WLR089U0

WLR089U0 Low Power LoRa® Sub-GHz Module Data Sheet

Introduction

The WLR089U0 is a Long Range (LoRa) transceiver module for the sub-1GHz ISM bands such as 868 MHz (Europe) and 915 MHz (North America), optimized for ultra-low-power applications. This module combines the ATSAMR34J18B SiP (System-in-Package), 32.768 kHz crystal, 32 MHz TCXO, RF switch, lumped element harmonics rejection filter, impedance matching circuits, Low Pass Filter (LPF) and required RF shielding in a compact 17 mm x 13.5 mm design. The module supports LoRa® and FSK modulation.

The LoRa technology is a spread spectrum protocol optimized for low data-rate, ultra-long range signaling. It is ideal for battery-powered remote sensors and controls. The module also includes USB, making it suitable for USB dongle applications or for software updates via USB.

Note: For a detailed description on the supported peripherals, refer to the *SAM R34/R35 Low Power LoRa Sub-GHz SiP Datasheet (DS70005356)*.

Features

- Processor:
    - ARM Cortex -M0+ CPU running at up to 48 MHz (2.46CoreMark®/MHz)
        - Single-cycle hardware multiplier
        - Micro Trace Buffer (MTB)
- Memory:
    - In-system self-programmable 256 KB Flash memory
    - 32 KB Static Random Access Memory (SRAM)
    - 8 KB low power SRAM memory
- System:
    - Power-on Reset (POR) and Brown-out Reset (BOR)
    - Internal and external clock options with 48 MHz Digital Frequency Locked Loop (DFLL48M) and 48 MHz to 96 MHz Fractional Digital Phase Locked Loop (FDPLL96M)
    - External Interrupt Controller (EIC)
    - Up to 15 external interrupts
    - One Non-Maskable Interrupt (NMI)
    - 2-pin Serial Wire Debug (SWD) programming, test and debugging interface
- Operating Voltage: 1.8V – 3.5V
- Low Power Consumption
    - Transceiver:
        - RX = 12.64 mA (typical)
        - RFO_HF = 41.54 mA (typical)
        - PA_BOOST = 114.68 mA (typical)
    - MCU:
        - Standby and Backup Sleep modes
        - SleepWalking peripherals
- Temperature Range: −40°C to +85°C (Industrial)

RF/Analog Features

- Integrated LoRa Technology Transceiver:
  - 863 MHz to 928 MHz dual-band coverage
  - +18.59 dBm maximum power (V_{CC} > 2.4 V_{DC})
- High Sensitivity:
  - -136 dBm (LoRaWAN® protocol compliant modes)
- Up to 154.59 dB Maximum Link Budget
- Robust Front-end: IIp3 = -11 dBm
- Excellent Blocking Immunity
- Fully Integrated Synthesizer with a Resolution of 61 Hz
- LoRa Technology and (G)FSK Modulations
- Preamble Detection
- 127 dB Dynamic Range RSSI
- Automatic RF Sense and Channel Activity Detection (CAD) with Ultra-Fast Automatic Frequency Control (AFC)
- Packet Engine up to 256 Bytes with Cyclic Redundancy Check (CRC)

Peripheral Information

- 16-Channel Direct Memory Access Controller (DMAC)
- 12-Channel Event System
- Three 16-bit Timer/Counters (TC), Configurable as Either of the Following:
  - One 8-bit TC with compare/capture channels
  - One 16-bit TC with compare/capture channels
  - One 32-bit TC with compare/capture channels, by using two TCs
- Two 24-bit and one 16-bit Timer/Counters for Control (TCC), with Extended Functions:
  - Up to four compare channels with optional complementary output
  - Generation of synchronized Pulse Width Modulation (PWM) pattern across port pins
  - Deterministic fault protection, fast decay and configurable dead-time between complementary output
  - Dithering that increases resolution with up to five bit and reduces quantization error
- 32-Bit Real Time Counter (RTC) with Clock/Calendar Function
- Watch-dog Timer (WDT)
- CRC-32 Generator
- One Full-speed (12 Mbps) Universal Serial Bus (USB) 2.0 Interface:
  - Embedded host and device function
  - Eight endpoints
- Up to Four Serial Communication Interfaces (SERCOM) Including One Low-Power SERCOM (SERCOM5[3]), Each Configurable to Operate as Either of the Following:
  - USART with full-duplex[1] or single-wire half-duplex configuration
  - I2C up to 3.4 MHz[2]
  - Serial Peripheral Interface (SPI)
  - Local Interconnect Network (LIN) slave
- One 12-bit, 1 Msps Analog-To-Digital Converter (ADC) with up to Seven External Channels:
  - Differential and single-ended input
  - Automatic offset and gain error compensation
  - Oversampling and decimation in hardware to support 13-, 14-, 15- or 16-bit resolution
- Two Analog Comparators (AC) with Window Compare Function
- Peripheral Touch Controller (PTC)
  - 12-channel capacitive touch and proximity sensing
- 23 Programmable I/O Pins

Note:

1. SERCOM2 has only 2 interface lines for use so it can be used only for single-wire half-duplex configuration. USART Full duplex and SPI modes are not supported.

2. I2C support is available only in PA16, PA17, PA22 and PA23 pins.

3. SERCOM5, due to its location in Power Domain (PD0) in SAM L21, has a reduced feature set and does not support the following features:

   – DMA support
   – USART:
     • 3x or 8x oversampling
     • Flow control (RTS/CTS)
     • IrDA
     • Single wire UART according to EN54
     • Start of Frame (SOF)/End of Frame (EOF) function

   – I2C:
     • Fast mode plus (Fm+) and High-speed (Hs) mode
     • SMBus Serial Clock Low (SCL) timeout
     • 10-bit addressing
     • Power Management Bus (PMBus) group command support

   – SPI:
     • Hardware chip select
     • Wake on Slave Select (SS) assertion

Table of Contents

1.   Quick References

1.1   Reference Documentation

For further details, refer to the following:

- *SAM R34-R35 Low Power LoRa Sub-GHz SiP Datasheet* (DS70005356)
- *SAM L21 Family Data Sheet* (DS60001477)
- *SAM R34/R35 Errata Sheet* (DS80000834)[1]
- *AN2468 Production Programming of Microchip AVR® and SAM Microcontrollers Application Note* (DS00002468)
- *Semtech SX1276/77/78/79 Low Power Long Range Transceiver Datasheet*
- *LoRaWAN® Regional Parameters*
- *WLR089U0 Module Reference Design Package* (available in www.microchip.com/WLR089U0)

Notes:
1. This Errata is also applicable for the WLR089U0 module.
2. For a complete list of development support tools and documentation, visit www.microchip.com/WLR089U0.

1.2   Acronyms/Abbreviations

Table 1-1. Acronyms/Abbreviations

Acronyms/Abbreviations	Description
AC	Analog Comparators
ADC	Analog-To-Digital Converter
AFC	Automatic Frequency Control
AHB	AMBA Advanced High-Performance Bus
AIN	Analog Inputs
AMBA	Advanced Microcontroller Bus Architecture
APB	AMBA Advanced Peripheral Bus
BOR	Brown-out Reset
BUPDIV	Backup Clock Division
BW	Bandwidth
CCL	Custom Control Logic
CPUDIV	CPU Clock Division
CRC	Cyclic Redundancy Check
CTS	Clear To Send
EC	Error Correction Code
EIC	External Interrupt Controller
EMI	Electro Magnetic Interference
FSK	Frequency Shift Keying
GCLK	Generic Clock Generator

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Acronyms/Abbreviations	Description
GPIO	General Purpose I/O pin
HVIN	Hardware Version Identification Number
IPA	Isopropyl alcohol
IrDA	Infrared Data Association
IRQ	Interrupt Request
ISM	Industrial, Scientific and Medical
LIN	Local Interconnect Network
LNA	Low Noise Amplifier
LoRa	Long Range
LoRaWAN®	Long Range Wide Area Network
LPDIV	Low Power Clock Division
MTB	Micro Trace Buffer
NMI	Non-Maskable Interrupt
OEM	Original Equipment Manufacturer
PA	Power Amplifier
PER	Packet Error Rate
PMN	Product Marketing Name
POR	Power-on Reset
PTC	Peripheral Touch Controller
RF	Radio frequency
RFI_HF	RF Input High Frequency
RFO_HF	RF Output High Frequency
RSSI	Received signal strength indication
RSTC	Reset Controller
RTC	Real Time Counter
RTS	Request To Send
RX	Receive/Receiver
SERCOM	Serial Communication
SF	Spreading Factor
SiP	System-in-package
SMBus	System Management Bus
SP3T	Single Pole Three Throw
SRAM	Static Random Access Memory
SUPC	Supply Controller
SWD	Serial Wire Debug

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Acronyms/Abbreviations	**Description**
TCXO	Temperature Compensated Crystal Oscillator
TRX	Transceiver
TX	Transmit/Transmitter
UART	Universal Asynchronous Receiver Transmitter
UHF	Ultra-High Frequency
USART	Universal Synchronous and Asynchronous Receiver and Transmitter
USB	Universal Serial Bus
WDT	Watch-dog Timer
WiSUN	Wireless Smart Utility Network
WMBus	Wireless Meter Bus
WO	Waveform Outputs

2.   Ordering Information

The following table provides the ordering details for the module.

Table 2-1. Ordering Information for WLR089U0

Model Number	IC Name	Description	Regulatory Approval	Ordering Code
WLR089U0	ATSAMR34J18B	Low Power Long Range (LoRa®) module with RF Shield CAN, u.FL connector for external antenna, castellated pads and available in Tray package.	FCC, ISED, CE	WLR089U0-I/RM

The following figure illustrates the module ordering code information.

Figure 2-1. Module Ordering Code Information

| W | LR | 089 | U | 0 | - | I | / | RM |

Brand
W = Standalone

Technology
LR = LoRa®

Family
868 MHz (European) and 915 MHz (North American)

Antenna
U = u.FL Connector

Encryption
0 = No Encryption

Temperature Range
I = Industrial (-40°C to +85°C)

Module
RM = Radio Module
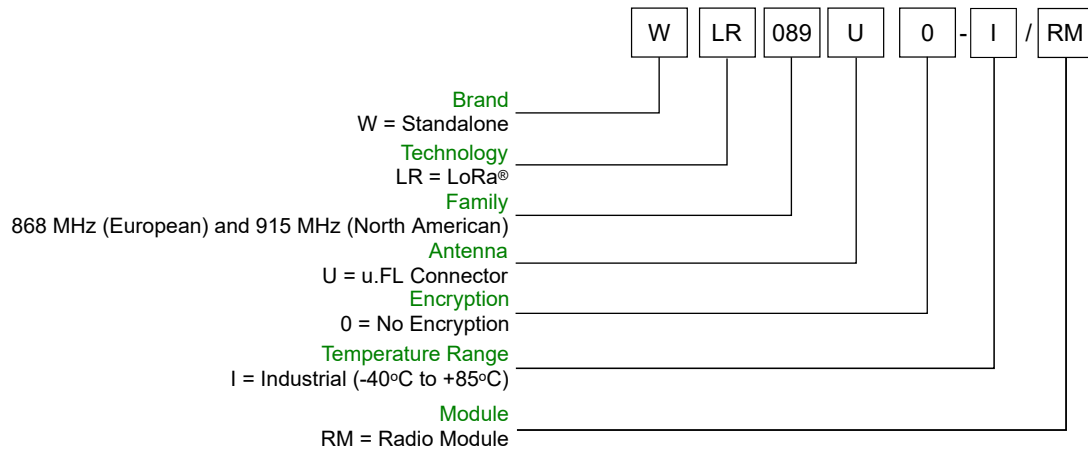
3. Functional Overview

The WLR089U0 module contains ATSAMR34J18B SiP, 32.768 kHz crystal, 32 MHz TCXO, RF switch (SP3T), lumped element harmonic filter, RF matching components and a Low Pass Filter (LPF) (see the following figure).

Figure 3-1. WLR089U0 Module Block Diagram
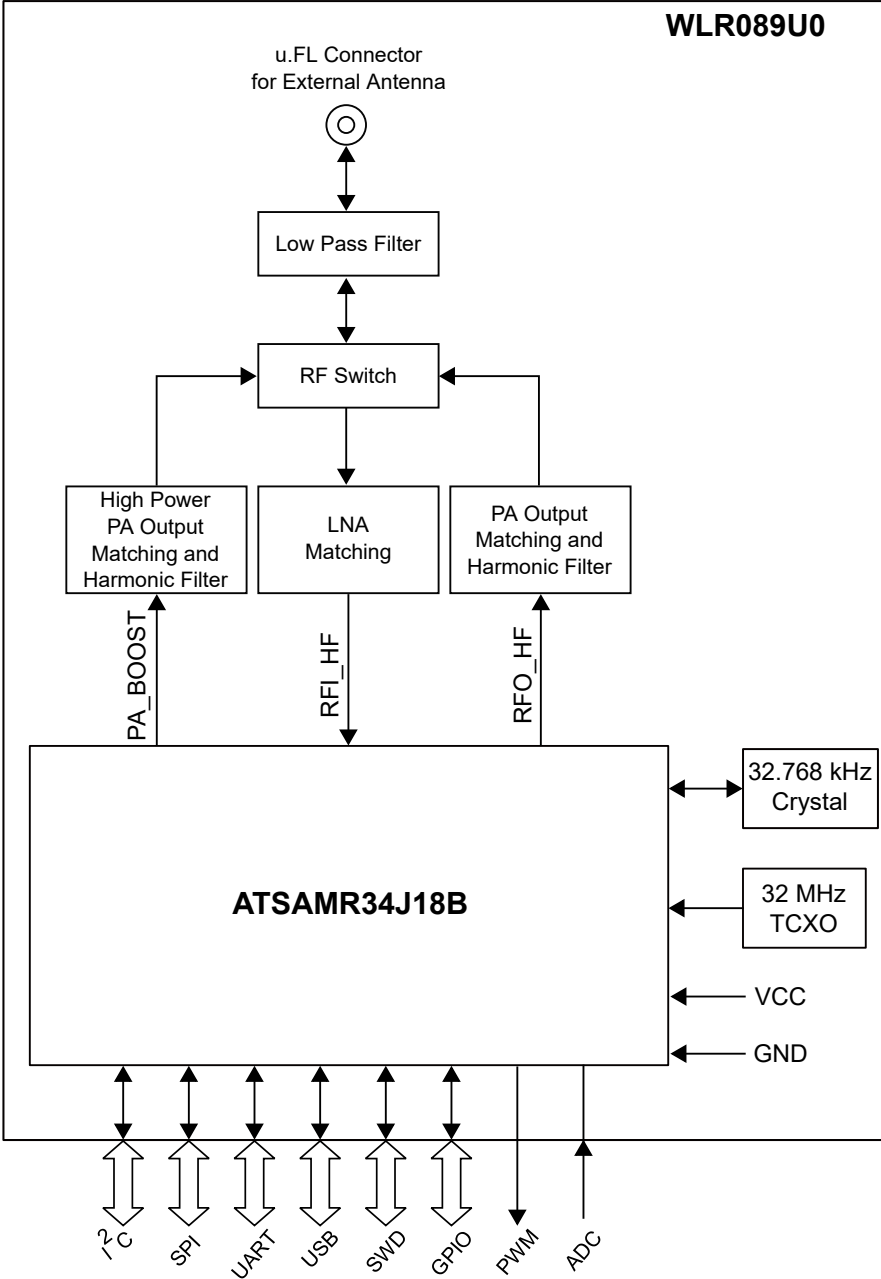
Note: The ATSAMR34J18B SiP includes an ultra-low power SAM L21 ARM Cortex M0+ based microcontroller along with a low power long range transceiver.

3.1 ATSAMR34J18B SiP Description

The ATSAMR34J18B device is an ultra-low power microcontroller equipped with a UHF transceiver. It uses the 32-bit ARM Cortex-M0+ processor at the maximum 48 MHz (2.46 CoreMark/MHz) and offers 256 KB of Flash, 32 KB of SRAM and 8 KB of low power SRAM. Sophisticated power management technologies, such as power domain gating, SleepWalking, ultra-low power peripherals and more, allow for very low line-power consumptions.

The UHF transceiver supports LoRa and FSK modulation schemes. The LoRa technology is optimized for long-range communication with minimal line-power demand. The transceiver can work from 863 MHz to 928 MHz. The maximum transmit power is +18.59 dBm without an external amplification. Operational frequency bands and power limits are defined by local regulations and the LoRa Alliance. LoRa network stack regional options ensure compliance.

All devices have accurate low power external and internal oscillators. Different clock domains can be independently configured to run at different frequencies, enabling power-saving by running each peripheral at its optimal clock frequency, thus maintaining a high CPU frequency while reducing power consumption.

The ATSAMR34J18B device supports the following software-selectable sleep modes:

- Standby – All the clocks and functions are stopped except those selected to continue running, and all the RAMs and logic contents are retained.
- Backup – Allows achieving the lowest power consumption. In this mode, the device is entirely powered off except for the backup domain. The internal regulator is turned off and the power manager allows retaining the state of the I/O lines, preventing I/O lines from toggling during wake-up. The external wake-up function is active and the debounce counter is running if at least one external wake-up pin is enabled.

The ATSAMR34J18B device supports SleepWalking, which allows some peripherals to wake-up from sleep based on predefined conditions. Thus, allowing some internal operations like DMA transfer and/or the CPU to wake up only when needed; for example, when a threshold is crossed or a result is ready. The event system supports synchronous and asynchronous events, allowing peripherals to receive, react to and send events even in Standby mode.

The ATSAMR34J18B device has two software selectable performance levels (PL0 and PL2), allowing the user to scale down to the lowest core voltage level that supports the operating frequency.

The device utilizes a power domain gating technique with retention to turn off some logic areas to minimize leakage current consumption while retaining their logic states. This technique is fully handled by hardware.

The Flash program memory can be reprogrammed through the Serial Wire Debug (SWD) interface. The same interface can also be used for non-intrusive, on-chip debugging of application code.

The ATSAMR34J18B device is supported with a full suite of programs and system development tools, including C compilers, macro assemblers, program debugger/simulators, programmers and evaluation kits.

3.2 Pinout Diagram

The WLR089U0 module pinout diagram is shown in the following figure.

Figure 3-2. WLR089U0 Module Pinout Diagram
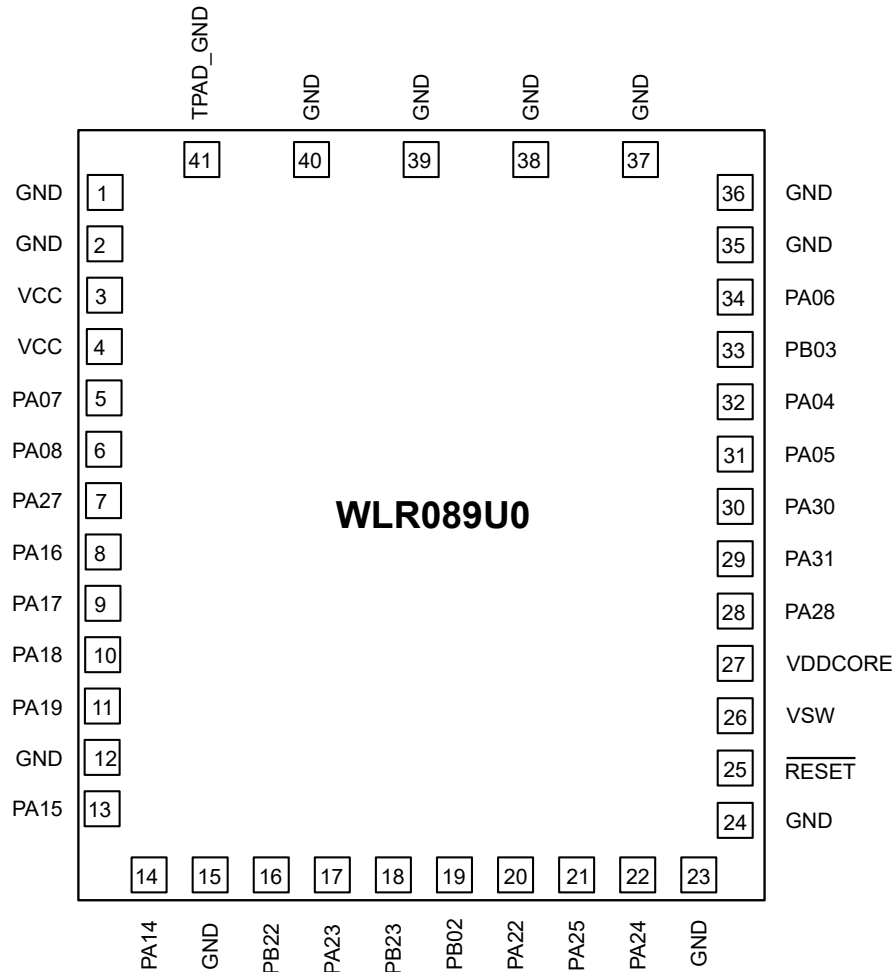
The following table describes the module pin assignment and descriptions. The ATSAMR34J18B pin numbers are added here for reference. For more details on the SiP pin descriptions, refer to *SAM R34/R35 Low Power LoRa Sub-GHz SiP Datasheet (DS70005356)*.

Table 3-1. WLR089U0 Module Pinout Assignment

WLR089U0 Module			ATSAMR34J18B SiP	
Pin No.	Pin Name	Possible Peripheral Function[1]	SiP Pin No.	Pin Function
1	GND	—	B5, B7, D4, D6, B3, E2, A2, B2, E1, F2, G2, G3, G5, G6, G7 and H5	Ground
2				
3	VCC	—	A7, A8, G4 and H8	VDDIN, VDDIO2, VDDIO1 and VBAT_DIG, respectively
4				

WLR089U0 Module			**ATSAMR34J18B SiP**	
..........continued				
Pin No.	**Pin Name**	**Possible Peripheral Function**[1]	**SiP Pin No.**	**Pin Function**
5	PA07	ADC_AIN[7]	F3	EIC_EXTINT[7], RSTC_EXTWAKE[7], ADC_AIN[7], AC_AIN[3], SERCOM0/PAD[3], TCC1/WO[1], CCL0/OUT[0]
6	PA08	GPIO	F4	EIC_NMI, ADC_AIN[16], PTC_X[0], PTC_Y[6], SERCOM0/PAD[0], SERCOM2/PAD[0], TCC0/WO[0], TCC1/WO[2], CCL1/IN[3]
7	PA27	GPIO	E4	EIC_EXTINT[15], GCLK_IO[0]
8	PA16	SERCOM1_I2C_SDA	F7	EIC_EXTINT[0], PTC_X[4], SERCOM1/PAD[0], SERCOM3/PAD[0], TCC2/WO[0], TCC0/WO[6], GCLK_IO[2], CCL0/IN[0]
9	PA17	SERCOM1_I2C_SCL	E6	EIC_EXTINT[1], PTC_X[5], SERCOM1/PAD[1], SERCOM3/PAD[1], TCC2/WO[1], TCC0/WO[1], GCLK_IO[3], CCL0/IN[1]
10	PA18	PWM_T0_W2	E7	EIC_EXTINT[2], PTC_X[6], SERCOM1/PAD[2], SERCOM3/PAD[2], TC4/WO[0], TCC0/WO[2], AC/CMP[0], CCL0/ IN[2]
11	PA19	PWM_T0_W3	E8	EIC_EXTINT[3], PTC_X[7], SERCOM1/PAD[3], SERCOM3/PAD[3], TC4/WO[1], TCC0/WO[3], AC/CMP[1], CCL0/OUT[0]
12	GND	—	B5, B7, D4, D6, B3, E2, A2, B2, E1, F2, G2, G3, G5, G6, G7 and H5	Ground
13	PA15	GPIO	G8	EIC_EXTINT[15], SERCOM2/PAD[3], TC4/WO[1], TCC0/WO[5], GCLK_IO[1]
14	PA14	GPIO	F8	EIC_EXTINT[14], SERCOM2/PAD[2], TC4/WO[0], TCC0/WO[4], GCLK_IO[0]
15	GND	—	B5, B7, D4, D6, B3, E2, A2, B2, E1, F2, G2, G3, G5, G6, G7 and H5	Ground
16	PB22	SERCOM5_SPI_MOSI	E5	EIC_EXTINT[6], SERCOM5/PAD[2], TC3/WO[0], GCLK_IO[0], CCL0/IN[0]
17	PA23	SERCOM5_SPI_Slave_Select	D7	EIC_EXTINT[7], PTC_X[11], SERCOM3/PAD[1], SERCOM5/PAD[1], TC0/WO[1], TCC0/WO[5], USB/SOF 1kHz[6], GCLK_IO[7], CCL2/IN[1]
18	PB23	SERCOM5_SPI_CLK	C7	EIC_EXTINT[7], SERCOM5/PAD[3], TC3/WO[1], GCLK_IO[1], CCL0/OUT[0]

WLR089U0 Module			ATSAMR34J18B SiP	
Pin No.	**Pin Name**	**Possible Peripheral Function**[1]	**SiP Pin No.**	**Pin Function**
19	PB02	SERCOM5_SPI_MISO	B4	EIC_EXTINT[2], ADC_AIN[10], SERCOM5/PAD[0], TC2/WO[0], SUPC/OUT[1], CCL0/OUT[0]
20	PA22	GPIO	D8	EIC_EXTINT[6], PTC_X[10], SERCOM3/PAD[0], SERCOM5/PAD[0], TC0/WO[0], TCC0/WO[4], GCLK_IO[6], CCL2/IN[0]
21	PA25	USB_DP[6]	C8	EIC_EXTINT[13], SERCOM3/PAD[3], SERCOM5/PAD[3], TC1/WO[1], TCC1/WO[3], USB/DP[6], CCL2/OUT[2]
22	PA24	USB_DM[6]	B8	EIC_EXTINT[12], SERCOM3/PAD[2], SERCOM5/PAD[2], TC1/WO[0], TCC1/WO[2], USB/DM[6], CCL2/IN[2]
23	GND	—	B5, B7, D4, D6, B3, E2, A2, B2, E1, F2, G2, G3, G5, G6, G7 and H5	Ground
24	GND	—		Ground
25	RESET	RESET_N	B6	RESET
26	VSW	VSW	A6	VSW
27	VDDCORE	VDDCORE	A5	VDDCORE
28	PA28	GPIO	C6	EIC_EXTINT[8], GCLK_IO[0]
29	PA31	SWDIO[2]	D5	EIC_EXTINT[11], SERCOM1/PAD[3], TCC1/WO[1], SWDIO[2], CCL1/OUT[1]
30	PA30	SWDCLK[2]	C5	EIC_EXTINT[10], SERCOM1/PAD[2], TCC1/WO[0], SWCLK[2], GCLK_IO[0], CCL1/IN[0]
31	PA05	SERCOM0_UART_RX	C4	EIC_EXTINT[5], RSTC_EXTWAKE[5], ADC_AIN[5], AC_AIN[1], SERCOM0/PAD[1], TCC0/WO[1], CCL0/IN[1]
32	PA04	SERCOM0_UART_TX	D3	EIC_EXTINT[4], RSTC_EXTWAKE[4], VREFB, ADC_AIN[4], AC_AIN[0], SERCOM0/PAD[0], TCC0/WO[0], CCL0/IN[0]
33	PB03	SUPC_VBAT	C3	EIC_EXTINT[3], ADC_AIN[11], SERCOM5/PAD[1], TC2/WO[1], SUPC/VBAT
34	PA06	PTC_Y4	E3	EIC_EXTINT[6], RSTC_EXTWAKE[6], ADC_AIN[6], AC_AIN[2], PTC_Y[4], SERCOM0/PAD[2], TCC1/WO[0], CCL0/IN[2]

WLR089U0 Module			ATSAMR34J18B SiP	
Pin No.	**Pin Name**	**Possible Peripheral Function[1]**	**SiP Pin No.**	**Pin Function**
35	GND	—	B5, B7, D4, D6, B3, E2, A2, B2, E1, F2, G2, G3, G5, G6, G7 and H5	Ground
36	GND	—		Ground
37	GND	—		Ground
38	GND	—		Ground
39	GND	—		Ground
40	GND	—		Ground
41	TPAD_GND	—		Thermal Pad Ground

Notes:
1. The peripheral function indicated in this column is based on the reference design. This is one of the possibilities as each WLR089U0 pin supports several multiplexed peripheral functions mentioned in the pin function column.
2. This function is only activated in the presence of a debugger.

3.3 Package Details

The following table provides the WLR089U0 module package details.

Table 3-2. WLR089U0 Package Information

Parameter	Value	Units
Package size	17x13.5	mm
Pad count	41	-
Total thickness	2.8	mm
Pad pitch	1	mm
Pad width	0.7	mm

Note: For more information on the package dimensions, refer to 10.2 Module Outline Drawings.

4. Radio Transceiver

Note: The ATSAMR34J18B SiP incorporates a LoRa transceiver.

The integrated Sub-GHz transceiver supports LoRa technology spread spectrum modulation, combining ultra-long range communications and high interference immunity with extremely low current consumption. Receive sensitivity of -136 dBm can be achieved in LoRaWAN protocol compliant mode using a TCXO and bill of materials.

The transmit section offers two integrated power amplifiers. The highly efficient RFO port delivers up to +14.35 dBm for the European region and battery conservation. The high-powered PA_BOOST port delivers up to +18.59 dBm of raw RF power with high-voltage supplies. This combination of high power and high RX sensitivity yields an industry-leading link budget, making it ideal for any application requiring long-range, low-data-rate communications. LoRa technology also provides significant advantages in both blocking and selectivity over conventional modulation techniques, solving the traditional design compromise between range, interference robustness and energy consumption. For maximum flexibility, the user may decide on the spread spectrum modulation bandwidth (BW), spreading factor (SF) and forward error correction rate. Another benefit of the spread spectrum modulation is that each spreading factor is orthogonal; thus, multiple transmitted signals can occupy the same channel without interfering.

This transceiver offers bandwidth options ranging from 125 kHz to 500 kHz with spreading factors ranging from 7 to 12.

4.1 Transceiver Validation

The WLR089U0 module has been extensively tested using LoRa modulation for 863-928 MHz frequency range. Validation of the WLR089U0 module was performed at frequencies typically used in LoRa applications.

5. Nonvolatile Memory

The WLR089U0 provides the user with a readable Nonvolatile Memory (NVM) space called user row, programmed in the factory. The base address for the application is `0x804008`. The following table shows the implemented data structure.

Table 5-1. NVM (User Row) Data

| Address Offset	Field Name	Field Description	Length
`BaseAddr. + 0x00`	MIB_REVISION	Data structure revision. `0x1501`	2 bytes
+ `0x02`	MAC_IEEE_ADDRESS	Module specific IEEE MAC Address	8 bytes
+ `0x0A`	BOARD_SERIAL	Module specific serial number	10 bytes
+ `0x14`	PART_NO	Product specific part number	8 bytes
+ `0x1C`	PCBA_REV	Product PCB/assembly revision	1 byte
+ `0x1D`	XTAL_TRIM	Reference crystal calibration value	1 byte
+ `0x1E`	CRC16	Checksum for this data structure	2 bytes

BOARD_SERIAL, PART_NO and XTAL_TRIM for this WLR089U0 module is programmed with `0xFF`. As the module uses TCXO on board, XTAL_TRIM is not applicable. The MAC_IEEE_ADDRESS is stored little-endian with the first byte stored at the lowest address.

6. Host Interface

6.1 Interconnection between SAM L21 and Transceiver within ATSAMR34J18B SiP

This section describes the transceiver to microcontroller interface. The interface is comprised of a slave SPI and additional control signals. This interface is connected to a SAM L21 master interface as shown below. The SERCOM4 and GPIO signals dedicated to the CPU-TRX interface are not externally exposed and may not be used for any other purposes.

Figure 6-1. Microcontroller to Transceiver Interface
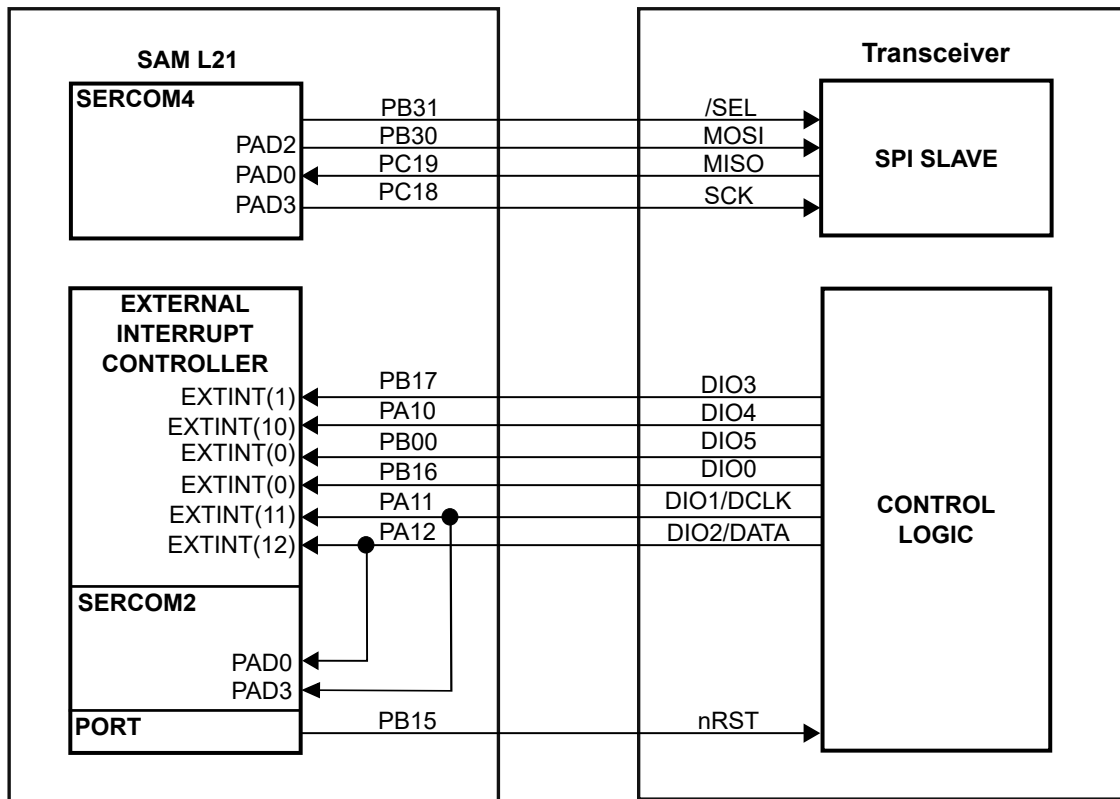
The SPI is used for register, Frame Buffer and SRAM access. The additional control signals are connected to the GPIO/IRQ interface of the microcontroller. The table below introduces the radio transceiver I/O signals and their functionalities.

Table 6-1. Microcontroller Interface Signal Description

TRX Signal	CPU Signal Name	Description
/SEL	PB31	SPI select signal, active-low
MOSI	PB30	SPI data (master output slave input) signal
MISO	PC19	SPI data (master input slave output) signal
SCLK	PC18	SPI clock signal
nRST	PB15	Transceiver Reset signal, active-low
DIO0	PB16	Digital I/O, software-configured

TRX Signal	CPU Signal Name	Description
..........continued		
DIO1	PA11	Digital I/O, software-configured
DIO2	PA12	Digital I/O, software-configured
DIO3	PB17	Digital I/O, software-configured
DIO4	PA10	Digital I/O, software-configured
DIO5	PB00	Digital I/O, software-configured

6.2 Programming and Debugging

The SWD interface on the WLR089U0 module is supported by Microchip's programmers and debuggers like Atmel-ICE, SAM-ICE™ and an on-board Embedded Debugger in the WLR089 Xplained Pro. It is also supported by several third-party programmers and debuggers. For programming and/or debugging the WLR089U0 module:

1. Connect the Programmer/Debugger with the module using the Serial Wire Debug (SWD) interface.
2. Select the Device as WLR089U0.

Notes: For more details, refer the following documents:

- For Programming and Debugging, refer to the *Atmel-ICE, SAM-ICE or WLR089 Xplained Pro Board User Guide*.
- For Microchip, third-party programmers and third-party programming houses, refer to the *AN2468 Production Programming of Microchip AVR® and SAM Microcontrollers Application Note* (DS00002468).
- Connecting to any other programming or debugging tool, refer to that specific *programmer's guide or debugger's user guide*.

7. Electrical Specifications

This section provides the WLR089U0 module electrical specifications.

7.1 Absolute Maximum Ratings

The following table provides the absolute maximum ratings for the WLR089U0 module.

Table 7-1. Absolute Maximum Ratings

Symbol	Parameter	Min.	Max.	Unit
V_{CC}	Power supply voltage	0	3.6	V
V_{PIN}[1]	Pin voltage with respect to GND and V_{CC} (V_{CC} MAX = 3.6V)	GND−0.6V	V_{CC}+0.6V	V
P_{RF}[1]	Input RF level	—	+10	dBm
$T_{storage}$[1]	Storage temperature	-50	150	°C
V_{ESD}	Electrostatic Discharge (ESD)[2]	—	±4	kV

Notes:
1. These values are derived from the ATSAMR34J18B SiP.
2. The contact discharge test was performed by coupling planes (horizontal coupling plane and the vertical coupling plane).

⚠ **CAUTION**   Stresses beyond those listed in the above table may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these or other conditions beyond those indicated in the operational sections of this specification is not implied. Exposure to the absolute maximum rating conditions for extended periods may affect device reliability.

7.2 Recommended Operating Conditions

The following table provides the recommended operating conditions for the WLR089U0 module.

Table 7-2. Recommended Operating Conditions

Symbol	Parameter	Min.	Typ.	Max.	Unit
T_{OP}	Operating temperature range	-40	25	85	°C
V_{CC}	Supply voltage	1.8	3.3	3.5	V

7.3 Transceiver Performance Characteristics

The following data shows the WLR089U0 performance as a combined system under the following conditions:

- Modulation = LoRa
- V_{CC} = 3.3 V_{DC}
- Temperature = 25°C
- F_{RF_XTA} = 32.000000 MHz +/- 1 ppm (TCXO)
- DFLL = 48 MHz

- BW = 125 kHz
- SF = 12
- EC = 4/6
- PER = 1%
- CRC = Enabled
- Payload = 64 bytes
- Preamble = 12 symbols
- Matched Impedance

Estimates for the module's ACTIVE state are derived using the CoreMark benchmarking algorithm, a 48 MHz DFLL clock and a 3.3 V_{DC} supply to show a conservative estimation of power consumption. Results are related to CPU activity, clock speed and temperature, which can be optimized further.

7.3.1 Transmitter Output Power

Table 7-3. Transmitter Output Power

Frequency (MHz)	Output Port	Modulation Mode	Power Setting	Typical Output Power (dBm)
915	PA_BOOST	CW	20	18.39
915	PA_BOOST	LoRa	20	18.52
868	RFO_HF	CW	15	14.35
868	RFO_HF	LoRa	15	14.17

7.3.2 Transmitter Phase Noise

Table 7-4. Phase Noise

Offset	Phase Noise (dBc/Hz)
10k	-101.74
50k	-102.14
400k	-113.73
1M	-118.05

7.3.3 Receiver Sensitivity

Table 7-5. Receiver Sensitivity in LoRa Mode

Frequency (MHz)	Bandwidth (kHz)	Spreading Factor	Sensitivity (dBm)
915	125	12	-136
868	125	12	-136

Table 7-6. Receiver Sensitivity in FSK Mode

Frequency (MHz)	Conditions	Bit Rate (kbps)	Sensitivity (dBm)
868	Frequency deviation (FDA) = 5 kHz, Rx bandwidth = 10 kHz (Single Side Bandwidth)	1.2	-118
		4.8	-117

7.3.4 Blocking

Table 7-7. Blocking in LoRa Mode

Frequency (MHz)	1 MHz	2 MHz	10 MHz	Unit
915	89	94	100	dB (TYP)
868	89	94	100	dB (TYP)

7.3.5 Transmitter High-Power Operation

Supply high voltage to V_{CC} to operate in the High-Power mode. For some regions, additional EMI filtering may be needed at High-Power mode. The following table lists the operational parameters and their values for the High-Power mode.

Table 7-8. High-Power Operational Parameters

Parameter	Value
RF Output Power (max.)	+18.59 dBm
V_{CC} (min.)	2.4 V_{DC}
V_{CC} (max.)	3.5 V_{DC}
Typical Current	114.68 mA
Max. Duty Cycle (max.)	1%
VSWR (max.)	3:1

7.4 DC Characteristics

7.4.1 Current Consumption

The following table provides the current consumption values of the transceiver.

Table 7-9. Current Consumption [1] [2]

Mode/Parameter	MCU Mode	Transceiver Conditions	Measured Current (Typical)	Units
TX mode[3]	ACTIVE	TX; North American band, f_{RF} = 915 MHz, TX power setting = 20, PA = ON	114.68	mA
		TX; North American band, f_{RF} = 915 MHz, TX power setting = 17, PA = ON	93.64	
		TX; North American band, f_{RF} = 915 MHz, TX power setting = 15, PA = OFF	38.44	
		TX; North American band, f_{RF} = 915 MHz, TX power setting = 7, PA = OFF	25.24	
		TX; European band, f_{RF} = 868 MHz, TX power setting = 15, PA = OFF	41.54	
		TX; European band, f_{RF} = 868 MHz, TX power setting = 7, PA = OFF	25.68	

| Mode/ Parameter	MCU Mode	Transceiver Conditions	Measured Current (Typical)	Units
RX mode	ACTIVE	RX; North American band, f_{RF} = 915 MHz, Bandwidth = 125 kHz	12.64	mA
		RX; North American band, f_{RF} = 915 MHz, Bandwidth = 250 kHz	13.34	
		RX; European band, f_{RF} = 868 MHz, Bandwidth = 125 kHz	12.68	
		RX; European band, f_{RF} = 868 MHz, Bandwidth = 250 kHz	13.36	
Low power modes	Standby	Sleep	1.608	μA
	Backup	Sleep	642	nA

Notes:

1. This parameter is characterized but not tested in manufacturing.
2. The following are the typical conditions for the measurement:
   - Operating Conditions:
     - VDD = 3.3V and Temperature at 25°C
     - CPU is running on Flash with two Wait states in PL2
     - Low power cache is enabled and BOD33 (Brown-out detector on On-chip Switching mode regulator output (VSWOUT)/battery input voltage (VBAT) is disabled
     - Transceiver conditions as specified in the table
   - Oscillators:
     - XOSC (crystal oscillator) is disabled
     - When MCU is in Active Performance Level 2 (PL2) mode, the DFLL48M is running at 48 MHz in Open-Loop mode
   - Clocks:
     - In the PL2 mode, DFLL48M is running in the Open-Loop mode and is used as the main clock source
     - The clock masks and dividers are at Reset values: All AHB and APB clocks are enabled, CPUDIV = 1, BUPDIV = 1 and LPDIV = 1
     - I/Os are configured in the Digital Functionality Disabled mode. Except for PA04 and PA05, which are used to provide the UART input to the device
3. RF output is terminated with 50Ω when the module is transmitting a Continuous Wave (CW) tone

8. Reference Circuit

The following figure illustrates the reference application schematics for the WLR089U0 module.

Figure 8-1. Reference Application Schematic
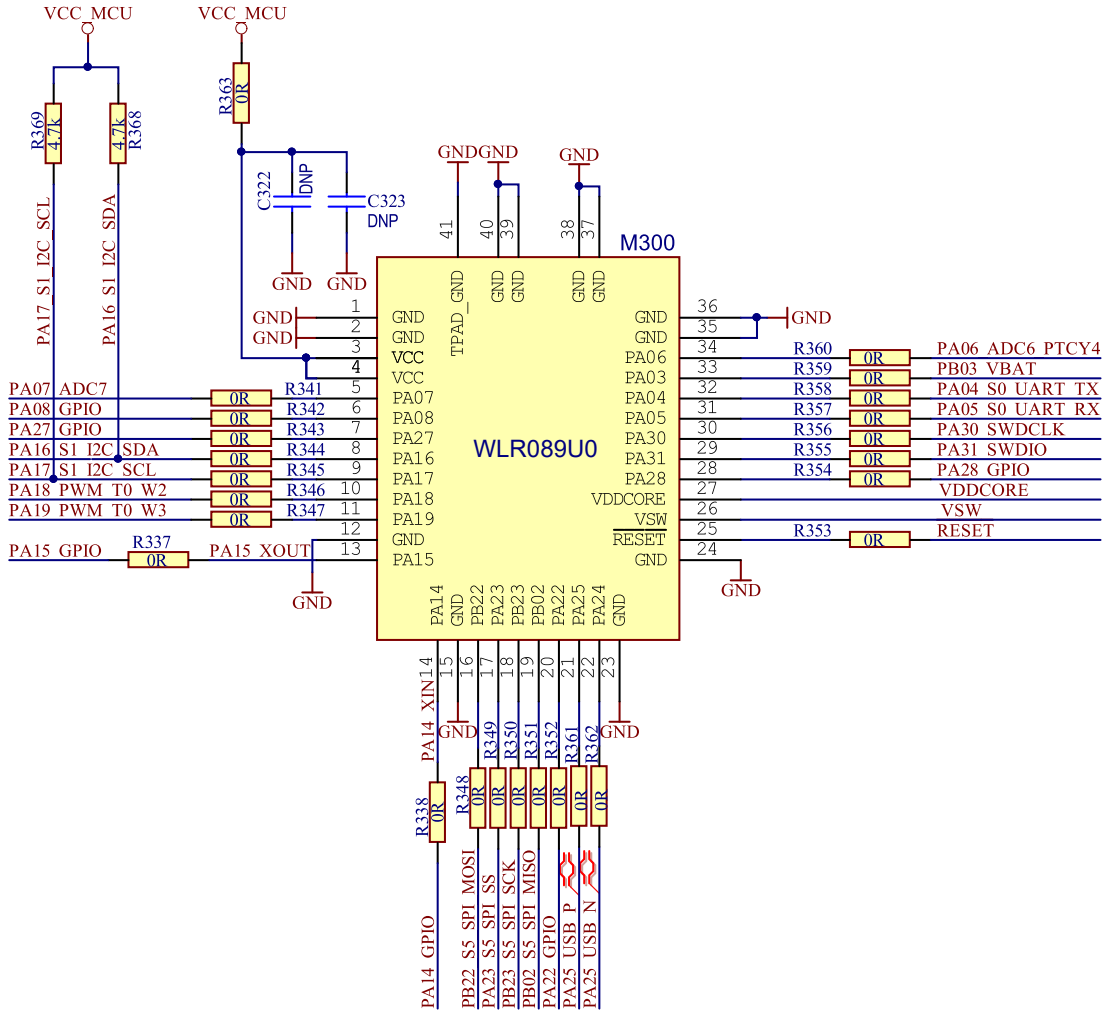
9. Design Considerations

9.1 Approved External Antennas

The WLR089U0 module is tested and approved for use with the antenna type listed in the following table. It is permissible to use a different antenna, provided the same antenna type and antenna gain (equal to or less than) is used. An antenna type comprises antennas having similar in-band and out-of-band characteristics (refer to the specification sheet for cutoff frequencies).

To use with other antenna types, the OEM installer must be authorized by the respective regulatory agencies to ensure compliance.

Table 9-1. List of Approved External Antennas

No.	Part Number	Manufacturer	Antenna Gain (dBi)	Antenna Type	Regulatory Authority[1]			Cable Length/ Remarks
					FCC[2][3]	ISED	CE	
1	RFA-S1-C55H1-150D034	Alead technology	2.0	Half-wave dipole	X	X	X	150 mm
2	RFA-ZW-C55-B70-D034	Alead technology	2.0	Half-wave dipole	—	—	X	SMA to u.FL cable (ASMA-UFL-10) of length 203.20 mm used as adapter
3	AEACAC053010-S868	Abracon	2	Compact, low profile whip antenna	—	—	X	SMA to u.FL cable (ASMA-UFL-10) of length 203.20 mm used as adapter
4	TH-89F-150mm-IPEX	BJTEK NAVIGATION,INC.	1.5	Half-wave dipole	X	X	X	150 mm
5	ANT-868-PW-QW-UFL	Linx	1.6	¼-wave monopole antenna	—	—	X	216 mm
6	ANT-916-PW-QW-UFL	Linx	1.8	¼-wave monopole antenna	—	—	X	216 mm
7	GWF-152XMPXX-H015	Joymax Electronics Co., Ltd	2	Half-wave dipole	X	X	X	153 mm
8	GWF-152XRSXX-H015	Joymax Electronics Co., Ltd	2	Half-wave dipole	X	X	X	Antenna has 156 mm cable with RP-SMA plug and RP-SMA receptacle to u.FL cable of length 50 mm used as adapter [2][3]
9	6610D13081-100	Kinsun	2	Half-wave dipole	X	X	—	100 mm
10	6610C03061	Kinsun	2	Half-wave dipole	X	X	X	RP-SMA to u.FL cable of length 203.20 mm used as adapter[2][3]
11	6610-868MHz	Kinsun	2	Half-wave dipole	—	—	X	150 mm

No.	Part Number	Manufacturer	Antenna Gain (dBi)	Antenna Type	Regulatory Authority[1]			Cable Length/ Remarks
					FCC[2][3]	ISED	CE	
12	DL868&915M-F-01	Dolin Electronics Co., Ltd	2	¼-wave monopole antenna	—	—	X	150 mm
13	DL868&915M-R-H76	Dolin Electronics Co., Ltd	2	¼-wave monopole antenna	—	—	X	SMA to u.FL cable (ASMA-UFL-10) of length 203.20 mm used as adapter
14	RFDPA131015IMBB301	PSA Walsin technology Corporation	0.90	Half-wave dipole	X	X	X	150 mm
15	RFA-ZW-C55-B-RP-D034	Alead technology	2.0	Half-wave dipole	X	X	X	RP-SMA to u.FL cable of length 203.20 mm used as adapter[2][3]

Notes:

1. 'X' denotes the antennas covered under the certification.
2. If the end product using the Module is designed to have an antenna port that is accessible to the end user, then a unique (non-standard) antenna connector (as permissible by FCC) must be used (e.g., RP (Reverse Polarity)-SMA socket).
3. If an RF coaxial cable is used between the module RF output and the enclosure, then a unique (non-standard) antenna connector must be used in the enclosure wall for interfacing with the antenna.

9.2 Module Assembly Considerations

The WLR089U0 module is assembled with an EMI Shield to ensure compliance with EMI emission and immunity rules. The EMI shield is made of a Cold Rolled Steel (common or ordinary low carbon steel) material with Matte Tin Pre-plating. Use IPA solutions and similar solvents to clean the WLR089U0 module. However, cleaning solutions that contain acid must never be used on the module.

9.2.1 Conformal Coating

The modules are not intended for use with a conformal coating and the customer assumes all risks (such as the module reliability, performance degradation and so on) if a conformal coating is applied to the modules.

9.2.2 Reflow Profile Information

For information on the reflow process guidelines, refer to the "Solder Reflow Recommendation" Application Note (www.microchip.com/DS00233).

10. Packaging Information

This chapter provides the information on package markings, dimension and footprint of the WLR089U0 module.

10.1 Module Package Marking

The following figure shows the WLR089U0 module packaging information.
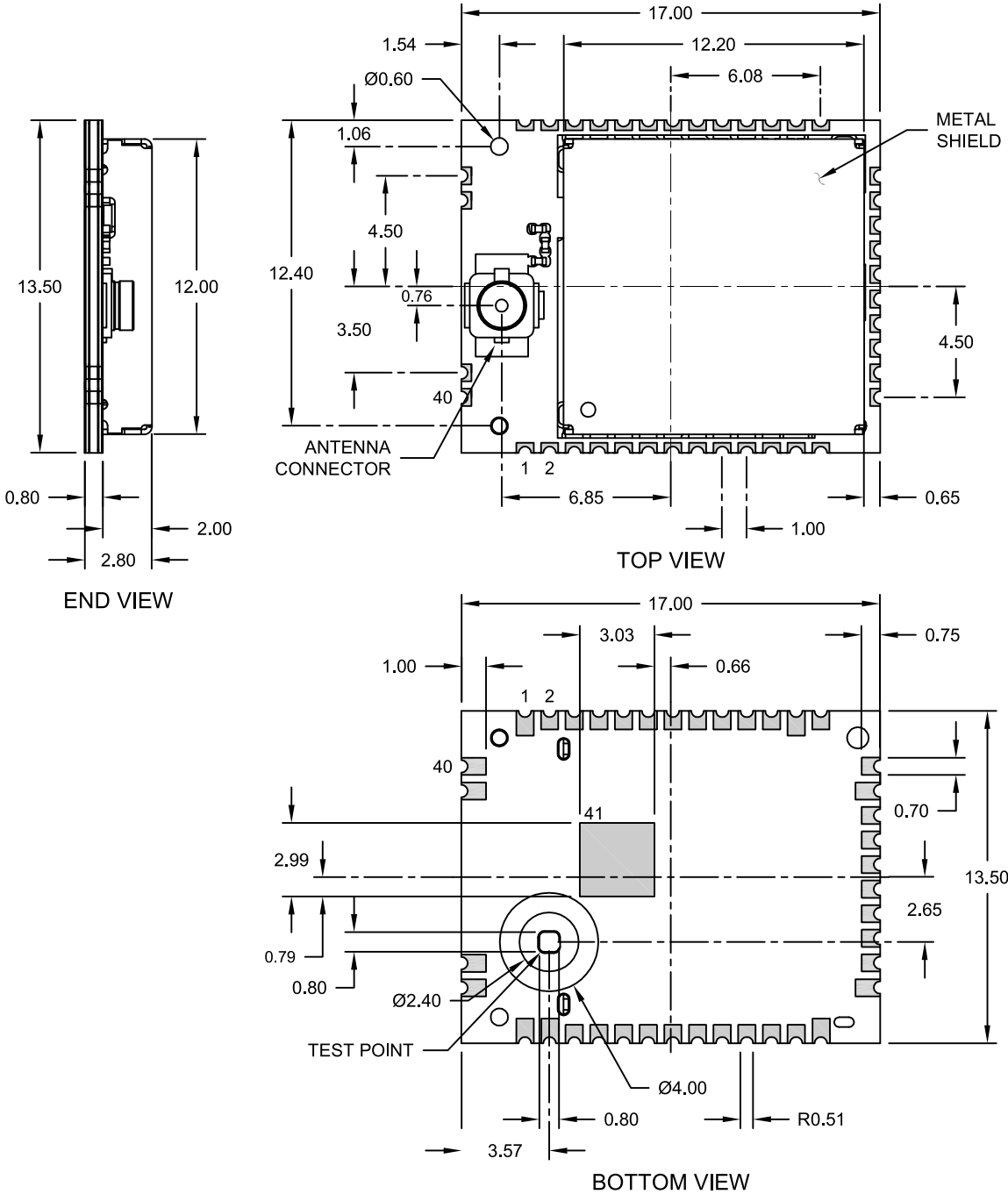
Figure 10-1. Module Package Marking Information

XXXXXXXXXXXXXXXX
XXXXXXXXXXXXXXXX
XXXXXXXXXXXXXXXX
YYWWNNN

WLR089U0
FCC ID: 2ADHKR34M
IC: 20266-R34M
YYWWNNN

Legend:

XX....X	Module part number and version and regulatory designator
YY:	Year code (last 2 digits of calendar year)
WW	Week code (week of January 1 is week "01")
NNN	Alphanumeric traceability code

10.2 Module Outline Drawings

This section provides the package dimension details of the WLR089U0 module.
Note: For the most recent package drawings, see the Microchip Packaging Specification located at http://www.microchip.com/packaging.
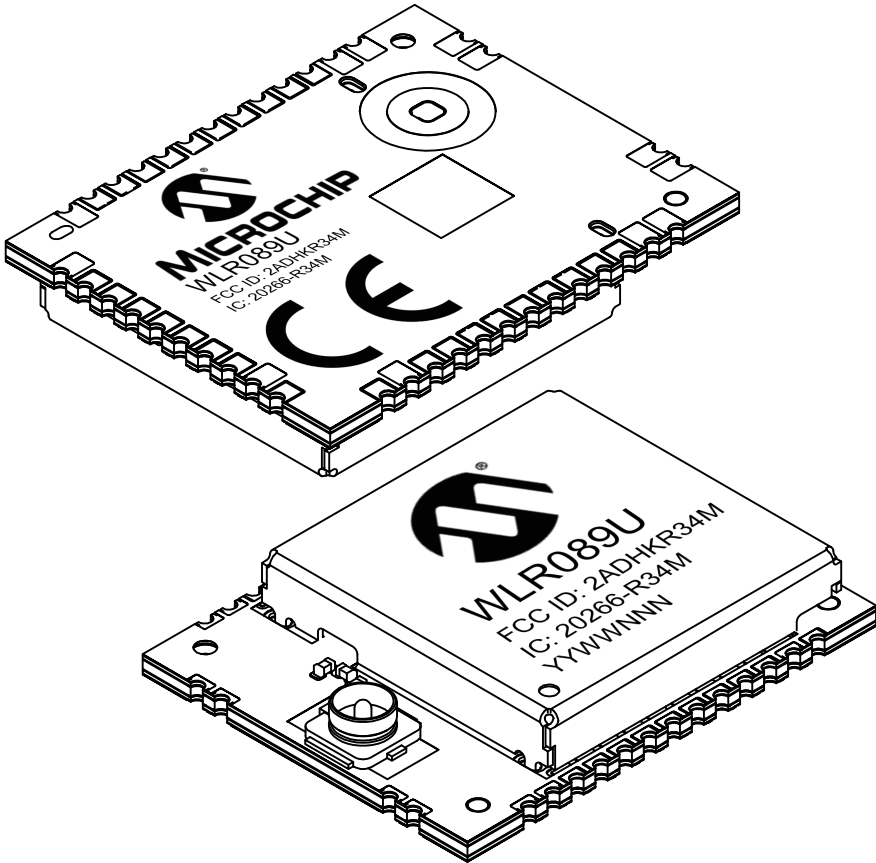
Figure 10-2. WLR089U0 Module Package Outline Drawings

1. The module pins are arranged with a 1 mm pitch distance. The module is designed symmetrically.

Figure 10-3. WLR089U0 Module Package Outline Drawings – Contd.,

10.2.1 Footprint

The recommended land pattern is shown in the following figure.

Figure 10-4. Recommended WLR089U0 Module Footprint

11. Appendix A: Regulatory Approval

The WLR089U0 module has received regulatory approval from the following countries:

- WLR089U0
  - United States/FCC ID: 2ADHKR34M
  - Canada/ISED:
    - IC: 20266-R34M
    - HVIN: WLR089U0
    - PMN: WLR089U
  - Europe/CE

For USA/Canada, the module has been certified for the modulation modes listed below. The user must ensure that the module works only on the 902-928 MHz frequency band.

- Operating Channels:
  - 500 kHz bandwidth:
    - 903 MHz ~ 927.5 MHz
      - 8 Upstream Channels, Channel Spacing 1.6 MHz
      - 8 Downstream Channels, Channel Spacing 0.6 MHz
  - 125 kHz bandwidth:
    - 902.3MHz ~ 927.5MHz
      - 64 Channels, Channel Spacing 200 kHz
    - 902.3MHz ~ 927.3 MHz
      - 26 Channels, Channel Spacing 1 MHz
- Modulation: LoRa®
- Spreading Factor:
  - 500 kHz bandwidth: 7~12
  - 125 kHz bandwidth: 7~10

The host product manufacturer must ensure that the RF behavior adheres to the certification (for example, FCC, ISED) requirements when the module is installed in the final host product.

For Europe, the module has been certified for the modulation modes listed below. The user must ensure that the module work only on the 868-868.6 MHz frequency band.

- Operating Channels:
  - 125 kHz bandwidth:
    - 868.1 MHz ~ 868.5 MHz
      - 3 Channels, Channel Spacing 200 kHz
- Modulation: LoRa®
- Spreading Factor: 125 kHz bandwidth: 7~12

Notes:

1. Tests are done only on the worst-case modes.
2. The availability of some specific channels and/or operating frequency bands are country-dependent and must be programmed at the Host product factory to match the intended destination. Regulatory bodies prohibit exposing the settings to the end user. This requirement needs to be taken care of via Host implementation.

11.1 United States

The The WLR089U0 module has received Federal Communications Commission (FCC) CFR47 Telecommunications, Part 15 Subpart C "Intentional Radiators" single-modular approval in accordance with Part 15.212 Modular Transmitter approval. Single-modular transmitter approval is defined as a complete RF transmission sub-assembly, designed to be incorporated into another device, that must demonstrate compliance with FCC rules and policies independent of any host. A transmitter with a modular grant can be installed in different end-use products (referred to

as a host, host product, or host device) by the grantee or other equipment manufacturer, then the host product may not require additional testing or equipment authorization for the transmitter function provided by that specific module or limited module device.

The user must comply with all of the instructions provided by the Grantee, which indicate installation and/or operating conditions necessary for compliance.

A host product itself is required to comply with all other applicable FCC equipment authorization regulations, requirements, and equipment functions that are not associated with the transmitter module portion. For example, compliance must be demonstrated: to regulations for other transmitter components within a host product; to requirements for unintentional radiators (Part 15 Subpart B), such as digital devices, computer peripherals, radio receivers, etc.; and to additional authorization requirements for the non-transmitter functions on the transmitter module (i.e., Suppliers Declaration of Conformity (SDoC) or certification) as appropriate (e.g., Bluetooth and Wi-Fi transmitter modules may also contain digital logic functions).

11.1.1 Labeling and User Information Requirements

The The WLR089U0 module has been labeled with its own FCC ID number, and if the FCC ID is not visible when the module is installed inside another device, then the outside of the finished product into which the module is installed must display a label referring to the enclosed module. This exterior label must use the following wording:

• For WLR089U0
Contains Transmitter Module FCC ID: 2ADHKR34M or Contains FCC ID: 2ADHKR34M **This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) this device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation**.

The user's manual for the finished product must include the following statement:

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy, and if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:
• Reorient or relocate the receiving antenna • Increase the separation between the equipment and receiver • Connect the equipment into an outlet on a circuit different from that to which the receiver is connected • Consult the dealer or an experienced radio/TV technician for help

Additional information on labeling and user information requirements for Part 15 devices can be found in KDB Publication 784748, which is available at the FCC Office of Engineering and Technology (OET) Laboratory Division Knowledge Database (KDB) apps.fcc.gov/oetcf/kdb/index.cfm.

11.1.2   RF Exposure

All transmitters regulated by FCC must comply with RF exposure requirements. KDB 447498 General RF Exposure Guidance provides guidance in determining whether proposed or existing transmitting facilities, operations or devices comply with limits for human exposure to Radio Frequency (RF) fields adopted by the Federal Communications Commission (FCC).

From the FCC Grant: Output power listed is conducted. This transmitter is restricted for use with the specific antenna(s) tested in this application for Certification.

The antenna(s) used with this transmitter must be installed to provide a separation distance of at least 20 mm from all persons and must not be co-located or operating in conjunction with any other antenna or transmitter. Users and installers must be provided with antenna installation instructions and transmitter operating conditions for satisfying RF exposure compliance.

11.1.3   Approved External Antennas

To maintain modular approval in the United States, only the antenna types that have been tested shall be used.

Testing of the WLR089U0 module was performed with the antenna types listed in Table 9-1.

11.1.4   Helpful Web Sites

- Federal Communications Commission (FCC): www.fcc.gov.
- FCC Office of Engineering and Technology (OET) Laboratory Division Knowledge Database (KDB) apps.fcc.gov/oetcf/kdb/index.cfm.

11.2   Canada

The The WLR089U0 module has been certified for use in Canada under Innovation, Science and Economic Development Canada (ISED, formerly Industry Canada) Radio Standards Procedure (RSP) RSP-100, Radio Standards Specification (RSS) RSS-Gen and RSS-247. Modular approval permits the installation of a module in a host device without the need to recertify the device.

11.2.1   Labeling and User Information Requirements

Labeling Requirements (from RSP-100 - Issue 11, Section 3): The host product shall be properly labeled to identify the module within the host device.

The Innovation, Science and Economic Development Canada certification label of a module shall be clearly visible at all times when installed in the host device; otherwise, the host product must be labeled to display the Innovation, Science and Economic Development Canada certification number of the module, preceded by the word "Contains" or similar wording expressing the same meaning, as follows:

• For WLR089U0
Contains IC: 20266-R34M

User Manual Notice for License-Exempt Radio Apparatus (from Section 8.4 RSS-Gen, Issue 4, November 2014): User manuals for license-exempt radio apparatus shall contain the following or equivalent notice in a conspicuous location in the user manual or alternatively on the device or both:

> **This device complies with Industry Canada's license exempt RSS standard(s). Operation is subject to the following two conditions:**
>
> **(1) This device may not cause interference, and**
>
> **(2) This device must accept any interference, including interference that may cause undesired operation of the device.**
>
> **Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes:**
>
> **(1) l'appareil ne doit pas produire de brouillage, et**
>
> **(2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.**

Guidelines on Transmitter Antenna for License Exempt Radio Apparatus:

> **Under Industry Canada regulations, this radio transmitter may only operate using an antenna of a type and maximum (or lesser) gain approved for the transmitter by Industry Canada. To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (e.i.r.p.) is not more than that necessary for successful communication.**
>
> **Conformément à la réglementation d'Industrie Canada, le présent émetteur radio peut fonctionner avec une antenne d'un type et d'un gain maximal (ou inférieur) approuvé pour l'émetteur par Industrie Canada. Dans le but de réduire les risques de brouillage radioélectrique à l'intention des autres utilisateurs, il faut choisir le type d'antenne et son gain de sorte que la puissance isotrope rayonnée équivalente (p.i.r.e.) ne dépasse pas l'intensité nécessaire à l'établisse-ment d'une communication satisfaisante.**

Immediately following the above notice, the manufacturer shall provide a list of all antenna types approved for use with the transmitter, indicating the maximum permissible antenna gain (in dBi) and required impedance for each. Testing of the WLR089U0 module was performed with the antenna types listed in Table 9-1.

11.2.2   RF Exposure

All transmitters regulated by Innovation, Science and Economic Development Canada (ISED) must comply with RF exposure requirements listed in RSS-102 - Radio Frequency (RF) Exposure Compliance of Radio communication Apparatus (All Frequency Bands).

This transmitter is restricted for use with a specific antenna tested in this application for certification, and must not be co-located or operating in conjunction with any other antenna or transmitters within a host device, except in accordance with Canada multi-transmitter product procedures.

The installation of the transmitter must ensure that the antenna has a separation distance of at least 35 mm from all persons or compliance must be demonstrated according to the ISED SAR procedures.

11.2.3   Helpful Web Sites

Innovation, Science and Economic Development Canada (ISED): www.ic.gc.ca/.

11.3   Europe

The WLR089U0 is a Radio Equipment Directive (RED) assessed radio module that is CE marked and has been manufactured and tested with the intention of being integrated into a final product.

The The WLR089U0 module has been tested to RED 2014/53/EU Essential Requirements for Health and Safety (Article (3.1(a)), Electromagnetic Compatibility (EMC) (Article 3.1(b)), and Radio (Article 3.2).

The ETSI provides guidance on modular devices in the "*Guide to the application of harmonised standards covering articles 3.1b and 3.2 of the RED 2014/53/EU (RED) to multi-radio and combined radio and non-radio equipment*" document available at http://www.etsi.org/deliver/etsi_eg/203300_203399/20 3367/01.01.01_60/ eg_203367v010101p.pdf.

Note: To maintain European Compliance, the module shall be installed in accordance with the installation instructions in this data sheet and shall not be modified. When integrating a radio module into a completed product, the integrator becomes the manufacturer of the final product and is therefore responsible for demonstrating compliance of the final product with the essential requirements against the RED.

11.3.1 Labeling and User Information Requirements

The label on the final product that contains the WLR089U0 module must follow CE marking requirements.

11.3.2 Conformity Assessment

From ETSI Guidance Note EG 203367, section 6.1, when non-radio products are combined with a radio product:

If the manufacturer of the combined equipment installs the radio product in a host, non-radio product in equivalent assessment conditions (i.e., host equivalent to the one used for the assessment of the radio product) and according to the installation instructions for the radio product, then no additional assessment of the combined equipment against article 3.2 of the RED is required.

For the WLR089U0, the European Compliance requirements were tested using the antennas listed in Table 9-1.

11.3.2.1 Simplified EU Declaration of Conformity

Hereby, Microchip Technology Inc. declares that the radio equipment type WLR089U0 is in compliance with Directive 2014/53/EU.

The full text of the EU declaration of conformity for this product is available at www.microchip.com/design-centers/wireless-connectivity/.

11.3.3 Helpful Websites

A document that can be used as a starting point in understanding the use of Short Range Devices (SRD) in Europe is the European Radio Communications Committee (ERC) Recommendation 70-03 E, which can be downloaded from the European Communications Committee (ECC) at: http://www.ecodocdb.dk/.

Additional helpful web sites are:

- Radio Equipment Directive (2014/53/EU):
  https://ec.europa.eu/growth/single-market/european-standards/harmonised-standards/red_en
- European Conference of Postal and Telecommunications Administrations (CEPT):
  http://www.cept.org
- European Telecommunications Standards Institute (ETSI):
  http://www.etsi.org
- The Radio Equipment Directive Compliance Association (REDCA):
  http://www.redca.eu/

11.4 Other Regulatory Information

- For information about other countries' jurisdictions not covered here, refer to the specific product listed in the Microchip Wireless Connectivity Solutions (http://www.microchip.com/design-centers/wireless-connectivity).
- If the customer needs another regulatory jurisdiction certification or to recertify the module for other reasons, contact Microchip for the required utilities and documentation.

12.   Document Revision History

Revision	Date	Section	Description
A	08/2020	Document	Initial Revision

The Microchip Website

Microchip provides online support via our website at www.microchip.com/. This website is used to make files and information easily available to customers. Some of the content available includes:

- **Product Support** – Data sheets and errata, application notes and sample programs, design resources, user's guides and hardware support documents, latest software releases and archived software
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- Embedded Solutions Engineer (ESE)
- Technical Support

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