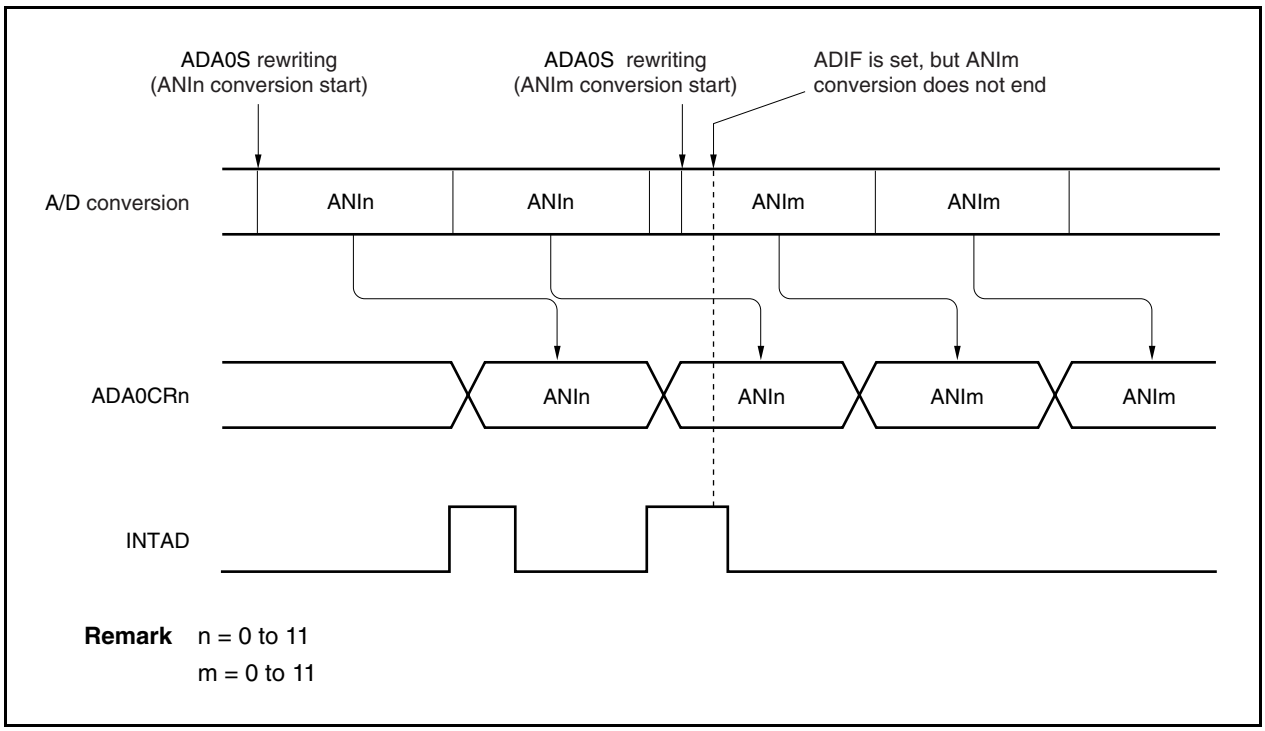
Also the conversion resolution may drop at the pins set as output port pins during A/D conversion if the output current fluctuates due to the effect of the external circuit connected to the port pins.

If a digital pulse is applied to a pin adjacent to the pin whose input signal is being converted, the A/D conversion value may not be as expected due to the effect of coupling noise. Therefore, do not apply a pulse to a pin adjacent to the pin undergoing A/D conversion.

(5) Interrupt request flag (ADIF)

The interrupt request flag (ADIF) is not cleared even if the contents of the ADA0S register are changed. If the analog input pin is changed during A/D conversion, therefore, the result of converting the previously selected analog input signal may be stored and the conversion end interrupt request flag may be set immediately before the ADA0S register is rewritten. If the ADIF flag is read immediately after the ADA0S register is rewritten, the ADIF flag may be set even though the A/D conversion of the newly selected analog input pin has not been completed. When A/D conversion is stopped, clear the ADIF flag before resuming conversion.

Figure 15-13. Generation Timing of A/D Conversion End Interrupt Request

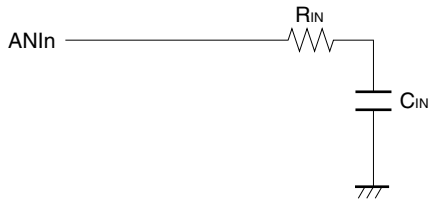


Remark n = 0 to 11
m = 0 to 11

(6) Internal equivalent circuit

The following shows the equivalent circuit of the analog input block.

Figure 15-14. Internal Equivalent Circuit of ANIn Pin



R_{IN}	C_{IN}
14 kΩ	8.4 pF

Remarks 1. The above values are reference values.

2. n = 0 to 11

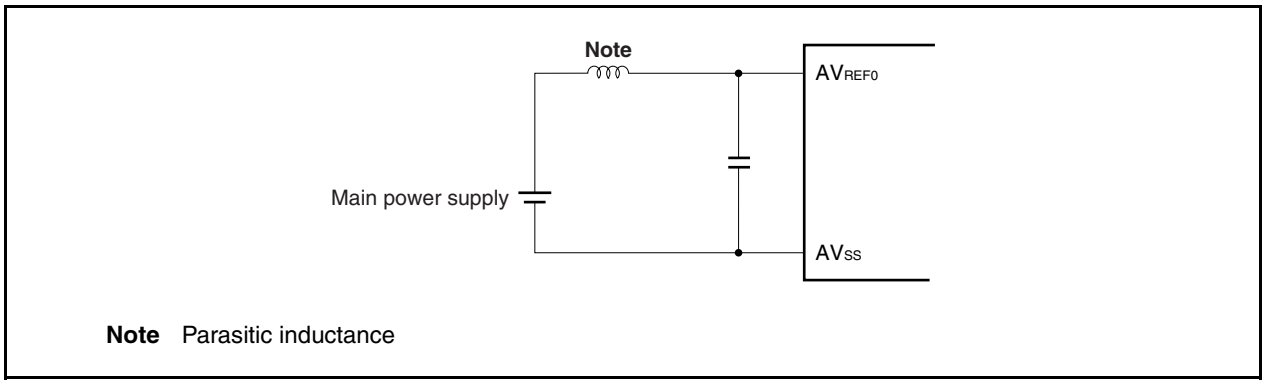
(7) AV_{REF0} pin

(a) The AV_{REF0} pin is used as the power supply pin of the A/D converter and also supplies power to the alternate-function ports. In an application where a backup power supply is used, be sure to supply the same potential as V_{DD} to the AV_{REF0} pin as shown in Figure 15-15.

(b) The AV_{REF0} pin is also used as the reference voltage pin of the A/D converter. If the source supplying power to the AV_{REF0} pin has a high impedance or if the power supply has a low current supply capability, the reference voltage may fluctuate due to the current that flows during conversion (especially, immediately after the conversion operation enable bit ADA0CE has been set to 1). As a result, the conversion accuracy may drop. To avoid this, it is recommended to connect a capacitor across the AV_{REF0} and AV_{SS} pins to suppress the reference voltage fluctuation as shown in Figure 15-15.

(c) If the source supplying power to the AV_{REF0} pin has a high DC resistance (for example, because of insertion of a diode), the voltage when conversion is enabled may be lower than the voltage when conversion is stopped, because of a voltage drop caused by the A/D conversion current.

Figure 15-15. AV_{REF0} Pin Processing Example



Note Parasitic inductance

(8) Reading ADA0CRn register

When the ADA0M0 to ADA0M2, ADA0S, ADA0PFM, or ADA0PFT register is written, the contents of the ADA0CRn register may be undefined. Read the conversion result after completion of conversion and before writing to the ADA0M0 to ADA0M2, ADA0S, ADA0PFM, or ADA0PFT register. Also, when an external/timer trigger is acknowledged, the contents of the ADA0CRn register may be undefined. Read the conversion result after completion of conversion and before the next external/timer trigger is acknowledged. The correct conversion result may not be read at a timing different from the above.

(9) External trigger mode

When using the external trigger mode, the input trigger during A/D conversion will not be acknowledged.

(10) Standby mode

Because the A/D converter stops operating in the STOP mode, the conversion results are invalid, so power consumption can be reduced. Operations are resumed after the STOP mode is released, but the A/D conversion results after the STOP mode is released are invalid. When using the A/D converter after the STOP mode is released, clear the ADA0M0.ADA0CE bit to 0 before setting the STOP mode or after releasing the STOP mode, then set the ADA0CE bit to 1 after releasing the STOP mode.

In the IDLE1, IDLE2, or subclock operation mode, operation continues. To lower the power consumption, therefore, clear the ADA0M0.ADA0CE bit to 0. In the IDLE1 and IDLE2 modes, since the analog input voltage value cannot be retained, the A/D conversion results after the IDLE1 and IDLE2 modes are released are invalid. The results of conversions before the IDLE1 and IDLE2 modes were set are valid.

(11) High-speed conversion mode

In the high-speed conversion mode, rewriting the ADA0M0, ADA0M2, ADA0S, ADA0PFM, and ADA0PFT registers and trigger input during the stabilization time are prohibited.

(12) A/D conversion time

The A/D conversion time is the total of the stabilization time, conversion time, wait time, and trigger response time (for details of these times, refer to **Table 15-2 Conversion Time Selection in Normal Conversion Mode (ADA0HS1 Bit = 0)** and **Table 15-3 Conversion Time Selection in High-Speed Conversion Mode (ADA0HS1 Bit = 1)**).

During A/D conversion in the normal conversion mode, if the ADA0M0, ADA0M2, ADA0S, ADA0PFM, and ADA0PFT registers are written or a trigger is input, reconversion is carried out. However, if the stabilization time end timing conflicts with writing to these registers, or if the stabilization time end timing conflicts with the trigger input, a stabilization time of 64 clocks is reinserted.

If a conflict occurs again with the reinserted stabilization time end timing, the stabilization time is reinserted. Therefore do not set the trigger input interval and control register write interval to 64 clocks or lower.

(13) Variation of A/D conversion results

The results of A/D conversion may vary due to a fluctuation in the supply voltage or the effect of noise. To reduce this variation, take countermeasures with the program such as averaging the A/D conversion results.

(14) A/D conversion result hysteresis characteristics

The successive comparison type A/D converter holds the analog input voltage in the internal sample & hold capacitor and then performs A/D conversion. After A/D conversion has finished, the analog input voltage remains in the internal sample & hold capacitor. As a result, the following phenomena may occur.

- When the same channel is used for A/D conversions, if the voltage is higher or lower than the previous A/D conversion, then hysteresis characteristics may appear in which the conversion result is affected by the previous value. Thus, even if the conversion is performed at the same potential, the result may vary.
- When switching the analog input channel, hysteresis characteristics may appear in which the conversion result is affected by the previous channel value. This is because one A/D converter is used for the A/D conversions. Thus, even if the conversion is performed at the same potential, the result may vary.

15.7 How to Read A/D Converter Characteristics Table

This section describes the terms related to the A/D converter.

(1) Resolution

The minimum analog input voltage that can be recognized, i.e., the ratio of an analog input voltage to 1 bit of digital output is called 1 LSB (least significant bit). The ratio of 1 LSB to the full scale is expressed as %FSR (full-scale range). %FSR is the ratio of a range of convertible analog input voltages expressed as a percentage, and can be expressed as follows, independently of the resolution.

1%FSR = (Maximum value of convertible analog input voltage – Minimum value of convertible analog input voltage)/100

$= (AV_{REF0} - 0)/100$

$= AV_{REF0}/100$

When the resolution is 10 bits, 1 LSB is as follows:

$1\ LSB = 1/2^{10} = 1/1,024$

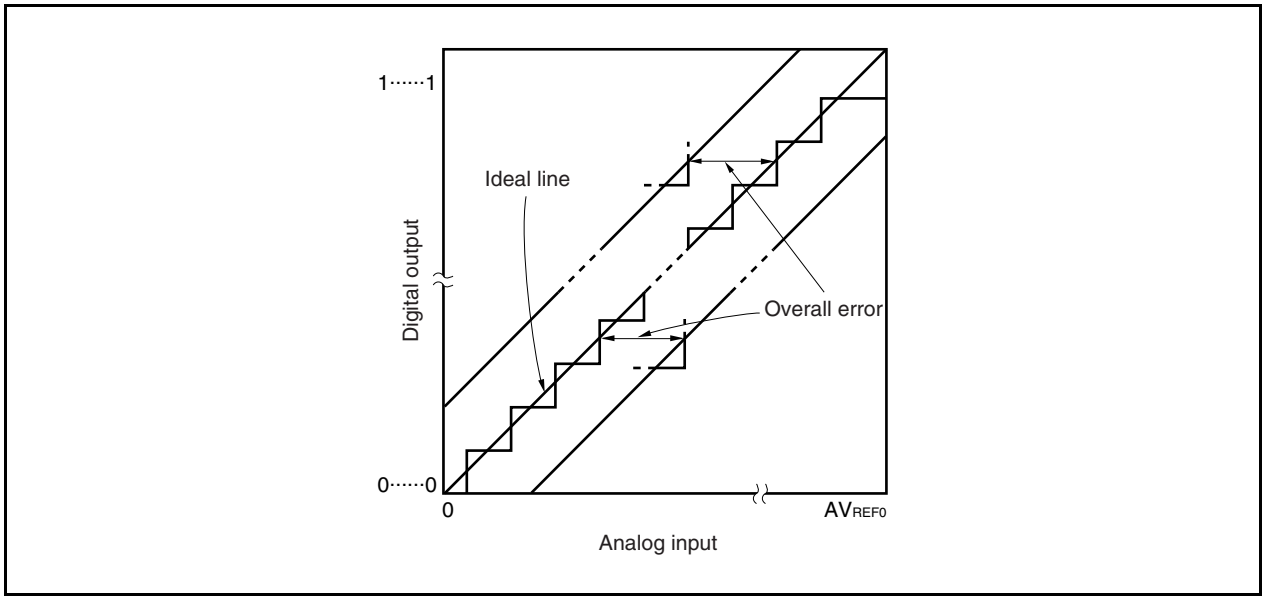
$= 0.098\%FSR$

The accuracy is determined by the overall error, independently of the resolution.

(2) Overall error

This is the maximum value of the difference between an actually measured value and a theoretical value.
It is a total of zero-scale error, full-scale error, linearity error, and a combination of these errors.
The overall error in the characteristics table does not include the quantization error.

Figure 15-16. Overall Error

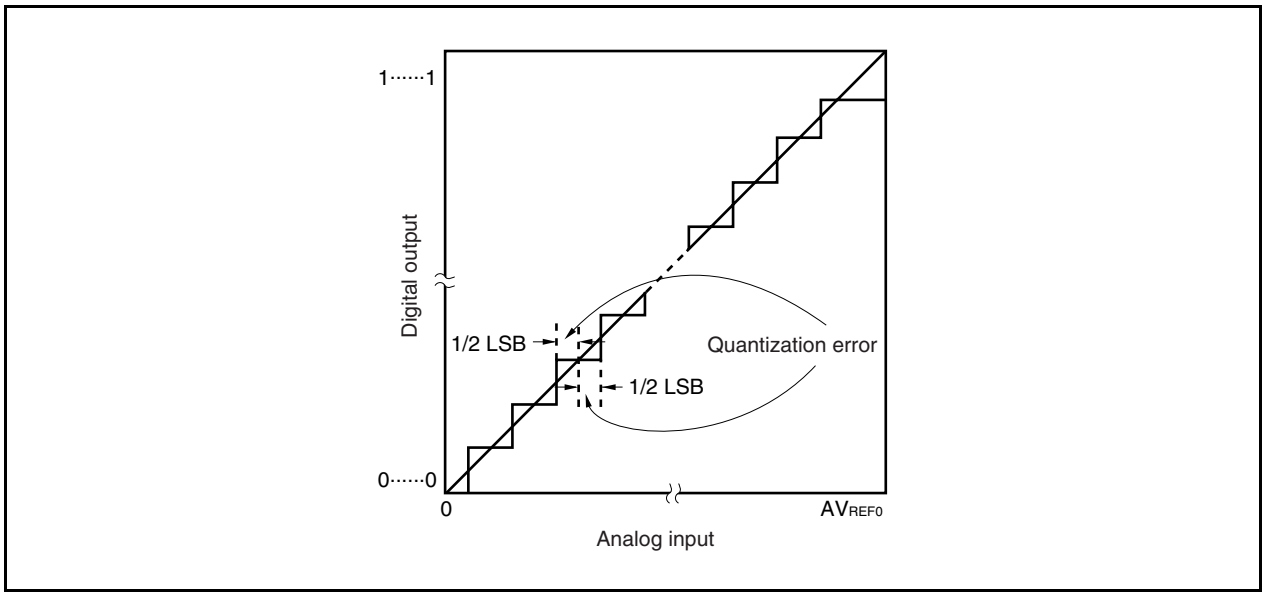


(3) Quantization error

This is an error of ±1/2 LSB that inevitably occurs when an analog value is converted into a digital value. Because the A/D converter converts analog input voltages in a range of ±1/2 LSB into the same digital codes, a quantization error is unavoidable.

This error is not included in the overall error, zero-scale error, full-scale error, integral linearity error, or differential linearity error in the characteristics table.

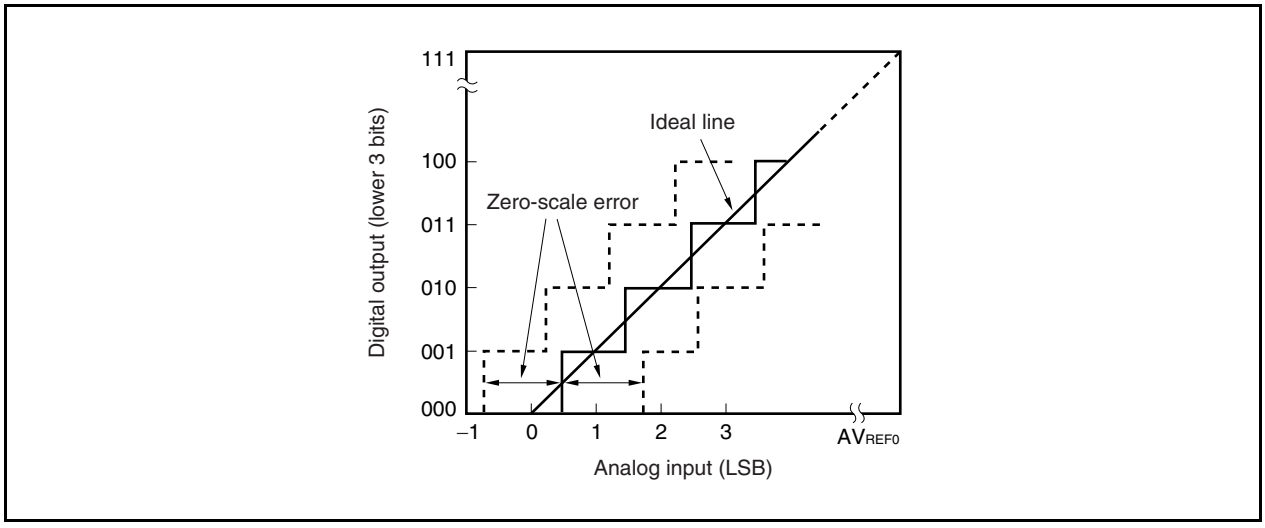
Figure 15-17. Quantization Error



(4) Zero-scale error

This is the difference between the actually measured analog input voltage and its theoretical value when the digital output changes from 0…000 to 0…001 (1/2 LSB).

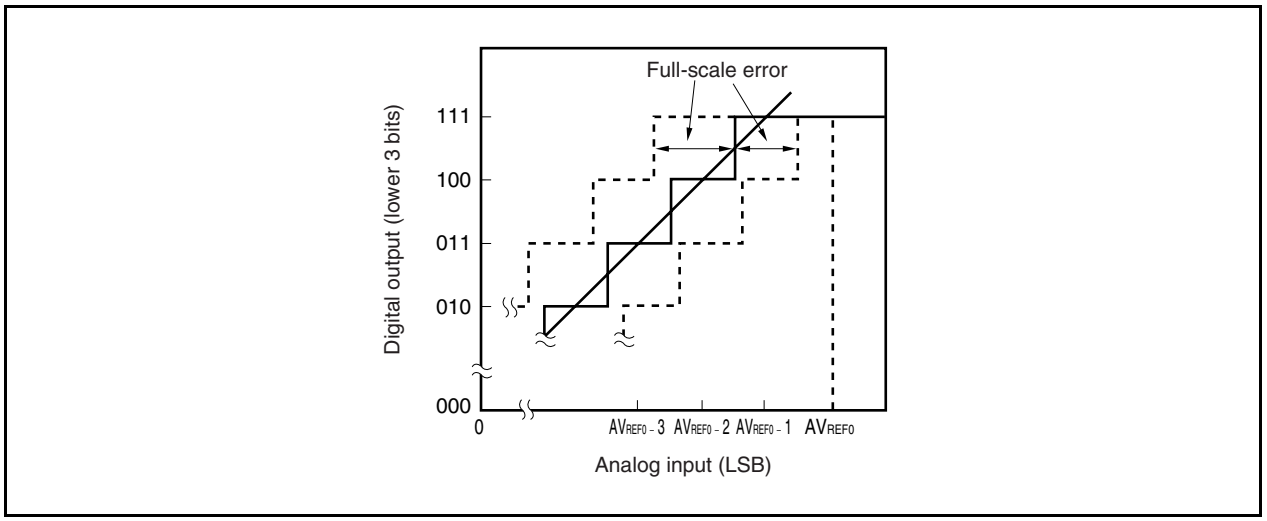
Figure 15-18. Zero-Scale Error



(5) Full-scale error

This is the difference between the actually measured analog input voltage and its theoretical value when the digital output changes from 1…110 to 1…111 (full scale – 3/2 LSB).

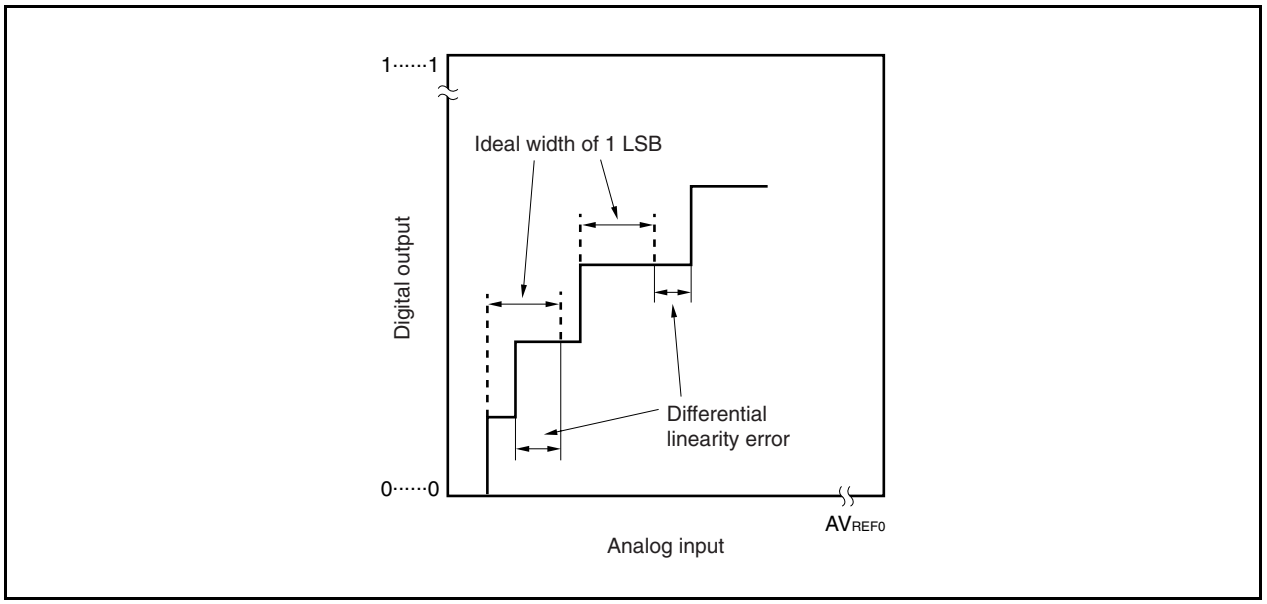
Figure 15-19. Full-Scale Error



(6) Differential linearity error

Ideally, the width to output a specific code is 1 LSB. This error indicates the difference between the actually measured value and its theoretical value when a specific code is output. This indicates the basic characteristics of the A/D conversion when the voltage applied to the analog input pins of the same channel is consistently increased bit by bit from AV_{SS} to AV_{REF0}. When the input voltage is increased or decreased, or when two or more channels are used, see **15.7 (2) Overall error**.

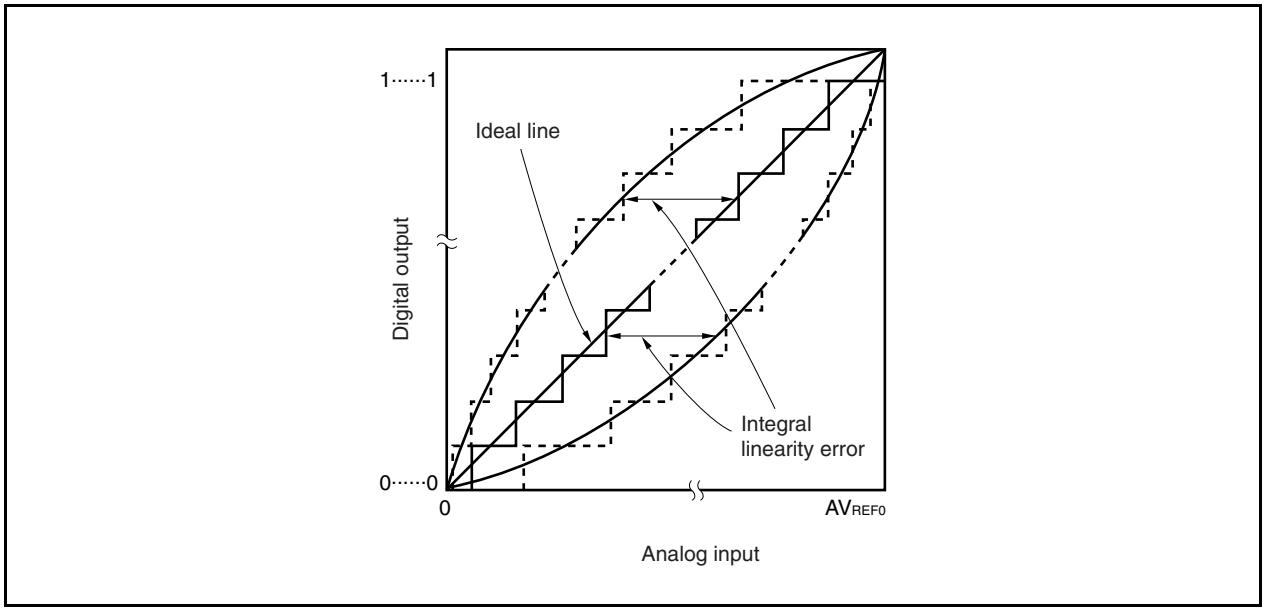
Figure 15-20. Differential Linearity Error



(7) Integral linearity error

This error indicates the extent to which the conversion characteristics differ from the ideal linear relationship. It indicates the maximum value of the difference between the actually measured value and its theoretical value where the zero-scale error and full-scale error are 0.

Figure 15-21. Integral Linearity Error



(8) Conversion time

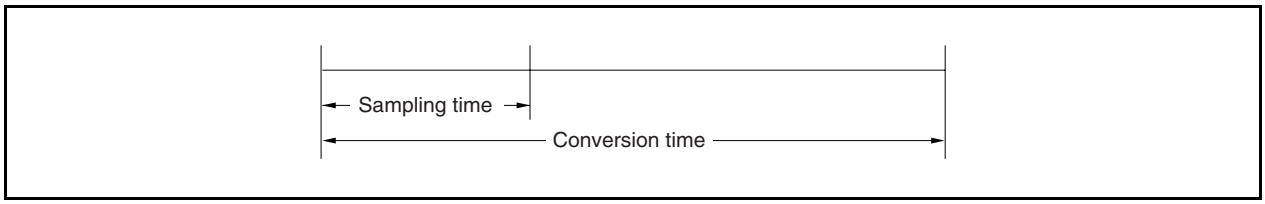
This is the time required to obtain a digital output after each trigger has been generated.

The conversion time in the characteristics table includes the sampling time.

(9) Sampling time

This is the time for which the analog switch is ON to load an analog voltage to the sample & hold circuit.

Figure 15-22. Sampling Time



CHAPTER 16 D/A CONVERTER

16.1 Functions

The D/A converter has the following functions.

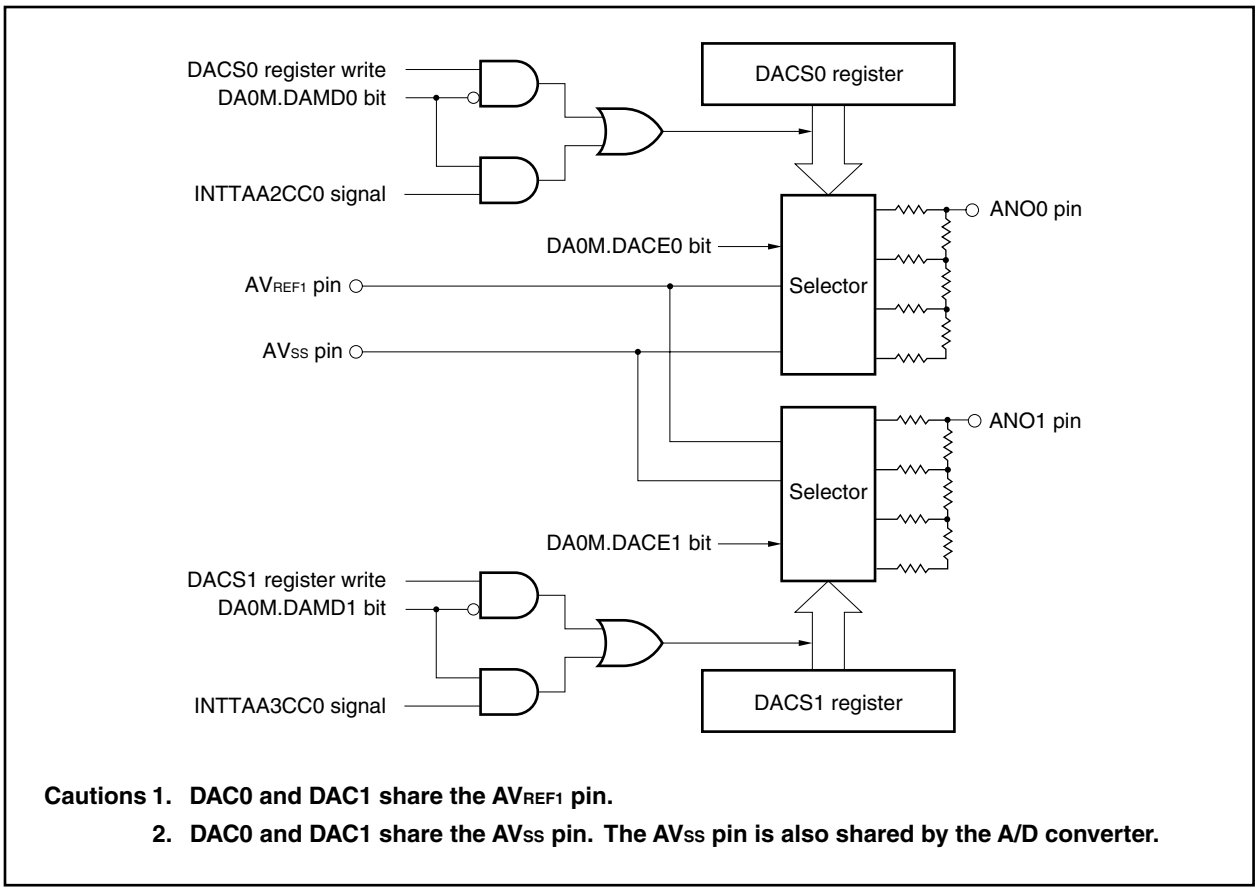
- ○ 8-bit resolution × 2 channels (DA0CS0, DA0CS1)
- ○ R-2R ladder method
- ○ Settling time: 3 μs max. (when AV_{REF1} is 3.0 to 3.6 V and external load is 20 pF)
- ○ Analog output voltage: AV_{REF1} × m/256 (m = 0 to 255; value set to DA0CSn register)
- ○ Operation modes: Normal mode, real-time output mode

Remark n = 0, 1

16.2 Configuration

The D/A converter configuration is shown below.

Figure 16-1. Block Diagram of D/A Converter



Cautions 1. DAC0 and DAC1 share the AV_{REF1} pin.

2. DAC0 and DAC1 share the AV_{SS} pin. The AV_{SS} pin is also shared by the A/D converter.

The D/A converter includes the following hardware.

Table 16-1. Configuration of D/A Converter

Item	Configuration
Control registers	D/A converter mode register (DA0M) D/A conversion value setting registers 0, 1 (DA0CS0, DA0CS1)

16.3 Registers

The registers that control the D/A converter are as follows.

- D/A converter mode register (DA0M)
- D/A conversion value setting registers 0, 1 (DA0CS0, DA0CS1)

(1) D/A converter mode register (DA0M)

The DA0M register controls the operation of the D/A converter.

This register can be read or written in 8-bit or 1-bit units.

Reset sets this register to 00H.

After reset: 00H R/W Address: FFFFF282H

	7	6	<5>	<4>	3	2	1	0
DA0M	0	0	DA0CE1	DA0CE0	0	0	DA0MD1	DA0MD0

DA0CEn	Control of D/A converter operation enable/disable (n = 0, 1)
0	Disables operation
1	Enables operation

DA0MDn	Selection of D/A converter operation mode (n = 0, 1)
0	Normal mode
1	Real-time output mode[Note]

Note The output trigger in the real-time output mode (DA0MDn bit = 1) is as follows.

- When n = 0: INTTAA2CC0 signal (see **CHAPTER 7 16-BIT TIMER/EVENT COUNTER AA (TAA)**)
- When n = 1: INTTAA3CC0 signal (see **CHAPTER 7 16-BIT TIMER/EVENT COUNTER AA (TAA)**)

(2) D/A conversion value setting registers 0, 1 (DA0CS0, DA0CS1)

The DA0CS0 and DA0CS1 registers set the analog voltage value output to the ANO0 and ANO1 pins.

These registers can be read or written in 8-bit units.

Reset sets these registers to 00H.

After reset: 00H R/W Address: DA0CS0 FFFFF280H, DA0CS1 FFFFF281H

	7	6	5	4	3	2	1	0
DA0CSn	DA0CSn7	DA0CSn6	DA0CSn5	DA0CSn4	DA0CSn3	DA0CSn2	DA0CSn1	DA0CSn0

Caution In the real-time output mode (DA0M.DA0MDn bit = 1), set the DA0CSn register before the INTTAA2CC0/INTTAA3CC0 signals are generated. D/A conversion starts when the INTTAA2CC0/INTTAA3CC0 signals are generated.

Remark n = 0, 1

16.4 Operation

16.4.1 Operation in normal mode

D/A conversion is performed using a write operation to the DA0CSn register as the trigger.

The setting method is described below.

<1> Set the DA0M.DA0MDn bit to 0 (normal mode).

<2> Set the analog voltage value to be output to the ANOn pin to the DA0CSn register.

Steps <1> and <2> above constitute the initial settings.

<3> Set the DA0M.DA0CEn bit to 1 (D/A conversion enable).

D/A conversion starts when this setting is performed.

<4> To perform subsequent D/A conversions, write to the DA0CSn register.

The previous D/A conversion result is held until the next D/A conversion is performed.

Remarks 1. For the alternate-function pin settings, see **Table 4-20 Using Port Pins as Alternate-Function Pins**.

2. n = 0, 1

16.4.2 Operation in real-time output mode

D/A conversion is performed using the interrupt request signals (INTTAA2CC0 and INTTAA3CC0) of TAA2 and TAA3 as triggers.

The setting method is described below.

<1> Set the DA0M.DA0MDn bit to 1 (real-time output mode).

<2> Set the analog voltage value to be output to the ANOn pin to the DA0CSn register.

<3> Set the DA0M.DA0CEn bit to 1 (D/A conversion enable).

Steps <1> to <3> above constitute the initial settings.

<4> Operate TAA2 and TAA3.

<5> D/A conversion starts when the INTTAA2CC0 and INTTAA3CC0 signals are generated.

<6> After that, the value set in DA0CSn register is output every time the INTTAA2CC0 and INTTAA3CC0 signals are generated.

Remarks 1. The output values of the ANO0 and ANO1 pins up to <5> above are undefined.

2. For the output values of the ANO0 and ANO1 pins in the HALT, IDLE1, IDLE2, and STOP modes, see **CHAPTER 21 STANDBY FUNCTION**.

3. For the alternate-function pin settings, see **Table 4-20 Using Port Pins as Alternate-Function Pins**.

16.4.3 Cautions

Observe the following cautions when using the D/A converter of the V850ES/JG3-H and V850ES/JH3-H.

(1) Do not change the set value of the DA0CSn register while the trigger signal is being issued in the real-time output mode.

(2) Before changing the operation mode, be sure to clear the DA0M.DA0CEn bit to 0.

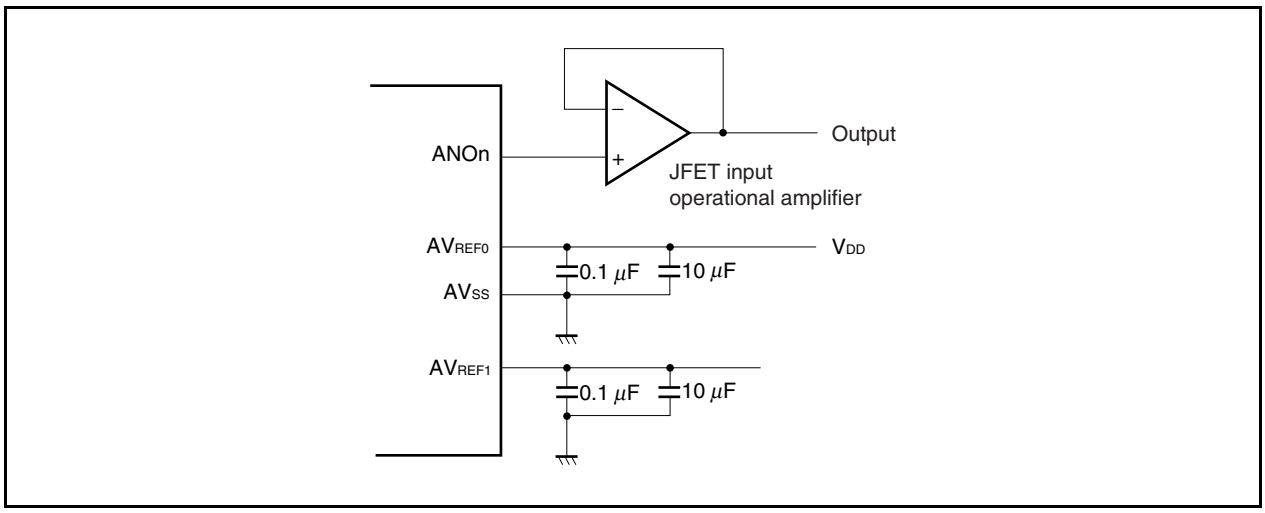
(3) When using one of the P10/AN00 and P11/AN01 pins as an I/O port and the other as a D/A output pin, do so in an application where the port I/O level does not change during D/A output.

(4) Make sure that $AV_{REF0} = V_{DD} = AV_{REF1}$ = 3.0 to 3.6 V. If this range is exceeded, the operation is not guaranteed.

(5) Apply power to AV_{REF1} at the same timing as AV_{REF0}.

(6) No current can be output from the ANOn pin (n = 0, 1) because the output impedance of the D/A converter is high. When connecting a resistor of 2 MΩ or less, insert a JFET input operational amplifier between the resistor and the ANOn pin.

Figure 16-2. External Pin Connection Example



(7) Because the D/A converter stops operating in the STOP mode, the ANO0 and ANO1 pins go into a high-impedance state, and the power consumption can be reduced.
In the IDLE1, IDLE2, or subclock operation mode, however, operation continues. To lower the power consumption, therefore, clear the DA0M.DA0CEn bit to 0.

CHAPTER 17 ASYNCHRONOUS SERIAL INTERFACE C (UARTC)

The V850ES/JG3-H and V850ES/JH3-H have a 5-channel UARTC.

17.1 Features

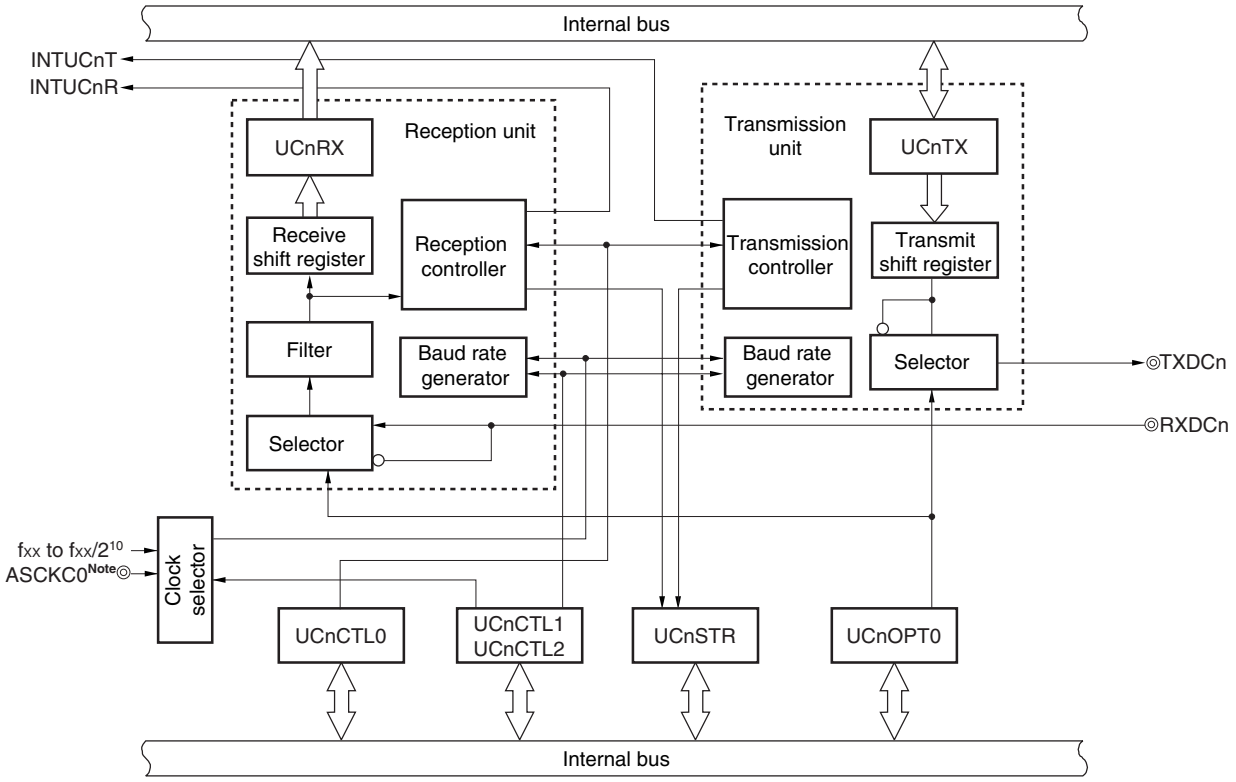
- Transfer rate: 300 bps to 3 Mbps (using internal system clock of 24 MHz and dedicated baud rate generator)
- Full-duplex communication: Internal UARTCn receive data register (UCnRX)
  Internal UARTCn transmit data register (UCnTX)
- 2-pin configuration: TXDCn: Transmit data output pin
  RXDCn: Receive data input pin
- Reception error detection function
  - Parity error
  - Framing error
  - Overrun error
- Interrupt sources: 2 types
  - Reception completion interrupt (INTUCnR): This interrupt occurs upon transfer of receive data from the receive shift register to the receive data register after serial transfer is complete, in the reception enabled status.
  - Transmission enable interrupt (INTUCnT): This interrupt occurs upon transfer of transmit data from the transmit data register to the transmit shift register in the transmission enabled status.
- Character length: 7 to 9 bits
- Parity function: Odd, even, 0, none
- Transmission stop bit: 1, 2 bits
- On-chip dedicated baud rate generator
- MSB-/LSB-first transfer selectable
- Transmit/receive data inverted input/output possible
- SBF (Sync Break Field) transmission in the LIN (Local Interconnect Network) communication format
  - 13 to 20 bits selectable for the SBF transmission
  - Recognition of 11 bits or more possible for SBF reception
  - SBF reception flag provided

Remark n = 0 to 4

17.2 Configuration

The block diagram of the UARTCn is shown below.

Figure 17-1. Block Diagram of Asynchronous Serial Interface Cn



Note UARTC0 only

Remarks 1. n = 0 to 4

2. For the configuration of the baud rate generator, see **Figure 17-19**.

UARTCn includes the following hardware.

Table 17-1. Configuration of UARTCn

Item	Configuration
Registers	UARTCn control register 0 (UCnCTL0) UARTCn control register 1 (UCnCTL1) UARTCn control register 2 (UCnCTL2) UARTCn option control register 0 (UCnOPT0) UARTCn option control register 1 (UCnOPT1) UARTCn status register (UCnSTR) UARTCn receive shift register UARTCn receive data register (UCnRX) UARTCn transmit shift register UARTCn transmit data register (UCnTX)

(1) UARTCn control register 0 (UCnCTL0)

The UCnCTL0 register is an 8-bit register used to specify the UARTCn operation.

(2) UARTCn control register 1 (UCnCTL1)

The UCnCTL1 register is an 8-bit register used to select the input clock for the UARTCn.

(3) UARTCn control register 2 (UCnCTL2)

The UCnCTL2 register is an 8-bit register used to control the baud rate for the UARTCn.

(4) UARTCn option control register 0 (UCnOPT0)

The UCnOPT0 register is an 8-bit register used to control serial transfer for the UARTCn.

(5) UARTCn option control register 1 (UCnOPT1)

The UCnOPT1 register is an 8-bit register used to control 9-bit length serial transfer for the UARTCn.

(6) UARTCn status register (UCnSTR)

The UCnSTRn register consists of flags indicating the error contents when a reception error occurs. Each one of the reception error flags is set (to 1) upon occurrence of a reception error.

(7) UARTCn receive shift register

This is a shift register used to convert the serial data input to the RXDCn pin into parallel data. Upon reception of 1 byte of data and detection of the stop bit, the receive data is transferred to the UCnRX register.

This register cannot be manipulated directly.

(8) UARTCn receive data register (UCnRX)

The UCnRX register is an 8-bit register that holds receive data. When 7 characters are received, 0 is stored in the most significant bit (when data is received with the LSB first).

In the reception enabled status, receive data is transferred from the UARTCn receive shift register to the UCnRX register in synchronization with the completion of shift-in processing of 1 frame.

Transfer to the UCnRX register also causes the reception completion interrupt request signal (INTUCnR) to be output.

(9) UARTCn transmit shift register

The transmit shift register is a shift register used to convert the parallel data transferred from the UCnTX register into serial data.

When 1 byte of data is transferred from the UCnTX register, the shift register data is output from the TXDCn pin.

This register cannot be manipulated directly.

(10) UARTCn transmit data register (UCnTX)

The UCnTX register is an 8-bit transmit data buffer. Transmission starts when transmit data is written to the UCnTX register. When data can be written to the UCnTX register (when data of one frame is transferred from the UCnTX register to the UARTCn transmit shift register), the transmission enable interrupt request signal (INTUCnT) is generated.

17.3 Mode Switching Between UARTC and Other Serial Interfaces

17.3.1 Mode switching between UARTC0 and CSIF4

In the V850ES/JG3-H and V850ES/JH3-H, CSIF4 and UARTC0 share the same pins and therefore cannot be used simultaneously. Set UARTC0 in advance, using the PMC3 and PFC3 registers, before use.

Caution The transmit/receive operation of CSIF4 and UARTC0 is not guaranteed if these functions are switched during transmission or reception. Be sure to disable the one that is not used.

Figure 17-2. CSIF4 and UARTC0 Mode Switch Settings

After reset: 00H R/W Address: FFFFF446H

	7	6	5	4	3	2	1	0
PMC3	PMC37	PMC36	PMC35	PMC34	PMC33	PMC32	PMC31	PMC30

After reset: 00H R/W Address: FFFFF466H

	7	6	5	4	3	2	1	0
PFC3	PFC37	PFC36	PFC35	PFC34	PFC33	PFC32	PFC31	PFC30

After reset: 00H R/W Address: FFFFF706H

	7	6	5	4	3	2	1	0
PFCE3	PFCE37	PFCE36	PFCE35	PFCE34	PFCE33	PFCE32	PFCE31	PFCE30

PMC32	PFCE32	PFC32	Operation mode
0	×	×	Port I/O mode
1	0	0	ASCKC0 (UARTC0)
1	0	1	$\overline{\text{SCKF4}}$ (CSIF4)

PMC31	PFCE31	PFC31	Operation mode
0	×	×	Port I/O mode
1	0	0	RXDC0 (UARTC)
1	0	1	SIF4 (CSIF4)

PMC30	PFCE30	PFC30	Operation mode
0	×	×	Port I/O mode
1	0	0	TXDC0 (UARTC)
1	0	1	SOF4 (CSIF4)

Remark × = don't care

17.3.2 Mode switching between UARTC1 and I²C02

In the V850ES/JG3-H and V850ES/JH3-H, UARTC1 and I²C02 share the same pins and therefore cannot be used simultaneously. Set UARTC1 in advance, using the PMC9, PFC9 and PFCE9 registers, before use.

Caution The transmit/receive operation of UARTC1 and I²C02 is not guaranteed if these functions are switched during transmission or reception. Be sure to disable the one that is not used.

Figure 17-3. UARTC1 and I²C02 Mode Switch Settings

After reset: 0000H R/W Address: FFFFF452H, FFFFF453H

PMC9

15	14	13	12	11	10	9	8
PMC915	PMC914	PMC913	PMC912	PMC911	PMC910	PMC99	PMC98
7	6	5	4	3	2	1	0
PMC97	PMC96	PMC95	PMC94	PMC93	PMC92	PMC91	PMC90

After reset: 0000H R/W Address: FFFFF472H, FFFFF473H

PFC9

15	14	13	12	11	10	9	8
PFC915	PFC914	PFC913	PFC912	PFC911	PFC910	PFC99	PFC98
7	6	5	4	3	2	1	0
PFC97	PFC96	PFC95	PFC94	PFC93	PFC92	PFC91	PFC90

After reset: 0000H R/W Address: FFFFF712H, FFFFF713H

PFCE9

15	14	13	12	11	10	9	8
PFCE915	PFCE914	0	0	PFCE911	PFCE910	PFCE99	PFCE98
7	6	5	4	3	2	1	0
PFCE97	PFCE96	PFCE95	PFCE94	PFCE93	PFCE92	PFCE91	PFCE90

PMC91	PFCE91	PFC91	Operation mode
0	×	×	Port I/O mode
1	0	1	TXDC1 (UARTC1)
1	1	0	SDA02 (I²C02)

PMC90	PFCE90	PFC90	Operation mode
0	×	×	Port I/O mode
1	0	1	RXDC1 (UARTC1)
1	1	0	SCL02 (I²C02)

Remark × = don't care

17.3.3 Mode switching between UARTC2 and CSIF3

In the V850ES/JG3-H and V850ES/JH3-H, UARTC2 and CSIF3 share of the same pin and therefore cannot be used simultaneously. Set UARTC2 in advance, using the PMC9, PFC9 and PFCE9 registers, before use.

Caution The transmit/receive operation of UARTC2 and CSIF3 is not guaranteed if these functions are switched during transmission or reception. Be sure to disable the one that is not used.

Figure 17-4. UARTC2 and CSIF3 Mode Switch Settings

After reset: 0000H R/W Address: FFFFF452H, FFFFF453H

PMC9

15	14	13	12	11	10	9	8
PMC915	PMC914	PMC913	PMC912	PMC911	PMC910	PMC99	PMC98
7	6	5	4	3	2	1	0
PMC97	PMC96	PMC95	PMC94	PMC93	PMC92	PMC91	PMC90

After reset: 0000H R/W Address: FFFFF472H, FFFFF473H

PFC9

15	14	13	12	11	10	9	8
PFC915	PFC914	PFC913	PFC912	PFC911	PFC910	PFC99	PFC98
7	6	5	4	3	2	1	0
PFC97	PFC96	PFC95	PFC94	PFC93	PFC92	PFC91	PFC90

After reset: 0000H R/W Address: FFFFF712H, FFFFF713H

PFCE9

15	14	13	12	11	10	9	8
PFCE915	PFCE914	0	0	PFCE911	PFCE910	PFCE99	PFCE98
7	6	5	4	3	2	1	0
PFCE97	PFCE96	PFCE95	PFCE94	PFCE93	PFCE92	PFCE91	PFCE90

PMC91	PFCE91	PFC91	Operation mode
0	×	×	Port I/O mode
1	0	1	TXDC1 (UARTC1)
1	1	0	SDA02 (I^2C02)

PMC90	PFCE90	PFC90	Operation mode
0	×	×	Port I/O mode
1	0	1	RXDC1 (UARTC1)
1	1	0	SCL02 (I^2C02)

Remark × = don't care

17.3.4 Mode switching between UARTC3, I²C00 and CAN0

In the V850ES/JG3-H and V850ES/JH3-H, UARTC3, I²C00, and CAN0 (μPD70F3770, 70F3771 only) share the same pins and therefore cannot be used simultaneously. Set UARTC3 in advance, using the PMC3, PFC3 and PFCE3 registers, before use.

Caution The transmit/receive operation of UARTC3, I²C00, and CAN0 (μPD70F3770, 70F3771 only) is not guaranteed if these functions are switched during transmission or reception. Be sure to disable the one that is not used.

Figure 17-5. UARTC3, I²C00, and CAN0 Mode Switch Settings

After reset: 00H R/W Address: FFFFF446H

	7	6	5	4	3	2	1	0
PMC3	PMC37	PMC36	PMC35	PMC34	PMC33	PMC32	PMC31	PMC30

After reset: 00H R/W Address: FFFFF466H

	7	6	5	4	3	2	1	0
PFC3	PFC37	PFC36	PFC35	PFC34	PFC33	PFC32	PFC31	PFC30

After reset: 00H R/W Address: FFFFF706H

	7	6	5	4	3	2	1	0
PFCE3	PFCE37	PFCE36	PFCE35	PFCE34	PFCE33	PFCE32	PFCE31	PFCE30

PMC37	PFCE37	PFC37	Operation mode
0	×	×	Port I/O mode
1	0	0	RXDC3 (UARTC3)
1	0	1	SDA00 (I²C00)
1	1	0	CRXD0 (CAN0)Note

PMC36	PFCE36	PFC36	Operation mode
0	×	×	Port I/O mode
1	0	0	TXDC3 (UARTC3)
1	0	1	SCL00 (I²C00)
1	1	0	CTXD0 (CAN0)Note

Note μPD70F3770, 70F3771 only

Remark × = don't care

17.3.5 Mode switching between UARTC4, CSIF0, and I²C01

In the V850ES/JG3-H and V850ES/JH3-H, UARTC4, CSIF0, and I²C01 share the same pin and therefore cannot be used simultaneously. Set UARTC4 in advance, using the PMC4, PFC4, and PMCE4 registers, before use.

Caution The transmit/receive operation of UARTC4, CSIF0, and I²C01 is not guaranteed if these functions are switched during transmission or reception. Be sure to disable the one that is not used.

Figure 17-6. UARTC4, CSIF0 and I²C01 Mode Switch Settings

After reset: 00H R/W Address: FFFFF448H

	7	6	5	4	3	2	1	0
PMC4	0	0	0	0	0	PMC42	PMC41	PMC40

After reset: 00H R/W Address: FFFFF468H

	7	6	5	4	3	2	1	0
PFC4	0	0	0	0	0	PFC42	PFC41	PFC40

After reset: 00H R/W Address: FFFFF708H

	7	6	5	4	3	2	1	0
PFCE4	0	0	0	0	0	0	PFCE41	PFCE40

PMC41	PFCE41	PFC41	Operation mode
0	×	×	Port I/O mode
1	0	0	SOF0 (CSIF0)
1	0	1	RXDC4 (UARTC4)
1	1	0	SCL01 (I²C01)

PMC40	PFCE40	PFC40	Operation mode
0	×	×	Port I/O mode
1	0	0	SIF0 (CSIF0)
1	0	1	TXDC4 (UARTC4)
1	1	0	SDA01 (I²C01)

Remark × = don't care

17.4 Registers

(1) UARTCn control register 0 (UCnCTL0)

The UCnCTL0 register is an 8-bit register that controls the UARTCn serial transfer operation.

This register can be read or written in 8-bit or 1-bit units.

Reset sets this register to 10H.

(1/2)

After reset: 10H R/W Address: UC0CTL0 FFFFFA00H, UC1CTL0 FFFFFA10H, UC2CTL0 FFFFFA20H, UC3CTL0 FFFFFA30H, UC4CTL0 FFFFFA40H

	<7>	<6>	<5>	<4>	3	2	1	0
UCnCTL0 (n = 0 to 4)	UCnPWR	UCnTXE	UCnRXE	UCnDIR	UCnPS1	UCnPS0	UCnCL	UCnSL

UCnPWR	UCRTCn operation control
0	Disable UCRTCn operation (UCRTCn reset asynchronously)
1	Enable UCRTCn operation
The UARTCn operation is controlled by the UCnPWR bit. The TXDCn pin output is fixed to high level by clearing the UCnPWR bit to 0 (fixed to low level if UCnOPT0.UCnTDL bit = 1).	

UCnTXE	Transmission operation enable
0	Disable transmission operation
1	Enable transmission operation
• To start transmission, set the UCnPWR bit to 1 and then set the UCnTXE bit to 1. To stop transmission, clear the UCnTXE bit to 0 and then UCnPWR bit to 0. • To initialize the transmission unit, clear the UCnTXE bit to 0, wait for two cycles of the base clock, and then set the UCnTXE bit to 1 again. Otherwise, initialization may not be executed (for the base clock, see **17.7 (1) (a) Base clock**).	

UCnRXE	Reception operation enable
0	Disable reception operation
1	Enable reception operation
• To start reception, set the UCnPWR bit to 1 and then set the UCnRXE bit to 1. To stop reception, clear the UCnRXE bit to 0 and then UCnPWR bit to 0. • To initialize the reception unit, clear the UCnRXE bit to 0, wait for two periods of the base clock, and then set the UCnRXE bit to 1 again. Otherwise, initialization may not be executed (for the base clock, see **17.7 (1) (a) Base clock**).	

(2/2)

UCnDIR	Transfer direction selection
0	MSB-first transfer
1	LSB-first transfer
• This register can be rewritten only when the UCnPWR bit = 0 or the UCnTXE bit = the UCnRXE bit = 0. • When transmission and reception are performed in the LIN format, set the UCnDIR bit to 1.	

UCnPS1	UCnPS0	Parity selection during transmission	Parity selection during reception
0	0	No parity output	Reception with no parity
0	1	0 parity output	Reception with 0 parity
1	0	Odd parity output	Odd parity check
1	1	Even parity output	Even parity check
• This register is rewritten only when the UCnPWR bit = 0 or the UCnTXE bit = the UCnRXE bit = 0. • If “Reception with 0 parity” is selected during reception, a parity check is not performed. Therefore, the UCnSTR.UCnPE bit is not set. • When transmission and reception are performed in the LIN format, clear the UCnPS1 and UCnPS0 bits to 00.			

UCnCL	Specification of data character length of 1 frame of transmit/receive data
0	7 bits
1	8 bits
• This register can be rewritten only when the UCnPWR bit = 0 or the UCnTXE bit = the UCnRXE bit = 0. • When transmission and reception are performed in the LIN format, set the UCnCL bit to 1.	

UCnSL	Specification of length of stop bit for transmit data
0	1 bit
1	2 bits
This register can be rewritten only when the UCnPWR bit = 0 or the UCnTXE bit = the UCnRXE bit = 0.	

Remark For details of parity, see **17.6.9 Parity types and operations**.

(2) UARTCn control register 1 (UCnCTL1)

For details, see **17.7 (2) UARTCn control register 1 (UCnCTL1)**.

(3) UARTCn control register 2 (UCnCTL2)

For details, see **17.7 (3) UARTCn control register 2 (UCnCTL2)**.

(4) UARTCn option control register 0 (UCnOPT0)

The UCnOPT0 register is an 8-bit register that controls the serial transfer operation of the UARTCn register.

This register can be read or written in 8-bit or 1-bit units.

Reset sets this register to 14H.

(1/2)

After reset: 14H R/W Address: UC0OPT0 FFFFFA03H, UC1OPT0 FFFFFA13H, UC2OPT0 FFFFFA23H, UC3OPT0 FFFFFA33H, UC4OPT0 FFFFFA43H

UCnOPT0 (n = 0 to 4)

<7>	6	5	4	3	2	1	0
UCnSRF	UCnSRT	UCnSTT	UCnSLS2	UCnSLS1	UCnSLS0	UCnTDL	UCnRDL

UCnSRF	SBF reception flag
0	When the UCnCTL0.UCnPWR bit = UCnCTL0.UCnRXE bit = 0 are set, or upon normal end of SBF reception.
1	During SBF reception

- SBF (Sync Brake Field) reception is judged during LIN communication.
- The UCnSRF bit is held at 1 when an SBF reception error occurs, and then SBF reception is started again.
- The UCnSRF bit is a read-only bit.

UCnSRT	SBF reception trigger
0	–
1	SBF reception trigger

- This is the SBF reception trigger bit during LIN communication, and when read, “0” is always read. For SBF reception, set the UCnSRT bit (to 1) to enable SBF reception.
- Set the UCnSRT bit after setting the UCnPWR bit = UCnRXE bit = 1.

UCnSTT	SBF transmission trigger
0	–
1	SBF transmission trigger

- This is the SBF transmission trigger bit during LIN communication, and when read, “0” is always read.
- Set the UCnSTT bit after setting the UCnPWR bit = UCnTXE bit = 1.

Caution Do not set the UCnSRT and UCnSTT bits (to 1) during SBF reception (UCnSRF bit = 1).

(2/2)

UCnSLS2	UCnSLS1	UCnSLS0	SBF transmission length selection
1	0	1	13-bit output (reset value)
1	1	0	14-bit output
1	1	1	15-bit output
0	0	0	16-bit output
0	0	1	17-bit output
0	1	0	18-bit output
0	1	1	19-bit output
1	0	0	20-bit output
This register can be set when the UCnPWR bit = 0 or when the UCnTXE bit = 0.			

UCnTDL	Transmit data level bit
0	Normal output of transfer data
1	Inverted output of transfer data
• The output level of the TXDCn pin can be inverted using the UCnTDL bit. • This register can be set when the UCnPWR bit = 0 or when the UCnTXE bit = 0.	

UCnRDL	Receive data level bit
0	Normal input of transfer data
1	Inverted input of transfer data
• The input level of the RXDCn pin can be inverted using the UCnRDL bit. • This register can be set when the UCnPWR bit = 0 or the UCnRXE bit = 0.	

(5) UARTCn option control register 1 (UCnOPT1)

The UCnOPT1 register is an 8-bit register that controls the serial transfer operation of UARTCn.

This register can be read or written in 8-bit or 1-bit units.

Reset sets this register to 00H.

Caution Set the UCnEBE bit while the operation of UARTC is disabled (UCnCTL0.UCnPWR = 0).

After reset: 00H R/W Address: UC0OPT1 FFFFFA0AH, UC1OPT1 FFFFFA1AH, UC2OPT1 FFFFFA2AH, UC3OPT1 FFFFFA3AH, UC4OPT1 FFFFFA4AH

	7	6	5	4	3	2	1	0
UCnOPT1 (n = 0 to 4)	0	0	0	0	0	0	0	UCnEBE

UCnEBE	Extension bit enable/disable
0	Extension-bit operation is prohibited. Transmission/reception is performed in the data length set by the UCnCTL0.UCnCL bit.
1	Extension-bit operation enabled. Transmission/reception can be performed in 9-bit character length.

- When setting the UCnEBE bit to 1, and transmitting in 9-bit data length, be sure to set the following. If this setting is not performed, the setting of UCnEBE bit is invalid.
  - UCnCTL0.UCnPS1, UCnPS0 = 00 (no parity)
  - CnCTL0.UCnCL = 1 (8-bit character length)
- If transmitting or receiving in the LIN communication format, set the UCnEBE to 0.

The following shows the relationship between the register setting value and the data format.

Table 17-2. Relationship Between Register Setting and Data Format

Register Setting					Data Format				
UCnCTL0				UCnOPT1	D0 to D6	D7	D8	D9	D10
UCnCL	UCnPS1	UCnPS0	UCnSL	UCnEBE					
0	0	0	0	0	Data	Stop	–	–	–
0	Other than 00				Data	Parity	Stop	–	–
1	0	0			Data	Data	Stop	–	–
1	Other than 00				Data	Data	Parity	Stop	–
0	0	0	1	0	Data	Stop	Stop	–	–
0	Other than 00				Data	Parity	Stop	Stop	–
1	0	0			Data	Data	Stop	Stop	–
1	Other than 00				Data	Data	Parity	Stop	Stop
0	0	0	0	1	Data	Stop	–	–	–
0	Other than 00				Data	Parity	Stop	–	–
1	0	0			Data	Data	Data	Stop	–
1	Other than 00				Data	Data	Parity	Stop	–
0	0	0	1	1	Data	Stop	Stop	–	–
0	Other than 00				Data	Parity	Stop	Stop	–
1	0	0			Data	Data	Data	Stop	Stop
1	Other than 00				Data	Data	Parity	Stop	Stop

Remark Data: Data bit
Stop: Stop bit
Parity: Parity bit

(6) UARTCn status register (UCnSTR)

The UCnSTR register is an 8-bit register that displays the UARTCn transfer status and reception error contents.

This register can be read or written in 8-bit or 1-bit units, but the UCnTSF bit is a read-only bit, while the UCnPE, UCnFE, and UCnOVE bits can both be read and written. However, these bits can only be cleared by writing 0; they cannot be set by writing 1 (even if 1 is written to them, the value is retained).

The initialization conditions are shown below.

Register/Bit	Initialization Conditions
UCnSTR register	• Reset • UCnCTL0.UCnPWR = 0
UCnTSF bit	• UCnCTL0.UCnTXE = 0
UCnPE, UCnFE, UCnOVE bits	• 0 write • UCnCTL0.UCnRXE = 0

After reset: 00H R/W Address: UC0STR FFFFFA04H, UC1STR FFFFFA14H, UC2STR FFFFFA24H, UC3STR FFFFFA34H, UC4STR FFFFFA44H

UCnSTR (n = 0 to 4)

<7>	6	5	4	3	<2>	<1>	<0>
UCnTSF	0	0	0	0	UCnPE	UCnFE	UCnOVE

UCnTSF	Transfer status flag
0	• When the UCnPWR bit = 0 or the UCnTXE bit = 0 has been set. • When, following transfer completion, there was no next data transfer from UCnTX register
1	Write to UCnTX register
The UCnTSF bit is always 1 when performing continuous transmission. When initializing the transmission unit, check that the UCnTSF bit = 0 before performing initialization. The transmit data is not guaranteed when initialization is performed while the UCnTSF bit = 1.	

UCnPE	Parity error flag
0	• When the UCnPWR bit = 0 or the UCnRXE bit = 0 has been set. • When 0 has been written
1	When parity of data and parity bit do not match during reception.
• The operation of the UCnPE bit is controlled by the settings of the UCnCTL0.UCnPS1 and UCnCTL0.UCnPS0 bits. • The UCnPE bit can be read and written, but it can only be cleared by writing 0 to it, and it cannot be set by writing 1 to it. When 1 is written to this bit, the value is retained.	

UCnFE	Framing error flag
0	• When the UCnPWR bit = 0 or the UCnRXE bit = 0 has been set • When 0 has been written
1	When no stop bit is detected during reception
• Only the first bit of the receive data stop bits is checked, regardless of the value of the UCnCTL0.UCnSL bit. • The UCnFE bit can be both read and written, but it can only be cleared by writing 0 to it, and it cannot be set by writing 1 to it. When 1 is written to this bit, the value is retained.	

UCnOVE	Overrun error flag
0	• When the UCnPWR bit = 0 or the UCnRXE bit = 0 has been set. • When 0 has been written
1	When receive data has been set to the UCnRX register and the next receive operation is completed before that receive data has been read
• When an overrun error occurs, the data is discarded without the next receive data being written to the receive buffer. • The UCnOVE bit can be both read and written, but it can only be cleared by writing 0 to it. When 1 is written to this bit, the value is retained.	

(7) UARTCn receive data register L (UCnRXL) and UARTCn receive data register (UCnRX)

The UCnRXL and UCnRX register are an 8- bit or 9-bit buffer register that stores parallel data converted by the receive shift register.

The data stored in the receive shift register is transferred to the UCnRXL and UCnRX register upon completion of reception of 1 byte of data.

During LSB-first reception when the data length has been specified as 7 bits, the receive data is transferred to bits 6 to 0 of the UCnRXL register and the MSB always becomes 0. During MSB-first reception, the receive data is transferred to bits 7 to 1 of the UCnRXL register and the LSB always becomes 0.

When an overrun error (UCnOVE) occurs, the receive data at this time is not transferred to the UCnRXL and UCnRX register and is discarded.

The access unit or reset value differs depending on the character length.

- Character length 7/8-bit (UCnOPT1.UCnEBE = 0)

  This register is read-only, in 8-bit units.

  Reset or UCnCTL0.UCnPWR bit = 0 sets this register to FFH.
- Character length 9-bit (UCnOPT1.UCnEBE = 0)

  This register is read-only, in 16-bit units.

  Reset or UCnCTL0.UCnPWR bit = 0 sets this register to 01FFH.

(a) Character length 7/8-bit (UCnOPT1.UCnEBE = 0)

After reset: FFH R Address: UC0RXL FFFFFA06H, UC1RXL FFFFFA16H, UC2RXL FFFFFA26H, UC3RXL FFFFFA36H, UC4RXL FFFFFA46H

	7	6	5	4	3	2	1	0
UCnRXL (n = 0 to 4)								

(b) Character length 9-bit (UCnOPT1.UCnEBE = 1)

After reset: 01FFH R Address: UC0RX FFFFFA06H, UC1RX FFFFFA16H, UC2RX FFFFFA26H, UC3RX FFFFFA36H, UC4RX FFFFFA46H

	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
UCnRX (n = 0 to 4)	0	0	0	0	0	0	0									

(8) UARTCn transmit data register L (UCnTXL), UARTCn transmit data register (UCnTX)

The UCnTXL and UCnTX register is an 8-bit or 9-bit register used to set transmit data.

During LSB-first transmission when the data length has been specified as 7 bits, the transmit data is transferred to bits 6 to 0 of the UCnRX register. During MSB-first transmission, the receive data is transferred to bits 7 to 1 of the UCnRX register.

The access unit or reset value differs depending on the character length.

- Character length 7/8-bit (UCnOPT1.UCnEBE = 0)
  This register can be read or written in 8-bit units.
  Reset sets this register to FFH.
- Character length 9-bit (UCnOPT1.UCnEBE = 0)
  This register can be read or written in 16-bit units.
  Reset sets this register to 01FFH.

Cautions 1. In the transmission operation enable status (UCnPWR = 1 and UCnTXE = 1), Writing to the UCnTXL, UCnTX register, as operate as trigger of transmission star, if writing the value of as soon as before and save value, before the INTUCnT interrupt is occurred, the same data is transferred at twice.

2. Data writing for consecutive transmission, after be generated the INTUCnT interrupt.
If writing the next data before the INTUCnT interrupt is occurred, transmission start processing and source of conflict writing the UCnTXL, UCnTX register, unexpected operations may occur.

3. If perform to write the UCnTXL, UCnTXLin the disable transmission operation register, can not be used as transmission start trigger. Consequently, even if transmission enable status after perform to write the UCnTXL, UCnTX register in the disable transmission operation status, can not be started transmission.

(a) Character length 7/8-bit (UCnOPT1.UCnEBE = 0)

After reset: FFH R/W Address: UC0TXL FFFFFA08H, UC1TXL FFFFFA18H, UC2TXL FFFFFA28H, UC3TXL FFFFFA38H, UC4TXL FFFFFA48H

	7	6	5	4	3	2	1	0
UCnTXL								

(n = 0 to 4)

(b) Character length 9-bit (UCnOPT1.UCnEBE = 1)

After reset: 01FFH R/W Address: UC0TX FFFFFA08H, UC1TX FFFFFA18H, UC2TX FFFFFA28H, UC3TX FFFFFA38H, UC4TX FFFFFA48H

	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
UCnTX	0	0	0	0	0	0	0									

(n = 0 to 4)

17.5 Interrupt Request Signals

The following two interrupt request signals are generated from UARTCn.

- Reception completion interrupt request signal (INTUCnR)
- Transmission enable interrupt request signal (INTUCnT)

The default priority for these two interrupt request signals is reception completion interrupt request signal then transmission enable interrupt request signal.

Table 17-3. Interrupts and Their Default Priorities

Interrupt	Priority
Reception complete	High
Transmission enable	Low

(1) Reception completion interrupt request signal (INTUCnR)

A reception completion interrupt request signal is output when data is shifted into the receive shift register and transferred to the UCnRX register in the reception enabled status.

A reception completion interrupt request signal is also output when a reception error occurs. Therefore, when a reception completion interrupt request signal is acknowledged and the data is read, read the UCnSTR register and check that the reception result is not an error.

No reception completion interrupt request signal is generated in the reception disabled status.

(2) Transmission enable interrupt request signal (INTUCnT)

If transmit data is transferred from the UCnTX register to the UARTCn transmit shift register with transmission enabled, the transmission enable interrupt request signal is generated.

17.6 Operation

17.6.1 Data format

Full-duplex serial data reception and transmission is performed.

As shown in Figure 17-7, one data frame of transmit/receive data consists of a start bit, character bits, parity bit, and stop bit(s).

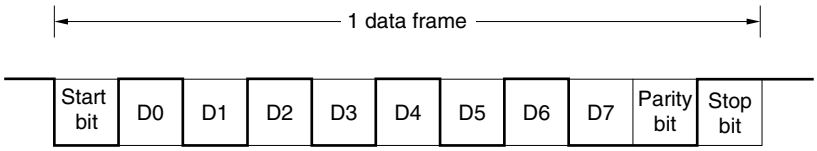
Specification of the character bit length within 1 data frame, parity selection, specification of the stop bit length, and specification of MSB/LSB-first transfer are performed using the UCnCTL0 register.

Moreover, control of UART output/inverted output for the TXDCn bit is performed using the UCnOPT0.UCnTDL bit.

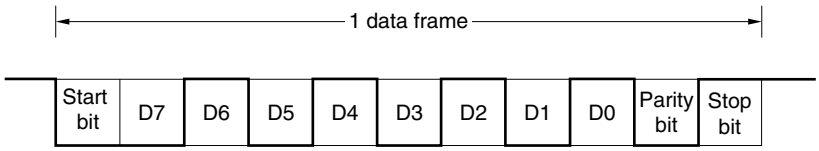
- Start bit.....1 bit
- Character bits.....7 bits/8 bits
- Parity bit .....Even parity/odd parity/0 parity/no parity
- Stop bit .....1 bit/2 bits

Figure 17-7. UARTC Transmit/Receive Data Format

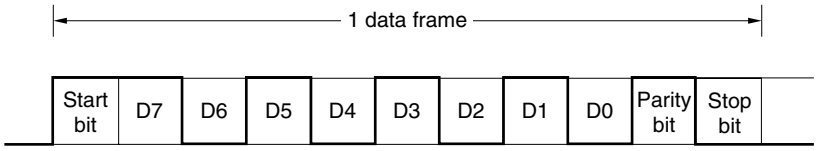
(a) 8-bit data length, LSB first, even parity, 1 stop bit, transfer data: 55H



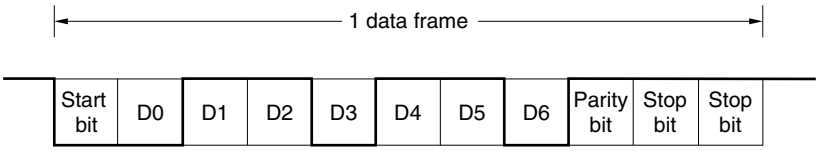
(b) 8-bit data length, MSB first, even parity, 1 stop bit, transfer data: 55H



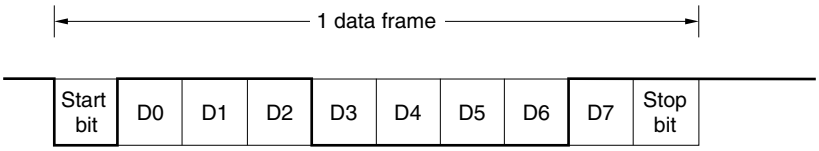
(c) 8-bit data length, MSB first, even parity, 1 stop bit, transfer data: 55H, TXDCn inversion



(d) 7-bit data length, LSB first, odd parity, 2 stop bits, transfer data: 36H



(e) 8-bit data length, LSB first, no parity, 1 stop bit, transfer data: 87H



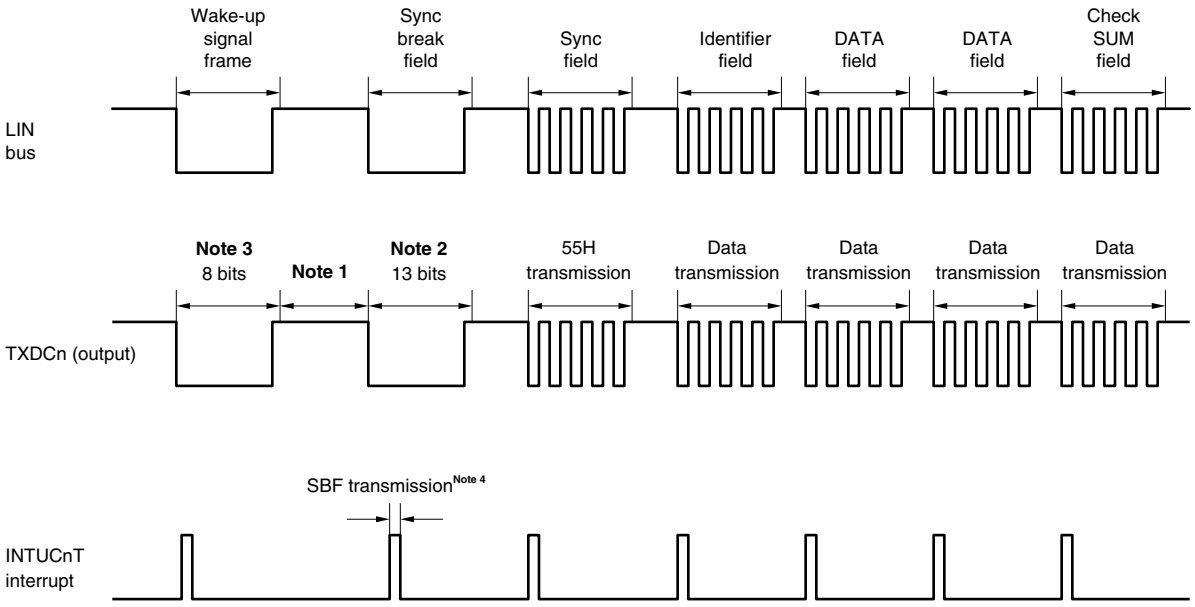
17.6.2 SBF transmission/reception format

The V850ES/JG3-H and V850ES/JH3-H have an SBF (Sync Break Field) transmission/reception control function to enable use of the LIN function.

Remark LIN stands for Local Interconnect Network and is a low-speed (1 to 20 kbps) serial communication protocol intended to aid the cost reduction of an automotive network.
LIN communication is single-master communication, and up to 15 slaves can be connected to one master.
The LIN slaves are used to control the switches, actuators, and sensors, and these are connected to the LIN master via the LIN network.
Normally, the LIN master is connected to a network such as CAN (Controller Area Network).
In addition, the LIN bus uses a single-wire method and is connected to the nodes via a transceiver that complies with ISO9141.
In the LIN protocol, the master transmits a frame with baud rate information and the slave receives it and corrects the baud rate error. Therefore, communication is possible when the baud rate error in the slave is ±15% or less.

Figures 17-8 and 17-9 outline the transmission and reception manipulations of LIN.

Figure 17-8. LIN Transmission Manipulation Outline



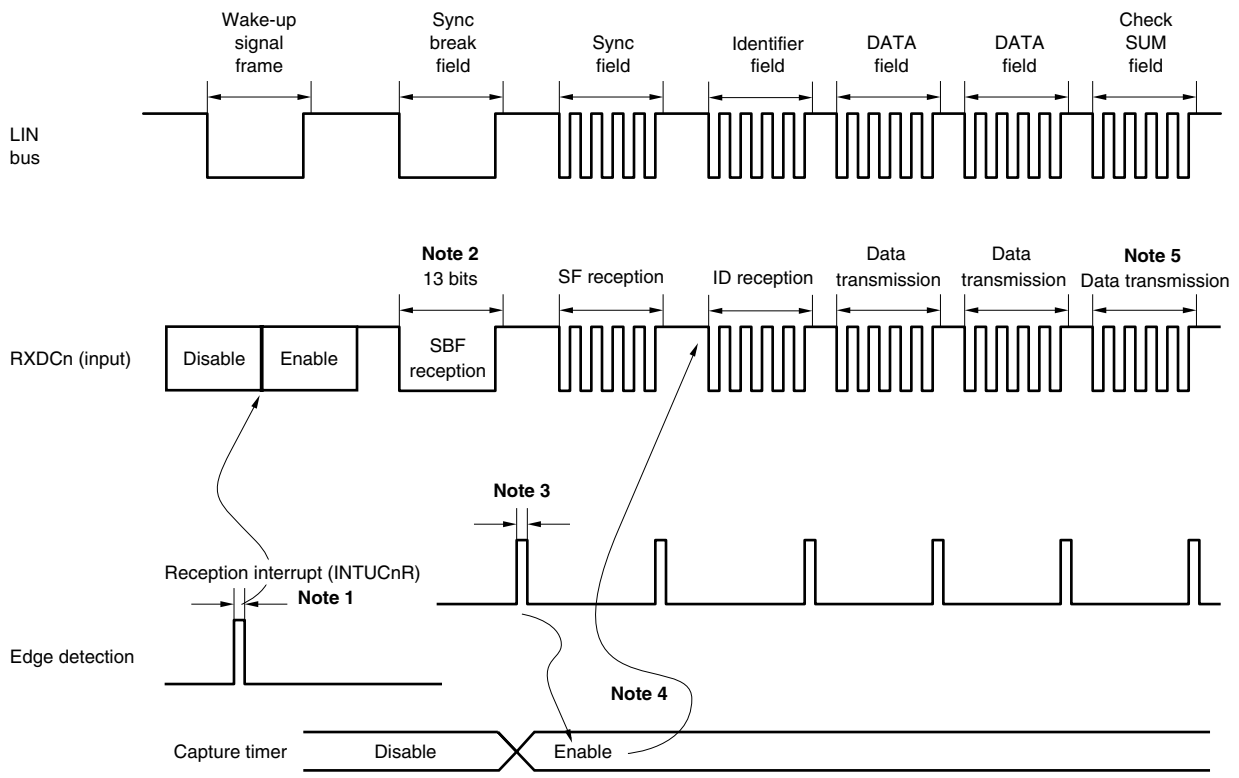
Notes 1. The interval between each field is controlled by software.

2. SBF output is performed by hardware. The output width is the bit length set by the UCnOPT0.UCnSLS2 to UCnOPT0.UCnSLS0 bits. If even finer output width adjustments are required, such adjustments can be performed using the UCnCTL2.UCnBRS7 to UCnCTL2.UCnBRS0 bits.

3. 80H transfer in the 8-bit mode is substituted for the wakeup signal frame.

4. A transmission enable interrupt request signal (INTUCnT) is output at the start of each transmission. The INTUCnT signal is also output at the start of each SBF transmission.

Figure 17-9. LIN Reception Manipulation Outline



Notes 1. The wakeup signal is sent by the pin edge detector, UARTCn is enabled, and the SBF reception mode is set.

2. The receive operation is performed until detection of the stop bit. Upon detection of SBF reception of 11 or more bits, normal SBF reception end is judged, and an interrupt signal is output. Upon detection of SBF reception of less than 11 bits, an SBF reception error is judged, no interrupt signal is output, and the mode returns to the SBF reception mode.

3. If SBF reception ends normally, an interrupt request signal is output. The timer is enabled by an SBF reception completion interrupt. Moreover, error detection for the UCnSTR.UCnOVE, UCnSTR.UCnPE, and UCnSTR.UCnFE bits is suppressed and UART communication error detection processing and UARTCn receive shift register and data transfer of the UCnRX register are not performed. The UARTCn receive shift register holds the initial value, FFH.

4. The RXDCn pin is connected to TI (capture input) of the timer, the transfer rate is calculated, and the baud rate error is calculated. The value of the UCnCTL2 register obtained by correcting the baud rate error after dropping UARTC enable is set again, causing the status to become the reception status.

5. Check-sum field distinctions are made by software. UARTCn is initialized following CSF reception, and the processing for setting the SBF reception mode again is performed by software.

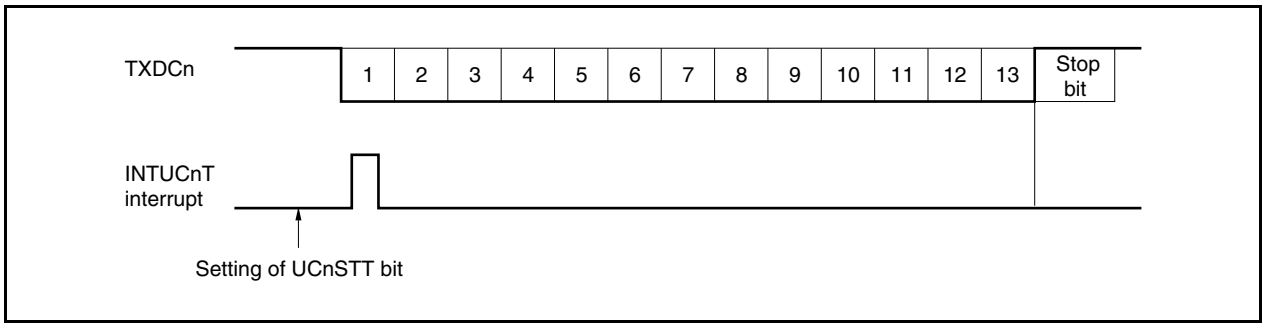
17.6.3 SBF transmission

When the UCnCTL0.UCnPWR bit = UCnCTL0.UCnTXE bit = 1, the transmission enabled status is entered, and SBF transmission is started by setting (to 1) the SBF transmission trigger (UCnOPT0.UCnSTT bit).

Thereafter, a low level the width of bits 13 to 20 specified by the UCnOPT0.UCnSLS2 to UCnOPT0.UCnSLS0 bits is output. A transmission enable interrupt request signal (INTUCnT) is generated upon SBF transmission start. Following the end of SBF transmission, the UCnSTT bit is automatically cleared. Thereafter, the UART transmission mode is restored.

Transmission is suspended until the data to be transmitted next is written to the UCnTX register, or until the SBF transmission trigger (UCnSTT bit) is set.

Figure 17-10. SBF Transmission



17.6.4 SBF reception

The reception wait status is entered by setting the UCnCTL0.UCnPWR bit to 1 and then setting the UCnCTL0.UCnRXE bit to 1.

The SBF reception wait status is set by setting the SBF reception trigger (UCnOPT0.UCnSRT bit) to 1.

In the SBF reception wait status, similarly to the UART reception wait status, the RXDCn pin is monitored and start bit detection is performed.

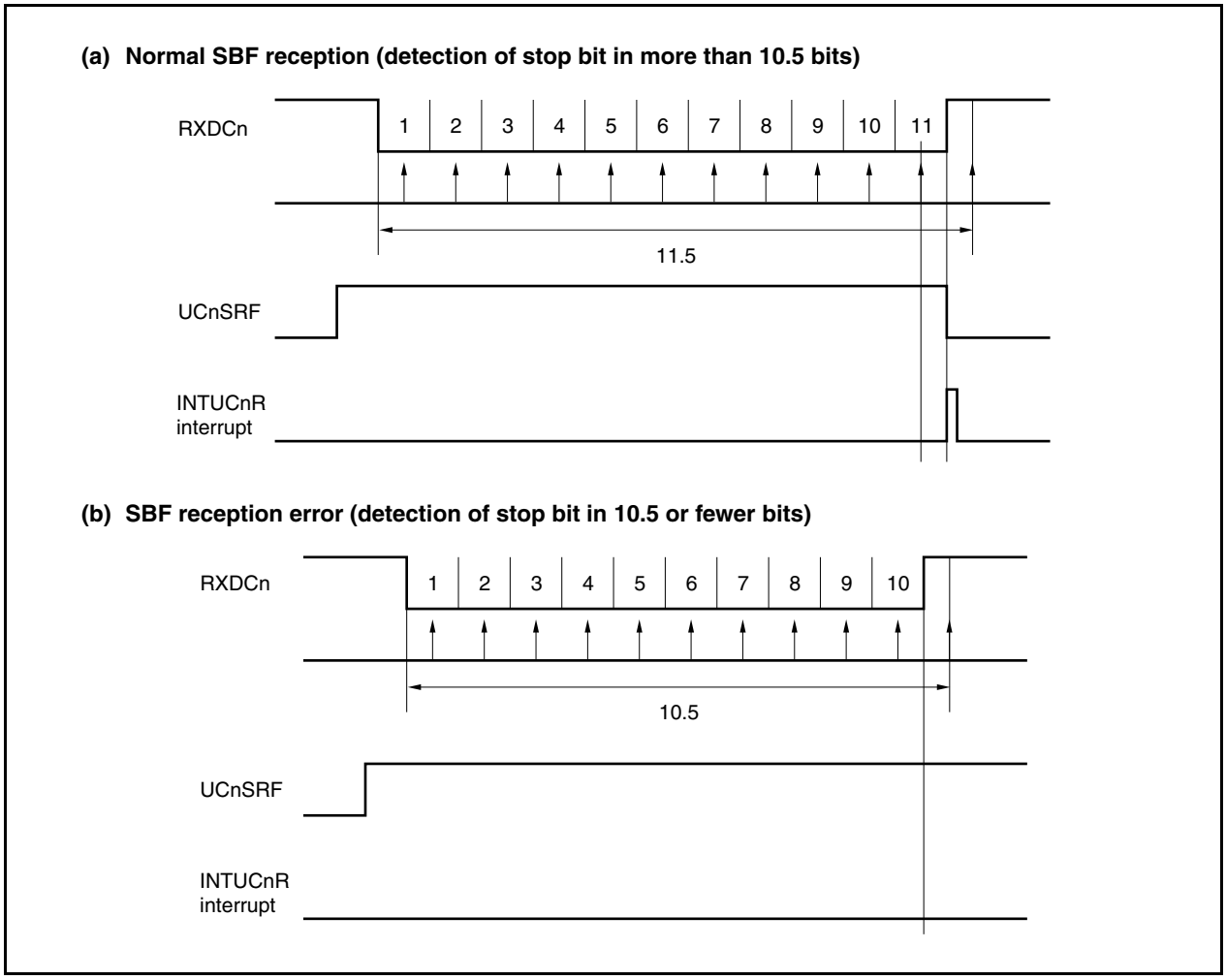
Following detection of the start bit, reception is started and the internal counter counts up according to the set baud rate.

When a stop bit is received, if the SBF width is 11 or more bits, normal processing is judged and a reception completion interrupt request signal (INTUCnR) is output. The UCnOPT0.UCnSRF bit is automatically cleared and SBF reception ends. Error detection for the UCnSTR.UCnOVE, UCnSTR.UCnPE, and UCnSTR.UCnFE bits is suppressed and UART communication error detection processing is not performed. Moreover, data transfer of the UARTCn reception shift register and UCnRX register is not performed and FFH, the initial value, is held. If the SBF width is 10 or fewer bits, reception is terminated as error processing without outputting an interrupt, and the SBF reception mode is returned to. The UCnSRF bit is not cleared at this time.

Cautions 1. If SBF is transmitted during a data reception, a framing error occurs.

2. Do not set the SBF reception trigger bit (UCnSRT) and SBF transmission trigger bit (UCnSTT) to 1 during an SBF reception (UCnSRF = 1).

Figure 17-11. SBF Reception



17.6.5 UART transmission

A high level is output to the TXDCn pin by setting the UCnCTL0.UCnPWR bit to 1.

Next, the transmission enabled status is set by setting the UCnCTL0.UCnTXE bit to 1, and transmission is started by writing transmit data to the UCnTX register. The start bit, parity bit, and stop bit are automatically added.

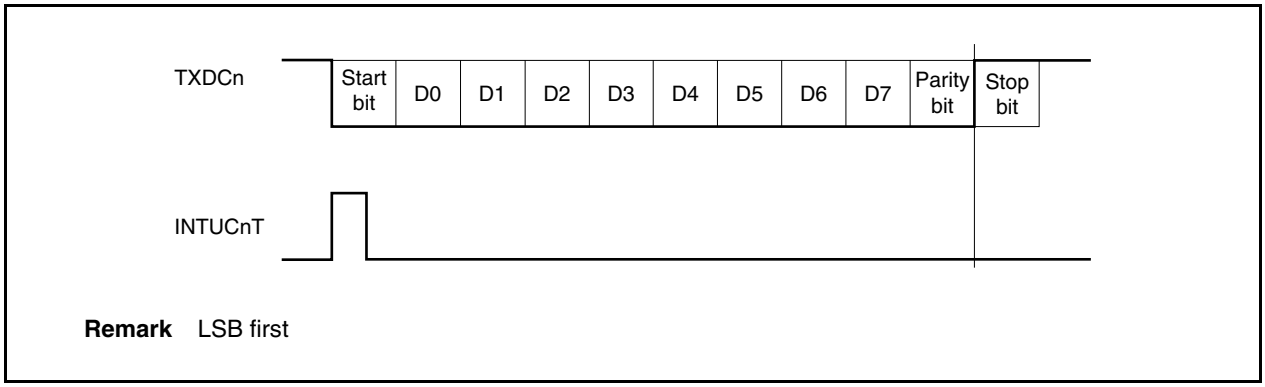
Since the CTS (transmit enable signal) input pin is not provided in UARTCn, use a port to check that reception is enabled at the transmit destination.

The data in the UCnTX register is transferred to the UARTCn transmit shift register upon the start of the transmit operation.

A transmission enable interrupt request signal (INTUCnT) is generated upon completion of transmission of the data of the UCnTX register to the UARTCn transmit shift register, and thereafter the contents of the UARTCn transmit shift register are output to the TXDCn pin.

Write of the next transmit data to the UCnTX register is enabled after the INTUCnT signal is generated.

Figure 17-12. UART Transmission



Remark LSB first

17.6.6 Continuous transmission procedure

UARTCn can write the next transmit data to the UCnTX register when the UARTCn transmit shift register starts the shift operation. The transmit timing of the UARTCn transmit shift register can be judged from the transmission enable interrupt request signal (INTUCnT). An efficient communication rate is realized by writing the data to be transmitted next to the UCnTX register during transfer.

Caution When initializing transmissions during the execution of continuous transmissions, make sure that the UCnSTR.UCnTSF bit is 0, then perform the initialization. Transmit data that is initialized when the UCnTSF bit is 1 cannot be guaranteed.

Figure 17-13. Continuous Transmission Processing Flow

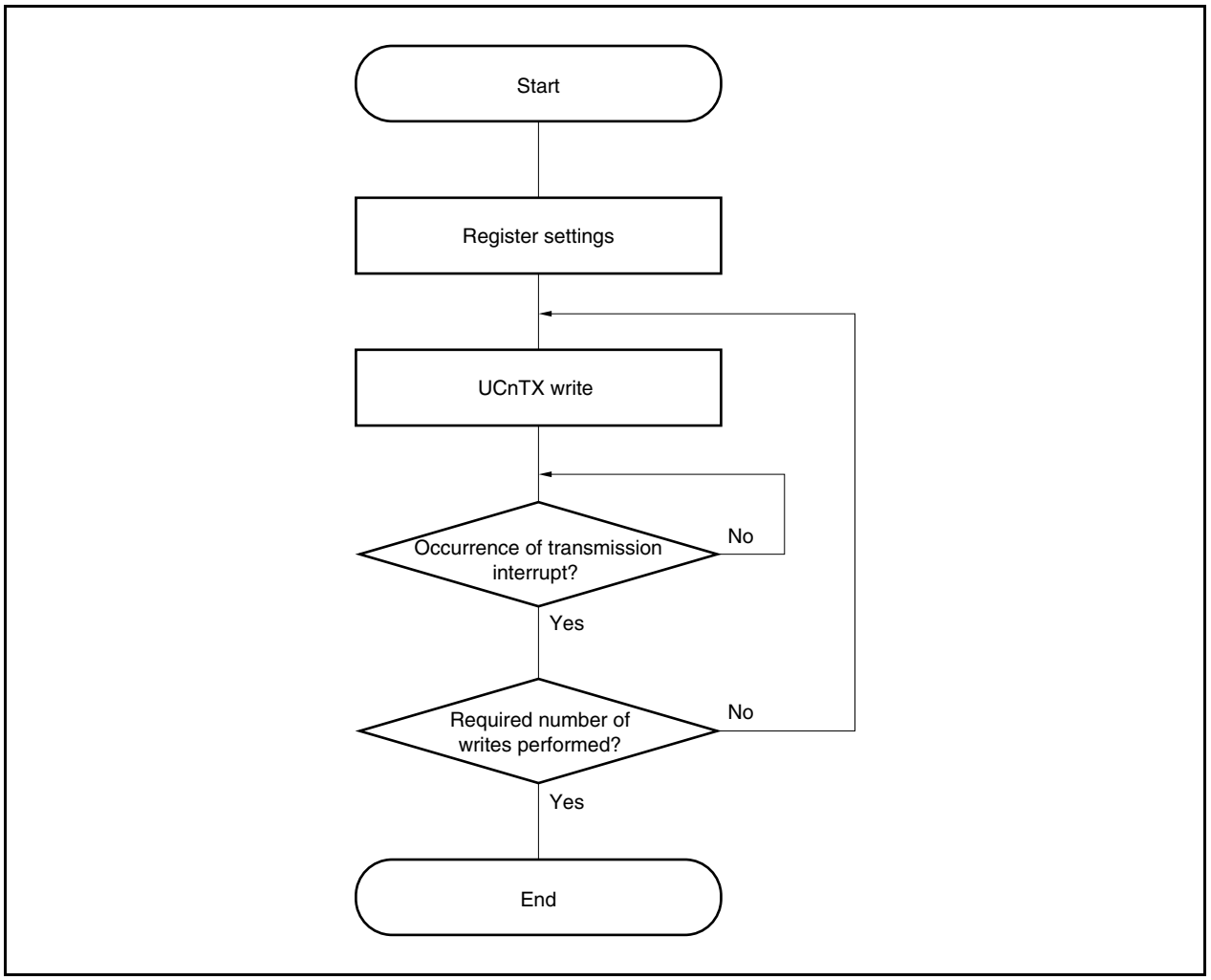
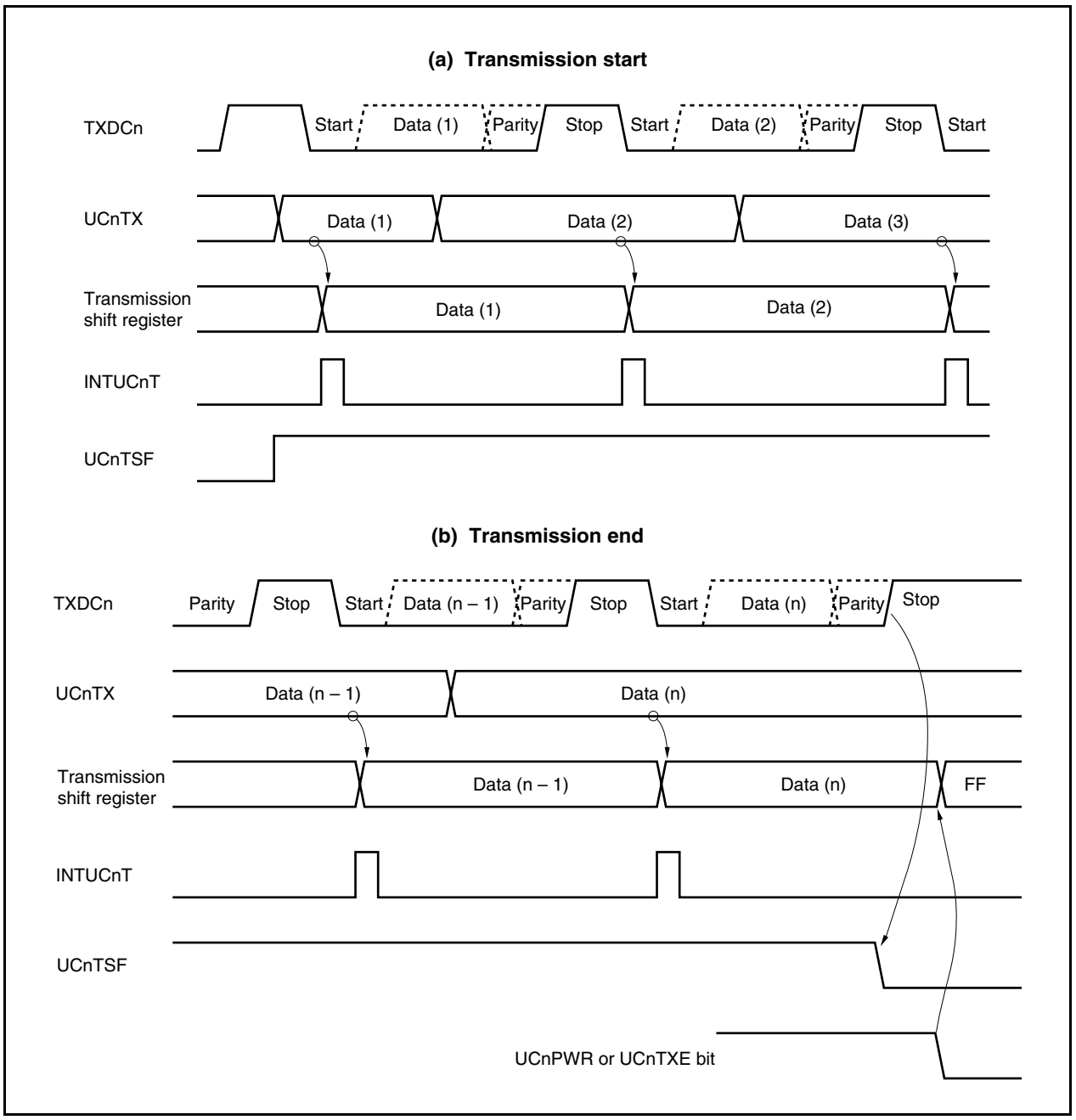


Figure 17-14. Continuous Transmission Operation Timing



17.6.7 UART reception

The reception wait status is set by setting the UCnCTL0.UCnPWR bit to 1 and then setting the UCnCTL0.UCnRXE bit to 1. In the reception wait status, the RXDCn pin is monitored and start bit detection is performed.

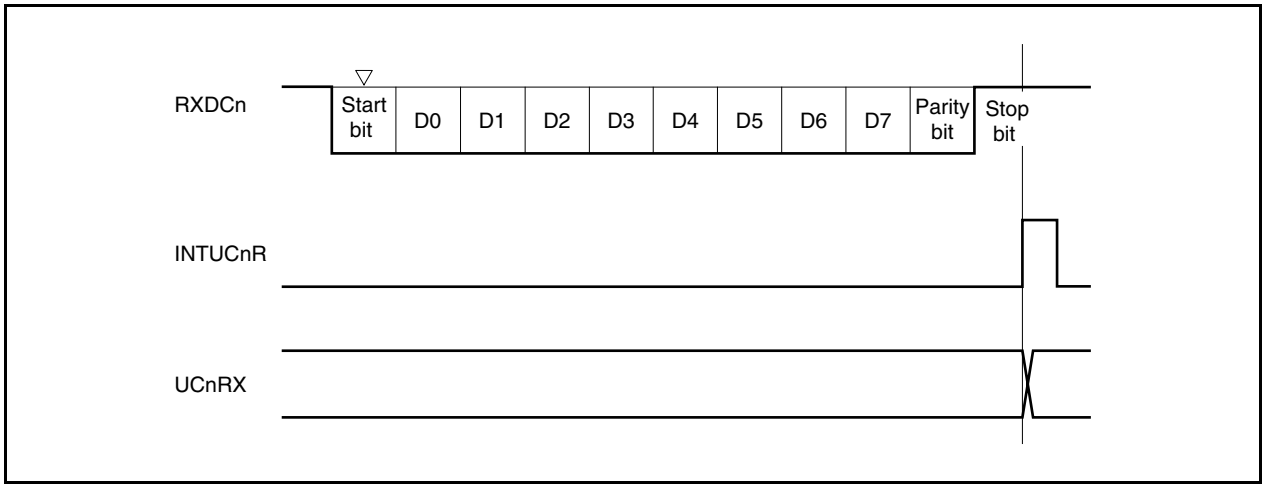
Start bit detection is performed using a two-step detection routine.

First the rising edge of the RXDCn pin is detected and sampling is started at the falling edge. The start bit is recognized if the RXDCn pin is low level at the start bit sampling point. After a start bit has been recognized, the receive operation starts, and serial data is saved to the UARTCn receive shift register according to the set baud rate.

When the reception completion interrupt request signal (INTUCnR) is output upon reception of the stop bit, the data of the UARTCn receive shift register is written to the UCnRX register. However, if an overrun error (UCnSTR.UCnOVE bit) occurs, the receive data at this time is not written to the UCnRX register and is discarded.

Even if a parity error (UCnSTR.UCnPE bit) or a framing error (UCnSTR.UCnFE bit) occurs during reception, reception continues until the reception position of the first stop bit, and INTUCnR is output following reception completion.

Figure 17-15. UART Reception



Cautions 1. Be sure to read the UCnRX register even when a reception error occurs. If the UCnRX register is not read, an overrun error occurs during reception of the next data, and reception errors continue occurring indefinitely.

2. The operation during reception is performed assuming that there is only one stop bit. A second stop bit is ignored.

3. When reception is completed, read the UCnRX register after the reception completion interrupt request signal (INTUCnR) has been generated, and clear the UCnPWR or UCnRXE bit to 0. If the UCnPWR or UCnRXE bit is cleared to 0 before the INTUCnR signal is generated, the read value of the UCnRX register cannot be guaranteed.

4. If receive completion processing (INTUCnR signal generation) of UARTCn and the UCnPWR bit = 0 or UCnRXE bit = 0 conflict, the INTUCnR signal may be generated in spite of these being no data stored in the UCnRX register.

To complete reception without waiting for the INTUCnR signal to be generated, be sure to set (1) the interrupt mask flag (UCnRMK) of the interrupt control register (UCnRIC), clear (0) the UCnPWR bit or UCnRXE bit, and then clear the interrupt request flag (UCnRIF) of the UCnRIC register.

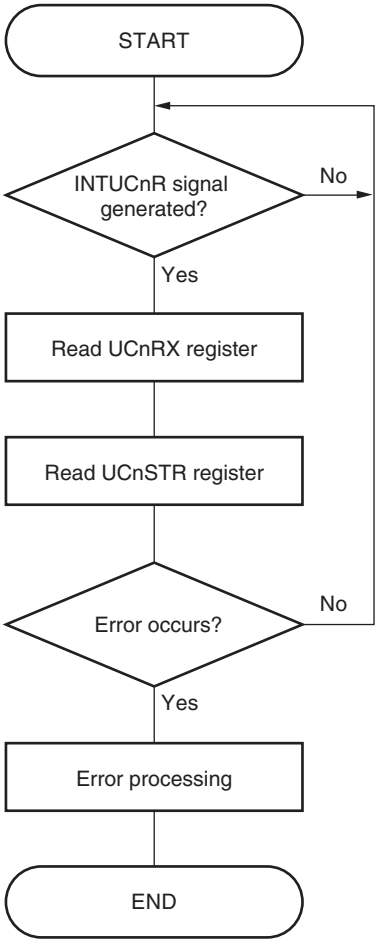
17.6.8 Reception errors

Errors during a receive operation are of three types: parity errors, framing errors, and overrun errors. Data reception result error flags are set in the UCnSTR register and a reception completion interrupt request signal (INTUCnR) is output when an error occurs.

It is possible to ascertain which error occurred during reception by reading the contents of the UCnSTR register.

Clear the reception error flag by writing 0 to it after reading it.

Figure 17-16. Receive Data Read Flow



Caution When an INTUCnR signal is generated, the UCnSTR register must be read to check for errors.

- Reception error causes

Error Flag	Reception Error	Cause
UCnPE	Parity error	Received parity bit does not match the setting
UCnFE	Framing error	Stop bit not detected
UCnOVE	Overrun error	Reception of next data completed before data was read from receive buffer

When reception errors occur, perform the following procedures depending upon the kind of error.

- Parity error
  If false data is received due to problems such as noise in the reception line, discard the received data and retransmit.

- Framing error
  A baud rate error may have occurred between the reception side and transmission side or the start bit may have been erroneously detected. Since this is a fatal error for the communication format, check the operation stop in the transmission side, perform initialization processing each other, and then start the communication again.

- Overrun error
  Since the next reception is completed before reading receive data, 1 frame of data is discarded. If this data was needed, do a retransmission.

Caution If a receive error interrupt occurs during continuous reception, read the contents of the UCnSTR register must be read before the next reception is completed, then perform error processing.

17.6.9 Parity types and operations

Caution When using the LIN function, fix the UCnCTL0.UCnPS1 and UCnCTL0.UCnPS0 bits to 00.

The parity bit is used to detect bit errors in the communication data. Normally the same parity is used on the transmission side and the reception side.

In the case of even parity and odd parity, it is possible to detect odd-count bit errors. In the case of 0 parity and no parity, errors cannot be detected.

(a) Even parity

(i) During transmission

The number of bits whose value is "1" among the transmit data, including the parity bit, is controlled so as to be an even number. The parity bit values are as follows.

- Odd number of bits whose value is "1" among transmit data: 1
- Even number of bits whose value is "1" among transmit data: 0

(ii) During reception

The number of bits whose value is "1" among the reception data, including the parity bit, is counted, and if it is an odd number, a parity error is output.

(b) Odd parity

(i) During transmission

Opposite to even parity, the number of bits whose value is "1" among the transmit data, including the parity bit, is controlled so that it is an odd number. The parity bit values are as follows.

- Odd number of bits whose value is "1" among transmit data: 0
- Even number of bits whose value is "1" among transmit data: 1

(ii) During reception

The number of bits whose value is "1" among the receive data, including the parity bit, is counted, and if it is an even number, a parity error is output.

(c) 0 parity

During transmission, the parity bit is always made 0, regardless of the transmit data.

During reception, parity bit check is not performed. Therefore, no parity error occurs, regardless of whether the parity bit is 0 or 1.

(d) No parity

No parity bit is added to the transmit data.

Reception is performed assuming that there is no parity bit. No parity error occurs since there is no parity bit.

17.6.10 Receive data noise filter

This filter samples the RXDCn pin using the base clock of the prescaler output.

When the same sampling value is read twice, the match detector output changes and the RXDCn signal is sampled as the input data. Therefore, data not exceeding 2 clock width is judged to be noise and is not delivered to the internal circuit (see **Figure 17-18**). See **17.7 (1) (a) Base clock** regarding the base clock.

Moreover, since the circuit is as shown in Figure 17-17, the processing that goes on within the receive operation is delayed by 3 clocks in relation to the external signal status.

Figure 17-17. Noise Filter Circuit

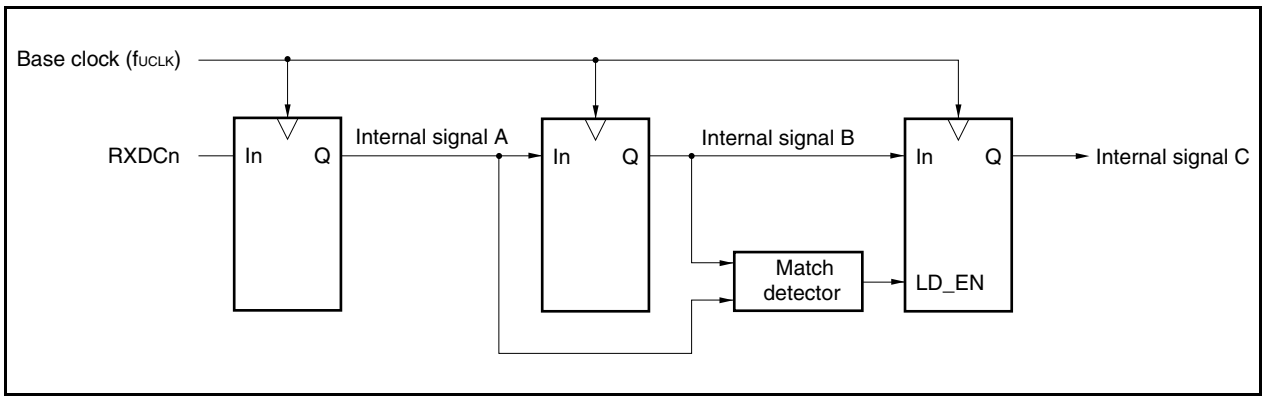
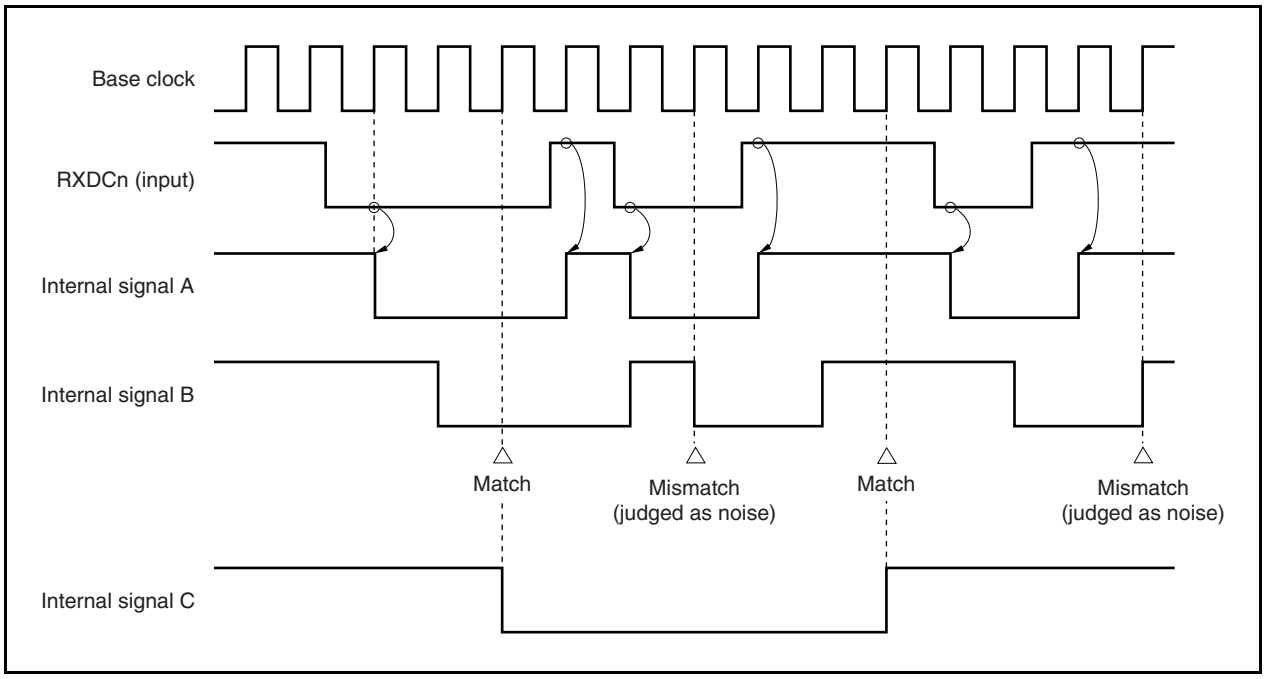


Figure 17-18. Timing of RXDCn Signal Judged as Noise



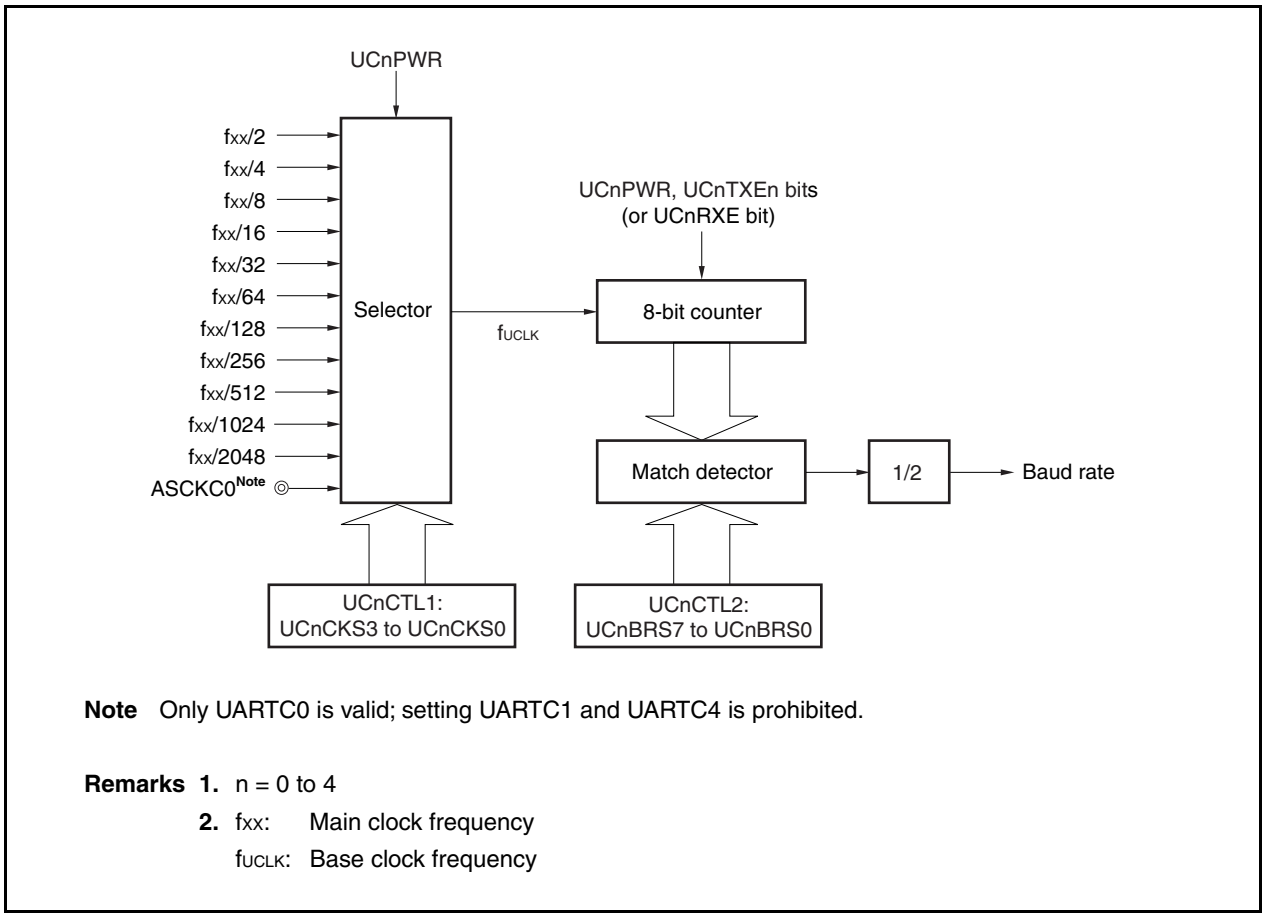
17.7 Dedicated Baud Rate Generator

The dedicated baud rate generator consists of a source clock selector block and an 8-bit programmable counter, and generates a serial clock during transmission and reception with UARTCn. Regarding the serial clock, a dedicated baud rate generator output can be selected for each channel.

There is an 8-bit counter for transmission and another one for reception.

(1) Baud rate generator configuration

Figure 17-19. Configuration of Baud Rate Generator



Note Only UARTC0 is valid; setting UARTC1 and UARTC4 is prohibited.

Remarks 1. n = 0 to 4

2. fxx: Main clock frequency

fUCLK: Base clock frequency

(a) Base clock

When the UCnCTL0.UCnPWR bit is 1, the clock selected by the UCnCTL1.UCnCKS3 to UCnCTL1.UCnCKS0 bits is supplied to the 8-bit counter. This clock is called the base clock (fUCLK).

(b) Serial clock generation

A serial clock can be generated by setting the UCnCTL1 register and the UCnCTL2 register (n = 0 to 4).

The base clock is selected by UCnCTL1.UCnCKS3 to UCnCTL1.UCnCKS0 bits.

The frequency division value for the 8-bit counter can be set using the UCnCTL2.UCnBRS7 to UCnCTL2.UCnBRS0 bits.

(2) UARTCn control register 1 (UCnCTL1)

The UCnCTL1 register is an 8-bit register that selects the UARTCn base clock.

This register can be read or written in 8-bit units.

Reset sets this register to 00H.

Caution Clear the UCnCTL0.UCnPWR bit to 0 before rewriting the UCnCTL1 register.

After reset: 00H R/W Address: UC0CTL1 FFFFFA01H, UC1CTL1 FFFFFA11H, UC2CTL1 FFFFFA21H, UC3CTL1 FFFFFA31H, UC4CTL1 FFFFFA41H

	7	6	5	4	3	2	1	0
UCnCTL1 (n = 0 to 4)	0	0	0	0	UCnCKS3	UCnCKS2	UCnCKS1	UCnCKS0

UCnCKS3	UCnCKS2	UCnCKS1	UCnCKS0	Base clock (f_{UCLK}) selection
0	0	0	0	fxx/2
0	0	0	1	fxx/4
0	0	1	0	fxx/8
0	0	1	1	fxx/16
0	1	0	0	fxx/32
0	1	0	1	fxx/64
0	1	1	0	fxx/128
0	1	1	1	fxx/256
1	0	0	0	fxx/512
1	0	0	1	fxx/1,024
1	0	1	0	fxx/2,048
1	0	1	1	External clock[Note] (ASCKC0 pin)
Other than above				Setting prohibited

Note Only UARTC0 is valid; setting UARTC1 to UARTC4 is prohibited.

Remark fxx: Main clock frequency

(3) UARTCn control register 2 (UCnCTL2)

The UCnCTL2 register is an 8-bit register that selects the baud rate (serial transfer speed) clock of UARTCn.

This register can be read or written in 8-bit units.

Reset sets this register to FFH.

Caution Clear the UCnCTL0.UCnPWR bit to 0 or clear the UCnTXE and UCnRXE bits to 00 before rewriting the UCnCTL2 register.

After reset FFH R/W Address: UC0CTL2 FFFFFA02H, UC1CTL2 FFFFFA12H, UC2CTL2 FFFFFA22H, UC3CTL2 FFFFFA32H, UC4CTL2 FFFFFA42H

UCnCTL2 (n = 0 to 4)

7	6	5	4	3	2	1	0
UCnBRS7	UCnBRS6	UCnBRS5	UCnBRS4	UCnBRS3	UCnBRS2	UCnBRS1	UCnBRS0

UCn BRS7	UCn BRS6	UCn BRS5	UCn BRS4	UCn BRS3	UCn BRS2	UCn BRS1	UCn BRS0	Default (k)	Serial clock
0	0	0	0	0	0	×	×	×	Setting prohibited
0	0	0	0	0	1	0	0	4	f_{UCLK}/4
0	0	0	0	0	1	0	1	5	f_{UCLK}/5
0	0	0	0	0	1	1	0	6	f_{UCLK}/6
:	:	:	:	:	:	:	:	:	:
1	1	1	1	1	1	0	0	252	f_{UCLK}/252
1	1	1	1	1	1	0	1	253	f_{UCLK}/253
1	1	1	1	1	1	1	0	254	f_{UCLK}/254
1	1	1	1	1	1	1	1	255	f_{UCLK}/255

Remark f_{UCLK}: Clock frequency selected by the UCnCTL1.UCnCKS3 to UCnCTL1.UCnCKS0 bits

(4) Baud rate

The baud rate is obtained by the following equation.

$$\text{Baud rate} = \frac{f_{UCLK}}{2 \times k} \quad [\text{bps}]$$

When using the internal clock, the equation will be as follows (when using the ASCKC0 pin as clock at UARTC0, calculate using the above equation).

$$\text{Baud rate} = \frac{f_{XX}}{2^{m+1} \times k} \quad [\text{bps}]$$

Remark f_{UCLK} = Frequency of base clock selected by the UCnCTL1.UCnCKS3 to UCnCTL1.UCnCKS0 bits
f_{XX}: Main clock frequency
m = Value set using the UCnCTL1.UCnCKS3 to UCnCTL1.UCnCKS0 bits (m = 0 to 10)
k = Value set using the UCnCTL2.UCnBRS7 to UCnCTL2.UCnBRS0 bits (k = 4 to 255)

The baud rate error is obtained by the following equation.

$$\text{Error (\%)} = \left(\frac{\text{Actual baud rate (baud rate with error)}}{\text{Target baud rate (correct baud rate)}} - 1 \right) \times 100 \ [\%]$$

$$= \left(\frac{f_{UCLK}}{2 \times k \times \text{Target baud rate}} - 1 \right) \times 100 \ [\%]$$

When using the internal clock, the equation will be as follows (when using the ASCKC0 pin input as the clock for UARTC0, calculate the baud rate error using the above equation).

$$\text{Error (\%)} = \left(\frac{f_{XX}}{2^{m+1} \times k \times \text{Target baud rate}} - 1 \right) \times 100 \ [\%]$$

Cautions 1. The baud rate error during transmission must be within the error tolerance on the receiving side.

2. The baud rate error during reception must satisfy the range indicated in (5) Allowable baud rate range during reception.

To set the baud rate, perform the following calculation for setting the UCnCTL1 and UCnCTL2 registers (when using internal clock).

<1> Set k to fxx/2/(2 × target baud rate) and m to 0.
<2> If k is 256 or greater (k ≥ 256), reduce k to half (k/2) and increment m by 1 (m + 1).
<3> Repeat Step <2> until k becomes less than 256 (k < 256).
<4> Round off the first decimal point of k to the nearest whole number.
If k becomes 256 after round-off, perform Step <2> again to set k to 128.
<5> Set the value of m to UCnCTL1 register and the value of k to the UCnCTL2 register.

Example: When fxx = 48 MHz and target baud rate = 153,600 bps
<1> k = 480,000,000/2/(2 × 153,600) = 78.125…, m = 0
<2>, <3> k = 78.125… < 256, m = 0
<4> Set value of UCnCTL2 register: k = 78 = 4EH, set value of UCnCTL1 register: m = 0

Actual baud rate = 48,000,000/2/(2 × 78)
= 153,846 [bps]

Baud rate error = {48,000,000/2/(2 × 78 × 153,600) − 1} × 100
= 0.160 [%]

The representative examples of baud rate settings are shown below.

Table 17-4. Baud Rate Generator Setting Data

Baud Rate (bps)	fxx = 48 MHz			fxx = 32 MHz			fxx = 24 MHz		
	UCnCTL1	UCnCTL2	ERR (%)	UCnCTL1	UCnCTL2	ERR (%)	UCnCTL1	UCnCTL2	ERR (%)
300	08H	9CH	0.16	07H	D0H	0.16	07H	9CH	−2.3
600	07H	9CH	0.16	06H	D0H	0.16	06H	9CH	0.16
1,200	06H	9CH	0.16	05H	D0H	0.16	05H	9CH	0.16
2,400	05H	9CH	0.16	04H	D0H	0.16	04H	9CH	0.16
4,800	04H	9CH	0.16	03H	D0H	0.16	03H	9CH	0.16
9,600	03H	9CH	0.16	02H	D0H	0.16	02H	9CH	0.16
19,200	02H	9CH	0.16	01H	D0H	0.16	01H	9CH	0.16
31,250	01H	C0H	0.00	01H	80H	0.00	00H	C0H	0.00
38,400	01H	9CH	0.16	00H	D0H	0.16	00H	9CH	0.16
76,800	00H	9CH	0.16	00H	68H	0.16	00H	4EH	0.16
153,600	00H	4EH	0.16	00H	34H	0.16	00H	27H	0.16
312,500	00H	26H	1.05	00H	1AH	−1.54	00H	13H	1.05
625,000	00H	13H	1.05	00H	0DH	−1.54	00H	0AH	−4.00
1,000,000	00H	0CH	0.00	00H	08H	0.00	00H	06H	0.00
1,250,000	00H	0AH	−4.00	Setting prohibited			00H	05H	−4.00
2,000,000	00H	06H	0.00	00H	04H	0.00	Setting prohibited		
2,500,000	00H	05H	−4.00	Setting prohibited					
3,000,000	00H	04H	0.00						

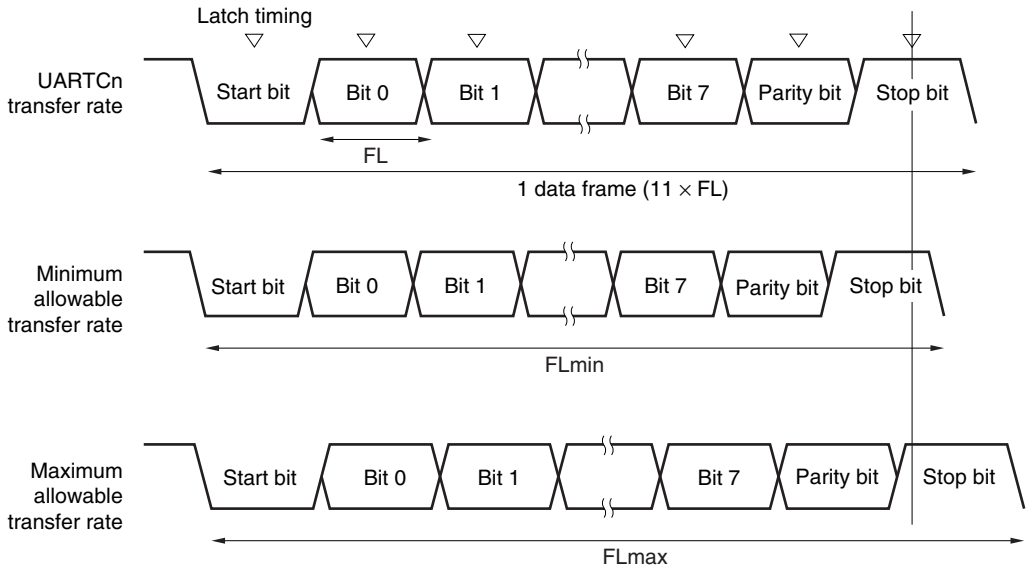
Remark fxx: Main clock frequency
ERR: Baud rate error (%)

(5) Allowable baud rate range during reception

The baud rate error range at the destination that is allowable during reception is shown below.

Caution The baud rate error during reception must be set within the allowable error range using the following equation.

Figure 17-20. Allowable Baud Rate Range During Reception



Remark n = 0 to 4

As shown in Figure 17-20, the receive data latch timing is determined by the counter set using the UCnCTL2 register following start bit detection. The transmit data can be normally received if up to the last data (stop bit) can be received in time for this latch timing.

When this is applied to 11-bit reception, the following is the theoretical result.

$FL = (Brate)^{-1}$

Brate: UARTCn baud rate (n = 0 to 4)

k: Set value of UCnCTL2.UCnBRS7 to UCnCTL2.UCnBRS0 bits (n = 0 to 4)

FL: 1-bit data length

Latch timing margin: 2 clocks

Minimum allowable transfer rate: $FLmin = 11 \times FL - \frac{k-2}{2k} \times FL = \frac{21k+2}{2k} FL$

Therefore, the maximum baud rate that can be received by the destination is as follows.

$$BRmax = (FLmin/11)^{-1} = \frac{22k}{21k + 2} Brate$$

Similarly, obtaining the following maximum allowable transfer rate yields the following.

$$\frac{10}{11} \times FLmax = 11 \times FL - \frac{k + 2}{2 \times k} \times FL = \frac{21k - 2}{2 \times k} FL$$

$$FLmax = \frac{21k - 2}{20\ k} FL \times 11$$

Therefore, the minimum baud rate that can be received by the destination is as follows.

$$BRmin = (FLmax/11)^{-1} = \frac{20k}{21k - 2} Brate$$

Obtaining the allowable baud rate error for UARTCn and the destination from the above-described equations for obtaining the minimum and maximum baud rate values yields the following.

Table 17-5. Maximum/Minimum Allowable Baud Rate Error

Division Ratio (k)	Maximum Allowable Baud Rate Error	Minimum Allowable Baud Rate Error
4	+2.32%	−2.43%
8	+3.52%	−3.61%
20	+4.26%	−4.30%
50	+4.56%	−4.58%
100	+4.66%	−4.67%
255	+4.72%	−4.72%

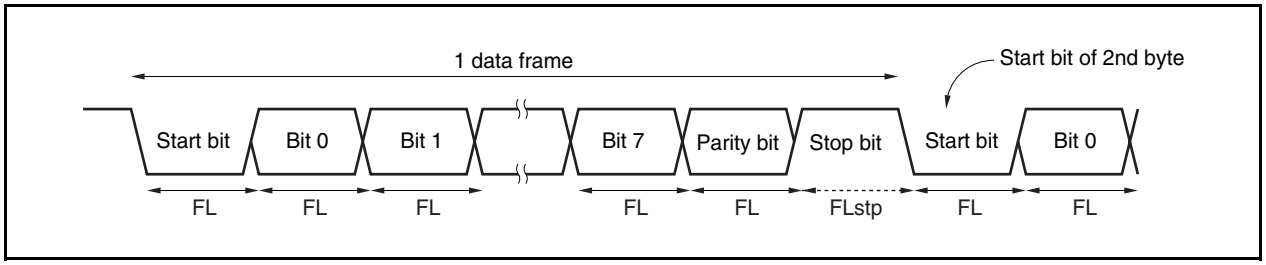
Remarks 1. The reception accuracy depends on the bit count in 1 frame, the input clock frequency, and the division ratio (k). The higher the input clock frequency and the larger the division ratio (k), the higher the accuracy.

2. k: Set value of UCnCTL2.UCnBRS7 to UCnCTL2.UCnBRS0 bits (n = 0 to 4)

(6) Transfer rate during continuous transmission

During continuous transmission, the transfer rate from the stop bit to the next start bit is usually 2 base clocks longer. However, timing initialization is performed via start bit detection by the receiving side, so this has no influence on the transfer result.

Figure 17-21. Transfer Rate During Continuous Transfer



The following equation can be obtained assuming 1 bit data length: FL; stop bit length: FLstp; and base clock frequency: f_{UCLK}.

$$FLstp = FL + 2/f_{UCLK}$$

Therefore, the transfer rate during continuous transmission is as follows.

$$\text{Transfer rate} = 11 \times FL + (2/f_{UCLK})$$

17.8 Cautions

(1) When the clock supply to UARTCn is stopped (for example, in IDLE1, IDLE2, or STOP mode), the operation stops with each register retaining the value it had immediately before the clock supply was stopped. The TXDCn pin output also holds and outputs the value it had immediately before the clock supply was stopped. However, the operation is not guaranteed after the clock supply is resumed. Therefore, after the clock supply is resumed, the circuits should be initialized by setting the UCnCTL0.UCnPWR, UCnCTL0.UCnRXEn, and UCnCTL0.UCnTXEn bits to 000.

(2) The RXDC1 and KR7 pins must not be used at the same time. To use the RXDC1 pin, do not use the KR7 pin. To use the KR7 pin, do not use the RXDC1 pin (it is recommended to set the PFC91 bit to 1 and clear PFCE91 bit to 0).

(3) Start up the UARTCn in the following sequence.
<1> Set the UCnCTL0.UCnPWR bit to 1.
<2> Set the ports.
<3> Set the UCnCTL0.UCnTXE bit to 1, UCnCTL0.UCnRXE bit to 1.

(4) Stop the UARTCn in the following sequence.
<1> Set the UCnCTL0.UCnTXE bit to 0, UCnCTL0.UCnRXE bit to 0.
<2> Set the ports and set the UCnCTL0.UCnPWR bit to 0 (it is not a problem if port setting is not changed).

(5) In transmit mode (UCnCTL0.UCnPWR bit = 1 and UCnCTL0.UCnTXE bit = 1), do not overwrite the same value to the UCnTX register by software because transmission starts by writing to this register. To transmit the same value continuously, overwrite the same value.

(6) In continuous transmission, the communication rate from the stop bit to the next start bit is extended 2 base clocks more than usual. However, the reception side initializes the timing by detecting the start bit, so the reception result is not affected.

CHAPTER 18 3-WIRE VARIABLE-LENGTH SERIAL I/O (CSIF)

18.1 Mode Switching of CSIF and Other Serial Interfaces

18.1.1 CSIF4 and UARTC0 mode switching

In the V850ES/JG3-H and V850ES/JH3-H, CSIF4 and UARTC0 share the same pins and therefore cannot be used simultaneously. To use CSIF4, the use of CSIF4 must be set in advance, using the PMC3, PFC3 and PFCE3 registers.

Caution The transmit/receive operation of CSIF4 and UARTC0 is not guaranteed if these functions are switched during transmission or reception. Be sure to disable the one that is not used.

Figure 18-1. CSIF4 and UARTC0 Mode Switch Settings

After reset: 00H R/W Address: FFFFF446H

	7	6	5	4	3	2	1	0
PMC3	PMC37	PMC36	PMC35	PMC34	PMC33	PMC32	PMC31	PMC30

After reset: 00H R/W Address: FFFFF466H

	7	6	5	4	3	2	1	0
PFC3	PFC37	PFC36	PFC35	PFC34	PFC33	PFC32	PFC31	PFC30

After reset: 00H R/W Address: FFFFF706H

	7	6	5	4	3	2	1	0
PFCE3	PFCE37	PFCE36	PFCE35	PFCE34	PFCE33	PFCE32	PFCE31	PFCE30

PMC32	PFCE32	PFC32	Operation mode
0	×	×	Port I/O mode
1	0	0	ASCKC0
1	0	1	$\overline{\text{SCKF4}}$

PMC3n	PFC3n	Operation mode
0	×	Port I/O mode
1	0	UARTC0 mode
1	1	CSIF4 mode

Remarks 1. n = 0, 1

2. × = don't care

18.1.2 CSIF0, UARTC4, and I²C01 mode switching

In the V850ES/JG3-H and V850ES/JH3-H, CSIF0, UARTC4, and I²C01 share the same pins and therefore cannot be used simultaneously. Switching among CSIF0, UARTC4, and I²C01 must be set in advance, using the PMC4, PFC4, and PFCE4 registers.

Caution The transmit/receive operation of CSIF0, UARTC4, and I²C01 is not guaranteed if these functions are switched during transmission or reception. Be sure to disable the one that is not used.

Figure 18-2. CSIF0, UARTC4, and I²C01 Mode Switch Settings

After reset: 00H R/W Address: FFFFF448H

	7	6	5	4	3	2	1	0
PMC4	0	0	0	0	0	PMC42	PMC41	PMC40

After reset: 00H R/W Address: FFFFF468H

	7	6	5	4	3	2	1	0
PFC4	0	0	0	0	0	PFC42	PFC41	PFC40

After reset: 00H R/W Address: FFFFF708H

	7	6	5	4	3	2	1	0
PFCE4	0	0	0	0	0	0	PFCE41	PFCE40

PMC4n	PFCE4n	PFC4n	Operation mode
0	×	×	Port I/O mode
1	0	0	CSIF0 mode
1	0	1	UARTC4 mode
1	1	0	I²C01 mode

Remarks 1. n = 0, 1

2. × = don't care

18.1.3 CSIF3 and UARTC2 mode switching

In the V850ES/JG3-H and V850ES/JH3-H, CSIF3 and UARTC2 share the same pins and therefore cannot be used simultaneously. Switching between CSIF3 and UARTC2 must be set in advance, using the PMC9, PFC9 and PFCE9 registers.

Caution The transmit/receive operation of CSIF3 and UARTC2 is not guaranteed if these functions are switched during transmission or reception. Be sure to disable the one that is not used.

Figure 18-3. CSIF3 and UARTC2 Mode Switch Settings

After reset: 0000H R/W Address: FFFFF452H, FFFFF453H

PMC9

15	14	13	12	11	10	9	8
PMC915	PMC914	PMC913	PMC912	PMC911	PMC910	PMC99	PMC98
7	6	5	4	3	2	1	0
PMC97	PMC96	PMC95	PMC94	PMC93	PMC92	PMC91	PMC90

After reset: 0000H R/W Address: FFFFF472H, FFFFF473H

PFC9

15	14	13	12	11	10	9	8
PFC915	PFC914	PFC913	PFC912	PFC911	PFC910	PFC99	PFC98
7	6	5	4	3	2	1	0
PFC97	PFC96	PFC95	PFC94	PFC93	PFC92	PFC91	PFC90

After reset: 0000H R/W Address: FFFFF712H, FFFFF713H

PFCE9

15	14	13	12	11	10	9	8
PFCE915	PFCE914	0	0	PFCE911	PFCE910	PFCE99	PFCE98
7	6	5	4	3	2	1	0
PFCE97	PFCE96	PFCE95	PFCE94	PFCE93	PFCE92	PFCE91	PFCE90

PMC91n	PFCE91n	PFC91n	Operation mode
0	×	×	Port I/O mode
1	0	0	CSIF3 mode
1	0	1	UARTC2 mode

Remarks 1. n = 0, 1

2. × = don't care

18.2 Features

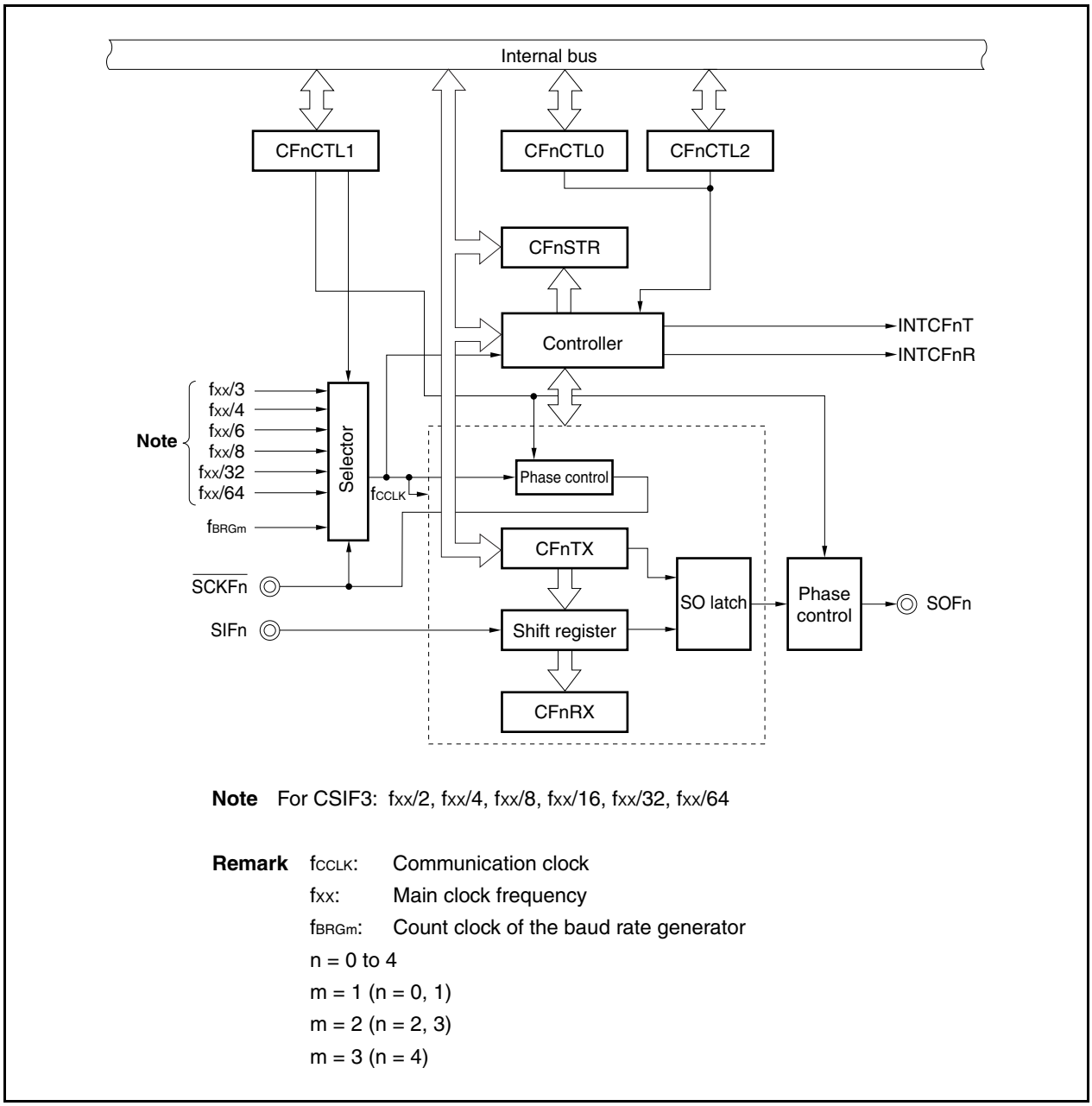
- Transfer rate: 12 Mbps max. (f_{XX} = 48 MHz, using internal clock, master mode: CSIF3)
  8 Mbps (f_{XX} = 48 MHz, using internal clock, master mode: CSIF0 to CSIF2, CSIF4)
- Master mode and slave mode selectable
- 8-bit to 16-bit transfer, 3-wire serial interface
- Interrupt request signals (INTCFnT, INTCFnR)
- Serial clock and data phase switchable
- Transfer data length selectable in 1-bit units between 8 and 16 bits
- Transfer data MSB-first/LSB-first switchable
- 3-wire transfer SOFn: Serial data output
  SIFn: Serial data input
  $\overline{\text{SCKFn}}$: Serial clock I/O
- Transmission mode, reception mode, and transmission/reception mode specifiable

Remark n = 0 to 4

18.3 Configuration

The following shows the block diagram of CSIFn.

Figure 18-4. Block Diagram of CSIFn



Note For CSIF3: fxx/2, fxx/4, fxx/8, fxx/16, fxx/32, fxx/64

Remark f_{CCLK}: Communication clock
f_{XX}: Main clock frequency
f_{BRGm}: Count clock of the baud rate generator
n = 0 to 4
m = 1 (n = 0, 1)
m = 2 (n = 2, 3)
m = 3 (n = 4)

CSIFn includes the following hardware.

Table 18-1. Configuration of CSIFn

Item	Configuration
Registers	CSIFn receive data register (CFnRX) CSIFn transmit data register (CFnTX) CSIFn control register 0 (CFnCTL0) CSIFn control register 1 (CFnCTL1) CSIFn control register 2 (CFnCTL2) CSIFn status register (CFnSTR)

(1) CSIFn receive data register (CFnRX)

The CFnRX register is a 16-bit buffer register that holds receive data.

This register is read-only, in 16-bit units.

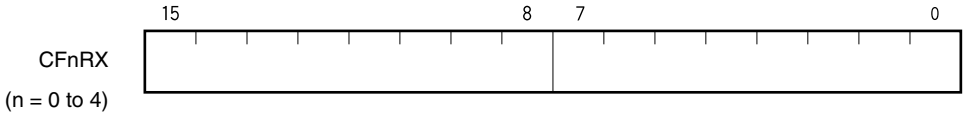
The receive operation is started by reading the CFnRX register in the reception enabled status.

If the transfer data length is 8 bits, the lower 8 bits of this register are read-only in 8-bit units as the CFnRXL register.

Reset sets this register to 0000H.

In addition to reset input, the CFnRX register can be initialized by clearing (to 0) the CFnPWR bit of the CFnCTL0 register.

After reset: 0000H R Address: CF0RX FFFFFD04H, CF1RX FFFFFD14H, CF2RX FFFFFD24H, CF3RX FFFFFD34H, CF4RX FFFFFD44H



(2) CSIFn transmit data register (CFnTX)

The CFnTX register is a 16-bit buffer register used to write the CSIFn transfer data.

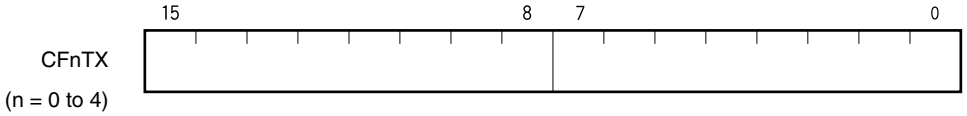
This register can be read or written in 16-bit units.

The transmit operation is started by writing data to the CFnTX register in the transmission enabled status.

If the transfer data length is 8 bits, the lower 8 bits of this register are read-only in 8-bit units as the CFnTXL register.

Reset sets this register to 0000H.

After reset 0000H R/W Address: CF0TX FFFFFD06H, CF1TX FFFFFD16H, CF2TX FFFFFD26H, CF3TX FFFFFD36H, CF4TX FFFFFD46H



Remark The communication start conditions are shown below.

Transmission mode (CFnTXE bit = 1, CFnRXE bit = 0):	Write to CFnTX register
Transmission/reception mode (CFnTXE bit = 1, CFnRXE bit = 1):	Write to CFnTX register
Reception mode (CFnTXE bit = 0, CFnRXE bit = 1):	Read from CFnRX register

18.4 Registers

The following registers are used to control CSIFn.

- CSIFn control register 0 (CFnCTL0)
- CSIFn control register 1 (CFnCTL1)
- CSIFn control register 2 (CFnCTL2)
- CSIFn status register (CFnSTR)

(1) CSIFn control register 0 (CFnCTL0)

CFnCTL0 is a register that controls the CSIFn serial transfer operation.

This register can be read or written in 8-bit or 1-bit units.

Reset sets this register to 01H.

(1/3)

After reset: 01H R/W Address: CF0CTL0 FFFFFD00H, CF1CTL0 FFFFFD10H, CF2CTL0 FFFFFD20H, CF3CTL0 FFFFFD30H, CF4CTL0 FFFFFD40H

CFnCTL0 (n = 0 to 4)

<7>	<6>	<5>	<4>	3	2	1	<0>
CFnPWR	CFnTXE[Note]	CFnRXE[Note]	CFnDIR[Note]	0	0	CFnTMS[Note]	CFnSCE

CFnPWR	Specification of CSIFn operation disable/enable
0	Disables CSIFn operation and resets the CFnSTR register
1	Enables CSIFn operation
• The CFnPWR bit controls the CSIFn operation and resets the internal circuit.	

CFnTXE[Note]	Specification of transmit operation disable/enable
0	Disables transmit operation
1	Enables transmit operation
• The SOFn output is low level when the CFnTXE bit is 0.	

CFnRXE[Note]	Specification of receive operation disable/enable
0	Disables receive operation
1	Enables receive operation
• No reception completion interrupt is output even when the prescribed data is transferred, and the receive data (CFnRX register) is not updated, because the receive operation is disabled by clearing the CFnRXE bit to 0.	

Note These bits can only be rewritten when the CFnPWR bit = 0. However, CFnPWR bit = 1 can also be set at the same time as rewriting these bits.

Caution To forcibly suspend transmission/reception, clear the CFnPWR bit to 0 instead of the CFnRXE and CFnTXE bits. At this time, the clock output is stopped.

(2/3)

CFnDIR[Note]	Specification of transfer direction mode (MSB/LSB)
0	MSB-first transfer
1	LSB-first transfer

CFnTMS[Note]	Transfer mode specification
0	Single transfer mode
1	Continuous transfer mode

[In single transfer mode]
The reception completion interrupt (INTCFnR) occurs when communication is complete.
Even if transmission is enabled (CFnTXE bit = 1), the transmission enable interrupt (INTCFnT) does not occur.
If the next transmit data is written during communication (CFnSTR.CFnTSF bit = 1), it is ignored and the next communication is not started. Also, if reception-only communication is set (CFnTXE bit = 0, CFnRXE bit = 1), the next communication is not started even if the receive data is read during communication (CFnSTR. CFnTSF bit = 1).

[In continuous transfer mode]
The continuous transmission is enabled by writing the next transmit data during communication (CFnSTR.CFnTSF bit = 1).
Writing the next transmission data is enabled after a transmission enable interrupt (INTCFnT) occurs.
If reception-only communication is set (CFnTXE bit = 0, CFnRXE bit = 1) in the continuous transfer mode, the next reception is started immediately after a reception completion interrupt (INTCFnR), regardless of the read operation of the CFnRX register.
Therefore, immediately read the receive data from the CFnRX register. If this read operation is delayed, an overrun error (CFnOVE bit = 1) occurs.

Note These bits can only be rewritten when the CFnPWR bit = 0. However, the CFnPWR can be set to 1 at the same time as these bits are rewritten.

(3/3)

CFnSCE	Specification of start transfer disable/enable
0	Communication start trigger invalid
1	Communication start trigger valid

- In master mode

  This bit enables or disables the communication start trigger.

  (a) In single transmission or transmission/reception mode, or continuous transmission or continuous transmission/reception mode

  A communication operation can be started by writing data to the CFnTX register when the CFnSCE bit is 1.

  Set the CFnSCE bit to 1.

  (b) In single reception mode

  Disable starting the next receive operation by clearing the CFnSCE bit to 0 before reading the last receive data, because a receive operation is started by reading receive data (CFnRX register)Note 1.

  (c) In continuous reception mode

  Clear the CFnSCE bit to 0 one communication clock before reception of the last data is completed to disable the start of reception after the last data is receivedNote 2.

- In slave mode

  This bit enables or disables the communication start trigger.

  Set the CFnSCE bit to 1.

[Usage of CFnSCE bit]

- In single reception mode

  <1> When reception of the last data is completed by INTCFnR interrupt servicing, clear the CFnSCE bit to 0 before reading the CFnRX register.

  <2> After confirming the CFnSTR.CFnTSF bit = 0, clear the CFnRXE bit to 0 to disable reception.

  To continue reception, set the CFnSCE bit to 1 to start the next reception by dummy-reading the CFnRX register.

- In continuous reception mode

  <1> Clear the CFnSCE bit to 0 during reception of the last data by INTCFnR interrupt servicing.

  <2> Read the CFnRX register.

  <3> Read the last reception data by reading the CFnRX register after acknowledging the CFnTIR interrupt.

  <4> After confirming the CFnSTR.CFnTSF bit = 0, clear the CFnRXE bit to 0 to disable reception.

  To continue reception, set the CFnSCE bit to 1 to wait for the next reception by dummy-reading the CFnRX register.

Notes 1. If the CFnSCE bit is read while it is 1, the next communication operation is started.

2. The CFnSCE bit is not cleared to 0 one communication clock before the completion of the last data reception, the next communication operation is automatically started.

Caution Be sure to clear bits 3 and 2 to “0”.

(2) CSIFn control register 1 (CFnCTL1)

CFnCTL1 is an 8-bit register that controls the CSIFn serial transfer operation.

This register can be read or written in 8-bit or 1-bit units.

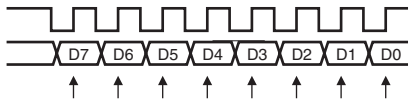
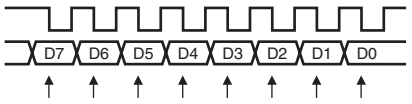
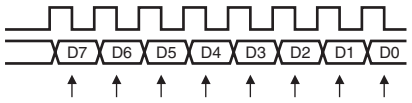
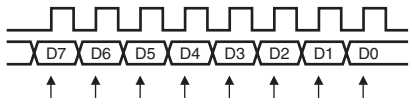
Reset sets this register to 00H.

Caution The CFnCTL1 register can be rewritten only when the CFnCTL0.CFnPWR bit = 0.

After reset: 00H R/W Address: CF0CTL1 FFFFFD01H, CF1CTL1 FFFFFD11H, CF2CTL1 FFFFFD21H, CF3CTL1 FFFFFD31H, CF4CTL1 FFFFFD41H

CFnCTL1 (n = 0 to 4)

7	6	5	4	3	2	1	0
0	0	0	CFnCKP	CFnDAP	CFnCKS2	CFnCKS1	CFnCKS0

	CFnCKP	CFnDAP	Specification of data transmission/ reception timing in relation to $\overline{SCKFn}$
Communication type 1	0	0	
Communication type 2	0	1	
Communication type 3	1	0	
Communication type 4	1	1	

CFnCKS2	CFnCKS1	CFnCKS0	Communication clock (f_{CCLK})		Mode
			n = 0 to 2, 4[Note 1]	n = 3[Note 2]	
0	0	0	$f_{XX}/3$	$f_{XX}/2$	Master mode
0	0	1	$f_{XX}/4$	$f_{XX}/4$	Master mode
0	1	0	$f_{XX}/6$	$f_{XX}/8$	Master mode
0	1	1	$f_{XX}/8$	$f_{XX}/16$	Master mode
1	0	0	$f_{XX}/32$	$f_{XX}/32$	Master mode
1	0	1	$f_{XX}/64$	$f_{XX}/64$	Master mode
1	1	0	f_{BRGm}		Master mode
1	1	1	External clock ($\overline{SCKFn}$)		Slave mode

Notes 1. Set the communication clock (f_{CCLK}) to 8 MHz or lower (master/slave mode).

2. Set the communication clock (f_{CCLK}) to 12 MHz or lower (master mode) and 8 MHz or lower (master/slave mode).

Remark When n = 0, 1, m = 1
When n = 2, 3, m = 2
When n = 4, m = 3
For details of f_{BRGm}, see **18.8 Baud Rate Generator**.

(3) CSIFn control register 2 (CFnCTL2)

CFnCTL2 is an 8-bit register that controls the number of CSIFn serial transfer bits.

This register can be read or written in 8-bit units.

Reset sets this register to 00H.

Caution The CFnCTL2 register can be rewritten only when the CFnCTL0.CFnPWR bit = 0 or when both the CFnTXE and CFnRXE bits = 0.

After reset: 00H R/W Address: CF0CTL2 FFFFFD02H, CF1CTL2 FFFFFD12H, CF2CTL2 FFFFFD22H, CF3CTL2 FFFFFD32H, CF4CTL2 FFFFFD42H

CFnCTL2 (n = 0 to 4)

7	6	5	4	3	2	1	0
0	0	0	0	CFnCL3	CFnCL2	CFnCL1	CFnCL0

CFnCL3	CFnCL2	CFnCL1	CFnCL0	Serial register bit length
0	0	0	0	8 bits
0	0	0	1	9 bits
0	0	1	0	10 bits
0	0	1	1	11 bits
0	1	0	0	12 bits
0	1	0	1	13 bits
0	1	1	0	14 bits
0	1	1	1	15 bits
1	×	×	×	16 bits

Remarks 1. If the number of transfer bits is other than 8 or 16, prepare and use data stuffed from the LSB of the CFnTX and CFnRX registers.

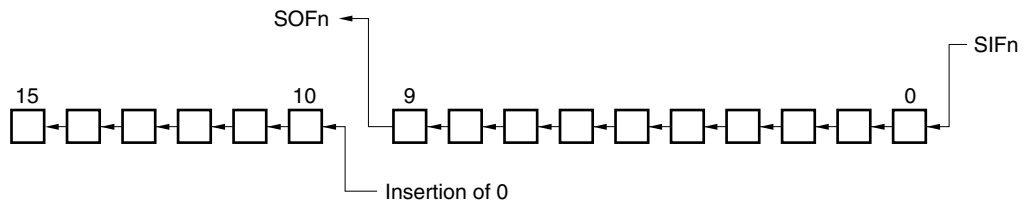
2. ×: don't care

(a) Transfer data length change function

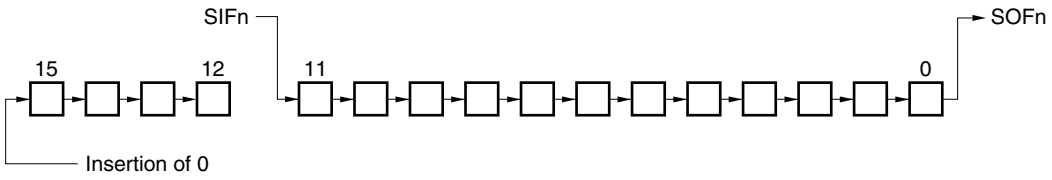
The CSIFn transfer data length can be set in 1-bit units between 8 and 16 bits using the CFnCTL2.CFnCL3 to CFnCTL2.CFnCL0 bits.

When the transfer bit length is set to a value other than 16 bits, set the data to the CFnTX or CFnRX register starting from the LSB, regardless of whether the transfer start bit is the MSB or LSB. Any data can be set for the higher bits that are not used, but the receive data becomes 0 following serial transfer.

(i) Transfer bit length = 10 bits, MSB first



(ii) Transfer bit length = 12 bits, LSB first



(4) CSIFn status register (CFnSTR)

CFnSTR is an 8-bit register that displays the CSIFn status.

This register can be read or written in 8-bit or 1-bit units, but the CFnTSF flag is read-only.

Reset sets this register to 00H.

In addition to reset input, the CFnSTR register can be initialized by clearing (0) the CFnCTL0.CFnPWR bit.

After reset: 00H R/W Address: CF0STR FFFFFD03H, CF1STR FFFFFD13H, CF2STR FFFFFD23H, CF3STR FFFFFD33H, CF4STR FFFFFD43H

CFnSTR (n = 0 to 4)

<7>	6	5	4	3	2	1	<0>
CFnTSF	0	0	0	0	0	0	CFnOVE

CFnTSF	Communication status flag
0	Communication stopped
1	Communicating

- During transmission, this register is set when data is prepared in the CFnTX register, and during reception, it is set when a dummy read of the CFnRX register is performed.
  When transfer ends, this flag is cleared to 0 at the last edge of the clock.

CFnOVE	Overrun error flag
0	No overrun
1	Overrun

- An overrun error occurs when the next reception is completed without the CPU reading the value of the receive buffer, upon completion of the receive operation. The CFnOVE flag displays the overrun error occurrence status in this case.
- The CFnOVE bit is valid also in the single transfer mode. Therefore, when only using transmission, note the following.
  - Do not check the CFnOVE flag.
  - Read this bit even if reading the reception data is not required.
- The CFnOVE flag is cleared by writing 0 to it. It cannot be set even by writing 1 to it.

18.5 Interrupt Request Signals

CSIFn can generate the following two types of interrupt request signals.

- Reception completion interrupt request signal (INTCFnR)
- Transmission enable interrupt request signal (INTCFnT)

Of these two interrupt request signals, the reception completion interrupt request signal has the higher priority by default, and the priority of the transmission enable interrupt request signal is lower.

Table 18-2. Interrupts and Their Default Priority

Interrupt	Priority
Reception complete	High
Transmission enable	Low

(1) Reception completion interrupt request signal (INTCFnR)

When receive data is transferred to the CFnRX register while reception is enabled, the reception completion interrupt request signal is generated.

This interrupt request signal can also be generated if an overrun error occurs.

When the reception completion interrupt request signal is acknowledged and the data is read, read the CFnSTR register to check that the result of reception is not an error.

In the single transfer mode, the INTCFnR interrupt request signal is generated upon completion of transmission, even when only transmission is executed.

(2) Transmission enable interrupt request signal (INTCFnT)

In the continuous transmission or continuous transmission/reception mode, transmit data is transferred from the CFnTX register and, as soon as writing to CFnTX has been enabled, the transmission enable interrupt request signal is generated.

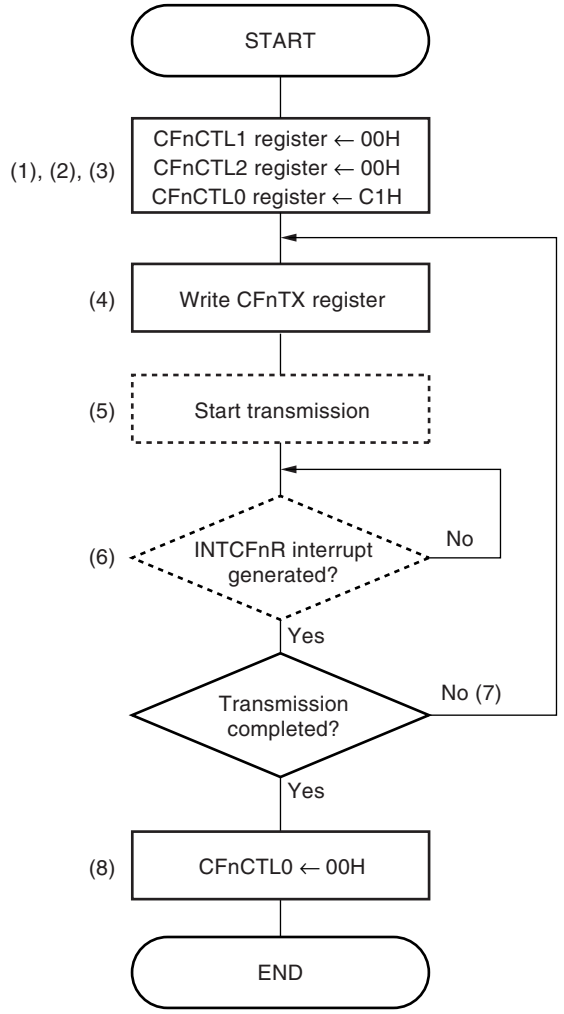
In the single transmission and single transmission/reception modes, the INTCFnT interrupt is not generated.

18.6 Operation

18.6.1 Single transfer mode (master mode, transmission mode)

MSB first (CFnCTL0.CFnDIR bit = 0), communication type 1 (CFnCTL1.CFnCKP and CFnCTL1.CFnDAP bits = 00), communication clock (f_{CCLK}) = f_{XX}/2 or f_{XX}/3 (CFnCTL1.CFnCKS2 to CFnCTL1.CFnCKS0 bits = 000), transfer data length = 8 bits (CFnCTL2.CFnCL3 to CFnCTL2.CFnCL0 bits = 0000)

(1) Operation flow

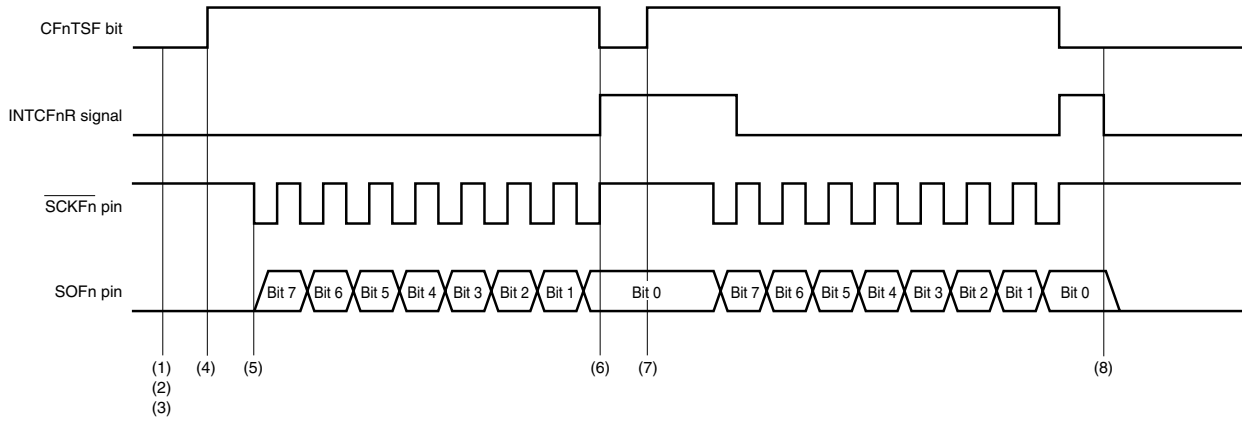


Remarks 1. The broken lines indicate the hardware processing.

2. The numbers in this figure correspond to the processing numbers in **(2) Operation timing**.

3. n = 0 to 4

(2) Operation timing



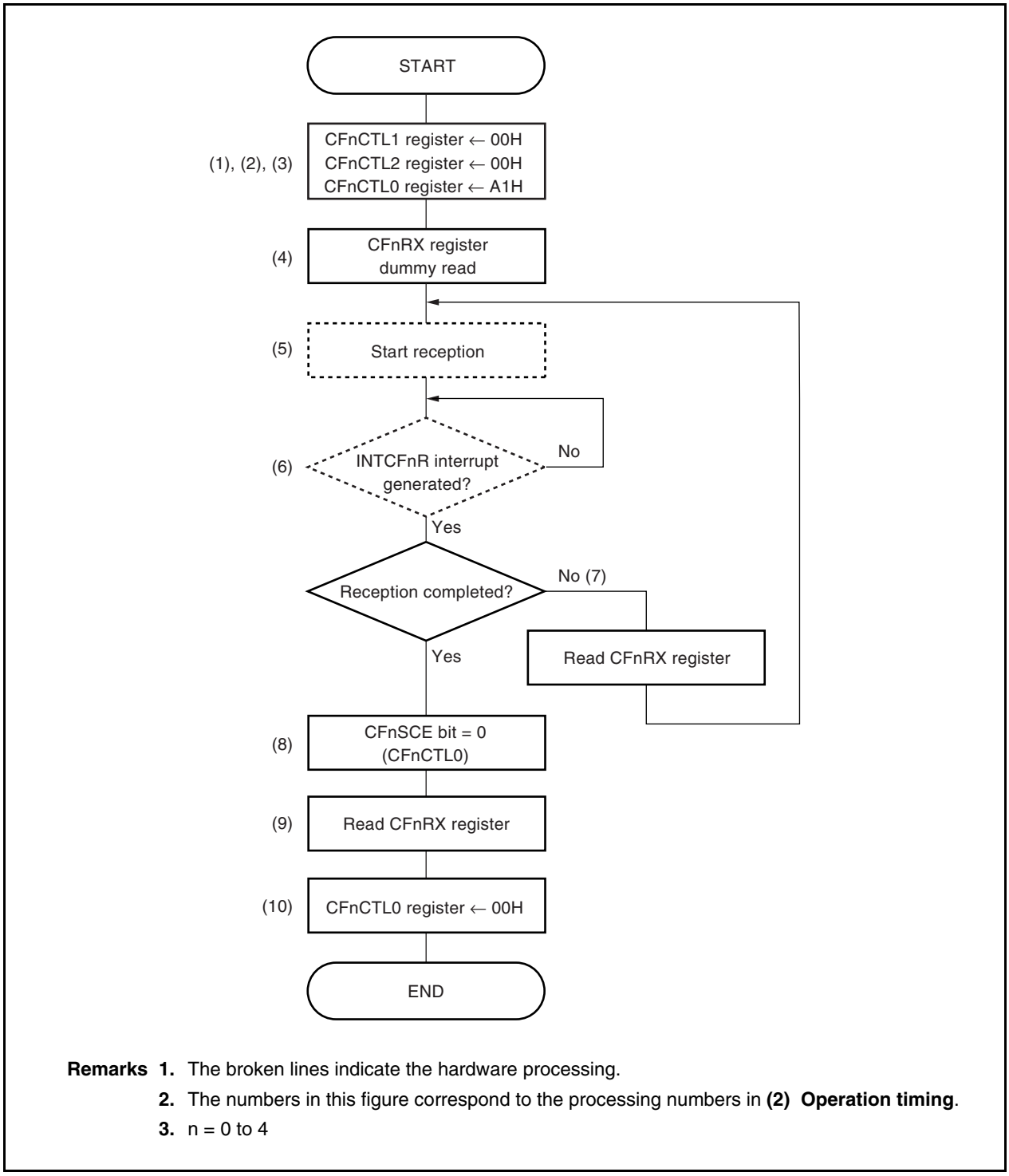
(1) Write 00H to the CFnCTL1 register, and select communication type 1, communication clock (f_{CCLK}) = f_{XX}/2 or f_{XX}/3, and master mode.
(2) Write 00H to the CFnCTL2 register, and set the transfer data length to 8 bits.
(3) Write C1H to the CFnCTL0 register, and select the transmission mode and MSB first at the same time as enabling the operation of the communication clock (f_{CCLK}).
(4) Set the CFnSTR.CFnTSF bit to 1 by writing the transmit data to the CFnTX register, and start transmission.
(5) When transmission is started, output the serial clock to the $\overline{\text{SCKFn}}$ pin, and output the transmit data from the SOFn pin in synchronization with the serial clock.
(6) When transmission of the transfer data length set with the CFnCTL2 register is completiond, stop the serial clock output and transmit data output, generate the reception completion interrupt request signal (INTCFnR) at the last edge of the serial clock, and clear the CFnTSF bit to 0.
(7) To continue transmission, start the next transmission by writing the transmit data to the CFnTX register again after the INTCFnR signal is generated.
(8) To end transmission, write CFnCTL0.CFnPWR bit = 0 and CFnCTL0.CFnTXE bit = 0.

Remark n = 0 to 4

18.6.2 Single transfer mode (master mode, reception mode)

MSB first (CFnCTL0.CFnDIR bit = 0), communication type 1 (CFnCTL1.CFnCKP and CFnCTL1.CFnDAP bits = 00), communication clock (f_{CCLK}) = f_{XX}/2 or f_{XX}/3 (CFnCTL1.CFnCKS2 to CFnCTL1.CFnCKS0 bits = 000), transfer data length = 8 bits (CFnCTL2.CFnCL3 to CFnCTL2.CFnCL0 bits = 0000)

(1) Operation flow

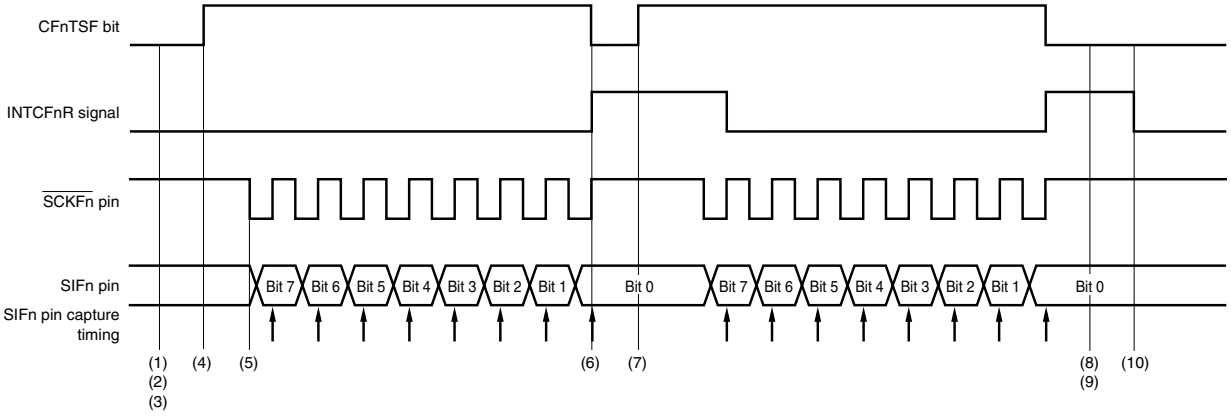


Remarks 1. The broken lines indicate the hardware processing.

2. The numbers in this figure correspond to the processing numbers in **(2) Operation timing**.

3. n = 0 to 4

(2) Operation timing



(1) Write 00H to the CFnCTL1 register, and select communication type 1, communication clock (f_{CCLK}) = f_{XX}/2 or f_{XX}/3, and master mode.

(2) Write 00H to the CFnCTL2 register, and set the transfer data length to 8 bits.

(3) Write A1H to the CFnCTL0 register, and select the reception mode and MSB first at the same time as enabling the operation of the communication clock (f_{CCLK}).

(4) Set the CFnSTR.CFnTSF bit to 1 by performing a dummy read of the CFnRX register, and start reception.

(5) When reception is started, output the serial clock to the $\overline{\text{SCKFn}}$ pin, and capture the receive data of the SIFn pin in synchronization with the serial clock.

(6) When reception of the transfer data length set with the CFnCTL2 register is completed, stop the serial clock output and data capturing, generate the reception completion interrupt request signal (INTCFnR) at the last edge of the serial clock, and clear the CFnTSF bit to 0.

(7) To continue reception, read the CFnRX register while keeping the CFnCTL0.CFnSCE bit = 1 after the INTCFnR signal is generated.

(8) To read the CFnRX register without starting the next reception, write the CFnSCE bit = 0.

(9) Read the CFnRX register.

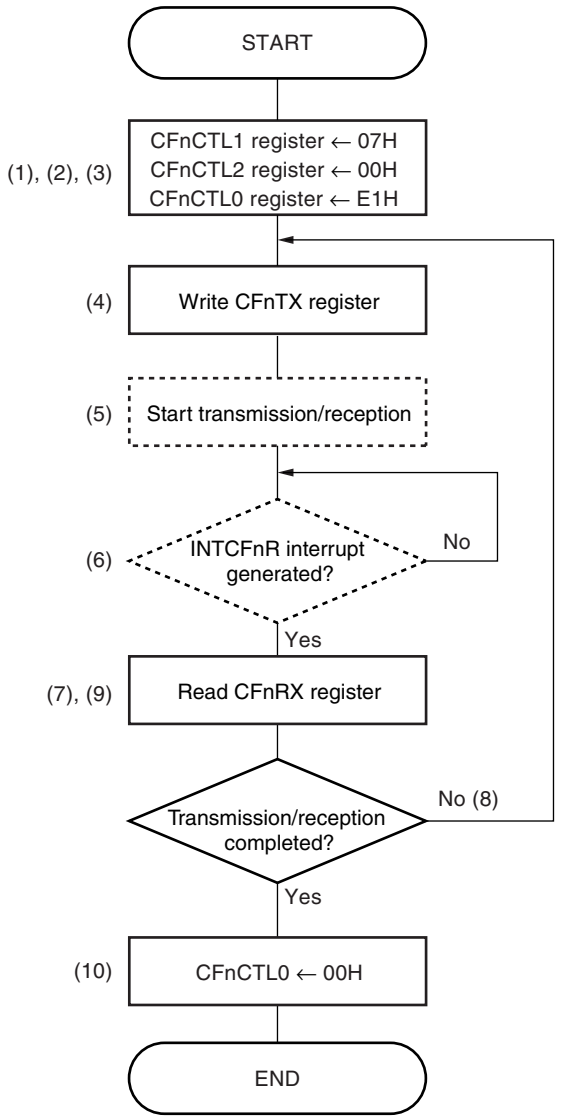
(10) To end reception, write CFnCTL0.CFnPWR bit = 0 and CFnCTL0.CFnRXE bit = 0.

Remark n = 0 to 4

18.6.3 Single transfer mode (master mode, transmission/reception mode)

MSB first (CFnCTL0.CFnDIR bit = 0), communication type 1 (CFnCTL1.CFnCKP and CFnCTL1.CFnDAP bits = 00), communication clock (f_{CCLK}) = f_{XX}/2 or f_{XX}/3 (CFnCTL1.CFnCKS2 to CFnCTL1.CFnCKS0 bits = 000), transfer data length = 8 bits (CFnCTL2.CFnCL3 to CFnCTL2.CFnCL0 bits = 0000)

(1) Operation flow

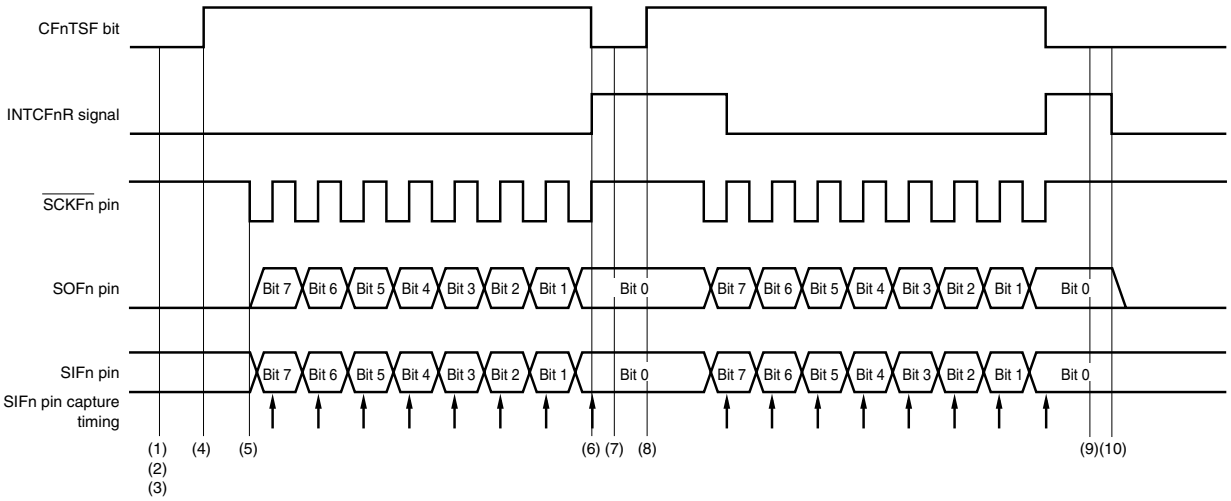


Remarks 1. The broken lines indicate the hardware processing.

2. The numbers in this figure correspond to the processing numbers in **(2) Operation timing**.

3. n = 0 to 4

(2) Operation timing



(1) Write 00H to the CFnCTL1 register, and select communication type 1, communication clock (f_{CCLK}) = f_{XX}/2 or f_{XX}/3, and master mode.

(2) Write 00H to the CFnCTL2 register, and set the transfer data length to 8 bits.

(3) Write E1H to the CFnCTL0 register, and select the transmission/reception mode and MSB first at the same time as enabling the operation of the communication clock (f_{CCLK}).

(4) Set the CFnSTR.CFnTSF bit to 1 by writing the transmit data to the CFnTX register, and start transmission/reception.

(5) When transmission/reception is started, output the serial clock to the $\overline{\text{SCKFn}}$ pin, output the transmit data to the SOFn pin in synchronization with the serial clock, and capture the receive data of the SIFn pin.

(6) When transmission/reception of the transfer data length set by the CFnCTL2 register is completed, stop the serial clock output, transmit data output, and data capturing, generate the reception completion interrupt request signal (INTCFnR) at the last edge of the serial clock, and clear the CFnTSF bit to 0.

(7) Read the CFnRX register.

(8) To continue transmission/reception, write the transmit data to the CFnTX register again.

(9) Read the CFnRX register.

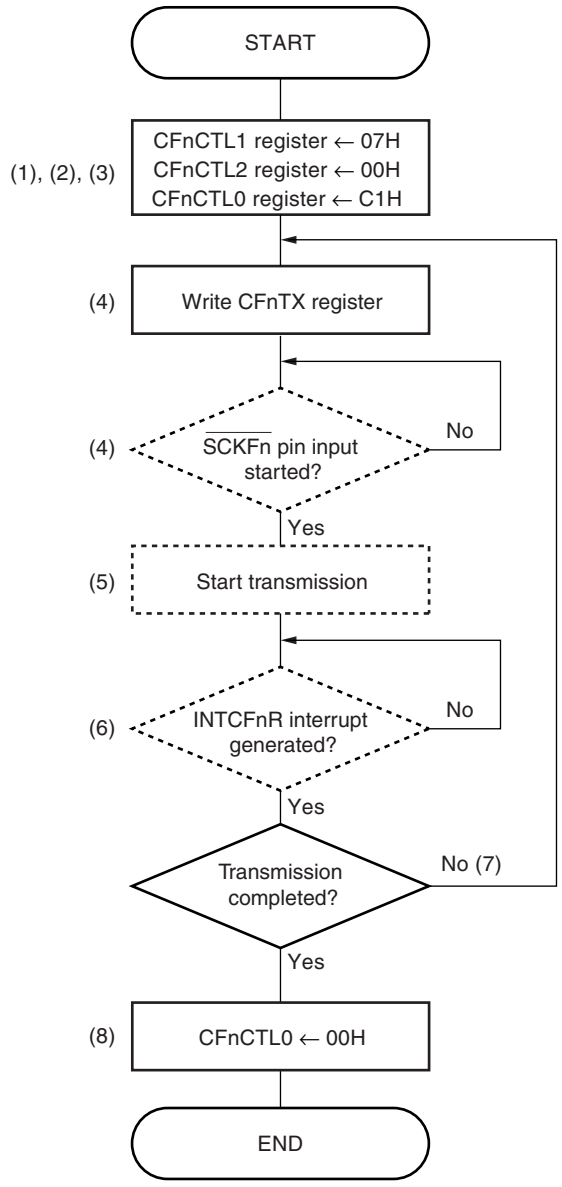
(10) To end transmission/reception, write CFnCTL0.CFnPWR bit = 0, CFnCTL0.CFnTXE bit = 0, and CFnCTL0.CFnRXE bit = 0.

Remark n = 0 to 4

18.6.4 Single transfer mode (slave mode, transmission mode)

MSB first (CFnCTL0.CFnDIR bit = 0), communication type 1 (CFnCTL1.CFnCKP and CFnCTL1.CFnDAP bits = 00), communication clock (f_{CCLK}) = external clock ($\overline{SCKFn}$) (CFnCTL1.CFnCKS2 to CFnCTL1.CFnCKS0 bits = 111), transfer data length = 8 bits (CFnCTL2.CFnCL3 to CFnCTL2.CFnCL0 bits = 0000)

(1) Operation flow

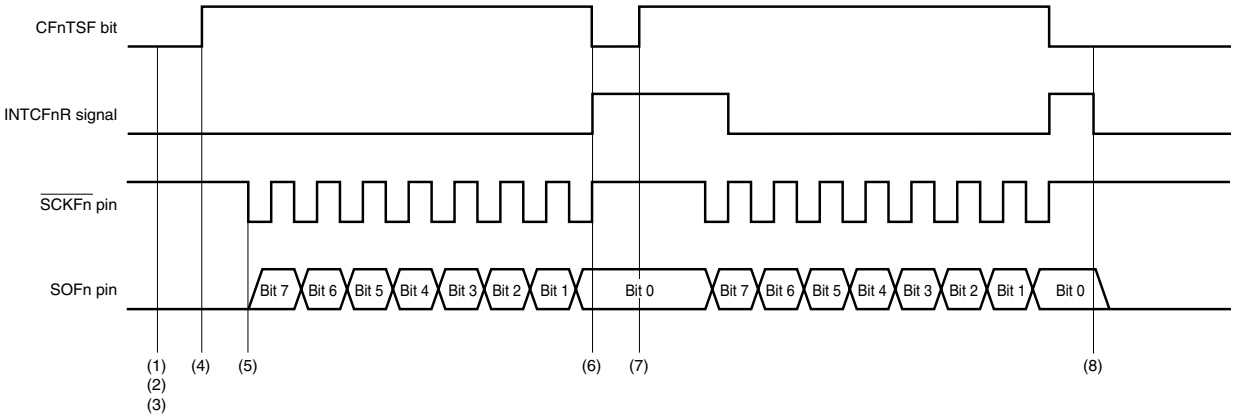


Remarks 1. The broken lines indicate the hardware processing.

2. The numbers in this figure correspond to the processing numbers in **(2) Operation timing**.

3. n = 0 to 4

(2) Operation timing



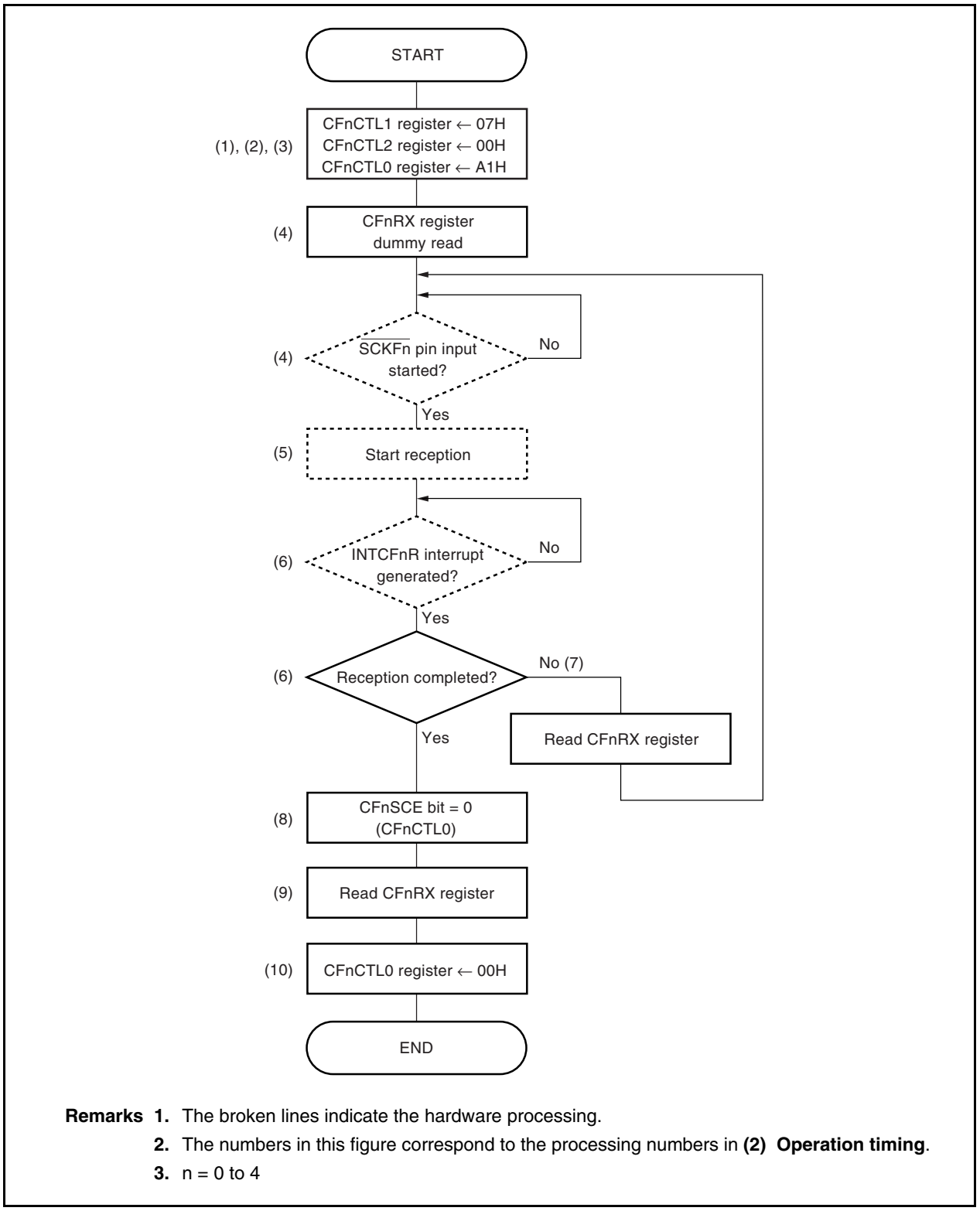
(1) Write 07H to the CFnCTL1 register, and select communication type 1, communication clock (f_{CCLK}) = external clock ($\overline{SCKFn}$), and slave mode.
(2) Write 00H to the CFnCTL2 register, and set the transfer data length to 8 bits.
(3) Write C1H to the CFnCTL0 register, and select the transmission mode and MSB first at the same time as enabling the operation of the communication clock (f_{CCLK}).
(4) The CFnSTR.CFnTSF bit is set to 1 by writing the transmit data to the CFnTX register, and the device waits for a serial clock input.
(5) When a serial clock is input, output the transmit data from the SOFn pin in synchronization with the serial clock.
(6) When transmission of the transfer data length set with the CFnCTL2 register is completed, stop the serial clock input and transmit data output, generate the reception completion interrupt request signal (INTCFnR) at the last edge of the serial clock, and clear the CFnTSF bit to 0.
(7) To continue transmission, write the transmit data to the CFnTX register again after the INTCFnR signal is generated, and wait for a serial clock input.
(8) To end transmission, write CFnCTL0.CFnPWR bit = 0 and CFnCTL0.CFnTXE bit = 0.

Remark n = 0 to 4

18.6.5 Single transfer mode (slave mode, reception mode)

MSB first (CFnCTL0.CFnDIR bit = 0), communication type 1 (CFnCTL1.CFnCKP and CFnCTL1.CFnDAP bits = 00), communication clock (f_{CCLK}) = external clock ($\overline{SCKFn}$) (CFnCTL1.CFnCKS2 to CFnCTL1.CFnCKS0 bits = 111), transfer data length = 8 bits (CFnCTL2.CFnCL3 to CFnCTL2.CFnCL0 bits = 0000)

(1) Operation flow

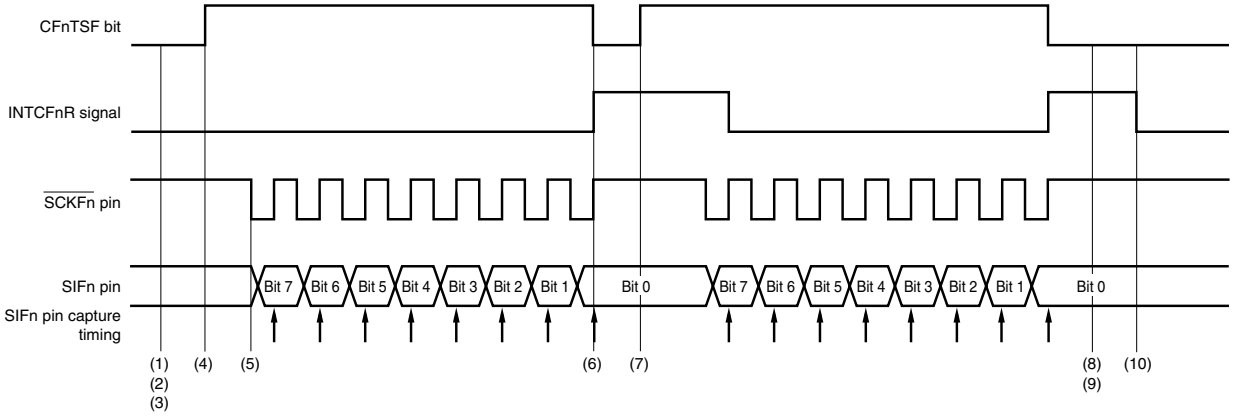


Remarks 1. The broken lines indicate the hardware processing.

2. The numbers in this figure correspond to the processing numbers in **(2) Operation timing**.

3. n = 0 to 4

(2) Operation timing



(1) Write 07H to the CFnCTL1 register, and select communication type 1, communication clock (f_{CCLK}) = external clock ($\overline{SCKFn}$), and slave mode.

(2) Write 00H to the CFnCTL2 register, and set the transfer data length to 8 bits.

(3) Write A1H to the CFnCTL0 register, and select the reception mode and MSB first at the same time as enabling the operation of the communication clock (f_{CCLK}).

(4) The CFnSTR.CFnTSF bit is set to 1 by performing a dummy read of the CFnRX register, and the device waits for a serial clock input.

(5) When a serial clock is input, capture the receive data of the SIFn pin in synchronization with the serial clock.

(6) When reception of the transfer data length set with the CFnCTL2 register is completed, stop the serial clock input and data capturing, generate the reception completion interrupt request signal (INTCFnR) at the last edge of the serial clock, and clear the CFnTSF bit to 0.

(7) To continue reception, read the CFnRX register while keeping the CFnCTL0.CFnSCE bit = 1 after the INTCFnR signal is generated, and wait for a serial clock input.

(8) To end reception, write the CFnSCE bit = 0.

(9) Read the CFnRX register.

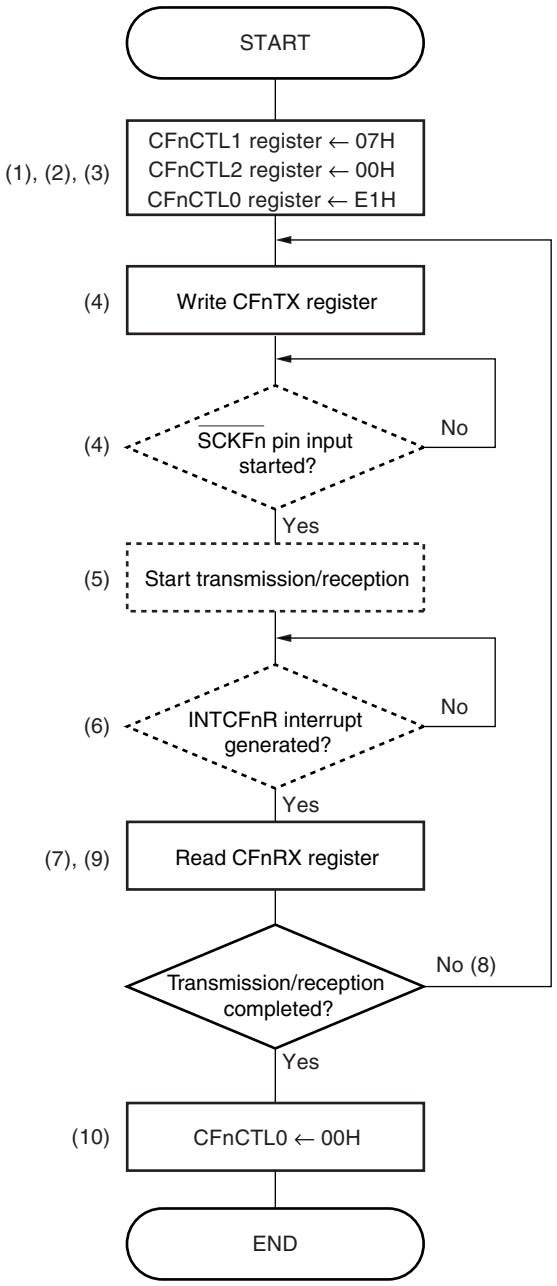
(10) To end reception, write CFnCTL0.CFnPWR bit = 0 and CFnCTL0.CFnRXE bit = 0.

Remark n = 0 to 4

18.6.6 Single transfer mode (slave mode, transmission/reception mode)

MSB first (CFnCTL0.CFnDIR bit = 0), communication type 1 (CFnCTL1.CFnCKP and CFnCTL1.CFnDAP bits = 00), communication clock (f_{CCLK}) = external clock ($\overline{SCKFn}$) (CFnCTL1.CFnCKS2 to CFnCTL1.CFnCKS0 bits = 111), transfer data length = 8 bits (CFnCTL2.CFnCL3 to CFnCTL2.CFnCL0 bits = 0000)

(1) Operation flow

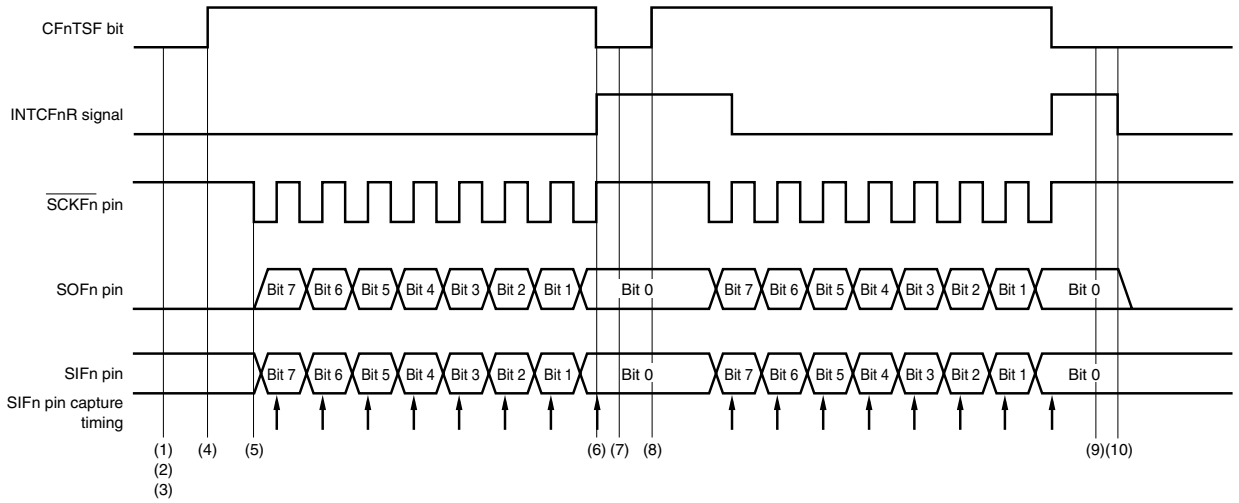


Remarks 1. The broken lines indicate the hardware processing.

2. The numbers in this figure correspond to the processing numbers in **(2) Operation timing**.

3. n = 0 to 4

(2) Operation timing



(1) Write 07H to the CFnCTL1 register, and select communication type 1, communication clock (f_{CCLK}) = external clock ($\overline{SCKFn}$), and slave mode.

(2) Write 00H to the CFnCTL2 register, and set the transfer data length to 8 bits.

(3) Write E1H to the CFnCTL0 register, and select the transmission/reception mode and MSB first at the same time as enabling the operation of the communication clock (f_{CCLK}).

(4) The CFnSTR.CFnTSF bit is set to 1 by writing the transmit data to the CFnTX register, and the device waits for a serial clock input.

(5) When a serial clock is input, output the transmit data to the SOFn pin in synchronization with the serial clock, and capture the receive data of the SIFn pin.

(6) When transmission/reception of the transfer data length set with the CFnCTL2 register is completed, stop the serial clock input, transmit data output, and data capturing, generate the reception completion interrupt request signal (INTCFnR) at the last edge of the serial clock, and clear the CFnTSF bit to 0.

(7) Read the CFnRX register.

(8) To continue transmission/reception, write the transmit data to the CFnTX register again, and wait for a serial clock input.

(9) Read the CFnRX register.

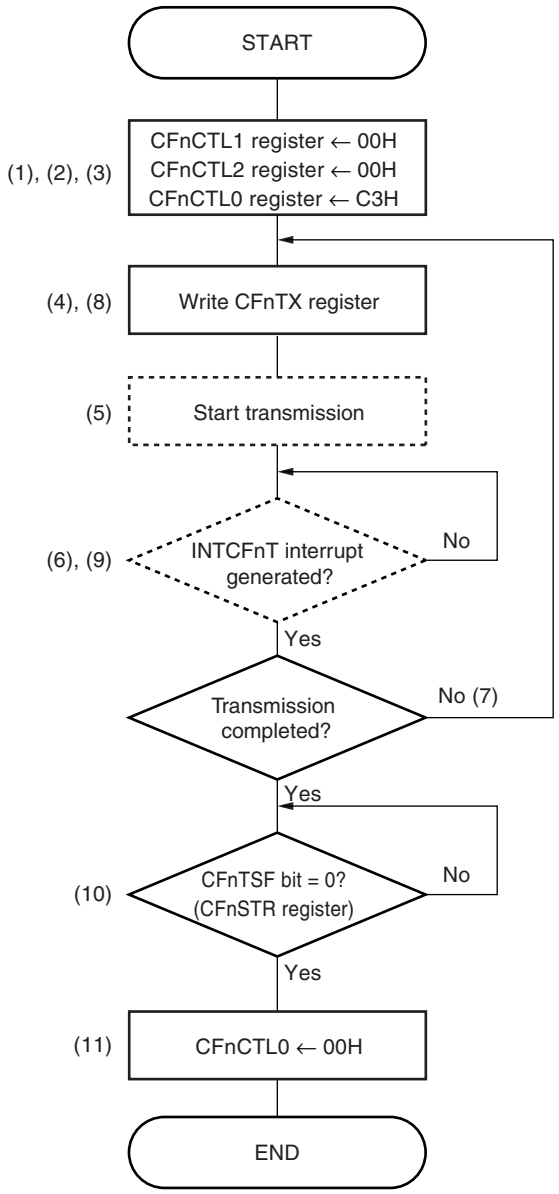
(10) To end transmission/reception, write CFnCTL0.CFnPWR bit = 0, CFnCTL0.CFnTXE bit = 0, and CFnCTL0.CFnRXE bit = 0.

Remark n = 0 to 4

18.6.7 Continuous transfer mode (master mode, transmission mode)

MSB first (CFnCTL0.CFnDIR bit = 0), communication type 1 (CFnCTL1.CFnCKP and CFnCTL1.CFnDAP bits = 00), communication clock (f_{CCLK}) = f_{XX}/2 or f_{XX}/3 (CFnCTL1.CFnCKS2 to CFnCTL1.CFnCKS0 bits = 000), transfer data length = 8 bits (CFnCTL2.CFnCL3 to CFnCTL2.CFnCL0 bits = 0000)

(1) Operation flow

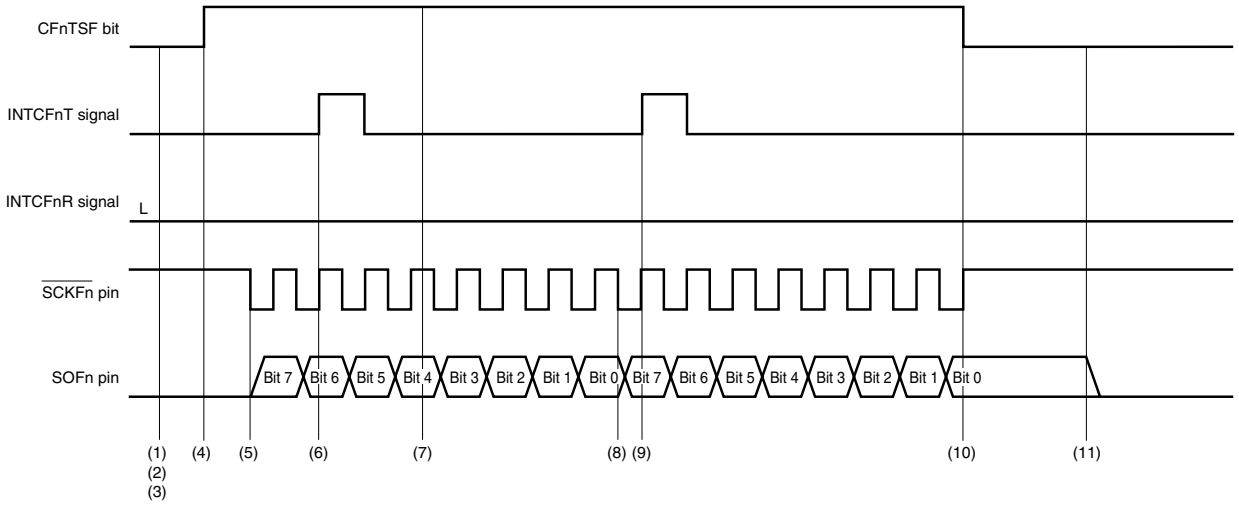


Remarks 1. The broken lines indicate the hardware processing.

2. The numbers in this figure correspond to the processing numbers in **(2) Operation timing**.

3. n = 0 to 4

(2) Operation timing



(1) Write 00H to the CFnCTL1 register, and select communication type 1, communication clock (f_{CCLK}) = f_{XX}/2 or f_{XX}/3, and master mode.

(2) Write 00H to the CFnCTL2 register, and set the transfer data length to 8 bits.

(3) Write C3H to the CFnCTL0 register, and select the transmission mode, MSB first, and continuous transfer mode at the same time as enabling the operation of the communication clock (f_{CCLK}).

(4) Set the CFnSTR.CFnTSF bit to 1 by writing the transmit data to the CFnTX register, and start transmission.

(5) When transmission is started, output the serial clock to the $\overline{\text{SCKFn}}$ pin, and output the transmit data from the SOFn pin in synchronization with the serial clock.

(6) When transfer of the transmit data from the CFnTX register to the shift register is completed and writing to the CFnTX register is enabled, the transmission enable interrupt request signal (INTCFnT) is generated.

(7) To continue transmission, write the transmit data to the CFnTX register again after the INTCFnT signal is generated.

(8) When a new transmit data is written to the CFnTX register before communication completion, the next communication is started following communication completion.

(9) The transfer of the transmit data from the CFnTX register to the shift register is completed and the INTCFnT signal is generated. To end continuous transmission with the current transmission, do not write to the CFnTX register.

(10) When the next transmit data is not written to the CFnTX register before transfer completion, stop the serial clock output to the $\overline{\text{SCKFn}}$ pin after transfer completion, and clear the CFnTSF bit to 0.

(11) To release the transmission enable status, write CFnCTL0.CFnPWR bit = 0 and CFnCTL0.CFnTXE bit = 0 after checking that the CFnTSF bit = 0.

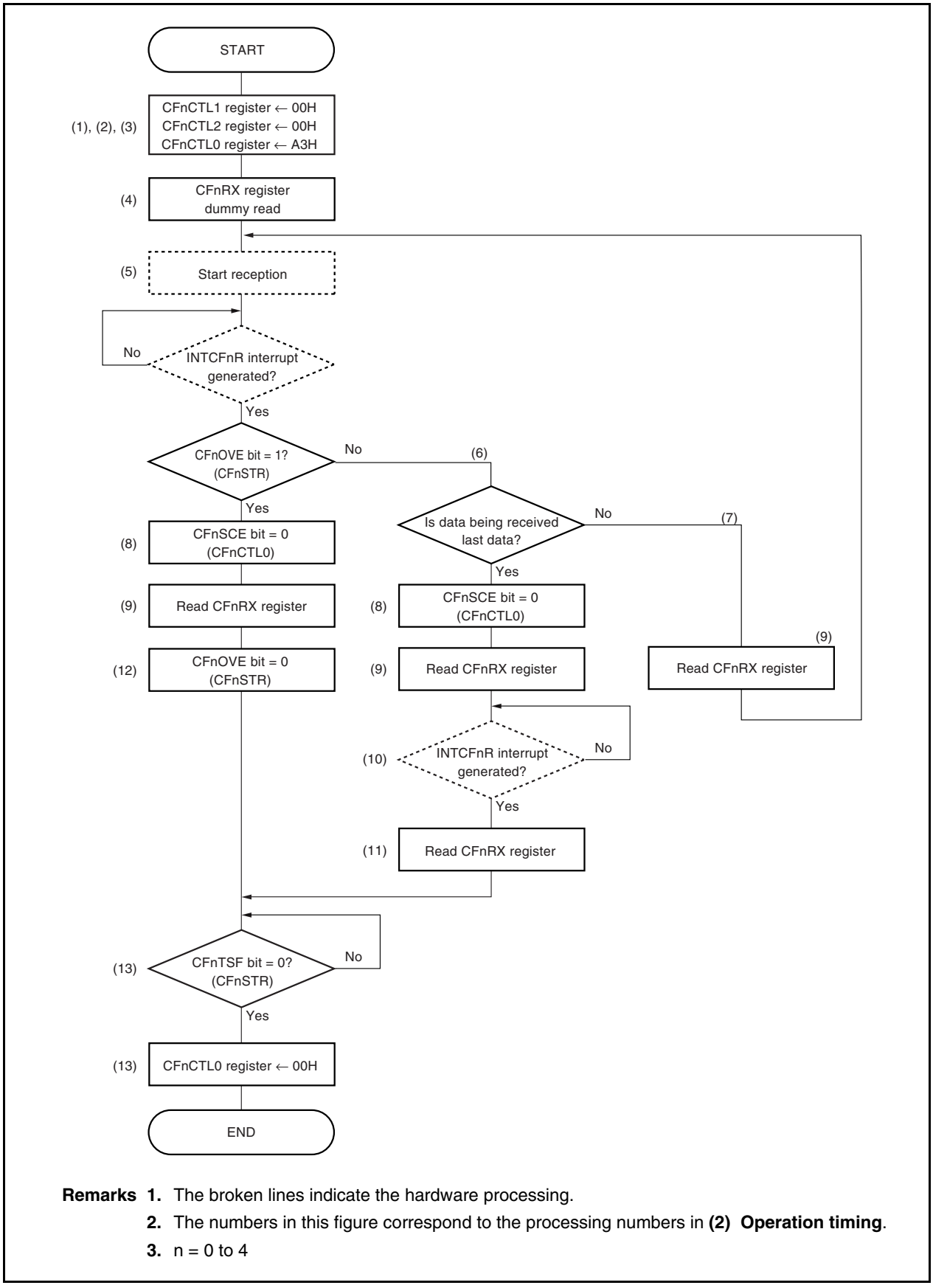
Caution In continuous transmission mode, the reception completion interrupt request signal (INTCFnR) is not generated.

Remark n = 0 to 4

18.6.8 Continuous transfer mode (master mode, reception mode)

MSB first (CFnCTL0.CFnDIR bit = 0), communication type 1 (CFnCTL1.CFnCKP and CFnCTL1.CFnDAP bits = 00), communication clock (f_{CCLK}) = f_{XX}/2 or f_{XX}/3 (CFnCTL1.CFnCKS2 to CFnCTL1.CFnCKS0 bits = 000), transfer data length = 8 bits (CFnCTL2.CFnCL3 to CFnCTL2.CFnCL0 bits = 0000)

(1) Operation flow

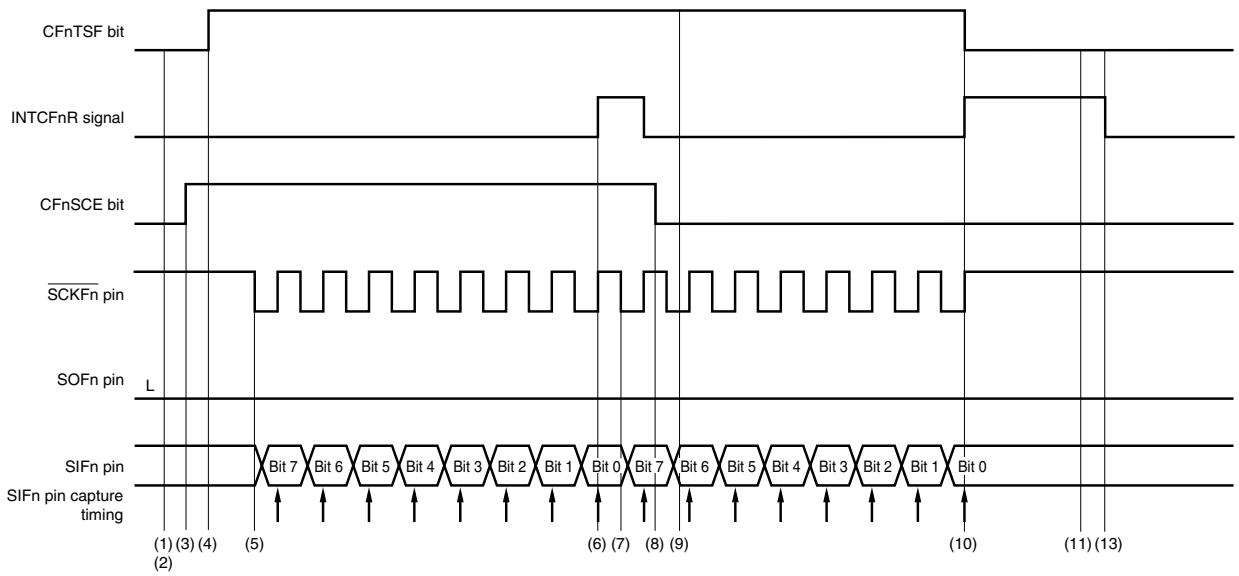


Remarks 1. The broken lines indicate the hardware processing.

2. The numbers in this figure correspond to the processing numbers in **(2) Operation timing**.

3. n = 0 to 4

(2) Operation timing



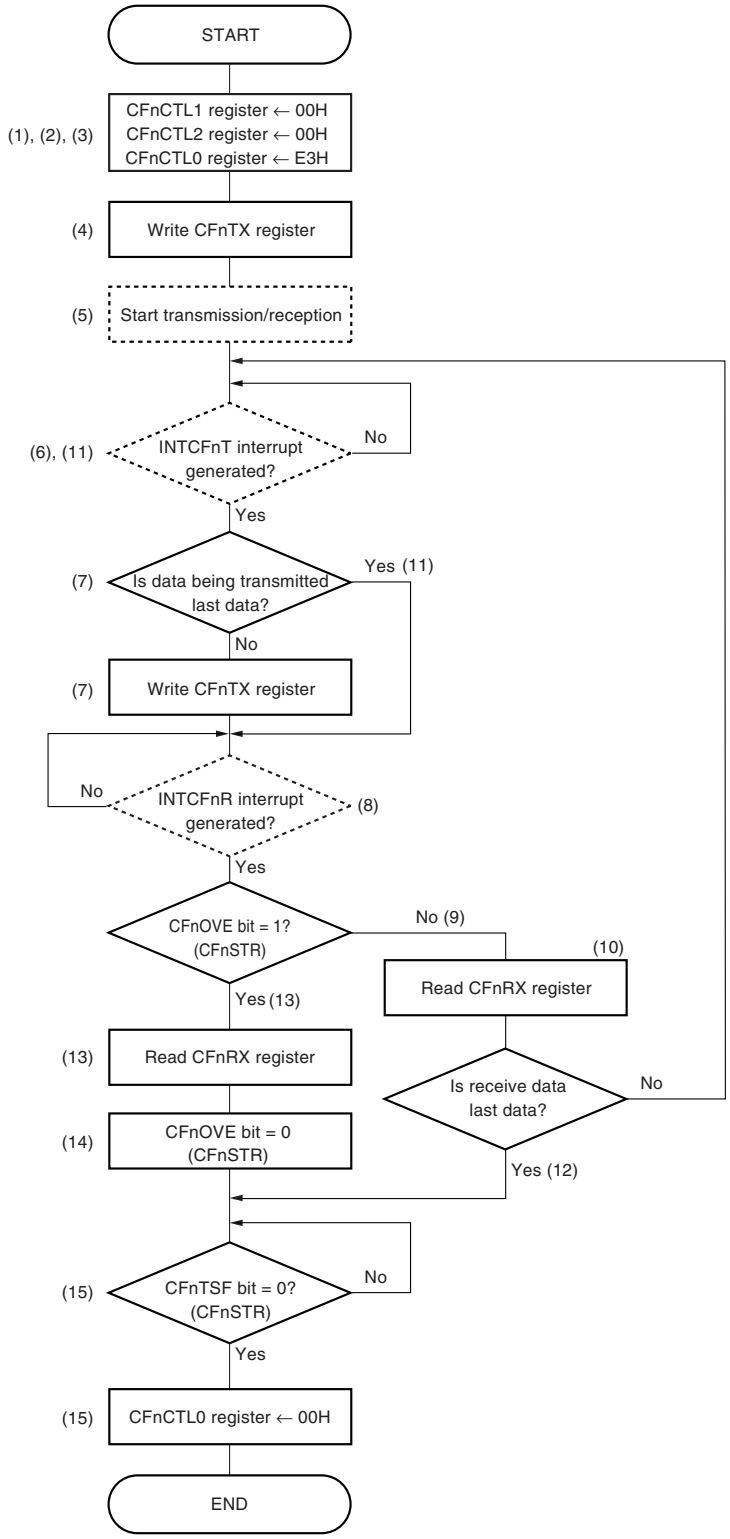
(1) Write 00H to the CFnCTL1 register, and select communication type 1, communication clock (f_{CCLK}) = f_{XX}/2, and master mode.
(2) Write 00H to the CFnCTL2 register, and set the transfer data length to 8 bits.
(3) Write A3H to the CFnCTL0 register, and select the reception mode, MSB first, and continuous transfer mode at the same time as enabling the operation of the communication clock (f_{CCLK}).
(4) Set the CFnSTR.CFnTSF bit to 1 by performing a dummy read of the CFnRX register, and start reception.
(5) When reception is started, output the serial clock to the $\overline{\text{SCKFn}}$ pin, and capture the receive data of the SIFn pin in synchronization with the serial clock.
(6) When reception is completed, the reception completion interrupt request signal (INTCFnR) is generated, and reading of the CFnRX register is enabled.
(7) When the CFnCTL0.CFnSCE bit = 1 upon communication completion, the next communication is started following communication completion.
(8) To end continuous reception with the current reception, write the CFnSCE bit = 0.
(9) Read the CFnRX register.
(10) When reception is completed, the INTCFnR signal is generated, and reading of the CFnRX register is enabled. When the CFnSCE bit = 0 is set before communication completion, stop the serial clock output to the $\overline{\text{SCKFn}}$ pin, and clear the CFnTSF bit to 0, to end the receive operation.
(11) Read the CFnRX register.
(12) If an overrun error occurs, write the CFnSTR.CFnOVE bit = 0, and clear the error flag.
(13) To release the reception enable status, write CFnCTL0.CFnPWR bit = 0 and CFnCTL0.CFnRXE bit = 0 after checking that the CFnTSF bit = 0.

Remark n = 0 to 4

18.6.9 Continuous transfer mode (master mode, transmission/reception mode)

MSB first (CFnCTL0.CFnDIR bit = 0), communication type 1 (CFnCTL1.CFnCKP and CFnCTL1.CFnDAP bits = 00), communication clock (f_{CCLK}) = f_{XX}/2 or f_{XX}/3 (CFnCTL1.CFnCKS2 to CFnCTL1.CFnCKS0 bits = 000), transfer data length = 8 bits (CFnCTL2.CFnCL3 to CFnCTL2.CFnCL0 bits = 0000)

(1) Operation flow



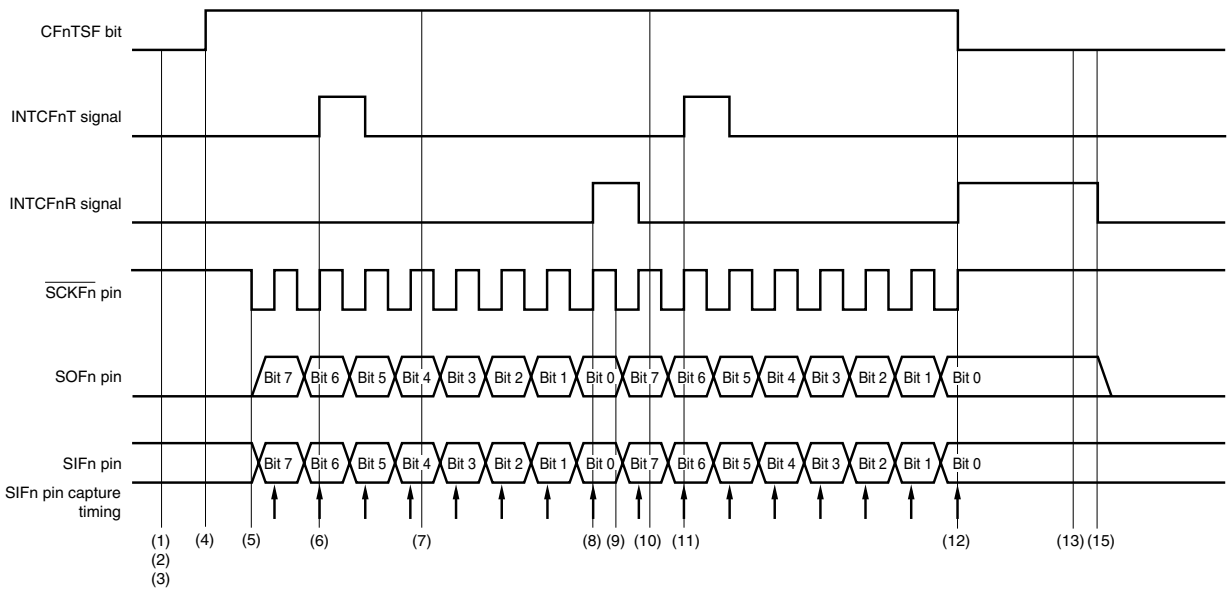
Remarks 1. The broken lines indicate the hardware processing.

2. The numbers in this figure correspond to the processing numbers in **(2) Operation timing**.

3. n = 0 to 4

(2) Operation timing

(1/2)



(1) Write 00H to the CFnCTL1 register, and select communication type 1, communication clock (f_{CCLK}) = f_{XX}/2 or f_{XX}/3, and master mode.

(2) Write 00H to the CFnCTL2 register, and set the transfer data length to 8 bits.

(3) Write E3H to the CFnCTL0 register, and select the transmission/reception mode, MSB first, and continuous transfer mode at the same time as enabling the operation of the communication clock (f_{CCLK}).

(4) Set the CFnSTR.CFnTSF bit to 1 by writing the transmit data to the CFnTX register, and start transmission/reception.

(5) When transmission/reception is started, output the serial clock to the $\overline{\text{SCKFn}}$ pin, output the transmit data to the SOFn pin in synchronization with the serial clock, and capture the receive data of the SIFn pin.

(6) When transfer of the transmit data from the CFnTX register to the shift register is completed and writing to the CFnTX register is enabled, the transmission enable interrupt request signal (INTCFnT) is generated.

(7) To continue transmission/reception, write the transmit data to the CFnTX register again after the INTCFnT signal is generated.

(8) When one transmission/reception is completed, the reception completion interrupt request signal (INTCFnR) is generated, and reading of the CFnRX register is enabled.

(9) When a new transmit data is written to the CFnTX register before communication completion, the next communication is started following communication completion.

(10) Read the CFnRX register.

Remark n = 0 to 4

(2/2)

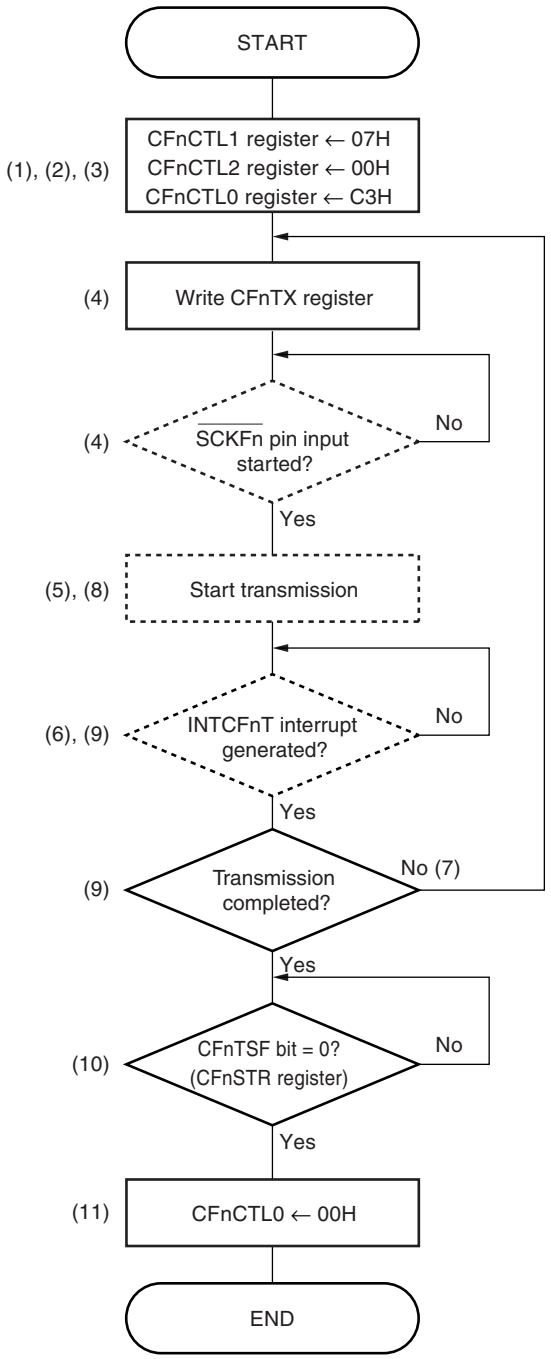
(11) The transfer of the transmit data from the CFnTX register to the shift register is completed and the INTCFnT signal is generated. To end continuous transmission/reception with the current transmission/reception, do not write to the CFnTX register.
(12) When the next transmit data is not written to the CFnTX register before transfer completion, stop the serial clock output to the $\overline{\text{SCKFn}}$ pin after transfer completion, and clear the CFnTSF bit to 0.
(13) When the reception error interrupt request signal (INTCFnR) is generated, read the CFnRX register.
(14) If an overrun error occurs, write CFnSTR.CFnOVE bit = 0, and clear the error flag.
(15) To release the transmission/reception enable status, write CFnCTL0.CFnPWR bit = 0, CFnCTL0.CFnTXE bit = 0, and CFnCTL0.CFnRXE bit = 0 after checking that the CFnTSF bit = 0.

Remark n = 0 to 4

18.6.10 Continuous transfer mode (slave mode, transmission mode)

MSB first (CFnCTL0.CFnDIR bit = 0), communication type 1 (CFnCTL1.CFnCKP and CFnCTL1.CFnDAP bits = 00), communication clock (f_{CCLK}) = external clock ($\overline{SCKFn}$) (CFnCTL1.CFnCKS2 to CFnCTL1.CFnCKS0 bits = 111), transfer data length = 8 bits (CFnCTL2.CFnCL3 to CFnCTL2.CFnCL0 bits = 0000)

(1) Operation flow

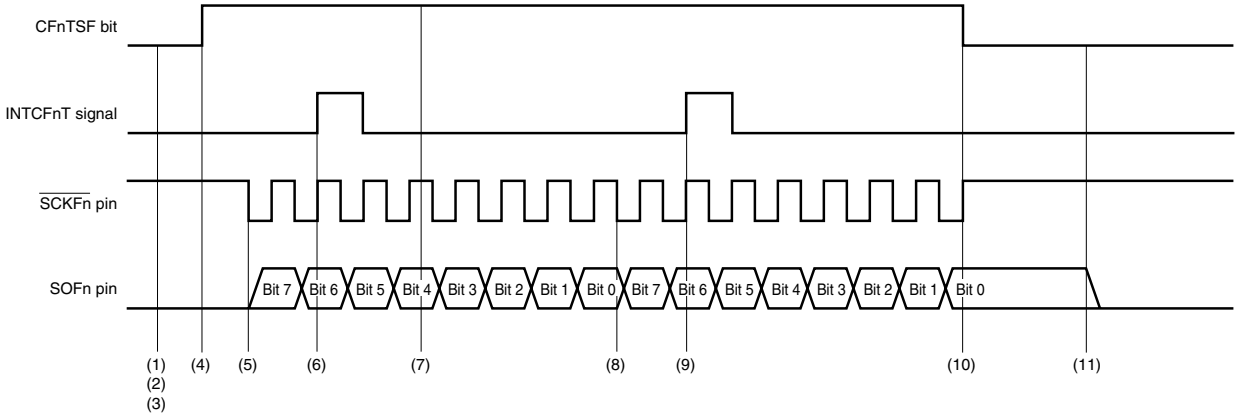


Remarks 1. The broken lines indicate the hardware processing.

2. The numbers in this figure correspond to the processing numbers in **(2) Operation timing**.

3. n = 0 to 4

(2) Operation timing



(1) Write 07H to the CFnCTL1 register, and select communication type 1, communication clock (f_{CCLK}) = external clock ($\overline{SCKFn}$), and slave mode.

(2) Write 00H to the CFnCTL2 register, and set the transfer data length to 8 bits.

(3) Write C3H to the CFnCTL0 register, and select the transmission mode, MSB first, and continuous transfer mode at the same time as enabling the operation of the communication clock (f_{CCLK}).

(4) The CFnSTR.CFnTSF bit is set to 1 by writing the transmit data to the CFnTX register, and the device waits for a serial clock input.

(5) When a serial clock is input, output the transmit data from the SOFn pin in synchronization with the serial clock.

(6) When transfer of the transmit data from the CFnTX register to the shift register is completed and writing to the CFnTX register is enabled, the transmission enable interrupt request signal (INTCFnT) is generated.

(7) To continue transmission, write the transmit data to the CFnTX register again after the INTCFnT signal is generated.

(8) When a serial clock is input following completion of the transmission of the transfer data length set with the CFnCTL2 register, continuous transmission is started.

(9) When transfer of the transmit data from the CFnTX register to the shift register is completed and writing to the CFnTX register is enabled, the INTCFnT signal is generated. To end continuous transmission with the current transmission, do not write to the CFnTX register.

(10) When the clock of the transfer data length set with the CFnCTL2 register is input without writing to the CFnTX register, clear the CFnTSF bit to 0 to end transmission.

(11) To release the transmission enable status, write CFnCTL0.CFnPWR bit = 0 and CFnCTL0.CFnTXE bit = 0 after checking that the CFnTSF bit = 0.

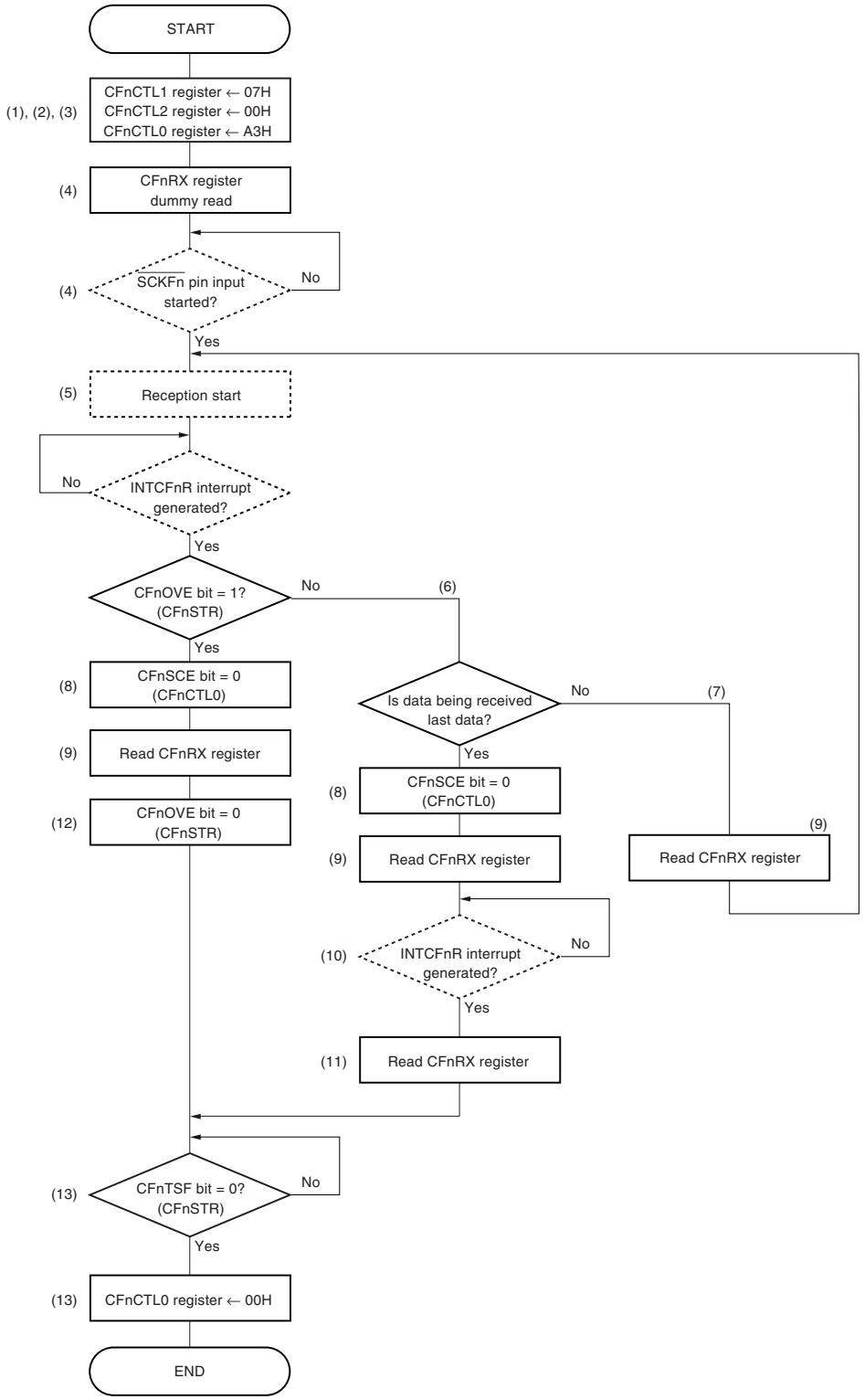
Caution In continuous transmission mode, the reception completion interrupt request signal (INTCFnR) is not generated.

Remark n = 0 to 4

18.6.11 Continuous transfer mode (slave mode, reception mode)

MSB first (CFnCTL0.CFnDIR bit = 0), communication type 1 (CFnCTL1.CFnCKP and CFnCTL1.CFnDAP bits = 00), communication clock (f_{CCLK}) = external clock ($\overline{SCKFn}$) (CFnCTL1.CFnCKS2 to CFnCTL1.CFnCKS0 bits = 111), transfer data length = 8 bits (CFnCTL2.CFnCL3 to CFnCTL2.CFnCL0 bits = 0000)

(1) Operation flow

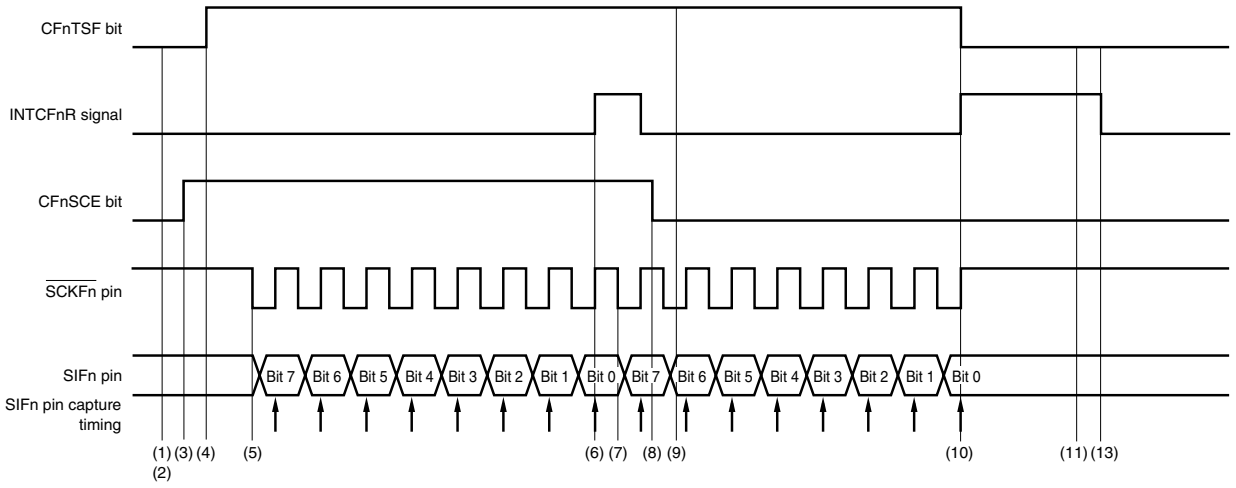


Remarks 1. The broken lines indicate the hardware processing.

2. The numbers in this figure correspond to the processing numbers in **(2) Operation timing**.

3. n = 0 to 4

(2) Operation timing



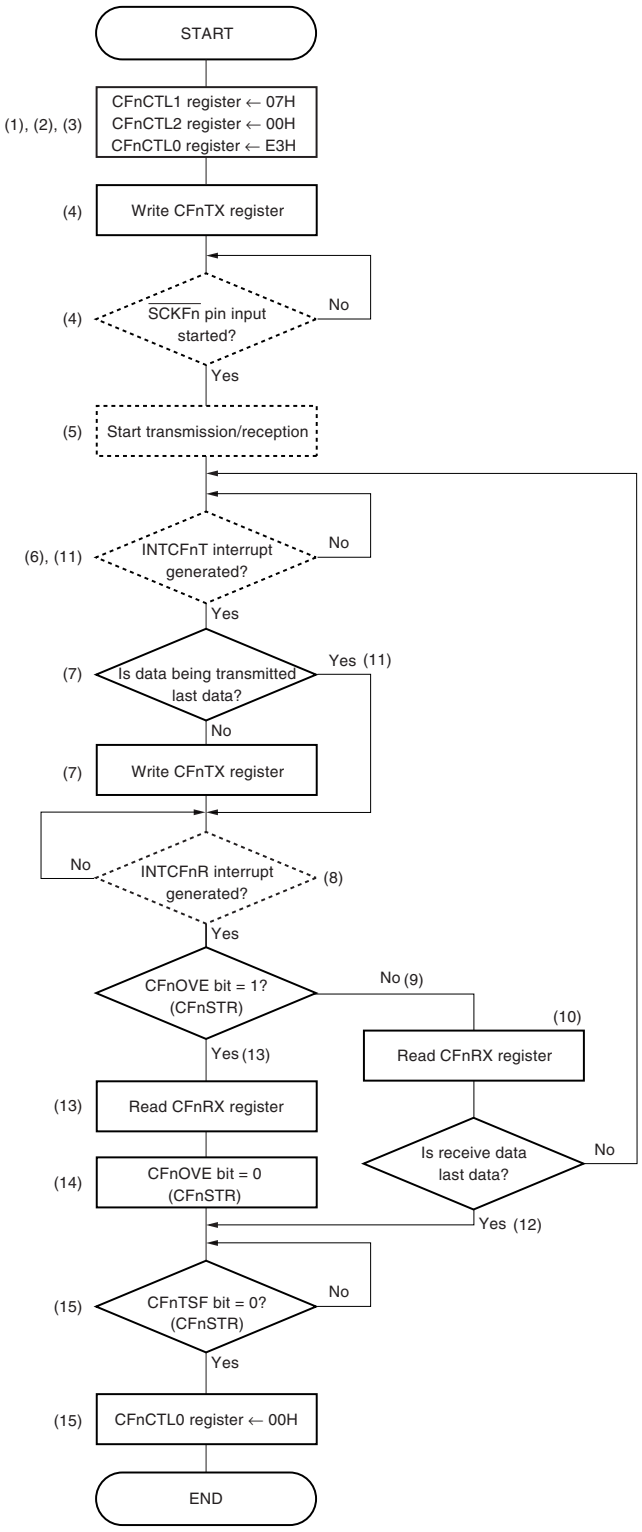
(1) Write 07H to the CFnCTL1 register, and select communication type 1, communication clock (f_{CCLK}) = external clock ($\overline{SCKFn}$), and slave mode.
(2) Write 00H to the CFnCTL2 register, and set the transfer data length to 8 bits.
(3) Write A3H to the CFnCTL0 register, and select the reception mode, MSB first, and continuous transfer mode at the same time as enabling the operation of the communication clock (f_{CCLK}).
(4) The CFnSTR.CFnTSF bit is set to 1 by performing a dummy read of the CFnRX register, and the device waits for a serial clock input.
(5) When a serial clock is input, capture the receive data of the SIFn pin in synchronization with the serial clock.
(6) When reception is completed, the reception completion interrupt request signal (INTCFnR) is generated, and reading of the CFnRX register is enabled.
(7) When a serial clock is input in the CFnCTL0.CFnSCE bit = 1 status, continuous reception is started.
(8) To end continuous reception with the current reception, write the CFnSCE bit = 0.
(9) Read the CFnRX register.
(10) When reception is completed, the INTCFnR signal is generated, and reading of the CFnRX register is enabled. When CFnSCE bit = 0 is set before communication completion, clear the CFnTSF bit to 0 to end the receive operation.
(11) Read the CFnRX register.
(12) If an overrun error occurs, write CFnSTR.CFnOVE bit = 0, and clear the error flag.
(13) To release the reception enable status, write CFnCTL0.CFnPWR bit = 0 and CFnCTL0.CFnRXE bit = 0 after checking that the CFnTSF bit = 0.

Remark n = 0 to 4

18.6.12 Continuous transfer mode (slave mode, transmission/reception mode)

MSB first (CFnCTL0.CFnDIR bit = 0), communication type 1 (CFnCTL1.CFnCKP and CFnCTL1.CFnDAP bits = 00), communication clock (f_{CCLK}) = external clock ($\overline{SCKFn}$) (CFnCTL1.CFnCKS2 to CFnCTL1.CFnCKS0 bits = 111), transfer data length = 8 bits (CFnCTL2.CFnCL3 to CFnCTL2.CFnCL0 bits = 0000)

(1) Operation flow



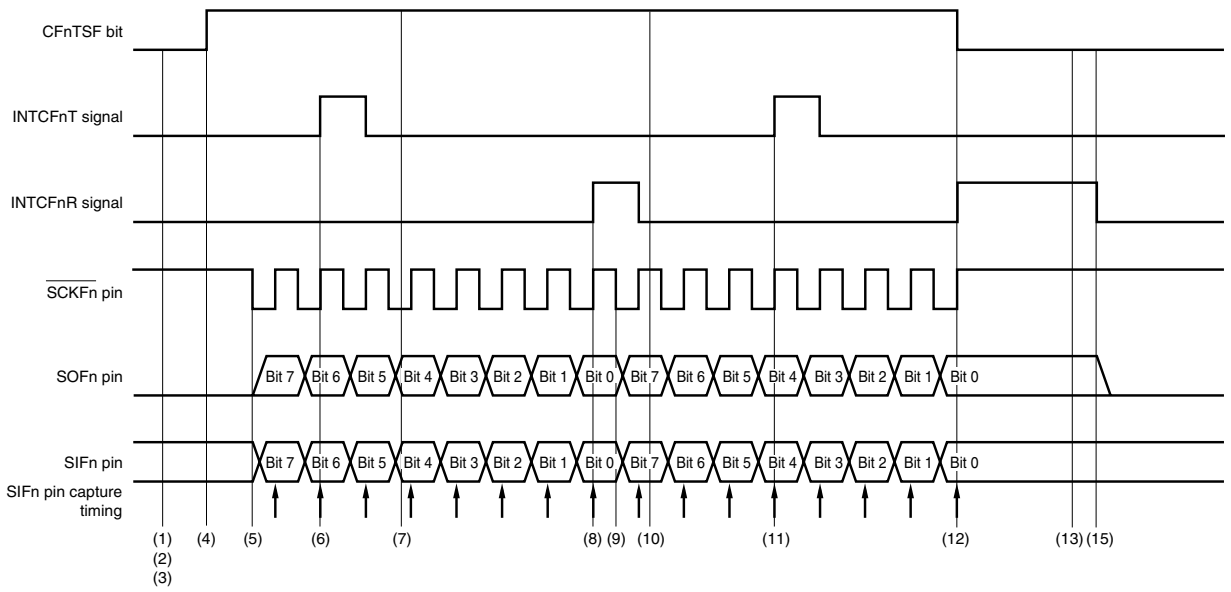
Remarks 1. The broken lines indicate the hardware processing.

2. The numbers in this figure correspond to the processing numbers in **(2) Operation timing**.

3. n = 0 to 4

(2) Operation timing

(1/2)



(1) Write 07H to the CFnCTL1 register, and select communication type 1, communication clock (f_{CCLK}) = external clock ($\overline{SCKFn}$), and slave mode.

(2) Write 00H to the CFnCTL2 register, and set the transfer data length to 8 bits.

(3) Write E3H to the CFnCTL0 register, and select the transmission/reception mode, MSB first, and continuous transfer mode at the same time as enabling the operation of the communication clock (f_{CCLK}).

(4) The CFnSTR.CFnTSF bit is set to 1 by writing the transmit data to the CFnTX register, and the device waits for a serial clock input.

(5) When a serial clock is input, output the transmit data to the SOFn pin in synchronization with the serial clock, and capture the receive data of the SIFn pin.

(6) When transfer of the transmit data from the CFnTX register to the shift register is completed and writing to the CFnTX register is enabled, the transmission enable interrupt request signal (INTCFnT) is generated.

(7) To continue transmission, write the transmit data to the CFnTX register again after the INTCFnT signal is generated.

(8) When reception of the transfer data length set with the CFnCTL2 register is completed, the reception completion interrupt request signal (INTCFnR) is generated, and reading of the CFnRX register is enabled.

(9) When a serial clock is input continuously, continuous transmission/reception is started.

(10) Read the CFnRX register.

(11) When transfer of the transmit data from the CFnTX register to the shift register is completed and writing to the CFnTX register is enabled, the INTCFnT signal is generated. To end continuous transmission/reception with the current transmission/reception, do not write to the CFnTX register.

Remark n = 0 to 4

(2/2)

(12) When the clock of the transfer data length set with the CFnCTL2 register is input without writing to the CFnTX register, the INTCFnR signal is generated. Clear the CFnTSF bit to 0 to end transmission/reception.
(13) When the INTCFnR signal is generated, read the CFnRX register.
(14) If an overrun error occurs, write CFnSTR.CFnOVE bit = 0, and clear the error flag.
(15) To release the transmission/reception enable status, write CFnCTL0.CFnPWR bit = 0, CFnCTL0.CFnTXE bit = 0, and CFnCTL0.CFnRXE bit = 0 after checking that the CFnTSF bit = 0.

Remark n = 0 to 4

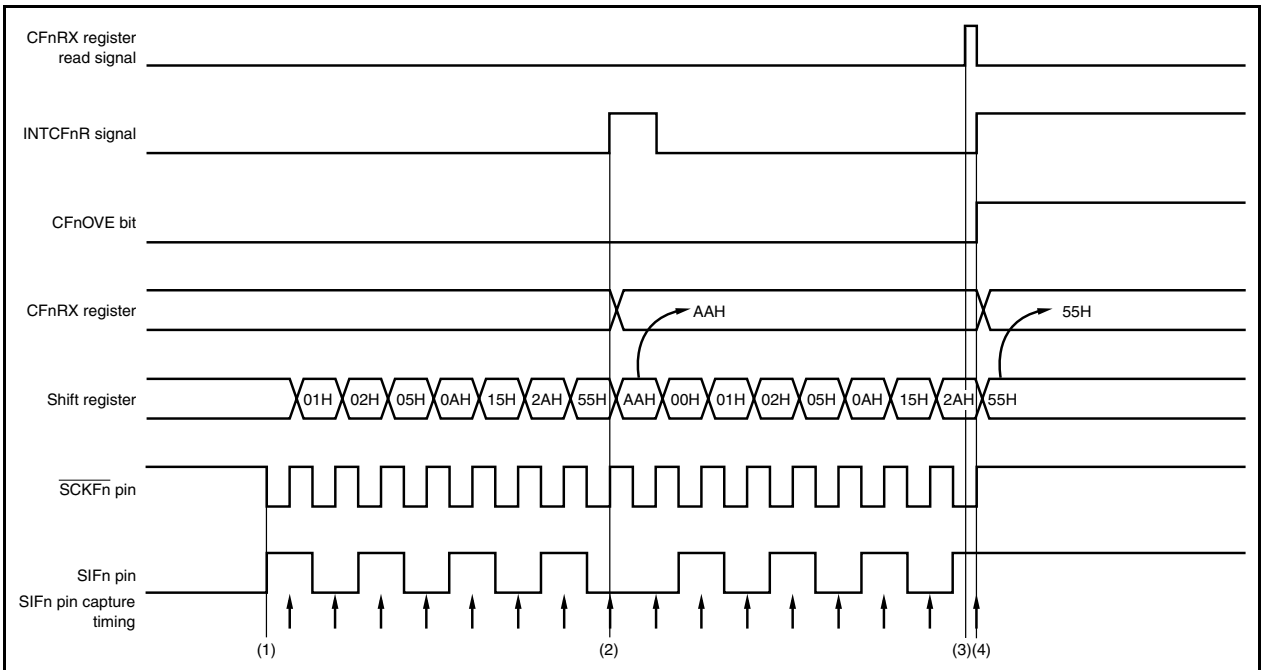
18.6.13 Reception error

When transfer is performed with reception enabled (CFnCTL0.CFnRXE bit = 1) in the continuous transfer mode, the reception completion interrupt request signal (INTCFnR) is generated again when the next receive operation is completed before the CFnRX register is read after the INTCFnR signal is generated, and the overrun error flag (CFnSTR.CFnOVE) is set to 1.

Even if an overrun error has occurred, the previous receive data is lost since the CFnRX register is updated. Even if a reception error has occurred, the INTCFnR signal is generated again upon the next reception completion if the CFnRX register is not read.

To avoid an overrun error, complete reading the CFnRX register by one half clock before sampling the last bit of the next receive data from the INTCFnR signal generation.

(1) Operation timing



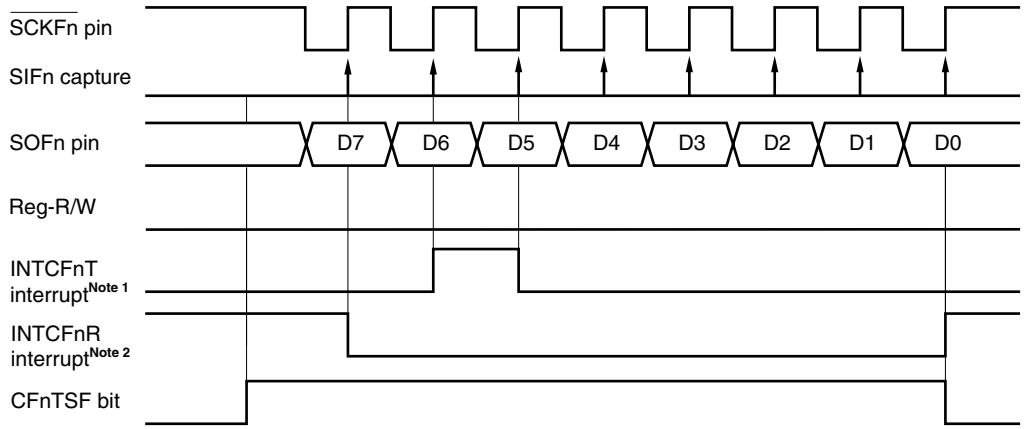
(1) Start continuous transfer.
(2) Completion of the first transfer
(3) The CFnRX register cannot be read until one half clock before the completion of the second transfer.
(4) An overrun error occurs, and the reception completion interrupt request signal (INTCFnR) is generated, and then the overrun error flag (CFnSTR.CFnOVE) is set to 1. The receive data is overwritten.

Remark n = 0 to 4

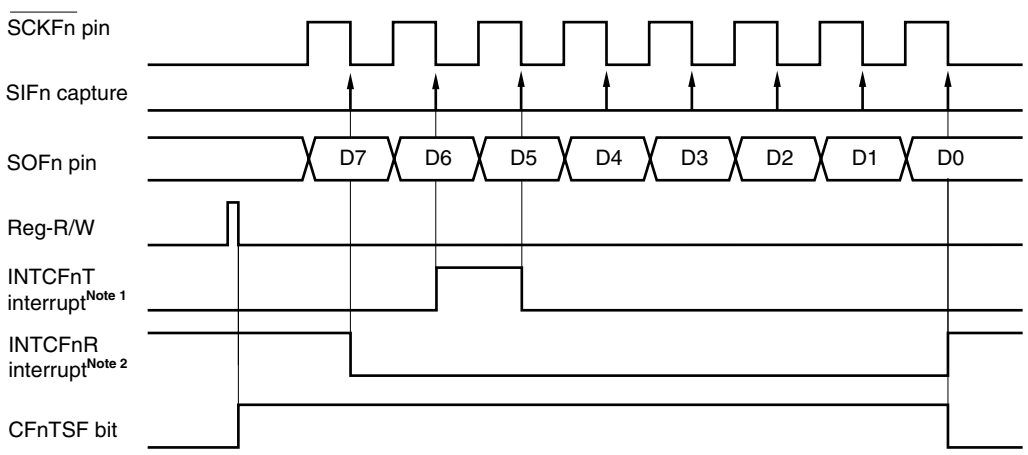
18.6.14 Clock timing

(1/2)

(i) Communication type 1 (CFnCKP and CFnDAP bits = 00)



(ii) Communication type 3 (CFnCKP and CFnDAP bits = 10)



Notes 1. The INTCFnT interrupt is set when the data written to the CFnTX register is transferred to the data shift register in the continuous transmission or continuous transmission/reception mode. In the single transmission or single transmission/reception mode, the INTCFnT interrupt request signal is not generated, but the INTCFnR interrupt request signal is generated upon end of communication.

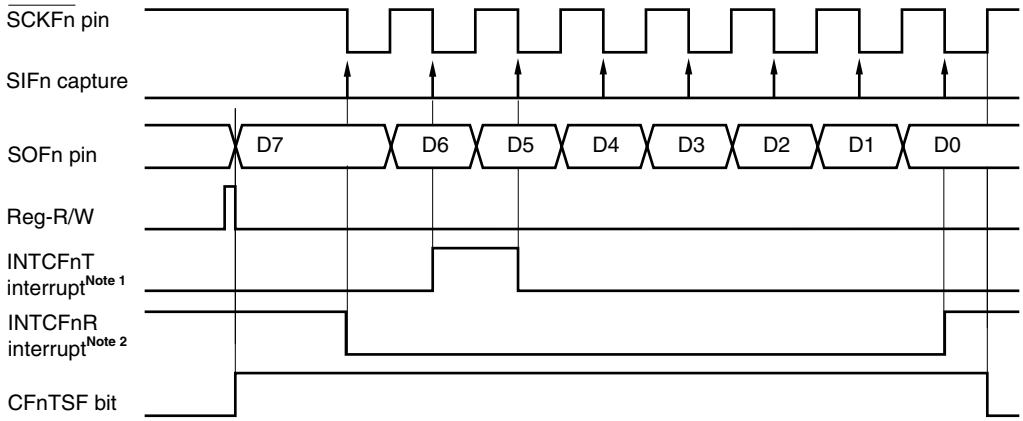
2. The INTCFnR interrupt occurs if reception is correctly ended and receive data is ready in the CFnRX register while reception is enabled. In the single mode, the INTCFnR interrupt request signal is generated even in the transmission mode, upon end of communication.

Caution In single transfer mode, writing to the CFnTX register with the CFnTSF bit set to 1 is ignored. This has no effect on the operation during transfer.
For example, if the next data is written to the CFnTX register when DMA is started by generating the INTCFnR signal, the written data is not transferred because the CFnTSF bit is set to 1.
Use the continuous transfer mode, not the single transfer mode, for such applications.

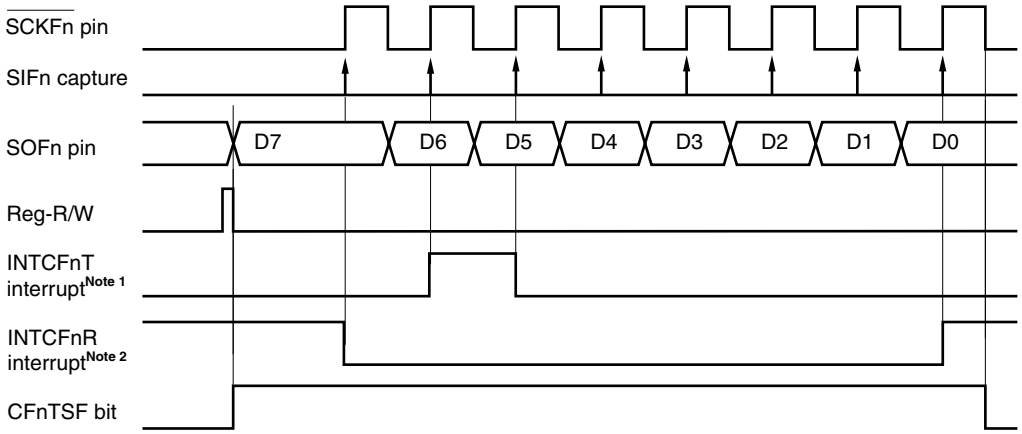
Remark n = 0 to 4

(2/2)

(iii) Communication type 2 (CFnCKP and CFnDAP bits = 01)



(iv) Communication type 4 (CFnCKP and CFnDAP bits = 11)



Notes 1. The INTCFnT interrupt is set when the data written to the CFnTX register is transferred to the data shift register in the continuous transmission or continuous transmission/reception modes. In the single transmission or single transmission/reception modes, the INTCFnT interrupt request signal is not generated, but the INTCFnR interrupt request signal is generated upon end of communication.

2. The INTCFnR interrupt occurs if reception is correctly ended and receive data is ready in the CFnRX register while reception is enabled. In the single mode, the INTCFnR interrupt request signal is generated even in the transmission mode, upon end of communication.

Caution In single transfer mode, writing to the CFnTX register with the CFnTSF bit set to 1 is ignored. This has no effect on the operation during transfer.
For example, if the next data is written to the CFnTX register when DMA is started by generating the INTCFnR signal, the written data is not transferred because the CFnTSF bit is set to 1.
Use the continuous transfer mode, not the single transfer mode, for such applications.

Remark n = 0 to 4

18.7 Output Pins

(1) $\overline{\text{SCKFn}}$ pin

When CSIFn operation is disabled (CFnCTL0.CFnPWR bit = 0), the $\overline{\text{SCKFn}}$ pin output status is as follows.

CFnCKP	CFnCKS2	CFnCKS1	CFnCKS0	$\overline{\text{SCKFn}}$ Pin Output
0	1	1	1	High impedance
	Other than above			Fixed to high level
1	1	1	1	High impedance
	Other than above			Fixed to low level

Remarks 1. The output level of the $\overline{\text{SCKFn}}$ pin changes if any of the CFnCTL1.CFnCKP or CFnCKS2 to CFnCKS0 bits is rewritten.

2. n = 0 to 4

(2) SOFn pin

When CSIFn operation is disabled (CFnPWR bit = 0), the SOFn pin output status is as follows.

CFnTXE	CFnDAP	CFnDIR	SOFn Pin Output
0	×	×	Fixed to low level
1	0	×	SOFn latch value (low level)
	1	0	CFnTX value (MSB)
		1	CFnTX value (LSB)

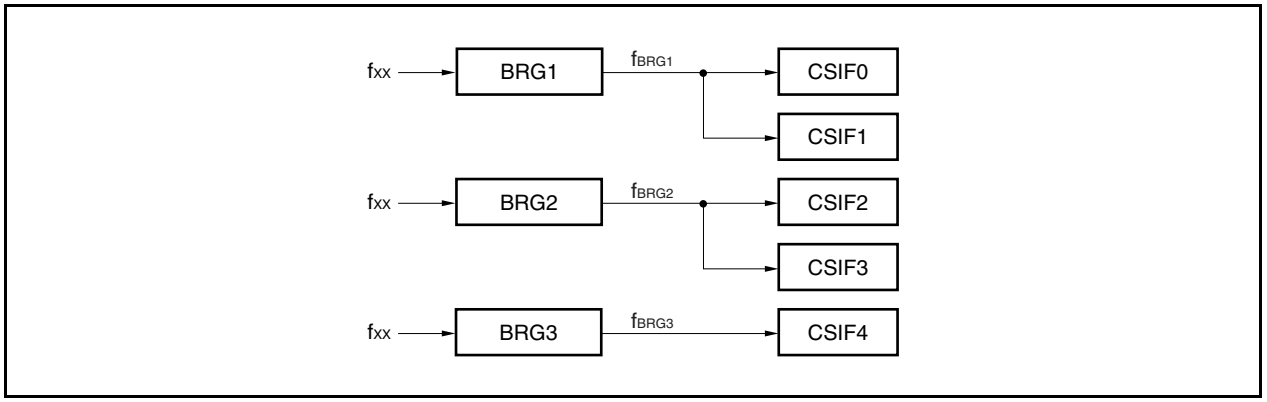
Remarks 1. The SOFn pin output changes when any one of the CFnCTL0.CFnTXE, CFnCTL0.CFnDIR or CFnCTL1.CFnDAP bit is rewritten.

2. ×: Don't care

3. n = 0 to 4

18.8 Baud Rate Generator

The BRG1 to BRG3 baud rate generators are connected to CSIF0 to CSIF4 as shown in the following block diagram.



(1) Prescaler mode registers 1 to 3 (PRSM1 to PRSM3)

The PRSM1 to PRSM3 registers control generation of the baud rate signal for CSIF.

These registers can be read or written in 8-bit or 1-bit units.

Reset sets these registers to 00H.

After reset: 00H R/W Address: PRSM1 FFFFF320H, PRSM2 FFFFF324H, PRSM3 FFFFF328H

PRSMm (m = 1 to 3)

7	6	5	<4>	3	2	1	0
0	0	0	BGCEm	0	0	BGCSm1	BGCSm0

BGCEm	Baud rate output
0	Disabled
1	Enabled

BGCSm1	BGCSm0	Input clock selection (f_{BGCSm})	Setting value (k)
0	0	f_{XX}	0
0	1	$f_{XX}/2$	1
1	0	$f_{XX}/4$	2
1	1	$f_{XX}/8$	3

Cautions 1. Do not rewrite the PRSMm register during operation.

2. Set the PRSMm register before setting the BGCEm bit to 1.

2. Be sure to set bits 7 to 5, 3, and 2 to “0”.

(2) Prescaler compare registers 1 to 3 (PRSCM1 to PRSCM3)

The PRSCM1 to PRSCM3 registers are 8-bit compare registers.

These registers can be read or written in 8-bit units.

Reset sets these registers to 00H.

After reset: 00H R/W Address: PRSCM1 FFFFF321H, PRSCM2 FFFFF325H, PRSCM3 FFFFF329H

	7	6	5	4	3	2	1	0
PRSCMm	PRSCMm7	PRSCMm6	PRSCMm5	PRSCMm4	PRSCMm3	PRSCMm2	PRSCMm1	PRSCMm0

Cautions 1. Do not rewrite the PRSCMm register during operation.

2. Set the PRSCMm register before setting the PRSMm.BGCEm bit to 1.

18.8.1 Baud rate generation

The transmission/reception clock is generated by dividing the main clock. The baud rate generated from the main clock is obtained by the following equation.

$$f_{BRGm} = \frac{f_{XX}}{2^{k+1} \times N}$$

Caution Set f_{BRGm} to 8 MHz, (CSIF0 to CSIF2 and CSIF4), 12 MHz (CSIF3), or lower.

Remark f_{BRGm}: BRGm count clock

f_{XX}: Main clock oscillation frequency

k: PRSMm register setting value = 0 to 3

N: PRSCMm register setting value = 1 to 256

However, N = 256 only when the PRSCMm register is set to 00H.

m = 1 to 3

18.9 Cautions

(1) When transferring transmit data and receive data using DMA transfer, error processing cannot be performed even if an overrun error occurs during serial transfer. Check that the no overrun error has occurred by reading the CFnSTR.CFnOVE bit after DMA transfer has been completed.

(2) If a register that is prohibited to be rewritten during operation (CFnCTL0.CFnPWR bit = 1) is rewritten by mistake during operation, set the CFnCTL0.CFnPWR bit to 0 once, then initialize CSIFn.
Registers to which rewriting during operation is prohibited are shown below.
- CFnCTL0 register: CFnTXE, CFnRXE, CFnDIR, CFnTMS bits
- CFnCTL1 register: CFnCKP, CFnDAP, CFnCKS2 to CFnCKS0 bits
- CFnCTL2 register: CFnCL3 to CFnCL0 bits

(3) In communication type 2 or 4 (CFnCTL1.CFnDAP bit = 1), the CFnSTR.CFnTSF bit is cleared half a $\overline{\text{SCKFn}}$ clock after the occurrence of a reception completion interrupt (INTCFnR).
In the single transfer mode, writing the next transmit data is ignored during communication (CFnTSF bit = 1), and the next communication is not started. Also if reception-only communication (CFnCTL0.CFnTXE bit = 0, CFnCTL0.CFnRXE bit = 1) is set, the next communication is not started even if the receive data is read during communication (CFnTSF bit = 1).
Therefore, when using the single transfer mode with communication type 2 or 4 (CFnDAP bit = 1), pay particular attention to the following.

- To start the next transmission, confirm that CFnTSF bit = 0 and then write the transmit data to the CFnTX register.
- To perform the next reception continuously when reception-only communication (CFnTXE bit = 0, CFnRXE bit = 1) is set, confirm that CFnTSF bit = 0 and then read the CFnRX register.

Or, use the continuous transfer mode instead of the single transfer mode. Use of the continuous transfer mode is recommended especially when using DMA.

Remark n = 0 to 4

CHAPTER 19 I²C BUS

To use the I²C bus function, set the P36/SCL00, P37/SDA00, P40/SDA01, P41/SCL01, P90/SDA02, and P91/SCL02 pins as alternate-function pins, and set them to N-ch open-drain output.

19.1 Mode Switching of I²C Bus and Other Serial Interfaces

19.1.1 UARTC3 and I²C00 mode switching

In the V850ES/JG3-H and V850ES/JH3-H, UARTC3 and I²C00 share the same pins and therefore cannot be used simultaneously. Switching between UARTC3 and I²C00 must be set in advance, using the PMC3, PFC3, and PFCE3 registers.

Caution The transmit/receive operation of UARTC3 and I²C00 is not guaranteed if these functions are switched during transmission or reception. Be sure to disable the one that is not used.

Figure 19-1. UARTC3 and I²C00 Mode Switch Settings

After reset: 00H R/W Address: FFFFF446H

	7	6	5	4	3	2	1	0
PMC3	PMC37	PMC36	PMC35	PMC34	PMC33	PMC32	PMC31	PMC30

After reset: 00H R/W Address: FFFFF466H

	7	6	5	4	3	2	1	0
PFC3	PFC37	PFC36	PFC35	PFC34	PFC33	PFC32	PFC31	PFC30

After reset: 00H R/W Address: FFFFF706H

	7	6	5	4	3	2	1	0
PFCE3	PFCE37	PFCE36	PFCE35	PFCE34	PFCE33	PFCE32	PFCE31	PFCE30

PMC3n	PFCE3n	PFC3n	Operation mode
0	×	×	Port I/O mode
1	0	0	UARTC3 mode
1	0	1	I²C00 mode

Remarks 1. n = 6, 7

2. × = don't care

19.1.2 UARTC4, CSIF0, and I²C01 mode switching

In the V850ES/JG3-H and V850ES/JH3-H, UARTC4, CSIF0, and I²C01 share the same pins and therefore cannot be used simultaneously. Switching among UARTC4, CSIF0, and I²C01 must be set in advance, using the PMC4, PFC4, and PFCE4 registers.

Caution The transmit/receive operation of UARTC4, CSIF0, and I²C01 is not guaranteed if these functions are switched during transmission or reception. Be sure to disable the one that is not used.

Figure 19-2. UARTC4, CSIF0, and I²C01 Mode Switch Settings

After reset: 00H R/W Address: FFFFF448H

	7	6	5	4	3	2	1	0
PMC4	0	0	0	0	0	PMC42	PMC41	PMC40

After reset: 00H R/W Address: FFFFF468H

	7	6	5	4	3	2	1	0
PFC4	0	0	0	0	0	PFC42	PFC41	PFC40

After reset: 00H R/W Address: FFFFF708H

	7	6	5	4	3	2	1	0
PFCE4	0	0	0	0	0	0	PFCE41	PFCE40

PMC4n	PFC4n	PFCE4n	Operation mode
0	×	×	Port I/O mode
1	0	0	CSIF0 mode
1	0	1	I²C01 mode
1	1	0	UARTC4 mode

Remarks 1. n = 0, 1

2. × = don't care

19.1.3 UARTC1 and I²C02 mode switching

In the V850ES/JG3-H and V850ES/JH3-H, UARTC1 and I²C02 share the same pins and therefore cannot be used simultaneously. Switching between UARTC1 and I²C02 must be set in advance, using the PMC9, PFC9, and PFCE9 registers.

Caution The transmit/receive operation of UARTC1 and I²C02 is not guaranteed if these functions are switched during transmission or reception. Be sure to disable the one that is not used.

Figure 19-3. UARTC1 and I²C02 Mode Switch Settings

After reset: 0000H R/W Address: FFFFF452H, FFFFF453H

PMC9

15	14	13	12	11	10	9	8
PMC915	PMC914	PMC913	PMC912	PMC911	PMC910	PMC99	PMC98
7	6	5	4	3	2	1	0
PMC97	PMC96	PMC95	PMC94	PMC93	PMC92	PMC91	PMC90

After reset: 0000H R/W Address: FFFFF472H, FFFFF473H

PFC9

15	14	13	12	11	10	9	8
PFC915	PFC914	PFC913	PFC912	PFC911	PFC910	PFC99	PFC98
7	6	5	4	3	2	1	0
PFC97	PFC96	PFC95	PFC94	PFC93	PFC92	PFC91	PFC90

After reset: 0000H R/W Address: FFFFF712H, FFFFF713H

PFCE9

15	14	13	12	11	10	9	8
PFCE915	PFCE914	0	0	PFCE911	PFCE910	PFCE99	PFCE98
7	6	5	4	3	2	1	0
PFCE97	PFCE96	PFCE95	PFCE94	PFCE93	PFCE92	PFCE91	PFCE90

<R>

PMC9n	PFCE9n	PFC9n	Operation mode
1	0	1	UARTC1 mode
1	1	0	I²C02 mode

Remark n = 0, 1

19.2 Features

I²C00 to I²C02 have the following two modes.

- Operation stop mode
- I²C (Inter IC) bus mode (multimasters supported)

(1) Operation stop mode

In this mode, serial transfer is not performed, thus enabling a reduction in power consumption.

(2) I²C bus mode (multimaster support)

This mode is used for 8-bit data transfers with several devices via two lines: a serial clock pin (SCL0n) and a serial data bus pin (SDA0n).

This mode complies with the I²C bus format and the master device can generate “start condition”, “address”, “transfer direction specification”, “data”, and “stop condition” data for the slave device on the serial data bus. The slave device automatically detects the received statuses and data by hardware. This function can simplify the part of an application program that controls the I²C bus.

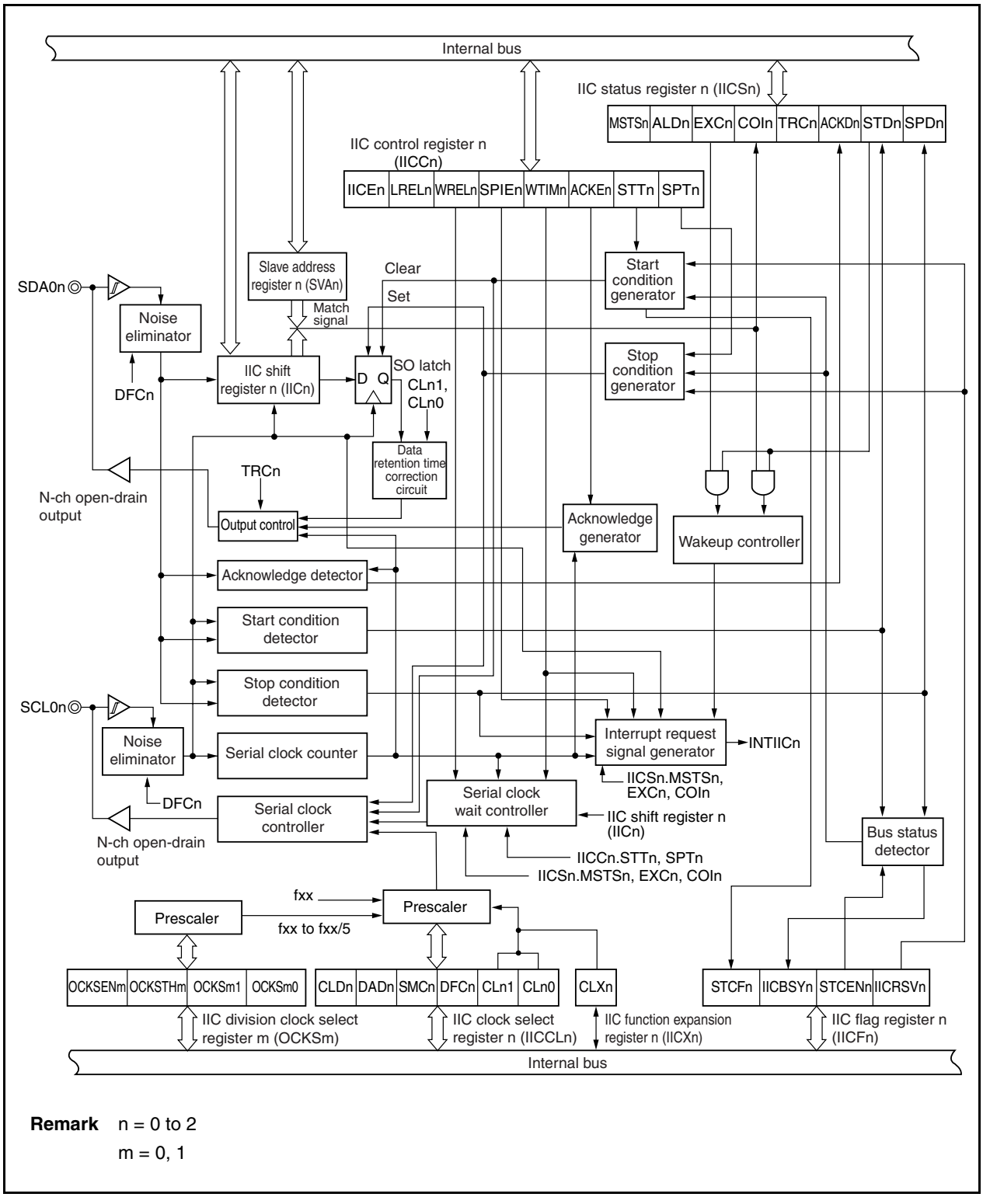
Since SCL0n and SDA0n pins are used for N-ch open-drain outputs, I²C0n requires pull-up resistors for the serial clock line and the serial data bus line.

Remark n = 0 to 2

19.3 Configuration

The block diagram of the I²C0n is shown below.

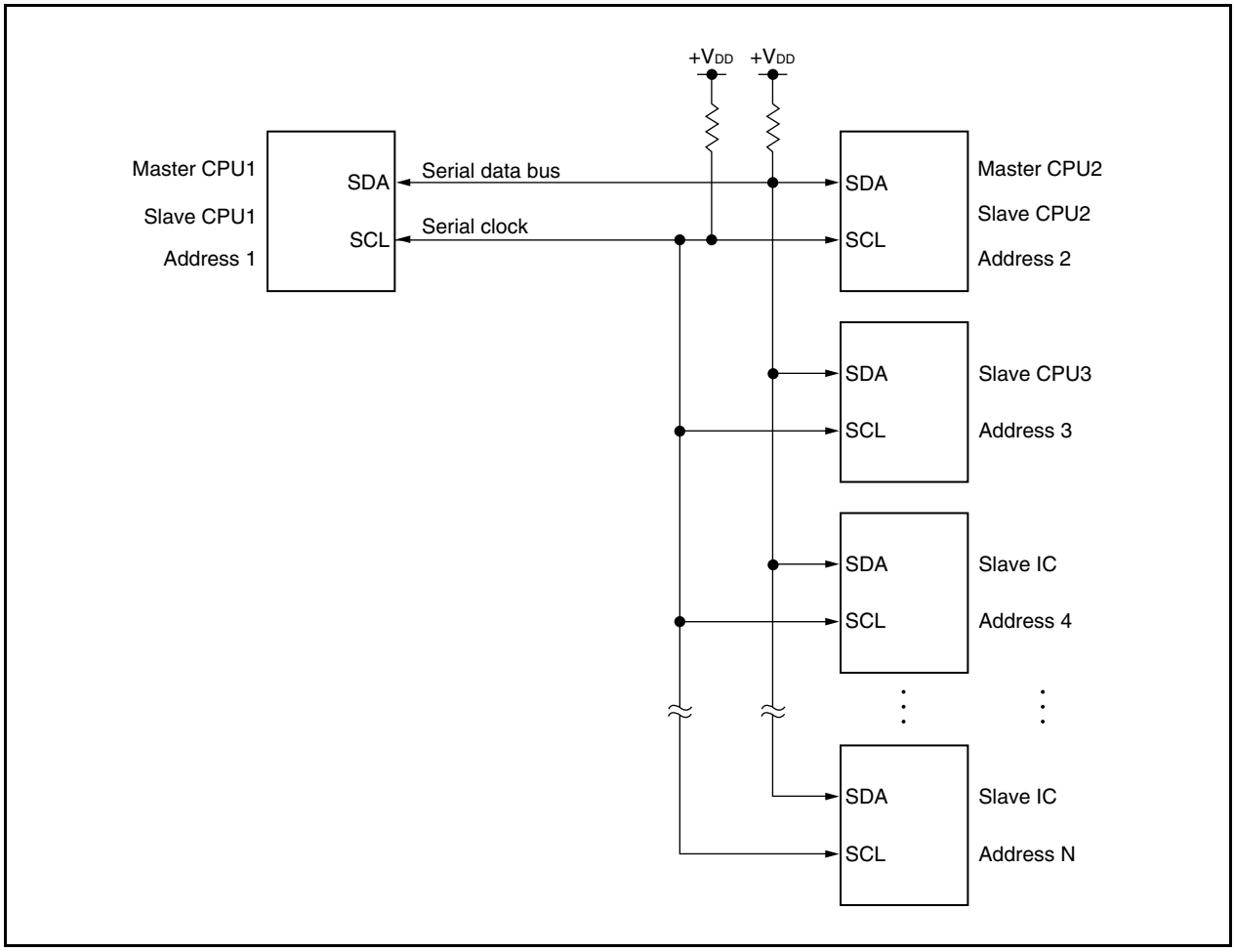
Figure 19-4. Block Diagram of I²C0n



Remark n = 0 to 2
m = 0, 1

A serial bus configuration example is shown below.

Figure 19-5. Serial Bus Configuration Example Using I²C Bus



I²C0n includes the following hardware (n = 0 to 2).

Table 19-1. Configuration of I²C0n

Item	Configuration
Registers	IIC shift register n (IICn) Slave address register n (SVAn)
Control registers	IIC control register n (IICCn) IIC status register n (IICSn) IIC flag register n (IICF0n) IIC clock select register n (IICCLn) IIC function expansion register n (IICXn) IIC division clock select registers 0, 1 (OCKS0, OCKS1)

(1) IIC shift register n (IICn)

The IICn register converts 8-bit serial data into 8-bit parallel data and vice versa, and can be used for both transmission and reception (n = 0 to 2).

Write and read operations to the IICn register are used to control the actual transmit and receive operations.

This register can be read or written in 8-bit units.

Reset sets this register to 00H.

(2) Slave address register n (SVAn)

The SVAn register sets local addresses when in slave mode (n = 0 to 2).

This register can be read or written in 8-bit units.

Reset sets this register to 00H.

(3) SO latch

The SO latch is used to retain the output level of the SDA0n pin (n = 0 to 2).

(4) Wakeup controller

This circuit generates an interrupt request signal (INTIICn) when the address value set to the SVAn register matches the received address or when an extension code is received (n = 0 to 2).

(5) Prescaler

This selects the sampling clock to be used.

(6) Serial clock counter

This counter counts the serial clocks that are output or input during transmit/receive operations and is used to verify that 8-bit data was transmitted or received.

(7) Interrupt request signal generator

This circuit controls the generation of interrupt request signals (INTIICn).

An I²C interrupt is generated by either of the following two triggers.

- The falling edge of the eighth or ninth clock of the serial clock (set by IICCn.WTIMn bit)
- Interrupt occurrence due to stop condition detection (set by IICCn.SPIEn bit)

Remark n = 0 to 2

(8) Serial clock controller

In master mode, this circuit generates the clock output via the SCL0n pin from the sampling clock (n = 0 to 2).

(9) Serial clock wait controller

This circuit controls the wait timing.

(10) $\overline{\text{ACK}}$ generator, stop condition detector, start condition detector, and $\overline{\text{ACK}}$ detector

These circuits are used to generate and detect various statuses.

(11) Data hold time correction circuit

This circuit generates the hold time for the data corresponding to the falling edge of the SCL0n pin.

(12) Start condition generator

This circuit generates a start condition when the IICCn.STTn bit is set.

However, when in the communication reservation disabled status (IICFn.IICRSVn bit = 1) and when the bus is not released (IICFn.IICBSYn bit = 1), this request is ignored and the IICFn.STCFn bit is set to 1.

(13) Stop condition generator

This circuit generates a stop condition when the IICCn.SPTn bit is set.

(14) Bus status detector

This circuit detects whether the bus is released by detecting a start condition and stop condition.

However, the bus status cannot be detected immediately after operation, so set the bus status detector to the initial status by using the IICFn.STCENn bit.

19.4 Registers

I²C00 to I²C02 are controlled by the following registers.

- IIC control registers 0 to 2 (IICC0 to IICC2)
- IIC status registers 0 to 2 (IICS0 to IICS2)
- IIC flag registers 0 to 2 (IICF0 to IICF2)
- IIC clock select registers 0 to 2 (IICCL0 to IICCL2)
- IIC function expansion registers 0 to 2 (IICX0 to IICX2)
- IIC division clock select registers 0, 1 (OCKS0, OCKS1)

The following registers are also used.

- IIC shift registers 0 to 2 (IIC0 to IIC2)
- Slave address registers 0 to 2 (SVA0 to SVA2)

Remark For the alternate-function pin settings, see **Table 4-20 Settings When Port Pins Are Used for Alternate Functions**.

(1) IIC control registers 0 to 2 (IICC0 to IICC2)

The IICCn registers enable/stop I²C0n operations, set the wait timing, and set other I²C operations (n = 0 to 2).

These registers can be read or written in 8-bit or 1-bit units. However, set the SPIEn, WTIMn, and ACKEn bits when the IICEn bit is 0 or during the wait period. When changing the IICEn bit from “0” to “1”, these bits can also be set at the same time.

Reset sets these registers to 00H.

(1/4)

After reset: 00H R/W Address: IICC0 FFFFFD82H, IICC1 FFFFFD92H, IICC2 FFFFFDA2H

	<7>	<6>	<5>	<4>	<3>	<2>	<1>	<0>
IICCn	IICEn	LRELn	WRELn	SPIEn	WTIMn	ACKEn	STTn	SPTn

(n = 0 to 2)

IICEn	Specification of I²Cn operation enable/disable
0	Operation stopped. IICSn register reset[Note 1]. Internal operation stopped.
1	Operation enabled.
Be sure to set this bit to 1 when the SCL0n and SDA0n lines are high level.	
Condition for clearing (IICEn bit = 0)	Condition for setting (IICEn bit = 1)
• Cleared by instruction • After reset	• Set by instruction

LRELn[Note 2]	Exit from communications
0	Normal operation
1	This exits from the current communication operation and sets standby mode. This setting is automatically cleared after being executed. Its uses include cases in which a locally irrelevant extension code has been received. The SCL0n and SDA0n lines are set to high impedance. The STTn and SPTn bits and the MSTSn, EXCn, COIn, TRCn, ACKDn, and STDn bits of the IICSn register are cleared.
The standby mode following exit from communications remains in effect until the following communication entry conditions are met. • After a stop condition is detected, restart is in master mode. • An address match occurs or an extension code is received after the start condition.	
Condition for clearing (LRELn bit = 0)	Condition for setting (LRELn bit = 1)
• Automatically cleared after execution • After reset	• Set by instruction

WRELn[Note 2]	Wait state cancellation control
0	Wait state not canceled
1	Wait state canceled. This setting is automatically cleared after wait state is canceled.
Condition for clearing (WRELn bit = 0)	Condition for setting (WRELn bit = 1)
• Automatically cleared after execution • After reset	• Set by instruction

Notes 1. The IICSn register, IICFn.STCFn and IICFn.IICBSYn bits, and IICCLn.CLDn and IICCLn.DADn bits are reset.

2. This flag's signal is invalid when the IICEn bit = 0.

Caution If the I²Cn operation is enabled (IICEn bit = 1) when the SCL0n line is high level and the SDA0n line is low level, the start condition is detected immediately. To avoid this, after enabling the I²Cn operation, immediately set the LRELn bit to 1 with a bit manipulation instruction.

Remark The LRELn and WRELn bits are 0 when read after the data has been set.

(2/4)

SPIEn[Note]	Enabling/disabling generation of interrupt request when stop condition is detected
0	Disabled
1	Enabled

Condition for clearing (SPIEn bit = 0)	Condition for setting (SPIEn bit = 1)
• Cleared by instruction • After reset	• Set by instruction

WTIMn[Note]	Control of wait state and interrupt request generation
0	Interrupt request is generated at the eighth clock's falling edge. Master mode: After output of eight clocks, clock output is set to low level and the wait state is set. Slave mode: After input of eight clocks, the clock is set to low level and the wait state is set for the master device.
1	Interrupt request is generated at the ninth clock's falling edge. Master mode: After output of nine clocks, clock output is set to low level and the wait state is set. Slave mode: After input of nine clocks, the clock is set to low level and the wait state is set for the master device.
During address transfer, an interrupt occurs at the falling edge of the ninth clock regardless of this bit setting. This bit setting becomes valid when the address transfer is completed. In master mode, a wait state is inserted at the falling edge of the ninth clock during address transfer. For a slave device that has received a local address, a wait state is inserted at the falling edge of the ninth clock after $\overline{ACK}$ is generated. The slave device that has received an extension code, however, enters a wait state at the falling edge of the eighth clock.	

Condition for clearing (WTIMn bit = 0)	Condition for setting (WTIMn bit = 1)
• Cleared by instruction • After reset	• Set by instruction

ACKEn[Note]	Acknowledgment control
0	Acknowledgment disabled.
1	Acknowledgment enabled. During the ninth clock period, the SDA0n line is set to low level.
The ACKEn bit setting is invalid for address reception by the slave device. In this case, $\overline{ACK}$ is generated when the addresses match. However, the ACKEn bit setting is valid for reception of the extension code. Set the ACKEn bit in the system that receives the extension code.	

Condition for clearing (ACKEn bit = 0)	Condition for setting (ACKEn bit = 1)
• Cleared by instruction • After reset	• Set by instruction

Note This flag's signal is invalid when the IICEn bit = 0.

Remark n = 0 to 2

(3/4)

STTn	Start condition trigger
0	Start condition is not generated.
1	When bus is released (in STOP mode): A start condition is generated (for starting as master). The SDA0n line is changed from high level to low level while the SCLn line is high level and then the start condition is generated. Next, after the rated amount of time has elapsed, the SCL0n line is changed to low level. During communication with a third party: If the communication reservation function is enabled (IICFn.IICRSVn bit = 0) • This trigger functions as a start condition reserve flag. When set to 1, it releases the bus and then automatically generates a start condition. If the communication reservation function is disabled (IICRSVn = 1) • The IICFn.STCFn bit is set to 1 and information set (1) to the STTn bit is cleared. This trigger does not generate a start condition. In the wait state (when master device): A restart condition is generated after the wait state is released.

Cautions concerning set timing

For master reception: Cannot be set to 1 during transfer. Can be set to 1 only when the ACKEn bit has been set to 0 and the slave has been notified of final reception.

For master transmission: A start condition may not be generated normally during the $\overline{\text{ACK}}$ period. Set to 1 during the wait period that follows output of the ninth clock.

For slave: Even when the communication reservation function is disabled (IICRSVn bit = 1), the communication reservation status is entered.

- Setting to 1 at the same time as the SPTn bit is prohibited.
- When the STTn bit is set to 1, setting the STTn bit to 1 again is disabled until the setting is cleared to 0.

Condition for clearing (STTn bit = 0)	Condition for setting (STTn bit = 1)
• When the STTn bit is set to 1 in the communication reservation disabled status • Cleared by loss in arbitration • Cleared after start condition is generated by master device • When the LRELn bit = 1 (communication save) • When the IICEn bit = 0 (operation stop) • After reset	• Set by instruction

Remarks 1. The STTn bit is 0 if it is read immediately after data setting.

2. n = 0 to 2

(4/4)

SPTn	Stop condition trigger
0	Stop condition is not generated.
1	Stop condition is generated (termination of master device's transfer). After the SDA0n line goes to low level, either set the SCL0n line to high level or wait until the SCL0n pin goes to high level. Next, after the rated amount of time has elapsed, the SDA0n line is changed from low level to high level and a stop condition is generated.

Cautions concerning set timing

For master reception: Cannot be set to 1 during transfer.
Can be set to 1 only when the ACKEn bit has been set to 0 and during the wait period after the slave has been notified of final reception.

For master transmission: A stop condition may not be generated normally during the $\overline{\text{ACK}}$ reception period. Set to 1 during the wait period that follows output of the ninth clock.

- Cannot be set to 1 at the same time as the STTn bit.
- The SPTn bit can be set to 1 only when in master mode[Note].
- When the WTIMn bit has been set to 0, if the SPTn bit is set to 1 during the wait period that follows output of eight clocks, note that a stop condition will be generated during the high-level period of the ninth clock.
  The WTIMn bit should be changed from 0 to 1 during the wait period following output of eight clocks, and the SPTn bit should be set to 1 during the wait period that follows output of the ninth clock.
- When the SPTn bit is set to 1, setting the SPTn bit to 1 again is disabled until the setting is cleared to 0.

Condition for clearing (SPTn bit = 0)	Condition for setting (SPTn bit = 1)
• Cleared by loss in arbitration • Automatically cleared after stop condition is detected • Cleared when the LRELn bit = 1 (communication save) • When the IICEn bit = 0 (operation stop) • After reset	• Set by instruction

Note Set the SPTn bit to 1 only in master mode. However, to perform a master operation before detecting the first stop condition after operation has been enabled when the IICRSVn bit is 0, the SPTn bit must be set to 1 and a stop condition must be set. For details, see **19.15 Cautions**.

Caution If the WRELn bit is set to 1 during the ninth clock and the wait state is canceled when the TRCn bit is 1, the TRCn bit is cleared to 0 and the SDA0n line is set to high impedance.

Remarks 1. The SPTn bit is 0 if it is read immediately after data setting.

2. n = 0 to 2

(2) IIC status registers 0 to 2 (IICS0 to IICS2)

The IICSn registers indicate the status of I²C0n (n = 0 to 2).

These registers are read-only, in 8-bit or 1-bit units. However, the IICSn registers can only be read when the IICCn.STTn bit is 1 or during the wait period.

Reset sets these registers to 00H.

Caution Accessing the IICSn registers is prohibited in the following statuses. For details, see 3.4.8 (2) Accessing specific on-chip peripheral I/O registers.

- **When the CPU operates on the subclock and the main clock oscillation is stopped**
- **When the CPU operates on the internal oscillation clock**

(1/3)

After reset: 00H R Address: IICS0 FFFFFD86H, IICS1 FFFFFD96H, IICS2 FFFFFDA6H

	<7>	<6>	<5>	<4>	<3>	<2>	<1>	<0>
IICSn	MSTSn	ALDn	EXCn	COIn	TRCn	ACKDn	STDn	SPDn

(n = 0 to 2)

MSTSn	Master device status
0	Slave device status or communication standby status
1	Master device communication status

Condition for clearing (MSTSn bit = 0)	Condition for setting (MSTSn bit = 1)
• When a stop condition is detected • When the ALDn bit = 1 (arbitration loss) • Cleared by LRELn bit = 1 (communication save) • When the IICEn bit changes from 1 to 0 (operation stop) • After reset	• When a start condition is generated

ALDn	Arbitration loss detection
0	This status means either that there was no arbitration or that the arbitration result was a “win”.
1	This status indicates the arbitration result was a “loss”. The MSTSn bit is cleared to 0.

Condition for clearing (ALDn bit = 0)	Condition for setting (ALDn bit = 1)
• Automatically cleared after the IICSn register is read[Note] • When the IICEn bit changes from 1 to 0 (operation stop) • After reset	• When the arbitration result is a “loss”.

EXCn	Detection of extension code reception
0	Extension code was not received.
1	Extension code was received.

Condition for clearing (EXCn bit = 0)	Condition for setting (EXCn bit = 1)
• When a start condition is detected • When a stop condition is detected • Cleared by LRELn bit = 1 (communication save) • When the IICEn bit changes from 1 to 0 (operation stop) • After reset	• When the higher four bits of the received address data are either “0000” or “1111” (set at the rising edge of the eighth clock).

Note This bit is also cleared when a bit manipulation instruction is executed for another bit in the IICSn register.

(2/3)

COIn	Matching address detection
0	Addresses do not match.
1	Addresses match.

Condition for clearing (COIn bit = 0)	Condition for setting (COIn bit = 1)
• When a start condition is detected • When a stop condition is detected • Cleared by LRELn bit = 1 (communication save) • When the IICEn bit changes from 1 to 0 (operation stop) • After reset	• When the received address matches the local address (SVAn register) (set at the rising edge of the eighth clock).

TRCn	Transmit/receive status detection
0	Receive status (other than transmit status). The SDA0n line is set to high impedance.
1	Transmit status. The value in the SO latch is enabled for output to the SDA0n line (valid starting at the falling edge of the first byte's ninth clock).

Condition for clearing (TRCn bit = 0)	Condition for setting (TRCn bit = 1)
• When a stop condition is detected • Cleared by LRELn bit = 1 (communication save) • When the IICEn bit changes from 1 to 0 (operation stop) • Cleared by IICCn.WRELn bit = 1[Note] • When the ALDn bit changes from 0 to 1 (arbitration loss) • After reset Master • When "1" is output to the first byte's LSB (transfer direction specification bit) Slave • When a start condition is detected When not used for communication	Master • When a start condition is generated • When "0" is output to the first byte's LSB (transfer direction specification bit) Slave • When "1" is input by the first byte's LSB (transfer direction specification bit)

ACKDn	$\overline{\text{ACK}}$ detection
0	$\overline{\text{ACK}}$ was not detected.
1	$\overline{\text{ACK}}$ was detected.

Condition for clearing (ACKDn bit = 0)	Condition for setting (ACKD bit = 1)
• When a stop condition is detected • At the rising edge of the next byte's first clock • Cleared by LRELn bit = 1 (communication save) • When the IICEn bit changes from 1 to 0 (operation stop) • After reset	• After the SDA0n bit is set to low level at the rising edge of the SCL0n pin's ninth clock

Note The TRCn bit is cleared to 0 and SDA0n line becomes high impedance when the WRELn bit is set to 1 and the wait state is canceled to 0 at the ninth clock by TRCn bit = 1.

Remark n = 0 to 2

(3/3)

STDn	Start condition detection
0	Start condition was not detected.
1	Start condition was detected. This indicates that the address transfer period is in effect

Condition for clearing (STDn bit = 0)	Condition for setting (STDn bit = 1)
• When a stop condition is detected • At the rising edge of the next byte's first clock following address transfer • Cleared by LRELn bit = 1 (communication save) • When the IICEn bit changes from 1 to 0 (operation stop) • After reset	• When a start condition is detected

SPDn	Stop condition detection
0	Stop condition was not detected.
1	Stop condition was detected. The master device's communication is terminated and the bus is released.

Condition for clearing (SPDn bit = 0)	Condition for setting (SPDn bit = 1)
• At the rising edge of the address transfer byte's first clock following setting of this bit and detection of a start condition • When the IICEn bit changes from 1 to 0 (operation stop) • After reset	• When a stop condition is detected

Remark n = 0 to 2

(3) IIC flag registers 0 to 2 (IICF0 to IICF2)

The IICFn registers set the I²C0n operation mode and indicate the I²C bus status.

These registers can be read or written in 8-bit or 1-bit units. However, the STCFn and IICBSYn bits are read-only.

IICRSVn enables/disables the communication reservation function (see **19.14 Communication Reservation**).

The initial value of the IICBSYn bit is set by using the STCENn bit (see **19.15 Cautions**).

The IICRSVn and STCENn bits can be written only when operation of I²C0n is disabled (IICCn.IICEn bit = 0). After operation is enabled, IICFn can be read (n = 0 to 2).

Reset sets these registers to 00H.

After reset: 00H R/W[Note] Address: IICF0 FFFFFD8AH, IICF1 FFFFFD9AH, IICF2 FFFFFDAAH

	<7>	<6>	5	4	3	2	<1>	<0>
IICFn	STCFn	IICBSYn	0	0	0	0	STCENn	IICRSVn

(n = 0 to 2)

STCFn	STTn bit clear
0	Start condition issued
1	Start condition cannot be issued, STTn bit cleared

Condition for clearing (STCFn bit = 0)	Condition for setting (STCFn bit = 1)
• Cleared by IICCn.STTn bit = 1 • When the IICCn.IICEn bit = 0 • After reset	• When start condition is not issued and STTn flag is cleared to 0 when communication reservation is disabled (IICRSVn bit = 1).

IICBSYn	I²C0n bus status
0	Bus release status (default communication status when STCENn bit = 1)
1	Bus communication status (default communication status when STCENn bit = 0)

Condition for clearing (IICBSYn bit = 0)	Condition for setting (IICBSYn bit = 1)
• When stop condition is detected • When the IICEn bit = 0 • After reset	• When start condition is detected • By setting the IICEn bit when the STCENn bit = 0

STCENn	Initial start enable trigger
0	Start conditions cannot be generated until a stop condition is detected following operation enable (IICEn bit = 1).
1	Start conditions can be generated even if a stop condition is not detected following operation enable (IICEn bit = 1).

Condition for clearing (STCENn bit = 0)	Condition for setting (STCENn bit = 1)
• When start condition is detected • After reset	• Setting by instruction

IICRSVn	Communication reservation function disable bit
0	Communication reservation enabled
1	Communication reservation disabled

Condition for clearing (IICRSVn bit = 0)	Condition for setting (IICRSVn bit = 1)
• Clearing by instruction • After reset	• Setting by instruction

Note Bits 6 and 7 are read-only bits.

Cautions 1. Write the STCENn bit only when operation is stopped (IICEn bit = 0).

2. When the STCENn bit = 1, the bus released status (IICBSYn bit = 0) is recognized regardless of the actual bus status immediately after the I²Cn bus operation is enabled. Therefore, to issue the first start condition (STTn bit = 1), it is necessary to confirm that the bus has been released, so as to not disturb other communications.

3. Write the IICRSVn bit only when operation is stopped (IICEn bit = 0).

(4) IIC clock select registers 0 to 2 (IICCL0 to IICCL2)

The IICCLn registers set the transfer clock for I²C0n.

These registers can be read or written in 8-bit or 1-bit units. However, the CLDn and DADn bits are read-only.

Set the IICCLn registers when the IICCn.IICEn bit = 0.

The SMCn, CLn1, and CLn0 bits are set by combining the IICXn.CLXn bit and the OCKSTHm, OCKSm1, and OCKSm0 bits of the OCKSm register (see **19.4 (6) I²C0n transfer clock setting method**) (n = 0 to 2, m = 0, 1).

Reset sets these registers to 00H.

After reset: 00H R/W[Note] Address: IICCL0 FFFFFD84H, IICCL1 FFFFFD94H, IICCL2 FFFFFDA4H

IICCLn (n = 0 to 2)

7	6	<5>	<4>	3	2	1	0
0	0	CLDn	DADn	SMCn	DFCn	CLn1	CLn0

CLDn	Detection of SCL0n pin level (valid only when IICCn.IICEn bit = 1)
0	The SCL0n pin was detected at low level.
1	The SCL0n pin was detected at high level.

Condition for clearing (CLDn bit = 0)	Condition for setting (CLDn bit = 1)
• When the SCL0n pin is at low level • When the IICEn bit = 0 (operation stop) • After reset	• When the SCL0n pin is at high level

DADn	Detection of SDA0n pin level (valid only when IICEn bit = 1)
0	The SDA0n pin was detected at low level.
1	The SDA0n pin was detected at high level.

Condition for clearing (DADn bit = 0)	Condition for setting (DAD0n bit = 1)
• When the SDA0n pin is at low level • When the IICEn bit = 0 (operation stop) • After reset	• When the SDA0n pin is at high level

SMCn	Operation mode switching
0	Operation in standard mode.
1	Operation in high-speed mode.

DFCn	Digital filter operation control
0	Digital filter off.
1	Digital filter on.
The digital filter can be used only in high-speed mode. In high-speed mode, the transfer clock does not vary according to the DFCn bit setting (on/off). The digital filter is used to eliminate noise in high-speed mode.	

Note Bits 4 and 5 are read-only bits.

Caution Be sure to clear bits 7 and 6 to "0".

Remark When the IICCn.IICEn bit = 0, 0 is read when reading the CLDn and DADn bits.

(5) IIC function expansion registers 0 to 2 (IICX0 to IICX2)

The IICXn registers set I²C0n function expansion (valid only in the high-speed mode).

These registers can be read or written in 8-bit or 1-bit units.

Setting of the CLXn bit is performed in combination with the SMCn, CLn1, and CLn0 bits of the IICCLn register and the OCKSTHm, OCKSm1, and OCKSm0 bits of the OCKSm register (see **19.4 (6) I²C0n transfer clock setting method**) (m = 0, 1).

Set the IICXn registers when the IICCn.IICEn bit = 0.

Reset sets these registers to 00H.

After reset: 00H R/W Address: IICX0 FFFFFD85H, IICX1 FFFFFD95H, IICX2 FFFFFDA5H

	7	6	5	4	3	2	1	<0>
IICXn	0	0	0	0	0	0	0	CLXn

(n = 0 to 2)

(6) I²C0n transfer clock setting method

The I²C0n transfer clock frequency (f_{SCL}) is calculated using the following expression (n = 0 to 2).

$$f_{SCL} = 1/(m \times T + t_R + t_F)$$

m = 24, 48, 72, 96, 108, 120, 144, 172, 192, 240, 264, 344, 352, 396, 440, 516, 688, 860 (see **Table 19-2 Clock Settings**).

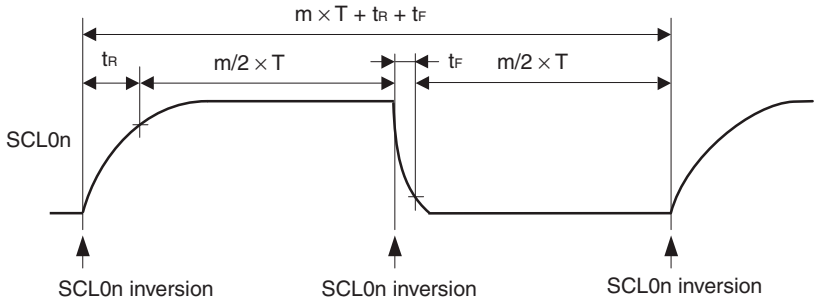
T: 1/f_{XX}

t_R: SCL0n pin rise time

t_F: SCL0n pin fall time

For example, the I²C0n transfer clock frequency (f_{SCL}) when f_{XX} = 19.2 MHz, m = 198, t_R = 200 ns, and t_F = 50 ns is calculated using following expression.

$$f_{SCL} = 1/(198 \times 52 \text{ ns} + 200 \text{ ns} + 50 \text{ ns}) \cong 94.7 \text{ kHz}$$



The clock to be selected can be set by combining of the SMCn, CLn1, and CLn0 bits of the IICCLn register, the CLXn bit of the IICXn register, and the OCKSTHm, OCKSm1, and OCKSm0 bits of the OCKSm register (n = 0 to 2, m = 0, 1).

Table 19-2. Clock Settings

IICXn	IICCLn			Selection Clock	Transfer Clock	Settable Main Clock Frequency (fxx) Range	Transfer Speed	Operating Mode
CLXn	SMCn	CLn1	CLn0					
0	0	0	0	fxx/6 (OCKSm = 11H)	fxx/264	24.00 MHz ≤ fxx ≤ 25.14 MHz	90.91 kHz to 95.23 kHz	Standard mode (SMCn = 0)
				fxx/8 (OCKSm= 12H)	fxx/352	24.00 MHz ≤ fxx ≤ 33.52 MHz	68.18 kHz to 95.23 kHz	
				fxx/10 (OCKSm = 13H)	fxx/440	30.00 MHz ≤ fxx ≤ 41.90 MHz	68.18 kHz to 95.23 kHz	
0	0	0	1	fxx/4 (OCKSm = 10H)	fxx/344	24.00 MHz ≤ fxx ≤ 33.52 MHz	48.72 kHz to 97.44 kHz	
				fxx/6 (OCKSm= 11H)	fxx/516	25.14 MHz ≤ fxx ≤ 48.00 MHz	48.72 kHz to 93.02 kHz	
				fxx/8 (OCKSm = 12H)	fxx/688	33.52 MHz ≤ fxx ≤ 48.00 MHz	48.72 kHz to 69.77 kHz	
				fxx/10 (OCKSm = 13H)	fxx/860	41.90 MHz ≤ fxx ≤ 48.00 MHz	48.72 kHz to 55.81 kHz	
0	0	1	1	fxx/4 (OCKSm = 10H)	fxx/264	24.00 MHz ≤ fxx ≤ 25.60 MHz	90.91 kHz to 96.97 kHz	
				fxx/6 (OCKSm = 11H)	fxx/396	38.40 MHz	96.97 kHz	
0	1	0	X	fxx/4 (OCKSm = 10H)	fxx/96	24.00 MHz ≤ fxx ≤ 33.52 MHz	250.00 kHz to 349.17 kHz	High-speed mode (SMCn = 1)
				fxx/6 (OCKSm = 11H)	fxx/144	24.00 MHz ≤ fxx ≤ 48.00 MHz	166.67 kHz to 333.33 kHz	
				fxx/8 (OCKSm = 12H)	fxx/192	32.00 MHz ≤ fxx ≤ 48.00 MHz	166.67 kHz to 250.00 kHz	
				fxx/10 (OCKSm = 13H)	fxx/240	40.00 MHz ≤ fxx ≤ 48.00 MHz	166.67 kHz to 200.00 kHz	
0	1	1	1	fxx/4 (OCKSm = 10H)	fxx/72	24.00 MHz ≤ fxx ≤ 25.60 MHz	333.33 kHz to 355.56 kHz	
				fxx/6 (OCKSm= 11H)	fxx/108	38.40 MHz	355.56 kHz	
1	1	0	X	fxx/6 (OCKSm = 11H)	fxx/72	24.00 MHz ≤ fxx ≤ 25.14 MHz	333.33 kHz to 349.17 kHz	
				fxx/8 (OCKSm = 12H)	fxx/96	32.00 MHz ≤ fxx ≤ 33.52 MHz	333.33 kHz to 349.17 kHz	
				fxx/10 (OCKSm = 13H)	fxx/120	40.00 MHz ≤ fxx ≤ 41.90 MHz	333.33 kHz to 349.17 kHz	
Other than above				Setting prohibited	–	–	–	–

Remarks 1. n = 0 to 2,
m = 0, 1

2. ×: don't care

(7) IIC division clock select registers 0, 1 (OCKS0, OCKS1)

The OCKSm registers control the I²C0n division clock (n = 0 to 2, m = 0, 1).

These registers control the I²C00 division clock via the OCKS0 register and the I²C01 and I²C02 division clocks via the OCKS1 register.

These registers can be read or written in 8-bit units.

Reset sets these registers to 00H.

After reset: 00H R/W Address: OCKS0 FFFFF340H, OCKS1 FFFFF344H

	7	6	5	4	3	2	1	0
OCKSm	0	0	0	OCKSENm	OCKSTHm	0	OCKSm1	OCKSm0

(m = 0, 1)

OCKSENm	Operation setting of I²C division clock
0	Stops I²C division clock operation
1	Enables I²C division clock operation

OCKSTHm	OCKSm1	OCKSm0	Selection of I²C division clock
0	0	0	fxx/4
0	0	1	fxx/6
0	1	0	fxx/8
0	1	1	fxx/10
1	0	0	fxx/2

(8) IIC shift registers 0 to 2 (IIC0 to IIC2)

The IICn registers are used for serial transmission/reception (shift operations) synchronized with the serial clock. These registers can be read or written in 8-bit units, but data should not be written to the IICn registers during a data transfer.

Access (read/write) the IICn registers only during the wait period. Accessing these registers in communication states other than the wait period is prohibited. However, for the master device, the IICn registers can be written once only after the transmission trigger bit (IICCn.STTn bit) has been set to 1.

A wait state is released by writing the IICn registers during the wait period, and data transfer is started (n = 0 to 2).

Reset sets these registers to 00H.

After reset: 00H R/W Address: IIC0 FFFFFD80H, IIC1 FFFFFD90H, IIC2 FFFFFDA0H

	7	6	5	4	3	2	1	0
IICn								

(n = 0 to 2)

(9) Slave address registers 0 to 2 (SVA0 to SVA2)

The SVAn registers hold the I2C bus's slave address.

These registers can be read or written in 8-bit units, but bit 0 should be fixed to 0. However, rewriting these registers is prohibited when the IICSn.STDn bit = 1 (start condition detection).

Reset sets these registers to 00H.

After reset: 00H R/W Address: SVA0 FFFFFD83H, SVA1 FFFFFD93H, SVA2 FFFFFDA3H

	7	6	5	4	3	2	1	0
SVAn								0

(n = 0 to 2)

19.5 I²C Bus Mode Functions

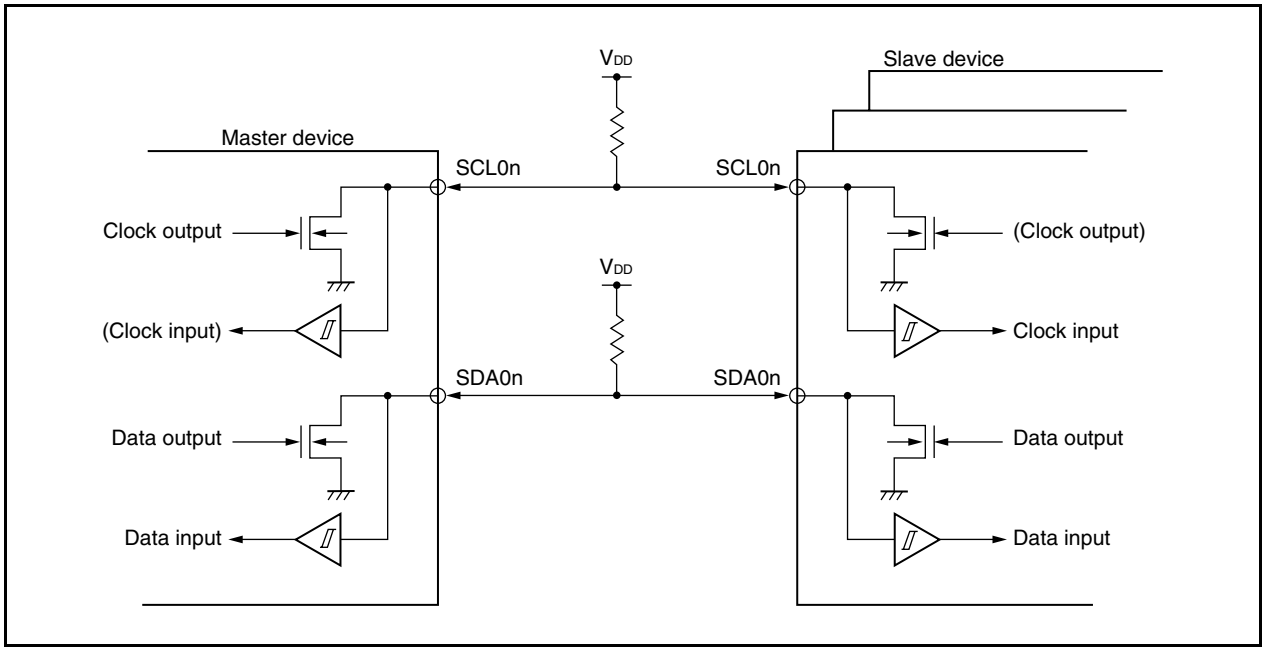
19.5.1 Pin configuration

The serial clock pin (SCL0n) and serial data bus pin (SDA0n) are configured as follows (n = 0 to 2).

SCL0n .....This pin is used for serial clock input and output.
This pin is an N-ch open-drain output for both master and slave devices. Input is Schmitt input.
SDA0n .....This pin is used for serial data input and output.
This pin is an N-ch open-drain output for both master and slave devices. Input is Schmitt input.

Since outputs from the serial clock line and the serial data bus line are N-ch open-drain outputs, an external pull-up resistor is required.

Figure 19-6. Pin Configuration Diagram

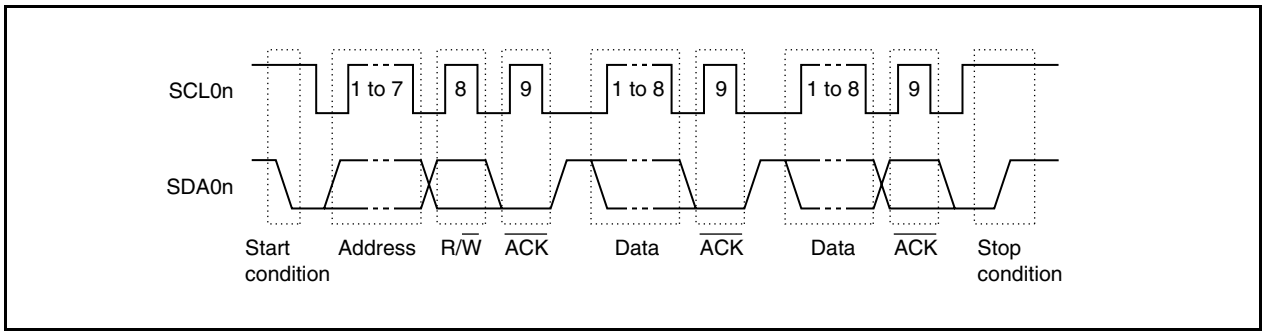


19.6 I²C Bus Definitions and Control Methods

The following section describes the I²C bus's serial data communication format and the signals used by the I²C bus.

The transfer timing for the "start condition", "address", "transfer direction specification", "data", and "stop condition" generated on the I²C bus's serial data bus is shown below.

Figure 19-7. I²C Bus Serial Data Transfer Timing



The master device generates the start condition, slave address, and stop condition.

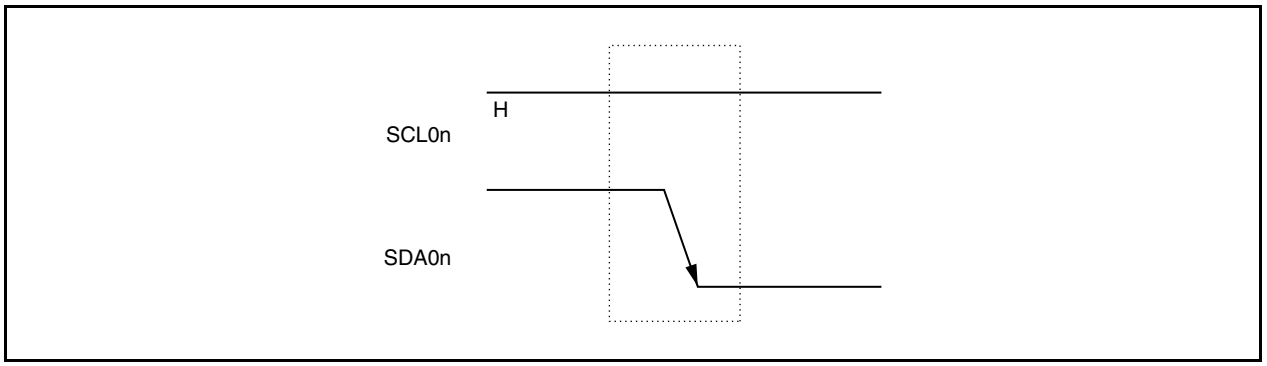
$\overline{ACK}$ can be generated by either the master or slave device (normally, it is generated by the device that receives 8-bit data).

The serial clock (SCL0n) is continuously output by the master device. However, in the slave device, the SCL0n pin's low-level period can be extended and a wait state can be inserted (n = 0 to 2).

19.6.1 Start condition

A start condition is met when the SCL0n pin is high level and the SDA0n pin changes from high level to low level. The start condition for the SCL0n and SDA0n pins is a signal that the master device outputs to the slave device when starting a serial transfer. The slave device can detect the start condition (n = 0 to 2).

Figure 19-8. Start Condition



A start condition is output when the IICCn.STTn bit is set (1) after a stop condition has been detected (IICSn.SPDn bit = 1). When a start condition is detected, the IICSn.STDn bit is set (1) (n = 0 to 2).

Caution When the IICCn.IICEn bit of the V850ES/JG3-H and V850ES/JH3-H is set to 1 while other devices are communicating, the start condition may be detected depending on the status of the communication line. Be sure to set the IICCn.IICEn bit to 1 when the SCL0n and SDA0n lines are high level.

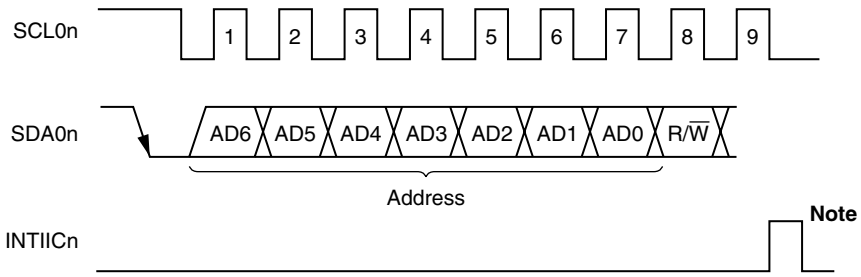
19.6.2 Addresses

The 7 bits of data that follow the start condition are defined as an address.

An address is a 7-bit data segment that is output so that the master device can select one of the slave devices that are connected to the bus lines. Therefore, each slave device connected via the bus lines must have a unique address.

The slave devices detect via hardware the start condition and check whether or not the 7-bit address data matches the data values stored in the SVAn register. If the address data matches the values of the SVAn register, the slave device is selected and communicates with the master device until the master device generates a start condition or stop condition (n = 0 to 2).

Figure 19-9. Address



Note The interrupt request signal (INTIICn) is generated if a local address or extension code is received during slave device operation.

Remark n = 0 to 2

An address is output when the slave address and the transfer direction described in **19.6.3 Transfer direction specification** are written together to the IICn registers as eight bits of data. Received addresses are written to the IICn register (n = 0 to 2).

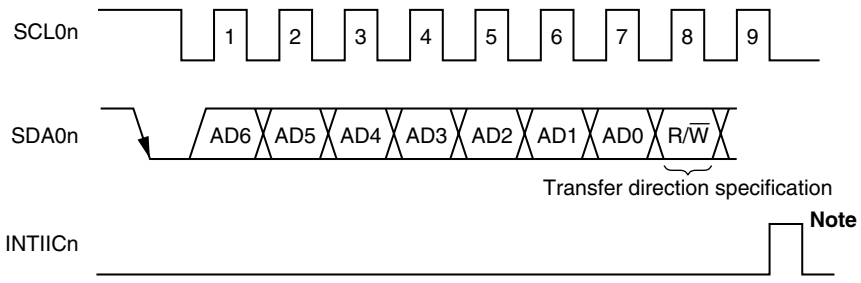
The slave address is assigned to the higher 7 bits of the IICn register.

19.6.3 Transfer direction specification

In addition to the 7-bit address data, the master device sends 1 bit of data that specifies the transfer direction.

When this transfer direction specification bit has a value of 0, it indicates that the master device is transmitting data to a slave device. When the transfer direction specification bit has a value of 1, it indicates that the master device is receiving data from a slave device.

Figure 19-10. Transfer Direction Specification



Note The INTIICn signal is generated if a local address or extension code is received during slave device operation.

Remark n = 0 to 2

19.6.4 $\overline{\text{ACK}}$

$\overline{\text{ACK}}$ is used to confirm the serial data status of the transmitting and receiving devices.

The receiving device returns $\overline{\text{ACK}}$ for every 8 bits of data it receives.

The transmitting device normally receives $\overline{\text{ACK}}$ after transmitting 8 bits of data. When $\overline{\text{ACK}}$ is returned from the receiving device, the reception is judged as normal and processing continues. The detection of $\overline{\text{ACK}}$ is confirmed using the IICSn.ACKDn bit.

When the master device is the receiving device, after receiving the final data, it does not return $\overline{\text{ACK}}$ and generates a stop condition. When the slave device is the receiving device and does not return $\overline{\text{ACK}}$, the master device generates either a stop condition or a restart condition, and then stops the current transmission. Failure to return $\overline{\text{ACK}}$ may be caused by the following factors.

(a) Reception was not performed normally.
(b) The final data was received.
(c) The receiving device (slave) does not exist at the specified address.

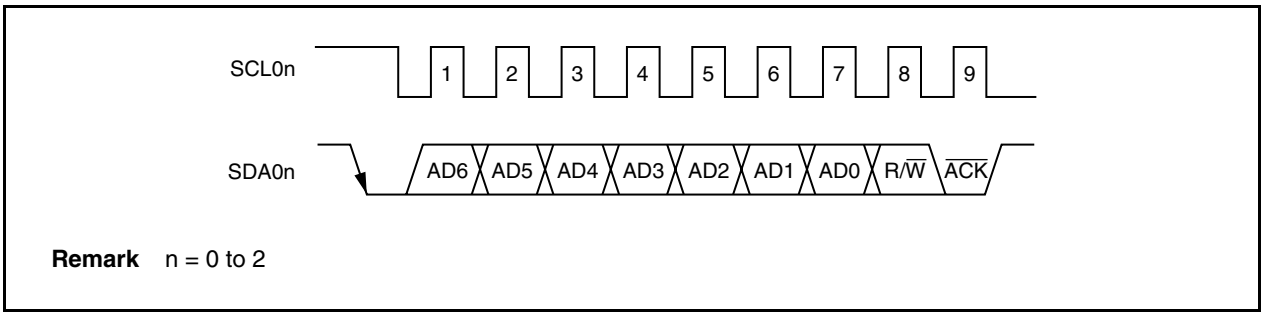
When the receiving device sets the SDA0n line to low level during the ninth clock, $\overline{\text{ACK}}$ is generated (normal reception).

When the IICCn.ACKEn bit is set to 1, automatic $\overline{\text{ACK}}$ generation is enabled. Transmission of the eighth bit following the 7 address data bits causes the IICSn.TRCn bit to be set. Normally, set the ACKEn bit to 1 for reception (TRCn bit = 0).

When the slave device is receiving (when TRCn bit = 0), if the slave device cannot receive data or does not need the subsequent data, clear the ACKEn bit to 0 to indicate to the master that no more data can be received.

Similarly, when the master device is receiving (when TRCn bit = 0) and the subsequent data is not needed, clear the ACKEn bit to 0 to prevent $\overline{\text{ACK}}$ from being generated. This notifies the slave device (transmitting device) of the end of the data transmission (transmission stopped).

Figure 19-11. $\overline{\text{ACK}}$



Remark n = 0 to 2

When the local address is received, $\overline{\text{ACK}}$ is automatically generated regardless of the value of the ACKEn bit. No $\overline{\text{ACK}}$ is generated if an address other than the local address is received (NACK).

When receiving the extension code, set the ACKEn bit to 1 in advance to generate $\overline{\text{ACK}}$.

The $\overline{\text{ACK}}$ generation method during data reception is based on the wait timing setting, as described by the following.

- When 8-clock wait is selected (IICCn.WTIMn bit = 0):
  $\overline{\text{ACK}}$ is generated in synchronization with the falling edge of the SCL0n pin's eighth clock if the ACKEn bit is set to 1 before wait state cancellation.
- When 9-clock wait is selected (IICCn.WTIMn bit = 1):
  $\overline{\text{ACK}}$ is generated if the ACKEn bit is set to 1 in advance.

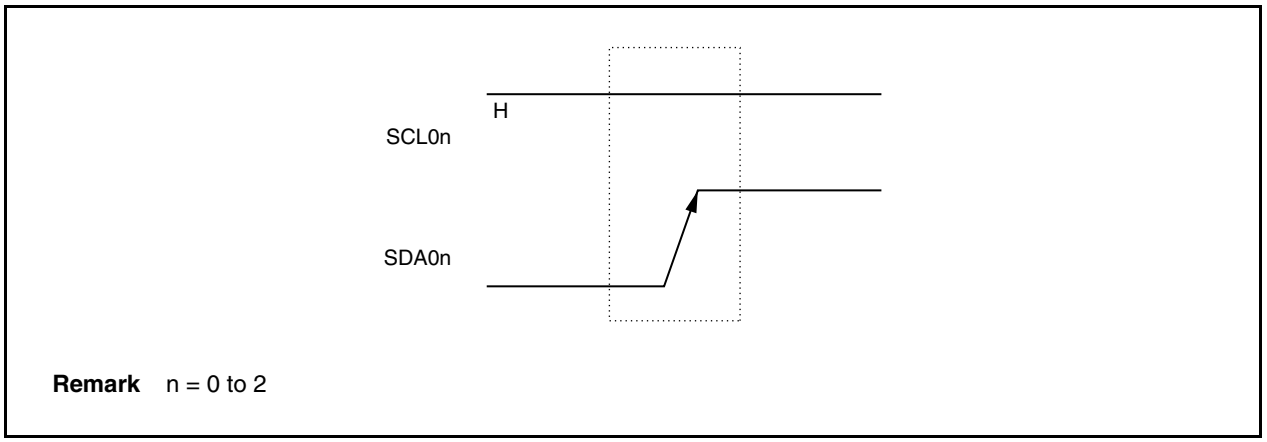
Remark n = 0 to 2

19.6.5 Stop condition

When the SCL0n pin is high level, changing the SDA0n pin from low level to high level generates a stop condition (n = 0 to 2).

A stop condition is generated when serial transfer from the master device to the slave device has been completed. When the V850ES/JG3-H or V850ES/JH3-H is used as the slave device, it can detect the stop condition.

Figure 19-12. Stop Condition



Remark n = 0 to 2

A stop condition is generated when the IICCn.SPTn bit is set to 1. When the stop condition is detected, the IICSn.SPDn bit is set to 1 and the interrupt request signal (INTIICn) is generated when the IICCn.SPIEn bit is set to 1 (n = 0 to 2).

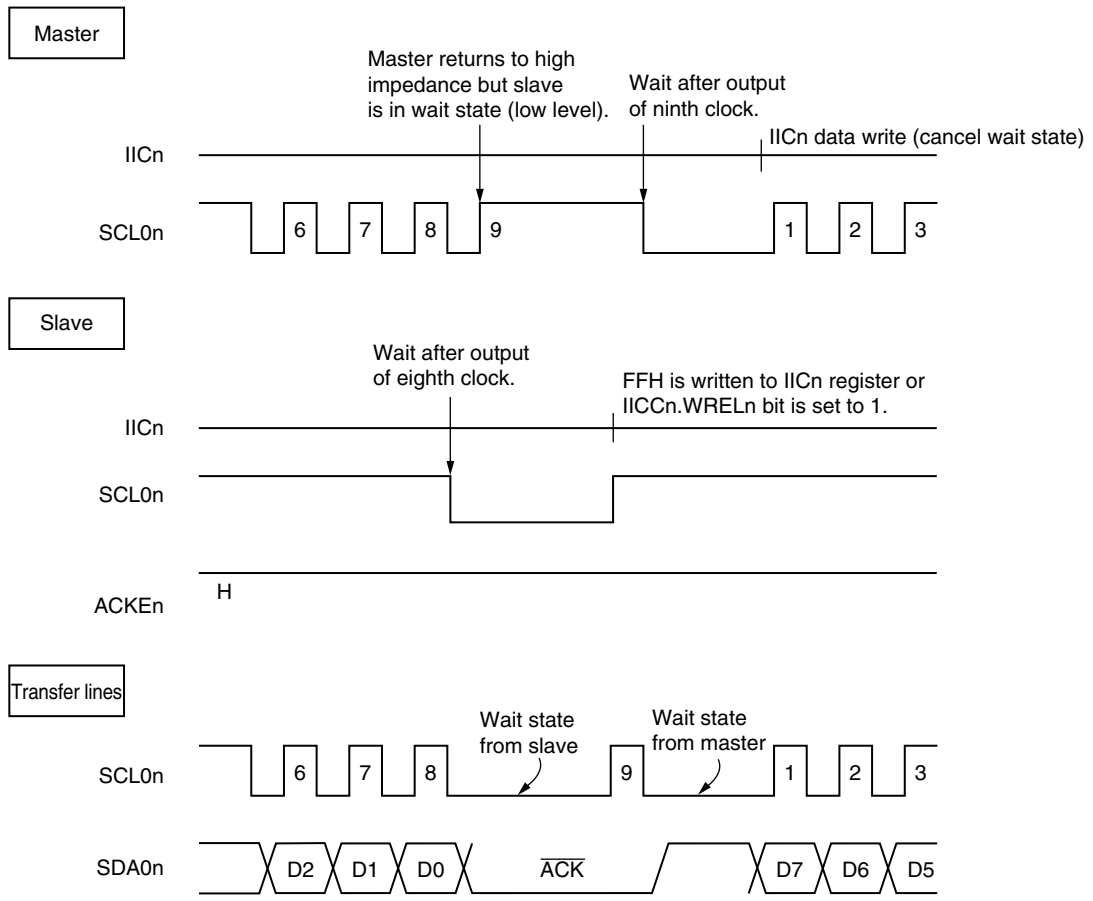
19.6.6 Wait state

A wait state is used to notify the communication partner that a device (master or slave) is preparing to transmit or receive data (i.e., is in a wait state).

Setting the SCL0n pin to low level notifies the communication partner of the wait state. When the wait state has been canceled for both the master and slave devices, the next data transfer can begin (n = 0 to 2).

Figure 19-13. Wait State (1/2)

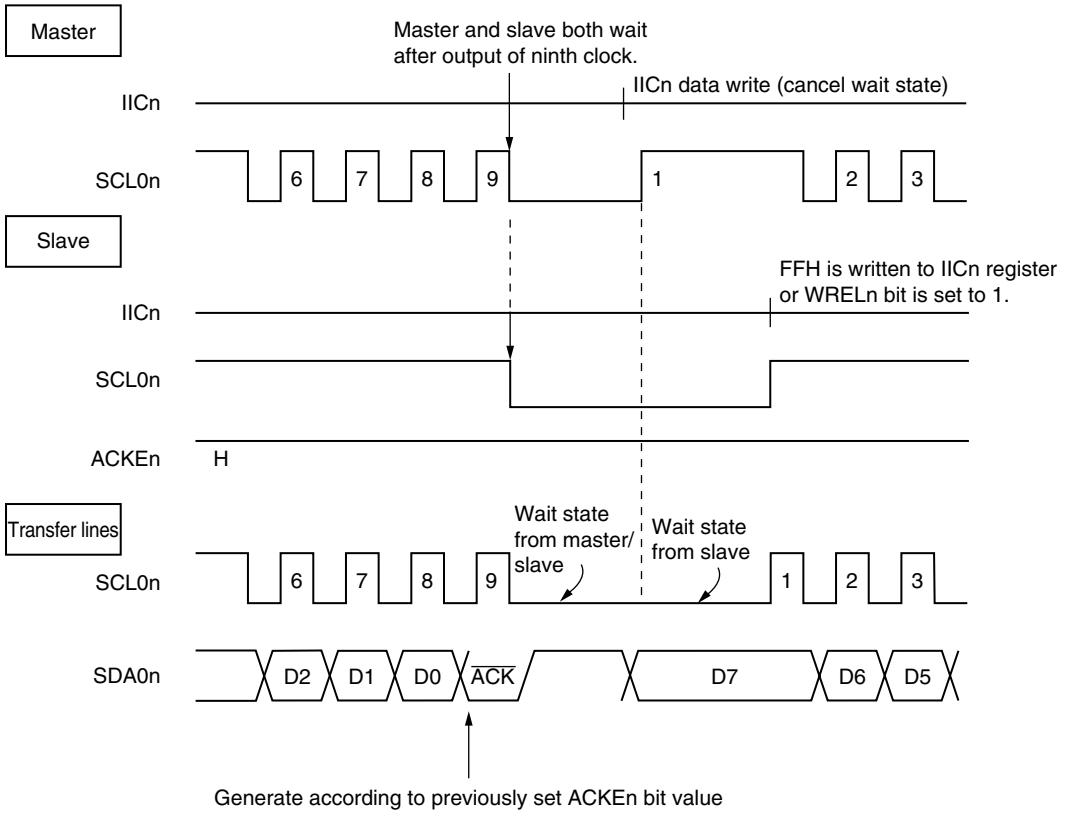
(a) When master device is in a nine-clock wait state and slave device is in an eight-clock wait state (master: transmission, slave: reception, and IICCn.ACKEn bit = 1)



Remark n = 0 to 2

Figure 19-13. Wait State (2/2)

(b) When master and slave devices are both in a nine-clock wait state (master: transmission, slave: reception, and ACKEn bit = 1)



Remark n = 0 to 2

A wait state may be automatically generated depending on the setting of the IICCn.WTIMn bit (n = 0 to 2).

Normally, the receiving side cancels the wait state when the IICCn.WRELn bit is set to 1 or when FFH is written to the IICn register and the transmitting side cancels the wait state when data is written to the IICn register.

The master device can also cancel the wait state via either of the following methods.

- By setting the IICCn.STTn bit to 1
- By setting the IICCn.SPTn bit to 1

19.6.7 Wait state cancellation method

In the case of I²C0n, a wait state can be canceled normally in the following ways (n = 0 to 2).

- By writing data to the IICn register
- By setting the IICCn.WRELn bit to 1 (wait state cancellation)
- By setting the IICCn.STTn bit to 1 (start condition generation)
- By setting the IICCn.SPTn bit to 1 (stop condition generation)

If any of these wait state cancellation actions is performed, I²C0n will cancel the wait state and restart communication.

When canceling the wait state and sending data (including address), write data to the IICn register.

To receive data after canceling the wait state, or to complete data transmission, set the WRELn bit to 1.

To generate a restart condition after canceling the wait state, set the STTn bit to 1.

To generate a stop condition after canceling the wait state, set the SPTn bit to 1.

Execute cancellation only once for each wait state.

For example, if data is written to the IICn register following wait state cancellation by setting the WRELn bit to 1, a conflict between the SDA0n line change timing and IICn register write timing may result in the data output to SDA0n being an incorrect value.

Even in other operations, if communication is stopped halfway, clearing the IICCn.IICEn bit to 0 will stop communication, enabling the wait state to be cancelled.

If the I²C bus dead-locks due to noise, etc., setting the IICCn.LRELn bit to 1 causes the communication operation to be exited, enabling the wait state to be cancelled.

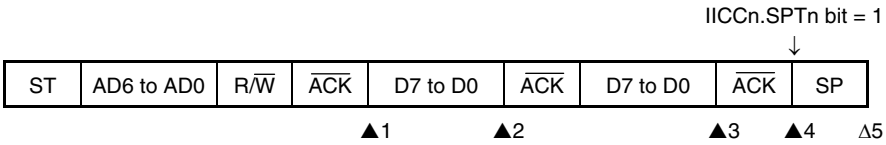
19.7 I²C Interrupt Request Signals (INTIICn)

The following shows the value of the IICSn register at the INTIICn interrupt request signal generation timing and at the INTIICn signal timing (n = 0 to 2).

19.7.1 Master device operation

(1) Start ~ Address ~ Data ~ Data ~ Stop (normal transmission/reception)

<1> When IICCn.WTIMn bit = 0



▲1: IICSn register = 1000X110B

▲2: IICSn register = 1000X000B

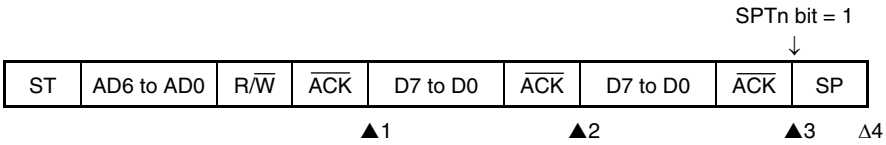
▲3: IICSn register = 1000X000B (WTIMn bit = 1)

▲4: IICSn register = 1000XX00B

Δ 5: IICSn register = 00000001B

Remarks 1. ▲: Always generated
Δ: Generated only when SPIEn bit = 1
X: don't care
2. n = 0 to 2

<2> When WTIMn bit = 1



▲1: IICSn register = 1000X110B

▲2: IICSn register = 1000X100B

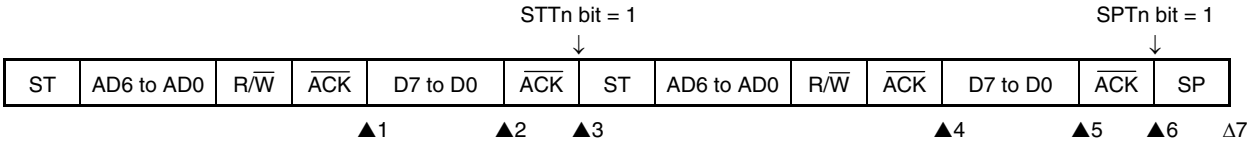
▲3: IICSn register = 1000XX00B

Δ 4: IICSn register = 00000001B

Remarks 1. ▲: Always generated
Δ: Generated only when SPIEn bit = 1
X: don't care
2. n = 0 to 2

(2) Start ~ Address ~ Data ~ Start ~ Address ~ Data ~ Stop (restart)

<1> When WTIMn bit = 0



▲1: IICSn register = 1000X110B

▲2: IICSn register = 1000X000B (WTIMn bit = 1)

▲3: IICSn register = 1000XX00B (WTIMn bit = 0)

▲4: IICSn register = 1000X110B (WTIMn bit = 0)

▲5: IICSn register = 1000X000B (WTIMn bit = 1)

▲6: IICSn register = 1000XX00B

Δ 7: IICSn register = 00000001B

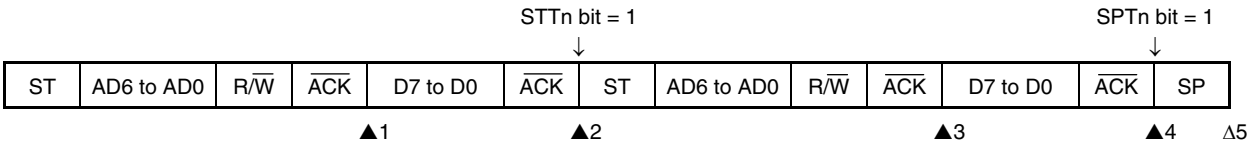
Remarks 1. ▲: Always generated

Δ: Generated only when SPIEn bit = 1

X: don't care

2. n = 0 to 2

<2> When WTIMn bit = 1



▲1: IICSn register = 1000X110B

▲2: IICSn register = 1000XX00B

▲3: IICSn register = 1000X110B

▲4: IICSn register = 1000XX00B

Δ 5: IICSn register = 00000001B

Remarks 1. ▲: Always generated

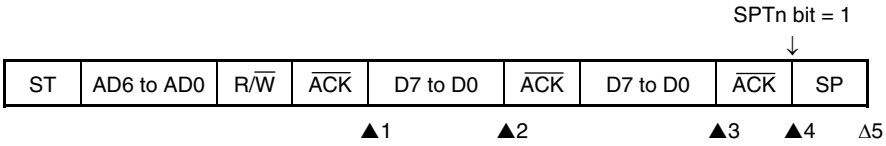
Δ: Generated only when SPIEn bit = 1

X: don't care

2. n = 0 to 2

(3) Start ~ Code ~ Data ~ Data ~ Stop (extension code transmission)

<1> When WTIMn bit = 0



▲1: IICSn register = 1010X110B

▲2: IICSn register = 1010X000B

▲3: IICSn register = 1010X000B (WTIMn bit = 1)

▲4: IICSn register = 1010XX00B

Δ 5: IICSn register = 00000001B

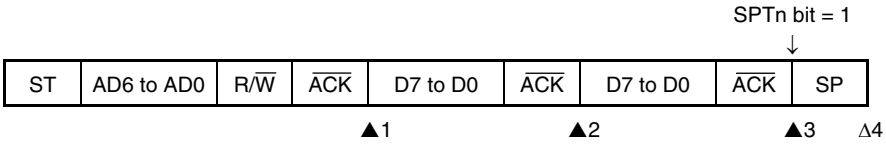
Remarks 1. ▲: Always generated

Δ: Generated only when SPIEn bit = 1

X: don't care

2. n = 0 to 2

<2> When WTIMn bit = 1



▲1: IICSn register = 1010X110B

▲2: IICSn register = 1010X100B

▲3: IICSn register = 1010XX00B

Δ 4: IICSn register = 00000001B

Remarks 1. ▲: Always generated

Δ: Generated only when SPIEn bit = 1

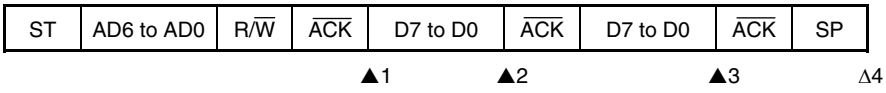
X: don't care

2. n = 0 to 2

19.7.2 Slave device operation (when receiving slave address data (address match))

(1) Start ~ Address ~ Data ~ Data ~ Stop

<1> When IICCn.WTIMn bit = 0



▲1: IICSn register = 0001X110B

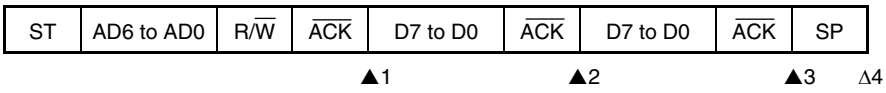
▲2: IICSn register = 0001X000B

▲3: IICSn register = 0001X000B

Δ 4: IICSn register = 00000001B

Remarks 1. ▲: Always generated
Δ: Generated only when IICCn.SPIEn bit = 1
X: don't care
2. n = 0 to 2

<2> When WTIMn bit = 1



▲1: IICSn register = 0001X110B

▲2: IICSn register = 0001X100B

▲3: IICSn register = 0001XX00B

Δ 4: IICSn register = 00000001B

Remarks 1. ▲: Always generated
Δ: Generated only when SPIEn bit = 1
X: don't care
2. n = 0 to 2

(2) Start ~ Address ~ Data ~ Start ~ Address ~ Data ~ Stop

<1> When WTIMn bit = 0 (after restart, address match)

ST	AD6 to AD0	R/$\overline{W}$	$\overline{ACK}$	D7 to D0	$\overline{ACK}$	ST	AD6 to AD0	R/$\overline{W}$	$\overline{ACK}$	D7 to D0	$\overline{ACK}$	SP
			▲1		▲2					▲3	▲4	Δ5

▲1: IICSn register = 0001X110B

▲2: IICSn register = 0001X000B

▲3: IICSn register = 0001X110B

▲4: IICSn register = 0001X000B

Δ 5: IICSn register = 00000001B

Remarks 1. ▲: Always generated

Δ: Generated only when SPIEn bit = 1

X: don't care

2. n = 0 to 2

<2> When WTIMn bit = 1 (after restart, address match)

ST	AD6 to AD0	R/$\overline{W}$	$\overline{ACK}$	D7 to D0	$\overline{ACK}$	ST	AD6 to AD0	R/$\overline{W}$	$\overline{ACK}$	D7 to D0	$\overline{ACK}$	SP
			▲1		▲2					▲3	▲4	Δ5

▲1: IICSn register = 0001X110B

▲2: IICSn register = 0001XX00B

▲3: IICSn register = 0001X110B

▲4: IICSn register = 0001XX00B

Δ 5: IICSn register = 00000001B

Remarks 1. ▲: Always generated

Δ: Generated only when SPIEn bit = 1

X: don't care

2. n = 0 to 2

(3) Start ~ Address ~ Data ~ Start ~ Code ~ Data ~ Stop

<1> When WTIMn bit = 0 (after restart, extension code reception)

ST	AD6 to AD0	R/$\overline{W}$	$\overline{ACK}$	D7 to D0	$\overline{ACK}$	ST	AD6 to AD0	R/$\overline{W}$	$\overline{ACK}$	D7 to D0	$\overline{ACK}$	SP
			▲1		▲2				▲3		▲4	Δ5

▲1: IICSn register = 0001X110B

▲2: IICSn register = 0001X000B

▲3: IICSn register = 0010X010B

▲4: IICSn register = 0010X000B

Δ 5: IICSn register = 00000001B

Remarks 1. ▲: Always generated

Δ: Generated only when SPIEn bit = 1

X: don't care

2. n = 0 to 2

<2> When WTIMn bit = 1 (after restart, extension code reception)

ST	AD6 to AD0	R/$\overline{W}$	$\overline{ACK}$	D7 to D0	$\overline{ACK}$	ST	AD6 to AD0	R/$\overline{W}$	$\overline{ACK}$	D7 to D0	$\overline{ACK}$	SP
			▲1		▲2				▲3	▲4	▲5	Δ6

▲1: IICSn register = 0001X110B

▲2: IICSn register = 0001XX00B

▲3: IICSn register = 0010X010B

▲4: IICSn register = 0010X110B

▲5: IICSn register = 0010XX00B

Δ 6: IICSn register = 00000001B

Remarks 1. ▲: Always generated

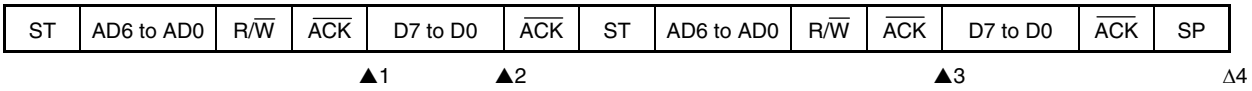
Δ: Generated only when SPIEn bit = 1

X: don't care

2. n = 0 to 2

(4) Start ~ Address ~ Data ~ Start ~ Address ~ Data ~ Stop

<1> When WTIMn bit = 0 (after restart, address mismatch (= not extension code))



▲1: IICSn register = 0001X110B

▲2: IICSn register = 0001X000B

▲3: IICSn register = 00000X10B

Δ 4: IICSn register = 00000001B

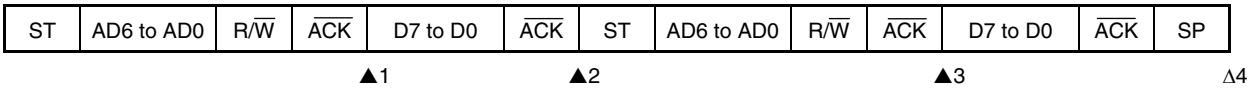
Remarks 1. ▲: Always generated

Δ: Generated only when SPIEn bit = 1

X: don't care

2. n = 0 to 2

<2> When WTIMn bit = 1 (after restart, address mismatch (= not extension code))



▲1: IICSn register = 0001X110B

▲2: IICSn register = 0001XX00B

▲3: IICSn register = 00000X10B

Δ 4: IICSn register = 00000001B

Remarks 1. ▲: Always generated

Δ: Generated only when SPIEn bit = 1

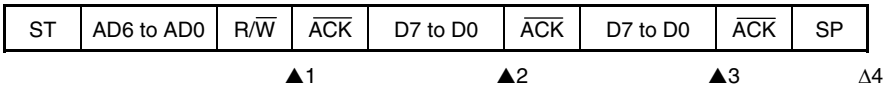
X: don't care

2. n = 0 to 2

19.7.3 Slave device operation (when receiving extension code)

(1) Start ~ Code ~ Data ~ Data ~ Stop

<1> When IICCn.WTIMn bit = 0



▲1: IICSn register = 0010X010B

▲2: IICSn register = 0010X000B

▲3: IICSn register = 0010X000B

Δ 4: IICSn register = 00000001B

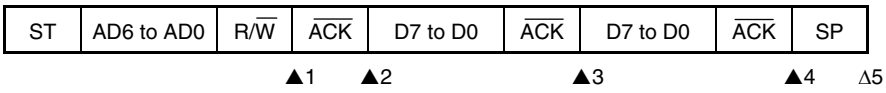
Remarks 1. ▲: Always generated

Δ: Generated only when IICCn.SPIEn bit = 1

X: don't care

2. n = 0 to 2

<2> When WTIMn bit = 1



▲1: IICSn register = 0010X010B

▲2: IICSn register = 0010X110B

▲3: IICSn register = 0010X100B

▲4: IICSn register = 0010XX00B

Δ 5: IICSn register = 00000001B

Remarks 1. ▲: Always generated

Δ: Generated only when SPIEn bit = 1

X: don't care

2. n = 0 to 2

(2) Start ~ Code ~ Data ~ Start ~ Address ~ Data ~ Stop

<1> When WTIMn bit = 0 (after restart, address match)

ST	AD6 to AD0	R/$\overline{W}$	$\overline{ACK}$	D7 to D0	$\overline{ACK}$	ST	AD6 to AD0	R/$\overline{W}$	$\overline{ACK}$	D7 to D0	$\overline{ACK}$	SP
			▲1		▲2					▲3	▲4	Δ5

▲1: IICSn register = 0010X010B

▲2: IICSn register = 0010X000B

▲3: IICSn register = 0001X110B

▲4: IICSn register = 0001X000B

Δ 5: IICSn register = 00000001B

Remarks 1. ▲: Always generated

Δ: Generated only when SPIEn bit = 1

X: don't care

2. n = 0 to 2

<2> When WTIMn bit = 1 (after restart, address match)

ST	AD6 to AD0	R/$\overline{W}$	$\overline{ACK}$	D7 to D0	$\overline{ACK}$	ST	AD6 to AD0	R/$\overline{W}$	$\overline{ACK}$	D7 to D0	$\overline{ACK}$	SP
			▲1	▲2		▲3				▲4	▲5	Δ6

▲1: IICSn register = 0010X010B

▲2: IICSn register = 0010X110B

▲3: IICSn register = 0010XX00B

▲4: IICSn register = 0001X110B

▲5: IICSn register = 0001XX00B

Δ 6: IICSn register = 00000001B

Remarks 1. ▲: Always generated

Δ: Generated only when SPIEn bit = 1

X: don't care

2. n = 0 to 2

(3) Start ~ Code ~ Data ~ Start ~ Code ~ Data ~ Stop

<1> When WTIMn bit = 0 (after restart, extension code reception)

ST	AD6 to AD0	R/$\overline{W}$	$\overline{ACK}$	D7 to D0	$\overline{ACK}$	ST	AD6 to AD0	R/$\overline{W}$	$\overline{ACK}$	D7 to D0	$\overline{ACK}$	SP
			▲1		▲2				▲3		▲4	Δ5

▲1: IICSn register = 0010X010B

▲2: IICSn register = 0010X000B

▲3: IICSn register = 0010X010B

▲4: IICSn register = 0010X000B

Δ 5: IICSn register = 00000001B

Remarks 1. ▲: Always generated

Δ: Generated only when SPIEn bit = 1

X: don't care

2. n = 0 to 2

<2> When WTIMn bit = 1 (after restart, extension code reception)

ST	AD6 to AD0	R/$\overline{W}$	$\overline{ACK}$	D7 to D0	$\overline{ACK}$	ST	AD6 to AD0	R/$\overline{W}$	$\overline{ACK}$	D7 to D0	$\overline{ACK}$	SP
			▲1	▲2		▲3			▲4	▲5		▲6 Δ7

▲1: IICSn register = 0010X010B

▲2: IICSn register = 0010X110B

▲3: IICSn register = 0010XX00B

▲4: IICSn register = 0010X010B

▲5: IICSn register = 0010X110B

▲6: IICSn register = 0010XX00B

Δ 7: IICSn register = 00000001B

Remarks 1. ▲: Always generated

Δ: Generated only when SPIEn bit = 1

X: don't care

2. n = 0 to 2

(4) Start ~ Code ~ Data ~ Start ~ Address ~ Data ~ Stop

<1> When WTIMn bit = 0 (after restart, address mismatch (= not extension code))

ST	AD6 to AD0	R/$\overline{W}$	$\overline{ACK}$	D7 to D0	$\overline{ACK}$	ST	AD6 to AD0	R/$\overline{W}$	$\overline{ACK}$	D7 to D0	$\overline{ACK}$	SP
			▲1		▲2					▲3		Δ4

▲1: IICSn register = 0010X010B

▲2: IICSn register = 0010X000B

▲3: IICSn register = 00000X10B

Δ 4: IICSn register = 00000001B

Remarks 1. ▲: Always generated

Δ: Generated only when SPIEn bit = 1

X: don't care

2. n = 0 to 2

<2> When WTIMn bit = 1 (after restart, address mismatch (= not extension code))

ST	AD6 to AD0	R/$\overline{W}$	$\overline{ACK}$	D7 to D0	$\overline{ACK}$	ST	AD6 to AD0	R/$\overline{W}$	$\overline{ACK}$	D7 to D0	$\overline{ACK}$	SP
			▲1	▲2		▲3				▲4		Δ5

▲1: IICSn register = 0010X010B

▲2: IICSn register = 0010X110B

▲3: IICSn register = 0010XX00B

▲4: IICSn register = 00000X10B

Δ 5: IICSn register = 00000001B

Remarks 1. ▲: Always generated

Δ: Generated only when SPIEn bit = 1

X: don't care

2. n = 0 to 2

19.7.4 Operation without communication

(1) Start ~ Code ~ Data ~ Data ~ Stop

ST	AD6 to AD0	R/$\overline{W}$	$\overline{ACK}$	D7 to D0	$\overline{ACK}$	D7 to D0	$\overline{ACK}$	SP

Δ1

Δ 1: IICSn register = 00000001B

Remarks 1. Δ: Generated only when SPIEn bit = 1

2. n = 0 to 2

19.7.5 Arbitration loss operation (operation as slave after arbitration loss)

(1) When arbitration loss occurs during transmission of slave address data

<1> When IICCn.WTIMn bit = 0

ST	AD6 to AD0	R/$\overline{W}$	$\overline{ACK}$	D7 to D0	$\overline{ACK}$	D7 to D0	$\overline{ACK}$	SP

▲1 ▲2 ▲3 Δ4

▲1: IICSn register = 0101X110B (Example: When IICSn.ALDn bit is read during interrupt servicing)

▲2: IICSn register = 0001X000B

▲3: IICSn register = 0001X000B

Δ 4: IICSn register = 00000001B

Remarks 1. ▲: Always generated

Δ: Generated only when IICCn.SPIEn bit = 1

X: don't care

2. n = 0 to 2

<2> When WTIMn bit = 1

ST	AD6 to AD0	R/$\overline{W}$	$\overline{ACK}$	D7 to D0	$\overline{ACK}$	D7 to D0	$\overline{ACK}$	SP

▲1 ▲2 ▲3 Δ4

▲1: IICSn register = 0101X110B (Example: When ALDn bit is read during interrupt servicing)

▲2: IICSn register = 0001X100B

▲3: IICSn register = 0001XX00B

Δ 4: IICSn register = 00000001B

Remarks 1. ▲: Always generated

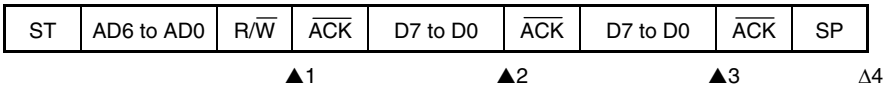
Δ: Generated only when SPIEn bit = 1

X: don't care

2. n = 0 to 2

(2) When arbitration loss occurs during transmission of extension code

<1> When WTIMn bit = 0



▲1: IICSn register = 0110X010B (Example: When ALDn bit is read during interrupt servicing)

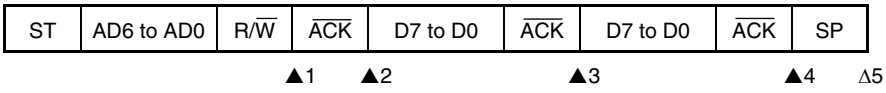
▲2: IICSn register = 0010X000B

▲3: IICSn register = 0010X000B

Δ 4: IICSn register = 00000001B

Remarks 1. ▲: Always generated
Δ: Generated only when SPIEn bit = 1
X: don't care
2. n = 0 to 2

<2> When WTIMn bit = 1



▲1: IICSn register = 0110X010B (Example: When ALDn bit is read during interrupt servicing)

▲2: IICSn register = 0010X110B

▲3: IICSn register = 0010X100B

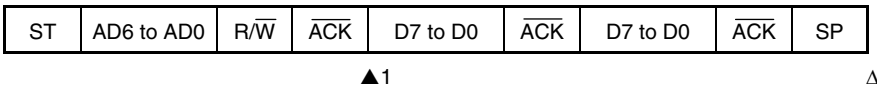
▲4: IICSn register = 0010XX00B

Δ 5: IICSn register = 00000001B

Remarks 1. ▲: Always generated
Δ: Generated only when SPIEn bit = 1
X: don't care
2. n = 0 to 2

19.7.6 Operation when arbitration loss occurs (no communication after arbitration loss)

(1) When arbitration loss occurs during transmission of slave address data

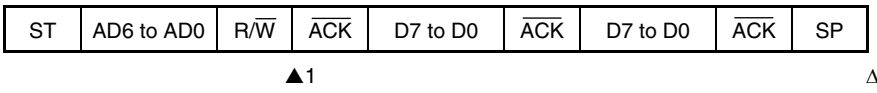


▲1: IICSn register = 01000110B (Example: When IICSn.ALDn bit is read during interrupt servicing)

Δ 2: IICSn register = 00000001B

Remarks 1. ▲: Always generated
Δ: Generated only when IICCn.SPIEn bit = 1
2. n = 0 to 2

(2) When arbitration loss occurs during transmission of extension code



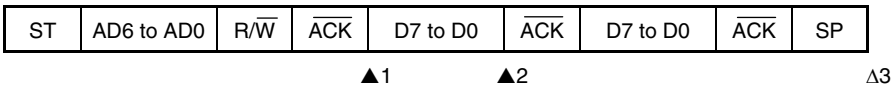
▲1: IICSn register = 0110X010B (Example: When ALDn bit is read during interrupt servicing)
IICCn.LRELn bit is set to 1 by software

Δ 2: IICSn register = 00000001B

Remarks 1. ▲: Always generated
Δ: Generated only when SPIEn bit = 1
X: don't care
2. n = 0 to 2

(3) When arbitration loss occurs during data transfer

<1> When IICCn.WTIMn bit = 0



▲1: IICSn register = 10001110B

▲2: IICSn register = 01000000B (Example: When ALDn bit is read during interrupt servicing)

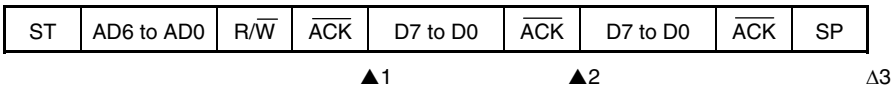
Δ 3: IICSn register = 00000001B

Remarks 1. ▲: Always generated

Δ: Generated only when SPIEn bit = 1

2. n = 0 to 2

<2> When WTIMn bit = 1



▲1: IICSn register = 10001110B

▲2: IICSn register = 01000100B (Example: When ALDn bit is read during interrupt servicing)

Δ 3: IICSn register = 00000001B

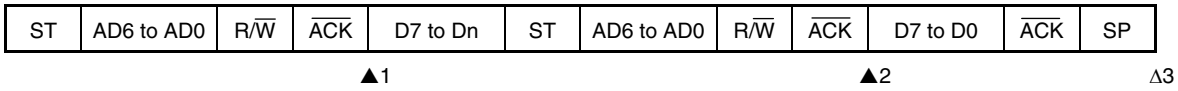
Remarks 1. ▲: Always generated

Δ: Generated only when SPIEn bit = 1

2. n = 0 to 2

(4) When arbitration loss occurs due to restart condition during data transfer

<1> Not extension code (Example: Address mismatch)



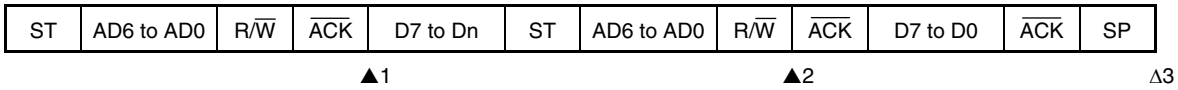
▲1: IICSn register = 1000X110B

▲2: IICSn register = 01000110B (Example: When ALDn bit is read during interrupt servicing)

Δ 3: IICSn register = 00000001B

Remarks 1. ▲: Always generated
Δ: Generated only when SPIEn bit = 1
X: don't care
2. Dn = D6 to D0
n = 0 to 2

<2> Extension code



▲1: IICSn register = 1000X110B

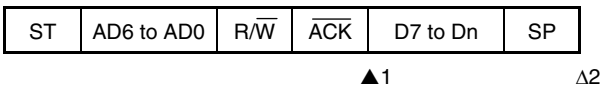
▲2: IICSn register = 0110X010B (Example: When ALDn bit is read during interrupt servicing)

IICCn.LRELn bit is set to 1 by software

Δ 3: IICSn register = 00000001B

Remarks 1. ▲: Always generated
Δ: Generated only when SPIEn bit = 1
X: don't care
2. Dn = D6 to D0
n = 0 to 2

(5) When arbitration loss occurs due to stop condition during data transfer



▲1 Δ2

▲1: IICSn register = 1000X110B

Δ 2: IICSn register = 01000001B

Remarks 1. ▲: Always generated

Δ: Generated only when SPIEn bit = 1

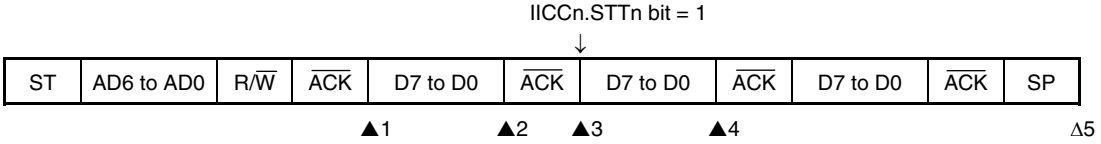
X: don't care

2. Dn = D6 to D0

n = 0 to 2

(6) When arbitration loss occurs due to low level of SDA0n pin when attempting to generate a restart condition

<1> When WTIMn bit = 0



▲1: IICSn register = 1000X110B

▲2: IICSn register = 1000X000B (WTIMn bit = 1)

▲3: IICSn register = 1000XX00B (WTIMn bit = 0)

▲4: IICSn register = 01000000B (Example: When ALDn bit is read during interrupt servicing)

Δ 5: IICSn register = 00000001B

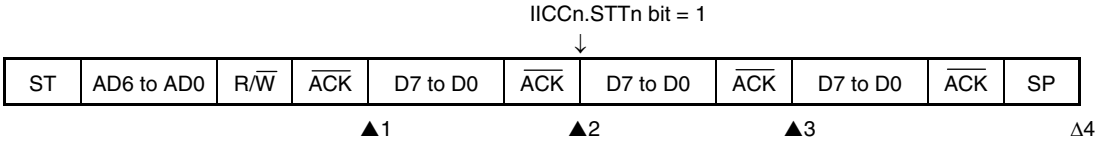
Remarks 1. ▲: Always generated

Δ: Generated only when SPIEn bit = 1

X: don't care

2. n = 0 to 2

<2> When WTIMn bit = 1



▲1: IICSn register = 1000X110B

▲2: IICSn register = 1000XX00B

▲3: IICSn register = 01000100B (Example: When ALDn bit is read during interrupt servicing)

Δ 4: IICSn register = 00000001B

Remarks 1. ▲: Always generated

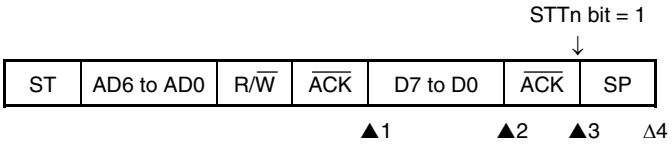
Δ: Generated only when SPIEn bit = 1

X: don't care

2. n = 0 to 2

(7) When arbitration loss occurs due to a stop condition when attempting to generate a restart condition

<1> When WTIMn bit = 0



▲1: IICSn register = 1000X110B

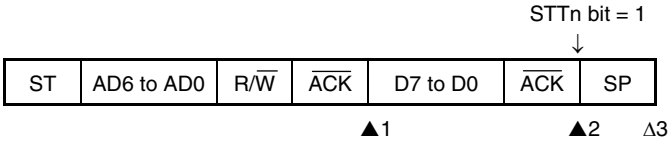
▲2: IICSn register = 1000X000B (WTIMn bit = 1)

▲3: IICSn register = 1000XX00B

Δ 4: IICSn register = 01000001B

Remarks 1. ▲: Always generated
Δ: Generated only when SPIEn bit = 1
X: don't care
2. n = 0 to 2

<2> When WTIMn bit = 1



▲1: IICSn register = 1000X110B

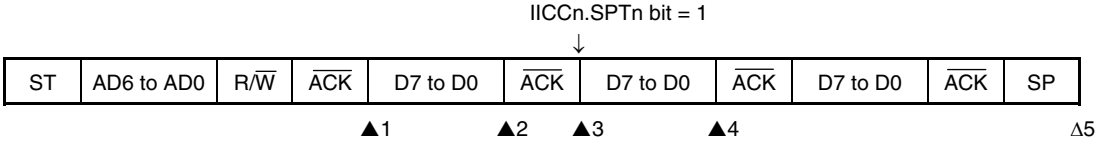
▲2: IICSn register = 1000XX00B

Δ 3: IICSn register = 01000001B

Remarks 1. ▲: Always generated
Δ: Generated only when SPIEn bit = 1
X: don't care
2. n = 0 to 2

(8) When arbitration loss occurs due to low level of SDA0n pin when attempting to generate a stop condition

<1> When WTIMn bit = 0



▲1: IICSn register = 1000X110B

▲2: IICSn register = 1000X000B (WTIMn bit = 1)

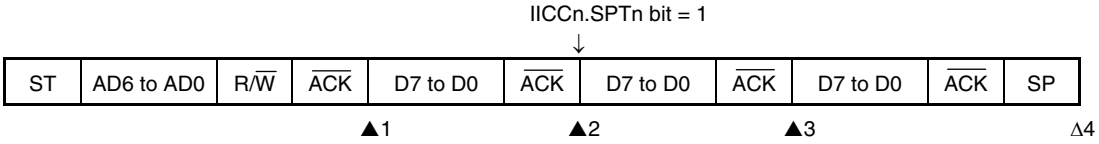
▲3: IICSn register = 1000XX00B (WTIMn bit = 0)

▲4: IICSn register = 01000000B (Example: When ALDn bit is read during interrupt servicing)

Δ 5: IICSn register = 00000001B

Remarks 1. ▲: Always generated
Δ: Generated only when SPIEn bit = 1
X: don't care
2. n = 0 to 2

<2> When WTIMn bit = 1



▲1: IICSn register = 1000X110B

▲2: IICSn register = 1000XX00B

▲3: IICSn register = 01000000B (Example: When ALDn bit is read during interrupt servicing)

Δ 4: IICSn register = 00000001B

Remarks 1. ▲: Always generated
Δ: Generated only when SPIEn bit = 1
X: don't care
2. n = 0 to 2

19.8 Interrupt Request Signal (INTIICn) Generation Timing and Wait Control

The setting of the IICCn.WTIMn bit determines the timing by which the INTIICn register is generated and the corresponding wait control, as shown below (n = 0 to 2).

Table 19-3. INTIICn Generation Timing and Wait Control

WTIMn Bit	During Slave Device Operation			During Master Device Operation		
	Address	Data Reception	Data Transmission	Address	Data Reception	Data Transmission
0	9 Notes 1, 2	8 Note 2	8 Note 2	9	8	8
1	9 Notes 1, 2	9 Note 2	9 Note 2	9	9	9

Notes 1. The slave device's INTIICn signal and wait period occur at the falling edge of the ninth clock only when there is a match with the address set to the SVAn register.
At this point, the $\overline{ACK}$ is generated regardless of the value set to the IICCn.ACKEn bit. For a slave device that has received an extension code, the INTIICn signal occurs at the falling edge of the eighth clock.
When the address does not match after restart, the INTIICn signal is generated at the falling edge of the ninth clock, but no wait occurs.

2. If the received address does not match the contents of the SVAn register and an extension code is not received, neither the INTIICn signal nor a wait occurs.

Remarks 1. The numbers in the table indicate the number of the serial clock's clock signals. Interrupt requests and wait control are both synchronized with the falling edge of these clock signals.

2. n = 0 to 2

(1) During address transmission/reception

- Slave device operation: Interrupt and wait timing are determined according to the conditions described in **Notes 1** and **2** above, regardless of the WTIMn bit.
- Master device operation: Interrupt and wait timing occur at the falling edge of the ninth clock regardless of the WTIMn bit.

(2) During data reception

- Master/slave device operation: Interrupt and wait timing are determined according to the WTIMn bit.

(3) During data transmission

- Master/slave device operation: Interrupt and wait timing are determined according to the WTIMn bit.

(4) Wait cancellation method

The four wait cancellation methods are as follows.

- By setting the IICCn.WRELn bit to 1
- By writing to the IICn register
- By start condition setting (IICCn.STTn bit = 1)[Note]
- By stop condition setting (IICCn.SPTn bit = 1)[Note]

Note Master only

When an 8-clock wait has been selected (WTIMn bit = 0), whether or not $\overline{\text{ACK}}$ has been generated must be determined prior to wait cancellation.

Remark n = 0 to 2

(5) Stop condition detection

The INTIICn signal is generated when a stop condition is detected.

Remark n = 0 to 2

19.9 Address Match Detection Method

In I²C bus mode, the master device can select a particular slave device by transmitting the corresponding slave address.

Address match detection is performed automatically by hardware. The INTIICn signal occurs when a local address has been set to the SVAn register and when the address set to the SVAn register matches the slave address sent by the master device, or when an extension code has been received (n = 0 to 2).

19.10 Error Detection

In I²C bus mode, the status of the serial data bus pin (SDA0n) during data transmission is captured by the IICn register of the transmitting device, so the data of the IICn register prior to transmission can be compared with the transmitted IICn data to enable detection of transmission errors. A transmission error is judged as having occurred when the compared data values do not match (n = 0 to 2).

19.11 Extension Code

(1) When the higher 4 bits of the receive address are either 0000 or 1111, the extension code flag (IICSn.EXCn bit) is set for extension code reception and an interrupt request signal (INTIICn) is issued at the falling edge of the eighth clock (n = 0 to 2).
The local address stored in the SVAn register is not affected.

(2) If 11110xx0 is set to the SVAn register by a 10-bit address transfer and 11110xx0 is transferred from the master device, the results are as follows. Note that the INTIICn signal occurs at the falling edge of the eighth clock (n = 0 to 2)

- Higher four bits of data match: EXCn bit = 1
- Seven bits of data match: IICSn.COIn bit = 1

(3) Since the processing after the interrupt request signal occurs differs according to the data that follows the extension code, such processing is performed by software.
For example, when operation as a slave is not desired after the extension code is received, set the IICCn.LRELn bit to 1 and the CPU will enter the next communication wait state.

Table 19-4. Extension Code Bit Definitions

Slave Address	R/$\overline{W}$ Bit	Description
0000 000	0	General call address
1111 0xx	0	10-bit slave address specification (when the address is authorized)
1111 0xx	1	10-bit slave address specification (after the address match, the read command is issued)

Remark For the expansion codes other than the above, see I²C bus specifications issued by NXP.

19.12 Arbitration

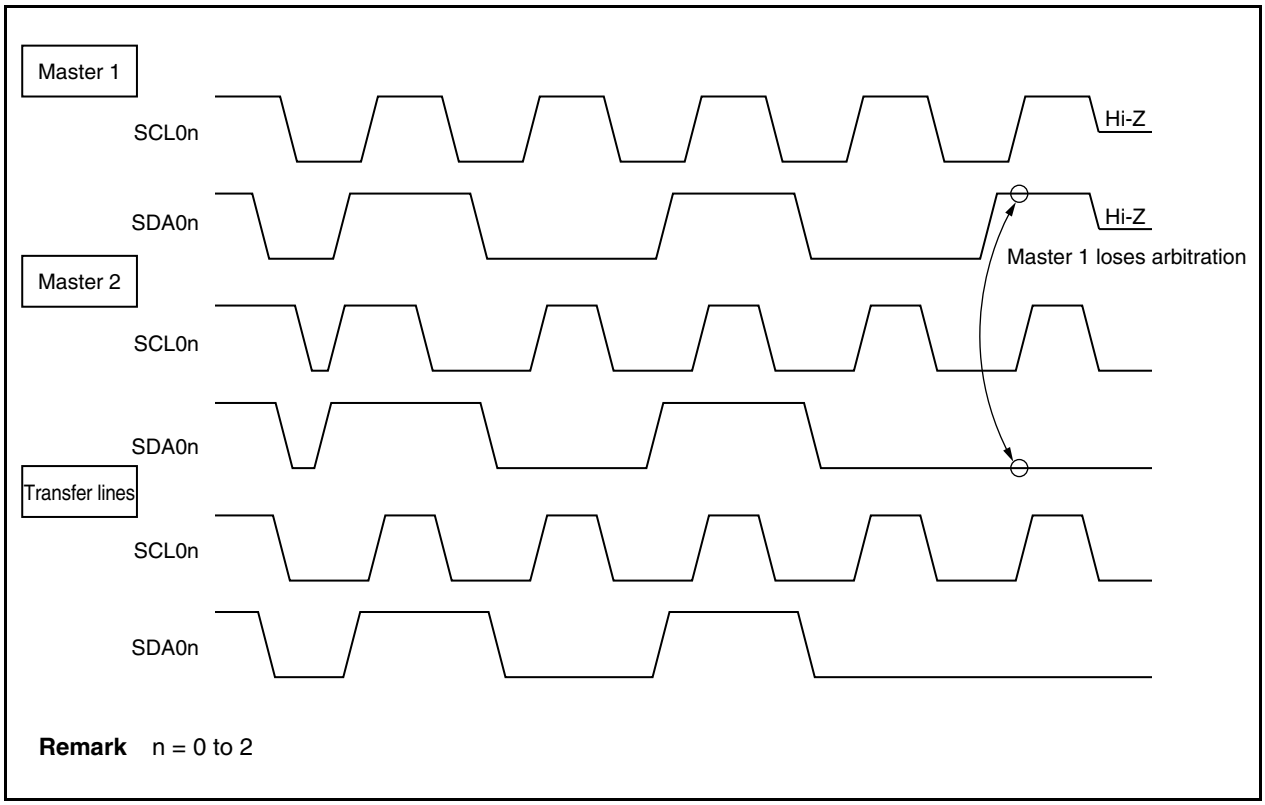
When several master devices simultaneously generate a start condition (when the IICCn.STTn bit is set to 1 before the IICSn.STDn bit is set to 1), communication between the master devices is performed while the number of clocks is adjusted until the data differs. This kind of operation is called arbitration (n = 0 to 2).

When one of the master devices loses in arbitration, an arbitration loss flag (IICSn.ALDn bit) is set to 1 via the timing at which the arbitration loss occurred, and the SCL0n and SDA0n lines are both set to high impedance, which releases the bus (n = 0 to 2).

Arbitration loss is detected based on the timing of the next interrupt request signal (INTIICn) (the eighth or ninth clock, when a stop condition is detected, etc.) and the setting of the ALDn bit to 1, which is made by software (n = 0 to 2).

For details of interrupt request timing, see **19.7 I²C Interrupt Request Signals (INTIICn)**.

Figure 19-14. Arbitration Timing Example



Remark n = 0 to 2

Table 19-5. Status During Arbitration and Interrupt Request Signal Generation Timing

Status During Arbitration	Interrupt Request Generation Timing
Transmitting address transmission	At falling edge of eighth or ninth clock following byte transfer[Note 1]
Read/write data after address transmission	
Transmitting extension code	
Read/write data after extension code transmission	
Transmitting data	
$\overline{\text{ACK}}$ transfer period after data reception	
When restart condition is detected during data transfer	
When stop condition is detected during data transfer	When stop condition is generated (when IICCn.SPIEn bit = 1)[Note 2]
When SDA0n pin is low level while attempting to generate restart condition	At falling edge of eighth or ninth clock following byte transfer[Note 1]
When stop condition is detected while attempting to generate restart condition	When stop condition is generated (when IICCn.SPIEn bit = 1)[Note 2]
When DSA0n pin is low level while attempting to generate stop condition	At falling edge of eighth or ninth clock following byte transfer[Note 1]
When SCL0n pin is low level while attempting to generate restart condition	

Notes 1. When the IICCn.WTIMn bit = 1, an INTIICn signal occurs at the falling edge of the ninth clock. When the WTIMn bit = 0 and the extension code's slave address is received, an INTIICn signal occurs at the falling edge of the eighth clock (n = 0 to 2).

2. When there is a possibility that arbitration will occur, set the SPIEn bit to 1 for master device operation (n = 0 to 2).

19.13 Wakeup Function

The makeup function is a function that generates an interrupt request signal (INTIICn) when a local address or extension code has been received by using the slave function of the I²C bus. This function makes processing more efficient by preventing unnecessary INTIICn signals from occurring when addresses do not match.

When a start condition is detected, wakeup standby mode is set. This wakeup standby mode is in effect while addresses are transmitted due to the possibility that an arbitration loss may change the master device (which generated the start condition) to a slave device.

However, when a stop condition is detected, the IICCn.SPIEn bit is set regardless of the wakeup function, and this determines whether INTIICn signal is enabled or disabled (n = 0 to 2).

19.14 Communication Reservation

19.14.1 When communication reservation function is enabled (IICFn.IICRSVn bit = 0)

To start master device communications when not currently using the bus, a communication reservation can be made to enable transmission of a start condition when the bus is released. There are two modes in which the bus is not used.

- When arbitration results in neither master nor slave operation
- When an extension code is received and slave operation is disabled ($\overline{\text{ACK}}$ is not returned and the bus was released when the IICCn.LRELn bit was set to 1) (n = 0 to 2).

If the IICCn.STTn bit is set to 1 while the bus is not being used, a start condition is automatically generated and a wait status is set after the bus is released (after the stop condition is detected).

When the bus release is detected (when the stop condition is detected), writing to the IICn register causes master address transfer to start. At this point, the IICCn.SPIEn bit should be set to 1 (n = 0 to 2).

When STTn has been set to 1, the operation mode (as start condition or as communication reservation) is determined according to the bus status (n = 0 to 2).

If the bus has been released .....A start condition is generated
If the bus has not been released (standby mode).....Communication reservation

To detect which operation mode has been determined, set the STTn bit to 1, wait for the wait period, then check the IICSn.MSTSn bit (n = 0 to 2).

The wait periods, which should be set via software, are listed in Table 19-6. These wait periods can be set by the SMCn, CLn1, and CLn0 bits of the IICCLn register and the IICXn.CLXn bit (n = 0 to 2).

Table 19-6. Wait Periods

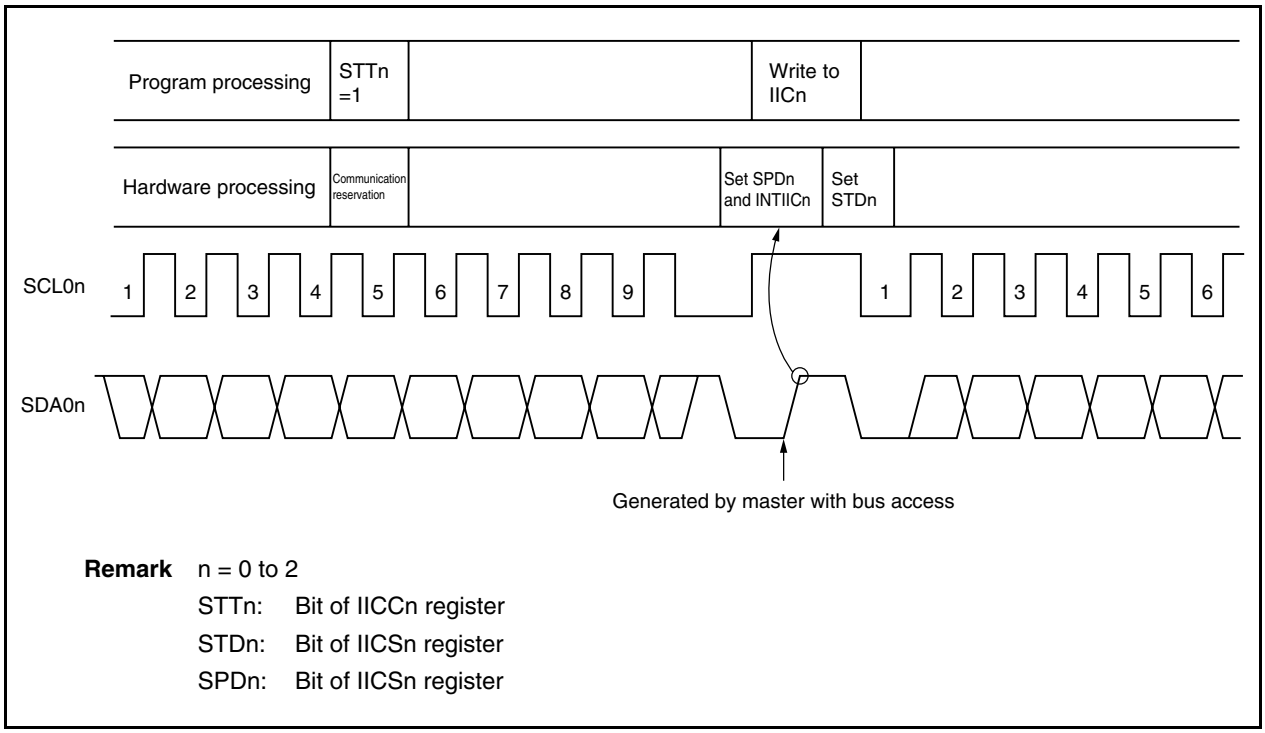
Clock Selection	CLXn	SMCn	CLn1	CLn0	Wait Period
fxx/6 (OCKSm = 11H)	0	0	0	0	156 clocks
fxx/8 (OCKSm = 12H)	0	0	0	0	208 clocks
fxx/10 (OCKSm = 13H)	0	0	0	0	260 clocks
fxx/4 (OCKSm = 10H)	0	0	0	1	188 clocks
fxx/6 (OCKSm = 11H)	0	0	0	1	282 clocks
fxx/8 (OCKSm = 12H)	0	0	0	1	376 clocks
fxx/10 (OCKSm = 13H)	0	0	0	1	470 clocks
fxx/4 (OCKSm = 10H)	0	0	1	1	148 clocks
fxx/6 (OCKSm = 11H)	0	0	1	1	222 clocks
fxx/4 (OCKSm = 10H)	0	1	0	×	64 clocks
fxx/6 (OCKSm = 11H)	0	1	0	×	96 clocks
fxx/8 (OCKSm = 12H)	0	1	0	×	128 clocks
fxx/10 (OCKSm = 13H)	0	1	0	×	160 clocks
fxx/4 (OCKSm = 10H)	0	1	1	1	52 clocks
fxx/6 (OCKSm = 11H)	0	1	1	1	78 clocks
fxx/6 (OCKSm = 11H)	1	1	0	×	60 clocks
fxx/8 (OCKSm = 12H)	1	1	0	×	80 clocks
fxx/10 (OCKSm = 13H)	1	1	0	×	100 clocks

Remarks 1. m = 0 and 1
n = 0 to 2

2. × = Don't care

The communication reservation timing is shown below.

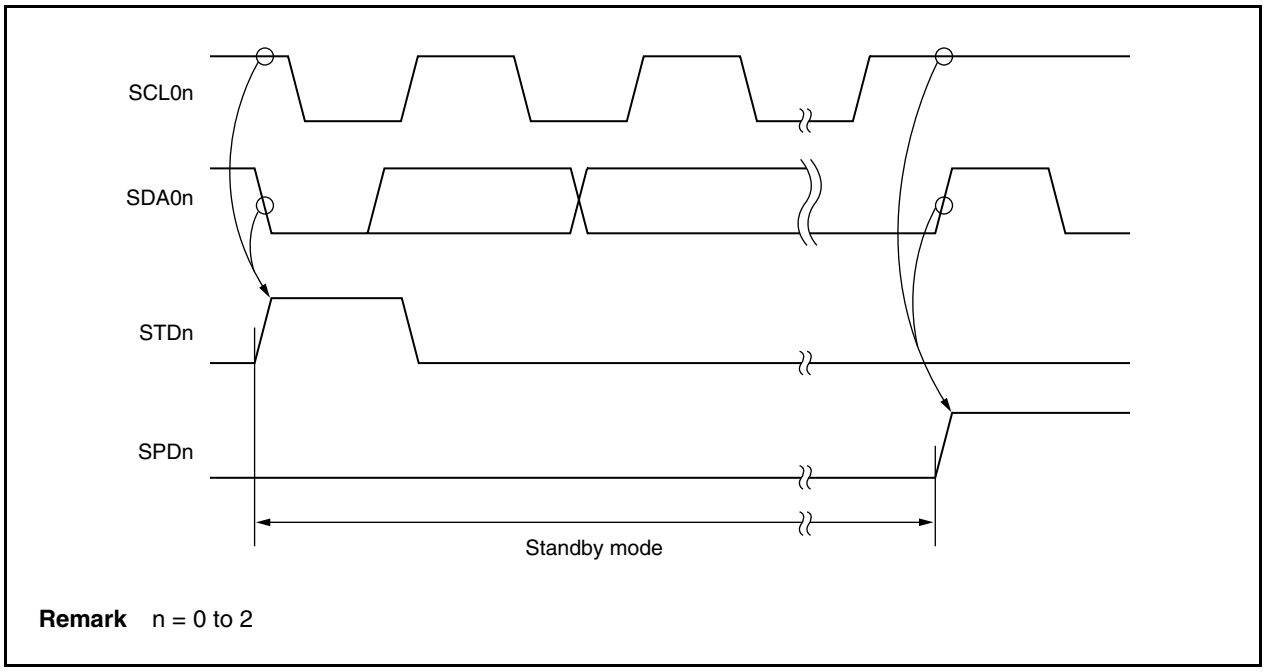
Figure 19-15. Communication Reservation Timing



Remark n = 0 to 2
STTn: Bit of IICCn register
STDn: Bit of IICSn register
SPDn: Bit of IICSn register

Communication reservations are accepted via the following timing. After the IICSn.STDn bit is set to 1, a communication reservation can be made by setting the IICCn.STTn bit to 1 before a stop condition is detected (n = 0 to 2).

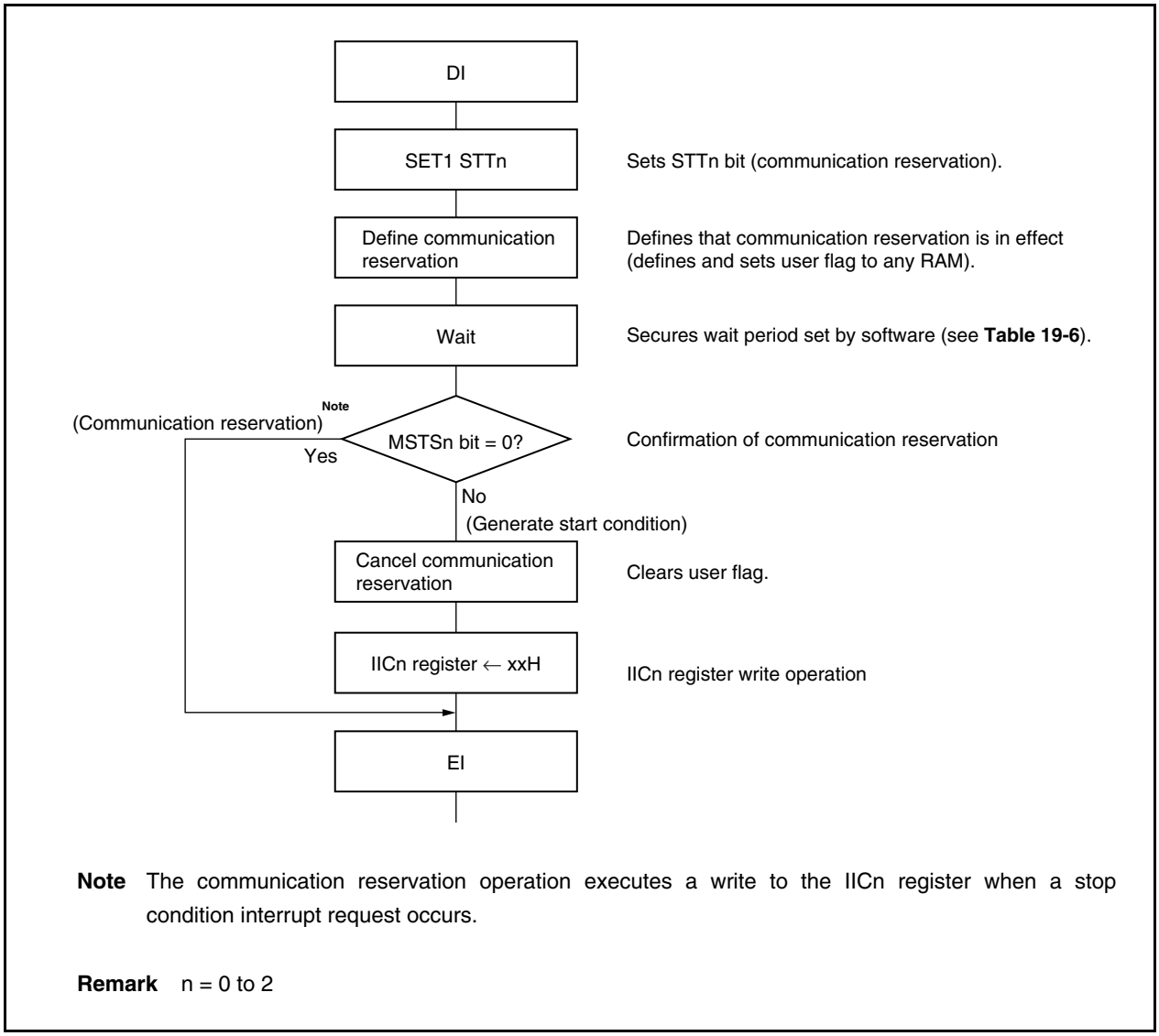
Figure 19-16. Timing for Accepting Communication Reservations



Remark n = 0 to 2

The communication reservation flowchart is illustrated below.

Figure 19-17. Communication Reservation Flowchart



Note The communication reservation operation executes a write to the IICn register when a stop condition interrupt request occurs.

Remark n = 0 to 2

19.14.2 When communication reservation function is disabled (IICFn.IICRSVn bit = 1)

When the IICCn.STTn bit is set when the bus is not being used for communication during bus communication, this request is rejected and a start condition is not generated. There are two modes in which the bus is not used.

- When arbitration results in neither master nor slave operation
- When an extension code is received and slave operation is disabled ($\overline{\text{ACK}}$ is not returned and the bus was released when the IICCn.LRELn bit was set to 1) (n = 0 to 2)

To confirm whether the start condition was generated or the request was rejected, check the IICFn.STCFn flag. The time shown in Table 19-7 is required until the STCFn flag is set after setting the STTn bit to 1. Therefore, secure the time by software.

Table 19-7. Wait Periods

OCKSENm	OCKSm1	OCKSm0	CLn1	CLn0	Wait Period
1	0	0	0	×	20 clocks
1	0	1	0	×	30 clocks
1	1	0	0	×	40 clocks
1	1	1	0	×	50 clocks
0	0	0	1	0	10 clocks

Remarks **1.** ×: don't care
2. n = 0 to 2
m = 0, 1

19.15 Cautions

(1) When IICFn.STCENn bit = 0

Immediately after the I²C0n operation is enabled, the bus communication status (IICFn.IICBSYn bit = 1) is recognized regardless of the actual bus status. To execute master communication in the status where a stop condition has not been detected, generate a stop condition and then release the bus before starting the master communication.

Use the following sequence for generating a stop condition.

<1> Set the IICCLn register.
<2> Set the IICCn.IICEn bit.
<3> Set the IICCn.SPTn bit.

(2) When IICFn.STCENn bit = 1

Immediately after I²C0n operation is enabled, the bus release status (IICBSYn bit = 0) is recognized regardless of the actual bus status. To generate the first start condition (IICCn.STTn bit = 1), it is necessary to confirm that the bus has been released, so as to not disturb other communications.

(3) When the IICCn.IICEn bit of the V850ES/JG3-H and V850ES/JH3-H is set to 1 while other devices are communicating, the start condition may be detected depending on the status of the communication line. Be sure to set the IICCn.IICEn bit to 1 when the SCL0n and SDA0n lines are high level.

(4) Determine the operation clock frequency by using the IICCLn, IICXn, and OCKSm registers before enabling the operation (IICCn.IICEn bit = 1). To change the operation clock frequency, first clear the IICCn.IICEn bit to 0.

(5) After the IICCn.STTn and IICCn.SPTn bits have been set to 1, they must not be re-set without being cleared to 0 first.

(6) If transmission has been reserved, set the IICCN.SPIEn bit to 1 so that an interrupt request is generated by the detection of a stop condition. After an interrupt request has been generated, the wait status will be released by writing communication data to I²Cn, then transfer will begin. If an interrupt is not generated by the detection of a stop condition, transmission will halt in the wait status because an interrupt request was not generated. However, it is not necessary to set the SPIEn bit to 1 for the software to detect the IICSn.MSTSn bit.

Remark n = 0 to 2
m = 0, 1

19.16 Communication Operations

The following shows three operation procedures together with flowcharts.

(1) Master operation in single master system

The flowchart when using the V850ES/JG3-H and V850ES/JH3-H as the master in a single master system is shown below.

This flowchart is broadly divided into initial settings and communication processing. Execute the initial settings at startup. If communication with a slave is required, prepare the communication and then execute communication processing.

(2) Master operation in multimaster system

In the I²C0n bus multimaster system, whether the bus is released or used cannot be judged by the I²C bus specifications when the bus takes part in a communication. Here, when data and the clock are at a high level for a certain period (1 frame), the V850ES/JG3-H or V850ES/JH3-H takes part in communication in a bus release state.

This flowchart is broadly divided into initial settings, communication waiting, and communication processing. The processing when the V850ES/JG3-H or V850ES/JH3-H loses in arbitration and is specified as the slave is omitted here, and only the processing as the master is shown. Execute the initial settings at startup to take part in communication. Then, wait for the communication request as the master or wait for the specification as the slave. The actual communication is performed in the communication processing, and includes arbitration with other masters data as well as transmission/reception with the slave.

(3) Slave operation

An example of when the V850ES/JG3-H or V850ES/JH3-H is used as the slave of the I²C0n bus is shown below.

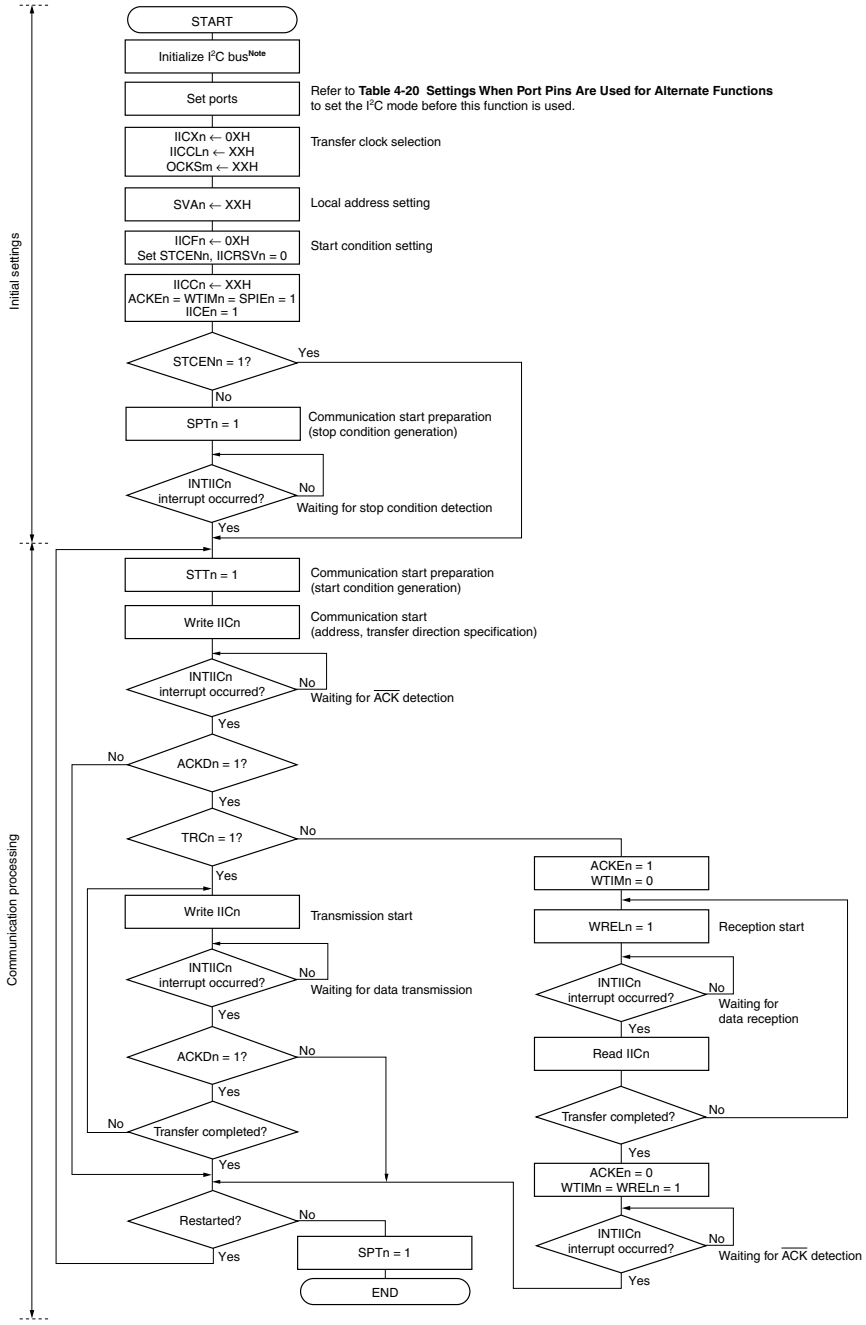
When used as the slave, operation is started by an interrupt. Execute the initial settings at startup, then wait for INTIICn interrupt occurrence (communication waiting). When the INTIICn interrupt occurs, the communication status is judged and its result is passed as a flag to the main processing.

By checking the flags, the necessary communication processing can be performed.

Remark n = 0 to 2

19.16.1 Master operation in single master system

Figure 19-18. Master Operation in Single Master System



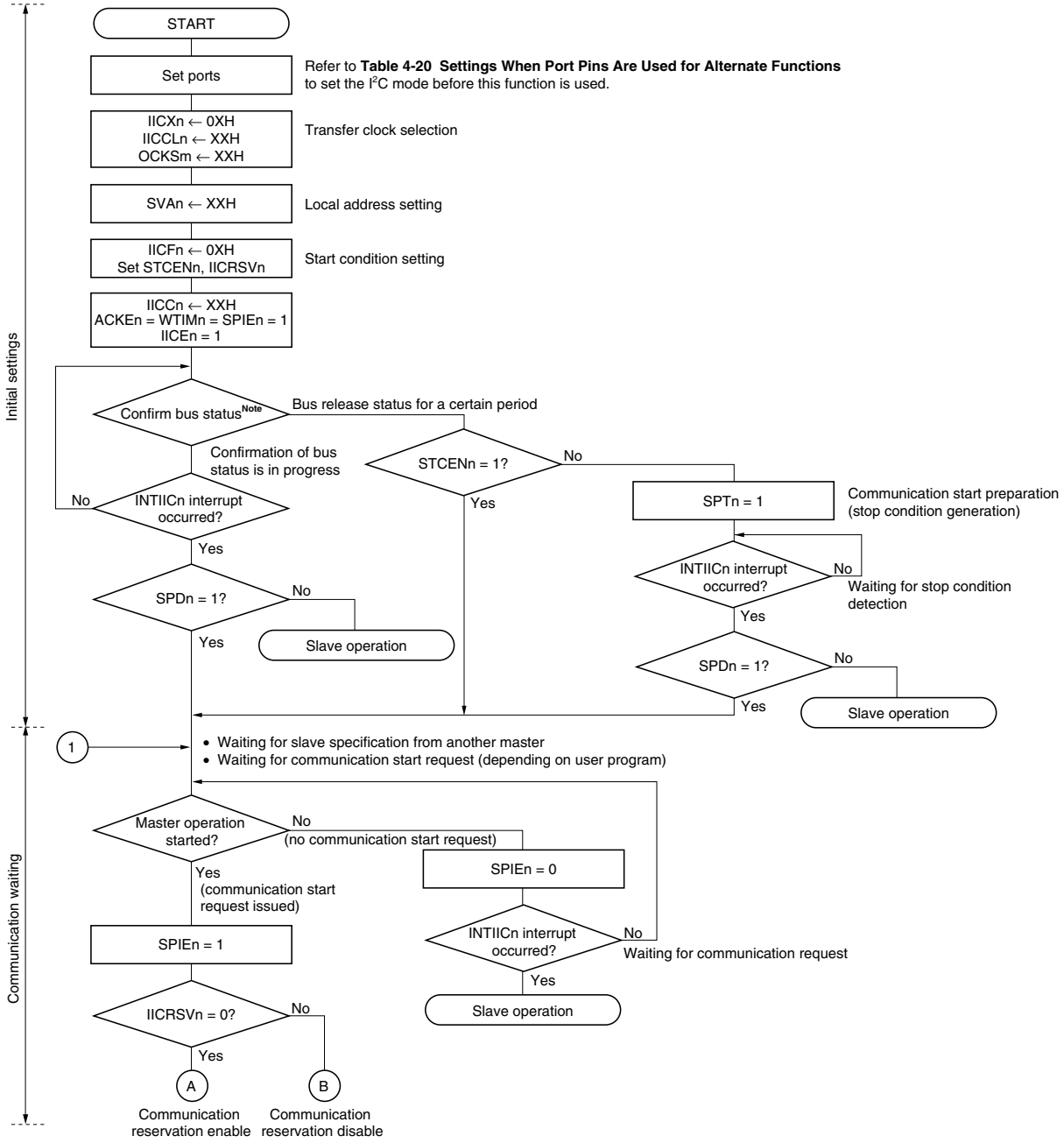
Note Release the I²C0n bus (SCL0n, SDA0n pins = high level) in compliance with the specifications of the communicating product. For example, when the EEPROM™ outputs a low level to the SDA0n pin, set the SCL0n pin to the output port and output clock pulses from that output port until the SDA0n pin becomes constantly high level.

Remarks 1. For the transmission and reception formats, comply with the specifications of the communicating product.

2. n = 0 to 2, m = 0, 1

19.16.2 Master operation in multimaster system

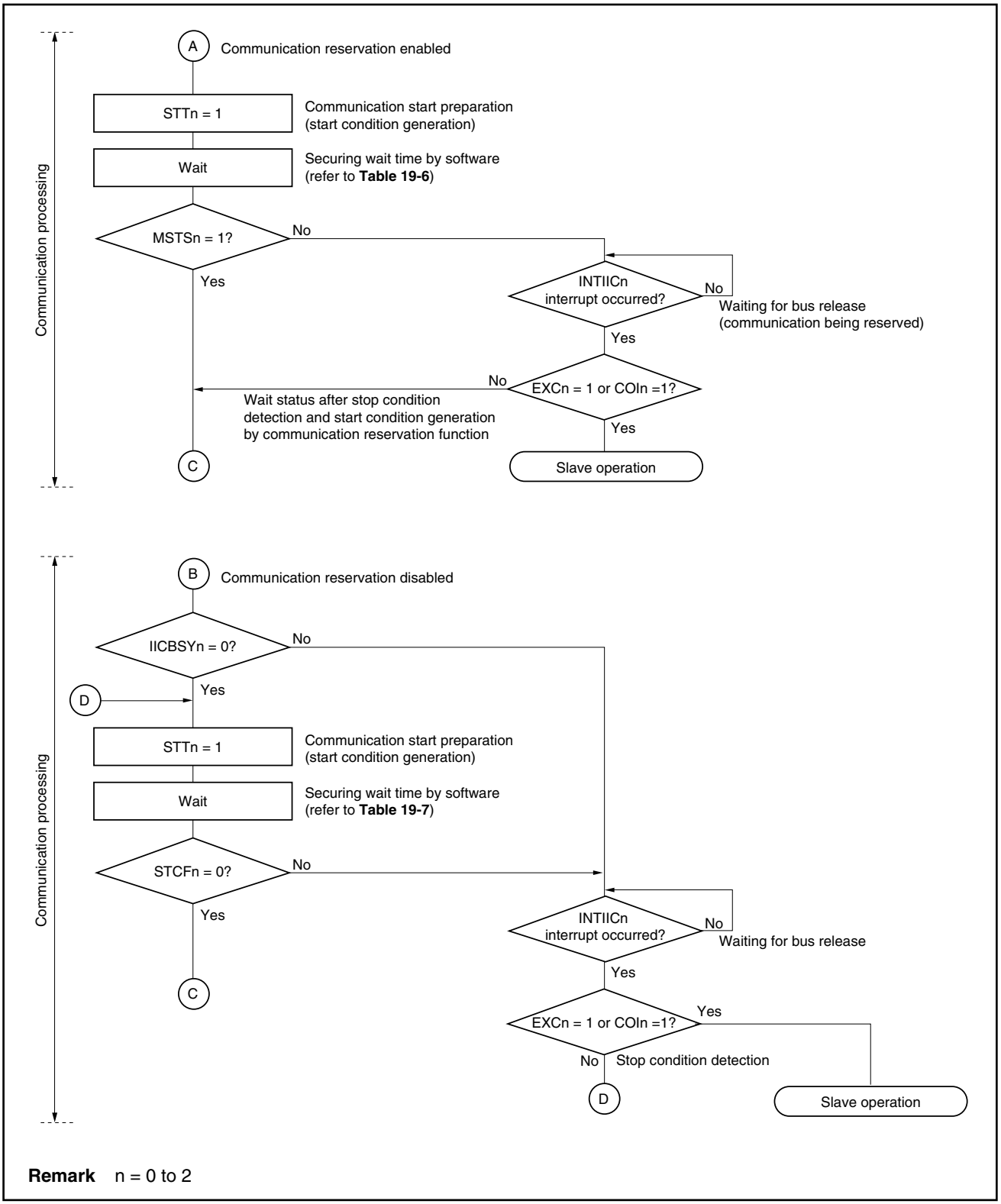
Figure 19-19. Master Operation in Multimaster System (1/3)



Note Confirm that the bus release status (IICCLn.CLDn bit = 1, IICCLn.DADn bit = 1) has been maintained for a certain period (1 frame, for example). When the SDA0n pin is constantly low level, determine whether to release the I²C0n bus (SCL0n, SDA0n pins = high level) by referring to the specifications of the communicating product.

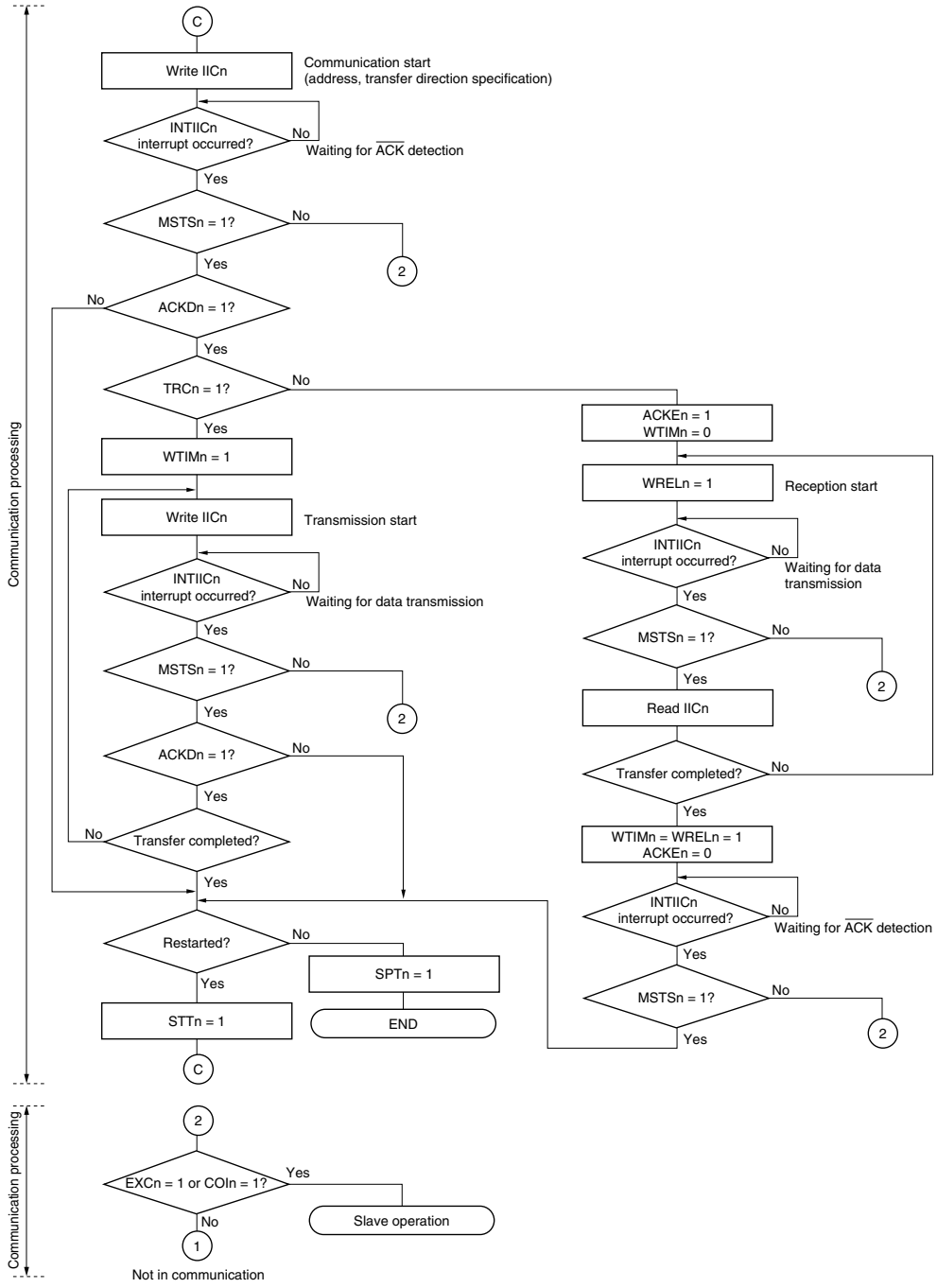
Remark n = 0 to 2, m = 0, 1

Figure 19-19. Master Operation in Multimaster System (2/3)



Remark n = 0 to 2

Figure 19-19. Master Operation in Multimaster System (3/3)



Remarks 1. For the transmission and reception formats, comply with the specifications of the communicating product.

2. When using the V850ES/JG3-H or V850ES/JH3-H as the master in a multimaster system, read the IICSn.MSTSn bit for each INTIICn interrupt occurrence to confirm the arbitration result.

3. When using the V850ES/JG3-H or V850ES/JH3-H as the slave in a multimaster system, confirm the status using the IICSn and IICFn registers for each INTIICn interrupt occurrence to determine the next processing.

4. n = 0 to 2

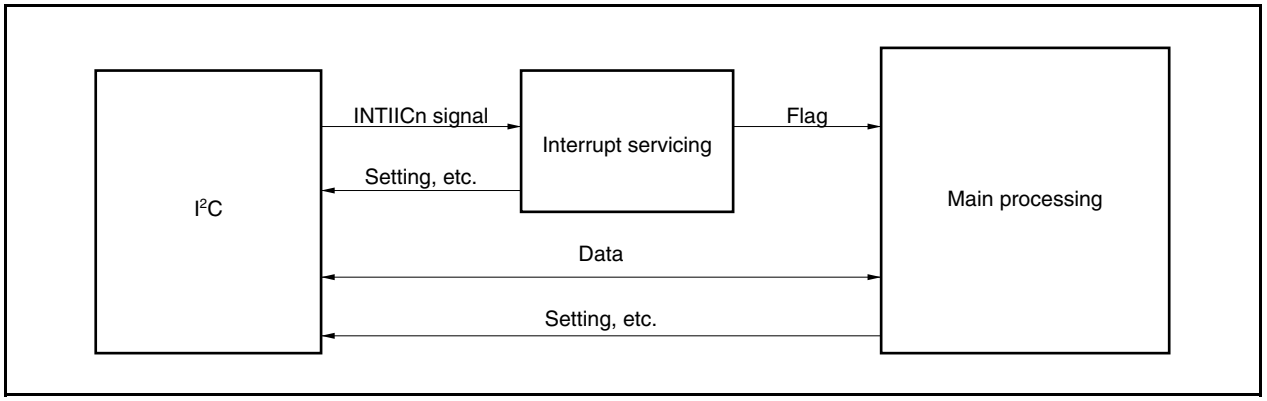
19.16.3 Slave operation

The following shows the processing procedure of slave operation.

Basically, the operation of the slave device is event-driven. Therefore, processing by an INTIICn interrupt (processing requiring a significant change of the operation status, such as stop condition detection during communication) is necessary.

The following description assumes that data communication does not support extension codes. Also, it is assumed that the INTIICn interrupt servicing performs only status change processing and that the actual data communication is performed during the main processing.

Figure 19-20. Overview of Software During Slave Operation



Therefore, the following three flags are prepared so that the data transfer processing can be performed by passing these flags to the main processing instead of the INTIICn signal.

(1) Communication mode flag

This flag indicates the following communication statuses.

Clear mode: Data communication not in progress

Communication mode: Data communication in progress (valid address detection stop condition detection, $\overline{\text{ACK}}$ from master not detected, address mismatch)

(2) Ready flag

This flag indicates that data communication is enabled. This is the same status as an INTIICn interrupt during normal data transfer. This flag is set in the interrupt processing block and cleared in the main processing block. The ready flag for the first data for transmission is not set in the interrupt processing block, so the first data is transmitted without clear processing (the address match is regarded as a request for the next data).

(3) Communication direction flag

This flag indicates the direction of communication and is the same as the value of IICSn.TRCn bit.

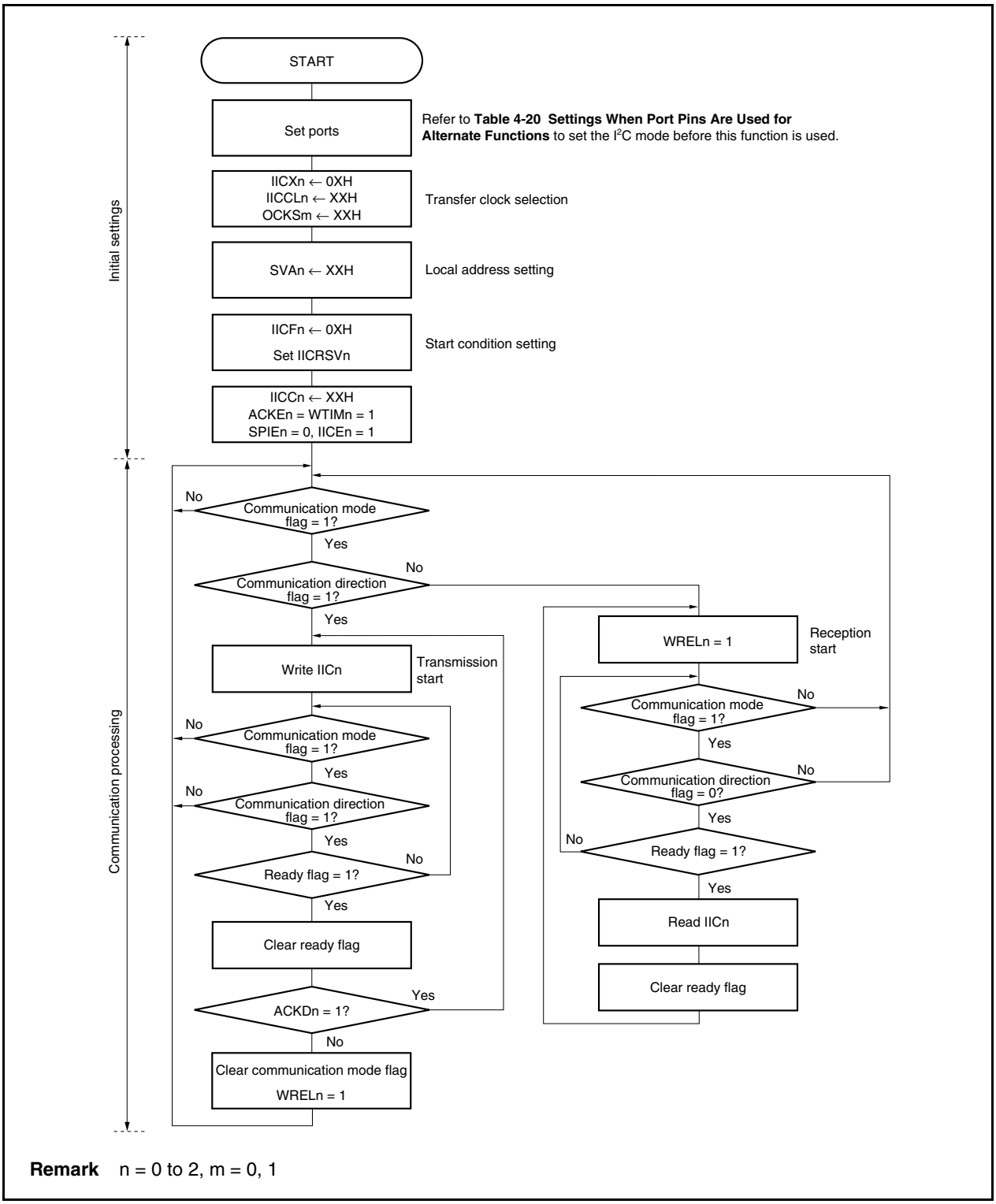
The following shows the operation of the main processing block during slave operation.

I²C0n starts and waits for the communication enable status. When communication is enabled, I²C0n performs transfer using the communication mode flag and ready flag (the processing of the stop condition and start condition is performed by interrupts, conditions are confirmed by flags).

For transmission, the transmission operation is repeated until the master device stops returning $\overline{\text{ACK}}$. When the master device stops returning $\overline{\text{ACK}}$, transfer is complete.

For reception, the required number of data is received and $\overline{ACK}$ is not returned for the next data immediately after transfer is complete. After that, the master device generates the stop condition or restart condition. This causes exit from communications.

Figure 19-21. Slave Operation Flowchart (1)



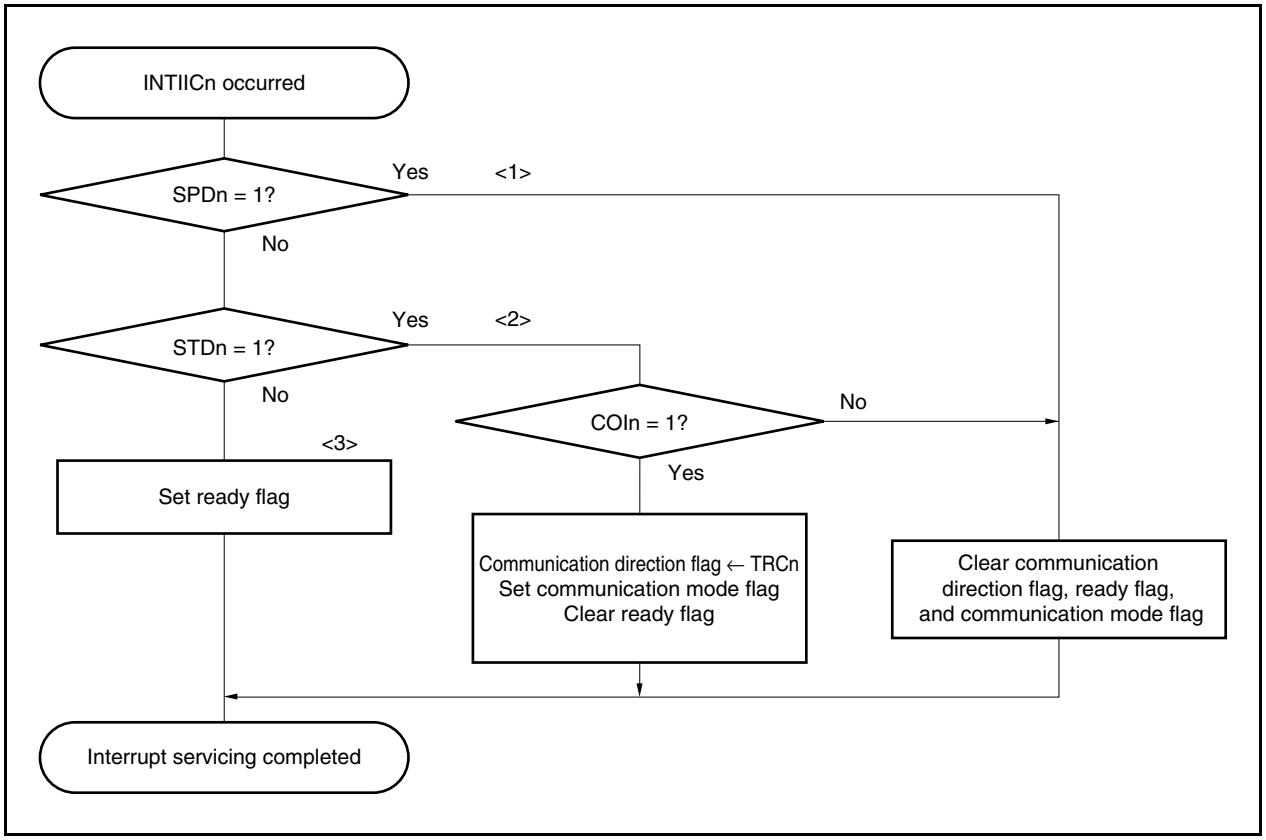
Remark n = 0 to 2, m = 0, 1

The following shows an example of the processing of the slave device by an INTIICn interrupt (it is assumed that no extension codes are used here). During INTIICn interrupt servicing, the status is confirmed and the following steps are executed.

<1> When a stop condition is detected, communication is terminated.
<2> When a start condition is detected, the address is confirmed. If the address does not match, communication is terminated. If the address matches, the communication mode is set, the wait state is released, and operation returns from the interrupt (the ready flag is cleared).
<3> For data transmission/reception, when the ready flag is set, operation returns from the interrupt while the I²C0n bus remains in the wait status.

Remark <1> to <3> above correspond to <1> to <3> in **Figure 19-22 Slave Operation Flowchart (2)**.

Figure 19-22. Slave Operation Flowchart (2)



19.17 Timing of Data Communication

When using I²C bus mode, the master device outputs an address via the serial bus to select one of several slave devices as its communication partner.

After outputting the slave address, the master device transmits the IICSn.TRCn bit, which specifies the data transfer direction, and then starts serial communication with the slave device.

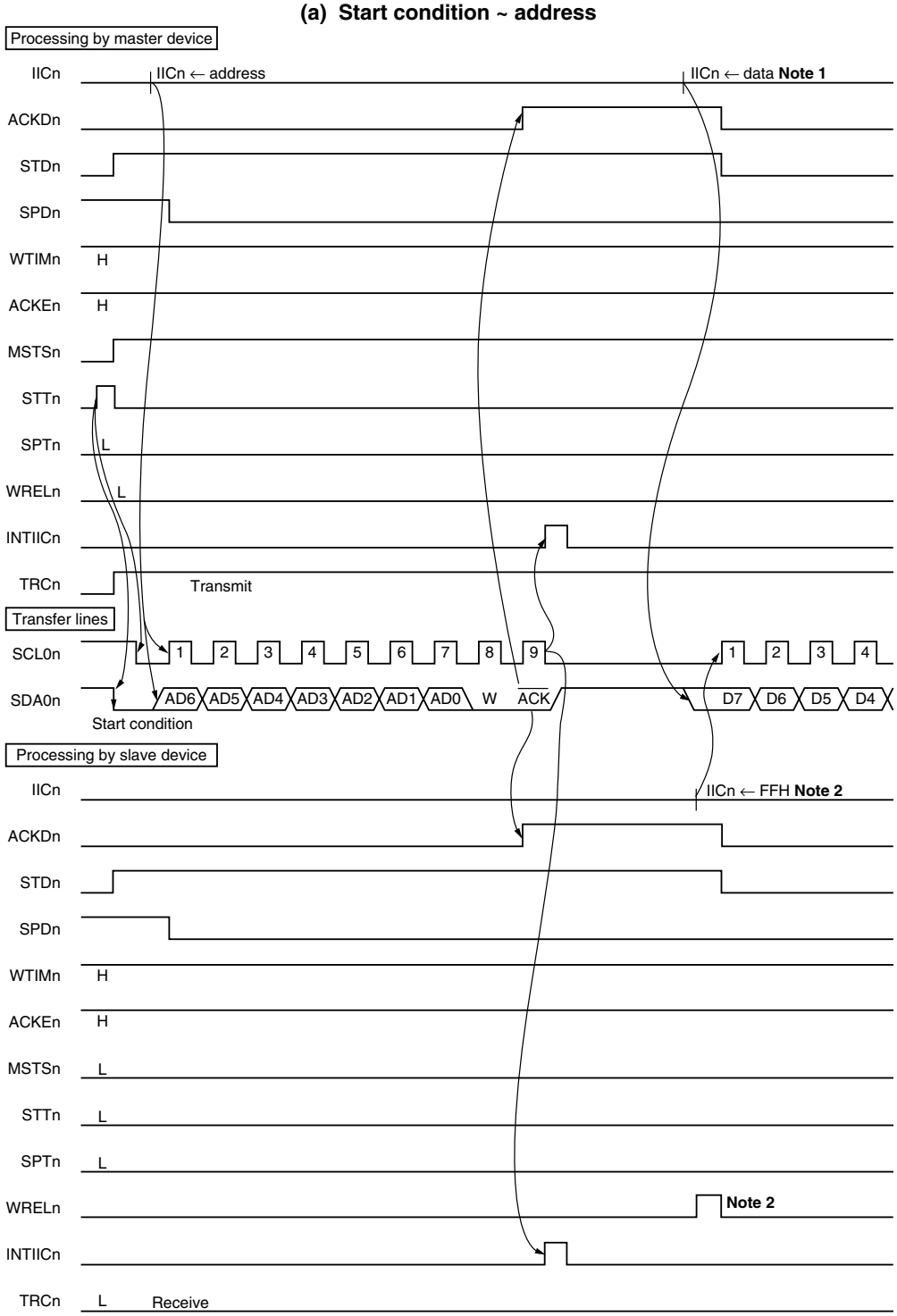
The shift operation of the IICn register is synchronized with the falling edge of the serial clock pin (SCL0n). The transmit data is transferred to the SO latch and is output (MSB first) via the SDA0n pin.

Data input via the SDA0n pin is captured by the IICn register at the rising edge of the SCL0n pin.

The data communication timing is shown below.

Remark n = 0 to 2

Figure 19-23. Example of Master to Slave Communication (When 9-Clock Wait Is Selected for Both Master and Slave) (1/3)



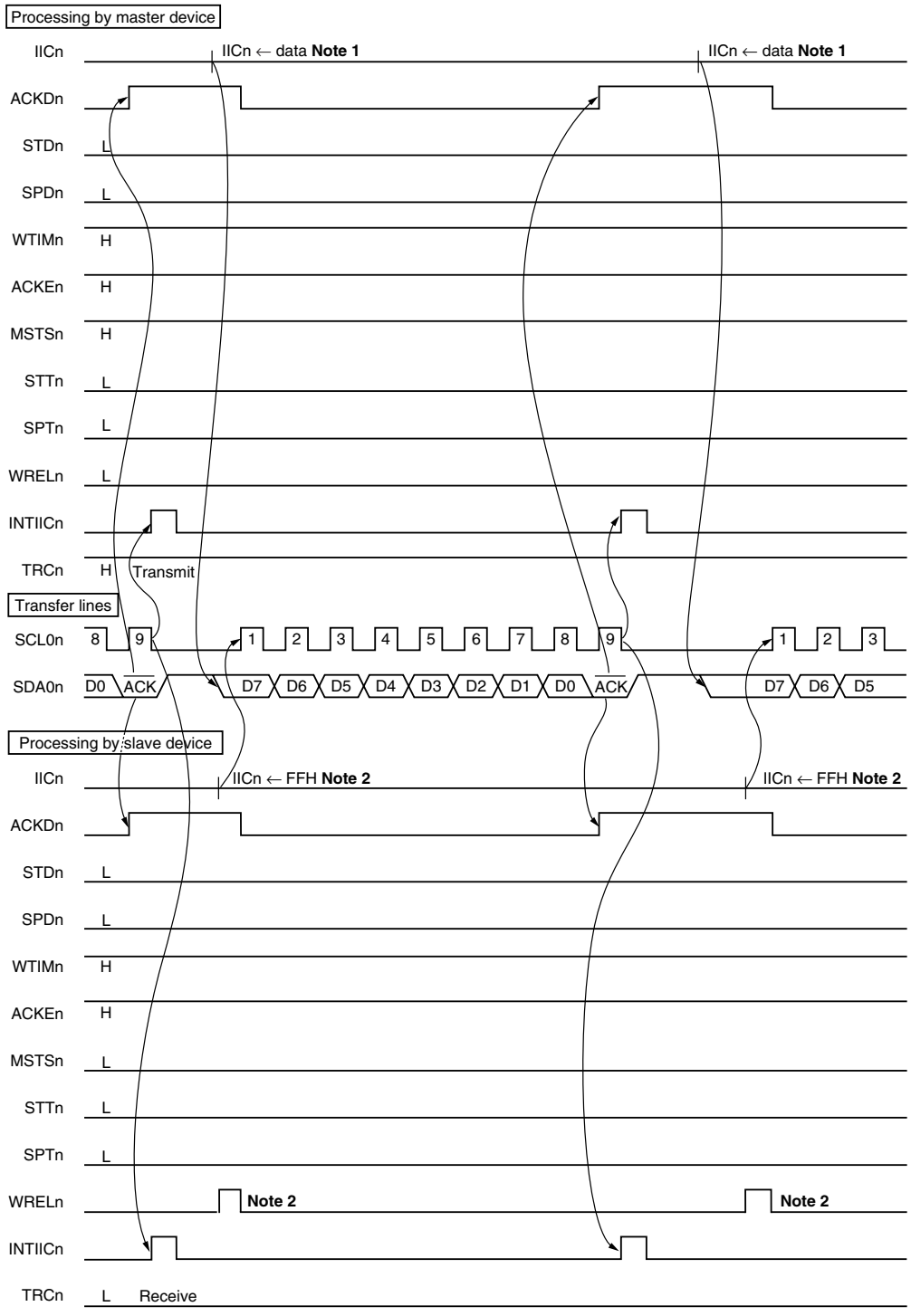
Notes 1. Cancel the wait during a master transmission by writing data to IICn, not by setting WRELn.

2. To cancel the slave wait state, write FFH to IICn or set WRELn.

Remark n = 0 to 2

Figure 19-23. Example of Master to Slave Communication (When 9-Clock Wait Is Selected for Both Master and Slave) (2/3)

(b) Data



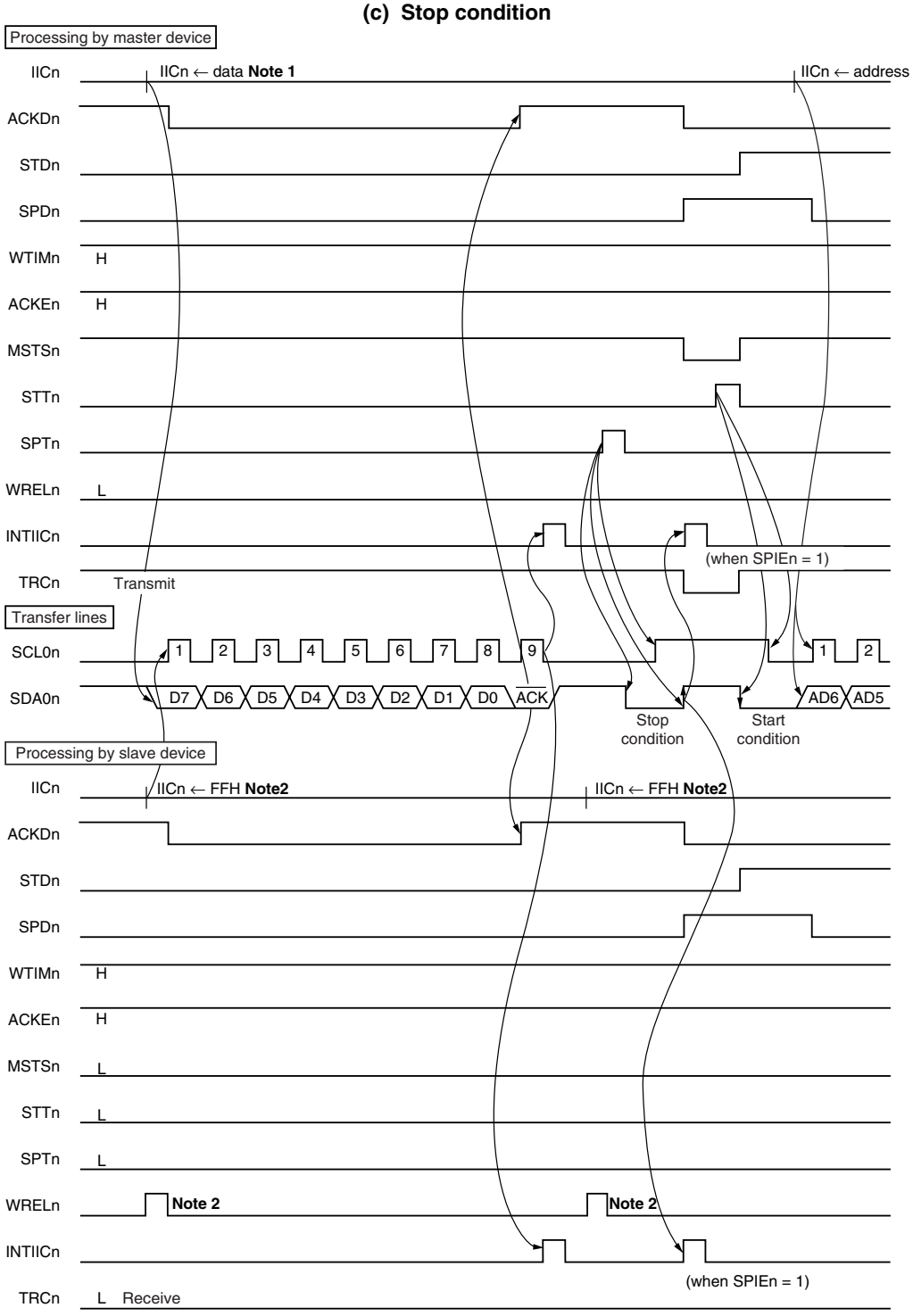
Notes 1. Cancel the wait during a master transmission by writing data to IICn, not by setting WRELn.

2. To cancel the slave wait state, write FFH to IICn or set WRELn.

Remark n = 0 to 2

Figure 19-23. Example of Master to Slave Communication (When 9-Clock Wait Is Selected for Both Master and Slave) (3/3)

(c) Stop condition

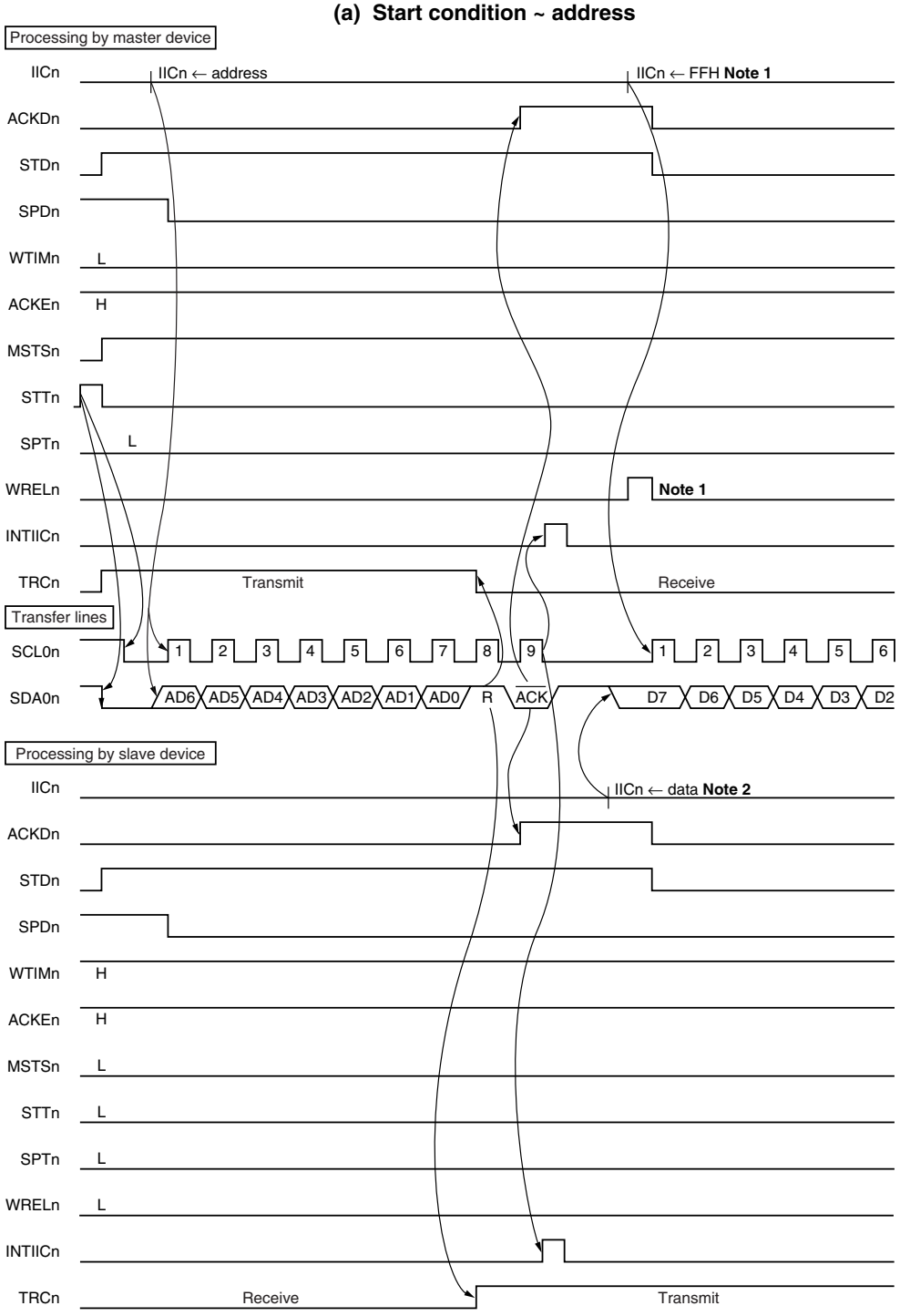


Notes 1. Cancel the wait during a master transmission by writing data to IICn, not by setting WRELn.

2. To cancel the slave wait state, write FFH to IICn or set WRELn.

Remark n = 0 to 2

Figure 19-24. Example of Slave to Master Communication
(When 8-Clock Wait for Master and 9-Clock Wait for Slave Are Selected) (1/3)



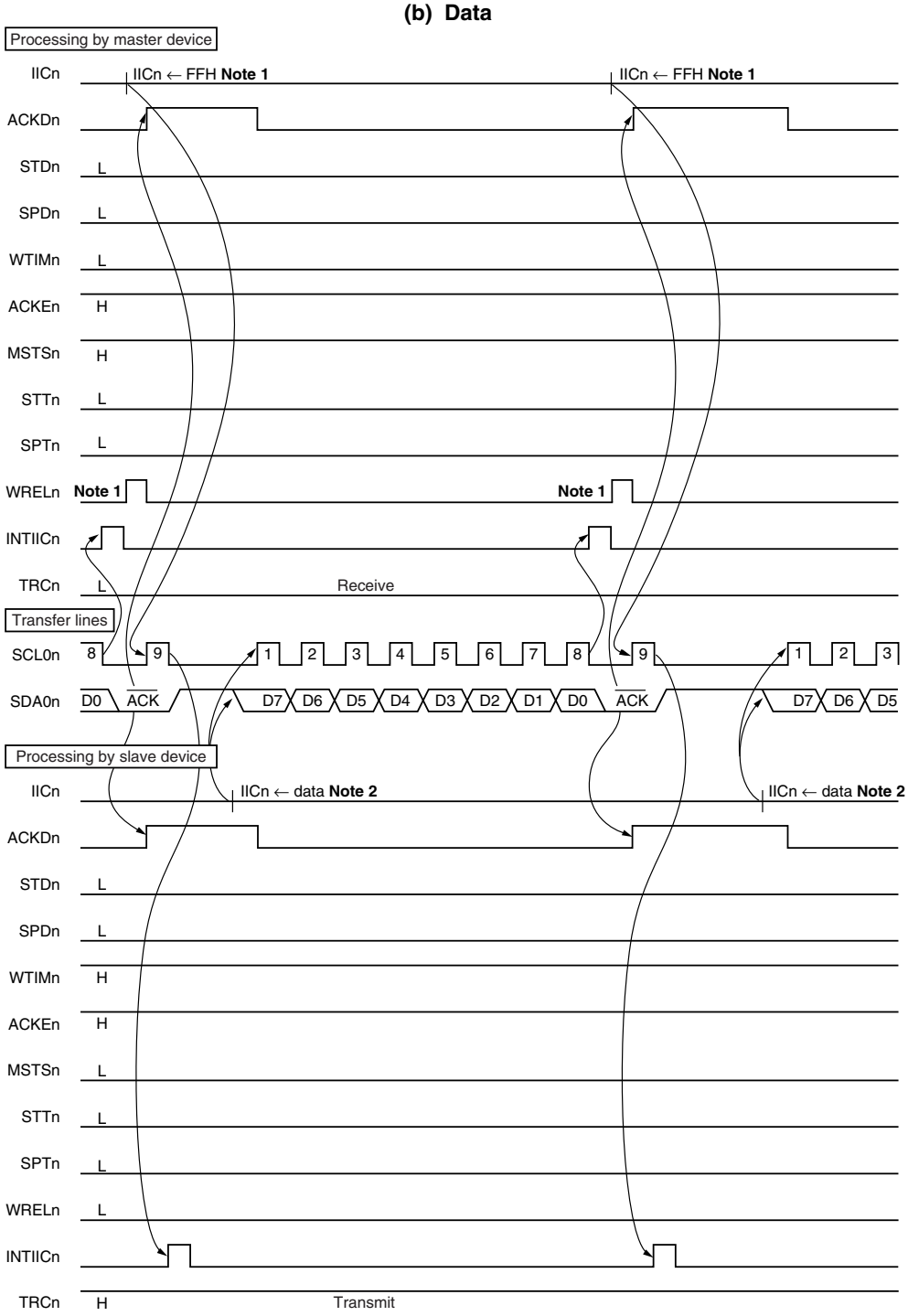
Notes 1. To cancel the master wait state, write FFH to IICn or set WRELn.

2. Cancel the wait during a slave transmission by writing to IICn, not by setting WRELn.

Remark n = 0 to 2

Figure 19-24. Example of Slave to Master Communication
(When 8-Clock Wait for Master and 9-Clock Wait for Slave Are Selected) (2/3)

(b) Data

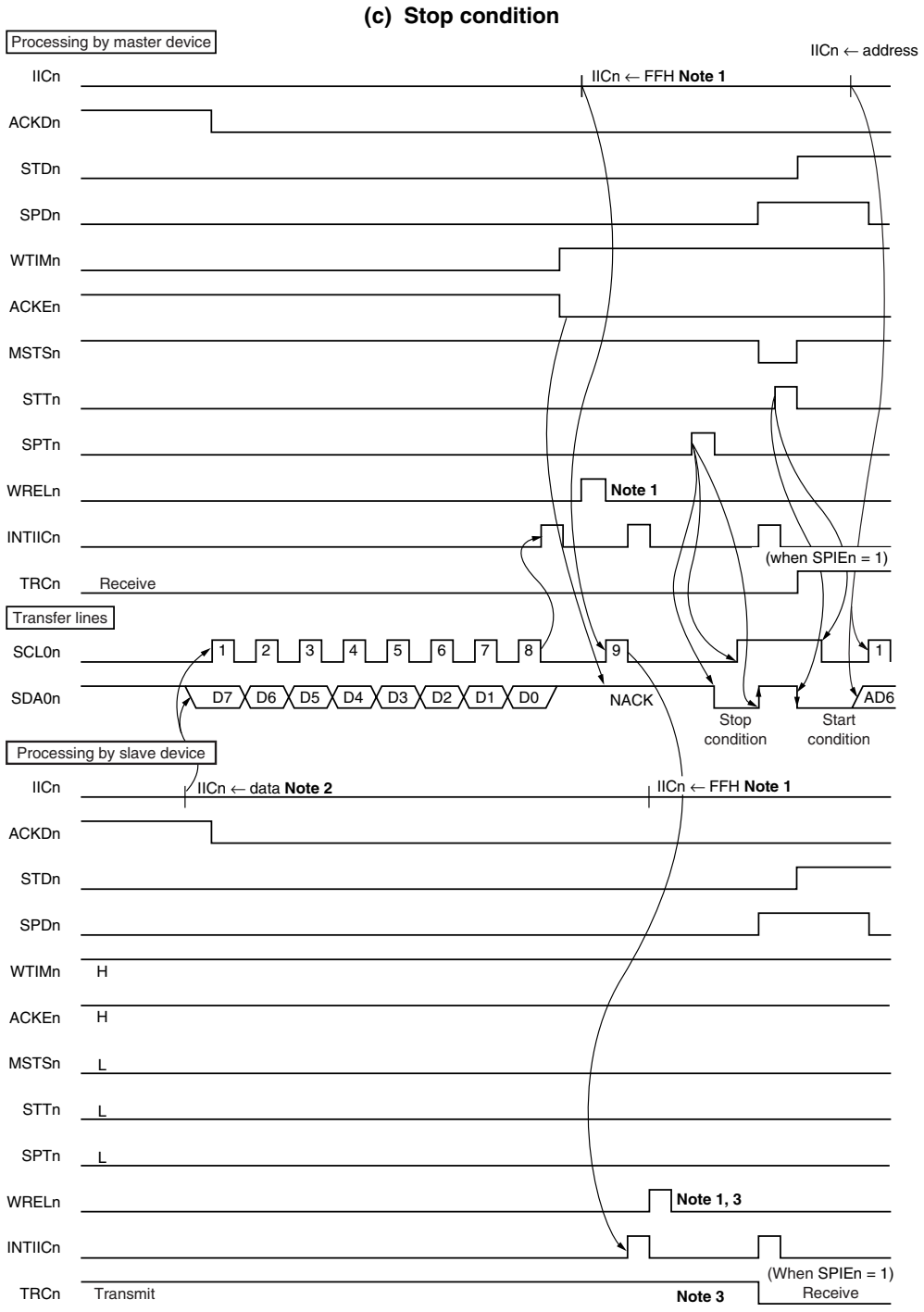


Notes 1. To cancel the master wait state, write FFH to IICn or set WRELn.

2. Cancel the wait during a slave transmission by writing to IICn, not by setting WRELn.

Remark n = 0 to 2

Figure 19-24. Example of Slave to Master Communication
(When 8-Clock Wait for Master and 9-Clock Wait for Slave Are Selected) (3/3)



Notes 1. To cancel the wait state, write FFH to IICn or set WRELn.

2. Cancel the wait during a slave transmission by writing to IICn, not by setting WRELn.

3. When the wait during a slave transmission is canceled by setting WRELn, TRCn is cleared.

Remark n = 0 to 2

CHAPTER 20 CAN CONTROLLER

Caution 1. The CAN controller is allocated in the programmable peripheral I/O area.
Before using the CAN controller, enable use of the programmable peripheral I/O area by using the BPC register.
For details, refer to 3.4.7 Programmable peripheral I/O registers.
2. When using the CAN controller, make sure that f_{XX} = 32 to 48 MHz.

20.1 Overview

The V850ES/JG3-H and V850ES/JH3-H feature an on-chip 1-channel CAN (Controller Area Network) controller that complies with the CAN protocol as standardized in ISO 11898.
The V850ES/JG3-H and V850ES/JH3-H products with an on-chip CAN controller are as follows.

- μPD70F3770, 70F3771

20.1.1 Features

- Compliant with ISO 11898 and tested according to ISO/DIS 16845 (CAN conformance test)
- Standard frame and extended frame transmission/reception enabled
- Transfer rate: 1 Mbps max. (CAN clock input ≥ 8 MHz)
- 32 message buffers/channels
- Receive/transmit history list function
- Automatic block transmission function
- Multi-buffer receive block function
- Mask setting of four patterns is possible for each channel

20.1.2 Overview of functions

Table 20-1 presents an overview of the CAN controller functions.

Table 20-1. Overview of Functions

Function	Details
Protocol	CAN protocol ISO 11898 (standard and extended frame transmission/reception)
Baud rate	Maximum 1 Mbps (CAN clock input ≥ 8 MHz)
Data storage	Storing messages in the CAN RAM
Number of messages	• 32 message buffers/channels • Each message buffer can be set to be either a transmit message buffer or a receive message buffer.
Message reception	• Unique ID can be set to each message buffer. • Mask setting of four patterns is possible for each channel. • A receive completion interrupt is generated each time a message is received and stored in a message buffer. • Two or more receive message buffers can be used as a FIFO receive buffer (multi-buffer receive block function). • Receive history list function
Message transmission	• Unique ID can be set to each message buffer. • Transmit completion interrupt for each message buffer • Message buffer numbers 0 to 7 specified as transmit message buffers can be used for automatic block transfer. Message transmission interval is programmable (automatic block transmission function (hereafter referred to as “ABT”)). • Transmission history list function
Remote frame processing	Remote frame processing by transmit message buffer
Time stamp function	• The time stamp function can be set for a receive message when a 16-bit timer is used in combination. • The time stamp capture trigger can be selected (SOF or EOF in a CAN message frame can be detected).
Diagnostic function	• Readable error counters • “Valid protocol operation flag” for verification of bus connections • Receive-only mode • Single-shot mode • CAN protocol error type decoding • Self-test mode
Release from bus-off state	• Can be forcibly released from bus-off by software (timing restrictions are ignored). • Cannot be automatically released from bus-off (release request by software is required).
Power save mode	• CAN sleep mode (can be woken up by CAN bus) • CAN stop mode (cannot be woken up by CAN bus)

20.1.3 Configuration

The CAN controller is composed of the following four blocks.

(1) Internal bus interface

This functional block provides an internal bus interface and means of transmitting and receiving signals between the CAN module and the host CPU.

(2) MCM (Memory Control Module)

This functional block controls access to the CAN protocol layer and to the CAN RAM within the CAN module.

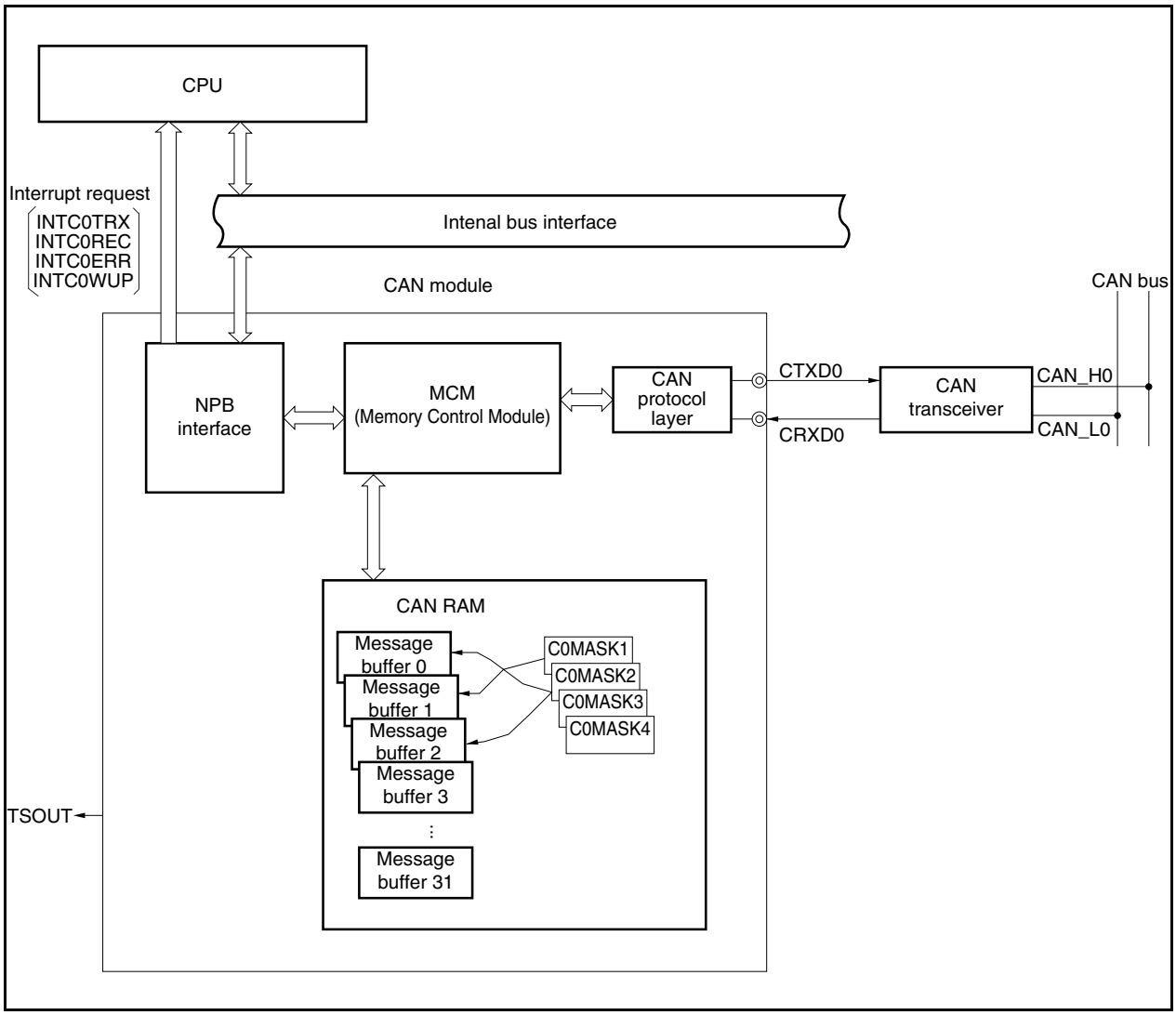
(3) CAN protocol layer

This functional block is involved in the operation of the CAN protocol and its related settings.

(4) CAN RAM

This is the CAN memory functional block, which is used to store message IDs, message data, etc.

Figure 20-1. Block Diagram of CAN Module



20.2 CAN Protocol

CAN (Controller Area Network) is a high-speed multiplex communication protocol for real-time communication in automotive applications (class C). CAN is prescribed by ISO 11898. For details, refer to the ISO 11898 specifications.

The CAN specification is generally divided into two layers: a physical layer and a data link layer. In turn, the data link layer includes logical link and medium access control. The composition of these layers is illustrated below.

Figure 20-2. Composition of Layers

Higher

Lower

Data link layer[Note]	• Logical link control (LLC)	• Acceptance filtering • Overload report • Recovery management
	• Medium access control (MAC)	• Data capsuled/not capsuled • Frame coding (stuffing/no stuffing) • Medium access management • Error detection • Error report • Acknowledgment • Seriated/not seriated
Physical layer		Prescription of signal level and bit description

Note CAN controller specification

20.2.1 Frame format

(1) Standard format frame

- The standard format frame uses 11-bit identifiers, which means that it can handle up to 2,048 messages.

(2) Extended format frame

- The extended format frame uses 29-bit (11 bits + 18 bits) identifiers, which increases the number of messages that can be handled to $2{,}048 \times 2^{18}$ messages.
- An extended format frame is set when “recessive level” (CMOS level of “1”) is set for both the SRR and IDE bits in the arbitration field.

20.2.2 Frame types

The following four types of frames are used in the CAN protocol.

Table 20-2. Frame Types

Frame Type	Description
Data frame	Frame used to transmit data
Remote frame	Frame used to request a data frame
Error frame	Frame used to report error detection
Overload frame	Frame used to delay the next data frame or remote frame

(1) Bus value

The bus values are divided into dominant and recessive.

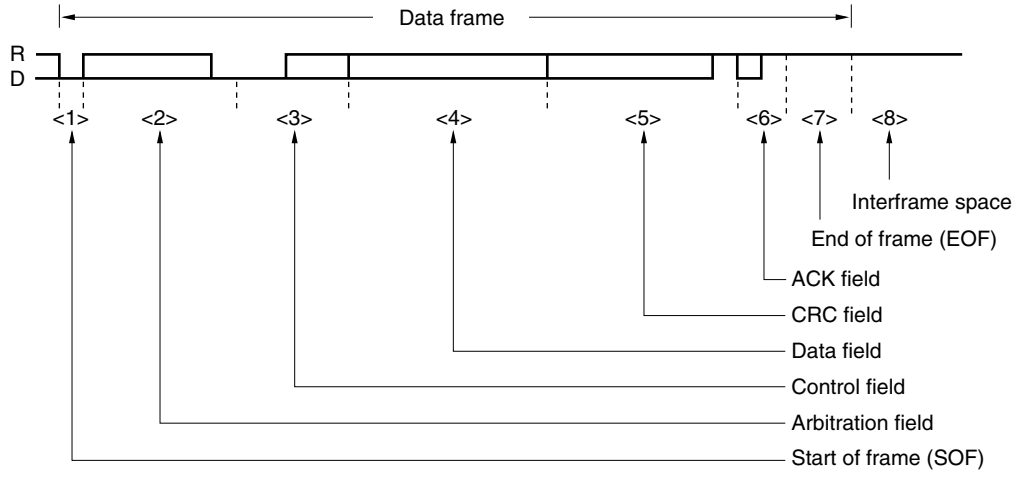
- Dominant level is indicated by logical 0.
- Recessive level is indicated by logical 1.
- When a dominant level and a recessive level are transmitted simultaneously, the bus value becomes dominant level.

20.2.3 Data frame and remote frame

(1) Data frame

A data frame is composed of seven fields.

Figure 20-3. Data Frame

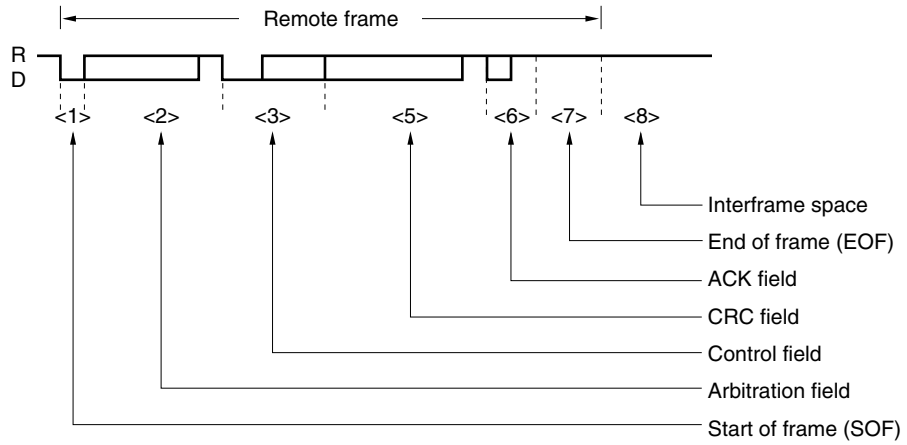


Remark D: Dominant = 0
R: Recessive = 1

(2) Remote frame

A remote frame is composed of six fields.

Figure 20-4. Remote Frame



Remarks 1. The data field is not transferred even if the control field's data length code is not "0000B".

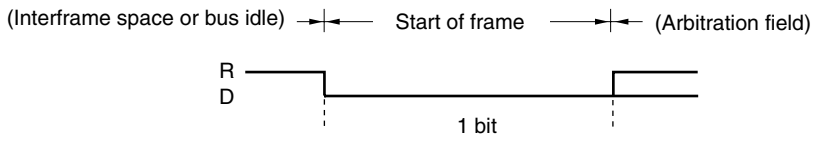
2. D: Dominant = 0
R: Recessive = 1

(3) Description of fields

<1> Start of frame (SOF)

The start of frame field is located at the start of a data frame or remote frame.

Figure 20-5. Start of Frame (SOF)



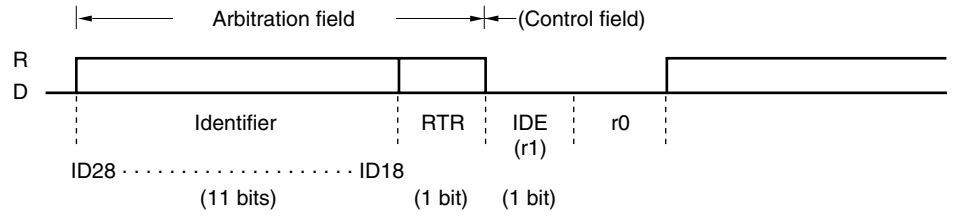
Remark D: Dominant = 0
R: Recessive = 1

- If a dominant level is detected in the bus idle state, a hardware synchronization is performed (the current TQ is assigned to be the SYNC segment).
- If a dominant level is sampled at the sample point following such a hardware synchronization, the bit is assigned to be a SOF. If a recessive level is detected, the protocol layer returns to the bus idle state and regards the preceding dominant pulse as a noise only. In this case an error frame is not generated.

<2> Arbitration field

The arbitration field is used to set the priority, data frame/remote frame, and frame format.

Figure 20-6. Arbitration Field (in Standard Format Mode)



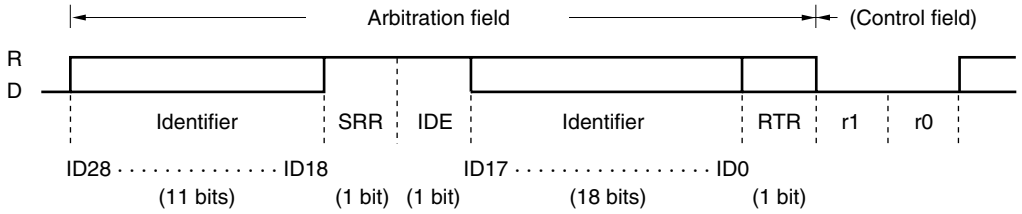
Cautions 1. ID28 to ID18 are identifiers.

2. An identifier is transmitted MSB first.

Remark D: Dominant = 0

R: Recessive = 1

Figure 20-7. Arbitration Field (in Extended Format Mode)



Cautions 1. ID28 to ID18 are identifiers.

2. An identifier is transmitted MSB first.

Remark D: Dominant = 0

R: Recessive = 1

Table 20-3. RTR Frame Settings

Frame Type	RTR Bit
Data frame	0 (D)
Remote frame	1 (R)

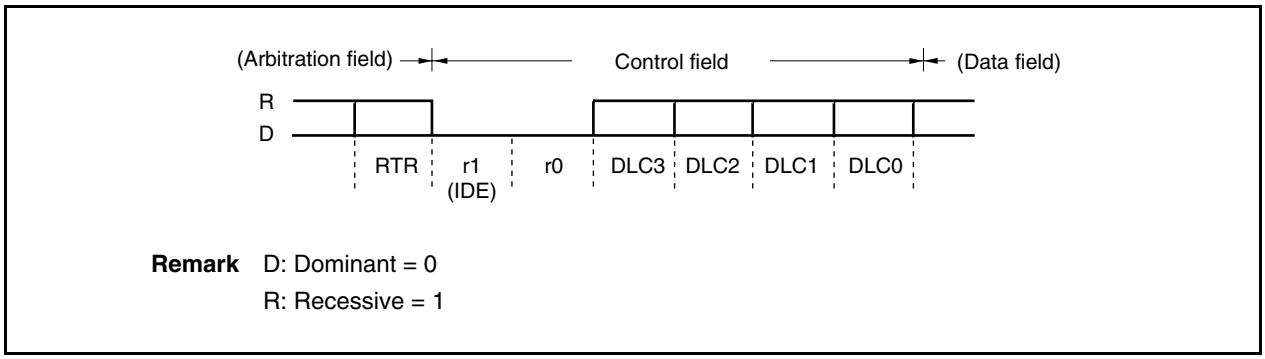
Table 20-4. Frame Format Setting (IDE Bit) and Number of Identifier (ID) Bits

Frame Format	SRR Bit	IDE Bit	Number of Bits
Standard format mode	None	0 (D)	11 bits
Extended format mode	1 (R)	1 (R)	29 bits

<3> Control field

The control field sets “DLC” as the number of data bytes in the data field (DLC = 0 to 8).

Figure 20-8. Control Field



Remark D: Dominant = 0
R: Recessive = 1

In a standard format frame, the control field’s IDE bit is the same as the r1 bit.

Table 20-5. Data Length Setting

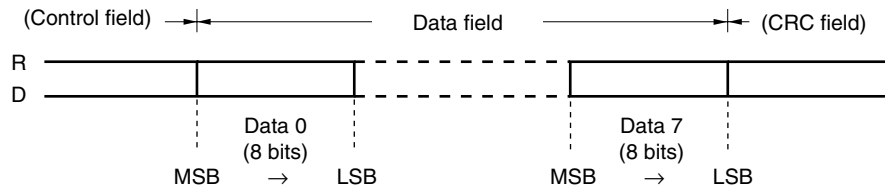
Data Length Code				Data Byte Count
DLC3	DLC2	DLC1	DLC0	
0	0	0	0	0 bytes
0	0	0	1	1 byte
0	0	1	0	2 bytes
0	0	1	1	3 bytes
0	1	0	0	4 bytes
0	1	0	1	5 bytes
0	1	1	0	6 bytes
0	1	1	1	7 bytes
1	0	0	0	8 bytes
Other than above				8 bytes regardless of the value of DLC3 to DLC0

Caution In the remote frame, there is no data field even if the data length code is not 0000B.

<4> Data field

The data field contains the amount of data (byte units) set by the control field. Up to 8 units of data can be set.

Figure 20-9. Data Field

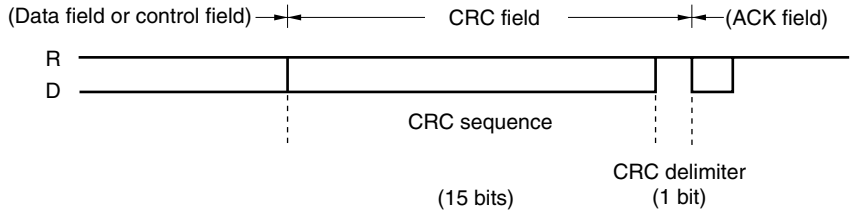


Remark D: Dominant = 0
R: Recessive = 1

<5> CRC field

The CRC field is a 16-bit field that is used to check for errors in transmit data.

Figure 20-10. CRC Field



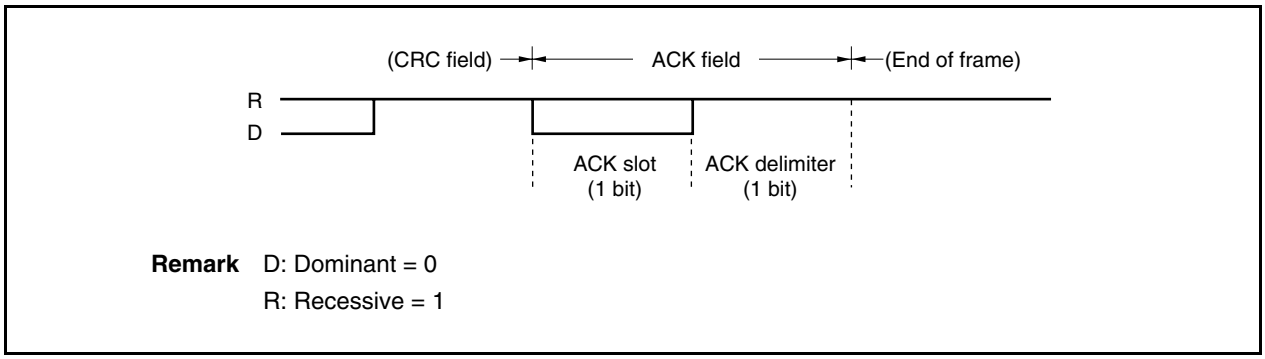
Remark D: Dominant = 0
R: Recessive = 1

- The polynomial P(X) used to generate the 15-bit CRC sequence is expressed as follows.
  $P(X) = X^{15} + X^{14} + X^{10} + X^8 + X^7 + X^4 + X^3 + 1$
- Transmitting node: Transmits the CRC sequence calculated from the data (before bit stuffing) in the start of frame, arbitration field, control field, and data field.
- Receiving node: Compares the CRC sequence calculated using data bits that exclude the stuffing bits in the receive data with the CRC sequence in the CRC field. If the two CRC sequences do not match, the node issues an error frame.

<6> ACK field

The ACK field is used to acknowledge normal reception.

Figure 20-11. ACK Field



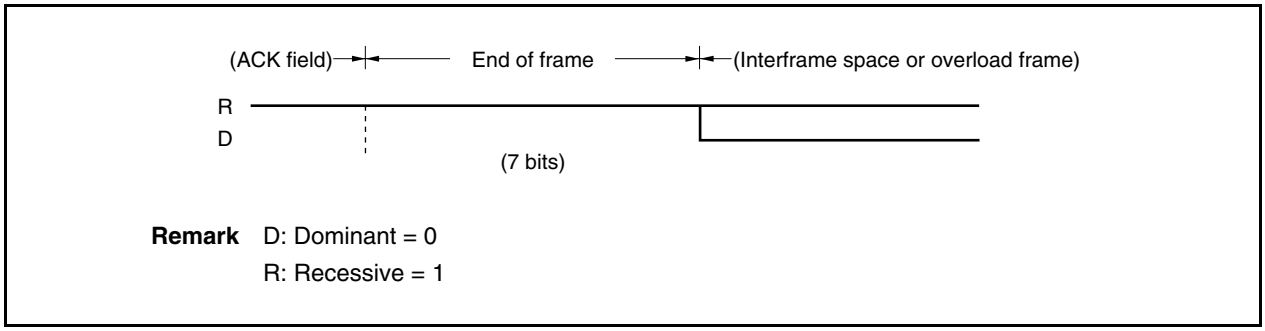
Remark D: Dominant = 0
R: Recessive = 1

- If no CRC error is detected, the receiving node sets the ACK slot to the dominant level.
- The transmitting node outputs two recessive-level bits.

<7> End of frame (EOF)

The end of frame field indicates the end of data frame/remote frame.

Figure 20-12. End of Frame (EOF)



Remark D: Dominant = 0
R: Recessive = 1

<8> Interframe space

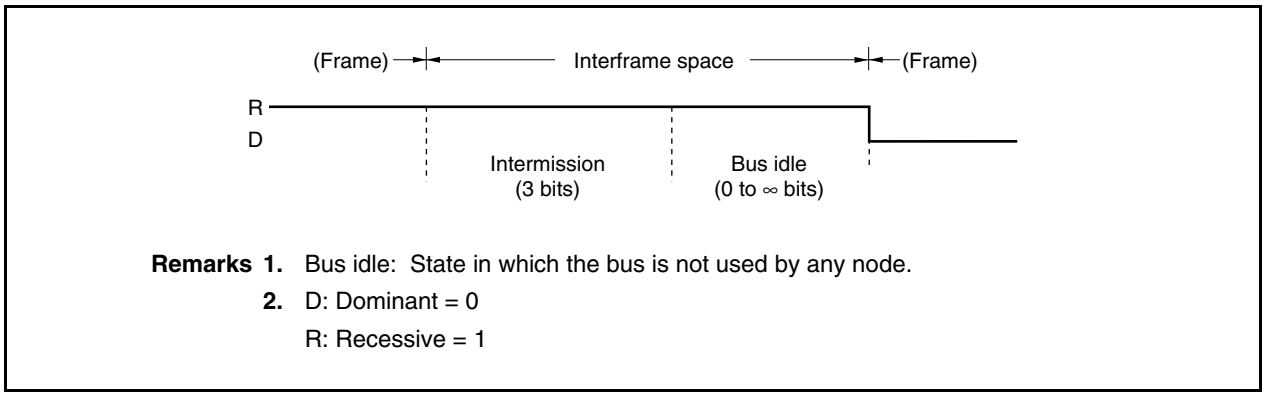
The interframe space is inserted after a data frame, remote frame, error frame, or overload frame to separate one frame from the next.

- The bus state differs depending on the error status.

(a) Error active node

The interframe space consists of a 3-bit intermission field and a bus idle field.

Figure 20-13. Interframe Space (Error Active Node)



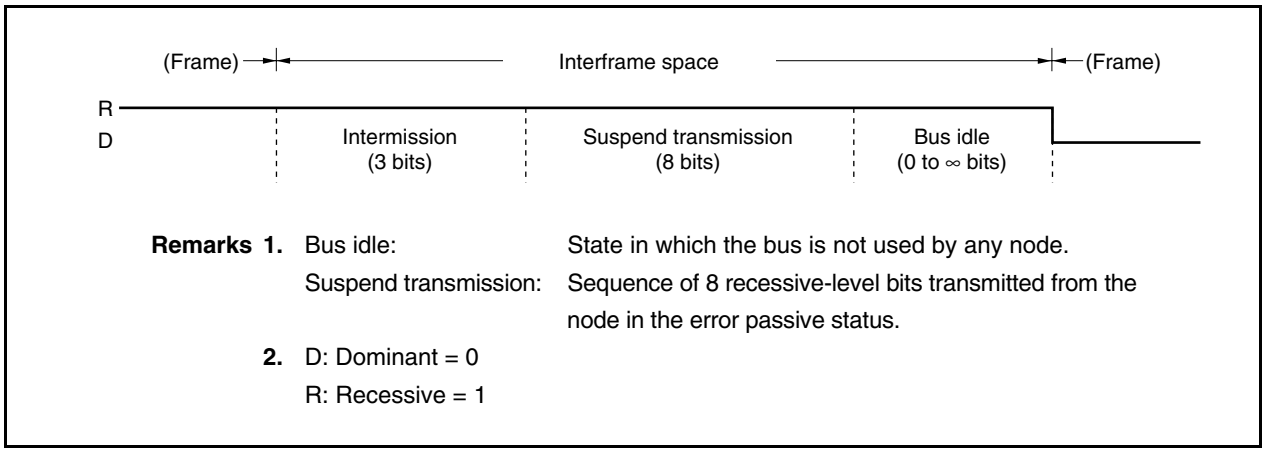
Remarks 1. Bus idle: State in which the bus is not used by any node.

2. D: Dominant = 0
R: Recessive = 1

(b) Error passive node

The interframe space consists of an intermission field, a suspend transmission field, and a bus idle field.

Figure 20-14. Interframe Space (Error Passive Node)



Remarks 1. Bus idle: State in which the bus is not used by any node.
Suspend transmission: Sequence of 8 recessive-level bits transmitted from the node in the error passive status.

2. D: Dominant = 0
R: Recessive = 1

Usually, the intermission field is 3 bits. If the transmitting node detects a dominant level at the third bit of the intermission field, however, it executes transmission.

- Operation in error status

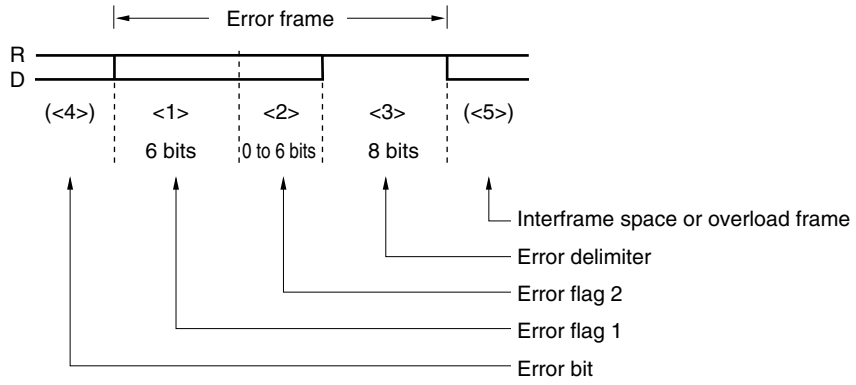
Table 20-6. Operation in Error Status

Error Status	Operation
Error active	A node in this status can transmit immediately after a 3-bit intermission.
Error passive	A node in this status can transmit 8 bits after the intermission.

20.2.4 Error frame

An error frame is output by a node that has detected an error.

Figure 20-15. Error Frame



Remark D: Dominant = 0
R: Recessive = 1

Table 20-7. Definition of Error Frame Fields

No.	Name	Bit Count	Definition
<1>	Error flag 1	6	Error active node: Outputs 6 dominant-level bits consecutively. Error passive node: Outputs 6 recessive-level bits consecutively. If another node outputs a dominant level while one node is outputting a passive error flag, the passive error flag is not cleared until the same level is detected 6 bits in a row.
<2>	Error flag 2	0 to 6	Nodes receiving error flag 1 detect bit stuff errors and issues this error flag.
<3>	Error delimiter	8	Outputs 8 recessive-level bits consecutively. If a dominant level is detected at the 8th bit, an overload frame is transmitted from the next bit.
<4>	Error bit	–	The bit at which the error was detected. The error flag is output from the bit next to the error bit. In the case of a CRC error, this bit is output following the ACK delimiter.
<5>	Interframe space/overload frame	–	An interframe space or overload frame starts from here.

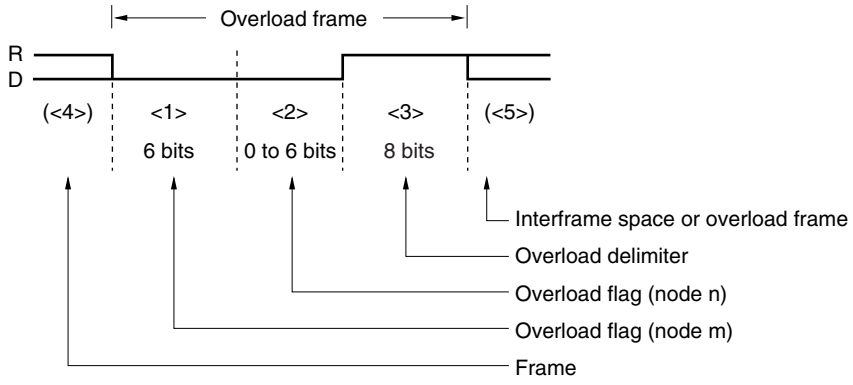
20.2.5 Overload frame

An overload frame is transmitted under the following conditions.

- When the receiving node has not completed the reception operation[Note]
- If a dominant level is detected at the first two bits during intermission
- If a dominant level is detected at the last bit (7th bit) of the end of frame or at the last bit (8th bit) of the error delimiter/overload delimiter

Note In this CAN controller, all reception frames can be loaded without outputting an overload frame because of the enough high-speed internal processing.

Figure 20-16. Overload Frame



Remark D: Dominant = 0
R: Recessive = 1
Node n ≠ node m

Table 20-8. Definition of Overload Frame Fields

No	Name	Bit Count	Definition
<1>	Overload flag	6	Outputs 6 dominant-level bits consecutively.
<2>	Overload flag from other node	0 to 6	The node that received an overload flag in the interframe space outputs an overload flag.
<3>	Overload delimiter	8	Outputs 8 recessive-level bits consecutively. If a dominant level is detected at the 8th bit, an overload frame is transmitted from the next bit.
<4>	Frame	–	Output following an end of frame, error delimiter, or overload delimiter.
<5>	Interframe space/overload frame	–	An interframe space or overload frame starts from here.

20.3 Functions

20.3.1 Determining bus priority

(1) When a node starts transmission:

- During bus idle, the node that output data first transmits the data.

(2) When more than one node starts transmission:

- The node that consecutively outputs the dominant level for the longest from the first bit of the arbitration field has the bus priority (if a dominant level and a recessive level are simultaneously transmitted, the dominant level is taken as the bus value).
- The transmitting node compares its output arbitration field and the data level on the bus.

Table 20-9. Determining Bus Priority

Level match	Continuous transmission
Level mismatch	Continuous transmission

(3) Priority of data frame and remote frame

- When a data frame and a remote frame are on the bus, the data frame has priority because its RTR bit, the last bit in the arbitration field, carries a dominant level.

Remark If the extended-format data frame and the standard-format remote frame conflict on the bus (if ID28 to ID18 of both of them are the same), the standard-format remote frame takes priority.

20.3.2 Bit stuffing

Bit stuffing is used to establish synchronization by appending 1 bit of inverted-level data if the same level continues for 5 bits, in order to prevent a burst error.

Table 20-10. Bit Stuffing

Transmission	During the transmission of a data frame or remote frame, when the same level continues for 5 bits in the data between the start of frame and the ACK field, 1 inverted-level bit of data is inserted before the following bit.
Reception	During the reception of a data frame or remote frame, when the same level continues for 5 bits in the data between the start of frame and the ACK field, reception is continued after deleting the next bit.

20.3.3 Multi masters

As the bus priority (a node which acquires transmission rights) is determined by the identifier, any node can be the bus master.

20.3.4 Multi cast

Although there is one transmitting node, two or more nodes can receive the same data at the same time because the same identifier can be set to two or more nodes.

20.3.5 CAN sleep mode/CAN stop mode function

The CAN sleep mode/CAN stop mode function puts the CAN controller in waiting mode to achieve low power consumption.

The controller is woken up from the CAN sleep mode by bus operation but it is not woken up from the CAN stop mode by bus operation (the CAN stop mode is controlled by CPU access).

20.3.6 Error control function

(1) Error types

Table 20-11. Error Types

Type	Description of Error		Detection State	
	Detection Method	Detection Condition	Transmission/ Reception	Field/Frame
Bit error	Comparison of the output level and level on the bus	Mismatch of levels	Transmitting/ receiving node	Bit that is outputting data on the bus at the start of frame to end of frame, error frame and overload frame.
Stuff error	Check of the receive data at the stuff bit	6 consecutive bits of the same output level	Receiving node	Start of frame to CRC sequence
CRC error	Comparison of the CRC sequence generated from the receive data and the received CRC sequence	Mismatch of CRC	Receiving node	CRC field
Form error	Field/frame check of the fixed format	Detection of fixed format violation	Receiving node	CRC delimiter ACK field End of frame Error frame Overload frame
ACK error	Check of the ACK slot by the transmitting node	Detection of recessive level in ACK slot	Transmitting node	ACK slot

(2) Output timing of error frame

Table 20-12. Output Timing of Error Frame

Type	Output Timing
Bit error, stuff error, form error, ACK error	Error frame output is started at the timing of the bit following the detected error.
CRC error	Error frame output is started at the timing of the bit following the ACK delimiter.

(3) Processing in case of error

The transmission node re-transmits the data frame or remote frame after the error frame. (However, it does not re-transmit the frame in the single-shot mode.)

(4) Error state

(a) Types of error states

The following three types of error states are defined by the CAN specification.

- Error active
- Error passive
- Bus-off

These types of error states are classified by the values of the C0ERC.TEC7 to C0ERC.TEC0 bits (transmission error counter bits) and the C0ERC.REC6 to C0ERC.REC0 bits (reception error counter bits) as shown in Table 20-13.

The present error state is indicated by the C0INFO register.

When each error counter value becomes equal to or greater than the error warning level (96), the C0INFO.TECS0 or C0INFO.RECS0 bit is set to 1. In this case, the bus state must be tested because it is considered that the bus has a serious fault. An error counter value of 128 or more indicates an error passive state and the TECS1 or RECS1 bit is set to 1.

- If the value of the transmission error counter is greater than or equal to 256 (actually, the transmission error counter does not indicate a value greater than or equal to 256), the bus-off state is reached and the C0INFO.BOFF bit is set to 1.
- If only one node is active on the bus at startup (i.e., when the bus is connected only to the local station), ACK is not returned even if data is transmitted. Consequently, re-transmission of the error frame and data is repeated. In the error passive state, however, the transmission error counter is not incremented and the bus-off state is not reached.

Table 20-13. Types of Error States

Type	Operation	Value of Error Counter	Indication of C0INFO Register	Operation Specific to Error State
Error active	Transmission	0 to 95	TECS1, TECS0 = 00	• Outputs an active error flag (6 consecutive dominant-level bits) on detection of the error.
	Reception	0 to 95	RECS1, RECS0 = 00	
	Transmission	96 to 127	TECS1, TECS0 = 01	
	Reception	96 to 127	RECS1, RECS0 = 01	
Error passive	Transmission	128 to 255	TECS1, TECS0 = 11	• Outputs a passive error flag (6 consecutive recessive-level bits) on detection of the error. • Transmits 8 recessive-level bits, in between transmissions, following an intermission (suspend transmission).
	Reception	128 or more	RECS1, RECS0 = 11	
Bus-off	Transmission	256 or more (not indicated)[Note]	BOFF = 1, TECS1, TECS0 = 11	• Communication is not possible. However, when the frame is received, no messages are stored and the following operations are performed. <1> TSOUT toggles. <2> REC is incremented/decremented. <3> VALID bit is set. • If the initialization mode is set, after request to transit to an operation mode other than the initialization mode, 11 consecutive recessive-level bits are generated 128 times, and then the error counter is reset to 0 and the error active state can be restored.

Note The value of the transmit error counter (TEC) does not carry any meaning if BOFF has been set. If an error that increments the value of the transmission error counter by 8 while the counter value is in a range of 248 to 255 occurs, the counter is not incremented and the bus-off state is assumed.

(b) Error counter

The error counter counts up when an error has occurred, and counts down upon successful transmission and reception. The error counter counts up immediately after error detection.

Table 20-14. Error Counter

State	Transmission Error Counter (TEC7 to TEC0 Bits)	Reception Error Counter (REC6 to REC0 Bits)
Receiving node detects an error (except bit error in the active error flag or overload flag).	No change	+1 (REPS bit = 0)
Receiving node detects dominant level following error flag of error frame.	No change	+8 (REPS bit = 0)
Transmitting node transmits an error flag. [As exceptions, the error counter does not change in the following cases.] <1> ACK error is detected in error passive state and dominant level is not detected while the passive error flag is being output. <2> A stuff error is detected in an arbitration field that transmitted a recessive level as a stuff bit, but a dominant level is detected.	+8	No change
Bit error detection while active error flag or overload flag is being output (error-active transmitting node)	+8	No change
Bit error detection while active error flag or overload flag is being output (error-active receiving node)	No change	+8 (REPS bit = 0)
When the node detects 14 consecutive dominant-level bits from the beginning of the active error flag or overload flag, and then subsequently detects 8 consecutive dominant-level bits. When the node detects 8 consecutive dominant levels after a passive error flag	+8 (transmitting)	+8 (receiving, REPS bit = 0)
When the transmitting node has completed transmission without error (±0 if error counter = 0)	−1	No change
When the receiving node has completed reception without error	No change	• −1 (1 ≤ REC6 to REC0 ≤ 127, REPS bit = 0) • ±0 (REC6 to REC0 = 0, REPS bit = 0) • Any value of 119 to 127 is set (REPS bit = 1)

(c) Occurrence of bit error in intermission

An overload frame is generated.

Caution If an error occurs, it is controlled according to the contents of the transmission error counter and reception error counter before the error occurred. The value of the error counter is incremented after the error flag has been output.

(5) Recovery from bus-off state

When the CAN module is in the bus-off state, the transmission pins (CTXD0) cut off from the CAN bus always output the recessive level.

The CAN module recovers from the bus-off state in the following bus-off recovery sequence.

<1> Request to enter the CAN initialization mode

<2> Request to enter a CAN operation mode

(a) Recovery operation through normal recovery sequence

(b) Forced recovery operation that skips recovery sequence

(a) Recovery from bus-off state through normal recovery sequence

The CAN module first issues a request to enter the initialization mode (refer to timing <1> in Figure 20-17). This request will be immediately acknowledged, and the C0CTRL.OPMODE2 to OPMODE0 bits are cleared to 000B. Processing such as analyzing the fault that has caused the bus-off state, re-defining the CAN module and message buffer using application software, or stopping the operation of the CAN module can be performed by clearing the C0GMCTRL.GOM bit to 0.

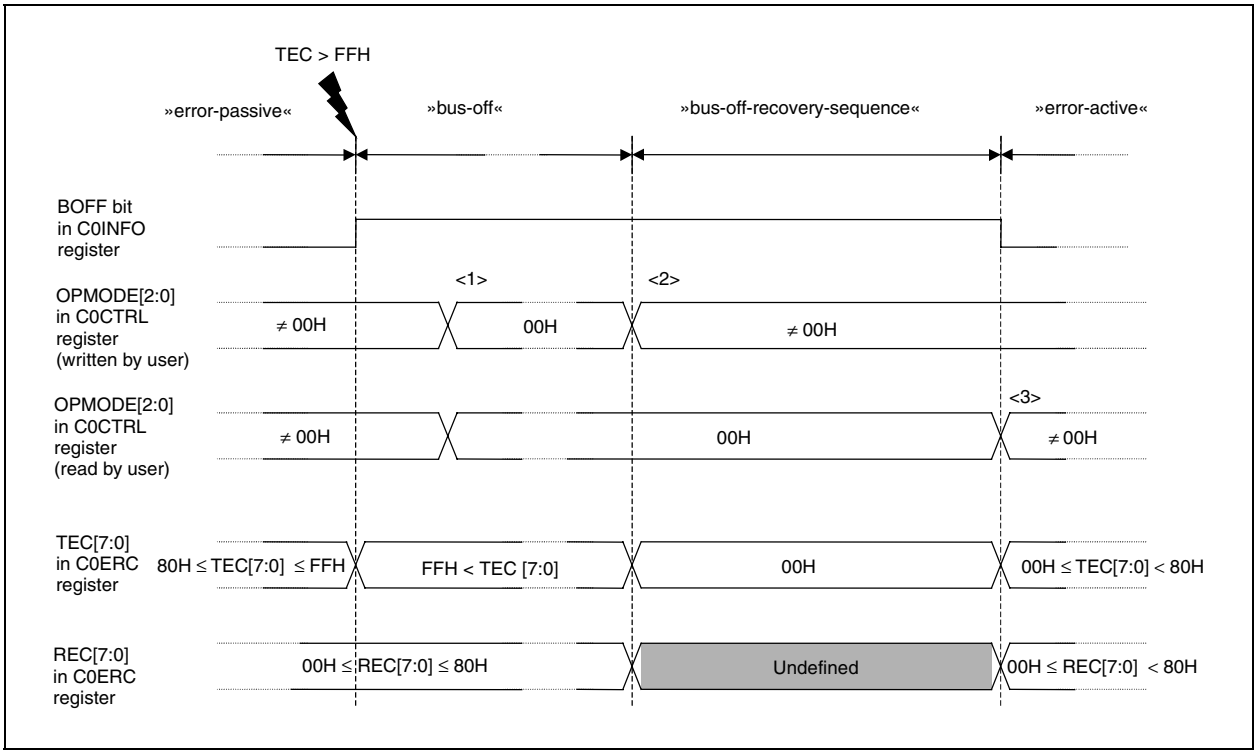
Next, the module requests to change the mode from the initialization mode to an operation mode (refer to timing <2> in Figure 20-17). This starts an operation to recover the CAN module from the bus-off state. The conditions under which the module can recover from the bus-off state are defined by the CAN protocol ISO 11898, and it is necessary to detect 11 consecutive recessive-level bits more than 128 times. At this time, the request to change the mode to an operation mode is held pending until the recovery conditions are satisfied. When the recovery conditions are satisfied (refer to timing <3> in Figure 20-17), the CAN module can enter the operation mode it has requested. Until the CAN module enters this operation mode, it stays in the initialization mode. Whether the CAN module has completed transition to any other operation mode can be confirmed by reading the OPMODE2 to OPMODE0 bits. Before transition to any other operation mode is completed, OPMODE2 to OPMODE0 bits = 000B is read.

During the bus-off period and bus-off recovery sequence, the C0INFO.BOFF bit stays set (to 1). In the bus-off recovery sequence, the reception error counter (C0ERC.REC0 to C0ERC.REC6) counts the number of times 11 consecutive recessive-level bits have been detected on the bus. Therefore, the recovery state can be checked by reading the REC0 to REC6 bits.

Cautions 1. If a request to change the mode from the initialization mode to any operation mode to execute the bus-off recovery sequence again during a bus-off recovery sequence, the bus-off recovery sequence starts from the beginning and 11 contiguous recessive bits are counted 128 times again on the bus.

2. In the bus-off recovery sequence, the REC0 to REC6 bits counts up (+1) each time 11 consecutive recessive-level bits have been detected. Even during the bus-off period, the CAN module can enter the CAN sleep mode or CAN stop mode. To be released from the bus-off state, the module must enter the initialization mode once. If the module is in the CAN sleep mode or CAN stop mode, however, it cannot directly enter the initialization mode. In this case, the bus off recovery sequence is started at the same time as the CAN sleep mode is released even without shifting to the initialization mode. In addition to clearing the C0CTRL.PSMODE1 and C0CTRL.PSMODE0 bits by software, the bus off recovery sequence is also started due to wakeup by dominant edge detection on the CAN bus (While the CAN clock is supplied, the C0CTRL.PSMODE0 bit must be cleared by software after a dominant edge is detected.) .

Figure 20-17. Recovery from Bus-off State Through Normal Recovery Sequence



(b) Forced recovery operation that skips bus-off recovery sequence

The CAN module can be forcibly released from the bus-off state, regardless of the bus state, by skipping the bus-off recovery sequence. Here is the procedure.

First, the CAN module requests to enter the initialization mode. For the operation and points to be noted at this time, see **20.3.6 (5) (a) Recovery from bus-off state through normal recovery sequence**.

Next, the module requests to enter an operation mode. At the same time, the C0CTRL.CCERC bit must be set to 1.

As a result, the bus-off recovery sequence defined by the CAN protocol ISO 11898 is skipped, and the module immediately enters the operation mode. In this case, the module is connected to the CAN bus after it has monitored 11 consecutive recessive-level bits. For details, refer to the processing in Figure 20-54.

Caution This function is not defined by the CAN protocol ISO 11898. When using this function, thoroughly evaluate its effect on the network system.

(6) Initializing CAN module error counter register (C0ERC) in initialization mode

If it is necessary to initialize the C0ERC and C0INFO registers for debugging or evaluating a program, they can be initialized to the default value by setting the C0CTRL.CCERC bit in the initialization mode. When initialization has been completed, the CCERC bit is automatically cleared to 0.

Cautions 1. This function is enabled only in the initialization mode. Even if the CCERC bit is set to 1 in a CAN operation mode, the C0ERC and C0INFO registers are not initialized.

2. The CCERC bit can be set at the same time as the request to enter a CAN operation mode.

20.3.7 Baud rate control function

(1) Prescaler

The CAN controller has a prescaler that divides the clock (f_{CAN}) supplied to CAN. This prescaler generates a CAN protocol layer base clock (f_{TQ}) that is the CAN module system clock (f_{CANMOD}) divided by 1 to 256 (see **20.6 (12) CAN0 module bit rate prescaler register (C0BRP)**).

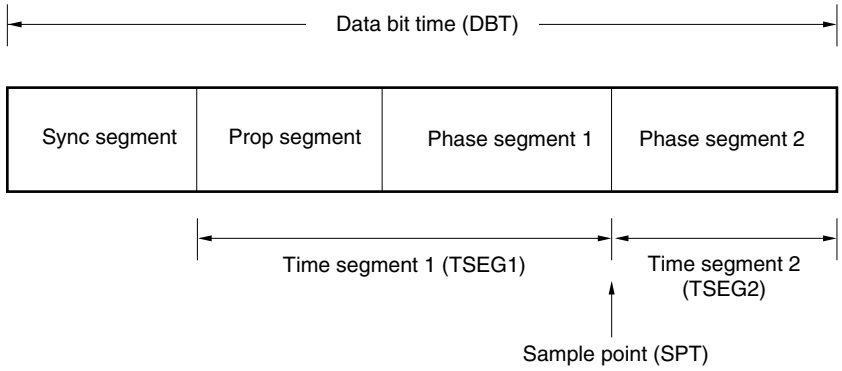
(2) Data bit time (8 to 25 time quanta)

One data bit time is defined as shown in Figure 20-18.

1 Time Quanta = $1/f_{TQ}$

The CAN controller sets the data bit time by replacing it with the bit timing parameters such as time segment 1, time segment 2, and reSynchronization Jump Width (SJW), as shown in Figure 20-18. Time segment 1 is equivalent to the total of the propagation (prop) segment and phase segment 1 that are defined by the CAN protocol specification. Time segment 2 is equivalent to phase segment 2.

Figure 20-18. Segment Setting

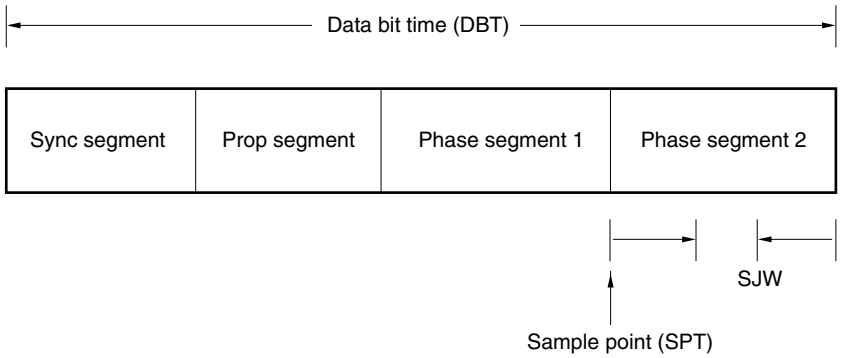


Segment name	Settable range	Notes on setting to conform to CAN specification
Time segment 1 (TSEG1)	2TQ to 16TQ	–
Time segment 2 (TSEG2)	1TQ to 8TQ	IPT of the CAN controller is 0TQ. To conform to the CAN protocol specification, therefore, a length equal or less to phase segment 1 must be set here. This means that the length of time segment 1 minus 1TQ is the settable upper limit of time segment 2.
reSynchronization Jump Width (SJW)	1TQ to 4TQ	The length of time segment 1 minus 1TQ or 4TQ, whichever smaller.

Remark IPT: Information Processing Time
TQ: Time Quanta

Remark The CAN protocol specification defines the segments constituting the data bit time as shown in Figure 20-19.

Figure 20-19. Configuration of Data Bit Time Defined by CAN Specification



Segment name	Segment length	Description
Sync segment (Synchronization segment)	1	This segment starts at the edge where the level changes from recessive to dominant when hardware synchronization is established.
Prop segment (Propagation segment)	Programmable to 1 to 8, or greater	This segment absorbs the delay of the output buffer, CAN bus, and input buffer. The length of this segment is set so that ACK is returned before the start of phase segment 1. Time of prop segment ≥ (Delay of output buffer) + 2 × (Delay of CAN bus) + (Delay of input buffer)
Phase segment 1 (Phase buffer segment 1)	Programmable to 1 to 8	This segment compensates for an error in the data bit time. The longer this segment, the wider the permissible range but the slower the communication speed.
Phase segment 2 (Phase buffer segment 2)	Phase segment 1 or IPT, whichever greater	
SJW (reSynchronization Jump Width)	Programmable from 1TQ to segment 1TQ to 4TQ, whichever is smaller	This width sets the upper limit of expansion or contraction of the phase segment during resynchronization.

Remark IPT: Information Processing Time
TQ: Time Quanta

(3) Synchronizing data bit

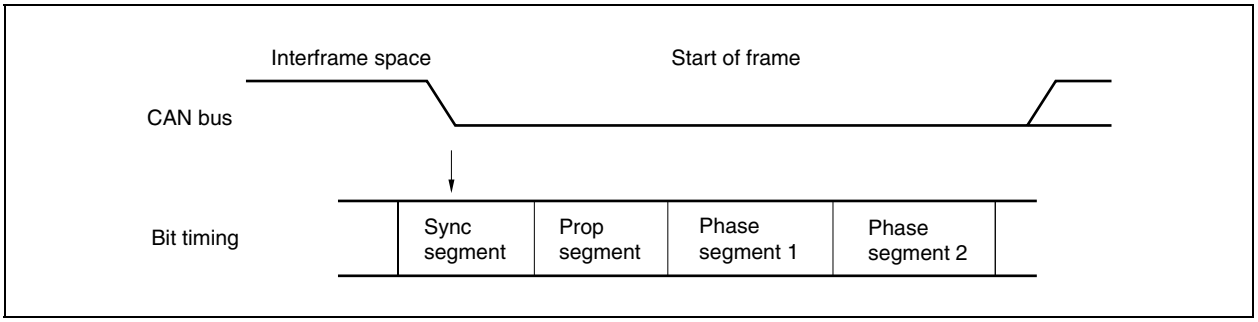
- The receiving node establishes synchronization by a level change on the bus because it does not have a sync signal.
- The transmitting node transmits data in synchronization with the bit timing of the transmitting node.

(a) Hardware synchronization

This synchronization is established when the receiving node detects the start of frame in the interframe space.

- When a falling edge is detected on the bus, that TQ means the sync segment and the next segment is the prop segment. In this case, synchronization is established regardless of SJW.

Figure 20-20. Hardware Synchronization Due to Dominant Level Detection During Bus Idle

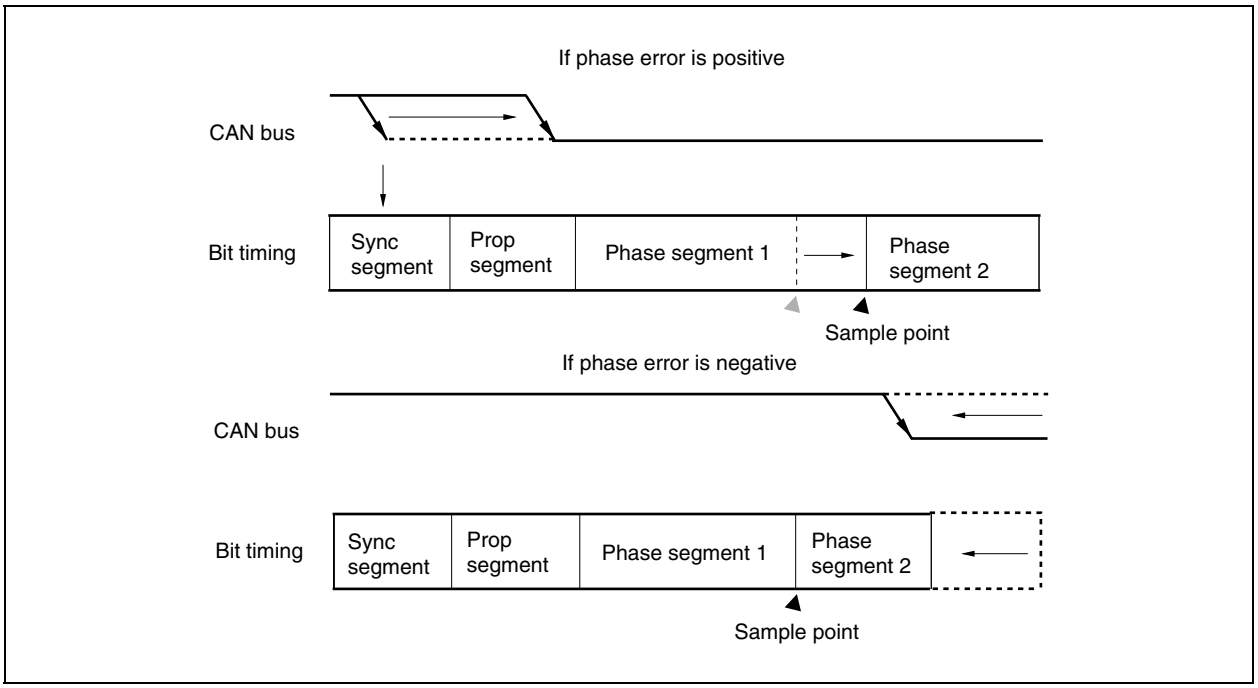


(b) Resynchronization

Synchronization is established again if a level change is detected on the bus during reception (only if a recessive level was sampled previously).

- The phase error of the edge is given by the relative position of the detected edge and sync segment.
  <Sign of phase error>
  0: If the edge is within the sync segment
  Positive: If the edge is before the sample point (phase error)
  Negative: If the edge is after the sample point (phase error)
  If phase error is positive: Phase segment 1 is longer by specified SJW.
  If phase error is negative: Phase segment 2 is shorter by specified SJW.
- The sample point of the data of the receiving node moves relatively due to the “discrepancy” in the baud rate between the transmitting node and receiving node.

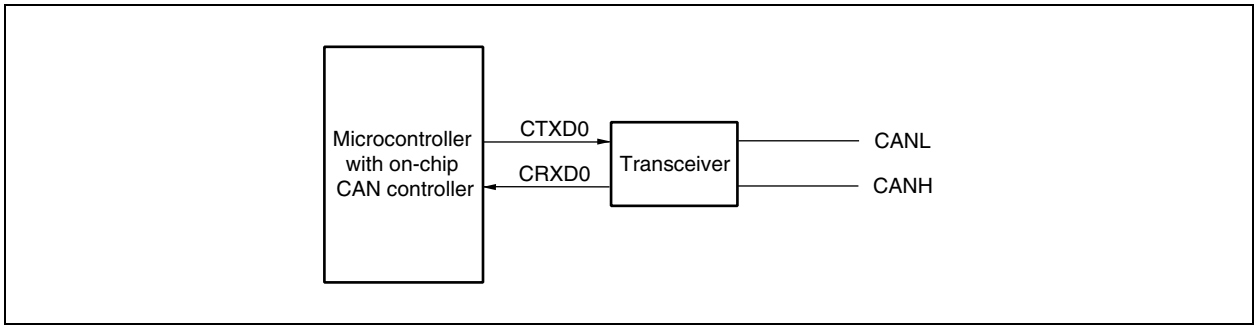
Figure 20-21. Resynchronization



20.4 Connection with Target System

The microcontroller with on-chip CAN controller has to be connected to the CAN bus using an external transceiver.

Figure 20-22. Connection to CAN Bus



20.5 Internal Registers of CAN Controller

20.5.1 CAN controller configuration

Table 20-15. List of CAN Controller Registers

Item	Register Name
CAN global registers	CAN0 global control register (C0GMCTRL)
	CAN0 global clock selection register (C0GMCS)
	CAN0 global automatic block transmission control register (C0GMABT)
	CAN0 global automatic block transmission delay setting register (C0GMABTD)
CAN module registers	CAN0 module mask 1 register (C0MASK1L, C0MASK1H)
	CAN0 module mask 2 register (C0MASK2L, C0MASK2H)
	CAN0 module mask 3 register (C0MASK3L, C0MASK3H)
	CAN0 module mask 4 registers (C0MASK4L, C0MASK4H)
	CAN0 module control register (C0CTRL)
	CAN0 module last error information register (C0LEC)
	CAN0 module information register (C0INFO)
	CAN0 module error counter register (C0ERC)
	CAN0 module interrupt enable register (C0IE)
	CAN0 module interrupt status register (C0INTS)
	CAN0 module bit rate prescaler register (C0BRP)
	CAN0 module bit rate register (C0BTR)
	CAN0 module last in-pointer register (C0LIPT)
	CAN0 module receive history list register (C0RGPT)
	CAN0 module last out-pointer register (C0LOPT)
	CAN0 module transmit history list register (C0TGPT)
	CAN0 module time stamp register (C0TS)
Message buffer registers	CAN0 message data byte 01 register m (C0MDATA01m)
	CAN0 message data byte 0 register m (C0MDATA0m)
	CAN0 message data byte 1 register m (C0MDATA1m)
	CAN0 message data byte 23 register m (C0MDATA23m)
	CAN0 message data byte 2 register m (C0MDATA2m)
	CAN0 message data byte 3 register m (C0MDATA3m)
	CAN0 message data byte 45 register m (C0MDATA45m)
	CAN0 message data byte 4 register m (C0MDATA4m)
	CAN0 message data byte 5 register m (C0MDATA5m)
	CAN0 message data byte 67 register m (C0MDATA67m)
	CAN0 message data byte 6 register m (C0MDATA6m)
	CAN0 message data byte 7 register m (C0MDATA7m)
	CAN0 message data length register m (C0MDLCm)
	CAN0 message configuration register m (C0MCONFm)
	CAN0 message ID register m (C0MIDLm, C0MIDHm)
	CAN0 message control register m (C0MCTRLm)

Remarks 1. The CAN global register is defined as C0GM <register function>.
The CAN module register is defined as C0 <register function>.
The message buffer register is defined as C0M <register function>.

2. m = 00 to 31

20.5.2 Register access type

Table 20-16. Register Access Types (1/17)

Address	Register Name	Symbol	R/W	Bit Manipulation Units			After Reset
				1 Bit	8 Bits	16 Bits	
03FEC000H	CAN0 global control register	C0GMCTRL	R/W			√	0000H
03FEC002H	CAN0 global clock selection register	C0GMCS			√		0FH
03FEC006H	CAN0 global automatic block transmission register	C0GMABT				√	0000H
03FEC008H	CAN0 global automatic block transmission delay register	C0GMABTD			√		00H
03FEC040H	CAN0 module mask 1 register	C0MASK1L				√	Undefined
03FEC042H		C0MASK1H				√	Undefined
03FEC044H	CAN0 module mask 2 register	C0MASK2L				√	Undefined
03FEC046H		C0MASK2H				√	Undefined
03FEC048H	CAN0 module mask 3 register	C0MASK3L				√	Undefined
03FEC04AH		C0MASK3H				√	Undefined
03FEC04CH	CAN0 module mask 4 register	C0MASK4L				√	Undefined
03FEC04EH		C0MASK4H				√	Undefined
03FEC050H	CAN0 module control register	C0CTRL				√	0000H
03FEC052H	CAN0 module last error code register	C0LEC			√		00H
03FEC053H	CAN0 module information register	C0INFO	R		√		00H
03FEC054H	CAN0 module error counter register	C0ERC				√	0000H
03FEC056H	CAN0 module interrupt enable register	C0IE	R/W			√	0000H
03FEC058H	CAN0 module interrupt status register	C0INTS				√	0000H
03FEC05AH	CAN0 module bit-rate prescaler register	C0BRP			√		FFH
03FEC05CH	CAN0 module bit-rate register	C0BTR				√	370FH
03FEC05EH	CAN0 module last in-pointer register	C0LIPT	R		√		Undefined
03FEC060H	CAN0 module receive history list register	C0RGPT	R/W			√	xx02H
03FEC062H	CAN0 module last out-pointer register	C0LOPT	R		√		Undefined
03FEC064H	CAN0 module transmit history list register	C0TGPT	R/W			√	xx02H
03FEC066H	CAN0 module time stamp register	C0TS				√	0000H

Table 20-16. Register Access Types (2/17)

Address	Register Name	Symbol	R/W	Bit Manipulation Units			After Reset
				1 Bit	8 Bits	16 Bits	
03FEC100H	CAN0 message data byte 01 register 00	C0MDATA0100	R/W			√	Undefined
03FEC100H	CAN0 message data byte 0 register 00	C0MDATA000			√		Undefined
03FEC101H	CAN0 message data byte 1 register 00	C0MDATA100			√		Undefined
03FEC102H	CAN0 message data byte 23 register 00	C0MDATA2300				√	Undefined
03FEC102H	CAN0 message data byte 2 register 00	C0MDATA200			√		Undefined
03FEC103H	CAN0 message data byte 3 register 00	C0MDATA300			√		Undefined
03FEC104H	CAN0 message data byte 45 register 00	C0MDATA4500				√	Undefined
03FEC104H	CAN0 message data byte 4 register 00	C0MDATA400			√		Undefined
03FEC105H	CAN0 message data byte 5 register 00	C0MDATA500			√		Undefined
03FEC106H	CAN0 message data byte 67 register 00	C0MDATA6700				√	Undefined
03FEC106H	CAN0 message data byte 6 register 00	C0MDATA600			√		Undefined
03FEC107H	CAN0 message data byte 7 register 00	C0MDATA700			√		Undefined
03FEC108H	CAN0 message data length register 00	C0MDLC00			√		0000xxxxB
03FEC109H	CAN0 message configuration register 00	C0MCONF00			√		Undefined
03FEC10AH	CAN0 message identifier register 00	C0MIDL00				√	Undefined
03FEC10CH		C0MIDH00				√	Undefined
03FEC10EH	CAN0 message control register 00	C0MCTRL00				√	00x00000 000xx000B
03FEC120H	CAN0 message data byte 01 register 01	C0MDATA0101				√	Undefined
03FEC120H	CAN0 message data byte 0 register 01	C0MDATA001			√		Undefined
03FEC121H	CAN0 message data byte 1 register 01	C0MDATA101			√		Undefined
03FEC122H	CAN0 message data byte 23 register 01	C0MDATA2301				√	Undefined
03FEC122H	CAN0 message data byte 2 register 01	C0MDATA201			√		Undefined
03FEC123H	CAN0 message data byte 3 register 01	C0MDATA301			√		Undefined
03FEC124H	CAN0 message data byte 45 register 01	C0MDATA4501				√	Undefined
03FEC124H	CAN0 message data byte 4 register 01	C0MDATA401			√		Undefined
03FEC125H	CAN0 message data byte 5 register 01	C0MDATA501			√		Undefined
03FEC126H	CAN0 message data byte 67 register 01	C0MDATA6701				√	Undefined
03FEC126H	CAN0 message data byte 6 register 01	C0MDATA601			√		Undefined
03FEC127H	CAN0 message data byte 7 register 01	C0MDATA701			√		Undefined
03FEC128H	CAN0 message data length register 01	C0MDLC01			√		0000xxxxB
03FEC129H	CAN0 message configuration register 01	C0MCONF01			√		Undefined
03FEC12AH	CAN0 message identifier register 01	C0MIDL01				√	Undefined
03FEC12CH		C0MIDH01				√	Undefined
03FEC12EH	CAN0 message control register 01	C0MCTRL01				√	00x00000 000xx000B

Table 20-16. Register Access Types (3/17)

Address	Register Name	Symbol	R/W	Bit Manipulation Units			After Reset
				1 Bit	8 Bits	16 Bits	
03FEC140H	CAN0 message data byte 01 register 02	C0MDATA0102	R/W			√	Undefined
03FEC140H	CAN0 message data byte 0 register 02	C0MDATA002			√		Undefined
03FEC141H	CAN0 message data byte 1 register 02	C0MDATA102			√		Undefined
03FEC142H	CAN0 message data byte 23 register 02	C0MDATA2302				√	Undefined
03FEC142H	CAN0 message data byte 2 register 02	C0MDATA202			√		Undefined
03FEC143H	CAN0 message data byte 3 register 02	C0MDATA302			√		Undefined
03FEC144H	CAN0 message data byte 45 register 02	C0MDATA4502				√	Undefined
03FEC144H	CAN0 message data byte 4 register 02	C0MDATA402			√		Undefined
03FEC145H	CAN0 message data byte 5 register 02	C0MDATA502			√		Undefined
03FEC146H	CAN0 message data byte 67 register 02	C0MDATA6702				√	Undefined
03FEC146H	CAN0 message data byte 6 register 02	C0MDATA602			√		Undefined
03FEC147H	CAN0 message data byte 7 register 02	C0MDATA702			√		Undefined
03FEC148H	CAN0 message data length register 02	C0MDLC02			√		0000xxxxB
03FEC149H	CAN0 message configuration register 02	C0MCONF02			√		Undefined
03FEC14AH	CAN0 message identifier register 02	C0MIDL02				√	Undefined
03FEC14CH		C0MIDH02				√	Undefined
03FEC14EH	CAN0 message control register 02	C0MCTRL02				√	00x00000 000xx000B
03FEC160H	CAN0 message data byte 01 register 03	C0MDATA0103				√	Undefined
03FEC160H	CAN0 message data byte 0 register 03	C0MDATA003			√		Undefined
03FEC161H	CAN0 message data byte 1 register 03	C0MDATA103			√		Undefined
03FEC162H	CAN0 message data byte 23 register 03	C0MDATA2303				√	Undefined
03FEC162H	CAN0 message data byte 2 register 03	C0MDATA203			√		Undefined
03FEC163H	CAN0 message data byte 3 register 03	C0MDATA303			√		Undefined
03FEC164H	CAN0 message data byte 45 register 03	C0MDATA4503				√	Undefined
03FEC164H	CAN0 message data byte 4 register 03	C0MDATA403			√		Undefined
03FEC165H	CAN0 message data byte 5 register 03	C0MDATA503			√		Undefined
03FEC166H	CAN0 message data byte 67 register 03	C0MDATA6703				√	Undefined
03FEC166H	CAN0 message data byte 6 register 03	C0MDATA603			√		Undefined
03FEC167H	CAN0 message data byte 7 register 03	C0MDATA703			√		Undefined
03FEC168H	CAN0 message data length register 03	C0MDLC03			√		0000xxxxB
03FEC169H	CAN0 message configuration register 03	C0MCONF03			√		Undefined
03FEC16AH	CAN0 message identifier register 03	C0MIDL03				√	Undefined
03FEC16CH		C0MIDH03				√	Undefined
03FEC16EH	CAN0 message control register 03	C0MCTRL03				√	00x00000 000xx000B

Table 20-16. Register Access Types (4/17)

Address	Register Name	Symbol	R/W	Bit Manipulation Units			After Reset
				1 Bit	8 Bits	16 Bits	
03FEC180H	CAN0 message data byte 01 register 04	C0MDATA0104	R/W			√	Undefined
03FEC180H	CAN0 message data byte 0 register 04	C0MDATA004			√		Undefined
03FEC181H	CAN0 message data byte 1 register 04	C0MDATA104			√		Undefined
03FEC182H	CAN0 message data byte 23 register 04	C0MDATA2304				√	Undefined
03FEC182H	CAN0 message data byte 2 register 04	C0MDATA204			√		Undefined
03FEC183H	CAN0 message data byte 3 register 04	C0MDATA304			√		Undefined
03FEC184H	CAN0 message data byte 45 register 04	C0MDATA4504				√	Undefined
03FEC184H	CAN0 message data byte 4 register 04	C0MDATA404			√		Undefined
03FEC185H	CAN0 message data byte 5 register 04	C0MDATA504			√		Undefined
03FEC186H	CAN0 message data byte 67 register 04	C0MDATA6704				√	Undefined
03FEC186H	CAN0 message data byte 6 register 04	C0MDATA604			√		Undefined
03FEC187H	CAN0 message data byte 7 register 04	C0MDATA704			√		Undefined
03FEC188H	CAN0 message data length register 04	C0MDLC04			√		0000xxxxB
03FEC189H	CAN0 message configuration register 04	C0MCONF04			√		Undefined
03FEC18AH	CAN0 message identifier register 04	C0MIDL04				√	Undefined
03FEC18CH		C0MIDH04				√	Undefined
03FEC18EH	CAN0 message control register 04	C0MCTRL04				√	00x00000 000xx000B
03FEC1A0H	CAN0 message data byte 01 register 05	C0MDATA0105				√	Undefined
03FEC1A0H	CAN0 message data byte 0 register 05	C0MDATA005			√		Undefined
03FEC1A1H	CAN0 message data byte 1 register 05	C0MDATA105			√		Undefined
03FEC1A2H	CAN0 message data byte 23 register 05	C0MDATA2305				√	Undefined
03FEC1A2H	CAN0 message data byte 2 register 05	C0MDATA205			√		Undefined
03FEC1A3H	CAN0 message data byte 3 register 05	C0MDATA305			√		Undefined
03FEC1A4H	CAN0 message data byte 45 register 05	C0MDATA4505				√	Undefined
03FEC1A4H	CAN0 message data byte 4 register 05	C0MDATA405			√		Undefined
03FEC1A5H	CAN0 message data byte 5 register 05	C0MDATA505			√		Undefined
03FEC1A6H	CAN0 message data byte 67 register 05	C0MDATA6705				√	Undefined
03FEC1A6H	CAN0 message data byte 6 register 05	C0MDATA605			√		Undefined
03FEC1A7H	CAN0 message data byte 7 register 05	C0MDATA705			√		Undefined
03FEC1A8H	CAN0 message data length register 05	C0MDLC05			√		0000xxxxB
03FEC1A9H	CAN0 message configuration register 05	C0MCONF05			√		Undefined
03FEC1AAH	CAN0 message identifier register 05	C0MIDL05				√	Undefined
03FEC1ACH		C0MIDH05				√	Undefined
03FEC1AEH	CAN0 message control register 05	C0MCTRL05				√	00x00000 000xx000B

Table 20-16. Register Access Types (5/17)

Address	Register Name	Symbol	R/W	Bit Manipulation Units			After Reset
				1 Bit	8 Bits	16 Bits	
03FEC1C0H	CAN0 message data byte 01 register 06	C0MDATA0106	R/W			√	Undefined
03FEC1C0H	CAN0 message data byte 0 register 06	C0MDATA006			√		Undefined
03FEC1C1H	CAN0 message data byte 1 register 06	C0MDATA106			√		Undefined
03FEC1C2H	CAN0 message data byte 23 register 06	C0MDATA2306				√	Undefined
03FEC1C2H	CAN0 message data byte 2 register 06	C0MDATA206			√		Undefined
03FEC1C3H	CAN0 message data byte 3 register 06	C0MDATA306			√		Undefined
03FEC1C4H	CAN0 message data byte 45 register 06	C0MDATA4506				√	Undefined
03FEC1C4H	CAN0 message data byte 4 register 06	C0MDATA406			√		Undefined
03FEC1C5H	CAN0 message data byte 5 register 06	C0MDATA506			√		Undefined
03FEC1C6H	CAN0 message data byte 67 register 06	C0MDATA6706				√	Undefined
03FEC1C6H	CAN0 message data byte 6 register 06	C0MDATA606			√		Undefined
03FEC1C7H	CAN0 message data byte 7 register 06	C0MDATA706			√		Undefined
03FEC1C8H	CAN0 message data length register 06	C0MDLC06			√		0000xxxxB
03FEC1C9H	CAN0 message configuration register 06	C0MCONF06			√		Undefined
03FEC1CAH	CAN0 message identifier register 06	C0MIDL06				√	Undefined
03FEC1CCH		C0MIDH06				√	Undefined
03FEC1CEH	CAN0 message control register 06	C0MCTRL06				√	00x00000 000xx000B
03FEC1E0H	CAN0 message data byte 01 register 07	C0MDATA0107				√	Undefined
03FEC1E0H	CAN0 message data byte 0 register 07	C0MDATA007			√		Undefined
03FEC1E1H	CAN0 message data byte 1 register 07	C0MDATA107			√		Undefined
03FEC1E2H	CAN0 message data byte 23 register 07	C0MDATA2307				√	Undefined
03FEC1E2H	CAN0 message data byte 2 register 07	C0MDATA207			√		Undefined
03FEC1E3H	CAN0 message data byte 3 register 07	C0MDATA307			√		Undefined
03FEC1E4H	CAN0 message data byte 45 register 07	C0MDATA4507				√	Undefined
03FEC1E4H	CAN0 message data byte 4 register 07	C0MDATA407			√		Undefined
03FEC1E5H	CAN0 message data byte 5 register 07	C0MDATA507			√		Undefined
03FEC1E6H	CAN0 message data byte 67 register 07	C0MDATA6707				√	Undefined
03FEC1E6H	CAN0 message data byte 6 register 07	C0MDATA607			√		Undefined
03FEC1E7H	CAN0 message data byte 7 register 07	C0MDATA707			√		Undefined
03FEC1E8H	CAN0 message data length register 07	C0MDLC07			√		0000xxxxB
03FEC1E9H	CAN0 message configuration register 07	C0MCONF07			√		Undefined
03FEC1EAH	CAN0 message identifier register 07	C0MIDL07				√	Undefined
03FEC1ECH		C0MIDH07				√	Undefined
03FEC1EEH	CAN0 message control register 07	C0MCTRL07				√	00x00000 000xx000B

Table 20-16. Register Access Types (6/17)

Address	Register Name	Symbol	R/W	Bit Manipulation Units			After Reset
				1 Bit	8 Bits	16 Bits	
03FEC200H	CAN0 message data byte 01 register 08	C0MDATA0108	R/W			√	Undefined
03FEC200H	CAN0 message data byte 0 register 08	C0MDATA008			√		Undefined
03FEC201H	CAN0 message data byte 1 register 08	C0MDATA108			√		Undefined
03FEC202H	CAN0 message data byte 23 register 08	C0MDATA2308				√	Undefined
03FEC202H	CAN0 message data byte 2 register 08	C0MDATA208			√		Undefined
03FEC203H	CAN0 message data byte 3 register 08	C0MDATA308			√		Undefined
03FEC204H	CAN0 message data byte 45 register 08	C0MDATA4508				√	Undefined
03FEC204H	CAN0 message data byte 4 register 08	C0MDATA408			√		Undefined
03FEC205H	CAN0 message data byte 5 register 08	C0MDATA508			√		Undefined
03FEC206H	CAN0 message data byte 67 register 08	C0MDATA6708				√	Undefined
03FEC206H	CAN0 message data byte 6 register 08	C0MDATA608			√		Undefined
03FEC207H	CAN0 message data byte 7 register 08	C0MDATA708			√		Undefined
03FEC208H	CAN0 message data length register 08	C0MDLC08			√		0000xxxxB
03FEC209H	CAN0 message configuration register 08	C0MCONF08			√		Undefined
03FEC20AH	CAN0 message identifier register 08	C0MIDL08				√	Undefined
03FEC20CH		C0MIDH08				√	Undefined
03FEC20EH	CAN0 message control register 08	C0MCTRL08				√	00x00000 000xx000B
03FEC220H	CAN0 message data byte 01 register 09	C0MDATA0109				√	Undefined
03FEC220H	CAN0 message data byte 0 register 09	C0MDATA009			√		Undefined
03FEC221H	CAN0 message data byte 1 register 09	C0MDATA109			√		Undefined
03FEC222H	CAN0 message data byte 23 register 09	C0MDATA2309				√	Undefined
03FEC222H	CAN0 message data byte 2 register 09	C0MDATA209			√		Undefined
03FEC223H	CAN0 message data byte 3 register 09	C0MDATA309			√		Undefined
03FEC224H	CAN0 message data byte 45 register 09	C0MDATA4509				√	Undefined
03FEC224H	CAN0 message data byte 4 register 09	C0MDATA409			√		Undefined
03FEC225H	CAN0 message data byte 5 register 09	C0MDATA509			√		Undefined
03FEC226H	CAN0 message data byte 67 register 09	C0MDATA6709				√	Undefined
03FEC226H	CAN0 message data byte 6 register 09	C0MDATA609			√		Undefined
03FEC227H	CAN0 message data byte 7 register 09	C0MDATA709			√		Undefined
03FEC228H	CAN0 message data length register 09	C0MDLC09			√		0000xxxxB
03FEC229H	CAN0 message configuration register 09	C0MCONF09			√		Undefined
03FEC22AH	CAN0 message identifier register 09	C0MIDL09				√	Undefined
03FEC22CH		C0MIDH09				√	Undefined
03FEC22EH	CAN0 message control register 09	C0MCTRL09				√	00x00000 000xx000B

Table 20-16. Register Access Types (7/17)

Address	Register Name	Symbol	R/W	Bit Manipulation Units			After Reset
				1 Bit	8 Bits	16 Bits	
03FEC240H	CAN0 message data byte 01 register 10	C0MDATA0110	R/W			√	Undefined
03FEC240H	CAN0 message data byte 0 register 10	C0MDATA010			√		Undefined
03FEC241H	CAN0 message data byte 1 register 10	C0MDATA110			√		Undefined
03FEC242H	CAN0 message data byte 23 register 10	C0MDATA2310				√	Undefined
03FEC242H	CAN0 message data byte 2 register 10	C0MDATA210			√		Undefined
03FEC243H	CAN0 message data byte 3 register 10	C0MDATA310			√		Undefined
03FEC244H	CAN0 message data byte 45 register 10	C0MDATA4510				√	Undefined
03FEC244H	CAN0 message data byte 4 register 10	C0MDATA410			√		Undefined
03FEC245H	CAN0 message data byte 5 register 10	C0MDATA510			√		Undefined
03FEC246H	CAN0 message data byte 67 register 10	C0MDATA6710				√	Undefined
03FEC246H	CAN0 message data byte 6 register 10	C0MDATA610			√		Undefined
03FEC247H	CAN0 message data byte 7 register 10	C0MDATA710			√		Undefined
03FEC248H	CAN0 message data length register 10	C0MDLC10			√		0000xxxxB
03FEC249H	CAN0 message configuration register 10	C0MCONF10			√		Undefined
03FEC24AH	CAN0 message identifier register 10	C0MIDL10				√	Undefined
03FEC24CH		C0MIDH10				√	Undefined
03FEC24EH	CAN0 message control register 10	C0MCTRL10				√	00x00000 000xx000B
03FEC260H	CAN0 message data byte 01 register 11	C0MDATA0111				√	Undefined
03FEC260H	CAN0 message data byte 0 register 11	C0MDATA011			√		Undefined
03FEC261H	CAN0 message data byte 1 register 11	C0MDATA111			√		Undefined
03FEC262H	CAN0 message data byte 23 register 11	C0MDATA2311				√	Undefined
03FEC262H	CAN0 message data byte 2 register 11	C0MDATA211			√		Undefined
03FEC263H	CAN0 message data byte 3 register 11	C0MDATA311			√		Undefined
03FEC264H	CAN0 message data byte 45 register 11	C0MDATA4511				√	Undefined
03FEC264H	CAN0 message data byte 4 register 11	C0MDATA411			√		Undefined
03FEC265H	CAN0 message data byte 5 register 11	C0MDATA511			√		Undefined
03FEC266H	CAN0 message data byte 67 register 11	C0MDATA6711				√	Undefined
03FEC266H	CAN0 message data byte 6 register 11	C0MDATA611			√		Undefined
03FEC267H	CAN0 message data byte 7 register 11	C0MDATA711			√		Undefined
03FEC268H	CAN0 message data length register 11	C0MDLC11			√		0000xxxxB
03FEC269H	CAN0 message configuration register 11	C0MCONF11			√		Undefined
03FEC26AH	CAN0 message identifier register 11	C0MIDL11				√	Undefined
03FEC26CH		C0MIDH11				√	Undefined
03FEC26EH	CAN0 message control register 11	C0MCTRL11				√	00x00000 000xx000B

Table 20-16. Register Access Types (8/17)

Address	Register Name	Symbol	R/W	Bit Manipulation Units			After Reset
				1 Bit	8 Bits	16 Bits	
03FEC280H	CAN0 message data byte 01 register 12	C0MDATA0112	R/W			√	Undefined
03FEC280H	CAN0 message data byte 0 register 12	C0MDATA012			√		Undefined
03FEC281H	CAN0 message data byte 1 register 12	C0MDATA112			√		Undefined
03FEC282H	CAN0 message data byte 23 register 12	C0MDATA2312				√	Undefined
03FEC282H	CAN0 message data byte 2 register 12	C0MDATA212			√		Undefined
03FEC283H	CAN0 message data byte 3 register 12	C0MDATA312			√		Undefined
03FEC284H	CAN0 message data byte 45 register 12	C0MDATA4512				√	Undefined
03FEC284H	CAN0 message data byte 4 register 12	C0MDATA412			√		Undefined
03FEC285H	CAN0 message data byte 5 register 12	C0MDATA512			√		Undefined
03FEC286H	CAN0 message data byte 67 register 12	C0MDATA6712				√	Undefined
03FEC286H	CAN0 message data byte 6 register 12	C0MDATA612			√		Undefined
03FEC287H	CAN0 message data byte 7 register 12	C0MDATA712			√		Undefined
03FEC288H	CAN0 message data length register 12	C0MDLC12			√		0000xxxxB
03FEC289H	CAN0 message configuration register 12	C0MCONF12			√		Undefined
03FEC28AH	CAN0 message identifier register 12	C0MIDL12				√	Undefined
03FEC28CH		C0MIDH12				√	Undefined
03FEC28EH	CAN0 message control register 12	C0MCTRL12				√	00x00000 000xx000B
03FEC2A0H	CAN0 message data byte 01 register 13	C0MDATA0113				√	Undefined
03FEC2A0H	CAN0 message data byte 0 register 13	C0MDATA013			√		Undefined
03FEC2A1H	CAN0 message data byte 1 register 13	C0MDATA113			√		Undefined
03FEC2A2H	CAN0 message data byte 23 register 13	C0MDATA2313				√	Undefined
03FEC2A2H	CAN0 message data byte 2 register 13	C0MDATA213			√		Undefined
03FEC2A3H	CAN0 message data byte 3 register 13	C0MDATA313			√		Undefined
03FEC2A4H	CAN0 message data byte 45 register 13	C0MDATA4513				√	Undefined
03FEC2A4H	CAN0 message data byte 4 register 13	C0MDATA413			√		Undefined
03FEC2A5H	CAN0 message data byte 5 register 13	C0MDATA513			√		Undefined
03FEC2A6H	CAN0 message data byte 67 register 13	C0MDATA6713				√	Undefined
03FEC2A6H	CAN0 message data byte 6 register 13	C0MDATA613			√		Undefined
03FEC2A7H	CAN0 message data byte 7 register 13	C0MDATA713			√		Undefined
03FEC2A8H	CAN0 message data length register 13	C0MDLC13			√		0000xxxxB
03FEC2A9H	CAN0 message configuration register 13	C0MCONF13			√		Undefined
03FEC2AAH	CAN0 message identifier register 13	C0MIDL13				√	Undefined
03FEC2ACH		C0MIDH13				√	Undefined
03FEC2AEH	CAN0 message control register 13	C0MCTRL13				√	00x00000 000xx000B

Table 20-16. Register Access Types (9/17)

Address	Register Name	Symbol	R/W	Bit Manipulation Units			After Reset
				1 Bit	8 Bits	16 Bits	
03FEC2C0H	CAN0 message data byte 01 register 14	C0MDATA0114	R/W			√	Undefined
03FEC2C0H	CAN0 message data byte 0 register 14	C0MDATA014			√		Undefined
03FEC2C1H	CAN0 message data byte 1 register 14	C0MDATA114			√		Undefined
03FEC2C2H	CAN0 message data byte 23 register 14	C0MDATA2314				√	Undefined
03FEC2C2H	CAN0 message data byte 2 register 14	C0MDATA214			√		Undefined
03FEC2C3H	CAN0 message data byte 3 register 14	C0MDATA314			√		Undefined
03FEC2C4H	CAN0 message data byte 45 register 14	C0MDATA4514				√	Undefined
03FEC2C4H	CAN0 message data byte 4 register 14	C0MDATA414			√		Undefined
03FEC2C5H	CAN0 message data byte 5 register 14	C0MDATA514			√		Undefined
03FEC2C6H	CAN0 message data byte 67 register 14	C0MDATA6714				√	Undefined
03FEC2C6H	CAN0 message data byte 6 register 14	C0MDATA614			√		Undefined
03FEC2C7H	CAN0 message data byte 7 register 14	C0MDATA714			√		Undefined
03FEC2C8H	CAN0 message data length register 14	C0MDLC14			√		0000xxxxB
03FEC2C9H	CAN0 message configuration register 14	C0MCONF14			√		Undefined
03FEC2CAH	CAN0 message identifier register 14	C0MIDL14				√	Undefined
03FEC2CCH		C0MIDH14				√	Undefined
03FEC2CEH	CAN0 message control register 14	C0MCTRL14				√	00x00000 000xx000B
03FEC2E0H	CAN0 message data byte 01 register 15	C0MDATA0115				√	Undefined
03FEC2E0H	CAN0 message data byte 0 register 15	C0MDATA015			√		Undefined
03FEC2E1H	CAN0 message data byte 1 register 15	C0MDATA115			√		Undefined
03FEC2E2H	CAN0 message data byte 23 register 15	C0MDATA2315				√	Undefined
03FEC2E2H	CAN0 message data byte 2 register 15	C0MDATA215			√		Undefined
03FEC2E3H	CAN0 message data byte 3 register 15	C0MDATA315			√		Undefined
03FEC2E4H	CAN0 message data byte 45 register 15	C0MDATA4515				√	Undefined
03FEC2E4H	CAN0 message data byte 4 register 15	C0MDATA415			√		Undefined
03FEC2E5H	CAN0 message data byte 5 register 15	C0MDATA515			√		Undefined
03FEC2E6H	CAN0 message data byte 67 register 15	C0MDATA6715				√	Undefined
03FEC2E6H	CAN0 message data byte 6 register 15	C0MDATA615			√		Undefined
03FEC2E7H	CAN0 message data byte 7 register 15	C0MDATA715			√		Undefined
03FEC2E8H	CAN0 message data length register 15	C0MDLC15			√		0000xxxxB
03FEC2E9H	CAN0 message configuration register 15	C0MCONF15			√		Undefined
03FEC2EAH	CAN0 message identifier register 15	C0MIDL15				√	Undefined
03FEC2ECH		C0MIDH15				√	Undefined
03FEC2EEH	CAN0 message control register 15	C0MCTRL15				√	00x00000 000xx000B

Table 20-16. Register Access Types (10/17)

Address	Register Name	Symbol	R/W	Bit Manipulation Units			After Reset
				1 Bit	8 Bits	16 Bits	
03FEC300H	CAN0 message data byte 01 register 16	C0MDATA0116	R/W			√	Undefined
03FEC300H	CAN0 message data byte 0 register 16	C0MDATA016			√		Undefined
03FEC301H	CAN0 message data byte 1 register 16	C0MDATA116			√		Undefined
03FEC302H	CAN0 message data byte 23 register 16	C0MDATA2316				√	Undefined
03FEC302H	CAN0 message data byte 2 register 16	C0MDATA216			√		Undefined
03FEC303H	CAN0 message data byte 3 register 16	C0MDATA316			√		Undefined
03FEC304H	CAN0 message data byte 45 register 16	C0MDATA4516				√	Undefined
03FEC304H	CAN0 message data byte 4 register 16	C0MDATA416			√		Undefined
03FEC305H	CAN0 message data byte 5 register 16	C0MDATA516			√		Undefined
03FEC306H	CAN0 message data byte 67 register 16	C0MDATA6716				√	Undefined
03FEC306H	CAN0 message data byte 6 register 16	C0MDATA616			√		Undefined
03FEC307H	CAN0 message data byte 7 register 16	C0MDATA716			√		Undefined
03FEC308H	CAN0 message data length register 16	C0MDLC16			√		0000xxxxB
03FEC309H	CAN0 message configuration register 16	C0MCONF16			√		Undefined
03FEC30AH	CAN0 message identifier register 16	C0MIDL16				√	Undefined
03FEC30CH		C0MIDH16				√	Undefined
03FEC30EH	CAN0 message control register 16	C0MCTRL16				√	00x00000 000xx000B
03FEC320H	CAN0 message data byte 01 register 17	C0MDATA0117				√	Undefined
03FEC320H	CAN0 message data byte 0 register 17	C0MDATA017			√		Undefined
03FEC321H	CAN0 message data byte 1 register 17	C0MDATA117			√		Undefined
03FEC322H	CAN0 message data byte 23 register 17	C0MDATA2317				√	Undefined
03FEC322H	CAN0 message data byte 2 register 17	C0MDATA217			√		Undefined
03FEC323H	CAN0 message data byte 3 register 17	C0MDATA317			√		Undefined
03FEC324H	CAN0 message data byte 45 register 17	C0MDATA4517				√	Undefined
03FEC324H	CAN0 message data byte 4 register 17	C0MDATA417			√		Undefined
03FEC325H	CAN0 message data byte 5 register 17	C0MDATA517			√		Undefined
03FEC326H	CAN0 message data byte 67 register 17	C0MDATA6717				√	Undefined
03FEC326H	CAN0 message data byte 6 register 17	C0MDATA617			√		Undefined
03FEC327H	CAN0 message data byte 7 register 17	C0MDATA717			√		Undefined
03FEC328H	CAN0 message data length register 17	C0MDLC17			√		0000xxxxB
03FEC329H	CAN0 message configuration register 17	C0MCONF17			√		Undefined
03FEC32AH	CAN0 message identifier register 17	C0MIDL17				√	Undefined
03FEC32CH		C0MIDH17				√	Undefined
03FEC32EH	CAN0 message control register 17	C0MCTRL17				√	00x00000 000xx000B

Table 20-16. Register Access Types (11/17)

Address	Register Name	Symbol	R/W	Bit Manipulation Units			After Reset
				1 Bit	8 Bits	16 Bits	
03FEC340H	CAN0 message data byte 01 register 18	C0MDATA0118	R/W			√	Undefined
03FEC340H	CAN0 message data byte 0 register 18	C0MDATA018			√		Undefined
03FEC341H	CAN0 message data byte 1 register 18	C0MDATA118			√		Undefined
03FEC342H	CAN0 message data byte 23 register 18	C0MDATA2318				√	Undefined
03FEC342H	CAN0 message data byte 2 register 18	C0MDATA218			√		Undefined
03FEC343H	CAN0 message data byte 3 register 18	C0MDATA318			√		Undefined
03FEC344H	CAN0 message data byte 45 register 18	C0MDATA4518				√	Undefined
03FEC344H	CAN0 message data byte 4 register 18	C0MDATA418			√		Undefined
03FEC345H	CAN0 message data byte 5 register 18	C0MDATA518			√		Undefined
03FEC346H	CAN0 message data byte 67 register 18	C0MDATA6718				√	Undefined
03FEC346H	CAN0 message data byte 6 register 18	C0MDATA618			√		Undefined
03FEC347H	CAN0 message data byte 7 register 18	C0MDATA718			√		Undefined
03FEC348H	CAN0 message data length register 18	C0MDLC18			√		0000xxxxB
03FEC349H	CAN0 message configuration register 18	C0MCONF18			√		Undefined
03FEC34AH	CAN0 message identifier register 18	C0MIDL18				√	Undefined
03FEC34CH		C0MIDH18				√	Undefined
03FEC34EH	CAN0 message control register 18	C0MCTRL18				√	00x00000 000xx000B
03FEC360H	CAN0 message data byte 01 register 19	C0MDATA0119				√	Undefined
03FEC360H	CAN0 message data byte 0 register 19	C0MDATA019			√		Undefined
03FEC361H	CAN0 message data byte 1 register 19	C0MDATA119			√		Undefined
03FEC362H	CAN0 message data byte 23 register 19	C0MDATA2319				√	Undefined
03FEC362H	CAN0 message data byte 2 register 19	C0MDATA219			√		Undefined
03FEC363H	CAN0 message data byte 3 register 19	C0MDATA319			√		Undefined
03FEC364H	CAN0 message data byte 45 register 19	C0MDATA4519				√	Undefined
03FEC364H	CAN0 message data byte 4 register 19	C0MDATA419			√		Undefined
03FEC365H	CAN0 message data byte 5 register 19	C0MDATA519			√		Undefined
03FEC366H	CAN0 message data byte 67 register 19	C0MDATA6719				√	Undefined
03FEC366H	CAN0 message data byte 6 register 19	C0MDATA619			√		Undefined
03FEC367H	CAN0 message data byte 7 register 19	C0MDATA719			√		Undefined
03FEC368H	CAN0 message data length register 19	C0MDLC19			√		0000xxxxB
03FEC369H	CAN0 message configuration register 19	C0MCONF19			√		Undefined
03FEC36AH	CAN0 message identifier register 19	C0MIDL19				√	Undefined
03FEC36CH		C0MIDH19				√	Undefined
03FEC36EH	CAN0 message control register 19	C0MCTRL19				√	00x00000 000xx000B

Table 20-16. Register Access Types (12/17)

Address	Register Name	Symbol	R/W	Bit Manipulation Units			After Reset
				1 Bit	8 Bits	16 Bits	
03FEC380H	CAN0 message data byte 01 register 20	C0MDATA0120	R/W			√	Undefined
03FEC380H	CAN0 message data byte 0 register 20	C0MDATA020			√		Undefined
03FEC381H	CAN0 message data byte 1 register 20	C0MDATA120			√		Undefined
03FEC382H	CAN0 message data byte 23 register 20	C0MDATA2320				√	Undefined
03FEC382H	CAN0 message data byte 2 register 20	C0MDATA220			√		Undefined
03FEC383H	CAN0 message data byte 3 register 20	C0MDATA320			√		Undefined
03FEC384H	CAN0 message data byte 45 register 20	C0MDATA4520				√	Undefined
03FEC384H	CAN0 message data byte 4 register 20	C0MDATA420			√		Undefined
03FEC385H	CAN0 message data byte 5 register 20	C0MDATA520			√		Undefined
03FEC386H	CAN0 message data byte 67 register 20	C0MDATA6720				√	Undefined
03FEC386H	CAN0 message data byte 6 register 20	C0MDATA620			√		Undefined
03FEC387H	CAN0 message data byte 7 register 20	C0MDATA720			√		Undefined
03FEC388H	CAN0 message data length register 20	C0MDLC20			√		0000xxxxB
03FEC389H	CAN0 message configuration register 20	C0MCONF20			√		Undefined
03FEC38AH	CAN0 message identifier register 20	C0MIDL20				√	Undefined
03FEC38CH		C0MIDH20				√	Undefined
03FEC38EH	CAN0 message control register 20	C0MCTRL20				√	00x00000 000xx000B
03FEC3A0H	CAN0 message data byte 01 register 21	C0MDATA0121				√	Undefined
03FEC3A0H	CAN0 message data byte 0 register 21	C0MDATA021			√		Undefined
03FEC3A1H	CAN0 message data byte 1 register 21	C0MDATA121			√		Undefined
03FEC3A2H	CAN0 message data byte 23 register 21	C0MDATA2321				√	Undefined
03FEC3A2H	CAN0 message data byte 2 register 21	C0MDATA221			√		Undefined
03FEC3A3H	CAN0 message data byte 3 register 21	C0MDATA321			√		Undefined
03FEC3A4H	CAN0 message data byte 45 register 21	C0MDATA4521				√	Undefined
03FEC3A4H	CAN0 message data byte 4 register 21	C0MDATA421			√		Undefined
03FEC3A5H	CAN0 message data byte 5 register 21	C0MDATA521			√		Undefined
03FEC3A6H	CAN0 message data byte 67 register 21	C0MDATA6721				√	Undefined
03FEC3A6H	CAN0 message data byte 6 register 21	C0MDATA621			√		Undefined
03FEC3A7H	CAN0 message data byte 7 register 21	C0MDATA721			√		Undefined
03FEC3A8H	CAN0 message data length register 21	C0MDLC21			√		0000xxxxB
03FEC3A9H	CAN0 message configuration register 21	C0MCONF21			√		Undefined
03FEC3AAH	CAN0 message identifier register 21	C0MIDL21				√	Undefined
03FEC3ACH		C0MIDH21				√	Undefined
03FEC3AEH	CAN0 message control register 21	C0MCTRL21				√	00x00000 000xx000B

Table 20-16. Register Access Types (13/17)

Address	Register Name	Symbol	R/W	Bit Manipulation Units			After Reset
				1 Bit	8 Bits	16 Bits	
03FEC3C0H	CAN0 message data byte 01 register 22	C0MDATA0122	R/W			√	Undefined
03FEC3C0H	CAN0 message data byte 0 register 22	C0MDATA022			√		Undefined
03FEC3C1H	CAN0 message data byte 1 register 22	C0MDATA122			√		Undefined
03FEC3C2H	CAN0 message data byte 23 register 22	C0MDATA2322				√	Undefined
03FEC3C2H	CAN0 message data byte 2 register 22	C0MDATA222			√		Undefined
03FEC3C3H	CAN0 message data byte 3 register 22	C0MDATA322			√		Undefined
03FEC3C4H	CAN0 message data byte 45 register 22	C0MDATA4522				√	Undefined
03FEC3C4H	CAN0 message data byte 4 register 22	C0MDATA422			√		Undefined
03FEC3C5H	CAN0 message data byte 5 register 22	C0MDATA522			√		Undefined
03FEC3C6H	CAN0 message data byte 67 register 22	C0MDATA6722				√	Undefined
03FEC3C6H	CAN0 message data byte 6 register 22	C0MDATA622			√		Undefined
03FEC3C7H	CAN0 message data byte 7 register 22	C0MDATA722			√		Undefined
03FEC3C8H	CAN0 message data length register 22	C0MDLC22			√		0000xxxxB
03FEC3C9H	CAN0 message configuration register 22	C0MCONF22			√		Undefined
03FEC3CAH	CAN0 message identifier register 22	C0MIDL22				√	Undefined
03FEC3CCH		C0MIDH22				√	Undefined
03FEC3CEH	CAN0 message control register 22	C0MCTRL22				√	00x00000 000xx000B
03FEC3E0H	CAN0 message data byte 01 register 23	C0MDATA0123				√	Undefined
03FEC3E0H	CAN0 message data byte 0 register 23	C0MDATA023			√		Undefined
03FEC3E1H	CAN0 message data byte 1 register 23	C0MDATA123			√		Undefined
03FEC3E2H	CAN0 message data byte 23 register 23	C0MDATA2323				√	Undefined
03FEC3E2H	CAN0 message data byte 2 register 23	C0MDATA223			√		Undefined
03FEC3E3H	CAN0 message data byte 3 register 23	C0MDATA323			√		Undefined
03FEC3E4H	CAN0 message data byte 45 register 23	C0MDATA4523				√	Undefined
03FEC3E4H	CAN0 message data byte 4 register 23	C0MDATA423			√		Undefined
03FEC3E5H	CAN0 message data byte 5 register 23	C0MDATA523			√		Undefined
03FEC3E6H	CAN0 message data byte 67 register 23	C0MDATA6723				√	Undefined
03FEC3E6H	CAN0 message data byte 6 register 23	C0MDATA623			√		Undefined
03FEC3E7H	CAN0 message data byte 7 register 23	C0MDATA723			√		Undefined
03FEC3E8H	CAN0 message data length register 23	C0MDLC23			√		0000xxxxB
03FEC3E9H	CAN0 message configuration register 23	C0MCONF23			√		Undefined
03FEC3EAH	CAN0 message identifier register 23	C0MIDL23				√	Undefined
03FEC3ECH		C0MIDH23				√	Undefined
03FEC3EEH	CAN0 message control register 23	C0MCTRL23				√	00x00000 000xx000B

Table 20-16. Register Access Types (14/17)

Address	Register Name	Symbol	R/W	Bit Manipulation Units			After Reset
				1 Bit	8 Bits	16 Bits	
03FEC400H	CAN0 message data byte 01 register 24	C0MDATA0124	R/W			√	Undefined
03FEC400H	CAN0 message data byte 0 register 24	C0MDATA024			√		Undefined
03FEC401H	CAN0 message data byte 1 register 24	C0MDATA124			√		Undefined
03FEC402H	CAN0 message data byte 23 register 24	C0MDATA2324				√	Undefined
03FEC402H	CAN0 message data byte 2 register 24	C0MDATA224			√		Undefined
03FEC403H	CAN0 message data byte 3 register 24	C0MDATA324			√		Undefined
03FEC404H	CAN0 message data byte 45 register 24	C0MDATA4524				√	Undefined
03FEC404H	CAN0 message data byte 4 register 24	C0MDATA424			√		Undefined
03FEC405H	CAN0 message data byte 5 register 24	C0MDATA524			√		Undefined
03FEC406H	CAN0 message data byte 67 register 24	C0MDATA6724				√	Undefined
03FEC406H	CAN0 message data byte 6 register 24	C0MDATA624			√		Undefined
03FEC407H	CAN0 message data byte 7 register 24	C0MDATA724			√		Undefined
03FEC408H	CAN0 message data length register 24	C0MDLC24			√		0000xxxxB
03FEC409H	CAN0 message configuration register 24	C0MCONF24			√		Undefined
03FEC40AH	CAN0 message identifier register 24	C0MIDL24				√	Undefined
03FEC40CH		C0MIDH24				√	Undefined
03FEC40EH	CAN0 message control register 24	C0MCTRL24				√	00x00000 000xx000B
03FEC420H	CAN0 message data byte 01 register 25	C0MDATA0125				√	Undefined
03FEC420H	CAN0 message data byte 0 register 25	C0MDATA025			√		Undefined
03FEC421H	CAN0 message data byte 1 register 25	C0MDATA125			√		Undefined
03FEC422H	CAN0 message data byte 23 register 25	C0MDATA2325				√	Undefined
03FEC422H	CAN0 message data byte 2 register 25	C0MDATA225			√		Undefined
03FEC423H	CAN0 message data byte 3 register 25	C0MDATA325			√		Undefined
03FEC424H	CAN0 message data byte 45 register 25	C0MDATA4525				√	Undefined
03FEC424H	CAN0 message data byte 4 register 25	C0MDATA425			√		Undefined
03FEC425H	CAN0 message data byte 5 register 25	C0MDATA525			√		Undefined
03FEC426H	CAN0 message data byte 67 register 25	C0MDATA6725				√	Undefined
03FEC426H	CAN0 message data byte 6 register 25	C0MDATA625			√		Undefined
03FEC427H	CAN0 message data byte 7 register 25	C0MDATA725			√		Undefined
03FEC428H	CAN0 message data length register 25	C0MDLC25			√		0000xxxxB
03FEC429H	CAN0 message configuration register 25	C0MCONF25			√		Undefined
03FEC42AH	CAN0 message identifier register 25	C0MIDL25				√	Undefined
03FEC42CH		C0MIDH25				√	Undefined
03FEC42EH	CAN0 message control register 25	C0MCTRL25				√	00x00000 000xx000B

Table 20-16. Register Access Types (15/17)

Address	Register Name	Symbol	R/W	Bit Manipulation Units			After Reset
				1 Bit	8 Bits	16 Bits	
03FEC440H	CAN0 message data byte 01 register 26	C0MDATA0126	R/W			√	Undefined
03FEC440H	CAN0 message data byte 0 register 26	C0MDATA026			√		Undefined
03FEC441H	CAN0 message data byte 1 register 26	C0MDATA126			√		Undefined
03FEC442H	CAN0 message data byte 23 register 26	C0MDATA2326				√	Undefined
03FEC442H	CAN0 message data byte 2 register 26	C0MDATA226			√		Undefined
03FEC443H	CAN0 message data byte 3 register 26	C0MDATA326			√		Undefined
03FEC444H	CAN0 message data byte 45 register 26	C0MDATA4526				√	Undefined
03FEC444H	CAN0 message data byte 4 register 26	C0MDATA426			√		Undefined
03FEC445H	CAN0 message data byte 5 register 26	C0MDATA526			√		Undefined
03FEC446H	CAN0 message data byte 67 register 26	C0MDATA6726				√	Undefined
03FEC446H	CAN0 message data byte 6 register 26	C0MDATA626			√		Undefined
03FEC447H	CAN0 message data byte 7 register 26	C0MDATA726			√		Undefined
03FEC448H	CAN0 message data length register 26	C0MDLC26			√		0000xxxxB
03FEC449H	CAN0 message configuration register 26	C0MCONF26			√		Undefined
03FEC44AH	CAN0 message identifier register 26	C0MIDL26				√	Undefined
03FEC44CH		C0MIDH26				√	Undefined
03FEC44EH	CAN0 message control register 26	C0MCTRL26				√	00x00000 000xx000B
03FEC460H	CAN0 message data byte 01 register 27	C0MDATA0127				√	Undefined
03FEC460H	CAN0 message data byte 0 register 27	C0MDATA027			√		Undefined
03FEC461H	CAN0 message data byte 1 register 27	C0MDATA127			√		Undefined
03FEC462H	CAN0 message data byte 23 register 27	C0MDATA2327				√	Undefined
03FEC462H	CAN0 message data byte 2 register 27	C0MDATA227			√		Undefined
03FEC463H	CAN0 message data byte 3 register 27	C0MDATA327			√		Undefined
03FEC464H	CAN0 message data byte 45 register 27	C0MDATA4527				√	Undefined
03FEC464H	CAN0 message data byte 4 register 27	C0MDATA427			√		Undefined
03FEC465H	CAN0 message data byte 5 register 27	C0MDATA527			√		Undefined
03FEC466H	CAN0 message data byte 67 register 27	C0MDATA6727				√	Undefined
03FEC466H	CAN0 message data byte 6 register 27	C0MDATA627			√		Undefined
03FEC467H	CAN0 message data byte 7 register 27	C0MDATA727			√		Undefined
03FEC468H	CAN0 message data length register 27	C0MDLC27			√		0000xxxxB
03FEC469H	CAN0 message configuration register 27	C0MCONF27			√		Undefined
03FEC46AH	CAN0 message identifier register 27	C0MIDL27				√	Undefined
03FEC46CH		C0MIDH27				√	Undefined
03FEC46EH	CAN0 message control register 27	C0MCTRL27				√	00x00000 000xx000B

Table 20-16. Register Access Types (16/17)

Address	Register Name	Symbol	R/W	Bit Manipulation Units			After Reset
				1 Bit	8 Bits	16 Bits	
03FEC480H	CAN0 message data byte 01 register 28	C0MDATA0128	R/W			√	Undefined
03FEC480H	CAN0 message data byte 0 register 28	C0MDATA028			√		Undefined
03FEC481H	CAN0 message data byte 1 register 28	C0MDATA128			√		Undefined
03FEC482H	CAN0 message data byte 23 register 28	C0MDATA2328				√	Undefined
03FEC482H	CAN0 message data byte 2 register 28	C0MDATA228			√		Undefined
03FEC483H	CAN0 message data byte 3 register 28	C0MDATA328			√		Undefined
03FEC484H	CAN0 message data byte 45 register 28	C0MDATA4528				√	Undefined
03FEC484H	CAN0 message data byte 4 register 28	C0MDATA428			√		Undefined
03FEC485H	CAN0 message data byte 5 register 28	C0MDATA528			√		Undefined
03FEC486H	CAN0 message data byte 67 register 28	C0MDATA6728				√	Undefined
03FEC486H	CAN0 message data byte 6 register 28	C0MDATA628			√		Undefined
03FEC487H	CAN0 message data byte 7 register 28	C0MDATA728			√		Undefined
03FEC488H	CAN0 message data length register 28	C0MDLC28			√		0000xxxxB
03FEC489H	CAN0 message configuration register 28	C0MCONF28			√		Undefined
03FEC48AH	CAN0 message identifier register 28	C0MIDL28				√	Undefined
03FEC48CH		C0MIDH28				√	Undefined
03FEC48EH	CAN0 message control register 28	C0MCTRL28				√	00x00000 000xx000B
03FEC4A0H	CAN0 message data byte 01 register 29	C0MDATA0129				√	Undefined
03FEC4A0H	CAN0 message data byte 0 register 29	C0MDATA029			√		Undefined
03FEC4A1H	CAN0 message data byte 1 register 29	C0MDATA129			√		Undefined
03FEC4A2H	CAN0 message data byte 23 register 29	C0MDATA2329				√	Undefined
03FEC4A2H	CAN0 message data byte 2 register 29	C0MDATA229			√		Undefined
03FEC4A3H	CAN0 message data byte 3 register 29	C0MDATA329			√		Undefined
03FEC4A4H	CAN0 message data byte 45 register 29	C0MDATA4529				√	Undefined
03FEC4A4H	CAN0 message data byte 4 register 29	C0MDATA429			√		Undefined
03FEC4A5H	CAN0 message data byte 5 register 29	C0MDATA529			√		Undefined
03FEC4A6H	CAN0 message data byte 67 register 29	C0MDATA6729				√	Undefined
03FEC4A6H	CAN0 message data byte 6 register 29	C0MDATA629			√		Undefined
03FEC4A7H	CAN0 message data byte 7 register 29	C0MDATA729			√		Undefined
03FEC4A8H	CAN0 message data length register 29	C0MDLC29			√		0000xxxxB
03FEC4A9H	CAN0 message configuration register 29	C0MCONF29			√		Undefined
03FEC4AAH	CAN0 message identifier register 29	C0MIDL29				√	Undefined
03FEC4ACH		C0MIDH29				√	Undefined
03FEC4AEH	CAN0 message control register 29	C0MCTRL29				√	00x00000 000xx000B

Table 20-16. Register Access Types (17/17)

Address	Register Name	Symbol	R/W	Bit Manipulation Units			After Reset
				1 Bit	8 Bits	16 Bits	
03FEC4C0H	CAN0 message data byte 01 register 30	C0MDATA0130	R/W			√	Undefined
03FEC4C0H	CAN0 message data byte 0 register 30	C0MDATA030			√		Undefined
03FEC4C1H	CAN0 message data byte 1 register 30	C0MDATA130			√		Undefined
03FEC4C2H	CAN0 message data byte 23 register 30	C0MDATA2330				√	Undefined
03FEC4C2H	CAN0 message data byte 2 register 30	C0MDATA230			√		Undefined
03FEC4C3H	CAN0 message data byte 3 register 30	C0MDATA330			√		Undefined
03FEC4C4H	CAN0 message data byte 45 register 30	C0MDATA4530				√	Undefined
03FEC4C4H	CAN0 message data byte 4 register 30	C0MDATA430			√		Undefined
03FEC4C5H	CAN0 message data byte 5 register 30	C0MDATA530			√		Undefined
03FEC4C6H	CAN0 message data byte 67 register 30	C0MDATA6730				√	Undefined
03FEC4C6H	CAN0 message data byte 6 register 30	C0MDATA630			√		Undefined
03FEC4C7H	CAN0 message data byte 7 register 30	C0MDATA730			√		Undefined
03FEC4C8H	CAN0 message data length register 30	C0MDLC30			√		0000xxxxB
03FEC4C9H	CAN0 message configuration register 30	C0MCONF30			√		Undefined
03FEC4CAH	CAN0 message identifier register 30	C0MIDL30				√	Undefined
03FEC4CCH		C0MIDH30				√	Undefined
03FEC4CEH	CAN0 message control register 30	C0MCTRL30				√	00x00000 000xx000B
03FEC4E0H	CAN0 message data byte 01 register 31	C0MDATA0131				√	Undefined
03FEC4E0H	CAN0 message data byte 0 register 31	C0MDATA031			√		Undefined
03FEC4E1H	CAN0 message data byte 1 register 31	C0MDATA131			√		Undefined
03FEC4E2H	CAN0 message data byte 23 register 31	C0MDATA2331				√	Undefined
03FEC4E2H	CAN0 message data byte 2 register 31	C0MDATA231			√		Undefined
03FEC4E3H	CAN0 message data byte 3 register 31	C0MDATA331			√		Undefined
03FEC4E4H	CAN0 message data byte 45 register 31	C0MDATA4531				√	Undefined
03FEC4E4H	CAN0 message data byte 4 register 31	C0MDATA431			√		Undefined
03FEC4E5H	CAN0 message data byte 5 register 31	C0MDATA531			√		Undefined
03FEC4E6H	CAN0 message data byte 67 register 31	C0MDATA6731				√	Undefined
03FEC4E6H	CAN0 message data byte 6 register 31	C0MDATA631			√		Undefined
03FEC4E7H	CAN0 message data byte 7 register 31	C0MDATA731			√		Undefined
03FEC4E8H	CAN0 message data length register 31	C0MDLC31			√		0000xxxxB
03FEC4E9H	CAN0 message configuration register 31	C0MCONF31			√		Undefined
03FEC4EAH	CAN0 message identifier register 31	C0MIDL31				√	Undefined
03FEC4ECH		C0MIDH31				√	Undefined
03FEC4EEH	CAN0 message control register 31	C0MCTRL31				√	00x00000 000xx000B

20.5.3 Register bit configuration

Table 20-17. CAN Global Register Bit Configuration

Address	Symbol	Bit 7/15	Bit 6/14	Bit 5/13	Bit 4/12	Bit 3/11	Bit 2/10	Bit 1/9	Bit 0/8
03FEC000H	C0GMCTRL (W)	0	0	0	0	0	0	0	Clear GOM
03FEC001H		0	0	0	0	0	0	Set EFSD	Set GOM
03FEC000H	C0GMCTRL (R)	0	0	0	0	0	0	EFSD	GOM
03FEC001H		MBON	0	0	0	0	0	0	0
03FEC002H	C0GMCS	0	0	0	0	CCP3	CCP2	CCP1	CCP0
03FEC006H	C0GMABT (W)	0	0	0	0	0	0	0	Clear ABTTRG
03FEC007H		0	0	0	0	0	0	Set ABTCLR	Set ABTTRG
03FEC006H	C0GMABT (R)	0	0	0	0	0	0	ABTCLR	ABTTRG
03FEC007H		0	0	0	0	0	0	0	0
03FEC008H	C0GMABTD	0	0	0	0	ABTD3	ABTD2	ABTD1	ABTD0

Table 20-18. CAN Module Register Bit Configuration (1/2)

Address	Symbol	Bit 7/15	Bit 6/14	Bit 5/13	Bit 4/12	Bit 3/11	Bit 2/10	Bit 1/9	Bit 0/8
03FEC040H	C0MASK1L	CMID7 to CMID0							
03FEC041H		CMID15 to CMID8							
03FEC042H	C0MASK1H	CMID23 to CMID16							
03FEC043H		0	0	0	CMID28 to CMID24				
03FEC044H	C0MASK2L	CMID7 to CMID0							
03FEC045H		CMID15 to CMID8							
03FEC046H	C0MASK2H	CMID23 to CMID16							
03FEC047H		0	0	0	CMID28 to CMID24				
03FEC048H	C0MASK3L	CMID7 to CMID0							
03FEC049H		CMID15 to CMID8							
03FEC04AH	C0MASK3H	CMID23 to CMID16							
03FEC04BH		0	0	0	CMID28 to CMID24				
03FEC04CH	C0MASK4L	CMID7 to CMID0							
03FEC04DH		CMID15 to CMID8							
03FEC04EH	C0MASK4H	CMID23 to CMID16							
03FEC04FH		0	0	0	CMID28 to CMID24				
03FEC050H	C0CTRL (W)	0	Clear AL	Clear VALID	Clear PSMODE1	Clear PSMODE0	Clear OPMODE2	Clear OPMODE1	Clear OPMODE0
03FEC051H		Set CCERC	Set AL	0	Set PSMODE1	Set PSMODE0	Set OPMODE2	Set OPMODE1	Set OPMODE0
03FEC050H	C0CTRL (R)	CCERC	AL	VALID	PS MODE1	PS MODE0	OP MODE2	OP MODE1	OP MODE0
03FEC051H		0	0	0	0	0	0	RSTAT	TSTAT
03FEC052H	C0LEC (W)	0	0	0	0	0	0	0	0
03FEC052H	C0LEC (R)	0	0	0	0	0	LEC2	LEC1	LEC0
03FEC053H	C0INFO	0	0	0	BOFF	TECS1	TECS0	RECS1	RECS0
03FEC054H	C0ERC	TEC7 to TEC0							
03FEC055H		REC7 to REC0							
03FEC056H	C0IE (W)	0	0	Clear CIE5	Clear CIE4	Clear CIE3	Clear CIE2	Clear CIE1	Clear CIE0
03FEC057H		0	0	Set CIE5	Set CIE4	Set CIE3	Set CIE2	Set CIE1	Set CIE0
03FEC056H	C0IE (R)	0	0	CIE5	CIE4	CIE3	CIE2	CIE1	CIE0
03FEC057H		0	0	0	0	0	0	0	0
03FEC058H	C0INTS (W)	0	0	Clear CINTS5	Clear CINTS4	Clear CINTS3	Clear CINTS2	Clear CINTS1	Clear CINTS0
03FEC059H		0	0	0	0	0	0	0	0
03FEC058H	C0INTS (R)	0	0	CINTS5	CINTS4	CINTS3	CINTS2	CINTS1	CINTS0
03FEC059H		0	0	0	0	0	0	0	0

Table 20-18. CAN Module Register Bit Configuration (2/2)

Address	Symbol	Bit 7/15	Bit 6/14	Bit 5/13	Bit 4/12	Bit 3/11	Bit 2/10	Bit 1/9	Bit 0/8
03FEC05AH	C0BRP	TQPRS7 to TQPRS0							
03FEC05CH	C0BTR	0	0	0	0	TSEG13 to TSEG10			
03FEC05DH		0	0	SJW1, SJW0		0	TSEG22 to TSEG20		
03FEC05EH	C0LIPT	LIPT7 to LIPT0							
03FEC060H	C0RGPT (W)	0	0	0	0	0	0	0	Clear ROVF
03FEC061H		0	0	0	0	0	0	0	0
03FEC060H	C0RGPT (R)	0	0	0	0	0	0	RHPM	ROVF
03FEC061H		RGPT7 to RGPT0							
03FEC062H	C0LOPT	LOPT7 to LOPT0							
03FEC064H	C0TGPT (W)	0	0	0	0	0	0	0	Clear TOVF
03FEC065H		0	0	0	0	0	0	0	0
03FEC064H	C0TGPT (R)	0	0	0	0	0	0	THPM	TOVF
03FEC065H		TGPT7 to TGPT0							
03FEC066H	C0TS (W)	0	0	0	0	0	Clear TSLOCK	Clear TSSEL	Clear TSEN
03FEC067H		0	0	0	0	0	Set TSLOCK	Set TSSEL	Set TSEN
03FEC066H	C0TS (R)	0	0	0	0	0	TSLOCK	TSSEL	TSEN
03FEC067H		0	0	0	0	0	0	0	0
03FEC068H to 03FEC0FFH	–	Access prohibited (reserved for future use)							

Table 20-19. Message Buffer Register Bit Configuration

Address	Symbol	Bit 7/15	Bit 6/14	Bit 5/13	Bit 4/12	Bit 3/11	Bit 2/10	Bit 1/9	Bit 0/8
03FECxx0H	C0MDATA01m	Message data (byte 0)							
03FECxx1H		Message data (byte 1)							
03FECxx0H	C0MDATA0m	Message data (byte 0)							
03FECxx1H	C0MDATA1m	Message data (byte 1)							
03FECxx2H	C0MDATA23m	Message data (byte 2)							
03FECxx3H		Message data (byte 3)							
03FECxx2H	C0MDATA2m	Message data (byte 2)							
03FECxx3H	C0MDATA3m	Message data (byte 3)							
03FECxx4H	C0MDATA45m	Message data (byte 4)							
03FECxx5H		Message data (byte 5)							
03FECxx4H	C0MDATA4m	Message data (byte 4)							
03FECxx5H	C0MDATA5m	Message data (byte 5)							
03FECxx6H	C0MDATA67m	Message data (byte 6)							
03FECxx7H		Message data (byte 7)							
03FECxx6H	C0MDATA6m	Message data (byte 6)							
03FECxx7H	C0MDATA7m	Message data (byte 7)							
03FECxx8H	C0MDLCm	0				MDLC3	MDLC2	MDLC1	MDLC0
03FECxx9H	C0MCONFm	OWS	RTR	MT2	MT1	MT0	0	0	MA0
03FECxxAH	C0MIDLm	ID7	ID6	ID5	ID4	ID3	ID2	ID1	ID0
03FECxxBH		ID15	ID14	ID13	ID12	ID11	ID10	ID9	ID8
03FECxxCH	C0MIDHm	ID23	ID22	ID21	ID20	ID19	ID18	ID17	ID16
03FECxxDH		IDE	0	0	ID28	ID27	ID26	ID25	ID24
03FECxxEH	C0MCTRLm (W)	0	0	0	Clear MOW	Clear IE	Clear DN	Clear TRQ	Clear RDY
03FECxxFH		0	0	0	0	Set IE	0	Set TRQ	Set RDY
03FECxxEH	C0MCTRLm (R)	0	0	0	MOW	IE	DN	TRQ	RDY
03FECxxFH		0	0	MUC	0	0	0	0	0
03FECxx0 to 03FECxxFH	–	Access prohibited (reserved for future use)							

Remark m = 00 to 31

xx = 10, 12, 14, 16, 18, 1A, 1C, 1E, 20, 22, 24, 26, 28, 2A, 2C, 2E, 30, 32, 34, 36, 38, 3A, 3C, 3E, 40, 42, 44, 46, 48, 4A, 4C, 4E

20.6 Registers

Caution Accessing the CAN controller registers is prohibited in the following statuses. For details, refer to 3.4.9 (2) Accessing specific on-chip peripheral I/O registers.

- **When the CPU operates with the subclock and the main clock oscillation is stopped**
- **When the CPU operates with the internal oscillation clock**

Remark m = 00 to 31

(1) CAN0 global control register (C0GMCTRL)

The C0GMCTRL register is used to control the operation of the CAN module.

(1/2)

After reset: 0000H R/W Address: 03FEC000H

(a) Read

	15	14	13	12	11	10	9	8
C0GMCTRL	MBON	0	0	0	0	0	0	0
	7	6	5	4	3	2	1	0
	0	0	0	0	0	0	EFSD	GOM

(b) Write

	15	14	13	12	11	10	9	8
C0GMCTRL	0	0	0	0	0	0	Set EFSD	Set GOM
	7	6	5	4	3	2	1	0
	0	0	0	0	0	0	0	Clear GOM

(a) Read

MBON	Bit enabling access to message buffer register, transmit/receive history registers
0	Write access and read access to the message buffer register and the transmit/receive history list registers is disabled.
1	Write access and read access to the message buffer register and the transmit/receive history list registers is enabled.

Cautions 1. While the MBON bit is cleared (to 0), software access to the message buffers (C0MDATA0m, C0MDATA1m, C0MDATA01m, C0MDATA2m, C0MDATA3m, C0MDATA23m, C0MDATA4m, C0MDATA5m, C0MDATA45m, C0MDATA6m, C0MDATA7m, C0MDATA67m, C0MDLCm, C0MCONFm, C0MIDLm, C0MIDHm, and C0MCTRLm), or registers related to transmit history or receive history (C0LOPT, C0TGPT, C0LIPT, and C0RGPT) is disabled.

2. This bit is read-only. Even if 1 is written to the MBON bit while it is 0, the value of the MBON bit does not change, and access to the message buffer registers, or registers related to transmit history or receive history remains disabled.

Remark When the CAN sleep mode/CAN stop mode is entered, or when the GOM bit is cleared to 0, the MBON bit is cleared to 0. When the CAN sleep mode/CAN stop mode is released, or when the GOM bit is set to 1, the MBON bit is set to 1.

(2/2)

EFSD	Bit enabling forced shut down
0	Forced shut down by GOM bit = 0 disabled.
1	Forced shut down by GOM bit = 0 enabled.

Caution To request forced shut down, clear the GOM bit to 0 immediately after the EFSD bit has been set to 1. If access to another register (including reading the C0GMCTRL register) is executed without clearing the GOM bit immediately after the EFSD bit has been set to 1, the EFSD bit is forcibly cleared to 0, and the forced shut down request is invalid.

GOM	Global operation mode bit
0	CAN module is disabled from operating.
1	CAN module is enabled to operate.

Caution The GOM bit is cleared to 0 only in the initialization mode or immediately after the EFSD bit is set to 1.

(b) Write

Set EFSD	EFSD bit setting
0	No change in EFSD bit.
1	EFSD bit set to 1.

Set GOM	Clear GOM	GOM bit setting
0	1	GOM bit cleared to 0.
1	0	GOM bit set to 1.
Other than above		No change in GOM bit.

Caution Be sure to set the GOM bit and EFSD bit separately.

(2) CAN0 global clock selection register (C0GMCS)

The C0GMCS register is used to select the CAN module system clock.

After reset: 0FH R/W Address: 03FEC002H

	7	6	5	4	3	2	1	0
C0GMCS	0	0	0	0	CCP3	CCP2	CCP1	CCP0

CCP3	CCP2	CCP1	CCP0	CAN module system clock (f_{CANMOD})
0	0	0	0	f_{CAN}/1
0	0	0	1	f_{CAN}/2
0	0	1	0	f_{CAN}/3
0	0	1	1	f_{CAN}/4
0	1	0	0	f_{CAN}/5
0	1	0	1	f_{CAN}/6
0	1	1	0	f_{CAN}/7
0	1	1	1	f_{CAN}/8
1	0	0	0	f_{CAN}/9
1	0	0	1	f_{CAN}/10
1	0	1	0	f_{CAN}/11
1	0	1	1	f_{CAN}/12
1	1	0	0	f_{CAN}/13
1	1	0	1	f_{CAN}/14
1	1	1	0	f_{CAN}/15
1	1	1	1	f_{CAN}/16 (Default value)

Caution Make sure that f_{XX} = 32 to 48 MHz.

Remark $f_{CAN} = f_{XX}/2$

f_{CAN}: CAN clock frequency

f_{XX}: Main clock frequency

(3) CAN0 global automatic block transmission control register (C0GMABT)

The C0GMABT register is used to control the automatic block transmission (ABT) operation.

(1/2)

After reset: 0000H R/W Address: 03FEC006H

(a) Read

	15	14	13	12	11	10	9	8
C0GMABT	0	0	0	0	0	0	0	0
	7	6	5	4	3	2	1	0
	0	0	0	0	0	0	ABTCLR	ABTTRG

(b) Write

	15	14	13	12	11	10	9	8
C0GMABT	0	0	0	0	0	0	Set ABTCLR	Set ABTTRG
	7	6	5	4	3	2	1	0
	0	0	0	0	0	0	0	Clear ABTTRG

Caution Before changing the normal operation mode with ABT to the initialization mode, be sure to set the C0GMABT register to the default value (0000H). After setting, confirm that the C0GMABT register is initialized to 0000H.

(a) Read

ABTCLR	Automatic block transmission engine clear status bit
0	Clearing the automatic transmission engine is completed.
1	The automatic transmission engine is being cleared.

Remarks 1. Set the ABTCLR bit to 1 while the ABTTRG bit is cleared to 0.
The operation is not guaranteed if the ABTCLR bit is set to 1 while the ABTTRG bit is set to 1.

2. When the automatic block transmission engine is cleared by setting the ABTCLR bit to 1, the ABTCLR bit is automatically cleared to 0 as soon as the requested clearing processing is complete.

ABTTRG	Automatic block transmission status bit
0	Automatic block transmission is stopped.
1	Automatic block transmission is under execution.

Cautions 1. Do not set the ABTTRG bit to 1 in the initialization mode. If the ABTTRG bit is set to 1 in the initialization mode, the operation is not guaranteed after the CAN module has entered the normal operation mode with ABT.

2. Do not set the ABTTRG bit to 1 while the C0CTRL.TSTAT bit is set to 1. Directly confirm that the TSTAT bit = 0 before setting the ABTTRG bit to 1.

(2/2)

(b) Write

Set ABTCLR	Automatic block transmission engine clear request bit
0	The automatic block transmission engine is in idle status or under operation.
1	Request to clear the automatic block transmission engine. After the automatic block transmission engine has been cleared, automatic block transmission is started from message buffer 0 by setting the ABTTRG bit to 1.

Set ABTTRG	Clear ABTTRG	Automatic block transmission start bit
0	1	Request to stop automatic block transmission.
1	0	Request to start automatic block transmission.
Other than above		No change in ABTTRG bit.

Caution Even if the ABTTRG bit is set (1), transmission is not immediately executed, depending on the situation such as when a message is received from another node or when a message other than the ABT message (message buffers 8 to 31) is transmitted. Even if the ABTTRG bit is cleared (0), transmission is not terminated midway. If transmission is under execution, it is continued until completed (regardless of whether transmission is successful or fails).

(4) CAN0 global automatic block transmission delay register (C0GMABTD)

The C0GMABTD register is used to set the interval at which the data of the message buffer assigned to ABT is to be transmitted in the normal operation mode with ABT.

After reset: 00H R/W Address: 03FEC008H

	7	6	5	4	3	2	1	0
C0GMABTD	0	0	0	0	ABTD3	ABTD2	ABTD1	ABTD0

ABTD3	ABTD2	ABTD1	ABTD0	Data frame interval during automatic block transmission (Unit: Data bit time (DBT))
0	0	0	0	0 DBT (default value)
0	0	0	1	2^5 DBT
0	0	1	0	2^6 DBT
0	0	1	1	2^7 DBT
0	1	0	0	2^8 DBT
0	1	0	1	2^9 DBT
0	1	1	0	2^{10} DBT
0	1	1	1	2^{11} DBT
1	0	0	0	2^{12} DBT
Other than above				Setting prohibited

Cautions 1. Do not change the contents of the C0GMABTD register while the ABTTRG bit is set to 1.

2. The timing at which the ABT message is actually transmitted onto the CAN bus differs depending on the status of transmission from the other station or how a request to transmit a message other than an ABT message (message buffers 8 to 31) is made.

3. Be sure to set bits 4 to 7 to "0".

(5) CAN0 module mask control register (C0MASKaL, C0MASKaH) (a = 1, 2, 3, or 4)

The C0MASKaL and C0MASKaH registers are used to extend the number of receivable messages in the same message buffer by masking part of the identifier (ID) of a message and invalidating the ID comparison of the masked part.

(1/2)

- CAN0 module mask 1 register (C0MASK1L, C0MASK1H)

After reset: Undefined R/W Address: C0MASK1L 03FEC040H, C0MASK1H 03FEC042H

	15	14	13	12	11	10	9	8
C0MASK1L	CMID15	CMID14	CMID13	CMID12	CMID11	CMID10	CMID9	CMID8
	7	6	5	4	3	2	1	0
	CMID7	CMID6	CMID5	CMID4	CMID3	CMID2	CMID1	CMID0
	15	14	13	12	11	10	9	8
C0MASK1H	0	0	0	CMID28	CMID27	CMID26	CMID25	CMID24
	7	6	5	4	3	2	1	0
	CMID23	CMID22	CMID21	CMID20	CMID19	CMID18	CMID17	CMID16

- CAN0 module mask 2 register (C0MASK2L, C0MASK2H)

After reset: Undefined R/W Address: C0MASK2L 03FEC044H, C0MASK2H 03FEC046H

	15	14	13	12	11	10	9	8
C0MASK2L	CMID15	CMID14	CMID13	CMID12	CMID11	CMID10	CMID9	CMID8
	7	6	5	4	3	2	1	0
	CMID7	CMID6	CMID5	CMID4	CMID3	CMID2	CMID1	CMID0
	15	14	13	12	11	10	9	8
C0MASK2H	0	0	0	CMID28	CMID27	CMID26	CMID25	CMID24
	7	6	5	4	3	2	1	0
	CMID23	CMID22	CMID21	CMID20	CMID19	CMID18	CMID17	CMID16

(2/2)

- CAN0 module mask 3 register (C0MASK3L, C0MASK3H)

After reset: Undefined R/W Address: C0MASK3L 03FEC048H, C0MASK3H 03FEC04AH

	15	14	13	12	11	10	9	8
C0MASK3L	CMID15	CMID14	CMID13	CMID12	CMID11	CMID10	CMID9	CMID8
	7	6	5	4	3	2	1	0
	CMID7	CMID6	CMID5	CMID4	CMID3	CMID2	CMID1	CMID0
	15	14	13	12	11	10	9	8
C0MASK3H	0	0	0	CMID28	CMID27	CMID26	CMID25	CMID24
	7	6	5	4	3	2	1	0
	CMID23	CMID22	CMID21	CMID20	CMID19	CMID18	CMID17	CMID16

- CAN0 module mask 4 register (C0MASK4L, C0MASK4H)

After reset: Undefined R/W Address: C0MASK4L 03FEC04CH, C0MASK4H 03FEC04EH

	15	14	13	12	11	10	9	8
C0MASK4L	CMID15	CMID14	CMID13	CMID12	CMID11	CMID10	CMID9	CMID8
	7	6	5	4	3	2	1	0
	CMID7	CMID6	CMID5	CMID4	CMID3	CMID2	CMID1	CMID0
	15	14	13	12	11	10	9	8
C0MASK4H	0	0	0	CMID28	CMID27	CMID26	CMID25	CMID24
	7	6	5	4	3	2	1	0
	CMID23	CMID22	CMID21	CMID20	CMID19	CMID18	CMID17	CMID16

CMID28 to CMID0	Mask pattern setting of ID bit
0	The ID bits of the message buffer set by the CMID28 to CMID0 bits are compared with the ID bits of the received message frame.
1	The ID bits of the message buffer set by the CMID28 to CMID0 bits are not compared with the ID bits of the received message frame (they are masked).

Caution Be sure to set bits 13 to 15 of the C0MASKaH register to 0.

Remark Masking is always defined by an ID length of 29 bits. If a mask is assigned to a message with a standard ID, the CMID17 to CMID0 bits are ignored. Therefore, only the CMID28 to CMID18 bits of the received ID are masked. The same mask can be used for both the standard and extended IDs.

(6) CAN0 module control register (C0CTRL)

The C0CTRL register is used to control the operation mode of the CAN module.

(1/4)

After reset: 0000H R/W Address: 03FEC050H

(a) Read

	15	14	13	12	11	10	9	8
C0CTRL	0	0	0	0	0	0	RSTAT	TSTAT
	7	6	5	4	3	2	1	0
	CCERC	AL	VALID	PSMODE 1	PSMODE 0	OPMODE 2	OPMODE 1	OPMODE 0

(b) Write

	15	14	13	12	11	10	9	8
C0CTRL	Set CCERC	Set AL	0	Set PSMODE 1	Set PSMODE 0	Set OPMODE 2	Set OPMODE 1	Set OPMODE 0
	7	6	5	4	3	2	1	0
	0	Clear AL	Clear VALID	Clear PSMODE 1	Clear PSMODE 0	Clear OPMODE 2	Clear OPMODE 1	Clear OPMODE 0

(a) Read

RSTAT	Reception status bit
0	Reception is stopped.
1	Reception is in progress.

Remark
- The RSTAT bit is set to 1 under the following conditions (timing)
  - The SOF bit of a receive frame is detected
  - On occurrence of arbitration loss during a transmit frame
- The RSTAT bit is cleared to 0 under the following conditions (timing)
  - When a recessive level is detected at the second bit of the interframe space
  - On transition to the initialization mode at the first bit of the interframe space

TSTAT	Transmission status bit
0	Transmission is stopped.
1	Transmission is in progress.

Remark
- The TSTAT bit is set to 1 under the following conditions (timing)
  - The SOF bit of a transmit frame is detected
- The TSTAT bit is cleared to 0 under the following conditions (timing)
  - During transition to bus-off status
  - On occurrence of arbitration loss in transmit frame
  - On detection of recessive level at the second bit of the interframe space
  - On transition to the initialization mode at the first bit of the interframe space

(2/4)

CCERC	Error counter clear bit
0	The C0ERC and C0INFO registers are not cleared in the initialization mode.
1	The C0ERC and C0INFO registers are cleared in the initialization mode.

Remarks 1. The CCERC bit is used to clear the C0ERC and C0INFO registers for re-initialization or forced recovery from the bus-off status. This bit can be set to 1 only in the initialization mode.

2. When the C0ERC and C0INFO registers have been cleared, the CCERC bit is also cleared to 0 automatically.

3. The CCERC bit can be set to 1 at the same time as a request to change the initialization mode to an operation mode is made.

4. If the CCERC bit is set to 1 immediately after the INIT mode is entered in the self test mode, the receive data may be corrupted.

AL	Bit to set operation in case of arbitration loss
0	Re-transmission is not executed in case of an arbitration loss in the single-shot mode.
1	Re-transmission is executed in case of an arbitration loss in the single-shot mode.

Remark The AL bit is valid only in the single-shot mode.

VALID	Valid receive message frame detection bit
0	A valid message frame has not been received since the VALID bit was last cleared to 0.
1	A valid message frame has been received since the VALID bit was last cleared to 0.

Remarks 1. Detection of a valid receive message frame is not dependent upon the existence or non-existence of the storage in the receive message buffer (data frame) or transmit message buffer (remote frame).

2. Clear the VALID bit (0) before changing the initialization mode to an operation mode.

3. If only two CAN nodes are connected to the CAN bus with one transmitting a message frame in the normal mode and the other in the receive-only mode, since no ACK is generated in the receive-only mode, the VALID bit is not set to 1 before the transmitting node enters the error passive status.

4. To clear the VALID bit, set the Clear VALID bit to 1 first and confirm that the VALID bit is cleared. If it is not cleared, perform clearing processing again.

(3/4)

PSMODE1	PSMODE0	Power save mode
0	0	No power save mode is selected.
0	1	CAN sleep mode
1	0	Setting prohibited
1	1	CAN stop mode

Cautions 1. Transition to and from the CAN stop mode must be made via CAN sleep mode. A request for direct transition to and from the CAN stop mode is ignored.

2. After releasing the power save mode, the C0GMCTRL.MBON flag must be checked before accessing the message buffer again.

3. A request for transition to the CAN sleep mode is held pending until it is canceled by software or until the CAN bus enters the bus idle state. The software can check transition to the CAN sleep mode by reading the PSMODE0 and PSMODE1 bits.

OPMODE2	OPMODE1	OPMODE0	Operation mode
0	0	0	No operation mode is selected (CAN module is in the initialization mode).
0	0	1	Normal operation mode
0	1	0	Normal operation mode with automatic block transmission function (normal operation mode with ABT)
0	1	1	Receive-only mode
1	0	0	Single-shot mode
1	0	1	Self-test mode
Other than above			Setting prohibited

Caution It may take time to change the mode to the initialization mode or power save mode. Therefore, be sure to check if the mode has been successfully changed, by reading the register value before executing the processing.

Remark The OPMODE0 to OPMODE2 bits are read-only in the CAN sleep mode or CAN stop mode.

(b) Write

Set CCERC	Setting of CCERC bit
1	CCERC bit is set to 1.
Other than above	CCERC bit is not changed.

Set AL	Clear AL	Setting of AL bit
0	1	AL bit is cleared to 0.
1	0	AL bit is set to 1.
Other than above		AL bit is not changed.

Clear VALID	Setting of VALID bit
0	VALID bit is not changed.
1	VALID bit is cleared to 0.

(4/4)

Set PSMODE0	Clear PSMODE0	Setting of PSMODE0 bit
0	1	PSMODE0 bit is cleared to 0.
1	0	PSMODE bit is set to 1.
Other than above		PSMODE0 bit is not changed.

Set PSMODE1	Clear PSMODE1	Setting of PSMODE1 bit
0	1	PSMODE1 bit is cleared to 0.
1	0	PSMODE1 bit is set to 1.
Other than above		PSMODE1 bit is not changed.

Set OPMODE0	Clear OPMODE0	Setting of OPMODE0 bit
0	1	OPMODE0 bit is cleared to 0.
1	0	OPMODE0 bit is set to 1.
Other than above		OPMODE0 bit is not changed.

Set OPMODE1	Clear OPMODE1	Setting of OPMODE1 bit
0	1	OPMODE1 bit is cleared to 0.
1	0	OPMODE1 bit is set to 1.
Other than above		OPMODE1 bit is not changed.

Set OPMODE2	Clear OPMODE2	Setting of OPMODE2 bit
0	1	OPMODE2 bit is cleared to 0.
1	0	OPMODE2 bit is set to 1.
Other than above		OPMODE2 bit is not changed.

(7) CAN0 module last error information register (C0LEC)

The C0LEC register provides the error information of the CAN protocol.

After reset: 00H R/W Address: 03FEC052H

	7	6	5	4	3	2	1	0
C0LEC	0	0	0	0	0	LEC2	LEC1	LEC0

LEC2	LEC1	LEC0	Last CAN protocol error information
0	0	0	No error
0	0	1	Stuff error
0	1	0	Form error
0	1	1	ACK error
1	0	0	Bit error. (The CAN module tried to transmit a recessive-level bit as part of a transmit message (except the arbitration field), but the value on the CAN bus is a dominant-level bit.)
1	0	1	Bit error. (The CAN module tried to transmit a dominant-level bit as part of a transmit message, ACK bit, error frame, or overload frame, but the value on the CAN bus is a recessive-level bit.)
1	1	0	CRC error
1	1	1	Undefined

Caution Be sure to set bits 3 to 7 to “0”.

Remarks 1. The contents of the C0LEC register are not cleared when the CAN module changes from an operation mode to the initialization mode.

2. If an attempt is made to write a value other than 00H to the C0LEC register by software, the access is ignored.

(8) CAN0 module information register (C0INFO)

The C0INFO register indicates the status of the CAN module.

After reset: 00H R Address: 03FEC053H

	7	6	5	4	3	2	1	0
C0INFO	0	0	0	BOFF	TECS1	TECS0	RECS1	RECS0

BOFF	Bus-off status bit
0	Not bus-off status (transmit error counter ≤ 255). (The value of the transmit counter is less than 256.)
1	Bus-off status (transmit error counter > 255). (The value of the transmit error counter is 256 or more.)

TECS1	TECS0	Transmission error counter status bit
0	0	The value of the transmission error counter is less than that of the warning level (< 96).
0	1	The value of the transmission error counter is in the range of the warning level (96 to 127).
1	0	Undefined
1	1	The value of the transmission error counter is in the range of the error passive or bus-off status (≥ 128).

RECS1	RECS0	Reception error counter status bit
0	0	The value of the reception error counter is less than that of the warning level (< 96).
0	1	The value of the reception error counter is in the range of the warning level (96 to 127).
1	0	Undefined
1	1	The value of the reception error counter is in the error passive range (≥ 128).

Caution Be sure to set bits 5 to 7 to “0”.

(9) CAN0 module error counter register (C0ERC)

The C0ERC register indicates the count value of the transmission/reception error counter.

After reset: 0000H R Address: 03FEC054H

	15	14	13	12	11	10	9	8
C0ERC	REPS	REC6	REC5	REC4	REC3	REC2	REC1	REC0
	7	6	5	4	3	2	1	0
	TEC7	TEC6	TEC5	TEC4	TEC3	TEC2	TEC1	TEC0

REPS	Reception error passive status bit
0	The value of the reception error counter is not error passive (< 128)
1	The value of the reception error counter is in the error passive range (≥ 128)

REC6 to REC0	Reception error counter bit
0 to 127	Number of reception errors. These bits reflect the status of the reception error counter. The number of errors is defined by the CAN protocol.

Remark The REC6 to REC0 bits of the reception error counter are invalid in the reception error passive status (C0INFO.RECS1, C0INFO.RECS0 bit = 11B).

TEC7 to TEC0	Transmission error counter bit
0 to 255	Number of transmission errors. These bits reflect the status of the transmission error counter. The number of errors is defined by the CAN protocol.

Remark The TEC7 to TEC0 bits of the transmission error counter are invalid in the bus-off status (C0INFO.BOFF bit = 1).

(10) CAN0 module interrupt enable register (C0IE)

The C0IE register is used to enable or disable the interrupts of the CAN module.

(1/2)

After reset: 0000H R/W Address: 03FEC056H

(a) Read

	15	14	13	12	11	10	9	8
C0IE	0	0	0	0	0	0	0	0
	7	6	5	4	3	2	1	0
	0	0	CIE5	CIE4	CIE3	CIE2	CIE1	CIE0

(b) Write

	15	14	13	12	11	10	9	8
C0IE	0	0	Set CIE5	Set CIE4	Set CIE3	Set CIE2	Set CIE1	Set CIE0
	7	6	5	4	3	2	1	0
	0	0	Clear CIE5	Clear CIE4	Clear CIE3	Clear CIE2	Clear CIE1	Clear CIE0

(a) Read

CIE5 to CIE0	CAN module interrupt enable bit
0	Output of the interrupt corresponding to interrupt status register CINTSx is disabled.
1	Output of the interrupt corresponding to interrupt status register CINTSx is enabled.

(2/2)

(b) Write

Set CIE5	Clear CIE5	Setting of CIE5 bit
0	1	CIE5 bit is cleared to 0.
1	0	CIE5 bit is set to 1.
Other than above		CIE5 bit is not changed.

Set CIE4	Clear CIE4	Setting of CIE4 bit
0	1	CIE4 bit is cleared to 0.
1	0	CIE4 bit is set to 1.
Other than above		CIE4 bit is not changed.

Set CIE3	Clear CIE3	Setting of CIE3 bit
0	1	CIE3 bit is cleared to 0.
1	0	CIE3 bit is set to 1.
Other than above		CIE3 bit is not changed.

Set CIE2	Clear CIE2	Setting of CIE2 bit
0	1	CIE2 bit is cleared to 0.
1	0	CIE2 bit is set to 1.
Other than above		CIE2 bit is not changed.

Set CIE1	Clear CIE1	Setting of CIE1 bit
0	1	CIE1 bit is cleared to 0.
1	0	CIE1 bit is set to 1.
Other than above		CIE1 bit is not changed.

Set CIE0	Clear CIE0	Setting of CIE0 bit
0	1	CIE0 bit is cleared to 0.
1	0	CIE0 bit is set to 1.
Other than above		CIE0 bit is not changed.

(11) CAN0 module interrupt status register (C0INTS)

The C0INTS register indicates the interrupt status of the CAN module.

After reset: 0000H R/W Address: 03FEC058H

(a) Read

	15	14	13	12	11	10	9	8
C0INTS	0	0	0	0	0	0	0	0
	7	6	5	4	3	2	1	0
	0	0	CINTS5	CINTS4	CINTS3	CINTS2	CINTS1	CINTS0

(b) Write

	15	14	13	12	11	10	9	8
C0INTS	0	0	0	0	0	0	0	0
	7	6	5	4	3	2	1	0
	0	0	Clear CINTS5	Clear CINTS4	Clear CINTS3	Clear CINTS2	Clear CINTS1	Clear CINTS0

(a) Read

CINTS5 to CINTS0	CAN interrupt status bit
0	No related interrupt source event is generated.
1	A related interrupt source event is generated.

Interrupt status bit	Related interrupt source event
CINTS5	Wakeup interrupt from CAN sleep mode[Note]
CINTS4	Arbitration loss interrupt
CINTS3	CAN protocol error interrupt
CINTS2	CAN error status interrupt
CINTS1	Interrupt on completion of reception of valid message frame to message buffer m
CINTS0	Interrupt on normal completion of transmission of message frame from message buffer m

Note The CINTS5 bit is set (1) only when the CAN module is woken up from the CAN sleep mode by a CAN bus operation. The CINTS5 bit is not set (1) when the CAN sleep mode has been released by software.

(b) Write

Clear CINTS5 to CINTS0	Setting of CINTS5 to CINTS0 bits
0	CINTS5 to CINTS0 bits are not changed.
1	CINTS5 to CINTS0 bits are cleared to 0.

Caution The status bit of this register is not automatically cleared. Clear it (0) by software if each status must be checked in the interrupt servicing.

(12) CAN0 module bit rate prescaler register (C0BRP)

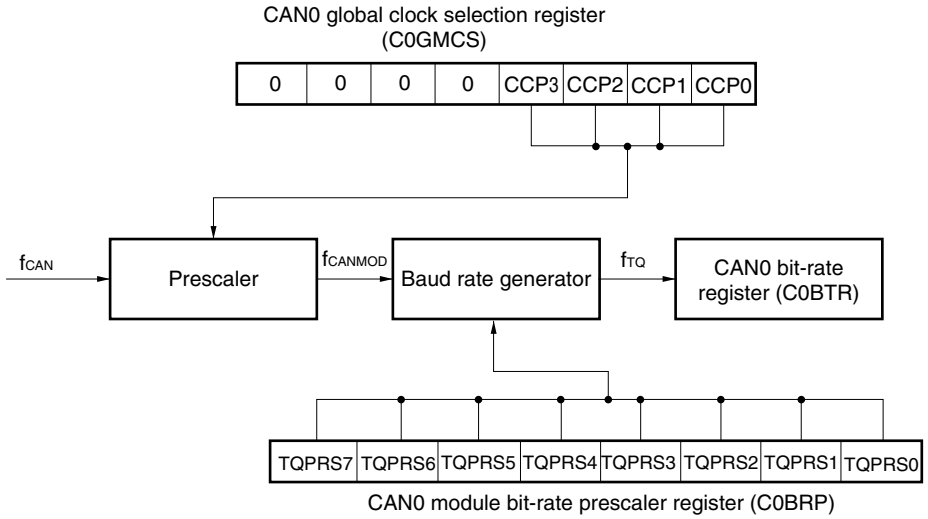
The C0BRP register is used to select the CAN protocol layer base clock (f_{TQ}). The communication baud rate is set to the C0BTR register.

After reset: FFH R/W Address: 03FEC05AH

	7	6	5	4	3	2	1	0
C0BRP	TQPRS7	TQPRS6	TQPRS5	TQPRS4	TQPRS3	TQPRS2	TQPRS1	TQPRS0

TQPRS7 to TQPRS0	CAN protocol layer base system clock (f_{TQ})
0	f_{CANMOD}/1
1	f_{CANMOD}/2
n	f_{CANMOD}/(n + 1)
:	:
255	f_{CANMOD}/256 (default value)

Figure 20-23. CAN Module Clock



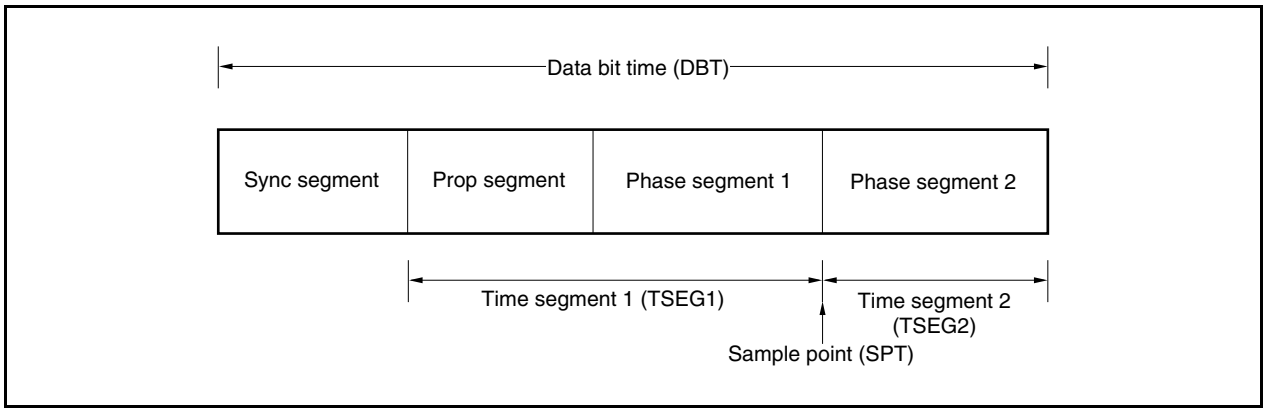
Remark f_{CAN}: CAN clock frequency
f_{CANMOD}: CAN module system clock frequency
f_{TQ}: CAN protocol layer base system clock frequency

Caution The C0BRP register can be write-accessed only in the initialization mode.

(13) CAN0 module bit rate register (C0BTR)

The C0BTR register is used to control the data bit time of the communication baud rate.

Figure 20-24. Data Bit Time



After reset: 370FH R/W Address: 03FEC05CH

	15	14	13	12	11	10	9	8
C0BTR	0	0	SJW1	SJW0	0	TSEG22	TSEG21	TSEG20
	7	6	5	4	3	2	1	0
	0	0	0	0	TSEG13	TSEG12	TSEG11	TSEG10

SJW1	SJW0	Length of synchronization jump width
0	0	1TQ
0	1	2TQ
1	0	3TQ
1	1	4TQ (default value)

TSEG22	TSEG21	TSEG20	Length of time segment 2
0	0	0	1TQ
0	0	1	2TQ
0	1	0	3TQ
0	1	1	4TQ
1	0	0	5TQ
1	0	1	6TQ
1	1	0	7TQ
1	1	1	8TQ (default value)

TSEG13	TSEG12	TSEG11	TSEG10	Length of time segment 1
0	0	0	0	Setting prohibited
0	0	0	1	2TQ[Note]
0	0	1	0	3TQ[Note]
0	0	1	1	4TQ
0	1	0	0	5TQ
0	1	0	1	6TQ
0	1	1	0	7TQ
0	1	1	1	8TQ
1	0	0	0	9TQ
1	0	0	1	10TQ
1	0	1	0	11TQ
1	0	1	1	12TQ
1	1	0	0	13TQ
1	1	0	1	14TQ
1	1	1	0	15TQ
1	1	1	1	16TQ (default value)

Note This setting must not be made when the C0BRP register = 00H.

Remark TQ = 1/f_{TQ} (f_{TQ}: CAN protocol layer base system clock)

(14) CAN0 module last in-pointer register (C0LIPT)

The C0LIPT register indicates the number of the message buffer in which a data frame or a remote frame was last stored.

After reset: Undefined R Address: 03FEC05EH

	7	6	5	4	3	2	1	0
C0LIPT	LIPT7	LIPT6	LIPT5	LIPT4	LIPT3	LIPT2	LIPT1	LIPT0

LIPT7 to LIPT0	Last in-pointer register (C0LIPT)
0 to 31	When the C0LIPT register is read, the contents of the element indexed by the last in-pointer (LIPT) of the receive history list are read. These contents indicate the number of the message buffer in which a data frame or a remote frame was last stored.

Remark The read value of the C0LIPT register is undefined if a data frame or a remote frame has never been stored in the message buffer. If the C0RGPT.RHPM bit is set to 1 after the CAN module has changed from the initialization mode to an operation mode, therefore, the read value of the C0LIPT register is undefined.

(15) CAN0 module receive history list register (C0RGPT)

The C0RGPT register is used to read the receive history list.

(1/2)

After reset: xx02H R/W Address: 03FEC060H

(a) Read

	15	14	13	12	11	10	9	8
C0RGPT	RGPT7	RGPT6	RGPT5	RGPT4	RGPT3	RGPT2	RGPT1	RGPT0
	7	6	5	4	3	2	1	0
	0	0	0	0	0	0	RHPM	ROVF

(b) Write

	15	14	13	12	11	10	9	8
C0RGPT	0	0	0	0	0	0	0	0
	7	6	5	4	3	2	1	0
	0	0	0	0	0	0	0	Clear ROVF

(a) Read

RGPT7 to RGPT0	Receive history list read pointer
0 to 31	When the C0RGPT register is read, the contents of the element indexed by the receive history list get pointer (RGPT) of the receive history list are read. These contents indicate the number of the message buffer in which a data frame or a remote frame has been stored.

RHPM[Note 1]	Receive history list pointer match
0	The receive history list has at least one message buffer number that has not been read.
1	The receive history list has no message buffer numbers that have not been read.

ROVF[Note 2]	Receive history list overflow bit
0	All the message buffer numbers that have not been read are preserved. All the numbers of the message buffers in which a new data frame or remote frame has been received and stored are recorded to the receive history list (the receive history list has a vacant element).
1	At least 23 entries have been stored since the host processor serviced the RHL last time (i.e. read C0RGPT). The first 22 entries are sequentially stored whereas the last entry might have been overwritten by newly received messages a number of times because all buffer numbers are stored at position LIPT-1 when the ROVF bit is set to 1. As a consequence receptions cannot be completely recovered in the order that they were received.

Notes 1. The read value of the RGPT0 to RGPT7 bits is invalid when the RHPM bit = 1.

2. If all the receive history is read by the C0RGPT register while the ROVF bit is set (1), the RHPM bit is not cleared (0) but kept set (1) even if newly received data is stored.

(2/2)

(b) Write

Clear ROVF	Setting of ROVF bit
0	ROVF bit is not changed.
1	ROVF bit is cleared to 0.

(16) CAN0 module last out-pointer register (C0LOPT)

The C0LOPT register indicates the number of the message buffer to which a data frame or a remote frame was transmitted last.

After reset: Undefined R Address: C0LOPT 03FEC062H, C1LOPT 03FEC662H

	7	6	5	4	3	2	1	0
C0LOPT	LOPT7	LOPT6	LOPT5	LOPT4	LOPT3	LOPT2	LOPT1	LOPT0

LOPT7 to LOPT0	Last out-pointer of transmit history list (LOPT)
0 to 31	When the C0LOPT register is read, the contents of the element indexed by the last out-pointer (LOPT) of the receive history list are read. These contents indicate the number of the message buffer to which a data frame or a remote frame was transmitted last.

Remark The value read from the C0LOPT register is undefined if a data frame or remote frame has never been transmitted from a message buffer. If the C0TGPT.THPM bit is set to 1 after the CAN module has changed from the initialization mode to an operation mode, therefore, the read value of the C0LOPT register is undefined.

(17) CAN0 module transmit history list register (C0TGPT)

The C0TGPT register is used to read the transmit history list.

(1/2)

After reset: xx02H R/W Address: 03FEC064H

(a) Read

	15	14	13	12	11	10	9	8
C0TGPT	TGPT7	TGPT6	TGPT5	TGPT4	TGPT3	TGPT2	TGPT1	TGPT0
	7	6	5	4	3	2	1	0
	0	0	0	0	0	0	THPM	TOVF

(b) Write

	15	14	13	12	11	10	9	8
C0TGPT	0	0	0	0	0	0	0	0
	7	6	5	4	3	2	1	0
	0	0	0	0	0	0	0	Clear TOVF

(a) Read

TGPT7 to TGPT0	Transmit history list read pointer
0 to 31	When the C0TGPT register is read, the contents of the element indexed by the read pointer (TGPT) of the transmit history list are read. These contents indicate the number of the message buffer to which a data frame or a remote frame was transmitted last.

THPM[Note 1]	Transmit history pointer match
0	The transmit history list has at least one message buffer number that has not been read.
1	The transmit history list has no message buffer numbers that have not been read.

TOVF[Note 2]	Transmit history list overflow bit
0	All the message buffer numbers that have not been read are preserved. All the numbers of the message buffers to which a new data frame or remote frame has been transmitted are recorded to the transmit history list (the transmit history list has a vacant element).
1	At least 7 entries have been stored since the host processor serviced the THL last time (i.e. read C0TGPT). The first 6 entries are sequentially stored whereas the last entry might have been overwritten by newly transmitted messages a number of times because all buffer numbers are stored at position LOPT-1 when TOVF bit is set to 1. As a consequence receptions cannot be completely recovered in the order that they were received.

Notes 1. The read value of the TGPT0 to TGPT7 bits is invalid when the THPM bit = 1.

2. If all the transmit history is read by the C0TGPT register while the TOVF bit is set (1), the THPM bit is not cleared (0) but kept set (1), even if transmission of new data has been completed.

Remark Transmission from message buffers 0 to 7 is not recorded to the transmit history list in the normal operation mode with ABT.

(2/2)

(b) Write

Clear TOVF	Setting of TOVF bit
0	TOVF bit is not changed.
1	TOVF bit is cleared to 0.

(18) CAN0 module time stamp register (C0TS)

The C0TS register is used to control the time stamp function.

(1/2)

After reset: 0000H R/W Address: 03FEC066H

(a) Read

	15	14	13	12	11	10	9	8
C0TS	0	0	0	0	0	0	0	0
	7	6	5	4	3	2	1	0
	0	0	0	0	0	TSLOCK	TSSEL	TSEN

(b) Write

	15	14	13	12	11	10	9	8
C0TS	0	0	0	0	0	Set TSLOCK	Set TSSEL	Set TSEN
	7	6	5	4	3	2	1	0
	0	0	0	0	0	Clear TSLOCK	Clear TSSEL	Clear TSEN

Remark The lock function of the time stamp functions must not be used when the CAN module is in the normal operation mode with ABT.

(2/2)

(a) Read

TSLOCK	Time stamp lock function enable bit
0	Time stamp lock function stopped. The TSOUT signal toggles each time the selected time stamp capture event occurs.
1	Time stamp lock function enabled. The TSOUT signal toggled each time the selected time stamp capture event occurred. However, the TSOUT output signal is locked when a data frame has been correctly received to message buffer 0[Note].

Note The TSEN bit is automatically cleared to 0.

TSSEL	Time stamp capture event selection bit
0	The time stamp capture event is SOF.
1	The time stamp capture event is the last bit of EOF.

TSEN	TSOUT operation setting bit
0	TSOUT toggle operation is disabled.
1	TSOUT toggle operation is enabled.

Remark The TSOUT signal is output from the CAN controller to a timer. For details, refer to **CHAPTER 7 16-BIT TIMER/EVENT COUNTER A (TAA)**.

(b) Write

Set TSLOCK	Clear TSLOCK	Setting of TSLOCK bit
0	1	TSLOCK bit is cleared to 0.
1	0	TSLOCK bit is set to 1.
Other than above		TSLOCK bit is not changed.

Set TSSEL	Clear TSSEL	Setting of TSSEL bit
0	1	TSSEL bit is cleared to 0.
1	0	TSSEL bit is set to 1.
Other than above		TSSEL bit is not changed.

Set TSEN	Clear TSEN	Setting of TSEN bit
0	1	TSEN bit is cleared to 0.
1	0	TSEN bit is set to 1.
Other than above		TSEN bit is not changed.

(19) CAN0 message data byte register (C0MDATAxm, C0MDATAym) (x = 0 to 7, y = 01, 23, 45, 67)

The C0MDATAxm register is used to store the data of a transmit/receive message, and can be accessed in 8-bit unit.

The C0MDATAxm register can be accessed in 16-bit units by the C0MDATAym register.

(1/2)

After reset: Undefined R/W Address: See **Table 20-16**.

C0MDATA01m

15	14	13	12	11	10	9	8
MDATA01 15	MDATA01 14	MDATA01 13	MDATA01 12	MDATA01 11	MDATA01 10	MDATA01 9	MDATA01 8
7	6	5	4	3	2	1	0
MDATA01 7	MDATA01 6	MDATA01 5	MDATA01 4	MDATA01 3	MDATA01 2	MDATA01 1	MDATA01 0

C0MDATA0m

7	6	5	4	3	2	1	0
MDATA0 7	MDATA0 6	MDATA0 5	MDATA0 4	MDATA0 3	MDATA0 2	MDATA0 1	MDATA0 0

C0MDATA1m

7	6	5	4	3	2	1	0
MDATA1 7	MDATA1 6	MDATA1 5	MDATA1 4	MDATA1 3	MDATA1 2	MDATA1 1	MDATA1 0

C0MDATA23m

15	14	13	12	11	10	9	8
MDATA23 15	MDATA23 14	MDATA23 13	MDATA23 12	MDATA23 11	MDATA23 10	MDATA23 9	MDATA23 8
7	6	5	4	3	2	1	0
MDATA23 7	MDATA23 6	MDATA23 5	MDATA23 4	MDATA23 3	MDATA23 2	MDATA23 1	MDATA23 0

C0MDATA2m

7	6	5	4	3	2	1	0
MDATA2 7	MDATA2 6	MDATA2 5	MDATA2 4	MDATA2 3	MDATA2 2	MDATA2 1	MDATA2 0

C0MDATA3m

7	6	5	4	3	2	1	0
MDATA3 7	MDATA3 6	MDATA3 5	MDATA3 4	MDATA3 3	MDATA3 2	MDATA3 1	MDATA3 0

(2/2)

C0MDATA45m

15	14	13	12	11	10	9	8
MDATA45 15	MDATA45 14	MDATA45 13	MDATA45 12	MDATA45 11	MDATA45 10	MDATA45 9	MDATA45 8
7	6	5	4	3	2	1	0
MDATA45 7	MDATA45 6	MDATA45 5	MDATA45 4	MDATA45 3	MDATA45 2	MDATA45 1	MDATA45 0

C0MDATA4m

7	6	5	4	3	2	1	0
MDATA4 7	MDATA4 6	MDATA4 5	MDATA4 4	MDATA4 3	MDATA4 2	MDATA4 1	MDATA4 0

C0MDATA5m

7	6	5	4	3	2	1	0
MDATA5 7	MDATA5 6	MDATA5 5	MDATA5 4	MDATA5 3	MDATA5 2	MDATA5 1	MDATA5 0

C0MDATA67m

15	14	13	12	11	10	9	8
MDATA67 15	MDATA67 14	MDATA67 13	MDATA67 12	MDATA67 11	MDATA67 10	MDATA67 9	MDATA67 8
7	6	5	4	3	2	1	0
MDATA67 7	MDATA67 6	MDATA67 5	MDATA67 4	MDATA67 3	MDATA67 2	MDATA67 1	MDATA67 0

C0MDATA6m

7	6	5	4	3	2	1	0
MDATA6 7	MDATA6 6	MDATA6 5	MDATA6 4	MDATA6 3	MDATA6 2	MDATA6 1	MDATA6 0

C0MDATA7m

7	6	5	4	3	2	1	0
MDATA7 7	MDATA7 6	MDATA7 5	MDATA7 4	MDATA7 3	MDATA7 2	MDATA7 1	MDATA7 0

(20) CAN0 message data length register m (C0MDLCm)

The C0MDLCm register is used to set the number of bytes of the data field of a message buffer.

After reset: 0000xxxxB R/W Address: See **Table 20-16**.

	7	6	5	4	3	2	1	0
C0MDLCm	0	0	0	0	MDLC3	MDLC2	MDLC1	MDLC0

MDLC3	MDLC2	MDLC1	MDLC0	Data length of transmit/receive message
0	0	0	0	0 bytes
0	0	0	1	1 byte
0	0	1	0	2 bytes
0	0	1	1	3 bytes
0	1	0	0	4 bytes
0	1	0	1	5 bytes
0	1	1	0	6 bytes
0	1	1	1	7 bytes
1	0	0	0	8 bytes
1	0	0	1	Setting prohibited (If these bits are set during transmission, 8-byte data is transmitted regardless of the set DLC value when a data frame is transmitted. However, the DLC actually transmitted to the CAN bus is the DLC value set to this register.)Note
1	0	1	0	
1	0	1	1	
1	1	0	0	
1	1	0	1	
1	1	1	0	
1	1	1	1	

Note The data and DLC value actually transmitted to CAN bus are as follows.

Type of transmit frame	Length of transmit data	DLC transmitted
Data frame	Number of bytes specified by DLC (However, 8 bytes if DLC ≥ 8)	MDLC3 to MDLC0 bits
Remote frame	0 bytes	

Cautions 1. Be sure to set bits 7 to 4 to 0000B.

2. Receive data is stored in as many C0MDATAxm register as the number of bytes (however, the upper limit is 8) corresponding to DLC of receive frame. The C0MDATAxm register in which no data is stored is undefined.

3. Be sure to set bits 4 to 7 to "0".

(21) CAN0 message configuration register m (C0MCONFm)

The C0MCONFm register is used to specify the type of the message buffer and to set a mask.

(1/2)

After reset: Undefined R/W Address: See **Table 20-16**.

	7	6	5	4	3	2	1	0
C0MCONFm	OWS	RTR	MT2	MT1	MT0	0	0	MA0

OWS	Overwrite control bit
0	The message buffer[Note] that has already received a data frame is not overwritten by a newly received data frame. The newly received data frame is discarded.
1	The message buffer that has already received a data frame is overwritten by a newly received data frame.

Note The “message buffer that has already received a data frame” is a receive message buffer whose the C0MCTRLm.DN bit has been set to 1.

Remark A remote frame is received and stored, regardless of the setting of the OWS and DN bits. A remote frame that satisfies the other conditions (ID matches, the RTR bit = 0, the C0MCTRLm.TRQ bit = 0) is always received and stored in the corresponding message buffer (interrupt generated, DN flag set, the C0MDLCm.MDLC0 to C0MDLCm.MDLC3 bits updated, and recorded to the receive history list).

RTR	Remote frame request bit[Note]
0	Transmit a data frame.
1	Transmit a remote frame.

Note The RTR bit specifies the type of message frame that is transmitted from a message buffer defined as a transmit message buffer. Even if a valid remote frame has been received, the RTR bit of the transmit message buffer that has received the frame remains cleared to 0. Even if a remote frame whose ID matches has been received from the CAN bus with the RTR bit of the transmit message buffer set to 1 to transmit a remote frame, that remote frame is not received or stored (interrupt generated, DN flag set, the MDLC0 to MDLC3 bits updated, and recorded to the receive history list).

MT2	MT1	MT0	Message buffer type setting bit
0	0	0	Transmit message buffer
0	0	1	Receive message buffer (no mask setting)
0	1	0	Receive message buffer (mask 1 set)
0	1	1	Receive message buffer (mask 2 set)
1	0	0	Receive message buffer (mask 3 set)
1	0	1	Receive message buffer (mask 4 set)
Other than above			Setting prohibited

(2/2)

MA0	Message buffer assignment bit
0	Message buffer not used.
1	Message buffer used.

Caution Be sure to set bits 2 and 1 to "0".

(22) CAN0 message ID register m (C0MIDLm, C0MIDHm)

The C0MIDLm and C0MIDHm registers are used to set an identifier (ID).

After reset: Undefined R/W Address: See **Table 20-16**.

	15	14	13	12	11	10	9	8
C0MIDLm	ID15	ID14	ID13	ID12	ID11	ID10	ID9	ID8
	7	6	5	4	3	2	1	0
	ID7	ID6	ID5	ID4	ID3	ID2	ID1	ID0

	15	14	13	12	11	10	9	8
C0MIDHm	IDE	0	0	ID28	ID27	ID26	ID25	ID24
	7	6	5	4	3	2	1	0
	ID23	ID22	ID21	ID20	ID19	ID18	ID17	ID16

IDE	Format mode specification bit
0	Standard format mode (ID28 to ID18: 11 bits)[Note]
1	Extended format mode (ID28 to ID0: 29 bits)

Note The ID17 to ID0 bits are not used.

ID28 to ID0	Message ID
ID28 to ID18	Standard ID value of 11 bits (when IDE = 0)
ID28 to ID0	Extended ID value of 29 bits (when IDE = 1)

Cautions 1. Be sure to write 0 to bits 14 and 13 of the C0MIDHm register.

2. Be sure to arrange the ID values to be registered in accordance with the bit positions of this register. For the standard ID, shift the bit positions of ID28 to ID18 of the ID value.

(23) CAN0 message control register m (C0MCTRLm)

The C0MCTRLm register is used to control the operation of the message buffer.

(1/3)

After reset: 00x000000 R/W Address: See **Table 20-16**.
000xx000B

(a) Read

	15	14	13	12	11	10	9	8
C0MCTRLm	0	0	MUC	0	0	0	0	0
	7	6	5	4	3	2	1	0
	0	0	0	MOW	IE	DN	TRQ	RDY

(b) Write

	15	14	13	12	11	10	9	8
C0MCTRLm	0	0	0	0	Set IE	0	Set TRQ	Set RDY
	7	6	5	4	3	2	1	0
	0	0	0	Clear MOW	Clear IE	Clear DN	Clear TRQ	Clear RDY

(a) Read

MUC[Note]	Bit indicating that message buffer data is being updated
0	The CAN module is not updating the message buffer (reception and storage).
1	The CAN module is updating the message buffer (reception and storage).

Note The MUC bit is undefined until the first reception and storage is performed.

MOW	Message buffer overwrite status bit
0	The message buffer is not overwritten by a newly received data frame.
1	The message buffer is overwritten by a newly received data frame.

Remark The MOW bit is not set to 1 even if a remote frame is received and stored in the transmit message buffer with the DN bit = 1.

IE	Message buffer interrupt request enable bit
0	Receive message buffer: Valid message reception completion interrupt disabled. Transmit message buffer: Normal message transmission completion interrupt disabled.
1	Receive message buffer: Valid message reception completion interrupt enabled. Transmit message buffer: Normal message transmission completion interrupt enabled.

DN	Message buffer data update bit
0	A data frame or remote frame is not stored in the message buffer.
1	A data frame or remote frame is stored in the message buffer.

(2/3)

TRQ	Message buffer transmission request bit
0	No message frame transmitting request that is pending or being transmitted is in the message buffer.
1	The message buffer is holding transmission of a message frame pending or is transmitting a message frame.

Caution Do not set the TRQ bit and RDY bit to 1 at the same time. Be sure to set the RDY bit to 1 before setting the TRQ bit to 1.

RDY	Message buffer ready bit
0	The message buffer can be written by software. The CAN module cannot write to the message buffer.
1	Writing the message buffer by software is ignored (except a write access to the RDY, TRQ, DN, and MOW bits). The CAN module can write to the message buffer.

Cautions 1. Do not clear the RDY bit (0) during message transmission. Follow transmission abort procedures in order to clear the RDY bit for redefinition.

2. If the RDY bit is not cleared (0) even when the processing to clear it is executed, execute the clearing processing again.

3. Confirm, by reading the RDY bit again, that the RDY bit has been cleared (0) before writing data to the message buffer.
However, it is unnecessary to confirm that the TRQ or RDY bit has been set (1) or that the DN or MOW bit has been cleared (0).

(b) Write

Clear MOW	Setting of MOW bit
0	MOW bit is not changed.
1	MOW bit is cleared to 0.

Set IE	Clear IE	Setting of IE bit
0	1	IE bit is cleared to 0.
1	0	IE bit is set to 1.
Other than above		IE bit is not changed.

Caution Be sure to set the IE and RDY bits separately.

Clear DN	Setting of DN bit
1	DN bit is cleared to 0.
0	DN bit is not changed.

Caution Do not set the DN bit to 1 by software. Be sure to write 0 to bit 10.

(3/3)

Set TRQ	Clear TRQ	Setting of TRQ bit
0	1	TRQ bit is cleared to 0.
1	0	TRQ bit is set to 1.
Other than above		TRQ bit is not changed.

Caution Even if the TRQ bit is set (1), transmission may not be immediately executed depending on the situation such as when a message is received from another node or when a message is transmitted from the message buffer.
Transmission under execution is not terminated midway even if the TRQ bit is cleared. Transmission is continued until it is completed (regardless of whether it is executed successfully or fails).

Set RDY	Clear RDY	Setting of RDY bit
0	1	RDY bit is cleared to 0.
1	0	RDY bit is set to 1.
Other than above		RDY bit is not changed.

Caution Be sure to set the TRQ and RDY bits separately.

20.7 Bit Set/Clear Function

The CAN control registers include registers whose bits can be set or cleared via the CPU and via the CAN interface. An operation error occurs if the following registers are written directly. Do not write any values directly via bit manipulation, read/modify/write, or direct writing of target values.

- CAN0 global control register (C0GMCTRL)
- CAN0 global automatic block transmission control register (C0GMABT)
- CAN0 module control register (C0CTRL)
- CAN0 module interrupt enable register (C0IE)
- CAN0 module interrupt status register (C0INTS)
- CAN0 module receive history list register (C0RGPT)
- CAN0 module transmit history list register (C0TGPT)
- CAN0 module time stamp register (C0TS)
- CAN0 message control register (C0MCTRLm)

Remark m = 00 to 31

All the 16 bits in the above registers can be read via the usual method. Use the procedure described in Figure 20-25 below to set or clear the lower 8 bits in these registers.

Setting or clearing of lower 8 bits in the above registers is performed in combination with the higher 8 bits (refer to the bit status after set/clear operation is specified in Figure 20-26). Figure 20-25 shows how the values of set bits or clear bits relate to set/clear/no change operations in the corresponding register.

Figure 20-25. Example of Bit Setting/Clearing Operations

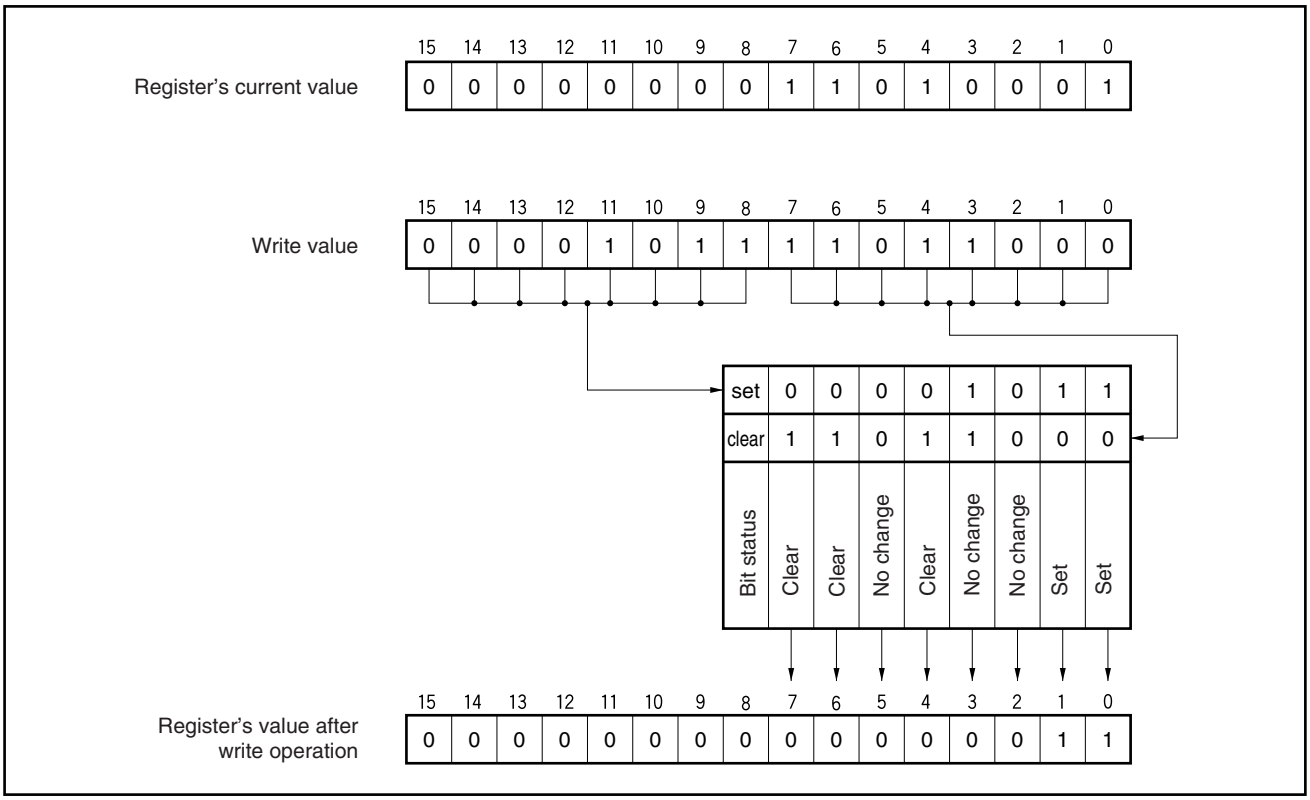


Figure 20-26. Bit Status After Bit Setting/Clearing Operations

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Set 7	Set 6	Set 5	Set 4	Set 3	Set 2	Set 1	Set 0	Clear 7	Clear 6	Clear 5	Clear 4	Clear 3	Clear 2	Clear 1	Clear 0

Set n	Clear n	Status of bit n after bit set/clear operation
0	0	No change
0	1	0
1	0	1
1	1	No change

Remark n = 0 to 7

20.8 CAN Controller Initialization

20.8.1 Initialization of CAN module

Before CAN module operation is enabled, the CAN module system clock needs to be determined by setting the C0GMCS.CCP0 to C0GMCS.CCP3 bits by software. Do not change the setting of the CAN module system clock after CAN module operation is enabled.

The CAN module is enabled by setting the C0GMCTRL.GOM bit.

For the procedure of initializing the CAN module, see **20.16 Operation of CAN Controller.**

20.8.2 Initialization of message buffer

After the CAN module is enabled, the message buffers contain undefined values. A minimum initialization for all the message buffers, even for those not used in the application, is necessary before switching the CAN module from the initialization mode to one of the operation modes.

- Clear the C0MCTRLm.RDY, C0MCTRLm.TRQ, and C0MCTRLm.DN bits to 0.
- Clear the C0MCONFm.MA0 bit to 0.

Remark m = 00 to 31

20.8.3 Redefinition of message buffer

Redefining a message buffer means changing the ID and control information of the message buffer while a message is being received or transmitted, without affecting other transmission/reception operations.

(1) To redefine message buffer in initialization mode

Place the CAN module in the initialization mode once and then change the ID and control information of the message buffer in the initialization mode. After changing the ID and control information, set the CAN module to an operation mode.

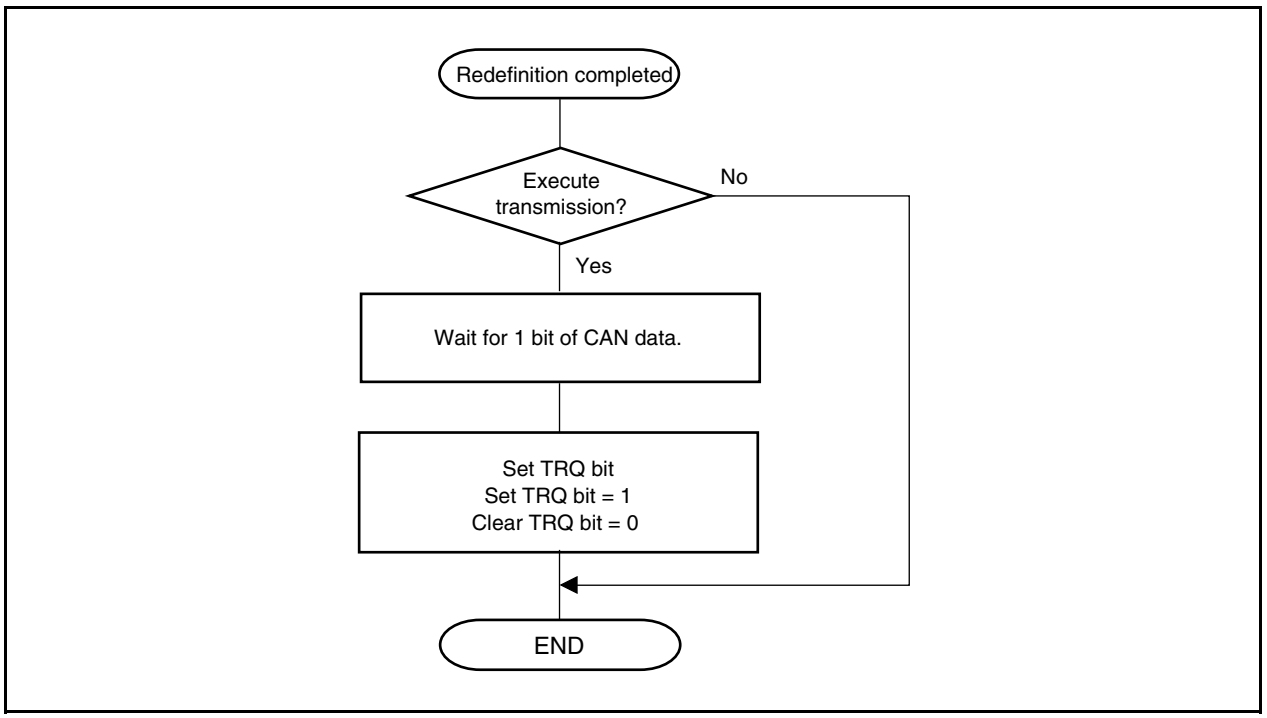
(2) To redefine message buffer during reception

Perform redefinition as shown in Figure 20-39.

(3) To redefine message buffer during transmission

To rewrite the contents of a transmit message buffer to which a transmission request has been set, perform transmission abort processing (see **20.10.4 (1) Transmission abort process other than in normal operation mode with automatic block transmission (ABT), 20.10.4 (2) Transmission abort process except for ABT transmission in normal operation mode with automatic block transmission (ABT)**). Confirm that transmission has been aborted or completed, and then redefine the message buffer. After redefining the transmit message buffer, set a transmission request using the procedure described below. When setting a transmission request to a message buffer that has been redefined without aborting the transmission in progress, however, the 1-bit wait time is not necessary.

Figure 20-27. Setting Transmission Request (TRQ) to Transmit Message Buffer After Redefinition



Cautions 1. When a message is received, reception filtering is performed in accordance with the ID and mask set to each receive message buffer. If the procedure in Figure 20-39 is not observed, the contents of the message buffer after it has been redefined may contradict the result of reception (result of reception filtering). If this happens, check that the ID and IDE received first and stored in the message buffer following redefinition are those stored after the message buffer has been redefined. If no ID and IDE are stored after redefinition, redefine the message buffer again.

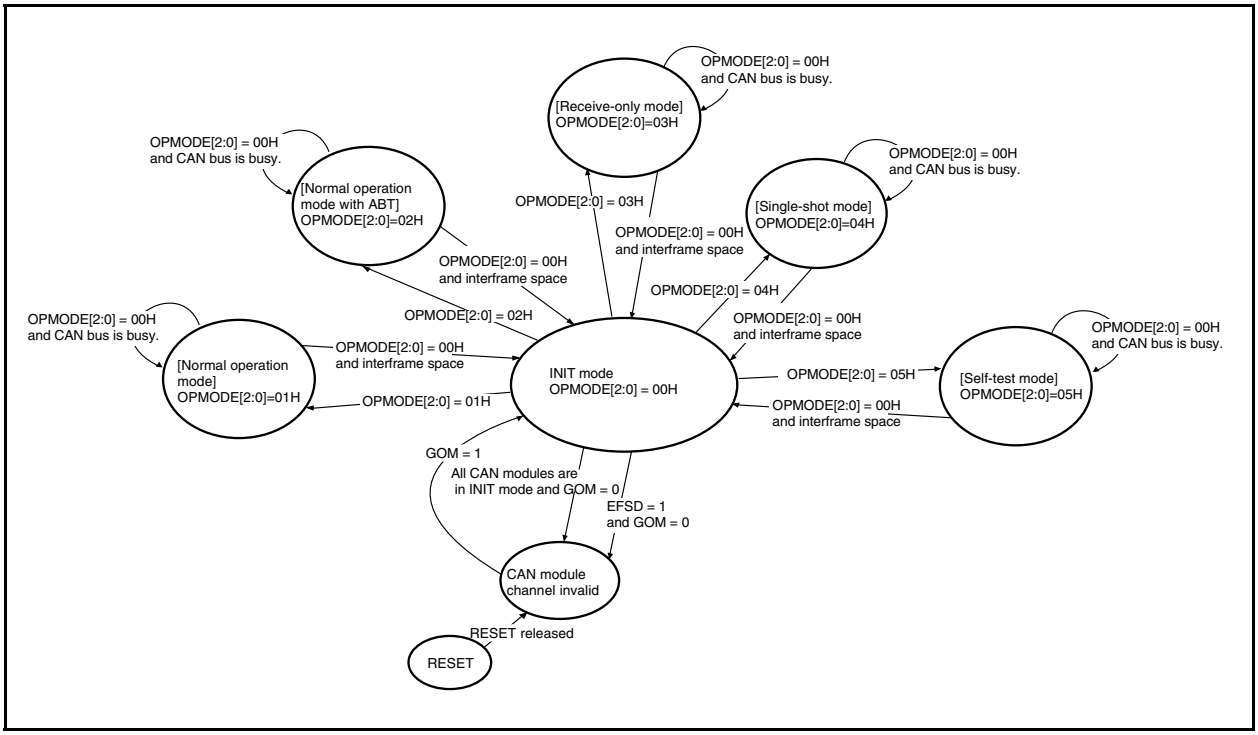
2. When a message is transmitted, the transmission priority is checked in accordance with the ID, IDE, and RTR bits set to each transmit message buffer to which a transmission request was set. The transmit message buffer having the highest priority is selected for transmission. If the procedure in Figure 20-27 is not observed, a message with an ID not having the highest priority may be transmitted after redefinition.

20.8.4 Transition from initialization mode to operation mode

The CAN module can be switched to the following operation modes.

- Normal operation mode
- Normal operation mode with ABT
- Receive-only mode
- Single-shot mode
- Self-test mode

Figure 20-28. Transition to Operation Modes



The transition from the initialization mode to an operation mode is controlled by the C0CTRL.OPMODE2 to C0CTRL.OPMODE0 bits.

Changing from one operation mode into another requires shifting to the initialization mode in between. Do not change one operation mode to another directly; otherwise the operation will not be guaranteed.

Requests for transition from an operation mode to the initialization mode are held pending when the CAN bus is not in the interframe space (i.e., frame reception or transmission is in progress), and the CAN module enters the initialization mode at the first bit in the interframe space (the values of the OPMODE2 to OPMODE0 bits are changed to 000B). After issuing a request to change the mode to the initialization mode, read the OPMODE2 to OPMODE0 bits until their values become 000B to confirm that the module has entered the initialization mode (see **Figure 20-37**).

20.8.5 Resetting error counter C0ERC of CAN module

If it is necessary to reset the C0ERC and C0INFO registers when re-initialization or forced recovery from the bus-off status is made, set the C0CTRL.CCERC bit to 1 in the initialization mode. When this bit is set to 1, the C0ERC and C0INFO registers are cleared to their default values.

20.9 Message Reception

20.9.1 Message reception

All buffers satisfying the following conditions are searched in all the message buffer areas in all the operation modes in order to store newly receive messages.

- Used as a message buffer
  (C0MCONFm.MA0 bit is set to 1.)
- Set as a receive message buffer
  (C0MCONFm.MT2 to C0MCONFm.MT0 bits are set to 001B, 010B, 011B, 100B, or 101B.)
- Ready for reception
  (C0MCTRLm.RDY bit is set to 1.)

Remark m = 00 to 31

When two or more message buffers of the CAN module receive a message, the message is stored according to the priority explained below. The message is always stored in the message buffer with the highest priority, not in a message buffer with a low priority. For example, when an unmasked receive message buffer and a receive message buffer linked to mask 1 have the same ID, the received message is not stored in the message buffer linked to mask 1 that has not received a message, even if a message has already been received in the unmasked receive message buffer. In other words, when a condition has been set to store a message in two or more message buffers with different priorities, the message buffer with the highest priority always stores the message; the message is not stored in message buffers with a lower priority. This also applies when the message buffer with the highest priority is unable to receive and store a message (i.e., when the DN bit = 1 indicating that a message has already been received, but rewriting is disabled because the OWS bit = 0). In this case, the message is not actually received and stored in the candidate message buffer with the highest priority, but neither is it stored in a message buffer with a lower priority.

Priority	Storing Condition If Same ID Is Set	
1 (high)	Unmasked message buffer	DN bit = 0
		DN bit = 1 and OWS bit = 1
2	Message buffer linked to mask 1	DN bit = 0
		DN bit = 1 and OWS bit = 1
3	Message buffer linked to mask 2	DN bit = 0
		DN bit = 1 and OWS bit = 1
4	Message buffer linked to mask 3	DN bit = 0
		DN bit = 1 and OWS bit = 1
5 (low)	Message buffer linked to mask 4	DN bit = 0
		DN bit = 1 and OWS bit = 1

20.9.2 Reading reception data

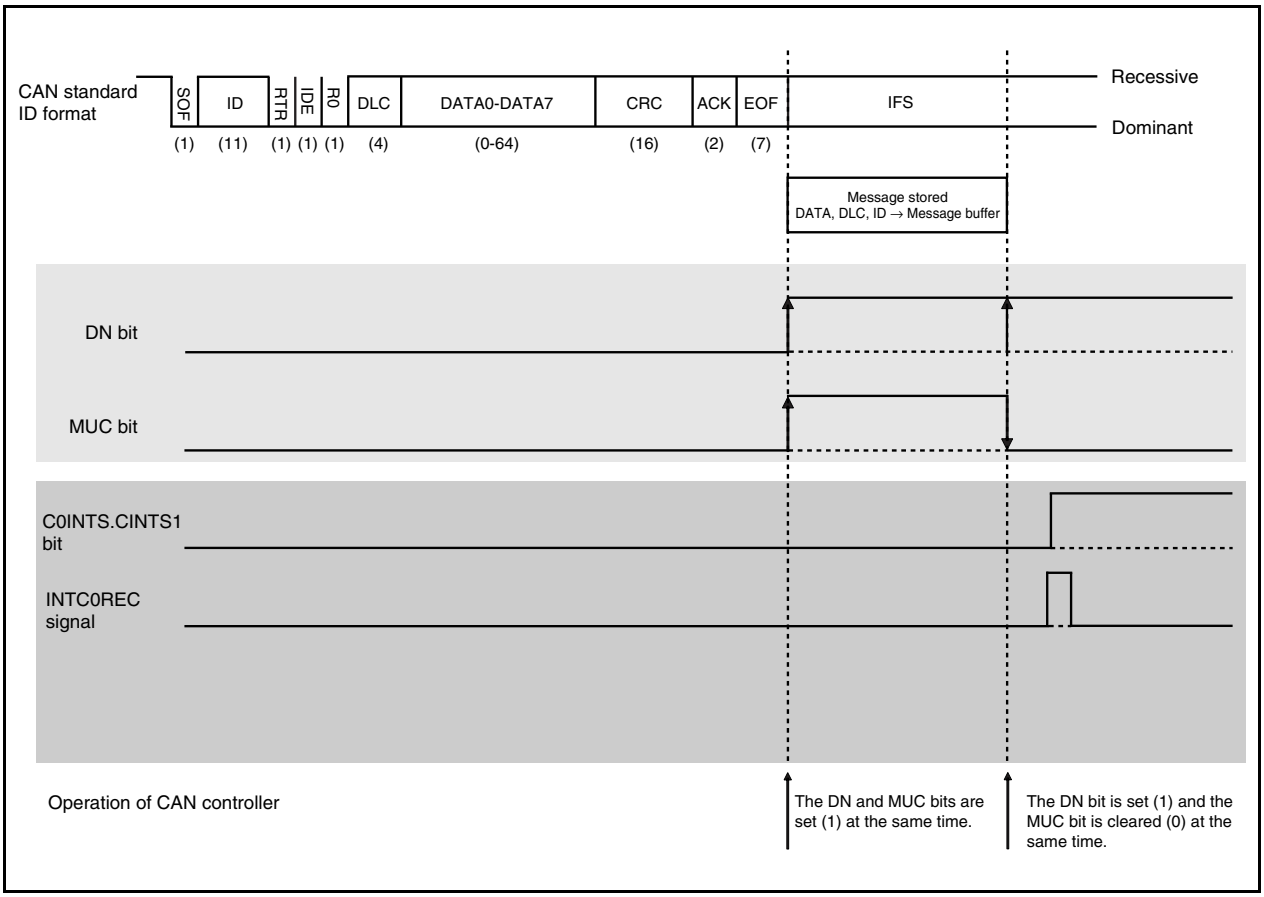
If it is necessary to consistently read data from the CAN message buffer by software, follow the recommended procedures shown in Figures 20-49 and 20-50.

While receiving a message, the CAN module sets the C0MCTRLm.DN bit two times, at the beginning of the processing to store data in the message buffer and at the end of this storing processing. During this storing processing, the C0MCTRLm.MUC bit of the message buffer is set (1) (refer to **Figure 20-29**).

Before the data is completely stored, the receive history list is written. During this data storing period (MUC bit = 1), the CPU is prohibited from rewriting the C0MCTRLm.RDY bit of the message buffer in which the data is to be stored. Completion of this data storing processing may be delayed by a CPU's access to any message buffer.

Remark m = 0 to 31

Figure 20-29. DN and MUC Bit Setting Period (in Standard ID Format)



20.9.3 Receive history list function

The receive history list (RHL) function records in the receive history list the number of the receive message buffer in which each data frame or remote frame was received and stored. The RHL consists of storage elements equivalent to up to 23 messages, the last in-message pointer (LIPT) with the corresponding C0LIPT register and the receive history list get pointer (RGPT) with the corresponding C0RGPT register.

The RHL is undefined immediately after the transition of the CAN module from the initialization mode to one of the operation modes.

The C0LIPT register holds the contents of the RHL element indicated by the value of the LIPT pointer minus 1. By reading the C0LIPT register, therefore, the number of the message buffer that received and stored a data frame or remote frame first can be checked. The LIPT pointer is utilized as a write pointer that indicates to what part of the RHL a message buffer number is recorded. Any time a data frame or remote frame is received and stored, the corresponding message buffer number is recorded to the RHL element indicated by the LIPT pointer. Each time recording to the RHL has been completed, the LIPT pointer is automatically incremented. In this way, the number of the message buffer that has received and stored a frame will be recorded chronologically.

The RGPT pointer is utilized as a read pointer that reads a recorded message buffer number from the RHL. This pointer indicates the first RHL element that the CPU has not read yet. By reading the C0RGPT register by software, the number of a message buffer that has received and stored a data frame or remote frame can be read. Each time a message buffer number is read from the C0RGPT register, the RGPT pointer is automatically incremented.

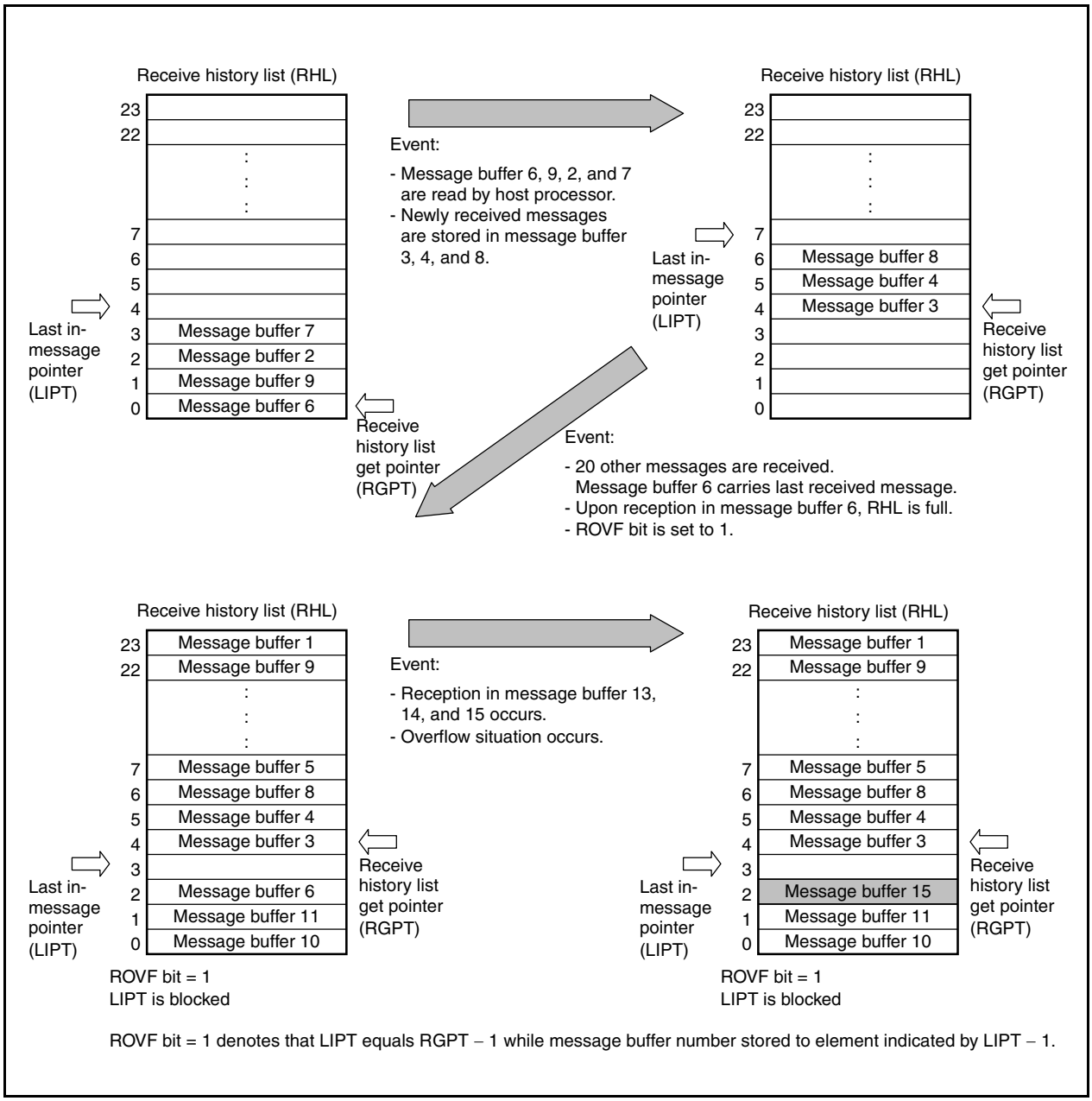
If the value of the RGPT pointer matches the value of the LIPT pointer, the C0RGPT.RHPM bit (receive history list pointer match) is set to 1. This indicates that no message buffer number that has not been read remains in the RHL. If a new message buffer number is recorded, the LIPT pointer is incremented and because its value no longer matches the value of the RGPT pointer, the RHPM bit is cleared. In other words, the numbers of the unread message buffers exist in the RHL.

If the LIPT pointer is incremented and matches the value of the RGPT pointer minus 1, the C0RGPT.ROVF bit (receive history list overflow) is set to 1. This indicates that the RHL is full of numbers of message buffers that have not been read. When further message reception and storing occur, the last recorded message buffer number is overwritten by the number of the message buffer that received and stored the new message. After the ROVF bit has been set to 1, the recorded message buffer numbers in the RHL do not completely reflect chronological order. However the messages themselves are not lost and can be located by a CPU search in the message buffer memory with the help of the DN bit.

Caution Even if the receive history list overflows (C0RGPT.ROVF bit = 1), the receive history can be read until no more history is left unread and the C0RGPT.RHPM bit is set (1). However, the ROVF bit is kept set (1) (= overflow occurs) until cleared (0) by software. In this status, the RHPM bit is not cleared (0), unless the ROVF bit is cleared (0), even if a new receive history is stored and written to the list. If ROVF bit = 1 and RHPM bit = 1 and the receive history list overflows, therefore, the RHPM bit indicates that no more history is left unread even if new history is received and stored.

As long as the RHL contains 23 or less entries the sequence of occurrence is maintained. If more receptions occur without the RHL being read by the host processor, a complete sequence of receptions can not be recovered.

Figure 20-30. Receive History List



20.9.4 Mask function

For some message buffers that are used for reception, whether one of four global reception masks is applied can be selected.

Load resulting from comparing message identifiers is reduced by masking some bits, and, as a result, some different identifiers can be received in a buffer.

By using the mask function, the identifier of a message received from the CAN bus can be compared with the identifier set to a message buffer in advance. Regardless of whether the masked ID is set to 0 or 1, the received message can be stored in the defined message buffer.

While the mask function is in effect, an identifier bit that is defined to be 1 by a mask in the received message is not compared with the corresponding identifier bit in the message buffer.

However, this comparison is performed for any bit whose value is defined as 0 by the mask.

For example, let us assume that all messages that have a standard-format ID, in which bits ID27 to ID25 are 0 and bits ID24 and ID22 are 1, are to be stored in message buffer 14. The procedure for this example is shown below.

<1> Identifier to be stored in message buffer

ID28	ID27	ID26	ID25	ID24	ID23	ID22	ID21	ID20	ID19	ID18
x	0	0	0	1	x	1	x	x	x	x

Remark x = don't care

<2> Identifier to be configured in message buffer 14 (example)
(Using C0MIDL14 and C0MIDH14 registers)

ID28	ID27	ID26	ID25	ID24	ID23	ID22	ID21	ID20	ID19	ID18
x	0	0	0	1	x	1	x	x	x	x

ID17	ID16	ID15	ID14	ID13	ID12	ID11	ID10	ID9	ID8	ID7
x	x	x	x	x	x	x	x	x	x	x

ID6	ID5	ID4	ID3	ID2	ID1	ID0
x	x	x	x	x	x	x

ID with the ID27 to ID25 bits cleared to 0 and the ID24 and ID22 bits set to 1 is registered (initialized) to message buffer 14.

Remark x = don't care

Remark Message buffer 14 is set as a standard format identifier that is linked to mask 1 (C0MCONF14.MT2 to C0MCONF14.MT0 bits are set to 010B).

<3> Mask setting for CAN module 1 (mask 1) (Example)
(Using CAN1 address mask 1 registers L and H (C1MASK1L and C1MASK1H))

CMID28	CMID27	CMID26	CMID25	CMID24	CMID23	CMID22	CMID21	CMID20	CMID19	CMID18
1	0	0	0	0	1	0	1	1	1	1

CMID17	CMID16	CMID15	CMID14	CMID13	CMID12	CMID11	CMID10	CMID9	CMID8	CMID7
1	1	1	1	1	1	1	1	1	1	1

CMID6	CMID5	CMID4	CMID3	CMID2	CMID1	CMID0
1	1	1	1	1	1	1

1: Not compared (masked)
0: Compared

The CMID27 to CMID24 and CMID22 bits are cleared to 0, and the CMID28, CMID23, and CMID21 to CMID0 bits are set to 1.

20.9.5 Multi buffer receive block function

The multi buffer receive block (MBRB) function is used to store a block of data in two or more message buffers sequentially with no CPU interaction, by setting the same ID to two or more message buffers with the same message buffer type. These message buffers can be allocated in any area in the message buffer memory, and they are not necessarily to be allocated adjacent to each other.

Suppose, for example, the same message buffer type is set to 10 message buffers, message buffers 10 to 19, and the same ID is set to each message buffer. If the first message whose ID matches an ID of the message buffers is received, it is stored in message buffer 10. At this point, the DN bit of message buffer 10 is set, prohibiting overwriting the message buffer.

When the next message with a matching ID is received, it is received and stored in message buffer 11. Each time a message with a matching ID is received, it is sequentially (in the ascending order) stored in message buffers 12, 13, and so on. Even when a data block consisting of multiple messages is received, the messages can be stored and received without overwriting the previously received matching-ID data.

Whether a data block has been received and stored can be checked by setting the C0MCTRLm.IE bit of each message buffer. For example, if a data block consists of k messages, k message buffers are initialized for reception of the data block. The IE bit in message buffers 0 to (k-2) is cleared to 0 (interrupts disabled), and the IE bit in message buffer k-1 is set to 1 (interrupts enabled). In this case, a reception completion interrupt occurs when a message has been received and stored in message buffer k-1, indicating that MBRB has become full. Alternatively, by clearing the IE bit of message buffers 0 to (k-3) and setting the IE bit of message buffer k-2, a warning that MBRB is about to overflow can be issued.

The basic conditions of storing receive data in each message buffer for the MBRB are the same as the conditions of storing data in a single message buffer.

Cautions 1. MBRB can be configured for each of the same message buffer types. Therefore, even if a message buffer of another MBRB whose ID matches but whose message buffer type is different has a vacancy, the received message is not stored in that message buffer, but instead discarded.

2. MBRB does not have a ring buffer structure. Therefore, after a message is stored in the message buffer having the highest number in the MBRB configuration, a newly received message will no longer be stored in the message buffer in the order from the lowest message buffer number.

3. MBRB operates based on the reception and storage conditions; there are no settings dedicated to MBRB, such as function enable bits. By setting the same message buffer type and ID to two or more message buffers, MBRB is automatically configured.

4. With MBRB, "matching ID" means "matching ID after mask". Even if the ID set to each message buffer is not the same, if the ID that is masked by the mask register matches, it is considered a matching ID and the buffer that has this ID is treated as the storage destination of a message.

5. Priority among each MBRB conforms to the priority shown in 20.9.1 Message reception.

Remark m = 00 to 31

20.9.6 Remote frame reception

In all the operation modes, when a remote frame is received, the message buffer that is to store the remote frame is searched from all the message buffers satisfying the following conditions.

- Used as a message buffer
  (C0MCONFm.MA0 bit set to 1.)
- Set as a transmit message buffer
  (C0MCONFm.MT2 to C0MCONFm.MT0 bits set to 000B)
- Ready for reception
  (C0MCTRLm.RDY bit set to 1.)
- Set to transmit message
  (C0MCONFm.RTR bit is cleared to 0.)
- Transmission request is not set.
  (C0MCTRLm.TRQ bit is set to 0.)

Upon acceptance of a remote frame, the following actions are executed if the ID of the received remote frame matches the ID of a message buffer that satisfies the above conditions.

- The C0MDLCm.DLC3 to C0MDLCm.DLC0 bits store the received DLC value.
- The C0MDATA0m to C0MDATA7m registers in the data area are not updated (data before reception is saved).
- The C0MCTRLm.DN bit is set to 1.
- The C0INTS.CINTS1 bit is set to 1 (if the C0MCTRLm.IE bit of the message buffer that receives and stores the frame is set to 1).
- The receive completion interrupt (INTC0REC) is output (if the IE bit of the message buffer that receives and stores the frame is set to 1 and if the C0IE.CIE1 bit is set to 1).
- The message buffer number is recorded in the receive history list.

Caution When a message buffer is searched for receiving and storing a remote frame, overwrite control by the C0MCONFm.OWS bit of the message buffer and the DN bit are not affected. The setting of the OWS bit is ignored and the DN bit is set to 1 in every case.
If more than one transmit message buffer has the same ID and the ID of the received remote frame matches that ID, the remote frame is stored in the transmit message buffer with the lowest message buffer number.

Remark m = 00 to 31

20.10 Message Transmission

20.10.1 Message transmission

In all the operation modes, if the C0MCTRLm.TRQ bit is set to 1 in a message buffer that satisfies the following conditions, the message buffer that is to transmit a message is searched.

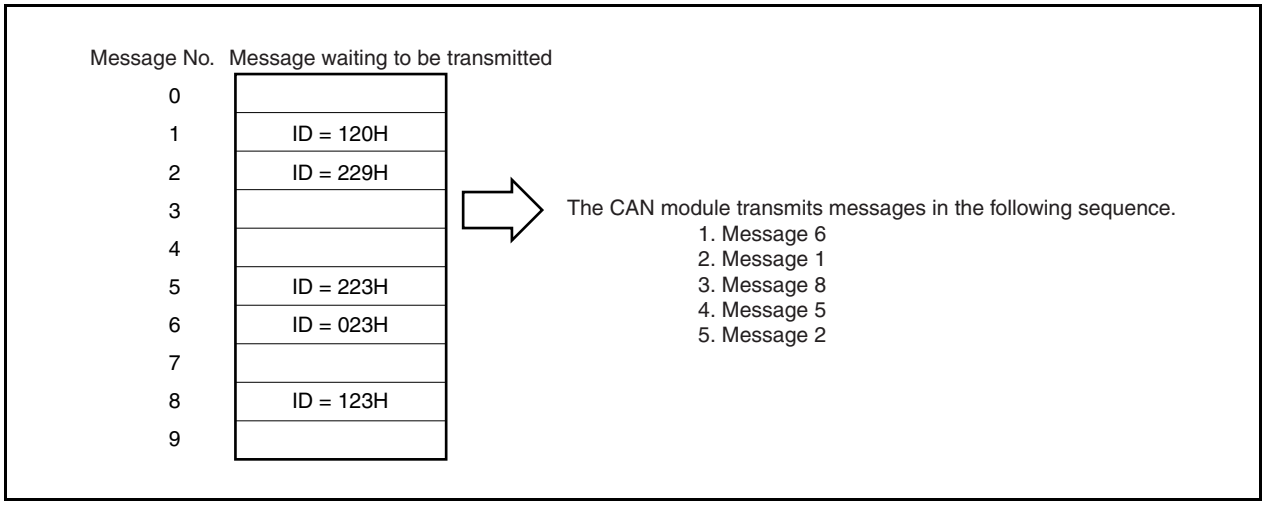
- Used as a message buffer
  (C0MCONFm.MA0 bit set to 1.)
- Set as a transmit message buffer
  (C0MCONFm.MT2 to C0MCONFm.MT0 bits set to 000B.)
- Ready for transmission
  (C0MCTRLm.RDY bit is set to 1.)

Remark m = 00 to 31

The CAN system is a multi-master communication system. In a system like this, the priority of message transmission is determined based on message identifiers (IDs). To facilitate transmission processing by software when there are several messages awaiting transmission, the CAN module uses hardware to check the ID of the message with the highest priority and automatically identifies that message. This eliminates the need for software-based priority control.

Transmission priority is controlled by the identifier (ID).

Figure 20-31. Message Processing Example



After the transmit message search, the transmit message with the highest priority of the transmit message buffers that have a pending transmission request (message buffers with the TRQ bit set to 1 in advance) is transmitted.

If a new transmission request is set, the transmit message buffer with the new transmission request is compared with the transmit message buffer with a pending transmission request. If the new transmission request has a higher priority, it is transmitted, unless transmission of a message with a low priority has already started. To solve this reversal of priorities, software can request that transmission of a message of low priority be stopped. The highest priority is determined according to the following rules.

Priority	Conditions	Description
1 (high)	Value of first 11 bits of ID [ID28 to ID18]:	The message frame with the lowest value represented by the first 11 bits of the ID is transmitted first. If the value of an 11-bit standard ID is equal to or smaller than the first 11 bits of a 29-bit extended ID, the 11-bit standard ID has a higher priority than a message frame with a 29-bit extended ID.
2	Frame type	A data frame with an 11-bit standard ID (C0MCONFm.RTR bit is cleared to 0) has a higher priority than a remote frame with a standard ID and a message frame with an extended ID.
3	ID type	A message frame with a standard ID (C0MIDHm.IDE bit is cleared to 0) has a higher priority than a message frame with an extended ID.
4	Value of lower 18 bits of ID [ID17 to ID0]:	If one or more transmission-pending extended ID message frame has equal values in the first 11 bits of the ID and the same frame type (equal RTR bit values), the message frame with the lowest value in the lower 18 bits of its extended ID is transmitted first.
5 (low)	Message buffer number	If two or more message buffers request transmission of message frames with the same ID, the message from the message buffer with the lowest message buffer number is transmitted first.

Remarks 1. If the automatic block transmission request bit C0GMABT.ABTTRG bit is set to 1 in the normal operation mode with ABT, the TRQ bit is set to 1 only for one message buffer in the ABT message buffer group.
If the ABT mode was triggered by the ABTTRG bit (1), one TRQ bit is set to 1 in the ABT area (buffers 0 to 7). In addition to this TRQ bit, the application can request transmissions (set TRQ bit to 1) for other TX-message buffers that do not belong to the ABT area. In that case an internal arbitration process (TX-search) evaluates all of the TX-message buffers with the TRQ bit set to 1 and chooses the message buffer that contains the highest prioritized identifier for the next transmission. If there are 2 or more identifiers that have the highest priority (i.e. identical identifiers), the message located at the lowest message buffer number is transmitted first.
Upon successful transmission of a message frame, the following operations are performed.

- The TRQ bit of the corresponding transmit message buffer is automatically cleared to 0.
- The transmission completion status bit CINTS0 of the C0INTS register is set to 1 (if the interrupt enable bit (IE) of the corresponding transmit message buffer is set to 1).
- An interrupt request signal INTC0TRX is output (if the C0IE.CIE0 bit is set to 1 and if the interrupt enable bit (IE) of the corresponding transmit message buffer is set to 1).

2. Before changing the contents of the transmit message buffer, the RDY flag of this buffer must be cleared. Since the RDY flag may be temporarily locked while the internal processing is changed, it is necessary to check the status of the RDY flag by software after changing the buffer contents.

3. m = 00 to 31

20.10.2 Transmit history list function

The transmit history list (THL) function records in the transmit history list the number of the transmit message buffer in which each data frame or remote frame was received and stored. The THL consists of storage elements equivalent to up to seven messages, the last out-message pointer (LOPT) with the corresponding C0LOPT register, and the transmit history list get pointer (TGPT) with the corresponding C0TGPT register.

The THL is undefined immediately after the transition of the CAN module from the initialization mode to one of the operation modes.

The C0LOPT register holds the contents of the THL element indicated by the value of the LOPT pointer minus 1. By reading the C0LOPT register, therefore, the number of the message buffer that transmitted a data frame or remote frame first can be checked. The LOPT pointer is utilized as a write pointer that indicates to what part of the THL a message buffer number is recorded. Any time a data frame or remote frame is transmitted, the corresponding message buffer number is recorded to the THL element indicated by the LOPT pointer. Each time recording to the THL has been completed, the LOPT pointer is automatically incremented. In this way, the number of the message buffer that has received and stored a frame will be recorded chronologically.

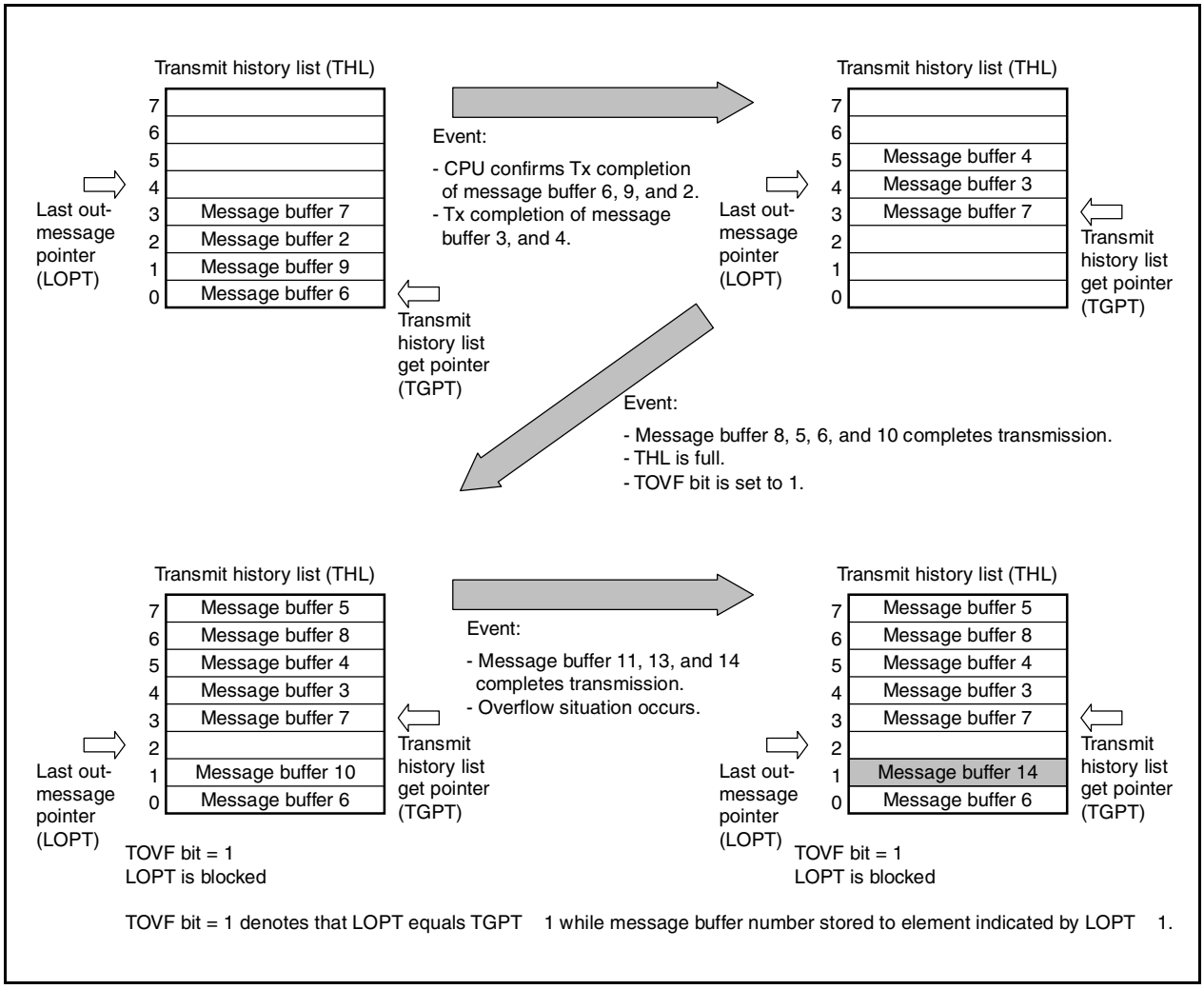
The TGPT pointer is utilized as a read pointer that reads a recorded message buffer number from the THL. This pointer indicates the first THL element that the CPU has not yet read. By reading the C0TGPT register by software, the number of a message buffer that has completed transmission can be read. Each time a message buffer number is read from the C0TGPT register, the TGPT pointer is automatically incremented.

If the value of the TGPT pointer matches the value of the LOPT pointer, the C0TGPT.THPM bit (transmit history list pointer match) is set to 1. This indicates that no message buffer numbers that have not been read remain in the THL. If a new message buffer number is recorded, the LOPT pointer is incremented and because its value no longer matches the value of the TGPT pointer, the THPM bit is cleared. In other words, the numbers of the unread message buffers exist in the THL.

If the LOPT pointer is incremented and matches the value of the TGPT pointer minus 1, the TOVF bit (transmit history list overflow) of the C0TGPT register is set to 1. This indicates that the THL is full of message buffer numbers that have not been read. If a new message is received and stored, the message buffer number recorded last is overwritten by the number of the message buffer that received and stored the new message. After the TOVF bit has been set (1), therefore, the recorded message buffer numbers in the THL do not completely reflect chronological order. However the transmitted messages can be found by a CPU search applied to all transmit message buffers unless the CPU has not overwritten a transmit object in one of these buffers beforehand. In total up to six transmission completions can occur without overflowing the THL.

Caution Even if the transmit history list overflows (C0TGPT.TOVF bit = 1), the transmit history can be read until no more history is left unread and the C0TGPT.THPM bit is set (1). However, the TOVF bit is kept set (1) (= overflow occurs) until cleared (0) by software. In this status, the THPM bit is not cleared (0), unless the TOVF bit is cleared (0), even if a new transmit history is stored and written to the list. If the TOVF bit = 1 and the THPM bit = 1 and the receive history list overflows, therefore, the THPM bit indicates that no more history is left unread even if new history is received and stored.

Figure 20-32. Transmit History List



20.10.3 Automatic block transmission (ABT)

The automatic block transmission (ABT) function is used to transmit two or more data frames successively with no CPU interaction. The maximum number of transmit message buffers assigned to the ABT function is eight (message buffer numbers 0 to 7).

By setting the C0CTRL.OPMODE2 to C0CTRL.OPMODE0 bits to 010B, “normal operation mode with automatic block transmission function” (hereafter referred to as ABT mode) can be selected.

To issue an ABT transmission request, define the message buffers by software first. Set the C0MCONFm.MA0 bit (1) in all the message buffers used for ABT, and define all the buffers as transmit message buffers by setting the C0MCONFm.MT2 to C0MCONFm.MT0 bits to 000B. Be sure to set the ID for the message buffers for ATB for each message buffer, even when that ID is being used for all the message buffers. To use two or more IDs, set the ID of each message buffer by using the C0MIDLm and C0MIDHm registers. Set the C0MDLCm and C0MDATA0m to C0MDATA7m registers before issuing a transmission request for the ABT function.

After initialization of message buffers for ABT is finished, the C0MCTRLm.RDY bit needs to be set (1). In the ABT mode, the C0MCTRLm.TRQ bit does not have to be manipulated by software.

After the data for the ABT message buffers has been prepared, set the C0GMABT.ABTTRG bit to 1. Automatic block transmission is then started. When ABT is started, the TRQ bit in the first message buffer (message buffer 0) is automatically set to 1. After transmission of the data of message buffer 0 is finished, the TRQ bit of the next message buffer, message buffer 1, is set automatically. In this way, transmission is executed successively.

A delay time can be inserted by program in the interval in which the transmission request (TRQ bit) is automatically set while successive transmission is being executed. The delay time to be inserted is defined by the C0GMABTD register. The unit of the delay time is DBT (data bit time). DBT depends on the setting of the C0BRP and C0BTR registers.

During ABT, the priority of the transmission ID is not searched in the ABT transmit message buffer. The data of message buffers 0 to 7 is sequentially transmitted. When transmission of the data frame from message buffer 7 has been completed, the ABTTRG bit is automatically cleared to 0 and the ABT operation is finished.

If the RDY bit of an ABT message buffer is cleared during ABT, no data frame is transmitted from that buffer, ABT is stopped, and the ABTTRG bit is cleared. After that, transmission can be resumed from the message buffer where ABT stopped, by setting the RDY and ABTTRG bits to 1 by software. To not resume transmission from the message buffer where ABT stopped, the internal ABT engine can be reset by setting the C0GMABT.ABTCLR bit to 1 while ABT mode is stopped and the ABTTRG bit is cleared to 0. In this case, transmission is started from message buffer 0 if the ABTCLR bit is cleared to 0 and then the ABTTRG bit is set to 1.

An interrupt can be used to check if data frames have been transmitted from all the message buffers for ABT. To do so, the C0MCTRLm.IE bit of each message buffer except the last message buffer needs to be cleared (0).

If a transmit message buffer other than those used by the ABT function (message buffers 8 to 31) is assigned to a transmit message buffer, the priority of the message to be transmitted is determined by the priority of the transmission message buffer of the ABT message buffer whose transmission is currently held pending and the transmission message buffer of the message buffers other than those used by the ABT function.

Transmission of a data frame from an ABT message buffer is not recorded in the transmit history list (THL).

Cautions 1. To resume the normal operation mode with ABT from the message buffer 0, set the ABTCLR bit to 1 while the ABTTRG bit is cleared to 0. If the ABTCLR bit is set to 1 while the ABTTRG bit is set to 1, the subsequent operation is not guaranteed.

2. Whether the automatic block transmission engine is cleared by setting the ABTCLR bit to 1 can be confirmed if the ABTCLR bit is automatically cleared to 0 immediately after the processing of the clearing request is completed.

3. Do not set the ABTTRG bit in the initialization mode. If the ABTTRG bit is set in the initialization mode, the proper operation is not guaranteed after the mode is changed from the initialization mode to the ABT mode.

4. Do not set the TRQ bit of the ABT message buffers to 1 by software in the normal operation mode with ABT. Otherwise, the operation is not guaranteed.

5. The C0GMABTD register is used to set the delay time that is inserted in the period from completion of the preceding ABT message to setting of the TRQ bit for the next ABT message when the transmission requests are set in the order of message numbers for each message for ABT that is successively transmitted in the ABT mode. The timing at which the messages are actually transmitted onto the CAN bus varies depending on the status of transmission from other stations and the status of the setting of the transmission request for messages other than the ABT messages (message buffers 8 to 31).

6. If a transmission request is made for a message other than an ABT message and if no delay time is inserted in the interval in which transmission requests for ABT are automatically set (C0GMABTD register = 00H), messages other than ABT messages may be transmitted regardless of their priority in regards to the ABT message.

7. Do not clear the RDY bit to 0 when the ABTTRG bit = 1.

8. If a message is received from another node in the normal operation mode with ABT, the message may be transmitted after the time of one frame has elapsed even when C0GMABTD register = 00H.

Remark m = 00 to 31

20.10.4 Transmission abort process

Remark m = 00 to 31

(1) Transmission abort process other than in normal operation mode with automatic block transmission (ABT)

The user can clear the C0MCTRLm.TRQ bit to 0 to abort a transmission request. The TRQ bit will be cleared immediately if the abort was successful. Whether the transmission was successfully aborted or not can be checked using the C0CTRL.TSTAT bit and the C0TGPT register, which indicate the transmission status on the CAN bus (for details, refer to the processing in **Figure 20-46**).

(2) Transmission abort process except for ABT transmission in normal operation mode with automatic block transmission (ABT)

The user can clear the C0GMABT.ABTTRG bit to 0 to abort a transmission request. After checking the ABTTRG bit of the C0GMABT register = 0, clear the C0MCTRLm.TRQ bit to 0. The TRQ bit will be cleared immediately if the abort was successful. Whether the transmission was successfully aborted or not can be checked by using the C0CTRL.TSTAT bit and the C0TGPT register, which indicate the transmission status on the CAN bus (for details, refer to the process in **Figure 20-47**).

(3) Transmission abort in normal operation mode with automatic block transmission (ABT)

To abort ABT that is already started, clear the C0GMABT.ABTTRG bit to 0. In this case, the ABTTRG bit remains 1 if an ABT message is currently being transmitted and until the transmission is completed (successfully or not), and is cleared to 0 as soon as transmission is finished. This aborts ABT.

If the last transmission (before ABT) was successful, the normal operation mode with ABT is left with the internal ABT pointer pointing to the next message buffer to be transmitted.

In the case of an erroneous transmission, the position of the internal ABT pointer depends on the status of the TRQ bit in the last transmitted message buffer. If the TRQ bit is set to 1 when clearing the ABTTRG bit is requested, the internal ABT pointer points to the last transmitted message buffer (for details, refer to the process in **Figure 20-48 (a)**). If the TRQ bit is cleared to 0 when clearing the ABTTRG bit is requested, the internal ABT pointer is increased in increments of 1 and indicates the next message buffer in the ABT area (for details, refer to the process in **Figure 20-48 (b)**).

Caution Be sure to abort ABT by clearing the ABTTRG bit to 0. The operation is not guaranteed if aborting transmission is requested by clearing RDY.

When the normal operation mode with ABT is resumed after ABT has been aborted and the ABTTRG bit is set to 1, the next ABT message buffer to be transmitted can be determined from the following table.

Status of TRQ of ABT Message Buffer	Abort After Successful Transmission	Abort After Erroneous Transmission
Set (1)	Next message buffer in the ABT area[Note]	Same message buffer in the ABT area
Cleared (0)	Next message buffer in the ABT area[Note]	Next message buffer in the ABT area[Note]

Note The above resumption operation can be performed only if a message buffer ready for ABT exists in the ABT area. For example, an abort request that is issued while ABT of message buffer 7 is in progress is regarded as completion of ABT, rather than abort, if transmission of message buffer 7 has been successfully completed, even if the ABTTRG bit is cleared to 0. If the C0MCTRLm.RDY bit in the next message buffer in the ABT area is cleared to 0, the internal ABT pointer is retained, but the resumption operation is not performed even if the ABTTRG bit is set to 1, and ABT ends immediately.

Remark m = 00 to 31

20.10.5 Remote frame transmission

Remote frames can be transmitted only from transmit message buffers. Set whether a data frame or remote frame is transmitted via the C0MCONFm.RTR bit. Setting (1) the RTR bit sets remote frame transmission.

Remark m = 00 to 31

20.11 Power Saving Modes

20.11.1 CAN sleep mode

The CAN sleep mode can be used to set the CAN controller to standby mode in order to reduce power consumption. The CAN module can enter the CAN sleep mode from all operation modes. Release of the CAN sleep mode returns the CAN module to exactly the same operation mode from which the CAN sleep mode was entered.

In the CAN sleep mode, the CAN module does not transmit messages, even when transmission requests are issued or pending.

(1) Entering CAN sleep mode

The CPU issues a CAN sleep mode transition request by writing 01B to the C0CTRL.PSMODE1 and C0CTRL.PSMODE0 bits.

This transition request is only acknowledged only under the following conditions.

(i) The CAN module is already in one of the following operation modes

- Normal operation mode
- Normal operation mode with ABT
- Receive-only mode
- Single-shot mode
- Self-test mode
- CAN stop mode in all the above operation modes

(ii) The CAN bus state is bus idle (the 4th bit in the interframe space is recessive)[Note]

Note If the CAN bus is fixed to dominant, the request for transition to the CAN sleep mode is held pending. Also the transition from CAN stop mode to CAN sleep mode is independent of the CAN bus state.

(iii) No transmission request is pending

If any one of the conditions mentioned above is not met, the CAN module will operate as follows.

- If the CAN sleep mode is requested from the initialization mode, the CAN sleep mode transition request is ignored and the CAN module remains in the initialization mode.
- If the CAN bus state is not bus idle (i.e., the CAN bus state is either transmitting or receiving) when the CAN sleep mode is requested in one of the operation modes, immediate transition to the CAN sleep mode is not possible. In this case, the CAN sleep mode transition request has to be held pending until the CAN bus state becomes bus idle (the 4th bit in the interframe space is recessive). In the time from the CAN sleep mode request to successful transition, the PSMODE1 and PSMODE0 bits remain 00B. When the module has entered the CAN sleep mode, the PSMODE1 and PSMODE0 bits are set to 01B.
- If a request for transition to the initialization mode and a request for transition to the CAN sleep mode are made at the same time while the CAN module is in one of the operation modes, the request for the initialization mode is enabled. The CAN module enters the initialization mode at a predetermined timing. At this time, the CAN sleep mode request is not held pending and is ignored.
- Even when the initialization mode and sleep mode are not requested simultaneously (i.e the first request was not granted when a second request was made), the request for initialization has priority over the CAN sleep mode request. The CAN sleep mode request is cancelled when the initialization mode is requested. When a pending request for the initialization mode is present, a subsequent request for the CAN sleep mode request is cancelled right at the point in time when it was submitted.

(2) Status in CAN sleep mode

The CAN module is in one of the following states after it enters the CAN sleep mode.

- The internal operating clock is stopped and the power consumption is minimized.
- The function to detect the falling edge of the CAN reception pin (CRXD0) remains in effect to wake up the CAN module from the CAN bus.
- To wake up the CAN module from the CPU, data can be written to the PSMODE1 and PSMODE0 bits, but nothing can be written to other CANn module registers or bits.
- The CAN0 module registers can be read, except for the C0LIPT, C0RGPT, C0LOPT, and C0TGPT registers.
- The CAN0 message buffer registers cannot be written or read.
- C0GMCTRL.MBON bit is cleared to 0.
- A request for transition to the initialization mode is not acknowledged and is ignored.

(3) Releasing CAN sleep mode

The CAN sleep mode is released by the following events.

- When the CPU writes 00B to the PSMODE1 and PSMODE0 bits
- A falling edge at the CAN reception pin (CRXD0) (i.e. the CAN bus level shifts from recessive to dominant)

Cautions1. Even if the falling edge belongs to the SOF of a receive message, this message will not be received and stored. If the CPU has turned off the clock to the CAN while the CAN was in sleep mode, later on the CAN sleep mode will not be released and PSMODE[1:0] bits will continue to be 01B unless the clock for the CAN is provided again. In addition to this, the receive message will not be received afterwards.

2. If a falling edge is detected at the CAN reception pin (CRXD0) while the CAN clock is supplied, the PSMODE0 bit must be cleared by software. (For details, refer to the processing in Figure 20-53.)

After releasing the sleep mode, the CAN module returns to the operation mode from which the CAN sleep mode was requested and the PSMODE1 and PSMODE0 bits are reset to 00B. If the CAN sleep mode is released by a change in the CAN bus state, the C0INTS.CINTS5 bit is set to 1, regardless of the C0IE.CIE bit. After the CAN module is released from the CAN sleep mode, it participates in the CAN bus again by automatically detecting 11 consecutive recessive-level bits on the CAN bus. After releasing the sleep mode and before accessing the message buffer by application again, confirm that C0GMCTRL.MBON bit = 1.

When a request for transition to the initialization mode is made while the CAN module is in the CAN sleep mode, that request is ignored; the CPU has to be released from sleep mode by software first before entering the initialization mode.

Caution When the CAN sleep mode is released by an event of the CAN bus, a wakeup interrupt occurs even if the event of the CAN bus occurs immediately after the mode has been changed to the sleep mode. Note that the interrupt can occur at any time.

20.11.2 CAN stop mode

The CAN stop mode can be used to set the CAN controller to standby mode to reduce power consumption. The CAN module can enter the CAN stop mode only from the CAN sleep mode. Release of the CAN stop mode puts the CAN module in the CAN sleep mode.

The CAN stop mode can only be released (shifting to CAN sleep mode) by writing 01B to the C0CTRL.PSMODE1 and C0CTRL.PSMODE0 bits and not by a change in the CAN bus state. No message is transmitted even when transmission requests are issued or pending.

(1) Entering CAN stop mode

A CAN stop mode transition request is issued by writing 11B to the PSMODE1 and PSMODE0 bits.

A CAN stop mode request is only acknowledged when the CAN module is in the CAN sleep mode. In all other modes, the request is ignored.

Caution To set the CAN module to the CAN stop mode, the module must be in the CAN sleep mode. To confirm that the module is in the sleep mode, check that the PSMODE1 and PSMODE0 bits = 01B, and then request the CAN stop mode. If a bus change occurs at the CAN reception pin (CRXD0) while this process is being performed, the CAN sleep mode is automatically released. In this case, the CAN stop mode transition request cannot be acknowledged (while the CAN clock is supplied, however, the PSMODE0 must be cleared by software after the bus level of the CAN reception pin (CRXD0) is changed).

(2) Status in CAN stop mode

The CAN module is in one of the following states after it enters the CAN stop mode.

- The internal operating clock is stopped and the power consumption is minimized.
- To wake up the CAN module from the CPU, data can be written to the PSMODE1 and PSMODE0 bits, but nothing can be written to other CAN0 module registers or bits.
- The CAN0 module registers can be read, except for the C0LIPT, C0RGPT, C0LOPT, and C0TGPT registers.
- The CAN0 message buffer registers cannot be written or read.
- The C0GMCTRL.MBON bit is cleared to 0.
- An initialization mode transition request is not acknowledged and is ignored.

(3) Releasing CAN stop mode

The CAN stop mode can only be released by writing 01B to the PSMODE1 and PSMODE0 bits. After releasing the CAN stop mode, the CAN module enters the CAN sleep mode.

When the initialization mode is requested while the CAN module is in the CAN stop mode, that request is ignored; the CPU has to release the stop mode and subsequently the CAN sleep mode before entering into initialization mode. It is impossible to enter another operation mode directly from the CAN stop mode without entering the CAN sleep mode, the request will be ignored.

20.11.3 Example of using power saving modes

In some application systems, it may be necessary to place the CPU in a power saving mode to reduce the power consumption. By using the power saving mode specific to the CAN module and the power saving mode specific to the CPU in combination, the CPU can be woken up from the power saving status by the CAN bus.

Here is an example of using the power saving modes.

First, put the CAN module in the CAN sleep mode (PSMODE1, PSMODE0 bits = 01B). Next, put the CPU in the power saving mode. If an edge transition from recessive to dominant is detected at the CRXD0 signal in this status, the CINTS5 bit in the CAN module is set to 1. If the C0CTRL.CIE5 bit is set to 1, a wakeup interrupt (INTC0WUP) is generated. The CAN module is automatically released from the CAN sleep mode (PSMODE1, PSMODE0 bits = 00B) and returns to normal operation mode (while the CAN clock is supplied, however, the PSMODE0 must be cleared by software after a bus level change is detected at the CAN reception pin (CRXD0).). The CPU, in response to INTC0WUP, can release its own power saving mode and return to normal operation mode.

To further reduce the power consumption of the CPU, the internal clocks, including that of the CAN module, may be tuned off. In this case, the operating clock supplied to the CAN module is turned off after the CAN module is put in the CAN sleep mode. Then the CPU enters a power saving mode in which the clock supplied to the CPU is turned off. If an edge transition from recessive to dominant is detected at the CRXD0 signal in this status, the CAN module can set the CINTS5 bit to 1 and generate a wakeup interrupt (INTC0WUP) even if it is not supplied with a clock. The other functions, however, do not operate because the clock supply to the CAN module is shut off, and the module remains in the CAN sleep mode. The CPU, in response to INTC0WUP, releases its power saving mode, resumes supply of the internal clocks, including the clock to the CAN module, after oscillation stabilization time has elapsed, and starts instruction execution. The CAN module is immediately released from the CAN sleep mode when the clock supply is resumed, and returns to normal operation mode (PSMODE1, PSMODE0 bits = 00B).

20.12 Interrupt Function

The CAN module provides 6 different interrupt sources.

The occurrence of these interrupt sources is stored in interrupt status registers. Four separate interrupt request signals are generated from the six interrupt sources. When an interrupt request signal that corresponds to two or more interrupt sources is generated, the interrupt sources can be identified by using an interrupt status register. After an interrupt source has occurred, the corresponding interrupt status bit must be cleared to 0 by software.

Table 20-20. List of CAN Module Interrupt Sources

No.	Interrupt Status Bit		Interrupt Enable Bit		Interrupt Request Signal	Interrupt Source Description
	Name	Register	Name	Register		
1	CINTS0[Note 1]	C0INTS	CIE0[Note 1]	C0IE	INTC0TRX	Message frame successfully transmitted from message buffer m
2	CINTS1[Note 1]	C0INTS	CIE1[Note 1]	C0IE	INTC0REC	Valid message frame reception in message buffer m
3	CINTS2	C0INTS	CIE2	C0IE	INTC0ERR	CAN module error state interrupt[Note 2]
4	CINTS3	C0INTS	CIE3	C0IE		CAN module protocol error interrupt[Note 3]
5	CINTS4	C0INTS	CIE4	C0IE		CAN module arbitration loss interrupt
6	CINTS5	C0INTS	CIE5	C0IE	INTC0WUP	CAN module wakeup interrupt from CAN sleep mode[Note 4]

Notes 1. The C0MCTRL.IE bit (message buffer interrupt enable bit) of the corresponding message buffer has to be set to 1 for that message buffer to participate in the interrupt generation process.

2. This interrupt is generated when the transmission/reception error counter is at the warning level, or in the error passive or bus-off state.

3. This interrupt is generated when a stuff error, form error, ACK error, bit error, or CRC error occurs.

4. This interrupt is generated when the CAN module is woken up from the CAN sleep mode because a falling edge is detected at the CAN reception pin (CAN bus transition from recessive to dominant).

Remark m = 00 to 31

20.13 Diagnosis Functions and Special Operational Modes

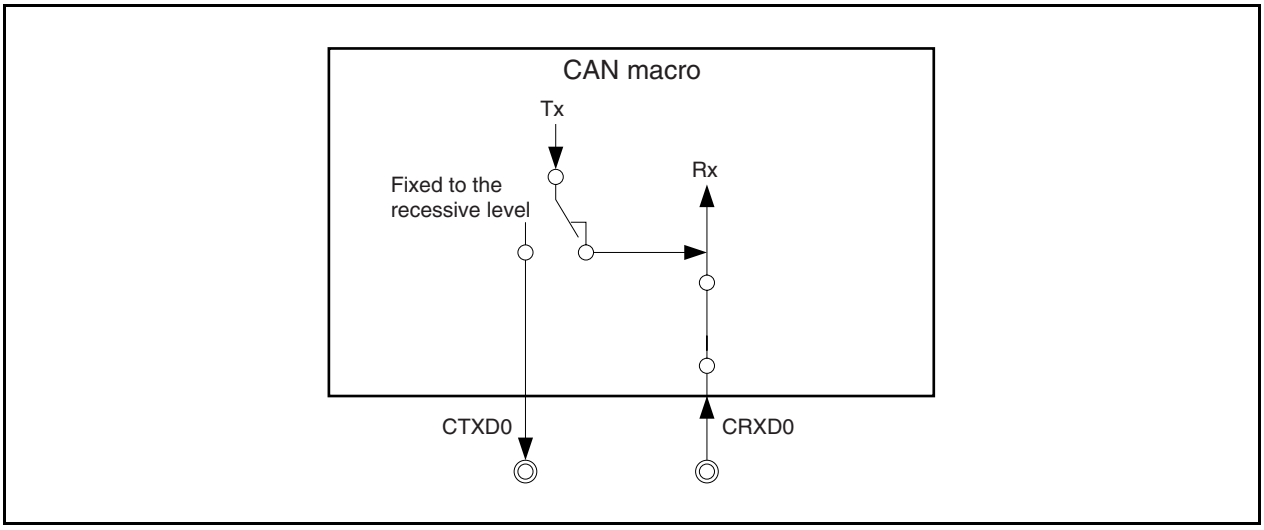
The CAN module provides a receive-only mode, single-shot mode, and self-test mode to support CAN bus diagnosis functions or the operation of special CAN communication methods.

20.13.1 Receive-only mode

The receive-only mode is used to monitor receive messages without causing any interference on the CAN bus and can be used for CAN bus analysis nodes.

For example, this mode can be used for automatic baud-rate detection. The baud rate in the CAN module is changed until “valid reception” is detected, so that the baud rates in the module match (“valid reception” means a message frame has been received in the CAN protocol layer without occurrence of an error and with an appropriate ACK between nodes connected to the CAN bus). A valid reception does not require message frames to be stored in a receive message buffer (data frames) or transmit message buffer (remote frames). The event of valid reception is indicated by setting the C0CTRL.VALID bit (1).

Figure 20-33. CAN Module Terminal Connection in Receive-Only Mode



In the receive-only mode, no message frames can be transmitted from the CAN module to the CAN bus. Transmit requests issued for message buffers defined as transmit message buffers are held pending.

In the receive-only mode, the CAN transmission pin (CTXD0) in the CAN module is fixed to the recessive level. Therefore, no active error flag can be transmitted from the CAN module to the CAN bus even when a CAN bus error is detected while receiving a message frame. Since no transmission can be issued from the CAN module, the transmission error counter the C0ERC.TEC7 to C0ERC.TEC0 bits are never updated. Therefore, a CAN module in the receive-only mode does not enter the bus-off state.

Furthermore, ACK is not returned to the CAN bus in this mode upon the valid reception of a message frame. Internally, the local node recognizes that it has transmitted ACK. An overload frame cannot be transmitted to the CAN bus.

Caution If only two CAN nodes are connected to the CAN bus and one of them is operating in the receive-only mode, there is no ACK on the CAN bus. Due to the missing ACK, the transmitting node will transmit an active error flag, and repeat transmitting a message frame. The transmitting node becomes error passive after transmitting the message frame 16 times (assuming that the error counter was 0 in the beginning and no other errors have occurred). When the message frame is transmitted for the 17th time, the transmitting node generates a passive error flag. The receiving node in the receive-only mode detects the first valid message frame at this point, and the VALID bit is set to 1 for the first time.

20.13.2 Single-shot mode

In the single-shot mode, automatic re-transmission as defined in the CAN protocol is switched off. (According to the CAN protocol, a message frame transmission that has been aborted by either arbitration loss or error occurrence has to be repeated without control by software.) All other behavior of single-shot mode is identical to normal operation mode. Features of single-shot mode can not be used in combination with normal mode with ABT.

The single-shot mode disables the re-transmission of an aborted message frame transmission according to the setting of the C0CTRL.AL bit. When the AL bit is cleared to 0, re-transmission upon arbitration loss and upon error occurrence is disabled. If the AL bit is set to 1, re-transmission upon error occurrence is disabled, but re-transmission upon arbitration loss is enabled. As a consequence, the C0MCTRLm.TRQ bit in a message buffer defined as a transmit message buffer is cleared to 0 by the following events.

- Successful transmission of the message frame
- Arbitration loss while sending the message frame (AL bit = 0)
- Error occurrence while sending the message frame

The events arbitration loss and error occurrence can be distinguished by checking the C0INTS.CINTS4 and C0INTS.CINTS3 bits, and the type of the error can be identified by reading the C0LEC.LEC2 to C0LEC.LEC0 bits of the register.

Upon successful transmission of the message frame, the transmit completion interrupt the CINTS0 bit of the C0INTS register is set to 1. If the C0IE.CIE0 bit is set to 1 at this time, an interrupt request signal is output.

The single-shot mode can be used when emulating time-triggered communication methods (e.g., TTCAN level 1).

Caution The AL bit is only valid in single-shot mode. It does not affect the operation of re-transmission upon arbitration loss in other operation modes.

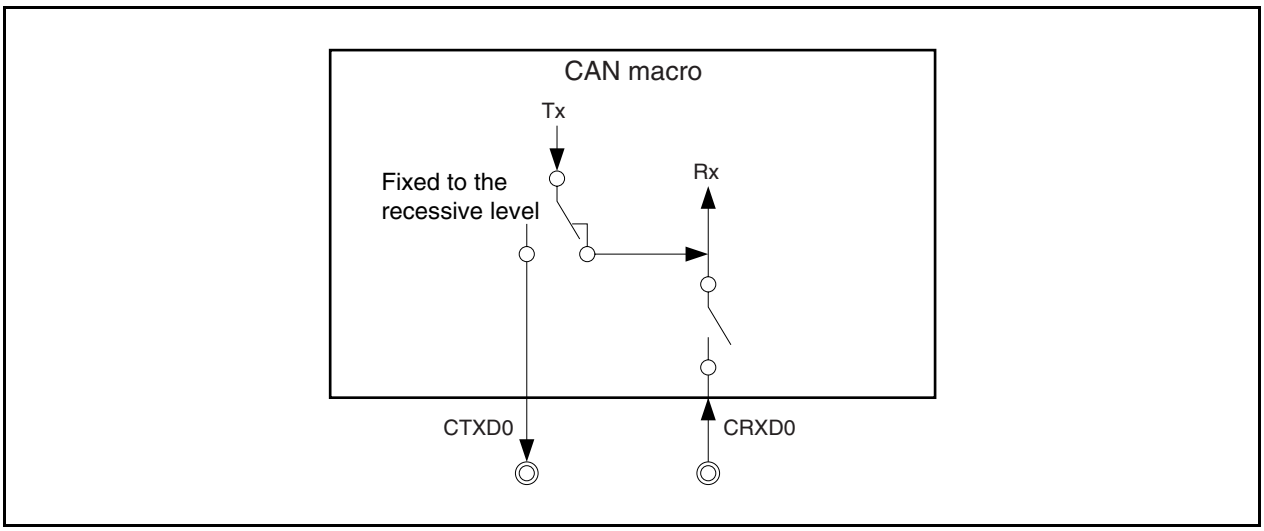
20.13.3 Self-test mode

In the self-test mode, message frame transmission and message frame reception can be tested without connecting the CAN node to the CAN bus or without affecting the CAN bus.

In the self-test mode, the CAN module is completely disconnected from the CAN bus, but transmission and reception are internally looped back. The CAN transmission pin (CTXD0) is fixed to the recessive level.

If the falling edge on the CAN reception pin (CRXD0) is detected after the CAN module has entered the CAN sleep mode from the self-test mode, however, the module is released from the CAN sleep mode in the same manner as the other operation modes (when the sleep mode is released while the CAN clock is supplied, however, the PSMODE0 bit must be cleared by software after a falling edge is detected at the CAN reception pin (CRXD0).). To keep the module in the CAN sleep mode, use the CAN reception pin (CRXD0) as a port pin.

Figure 20-34. CAN Module Terminal Connection in Self-Test Mode



20.13.4 Transmission/reception operation in each operation mode

Table 20-21 shows the transmission/reception operation in each operation mode.

Table 20-21. Overview of Transmission/Reception Operation in Each Operation Mode

Operation Mode	Data Frame/ Remote Frame Transmission	ACK Transmission	Error Frame/ Overload Frame Transmission	Retransmission	Automatic Block Transmission (ABT)	Setting of VALID Bit	Storing Data in Message Buffer
Initialization Mode	–	–	–	–	–	–	–
Normal operation mode	√	√	√	√	–	√	√
Normal operation mode with ABT	√	√	√	√	√	√	√
Receive-only mode	–	–	–	–	–	√	√
Single-shot mode	√	√	√	–Note 1	–	√	√
Self test mode	√Note 2	√Note 2	√Note 2	√Note 2	–	√Note 2	√Note 2

Notes 1. If arbitration is lost, retransmission can be selected by the C0CTRL.AL bit.

2. Each signal is not output to the external circuit but is internally generated by the CAN module.

20.14 Time Stamp Function

CAN is an asynchronous, serial protocol. All nodes connected to the CAN bus have a local, autonomous clock. As a consequence, the clocks of the nodes have no relation (i.e., the clocks are asynchronous and may even have different frequencies).

In some applications, however, a common time base over the network (= global time base) is needed. In order to build up a global time base, a time stamp function is used. The essential mechanism of a time stamp function is the capture of timer values triggered by signals on the CAN bus.

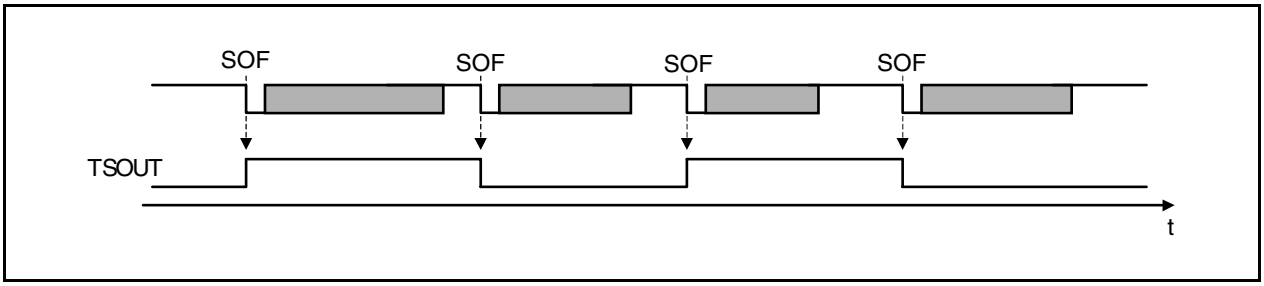
20.14.1 Time stamp function

The CAN controller supports the capturing of timer values triggered by a specific frame. An on-chip 16-bit capture timer unit in a microcontroller system is used in addition to the CAN controller. The 16-bit capture timer unit captures the timer value according to a trigger signal (TSOUT) for capturing that is output when a data frame is received from the CAN controller. The CPU can retrieve the time of occurrence of the capture event, i.e., the time stamp of the message received from the CAN bus, by reading the captured value. The TSOUT signal can be selected from the following two event sources and is specified by the C0TS.TSSEL bit.

- SOF event (start of frame) (TSSEL bit = 0)
- EOF event (last bit of end of frame) (TSSEL bit = 1)

The TSOUT signal is enabled by setting the C0TS.TSEN bit to 1.

Figure 20-35. Timing Diagram of Capture Signal TSOUT



The TSOUT signal toggles its level upon occurrence of the selected event during data frame reception (in Figure 20-34, the SOF is used as the trigger event source). To capture a timer value by using the TSOUT signal, the capture timer unit must detect the capture signal at both the rising edge and falling edge.

This time stamp function is controlled by the C0TS.TSLOCK bit. When the TSLOCK bit is cleared to 0, the TSOUT signal toggles upon occurrence of the selected event. If the TSLOCK bit is set to 1, the TSOUT signal toggles upon occurrence of the selected event, but the toggle is stopped as the TSEN bit is automatically cleared to 0 when a data frame starts to be received and stored in message buffer 0. This suppresses the subsequent toggle occurrence by the TSOUT signal, so that the time stamp value toggled last (= captured last) can be saved as the time stamp value of the time at which the data frame was received in message buffer 0.

Caution The time stamp function using the TSLOCK bit stops toggle of the TSOUT signal by receiving a data frame in message buffer 0. Therefore, message buffer 0 must be set as a receive message buffer. Since a receive message buffer cannot receive a remote frame, toggle of the TSOUT signal cannot be stopped by reception of a remote frame. Toggle of the TSOUT signal does not stop when a data frame is received in a message buffer other than message buffer 0.

For these reasons, a data frame cannot be received in message buffer 0 when the CAN module is in the normal operation mode with ABT, because message buffer 0 must be set as a transmit message buffer. In this operation mode, therefore, the function to stop toggle of the TSOUT signal by the TSLOCK bit cannot be used.

20.15 Baud Rate Settings

20.15.1 Bit rate setting conditions

Make sure that the settings are within the range of limit values for ensuring correct operation of the CAN controller, as follows.

(a) 5TQ ≤ SPT (sampling point) ≤ 17 TQ
SPT = TSEG1 + 1TQ
(b) 8 TQ ≤ DBT (data bit time) ≤ 25 TQ
DBT = TSEG1 + TSEG2 + 1TQ = TSEG2 + SPT
(c) 1 TQ ≤ SJW (synchronization jump width) ≤ 4TQ
SJW ≤ DBT – SPT
(d) 4TQ ≤ TSEG1 ≤ 16TQ [3 ≤ Setting value of TSEG1[3:0] ≤ 15]
(e) 1TQ ≤ TSEG2 ≤ 8TQ [0 ≤ Setting value of TSEG2[2:0] ≤ 7]

Remark TQ = 1/f_{TQ} (f_{TQ}: CAN protocol layer base system clock)
TSEG1[3:0] (C0BTR.TSEG13 to C0BTR.TSEG10 bits)
TSEG2[2:0] (C0BTR.TSEG22 to C0BTR.TSEG20 bits)

Table 20-22 shows the combinations of bit rates that satisfy the above conditions.

Table 20-22. Settable Bit Rate Combinations (1/3)

Valid Bit Rate Setting					C0BTR Register Setting Value		Sampling Point (Unit: %)
DBT Length	SYNC SEGMENT	PROP SEGMENT	PHASE SEGMENT1	PHASE SEGMENT2	TSEG13 to TSEG10	TSEG22 to TSEG20	
25	1	8	8	8	1111	111	68.0
24	1	7	8	8	1110	111	66.7
24	1	9	7	7	1111	110	70.8
23	1	6	8	8	1101	111	65.2
23	1	8	7	7	1110	110	69.6
23	1	10	6	6	1111	101	73.9
22	1	5	8	8	1100	111	63.6
22	1	7	7	7	1101	110	68.2
22	1	9	6	6	1110	101	72.7
22	1	11	5	5	1111	100	77.3
21	1	4	8	8	1011	111	61.9
21	1	6	7	7	1100	110	66.7
21	1	8	6	6	1101	101	71.4
21	1	10	5	5	1110	100	76.2
21	1	12	4	4	1111	011	81.0
20	1	3	8	8	1010	111	60.0
20	1	5	7	7	1011	110	65.0
20	1	7	6	6	1100	101	70.0
20	1	9	5	5	1101	100	75.0
20	1	11	4	4	1110	011	80.0
20	1	13	3	3	1111	010	85.0
19	1	2	8	8	1001	111	57.9
19	1	4	7	7	1010	110	63.2
19	1	6	6	6	1011	101	68.4
19	1	8	5	5	1100	100	73.7
19	1	10	4	4	1101	011	78.9
19	1	12	3	3	1110	010	84.2
19	1	14	2	2	1111	001	89.5
18	1	1	8	8	1000	111	55.6
18	1	3	7	7	1001	110	61.1
18	1	5	6	6	1010	101	66.7
18	1	7	5	5	1011	100	72.2
18	1	9	4	4	1100	011	77.8
18	1	11	3	3	1101	010	83.3
18	1	13	2	2	1110	001	88.9
18	1	15	1	1	1111	000	94.4

Table 20-22. Settable Bit Rate Combinations (2/3)

Valid Bit Rate Setting					C0BTR Register Setting Value		Sampling Point (Unit: %)
DBT Length	SYNC SEGMENT	PROP SEGMENT	PHASE SEGMENT1	PHASE SEGMENT2	TSEG13 to TSEG10	TSEG22 to TSEG20	
17	1	2	7	7	1000	110	58.8
17	1	4	6	6	1001	101	64.7
17	1	6	5	5	1010	100	70.6
17	1	8	4	4	1011	011	76.5
17	1	10	3	3	1100	010	82.4
17	1	12	2	2	1101	001	88.2
17	1	14	1	1	1110	000	94.1
16	1	1	7	7	0111	110	56.3
16	1	3	6	6	1000	101	62.5
16	1	5	5	5	1001	100	68.8
16	1	7	4	4	1010	011	75.0
16	1	9	3	3	1011	010	81.3
16	1	11	2	2	1100	001	87.5
16	1	13	1	1	1101	000	93.8
15	1	2	6	6	0111	101	60.0
15	1	4	5	5	1000	100	66.7
15	1	6	4	4	1001	011	73.3
15	1	8	3	3	1010	010	80.0
15	1	10	2	2	1011	001	86.7
15	1	12	1	1	1100	000	93.3
14	1	1	6	6	0110	101	57.1
14	1	3	5	5	0111	100	64.3
14	1	5	4	4	1000	011	71.4
14	1	7	3	3	1001	010	78.6
14	1	9	2	2	1010	001	85.7
14	1	11	1	1	1011	000	92.9
13	1	2	5	5	0110	100	61.5
13	1	4	4	4	0111	011	69.2
13	1	6	3	3	1000	010	76.9
13	1	8	2	2	1001	001	84.6
13	1	10	1	1	1010	000	92.3
12	1	1	5	5	0101	100	58.3
12	1	3	4	4	0110	011	66.7
12	1	5	3	3	0111	010	75.0
12	1	7	2	2	1000	001	83.3
12	1	9	1	1	1001	000	91.7

Table 20-22. Settable Bit Rate Combinations (3/3)

Valid Bit Rate Setting					C0BTR Register Setting Value		Sampling Point (Unit: %)
DBT Length	SYNC SEGMENT	PROP SEGMENT	PHASE SEGMENT1	PHASE SEGMENT2	TSEG13 to TSEG10	TSEG22 to TSEG20	
11	1	2	4	4	0101	011	63.6
11	1	4	3	3	0110	010	72.7
11	1	6	2	2	0111	001	81.8
11	1	8	1	1	1000	000	90.9
10	1	1	4	4	0100	011	60.0
10	1	3	3	3	0101	010	70.0
10	1	5	2	2	0110	001	80.0
10	1	7	1	1	0111	000	90.0
9	1	2	3	3	0100	010	66.7
9	1	4	2	2	0101	001	77.8
9	1	6	1	1	0110	000	88.9
8	1	1	3	3	0011	010	62.5
8	1	3	2	2	0100	001	75.0
8	1	5	1	1	0101	000	87.5
7Note	1	2	2	2	0011	001	71.4
7Note	1	4	1	1	0100	000	85.7
6Note	1	1	2	2	0010	001	66.7
6Note	1	3	1	1	0011	000	83.3
5Note	1	2	1	1	0010	000	80.0
4Note	1	1	1	1	0001	000	75.0

Note Setting with a DBT value of 7 or less is valid only when the value of the C0BRP register is other than 00H.

Caution The values in Table 20-22 do not guarantee the operation of the network system. Thoroughly check the effect on the network system, taking into consideration oscillation errors and delays of the CAN bus and CAN transceiver.

20.15.2 Representative examples of baud rate settings

Tables 20-23 and 20-24 show representative examples of baud rate settings.

Table 20-23. Representative Examples of Baud Rate Settings (f_{CANMOD} = 8 MHz) (1/2)

Set Baud Rate Value (Unit: kbps)	Division Ratio of C0BRP Register	C0BRP Register Set Value	Valid Bit Rate Setting (Unit: kbps)					C0BTR Register Setting Value		Sampling Point (Unit: %)
			Length of DBT	SYNC SEGMENT	PROP SEGMENT	PHASE SEGMENT1	PHASE SEGMENT2	TSEG13 to TSEG10	TSEG22 to TSEG20	
1000	1	00000000	8	1	1	3	3	0011	010	62.5
1000	1	00000000	8	1	3	2	2	0100	001	75.0
1000	1	00000000	8	1	5	1	1	0101	000	87.5
500	1	00000000	16	1	1	7	7	0111	110	56.3
500	1	00000000	16	1	3	6	6	1000	101	62.5
500	1	00000000	16	1	5	5	5	1001	100	68.8
500	1	00000000	16	1	7	4	4	1010	011	75.0
500	1	00000000	16	1	9	3	3	1011	010	81.3
500	1	00000000	16	1	11	2	2	1100	001	87.5
500	1	00000000	16	1	13	1	1	1101	000	93.8
500	2	00000001	8	1	1	3	3	0011	010	62.5
500	2	00000001	8	1	3	2	2	0100	001	75.0
500	2	00000001	8	1	5	1	1	0101	000	87.5
250	2	00000001	16	1	1	7	7	0111	110	56.3
250	2	00000001	16	1	3	6	6	1000	101	62.5
250	2	00000001	16	1	5	5	5	1001	100	68.8
250	2	00000001	16	1	7	4	4	1010	011	75.0
250	2	00000001	16	1	9	3	3	1011	010	81.3
250	2	00000001	16	1	11	2	2	1100	001	87.5
250	2	00000001	16	1	13	1	1	1101	000	93.8
250	4	00000011	8	1	3	2	2	0100	001	75.0
250	4	00000011	8	1	5	1	1	0101	000	87.5
125	4	00000011	16	1	1	7	7	0111	110	56.3
125	4	00000011	16	1	3	6	6	1000	101	62.5
125	4	00000011	16	1	5	5	5	1001	100	68.8
125	4	00000011	16	1	7	4	4	1010	011	75.0
125	4	00000011	16	1	9	3	3	1011	010	81.3
125	4	00000011	16	1	11	2	2	1100	001	87.5
125	4	00000011	16	1	13	1	1	1101	000	93.8
125	8	00000111	8	1	3	2	2	0100	001	75.0
125	8	00000111	8	1	5	1	1	0101	000	87.5

Caution The values in Table 20-23 do not guarantee the operation of the network system. Thoroughly check the effect on the network system, taking into consideration oscillation errors and delays of the CAN bus and CAN transceiver.

Table 20-23. Representative Examples of Baud Rate Settings (f_{CANMOD} = 8 MHz) (2/2)

Set Baud Rate Value (Unit: kbps)	Division Ratio of C0BRP Register	C0BRP Register Set Value	Valid Bit Rate Setting (Unit: kbps)					C0BTR Register Setting Value		Sampling Point (Unit: %)
			Length of DBT	SYNC SEGMENT	PROP SEGMENT	PHASE SEGMENT1	PHASE SEGMENT2	TSEG13 to TSEG10	TSEG22 to TSEG20	
100	4	00000011	20	1	7	6	6	1100	101	70.0
100	4	00000011	20	1	9	5	5	1101	100	75.0
100	5	00000100	16	1	7	4	4	1010	011	75.0
100	5	00000100	16	1	9	3	3	1011	010	81.3
100	8	00000111	10	1	3	3	3	0101	010	70.0
100	8	00000111	10	1	5	2	2	0110	001	80.0
100	10	00001001	8	1	3	2	2	0100	001	75.0
100	10	00001001	8	1	5	1	1	0101	000	87.5
83.3	4	00000011	24	1	7	8	8	1110	111	66.7
83.3	4	00000011	24	1	9	7	7	1111	110	70.8
83.3	6	00000101	16	1	5	5	5	1001	100	68.8
83.3	6	00000101	16	1	7	4	4	1010	011	75.0
83.3	6	00000101	16	1	9	3	3	1011	010	81.3
83.3	6	00000101	16	1	11	2	2	1100	001	87.5
83.3	8	00000111	12	1	5	3	3	0111	010	75.0
83.3	8	00000111	12	1	7	2	2	1000	001	83.3
83.3	12	00001011	8	1	3	2	2	0100	001	75.0
83.3	12	00001011	8	1	5	1	1	0101	000	87.5
33.3	10	00001001	24	1	7	8	8	1110	111	66.7
33.3	10	00001001	24	1	9	7	7	1111	110	70.8
33.3	12	00001011	20	1	7	6	6	1100	101	70.0
33.3	12	00001011	20	1	9	5	5	1101	100	75.0
33.3	15	00001110	16	1	7	4	4	1010	011	75.0
33.3	15	00001110	16	1	9	3	3	1011	010	81.3
33.3	16	00001111	15	1	6	4	4	1001	011	73.3
33.3	16	00001111	15	1	8	3	3	1010	010	80.0
33.3	20	00010011	12	1	5	3	3	0111	010	75.0
33.3	20	00010011	12	1	7	2	2	1000	001	83.3
33.3	24	00010111	10	1	3	3	3	0101	010	70.0
33.3	24	00010111	10	1	5	2	2	0110	001	80.0
33.3	30	00011101	8	1	3	2	2	0100	001	75.0
33.3	30	00011101	8	1	5	1	1	0101	000	87.5

Caution The values in Table 20-23 do not guarantee the operation of the network system. Thoroughly check the effect on the network system, taking into consideration oscillation errors and delays of the CAN bus and CAN transceiver.

Table 20-24. Representative Examples of Baud Rate Settings (f_{CANMOD} = 16 MHz) (1/2)

Set Baud Rate Value (Unit: kbps)	Division Ratio of C0BRP Register	C0BRP Register Set Value	Valid Bit Rate Setting (Unit: kbps)					C0BTR Register Setting Value		Sampling Point (Unit: %)
			Length of DBT	SYNC SEGMENT	PROP SEGMENT	PHASE SEGMENT1	PHASE SEGMENT2	TSEG13 to TSEG10	TSEG22 to TSEG20	
1000	1	00000000	16	1	1	7	7	0111	110	56.3
1000	1	00000000	16	1	3	6	6	1000	101	62.5
1000	1	00000000	16	1	5	5	5	1001	100	68.8
1000	1	00000000	16	1	7	4	4	1010	011	75.0
1000	1	00000000	16	1	9	3	3	1011	010	81.3
1000	1	00000000	16	1	11	2	2	1100	001	87.5
1000	1	00000000	16	1	13	1	1	1101	000	93.8
1000	2	00000001	8	1	3	2	2	0100	001	75.0
1000	2	00000001	8	1	5	1	1	0101	000	87.5
500	2	00000001	16	1	1	7	7	0111	110	56.3
500	2	00000001	16	1	3	6	6	1000	101	62.5
500	2	00000001	16	1	5	5	5	1001	100	68.8
500	2	00000001	16	1	7	4	4	1010	011	75.0
500	2	00000001	16	1	9	3	3	1011	010	81.3
500	2	00000001	16	1	11	2	2	1100	001	87.5
500	2	00000001	16	1	13	1	1	1101	000	93.8
500	4	00000011	8	1	3	2	2	0100	001	75.0
500	4	00000011	8	1	5	1	1	0101	000	87.5
250	4	00000011	16	1	3	6	6	1000	101	62.5
250	4	00000011	16	1	5	5	5	1001	100	68.8
250	4	00000011	16	1	7	4	4	1010	011	75.0
250	4	00000011	16	1	9	3	3	1011	010	81.3
250	4	00000011	16	1	11	2	2	1100	001	87.5
250	8	00000111	8	1	3	2	2	0100	001	75.0
250	8	00000111	8	1	5	1	1	0101	000	87.5
125	8	00000111	16	1	3	6	6	1000	101	62.5
125	8	00000111	16	1	7	4	4	1010	011	75.0
125	8	00000111	16	1	9	3	3	1011	010	81.3
125	8	00000111	16	1	11	2	2	1100	001	87.5
125	16	00001111	8	1	3	2	2	0100	001	75.0
125	16	00001111	8	1	5	1	1	0101	000	87.5

Caution The values in Table 20-24 do not guarantee the operation of the network system. Thoroughly check the effect on the network system, taking into consideration oscillation errors and delays of the CAN bus and CAN transceiver.

Table 20-24. Representative Examples of Baud Rate Settings (f_{CANMOD} = 16 MHz) (2/2)

Set Baud Rate Value (Unit: kbps)	Division Ratio of C0BRP Register	C0BRP Register Set Value	Valid Bit Rate Setting (Unit: kbps)					C0BTR Register Setting Value		Sampling Point (Unit: %)
			Length of DBT	SYNC SEGMENT	PROP SEGMENT	PHASE SEGMENT1	PHASE SEGMENT2	TSEG13 to TSEG10	TSEG22 to TSEG20	
100	8	00000111	20	1	9	5	5	1101	100	75.0
100	8	00000111	20	1	11	4	4	1110	011	80.0
100	10	00001001	16	1	7	4	4	1010	011	75.0
100	10	00001001	16	1	9	3	3	1011	010	81.3
100	16	00001111	10	1	3	3	3	0101	010	70.0
100	16	00001111	10	1	5	2	2	0110	001	80.0
100	20	00010011	8	1	3	2	2	0100	001	75.0
83.3	8	00000111	24	1	7	8	8	1110	111	66.7
83.3	8	00000111	24	1	9	7	7	1111	110	70.8
83.3	12	00001011	16	1	7	4	4	1010	011	75.0
83.3	12	00001011	16	1	9	3	3	1011	010	81.3
83.3	12	00001011	16	1	11	2	2	1100	001	87.5
83.3	16	00001111	12	1	5	3	3	0111	010	75.0
83.3	16	00001111	12	1	7	2	2	1000	001	83.3
83.3	24	00010111	8	1	3	2	2	0100	001	75.0
83.3	24	00010111	8	1	5	1	1	0101	000	87.5
33.3	30	00011101	24	1	7	8	8	1110	111	66.7
33.3	30	00011101	24	1	9	7	7	1111	110	70.8
33.3	24	00010111	20	1	9	5	5	1101	100	75.0
33.3	24	00010111	20	1	11	4	4	1110	011	80.0
33.3	30	00011101	16	1	7	4	4	1010	011	75.0
33.3	30	00011101	16	1	9	3	3	1011	010	81.3
33.3	32	00011111	15	1	8	3	3	1010	010	80.0
33.3	32	00011111	15	1	10	2	2	1011	001	86.7
33.3	37	00100100	13	1	6	3	3	1000	010	76.9
33.3	37	00100100	13	1	8	2	2	1001	001	84.6
33.3	40	00100111	12	1	5	3	3	0111	010	75.0
33.3	40	00100111	12	1	7	2	2	1000	001	83.3
33.3	48	00101111	10	1	3	3	3	0101	010	70.0
33.3	48	00101111	10	1	5	2	2	0110	001	80.0
33.3	60	00111011	8	1	3	2	2	0100	001	75.0
33.3	60	00111011	8	1	5	1	1	0101	000	87.5

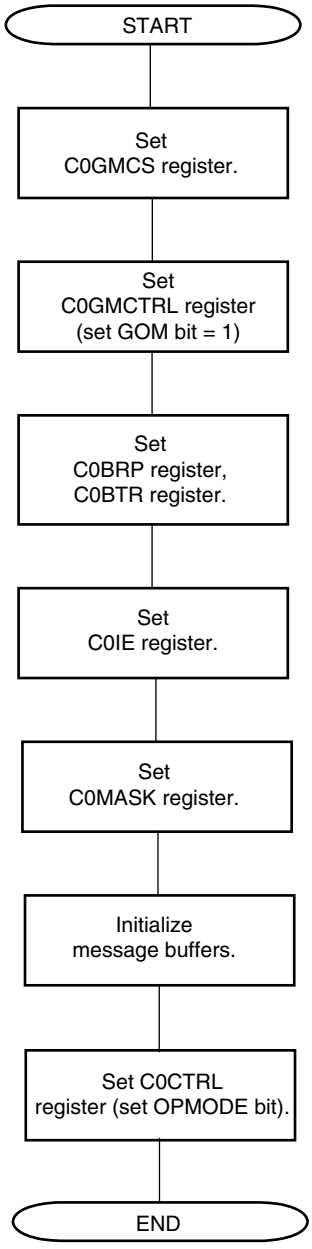
Caution The values in Table 20-24 do not guarantee the operation of the network system. Thoroughly check the effect on the network system, taking into consideration oscillation errors and delays of the CAN bus and CAN transceiver.

20.16 Operation of CAN Controller

The processing procedure shown below is recommended to operate the CAN controller. Develop your program by referring to this recommended processing procedure.

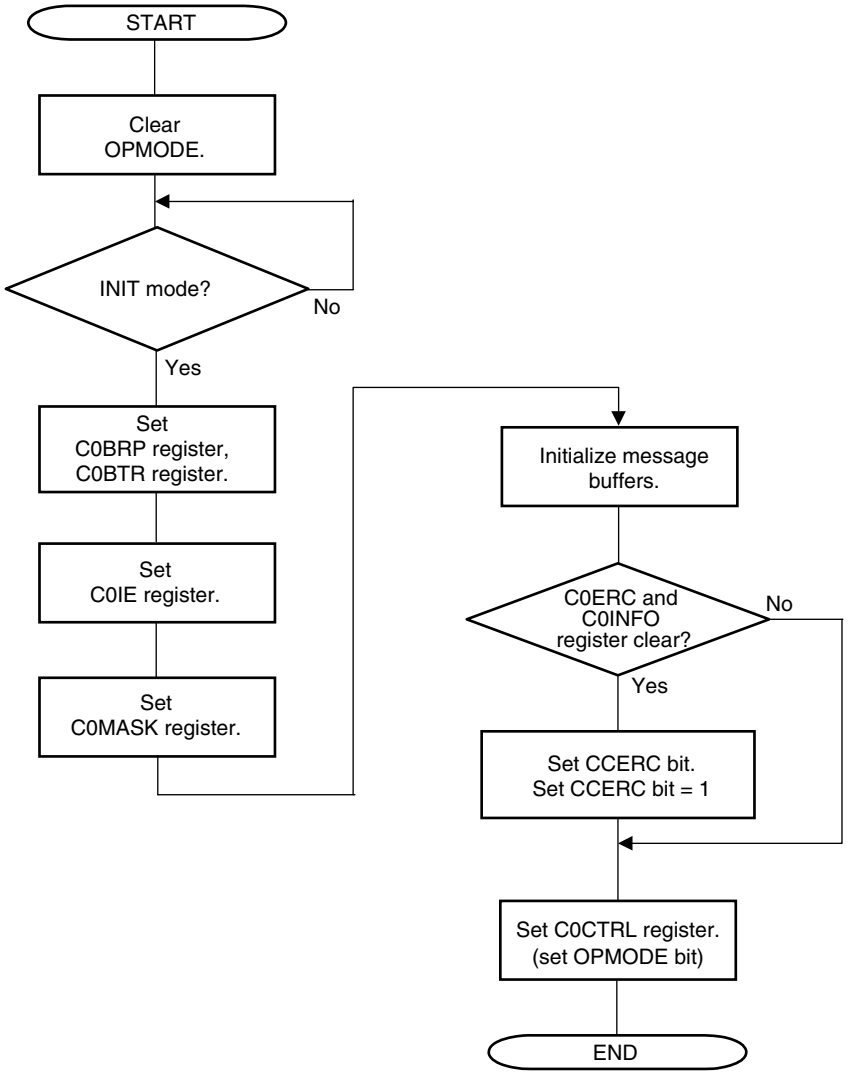
Remark m = 00 to 31

Figure 20-36. Initialization



Remark OPMODE: Normal operation mode, normal operation mode with ABT, receive-only mode, single-shot mode, self-test mode

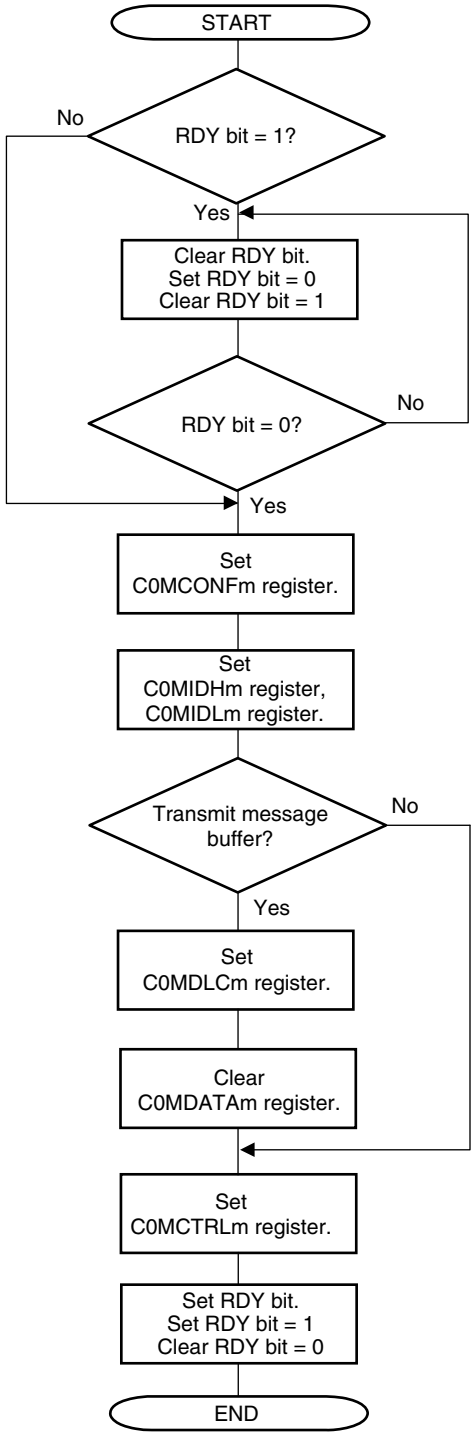
Figure 20-37. Re-initialization



Caution After setting the CAN module to the initialization mode, avoid setting the module to another operation mode immediately after. If it is necessary to immediately set the module to another operation mode, be sure to access registers other than the C0CTRL and C0GMCTRL registers (e.g., set a message buffer).

Remark OPMODE: Normal operation mode, normal operation mode with ABT, receive-only mode, single-shot mode, self-test mode

Figure 20-38. Message Buffer Initialization



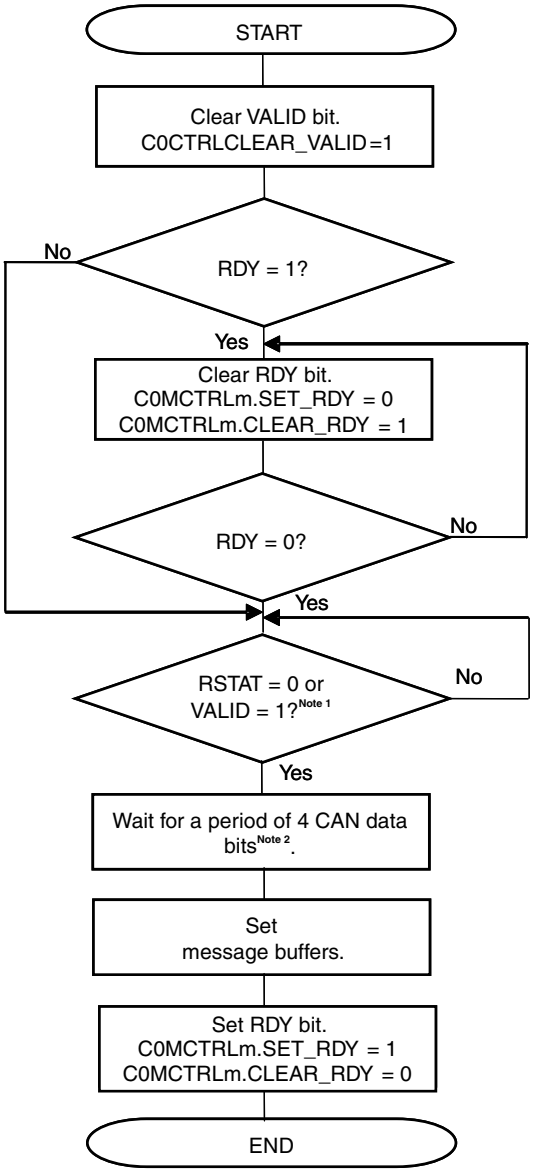
Cautions 1. Before a message buffer is initialized, the RDY bit must be cleared.

2. Make the following settings for message buffers not used by the application.

- **Clear the C0MCTRLm.RDY, C0MCTRLm.TRQ, and C0MCTRLm.DN bits to 0.**
- **Clear the C0MCONFm.MA0 bit to 0.**

Figure 20-39 shows the processing for a receive message buffer (C0MCONFm.MT2 to C0MCONFm.MT0 bits = 001B to 101B).

Figure 20-39. Message Buffer Redefinition



Notes 1. If redefinition is performed during a message reception, confirm that a message is being received because the RDY bit must be set after a message is completely received.

2. This 4-bit period may redefine the message buffer while a message is received and stored.

Figure 20-40 shows the processing for a transmit message buffer during transmission (MT2 to MT0 bits of C0MCONFm register = 000B).

Figure 20-40. Message Buffer Redefinition during Transmission

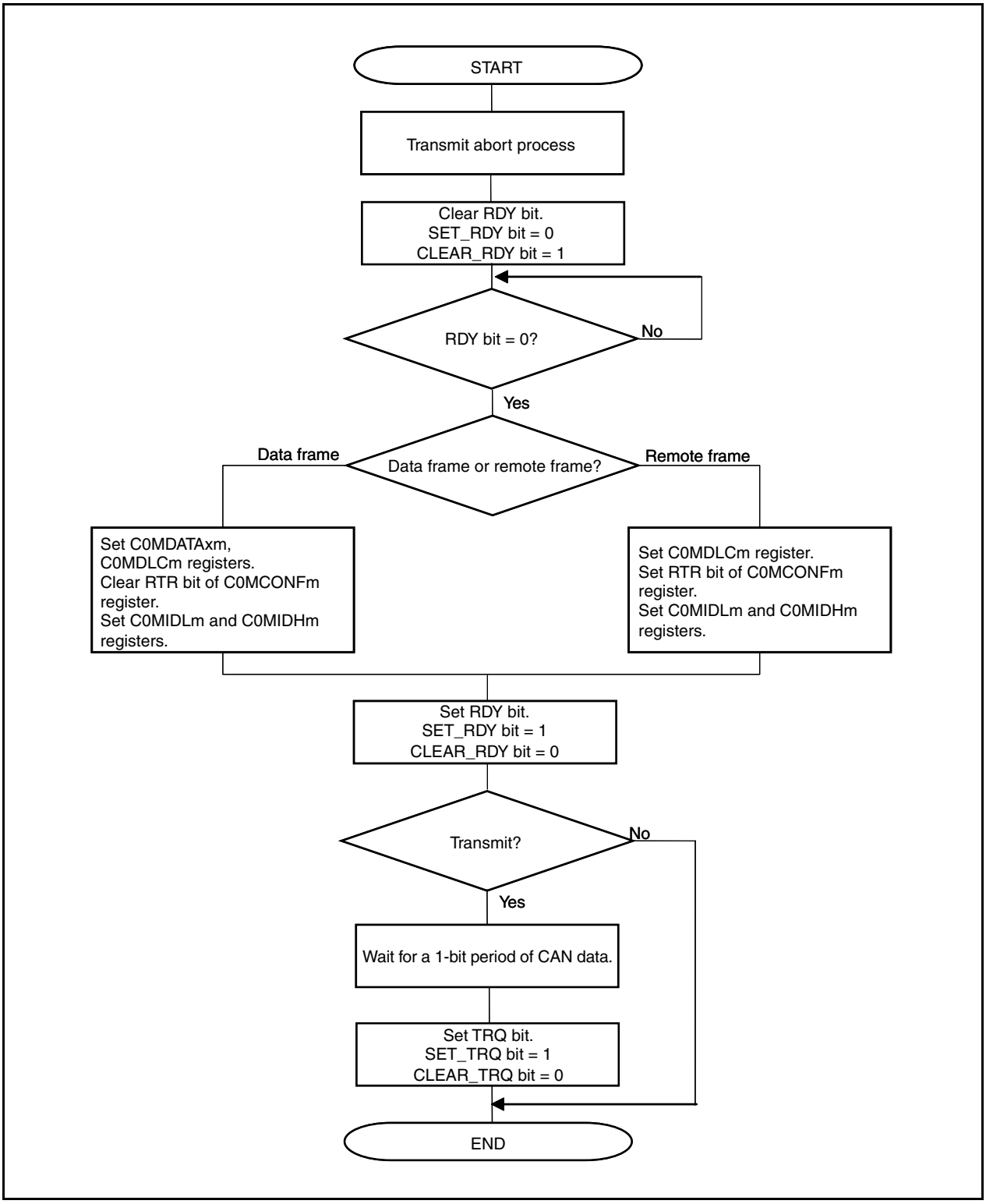
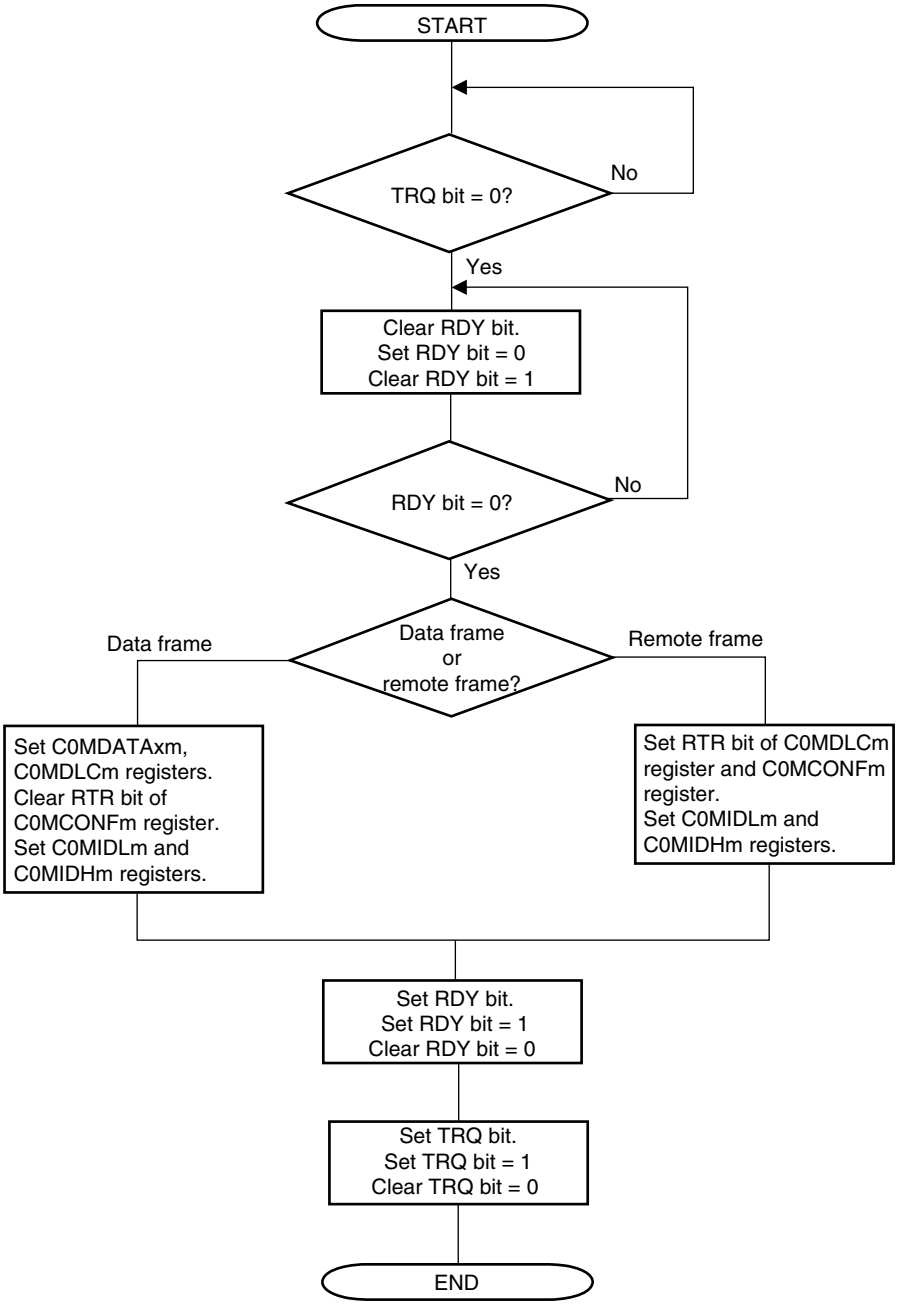


Figure 20-41 shows the processing for a transmit message buffer (C0MCONFm.MT2 to C0MCONFm.MT0 bits = 000B).

Figure 20-41. Message Transmit Processing

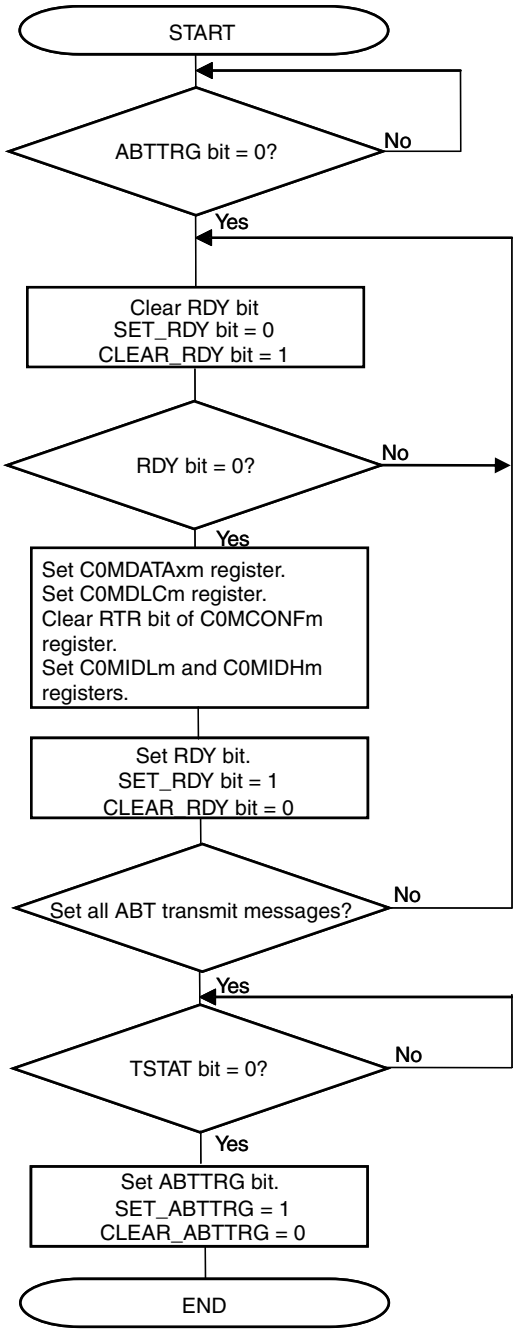


Cautions 1. The TRQ bit should be set after the RDY bit is set.

2. The RDY bit and TRQ bit should not be set at the same time.

Figure 20-42 shows the processing for a transmit message buffer (C0MCONFm.MT2 to C0MCONFm.MT0 bits = 000B).

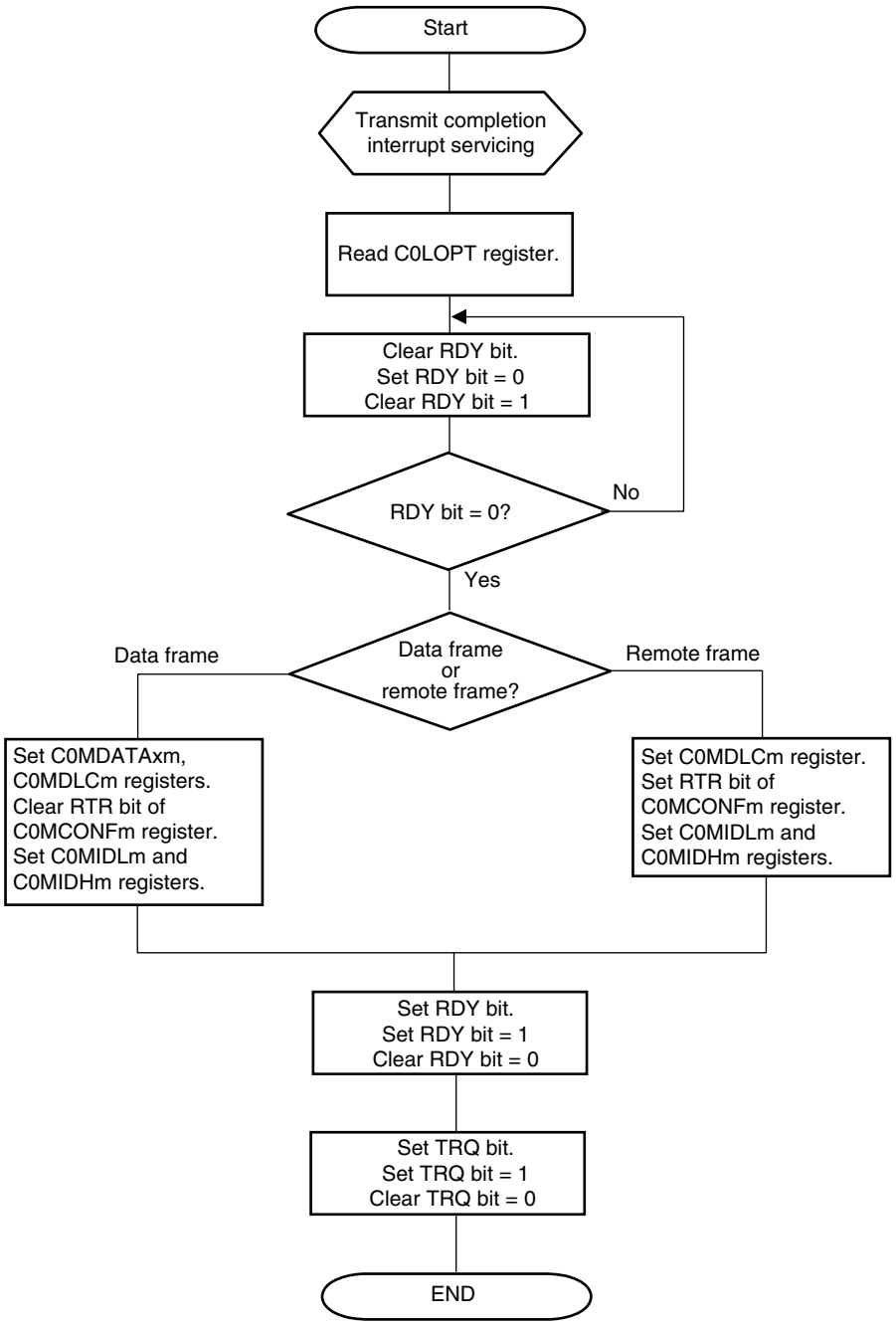
Figure 20-42. ABT Message Transmit Processing



Caution The ABTTRG bit should be set to 1 after the TSTAT bit is cleared to 0. The checking of the TSTAT bit and the setting for the ABTTRG bit to 1 must be continuous.

Remark This processing (message transmit processing with ABS) can only be applied to message buffers 0 to 7. For message buffers other than the ABT message buffers, refer to **Figure 20-41**.

Figure 20-43. Transmission via Interrupt (Using C0LOPT Register)

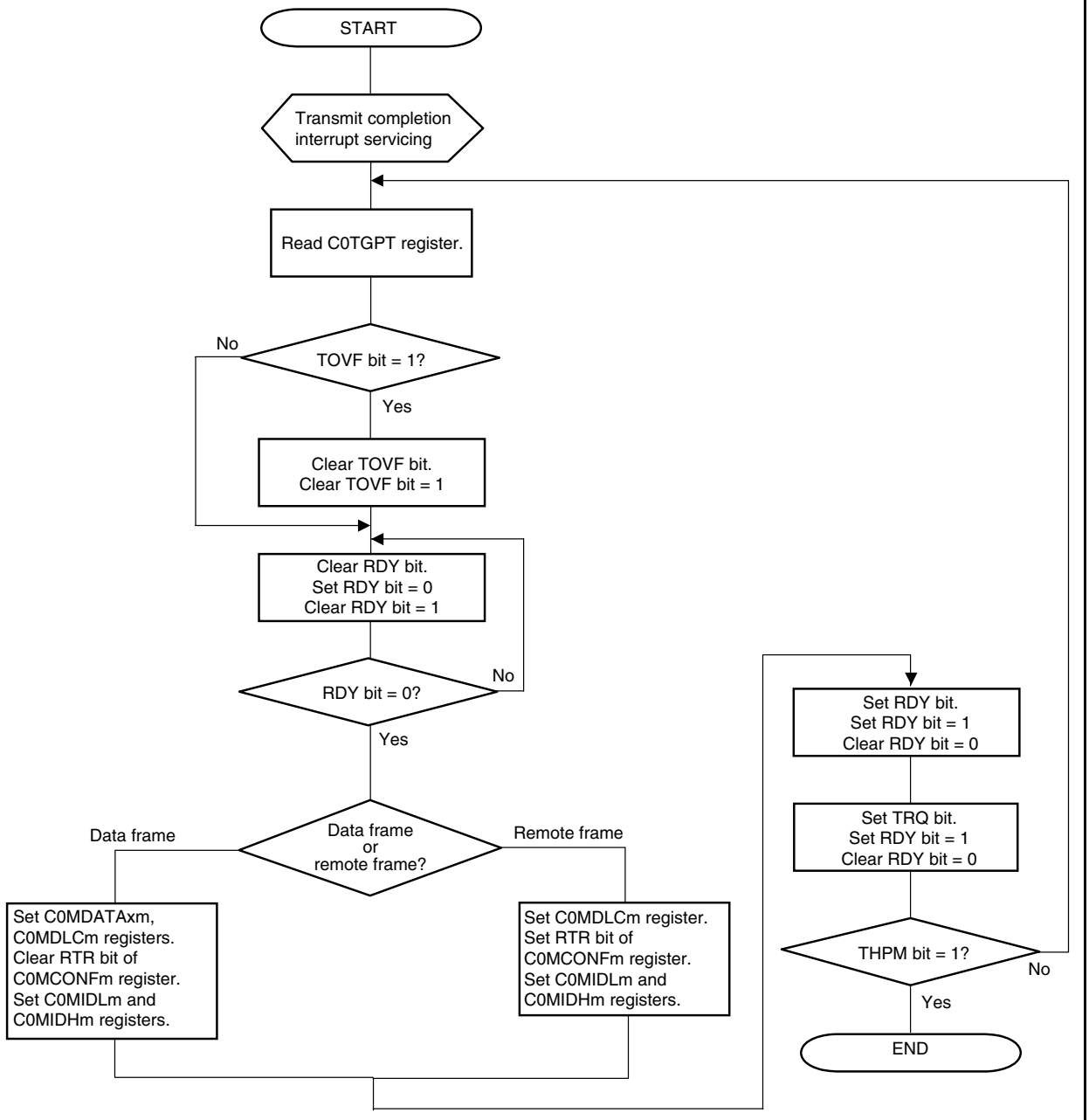


Cautions 1. The TRQ bit should be set after the RDY bit is set.

2. The RDY bit and TRQ bit should not be set at the same time.

Remark Check the MBON bit at the start and end of the interrupt routine to see if the message buffer and transmit history register can be accessed, because a CAN sleep mode transition request which has been held pending may be under execution. If the MBON bit is cleared (0), stop the processing under execution. Re-execute the processing after the MBON bit is set (1) again. It is therefore recommended to cancel the CAN sleep mode transition request before executing transmission interrupt servicing.

Figure 20-44. Transmission via Interrupt (Using C0TGPT Register)



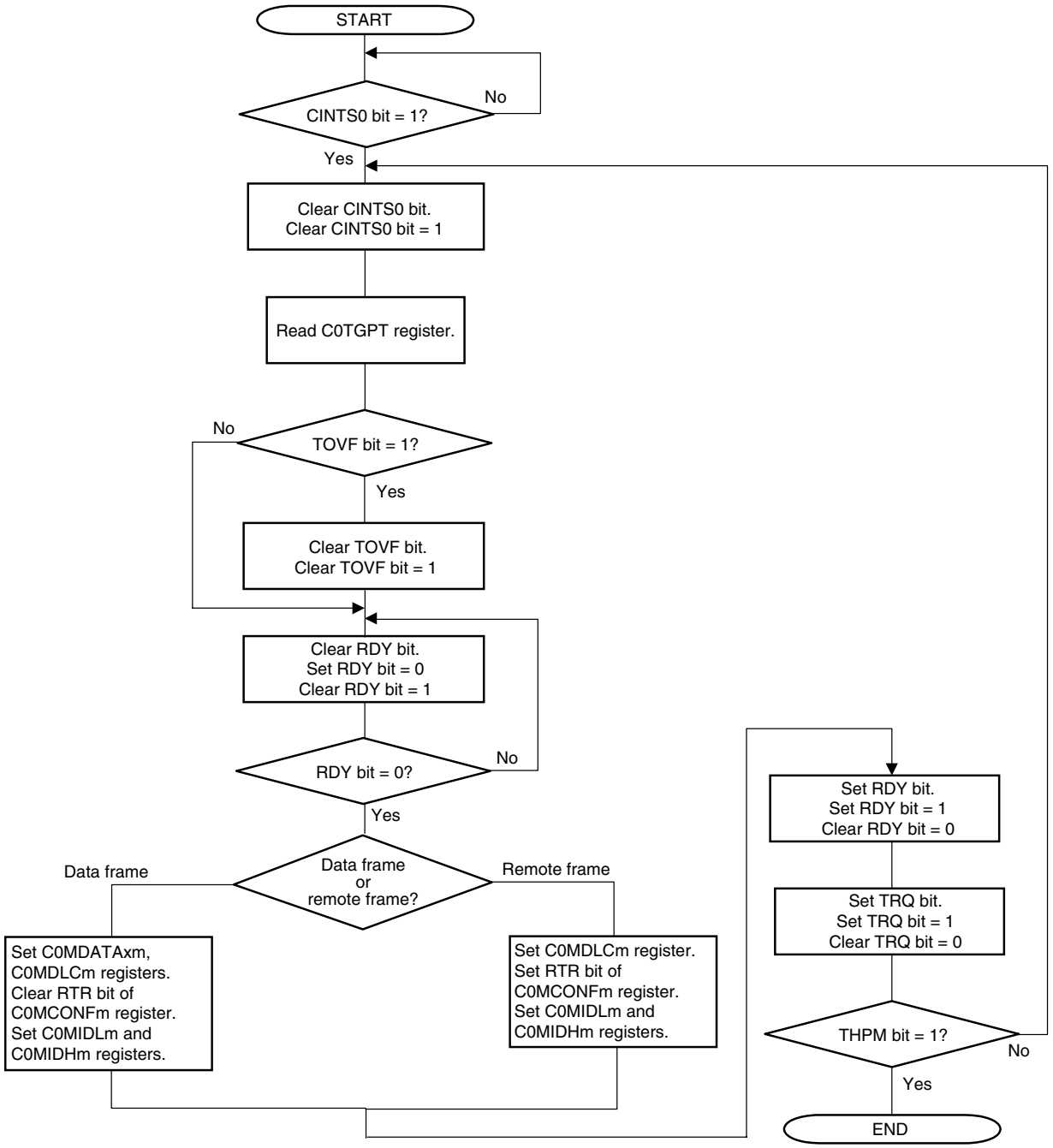
Cautions 1. The TRQ bit should be set after the RDY bit is set.

2. The RDY bit and TRQ bit should not be set at the same time.

Remarks 1. Check the MBON bit at the start and end of the interrupt routine to see if the message buffer and transmit history register can be accessed, because a CAN sleep mode transition request which has been held pending may be under execution. If the MBON bit is cleared (0), stop the processing under execution. Re-execute the processing after the MBON bit is set (1) again. It is therefore recommended to cancel the CAN sleep mode transition request before executing transmission interrupt servicing.

2. If the TOVF bit is set (1) again, the transmit history list contradicts. Therefore, scan all the transmit message buffers that have completed transmission.

Figure 20-45. Transmission via Software Polling



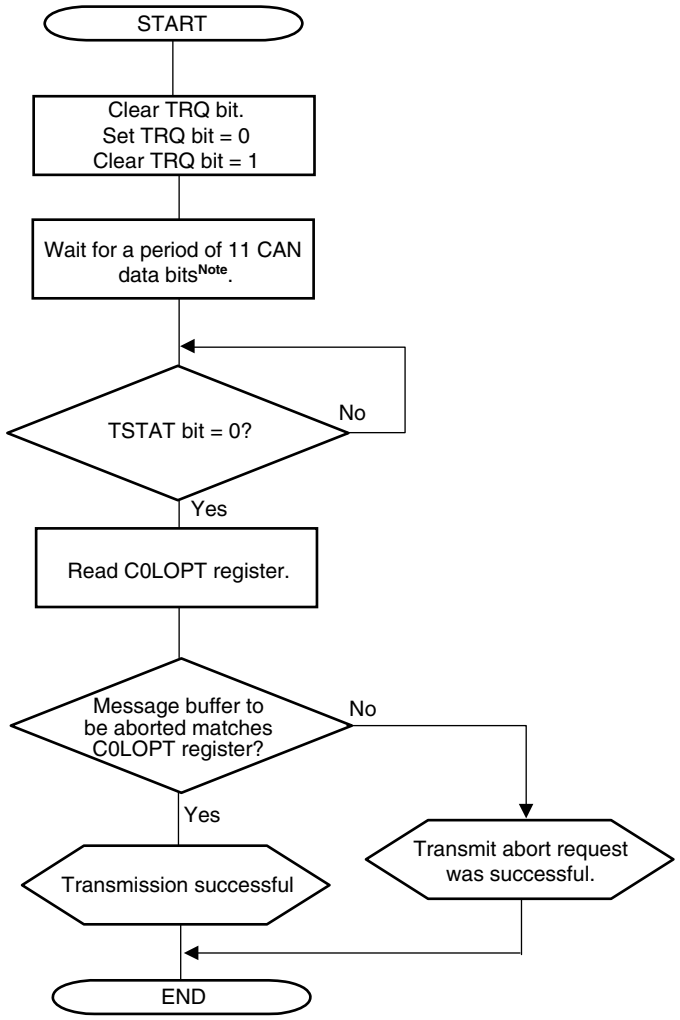
Cautions 1. The TRQ bit should be set after the RDY bit is set.

2. The RDY bit and TRQ bit should not be set at the same time.

Remarks 1. Check the MBON bit at the start and end of the polling routine to see if the message buffer and transmit history register can be accessed, because a CAN sleep mode transition request which has been held pending may be under execution. If the MBON bit is cleared (0), stop the processing under execution. Re-execute the processing after the MBON bit is set (1) again.

2. If the TOVF bit is set (1) again, the transmit history list contradicts. Therefore, scan all the transmit message buffers that have completed transmission.

Figure 20-46. Transmission Abort Processing (Other Than in Normal Operation Mode with ABT)



Note During a period of a total of 11 bits, 3 bits of interframe space and 8 bits of suspend transmission, the transmission request may have already been acknowledged by the protocol layer. Consequently, transmission may not be aborted but started even if the TRQ bit is cleared.

Cautions 1. Execute transmission abort processing by clearing the TRQ bit, not the RDY bit.

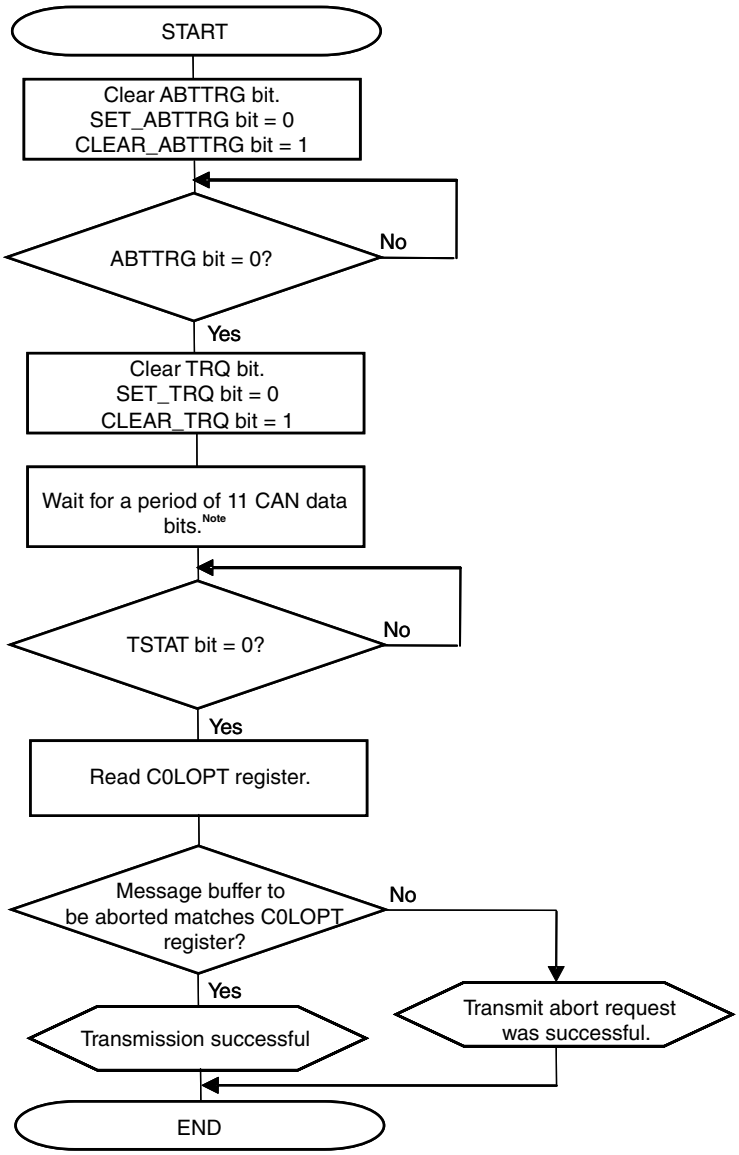
2. Before making a sleep mode transition request, confirm that there is no transmission request left using this processing.

3. The TSTAT bit can be periodically checked by a user application or can be checked after the transmit completion interrupt.

4. Do not execute a new transmission request that includes other message buffers while transmission abort processing is in progress.

5. If data of the same message buffer are successively transmitted or if only one message buffer is used, judgments whether transmission has been successfully executed or failed may contradict. In such a case, make a judgment by using the history information of the C0TGPT register.

Figure 20-47. Transmission Abort Processing Except for ABT Transmission (Normal Operation Mode with ABT)



Note During a period of a total of 11 bits, 3 bits of interframe space and 8 bits of suspend transmission, the transmission request may have already been acknowledged by the protocol layer. Consequently, transmission may not be aborted but started even if the TRQ bit is cleared.

Cautions 1. Execute transmission abort processing by clearing the TRQ bit, not the RDY bit.

2. Before making a sleep mode transition request, confirm that there is no transmission request left using this processing.

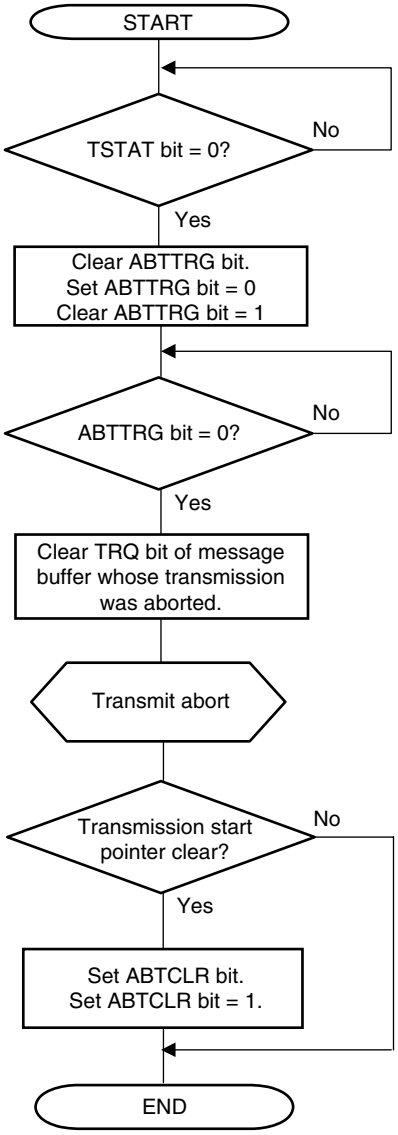
3. The TSTAT bit can be periodically checked by a user application or can be checked after the transmit completion interrupt.

4. Do not execute a new transmission request including in the other message buffers while transmission abort processing is in progress.

5. If data of the same message buffer are successively transmitted or if only one message buffer is used, judgments whether transmission has been successfully executed or failed may contradict. In such a case, make a judgment by using the history information of the C0TGPT register.

Figure 20-48 (a) shows processing that does not skip resuming the transmission of a message that was interrupted when the transmission of an ABT message buffer was aborted.

Figure 20-48 (a). ABT Transmission Abort Processing (Normal Operation Mode with ABT)

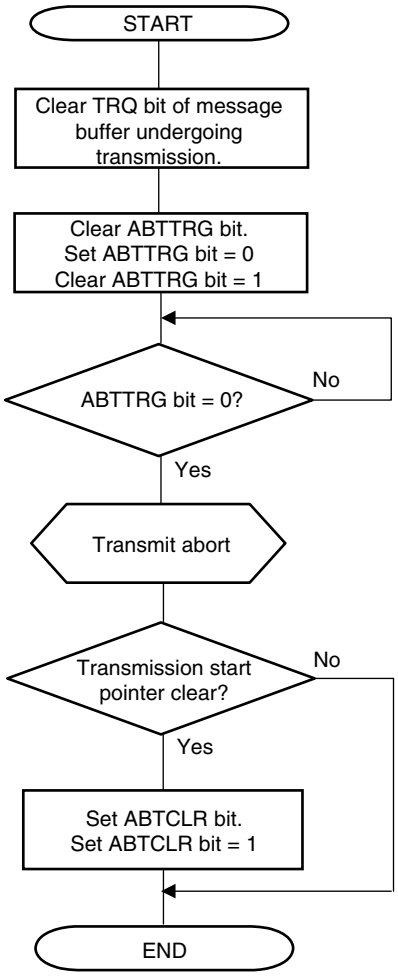


Cautions 1. Do not set any transmission requests while ABT transmission abort processing is in progress.

2. Make a CAN sleep mode/CAN stop mode transition request after the ABTTRG bit is cleared (after ABT mode is stopped) following the procedure shown in Figure 20-48 (a) or (b). When clearing a transmission request in an area other than the ABT area, follow the procedure shown in Figure 20-46.

Figure 20-48 (b) shows the processing that does not skip resuming the transmission of a message that was interrupted when the transmission of an ABT message buffer was aborted.

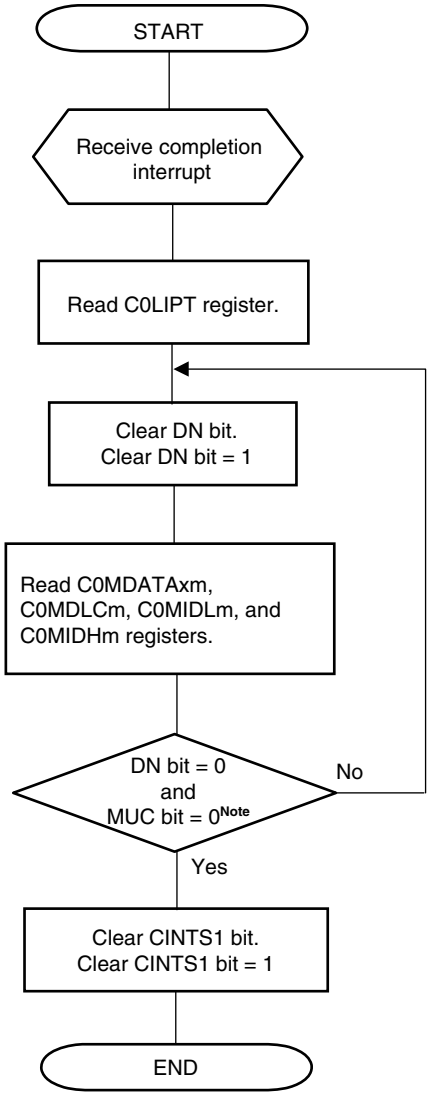
Figure 20-48 (b). ABT Transmission Abort Processing (Normal Operation Mode with ABT)



Cautions 1. Do not set any transmission requests while ABT transmission abort processing is in progress.

2. Make a CAN sleep mode/CAN stop mode request after the ABTTRG bit is cleared (after ABT mode is stopped) following the procedure shown in Figure 20-48 (a) or (b). When clearing a transmission request in an area other than the ABT area, follow the procedure shown in Figure 20-46.

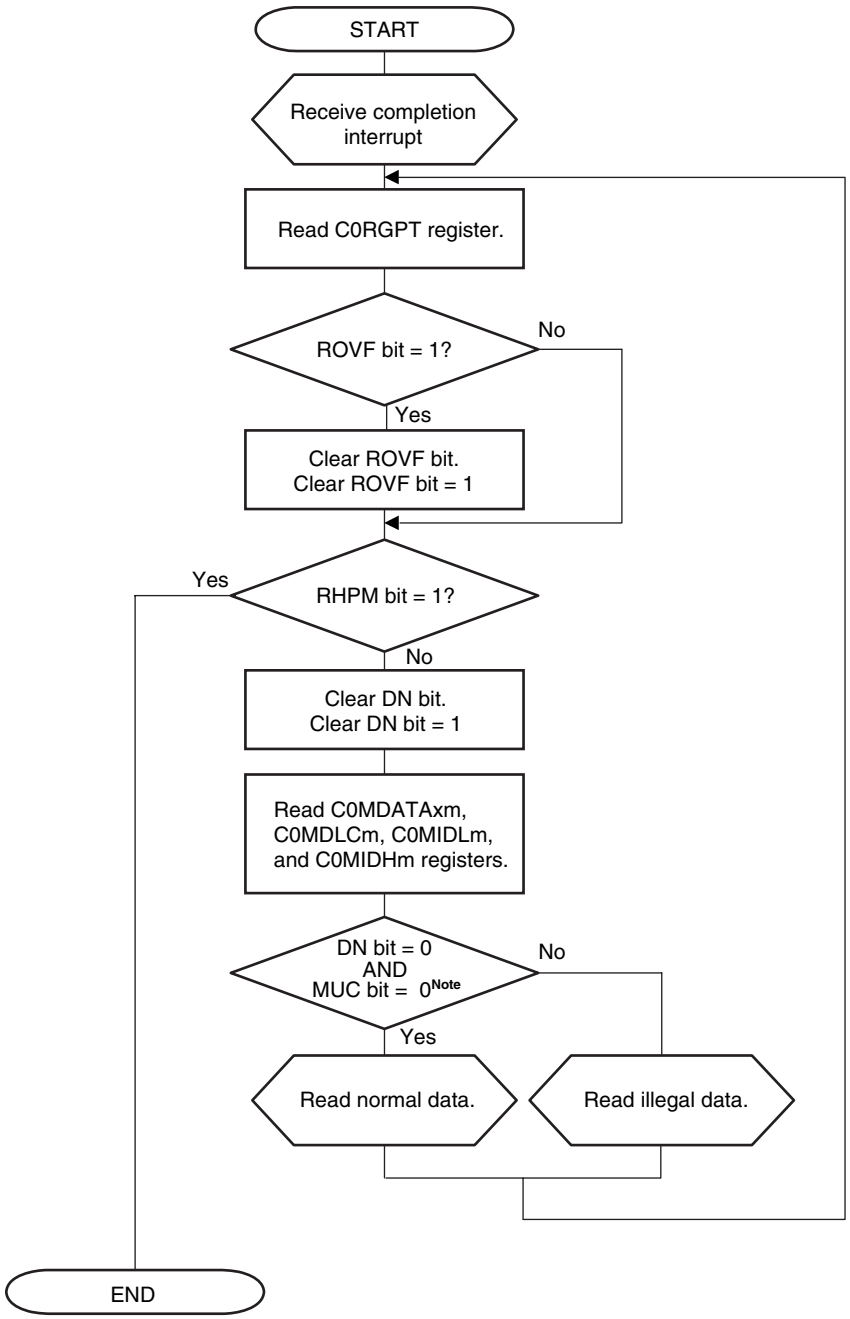
Figure 20-49. Reception via Interrupt (Using C0LIPT Register)



Note Check the MUC and DN bits using one read access.

Remark Check the MBON bit at the start and end of the interrupt routine to see if the message buffer and receive history register can be accessed, because a CAN sleep mode transition request which has been held pending may be under execution. If the MBON bit is cleared (0), stop the processing under execution. Re-execute the processing after the MBON bit is set (1) again. It is therefore recommended to cancel the CAN sleep mode transition request before executing reception interrupt servicing.

Figure 20-50. Reception via Interrupt (Using C0RGPT Register)

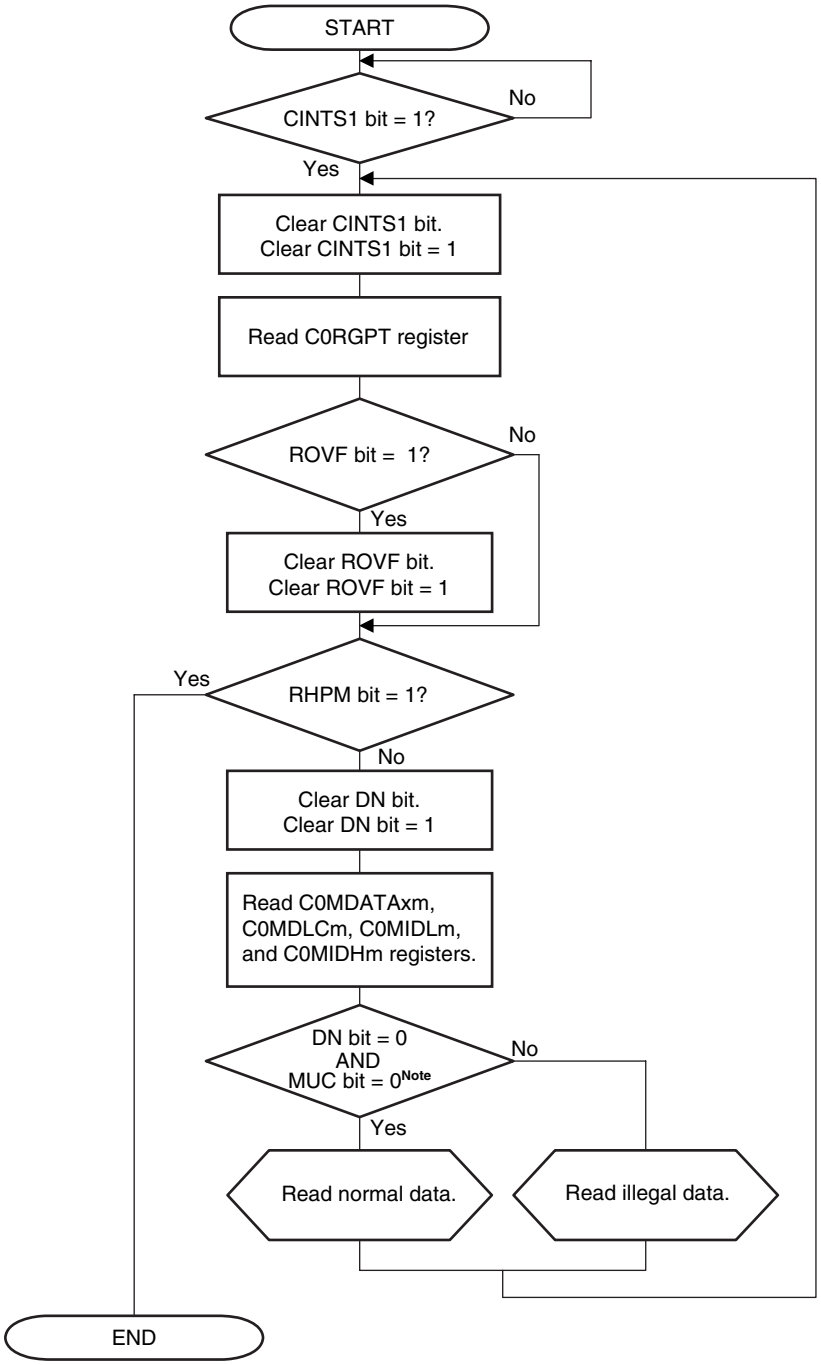


Note Check the MUC and DN bits using one read access.

Remarks 1. Check the MBON bit at the start and end of the interrupt routine to see if the message buffer and receive history register can be accessed, because a CAN sleep mode transition request which has been held pending may be under execution. If the MBON bit is cleared (0), stop the processing under execution. Re-execute the processing after the MBON bit is set (1) again. It is therefore recommended to cancel the CAN sleep mode transition request before executing reception interrupt servicing.

2. If the ROVF bit has been once set (1), the receive history list contradicts. Therefore, scan all the receive message buffers that have completed reception.

Figure 20-51. Reception via Software Polling

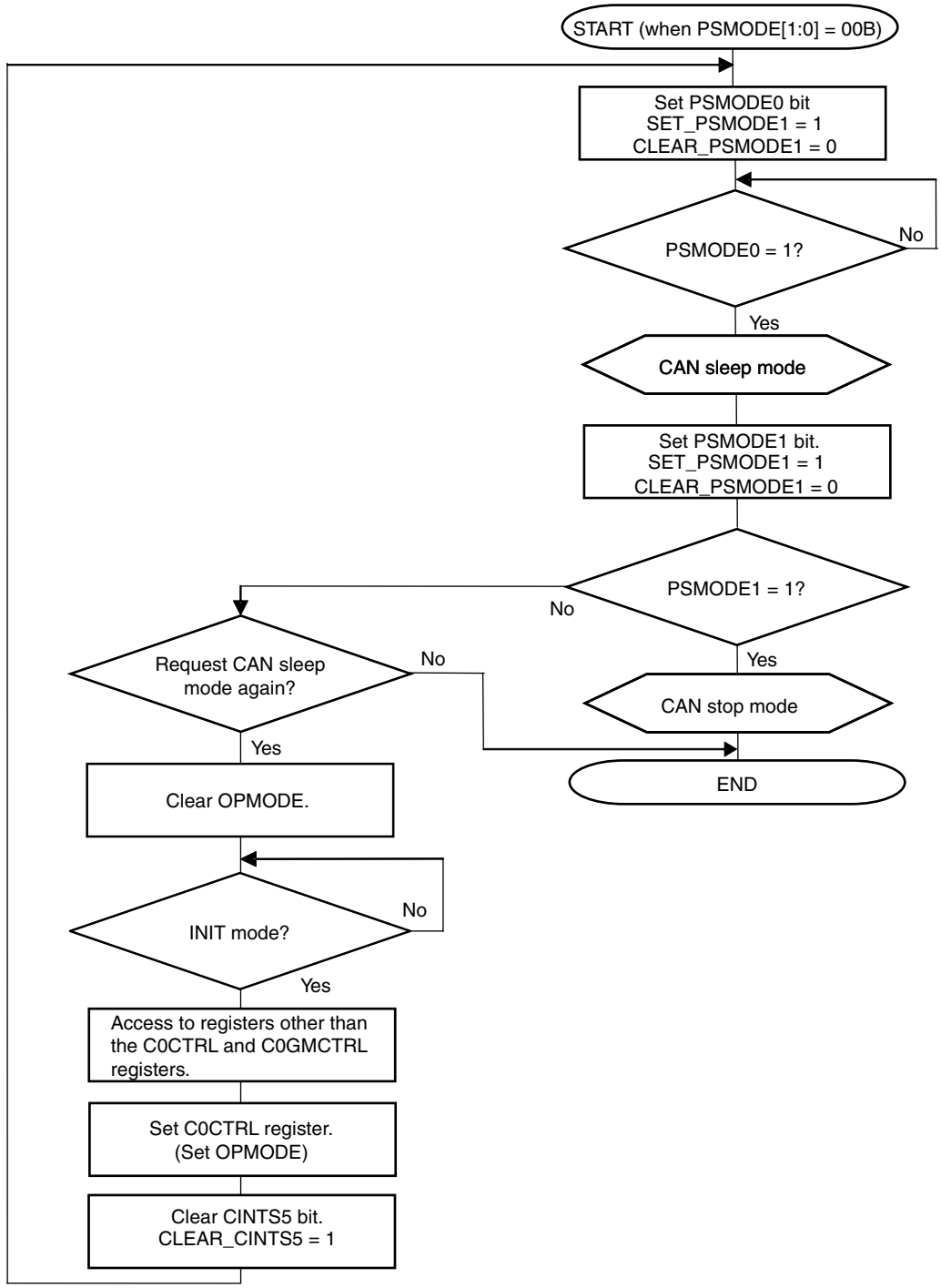


Note Check the MUC and DN bits using one read access.

Remarks 1. Check the MBON bit at the start and end of the polling routine to see if the message buffer and receive history register can be accessed, because a CAN sleep mode transition request which has been held pending may be under execution. If the MBON bit is cleared (0), stop the processing under execution. Re-execute the processing after the MBON bit is set (1) again.

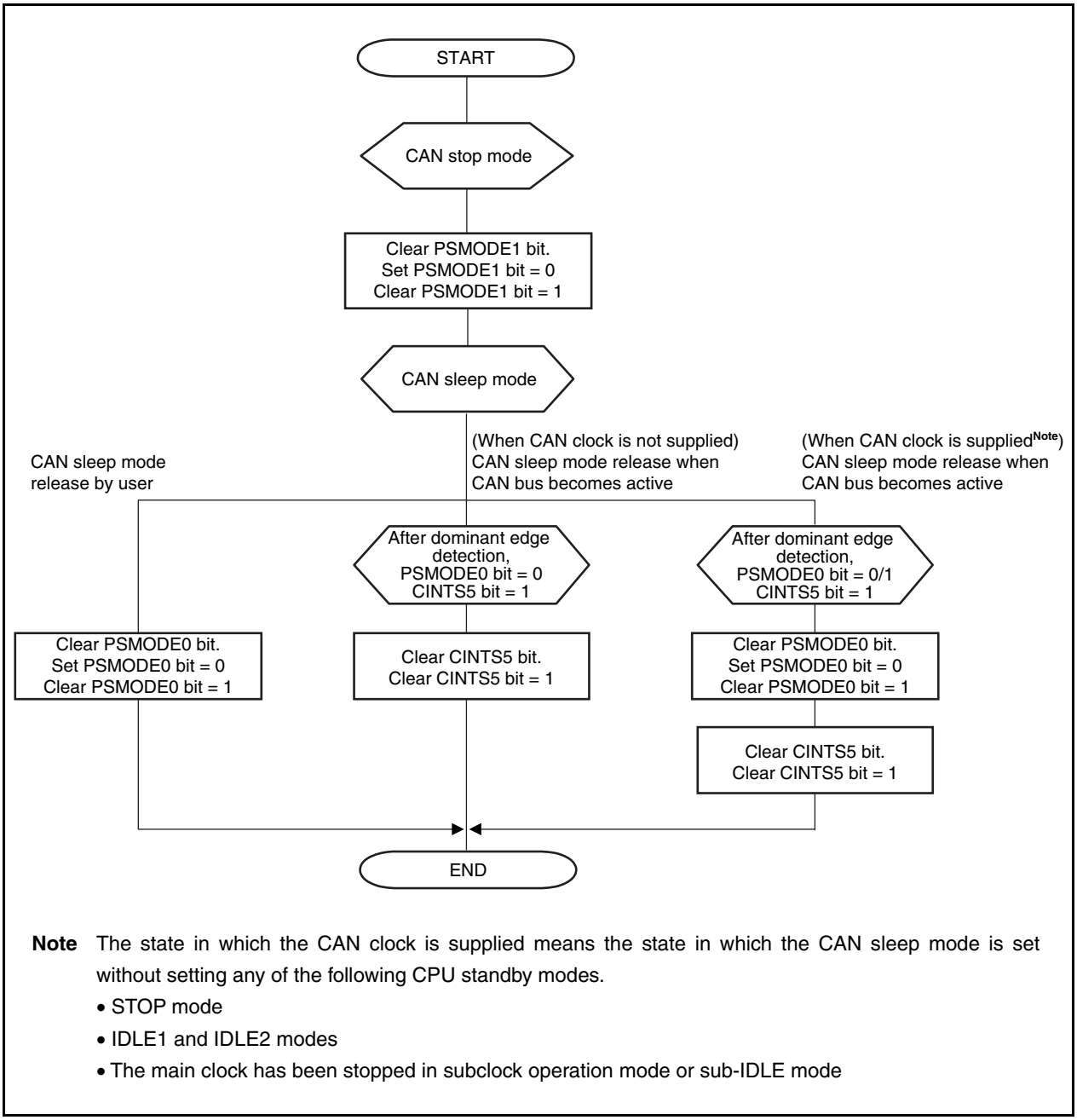
2. If the ROVF bit has been once set (1), the receive history list contradicts. Therefore, scan all the receive message buffers that have completed reception.

Figure 20-52. Setting CAN Sleep Mode/Stop Mode



Caution To abort transmission before making a request for the CAN sleep mode, perform processing according to Figures 20-46 to 20-48.

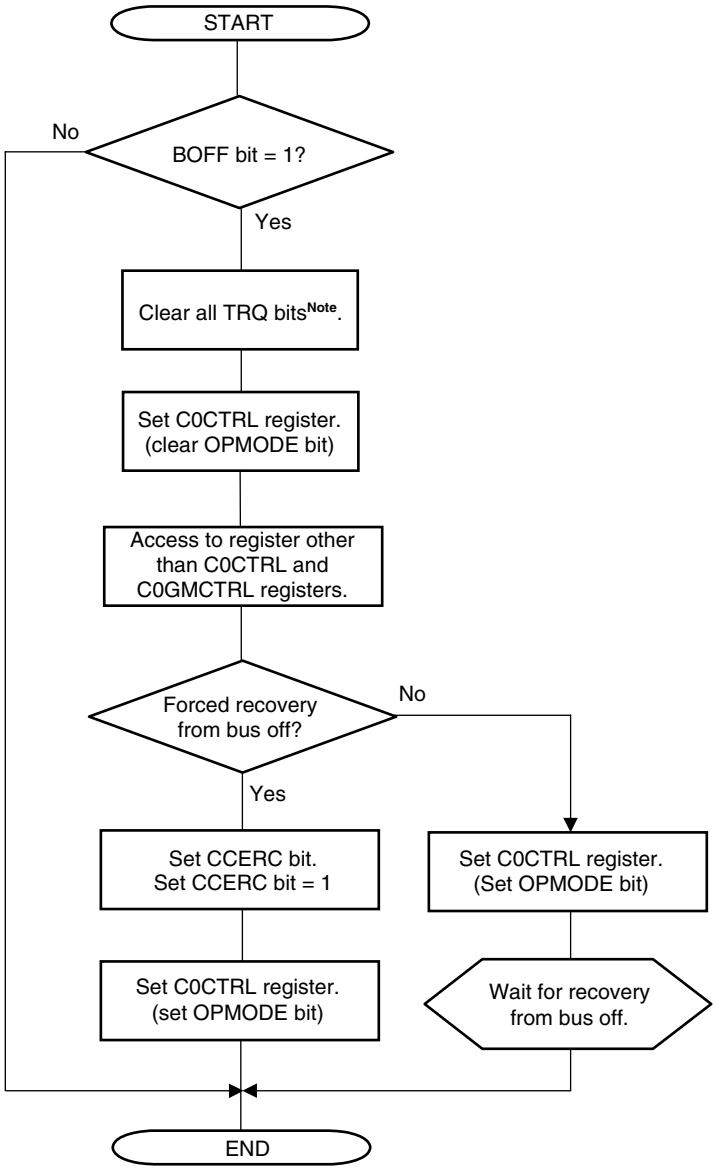
Figure 20-53. Clear CAN Sleep/Stop Mode



Note The state in which the CAN clock is supplied means the state in which the CAN sleep mode is set without setting any of the following CPU standby modes.

- STOP mode
- IDLE1 and IDLE2 modes
- The main clock has been stopped in subclock operation mode or sub-IDLE mode

Figure 20-54. Bus-off Recovery (Other Than in Normal Operation Mode with ABT)

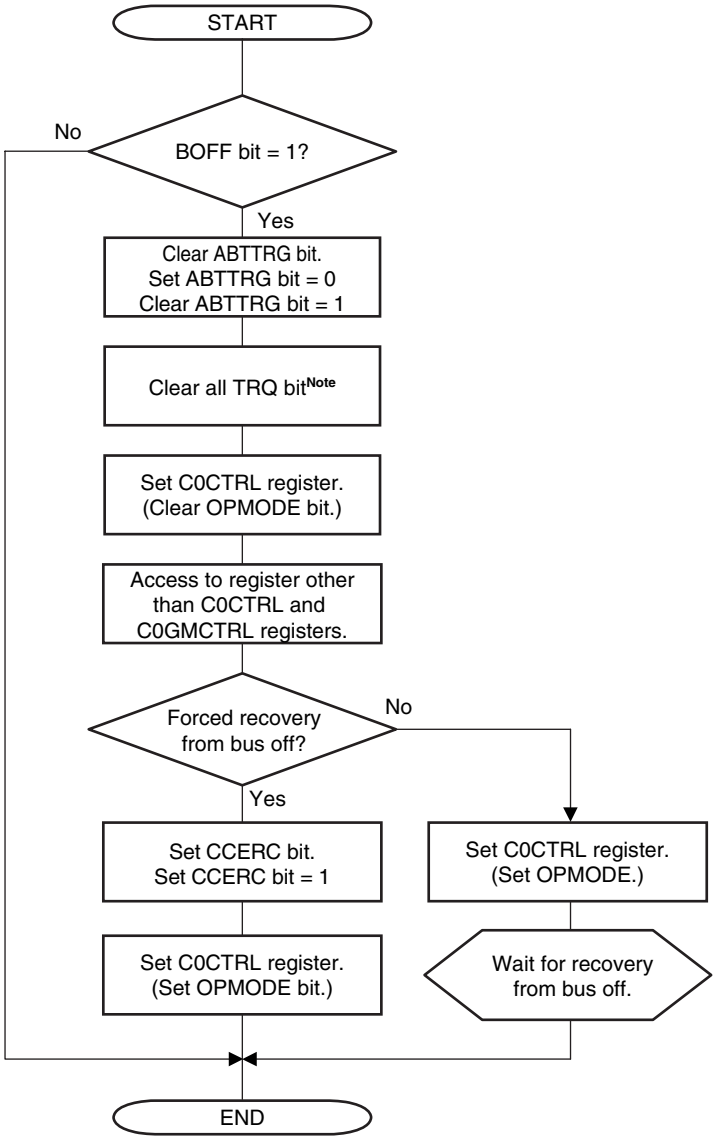


Note To initialize the message buffer by clearing the RDY bit before starting the bus-off recovery sequence, clear all the TRQ bits.

Caution If a request to change the mode from the initialization mode to any operation mode is made to execute the bus-off recovery sequence again during a bus-off recovery sequence, the receive error counter (C0ERC.REC0 to REC6 bits) is cleared. It is therefore necessary to detect 11 contiguous recessive bits 128 times on the bus again.

Remark OPMODE: Normal operation mode, normal operation mode with ABT, receive-only mode, single-shot mode, self-test mode

Figure 20-55. Bus-off Recovery (Normal Operation Mode with ABT)



Note To initialize the message buffer by clearing the RDY bit before starting the bus-off recovery sequence, clear all the TRQ bits.

Caution If a request to change the mode from the initialization mode to any operation mode is made to execute the bus-off recovery sequence again during a bus-off recovery sequence, the receive error counter (C0ERC.REC0 to REC6 bits) is cleared. It is therefore necessary to detect 11 contiguous recessive bits 128 times on the bus again.

Remark OPMODE: Normal operation mode, normal operation mode with ABT, receive-only mode, single-shot mode, self-test mode

Figure 20-56. Normal Shutdown Process

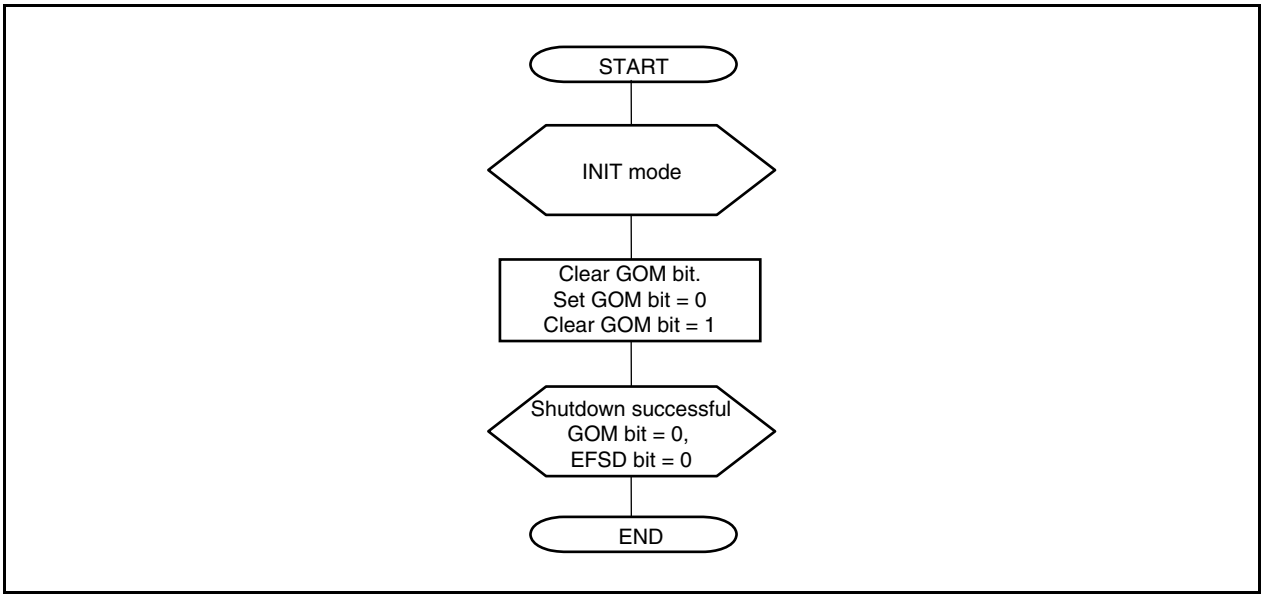
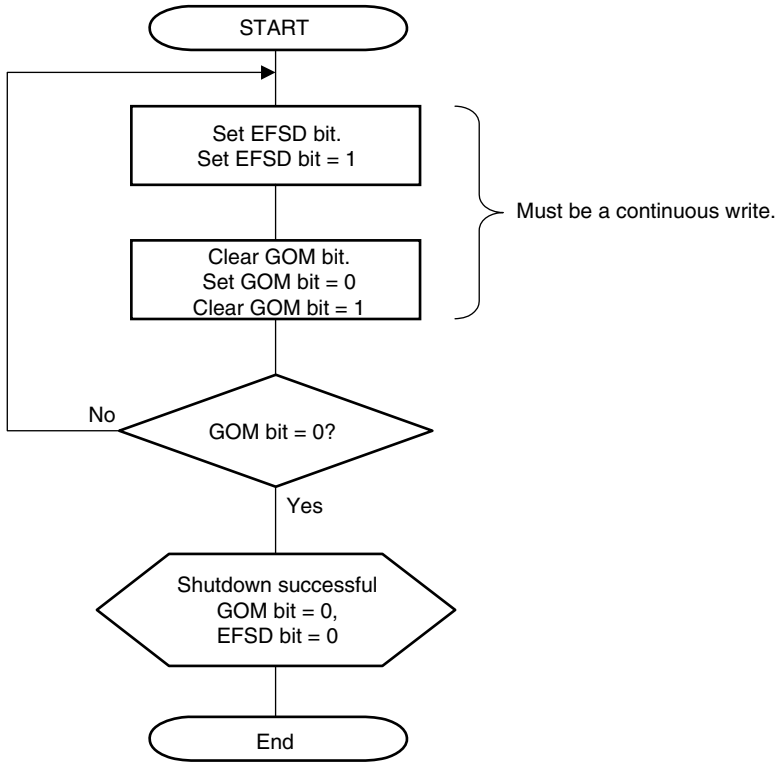


Figure 20-57. Forced Shutdown Process



Caution Do not read- or write-access any registers by software between setting the EFSD bit and clearing the GOM bit.

Figure 20-58. Error Handling

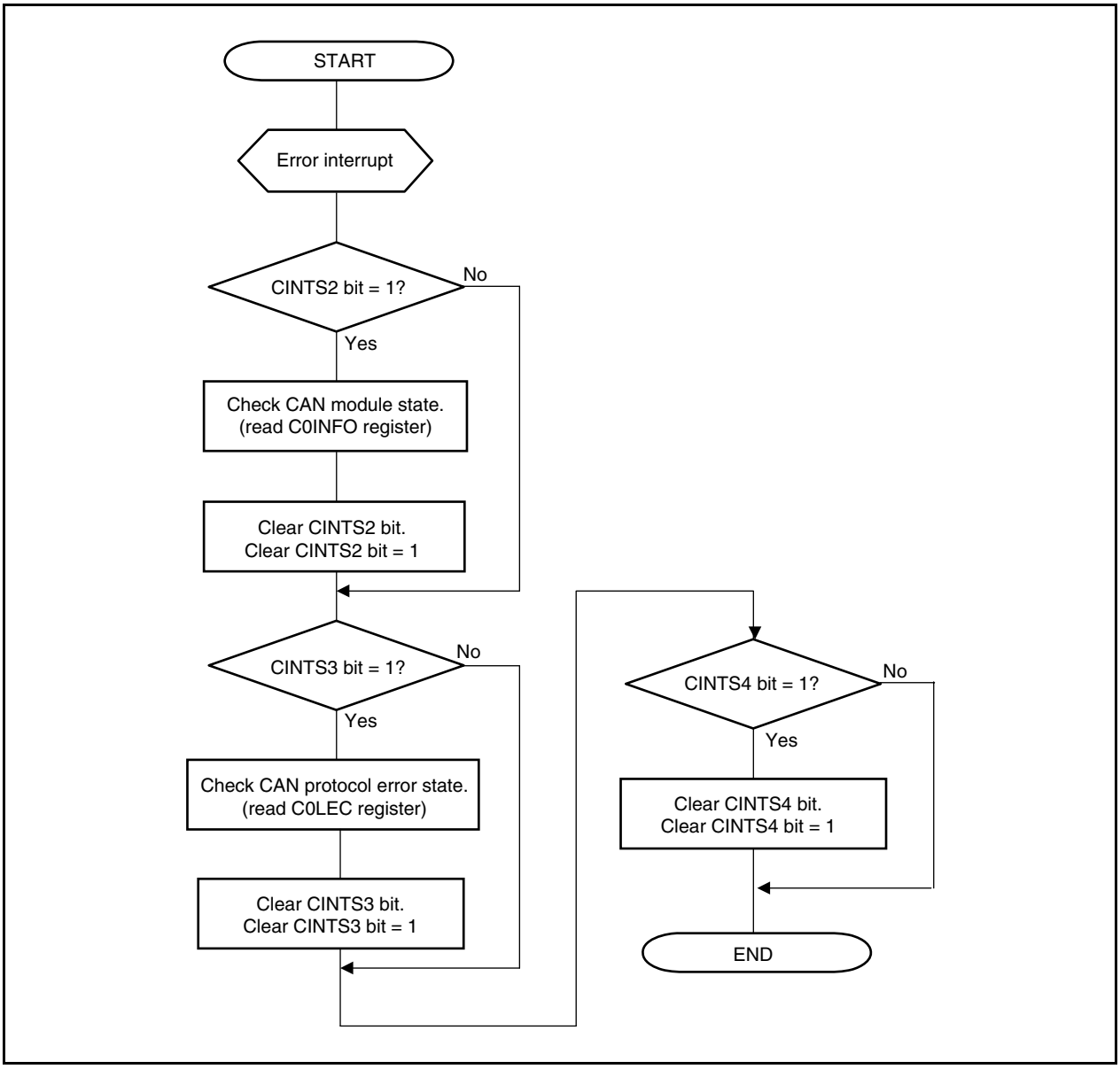
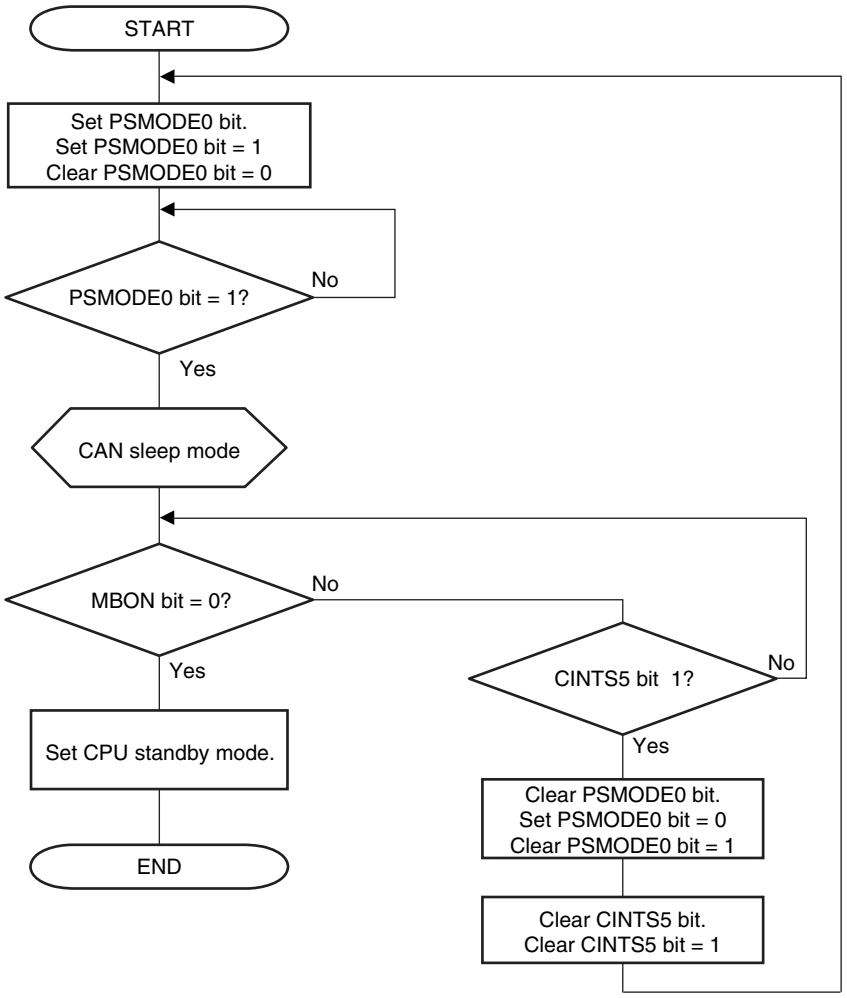
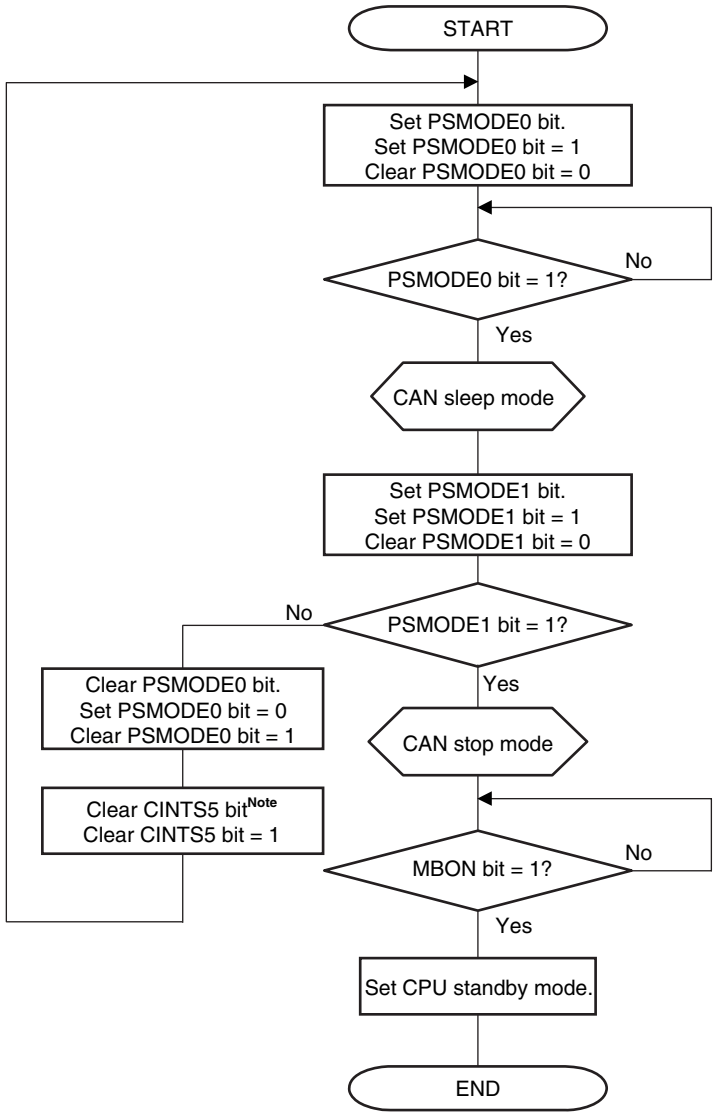


Figure 20-59. Setting CPU Standby (from CAN Sleep Mode)



Note Check if the CPU is in the CAN sleep mode before setting it to the standby mode. The CAN sleep mode may be released by wakeup after it is checked if the CPU is in the CAN sleep mode and before the CPU is set in the standby mode.

Figure 20-60. Setting CPU Standby (from CAN Stop Mode)



Note During wakeup interrupts

Caution The CAN stop mode can only be released by writing 01 to the C0CTRL.PSMODE1 and C0CTRL.PSMODE0 bits. The CAN stop mode cannot be released by changing the CAN bus.

CHAPTER 21 USB FUNCTION CONTROLLER (USBF)

The V850ES/JG3-H and V850ES/JH3-H have an internal USB function controller (USBF) conforming to the Universal Serial Bus Specification. Data communication using the polling method is performed between the USB function controller and external host device by using a token-based protocol.

21.1 Overview

- Conforms to the Universal Serial Bus Specification
- Supports 12 Mbps (full-speed) transfer
- Endpoint for transfer incorporated

Endpoint Name	FIFO Size (Bytes)	Transfer Type	Remark
Endpoint0 Read	64	Control transfer	–
Endpoint0 Write	64	Control transfer	–
Endpoint1	64 × 2	Bulk 1 transfer (IN)	2-buffer configuration
Endpoint2	64 × 2	Bulk 1 transfer (OUT)	2-buffer configuration
Endpoint3	64 × 2	Bulk 2 transfer (IN)	2-buffer configuration
Endpoint4	64 × 2	Bulk 2 transfer (OUT)	2-buffer configuration
Endpoint7	8	Interrupt transfer	–

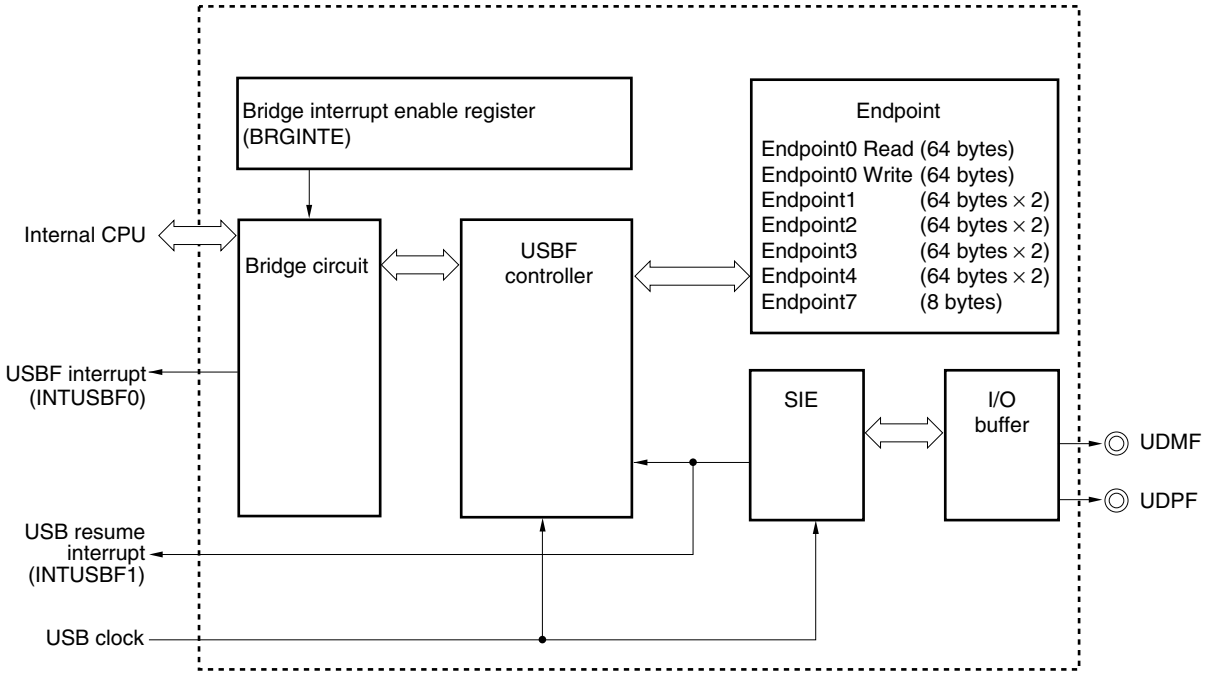
- Bulk transfer (IN/OUT) can be executed as DMA transfer (2-cycle single-transfer mode)
- Clock: Internal clock (6 MHz external clock × internal clock multiplied by 8 = 48 MHz internal clock) or external clock (external clock input to UCLK pin (f_{USB} = 48 MHz)) selectable

Caution The registers listed in 21.6.2 USB function controller register list must be accessed after specifying that the internal clock or the external clock is to be used as the USB clock and supplying clock to the USB function controller.

21.2 Configuration

21.2.1 Block diagram

Figure 21-1. Block Diagram of USB Function Controller



Remarks 1. Inside broken lines: These functions are included in the USB function controller.

2. n = 0, 1

21.2.2 USB memory map

The USB function controller seen from the CPU is assigned to the CS1 space in the microcontroller. The memory space is divided for use as follows.

Table 21-1. Division of CPU Memory Space

Address	Area	
00200000H to 00200092H	EPC control register area	
00200100H to 00200114H	EPC data hold register area	
00200144H to 002003C4H	EPC request data register area	
00200400H to 00200408H	Bridge register area	
00200500H to 0020050EH	DMA register area	
00201000H	Bulk-in register area	EP1 (Bulk-IN1)
00202000H		EP3 (Bulk-IN2)
00210000H	Bulk-out register area	EP2 (Bulk-Out1)
00220000H		EP4 (Bulk-Out2)
00240000H	Peripheral control register area	

21.3 External Circuit Configuration

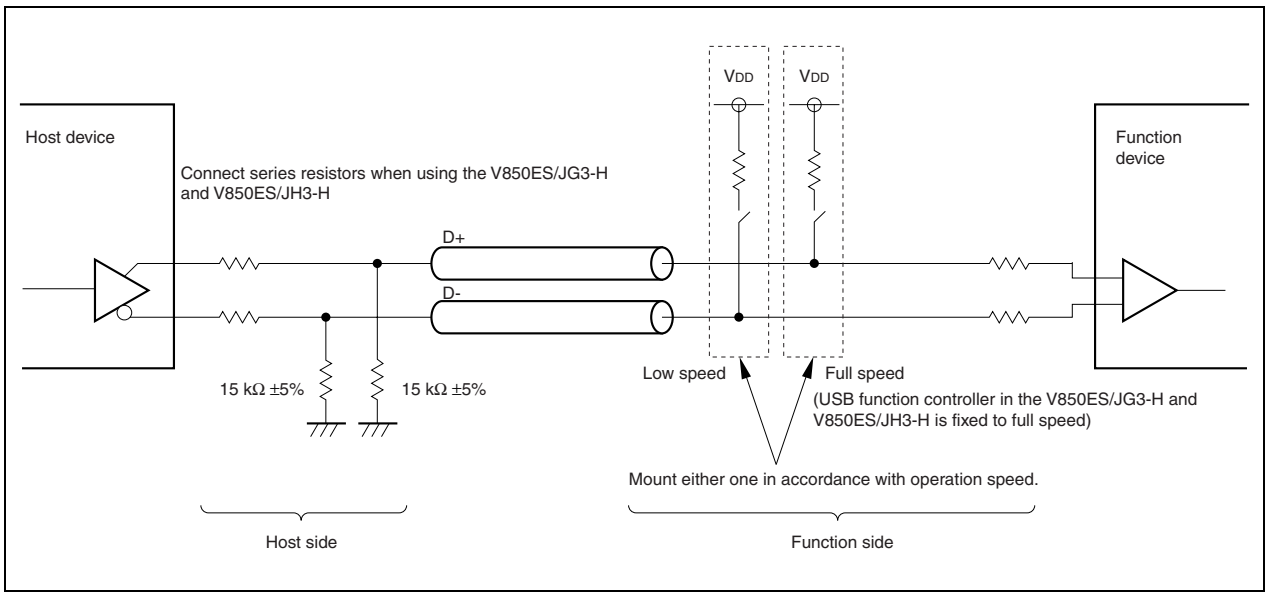
21.3.1 Outline

In USB transmission, when communication is performed with the host controller and function controller facing each other, pull-up/pull-down resistors must be connected to the USB signal (D+/D–) to identify the communication partner. Moreover in the V850ES/JG3-H and V850ES/JH3-H, series resistors must also be connected.

Because the V850ES/JG3-H and V850ES/JH3-H do not include these pull-up/pull-down resistors and series resistors, be sure to connect them externally.

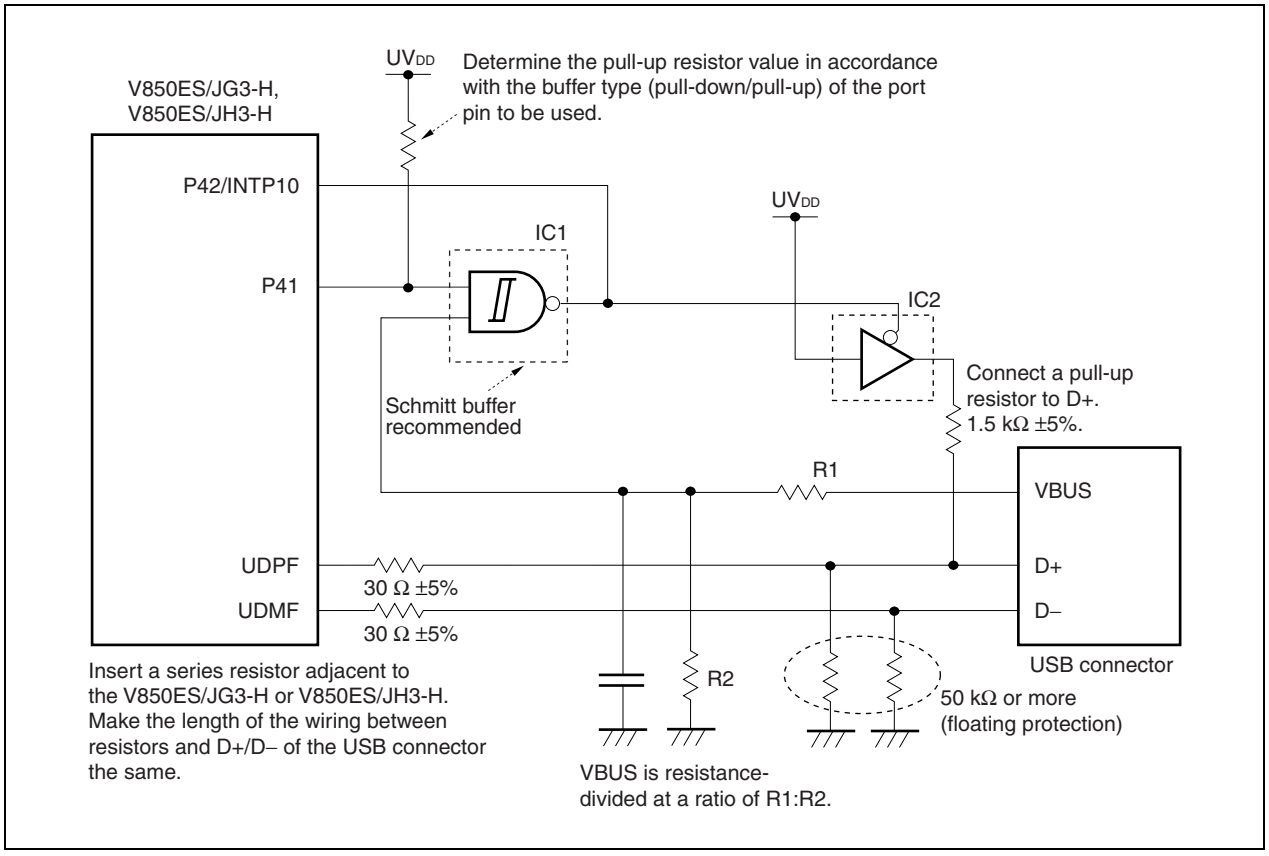
The following shows the outline configuration of the USB transmission line. For details of the external configuration, see the description provided in each section.

Figure 21-2. Outline Configuration of Pull-up, Pull-down, Series Resistors in USB Transmission Line



21.3.2 Connection configuration

Figure 21-3. Example of USB Function Controller Connection



(1) Series resistor connection to D+/D–

Connect series resistors of 30 Ω ±5% to the D+/D– pins (UFDP, UFDM) of the USB function controller in the V850ES/JG3-H and V850ES/JH3-H. If they are not connected, the impedance rating cannot be satisfied and the output waveform may be disturbed.

Allocate the series resistors adjacent to the V850ES/JG3-H or V850ES/JH3-H, and make the length of the wiring between the series resistors and the USB connectors the same, to make the impedance of D+ and D– equal (a differential with 90 Ω ±5% is recommended).

(2) Pull-up control of D+

Because the function controller of the V850ES/JG3-H and V850ES/JH3-H is fixed to full speed (FS), be sure to pull up the D+ pin (UFDP) by 1.5 kΩ ±5% to UV_{DD}.

To disable a connection report (D+ pull up) to the USB host/HUB (such as during high priority servicing or initialization), control the pull-up resistor of D+ via a general-purpose port in the system. For a circuit such as the one shown in Figure 21-3, control the pull-up control signal and the VBUS input signal of the D+ pin by using a general-purpose port and the USB cable VBUS (AND circuit). In Figure 21-3, if the general-purpose port is low level, pulling up of D+ is prohibited.

For the IC2 in Figure 21-3, use an IC to which voltage can be applied when the system power is off.

(3) Detection of USB cable connection/disconnection

The USB function controller (USBF) requires a VBUS input signal to recognize whether the USB cable is connected or disconnected, because the state of the USBF is controlled by hardware. The voltage from the USB host or HUB (5 V) is applied as the VBUS input signal when the USB cable VBUS is connected to the USB host or HUB while the USBF power is off. Therefore, for IC1 in Figure 21-3, use an IC to which voltage can be applied when the system power is off. When disconnecting the USB cable in the circuit in Figure 21-3, the input signal to INTP10 may be unstable while the VBUS voltage is dropping. It is therefore recommended to use a Schmitt buffer for IC1 in Figure 21-3.

(4) Floating protection during initialization or when USBF is unused

When the USB function controller is initialized or unused, to avoid a floating status, pull the D+/D− pins down using a resistor of 50 kΩ or higher.

21.4 Cautions

(1) Clock accuracy

To operate the USB function controller, the internal clock (6 MHz external clock × internal clock multiplied by 8 = 48 MHz internal clock) or external clock (external clock input to UCLK pin (f_{USB} = 48 MHz)) must be used as the USB clock. When the internal clock is used as the USB clock, use a resonator with an accuracy of 6 MHz ±500 ppm (max.). When the external clock is used, apply a clock with an accuracy of 48 MHz ±500 ppm (max.) to the UCLK pin. If the USB clock accuracy drops, the transmission data cannot satisfy the USB rating.

(2) Stopping the USB clock

When the main clock (f_{XX}) has been selected as the USB function controller clock and it is necessary to stop the USB function controller, be sure to stop the USB function controller (by setting bits 1 and 0 of the UFCKMSK register to 1) first before stopping the main clock (f_{XX}).

If the main clock (f_{XX}) is stopped without first stopping the USB function controller, a malfunction might occur due to noise in the clock pulse when the main clock (f_{XX}) is restarted.

Similarly, when an external clock whose signal is input from the EXCLK pin is selected as the USB function controller clock, measures must be taken to prevent noise from being generated in the clock pulse by the external circuit. If this is not feasible, then the USB function controller must be stopped first before stopping the main clock (f_{XX}).

21.5 Requests

The USB standard has a request command that reports requests from the host device to the function device to execute response processing.

The requests are received in the SETUP stage of control transfer, and most can be automatically processed via the hardware of the USB function controller (USBF).

21.5.1 Automatic requests

(1) Decode

The following tables show the request format and the correspondence between requests and decoded values.

Table 21-2. Request Format

Offset	Field Name	
0	bmRequestType	
1	bRequest	
2	wValue	Lower side
3		Higher side
4	wIndex	Lower side
5		Higher side
6	wLength	Lower side
7		Higher side

Table 21-3. Correspondence Between Requests and Decoded Values

Offset / Request	Decoded Value								Response			Data Stage
	bmRequestType	bRequest	wValue		wIndex		wLength		Df	Ad	Cf	
	0	1	3	2	5	4	7	6				
GET_INTERFACE	81H	0AH	00H	00H	00H	0nH	00H	01H	STALL	STALL	ACK NAK	√
GET_CONFIGURATION	80H	08H	00H	00H	00H	00H	00H	01H	ACK NAK	ACK NAK	ACK NAK	√
GET_DESCRIPTOR Device	80H	06H	01H	00H	00H	00H	XXH	XXH[Note 1]	ACK NAK	ACK NAK	ACK NAK	√
GET_DESCRIPTOR Configuration	80H	06H	02H	00H	00H	00H	XXH	XXH[Note 1]	ACK NAK	ACK NAK	ACK NAK	√
GET_STATUS Device	80H	00H	00H	00H	00H	00H	00H	02H	ACK NAK	ACK NAK	ACK NAK	√
GET_STATUS Endpoint 0	82H	00H	00H	00H	00H	00H 80H	00H	02H	ACK NAK	ACK NAK	ACK NAK	√
GET_STATUS Endpoint X	82H	00H	00H	00H	00H	$$H	00H	02H	STALL	STALL	ACK NAK	√
CLEAR_FEATURE Device[Note 2]	00H	01H	00H	01H	00H	00H	00H	00H	ACK NAK	ACK NAK	ACK NAK	×
CLEAR_FEATURE Endpoint 0[Note 2]	02H	01H	00H	00H	00H	00H 80H	00H	00H	ACK NAK	ACK NAK	ACK NAK	×
CLEAR_FEATURE Endpoint X[Note 2]	02H	01H	00H	00H	00H	$$H	00H	00H	STALL	STALL	ACK NAK	×
SET_FEATURE Device[Note 3]	00H	03H	00H	01H	00H	00H	00H	00H	ACK NAK	ACK NAK	ACK NAK	×
SET_FEATURE Endpoint 0[Note 3]	02H	03H	00H	00H	00H	00H 80H	00H	00H	ACK NAK	ACK NAK	ACK NAK	×
SET_FEATURE Endpoint X[Note 3]	02H	03H	00H	00H	00H	$$H	00H	00H	STALL	STALL	ACK NAK	×
SET_INTERFACE	01H	0BH	00H	0#H	00H	0?H	00H	00H	STALL	STALL	ACK NAK	×
SET_CONFIGURATION[Note 4]	00H	09H	00H	00H 01H	00H	00H	00H	00H	ACK NAK	ACK NAK	ACK NAK	×
SET_ADDRESS	00H	05H	XXH	XXH	00H	00H	00H	00H	ACK NAK	ACK NAK	ACK NAK	×

Remark √: Data stage
×: No data stage

Notes 1. If the wLength value is lower than the prepared value, the wLength value is returned; if the wLength value is the prepared value or higher, the prepared value is returned.

2. The CLEAR_FEATURE request clears UF0 device status register L (UF0DSTL) and UF0 EPn status register L (UF0EnSL) (n = 0 to 4, 7) when ACK is received in the status stage.

Notes 3. The SET_FEATURE request sets the UF0 device status register L (UF0DSTL) and UF0 EPn status register L (UF0EnSL) (n = 0 to 4, 7) when ACK is received in the status stage. If the E0HALT bit of the UF0E0SL register is set, a STALL response is made in the status stage or data stage of control transfer for a request other than the GET_STATUS Endpoint0 request, SET_FEATURE Endpoint0 request, and a request generated by the CPUDEC interrupt request, until the CLEAR_FEATURE Endpoint0 request is received. A STALL response to an unsupported request does not set the E0HALT bit of the UF0E0SL register to 1, and the STALL response is cleared as soon as the next SETUP token has been received.

4. If the wValue is not the default value, an automatic STALL response is made.

Cautions 1. The sequence of control transfer defined by the Universal Serial Bus Specification is not satisfied under the following conditions. The operation is not guaranteed under these conditions.

- **If an IN/OUT token is suddenly received without a SETUP stage**
- **If DATA PID1 is sent in the data phase of the SETUP stage**
- **If a token of 128 addresses or more is received**
- **If the request data transmitted in the SETUP stage is of less than 8 bytes**

2. An ACK response is made even when the host transmits data other than a Null packet in the status stage.

3. If the wLength value is 00H during control transfer (read) of FW processing, a Null packet is automatically transmitted for control transfer (without data). The FW request does not automatically transmit a Null packet.

Remarks 1. Df: Default state, Ad: Addressed state, Cf: Configured state

2. n = 0 to 4

It is determined by the setting of the UF0 active interface number register (UF0AIFN) whether a request with Interface number 1 to 4 is correctly responded to, depending on whether the Interface number of the target is valid or not.

3. $$: Valid endpoint number including transfer direction

The valid endpoint is determined by the currently set Alternate Setting number (see **21.6.3 (36) UF0 active alternative setting register (UF0AAS)**, **(38) UF0 endpoint 1 interface mapping register (UF0E1IM)** to **(42) UF0 endpoint 7 interface mapping register (UF0E7IM)**).

4. ? and #: Value transmitted from host (information on Interface numbers 0 to 4)

It is determined by the UF0 active interface number register (UF0AIFN) and UF0 active alternative setting register (UF0AAS) whether an Alternate Setting request corresponding to each Interface number is correctly responded to or not, depending on whether the Interface number and Alternate Setting of the target are valid or not.

(2) Processing

The processing of an automatic request in the Default state, Addressed state, and Configured state is described below.

Remark Default state: State in which an operation is performed with the Default address
Addressed state: State after an address has been allocated
Configured state: State after SET_CONFIGURATION wValue = 1 has been correctly received

(a) CLEAR_FEATURE() request

A STALL response is made in the status stage if the CLEAR_FEATURE() request cannot be cleared, if FEATURE does not exist, or if the target is an interface or an endpoint that does not exist. A STALL response is also made if the wLength value is other than 0.

- Default state: The correct response is made when the CLEAR_FEATURE() request has been received only if the target is a device or a request for Endpoint0; otherwise a STALL response is made in the status stage.
- Addressed state: The correct response is made when the CLEAR_FEATURE() request has been received only if the target is a device or a request for Endpoint0; otherwise a STALL response is made in the status stage.
- Configured state: The correct response is made when the CLEAR_FEATURE() request has been received only if the target is a device or a request for an endpoint that exists; otherwise a STALL response is made in the status stage.

When the CLEAR_FEATURE() request has been correctly processed, the corresponding bit of the UF0 CLR request register (UF0CLR) is set to 1, the EnHALT bit of the UF0 EPn status register L (UF0EnSL) is cleared to 0, and an interrupt is issued (n = 0 to 4, 7). If the CLEAR_FEATURE() request is received when the subject is an endpoint, the toggle bit (that controls switching between DATA0 and DATA1) of the corresponding endpoint is always re-set to DATA0.

(b) GET_CONFIGURATION() request

A STALL response is made in the data stage if any of wValue, wIndex, or wLength is other than the values shown in Table 21-3.

- Default state: The value stored in the UF0 configuration register (UF0CNF) is returned when the GET_CONFIGURATION() request has been received.
- Addressed state: The value stored in the UF0CNF register is returned when the GET_CONFIGURATION() request has been received.
- Configured state: The value stored in the UF0CNF register is returned when the GET_CONFIGURATION() request has been received.

(c) GET_DESCRIPTOR() request

If the subject descriptor has a length that is a multiple of wMaxPacketSize, a Null packet is returned to indicate the end of the data stage. If the length of the descriptor at this time is less than the wLength value, the entire descriptor is returned; if the length of the descriptor is greater than the wLength value, the descriptor up to the wLength value is returned.

- Default state: The value stored in UF0 device descriptor register n (UF0DDn) and UF0 configuration/interface/endpoint descriptor register m (UF0CIEm) is returned (n = 0 to 17, m = 0 to 255) when the GET_DESCRIPTOR() request has been received.
- Addressed state: The value stored in the UF0DDn register and UF0CIEm register is returned when the GET_DESCRIPTOR() request has been received.
- Configured state: The value stored in the UF0DDn register and UF0CIEm register is returned when the GET_DESCRIPTOR() request has been received.

A descriptor of up to 256 bytes can be stored in the UF0CIEm register. To return a descriptor of more than 256 bytes, set the CDCGDST bit of the UF0MODC register to 1 and process the GET_DESCRIPTOR() request by FW.

Store the value of the total number of bytes of the descriptor set by the UF0CIEm register – 1 in the UF0 descriptor length register (UF0DSCL). The transfer data is controlled by the value of this data + 1 and wLength.

(d) GET_INTERFACE() request

If either of wValue and wLength is other than that shown in Table 21-3, or if wIndex is other than that set by the UF0 active interface number register (UF0AIFN), a STALL response is made in the data stage.

- Default state: A STALL response is made in the data stage when the GET_INTERFACE() request has been received.
- Addressed state: A STALL response is made in the data stage when the GET_INTERFACE() request has been received.
- Configured state: The value stored in the UF0 interface n register (UF0IFn) corresponding to the wIndex value is returned (n = 0 to 4) when the GET_INTERFACE() request has been received.

(e) GET_STATUS() request

A STALL response is made in the data stage if any of wValue, wIndex, or wLength is other than the values shown in Table 21-3. A STALL response is also made in the data stage if the target is an interface or an endpoint that does not exist.

- Default state: The value stored in the target status register[Note] is returned only when the GET_STATUS() request has been received and when the request is for a device or Endpoint0; otherwise a STALL response is made in the data stage.
- Addressed state: The value stored in the target status register[Note] is returned only when the GET_STATUS() request has been received and when the request is for a device or Endpoint0; otherwise a STALL response is made in the data stage.
- Configured state: The value stored in the target status register[Note] is returned only when the GET_STATUS() request has been received and when the request is for a device or an endpoint that exists; otherwise a STALL response is made in the data stage.

Note The target status register is as follows.
- If the target is a device: UF0 device status register L (UF0DSTL)
- If the target is endpoint 0: UF0 EP0 status register L (UF0E0SL)
- If the target is endpoint n: UF0 EPn status register L (UF0EnSL) (n = 1 to 4, 7)

(f) SET_ADDRESS() request

A STALL response is made in the status stage if either of wIndex or wLength is other than the values shown in Table 21-3. A STALL response is also made if the specified device address is greater than 127.

- Default state: The device enters the Addressed state and changes the USB Address value to be input to SIE into a specified address value if the specified address is other than 0 when the SET_ADDRESS() request has been received. If the specified address is 0, the device remains in the Default state.
- Addressed state: The device enters the Default state and returns the USB Address value to be input to SIE to the default address if the specified address is 0 when the SET_ADDRESS() request has been received. If the specified address is other than 0, the device remains in the Addressed state, and changes the USB Address value to be input to SIE into a specified new address value.
- Configured state: The device remains in the Configured state and returns the USB Address value to be input to SIE to the default address if the specified address is 0 when the SET_ADDRESS() request has been received. In this case, the endpoints other than endpoint 0 remain valid, and control transfer (IN), control transfer (OUT), bulk transfer and interrupt transfer for an endpoint other than endpoint 0 are also acknowledged. If the specified address is other than 0, the device remains in the Configured state and changes the USB Address value to be input to SIE into a specified new address value.

(g) SET_CONFIGURATION() request

If any of wValue, wIndex, or wLength is other than the values shown in Table 21-3, a STALL response is made in the status stage.

- Default state: The CONF bit of the UF0 mode status register (UF0MODS) and the UF0 configuration register (UF0CNF) are set to 1 if the specified configuration value is 1 when the SET_CONFIGURATION() request has been received. If the specified configuration value is 0, the CONF bit of the UF0MODS register and UF0CNF register are cleared to 0. In other words, the device skips the Addressed state and moves to the Configured state in which it responds to the Default address.
- Addressed state: The CONF bit of the UF0MODS register and UF0CNF register are set to 1 and the device enters the Configured state if the specified configuration value is 1 when the SET_CONFIGURATION() request has been received. If the specified configuration value is 0, the device remains in the Addressed state.
- Configured state: The CONF bit of the UF0MODS register and UF0CNF register are set to 1 and the device returns to the Addressed state if the specified configuration value is 0 when the SET_CONFIGURATION() request has been received. If the specified configuration value is 1, the device remains in the Configured state.

If the SET_CONFIGURATION() request has been correctly processed, the target bit of the UF0 SET request register (UF0SET) is set to 1, and an interrupt is issued. All Halt Features are cleared after the SET_CONFIGURATION() request has been completed even if the specified configuration value is the same as the current configuration value. If the SET_CONFIGURATION() request has been correctly processed, the data toggle of all endpoints is always initialized to DATA0 again (it is defined that the default status, Alternative Setting 0, is set from when the SET_CONFIGURATION request is received to when the SET_INTERFACE request is received).

(h) SET_FEATURE() request

A STALL response is made in the status stage if the SET_FEATURE() request is for a Feature that cannot be set or does not exist, or if the target is an interface or an endpoint that does not exist. A STALL response is also made if the wLength value is other than 0.

- Default state: The correct response is made when the SET_FEATURE() request has been received, only if the request is for a device or Endpoint0; otherwise a STALL response is made in the status stage.
- Addressed state: The correct response is made when the SET_FEATURE() request has been received, only if the request is for a device or Endpoint0; otherwise a STALL response is made in the status stage.
- Configured state: The correct response is made when the SET_FEATURE() request has been received, only if the request is for a device or an endpoint that exists; otherwise a STALL response is made in the status stage.

When the SET_FEATURE() request has been correctly processed, the target bit of the UF0 SET request register (UF0SET) and the EnHALT bit of the UF0 EPn status register L (UF0EnSL) are set to 1, and an interrupt is issued (n = 0 to 4, 7).

(i) SET_INTERFACE() request

If wLength is other than the values shown in Table 21-3, if wIndex is other than the value set to the UF0 active interface number register (UF0AIFN), or if wValue is other than the value set to the UF0 active alternative setting register (UF0AAS), a STALL response is made in the status stage.

- Default state: A STALL response is made in the status stage when the SET_INTERFACE() request has been received.
- Addressed state: A STALL response is made in the status stage when the SET_INTERFACE() request has been received.
- Configured state: Null packet is transmitted in the status stage when the SET_INTERFACE() request has been received.

When the SET_INTERFACE() request has been correctly processed, an interrupt is issued. All the Halt Features of the endpoint linked to the target Interface are cleared after the SET_INTERFACE() request has been cleared. The data toggle of all the endpoints related to the target Interface number is always initialized again to DATA0. When the currently selected Alternative Setting is to be changed by correctly processing the SET_INTERFACE() request, the FIFO of the endpoint that is affected is completely cleared, and all the related interrupt sources are also initialized.

When the SET_INTERFACE() request has been completed, the FIFO of all the endpoints linked to the target Interface are cleared. At the same time, Halt Feature and Data PID are initialized, and the related UF0 INT status n register (UF0ISn) is cleared to 0 (n = 0 to 4). (Only Halt Feature and Data PID are cleared when the SET_CONFIGURATION request has been completed.)

If the target Endpoint is not supported by the SET_INTERFACE() request during DMA transfer, the DMA request signal is immediately deasserted, and the FIFO of the Endpoint that has been linked when the SET_INTERFACE() request has been completed is completely cleared. As a result of this clearing of the FIFO, data transferred by DMA is not correctly processed.

21.5.2 Other requests

(1) Response and processing

The following table shows how other requests are responded to and processed.

Table 21-4. Response and Processing of Other Requests

Request	Response and Processing
GET_DESCRIPTOR String	Generation of CPUDEC interrupt request
GET_STATUS Interface	Automatic STALL response
CLEAR_FEATURE Interface	Automatic STALL response
SET_FEATURE Interface	Automatic STALL response
all SET_DESCRIPTOR	Generation of CPUDEC interrupt request
All other requests	Generation of CPUDEC interrupt request

21.6 Register Configuration

21.6.1 USB control registers

(1) USB clock select register (UCKSEL)

The UCKSEL register selects the operation clock of the USB controller.

The UCKSEL register can be read or written in 8-bit or 1-bit units.

Reset sets this register to 00H.

After reset: 00H R/W Address: FFFFFF40H

	7	6	5	4	3	2	1	0
UCKSEL	0	0	0	0	0	0	UUSEL1	0

UUSEL1	Selection of USB controller operation clock
0	External clock input from UCLK pin (f_{USB} = 48 MHz)
1	Main clock (f_{XX} = 48 MHz)

Caution Be sure to set bits 7 to 2, and 0 to "0".

(2) USB function control register (UFCKMSK)

The UFCKMSK register controls enable/disable of USB function controller operation.

The UFCKMSK register can be read or written in 8-bit or 1-bit units.

Reset sets this register to 03H.

After reset: 03H R/W Address: FFFFFF41H

	7	6	5	4	3	2	1	0
UFCKMSK	0	0	0	0	0	0	UFBUFMSK	UFMSK

UFBUFMSK	UFMSK	USB function controller operation enable/stop
0	0	Operation enabled
0	1	Operation stopped (set while USB is suspended)
1	1	Operation stopped
Other than above		Setting prohibited

(3) USB function select register (UHCKMSK)

The UHCKMSK register controls the operation of the data-only RAM when the USB controller function is used.

Even when the USB function controller is not being used, the data-only RAM can be used by setting the UHCKMSK register.

The UHCKMSK register can be read or written in 8-bit or 1-bit units.

Reset sets this register to 03H.

After reset: 03H R/W Address: FFFFFF42H

	7	6	5	4	3	2	1	0
UHCKMSK	0	0	0	0	0	0	1	UHMSK

UHMSK	USB controller function selection
0	Data-only RAM (8 KB) operation enabled
1	Use of USB host controller/data-only RAM (8 KB) disabled

Caution Be sure to set bits 7 to 2 to “0”, and bit 1 to “1”.

21.6.2 USB function controller register list

(1) EPC control register

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Address	Function Register Name	Symbol	R/W	Manipulatable Bits			Default Value
				1	8	16	
00200000H	UF0 EP0NAK register	UF0E0N	R/W		√		00H
00200002H	UF0 EP0NAKALL register	UF0E0NA	R/W		√		00H
00200004H	UF0 EPNAK register	UF0EN	R/W		√		00H
00200006H	UF0 EPNAK mask register	UF0ENM	R/W		√		00H
00200008H	UF0 SNDSIE register	UF0SDS	R/W		√		00H
0020000AH	UF0 CLR request register	UF0CLR	R		√		00H
0020000CH	UF0 SET request register	UF0SET	R		√		00H
0020000EH	UF0 EP status 0 register	UF0EPS0	R		√		00H
00200010H	UF0 EP status 1 register	UF0EPS1	R		√		00H
00200012H	UF0 EP status 2 register	UF0EPS2	R		√		00H
00200020H	UF0 INT status 0 register	UF0IS0	R		√		00H
00200022H	UF0 INT status 1 register	UF0IS1	R		√		00H
00200024H	UF0 INT status 2 register	UF0IS2	R		√		00H
00200026H	UF0 INT status 3 register	UF0IS3	R		√		00H
00200028H	UF0 INT status 4 register	UF0IS4	R		√		00H
0020002EH	UF0 INT mask 0 register	UF0IM0	R/W		√		00H
00200030H	UF0 INT mask 1 register	UF0IM1	R/W		√		00H
00200032H	UF0 INT mask 2 register	UF0IM2	R/W		√		00H
00200034H	UF0 INT mask 3 register	UF0IM3	R/W		√		00H
00200036H	UF0 INT mask 4 register	UF0IM4	R/W		√		00H
0020003CH	UF0 INT clear 0 register	UF0IC0	W		√		FFH
0020003EH	UF0 INT clear 1 register	UF0IC1	W		√		FFH
00200040H	UF0 INT clear 2 register	UF0IC2	W		√		FFH
00200042H	UF0 INT clear 3 register	UF0IC3	W		√		FFH
00200044H	UF0 INT clear 4 register	UF0IC4	W		√		FFH
0020004CH	UF0 INT & DMARQ register	UF0IDR	R/W		√		00H
0020004EH	UF0 DMA status 0 register	UF0DMS0	R		√		00H
00200050H	UF0 DMA status 1 register	UF0DMS1	R		√		00H
00200060H	UF0 FIFO clear 0 register	UF0FIC0	W		√		00H
00200062H	UF0 FIFO clear 1 register	UF0FIC1	W		√		00H
0020006AH	UF0 data end register	UF0DEND	R/W		√		00H
0020006EH	UF0 GPR register	UF0GPR	W		√		00H
00200074H	UF0 mode control register	UF0MODC	R/W		√		00H
00200078H	UF0 mode status register	UF0MODS	R		√		00H

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Address	Function Register Name	Symbol	R/W	Manipulatable Bits			Default Value
				1	8	16	
00200080H	UF0 active interface number register	UF0AIFN	R/W		√		00H
00200082H	UF0 active alternative setting register	UF0AAS	R/W		√		00H
00200084H	UF0 alternative setting status register	UF0ASS	R		√		00H
00200086H	UF0 endpoint 1 interface mapping register	UF0E1IM	R/W		√		00H
00200088H	UF0 endpoint 2 interface mapping register	UF0E2IM	R/W		√		00H
0020008AH	UF0 endpoint 3 interface mapping register	UF0E3IM	R/W		√		00H
0020008CH	UF0 endpoint 4 interface mapping register	UF0E4IM	R/W		√		00H
00200092H	UF0 endpoint 7 interface mapping register	UF0E7IM	R/W		√		00H

(2) EPC data hold register

Address	Function Register Name	Symbol	R/W	Manipulatable Bits			Default Value
				1	8	16	
00200100 H	UF0 EP0 read register	UF0E0R	R		√		Undefined
00200102H	UF0 EP0 length register	UF0E0L	R		√		00H
00200104H	UF0 EP0 setup register	UF0E0ST	R		√		00H
00200106H	UF0 EP0 write register	UF0E0W	W		√		Undefined
00200108H	UF0 bulk-out 1 register	UF0BO1	R		√		Undefined
0020010AH	UF0 bulk-out 1 length register	UF0BO1L	R		√		00H
0020010CH	UF0 bulk-out 2 register	UF0BO2	R		√		Undefined
0020010EH	UF0 bulk-out 2 length register	UF0BO2L	R		√		00H
00200110H	UF0 bulk-in 1 register	UF0BI1	W		√		Undefined
00200112H	UF0 bulk-in 2 register	UF0BI2	W		√		Undefined
00200114H	UF0 interrupt 1 register	UF0INT1	W		√		Undefined

(3) EPC request data register

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Address	Function Register Name	Symbol	R/W	Manipulatable Bits			Default Value
				1	8	16	
00200144H	UF0 device status register L	UF0DSTL	R/W		√		00H
0020014CH	UF0 EP0 status register L	UF0E0SL	R/W		√		00H
00200150H	UF0 EP1 status register L	UF0E1SL	R/W		√		00H
00200154H	UF0 EP2 status register L	UF0E2SL	R/W		√		00H
00200158H	UF0 EP3 status register L	UF0E3SL	R/W		√		00H
0020015CH	UF0 EP4 status register L	UF0E4SL	R/W		√		00H
00200168H	UF0 EP7 status register L	UF0E7SL	R/W		√		00H
00200180H	UF0 address register	UF0ADRS	R		√		00H
00200182H	UF0 configuration register	UF0CNF	R		√		00H
00200184H	UF0 interface 0 register	UF0IF0	R		√		00H
00200186H	UF0 interface 1 register	UF0IF1	R		√		00H
00200188H	UF0 interface 2 register	UF0IF2	R		√		00H
0020018AH	UF0 interface 3 register	UF0IF3	R		√		00H
0020018CH	UF0 interface 4 register	UF0IF4	R		√		00H
002001A0H	UF0 descriptor length register	UF0DSCL	R/W		√		00H
002001A2H	UF0 device descriptor register 0	UF0DD0	R/W		√		Undefined
002001A4H	UF0 device descriptor register 1	UF0DD1	R/W		√		Undefined
002001A6H	UF0 device descriptor register 2	UF0DD2	R/W		√		Undefined
002001A8H	UF0 device descriptor register 3	UF0DD3	R/W		√		Undefined
002001AAH	UF0 device descriptor register 4	UF0DD4	R/W		√		Undefined
002001ACH	UF0 device descriptor register 5	UF0DD5	R/W		√		Undefined
002001AEH	UF0 device descriptor register 6	UF0DD6	R/W		√		Undefined
002001B0H	UF0 device descriptor register 7	UF0DD7	R/W		√		Undefined
002001B2H	UF0 device descriptor register 8	UF0DD8	R/W		√		Undefined
002001B4H	UF0 device descriptor register 9	UF0DD9	R/W		√		Undefined
002001B6H	UF0 device descriptor register 10	UF0DD10	R/W		√		Undefined
002001B8H	UF0 device descriptor register 11	UF0DD11	R/W		√		Undefined
002001BAH	UF0 device descriptor register 12	UF0DD12	R/W		√		Undefined
002001BCH	UF0 device descriptor register 13	UF0DD13	R/W		√		Undefined
002001BEH	UF0 device descriptor register 14	UF0DD14	R/W		√		Undefined
002001C0H	UF0 device descriptor register 15	UF0DD15	R/W		√		Undefined
002001C2H	UF0 device descriptor register 16	UF0DD16	R/W		√		Undefined
002001C4H	UF0 device descriptor register 17	UF0DD17	R/W		√		Undefined
002001C6H	UF0 configuration/interface/endpoint descriptor register 0	UF0CIE0	R/W		√		Undefined
002001C8H	UF0 configuration/interface/endpoint descriptor register 1	UF0CIE1	R/W		√		Undefined
002001CAH	UF0 configuration/interface/endpoint descriptor register 2	UF0CIE2	R/W		√		Undefined
002001CCH	UF0 configuration/interface/endpoint descriptor register 3	UF0CIE3	R/W		√		Undefined

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Address	Function Register Name	Symbol	R/W	Manipulatable Bits			Default Value
				1	8	16	
002001CEH	UF0 configuration/interface/endpoint descriptor register 4	UF0CIE4	R/W		√		Undefined
002001D0H	UF0 configuration/interface/endpoint descriptor register 5	UF0CIE5	R/W		√		Undefined
002001D2H	UF0 configuration/interface/endpoint descriptor register 6	UF0CIE6	R/W		√		Undefined
002001D4H	UF0 configuration/interface/endpoint descriptor register 7	UF0CIE7	R/W		√		Undefined
002001D6H	UF0 configuration/interface/endpoint descriptor register 8	UF0CIE8	R/W		√		Undefined
002001D8H	UF0 configuration/interface/endpoint descriptor register 9	UF0CIE9	R/W		√		Undefined
002001DAH	UF0 configuration/interface/endpoint descriptor register 10	UF0CIE10	R/W		√		Undefined
002001DCH	UF0 configuration/interface/endpoint descriptor register 11	UF0CIE11	R/W		√		Undefined
002001DEH	UF0 configuration/interface/endpoint descriptor register 12	UF0CIE12	R/W		√		Undefined
002001E0H	UF0 configuration/interface/endpoint descriptor register 13	UF0CIE13	R/W		√		Undefined
002001E2H	UF0 configuration/interface/endpoint descriptor register 14	UF0CIE14	R/W		√		Undefined
002001E4H	UF0 configuration/interface/endpoint descriptor register 15	UF0CIE15	R/W		√		Undefined
002001E6H	UF0 configuration/interface/endpoint descriptor register 16	UF0CIE16	R/W		√		Undefined
002001E8H	UF0 configuration/interface/endpoint descriptor register 17	UF0CIE17	R/W		√		Undefined
002001EAH	UF0 configuration/interface/endpoint descriptor register 18	UF0CIE18	R/W		√		Undefined
002001ECH	UF0 configuration/interface/endpoint descriptor register 19	UF0CIE19	R/W		√		Undefined
002001EEH	UF0 configuration/interface/endpoint descriptor register 20	UF0CIE20	R/W		√		Undefined
002001F0H	UF0 configuration/interface/endpoint descriptor register 21	UF0CIE21	R/W		√		Undefined
002001F2H	UF0 configuration/interface/endpoint descriptor register 22	UF0CIE22	R/W		√		Undefined
002001F4H	UF0 configuration/interface/endpoint descriptor register 23	UF0CIE23	R/W		√		Undefined
002001F6H	UF0 configuration/interface/endpoint descriptor register 24	UF0CIE24	R/W		√		Undefined
002001F8H	UF0 configuration/interface/endpoint descriptor register 25	UF0CIE25	R/W		√		Undefined

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Address	Function Register Name	Symbol	R/W	Manipulatable Bits			Default Value
				1	8	16	
002001FAH	UF0 configuration/interface/endpoint descriptor register 26	UF0CIE26	R/W		√		Undefined
002001FCH	UF0 configuration/interface/endpoint descriptor register 27	UF0CIE27	R/W		√		Undefined
002001FEH	UF0 configuration/interface/endpoint descriptor register 28	UF0CIE28	R/W		√		Undefined
00200200H	UF0 configuration/interface/endpoint descriptor register 29	UF0CIE29	R/W		√		Undefined
00200202H	UF0 configuration/interface/endpoint descriptor register 30	UF0CIE30	R/W		√		Undefined
00200204H	UF0 configuration/interface/endpoint descriptor register 31	UF0CIE31	R/W		√		Undefined
00200206H	UF0 configuration/interface/endpoint descriptor register 32	UF0CIE32	R/W		√		Undefined
00200208H	UF0 configuration/interface/endpoint descriptor register 33	UF0CIE33	R/W		√		Undefined
0020020AH	UF0 configuration/interface/endpoint descriptor register 34	UF0CIE34	R/W		√		Undefined
0020020CH	UF0 configuration/interface/endpoint descriptor register 35	UF0CIE35	R/W		√		Undefined
0020020EH	UF0 configuration/interface/endpoint descriptor register 36	UF0CIE36	R/W		√		Undefined
00200210H	UF0 configuration/interface/endpoint descriptor register 37	UF0CIE37	R/W		√		Undefined
00200212H	UF0 configuration/interface/endpoint descriptor register 38	UF0CIE38	R/W		√		Undefined
00200214H	UF0 configuration/interface/endpoint descriptor register 39	UF0CIE39	R/W		√		Undefined
00200216H	UF0 configuration/interface/endpoint descriptor register 40	UF0CIE40	R/W		√		Undefined
00200218H	UF0 configuration/interface/endpoint descriptor register 41	UF0CIE41	R/W		√		Undefined
0020021AH	UF0 configuration/interface/endpoint descriptor register 42	UF0CIE42	R/W		√		Undefined
0020021CH	UF0 configuration/interface/endpoint descriptor register 43	UF0CIE43	R/W		√		Undefined
0020021EH	UF0 configuration/interface/endpoint descriptor register 44	UF0CIE44	R/W		√		Undefined
00200220H	UF0 configuration/interface/endpoint descriptor register 45	UF0CIE45	R/W		√		Undefined
00200222H	UF0 configuration/interface/endpoint descriptor register 46	UF0CIE46	R/W		√		Undefined
00200224H	UF0 configuration/interface/endpoint descriptor register 47	UF0CIE47	R/W		√		Undefined

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Address	Function Register Name	Symbol	R/W	Manipulatable Bits			Default Value
				1	8	16	
00200226H	UF0 configuration/interface/endpoint descriptor register 48	UF0CIE48	R/W		√		Undefined
00200228H	UF0 configuration/interface/endpoint descriptor register 49	UF0CIE49	R/W		√		Undefined
0020022AH	UF0 configuration/interface/endpoint descriptor register 50	UF0CIE50	R/W		√		Undefined
0020022CH	UF0 configuration/interface/endpoint descriptor register 51	UF0CIE51	R/W		√		Undefined
0020022EH	UF0 configuration/interface/endpoint descriptor register 52	UF0CIE52	R/W		√		Undefined
00200230H	UF0 configuration/interface/endpoint descriptor register 53	UF0CIE53	R/W		√		Undefined
00200232H	UF0 configuration/interface/endpoint descriptor register 54	UF0CIE54	R/W		√		Undefined
00200234H	UF0 configuration/interface/endpoint descriptor register 55	UF0CIE55	R/W		√		Undefined
00200236H	UF0 configuration/interface/endpoint descriptor register 56	UF0CIE56	R/W		√		Undefined
00200238H	UF0 configuration/interface/endpoint descriptor register 57	UF0CIE57	R/W		√		Undefined
0020023AH	UF0 configuration/interface/endpoint descriptor register 58	UF0CIE58	R/W		√		Undefined
0020023CH	UF0 configuration/interface/endpoint descriptor register 59	UF0CIE59	R/W		√		Undefined
0020023EH	UF0 configuration/interface/endpoint descriptor register 60	UF0CIE60	R/W		√		Undefined
00200240H	UF0 configuration/interface/endpoint descriptor register 61	UF0CIE61	R/W		√		Undefined
00200242H	UF0 configuration/interface/endpoint descriptor register 62	UF0CIE62	R/W		√		Undefined
00200244H	UF0 configuration/interface/endpoint descriptor register 63	UF0CIE63	R/W		√		Undefined
00200246H	UF0 configuration/interface/endpoint descriptor register 64	UF0CIE64	R/W		√		Undefined
00200248H	UF0 configuration/interface/endpoint descriptor register 65	UF0CIE65	R/W		√		Undefined
0020024AH	UF0 configuration/interface/endpoint descriptor register 66	UF0CIE66	R/W		√		Undefined
0020024CH	UF0 configuration/interface/endpoint descriptor register 67	UF0CIE67	R/W		√		Undefined
0020024EH	UF0 configuration/interface/endpoint descriptor register 68	UF0CIE68	R/W		√		Undefined
00200250H	UF0 configuration/interface/endpoint descriptor register 69	UF0CIE69	R/W		√		Undefined

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Address	Function Register Name	Symbol	R/W	Manipulatable Bits			Default Value
				1	8	16	
00200252H	UF0 configuration/interface/endpoint descriptor register 70	UF0CIE70	R/W		√		Undefined
00200254H	UF0 configuration/interface/endpoint descriptor register 71	UF0CIE71	R/W		√		Undefined
00200256H	UF0 configuration/interface/endpoint descriptor register 72	UF0CIE72	R/W		√		Undefined
00200258H	UF0 configuration/interface/endpoint descriptor register 73	UF0CIE73	R/W		√		Undefined
0020025AH	UF0 configuration/interface/endpoint descriptor register 74	UF0CIE74	R/W		√		Undefined
0020025CH	UF0 configuration/interface/endpoint descriptor register 75	UF0CIE75	R/W		√		Undefined
0020025EH	UF0 configuration/interface/endpoint descriptor register 76	UF0CIE76	R/W		√		Undefined
00200260H	UF0 configuration/interface/endpoint descriptor register 77	UF0CIE77	R/W		√		Undefined
00200262H	UF0 configuration/interface/endpoint descriptor register 78	UF0CIE78	R/W		√		Undefined
00200264H	UF0 configuration/interface/endpoint descriptor register 79	UF0CIE79	R/W		√		Undefined
00200266H	UF0 configuration/interface/endpoint descriptor register 80	UF0CIE80	R/W		√		Undefined
00200268H	UF0 configuration/interface/endpoint descriptor register 81	UF0CIE81	R/W		√		Undefined
0020026AH	UF0 configuration/interface/endpoint descriptor register 82	UF0CIE82	R/W		√		Undefined
0020026CH	UF0 configuration/interface/endpoint descriptor register 83	UF0CIE83	R/W		√		Undefined
0020026EH	UF0 configuration/interface/endpoint descriptor register 84	UF0CIE84	R/W		√		Undefined
00200270H	UF0 configuration/interface/endpoint descriptor register 85	UF0CIE85	R/W		√		Undefined
00200272H	UF0 configuration/interface/endpoint descriptor register 86	UF0CIE86	R/W		√		Undefined
00200274H	UF0 configuration/interface/endpoint descriptor register 87	UF0CIE87	R/W		√		Undefined
00200276H	UF0 configuration/interface/endpoint descriptor register 88	UF0CIE88	R/W		√		Undefined
00200278H	UF0 configuration/interface/endpoint descriptor register 89	UF0CIE89	R/W		√		Undefined
0020027AH	UF0 configuration/interface/endpoint descriptor register 90	UF0CIE90	R/W		√		Undefined
0020027CH	UF0 configuration/interface/endpoint descriptor register 91	UF0CIE91	R/W		√		Undefined

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Address	Function Register Name	Symbol	R/W	Manipulatable Bits			Default Value
				1	8	16	
0020027EH	UF0 configuration/interface/endpoint descriptor register 92	UF0CIE92	R/W		√		Undefined
00200280H	UF0 configuration/interface/endpoint descriptor register 93	UF0CIE93	R/W		√		Undefined
00200282H	UF0 configuration/interface/endpoint descriptor register 94	UF0CIE94	R/W		√		Undefined
00200284H	UF0 configuration/interface/endpoint descriptor register 95	UF0CIE95	R/W		√		Undefined
00200286H	UF0 configuration/interface/endpoint descriptor register 96	UF0CIE96	R/W		√		Undefined
00200288H	UF0 configuration/interface/endpoint descriptor register 97	UF0CIE97	R/W		√		Undefined
0020028AH	UF0 configuration/interface/endpoint descriptor register 98	UF0CIE98	R/W		√		Undefined
0020028CH	UF0 configuration/interface/endpoint descriptor register 99	UF0CIE99	R/W		√		Undefined
0020028EH	UF0 configuration/interface/endpoint descriptor register 100	UF0CIE100	R/W		√		Undefined
00200290H	UF0 configuration/interface/endpoint descriptor register 101	UF0CIE101	R/W		√		Undefined
00200292H	UF0 configuration/interface/endpoint descriptor register 102	UF0CIE102	R/W		√		Undefined
00200294H	UF0 configuration/interface/endpoint descriptor register 103	UF0CIE103	R/W		√		Undefined
00200296H	UF0 configuration/interface/endpoint descriptor register 104	UF0CIE104	R/W		√		Undefined
00200298H	UF0 configuration/interface/endpoint descriptor register 105	UF0CIE105	R/W		√		Undefined
0020029AH	UF0 configuration/interface/endpoint descriptor register 106	UF0CIE106	R/W		√		Undefined
0020029CH	UF0 configuration/interface/endpoint descriptor register 107	UF0CIE107	R/W		√		Undefined
0020029EH	UF0 configuration/interface/endpoint descriptor register 108	UF0CIE108	R/W		√		Undefined
002002A0H	UF0 configuration/interface/endpoint descriptor register 109	UF0CIE109	R/W		√		Undefined
002002A2H	UF0 configuration/interface/endpoint descriptor register 110	UF0CIE110	R/W		√		Undefined
002002A4H	UF0 configuration/interface/endpoint descriptor register 111	UF0CIE111	R/W		√		Undefined
002002A6H	UF0 configuration/interface/endpoint descriptor register 112	UF0CIE112	R/W		√		Undefined
002002A8H	UF0 configuration/interface/endpoint descriptor register 113	UF0CIE113	R/W		√		Undefined

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Address	Function Register Name	Symbol	R/W	Manipulatable Bits			Default Value
				1	8	16	
002002AAH	UF0 configuration/interface/endpoint descriptor register 114	UF0CIE114	R/W		√		Undefined
002002ACH	UF0 configuration/interface/endpoint descriptor register 115	UF0CIE115	R/W		√		Undefined
002002AEH	UF0 configuration/interface/endpoint descriptor register 116	UF0CIE116	R/W		√		Undefined
002002B0H	UF0 configuration/interface/endpoint descriptor register 117	UF0CIE117	R/W		√		Undefined
002002B2H	UF0 configuration/interface/endpoint descriptor register 118	UF0CIE118	R/W		√		Undefined
002002B4H	UF0 configuration/interface/endpoint descriptor register 119	UF0CIE119	R/W		√		Undefined
002002B6H	UF0 configuration/interface/endpoint descriptor register 120	UF0CIE120	R/W		√		Undefined
002002B8H	UF0 configuration/interface/endpoint descriptor register 121	UF0CIE121	R/W		√		Undefined
002002BAH	UF0 configuration/interface/endpoint descriptor register 122	UF0CIE122	R/W		√		Undefined
002002BCH	UF0 configuration/interface/endpoint descriptor register 123	UF0CIE123	R/W		√		Undefined
002002BEH	UF0 configuration/interface/endpoint descriptor register 124	UF0CIE124	R/W		√		Undefined
002002C0H	UF0 configuration/interface/endpoint descriptor register 125	UF0CIE125	R/W		√		Undefined
002002C2H	UF0 configuration/interface/endpoint descriptor register 126	UF0CIE126	R/W		√		Undefined
002002C4H	UF0 configuration/interface/endpoint descriptor register 127	UF0CIE127	R/W		√		Undefined
002002C6H	UF0 configuration/interface/endpoint descriptor register 128	UF0CIE128	R/W		√		Undefined
002002C8H	UF0 configuration/interface/endpoint descriptor register 129	UF0CIE129	R/W		√		Undefined
002002CAH	UF0 configuration/interface/endpoint descriptor register 130	UF0CIE130	R/W		√		Undefined
002002CCH	UF0 configuration/interface/endpoint descriptor register 131	UF0CIE131	R/W		√		Undefined
002002CEH	UF0 configuration/interface/endpoint descriptor register 132	UF0CIE132	R/W		√		Undefined
002002D0H	UF0 configuration/interface/endpoint descriptor register 133	UF0CIE133	R/W		√		Undefined
002002D2H	UF0 configuration/interface/endpoint descriptor register 134	UF0CIE134	R/W		√		Undefined
002002D4H	UF0 configuration/interface/endpoint descriptor register 135	UF0CIE135	R/W		√		Undefined

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Address	Function Register Name	Symbol	R/W	Manipulatable Bits			Default Value
				1	8	16	
002002D6H	UF0 configuration/interface/endpoint descriptor register 136	UF0CIE136	R/W		√		Undefined
002002D8H	UF0 configuration/interface/endpoint descriptor register 137	UF0CIE137	R/W		√		Undefined
002002DAH	UF0 configuration/interface/endpoint descriptor register 138	UF0CIE138	R/W		√		Undefined
002002DCH	UF0 configuration/interface/endpoint descriptor register 139	UF0CIE139	R/W		√		Undefined
002002DEH	UF0 configuration/interface/endpoint descriptor register 140	UF0CIE140	R/W		√		Undefined
002002E0H	UF0 configuration/interface/endpoint descriptor register 141	UF0CIE141	R/W		√		Undefined
002002E2H	UF0 configuration/interface/endpoint descriptor register 142	UF0CIE142	R/W		√		Undefined
002002E4H	UF0 configuration/interface/endpoint descriptor register 143	UF0CIE143	R/W		√		Undefined
002002E6H	UF0 configuration/interface/endpoint descriptor register 144	UF0CIE144	R/W		√		Undefined
002002E8H	UF0 configuration/interface/endpoint descriptor register 145	UF0CIE145	R/W		√		Undefined
002002EAH	UF0 configuration/interface/endpoint descriptor register 146	UF0CIE146	R/W		√		Undefined
002002ECH	UF0 configuration/interface/endpoint descriptor register 147	UF0CIE147	R/W		√		Undefined
002002EEH	UF0 configuration/interface/endpoint descriptor register 148	UF0CIE148	R/W		√		Undefined
002002F0H	UF0 configuration/interface/endpoint descriptor register 149	UF0CIE149	R/W		√		Undefined
002002F2H	UF0 configuration/interface/endpoint descriptor register 150	UF0CIE150	R/W		√		Undefined
002002F4H	UF0 configuration/interface/endpoint descriptor register 151	UF0CIE151	R/W		√		Undefined
002002F6H	UF0 configuration/interface/endpoint descriptor register 152	UF0CIE152	R/W		√		Undefined
002002F8H	UF0 configuration/interface/endpoint descriptor register 153	UF0CIE153	R/W		√		Undefined
002002FAH	UF0 configuration/interface/endpoint descriptor register 154	UF0CIE154	R/W		√		Undefined
002002FCH	UF0 configuration/interface/endpoint descriptor register 155	UF0CIE155	R/W		√		Undefined
002002FEH	UF0 configuration/interface/endpoint descriptor register 156	UF0CIE156	R/W		√		Undefined
00200300H	UF0 configuration/interface/endpoint descriptor register 157	UF0CIE157	R/W		√		Undefined

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Address	Function Register Name	Symbol	R/W	Manipulatable Bits			Default Value
				1	8	16	
00200302H	UF0 configuration/interface/endpoint descriptor register 158	UF0CIE158	R/W		√		Undefined
00200304H	UF0 configuration/interface/endpoint descriptor register 159	UF0CIE159	R/W		√		Undefined
00200306H	UF0 configuration/interface/endpoint descriptor register 160	UF0CIE160	R/W		√		Undefined
00200308H	UF0 configuration/interface/endpoint descriptor register 161	UF0CIE161	R/W		√		Undefined
0020030AH	UF0 configuration/interface/endpoint descriptor register 162	UF0CIE162	R/W		√		Undefined
0020030CH	UF0 configuration/interface/endpoint descriptor register 163	UF0CIE163	R/W		√		Undefined
0020030EH	UF0 configuration/interface/endpoint descriptor register 164	UF0CIE164	R/W		√		Undefined
00200310H	UF0 configuration/interface/endpoint descriptor register 165	UF0CIE165	R/W		√		Undefined
00200312H	UF0 configuration/interface/endpoint descriptor register 166	UF0CIE166	R/W		√		Undefined
00200314H	UF0 configuration/interface/endpoint descriptor register 167	UF0CIE167	R/W		√		Undefined
00200316H	UF0 configuration/interface/endpoint descriptor register 168	UF0CIE168	R/W		√		Undefined
00200318H	UF0 configuration/interface/endpoint descriptor register 169	UF0CIE169	R/W		√		Undefined
0020031AH	UF0 configuration/interface/endpoint descriptor register 170	UF0CIE170	R/W		√		Undefined
0020031CH	UF0 configuration/interface/endpoint descriptor register 171	UF0CIE171	R/W		√		Undefined
0020031EH	UF0 configuration/interface/endpoint descriptor register 172	UF0CIE172	R/W		√		Undefined
00200320H	UF0 configuration/interface/endpoint descriptor register 173	UF0CIE173	R/W		√		Undefined
00200322H	UF0 configuration/interface/endpoint descriptor register 174	UF0CIE174	R/W		√		Undefined
00200324H	UF0 configuration/interface/endpoint descriptor register 175	UF0CIE175	R/W		√		Undefined
00200326H	UF0 configuration/interface/endpoint descriptor register 176	UF0CIE176	R/W		√		Undefined
00200328H	UF0 configuration/interface/endpoint descriptor register 177	UF0CIE177	R/W		√		Undefined
0020032AH	UF0 configuration/interface/endpoint descriptor register 178	UF0CIE178	R/W		√		Undefined
0020032CH	UF0 configuration/interface/endpoint descriptor register 179	UF0CIE179	R/W		√		Undefined

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Address	Function Register Name	Symbol	R/W	Manipulatable Bits			Default Value
				1	8	16	
0020032EH	UF0 configuration/interface/endpoint descriptor register 180	UF0CIE180	R/W		√		Undefined
00200330H	UF0 configuration/interface/endpoint descriptor register 181	UF0CIE181	R/W		√		Undefined
00200332H	UF0 configuration/interface/endpoint descriptor register 182	UF0CIE182	R/W		√		Undefined
00200334H	UF0 configuration/interface/endpoint descriptor register 183	UF0CIE183	R/W		√		Undefined
00200336H	UF0 configuration/interface/endpoint descriptor register 184	UF0CIE184	R/W		√		Undefined
00200338H	UF0 configuration/interface/endpoint descriptor register 185	UF0CIE185	R/W		√		Undefined
0020033AH	UF0 configuration/interface/endpoint descriptor register 186	UF0CIE186	R/W		√		Undefined
0020033CH	UF0 configuration/interface/endpoint descriptor register 187	UF0CIE187	R/W		√		Undefined
0020033EH	UF0 configuration/interface/endpoint descriptor register 188	UF0CIE188	R/W		√		Undefined
00200340H	UF0 configuration/interface/endpoint descriptor register 189	UF0CIE189	R/W		√		Undefined
00200342H	UF0 configuration/interface/endpoint descriptor register 190	UF0CIE190	R/W		√		Undefined
00200344H	UF0 configuration/interface/endpoint descriptor register 191	UF0CIE191	R/W		√		Undefined
00200346H	UF0 configuration/interface/endpoint descriptor register 192	UF0CIE192	R/W		√		Undefined
00200348H	UF0 configuration/interface/endpoint descriptor register 193	UF0CIE193	R/W		√		Undefined
0020034AH	UF0 configuration/interface/endpoint descriptor register 194	UF0CIE194	R/W		√		Undefined
0020034CH	UF0 configuration/interface/endpoint descriptor register 195	UF0CIE195	R/W		√		Undefined
0020034EH	UF0 configuration/interface/endpoint descriptor register 196	UF0CIE196	R/W		√		Undefined
00200350H	UF0 configuration/interface/endpoint descriptor register 197	UF0CIE197	R/W		√		Undefined
00200352H	UF0 configuration/interface/endpoint descriptor register 198	UF0CIE198	R/W		√		Undefined
00200354H	UF0 configuration/interface/endpoint descriptor register 199	UF0CIE199	R/W		√		Undefined
00200356H	UF0 configuration/interface/endpoint descriptor register 200	UF0CIE200	R/W		√		Undefined
00200358H	UF0 configuration/interface/endpoint descriptor register 201	UF0CIE201	R/W		√		Undefined

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Address	Function Register Name	Symbol	R/W	Manipulatable Bits			Default Value
				1	8	16	
0020035AH	UF0 configuration/interface/endpoint descriptor register 202	UF0CIE202	R/W		√		Undefined
0020035CH	UF0 configuration/interface/endpoint descriptor register 203	UF0CIE203	R/W		√		Undefined
0020035EH	UF0 configuration/interface/endpoint descriptor register 204	UF0CIE204	R/W		√		Undefined
00200360H	UF0 configuration/interface/endpoint descriptor register 205	UF0CIE205	R/W		√		Undefined
00200362H	UF0 configuration/interface/endpoint descriptor register 206	UF0CIE206	R/W		√		Undefined
00200364H	UF0 configuration/interface/endpoint descriptor register 207	UF0CIE207	R/W		√		Undefined
00200366H	UF0 configuration/interface/endpoint descriptor register 208	UF0CIE208	R/W		√		Undefined
00200368H	UF0 configuration/interface/endpoint descriptor register 209	UF0CIE209	R/W		√		Undefined
0020036AH	UF0 configuration/interface/endpoint descriptor register 210	UF0CIE210	R/W		√		Undefined
0020036CH	UF0 configuration/interface/endpoint descriptor register 211	UF0CIE211	R/W		√		Undefined
0020036EH	UF0 configuration/interface/endpoint descriptor register 212	UF0CIE212	R/W		√		Undefined
00200370H	UF0 configuration/interface/endpoint descriptor register 213	UF0CIE213	R/W		√		Undefined
00200372H	UF0 configuration/interface/endpoint descriptor register 214	UF0CIE214	R/W		√		Undefined
00200374H	UF0 configuration/interface/endpoint descriptor register 215	UF0CIE215	R/W		√		Undefined
00200376H	UF0 configuration/interface/endpoint descriptor register 216	UF0CIE216	R/W		√		Undefined
00200378H	UF0 configuration/interface/endpoint descriptor register 217	UF0CIE217	R/W		√		Undefined
0020037AH	UF0 configuration/interface/endpoint descriptor register 218	UF0CIE218	R/W		√		Undefined
0020037CH	UF0 configuration/interface/endpoint descriptor register 219	UF0CIE219	R/W		√		Undefined
0020037EH	UF0 configuration/interface/endpoint descriptor register 220	UF0CIE220	R/W		√		Undefined
00200380H	UF0 configuration/interface/endpoint descriptor register 221	UF0CIE221	R/W		√		Undefined
00200382H	UF0 configuration/interface/endpoint descriptor register 222	UF0CIE222	R/W		√		Undefined
00200384H	UF0 configuration/interface/endpoint descriptor register 223	UF0CIE223	R/W		√		Undefined

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Address	Function Register Name	Symbol	R/W	Manipulatable Bits			Default Value
				1	8	16	
00200386H	UF0 configuration/interface/endpoint descriptor register 224	UF0CIE224	R/W		√		Undefined
00200388H	UF0 configuration/interface/endpoint descriptor register 225	UF0CIE225	R/W		√		Undefined
0020038AH	UF0 configuration/interface/endpoint descriptor register 226	UF0CIE226	R/W		√		Undefined
0020038CH	UF0 configuration/interface/endpoint descriptor register 227	UF0CIE227	R/W		√		Undefined
0020038EH	UF0 configuration/interface/endpoint descriptor register 228	UF0CIE228	R/W		√		Undefined
00200390H	UF0 configuration/interface/endpoint descriptor register 229	UF0CIE229	R/W		√		Undefined
00200392H	UF0 configuration/interface/endpoint descriptor register 230	UF0CIE230	R/W		√		Undefined
00200394H	UF0 configuration/interface/endpoint descriptor register 231	UF0CIE231	R/W		√		Undefined
00200396H	UF0 configuration/interface/endpoint descriptor register 232	UF0CIE232	R/W		√		Undefined
00200398H	UF0 configuration/interface/endpoint descriptor register 233	UF0CIE233	R/W		√		Undefined
0020039AH	UF0 configuration/interface/endpoint descriptor register 234	UF0CIE234	R/W		√		Undefined
0020039CH	UF0 configuration/interface/endpoint descriptor register 235	UF0CIE235	R/W		√		Undefined
0020039EH	UF0 configuration/interface/endpoint descriptor register 236	UF0CIE236	R/W		√		Undefined
002003A0H	UF0 configuration/interface/endpoint descriptor register 237	UF0CIE237	R/W		√		Undefined
002003A2H	UF0 configuration/interface/endpoint descriptor register 238	UF0CIE238	R/W		√		Undefined
002003A4H	UF0 configuration/interface/endpoint descriptor register 239	UF0CIE239	R/W		√		Undefined
002003A6H	UF0 configuration/interface/endpoint descriptor register 240	UF0CIE240	R/W		√		Undefined
002003A8H	UF0 configuration/interface/endpoint descriptor register 241	UF0CIE241	R/W		√		Undefined
002003AAH	UF0 configuration/interface/endpoint descriptor register 242	UF0CIE242	R/W		√		Undefined
002003ACH	UF0 configuration/interface/endpoint descriptor register 243	UF0CIE243	R/W		√		Undefined
002003AEH	UF0 configuration/interface/endpoint descriptor register 244	UF0CIE244	R/W		√		Undefined
002003B0H	UF0 configuration/interface/endpoint descriptor register 245	UF0CIE245	R/W		√		Undefined

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Address	Function Register Name	Symbol	R/W	Manipulatable Bits			Default Value
				1	8	16	
002003B2H	UF0 configuration/interface/endpoint descriptor register 246	UF0CIE246	R/W		√		Undefined
002003B4H	UF0 configuration/interface/endpoint descriptor register 247	UF0CIE247	R/W		√		Undefined
002003B6H	UF0 configuration/interface/endpoint descriptor register 248	UF0CIE248	R/W		√		Undefined
002003B8H	UF0 configuration/interface/endpoint descriptor register 249	UF0CIE249	R/W		√		Undefined
002003BAH	UF0 configuration/interface/endpoint descriptor register 250	UF0CIE250	R/W		√		Undefined
002003BCH	UF0 configuration/interface/endpoint descriptor register 251	UF0CIE251	R/W		√		Undefined
002003BEH	UF0 configuration/interface/endpoint descriptor register 252	UF0CIE252	R/W		√		Undefined
002003C0H	UF0 configuration/interface/endpoint descriptor register 253	UF0CIE253	R/W		√		Undefined
002003C2H	UF0 configuration/interface/endpoint descriptor register 254	UF0CIE254	R/W		√		Undefined
002003C4H	UF0 configuration/interface/endpoint descriptor register 255	UF0CIE255	R/W		√		Undefined

(4) Bridge register

Address	Function Register Name	Symbol	R/W	Manipulatable Bits			Default Value
				1	8	16	
00200400H	Bridge interrupt control register	BRGINTT	R/W			√	0000H
00200402H	Bridge interrupt enable register	BRGINTE	R/W			√	0000H
00200404H	EPC macro control register	EPCCLT	R/W			√	0000H
00200408H	CPU I/F bus control register	CPUBCTL	R/W			√	0000H

(5) DMA register

Address	Function Register Name	Symbol	R/W	Manipulatable Bits			Default Value
				1	8	16	
00200500H	EP1 DMA control register 1	UF0E1DC1	R/W			√	0000H
00200502H	EP1 DMA control register 2	UF0E1DC2	R/W			√	0000H
00200504H	EP2 DMA control register 1	UF0E2DC1	R/W			√	0000H
00200506H	EP2 DMA control register 2	UF0E2DC2	R/W			√	0000H
00200508H	EP3 DMA control register 1	UF0E3DC1	R/W			√	0000H
0020050AH	EP3 DMA control register 2	UF0E3DC2	R/W			√	0000H
0020050CH	EP4 DMA control register 1	UF0E4DC1	R/W			√	0000H
0020050EH	EP4 DMA control register 2	UF0E4DC2	R/W			√	0000H

(6) Bulk-in register

Address	Function Register Name	Symbol	R/W	Manipulatable Bits			Default Value
				1	8	16	
00201000H	UF0 EP1 bulk-in transfer data register	UF0EP1BI	W			√	0000H
00202000H	UF0 EP3 bulk-in transfer data register	UF0EP3BI	W			√	0000H

(7) Bulk-out register

Address	Function Register Name	Symbol	R/W	Manipulatable Bits			Default Value
				1	8	16	
00210000H	UF0 EP2 bulk-out transfer data register	UF0EP2BO	R		√	√	0000H
00220000H	UF0 EP4 bulk-out transfer data register	UF0EP4BO	R		√	√	0000H

(8) Peripheral control register

Address	Function Register Name	Symbol	R/W	Manipulatable Bits			Default Value
				1	8	16	
00240000H	USBF DMA request enable register	UFDRQEN	R/W		√	√	0000H

21.6.3 EPC control registers

(1) UF0 EP0NAK register (UF0E0N)

This register controls NAK of Endpoint0 (except an automatically executed request).

This register can be read or written in 8-bit units (however, bit 0 can only be read).

It takes five USB clocks to reflect the status on this register after the UF0FIC0 and UF0FIC1 registers have been set. If it is necessary to read the status correctly, therefore, separate a write signal that accesses the UF0FIC0 and UF0FIC1 registers from a read signal that accesses the UF0EPS0, UF0EPS1, UF0EPS2, UF0E0N, and UF0EN registers by at least four USB clocks.

While NAK is being transmitted to Endpoint0 Read, Endpoint2, and Endpoint4, a write access to the EP0NKR bit is ignored.

	7	6	5	4	3	2	1	0	Address	After reset
UF0E0N	0	0	0	0	0	0	EP0NKR	EP0NKW	00200000H	00H

Bit position	Bit name	Function
1	EP0NKR	This bit controls NAK to the OUT token to Endpoint0 (except an automatically executed request). It is automatically set to 1 by hardware when Endpoint0 has correctly received data. It is also cleared to 0 by hardware when the data of the UF0E0R register has been read by FW (counter value = 0). 1: Transmit NAK. 0: Do not transmit NAK (default value). Set this bit to 1 by FW when data should not be received from the USB bus for some reason even when USBF is ready for receiving data. In this case, USBF continues transmitting NAK until this bit is cleared to 0 by FW. This bit is also cleared to 0 as soon as the UF0E0R register has been cleared.
0	EP0NKW	This bit indicates how NAK to the IN token to Endpoint0 is controlled (except an automatically executed request). This bit is automatically cleared to 0 by hardware when the data of Endpoint0 is transmitted and the host correctly receives the transmitted data. The data of the UF0E0W register is retained until this bit is cleared. Therefore, it is not necessary to rewrite this bit even in the case of a retransmission request that is made if the host could not receive data correctly. To send a short packet, be sure to set the E0DED bit of the UF0DEND register to 1. This bit is automatically set to 1 when the FIFO is full. As soon as the E0DED bit of the UF0DEND register is set to 1, the EP0NKW bit is automatically set to 1 at the same time. 1: Do not transmit NAK. 0: Transmit NAK (default value). If control transfer enters the status stage while ACK cannot be correctly received in the data stage, this bit is cleared to 0 as soon as the UF0E0W register is cleared. This bit is also cleared to 0 when UF0E0W is cleared by FW.

Next, the procedure of a SETUP transaction that uses IN/OUT tokens is explained below.

(a) When IN token is used (except a request automatically executed by hardware)

FW should be used to clear the PROT bit of the UF0IS1 register to 0 after receiving the CPUDEC interrupt and before reading data from the UF0E0ST register. Next, perform processing in accordance with the request and, if it is necessary to return data by an IN token, write data to the UF0E0W register. Confirm that the PROT bit of the UF0IS1 register is 0 after writing has been completed, and set the E0DED bit of the UF0DEND register to 1. The hardware sends out data at the first IN token after the EP0NKW bit has been set to 1. If the PROT bit of the UF0IS1 register is 1, it indicates that a SETUP transaction has occurred again before completion of control transfer. In this case, clear the PROT bit of the UF0IS1 register to 0 by clearing the PROTC bit of the UF0IC1 register to 0, and then read data from the UF0E0ST register again. A request received later can be read.

(b) When OUT token is used (except a request automatically executed by hardware)

FW should be used to clear the PROT bit of the UF0IS1 register after receiving the CPUDEC interrupt and before reading data from the UF0E0ST register. Confirm that the PROT bit of the UF0IS1 register is 0 before reading data from the UF0E0R register. If the PROT bit is 1, it means that invalid data is retained. Clear the FIFO by FW (the EP0NKR bit is automatically cleared to 0). If the PROT bit of the UF0IS1 register is 0, read the data of the UF0E0L register and read as many data from the UF0E0R register as set. When reading data from the UF0E0R register has been completed (when the counter of the UF0E0R register has been cleared to 0), the hardware automatically clears the EP0NKR bit to 0.

(2) UF0 EP0NAKALL register (UF0E0NA)

This register controls NAK to all the requests of Endpoint0. It is also valid for automatically executed requests.

This register can be read or written in 8-bit units.

	7	6	5	4	3	2	1	0	Address	After reset
UF0E0NA	0	0	0	0	0	0	0	EP0NKA	00200002H	00H

Bit position	Bit name	Function
0	EP0NKA	This bit controls NAK to a transaction other than a SETUP transaction to Endpoint0 (including an automatically executed request). This bit is manipulated by FW. 1: Transmit NAK. 0: Do not transmit NAK (default value). This register is used to prevent a conflict between a write access by FW and a read access from SIE when the data used for an automatically executed request is to be changed. It postpones reflecting a write access on this bit from FW while an access from SIE is being made. Before rewriting the request data register from FW, confirm that this bit has been correctly set to 1. Setting this bit to 1 is reflected only in the following cases. • Immediately after USBF has been reset and a SETUP token has never been received • Immediately after reception of Bus Reset and a SETUP token has never been received • PID of a SETUP token has been detected • The stage has been changed to the status stage Clearing this bit to 0 is reflected immediately, except while an IN token is being received and a NAK response is being made. Setting the EP0NKA bit to 1 is reflected in the above four cases during Endpoint0 transfer, but it is reflected immediately after data has been written to the bit while Endpoint0 is transferring no data.

(3) UF0 EPNAK register (UF0EN)

This register controls NAK of endpoints other than Endpoint0.

This register can be read or written in 8-bit units (however, bits 4, 1, and 0 can only be read).

The BKO2NK bit can be written only when the BKO2NKM bit of the UF0ENM register is 1 and the BKO1NK bit can be written only when the BKO1NKM bit of the UF0ENM register is 1.

The related bits are invalid if each endpoint is not supported by the setting of the UF0EnIM register (n = 1 to 4, 7) and the current setting of the interface.

It takes five USB clocks to reflect the status on this register after the UF0FIC0 and UF0FIC1 registers have been set. If it is necessary to read the status correctly, therefore, separate a write signal that accesses the UF0FIC0 and UF0FIC1 registers from a read signal that accesses the UF0EPS0, UF0EPS1, UF0EPS2, UF0E0N, and UF0EN registers by at least four USB clocks.

While NAK is being transmitted to Endpoint0 Read, Endpoint2, and Endpoint4, a write access to the BKO1NK and BKO2NK bits is ignored.

Be sure to clear bits 7 to 5 to “0”. If it is set to 1, the operation is not guaranteed.

(1/4)

	7	6	5	4	3	2	1	0	Address	After reset
UF0EN	0	0	0	IT1NK	BKO2NK	BKO1NK	BKI2NK	BKI1NK	00200004H	00H

Bit position	Bit name	Function
4	IT1NK	This bit controls NAK to Endpoint7 (interrupt 1 transfer). It is automatically set to 1 and transmission is started when the UF0INT1 register has become full as a result of writing data to it. To send a short packet that does not make the FIFO full, set the IT1DEND bit of the UF0DEND register to 1. As soon as the IT1DEND bit has been set to 1, this bit is automatically set to 1. 1: Do not transmit NAK. 0: Transmit NAK (default value). This bit is also cleared to 0 when the UF0INT1 register has been cleared.

(2/4)

Bit position	Bit name	Function
3	BKO2NK	This bit controls NAK to Endpoint4 (bulk 2 transfer (OUT)). 1: Transmit NAK. 0: Do not transmit NAK (default value). This bit is set to 1 only when the FIFO connected to the SIE side of the UF0BO2 register (64-byte FIFO of bank configuration) cannot receive data. It is cleared to 0 when a toggle operation is performed. The bank is changed (toggle operation) when the following conditions are satisfied. • Data correctly received is stored in the FIFO connected to the SIE side. • The value of the FIFO counter connected to the CPU side is 0 (completion of reading). FW should be used to read data of the UF0BO2L register when it has received the BLKO2DT interrupt request and read as many data from the UF0BO2 register as the value of that data. To not receive data from the USB bus for some reason even if USBF is ready to receive data, set this bit to 1 by FW. In this case, USBF keeps transmitting NAK until the FW clears this bit to 0. This bit is also cleared to 0 as soon as the UF0BO2 register has been cleared.
2	BKO1NK	This bit controls NAK to Endpoint2 (bulk 1 transfer (OUT)). 1: Transmit NAK. 0: Do not transmit NAK (default value). This bit is set to 1 only when the FIFO connected to the SIE side of the UF0BO1 register (64-byte FIFO of bank configuration) cannot receive data. It is cleared to 0 when a toggle operation is performed. The bank is changed (toggle operation) when the following conditions are satisfied. • Data correctly received is stored in the FIFO connected to the SIE side. • The value of the FIFO counter connected to the CPU side is 0 (completion of reading). FW should be used to read data of the UF0BO1L register when it has received the BLKO1DT interrupt request and read as many data from the UF0BO1 register as the value of that data. To not receive data from the USB bus for some reason even if USBF is ready to receive data, set this bit to 1 by FW. In this case, USBF keeps transmitting NAK until the FW clears this bit to 0. This bit is also cleared to 0 as soon as the UF0BO1 register has been cleared.

Cautions 1. If DMA is enabled while data is being read from the UF0BO2 register in the PIO mode, a DMA request is immediately issued.

2. If the last data of the FIFO on the CPU side is read in the DMA transfer mode, the DMA request signal becomes inactive.

3. If the TC signal is received in the DMA transfer mode, the DMA request signal becomes inactive.

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Bit position	Bit name	Function
1	BKI2NK	This bit controls NAK to Endpoint3 (bulk 2 transfer (IN)). 1: Do not transmit NAK. 0: Transmit NAK (default value). This bit is cleared to 0 only when the FIFO connected to the SIE side of the UF0BI2 register (64-byte FIFO of bank configuration) cannot receive data. It is set to 1 when a toggle operation is performed (the data of the UF0BI2 register is retained until transmission has been correctly completed). The bank is changed (toggle operation) when the following conditions are satisfied. • Data is correctly written to the FIFO connected to the CPU bus side (writing has been completed and the FIFO is full or the UF0DEND register is set). • The value of the FIFO counter connected to the SIE side is 0. This bit is automatically set to 1 and data transmission is started when the FIFO on the CPU side becomes full and a FIFO toggle operation is performed as a result of writing data to the FIFO. However, if the FIFO on the CPU side becomes full as a result of writing data to it by DMA while the BKI2T bit of the UF0DEND register is cleared to 0, the toggle operation is not performed because the condition of the toggle operation is not satisfied until the BKI2DED bit of the UF0DEND register is set to 1. To send a short packet that does not make the FIFO on the CPU side full, set the BKI2DED bit to 1 after completing writing data. When the BKI2DED bit is set to 1, a toggle operation is performed and at the same time, this bit is automatically set to 1. This bit is also cleared to 0 as soon as the UF0BI2 register has been cleared.

Cautions 1. If DMA is enabled while data is being written to the UF0BI2 register in the PIO mode, a DMA request is immediately issued.

2. If 64-byte data is written in the DMA transfer mode, the DMA request signal becomes inactive. If the BKI2NK bit is then set to 1, data is transmitted in synchronization with an IN token. The DMA request signal becomes active again as long as the DMA request is not masked as soon as the FIFO is toggled. If the BKI2NK bit is not set, data is not transmitted even if an IN token has been received. In this case, set the BKI2DED bit of the UF0DEND register to 1.

3. If the TC signal is received in the DMA transfer mode, the DMA request signal becomes inactive. At the same time, the DMA request is masked. If the BKI2NK bit is not set to 1, data is not transmitted even if an IN token is received. When the BKI2DED bit of the UF0DEND register is set to 1 by FW, data is transmitted in synchronization with the IN token. To execute DMA transfer again, unmask the DMA request.

(4/4)

Bit position	Bit name	Function
0	BKI1NK	This bit controls NAK to Endpoint1 (bulk 1 transfer (IN)). 1: Do not transmit NAK. 0: Transmit NAK (default value). This bit is cleared to 0 only when the FIFO connected to the SIE side of the UF0BI1 register (64-byte FIFO of bank configuration) cannot receive data. It is set to 1 when a toggle operation is performed (the data of the UF0BI1 register is retained until transmission has been correctly completed). The bank is changed (toggle operation) when the following conditions are satisfied. • Data is correctly written to the FIFO connected to the CPU bus side (writing has been completed and the FIFO is full or the UF0DEND register is set). • The value of the FIFO counter connected to the SIE side is 0. This bit is automatically set to 1 and data transmission is started when the FIFO on the CPU side becomes full and a FIFO toggle operation is performed as a result of writing data to the FIFO. However, if the FIFO on the CPU side becomes full as a result of writing data to it by DMA while the BKI1T bit of the UF0DEND register is cleared to 0, the toggle operation is not performed because the condition of the toggle operation is not satisfied until the BKI1DED bit of the UF0DEND register is set to 1. To send a short packet that does not make the FIFO on the CPU side full, set the BKI1DED bit to 1 after completing writing data. When the BKI1DED bit is set to 1, a toggle operation is performed and at the same time, this bit is automatically set to 1. This bit is also cleared to 0 as soon as the UF0BI1 register has been cleared.

Cautions 1. If DMA is enabled while data is being written to the UF0BI1 register in the PIO mode, a DMA request is immediately issued.

2. If 64-byte data is written in the DMA transfer mode, the DMA request signal becomes inactive. If the BKI1NK bit is then set to 1, data is transmitted in synchronization with an IN token. The DMA request signal becomes active again as long as the DMA request is not masked as soon as the FIFO is toggled. If the BKI1NK bit is not set, data is not transmitted even if an IN token has been received. In this case, set the BKI1DED bit of the UF0DEND register to 1.

3. If the TC signal is received in the DMA transfer mode, the DMA request signal becomes inactive. At the same time, the DMA request is masked. If the BKI1NK bit is not set to 1, data is not transmitted even if an IN token is received. When the BKI1DED bit of the UF0DEND register is set to 1 by FW, data is transmitted in synchronization with the IN token. To execute DMA transfer again, unmask the DMA request.

(4) UF0 EPNAK mask register (UF0ENM)

This register controls masking a write access to the UF0EN register.

This register can be read or written in 8-bit units.

Be sure to clear bits 7 to 4, 1, and 0 to “0”. If it is set to 1, the operation is not guaranteed.

	7	6	5	4	3	2	1	0	Address	After reset
UF0ENM	0	0	0	0	BKO2NKM	BKO1NKM	0	0	00200006H	00H

Bit position	Bit name	Function
3	BKO2NKM	This bit specifies whether a write access to bit 3 (BKO2NK) of the UF0EN register is masked or not. 1: Do not mask. 0: Mask (default value).
2	BKO1NKM	This bit specifies whether a write access to bit 2 (BKO1NK) of the UF0EN register is masked or not. 1: Do not mask. 0: Mask (default value).

(5) UF0 SNDSIE register (UF0SDS)

This register performs manipulation such as no handshake. It can directly manipulate the pins of SIE.

This register can be read or written in 8-bit units.

Be sure to clear bit 2 to “0”. If it is set to 1, the operation is not guaranteed.

	7	6	5	4	3	2	1	0	Address	After reset
UF0SDS	0	0	0	0	SNDSTL	0	0	RSUMIN	00200008H	00H

Bit position	Bit name	Function
3	SNDSTL	This bit makes Endpoint0 issue a STALL handshake. Setting this bit to 1 if a request for CPUDEC processing is not supported by the system results in a STALL handshake response. If an unsupported wValue is sent by the SET_CONFIGURATION or SET_INTERFACE request, the hardware sets this bit to 1. If a problem occurs in Endpoint0 due to overrun of an automatically executed request, this bit is also set to 1. However, the E0HALT bit of the UF0E0SL register is not set to 1. 1: Respond with STALL handshake. 0: Do not respond with STALL handshake (default value). This bit is cleared to 0 and the handshake response to the bus is other than STALL when the next SETUP token is received. To set the SNDSTL bit to 1 by FW, do not write data to the UF0E0W register. Depending on the timing of setting this bit, the STALL response is not made in time, and it may be made to the next transfer after a NAK response has been made. Setting this bit is valid only while an FW-executed request is under execution when this bit is set to 1. It is automatically cleared to 0 when the next SETUP token is received. **Remark** The SNDSTL bit is valid only for an FW-executed request.
0	RSUMIN	This bit outputs the Resume signal onto the USB bus. Writing this bit is invalid unless the RMWK bit of the UF0DSTL register is set to 1. 1: Generate the Resume signal. 0: Do not generate the Resume signal (default value). While this bit is set to 1, the Resume signal continues to be generated. Clear this bit to 0 by FW after a specific time has elapsed. Because the signal is internally sampled at the clock, the operation is guaranteed only while CLK is supplied. Care must be exercised when CLK of the system is stopped.

(6) UF0 CLR request register (UF0CLR)

This register indicates the target of the received CLEAR_FEATURE request.

This register is read-only, in 8-bit units.

This register is meaningful only when an interrupt request is generated. Each bit is set to 1 after completion of the status stage, and automatically cleared to 0 when this register is read.

The related bits are invalid if each endpoint is not supported by the setting of the UF0EnIM register (n = 1 to 4, 7) and the current setting of the interface.

	7	6	5	4	3	2	1	0	Address	After reset
UF0CLR	0	CLREP7	CLREP4	CLREP3	CLREP2	CLREP1	CLREP0	CLRDEV	0020000AH	00H

Bit position	Bit name	Function
6 to 1	CLREPn	These bits indicate that a CLEAR_FEATURE Endpoint n request is received and automatically processed. 1: Automatically processed 0: Not automatically processed (default value)
0	CLRDEV	This bit indicates that a CLEAR_FEATURE Device request is received and automatically processed. 1: Automatically processed 0: Not automatically processed (default value)

Remark n = 0 to 4, 7

(7) UF0 SET request register (UF0SET)

This register indicates the target of the automatically processed SET_XXXX (except SET_INTERFACE) request.

This register is read-only, in 8-bit units.

This register is meaningful only when an interrupt request is generated. Each bit is set to 1 after completion of the status stage, and automatically cleared to 0 when this register is read.

	7	6	5	4	3	2	1	0	Address	After reset
UF0SET	SETCON	0	0	0	0	SETEP	0	SETDEV	0020000CH	00H

Bit position	Bit name	Function
7	SETCON	This bit indicates that a SET_CONFIGURATION request is received and automatically processed. 1: Automatically processed 0: Not automatically processed (default value)
2	SETEP	This bit indicates that a SET_FEATURE Endpoint n request (n = 0 to 4, 7) is received and automatically processed. 1: Automatically processed 0: Not automatically processed (default value)
0	SETDEV	This bit indicates that a SET_FEATURE Device request is received and automatically processed. 1: Automatically processed 0: Not automatically processed (default value)

(8) UF0 EP status 0 register (UF0EPS0)

This register indicates the USB bus status and the presence or absence of register data.

This register is read-only, in 8-bit units.

The related bits are invalid if each endpoint is not supported by the setting of the UF0EnIM register (n = 1 to 4, 7) and the current setting of the interface.

It takes five USB clocks to reflect the status on this register after the UF0FIC0 and UF0FIC1 registers have been set. If it is necessary to read the status correctly, therefore, separate writing to the UF0FIC0 and UF0FIC1 registers from reading from the UF0EPS0, UF0EPS1, UF0EPS2, UF0E0N, and UF0EN registers by at least four USB clocks.

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	7	6	5	4	3	2	1	0	Address	After reset
UF0EPS0	0	IT1	BKOUT2	BKOUT1	BKIN2	BKIN1	EP0W	EP0R	0020000EH	00H

Bit position	Bit name	Function
6	IT1	These bits indicate that data is in the UF0INT1 register (FIFO). By setting the IT1DEND bit of the UF0DEND register to 1, the status in which data is in the UF0INT1 register can be created even if data is not written to the register (Null data transmission). As soon as the IT1DEND bit of the UF0DEND register is set to 1 even when the counter of the UF0INT1 register is 0, this bit is set to 1 by hardware. It is cleared to 0 after correct transmission. 1: Data is in the register. 0: No data is in the register (default value).
5, 4	BKOUTn	These bits indicate that data is in the UF0BOn register (FIFO) connected to the CPU side. When the FIFO configuring the UF0BOn register is toggled, this bit is automatically set to 1 by hardware. It is automatically cleared to 0 by hardware when reading the UF0BOn register (FIFO) connected to the CPU side has been completed (counter value = 0). It is not set to 1 when Null data is received (toggling the FIFO does not take place either). 1: Data is in the register. 0: No data is in the register (default value).
3, 2	BKINn	These bits indicate that data is in the UF0BIn register (FIFO) connected to the CPU side. By setting the BKInDED bit of the UF0DEND register to 1, the status in which data is in the UF0BIn register can be created even if data is not written to the register (Null data transmission). As soon as the BKInDED bit of the UF0DEND register has been set to 1 while the counter of the UF0BIn register is 0, this bit is set to 1 by hardware. It is cleared to 0 when a toggle operation is performed. 1: Data is in the register. 0: No data is in the register (default value).

Remark n = 1, 2

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Bit position	Bit name	Function
1	EP0W	This bit indicates that data is in the UF0E0W register (FIFO). By setting the E0DED bit of the UF0DEND register to 1, the status in which data is in the UF0E0W register can be created even if data is not written to the register (Null data transmission). As soon as the E0DED bit of the UF0DEND register is set to 1 even when the counter of the UF0E0W register is 0, this bit is set to 1 by hardware. It is cleared to 0 after correct transmission. 1: Data is in the register. 0: No data is in the register (default value).
0	EP0R	This bit indicates that data is in the UF0E0R register (FIFO). It is automatically cleared to 0 by hardware when reading the UF0E0R register (FIFO) has been completed (counter value = 0). It is not set to 1 if Null data is received. 1: Data is in the register. 0: No data is in the register (default value).

(9) UF0 EP status 1 register (UF0EPS1)

This register indicates the USB bus status and the presence or absence of register data.

This register is read-only, in 8-bit units.

	7	6	5	4	3	2	1	0	Address	After reset
UF0EPS1	RSUM	0	0	0	0	0	0	0	00200010H	00H

Bit position	Bit name	Function
7	RSUM	This bit indicates that the USB bus is in the Resume status. This bit is meaningful only when an interrupt request is generated. 1: Suspend status 0: Resume status (default value) Because sampling is internally performed with the clock, the operation is guaranteed only when CLK is supplied. Care must be exercised when CLK of the system is stopped. The INTUSBF1 signal of SIE operates even when CLK is stopped. It can therefore be supported by making the interrupt control register (UFIC1) valid or lowering the frequency of CLK to the USBF. This bit is automatically cleared to 0 when it is read.

(10) UF0 EP status 2 register (UF0EPS2)

This register indicates the USB bus status and the presence or absence of register data.

This register is read-only, in 8-bit units.

The related bits are invalid if each endpoint is not supported by the setting of the UF0EnIM register (n = 1 to 4, 7) and the current setting of the interface.

	7	6	5	4	3	2	1	0	Address	After reset
UF0EPS2	0	0	HALT7	HALT4	HALT3	HALT2	HALT1	HALT0	00200012H	00H

Bit position	Bit name	Function
5 to 0	HALTn	These bits indicate that Endpoint n is currently stalled. They are set to 1 when a stall condition, such as occurrence of an overrun and reception of an undefined request, is satisfied. These bits are automatically set to 1 by hardware. 1: Endpoint is stalled. 0: Endpoint is not stalled (default value). The SNDSTL bit is set to 1 as soon as the HALT0 bit has been set to 1 as a result of occurrence of an overrun or reception of an undefined request. If the next SETUP token is received in this status, the SNDSTL bit is cleared to 0 and, therefore, the HALT0 bit is also cleared to 0. If Endpoint0 is stalled by the SET_FEATURE Endpoint0 request, this bit is not cleared to 0 until the CLEAR_FEATURE Endpoint0 request is received or Halt Feature is cleared by FW. If the GET_STATUS Endpoint0, CLEAR_FEATURE Endpoint0, or SET_FEATURE Endpoint0 request is received, or if a request to be processed by FW is received due to the CPUDEC interrupt request, the HALT0 bit is masked and cleared to 0, until the next SETUP token is received. The HALTn bit is not cleared to 0 until Endpoint n receives the CLEAR_FEATURE Endpoint request, Halt Feature is cleared by the SET_INTERFACE or SET_CONFIGURATION request to the interface to which the endpoint is linked, or Halt Feature is cleared by FW. When the SET_INTERFACE or SET_CONFIGURATION request is correctly processed, the Halt Feature of all the target endpoints, except Endpoint0, is cleared after the request has been processed, even if the wValue is the same as the currently set value, and these bits are also cleared to 0. Halt Feature of Endpoint0 cannot be cleared if it is set because the STALL response is made in response to the SET_INTERFACE and SET_CONFIGURATION requests.

Remark n = 0 to 4, 7, 8

(11) UF0 INT status 0 register (UF0IS0)

This register indicates the interrupt source. If the contents of this register are changed, the EPCINT0B signal becomes active.

This register is read-only, in 8-bit units.

If an interrupt request (INTUSBF0) is generated from USBF, the FW must read this register to identify the interrupt source.

Each bit of this register is forcibly cleared to 0 when 0 is written to the corresponding bit of the UF0IC0 register.

Caution In the USBF, multiple interrupt sources, such as Bus Reset, Resume, and Short, are ORed internally and are issued as a single interrupt request (INTUSBF0). Therefore, in the case of the occurrence of multiple interrupt sources, they are ORed and issued as an INTUSBF0 interrupt request.

For example, if a Bus Reset interrupt source and Resume interrupt source occur, the two sources are ORed and an INTUSBF0 interrupt request is issued.

Under these conditions, if the Bus Reset interrupt source is cleared to 0 (UF0IC0.BUSRSTC = 0), the V850ES/JG3-H or V850ES/JH3-H internal INTUSBF0 interrupt request may remain set to 1 since the Resume interrupt source will still remain. The new interrupt request flag (US0BIC.US0BIF), therefore, might not be set to 1.

In this case, after performing clear processing for each interrupt request with the INTUSBF0 interrupt servicing routine, confirm the flag status for the UF0IS0 and UF0IS1 registers again, and if there are any interrupt sources with flags set to 1, perform flag clearing (only the applicable bits need to be cleared (do not perform a batch clearing)).

	7	6	5	4	3	2	1	0	Address	After reset
UF0IS0	BUSRST	RSUSPD	0	SHORT	DMAED	SETRQ	CLRRQ	EPHALT	00200020H	00H

Bit position	Bit name	Function
7	BUSRST	This bit indicates that Bus Reset has occurred. 1: Bus Reset has occurred (interrupt request is generated). 0: Not Bus Reset status (default value)
6	RSUSPD	This bit indicates that the Resume or Suspend status has occurred. Reference bit 7 of the UF0EPS1 register by FW. 1: Resume or Suspend status has occurred (interrupt request is generated). 0: Resume or Suspend status has not occurred (default value).
4	SHORT	This bit indicates that data is read from the FIFO of either the UF0BO1 or UF0BO2 register and that the USBSPnB signal (n = 2, 4) is active. It is valid only when the FIFO is full in the DMA mode. 1: USBSPnB signal is active (interrupt request is generated). 0: USBSPnB signal is not active (default value). Identify on which endpoint the operation is performed, by using the UF0DMS1 register. This bit is not automatically cleared to 0 even when the UF0DMS1 register is read by FW.

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Bit position	Bit name	Function
3	DMAED	This bit indicates that the DMA end (TC) signal for Endpoint n (n = 1 to 4, 7) is active. 1: DMA end signal for Endpoint n has been input (interrupt request is generated). 0: DMA end signal for Endpoint n has not been input (default value). When this bit is set to 1, the DMA request signal for Endpoint n becomes inactive. The DMA request signal for Endpoint n does not become active unless FW enables DMA transfer. Use the UF0DMS0 register to confirm on which endpoint the operation is actually performed. However, this bit is not automatically cleared to 0 even if the UF0DMS0 register is read by FW.
2	SETRQ	This bit indicates that the SET_XXXX request to be automatically processed has been received and automatically processed (XXXX = CONFIGURATION or FEATURE). 1: SET_XXXX request to be automatically processed has been received (interrupt request is generated). 0: SET_XXXX request to be automatically processed has not been received (default value). This bit is set to 1 after completion of the status stage. Reference the UF0SET register to identify what is the target of the request. This bit is not automatically cleared to 0 even if the UF0SET register is read by FW. The EPHALT bit is also set to 1 when the SET_FEATURE Endpoint request has been received.
1	CLRRQ	This bit indicates that the CLEAR_FEATURE request has been received and automatically processed. 1: CLEAR_FEATURE request has been received (interrupt request is generated). 0: CLEAR_FEATURE request has not been received (default value). This bit is set to 1 after completion of the status stage. Reference the UF0CLR register to identify what is the target of the request. This bit is not automatically cleared to 0 even if the UF0CLR register is read by FW.
0	EPHALT	This bit indicates that an endpoint has stalled. 1: Endpoint has stalled (interrupt request is generated). 0: Endpoint has not stalled (default value). This bit is also set to 1 when an endpoint has stalled by setting FW. Identify the endpoint that has stalled, by referencing the UF0EPS2 register. This bit is not automatically cleared to 0 even when the CLEAR_FEATURE Endpoint, SET_INTERFACE, or SET_CONFIGURATION request is received. It is not automatically cleared to 0, either, if the next SETUP token is received in case of overrun of Endpoint0. **Caution Even if Halt Feature of Endpoint0 is set and this interrupt request is generated, bit 0 of the UF0EPS2 register is masked and cleared to 0 between when a SET_FEATURE Endpoint0, CLEAR_FEATURE Endpoint0, or GET_STATUS Endpoint0 request, or FW-processed request is received and when a SETUP token other than the above is received.**

(12) UF0 INT status 1 register (UF0IS1)

This register indicates the interrupt source. If the contents of this register are changed, the EPCINT0B signal becomes active.

This register is read-only, in 8-bit units.

If an interrupt request (INTUSBF0) is generated from USBF, the FW must read this register to identify the interrupt source.

Each bit of this register is forcibly cleared to 0 when 0 is written to the corresponding bit of the UF0IC1 register. However, the SUCES and STG bits of the UF0IS1 register are automatically cleared to 0 when the next SETUP token has been received.

Caution In the USBF, multiple interrupt sources, such as Bus Reset, Resume, and Short, are ORed internally and are issued as a single interrupt request (INTUSBF0). Therefore, in the case of the occurrence of multiple interrupt sources, they are ORed and issued as an INTUSBF0 interrupt request.

For example, if a Bus Reset interrupt source and Resume interrupt source occur, the two sources are ORed and an INTUSBF0 interrupt request is issued.

Under these conditions, if the Bus Reset interrupt source is cleared to 0 (UF0IC0.BUSRSTC = 0), the V850ES/JG3-H or V850ES/JH3-H internal INTUSBF0 interrupt request may remain set to 1 since the Resume interrupt source will still be remaining. The new interrupt request flag (US0BIC.US0BIF), therefore, might not be set to 1.

In this case, after performing clear processing for each interrupt request with the INTUSBF0 interrupt servicing routine, confirm the flag status for the UF0IS0 and UF0IS1 registers again, and if there are any interrupt sources with flags set to 1, perform flag clearing (only the applicable bits need to be cleared (do not perform a batch clearing)).

(1/2)

	7	6	5	4	3	2	1	0	Address	After reset
UF0IS1	0	E0IN	E0INDT	E0ODT	SUCES	STG	PROT	CPU DEC	00200022H	00H

Bit position	Bit name	Function
6	E0IN	This bit indicates that an IN token for Endpoint0 has been received and that the hardware has automatically transmitted NAK. 1: IN token is received and NAK is transmitted (interrupt request is generated). 0: IN token is not received (default value).
5	E0INDT	This bit indicates that data has been correctly transmitted from the UF0E0W register. 1: Transmission from UF0E0W register is completed (interrupt request is generated). 0: Transmission from UF0E0W register is not completed (default value). Data is transmitted in synchronization with the IN token next to the one that set the EP0NKW bit of the UF0E0N register to 1. This bit is automatically set to 1 by hardware when the host correctly receives that data. It is also set to 1 even if the data is a Null packet. This bit is automatically cleared to 0 by hardware when the first write access is made to the UF0E0W register.

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Bit position	Bit name	Function
4	E0ODT	This bit indicates that data has been correctly received in the UF0E0R register. 1: Data is in UF0E0R register (interrupt request is generated). 0: Data is not in UF0E0R register (default value). This bit is automatically set to 1 by hardware when data has been correctly received. At the same time, the EP0R bit of the UF0EPS0 register is also set to 1. If a Null packet has been received, this bit is not set to 1. It is automatically cleared to 0 by hardware when the FW reads the UF0E0R register and the value of the UF0E0L register becomes 0.
3	SUCES	This bit indicates that either an FW-processed or hardware-processed request has been received and that the status stage has been correctly completed. 1: Control transfer has been correctly processed (interrupt request is generated). 0: Control transfer has not been processed correctly (default value). This bit is set to 1 upon completion of the status stage. It is automatically cleared to 0 by hardware when the next SETUP token is received. This bit is also set to 1 when data with Data PID of 0 (Null data) is received in the status stage of control transfer.
2	STG	This bit is set to 1 when the stage of control transfer has changed to the status stage. It is valid for both FW-processed and hardware-processed requests. This bit is also set to 1 when the stage of control transfer (without data) has changed to the status stage. 1: Status stage (interrupt request is generated) 0: Not status stage (default value) This bit is automatically cleared to 0 by hardware when the next SETUP token is received. It is also set to 1 when the stage of control transfer has changed to the status stage while ACK cannot be correctly received in the data stage. In this case, the EP0NKW bit of the UF0E0N register is also cleared to 0 as soon as the UF0E0W register has been cleared, if the FW is processing control transfer (read).
1	PROT	This bit indicates that a SETUP token has been received. It is valid for both FW-processed and hardware-processed requests. 1: SETUP token is correctly received (interrupt request is generated). 0: SETUP token is not received (default value). This bit is set to 1 when data has been correctly received in the UF0E0ST register. Clear this bit to 0 by FW when the first read access is made to the UF0E0ST register. If it is not cleared to 0 by FW, reception of the next SETUP token cannot be correctly recognized. This bit is used to accurately recognize that a SETUP transaction has been executed again during control transfer. If the SETUP transaction is re-executed during control transfer and if a second request is executed by hardware, the CPUDEC bit is not set to 1, but the PROT bit can be used for recognition of the re-execution.
0	CPUDEC	This bit indicates that the UF0E0ST register has a request that is to be decoded by FW. 1: Data is in UF0E0ST register (interrupt request is generated). 0: Data is not in UF0E0ST register (default value). This bit is automatically cleared to 0 by hardware when all the data of the UF0E0ST register is read.

(13) UF0 INT status 2 register (UF0IS2)

This register indicates the interrupt source. If the contents of this register are changed, the EPCINT1B signal becomes active.

This register is read-only, in 8-bit units.

If an interrupt request (INTUSBF0) is generated from USBF, the FW must read this register to identify the interrupt source.

Each bit of this register is forcibly cleared to 0 when 0 is written to the corresponding bit of the UF0IC2 register.

The related bits are invalid if each endpoint is not supported by the setting of the UF0EnIM register (n = 1, 3, 7) and the current setting of the interface.

	7	6	5	4	3	2	1	0	Address	After reset
UF0IS2	BKI2IN	BKI2DT	BKI1IN	BKI1DT	0	0	0	IT1DT	00200024H	00H

Bit position	Bit name	Function
7, 5	BKInIN	These bits indicate that an IN token has been received in the UF0BIn register (Endpoint m) and that NAK has been returned. 1: IN token is received and NAK is transmitted (interrupt request is generated). 0: IN token is not received (default value).
6, 4	BKInDT	These bits indicate that the FIFO of the UF0BIn register (Endpoint m) has been toggled. This means that data can be written to Endpoint m. 1: FIFO has been toggled (interrupt request is generated). 0: FIFO has not been toggled (default value). The data written to Endpoint m is transmitted in synchronization with the IN token next to the one that set the BKInNK bit of the UF0EN register to 1. When the FIFO has been toggled and then data can be written from the CPU, this bit is automatically set to 1 by hardware. It is also set to 1 when the FIFO has been toggled, even if the data is a Null packet. This bit is automatically cleared to 0 by hardware when the first write access is made to the UF0BIn register.
0	IT1DT	These bits indicate that data has been correctly received from the UF0INT1 register (Endpoint x). 1: Transmission is completed (interrupt request is generated). 0: Transmission is not completed (default value). Data is transmitted in synchronization with the IN token next to the one that set the ITnNK bit of the UF0EN register to 1. This bit is automatically set to 1 by hardware when the host has correctly received that data. It is automatically cleared to 0 by hardware when the first write access is made to the UF0INT1 register. This bit is also set to 1 even when the data is a Null packet.

Remark n = 1, 2

m = 1 and x = 7 where n = 1

m = 3 where n = 2

(14) UF0 INT status 3 register (UF0IS3)

This register indicates the interrupt source. If the contents of this register are changed, the EPCINT1B signal becomes active.

This register is read-only, in 8-bit units.

If an interrupt request (INTUSBF0) is generated from USBF, the FW must read this register to identify the interrupt source.

Each bit of this register is forcibly cleared to 0 when 0 is written to the corresponding bit of the UF0IC3 register.

The related bits are invalid if each endpoint is not supported by the setting of the UF0EnIM register (n = 2, 4) and the current setting of the interface.

(1/2)

	7	6	5	4	3	2	1	0	Address	After reset
UF0IS3	BKO2FL	BKO2NL	BKO2 NAK	BKO2DT	BKO1FL	BKO1NL	BKO1 NAK	BKO1DT	00200026H	00H

Bit position	Bit name	Function
7, 3	BKOnFL	These bits indicate that data has been correctly received in the UF0BOn register (Endpoint m) and that both the FIFOs of the CPU and SIE hold the data. 1: Received data is in both the FIFOs of the UF0BOn register (interrupt request is generated). 0: Received data is not in the FIFO on the SIE side of the UF0BOn register (default value). If data is held in both the FIFOs of the CPU and SIE, these bits are automatically set to 1 by hardware. They are automatically cleared to 0 by hardware when the FIFO is toggled.
6, 2	BKOnNL	These bits indicate that a Null packet (packet with a length of 0) has been received in the UF0BOn register (Endpoint m). 1: Null packet is received (interrupt request is generated). 0: Null packet is not received (default value). These bits are set to 1 immediately after reception of a Null packet when the FIFO is empty. They are set to 1 when the FIFO on the CPU side has been completely read if data is in that FIFO.
5, 1	BKOnNAK	These bits indicate that an OUT token has been received to the UF0BOn register (Endpoint m) and that NAK has been returned. 1: OUT token is received and NAK is transmitted (interrupt request is generated). 0: OUT token is not received (default value).

Remark n = 1, 2
m = 2 where n = 1
m = 4 where n = 2

(2/2)

Bit position	Bit name	Function
4, 0	BKOnDT	These bits indicate that data has been correctly received in the UF0BOn register (Endpoint m). 1: Reception has been completed correctly (interrupt request is generated). 0: Reception has not been completed (default value). These bits are automatically set to 1 by hardware when data has been correctly received and the FIFO has been toggled. At the same time, the corresponding bits of the UF0EPS0 register are also set to 1. They are not set to 1 when the data is a Null packet. These bits are automatically cleared to 0 by hardware when the value of the UF0BOnL register becomes 0 as a result of reading the UF0BOn register by FW. These bits are automatically cleared to 0 when all the contents of the FIFO on the CPU side have been read. However, the interrupt request is not cleared if data is in the FIFO on the SIE side at this time, and the INTUSBF1 signal does not become inactive. The signal is kept active if data is successively received.

Remark n = 1, 2
m = 2 where n = 1
m = 4 where n = 2

(15) UF0 INT status 4 register (UF0IS4)

This register indicates the interrupt source. If the contents of this register are changed, the EPCINT2B signal becomes active.

This register is read-only, in 8-bit units.

If an interrupt request (INTUSBF0) is generated from USBF, the FW must read this register to identify the interrupt source.

Each bit of this register is forcibly cleared to 0 when 0 is written to the corresponding bit of the UF0IC4 register.

The related bits are invalid if each endpoint is not supported by the setting of the UF0EnIM register (n = 1 to 4, 7) and the current setting of the interface.

	7	6	5	4	3	2	1	0	Address	After reset
UF0IS4	0	0	SETINT	0	0	0	0	0	00200028H	00H

Bit position	Bit name	Function
5	SETINT	This bit indicates that the SET_INTERFACE request has been received and automatically processed. 1: The request has been automatically processed (interrupt request is generated). 0: The request has not been automatically processed (default value). The current setting of this bit can be identified by reading the UF0ASS or UF0IFn register (n = 0 to 4).

(16) UF0 INT mask 0 register (UF0IM0)

This register controls masking of the interrupt sources indicated by the UF0IS0 register.

This register can be read or written in 8-bit units.

FW can mask occurrence of an interrupt request from USBF (INTUSBF0) by writing 1 to the corresponding bit of this register.

	7	6	5	4	3	2	1	0	Address	After reset
UF0IM0	BUS RSTM	RSU SPDM	0	SHORTM	DMA EDM	SET RQM	CLR RQM	EP HALTM	0020002EH	00H

Bit position	Bit name	Function
7	BUSRSTM	This bit masks the Bus Reset interrupt. 1: Mask 0: Do not mask (default value)
6	RSUSPDM	This bit masks the Resume/Suspend interrupt. 1: Mask 0: Do not mask (default value)
4	SHORTM	This bit masks the Short interrupt. 1: Mask 0: Do not mask (default value)
3	DMAEDM	This bit masks the DMA_END interrupt. 1: Mask 0: Do not mask (default value)
2	SETRQM	This bit masks the SET_RQ interrupt. 1: Mask 0: Do not mask (default value)
1	CLRRQM	This bit masks the CLR_RQ interrupt. 1: Mask 0: Do not mask (default value)
0	EPHALTM	This bit masks the EP_Halt interrupt. 1: Mask 0: Do not mask (default value)

(17) UF0 INT mask 1 register (UF0IM1)

This register controls masking of the interrupt sources indicated by the UF0IS1 register.

This register can be read or written in 8-bit units.

FW can mask occurrence of an interrupt request from USBF (INTUSBF0) by writing 1 to the corresponding bit of this register.

	7	6	5	4	3	2	1	0	Address	After reset
UF0IM1	0	E0INM	E0 INDTM	E0 ODTM	SUCESM	STGM	PROTM	CPU DECM	00200030H	00H

Bit position	Bit name	Function
6	E0INM	This bit masks the EP0IN interrupt. 1: Mask 0: Do not mask (default value)
5	E0INDTM	This bit masks the EP0INDT interrupt. 1: Mask 0: Do not mask (default value)
4	E0ODTM	This bit masks the EP0OUTDT interrupt. 1: Mask 0: Do not mask (default value)
3	SUCESM	This bit masks the Success interrupt. 1: Mask 0: Do not mask (default value)
2	STGM	This bit masks the Stg interrupt. 1: Mask 0: Do not mask (default value)
1	PROTM	This bit masks the Protect interrupt. 1: Mask 0: Do not mask (default value)
0	CPUDECM	This bit masks the CPUDEC interrupt. 1: Mask 0: Do not mask (default value)

(18) UF0 INT mask 2 register (UF0IM2)

This register controls masking of the interrupt sources indicated by the UF0IS2 register.

This register can be read or written in 8-bit units.

FW can mask occurrence of an interrupt request from USBF (INTUSBF0) by writing 1 to the corresponding bit of this register.

The related bits are invalid if each endpoint is not supported by the setting of the UF0EnIM register (n = 1, 3, 7) and the current setting of the interface.

	7	6	5	4	3	2	1	0	Address	After reset
UF0IM2	BKI2INM	BKI2 DTM	BKI1INM	BKI1 DTM	0	0	0	IT1DTM	00200032H	00H

Bit position	Bit name	Function
7, 5	BKInINM	These bits mask the BLKInIN interrupt. 1: Mask 0: Do not mask (default value)
6, 4	BKInDTM	These bits mask the BLKInDT interrupt. 1: Mask 0: Do not mask (default value)
0	IT1DTM	These bits mask the INTnDT interrupt. 1: Mask 0: Do not mask (default value)

Remark n = 1, 2

(19) UF0 INT mask 3 register (UF0IM3)

This register controls masking of the interrupt sources indicated by the UF0IS3 register.

This register can be read or written in 8-bit units.

FW can mask occurrence of an interrupt request from USBF (INTUSBF0) by writing 1 to the corresponding bit of this register.

The related bits are invalid if each endpoint is not supported by the setting of the UF0EnIM register (n = 2, 4) and the current setting of the interface.

	7	6	5	4	3	2	1	0	Address	After reset
UF0IM3	BKO2 FLM	BKO2 NLM	BKO2 NAKM	BKO2 DTM	BKO1 FLM	BKO1 NLM	BKO1 NAKM	BKO1 DTM	00200034H	00H

Bit position	Bit name	Function
7, 3	BKOnFLM	These bits mask the BLKOnFL interrupt. 1: Mask 0: Do not mask (default value)
6, 2	BKOnNLM	These bits mask the BLKOnNL interrupt. 1: Mask 0: Do not mask (default value)
5, 1	BKOnNAKM	These bits mask the BLKOnNK interrupt. 1: Mask 0: Do not mask (default value)
4, 0	BKOnDTM	These bits mask the BLKOnDT interrupt. 1: Mask 0: Do not mask (default value)

Remark n = 1, 2

(20) UF0 INT mask 4 register (UF0IM4)

This register controls masking of the interrupt sources indicated by the UF0IS4 register.

This register can be read or written in 8-bit units.

FW can mask occurrence of an interrupt request from USBF (INTUSBF0) by writing 1 to the corresponding bit of this register.

The related bits are invalid if each endpoint is not supported by the setting of the UF0EnIM register (n = 1 to 4, 7) and the current setting of the interface.

	7	6	5	4	3	2	1	0	Address	After reset
UF0IM4	0	0	SETINTM	0	0	0	0	0	00200036H	00H

Bit position	Bit name	Function
5	SETINTM	This bit masks the SET_INT interrupt. 1: Mask 0: Do not mask (default value)

(21) UF0 INT clear 0 register (UF0IC0)

This register controls clearing the interrupt sources indicated by the UF0IS0 register.

This register is write-only, in 8-bit units. If this register is read, the value FFH is read.

FW can clear an interrupt source by writing 0 to the corresponding bit of this register. Even a bit that is automatically cleared to 0 by hardware can be cleared by FW before it is cleared by hardware. Writing 0 to a bit of this register automatically sets the bit to 1. Writing 1 is invalid.

	7	6	5	4	3	2	1	0	Address	After reset
UF0IC0	BUS RSTC	RSU SPDC	1	SHORTC	DMA EDC	SET RQC	CLR RQC	EP HALTC	0020003CH	FFH

Bit position	Bit name	Function
7	BUSRSTC	This bit clears the Bus Reset interrupt. 0: Clear
6	RSUSPDC	This bit clears the Resume/Suspend interrupt. 0: Clear
4	SHORTC	This bit clears the Short interrupt. 0: Clear
3	DMAEDC	This bit clears the DMA_END interrupt. 0: Clear
2	SETRQC	This bit clears the SET_RQ interrupt. 0: Clear
1	CLRRQC	This bit clears the CLR_RQ interrupt. 0: Clear
0	EPHALTC	This bit clears the EP_Halt interrupt. 0: Clear

(22) UF0 INT clear 1 register (UF0IC1)

This register controls clearing the interrupt sources indicated by the UF0IS1 register.

This register is write-only, in 8-bit units. If this register is read, the value FFH is read.

FW can clear an interrupt source by writing 0 to the corresponding bit of this register. Even a bit that is automatically cleared to 0 by hardware can be cleared by FW before it is cleared by hardware. Writing 0 to a bit of this register automatically sets the bit to 1. Writing 1 is invalid.

	7	6	5	4	3	2	1	0	Address	After reset
UF0IC1	1	E0INC	E0 INDTC	E0ODTC	SUCESC	STGC	PROTC	CPU DECC	0020003EH	FFH

Bit position	Bit name	Function
6	E0INC	This bit clears the EP0IN interrupt. 0: Clear
5	E0INDTC	This bit clears the EP0INDT interrupt. 0: Clear
4	E0ODTC	This bit clears the EP0OUTDT interrupt. 0: Clear
3	SUCESC	This bit clears the Success interrupt. 0: Clear
2	STGC	This bit clears the Stg interrupt. 0: Clear
1	PROTC	This bit clears the Protect interrupt. 0: Clear
0	CPUDECC	This bit clears the CPUDEC interrupt. 0: Clear

(23) UF0 INT clear 2 register (UF0IC2)

This register controls clearing the interrupt sources indicated by the UF0IS2 register.

This register is write-only, in 8-bit units. If this register is read, the value FFH is read.

FW can clear an interrupt source by writing 0 to the corresponding bit of this register. Even a bit that is automatically cleared to 0 by hardware can be cleared by FW before it is cleared by hardware. Writing 0 to a bit of this register automatically sets the bit to 1. Writing 1 is invalid.

The related bits are invalid if each endpoint is not supported by the setting of the UF0EnIM register (n = 1, 3, 7) and the current setting of the interface.

	7	6	5	4	3	2	1	0	Address	After reset
UF0IC2	BKI2INC	BKI2 DTC	BKI1INC	BKI1 DTC	1	1	1	IT1DTC	00200040H	FFH

Bit position	Bit name	Function
7, 5	BKInINC	These bits clear the BLKInIN interrupt. 0: Clear
6, 4	BKInDTC	These bits clear the BLKInDT interrupt. 0: Clear
0	IT1DTC	These bits clear the INTnDT interrupt. 0: Clear

Remark n = 1, 2

(24) UF0 INT clear 3 register (UF0IC3)

This register controls clearing the interrupt sources indicated by the UF0IS3 register.

This register is write-only, in 8-bit units. If this register is read, the value FFH is read.

FW can clear an interrupt source by writing 0 to the corresponding bit of this register. Even a bit that is automatically cleared to 0 by hardware can be cleared by FW before it is cleared by hardware. Writing 0 to a bit of this register automatically sets the bit to 1. Writing 1 is invalid.

The related bits are invalid if each endpoint is not supported by the setting of the UF0EnIM register (n = 2, 4) and the current setting of the interface.

	7	6	5	4	3	2	1	0	Address	After reset
UF0IC3	BKO2 FLC	BKO2 NLC	BKO2 NAKC	BKO2 DTC	BKO1 FLC	BKO1 NLC	BKO1 NAKC	BKO1 DTC	00200042H	FFH

Bit position	Bit name	Function
7, 3	BKOnFLC	These bits clear the BLKOnFL interrupt. 0: Clear
6, 2	BKOnNLC	These bits clear the BLKOnNL interrupt. 0: Clear
5, 1	BKOnNAKC	These bits clear the BLKOnNK interrupt. 0: Clear
4, 0	BKOnDTC	These bits clear the BLKOnDT interrupt. 0: Clear

Remark n = 1, 2

(25) UF0 INT clear 4 register (UF0IC4)

This register controls clearing the interrupt sources indicated by the UF0IS4 register.

This register is write-only, in 8-bit units. If this register is read, the value FFH is read.

FW can clear an interrupt source by writing 0 to the corresponding bit of this register. Even a bit that is automatically cleared to 0 by hardware can be cleared by FW before it is cleared by hardware. Writing 0 to a bit of this register automatically sets the bit to 1. Writing 1 is invalid.

The related bits are invalid if each endpoint is not supported by the setting of the UF0EnIM register (n = 1 to 4, 7) and the current setting of the interface.

	7	6	5	4	3	2	1	0	Address	After reset
UF0IC4	1	1	SETINTC	1	1	1	1	1	00200044H	FFH

Bit position	Bit name	Function
5	SETINTC	This bit clears the SET_INT interrupt. 0: Clear

(26) UF0 INT & DMARQ register (UF0IDR)

This register selects reporting via an interrupt request or starting DMA.

This register can be read or written in 8-bit units.

If data exists in either the UF0BO1 or UF0BO1 register, or if data can be written to the UF0BI1 or UF0BI2 register, this register selects whether it is reported to the FW by an interrupt request, or whether starting DMA is requested.

If starting DMA is requested, the DMA transfer mode can be selected according to the setting of bits 0 and 1.

The related bits are invalid if each endpoint is not supported by the setting of the UF0EnIM register (n = 1 to 4) and the current setting of the interface.

Be sure to clear bits 3 and 2 to “0”. If they are set to 1, the operation is not guaranteed.

Caution If the target endpoint is not supported by the SET_INTERFACE request under DMA transfer, the DMA request signal becomes inactive immediately, and the corresponding bit is automatically cleared to 0 by hardware.

(1/2)

	7	6	5	4	3	2	1	0	Address	After reset
UF0IDR	DQBI2MS	DQBI1MS	DQBO2MS	DQBO1MS	0	0	MODE1	MODE0	0020004CH	00H

Bit position	Bit name	Function
7, 6	DQBInMS	These bits enable (mask) a write DMA transfer request (DMA request signal for Endpoint m) to the UF0BIn register. When these bits are set to 1, the DMA request signal for Endpoint m becomes active while writing data can be acknowledged. If the DMA end signal for Endpoint m is input (if the DMA controller issues TC), these bits are automatically cleared to 0 by hardware. To continue DMA transfer, re-set these bits to 1 by FW. 1: Enables active DMA request signal for Endpoint m (masks BKInDT interrupt). 0: Disables active DMA request signal for Endpoint m (default value).
5, 4	DQBOnMS	These bits enable (mask) a read DMA transfer request (DMA request signal for Endpoint x) to the UF0BOn register. When these bits are set to 1, the DMA request signal for Endpoint x becomes active if the data to be read is prepared in the UF0BOn register. If the DMA end signal for Endpoint x is input (if the DMA controller issues TC), these bits are automatically cleared to 0 by hardware. They are also cleared to 0 when the USBSPxB signal is active. To continue DMA transfer, re-set these bits to 1 by FW. 1: Enables active DMA request signal for Endpoint x (masks BKOnDT interrupt). 0: Disables active DMA request signal for Endpoint x (default value).

Remark n = 1, 2

m = 1 and x = 2 where n = 1

m = 3 and x = 4 where n = 2

(2/2)

<table>
<tr><th>Bit position</th><th>Bit name</th><th>Function</th></tr>
<tr><td>1, 0</td><td>MODE1,
MODE0</td><td>These bits select the DMA transfer mode.
<table>
<tr><th>MODE1</th><th>MODE0</th><th>Mode</th><th>Remark</th></tr>
<tr><td>1</td><td>0</td><td>Demand mode</td><td>DMA request signal becomes active as long as there is data. It becomes inactive if there is no more data.</td></tr>
<tr><td colspan="2">Other than above</td><td colspan="2">Setting prohibited</td></tr>
</table></td></tr>
</table>

(27) UF0 DMA status 0 register (UF0DMS0)

This register indicates the DMA status of Endpoint1 to Endpoint4.

This register is read-only, in 8-bit units.

The related bits are invalid if each endpoint is not supported by the setting of the UF0EnIM register (n = 1 to 4) and the current setting of the interface.

	7	6	5	4	3	2	1	0	Address	After reset
UF0DMS0	0	0	DQE4	DQE3	DQE2	DQE1	0	0	0020004EH	00H

Bit position	Bit name	Function
5	DQE4	This bit indicates that a DMA read request is being issued from Endpoint4 to memory. 1: DMA read request from Endpoint4 is being issued. 0: DMA read request from Endpoint4 is not being issued (default value).
4	DQE3	This bit indicates that a DMA write request is being issued from memory to Endpoint3. Note that, even if data is in Endpoint3 (when the FIFO is not full and after the BKI2DED bit has been set to 1), the DMA request signal becomes active immediately and DMA transfer is started when the DQBI2MS bit of the UF0IDR register is set to 1. 1: DMA write request for Endpoint3 is being issued. 0: DMA write request for Endpoint3 is not being issued (default value).
3	DQE2	This bit indicates that a DMA read request is being issued from Endpoint2 to memory. 1: DMA read request from Endpoint2 is being issued. 0: DMA read request from Endpoint2 is not being issued (default value).
2	DQE1	This bit indicates that a DMA write request is being issued from memory to Endpoint1. Note that, even if data is in Endpoint1 (when the FIFO is not full and after the BKI1DED bit has been set to 1), the DMA request signal becomes active immediately and DMA transfer is started when the DQBI1MS bit of the UF0IDR register is set to 1. 1: DMA write request for Endpoint1 is being issued. 0: DMA write request for Endpoint1 is not being issued (default value).

(28) UF0 DMA status 1 register (UF0DMS1)

This register indicates the DMA status of Endpoint1 to Endpoint4.

This register is read-only, in 8-bit units.

The related bits are invalid if each endpoint is not supported by the setting of the UF0EnIM register (n = 1 to 4) and the current setting of the interface.

Each bit is automatically cleared to 0 when this register is read. Even when this register is read, however, bits 4 and 3 of the UF0IS0 register are not cleared to 0. If the target endpoint is no longer supported by the SET_INTERFACE request, each bit is automatically cleared to 0 by hardware (however, the DMA_END interrupt request and Short interrupt request are not cleared).

	7	6	5	4	3	2	1	0	Address	After reset
UF0DMS1	DEDE4	DSPE4	DEDE3	DEDE2	DSPE2	DEDE1	0	0	00200050H	00H

Bit position	Bit name	Function
7, 5, 4, 2	DEDEn	These bits indicate that the DMA end (TC) signal for Endpoint n becomes active and DMA is stopped while a DMA read request is being issued from Endpoint n to memory. 1: DMA end signal for Endpoint n is active. 0: DMA end signal for Endpoint n is inactive (default value).
6, 3	DSPEm	These bits indicate that, although a DMA read request was being issued from Endpoint m to memory, DMA has been stopped because the received data is a short packet and there is no more data to be transferred. 1: DMASTOP_EPm signal is active. 0: DMASTOP_EPm signal is inactive (default value).

Remark n = 1 to 4
m = 2, 4

(29) UF0 FIFO clear 0 register (UF0FIC0)

This register clears each FIFO.

This register is write-only, in 8-bit units. If this register is read, 00H is read.

FW can clear the target FIFO by writing 1 to the corresponding bit of this register. The bit to which 1 has been written is automatically cleared to 0. Writing 0 to the bit is invalid.

The related bits are invalid if each endpoint is not supported by the setting of the UF0EnIM register (n = 1, 3, 7) and the current setting of the interface.

	7	6	5	4	3	2	1	0	Address	After reset
UF0FIC0	BKI2SC	BKI2CC	BKI1SC	BKI1CC	ITR2C	ITR1C	EP0WC	EP0RC	00200060H	00H

Bit position	Bit name	Function
7, 5	BKInSC	These bits clear only the FIFO on the SIE side of the UF0BIn register (reset the counter). 1: Clear Writing these bits is invalid while an IN token for Endpoint m is being processed with the BKInNK bit set to 1. The BKInNK bit is automatically cleared to 0 by clearing the FIFO. Make sure that the FIFO on the CPU side is empty when these bits are used.
6, 4	BKInCC	These bits clear only the FIFO on the CPU side of the UF0BIn register (reset the counter). 1: Clear
2	ITR1C	These bits clear the UF0INT1 register (reset the counter). 1: Clear Writing these bits is invalid while an IN token for Endpoint 7 is being processed with the IT1NK bit set to 1. The IT1NK bit is automatically cleared to 0 by clearing the FIFO.
1	EP0WC	This bit clears the UF0E0W register (resets the counter). 1: Clear Writing this bit is invalid while an IN token for Endpoint0 is being processed with the EP0NKW bit set to 1. The EP0NKW bit is automatically cleared to 0 by clearing the FIFO.
0	EP0RC	This bit clears the UF0E0R register (resets the counter). 1: Clear When the EP0NKR bit is set to 1 (except when it has been set by FW), the EP0NKR bit is automatically cleared to 0 by clearing the FIFO.

Remark n = 1, 2
m = 1 where n = 1
m = 3 where n = 2

(30) UF0 FIFO clear 1 register (UF0FIC1)

This register clears each FIFO.

This register is write-only, in 8-bit units. If this register is read, 00H is read.

FW can clear the target FIFO by writing 1 to the corresponding bit of this register. The bit to which 1 has been written is automatically cleared to 0. Writing 0 to the bit is invalid.

The related bits are invalid if each endpoint is not supported by the setting of the UF0EnIM register (n = 2, 4) and the current setting of the interface.

	7	6	5	4	3	2	1	0	Address	After reset
UF0FIC1	0	0	0	0	BKO2C	BKO2CC	BKO1C	BKO1CC	00200062H	00H

Bit position	Bit name	Function
3, 1	BKOnC	These bits clear the FIFOs on both the SIE and CPU sides of the UF0BOn register (reset the counter). 1: Clear When the BKOnNK bit is set to 1 (except when it has been set by FW), the BKOnNK bit is automatically cleared to 0 by clearing the FIFO.
2, 0	BKOnCC	These bits clear only the FIFO on the CPU side of the UF0BOn register (reset the counter). 1: Clear When the BKOnNK bit is set to 1 (except when it has been set by FW), the BKOnNK bit is automatically cleared to 0 by clearing the FIFO.

Remark n = 1, 2

(31) UF0 data end register (UF0DEND)

This register reports the end of writing to the transmission system.

This register is write-only, in 8-bit units (however, bits 7 and 6 can be read and written). If this register is read, 00H is read.

FW can start data transfer of the target endpoint by writing 1 to the corresponding bit of this register. The bit to which 1 has been written is automatically cleared to 0. Writing 0 to the bit is invalid.

The related bits are invalid if each endpoint is not supported by the setting of the UF0EnIM register (n = 1, 3, 7) and the current setting of the interface.

(1/2)

	7	6	5	4	3	2	1	0	Address	After reset
UF0DEND	BKI2T	BKI1T	0	0	IT1DEND	BKI2DED	BKI1DED	E0DED	0020006AH	00H

Bit position	Bit name	Function
7, 6	BKInT	These bits specify whether toggling the FIFO is automatically executed if the FIFO on the CPU side of the UF0BIn register becomes full as a result of DMA. 1: Automatically execute a toggle operation of the FIFO as soon as the FIFO has become full. 0: Do not automatically execute a toggle operation of the FIFO even if the FIFO becomes full (default value).
3	IT1DEND	Set these bits to 1 to transmit the data of the UF0INT1 register. When these bits are set to 1, the IT1NK bit is set to 1 and data transfer is executed. 1: Transmit a short packet. 0: Do not transmit a short packet (default value). If the ITR1C bit of the UF0FIC0 register is set to 1 and then these bits are set to 1 (counter of UF0INT1 register = 0 and the corresponding bit of the UF0EPS1 register = 1), a Null packet (with a data length of 0) is transmitted. If data exists in the UF0INT1 register and if these bits are set to 1 (counter of UF0INT1 register ≠ 0 and the corresponding bit of the UF0EPS0 register = 1), a short packet is transmitted. These bits are automatically controlled by hardware when the FIFO is full.

Remark n = 1, 2

(2/2)

Bit position	Bit name	Function
2, 1	BKInDED	Set these bits to 1 when writing transmit data to the UF0BIn register has been completed. When these bits are set to 1, the FIFO is toggled as soon as possible, the BKInNK bit is set to 1, and data is transferred. 1: Transmit a short packet. 0: Do not transmit a short packet (default value). These bits control the FIFO on the CPU side. If the BKInCC bit of the UF0FIC0 register is set to 1 and then these bits are set to 1 (counter of UF0BIn register = 0), a Null packet (with a data length of 0) is transmitted. If data exists in the UF0BIn register and if these bits are set to 1 (counter of UF0BIn register ≠ 0), and if the FIFO is not full, a short packet is transmitted. If the FIFO on the CPU side of the UF0BIn register becomes full as a result of DMA, with the PIO or BKInT bit set to 1, the hardware starts data transmission even if these bits are not set to 1. If the FIFO on the CPU side of the UF0BIn register becomes full as a result of DMA, with the BKInT bit cleared to 0, be sure to set these bits to 1 (see **21.6.3 (3) UF0 EPNAK register (UF0EN)**).
0	E0DED	Set this bit to 1 to transmit data of the UF0E0W register. When this bit is set to 1, the EP0NKW bit is set to 1 and data is transferred. 1: Transmit a short packet. 0: Do not transmit a short packet (default value). If the EP0WC bit of the UF0FIC0 register is set to 1 and if this bit is set to 1 (counter of UF0E0W register = 0 and bit 1 of UF0EPS0 register = 1), a Null packet (with a data length of 0) is transmitted. If data exists in the UF0E0W register and if this bit is set to 1 (counter of UF0E0W register ≠ 0 and bit 1 of the UF0EPS0 register = 1), and if the FIFO is not full, a short packet is transmitted.

Remark n = 1, 2

(32) UF0 GPR register (UF0GPR)

This register controls USBF and the USB interface.

This register is write-only, in 8-bit units. If this register is read, 00H is read. Be sure to clear bits 7 to 1 to “0”.

FW can reset the USBF by writing 1 to bit 0 of this register. This bit is automatically cleared to 0 after 1 has been written to it. Writing 0 to this bit is invalid.

	7	6	5	4	3	2	1	0	Address	After reset
UF0GPR	0	0	0	0	0	0	0	MRST	0020006EH	00H

Bit position	Bit name	Function
0	MRST	Set this bit to 1 to reset USBF. 1: Reset Actually, USBF is reset two USB clocks after this bit has been set to 1 by FW and the write signal has become inactive. Resetting USBF by the MRST bit while the system clock is operating has the same result as resetting by the $\overline{\text{RESET}}$ pin (hardware reset) (register value back to default value).

(33) UF0 mode control register (UF0MODC)

This register controls CPUDEC processing.

This register can be read or written in 8-bit units.

By setting each bit of this register, the setting of the UF0MODS register can be changed. The bit of this register is automatically cleared to 0 only at hardware reset and when the MRST bit of the UF0GRP register has been set to 1.

Even if the bit of this register has automatically been set to 1 by hardware, the setting by FW takes precedence.

Be sure to clear bits 7 and 5 to 2 to “0”. If they are set to 1, the operation is not guaranteed.

Caution This register is provided for debugging purposes. Usually, do not set this register except for verifying the operation or when a special mode is used.

	7	6	5	4	3	2	1	0	Address	After reset
UF0MODC	0	CDC GDST	0	0	0	0	0	0	00200074H	00H

Bit position	Bit name	Function
6	CDCGDST	Set this bit to 1 to switch the GET_DESCRIPTOR Configuration request to CPUDEC processing. By setting this bit to 1, the CDCGD bit of the UF0MODS register can be forcibly set to 1. 1: Forcibly change the GET_DESCRIPTOR Configuration request to CPUDEC processing (sets the CDCGD bit of the UF0MODS register to 1). 0: Automatically process the GET_DESCRIPTOR Configuration request (default value).

(34) UF0 mode status register (UF0MODS)

This register indicates the configuration status.

This register is read-only, in 8-bit units.

	7	6	5	4	3	2	1	0	Address	After reset
UF0MODS	0	CDCGD	0	MPACK	DFLT	CONF	0	0	00200078H	00H

Bit position	Bit name	Function
6	CDCGD	This bit specifies whether CPUDEC processing is performed for the GET_DESCRIPTOR Configuration request. 1: Forcibly change the GET_DESCRIPTOR Configuration request to CPUDEC processing. 0: Automatically process the GET_DESCRIPTOR Configuration request (default value).
4	MPACK	This bit indicates the transmit packet size of Endpoint0. 1: Transmit a packet of other than 8 bytes. 0: Transmit a packet of 8 bytes (default value). This bit is automatically set to 1 by hardware after the GET_DESCRIPTOR Device request has been processed (on normal completion of the status stage). It is not cleared to 0 until the USBF has been reset (it is not cleared to 0 by Bus Reset). If this bit is not set to 1, the hardware transfers only the automatically-executed request in 8-byte units. Therefore, even if data of more than 8 bytes is sent by the OUT token to be processed by FW before completion of the GET_DESCRIPTOR Device request, the data is correctly received. This bit is ignored if the size of Endpoint0 is 8 bytes.
3	DFLT	This bit indicates the default status (DFLT bit = 1). 1: Enables response. 0: Disables response (always no response) (default value). This bit is automatically set to 1 by Bus Reset. The transaction for all the endpoints is not responded to until this bit is set to 1.
2	CONF	This bit indicates whether the SET_CONFIGURATION request has been completed. 1: SET_CONFIGURATION request has been completed. 0: SET_CONFIGURATION request has not been completed (default value). This bit is set to 1 when Configuration value = 1 is received by the SET_CONFIGURATION request. Unless this bit is set to 1, access to an endpoint other than Endpoint0 is ignored. This bit is cleared to 0 when Configuration value = 0 is received by the SET_CONFIGURATION request. It is also cleared to 0 when Bus Reset is detected.

(35) UF0 active interface number register (UF0AIFN)

This register sets the valid Interface number that correctly responds to the GET/SET_INTERFACE request. Because Interface 0 is always valid, Interfaces 1 to 4 can be selected.

This register can be read or written in 8-bit units.

	7	6	5	4	3	2	1	0	Address	After reset
UF0AIFN	ADDIF	0	0	0	0	0	IFNO1	IFNO0	00200080H	00H

Bit position	Bit name	Function
7	ADDIF	This bit allows use of Interfaces numbered other than 0. 1: Support up to the Interface number specified by the IFNO1 and IFNO0 bits. 0: Support only Interface 0 (default value). Setting bits 1 and 0 of this register is invalid when this bit is not set to 1.
1, 0	IFNO1, IFNO0	These bits specify the range of Interface numbers to be supported.

IFNO1	IFNO0	Valid Interface No.
1	1	0, 1, 2, 3, 4
1	0	0, 1, 2, 3
0	1	0, 1, 2
0	0	0, 1

(36) UF0 active alternative setting register (UF0AAS)

This register specifies a link between the Interface number and Alternative Setting.

This register can be read or written in 8-bit units.

USBF of the V850ES/JG3-H and V850ES/JH3-H can set a five-series Alternative Setting (Alternate Setting 0, 1, 2, 3, and 4 can be defined) and a two-series Alternative Setting (Alternative Setting 0 and 1 can be defined) for one Interface.

	7	6	5	4	3	2	1	0	Address	After reset
UF0AAS	ALT2	IFAL21	IFAL20	ALT2EN	ALT5	IFAL51	IFAL50	ALT5EN	00200082H	00H

Bit position	Bit name	Function
7, 3	ALTn	These bits specify whether an n-series Alternative Setting is linked with Interface 0. When these bits are set to 1, the setting of the IFALn1 and IFALn0 bits is invalid. 1: Link n-series Alternative Setting with Interface 0. 0: Do not link n-series Alternative Setting with Interface 0 (default value).
6, 5, 2, 1	IFALn1, IFALn0	These bits specify the Interface number to be linked with the n-series Alternative Setting. If the linked Interface number is outside the range specified by the UF0AIFN register, the n-series Alternative Setting is invalid (ALTnEN bit = 0). IFALn1 / IFALn0 / Interface number to be linked 1 / 1 / Links Interface 4. 1 / 0 / Links Interface 3. 0 / 1 / Links Interface 2. 0 / 0 / Links Interface 1. Do not link a five-series Alternative Setting and a two-series Alternative Setting with the same Interface number.
4, 0	ALTnEN	These bits validate the n-series Alternative Setting. Unless these bits are set to 1, the setting of the ALTn, IFALn1, and IFALn0 bits is invalid. 1: Validate the n-series Alternative Setting. 0: Do not validate the n-series Alternative Setting (default value).

Remark n = 2, 5

For example, when the UF0AIFN register is set to 82H and the UF0AAS register is set to 15H, Interfaces 0, 1, 2, and 3 are valid. Interfaces 0 and 2 support only Alternative Setting 0. Interface 1 supports Alternative Setting 0 and 1, and Interface 3 supports Alternative Setting 0, 1, 2, 3, and 4. With this setting, requests GET_INTERFACE wIndex = 0/1/2/3, SET_INTERFACE wValue = 0 & wIndex = 0/2, SET_INTERFACE wValue = 0/1 & wIndex = 1, and SET_INTERFACE wValue = 0/1/2/3/4 & wIndex = 3 are automatically responded to, and a STALL response is made to the other GET/SET_INTERFACE requests.

(37) UF0 alternative setting status register (UF0ASS)

This register indicates the current status of the Alternative Setting.

This register is read-only, in 8-bit units.

Check this register when the SET_INT interrupt request has been issued. The value received by the SET_INTERFACE request is reflected on the UF0IFn register (n = 0 to 4) as well as on this register.

	7	6	5	4	3	2	1	0	Address	After reset
UF0ASS	0	0	0	0	AL5ST3	AL5ST2	AL5ST1	AL2ST	00200084H	00H

Bit position	Bit name	Function
3 to 1	AL5ST3 to AL5ST1	These bits indicate the current status of the five-series Alternative Setting.
0	AL2ST	This bit indicates the current status of the two-series Alternative Setting (selected Alternative Setting number). 1: Alternative Setting 1 0: Alternative Setting 0

AL5ST3	AL5ST2	AL5ST1	Selected Alternative Setting number
1	0	0	Alternative Setting 4
0	1	1	Alternative Setting 3
0	1	0	Alternative Setting 2
0	0	1	Alternative Setting 1
0	0	0	Alternative Setting 0

(38) UF0 endpoint 1 interface mapping register (UF0E1IM)

This register specifies for which Interface and Alternative Setting Endpoint1 is valid.

This register can be read or written in 8-bit units.

The setting of this register and the Alternative Setting selected by the SET_INTERFACE request indicate whether Endpoint1 is currently valid, and the hardware determines how the GET_STATUS/CLEAR_FEATURE/SET_FEATURE Endpoint1 request and the IN transaction to Endpoint1 are responded to, and whether the related bits are valid or invalid.

	7	6	5	4	3	2	1	0	Address	After reset
UF0E1IM	E1EN2	E1EN1	E1EN0	E12AL1	E15AL4	E15AL3	E15AL2	E15AL1	00200086H	00H

Bit position	Bit name	Function
7 to 5	E1EN2 to E1EN0	These bits set a link between the Interface of Endpoint1 and the two-/five-series Alternative Setting. The endpoint is linked with Alternative Setting 0. The endpoint linked with Alternative Setting 0 cannot be excluded from Alternative Setting 1 to 4.

E1EN2	E1EN1	E1EN0	Link status
1	1	1	Not linked with Interface
1	1	0	
1	0	1	Linked with Interface 4 and Alternative Setting 0
1	0	0	Linked with Interface 3 and Alternative Setting 0
0	1	1	Linked with Interface 2 and Alternative Setting 0
0	1	0	Linked with Interface 1 and Alternative Setting 0
0	0	1	Linked with Interface 0 and Alternative Setting 0
0	0	0	Not linked with Interface (default value)

When these bits are set to 110 or 111, they are invalid even if the E12AL1 bit is cleared to 0.

If the endpoint is linked, setting of the CONF bit of the UF0MODS register to 1 indicates that Endpoint1 is valid.

4	E12AL1	This bit validates Endpoint1 when the two-series Alternative Setting and the Alternative Setting of the linked Interface are set to 1. 1: Validate the endpoint when Alternative Setting 1 is set with CONF bit = 1. 0: Do not validate the endpoint even when Alternative Setting 1 is set with CONF bit = 1 (default value). This bit is valid when the E15AL4 to E15AL1 bits are 0000.
3 to 0	E15ALn	These bits validate Endpoint1 when the five-series Alternative Setting and the Alternative Setting of the linked Interface are set to n. 1: Validate the endpoint when Alternative Setting n is set with CONF bit = 1. 0: Do not validate the endpoint even when Alternative Setting n is set with CONF bit = 1 (default value).

Remark n = 1 to 4

(39) UF0 endpoint 2 interface mapping register (UF0E2IM)

This register specifies for which Interface and Alternative Setting Endpoint2 is valid.

This register can be read or written in 8-bit units.

The setting of this register and the Alternative Setting selected by the SET_INTERFACE request indicate whether Endpoint2 is currently valid, and the hardware determines how the GET_STATUS/CLEAR_FEATURE/SET_FEATURE Endpoint2 request and the OUT transaction to Endpoint2 are responded to, and whether the related bits are valid or invalid.

	7	6	5	4	3	2	1	0	Address	After reset
UF0E2IM	E2EN2	E2EN1	E2EN0	E22AL1	E25AL4	E25AL3	E25AL2	E25AL1	00200088H	00H

Bit position	Bit name	Function
7 to 5	E2EN2 to E2EN0	These bits set a link between the Interface of Endpoint2 and the two-/five-series Alternative Setting. The endpoint is linked with Alternative Setting 0. The endpoint linked with Alternative Setting 0 cannot be excluded from Alternative Setting 1 to 4.

E2EN2	E2EN1	E2EN0	Link status
1	1	1	Not linked with Interface
1	1	0	
1	0	1	Linked with Interface 4 and Alternative Setting 0
1	0	0	Linked with Interface 3 and Alternative Setting 0
0	1	1	Linked with Interface 2 and Alternative Setting 0
0	1	0	Linked with Interface 1 and Alternative Setting 0
0	0	1	Linked with Interface 0 and Alternative Setting 0
0	0	0	Not linked with Interface (default value)

When these bits are set to 110 or 111, they are invalid even if the E22AL1 bit is cleared to 0.

If the endpoint is linked, setting of the CONF bit of the UF0MODS register to 1 indicates that Endpoint2 is valid.

4	E22AL1	This bit validates Endpoint2 when the two-series Alternative Setting and the Alternative Setting of the linked Interface are set to 1. 1: Validate the endpoint when Alternative Setting 1 is set with CONF bit = 1. 0: Do not validate the endpoint even when Alternative Setting 1 is set with CONF bit = 1 (default value). This bit is valid when the E25AL4 to E25AL1 bits are 0000.
3 to 0	E25ALn	These bits validate Endpoint2 when the five-series Alternative Setting and the Alternative Setting of the linked Interface are set to n. 1: Validate the endpoint when Alternative Setting n is set with CONF bit = 1. 0: Do not validate the endpoint even when Alternative Setting n is set with CONF bit = 1 (default value).

Remark n = 1 to 4

(40) UF0 endpoint 3 interface mapping register (UF0E3IM)

This register specifies for which Interface and Alternative Setting Endpoint3 is valid.

This register can be read or written in 8-bit units.

The setting of this register and the Alternative Setting selected by the SET_INTERFACE request indicate whether Endpoint3 is currently valid, and the hardware determines how the GET_STATUS/CLEAR_FEATURE/SET_FEATURE Endpoint3 request and the IN transaction to Endpoint3 are responded to, and whether the related bits are valid or invalid.

	7	6	5	4	3	2	1	0	Address	After reset
UF0E3IM	E3EN2	E3EN1	E3EN0	E32AL1	E35AL4	E35AL3	E35AL2	E35AL1	0020008AH	00H

Bit position	Bit name	Function
7 to 5	E3EN2 to E3EN0	These bits set a link between the Interface of Endpoint3 and the two-/five-series Alternative Setting. The endpoint is linked with Alternative Setting 0. The endpoint linked with Alternative Setting 0 cannot be excluded from Alternative Setting 1 to 4.

E3EN2	E3EN1	E3EN0	Link status
1	1	1	Not linked with Interface
1	1	0	
1	0	1	Linked with Interface 4 and Alternative Setting 0
1	0	0	Linked with Interface 3 and Alternative Setting 0
0	1	1	Linked with Interface 2 and Alternative Setting 0
0	1	0	Linked with Interface 1 and Alternative Setting 0
0	0	1	Linked with Interface 0 and Alternative Setting 0
0	0	0	Not linked with Interface (default value)

When these bits are set to 110 or 111, they are invalid even if the E32AL1 bit is cleared to 0.

If the endpoint is linked, setting of the CONF bit of the UF0MODS register to 1 indicates that Endpoint3 is valid.

4	E32AL1	This bit validates Endpoint3 when the two-series Alternative Setting and the Alternative Setting of the linked Interface are set to 1. 1: Validate the endpoint when Alternative Setting 1 is set with CONF bit = 1. 0: Do not validate the endpoint even when Alternative Setting 1 is set with CONF bit = 1 (default value). This bit is valid when the E35AL4 to E35AL1 bits are 0000.
3 to 0	E35ALn	These bits validate Endpoint3 when the five-series Alternative Setting and the Alternative Setting of the linked Interface are set to n. 1: Validate the endpoint when Alternative Setting n is set with CONF bit = 1. 0: Do not validate the endpoint even when Alternative Setting n is set with CONF bit = 1 (default value).

Remark n = 1 to 4

(41) UF0 endpoint 4 interface mapping register (UF0E4IM)

This register specifies for which Interface and Alternative Setting Endpoint4 is valid.

This register can be read or written in 8-bit units.

The setting of this register and the Alternative Setting selected by the SET_INTERFACE request indicate whether Endpoint4 is currently valid, and the hardware determines how the GET_STATUS/CLEAR_FEATURE/SET_FEATURE Endpoint4 request and the OUT transaction to Endpoint4 are responded to, and whether the related bits are valid or invalid.

	7	6	5	4	3	2	1	0	Address	After reset
UF0E4IM	E4EN2	E4EN1	E4EN0	E42AL1	E45AL4	E45AL3	E45AL2	E45AL1	0020008CH	00H

Bit position	Bit name	Function
7 to 5	E4EN2 to E4EN0	These bits set a link between the Interface of Endpoint4 and the two-/five-series Alternative Setting. The endpoint is linked with Alternative Setting 0. The endpoint linked with Alternative Setting 0 cannot be excluded from Alternative Setting 1 to 4.

E4EN2	E4EN1	E4EN0	Link status
1	1	1	Not linked with Interface
1	1	0	
1	0	1	Linked with Interface 4 and Alternative Setting 0
1	0	0	Linked with Interface 3 and Alternative Setting 0
0	1	1	Linked with Interface 2 and Alternative Setting 0
0	1	0	Linked with Interface 1 and Alternative Setting 0
0	0	1	Linked with Interface 0 and Alternative Setting 0
0	0	0	Not linked with Interface (default value)

When these bits are set to 110 or 111, they are invalid even if the E42AL1 bit is cleared to 0.

If the endpoint is linked, setting of the CONF bit of the UF0MODS register to 1 indicates that Endpoint4 is valid.

4	E42AL1	This bit validates Endpoint4 when the two-series Alternative Setting and the Alternative Setting of the linked Interface are set to 1. 1: Validate the endpoint when Alternative Setting 1 is set with CONF bit = 1. 0: Do not validate the endpoint even when Alternative Setting 1 is set with CONF bit = 1 (default value). This bit is valid when the E45AL4 to E45AL1 bits are 0000.
3 to 0	E45ALn	These bits validate Endpoint4 when the five-series Alternative Setting and the Alternative Setting of the linked Interface are set to n. 1: Validate the endpoint when Alternative Setting n is set with CONF bit = 1. 0: Do not validate the endpoint even when Alternative Setting n is set with CONF bit = 1 (default value).

Remark n = 1 to 4

(42) UF0 endpoint 7 interface mapping register (UF0E7IM)

This register specifies for which Interface and Alternative Setting Endpoint7 is valid.

This register can be read or written in 8-bit units.

The setting of this register and the Alternative Setting selected by the SET_INTERFACE request indicate whether Endpoint7 is currently valid, and the hardware determines how the GET_STATUS/CLEAR_FEATURE/SET_FEATURE Endpoint7 request and the IN transaction to Endpoint7 are responded to, and whether the related bits are valid or invalid.

	7	6	5	4	3	2	1	0	Address	After reset
UF0E7IM	E7EN2	E7EN1	E7EN0	E72AL1	E75AL4	E75AL3	E75AL2	E75AL1	00200092H	00H

Bit position	Bit name	Function
7 to 5	E7EN2 to E7EN0	These bits set a link between the Interface of Endpoint7 and the two-/five-series Alternative Setting. The endpoint is linked with Alternative Setting 0. The endpoint linked with Alternative Setting 0 cannot be excluded from Alternative Setting 1 to 4.

E7EN2	E7EN1	E7EN0	Link status
1	1	1	Not linked with Interface
1	1	0	
1	0	1	Linked with Interface 4 and Alternative Setting 0
1	0	0	Linked with Interface 3 and Alternative Setting 0
0	1	1	Linked with Interface 2 and Alternative Setting 0
0	1	0	Linked with Interface 1 and Alternative Setting 0
0	0	1	Linked with Interface 0 and Alternative Setting 0
0	0	0	Not linked with Interface (default value)

When these bits are set to 110 or 111, they are invalid even if the E72AL1 bit is cleared to 0.

If the endpoint is linked, setting of the CONF bit of the UF0MODS register to 1 indicates that Endpoint7 is valid.

4	E72AL1	This bit validates Endpoint7 when the two-series Alternative Setting and the Alternative Setting of the linked Interface are set to 1. 1: Validate the endpoint when Alternative Setting 1 is set with CONF bit = 1. 0: Do not validate the endpoint even when Alternative Setting 1 is set with CONF bit = 1 (default value). This bit is valid when the E75AL4 to E75AL1 bits are 0000.
3 to 0	E75ALn	These bits validate Endpoint7 when the five-series Alternative Setting and the Alternative Setting of the linked Interface are set to n. 1: Validate the endpoint when Alternative Setting n is set with CONF bit = 1. 0: Do not validate the endpoint even when Alternative Setting n is set with CONF bit = 1 (default value).

Remark n = 1 to 4

21.6.4 Data hold registers

(1) UF0 EP0 read register (UF0E0R)

The UF0E0R register is a 64-byte FIFO that stores the OUT data sent from the host in the data stage of control transfer to/from Endpoint0.

This register is read-only, in 8-bit units. A write access to this register is ignored.

The hardware automatically transfers data to the UF0E0R register when it has received the data from the host. When the data has been correctly received, the E0ODT bit of the UF0IS1 register is set to 1. The UF0E0L register holds the quantity of the received data, and an interrupt request (INTUSBF0) is issued. The UF0E0L register always updates the length of the received data while it is receiving data. If the final transfer is correct reception, the interrupt request is generated. If the reception is abnormal, the UF0E0L register is cleared to 0 and the interrupt request is not generated.

The data held by the UF0E0R register must be read by FW up to the value of the amount of data read by the UF0E0L register. Check that all data has been read by using the EP0R bit of the UF0EPS0 register (EP0R bit = 0 when all data has been read). If the value of the UF0E0L register is 0, the EP0NKR bit of the UF0E0N register is cleared to 0, and the UF0E0R register is ready for reception. The UF0E0R register is cleared when the next SETUP token has been received.

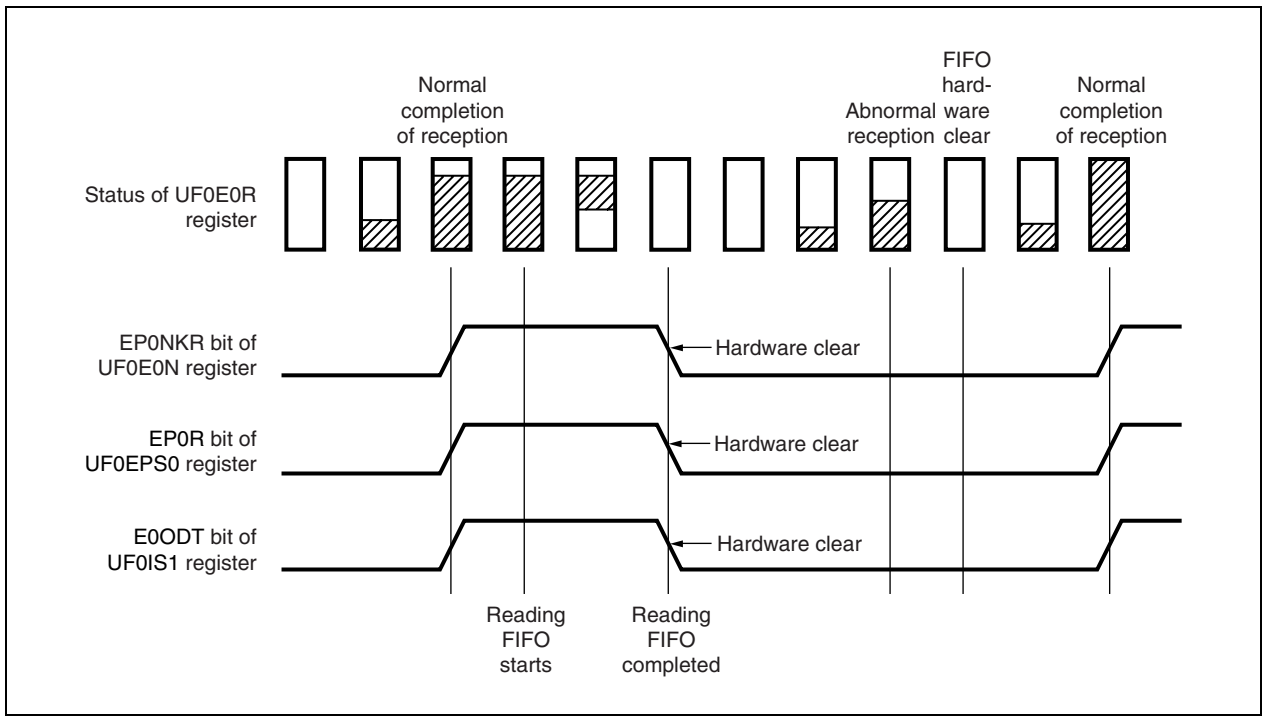
Caution Read all the data stored. Clear the FIFO to discard some data.

	7	6	5	4	3	2	1	0	Address	After reset
UF0E0R	E0R7	E0R6	E0R5	E0R4	E0R3	E0R2	E0R1	E0R0	00200100H	Undefined

Bit position	Bit name	Function
7 to 0	E0R7 to E0R0	These bits store the OUT data sent from the host in the data stage of control transfer to/from Endpoint0.

The operation of the UF0E0R register is illustrated below.

Figure 21-4. Operation of UF0E0R Register



(2) UF0 EP0 length register (UF0E0L)

The UF0E0L register stores the data length held by the UF0E0R register.

This register is read-only, in 8-bit units. A write access to this register is ignored.

The UF0E0L register always updates the length of the received data while it is receiving data. If the final transfer is abnormal reception, the UF0E0L register is cleared to 0 and the interrupt request is not generated. The interrupt request is generated only when the reception is normal, and the FW can read as many data from the UF0E0R register as the value read from the UF0E0L register. The value of the UF0E0L register is decremented each time the UF0E0R register has been read.

	7	6	5	4	3	2	1	0	Address	After reset
UF0E0L	E0L7	E0L6	E0L5	E0L4	E0L3	E0L2	E0L1	E0L0	00200102H	00H

Bit position	Bit name	Function
7 to 0	E0L7 to E0L0	These bits store the data length held by the UF0E0R register.

(3) UF0 EP0 setup register (UF0E0ST)

The UF0E0ST register holds the SETUP data sent from the host.

This register is read-only, in 8-bit units. A write access to this register is ignored.

The UF0E0ST register always writes data when a SETUP transaction has been received. The hardware sets the PROT bit of the UF0IS1 register when it has correctly received the SETUP transaction. It sets the CPUDEC bit of the UF0IS1 register in the case of an FW-processed request. Then an interrupt request (INTUSBF0) is issued. In the case of an FW-processed request, be sure to read the request in 8-byte units. If it is not read in 8-byte units, the subsequent requests cannot be correctly decoded. The read counter of the UF0E0ST register is not cleared even when Bus Reset is received. Always read this counter in 8-byte units regardless of whether Bus Reset is received or not.

Because the UF0E0ST register always enables writing, the hardware overwrites data to this register even if a SETUP transaction is received while the data of the register is being read. Even if the SETUP transaction cannot be correctly received, the CPUDEC interrupt request and Protect interrupt request are not generated, but the previous data is discarded. If a SETUP token of less than 8 bytes is received, however, the received SETUP token is discarded, and the previously received SETUP data is retained. If the SETUP token is received more than once when control transfer is executed once, be sure to check the PROT bit of the UF0IS1 register under the conditions below. If PROT bit = 1, read the UF0E0ST register again because the SETUP transaction has been received more than once.

<1> If a request is decoded by FW and the UF0E0R register is read or the UF0E0W register is written

<2> When preparing for a STALL response for the request to which the decode result does not correspond

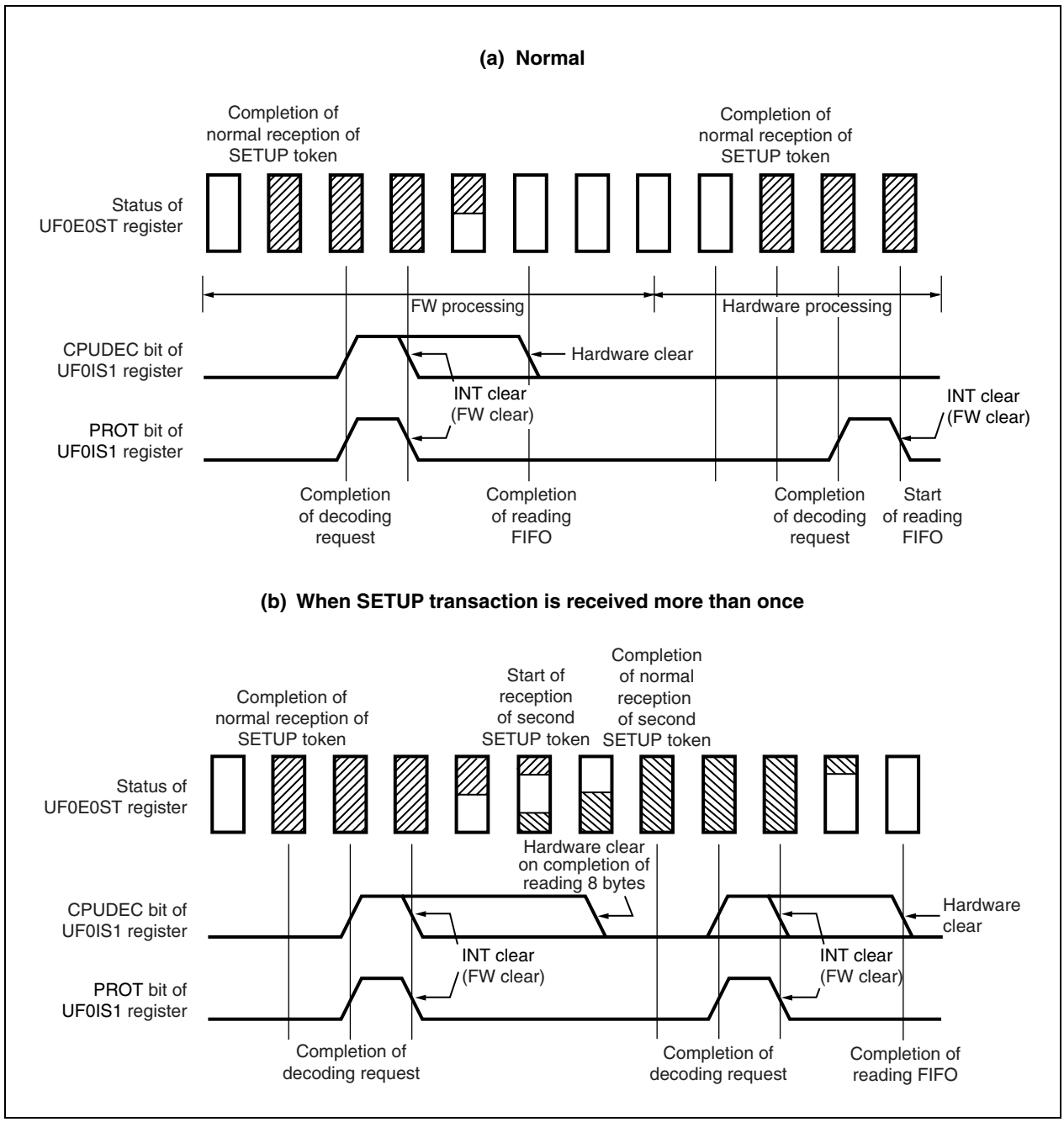
Caution Be sure to read all the stored data. The UF0E0ST register is always updated by the request in the SETUP transaction.

	7	6	5	4	3	2	1	0	Address	After reset
UF0E0ST	E0S7	E0S6	E0S5	E0S4	E0S3	E0S2	E0S1	E0S0	00200104H	00H

Bit position	Bit name	Function
7 to 0	E0S7 to E0S0	These bits hold the SETUP data sent from the host.

The operation of the UF0E0ST register is illustrated below.

Figure 21-5. Operation of UF0E0ST Register



(4) UF0 EP0 write register (UF0E0W)

The UF0E0W register is a 64-byte FIFO that stores the IN data (passes it to SIE) sent to the host in the data stage to Endpoint0.

This register is write-only, in 8-bit units. When this register is read, 00H is read.

The hardware transmits data to the USB bus in synchronization with an IN token only when the EP0NKW bit of the UF0E0N register is set to 1 (when NAK is not transmitted). When data is transmitted and when the host correctly receives the data, the EP0NKW bit of the UF0E0N register is automatically cleared to 0 by hardware. A short packet is transmitted when data is written to the UF0E0W register and the E0DED bit of the UF0DEND register is set to 1 (EP0W bit of the UF0EPS0 register = 1 (data exists)). A Null packet is transmitted when the UF0E0W register is cleared and the E0DED bit of the UF0DEND register is set to 1 (EP0W bit of the UF0EPS0 register = 1 (data exists)).

The UF0E0W register is cleared to 0 when the next SETUP token is received while transmission has not been completed yet. If the stage of control transfer (read) changes to the status stage while ACK has not been correctly received in the data stage, the UF0E0W register is automatically cleared to 0. At the same time, it is also cleared to 0 if the EP0NKW bit of the UF0E0N register is 1.

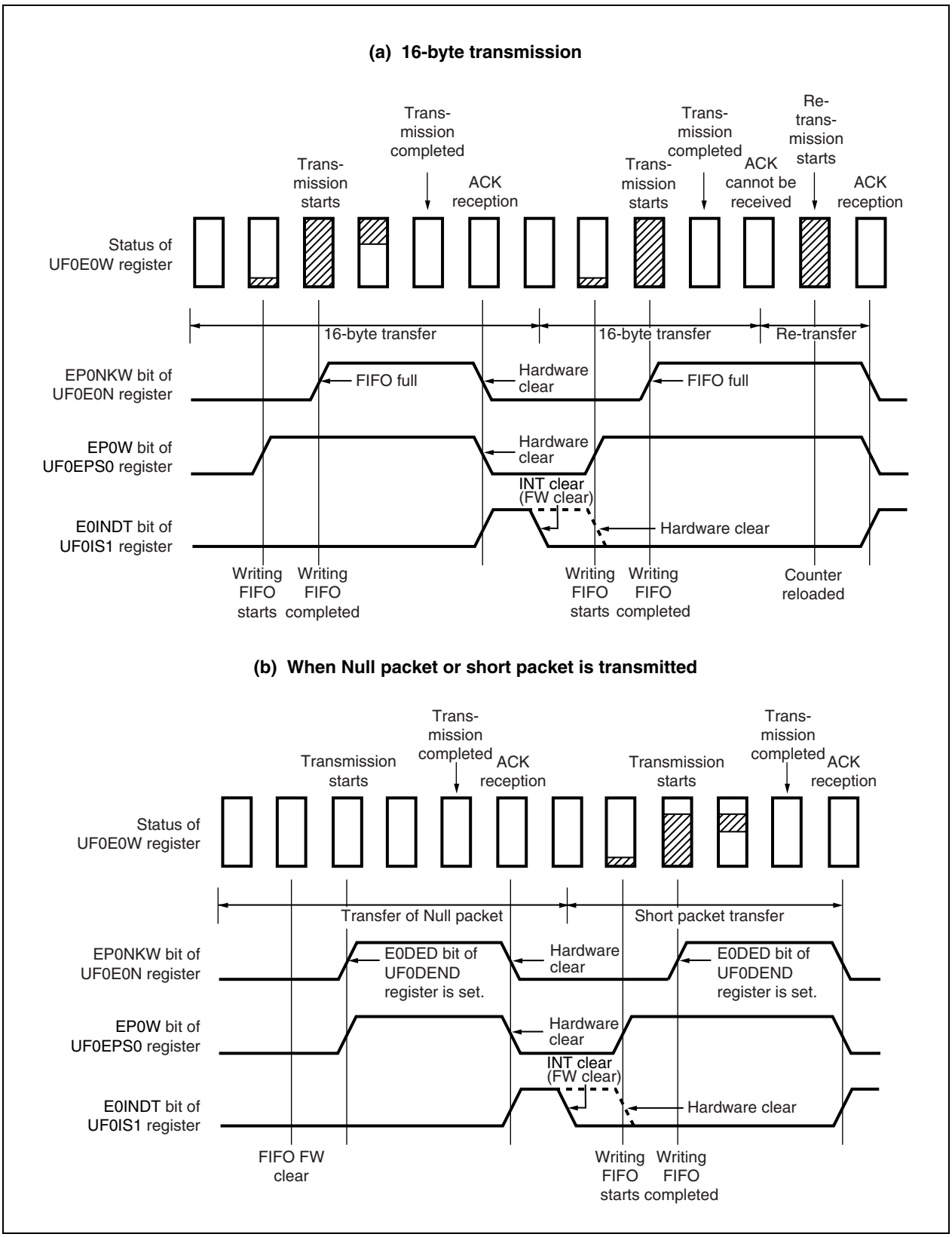
If the UF0E0W register is read while no data is in it, 00H is read.

	7	6	5	4	3	2	1	0	Address	After reset
UF0E0W	E0W7	E0W6	E0W5	E0W4	E0W3	E0W2	E0W1	E0W0	00200106H	Undefined

Bit position	Bit name	Function
7 to 0	E0W7 to E0W0	These bits store the IN data sent to the host in the data stage to Endpoint0.

The operation of the UF0E0W register is illustrated below.

Figure 21-6. Operation of UF0E0W Register



(5) UF0 bulk-out 1 register (UF0BO1)

The UF0BO1 register is a 64-byte × 2 FIFO that stores data for Endpoint2. This register consists of two banks of 64-byte FIFOs each of which performs a toggle operation and repeatedly connects the buses on the SIE and CPU sides. The toggle operation takes place when data is in the FIFO on the SIE side and when no data is in the FIFO on the CPU side (counter value = 0).

This register is read-only, in 8-bit units. A write access to this register is ignored.

When the hardware receives data for Endpoint2 from the host, it automatically transfers the data to the UF0BO1 register. When the register correctly receives the data, a FIFO toggle operation occurs. As a result, the BKO1DT bit of the UF0IS3 register is set to 1, the quantity of the received data is held by the UF0BO1L register, and an interrupt request or DMA request is issued to the CPU. Whether the interrupt request or DMA request is issued can be selected by using the DQBO1MS bit of the UF0IDR register.

Read the data held by the UF0BO1 register by FW, up to the value of the amount of data read by the UF0BO1L register. When the correct received data is held by the FIFO connected to the SIE side and the value of the UF0BO1L register reaches 0, the toggle operation of the FIFO occurs, and the BKO1NK bit of the UF0EN register is automatically cleared to 0. If data greater than the value of the UF0BO1L register is read and if the FIFO toggle condition is satisfied, the toggle operation of the FIFO occurs. As a result, the next packet may be read by mistake. Note that, if the toggle condition is not satisfied, the first data is repeatedly read.

If overrun data is received while data is held by the FIFO connected to the CPU side, Endpoint2 stalls, and the FIFO on the CPU side is cleared.

When the UF0BO1 register is read while no data is in it, an undefined value is read.

Caution Be sure to read all the data stored in this register.

	7	6	5	4	3	2	1	0	Address	After reset
UF0BO1	BKO17	BKO16	BKO15	BKO14	BKO13	BKO12	BKO11	BKO10	00200108H	Undefined

Bit position	Bit name	Function
7 to 0	BKO17 to BKO10	These bits store data for Endpoint2.

The operation of the UF0BO1 register is illustrated below.

Figure 21-7. Operation of UF0BO1 Register (1/2)

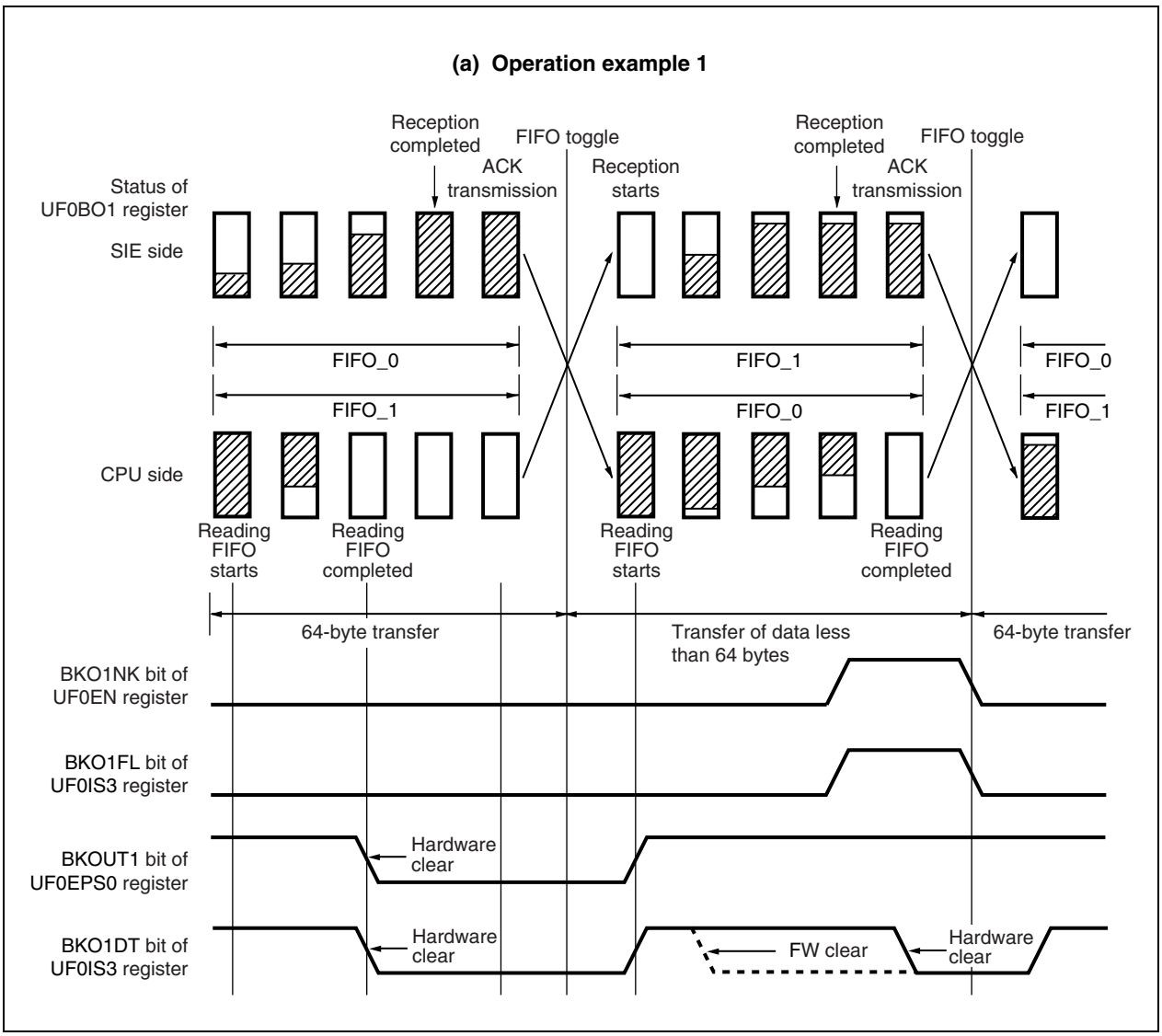
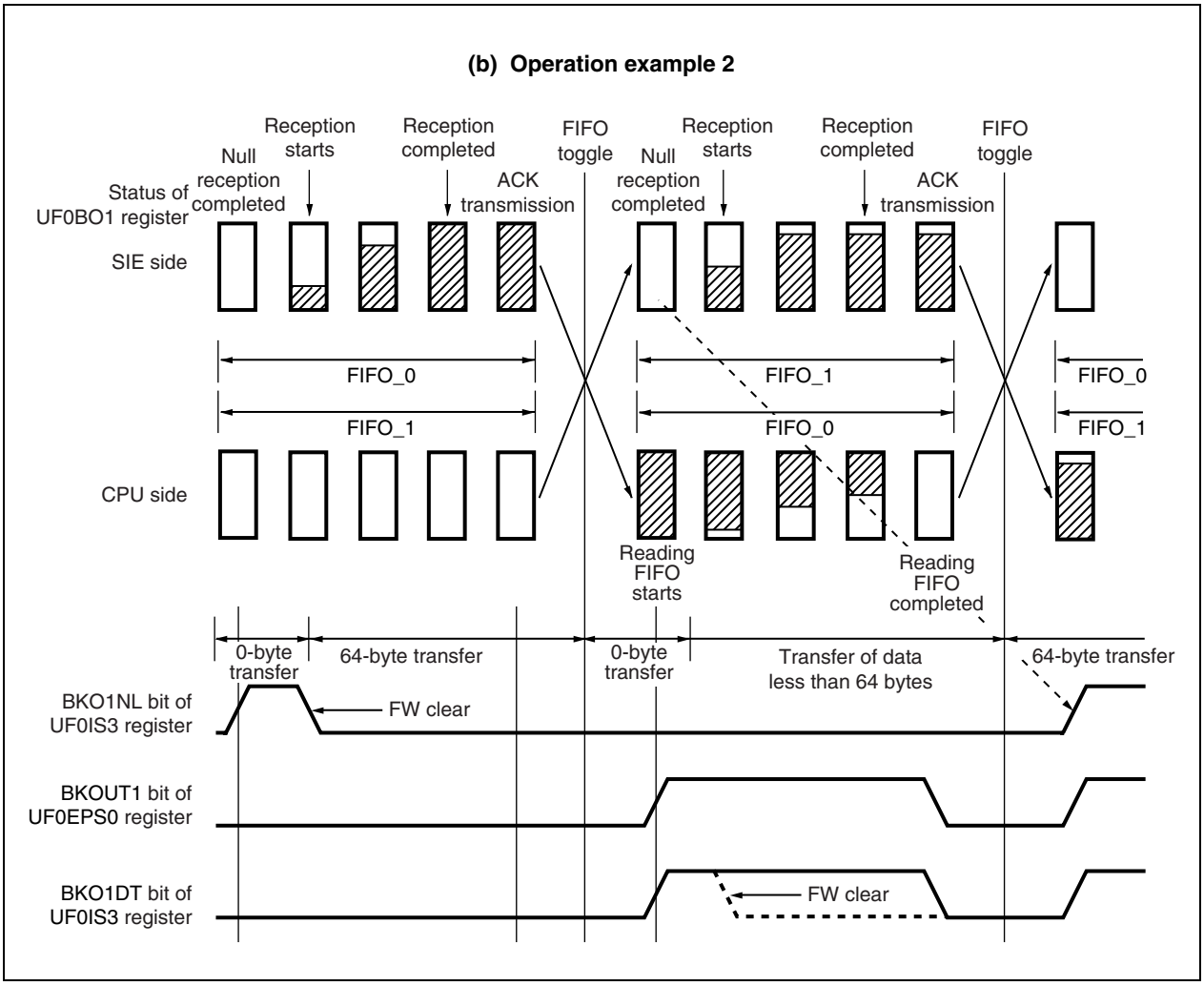


Figure 21-7. Operation of UF0BO1 Register (2/2)



(6) UF0 bulk-out 1 length register (UF0BO1L)

The UF0BO1L register stores the length of the data held by the UF0BO1 register.

This register is read-only, in 8-bit units. A write access to this register is ignored.

The UF0BO1L register always updates the received data length while it is receiving data. If the final transfer is abnormal reception, the UF0BO1L register is cleared to 00H, and an interrupt request is not generated. Only if the reception is normal, the interrupt request is generated, and FW can read as much data from the UF0BO1 register as the value read from the UF0BO1L register. The value of the UF0BO1L register is decremented each time the UF0BO1 register has been read.

	7	6	5	4	3	2	1	0	Address	After reset
UF0BO1L	BKO1L7	BKO1L6	BKO1L5	BKO1L4	BKO1L3	BKO1L2	BKO1L1	BKO1L0	0020010AH	00H

Bit position	Bit name	Function
7 to 0	BKO1L7 to BKO1L0	These bits store the length of the data held by the UF0BO1 register.

(7) UF0 bulk-out 2 register (UF0BO2)

The UF0BO2 register is a 64-byte × 2 FIFO that stores data for Endpoint4. This register consists of two banks of 64-byte FIFOs each of which performs a toggle operation and repeatedly connects the buses on the SIE and CPU sides. The toggle operation takes place when data is in the FIFO on the SIE side and when no data is in the FIFO on the CPU side (counter value = 0).

This register is read-only, in 8-bit units. A write access to this register is ignored.

When the hardware receives data for Endpoint4 from the host, it automatically transfers the data to the UF0BO2 register. When the register correctly receives the data, a FIFO toggle operation occurs. As a result, the BKO2DT bit of the UF0IS3 register is set to 1, the quantity of the received data is held by the UF0BO2L register, and an interrupt request or DMA request is issued to the CPU. Whether the interrupt request or DMA request is issued can be selected by using the DQBO2MS bit of the UF0IDR register.

Read the data held by the UF0BO2 register by FW, up to the value of the amount of data read by the UF0BO2L register. When the correct received data is held by the FIFO connected to the SIE side and the value of the UF0BO2L register reaches 0, the toggle operation of the FIFO occurs, and the BKO2NK bit of the UF0EN register is automatically cleared to 0. If data greater than the value of the UF0BO2L register is read and if the FIFO toggle condition is satisfied, the toggle operation of the FIFO occurs. As a result, the next packet may be read by mistake. Note that, if the toggle condition is not satisfied, the first data is repeatedly read.

If overrun data is received while data is held by the FIFO connected to the CPU side, Endpoint4 stalls, and the FIFO on the CPU side is cleared.

When the UF0BO2 register is read while no data is in it, an undefined value is read.

Caution Be sure to read all the data stored in this register.

	7	6	5	4	3	2	1	0	Address	After reset
UF0BO2	BKO27	BKO26	BKO25	BKO24	BKO23	BKO22	BKO21	BKO20	0020010CH	Undefined

Bit position	Bit name	Function
7 to 0	BKO27 to BKO20	These bits store data for Endpoint4.

The operation of the UF0BO2 register is illustrated below.

Figure 21-8. Operation of UF0BO2 Register (1/2)

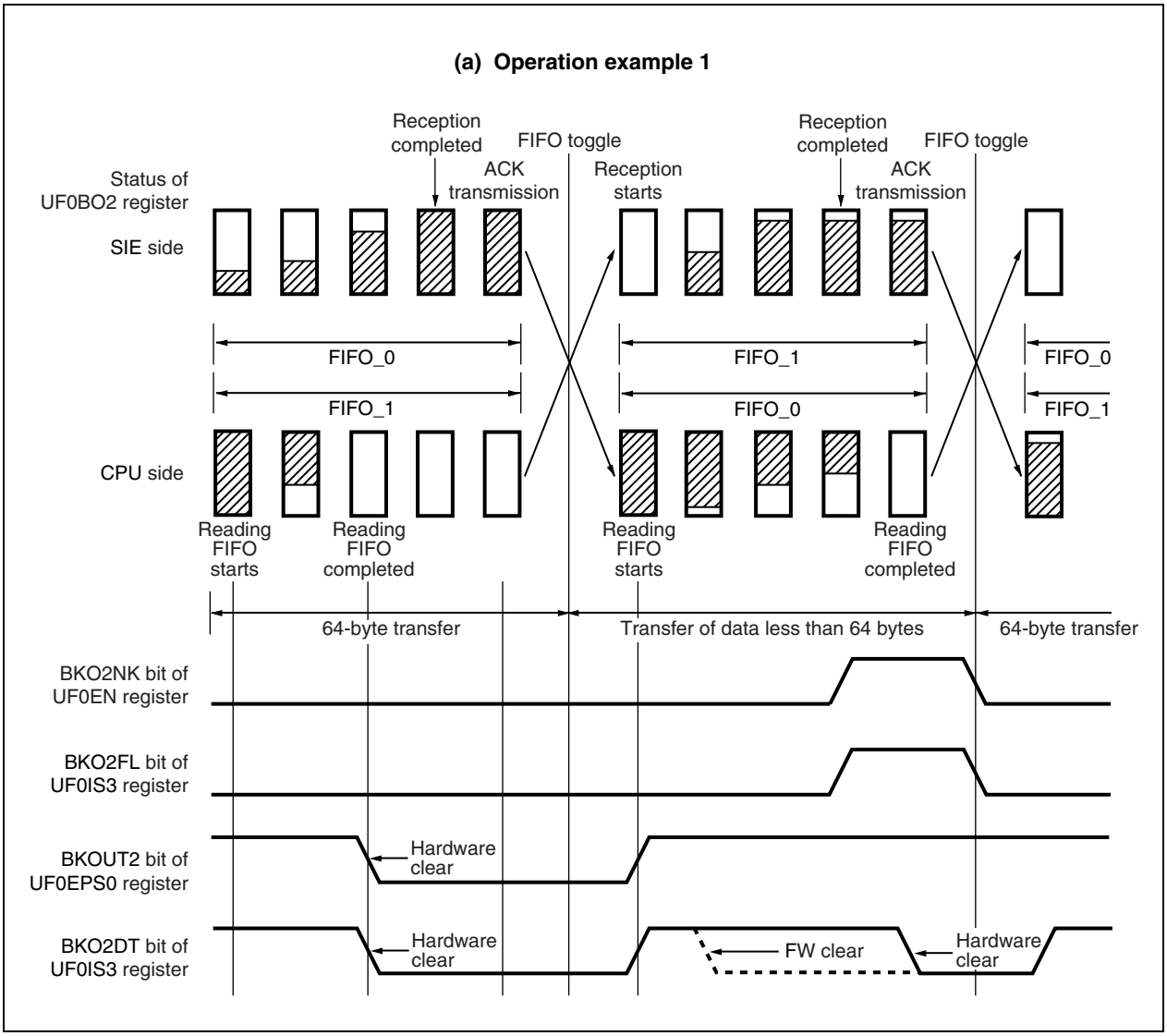
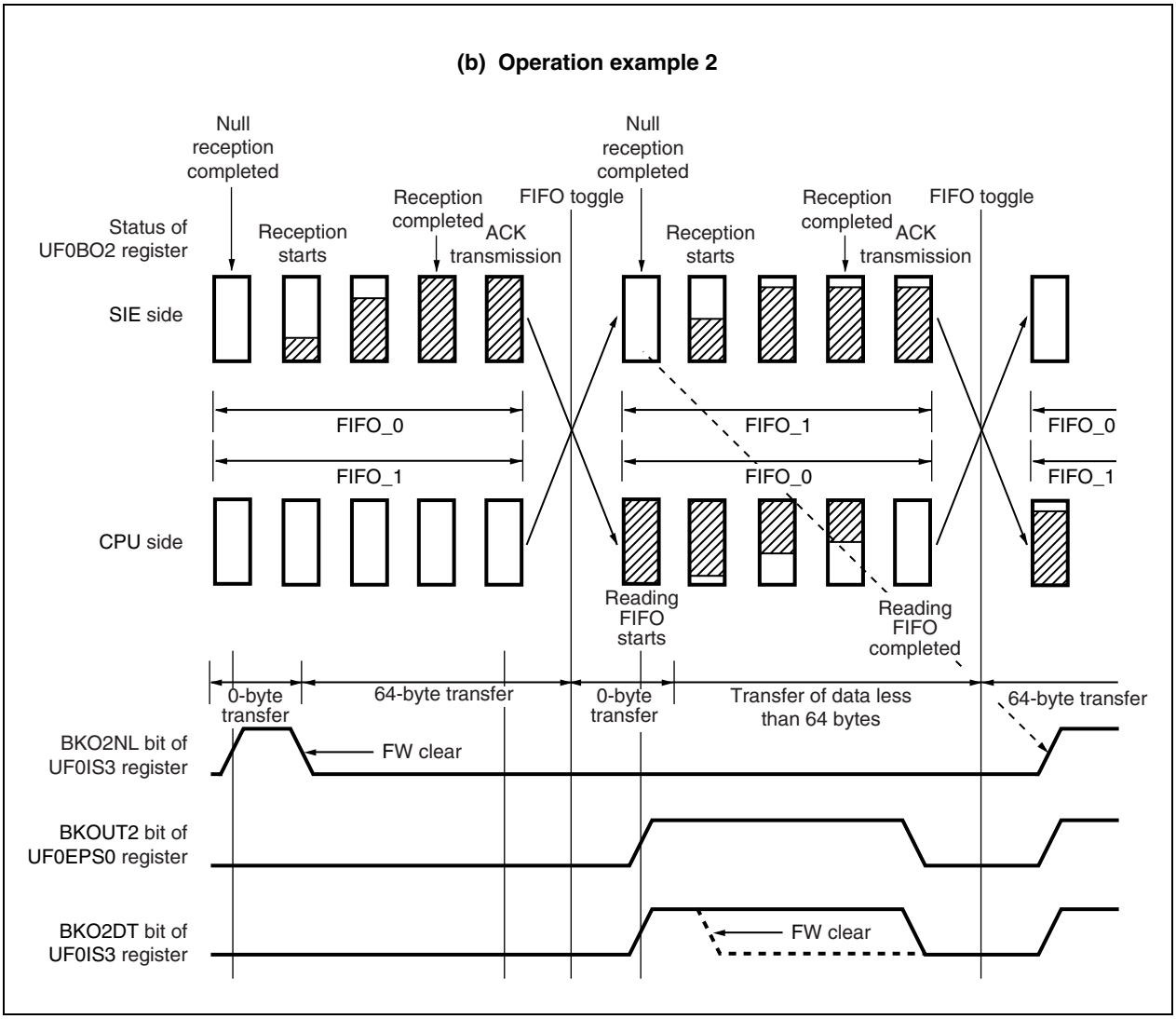


Figure 21-8. Operation of UF0BO2 Register (2/2)



(8) UF0 bulk-out 2 length register (UF0BO2L)

The UF0BO2L register stores the length of the data held by the UF0BO2 register.

This register is read-only, in 8-bit units. A write access to this register is ignored.

The UF0BO2L register always updates the received data length while it is receiving data. If the final transfer is abnormal reception, the UF0BO2L register is cleared to 00H, and an interrupt request is not generated. Only if the reception is normal, the interrupt request is generated, and FW can read as much data from the UF0BO2 register as the value read from the UF0BO2L register. The value of the UF0BO2L register is decremented each time the UF0BO2 register has been read.

	7	6	5	4	3	2	1	0	Address	After reset
UF0BO2L	BKO2L7	BKO2L6	BKO2L5	BKO2L4	BKO2L3	BKO2L2	BKO2L1	BKO2L0	0020010EH	00H

Bit position	Bit name	Function
7 to 0	BKO2L7 to BKO2L0	These bits store the length of the data held by the UF0BO2 register.

(9) UF0 bulk-in 1 register (UF0BI1)

The UF0BI1 register is a 64-byte × 2 FIFO that stores data for Endpoint1. This register consists of two banks of 64-byte FIFOs each of which performs a toggle operation and repeatedly connects the buses on the SIE and CPU sides. The toggle operation takes place when no data is in the FIFO on the SIE side (counter value = 0) and when the FIFO on the CPU side is correctly written (FIFO full or BKI1DED bit = 1).

This register is write-only, in 8-bit units. When this register is read, 00H is read.

The hardware transmits data to the USB bus in synchronization with the IN token for Endpoint1 only when the BKI1NK bit of the UF0EN register is set to 1 (when NAK is not transmitted). The address at which data is to be written or read is managed by the hardware. Therefore, FW can transmit data to the host only by writing the data to the UF0BI1 register sequentially. A short packet is transmitted when data is written to the UF0BI1 register and the BKI1DED bit of the UF0DEND register is set to 1 (BKIN1 bit of UF0EPS0 register = 1 (data exists)). A Null packet is transmitted when the UF0BI1 register is cleared and the BKI1DED bit of the UF0DEND register is set to 1 (BKIN1 bit of the UF0EPS0 register = 1 (data exists)). When the data is transmitted correctly, a FIFO toggle operation occurs. The BKI1DT bit of the UF0IS2 register is set to 1, and an interrupt request is generated for the CPU. An interrupt request or DMA request can be selected by using the DQBI1MS bit of the UF0IDR register.

	7	6	5	4	3	2	1	0	Address	After reset
UF0BI1	BKI17	BKI16	BKI15	BKI14	BKI13	BKI12	BKI11	BKI10	00200110H	Undefined

Bit position	Bit name	Function
7 to 0	BKI17 to BKI10	These bits store data for Endpoint1.

The operation of the UF0BI1 register is illustrated below.

Figure 21-9. Operation of UF0BI1 Register (1/3)

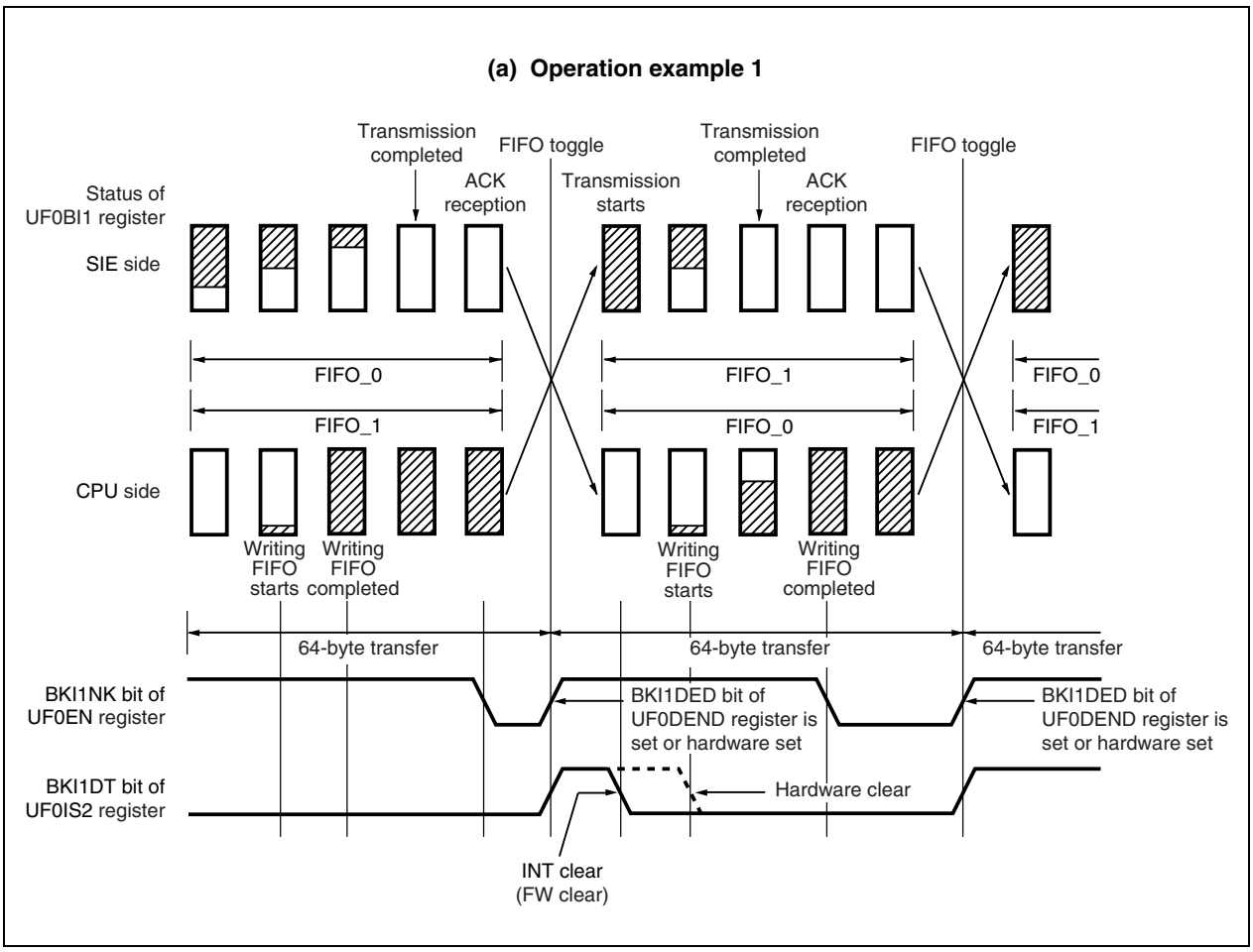


Figure 21-9. Operation of UF0BI1 Register (2/3)

(b) Operation example 2

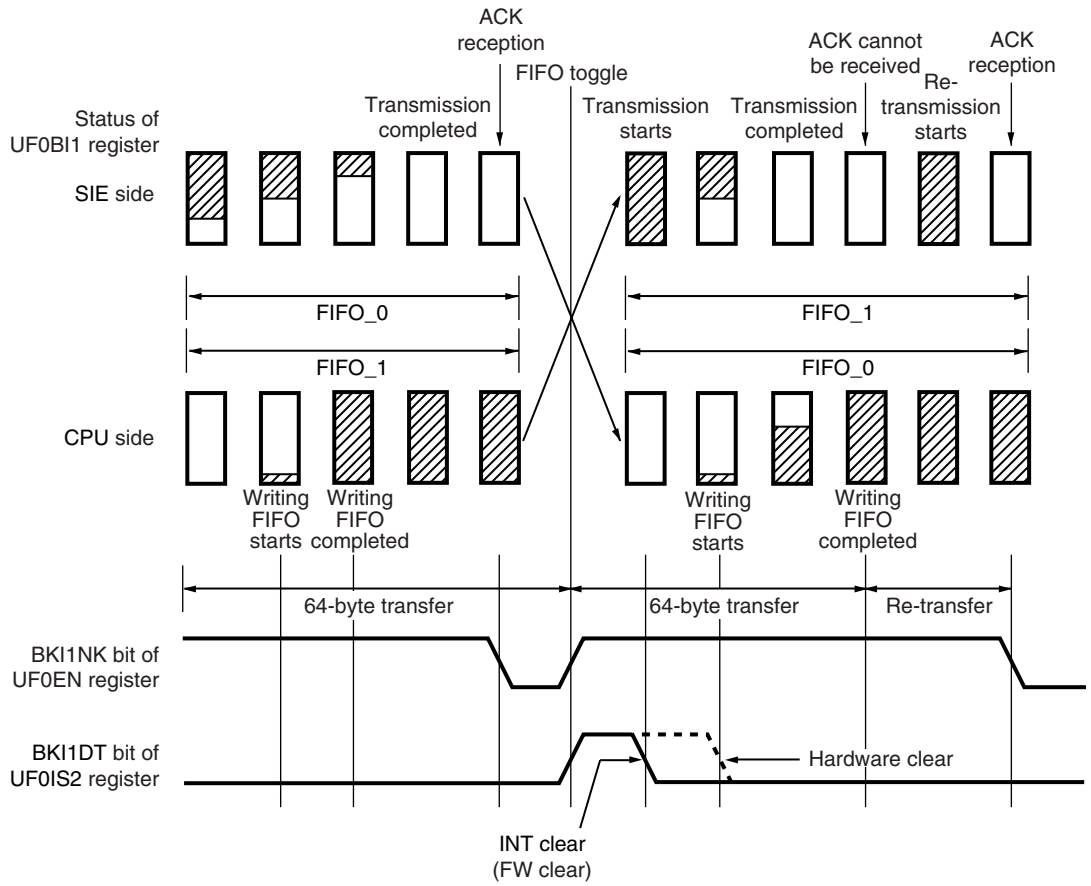
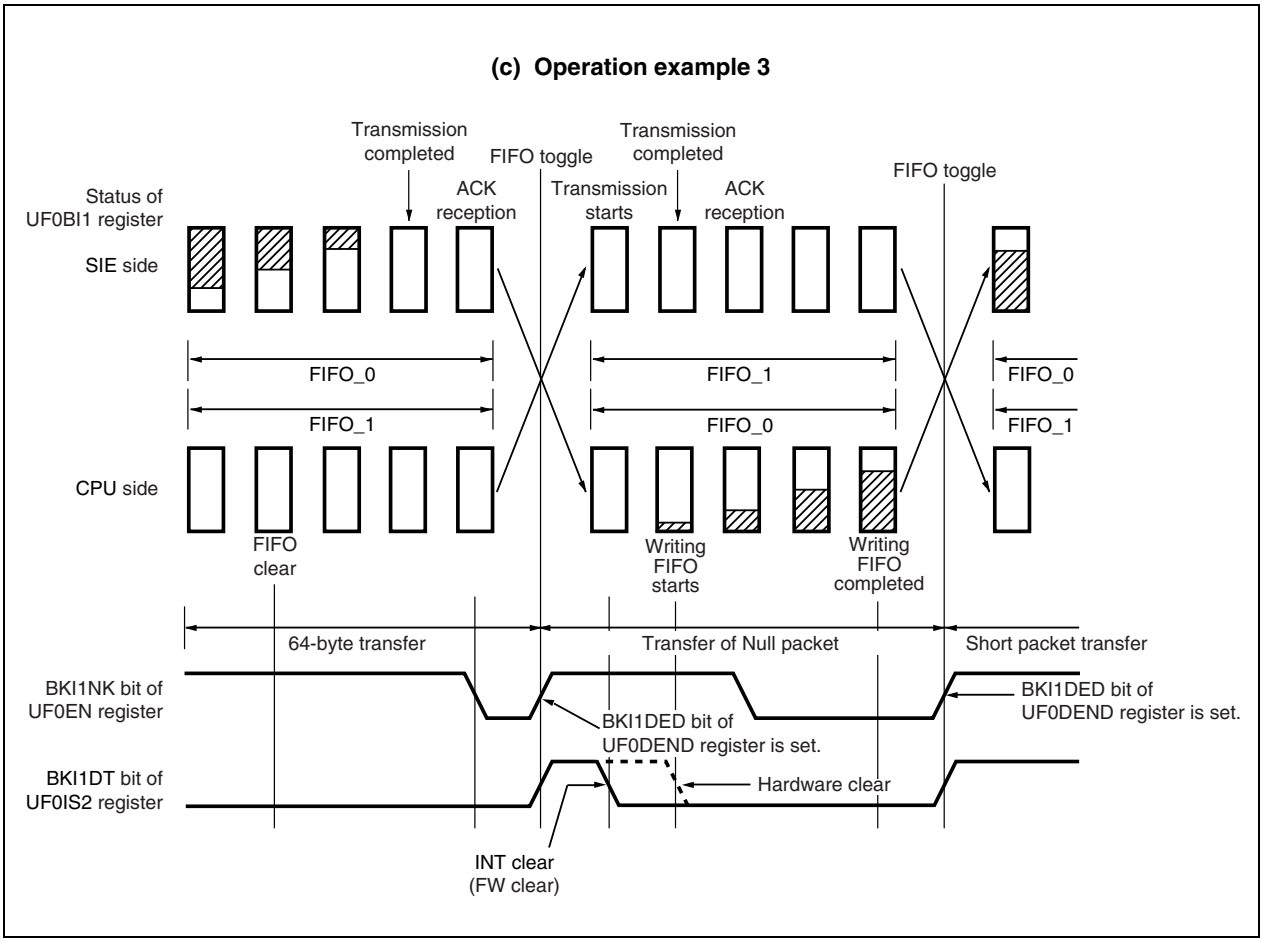


Figure 21-9. Operation of UF0BI1 Register (3/3)



(10) UF0 bulk-in 2 register (UF0BI2)

The UF0BI2 register is a 64-byte × 2 FIFO that stores data for Endpoint3. This register consists of two banks of 64-byte FIFOs each of which performs a toggle operation and repeatedly connects the buses on the SIE and CPU sides. The toggle operation takes place when no data is in the FIFO on the SIE side (counter value = 0) and when the FIFO on the CPU side is correctly written (FIFO full or BKI2DED bit = 1).

This register is write-only, in 8-bit units. When this register is read, 00H is read.

The hardware transmits data to the USB bus in synchronization with the IN token for Endpoint3 only when the BKI2NK bit of the UF0EN register is set to 1 (when NAK is not transmitted). The address at which data is to be written or read is managed by the hardware. Therefore, FW can transmit data to the host only by writing the data to the UF0BI2 register sequentially. A short packet is transmitted when data is written to the UF0BI2 register and the BKI2DED bit of the UF0DEND register is set to 1 (BKIN2 bit of UF0EPS0 register = 1 (data exists)). A Null packet is transmitted when the UF0BI2 register is cleared and the BKI2DED bit of the UF0DEND register is set to 1 (BKIN2 bit of the UF0EPS0 register = 1 (data exists)). When the data is transmitted correctly, a FIFO toggle operation occurs. The BKI2DT bit of the UF0IS2 register is set to 1, and an interrupt request is generated for the CPU. An interrupt request or DMA request can be selected by using the DQBI2MS bit of the UF0IDR register.

	7	6	5	4	3	2	1	0	Address	After reset
UF0BI2	BKI27	BKI26	BKI25	BKI24	BKI23	BKI22	BKI21	BKI20	00200112H	Undefined

Bit position	Bit name	Function
7 to 0	BKI27 to BKI20	These bits store data for Endpoint3.

The operation of the UF0BI2 register is illustrated below.

Figure 21-10. Operation of UF0BI2 Register (1/3)

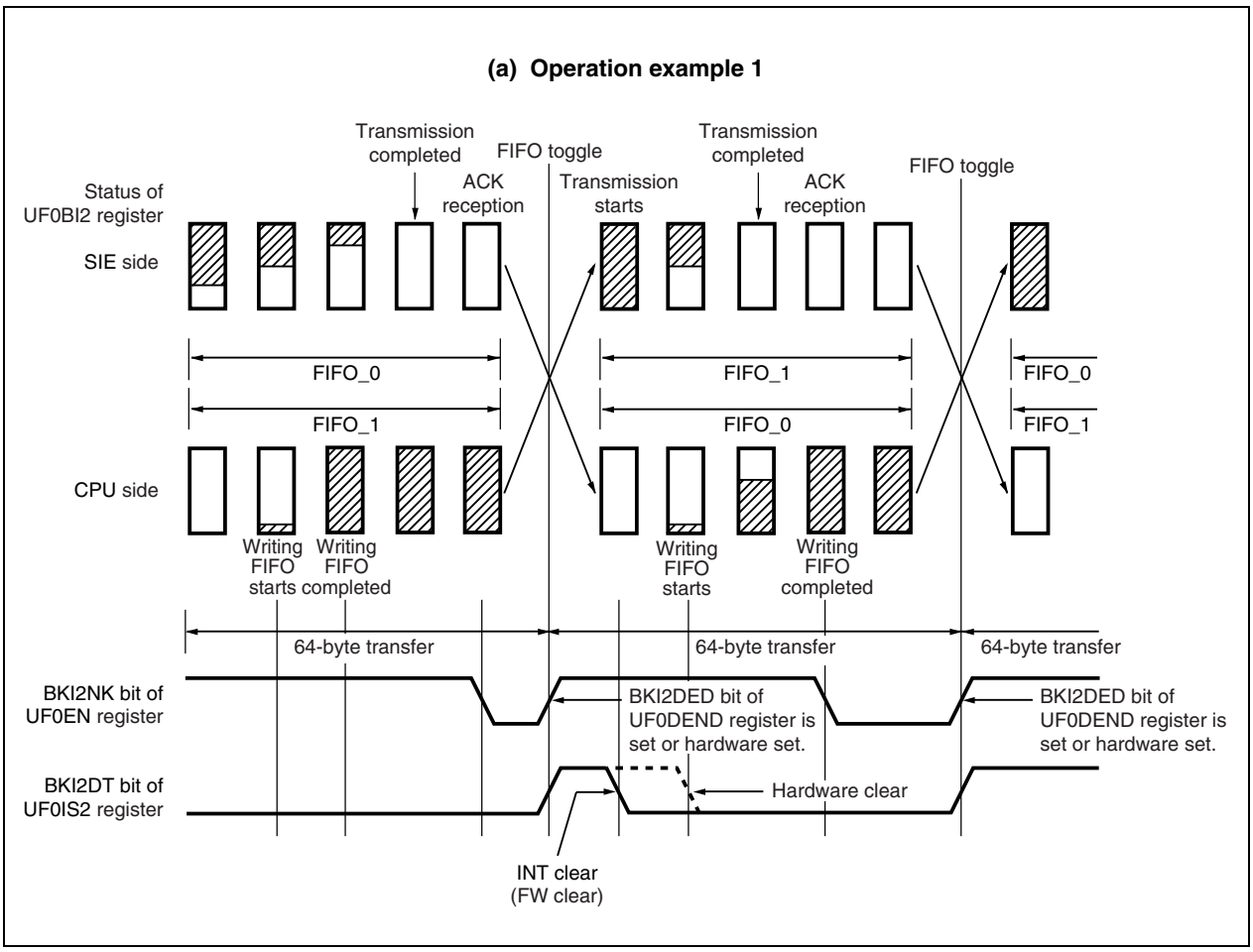


Figure 21-10. Operation of UF0BI2 Register (2/3)

(b) Operation example 2

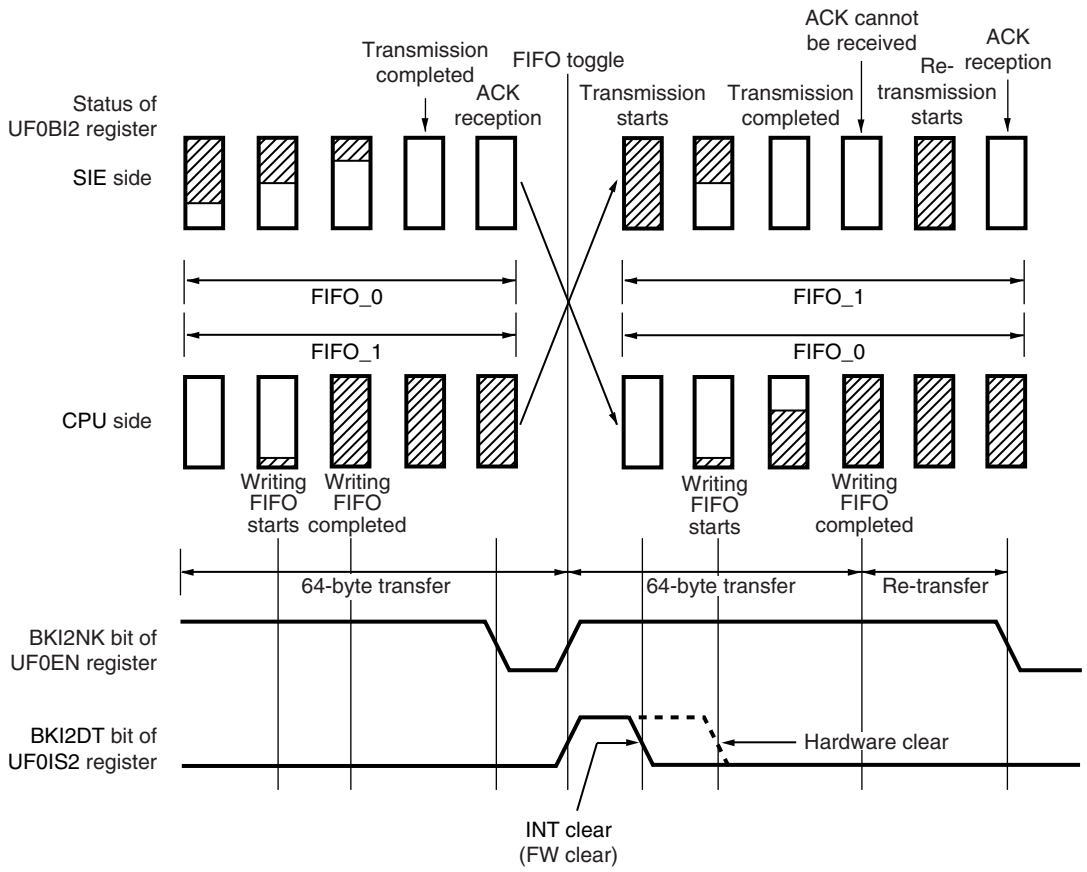
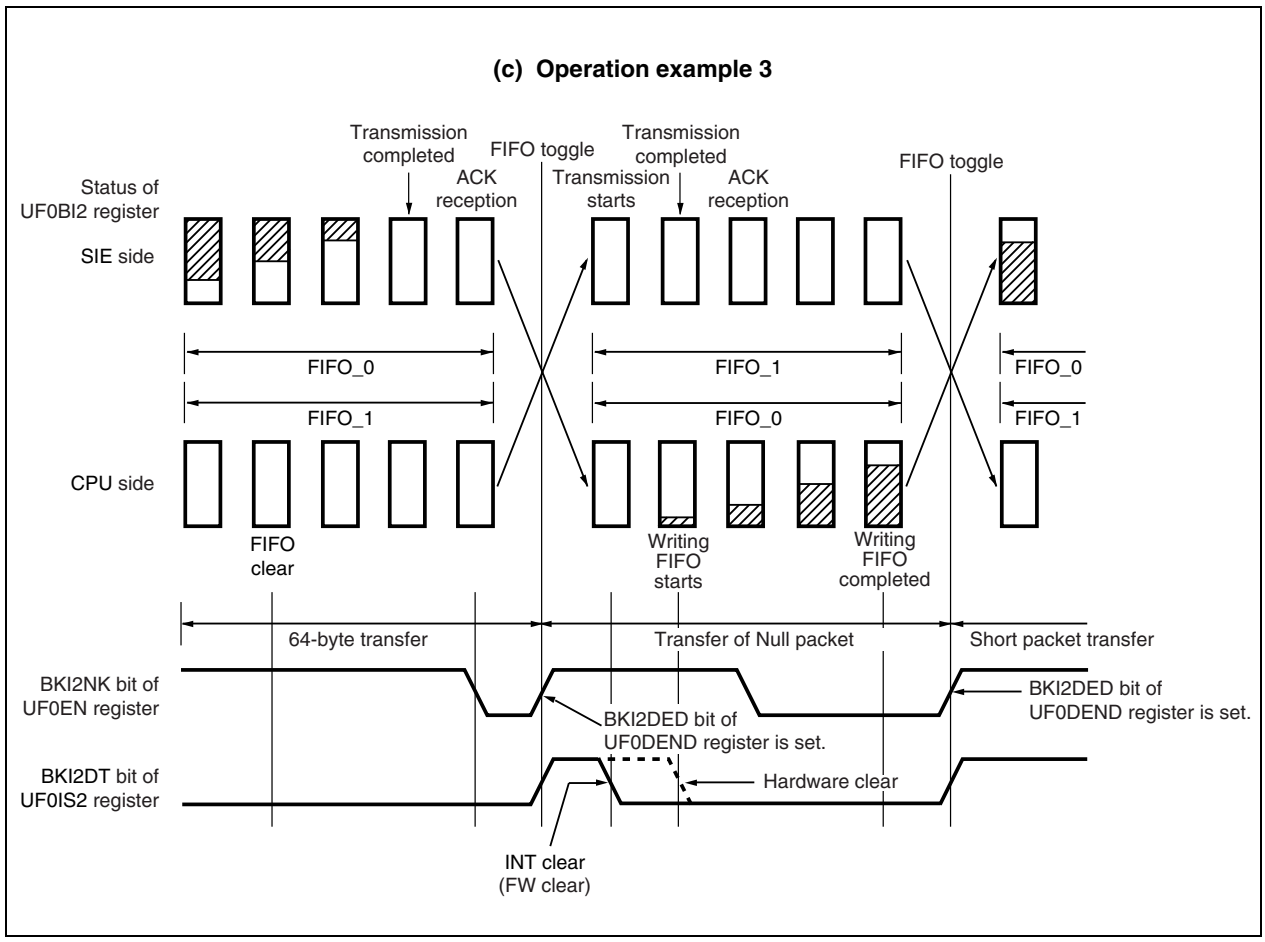


Figure 21-10. Operation of UF0BI2 Register (3/3)



(11) UF0 interrupt 1 register (UF0INT1)

The UF0INT1 register is an 8-byte FIFO that stores data for Endpoint7 (to be passed to SIE).

This register is write-only, in 8-bit units. When this register is read, 00H is read.

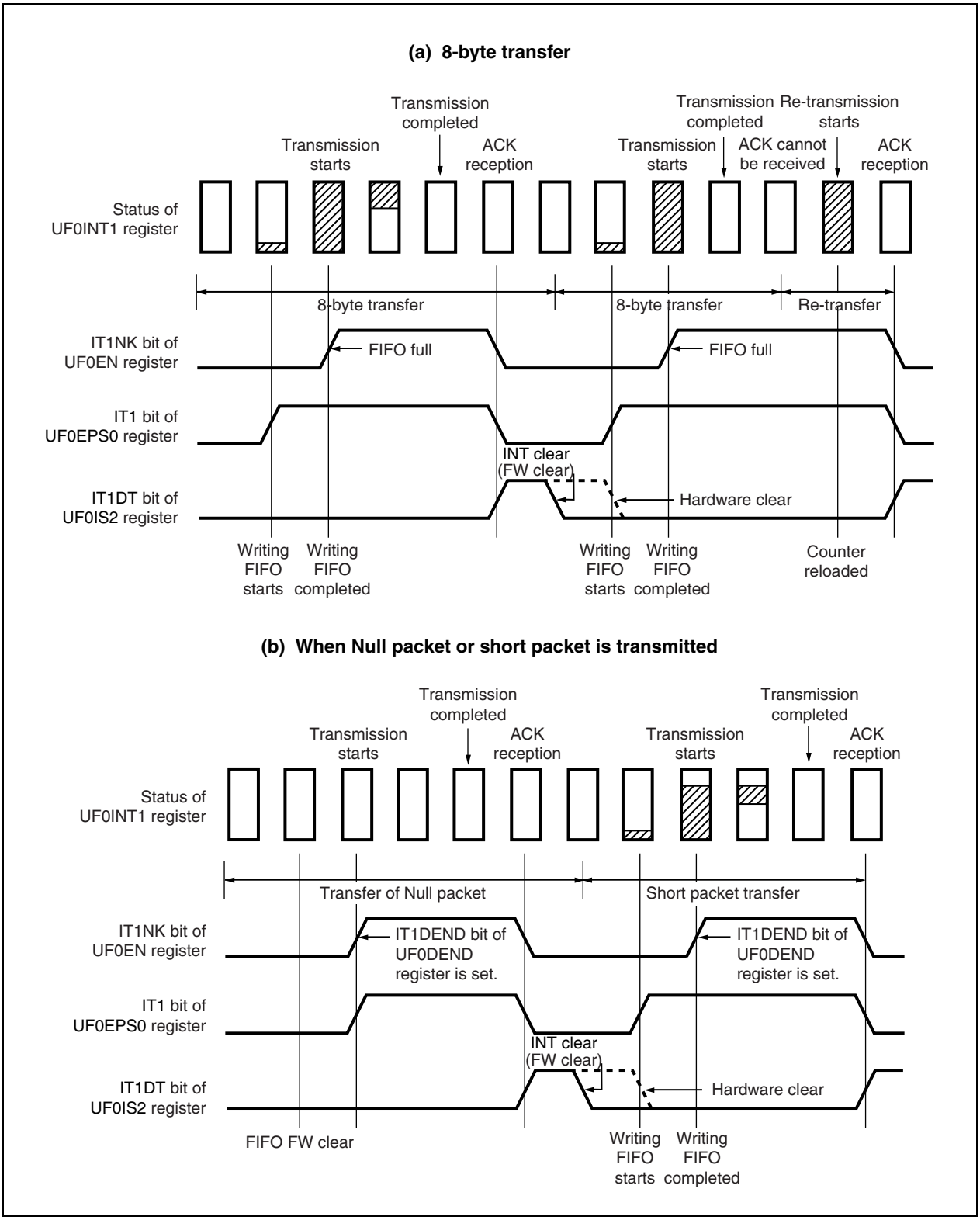
The hardware transmits data to the USB bus in synchronization with the IN token for Endpoint7 only when the IT1NK bit of the UF0EN register is set to 1 (when NAK is not transmitted). When the data is transmitted and the host correctly receives it, the IT1NK bit of the UF0EN register is automatically cleared to 0 by hardware. A short packet is transmitted when data is written to the UF0INT1 register and the IT1DEND bit of the UF0DEND register is set to 1 (IT1 bit of the UF0EPS0 register = 1 (data exists)). A Null packet is transmitted when the UF0INT1 register is cleared and the IT1DEND bit of the UF0DEND register is set to 1 (IT1 bit of the UF0EPS0 register = 1 (data exists)).

	7	6	5	4	3	2	1	0	Address	After reset
UF0INT1	IT17	IT16	IT15	IT14	IT13	IT12	IT11	IT10	00200114H	Undefined

Bit position	Bit name	Function
7 to 0	IT17 to IT10	These bits store data for Endpoint7.

The operation of the UF0INT1 register is illustrated below.

Figure 21-11. Operation of UF0INT1 Register



21.6.5 EPC request data registers

(1) UF0 device status register L (UF0DSTL)

This register stores the value that is to be returned in response to the GET_STATUS Device request.

This register can be read or written in 8-bit units.

The hardware automatically transmits the contents of this register to the host when it has received the GET_STATUS Device request.

Caution To rewrite this register, set the EP0NKA bit to 1 before reading the register contents, and rewrite the register contents after confirming that the bit has been set, in order to prevent conflict between a read access and a write access.

	7	6	5	4	3	2	1	0	Address	After reset
UF0DSTL	0	0	0	0	0	0	RMWK	SFPW	00200144H	00H

Bit position	Bit name	Function
1	RMWK	This bit specifies whether the remote wakeup function of the device is used. 1: Enabled 0: Disabled If the device supports a remote wakeup function, this bit is set to 1 by hardware when the SET_FEATURE Device request has been received, and is cleared to 0 by hardware when the CLEAR_FEATURE Device request has been received. If the device does not support a remote wakeup function, make sure that the SET_FEATURE Device request is not issued from the host.
0	SFPW	This bit indicates whether the device is self-powered or bus-powered. 1: Self-powered 0: Bus-powered

(2) UF0 EP0 status register L (UF0E0SL)

This register stores the value that is to be returned in response to the GET_STATUS Endpoint0 request.

This register can be read or written in 8-bit units. Note, however, that data can be written to this register only when the EP0NKA bit is set to 1.

If an error occurs in USBF, the E0HALT bit is set to 1 by FW. A write access to this register is ignored while a USB-side access to Endpoint0 is being received.

When the E0HALT bit is set to 1 by FW, it is not reflected until the next SETUP token is received if the control transfer immediately before is for the SET_FEATURE Endpoint0, CLEAR_FEATURE Endpoint0, GET_STATUS Endpoint0 request, or an FW-processed request.

The hardware automatically transmits the contents of this register to the host when it has received the GET_STATUS Endpoint0 request. If Endpoint0 has stalled, the UF0E0W and UF0E0R registers are cleared, and the EP0NKW and EP0NKR bits of the UF0E0N register are cleared to 0.

Caution To rewrite this register, set the EP0NKA bit to 1 before reading the register contents, and rewrite the register contents after confirming that the bit has been set, in order to prevent conflict between a read access and a write access.

	7	6	5	4	3	2	1	0	Address	After reset
UF0E0SL	0	0	0	0	0	0	0	E0HALT	0020014CH	00H

Bit position	Bit name	Function
0	E0HALT	This bit indicates the status of Endpoint0. 1: Stalled 0: Not stalled This bit is set to 1 by hardware when the SET_FEATURE Endpoint0 request has been received, and cleared to 0 by hardware when the CLEAR_FEATURE Endpoint0 request has been received. DATA PID is initialized to DATA0.

(3) UF0 EP1 status register L (UF0E1SL)

This register stores the value that is to be returned in response to the GET_STATUS Endpoint1 request.

This register can be read or written in 8-bit units. Note, however, that data can be written to this register only when the EP0NKA bit is set to 1.

If an error occurs in Endpoint1, the E1HALT bit is set to 1. A write access to this register is ignored while a USB-side access to Endpoint1 is being received.

The hardware automatically transmits the contents of this register to the host when it has received the GET_STATUS Endpoint1 request. If Endpoint1 has stalled, the UF0BI1 register is cleared and the BKI1NK bit is cleared to 0.

Because writing this register is always masked when transfer to Endpoint1, rather than control transfer, is executed, be sure to check this register to see if data has been correctly written to it.

Caution To rewrite this register, set the EP0NKA bit to 1 before reading the register contents, and rewrite the register contents after confirming that the bit has been set, in order to prevent conflict between a read access and a write access.

	7	6	5	4	3	2	1	0	Address	After reset
UF0E1SL	0	0	0	0	0	0	0	E1HALT	00200150H	00H

Bit position	Bit name	Function
0	E1HALT	This bit indicates the status of Endpoint1. 1: Stalled 0: Not stalled This bit is set to 1 by hardware when the SET_FEATURE Endpoint1 request has been received. It is cleared to 0 by hardware when the CLEAR_FEATURE Endpoint1 request, SET_CONFIGURATION request, or the SET_INTERFACE request for the Interface to which Endpoint1 is linked has correctly been received. DATA PID is initialized to DATA0.

(4) UF0 EP2 status register L (UF0E2SL)

This register stores the value that is to be returned in response to the GET_STATUS Endpoint2 request.

This register can be read or written in 8-bit units. Note, however, that data can be written to this register only when the EP0NKA bit is set to 1.

If an error occurs in Endpoint2, the E2HALT bit is set to 1. A write access to this register is ignored while a USB-side access to Endpoint2 is being received.

The hardware automatically transmits the contents of this register to the host when it has received the GET_STATUS Endpoint2 request. If Endpoint2 has stalled, the UF0BO1 register is cleared and the BKO1NK bit is cleared to 0.

Because writing this register is always masked when transfer to Endpoint2, rather than control transfer, is executed, be sure to check this register to see if data has been correctly written to it.

Caution To rewrite this register, set the EP0NKA bit to 1 before reading the register contents, and rewrite the register contents after confirming that the bit has been set, in order to prevent conflict between a read access and a write access.

	7	6	5	4	3	2	1	0	Address	After reset
UF0E2SL	0	0	0	0	0	0	0	E2HALT	00200154H	00H

Bit position	Bit name	Function
0	E2HALT	This bit indicates the status of Endpoint2. 1: Stalled 0: Not stalled This bit is set to 1 by hardware when the SET_FEATURE Endpoint2 request has been received. It is cleared to 0 by hardware when the CLEAR_FEATURE Endpoint2 request, SET_CONFIGURATION request, or the SET_INTERFACE request for the Interface to which Endpoint2 is linked has correctly been received. DATA PID is initialized to DATA0.

(5) UF0 EP3 status register L (UF0E3SL)

This register stores the value that is to be returned in response to the GET_STATUS Endpoint3 request.

This register can be read or written in 8-bit units. Note, however, that data can be written to this register only when the EP0NKA bit is set to 1.

If an error occurs in Endpoint3, the E3HALT bit is set to 1. A write access to this register is ignored while a USB-side access to Endpoint3 is being received.

The hardware automatically transmits the contents of this register to the host when it has received the GET_STATUS Endpoint3 request. If Endpoint3 has stalled, the UF0BI2 register is cleared and the BKI2NK bit is cleared to 0.

Because writing this register is always masked when transfer to Endpoint3, rather than control transfer, is executed, be sure to check this register to see if data has been correctly written to it.

Caution To rewrite this register, set the EP0NKA bit to 1 before reading the register contents, and rewrite the register contents after confirming that the bit has been set, in order to prevent conflict between a read access and a write access.

	7	6	5	4	3	2	1	0	Address	After reset
UF0E3SL	0	0	0	0	0	0	0	E3HALT	00200158H	00H

Bit position	Bit name	Function
0	E3HALT	This bit indicates the status of Endpoint3. 1: Stalled 0: Not stalled This bit is set to 1 by hardware when the SET_FEATURE Endpoint3 request has been received. It is cleared to 0 by hardware when the CLEAR_FEATURE Endpoint3 request, SET_CONFIGURATION request, or the SET_INTERFACE request for the Interface to which Endpoint3 is linked has correctly been received. DATA PID is initialized to DATA0.

(6) UF0 EP4 status register L (UF0E4SL)

This register stores the value that is to be returned in response to the GET_STATUS Endpoint4 request.

This register can be read or written in 8-bit units. Note, however, that data can be written to this register only when the EP0NKA bit is set to 1.

If an error occurs in Endpoint4, the E4HALT bit is set to 1. A write access to this register is ignored while a USB-side access to Endpoint4 is being received.

The hardware automatically transmits the contents of this register to the host when it has received the GET_STATUS Endpoint4 request. If Endpoint4 has stalled, the UF0BO2 register is cleared and the BKO2NK bit is cleared to 0.

Because writing this register is always masked when transfer to Endpoint4, rather than control transfer, is executed, be sure to check this register to see if data has been correctly written to it.

Caution To rewrite this register, set the EP0NKA bit to 1 before reading the register contents, and rewrite the register contents after confirming that the bit has been set, in order to prevent conflict between a read access and a write access.

	7	6	5	4	3	2	1	0	Address	After reset
UF0E4SL	0	0	0	0	0	0	0	E4HALT	0020015CH	00H

Bit position	Bit name	Function
0	E4HALT	This bit indicates the status of Endpoint4. 1: Stalled 0: Not stalled This bit is set to 1 by hardware when the SET_FEATURE Endpoint4 request has been received. It is cleared to 0 by hardware when the CLEAR_FEATURE Endpoint4 request, SET_CONFIGURATION request, or the SET_INTERFACE request for the Interface to which Endpoint4 is linked has correctly been received. DATA PID is initialized to DATA0.

(7) UF0 EP7 status register L (UF0E7SL)

This register stores the value that is to be returned in response to the GET_STATUS Endpoint7 request.

This register can be read or written in 8-bit units. Note, however, that data can be written to this register only when the EP0NKA bit is set to 1.

If an error occurs in Endpoint7, the E7HALT bit is set to 1. A write access to this register is ignored while a USB-side access to Endpoint7 is being received.

The hardware automatically transmits the contents of this register to the host when it has received the GET_STATUS Endpoint7 request. If Endpoint7 has stalled, the UF0INT1 register is cleared and the IT1NK bit is cleared to 0.

Because writing this register is always masked when transfer to Endpoint7, rather than control transfer, is executed, be sure to check this register to see if data has been correctly written to it.

Caution To rewrite this register, set the EP0NKA bit to 1 before reading the register contents, and rewrite the register contents after confirming that the bit has been set, in order to prevent conflict between a read access and a write access.

	7	6	5	4	3	2	1	0	Address	After reset
UF0E7SL	0	0	0	0	0	0	0	E7HALT	00200168H	00H

Bit position	Bit name	Function
0	E7HALT	This bit indicates the status of Endpoint7. 1: Stalled 0: Not stalled This bit is set to 1 by hardware when the SET_FEATURE Endpoint7 request has been received. It is cleared to 0 by hardware when the CLEAR_FEATURE Endpoint7 request, SET_CONFIGURATION request, or the SET_INTERFACE request for the Interface to which Endpoint7 is linked has correctly been received. DATA PID is initialized to DATA0.

(8) UF0 address register (UF0ADRS)

This register stores the device address.

This register is read-only, in 8-bit units.

The device address sent by the SET_ADDRESS request is analyzed and the resultant value is automatically written to this register. If the SET_ADDRESS request is processed by FW, the value of this register is reflected as the device address when the SUCCESS signal is received in the status stage.

Caution Do not execute a write access to this register. If written, the operation is not guaranteed.

	7	6	5	4	3	2	1	0	Address	After reset
UF0ADRS	0	ADRS6	ADRS5	ADRS4	ADRS3	ADRS2	ADRS1	ADRS0	00200180H	00H

Bit position	Bit name	Function
6 to 0	ADRS6 to ADRS0	These bits hold the device address of SIE.

(9) UF0 configuration register (UF0CNF)

This register stores the value that is to be returned in response to the GET_CONFIGURATION request.

This register is read-only, in 8-bit units.

When the SET_CONFIGURATION request is received, its wValue is automatically written to this register.

When a change of the value of this register from 00H to other than 00H is detected, the CONF bit of the UF0MODS register is set to 1. If the SET_CONFIGURATION request is processed by FW, the status of this register is immediately reflected on the UF0MODS register as soon as data has been written to this register (CONF bit = 1 before completion of the status stage).

Caution Do not execute a write access to this register. If written, the operation is not guaranteed.

	7	6	5	4	3	2	1	0	Address	After reset
UF0CNF	0	0	0	0	0	0	CONF1	CONF0	00200182H	00H

Bit position	Bit name	Function
1, 0	CONF1, CONF0	These bits hold the data to be returned in response to the GET_CONFIGURATION request.

(10) UF0 interface 0 register (UF0IF0)

This register stores the value that is to be returned in response to the GET_INTERFACE wIndex = 0 request.

This register is read-only, in 8-bit units.

When the SET_INTERFACE request is received, its wValue is automatically written to this register.

If the SET_INTERFACE request is processed by FW, wIndex and wValue are decoded, and the setting of endpoint is automatically changed. At this time, the status bit of the target endpoint and DPID are automatically cleared to 0, depending on the setting. The FIFO is not cleared automatically.

Caution Do not execute a write access to this register. If written, the operation is not guaranteed.

	7	6	5	4	3	2	1	0	Address	After reset
UF0IF0	0	0	0	0	0	IF02	IF01	IF00	00200184H	00H

Bit position	Bit name	Function
2 to 0	IF02 to IF00	These bits hold the data to be returned in response to GET_INTERFACE wIndex = 0 request.

(11) UF0 interface 1 to 4 registers (UF0IF1 to UF0IF4)

These registers store the value that is to be returned in response to the GET_INTERFACE wIndex = n request (n = 1 to 4).

These registers are read-only, in 8-bit units.

When the SET_INTERFACE request is received, its wValue is automatically written to these registers.

These registers are invalidated according to the setting of the UF0AIFN and UF0AAS registers.

If the SET_INTERFACE request is processed by FW, wIndex and wValue are decoded, and the setting of endpoint is automatically changed. At this time, the status bit of the target endpoint and DPID are automatically cleared to 0, depending on the setting. The FIFO is not cleared automatically.

Caution Do not execute a write access to this register. If written, the operation is not guaranteed.

	7	6	5	4	3	2	1	0	Address	After reset
UF0IF1	0	0	0	0	0	IF12	IF11	IF10	00200186H	00H
UF0IF2	0	0	0	0	0	IF22	IF21	IF20	00200188H	00H
UF0IF3	0	0	0	0	0	IF32	IF31	IF30	0020018AH	00H
UF0IF4	0	0	0	0	0	IF42	IF41	IF40	0020018CH	00H

Bit position	Bit name	Function
2 to 0	IFn2 to IFn0	These bits hold the data to be returned in response to GET_INTERFACE wIndex = n request.

Remark n = 1 to 4

(12) UF0 descriptor length register (UF0DSCL)

This register stores the length of the value that is to be returned in response to the GET_DESCRIPTOR Configuration request. The value of this register is the number of bytes of all the descriptors set by the UF0CIEn register minus 1 (n = 0 to 255). The total descriptor length that is to be returned in response to the GET_DESCRIPTOR Configuration request is determined according to the value of this register.

This register can be read or written in 8-bit units. However, data can be written to this register only when the EP0NKA bit is set to 1.

Processing of wLength is automatically controlled. If this register is set to 00H, it means that the descriptor to be returned is 1 byte long. If the register is set to FFH, a descriptor length of 256 bytes is returned. When a descriptor exceeding 256 bytes in length is used, set the CDCGDST bit of the UF0MODC register to 1 and process the GET_DESCRIPTOR request by FW (at this time, the CDCGD bit of the UF0MODS register is also set to 1).

Caution To rewrite this register, set the EP0NKA bit to 1 before reading the register contents, and rewrite the register contents after confirming that the bit has been set, in order to prevent conflict between a read access and a write access.

	7	6	5	4	3	2	1	0	Address	After reset
UF0DSCL	DPL7	DPL6	DPL5	DPL4	DPL3	DPL2	DPL1	DPL0	002001A0H	00H

Bit position	Bit name	Function
7 to 0	DPL7 to DPL0	These bits set the value of the number of bytes of all the descriptors to be returned in response to the GET_DESCRIPTOR Configuration request minus 1.

(13) UF0 device descriptor registers 0 to 17 (UF0DD0 to UF0DD17)

These registers store the value to be returned in response to the GET_DESCRIPTOR Device request.

These registers can be read or written in 8-bit units. However, data can be written to these registers only when the EP0NKA bit is set to 1.

Cautions 1. To rewrite these registers, set the EP0NKA bit to 1 before reading the register contents, and rewrite the register contents after confirming that the bit has been set, in order to prevent conflict between a read access and a write access.

2. Use the value defined by USB Specification Ver. 2.0 and the latest Class Specification as the set value.

	7	6	5	4	3	2	1	0	Address	After reset
UF0DDn (n = 0 to 17)									See **Table 21-5**.	Undefined

Table 21-5. Mapping and Data of UF0 Device Descriptor Registers

Symbol	Address	Field Name	Contents
UF0DD0	002001A2H	bLength	Size of this descriptor
UF0DD1	002001A4H	bDescriptorType	Device descriptor type
UF0DD2	002001A6H	bcdUSB	Value below decimal point of Rev. number of USB specification
UF0DD3	002001A8H		Value above decimal point of Rev. number of USB specification
UF0DD4	002001AAH	bDeviceClass	Class code
UF0DD5	002001ACH	bDeviceSubClass	Subclass code
UF0DD6	002001AEH	bDeviceProtocol	Protocol code
UF0DD7	002001B0H	bMaxPacketSize0	Maximum packet size of Endpoint0
UF0DD8	002001B2H	idVendor	Lower value of vendor ID
UF0DD9	002001B4H		Higher value of vendor ID
UF0DD10	002001B6H	idProduct	Lower value of product ID
UF0DD11	002001B8H		Higher value of product ID
UF0DD12	002001BAH	bcdDevice	Lower value of device release number
UF0DD13	002001BCH		Higher value of device release number
UF0DD14	002001BEH	iManufacturer	Index of string descriptor describing manufacturer
UF0DD15	002001C0H	iProduct	Index of string descriptor describing product
UF0DD16	002001C2H	lSerialNumber	Index of string descriptor describing device serial number
UF0DD17	002001C4H	BNumConfigurations	Number of settable configurations

(14) UF0 configuration/interface/endpoint descriptor registers 0 to 255 (UF0CIE0 to UF0CIE255)

These registers store the value to be returned in response to the GET_DESCRIPTOR Configuration request.

These registers can be read or written in 8-bit units. However, data can be written to these registers only when the EP0NKA bit is set to 1.

Descriptor information of up to 256 bytes can be stored in these registers. Store each descriptor in the order of Configuration, Interface, and Endpoint (see **Table 21-6**). If there are two or more Interfaces, repeatedly store the data following the Interface descriptor.

Table 21-6. Mapping of UF0CIEn Register

Address	Descriptor Stored
002001C6H	Configuration descriptor (9 bytes)
002001D8H	Interface descriptor (9 bytes)
002001EAH	Endpoint1 descriptor (7 bytes)
002001F8H	Endpoint2 descriptor (7 bytes)
00200206H	Endpoint3 descriptor (7 bytes)
:	:
002002xxH	Interface descriptor (9 bytes)
002002xxH+9	Endpoint1 descriptor (7 bytes)
002002xxH+16	Endpoint2 descriptor (7 bytes)
002002xxH+23	Endpoint3 descriptor (7 bytes)
:	:

The range of the valid data that can be set to these registers varies according to the setting of the UF0DSCL register. In addition to the descriptors listed in Table 21-7, descriptors peculiar to classes and vendors can also be stored.

If all the values are fixed, they can be stored in ROM.

Cautions 1. To rewrite these registers, set the EP0NKA bit to 1 before reading the register contents, and rewrite the register contents after confirming that the bit has been set, in order to prevent conflict between a read access and a write access.

2. Use the value defined by USB Specification Ver. 2.0 and the latest Class Specification as the set value.

	7	6	5	4	3	2	1	0	Address	After reset
UF0CIEn (n = 0 to 255)									002001C6H to 002003C4H	Undefined

Table 21-7. Data of UF0CIEn Register

(a) Configuration descriptor (9 bytes)

Offset	Field Name	Contents
0	bLength	Size of this descriptor
1	bDescriptorType	Descriptor type
2	wTotalLength	Lower value of the total number of bytes of Configuration, all Interface, and all Endpoint descriptors
3		Higher value of the total number of bytes of Configuration, all Interface, and all Endpoint descriptors
4	bNumInterface	Number of Interfaces
5	bConfigurationValue	Value to select this Configuration
6	iConfiguration	Index of string descriptor describing this Configuration
7	bmAttributes	Features of this Configuration (self-powered, without remote wakeup)
8	MaxPower	Maximum power consumption of this Configuration (unit: mA)[Note]

Note Shown in 2 mA units. (example: 50 = 100 mA)

(b) Interface descriptor (9 bytes)

Offset	Field Name	Contents
0	bLength	Size of this descriptor
1	bDescriptorType	Descriptor type
2	bInterfaceNumber	Value of this Interface
3	bAlternateSetting	Value to select alternative setting of Interface
4	bNumEndpoints	Number of usable Endpoints
5	bInterfaceClass	Class code
6	bInterfaceSubClass	Subclass code
7	bInterfaceProtocol	Protocol code
8	Interface	Index of string descriptor describing this Interface

(c) Endpoint descriptor (7 bytes)

Offset	Field Name	Contents
0	bLength	Size of this descriptor
1	bDescriptorType	Descriptor type
2	bEndpointAddress	Address/transfer direction of this Endpoint
3	bmAttributes	Transfer type
4	wMaxPaketSize	Lower value of maximum number of transfer data
5		Higher value of maximum number of transfer data
6	bInterval	Transfer interval

21.6.6 Bridge register

(1) Bridge interrupt control register (BRGINTT)

The BRGINTT register controls the DMA transfer status of the interrupt generate status, and each end point (EP1 to EP4) from EPC to bridge circuit.

The BRGINTT register can be read or written in 16-bit units.

After reset: 0000H R/W Address: 00200400H

	15	14	13	12	11	10	9	8
BRGINTT	0	0	0	0	EP4INT	EP3INT	EP2INT	EP1INT

7	6	5	4	3	2	1	0
0	0	0	0	0	EPCINT2B	EPCINT1B	EPCINT0B

Bit position	Bit name	Function
11	EP4INT	In EP4, when the DMA transfer is normal terminate, or the error finished in the DMA transferring, this bit is setting. Clearing to “0” by writing “1”. 0: DMA transfer not completion 1: DMA transfer completion
10	EP3NT	In EP3, when the DMA transfer is normal terminate, or the error finished in the DMA transferring, this bit is setting. Clearing to “0” by writing “1”. 0: DMA transfer not completion 1: DMA transfer completion
9	EP2NT	In EP2, when the DMA transfer is normal terminate, or the error finished in the DMA transferring, this bit is setting. Clearing to “0” by writing “1”. 0: DMA transfer not completion 1: DMA transfer completion
8	EP1NT	In EP1, when the DMA transfer is normal terminate, or the error finished in the DMA transferring, this bit is setting. Clearing to “0” by writing “1”. 0: DMA transfer not completion 1: DMA transfer completion
2	EPCINT2B	Showing the status of the interrupt signal “EPC_INT2B” from EPC. Clear controlling from the request of EPC register 0: Interrupt not issued 1: Interrupt issued
1	EPCINT1B	Showing the status of the interrupt signal “EPC_INT1B” from EPC. Clear controlling from the request of EPC register 0: Interrupt not issued 1: Interrupt issued
0	EPCINT0B	Showing the status of the interrupt signal ”EPC_INT0B” from EPC. Clear controlling from the request of EPC register 0: Interrupt not issued 1: Interrupt issued

(2) Bridge interrupt enable register (BRGINTE)

The BRGINTE register controls whether the interrupt generated in the bridge circuit is enabled or disabled.

The BRGINTE register can be read or written in 16-bit units.

After reset: 0000H R/W Address: 00200402H

	15	14	13	12	11	10	9	8
BRGINTE	0	0	0	0	EP4INTN	EP3INTN	EP2INTN	EP1INTN

7	6	5	4	3	2	1	0
0	0	0	0	0	EPC INT2BEN	EPC INT1BEN	EPC INT0BEN

Bit position	Bit name	Function
11	EP4INTN	Setting the interrupt occur enable or disable when EP4INT bit is setting. 0: Interrupt disabled 1: Interrupt enabled
10	EP3NTN	Setting the interrupt occur enable or disable when EP3INT bit is setting. 0: Interrupt disabled 1: Interrupt enabled
9	EP2NTN	Setting the interrupt occur enable or disable when EP2INT bit is setting. 0: Interrupt disabled 1: Interrupt enabled
8	EP1NTN	Setting the interrupt occur enable or disable when EP1INT bit is setting. 0: Interrupt disabled 1: Interrupt enabled
2	EPCINT2BEN	Setting the interrupt occur enable or disable when EPCINT2BEN bit is setting. 0: Interrupt disabled 1: Interrupt enabled
1	EPCINT1BEN	Setting the interrupt occur enable or disable when EPCINT1BEN bit is setting. 0: Interrupt disabled 1: Interrupt enabled
0	EPCINT0BEN	Setting the interrupt occur enable or disable when EPCINT0BEN bit is setting. 0: Interrupt disabled 1: Interrupt enabled

(3) EPC macro control register (EPCCLT)

The EPCCLT register controls the reset generator to the EPC macro.

The EPCCLT register can be read or written in 16-bit units.

After reset: 0000H R/W Address: 00200404H

	15	14	13	12	11	10	9	8
EPCCLT	0	0	0	0	0	0	0	0

7	6	5	4	3	2	1	0
0	0	0	0	0	0	0	EPCRST

Bit position	Bit name	Function
0	EPCRST	Setting the reset occurs to EPC. 0: Reset released 1: Reset issued

(4) CPU I/F bus control register (CPUBCTL)

The CPUBCTL register controls the interface between bridge circuit and CPU.

The CPUBCTL register can be read or written in 16-bit units.

After reset: Undefined R/W Address: 00200408H

	15	14	13	12	11	10	9	8
CPUBCTL	0	0	0	0	0	0	0	0

7	6	5	4	3	2	1	0
0	0	0	0	0	BULKWAIT	DATAWAIT	NOWAIT

Bit position	Bit name	Function
2	BULKWAIT	Forcibly inserting the 1 wait (bulk wait) when the bulk register is accessed. 0: No forcibly insert the bulk wait[Note] (default value) 1: Forcibly insert the bulk wait **Note** The setting is invalid in write accessing, the bulk wait is forcibly inserted.
1	DATAWAIT	Forcibly inserting the 1 wait (data wait) after the CPU bus cycle. 0: No forcibly insert the data wait (default value) 1: Forcibly insert the data wait
0	NOWAIT	Setting enables/disable the no wait operation of CPU bus cycle. 0: No wait disables[Note] (default value) 1: No wait enables **Note** 1 wait or more is inserted.

21.6.7 DMA register

(1) EPn DMA control register 1 (UF0E1DC1 to UF0E4DC1)

The UF0E1DC1 to UF0E4DC1 register controls the DMA transfer of end point n (EPn). (n = 1 to 4)

The UF0E1DC1 to UF0E4DC1 register can be read or written in 16-bit units.

(1/2)

After reset: 0000H R/W Address: 00200500H

	15	14	13	12	11	10	9	8
UF0E1DC1	0	0	0	0	0	0	0	0

7	6	5	4	3	2	1	0
0	0	EP1BULK2	EP1BULK1	EP1BULK0	EP1STOP	EP1REQ	EP1DMAEN

After reset: 0000H R/W Address: 00200504H

	15	14	13	12	11	10	9	8
UF0E2DC1	0	0	0	0	0	0	0	0

7	6	5	4	3	2	1	0
0	0	EP2BULK2	EP2BULK1	EP2BULK0	EP2STOP	EP2REQ	EP2DMAEN

After reset: 0000H R/W Address: 00200508H

	15	14	13	12	11	10	9	8
UF0E3DC1	0	0	0	0	0	0	0	0

7	6	5	4	3	2	1	0
0	0	EP3BULK2	EP3BULK1	EP3BULK0	EP3STOP	EP3REQ	EP3DMAEN

After reset: 0000H R/W Address: 0020050CH

	15	14	13	12	11	10	9	8
UF0E4DC1	0	0	0	0	0	0	0	0

7	6	5	4	3	2	1	0
0	0	EP4BULK2	EP4BULK1	EP4BULK0	EP4STOP	EP4REQ	EP4DMAEN

(2/2)

<table>
<tr><th>Bit position</th><th>Bit name</th><th>Function</th></tr>
<tr><td>5 to 3</td><td>EPnBULK2,
EPnBULK1,
EPnBULK0</td><td>Shown the status the state machine “BIN_STATE” for bulk transfer of the internal bridge
<table>
<tr><th>EPnBULK2</th><th>EPnBULK1</th><th>EPnBULK0</th><th>”BIN_STATE” status</th></tr>
<tr><td>0</td><td>0</td><td>0</td><td>BIN_IDLE</td></tr>
<tr><td>0</td><td>0</td><td>1</td><td>BIN_CPU</td></tr>
<tr><td>0</td><td>1</td><td>0</td><td>BIN_EPC</td></tr>
<tr><td>0</td><td>1</td><td>1</td><td>BIN_CMP</td></tr>
<tr><td>1</td><td>0</td><td>0</td><td>BIN_END</td></tr>
</table></td></tr>
<tr><td>2</td><td>EPnSTOP</td><td>Showing the status (end factor of DMA transfer) of DMA transfer end from EPC
0: End of DMA transfer by EPn_TCNT value “0”
1: End of DMA transfer by negate of “EPC_DMARQ_EPnB”
Automatically clear (0) by setting next EP1_DMAEN to “1”.</td></tr>
<tr><td>1</td><td>EPnREQ</td><td>Showing the status of “EPC_DMARQ_EPnB” signal from EPC
0: No DMA request signal
1: DMA request signal</td></tr>
<tr><td>0</td><td>EPnDMAEN</td><td>Setting the control of DMA request from EPC
0: Masks DMA request
1: Enables DMA request
Automatically clear (0) by complete number of packet transfer setting in EPn_TCNT, or complete the DMA transfer by the negate of DMARQ_EPnB.

Caution The setting value is not guaranteed in forcibly end.</td></tr>
</table>

Remark n = 1 to 4

(2) EPn DMA control register 2 (UF0E1DC2 to UF0E4DC2)

The UF0E1DC2 to UF0E4DC2 register controls the DMA transfer of end point n (EPn). (n = 1 to 4)

The UF0E1DC2 to UF0E4DC2 register can be read or written in 16-bit units.

(1/2)

After reset: 0000H R/W Address: 00200502H

UF0E1DC2

15	14	13	12	11	10	9	8
EP1 TCNT15	EP1 TCNT14	EP1 TCNT13	EP1 TCNT12	EP1 TCNT11	EP1 TCNT10	EP1 TCNT9	EP1 TCNT8

7	6	5	4	3	2	1	0
EP1 TCNT7	EP1 TCNT6	EP1 TCNT5	EP1 TCNT4	EP1 TCNT3	EP1 TCNT2	EP1 TCNT1	EP1 TCNT0

After reset: 0000H R/W Address: 00200506H

UF0E2DC2

15	14	13	12	11	10	9	8
EP2 TCNT15	EP2 TCNT14	EP2 TCNT13	EP2 TCNT12	EP2 TCNT11	EP2 TCNT10	EP2 TCNT9	EP2 TCNT8

7	6	5	4	3	2	1	0
EP2 TCNT7	EP2 TCNT6	EP2 TCNT5	EP2 TCNT4	EP2 TCNT3	EP2 TCNT2	EP2 TCNT1	EP2 TCNT0

After reset: 0000H R/W Address: 0020050AH

UF0E3DC2

15	14	13	12	11	10	9	8
EP3 TCNT15	EP3 TCNT14	EP3 TCNT13	EP3 TCNT12	EP3 TCNT11	EP3 TCNT10	EP3 TCNT9	EP3 TCNT8

7	6	5	4	3	2	1	0
EP3 TCNT7	EP3 TCNT6	EP3 TCNT5	EP3 TCNT4	EP3 TCNT3	EP3 TCNT2	EP3 TCNT1	EP3 TCNT0

After reset: 0000H R/W Address: 0020050EH

UF0E4DC2

15	14	13	12	11	10	9	8
EP4 TCNT15	EP4 TCNT14	EP4 TCNT13	EP4 TCNT12	EP4 TCNT11	EP4 TCNT10	EP4 TCNT9	EP4 TCNT8

7	6	5	4	3	2	1	0
EP4 TCNT7	EP4 TCNT6	EP4 TCNT5	EP4 TCNT4	EP4 TCNT3	EP4 TCNT2	EP4 TCNT1	EP4 TCNT0

(2/2)

Bit position	Bit name	Function
15 to 0	EPnTCNT15 to EPnTCNT0	Setting the number of byte to DMA transfer in EPn. End the DMA transfer after the value of EPn_TCNT is “0” to decrement each transfer. **Cautions 1. Set this register when EPn_DMAEN = 0.** **2. Setting this register to “0” is prohibited.** **Be sure to set this register +1 value for the value of DMA transfer count register DBC0 to DBC3.** **3. The setting value of this register is reflected the counter BIN_TCNT for bulk transfer of the bridge inside. And the value of BIN_TCNT is “0”, EPn_TCN is “0”, too.** **4. Update the value of the counter BIN_TCNT for bulk transfer is stopped when forcibly terminated.**

Remark n = 1 to 4

21.6.8 Bulk-in register

(1) UF0 EP1 bulk-in transfer data register (UF0EP1BI)

The UF0EP1BI register writes the bulk-in transfer data of EP1.

The UF0EP1BI register can be read or written in 8-bit or 16-bit units.

After reset: 0000H R/W Address: 00201000H

	15	14	13	12	11	10	9	8
UF0EP1BI	0	0	0	0	0	0	0	0

7	6	5	4	3	2	1	0
EP1BI7	EP1BI6	EP1BI5	EP1BI4	EP1BI3	EP1BI2	EP1BI1	EP1BI0

Bit position	Bit name	Function
7 to 0	EP1BI7 to EP1BI0	Writing the bulk-out transfer data of EP1. Data outputting to the EPC macro by writing data to this register. If using this register, setting the address (00201000H) in DMA destination address register (DDAn (n = 0 to 3)) of DMAC. In addition, set the RQnUR1E (n = 0 to 3) bit of the UFDRQEN register to 1 to assign a DMA channel.

(2) UF0 EP3 bulk-in transfer data register (UF0EP3BI)

The UF0EP3BI register writes the bulk-in transfer data of EP1.

The UF0EP3BI register can be read or written in 8-bit or 16-bit units.

After reset: 0000H R/W Address: 00202000H

	15	14	13	12	11	10	9	8
UF0EP3BI	0	0	0	0	0	0	0	0

7	6	5	4	3	2	1	0
EP3BI7	EP3BI6	EP3BI5	EP3BI4	EP3BI3	EP3BI2	EP3BI1	EP3BI0

Bit position	Bit name	Function
7 to 0	EP3BI7 to EP3BI0	Writing the bulk-out transfer data of EP3. Data outputting to the EPC macro by writing data to this register. If using this register, setting the address (00202000H) in DMA destination address register (DDAn (n = 0 to 3)) of DMAC. In addition, set the RQnUR3E (n = 0 to 3) bit of the UFDRQEN register to 1 to assign a DMA channel.

21.6.9 Bulk-out register

(1) UF0 EP2 bulk-out transfer data register (UF0EP2BO)

The UF0EP2BO register writes the bulk-out transfer data of EP2.

The UF0EP2BO register can be read or written in 8-bit or 16-bit units.

After reset: 0000H R Address: 00210000H

	15	14	13	12	11	10	9	8
UF0EP2BO	0	0	0	0	0	0	0	0

7	6	5	4	3	2	1	0
EP2BO7	EP2BO6	EP2BO5	EP2BO4	EP2BO3	EP2BO2	EP2BO1	EP2BO0

Bit position	Bit name	Function
7 to 0	EP2BO7 to EP2BO0	Reading the bulk-out transfer data of EP2. Reading the input data from the EPC macro from this register. If using this register, setting the address (00210000H) in DMA source address register (DSAn (n = 0 to 3)) of DMAC. In addition, set the RQnUR0E (n = 0 to 3) bit of the UFDRQEN register to 1 to assign a DMA channel.

Caution If either of the following operations is performed, the data stored in this register is read out and the next bulk-out transfer data is stored into this register.

- **The UF0EP2BO register is read during program execution.**
- **The UF0EP2BO register is monitored on the memory window while the debugger is being used.**

(2) UF0 EP4 bulk-out transfer data register (UF0EP4BO)

The UF0EP4BO register writes the bulk-out transfer data of EP4.

The UF0EP4BO register can be read or written in 8-bit or 16-bit units.

After reset: 0000H R Address: 00220000H

	15	14	13	12	11	10	9	8
UF0EP4BO	0	0	0	0	0	0	0	0

7	6	5	4	3	2	1	0
EP4BO7	EP4BO6	EP4BO5	EP4BO4	EP4BO3	EP4BO2	EP4BO1	EP4BO0

Bit position	Bit name	Function
7 to 0	EP4BO7 to EP4BO0	Reading the bulk-out transfer data of EP4. Reading the input data from the EPC macro from this register. If using this register, setting the address (00220000H) in DMA source address register (DSAn (n = 0 to 3)) of DMAC. In addition, set the RQnUR2E (n = 0 to 3) bit of the UFDRQEN register to 1 to assign a DMA channel.

Caution If either of the following operations is performed, the data stored in this register is read out and the next bulk-out transfer data is stored into this register.

- **The UF0EP4BO register is read during program execution.**
- **The UF0EP4BO register is monitored on the memory window while the debugger is being used.**

21.6.10 Peripheral control registers

(1) USBF DMA request enable register (UFDRQEN)

The UFDRQEN register specifies the DMA channel to be used and the endpoint to be transferred.

The UFDRQEN register can be read or written in 8-bit or 16-bit units.

(1/2)

After reset: 0000H R/W Address: 00240000H

	15	14	13	12	11	10	9	8
UFDRQEN	RQ3UR3E	RQ2UR3E	RQ1UR3E	RQ0UR3E	RQ3UR2E	RQ2UR2E	RQ1UR2E	RQ0UR2E

7	6	5	4	3	2	1	0
RQ3UR1E	RQ2UR1E	RQ1UR1E	RQ0UR1E	RQ3UR0E	RQ2UR0E	RQ1UR0E	RQ0UR0E

<table>
<tr><th>Bit position</th><th>Bit name</th><th>Function</th></tr>
<tr><td>15, 11, 7, 3</td><td>RQ3UR3E,
RQ3UR2E,
RQ3UR1E,
RQ3UR0E</td><td>Specify the endpoint n (EPn) to be transferred by DMA channel 3.
(n = 1 to 4)
<table>
<tr><th>RQ3UR3E</th><th>RQ3UR2E</th><th>RQ3UR1E</th><th>RQ3UR0E</th><th>EP transferred by DMA3</th></tr>
<tr><td>1</td><td>0</td><td>0</td><td>0</td><td>EP4</td></tr>
<tr><td>0</td><td>1</td><td>0</td><td>0</td><td>EP3</td></tr>
<tr><td>0</td><td>0</td><td>1</td><td>0</td><td>EP2</td></tr>
<tr><td>0</td><td>0</td><td>0</td><td>1</td><td>EP1</td></tr>
<tr><td colspan="4">Other than above</td><td>DMA3 does not transfer EPn
(DMA3 not used)</td></tr>
</table></td></tr>
<tr><td>14, 10, 6, 2</td><td>RQ2UR3E,
RQ2UR2E,
RQ2UR1E,
RQ2UR0E</td><td>Specify the endpoint n (EPn) to be transferred by DMA channel 2.
(n = 1 to 4)
<table>
<tr><th>RQ2UR3E</th><th>RQ2UR2E</th><th>RQ2UR1E</th><th>RQ2UR0E</th><th>EP transferred by DMA2</th></tr>
<tr><td>1</td><td>0</td><td>0</td><td>0</td><td>EP4</td></tr>
<tr><td>0</td><td>1</td><td>0</td><td>0</td><td>EP3</td></tr>
<tr><td>0</td><td>0</td><td>1</td><td>0</td><td>EP2</td></tr>
<tr><td>0</td><td>0</td><td>0</td><td>1</td><td>EP1</td></tr>
<tr><td colspan="4">Other than above</td><td>DMA2 does not transfer EPn
(DMA2 not used)</td></tr>
</table></td></tr>
</table>

(2/2)

<table>
<tr><th>Bit position</th><th>Bit name</th><th>Function</th></tr>
<tr><td>13, 9, 5, 1</td><td>RQ1UR3E,
RQ1UR2E,
RQ1UR1E,
RQ1UR0E</td><td>Specify the endpoint n (EPn) to be transferred by DMA channel 1.
(n = 1 to 4)
<table>
<tr><th>RQ1UR3E</th><th>RQ1UR2E</th><th>RQ1UR1E</th><th>RQ1UR0E</th><th>EP transferred by DMA2</th></tr>
<tr><td>1</td><td>0</td><td>0</td><td>0</td><td>EP4</td></tr>
<tr><td>0</td><td>1</td><td>0</td><td>0</td><td>EP3</td></tr>
<tr><td>0</td><td>0</td><td>1</td><td>0</td><td>EP2</td></tr>
<tr><td>0</td><td>0</td><td>0</td><td>1</td><td>EP1</td></tr>
<tr><td colspan="4">Other than above</td><td>DMA1 does not transfer EPn
(DMA1 not used)</td></tr>
</table></td></tr>
<tr><td>12, 8, 4, 0</td><td>RQ0UR3E,
RQ0UR2E,
RQ0UR1E,
RQ0UR0E</td><td>Specify the endpoint n (EPn) to be transferred by DMA channel 0.
(n = 1 to 4)
<table>
<tr><th>RQ0UR3E</th><th>RQ0UR2E</th><th>RQ0UR1E</th><th>RQ0UR0E</th><th>EP transferred by DMA0</th></tr>
<tr><td>1</td><td>0</td><td>0</td><td>0</td><td>EP4</td></tr>
<tr><td>0</td><td>1</td><td>0</td><td>0</td><td>EP3</td></tr>
<tr><td>0</td><td>0</td><td>1</td><td>0</td><td>EP2</td></tr>
<tr><td>0</td><td>0</td><td>0</td><td>1</td><td>EP1</td></tr>
<tr><td colspan="4">Other than above</td><td>DMA0 does not transfer EPn
(DMA0 not used)</td></tr>
</table></td></tr>
</table>

Cautions 1. Setting the same DMA transfer target to multiple DMA channels, and setting multiple DMA transfer targets to the same DMA channel are prohibited.

2. If using the function of this register, set the DMA trigger factor register (DTFRn (n = 0 to 3)) to disable DMA requests by interrupt (00H).

The following flowcharts illustrate the program execution when the host is disconnected and then reconnected, and the program execution when power is supplied.

Figure 21-12. Flowchart of Program When Host Is Disconnected and Then Reconnected

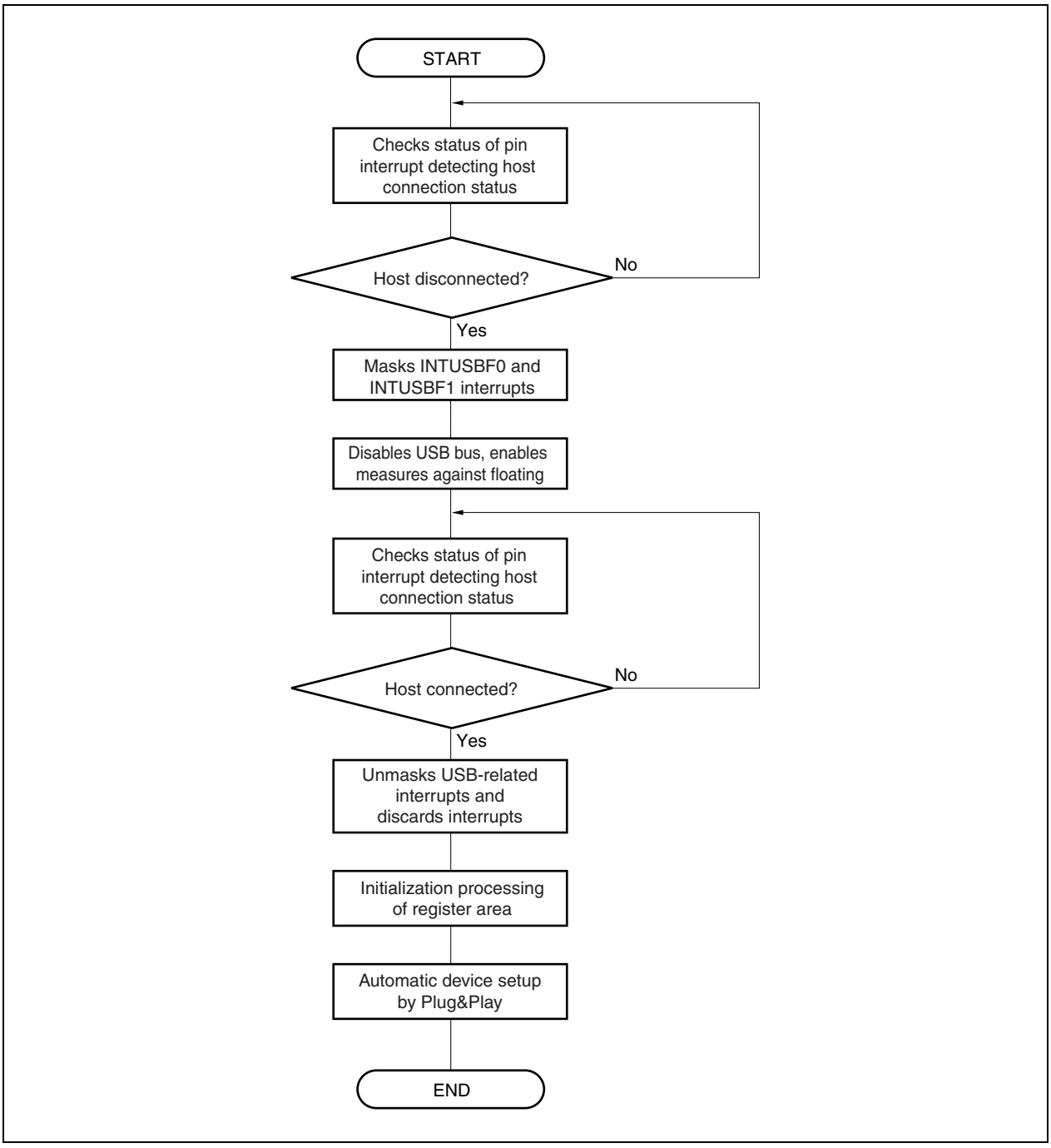
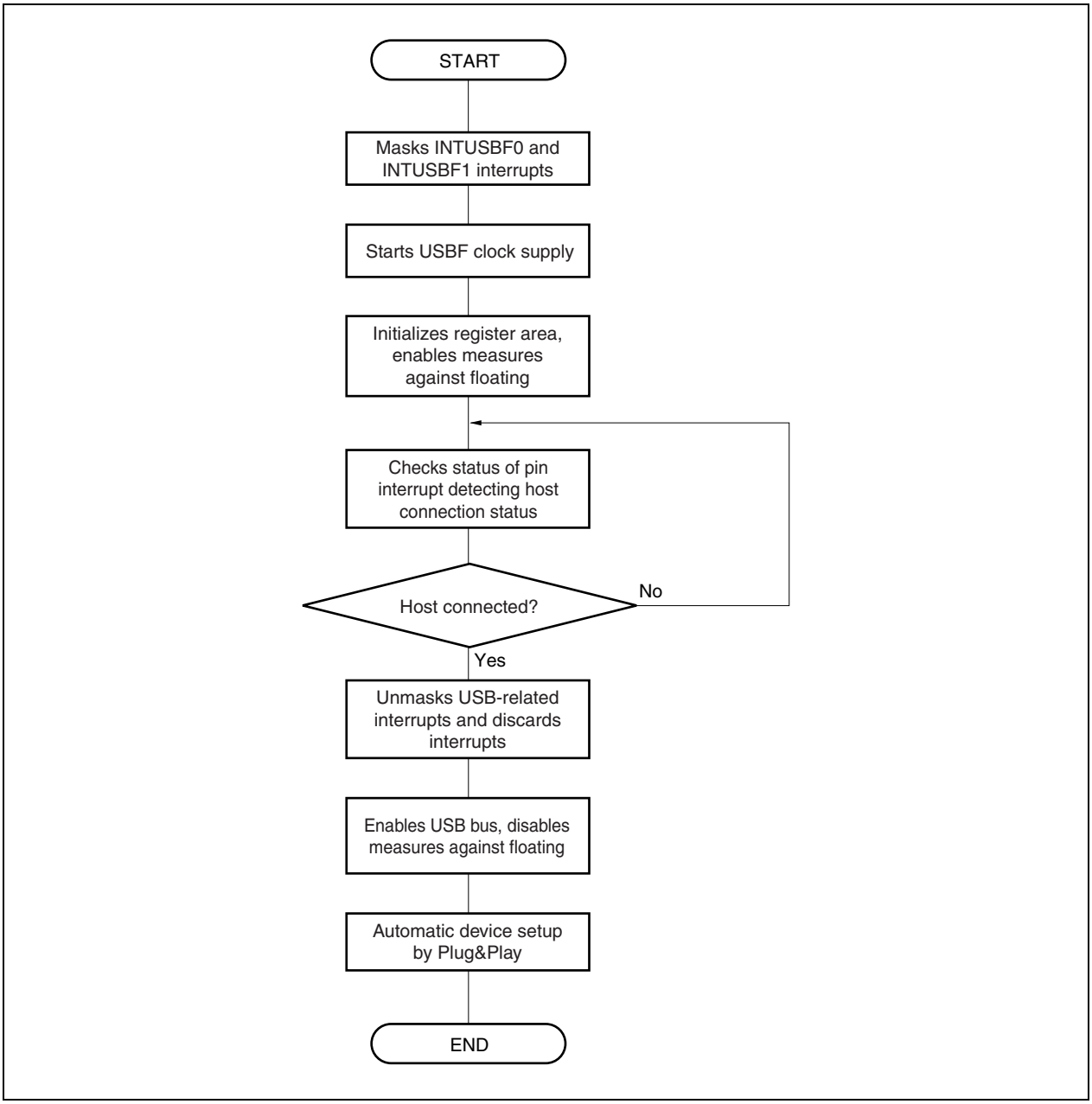


Figure 21-13. Flowchart of Program When Power Is Supplied



21.7 STALL Handshake or No Handshake

Errors of USBF are defined to be handled as follows.

Transfer Type	Transaction	Target Packet	Error Type	Function Response	Processing
Control transfer/ bulk transfer/ interrupt transfer	IN/OUT/SETUP	Token	Endpoint not supported	No response	None
			Endpoint transfer direction mismatch	No response	None
			CRC error	No response	None
			Bit stuffing error	No response	None
Control transfer/ bulk transfer	OUT/SETUP	Data	Timeout	No response	None
			PID check error	No response	None
			Unsupported PID (other than Data PID)	No response	None
			CRC error	No response	Discard received data
			Bit stuffing error	No response	Discard received data
	OUT	Data	Data PID mismatch	ACK	Discard received data
Control transfer (SETUP stage)	SETUP	Data	Overrun	No response	Discard received data
Control transfer (data stage)	OUT	Data	Overrun	No response[Note 1]	Set SNDSTL bit of UF0SDS register to 1 and discard received data
Control transfer (status stage)	OUT	Data	Overrun	ACK or no response[Note 2]	Set SNDSTL bit of UF0SDS register to 1 and discard received data
Bulk transfer	OUT	Data	Overrun	No response[Note 1]	Set EnHALT bit of UF0EnSL register (n = 0 to 4, 7) to 1
Control transfer/ bulk transfer/ interrupt transfer	IN	Handshake	PID check error	–	Hold transferred data and re-transfer data[Note 3]
			Unsupported PID (other than ACK PID)	–	Hold transferred data and re-transfer data[Note 3]
			Timeout	–	Hold transferred data and re-transfer data[Note 3]

Notes 1. A STALL response is made to re-transfer by the host.

2. An ACK response is made if the transfer data is of less than MaxPacketSize and the data received in the status stage is discarded. If MaxPacketSize is exceeded, no response is made, the SNDSTL bit of the UF0SDS register is set to 1, and the received data is discarded.

3. If an OUT transaction indicating a change from the data stage to the status stage is received during control transfer, an error is not handled and it is assumed that reception has been correctly completed.

Cautions 1. It is judged by the Alternative Setting number currently set whether the target Endpoint is valid or invalid.

2. For the response to the request included in control transfer to/from Endpoint0, see 21.5 Requests.

21.8 Register Values in Specific Status

Table 21-8. Register Values in Specific Status (1/2)

Register Name	After CPU Reset ($\overline{\text{RESET}}$)	After Bus Reset
UF0E0N register	00H	Value is held.
UF0E0NA register	00H	Value is held.
UF0EN register	00H	Value is held.
UF0ENM register	00H	Value is held.
UF0SDS register	00H	Value is held.
UF0CLR register	00H	Value is held.
UF0SET register	00H	Value is held.
UF0EPS0 register	00H	Value is held.
UF0EPS1 register	00H	Value is held.
UF0EPS2 register	00H	Value is held.
UF0IS0 register	00H	Value is held.
UF0IS1 register	00H	Value is held.
UF0IS2 register	00H	Value is held.
UF0IS3 register	00H	Value is held.
UF0IS4 register	00H	Value is held.
UF0IM0 register	00H	Value is held.
UF0IM1 register	00H	Value is held.
UF0IM2 register	00H	Value is held.
UF0IM3 register	00H	Value is held.
UF0IM4 register	00H	Value is held.
UF0IC0 register	FFH	Value is held.
UF0IC1 register	FFH	Value is held.
UF0IC2 register	FFH	Value is held.
UF0IC3 register	FFH	Value is held.
UF0IC4 register	FFH	Value is held.
UF0IDR register	00H	Value is held.
UF0DMS0 register	00H	Value is held.
UF0DMS1 register	00H	Value is held.
UF0FIC0 register	00H	Value is held.
UF0FIC1 register	00H	Value is held.
UF0DEND register	00H	Value is held.
UF0GPR register	00H	Value is held.
UF0MODC register	00H	Value is held.
UF0MODS register	00H	Bit 2 (CONF): Cleared (0), Other bits: Value is held.
UF0AIFN register	00H	Value is held.
UF0AAS register	00H	Value is held.
UF0ASS register	00H	00H
UF0E1IM register	00H	Value is held.
UF0E2IM register	00H	Value is held.

Table 21-8. Register Values in Specific Status (2/2)

Register Name	After CPU Reset ($\overline{\text{RESET}}$)	After Bus Reset
UF0E3IM register	00H	Value is held.
UF0E4IM register	00H	Value is held.
UF0E7IM register	00H	Value is held.
UF0E0R register	Undefined[Note 1]	Value is held.
UF0E0L register	00H	Value is held.
UF0E0ST register	00H	00H
UF0E0W register	Undefined[Note 1]	Value is held.
UF0BO1 register	Undefined[Note 1]	Value is held.
UF0BO1L register	00H	Value is held.
UF0BO2 register	Undefined[Note 1]	Value is held.
UF0BO2L register	00H	Value is held.
UF0BI1 register	Undefined[Note 1]	Value is held.
UF0BI2 register	Undefined[Note 1]	Value is held.
UF0INT1 register	Undefined	Value is held.
UF0DSTL register	00H	00H
UF0E0SL register	00H	00H
UF0E1SL register	00H	00H
UF0E2SL register	00H	00H
UF0E3SL register	00H	00H
UF0E4SL register	00H	00H
UF0E7SL register	00H	00H
UF0ADRS register	00H	00H
UF0CNF register	00H	00H
UF0IF0 register	00H	00H
UF0IF1 register	00H	00H
UF0IF2 register	00H	00H
UF0IF3 register	00H	00H
UF0IF4 register	00H	00H
UF0DSCL register	00H	Value is held.
UF0DDn register (n = 0 to 17)	**Note 2**	**Note 2**
UF0CIEn register (n = 0 to 255)	**Note 2**	**Note 2**

Notes 1. This register can be cleared to 0 by the $\overline{\text{RESET}}$ signal because its write pointer, counter, and read pointer are cleared to 0 when the $\overline{\text{RESET}}$ signal becomes active, in the same manner as clearing by the UF0FICn register, as the register is controlled by FIFO.

2. This register cannot be cleared to 0. Because data can be written to it by FW, however, any value can be written to the register (before doing so, however, be sure to set the EP0NKA bit of the UF0E0NA register to 1).

21.9 FW Processing

The following FW processing is performed.

- Setting processing on device side for the SET_CONFIGURATION, SET_INTERFACE, SET_FEATURE, and CLEAR_FEATURE requests during enumeration processing
- Analysis and processing of XXXXStandard, XXXXClass, and XXXXVendor requests not subject to automatic processing
- Reading data following bulk-transferred OUT token from receive buffer
- Writing data to be returned in response to bulk-transferred IN token
- Writing data to be returned in response to interrupt-transferred token

The following table lists the requests supported by FW.

Table 21-9. FW-Supported Standard Requests

Request	Reception Side	Processing/ Frequency	Explanation
CLEAR_FEATURE	Interface	Automatic STALL response	It is considered that this request does not come to Interface because there is no function selector value, though it is reserved for bmRequestType. When this request is received, the hardware makes an automatic STALL response.
SET_FEATURE	Interface	Automatic STALL response	It is considered that this request does not come to Interface because there is no function selector value, though it is reserved for bmRequestType. When this request is received, the hardware makes an automatic STALL response.
GET_DESCRIPTOR	String	FW	Returns the string descriptor. When this request is received by the SETUP token, the hardware generates the CPUDEC interrupt request for FW. FW decodes the contents of the request from the CPUDEC interrupt request, and writes the data to be returned to the host, to the UF0E0W register.
SET_DESCRIPTOR	Device	FW	Rewrites the device descriptor. When this request is received by the SETUP token, the hardware generates the CPUDEC interrupt request for FW. FW decodes the contents of the request from the CPUDEC interrupt request, and the writes the data for the next control transfer (OUT) to the UF0DDn register (n = 0 to 17).
SET_DESCRIPTOR	Configuration	FW	Rewrites the configuration descriptor. When this request is received by the SETUP token, the hardware generates the CPUDEC interrupt request for FW. FW decodes the contents of the request from the CPUDEC interrupt request, and the writes the data for the next control transfer (OUT) to the UF0CIEn register (n = 0 to 255).
SET_DESCRIPTOR	String	FW	Rewrites the string descriptor. When this request is received by the SETUP token, the hardware generates the CPUDEC interrupt request for FW. FW decodes the contents of the request from the CPUDEC interrupt request, and loads the data for the next control transfer (OUT).
Other	NA	FW	When this request is received by the SETUP token, the hardware generates the CPUDEC interrupt request for FW. FW decodes the contents of the request from the CPUDEC interrupt request, and performs the necessary processing.

21.9.1 Initialization processing

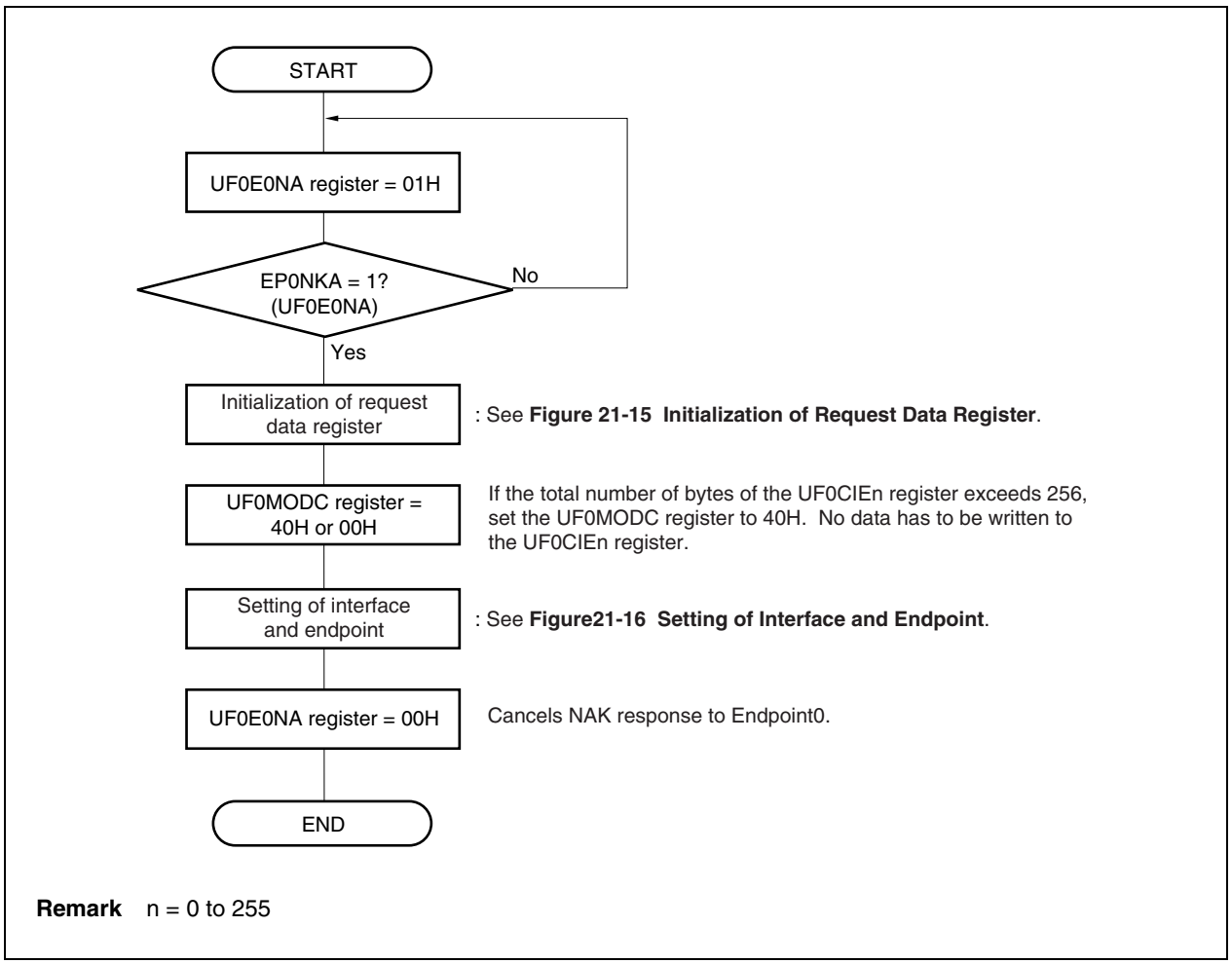
Initialization processing is executed in the following two ways.

- Initialization of request data register
- Setting of interrupt

When a request data register is initialized, data for the GET_XXXX request to which a value is to be automatically returned is written and an endpoint is allocated to an interface. In the interrupt settings, the interrupt sources that do not have to be checked can be masked by using the UF0IMn register (n = 0 to 4).

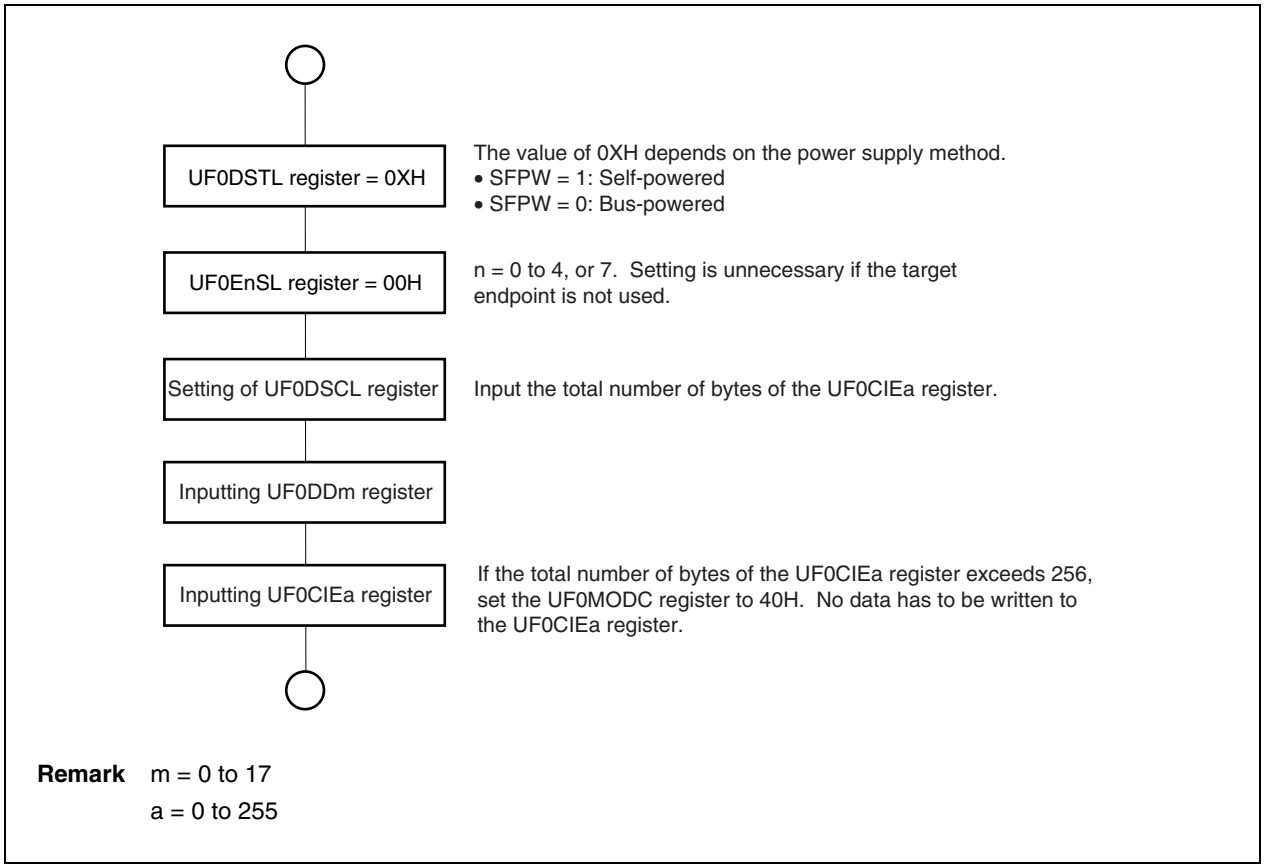
The following flowcharts illustrate the above processing.

Figure 21-14. Initializing Request Data Register



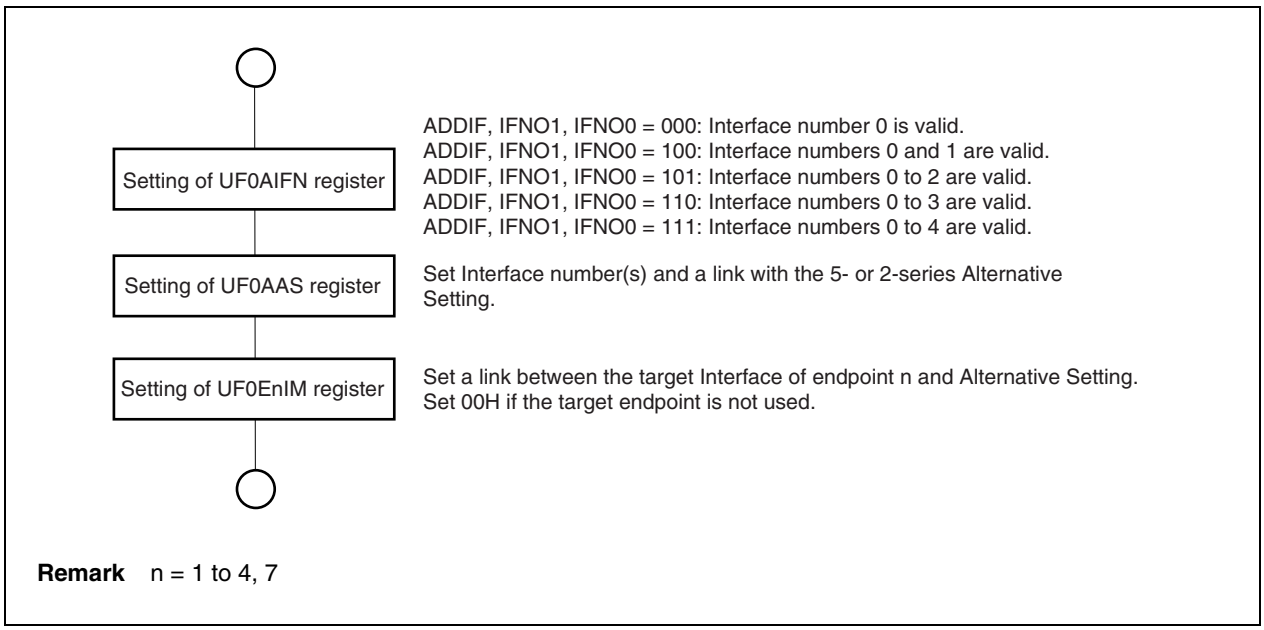
Remark n = 0 to 255

Figure 21-15. Initialization Settings of Request Data Register



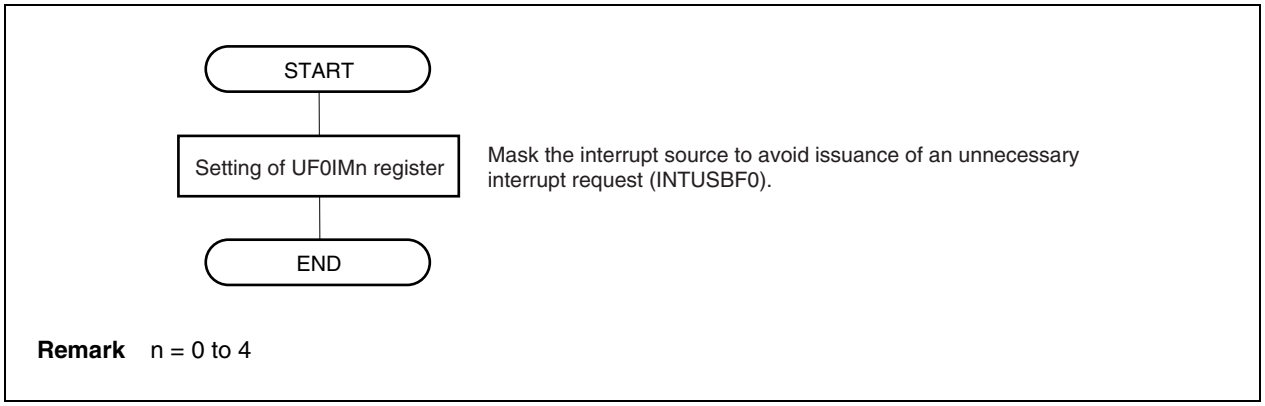
Remark m = 0 to 17
a = 0 to 255

Figure 21-16. Setting of Interface and Endpoint



Remark n = 1 to 4, 7

Figure 21-17. Setting of Interrupt

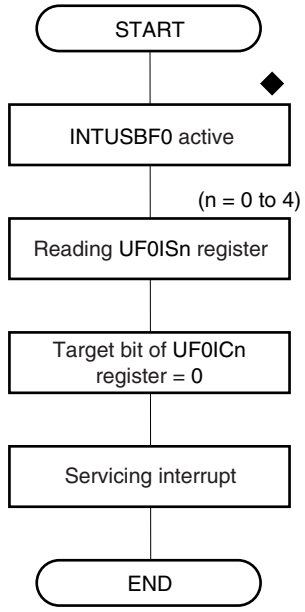


Remark n = 0 to 4

21.9.2 Interrupt servicing

The following flowchart illustrates how an interrupt is serviced.

Figure 21-18. Interrupt Servicing



Remark ♦: Processing by hardware

The following bits of the UF0ISn register are automatically cleared by hardware when a given condition is satisfied (n = 0 to 4).

- E0INDT, E0ODT, SUCES, STG, and CPUDEC bits of UF0IS1 register
- BKI2DT, BKI1DT, and IT1DT bits of UF0IS2 register
- BKO2FL, BKO2DT, BKO1FL, and BKO1DT bits of UF0IS3 register

Because clearing an interrupt source by the UF0ICn register is given a lower priority than setting an interrupt source by hardware, the interrupt source may not be cleared depending on the timing (n = 0 to 4).

21.9.3 USB main processing

USB main processing involves processing USB transactions. The types of transactions to be processed are as follows.

- Fully automatically processed request for control transfer
- Automatically processed requests for control transfer
  (SET_CONFIGURATION, SET_INTERFACE, SET_FEATURE, CLEAR_FEATURE)
- CPUDEC request for control transfer
- Processing for bulk transfer (IN)
- Processing for bulk transfer (OUT)
- Processing for interrupt transfer (IN)

Processing for endpoint n involves writing or reading for data transfer. The flowchart shown below is for PIO.

(1) Fully automatically processed request for control transfer

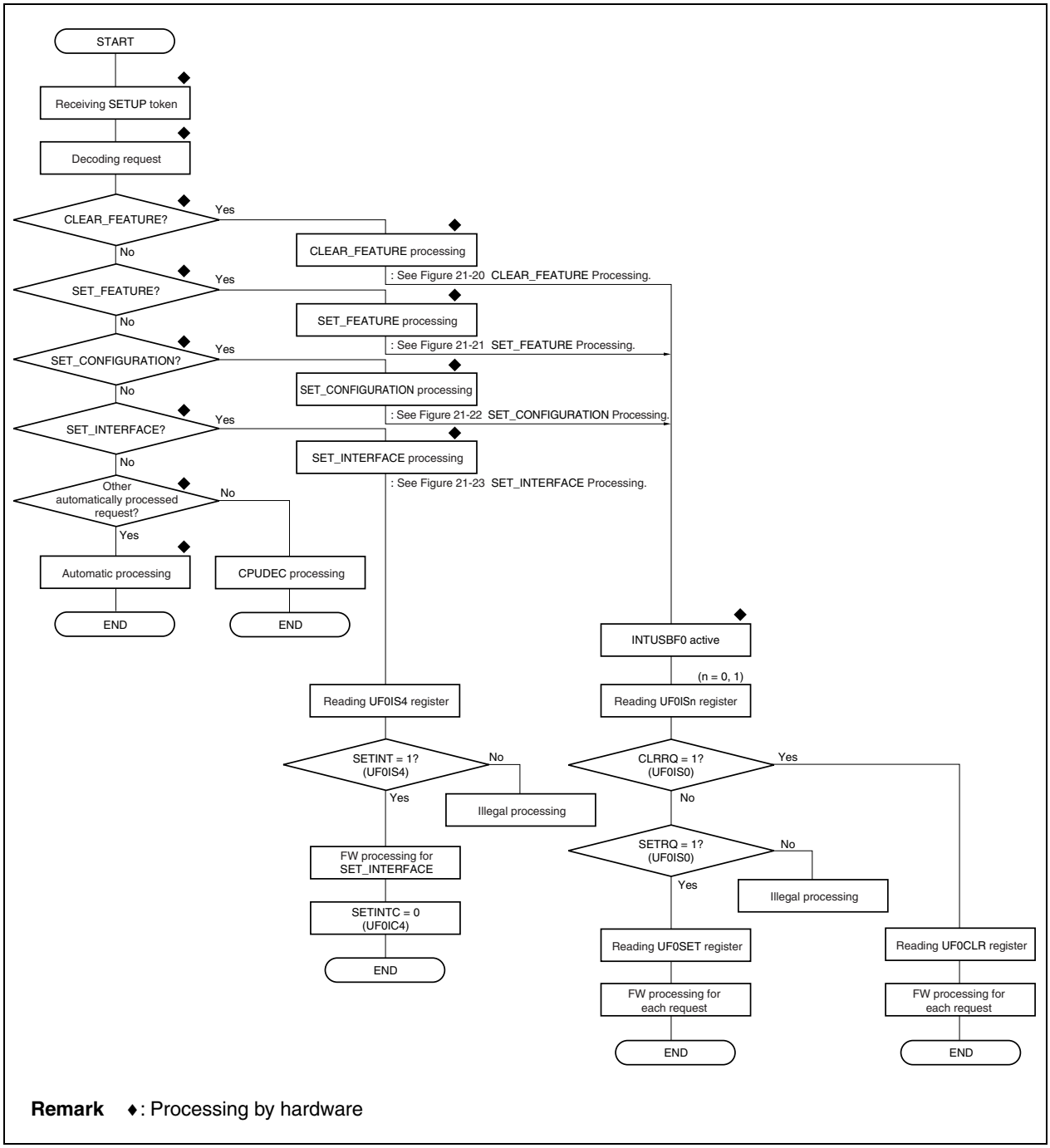
Because the fully automatically processed request for control transfer is executed by hardware, it cannot be referenced by FW. Therefore, FW does not have to perform any special processing for this request.

(2) Automatically processed requests for control transfer
(SET_CONFIGURATION, SET_INTERFACE, SET_FEATURE, CLEAR_FEATURE)

Processing to write a register for automatically processed requests for control transfer, such as SET_CONFIGURATION, SET_INTERFACE, SET_FEATURE, and CLEAR_FEATURE requests, is automatically executed by hardware, but an interrupt request is issued for recognition on the device side. This processing may be ignored if there is no special processing to be executed.

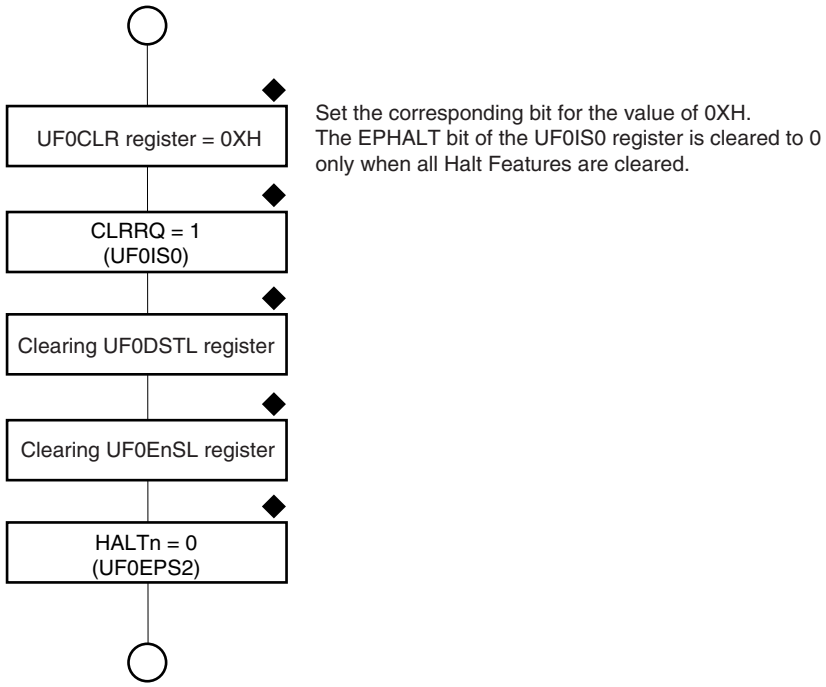
The flowcharts are shown below.

Figure 21-19. Automatically Processed Requests for Control Transfer



Remark ♦: Processing by hardware

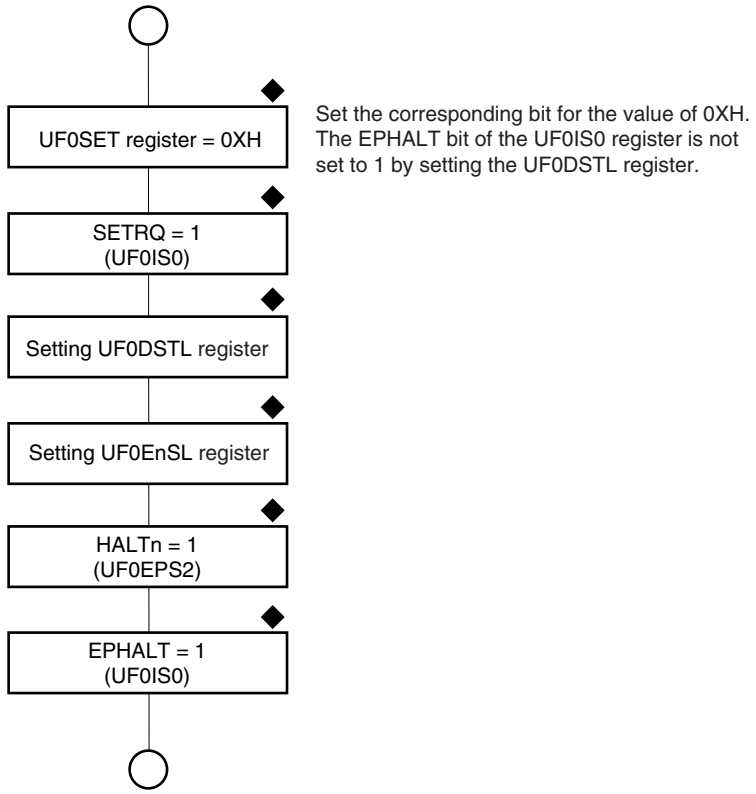
Figure 21-20. CLEAR_FEATURE Processing



Remarks 1. n = 0 to 4, 7

2. ♦: Processing by hardware

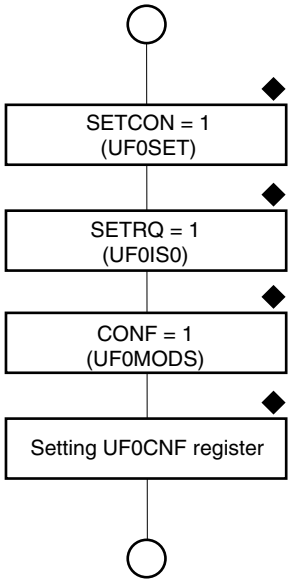
Figure 21-21. SET_FEATURE Processing



Remarks 1. n = 0 to 4, 7

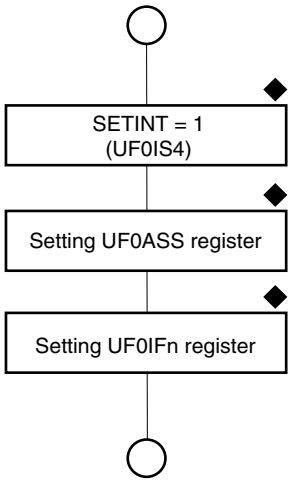
2. ♦: Processing by hardware

Figure 21-22. SET_CONFIGURATION Processing



Remark ♦: Processing by hardware

Figure 21-23. SET_INTERFACE Processing



Remarks 1. n = 0 to 4

2. ♦: Processing by hardware

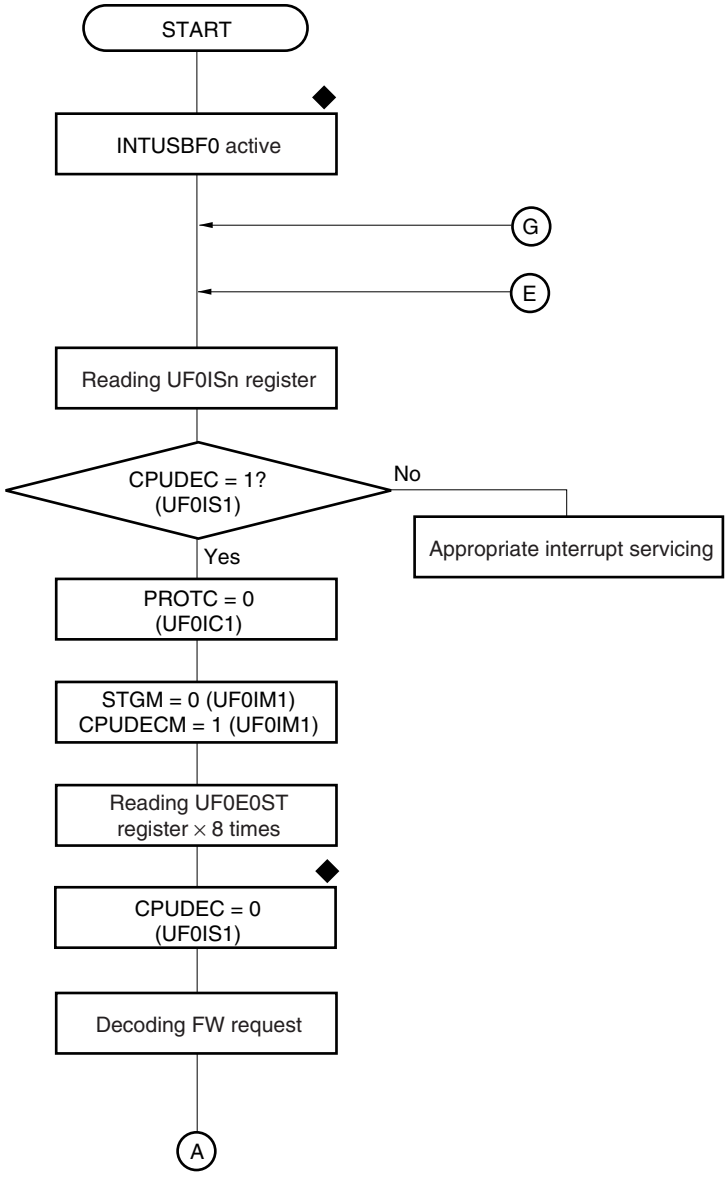
(3) CPUDEC request for control transfer

The CPUDEC request can be classified into three types of processing: control transfer (write), control transfer (read), and control transfer (without data). Control transfer (write) indicates a request that uses the OUT transaction in the data stage (e.g., SET_DESCRIPTOR), and control transfer (read) indicates a request that uses the IN transaction in the data stage (e.g., GET_DESCRIPTOR). Control transfer (without data) indicates a request that has no data stage (e.g., SET_CONFIGURATION).

The flowcharts are shown below.

Figure 21-24. CPUDEC Request for Control Transfer (1/12)

(a) Token phase (1/2)

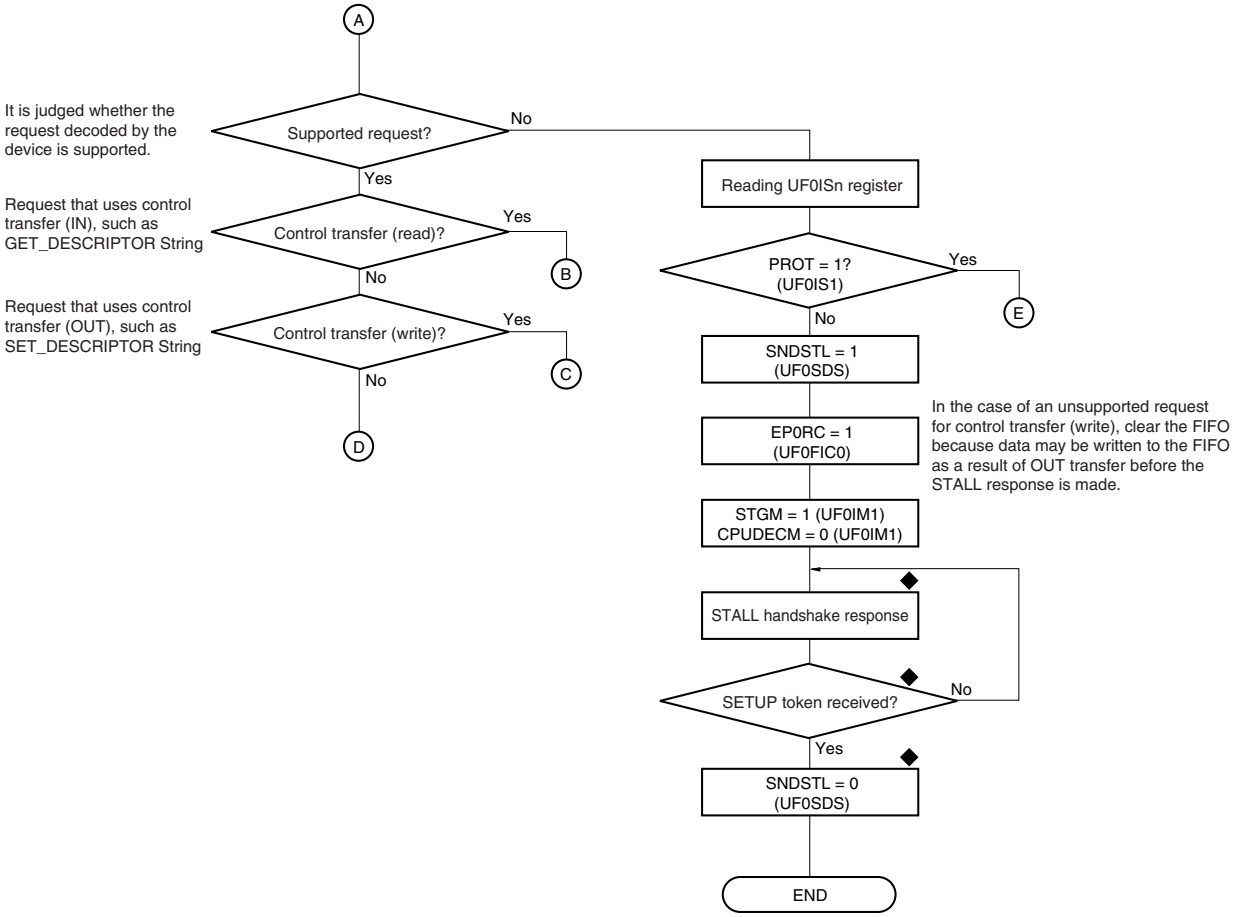


Remarks 1. n = 0, 1

2. ♦: Processing by hardware

Figure 21-24. CPUDEC Request for Control Transfer (2/12)

(a) Token phase (2/2)

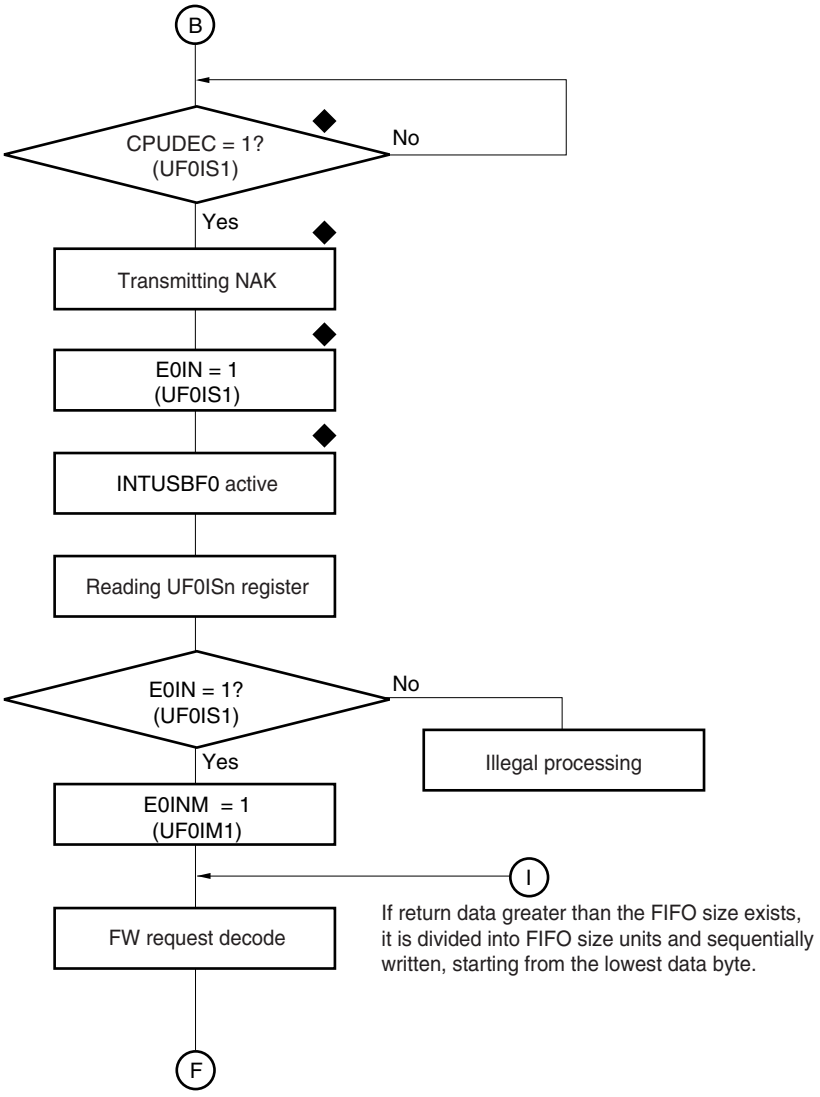


Remarks 1. n = 0, 1

2. ♦: Processing by hardware

Figure 21-24. CPUDEC Request for Control Transfer (3/12)

(b) Control transfer (read) (1/4)

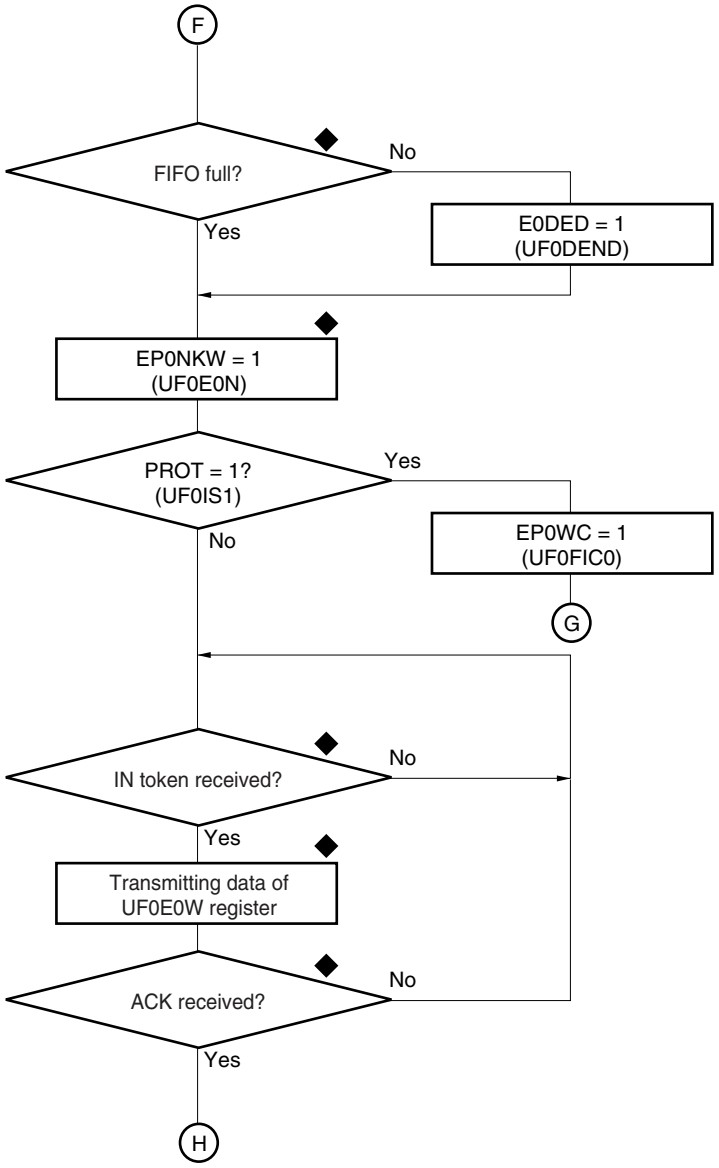


Remarks 1. n = 0, 1

2. ♦: Processing by hardware

Figure 21-24 CPUDEC Request for Control Transfer (4/12)

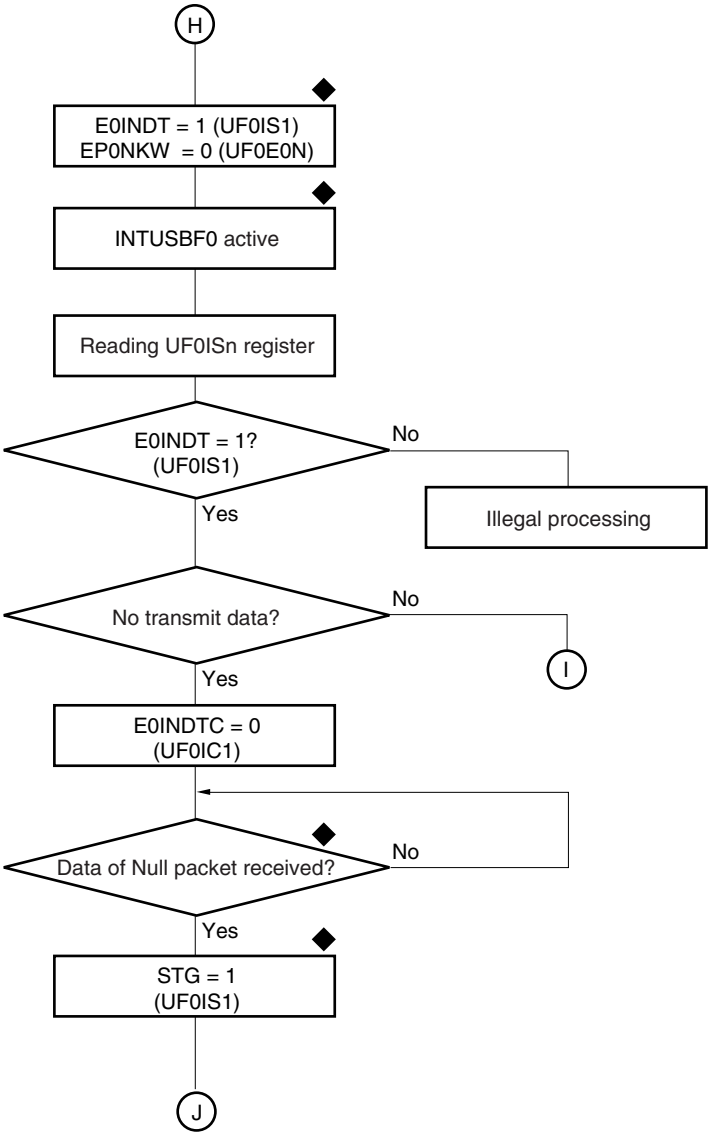
(b) Control transfer (read) (2/4)



Remark ♦: Processing by hardware

Figure 21-24. CPUDEC Request for Control Transfer (5/12)

(b) Control transfer (read) (3/4)

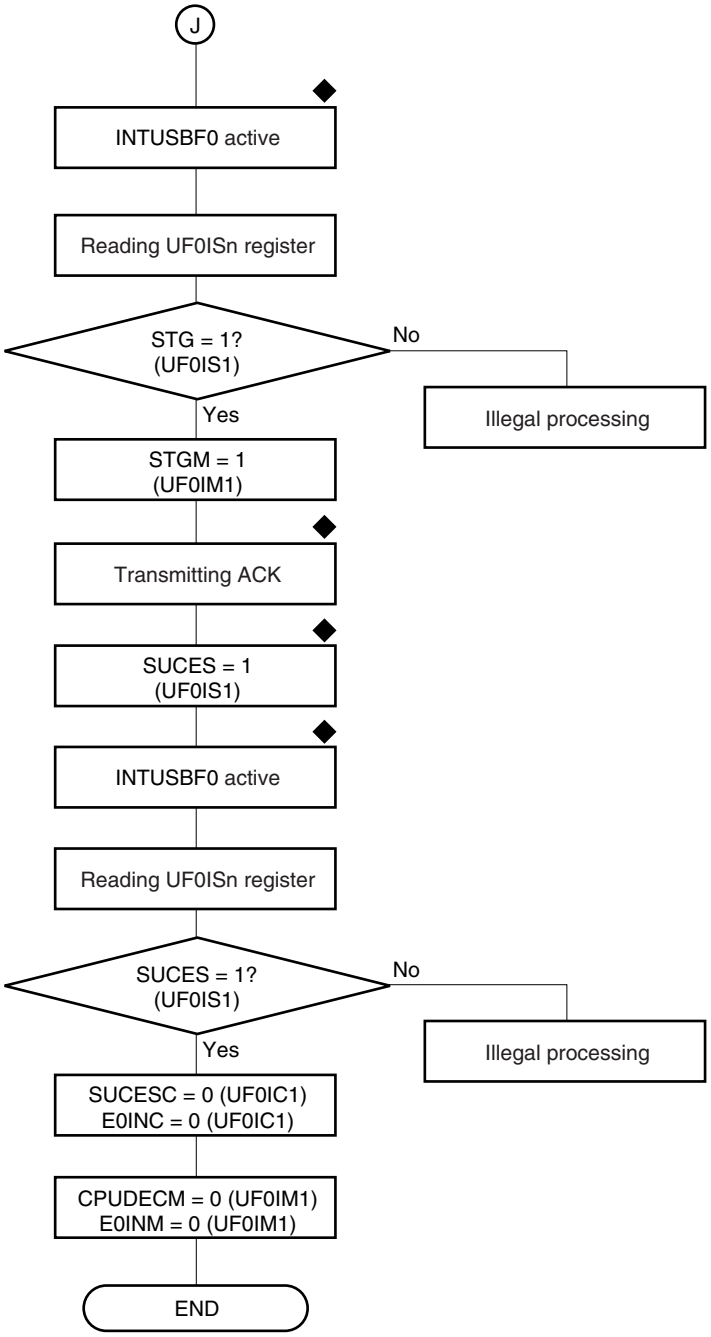


Remarks 1. n = 0, 1

2. ♦: Processing by hardware

Figure 21-24. CPUDEC Request for Control Transfer (6/12)

(b) Control transfer (read) (4/4)

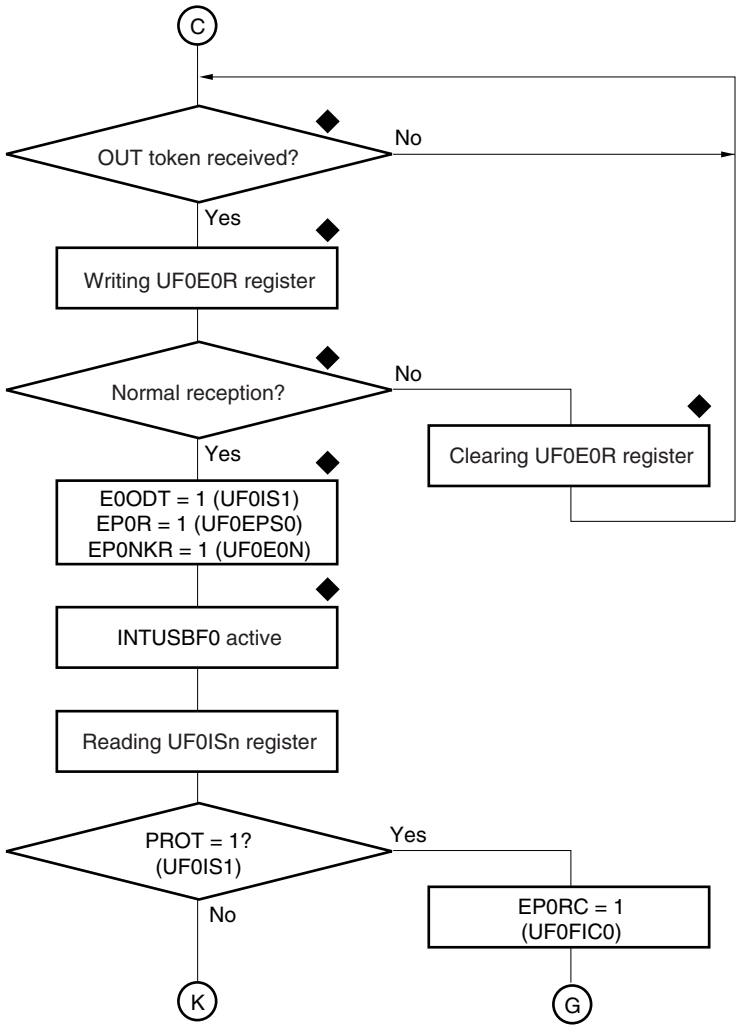


Remarks 1. n = 0, 1

2. ♦: Processing by hardware

Figure 21-24. CPUDEC Request for Control Transfer (7/12)

(c) Control transfer (write) (1/4)

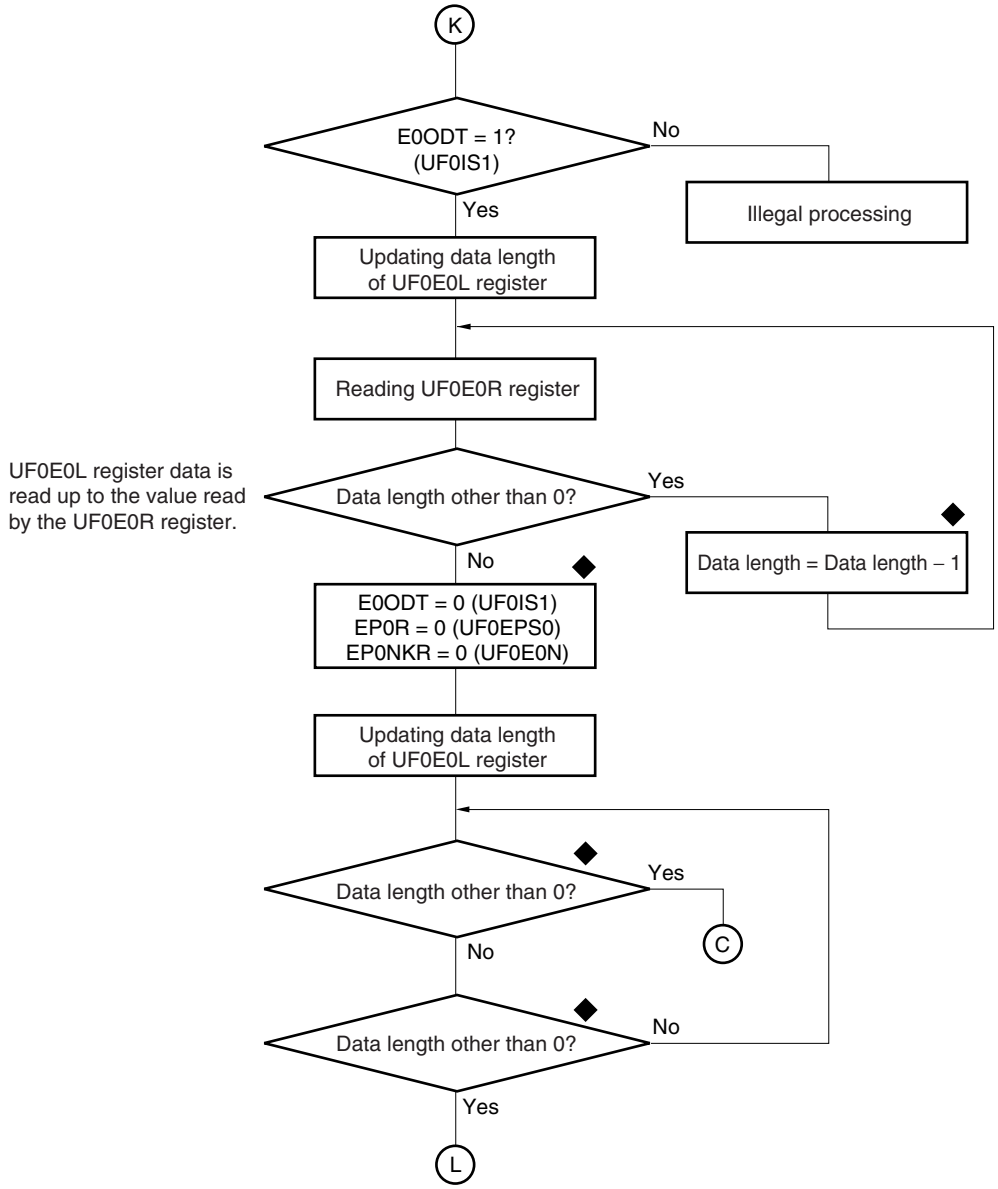


Remarks 1. n = 0, 1

2. ♦: Processing by hardware

Figure 21-24. CPUDEC Request for Control Transfer (8/12)

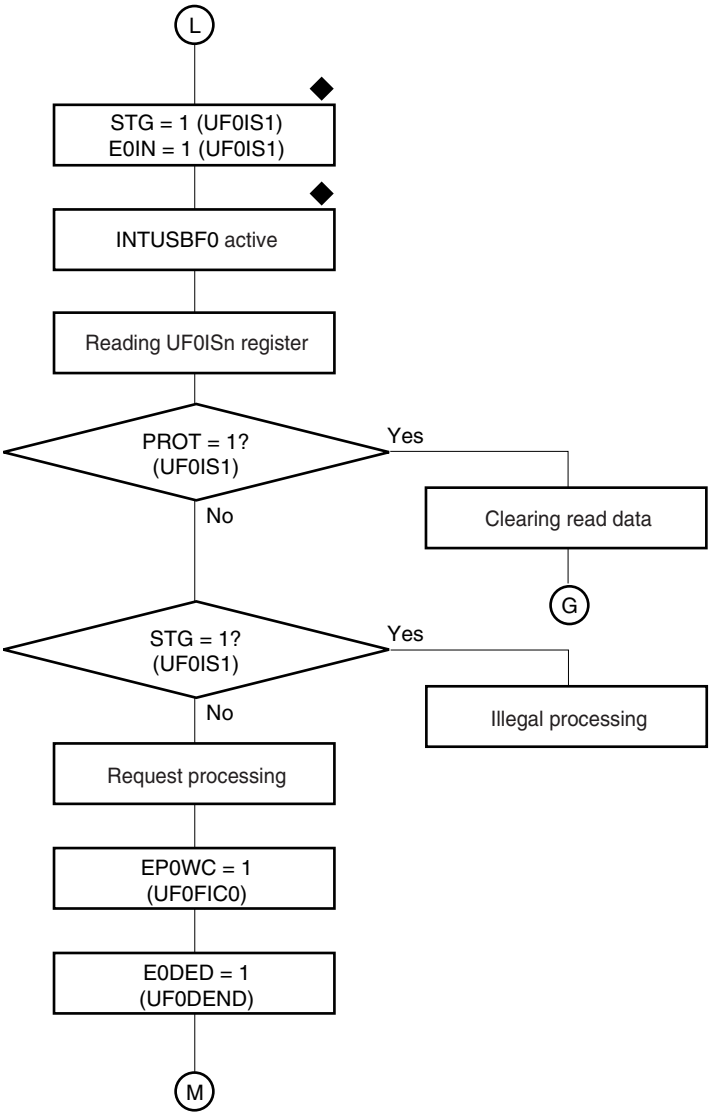
(c) Control transfer (write) (2/4)



Remark ♦: Processing by hardware

Figure 21-24. CPUDEC Request for Control Transfer (9/12)

(c) Control transfer (write) (3/4)

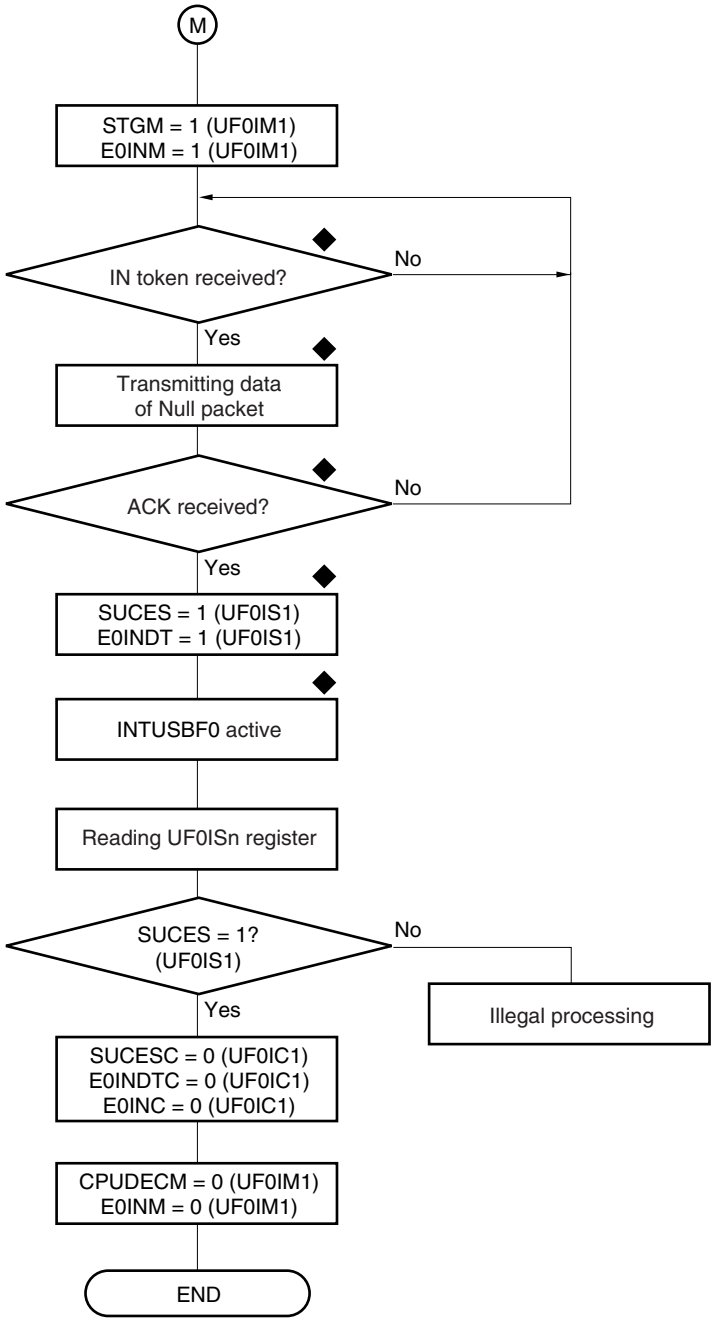


Remarks 1. n = 0, 1

2. ♦: Processing by hardware

Figure 21-24. CPUDEC Request for Control Transfer (10/12)

(c) Control transfer (write) (4/4)

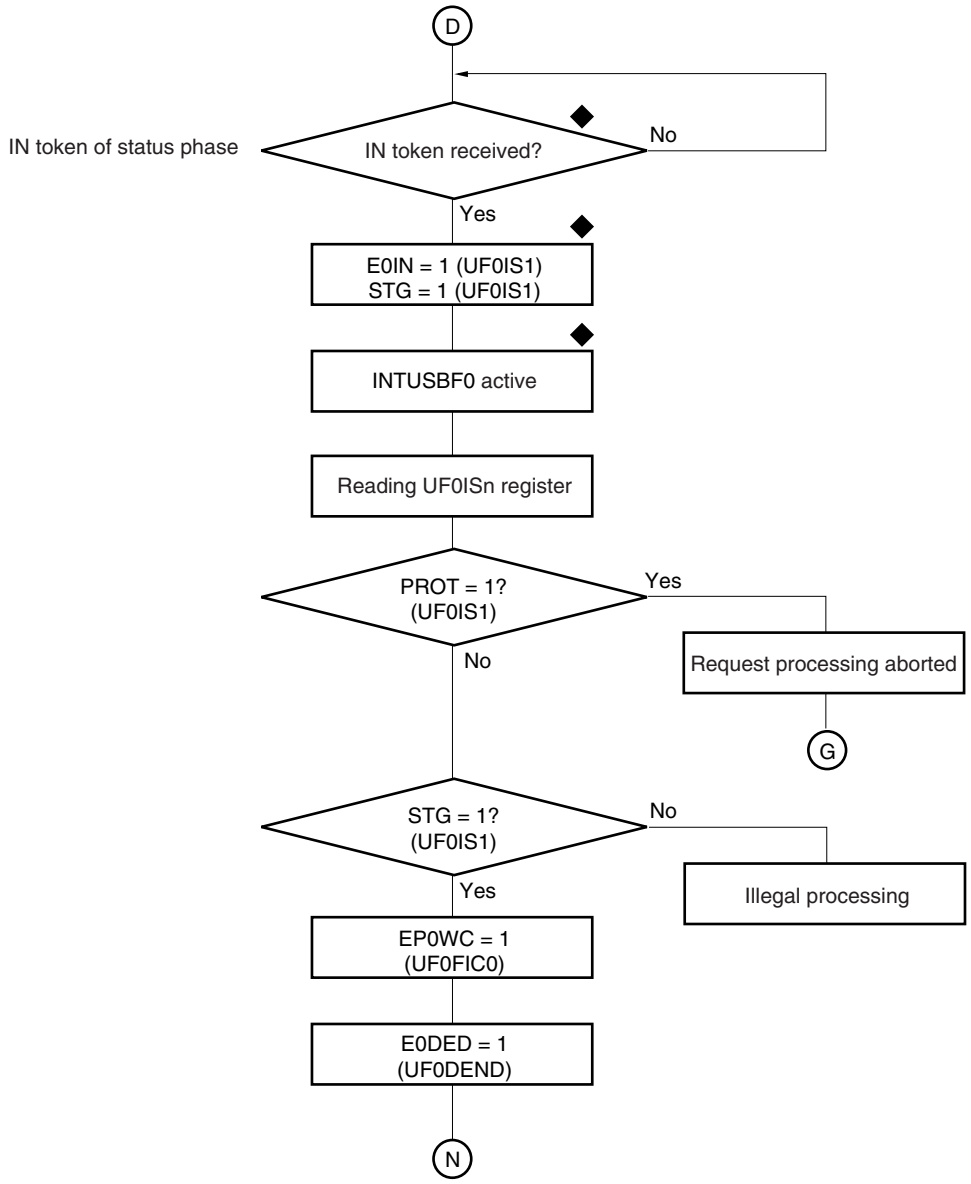


Remarks 1. n = 0, 1

2. ♦: Processing by hardware

Figure 21-24. CPUDEC Request for Control Transfer (11/12)

(d) Control transfer (without data stage) (1/2)

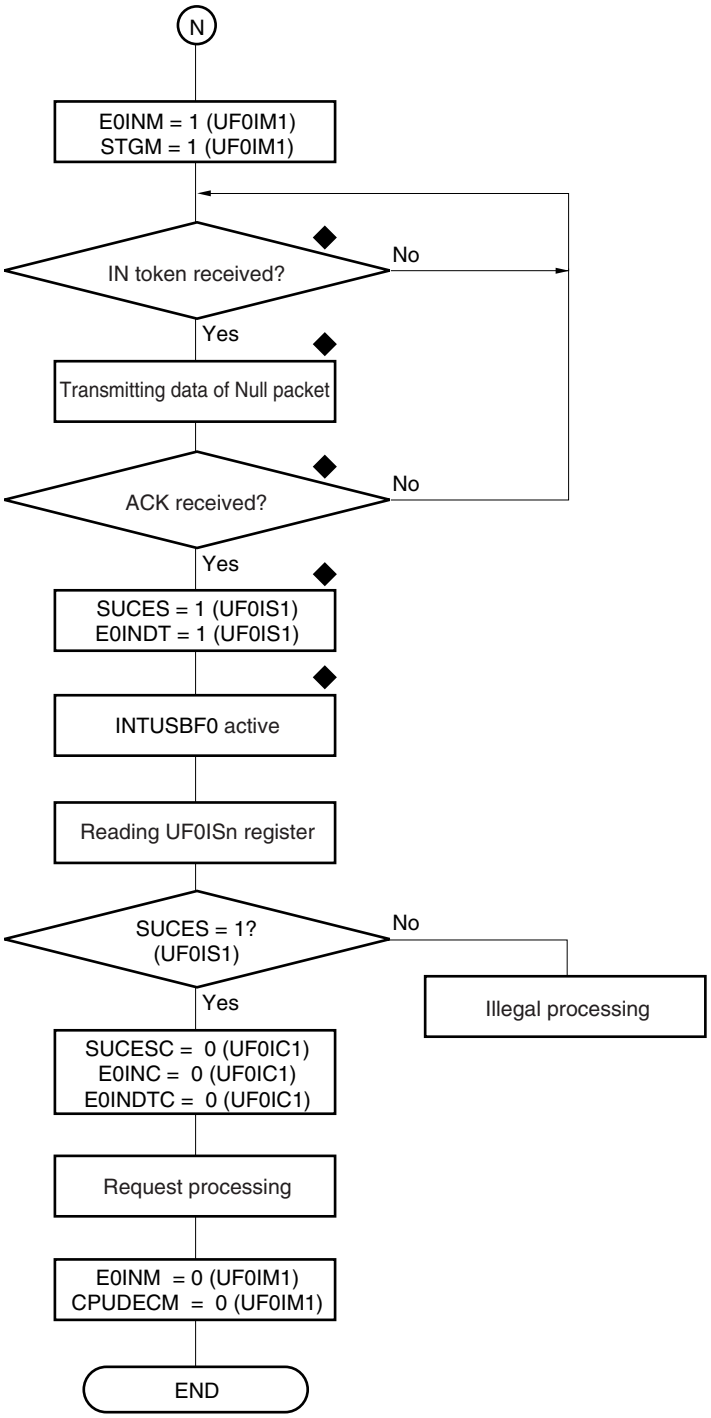


Remarks 1. n = 0, 1

2. ♦: Processing by hardware

Figure 21-24. CPUDEC Request for Control Transfer (12/12)

(d) Control transfer (without data stage) (2/2)



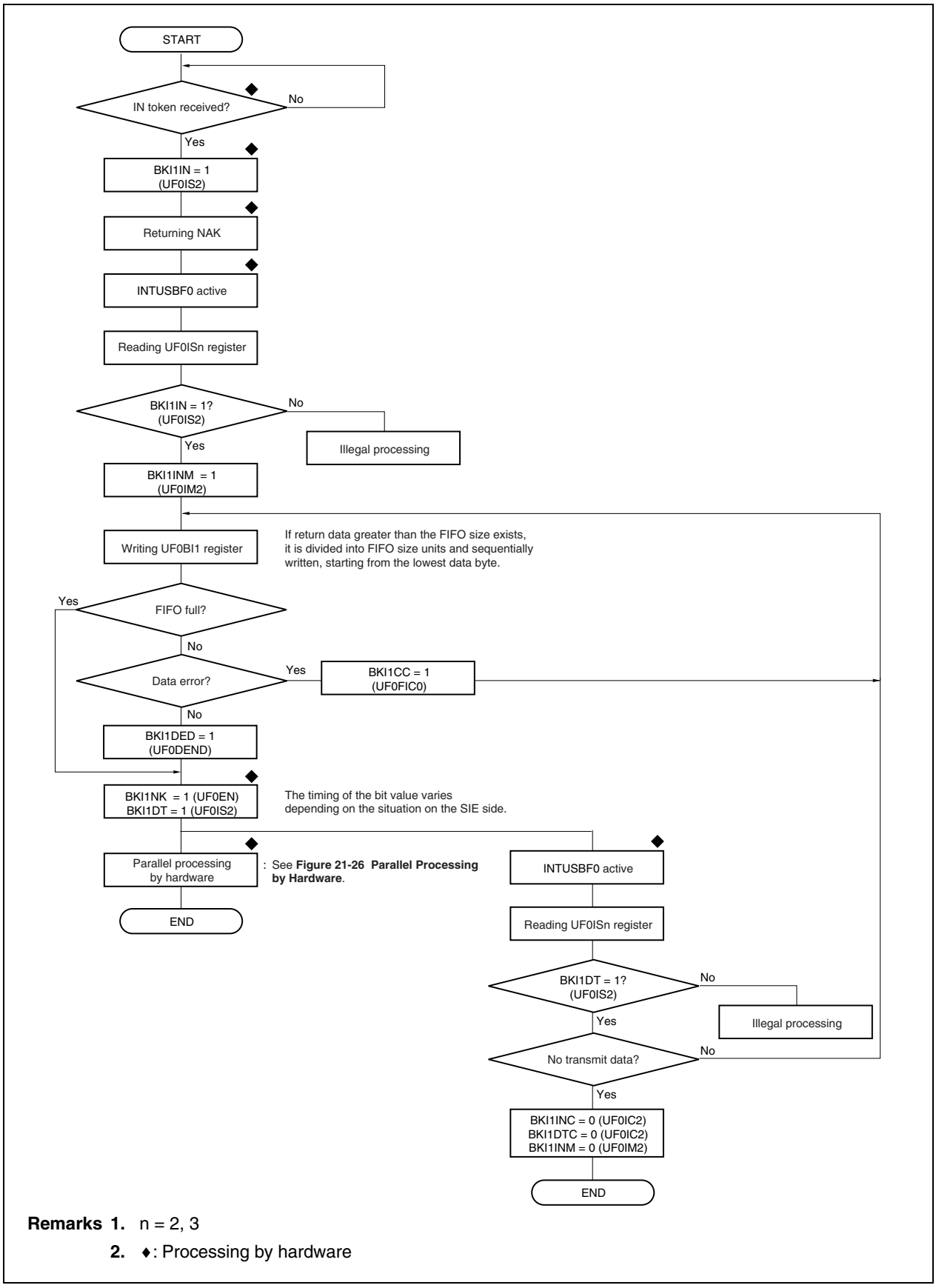
Remarks 1. n = 0, 1

2. ♦: Processing by hardware

(4) Processing for bulk transfer (IN)

Bulk transfer (IN) is allocated to Endpoint1 and Endpoint3. The flowchart shown below illustrates how Endpoint1 is controlled. Endpoint3 can also be controlled in the same sequence. To use this flowchart as the control flow of Endpoint3, therefore, read the bit names of Endpoint1 in the flowchart as those of Endpoint3.

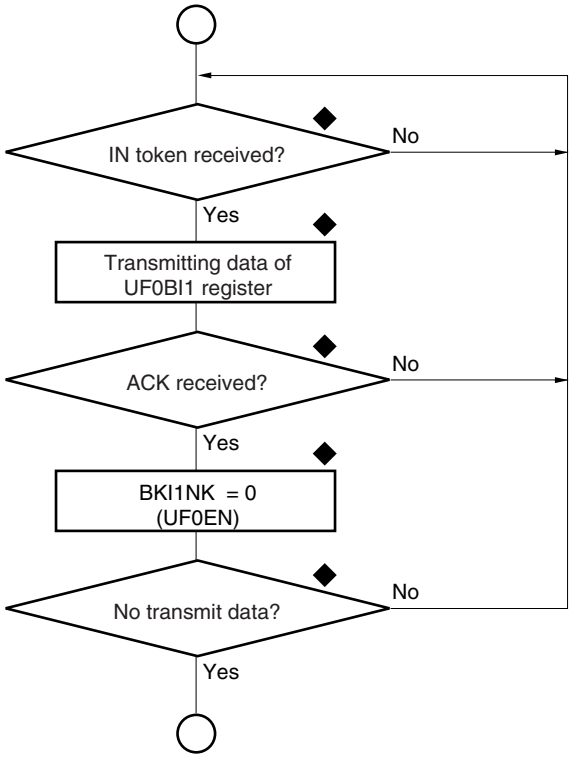
Figure 21-25. Processing for Bulk Transfer (IN) (Endpoint1)



Remarks 1. n = 2, 3

2. ♦: Processing by hardware

Figure 21-26. Parallel Processing by Hardware

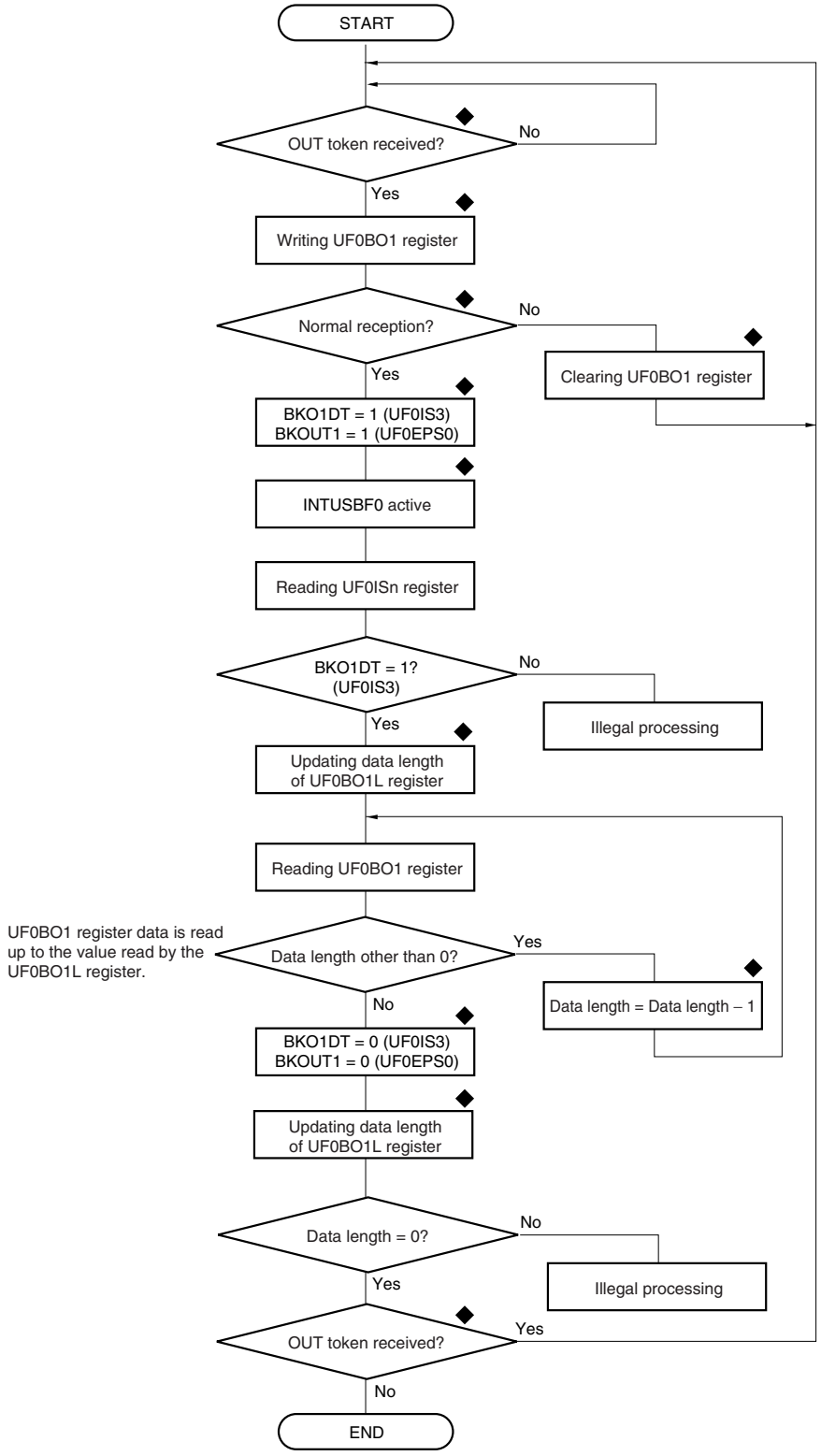


Remark ♦: Processing by hardware

(5) Processing for bulk transfer (OUT)

Bulk transfer (OUT) is allocated to Endpoint2 and Endpoint4. The flowchart shown below illustrates how Endpoint2 is controlled. Endpoint4 can also be controlled in the same sequence. To use this flowchart as the control flow of Endpoint4, therefore, read the bit names of Endpoint2 in the flowchart as those of Endpoint4.

Figure 21-27. Normal Processing for Bulk Transfer (OUT) (Endpoint2)

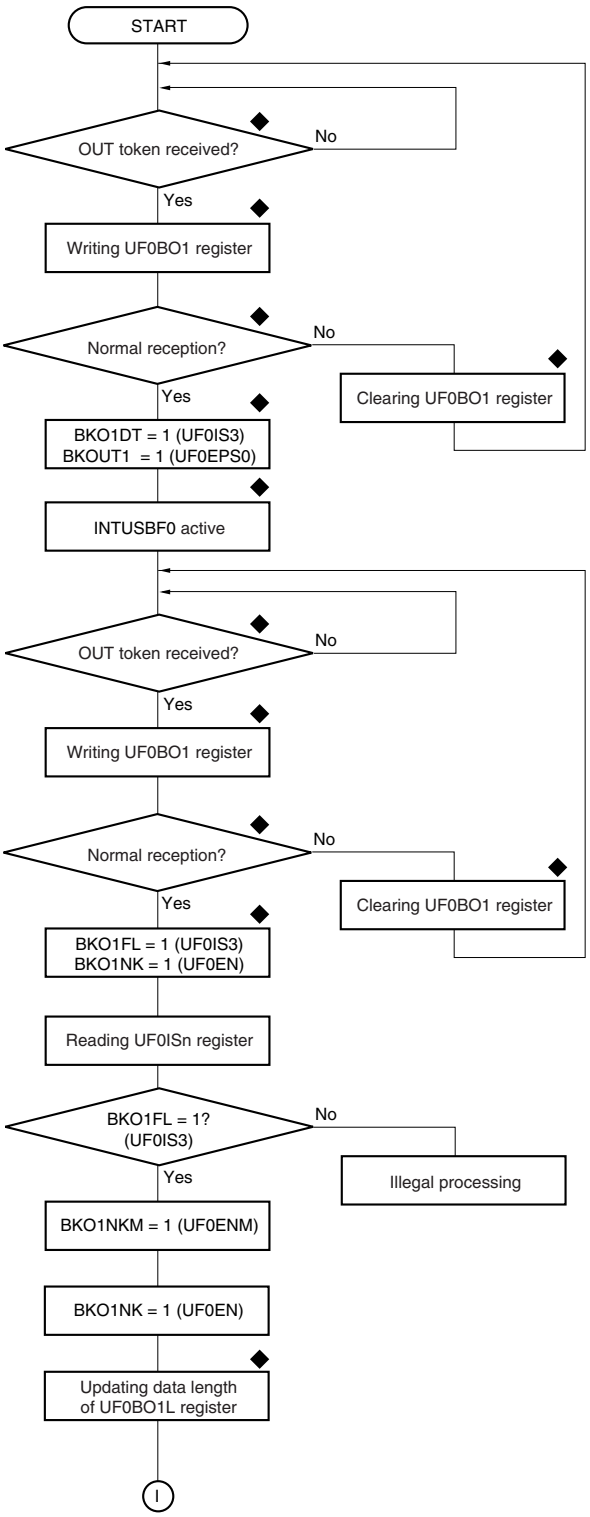


Remarks 1. n = 2, 3

2. ♦: Processing by hardware

During bulk transfer (OUT), more data may be transmitted from the host than expected by the system. Endpoint2 and Endpoint4 for bulk transfer (OUT) of the V850ES/JG3-H and V850ES/JH3-H consist of two 64-byte buffers so that NAK responses are suppressed as much as possible and data can be read from the CPU side even while the bus side is being accessed as the transfer rate of the USB bus increases. Consequently, if the host sends more data than expected by the system, up to 128 bytes of extra data may be automatically received in the worst case. In this case, change the control flow from that of the normal processing of Endpoint2 and Endpoint4 to the flow illustrated below when the quantity of data expected by the system has decreased to two packets. This flowchart illustrates how Endpoint2 is controlled. Endpoint4 can also be controlled in the same sequence. To use this flowchart as the control flow of Endpoint4, therefore, read the bit names of Endpoint2 in the flowchart as those of Endpoint4.

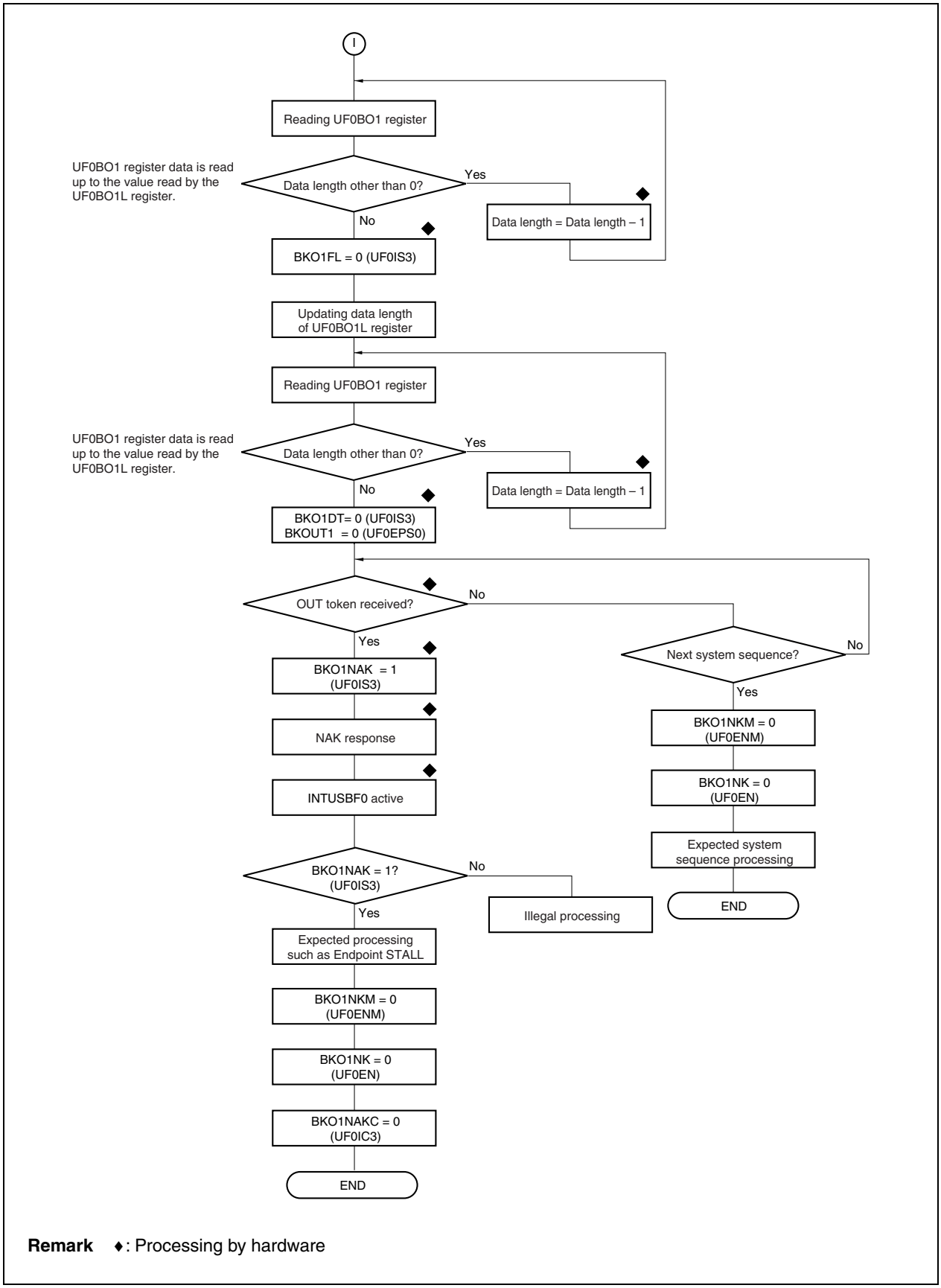
Figure 21-28. Processing If More Data Than Expected by System Is Transmitted (Endpoint2) (1/2)



Remarks 1. n = 2, 3

2. ♦: Processing by hardware

Figure 21-28. Processing If More Data Than Expected by System Is Transmitted (Endpoint2) (2/2)

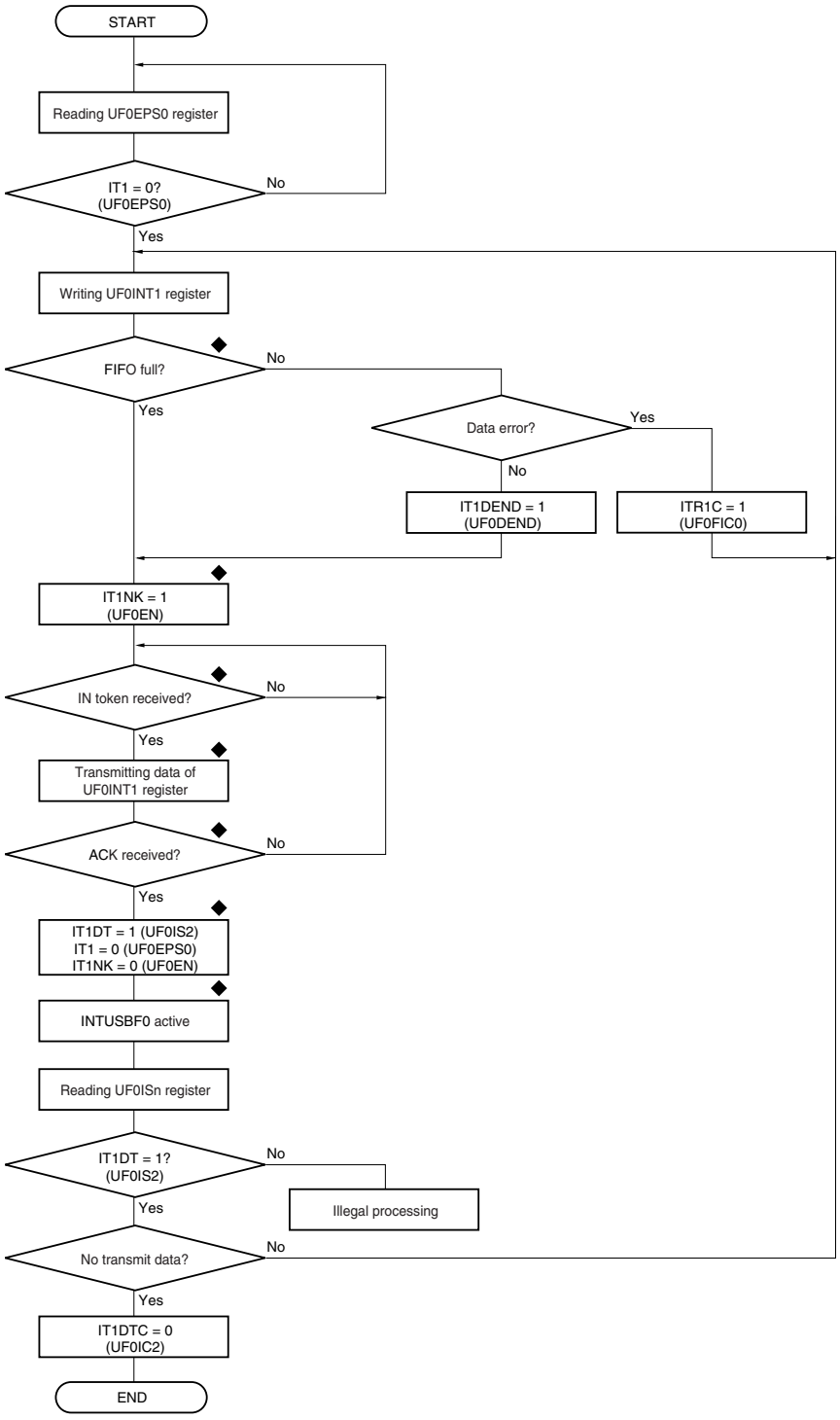


Remark ♦: Processing by hardware

(6) Processing for interrupt transfer (IN)

Interrupt transfer (IN) is allocated to Endpoint7. The flowchart is shown in **Figure 21-29**.

Figure 21-29. Processing for Interrupt Transfer (IN) (Endpoint7)



Remarks 1. n = 2, 3

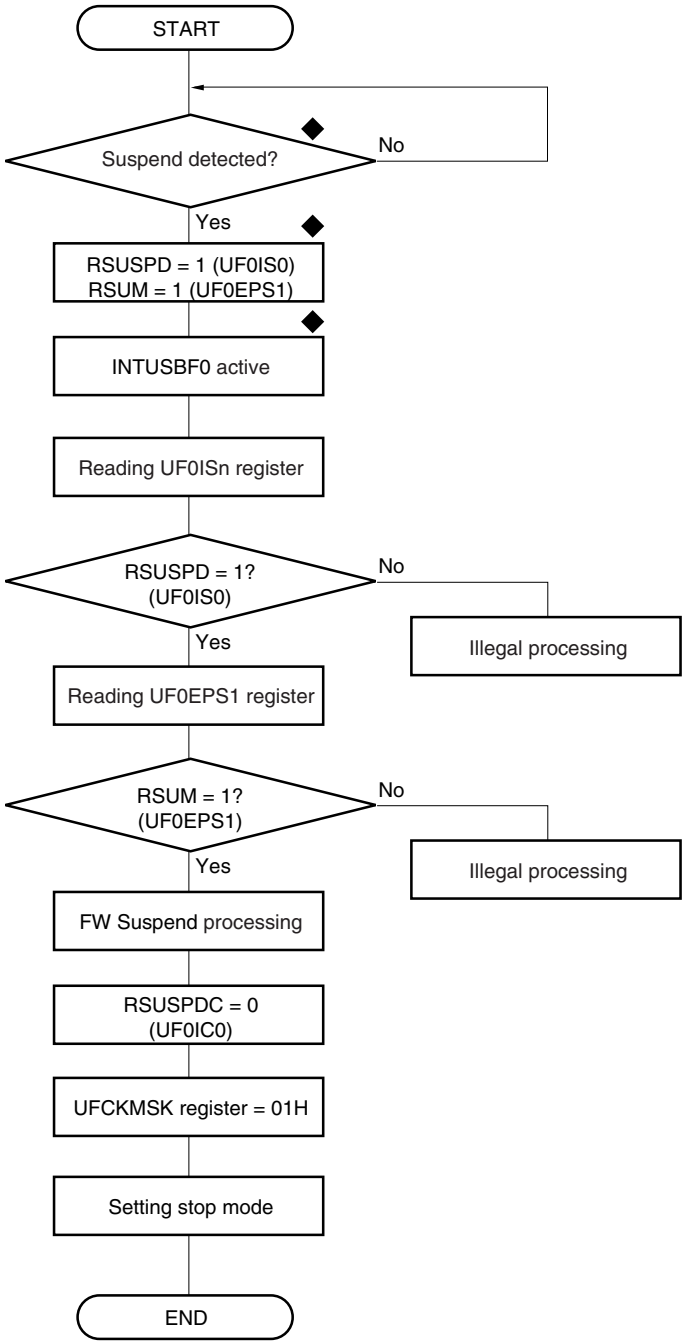
2. ♦: Processing by hardware

21.9.4 Suspend/Resume processing

How Suspend/Resume processing is performed differs depending on the configuration of the system. One example is given below.

Figure 21-30. Example of Suspend/Resume Processing (1/3)

(a) Example of Suspend processing

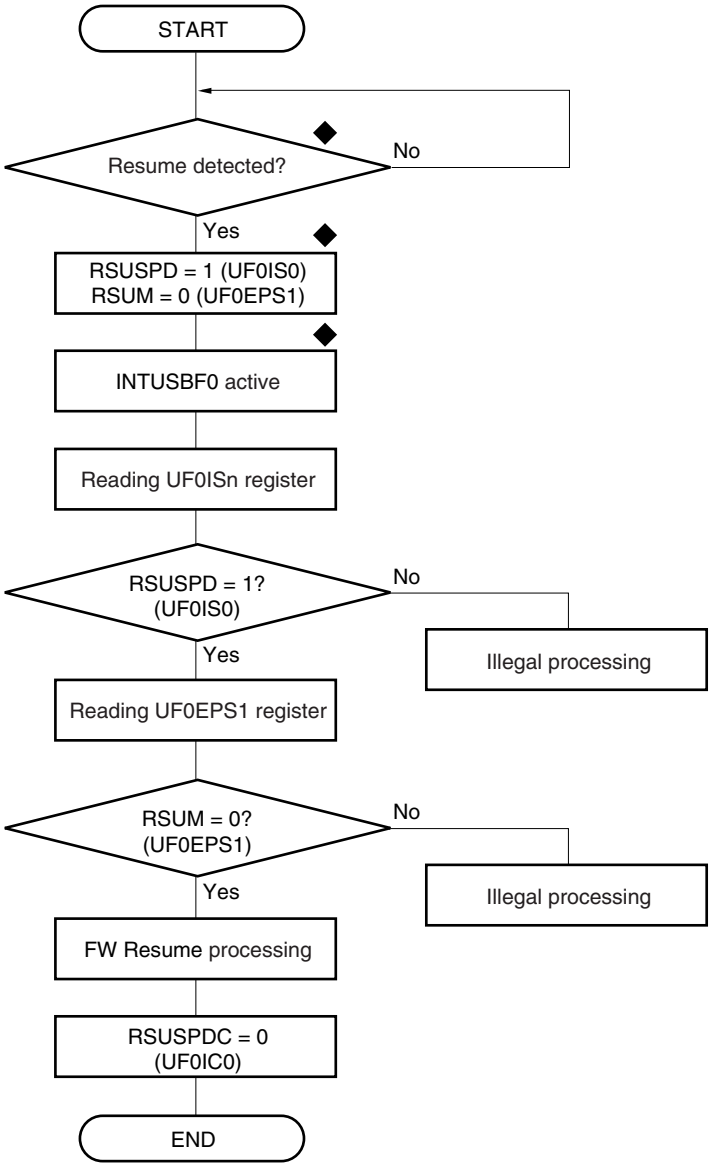


Remarks 1. n = 0, 1

2. ♦: Processing by hardware

Figure 21-30. Example of Suspend/Resume Processing (2/3)

(b) Example of Resume processing

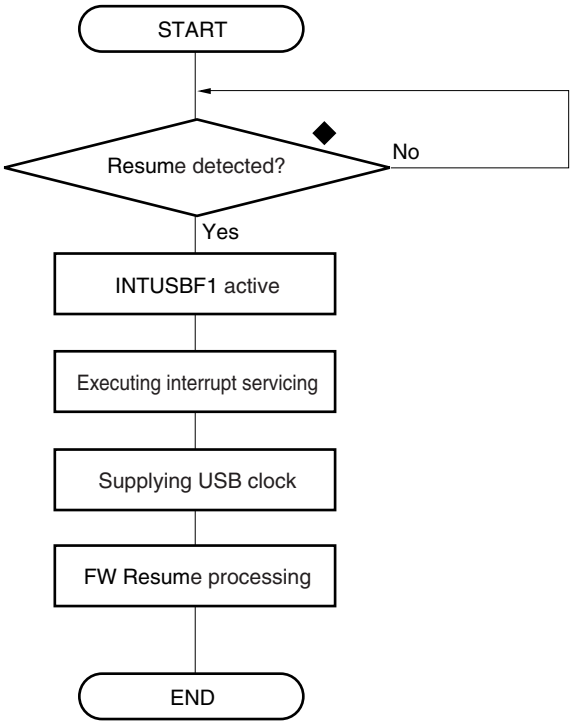


Remarks 1. n = 0, 1

2. ♦: Processing by hardware

Figure 21-30. Example of Suspend/Resume Processing (3/3)

(c) Example of Resume processing (when supply of USB clock to USBF is stopped)



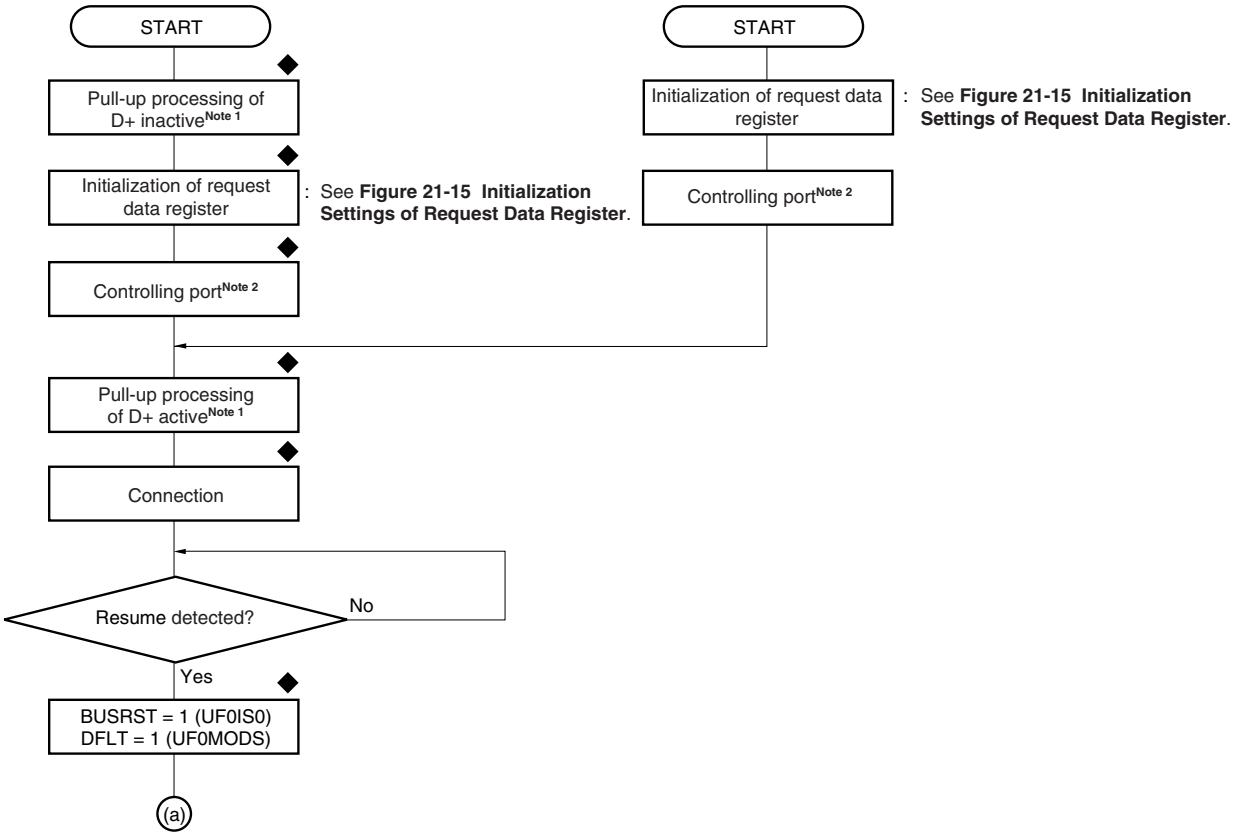
Remark ♦: Processing by hardware

21.9.5 Processing after power application

The processing to be performed after power application differs depending on the configuration of the system. One example is given below.

Figure 21-31. Example of Processing After Power Application/Power Failure (1/3)

(a) Processing after power application (1/2)



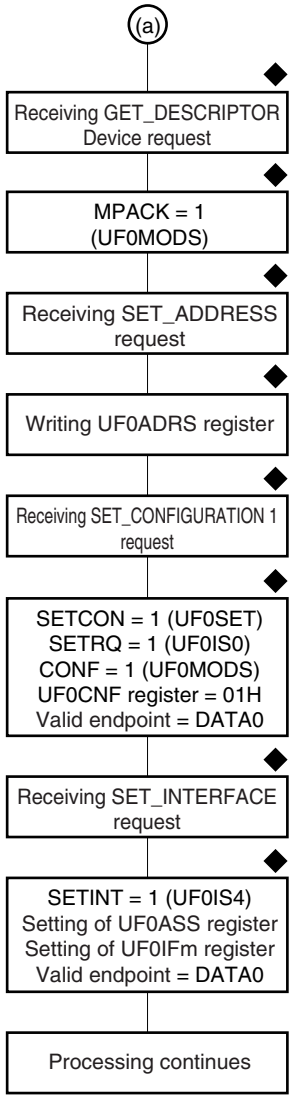
Notes 1. Use one general-purpose port pin for the signal that controls switching of the pull-up resistor of the USB bus.

2. The input mode or control mode of the general-purpose port pin allocated in **Note 1** may be selected as the default value. Note the active level of pull-up processing of D+ on power application.

Remark ♦: Processing by hardware

Figure 21-31. Example of Processing After Power Application/Power Failure (2/3)

(a) Processing after power application (2/2)

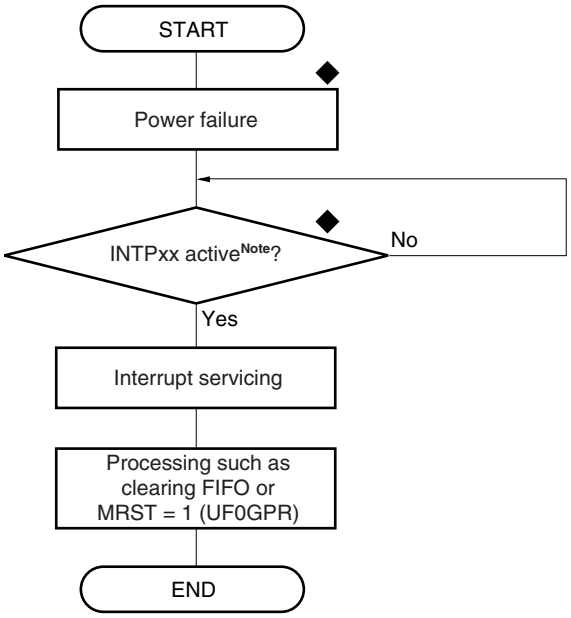


Remarks 1. m = 0 to 4

2. ♦: Processing by hardware

Figure 21-31. Example of Processing After Power Application/Power Failure (3/3)

(b) Processing on power failure



Note INTPxx indicates the external interrupt pins of the V850ES/JG3-H and V850ES/JH3-H (INTP00 to INTP18), and also indicates interrupts input by the external trigger pins (TIAA00, TAA01, TIAA10, TIAA11, TIAA20, TIAA21, TIAA30, TIAA31, TIAA50, TIAA51, TIAB00, TIAB10, TRGAB1, TIT00) of the timer.
Allocate one external interrupt pin to the following applications.

- Detecting disconnection of the connector in the case of self-powered mode (SFPW bit of UF0DSTL register = 1). In this case, monitor the VDD line of the USB connector, and input the result to the external interrupt pin at the edge. Note that the noise elimination time is that of the interrupt input pin, and that of each timer.
- Detecting turning off power from the HUB when the device is mounted on the same board as a HUB chip.

Remark ♦: Processing by hardware

21.9.6 Receiving data for bulk transfer (OUT) in DMA mode

Bulk transfer (OUT) is allocated to Endpoint2 and Endpoint4. The flowchart shown below illustrates how Endpoint2 is controlled when DMA is used. Endpoint4 can also be controlled in the same sequence. To use this flowchart as the control flow of Endpoint4, therefore, read the bit names of Endpoint2 in the flowchart as those of Endpoint4. The control flowchart shown below illustrates how remaining data is read by the CPU.

If data for bulk transfer (OUT) has been correctly received by setting the DQBO1MS bit of the UF0IDR register to 1, the DMA request signal for Endpoint2, instead of an interrupt request (INTUSBF0), becomes active. This DMA request signal for Endpoint2 operates according to the setting of the MODEn bit of the UF0IDR register (n = 0, 1). If all the data stored in the UF0BO1 register has been read by DMA, the DMA request signal for Endpoint2 becomes inactive. In this status, if data for the next bulk transfer (OUT) has been correctly received, the DMA request signal for Endpoint2 becomes active again. If the data for bulk transfer (OUT) that has been received is equal to or less than the FIFO size, a Short interrupt request is issued and the INTUSBF0 (EP2_ENDINT) signal becomes active, as soon as reading the data by DMA is completed. To read data by DMA again, set the DQBO1MS bit to 1 again. If DMA is completed by the DMA end signal for Endpoint2, the DQBO1MS bit of the UF0IDR register is cleared to 0, and the DMA request signal for Endpoint2 becomes inactive. At the same time, the DMA_END interrupt request is issued. If data remains in the UF0BO1 register at this time, DMA can be started again by setting the DQBO1MS bit of the UF0IDR register again. However, the data for bulk transfer (OUT) is always equal to or less than the FIFO size. Consequently, a Short interrupt request is issued, the INTUSBF0 (EP2_ENDINT) signal becomes active, the DQBO1MS bit is cleared, and the DMA request signal for Endpoint2 becomes inactive, as soon as the data is read by DMA.

Cautions 1. The DMA request signal for Endpoint n (n = 2, 4) becomes active in the demand mode (MODE1 and MODE0 bits of the UF0IDR register = 10), as long as there is data to be transferred.

2. For a DMA transfer for which the data for a bulk transfer (OUT) is a Short packet (63 bytes or less), after the transfer finishes, clear the UF0IC0.SHORTC and UF0IS0.SHORT bits.
If the SHORT bits are not cleared, the DMASTOP_EPnB signal is asserted and the next DMA transfer operation is not performed.

(1) Initial settings for a bulk transfer (OUT: EP2, EP4)

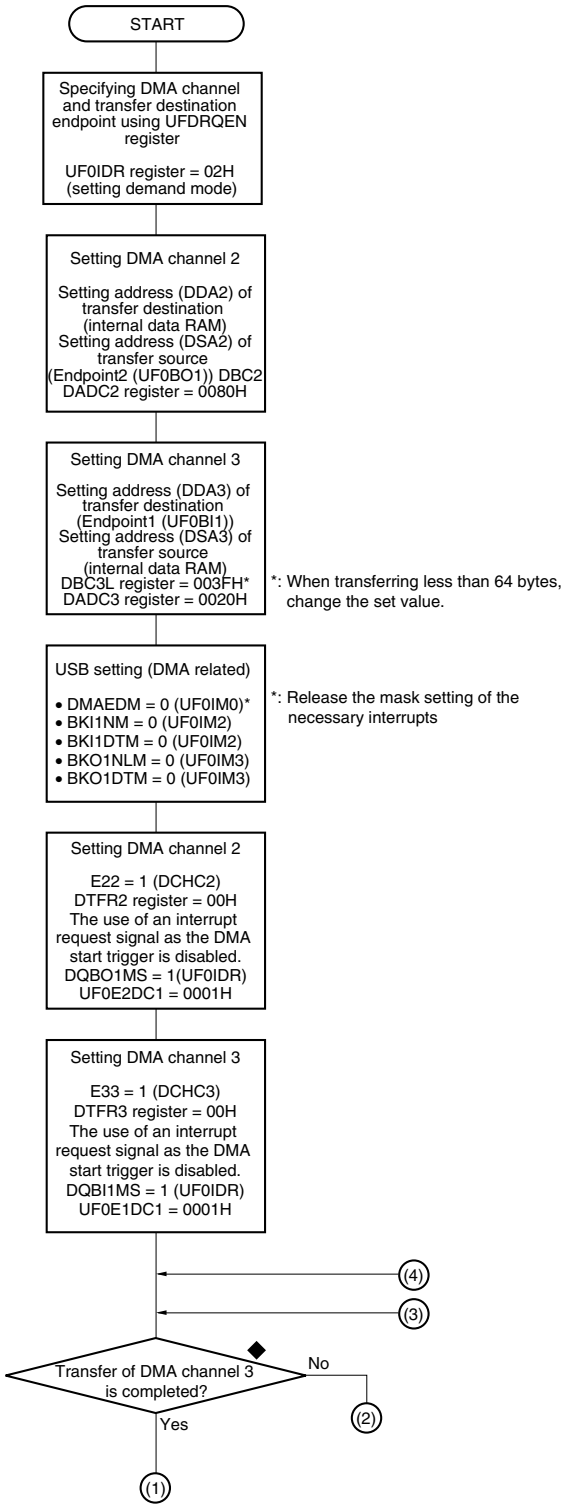
(a) Initial settings for DMAC

- The DSAn registers (n = 0 to 3) are set to 00210000H (for EP2) or 00220000H (for EP4).
- The DADCn registers (n = 0 to 3) are set to 0080H.
  (8-bit transfer, transfer source address: fixed, transfer destination address: incremental)
- The DTFRn registers (n = 0 to 3) are set to 0000H.
- The UFDRQEN register is set up according to the DMA channel to be used.
  (For details, see 20.6.10 (1) USBF DMA request enable register (UFDRQEN).)

(b) Initial settings for EPC

- The UF0IDR register is set to 12H (for EP2) or 22H (for EP4) (demand mode).
- The UF0IM0.DMAEDM bit = 0
- The UF0IM3.BKO1NLM bit = 0 (for EP2)
- The UF0IM3.BKO1DTM bit = 0 (for EP2)
- The UF0IM3.BKO2NLM bit = 0 (for EP4)
- The UF0IM3.BKO2DTM bit = 0 (for EP4)

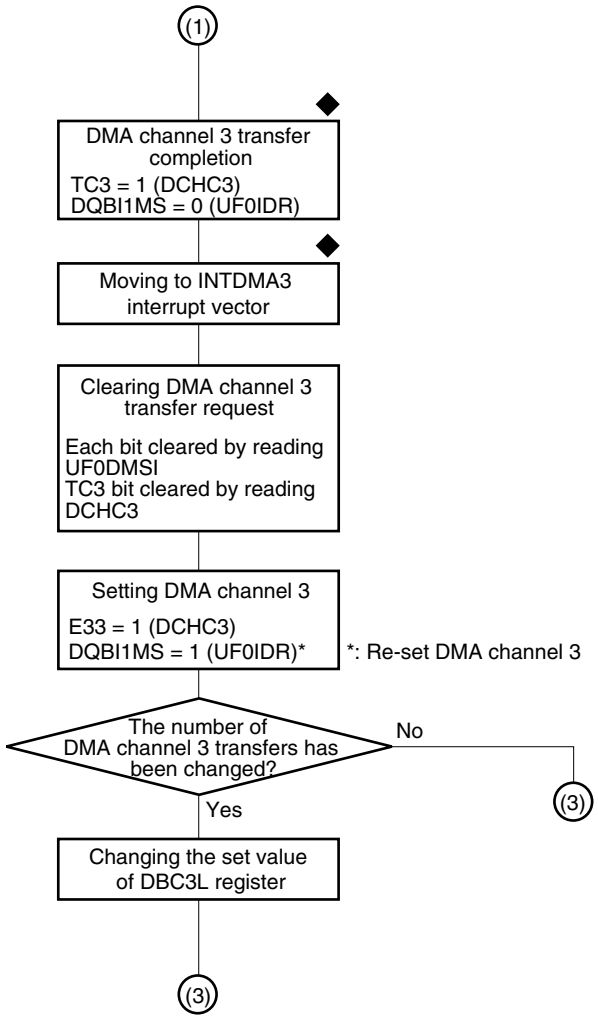
Figure 21-32. DMA Processing by Bulk Transfer (OUT) (1/3)



Remarks 1. The above flowchart shows the case where the transfer by DMA channel 2 is from Endpoint2 to internal data RAM, and the transfer by DMA channel 3 is from internal data RAM to Endpoint1.

2. ♦: Processing by hardware

Figure 21-32. DMA Processing by Bulk Transfer (OUT) (2/3)

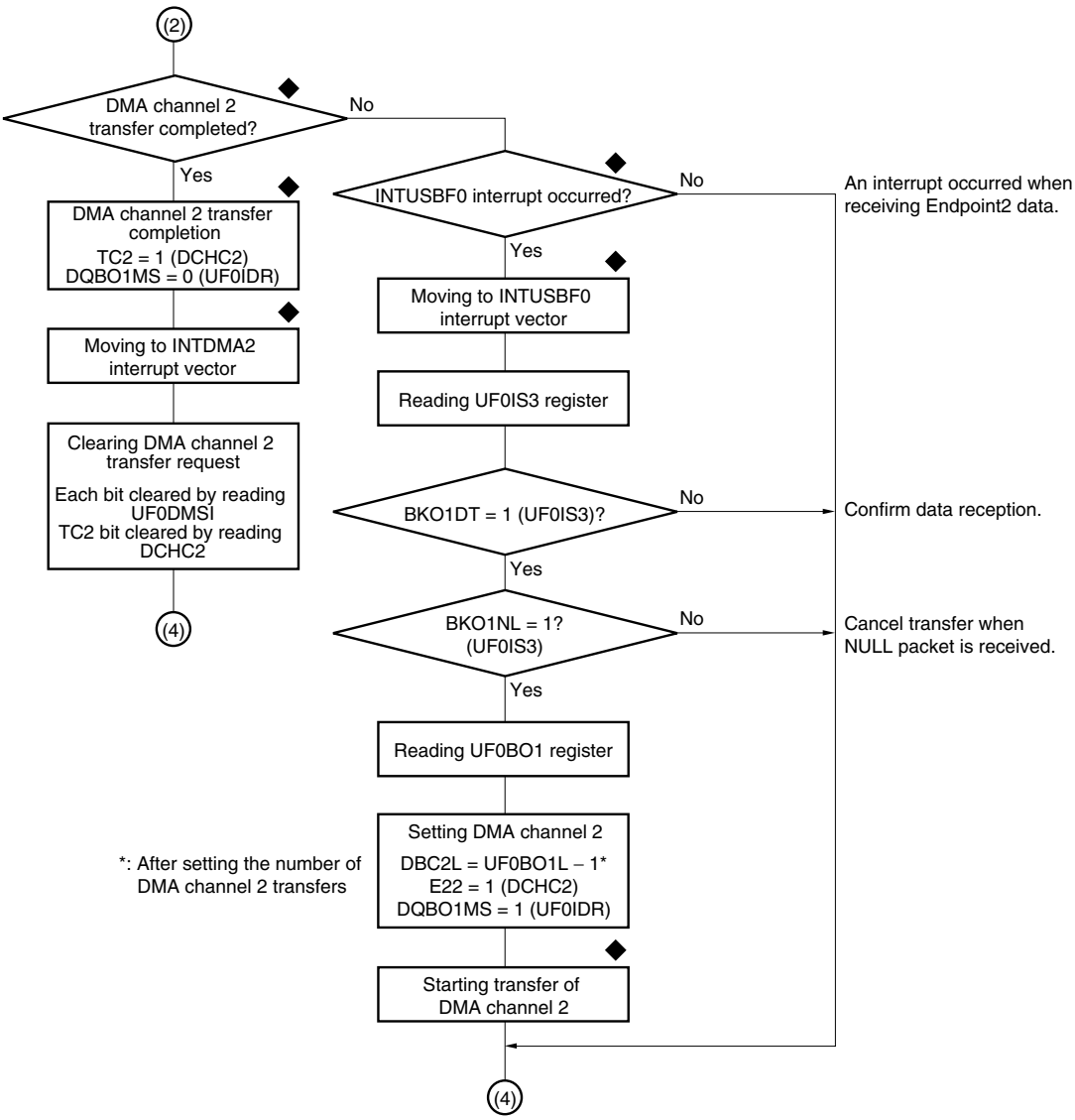


Remarks 1. The above flowchart shows the case where the transfer by DMA channel 2 is from Endpoint2 to internal data RAM, and the transfer by DMA channel 3 is from internal data RAM to Endpoint1.

2. n = 0, 1

3. ♦: Processing by hardware

Figure 21-32. DMA Processing by Bulk Transfer (OUT) (3/3)



Remarks 1. The above flowchart shows the case where the transfer by DMA channel 2 is from Endpoint2 to internal data RAM, and the transfer by DMA channel 3 is from internal data RAM to Endpoint1.

2. n = 0, 1

m = 2, 3

3. ♦: Processing by hardware

21.9.7 Transmitting data for bulk transfer (IN) in DMA mode

Bulk transfer (IN) is allocated to Endpoint1 and Endpoint3. The flowchart shown below illustrates how Endpoint1 is controlled when DMA is used. Endpoint3 can also be controlled in the same sequence. To use this flowchart as the control flow of Endpoint3, therefore, read the bit names of Endpoint1 in the flowchart as those of Endpoint3.

If data for bulk transfer (IN) can be written by setting the DQBI1MS bit of the UF0IDR register to 1, the DMA request signal for Endpoint1, instead of an interrupt request (INTUSBF0), becomes active. This DMA request signal for Endpoint1 operates according to the setting of the MODEn bit of the UF0IDR register (n = 0, 1). If all the data that can be written to the UF0BI1 register has been written by DMA, the DMA request signal for Endpoint1 becomes inactive. In this status, the toggle operation of the FIFO takes place and, if data for bulk transfer (IN) can be written, the DMA request signal for Endpoint1 becomes active again. The automatic toggle operation of the FIFO is not executed even if the FIFO has become full as a result of DMA transfer, unless the BKI1T bit of the UF0DEND register is set to 1. Therefore, be sure to set the BKI1DED bit of the UF0DEND register to 1 to transfer data. If DMA is completed by the DMA end signal for Endpoint1, the DQBI1MS bit of the UF0IDR register is cleared to 0, and the DMA request signal for Endpoint1 becomes inactive. At the same time, the DMA_END interrupt request is issued. To transmit a short packet at this time when the FIFO is not full, set the BKI1DED bit of the UF0DEND register to 1.

Caution The DMA request signal for Endpoint n (n = 1, 3) becomes active in the demand mode (MODE1 and MODE0 bits of the UF0IDR register = 10), as long as data can be transferred.

(1) Initial settings for a bulk transfer (IN: EP1, EP3)

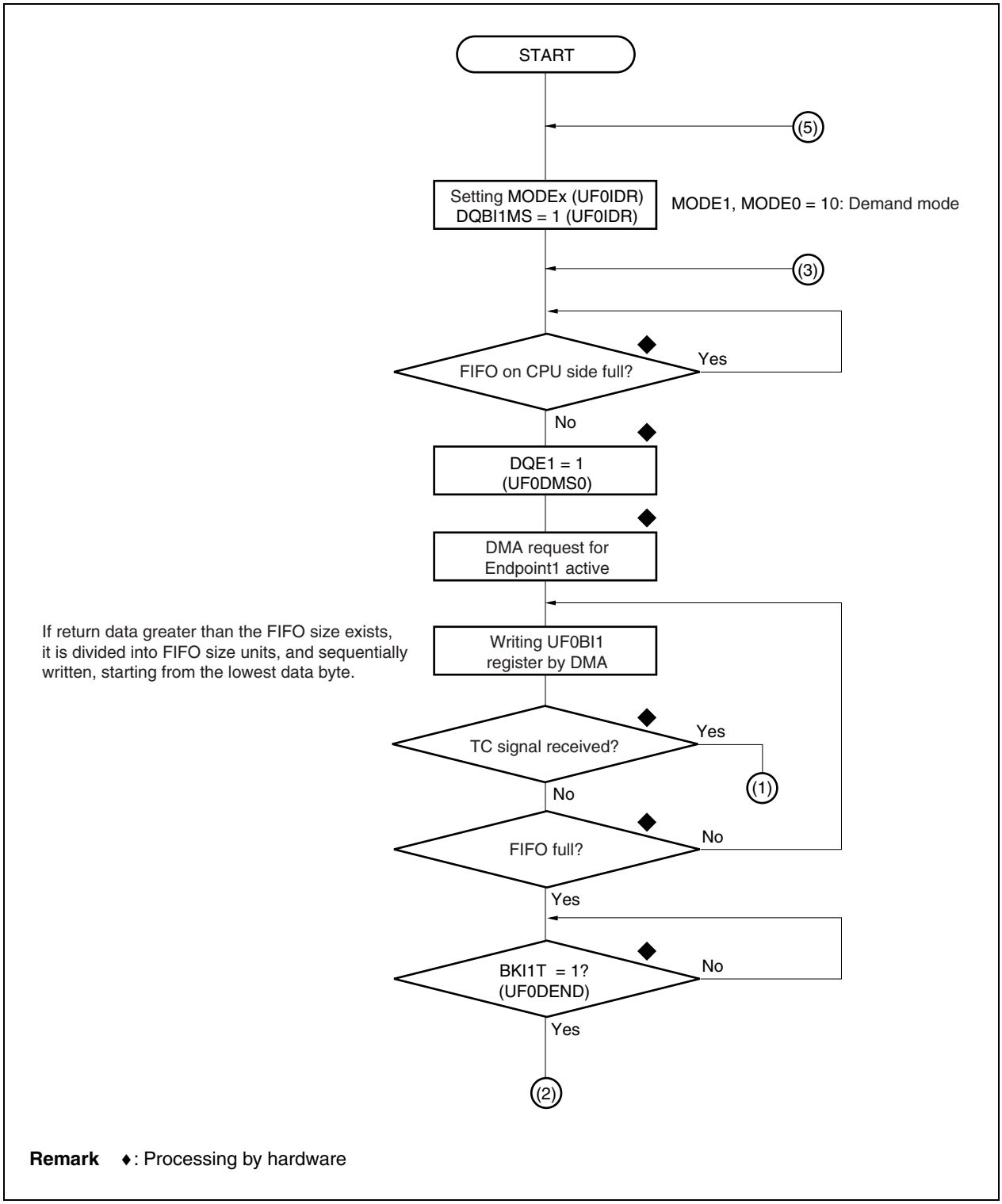
(a) Initial settings for DMAC

- The DSAn registers (n = 0 to 3) are set to 00201000H (for EP1) or 00202000H (for EP3).
- The DADCn registers (n = 0 to 3) are set to 0020H.
  (8-bit transfer, transfer source address: incremental, transfer destination address: fixed)
- The DTFRn registers (n = 0 to 3) are set to 0000H.
- The UFDRQEN register is set up according to the DMA channel to be used.
  (For details, see 20.6.10 (1) USBF DMA request enable register (UFDRQEN).)

(b) Initial settings for EPC

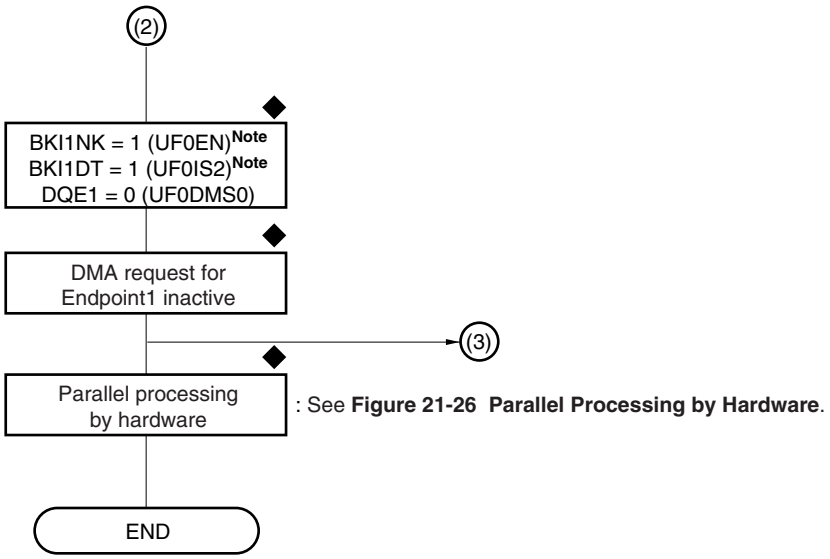
- The UF0IDR register is set to 42H (for EP1) or 82H (for EP3) (demand mode).
- The UF0IM0.DMAEDM bit = 0
- The UF0IM2.BKI1NLM bit = 0 (for EP1)
- The UF0IM2.BKI1DTM bit = 0 (for EP1)
- The UF0IM2.BKI2NLM bit = 0 (for EP3)
- The UF0IM2.BKI2DTM bit = 0 (for EP3)

Figure 21-33. DMA Processing by Bulk Transfer (IN) (1/4)



Remark ♦: Processing by hardware

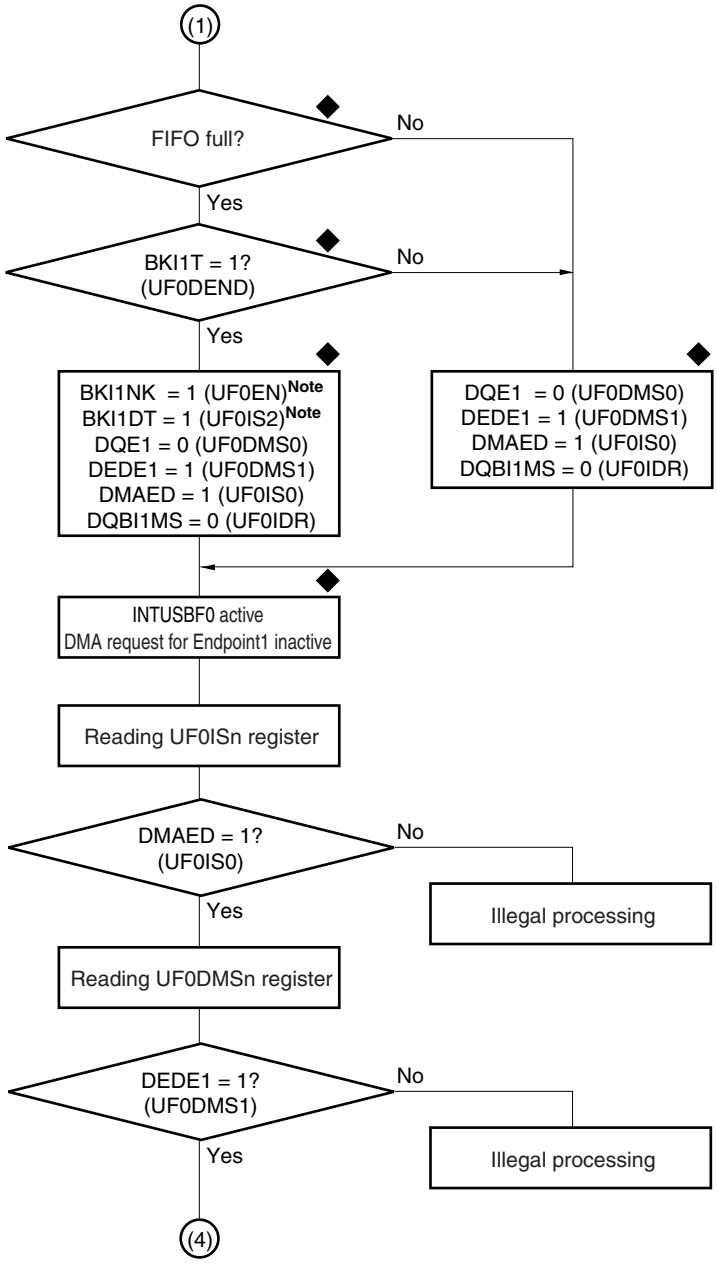
Figure 21-33. DMA Processing by Bulk Transfer (IN) (2/4)



Note The timing of the bit value changes depending on the status on the SIE side.

Remark ♦: Processing by hardware

Figure 21-33. DMA Processing by Bulk Transfer (IN) (3/4)

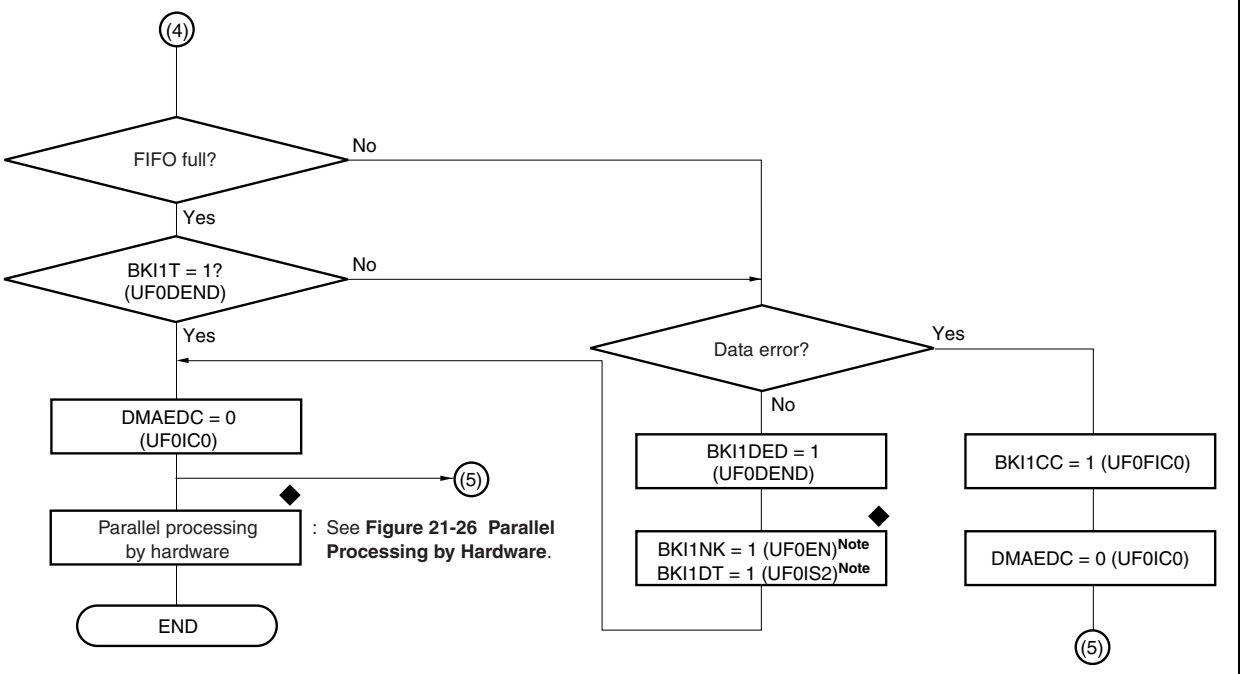


Note The timing of the bit value changes depending on the status on the SIE side.

Remarks 1. n = 0, 1

2. ♦: Processing by hardware

Figure 21-33 DMA Processing by Bulk Transfer (IN) (4/4)



Note The timing of the bit value changes depending on the status on the SIE side.

Remark ♦: Processing by hardware

CHAPTER 22 DMA FUNCTION (DMA CONTROLLER)

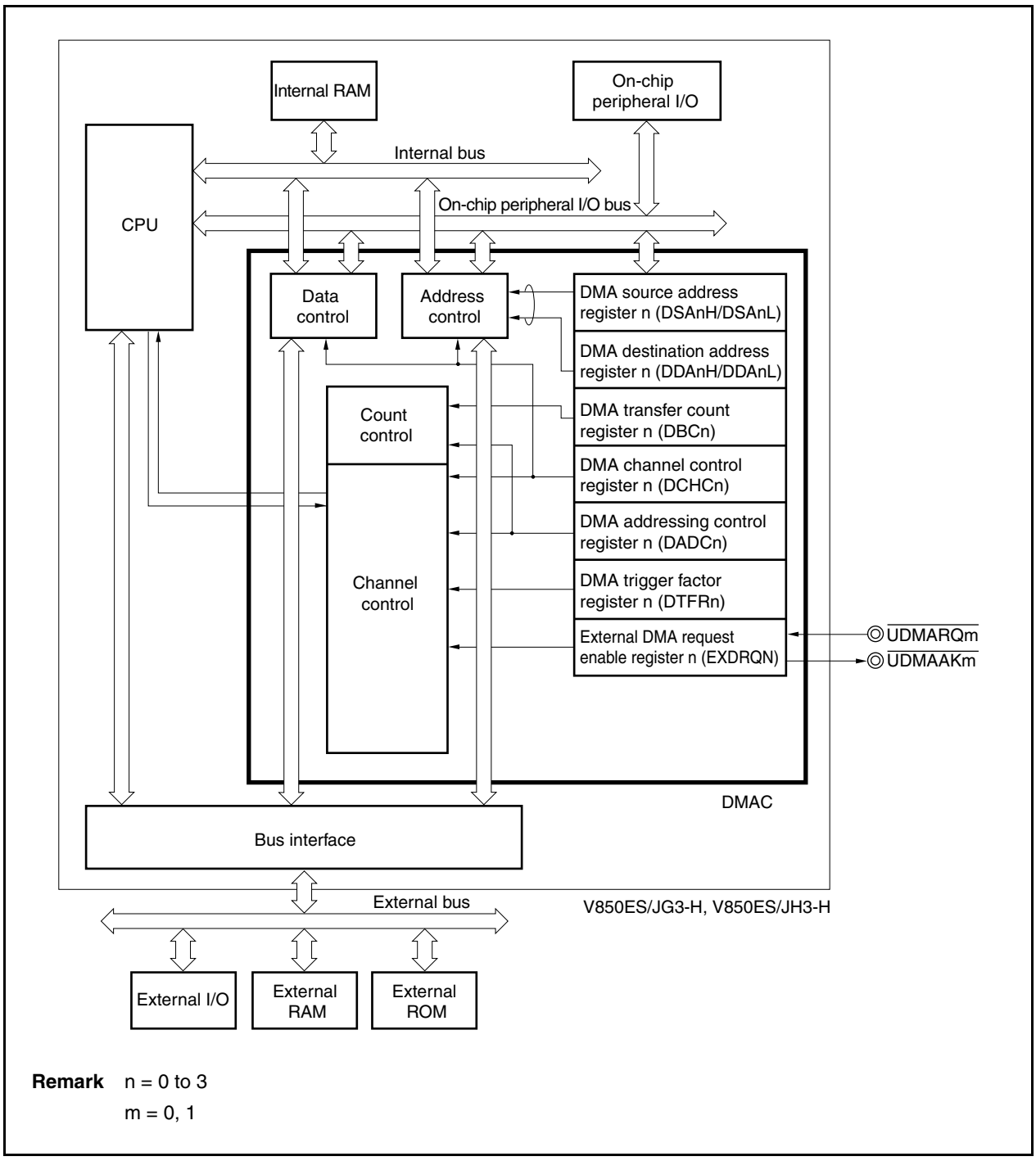
The V850ES/JG3-H and V850ES/JH3-H include a direct memory access (DMA) controller (DMAC) that executes and controls DMA transfer.

The DMAC controls data transfer between memory and I/O, between memories, or between I/Os based on DMA requests issued by the on-chip peripheral I/O (serial interface, timer/counter, and A/D converter), interrupts from external input pins, or software triggers (memory refers to internal RAM or external memory).

22.1 Features

- 4 independent DMA channels
- Transfer unit: 8/16 bits
- Maximum transfer count: 65,536 (2^{16})
- Transfer type: Two-cycle transfer
- Transfer mode: Single transfer mode
- Transfer requests
  - Request by interrupts from on-chip peripheral I/O (serial interface, timer/counter, A/D converter) or interrupts from external input pin
  - Requests by software trigger
- Transfer targets
  - Internal RAM ↔ Peripheral I/O
  - Peripheral I/O ↔ Peripheral I/O
  - Internal RAM ↔ External memory
  - External memory ↔ Peripheral I/O
  - External memory ↔ External memory

22.2 Configuration



Remark n = 0 to 3
m = 0, 1

22.3 Registers

(1) DMA source address registers 0 to 3 (DSA0 to DSA3)

The DSA0 to DSA3 registers set the DMA source addresses (26 bits each) for DMA channel n (n = 0 to 3).

These registers are divided into two 16-bit registers, DSAnH and DSAnL.

These registers can be read or written in 16-bit units.

After reset: Undefined R/W Address: DSA0H FFFFF082H, DSA1H FFFFF08AH, DSA2H FFFFF092H, DSA3H FFFFF09AH, DSA0L FFFFF080H, DSA1L FFFFF088H, DSA2L FFFFF090H, DSA3L FFFFF098H

DSAnH (n = 0 to 3)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
IR	0	0	0	0	0	SA25	SA24	SA23	SA22	SA21	SA20	SA19	SA18	SA17	SA16

DSAnL (n = 0 to 3)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
SA15	SA14	SA13	SA12	SA11	SA10	SA9	SA8	SA7	SA6	SA5	SA4	SA3	SA2	SA1	SA0

IR	Specification of DMA transfer source
0	External memory or on-chip peripheral I/O
1	Internal RAM

SA25 to SA16	Set the address (A25 to A16) of the DMA transfer source (default value is undefined). During DMA transfer, the next DMA transfer source address is held. When DMA transfer is completed, the DMA address set first is held.

SA15 to SA0	Set the address (A15 to A0) of the DMA transfer source (default value is undefined). During DMA transfer, the next DMA transfer source address is held. When DMA transfer is completed, the DMA address set first is held.

Cautions 1. Be sure to clear bits 14 to 10 of the DSAnH register to 0.

2. Set the DSAnH and DSAnL registers at the following timing when DMA transfer is disabled (DCHCn.Enn bit = 0).

- **Period from after reset to start of first DMA transfer**
- **Period from after channel initialization by DCHCn.INITn bit to start of DMA transfer**
- **Period from after completion of DMA transfer (DCHCn.TCn bit = 1) to start of the next DMA transfer**

3. When the value of the DSAn register is read, two 16-bit registers, DSAnH and DSAnL, are read. If reading and updating conflict, the value being updated may be read (see 22.13 Cautions).

4. Following reset, set the DSAnH, DSAnL, DDAnH, DDAnL, and DBCn registers before starting DMA transfer. If these registers are not set, the operation when DMA transfer is started is not guaranteed.

(2) DMA destination address registers 0 to 3 (DDA0 to DDA3)

The DDA0 to DDA3 registers set the DMA destination address (26 bits each) for DMA channel n (n = 0 to 3). These registers are divided into two 16-bit registers, DDAnH and DDAnL.

These registers can be read or written in 16-bit units.

After reset: Undefined R/W Address: DDA0H FFFFF086H, DDA1H FFFFF08EH, DA2H FFFFF096H, DDA3H FFFFF09EH, DDA0L FFFFF084H, DDA1L FFFFF08CH, DDA2L FFFFF094H, DDA3L FFFFF09CH

DDAnH (n = 0 to 3)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
IR	0	0	0	0	0	DA25	DA24	DA23	DA22	DA21	DA20	DA19	DA18	DA17	DA16

DDAnL (n = 0 to 3)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
DA15	DA14	DA13	DA12	DA11	DA10	DA9	DA8	DA7	DA6	DA5	DA4	DA3	DA2	DA1	DA0

IR	Specification of DMA transfer destination
0	External memory or on-chip peripheral I/O
1	Internal RAM

DA25 to DA16	Set an address (A25 to A16) of DMA transfer destination (default value is undefined). During DMA transfer, the next DMA transfer destination address is held. When DMA transfer is completed, the DMA transfer source address set first is held.

DA15 to DA0	Set an address (A15 to A0) of DMA transfer destination (default value is undefined). During DMA transfer, the next DMA transfer destination address is held. When DMA transfer is completed, the DMA transfer source address set first is held.

Cautions 1. Be sure to clear bits 14 to 10 of the DDAnH register to 0.

2. Set the DDAnH and DDAnL registers at the following timing when DMA transfer is disabled (DCHCn.Enn bit = 0).

- **Period from after reset to start of first DMA transfer**
- **Period from after channel initialization by DCHCn.INITn bit to start of DMA transfer**
- **Period from after completion of DMA transfer (DCHCn.TCn bit = 1) to start of the next DMA transfer**

3. When the value of the DDAn register is read, two 16-bit registers, DDAnH and DDAnL, are read. If reading and updating conflict, a value being updated may be read (see 22.13 Cautions).

4. Following reset, set the DSAnH, DSAnL, DDAnH, DDAnL, and DBCn registers before starting DMA transfer. If these registers are not set, the operation when DMA transfer is started is not guaranteed.

(3) DMA transfer count registers 0 to 3 (DBC0 to DBC3)

The DBC0 to DBC3 registers are 16-bit registers that set the transfer count for DMA channel n (n = 0 to 3). These registers hold the remaining transfer count during DMA transfer.

These registers are decremented by 1 per transfer regardless of the transfer data unit (8/16 bits), and the transfer is terminated if a borrow occurs.

These registers can be read or written in 16-bit units.

After reset: Undefined R/W Address: DBC0 FFFFF0C0H, DBC1 FFFFF0C2H, DBC2 FFFFF0C4H, DBC3 FFFFF0C6H

DBCn (n = 0 to 3)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
BC15	BC14	BC13	BC12	BC11	BC10	BC9	BC8	BC7	BC6	BC5	BC4	BC3	BC2	BC1	BC0

BC15 to BC0	Transfer count setting or remaining transfer count during DMA transfer
0000H	Transfer count of 1st transfer or remaining transfer count
0001H	Transfer count of 2nd transfer or remaining transfer count
:	:
FFFFH	Transfer count of 65,536 (2^{16})th transfer or remaining transfer count
The number of transfer data set first is held when DMA transfer is complete.	

Cautions 1. Set the DBCn register at the following timing when DMA transfer is disabled (DCHCn.Enn bit = 0).

- **Period from after reset to start of first DMA transfer**
- **Period from after channel initialization by DCHCn.INITn bit to start of DMA transfer**
- **Period from after completion of DMA transfer (DCHCn.TCn bit = 1) to start of the next DMA transfer**

2. Following reset, set the DSAnH, DSAnL, DDAnH, DDAnL, and DBCn registers before starting DMA transfer. If these registers are not set, the operation when DMA transfer is started is not guaranteed.

(4) DMA addressing control registers 0 to 3 (DADC0 to DADC3)

The DADC0 to DADC3 registers are 16-bit registers that control the DMA transfer mode for DMA channel n (n = 0 to 3).

These registers can be read or written in 16-bit units.

Reset sets these registers to 0000H.

After reset: 0000H R/W Address: DADC0 FFFFF0D0H, DADC1 FFFFF0D2H, DADC2 FFFFF0D4H, DADC3 FFFFF0D6H

DADCn (n = 0 to 3)

15	14	13	12	11	10	9	8
0	DS0	0	0	0	0	0	0

7	6	5	4	3	2	1	0
SAD1	SAD0	DAD1	DAD0	0	0	0	0

DS0	Setting of transfer data size
0	8 bits
1	16 bits

SAD1	SAD0	Setting of count direction of the transfer source address
0	0	Increment
0	1	Decrement
1	0	Fixed
1	1	Setting prohibited

DAD1	DAD0	Setting of count direction of the destination address
0	0	Increment
0	1	Decrement
1	0	Fixed
1	1	Setting prohibited

Cautions 1. Be sure to clear bits 15, 13 to 8, and 3 to 0 of the DADCn register to 0.

2. Set the DADCn register at the following timing when DMA transfer is disabled (DCHCn.Enn bit = 0).

- **Period from after reset to start of first DMA transfer**
- **Period from after channel initialization by DCHCn.INITn bit to start of DMA transfer**
- **Period from after completion of DMA transfer (DCHCn.TCn bit = 1) to start of the next DMA transfer**

3. The DS0 bit specifies the size of the transfer data, and does not control bus sizing. If 8-bit data (DS0 bit = 0) is set, therefore, the lower data bus is not always used.

4. If the transfer data size is set to 16 bits (DS0 bit = 1), transfer cannot be started from an odd address. Transfer is always started from an address with the first bit of the lower address aligned to 0.

5. If DMA transfer is executed on an on-chip peripheral I/O register (as the transfer source or destination), be sure to specify the same transfer size as the register size. For example, to execute DMA transfer on an 8-bit register, be sure to specify 8-bit transfer.

(5) DMA channel control registers 0 to 3 (DCHC0 to DCHC3)

The DCHC0 to DCHC3 registers are 8-bit registers that control the DMA transfer operating mode for DMA channel n.

These registers can be read or written in 8-bit or 1-bit units. (However, bit 7 is read-only and bits 1 and 2 are write-only. If bit 1 or 2 is read, the read value is always 0.)

Reset sets these registers to 00H.

After reset: 00H R/W Address: DCHC0 FFFFF0E0H, DCHC1 FFFFF0E2H, DCHC2 FFFFF0E4H, DCHC3 FFFFF0E6H

DCHCn (n = 0 to 3)

	<7>	6	5	4	3	<2>	<1>	<0>
DCHCn	TCn Note 1	0	0	0	0	INITn Note 2	STGn Note 2	Enn

TCn Note 1	Status flag indicates whether DMA transfer through DMA channel n has completed or not
0	DMA transfer had not completed.
1	DMA transfer had completed.
It is set to 1 on the last DMA transfer and cleared to 0 when it is read.	

INITn Note 2	If the INITn bit is set to 1 with DMA transfer disabled (Enn bit = 0), the DMA transfer status can be initialized. When re-setting the DMA transfer status (re-setting the DDAnH, DDAnL, DSAnH, DSAnL, DBCn, and DADCn registers) before DMA transfer is completed (before the TCn bit is set to 1), be sure to initialize the DMA channel. When initializing the DMA controller, however, be sure to observe the procedure described in **22.13 Cautions**.

STGn Note 2	This is a software startup trigger of DMA transfer. If this bit is set to 1 in the DMA transfer enable state (TCn bit = 0, Enn bit = 1), DMA transfer is started.

Enn	Setting of whether DMA transfer through DMA channel n is to be enabled or disabled
0	DMA transfer disabled
1	DMA transfer enabled
DMA transfer is enabled when the Enn bit is set to 1. When DMA transfer is completed (when a terminal count is generated), this bit is automatically cleared to 0. To abort DMA transfer, clear the Enn bit to 0 by software. To resume, set the Enn bit to 1 again. When aborting or resuming DMA transfer, however, be sure to observe the procedure described in **22.13 Cautions**.	

Notes 1. The TCn bit is read-only.

2. The INITn and STGn bits are write-only.

Cautions 1. Be sure to clear bits 6 to 3 of the DCHCn register to 0.

2. When DMA transfer is completed (when a terminal count is generated), the Enn bit is cleared to 0 and then the TCn bit is set to 1. If the DCHCn register is read while its bits are being updated, a value indicating "transfer not completed and transfer is disabled" (TCn bit = 0 and Enn bit = 0) may be read.

(6) DMA trigger factor registers 0 to 3 (DTFR0 to DTFR3)

The DTFR0 to DTFR3 registers are 8-bit registers that control the DMA transfer start trigger via interrupt request signals from on-chip peripheral I/O.

The interrupt request signals set by these registers serve as DMA transfer start factors.

These registers can be read or written in 8-bit units. However, DFn bit can be read or written in 1-bit units.

Reset sets these registers to 00H.

After reset: 00H R/W Address: DTFR0 FFFFF810H, DTFR1 FFFFF812H, DTFR2 FFFFF814H, DTFR3 FFFFF816H

	<7>	6	5	4	3	2	1	0
DTFRn	DFn	0	IFCn5	IFCn4	IFCn3	IFCn2	IFCn1	IFCn0

(n = 0 to 3)

DFn[Note]	DMA transfer request status flag
0	No DMA transfer request
1	DMA transfer request

Note Do not set the DFn bit to 1 by software. Write 0 to this bit to clear a DMA transfer request if an interrupt that is specified as the DMA transfer start factor occurs while DMA transfer is disabled.

Cautions 1. Set the IFCn5 to IFCn0 bits at the following timing when DMA transfer is disabled (DCHCn.Enn bit = 0).

- **Period from after reset to start of first DMA transfer**
- **Period from after channel initialization by DCHCn.INITn bit to start of DMA transfer**
- **Period from after completion of DMA transfer (DCHCn.TCn bit = 1) to start of the next DMA transfer**

2. An interrupt request that is generated in the standby mode (IDEL1, IDLE2, STOP, or sub-IDLE mode) does not start the DMA transfer cycle (nor is the DFn bit set to 1).

3. If a DMA start factor is selected by the IFCn5 to IFCn0 bits, the DFn bit is set to 1 when an interrupt occurs from the selected on-chip peripheral I/O, regardless of whether the DMA transfer is enabled or disabled. If DMA is enabled in this status, DMA transfer is immediately started.

4. Be sure to follow the steps below when changing the DTFRn register settings.

- **When the values to be set to bits IFCn5 to IFCn0 are not set to bits IFCm5 to IFCm0 of another channel (n = 0 to 3, m = 0 to 3, n ≠ m)**
  - **<1> Stop the DMAn operation of the channel to be rewritten (DCHCn.Enn bit = 0).**
  - **<2> Change the DTFRn register settings. (Be sure to set DFn bit = 0 and change the settings in the 8-bit manipulation.)**
  - **<3> Confirm that DFn bit = 0. (Stop the interrupt generation source operation beforehand.)**
  - **<4> Enable the DMAn operation (Enn bit = 1).**
- **When the values to be set to bits IFCn5 to IFCn0 are set to bits IFCm5 to IFCm0 of another channel (n = 0 to 3, m = 0 to 3, n ≠ m)**
  - **<1> Stop the DMAn operation of the channel to be rewritten (DCHCn.Enn bit = 0).**
  - **<2> Stop the DMAm operation of the channel where the same values are set to bits IFCm5 to IFCm0 as the values to be used to rewrite bits IFCn5 to IFCn0 (DCHCm.Emm bit = 0).**
  - **<3> Change the DTFRn register settings. (Be sure to set DFn bit = 0 and change the settings in the 8-bit manipulation.)**
  - **<4> Confirm that bits DFn and DFm = 0. (Stop the interrupt generation source operation beforehand.)**
  - **<5> Enable the DMAn operation (bits Enn and Emm = 1).**

Remark For the IFCn5 to IFCn0 bits, see **Table 22-1 DMA Start Factors**.

Table 22-1. DMA Start Factors (1/2)

IFCn5	IFCn4	IFCn3	IFCn2	IFCn1	IFCn0	Interrupt Source
0	0	0	0	0	0	DMA request by interrupt disabled
0	0	0	0	0	1	INTP02
0	0	0	0	1	0	INTP05
0	0	0	0	1	1	INTP09
0	0	0	1	0	0	INTP10
0	0	0	1	0	1	INTP13
0	0	0	1	1	0	INTP16
0	0	0	1	1	1	INTTAB0OV
0	0	1	0	0	0	INTTAB0CC0
0	0	1	0	0	1	INTTAB0CC1
0	0	1	0	1	0	INTTAB0CC2
0	0	1	0	1	1	INTTAB0CC3
0	0	1	1	0	0	INTTAB1OV_BASE[Note]
0	0	1	1	0	1	INTTAB1CC0
0	0	1	1	1	0	INTTAB1CC1
0	0	1	1	1	1	INTTAB1CC2
0	1	0	0	0	0	INTTAB1CC3
0	1	0	0	0	1	INTTT0OV
0	1	0	0	1	0	INTTT0CC0
0	1	0	0	1	1	INTTT0CC1
0	1	0	1	0	0	INTTAA0OV
0	1	0	1	0	1	INTTAA0CC0
0	1	0	1	1	0	INTTAA0CC1
0	1	0	1	1	1	INTTAA1OV
0	1	1	0	0	0	INTTAA1CC0
0	1	1	0	0	1	INTTAA1CC1
0	1	1	0	1	0	INTTAA2CC0
0	1	1	0	1	1	INTTAA2CC1
0	1	1	1	0	0	INTTAA3CC0
0	1	1	1	0	1	INTTAA3CC1
0	1	1	1	1	0	INTTAA4CC0
0	1	1	1	1	1	INTTAA4CC1
1	0	0	0	0	0	INTTAA5CC0
1	0	0	0	0	1	INTTAA5CC1
1	0	0	0	1	0	INTTM0EQ0
1	0	0	0	1	1	INTTM1EQ0
1	0	0	1	0	0	INTTM2EQ0
1	0	0	1	0	1	INTTM3EQ0
1	0	0	1	1	0	INTCF0R/INTIIC1
1	0	0	1	1	1	INTCF0T
1	0	1	0	0	0	INTCF1R
1	0	1	0	0	1	INTCF1T

Note INTTAB1OV_BASE is the interrupt signal from before the overflow interrupt of TAB1 (INTTAB1OV) was culled by TMQOP.

Table 22-1. DMA Start Factors (2/2)

IFCn5	IFCn4	IFCn3	IFCn2	IFCn1	IFCn0	Interrupt Source
1	0	1	0	1	0	INTCF2R
1	0	1	0	1	1	INTCF2T
1	0	1	1	0	0	INTCF3R
1	0	1	1	0	1	INTCF3T
1	0	1	1	1	0	INTCF4R
1	0	1	1	1	1	INTCF4T
1	1	0	0	0	0	INTUC0R
1	1	0	0	0	1	INTUC0T
1	1	0	0	1	0	INTUC1R/INTIIC2
1	1	0	0	1	1	INTUC1T
1	1	0	1	0	0	INTUC2R
1	1	0	1	0	1	INTUC2T
1	1	0	1	1	0	INTUC3R/INTIIC0
1	1	0	1	1	1	INTUC3T
1	1	1	0	0	0	INTUC4R
1	1	1	0	0	1	INTUC4T
1	1	1	0	1	0	INTAD
1	1	1	0	1	1	INTKR
1	1	1	1	0	0	INTRTC1

Remark n = 0 to 3

(7) External DMA request enable register (EXDRQEN)

The EXDRQEN register sets the DMA request to each DMA channel when connecting the external USB device by using the $\overline{\text{UDMARQm}}$/$\overline{\text{UDMAAKm}}$ pin (m = 0, 1).

This register can be read or written in 8-bit units.

Reset sets This register to 00H.

After reset: 00H R/W Address: FFFFFF60H

	7	6	5	4	3	2	1	0
EXDRQEN	RQ3EX1E	RQ2EX1E	RQ1EX1E	RQ0EX1E	RQ3EX0E	RQ2EX0E	RQ1EX0E	RQ0EX0E

RQnEX1E	Assignment of DMA channel n (n = 0 to 3)
0	Does not assign DMA channel n to $\overline{\text{UDMARQ1}}$/$\overline{\text{UDMAAK1}}$ pin
1	Assigns DMA channel n to $\overline{\text{UDMARQ1}}$/$\overline{\text{UDMAAK1}}$ pin

RQnEX0E	Assignment of DMA channel n (n = 0 to 3)
0	Does not assign DMA channel n to $\overline{\text{UDMARQ0}}$/$\overline{\text{UDMAAK0}}$ pin
1	Assigns DMA channel n to $\overline{\text{UDMARQ0}}$/$\overline{\text{UDMAAK0}}$ pin

Cautions 1. Assigning multiple DMA channels to the $\overline{\text{UDMARQ1}}$/$\overline{\text{UDMAAK1}}$ pin is prohibited (setting the RQ3EX1E, RQ2EX1E, RQ1EX1E, and RQ0EX1E bits to the $\overline{\text{UDMARQ1}}$/$\overline{\text{UDMAAK1}}$ pin at the same time is prohibited).

2. Assigning multiple DMA channels to the $\overline{\text{UDMARQ0}}$/$\overline{\text{UDMAAK0}}$ pin is prohibited (setting the RQ3EX0E, RQ2EX0E, RQ1EX0E, and RQ0EX0E bits to the $\overline{\text{UDMARQ0}}$/$\overline{\text{UDMAAK0}}$ pin at the same time is prohibited).

3. Assigning both the $\overline{\text{UDMARQ1}}$/$\overline{\text{UDMAAK1}}$ pin and the $\overline{\text{UDMARQ0}}$/$\overline{\text{UDMAAK0}}$ pin to the same DMA channel is prohibited (setting the RQ3EX1E and RQ3EX0E, RQ2EX1E and RQ2EX0E, RQ1EX1E and RQ1EX0E, and RQ0EX1E and RQ0EX0E bits respectively at the same time is prohibited).

4. When using a DMA request from an external source by setting the EXDRQEN register, set the DTFRn.IFCn5-IFCn0 bit to 000000 (to prohibit a DMA request via an interrupt).
For details, see 22.3 (6) DMA trigger factor registers 0 to 3 (DTFR0 to DTFR3).

22.4 Transfer Targets

Table 22-2 shows the relationship between the transfer targets (√: Transfer enabled, ×: Transfer disabled).

Table 22-2. Relationship Between Transfer Targets

		Transfer Destination			
		Internal ROM	On-Chip Peripheral I/O	Internal RAM	External Memory
Source	On-chip peripheral I/O	×	√	√	√
	Internal RAM	×	√	×	√
	External memory	×	√	√	√
	Internal ROM	×	×	×	×

Caution The operation is not guaranteed for combinations of transfer destination and source marked with "×" in Table 22-2.

22.5 Transfer Modes

Single transfer is supported as the transfer mode.

In single transfer mode, the bus is released at each byte/halfword transfer. If there is a subsequent DMA transfer request, transfer is performed again once. This operation continues until a terminal count occurs.

When the DMAC has released the bus, if another higher priority DMA transfer request is issued, the higher priority DMA request always takes precedence.

If a new transfer request of the same channel and a transfer request of another channel with a lower priority are generated in a transfer cycle, DMA transfer of the channel with the lower priority is executed after the bus is released to the CPU (the new transfer request of the same channel is ignored in the transfer cycle).

22.6 Transfer Types

As a transfer type, the 2-cycle transfer is supported.

In two-cycle transfer, data transfer is performed in two cycles, a read cycle and a write cycle.

In the read cycle, the transfer source address is output and reading is performed from the source to the DMAC. In the write cycle, the transfer destination address is output and writing is performed from the DMAC to the destination.

An idle cycle of one clock is always inserted between a read cycle and a write cycle. If the data bus width differs between the transfer source and destination for DMA transfer of two cycles, the operation is performed as follows.

<16-bit data transfer>

<1> Transfer from 32-bit bus → 16-bit bus
A read cycle (the higher 16 bits are in a high-impedance state) is generated, followed by generation of a write cycle (16 bits).

<2> Transfer from 16-/32-bit bus to 8-bit bus
A 16-bit read cycle is generated once, and then an 8-bit write cycle is generated twice.

<3> Transfer from 8-bit bus to 16-/32-bit bus
An 8-bit read cycle is generated twice, and then a 16-bit write cycle is generated once.

<4> Transfer between 16-bit bus and 32-bit bus
A 16-bit read cycle is generated once, and then a 16-bit write cycle is generated once.

For DMA transfer executed to an on-chip peripheral I/O register (transfer source/destination), be sure to specify the same transfer size as the register size. For example, for DMA transfer to an 8-bit register, be sure to specify byte (8-bit) transfer.

Remark The bus width of each transfer target (transfer source/destination) is as follows.

- On-chip peripheral I/O: 16-bit bus width
- Internal RAM: 32-bit bus width
- External memory: 8-bit or 16-bit bus width

22.7 DMA Channel Priorities

The DMA channel priorities are fixed as follows.

DMA channel 0 > DMA channel 1 > DMA channel 2 > DMA channel 3

The priorities are checked for every transfer cycle.

22.8 Time Related to DMA Transfer

The time required to respond to a DMA request, and the minimum number of clocks required for DMA transfer are shown below.

Single transfer: DMA response time (<1>) + Transfer source memory access (<2>) + 1[Note 1] + Transfer destination memory access (<2>)

DMA Cycle		Minimum Number of Execution Clocks
<1> DMA request response time		4 clocks (MIN.) + Noise elimination time[Note 2]
<2> Memory access	External memory access	Depends on connected memory.
	Internal RAM access	2 clocks[Note 3]
	Peripheral I/O register access	3 clocks + Number of wait cycles specified by VSWC register[Note 4]
	USB register access	4 clocks[Note 5]
	Data-only RAM access	4 clocks[Note 5]

Notes 1. One clock is always inserted between a read cycle and a write cycle in DMA transfer.

2. If an external interrupt (INTPn) is specified as the trigger to start DMA transfer, noise elimination time is added (n = 00 to 18).

3. Two clocks are required for a DMA cycle.

4. More wait cycles are necessary for accessing a specific peripheral I/O register (for details, see **3.4.9 (2)**).

5. This is the number of clocks required when the following wait specifications have been made: 1 data wait (set by the DWC0 register), 0 address waits (set by the AWC register), and 0 idle waits (set by the BCC register).

22.9 DMA Transfer Start Factors

There are two types of DMA transfer start factors, as shown below.

(1) Request by software

If the STGn bit is set to 1 while the DCHCn.TCn bit = 1 and Enn bit = 1 (DMA transfer enabled), DMA transfer is started.

To request the next DMA transfer cycle immediately after that, confirm, by using the DBCn register, that the preceding DMA transfer cycle has been completed, and set the STGn bit to 1 again (n = 0 to 3).

TCn bit = 0, Enn bit = 1
↓
STGn bit = 1 … Starts the first DMA transfer.
↓
Confirm that the contents of the DBCn register have been updated.
STGn bit = 1 … Starts the second DMA transfer.
↓
:
↓
Generation of terminal count … Enn bit = 0, TCn bit = 1, and INTDMAn signal is generated.

(2) Request by on-chip peripheral I/O

If an interrupt request is generated from the on-chip peripheral I/O set by the DTFRn register when the DCHCn.TCn bit = 0 and Enn bit = 1 (DMA transfer enabled), DMA transfer is started.

Cautions 1. Two start factors (software trigger and hardware trigger) cannot be used for one DMA channel. If two start factors are simultaneously generated for one DMA channel, only one of them is valid. The start factor that is valid cannot be identified.

2. A new transfer request that is generated after the preceding DMA transfer request was generated or in the preceding DMA transfer cycle is ignored (cleared).

3. The transfer request interval of the same DMA channel varies depending on the setting of bus wait in the DMA transfer cycle, the start status of the other channels, or the external bus hold request. In particular, as described in Caution 2, a new transfer request that is generated for the same channel before the DMA transfer cycle or during the DMA transfer cycle is ignored. Therefore, the transfer request intervals for the same DMA channel must be sufficiently separated by the system. When the software trigger is used, completion of the DMA transfer cycle that was generated before can be checked by updating the DBCn register.

22.10 DMA Abort Factors

DMA transfer is aborted if a bus hold occurs.

The same applies if transfer is executed between the internal memory/on-chip peripheral I/O and internal memory/on-chip peripheral I/O.

When the bus hold is cleared, DMA transfer is resumed.

22.11 End of DMA Transfer

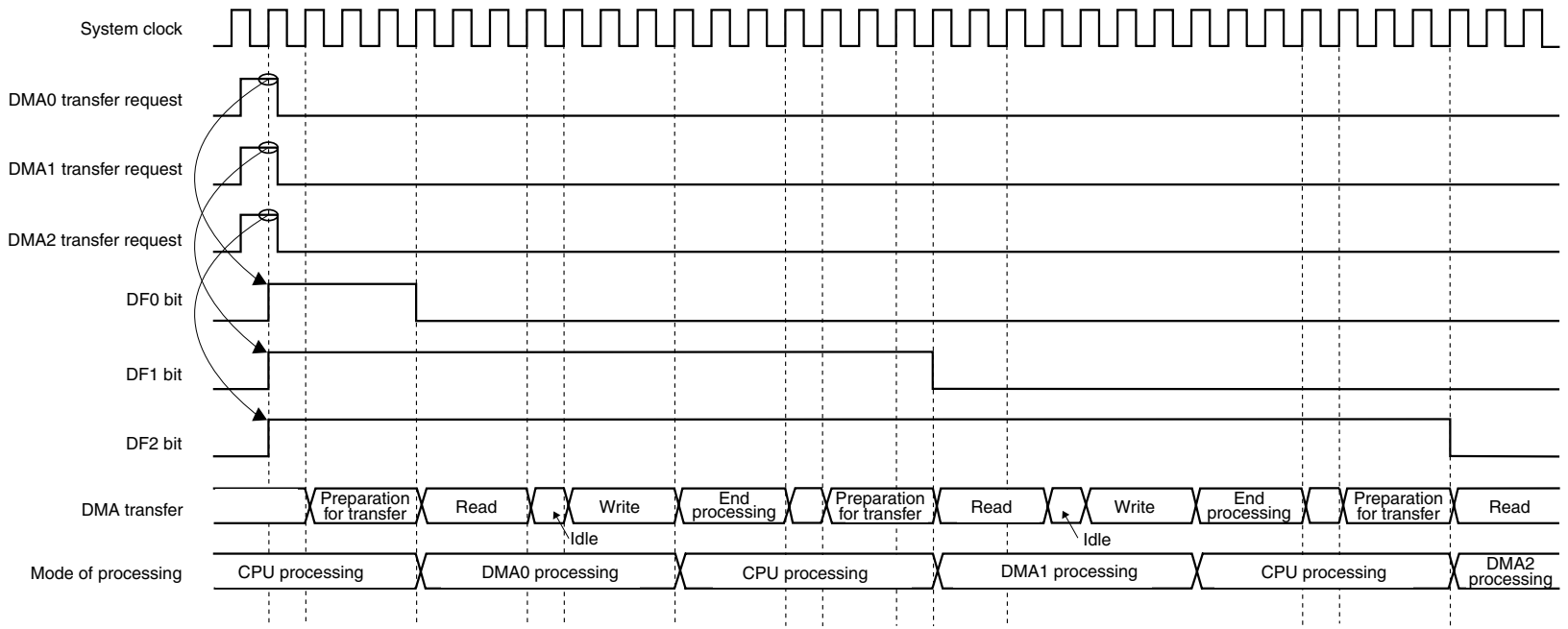
When DMA transfer has been completed the number of times set to the DBCn register and when the DCHCn.Enn bit is cleared to 0 and TCn bit is set to 1, a DMA transfer end interrupt request signal (INTDMAn) is generated for the interrupt controller (INTC) (n = 0 to 3).

The V850ES/JG3-H and V850ES/JH3-H do not output a terminal count signal to external devices. Therefore, confirm completion of DMA transfer by using the DMA transfer end interrupt or polling the TCn bit.

22.12 Operation Timing

Figures 22-1 to 22-4 show DMA operation timing.

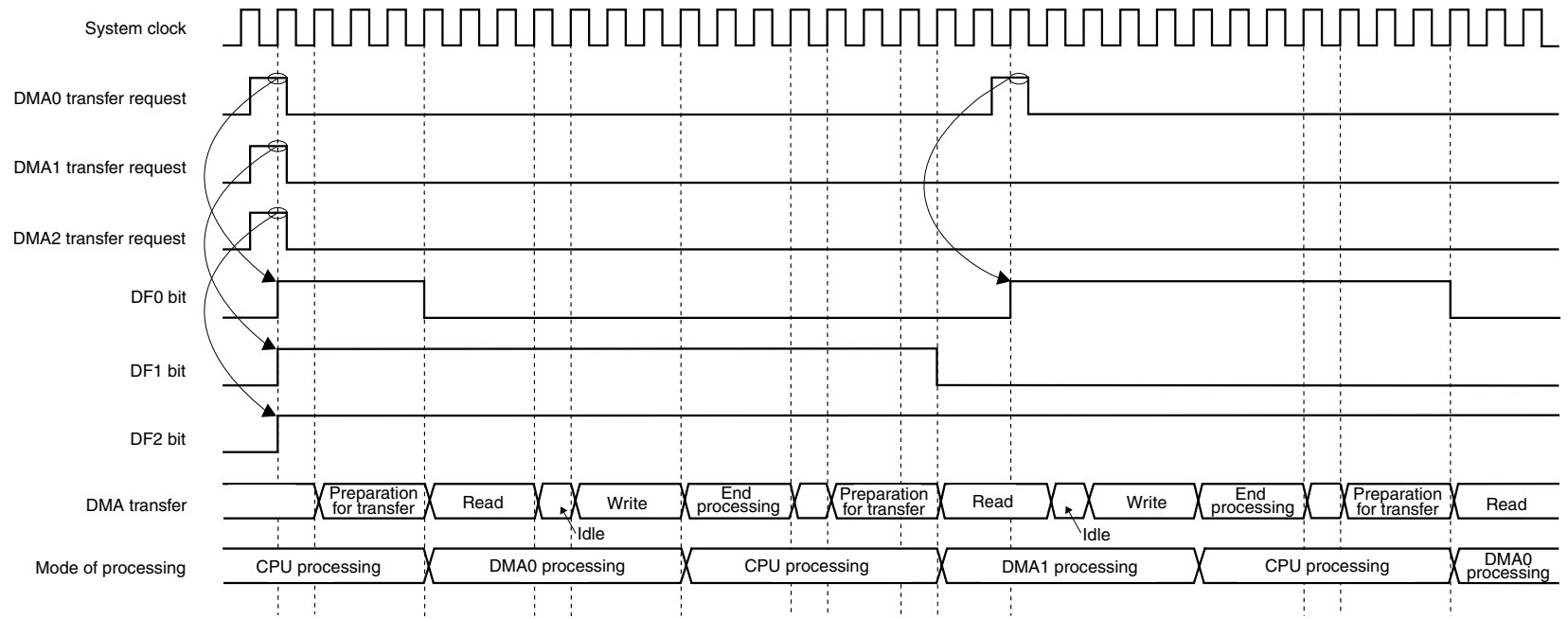
Figure 22-1. Priority of DMA (1)



Remarks 1. Transfer in the order of DMA0 → DMA1 → DMA2

2. In the case of transfer between external memory spaces (multiplexed bus, no wait)

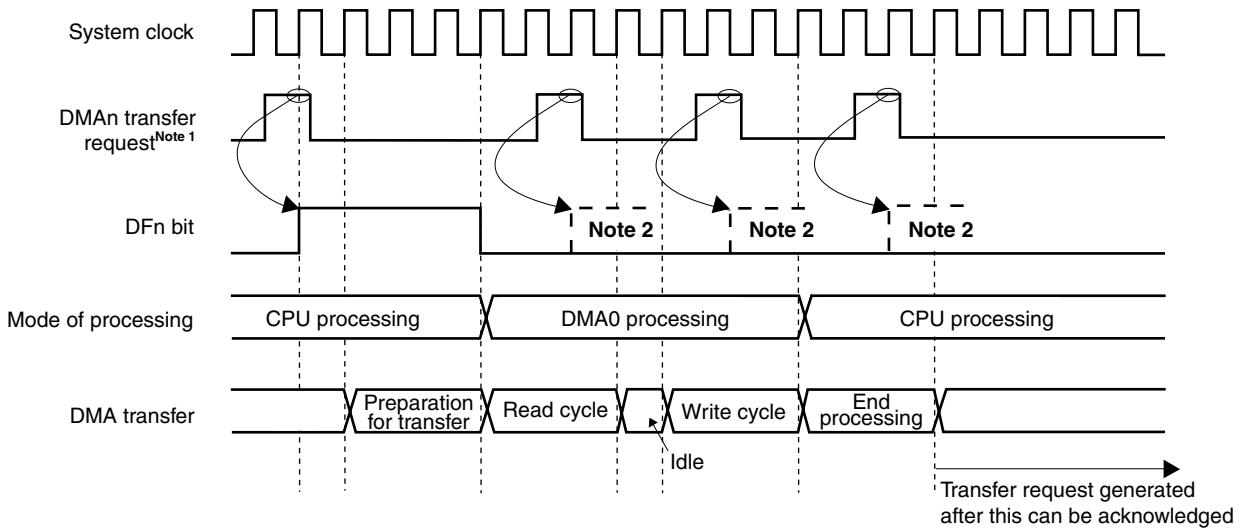
Figure 22-2. Priority of DMA (2)



Remarks 1. Transfer in the order of DMA0 → DMA1 → DMA0 (DMA2 is held pending.)

2. In the case of transfer between external memory spaces (multiplexed bus, no wait)

Figure 22-3. Period in Which DMA Transfer Request Is Ignored (1)

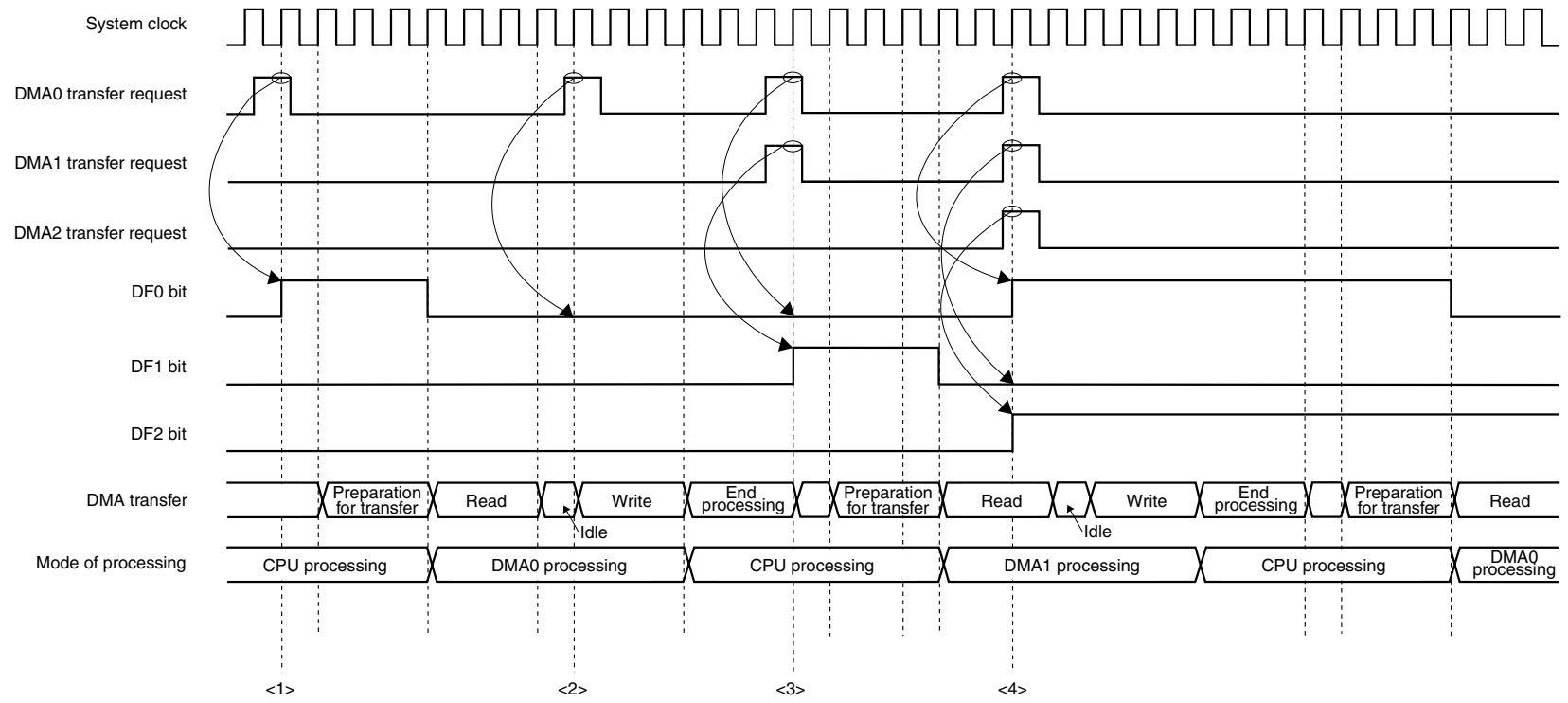


Notes 1. Interrupt from on-chip peripheral I/O, or software trigger (STGn bit)

2. New DMA request of the same channel is ignored between when the first request is generated and the end processing is complete.

Remark In the case of transfer between external memory spaces (multiplexed bus, no wait)

Figure 22-4. Period in Which DMA Transfer Request Is Ignored (2)



<1> DMA0 transfer request

<2> New DMA0 transfer request is generated during DMA0 transfer.

→ A DMA transfer request of the same channel is ignored during DMA transfer.

<3> Requests for DMA0 and DMA1 are generated at the same time.

→ DMA0 request is ignored (a DMA transfer request of the same channel during transfer is ignored).

→ DMA1 request is acknowledged.

<4> Requests for DMA0, DMA1, and DMA2 are generated at the same time.

→ DMA1 request is ignored (a DMA transfer request of the same channel during transfer is ignored).

→ DMA0 request is acknowledged according to priority. DMA2 request is held pending (transfer of DMA2 occurs next).

22.13 Cautions

(1) Caution for VSWC register

When using the DMAC, be sure to set an appropriate value, in accordance with the operating frequency, to the VSWC register.

When the default value (77H) of the VSWC register is used, or if an inappropriate value is set to the VSWC register, the operation is not correctly performed (for details of the VSWC register, see **3.4.9 (1) (a) System wait control register (VSWC)**).

(2) Caution for reading DCHCn.TCn bit (n = 0 to 3)

The TCn bit is cleared to 0 when it is read, but it is not automatically cleared even if it is read at a specific timing. To accurately clear the TCn bit, add the following processing.

(a) When waiting for completion of DMA transfer by polling TCn bit

Confirm that the TCn bit has been set to 1 (after TCn bit = 1 is read), and then read the TCn bit three more times.

(b) When reading TCn bit in interrupt servicing routine

Execute reading the TCn bit three times.

(3) DMA transfer initialization procedure (setting DCHCn.INITn bit to 1)

Even if the INITn bit is set to 1 when the channel executing DMA transfer is to be initialized, the channel may not be initialized. To accurately initialize the channel, execute either of the following two procedures.

(a) Temporarily stop transfer of all DMA channels

Initialize the channel executing DMA transfer using the procedure in <1> to <7> below.

Note, however, that TCn bit is cleared to 0 when step <5> is executed. Make sure that the other processing programs do not expect that the TCn bit is 1.

<1> Disable interrupts (DI).

<2> Read the DCHCn.Enn bit of DMA channels other than the one to be forcibly terminated, and transfer the value to a general-purpose register.

<3> Clear the Enn bit of the DMA channels used (including the channel to be forcibly terminated) to 0. To clear the Enn bit of the last DMA channel, execute the clear instruction twice. If the target of DMA transfer (transfer source/destination) is the internal RAM, execute the instruction three times.

Example: Execute instructions in the following order if channels 0, 1, and 2 are used (if the target of transfer is not the internal RAM).

- Clear DCHC0.E00 bit to 0.
- Clear DCHC1.E11 bit to 0.
- Clear DCHC2.E22 bit to 0.
- Clear DCHC2.E22 bit to 0 again.

<4> Set the INITn bit of the channel to be forcibly terminated to 1.

<5> Read the TCn bit of each channel not to be forcibly terminated. If both the TCn bit and the Enn bit read in <2> are 1 (logical product (AND) is 1), clear the saved Enn bit to 0.

<6> After the operation in <5>, write the Enn bit value to the DCHCn register.

<7> Enable interrupts (EI).

Caution Be sure to execute step <5> above to prevent illegal setting of the Enn bit of the channels whose DMA transfer has been normally completed between <2> and <3>.

(b) Repeatedly execute setting INITn bit until transfer is forcibly terminated correctly

<1> Suppress a request from the DMA request source of the channel to be forcibly terminated (stop operation of the on-chip peripheral I/O).
<2> Check that the DMA transfer request of the channel to be forcibly terminated is not held pending, by using the DTFRn.DFn bit. If a DMA transfer request is held pending, wait until execution of the pending request is completed.
<3> When it has been confirmed that the DMA request of the channel to be forcibly terminated is not held pending, clear the Enn bit to 0.
<4> Again, clear the Enn bit of the channel to be forcibly terminated.
If the target of transfer for the channel to be forcibly terminated (transfer source/destination) is the internal RAM, execute this operation once more.
<5> Copy the initial number of transfers of the channel to be forcibly terminated to a general-purpose register.
<6> Set the INITn bit of the channel to be forcibly terminated to 1.
<7> Read the value of the DBCn register of the channel to be forcibly terminated, and compare it with the value copied in <5>. If the two values do not match, repeat operations <6> and <7>.

Remarks 1. When the value of the DBCn register is read in <7>, the initial number of transfers is read if forced termination has been correctly completed. If not, the remaining number of transfers is read.
2. Note that method (b) may take a long time if the application frequently uses DMA transfer for a channel other than the DMA channel to be forcibly terminated.

(4) Procedure of temporarily stopping DMA transfer (clearing Enn bit)

Stop and resume the DMA transfer under execution using the following procedure.

<1> Suppress a transfer request from the DMA request source (stop the operation of the on-chip peripheral I/O).
<2> Check the DMA transfer request is not held pending, by using the DFn bit (check if the DFn bit = 0).
If a request is pending, wait until execution of the pending DMA transfer request is completed.
<3> If it has been confirmed that no DMA transfer request is held pending, clear the Enn bit to 0 (this operation stops DMA transfer).
<4> Set the Enn bit to 1 to resume DMA transfer.
<5> Resume the operation of the DMA request source that has been stopped (start the operation of the on-chip peripheral I/O).

(5) Memory boundary

The operation is not guaranteed if the address of the transfer source or destination exceeds the area of the DMA target (external memory, internal RAM, or on-chip peripheral I/O) during DMA transfer.

(6) Transferring misaligned data

DMA transfer of misaligned data with a 16-bit bus width is not supported.

If an odd address is specified as the transfer source or destination, the least significant bit of the address is forcibly assumed to be 0.

(7) Bus arbitration for CPU

Because the DMA controller has a higher priority bus mastership than the CPU, a CPU access that takes place during DMA transfer is held pending until the DMA transfer cycle is completed and the bus is released to the CPU. However, the CPU can access the external memory, internal peripheral I/O, and internal RAM for which DMA transfer is not being executed.

- The CPU can access the internal ROM and internal RAM when DMA transfer is being executed between the external memory and on-chip peripheral I/O.
- The CPU can access the internal ROM, and internal peripheral I/O when DMA transfer is being executed between external memories.

(8) Registers/bits that must not be rewritten during DMA operation

Set the following registers at the following timing when a DMA operation is not under execution.

[Registers]

- DSAnH, DSAnL, DDAnH, DDAnL, DBCn, and DADCn registers
- DTFRn.IFCn5 to DTFRn.IFCn0 bits

[Settable timing]

- Period from after reset to start of the first DMA transfer
- Time after channel initialization to start of DMA transfer
- Period from after completion of DMA transfer (TCn bit = 1) to start of the next DMA transfer

(9) Be sure to set the following register bits to 0.

- Bits 14 to 10 of DSAnH register
- Bits 14 to 10 of DDAnH register
- Bits 15, 13 to 8, and 3 to 0 of DADCn register
- Bits 6 to 3 of DCHCn register

(10) DMA start factor

Do not start two or more DMA channels with the same start factor. If two or more channels are started with the same factor, DMA for which a channel has already been set may be started or a DMA channel with a lower priority may be acknowledged earlier than a DMA channel with a higher priority. The operation cannot be guaranteed.

(11) Read values of DSAn and DDAn registers

Values in the middle of updating may be read from the DSAn and DDAn registers during DMA transfer (n = 0 to 3). For example, if the DSAnH register and then the DSAnL register are read when the DMA transfer source address (DSAn register) is 0000FFFFH and the count direction is incremental (DADCn.SAD1 and DADCn.SAD0 bits = 00), the value of the DSAn register differs as follows, depending on whether DMA transfer is executed immediately after the DSAnH register is read.

(a) If DMA transfer does not occur while DSAn register is read

<1> Read value of DSAnH register: DSAnH = 0000H

<2> Read value of DSAnL register: DSAnL = FFFFH

(b) If DMA transfer occurs while DSAn register is read

<1> Read value of DSAnH register: DSAnH = 0000H

<2> Occurrence of DMA transfer

<3> Incrementing DSAn register: DSAn = 00100000H

<4> Read value of DSAnL register: DSAnL = 0000H

CHAPTER 23 INTERRUPT/EXCEPTION PROCESSING FUNCTION

The V850ES/JG3-H and V850ES/JH3-H are provided with a dedicated interrupt controller (INTC) for interrupt servicing and can process a total of 86 to 93 interrupt requests.

An interrupt is an event that occurs independently of program execution, and an exception is an event whose occurrence is dependent on program execution.

The V850ES/JG3-H and V850ES/JH3-H can process interrupt request signals from the on-chip peripheral hardware and external sources. Moreover, exception processing can be started by the TRAP instruction (software exception) or by generation of an exception event (i.e. fetching of an illegal opcode) (exception trap).

23.1 Features

○ Interrupts

Table 23-1. Interrupts of V850ES/JG3-H and V850ES/JH3-H

		Internal			External		
		Non-maskable	Maskable	Total	Non-maskable	Maskable	Total
V850ES/JG3-H	μPD70F3760	1	68	69	1	16	17
	μPD70F3761	1	68	69	1	16	17
	μPD70F3762	1	68	69	1	16	17
	μPD70F3770	1	72	73	1	16	17
V850ES/JH3-H	μPD70F3765	1	68	69	1	19	20
	μPD70F3766	1	68	69	1	19	20
	μPD70F3767	1	68	69	1	19	20
	μPD70F3771	1	72	73	1	19	20

- 8 levels of programmable priorities (maskable interrupts)
- Multiple interrupt control according to priority
- Masks can be specified for each maskable interrupt request.
- Noise elimination, edge detection, and valid edge specification for external interrupt request signals.

○ Exceptions

- Software exceptions: 32 sources
- Exception trap: 2 sources (illegal opcode exception)

Interrupt/exception sources of the V850ES/JG3-H and V850ES/JH3-H are listed in **Tables 23-2** and **23-3**, respectively.

Table 23-2. V850ES/JG3-H Interrupt Sources (1/4)

Type	Classification	Default Priority	Name	Trigger	Generating Unit	Exception Code	Handler Address	Restored PC	Interrupt Control Register
Reset	Interrupt	–	RESET	$\overline{\text{RESET}}$ pin input/ reset input by internal source	RESET	0000H	00000000H	Undefined	–
Non-maskable	Interrupt	–	NMI	NMI pin valid edge input	Pin	0010H	00000010H	nextPC	–
		–	INTWDT2	WDT2 overflow	WDT2	0020H	00000020H	**Note 1**	–
Software exception	Exception	–	TRAP0n[Note 2]	TRAP instruction	–	004nH[Note 2]	00000040H	nextPC	–
		–	TRAP1n[Note 2]	TRAP instruction	–	005nH[Note 2]	00000050H	nextPC	–
Exception trap	Exception	–	ILGOP/ DBG0	Illegal opcode/DBTRAP instruction	–	0060H	00000060H	nextPC	–
Maskable	Interrupt	0	INTLVI	Low voltage detection	POCLVI	0080H	00000080H	nextPC	LVIIC
		3	INTP02	External interrupt pin input edge detection (INTP02)	Pin	00B0H	000000B0H	nextPC	PIC02
		4	INTP03	External interrupt pin input edge detection (INTP03)	Pin	00C0H	000000C0H	nextPC	PIC03
		5	INTP04	External interrupt pin input edge detection (INTP04)	Pin	00D0H	000000D0H	nextPC	PIC04
		6	INTP05	External interrupt pin input edge detection (INTP05)	Pin	00E0H	000000E0H	nextPC	PIC05
		8	INTP07	External interrupt pin input edge detection (INTP07)	Pin	0100H	00000100H	nextPC	PIC07
		9	INTP08	External interrupt pin input edge detection (INTP08)	Pin	0110H	00000110H	nextPC	PIC08
		10	INTP09	External interrupt pin input edge detection (INTP09)	Pin	0120H	00000120H	nextPC	PIC09
		11	INTP10	External interrupt pin input edge detection (INTP10)	Pin	0130H	00000130H	nextPC	PIC10
		12	INTP11	External interrupt pin input edge detection (INTP11)	Pin	0140H	00000140H	nextPC	PIC11
		13	INTP12	External interrupt pin input edge detection (INTP12)	Pin	0150H	00000150H	nextPC	PIC12
		14	INTP13	External interrupt pin input edge detection (INTP16)	Pin	0160H	00000160H	nextPC	PIC13
		15	INTP14	External interrupt pin input edge detection (INTP14)	Pin	0170H	00000170H	nextPC	PIC14
		16	INTP15	External interrupt pin input edge detection (INTP15)	Pin	0180H	00000180H	nextPC	PIC15
		17	INTP16	External interrupt pin input edge detection (INTP16)	Pin	0190H	00000190H	nextPC	PIC16

Notes 1. For restoring in the case of INTWDT2, see **23.2.2 (2) From INTWDT2 signal**.

2. n = 0 to FH

Table 23-2. V850ES/JG3-H Interrupt Sources (2/4)

Type	Classification	Default Priority	Name	Trigger	Generating Unit	Exception Code	Handler Address	Restored PC	Interrupt Control Register
Maskable	Interrupt	18	INTP17	External interrupt pin input edge detection (INTP17)	Pin	01A0H	000001A0H	nextPC	PIC17
		19	INTP18	External interrupt pin input edge detection (INTP18)	Pin	01B0H	000001B0H	nextPC	PIC18
		20	INTTAB0OV	TAB0 overflow	TAB0	01C0H	000001C0H	nextPC	TAB0OVIC
		21	INTTAB0CC0	TAB0 capture 0/ compare 0 match	TAB0	01D0H	000001D0H	nextPC	TAB0CCIC0
		22	INTTAB0CC1	TAB0 capture 1/ compare 1 match	TAB0	01E0H	000001E0H	nextPC	TAB0CCIC1
		23	INTTAB0CC2	TAB0 capture 2/ compare 2 match	TAB0	01F0H	000001F0H	nextPC	TAB0CCIC2
		24	INTTAB0CC3	TAB0 capture 3/ compare 3 match	TAB0	0200H	00000200H	nextPC	TAB0CCIC3
		25	INTTAB1OV[Note 1]	TAB1 overflow	TAB1	0210H	00000210H	nextPC	TAB1OVIC
		26	INTTAB1CC0[Note 2]	TAB1 capture 0/ compare 0 match	TAB1	0220H	00000220H	nextPC	TAB1CCIC0
		27	INTTAB1CC1	TAB1 capture 1/ compare 1 match	TAB1	0230H	00000230H	nextPC	TAB1CCIC1
		28	INTTAB1CC2	TAB1 capture 2/ compare 2 match	TAB1	0240H	00000240H	nextPC	TAB1CCIC2
		29	INTTAB1CC3	TAB1 capture 3/ compare 3 match	TAB1	0250H	00000250H	nextPC	TAB1CCIC3
		30	INTTT0OV	TMT0 overflow	TMT0	0260H	00000260H	nextPC	TT0OVIC
		31	INTTT0CC0	TMT0 capture 0/ compare 0 match	TMT0	0270H	00000270H	nextPC	TT0CCIC0
		32	INTTT0CC1	TMT0 capture 1/ compare 1 match	TMT0	0280H	00000280H	nextPC	TT0CCIC1
		33	INTTT0EC	TMT0 encoder input	TMT0	0290H	00000290H	nextPC	TT0ECIC
		34	INTTAA0OV	TAA0 overflow	TAA0	02A0H	000002A0H	nextPC	TAA0OVIC
		35	INTTAA0CC0	TAA0 capture 0/ compare 0 match	TAA0	02B0H	000002B0H	nextPC	TAA0CCIC0
		36	INTTAA0CC1	TAA0 capture 1/ compare 1 match	TAA0	02C0H	000002C0H	nextPC	TAA0CCIC1
		37	INTTAA1OV	TAA1 overflow	TAA1	02D0H	000002D0H	nextPC	TAA1OVIC
		38	INTTAA1CC0	TAA1 capture 0/ compare 0 match	TAA1	02E0H	000002E0H	nextPC	TAA1CCIC0
		39	INTTAA1CC1	TAA1 capture 1/ compare 1 match	TAA1	02F0H	000002F0H	nextPC	TAA1CCIC1
		40	INTTAA2OV	TAA2 overflow	TAA2	0300H	00000300H	nextPC	TAA2OVIC

Notes 1. When using TAB1 in the 6-phase PWM output mode, functions as the zero match interrupt (TAB1TIOD) request from TMQOP.

2. When using TAB1 in the 6-phase PWM output mode, functions as the compare match interrupt (TAB1TICD0) request from TMQOP.

Table 23-2. V850ES/JG3-H Interrupt Sources (3/4)

Type	Classification	Default Priority	Name	Trigger	Generating Unit	Exception Code	Handler Address	Restored PC	Interrupt Control Register
Maskable	Interrupt	41	INTTAA2CC0	TAA2 capture 0/ compare 0 match	TAA2	0310H	00000310H	nextPC	TAA2CCIC0
		42	INTTAA2CC1	TAA2 capture 1/ compare 1 match	TAA2	0320H	00000320H	nextPC	TAA2CCIC1
		43	INTTAA3OV	TAA3 overflow	TAA3	0330H	00000330H	nextPC	TAA3OVIC
		44	INTTAA3CC0	TAA3 capture 0/ compare 0 match	TAA3	0340H	00000340H	nextPC	TAA3CCIC0
		45	INTTAA3CC1	TAA3 capture 1/ compare 1 match	TAA3	0350H	00000350H	nextPC	TAA3CCIC1
		46	INTTAA4OV	TAA4 overflow	TAA4	0360H	00000360H	nextPC	TAA4OVIC
		47	INTTAA4CC0	TAA4 compare 0 match	TAA4	0370H	00000370H	nextPC	TAA4CCIC0
		48	INTTAA4CC1	TAA4 compare 1 match	TAA4	0380H	00000380H	nextPC	TAA4CCIC1
		49	INTTAA5OV	TAA5 overflow	TAA5	0390H	00000390H	nextPC	TAA5OVIC
		50	INTTAA5CC0	TAA5 capture 0/ compare 0 match	TAA5	03A0H	000003A0H	nextPC	TAA5CCIC0
		51	INTTAA5CC1	TAA5 capture 1/ compare 1 match	TAA5	03B0H	000003B0H	nextPC	TAA5CCIC1
		52	INTTM0EQ0	TMM0 compare match	TMM0	03C0H	000003C0H	nextPC	TM0EQIC0
		53	INTTM1EQ0	TMM1 compare match	TMM1	03D0H	000003D0H	nextPC	TM1EQIC0
		54	INTTM2EQ0	TMM2 compare match	TMM2	03E0H	000003E0H	nextPC	TM2EQIC0
		55	INTTM3EQ0	TMM3 compare match	TMM3	03F0H	000003F0H	nextPC	TM3EQIC0
		56	INTCF0R /INTIIC1	CSIF0 reception completion/ CSIF0 reception error/ IIC1 transfer completion	CSIF0/ IIC1	0400H	00000400H	nextPC	CF0RIC/ IICIC1
		57	INTCF0T	CSIF0 consecutive transmission write enable	CSIF0	0410H	00000410H	nextPC	CF0TIC
		58	INTCF1R	CSIF1 reception completion/ CSIF1 reception error	CSIF1	0420H	00000420H	nextPC	CF1RIC
		59	INTCF1T	CSIF1 consecutive transmission write enable	CSIF1	0430H	00000430H	nextPC	CF1TIC
		60	INTCF2R	CSIF2 reception completion/ CSIF2 reception error	CSIF2	0440H	00000440H	nextPC	CF2RIC
		61	INTCF2T	CSIF2 consecutive transmission write enable	CSIF2	0450H	00000450H	nextPC	CF2TIC
		62	INTCF3R	CSIF3 reception completion/ CSIF3 reception error	CSIF3	0460H	00000460H	nextPC	CF3RIC
		63	INTCF3T	CSIF3 consecutive transmission write enable	CSIF3	0470H	00000470H	nextPC	CF3TIC
		64	INTCF4R	CSIF4 reception completion/ CSIF4 reception error	CSIF4	0480H	00000480H	nextPC	CF4RIC
		65	INTCF4T	CSIF4 consecutive transmission write enable	CSIF4	0490H	00000490H	nextPC	CF4TIC

Table 23-2. V850ES/JG3-H Interrupt Sources (4/4)

Type	Classification	Default Priority	Name	Trigger	Generating Unit	Exception Code	Handler Address	Restored PC	Interrupt Control Register
Maskable	Interrupt	66	INTUC0R	UARTC0 reception completion/UARTC0 reception error	UARTC0	04A0H	000004A0H	nextPC	UC0RIC
		67	INTUC0T	UARTC0 consecutive transmission enable	UARTC0	04B0H	000004B0H	nextPC	UC0TIC
		68	INTUC1R/ INTIIC2	UARTC1 reception completion/UARTC1 reception error/IIC2 transfer completion	UARTC1/ IIC2	04C0H	000004C0H	nextPC	UC1RIC/ IICIC2
		69	INTUC1T	UARTC1 consecutive transmission enable	UARTC1	04D0H	000004D0H	nextPC	UC1TIC
		70	INTUC2R	UARTC2 reception completion/UARTC2 reception error	UARTC2	04E0H	000004E0H	nextPC	UC2RIC
		71	INTUC2T	UARTC2 consecutive transmission enable	UARTC2	04F0H	000004F0H	nextPC	UC2TIC
		72	INTUC3R/ INTIIC0	UARTC3 reception completion/UARTC0 reception error/IIC0 transfer completion	UARTC3/ IIC0	0500H	00000500H	nextPC	UC3RIC/ IICIC0
		73	INTUC3T	UARTC3 consecutive transmission enable	UARTC3	0510H	00000510H	nextPC	UC3TIC
		74	INTUC4R	UARTC4 reception completion/UARTC4 reception error	UARTC4	0520H	00000520H	nextPC	UC4RIC
		75	INTUC4T	UARTC4 consecutive transmission enable	UARTC4	0530H	00000530H	nextPC	UC4TIC
		76	INTAD	A/D conversion completion	A/D	0540H	00000540H	nextPC	ADIC
		77	INTDMA0	DMA0 transfer completion	DMA	0550H	00000550H	nextPC	DMAIC0
		78	INTDMA1	DMA1 transfer completion	DMA	0560H	00000560H	nextPC	DMAIC1
		79	INTDMA2	DMA2 transfer completion	DMA	0570H	00000570H	nextPC	DMAIC2
		80	INTDMA3	DMA3 transfer completion	DMA	0580H	00000580H	nextPC	DMAIC3
		81	INTKR	Key return interrupt	KR	0590H	00000590H	nextPC	KRIC
		82	INTRTC0	RTC constant cycle signal	RTC	05A0H	000005A0H	nextPC	RTC0IC
		83	INTRTC1	RTC alarm match	RTC	05B0H	000005B0H	nextPC	RTC1IC
		84	INTRTC2	RTC interval signal	RTC	05C0H	000005C0H	nextPC	RTC2IC
		85	INTC0ERR[Note]	CAN0 error	CAN0	05D0H	000005D0H	nextPC	ERRIC0
		86	INTC0WUP1[Note]	CAN0 wake up	CAN0	05E0H	000005E0H	nextPC	WUPIC0
		87	INTC0REC[Note]	CAN0 reception	CAN0	05F0H	000005F0H	nextPC	RECIC0
		88	INTC0TRX[Note]	CAN0 transmission	CAN0	0600H	00000600H	nextPC	TRXIC0
		92	INTUSBF0	USBF interrupt	USBF	0640H	00000640H	nextPC	UFIC0
		93	INTUSBF1	USBF resume interrupt	USBF	0650H	00000650H	nextPC	UFIC1

Note μPD70F3770 only

Remarks 1. Default Priority: The priority order when two or more maskable interrupt requests occur at the same time. The highest priority is 0.

The priority order of non-maskable interrupt is INTWDT2 > NMI.

Restored PC: The value of the program counter (PC) saved to EIPC, FEPC, or DBPC when interrupt servicing is started. Note, however, that the restored PC when a non-maskable or maskable interrupt is acknowledged while one of the following instructions is being executed does not become the nextPC (if an interrupt is acknowledged during interrupt execution, execution stops, and then resumes after the interrupt servicing has finished).

- Load instructions (SLD.B, SLD.BU, SLD.H, SLD.HU, SLD.W)
- Division instructions (DIV, DIVH, DIVU, DIVHU)
- PREPARE, DISPOSE instructions (only if an interrupt is generated before the stack pointer is updated)

nextPC: The PC value that starts the processing following interrupt/exception processing.

2. The execution address of the illegal instruction when an illegal opcode exception occurs is calculated by (Restored PC − 4).

Table 23-3. V850ES/JH3-H Interrupt Sources (1/4)

Type	Classification	Default Priority	Name	Trigger	Generating Unit	Exception Code	Handler Address	Restored PC	Interrupt Control Register
Reset	Interrupt	–	RESET	$\overline{\text{RESET}}$ pin input/ Reset input by internal source	RESET	0000H	00000000H	Undefined	–
Non-maskable	Interrupt	–	NMI	NMI pin valid edge input	Pin	0010H	00000010H	nextPC	–
		–	INTWDT2	WDT2 overflow	WDT2	0020H	00000020H	**Note 1**	–
Software exception	Exception	–	TRAP0n[Note 2]	TRAP instruction	–	004nH[Note 2]	00000040H	nextPC	–
		–	TRAP1n[Note 2]	TRAP instruction	–	005nH[Note 2]	00000050H	nextPC	–
Exception trap	Exception	–	ILGOP/DBG0	Illegal opcode/ DBTRAP instruction	–	0060H	00000060H	nextPC	–
Maskable	Interrupt	0	INTLVI	Low voltage detection	POCLVI	0080H	00000080H	nextPC	LVIIC
		1	INTP00	External interrupt pin input edge detection (INTP00)	Pin	0090H	00000090H	nextPC	PIC00
		2	INTP01	External interrupt pin input edge detection (INTP01)	Pin	00A0H	000000A0H	nextPC	PIC01
		3	INTP02	External interrupt pin input edge detection (INTP02)	Pin	00B0H	000000B0H	nextPC	PIC02
		4	INTP03	External interrupt pin input edge detection (INTP03)	Pin	00C0H	000000C0H	nextPC	PIC03
		5	INTP04	External interrupt pin input edge detection (INTP04)	Pin	00D0H	000000D0H	nextPC	PIC04
		6	INTP05	External interrupt pin input edge detection (INTP05)	Pin	00E0H	000000E0H	nextPC	PIC05
		7	INTP06	External interrupt pin input edge detection (INTP06)	Pin	00F0H	000000F0H	nextPC	PIC06
		8	INTP07	External interrupt pin input edge detection (INTP07)	Pin	0100H	00000100H	nextPC	PIC07
		9	INTP08	External interrupt pin input edge detection (INTP08)	Pin	0110H	00000110H	nextPC	PIC08
		10	INTP09	External interrupt pin input edge detection (INTP09)	Pin	0120H	00000120H	nextPC	PIC09
		11	INTP10	External interrupt pin input edge detection (INTP10)	Pin	0130H	00000130H	nextPC	PIC10
		12	INTP11	External interrupt pin input edge detection (INTP11)	Pin	0140H	00000140H	nextPC	PIC11
		13	INTP12	External interrupt pin input edge detection (INTP12)	Pin	0150H	00000150H	nextPC	PIC12
		14	INTP13	External interrupt pin input edge detection (INTP16)	Pin	0160H	00000160H	nextPC	PIC13
		15	INTP14	External interrupt pin input edge detection (INTP14)	Pin	0170H	00000170H	nextPC	PIC14

Notes 1. For restoring in the case of INTWDT2, see **23.2.2 (2) From INTWDT2 signal**.

2. n = 0 to FH

Table 23-3. V850ES/JH3-H Interrupt Sources (2/4)

Type	Classification	Default Priority	Name	Trigger	Generating Unit	Exception Code	Handler Address	Restored PC	Interrupt Control Register
Maskable	Interrupt	16	INTP15	External interrupt pin input edge detection (INTP15)	Pin	0180H	00000180H	nextPC	PIC15
		17	INTP16	External interrupt pin input edge detection (INTP16)	Pin	0190H	00000190H	nextPC	PIC16
		18	INTP17	External interrupt pin input edge detection (INTP17)	Pin	01A0H	000001A0H	nextPC	PIC17
		19	INTP18	External interrupt pin input edge detection (INTP18)	Pin	01B0H	000001B0H	nextPC	PIC18
		20	INTTAB0OV	TAB0 overflow	TAB0	01C0H	000001C0H	nextPC	TAB0OVIC
		21	INTTAB0CC0	TAB0 capture 0/ compare 0 match	TAB0	01D0H	000001D0H	nextPC	TAB0CCIC0
		22	INTTAB0CC1	TAB0 capture 1/ compare 1 match	TAB0	01E0H	000001E0H	nextPC	TAB0CCIC1
		23	INTTAB0CC2	TAB0 capture 2/ compare 2 match	TAB0	01F0H	000001F0H	nextPC	TAB0CCIC2
		24	INTTAB0CC3	TAB0 capture 3/ compare 3 match	TAB0	0200H	00000200H	nextPC	TAB0CCIC3
		25	INTTAB1OV[Note 1]	TAB1 overflow	TAB1	0210H	00000210H	nextPC	TAB1OVIC
		26	INTTAB1CC0[Note 2]	TAB1 capture 0/ compare 0 match	TAB1	0220H	00000220H	nextPC	TAB1CCIC0
		27	INTTAB1CC1	TAB1 capture 1/ compare 1 match	TAB1	0230H	00000230H	nextPC	TAB1CCIC1
		28	INTTAB1CC2	TAB1 capture 2/ compare 2 match	TAB1	0240H	00000240H	nextPC	TAB1CCIC2
		29	INTTAB1CC3	TAB1 capture 3/ compare 3 match	TAB1	0250H	00000250H	nextPC	TAB1CCIC3
		30	INTTT0OV	TMT0 overflow	TMT0	0260H	00000260H	nextPC	TT0OVIC
		31	INTTT0CC0	TMT0 capture 0/ compare 0 match	TMT0	0270H	00000270H	nextPC	TT0CCIC0
		32	INTTT0CC1	TMT0 capture 1/ compare 1 match	TMT0	0280H	00000280H	nextPC	TT0CCIC1
		33	INTTT0EC	TMT0 encoder input	TMT0	0290H	00000290H	nextPC	TT0ECIC
		34	INTTAA0OV	TAA0 overflow	TAA0	02A0H	000002A0H	nextPC	TAA0OVIC
		35	INTTAA0CC0	TAA0 capture 0/ compare 0 match	TAA0	02B0H	000002B0H	nextPC	TAA0CCIC0
		36	INTTAA0CC1	TAA0 capture 1/ compare 1 match	TAA0	02C0H	000002C0H	nextPC	TAA0CCIC1
		37	INTTAA1OV	TAA1 overflow	TAA1	02D0H	000002D0H	nextPC	TAA1OVIC

Notes 1. When using TAB1 in the 6-phase PWM output mode, functions as the zero match interrupt (TAB1TIOD) request from TMQOP.

2. When using TAB1 in the 6-phase PWM output mode, functions as the compare match interrupt (TAB1TICD0) request from TMQOP.

Table 23-3. V850ES/JH3-H Interrupt Sources (3/4)

Type	Classification	Default Priority	Name	Trigger	Generating Unit	Exception Code	Handler Address	Restored PC	Interrupt Control Register
Maskable	Interrupt	38	INTTAA1CC0	TAA1 capture 0/ compare 0 match	TAA1	02E0H	000002E0H	nextPC	TAA1CCIC0
		39	INTTAA1CC1	TAA1 capture 1/ compare 1 match	TAA1	02F0H	000002F0H	nextPC	TAA1CCIC1
		40	INTTAA2OV	TAA2 overflow	TAA2	0300H	00000300H	nextPC	TAA2OVIC
		41	INTTAA2CC0	TAA2 capture 0/ compare 0 match	TAA2	0310H	00000310H	nextPC	TAA2CCIC0
		42	INTTAA2CC1	TAA2 capture 1/ compare 1 match	TAA2	0320H	00000320H	nextPC	TAA2CCIC1
		43	INTTAA3OV	TAA3 overflow	TAA3	0330H	00000330H	nextPC	TAA3OVIC
		44	INTTAA3CC0	TAA3 capture 0/ compare 0 match	TAA3	0340H	00000340H	nextPC	TAA3CCIC0
		45	INTTAA3CC1	TAA3 capture 1/ compare 1 match	TAA3	0350H	00000350H	nextPC	TAA3CCIC1
		46	INTTAA4OV	TAA4 overflow	TAA4	0360H	00000360H	nextPC	TAA4OVIC
		47	INTTAA4CC0	TAA4 compare 0 match	TAA4	0370H	00000370H	nextPC	TAA4CCIC0
		48	INTTAA4CC1	TAA4 compare 1 match	TAA4	0380H	00000380H	nextPC	TAA4CCIC1
		49	INTTAA5OV	TAA5 overflow	TAA5	0390H	00000390H	nextPC	TAA5OVIC
		50	INTTAA5CC0	TAA5 capture 0/ compare 0 match	TAA5	03A0H	000003A0H	nextPC	TAA5CCIC0
		51	INTTAA5CC1	TAA5 capture 1/ compare 1 match	TAA5	03B0H	000003B0H	nextPC	TAA5CCIC1
		52	INTTM0EQ0	TMM0 compare match	TMM0	03C0H	000003C0H	nextPC	TM0EQIC0
		53	INTTM1EQ0	TMM1 compare match	TMM1	03D0H	000003D0H	nextPC	TM1EQIC0
		54	INTTM2EQ0	TMM2 compare match	TMM2	03E0H	000003E0H	nextPC	TM2EQIC0
		55	INTTM3EQ0	TMM3 compare match	TMM3	03F0H	000003F0H	nextPC	TM3EQIC0
		56	INTCF0R/ INTIIC1	CSIF0 reception completion/ CSIF0 reception error/ IIC1 transfer completion	CSIF0/ IIC1	0400H	00000400H	nextPC	CF0RIC/ IICIC1
		57	INTCF0T	CSIF0 consecutive transmission write enable	CSIF0	0410H	00000410H	nextPC	CF0TIC
		58	INTCF1R	CSIF1 reception completion/ CSIF1 reception error	CSIF1	0420H	00000420H	nextPC	CF1RIC
		59	INTCF1T	CSIF1 consecutive transmission write enable	CSIF1	0430H	00000430H	nextPC	CF1TIC
		60	INTCF2R	CSIF2 reception completion/ CSIF2 reception error	CSIF2	0440H	00000440H	nextPC	CF2RIC
		61	INTCF2T	CSIF2 consecutive transmission write enable	CSIF2	0450H	00000450H	nextPC	CF2TIC
		62	INTCF3R	CSIF3 reception completion/ CSIF3 reception error	CSIF3	0460H	00000460H	nextPC	CF3RIC

Table 23-3. V850ES/JH3-H Interrupt Sources (4/4)

Type	Classification	Default Priority	Name	Trigger	Generating Unit	Exception Code	Handler Address	Restored PC	Interrupt Control Register
Maskable	Interrupt	63	INTCF3T	CSIF3 consecutive transmission write enable	CSIF3	0470H	00000470H	nextPC	CF3TIC
		64	INTCF4R	CSIF4 reception completion/ CSIF4 reception error	CSIF4	0480H	00000480H	nextPC	CF4RIC
		65	INTCF4T	CSIF4 consecutive transmission write enable	CSIF4	0490H	00000490H	nextPC	CF4TIC
		66	INTUC0R	UARTC0 reception completion/UARTC0 reception error	UARTC0	04A0H	000004A0H	nextPC	UC0RIC
		67	INTUC0T	UARTC0 consecutive transmission enable	UARTC0	04B0H	000004B0H	nextPC	UC0TIC
		68	INTUC1R /INTIIC2	UARTC1 reception completion/UARTC1 reception error/IIC2 transfer completion	UARTC1/ IIC2	04C0H	000004C0H	nextPC	UC1RIC/ IICIC2
		69	INTUC1T	UARTC1 consecutive transmission enable	UARTC1	04D0H	000004D0H	nextPC	UC1TIC
		70	INTUC2R	UARTC2 reception completion/UARTC2 reception error	UARTC2	04E0H	000004E0H	nextPC	UC2RIC
		71	INTUC2T	UARTC2 consecutive transmission enable	UARTC2	04F0H	000004F0H	nextPC	UC2TIC
		72	INTUC3R/ INTIIC0	UARTC3 reception completion/UARTC0 reception error/IIC0 transfer completion	UARTC3/ IIC0	0500H	00000500H	nextPC	UC3RIC/ IICIC0
		73	INTUC3T	UARTC3 consecutive transmission enable	UARTC3	0510H	00000510H	nextPC	UC3TIC
		74	INTUC4R	UARTC4 reception completion/UARTC4 reception error	UARTC4	0520H	00000520H	nextPC	UC4RIC
		75	INTUC4T	UARTC4 consecutive transmission enable	UARTC4	0530H	00000530H	nextPC	UC4TIC
		76	INTAD	A/D conversion completion	A/D	0540H	00000540H	nextPC	ADIC
		77	INTDMA0	DMA0 transfer completion	DMA	0550H	00000550H	nextPC	DMAIC0
		78	INTDMA1	DMA1 transfer completion	DMA	0560H	00000560H	nextPC	DMAIC1
		79	INTDMA2	DMA2 transfer completion	DMA	0570H	00000570H	nextPC	DMAIC2
		80	INTDMA3	DMA3 transfer completion	DMA	0580H	00000580H	nextPC	DMAIC3
		81	INTKR	Key return interrupt	KR	0590H	00000590H	nextPC	KRIC
		82	INTRTC0	RTC constant cycle signal	RTC	05A0H	000005A0H	nextPC	RTC0IC
		83	INTRTC1	RTC alarm match	RTC	05B0H	000005B0H	nextPC	RTC1IC
		84	INTRTC2	RTC interval signal	RTC	05C0H	000005C0H	nextPC	RTC2IC
		85	INTC0ERR[Note]	CAN0 error	CAN0	05D0H	000005D0H	nextPC	ERRIC0
		86	INTC0WUP1[Note]	CAN0 wake up	CAN0	05E0H	000005E0H	nextPC	WUPIC0
		87	INTC0REC[Note]	CAN0 reception	CAN0	05F0H	000005F0H	nextPC	RECIC0
		88	INTC0TRX[Note]	CAN0 transmission	CAN0	0600H	00000600H	nextPC	TRXIC0
		92	INTUSBF0	USBF interrupt	USBF	0640H	00000640H	nextPC	UFIC0
		93	INTUSBF1	USBF resume interrupt	USBF	0650H	00000650H	nextPC	UFIC1

Note μPD70F3771 only

Remarks 1. Default Priority: The priority order when two or more maskable interrupt requests occur at the same time. The highest priority is 0.

The priority order of non-maskable interrupt is INTWDT2 > NMI.

Restored PC: The value of the program counter (PC) saved to EIPC, FEPC, or DBPC when interrupt servicing is started. Note, however, that the restored PC when a non-maskable or maskable interrupt is acknowledged while one of the following instructions is being executed does not become the nextPC (if an interrupt is acknowledged during interrupt execution, execution stops, and then resumes after the interrupt servicing has finished).

- Load instructions (SLD.B, SLD.BU, SLD.H, SLD.HU, SLD.W)
- Division instructions (DIV, DIVH, DIVU, DIVHU)
- PREPARE, DISPOSE instructions (only if an interrupt is generated before the stack pointer is updated)

nextPC: The PC value that starts the processing following interrupt/exception processing.

2. The execution address of the illegal instruction when an illegal opcode exception occurs is calculated by (Restored PC − 4).

23.2 Non-Maskable Interrupts

A non-maskable interrupt request signal is acknowledged unconditionally, even when interrupts are in the interrupt disabled (DI) status. An NMI is not subject to priority control and takes precedence over all the other interrupt request signals.

This product has the following two non-maskable interrupt request signals.

- NMI pin input (NMI)
- Non-maskable interrupt request signal generated by overflow of watchdog timer (INTWDT2)

The valid edge of the NMI pin can be selected from four types: “rising edge”, “falling edge”, “both edges”, and “no edge detection”.

The non-maskable interrupt request signal generated by overflow of watchdog timer 2 (INTWDT2) functions when the WDTM2.WDM21 and WDTM2.WDM20 bits are set to “01”.

If two or more non-maskable interrupt request signals occur at the same time, the interrupt with the higher priority is serviced, as follows (the interrupt request signal with the lower priority is ignored).

INTWDT2 > NMI

If a new NMI or INTWDT2 request signal is issued while an NMI is being serviced, it is serviced as follows.

(1) If new NMI request signal is issued while NMI is being serviced

The new NMI request signal is held pending, regardless of the value of the PSW.NP bit. The pending NMI request signal is acknowledged after the NMI currently under execution has been serviced (after the RETI instruction has been executed).

(2) If INTWDT2 request signal is issued while NMI is being serviced

The INTWDT2 request signal is held pending if the NP bit remains set (1) while the NMI is being serviced. The pending INTWDT2 request signal is acknowledged after the NMI currently under execution has been serviced (after the RETI instruction has been executed).

If the NP bit is cleared (0) while the NMI is being serviced, the newly generated INTWDT2 request signal is executed (the NMI servicing is stopped).

Caution For the non-maskable interrupt servicing executed by the non-maskable interrupt request signal (INTWDT2), see 23.2.2 (2) From INTWDT2 signal.

Figure 23-1. Non-Maskable Interrupt Request Signal Acknowledgment Operation (1/2)

(a) NMI and INTWDT2 request signals generated at the same time

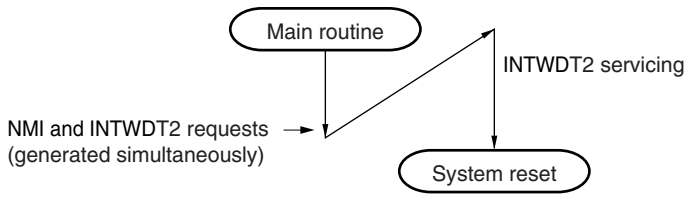
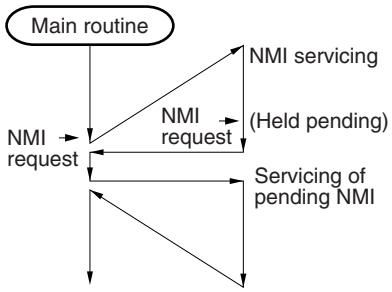
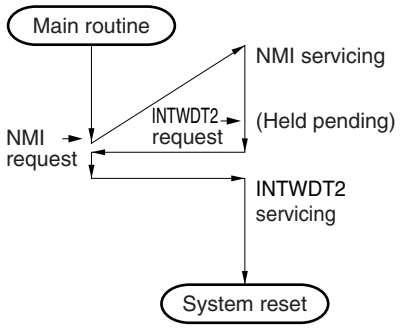
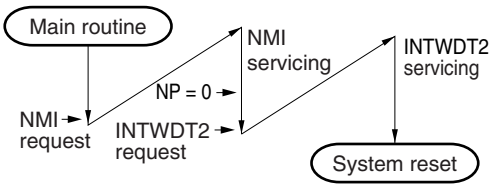
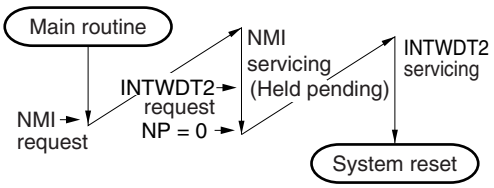
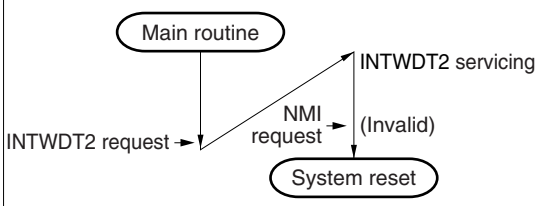
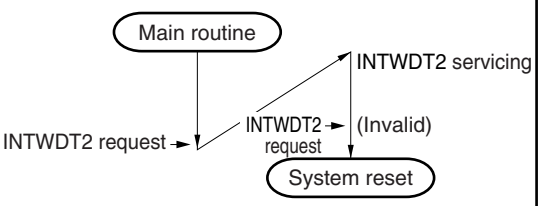


Figure 23-1. Non-Maskable Interrupt Request Signal Acknowledgment Operation (2/2)

(b) Non-maskable interrupt request signal generated during non-maskable interrupt servicing

Non-maskable interrupt being serviced	Non-maskable interrupt request signal generated during non-maskable interrupt servicing	
	NMI	INTWDT2
NMI	• NMI request generated during NMI servicing 	• INTWDT2 request generated during NMI servicing (NP bit = 1 retained before INTWDT2 request)  • INTWDT2 request generated during NMI servicing (NP bit = 0 set before INTWDT2 request)  • INTWDT2 request generated during NMI servicing (NP = 0 set after INTWDT2 request) 
INTWDT2	• NMI request generated during INTWDT2 servicing 	• INTWDT2 request generated during INTWDT2 servicing 

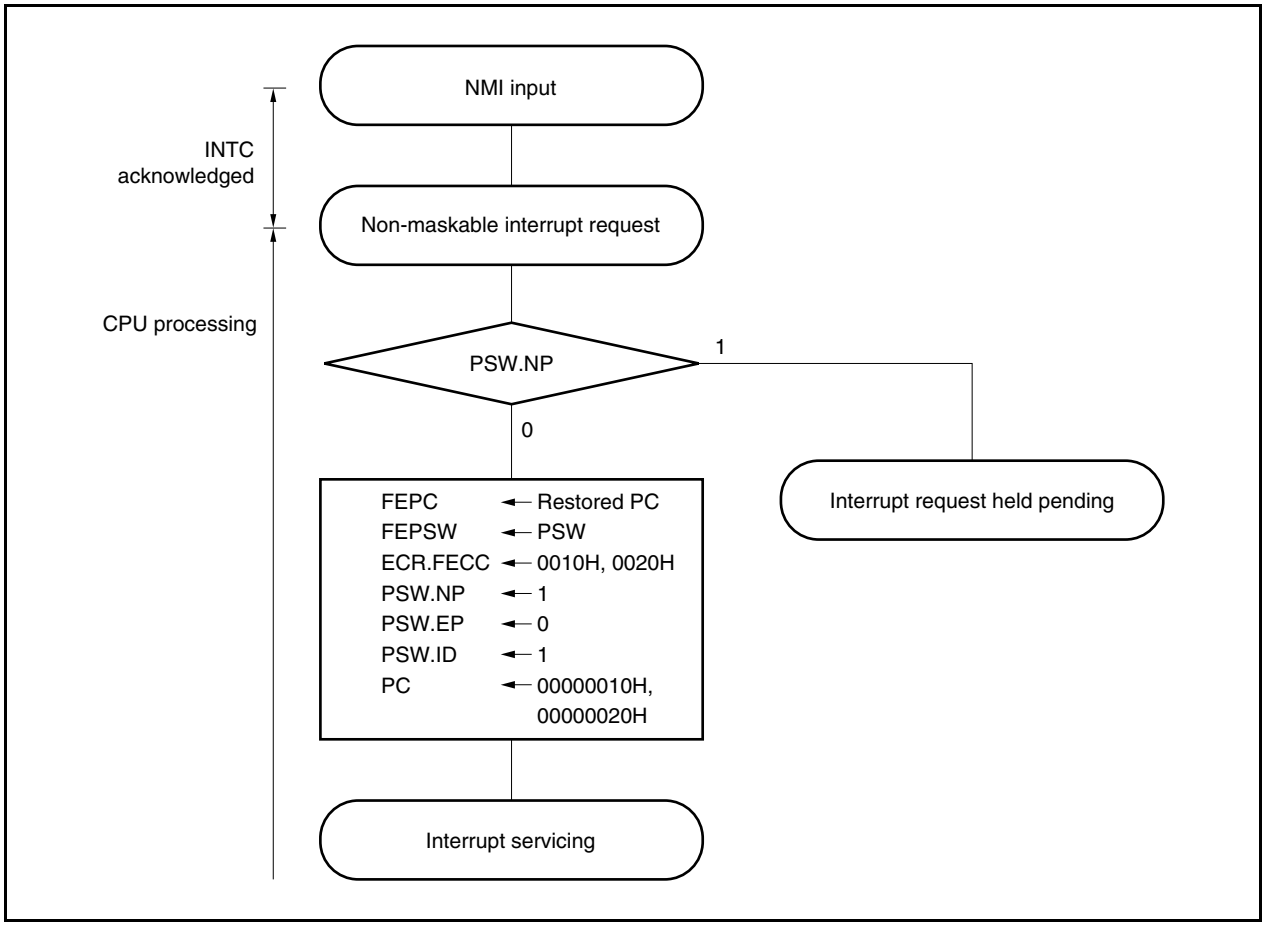
23.2.1 Operation

If a non-maskable interrupt request signal is generated, the CPU performs the following processing, and transfers control to the handler routine.

<1> Saves the restored PC to FEPC.
<2> Saves the current PSW to FEPSW.
<3> Writes exception code (0010H, 0020H) to the higher halfword (FECC) of ECR.
<4> Sets the PSW.NP and PSW.ID bits to 1 and clears the PSW.EP bit to 0.
<5> Sets the handler address (00000010H, 00000020H) corresponding to the non-maskable interrupt to the PC, and transfers control.

The servicing configuration of a non-maskable interrupt is shown below.

Figure 23-2. Servicing Configuration of Non-Maskable Interrupt



23.2.2 Restore

(1) From NMI pin input

Execution is restored from the NMI servicing by the RETI instruction.

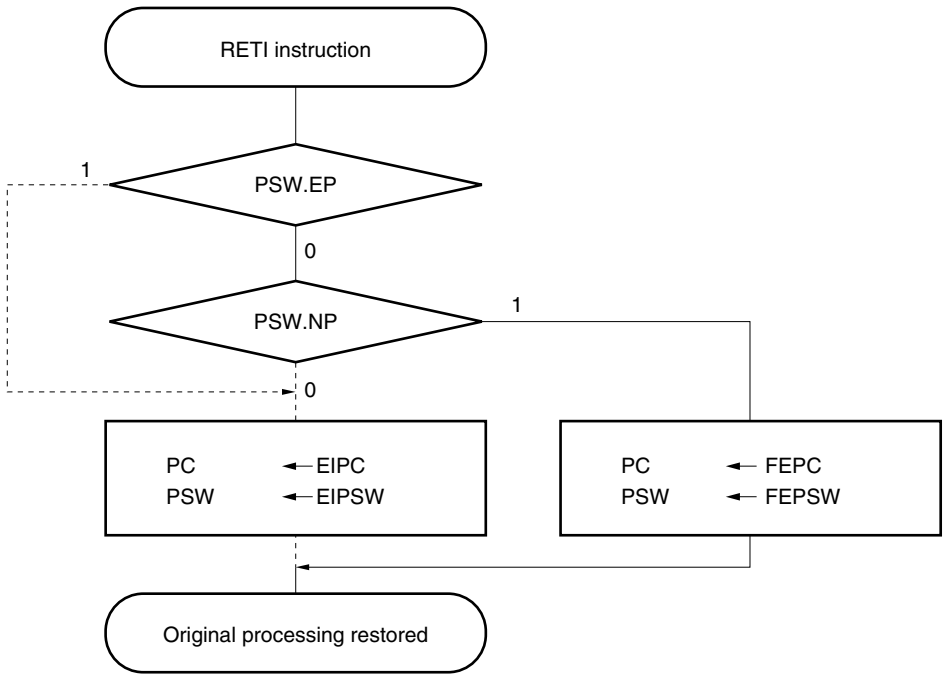
When the RETI instruction is executed, the CPU performs the following processing, and transfers control to the address of the restored PC.

<1> Loads the restored PC and PSW from FEPC and FEPSW, respectively, because the PSW.EP bit is 0 and the PSW.NP bit is 1.

<2> Transfers control back to the address of the restored PC and PSW.

The processing of the RETI instruction is shown below.

Figure 23-3. RETI Instruction Processing



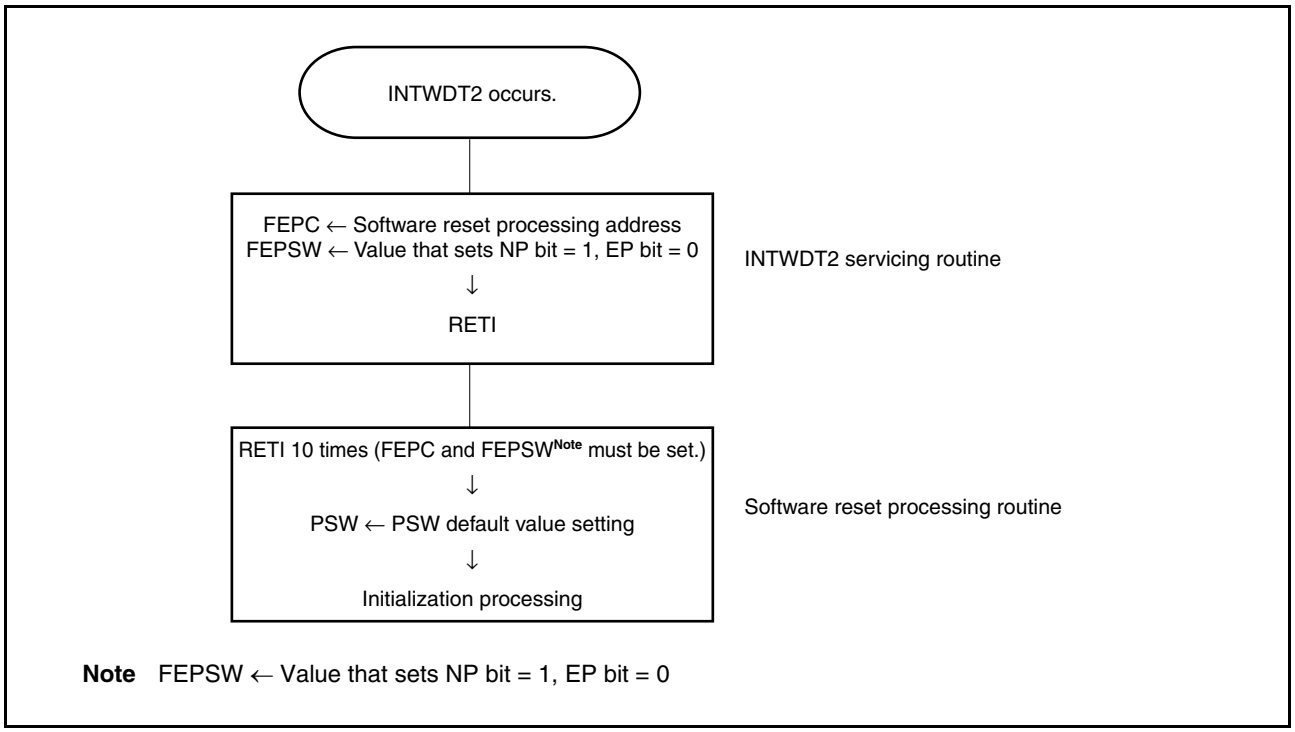
Caution When the EP and NP bits are changed by the LDSR instruction during non-maskable interrupt servicing, in order to restore the PC and PSW correctly during recovery by the RETI instruction, it is necessary to set the EP bit back to 0 and the NP bit back to 1 using the LDSR instruction immediately before the RETI instruction.

Remark The solid line shows the CPU processing flow.

(2) From INTWDT2 signal

Restoring from non-maskable interrupt servicing executed by the non-maskable interrupt request (INTWDT2) by using the RETI instruction is disabled. Execute the following software reset processing.

Figure 23-4. Software Reset Processing



Note FEPSW ← Value that sets NP bit = 1, EP bit = 0

23.2.3 NP flag

The NP flag is a status flag that indicates that non-maskable interrupt servicing is under execution.

This flag is set when a non-maskable interrupt request signal has been acknowledged, and masks non-maskable interrupt requests to prohibit multiple interrupts from being acknowledged.

After reset: 00000020H

	31 to 8	7	6	5	4	3	2	1	0
PSW	0	**NP**	EP	ID	SAT	CY	OV	S	Z

NP	NMI interrupt servicing status
0	No NMI interrupt servicing
1	NMI interrupt currently being serviced

23.3 Maskable Interrupts

Maskable interrupt request signals can be masked by interrupt control registers. The V850ES/JG3-H and V850ES/JH3-H have 84 to 91 maskable interrupt sources.

If two or more maskable interrupt request signals are generated at the same time, they are acknowledged according to the default priority. In addition to the default priority, eight levels of priorities can be specified by using the interrupt control registers (programmable priority control).

When an interrupt request signal has been acknowledged, the acknowledgment of other maskable interrupt request signals is disabled and the interrupt disabled (DI) status is set.

When the EI instruction is executed in an interrupt service routine, the interrupt enabled (EI) status is set, which enables servicing of interrupts having a higher priority than the interrupt request signal in progress (specified by the interrupt control register). Note that only interrupts with a higher priority will have this capability; interrupts with the same priority level cannot be nested.

To enable multiple interrupts, however, save EIPC and EIPSW to memory or general-purpose registers before executing the EI instruction, and execute the DI instruction before the RETI instruction to restore the original values of EIPC and EIPSW.

23.3.1 Operation

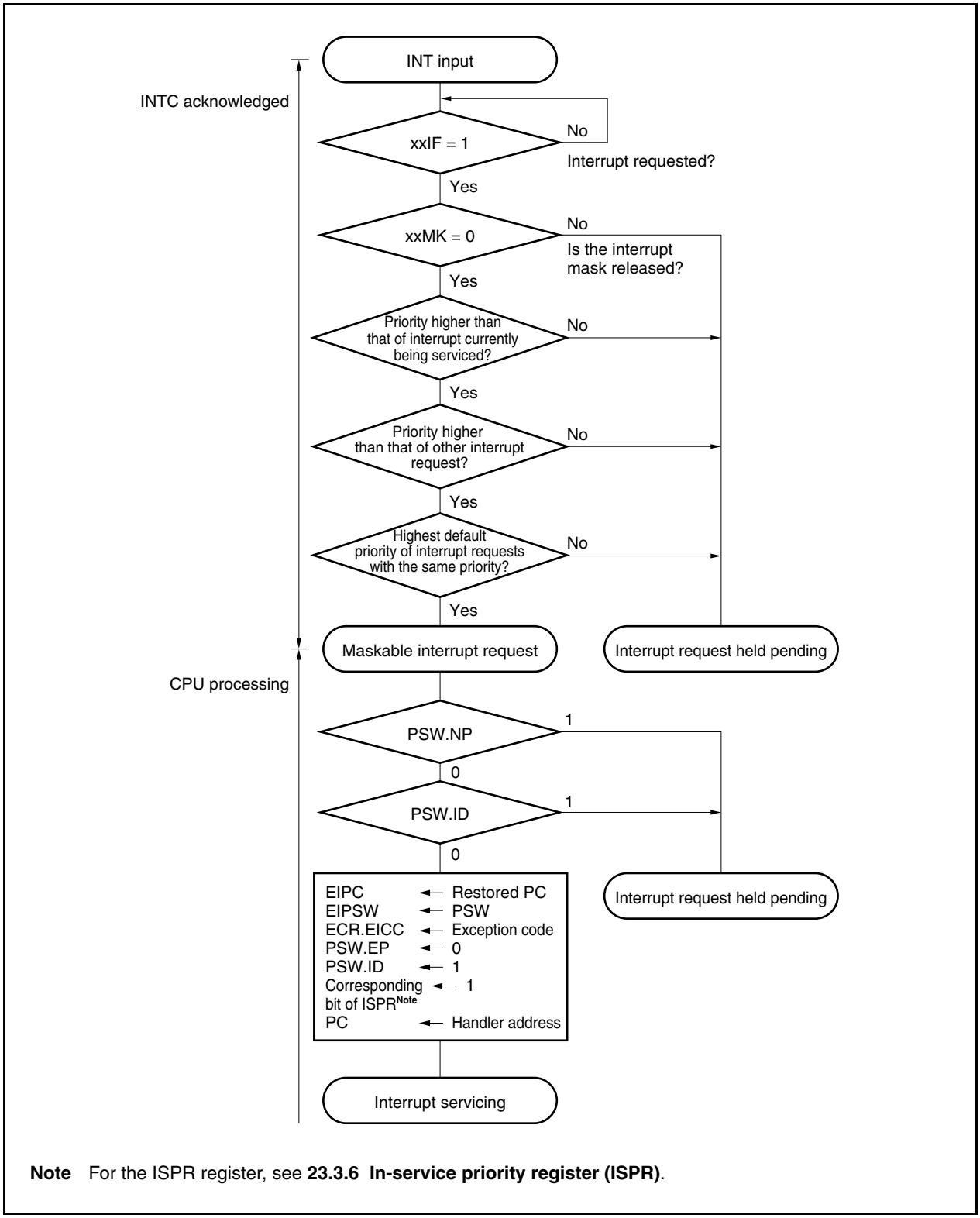
If a maskable interrupt occurs, the CPU performs the following processing, and transfers control to a handler routine.

<1> Saves the restored PC to EIPC.
<2> Saves the current PSW to EIPSW.
<3> Writes an exception code to the lower halfword of ECR (EICC).
<4> Sets the PSW. ID bit to 1 and clears the PSW. EP bit to 0.
<5> Sets the handler address corresponding to each interrupt to the PC, and transfers control.

The maskable interrupt request signal masked by INTC and the maskable interrupt request signal generated while another interrupt is being serviced (while the PSW.NP bit = 1 or the PSW.ID bit = 1) are held pending inside INTC. In this case, servicing a new maskable interrupt is started in accordance with the priority of the pending maskable interrupt request signal if either the maskable interrupt is unmasked or the NP and ID bits are set to 0 by using the RETI or LDSR instruction.

How maskable interrupts are serviced is illustrated below.

Figure 23-5. Maskable Interrupt Servicing



Note For the ISPR register, see **23.3.6 In-service priority register (ISPR)**.

23.3.2 Restore

Recovery from maskable interrupt servicing is carried out by the RETI instruction.

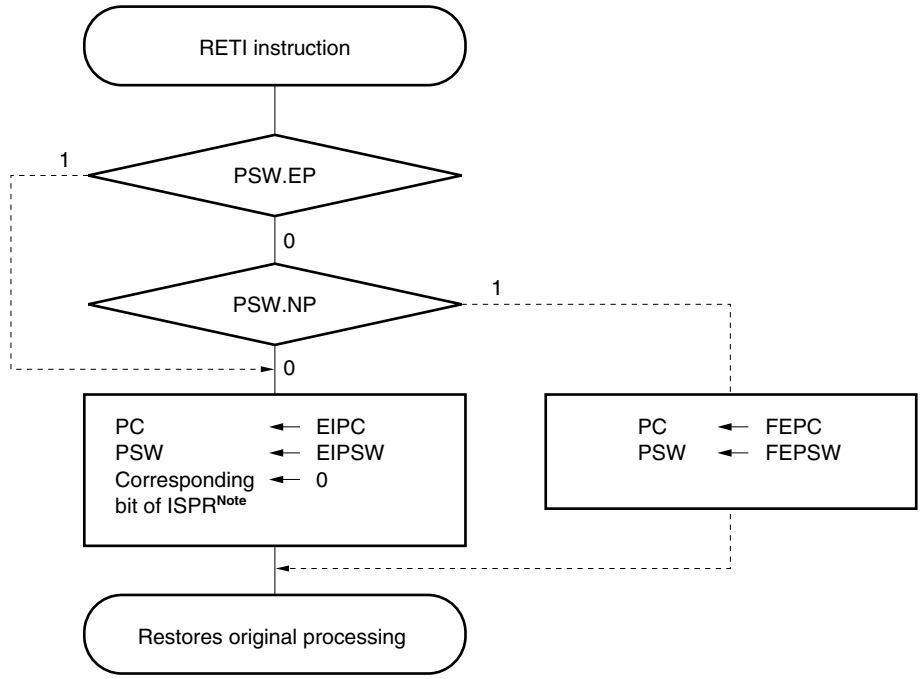
When the RETI instruction is executed, the CPU performs the following processing, and transfers control to the address of the restored PC.

<1> Loads the restored PC and PSW from EIPC and EIPSW because the PSW.EP bit is 0 and the PSW.NP bit is 0.

<2> Transfers control back to the address of the restored PC and PSW.

The processing of the RETI instruction is shown below.

Figure 23-6. RETI Instruction Processing



Note For the ISPR register, see **23.3.6 In-service priority register (ISPR)**.

Caution When the EP and NP bits are changed by the LDSR instruction during maskable interrupt servicing, in order to restore the PC and PSW correctly during recovery by the RETI instruction, it is necessary to set the EP bit back to 0 and the NP bit back to 0 using the LDSR instruction immediately before the RETI instruction.

Remark The solid line shows the CPU processing flow.

23.3.3 Priorities of maskable interrupts

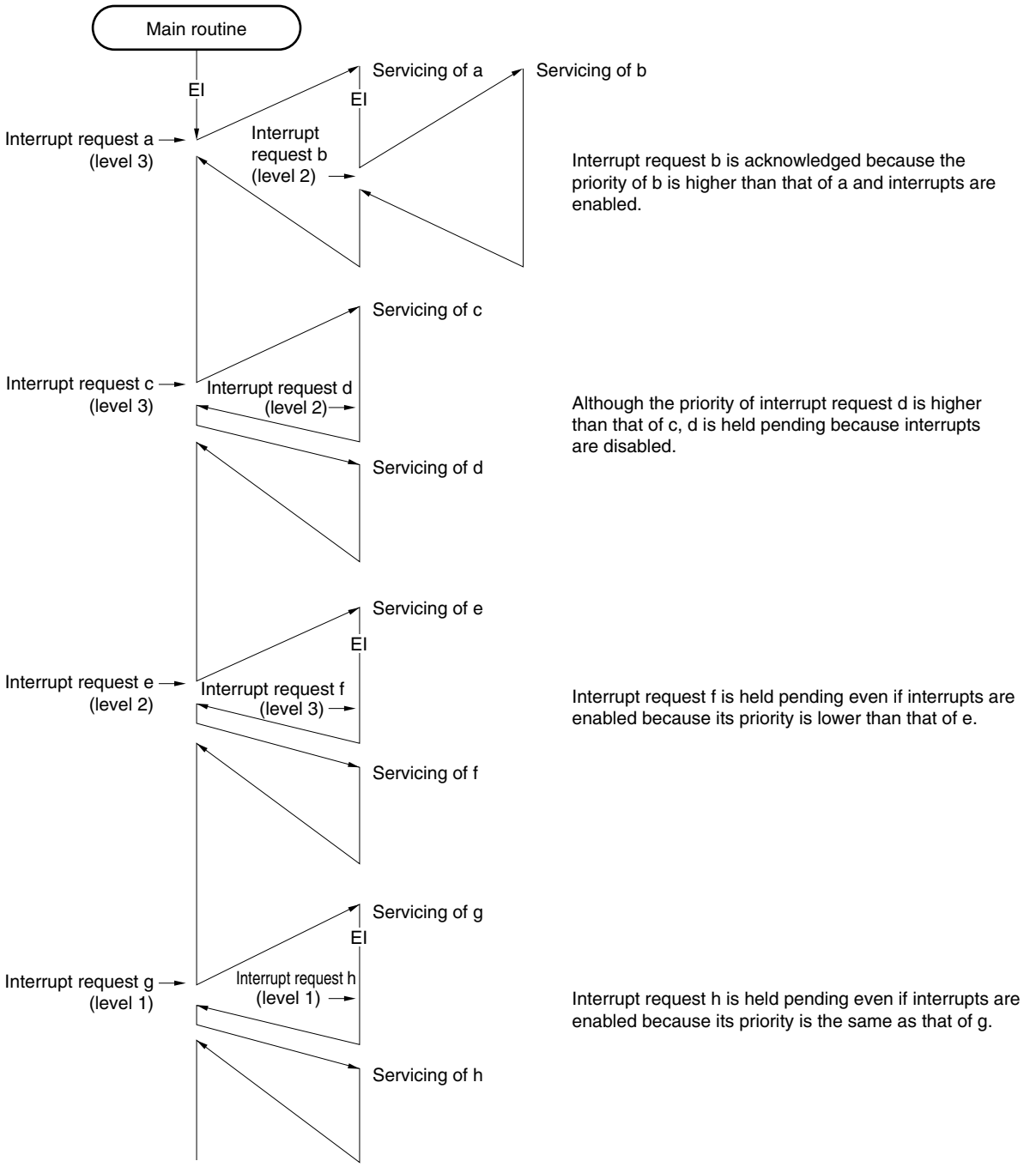
The INTC performs multiple interrupt servicing in which an interrupt is acknowledged while another interrupt is being serviced. Multiple interrupts can be controlled by priority levels.

There are two types of priority level control: control based on the default priority levels, and control based on the programmable priority levels that are specified by the interrupt priority level specification bit (xxPRn) of the interrupt control register (xxICn). When two or more interrupts having the same priority level specified by the xxPRn bit are generated at the same time, interrupt request signals are serviced in order depending on the priority level allocated to each interrupt request type (default priority level) beforehand. For more information, see **Table 23-2** and **Table 23-3**. The programmable priority control customizes interrupt request signals into eight levels by setting the priority level specification flag.

Note that when an interrupt request signal is acknowledged, the PSW.ID flag is automatically set to 1. Therefore, when multiple interrupts are to be used, clear the ID flag to 0 beforehand (for example, by placing the EI instruction in the interrupt service program) to set the interrupt enable mode.

Remark xx: Identification name of each peripheral unit (see **Table 23-4 Interrupt Control Register (xxICn)**)
n: Peripheral unit number (see **Table 23-4 Interrupt Control Register (xxICn)**).

Figure 23-7. Example of Processing in Which Another Interrupt Request Signal Is Issued While an Interrupt Is Being Serviced (1/2)

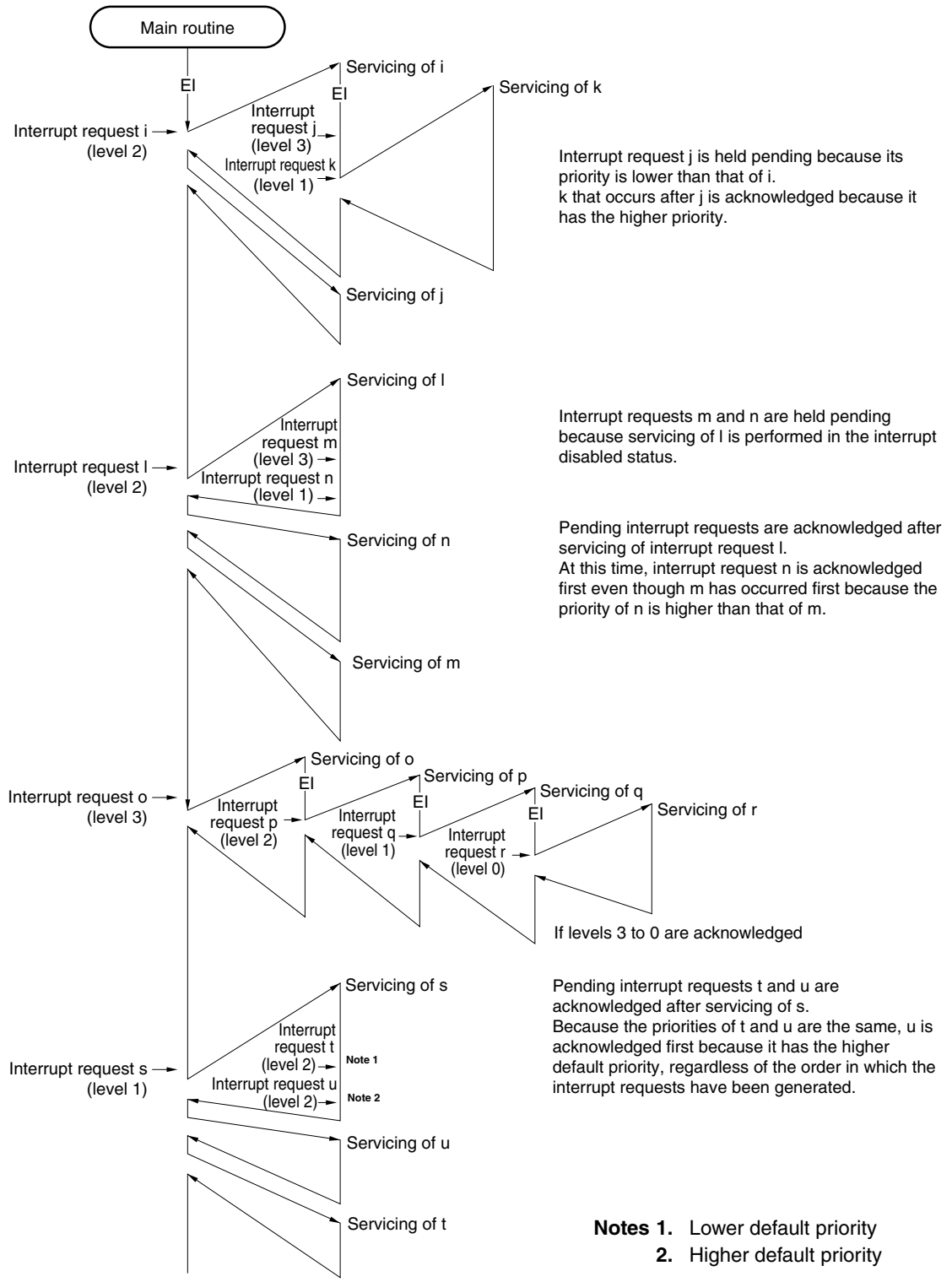


Caution To perform multiple interrupt servicing, the values of the EIPC and EIPSW registers must be saved before executing the EI instruction. When returning from multiple interrupt servicing, restore the values of EIPC and EIPSW after executing the DI instruction.

Remarks 1. a to u in the figure are the temporary names of interrupt request signals shown for the sake of explanation.

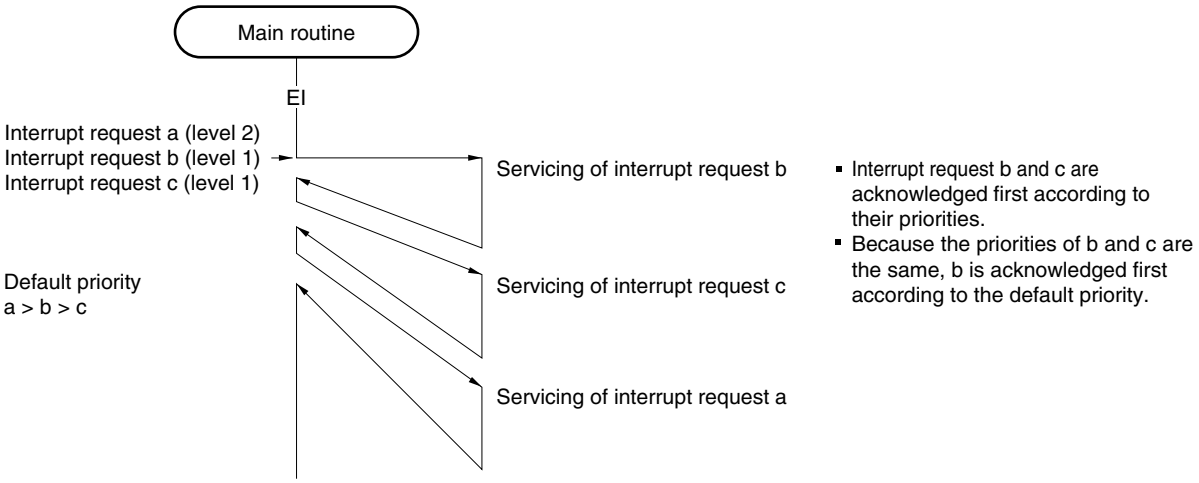
2. The default priority in the figure indicates the relative priority between two interrupt request signals.

Figure 23-7. Example of Processing in Which Another Interrupt Request Signal Is Issued While an Interrupt Is Being Serviced (2/2)



Caution To perform multiple interrupt servicing, the values of the EIPC and EIPSW registers must be saved before executing the EI instruction. When returning from multiple interrupt servicing, restore the values of EIPC and EIPSW after executing the DI instruction.

Figure 23-8. Example of Servicing Interrupt Request Signals Simultaneously Generated



Caution To perform multiple interrupt servicing, the values of the EIPC and EIPSW registers must be saved before executing the EI instruction. When returning from multiple interrupt servicing, restore the values of EIPC and EIPSW after executing the DI instruction.

Remarks 1. a to c in the figure are the temporary names of interrupt request signals shown for the sake of explanation.

2. The default priority in the figure indicates the relative priority between two interrupt request signals.

23.3.4 Interrupt control register (xxICn)

The xxICn register is assigned to each interrupt request signal (maskable interrupt) and sets the control conditions for each maskable interrupt request.

This register can be read or written in 8-bit or 1-bit units.

Reset sets this register to 47H.

Caution Disable interrupts (DI) or mask the interrupt to read the xxICn.xxIFn bit. If the xxIFn bit is read while interrupts are enabled (EI) or while the interrupt is unmasked, the correct value may not be read when acknowledging an interrupt and reading the bit conflict.

After reset: 47H R/W Address: FFFFF112H to FFFFF184H

	<7>	<6>	5	4	3	2	1	0
xxICn	xxIFn	xxMKn	0	0	0	xxPRn2	xxPRn1	xxPRn0

xxIFn	Interrupt request flag[Note]
0	Interrupt request not issued
1	Interrupt request issued

xxMKn	Interrupt mask flag
0	Interrupt servicing enabled
1	Interrupt servicing disabled (pending)

xxPRn2	xxPRn1	xxPRn0	Interrupt priority specification bit
0	0	0	Specifies level 0 (highest).
0	0	1	Specifies level 1.
0	1	0	Specifies level 2.
0	1	1	Specifies level 3.
1	0	0	Specifies level 4.
1	0	1	Specifies level 5.
1	1	0	Specifies level 6.
1	1	1	Specifies level 7 (lowest).

Note The flag xxIFn is reset automatically by the hardware if an interrupt request signal is acknowledged.

Remark xx: Identification name of each peripheral unit (see **Table 23-4 Interrupt Control Register (xxICn)**)
n: Peripheral unit number (see **Table 23-4 Interrupt Control Register (xxICn)**).

The addresses and bits of the interrupt control registers are as follows.

Table 23-4. Interrupt Control Register (xxICn) (1/3)

Address	Register	Bit							
		<7>	<6>	5	4	3	2	1	0
FFFFF110H	LVIIC	LVIIF	LVIMK	0	0	0	LVIPR2	LVIPR1	LVIPR0
FFFFF112H	PIC00[Note]	PIF00	PMK00	0	0	0	PPR002	PPR001	PPR000
FFFFF114H	PIC01[Note]	PIF01	PMK01	0	0	0	PPR012	PPR011	PPR010
FFFFF116H	PIC02	PIF02	PMK02	0	0	0	PPR022	PPR021	PPR020
FFFFF118H	PIC03	PIF03	PMK03	0	0	0	PPR032	PPR031	PPR030
FFFFF11AH	PIC04	PIF04	PMK04	0	0	0	PPR042	PPR041	PPR040
FFFFF11CH	PIC05	PIF05	PMK05	0	0	0	PPR052	PPR051	PPR050
FFFFF11EH	PIC06[Note]	PIF06	PMK06	0	0	0	PPR062	PPR061	PPR060
FFFFF120H	PIC07	PIF07	PMK07	0	0	0	PPR072	PPR071	PPR070
FFFFF122H	PIC08	PIF08	PMK08	0	0	0	PPR082	PPR081	PPR080
FFFFF124H	PIC09	PIF09	PMK09	0	0	0	PPR092	PPR091	PPR090
FFFFF126H	PIC10	PIF10	PMK10	0	0	0	PPR102	PPR101	PPR100
FFFFF128H	PIC11	PIF11	PMK11	0	0	0	PPR112	PPR111	PPR110
FFFFF12AH	PIC12	PIF12	PMK12	0	0	0	PPR122	PPR121	PPR120
FFFFF12CH	PIC13	PIF13	PMK13	0	0	0	PPR132	PPR131	PPR130
FFFFF12EH	PIC14	PIF14	PMK14	0	0	0	PPR142	PPR141	PPR140
FFFFF130H	PIC15	PIF15	PMK15	0	0	0	PPR152	PPR151	PPR150
FFFFF132H	PIC16	PIF16	PMK16	0	0	0	PPR162	PPR161	PPR160
FFFFF134H	PIC17	PIF17	PMK17	0	0	0	PPR172	PPR171	PPR170
FFFFF136H	PIC18	PIF18	PMK18	0	0	0	PPR182	PPR181	PPR180
FFFFF138H	TAB0OVIC	TAB0OVIF	TAB0OVMK	0	0	0	TAB0OVPPR2	TAB0OVPPR1	TAB0OVPPR0
FFFFF13AH	TAB0CCIC0	TAB0CCIF0	TAB0CCMK0	0	0	0	TAB0CCPPR02	TAB0CCPPR01	TAB0CCPPR00
FFFFF13CH	TAB0CCIC1	TAB0CCIF1	TAB0CCMK1	0	0	0	TAB0CCPPR12	TAB0CCPPR11	TAB0CCPPR10
FFFFF13EH	TAB0CCIC2	TAB0CCIF2	TAB0CCMK2	0	0	0	TAB0CCPPR22	TAB0CCPPR21	TAB0CCPPR20
FFFFF140H	TAB0CCIC3	TAB0CCIF3	TAB0CCMK3	0	0	0	TAB0CCPPR32	TAB0CCPPR31	TAB0CCPPR30
FFFFF142H	TAB1OVIC	TAB1OVIF	TAB1OVMK	0	0	0	TAB1OVPPR2	TAB1OVPPR1	TAB1OVPPR0
FFFFF144H	TAB1CCIC0	TAB1CCIF0	TAB1CCMK0	0	0	0	TAB1CCPPR02	TAB1CCPPR01	TAB1CCPPR00
FFFFF146H	TAB1CCIC1	TAB1CCIF1	TAB1CCMK1	0	0	0	TAB1CCPPR12	TAB1CCPPR11	TAB1CCPPR10
FFFFF148H	TAB1CCIC2	TAB1CCIF2	TAB1CCMK2	0	0	0	TAB1CCPPR22	TAB1CCPPR21	TAB1CCPPR20
FFFFF14AH	TAB1CCIC3	TAB1CCIF3	TAB1CCMK3	0	0	0	TAB1CCPPR32	TAB1CCPPR31	TAB1CCPPR30
FFFFF14CH	TT0OVIC	TT0OVIF	TT0OVMK	0	0	0	TT0OVPPR2	TT0OVPPR1	TT0OVPPR0
FFFFF14EH	TT0CCIC0	TT0CCIF0	TT0CCMK0	0	0	0	TT0CCPPR02	TT0CCPPR01	TT0CCPPR00
FFFFF150H	TT0CCIC1	TT0CCIF1	TT0CCMK1	0	0	0	TT0CCPPR12	TT0CCPPR11	TT0CCPPR10
FFFFF152H	TT0IECIC	TT0IECIF	TT0IECMK	0	0	0	TT0IECPPR2	TT0IECPPR1	TT0IECPPR0
FFFFF154H	TAA0OVIC	TAA0OVIF	TAA0OVMK	0	0	0	TAA0OVPPR2	TAA0OVPPR1	TAA0OVPPR0
FFFFF156H	TAA0CCIC0	TAA0CCIF0	TAA0CCMK0	0	0	0	TAA0CCPPR02	TAA0CCPPR01	TAA0CCPPR00
FFFFF158H	TAA0CCIC1	TAA0CCIF1	TAA0CCMK1	0	0	0	TAA0CCPPR12	TAA0CCPPR11	TAA0CCPPR10
FFFFF15AH	TAA1OVIC	TAA1OVIF	TAA1OVMK	0	0	0	TAA1OVPPR2	TAA1OVPPR1	TAA1OVPPR0
FFFFF15CH	TAA1CCIC0	TAA1CCIF0	TAA1CCMK0	0	0	0	TAA1CCPPR02	TAA1CCPPR01	TAA1CCPPR00
FFFFF15EH	TAA1CCIC1	TAA1CCIF1	TAA1CCMK1	0	0	0	TAA1CCPPR12	TAA1CCPPR11	TAA1CCPPR10

Note V850ES/JH3-H only

Table 23-4. Interrupt Control Register (xxICn) (2/3)

Address	Register	Bit							
		<7>	<6>	5	4	3	2	1	0
FFFFF160H	TAA2OVIC	TAA2OVIF	TAA2OVMK	0	0	0	TAA2OVPPR2	TAA2OVPPR1	TAA2OVPPR0
FFFFF162H	TAA2CCIC0	TAA2CCIF0	TAA2CCMK0	0	0	0	TAA2CCPPR02	TAA2CCPPR01	TAA2CCPPR00
FFFFF164H	TAA2CCIC1	TAA2CCIF1	TAA2CCMK1	0	0	0	TAA2CCPPR12	TAA2CCPPR11	TAA2CCPPR10
FFFFF166H	TAA3OVIC	TAA3OVIF	TAA3OVMK	0	0	0	TAA3OVPPR2	TAA3OVPPR1	TAA3OVPPR0
FFFFF168H	TAA3CCIC0	TAA3CCIF0	TAA3CCMK0	0	0	0	TAA3CCPPR02	TAA3CCPPR01	TAA3CCPPR00
FFFFF16AH	TAA3CCIC1	TAA3CCIF1	TAA3CCMK1	0	0	0	TAA3CCPPR12	TAA3CCPPR11	TAA3CCPPR10
FFFFF16CH	TAA4OVIC	TAA4OVIF	TAA4OVMK	0	0	0	TAA4OVPPR2	TAA4OVPPR1	TAA4OVPPR0
FFFFF16EH	TAA4CCIC0	TAA4CCIF0	TAA4CCMK0	0	0	0	TAA4CCPPR02	TAA4CCPPR01	TAA4CCPPR00
FFFFF170H	TAA4CCIC1	TAA4CCIF1	TAA4CCMK1	0	0	0	TAA4CCPPR12	TAA4CCPPR11	TAA4CCPPR10
FFFFF172H	TAA5OVIC	TAA5OVIF	TAA5OVMK	0	0	0	TAA5OVPPR2	TAA5OVPPR1	TAA5OVPPR0
FFFFF174H	TAA5CCIC0	TAA5CCIF0	TAA5CCMK0	0	0	0	TAA5CCPPR02	TAA5CCPPR01	TAA5CCPPR00
FFFFF176H	TAA5CCIC1	TAA5CCIF1	TAA5CCMK1	0	0	0	TAA5CCPPR12	TAA5CCPPR11	TAA5CCPPR10
FFFFF178H	TM0EQIC0	TM0EQIF0	TM0EQMK0	0	0	0	TM0EQPR02	TM0EQPR01	TM0EQPR00
FFFFF17AH	TM1EQIC0	TM1EQIF0	TM1EQMK0	0	0	0	TM1EQPR02	TM1EQPR01	TM1EQPR00
FFFFF17CH	TM2EQIC0	TM2EQIF0	TM2EQMK0	0	0	0	TM2EQPR02	TM2EQPR01	TM2EQPR00
FFFFF17EH	TM3EQIC0	TM3EQIF0	TM3EQMK0	0	0	0	TM3EQPR02	TM3EQPR01	TM3EQPR00
FFFFF180H	CF0RIC/ IICIC1	CF0RIF/ IICIF1	CF0RMK/ IICMK1	0	0	0	CF0RPPR2/ IICPPR12	CF0RPPR1/ IICPPR11	CF0RPPR0/ IICPPR10
FFFFF182H	CF0TIC	CF0TIF	CF0TMK	0	0	0	CF0TPPR2	CF0TPPR1	CF0TPPR0
FFFFF184H	CF1RIC	CF1RIF	CF1RMK	0	0	0	CF1RPPR2	CF1RPPR1	CF1RPPR0
FFFFF186H	CF1TIC	CF1TIF	CF1TMK	0	0	0	CF1TPPR2	CF1TPPR1	CF1TPPR0
FFFFF188H	CF2RIC	CF2RIF	CF2RMK	0	0	0	CF2RPPR2	CF2RPPR1	CF2RPPR0
FFFFF18AH	CF2TIC	CF2TIF	CF2TMK	0	0	0	CF2TPPR2	CF2TPPR1	CF2TPPR0
FFFFF18CH	CF3RIC	CF3RIF	CF3RMK	0	0	0	CF3RPPR2	CF3RPPR1	CF3RPPR0
FFFFF18EH	CF3TIC	CF3TIF	CF3TMK	0	0	0	CF3TPPR2	CF3TPPR1	CF3TPPR0
FFFFF190H	CF4RIC	CF3RIF	CF3RMK	0	0	0	CF3RPPR2	CF3RPPR1	CF3RPPR0
FFFFF192H	CF4TIC	CF3TIF	CF3TMK	0	0	0	CF3TPPR2	CF3TPPR1	CF3TPPR0
FFFFF194H	UC0RIC	UC0RIF	UC0RMK	0	0	0	UC0RPPR2	UC0RPPR1	UC0RPPR0
FFFFF196H	UC0TIC	UC0TIF	UC0TMK	0	0	0	UC0TPPR2	UC0TPPR1	UC0TPPR0
FFFFF198H	UC1RIC/ IICIC2	UC1RIF/ IICIF2	UC1RMK/ IICMK2	0	0	0	UC1RPPR2/ IICPPR22	UC1RPPR1/ IICPPR21	UC1RPPR0/ IICPPR20
FFFFF19AH	UC1TIC	UC1TIF	UC1TMK	0	0	0	UC1TPPR2	UC1TPPR1	UC1TPPR0
FFFFF19CH	UC2RIC	UC2RIF	UC2RMK	0	0	0	UC2RPPR2	UC2RPPR1	UC2RPPR0
FFFFF19EH	UC2TIC	UC2TIF	UC2TMK	0	0	0	UC2TPPR2	UC2TPPR1	UC2TPPR0
FFFFF1A0H	UC3RIC/ IICIC0	UC3RIF/ IICIF0	UC3RMK/ IICMK0	0	0	0	UC3RPPR2/ IICPPR02	UC3RPPR1/ IICPPR01	UC3RPPR0/ IICPPR00
FFFFF1A2H	UC3TIC	UC3TIF	UC3TMK	0	0	0	UC3TPPR2	UC3TPPR1	UC3TPPR0
FFFFF1A4H	UC4RIC	UC4RIF	UC4RMK	0	0	0	UC4RPPR2	UC4RPPR1	UC4RPPR0
FFFFF1A6H	UC4TIC	UC4TIF	UC4TMK	0	0	0	UC4TPPR2	UC4TPPR1	UC4TPPR0
FFFFF1A8H	ADIC	ADIF	ADMK	0	0	0	ADPPR2	ADPPR1	ADPPR0
FFFFF1AAH	DMAIC0	DMAIC0	DMAMK0	0	0	0	DMAPPR02	DMAPPR01	DMAPPR00
FFFFF1ACH	DMAIC1	DMAIC1	DMAMK1	0	0	0	DMAPPR12	DMAPPR11	DMAPPR10

Table 23-4. Interrupt Control Register (xxICn) (3/3)

Address	Register	Bit							
		<7>	<6>	5	4	3	2	1	0
FFFFF1AEH	DMAIC2	DMAIC2	DMAMK2	0	0	0	DMAPPR22	DMAPPR21	DMAPPR20
FFFFF1B0H	DMAIC3	DMAIC3	DMAMK3	0	0	0	DMAPPR32	DMAPPR31	DMAPPR30
FFFFF1B2H	KRIC	KRIF	KRMK	0	0	0	KRPPR2	KRPPR1	KRPPR0
FFFFF1B4H	RTC0IC	RTC0IF	RTC0MK	0	0	0	RTC0PPR2	RTC0PPR1	RTC0PPR0
FFFFF1B6H	RTC1IC	RTC1IF	RTC1MK	0	0	0	RTC1PPR2	RTC1PPR1	RTC1PPR0
FFFFF1B8H	RTC2IC	RTC2IF	RTC2MK	0	0	0	RTC2PPR2	RTC2PPR1	RTC2PPR0
FFFFF1BAH	ERRIC0Note	ERRIF0	ERRMK0/	0	0	0	ERRPPR02	ERRPPR01	ERRPPR00
FFFFF1BCH	WUPIC0Note	WUPIF0	WUPMK0	0	0	0	WUPPPR02	WUPPPR01	WUPPPR00
FFFFF1BEH	RECIC0Note	RECIF0	RECMK0	0	0	0	RECPPR02	RECPPR01	RECPPR00
FFFFF1C0H	TRXIC0Note	TRXIF0	TRXMK0/ IEMK2	0	0	0	TRXPPR02/ IEPPR22	TRXPPR01/ IEPPR21	TRXPPR00/ IEPPR20
FFFFF1C8H	UFIC0	UFIC0	UFMK0	0	0	0	UFPPR02	UFPPR01	UFPPR00
FFFFF1CAH	UFIC1	UFIC1	UFMK1	0	0	0	UFPPR12	UFPPR11	UFPPR10

Note μPD70F3770, 70F3771 only

23.3.5 Interrupt mask registers 0 to 5 (IMR0 to IMR5)

The IMR0 to IMR5 registers set the interrupt mask state for the maskable interrupts. The xxMKn bit of the IMR0 to IMR5 registers is equivalent to the xxICn.xxMKn bit.

The IMRm register can be read or written in 16-bit units.

If the higher 8 bits of the IMRm register are used as an IMRmH register and the lower 8 bits as an IMRmL register, these registers can be read or written in 8-bit or 1-bit units (m = 0 to 5).

Reset sets these registers to FFFFH.

Caution The device file defines the xxICn.xxMKn bit as a reserved word. If a bit is manipulated using the name of xxMKn, the contents of the xxICn register, instead of the IMRm register, are rewritten (as a result, the contents of the IMRm register are also rewritten).

(1/2)

After reset: FFFFH R/W Address: IMR5 FFFFF10AH, IMR5L FFFFF10AH, IMR5H FFFFF10BH

	15	14	13	12	11	10	9	8
IMR5 (IMR5H[Note 1])	1	1	UFMK1	UFMK0	1	1	1	TRXMK0[Note 2]
	7	6	5	4	3	2	1	0
IMR5L	RECMK0[Note 2]	WUPMK0[Note 2]	ERRMK0[Note 2]	RTC2MK	RTC1MK	RTC0MK	KRMK	DMAMK3

After reset: FFFFH R/W Address: IMR4 FFFFF108H, IMR4L FFFFF108H, IMR4H FFFFF109H

	15	14	13	12	11	10	9	8
IMR4 (IMR4H[Note 1])	DMAMK2	DMAMK1	DMAMK0	ADMK	UC4TMK	UC4RMK	UC3TMK	UC3RMK/ IICMK0
	7	6	5	4	3	2	1	0
IMR4L	UC2TMK	UC2RMK	UC1TMK	UC1RMK/ IICMK2	UC0TMK	UC0RMK	CF3TMK	CF3RMK

After reset: FFFFH R/W Address: IMR3 FFFFF106H, IMR3L FFFFF106H, IMR3H FFFFF107H

	15	14	13	12	11	10	9	8
IMR3 (IMR3H[Note 1])	CF3TMK	CF3RMK	CF2TMK	CF2RMK	CF1TMK	CF1RMK	CF0TMK	CF0RMK/ IICMK1
	7	6	5	4	3	2	1	0
IMR3L	TM3EQMK0	TM2EQMK0	TM1EQMK0	TM0EQMK0	TAA5CCMK1	TAA5CCMK0	TAA5OVMK	TAA4CCMK1

Notes 1. To read bits 8 to 15 of the IMR3 to IMR5 registers in 8-bit or 1-bit units, specify them as bits 0 to 7 of IMR3H to IMR5H registers.

2. μPD70F3770, 70F3771 only

Caution Set bits 9 to 11, 14, 15 of the IMR5 register to 1. If the setting of these bits is changed, the operation is not guaranteed.

Remark xx: Identification name of each peripheral unit (see **Table 23-4 Interrupt Control Register (xxICn)**).

n: Peripheral unit number (see **Table 23-4 Interrupt Control Register (xxICn)**)

(2/2)

After reset: FFFFH R/W Address: IMR2 FFFFF104H, IMR2L FFFFF104H, IMR2H FFFFF105H

	15	14	13	12	11	10	9	8
IMR2 (IMR2H[Note 1])	TAA4CCMK0	TAA4OVMK	TAA3CCMK1	TAA3CCMK0	TAA3OVMK	TAA2CCMK1	TAA2CCMK0	TAA2OVMK

	7	6	5	4	3	2	1	0
IMR2L	TAA1CCMK1	TAA1CCMK0	TAA1OVMK	TAA0CCMK1	TAA0CCMK0	TAA0OVMK	TMTIECMK	TMT0CCMK1

After reset: FFFFH R/W Address: IMR1 FFFFF102H, IMR1L FFFFF102H, IMR1H FFFFF103H

	15	14	13	12	11	10	9	8
IMR1 (IMR1H[Note 1])	TT0CCMK0	TT0OVMK	TAB1CCMK3	TAB1CCMK2	TAB1CCMK1	TAB1CCMK0	TAB1OVMK	TAB0CCMK3

	7	6	5	4	3	2	1	0
IMR1L	TAB0CCMK2	TAB0CCMK1	TAB0CCMK0	TAB0OVMK	PMK18	PMK17	PMK16	PMK15

After reset: FFFFH R/W Address: IMR0 FFFFF100H, IMR0L FFFFF100H, IMR0H FFFFF101H

	15	14	13	12	11	10	9	8
IMR0 (IMR0H[Note 1])	PMK14	PMK13	PMK12	PMK11	PMK10	PMK09	PMK08	PMK07

	7	6	5	4	3	2	1	0
IMR0L	PMK06[Note 2]	PMK05	PMK04[Note 2]	PMK03[Note 2]	PMK02	PMK01[Note 2]	PMK00[Note 2]	LVIMK

xxMKn	Setting of interrupt mask flag
0	Interrupt servicing enabled
1	Interrupt servicing disabled

Notes 1. To read bits 8 to 15 of the IMR0 to IMR2 registers in 8-bit or 1-bit units, specify them as bits 0 to 7 of IMR0H to IMR2H registers.

2. V850ES/JH3-H only

Remark xx: Identification name of each peripheral unit (see **Table 23-4 Interrupt Control Register (xxICn)**).

n: Peripheral unit number (see **Table 23-4 Interrupt Control Register (xxICn)**)

23.3.6 In-service priority register (ISPR)

The ISPR register holds the priority level of the maskable interrupt currently acknowledged. When an interrupt request signal is acknowledged, the bit of this register corresponding to the priority level of that interrupt request signal is set to 1 and remains set while the interrupt is serviced.

When the RETI instruction is executed, the bit corresponding to the interrupt request signal having the highest priority is automatically reset to 0 by hardware. However, it is not reset to 0 when execution is returned from non-maskable interrupt servicing or exception processing.

This register is read-only, in 8-bit or 1-bit units.

Reset sets this register to 00H.

Caution If an interrupt is acknowledged while the ISPR register is being read in the interrupt enabled (EI) status, the value of the ISPR register after the bits of the register have been set by acknowledging the interrupt may be read. To accurately read the value of the ISPR register before an interrupt is acknowledged, read the register while interrupts are disabled (DI).

After reset: 00H R Address: FFFFF1FAH

	<7>	<6>	<5>	<4>	<3>	<2>	<1>	<0>
ISPR	ISPR7	ISPR6	ISPR5	ISPR4	ISPR3	ISPR2	ISPR1	ISPR0

ISPRn	Priority of interrupt currently acknowledged
0	Interrupt request signal with priority n not acknowledged
1	Interrupt request signal with priority n acknowledged

Remark n = 0 to 7 (priority level)

23.3.7 ID flag

This flag controls the maskable interrupt's operating state, and stores control information regarding enabling or disabling of interrupt request signals. An interrupt disable flag (ID) is assigned to the PSW.

Reset sets this flag to 00000020H.

After reset: 00000020H

	31	8	7	6	5	4	3	2	1	0
PSW	0		NP	EP	**ID**	SAT	CY	OV	S	Z

ID	Specification of maskable interrupt servicing[Note]
0	Maskable interrupt request signal acknowledgment enabled
1	Maskable interrupt request signal acknowledgment disabled

Note Interrupt disable flag (ID) function

This bit is set to 1 by the DI instruction and cleared to 0 by the EI instruction. Its value is also modified by the RETI instruction or LDSR instruction when referencing the PSW.

Non-maskable interrupt request signals and exceptions are acknowledged regardless of this flag. When a maskable interrupt request signal is acknowledged, the ID flag is automatically set to 1 by hardware.

The interrupt request signal generated during the acknowledgment disabled period (ID flag = 1) is acknowledged when the xxICn.xxIFn bit is set to 1, and the ID flag is cleared to 0.

23.3.8 Watchdog timer mode register 2 (WDTM2)

This register can be read or written in 8-bit units (for details, see **CHAPTER 13 FUNCTIONS OF WATCHDOG TIMER 2**).

Reset sets this register to 67H.

After reset: 67H R/W Address: FFFFF6D0H

	7	6	5	4	3	2	1	0
WDTM2	0	WDM21	WDM20	0	0	0	0	0

WDM21	WDM20	Selection of watchdog timer operation mode
0	0	Stops operation
0	1	Non-maskable interrupt request mode
1	×	Reset mode (initial value)

23.4 Software Exception

A software exception is generated when the CPU executes the TRAP instruction, and can always be acknowledged.

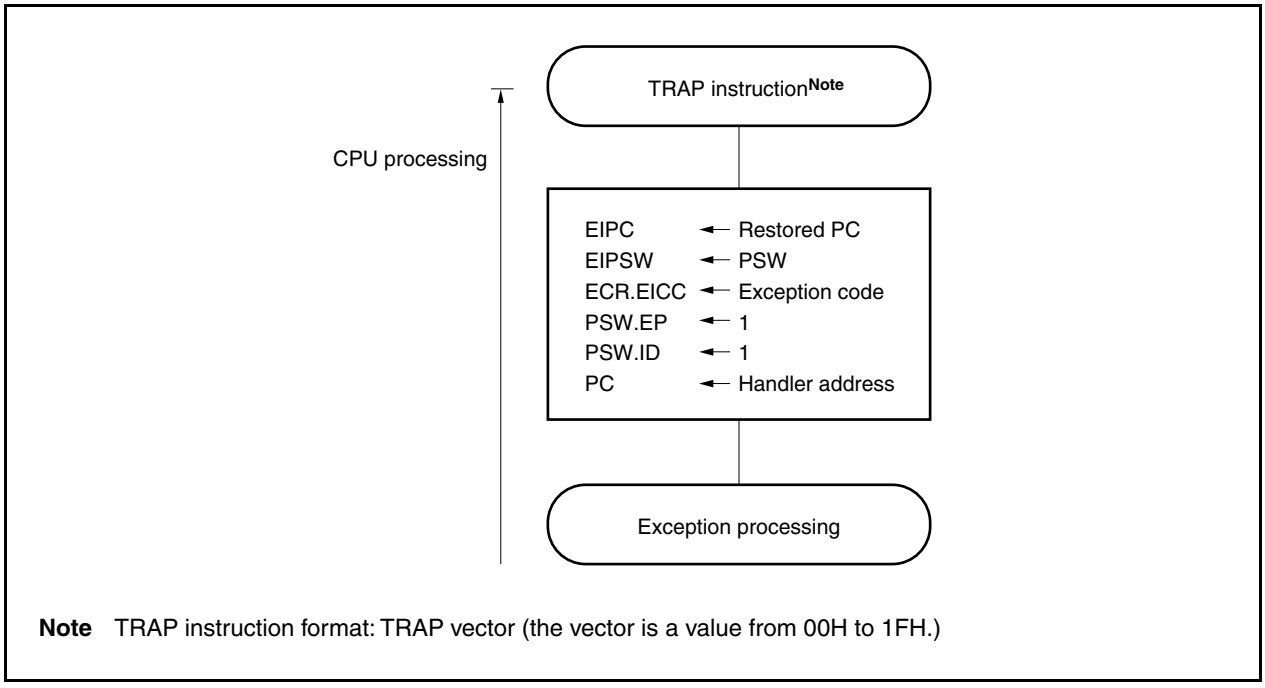
23.4.1 Operation

If a software exception occurs, the CPU performs the following processing, and transfers control to the handler routine.

<1> Saves the restored PC to EIPC.
<2> Saves the current PSW to EIPSW.
<3> Writes an exception code to the lower 16 bits (EICC) of ECR (interrupt source).
<4> Sets the PSW.EP and PSW.ID bits to 1.
<5> Sets the handler address (00000040H or 00000050H) corresponding to the software exception to the PC, and transfers control.

The processing of a software exception is shown below.

Figure 23-9. Software Exception Processing



Note TRAP instruction format: TRAP vector (the vector is a value from 00H to 1FH.)

The handler address is determined by the TRAP instruction's operand (vector). If the vector is 00H to 0FH, it becomes 00000040H, and if the vector is 10H to 1FH, it becomes 00000050H.

23.4.2 Restore

Restoration from software exception processing is carried out by the RETI instruction.

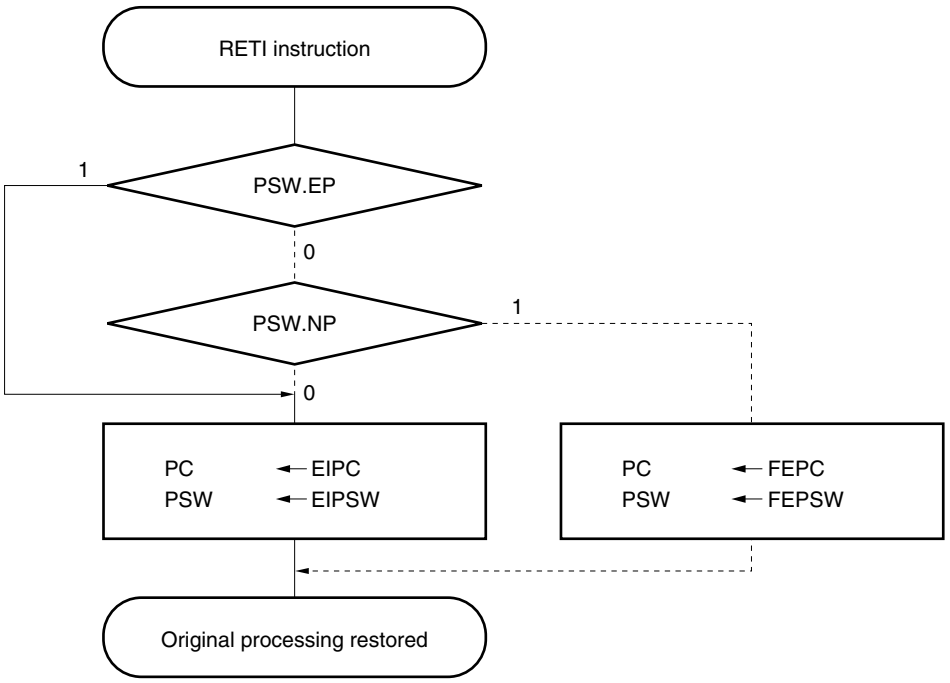
By executing the RETI instruction, the CPU carries out the following processing and shifts control to the restored PC's address.

<1> Loads the restored PC and PSW from EIPC and EIPSW because the PSW.EP bit is 1.

<2> Transfers control to the address of the restored PC and PSW.

The processing of the RETI instruction is shown below.

Figure 23-10. RETI Instruction Processing



Caution When the EP and NP bits are changed by the LDSR instruction during the software exception processing, in order to restore the PC and PSW correctly during recovery by the RETI instruction, it is necessary to set the EP bit back to 1 and the NP bit back to 0 using the LDSR instruction immediately before the RETI instruction.

Remark The solid line shows the CPU processing flow.

23.4.3 EP flag

The EP flag is a status flag used to indicate that exception processing is in progress. It is set when an exception occurs.

After reset: 00000020H

	31	8	7	6	5	4	3	2	1	0
PSW	0		NP	**EP**	ID	SAT	CY	OV	S	Z

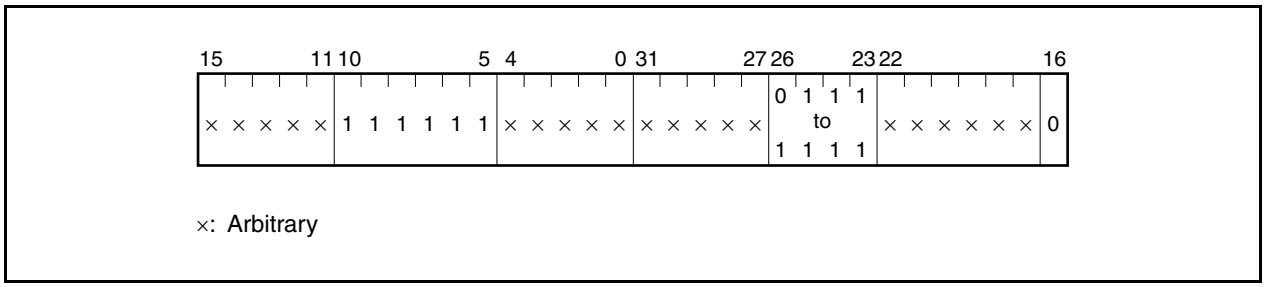
EP	Exception processing status
0	Exception processing not in progress.
1	Exception processing in progress.

23.5 Exception Trap

An exception trap is an interrupt that is requested when the illegal execution of an instruction takes place. In the V850ES/JG3-H and V850ES/JH3-H, an illegal opcode exception (ILGOP: Illegal Opcode Trap) is considered as an exception trap.

23.5.1 Illegal opcode

An illegal opcode is defined as an instruction with instruction opcode (bits 10 to 5) = 111111B, sub-opcode (bits 26 to 23) = 0111B to 1111B, and sub-opcode (bit 16) = 0B. When such an instruction is executed, an exception trap is generated.



Caution It is recommended not to use an illegal opcode because instructions may newly be assigned in the future.

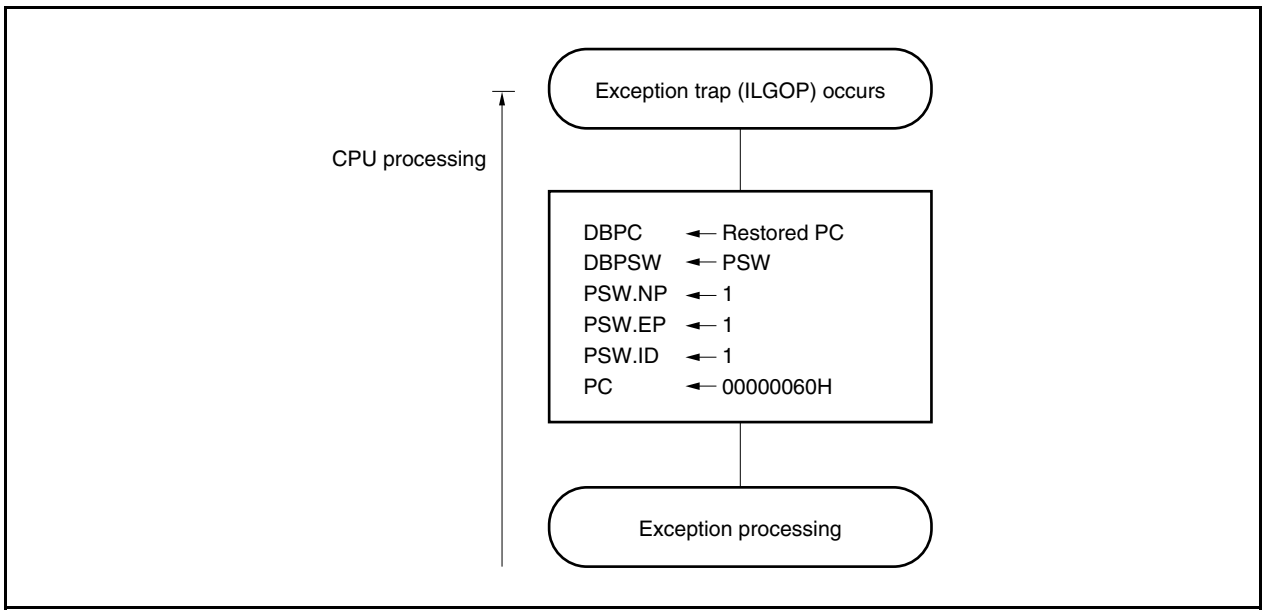
(1) Operation

If an exception trap occurs, the CPU performs the following processing, and transfers control to the handler routine.

<1> Saves the restored PC to DBPC.
<2> Saves the current PSW to DBPSW.
<3> Sets the PSW.NP, PSW.EP, and PSW.ID bits to 1.
<4> Sets the handler address (00000060H) corresponding to the exception trap to the PC, and transfers control.

The processing of the exception trap is shown below.

Figure 23-11. Exception Trap Processing



(2) Restoration

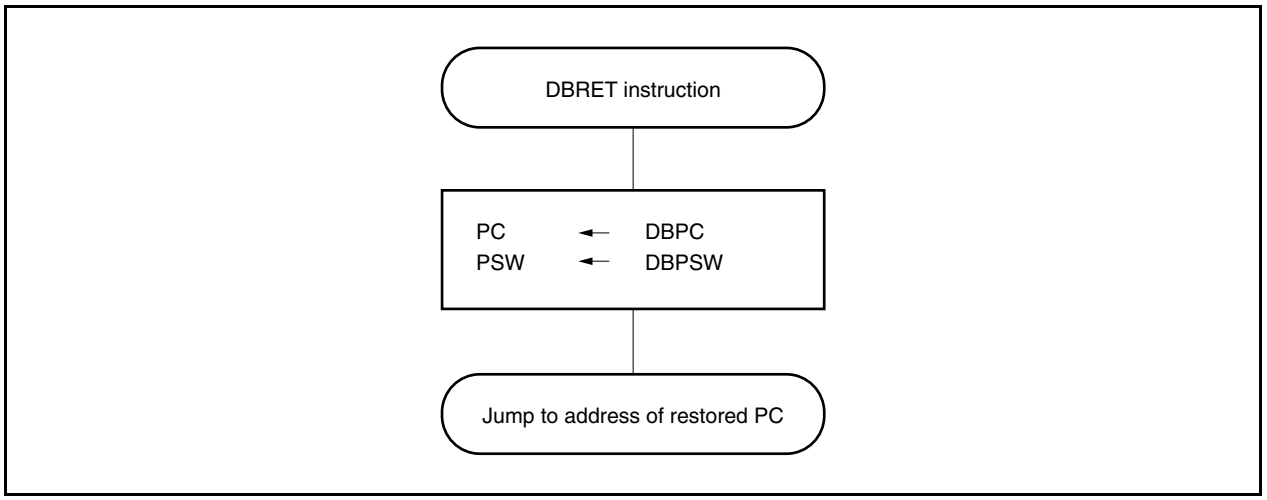
Restoration from an exception trap is carried out by the DBRET instruction. By executing the DBRET instruction, the CPU carries out the following processing and controls the address of the restored PC.

<1> Loads the restored PC and PSW from DBPC and DBPSW.
<2> Transfers control to the address indicated by the restored PC and PSW.

Caution DBPC and DBPSW can be accessed only during the interval between the execution of an illegal opcode and DBRET instruction.

Processing for restoring from an exception trap is shown below.

Figure 23-12. Processing for Restoring from Exception Trap



23.5.2 Debug trap

A debug trap is an exception that is generated when the DBTRAP instruction is executed and is always acknowledged.

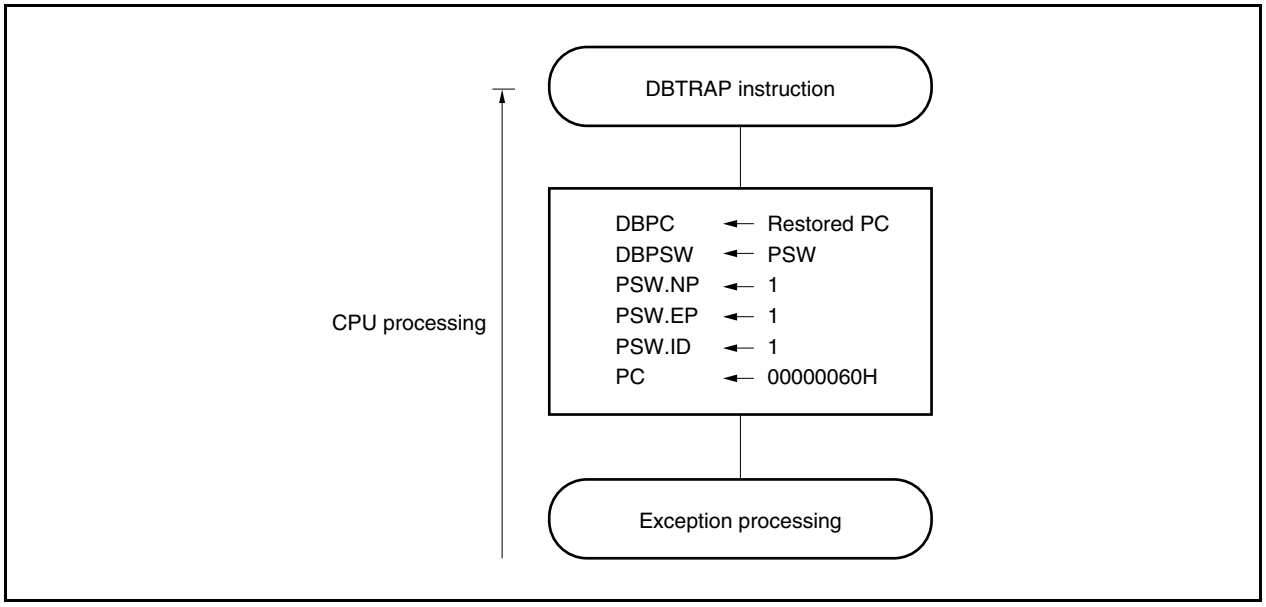
(1) Operation

Upon occurrence of a debug trap, the CPU performs the following processing.

<1> Saves restored PC to DBPC.
<2> Saves current PSW to DBPSW.
<3> Sets the PSW.NP, PSW.EP, and PSW.ID bits to 1.
<4> Sets handler address (00000060H) for debug trap to PC and transfers control.

The debug trap processing format is shown below.

Figure 23-13. Debug Trap Processing Format



(2) Restoration

Restoration from a debug trap is executed with the DBRET instruction.

With the DBRET instruction, the CPU performs the following steps and transfers control to the address of the restored PC.

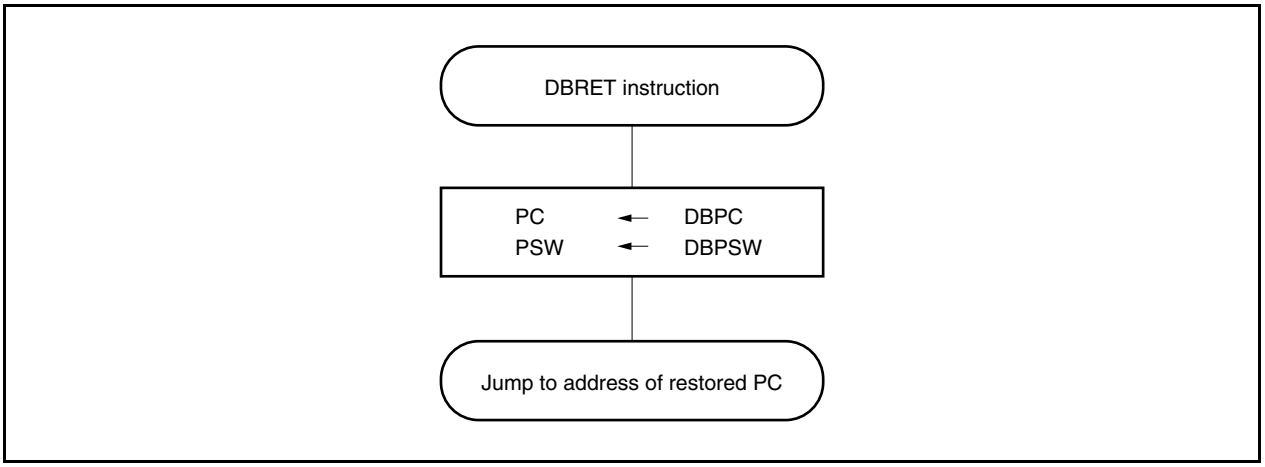
<1> The restored PC and PSW are read from DBPC and DBPSW.

<2> Control is transferred to the fetched address of the restored PC and PSW.

Caution DBPC and DBPSW can be accessed only during the interval between the execution of the DBTRAP instruction and DBRET instruction.

The processing format for restoration from a debug trap is shown below.

Figure 23-14. Processing Format of Restoration from Debug Trap



23.6 External Interrupt Request Input Pins (NMI and INTP00 to INTP18)

23.6.1 Noise elimination

(1) Eliminating noise on NMI pin

The NMI pin has an internal noise elimination circuit that uses analog delay. Therefore, the input level of the NMI pin is not detected as an edge unless it is maintained for a specific time or longer. Therefore, an edge is detected after specific time.

The NMI pin can be used to release the STOP mode. In the STOP mode, noise is not eliminated by using the system clock because the internal system clock is stopped.

(2) Eliminating noise on INTP00, INTP01, and INTP03 to INTP18 pins

The INTP00, INTP01, and INTP03 to INTP18 pins have an internal noise elimination circuit that uses analog delay. Therefore, the input level of the NMI pin is not detected as an edge unless it is maintained for a specific time or longer. Therefore, an edge is detected after specific time.

(3) Eliminating noise on INTP02

The INTP02 pin has an internal noise elimination circuit that uses analog delay and an internal digital noise elimination circuit. Either can be selected by using the noise elimination control register (INTNFC) (see **23.6.2 (7)**).

23.6.2 Edge detection

The valid edge of each of the NMI and INTP00 to INTP18 pins can be selected from the following four.

- Rising edge
- Falling edge
- Both rising and falling edges
- No edge detected

The edge of the NMI pin is not detected after reset. Therefore, the interrupt request signal is not acknowledged unless a valid edge is enabled by using the INTF0 and INTR0 register (the NMI pin functions as a normal port pin).

(1) External interrupt falling, rising edge specification register 0 (INTF0, INTR0)

The INTF0 and INTR0 registers are 8-bit registers that specify detection of the falling and rising edges of the NMI pin via bit 2 and the external interrupt pins (INTP00 to INTP04) via bits 0, 1, 3 to 5.

These registers can be read or written in 8-bit or 1-bit units.

Reset sets these registers to 00H.

Caution When the function is changed from the external interrupt function (alternate function) to the port function, an edge may be detected. Therefore, set the INTF0n and INTR0n bits to 00, and then set the port mode.

After reset: 00H R/W Address: INTF0 FFFFFC00H, INTR0 FFFFFC20H

	7	6	5	4	3	2	1	0
INTF0	0	0	INTF05	INTF04	INTF03	INTF02	INTF01 Note	INTF00 Note
			INTP04	INTP03	INTP02	NMI	INTP01	INTP00

	7	6	5	4	3	2	1	0
INTR0	0	0	INTR05	INTR04	INTR03	INTR02	INTR01 Note	INTR00 Note
			INTP04	INTP03	INTP02	NMI	INTP01	INTP00

Note V850ES/JH3-H only

Remark For how to specify a valid edge, see **Table 23-5**.

Table 23-5. Valid Edge Specification

INTF0n	INTR0n	Valid Edge Specification (n = 0 to 5)
0	0	No edge detected
0	1	Rising edge
1	0	Falling edge
1	1	Both rising and falling edges

Caution Be sure to set the INTF0n and INTR0n bits to 00 when these registers are not used as the NMI or INTP00 to INTP04 pins.

Remark n = 0, 1: Control of INTP00 and INTP01 pins
n = 2: Control of NMI pin
n = 3 to 5: Control of INTP02 to INTP04 pins

(2) External interrupt falling, rising edge specification register 2 (INTF2, INTR2) (V850ES/JH3-H only)

The INTF2 and INTR2 registers are 8-bit registers that specify detection of the falling and rising edges of the external interrupt pins (INTP05 to INTP06).

These registers can be read or written in 8-bit or 1-bit units.

Reset sets these registers to 00H.

Caution When the function is changed from the external interrupt function (alternate function) to the port function, an edge may be detected. Therefore, set the INTF2n and INTR2n bits to 00, and then set the port mode.

After reset: 00H R/W Address: INTF2 FFFFFC04H, INTR2 FFFFFC24H

	7	6	5	4	3	2	1	0
INTF2	0	0	INTF25	INTF24	0	0	0	0
			INTP06	INTP05				
INTR2	0	0	INTR25	INTR24	0	0	0	0
			INTP06	INTP05				

Remark For how to specify a valid edge, see **Table 23-6**.

Table 23-6. Valid Edge Specification

INTF2n	INTR2n	Valid Edge Specification (n = 4, 5)
0	0	No edge detected
0	1	Rising edge
1	0	Falling edge
1	1	Both rising and falling edges

Caution Be sure to set the INTF2n and INTR2n bits to 00 when these registers are not used as the INTP05 and INTP06 pins.

Remark n = 4, 5: Control of INTP05 and INTP06 pins

(3) External interrupt falling, rising edge specification register 3 (INTF3, INTR3)

The INTF3 and INTR3 registers are 8-bit registers that specify detection of the falling and rising edges of the external interrupt pin (INTP07 to INTP09).

These registers can be read or written in 8-bit or 1-bit units.

Reset sets these registers to 00H.

Caution When the function is changed from the external interrupt function (alternate function) to the port function, an edge may be detected. Therefore, set the INTF3n and INTR3n bits to 00, and then set the port mode.

After reset: 00H R/W Address: INTF3 FFFFFC06H, INTR3 FFFFFC26H

	7	6	5	4	3	2	1	0
INTF3	0	0	0	INTF34	0	0	INTF31	INTF30
				INTP09			INTP08	INTP07
INTR3	0	0	0	INTR34	0	0	INTR31	INTR30
				INTP09			INTP08	INTP07

Remark For how to specify a valid edge, see **Table 23-7**.

Table 23-7. Valid Edge Specification

INTF3n	INTR3n	Valid Edge Specification
0	0	No edge detected
0	1	Rising edge
1	0	Falling edge
1	1	Both rising and falling edges

Caution Be sure to set the INTF3n and INTR3n bits to 00 when these registers are not used as the INTP07 to INTP09 pin.

Remark n = 0, 1, 4: Control of INTP07 to INTP09 pins

(4) External interrupt falling, rising edge specification registers 4 (INTF4, INTR4)

The INTF4 and INTR4 registers are 8-bit registers that specify detection of the falling and rising edges of the external interrupt pin (INTP10).

These registers can be read or written in 8-bit or 1-bit units.

Reset sets these registers to 00H.

Caution When the function is changed from the external interrupt function (alternate function) to the port function, an edge may be detected. Therefore, set the INTF42 and INTR42 bits to 00, and then set the port mode.

After reset: 00H R/W Address: INTF4 FFFFFC08H, INTR4 FFFFFC28H

	7	6	5	4	3	2	1	0
INTF4	0	0	0	0	0	INTF42	0	0
						INTP10		

	7	6	5	4	3	2	1	0
INTR4	0	0	0	0	0	INTR42	0	0
						INTP10		

Remark For the valid edge specification combinations, see **Table 23-8**.

Table 23-8. Valid Edge Specification

INTF42	INTR42	Valid Edge Specification
0	0	No edge detected
0	1	Rising edge
1	0	Falling edge
1	1	Both rising and falling edges

Caution Be sure to set the INTF42 and INTR42 bits to 00 if the corresponding pin is not used as the INTP10 pin.

(5) External interrupt falling, rising edge specification registers 5 (INTF5, INTR5) (V850ES/JG3-H only)

The INTF5 and INTR5 registers are 8-bit registers that specify detection of the falling and rising edges of the external interrupt pin (INTP05).

These registers can be read or written in 8-bit or 1-bit units.

Reset sets these registers to 00H.

Caution When the function is changed from the external interrupt function (alternate function) to the port function, an edge may be detected. Therefore, set the INTF56 and INTR56 bits to 00, and then set the port mode.

After reset: 00H R/W Address: INTF5 FFFFFC0AH, INTR5 FFFFFC2AH

	7	6	5	4	3	2	1	0
INTF5	0	INTF56	0	0	0	0	0	0
		INTP05						

	7	6	5	4	3	2	1	0
INTR5	0	INTR56	0	0	0	0	0	0
		INTP05						

Remark For the valid edge specification combinations, see **Table 23-9**.

Table 23-9. Valid Edge Specification

INTF56	INTR56	Valid Edge Specification
0	0	No edge detected
0	1	Rising edge
1	0	Falling edge
1	1	Both rising and falling edges

Caution Be sure to set the INTF56 and INTR56 bits to 00 if the corresponding pin is not used as the INTP05 pin.

(6) External interrupt falling, rising edge specification register 9H (INTF9H, INTR9H)

The INTF9H and INTR9H registers are 16-bit or 8-bit registers that specify detection of the falling and rising edges of the external interrupt pins (INTP11 to INTP18).

These registers can be read or written in 8-bit or 1-bit units.

Reset sets these registers to 0000H/00H.

Caution When the function is changed from the external interrupt function (alternate function) to the port function, an edge may be detected. Therefore, clear the INTF9n and INTR9n bits to 0, and then set the port mode.

After reset: 0000H R/W Address: INTF9 FFFFFC12H, INTF9L FFFFFC12H, INTF9H FFFFFC13H

	15	14	13	12	11	10	9	8
INTF9 (INTF9H[Note])	INTF915	INTF914	INTF913	0	INTF911	INTF910	INTF99	INTF98
	INTP18	INTP17	INTP16		INTP15	INTP14	INTP13	INTP12

	7	6	5	4	3	2	1	0
(INTF9L)	0	INTF96	0	0	0	0	0	0
		INTP11						

After reset: 0000H R/W Address: INTR9 FFFFFC32H, INTR9L FFFFFC32H, INTR9H FFFFFC33H

	15	14	13	12	11	10	9	8
INTR9 (INTR9H[Note])	INTR915	INTR914	INTF913	0	INTR911	INTR910	INTR99	INTR98
	INTP18	INTP17	INTP16		INTP15	INTP14	INTP13	INTP12

	7	6	5	4	3	2	1	0
(INTR9L)	0	INTR96	0	0	0	0	0	0
		INTP11						

Note To read bits 8 to 15 of the INTF9 and INTR9 registers in 8-bit or 1-bit units, specify them as bits 0 to 7 of the INTF9H and INTR9H registers.

Remark For how to specify a valid edge, see **Table 23-10**.

Table 23-10. Valid Edge Specification

INTF9n	INTR9n	Valid Edge Specification (n = 11 to 18)
0	0	No edge detected
0	1	Rising edge
1	0	Falling edge
1	1	Both rising and falling edges

Caution Be sure to clear the INTF9n and INTR9n bits to 00 when these registers are not used as the INTP11 to INTP18 pins.

Remark n = 6, 8 to 11, 13 to 15: Control of INTP11 to INTP18 pins

(7) Noise elimination control register (INTNFC)

Analog noise elimination and digital noise elimination can be selected for the INTP02 pin. The noise elimination settings are performed using the INTNFC register.

When analog noise elimination is selected, the input level of the pin is detected as an edge by maintaining it for a specific time or longer.

When digital noise elimination is selected, the sampling clock for digital sampling can be selected from among fxx/64, fxx/128, fxx/256, fxx/512, fxx/1,024, and fXT. Sampling is performed 3 times.

Even when digital noise elimination is selected, using fXT as the sampling clock makes it possible to use the INTP02 interrupt request signal to release the IDLE1, IDLE2, and STOP modes.

This register can be read or written in 8-bit units.

Reset sets this register to 00H.

Caution After the sampling clock has been changed, it takes 3 sampling clocks to initialize the digital noise eliminator. Therefore, if an INTP02 valid edge is input within these 3 sampling clocks after the sampling clock has been changed, an interrupt request signal may be generated. Therefore, be careful about the following points when using the interrupt and DMA functions.

- **When using the interrupt function, after the 3 sampling clocks have elapsed, enable interrupts after the interrupt request flag (PIC2.PIF2 bit) has been cleared.**
- **When using the DMA function (started by INTP02), enable DMA after 3 sampling clocks have elapsed.**

After reset: 00H R/W Address: FFFFF728H

	7	6	5	4	3	2	1	0
INTNFC	INTNFEN	0	0	0	0	INTNFC2	INTNFC1	INTNFC0

INTNFEN	Settings of INTP02 pin noise elimination
0	Analog noise elimination (60 ns (TYP.))
1	Digital noise elimination

INTNFC2	INTNFC1	INTNFC0	Digital sampling clock
0	0	0	fxx/64
0	0	1	fxx/128
0	1	0	fxx/256
0	1	1	fxx/512
1	0	0	fxx/1,024
1	0	1	fXT (subclock)
Other than above			Setting prohibited

Remarks 1. Since sampling is performed 3 times, the reliably eliminated noise width is 2 sampling clocks.

2. In the case of noise with a width smaller than 2 sampling clocks, an interrupt request signal is generated if noise synchronized with the sampling clock is input.

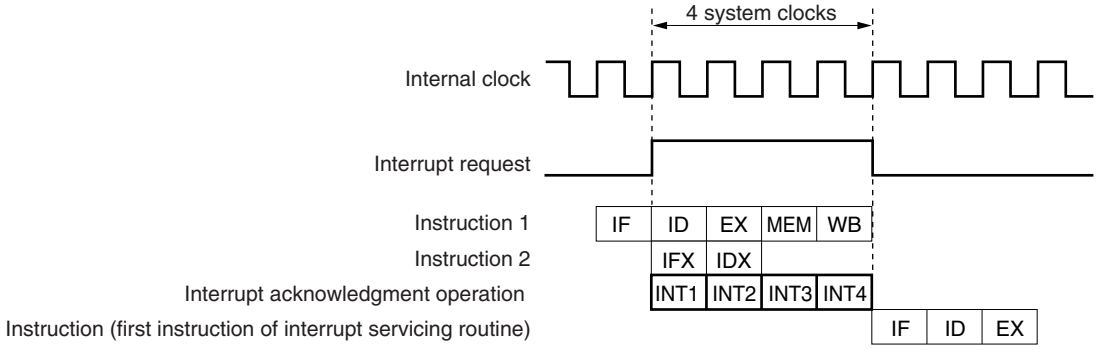
23.7 Interrupt Acknowledge Time of CPU

Except the following cases, the interrupt acknowledge time of the CPU is 4 clocks minimum. To input interrupt request signals successively, input the next interrupt request signal at least 5 clocks after the preceding interrupt.

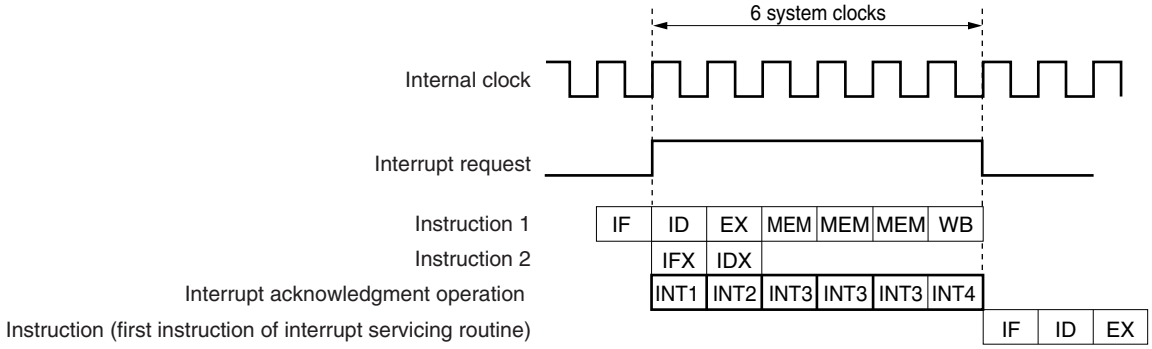
- In IDLE1/IDLE2/STOP mode
- When the external bus is accessed
- When interrupt request non-sampling instructions are successively executed (see **23.8 Periods in Which Interrupts Are Not Acknowledged by CPU**.)
- When the interrupt control register is accessed

Figure 23-15. Pipeline Operation at Interrupt Request Signal Acknowledgment (Outline)

(1) Minimum interrupt response time



(2) Maximum interrupt response time



Remark INT1 to INT4: Interrupt acknowledgment processing
IFX: Invalid instruction fetch
IDX: Invalid instruction decode

Interrupt acknowledge time (internal system clock)			Condition
	Internal interrupt	External interrupt	
Minimum	4	4 + Analog delay time	The following cases are exceptions. • In IDLE1/IDLE2/STOP mode • External bus access • Two or more interrupt request non-sample instructions are executed in succession • Access to peripheral I/O register
Maximum	6	6 + Analog delay time	

23.8 Periods in Which Interrupts Are Not Acknowledged by CPU

An interrupt is acknowledged by the CPU while an instruction is being executed. However, no interrupt will be acknowledged between an interrupt request non-sample instruction and the next instruction (interrupt is held pending).

The interrupt request non-sample instructions are as follows.

- EI instruction
- DI instruction
- LDSR reg2, 0x5 instruction (for PSW)
- The store instruction for the PRCMD register
- The store, SET1, NOT1, or CLR1 instructions for the following registers.
  - Interrupt-related registers:
    Interrupt control register (xxICn), interrupt mask registers 0 to 5 (IMR0 to IMR5)
  - Power save control register (PSC)
  - On-chip debug mode register (OCDM)

Remark xx: Identification name of each peripheral unit (see **Table 23-4 Interrupt Control Register (xxICn)**)
n: Peripheral unit number (see **Table 23-4 Interrupt Control Register (xxICn)**).

23.9 Cautions

The NMI pin alternately functions as the P02 pin, and functions as a normal port pin after being reset. To enable the NMI pin, validate the NMI pin with the PMC0 register. The initial setting of the NMI pin is “No edge detected”. Select the NMI pin valid edge using the INTF0 and INTR0 registers.

CHAPTER 24 KEY INTERRUPT FUNCTION

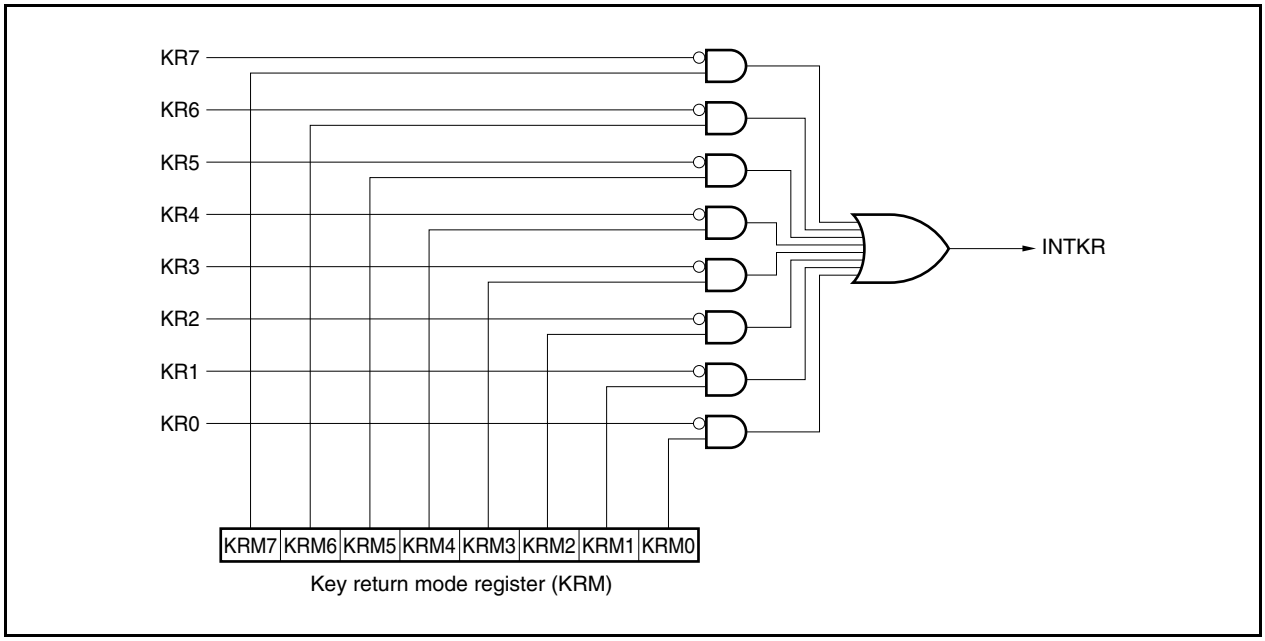
24.1 Function

A key interrupt request signal (INTKR) can be generated by inputting a falling edge to the eight key input pins (KR0 to KR7) by setting the KRM register.

Table 24-1. Assignment of Key Return Detection Pins

Flag	Pin Description
KRM0	Controls KR0 signal in 1-bit units
KRM1	Controls KR1 signal in 1-bit units
KRM2	Controls KR2 signal in 1-bit units
KRM3	Controls KR3 signal in 1-bit units
KRM4	Controls KR4 signal in 1-bit units
KRM5	Controls KR5 signal in 1-bit units
KRM6	Controls KR6 signal in 1-bit units
KRM7	Controls KR7 signal in 1-bit units

Figure 24-1. Key Return Block Diagram



24.2 Register

(1) Key return mode register (KRM)

The KRM register controls the KRM0 to KRM7 bits using the KR0 to KR7 signals.

This register can be read or written in 8-bit or 1-bit units.

Reset sets this register to 00H.

After reset: 00H R/W Address: FFFFF300H

	7	6	5	4	3	2	1	0
KRM	KRM7	KRM6	KRM5	KRM4	KRM3	KRM2	KRM1	KRM0

KRMn	Control of key return mode
0	Does not detect key return signal
1	Detects key return signal

Caution Rewrite the KRM register after once setting the KRM register to 00H.

Remark For the alternate-function pin settings, see **Table 4-20 Settings When Port Pins Are Used for Alternate Functions**.

24.3 Cautions

(1) If a low level is input to any of the KR0 to KR7 pins, the INTKR signal is not generated even if the falling edge of another pin is input.

(2) If the KRM register is changed, an interrupt request signal (INTKR) may be generated. To prevent this, change the KRM register after disabling interrupts (DI) or masking, then clear the interrupt request flag (KRIC.KRIF bit) to 0, and enable interrupts (EI) or clear the mask.

(3) To use the key interrupt function, be sure to set the port pin to the key return pin and then enable the operation with the KRM register. To switch from the key return pin to the port pin, disable the operation with the KRM register and then set the port pin.

CHAPTER 25 STANDBY FUNCTION

25.1 Overview

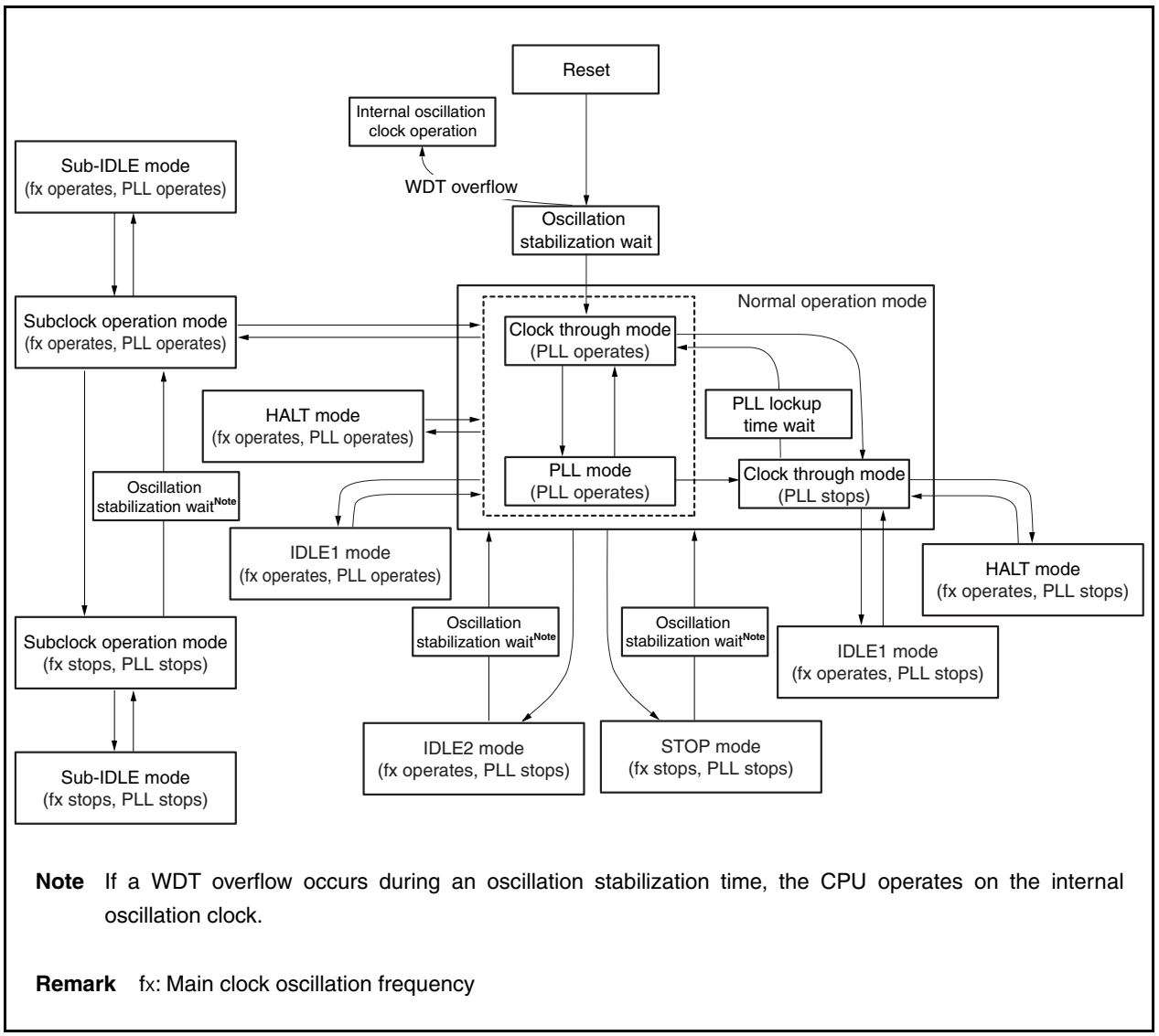
The power consumption of the system can be effectively reduced by using the standby modes in combination and selecting the appropriate mode for the application. The available standby modes are listed in Table 25-1.

Table 25-1. Standby Modes

Mode	Functional Outline
HALT mode	Mode in which only the operating clock of the CPU is stopped
IDLE1 mode	Mode in which all the operations of the internal circuits except the oscillator, PLL[Note], and flash memory are stopped
IDLE2 mode	Mode in which all the operations of internal circuits except the oscillator are stopped
STOP mode	Mode in which all the operations of internal circuits except the subclock oscillator are stopped
Subclock operation mode	Mode in which the subclock is used as the internal system clock
Sub-IDLE mode	Mode in which all the operations of internal circuits except the oscillator are stopped, in the subclock operation mode

Note The PLL holds the previous operating status.

Figure 25-1. Status Transition



Note If a WDT overflow occurs during an oscillation stabilization time, the CPU operates on the internal oscillation clock.

Remark fx: Main clock oscillation frequency

25.2 Registers

(1) Power save control register (PSC)

The PSC register is an 8-bit register that controls the standby function. The STP bit of this register is used to specify the standby mode. This register is a special register that can be written only by the special sequence combinations (see **3.4.8 Special registers**).

This register can be read or written in 8-bit or 1-bit units.

Reset sets this register to 00H.

After reset: 00H R/W Address: FFFFF1FEH

	7	<6>	<5>	<4>	3	2	<1>	0
PSC	0	NMI1M	NMI0M	INTM	0	0	STP	0

NMI1M	Control of releasing standby mode by INTWDT2 signal
0	Releasing standby mode by INTWDT2 signal enabled
1	Releasing standby mode by INTWDT2 signal disabled

NMI0M	Control of releasing standby mode by NMI pin input
0	Releasing standby mode by NMI pin input enabled
1	Releasing standby mode by NMI pin input disabled

INTM	Control of releasing standby mode by maskable interrupt request signals
0	Releasing standby mode by maskable interrupt request signals enabled
1	Releasing standby mode by maskable interrupt request signals disabled

STP	Standby mode[Note] setting
0	Normal mode
1	Standby mode

Note Standby mode set by STP bit: IDLE1, IDLE2, STOP, or sub-IDLE mode

Cautions 1. Before setting the IDLE1, IDLE2, STOP, or sub-IDLE mode, set the PSMR.PSM1 and PSMR.PSM0 bits and then set the STP bit.

2. Settings of the NMI1M, NMI0M, and INTM bits are invalid when HALT mode is released.

3. If the NMI1M, NMI0M, or INTM bit is set to 1 at the same time the STP bit is set to 1, the setting of NMI1M, NMI0M, or INTM bit becomes invalid. If there is an unmasked interrupt request signal being held pending when the IDLE1/IDLE2/STOP mode is set, set the bit corresponding to the interrupt request signal (NMI1M, NMI0M, or INTM) to 1, and then set the STP bit to 1.

(2) Power save mode register (PSMR)

The PSMR register is an 8-bit register that controls the operation status in the power save mode and the clock operation.

This register can be read or written in 8-bit or 1-bit units.

Reset sets this register to 00H.

After reset: 00H R/W Address: FFFFF820H

	7	6	5	4	3	2	<1>	<0>
PSMR	0	0	0	0	0	0	PSM1	PSM0

PSM1	PSM0	Specification of operation in software standby mode
0	0	IDLE1, sub-IDLE modes
0	1	STOP mode
1	0	IDLE2, sub-IDLE modes
1	1	STOP mode

Cautions 1. Be sure to set bits 2 to 7 to "0".

2. The PSM0 and PSM1 bits are valid only when the PSC.STP bit is 1.

Remark IDLE1: In this mode, all operations except the oscillator operation and some other circuits (flash memory and PLL) are stopped.
After the IDLE1 mode is released, the normal operation mode is restored without needing to secure the oscillation stabilization time, like the HALT mode.

IDLE2: In this mode, all operations except the oscillator operation are stopped.
After the IDLE2 mode is released, the normal operation mode is restored following the lapse of the setup time specified by the OSTS register (flash memory and PLL).

STOP: In this mode, all operations except the subclock oscillator operation are stopped.
After the STOP mode is released, the normal operation mode is restored following the lapse of the oscillation stabilization time specified by the OSTS register.

Sub-IDLE: In this mode, all other operations are halted except for the oscillator. After the IDLE mode has been released by the interrupt request signal, the subclock operation mode will be restored after 12 cycles of the subclock have been secured.

(3) Oscillation stabilization time select register (OSTS)

The wait time until the oscillation stabilizes after the STOP mode is released or the wait time until the on-chip flash memory stabilizes after the IDLE2 mode is released is controlled by the OSTS register.

This register can be read or written in 8-bit units.

Reset sets this register to 06H.

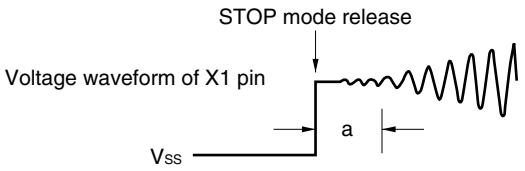
After reset: 06H R/W Address: FFFFF6C0H

	7	6	5	4	3	2	1	0
OSTS	0	0	0	0	0	OSTS2	OSTS1	OSTS0

OSTS2	OSTS1	OSTS0	Selection of oscillation stabilization time/setup time[Note]	fx	
				3 MHz	6 MHz
0	0	0	$2^{10}/f_x$	0.341 ms	0.171 ms
0	0	1	$2^{11}/f_x$	0.683 ms	0.341 ms
0	1	0	$2^{12}/f_x$	1.365 ms	0.683 ms
0	1	1	$2^{13}/f_x$	2.730 ms	1.365 ms
1	0	0	$2^{14}/f_x$	5.461 ms	2.731 ms
1	0	1	$2^{15}/f_x$	10.923 ms	5.461 ms
1	1	0	$2^{16}/f_x$	21.85 ms	10.92 ms
1	1	1	Setting prohibited		

Note The oscillation stabilization time and setup time are required when the STOP mode and IDLE2 mode are released, respectively.

Cautions 1. The wait time following release of the STOP mode does not include the time until the clock oscillation starts ("a" in the figure below) following release of the STOP mode, regardless of whether the STOP mode is released by reset or the occurrence of an interrupt request signal.



2. Be sure to set bits 3 to 7 to "0".

3. The oscillation stabilization time following reset release is $2^{16}/f_x$ (because the initial value of the OSTS register = 06H).

Remark fx = Main clock oscillation frequency

25.3 HALT Mode

25.3.1 Setting and operation status

The HALT mode is set when a dedicated instruction (HALT) is executed in the normal operation mode.

In the HALT mode, the clock oscillator continues operating. Only clock supply to the CPU is stopped; clock supply to the other on-chip peripheral functions continues.

As a result, program execution is stopped, and the internal RAM retains the contents before the HALT mode was set. The on-chip peripheral functions that are independent of instruction processing by the CPU continue operating.

Table 25-3 shows the operating status in the HALT mode.

The average current consumption of the system can be reduced by using the HALT mode in combination with the normal operation mode for intermittent operation.

Cautions 1. Insert five or more NOP instructions after the HALT instruction.

2. If the HALT instruction is executed while an unmasked interrupt request signal is being held pending, the status shifts to HALT mode, but the HALT mode is then released immediately by the pending interrupt request.

25.3.2 Releasing HALT mode

The HALT mode is released by a non-maskable interrupt request signal (NMI pin input, INTWDT2 signal), unmasked external interrupt request signal (INTP00 to INTP18 pin input), unmasked internal interrupt request signal from a peripheral function operable in the HALT mode, or reset signal (reset by $\overline{\text{RESET}}$ pin input, WDT2RES signal, low-voltage detector (LVI), or clock monitor (CLM)).

After the HALT mode has been released, the normal operation mode is restored.

(1) Releasing HALT mode by non-maskable interrupt request signal or unmasked maskable interrupt request signal

The HALT mode is released by a non-maskable interrupt request signal or an unmasked maskable interrupt request signal, regardless of the priority of the interrupt request signal. If the HALT mode is set in an interrupt servicing routine, however, an interrupt request signal that is issued later is serviced as follows.

(a) If an interrupt request signal with a priority lower than that of the interrupt request currently being serviced is issued, the HALT mode is released, but that interrupt request signal is not acknowledged. The interrupt request signal itself is retained.

(b) If an interrupt request signal with a priority higher than that of the interrupt request currently being serviced is issued (including a non-maskable interrupt request signal), the HALT mode is released and that interrupt request signal is acknowledged.

Table 25-2. Operation After Releasing HALT Mode by Interrupt Request Signal

Release Source	Interrupt Enabled (EI) Status	Interrupt Disabled (DI) Status
Non-maskable interrupt request signal	Execution branches to the handler address.	
Maskable interrupt request signal	Execution branches to the handler address or the next instruction is executed.	The next instruction is executed.

(2) Releasing HALT mode by reset

The same operation as the normal reset operation is performed.

Table 25-3. Operating Status in HALT Mode

Setting of HALT Mode / Item		Operating Status	
		When Subclock Is Not Used	When Subclock Is Used
Main clock oscillator (f_X)		Oscillation enabled	
Subclock oscillator (f_{XT})		–	Oscillation enabled
Internal oscillator (f_R)		Oscillation enabled	
PLL		Operable	
CPU		Stops operation	
DMA controller		Operable	
Interrupt controller		Operable	
Timer	TAA0 to TAA5	Operable	
	TAB0, TAB1	Operable	
	TMM0 to TMM3	Operable when a clock other than f_{XT} is selected as the count clock	Operable
	TMT0	Operable	
Real-time counter (RTC)		Operable when f_X (divided BRG) is selected as the count clock	Operable
Watchdog timer (WDT2)		Operable when a clock other than f_{XT} is selected as the count clock	Operable
Serial interface	CSIF0 to CSIF4	Operable	
	I^2C00 to I^2C02	Operable	
	UARTC0 to UARTC4	Operable	
A/D converter		Operable	
D/A converter		Operable	
Real-time output function (RTO)		Operable	
Key interrupt function (KR)		Operable	
CRC operation circuit		Operable (No data input to the CRCIN register because the CPU is stopped)	
External bus interface		See **CHAPTER 5 BUS CONTROL FUNCTION**.	
Port function		Retains status before HALT mode was set	
Internal data		The CPU registers, statuses, data, and all other internal data such as the contents of the internal RAM are retained as they were before the HALT mode was set.	
CAN[Note]		Operable	
USB function		Operable	

Note μPD70F3770, 70F3771 only

25.4 IDLE1 Mode

25.4.1 Setting and operation status

The IDLE1 mode is set by setting the PSMR.PSM1 and PSMR.PSM0 bits to 00 and setting the PSC.STP bit to 1 in the normal operation mode.

In the IDLE1 mode, the clock oscillator, PLL, and flash memory continue operating but clock supply to the CPU and other on-chip peripheral functions stops.

As a result, program execution stops and the contents of the internal RAM before the IDLE1 mode was set are retained. The CPU and other on-chip peripheral functions stop operating. However, the on-chip peripheral functions that can operate with the subclock or an external clock continue operating.

Table 25-5 shows the operating status in the IDLE1 mode.

The IDLE1 mode can reduce the power consumption more than the HALT mode because it stops the operation of the on-chip peripheral functions. The main clock oscillator does not stop, so the normal operation mode can be restored without waiting for the oscillation stabilization time after the IDLE1 mode has been released, in the same manner as when the HALT mode is released.

Cautions 1. Insert five or more NOP instructions after the instruction that stores data in the PSC register to set the IDLE1 mode.

2. If the IDLE1 mode is set while an unmasked interrupt request signal is being held pending, the IDLE1 mode is released immediately by the pending interrupt request.

25.4.2 Releasing IDLE1 mode

The IDLE1 mode is released by a non-maskable interrupt request signal (NMI pin input, INTWDT2 signal), unmasked external interrupt request signal (INTP00 to INTP18 pin input), unmasked internal interrupt request signal from a peripheral function operable in the IDLE1 mode, or reset signal (reset by $\overline{\text{RESET}}$ pin input, WDT2RES signal, low-voltage detector (LVI), or clock monitor (CLM)).

After the IDLE1 mode has been released, the normal operation mode is restored.

(1) Releasing IDLE1 mode by non-maskable interrupt request signal or unmasked maskable interrupt request signal

The IDLE1 mode is released by a non-maskable interrupt request signal or an unmasked maskable interrupt request signal, regardless of the priority of the interrupt request signal. If the IDLE1 mode is set in an interrupt servicing routine, however, an interrupt request signal that is issued later is processed as follows.

(a) If an interrupt request signal with a priority lower than that of the interrupt request currently being serviced is issued, the IDLE1 mode is released, but that interrupt request signal is not acknowledged. The interrupt request signal itself is retained.

(b) If an interrupt request signal with a priority higher than that of the interrupt request currently being serviced is issued (including a non-maskable interrupt request signal), the IDLE1 mode is released and that interrupt request signal is acknowledged.

Caution An interrupt request signal that is disabled by setting the PSC.NMI1M, PSC.NMI0M, and PSC.INTM bits to 1 becomes invalid and IDLE1 mode is not released.

Table 25-4. Operation After Releasing IDLE1 Mode by Interrupt Request Signal

Release Source	Interrupt Enabled (EI) Status	Interrupt Disabled (DI) Status
Non-maskable interrupt request signal	Execution branches to the handler address after securing the prescribed setup time.	
Maskable interrupt request signal	Execution branches to the handler address or the next instruction is executed after securing the prescribed setup time.	The next instruction is executed after securing the prescribed setup time.

(2) Releasing IDLE1 mode by reset

The same operation as the normal reset operation is performed.

Table 25-5. Operating Status in IDLE1 Mode

Item \ Setting of IDLE1 Mode		Operating Status	
		When Subclock Is Not Used	When Subclock Is Used
Main clock oscillator (f_X)		Oscillation enabled	
Subclock oscillator (f_{XT})		–	Oscillation enabled
Internal oscillator (f_R)		Oscillation enabled	
PLL		Operable	
CPU		Stops operation	
DMA controller		Stops operation	
Interrupt controller		Stops operation (but standby mode release is possible)	
Timer	TAA0 to TAA5	Stops operation	
	TAB0, TAB1	Stops operation	
	TMM0 to TMM3	Operable when f_R/8 is selected as the count clock	Operable when f_R/8 or f_{XT} is selected as the count clock
	TMT0	Stops operation	
Real-time counter (RTC)		Operable when f_X (divided BRG) is selected as the count clock	Operable
Watchdog timer (WDT2)		Operable when f_R is selected as the count clock	Operable when f_R or f_{XT} is selected as the count clock
Serial interface	CSIF0 to CSIF4	Operable when the $\overline{\text{SCKFn}}$ input clock is selected as the count clock (n = 0 to 4)	
	I^2C00 to I^2C02	Stops operation	
	UARTC0 to UARTC4	Stops operation (but UARTC0 is operable when the ASCKC0 input clock is selected)	
A/D converter		Holds operation (conversion result held)[Note 1]	
D/A converter		Holds operation (output held[Note 1])	
Real-time output function (RTO)		Stops operation (output held)	
Key interrupt function (KR)		Operable	
CRC operation circuit		Stops operation	
External bus interface		See **CHAPTER 5 BUS CONTROL FUNCTION**.	
Port function		Retains status before IDLE1 mode was set	
Internal data		The CPU registers, statuses, data, and all other internal data such as the contents of the internal RAM are retained as they were before the IDLE1 mode was set.	
CAN[Note 2]		Stops operation	
USB function		Operable when the UCLK input is selected as the operation clock or when the PLL is operating.[Note 1]	

Notes 1. To lower the power consumption, stop the A/D converter, D/A converter, and USB function controller before shifting to the IDLE1 mode.

2. μPD70F3770, 70F3771 only

25.5 IDLE2 Mode

25.5.1 Setting and operation status

The IDLE2 mode is set by setting the PSMR.PSM1 and PSMR.PSM0 bits to 10 and setting the PSC.STP bit to 1 in the normal operation mode.

In the IDLE2 mode, the clock oscillator continues operation but clock supply to the CPU, PLL, flash memory, and other on-chip peripheral functions stops.

As a result, program execution stops and the contents of the internal RAM before the IDLE2 mode was set are retained. The CPU, PLL, and other on-chip peripheral functions stop operating. However, the on-chip peripheral functions that can operate with the subclock or an external clock continue operating.

Table 25-7 shows the operating status in the IDLE2 mode.

The IDLE2 mode can reduce the power consumption more than the IDLE1 mode because it stops the operations of the on-chip peripheral functions, PLL, and flash memory. However, because the PLL and flash memory are stopped, a setup time for the PLL and flash memory is required when IDLE2 mode is released.

Cautions 1. Insert five or more NOP instructions after the instruction that stores data in the PSC register to set the IDLE2 mode.

2. If the IDLE2 mode is set while an unmasked interrupt request signal is being held pending, the IDLE2 mode is released immediately by the pending interrupt request.

25.5.2 Releasing IDLE2 mode

The IDLE2 mode is released by a non-maskable interrupt request signal (NMI pin input, INTWDT2 signal), unmasked external interrupt request signal (INTP0 to INTP18 pin input), unmasked internal interrupt request signal from the peripheral functions operable in the IDLE2 mode, or reset signal (reset by $\overline{\text{RESET}}$ pin input, WDT2RES signal, low-voltage detector (LVI), or clock monitor (CLM)). The PLL returns to the operating status it was in before the IDLE2 mode was set.

After the IDLE2 mode has been released, the normal operation mode is restored.

(1) Releasing IDLE2 mode by non-maskable interrupt request signal or unmasked maskable interrupt request signal

The IDLE2 mode is released by a non-maskable interrupt request signal or an unmasked maskable interrupt request signal, regardless of the priority of the interrupt request signal. If the IDLE2 mode is set in an interrupt servicing routine, however, an interrupt request signal that is issued later is processed as follows.

(a) If an interrupt request signal with a priority lower than that of the interrupt request currently being serviced is issued, the IDLE2 mode is released, but that interrupt request signal is not acknowledged. The interrupt request signal itself is retained.

(b) If an interrupt request signal with a priority higher than that of the interrupt request currently being serviced is issued (including a non-maskable interrupt request signal), the IDLE2 mode is released and that interrupt request signal is acknowledged.

Caution The interrupt request signal that is disabled by setting the PSC.NMI1M, PSC.NMI0M, and PSC.INTM bits to 1 becomes invalid and IDLE2 mode is not released.

Table 25-6. Operation After Releasing IDLE2 Mode by Interrupt Request Signal

Release Source	Interrupt Enabled (EI) Status	Interrupt Disabled (DI) Status
Non-maskable interrupt request signal	Execution branches to the handler address after securing the prescribed setup time.	
Maskable interrupt request signal	Execution branches to the handler address or the next instruction is executed after securing the prescribed setup time.	The next instruction is executed after securing the prescribed setup time.

(2) Releasing IDLE2 mode by reset

The same operation as the normal reset operation is performed.

Table 25-7. Operating Status in IDLE2 Mode

Item \ Setting of IDLE2 Mode		Operating Status	
		When Subclock Is Not Used	When Subclock Is Used
Main clock oscillator (f_X)		Oscillation enabled	
Subclock oscillator (f_{XT})		–	Oscillation enabled
Internal oscillator (f_R)		Oscillation enabled	
PLL		Stops operation	
CPU		Stops operation	
DMA controller		Stops operation	
Interrupt controller		Stops operation	
Timer	TAA0 to TAA5	Stops operation	
	TAB0, TAB1	Stops operation	
	TMM0 to TMM3	Operable when f_R/8 is selected as the count clock	Operable when f_R/8 or f_{XT} is selected as the count clock
	TMT0	Stops operation	
Real-time counter (RTC)		Operable when f_X (divided BRG) is selected as the count clock	Operable
Watchdog timer (WDT2)		Operable when f_R is selected as the count clock	Operable when f_R or f_{XT} is selected as the count clock
Serial interface	CSIF0 to CSIF4	Operable when the $\overline{\text{SCKFn}}$ input clock is selected as the count clock (n = 0 to 4)	
	I^2C00 to I^2C02	Stops operation	
	UARTC0 to UARTC4	Stops operation (but UARTC0 is operable when the ASCKC0 input clock is selected)	
A/D converter		Holds operation (conversion result held)[Note 1]	
D/A converter		Holds operation (output held[Note 1])	
Real-time output function (RTO)		Stops operation (output held)	
Key interrupt function (KR)		Operable	
CRC operation circuit		Stops operation	
External bus interface		See **CHAPTER 5 BUS CONTROL FUNCTION**.	
Port function		Retains status before IDLE2 mode was set	
Internal data		The CPU registers, statuses, data, and all other internal data such as the contents of the internal RAM are retained as they were before the IDLE2 mode was set.	
CAN[Note 2]		Stops operation	
USB function		Operable when the UCLK input is selected as the operation clock or when the PLL is operating.[Note 1]	

Notes 1. To lower the power consumption, stop the A/D converter, D/A converter, and USB function controller before shifting to the IDLE2 mode.

2. μPD70F3770, 70F3771 only

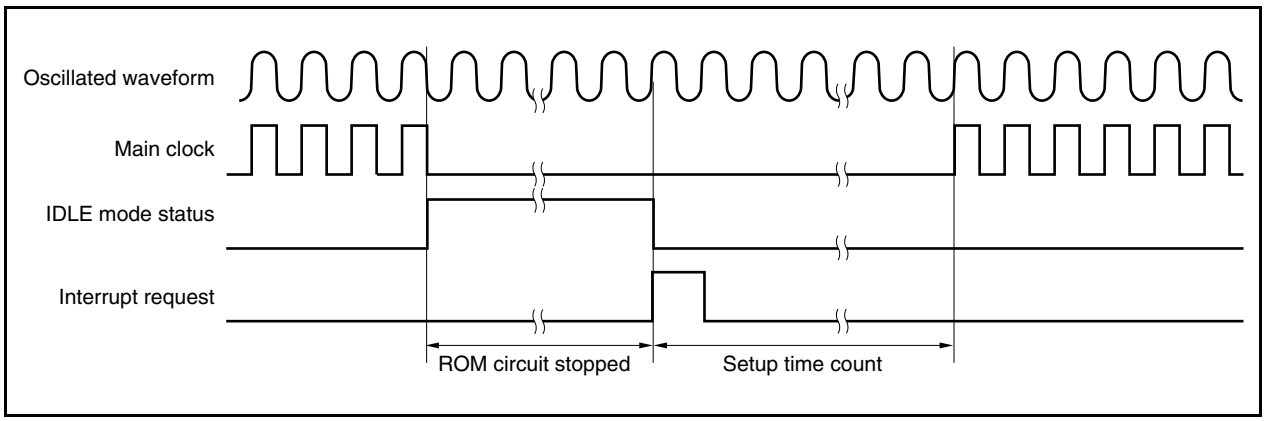
25.5.3 Securing setup time when releasing IDLE2 mode

Secure the setup time for the flash memory after releasing the IDLE2 mode because the operation of the blocks other than the main clock oscillator stops after the IDLE2 mode is set.

(1) Releasing IDLE2 mode by non-maskable interrupt request signal or unmasked maskable interrupt request signal

Secure the specified setup time by setting the OSTS register.

When the releasing source is generated, the dedicated internal timer starts counting according to the OSTS register setting. When it overflows, the normal operation mode is restored.



(2) Release by reset ($\overline{\text{RESET}}$ pin input, WDT2RES generation)

This operation is the same as that of a normal reset.

The oscillation stabilization time is the initial value of the OSTS register, 2^{16}/fx.

25.6 STOP Mode

25.6.1 Setting and operation status

The STOP mode is set by setting the PSMR.PSM1 and PSMR.PSM0 bits to 01 or 11 and setting the PSC.STP bit to 1 in the normal operation mode.

In the STOP mode, the subclock oscillator continues operating but the main clock oscillator stops. Clock supply to the CPU and the on-chip peripheral functions is stopped.

As a result, program execution stops, and the contents of the internal RAM before the STOP mode was set are retained. The on-chip peripheral functions that operate with the clock oscillated by the subclock oscillator or an external clock continue operating.

Table 25-9 shows the operating status in the STOP mode.

Because the STOP mode stops operation of the main clock oscillator, it reduces the power consumption to a level lower than the IDLE2 mode. If the subclock oscillator, internal oscillator, and external clock are not used, the power consumption can be minimized with only leakage current flowing.

Cautions 1. Insert five or more NOP instructions after the instruction that stores data in the PSC register to set the STOP mode.

2. If the STOP mode is set while an unmasked interrupt request signal is being held pending, the STOP mode is released immediately by the pending interrupt request.

25.6.2 Releasing STOP mode

The STOP mode is released by a non-maskable interrupt request signal (NMI pin input, INTWDT2 signal), unmasked external interrupt request signal (INTP00 to INTP18 pin input), unmasked internal interrupt request signal from the peripheral functions operable in the STOP mode, or reset signal (reset by $\overline{\text{RESET}}$ pin input, WDT2RES signal, or low-voltage detector (LVI)).

After the STOP mode has been released, the normal operation mode is restored after the oscillation stabilization time has been secured.

(1) Releasing STOP mode by non-maskable interrupt request signal or unmasked maskable interrupt request signal

The STOP mode is released by a non-maskable interrupt request signal or an unmasked maskable interrupt request signal, regardless of the priority of the interrupt request signal. If the STOP mode is set in an interrupt servicing routine, however, an interrupt request signal that is issued later is serviced as follows.

(a) If an interrupt request signal with a priority lower than that of the interrupt request currently being serviced is issued, the STOP mode is released, but that interrupt request signal is not acknowledged. The interrupt request signal itself is retained.

(b) If an interrupt request signal with a priority higher than that of the interrupt request currently being serviced is issued (including a non-maskable interrupt request signal), the STOP mode is released and that interrupt request signal is acknowledged.

Caution The interrupt request that is disabled by setting the PSC.NMI1M, PSC.NMI0M, and PSC.INTM bits to 1 becomes invalid and STOP mode is not released.

Table 25-8. Operation After Releasing STOP Mode by Interrupt Request Signal

Release Source	Interrupt Enabled (EI) Status	Interrupt Disabled (DI) Status
Non-maskable interrupt request signal	Execution branches to the handler address after securing the oscillation stabilization time.	
Maskable interrupt request signal	Execution branches to the handler address or the next instruction is executed after securing the oscillation stabilization time.	The next instruction is executed after securing the oscillation stabilization time.

(2) Releasing STOP mode by reset

The same operation as the normal reset operation is performed.

Table 25-9. Operating Status in STOP Mode

Setting of STOP Mode / Item		Operating Status	
		When Subclock Is Not Used	When Subclock Is Used
Main clock oscillator (f_X)		Stops oscillation	
Subclock oscillator (f_{XT})		–	Oscillation enabled
Internal oscillator (f_R)		Oscillation enabled	
PLL		Stops operation	
CPU		Stops operation	
DMA controller		Stops operation	
Interrupt controller		Stops operation	
Timer	TAA0 to TAA5	Stops operation	
	TAB0, TAB1	Stops operation	
	TMM0 to TMM3	Operable when f_R/8 is selected as the count clock	Operable when f_R/8 or f_{XT} is selected as the count clock
	TMT0	Stops operation	
Real-time counter (RTC)		Stops operation	Operable when f_{XT} is selected as the count clock
Watchdog timer (WDT2)		Operable when f_R is selected as the count clock	Operable when f_R or f_{XT} is selected as the count clock
Serial interface	CSIF0 to CSIF4	Operable when the $\overline{SCKFn}$ input clock is selected as the count clock (n = 0 to 4)	
	I^2C00 to I^2C02	Stops operation	
	UARTC0 to UARTC4	Stops operation (but UARTC0 is operable when the ASCKC0 input clock is selected)	
A/D converter		Stops operation (conversion result undefined)Notes 1, 2	
D/A converter		Stops operationNotes 3, 4 (high impedance is output)	
Real-time output function (RTO)		Stops operation (output held)	
Key interrupt function (KR)		Operable	
CRC operation circuit		Stops operation	
External bus interface		See **CHAPTER 5 BUS CONTROL FUNCTION**.	
Port function		Retains status before STOP mode was set	
Internal data		The CPU registers, statuses, data, and all other internal data such as the contents of the internal RAM are retained as they were before the STOP mode was set.	
CANNote 5		Stops operation	
USB function		Stops operation	

Notes 1. If the STOP mode is set while the A/D converter is operating, the A/D converter is automatically stopped and starts operating again after the STOP mode is released. However, in that case, the A/D conversion results after the STOP mode is released are invalid. All the A/D conversion results before the STOP mode is set are invalid.

2. Even if the STOP mode is set while the A/D converter is operating, the power consumption is reduced equivalently to when the A/D converter is stopped before the STOP mode is set.

3. If the STOP mode is set while the D/A converter is operating, the D/A converter is automatically stopped and the pin status becomes high impedance. After the STOP mode is released, D/A conversion resumes, the setting time elapses, and the status returns to the output level before the STOP mode was set.

4. Even if the STOP mode is set while the D/A converter is operating, the power consumption is reduced equivalently to when the D/A converter is stopped before the STOP mode is set.

5. μPD70F3770, 70F3771 only

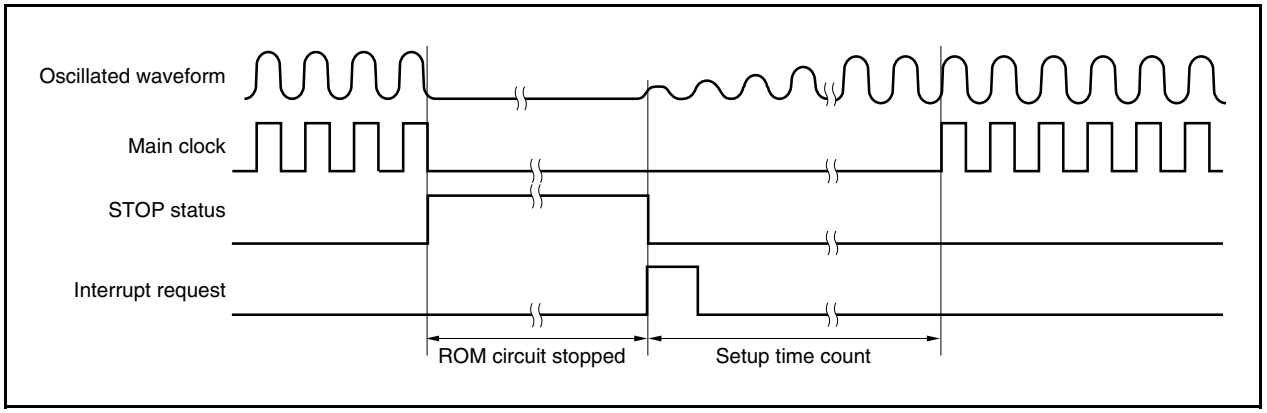
25.6.3 Securing oscillation stabilization time when releasing STOP mode

Secure the oscillation stabilization time for the main clock oscillator after releasing the STOP mode because the operation of the main clock oscillator stops after STOP mode is set.

(1) Releasing STOP mode by non-maskable interrupt request signal or unmasked maskable interrupt request signal

Secure the oscillation stabilization time by setting the OSTS register.

When the releasing source is generated, the dedicated internal timer starts counting according to the OSTS register setting. When it overflows, the normal operation mode is restored.



(2) Release by reset

This operation is the same as that of a normal reset.

The oscillation stabilization time is the initial value of the OSTS register, 2^{16}/fx.

25.7 Subclock Operation Mode

25.7.1 Setting and operation status

The subclock operation mode is set by setting the PCC.CK3 bit to 1 in the normal operation mode.

When the subclock operation mode is set, the internal system clock is changed from the main clock to the subclock. Check whether the clock has been switched by using the PCC.CLS bit.

When the PCC.MCK bit is set to 1, the operation of the main clock oscillator is stopped. As a result, the system operates only on the subclock.

In the subclock operation mode, the power consumption can be reduced to a level lower than in the normal operation mode because the subclock is used as the internal system clock. In addition, the power consumption can be further reduced to the level of the STOP mode by stopping the operation of the main clock oscillator.

Table 25-10 shows the operating status in subclock operation mode.

Cautions 1. When manipulating the CK3 bit, do not change the set values of the PCC.CK2 to PCC.CK0 bits (using a bit manipulation instruction to manipulate the bit is recommended). For details of the PCC register, see 6.3 (1) Processor clock control register (PCC).

2. If the following conditions are not satisfied, change the CK2 to CK0 bits so that the conditions are satisfied and set the subclock operation mode.

Internal system clock (f_{CLK}) > Subclock (f_{XT} = 32.768 kHz) × 4

Remark Internal system clock (f_{CLK}): Clock generated from main clock (f_{XX}) in accordance with the settings of the CK2 to CK0 bits

25.7.2 Releasing subclock operation mode

The subclock operation mode is released by a reset signal (reset by $\overline{\text{RESET}}$ pin input, WDT2RES signal, low-voltage detector (LVI), or clock monitor (CLM)) when the CK3 bit is set to 0.

If the main clock is stopped (MCK bit = 1), set the MCK bit to 1, secure the oscillation stabilization time of the main clock by software, and set the CK3 bit to 0.

The normal operation mode is restored when the subclock operation mode is released.

Caution When manipulating the CK3 bit, do not change the set values of the CK2 to CK0 bits (using a bit manipulation instruction to manipulate the bit is recommended).
For details of the PCC register, see 6.3 (1) Processor clock control register (PCC).

Table 25-10. Operating Status in Subclock Operation Mode

Setting of Subclock Operation Mode / Item		Operating Status	
		When Main Clock Is Oscillating	When Main Clock Is Stopped
Subclock oscillator (f_{XT})		Oscillation enabled	
Internal oscillator (f_R)		Oscillation enabled	
PLL		Operable	Stops operation[Note 1]
CPU		Operable	
DMA controller		Operable	
Interrupt controller		Operable	
Timer	TAA0 to TAA5	Operable	Stops operation
	TAB0, TAB1	Operable	Stops operation
	TMM0 to TMM3	Operable	Operable when f_R/8 or f_{XT} is selected as the count clock
	TMT0		
Real-time counter (RTC)		Operable	Operable when f_{XT} is selected as the count clock
Watchdog timer (WDT2)		Operable	Operable when f_R or f_{XT} is selected as the count clock
Serial interface	CSIF0 to CSIF4	Operable	Operable when the $\overline{SCKFn}$ input clock is selected as the count clock (n = 0 to 4)
	I^2C00 to I^2C02	Operable	Stops operation
	UARTC0 to UARTC4	Operable	Stops operation (but UARTC0 is operable when the ASCKC0 input clock is selected)
A/D converter		Operable	Stops operation
D/A converter		Operable	
Real-time output function (RTO)		Operable	Stops operation (output held)
Key interrupt function (KR)		Operable	
CRC operation circuit		Operable	
External bus interface		See **CHAPTER 5 BUS CONTROL FUNCTION**.	
Port function		Settable	
Internal data		Settable	
CAN[Note 2]		Operable	Stops operation
USB function		Operable	Stops operation

Notes 1, Be sure to stop the PLL (PLLCTL.PLLON bit = 0) before stopping the main clock.

2. μPD70F3770, 70F3771 only

Caution When the CPU is operating on the subclock and main clock oscillation is stopped, accessing a register in which a wait occurs is disabled. If a wait is generated, it can be released only by reset (see 3.4.9 (2)).

25.8 Sub-IDLE Mode

25.8.1 Setting and operation status

The sub-IDLE mode is set by setting the PSMR.PSM1 and PSMR.PSM0 bits to 00 or 10 and setting the PSC.STP bit to 1 in the subclock operation mode.

In this mode, the clock oscillator continues operating but clock supply to the CPU, flash memory, and the other on-chip peripheral functions is stopped.

As a result, program execution stops and the contents of the internal RAM before the sub-IDLE mode was set are retained. The CPU and the other on-chip peripheral functions are stopped. However, the on-chip peripheral functions that can operate with the subclock or an external clock continue operating.

Because the sub-IDLE mode stops operation of the CPU, flash memory, and other on-chip peripheral functions, it can reduce the power consumption more than the subclock operation mode. If the sub-IDLE mode is set after the main clock has been stopped, the current consumption can be reduced to a level as low as that in the STOP mode.

Table 25-12 shows the operating status in the sub-IDLE mode.

Cautions 1. Following the store instruction to the PSC register for setting the sub-IDLE mode, insert the five or more NOP instructions.

2. If the sub-IDLE mode is set while an unmasked interrupt request signal is being held pending, the sub-IDLE mode is then released immediately by the pending interrupt request.

25.8.2 Releasing sub-IDLE mode

The sub-IDLE mode is released by a non-maskable interrupt request signal (NMI pin input, INTWDT2 signal), unmasked external interrupt request signal (INTP0 to INTP18 pin input), unmasked internal interrupt request signal from the peripheral functions operable in the sub-IDLE mode, or reset signal (reset by $\overline{\text{RESET}}$ pin input, WDT2RES signal, low-voltage detector (LVI), or clock monitor (CLM)). The PLL returns to the operating status it was in before the sub-IDLE mode was set.

When the sub-IDLE mode is released by an interrupt request signal, the subclock operation mode is set.

(1) Releasing sub-IDLE mode by non-maskable interrupt request signal or unmasked maskable interrupt request signal

The sub-IDLE mode is released by a non-maskable interrupt request signal or an unmasked maskable interrupt request signal, regardless of the priority of the interrupt request signal.

If the sub-IDLE mode is set in an interrupt servicing routine, however, an interrupt request signal that is issued later is serviced as follows.

(a) If an interrupt request signal with a priority lower than that of the interrupt request currently being serviced is issued, the sub-IDLE mode is released, but that interrupt request signal is not acknowledged. The interrupt request signal itself is retained.

(b) If an interrupt request signal with a priority higher than that of the interrupt request currently being serviced is issued (including a non-maskable interrupt request signal), the sub-IDLE mode is released and that interrupt request signal is acknowledged.

Cautions 1. The interrupt request signal that is disabled by setting the PSC.NMI1M, PSC.NMI0M, and PSC.INTM bits to 1 becomes invalid and sub-IDLE mode is not released.

2. When the sub-IDLE mode is released, 12 cycles of the subclock (about 366 μs) elapse from when the interrupt request signal that releases the sub-IDLE mode is generated to when the mode is released.

Table 25-11. Operation After Releasing Sub-IDLE Mode by Interrupt Request Signal

Release Source	Interrupt Enabled (EI) Status	Interrupt Disabled (DI) Status
Non-maskable interrupt request signal	Execution branches to the handler address.	
Maskable interrupt request signal	Execution branches to the handler address or the next instruction is executed.	The next instruction is executed.

(2) Releasing sub-IDLE mode by reset

The same operation as the normal reset operation is performed.

Table 25-12. Operating Status in Sub-IDLE Mode

Item \ Setting of Sub-IDLE Mode		Operating Status	
		When Main Clock Is Oscillating	When Main Clock Is Stopped
Subclock oscillator (f_{XT})		Oscillation enabled	
Internal oscillator (f_R)		Oscillation enabled	
PLL		Operable	Stops operation[Note 1]
CPU		Stops operation	
DMA controller		Stops operation	
Interrupt controller		Stops operation	
Timer	TAA0 to TAA5	Stops operation	
	TAB0, TAB1	Stops operation	
	TMM0 to TMM3	Operable when f_R/8 or f_{XT} is selected as the count clock	
	TMT0	Stops operation	
Real-time counter (RTC)		Operable	Operable when f_{XT} is selected as the count clock
Watchdog timer (WDT2)		Operable when f_R or f_{XT} is selected as the count clock	
Serial interface	CSIF0 to CSIF4	Operable when the $\overline{\text{SCKFn}}$ input clock is selected as the count clock (n = 0 to 4)	
	I^2C00 to I^2C02	Stops operation	
	UARTC0 to UARTC4	Stops operation (but UARTC0 is operable when the ASCKC0 input clock is selected)	
A/D converter		Holds operation (conversion result held)[Note 2]	
D/A converter		Holds operation (output held[Note 2])	
Real-time output function (RTO)		Stops operation (output held)	
Key interrupt function (KR)		Operable	
CRC operation circuit		Stops operation	
External bus interface		See **CHAPTER 5 BUS CONTROL FUNCTION**. (same operation status as IDLE mode).	
Port function		Retains status before sub-IDLE mode was set	
Internal data		The CPU registers, statuses, data, and all other internal data such as the contents of the internal RAM are retained as they were before the sub-IDLE mode was set.	
CAN[Note 3]		Stops operation	
USB function		Stops operation	

Notes 1. Be sure to stop the PLL (PLLCTL.PLLON bit = 0) before stopping the main clock.

2. To realize low power consumption, stop the A/D and D/A converters before shifting to the sub-IDLE mode.

3. μPD70F3770, 70F3771 only

CHAPTER 26 RESET FUNCTIONS

26.1 Overview

The following reset functions are available.

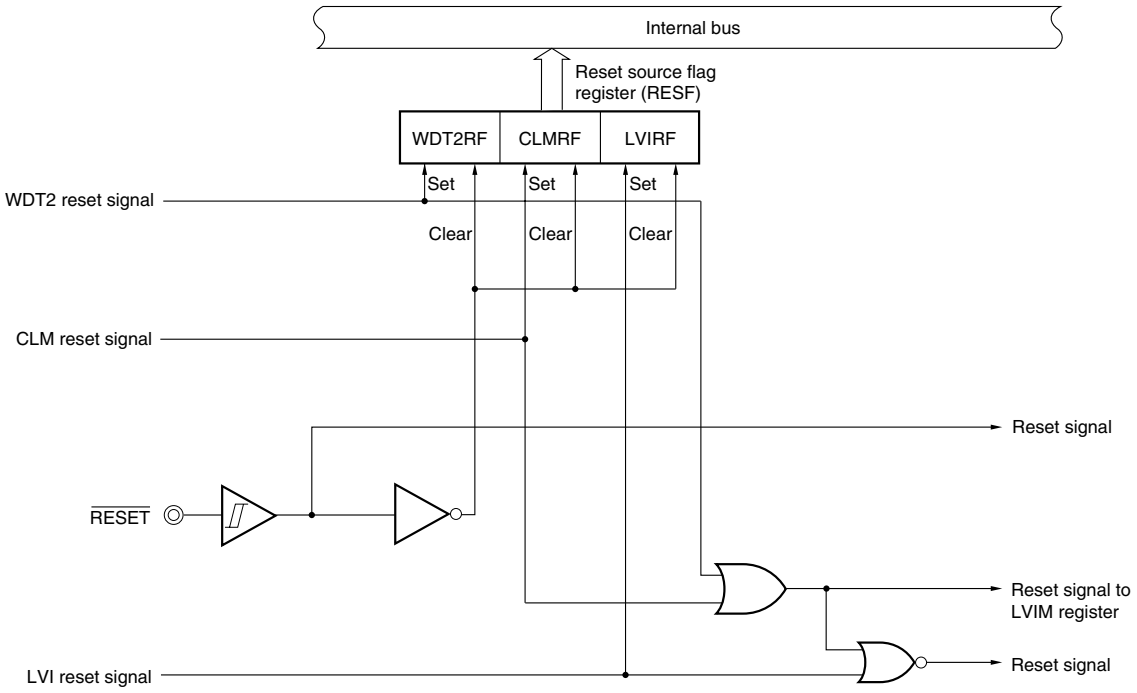
(1) Four kinds of reset sources
- External reset input via the $\overline{\text{RESET}}$ pin
- Reset via the watchdog timer 2 (WDT2) overflow (WDT2RES)
- System reset via the comparison of the low-voltage detector (LVI) supply voltage and detected voltage
- System reset via the detecting clock monitor (CLM) oscillation stop

After a reset is released, the source of the reset can be confirmed with the reset source flag register (RESF).

(2) Emergency operation mode
If the WDT2 overflows during the main clock oscillation stabilization time inserted after reset, a main clock oscillation anomaly is judged and the CPU starts operating on the internal oscillation clock.

Caution In emergency operation mode, do not access on-chip peripheral I/O registers other than registers used for interrupts, port function, WDT2, or timer M, each of which can operate with the internal oscillation clock. In addition, operation of CSIF0 to CSIF4 and UARTC0 using the externally input clock is also prohibited in this mode.

Figure 26-1. Block Diagram of Reset Function



Caution An LVI circuit internal reset does not reset the LVI circuit.

Remark LVIM: Low-voltage detection register

26.2 Registers to Check Reset Source

The V850ES/JG3-H and V850ES/JH3-H have four kinds of reset sources. After a reset has been released, the source of the reset that occurred can be checked with the reset source flag register (RESF).

(1) Reset source flag register (RESF)

The RESF register is a special register that can be written only by a combination of specific sequences (see **3.4.8 Special registers**).

The RESF register indicates the source from which a reset signal is generated.

This register can be read or written in 8-bit or 1-bit units.

$\overline{\text{RESET}}$ pin input sets this register to 00H. The initial value differs if the source of reset is other than the $\overline{\text{RESET}}$ pin signal.

After reset: 00H[Note] R/W Address: FFFFF888H

	7	6	5	4	3	2	1	0
RESF	0	0	0	WDT2RF	0	0	CLMRF	LVIRF

WDT2RF	Reset signal from WDT2
0	Not generated
1	Generated

CLMRF	Reset signal from CLM
0	Not generated
1	Generated

LVIRF	Reset signal from LVI
0	Not generated
1	Generated

Note The value of the RESF register is set to 00H when a reset is executed via the $\overline{\text{RESET}}$ pin. When a reset is executed by the watchdog timer 2 (WDT2), low-voltage detector (LVI), or clock monitor (CLM), the reset flags of this register (WDT2RF bit, CLMRF bit, and LVIRF bit) are set. However, other sources are retained.

Caution Only "0" can be written to each bit of this register. If writing "0" conflicts with setting the flag (occurrence of reset), setting the flag takes precedence.

26.3 Operation

26.3.1 Reset operation via $\overline{\text{RESET}}$ pin

When a low level is input to the $\overline{\text{RESET}}$ pin, the system is reset, and each hardware unit is initialized.

When the level of the $\overline{\text{RESET}}$ pin is changed from low to high, the reset status is released.

Table 26-1. Hardware Status on $\overline{\text{RESET}}$ Pin Input

Item	During Reset	After Reset
Main clock oscillator (f_X)	Oscillation stops	Oscillation starts
Subclock oscillator (f_{XT})	Oscillation continues	
Internal oscillator	Oscillation stops	Oscillation starts
Peripheral clock (f_X to f_X/1,024)	Operation stops	Operation starts after securing oscillation stabilization time
Internal system clock (f_{CLK}), CPU clock (f_{CPU})	Operation stops	Operation starts after securing oscillation stabilization time (initialized to fXX/8)
CPU	Initialized	Program execution starts after securing oscillation stabilization time
Watchdog timer 2	Operation stops (initialized to 0)	Counts up from 0 with internal oscillation clock as source clock.
Internal RAM	Undefined if power-on reset or CPU access and reset input conflict (data is damaged). Otherwise value immediately after reset input is retained.	
I/O lines (ports/alternate-function pins)	High impedance[Note]	
On-chip peripheral I/O registers	Initialized to specified status, OCDM register is set (01H).	
Other on-chip peripheral functions	Operation stops	Operation can be started after securing oscillation stabilization time

Note When the power is turned on, the following pin may output an undefined level temporarily, even during reset.

- P10/ANO0 pin
- P11/ANO1 pin
- DDO pin (V850ES/JH3-H only)
- P53/SIF2/TIAB00/KR3/TOAB00/RTP03/DDO pin (V850ES/JG3-H only)

Caution The OCDM register is initialized by the $\overline{\text{RESET}}$ pin input. Therefore, note with caution that, if a high level is input to the P56/INTP05/$\overline{\text{DRST}}$ pin after a reset release before the OCDM.OCDM0 bit is cleared, the on-chip debug mode is entered. For details, see CHAPTER 4 PORT FUNCTIONS.

Figure 26-2. Timing of Reset Operation by $\overline{\text{RESET}}$ Pin Input

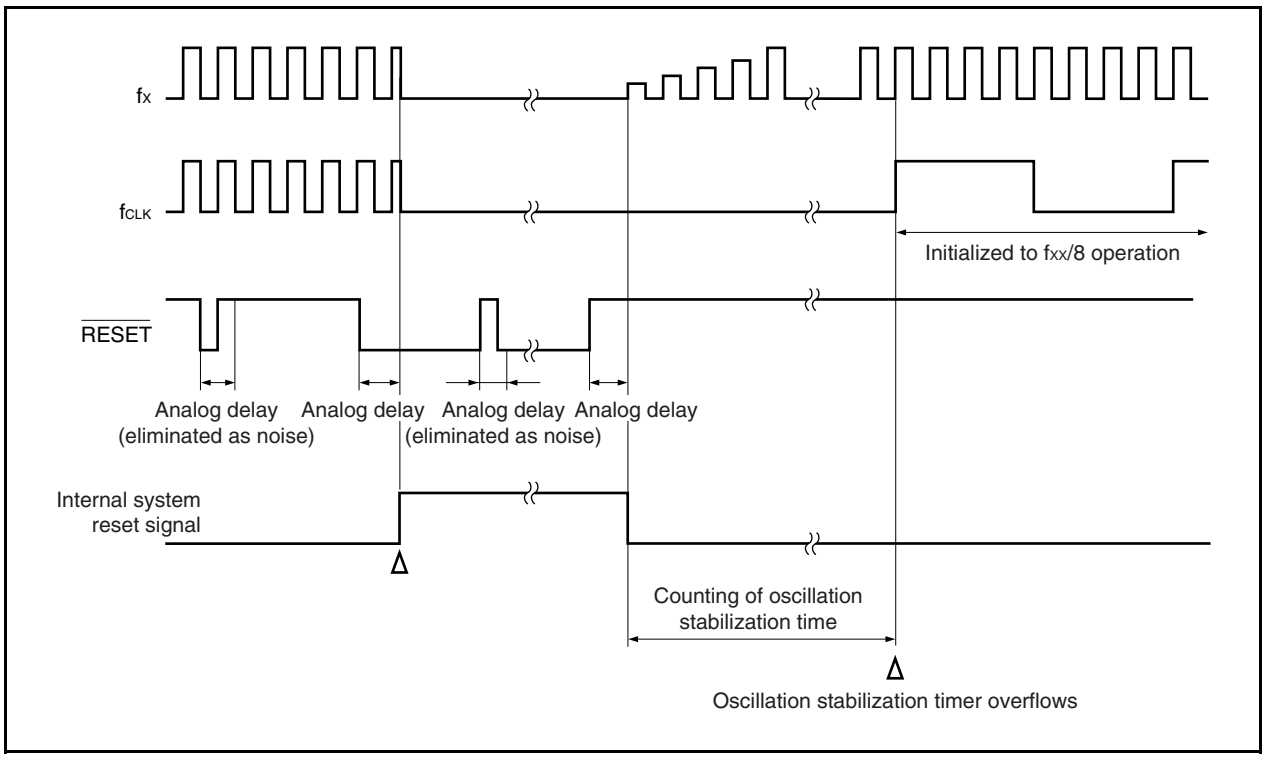
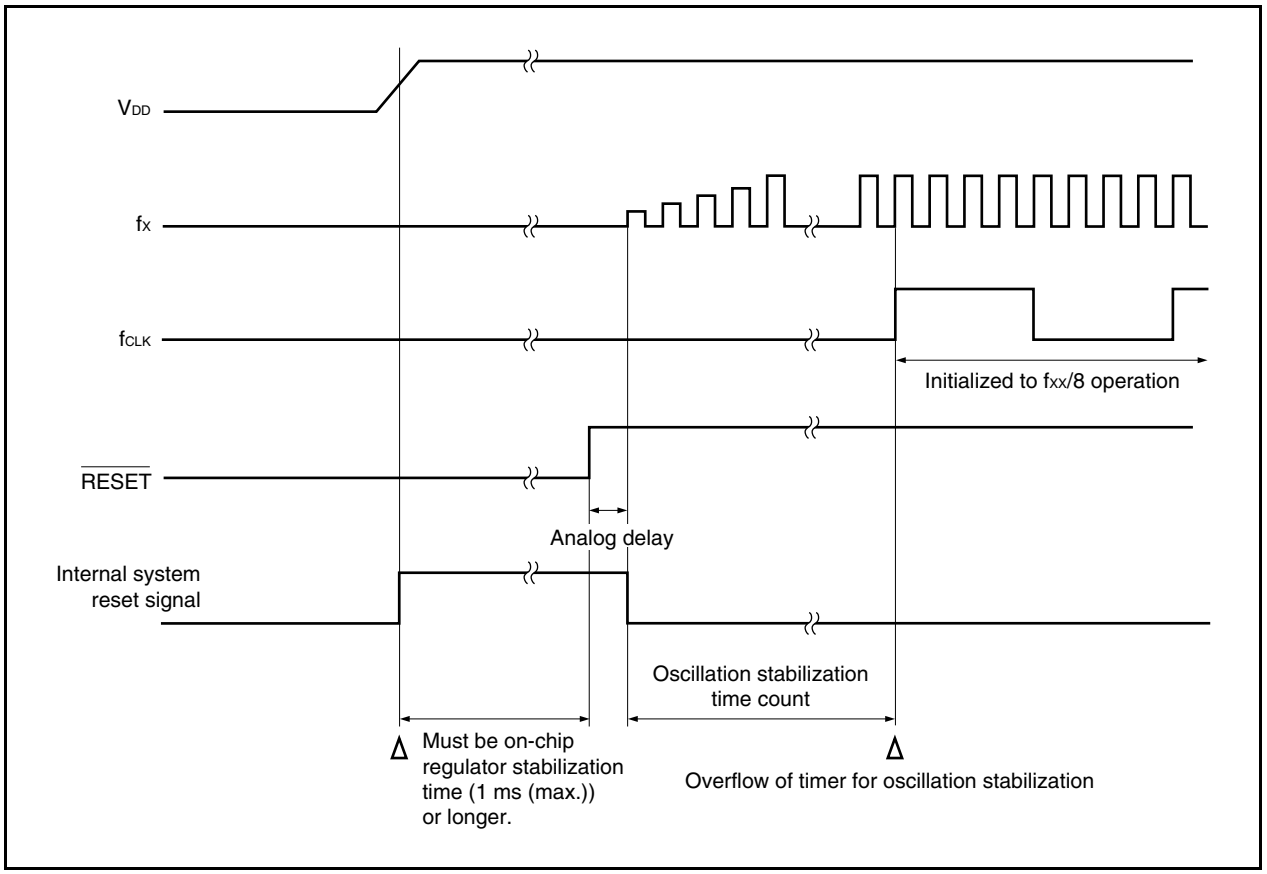


Figure 26-3. Timing of Power-on Reset Operation



26.3.2 Reset operation by watchdog timer 2

When watchdog timer 2 is set to the reset operation mode due to overflow, upon watchdog timer 2 overflow (WDT2RES signal generation), a system reset is executed and the hardware is initialized to the initial status.

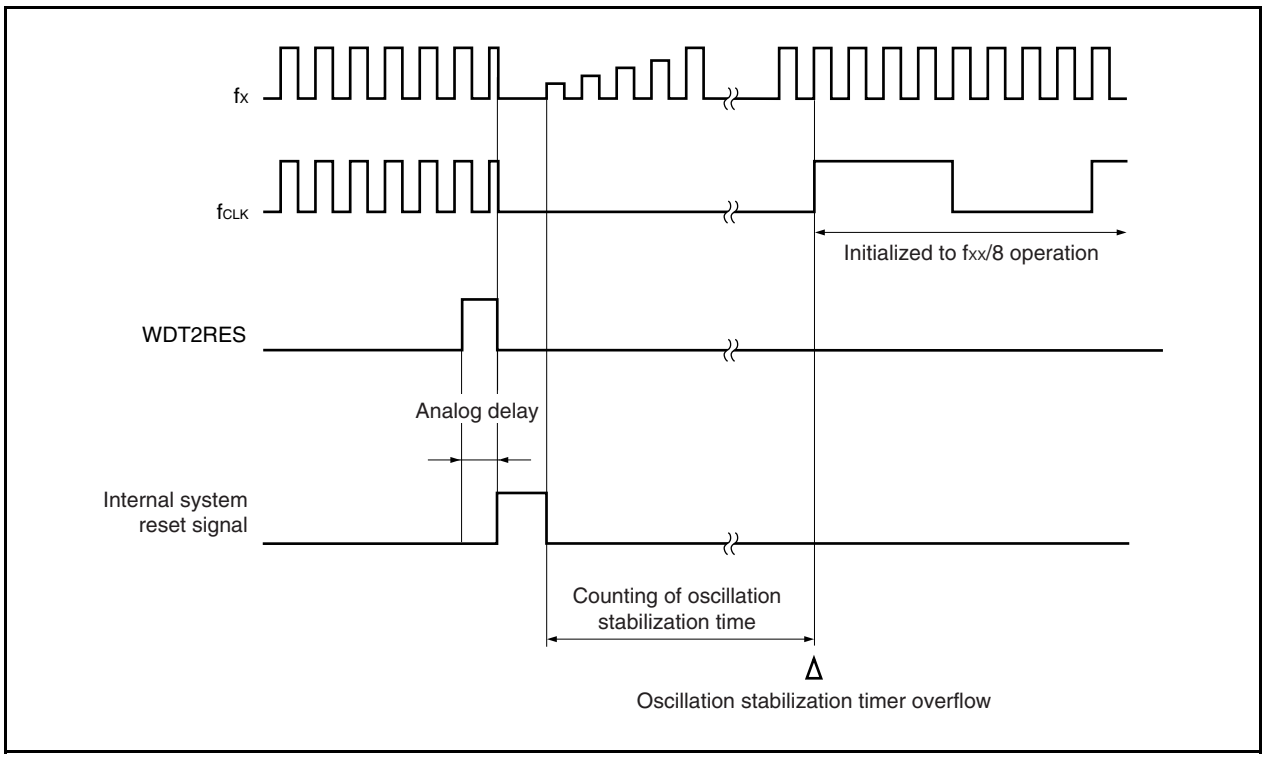
Following watchdog timer 2 overflow, the reset status is entered and lasts the predetermined time (analog delay), and the reset status is then automatically released.

The main clock oscillator is stopped during the reset period.

Table 26-2. Hardware Status During Watchdog Timer 2 Reset Operation

Item	During Reset	After Reset
Main clock oscillator (f_X)	Oscillation stops	Oscillation starts
Subclock oscillator (f_{XT})	Oscillation continues	
Internal oscillator	Oscillation stops	Oscillation starts
Peripheral clock (f_{XX} to f_{XX}/1,024)	Operation stops	Operation starts after securing oscillation stabilization time
Internal system clock (f_{XX}), CPU clock (f_{CPU})	Operation stops	Operation starts after securing oscillation stabilization time (initialized to f_{XX}/8)
CPU	Initialized	Program execution after securing oscillation stabilization time
Watchdog timer 2	Operation stops (initialized to 0)	Counts up from 0 with internal oscillation clock as source clock.
Internal RAM	Undefined if power-on reset or CPU access and reset input conflict (data is damaged). Otherwise value immediately after reset input is retained.	
I/O lines (ports/alternate-function pins)	High impedance	
On-chip peripheral I/O register	Initialized to specified status, OCDM register retains its value.	
On-chip peripheral functions other than above	Operation stops	Operation can be started after securing oscillation stabilization time.

Figure 26-4. Timing of Reset Operation by WDT2RES Signal Generation



26.3.3 Reset operation by low-voltage detector

If the supply voltage falls below the voltage detected by the low-voltage detector when LVI operation is enabled, a system reset is executed (when the LVIM.LVIMD bit is set to 1), and the hardware is initialized to the initial status.

The reset status lasts from when a supply voltage drop has been detected until the supply voltage rises above the LVI detection voltage.

The main clock oscillator is stopped during the reset period.

When the LVIMD bit = 0, an interrupt request signal (INTLVI) is generated if a low voltage is detected.

Table 26-3. Hardware Status During Reset Operation by Low-Voltage Detector

Item	During Reset	After Reset
Main clock oscillator (f_X)	Oscillation stops	Oscillation starts
Subclock oscillator (f_{XT})	Oscillation continues	
Internal oscillator	Oscillation stops	Oscillation starts
Peripheral clock (f_{XX} to f_{XX}/1,024)	Operation stops	Operation starts after securing oscillation stabilization time
Internal system clock (f_{XX}), CPU clock (f_{CPU})	Operation stops	Operation starts after securing oscillation stabilization time (initialized to f_{XX}/8)
CPU	Initialized	Program execution starts after securing oscillation stabilization time
WDT2	Operation stops (initialized to 0)	Counts up from 0 with internal oscillation clock as source clock.
Internal RAM	Undefined if power-on reset or CPU access and reset input conflict (data is damaged). Otherwise value immediately after reset input is retained.	
I/O lines (ports/alternate-function pins)	High impedance	
On-chip peripheral I/O register	Initialized to specified status, OCDM register retains its value.	
LVI	Operation stops	
On-chip peripheral functions other than above	Operation stops	Operation can be started after securing oscillation stabilization time.

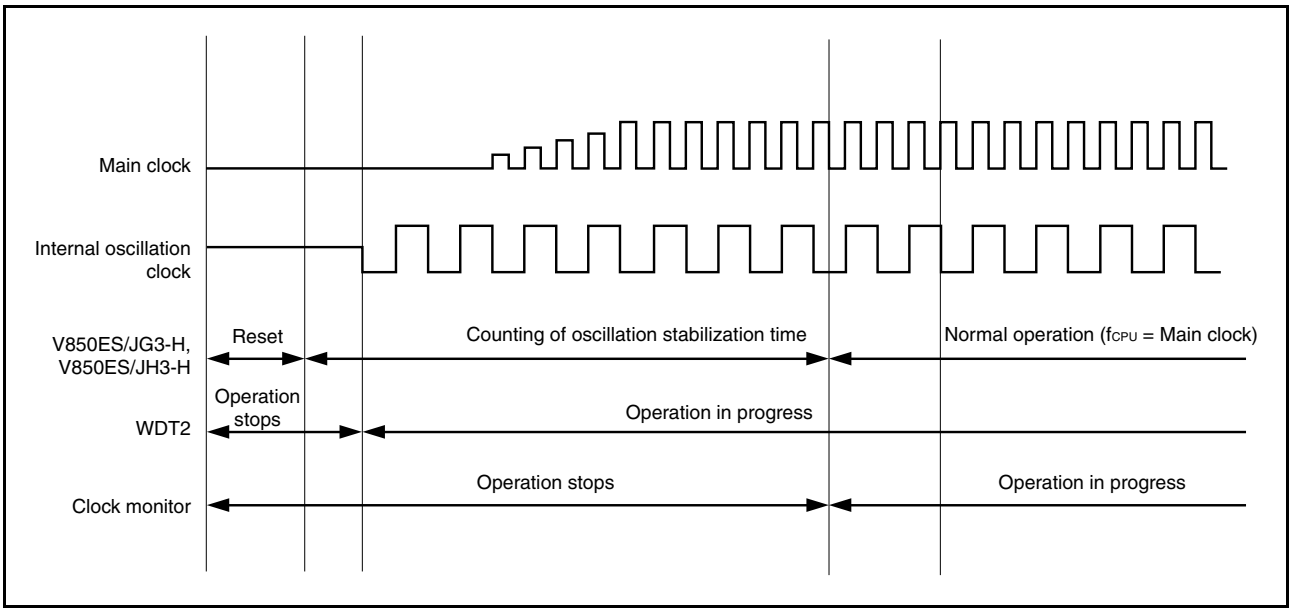
Remark For the reset timing of the low-voltage detector, see **CHAPTER 28 LOW-VOLTAGE DETECTOR (LVI)**.

26.3.4 Operation after reset release

After the reset is released, the main clock starts oscillation and oscillation stabilization time (OSTS register initial value: 2^{16}/fx) is secured, and the CPU starts program execution.

WDT2 immediately begins to operate after a reset has been released using the internal oscillation clock as a source clock.

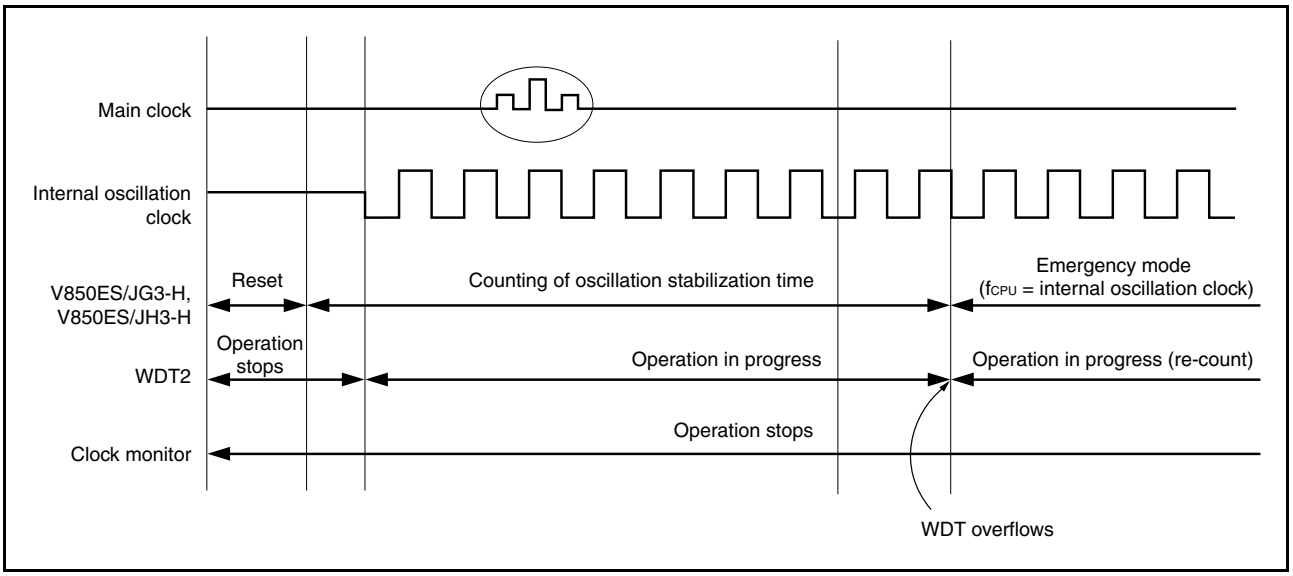
Figure 26-5. Operation After Reset Release



(1) Emergent operation mode

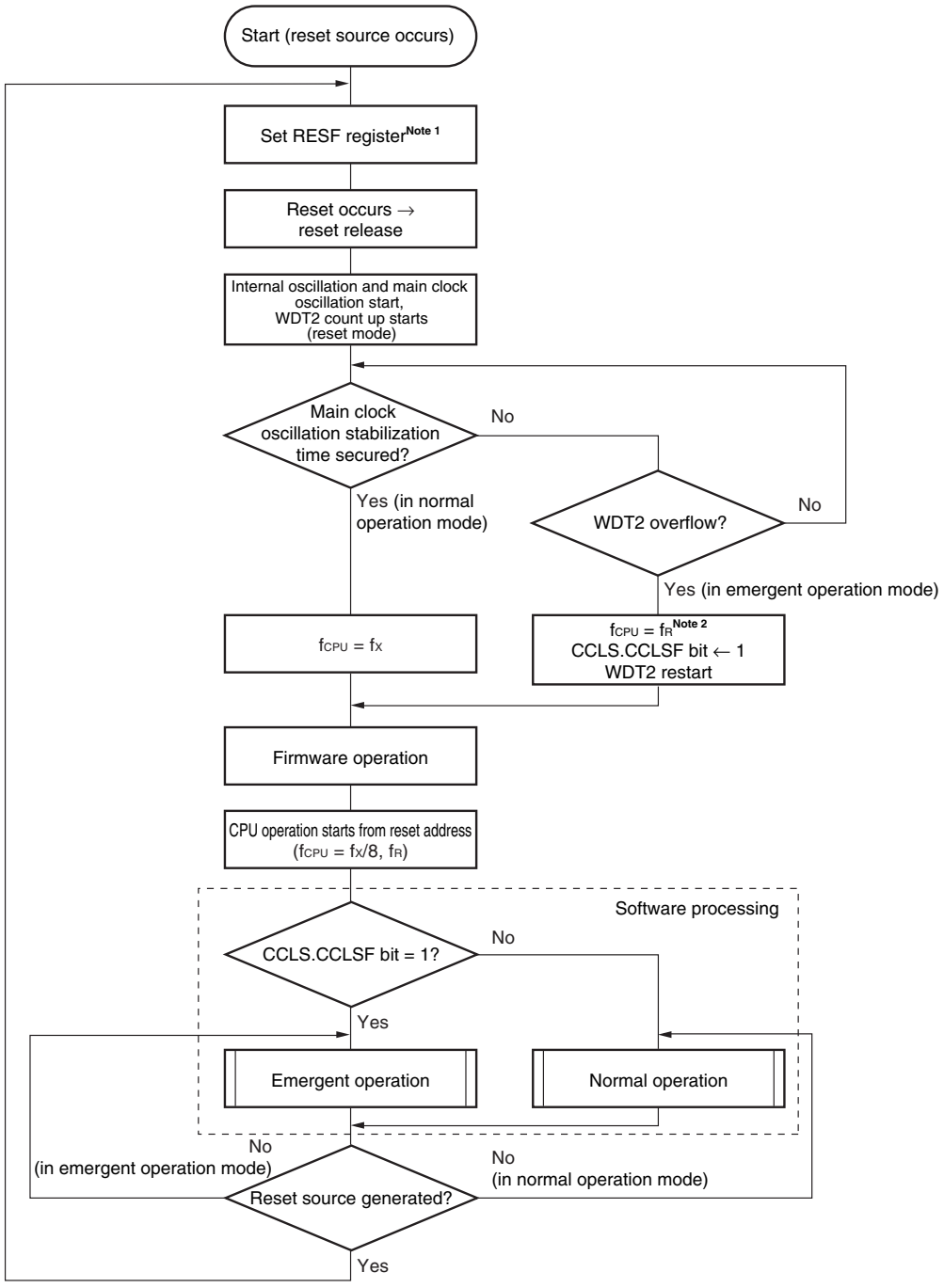
If an anomaly occurs in the main clock before oscillation stabilization time is secured, WDT2 overflows before executing the CPU program. At this time, the CPU starts program execution by using the internal oscillation clock as the source clock.

Figure 26-6. Operation After Reset Release



The CPU operation clock states can be checked with the CPU operation clock status register (CCLS).

26.3.5 Reset function operation flow



Notes 1. Bit to be set differs depending on the reset source.

Reset Source	WDT2RF Bit	CRMRF Bit	LVIRF Bit
$\overline{\text{RESET}}$ pin	0	0	0
WDT2	1	Value before reset is retained.	Value before reset is retained.
CLM	Value before reset is retained.	1	Value before reset is retained.
LVI	Value before reset is retained.	Value before reset is retained.	1

2. The internal oscillator cannot be stopped.

CHAPTER 27 CLOCK MONITOR

27.1 Functions

The clock monitor samples the main clock by using the internal oscillation clock and generates a reset request signal when oscillation of the main clock is stopped.

Once the operation of the clock monitor has been enabled by an operation enable flag, it cannot be cleared to 0 by any means other than reset.

When a reset by the clock monitor occurs, the RESF.CLMRF bit is set. For details on the RESF register, see **26.2 Registers to Check Reset Source**.

The clock monitor automatically stops under the following conditions.

- During oscillation stabilization time after STOP mode is released
- When the main clock is stopped (from when the PCC.MCK bit = 1 during subclock operation, until the PCC.CLS bit = 0 during main clock operation)
- When the sampling clock (internal oscillation clock) is stopped
- When the CPU operates with the internal oscillation clock

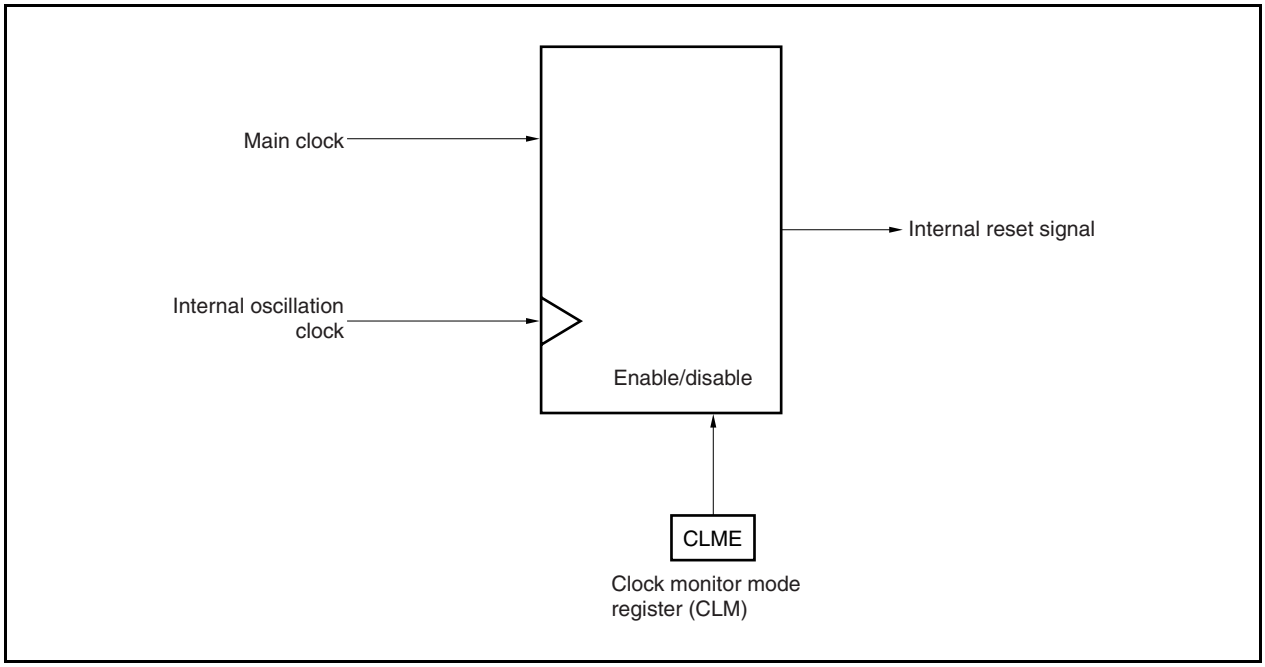
27.2 Configuration

The clock monitor includes the following hardware.

Table 27-1. Configuration of Clock Monitor

Item	Configuration
Control register	Clock monitor mode register (CLM)

Figure 27-1. Timing of Reset via $\overline{\text{RESET}}$ Pin Input



27.3 Register

The clock monitor is controlled by the clock monitor mode register (CLM).

(1) Clock monitor mode register (CLM)

The CLM register is a special register. This can be written only in a special combination of sequences (see **3.4.8 Special registers**).

This register is used to set the operation mode of the clock monitor.

This register can be read or written in 8-bit or 1-bit units.

Reset sets this register to 00H.

After reset: 00H R/W Address: FFFFF870H

	7	6	5	4	3	2	1	<0>
CLM	0	0	0	0	0	0	0	CLME

CLME	Clock monitor operation enable or disable
0	Disable clock monitor operation.
1	Enable clock monitor operation.

Cautions 1. Once the CLME bit has been set to 1, it cannot be cleared to 0 by any means other than reset.

2. When a reset by the clock monitor occurs, the CLME bit is cleared to 0 and the RESF.CLMRF bit is set to 1.

3. Be sure to set bits 7 to 1 to "0".

27.4 Operation

This section explains the functions of the clock monitor. The start and stop conditions are as follows.

<Start condition>

Enabling operation by setting the CLM.CLME bit to 1

<Stop conditions>

- While oscillation stabilization time is being counted after STOP mode is released
- When the main clock is stopped (from when PCC.MCK bit = 1 during subclock operation to when PCC.CLS bit = 0 during main clock operation)
- When the sampling clock (internal oscillation clock) is stopped
- When the CPU operates using the internal oscillation clock

Table 27-2. Operation Status of Clock Monitor
(When CLM.CLME Bit = 1, During Internal Oscillation Clock Operation)

CPU Operating Clock	Operation Mode	Status of Main Clock	Status of Internal Oscillation Clock	Status of Clock Monitor
Main clock	HALT mode	Oscillates	Oscillates[Note 1]	Operates[Note 2]
	IDLE1, IDLE2 modes	Oscillates	Oscillates[Note 1]	Operates[Note 2]
	STOP mode	Stops	Oscillates[Note 1]	Stops
Subclock (PCC.MCK = 0)	Sub-IDLE mode	Oscillates	Oscillates[Note 1]	Operates[Note 2]
Subclock (PCC.MCK = 1)	Sub-IDLE mode	Stops	Oscillates[Note 1]	Stops
Internal oscillation clock	–	Stops	Oscillates[Note 3]	Stops
During reset	–	Stops	Stops	Stops

Notes 1. The internal oscillator can be stopped by setting the RCM.RSTOP bit to 1.

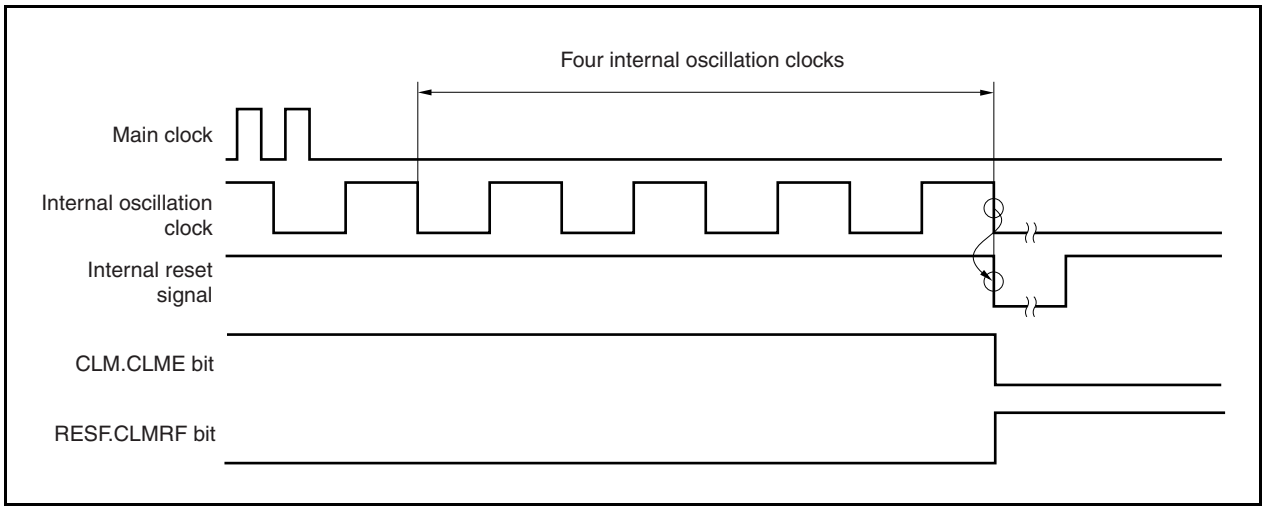
2. The clock monitor is stopped while the internal oscillator is stopped.

3. The internal oscillator cannot be stopped by software.

(1) Operation when main clock oscillation is stopped (CLME bit = 1)

If oscillation of the main clock is stopped when the CLME bit = 1, an internal reset signal is generated as shown in Figure 27-2.

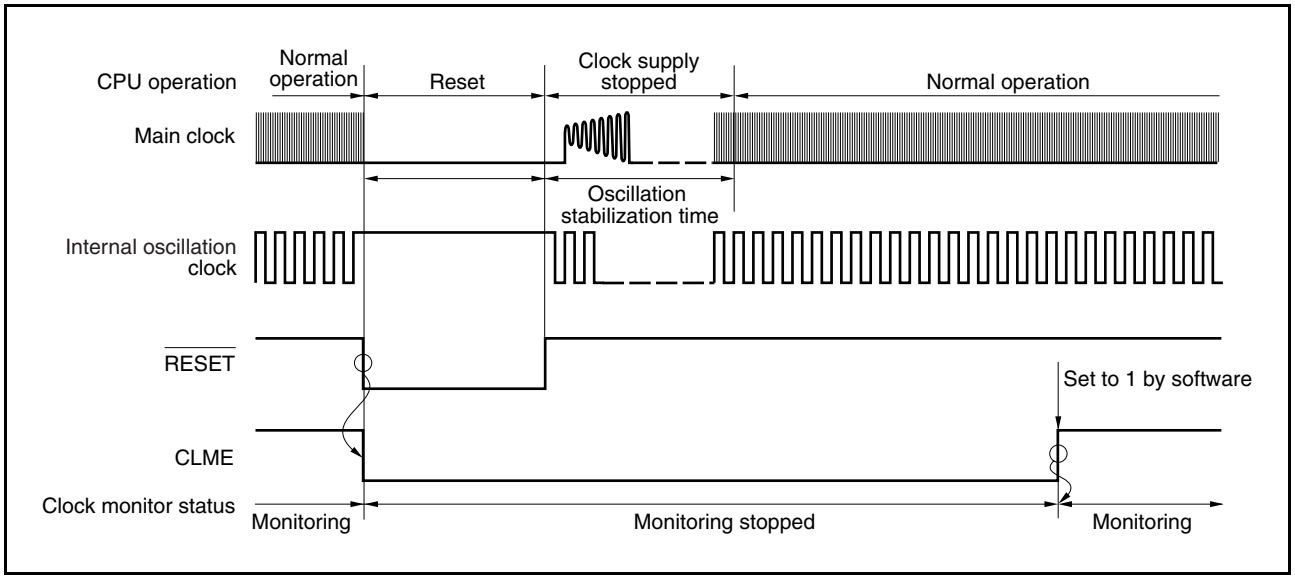
Figure 27-2. Reset Period Due to That Oscillation of Main Clock Is Stopped



(2) Clock monitor status after $\overline{\text{RESET}}$ input

$\overline{\text{RESET}}$ input clears the CLM.CLME bit to 0 and stops the clock monitor operation. When CLME bit is set to 1 by software at the end of the oscillation stabilization time of the main clock, monitoring is started.

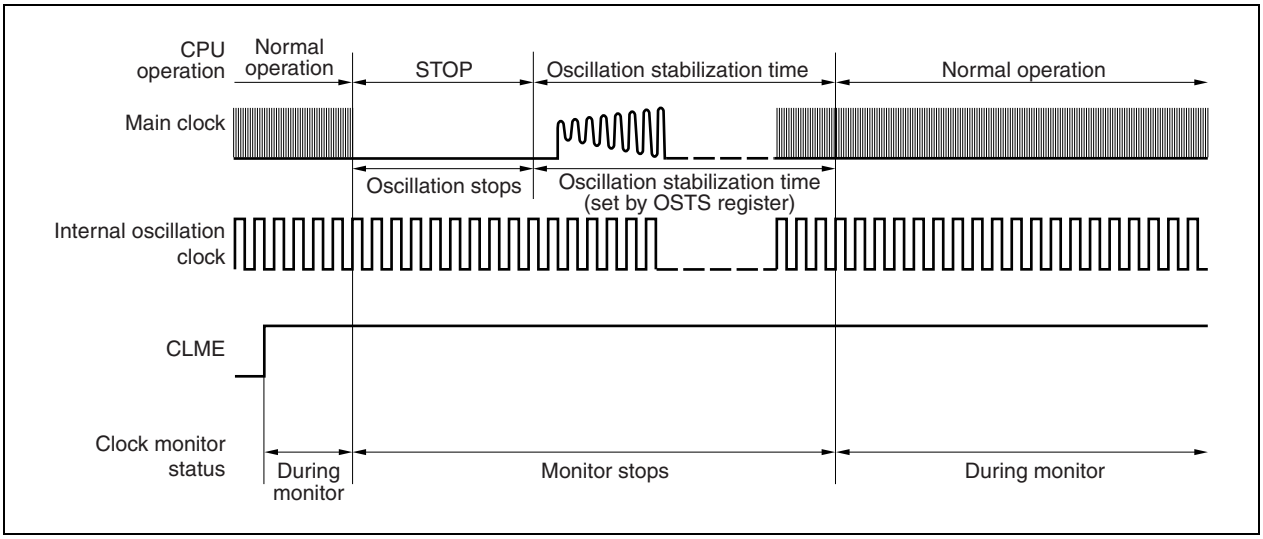
Figure 27-3. Clock Monitor Status After $\overline{\text{RESET}}$ Input
(CLM.CLME bit = 1 is set after $\overline{\text{RESET}}$ input and at the end of main clock oscillation stabilization time)



(3) Operation in STOP mode or after STOP mode is released

If the STOP mode is set with the CLM.CLME bit = 1, the monitor operation is stopped in the STOP mode and while the oscillation stabilization time is being counted. After the oscillation stabilization time, the monitor operation is automatically started.

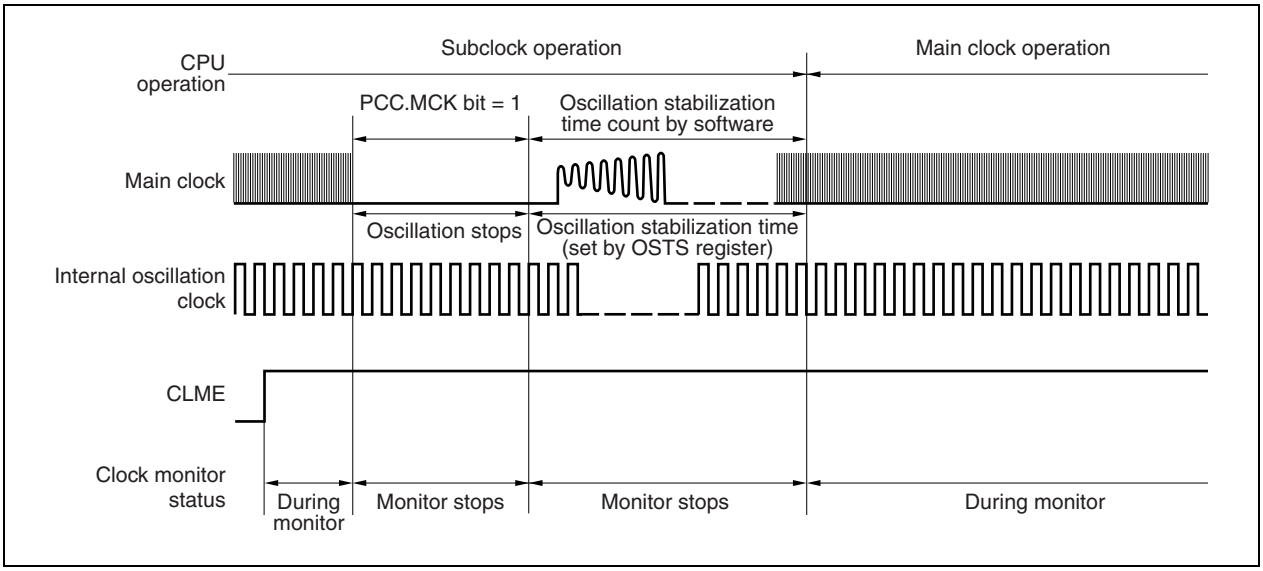
Figure 27-4. Operation in STOP Mode or After STOP Mode Is Released



(4) Operation when main clock is stopped (arbitrary)

During subclock operation (PCC.CLS bit = 1) or when the main clock is stopped by setting the PCC.MCK bit to 1, the monitor operation is stopped until the main clock operation is started (PCC.CLS bit = 0). The monitor operation is automatically started when the main clock operation is started.

Figure 27-5. Operation When Main Clock Is Stopped (Arbitrary)



(5) Operation while CPU is operating on internal oscillation clock (CCLS.CCLSF bit = 1)

The monitor operation is not stopped when the CCLSF bit is 1, even if the CLME bit is set to 1.

CHAPTER 28 LOW-VOLTAGE DETECTOR (LVI)

28.1 Functions

The low-voltage detector (LVI) has the following functions.

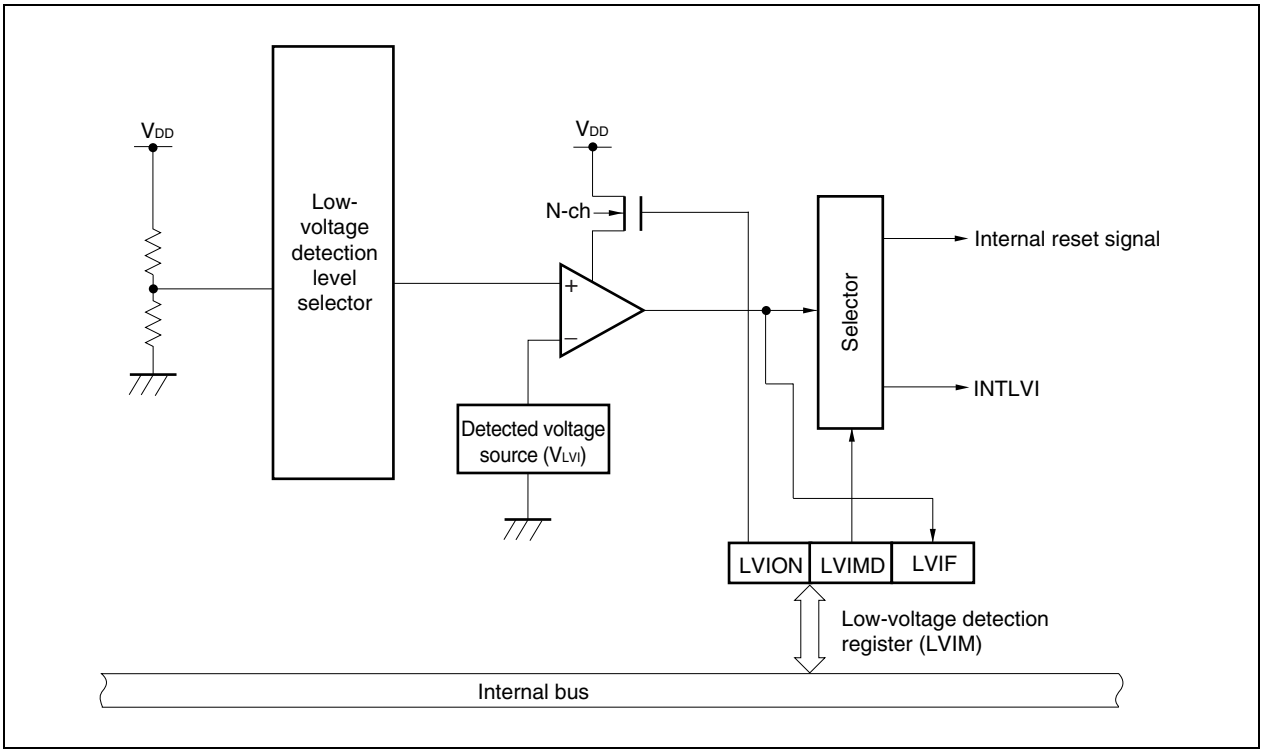
- If the interrupt occurrence at low voltage detection is selected, the low-voltage detector continuously compares the supply voltage (V_{DD}) and the detected voltage (V_{LVI}), and generates an internal interrupt signal when the supply voltage drops or rises across the detected voltage.
- If the reset occurrence at low voltage detection is selected, the low-voltage detector generates an interrupt reset signal when the supply voltage (V_{DD}) drops across the detected voltage (V_{LVI}).
- Interrupt or reset signal can be selected by software.
- Can operate in STOP mode.

If the low-voltage detector is used to generate a reset signal, the RESF.LVIRF bit is set to 1 when the reset signal is generated. For details of RESF register, see **26.2 Registers to Check Reset Source**.

28.2 Configuration

The block diagram of the low-voltage detector is shown below.

Figure 28-1. Block Diagram of Low-Voltage Detector



28.3 Registers

The low-voltage detector is controlled by the following registers.

- Low-voltage detection register (LVIM)
- Internal RAM data status register (RAMS)

(1) Low-voltage detection register (LVIM)

The LVIM register is a special register. This can be written only in the special combination of the sequences (see **3.4.8 Special registers**).

The LVIM register is used to enable or disable low-voltage detection, and to set the operation mode of the low-voltage detector.

This register can be read or written in 8-bit or 1-bit units. However, the LVIF bit is read-only.

After reset: 00H[Note 1] R/W Address: FFFFF890H

	<7>	6	5	4	3	2	<1>	<0>
LVIM	LVION	0	0	0	0	0	LVIMD	LVIF

LVION	Low-voltage detection operation enable or disable
0	Disable operation.
1	Enable operation.

LVIMD	Selection of operation mode of low-voltage detection
0	Generates interrupt signal INTLVI when the supply voltage drops or rises across the detection voltage value.
1	Generates internal reset signal LVIRES when the supply voltage drops across the detected voltage value.

LVIF[Note 2]	Low-voltage detection flag
0	When supply voltage > detected voltage, or when operation is disabled
1	Supply voltage of connected power supply < detected voltage

Notes 1. Reset by low-voltage detection: 82H
Reset due to other source: 00H

2. After the LVI operation has started (LVION bit = 1) or when INTLVI has occurred, confirm the supply voltage state using the LVIF bit.

Cautions 1. When the LVION and LVIMD bits to 1, the low-voltage detector cannot be stopped until the reset request due to other than the low-voltage detection is generated.

2. When the LVION bit is set to 1, the comparator in the LVI circuit starts operating. Wait 0.2 ms or longer by software before checking the voltage at the LVIF bit after the LVION bit is set.

3. Be sure to set bits 6 to 2 to "0".

(2) Internal RAM data status register (RAMS)

The RAMS register is a special register. This can be written only in a special combination of sequences (see **3.4.8 Special registers**).

This register is a flag register that indicates whether the internal RAM is valid or not.

This register can be read or written in 8-bit or 1-bit units.

The set/clear conditions for the RAMF bit are shown below.

- Setting conditions: Detection of voltage lower than specified level
  Set by instruction
- Clearing condition: Writing of 0 in specific sequence

After reset: 01H[Note] R/W Address: FFFFF892H

	7	6	5	4	3	2	1	<0>
RAMS	0	0	0	0	0	0	0	RAMF

RAMF	Internal RAM voltage detection
0	Voltage lower than RAM retention voltage is not detected.
1	Voltage lower than RAM retention voltage is detected.

Note This register is reset only when a voltage drop below the RAM retention voltage is detected.

28.4 Operation

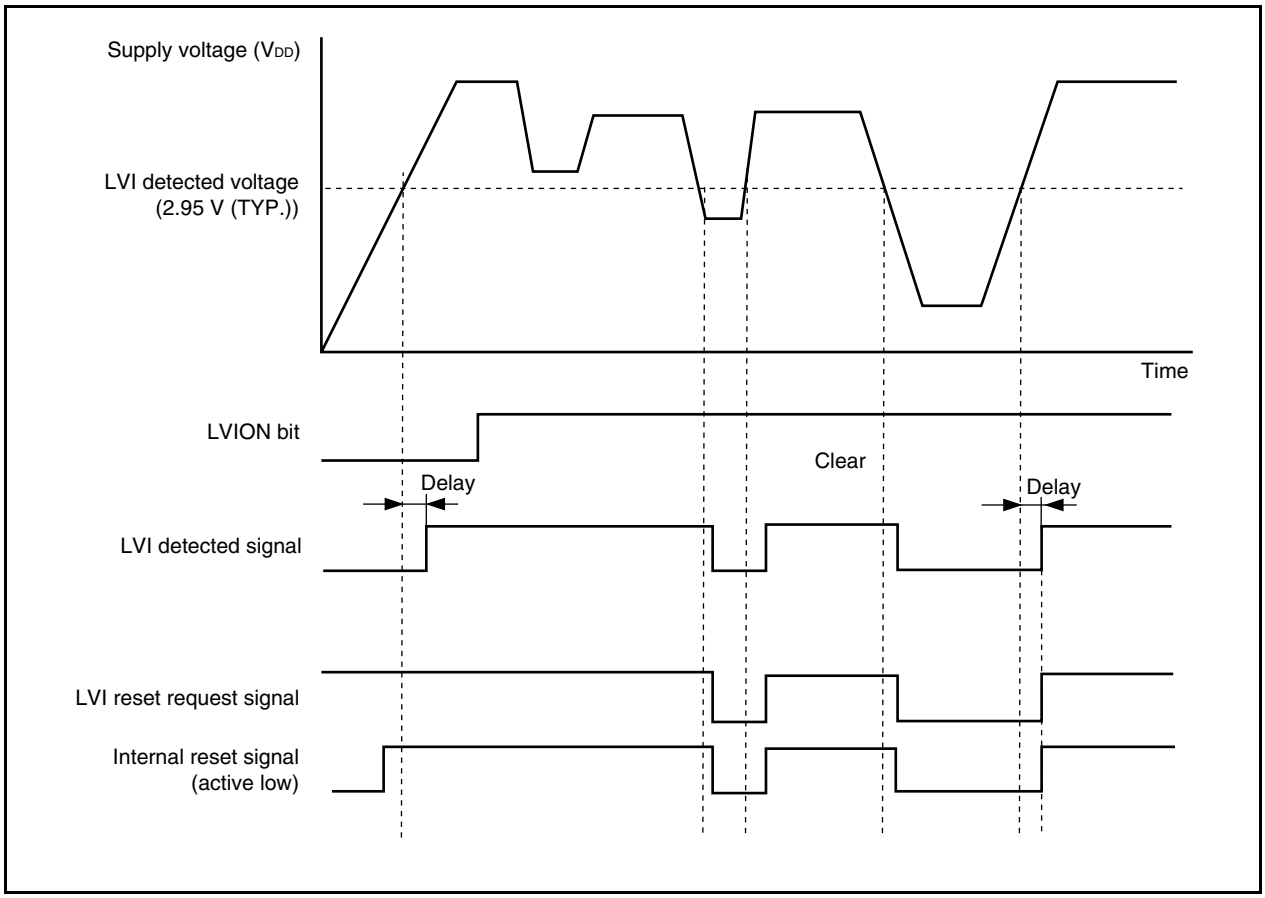
Depending on the setting of the LVIM.VIMD bit, an interrupt signal (INTLVI) or an internal reset signal is generated. How to specify each operation is described below, together with timing charts.

28.4.1 To use for internal reset signal

<To start operation>
<1> Mask the interrupt of LVI.
<2> Set the LVIM.LVION bit to 1 (to enable operation).
<3> Insert a wait cycle of 0.2 ms (max.) or more by software.
<4> By using the LVIM.LVIF bit, check if the supply voltage > detected voltage.
<5> Set the LVIMD bit to 1 (to generate an internal reset signal).

Caution If the LVIMD bit is set to 1, the contents of the LVIM register cannot be changed until a reset request other than LVI is generated.

Figure 28-2. Operation Timing of Low-Voltage Detector (LVIMD Bit = 1)

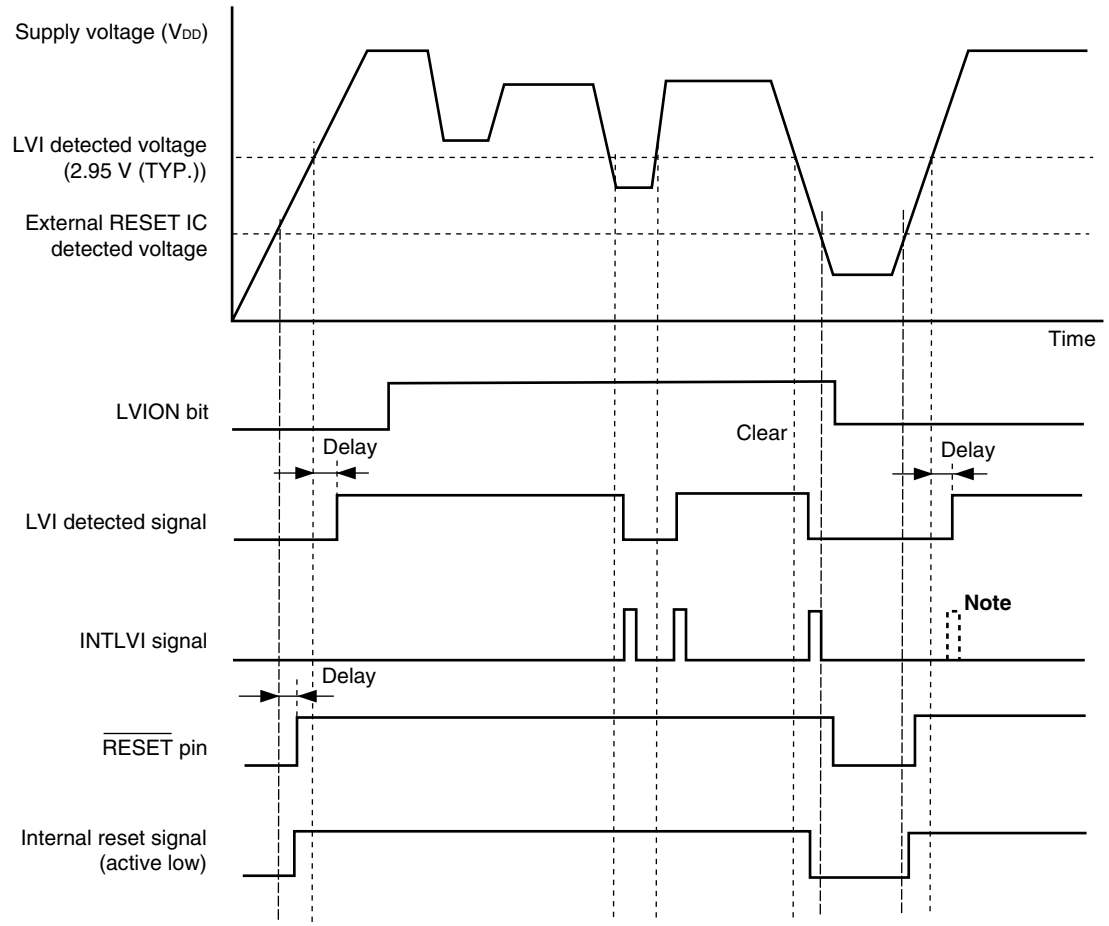


28.4.2 To use for interrupt

<To start operation>
<1> Mask the interrupt of LVI.
<2> Set the LVIM.LVION bit to 1 (to enable operation).
<3> Insert a wait cycle of 0.2 ms (max.) or more by software.
<4> By using the LVIM.LVIF bit, check if the supply voltage > detected voltage.
<5> Clear the interrupt request flag of LVI.
<6> Unmask the interrupt of LVI.

<To stop operation>
Clear the LVION bit to 0.

Figure 28-3. Operation Timing of Low-Voltage Detector (LVIMD Bit = 0)



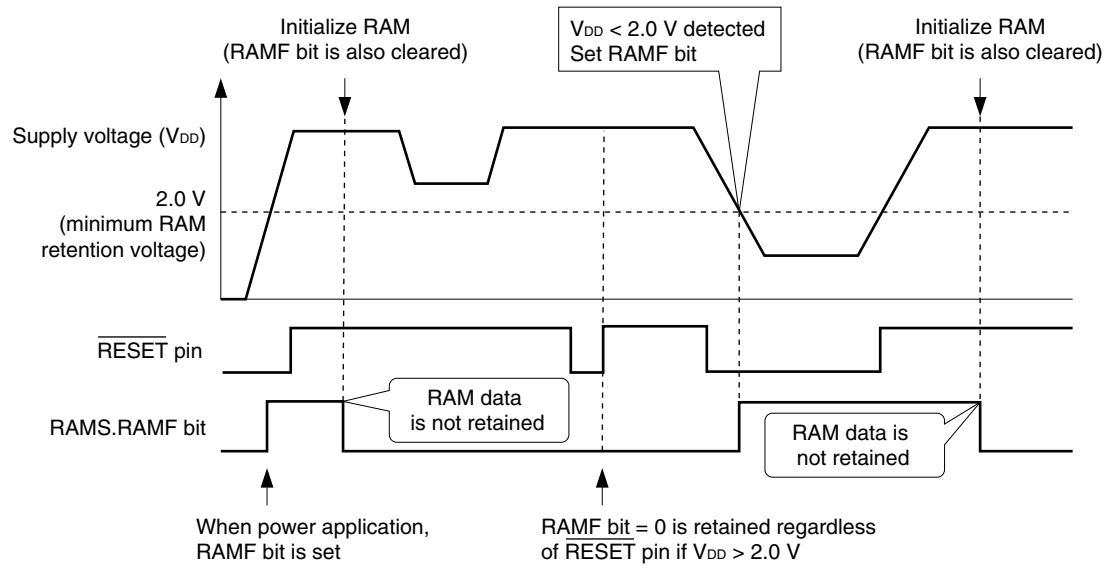
Note Since the LVION bit is the initial value (operation disabled) due to the external reset input, no INTLVI interrupts occur.

Caution When the INTLVI signal is generated, confirm, using the LVIM.LVIF bit, whether the INTLVI signal is generated due to a supply voltage drop or rise across the detected voltage.

28.5 RAM Retention Voltage Detection Operation

The supply voltage and detected voltage are compared. When the supply voltage drops below the detected voltage (including on power application), the RAMS.RAMF bit is set to 1.

Figure 28-4. Operation Timing of RAM Retention Voltage Detection Function



Remarks 1. The RAMF bit is set to 1 if the supply voltage drops under the minimum RAM retention voltage (2.0 V (TYP.)).

2. The RAMF bit operates regardless of the $\overline{\text{RESET}}$ pin status.

CHAPTER 29 CRC FUNCTION

29.1 Functions

- CRC operation circuit for detection of data block errors
- Generation of 16-bit CRC code using a CRC-CCITT ($X^{16} + X^{12} + X^5 + 1$) generation polynomial for blocks of data of any length in 8-bit units
- CRC code is set to the CRCD data register each time 1-byte data is transferred to the CRCIN register, after the initial value is set to the CRCD register.

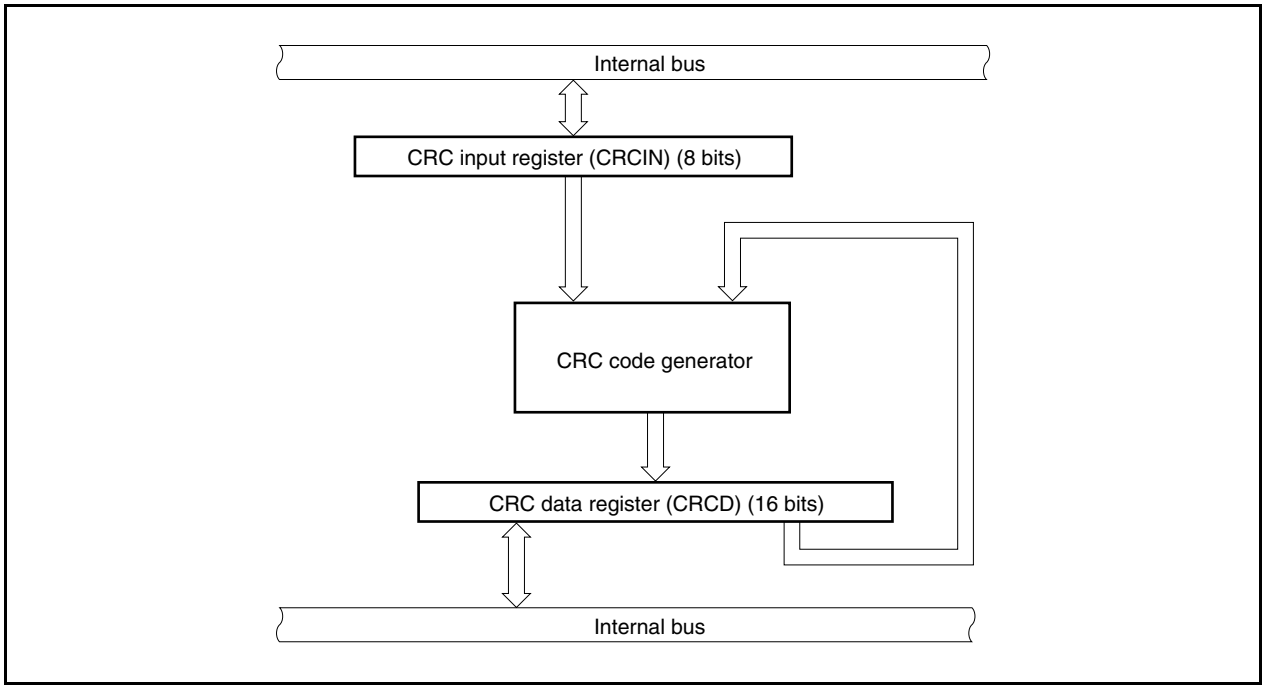
29.2 Configuration

The CRC function includes the following hardware.

Table 29-1. CRC Configuration

Item	Configuration
Control registers	CRC input register (CRCIN) CRC data register (CRCD)

Figure 29-1. Block Diagram of CRC Register



29.3 Registers

(1) CRC input register (CRCIN)

The CRCIN register is an 8-bit register for setting data.

This register can be read or written in 8-bit units.

Reset sets this register to 00H.

After reset: 00H R/W Address: FFFFF310H

	7	6	5	4	3	2	1	0
CRCIN								

(2) CRC data register (CRCD)

The CRCD register is a 16-bit register that stores the CRC-CCITT operation results.

This register can be read or written in 16-bit units.

Reset sets this register to 0000H.

Caution Accessing the CRCD register is prohibited in the following statuses. For details, see 3.4.9 (2) Accessing specific on-chip peripheral I/O registers.

- **When the CPU operates with the subclock and the main clock oscillation is stopped**
- **When the CPU operates with the internal oscillation clock**

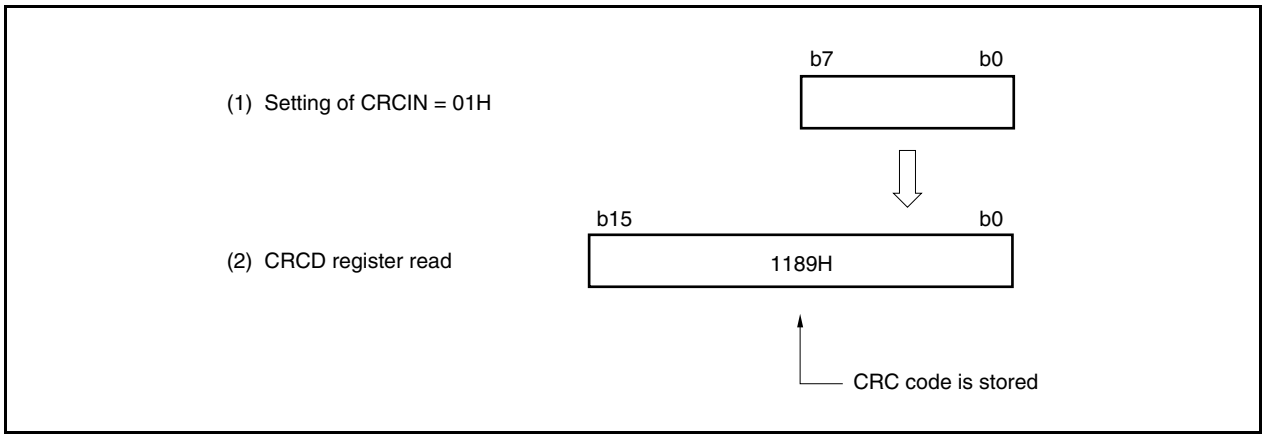
After reset: 0000H R/W Address: FFFFF312H

	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
CRCD																

29.4 Operation

An example of the CRC operation circuit is shown below.

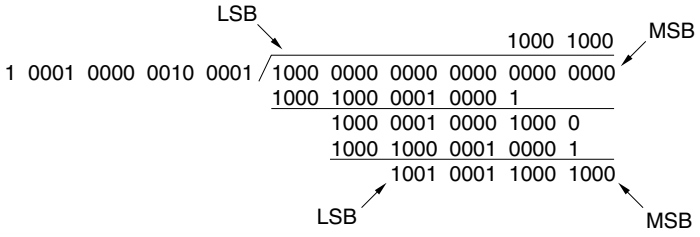
Figure 29-2. CRC Operation Circuit Operation Example (LSB First)



The code when 01H is sent LSB first is (1000 0000). Therefore, the CRC code from generation polynomial $X^{16} + X^{12} + X^5 + 1$ becomes the remainder when (1000 0000) X^{16} is divided by (1 0001 0000 0010 0001) using the modulo-2 operation formula.

The modulo-2 operation is performed based on the following formula.

0 + 0 = 0
0 + 1 = 1
1 + 0 = 1
1 + 1 = 0
−1 = 1

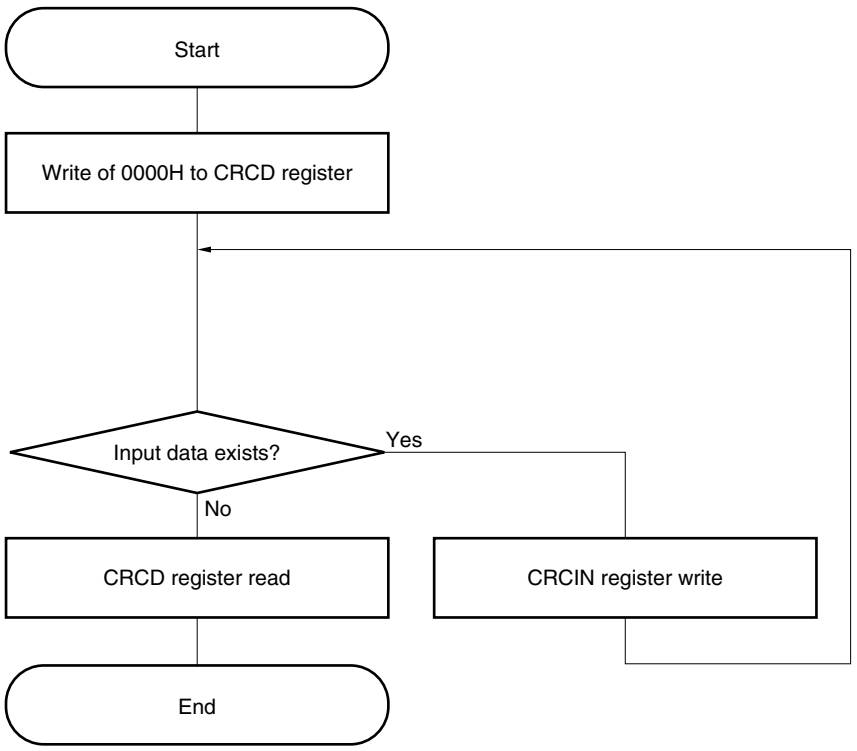


Therefore, the CRC code becomes $\overbrace{1001}^{9}\ \overbrace{0001}^{8}\ \overbrace{1000}^{1}\ \overbrace{1000}^{1}$ ince LSB first is used, this corresponds to 1189H in hexadecimal notation.

29.5 Usage Method

How to use the CRC logic circuit is described below.

Figure 29-3. CRC Operation Flow



[Basic usage method]

<1> Write 0000H to the CRCD register.

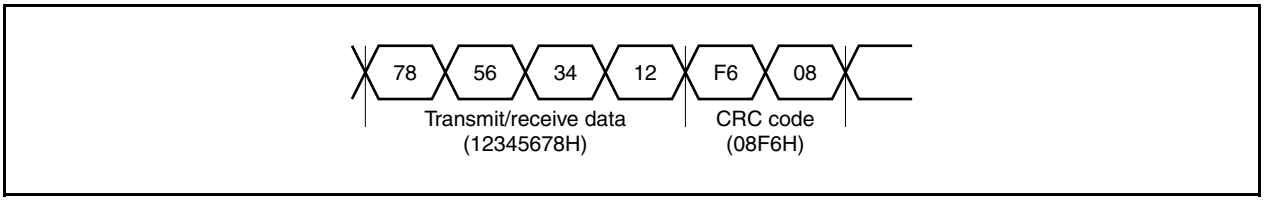
<2> Write the required quantity of data to the CRCIN register.

<3> Read the CRCD register.

Communication errors can easily be detected if the CRC code is transmitted/received along with transmit/receive data when transmitting/receiving data consisting of several bytes.

The following is an illustration using the transmission of 12345678H (0001 0010 0011 0100 0101 0110 0111 1000B) LSB-first as an example.

Figure 29-4. CRC Transmission Example



Setting procedure on transmitting side

<1> Write the initial value 0000H to the CRCD register.

<2> Write the 1 byte of data to be transmitted first to the transmit buffer register. (At this time, also write the same data to the CRCIN register.)

<3> When transmitting several bytes of data, write the same data to the CRCIN register each time transmit data is written to the transmit buffer register.

<4> After all the data has been transmitted, write the contents of the CRCD register (CRC code) to the transmit buffer register and transmit them. (Since this is LSB first, transmit the data starting from the lower bytes, then the higher bytes.)

Setting procedure on receiving side

<1> Write the initial value 0000H to the CRCD register.

<2> When reception of the first 1 byte of data is complete, write that receive data to the CRCIN register.

<3> If receiving several bytes of data, write the receive data to the CRCIN register upon every reception completion. (In the case of normal reception, when all the receive data has been written to the CRCIN register, the contents of the CRCD register on the receiving side and the contents of the CRCD register on the transmitting side are the same.)

<4> Next, the CRC code is transmitted from the transmitting side, so write this data to the CRCIN register similarly to receive data.

<5> When reception of all the data, including the CRC code, has been completed, reception was normal if the contents of the CRCD register are 0000H. If the contents of the CRCD register are other than 0000H, this indicates a communication error, so transmit a resend request to the transmitting side.

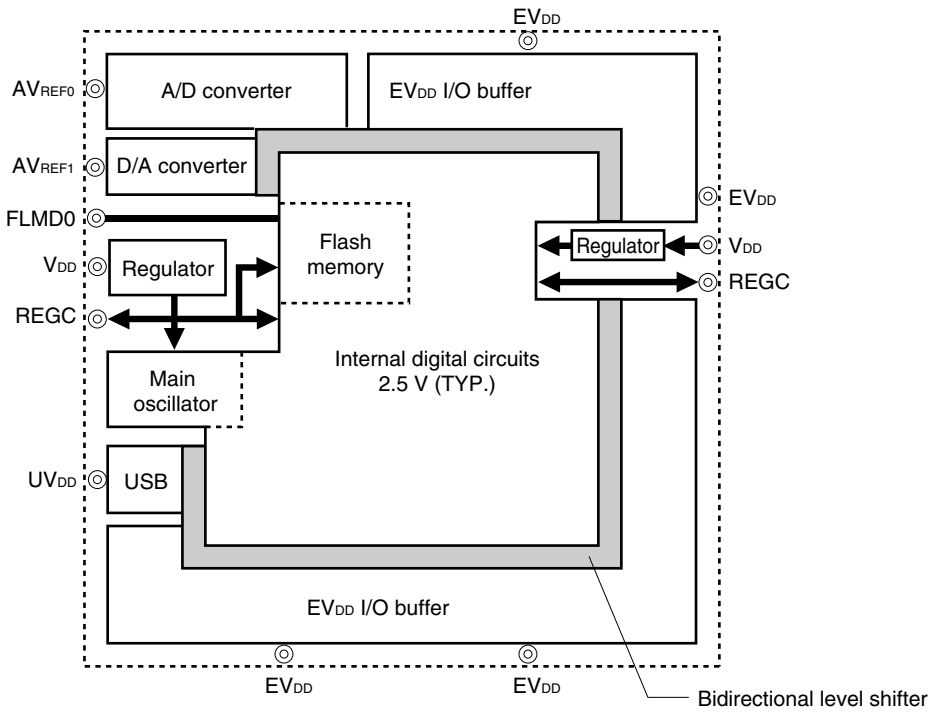
CHAPTER 30 REGULATOR

30.1 Overview

The V850ES/JG3-H and V850ES/JH3-H include a regulator to reduce power consumption and noise.

This regulator supplies a stepped-down V_{DD} power supply voltage to the oscillator block and internal logic circuits (except the A/D converter, D/A converter, and output buffers).

Figure 30-1. Regulator



Caution Be sure to use in $V_{DD} = UV_{DD} = EV_{DD} = AV_{REF0} = AV_{REF1}$.

30.2 Operation

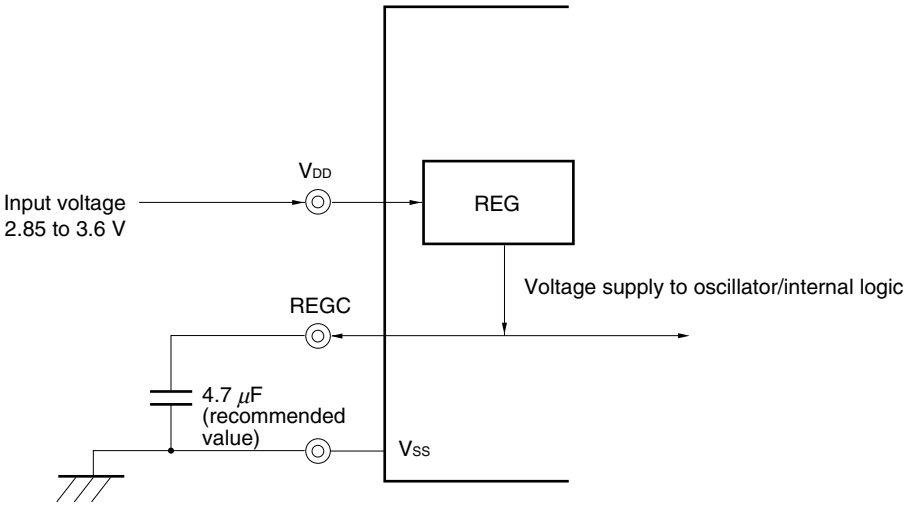
The regulators of the V850ES/JG3-H and V850ES/JH3-H always operate in any mode (normal operation mode, HALT mode, IDLE1 mode, IDLE2 mode, STOP mode, subclock operation mode, sub IDLE mode, or during reset).

Be sure to connect a capacitor (4.7 μF (recommended value)) to the REGC pin[Note] to stabilize the regulator output.

A diagram of the regulator pin connection method is shown below.

Note There are two REGC pins.

Figure 30-2. REGC Pin Connection



Caution The V850ES/JG3-H and V850ES/JH3-H have two regulators. Therefore, connect each of the two REGC pins to a capacitor.

CHAPTER 31 FLASH MEMORY

The V850ES/JG3-H and V850ES/JH3-H incorporate a flash memory.

- μPD70F3760, 70F3765, 70F3770, 70F3771: 256 KB flash memory
- μPD70F3761, 70F3766: 384 KB flash memory
- μPD70F3762, 70F3767: 512 KB flash memory

Flash memory versions offer the following advantages for development environments and mass production applications.

- For altering software after the V850ES/JG3-H and V850ES/JH3-H are soldered onto the target system.
- For data adjustment when starting mass production.
- For differentiating software according to the specification in small scale production of various models.
- For facilitating inventory management.
- For updating software after shipment.

31.1 Features

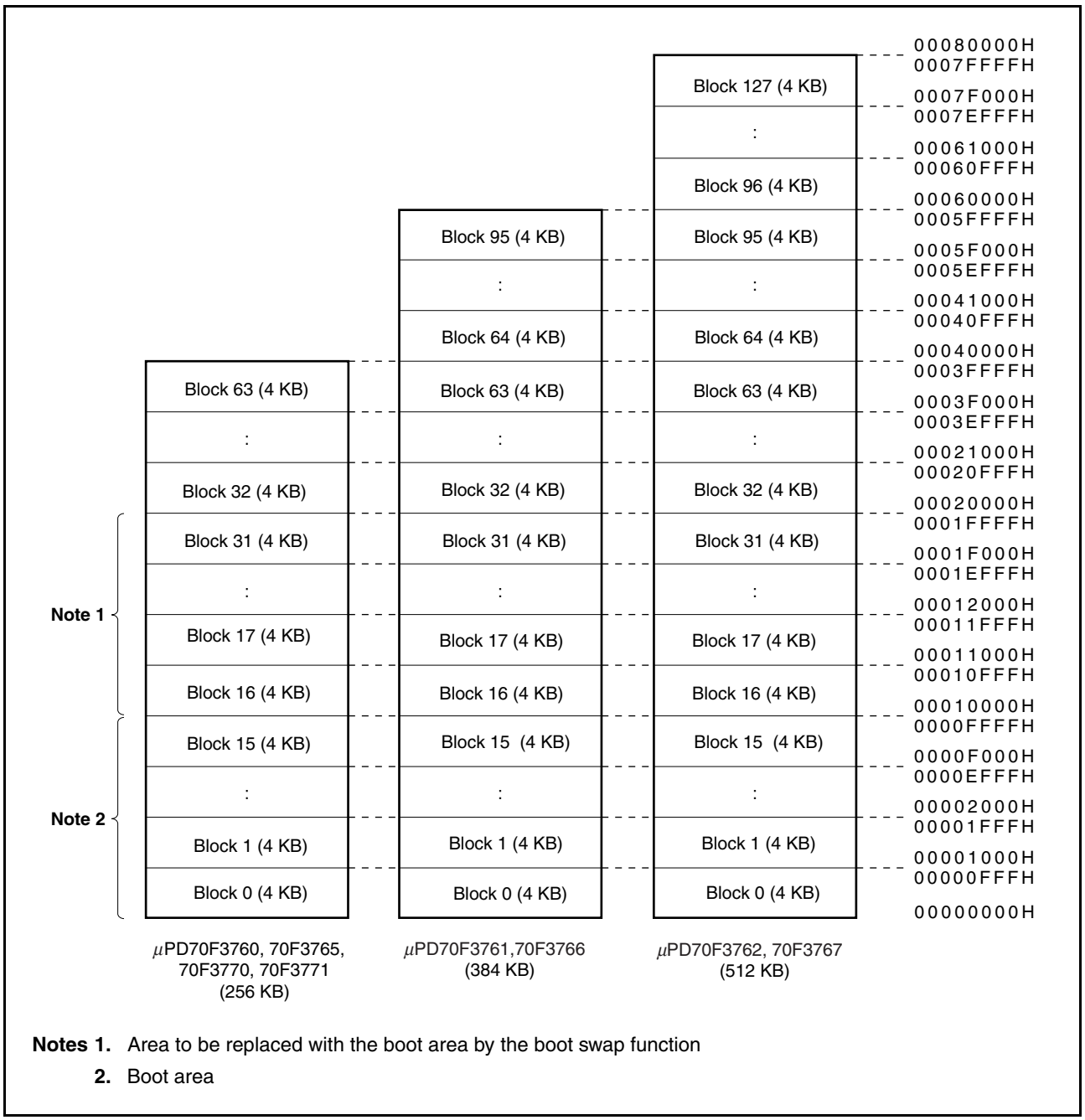
- 4-byte/1-clock access (when instruction is fetched)
- Capacity: 256/384/512 KB
- Rewrite voltage: Erase/write with a single power supply
- Rewriting method
  - Rewriting by communication with dedicated flash programmer via serial interface (on-board/off-board programming)
  - Rewriting flash memory by user program (self programming)
- Flash memory rewrite prohibit function supported (security function)
- Safe rewriting of entire flash memory area by self programming using boot swap function
- Interrupts can be acknowledged during self programming.

31.2 Memory Configuration

The internal flash memory area of the V850ES/JG3-H and V850ES/JH3-H is divided into 64, 96 or 128 blocks and can be programmed/erased in block units. All the blocks can also be erased at once.

When the boot swap function is used, the physical memory located at the addresses of blocks 0 to 15 is replaced by the physical memory located at the addresses of blocks 16 to 31. For details of the boot swap function, see **31.5 Rewriting by Self Programming**.

Figure 31-1. Flash Memory Mapping



Notes 1. Area to be replaced with the boot area by the boot swap function

2. Boot area

31.3 Functional Overview

The internal flash memory of the V850ES/JG3-H and V850ES/JH3-H can be rewritten by using the rewrite function of the dedicated flash programmer, regardless of whether the V850ES/JG3-H and V850ES/JH3-H have already been mounted on the target system or not (off-board/on-board programming).

In addition, a security function that prohibits rewriting the user program written to the internal flash memory is also supported, so that the program cannot be changed by an unauthorized person.

The rewrite function using the user program (self programming) is ideal for an application where it is assumed that the program is changed after production/shipment of the target system. A boot swap function that rewrites the entire flash memory area safely is also supported. In addition, interrupt servicing is supported during self programming, so that the flash memory can be rewritten under various conditions, such as while communicating with an external device.

Table 31-1. Rewrite Method

Rewrite Method	Functional Overview	Operation Mode
On-board programming	Flash memory can be rewritten after the device is mounted on the target system, by using a dedicated flash programmer.	Flash memory programming mode
Off-board programming	Flash memory can be rewritten before the device is mounted on the target system, by using a dedicated flash programmer and a dedicated program adapter board (FA series).	
Self programming	Flash memory can be rewritten by executing a user program that has been written to the flash memory in advance by means of off-board/on-board programming. (During self-programming, instructions cannot be fetched from or data access cannot be made to the internal flash memory area. Therefore, the rewrite program must be transferred to the internal RAM or external memory in advance).	Normal operation mode

Remark The FA series is a product of Naito Densei Machida Mfg. Co., Ltd.

Table 31-2. Basic Functions

Function	Functional Outline	Support (√: Supported, ×: Not supported)	
		On-Board/Off-Board Programming	Self Programming
Blank check	The erasure status of the entire memory is checked.	√	√
Chip erasure	The contents of the entire memory area are erased all at once.	√	×Note
Block erasure	The contents of specified memory blocks are erased.	√	√
Program	Writing to specified addresses, and a verify check to see if the write level is secured, are performed.	√	√
Verify/checksum	Data read from the flash memory is compared with data transferred from the flash memory programmer.	√	× (Can be read by user program)
Read	Data written to the flash memory is read.	√	×
Security setting	Use of the block erase command, chip erase command, program command, and read command, and boot area rewrite, are prohibited.	√	× (Supported only when setting is changed from enable to disable)

Note This is possible by selecting the entire memory area for the block erase function.

The following table lists the security functions. The block erase command prohibit, chip erase command prohibit, and program command prohibit functions are enabled by default after shipment, and security can be set by rewriting via on-board/off-board programming. Each security function can be used in combination with the others at the same time.

Table 31-3. Security Functions

Function	Function Outline
Block erase command prohibit	Execution of a block erase command on all blocks is prohibited. Setting of prohibition can be initialized by execution of a chip erase command.
Chip erase command prohibit	Execution of block erase and chip erase commands on all the blocks is prohibited. Once prohibition is set, setting of prohibition cannot be initialized because the chip erase command cannot be executed.
Program command prohibit	Execution of program and block erase commands on all the blocks is prohibited. Setting of prohibition can be initialized by execution of the chip erase command.
Read command prohibit	Execution of a read command on all of the blocks is prohibited. Setting of the prohibition can be initialized by execution of a chip erase command.
Boot area rewrite prohibit	Execution of write, block erase, and chip erase commands on the boot area is prohibited. Setting of the prohibition of rewriting the boot area cannot be initialized after it is once set.

Table 31-4. Security Setting

Function	Erase, Write, Read Operations When Each Security Is Set (√: Executable, ×: Not Executable, –: Not Supported)		Notes on Security Setting	
	On-Board/ Off-Board Programming	Self Programming	On-Board/ Off-Board Programming	Self Programming
Block erase command prohibit	Block erase command: × Chip erase command: √ Program command: √ Read command: √	Block erasure (FlashBlockErase): √ Chip erasure: – Write (FlashWordWrite): √ Read (FlashWordRead): √	Setting of prohibition can be initialized by chip erase command.	Supported only when setting is changed from enable to prohibit
Chip erase command prohibit	Block erase command: × Chip erase command: × Program command: √Note 1 Read command: √	Block erasure (FlashBlockErase): √ Chip erasure: – Write (FlashWordWrite): √ Read (FlashWordRead): √	Setting of prohibition cannot be initialized.	
Program command prohibit	Block erase command: × Chip erase command: √ Program command: × Read command: √	Block erasure (FlashBlockErase): √ Chip erasure: – Write (FlashWordWrite): √ Read (FlashWordRead): √	Setting of prohibition can be initialized by chip erase command.	
Read command prohibit	Block erase command: √ Chip erase command: √ Program command: √ Read command: ×	Block erasure (FlashBlockErase): √ Chip erasure: – Write (FlashWordWrite): √ Read (FlashWordRead): √	Setting of prohibition can be initialized by chip erase command.	
Boot area rewrite prohibit	Block erase command: ×Note 2 Chip erase command: × Program command: ×Note 2 Read command: √	Block erasure (FlashBlockErase): ×Note 2 Chip erasure: – Write (FlashWordWrite): ×Note 2 Read (FlashWordRead): √	Setting of prohibition cannot be initialized.	Supported only when setting is changed from enable to prohibitNote 3

Notes 1. In this case, since the erase command is invalid, data different from the data already written in the flash memory cannot be written.

2. Executable except in boot area.

3. The boot area rewrite prohibit function becomes effective after the reset input.

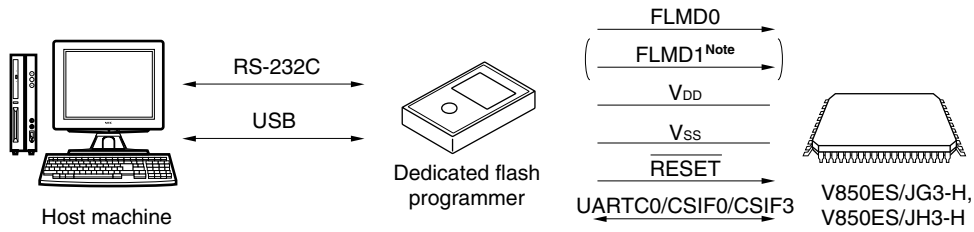
31.4 Rewriting by Dedicated Flash Programmer

The flash memory can be rewritten by using a dedicated flash programmer after the V850ES/JG3-H and V850ES/JH3-H are mounted on the target system (on-board programming). The flash memory can also be rewritten before the device is mounted on the target system (off-board programming) by using a dedicated program adapter (FA series).

31.4.1 Programming environment

The following shows the environment required for writing programs to the flash memory of the V850ES/JG3-H and V850ES/JH3-H.

Figure 31-2. Environment Required for Writing Programs to Flash Memory



Note Connect the FLMD1 pin to the flash programmer or connect to GND via a pull-down resistor on the board.

A host machine is required for controlling the dedicated flash programmer.

UARTC0, CSIF0, or CSIF3 is used for the interface between the dedicated flash programmer and the V850ES/JG3-H and V850ES/JH3-H to perform writing, erasing, etc. A dedicated program adapter (FA series) required for off-board writing.

Remark The FA series is a product of Naito Densei Machida Mfg. Co., Ltd.

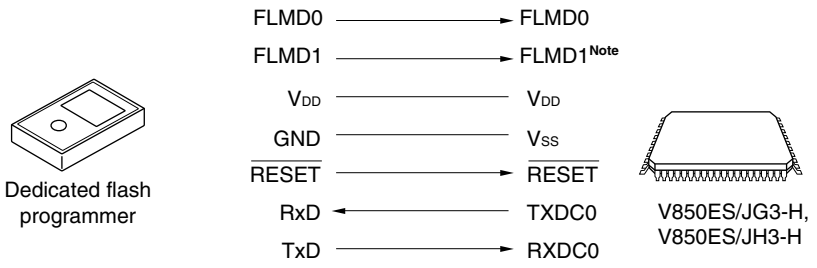
31.4.2 Communication mode

Communication between the dedicated flash programmer and the V850ES/JG3-H or V850ES/JH3-H is performed by serial communication using the UARTC0, CSIF0, or CSIF3 interface of the V850ES/JG3-H or V850ES/JH3-H.

(1) UARTC0

Transfer rate: 9,600 to 153,600 bps

Figure 31-3. Communication with Dedicated Flash Programmer (UARTC0)

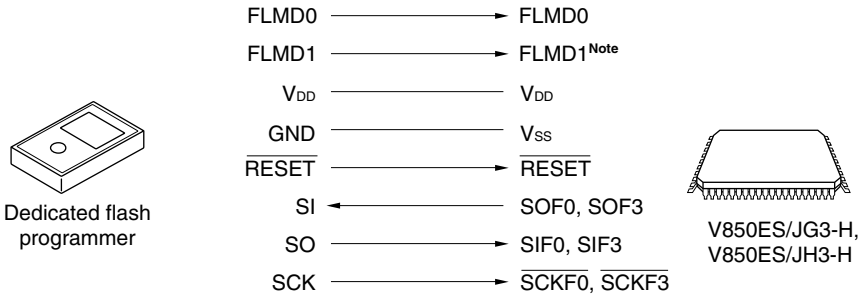


Note Connect the FLMD1 pin to the flash programmer or connect to GND via a pull-down resistor on the board.

(2) CSIF0, CSIF3

Serial clock: 5 MHz or less (MSB first)

Figure 31-4. Communication with Dedicated Flash Programmer (CSIF0, CSIF3)

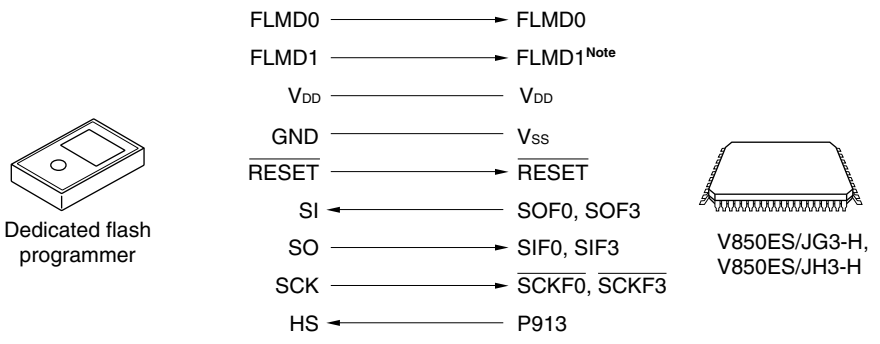


Note Connect the FLMD1 pin to the flash programmer or connect to GND via a pull-down resistor on the board.

(3) CSIF0 + HS, CSIF3 + HS

Serial clock: 5 MHz or less (MSB first)

Figure 31-5. Communication with Dedicated Flash Programmer (CSIF0 + HS, CSIF3 + HS)



Note Connect the FLMD1 pin to the flash programmer or connect to GND via a pull-down resistor on the board.

The dedicated flash programmer outputs the transfer clock, and the V850ES/JG3-H and V850ES/JH3-H operate as a slave.

When the PG-FP5 is used as the dedicated flash programmer, it generates the following signals to the V850ES/JG3-H and V850ES/JH3-H. For details, refer to the **PG-FP5 User's Manual (U18865E)**.

Table 31-5. Signal Connections of Dedicated Flash Programmer (PG-FP5)

PG-FP5			V850ES/JG3-H, V850ES/JH3-H	Processing for Connection		
Signal Name	I/O	Pin Function	Pin Name	UARTC0	CSIF0, CSIF3	CSIF0 + HS, CSIF3 + HS
FLMD0	Output	Write enable/disable	FLMD0	◎	◎	◎
FLMD1	Output	Write enable/disable	FLMD1	◎Note 1	◎Note 1	◎Note 1
VDD	–	V_{DD} voltage generation/voltage monitor	V_{DD}	◎	◎	◎
GND	–	Ground	V_{SS}	◎	◎	◎
CLK	Output	Clock output to V850ES/JG3-H and V850ES/JH3-H	X1, X2	×Note 2	×Note 2	×Note 2
$\overline{\text{RESET}}$	Output	Reset signal	$\overline{\text{RESET}}$	◎	◎	◎
SI/RxD	Input	Receive signal	SOF0, SOF3/ TXDC0	◎	◎	◎
SO/TxD	Output	Transmit signal	SIF0, SIF3/ RXDC0	◎	◎	◎
SCK	Output	Transfer clock	$\overline{\text{SCKF0}}$, $\overline{\text{SCKF3}}$	×	◎	◎
HS	Input	Handshake signal for CSIF0 + HS, CSIF3 + HS communication	P913	×	×	◎

Notes 1. Wire these pins as shown in Figures 31-6 and 31-7, or connect then to GND via pull-down resistor on board.

2. Clock cannot be supplied via the CLK pin of the flash programmer. Create an oscillator on board and supply the clock.

Remark ◎: Must be connected.

×: Does not have to be connected.

Table 31-6. Wiring of V850ES/JG3-H Flash Writing Adapters (1/3)

Pin No.	Pin Name	Recommended Connection
1	AV_{REF0}	Connect to VDD pin of the programmer
2	AV_{SS}	Connect to GND pin of the programmer
3	P10/ANO0	-
4	P11/ANO1	-
5	AV_{REF1}	Connect to VDD pin of the programmer
6	P02/NMI	-
7	P03/INTP02/ADTRG/UCLK	-
8	FLMD0	Connect to FLMD0 (output) pin of the programmer
9	V_{DD}	Connect to VDD pin of the programmer
10	REGC	Connect the REGC pin to GND via 4.7 μF capacitor
11	V_{SS}	Connect to GND pin of the programmer
12	X1	Connect to 3 to 6 MHz Resonator
13	X2	Connect to 3 to 6 MHz Resonator
14	$\overline{\text{RESET}}$	Connect to RESET (output) pin of the programmer
15	XT1	Connect to GND pin of the programmer
16	XT2	-
17	UDMF	-
18	UDPF	-
19	UV_{DD}	Connect to VDD pin of the programmer
20	P04/INTP03	-
21	P05/INTP04	-
22	P40/SIF0/TXDC4/SDA01	When CSI (CSIF0) is used : connect to SO (output) pin of the programmer When CSI (CSIF0)is not used : pull-down[Note]
23	P41/SOF0/RXDC4/SCL01	When CSI (CSIF0)is used : connect to SI (input) pin of the programmer When CSI (CSIF0)is not used : pull-down[Note]
24	P42/$\overline{\text{SCKF0}}$/INTP10	When CSI(CSIF0)is used : connect to SCK (output) pin of the programmer When CSI (CSIF0)is not used : pull-down[Note]
25	P30/TXDC0/SOF4/INTP07	When UART (UARTD0) is used : connect to RxD (input) pin of the programmer When UART (UARTD0) is not used : pull-down[Note]
26	P31/RXDC0/SIF4/INTP08	When UART (UARTD0) is used : connect to TxD (output) pin of the programmer When UART (UARTD0) is not used : pull-down[Note]
27	P32/ASCKC0/$\overline{\text{SCKF4}}$/TIAA00/TOAA00	-
28	P33/TIAA01/TOAA01/RTCDIV/RTCCL	-
29	P34/TIAA10/TOAA10/TOAA1OFF/INTP09	-
30	P35/TIAA11/TOAA11/RTC1HZ	-

Note Independently connect to EV_{SS} or V_{DD} via a resistor.

Table 31-6. Wiring of V850ES/JG3-H Flash Writing Adapters (2/3)

Pin No.	Pin Name	Recommended Connection
31	P36/TXDC3/SCL00/CTXD0[Note1]/$\overline{\text{UDMARQ0}}$	-
32	P37/RXDC3/SDA00/CRXD0[Note1]/$\overline{\text{UDMAAK0}}$	-
33	EV_{SS}	Connect to GND pin of the programmer
34	EV_{DD}	Connect to VDD pin of the programmer
35	P50/TIAB01/KR0/TOAB01/RTP00/$\overline{\text{UDMARQ1}}$	-
36	P51/TIAB02/KR1/TOAB02/RTP01/$\overline{\text{UDMAAK1}}$	-
37	P52/TIAB03/KR2/TOAB03/RTP02/DDI	-
38	P53/SIF2/TIAB00/KR3/TOAB00/RTP03/DDO	-
39	P54/SOF2/KR4/RTP04/DCK	-
40	P55/$\overline{\text{SCKF2}}$/KR5/RTP05/DMS	-
41	P56/INTP05/$\overline{\text{DRST}}$	-
42	P90/KR6/TXDC1/SDA02	-
43	P91/KR7/RXDC1/SCL02	-
44	P92/TENC01/TIT01/TOT01	-
45	P93/TECR0/TIT00/TOT00	-
46	P94/TIAA31/TOAA31/TENC00/EVTT00	-
47	P95/TIAA30/TOAA30	-
48	P96/TIAA21/TOAA21/INTP11	-
49	P97/SIF1/TIAA20/TOAA20	-
50	P98/SOF1/INTP12	-
51	P99/SCKF1/INTP13/A9	-
52	P910/SIF3/TXDC2/INTP14/A10	When CSI (CSIF3) is used : connect to SO (output) pin of the programmer When CSI (CSIF3) is not used : pull-down[Note2]
53	P911/SOF3/RXDC2/INTP15/A11	When CSI (CSIF3) is used : connect to SI (input) pin of the programmer When CSI (CSIF3) is not used : pull-down[Note2]
54	P912/$\overline{\text{SCKF3}}$/A12	When CSI (CSIF3) is used : connect to SCK (output) pin of the programmer When CSI (CSIF3) is not used : pull-down[Note2]
55	P913/TOAB1OFF/INTP16/A13 (HS)	When CSI-HS (CSIF3) is used : connect to H/S (input) pin of the programmer When CSI-HS (CSIF3) is not used : pull-down[Note2]
56	P914/TIAA51/TOAA51/INTP17/A14	-
57	P915/TIAA50/TOAA50/INTP18/A15	-
58	PCT0/$\overline{\text{WR0}}$	-
59	PCT1/$\overline{\text{WR1}}$	-
60	V_{DD}	Connect to VDD pin of the programmer

Notes 1. μPD70F3370, 70F3371 only

2. Independently connect to EV_{SS} or V_{DD} via a resistor.

Table 31-6. Wiring of V850ES/JG3-H Flash Writing Adapters (3/3)

Pin No.	Pin Name	Recommended Connection
61	REGC	Connect the REGC pin to GND via 4.7 μF capacitor
62	EV_{SS}	Connect to GND pin of the programmer
63	EV_{DD}	Connect to VDD pin of the programmer
64	PCM1/CLKOUT	-
65	P60/TOAB1T1/TOAB11/TIAB11/$\overline{WAIT}$	-
66	P61/TOAB1B1/TIAB10/TOAB10/$\overline{RD}$	-
67	P62/TOAB1T2/TOAB12/TIAB12/ASTB	-
68	P63/TOAB1B2/TRGAB1/$\overline{CS0}$	-
69	P64/TOAB1T3/TOAB13/TIAB13/$\overline{CS2}$	-
70	P65/TOAB1B3/EVTAB1/$\overline{CS3}$	Connect to VDD pin of the programmer
71	PDL0/AD0	Connect to VDD pin of the programmer
72	PDL1/AD1	Connect to VDD pin of the programmer
73	PDL2/AD2	Connect to VDD pin of the programmer
74	PDL3/AD3	Connect to VDD pin of the programmer
75	PDL4/AD4	Connect to VDD pin of the programmer
76	PDL5/AD5/FLMD1	Connect to FLMD1 (output) pin of the programmer
77	PDL6/AD6	-
78	PDL7/AD7	-
79	EVSS	Connect to GND pin of the programmer
80	EVDD	Connect to VDD pin of the programmer
81	PDL8/AD8	-
82	PDL9/AD9	-
83	PDL10/AD10	-
84	PDL11/AD11	-
85	PDL12/AD12	-
86	PDL13/AD13	-
87	PDL14/AD14	-
88	PDL15/AD15	-
89	P711/ANI11	-
90	P710/ANI10	-
91	P79/ANI9	-
92	P78/ANI8	-
93	P77/ANI7	-
94	P76/ANI6	-
95	P75/ANI5	-
96	P74/ANI4	-
97	P73/ANI3	-
98	P72/ANI2	-
99	P71/ANI1	-
100	P70/ANI0	-

Figure 31-6. Wiring Example of V850ES/JG3-H Flash Writing Adapter (In CSIF0 + HS Mode) (1/2)

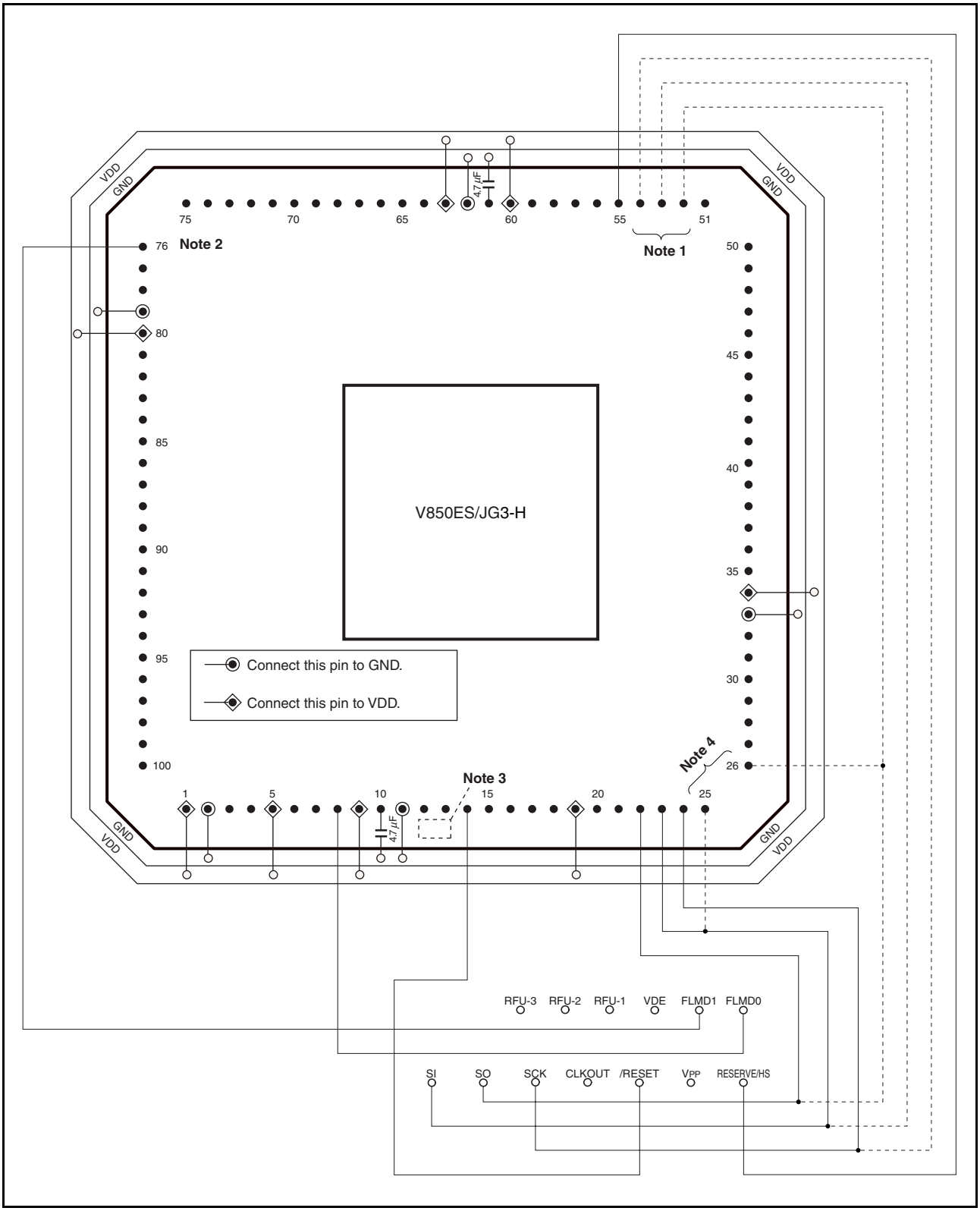


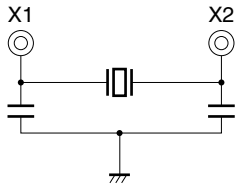
Figure 31-6. Wiring Example of V850ES/JG3-H Flash Writing Adapter (In CSIF0 + HS Mode) (2/2)

Notes 1. Corresponding pins when CSIF3 is used.

2. Wire the FLMD1 pin as shown below, or connect it to GND on board via a pull-down resistor.

3. Create an oscillator on the flash writing adapter (shown in broken lines) and supply a clock. Here is an example of the oscillator.

Example:



4. Corresponding pins when UARTC0 is used.

Caution Do not input a high level to the $\overline{\text{DRST}}$ pin.

Remarks 1. Process the pins not shown in accordance with the handling of unused pins (see **2.3 Pin I/O Circuit Types, I/O Buffer Power Supplies, and Connection of Unused Pins**).

2. This adapter is for the 100-pin plastic LQFP package.

Table 31-7. Wiring of V850ES/JH3-H Flash Writing Adapters (1/4)

Pin No.	Pin Name	Recommended Connection
1	AV_{REF0}	Connect to VDD pin of the programmer
2	AV_{SS}	Connect to GND pin of the programmer
3	P10/ANO0	-
4	P11/ANO1	-
5	AV_{REF1}	Connect to VDD pin of the programmer
6	P02/NMI	-
7	P03/INTP02/ADTRG/UCLK	-
8	P00/INTP00	-
9	P01/INTP01	-
10	PCM2/$\overline{\text{HLDAK}}$	-
11	PCM3/$\overline{\text{HLDRQ}}$	-
12	FLMD0	Connect to FLMD0 (output) pin of the programmer
13	V_{DD}	Connect to VDD pin of the programmer
14	REGC	Connect the REGC pin to GND via 4.7 μF capacitor
15	V_{SS}	Connect to GND pin of the programmer
16	X1	Connect to 3 to 6 MHz Resonator
17	X2	Connect to 3 to 6 MHz Resonator
18	$\overline{\text{RESET}}$	Connect to RESET (output) pin of the programmer
19	XT1	Connect to GND pin of the programmer
20	XT2	-
21	UDMF	-
22	UDPF	-
23	UV_{DD}	Connect to VDD pin of the programmer
24	P04/INTP03	-
25	P05/INTP04	-
26	P04/INTP03	-
27	P05/INTP04	-
28	P25/INTP06	-
29	P40/SIF0/TXDC4/SDA01	When CSI (CSIF0) is used : connect to SO (output) pin of the programmer When CSI (CSIF0)is not used : pull-down[Note]
30	P41/SOF0/RXDC4/SCL01	When CSI (CSIF0)is used : connect to SI (input) pin of the programmer When CSI (CSIF0)is not used : pull-down[Note]
31	P42/$\overline{\text{SCKF0}}$/INTP10	When CSI(CSIF0)is used : connect to SCK (output) pin of the programmer When CSI (CSIF0)is not used : pull-down[Note]
32	P20/TIAB03/KR2/TOAB03/RTP02	-
33	P21/SIF2/TIAB00/KR3/TOAB00/RTP03	-

Note Independently connect to EV_{SS} or V_{DD} via a resistor.

Table 31-7. Wiring of V850ES/JH3-H Flash Writing Adapters (2/4)

Pin No.	Pin Name	Recommended Connection
34	P22/SOF2/KR4/RTP04	-
35	P23/SCKF2/KR5/RTP05	-
36	P24/INTP05	-
37	P30/TXDC0/SOF4/INTP07	When UART (UARTD0) is used : connect to RxD (input) pin of the programmer When UART (UARTD0) is not used : pull-down[Note1]
38	P31/RXDC0/SIF4/INTP08	When UART (UARTD0) is used : connect to TxD (output) pin of the programmer When UART (UARTD0) is not used : pull-down[Note1]
39	P32/ASCKC0/$\overline{\text{SCKF4}}$/TIAA00/TOAA00	-
40	P33/TIAA01/TOAA01/RTCDIV/RTCCL	-
41	P34/TIAA10/TOAA10/TOAA1OFF/INTP09	-
42	P35/TIAA11/TOAA11/RTC1HZ	-
43	P36/TXDC3/SCL00/CTXD0[Note2]/$\overline{\text{UDMARQ0}}$	-
44	P37/RXDC3/SDA00/CRXD0[Note2]/$\overline{\text{UDMAAK0}}$	-
45	EV_{SS}	Connect to GND pin of the programmer
46	EV_{DD}	Connect to VDD pin of the programmer
47	P50/TIAB01/KR0/TOAB01/RTP00/$\overline{\text{UDMARQ1}}$	-
48	P51/TIAB02/KR1/TOAB02/RTP01/$\overline{\text{UDMAAK1}}$	-
49	DDI	-
50	DDO	-
51	DCK	-
52	DMS	-
53	$\overline{\text{DRST}}$	Connect to GND pin of the programmer
54	P90/KR6/TXDC1/SDA02/A0	-
55	P91/KR7/RXDC1/SCL02/A1	-
56	P92/TENC01/TIT01/TOT01/A2	-
57	P93/TECR0/TIT00/TOT00/A3	-
58	P94/TIAA31/TOAA31/TENC00/EVTT00/A4	-
59	P95/TIAA30/TOAA30/A5	-
60	EV_{SS}	Connect to GND pin of the programmer
61	EV_{DD}	Connect to VDD pin of the programmer
62	P96/TIAA21/TOAA21/INTP11/A6	-
63	P97/SIF1/TIAA20/TOAA20/A7	-
64	P98/SOF1/INTP12/A8	-
65	P99/SCKF1/INTP13/A9	-

Notes 1. Independently connect to EV_{SS} or V_{DD} via a resistor.

2. μPD70F3370, 70F3371 only

Table 31-7. Wiring of V850ES/JH3-H Flash Writing Adapters (3/4)

Pin No.	Pin Name	Recommended Connection
66	P910/SIF3/TXDC2/INTP14/A10	When CSI (CSIF3) is used : connect to SO (output) pin of the programmer When CSI (CSIF3) is not used : pull-down[Note]
67	P911/SOF3/RXDC2/INTP15/A11	When CSI (CSIF3) is used : connect to SI (input) pin of the programmer When CSI (CSIF3) is not used : pull-down[Note]
68	P912/$\overline{\text{SCKF3}}$/A12	When CSI (CSIF3) is used : connect to SCK (output) pin of the programmer When CSI (CSIF3) is not used : pull-down[Note]
69	P913/TOAB1OFF/INTP16/A13 (HS)	When CSI-HS (CSIF3) is used : connect to H/S (input) pin of the programmer When CSI-HS (CSIF3) is not used : pull-down[Note]
70	P914/TIAA51/TOAA51/INTP17/A14	-
71	P915/TIAA50/TOAA50/INTP18/A15	-
72	PDH0/A16	-
73	PDH1/A17	-
74	PDH2/A18	-
75	PDH3/A19	-
76	PCT0/$\overline{\text{WR0}}$	-
77	PCT1/$\overline{\text{WR1}}$	-
78	PDH4/A20	-
79	PDH5/A21	-
80	PDH6/A22	-
81	PDH7/A23	-
82	V_{DD}	Connect to VDD pin of the programmer
83	REGC	Connect the REGC pin to GND via 4.7 μF (recommended value) capacitor
84	EV_{SS}	Connect to GND pin of the programmer
85	EV_{DD}	Connect to VDD pin of the programmer
86	PCM1/CLKOUT	-
87	PCT4/$\overline{\text{RD}}$	-
88	PCT6/ASTB	-
89	PCM0/$\overline{\text{WAIT}}$	-
90	P60/TOAB1T1/TOAB11/TIAB11	-
91	P61/TOAB1B1/TIAB10/TOAB10	-
92	P62/TOAB1T2/TOAB12/TIAB12	-
93	P63/TOAB1B2/TRGAB1	-
94	P64/TOAB1T3/TOAB13/TIAB13	-
95	P65/TOAB1B3/EVTAB1	Connect to GND pin of the programmer

Note Independently connect to EV_{SS} or V_{DD} via a resistor.

Table 31-7. Wiring of V850ES/JH3-H Flash Writing Adapters (4/4)

Pin No.	Pin Name	Recommended Connection
96	PCS0/$\overline{CS0}$	-
97	PCS2/$\overline{CS2}$	-
98	PDL0/AD0	Connect to GND pin of the programmer
99	PDL1/AD1	Connect to GND pin of the programmer
100	PDL2/AD2	Connect to GND pin of the programmer
101	PDL3/AD3	Connect to GND pin of the programmer
102	PDL4/AD4	Connect to GND pin of the programmer
103	PDL5/AD5/FLMD1	Connect to FLMD1 (output) pin of the programmer
104	PDL6/AD6	-
105	PDL7/AD7	-
106	EVSS	Connect to GND pin of the programmer
107	EVDD	Connect to VDD pin of the programmer
108	PDL8/AD8	-
109	PDL9/AD9	-
110	PDL10/AD10	-
111	PDL11/AD11	-
112	PDL12/AD12	-
113	PDL13/AD13	-
114	PDL14/AD14	-
115	PDL15/AD15	-
116	PCS3/$\overline{CS3}$	-
117	P711/ANI11	-
118	P710/ANI10	-
119	P79/ANI9	-
120	P78/ANI8	-
121	P77/ANI7	-
122	P76/ANI6	-
123	P75/ANI5	-
124	P74/ANI4	-
125	P73/ANI3	-
126	P72/ANI2	-
127	P71/ANI1	-
128	P70/ANI0	-

Figure 31-7. Wiring Example of V850ES/JH3-H Flash Writing Adapter (In CSIF0 + HS Mode) (1/2)

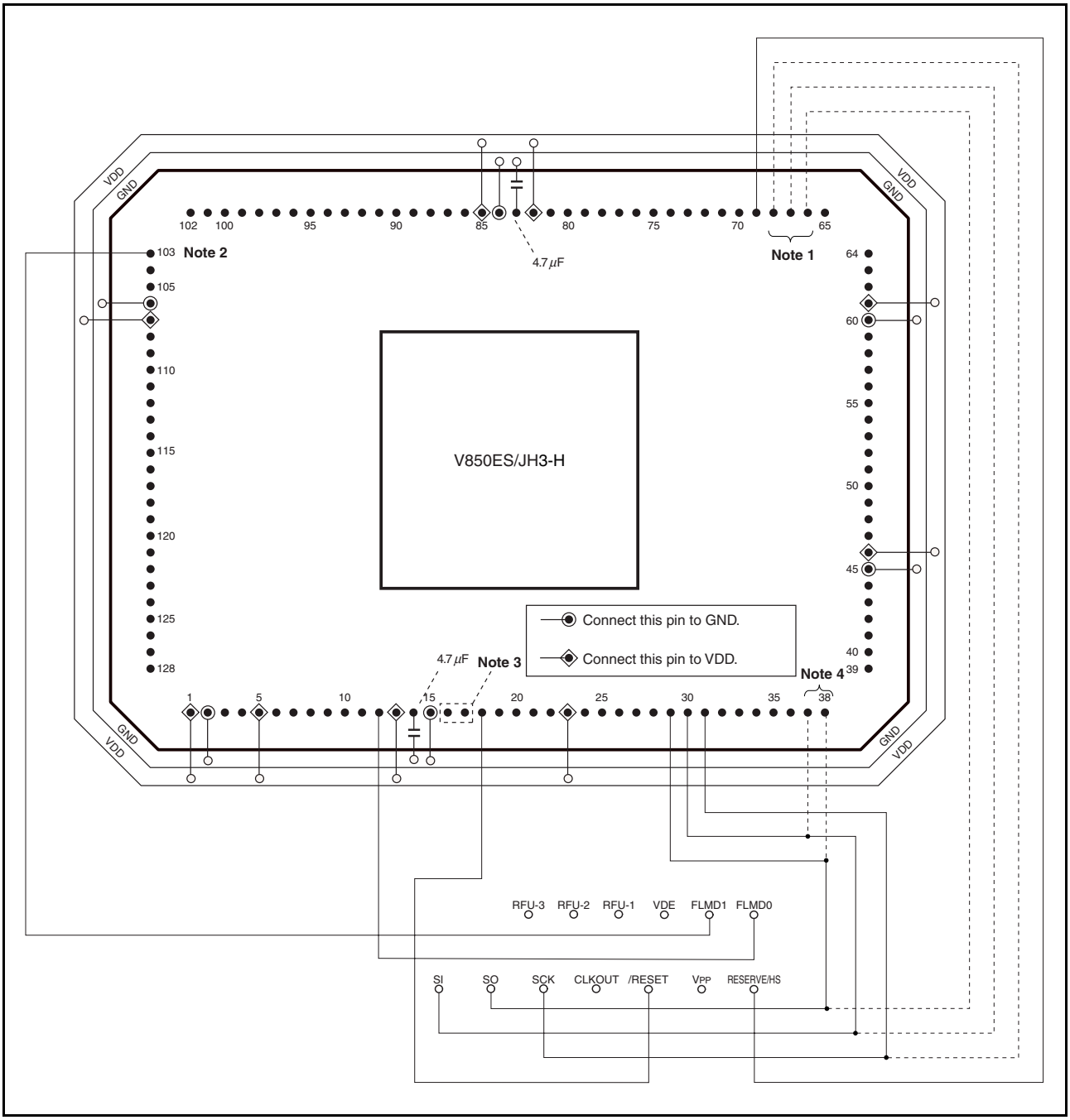


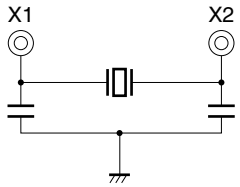
Figure 31-7. Wiring Example of V850ES/JH3-H Flash Writing Adapter (In CSIF0 + HS Mode) (2/2)

Notes 1. Corresponding pins when CSIF3 is used.

2. Wire the FLMD1 pin as shown below, or connect it to GND on board via a pull-down resistor.

3. Create an oscillator on the flash writing adapter (shown in broken lines) and supply a clock. Here is an example of the oscillator.

Example:



4. Corresponding pins when UARTC0 is used.

Caution Do not input a high level to the $\overline{\text{DRST}}$ pin.

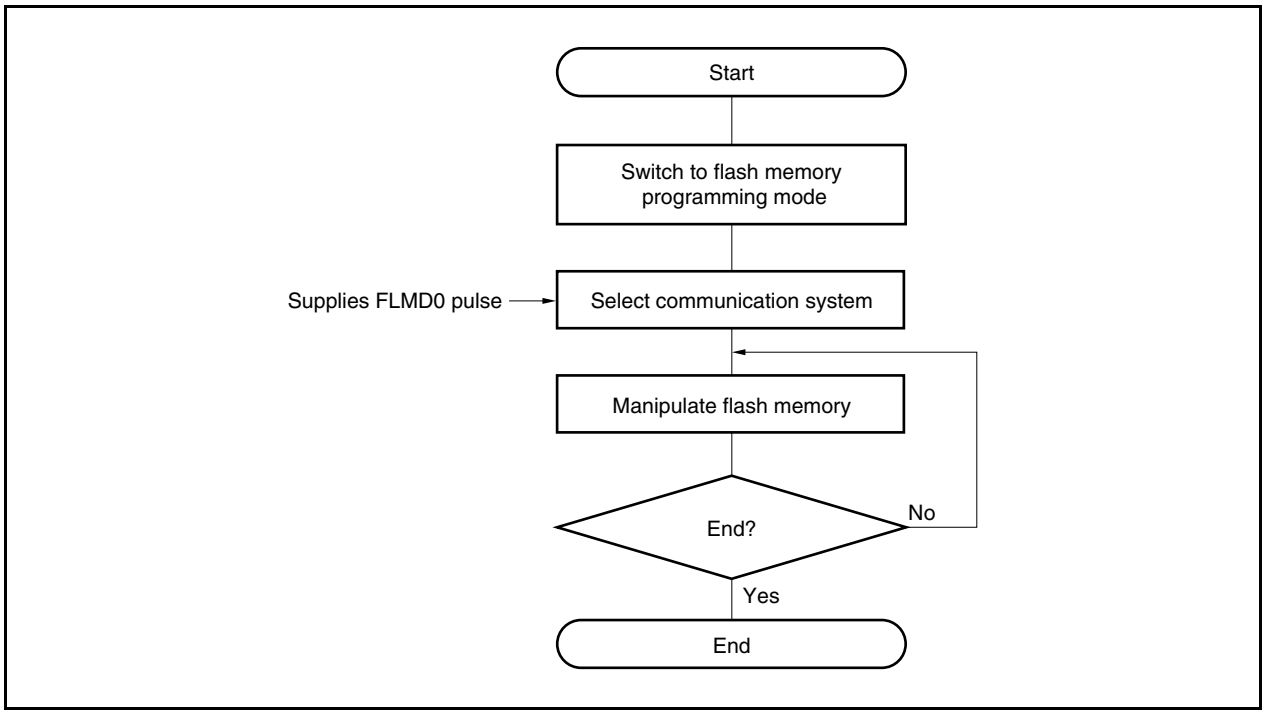
Remarks 1. Process the pins not shown in accordance with the handling of unused pins (see **2.3 Pin I/O Circuit Types, I/O Buffer Power Supplies, and Connection of Unused Pins**).

2. This adapter is for the 128-pin plastic LQFP package.

31.4.3 Flash memory control

The following shows the procedure for manipulating the flash memory.

Figure 31-8. Procedure for Manipulating Flash Memory

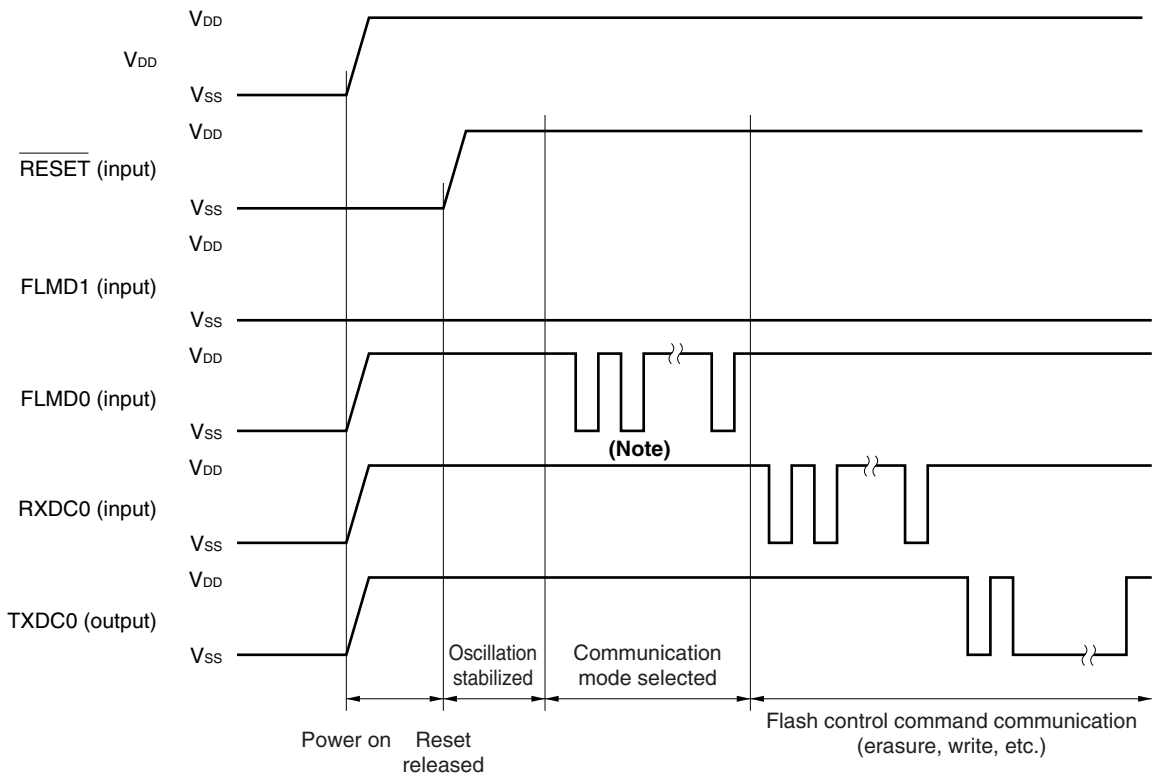


31.4.4 Selection of communication mode

In the V850ES/JG3-H and V850ES/JH3-H, the communication mode is selected by inputting pulses (12 pulses max.) to the FLMD0 pin after switching to the flash memory programming mode. The FLMD0 pulse is generated by the dedicated flash programmer.

The following shows the relationship between the number of pulses and the communication mode.

Figure 31-9. Selection of Communication Mode



Note The number of clocks is as follows depending on the communication mode.

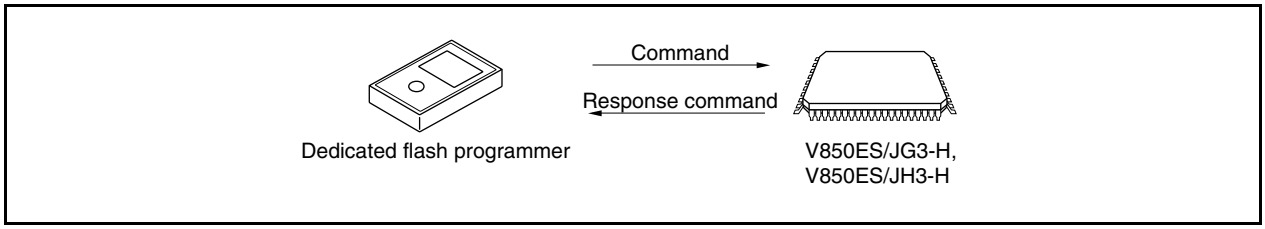
FLMD0 Pulse	Communication Mode	Remarks
0	UARTC0	Communication rate: 9,600 bps (after reset), LSB first
8	CSIF0	V850ES/Jx3-H performs slave operation, MSB first
9	CSIF3	V850ES/Jx3-H performs slave operation, MSB first
11	CSIF0 + HS	V850ES/Jx3-H performs slave operation, MSB first
12	CSIF3 + HS	V850ES/Jx3-H performs slave operation, MSB first
Other	RFU	Setting prohibited

Caution When UARTC0 is selected, the receive clock is calculated based on the reset command sent from the dedicated flash programmer after receiving the FLMD0 pulse.

31.4.5 Communication commands

The V850ES/JG3-H and V850ES/JH3-H communicate with the dedicated flash programmer by means of commands. The signals sent from the dedicated flash programmer to the V850ES/JG3-H and V850ES/JH3-H are called “commands”. The response signals sent from the V850ES/JG3-H and V850ES/JH3-H to the dedicated flash programmer are called “response commands”.

Figure 31-10. Communication Commands



The following shows the commands for flash memory control in the V850ES/JG3-H and V850ES/JH3-H. All of these commands are issued from the dedicated flash programmer, and the V850ES/JG3-H and V850ES/JH3-H perform the processing corresponding to the commands.

Table 31-8. Flash Memory Control Commands

Classification	Command Name	Support			Function
		CSIF0, CSIF3	CSIF0 + HS, CSIF3 + HS	UARTC0	
Blank check	Block blank check command	√	√	√	Checks if the contents of the memory in the specified block have been correctly erased.
Erase	Chip erase command	√	√	√	Erases the contents of the entire memory.
	Block erase command	√	√	√	Erases the contents of the memory of the specified block.
Write	Program command	√	√	√	Writes the specified address range, and executes a contents verify check.
Verify	Verify command	√	√	√	Compares the contents of memory in the specified address range with data transferred from the flash programmer.
	Checksum command	√	√	√	Reads the checksum in the specified address range.
Read	Read command	√	√	√	Reads the data written to flash memory.
System setting, control	Silicon signature command	√	√	√	Reads silicon signature information.
	Security setting command	√	√	√	Prohibits the chip erase command, block erase command, program command, read command, and boot area rewrite.

31.4.6 Pin connection

When performing on-board writing, mount a connector on the target system to connect to the dedicated flash programmer. Also, incorporate a function on-board to switch from the normal operation mode to the flash memory programming mode.

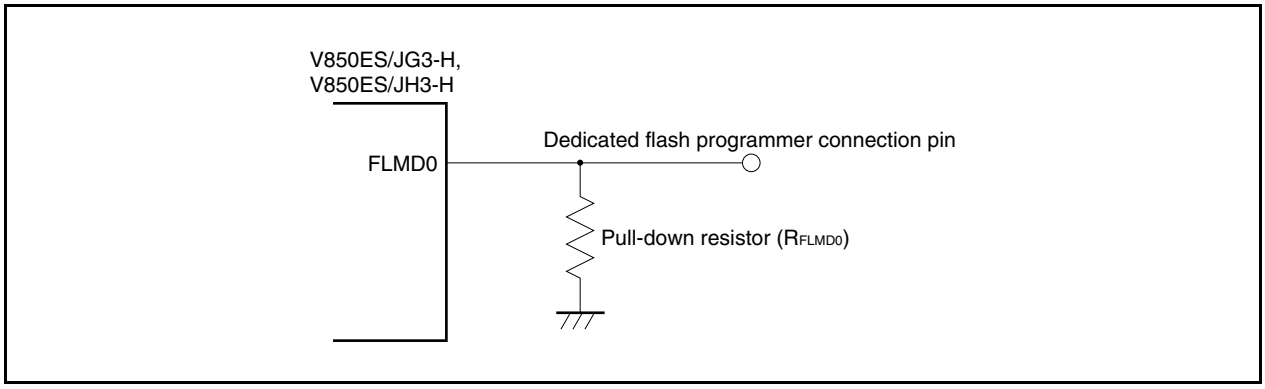
In the flash memory programming mode, all the pins not used for flash memory programming become the same status as that immediately after reset. Therefore, pin handling is required when the external device does not acknowledge the status immediately after a reset.

(1) FLMD0 pin

In the normal operation mode, input a voltage of V_{SS} level to the FLMD0 pin. In the flash memory programming mode, supply a write voltage of V_{DD} level to the FLMD0 pin.

Because the FLMD0 pin serves as a write protection pin in the self programming mode, a voltage of V_{DD} level must be supplied to the FLMD0 pin via port control, etc., before writing to the flash memory. For details, see **31.5.5 (1) FLMD0 pin**.

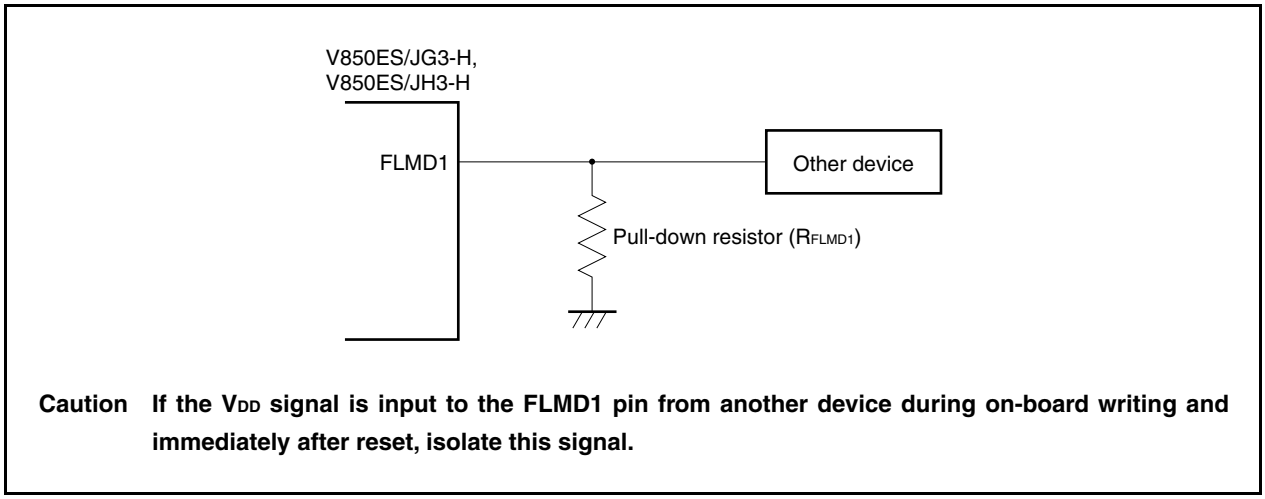
Figure 31-11. FLMD0 Pin Connection Example



(2) FLMD1 pin

When 0 V is input to the FLMD0 pin, the FLMD1 pin does not function. When V_{DD} is supplied to the FLMD0 pin, the flash memory programming mode is entered, so 0 V must be input to the FLMD1 pin. The following shows an example of the connection of the FLMD1 pin.

Figure 31-12. FLMD1 Pin Connection Example



Caution If the V_{DD} signal is input to the FLMD1 pin from another device during on-board writing and immediately after reset, isolate this signal.

Table 31-9. Relationship Between FLMD0 and FLMD1 Pins and Operation Mode When Reset Is Released

FLMD0	FLMD1	Operation Mode
0	Don't care	Normal operation mode
V_{DD}	0	Flash memory programming mode
V_{DD}	V_{DD}	Setting prohibited

(3) Serial interface pin

The following shows the pins used by each serial interface.

Table 31-10. Pins Used by Serial Interfaces

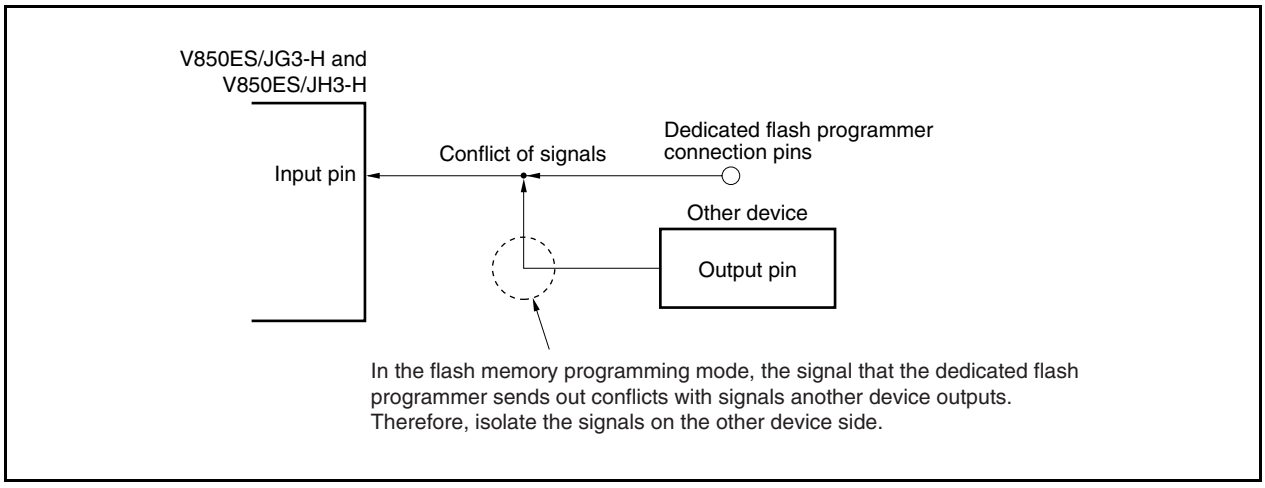
Serial Interface	Pins Used
UARTC0	TXDC0, RXDC0
CSIF0	SOF0, SIF0, $\overline{SCKF0}$
CSIF3	SOF3, SIF3, $\overline{SCKF3}$
CSIF0 + HS	SOF0, SIF0, $\overline{SCKF0}$, P913
CSIF3 + HS	SOF3, SIF3, $\overline{SCKF3}$, P913

When connecting a dedicated flash programmer to a serial interface pin that is connected to another device on-board, care should be taken to avoid conflict of signals and malfunction of the other device.

(a) Conflict of signals

When the dedicated flash programmer (output) is connected to a serial interface pin (input) that is connected to another device (output), a conflict of signals occurs. To avoid the conflict of signals, isolate the connection to the other device or set the other device to the output high-impedance status.

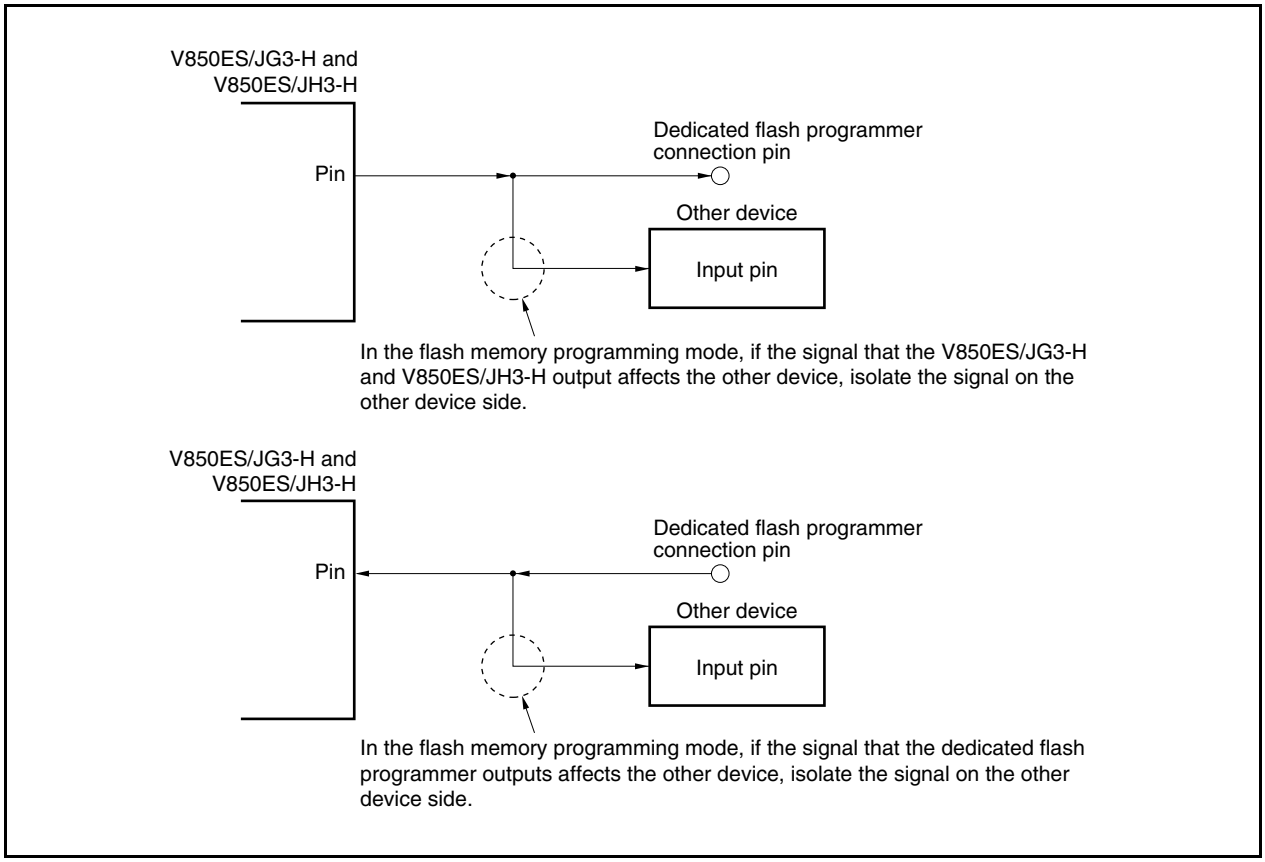
Figure 31-13. Conflict of Signals (Serial Interface Input Pin)



(b) Malfunction of other device

When the dedicated flash programmer (output or input) is connected to a serial interface pin (input or output) that is connected to another device (input), the signal is output to the other device, causing the device to malfunction. To avoid this, isolate the connection to the other device.

Figure 31-14. Malfunction of Other Device

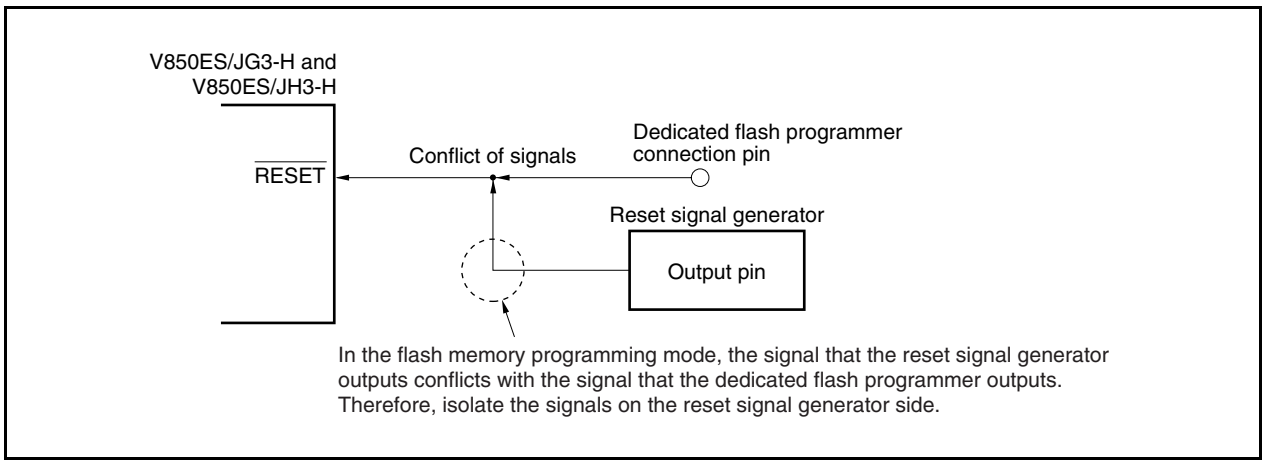


(4) $\overline{\text{RESET}}$ pin

When the reset signals of the dedicated flash programmer are connected to the $\overline{\text{RESET}}$ pin that is connected to the reset signal generator on-board, a conflict of signals occurs. To avoid the conflict of signals, isolate the connection to the reset signal generator.

When a reset signal is input from the user system in the flash memory programming mode, the programming operation will not be performed correctly. Therefore, do not input signals other than the reset signals from the dedicated flash programmer.

Figure 31-15. Conflict of Signals ($\overline{\text{RESET}}$ Pin)



(5) Port pins (including NMI)

When the system shifts to the flash memory programming mode, all the pins that are not used for flash memory programming are in the same status as that immediately after reset. If the external device connected to each port does not recognize the status of the port immediately after reset, pins require appropriate processing, such as connecting to V_{DD} via a resistor or connecting to V_{SS} via a resistor.

(6) Other signal pins

Connect X1, X2, XT1, XT2, and REGC in the same status as that in the normal operation mode.

During flash memory programming, input a low level to the $\overline{\text{DRST}}$ pin or leave it open. Do not input a high level.

(7) Power supply

Supply the same power (V_{DD}, V_{SS}, EV_{DD}, UV_{DD}, AV_{REF0}, AV_{REF1}, AV_{SS}) as in normal operation mode.

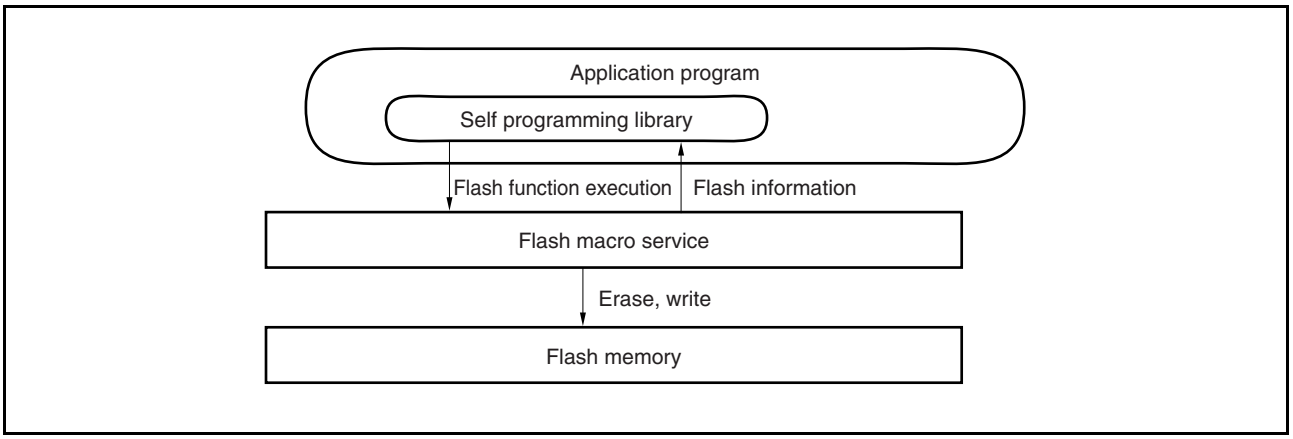
31.5 Rewriting by Self Programming

31.5.1 Overview

The V850ES/JG3-H and V850ES/JH3-H support a flash macro service that allows the user program to rewrite the internal flash memory by itself. By using this interface and a self programming library that is used to rewrite the flash memory with a user application program, the flash memory can be rewritten by a user application transferred in advance to the internal RAM or external memory. Consequently, the user program can be upgraded and constant data[Note] can be rewritten in the field.

Note Be sure not to allocate the program code to the block where the constant data of rewriting target is allocated. See **31.2 Memory Configuration** for the block configuration.

Figure 31-16. Concept of Self Programming

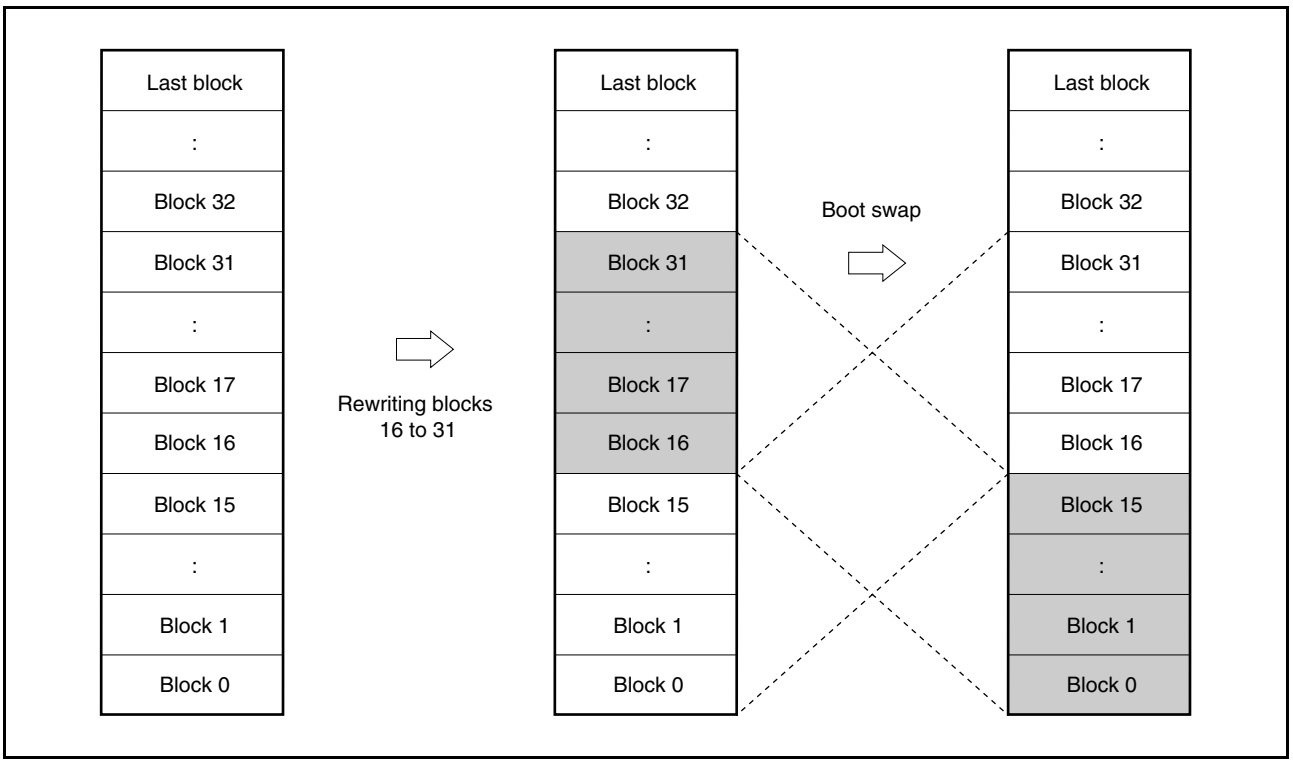


31.5.2 Features

(1) Secure self programming (boot swap function)

The V850ES/JG3-H and V850ES/JH3-H support a boot swap function that can exchange the physical memory of blocks 0 to 15 with the physical memory of blocks 16 to 31. By writing the start program to be rewritten to blocks 16 to 31 in advance and then swapping the physical memory, the entire area can be safely rewritten even if a power failure occurs during rewriting because the correct user program always exists in blocks 0 to 15.

Figure 31-17. Rewriting Entire Memory Area (Boot Swap)



(2) Interrupt support

Instructions cannot be fetched from the flash memory during self-programming. Consequently, a user handler written to the flash memory could not be used even if an interrupt has occurred.

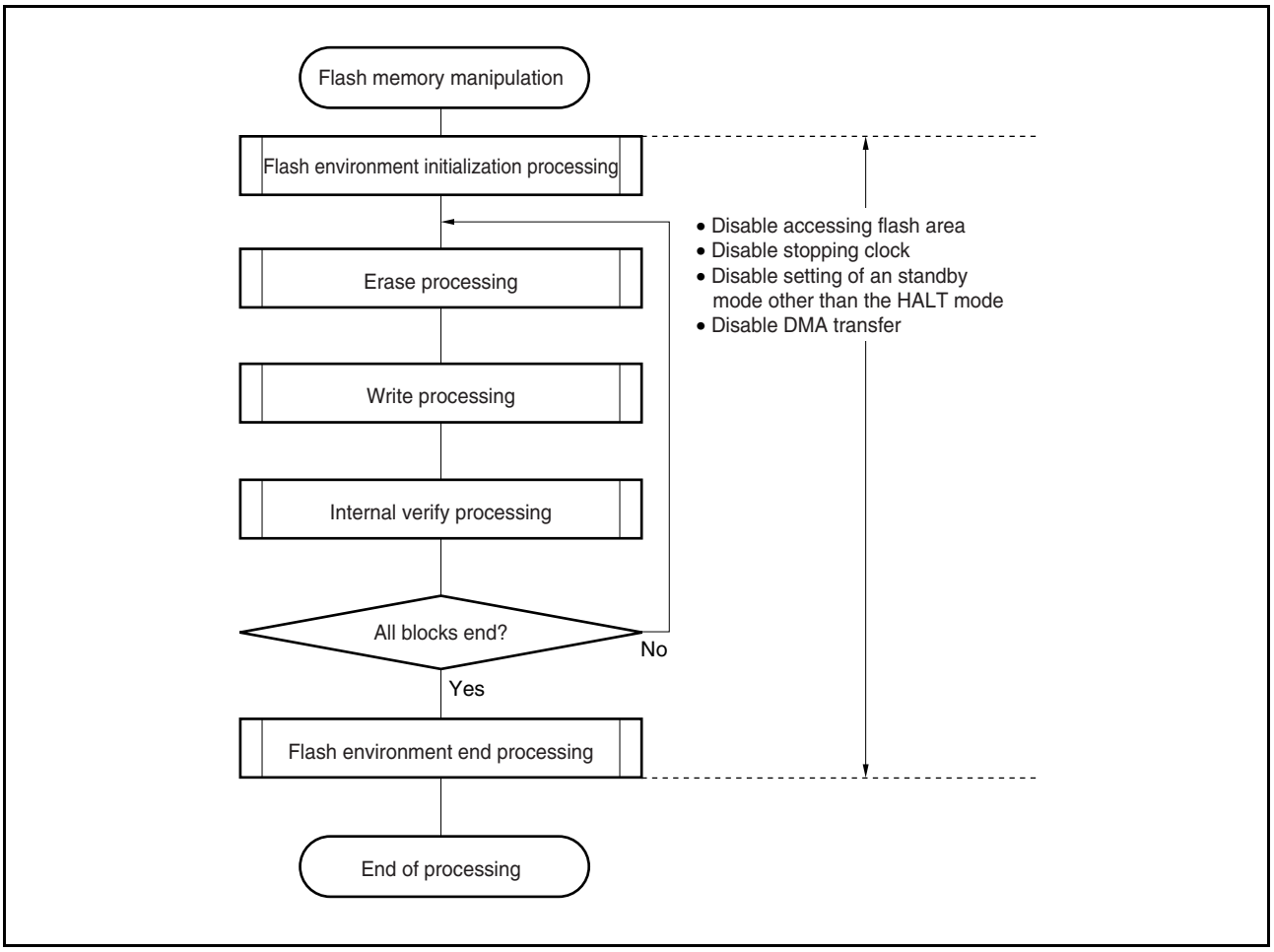
Therefore, in the V850ES/JG3-H and V850ES/JH3-H, to use an interrupt during self-programming, processing transits to the specific address[Note] in the internal RAM. Allocate the jump instruction that transits processing to the user interrupt servicing at the specific address[Note] in the internal RAM.

Note NMI interrupt: Start address of internal RAM
Maskable interrupt: Start address of internal RAM + 4 addresses

31.5.3 Standard self programming flow

The entire processing to rewrite the flash memory by flash self programming is illustrated below.

Figure 31-18. Standard Self Programming Flow



31.5.4 Flash functions

Table 31-11. Flash Function List

Function Name	Outline	Support
FlashInit	Self-programming library initialization	√
FlashEnv	Flash environment start/end	√
FlashFLMDCheck	FLMD pin check	√
FlashStatusCheck	Hardware processing execution status check	√
FlashBlockErase	Block erase	√
FlashWordWrite	Data write	√
FlashBlockIVerify	Internal verification of block	√
FlashBlockBlankCheck	Blank check of block	√
FlashSetInfo	Flash information setting	√
FlashGetInfo	Flash information acquisition	√
FlashBootSwap	Boot swap execution	√

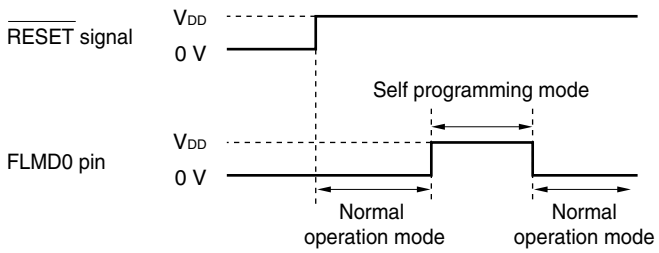
31.5.5 Pin processing

(1) FLMD0 pin

The FLMD0 pin is used to set the operation mode when reset is released and to protect the flash memory from being written during self rewriting. It is therefore necessary to keep the voltage applied to the FLMD0 pin at 0 V when reset is released and a normal operation is executed. It is also necessary to apply a voltage of V_{DD} level to the FLMD0 pin during the self programming mode period via port control before the memory is rewritten.

When self programming has been completed, the voltage on the FLMD0 pin must be returned to 0 V.

Figure 31-19. Mode Change Timing



Caution Make sure that the FLMD0 pin is at 0 V when reset is released.

31.5.6 Internal resources used

The following table lists the internal resources used for self programming. These internal resources can also be used freely for purposes other than self programming.

Table 31-12. Internal Resources Used

Resource Name	Description
Stack area	An extension of the stack used by the user is used by the library (can be used in both the internal RAM and external RAM).
Library code[Note]	Program entity of library (can be used anywhere other than the flash memory block to be manipulated).
Application program	Executed as user application. Calls flash functions.
Maskable interrupt	Can be used in the user application execution status or self-programming status. To use this interrupt in the self-programming status, since the processing transits to the address of the internal RAM start address + 4 addresses, allocate the jump instruction that transits the processing to the user interrupt servicing at the address of the internal RAM start address + 4 addresses in advance.
NMI interrupt	Can be used in the user application execution status or self-programming status. To use this interrupt in the self-programming status, since the processing transits to the address of the internal RAM start address, allocate the jump instruction that transits the processing to the user interrupt servicing at the internal RAM start address in advance.

Note About resources used, refer to the **Flash Memory Self-Programming Library User's Manual**.

31.6 Creating ROM code to place order for previously written product

Before placing an order with Renesas Electronics for a previously written product, the ROM code for the order must be created.

To create the ROM code, use the Hex Consolidation Utility (hereafter abbreviated to HCU) on the finished programs (hex files) and optional data (such as security settings for flash memory programs).

The HCU is a software tool that includes functions required for creating ROM code.

The HCU can be downloaded at the Renesas Electronics website.

(1) Website

http:www2.renesas.com/micro/en/ods → Click Version-up Service.

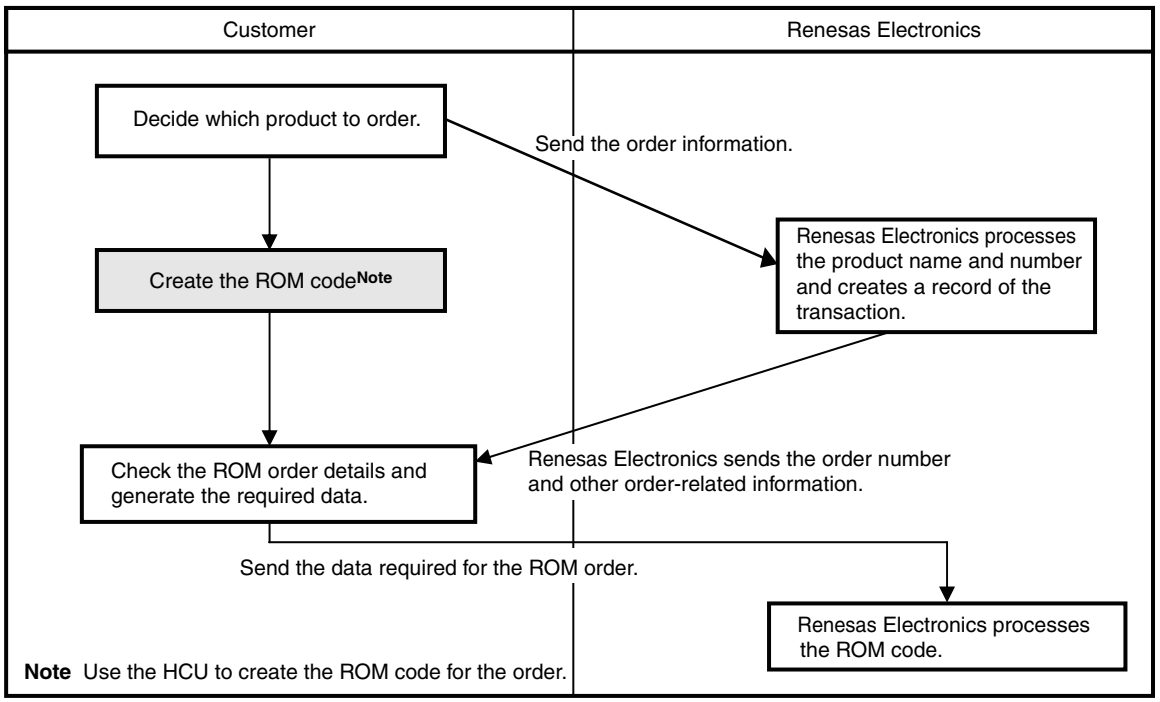
(2) Downloading the HCU

To download the HCU, click Software for previously written flash products and then HCU_GUI.

Remark For details about how to install and use the HCU, see the materials (the user's manual) that comes with the HCU at the above website.

31.6.1 Procedure for using ROM code to place an order

Use the HCU to create the ROM code by following the procedure below, and then place your order with Renesas Electronics. For details, see the ROM Code Ordering Method Information (C10302J).



CHAPTER 32 ON-CHIP DEBUG FUNCTION

The on-chip debug function of the V850ES/JG3-H and V850ES/JH3-H can be implemented by the following two methods.

- Using the DCU (debug control unit)
  On-chip debug function is implemented by the on-chip DCU in the V850ES/JG3-H and V850ES/JH3-H, with using the $\overline{\text{DRST}}$, DCK, DMS, DDI, and DDO pins as the debug interface pins.
- Not using the DCU
  On-chip debug function is implemented by MINICUBE2 or the like, using the user resources, instead of the DCU.

The following table shows the features of the two on-chip debug functions.

Table 32-1. On-Chip Debug Function Features

		Debugging Using DCU	Debugging Without Using DCU
Debug interface pins		$\overline{\text{DRST}}$, DCK, DMS, DDI, DDO	• When UARTC0 is used RXDC0, TXDC0 • When CSIF0 is used SIF0, SOF0, $\overline{\text{SCKF0}}$, HS (P913) • When CSIF3 is used SIF3, SOF3, $\overline{\text{SCKF3}}$, HS (P913)
Securement of user resources		Not required	Required
Hardware break function		2 points	2 points
Software break function	Internal ROM area	4 points	4 points
	Internal RAM area	2000 points	2000 points
Real-time RAM monitor function[Note 1]		Available	Available
Dynamic memory modification (DMM) function[Note 2]		Available	Available
Mask function		Reset, NMI, INTWDT2, $\overline{\text{HLDRQ}}$, $\overline{\text{WAIT}}$	$\overline{\text{RESET}}$ pin
ROM security function		10-byte ID code authentication	10-byte ID code authentication
Hardware used		NINICUBE, etc.	NINICUBE2, etc.
Trace function		Not supported.	Not supported.
Debug interrupt interface function (DBINT)		Not supported.	Not supported.

Notes 1. This is a function which reads out memory contents during program execution.

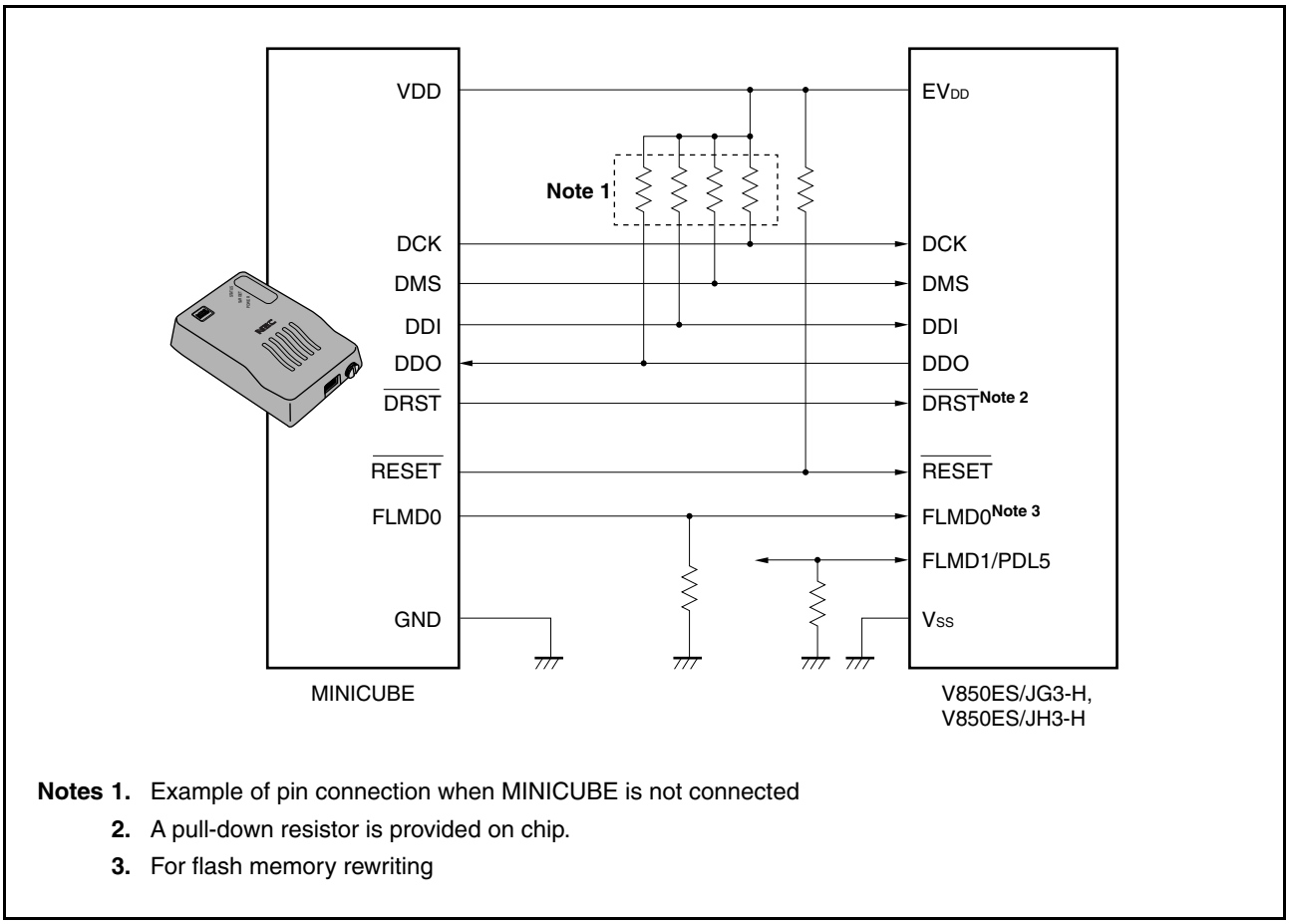
2. This is a function which rewrites RAM contents during program execution.

32.1 Debugging with DCU

Programs can be debugged using the debug interface pins ($\overline{\text{DRST}}$, DCK, DMS, DDI, and DDO) to connect the on-chip debug emulator (MINICUBE).

32.1.1 Connection circuit example

Figure 32-1. Circuit Connection Example When Debug Interface Pins Are Used for Communication Interface



Notes 1. Example of pin connection when MINICUBE is not connected

2. A pull-down resistor is provided on chip.

3. For flash memory rewriting

32.1.2 Interface signals

The interface signals are described below.

(1) $\overline{\text{DRST}}$

This is a reset input signal for the on-chip debug unit. It is a negative-logic signal that asynchronously initializes the debug control unit.

MINICUBE raises the $\overline{\text{DRST}}$ signal when it detects V_{DD} of the target system after the integrated debugger is started, and starts the on-chip debug unit of the device.

When the $\overline{\text{DRST}}$ signal goes high, a reset signal is also generated in the CPU.

When starting debugging by starting the integrated debugger, a CPU reset is always generated.

(2) DCK

This is a clock input signal. It supplies a 20 MHz or 10 MHz clock from MINICUBE. In the on-chip debug unit, the DMS and DDI signals are sampled at the rising edge of the DCK signal, and the data DDO is output at its falling edge.

(3) DMS

This is a transfer mode select signal. The transfer status in the debug unit changes depending on the level of the DMS signal.

(4) DDI

This is a data input signal. It is sampled in the on-chip debug unit at the rising edge of DCK.

(5) DDO

This is a data output signal. It is output from the on-chip debug unit at the falling edge of the DCK signal.

(6) EV_{DD}

This signal is used to detect VDD of the target system. If VDD from the target system is not detected, the signals output from MINICUBE ($\overline{DRST}$, DCK, DMS, DDI, FLMD0, and $\overline{RESET}$) go into a high-impedance state.

(7) FLMD0

The flash self programming function is used for the function to download data to the flash memory via the integrated debugger. During flash self programming, the FLMD0 pin must be kept high. In addition, connect a pull-down resistor to the FLMD0 pin.

The FLMD0 pin can be controlled in either of the following two ways.

<1> To control from MINICUBE

Connect the FLMD0 signal of MINICUBE to the FLMD0 pin.

In the normal mode, nothing is driven by MINICUBE (high impedance).

During a break, MINICUBE raises the FLMD0 pin to the high level when the download function of the integrated debugger is executed.

<2> To control from port

Connect any port of the device to the FLMD0 pin.

The same port as the one used by the user program to realize the flash self programming function may be used.

On the console of the integrated debugger, make a setting to raise the port pin to high level before executing the download function, or lower the port pin after executing the download function.

For details, refer to the **ID850QB Ver. 3.40 Integrated Debugger Operation User's Manual (U18604E)**.

(8) $\overline{RESET}$

This is a system reset input pin. If the $\overline{DRST}$ pin is made invalid by the value of the OCDM0 bit of the OCDM register set by the user program, on-chip debugging cannot be executed. Therefore, reset is effected by MINICUBE, using the $\overline{RESET}$ pin, to make the $\overline{DRST}$ pin valid (initialization).

32.1.3 Maskable functions

Reset, NMI, INTWDT2, $\overline{\text{WAIT}}$, and $\overline{\text{HLDRQ}}$ signals can be masked.

The maskable functions with the debugger (ID850QB) and the corresponding V850ES/JG3-H and V850ES/JH3-H functions are listed below.

Table 32-2. Maskable Functions

Maskable Functions with ID850QB	Corresponding V850ES/JG3-H and V850ES/JH3-H Functions
NMI0	NMI pin input
NMI2	Non-maskable interrupt request signal (INTWDT2) generation
STOP	–
HOLD	$\overline{\text{HLDRQ}}$ pin input
RESET	Reset signal generation by $\overline{\text{RESET}}$ pin input, low-voltage detector, clock monitor, or watchdog timer (WDT2) overflow
WAIT	$\overline{\text{WAIT}}$ pin input

32.1.4 Register

(1) On-chip debug mode register (OCDM) (V850ES/JG3-H only)

The OCDM register is used to select the normal operation mode or on-chip debug mode. This register is a special register and can be written only in a combination of specific sequences (see **3.4.8 Special registers**).

This register is also used to specify whether a pin provided with an on-chip debug function is used as an on-chip debug pin or as an ordinary port/peripheral function pin. It also is used to disconnect the internal pull-down resistor of the P56/INTP05/$\overline{\text{DRST}}$ pin.

The OCDM register can be written only while a low level is input to the $\overline{\text{DRST}}$ pin.

This register can be read or written in 8-bit or 1-bit units.

After reset: 01H[Note] R/W Address: FFFFF9FCH

	7	6	5	4	3	2	1	<0>
OCDM	0	0	0	0	0	0	0	OCDM0

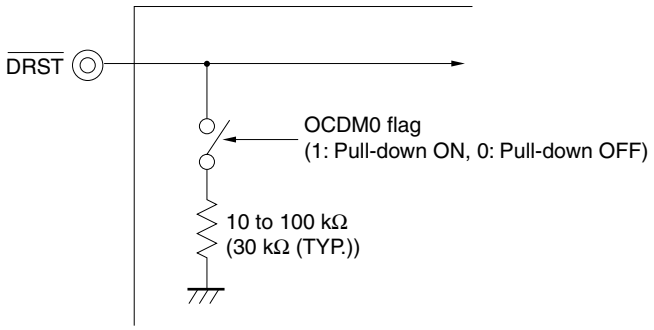
OCDM0	Operation mode
0	Selects normal operation mode (in which a pin that functions alternately as on-chip debug function pin is used as a port/peripheral function pin) and disconnects the on-chip pull-down resistor of the P56/INTP05/$\overline{\text{DRST}}$ pin.
1	When $\overline{\text{DRST}}$ pin is low: Normal operation mode (in which a pin that functions alternately as an on-chip debug function pin is used as a port/peripheral function pin) When $\overline{\text{DRST}}$ pin is high: On-chip debug mode (in which a pin that functions alternately as an on-chip debug function pin is used as an on-chip debug mode pin)

Note $\overline{\text{RESET}}$ input sets this register to 01H. After reset by the WDT2RES signal, clock monitor (CLM), or low-voltage detector (LVI), however, the value of the OCDM register is retained.

Cautions 1. When using the DDI, DDO, DCK, and DMS pins not as on-chip debug pins but as port pins after external reset, any of the following actions must be taken.

- **Input a low level to the P56/INTP05/$\overline{\text{DRST}}$ pin.**
- **Set the OCDM0 bit. In this case, take the following actions.**
  <1> Clear the OCDM0 bit to 0.
  <2> Fix the P56/INTP05/$\overline{\text{DRST}}$ pin to low level until <1> is completed.

2. The $\overline{\text{DRST}}$ pin has an on-chip pull-down resistor. This resistor is disconnected when the OCDM0 flag is set to 0.



32.1.5 Operation

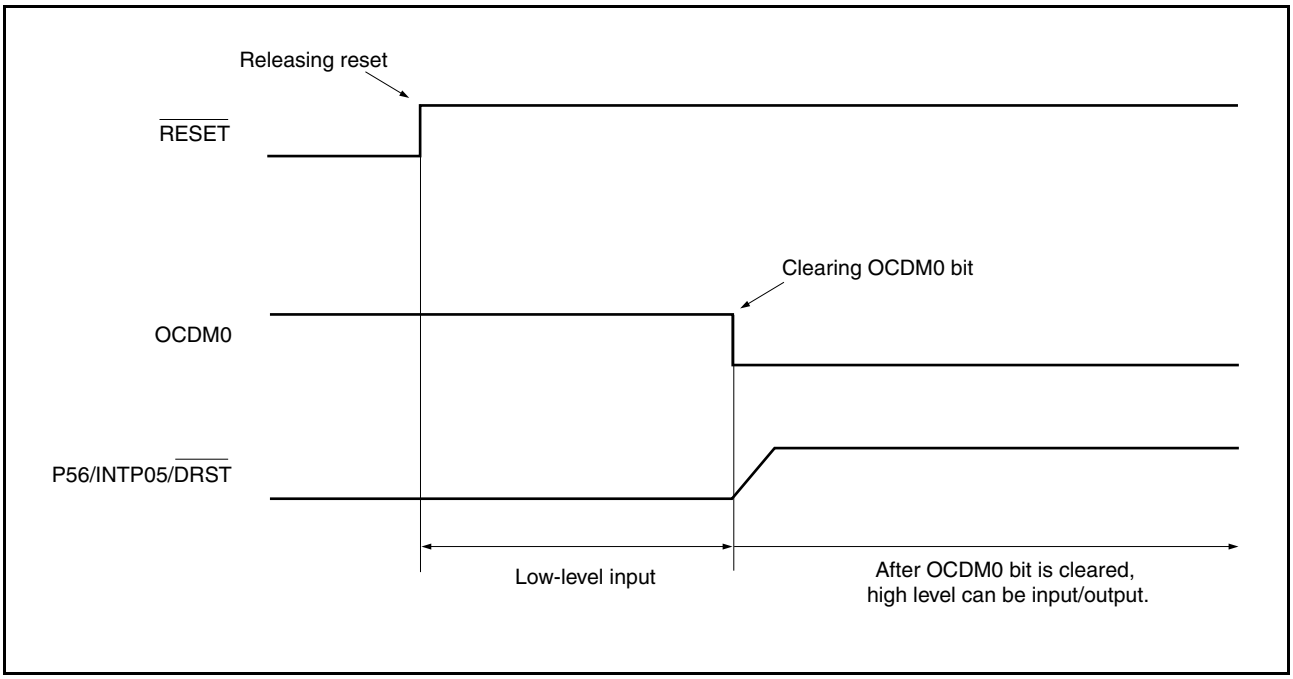
The on-chip debug function is made invalid under the conditions shown in the table below.

When this function is not used, keep the $\overline{\text{DRST}}$ pin low until the OCDM.OCDM0 flag is cleared to 0.

OCDM0 Flag / $\overline{\text{DRST}}$ Pin	0	1
L	Invalid	Invalid
H	Invalid	Valid

Remark L: Low-level input
H: High-level input

Figure 32-2. Timing When On-Chip Debug Function Is Not Used



32.1.6 Cautions

(1) If a reset signal is input (from the target system or a reset signal from an internal reset source) during RUN (program execution), the break function may malfunction.

(2) Even if the reset signal is masked by the mask function, the I/O buffer (port pin) may be reset if a reset signal is input from a pin.

(3) Pin reset during a break is masked and the CPU and peripheral I/O are not reset. If pin reset or internal reset is generated as soon as the flash memory is rewritten by DMM or read by the RAM monitor function while the user program is being executed, the CPU and peripheral I/O may not be correctly reset.

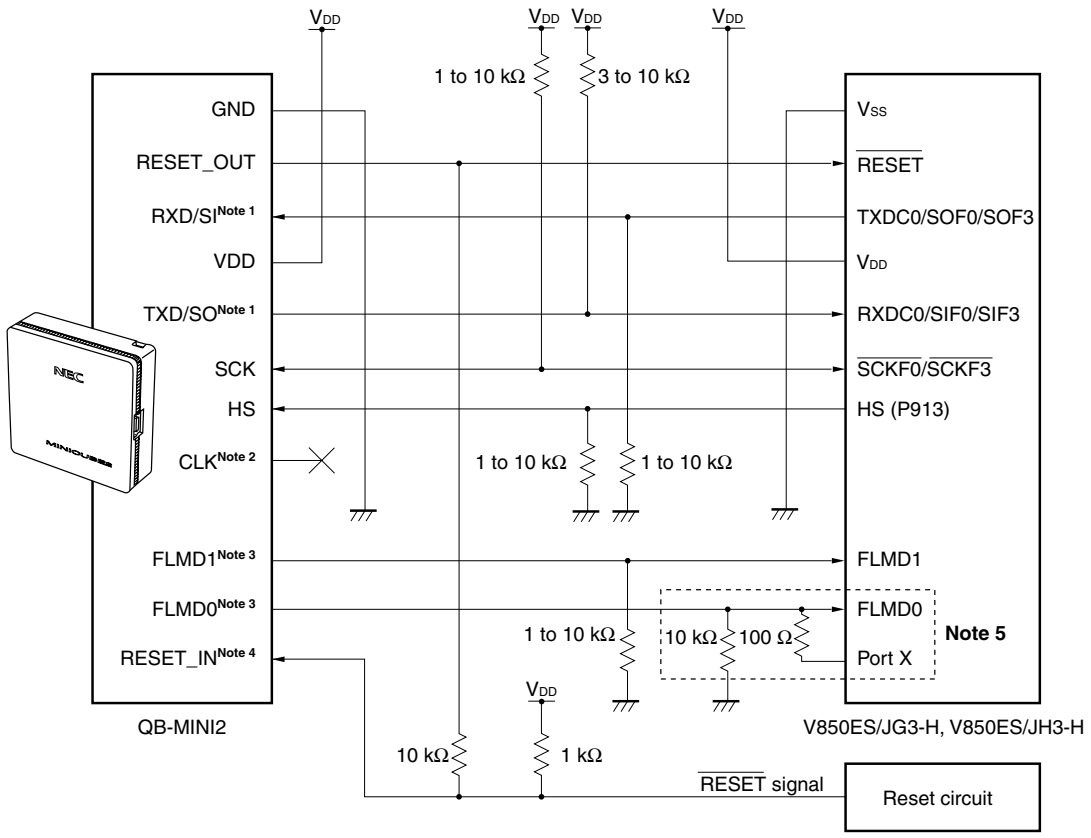
(4) In the on-chip debug mode, the DDO pin is forcibly set to the high-level output.

32.2 Debugging Without Using DCU

The following describes how to implement an on-chip debug function using MINICUBE2 with pins for UARTC0 (RXDC0 and TXDC0), pins for CSIF0 (SIF0, SOF0, $\overline{\text{SCKF0}}$, and HS (P913)), or pins for CSIF3 (SIF3, SOF3, $\overline{\text{SCKF3}}$, and HS (P913)) as debug interfaces, without using the DCU.

32.2.1 Circuit connection examples

Figure 32-3. Circuit Connection Example When UARTC0/CSIF0/CSIF3 Is Used for Communication Interface



Notes 1. Connect TXDC0/SOF0/SOF3 (transmit side) of the V850ES/JG3-H or V850ES/JH3-H to RXD/SI (receive side) of the target connector, and TXD/SO (transmit side) of the target connector to RXDC0/SIF0/SIF3 (receive side) of the V850ES/JG3-H or V850ES/JH3-H.

2. This pin may be used to supply a clock from MINICUBE2 during flash memory programming. For details, refer to **CHAPTER 31 FLASH MEMORY**.

3. Because this pin is an (unused) input during debugging, its alternate function can be used. Note that, within MINICUBE2, a 100 kΩ pull-down resistor is connected.

4. This connection is designed assuming that the $\overline{\text{RESET}}$ signal is output from the N-ch open-drain buffer (output resistance: 100 Ω or less).

5. The circuit enclosed by a dashed line is designed for flash self programming, which controls the FLMD0 pin via ports. Use the port for inputting or outputting the high level. When flash self programming is not performed, a pull-down resistance for the FLMD0 pin can be within 1 to 10 kΩ.

Remark Refer to **Table 32-3** for pins used when UARTC0, CSIF0, or CSIF3 is used for communication interface.

Table 32-3. Wiring Between V850ES/JG3-H and MINICUBE2

Pin Configuration of MINICUBE2 (QB-MINI2)			With CSIF0-HS		With CSIF3-HS		With UARTC0	
Signal Name	I/O	Pin Function	Pin Name	Pin No.	Pin Name	Pin No.	Pin Name	Pin No.
SI/RxD	Input	Pin to receive commands and data from V850ES/JG3-H	P41/SOF0	23	P911/SOF3	53	P30/TXDC0	25
SO/TxD	Output	Pin to transmit commands and data to V850ES/JG3-H	P40/SIF0	22	P910/SIF3	52	P31/RXDC0	26
SCK	Output	Clock output pin for 3-wire serial communication	P42/$\overline{\text{SCKF0}}$	24	P912/$\overline{\text{SCKF3}}$	54	Not needed	–
CLK[Note]	Output	Clock output pin to V850ES/JG3-H	Not needed[Note]	–	Not needed[Note]	–	Not needed[Note]	–
RESET_OUT	Output	Reset output pin to V850ES/JG3-H	$\overline{\text{RESET}}$	14	$\overline{\text{RESET}}$	14	$\overline{\text{RESET}}$	14
FLMD0	Output	Output pin to set V850ES/JG3-H to debug mode or programming mode	FLMD0	8	FLMD0	8	FLMD0	8
FLMD1	Output	Output pin to set programming mode	PDL5/FLMD1	76	PDL5/FLMD1	76	PDL5/FLMD1	76
HS	Input	Handshake signal for CSI0 + HS communication	P913	85	P913	85	Not needed	–
GND	–	Ground	V_{SS}	11, 33, 62, 79	V_{SS}	11, 33, 62, 79	V_{SS}	11, 33, 62, 79
			AV_{SS}	2	AV_{SS}	2	AV_{SS}	2
RESET_IN	Input	Reset input pin on the target system						

Note It is used as the clock output of the flash programmer for MINICUBE2. For details, refer to **CHAPTER 31 FLASH MEMORY**.

Table 32-4. Wiring Between V850ES/JH3-H and MINICUBE2

Pin Configuration of MINICUBE2 (QB-MINI2)			With CSIF0-HS		With CSIF3-HS		With UARTC0	
Signal Name	I/O	Pin Function	Pin Name	Pin No.	Pin Name	Pin No.	Pin Name	Pin No.
SI/RXD	Input	Pin to receive commands and data from V850ES/JH3-H	P41/SOF0	30	P911/SOF3	67	P30/TXDC0	37
SO/TXD	Output	Pin to transmit commands and data to V850ES/JH3-H	P40/SIF0	29	P910/SIF3	66	P31/RXDC0	31
SCK	Output	Clock output pin for 3-wire serial communication	P42/$\overline{\text{SCKF0}}$	31	P912/$\overline{\text{SCKF3}}$	68	Not needed	–
CLK[Note]	Output	Clock output pin to V850ES/JH3-H	Not needed[Note]	–	Not needed[Note]	–	Not needed[Note]	–
RESET_OUT	Output	Reset output pin to V850ES/JH3-H	$\overline{\text{RESET}}$	18	$\overline{\text{RESET}}$	18	$\overline{\text{RESET}}$	18
FLMD0	Output	Output pin to set V850ES/JH3-H to debug mode or programming mode	FLMD0	12	FLMD0	12	FLMD0	12
FLMD1	Output	Output pin to set programming mode	PDL5/FLMD1	103	PDL5/FLMD1	103	PDL5/FLMD1	103
HS	Input	Handshake signal for CSI0 + HS communication	P913	69	P913	69	Not needed	–
GND	–	Ground	V_{SS}	15, 45, 84, 106	V_{SS}	15, 45, 84, 106	V_{SS}	15, 45, 84, 106
			AV_{SS}	2	AV_{SS}	2	AV_{SS}	2
RESET_IN	Input	Reset input pin on the target system						

Note It is used as the clock output of the flash programmer for MINICUBE2. For details, refer to **CHAPTER 31 FLASH MEMORY**.

32.2.2 Maskable functions

Only reset signals can be masked.

The functions that can be masked in the debugger (ID850QB) and the corresponding functions of the V850ES/JG3-H and V850ES/JH3-H are listed below.

Table 32-5. Maskable Functions

Functions Maskable in ID850QB	Corresponding Functions of V850ES/JG3-H and V850ES/JH3-H
NMI0	–
NMI1	–
NMI2	–
STOP	–
HOLD	–
RESET	Reset signal generation by $\overline{\text{RESET}}$ pin input
WAIT	–

32.2.3 Securement of user resources

The user must prepare the following to perform communication between MINICUBE2 and the target device and implement each debug function. These items need to be set in the user program or using the compiler options.

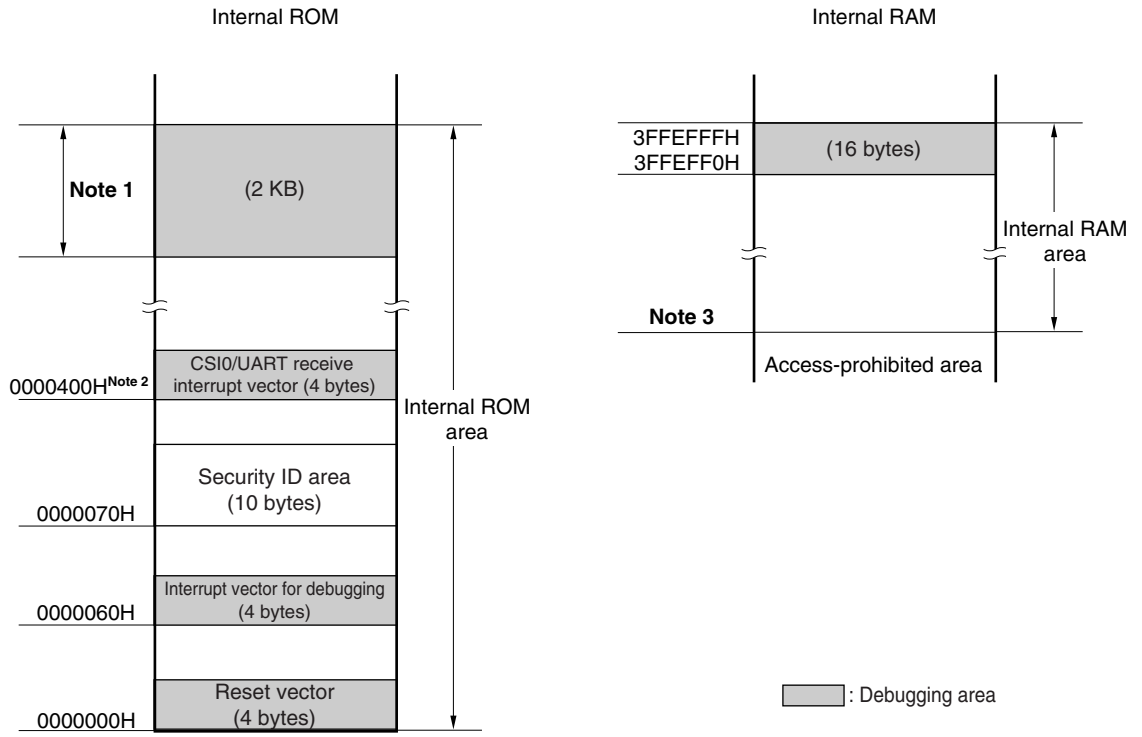
(1) Securement of memory space

The shaded portions in Figure 32-4 are the areas reserved for placing the debug monitor program, so user programs and data cannot be allocated in these spaces. These spaces must be secured so as not to be used by the user program.

(2) Security ID setting

The ID code must be embedded in the area between 0000070H and 0000079H in Figure 32-4, to prevent the memory from being read by an unauthorized person. For details, refer to **32.3 ROM Security Function**.

Figure 32-4. Memory Spaces Where Debug Monitor Programs Are Allocated



Notes 1. Address values vary depending on the product.

	Internal ROM Size	Address Value
μPD70F3760, 70F3765, 70F3770, 70F3771	256 KB	003F800H to 003FFFFH
μPD70F3761, 70F3766	384 KB	005F800H to 003FFFFH
μPD70F3762, 70F3767	512 KB	007F800H to 007FFFFH

2. This is the address when CSIF0 is used. It starts at 0000406H when CSIF3 is used, and at 00004A0H when UARTC0 is used.

3. Address values vary depending on the product.

	Internal RAM Size	Address Value
μPD70F3760, 70F3765, 70F3770, 70F3771	32 KB	3FF7000H
μPD70F3761, 70F3766	40 KB	3FF5000H
μPD70F3762, 70F3767	48 KB	3FF3000H

(3) Reset vector

A reset vector includes the jump instruction for the debug monitor program.

[How to secure areas]

It is not necessary to secure this area intentionally. When downloading a program, however, the debugger rewrites the reset vector in accordance with the following cases. If the rewritten pattern does not match the following cases, the debugger generates an error (F0C34 when using the ID850QB).

(a) When two nop instructions are placed in succession from address 0

Before rewriting		After rewriting
0x0 nop	→	Jumps to debug monitor program at 0x0
0x2 nop		0x4 xxxx
0x4 xxxx		

(b) When two 0xFFFF are successively placed from address 0 (already erased device)

Before rewriting		After rewriting
0x0 0xFFFF	→	Jumps to debug monitor program at 0x0
0x2 0xFFFF		0x4 xxxx
0x4 xxxx		

(c) The *jr* instruction is placed at address 0 (when using CA850)

Before rewriting		After rewriting
0x0 jr disp22	→	Jumps to debug monitor program at 0x0
		0x4 jr disp22 - 4

(d) *mov32* and *jmp* are placed in succession from address 0 (when using IAR compiler ICCV850)

Before rewriting		After rewriting
0x0 mov imm32,reg1	→	Jumps to debug monitor program at 0x0
0x6 jmp [reg1]		0x4 mov imm32,reg1
		0xa jmp [reg1]

(e) The jump instruction for the debug monitor program is placed at address 0

Before rewriting		After rewriting
Jumps to debug monitor program at 0x0	→	No change

(4) Securement of area for debug monitor program

The shaded portions in Figure 32-4 are the areas where the debug monitor program is allocated. The monitor program performs initialization processing for debug communication interface and RUN or break processing for the CPU. The internal ROM area must be filled with 0xFF. This area must not be rewritten by the user program.

[How to secure areas]

It is not necessarily required to secure this area if the user program does not use this area.

To avoid problems that may occur during the debugger startup, however, it is recommended to secure this area in advance, using the compiler.

The following shows examples for securing the area, using the Renesas Electronics compiler CA850. Add the assemble source file and link directive code, as shown below.

- Assemble source (Add the following code as an assemble source file.)

```
-- Secures 2 KB space for monitor ROM section
.section "MonitorROM", const
.space   0x800, 0xff

-- Secures interrupt vector for debugging
.section "DBG0"
.space   4, 0xff

-- Secures interrupt vector for serial communication
-- Change the section name according to the serial communication mode used
.section "INTCF0R"
.space   4, 0xff

-- Secures 16-byte space for monitor RAM section
.section "MonitorRAM", bss
.lcomm   monitorramsym, 16, 4     -- defines symbol monitorramsym
```

- Link directive (Add the following code to the link directive file.)

  The following shows an example when the internal ROM has 512 KB (end address is 007FFFFH) and internal RAM has 56 KB (end address is 3FFEFFFH).

```
MROMSEG       : !LOAD ?R V0x07f800{
              MonitorROM    = $PROGBITS   ?A MonitorROM;
};

MRAMSEG       : !LOAD ?RW V0x03ffeff0{
              MonitorRAM    = $NOBITS     ?AW MonitorRAM;
};
```

(5) Securement of communication serial interface

UARTC0, CSIF0, or CSIF3 is used for communication between MINICUBE2 and the target system. The settings related to the serial interface modes are performed by the debug monitor program, but if the setting is changed by the user program, a communication error may occur.

To prevent such a problem from occurring, communication serial interface must be secured in the user program.

[How to secure communication serial interface]

- On-chip debug mode register (OCDM)

  For the on-chip debug function using the UARTC0, CSIF0, or CSIF3, set the OCDM register functions to normal mode. Be sure to set as follows.

  - Input low level to the P56/INTP05/$\overline{\text{DRST}}$ pin.
  - Set the OCDM0 bit as shown below.

    <1> Clear the OCDM0 bit to 0.

    <2> Fix the P56/INTP05/$\overline{\text{DRST}}$ pin input to low level until the processing of <1> is complete.

- Serial interface registers

  Do not set the registers related to CSIF0, CSIF3, or UARTC0 in the user program.

- Interrupt mask register

  When CSIF0 is used, do not mask the transfer end interrupt (INTCF0R). When CSIF3 is used, do not mask the transfer end interrupt (INTCF3R). When UARTC0 is used, do not mask the reception completion interrupt (INTUC0R).

(a) When CSIF0 is used

	7	6	5	4	3	2	1	0
CF0RIC	×	0	×	×	×	×	×	×

(b) When CSIF3 is used

	7	6	5	4	3	2	1	0
CF3RIC	×	0	×	×	×	×	×	×

(C) When UARTC0 is used

	7	6	5	4	3	2	1	0
UC0RIC	×	0	×	×	×	×	×	×

Remark ×: don't care

- Port registers when UARTC0 is used

  When UARTC0 is used, port registers are set to make the TXDC0 and RXDC0 pins valid by the debug monitor program. Do not change the following register settings with the user program during debugging. (The same value can be overwritten.)

	7	6	5	4	3	2	1	0
PFC3	×	×	×	×	×	×	0	0
PFCE3	×	×	×	×	×	×	0	0
PMC3	×	×	×	×	×	×	1	1

Remark ×: don't care

- Port registers when CSIF0 is used

  When CSIF0 is used, port registers are set to make the SIF0, SOF0, $\overline{\text{SCKF0}}$, and HS (P913) pins valid by the debug monitor program. Do not change the following register settings with the user program during debugging. (The same value can be overwritten.)

(a) SIF0, SOF0, and $\overline{\text{SCKF0}}$ settings

	7	6	5	4	3	2	1	0
PMC4	×	×	×	×	×	1	1	1
PFC4	×	×	×	×	×	0	0	0
PFCE4	×	×	×	×	×	×	0	0

(b) HS (P913 pin) settings

	15	14	13	12	11	10	9	8
PM9H	×	×	0	×	×	×	×	×
P9H	×	×	**Note**	×	×	×	×	×

Note Writing to this bit is prohibited.

The port values corresponding to the HS pin are changed by the monitor program according to the debugger status. To perform port register settings in 8-bit units, the user program can usually use read-modify-write. If an interrupt for debugging occurs before writing, however, an unexpected operation may be performed.

Remark ×: don't care

- Port registers when CSIF3 is used

  When CSIF3 is used for communication, port registers are set to make the SIF3, SOF3, $\overline{\text{SCKF3}}$, and HS (P913) pins valid by the debug monitor program. Do not change the following register settings with the user program during debugging. (The same value can be overwritten.)

(a) SIF3, SOF3, and $\overline{\text{SCKF3}}$ settings

	15	14	13	12	11	10	9	8
PMC9H	×	×	×	1	1	1	×	×

	15	14	13	12	11	10	9	8
PFC9H	×	×	×	0Note1	0	0	×	×

	15	14	13	12	11	10	9	8
PFCE9H	×	×	×	×	0	0	×	×

(b) HS (P913 pin) settings

	15	14	13	12	11	10	9	8
PM9H	×	×	0	×	×	×	×	×

	15	14	13	12	11	10	9	8
P9H	×	×	**Note2**	×	×	×	×	×

Notes1. V850ES/JH3-H only

2. Writing to this bit is prohibited.

The port values corresponding to the HS pin are changed by the monitor program according to the debugger status. To perform port register settings in 8-bit units, the user program can usually use read-modify-write. If an interrupt for debugging occurs before writing, however, an unexpected operation may be performed.

Remark ×: don't care

32.2.4 Cautions

(1) Handling of device that was used for debugging

Do not mount a device that was used for debugging on a mass-produced product, because the flash memory was rewritten during debugging and the number of rewrites of the flash memory cannot be guaranteed. Moreover, do not embed the debug monitor program into mass-produced products.

(2) When breaks cannot be executed

Forced breaks cannot be executed if one of the following conditions is satisfied.

- Interrupts are disabled (DI)
- Interrupts issued for the serial interface, which is used for communication between MINICUBE2 and the target device, are masked
- Standby mode is entered while standby release by a maskable interrupt is prohibited
- Mode for communication between MINICUBE2 and the target device is UARTC0, and the main clock has been stopped

(3) When pseudo real-time RAM monitor (RRM) function and DMM function do not operate

The pseudo RRM function and DMM function do not operate if one of the following conditions is satisfied.

- Interrupts are disabled (DI)
- Interrupts issued for the serial interface, which is used for communication between MINICUBE2 and the target device, are masked
- Standby mode is entered while standby release by a maskable interrupt is prohibited
- Mode for communication between MINICUBE2 and the target device is UARTC0, and the main clock has been stopped
- Mode for communication between MINICUBE2 and the target device is UARTC0, and a clock different from the one specified in the debugger is used for communication

(4) Standby release with pseudo RRM and DMM functions enabled

The standby mode is released by the pseudo RRM function and DMM function if one of the following conditions is satisfied.

- Mode for communication between MINICUBE2 and the target device is CSIF0 or CSIF3
- Mode for communication between MINICUBE2 and the target device is UARTC0, and the main clock has been supplied.

(5) Rewriting to peripheral I/O registers that requires a specific sequence, using DMM function

Peripheral I/O registers that requires a specific sequence cannot be rewritten with the DMM function.

(6) Flash self programming

If a space where the debug monitor program is allocated is rewritten by flash self programming, the debugger can no longer operate normally.

32.3 ROM Security Function

32.3.1 Security ID

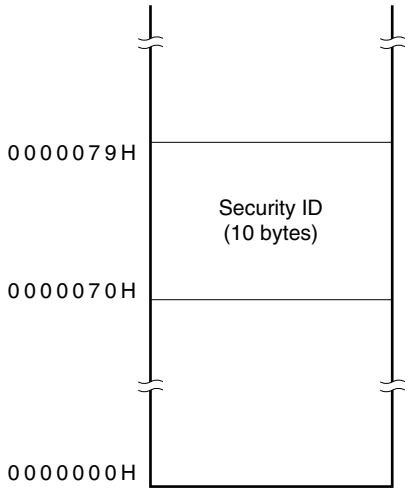
The flash memory versions of the V850ES/JG3-H and V850ES/JH3-H perform authentication using a 10-byte ID code to prevent the contents of the flash memory from being read by an unauthorized person during on-chip debugging by the on-chip debug emulator.

Set the ID code in the 10-byte on-chip flash memory area from 0000070H to 0000079H to allow the debugger perform ID authentication.

If the IDs match, the security is released and reading flash memory and using the on-chip debug emulator are enabled.

- Set the 10-byte ID code to 0000070H to 0000079H.
- Bit 7 of 0000079H is the on-chip debug emulator enable flag.
  (0: Disable, 1: Enable)
- When the on-chip debug emulator is started, the debugger requests ID input. When the ID code input on the debugger and the ID code set in 0000070H to 0000079H match, the debugger starts.
- Debugging cannot be performed if the on-chip debug emulator enable flag is 0, even if the ID codes match.

Figure 32-5. Security ID Area



Caution After the flash memory is erased, 1 is written to the entire area.

32.3.2 Setting

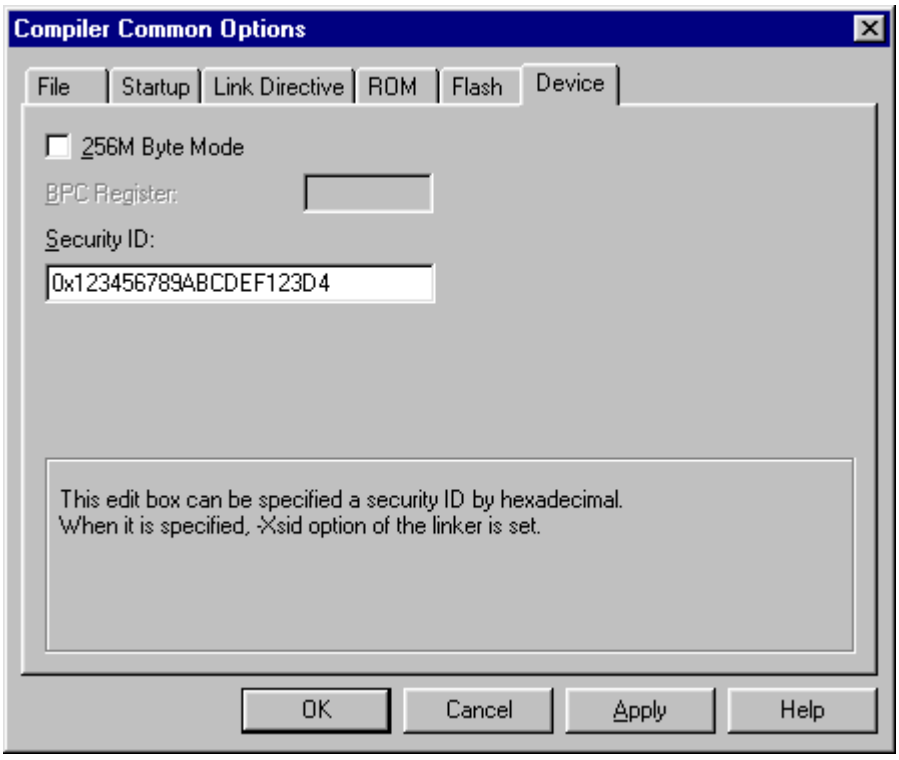
The following shows how to set the ID code as shown in Table 32-6.

When the ID code is set as shown in Table 32-6, the ID code input in the configuration dialog box of the ID850QB is “123456789ABCDEF123D4” (the ID code is case-insensitive).

Table 32-6. ID Code

Address	Value
0x70	0x12
0x71	0x34
0x72	0x56
0x73	0x78
0x74	0x9A
0x75	0xBC
0x76	0xDE
0x77	0XF1
0x78	0x23
0x79	0xD4

The ID code can be specified for the device file that supports CA850 Ver. 3.10 or later and the security ID using the PM+ compiler common option setting.



[Program example (when using CA850 Ver. 3.10 or later)]

```
#-------------------------------------
#       SECURITYID
#-------------------------------------
        .section    "SECURITY_ID"   --Interrupt handler address 0x70
        .word       0x78563412      --0-3 byte code
        .word       0xF1DEBC9A      --4-7 byte code
        .hword      0xD423          --8-9 byte code
```

Remark Add the above program example to the startup files.

CHAPTER 33 ELECTRICAL SPECIFICATIONS

33.1 Absolute Maximum Ratings

(T_A = 25°C) (1/2)

Parameter	Symbol	Conditions	Ratings	Unit
Supply voltage	V_{DD}	$V_{DD} = EV_{DD} = UV_{DD} = AV_{REF0} = AV_{REF1}$	−0.5 to +4.6	V
	EV_{DD}	$V_{DD} = EV_{DD} = UV_{DD} = AV_{REF0} = AV_{REF1}$	−0.5 to +4.6	V
	UV_{DD}	$V_{DD} = EV_{DD} = UV_{DD} = AV_{REF0} = AV_{REF1}$	−0.5 to +4.6	V
	AVREF0	$V_{DD} = EV_{DD} = UV_{DD} = AV_{REF0} = AV_{REF1}$	−0.5 to +4.6	V
	AVREF1	$V_{DD} = EV_{DD} = UV_{DD} = AV_{REF0} = AV_{REF1}$	−0.5 to +4.6	V
	V_{SS}	$V_{SS} = AV_{SS}$	−0.5 to +0.5	V
	AV_{SS}	$V_{SS} = AV_{SS}$	−0.5 to +0.5	V
Input voltage	V_{I1}	P60 to P65, P90 to P915, PCM0, PCM1, PCS0 PCS2, PCS3, PCT0, PCT1, PCT4, PCT6 PDL0 to PDL15, PDH0 to PDH7, $\overline{\text{RESET}}$, FLMD0	−0.5 to EV_{DD} + 0.5 Note 1	V
	V_{I2}	UDMF, UDPF	−0.5 to UV_{DD} + 0.5 Note 1	V
	V_{I3}	P10, P11	−0.5 to AV_{REF1} + 0.5 Note 1	V
	V_{I4}	X1, X2, XT1, XT2	−0.5 to V_{RO} Note 2 + 0.5 Note 1	V
	V_{I5}	P00 to P05, P20 to P25, P30 to P37, P40 to P42 P50 to P56, PCM2, PCM3	−0.5 to +6.0	V
Analog input voltage	VIAN	P70 to P711	−0.5 to AV_{REF0} + 0.5 Note 1	V

Cautions 1. Do not directly connect the output (or I/O) pins of IC products to each other, or to V_{DD}, V_{CC}, and GND. Open-drain pins or open-collector pins, however, can be directly connected to each other. Direct connection of the output pins between an IC product and an external circuit is possible, if the output pins can be set to the high-impedance state and the output timing of the external circuit is designed to avoid output conflict.

2. Product quality may suffer if the absolute maximum rating is exceeded even momentarily for any parameter. That is, the absolute maximum ratings are rated values at which the product is on the verge of suffering physical damage. Therefore the product must be used under conditions that ensure that the absolute maximum ratings are not exceeded.

The ratings and conditions indicated for DC characteristics and AC characteristics represent the quality assurance range during normal operation.

Notes 1. Be sure not to exceed the absolute maximum ratings (MAX. value) of each supply voltage.

2. On-chip regulator output voltage (2.5 V (TYP.))

Remark Unless specified otherwise, the characteristics of alternate-function pins are the same as those of port pins.

(T_A = 25°C) (2/2)

Parameter	Symbol	Conditions		Ratings	Unit
Output current, low	I_{OL}	P00 to P05, P20 to P25, P30 to P37 P40 to P42, P50 to P56, P60 to P65 P90 to P915 PCM0 to PCM3, PCS0, PCS2, PCS3 PCT0, PCT1, PCT4, PCT6 PDL0 to PDL15, PDH0 to PDH7	Per pin	4	mA
			Total of all pins	50	mA
		UDMF, UDPF	Per pin	4	mA
			Total of all pins	8	mA
		P10, P11	Per pin	4	mA
			Total of all pins	8	mA
		P70 to P711	Per pin	4	mA
			Total of all pins	20	mA
Output current, high	I_{OH}	P00 to P05, P20 to P25, P30 to P37 P40 to P42, P50 to P56, P60 to P65 P90 to P915, PCM0 to PCM3, PCS0 PCS2, PCS3, PCT0, PCT1, PCT4 PCT6, PDL0 to PDL15, PDH0 to PDH7	Per pin	−4	mA
			Total of all pins	−50	mA
		UDMF, UDPF	Per pin	−4	mA
			Total of all pins	−8	mA
		P10, P11	Per pin	−4	mA
			Total of all pins	−8	mA
		P70 to P711	Per pin	−4	mA
			Total of all pins	−20	mA
Operating ambient temperature	T_A	In normal operation		−40 to +85	°C
		In flash memory programming		−40 to +85	°C
Storage temperature	Tstg			−40 to +125	°C

Cautions 1. Do not directly connect the output (or I/O) pins of IC products to each other, or to V_{DD}, V_{CC}, and GND. Open-drain pins or open-collector pins, however, can be directly connected to each other. Direct connection of the output pins between an IC product and an external circuit is possible, if the output pins can be set to the high-impedance state and the output timing of the external circuit is designed to avoid output conflict.

2. Product quality may suffer if the absolute maximum rating is exceeded even momentarily for any parameter. That is, the absolute maximum ratings are rated values at which the product is on the verge of suffering physical damage. Therefore the product must be used under conditions that ensure that the absolute maximum ratings are not exceeded.

The ratings and conditions indicated for DC characteristics and AC characteristics represent the quality assurance range during normal operation.

Remark Unless specified otherwise, the characteristics of alternate-function pins are the same as those of port pins.

33.2 Capacitance

(T_A = 25°C, V_{DD} = EV_{DD} = UV_{DD} = AV_{REF0} = AV_{REF1}, V_{SS} = AV_{SS} = 0 V)

Parameter	Symbol	Conditions	MIN.	TYP.	MAX.	Unit
I/O capacitance	C_{IO}	f_X = 1 MHz Measured pins returned to 0 V			10	pF

33.3 Operating Conditions

(T_A = –40 to +85°C, V_{DD} = EV_{DD} = UV_{DD} = AV_{REF0} = AV_{REF1}, V_{SS} = AV_{SS} = 0 V, C_L = 50 pF)

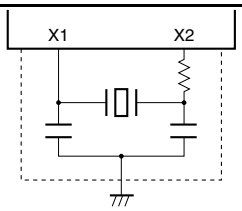
Internal System Clock Frequency	Conditions	Supply voltage				Unit
		V_{DD}	EV_{DD}	UV_{DD}	AV_{REF0}, AV_{REF1}	
f_{XX} = 3 to 6 MHz (during clock-through operation) f_{XX} = 24 to 48 MHz (during PLL operation)	C = 4.7 μF, A/D converter stopped, D/A converter stopped, USB stopped	2.85 to 3.6	2.85 to 3.6	2.85 to 3.6	2.85 to 3.6	V
	C = 4.7 μF, A/D converter operating, D/A converter operating, USB operating	3.0 to 3.6	3.0 to 3.6	3.0 to 3.6	3.0 to 3.6	V
f_{XT} = 32.768 kHz	C = 4.7 μF, **Note**	2.85 to 3.6	2.85 to 3.6	2.85 to 3.6	2.85 to 3.6	V

Note When the system is operating on the subclock (f_{XT} = 32.768 kHz), the A/D converter, D/A converter, and USB controller do not operate.

33.4 Oscillator Characteristics

33.4.1 Main clock oscillator characteristics

(T_A = –40 to +85°C, V_{DD} = EV_{DD} = UV_{DD} = AV_{REF0} = AV_{REF1}, V_{SS} = AV_{SS} = 0 V, C_L = 50 pF)

Resonator	Circuit Example	Parameter	Conditions	MIN.	TYP.	MAX.	Unit
Ceramic resonator/ crystal resonator		Oscillation frequency (f_X)Note 1		3		6	MHz
		Oscillation stabilization timeNote 2	After reset is released		216/f_X		s
			After STOP mode is released		Note 3		ms
			After IDLE2 mode is released		Note 3		μs

Notes 1. The oscillation frequency shown above indicates only oscillator characteristics. Use the V850ES/JG3-H and V850ES/JH3-H so that the internal operation conditions do not exceed the ratings shown in **AC Characteristics** and **DC Characteristics**.

2. Time required from start of oscillation until the resonator stabilizes.

3. The value varies depending on the setting of the OSTS register.

Cautions 1. When using the USB controller, be sure to use a ceramic resonator or crystal resonator with an accuracy of 6 MHz ±500 ppm or less when using the internal clock as the USB clock.

When using the external clock input by the UCLK pin, be sure to supply a clock with an accuracy of 48 MHz ±500 ppm or less.

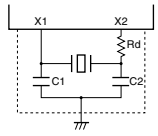
If the USB clock accuracy drops, the transmission/reception data cannot satisfy the USB specification.

2. When using the main clock oscillator, wire as follows in the area enclosed by the broken lines in the above figure to avoid an adverse effect from wiring capacitance.

- **Keep the wiring length as short as possible.**
- **Do not cross the wiring with the other signal lines.**
- **Do not route the wiring near a signal line through which a high fluctuating current flows.**
- **Always make the ground point of the oscillator capacitor the same potential as V_{SS}.**
- **Do not ground the capacitor to a ground pattern through which a high current flows.**
- **Do not fetch signals from the oscillator.**

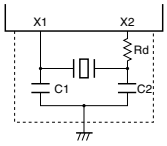
3. When the main clock is stopped and the device is operating on the subclock, wait until the oscillation stabilization time has been secured by the program before switching back to the main clock.

(1) KYOCERA KINSEKI CORPORATION: Crystal resonator

Type	Circuit Example	Part Number	Oscillation Frequency f_X (MHz)	Recommended Circuit Constant			Oscillation Voltage Range		Oscillation Stabilization Time
				C1 (pF)	C2 (pF)	Rd (Ω)	MIN. (V)	MAX. (V)	MAX. (ms)
Surface mounting		CX49GFWB04000D0PPTZ1	4.000	10	10	1000	2.85	3.6	14.86
		CX49GFWB05000D0PPTZ1	5.000	10	10	1000	2.85	3.6	13.98
		CX49GFWB06000D0PPTZ1	6.000	10	10	1000	2.85	3.6	12.8

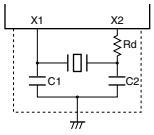
Caution This oscillator constant is a reference value based on evaluation under a specific environment by the resonator manufacturer.
If optimization of oscillator characteristics is necessary in the actual application, apply to the resonator manufacturer for evaluation on the implementation circuit.
The oscillation voltage and oscillation frequency indicate only oscillator characteristics. Use the V850ES/Jx3-H so that the internal operating conditions are within the specifications of the DC and AC characteristics.

(2) KYOCERA CORPORATION: Ceramic resonator

Type	Circuit Example	Part Number	Oscillation Frequency f_X (MHz)	Recommended Circuit Constant			Oscillation Voltage Range		Oscillation stabilization time
				C1 (pF)	C2 (pF)	Rd (Ω)	MIN. (V)	MAX. (V)	MAX. (ms)
Surface mounting		PBRC3.00HR10X000	3.000	30	30	1000	2.85	3.6	0.01
		PBRC4.00MR10X000	4.000	15	15	1000	2.85	3.6	0.01
		PBRC5.00MR10X000	5.000	15	15	1000	2.85	3.6	0.01
		PBRC6.00MR10X000	6.000	15	15	1000	2.85	3.6	0.01

Caution This oscillator constant is a reference value based on evaluation under a specific environment by the resonator manufacturer.
If optimization of oscillator characteristics is necessary in the actual application, apply to the resonator manufacturer for evaluation on the implementation circuit.
The oscillation voltage and oscillation frequency indicate only oscillator characteristics. Use the V850ES/Jx3-H so that the internal operating conditions are within the specifications of the DC and AC characteristics.

(3) Toyama Murata Mfg. Co. Ltd.: Ceramic resonator

Type	Circuit Example	Part Number	Oscillation Frequency f_X (MHz)	Recommended Circuit Constant			Oscillation Voltage Range		Oscillation Stabilization Time
				C1 (pF)	C2 (pF)	Rd (Ω)	MIN. (V)	MAX. (V)	MAX. (ms)
Surface mounting		CSTCR4M00GH5L99	4.000	(39)	(39)	1000	2.85	3.6	0.01
		CSTCR5M00GH5L99	5.000	(39)	(39)	1000	2.85	3.6	0.01
		CSTCR6M00GH5L99	6.000	(39)	(39)	680	2.85	3.6	0.01

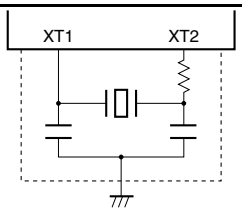
Caution This oscillator constant is a reference value based on evaluation under a specific environment by the resonator manufacturer.
If optimization of oscillator characteristics is necessary in the actual application, apply to the resonator manufacturer for evaluation on the implementation circuit.

The oscillation voltage and oscillation frequency indicate only oscillator characteristics. Use the V850ES/Jx3-H so that the internal operating conditions are within the specifications of the DC and AC characteristics.

Remark Figures in parentheses in columns C1 and C2 indicate the capacitance incorporated in the resonator.

33.4.2 Subclock oscillator characteristics

(T_A = –40 to +85°C, V_{DD} = EV_{DD} = UV_{DD} = AV_{REF0} = AV_{REF1}, V_{SS} = AV_{SS} = 0 V, C_L = 50 pF)

Resonator	Circuit Example	Parameter	Conditions	MIN.	TYP.	MAX.	Unit
Crystal resonator		Oscillation frequency (f_{XT})Note 1		32	32.768	35	kHz
		Oscillation stabilization timeNote 2				10	s

Notes 1. The oscillation frequency shown above indicates only oscillator characteristics. Use the V850ES/JG3-H and V850ES/JH3-H so that the internal operation conditions do not exceed the ratings shown in **AC Characteristics** and **DC Characteristics**.

2. Time required from when V_{DD} reaches the oscillation voltage range (2.85 V (MIN.)) to when the crystal resonator stabilizes.

Cautions 1. When using the subclock oscillator, wire as follows in the area enclosed by the broken lines in the above figure to avoid an adverse effect from wiring capacitance.

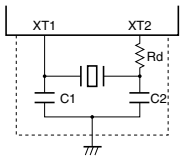
- **Keep the wiring length as short as possible.**
- **Do not cross the wiring with the other signal lines.**
- **Do not route the wiring near a signal line through which a high fluctuating current flows.**
- **Always make the ground point of the oscillator capacitor the same potential as V_{SS}.**
- **Do not ground the capacitor to a ground pattern through which a high current flows.**
- **Do not fetch signals from the oscillator.**

2. The subclock oscillator is designed as a low-amplitude circuit for reducing power consumption, and is more prone to malfunction due to noise than the main clock oscillator. Particular care is therefore required with the wiring method when the subclock is used.

3. For the resonator selection and oscillator constant, customers are requested to either evaluate the oscillation themselves or apply to the resonator manufacturer for evaluation.

(1) Seiko Instruments Inc.: Crystal resonator

Oscillation frequency: f_{XT} = 32.768 kHz

Type	Circuit Example	Part Number	Recommended Circuit Constant			Oscillation Voltage Range		Oscillation Stabilization Time
			C1 (pF)	C2 (pF)	Rd (Ω)	MIN. (V)	MAX. (V)	MAX. (ms)
Surface mounting		SSP-T7	7	7	0	2.85	3.6	1.4

Caution This oscillator constant is a reference value based on evaluation under a specific environment by the resonator manufacturer.

If optimization of oscillator characteristics is necessary in the actual application, apply to the resonator manufacturer for evaluation on the implementation circuit.

The oscillation voltage and oscillation frequency indicate only oscillator characteristics. Use the V850ES/Jx3-H so that the internal operating conditions are within the specifications of the DC and AC characteristics.

33.4.3 PLL characteristics

(T_A = –40 to +85°C, V_{DD} = EV_{DD} = UV_{DD} = AV_{REF0} = AV_{REF1}, V_{SS} = AV_{SS} = 0 V, C_L = 50 pF)

Parameter	Symbol	Conditions	MIN.	TYP.	MAX.	Unit
Input frequency	f_X		3		6	MHz
Output frequency	f_{XX}	Clock-through mode	3		6	MHz
		PLL mode (×8)	24		48	MHz
Lock time	t_{PLL}				800	μs

33.4.4 Internal oscillator characteristics

(T_A = –40 to +85°C, V_{DD} = EV_{DD} = UV_{DD} = AV_{REF0} = AV_{REF1}, V_{SS} = AV_{SS} = 0 V, C_L = 50 pF)

Parameter	Symbol	Conditions	MIN.	TYP.	MAX.	Unit
Output frequency	f_R		100	220	400	kHz

33.5 DC Characteristics

33.5.1 I/O level

(T_A = –40 to +85°C, V_{DD} = EV_{DD} = UV_{DD} = AV_{REF0} = AV_{REF1}, V_{SS} = AV_{SS} = 0 V, C_L = 50 pF)

Parameter	Symbol	Conditions	MIN.	TYP.	MAX.	Unit
Input voltage, high	V_{IH1}	$\overline{\text{RESET}}$, FLMD0, P60 to P65 P90 to P915	0.8EV_{DD}		EV_{DD}	V
	V_{IH2}	P00 to P05, P20 to P25, P30 to P35, P42, P50 to P56	0.8EV_{DD}		5.5	V
	V_{IH3}	P36, P37, P40, P41, PCM2, PCM3	0.7EV_{DD}		5.5	V
	V_{IH4}	PDL0 to PDL15, PDH0 to PDH7, PCM0, PCM1, PCS0, PCS2, PCS3, PCT0, PCT1, PCT4, PCT6	0.7EV_{DD}		EV_{DD}	V
	V_{IH5}	UDPF, UDMF	2.0		UV_{DD}	V
	V_{IH6}	P70 to P711	0.7AV_{REF0}		AV_{REF0}	V
	V_{IH7}	P10, P11	0.7AV_{REF1}		AV_{REF1}	V
Input voltage, low	V_{IL1}	$\overline{\text{RESET}}$, FLMD0, P60 to P65, P90 to P915	V_{SS}		0.2EV_{DD}	V
	V_{IL2}	P00 to P05, P20 to P25, P30 to P35, P42, P50 to P56	V_{SS}		0.2EV_{DD}	V
	V_{IL3}	P36, P37, P40, P41, PCM2, PCM3	V_{SS}		0.3EV_{DD}	V
	V_{IL4}	PDL0 to PDL15, PDH0 to PDH7, PCM0, PCM1, PCS0, PCS2, PCS3, PCT0, PCT1, PCT4, PCT6	V_{SS}		0.3EV_{DD}	V
	V_{IL5}	UDPF, UDMF	V_{SS}		0.8	V
	V_{IL6}	P70 to P711	AV_{SS}		0.3AV_{REF0}	V
	V_{IL7}	P10, P11	AV_{SS}		0.3AV_{REF1}	V
Input leakage current, high	I_{LIH}	V_I = V_{DD} = EV_{DD} = UV_{DD} = AV_{REF0} = AV_{REF1}			5	μA
Input leakage current, low	I_{LIL}	V_I = 0 V			–5	μA
Output leakage current, high	I_{LOH}	V_O = V_{DD} = EV_{DD} = UV_{DD} = AV_{REF0} = AV_{REF1}			5	μA
Output leakage current, low	I_{LOL}	V_O = 0 V			–5	μA

Remark Unless specified otherwise, the characteristics of alternate-function pins are the same as those of port pins.

(T_A = –40 to +85°C, V_{DD} = EV_{DD} = UV_{DD} = AV_{REF0} = AV_{REF1}, V_{SS} = AV_{SS} = 0 V, C_L = 50 pF)

Parameter	Symbol	Conditions		MIN.	TYP.	MAX.	Unit
Output voltage, high	V_{OH1}	Note 1	Per pin I_{OH} = –1.0 mA	EV_{DD} – 1.0		EV_{DD}	V
			Per pin I_{OH} = –100 μA	EV_{DD} – 0.5		EV_{DD}	V
	V_{OH2}	P70 to P711	Per pin I_{OH} = –0.4 mA	AV_{REF0} – 1.0		AV_{REF0}	V
			Per pin I_{OH} = –100 μA	AV_{REF0} – 0.5		AV_{REF0}	V
	V_{OH3}	P10, P11	Per pin I_{OH} = –0.4 mA	AV_{REF1} – 1.0		AV_{REF1}	V
			Per pin I_{OH} = –100 μA	AV_{REF1} – 0.5		AV_{REF1}	V
	V_{OH4}	UDPF, UDMF	R_L = 15 kΩ (Connect to V_{SS})	2.8			V
Output voltage, low	V_{OL1}	Note 2	Per pin I_{OL} = 1.0 mA	0		0.4	V
	V_{OL2}	P36, P37, P40, P41, P90, P91	Per pin I_{OL} = 3.0 mA	0		0.4	V
	V_{OL3}	P70 to P711	Per pin I_{OL} = 1.0 mA	0		0.4	V
	V_{OL4}	P10, P11	Per pin I_{OL} = 0.4 mA	0		0.4	V
	V_{OL5}	UDPF, UDMF	R_L = 1.5 kΩ (Connect to UV_{DD})	0		0.3	V
Software pull-down resistor	R_1	P56	V_I = V_{DD}	10	30	100	kΩ

Notes 1. P00 to P05, P20 to P25, P30 to P37, P40 to P42, P50 to P56, P60 to P65, P90 to P915, PCM0 to PCM3, PCS0, PCS2, PCS3
PCT0, PCT1, PCT4, PCT6, PDH0 to PDH7, PDL0 to PDL15

2. P00 to P05, P20 to P25, P30 to P35, P42, P50 to P56, P60 to P65, P92 to P915, PCM0 to PCM3, PCS0, PCS2, PCS3, PCT0, PCT1, PCT4, PCT6, PDH0 to PDH7, PDL0 to PDL15

Remarks 1. Unless specified otherwise, the characteristics of alternate-function pins are the same as those of port pins.

2. When the I_{OH} and I_{OL} conditions are not satisfied for one pin but the total value of all pins is satisfied, only that pin is deemed to not satisfy the DC characteristics.

33.5.2 Supply current

(T_A = –40 to +85°C, V_{DD} = EV_{DD} = UV_{DD} = AV_{REF0} = AV_{REF1}, V_{SS} = AV_{SS} = 0 V, C_L = 50 pF)

Parameter	Symbol	Conditions		MIN.	TYP.	MAX.	Unit
Supply current[Notes 1, 2]	I_{DD1}	Normal operation	f_{XX} = 48 MHz (f_X = 6 MHz) Peripheral function operating			120	mA
			f_{XX} = 48 MHz (f_X = 6 MHz) USBF operating		54		mA
	I_{DD2}	HALT mode	f_{XX} = 48 MHz (f_X = 6 MHz) Peripheral function operating		42	60	mA
	I_{DD3}	IDLE1 mode	f_{XX} = 48 MHz (f_X = 6 MHz), PLL on		4	7	mA
	I_{DD4}	IDLE2 mode	f_{XX} = 6 MHz (f_X = 6 MHz), PLL off		0.5	1	mA
	I_{DD5}	Subclock operation mode	f_{XT} = 32.768 kHz, main clock stopped, internal oscillator stopped		120	600	μA
	I_{DD6}	Sub-IDLE mode	f_{XT} = 32.768 kHz, main clock stopped, internal oscillator stopped, –40≤T_A≤+25°C		13	25	μA
			25≤T_A≤85°C			95	μA
	I_{DD7}	STOP mode	Subclock stopped, internal oscillator stopped, –40≤T_A≤+25°C		10	20	μA
			25≤T_A≤85°C			90	μA
			Subclock operating, internal oscillator stopped, –40≤T_A≤+25°C		13	25	μA
			25≤T_A≤85°C			95	μA
	I_{DD8}	Flash memory programming mode	f_{XX} = 48 MHz (f_X = 6 MHz)		65	130	mA

Notes 1. Total of V_{DD}, EV_{DD}, and UV_{DD} currents. Currents flowing through the output buffers, A/D converter, D/A converter, and on-chip pull-down resistor are not included.

2. The V_{DD} of the TYP. value is 3.3 V.

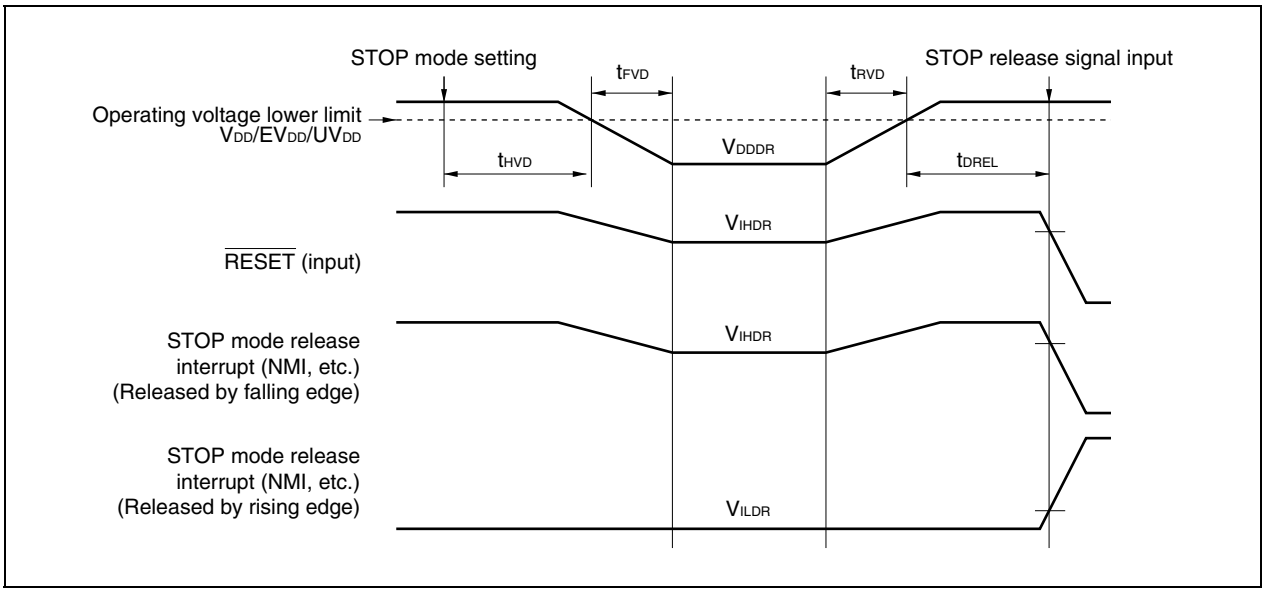
33.6 Data Retention Characteristics

(1) In STOP mode

(T_A = –40 to +85°C, V_{DD} = EV_{DD} = UV_{DD} = AV_{REF0} = AV_{REF1}, V_{SS} = AV_{SS} = 0 V, C_L = 50 pF)

Parameter	Symbol	Conditions	MIN.	TYP.	MAX.	Unit
Data retention voltage	V_{DDDR}	STOP mode (all functions stopped)	1.9		3.6	V
Data retention current	I_{DDDR}	STOP mode (all functions stopped), V_{DDDR} = 2.0 V		10	90	μA
Supply voltage rise time	t_{RVD}		200			μs
Supply voltage fall time	t_{FVD}		200			μs
Supply voltage retention time	t_{HVD}	After STOP mode setting	0			ms
STOP release signal input time	t_{DREL}	After V_{DD} reaches 2.85 V (MIN.)	0			ms
Data retention input voltage, high	V_{IHDR}	V_{DD} = EV_{DD} = UV_{DD} = V_{DDDR}	0.9V_{DDDR}		V_{DDDR}	V
Data retention input voltage, low	V_{ILDR}	V_{DD} = EV_{DD} = UV_{DD} = V_{DDDR}	0		0.1V_{DDDR}	V

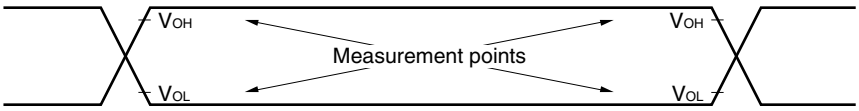
Caution Shifting to STOP mode and restoring from STOP mode must be performed within the rated operating range.



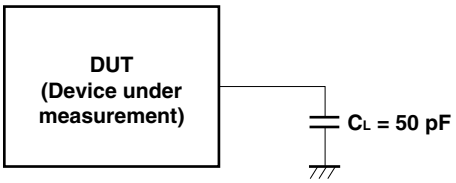
33.7 AC Characteristics

(1) AC test input measurement points (V_{DD}, AV_{REF0}, AV_{REF1}, EV_{DD})

(2) AC test output measurement points



(3) Load conditions



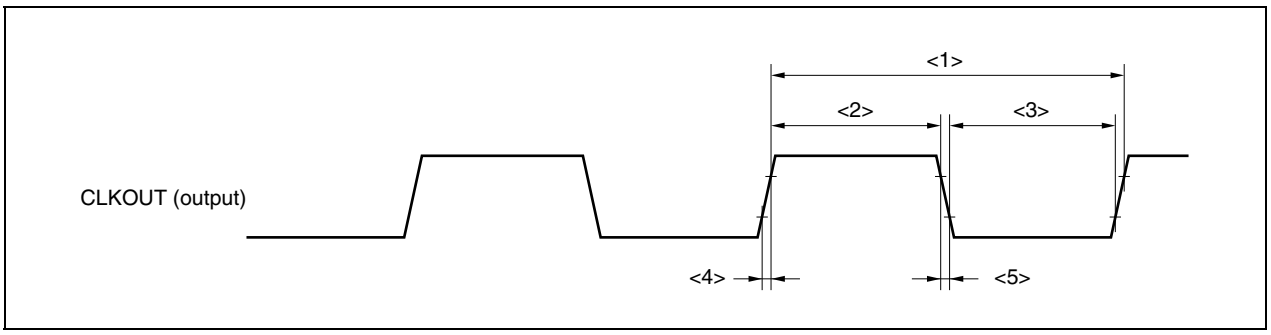
Caution If the load capacitance exceeds 50 pF due to the circuit configuration, bring the load capacitance of the device to 50 pF or less by inserting a buffer or by some other means.

33.7.1 CLKOUT output timing

(T_A = –40 to +85°C, V_{DD} = EV_{DD} = UV_{DD} = AV_{REF0} = AV_{REF1}, V_{SS} = AV_{SS} = 0 V, C_L = 50 pF)

Parameter	Symbol		Conditions	MIN.	MAX.	Unit
Output cycle	t_{CYK}	<1>		20.83 ns	31.25 μs	
High-level width	t_{WKH}	<2>		t_{CYK}/2 – 6		ns
Low-level width	t_{WKL}	<3>		t_{CYK}/2 – 6		ns
Rise time	t_{KR}	<4>			6	ns
Fall time	t_{KF}	<5>			6	ns

Clock Timing



33.7.2 Bus timing

(1) In multiplexed bus mode/separate bus output function

(a) Read/write cycle (CLKOUT asynchronous)

(T_A = –40 to +85°C, V_{DD} = EV_{DD} = UV_{DD} = AV_{REF0} = AV_{REF1}, V_{SS} = AV_{SS} = 0 V, C_L = 50 pF)

Parameter	Symbol		Conditions	MIN.	MAX.	Unit
Address setup time (to ASTB↓)	t_{DAST}	<6>		(0.5 + t_{ASw})T – 9		ns
Address hold time (from ASTB↓)	t_{HSTA}	<7>		(0.5 + t_{AHw})T – 8		ns
Delay time from $\overline{RD}$↓ to address float	t_{FRDA}	<8>			5	ns
Data input setup time from address	t_{DAID}	<9>			(2 + n + t_{ASw} + t_{AHw})T – 25	ns
Data input setup time from $\overline{RD}$↓	t_{DRDID2}	<10>			(1 + n)T – 15	ns
Delay time from ASTB↓ to $\overline{RD}$↓	t_{DSTRD}	<11>		(0.5 + t_{AHw})T – 4		ns
Delay time from ASTB↓ to $\overline{WRm}$↓	t_{DSTWR}					
Data input hold time (from $\overline{RD}$↑)	t_{HRDID}	<12>		0		ns
Address output delay time from $\overline{RD}$↑	t_{DRDOD}	<13>		(1 + i)T – 3		ns
Delay time from $\overline{RD}$↑ to ASTB↑	t_{DRDST}	<14>		0.5T – 5		ns
Delay time from $\overline{WRm}$↑ to ASTB↑	t_{DWRST}					
Delay time from $\overline{RD}$↑ to ASTB↓	t_{DRDST}	<15>		(1.5 + i + t_{ASw})T – 4		ns
$\overline{RD}$ low-level width	t_{WRDL}	<16>		(1 + n)T – 10		ns
$\overline{WRm}$ low-level width	t_{WWRL}					
ASTB high-level width	t_{WSTH}	<17>		(1 + i + t_{ASw})T – 10		ns
Data output delay time from $\overline{WRm}$↓	t_{DWROD}	<18>			9	ns
Data output delay time (from $\overline{WRm}$↑)	t_{DODWR}	<19>		(1 + n)T – 11		ns
Data output hold time (from $\overline{WRm}$↑)	t_{HWROD}	<20>		T – 3		ns
$\overline{WAIT}$ setup time (to address)	t_{SAWT1}	<21>	n ≥ 1		(1.5 + t_{ASw} + t_{AHw})T – 25	ns
	t_{SAWT2}	<22>			(1.5 + n + t_{ASw} + t_{AHw})T – 25	ns
$\overline{WAIT}$ hold time (from address)	t_{HAWT1}	<23>	n ≥ 1	(0.5 + n + t_{ASw} + t_{AHw})T		ns
	t_{HAWT2}	<24>		(1.5 + n + t_{ASw} + t_{AHw})T		ns
$\overline{WAIT}$ setup time (to ASTB↓)	t_{SSTWT1}	<25>	n ≥ 1		(1 + t_{AHw})T – 15	ns
	t_{SSTWT2}	<26>			(1 + n + t_{AHw})T – 15	ns
$\overline{WAIT}$ hold time (from ASTB↓)	t_{HSTWT1}	<27>	n ≥ 1	(n + t_{AHw})T		ns
	t_{HSTWT2}	<28>		(1 + n + t_{AHw})T		ns
Address hold time from $\overline{RD}$↑	t_{HRDA2}	<29>		(1 + i)T – 5		ns
Address hold time from $\overline{WRm}$↑	t_{HWRA2}	<30>		T – 5		ns
Hold time from $\overline{RD}$↑ to $\overline{CSn}$	t_{HRDC2}	<31>	i ≥ 1	T – 5		ns
Hold time from $\overline{WRm}$↑ to $\overline{CSn}$	t_{HWRC2}	<32>		T – 5		ns

Remarks 1. t_{ASW}: Number of address setup wait clocks
t_{AHW}: Number of address hold wait clocks

2. T = 1/f_{CPU} (f_{CPU}: CPU operating clock frequency)

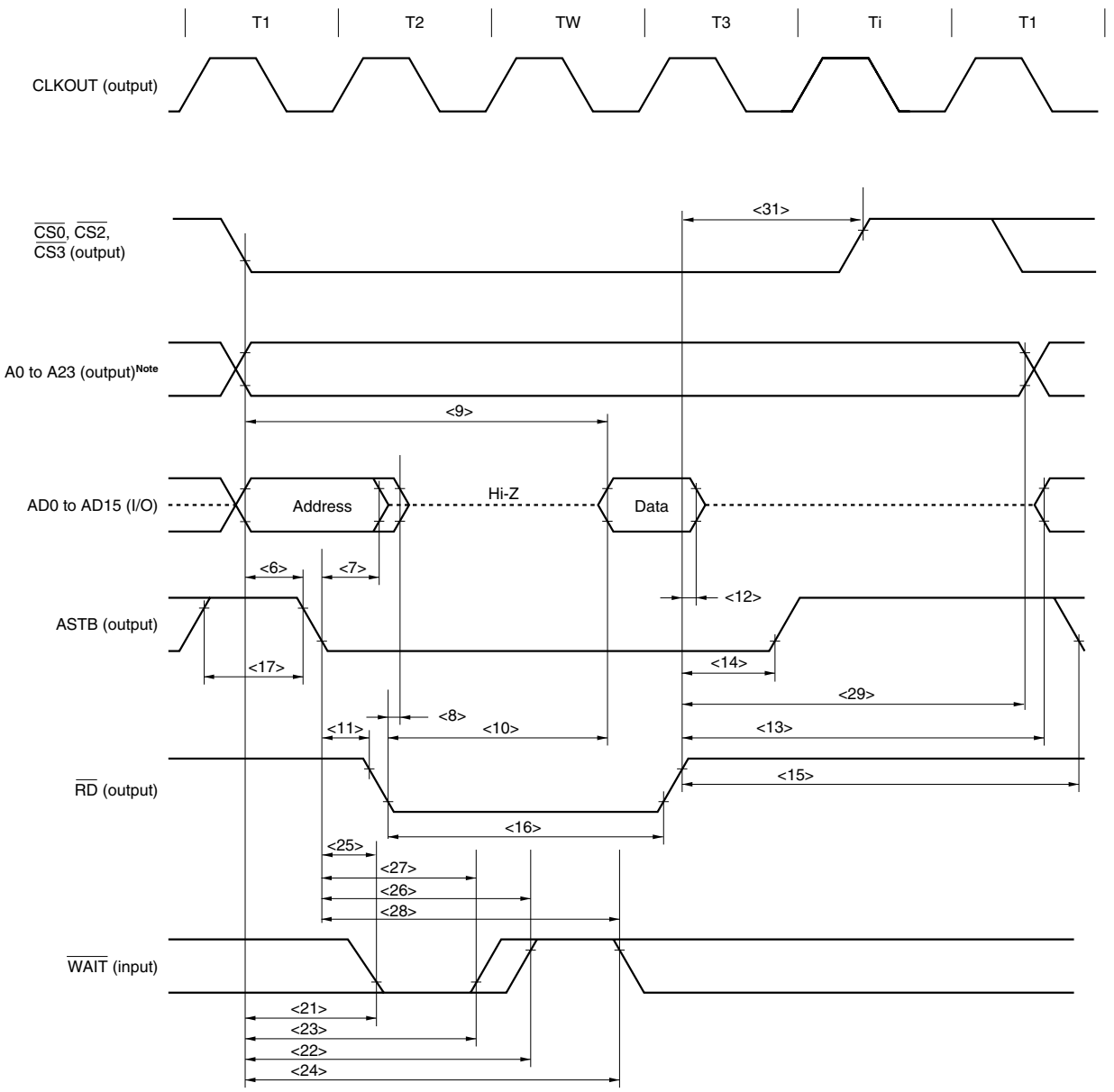
3. n: Number of wait clocks inserted in the bus cycle
The sampling timing changes when a programmable wait is inserted.

4. m = 0, 1

5. i: Number of idle states inserted after a read cycle (0 or 1)

6. The values in the above specifications are values for when clocks with a 1:1 duty ratio are input from X1.

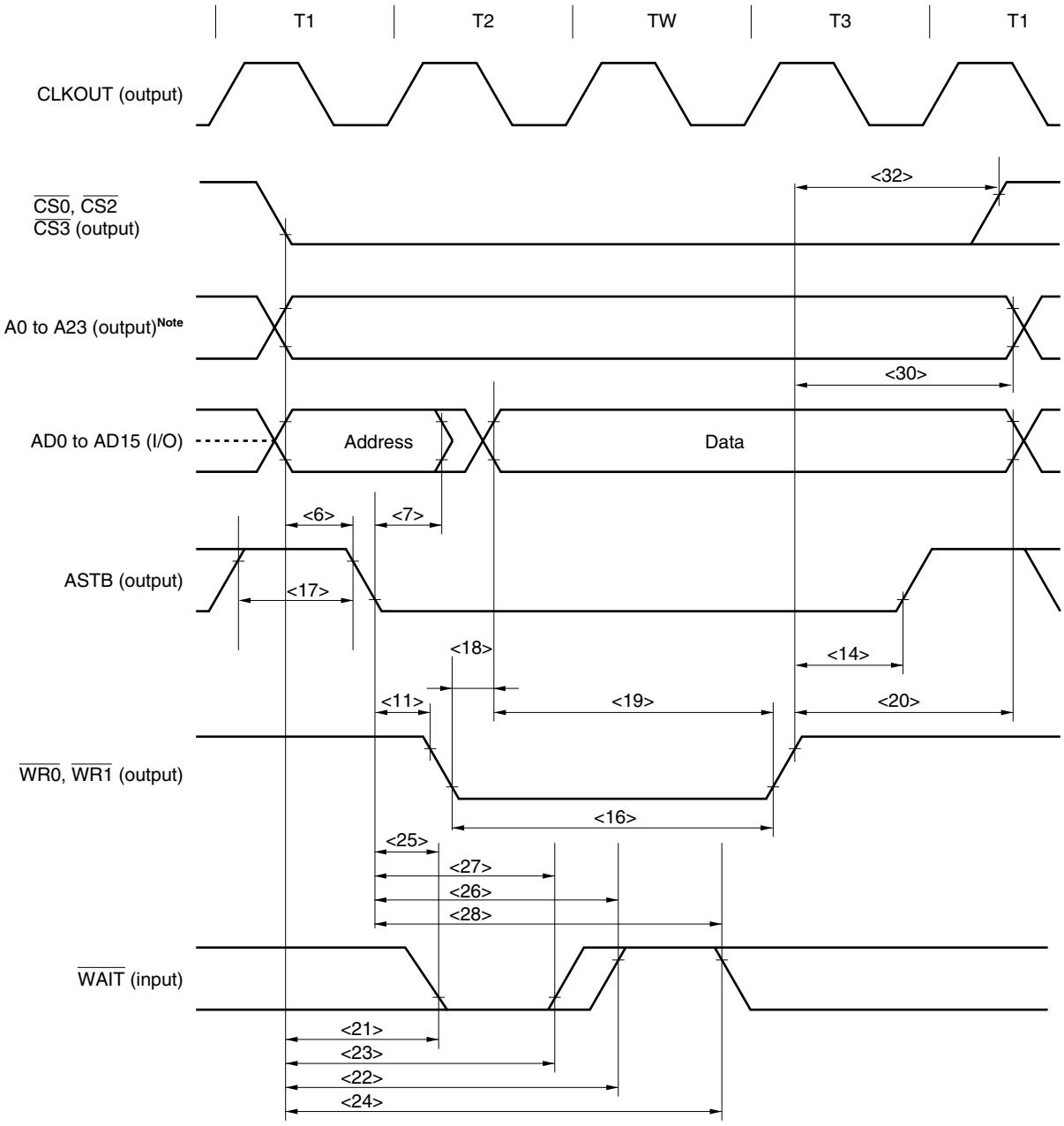
Read Cycle (CLKOUT Asynchronous): In Multiplexed Bus Mode/Separate Bus Output Function



Note V850ES/JH3-H only

Remark $\overline{WR0}$ and $\overline{WR1}$ are high level.

Write Cycle (CLKOUT Asynchronous): In Multiplexed Bus Mode/Separate Bus Output Function



Note V850ES/JH3-H only

Remark $\overline{RD}$ is high level.

(b) Read/write cycle (CLKOUT synchronous): In multiplexed bus mode/separate bus output function

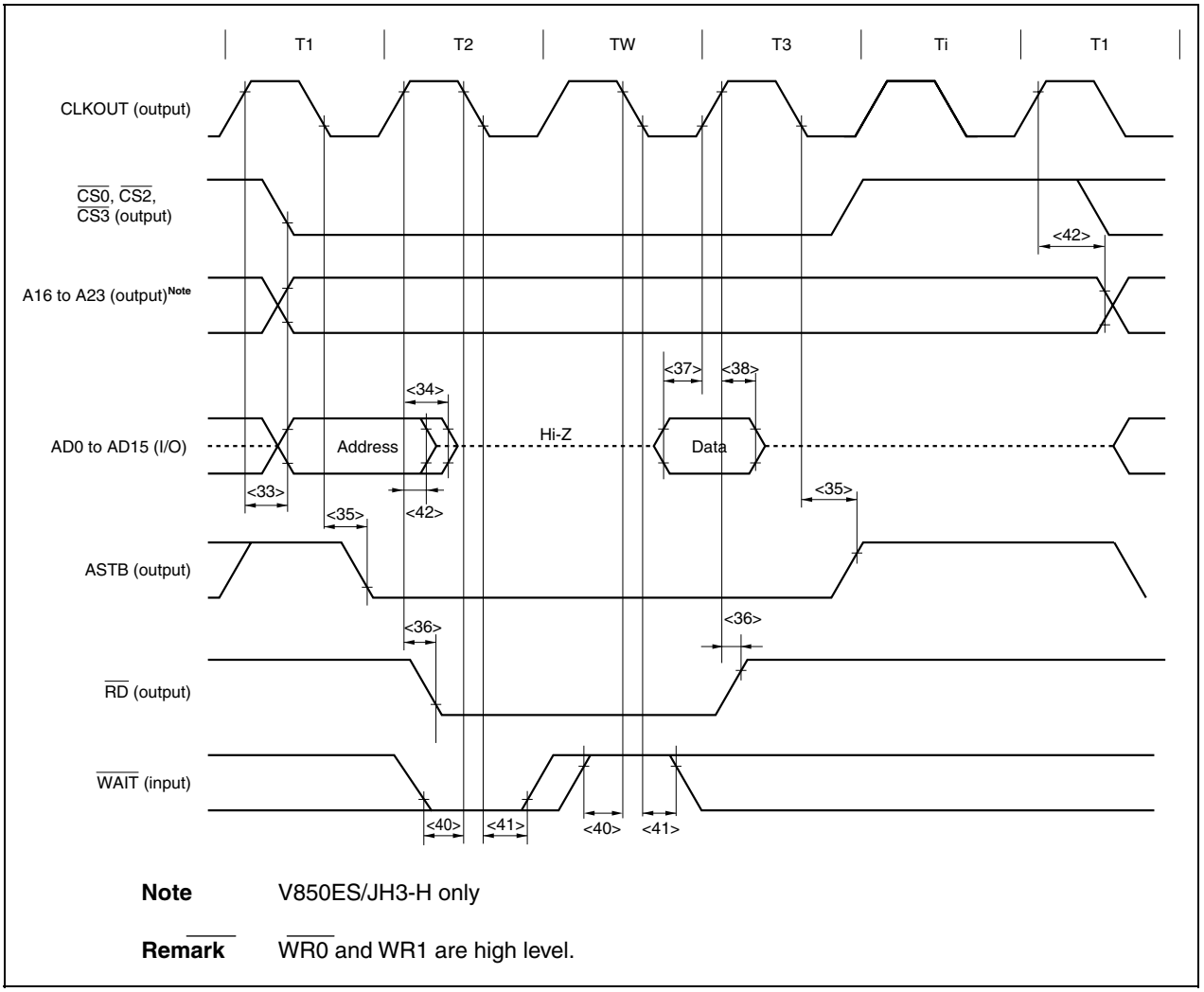
(T_A = –40 to +85°C, V_{DD} = EV_{DD} = UV_{DD} = AV_{REF0} = AV_{REF1}, V_{SS} = AV_{SS} = 0 V, C_L = 50 pF)

Parameter	Symbol		Conditions	MIN.	MAX.	Unit
Delay time from CLKOUT↑ to address	t_{DKA}	<33>		0	17	ns
Delay time from CLKOUT↑ to address float	t_{FKA}	<34>		0	15	ns
Delay time from CLKOUT↓ to ASTB	t_{DKST}	<35>		0	12	ns
Delay time from CLKOUT↑ to $\overline{RD}$, $\overline{WRm}$	t_{DKRDWR}	<36>		0	12	ns
Data input setup time (to CLKOUT↑)	t_{SIDK}	<37>		16		ns
Data input hold time (from CLKOUT↑)	t_{HKID}	<38>		0		ns
Data output delay time from CLKOUT↑	t_{DKOD}	<39>			17	ns
$\overline{WAIT}$ setup time (to CLKOUT↓)	t_{SWTK}	<40>		16		ns
$\overline{WAIT}$ hold time (from CLKOUT↓)	t_{HKWT}	<41>		0		ns
Address hold time from CLKOUT↑	t_{HKA2}	<42>		0		ns
Data output hold time from CLKOUT↑	t_{HKOD2}	<43>		0		ns

Remarks 1. m = 0, 1

2. The values in the above specifications are values for when clocks with a 1:1 duty ratio are input from X1.

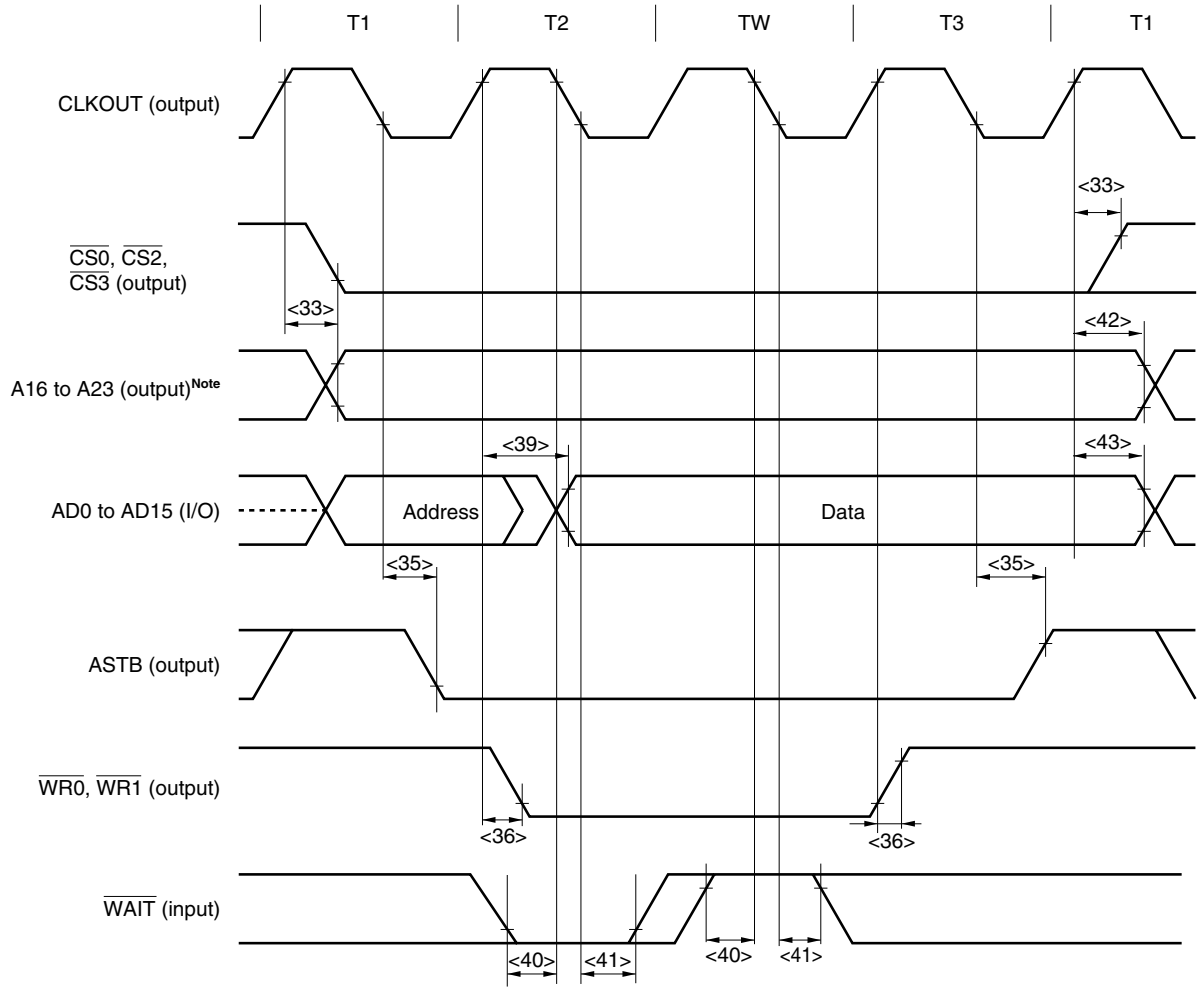
Read Cycle (CLKOUT Synchronous): In Multiplexed Bus Mode/Separate Bus Output Function



Note V850ES/JH3-H only

Remark $\overline{WR0}$ and WR1 are high level.

Write Cycle (CLKOUT Synchronous): In Multiplexed Bus Mode/Separate Bus Output Function



Note V850ES/JH3-H only

Remark $\overline{RD}$ is high level.

(2) During bus hold (V850ES/JH3-H only)

(a) CLKOUT asynchronous

(T_A = –40 to +85°C, V_{DD} = EV_{DD} = UV_{DD} = AV_{REF0} = AV_{REF1}, V_{SS} = AV_{SS} = 0 V, C_L = 50 pF)

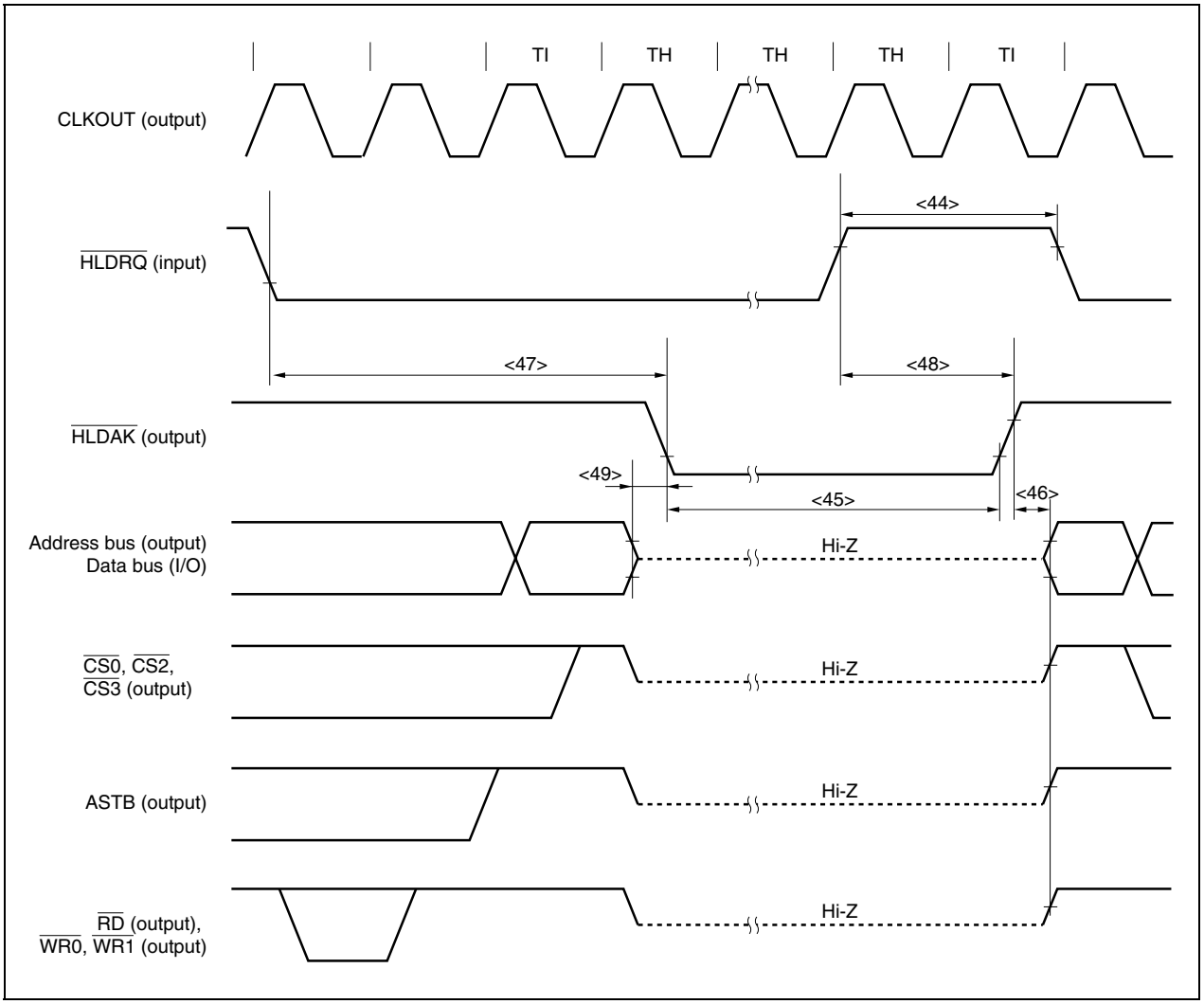
Parameter	Symbol		Conditions	MIN.	MAX.	Unit
$\overline{\text{HLDRQ}}$ high-level width	t_{WHQH}	<44>		T + 16		ns
$\overline{\text{HLDAK}}$ low-level width	t_{WHAL}	<45>		T – 10		ns
Delay time from $\overline{\text{HLDAK}}$↑ to bus output	t_{DHAC}	<46>		–7		ns
Delay time from $\overline{\text{HLDRQ}}$↓ to $\overline{\text{HLDAK}}$↓	t_{DHQHA1}	<47>		2.5T		ns
Delay time from $\overline{\text{HLDRQ}}$↑ to $\overline{\text{HLDAK}}$↑	t_{DHQHA2}	<48>		0.5T + 17	1.5T + 31	ns
Delay time from bus float to HLDAK↓	t_{DFHA}	<49>		0		ns

Remarks 1. T = 1/f_{CPU} (f_{CPU}: CPU operating clock frequency)

2. n: Number of wait clocks inserted in the bus cycle
The sampling timing changes when a programmable wait is inserted.

3. The values in the above specifications are values for when clocks with a 1:1 duty ratio are input from X1.

Bus Hold (CLKOUT Asynchronous)



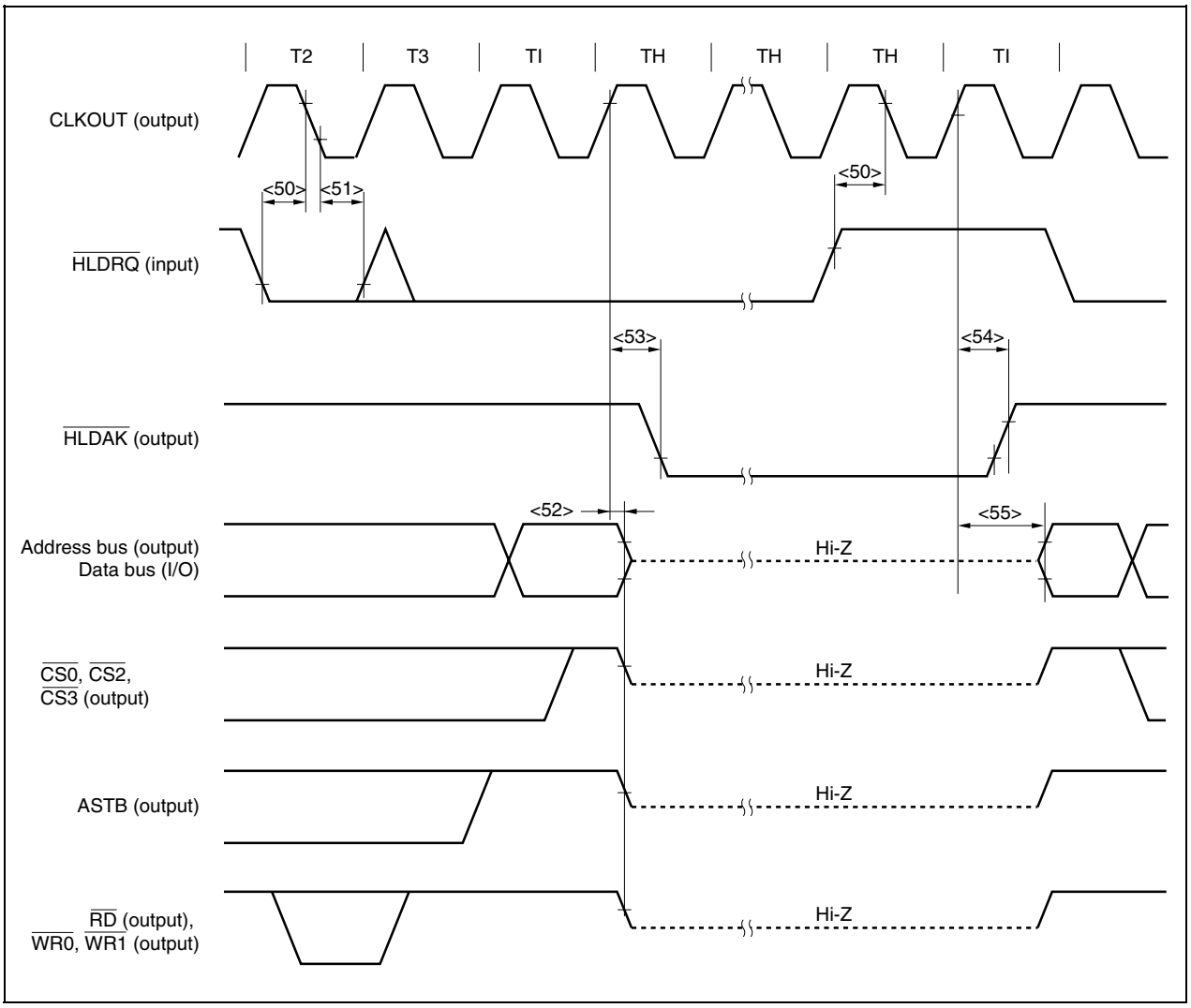
(b) CLKOUT synchronous

(T_A = –40 to +85°C, V_{DD} = EV_{DD} = UV_{DD} = AV_{REF0} = AV_{REF1}, V_{SS} = AV_{SS} = 0 V, C_L = 50 pF)

Parameter	Symbol		Conditions	MIN.	MAX.	Unit
$\overline{HLDRQ}$ setup time (to CLKOUT↓)	t_{SHQK}	<50>		16		ns
$\overline{HLDRQ}$ hold time (from CLKOUT↓)	t_{HKHQ}	<51>		0		ns
Delay time from CLKOUT↑ to bus float	t_{DKF}	<52>			15	ns
Delay time from CLKOUT↑ to $\overline{HLDAK}$↓	t_{DKHA1}	<53>		1	15	ns
Delay time from CLKOUT↑ to $\overline{HLDAK}$↑	t_{DKHA2}	<54>		1	15	ns
Delay time from CLKOUT↑ to data output	t_{DKBO}	<55>		1	17	ns

Remark The values in the above specifications are values for when clocks with a 1:1 duty ratio are input from X1.

Bus Hold (CLKOUT Synchronous)



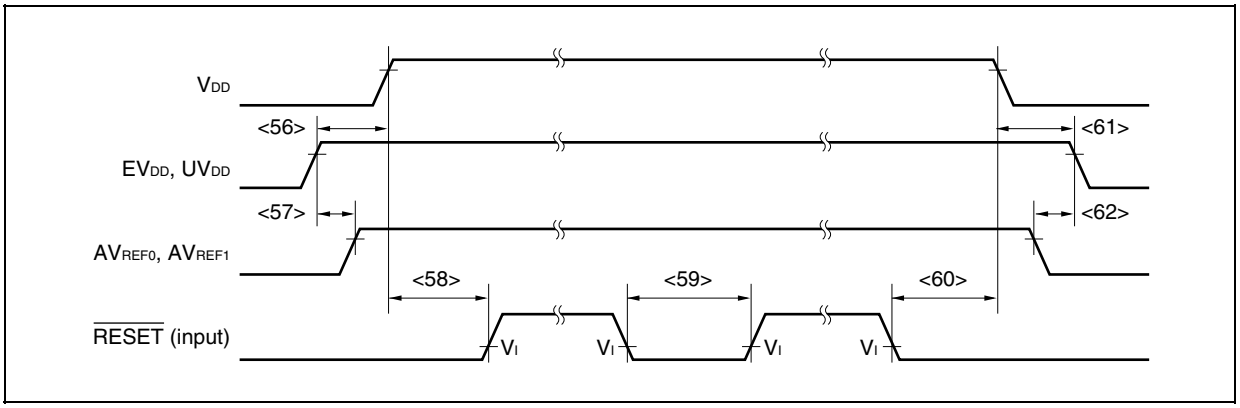
33.8 Basic Operation

(1) Power on/power off/reset timing

(T_A = –40 to +85°C, V_{DD} = EV_{DD} = UV_{DD} = AV_{REF0} = AV_{REF1}, V_{SS} = AV_{SS} = 0 V, C_L = 50 pF)

Parameter	Symbol		Conditions	MIN.	MAX.	Unit
Time from EV_{DD}, UV_{DD}↑ to V_{DD}↑	t_{REL}	<56>		0		ns
Time from EV_{DD}, UV_{DD}↑ to AV_{REF0}, AV_{REF1}↑	t_{REA}	<57>		0	t_{REL}	ns
Time from V_{DD}↑ to $\overline{RESET}$↑	t_{RER}	<58>		500 + t_{REG} Note		ns
$\overline{RESET}$ low-level width	t_{WRSL}	<59>	Analog noise elimination (during flash erase/writing)	500		ns
			Analog noise elimination	500		ns
Time from $\overline{RESET}$↓ to V_{DD}↓	t_{FRE}	<60>		500		ns
Time from V_{DD}↓ to EV_{DD}, UV_{DD}↓	t_{FEL}	<61>		0		ns
Time from AV_{REF0}, AV_{REF1}↓ to EV_{DD}, UV_{DD}↓	t_{FEA}	<62>		0	t_{FEL}	ns

Note Depends on the on-chip regulator characteristics.



(2) Reset, interrupt timing

(T_A = –40 to +85°C, V_{DD} = EV_{DD} = UV_{DD} = AV_{REF0} = AV_{REF1}, V_{SS} = AV_{SS} = 0 V, C_L = 50 pF)

Parameter	Symbol	Conditions	MIN.	MAX.	Unit
RESET input low-level width	t_{WRSL}		500		ns
NMI high-level width	t_{WNIH}	Analog noise elimination	500		ns
NMI low-level width	t_{WNIL}	Analog noise elimination	500		ns
INTPn high-level width	t_{WITH}	n = 0 to 18 (Analog noise elimination)	500		ns
		n = 2 (Digital noise elimination)	$3T_{SMP}$ + 20		ns
INTPn low-level width	t_{WITL}	n = 0 to 18 (Analog noise elimination)	500		ns
		n = 2 (Digital noise elimination)	$3T_{SMP}$ + 20		ns

Remark T_{SMP}: Set by the noise elimination control register (INTNFC). Selectable from f_{XX}/64, f_{XX}/128, f_{XX}/256, f_{XX}/512, and f_{XX}/1024.

(T_A = –40 to +85°C, V_{DD} = EV_{DD} = UV_{DD} = AV_{REF0} = AV_{REF1}, V_{SS} = AV_{SS} = 0 V, C_L = 50 pF)

Parameter	Symbol	Conditions	MIN.	MAX.	Unit
KRn high-level width	t_{WKRH}	Analog noise elimination	500		ns
KRn low-level width	t_{WKRL}	Analog noise elimination	500		ns

Remark n = 0 to 7

(3) Timer timing

(T_A = –40 to +85°C, V_{DD} = EV_{DD} = UV_{DD} = AV_{REF0} = AV_{REF1}, V_{SS} = AV_{SS} = 0 V, C_L = 50 pF)

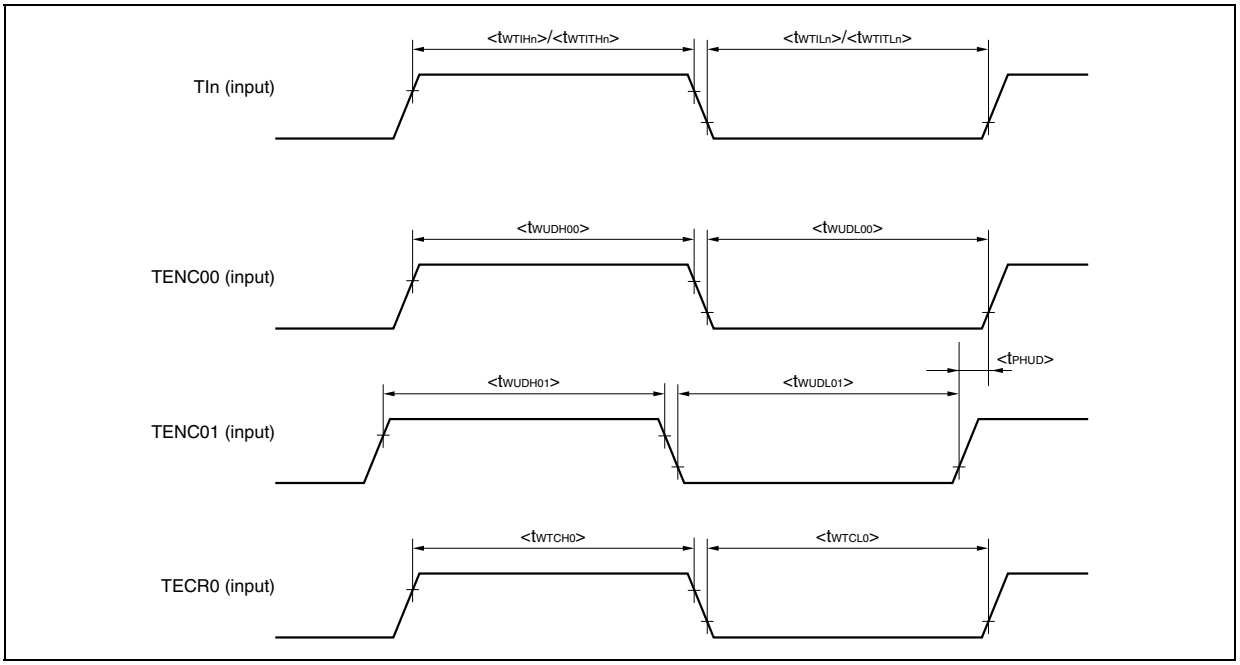
Parameter	Symbol	Conditions	MIN.	MAX.	Unit
TI high-level width	t_{TIH}	TAB00 to TAB03,TAB10 to TAB13, EVTAB1, TRGAB1	12T + 20		ns
		TIAA00, TIAA01, TIAA10, TIAA11, TIAA20, TIAA21, TIAA30, TIAA31, TIAA50, TIAA51,	$3T_{SMP1}$ + 20		ns
TI low-level width	t_{TIL}	TAB00 to TAB03, TAB10 to TAB13, EVTAB1, TRGAB1	12T + 20		ns
		TIAA00, TIAA01, TIAA10, TIAA11, TIAA20, TIAA21, TIAA30, TIAA31, TIAA50, TIAA51,	$3T_{SMP1}$ + 20		ns
TENCn high-level width	t_{WENCHn}	n = 0, 1	$3T_{SMP2}$ + 20		ns
TENCn low-level width	t_{WENCLn}	n = 0, 1	$3T_{SMP2}$ + 20		ns
TECR0 high-level width	t_{WCRH0}		$3T_{SMP2}$ + 20		ns
TECR0 low-level width	t_{WCRL0}		$3T_{SMP2}$ + 20		ns
TITn high-level width	t_{WTITHn}	n = 0, 1	$3T_{SMP2}$ + 20		ns
TITn low-level width	t_{WTITLn}	n = 0, 1	$3T_{SMP2}$ + 20		ns
EVTT0 high-level width	t_{WTITH0}		$3T_{SMP2}$ + 20		ns
EVTT0 low-level width	t_{WTITL0}		$3T_{SMP2}$ + 20		ns
TENCn input time difference	t_{PHUD}	n = 0, 1	$3T_{SMP2}$ + 20		ns

Remarks 1. T = 1/fxx

2. T_{SMP1}: Set by the noise elimination control register (TANFC). Selectable from fxx and fxx/4.

3. T_{SMP2}: Set by the noise elimination control register (TTNFC). Selectable from fxx/4, fxx/8, fxx/16, fxx/32, and fxx/64.

4. The specifications above show the pulse widths that can be accurately detected as valid edges. Therefore, even if a pulse width less than the above specifications is input, it may be detected as a valid edge.



(4) UARTC timing

(T_A = –40 to +85°C, V_{DD} = EV_{DD} = UV_{DD} = AV_{REF0} = AV_{REF1}, V_{SS} = AV_{SS} = 0 V, C_L = 50 pF)

Parameter	Symbol	Conditions	MIN.	MAX.	Unit
Transmit rate				3.0	Mbps
ASCK0 cycle time				10	MHz

(5) CSIF timing

(a) Master mode

[When using CSI0 to CSIF2, or CSIF4]

(T_A = –40 to +85°C, V_{DD} = EV_{DD} = UV_{DD} = AV_{REF0} = AV_{REF1}, V_{SS} = AV_{SS} = 0 V, C_L = 50 pF)

Parameter	Symbol		Conditions	MIN.	MAX.	Unit
$\overline{SCKFn}$ cycle time	t_{KCY1}	<63>		125		ns
$\overline{SCKFn}$ high-level width	t_{KH1}	<64>		$t_{KCY1}/2 - 8$		ns
$\overline{SCKFn}$ low-level width	t_{KL1}			$t_{KCY1}/2 - 8$		ns
SIFn setup time (to $\overline{SCKFn}$↑)	t_{SIK1}	<65>		27		ns
SIFn setup time (to $\overline{SCKFn}$↓)				27		ns
SIFn hold time (from $\overline{SCKFn}$↑)	t_{KSI1}	<66>		27		ns
SIFn hold time (from $\overline{SCKFn}$↓)				27		ns
SOFn output delay time (from $\overline{SCKFn}$↑)	t_{KSO1}	<67>			27	ns
SOFn output delay time (from $\overline{SCKFn}$↓)					27	ns
SOFn output hold time (from $\overline{SCKFn}$↑)	t_{HSO1}	<68>		$t_{KCY1}/2 - 10$		ns
SOFn output hold time (from $\overline{SCKFn}$↓)				$t_{KCY1}/2 - 10$		ns

Remark n = 0 to 2, 4

[When using CSI3]

(T_A = –40 to +85°C, V_{DD} = EV_{DD} = UV_{DD} = AV_{REF0} = AV_{REF1}, V_{SS} = AV_{SS} = 0 V, C_L = 50 pF)

Parameter	Symbol		Conditions	MIN.	MAX.	Unit
$\overline{SCKF3}$ cycle time	t_{KCYM}	<63>		83.3		ns
$\overline{SCKF3}$ high-level width	t_{KHM}	<64>		$t_{KCYM}/2 - 8$		ns
$\overline{SCKF3}$ low-level width				$t_{KCYM}/2 - 8$		ns
SIF3 setup time (to $\overline{SCKF3}$↑)	t_{SIKM}	<65>		16		ns
SIF3 setup time (to $\overline{SCKF3}$↓)				16		ns
SIF3 hold time (from $\overline{SCKF3}$↑)	t_{KSIM}	<66>		16		ns
SIF3 hold time (from $\overline{SCKF3}$↓)				16		ns
SOF3 output delay time (from $\overline{SCKF3}$↑)	t_{KSOM}	<67>			16	ns
SOF3 output delay time (from $\overline{SCKF3}$↓)					16	ns
SOF3 output hold time (from $\overline{SCKF3}$↑)	t_{HSOM}	<68>		$t_{KCYM}/2 - 10$		ns
SOF3 output hold time (from $\overline{SCKF3}$↓)				$t_{KCYM}/2 - 10$		ns

(b) Slave mode

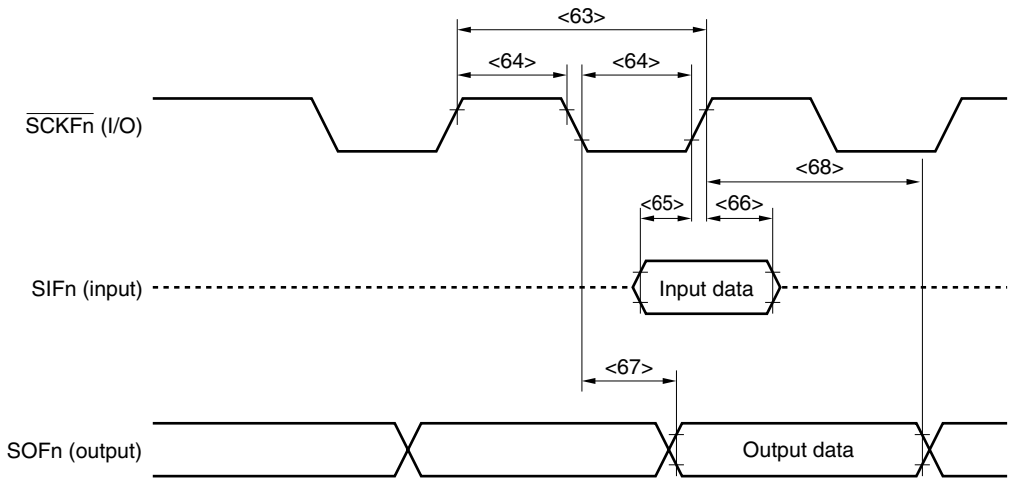
[When using CSI0 to CSIF2, or CSIF4]

(T_A = –40 to +85°C, V_{DD} = EV_{DD} = UV_{DD} = AV_{REF0} = AV_{REF1}, V_{SS} = AV_{SS} = 0 V, C_L = 50 pF)

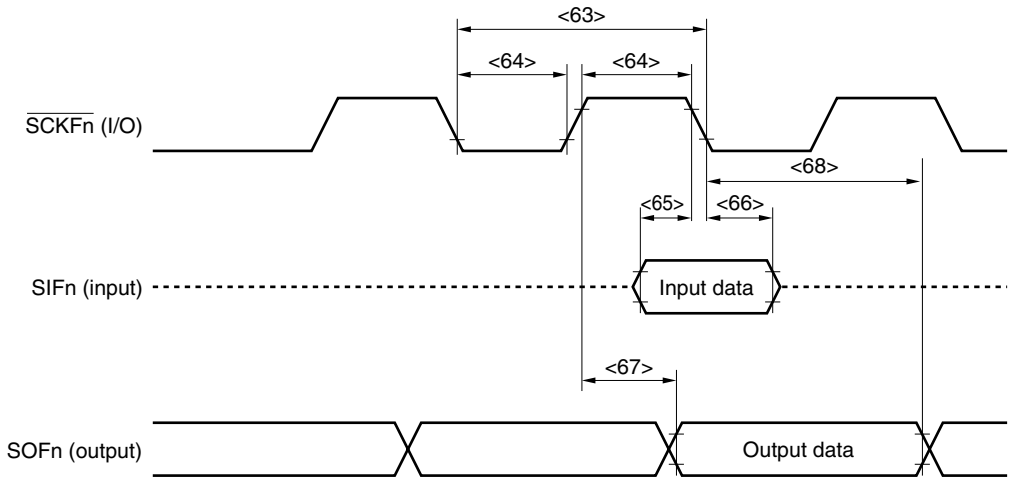
Parameter	Symbol		Conditions	MIN.	MAX.	Unit
$\overline{SCKFn}$ cycle time	t_{KCY2}	<63>		125		ns
$\overline{SCKFn}$ high-level width	t_{KH2}	<64>		$t_{KCYn}/2 - 8$		ns
$\overline{SCKFn}$ low-level width	t_{KL2}			$t_{KCYn}/2 - 8$		ns
SIFn setup time (to $\overline{SCKFn}\uparrow$)	t_{SIK2}	<65>		27		ns
SIFn setup time (from $\overline{SCKFn}\downarrow$)				27		ns
SIFn hold time (to $\overline{SCKFn}\uparrow$)	t_{KSI2}	<66>		27		ns
SIFn hold time (from $\overline{SCKFn}\downarrow$)				27		ns
SOFn output delay time (to $\overline{SCKFn}\uparrow$)	t_{KSO2}	<67>			27	ns
SOFn output delay time (from $\overline{SCKFn}\downarrow$)					27	ns
SOFn output delay time (to $\overline{SCKFn}\uparrow$)	t_{HSO2}	<68>		$t_{KCYn}/2 - 10$		ns
SOFn output delay time (from $\overline{SCKFn}\downarrow$)				$t_{KCYn}/2 - 10$		ns

Remark n = 0 to 4

(a) CFnCTL1.CFnCKP, CFnDAP bits = 00 or 11



(b) CFnCTL1.CFnCKP, CFnDAP bits = 10 or 01



Remark n = 0 to 4

(6) I^2C bus mode

(T_A = –40 to +85°C, V_{DD} = EV_{DD} = UV_{DD} = AV_{REF0} = AV_{REF1}, V_{SS} = AV_{SS} = 0 V)

Parameter		Symbol		Normal Mode		High-Speed Mode		Unit
				MIN.	MAX.	MIN.	MAX.	
SCL0n clock frequency		f_{CLK}		0	100	0	400	kHz
Bus free time (Between start and stop conditions)		t_{BUF}	<69>	4.7	–	1.3	–	μs
Hold time[Note 1]		$t_{HD:STA}$	<70>	4.0	–	0.6	–	μs
SCL0n clock low-level width		t_{LOW}	<71>	4.7	–	1.3	–	μs
SCL0n clock high-level width		t_{HIGH}	<72>	4.0	–	0.6	–	μs
Setup time for start/restart conditions		$t_{SU:STA}$	<73>	4.7	–	0.6	–	μs
Data hold time	CBUS compatible master	$t_{HD:DAT}$	<74>	5.0	–	–	–	μs
	I^2C mode			0[Note 2]	–	0[Note 2]	0.9[Note 3]	μs
Data setup time		$t_{SU:DAT}$	<75>	250	–	100[Note 4]	–	ns
SDA0n and SCL0n signal rise time		t_R	<76>	–	1000	20 + 0.1Cb[Note 5]	300	ns
SDA0n and SCL0n signal fall time		t_F	<77>	–	300	20 + 0.1Cb[Note 5]	300	ns
Stop condition setup time		$t_{SU:STO}$	<78>	4.0	–	0.6	–	μs
Pulse width of spike suppressed by input filter		t_{SP}	<79>	–	–	0	50	ns
Capacitive load of each bus line		Cb		–	400	–	400	pF

Notes 1. When the start condition is satisfied, the first clock pulse is generated after the hold time.

2. The system requires a minimum of 300 ns hold time internally for the SDA0n signal (at $V_{IHmin.}$ of the SCL0n signal) in order to occupy the undefined area at the falling edge of SCL0n.

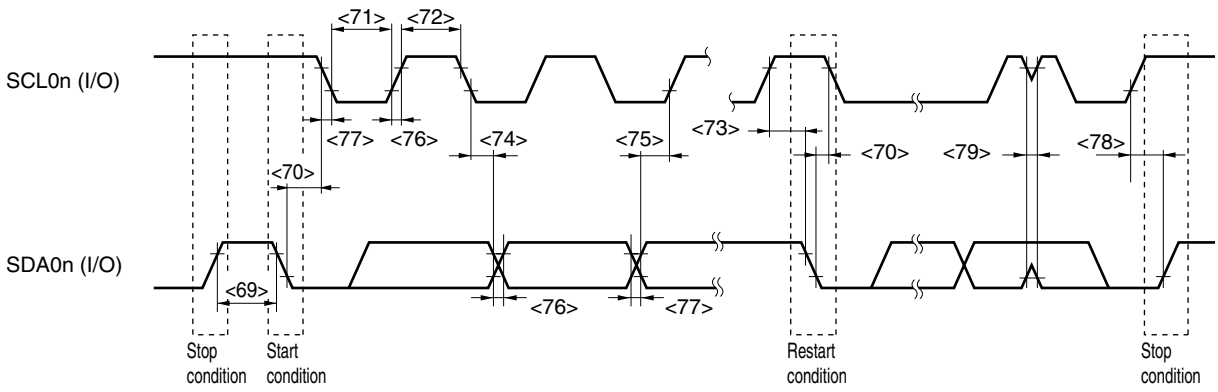
3. If the system does not extend the SCL0n signal low hold time (t_{LOW}), only the maximum data hold time ($t_{HD:DAT}$) needs to be satisfied.

4. The high-speed mode I^2C bus can be used in a normal-mode I^2C bus system. In this case, set the high-speed mode I^2C bus so that it meets the following conditions.

- If the system does not extend the SCL0n signal low hold time:
  $t_{SU:DAT} \geq 250$ ns
- If the system extends the SCL0n signal low hold time:
  Output the next data bit to the SDA0n line before the SCL0n line is released ($t_{Rmax.} + t_{SU:DAT} = 1{,}000 + 250 = 1{,}250$ ns: Normal mode I^2C bus specification).

5. Cb: Total capacitance of one bus line (unit: pF)

Remark n = 0 to 2

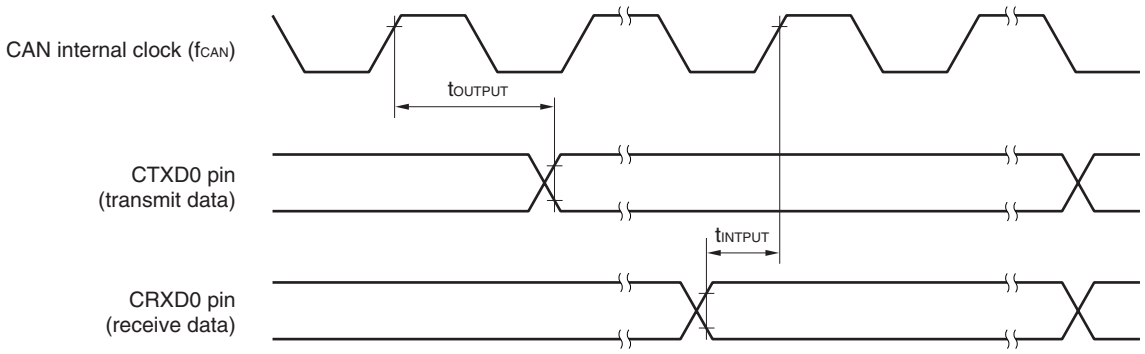


Remark n = 0 to 2

(7) CAN timing (CAN controller versions only)

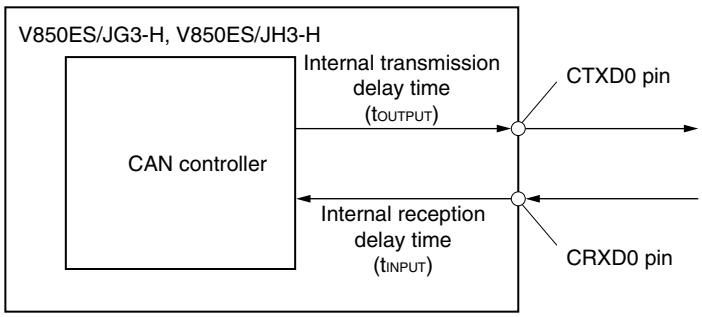
(T_A = –40 to +85°C, V_{DD} = EV_{DD} = UV_{DD} = AV_{REF0} = AV_{REF1}, V_{SS} = AV_{SS} = 0 V, C_L = 50 pF)

Parameter	Symbol	Conditions	MIN.	MAX.	Unit
Transmit rate				1	Mbps
Internal delay time	t_{NODE}			100	ns



Remark CAN internal clock (f_{CAN}): CAN baud rate clock

Internal delay time (t_{NODE}) = Internal transmission delay time (t_{OUTPUT}) + Internal reception delay time (t_{INPUT})



(8) High-impedance control timing

(T_A = –40 to +85°C, V_{DD} = EV_{DD} = UV_{DD} = AV_{REF0} = AV_{REF1}, V_{SS} = AV_{SS} = 0 V, C_L = 50 pF)

Parameter	Symbol	Conditions	MIN.	MAX.	Unit
Time from oscillator stop to timer output high impedance	t_{CLM}	Clock monitor operating		65	μs
Time from TOAB1OFF input → timer output high impedance	t_{HTQn}			300	ns
Time from TOAA1OFF input → timer output high impedance	t_{HTP2}			300	ns

(9) A/D converter

(T_A = –40 to +85°C, V_{DD} = EV_{DD} = UV_{DD} = AV_{REF0} = AV_{REF1}, 3.0 V ≤ AV_{REF0} ≤ 3.6 V, V_{SS} = AV_{SS} = 0 V, C_L = 50 pF)

Parameter	Symbol	Conditions	MIN.	TYP.	MAX.	Unit
Resolution					10	bit
Overall error[Note]		3.0 ≤ AV_{REF0} ≤ 3.6 V			±0.6	%FSR
Conversion time	t_{CONV}		2.17		24	μs
Zero scale error					±0.5	%FSR
Full scale error					±0.5	%FSR
Non-linearity error					±4.0	LSB
Differential linearity error					±4.0	LSB
Analog input voltage	V_{IAN}		AV_{SS}		AV_{REF0}	V
Reference voltage	AV_{REF0}		3.0		3.6	V
AV_{REF0} current	AI_{REF0}	Normal conversion mode		3	6.5	mA
		High-speed conversion mode		4	10	mA
		When A/D converter unused			5	μA

Note Excluding quantization error (±0.05 %FSR).

Caution Do not set (read/write) alternate-function ports during A/D conversion; otherwise the conversion resolution may be degraded.

Remark LSB: Least Significant Bit
FSR: Full Scale Range

(10) D/A converter

(T_A = –40 to +85°C, V_{DD} = EV_{DD} = UV_{DD} = AV_{REF0} = AV_{REF1}, 3.0 V ≤ AV_{REF1} ≤ 3.6 V, V_{SS} = AV_{SS} = 0 V, C_L = 50 pF)

Parameter	Symbol	Conditions	MIN.	TYP.	MAX.	Unit
Resolution					8	bit
Overall error[Note 1]		R = 2 MΩ			±1.2	%FSR
Settling time		C = 20 pF			3	μs
Output resistor	R_O	Output data 55H		6.42		kΩ
Reference voltage	AV_{REF1}		3.0		3.6	V
AV_{REF1} current[Note 2]	AI_{REF1}	D/A conversion operating		1	2.5	mA
		D/A conversion stopped			5	μA

Notes 1. Excluding quantization error (±0.5 %LSB).

2. Value of 1 channel of D/A converter

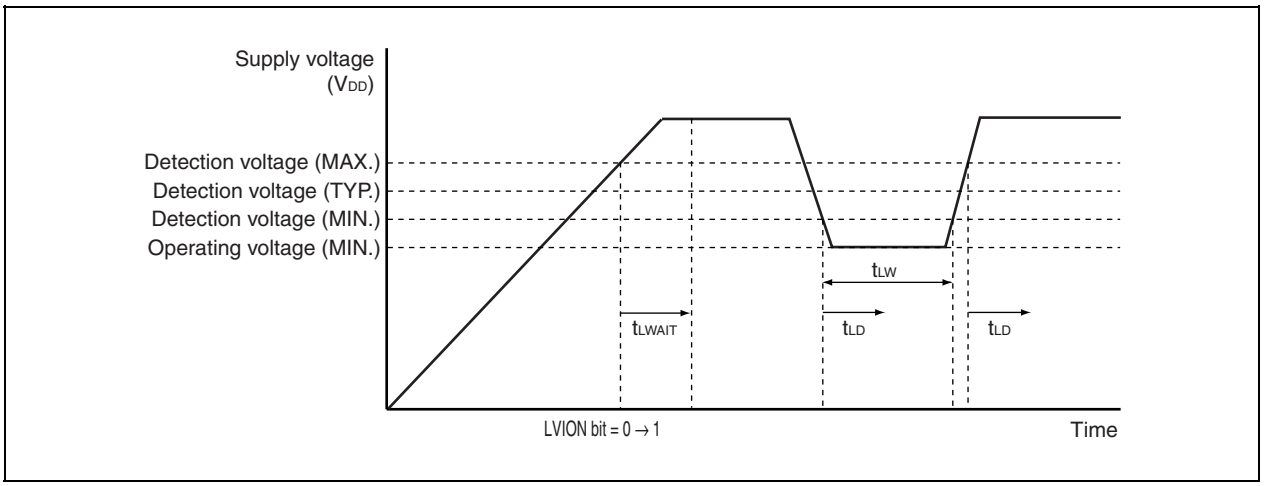
Remark R is the output pin load resistance and C is the output pin load capacitance.

(11) LVI circuit characteristics

(T_A = –40 to +85°C, V_{DD} = EV_{DD} = UV_{DD} = AV_{REF0} = AV_{REF1}, V_{SS} = AV_{SS} = 0 V, C_L = 50 pF)

Parameter	Symbol	Conditions	MIN.	TYP.	MAX.	Unit
Detection voltage	V_{LVI0}		2.85	2.95	3.05	V
Response time[Note]	t_{LD}	After V_{DD} reaches V_{LVI0} (MAX.), or after V_{DD} has dropped to V_{LVI0} (MAX.)		0.2	2.0	ms
Minimum pulse width	t_{LW}		0.2			ms
Reference voltage stabilization wait time	t_{LWAIT}	After V_{DD} reaches 2.85 V(MIN.)		0.1	0.2	ms

Note Time required to detect the detection voltage and output an interrupt or reset signal.

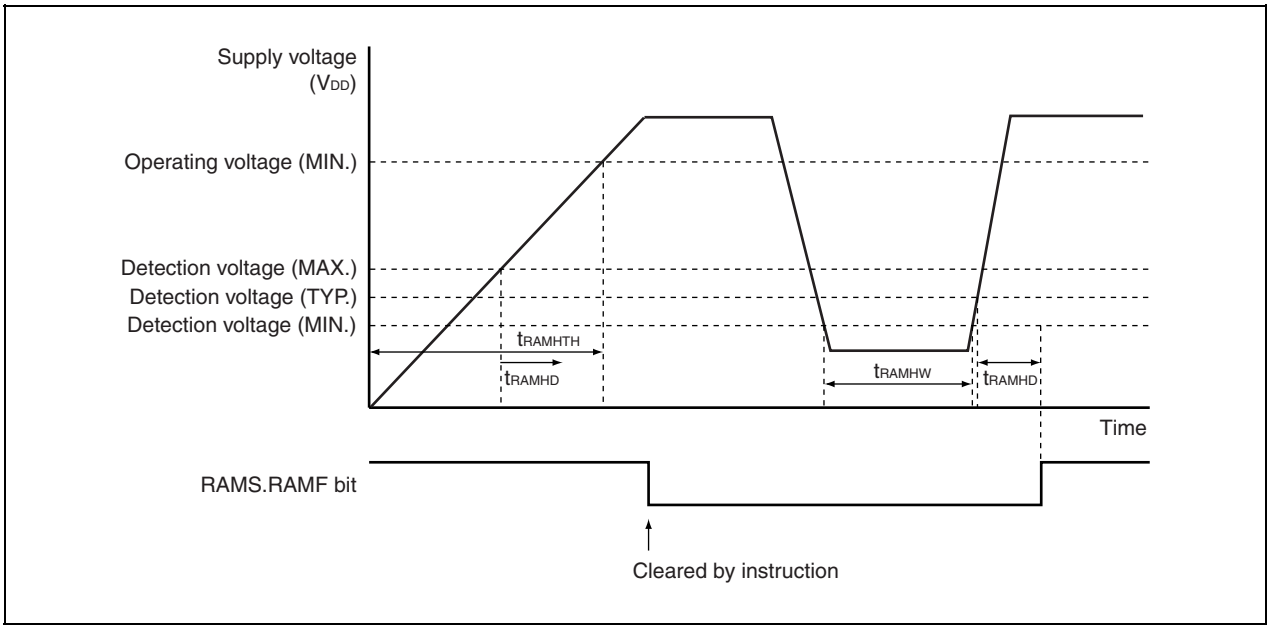


(12) RAM retention detection

(T_A = –40 to +85°C, V_{DD} = EV_{DD} = UV_{DD} = AV_{REF0} = AV_{REF1}, V_{SS} = AV_{SS} = 0 V, C_L = 50 pF)

Parameter	Symbol	Conditions	MIN.	TYP.	MAX.	Unit
Detection voltage	V_{RAMH}		1.9	2.0	2.1	V
Supply voltage rise time	t_{RAMHTH}	V_{DD} = 0 to 2.85 V	0.002			ms
Response time[Note]	t_{RAMHD}	After V_{DD} reaches 2.1 V		0.2	3.0	ms
Minimum pulse width	t_{RAMHW}		0.2			ms

Note Time required to detect the detection voltage and set the RAMS.RAMF bit.



33.9 Flash Memory Programming Characteristics

(T_A = −40 to +85°C, V_{DD} = EV_{DD} = UV_{DD} = AV_{REF0} = AV_{REF1}, V_{SS} = AV_{SS} = 0 V, C_L = 50 pF)

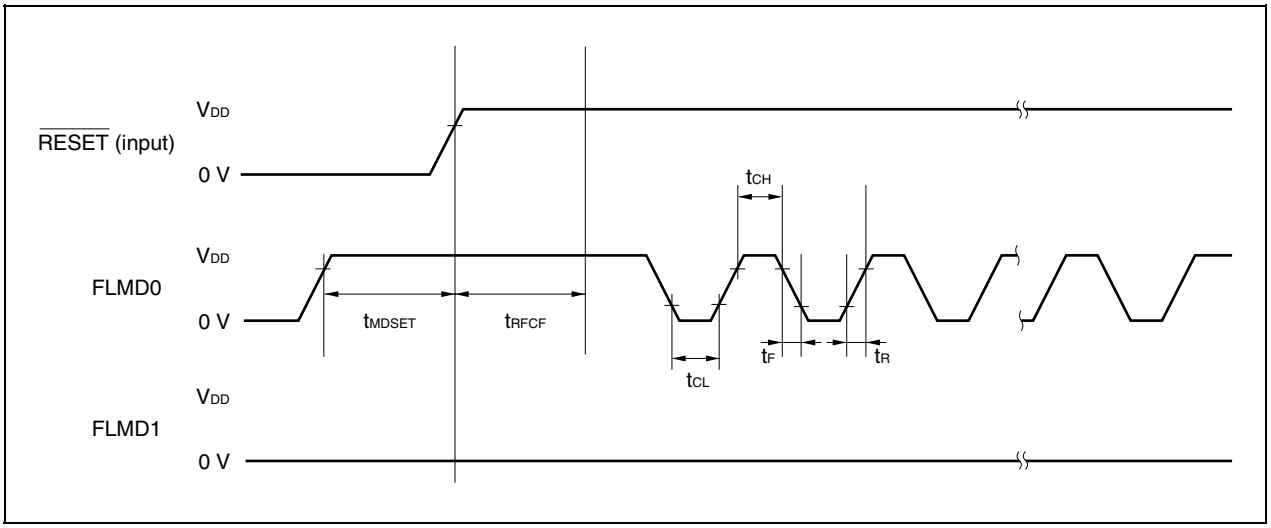
(1) Basic characteristics

Parameter	Symbol	Conditions		MIN.	TYP.	MAX.	Unit
Operating frequency	f_{CPU}			24		48	MHz
Supply voltage	V_{DD}			2.85		3.6	V
Number of rewrites	C_{WRT}	Used for updating programs When using flash memory programmer and Renesas Electronics self programming library	Retained for 15 years	1,000			times
		Used for updating data When using Renesas Electronics EEPROM emulation library (usable ROM size: 12 KB of 3 consecutive blocks)	Retained for 5 years	10,000			times
Programming temperature	t_{PRG}			−40		+85	°C

(2) Serial write operation characteristics

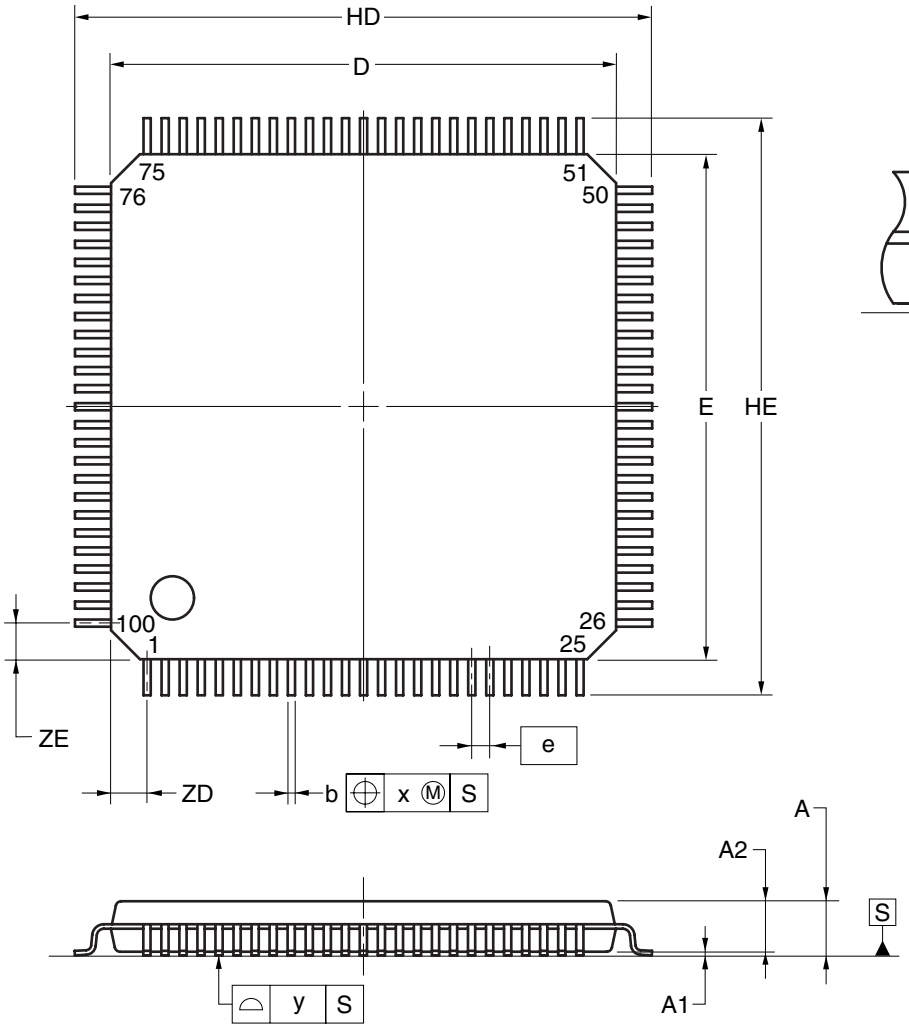
Parameter	Symbol	Conditions	MIN.	TYP.	MAX.	Unit
FLMD0, FLMD1 setup time	t_{MDSET}		2		3000	ms
FLMD0 count start time from $\overline{RESET}$↑	t_{RFCF}	f_X = 3 to 6 MHz	800			μs
FLMD0 counter high-level width/ low-level width	t_{CH}/t_{CL}		10		100	μs
FLMD0 counter rise time/fall time	t_R/t_F				1	μs

Flash write mode setup timing

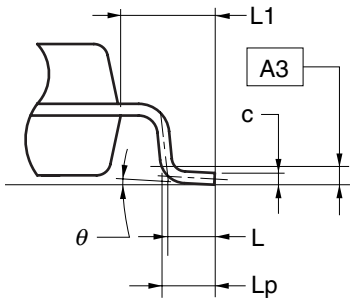


CHAPTER 34 PACKAGE DRAWINGS

100-PIN PLASTIC LQFP (FINE PITCH) (14x14)



detail of lead end

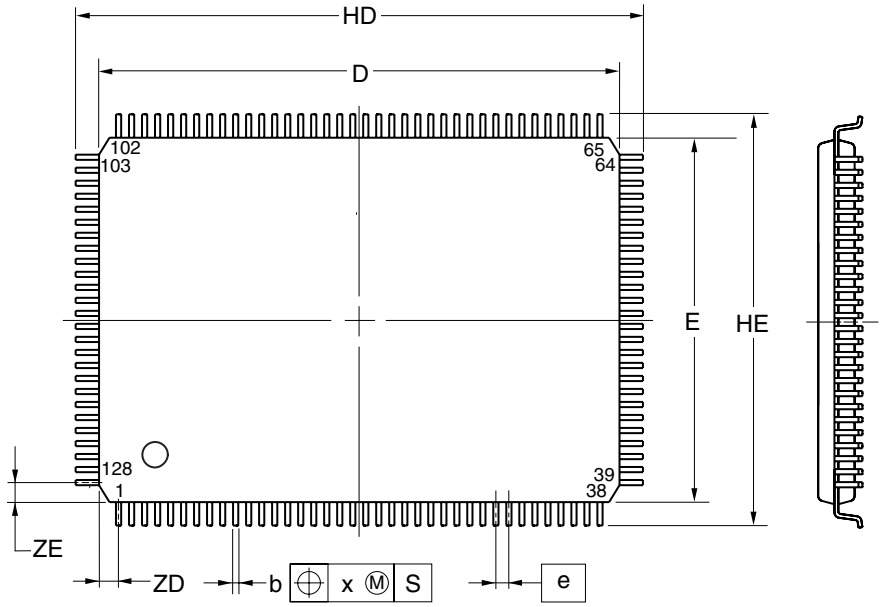


(UNIT:mm)

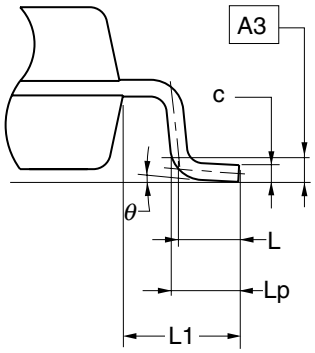
ITEM	DIMENSIONS
D	14.00±0.20
E	14.00±0.20
HD	16.00±0.20
HE	16.00±0.20
A	1.60 MAX.
A1	0.10±0.05
A2	1.40±0.05
A3	0.25
b	$0.20^{+0.07}_{-0.03}$
c	$0.125^{+0.075}_{-0.025}$
L	0.50
Lp	0.60±0.15
L1	1.00±0.20
θ	$3^{\circ}{}^{+5^{\circ}}_{-3^{\circ}}$
e	0.50
x	0.08
y	0.08
ZD	1.00
ZE	1.00

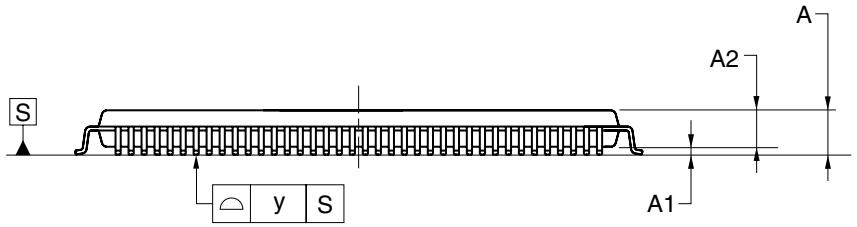
P100GC-50-UEU-1

128-PIN PLASTIC LQFP (FINE PITCH) (14x20)



detail of lead end





NOTE
Each lead centerline is located within 0.08 mm of its true position at maximum material condition.

(UNIT:mm)

ITEM	DIMENSIONS
D	20.00±0.20
E	14.00±0.20
HD	22.00±0.20
HE	16.00±0.20
A	1.60 MAX.
A1	0.10±0.05
A2	1.40±0.05
A3	0.25
b	$0.20^{+0.07}_{-0.03}$
c	$0.125^{+0.075}_{-0.025}$
L	0.50
Lp	0.60±0.15
L1	1.00±0.20
θ	$3^{\circ}{}^{+5^{\circ}}_{-3^{\circ}}$
e	0.50
x	0.08
y	0.08
ZD	0.75
ZE	0.75

P128GF-50-GAT

CHAPTER 35 RECOMMENDED SOLDERING CONDITIONS

These products should be soldered and mounted under the following recommended conditions.

For soldering methods and conditions other than those recommended below, please contact a Renesas Electronics sales representative.

For technical information, see the following website.

Semiconductor Device Mount Manual (http://www2.renesas.com/pkg/en/mount/index.html)

Remark Evaluation of the soldering conditions for the (A) standard products is incomplete because these products are under development.

Table 35-1. Surface Mounting Type Soldering Conditions (1/2)

μPD70F3760GC-UEU-AX: 100-pin plastic LQFP (fine pitch) (14 × 14 mm)
μPD70F3761GC-UEU-AX: 100-pin plastic LQFP (fine pitch) (14 × 14 mm)
μPD70F3762GC-UEU-AX: 100-pin plastic LQFP (fine pitch) (14 × 14 mm)
μPD70F3770GC-UEU-AX: 100-pin plastic LQFP (fine pitch) (14 × 14 mm)

Soldering Method	Soldering Conditions	Recommended Condition Symbol
Infrared reflow	Package peak temperature: 260°C, Time: 60 seconds max. (at 220°C or higher), Count: 3 times or less, Exposure limit: 7 days[Note] (after that, prebake at 125°C for 20 to 72 hours)	IR60-207-3
Partial heating	Pin temperature: 350°C max., Time: 3 seconds max. (per pin row)	–

Note After opening the dry pack, store it at 25°C or less and 65% RH or less for the allowable storage period.

Caution Do not use different soldering methods together (except for partial heating).

Remarks 1. Products with –AX at the end of the part number are lead-free products.

2. For soldering methods and conditions other than those recommended, please contact a Renesas Electronics sales representative.

Table 35-1. Surface Mounting Type Soldering Conditions (2/2)

μPD70F3765GF-GAT-AX: 128-pin plastic LQFP (fine pitch) (14 × 20 mm)
μPD70F3766GF-GAT-AX: 128-pin plastic LQFP (fine pitch) (14 × 20 mm)
μPD70F3767GF-GAT-AX: 128-pin plastic LQFP (fine pitch) (14 × 20 mm)
μPD70F3771GF-GAT-AX: 128-pin plastic LQFP (fine pitch) (14 × 20 mm)

Soldering Method	Soldering Conditions	Recommended Condition Symbol
Infrared reflow	Package peak temperature: 260°C, Time: 60 seconds max. (at 220°C or higher), Count: 3 times or less, Exposure limit: 7 days[Note] (after that, prebake at 125°C for 20 to 72 hours)	IR60-207-3
Partial heating	Pin temperature: 350°C max., Time: 3 seconds max. (per pin row)	–

Note After opening the dry pack, store it at 25°C or less and 65% RH or less for the allowable storage period.

Caution Do not use different soldering methods together (except for partial heating).

Remarks 1. Products with –AX at the end of the part number are lead-free products.

2. For soldering methods and conditions other than those recommended, please contact a Renesas Electronics sales representative.

APPENDIX A DEVELOPMENT TOOLS

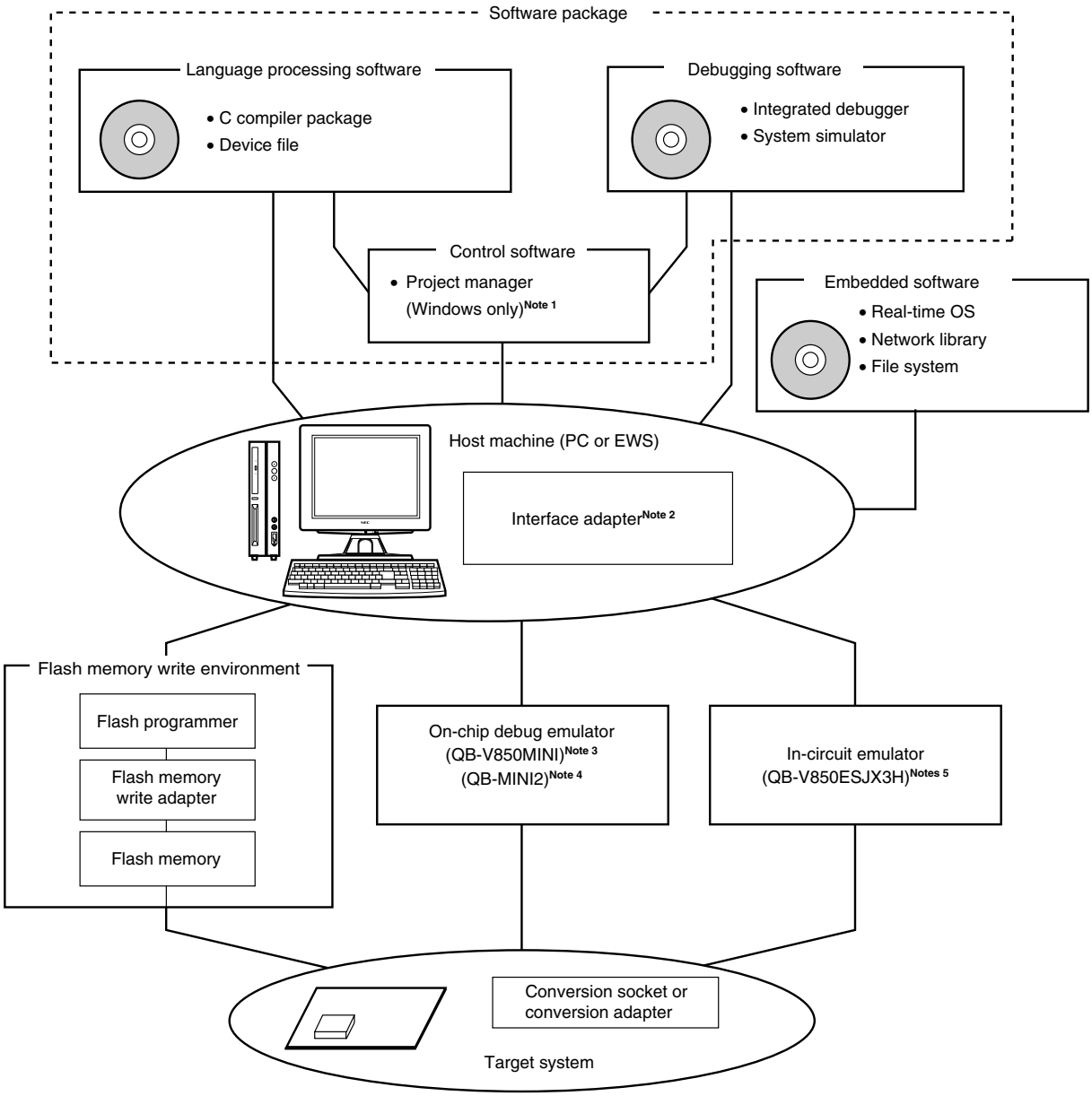
The following development tools are available for the development of systems that employ the V850ES/JG3-H or V850ES/JH3-H.

Figure A-1 shows the development tool configuration.

- **Support for PC98-NX series**
  Unless otherwise specified, products supported by IBM PC/AT™ compatibles are compatible with PC98-NX series computers. When using PC98-NX series computers, refer to the explanation for IBM PC/AT compatibles.

- **Windows™**
  Unless otherwise specified, “Windows” means the following OSs.
  - Windows 98, 2000
  - Windows Me
  - Windows XP
  - Windows NT™ Ver. 4.0

Figure A-1. Development Tool Configuration



Notes 1. Project manager PM+ is included in the C compiler package.
PM+ is only used in Windows.

2. The QB-V850MINI, QB-MINI2, and QB-V850ESJX3H (under development) support the USB interface only.

3. The QB-V850MINI is supplied with the ID850QB, USB interface cable, OCD cable, self-check board, KEL adapter, and KEL connector. All other products are optional.

4. The QB-MINI2 is supplied with USB interface cable, 16-pin target cable, 10-pin target cable, and 78K0-OCD board (integrated debugger is not supplied.) All other products are optional.

5. The QB-V850ESJX3H is supplied with the ID850QB, flash memory programmer (MINICUBE2), power supply unit, and USB interface adapter. All other products are optional.

A.1 Software Package

SP850 Software package for V850 microcontrollers	Development tools (software) commonly used with V850 microcontrollers are included this package.
	Part number: μS××××SP850

Remark ×××× in the part number differs depending on the host machine and OS used.

μS××××SP850

××××	Host Machine	OS	Supply Medium
AB17	PC-9800 series, IBM PC/AT compatibles	Windows (Japanese version)	CD-ROM
BB17		Windows (English version)	

A.2 Language Processing Software

CA850 C compiler package	This compiler converts programs written in C into object codes executable with a microcontroller. This compiler is started from project manager PM+.
	Part number: μS××××CA703000
DF703771 Device file	This file contains information peculiar to the device. This device file should be used in combination with a tool (CA850 or ID850QB). The corresponding OS and host machine differ depending on the tool to be used.

Remark ×××× in the part number differs depending on the host machine and OS used.

μS××××CA703000

××××	Host Machine	OS	Supply Medium
AB17	PC-9800 series, IBM PC/AT compatibles	Windows (Japanese version)	CD-ROM
BB17		Windows (English version)	
3K17	SPARCstation™	SunOS™ (Rel. 4.1.4), Solaris™ (Rel. 2.5.1)	

A.3 Control Software

PM+ Project manager	This is control software designed to enable efficient user program development in the Windows environment. All operations used in development of a user program, such as starting the editor, building, and starting the debugger, can be performed from PM+. **<Caution>** PM+ is included in C compiler package CA850. It can only be used in Windows.

A.4 Debugging Tools (Hardware)

A.4.1 When using IECUBE QB-V850ESJX3H

The system configuration when connecting the QB-V850ESJX3H to the host machine (PC-9821 series, PC/AT compatible) is shown below. Even if optional products are not prepared, connection is possible.

Figure A-2. System Configuration (When Using QB-V850ESJX3H) (1/2)

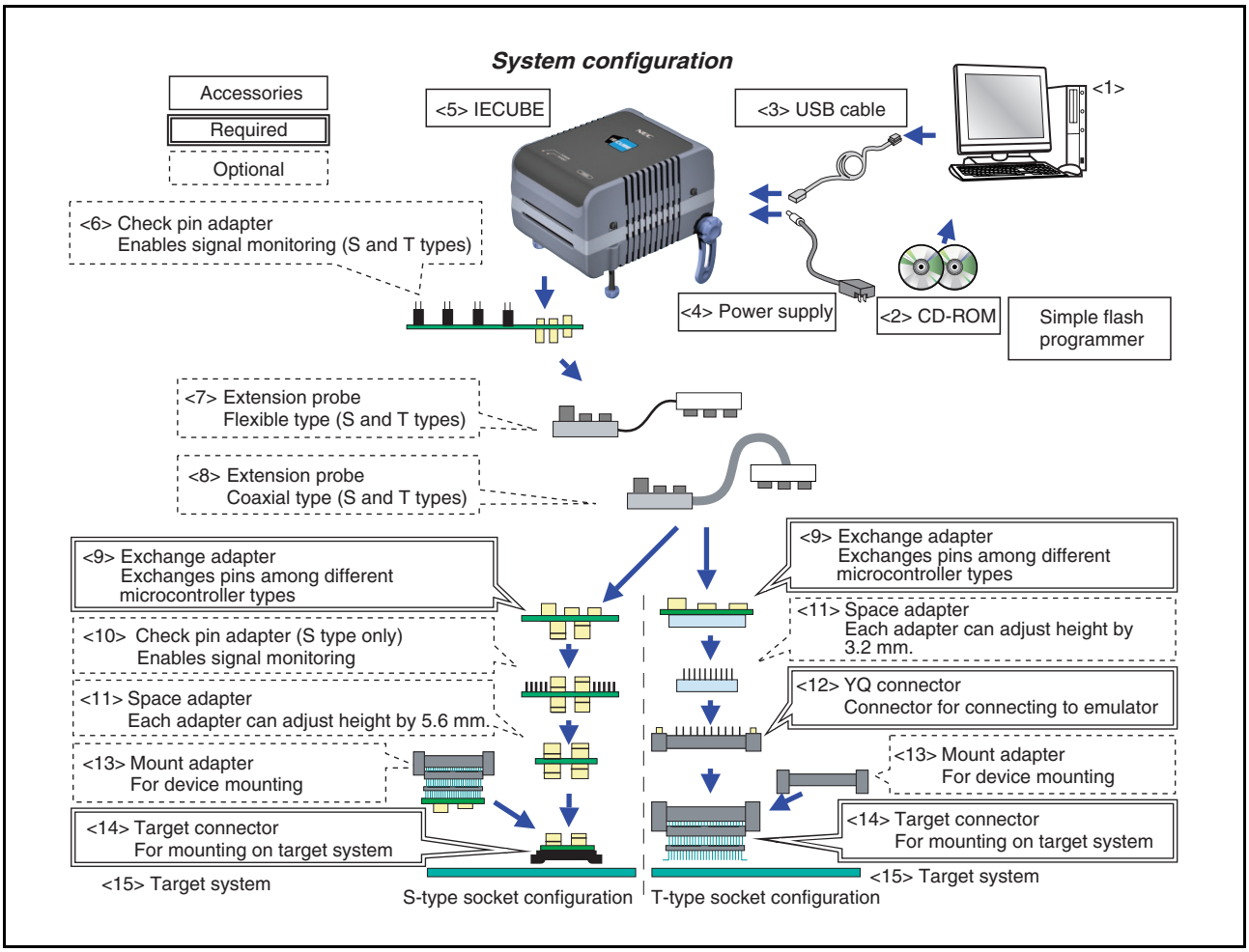


Figure A-2. System Configuration (When Using QB-V850ESJX3H) (2/2)

<1> Host machine (PC-9821 series, IBM-PC/AT compatibles)
<2> Debugger, USB driver, manuals, etc. (ID850QB Disk, Accessory Disk[Note 1])
<3> USB interface cable
<4> AC adapter
<5> In-circuit emulator (QB-V850ESJX3H)
<6> Check pin adapter (S and T types) (QB-144-CA-01) (optional)
<7> Extension probe (flexible type) (S and T types) (QB-144-EP-02S) (optional)
<8> Extension probe (coaxial type) (S and T types) (QB-144-EP-01S) (optional)
<9> Exchange adapter[Note 2] (S type: QB-100GC-EA-04S (GC package), QB-128GF-EA-01S (GF package), T type: QB-100GC-EA-05T (GC package), QB-128GF-EA-02T (GF package))
<10> Check pin adapter[Note 3] (S type only: QB-100-CA-01S (GC package), QB-128GF-CA-01S (GF package)) (optional)
<11> Space adapter[Note 3] (S type: QB-100-SA-01S (GC package), QB-144-SA-01S (GF package), T type: QB-100GC-YS-01T (GC package), QB-128GF-YS-01T (GF package) (optional)
<12> YQ connector[Note 2] (T type only) (QB-100GC-YQ-01T) (GC package), QB-128GF-YQ-01T (GF package)
<13> Mount adapter (S type: QB-100GC-MA-01S (GC package), QB-128GF-MA-01S (GF package), T type: QB-100GC-HQ-01T (GC package), QB-128GF-HQ-01T (GF package)) (optional)
<14> Target connector[Note 2] (S type: QB-100GC-TC-01S (GC package), QB-128GF-TC-01S (GF package), T type: QB-100GC-NQ-01T (GC package), QB-128GF-NQ-01T (GF package))
<15> Target system

Notes 1. Download the device file from the Renesas Electronics website.
http://www2.renesas.com/micro/en/ods/index.html

2. Supplied with the device depending on the ordering number.
- When QB-V850ESJX3H-ZZZ is ordered
  The exchange adapter and the target connector are not supplied.
- When QB-V850ESJX3H-S100GC is ordered
  The QB-100GC-EA-04S and QB-100GC-TC-01S are supplied.
- When QB-V850ESJX3H-S128GF is ordered
  The QB-128GF-EA-01S and QB-128GF-TC-01S are supplied.
- When QB-V850ESJX3H-T100GC is ordered
  The QB-100GC-EA-05T, QB-100GC-YQ-01T, and QB-100GC-NQ-01T are supplied.
- When QB-V850ESJX3H-T128GF is ordered
  The QB-1028GF-EA-02T, QB-128GF-YQ-01T, and QB-128GF-NQ-01T are supplied.

3. When using both <9> and <10>, the order between <9> and <10> is not cared.

<5> QB-V850ESJX3H[Note] In-circuit emulator	The in-circuit emulator serves to debug hardware and software when developing application systems using the V850ES/JG3-H or V850ES/JH3-H. It supports the integrated debugger ID850QB. This emulator should be used in combination with a power supply unit and emulation probe. Use the USB interface cable to connect this emulator to the host machine.
<3> USB interface cable	Cable to connect the host machine and the QB-V850ESJX3H.
<4> AC adapter	100 to 240 V can be supported by replacing the AC plug.
<9> QB-100GC-EA-04S QB-128GF-EA-01S QB-100GC-EA-05T QB-128GF-EA-02T Exchange adapter	Adapter to perform pin conversion. • QB-100GC-EA-04S: 100-pin plastic LQFP (GC-UEU type) • QB-128GF-EA-01S: 128-pin plastic LQFP (GF-GAT type) • QB-100GC-EA-05T: 100-pin plastic LQFP (GC-UEU type) • QB-128GF-EA-02T: 128-pin plastic LQFP (GC-GAT type)
<10> QB-100-CA-01S QB-128-CA-01S (S type only) Check pin adapter	Adapter used in waveform monitoring using the oscilloscope, etc. • QB-100-CA-01S: 100-pin plastic LQFP (GC-UEU type) • QB-128-CA-01S: 128-pin plastic LQFP (GF-GAT type)
<11> QB-100-SA-01S QB-144-SA-01S QB-100GC-YS-01T QB-128GF-YS-01T Space adapter	Adapter to adjust the height. • QB-100-SA-01S: 100-pin plastic LQFP (GC-UEU type) • QB-144-SA-01S: 128-pin plastic LQFP (GF-GAT type) • QB-100GC-YS-01T: 100-pin plastic LQFP (GC-UEU type) • QB-128GF-YS-01T: 128-pin plastic LQFP (GF-GAT type)
<12> QB-100GC-YQ-01T QB-128GF-YQ-01T (T type only) YQ connector	Conversion adapter to connect target connector and exchange adapter • QB-100GC-YQ-01T: 100-pin plastic LQFP (GC-UEU type) • QB-128GF-YQ-01T: 128-pin plastic LQFP (GF-GAT type)
<13> QB-100GC-MA-01S QB-128GF-MA-01S QB-100GC-HQ-01T QB-128GF-HQ-01T Mount adapter	Adapter to mount the V850ES/JG3-H or V850ES/JH3-H on a socket. • QB-100GC-MA-01S: 100-pin plastic LQFP (GC-UEU type) • QB-128GF-MA-01S: 128-pin plastic LQFP (GF-GAT type) • QB-100GC-HQ-01T: 100-pin plastic LQFP (GC-UEU type) • QB-128GF-HQ-01T: 128-pin plastic LQFP (GF-GAT type)
<14> QB-100GC-TC-01S QB-128GF-TC-01S QB-100GC-NQ-01T QB-128GF-NQ-01T Target connector	Connector to solder on the target system. • QB-100GC-TC-01S: 100-pin plastic LQFP (GC-UEU type) • QB-128GF-TC-01S: 128-pin plastic LQFP (GF-GAT type) • QB-100GC-NQ-01T: 100-pin plastic LQFP (GC-UEU type) • QB-128GF-NQ-01T: 128-pin plastic LQFP (GF-GAT type)

Note The QB-V850ESJX3H is supplied with a power supply unit, USB interface cable, and flash memory programmer (MINICUBE2). It is also supplied with integrated debugger ID850QB as control software.

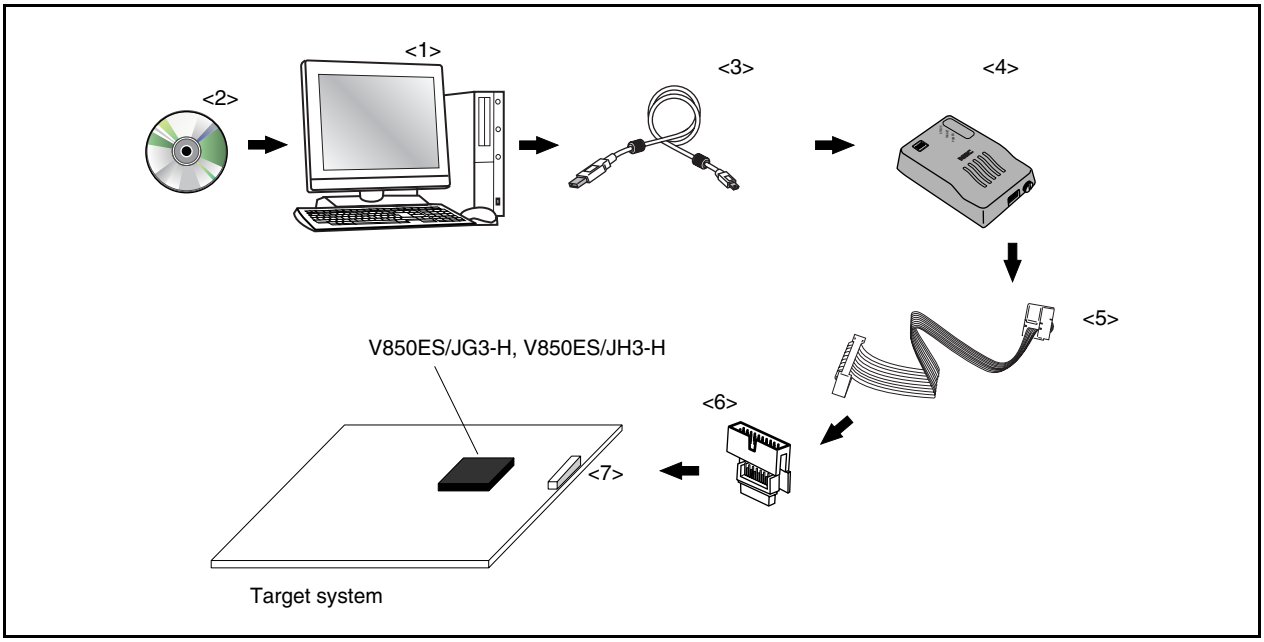
Remark The numbers in the angle brackets correspond to the numbers in Figure A-2.

A.4.2 When using MINICUBE QB-V850MINI

(1) On-chip emulation using MINICUBE

The system configuration when connecting MINICUBE to the host machine (PC-9821 series, PC/AT compatible) is shown below.

Figure A-3. On-Chip Emulation System Configuration



<1> Host machine	PC with USB ports
<2> CD-ROM[Note 1]	Contents such as integrated debugger ID850QB, N-Wire Checker, device driver, and documents are included in CD-ROM. It is supplied with MINICUBE.
<3> USB interface cable	USB cable to connect the host machine and MINICUBE. It is supplied with MINICUBE. The cable length is approximately 2 m.
<4> MINICUBE On-chip debug emulator	This on-chip debug emulator serves to debug hardware and software when developing application systems using the V850ES/JG3-H or V850ES/JH3-H. It supports integrated debugger ID850QB.
<5> OCD cable	Cable to connect MINICUBE and the target system. It is supplied with MINICUBE. The cable length is approximately 20 cm.
<6> Connector conversion board KEL adapter	This conversion board is supplied with MINICUBE.
<7> MINICUBE connector KEL connector[Note 2]	8830E-026-170S (supplied with MINICUBE) 8830E-026-170L (sold separately)

Notes 1. Download the device file from the Renesas Electronics website.
http://www2.renesas.com/micro/en/ods/index.html

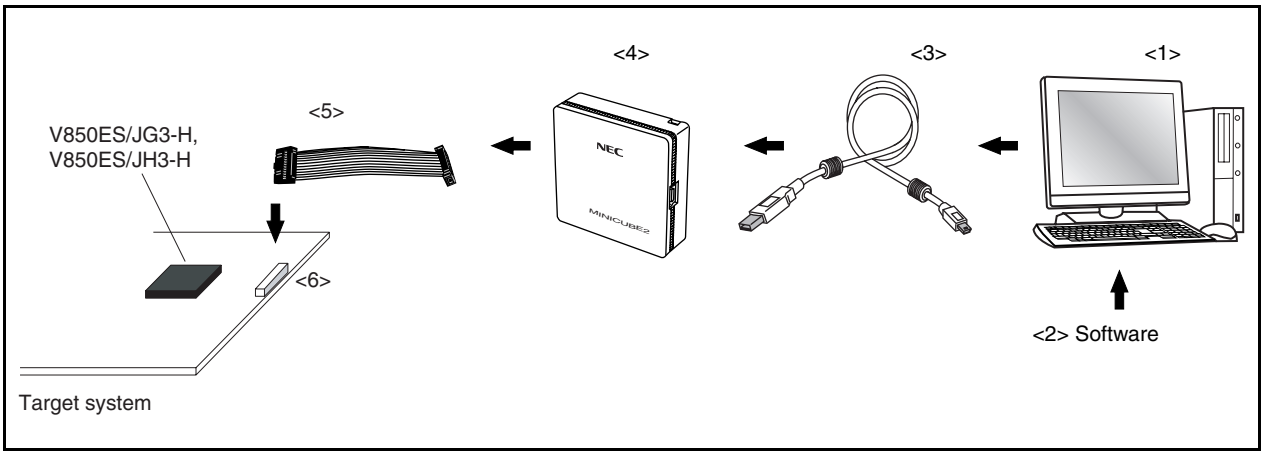
2. Product of KEL Corporation

Remark The numbers in the angular brackets correspond to the numbers in Figure A-3.

A.4.3 When using MINICUBE2 QB-MINI2

The system configuration when connecting MINICUBE2 to the host machine (PC-9821 series, PC/AT compatible) is shown below.

Figure A-4. System Configuration of On-Chip Emulation System



<1> Host machine	PC with USB ports
<2> Software	The integrated debugger ID850QB, device file, etc. Download the device file from the Renesas Electronics website. http://www2.renesas.com/micro/en/ods/index.html
<3> USB interface cable	USB cable to connect the host machine and MINICUBE. It is supplied with MINICUBE. The cable length is approximately 2 m.
<4> MINICUBE2 On-chip debug emulator	This on-chip debug emulator serves to debug hardware and software when developing application systems using the V850ES/JG3-H or V850ES/JH3-H. It supports integrated debugger ID850QB.
<5> 16-pin target cable	Cable to connect MINICUBE2 and the target system. It is supplied with MINICUBE. The cable length is approximately 15 cm.
<6> Target connector (sold separately)	Use a 16-pin general-purpose connector with 2.54 mm pitch.

Remark The numbers in the angular brackets correspond to the numbers in Figure A-4.

A.5 Debugging Tools (Software)

ID850QB Integrated debugger	This debugger supports the in-circuit emulators for V850 microcontrollers. The ID850QB is Windows-based software. It has improved C-compatible debugging functions and can display the results of tracing with the source program using a window integration function that associates the source program, disassemble display, and memory display with the trace result. It should be used in combination with the device file.
	Part number: μS×××× ID703000-QB (ID850QB)

Remark ×××× in the part number differs depending on the host machine and OS used.

μS××××ID703000-QB

××××	Host Machine	OS	Supply Medium
AB17	PC-9800 series, IBM PC/AT compatibles	Windows (Japanese version)	CD-ROM
BB17		Windows (English version)	

A.6 Embedded Software

RX850, RX850 Pro Real-time OS	The RX850 and RX850 Pro are real-time OSs conforming to μITRON 3.0 specifications. A tool (configurator) for generating multiple information tables is supplied. RX850 Pro has more functions than the RX850.
	Part number: μS××××RX703000-ΔΔΔΔ (RX850) μS××××RX703100-ΔΔΔΔ (RX850 Pro)
RX-FS850 (File system)	This is a FAT file system function. It is a file system that supports the CD-ROM file system function. This file system is used with the real-time OS RX850 Pro.

Caution To purchase the RX850 or RX850 Pro, first fill in the purchase application form and sign the license agreement.

Remark ×××× and ΔΔΔΔ in the part number differ depending on the host machine and OS used.

μS××××RX703000-ΔΔΔΔ
μS××××RX703100-ΔΔΔΔ

ΔΔΔΔ	Product Outline	Maximum Number for Use in Mass Production
001	Evaluation object	Do not use for mass-produced product.
100K	Mass-production object	0.1 million units
001M		1 million units
010M		10 million units
S01	Source program	Object source program for mass production

××××	Host Machine	OS	Supply Medium
AB17	PC-9800 series, IBM PC/AT compatibles	Windows (Japanese version)	CD-ROM
BB17		Windows (English version)	
3K17	SPARCstation	Solaris (Rel. 2.5.1)	

A.7 Flash Memory Writing Tools

Flashpro V (part number: PG-FP5) Flash programmer	Flash programmer dedicated to microcontrollers with internal flash memory.
QB-MINI2 (MINICUBE2)	On-chip debug emulator with programming function.
FA-100GC-UEU-B FA-128GF-GAT-B Flash memory writing adapter	Flash memory writing adapter (not wired) used by connecting to the Flashpro V, etc. • FA-100GC-UEU-B: 100-pin plastic LQFP (GC-UEU type) • FA-128GF-GAT-B: 100-pin plastic LQFP (GF-GAT type)

Remark FA-100GC-UEU-B and FA-128GF-GAT-B are products of Naito Densei Machida Mfg. Co., Ltd.
TEL: +81-42-750-4172

APPENDIX B MAJOR DIFFERENCES BETWEEN V850ES/Jx3-H AND V850ES/Jx3

Table B-1. Major Differences Between V850ES/Jx3-H and V850ES/Jx3

Major Difference	V850ES/Jx3-H	V850ES/Jx3
Minimum instruction execution time	20.8 ns (48 MHz operation)	31.25 ns (32 MHz operation)
16-bit timer	TAA (high-performance type of TMP)	TMP
	TAB (high-performance type of TMQ)	TMQ
	TMT (encoder timer)	None
Watch timer function	RTC (Hardware counter included)	WT (Hardware counter not included)
Motor control function	Available	None
USB interface	Function	None
Asynchronous serial interface	UARTC (high-performance type of UARTA)	UARTA
Package	100-pin LQFP 128-pin LQFP	100-pin LQFP 144-pin LQFP

APPENDIX C REGISTER INDEX

(1/37)

(2/37)

Symbol	Name	Unit	Page
C0BRP	CAN0 module bit rate prescaler register	CAN	960
C0BTR	CAN0 module bit rate register	CAN	962
C0CTRL	CAN0 module control register	CAN	950
C0ERC	CAN0 module error counter register	CAN	956
C0GMABT	CAN0 global automatic block transmission control register	CAN	945
C0GMABTD	CAN0 global automatic block transmission delay setting register	CAN	947
C0GMCS	CAN0 global clock selection register	CAN	944
C0GMCTRL	CAN0 global control register	CAN	942
C0IE	CAN0 module interrupt enable register	CAN	957
C0INFO	CAN0 module information register	CAN	955
C0INTS	CAN0 module interrupt status register	CAN	959
C0LEC	CAN0 module last error information register	CAN	954
C0LIPT	CAN0 module last in-pointer register	CAN	963
C0LOPT	CAN0 module last out-pointer register	CAN	965
C0MASK1H	CAN0 module mask 1 register H	CAN	948
C0MASK1L	CAN0 module mask 1 register L	CAN	948
C0MASK2H	CAN0 module mask 2 register H	CAN	948
C0MASK2L	CAN0 module mask 2 register L	CAN	948
C0MASK3H	CAN0 module mask 3 register H	CAN	948
C0MASK3L	CAN0 module mask 3 register L	CAN	948
C0MASK4H	CAN0 module mask 4 register H	CAN	948
C0MASK4L	CAN0 module mask 4 register L	CAN	948
C0MCONF00	CAN0 message configuration register 00	CAN	972
C0MCONF01	CAN0 message configuration register 01	CAN	972
C0MCONF02	CAN0 message configuration register 02	CAN	972
C0MCONF03	CAN0 message configuration register 03	CAN	972
C0MCONF04	CAN0 message configuration register 04	CAN	972
C0MCONF05	CAN0 message configuration register 05	CAN	972
C0MCONF06	CAN0 message configuration register 06	CAN	972
C0MCONF07	CAN0 message configuration register 07	CAN	972
C0MCONF08	CAN0 message configuration register 08	CAN	972
C0MCONF09	CAN0 message configuration register 09	CAN	972
C0MCONF10	CAN0 message configuration register 10	CAN	972
C0MCONF11	CAN0 message configuration register 11	CAN	972
C0MCONF12	CAN0 message configuration register 12	CAN	972
C0MCONF13	CAN0 message configuration register 13	CAN	972
C0MCONF14	CAN0 message configuration register 14	CAN	972
C0MCONF15	CAN0 message configuration register 15	CAN	972
C0MCONF16	CAN0 message configuration register 16	CAN	972
C0MCONF17	CAN0 message configuration register 17	CAN	972

(3/37)

Symbol	Name	Unit	Page
C0MCONF18	CAN0 message configuration register 18	CAN	972
C0MCONF19	CAN0 message configuration register 19	CAN	972
C0MCONF20	CAN0 message configuration register 20	CAN	972
C0MCONF21	CAN0 message configuration register 21	CAN	972
C0MCONF22	CAN0 message configuration register 22	CAN	972
C0MCONF23	CAN0 message configuration register 23	CAN	972
C0MCONF24	CAN0 message configuration register 24	CAN	972
C0MCONF25	CAN0 message configuration register 25	CAN	972
C0MCONF26	CAN0 message configuration register 26	CAN	972
C0MCONF27	CAN0 message configuration register 27	CAN	972
C0MCONF28	CAN0 message configuration register 28	CAN	972
C0MCONF29	CAN0 message configuration register 29	CAN	972
C0MCONF30	CAN0 message configuration register 30	CAN	972
C0MCONF31	CAN0 message configuration register 31	CAN	972
C0MCTRL00	CAN0 message control register 00	CAN	974
C0MCTRL01	CAN0 message control register 01	CAN	974
C0MCTRL02	CAN0 message control register 02	CAN	974
C0MCTRL03	CAN0 message control register 03	CAN	974
C0MCTRL04	CAN0 message control register 04	CAN	974
C0MCTRL05	CAN0 message control register 05	CAN	974
C0MCTRL06	CAN0 message control register 06	CAN	974
C0MCTRL07	CAN0 message control register 07	CAN	974
C0MCTRL08	CAN0 message control register 08	CAN	974
C0MCTRL09	CAN0 message control register 09	CAN	974
C0MCTRL10	CAN0 message control register 10	CAN	974
C0MCTRL11	CAN0 message control register 11	CAN	974
C0MCTRL12	CAN0 message control register 12	CAN	974
C0MCTRL13	CAN0 message control register 13	CAN	974
C0MCTRL14	CAN0 message control register 14	CAN	974
C0MCTRL15	CAN0 message control register 15	CAN	974
C0MCTRL16	CAN0 message control register 16	CAN	974
C0MCTRL17	CAN0 message control register 17	CAN	974
C0MCTRL18	CAN0 message control register 18	CAN	974
C0MCTRL19	CAN0 message control register 19	CAN	974
C0MCTRL20	CAN0 message control register 20	CAN	974
C0MCTRL21	CAN0 message control register 21	CAN	974
C0MCTRL22	CAN0 message control register 22	CAN	974
C0MCTRL23	CAN0 message control register 23	CAN	974
C0MCTRL24	CAN0 message control register 24	CAN	974
C0MCTRL25	CAN0 message control register 25	CAN	974

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Symbol	Name	Unit	Page
C0MCTRL26	CAN0 message control register 26	CAN	974
C0MCTRL27	CAN0 message control register 27	CAN	974
C0MCTRL28	CAN0 message control register 28	CAN	974
C0MCTRL29	CAN0 message control register 29	CAN	974
C0MCTRL30	CAN0 message control register 30	CAN	974
C0MCTRL31	CAN0 message control register 31	CAN	974
C0MDATA000	CAN0 message data byte 0 register 00	CAN	969
C0MDATA001	CAN0 message data byte 0 register 01	CAN	969
C0MDATA002	CAN0 message data byte 0 register 02	CAN	969
C0MDATA003	CAN0 message data byte 0 register 03	CAN	969
C0MDATA004	CAN0 message data byte 0 register 04	CAN	969
C0MDATA005	CAN0 message data byte 0 register 05	CAN	969
C0MDATA006	CAN0 message data byte 0 register 06	CAN	969
C0MDATA007	CAN0 message data byte 0 register 07	CAN	969
C0MDATA008	CAN0 message data byte 0 register 08	CAN	969
C0MDATA009	CAN0 message data byte 0 register 09	CAN	969
C0MDATA010	CAN0 message data byte 0 register 10	CAN	969
C0MDATA0100	CAN0 message data byte 01 register 00	CAN	969
C0MDATA0101	CAN0 message data byte 01 register 01	CAN	969
C0MDATA0102	CAN0 message data byte 01 register 02	CAN	969
C0MDATA0103	CAN0 message data byte 01 register 03	CAN	969
C0MDATA0104	CAN0 message data byte 01 register 04	CAN	969
C0MDATA0105	CAN0 message data byte 01 register 05	CAN	969
C0MDATA0106	CAN0 message data byte 01 register 06	CAN	969
C0MDATA0107	CAN0 message data byte 01 register 07	CAN	969
C0MDATA0108	CAN0 message data byte 01 register 08	CAN	969
C0MDATA0109	CAN0 message data byte 01 register 09	CAN	969
C0MDATA011	CAN0 message data byte 0 register 11	CAN	969
C0MDATA0110	CAN0 message data byte 01 register 10	CAN	969
C0MDATA0111	CAN0 message data byte 01 register 11	CAN	969
C0MDATA0112	CAN0 message data byte 01 register 12	CAN	969
C0MDATA0113	CAN0 message data byte 01 register 13	CAN	969
C0MDATA0114	CAN0 message data byte 01 register 14	CAN	969
C0MDATA0115	CAN0 message data byte 01 register 15	CAN	969
C0MDATA0116	CAN0 message data byte 01 register 16	CAN	969
C0MDATA0117	CAN0 message data byte 01 register 17	CAN	969
C0MDATA0118	CAN0 message data byte 01 register 18	CAN	969
C0MDATA0119	CAN0 message data byte 01 register 19	CAN	969
C0MDATA012	CAN0 message data byte 0 register 12	CAN	969
C0MDATA0120	CAN0 message data byte 01 register 20	CAN	969

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Symbol	Name	Unit	Page
C0MDATA0121	CAN0 message data byte 01 register 21	CAN	969
C0MDATA0122	CAN0 message data byte 01 register 22	CAN	969
C0MDATA0123	CAN0 message data byte 01 register 23	CAN	969
C0MDATA0124	CAN0 message data byte 01 register 24	CAN	969
C0MDATA0125	CAN0 message data byte 01 register 25	CAN	969
C0MDATA0126	CAN0 message data byte 01 register 26	CAN	969
C0MDATA0127	CAN0 message data byte 01 register 27	CAN	969
C0MDATA0128	CAN0 message data byte 01 register 28	CAN	969
C0MDATA0129	CAN0 message data byte 01 register 29	CAN	969
C0MDATA013	CAN0 message data byte 0 register 13	CAN	969
C0MDATA0130	CAN0 message data byte 01 register 30	CAN	969
C0MDATA0131	CAN0 message data byte 01 register 31	CAN	969
C0MDATA014	CAN0 message data byte 0 register 14	CAN	969
C0MDATA015	CAN0 message data byte 0 register 15	CAN	969
C0MDATA016	CAN0 message data byte 0 register 16	CAN	969
C0MDATA017	CAN0 message data byte 0 register 17	CAN	969
C0MDATA018	CAN0 message data byte 0 register 18	CAN	969
C0MDATA019	CAN0 message data byte 0 register 19	CAN	969
C0MDATA020	CAN0 message data byte 0 register 20	CAN	969
C0MDATA021	CAN0 message data byte 0 register 21	CAN	969
C0MDATA022	CAN0 message data byte 0 register 22	CAN	969
C0MDATA023	CAN0 message data byte 0 register 23	CAN	969
C0MDATA024	CAN0 message data byte 0 register 24	CAN	969
C0MDATA025	CAN0 message data byte 0 register 25	CAN	969
C0MDATA026	CAN0 message data byte 0 register 26	CAN	969
C0MDATA027	CAN0 message data byte 0 register 27	CAN	969
C0MDATA028	CAN0 message data byte 0 register 28	CAN	969
C0MDATA029	CAN0 message data byte 0 register 29	CAN	969
C0MDATA030	CAN0 message data byte 0 register 30	CAN	969
C0MDATA031	CAN0 message data byte 0 register 31	CAN	969
C0MDATA100	CAN0 message data byte 1 register 00	CAN	969
C0MDATA101	CAN0 message data byte 1 register 01	CAN	969
C0MDATA102	CAN0 message data byte 1 register 02	CAN	969
C0MDATA103	CAN0 message data byte 1 register 03	CAN	969
C0MDATA104	CAN0 message data byte 1 register 04	CAN	969
C0MDATA105	CAN0 message data byte 1 register 05	CAN	969
C0MDATA106	CAN0 message data byte 1 register 06	CAN	969
C0MDATA107	CAN0 message data byte 1 register 07	CAN	969
C0MDATA108	CAN0 message data byte 1 register 08	CAN	969
C0MDATA109	CAN0 message data byte 1 register 09	CAN	969

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Symbol	Name	Unit	Page
C0MDATA110	CAN0 message data byte 1 register 10	CAN	969
C0MDATA111	CAN0 message data byte 1 register 11	CAN	969
C0MDATA112	CAN0 message data byte 1 register 12	CAN	969
C0MDATA113	CAN0 message data byte 1 register 13	CAN	969
C0MDATA114	CAN0 message data byte 1 register 14	CAN	969
C0MDATA115	CAN0 message data byte 1 register 15	CAN	969
C0MDATA116	CAN0 message data byte 1 register 16	CAN	969
C0MDATA117	CAN0 message data byte 1 register 17	CAN	969
C0MDATA118	CAN0 message data byte 1 register 18	CAN	969
C0MDATA119	CAN0 message data byte 1 register 19	CAN	969
C0MDATA120	CAN0 message data byte 1 register 20	CAN	969
C0MDATA121	CAN0 message data byte 1 register 21	CAN	969
C0MDATA122	CAN0 message data byte 1 register 22	CAN	969
C0MDATA123	CAN0 message data byte 1 register 23	CAN	969
C0MDATA124	CAN0 message data byte 1 register 24	CAN	969
C0MDATA125	CAN0 message data byte 1 register 25	CAN	969
C0MDATA126	CAN0 message data byte 1 register 26	CAN	969
C0MDATA127	CAN0 message data byte 1 register 27	CAN	969
C0MDATA128	CAN0 message data byte 1 register 28	CAN	969
C0MDATA129	CAN0 message data byte 1 register 29	CAN	969
C0MDATA130	CAN0 message data byte 1 register 30	CAN	969
C0MDATA131	CAN0 message data byte 1 register 31	CAN	969
C0MDATA200	CAN0 message data byte 2 register 00	CAN	969
C0MDATA201	CAN0 message data byte 2 register 01	CAN	969
C0MDATA202	CAN0 message data byte 2 register 02	CAN	969
C0MDATA203	CAN0 message data byte 2 register 03	CAN	969
C0MDATA204	CAN0 message data byte 2 register 04	CAN	969
C0MDATA205	CAN0 message data byte 2 register 05	CAN	969
C0MDATA206	CAN0 message data byte 2 register 06	CAN	969
C0MDATA207	CAN0 message data byte 2 register 07	CAN	969
C0MDATA208	CAN0 message data byte 2 register 08	CAN	969
C0MDATA209	CAN0 message data byte 2 register 09	CAN	969
C0MDATA210	CAN0 message data byte 2 register 10	CAN	969
C0MDATA211	CAN0 message data byte 2 register 11	CAN	969
C0MDATA212	CAN0 message data byte 2 register 12	CAN	969
C0MDATA213	CAN0 message data byte 2 register 13	CAN	969
C0MDATA214	CAN0 message data byte 2 register 14	CAN	969
C0MDATA215	CAN0 message data byte 2 register 15	CAN	969
C0MDATA216	CAN0 message data byte 2 register 16	CAN	969
C0MDATA217	CAN0 message data byte 2 register 17	CAN	969

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Symbol	Name	Unit	Page
C0MDATA218	CAN0 message data byte 2 register 18	CAN	969
C0MDATA219	CAN0 message data byte 2 register 19	CAN	969
C0MDATA220	CAN0 message data byte 2 register 20	CAN	969
C0MDATA221	CAN0 message data byte 2 register 21	CAN	969
C0MDATA222	CAN0 message data byte 2 register 22	CAN	969
C0MDATA223	CAN0 message data byte 2 register 23	CAN	969
C0MDATA224	CAN0 message data byte 2 register 24	CAN	969
C0MDATA225	CAN0 message data byte 2 register 25	CAN	969
C0MDATA226	CAN0 message data byte 2 register 26	CAN	969
C0MDATA227	CAN0 message data byte 2 register 27	CAN	969
C0MDATA228	CAN0 message data byte 2 register 28	CAN	969
C0MDATA229	CAN0 message data byte 2 register 29	CAN	969
C0MDATA230	CAN0 message data byte 2 register 30	CAN	969
C0MDATA2300	CAN0 message data byte 23 register 00	CAN	969
C0MDATA2301	CAN0 message data byte 23 register 01	CAN	969
C0MDATA2302	CAN0 message data byte 23 register 02	CAN	969
C0MDATA2303	CAN0 message data byte 23 register 03	CAN	969
C0MDATA2304	CAN0 message data byte 23 register 04	CAN	969
C0MDATA2305	CAN0 message data byte 23 register 05	CAN	969
C0MDATA2306	CAN0 message data byte 23 register 06	CAN	969
C0MDATA2307	CAN0 message data byte 23 register 07	CAN	969
C0MDATA2308	CAN0 message data byte 23 register 08	CAN	969
C0MDATA2309	CAN0 message data byte 23 register 09	CAN	969
C0MDATA231	CAN0 message data byte 2 register 31	CAN	969
C0MDATA2310	CAN0 message data byte 23 register 10	CAN	969
C0MDATA2311	CAN0 message data byte 23 register 11	CAN	969
C0MDATA2312	CAN0 message data byte 23 register 12	CAN	969
C0MDATA2313	CAN0 message data byte 23 register 13	CAN	969
C0MDATA2314	CAN0 message data byte 23 register 14	CAN	969
C0MDATA2315	CAN0 message data byte 23 register 15	CAN	969
C0MDATA2316	CAN0 message data byte 23 register 16	CAN	969
C0MDATA2317	CAN0 message data byte 23 register 17	CAN	969
C0MDATA2318	CAN0 message data byte 23 register 18	CAN	969
C0MDATA2319	CAN0 message data byte 23 register 19	CAN	969
C0MDATA2320	CAN0 message data byte 23 register 20	CAN	969
C0MDATA2321	CAN0 message data byte 23 register 21	CAN	969
C0MDATA2322	CAN0 message data byte 23 register 22	CAN	969
C0MDATA2323	CAN0 message data byte 23 register 23	CAN	969
C0MDATA2324	CAN0 message data byte 23 register 24	CAN	969
C0MDATA2325	CAN0 message data byte 23 register 25	CAN	969

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Symbol	Name	Unit	Page
C0MDATA2326	CAN0 message data byte 23 register 26	CAN	969
C0MDATA2327	CAN0 message data byte 23 register 27	CAN	969
C0MDATA2328	CAN0 message data byte 23 register 28	CAN	969
C0MDATA2329	CAN0 message data byte 23 register 29	CAN	969
C0MDATA2330	CAN0 message data byte 23 register 30	CAN	969
C0MDATA2331	CAN0 message data byte 23 register 31	CAN	969
C0MDATA300	CAN0 message data byte 3 register 00	CAN	969
C0MDATA301	CAN0 message data byte 3 register 01	CAN	969
C0MDATA302	CAN0 message data byte 3 register 02	CAN	969
C0MDATA303	CAN0 message data byte 3 register 03	CAN	969
C0MDATA304	CAN0 message data byte 3 register 04	CAN	969
C0MDATA305	CAN0 message data byte 3 register 05	CAN	969
C0MDATA306	CAN0 message data byte 3 register 06	CAN	969
C0MDATA307	CAN0 message data byte 3 register 07	CAN	969
C0MDATA308	CAN0 message data byte 3 register 08	CAN	969
C0MDATA309	CAN0 message data byte 3 register 09	CAN	969
C0MDATA310	CAN0 message data byte 3 register 10	CAN	969
C0MDATA311	CAN0 message data byte 3 register 11	CAN	969
C0MDATA312	CAN0 message data byte 3 register 12	CAN	969
C0MDATA313	CAN0 message data byte 3 register 13	CAN	969
C0MDATA314	CAN0 message data byte 3 register 14	CAN	969
C0MDATA315	CAN0 message data byte 3 register 15	CAN	969
C0MDATA316	CAN0 message data byte 3 register 16	CAN	969
C0MDATA317	CAN0 message data byte 3 register 17	CAN	969
C0MDATA318	CAN0 message data byte 3 register 18	CAN	969
C0MDATA319	CAN0 message data byte 3 register 19	CAN	969
C0MDATA320	CAN0 message data byte 3 register 20	CAN	969
C0MDATA321	CAN0 message data byte 3 register 21	CAN	969
C0MDATA322	CAN0 message data byte 3 register 22	CAN	969
C0MDATA323	CAN0 message data byte 3 register 23	CAN	969
C0MDATA324	CAN0 message data byte 3 register 24	CAN	969
C0MDATA325	CAN0 message data byte 3 register 25	CAN	969
C0MDATA326	CAN0 message data byte 3 register 26	CAN	969
C0MDATA327	CAN0 message data byte 3 register 27	CAN	969
C0MDATA328	CAN0 message data byte 3 register 28	CAN	969
C0MDATA329	CAN0 message data byte 3 register 29	CAN	969
C0MDATA330	CAN0 message data byte 3 register 30	CAN	969
C0MDATA331	CAN0 message data byte 3 register 31	CAN	969
C0MDATA400	CAN0 message data byte 4 register 00	CAN	969
C0MDATA401	CAN0 message data byte 4 register 01	CAN	969

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Symbol	Name	Unit	Page
C0MDATA402	CAN0 message data byte 4 register 02	CAN	969
C0MDATA403	CAN0 message data byte 4 register 03	CAN	969
C0MDATA404	CAN0 message data byte 4 register 04	CAN	969
C0MDATA405	CAN0 message data byte 4 register 05	CAN	969
C0MDATA406	CAN0 message data byte 4 register 06	CAN	969
C0MDATA407	CAN0 message data byte 4 register 07	CAN	969
C0MDATA408	CAN0 message data byte 4 register 08	CAN	969
C0MDATA409	CAN0 message data byte 4 register 09	CAN	969
C0MDATA410	CAN0 message data byte 4 register 10	CAN	969
C0MDATA411	CAN0 message data byte 4 register 11	CAN	969
C0MDATA412	CAN0 message data byte 4 register 12	CAN	969
C0MDATA413	CAN0 message data byte 4 register 13	CAN	969
C0MDATA414	CAN0 message data byte 4 register 14	CAN	969
C0MDATA415	CAN0 message data byte 4 register 15	CAN	969
C0MDATA416	CAN0 message data byte 4 register 16	CAN	969
C0MDATA417	CAN0 message data byte 4 register 17	CAN	969
C0MDATA418	CAN0 message data byte 4 register 18	CAN	969
C0MDATA419	CAN0 message data byte 4 register 19	CAN	969
C0MDATA420	CAN0 message data byte 4 register 20	CAN	969
C0MDATA421	CAN0 message data byte 4 register 21	CAN	969
C0MDATA422	CAN0 message data byte 4 register 22	CAN	969
C0MDATA423	CAN0 message data byte 4 register 23	CAN	969
C0MDATA424	CAN0 message data byte 4 register 24	CAN	969
C0MDATA425	CAN0 message data byte 4 register 25	CAN	969
C0MDATA426	CAN0 message data byte 4 register 26	CAN	969
C0MDATA427	CAN0 message data byte 4 register 27	CAN	969
C0MDATA428	CAN0 message data byte 4 register 28	CAN	969
C0MDATA429	CAN0 message data byte 4 register 29	CAN	969
C0MDATA430	CAN0 message data byte 4 register 30	CAN	969
C0MDATA431	CAN0 message data byte 4 register 31	CAN	969
C0MDATA4500	CAN0 message data byte 45 register 00	CAN	969
C0MDATA4501	CAN0 message data byte 45 register 01	CAN	969
C0MDATA4502	CAN0 message data byte 45 register 02	CAN	969
C0MDATA4503	CAN0 message data byte 45 register 03	CAN	969
C0MDATA4504	CAN0 message data byte 45 register 04	CAN	969
C0MDATA4505	CAN0 message data byte 45 register 05	CAN	969
C0MDATA4506	CAN0 message data byte 45 register 06	CAN	969
C0MDATA4507	CAN0 message data byte 45 register 07	CAN	969
C0MDATA4508	CAN0 message data byte 45 register 08	CAN	969
C0MDATA4509	CAN0 message data byte 45 register 09	CAN	969

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Symbol	Name	Unit	Page
C0MDATA4510	CAN0 message data byte 45 register 10	CAN	973
C0MDATA4511	CAN0 message data byte 45 register 11	CAN	973
C0MDATA4512	CAN0 message data byte 45 register 12	CAN	973
C0MDATA4513	CAN0 message data byte 45 register 13	CAN	973
C0MDATA4514	CAN0 message data byte 45 register 14	CAN	973
C0MDATA4515	CAN0 message data byte 45 register 15	CAN	973
C0MDATA4516	CAN0 message data byte 45 register 16	CAN	973
C0MDATA4517	CAN0 message data byte 45 register 17	CAN	973
C0MDATA4518	CAN0 message data byte 45 register 18	CAN	973
C0MDATA4519	CAN0 message data byte 45 register 19	CAN	973
C0MDATA4520	CAN0 message data byte 45 register 20	CAN	973
C0MDATA4521	CAN0 message data byte 45 register 21	CAN	973
C0MDATA4522	CAN0 message data byte 45 register 22	CAN	973
C0MDATA4523	CAN0 message data byte 45 register 23	CAN	973
C0MDATA4524	CAN0 message data byte 45 register 24	CAN	973
C0MDATA4525	CAN0 message data byte 45 register 25	CAN	973
C0MDATA4526	CAN0 message data byte 45 register 26	CAN	973
C0MDATA4527	CAN0 message data byte 45 register 27	CAN	973
C0MDATA4528	CAN0 message data byte 45 register 28	CAN	973
C0MDATA4529	CAN0 message data byte 45 register 29	CAN	973
C0MDATA4530	CAN0 message data byte 45 register 30	CAN	973
C0MDATA4531	CAN0 message data byte 45 register 31	CAN	973
C0MDATA500	CAN0 message data byte 5 register 00	CAN	973
C0MDATA501	CAN0 message data byte 5 register 01	CAN	973
C0MDATA502	CAN0 message data byte 5 register 02	CAN	973
C0MDATA503	CAN0 message data byte 5 register 03	CAN	973
C0MDATA504	CAN0 message data byte 5 register 04	CAN	973
C0MDATA505	CAN0 message data byte 5 register 05	CAN	973
C0MDATA506	CAN0 message data byte 5 register 06	CAN	973
C0MDATA507	CAN0 message data byte 5 register 07	CAN	973
C0MDATA508	CAN0 message data byte 5 register 08	CAN	973
C0MDATA509	CAN0 message data byte 5 register 09	CAN	973
C0MDATA510	CAN0 message data byte 5 register 10	CAN	973
C0MDATA511	CAN0 message data byte 5 register 11	CAN	973
C0MDATA512	CAN0 message data byte 5 register 12	CAN	973
C0MDATA513	CAN0 message data byte 5 register 13	CAN	973
C0MDATA514	CAN0 message data byte 5 register 14	CAN	973
C0MDATA515	CAN0 message data byte 5 register 15	CAN	973
C0MDATA516	CAN0 message data byte 5 register 16	CAN	973
C0MDATA517	CAN0 message data byte 5 register 17	CAN	973

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Symbol	Name	Unit	Page
C0MDATA518	CAN0 message data byte 5 register 18	CAN	969
C0MDATA519	CAN0 message data byte 5 register 19	CAN	969
C0MDATA520	CAN0 message data byte 5 register 20	CAN	969
C0MDATA521	CAN0 message data byte 5 register 21	CAN	969
C0MDATA522	CAN0 message data byte 5 register 22	CAN	969
C0MDATA523	CAN0 message data byte 5 register 23	CAN	969
C0MDATA524	CAN0 message data byte 5 register 24	CAN	969
C0MDATA525	CAN0 message data byte 5 register 25	CAN	969
C0MDATA526	CAN0 message data byte 5 register 26	CAN	969
C0MDATA527	CAN0 message data byte 5 register 27	CAN	969
C0MDATA528	CAN0 message data byte 5 register 28	CAN	969
C0MDATA529	CAN0 message data byte 5 register 29	CAN	969
C0MDATA530	CAN0 message data byte 5 register 30	CAN	969
C0MDATA531	CAN0 message data byte 5 register 31	CAN	969
C0MDATA600	CAN0 message data byte 6 register 00	CAN	969
C0MDATA601	CAN0 message data byte 6 register 01	CAN	969
C0MDATA602	CAN0 message data byte 6 register 02	CAN	969
C0MDATA603	CAN0 message data byte 6 register 03	CAN	969
C0MDATA604	CAN0 message data byte 6 register 04	CAN	969
C0MDATA605	CAN0 message data byte 6 register 05	CAN	969
C0MDATA606	CAN0 message data byte 6 register 06	CAN	969
C0MDATA607	CAN0 message data byte 6 register 07	CAN	969
C0MDATA608	CAN0 message data byte 6 register 08	CAN	969
C0MDATA609	CAN0 message data byte 6 register 09	CAN	969
C0MDATA610	CAN0 message data byte 6 register 10	CAN	969
C0MDATA611	CAN0 message data byte 6 register 11	CAN	969
C0MDATA612	CAN0 message data byte 6 register 12	CAN	969
C0MDATA613	CAN0 message data byte 6 register 13	CAN	969
C0MDATA614	CAN0 message data byte 6 register 14	CAN	969
C0MDATA615	CAN0 message data byte 6 register 15	CAN	969
C0MDATA616	CAN0 message data byte 6 register 16	CAN	969
C0MDATA617	CAN0 message data byte 6 register 17	CAN	969
C0MDATA618	CAN0 message data byte 6 register 18	CAN	969
C0MDATA619	CAN0 message data byte 6 register 19	CAN	969
C0MDATA620	CAN0 message data byte 6 register 20	CAN	969
C0MDATA621	CAN0 message data byte 6 register 21	CAN	969
C0MDATA622	CAN0 message data byte 6 register 22	CAN	969
C0MDATA623	CAN0 message data byte 6 register 23	CAN	969
C0MDATA624	CAN0 message data byte 6 register 24	CAN	969
C0MDATA625	CAN0 message data byte 6 register 25	CAN	969

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Symbol	Name	Unit	Page
C0MDATA626	CAN0 message data byte 6 register 26	CAN	969
C0MDATA627	CAN0 message data byte 6 register 27	CAN	969
C0MDATA628	CAN0 message data byte 6 register 28	CAN	969
C0MDATA629	CAN0 message data byte 6 register 29	CAN	969
C0MDATA630	CAN0 message data byte 6 register 30	CAN	969
C0MDATA631	CAN0 message data byte 6 register 31	CAN	969
C0MDATA6700	CAN0 message data byte 67 register 00	CAN	969
C0MDATA6701	CAN0 message data byte 67 register 01	CAN	969
C0MDATA6702	CAN0 message data byte 67 register 02	CAN	969
C0MDATA6703	CAN0 message data byte 67 register 03	CAN	969
C0MDATA6704	CAN0 message data byte 67 register 04	CAN	969
C0MDATA6705	CAN0 message data byte 67 register 05	CAN	969
C0MDATA6706	CAN0 message data byte 67 register 06	CAN	969
C0MDATA6707	CAN0 message data byte 67 register 07	CAN	969
C0MDATA6708	CAN0 message data byte 67 register 08	CAN	969
C0MDATA6709	CAN0 message data byte 67 register 09	CAN	969
C0MDATA6710	CAN0 message data byte 67 register 10	CAN	969
C0MDATA6711	CAN0 message data byte 67 register 11	CAN	969
C0MDATA6712	CAN0 message data byte 67 register 12	CAN	969
C0MDATA6713	CAN0 message data byte 67 register 13	CAN	969
C0MDATA6714	CAN0 message data byte 67 register 14	CAN	969
C0MDATA6715	CAN0 message data byte 67 register 15	CAN	969
C0MDATA6716	CAN0 message data byte 67 register 16	CAN	969
C0MDATA6717	CAN0 message data byte 67 register 17	CAN	969
C0MDATA6718	CAN0 message data byte 67 register 18	CAN	969
C0MDATA6719	CAN0 message data byte 67 register 19	CAN	969
C0MDATA6720	CAN0 message data byte 67 register 20	CAN	969
C0MDATA6721	CAN0 message data byte 67 register 21	CAN	969
C0MDATA6722	CAN0 message data byte 67 register 22	CAN	969
C0MDATA6723	CAN0 message data byte 67 register 23	CAN	969
C0MDATA6724	CAN0 message data byte 67 register 24	CAN	969
C0MDATA6725	CAN0 message data byte 67 register 25	CAN	969
C0MDATA6726	CAN0 message data byte 67 register 26	CAN	969
C0MDATA6727	CAN0 message data byte 67 register 27	CAN	969
C0MDATA6728	CAN0 message data byte 67 register 28	CAN	969
C0MDATA6729	CAN0 message data byte 67 register 29	CAN	969
C0MDATA6730	CAN0 message data byte 67 register 30	CAN	969
C0MDATA6731	CAN0 message data byte 67 register 31	CAN	969
C0MDATA700	CAN0 message data byte 7 register 00	CAN	969
C0MDATA701	CAN0 message data byte 7 register 01	CAN	969

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Symbol	Name	Unit	Page
C0MDATA702	CAN0 message data byte 7 register 02	CAN	969
C0MDATA703	CAN0 message data byte 7 register 03	CAN	969
C0MDATA704	CAN0 message data byte 7 register 04	CAN	969
C0MDATA705	CAN0 message data byte 7 register 05	CAN	969
C0MDATA706	CAN0 message data byte 7 register 06	CAN	969
C0MDATA707	CAN0 message data byte 7 register 07	CAN	969
C0MDATA708	CAN0 message data byte 7 register 08	CAN	969
C0MDATA709	CAN0 message data byte 7 register 09	CAN	969
C0MDATA710	CAN0 message data byte 7 register 10	CAN	969
C0MDATA711	CAN0 message data byte 7 register 11	CAN	969
C0MDATA712	CAN0 message data byte 7 register 12	CAN	969
C0MDATA713	CAN0 message data byte 7 register 13	CAN	969
C0MDATA714	CAN0 message data byte 7 register 14	CAN	969
C0MDATA715	CAN0 message data byte 7 register 15	CAN	969
C0MDATA716	CAN0 message data byte 7 register 16	CAN	969
C0MDATA717	CAN0 message data byte 7 register 17	CAN	969
C0MDATA718	CAN0 message data byte 7 register 18	CAN	969
C0MDATA719	CAN0 message data byte 7 register 19	CAN	969
C0MDATA720	CAN0 message data byte 7 register 20	CAN	969
C0MDATA721	CAN0 message data byte 7 register 21	CAN	969
C0MDATA722	CAN0 message data byte 7 register 22	CAN	969
C0MDATA723	CAN0 message data byte 7 register 23	CAN	969
C0MDATA724	CAN0 message data byte 7 register 24	CAN	969
C0MDATA725	CAN0 message data byte 7 register 25	CAN	969
C0MDATA726	CAN0 message data byte 7 register 26	CAN	969
C0MDATA727	CAN0 message data byte 7 register 27	CAN	969
C0MDATA728	CAN0 message data byte 7 register 28	CAN	969
C0MDATA729	CAN0 message data byte 7 register 29	CAN	969
C0MDATA730	CAN0 message data byte 7 register 30	CAN	969
C0MDATA731	CAN0 message data byte 7 register 31	CAN	969
C0MDLC00	CAN0 message data length register 00	CAN	971
C0MDLC01	CAN0 message data length register 01	CAN	971
C0MDLC02	CAN0 message data length register 02	CAN	971
C0MDLC03	CAN0 message data length register 03	CAN	971
C0MDLC04	CAN0 message data length register 04	CAN	971
C0MDLC05	CAN0 message data length register 05	CAN	971
C0MDLC06	CAN0 message data length register 06	CAN	971
C0MDLC07	CAN0 message data length register 07	CAN	971
C0MDLC08	CAN0 message data length register 08	CAN	971
C0MDLC09	CAN0 message data length register 09	CAN	971

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Symbol	Name	Unit	Page
C0MDLC10	CAN0 message data length register 10	CAN	971
C0MDLC11	CAN0 message data length register 11	CAN	971
C0MDLC12	CAN0 message data length register 12	CAN	971
C0MDLC13	CAN0 message data length register 13	CAN	971
C0MDLC14	CAN0 message data length register 14	CAN	971
C0MDLC15	CAN0 message data length register 15	CAN	971
C0MDLC16	CAN0 message data length register 16	CAN	971
C0MDLC17	CAN0 message data length register 17	CAN	971
C0MDLC18	CAN0 message data length register 18	CAN	971
C0MDLC19	CAN0 message data length register 19	CAN	971
C0MDLC20	CAN0 message data length register 20	CAN	971
C0MDLC21	CAN0 message data length register 21	CAN	971
C0MDLC22	CAN0 message data length register 22	CAN	971
C0MDLC23	CAN0 message data length register 23	CAN	971
C0MDLC24	CAN0 message data length register 24	CAN	971
C0MDLC25	CAN0 message data length register 25	CAN	971
C0MDLC26	CAN0 message data length register 26	CAN	971
C0MDLC27	CAN0 message data length register 27	CAN	971
C0MDLC28	CAN0 message data length register 28	CAN	971
C0MDLC29	CAN0 message data length register 29	CAN	971
C0MDLC30	CAN0 message data length register 30	CAN	971
C0MDLC31	CAN0 message data length register 31	CAN	971
C0MIDH00	CAN0 message identifier register 00H	CAN	973
C0MIDH01	CAN0 message identifier register 01H	CAN	973
C0MIDH02	CAN0 message identifier register 02H	CAN	973
C0MIDH03	CAN0 message identifier register 03H	CAN	973
C0MIDH04	CAN0 message identifier register 04H	CAN	973
C0MIDH05	CAN0 message identifier register 05H	CAN	973
C0MIDH06	CAN0 message identifier register 06H	CAN	973
C0MIDH07	CAN0 message identifier register 07H	CAN	973
C0MIDH08	CAN0 message identifier register 08H	CAN	973
C0MIDH09	CAN0 message identifier register 09H	CAN	973
C0MIDH10	CAN0 message identifier register 10H	CAN	973
C0MIDH11	CAN0 message identifier register 11H	CAN	973
C0MIDH12	CAN0 message identifier register 12H	CAN	973
C0MIDH13	CAN0 message identifier register 13H	CAN	973
C0MIDH14	CAN0 message identifier register 14H	CAN	973
C0MIDH15	CAN0 message identifier register 15H	CAN	973
C0MIDH16	CAN0 message identifier register 16H	CAN	973
C0MIDH17	CAN0 message identifier register 17H	CAN	973

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Symbol	Name	Unit	Page
C0MIDH18	CAN0 message identifier register 18H	CAN	973
C0MIDH19	CAN0 message identifier register 19H	CAN	973
C0MIDH20	CAN0 message identifier register 20H	CAN	973
C0MIDH21	CAN0 message identifier register 21H	CAN	973
C0MIDH22	CAN0 message identifier register 22H	CAN	973
C0MIDH23	CAN0 message identifier register 23H	CAN	973
C0MIDH24	CAN0 message identifier register 24H	CAN	973
C0MIDH25	CAN0 message identifier register 25H	CAN	973
C0MIDH26	CAN0 message identifier register 26H	CAN	973
C0MIDH27	CAN0 message identifier register 27H	CAN	973
C0MIDH28	CAN0 message identifier register 28H	CAN	973
C0MIDH29	CAN0 message identifier register 29H	CAN	973
C0MIDH30	CAN0 message identifier register 30H	CAN	973
C0MIDH31	CAN0 message identifier register 31H	CAN	973
C0MIDL00	CAN0 message identifier register 00L	CAN	973
C0MIDL01	CAN0 message identifier register 01L	CAN	973
C0MIDL02	CAN0 message identifier register 02L	CAN	973
C0MIDL03	CAN0 message identifier register 03L	CAN	973
C0MIDL04	CAN0 message identifier register 04L	CAN	973
C0MIDL05	CAN0 message identifier register 05L	CAN	973
C0MIDL06	CAN0 message identifier register 06L	CAN	973
C0MIDL07	CAN0 message identifier register 07L	CAN	973
C0MIDL08	CAN0 message identifier register 08L	CAN	973
C0MIDL09	CAN0 message identifier register 09L	CAN	973
C0MIDL10	CAN0 message identifier register 10L	CAN	973
C0MIDL11	CAN0 message identifier register 11L	CAN	973
C0MIDL12	CAN0 message identifier register 12L	CAN	973
C0MIDL13	CAN0 message identifier register 13L	CAN	973
C0MIDL14	CAN0 message identifier register 14L	CAN	973
C0MIDL15	CAN0 message identifier register 15L	CAN	973
C0MIDL16	CAN0 message identifier register 16L	CAN	973
C0MIDL17	CAN0 message identifier register 17L	CAN	973
C0MIDL18	CAN0 message identifier register 18L	CAN	973
C0MIDL19	CAN0 message identifier register 19L	CAN	973
C0MIDL20	CAN0 message identifier register 20L	CAN	973
C0MIDL21	CAN0 message identifier register 21L	CAN	973
C0MIDL22	CAN0 message identifier register 22L	CAN	973
C0MIDL23	CAN0 message identifier register 23L	CAN	973
C0MIDL24	CAN0 message identifier register 24L	CAN	973
C0MIDL25	CAN0 message identifier register 25L	CAN	973

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Symbol	Name	Unit	Page
C0MIDL26	CAN0 message identifier register 26L	CAN	973
C0MIDL27	CAN0 message identifier register 27L	CAN	973
C0MIDL28	CAN0 message identifier register 28L	CAN	973
C0MIDL29	CAN0 message identifier register 29L	CAN	973
C0MIDL30	CAN0 message identifier register 30L	CAN	973
C0MIDL31	CAN0 message identifier register 31L	CAN	973
C0RGPT	CAN0 module receive history list register	CAN	964
C0TGPT	CAN0 module transmit history list register	CAN	966
C0TS	CAN0 module time stamp register	CAN	967
CCLS	CPU operation clock status register	CG	207
CF0CTL0	CSIF0 control register 0	CSIF	769
CF0CTL1	CSIF0 control register 1	CSIF	769
CF0CTL2	CSIF0 control register 2	CSIF	769
CF0RIC	Interrupt control register	INTC	1264
CF0RX	CSIF0 receive data register	CSIF	767
CF0RXL	CSIF0 receive data register L	CSIF	767
CF0STR	CSIF0 status register	CSIF	775
CF0TIC	Interrupt control register	INTC	1264
CF0TX	CSIF0 transmit data register	CSIF	768
CF0TXL	CSIF0 transmit data register L	CSIF	768
CF1CTL0	CSIF1 control register 0	CSIF	769
CF1CTL1	CSIF1 control register 1	CSIF	772
CF1CTL2	CSIF1 control register 2	CSIF	773
CF1RIC	Interrupt control register	INTC	1264
CF1RX	CSIF1 receive data register	CSIF	767
CF1RXL	CSIF1 receive data register L	CSIF	767
CF1STR	CSIF1 status register	CSIF	775
CF1TIC	Interrupt control register	INTC	1264
CF1TX	CSIF1 transmit data register	CSIF	768
CF1TXL	CSIF1 transmit data register L	CSIF	768
CF2CTL0	CSIF2 control register 0	CSIF	769
CF2CTL1	CSIF2 control register 1	CSIF	772
CF2CTL2	CSIF2 control register 2	CSIF	773
CF2RIC	Interrupt control register	INTC	1264
CF2RX	CSIF2 receive data register	CSIF	767
CF2RXL	CSIF2 receive data register L	CSIF	767
CF2STR	CSIF2 status register	CSIF	775
CF2TIC	Interrupt control register	INTC	1264
CF2TX	CSIF2 transmit data register	CSIF	768
CF2TXL	CSIF2 transmit data register L	CSIF	768
CF3CTL0	CSIF3 control register 0	CSIF	769
CF3CTL1	CSIF3 control register 1	CSIF	772

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Symbol	Name	Unit	Page
CF3CTL2	CSIF3 control register 2	CSIF	773
CF3RIC	Interrupt control register	INTC	1264
CF3RX	CSIF3 receive data register	CSIF	767
CF3RXL	CSIF3 receive data register L	CSIF	767
CF3STR	CSIF3 status register	CSIF	775
CF3TIC	Interrupt control register	INTC	1265
CF3TX	CSIF3 transmit data register	CSIF	768
CF3TXL	CSIF3 transmit data register L	CSIF	768
CF4CTL0	CSIF4 control register 0	CSIF	769
CF4CTL1	CSIF4 control register 1	CSIF	772
CF4CTL2	CSIF4 control register 2	CSIF	773
CF4RIC	Interrupt control register	INTC	1264
CF4RX	CSIF4 receive data register	CSIF	767
CF4RXL	CSIF4 receive data register L	CSIF	767
CF4STR	CSIF4 status register	CSIF	775
CF4TIC	Interrupt control register	INTC	1264
CF4TX	CSIF4 transmit data register	CSIF	768
CF4TXL	CSIF4 transmit data register L	CSIF	768
CKC	Clock control register	CG	210
CLM	Clock monitor mode register	CLM	1337
CPUBCTL	CPU I/F bus control register	USBF	1169
CRCD	CRC data register	CRC	1349
CRCIN	CRC input register	CRC	1349
CTBP	CALLT base pointer	CPU	62
CTPC	CALLT execution status saving register	CPU	61
CTPSW	CALLT execution status saving register	CPU	61
DA0CS0	D/A conversion value setting register 0	DAC	717
DA0CS1	D/A conversion value setting register 1	DAC	717
DA0M	D/A converter mode register	DAC	716
DADC0	DMA addressing control register 0	DMAC	1237
DADC1	DMA addressing control register 1	DMAC	1237
DADC2	DMA addressing control register 2	DMAC	1237
DADC3	DMA addressing control register 3	DMAC	1237
DBC0	DMA transfer count register 0	DMAC	1236
DBC1	DMA transfer count register 1	DMAC	1236
DBC2	DMA transfer count register 2	DMAC	1236
DBC3	DMA transfer count register 3	DMAC	1236
DBPC	Exception/debug trap status saving register	CPU	62
DBPSW	Exception/debug trap status saving register	CPU	62
DCHC0	DMA channel control register 0	DMAC	1238
DCHC1	DMA channel control register 1	DMAC	1238
DCHC2	DMA channel control register 2	DMAC	1238

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Symbol	Name	Unit	Page
DCHC3	DMA channel control register 3	DMAC	1238
DDA0H	DMA destination address register 0H	DMAC	1235
DDA0L	DMA destination address register 0L	DMAC	1235
DDA1H	DMA destination address register 1H	DMAC	1235
DDA1L	DMA destination address register 1L	DMAC	1235
DDA2H	DMA destination address register 2H	DMAC	1235
DDA2L	DMA destination address register 2L	DMAC	1235
DDA3H	DMA destination address register 3H	DMAC	1235
DDA3L	DMA destination address register 3L	DMAC	1235
DMAIC0	Interrupt control register	INTC	1260
DMAIC1	Interrupt control register	INTC	1260
DMAIC2	Interrupt control register	INTC	1260
DMAIC3	Interrupt control register	INTC	1260
DSA0H	DMA source address register 0H	DMAC	1234
DSA0L	DMA source address register 0L	DMAC	1234
DSA1H	DMA source address register 1H	DMAC	1234
DSA1L	DMA source address register 1L	DMAC	1234
DSA2H	DMA source address register 2H	DMAC	1234
DSA2L	DMA source address register 2L	DMAC	1234
DSA3H	DMA source address register 3H	DMAC	1234
DSA3L	DMA source address register 3L	DMAC	1234
DTFR0	DMA trigger factor register 0	DMAC	1239
DTFR1	DMA trigger factor register 1	DMAC	1239
DTFR2	DMA trigger factor register 2	DMAC	1239
DTFR3	DMA trigger factor register 3	DMAC	1239
DWC0	Data wait control register 0	BCU	89
ECR	Interrupt source register	CPU	59
EIPC	Interrupt status saving register	CPU	58
EIPSW	Interrupt status saving register	CPU	58
EPCCLT	EPC macro control register	USBF	1164
ERRIC0	Interrupt control register	INTC	1265
EXDRQEN	External DMA request enable register	DMA	1242
FEPC	NMI status saving register	CPU	59
FEPSW	NMI status saving register	CPU	59
HZA0CTL0	High-impedance output control register 0	Motor	586
HZA0CTL1	High-impedance output control register 1	Motor	586
IIC0	IIC shift register 0	I^2C	835
IIC1	IIC shift register 1	I^2C	835
IIC2	IIC shift register 2	I^2C	835
IICC0	IIC control register 0	I^2C	822
IICC1	IIC control register 1	I^2C	822
IICC2	IIC control register 2	I^2C	822

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Symbol	Name	Unit	Page
IICCL0	IIC clock select register 0	I^2C	832
IICCL1	IIC clock select register 1	I^2C	832
IICCL2	IIC clock select register 2	I^2C	832
IICF0	IIC flag register 0	I^2C	832
IICF1	IIC flag register 1	I^2C	832
IICF2	IIC flag register 2	I^2C	832
IICIC0	Interrupt control register	INTC	1260
IICIC1	Interrupt control register	INTC	1259
IICIC2	Interrupt control register	INTC	1260
IICS0	IIC status register 0	I^2C	827
IICS1	IIC status register 1	I^2C	827
IICS2	IIC status register 2	I^2C	827
IICX0	IIC function expansion register 0	I^2C	833
IICX1	IIC function expansion register 1	I^2C	833
IICX2	IIC function expansion register 2	I^2C	833
IMR0	Interrupt mask register 0	INTC	1283
IMR0H	Interrupt mask register 0H	INTC	1283
IMR0L	Interrupt mask register 0L	INTC	1283
IMR1	Interrupt mask register 1	INTC	1283
IMR1H	Interrupt mask register 1H	INTC	1283
IMR1L	Interrupt mask register 1L	INTC	1283
IMR2	Interrupt mask register 2	INTC	1283
IMR2H	Interrupt mask register 2H	INTC	1283
IMR2L	Interrupt mask register 2L	INTC	1283
IMR3	Interrupt mask register 3	INTC	1283
IMR3H	Interrupt mask register 3H	INTC	1283
IMR3L	Interrupt mask register 3L	INTC	1283
IMR4	Interrupt mask register 4	INTC	1283
IMR4H	Interrupt mask register 4H	INTC	1283
IMR4L	Interrupt mask register 4L	INTC	1283
IMR5	Interrupt mask register 5	INTC	1283
IMR5H	Interrupt mask register 5H	INTC	1283
IMR5L	Interrupt mask register 5L	INTC	1283
INTF0	External falling edge specification register 0	INTC	1245
INTF2	External falling edge specification register 2	INTC	1396
INTF3	External falling edge specification register 3	INTC	1397
INTF4	External falling edge specification register 4	INTC	1398
INTF5	External falling edge specification register 5	INTC	1399
INTF9	External falling edge specification register 9	INTC	1300
INTF9H	External falling edge specification register 9H	INTC	1300
INTF9L	External falling edge specification register 9L	INTC	1300
INTNFC	Noise elimination control register	INTC	1301
INTR0	External rising edge specification register 0	INTC	1295

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Symbol	Name	Unit	Page
INTR2	External rising edge specification register 2	INTC	1396
INTR3	External rising edge specification register 3	INTC	1397
INTR4	External rising edge specification register 4	INTC	1398
INTR5	External rising edge specification register 5	INTC	1399
INTR9	External rising edge specification register 9	INTC	1300
INTR9H	External rising edge specification register 9H	INTC	1300
INTR9L	External rising edge specification register 9L	INTC	1300
ISPR	In-service priority register	INTC	1285
KRIC	Interrupt control register	INTC	1260
KRM	Key return mode register	KR	1305
LOCKR	Lock register	CG	211
LVIIC	Interrupt control register	INTC	1280
LVIM	Low-voltage detection register	LVI	1343
OCDM	On-chip debug mode register	DCU	1391
OCKS0	IIC division clock select register 0	I^2C	835
OCKS1	IIC division clock select register 1	I^2C	835
OSTS	Oscillation stabilization time select register	Standby	1311
P0	Port 0 register	Port	108
P1	Port 1 register	Port	113
P2	Port 2 register	Port	114
P3	Port 3 register	Port	118
P4	Port 4 register	Port	123
P5	Port 5 register	Port	127
P6	Port 6 register	Port	133
P7H	Port 7 register H	Port	137
P7L	Port 7 register L	Port	137
P9	Port 9 register	Port	140
P9H	Port 9 register H	Port	140
P9L	Port 9 register L	Port	140
PC	Program counter	CPU	56
PCC	Processor clock control register	CG	203
PCM	Port CM register	Port	149
PCS	Port CS register	Port	152
PCT	Port CT register	Port	154
PDH	Port DH register	Port	158
PDL	Port DL register	Port	160
PDLH	Port DL register H	Port	160
PDLL	Port DL register L	Port	160
PF0	Port 0 function register	Port	112
PF2	Port 2 function register	Port	117
PF3	Port 3 function register	Port	122
PF4	Port 4 function register	Port	125
PF5	Port 5 function register	Port	132

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Symbol	Name	Unit	Page
PF9	Port 9 function register	Port	148
PF9L	Port 9 function register L	Port	148
PFC0	Port 0 function control register	Port	111
PFC2	Port 2 function control register	Port	115
PFC3	Port 3 function control register	Port	120
PFC4	Port 4 function control register	Port	124
PFC5	Port 5 function control register	Port	130
PFC6	Port 6 function control register	Port	135
PFC9	Port 9 function control register	Port	143
PFC9H	Port 9 function control register H	Port	143
PFC9L	Port 9 function control register L	Port	143
PFCE0	Port 0 function control expansion register	Port	112
PFCE2	Port 2 function control expansion register	Port	116
PFCE3	Port 3 function control expansion register	Port	120
PFCE4	Port 4 function control expansion register	Port	124
PFCE5	Port 5 function control expansion register	Port	130
PFCE6	Port 6 function control expansion register	Port	135
PFCE9	Port 9 function control expansion register	Port	144
PFCE9H	Port 9 function control expansion register H	Port	144
PFCE9L	Port 9 function control expansion register L	Port	144
PIC00	Interrupt control register	INTC	1280
PIC01	Interrupt control register	INTC	1280
PIC02	Interrupt control register	INTC	1280
PIC03	Interrupt control register	INTC	1280
PIC04	Interrupt control register	INTC	1280
PIC05	Interrupt control register	INTC	1280
PIC06	Interrupt control register	INTC	1280
PIC07	Interrupt control register	INTC	1280
PIC08	Interrupt control register	INTC	1280
PIC09	Interrupt control register	INTC	1280
PIC10	Interrupt control register	INTC	1280
PIC11	Interrupt control register	INTC	1280
PIC12	Interrupt control register	INTC	1280
PIC13	Interrupt control register	INTC	1280
PIC14	Interrupt control register	INTC	1280
PIC15	Interrupt control register	INTC	1280
PIC16	Interrupt control register	INTC	1280
PIC17	Interrupt control register	INTC	1280
PIC18	Interrupt control register	INTC	1280
PLLCTL	PLL control register	CG	209
PLLS	PLL lockup time specification register	CG	212
PM0	Port 0 mode register	Port	109
PM1	Port 1 mode register	Port	113

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Symbol	Name	Unit	Page
PM2	Port 2 mode register	Port	114
PM3	Port 3 mode register	Port	118
PM4	Port 4 mode register	Port	123
PM5	Port 5 mode register	Port	128
PM6	Port 6 mode register	Port	134
PM7H	Port 7 mode register H	Port	138
PM7L	Port 7 mode register L	Port	138
PM9	Port 9 mode register	Port	140
PM9H	Port 9 mode register H	Port	140
PM9L	Port 9 mode register L	Port	140
PMC0	Port 0 mode control register	Port	110
PMC2	Port 2 mode control register	Port	115
PMC3	Port 3 mode control register	Port	119
PMC4	Port 4 mode control register	Port	124
PMC5	Port 5 mode control register	Port	129
PMC6	Port 6 mode control register	Port	134
PMC9	Port 9 mode control register	Port	141
PMC9H	Port 9 mode control register H	Port	141
PMC9L	Port 9 mode control register L	Port	141
PMCCM	Port CM mode control register	Port	151
PMCCS	Port CS mode control register	Port	153
PMCCT	Port CT mode control register	Port	156
PMCDH	Port DH mode control register	Port	158
PMCDL	Port DL mode control register	Port	161
PMCDLH	Port DL mode control register H	Port	161
PMCDLL	Port DL mode control register L	Port	161
PMCM	Port CM mode register	Port	150
PMCS	Port CS mode register	Port	152
PMCT	Port CT mode register	Port	155
PMDH	Port DH mode register	Port	158
PMDL	Port DL mode register	Port	160
PMDLH	Port DL mode register H	Port	160
PMDLL	Port DL mode register L	Port	160
PRCMD	Command register	CPU	94
PRSCM0	Prescaler compare register 0	BRG	654
PRSCM1	Prescaler compare register 1	BRG	812
PRSCM2	Prescaler compare register 2	BRG	812
PRSCM3	Prescaler compare register 3	BRG	812
PRSM0	Prescaler mode register 0	BRG	653
PRSM1	Prescaler mode register 1	BRG	811
PRSM2	Prescaler mode register 2	BRG	811
PRSM3	Prescaler mode register 3	BRG	811
PSC	Power save control register	CG	1308

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Symbol	Name	Unit	Page
PSMR	Power save mode register	CG	1309
PSW	Program status word	CPU	60
r0-r31	General-purpose registers	CPU	56
RAMS	Internal RAM data status register	LVI	1344
RC1ALH	Alarm hour setting register	RTC	651
RC1ALM	Alarm minute setting register	RTC	651
RC1ALW	Alarm day-of week setting register	RTC	652
RC1CC0	Real-time counter control register 0	RTC	640
RC1CC1	Real-time counter control register 1	RTC	640
RC1CC2	Real-time counter control register 2	RTC	642
RC1CC3	Real-time counter control register 3	RTC	643
RC1DAY	Day count register	RTC	647
RC1HOUR	Hour count register	RTC	645
RC1MIN	Minute count register	RTC	645
RC1MONTH	Month count register	RTC	649
RC1SEC	Second count register	RTC	644
RC1SUBC	Sub-count register	RTC	644
RC1SUBU	Watch error correction register	RTC	650
RC1WEEK	Day-of-week count register	RTC	648
RC1YEAR	Year count register	RTC	649
RCM	Internal oscillation mode register	CG	207
RECIC0	Interrupt control register	INTC	1284
RESF	Reset source flag register	Reset	1329
RTBH0	Real-time output buffer register 0H	RTO	674
RTBL0	Real-time output buffer register 0L	RTO	674
RTC0IC	Interrupt control register	INTC	1282
RTC1IC	Interrupt control register	INTC	1282
RTC2IC	Interrupt control register	INTC	1282
RTPC0	Real-time output port control register 0	RTO	676
RTPM0	Real-time output port mode register 0	RTO	675
SELCNT0	Selector operation control register 0	Timer	328
SVA0	Slave address register 0	I^2C	836
SVA1	Slave address register 1	I^2C	836
SVA2	Slave address register 2	I^2C	836
SYS	System status register	CPU	95
TAA0CCIC0	Interrupt control register	INTC	1280
TAA0CCIC1	Interrupt control register	INTC	1280
TAA0CCR0	TAA0 capture/compare register 0	Timer	227
TAA0CCR1	TAA0 capture/compare register 1	Timer	229
TAA0CNT	TAA0 counter read buffer register	Timer	231
TAA0CTL0	TAA0 control register 0	Timer	218
TAA0CTL1	TAA0 control register 1	Timer	219
TAA0IOC0	TAA0 I/O control register 0	Timer	221

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Symbol	Name	Unit	Page
TAA0IOC1	TAA0 I/O control register 1	Timer	222
TAA0IOC2	TAA0 I/O control register 2	Timer	223
TAA0IOC4	TAA0 I/O control register 4	Timer	224
TAA0OPT0	TAA0 option register 0	Timer	225
TAA0OPT1	TAA0 option register 1	Timer	226
TAA0OVIC	Interrupt control register	INTC	1280
TAA1CCIC0	Interrupt control register	INTC	1280
TAA1CCIC1	Interrupt control register	INTC	1280
TAA1CCR0	TAA1 capture/compare register 0	Timer	227
TAA1CCR1	TAA1 capture/compare register 1	Timer	229
TAA1CNT	TAA1 counter read buffer register	Timer	231
TAA1CTL0	TAA1 control register 0	Timer	218
TAA1CTL1	TAA1 control register 1	Timer	219
TAA1IOC0	TAA1I/O control register 0	Timer	221
TAA1IOC1	TAA1I/O control register 1	Timer	222
TAA1IOC2	TAA1I/O control register 2	Timer	223
TAA1IOC4	TAA1I/O control register 4	Timer	224
TAA1OPT0	TAA1 option register 0	Timer	225
TAA1OVIC	Interrupt control register	INTC	1280
TAA2CCIC0	Interrupt control register	INTC	1280
TAA2CCIC1	Interrupt control register	INTC	1280
TAA2CCR0	TAA2 capture/compare register 0	Timer	227
TAA2CCR1	TAA2 capture/compare register 1	Timer	229
TAA2CNT	TAA2 counter read buffer register	Timer	231
TAA2CTL0	TAA2 control register 0	Timer	218
TAA2CTL1	TAA2 control register 1	Timer	219
TAA2IOC0	TAA2 I/O control register 0	Timer	221
TAA2IOC1	TAA2 I/O control register 1	Timer	222
TAA2IOC2	TAA2 I/O control register 2	Timer	223
TAA2IOC4	TAA2 I/O control register 4	Timer	224
TAA2OPT0	TAA2 option register 0	Timer	225
TAA2OPT1	TAA2 option register 1	Timer	226
TAA2OVIC	Interrupt control register	INTC	1280
TAA3CCIC0	Interrupt control register	INTC	1280
TAA3CCIC1	Interrupt control register	INTC	1280
TAA3CCR0	TAA3 capture/compare register 0	Timer	227
TAA3CCR1	TAA3 capture/compare register 1	Timer	229
TAA3CNT	TAA3 counter read buffer register	Timer	231
TAA3CTL0	TAA3 control register 0	Timer	218
TAA3CTL1	TAA3 control register 1	Timer	219
TAA3IOC0	TAA3 I/O control register 0	Timer	221
TAA3IOC1	TAA3 I/O control register 1	Timer	222
TAA3IOC2	TAA3 I/O control register 2	Timer	223

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Symbol	Name	Unit	Page
TAA3IOC4	TAA3 I/O control register 4	Timer	224
TAA3OPT0	TAA3 option register 0	Timer	225
TAA3OVIC	Interrupt control register	INTC	1280
TAA4CCIC0	Interrupt control register	INTC	1280
TAA4CCIC1	Interrupt control register	INTC	1280
TAA4CCR0	TAA4 capture/compare register 0	Timer	227
TAA4CCR1	TAA4 capture/compare register 1	Timer	229
TAA4CNT	TAA4 counter read buffer register	Timer	231
TAA4CTL0	TAA4 control register 0	Timer	218
TAA4CTL1	TAA4 control register 1	Timer	219
TAA4OVIC	Interrupt control register	INTC	1281
TAA5CCIC0	Interrupt control register	INTC	1281
TAA5CCIC1	Interrupt control register	INTC	1281
TAA5CCR0	TAA5 capture/compare register 0	Timer	227
TAA5CCR1	TAA5 capture/compare register 1	Timer	229
TAA5CNT	TAA5 counter read buffer register	Timer	231
TAA5CTL0	TAA5 control register 0	Timer	218
TAA5CTL1	TAA5 control register 1	Timer	219
TAA5IOC0	TAA5 I/O control register 0	Timer	221
TAA5IOC1	TAA5 I/O control register 1	Timer	222
TAA5IOC2	TAA5 I/O control register 2	Timer	223
TAA5IOC4	TAA5 I/O control register 4	Timer	224
TAA5OPT0	TAA5 option register 0	Timer	225
TAA5OVIC	Interrupt control register	INTC	1281
TAB0CCIC0	Interrupt control register	INTC	1280
TAB0CCIC1	Interrupt control register	INTC	1280
TAB0CCIC2	Interrupt control register	INTC	1280
TAB0CCIC3	Interrupt control register	INTC	1280
TAB0CCR0	TAB0 capture/compare register 0	Timer	342
TAB0CCR1	TAB0 capture/compare register 1	Timer	344
TAB0CCR2	TAB0 capture/compare register 2	Timer	346
TAB0CCR3	TAB0 capture/compare register 3	Timer	348
TAB0CNT	TAB0 counter read buffer register	Timer	350
TAB0CTL0	TAB0 control register 0	Timer	335
TAB0CTL1	TAB0 control register 1	Timer	336
TAB0IOC0	TAB0 I/O control register 0	Timer	337
TAB0IOC1	TAB0 I/O control register 1	Timer	338
TAB0IOC2	TAB0 I/O control register 2	Timer	339
TAB0OIC4	TAB0 I/O control register 4	Timer	340
TAB0OPT0	TAB0 option register 0	Timer	341
TAB0OVIC	Interrupt control register	INTC	1280
TAB1CCIC0	Interrupt control register	INTC	1280
TAB1CCIC1	Interrupt control register	INTC	1280

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Symbol	Name	Unit	Page
TAB1CCIC2	Interrupt control register	INTC	1280
TAB1CCIC3	Interrupt control register	INTC	1280
TAB1CCR0	TAB1 capture/compare register 0	Timer	342
TAB1CCR1	TAB1 capture/compare register 1	Timer	344
TAB1CCR2	TAB1 capture/compare register 2	Timer	346
TAB1CCR3	TAB1 capture/compare register 3	Timer	348
TAB1CNT	TAB1 counter read buffer register	Timer	350
TAB1CTL0	TAB1 control register 0	Timer	335
TAB1CTL1	TAB1 control register 1	Timer	346
TAB1DTC	TAB1 dead time compare register 1	Timer	580
TAB1IOC0	TAB1 I/O control register 0	Timer	337
TAB1IOC1	TAB1 I/O control register 1	Timer	338
TAB1IOC2	TAB1 I/O control register 2	Timer	339
TAB1IOC3	TAB1 I/O control register 3	Timer	584
TAB1OIC4	TAB1 I/O control register 4	Timer	340
TAB1OPT0	TAB1 option register 0	Timer	341
TAB1OPT1	TAB1 option register 1	Timer	581
TAB1OPT2	TAB1 option register 2	Timer	582
TAB1OVIC	Interrupt control register	INTC	1280
TANFC	Noise elimination control register	Timer	232
TM0CMP0	TMM0 compare register 0	Timer	568
TM0CTL0	TMM0 control register 0	Timer	569
TM0EQIC0	Interrupt control register	INTC	1281
TM1CMP0	TMM1 compare register 0	Timer	568
TM1CTL0	TMM1 control register 0	Timer	569
TM1EQIC0	Interrupt control register	INTC	1281
TM2CMP0	TMM2 compare register 0	Timer	568
TM2CTL0	TMM2 control register 0	Timer	569
TM2EQIC0	Interrupt control register	INTC	1281
TM3CMP0	TMM3 compare register 0	Timer	568
TM3CTL0	TMM3 control register 0	Timer	569
TM3EQIC0	Interrupt control register	INTC	1281
TTNFC	Noise elimination control register	Timer	458
TRXIC0	Interrupt control register	INTC	1282
TT0CCIC0	Interrupt control register	INTC	1280
TT0CCIC1	Interrupt control register	INTC	1280
TT0CCR0	TMT0 capture/compare register 0	Timer	453
TT0CCR1	TMT0 capture/compare register 1	Timer	455
TT0CNT	TMT0 counter read buffer register	Timer	457
TT0CTL0	TMT0 control register 0	Timer	439
TT0CTL1	TMT0 control register 1	Timer	440
TT0CTL2	TMT0 control register 2	Timer	442
TT0IECIC	Interrupt control register	INTC	1280

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Symbol	Name	Unit	Page
TT0IOC0	TMT0 I/O control register 0	Timer	444
TT0IOC1	TMT0 I/O control register 1	Timer	446
TT0IOC2	TMT0 I/O control register 2	Timer	447
TT0IOC3	TMT0 I/O control register 3	Timer	584
TT0OPT0	TMT0 option register 0	Timer	450
TT0OPT1	TMT0 option register 1	Timer	451
TT0OVIC	Interrupt control register	INTC	1280
TT0TCW	TMT0 count write register	Timer	457
UC0CTL0	UARTC0 control register 0	UARTC	728
UC0CTL1	UARTC0 control register 1	UARTC	754
UC0CTL2	UARTC0 control register 2	UARTC	755
UC0OPT0	UARTC0 option control register 0	UARTC	730
UC0OPT1	UARTC0 option control register 1	UARTC	732
UC0RIC	Interrupt control register	INTC	1281
UC0RX	UARTC0 receive data register	UARTC	736
UC0RXL	UARTC0 receive data register L	UARTC	736
UC0STR	UARTC0 status register	UARTC	734
UC0TIC	Interrupt control register	INTC	1281
UC0TX	UARTC0 transmit data register	UARTC	737
UC0TX	UARTC0 transmit data register L	UARTC	737
UC1CTL0	UARTC1 control register 0	UARTC	728
UC1CTL1	UARTC1 control register 1	UARTC	754
UC1CTL2	UARTC1 control register 2	UARTC	755
UC1OPT0	UARTC1 option control register 0	UARTC	730
UC1OPT1	UARTC1 option control register 1	UARTC	732
UC1RIC	Interrupt control register	INTC	1281
UC1RX	UARTC1 receive data register	UARTC	736
UC1RXL	UARTC1 receive data register L	UARTC	736
UC1STR	UARTC1 status register	UARTC	734
UC1TIC	Interrupt control register	INTC	1281
UC1TX	UARTC1 transmit data register	UARTC	737
UC1TXL	UARTC1 transmit data register L	UARTC	737
UC2CTL0	UARTC2 control register 0	UARTC	728
UC2CTL1	UARTC2 control register 1	UARTC	754
UC2CTL2	UARTC2 control register 2	UARTC	755
UC2OPT0	UARTC2 option control register 0	UARTC	730
UC2OPT1	UARTC2 option control register 1	UARTC	732
UC2RIC	Interrupt control register	INTC	1281
UC2RX	UARTC2 receive data register	UARTC	736
UC2RXL	UARTC2 receive data register L	UARTC	736
UC2STR	UARTC2 status register	UARTC	734
UC2TIC	Interrupt control register	INTC	1281
UC2TX	UARTC2 transmit data register	UARTC	737

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Symbol	Name	Unit	Page
UC2TXL	UARTC2 transmit data register L	UARTC	741
UC3CTL0	UARTC3 control register 0	UARTC	728
UC3CTL1	UARTC3 control register 1	UARTC	754
UC3CTL2	UARTC3 control register 2	UARTC	755
UC3OPT0	UARTC3 option control register 0	UARTC	730
UC3OPT1	UARTC3 option control register 1	UARTC	732
UC3RIC	Interrupt control register	INTC	1281
UC3RX	UARTC3 receive data register	UARTC	736
UC3RXL	UARTC3 receive data register L	UARTC	736
UC3STR	UARTC3 status register	UARTC	734
UC3TIC	Interrupt control register	INTC	1281
UC3TX	UARTC3 transmit data register	UARTC	737
UC3TXL	UARTC3 transmit data register L	UARTC	737
UC4CTL0	UARTC4 control register 0	UARTC	728
UC4CTL1	UARTC4 control register 1	UARTC	754
UC4CTL2	UARTC4 control register 2	UARTC	755
UC4OPT0	UARTC4 option control register 0	UARTC	730
UC4OPT1	UARTC4 option control register 1	UARTC	732
UC4RIC	Interrupt control register	INTC	1281
UC4RX	UARTC4 receive data register	UARTC	736
UC4RXL	UARTC4 receive data register L	UARTC	736
UC4STR	UARTC4 status register	UARTC	734
UC4TIC	Interrupt control register	INTC	1281
UC4TX	UARTC4 transmit data register	UARTC	737
UC4TXL	UARTC4 transmit data register L	UARTC	737
UCKSEL	USB clock select register	USBF	1058
UF0AAS	UF0 active alternative setting register	USBF	1121
UF0ADRS	UF0 address register	USBF	1158
UF0AIFN	UF0 active interface number register	USBF	1120
UF0ASS	UF0 alternative setting status register	USBF	1122
UF0BI1	UF0 bulk-in 1 register	USBF	1141
UF0BI2	UF0 bulk-in 2 register	USBF	1145
UF0BO1	UF0 bulk-out 1 register	USBF	1134
UF0BO1L	UF0 bulk-out 1 length register	USBF	1137
UF0BO2	UF0 bulk-out 2 register	USBF	1138
UF0BO2L	UF0 bulk-out 2 length register	USBF	1141
UF0CIE0	UF0 configuration/interface/endpoint descriptor register 0	USBF	1164
UF0CIE1	UF0 configuration/interface/endpoint descriptor register 1	USBF	1164
UF0CIE2	UF0 configuration/interface/endpoint descriptor register 2	USBF	1164
UF0CIE3	UF0 configuration/interface/endpoint descriptor register 3	USBF	1164
UF0CIE4	UF0 configuration/interface/endpoint descriptor register 4	USBF	1164
UF0CIE5	UF0 configuration/interface/endpoint descriptor register 5	USBF	1164

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Symbol	Name	Unit	Page
UF0CIE6	UF0 configuration/interface/endpoint descriptor register 6	USBF	1164
UF0CIE7	UF0 configuration/interface/endpoint descriptor register 7	USBF	1164
UF0CIE8	UF0 configuration/interface/endpoint descriptor register 8	USBF	1164
UF0CIE9	UF0 configuration/interface/endpoint descriptor register 9	USBF	1164
UF0CIE10	UF0 configuration/interface/endpoint descriptor register 10	USBF	1164
UF0CIE11	UF0 configuration/interface/endpoint descriptor register 11	USBF	1164
UF0CIE12	UF0 configuration/interface/endpoint descriptor register 12	USBF	1164
UF0CIE13	UF0 configuration/interface/endpoint descriptor register 13	USBF	1164
UF0CIE14	UF0 configuration/interface/endpoint descriptor register 14	USBF	1164
UF0CIE15	UF0 configuration/interface/endpoint descriptor register 15	USBF	1164
UF0CIE16	UF0 configuration/interface/endpoint descriptor register 16	USBF	1164
UF0CIE17	UF0 configuration/interface/endpoint descriptor register 17	USBF	1164
UF0CIE18	UF0 configuration/interface/endpoint descriptor register 18	USBF	1164
UF0CIE19	UF0 configuration/interface/endpoint descriptor register 19	USBF	1164
UF0CIE20	UF0 configuration/interface/endpoint descriptor register 20	USBF	1164
UF0CIE21	UF0 configuration/interface/endpoint descriptor register 21	USBF	1164
UF0CIE22	UF0 configuration/interface/endpoint descriptor register 22	USBF	1164
UF0CIE23	UF0 configuration/interface/endpoint descriptor register 23	USBF	1164
UF0CIE24	UF0 configuration/interface/endpoint descriptor register 24	USBF	1164
UF0CIE25	UF0 configuration/interface/endpoint descriptor register 25	USBF	1164
UF0CIE26	UF0 configuration/interface/endpoint descriptor register 26	USBF	1164
UF0CIE27	UF0 configuration/interface/endpoint descriptor register 27	USBF	1164
UF0CIE28	UF0 configuration/interface/endpoint descriptor register 28	USBF	1164
UF0CIE29	UF0 configuration/interface/endpoint descriptor register 29	USBF	1164
UF0CIE30	UF0 configuration/interface/endpoint descriptor register 30	USBF	1164
UF0CIE31	UF0 configuration/interface/endpoint descriptor register 31	USBF	1164
UF0CIE32	UF0 configuration/interface/endpoint descriptor register 32	USBF	1164
UF0CIE33	UF0 configuration/interface/endpoint descriptor register 33	USBF	1164
UF0CIE34	UF0 configuration/interface/endpoint descriptor register 34	USBF	1164
UF0CIE35	UF0 configuration/interface/endpoint descriptor register 35	USBF	1164
UF0CIE36	UF0 configuration/interface/endpoint descriptor register 36	USBF	1164
UF0CIE37	UF0 configuration/interface/endpoint descriptor register 37	USBF	1164
UF0CIE38	UF0 configuration/interface/endpoint descriptor register 38	USBF	1164
UF0CIE39	UF0 configuration/interface/endpoint descriptor register 39	USBF	1164
UF0CIE40	UF0 configuration/interface/endpoint descriptor register 40	USBF	1164
UF0CIE41	UF0 configuration/interface/endpoint descriptor register 41	USBF	1164
UF0CIE42	UF0 configuration/interface/endpoint descriptor register 42	USBF	1164
UF0CIE43	UF0 configuration/interface/endpoint descriptor register 43	USBF	1164
UF0CIE44	UF0 configuration/interface/endpoint descriptor register 44	USBF	1164
UF0CIE45	UF0 configuration/interface/endpoint descriptor register 45	USBF	1164

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UF0CIE46	UF0 configuration/interface/endpoint descriptor register 46	USBF	1164
UF0CIE47	UF0 configuration/interface/endpoint descriptor register 47	USBF	1164
UF0CIE48	UF0 configuration/interface/endpoint descriptor register 48	USBF	1164
UF0CIE49	UF0 configuration/interface/endpoint descriptor register 49	USBF	1164
UF0CIE50	UF0 configuration/interface/endpoint descriptor register 50	USBF	1164
UF0CIE51	UF0 configuration/interface/endpoint descriptor register 51	USBF	1164
UF0CIE52	UF0 configuration/interface/endpoint descriptor register 52	USBF	1164
UF0CIE53	UF0 configuration/interface/endpoint descriptor register 53	USBF	1164
UF0CIE54	UF0 configuration/interface/endpoint descriptor register 54	USBF	1164
UF0CIE55	UF0 configuration/interface/endpoint descriptor register 55	USBF	1164
UF0CIE56	UF0 configuration/interface/endpoint descriptor register 56	USBF	1164
UF0CIE57	UF0 configuration/interface/endpoint descriptor register 57	USBF	1164
UF0CIE58	UF0 configuration/interface/endpoint descriptor register 58	USBF	1164
UF0CIE59	UF0 configuration/interface/endpoint descriptor register 59	USBF	1164
UF0CIE60	UF0 configuration/interface/endpoint descriptor register 60	USBF	1164
UF0CIE61	UF0 configuration/interface/endpoint descriptor register 61	USBF	1164
UF0CIE62	UF0 configuration/interface/endpoint descriptor register 62	USBF	1164
UF0CIE63	UF0 configuration/interface/endpoint descriptor register 63	USBF	1164
UF0CIE64	UF0 configuration/interface/endpoint descriptor register 64	USBF	1164
UF0CIE65	UF0 configuration/interface/endpoint descriptor register 65	USBF	1164
UF0CIE66	UF0 configuration/interface/endpoint descriptor register 66	USBF	1164
UF0CIE67	UF0 configuration/interface/endpoint descriptor register 67	USBF	1164
UF0CIE68	UF0 configuration/interface/endpoint descriptor register 68	USBF	1164
UF0CIE69	UF0 configuration/interface/endpoint descriptor register 69	USBF	1164
UF0CIE70	UF0 configuration/interface/endpoint descriptor register 70	USBF	1164
UF0CIE71	UF0 configuration/interface/endpoint descriptor register 71	USBF	1164
UF0CIE72	UF0 configuration/interface/endpoint descriptor register 72	USBF	1164
UF0CIE73	UF0 configuration/interface/endpoint descriptor register 73	USBF	1164
UF0CIE74	UF0 configuration/interface/endpoint descriptor register 74	USBF	1164
UF0CIE75	UF0 configuration/interface/endpoint descriptor register 75	USBF	1164
UF0CIE76	UF0 configuration/interface/endpoint descriptor register 76	USBF	1164
UF0CIE77	UF0 configuration/interface/endpoint descriptor register 77	USBF	1164
UF0CIE78	UF0 configuration/interface/endpoint descriptor register 78	USBF	1164
UF0CIE79	UF0 configuration/interface/endpoint descriptor register 79	USBF	1164
UF0CIE80	UF0 configuration/interface/endpoint descriptor register 80	USBF	1164
UF0CIE81	UF0 configuration/interface/endpoint descriptor register 81	USBF	1164
UF0CIE82	UF0 configuration/interface/endpoint descriptor register 82	USBF	1164
UF0CIE83	UF0 configuration/interface/endpoint descriptor register 83	USBF	1164
UF0CIE84	UF0 configuration/interface/endpoint descriptor register 84	USBF	1164
UF0CIE85	UF0 configuration/interface/endpoint descriptor register 85	USBF	1164

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UF0CIE86	UF0 configuration/interface/endpoint descriptor register 86	USBF	1164
UF0CIE87	UF0 configuration/interface/endpoint descriptor register 87	USBF	1164
UF0CIE88	UF0 configuration/interface/endpoint descriptor register 88	USBF	1164
UF0CIE89	UF0 configuration/interface/endpoint descriptor register 89	USBF	1164
UF0CIE90	UF0 configuration/interface/endpoint descriptor register 90	USBF	1164
UF0CIE91	UF0 configuration/interface/endpoint descriptor register 91	USBF	1164
UF0CIE92	UF0 configuration/interface/endpoint descriptor register 92	USBF	1164
UF0CIE93	UF0 configuration/interface/endpoint descriptor register 93	USBF	1164
UF0CIE94	UF0 configuration/interface/endpoint descriptor register 94	USBF	1164
UF0CIE95	UF0 configuration/interface/endpoint descriptor register 95	USBF	1164
UF0CIE96	UF0 configuration/interface/endpoint descriptor register 96	USBF	1164
UF0CIE97	UF0 configuration/interface/endpoint descriptor register 97	USBF	1164
UF0CIE98	UF0 configuration/interface/endpoint descriptor register 98	USBF	1164
UF0CIE99	UF0 configuration/interface/endpoint descriptor register 99	USBF	1164
UF0CIE100	UF0 configuration/interface/endpoint descriptor register 100	USBF	1164
UF0CIE101	UF0 configuration/interface/endpoint descriptor register 101	USBF	1164
UF0CIE102	UF0 configuration/interface/endpoint descriptor register 102	USBF	1164
UF0CIE103	UF0 configuration/interface/endpoint descriptor register 103	USBF	1164
UF0CIE104	UF0 configuration/interface/endpoint descriptor register 104	USBF	1164
UF0CIE105	UF0 configuration/interface/endpoint descriptor register 105	USBF	1164
UF0CIE106	UF0 configuration/interface/endpoint descriptor register 106	USBF	1164
UF0CIE107	UF0 configuration/interface/endpoint descriptor register 107	USBF	1164
UF0CIE108	UF0 configuration/interface/endpoint descriptor register 108	USBF	1164
UF0CIE109	UF0 configuration/interface/endpoint descriptor register 109	USBF	1164
UF0CIE110	UF0 configuration/interface/endpoint descriptor register 110	USBF	1164
UF0CIE111	UF0 configuration/interface/endpoint descriptor register 111	USBF	1164
UF0CIE112	UF0 configuration/interface/endpoint descriptor register 112	USBF	1164
UF0CIE113	UF0 configuration/interface/endpoint descriptor register 113	USBF	1164
UF0CIE114	UF0 configuration/interface/endpoint descriptor register 114	USBF	1164
UF0CIE115	UF0 configuration/interface/endpoint descriptor register 115	USBF	1164
UF0CIE116	UF0 configuration/interface/endpoint descriptor register 116	USBF	1164
UF0CIE117	UF0 configuration/interface/endpoint descriptor register 117	USBF	1164
UF0CIE118	UF0 configuration/interface/endpoint descriptor register 118	USBF	1164
UF0CIE119	UF0 configuration/interface/endpoint descriptor register 119	USBF	1164
UF0CIE120	UF0 configuration/interface/endpoint descriptor register 120	USBF	1164
UF0CIE121	UF0 configuration/interface/endpoint descriptor register 121	USBF	1164
UF0CIE122	UF0 configuration/interface/endpoint descriptor register 122	USBF	1164
UF0CIE123	UF0 configuration/interface/endpoint descriptor register 123	USBF	1164
UF0CIE124	UF0 configuration/interface/endpoint descriptor register 124	USBF	1164
UF0CIE125	UF0 configuration/interface/endpoint descriptor register 125	USBF	1164

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UF0CIE126	UF0 configuration/interface/endpoint descriptor register 126	USBF	1164
UF0CIE127	UF0 configuration/interface/endpoint descriptor register 127	USBF	1164
UF0CIE128	UF0 configuration/interface/endpoint descriptor register 128	USBF	1164
UF0CIE129	UF0 configuration/interface/endpoint descriptor register 129	USBF	1164
UF0CIE130	UF0 configuration/interface/endpoint descriptor register 130	USBF	1164
UF0CIE131	UF0 configuration/interface/endpoint descriptor register 131	USBF	1164
UF0CIE132	UF0 configuration/interface/endpoint descriptor register 132	USBF	1164
UF0CIE133	UF0 configuration/interface/endpoint descriptor register 133	USBF	1164
UF0CIE134	UF0 configuration/interface/endpoint descriptor register 134	USBF	1164
UF0CIE135	UF0 configuration/interface/endpoint descriptor register 135	USBF	1164
UF0CIE136	UF0 configuration/interface/endpoint descriptor register 136	USBF	1164
UF0CIE137	UF0 configuration/interface/endpoint descriptor register 137	USBF	1164
UF0CIE138	UF0 configuration/interface/endpoint descriptor register 138	USBF	1164
UF0CIE139	UF0 configuration/interface/endpoint descriptor register 139	USBF	1164
UF0CIE140	UF0 configuration/interface/endpoint descriptor register 140	USBF	1164
UF0CIE141	UF0 configuration/interface/endpoint descriptor register 141	USBF	1164
UF0CIE142	UF0 configuration/interface/endpoint descriptor register 142	USBF	1164
UF0CIE143	UF0 configuration/interface/endpoint descriptor register 143	USBF	1164
UF0CIE144	UF0 configuration/interface/endpoint descriptor register 144	USBF	1164
UF0CIE145	UF0 configuration/interface/endpoint descriptor register 145	USBF	1164
UF0CIE146	UF0 configuration/interface/endpoint descriptor register 146	USBF	1164
UF0CIE147	UF0 configuration/interface/endpoint descriptor register 147	USBF	1164
UF0CIE148	UF0 configuration/interface/endpoint descriptor register 148	USBF	1164
UF0CIE149	UF0 configuration/interface/endpoint descriptor register 149	USBF	1164
UF0CIE150	UF0 configuration/interface/endpoint descriptor register 150	USBF	1164
UF0CIE151	UF0 configuration/interface/endpoint descriptor register 151	USBF	1164
UF0CIE152	UF0 configuration/interface/endpoint descriptor register 152	USBF	1164
UF0CIE153	UF0 configuration/interface/endpoint descriptor register 153	USBF	1164
UF0CIE154	UF0 configuration/interface/endpoint descriptor register 154	USBF	1164
UF0CIE155	UF0 configuration/interface/endpoint descriptor register 155	USBF	1164
UF0CIE156	UF0 configuration/interface/endpoint descriptor register 156	USBF	1164
UF0CIE157	UF0 configuration/interface/endpoint descriptor register 157	USBF	1164
UF0CIE158	UF0 configuration/interface/endpoint descriptor register 158	USBF	1164
UF0CIE159	UF0 configuration/interface/endpoint descriptor register 159	USBF	1164
UF0CIE160	UF0 configuration/interface/endpoint descriptor register 160	USBF	1164
UF0CIE161	UF0 configuration/interface/endpoint descriptor register 161	USBF	1164
UF0CIE162	UF0 configuration/interface/endpoint descriptor register 162	USBF	1164
UF0CIE163	UF0 configuration/interface/endpoint descriptor register 163	USBF	1164
UF0CIE164	UF0 configuration/interface/endpoint descriptor register 164	USBF	1164
UF0CIE165	UF0 configuration/interface/endpoint descriptor register 165	USBF	1164

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UF0CIE166	UF0 configuration/interface/endpoint descriptor register 166	USBF	1164
UF0CIE167	UF0 configuration/interface/endpoint descriptor register 167	USBF	1164
UF0CIE168	UF0 configuration/interface/endpoint descriptor register 168	USBF	1164
UF0CIE169	UF0 configuration/interface/endpoint descriptor register 169	USBF	1164
UF0CIE170	UF0 configuration/interface/endpoint descriptor register 170	USBF	1164
UF0CIE171	UF0 configuration/interface/endpoint descriptor register 171	USBF	1164
UF0CIE172	UF0 configuration/interface/endpoint descriptor register 172	USBF	1164
UF0CIE173	UF0 configuration/interface/endpoint descriptor register 173	USBF	1164
UF0CIE174	UF0 configuration/interface/endpoint descriptor register 174	USBF	1164
UF0CIE175	UF0 configuration/interface/endpoint descriptor register 175	USBF	1164
UF0CIE176	UF0 configuration/interface/endpoint descriptor register 176	USBF	1164
UF0CIE177	UF0 configuration/interface/endpoint descriptor register 177	USBF	1164
UF0CIE178	UF0 configuration/interface/endpoint descriptor register 178	USBF	1164
UF0CIE179	UF0 configuration/interface/endpoint descriptor register 179	USBF	1164
UF0CIE180	UF0 configuration/interface/endpoint descriptor register 180	USBF	1164
UF0CIE181	UF0 configuration/interface/endpoint descriptor register 181	USBF	1164
UF0CIE182	UF0 configuration/interface/endpoint descriptor register 182	USBF	1164
UF0CIE183	UF0 configuration/interface/endpoint descriptor register 183	USBF	1164
UF0CIE184	UF0 configuration/interface/endpoint descriptor register 184	USBF	1164
UF0CIE185	UF0 configuration/interface/endpoint descriptor register 185	USBF	1164
UF0CIE186	UF0 configuration/interface/endpoint descriptor register 186	USBF	1164
UF0CIE187	UF0 configuration/interface/endpoint descriptor register 187	USBF	1164
UF0CIE188	UF0 configuration/interface/endpoint descriptor register 188	USBF	1164
UF0CIE189	UF0 configuration/interface/endpoint descriptor register 189	USBF	1164
UF0CIE190	UF0 configuration/interface/endpoint descriptor register 190	USBF	1164
UF0CIE191	UF0 configuration/interface/endpoint descriptor register 191	USBF	1164
UF0CIE192	UF0 configuration/interface/endpoint descriptor register 192	USBF	1164
UF0CIE193	UF0 configuration/interface/endpoint descriptor register 193	USBF	1164
UF0CIE194	UF0 configuration/interface/endpoint descriptor register 194	USBF	1164
UF0CIE195	UF0 configuration/interface/endpoint descriptor register 195	USBF	1164
UF0CIE196	UF0 configuration/interface/endpoint descriptor register 196	USBF	1164
UF0CIE197	UF0 configuration/interface/endpoint descriptor register 197	USBF	1164
UF0CIE198	UF0 configuration/interface/endpoint descriptor register 198	USBF	1164
UF0CIE199	UF0 configuration/interface/endpoint descriptor register 199	USBF	1164
UF0CIE200	UF0 configuration/interface/endpoint descriptor register 200	USBF	1164
UF0CIE201	UF0 configuration/interface/endpoint descriptor register 201	USBF	1164
UF0CIE202	UF0 configuration/interface/endpoint descriptor register 202	USBF	1164
UF0CIE203	UF0 configuration/interface/endpoint descriptor register 203	USBF	1164
UF0CIE204	UF0 configuration/interface/endpoint descriptor register 204	USBF	1164
UF0CIE205	UF0 configuration/interface/endpoint descriptor register 205	USBF	1164

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Symbol	Name	Unit	Page
UF0CIE206	UF0 configuration/interface/endpoint descriptor register 206	USBF	1164
UF0CIE207	UF0 configuration/interface/endpoint descriptor register 207	USBF	1164
UF0CIE208	UF0 configuration/interface/endpoint descriptor register 208	USBF	1164
UF0CIE209	UF0 configuration/interface/endpoint descriptor register 209	USBF	1164
UF0CIE210	UF0 configuration/interface/endpoint descriptor register 210	USBF	1164
UF0CIE211	UF0 configuration/interface/endpoint descriptor register 211	USBF	1164
UF0CIE212	UF0 configuration/interface/endpoint descriptor register 212	USBF	1164
UF0CIE213	UF0 configuration/interface/endpoint descriptor register 213	USBF	1164
UF0CIE214	UF0 configuration/interface/endpoint descriptor register 214	USBF	1164
UF0CIE215	UF0 configuration/interface/endpoint descriptor register 215	USBF	1164
UF0CIE216	UF0 configuration/interface/endpoint descriptor register 216	USBF	1164
UF0CIE217	UF0 configuration/interface/endpoint descriptor register 217	USBF	1164
UF0CIE218	UF0 configuration/interface/endpoint descriptor register 218	USBF	1164
UF0CIE219	UF0 configuration/interface/endpoint descriptor register 219	USBF	1164
UF0CIE220	UF0 configuration/interface/endpoint descriptor register 220	USBF	1164
UF0CIE221	UF0 configuration/interface/endpoint descriptor register 221	USBF	1164
UF0CIE222	UF0 configuration/interface/endpoint descriptor register 222	USBF	1164
UF0CIE223	UF0 configuration/interface/endpoint descriptor register 223	USBF	1164
UF0CIE224	UF0 configuration/interface/endpoint descriptor register 224	USBF	1164
UF0CIE225	UF0 configuration/interface/endpoint descriptor register 225	USBF	1164
UF0CIE226	UF0 configuration/interface/endpoint descriptor register 226	USBF	1164
UF0CIE227	UF0 configuration/interface/endpoint descriptor register 227	USBF	1164
UF0CIE228	UF0 configuration/interface/endpoint descriptor register 228	USBF	1164
UF0CIE229	UF0 configuration/interface/endpoint descriptor register 229	USBF	1164
UF0CIE230	UF0 configuration/interface/endpoint descriptor register 230	USBF	1164
UF0CIE231	UF0 configuration/interface/endpoint descriptor register 231	USBF	1164
UF0CIE232	UF0 configuration/interface/endpoint descriptor register 232	USBF	1164
UF0CIE233	UF0 configuration/interface/endpoint descriptor register 233	USBF	1164
UF0CIE234	UF0 configuration/interface/endpoint descriptor register 234	USBF	1164
UF0CIE235	UF0 configuration/interface/endpoint descriptor register 235	USBF	1164
UF0CIE236	UF0 configuration/interface/endpoint descriptor register 236	USBF	1164
UF0CIE237	UF0 configuration/interface/endpoint descriptor register 237	USBF	1164
UF0CIE238	UF0 configuration/interface/endpoint descriptor register 238	USBF	1164
UF0CIE239	UF0 configuration/interface/endpoint descriptor register 239	USBF	1164
UF0CIE240	UF0 configuration/interface/endpoint descriptor register 240	USBF	1164
UF0CIE241	UF0 configuration/interface/endpoint descriptor register 241	USBF	1164
UF0CIE242	UF0 configuration/interface/endpoint descriptor register 242	USBF	1164
UF0CIE243	UF0 configuration/interface/endpoint descriptor register 243	USBF	1164
UF0CIE244	UF0 configuration/interface/endpoint descriptor register 244	USBF	1164
UF0CIE245	UF0 configuration/interface/endpoint descriptor register 245	USBF	1164

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Symbol	Name	Unit	Page
UF0CIE246	UF0 configuration/interface/endpoint descriptor register 246	USBF	1164
UF0CIE247	UF0 configuration/interface/endpoint descriptor register 247	USBF	1164
UF0CIE248	UF0 configuration/interface/endpoint descriptor register 248	USBF	1164
UF0CIE249	UF0 configuration/interface/endpoint descriptor register 249	USBF	1164
UF0CIE250	UF0 configuration/interface/endpoint descriptor register 250	USBF	1164
UF0CIE251	UF0 configuration/interface/endpoint descriptor register 251	USBF	1164
UF0CIE252	UF0 configuration/interface/endpoint descriptor register 252	USBF	1164
UF0CIE253	UF0 configuration/interface/endpoint descriptor register 253	USBF	1164
UF0CIE254	UF0 configuration/interface/endpoint descriptor register 254	USBF	1164
UF0CIE255	UF0 configuration/interface/endpoint descriptor register 255	USBF	1164
UF0CLR	UF0 CLR request register	USBF	1085
UF0CNF	UF0 configuration register	USBF	1159
UF0DD0	UF0 device descriptor register 0	USBF	1163
UF0DD1	UF0 device descriptor register 1	USBF	1163
UF0DD2	UF0 device descriptor register 2	USBF	1163
UF0DD3	UF0 device descriptor register 3	USBF	1163
UF0DD4	UF0 device descriptor register 4	USBF	1163
UF0DD5	UF0 device descriptor register 5	USBF	1163
UF0DD6	UF0 device descriptor register 6	USBF	1163
UF0DD7	UF0 device descriptor register 7	USBF	1163
UF0DD8	UF0 device descriptor register 8	USBF	1163
UF0DD9	UF0 device descriptor register 9	USBF	1163
UF0DD10	UF0 device descriptor register 10	USBF	1163
UF0DD11	UF0 device descriptor register 11	USBF	1163
UF0DD12	UF0 device descriptor register 12	USBF	1163
UF0DD13	UF0 device descriptor register 13	USBF	1163
UF0DD14	UF0 device descriptor register 14	USBF	1163
UF0DD15	UF0 device descriptor register 15	USBF	1163
UF0DD16	UF0 device descriptor register 16	USBF	1163
UF0DD17	UF0 device descriptor register 17	USBF	1163
UF0DEND	UF0 data end register	USBF	1115
UF0DMS0	UF0 DMA status 0 register	USBF	1111
UF0DMS1	UF0 DMA status 1 register	USBF	1112
UF0DSCL	UF0 descriptor length register	USBF	1162
UF0DSTL	UF0 device status register L	USBF	1151
UF0E0L	UF0 EP0 length register	USBF	1129
UF0E0N	UF0 EP0NAK register	USBF	1076
UF0E0NA	UF0 EP0NAKALL register	USBF	1078
UF0E0R	UF0 EP0 read register	USBF	1128
UF0E0SL	UF0 EP0 status register L	USBF	1152

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Symbol	Name	Unit	Page
UF0E0ST	UF0 EP0 setup register	USBF	1130
UF0E0W	UF0 EP0 write register	USBF	1132
UF0E1DC1	EP1 DMA control register 1	USBF	1170
UF0E1DC2	EP1 DMA control register 2	USBF	1172
UF0E1IM	UF0 endpoint 1 interface mapping register	USBF	1123
UF0E1SL	UF0 EP1 status register L	USBF	1153
UF0E2DC1	EP2 DMA control register 1	USBF	1170
UF0E2DC2	EP2 DMA control register 2	USBF	1172
UF0E2IM	UF0 endpoint 2 interface mapping register	USBF	1124
UF0E2SL	UF0 EP2 status register L	USBF	1154
UF0E3DC1	EP3 DMA control register 1	USBF	1170
UF0E3DC2	EP3 DMA control register 2	USBF	1172
UF0E3IM	UF0 endpoint 3 interface mapping register	USBF	1125
UF0E3SL	UF0 EP3 status register L	USBF	1155
UF0E4DC1	EP4 DMA control register 1	USBF	1170
UF0E4DC2	EP4 DMA control register 2	USBF	1172
UF0E4IM	UF0 endpoint 4 interface mapping register	USBF	1126
UF0E4SL	UF0 EP4 status register L	USBF	1156
UF0E7IM	UF0 endpoint 7 interface mapping register	USBF	1127
UF0E7SL	UF0 EP7 status register L	USBF	1127
UF0EN	UF0 EPNAK register	USBF	1079
UF0ENM	UF0 EPNAK mask register	USBF	1083
UF0EP1BI	UF0 EP1 bulk-in transfer data register	USBF	1174
UF0EP2BO	UF0 EP2 bulk-out transfer data register	USBF	1175
UF0EP3BI	UF0 EP3 bulk-in transfer data register	USBF	1174
UF0EP4BO	UF0 EP4 bulk-out transfer data register	USBF	1176
UF0EPS0	UF0 EP status 0 register	USBF	1087
UF0EPS1	UF0 EP status 1 register	USBF	1089
UF0EPS2	UF0 EP status 2 register	USBF	1090
UF0FIC0	UF0 FIFO clear 0 register	USBF	1113
UF0FIC1	UF0 FIFO clear 1 register	USBF	1114
UF0GPR	UF0 GPR register	USBF	1117
UF0IC0	UF0 INT clear 0 register	USBF	1104
UF0IC1	UF0 INT clear 1 register	USBF	1105
UF0IC2	UF0 INT clear 2 register	USBF	1106
UF0IC3	UF0 INT clear 3 register	USBF	1107
UF0IC4	UF0 INT clear 4 register	USBF	1108
UF0IDR	UF0 INT & DMARQ register	USBF	1109
UF0IF0	UF0 interface 0 register	USBF	1160
UF0IF1	UF0 interface 1 register	USBF	1161

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Symbol	Name	Unit	Page
UF0IF2	UF0 interface 2 register	USBF	1161
UF0IF3	UF0 interface 3 register	USBF	1161
UF0IF4	UF0 interface 4 register	USBF	1161
UF0IM0	UF0 INT mask 0 register	USBF	1099
UF0IM1	UF0 INT mask 1 register	USBF	1100
UF0IM2	UF0 INT mask 2 register	USBF	1101
UF0IM3	UF0 INT mask 3 register	USBF	1102
UF0IM4	UF0 INT mask 4 register	USBF	1103
UF0INT1	UF0 interrupt 1 register	USBF	1149
UF0IS0	UF0 INT status 0 register	USBF	1091
UF0IS1	UF0 INT status 1 register	USBF	1093
UF0IS2	UF0 INT status 2 register	USBF	1095
UF0IS3	UF0 INT status 3 register	USBF	1096
UF0IS4	UF0 INT status 4 register	USBF	1098
UF0MODC	UF0 mode control register	USBF	1118
UF0MODS	UF0 mode status register	USBF	1119
UF0SDS	UF0 SNDSIE register	USBF	1084
UF0SET	UF0 SET request register	USBF	1086
UFCKMSK	USB function control register	USBF	1058
UFDRQEN	USBF DMA request enable register	USBF	1177
UFIC0	Interrupt control register	INTC	1265
UFIC1	Interrupt control register	INTC	1265
UHCKMSK	USB function select register	USBF	1059
VSWC	System wait control register	CPU	96
WDTE	Watchdog timer enable register	WDT	671
WDTM2	Watchdog timer mode register 2	WDT	669
WUPIC0	Interrupt control register	INTC	1265

APPENDIX D INSTRUCTION SET LIST

D.1 Conventions

(1) Register symbols used to describe operands

Register Symbol	Explanation
reg1	General-purpose registers: Used as source registers.
reg2	General-purpose registers: Used mainly as destination registers. Also used as source register in some instructions.
reg3	General-purpose registers: Used mainly to store the remainders of division results and the higher 32 bits of multiplication results.
bit#3	3-bit data for specifying the bit number
immX	X bit immediate data
dispX	X bit displacement data
regID	System register number
vector	5-bit data that specifies the trap vector (00H to 1FH)
cccc	4-bit data that shows the conditions code
sp	Stack pointer (r3)
ep	Element pointer (r30)
listX	X item register list

(2) Register symbols used to describe opcodes

Register Symbol	Explanation
R	1-bit data of a code that specifies reg1 or regID
r	1-bit data of the code that specifies reg2
w	1-bit data of the code that specifies reg3
d	1-bit displacement data
I	1-bit immediate data (indicates the higher bits of immediate data)
i	1-bit immediate data
cccc	4-bit data that shows the condition codes
CCCC	4-bit data that shows the condition codes of Bcond instruction
bbb	3-bit data for specifying the bit number
L	1-bit data that specifies a program register in the register list

(3) Register symbols used in operations

Register Symbol	Explanation
←	Input for
GR [ ]	General-purpose register
SR [ ]	System register
zero-extend (n)	Expand n with zeros until word length.
sign-extend (n)	Expand n with signs until word length.
load-memory (a, b)	Read size b data from address a.
store-memory (a, b, c)	Write data b into address a in size c.
load-memory-bit (a, b)	Read bit b of address a.
store-memory-bit (a, b, c)	Write c to bit b of address a.
saturated (n)	Execute saturated processing of n (n is a 2's complement). If, as a result of calculations, n ≥ 7FFFFFFFH, let it be 7FFFFFFFH. n ≤ 80000000H, let it be 80000000H.
result	Reflects the results in a flag.
Byte	Byte (8 bits)
Halfword	Half word (16 bits)
Word	Word (32 bits)
+	Addition
–	Subtraction
ll	Bit concatenation
×	Multiplication
÷	Division
%	Remainder from division results
AND	Logical product
OR	Logical sum
XOR	Exclusive OR
NOT	Logical negation
logically shift left by	Logical shift left
logically shift right by	Logical shift right
arithmetically shift right by	Arithmetic shift right

(4) Register symbols used in execution clock

Register Symbol	Explanation
i	If executing another instruction immediately after executing the first instruction (issue).
r	If repeating execution of the same instruction immediately after executing the first instruction (repeat).
l	If using the results of instruction execution in the instruction immediately after the execution (latency).

(5) Register symbols used in flag operations

Identifier	Explanation
(Blank)	No change
0	Clear to 0
X	Set or cleared in accordance with the results.
R	Previously saved values are restored.

(6) Condition codes

Condition Code (cccc)	Condition Formula	Explanation
0 0 0 0	OV = 1	Overflow
1 0 0 0	OV = 0	No overflow
0 0 0 1	CY = 1	Carry Lower (Less than)
1 0 0 1	CY = 0	No carry Not lower (Greater than or equal)
0 0 1 0	Z = 1	Zero
1 0 1 0	Z = 0	Not zero
0 0 1 1	(CY or Z) = 1	Not higher (Less than or equal)
1 0 1 1	(CY or Z) = 0	Higher (Greater than)
0 1 0 0	S = 1	Negative
1 1 0 0	S = 0	Positive
0 1 0 1	–	Always (Unconditional)
1 1 0 1	SAT = 1	Saturated
0 1 1 0	(S xor OV) = 1	Less than signed
1 1 1 0	(S xor OV) = 0	Greater than or equal signed
0 1 1 1	((S xor OV) or Z) = 1	Less than or equal signed
1 1 1 1	((S xor OV) or Z) = 0	Greater than signed

D.2 Instruction Set (in Alphabetical Order)

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Mnemonic	Operand	Opcode	Operation		Execution Clock i	Execution Clock r	Execution Clock l	CY	OV	S	Z	SAT
ADD	reg1,reg2	rrrrr001110RRRRR	GR[reg2]←GR[reg2]+GR[reg1]		1	1	1	×	×	×	×	
	imm5,reg2	rrrrr010010iiiii	GR[reg2]←GR[reg2]+sign-extend(imm5)		1	1	1	×	×	×	×	
ADDI	imm16,reg1,reg2	rrrrr110000RRRRR iiiiiiiiiiiiiiii	GR[reg2]←GR[reg1]+sign-extend(imm16)		1	1	1	×	×	×	×	
AND	reg1,reg2	rrrrr001010RRRRR	GR[reg2]←GR[reg2]AND GR[reg1]		1	1	1		0	×	×	
ANDI	imm16,reg1,reg2	rrrrr110110RRRRR iiiiiiiiiiiiiiii	GR[reg2]←GR[reg1]AND zero-extend(imm16)		1	1	1		0	×	×	
Bcond	disp9	ddddd1011dddcccc **Note 1**	if conditions are satisfied then PC←PC+sign-extend(disp9)	When conditions are satisfied	2 Note 2	2 Note 2	2 Note 2					
				When conditions are not satisfied	1	1	1					
BSH	reg2,reg3	rrrrr11111100000 wwwww01101000010	GR[reg3]←GR[reg2] (23 : 16) ll GR[reg2] (31 : 24) ll GR[reg2] (7 : 0) ll GR[reg2] (15 : 8)		1	1	1	×	0	×	×	
BSW	reg2,reg3	rrrrr11111100000 wwwww01101000000	GR[reg3]←GR[reg2] (7 : 0) ll GR[reg2] (15 : 8) ll GR [reg2] (23 : 16) ll GR[reg2] (31 : 24)		1	1	1	×	0	×	×	
CALLT	imm6	0000001000iiiiii	CTPC←PC+2(return PC) CTPSW←PSW adr←CTBP+zero-extend(imm6 logically shift left by 1) PC←CTBP+zero-extend(Load-memory(adr,Halfword))		4	4	4					
CLR1	bit#3,disp16[reg1]	10bbb111110RRRRR dddddddddddddddd	adr←GR[reg1]+sign-extend(disp16) Z flag←Not(Load-memory-bit(adr,bit#3)) Store-memory-bit(adr,bit#3,0)		3 Note 3	3 Note 3	3 Note 3				×	
	reg2,[reg1]	rrrrr111111RRRRR 0000000011100100	adr←GR[reg1] Z flag←Not(Load-memory-bit(adr,reg2)) Store-memory-bit(adr,reg2,0)		3 Note 3	3 Note 3	3 Note 3				×	
CMOV	cccc,imm5,reg2,reg3	rrrrr111111iiiii wwwww011000cccc0	if conditions are satisfied then GR[reg3]←sign-extended(imm5) else GR[reg3]←GR[reg2]		1	1	1					
	cccc,reg1,reg2,reg3	rrrrr111111RRRR wwwww011001cccc0	if conditions are satisfied then GR[reg3]←GR[reg1] else GR[reg3]←GR[reg2]		1	1	1					
CMP	reg1,reg2	rrrrr001111RRRRR	result←GR[reg2]–GR[reg1]		1	1	1	×	×	×	×	
	imm5,reg2	rrrrr010011iiiii	result←GR[reg2]–sign-extend(imm5)		1	1	1	×	×	×	×	
CTRET		0000011111100000 0000000101000100	PC←CTPC PSW←CTPSW		3	3	3	R	R	R	R	R
DBRET		0000011111100000 0000000101000110	PC←DBPC PSW←DBPSW		3	3	3	R	R	R	R	R

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Mnemonic	Operand	Opcode	Operation	Execution Clock			Flags				
				i	r	l	CY	OV	S	Z	SAT
DBTRAP		1111100001000000	DBPC←PC+2 (restored PC) DBPSW←PSW PSW.NP←1 PSW.EP←1 PSW.ID←1 PC←00000060H	3	3	3					
DI		0000011111100000 0000000101100000	PSW.ID←1	1	1	1					
DISPOSE	imm5,list12	0000011001iiiiiL LLLLLLLLLLL00000	sp←sp+zero-extend(imm5 logically shift left by 2) GR[reg in list12]←Load-memory(sp,Word) sp←sp+4 repeat 2 steps above until all regs in list12 is loaded	n+1 Note 4	n+1 Note 4	n+1 Note 4					
	imm5,list12,[reg1]	0000011001iiiiiL LLLLLLLLLLRRRRR **Note 5**	sp←sp+zero-extend(imm5 logically shift left by 2) GR[reg in list12]←Load-memory(sp,Word) sp←sp+4 repeat 2 steps above until all regs in list12 is loaded PC←GR[reg1]	n+3 Note 4	n+3 Note 4	n+3 Note 4					
DIV	reg1,reg2,reg3	rrrrr111111RRRRR wwwww01011000000	GR[reg2]←GR[reg2]÷GR[reg1] GR[reg3]←GR[reg2]%GR[reg1]	35	35	35		×	×	×	
DIVH	reg1,reg2	rrrrr000010RRRRR	GR[reg2]←GR[reg2]÷GR[reg1] Note 6	35	35	35		×	×	×	
	reg1,reg2,reg3	rrrrr111111RRRRR wwwww01010000000	GR[reg2]←GR[reg2]÷GR[reg1] Note 6 GR[reg3]←GR[reg2]%GR[reg1]	35	35	35		×	×	×	
DIVHU	reg1,reg2,reg3	rrrrr111111RRRRR wwwww01010000010	GR[reg2]←GR[reg2]÷GR[reg1] Note 6 GR[reg3]←GR[reg2]%GR[reg1]	34	34	34		×	×	×	
DIVU	reg1,reg2,reg3	rrrrr111111RRRRR wwwww01011000010	GR[reg2]←GR[reg2]÷GR[reg1] GR[reg3]←GR[reg2]%GR[reg1]	34	34	34		×	×	×	
EI		1000011111100000 0000000101100000	PSW.ID←0	1	1	1					
HALT		0000011111100000 0000000100100000	Stop	1	1	1					
HSW	reg2,reg3	rrrrr11111100000 wwwww01101000100	GR[reg3]←GR[reg2](15 : 0) ll GR[reg2] (31 : 16)	1	1	1	×	0	×	×	
JARL	disp22,reg2	rrrrr11110ddddd ddddddddddddddd0 **Note 7**	GR[reg2]←PC+4 PC←PC+sign-extend(disp22)	2	2	2					
JMP	[reg1]	00000000011RRRRR	PC←GR[reg1]	3	3	3					
JR	disp22	0000011110ddddd ddddddddddddddd0 **Note 7**	PC←PC+sign-extend(disp22)	2	2	2					
LD.B	disp16[reg1],reg2	rrrrr111000RRRRR ddddddddddddddd	adr←GR[reg1]+sign-extend(disp16) GR[reg2]←sign-extend(Load-memory(adr,Byte))	1	1	Note 11					
LD.BU	disp16[reg1],reg2	rrrrr11110bRRRRR ddddddddddddd1 **Notes 8, 10**	adr←GR[reg1]+sign-extend(disp16) GR[reg2]←zero-extend(Load-memory(adr,Byte))	1	1	Note 11					

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Mnemonic	Operand	Opcode	Operation		Execution Clock i	Execution Clock r	Execution Clock l	Flags CY	Flags OV	Flags S	Flags Z	Flags SAT
LD.H	disp16[reg1],reg2	rrrrr111001RRRRR ddddddddddddddd0 **Note 8**	adr←GR[reg1]+sign-extend(disp16) GR[reg2]←sign-extend(Load-memory(adr,Halfword))		1	1	Note 11					
LDSR	reg2,regID	rrrrr111111RRRRR 0000000000100000 **Note 12**	SR[regID]←GR[reg2]	Other than regID = PSW	1	1	1					
				regID = PSW	1	1	1	×	×	×	×	×
LD.HU	disp16[reg1],reg2	rrrrr111111RRRRR ddddddddddddddd1 **Note 8**	adr←GR[reg1]+sign-extend(disp16) GR[reg2]←zero-extend(Load-memory(adr,Halfword)		1	1	Note 11					
LD.W	disp16[reg1],reg2	rrrrr111001RRRRR ddddddddddddddd1 **Note 8**	adr←GR[reg1]+sign-extend(disp16) GR[reg2]←Load-memory(adr,Word)		1	1	Note 11					
MOV	reg1,reg2	rrrrr000000RRRRR	GR[reg2]←GR[reg1]		1	1	1					
	imm5,reg2	rrrrr010000iiiii	GR[reg2]←sign-extend(imm5)		1	1	1					
	imm32,reg1	00000110001RRRRR iiiiiiiiiiiiiiii IIIIIIIIIIIIIIII	GR[reg1]←imm32		2	2	2					
MOVEA	imm16,reg1,reg2	rrrrr110001RRRRR iiiiiiiiiiiiiiii	GR[reg2]←GR[reg1]+sign-extend(imm16)		1	1	1					
MOVHI	imm16,reg1,reg2	rrrrr110010RRRRR iiiiiiiiiiiiiiii	GR[reg2]←GR[reg1]+(imm16 ll 0^{16})		1	1	1					
MUL	reg1,reg2,reg3	rrrrr111111RRRRR wwwww01000100000	GR[reg3] ll GR[reg2]←GR[reg2]xGR[reg1] **Note 14**		1	4	5					
	imm9,reg2,reg3	rrrrr111111iiiii wwwww01001IIII00 **Note 13**	GR[reg3] ll GR[reg2]←GR[reg2]xsign-extend(imm9)		1	4	5					
MULH	reg1,reg2	rrrrr000111RRRRR	GR[reg2]←GR[reg2]Note 6xGR[reg1]Note 6		1	1	2					
	imm5,reg2	rrrrr010111iiiii	GR[reg2]←GR[reg2]Note 6xsign-extend(imm5)		1	1	2					
MULHI	imm16,reg1,reg2	rrrrr110111RRRRR iiiiiiiiiiiiiiii	GR[reg2]←GR[reg1]Note 6ximm16		1	1	2					
MULU	reg1,reg2,reg3	rrrrr111111RRRRR wwwww01000100010	GR[reg3] ll GR[reg2]←GR[reg2]xGR[reg1] **Note 14**		1	4	5					
	imm9,reg2,reg3	rrrrr111111iiiii wwwww01001IIII10 **Note 13**	GR[reg3] ll GR[reg2]←GR[reg2]xzero-extend(imm9)		1	4	5					
NOP		0000000000000000	Pass at least one clock cycle doing nothing.		1	1	1					
NOT	reg1,reg2	rrrrr000001RRRRR	GR[reg2]←NOT(GR[reg1])		1	1	1		0	×	×	
NOT1	bit#3,disp16[reg1]	01bbb111110RRRRR dddddddddddddddd	adr←GR[reg1]+sign-extend(disp16) Z flag←Not(Load-memory-bit(adr,bit#3)) Store-memory-bit(adr,bit#3,Z flag)		3 Note 3	3 Note 3	3 Note 3				×	
	reg2,[reg1]	rrrrr111111RRRRR 0000000011100010	adr←GR[reg1] Z flag←Not(Load-memory-bit(adr,reg2)) Store-memory-bit(adr,reg2,Z flag)		3 Note 3	3 Note 3	3 Note 3				×	

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Mnemonic	Operand	Opcode	Operation	Execution Clock			Flags				
				i	r	l	CY	OV	S	Z	SAT
OR	reg1,reg2	rrrrr001000RRRRR	GR[reg2]←GR[reg2]OR GR[reg1]	1	1	1		0	×	×	
ORI	imm16,reg1,reg2	rrrrr110100RRRRR iiiiiiiiiiiiiiii	GR[reg2]←GR[reg1]OR zero-extend(imm16)	1	1	1		0	×	×	
PREPARE	list12,imm5	0000011110iiiiiL LLLLLLLLLLL00001	Store-memory(sp–4,GR[reg in list12],Word) sp←sp–4 repeat 1 step above until all regs in list12 is stored sp←sp-zero-extend(imm5)	n+1 Note 4	n+1 Note 4	n+1 Note 4					
	list12,imm5, sp/imm Note 15	0000011110iiiiiL LLLLLLLLLLLff011 imm16/imm32 **Note 16**	Store-memory(sp–4,GR[reg in list12],Word) sp←sp+4 repeat 1 step above until all regs in list12 is stored sp←sp-zero-extend (imm5) ep←sp/imm	n+2 Note 4 Note 17	n+2 Note 4 Note 17	n+2 Note 4 Note 17					
RETI		0000011111100000 0000000101000000	if PSW.EP=1 then PC ←EIPC PSW ←EIPSW else if PSW.NP=1 then PC ←FEPC PSW ←FEPSW else PC ←EIPC PSW ←EIPSW	3	3	3	R	R	R	R	R
SAR	reg1,reg2	rrrrr111111RRRRR 0000000010100000	GR[reg2]←GR[reg2]arithmetically shift right by GR[reg1]	1	1	1	×	0	×	×	
	imm5,reg2	rrrrr010101iiiii	GR[reg2]←GR[reg2]arithmetically shift right by zero-extend (imm5)	1	1	1	×	0	×	×	
SASF	cccc,reg2	rrrrr1111110cccc 0000001000000000	if conditions are satisfied then GR[reg2]←(GR[reg2]Logically shift left by 1) OR 00000001H else GR[reg2]←(GR[reg2]Logically shift left by 1) OR 00000000H	1	1	1					
SATADD	reg1,reg2	rrrrr000110RRRRR	GR[reg2]←saturated(GR[reg2]+GR[reg1])	1	1	1	×	×	×	×	×
	imm5,reg2	rrrrr010001iiiii	GR[reg2]←saturated(GR[reg2]+sign-extend(imm5)	1	1	1	×	×	×	×	×
SATSUB	reg1,reg2	rrrrr000101RRRRR	GR[reg2]←saturated(GR[reg2]–GR[reg1])	1	1	1	×	×	×	×	×
SATSUBI	imm16,reg1,reg2	rrrrr110011RRRRR iiiiiiiiiiiiiiii	GR[reg2]←saturated(GR[reg1]–sign-extend(imm16)	1	1	1	×	×	×	×	×
SATSUBR	reg1,reg2	rrrrr000100RRRRR	GR[reg2]←saturated(GR[reg1]–GR[reg2])	1	1	1	×	×	×	×	×
SETF	cccc,reg2	rrrrr1111110cccc 0000000000000000	If conditions are satisfied then GR[reg2]←00000001H else GR[reg2]←00000000H	1	1	1					

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Mnemonic	Operand	Opcode	Operation	Execution Clock			Flags				
				i	r	l	CY	OV	S	Z	SAT
SET1	bit#3,disp16[reg1]	00bbb111110RRRRR ddddddddddddddd	adr←GR[reg1]+sign-extend(disp16) Z flag←Not (Load-memory-bit(adr,bit#3)) Store-memory-bit(adr,bit#3,1)	3 Note 3	3 Note 3	3 Note 3				×	
	reg2,[reg1]	rrrrr111111RRRRR 0000000011100000	adr←GR[reg1] Z flag←Not(Load-memory-bit(adr,reg2)) Store-memory-bit(adr,reg2,1)	3 Note 3	3 Note 3	3 Note 3				×	
SHL	reg1,reg2	rrrrr111111RRRRR 0000000011000000	GR[reg2]←GR[reg2] logically shift left by GR[reg1]	1	1	1	×	0	×	×	
	imm5,reg2	rrrrr010110iiiii	GR[reg2]←GR[reg2] logically shift left by zero-extend(imm5)	1	1	1	×	0	×	×	
SHR	reg1,reg2	rrrrr111111RRRRR 0000000010000000	GR[reg2]←GR[reg2] logically shift right by GR[reg1]	1	1	1	×	0	×	×	
	imm5,reg2	rrrrr010100iiiii	GR[reg2]←GR[reg2] logically shift right by zero-extend(imm5)	1	1	1	×	0	×	×	
SLD.B	disp7[ep],reg2	rrrrr0110ddddddd	adr←ep+zero-extend(disp7) GR[reg2]←sign-extend(Load-memory(adr,Byte))	1	1	Note 9					
SLD.BU	disp4[ep],reg2	rrrrr0000110dddd **Note 18**	adr←ep+zero-extend(disp4) GR[reg2]←zero-extend(Load-memory(adr,Byte))	1	1	Note 9					
SLD.H	disp8[ep],reg2	rrrrr1000ddddddd **Note 19**	adr←ep+zero-extend(disp8) GR[reg2]←sign-extend(Load-memory(adr,Halfword))	1	1	Note 9					
SLD.HU	disp5[ep],reg2	rrrrr0000111dddd **Notes 18, 20**	adr←ep+zero-extend(disp5) GR[reg2]←zero-extend(Load-memory(adr,Halfword))	1	1	Note 9					
SLD.W	disp8[ep],reg2	rrrrr1010ddddddd0 **Note 21**	adr←ep+zero-extend(disp8) GR[reg2]←Load-memory(adr,Word)	1	1	Note 9					
SST.B	reg2,disp7[ep]	rrrrr0111ddddddd	adr←ep+zero-extend(disp7) Store-memory(adr,GR[reg2],Byte)	1	1	1					
SST.H	reg2,disp8[ep]	rrrrr1001ddddddd **Note 19**	adr←ep+zero-extend(disp8) Store-memory(adr,GR[reg2],Halfword)	1	1	1					
SST.W	reg2,disp8[ep]	rrrrr1010ddddddd1 **Note 21**	adr←ep+zero-extend(disp8) Store-memory(adr,GR[reg2],Word)	1	1	1					
ST.B	reg2,disp16[reg1]	rrrrr111010RRRRR ddddddddddddddd	adr←GR[reg1]+sign-extend(disp16) Store-memory(adr,GR[reg2],Byte)	1	1	1					
ST.H	reg2,disp16[reg1]	rrrrr111011RRRRR ddddddddddddddd0 **Note 8**	adr←GR[reg1]+sign-extend(disp16) Store-memory (adr,GR[reg2], Halfword)	1	1	1					
ST.W	reg2,disp16[reg1]	rrrrr111011RRRRR ddddddddddddddd1 **Note 8**	adr←GR[reg1]+sign-extend(disp16) Store-memory (adr,GR[reg2], Word)	1	1	1					
STSR	regID,reg2	rrrrr111111RRRRR 0000000001000000	GR[reg2]←SR[regID]	1	1	1					

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Mnemonic	Operand	Opcode	Operation	Execution Clock			Flags				
				i	r	l	CY	OV	S	Z	SAT
SUB	reg1,reg2	rrrrr001101RRRRR	GR[reg2]←GR[reg2]–GR[reg1]	1	1	1	×	×	×	×	
SUBR	reg1,reg2	rrrrr001100RRRRR	GR[reg2]←GR[reg1]–GR[reg2]	1	1	1	×	×	×	×	
SWITCH	reg1	00000000010RRRRR	adr←(PC+2) + (GR [reg1] logically shift left by 1) PC←(PC+2) + (sign-extend (Load-memory (adr,Halfword)) logically shift left by 1	5	5	5					
SXB	reg1	00000000101RRRRR	GR[reg1]←sign-extend (GR[reg1] (7 : 0))	1	1	1					
SXH	reg1	00000000111RRRRR	GR[reg1]←sign-extend (GR[reg1] (15 : 0))	1	1	1					
TRAP	vector	0000011111iiiii 0000000100000000	EIPC ←PC+4 (Restored PC) EIPSW ←PSW ECR.EICC ←Interrupt code PSW.EP ←1 PSW.ID ←1 PC ←00000040H (when vector is 00H to 0FH) 00000050H (when vector is 10H to 1FH)	3	3	3					
TST	reg1,reg2	rrrrr001011RRRRR	result←GR[reg2] AND GR[reg1]	1	1	1		0	×	×	
TST1	bit#3,disp16[reg1]	11bbb111110RRRRR ddddddddddddddd	adr←GR[reg1]+sign-extend(disp16) Z flag←Not (Load-memory-bit (adr,bit#3))	3 Note 3	3 Note 3	3 Note 3				×	
	reg2, [reg1]	rrrrr111111RRRRR 0000000011100110	adr←GR[reg1] Z flag←Not (Load-memory-bit (adr,reg2))	3 Note 3	3 Note 3	3 Note 3				×	
XOR	reg1,reg2	rrrrr001001RRRRR	GR[reg2]←GR[reg2] XOR GR[reg1]	1	1	1		0	×	×	
XORI	imm16,reg1,reg2	rrrrr110101RRRRR iiiiiiiiiiiiiiii	GR[reg2]←GR[reg1] XOR zero-extend (imm16)	1	1	1		0	×	×	
ZXB	reg1	00000000100RRRRR	GR[reg1]←zero-extend (GR[reg1] (7 : 0))	1	1	1					
ZXH	reg1	00000000110RRRRR	GR[reg1]←zero-extend (GR[reg1] (15 : 0))	1	1	1					

Notes 1. ddddddddd: Higher 8 bits of disp9.

2. 3 if there is an instruction that rewrites the contents of the PSW immediately before.

3. If there is no wait state (3 + the number of read access wait states).

4. n is the total number of list12 load registers. (According to the number of wait states. Also, if there are no wait states, n is the total number of list12 registers. If n = 0, same operation as when n = 1)

5. RRRRR: other than 00000.

6. The lower halfword data only are valid.

7. ddddddddddddddddddddd: The higher 21 bits of disp22.

8. ddddddddddddddd: The higher 15 bits of disp16.

9. According to the number of wait states (1 if there are no wait states).

10. b: bit 0 of disp16.

11. According to the number of wait states (2 if there are no wait states).

Notes 12. In this instruction, for convenience of mnemonic description, the source register is made reg2, but the reg1 field is used in the opcode. Therefore, the meaning of register specification in the mnemonic description and in the opcode differs from other instructions.

rrrrr = regID specification

RRRRR = reg2 specification

13. iiiii: Lower 5 bits of imm9.

IIII: Higher 4 bits of imm9.

14. Do not specify the same register for general-purpose registers reg1 and reg3.

15. sp/imm: Specified by bits 19 and 20 of the sub-opcode.

16. ff = 00: Load sp in ep.

01: Load sign-expanded 16-bit immediate data (bits 47 to 32) in ep.

10: Load 16-bit logically-left-shifted 16-bit immediate data (bits 47 to 32) in ep.

11: Load 32-bit immediate data (bits 63 to 32) in ep.

17. If imm = imm32, n + 3 clocks.

18. rrrrr: Other than 00000.

19. ddddddd: Higher 7 bits of disp8.

20. dddd: Higher 4 bits of disp5.

21. dddddd: Higher 6 bits of disp8.

APPENDIX E REVISION HISTORY

E.1 Major Revisions in This Edition

Page	Description
p.34	Modification of **2.1 (1) Port pins**
pp.38 to 46	Modification of **2.1 (2) Non-Port pins**
p.101	Addition of Caution to **Figure 4-1. Port Configuration Diagram (V850ES/JG3-H)**
p.101	Addition of Caution to **Figure 4-2. Port Configuration Diagram (V850ES/JH3-H)**
p.816	Modification of **Figure 19-3. UARTC1 and I2C02 Mode Switch Settings**

E.2 Revision History of Preceding Editions

Here is the revision history of the preceding editions. Chapter indicates the chapter of each edition.

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Edition	Description	Chapter
3rd	Addition of **Note** to **5.5.1(1) Data wait control register 0 (DWC0)**	**CHAPTER 5 BUS CONTROL FUNCTIONS**
	Addition of **Note** to **5.5.4(1) Address wait control register (AWC)**	
	Addition of **Note** to **5.6(1) Bus cycle control register (BCC)**	
	Modification of **CHAPTER 20 CAN CONTROLLER**	**CHAPTER 20 CAN CONTROLLER**
	Addition of **Caution** to **21.1 Overview**	**CHAPTER 21 USB FUNCTION CONTROLLER (USBF)**
	Modification of **Figure 21-3. Example of USB Function Controller Connection**	
	Modification of **21.4 (2) Stopping the USB clock**	
	Modification of **21.6.1 (2) USB function control register (UFCKMSK)**	
	Modification of **21.6.3 (26) UF0 INT & DMARQ register (UF0IDR)**	
	Modification of **21.6.8 (1) UF0 EP1 bulk-in transfer data register (UF0EP1BI)**	
	Modification of **21.6.8 (2) UF0 EP3 bulk-in transfer data register (UF0EP3BI)**	
	Modification of **21.6.9 (1) UF0 EP2 bulk-out transfer data register (UF0EP2BO)**	
	Modification of **21.6.9 (2) UF0 EP4 bulk-out transfer data register (UF0EP4BO)**	
	Addition of **21.9.6 (1) Initial settings for a bulk transfer (OUT: EP2, EP4)**	
	Addition of **21.9.7 (1) Initial settings for a bulk transfer (IN: EP1, EP3)**	
	Modification of **Table 31-6. Wiring of V850ES/JG3-H Flash Writing Adapters**	**CHAPTER 31 FLASH MEMORY**
	Modification of **Table 31-7. Wiring of V850ES/JH3-H Flash Writing Adapters**	
	Addition of **31.6 Creating ROM code to place order for previously written product**	
	Modification of "**Port registers when CSIF0 is used (a)**" in **32.2.3 (5) Securement of communication serial interface**	**CHAPTER 32 ON-CHIP DEBUG FUNCTION**
	Modification of "**Port registers when CSIF3 is used (a)**" in **32.2.3 (5) Securement of communication serial interface**	
	Modification of **33.1 Absolute Maximum Ratings**	**CHAPTER 33 ELECTRICAL SPECIFICATIONS**
	Addition of **33.4.1 (1) KYOCERA KINSEKI CORPORATION: Crystal resonator**	
	Addition of **33.4.1 (2) KYOCERA CORPORATION: Ceramic resonator**	
	Addition of **33.4.1 (3) Toyama Murata Mfg. Co. Ltd.: Ceramic resonator**	
	Addition of **33.4.2 (1) Seiko Instruments Inc.: Crystal resonator**	
	Modification of **33.5.1 I/O level**	
	Modification of **33.5.2 Supply current**	
	Modification of **33.6 (1) In STOP mode**	
	Modification of **33.9 (1) Basic characteristics**	
	Addition of **CHAPTER 35 RECOMMENDED SOLDERING CONDITIONS**	**CHAPTER 35 RECOMMEND SOLDERING CONDITIONS**
	Addition of **APPENDIX E REVISION HISTORY**	**APPENDIX E REVISION HISTORY**

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Edition	Description	Chapter
2nd	Modification of **3.4.4 (2) (d) Data-only RAM (8 KB)**	**CHAPTER 3 CPU FUNCTION**
	Addition of **Caution** to **3.4.4 (2) (d) Data-only RAM (8 KB)**	
	Modification of **Figure 3-10. Data only RAM (8 KB)**	
	Modification of **3.4.4 (4) External memory area**	
	Modification of **3.4.6 Peripheral I/O registers**	
	Modification of **Figure 7-23. (d) TAAn I/O control register 2 (TAAnIOC2)**	**CHAPTER 7 16-BIT TIMER/EVENT COUNTER AA (TAA)**
	Modification of **Figure 7-27. (d) TAAn I/O control register 2 (TAAnIOC2)**	
	Modification of **7.8 Cascade Connection**	
	Modification of **Table 12-1 Configuration of Real-Time Counter**	**CHAPTER 12 REAL-TIME COUNTER**
	Modification of **Figure 12-1. Block Diagram of Real-Time Counter**	
	Addition of **12.3 (17) Prescaler mode register 0 (PRSM0)**	
	Addition of **12.3 (18) Prescaler compare register 0 (PRSCM0)**	
	Addition of **Note 2** to **18.4 (2) CSIFn control register 1 (CFnCTL1)**	**CHAPTER 18 3-WIRE VARIABLE-LENGTH SERIAL I/O (CSIF)**
	Modification of **Table 19-4. Extension Code Bit Definitions**	**CHAPTER 19 I2C BUS**
	Modification of **Figure 19-23. Example of Master to Slave Communication (When 9-Clock Wait Is Selected for Both Master and Slave)**	
	Modification of **Figure 19-24. Example of Slave to Master Communication (When 8-Clock Wait for Master and 9-Clock Wait for Slave Are Selected)**	
	Modification of **Figure 21-1. Block Diagram of USB Function Controller**	**CHAPTER 21 USB FUNCTION CONTROLLER (USBF)**
	Addition of **22.3 (7) External DMA request enable register (EXDRQEN)**	**CHAPTER 22 DMA FUNCTION (DMA CONTROLLER)**
	Modification of **Table 25-10. Operating Status in Subclock Operation Mode**	**CHAPTER 25 STANDBY FUNCTION**
	Modification of **Figure 28-1. Block Diagram of Low-Voltage Detector**	**CHAPTER 28 LOW-VOLTAGE DETECTOR (LVI)**
	Modification of **33.5.1 I/O level**	**CHAPTER 33 ELECTRICAL SPECIFICATIONS**
	Modification of **33.7.2 (1) (a) Read/write cycle (CLKOUT asynchronous)**	
	Modification of **33.7.2 (1) (b) Read/write cycle (CLKOUT synchronous): In multiplexed bus mode/separate bus mode**	
	Modification of **33.7.2 (2) (a) CLKOUT asynchronous**	
	33.7.2 (2) (b) CLKOUT synchronous	
	Modification of **33.7.2 (6) (a) Master mode**	
	Modification of **33.7.2 (6) (b) Slave mode**	
	Modification of **33.8 (10) A/D converter**	
	Addition of **APPENDIX E REVISION HISTORY**	**APPENDIX E REVISION HISTORY**

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Edition	Description	Chapter
2nd	Modification of **3.4.4 (2) (d) Data-only RAM (8 KB)**	**CHAPTER 3 CPU FUNCTION**
	Addition of **Caution** to **3.4.4 (2) (d) Data-only RAM (8 KB)**	
	Modification of **Figure 3-10. Data only RAM (8 KB)**	
	Modification of **3.4.4 (4) External memory area**	
	Modification of **3.4.6 Peripheral I/O registers**	
	Modification of **Figure 7-23. (d) TAAn I/O control register 2 (TAAnIOC2)**	**CHAPTER 7 16-BIT TIMER/EVENT COUNTER AA (TAA)**
	Modification of **Figure 7-27. (d) TAAn I/O control register 2 (TAAnIOC2)**	
	Modification of **7.8 Cascade Connection**	
	Modification of **Table 12-1 Configuration of Real-Time Counter**	**CHAPTER 12 REAL-TIME COUNTER**
	Modification of **Figure 12-1. Block Diagram of Real-Time Counter**	
	Addition of **12.3 (17) Prescaler mode register 0 (PRSM0)**	
	Addition of **12.3 (18) Prescaler compare register 0 (PRSCM0)**	
	Addition of **Note 2** to **18.4 (2) CSIFn control register 1 (CFnCTL1)**	**CHAPTER 18 3-WIRE VARIABLE-LENGTH SERIAL I/O (CSIF)**
	Modification of **Table 19-4. Extension Code Bit Definitions**	**CHAPTER 19 I2C BUS**
	Modification of **Figure 19-23. Example of Master to Slave Communication (When 9-Clock Wait Is Selected for Both Master and Slave)**	
	Modification of **Figure 19-24. Example of Slave to Master Communication (When 8-Clock Wait for Master and 9-Clock Wait for Slave Are Selected)**	
	Modification of **Figure 21-1. Block Diagram of USB Function Controller**	**CHAPTER 21 USB FUNCTION CONTROLLER (USBF)**
	Addition of **22.3 (7) External DMA request enable register (EXDRQEN)**	**CHAPTER 22 DMA FUNCTION (DMA CONTROLLER)**
	Modification of **Table 25-10. Operating Status in Subclock Operation Mode**	**CHAPTER 25 STANDBY FUNCTION**
	Modification of **Figure 28-1. Block Diagram of Low-Voltage Detector**	**CHAPTER 28 LOW-VOLTAGE DETECTOR (LVI)**
	Modification of **33.5.1 I/O level**	**CHAPTER 33 ELECTRICAL SPECIFICATIONS**
	Modification of **33.7.2 (1) (a) Read/write cycle (CLKOUT asynchronous)**	
	Modification of **33.7.2 (1) (b) Read/write cycle (CLKOUT synchronous): In multiplexed bus mode/separate bus mode**	
	Modification of **33.7.2 (2) (a) CLKOUT asynchronous**	
	33.7.2 (2) (b) CLKOUT synchronous	
	Modification of **33.7.2 (6) (a) Master mode**	
	Modification of **33.7.2 (6) (b) Slave mode**	
	Modification of **33.8 (10) A/D converter**	
	Addition of **APPENDIX E REVISION HISTORY**	**APPENDIX E REVISION HISTORY**

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Edition	Description	Chapter
3rd	Modification of **4.3.3 (6)Port 2 alternate function specifications**	**CHAPTER 4 PORT FUNCTION**
	Modification of **4.3.9 Port 9 function control register (PFC9)**	
	Modification of **4.3.9 Port 9 function control expansion register (PFCE9)**	
	Modification of **Table 4-20. Using Port Pin as Alternate-Function Pin**	
	Modification of **Figure 12-1. Block Diagram of Real-Time Counter**	**CHAPTER 12 REAL-TIME COUNTER**
	Modification of **12.2.2 (3)**	
	Modification of **Figure 12-10. Watch Error Correction Example**	
	Modification of **18.4 (2) CSIFn control register 1 (CFnCTL1) Note**	**CHAPTER 18 3-WIRE VARIABLE-LENGTH SERIAL I/O (CSIF)**
	Modification of **Figure 21-30. Example of Suspend/Resume Processing**	**CHAPTER 21 USB FUNCTION CONTROLLER (USBF)**
	Addition of Caution to **(6) DMA trigger factor registers 0 to 3 (DTFR0 to DTFR3)**	**CHAPTER 22 DMA FUNCTION (DMA CONTROLLER)**
	Modification of **Table 31-2. Basic Functions**	**CHAPTER 31 FLASH MEMORY**
	Modification of **Table 31-8. Flash Memory Control Commands**	
	Modification of **33.9 (1) Basic characteristics**	**CHAPTER 33 ELECTRICAL SPECIFICATIONS**

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