PRODUCT MANUAL

OP7100

Serial Graphic Display

User's Manual

019–0065 • 070831–O

OP7100 User's Manual

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ABOUT THIS MANUAL

This manual provides instructions for installing, testing, configuring, and interconnecting the Rabbit Semiconductor OP7100 touchscreen operator interface. Instructions are also provided for using Dynamic C functions.

Assumptions

Assumptions are made regarding the user's knowledge and experience in the following areas.

- Ability to design and engineer the target system that interfaces with the OP7100.
- Understanding the basics of operating a software program and editing files under Windows on a PC.
- Knowledge of the basics of C programming.

For a full treatment of C, refer to the following texts.

The C Programming Language by Kernighan and Ritchie

and/or

C: A Reference Manual by Harbison and Steel

- Knowledge of basic assembly language and architecture for the Z180 microprocessor.

For documentation from Zilog, refer to the following texts.

Z180 MPU User's Manual
Z180 Serial Communication Controllers
Z80 Microprocessor Family User's Manual

Acronyms

Table 1 lists and defines the acronyms that may be used in this manual.

Table 1. Acronyms

Acronym	Meaning
EPROM	Erasable Programmable Read-Only Memory
EEPROM	Electronically Erasable Programmable Read-Only Memory
LCD	Liquid Crystal Display
LED	Light-Emitting Diode
NMI	Nonmaskable Interrupt
PIO	Parallel Input/Output Circuit (Individually Programmable Input/Output)
PRT	Programmable Reload Timer
RAM	Random Access Memory
RTC	Real-Time Clock
SIB	Serial Interface Board
SRAM	Static Random Access Memory
UART	Universal Asynchronous Receiver Transmitter

Icons

Table 2 displays and defines icons that may be used in this manual.

Table 2. Icons

Icon	Meaning	Icon	Meaning
	Refer to or see		Note
	Please contact	Tip	Tip
	Caution		High Voltage
	Factory Default		

Conventions

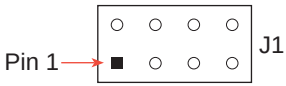
Table 3 lists and defines the typographical conventions that may be used in this manual.

Table 3. Typographical Conventions

Example	Description
`while`	Courier font (bold) indicates a program, a fragment of a program, or a Dynamic C keyword or phrase.
`// IN-01…`	Program comments are written in Courier font, plain face.
Italics	Indicates that something should be typed instead of the italicized words (e.g., in place of *filename*, type a file's name).
Edit	Sans serif font (bold) signifies a menu or menu selection.
. . .	An ellipsis indicates that (1) irrelevant program text is omitted for brevity or that (2) preceding program text may be repeated indefinitely.
[ ]	Brackets in a C function's definition or program segment indicate that the enclosed directive is optional.
< >	Angle brackets occasionally enclose classes of terms.
a | b | c	A vertical bar indicates that a choice should be made from among the items listed.

Pin Number 1

A black square indicates pin 1 of all headers.



Measurements

All diagram and graphic measurements are in inches followed by millimeters enclosed in parenthesis.

CHAPTER 1: OVERVIEW

Chapter 1 provides an overview and a brief description of the OP7100 features.

Introduction

The OP7100 is a serial graphic display in a compact, easy to integrate module. The OP7100 features an LCD that has a white background with blue images. The LCD has pixel graphics and provides two-color (monochrome) displays. Five standard fonts are included in the supplied software. Additional custom fonts are easily created to meet the needs of an application.

The OP7100 can operate with Rabbit Semiconductor single-board computers or other serial displays over an RS-485 network. The OP7100 also supports RS-232 communication.

The OP7100 display terminal uses display technologies that require minimal mounting depth and offer maximum viewing angles. The memory allows up to 25 application-screen bitmaps (240 × 320) to be stored without compression in a 256K flash EPROM. A further 256K is available for the application in a second flash EPROM.

Figure 1-1 illustrates the standard OP7100 board layout.

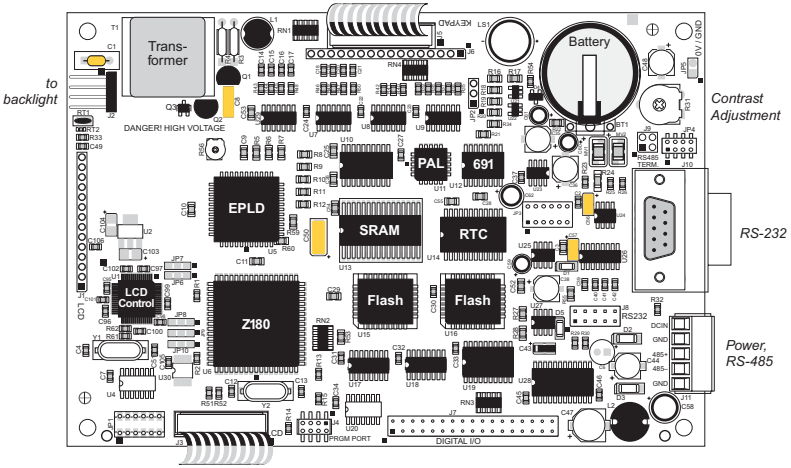


Figure 1-1. OP7100 Board Layout

Features

The OP7100 includes the following features.

- 240 × 320 ¼ VGA LCD (with touchscreen on OP7100 only)
- jumper-selectable background—positive (blue images on white background) or negative (white images on blue background)
- software-controlled cold-cathode fluorescent backlighting
- software-controlled contrast is enabled/disabled with jumper settting
- temperature compensation for LCD contrast changes with temperature
- RS-485 and RS-232 serial communication up to 57,600 bps
- 8 CMOS/TTL-level digital inputs and 8 CMOS/TTL-level digital outputs
- 18.432 MHz clock with Z180 microprocessor, 9.216 MHz LCD controller
- 256K flash EPROM for program, 256K flash EPROM for screen bitmaps
- switching voltage regulator

Appendix B provides detailed specifications for the OP7100.

The OP7100 also includes battery-backed RAM (128K) and a battery-backed real-time clock a watchdog timer, and power-failure interrupt.

Options

The OP7100 series of serial displays has two versions. Table 1-1 lists their standard features.

Table 1-1. OP7100 Series Features

Model	Features
OP7100	Serial graphic display, touchscreen, blue and white screen, ¼VGA LCD with bezel mount, software contrast control
OP7110	OP7100 with no touchscreen, manual contrast control

Either model may be used in either a portrait or a landscape orientation by using the corresponding software library.

For ordering information, call your Rabbit Semiconuctor Sales Representative.

Development and Evaluation Tools

The OP7100 is supported by a Tool Kit that include everything you need to start development with the OP7100.

The Tool Kit includes these items.

- Serial cable
- 24 V DC power supply capable of delivering 1.1 A
- User's manual with schematics

An optional Serial Interface Board (SIB) is available to program the OP7100 when a second RS-232 serial port is needed by the application being developed.

For ordering information, call your Rabbit Semiconductor Sales Representative.

Software

The OP7100 is programmed using Rabbit Semiconductor's Dynamic C, an integrated development environment that includes an editor, a C compiler, and a debugger. Library functions provide an easy and robust interface to the OP7100.

Rabbit Semiconductor's Dynamic C reference manuals provide complete software descriptions and programming instructions.

CE Compliance

The OP7100 has been tested and was found to be in conformity with applicable EN immunity and emission standards. Note the following requirements for incorporating the OP7100 into your application to comply with CE requirements.

- The power supply provided with the Tool Kit is for development purpose only. It is the customer's responsibility to provide a CE compliant power supply for their end-product application.
- The OP7100 has been tested to meet the following immunity standards.

  EN61000-4-2 (ESD)
  EN61000-4-3 (Radiated Immunity)
  EN61000-4-4 (EFT)
  EN61000-4-6 (Conducted Immunity)

  Additional shielding or filtering may be required for a heavy industrial environment.
- The OP7100 has been tested to meet the EN55022 Class A emissions standard with ferrite RFI suppressors on the I/O cables. Additional shielding or filtering may be needed to meet Class B emissions standards.

Since Rabbit Semiconductor products are connected to other devices, good EMC prac-tices should be taken to ensure compliance. CE compliance is eventually the responsibility of the integrator. For more information on tips and technical assistance, visit our Web site at www.rabbit.com/products/ce_certification/, or contact your local authorized Rabbit Semiconductor distributor.

CHAPTER 2: GETTING STARTED

Chapter 2 provides instructions for connecting the OP7100 to a host PC and running a sample program.

Initial OP7100 Setup

Parts Required

- 24 V unregulated DC power supply capable of delivering up to 1.1 A
- Serial cable

The necessary parts are supplied with the Tool Kit.

Setting Up the OP7100

1. Remove the green power connector shown in Figure 2-1 from the back of the OP7100.
2. Attach the bare leads from the power supply to the terminals on the power connector as shown in Figure 2-1.
3. Plug the connector back into the power connection header at the back of the OP7100. Watch the polarity of the connection so that the banded wire from the power supply goes to DCIN as shown in Figure 2-1.

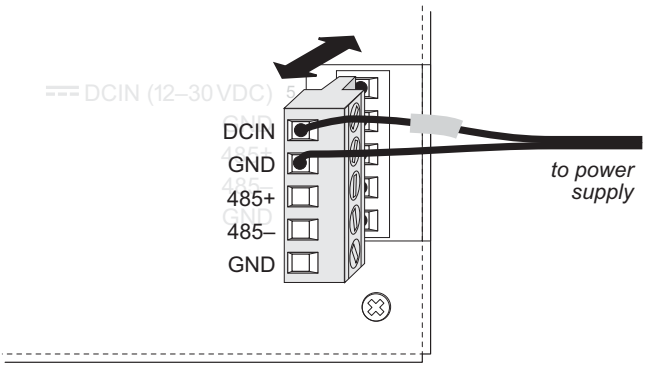


Figure 2-1. OP7100 Power Supply Connections

> Be careful to connect the power supply wires to the correct screw terminals on header J8. The OP7100 may be destroyed if the power supply is connected to the ***wrong*** screw terminal. A protective diode prevents damage to the OP7100 if the power supply polarity is reversed.

4. Plug the power supply into a wall outlet. The display should now light up with the demonstration screens shown in Figure 2-2.

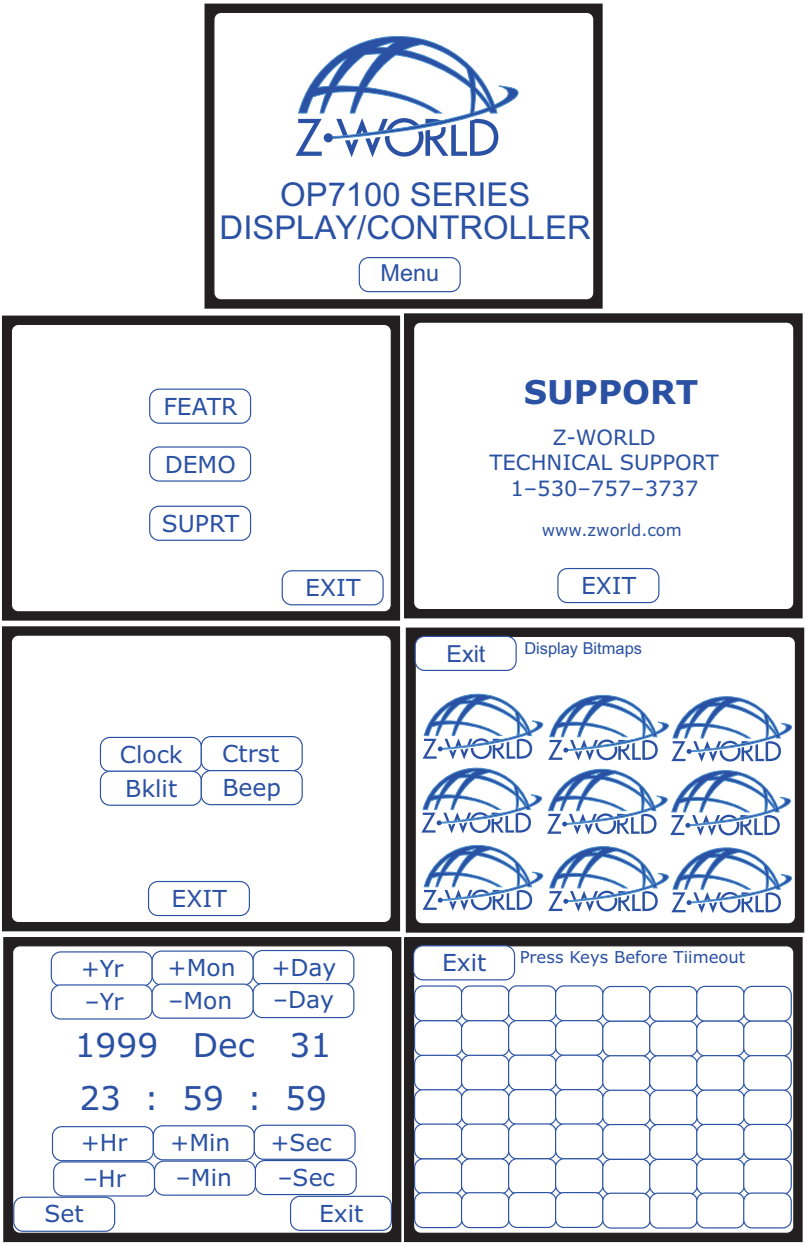


Figure 2-2. OP7100 Demo Screens

Connecting the OP7100 to a Host PC

1. Unplug any power supply connected to the OP7100 and remove the back cover from the OP7100 assembly. The back cover is attached with the two screws shown in Figure 2-3.

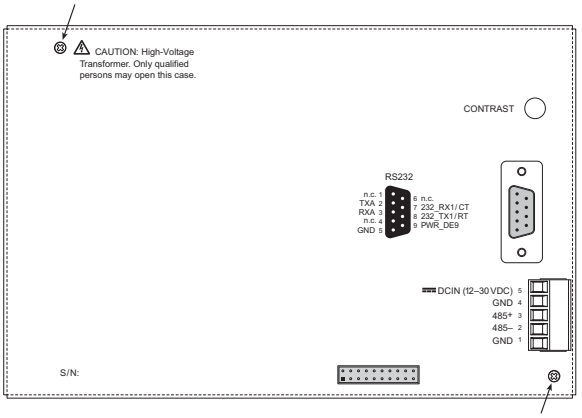


Figure 2-3. OP7100 Back Cover

2. Establish a serial communication link. A PC "communicates" with the OP7100 via Serial Port 0 or the Clocked Serial Input/Output port on the OP7100's Z180 microprocessor. There are two options for the serial communication link.

   Option 1 (via optional SIB)—Connect an RJ-12 cable between the PC and the SIB. An RJ-12 to DB9 adapter is included for DB9 PC COM ports. Remove any jumpers that may be installed on the OP7100's header J4 and plug the SIB's 8-pin connector onto header J4 as shown in Figure 2-4. Make sure that pin 1 on the ribbon cable connector (on the striped side) matches up with pin 1 on J4 (indicated by a small white circle next to the header).

   Option 2 (directly)—Place a jumper across pins 1–2 of header J4 on the OP7100 as shown in Figure 2-5. Connect the PC COM port to the DB9 jack on the OP7100, header J7, using the DB9 to DB9 serial cable supplied with the Tool Kit.

3. The OP7100 is now ready for programming. The power supply may be plugged in and turned on.

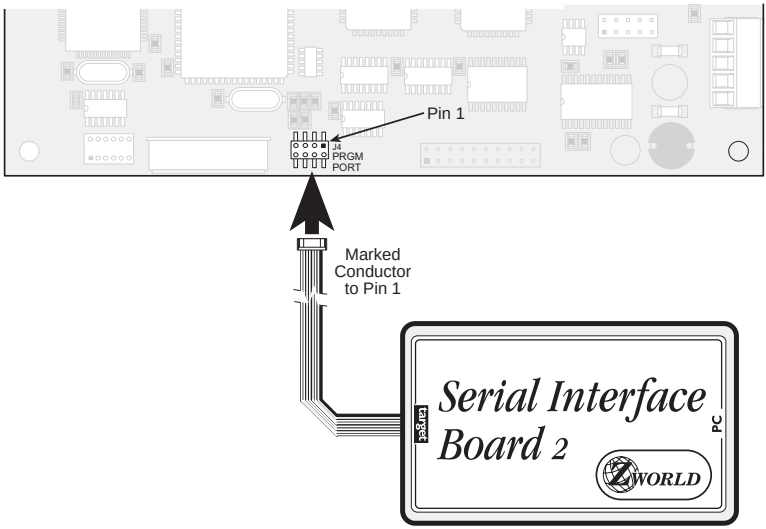


Figure 2-4. SIB Programming Connection

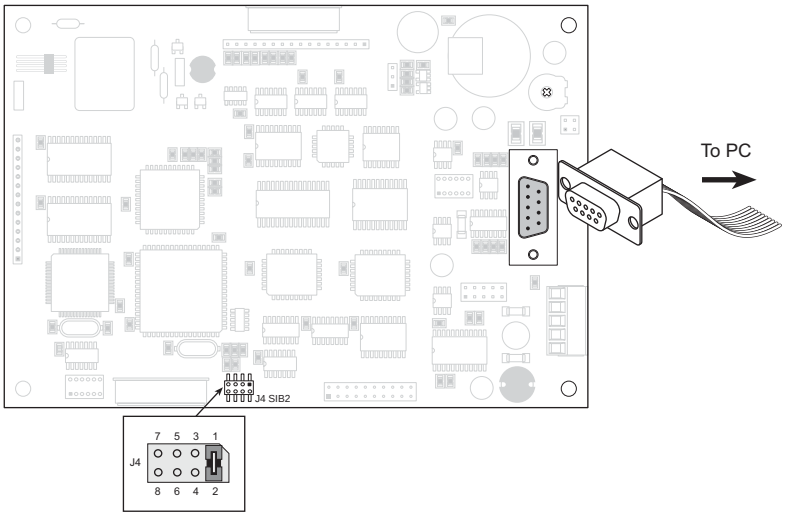


Figure 2-5. Direct Programming Connection

Option 2 uses an RS-232 serial port to program the OP7100. If this serial port is needed in your application, use the SIB as described in Option 1.

See Chapter 3, “Hardware,” for more information on the serial ports.

Running Dynamic C

Double-click the Dynamic C icon to start the software. Note that the PC attempts to communicate with the OP7100 each time Dynamic C is started. No error messages are displayed once communication is established.

The communication rate, port, and protocol are all selected by choosing **Serial Options** from Dynamic C's **OPTIONS** menu. The SIB and the OP7100 both set their baud rate automatically to match the communication rate set on the host PC using Dynamic C (9600 bps, 19,200 bps, 28,800 bps, or 57,600 bps). To begin, adjust the communications rate to 19,200 bps.

Make sure that the PC serial port used to connect the serial cable (COM1 or COM2) is the one selected in the Dynamic C **OPTIONS** menu. Select the 1-stop-bit protocol.

See Appendix A, "Troubleshooting," if an error message such as **Target Not Responding** or **Communication Error** appears.

Once the necessary changes have been made to establish communication between the host PC and the OP7100, use the Dynamic C shortcut **<Ctrl Y>** to reset the controller and initiate communication.

At this point, the LCD should be blank and the backlight should be off. Once communication is established, load the sample program **`DEFDEMOL.C`** in the Dynamic C **`SAMPLES\QVGA`** subdirectory. Compile and run the program by pressing **F9** or by selecting **Run** from the **Run** menu.

The OP7100 should now alternately display the large font (17x × 35h) and the small font (6w × 8h). The fonts should scroll across the display.

Compiling and running this sample program will overwrite the demonstration program shown in Figure 2-3.

CHAPTER 3: HARDWARE

Chapter 3 describes how to use the OP7100. Sections are included to describe the following features.

- Subsystems Overview
- Power Management
- Liquid Crystal Display
- Keyboard Interface
- Digital I/O
- Serial Communication

OP7100 Subsystems Overview

The OP7100 consists of several subsystems, including a computing module, serial communication channels, lquid crystal display (LCD), a buzzer, and a keypad interface. Figure 3-1 provides a block diagram of the OP7100.

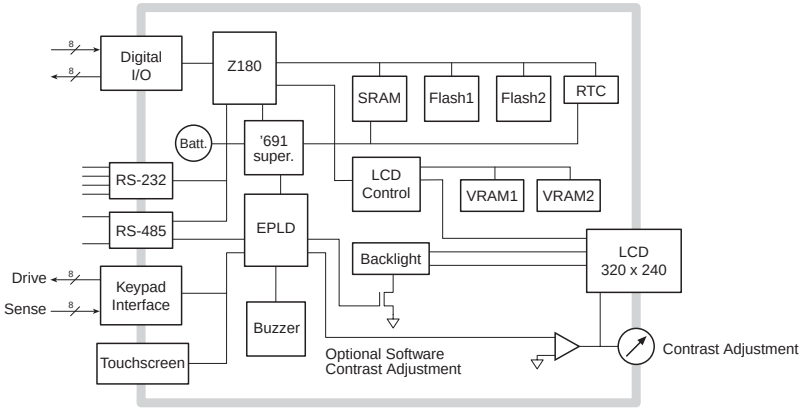


Figure 3-1. OP7100 Block Diagram

Computing Module

The OP7100 computing module consists of a Zilog Z180 microprocessor, 128K of battery-backed static RAM, and 512K of flash EPROM. The computing module operates in tandem with a real-time clock and a watchdog timer/microprocessor supervisor.

The Z180 CPU runs at 18.432 MHz, and the LCD controller runs at 9.216 MHz.

The watchdog timer/microprocessor chip provides a watchdog timer function, power-failure detection, RAM protection, and battery backup.

The real-time clock provides time and date information to applications running on the OP7100.

The EEPROM is simulated in flash EPROM for consistency with Rabbit Semiconductor controllers whose software libraries rely on exchanging information with the EEPROM. The simulated EEPROM in the OP7100 is unused at the present time, but addresses 0 and 1 are reserved for furture use. Do not use these addresses in your application.

Power Management

The OP7100 was designed to operate from a 12 V to 30 V DC source, and consumes about 4.5 W with the backlight on, 1.5 W with the backlight off. To allow for a surge current when the OP7100 is first turned on, the power supply used must be able to handle at least four times this power (for example, 800 mA at 24 V).

The OP7100 power supply is converted internally to supply three voltages.

1. A switching regulator outputs VCC (+ 5 V).
2. A linear regulator outputs VEE (approximately –20 V).
3. A high-voltage section supplies 300 V rms to drive the cold-cathode fluorescent backlight. The backlight can be turned on or off under software control whereby a high on the gate of Q3 enables Q1 and Q2 to oscillate, and a low turns off Q3, stopping the oscillation of Q1 and Q2.

Figure 3-2 shows these internal power supplies in a block diagram

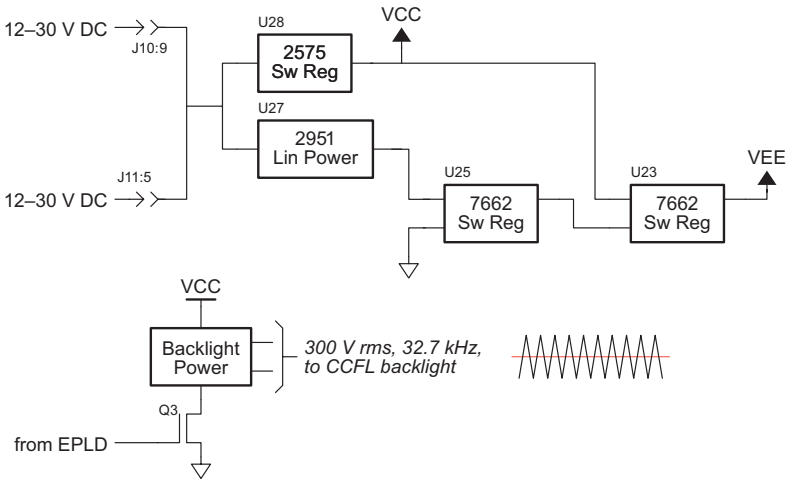


Figure 3-2. Block Diagram of OP7100 Internal Power Regulators

The DC input source can also be brought out on pin 9 of header J10, the DE-9 connector, by installing a 0 Ω resistor at R32. This option allows power to be supplied to a serial device connected to the OP7100 as long as the serial device's RS-232 port can handle the DC input on pin 9.

Be sure to use a power supply with sufficient capacity (for example, 1.1 A at 24 V) to handle surges when the OP7100 and any devices connected to it are first turned on.

ADM691 Supervisor Chip

A voltage divider consisting of R29 and R30 across the DC input provides a **PFI** signal to the ADM691 watchdog supervisor. The ADM691 chip performs the following services.

- Watchdog timer resets the microprocessor if software “hangs.”
- Power-failure shutdown and reset.
- Generates an “early warning” power-failure interrupt (PFI) that lets the system know when power is about to fail.
- Memory protection feature prevents writes to RAM when power is low.
- Supports battery backup.

Handling Power Fluctuations

During a normal power-down, an interrupt service routine is used in response to a power-failure interrupt to save vital state information for the application for when power recovers. The amount of code that the interrupt service routine can execute depends on how fast the voltage decreases.

Theoretically, a power failure would cause a single power-failure interrupt. Then, the interrupt service routine would restore data from the previous state when the voltage recovers.

However, fluctuations in the DC input line could cause the ADM691 to see multiple crossings of the 1.3 V input power-reset threshold. These multiple negative-edge transitions would, in turn, cause the Z180 to see multiple power-failure interrupts.

The ADM691 generates a power-failure interrupt, INT1. After reset, INT1 must be enabled by a write into the ITC register as well as execution of the EI instruction followed by a RETI instruction. The Z180 will restore saved state information when it executes the RETI instruction.

Ideally, the Z180 should be able to pop the stack and return to the location where the program was first interrupted. Also, depending on the number of fluctuations of the DC input (and hence, the number of stacked power-failure interrupts), the processor’s stack can overflow, possibly into your program’s code or data.

The following sample program shows how to handle a power-failure interrupt.

```
main(){
   ...
}
...
char dummy[24];
...
#define INT1_BIT     0   ; bit 0
#INT_VEC INT1_VEC power_fail_isr
#asm
  power_fail_isr::
    ld   sp,dummy+24     ; force stack pointer
                         ; to top of dummy vector
                         ; to prevent overwriting
                         ; code or data
```

do whatever service, within allowable execution time

```
  loop:
    call hitwd        ; make sure no watchdog reset
                      ; while low voltage
    ld   bc,INT1      ; load the read INT1 register
                      ; to bc
    in   a,(c)        ; read the read INT1 register
                      ; for /PFO
    bit  INT1_BIT, a  ; check for status of /PFO
    jr   nz,loop      ; wait until the brownout
                      ; clears
  timeout:            ; then...a tight loop to
                      ; force a watchdog timeout,
    jp   timeout      ; resetting the Z180
#endasm
```

Of course, if the DC input voltage continues to decrease, then the OP7100 will just power down.

Call the Dynamic C function **hitwd** during the power-failure service routine to make sure that the watchdog timer does not time out and thereby reset the processor. The controller can continue to run at low voltages, and so it might not be able to detect the low-voltage condition after the watchdog timer resets the processor.

Watchdog Timer

To increase reliability, the ADM691's watchdog timer forces a system reset if a program does not notify the supervisor nominally at least every second. The assumption is that if the program fails to "hit" the watchdog, the program must be stuck in a loop or halted. The Dynamic C function for hitting the

watchdog timer is **hitwd**. To hold the watchdog timer at bay, make a call to **hitwd** in a routine that runs periodically at the lowest software priority level.

A program can read the state of the **WDO** line with a call to **wderror**. This makes it possible to determine whether a watchdog timeout occurred. The following sample program shows how to do this when a program starts or restarts.

```
main(){
   if( wderror() ) wd_cleanup();
   hitwd();
   ...
}
```

Power Shutdown and Reset

When VCC (+5 V) drops below V_{MIN} (between 4.5 V and 4.75 V), the ADM691 supervisor asserts **/RESET** and holds it until VCC goes above V_{MIN} and stays that way for at least 50 ms. This delay allows the system's devices to power up and stabilize before the CPU starts.

PFI "Early Warning"

When **PFI** drops below 1.3 V ± 0.05 V (i.e., DCIN drops below ~10 V), the supervisor asserts **/NMI** (nonmaskable interrupt), and allows the program to clean up and get ready for shutdown. The underlying assumption here is that **PFI** will cause the interrupt during a power failure before the ADM691 asserts **/RESET**.

In order to improve the performance of the power-failure interrupt circuit, we have added some hysteresis to the power-failure comparator by adding a resistor, R34, between the comparator input and output pins. R34 can be found on the 175-0196 and the 175-0211 versions of the OP7100. The hysteresis prevents the comparator from switching rapidly—and therefore generating multiple interrupts—when the input voltage is falling slowly. Once the comparator switches (DC IN falls to approximately 8.5 V), this feedback holds the input (PFI) low and prevents further interrupts from being generated. At this point, the 5 V regulator still has sufficient voltage to keep the processor operating, so that an interrupt service routine can perform shutdown tasks and "tidying up" before the Vcc line fails. The comparator will not turn the output (PFO) high until DC IN has risen to about 9.2 V. The hysteresis will also help prevent any system oscillation in adverse power supply/loading situations.

The voltage at which the power-failure interrupt occurs may be changed by adjusting the values of R29 and R30, which are shown in Figure 3-3. To calculate the values of these components, let V_L be the voltage at which PFO turns off as DC IN falls, and let V_H be the voltage at which PFO turns on as DC IN rises.

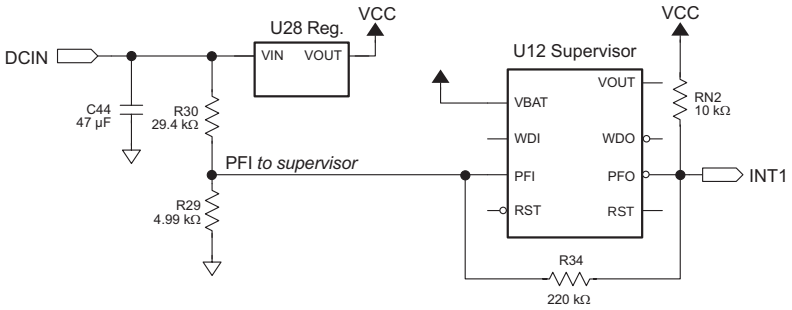


Figure 3-3. OP7100 Power-Failure Detection Circuit

$$V_L = 1.3\ V\left[1+\left(\frac{R30}{R29}\right)-\left(\frac{R30(5\ V - 1.3\ V)}{1.3\ V(R34+RN2)}\right)\right]$$

$$V_H = 1.3\ V\left[1+\left(\frac{R30}{R29}\right)+\left(\frac{R30}{R34}\right)\right]$$

Since R34 >> RN2, the difference between V_H and V_L, the hysteresis voltage, would be 5 V × (R30/R34). For a nominal hysteresis voltage of 1.25 V, R_{30} = 0.25 × R34.

Memory Protection

When **/RESET** is active, the ADM691 supervisor disables the RAM chip-select line, preventing accidental writes.

Battery Backup

The backup battery protects data in the RAM and the real-time clock (RTC). VRAM, the voltage supplied to the RAM and RTC, can also protect other devices attached to the system against power failures. The ADM691 supervisor switches VRAM to VBAT or VCC, whichever is greater. (To prevent "hunting," the switchover actually occurs when Vcc is 50 mV higher than VBAT.)

The circuit draws no current from the battery once regular power is applied.

System Reset

The ADM691 chip drives the **/RESET** line. The **/RESET** line is not pulled up internally.

Liquid Crystal Display (LCD)

The 240 × 320 ¼ VGA LCD supports both graphics and text. Automatic contrast control is built in so that the contrast, once set, does not drift as the OP7100 warms up or is moved.

Figure 3-4 provides a block diagram of the LCD control and RAM circuits.

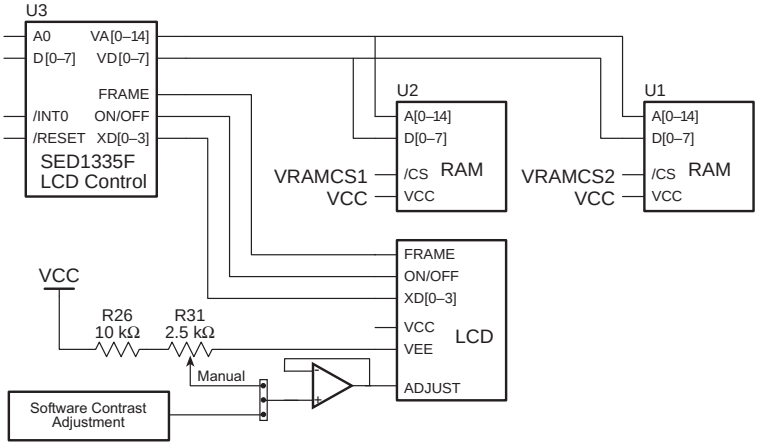


Figure 3-4. Block Diagram LCD Control and Memory

The LCD is connected to the OP7100 circuit board through header J1 or J3 on the circuit board.

Contrast Adjustment

Figure 3-5 shows the location of the manual contrast adjustment. This contrast adjustment is the factory default for the OP7110. The OP7100 is configured with software contrast control as the factory default. With software contrast control, the contrast level may be set via a software function call. Since it is hard to guess the correct level in software, buttons defined on the OP7100 touchscreen and in software can be used to adjust the contrast. A user-supplied keypad can facilitate this type of software control for the OP7110.

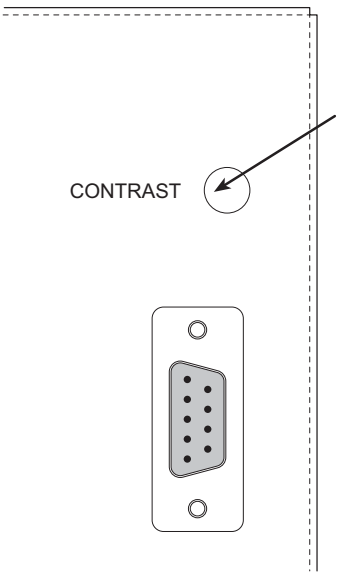


Figure 3-5. Location of OP7100 Manual Contrast Adjustment

Figure 3-6 shows the jumper settings for the contrast control options.

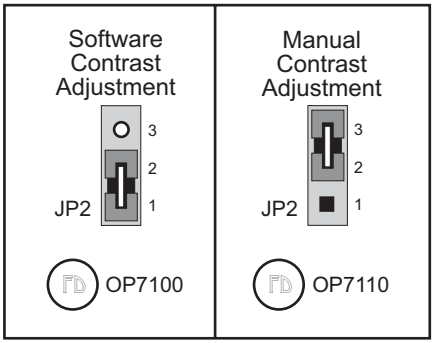


Figure 3-6. Contrast Control Jumper Configurations

Background

The OP7100 comes factory-configured to display blue characters on a white (positive) background. The jumpers on header JP1 may be rearranged as shown in Figure 3-7 to display white characters on a blue (negative) background.

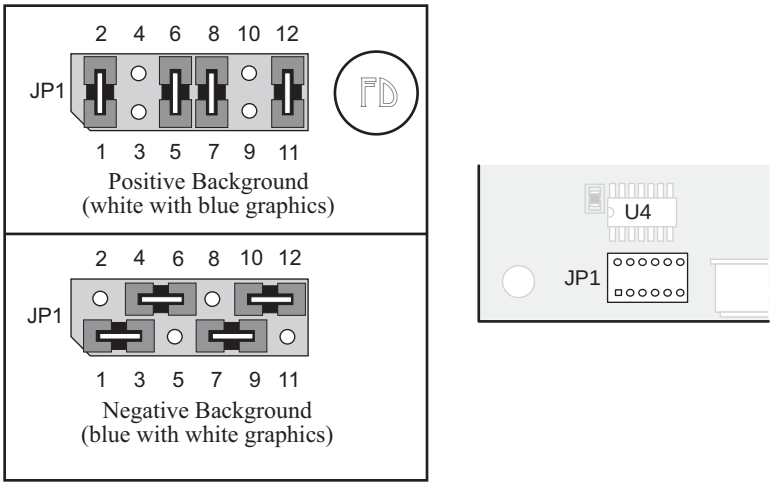


Figure 3-7. LCD Background Jumper Settings

Coordinate Systems

Figure 3-8 shows the coordinate systems for the touchscreen and the LCD.

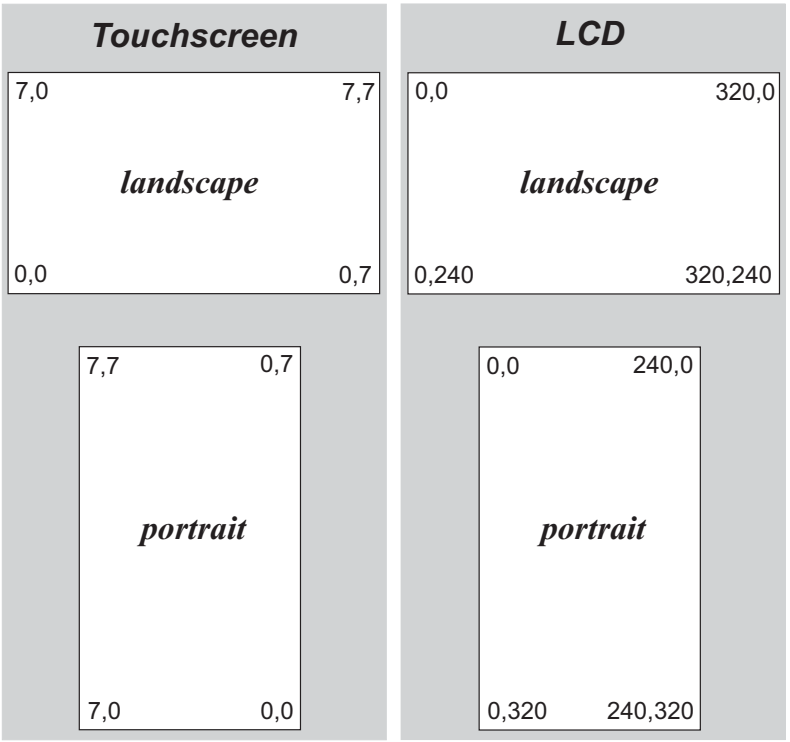


Figure 3-8. Coordinate Systems (row, column)

LCD Controller Chip

The LCD controller chip provides support for the LCD module. The controller chip is attached to the data bus on the OP7100, and is mapped to the I/O address space. This interface is composed of eight data bits, one address line, and three control lines (RD, WR, and 1335-CS).

The interface from the LCD controller to the LCD module is unidirectional. Data flow from the controller chip to the LCD module. A number of control lines are provided for this function, but not all of them are used for a particular LCD module. The controller continually reads the SRAM for data placed there by the microprocessor, and refreshes the display periodically.

Other functions support the LCD module to adjust its contrast and to turn the white CCFL backlight on and off. A variable resistor between two of the LCD module's terminals sets the contrast, which is set either by software or manually, depending on the jumper setting on header JP2. Once a contrast value is set, it will be maintained. A single programmed I/O bit is used to turn the backlight on or off.

The controller chip used in OP7100's sold before 2006 supported either 32K or 64K of SRAM. These OP7100s were designed using a dual-footprint SRAM to accept either one 32K or two 32K SRAM. One 32K part was standard.

OP7100 units sold after June, 2006, have a new LCD controller chip because the previously used LCD controller chip is no longer available. The new LCD controller chip has 32K of internal SRAM. Figure 3-9 shows the area of the OP7100 that changed to accommodate the new LCD controller chip. The new LCD controller is not 100% code-compatible with the old chip—the ***New LCD Controller Chip*** section on p. 73 explains how to handle programs developed for an OP7100 for the older LCD controller chip.

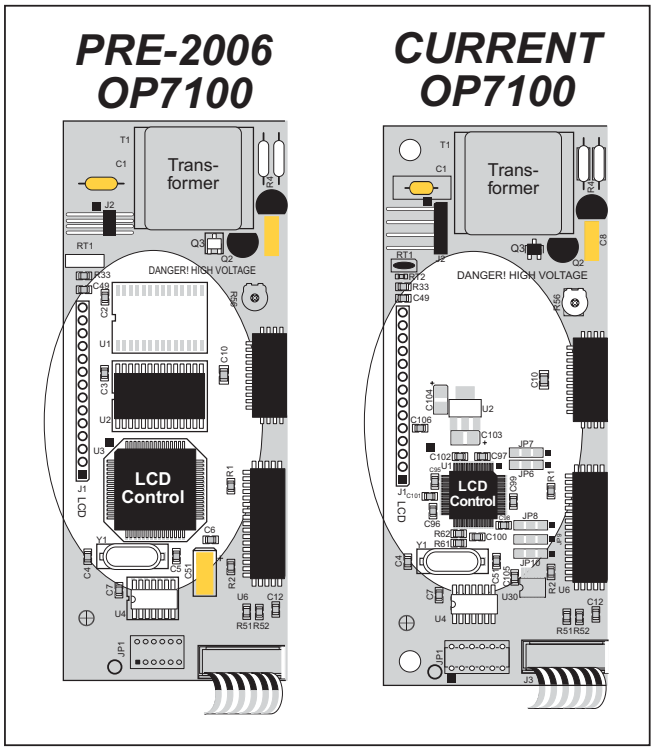


Figure 3-9. How to Identify Pre-2006 OP7100 Boards

Keypad Interface

The OP7100 has a touchscreen, which is connected to the circuit board at header J5. Header J6 is available for a customer-supplied keypad for the OP7110.

Table 3-1 lists the pinouts for headers J5 and J6. The pinout for header J5 is identical to the pinout for header J6.

Table 3-1. OP7100 Keypad Header Pinout

Signal	Header J5/J6 Pin	Signal	Header J5/J6 Pin
ROW0	1	**COL0**	9
ROW1	2	**COL1**	10
ROW2	3	**COL2**	11
ROW3	4	**COL3**	12
ROW4	5	**COL4**	13
ROW5	6	**COL5**	14
ROW6	7	**COL6**	15
ROW7	8	**COL7**	16

Figure 3-10 shows the location of headers J5 and J6.

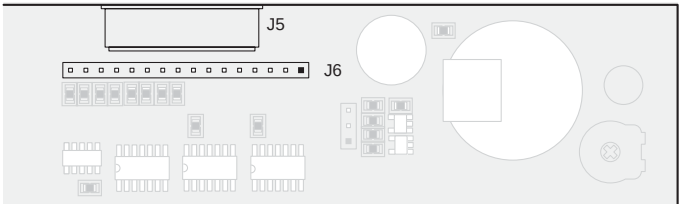


Figure 3-10. OP7100 Headers J5 and J6 (Keypad Interface)

Figure 3-11 shows a simplified diagram of the keypad interface.

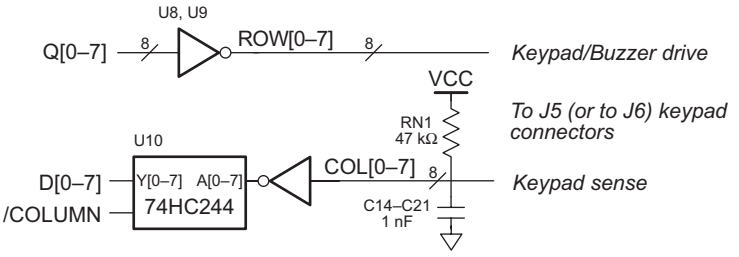


Figure 3-11. Block Diagram of OP7100 Keypad Interface

Digital I/O

The OP7100 has eight CMOS/TTL-level digital inputs and eight CMOS/TTL-level digital outputs. The digital inputs are provided with pullup resistors, shown in Figure 3-12, to provide a known state before a digital input is applied..

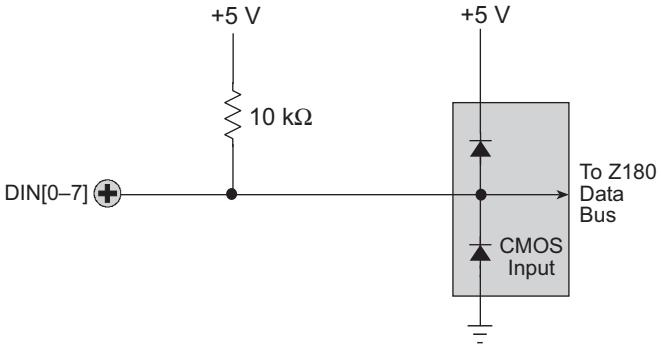


Figure 3-12. OP7100 Digital Inputs

The digital I/O are located on header J7, and are available through a connector on the outside of the OP7100 back cover. Figure 3-13 shows the pinout and the location of header J7.

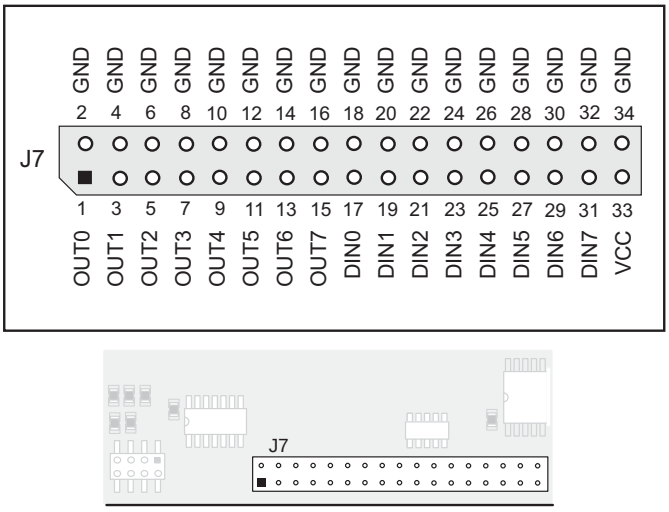


Figure 3-13. OP7100 Header J7

Serial Communication

Two serial channels support asynchronous communication at baud rates from 300 bps to 57,600 bps. Serial communication provides a simple and robust means for networking controllers and other devices.

Figure 3-14 illustrates the configuration of the OP7100 serial channels.

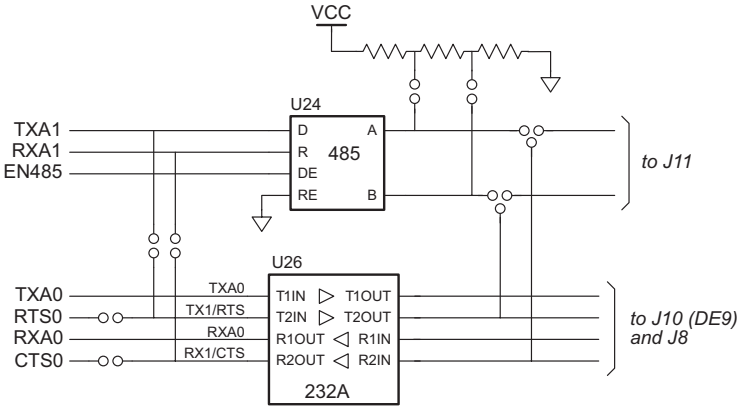


Figure 3-14. Serial Channels

The factory default configuration for the OP7100 is for one 5-wire RS-232 port (with RTS and CTS) and one half-duplex RS-485 port. An RS-485 channel can provide half-duplex asynchronous communication over twisted-pair wires for distances up to 3 km. Two other configurations, shown in Figure 3-14, are one 3-wire RS-232/one RS-485, and two 3-wire RS-232. The configurations are set with jumpers on header JP3.

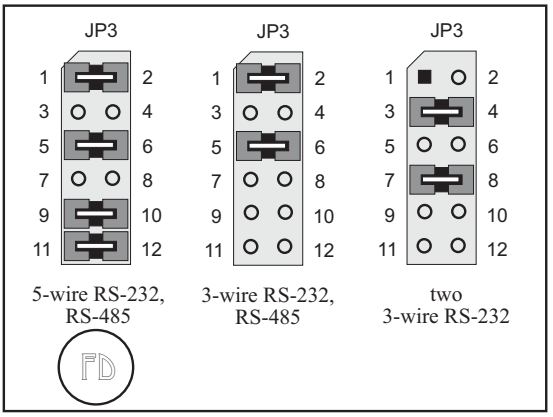


Figure 3-15. Serial Communication Jumper Configurations

The jumpers on header JP4 may be reconfigured so that header J11 carries the Z180 Port 1 TX1 and RX1 RS-232 signals on pins 2 and 3 instead of the factory-default RS-485+ and RS-485– signals.

Figure 3-16 shows the header JP4 jumper configurations and the location of headers JP3 and JP4.

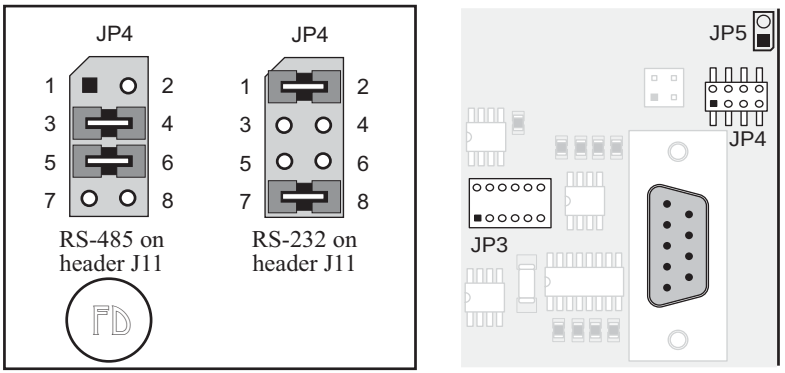


Figure 3-16. Serial Communication Options for External Plug Connector (Header J11)

RS-232 Communication

Figure 3-17 shows the RS-232 signals on header J8 and header J10 (the DE-9 connector).

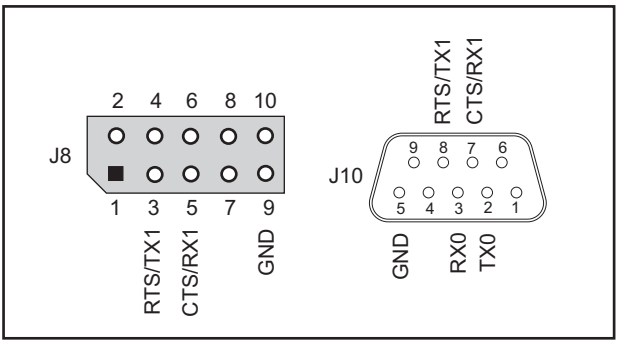


Figure 3-17. RS-232 Signals

Pin 9 on header J10, the DE-9 connector, may be configured to carry DCIN, the input voltage, by adding a 0 Ω resistor at R32. Be careful when connecting other devices to header J10 when R32 is installed since not all devices can handle DCIN. For example, PCs are limited to 12 V.

The availability of DCIN on pin 9 of header J7 allows a DC power supply to be made available to the device being connected to the OP7100.

Rabbit Semiconductor has RS-232 support libraries for Z180 Ports 0 and 1. The following functional support for serial communication is included.

- Initializing the serial ports.
- Monitoring and reading a circular receive buffer.
- Monitoring and writing to a circular transmit buffer.
- CTS (clear to send) and RTS (request to send) control for Z180 Port 0.

Receive and Transmit Buffers

Serial communication is easier with a background interrupt routine that updates receive and transmit buffers. Every time a port receives a character, the interrupt routine places it into the receive buffer. A program can read the data one character at a time or as a string of characters terminated by a special character.

A program sends data by writing characters into the transmit buffer. If the serial port is not already transmitting, the write functions will automatically initiate transmission. Once the last character of the buffer is sent, the transmit interrupt is turned off. A high-level application can write data one character at a time or in a string.

CTS/RTS Control

The Z180's hardware constrains its Port 0 to have the CTS (clear to send) pulled low by the RS-232 device to which it is talking. The OP7100 does not support CTS for the Z180's Port 1.

Modem Communication

Modems and telephone lines facilitate RS-232 communication across great distances.

The Dynamic C RS-232 library supports communication with a Hayes Smart Modem or compatible. The CTS, RTS and DTR lines of the modem are not used. If the modem used is not truly Hayes Smart Modem compatible, tie the CTS, RTS and DTR lines on the modem side together. The CTS and RTS lines on the controller also have to be tied together. A "NULL-modem" cable is also required for the TX and RX lines. A commercial NULL-modem cable would have its CTS and RTS lines tied together already on both sides.

Figure 3-18 shows the wiring for connections between a modem and the OP7100.

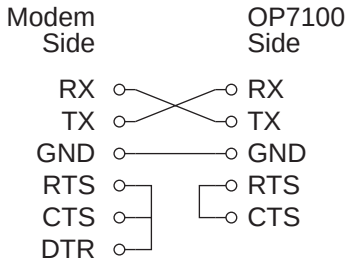


Figure 3-18. Connections Between Controller and Modem

RS-485 Communication

Figure 3-19 shows the RS-485 signals on header J11.

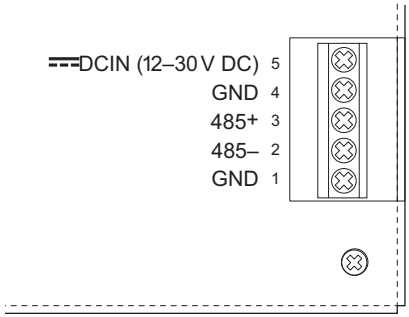


Figure 3-19. RS-485 Signals

Developing an RS-485 Network

The 2-wire RS-485 serial-communication port and Dynamic C network software are used to develop an RS-485 network.

The OP7100 can be linked together with other Rabbit Semiconductor controllers over a twisted-pair network for up to 1.2 km. When configuring a multidrop network, use single twisted-pair wires to connect RS-485+ to RS-485+ and RS-485- to RS-485- as shown in Figure 3-20.

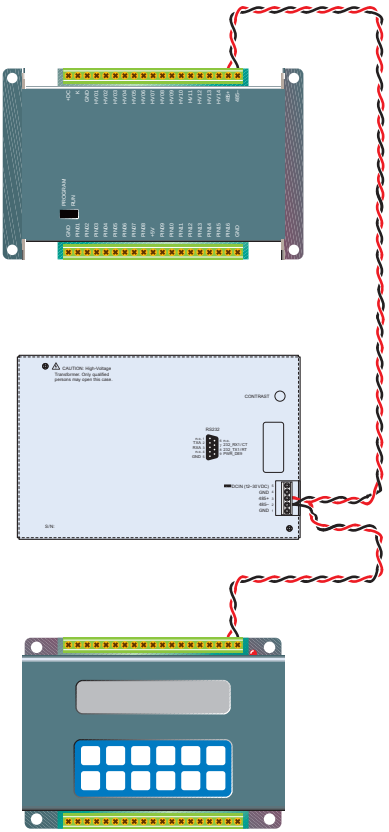


Figure 3-20. RS-485 Network

Any Rabbit Semiconductor controller or the OP7100 can be a master or a slave. A network can have up to 255 slaves, but only one master.

A multidrop network requires termination/bias resistors to minimize reflections (echoing) and to keep the network line active during an idle state. The OP7100 termination resistors are already installed, and by default are enabled by having jumpers installed on header J9. Remove the jumpers from header J9, as shown in Figure 3-21, to disable or remove the termination resistors. Only the first and last devices on a multidrop RS-485 network should have the termination resistors enabled.

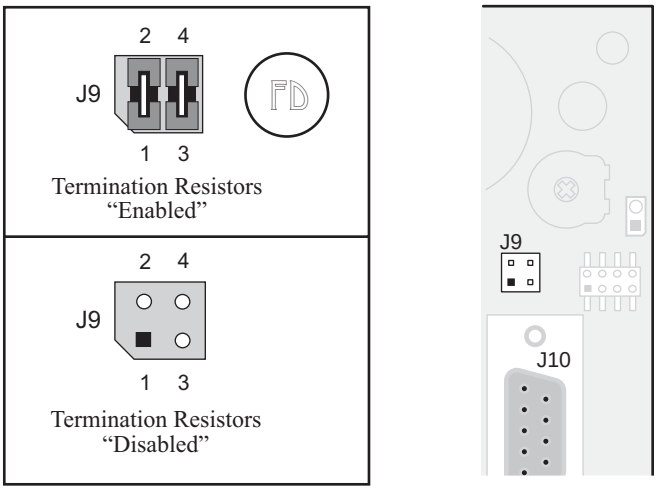


Figure 3-21. Enabling/Disabling Termination Resistors

Only a single, solid conductor should be placed in a screw clamp terminal. Bare copper, particularly if exposed to the air for a long period before installation, can become oxidized. The oxide can cause a high-resistance (~20 Ω) connection, especially if the clamping pressure is not sufficient. To avoid oxidation, use tinned wires or clean, shiny copper wire. If you are using multiple conductors or stranded wire, consider soldering the wire bundle or using a crimp connector to avoid a later loss of contact pressure to a spontaneous rearrangement of the wire bundle. Note that soldering a stranded wire may make the wire subject to fatigue failure at the junction with the solder if there is flexing or vibration.

Use of the Serial Ports

If you plan to use the serial ports extensively, or if you intend to use synchronous communications, Rabbit Semiconductor recommends that you obtain copies of the following Zilog technical manuals, available from Zilog, Inc, in Campbell, California.

Z180 MPU User's Manual

Z180 SIO Microprocessor Family User's Manual

Each serial port appears to the CPU as a set of registers. Each port can be accessed directly with the **inport** and **outport** library functions using the symbolic constants shown in Table 3-2.

Table 3-2. Z180 Serial Port Registers

Address	Name	Description
00	CNTLA0	Control Register A, Serial Channel 0
01	CNTLA1	Control Register A, Serial Channel 1
02	CNTLB0	Control Register B, Serial Channel 0
03	CNTLB1	Control Register B, Serial Channel 1
04	STAT0	Status Register, Serial Channel 0
05	STAT1	Status Register, Serial Channel 1
06	TDR0	Transmit Data Register, Serial Channel 0
07	TDR1	Transmit Data Register, Serial Channel 1
08	RDR0	Receive Data Register, Serial Channel 0
09	RDR1	Receive Data Register, Serial Channel 1

Z180 Serial Ports

The Z180's two independent, full-duplex asynchronous serial channels have a separate baud-rate generator for each channel. The baud rate can be divided down from the microprocessor clock, or from an external clock for either or both channels.

The serial ports have a multiprocessor communications feature. When enabled, this feature adds an extra bit to the transmitted character (where the parity bit would normally go). Receiving Z180s can be programmed to ignore all received characters except those with the extra multiprocessing bits enabled. This provides a 1-byte attention message that can be used to wake up a processor without the processor having to intelligently monitor all traffic on a shared communications link.

The block diagram in Figure 3-22 shows Serial Channel 0. Serial Channel 1 is similar, but control lines for **/RTS** and **/DCD** do not exist. The five unshaded registers shown in Figure 3-22 are directly accessible as internal registers.

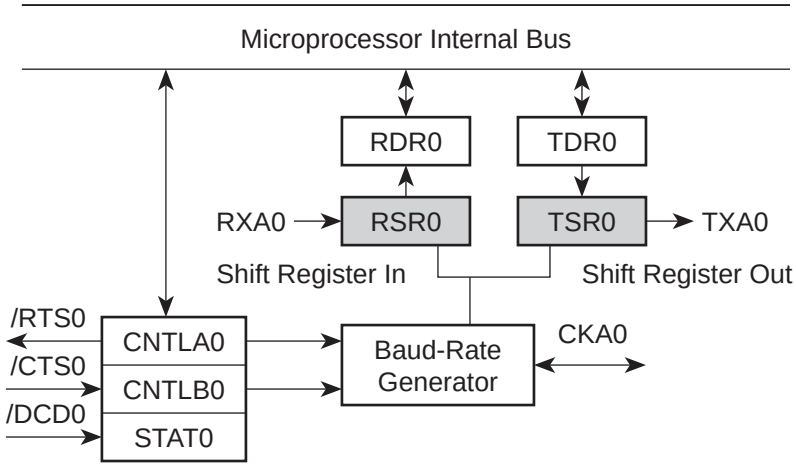


Figure 3-22. Z180 Serial Channel 0

The serial ports can be polled or interrupt-driven.

A *polling* driver tests the ready flags (TDRE and RDRF) until a ready condition appears (transmitter data register empty or receiver data register full). If an error condition occurs on receive, the routine must clear the error flags and take appropriate action, if any. If the **/CTS** line is used for flow control, transmission of data is automatically stopped when **/CTS** goes high because the TDRE flag is disabled. This prevents the driver from transmitting more characters because it thinks the transmitter is not ready. The transmitter will still function with **/CTS** high, but exercise care because TDRE is not available to synchronize loading the data register (TDR) properly.

An *interrupt-driven* port works as follows. The program enables the receiver interrupt as long as it wants to receive characters. The transmitter interrupt is enabled only while characters are waiting in the output buffer. When an interrupt occurs, the interrupt routine must determine the cause: receiver data register full, transmitter data register empty, receiver error, or **/DCD0** pin high (channel 0 only). None of these interrupts is edge-triggered. Another interrupt will occur immediately if interrupts are re-enabled without disabling the condition causing the interrupt. The signal **/DCD0** is grounded on the OP7100.

Table 3-3 lists the interrupt vectors.

Table 3-3. Serial Port Interrupt Vectors

Address	Name	Description
0E	**SER0_VEC**	Z180 Serial Port 0 (higher priority)
10	**SER1_VEC**	Z180 Serial Port 1

Asynchronous Serial Communication Interface

The Z180 incorporates an asynchronous serial communication interface (ACSI) that supports two independent full-duplex channels.

ASCI Status Registers

A status register for each channel provides information about the state of each channel and allows interrupts to be enabled and disabled.

STAT0 (04H)

7	6	5	4	3	2	1	0
RDRF	OVRN	PE	FE	RIE	/DCD0	TDRE	TIE
R	R	R	R	R / W	R	R	R / W

STAT1 (05H)

7	6	5	4	3	2	1	0
RDRF	OVRN	PE	FE	RIE	CTS1E	TDRE	TIE
R	R	R	R	R / W	R	R	R / W

/DCD0 (Data Carrier Detect)

This bit echoes the state of the **/DCD0** input pin for Channel 0. However, when the input to the pin switches from high to low, the data bit switches low only after STAT0 has been read. The receiver is held to reset as long as the input pin is held high. This function is not generally useful because an interrupt is requested as long as **/DCD0** is a 1. This forces the programmer to disable the receiver interrupts to avoid endless interrupts. A better design would cause an interrupt only when the state of the pin changes. This pin is tied to ground in the CM7000.

TIE (Transmitter Interrupt Enable)

This bit masks the transmitter interrupt. If set to 1, an interrupt is requested whenever TDRE is 1. The interrupt is not edge-triggered. Set this bit to 0 to stop sending. Otherwise, interrupts will be requested continuously as soon as the transmitter data register is empty.

TDRE (Transmitter Data Register Empty)

A 1 means that the channel is ready to accept another character. A high level on the **/CTS** pin forces this bit to 0 even though the transmitter is ready.

CTS1E (CTS Enable, Channel 1)

The signals RXS and CTS1 are multiplexed on the same pin. A 1 stored in this bit makes the pin serve the CTS1 function. A 0 selects the RXS function. (The pin RXS is the CSI/O data receive pin.) When RXS is selected, the CTS line has no effect.

RIE (Receiver Interrupt Enable)

A 1 enables receiver interrupts and 0 disables them. A receiver interrupt is requested under any of the following conditions: **/DCD0** (Channel 0 only), RDRF (read data register full), OVRN (overrun), PE (parity error), and FE (framing error). The condition causing the interrupt must be removed before the interrupts are re-enabled, or another interrupt will occur. Reading the receiver data register (RDR) clears the RDRF flag. The EFR bit in CNTLA is used to clear the other error flags.

FE (Framing Error)

A stop bit was missing, indicating scrambled data. This bit is cleared by the EFR bit in CNTLA.

PE (Parity Error)

Parity is tested only if MOD1 in CNTLA is set. This bit is cleared by the EFR bit in CNTLA.

OVRN (Overrun Error)

Overrun occurs when bytes arrive faster than they can be read from the receiver data register. The receiver shift register (RSR) and receiver data register (RDR) are both full. This bit is cleared by the EFR bit in CNTLA.

RDRF (Receiver Data Register Full)

This bit is set when data is transferred from the receiver shift register to the receiver data register. It is set even when one of the error flags is set, in which case defective data is still loaded to RDR. The bit is cleared when the receiver data register is read, when the **/DCD0** input pin is high, and by RESET and IOSTOP.

ASCI Control Register A

Control Register A affects various aspects of the asynchronous channel operation.

CNTLA0 (00H)

7	6	5	4	3	2	1	0
MPE	RE	TE	/RTS0	MPBR/ EFR	MOD2	MOD1	MOD0
R / W	R / W	R / W	R / W	R / W	R / W	R / W	R / W

CNTLA1 (01H)

7	6	5	4	3	2	1	0
MPE	RE	TE	CKA1D	MPBR/ EFR	MOD2	MOD1	MOD0
R / W	R / W	R / W	R / W	R / W	R / W	R / W	R / W

MOD0–MOD2 (Data Format Mode Bits)

MOD0 controls stop bits: 0 ⇒ 1 stop bit, 1 ⇒ 2 stop bits. If 2 stop bits are expected, then 2 stop bits must be supplied.

MOD1 controls parity: 0 ⇒ parity disabled, 1 ⇒ parity enabled. (See PEO in ASCI Control Register B for even/odd parity control.)

MOD2 controls data bits: 0 ⇒ 7 data bits, 1 ⇒ 8 data bits.

MPBR/EFR (Multiprocessor Bit Receive/Error Flag Reset)

Reads and writes on this bit are unrelated. Storing a byte when this bit is 0 clears all the error flags (OVRN, FE, PE). Reading this bit obtains the value of the MPB bit for the last read operation when the multiprocessor mode is enabled.

/RTS0 (Request to Send, Channel 0)

Store a 1 in this bit to set the RTS0 line from the Z180 high. This bit is essentially a 1-bit output port without other side effects.

CKA1D (CKA1 Disable)

This bit controls the function assigned to the multiplexed pin (CKA1/ ~TEND0): 1 ⇒ ~TEND0 (a DMA function) and 0 ⇒ CKA1 (external clock I/O for Channel 1 serial port).

TE (Transmitter Enable)

This bit controls the transmitter: 1 ⇒ transmitter enabled, 0 ⇒ transmitter disabled. When this bit is cleared, the processor aborts the operation in progress, but does not disturb TDR or TDRE.

RE (Receiver Enable)

This bit controls the receiver: 1 ⇒ enabled, 0 ⇒ disabled. When this bit is cleared, the processor aborts the operation in progress, but does not disturb RDRF or the error flags.

MPE (Multiprocessor Enable)

This bit (1 ⇒ enabled, 0 ⇒ disabled) controls multiprocessor communication mode which uses an extra bit for selective communication when a number of processors share a common serial bus. This bit has effect only when MP in Control Register B is set to 1. When this bit is 1, only bytes with the MP bit on will be detected. Others are ignored. If this bit is 0, all bytes received are processed. Ignored bytes do not affect the error flags or RDRF.

ASCI Control Register B

Control Register B configures the multiprocessor mode, parity, and baud rate for each channel.

CNTLB0 (02H) and CNTLB1 (03H)

7	6	5	4	3	2	1	0
MPBT	MP	/CTS PS	PEO	DR	SS2	SS1	SS0
R / W	R / W	R / W	R / W	R / W	R / W	R / W	R / W

SS (Source/Speed Select)

Coupled with the prescaler (PS) and the divide ratio (DR), the SS bits select the source (internal or external clock) and the baud rate divider, as shown in Table 3-4.

Table 3-4. Baud Rate Divide Ratios for Source/Speed Select Bits

SS2	SS1	SS0	Divide Ratio
0	0	0	÷ 1
0	0	1	÷ 2
0	1	0	÷ 4
0	1	1	÷ 8
1	0	0	÷ 16
1	0	1	÷ 32
1	1	0	÷ 64
1	1	1	external clock*

* May not exceed system clock ÷ 40

The prescaler (PS), the divide ratio (DR), and the SS bits form a baud-rate generator, as shown in Figure 3-23.

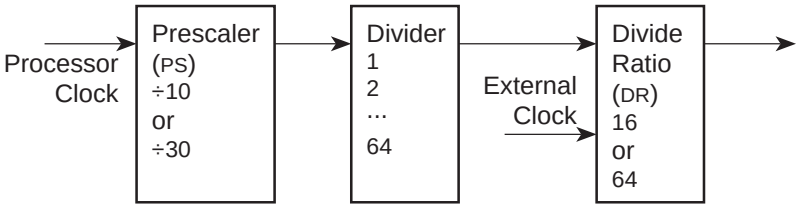


Figure 3-23. Z180 Baud-Rate Generator

DR (Divide Ratio)

This bit controls one stage of frequency division in the baud-rate generator. If 1 then divide by 64. If 0 then divide by 16. This is the only control bit that affects the external clock frequency.

PEO (Parity Even/Odd)

This bit affects parity: 0 ⇒ even parity, 1 ⇒ odd parity. It is effective only if MOD1 is set in CNTLA (parity enabled).

/CTS/PS (Clear to Send/Prescaler)

When read, this bit gives the state of external pin **/CTS**: 0 ⇒ low, 1 ⇒ high. When **/CTS** is high, RDRF is inhibited so that incoming receive characters are ignored. When written, this bit has an entirely different function. If a 0 is written, the baud-rate prescaler is set to divide by 10. If a 1 is written, it is set to divide by 30.

MP (Multiprocessor Mode)

When this bit is set to 1, the multiprocessor mode is enabled. The multiprocessor bit (MPB) is included in transmitted data as shown here.

start bit, data bits, MPB, stop bits

The MPB is 1 when MPBT is 1 and 0 when MPBT is 0.

MPBT (Multiprocessor Bit Transmit)

This bit controls the multiprocessor bit (MPB). When MPB is 1, transmitted bytes will get the attention of other units listening only for bytes with MPB set.

Table 3-5 relates the Z180's ASCI Control Register B to the baud rate.

Table 3-5. Baud Rates for ASCI Control Register B

ASCI B Value	Baud Rate at 9.216 MHz (bps)	Baud Rate at 18.432 MHz (bps)	ASCI B Value	Baud Rate at 9.216 MHz (bps)	Baud Rate at 18.432 MHz (bps)
00	57,600	115,200	20	19,200	38,400
01	28,800	57,600	21	9600	19,200
02 or 08	14,400	28,800	22 or 28	4800	9600
03 or 09	7200	14,400	23 or 29	2400	4800
04 or 0A	3600	7200	24 or 2A	1200	2400
05 or 0B	1800	3600	25 or 2B	600	1200
06 or 0C	900	1800	26 or 2C	300	600
0D	450	900	2D	150	300
0E	225	450	2E	75	150

CHAPTER 4: SOFTWARE

Chapter 4 describes the Dynamic C functions used with the OP7100.

Supplied Software

Software drivers for controlling the OP7100 are provided with Dynamic C. Depending on the version of Dynamic C you are using, the **OP71L.LIB**/**OP71P.LIB** or the **EZIOOP71.LIB** libraries provide drivers specific to the OP7100. In order to use the **OP71L.LIB**/**OP71P.LIB** and other libraries, it is necessary to include the appropriate Dynamic C libraries in your apppli-cation program. These libraries are listed in Table 4-1.

Table 4-1. OP7100 Software Libraries

Library	Application
AASCZ0.LIB	Serial communication applications Z180 Serial Port 0
AASCZ1.LIB	Serial communication applications Z180 Serial Port 1
BIOS.LIB	BIOS routines
DRIVERS.LIB	General drivers
OP71L.LIB **OP71P.LIB**	Select one of these DC 32 libraries to **#use** first, corresponding to landscape mode or portrait mode
OP71HW.LIB	DC 32 display hardware functions
EZIOOP71.LIB*	All OP7100 applications
GLCD.LIB*	LCD applications
KP_OP71.LIB	Touchscreen read applications (all DC versions)
LQVGA.LIB*	Landscape image VGA drivers
PQVGA.LIB*	Portrait image VGA drivers
SYS.LIB	General drivers

* Use these libraries with Dynamic C v. 5.xx versions.

Your application can use these libraries by including them in your pro-gram. To include these libraries, use the **#use** directive as shown below.

```
#use op71l.lib or #use op71p.lib
#use op71hw.lib
```

Choose the corresponding landscape or portrait libraries from Table 4-1 based on your version of Dynamic C and according to whether you will use your OP7100 in a landscape or a portrait orientation.

See the ***Dynamic C Technical Reference*** manual for more information on **#use** and other directives as well as for information on other libraries.

Digital I/O

No specific drivers have been written for the OP7100 digital I/O. The **inport** and **outport** functions in the Dynamic C **BIOS.LIB** library can be used to read the inputs and write the outputs. The eight digital inputs (DIN0–DIN7) are bitmapped bits 0 through 7 of the input at 0x4140. Each digital output (OUT0–OUT7) is controlled by bit 0 at 0x4140 through 0x4147.

For example, OUT2 can be turned on using the following statement.

```
outport( 0x4142,1 );
```

Likewise, OUT7 can be turned off using the following statement.

```
outport( 0x4147,0 );
```

The **inport** function reads all eight inputs simultaneously, so the bitwise AND operator (**&**) is useful in checking the status of a particular input. For example, the statement

```
if( inport(0x4140) & 0x04 )
```

can be used to check whether DIN2 (whose bit mask is 0x04) is on. Likewise

```
if( inport(0x4140) & 0x80 )
```

can be used to check the status of input DIN7.

The Dynamic C function **IBIT** can be used to determine the state of one input bit. For example, to check DIN2 (which is bit 2 of the inputs), use the statement

```
if( IBIT(0x4140,2) )
```

instead of the more complex statement below.

```
if( inport(0x4140) & 0x04 )
```

While **IBIT** works well for the digital inputs, its output equivalents, **ISET** and **IRES**, will not work with the digital output bits because the output register of the OP7100 is write-only. **ISET** and **IRES** will only operate on output registers whose current state can be read by the processor.

Refer to the ***Dynamic C Function Reference*** manual for more information on the use of these functions.

The sample program **OP71.C** below cycles through through the outputs with one bit high at a time while it displays the state of the digital inputs.

OP71.C

```
void delay( unsigned wDelay ){
   for(;--wDelay;hitwd());
}

void main( void ){
   unsigned wAddr;
   for (;;)
      for(wAddr=0x4140;wAddr<0x4148;++wAddr){
         outport( wAddr,0x01 );
         printf( "%04x%02x\n",wAddr,inport(0x4140) );
         delay( 0x8000 );
         outport( wAddr,0x00 );
      }
}
```

Real-Time Clock (RTC)

The OP7100 has an Epson 72423 chip. The chip stores time and date, and accounts for the number of days in a month, and for leap year. A backup battery will allow the values in the RTC to be preserved if a power failure occurs.

The Dynamic C function library **DRIVERS.LIB** provides the following RTC functions.

The ***Dynamic C Function Reference*** manual describes these functions and the associated data structure **tm**.

- **tm_rd**

  Reads time and date values from the RTC.

- **tm_wr**

  Writes time and date values into the RTC.

The following points apply when using the RTC.

1. The AM/PM bit is 0 for AM, 1 for PM. The RTC also has a 24-hour mode.
2. Set the year to 96 for 1996, 97 for 1997, and so on.

Constantly reading the RTC in a tight loop will result in a loss of accuracy.

Display

Flash EPROM

The **WriteFlash** function in the Dynamic C **DRIVERS.LIB** library is used to write data to the program flash EPROM.

- **int WriteFlash(unsigned long physical_addr, char *buf, int count)**

  Writes **count** number of bytes pointed to by **buf** to the program flash EPROM absolute data location **physical_adr**. Allocate data location by declaring the byte arrays as initialized arrays or declare an initialized **xdata** array. If byte array is declared, conert logical memory to physical memory with **phy_adr(array)**. For initialized **xdata**, you can pass the array name directly.

  PARAMETERS: **physical_adr** is the absolute data location in the flash EPROM.

  ***buf** is a pointer to the bytes to write.

  count is the number of bytes to write.

  RETURN VALUES:

  0 if **WriteFlash** is okay.

  -1 if the program flash EPROM is not in used.

  -2 if **physical_addr** is inside the BIOS area.

  -3 if **physical_addr** is within the symbol area or the simulated EEPROM area.

  -4 if **WriteFlash** times out.

The **WriteFlash** function writes to the program flash EPROM. See the **SYS.LIB** section later in this chapter for the functions associated with the second flash EPROM.

Dynamic C 32 Libraries

When you are using Dynamic C 32, you must first **`#use op71l.lib`** or **`#use op71p.lib`** before the **`#use op71hw.lib`** line as shown below.

```
#use op71l.lib or #use op71p.lib
#use op71hw.lib
```

Call the **`#use op71p.lib`** line to use your OP7100 in a portrait orientation, or call the **`#use op71l.lib`** line to use your OP7100 in a landscape orientation.

OP71HW.LIB

- **`void op71Init( void );`**

  This call must be used to initialize the OP7100 software and hardware. It also clears the LCD buffer and screen, sets the contrast to 35, turns on the LCD power, and turns on the LCD backlight.

- **`void op71BackLight( int isOn );`**

  Turns the OP7100 backlight on or off.

  PARAMETER: **`isOn`** turns the OP7100 backlight on or off.
  1 to turn backlight on
  0 to turn backlight off

- **`void op71Power( int isOn );`**

  Turns the OP7100 power on or off.

  PARAMETER: **`isOn`** turns the OP7100 power on or off.
  1 to turn power on
  0 to turn power off

- **`void op71SetContrast( unsigned level );`**

  Sets the OP7100 contrast level.

  PARAMETER: **`level`** is the contrast level (0–63), visibility increases with a lower level.

- **`void op71BlankScreen( void );`**

  Blanks (sets to white) the OP7100 screen.

- **`void op71FillScreen( char pattern );`**

  Fills the OP7100 LCD screen with a pattern. The screen will be set to all black if the pattern is 0xFF, all white if the pattern is 0x00, and vertical stripes for any other pattern.

- **`void op71BrdOff485( void );`**

  Disables the OP7100's RS-485 driver.

- **`void op71BrdOn485( void );`**

  Enables the OP7100's RS-485 driver.

- **`void op71Beep( int onOff );`**

  Controls the OP7100's beeper.

  PARAMETER: **`onOff`** is non-zero to beep, zero to stop beep.

- **`void op71BuffLock( void );`**

  Increments the OP7100 LCD screen locking counter. Graphics calls are recorded in the LCD memory buffer, but are not transferred to the LCD if the counter is non-zero.

  `op71BuffLock()` and **`op71BuffUnlock()`** can be nested up to a level of 255, but be sure to balance the calls. It is not a requirement to use these procedures, but a set of **`op71BuffLock`** and **`op71BuffUnlock`** bracketing a set of related graphics calls speeds up the rendering significantly.

- **`void op71BuffUnlock( void );`**

  Decrements the OP7100 LCD screen locking counter. The contents of the LCD buffer are transferred to the LCD if the counter goes to zero.

- **`void op71SetBrushType( int type );`**

  Sets the drawing method (or color) of pixels drawn by subsequent graphics calls.

  PARAMETER: **`type`** can be one of the following:

  `GL_SET` or **`OP71BLACK`** draws black pixels
  `GL_CLEAR` or **`OP71WHITE`** draws white pixels
  `GL_XOR` or **`OP71XOR`** draws "**`oldPixel xor newPixel`**" pixels
  `GL_BLOCK` or **`OP71BLACK`** draws black pixels

- **`int op71GetBrushType( void );`**

  Gets the current method (or color) of pixels drawn by subsequent graphics calls.

  RETURN: The current brush type.

- **`void op71Left1( int left, int top, int cols, int rows );`**

  Scrolls byte-aligned window left one pixel, right column is filled by current pixel type (color).

  PARAMETERS: **`left`** is the left edge of the window, must be evenly divisible by 8.

  `top` is the top edge of the window.

  `cols` is the number of columns in the window, must be evenly divisible by 8.

  `rows` is the number of rows in the window.

- **`void op71Right1( int left, int top, int cols, int rows );`**

  Scrolls byte-aligned window right one pixel, left column is filled by current pixel type (color).

  PARAMETERS: **`left`** is the left edge of the window, must be evenly divisible by 8.

  `top` is the top edge of the window.

  `cols` is the number of columns in the window, must be evenly divisible by 8.

  `rows` is the number of rows in the window.

- **`void op71Up1( int left, int top, int cols, int rows );`**

  Scrolls byte-aligned window up one pixel, bottom column is filled by current pixel type (color).

  PARAMETERS: **`left`** is the left edge of the window, must be evenly divisible by 8.

  `top` is the top edge of the window.

  `cols` is the number of columns in the window, must be evenly divisible by 8.

  `rows` is the number of rows in the window.

The **`op71Left1`**, **`op71Right1`**, **`op71Up1`**, and **`op71Down1`** function calls may be called multiple times to provide a smoother scrolling effect than provided by the scroll function calls. Do not change the parameters to preserve the window being scrolled.

- **`void op71Down1( int left, int top, int cols, int rows );`**

  Scrolls byte-aligned window down one pixel, top column is filled by current pixel type (color).

  PARAMETERS: **`left`** is the left edge of the window, must be evenly divisible by 8.

  `top` is the top edge of the window.

  `cols` is the number of columns in the window, must be evenly divisible by 8.

  `rows` is the number of rows in the window.

- **`void op71HScroll( int left, int top, int cols, int rows, int nPix );`**

  Scrolls byte-aligned window right or left, opposite edge is filled by white pixels.

  PARAMETERS: **`left`** is the left edge of the window, must be evenly divisible by 8.

  `top` is the top edge of the window.

  `cols` is the number of columns in the window, must be evenly divisible by 8.

  `rows` is the number of rows in the window.

  `nPix` is the number of pixels to scroll (negative to scroll left).

- **`void op71VScroll( int left, int top, int cols, int rows, int nPix );`**

  Scrolls byte-aligned window up or down, right column is filled by current pixel type (color).

  PARAMETERS: **`left`** is the left edge of the window, opposite edge is filled by white pixels.

  `top` is the top edge of the window.

  `cols` is the number of columns in the window, must be evenly divisible by 8.

  `rows` is the number of rows in the window.

  `nPix` is the number of pixels to scroll (negative to scroll up).

- **`void op71XPutBitmap( int left, int top, int width, int height, unsigned long bitmap );`**

  Draws bitmap in the specified space. The data for the bitmap are stored in **`xmem`**. Automatically calls **`op71XPutFastmap`** if bitmap is byte-aligned (left-edge and width each evenly divisible by 8).

  PARAMETERS: **`left`** is the left edge of the bitmap.

  `top` is the top edge of the bitmap.

  `width` is the width of the bitmap.

  `height` is the height of the bitmap.

  `bitmap` is the address of the bitmap in **`xmem`**.

- **`void op71XPutFastmap( int left, int top, int width, int height, unsigned long bitmap );`**

  Draws bitmap in the specified space. The data for the bitmap are stored in **`xmem`**.

  This function is like **`op71XPutBitmap`**, except that it is faster. The restriction is that the bitmap must be byte-aligned.

  PARAMETERS: **`left`** is the left edge of the bitmap.

  `top` is the top edge of the bitmap.

  `width` is the width of the bitmap.

  `height` is the height of the bitmap.

  `bitmap` is the address of the bitmap in **`xmem`**.

- **`void op71XGetBitmap( int x, int y, int bmWidth, int bmHeight, unsigned long xBm );`**

  Gets a bitmap from the LCD page buffer and stores it in **`xmem`** RAM. Automatically calls **`op71XGetFastmap`** if the bitmap is byte-aligned (the left edge and width are each evenly divisible by 8).

  PARAMETERS: **`x`** is the left edge of the bitmap (in pixels).

  `y` is the top edge of the bitmap (in pixels).

  `bmWidth` is the width of the bitmap (in pixels).

  `bmHeight` is the height of the bitmap (in pixels).

  `xBm` is the **`xmem`** RAM storage address.

Figure 3-8 shows the coordinate system for the LCD pixels.

- **`void op71XGetFastmap( int x, int y, int bmWidth, int bmHeight, unsigned long xBm );`**

  Gets a bitmap from the LCD page buffer and stores it in **`xmem`** RAM. This function is like **`op71XGetBitmap`**, except that it is faster. The restriction is that the bitmap must be byte-aligned.

  PARAMETERS: **`x`** is the left edge of the bitmap (in pixels), and must be evenly divisible by 8.

  `y` is the top edge of the bitmap (in pixels).

  `bmWidth` is the width of the bitmap (in pixels), and must be evenly divisible by 8.

  `bmHeight` is the height of the bitmap (in pixels).

  `xBm` is the **`xmem`** RAM storage address.

- **`void op71PlotDot( int x, int y );`**

  Draws a single pixel in the LCD buffer, and on the LCD if the buffer is unlocked.

  PARAMETERS: (**`x`**,**`y`**) are the coordinates of the dot.

- **`void op71PlotLine( int x0, int y0, int x1, int y1 );`**

  Draws a line in the LCD buffer, and on the LCD if the buffer is unlocked.

  PARAMETERS: (**`x0`**,**`y0`**) are the (x,y) coordinates of one endpoint.

  (**`x1`**,**`y1`**) are the (x,y) coordinates of the other endpoint.

- **`void op71Block( int x, int y, int bmWidth, int bmHeight );`**

  Draws a rectangular block in the page buffer, and on the LCD if the buffer is unlocked.

  PARAMETERS: **`x`** is the left edge of the pixel.

  `y` is the top edge of the pixel.

  `bmWidth` is the width of the block.

  `bmHeight` is the height of the block.

- **`void op71PlotCircle( int xc, int yc, int rad );`**

  Draws a circle in the LCD page buffer, and on the LCD if the buffer is unlocked.

  PARAMETERS: **`x`** is the x-coordinate of the center.

  `y` is the y-coordinate of the center.

  `rad` is the radius of the circle (in pixels).

- **`void op71FillCircle( int xc, int yc, int rad );`**

  Draws a filled circle in the LCD page buffer, and on the LCD if the buffer is unlocked.

  PARAMETERS: **`x`** is the x-coordinate of the center.

  `y` is the y-coordinate of the center.

  `rad` is the radius of the circle (in pixels).

- **`void op71PlotVPolygon( int n, int *pFirstCoord );`**

  Plots the outline of a polygon in the LCD page buffer, and on the LCD if the buffer is unlocked.

  PARAMETERS: **`n`** is the number of vertices.

  `pFirstCoord` is a pointer to the array for the vertex with coordinates (x1,y1), (x2,y2),(x3,y3)...

- **`void op71FillVPolygon( int n, int *pFirstCoord );`**

  Fills a polygon in the LCD page buffer, and on the LCD screen if the buffer is unlocked.

  PARAMETERS: **`n`** is the number of vertices.

  `pFirstCoord` is a pointer to the array for the vertex with coordinates (x1,y1), (x2,y2),(x3,y3)...

- **`void op71PlotPolygon( int n, int x1, int y1, int x2, int y2, ... );`**

  Plots the outline of a polygon in the LCD page buffer, and on the LCD if the buffer is unlocked.

  PARAMETERS: **`n`** is the number of vertices.

  (**`x1`**,**`y1`**) are the (x,y) coordinates of the first vertex.

  (**`x2`**,**`y2`**) are the (x,y) coordinates of the first vertex...

- **`void op71FillPolygon( int n, int x1, int y1, int x2, int y2, ... );`**

  Fills a polygon in the LCD page buffer, and on the LCD if the buffer is unlocked.

  PARAMETERS: **`n`** is the number of vertices.

  (**`x1`**,**`y1`**) are the (x,y) coordinates of the first vertex.

  (**`x2`**,**`y2`**) are the (x,y) coordinates of the first vertex...

- **`void op71XFontInit( struct _fontInfo *pInfo, char pixWidth, char pixHeight, unsigned startChar, unsigned endChar, unsigned long xmemBuffer );`**

  Initializes the font descriptor structure, where the font is stored in **`xmem`**. Each font character's bitmap is column major and is byte-aligned.

  PARAMETERS: **`pInfo`** is a pointer to the font descriptor to be initialized.

  `pixWidth` is the width of each font item (in pixels).

  `pixHeight` is the height of each font item (in pixels).

  `startChar` is the the first printable character in the font (does not have to be 0).

  `endChar` is the the last printable character in the font.

  `xmemBuffer` is a pointer to a linear array of font bitmaps in **`xmem`**.

- **`unsigned long op71FontChar( unsigned long font, char letter );`**

  Returns the bitmap address of the character in the font specified.

  PARAMETERS: **`font`** is the font address in **`xmem`**.

  `letter` is the ASCII letter code.

  RETURN: **`xmem`** bitmap address of the character in the font, column major and byte-aligned.

- **`void op71PutFont( int x, int y, struct _fontInfo *pInfo, char code );`**

  Puts an entry from the font table to the page buffer, and on the LCD if the buffer is unlocked. Each font character's bitmap is column major and byte-aligned.

  PARAMETERS: **`x`** is the left edge (in pixels).

  `y` is the top edge (in pixels).

  `pInfo` is a pointer to the font descriptor.

  `code` is the code (character) to display.

- **`int op71GetPfStep( void );`**

  Gets the current **`op71Printf`** printing step direction. Each step direction is independent of the other, and is treated as an 8-bit signed value. The actual step increments depend on the height and width of the font being displayed, which are multiplied by the step values.

  Use **`op71SetPfStep`** to control the x and y printing step direction.

  RETURN: The x step is returned in the MSB, and the y step is returned in the LSB of the integer result.

- **`void op71SetPfStep( int stepX, int stepY );`**

  Sets the **`op71Printf`** printing step direction. The x and y step directions are independent signed values. The actual step increments depend on the height and width of the font being displayed, which are multiplied by the step values.

  Use **`op71GetPfStep`** to examine the current x and y printing step direction.

  PARAMETERS: **`stepX`** is the **`op71Printf`** x step.

  `stepY` is the **`op71Printf`** y step.

- **`void op71Printf( int x, int y, struct _fontInfo *pInfo, char *fmt, ... );`**

  Prints a formatted string (much like **`printf`**) on the LCD screen. Only character codes that exist in the font are printed, others are skipped over. For example, '\b', '\t', '\n', and '\r' (ASCII backspace, tab, new line and carriage return, respectively) print if they exist in the font, but have no effect as control characters.

  Use **`op71SetPfStep`** to control or use **`op71GetPfStep`** to examine the current x and y printing step direction.

  PARAMETERS: **`x`** is the x-coordinate of the text (left edge).

  `y` is the y-coordinate of the text (top edge).

  `pInfo` is a pointer to the font descriptor.

  `fmt` is a pointer to the format string...

Keypad Programming

The same library used in Dynamic C v. 5.xx, **`KP_OP71.LIB`**, is used with Dynamic C 32. The function calls are described later in this chapter.

Using Dynamic C v. 5.xx

EZIOOP71.LIB

- **`void op71BackLight( int onOff )`**

  Turns the backlight of the OP7100 on or off.

  PARAMETER: **`onOff`** is non-zero to turn the backlight on, zero to turn the backlight off.

- **`void op71SetContrast( unsigned contrast )`**

  Controls the contrast of the LCD.

  PARAMETER: **`contrast`** values range from 0 to 127, 0 for the least contrast (minimum VEE), 127 for the most contrast (maximum VEE).

- **`void eioBeep( int onOff )`**

  Turns the buzzer on or off.

  PARAMETER: **`onOff`** is non-zero to turn the buzzer on, zero to turn the buzzer off.

GLCD.LIB

- **`void glFontInit( struct _fontInfo *pInfo,`**
  `char pixWidth, char pixHeight,`
  `unsigned startChar, unsigned endChar,`
  `char *bitmapBuffer )`

  Initializes a font descriptor with the bitmap defined in the root memory. For fonts with bitmaps defined in **`xmem`**, use **`glXFontInit`**.

  PARAMETERS: **`pInfo`** is a pointer to the font descriptor to be initialized.

  `pixWidth` is the width of each font item (**`pixWidth`** must be uniform for all items).

  `pixHeight` is the height of each font item (**`pixHeight`** must be uniform for all items).

  `startChar` is the offset to the first useable item (useful for fonts for ASCII or other fonts with an offset).

  `endChar` is the index of the last useable font item.

  `bitmapBuffer` is a pointer to a linear array of the font bitmap. The bitmap is a column with the major byte aligned.

- **`glXFontInit( struct _fontInfo *pInfo, char pixWidth, char pixHeight, unsigned startChar, unsigned endChar, unsigned long xmemBuffer )`**

  Initializes a font descriptor that has the bitmap defined in **`xmem`**. For bitmaps defined in root memory, use **`glFontInit`**.

  PARAMETERS: **`pInfo`** is a pointer to the font descriptor to be initialized.

  `pixWidth` is the width of each font item (**`pixWidth`** must be uniform for all items).

  `pixHeight` is the height of each font item (**`pixHeight`** must be uniform for all items).

  `startChar` is the offset to the first useable item (useful for fonts for ASCII or other fonts with an offset).

  `endChar` is the index of the last useable font item.

  `xmemBuffer` is a pointer to a linear array of the font bitmap. The bitmap is a column with the major byte aligned.

- **`void glSetBrushType( int type )`**

  Sets the type of brush type and controls how pixels are drawn on the screen until the next call to **`glSetBrushType`**.

  PARAMETER: **`type`** is the type of the brush. The four macros described below have been defined for valid values to pass to the function.

Macro	Description	Effect
`GL_SET`	Pixels specified by subsequent **`gl`** functions will turn on the LCD pixels	LCDPix = LCDPix | newPix
`GL_CLEAR`	Pixels specified by subsequent **`gl`** functions will turn off the LCD pixels	LCDPix = LCDPix & ~newPix
`GL_XOR`	Pixels specified by subsequent **`gl`** functions will toggle the LCD pixels	LCDPix = LCDPix ^ newPix
`GL_BLOCK`	Pixels specified by subsequent **`gl`** functions will be displayed on the LCD as is	LCDPix = newPix

All four brush types can be used to display text or bitmaps. Do not use **`GL_BLOCK`** for **`glPlot`** or **`glFill`** graphics primitive functions.

- **`int glInit()`**

  Initializes the LCD module (software and hardware).

  RETURN VALUE: the status of the LCD. If the initialization was successful, this function returns 0. Otherwise, the returned value indicates the LCD status.

- **`int glPlotDot( int x, int y )`**

  Plots one pixel on the screen at coordinate (x,y).

  PARAMETERS: **`x`** is the x coordinate of the pixel to be drawn.

  `y` is the y coordinate of the pixel to be drawn.

  RETURN VALUE: Status of the LCD after the operation.

- **`void glPlotLine( int x1, int y1, int x2, int y2 )`**

  Plots a line on the LCD.

  PARAMETERS: **`x1`** is the x coordinate of the first endpoint.

  `y1` is the y coordinate of the first endpoint.

  `x2` is the x coordinate of the second endpoint.

  `y2` is the y coordinate of the second endpoint.

- **`void glPrintf( int x, int y,`**
  `struct _fontInfo *pInfo, char *fmt,... )`

  Prints a formatted string (much like **`printf`**) on the LCD screen.

  PARAMETERS: **`x`** is the x coordinate of the text (left edge).

  `y` is the y coordinate of the text (top-edge).

  `*pInfo` is the pointer to the font descriptor used for printing on the LCD screen.

  `*fmt` is the pointer to the format string

- **`void glPlotCircle( int xc, int yc, int rad )`**

  Draws a circle on the LCD.

  PARAMETERS: **`xc`** is the x coordinate of the center.

  `yc` is the y coordinate of the center.

  `rad` is the radius of the circle.

- **`void glFillCircle( int xc, int yc, int rad )`**

  Draws a filled-in circle on the LCD.

  PARAMETERS: **`xc`** is the x coordinate of the center.

  `yc` is the y coordinate of the center.

  `rad` is the radius of the circle.

- **`void glPlotVPolygon( int n, int *pFirstCoord )`**

  Plots a filled-in polygon.

  PARAMETERS: **`n`** is the number of vertices.

  `*pFirstCoord` is an array of vertex coordinates (x_1,y_1), (x_2,y_2), …

- **`void glPlotPolygon( int n, int x1, int y1, int x2, int y2,... )`**

  Plots the outline of a polygon.

  PARAMETERS: **`n`** is the number of vertices.

  `x1` is the x coordinate of the first vertex.

  `y1` is the y coordinate of the first vertex.

  `x2` is the x coordinate of the second vertex.

  `y2` is the y coordinate of the second vertex.

- **`void glFillVPolygon( int n, int *pFirstCoord )`**

  Fills in a polygon.

  PARAMETERS: **`n`** is the number of vertices.

  `*pFirstCoord` is an array of vertex coordinates (x_1,y_1), (x_2,y_2), …

- **`void glFillPolygon( int n, int x1, int y1, int x2, int y2,... )`**

  Fllls in a polygon.

  PARAMETERS: **`n`** is the number of vertices.

  `x1` is the x coordinate of the first vertex.

  `y1` is the y coordinate of the first vertex.

  `x2` is the x coordinate of the second vertex.

  `y2` is the y coordinate of the second vertex.

- **`void glPutBitmap( int x, int y, int bmWidth, int bmHeight, char *bm )`**

  Displays a bitmap stored in root memory on the LCD. For bitmaps defined in **`xmem`** memory, use **`glXPutBitmap`**.

  PARAMETERS: **`x`** is the x coordinate of the bitmap left edge.

  `y` is the y coordinate of the bitmap top edge.

  `bmWidth` is the width of the bitmap.

  `bmHeight` is the height of the bitmap.

  `bm` is a pointer to the bitmap. The bitmap format is a column with the major byte aligned for each column.

- **`void glXPutBitmap( int x, int y, int bmWidth, int bmHeight, unsigned long bmPtr )`**

  Displays a bitmap stored in xmem on the LCD. For bitmaps stored in root memory, use **`glPutBitmap`**.

  PARAMETERS: **`x`** is the x coordinate of the bitmap left edge.

  `y` is the y coordinate of the bitmap top edge.

  `bmWidth` is the width of the bitmap.

  `bmHeight` is the height of the bitmap.

  `bmPtr` is a pointer to the bitmap. The bitmap format is a column with the major byte aligned for each column.

KP_OP71.LIB

- **`void kpInit( int (*changeFn)() )`**

  Initializes the **`kp`** module. Call this function before calling other functions in this library. If the default keypad scanning routine will be used, use **`kpDefInit`** instead of this function.

  PARAMETER: **`changeFn`** is a pointer to a function that will be called when the driver detects a change (when **`kpScanState`** is called). Two arguments are passed to the callback function. The first argument is a pointer to an array that indicates the current state of the keypad. The second is a pointer to an array that indicates what keypad positions are changed and detected by **`kpScanState`**. The byte offset in the array represents the line pulled high (row number), and the bits in a byte represents the positions (column number) read back.

- **`int kpScanState()`**

  Scans the keypad and detects any changes to the keypad status. If **`kpInit`** is called with a non-NULL function pointer, that function will be called with the state of the keypad. This function should be called periodically to scan for keypad activities.

  RETURN VALUE: 0 if there is no change to the keypad, non-zero if there is any change to the keypad.

- **`int kpDefStChgFn( char *curState, char *changed )`**

  This is the default state change function for the default get key function **`kpDefGetKey`**. This function is called back by **`kpScanState`** when there is a change in the keypad state. If the current key is not read by **`kpDefGetKey`**, the new key pressed will not be registered.

  PARAMETERS: **`curState`** points to an array that reflects the current state of the keypad (bitmapped, 1 indicates key is not currently pressed).

  `changed` points to an array that reflects the CHANGE of keypad state from the previous scan. (bitmapped, 1 indicates there was a change).

  RETURN VALUE: -1 if no key is pressed. Otherwise **`kpScanState`** returns the normalized key number. The normalized key number is **`8*row+col+edge*256`**. **`edge`** is 1 if the key is released, and 0 if the key is pressed.

- **`int kpDefGetKey()`**

  This is the default get key function. It returns the key previously pressed (i.e., from the one-keypress buffer). The key pressed is actually interpreted by **`kpDefStChgFn`**, which is called back by **`kpScanState`**. **`kpDefInit`** should be used to initialize the module.

  RETURN VALUE: -1 if no key is pressed. Otherwise, **`kpDefGetKey`** returns the normalized key number. The normalized key number is **`8*row+col+edge*256`**. **`edge`** is 1 if the key is released, and 0 if the key is pressed.

- **`void kpDefInit()`**

  Initializes the library to use the default state change function to interpret key presses when **`kpScanState`** is called. Use **`kpDefGetKey`** to get the code of the last key pressed.

- **`int sysChk2ndFlash( struct _flashInfo *pInfo )`**

  Checks for the existence and configuration of the second flash EPROM mapped to memory space.

  PARAMETER: **`pInfo`** is a pointer to **`struct _flashInfo`**, which stores the configuration of the flash.

  RETURN VALUE: 0 is returned if the second flash EPROM exists and the configuration is valid; otherwise, a negative number is returned.

- **`void sysRoot2FXmem( struct _flashInfo *pInfo, void *src, unsigned long int dest, unsigned integer len )`**

  Copies memory content from the root memory space to the second flash EPROM mapped to memory space.

  PARAMETERS: **`pInfo`** is a pointer to **`struct _flashInfo`** (initialized by **`sysChk2ndFlash`**).

  `src` points to the beginning of the block in root memory to be copied to the second flash EPROM.

  `dest` (a physical address) points to the beginning of the block in the second flash EPROM mapped to memory space.

  `len` is the length of the block to be copied.

Upgrading Dynamic C

Dynamic C patches that focus on bug fixes are available from time to time. Check the Web site

- www.rabbit.com/support/downloads/

for the latest patches, workarounds, and bug fixes.

You may need to download upgraded libraries to run an OP7100 purchased after June, 2006.

When downloading the libraries from the Web site, click on the product-specific links until you reach the links for the OP7100 download you require. You will be able to either run the download directly from the Web site, or you may choose to save it to run later.

New LCD Controller Chip

OP7100 units sold after June, 2006, have a new LCD controller chip because the previously used LCD controller chip is no longer available. The new LCD controller is not 100% code-compatible with the old chip, and therefore changes were made to the LCD drivers. The updated drivers for the OP7100 are backward-compatible for use with the old LCD controller chip.

If you are using a program developed for the now-obsolete LCD controller chip, you will need to replace either the existing Dynamic C **OP71L.LIB**, **OP71P.LIB**, and **OP71HW.LIB** libraries or the **LQVGA.LIB** and **PQVGA.LIB** libraries in your Dynamic C installation — you only have to replace one of these two sets of libraries, depending on which set you used when you created your original application. You may, of course, replace all five libraries, which will allow you to access the other updated set at a later date.

Unzip the contents of the compressed file you opened or downloaded into a non-Dynamic C folder to see the updated library files. If you customized any of these libraries, you should first make backup copies of the libraries you customized. Then customize the new libraries, if needed. Now copy and paste the new libraries to replace the old versions in the **LIB** folder in your Dynamic C installation. You will have to recompile your program once you have replaced the libraries.

The changes to the libraries will improve the OP7100 screen update time for OP7100 units using the new LCD controller chip. Otherwise, the form, fit, and function of the OP7100 are not affected by the changes.

For applications that are operating in the landscape mode using the new **OP71L.LIB** library, there is a macro that can be defined to enhance the LCD performance for older OP7100s using the original LCD controller chip. Add the following macro at the start of your program before the graphic libraries are **#used**. Using the macro may increase your interrupt latency.

```
#define LCD_ENHANCED_MODE
```

CHAPTER 5: GRAPHICS PROGRAMMING

Chapter 5 provides helpful guidelines for drawing graphics on the OP7100.

Initialization

The OP7100, unlike most other Rabbit Semiconductor controllers, uses the maximum I/O and memory wait states when **main()** gets control. The wait states can be reduced to improve performance. The following statement sets up the proper wait states for the standard OP7100 (using a 90 ns flash memory).

```
outport(DCNTL,(inport(DCNTL)&0xf)|0x60);
```

The graphic LCD can be set up by a simple function call to

```
op71Init();
```

This function initializes and starts the LCD controller before supplying voltage to the LCD screen.

The backlight is controlled by **op71BackLight(int isOn)**. Pass zero to turn off the backlight (default) or a non-zero value to turn on the backlight.

If you have an OP7100 equipped with software contrast control, call **op71SetContrast(unsigned level)** to change contrast. The range of **level** is from 0 to 63. A level of 30 usually yields reasonable contrast at room temperature.

Drawing Primitives

You can draw various objects on the LCD. Before doing any drawing, specify the type of the "brush" by calling **op71SetBrushType(int type)**. Four brush macros are supported:

GL_SET sets the pixels as specified by the plot commands, but leaves other pixels alone;

GL_CLEAR clears the pixels as specified by the plot commands, but leaves other pixels alone;

GL_XOR toggles the pixels as specified by the plot command, but leaves other pixels alone;

GL_BLOCK forces the value of pixels in groups of eight vertical pixels. **GL_BLOCK** is useful when speed is important, the current pixels need to be overwritten, and the overwriting pixels are aligned in eight-pixel rows.

Plot a Pixel

- **int op71PlotDot(int x, int y);**

  x and **y** are the coordinates, the upper left corner is (0,0).

  Figure 3-8 shows the coordinate system for the LCD pixels.

Plot a Line

- **`void op71PlotLine(int x1, int y1, int x2, int y2);`**

  (**`x1`**,**`y1`**) and (**`x2`**,**`y2`**) are the endpoints of the line.

Plot a Circle

- **`void op71PlotCircle(int xc, int yc, int rad);`**

  (**`xc`**,**`yc`**) is the center of the circle, **`rad`** is the radius.

Plot a Polygon

- **`void op71PlotPolygon(int n, int x1, int y1,...);`**

  `n` is the number of vertices, (**`x1`**,**`y1`**) is the first vertex, followed by the other vertices in the x-first order.

Fill a Circle

- **`void op71FillCircle(int xc, int yc, int rad);`**

  Similar to **`op71PlotCircle`**, but paints the circle solid.

Fill a Polygon

- **`void op71FillPolygon(int n, int x1, int y1,...);`**

  Similar to **`op71PlotPolygon`**, but paints the polygon solid. Note that this function works for polygons with concave angles.

Draw a Bitmap

- **`void op71XPutBitmap( int left, int top,`**
  `int width, int height, unsigned long bitmap );`

  Draws bitmap in the specified space. The data for the bitmap are stored in **`xmem`**. Automatically calls **`op71XPutFastmap`** if bitmap is byte-aligned (left-edge and width each evenly divisible by 8).

  PARAMETERS: **`left`** is the left edge of the bitmap.

  `top` is the top edge of the bitmap.

  `width` is the width of the bitmap.

  `height` is the height of the bitmap.

  `bitmap` is the address of the bitmap in **`xmem`**.

Font and Bitmap Conversion

Customers are encouraged to design their own fonts and bitmaps. These restrictions must be followed.

- Save bitmaps as Windows bitmaps (**.bmp**), not OS/2 bitmaps.
- The bitmap can only have two colors. Color 0 is the background, and color 1 is the foreground. This is the reverse of most bitmap editors.
- Fonts must be bitmapped (not true type) and must be of fixed pitch.
- Save font files as **.fnt** (version 3).

The OP7100 uses a "vertical stripe" display logic format. The conversion utility programs **fntstrip.exe** (landscape image) and **fntcvtr.exe** (portrait image) convert the **.fnt** and **.bmp** file format to the Rabbit Semiconductor vertical stripe format.

Follow these instructions to use these utilities.

1. Create the **.fnt** or **.bmp** file that conforms to the restrictions listed above.
2. Start **fntstrip** or **fntcvtr**.
3. Specify the file to convert (select the file from the menu **List files of type**), and choose either **.fnt** or **.bmp**.

Tip

Entering ***.fnt** or ***.bmp** in the **File name** window will not work. The file must be selected after clicking on **Font files** or **Bitmap files** in the **List files of type** window.

4. Click the OK button or double-click on the file to convert. At this point, the software asks the destination of the conversion. Specify a file to store the result (text file) of the conversion. Click OK when the file is specified.
5. The title bar displays "[inactive]" when the conversion is done. Close the window.

Dynamic C may be used to edit the text file that was generated. The generated file typically looks as follows.

```
/*Automatic output from Font Converter
font file is U:\TEST\DC5X\SAMPLES\QVGA\6X8.OUT.
dfVersion = 0x300
dfSize = 5148
dfCopyright = (c) Copyright 1997,1998 Rabbit Semi-
  conductor. All rights reserved.
dfType = 0x0
horizontal size is 6 pixels.
vertical size is 8 pixels.
first character is for code 0x20.
```

```
last character is for code 0xff.
make call to glFontInit(&fi, 6, 8, 32, 127, fontBitMap)
to initialize table*/

char fontBitMap[] = {
/* char 0x20 of width 6 at 0x5da */
'\x0',
'\x0',
'\x0',
'\x0',
'\x0',
'\x0',
...
'\x0'
};
```

The first task is to rename the array so that it is unique. Then you can decide whether the font/bitmap should be stored in root memory or in extended memory. Because bitmaps can be large and root memory space is precious, Rabbit Semiconductor recommends you to use **xmem** to store the font/bitmap. To store the font/bitmap in **xmem**, you need to change the following line.

```
char fontBitMap[] = {
```

to

```
xdata fontBitMap {
```

Once these changes are made, you can copy and paste the font (as an initialized character array or as an initialized **xdata** item) into your program or library.

Remember to **#use** either the **OP71L.LIB** (landscape image) or the **OP71P.LIB** (portrait image) library in your program.

Using the Font/Bitmap In Your Program

The array does not store the dimensions of the font or the bitmap. This information is contained in the comments. The following lines in the comments indicate the dimensions of the font.

```
/*horizontal size is 6 pixels.
vertical size is 8 pixels.*/
```

For fonts, the comments also indicate the starting character and the ending character code with the following line.

```
/*make call to op71XFontInit(&fi, 6, 8, 32, 127,
  fontBitMap)*/
```

The fourth argument is the first character code mapped to the font and the fifth argument is the last character code mapped to the font.

To initialize a font information structure (of type **struct _fontInfo**), you can call **op71XFontInit** for a font stored in **xmem**.

To display a bitmap, call **op71XPutBitmap** to display a bitmap stored in **xmem**.

Printing Text

Printing text involves setting the font information structures. Call

```
void op71XFontInit(struct _fontInfo *pInfo,
     char pixWidth, char pixHeight,
     unsigned startChar, unsigned endChar,
     unsigned long xmemBuffer);
```

to initialize a font information structure if the font is stored in **xmem**. **pInfo** points to a font information structure, **pixWidth** is the width of each character (fixed pitch), **pixHeight** is the height of each character, **startChar** is the ASCII code of the first character in the font, **endChar** is the ASCII code of the last character in the font, and **xmemBuffer** is a physical address pointing to the font table stored in **xmem**.

Rabbit Semiconductor supplies five font sizes for the OP7100. The smallest font, **engFont6x8**, compiles to **xmem**, and each character is 6 pixels wide by 8 pixels high. The largest font, **engFont17x35**, also compiles to **xmem**, and each character is 17 pixels wide by 35 pixels high.

When you need to print text to the LCD, call

```
void op71Printf(int x, int y,
     struct _fontInfo *pInfo, char *fmt,...);
```

where (**x**,**y**) is the upper left corner of the text, **pInfo** points to a font information structure, **fmt** points to a format string (much like **printf**), and the rest of the parameters specify what to print for each field in the format string (same as **printf**).

Keypad Programming

The sample program **KPDEFLT.C** in the Dynamic C **SAMPLES\QVGA** subdirectory demonstrates how to read the keypad. Add the following directives at the top of the program to make it possible to use the keypad routines.

#use op71l.lib (landscape orientation) OR
#use op71p.lib (portrait orientation)

```
#use op71hw.lib
#use kp_op71.lib
```

Initialization

To initialize the keypad driver, call **kpDefInit()**. This must be performed before other keypad operations.

Scanning the Keypad

The function **kpScanState()** must be called periodically to scan the keypad for changes. In a cooperative multitasking (big-loop style), this function should be called every 25 ms or so. If you are using a real-time kernel, you can also attach this function to one of the tasks and have it invoked approximately every 25 ms. Note that this function scans for changes, but it does not report what was changed.

Reading Keypad Activities

The function **kpDefGetKey()** returns the interpretation of the state change detected by **kpScanState()** into key activities. The means that the **kpDefGetKey()** function must be called no less frequently than **kpScanState()** to ensure no key activity is lost. The function **kpDefGetKey()** returns an integer. If the integer is –1, no key activity was detected. Otherwise, bit 0 to bit 3 indicates the index of the sense line of the key, and bit 4 to bit 7 indicate the index of the drive line of the key. Bit 8 indicates whether the key has been "pressed"—the key was pressed if bit 8 is a 1.

Note that if two key activities occur between two calls to **kpScanState()**, only one key activity is interpreted by the **kpDefGetKey()** function even though both activities may be registered by the **kpScanState()** function. The priority of key interpretation is from drive line 0 (highest priority) to drive line 7. On the same drive line, the priority is from sense line 0 (highest priority) to sense line 7.

Once a key activity is detected by **kpScanState()**, no further key activities will be detected by further calls to **kpScanState()** unless **kpDefGetKey()** is called.

CHAPTER 6: INSTALLATION

Chapter 6 provides installation and protective grounding guidelines for the OP7100.

Grounding

Many of the OP7100 ICs are sensitive to static. Use extra caution when handling units in high-static areas.

To meet electromagnetic compatibility requirements, and in particular to prevent misoperation or damage from electrostatic discharges, the bezel must be connected to a protective ground via a low-impedance path.

A protective building ground is recommended once the OP7100 is installed at the location where it will be used. In addition to providing protection against an unexpected electric shock, the connection to building ground also mitigates any problems from external electrostatic discharges and transients, and dampens any RF emissions.

The metal casing is already connected electrically to the bezel, and so does not require a separate ground connection. The connection to the building ground should always be made through the bezel.

The recommended way to connect an OP7100 to a building ground is to mount the unit in a metal panel that is already grounded. Ensure that the areas around the securing nuts are clean and free from corrosion or other contaminants so that a good electrical connection can be realized.

Alternatively, use a wire with a size of at least 20AWG (0.5 mm^2), preferably stranded, to establish a connection between one of the bezel mounting studs and the protective building ground. This wire should be as short as possible to keep its impedance low.

There is an electrical connection between the OP7100 bezel/casing and the connection marked GND on the power supply header, J11, via a jumper on header JP5. This connection is also the return for the DC power supply and the I/O signals, and should not be relied on for a protective ground connection.

Remove the jumper across JP5 if you wish to isolate the OP7100 bezel/casing ground from the power supply ground. Any common-mode voltage between signal ground and protective ground should be kept below 40 V DC.

Figure 6-1 shows the location of header JP5.

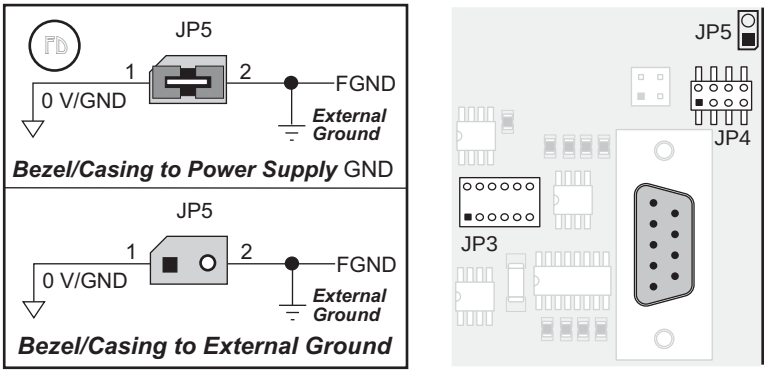


Figure 6-1. Location of Header JP5

Installation Guidelines

When possible, following these guidelines when mounting an OP7100.

1. Leave sufficient ventilation space
2. Do not install the OP7100 directly above machinery that radiates a lot of heat (for example, heaters, transformers, and high-power resistors).
3. Leave at least 8" (20 cm) distance from electric power lines and even more from high-voltage devices.
4. When installing the OP7100 near devices with strong electrical or magnetic fields (such as solenoids), allow a least 3" (8 cm), more if necessary.

The OP7100 has strong environmental resistance and high reliability, but you can maximize system reliability by avoiding or eliminating the following conditions at the installation site.

- Abrupt temperature changes and condensation
- Ambient temperatures exceeding a range of 0°C to 50°C
- Relative humidity exceeding a range of 25% to 65%
- Strong magnetism or high voltage
- Corrosive gasses
- Direct vibration or shock
- Excessive iron dust or salt
- Spray from harsh chemicals

Mounting

A bezel and a gasket are included with the OP7100. When properly mounted in a panel, the bezel of the OP7100 is designed to meet NEMA 4 specifications for water resistance.

Since the OP7100 employs an LCD display, the viewing angle must be considered when mounting the display. Install the OP7100 at a height and angle that makes it easy for the operator to see the screen.

Note that the contrast controls, both manual and software, act as view-angle controls, and should be adjusted to provide theoptimum display quality at the angle from which the display will normally be viewed.

Bezel-Mount Installation

This section describes and illustrates how to bezel-mount the OP7100. Follow these steps for bezel-mount installation.

1. Cut mounting holes in the mounting panel in accordance with the recommended dimensions in Figure 6-2, then use the bezel faceplate to mount the OP7100 onto the panel.

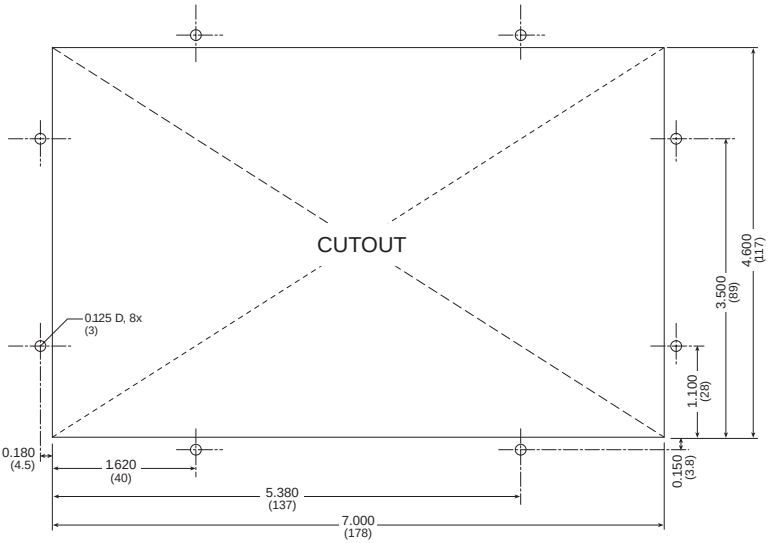


Figure 6-2. Recommended Cutout Dimensions

2. Remove all eight 4-40 locking hex nuts from their studs on the bezel, and carefully “drop in” the OP7100 with the bezel and gasket attached.

3. Fasten the unit with the eight 4-40 hex nuts that were removed in Step 2. Carefully tighten the nuts equally until the gasket is compressed to approximately 75% of its uncompressed thickness of 0.125" (3.2 mm).

Do ***not*** tighten each nut fully before moving on to the next nut since this risks distorting either the panel or the bezel (or both). Apply only one or two turns to each nut in sequence until all are tightened to the required amount.

Tip

In order to seal the bezel against the panel, the gasket must be compressed by the pressure of the mounting nuts. If the panel is very thin (<0.06" or 1.6 mm), this pressure may distort the panel, allowing water ingress. In this case, Rabbit Semiconductor recommends using strengthening brackets between the rear of the panel and the mounting nuts as shown in Figure 6-3.

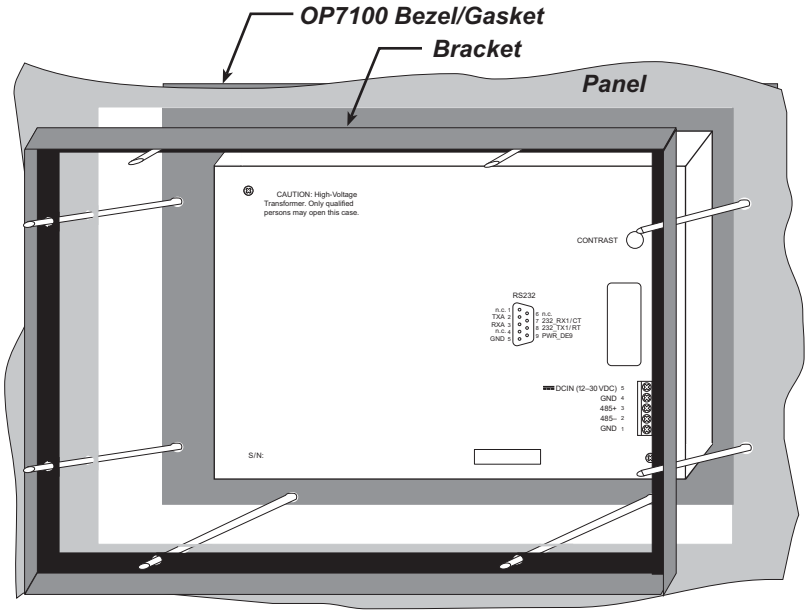


Figure 6-3. Strengthening Bracket

General Mounting Recommendations

If the OP7100 is mounted inside a panel, the enclosure must not be airtight to ensure that the touchscreen will not distorted by differences in air pressure. If the OP7100 is mounted in a completely airtight enclosure, a pressure differential may build up across the window overlay, and could adversely affect the operation of the touchscreen.

APPENDIX A: TROUBLESHOOTING

Appendix A provides procedures for troubleshooting system hardware and software. The sections include the following topics.

- Out of the Box
- Dynamic C Will Not Start
- Dynamic C Loses Serial Link
- OP7100 Repeatedly Resets
- Common Programming Errors

Out of the Box

Check the items mentioned in this section before starting development.

- Verify that the OP7100 runs in standalone mode before connecting any devices.
- Verify that the entire host system has good, low-impedance, separate grounds for analog and digital signals. The OP7100 might be connected between the host PC and another device. Any differences in ground potential from unit to unit can cause serious problems that are hard to diagnose.
- Do not connect analog ground to digital ground anywhere.
- Double-check the connecting ribbon cables to ensure that all wires go to the correct screw terminals on the OP7100.
- Verify that the host PC's COM port works by connecting a good serial device to the COM port. Remember that COM1/COM3 and COM2/COM4 share interrupts on a PC. User shells and mouse drivers, in particular, often interfere with proper COM port operation. For example, a mouse running on COM1 can preclude running Dynamic C on COM3.
- Use the supplied Rabbit Semiconductor power supply. If another power supply must be used, verify that it has enough capacity and filtering to support the OP7100.
- Use the supplied Rabbit Semiconductor cables. The most common fault of user-made cables is failure to properly assert CTS. Without CTS being asserted, theOP7100's RS-232 port will not transmit. Assert CTS by either connecting the RTS signal of the PC's COM port or looping back the OP7100's RTS.
- Experiment with each peripheral device connected to the OP7100 to determine how it appears to the OP7100 when powered up, powered down, and/or when its connecting wiring is open or shorted.
- The frame ground and 0 V are connected internally via a jumper on header JP5. Remove the jumper if this connection causes problems or is otherwise not required.

Dynamic C Will Not Start

In most situations, when Dynamic C will not start, an error message announcing a communication failure will be displayed. The following list describes situations causing an error message and possible resolutions.

- *Wrong Communication Mode* — Both sides must be talking RS-232.
- *Wrong COM Port* — A PC generally has two serial ports, COM1 and COM2. Specify the one being used in the Dynamic C "Target Setup" menu. Use trial and error, if necessary.
- *Wrong Operating Mode* — Communication with Dynamic C will be lost when the OP7100 is configured for standalone operation. Make sure pins 1–2 on header J4 are connected to reconfigure the board for programming mode as described in Chapter 2, "Getting Started."

If all else fails, connect the serial cable to the OP7100 after power up. If the PC's RS-232 port supplies a large current (most commonly on portable and industrial PCs), some RS-232 level converter ICs go into a nondestructive latch-up. Connect the RS-232 cable after power up to eliminate this problem.

Dynamic C Loses Serial Link

If the application disables interrupts for a period greater than 50 ms, Dynamic C will lose its serial link with the application. Make sure that interrupts are not disabled for a period greater than 50 ms.

OP7100 Repeatedly Resets

The OP7100 resets every 1.0 second if the watchdog timer is not "hit." If a program does not "hit" the watchdog timer, then the program will have trouble running in standalone mode. To "hit" the watchdog, make a call to the Dynamic C library function **`hitwd`**.

Common Programming Errors

- Values for constants or variables out of range. Table A-1 lists acceptable ranges for variables and constants.

Table A-1. Ranges of Dynamic C Function Types

Type	Range
`int`	–32,768 (-2^{15}) to +32,767 ($2^{15} - 1$)
`long int`	–2,147,483,648 (-2^{31}) to +2147483647 ($2^{31} - 1$)
`float`	1.18×10^{-38} to 3.40×10^{38}
`char`	0 to 255

- Mismatched "types." For example, the literal constant **3293** is of type **int** (16-bit integer). However, the literal constant **3293.0** is of type **float**. Although Dynamic C can handle some type mismatches, avoiding type mismatches is the best practice.
- Counting up from, or down to, one instead of zero. In software, ordinal series often begin or terminate with zero, not one.
- Confusing a function's definition with an instance of its use in a listing.
- Not ending statements with semicolons.
- Not inserting commas as required in functions' parameter lists.
- Leaving out ASCII space character between characters forming a different legal—but unwanted—operator.
- Confusing similar-looking operators such as **&&** with **&**, == with =, and // with /.
- Inadvertently inserting ASCII nonprinting characters into a source-code file.

APPENDIX B: SPECIFICATIONS

Appendix B provides comprehensive physical, electronic, and environmental specifications for the OP7100.

Electrical and Mechanical Specifications

LCD Dimensions

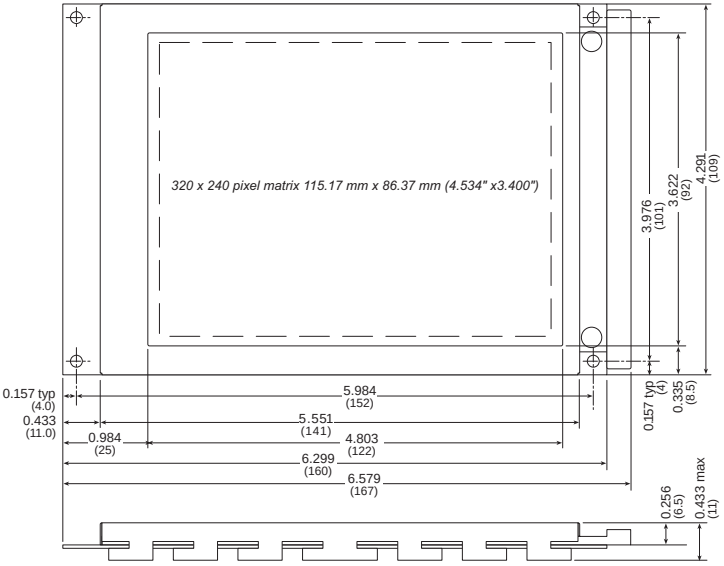


Figure B-1. OP7100 LCD Dimensions

Bezel Dimensions

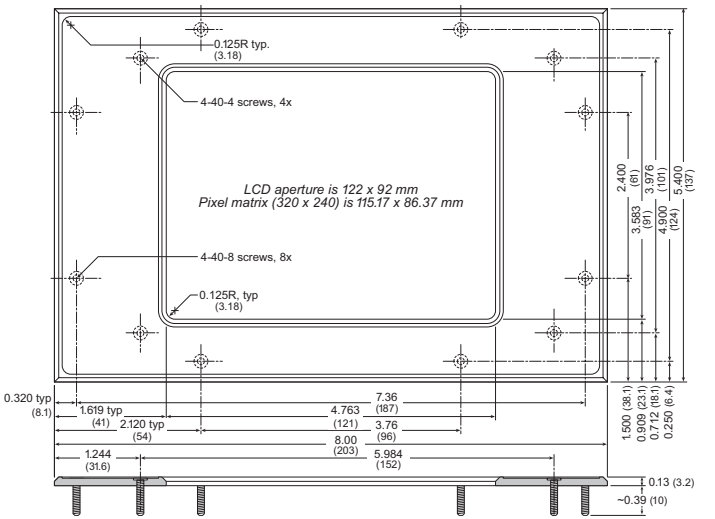


Figure B-2. OP7100 Bezel Dimensions

General Specifications

Table B-1 presents the physical, electronic and environmental specifications.

Table B-1. OP7100 General Specifications

Parameter	Specification
Module Size	6.63" × 4.40" × 1.36" (168 mm × 112 mm × 35 mm)
Bezel Size	8.00" × 5.4" × 0.156" (203 mm × 137 mm × 4.0 mm) with gasket
Package Size	8.0" × 5.4" × 1.6" (203 mm × 137 mm × 41 mm)
Backlight	Replaceable dual cold-cathode fluorescent tube rated at 20,000 h to 30,000 h with software on/off control
LCD	STN, 320 × 240 pixels, blue on white background. Pixel matrix is 115.2 mm × 86.4 mm, 0.36 mm pitch. Viewing area is 121 mm × 91 mm. Adjustable contrast with temperature compensation.
Touchscreen	8 × 8 matrix, 225 touch switches with software interpolation to 15 × 15, rated 10^6 contacts
Operating Temperature	0°C to 50°C, may be stored at –20°C to 70°C
Humidity	5% to 95%, noncondensing
Power	12 V to 30 V DC, 4.5 W with backlight on, 1.5 W with backlight off
Digital I/O	Eight CMOS/TTL-level inputs, –2.0 V to +7.0 V Eight CMOS/TTL-level outputs, up to 6 mA per channel
Processor	Z180 at 18.432 MHz
SRAM	128K standard, up to 512K
VRAM	32K standard, up to 64K
EEPROM	Simulated in flash EPROM
Flash EPROM	Two 256K
Serial Ports	One 5-wire RS-232 and one RS-485, one 3-wire RS-232 and one RS-485, or two 3-wire RS-232
Serial Rate	600 bps to 57,600 bps
Watchdog	Yes
Time/Date Clock	72423
Keypad	OP7100—touchscreen OP7110—up to 8 × 8 user-supplied
Backup Battery	Panasonic CR2330, 3 V DC lithium ion, rated life 265 mA·h

Header and Jumper Configurations

Figure B-3 shows the locations of the configurable headers on the OP7100.

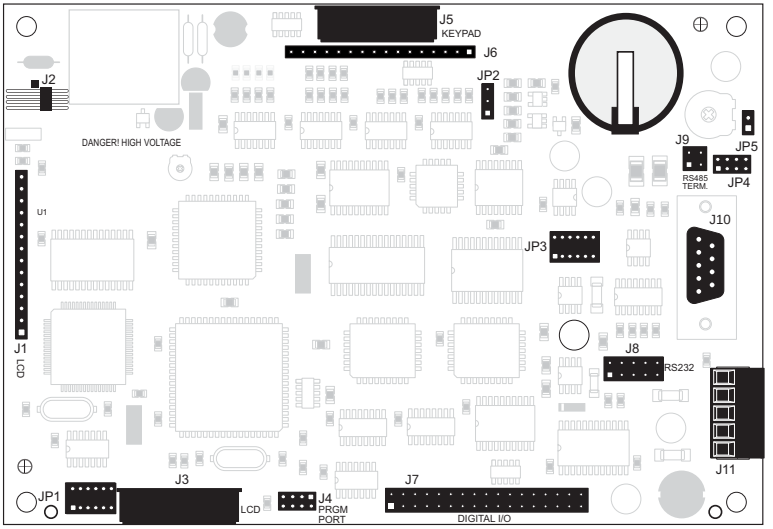


Figure B-3. OP7100 Headers

Table B-2 lists the headers that carry signals.

Table B-2. OP7100 Signal Headers

Header	Description
J1	LCD (hard-wired)
J2	Backlight
J3	LCD (ribbon cable)
J4	Programming port
J5	Touchscreen interface (OP7100 only)
J6	Keypad interface (OP7110 only)
J7	Digital I/O
J8	RS-232 port (header)
J10	RS-232 port (DE9)
J11	DC power supply, RS-485 port

Table B-3 lists the jumper configurations.

Table B-3. OP7100 Jumper Settings

Header	Pins Connected	Function	Factory Default
JP1	1–2 5–6 7–8 11–12	Positive LCD background (blue characters on white background)	FD
	1–3 4–6 7–9 10–12	Negative LCD background (white characters on blue background)	
JP2	1–2	Software contrast adjustment	OP7100
	2–3	Manual contrast adjustment	OP7110
JP3	1–2 5–6 9–10 11–12	One 5-wire RS-232, one RS-485	FD
	1–2 5–6	One 3-wire RS-232, one RS-485	
	3–4 7–8	Two 3-wire RS-232	
JP4	3–4 5–6	RS-485 on J11: 2–3	FD
	1–2 7–8	RS-232 on J11: 2–3	
JP5	1–2	Connect to connect frame ground to power supply ground	Connected
J4	1–2	Connect to enable program mode, disconnect for run mode	Not connected
J9	1–2 3–4	Connect to enable termination resistors, disconnect to disable termination resistors	Connected

APPENDIX C: MEMORY, I/O MAP, AND INTERRUPT VECTORS

Appendix C provides detailed information on memory and an I/O map. The interrupt vectors are also listed.

OP7100 Memory

Figure C-1 shows the memory map of the 1M address space.

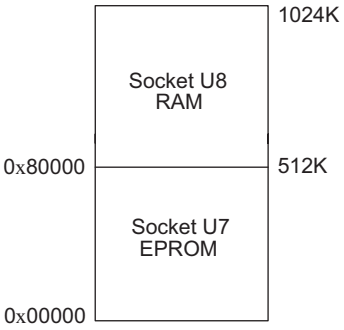


Figure C-1. Memory Map of 1M Address Space

Figure C-2 shows the memory map within the 64K virtual space.

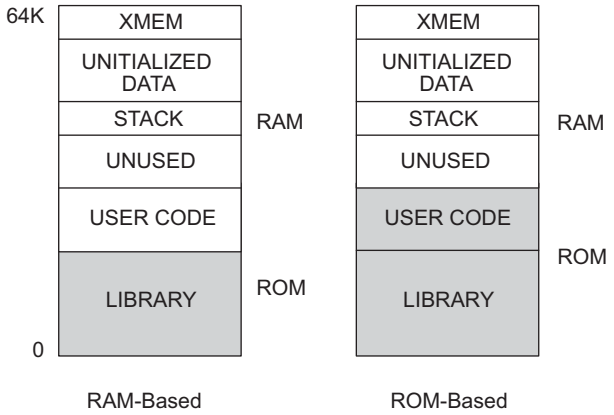


Figure C-2. Memory Map of 64K Virtual Space

The various registers in the input/output (I/O) space can be accessed in Dynamic C by the symbolic names listed below. These names are treated as unsigned integer constants. The Dynamic C library functions **`inport`** and **`outport`** access the I/O registers directly.

```
data_value = inport( CNTLA0 );
outport( CNTLA0, data_value );
```

Execution Timing

The times reported in Table C-1 were measured using Dynamic C and they reflect the use of Dynamic C libraries. The time required to fetch the arguments from memory, but not to store the result, is included in the timings. The times are for a 9.216 MHz clock with 0 wait states.

Table C-1. CM7000 Execution Times for Dynamic C

Operation	Execution Time (µs)
DMA copy (per byte)	0.73
Integer assignment (`i=j;`)	3.4
Integer add (`j+k;`)	4.4
Integer multiply (`j*k;`)	18
Integer divide (`j/k;`)	90
Floating add (`p+q;`) (typical)	85
Floating multiply (`p*q;`)	113
Floating divide (`p/q;`)	320
Long add (`l+m;`)	28
Long multiply (`l*m;`)	97
Long divide (`l/m;`)	415
Floating square root (`sqrt(q);`)	849
Floating exponent (`exp(q);`)	2503
Floating cosine (`cos(q);`)	3049

The execution times can be adjusted proportionally for clock speeds other than 9.216 MHz. Operations involving one wait state will slow the execution speed about 25%.

Memory Map

Input/Output Select Map

The Dynamic C library functions **IBIT**, **ISET**, and **IRES** in the **BIOS.LIB** library allow bits in the I/O registers to be tested, set, and cleared. Both 16-bit and 8-bit I/O addresses can be used.

Z180 Internal Input/Output Registers Addresses 00-3F

The internal registers for the I/O devices built into to the Z180 processor occupy the first 40 (hex) addresses of the I/O space. These addresses are listed in Table C-2.

Table C-2. Z180 Internal I/O Registers Addresses 0x00–0x3F

Address	Name	Description
0x00	CNTLA0	Serial Channel 0, Control Register A
0x01	CNTLA1	Serial Channel 1, Control Register A
0x02	CNTLB0	Serial Channel 0, Control Register B
0x03	CNTLB1	Serial Channel 1, Control Register B
0x04	STAT0	Serial Channel 0, Status Register
0x05	STAT1	Serial Channel 1, Status Register
0x06	TDR0	Serial Channel 0, Transmit Data Register
0x07	TDR1	Serial Channel 1, Transmit Data Register
0x08	RDR0	Serial Channel 0, Receive Data Register
0x09	RDR1	Serial Channel 1, Receive Data Register
0x0A	CNTR	Clocked Serial Control Register
0x0B	TRDR	Clocked Serial Data Register
0x0C	TMDR0L	Timer Data Register Channel 0, least
0x0D	TMDR0H	Timer Data Register Channel 0, most
0x0E	RLDR0L	Timer Reload Register Channel 0, least
0x0F	RLDR0H	Timer Reload Register Channel 0, most
0x10	TCR	Timer Control Register
0x11–0x13	—	Reserved
0x14	TMDR1L	Timer Data Register Channel 1, least
0x15	TMDR1H	Timer Data Register Channel 1, most
0x16	RLDR1L	Timer Reload Register Channel 1, least
0x17	RLDR1H	Timer Reload Register Channel 1, most

continued…

Table C-2. Z180 Internal I/O Registers Addresses 0x00–0x3F (concluded)

Address	Name	Description
0x18	FRC	Free-running counter
0x19–0x1F	—	Reserved
0x20	SAR0L	DMA source address Channel 0, least
0x21	SAR0H	DMA source address Channel 0, most
0x22	SAR0B	DMA source address Channel 0, extra bits
0x23	DAR0L	DMA destination address Channel 0, least
0x24	DAR0H	DMA destination address Channel 0, most
0x25	DAR0B	DMA destination address Channel 0, extra bits
0x26	BCR0L	DMA Byte Count Register Channel 0, least
0x27	BCR0H	DMA Byte Count Register Channel 0, most
0x28	MAR1L	DMA Memory Address Register Channel 1, least
0x29	MAR1H	DMA Memory Address Register Channel 1, most
0x2A	MAR1B	DMA Memory Address Register Channel 1, extra bits
0x2B	IAR1L	DMA I/O Address Register Channel 1, least
0x2C	IAR1H	DMA I/O Address Register Channel 1, most
0x2D	—	Reserved
0x2E	BCR1L	DMA Byte Count Register Channel 1, least
0x2F	BCR1H	DMA Byte Count Register Channel 1, most
0x30	DSTAT	DMA Status Register
0x31	DMODE	DMA Mode Register
0x32	DCNTL	DMA/WAIT Control Register
0x33	IL	Interrupt Vector Low Register
0x34	ITC	Interrupt/Trap Control Register
0x35	—	Reserved
0x36	RCR	Refresh Control Register
0x37	—	Reserved
0x38	CBR	MMU Common Base Register
0x39	BBR	MMU Bank Base Register
0x3A	CBAR	MMU Common/ Bank Area Register
0x3B–0x3D	—	Reserved
0x3E	OMCR	Operation Mode Control Register
0x3F	ICR	I/O Control Register

Epson 72423 Timer Registers 0x4180–0x418F

Table C-3 lists the Epson 72423 timer registers.

Table C-3. Epson 72423 Timer Registers 0x4180–0x418F

Address	Name	Data Bits	Description
0x4180	SEC1	D7–D0	seconds
0x4181	SEC10	D7–D0	10 seconds
0x4182	MIN1	D7–D0	minutes
0x4183	MIN10	D7–D0	10 minutes
0x4184	HOUR1	D7–D0	hours
0x4185	HOUR10	D7–D0	10 hours
0x4186	DAY1	D7–D0	days
0x4187	DAY10	D7–D0	10 days
0x4188	MONTH1	D7–D0	months
0x4189	MONTH10	D7–D0	10 months
0x418A	YEAR1	D7–D0	years
0x418B	YEAR10	D7–D0	10 years
0x418C	WEEK	D7–D0	day of week
0x418D	TREGD	D7–D0	Register D
0x418E	TREGE	D7–D0	Register E
0x418F	TREGF	D7–D0	Register F

Other Registers

Table C-4 lists the other registers.

Table C-4. Other I/O Addresses

Address	Name	Data Bits	Description
4000–403F	**CS1**		Chip Select 1
4040–407F	**CS2**		Chip Select 2
4080–40BF	**CS3**		Chip Select 3
40C0–40FF	**CS4**		Chip Select 4
4100–413F	**COLUMN**		Chip Select 5
4140–417F	I/O		Chip Select 6
41C0–41FF	**WDOG**	D0	Watchdog
8000	**FSHWE**		Flash EPROM write enable
A000	**INT1**	D0	Bit 0 is the power-failure state.
C000	**WDO**		Watchdog output

Interrupt Vectors

Table C-5 presents a suggested interrupt vector map. Most of these interrupt vectors can be altered under program control. The addresses are given here in hex, relative to the start of the interrupt vector page, as determined by the contents of the I-register. These are the default interrupt vectors set by the boot code in the Dynamic C EPROM.

Table C-5. Interrupt Vectors for Z180 Internal Devices

Address	Name	Description
—	**INT0**	Available for use.
0x00	**INT1_VEC**	Used for power-failure detection
0x02	**INT2_VEC**	Reserved for Development Board (CM7100), not available for use on CM7200
0x04	**PRT0_VEC**	PRT Timer Channel 0
0x06	**PRT1_VEC**	PRT Timer Channel 1
0x08	**DMA0_VEC**	DMA Channel 0
0x0A	**DMA1_VEC**	DMA Channel 1
0x0C	**CSI/O_VEC**	Available for programming (CM7200), not available for use on CM7100
0x0E	**SER0_VEC**	Asynchronous Serial Port Channel 0
0x10	**SER1_VEC**	Asynchronous Serial Port Channel 1

To "vector" an interrupt to a user function in Dynamic C, use a directive such as the following.

```
#INT_VEC 0x10 myfunction
```

The above example causes the interrupt at offset 0x10 (Serial Port 1 of the Z180) to invoke the function **myfunction()**. The function must be declared with the **interrupt** keyword, as shown below.

```
interrupt myfunction() {
      ...
}
```

Refer to the Dynamic C manuals for further details on interrupt functions.

Power-Failure Interrupts

The **INT1** line is connected to the power-failure output of the ADM691 supervisor. A power-failure interrupt occurs when **PFI** falls to 1.25 V ± 0.05 V. This advanced warning allows the program to perform some emergency processing before an unwanted power-down occurs.

The following example shows how to handle a power-failure interrupt.

```
#INT_VEC INT1_VEC power_fail_isr

interrupt power_fail_isr(){
  IRES(ITC,1); // clear bit 1 of ITC and disable /INT1
  body of interrupt routine
}
```

You also need to add the following line to **main()**.

```
ISET(ITC,1)   // enables /INT1
```

Interrupt Priorities

Table C-6 lists the interrupt priorities.

Table C-6. Interrupt Priorities

Interrupt Priorities	
(Highest Priority)	Trap (illegal instruction)
	NMI (nonmaskable interrupt)
	INT 0 (maskable interrupts, Level 0; three modes)
	INT 1 (maskable interrupts, Level 1; PLCBus attention line interrupt)
	INT 2 (maskable interrupts, Level 2)
	PRT Timer Channel 0
	PRT Timer Channel 1
	DMA Channel 0
	DMA Channel 1
	Z180 Serial Port 0
(Lowest Priority)	Z180 Serial Port 1

APPENDIX D:
SERIAL INTERFACE BOARD

Appendix D provides technical details and baud rate configuration data for Rabbit Semiconductor's Serial Interface Board (SIB).

Introduction

The SIB is an interface adapter used to program the OP7100. The SIB is contained in an ABS plastic enclosure, making it rugged and reliable. The SIB enables the OP7100 to communicate with Dynamic C via the Z180's clocked serial I/O (CSI/O) port, freeing the OP7100's serial ports for use by the application during programming and debugging.

The SIB's 8-pin cable plugs into the target OP7100's processor via header J4 on the OP7100, which is accessed by removing the back cover from the OP7100, and a 6-conductor RJ-12 phone cable connects the SIB to the host PC. The SIB automatically selects its baud rate to match the communication rates established by the host PC (9600, 19,200, or 57,600 bps). However, the SIB determines the host's communication baud rate only on the first communication after reset. To change baud rates, change the COM baud rate, reset the target OP7100 (which also resets the SIB), then select **Reset Target** from Dynamic C.

Chapter 2 provides detailed information on connecting the SIB to the OP7100.

The SIB receives power and resets from the target OP7100 via the 8-pin connector J1. Therefore, do not unplug the SIB from the target OP7100 while power is applied. To do so could damage both the OP7100 and the SIB; additionally, the target may reset.

The SIB consumes approximately 60 mA from the +5 V supply. The target-system current consumption therefore increases by this amount while the SIB is connected to the OP7100.

When the OP7100 is powered up or reset with the SIB attached, it is automatically in the program mode. To operate the OP7100 in the run mode, remove power, disconnect the SIB, and re-apply power to the OP7100.

Never connect or disconnect the SIB with power applied to the OP7100.

External Dimensions

Figure D-1 illustrates the external dimensions for the SIB.

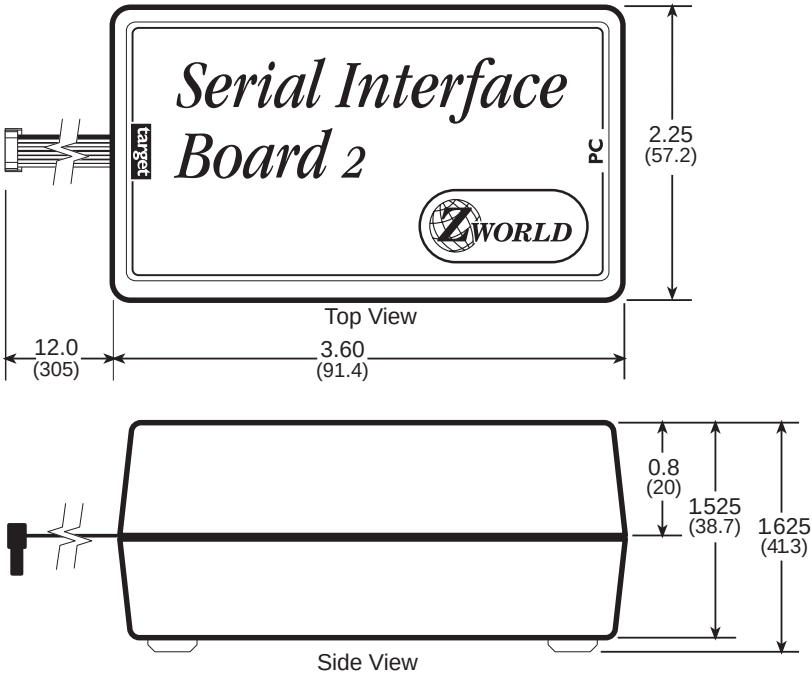


Figure D-1. SIB External Dimensions

APPENDIX E: BACKUP BATTERY

Battery Life and Storage Conditions

The battery on the OP7100 will provide approximately 9,000 hours of backup time for the onboard real-time clock and static RAM. However, backup time longevity is affected by many factors including the amount of time the OP7100 is unpowered. Most systems are operated on a continuous basis, with the battery supplying power to the real-time clock and the SRAM during power outages and/or during routine maintenance. The time estimate reflects the shelf life of a lithium battery with occasional use rather than the ability of the battery to power the circuitry full time.

The battery has a capacity of 265 mA·h. At 25°C, the real-time clock draws 3 µA when idle, and the 128K SRAM draws 4 µA. If the OP7100 were unpowered 100 percent of the time, the battery would last 32, 000 hours (3.6 years).

To maximize the battery life, the OP7100 should be stored at room temperature in the factory packaging until field installation. Take care that the OP7100 is not exposed to extreme temperature, humidity, and/or contaminants such as dust and chemicals.

To ensure maximum battery shelf life, follow proper storage procedures. Replacement batteries should be kept sealed in the factory packaging at room temperature until installation. Protection against environmental extremes will help maximize battery life.

Replacing the Lithium Battery

The battery is user-replaceable, and is fitted in a battery holder. To replace the battery, lift up on the spring clip and slide out the old battery. Use only a Panasonic CR2330 or equivalent replacement battery, and insert it into the battery holder with the + side facing up.

Note that the SRAM contents and the real-time clock settings will be lost if the battery is replaced with no power applied to the OP7100. Therefore, if you do replace the battery with external power applied to the OP7100, exercise caution since high voltages are present in the vicinity of T1 on the side of the printed circuit board opposite to the battery holder.

Battery Cautions

- Caution **(English)**

  There is a danger of explosion if battery is incorrectly replaced. Replace only with the same or equivalent type recommended by the manufacturer. Dispose of used batteries according to the manufacturer's instructions.

- Warnung **(German)**

  Explosionsgefahr durch falsches Einsetzen oder Behandein der Batterie. Nur durch gleichen Typ oder vom Hersteller empfohlenen Ersatztyp ersetzen. Entsorgung der gebrauchten Batterien gemäb den Anweisungen des Herstellers.

- Attention **(French)**

  Il y a danger d'explosion si la remplacement de la batterie est incorrect. Remplacez uniquement avec une batterie du même type ou d'un type équivalent recommandé par le fabricant. Mettez au rebut les batteries usagées conformément aux instructions du fabricant.

- Cuidado **(Spanish)**

  Peligro de explosión si la pila es instalada incorrectamente. Reemplace solamente con una similar o de tipo equivalente a la que el fabricante recomienda. Deshagase de las pilas usadas de acuerdo con las instrucciones del fabricante.

- Waarschuwing **(Dutch)**

  Explosiegevaar indien de batterij niet goed wordt vervagen. Vervanging alleen door een zelfde of equivalent type als aanbevolen door de fabrikant. Gebruikte batterijen afvoeren als door de fabrikant wordt aangegeven.

- Varning **(Swedish)**

  Explosionsfära vid felaktigt batteribyte. Använd samma batterityp eller en likvärdigt typ som rekommenderas av fabrikanten. Kassera använt batteri enligt fabrikantens instruktion.

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SCHEMATICS

090-0071 OP7100 Schematic

www.rabbit.com/documentation/schemat/090-0071.pdf

You may use the URL information provided above to access the latest schematic directly.

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