PRODUCT MANUAL

BL4S100

C-Programmable Single-Board Computer with Networking

User's Manual

019–0172_C

BL4S100 User's Manual

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Trademarks

The latest revision of this manual is available on the Rabbit Web site, www.rabbit.com, for free, unregistered download.

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1. INTRODUCTION

The BL4S100 series of high-performance, C-programmable single-board computers offers built-in RS-232, digital I/O and analog inputs combined with Ethernet and ZigBee network connectivity in a compact form factor. The BL4S100 single-board computers are ideal for both discrete manufacturing and process-control applications.

A Rabbit® 4000 microprocessor provides fast data processing.

1.1 BL4S100 Description

Throughout this manual, the term BL4S100 refers to the complete series of BL4S100 single-board computers unless other production models are referred to specifically.

The BL4S100 is an advanced single-board computer that incorporates the powerful Rabbit 4000 microprocessor, serial flash memory, static RAM, digital inputs, digital outputs, A/D converter inputs, RS-232 serial ports, and Ethernet and ZigBee network connectivity.

1.2 BL4S100 Features

- Rabbit® 4000 microprocessor operating at 40.00 MHz.
- Screw-terminal connectors
- 512KB SRAM (battery-backed), 512KB/1MB fast SRAM, and 1MB/2MB flash memory options.
- 20 digital I/O: 12 protected digital inputs, and 8 sinking digital outputs.
- Advanced input capabilities including event counting, event capture, and quadrature decoders that may be set up on all the digital input pins.
- Independent PWM and PPM capability on all the digital output pins.
- Eight 11-bit A/D converter inputs (plus one bit for sign).
- Ethernet and ZigBee network connectivity.
- Three serial ports:
  - ▶ Two 3-wire RS-232 serial ports or one 5-wire RS-232 serial port:
  - ▶ One serial port dedicated to programming/debugging.

- Battery-backed real-time clock.
- Watchdog supervisor.

Four BL4S100 models are available. Their standard features are summarized in Table 1.

Table 1. BL4S100 Models

Feature	BL4S100	BL4S110	BL4S150	BL4S160
Microprocessor	Rabbit® 4000 running at 40.00 MHz			
Program Execution SRAM	512KB		1MB	
Data SRAM	512KB			
Serial Flash Memory (program)	1MB		2MB	
A/D Converter	12 bits			
Ethernet Interface	10Base-T			
ZigBee Interface	ZigBee PRO (802.15.4)	—	ZigBee PRO (802.15.4)	—

BL4S100 single-board computers are programmed over a standard PC USB port through a programming cable supplied with the Tool Kit.

NOTE: BL4S100 Series single-board computers cannot be programmed via the RabbitLink.

Appendix A provides detailed specifications.

Visit the Web site for up-to-date information about additional add-ons and features as they become available. The Web site also has the latest revision of this user's manual.

1.3 Development and Evaluation Tools

1.3.1 Tool Kit

A Tool Kit contains the hardware essentials you will need to use your own BL4S100 single-board computer. These items are supplied in the Tool Kit.

- ***Getting Started*** instructions.
- ***Dynamic C*** CD-ROM, with complete product documentation on disk.
- USB programming cable, used to connect your PC USB port to the BL4S100.
- Universal AC adapter, 12 V DC, 1 A (includes Canada/Japan/U.S., Australia/N.Z., U.K., and European style plugs).
- Demonstration Board with pushbutton switches and LEDs. The Demonstration Board can be hooked up to the BL4S100 to demonstrate the I/O and capabilities of the BL4S100.
- DB9 to bare leads serial cable.
- CAT 5/6 Ethernet crossover cable.
- Screwdriver.
- ***Rabbit 4000 Processor Easy Reference*** poster.
- Registration card.

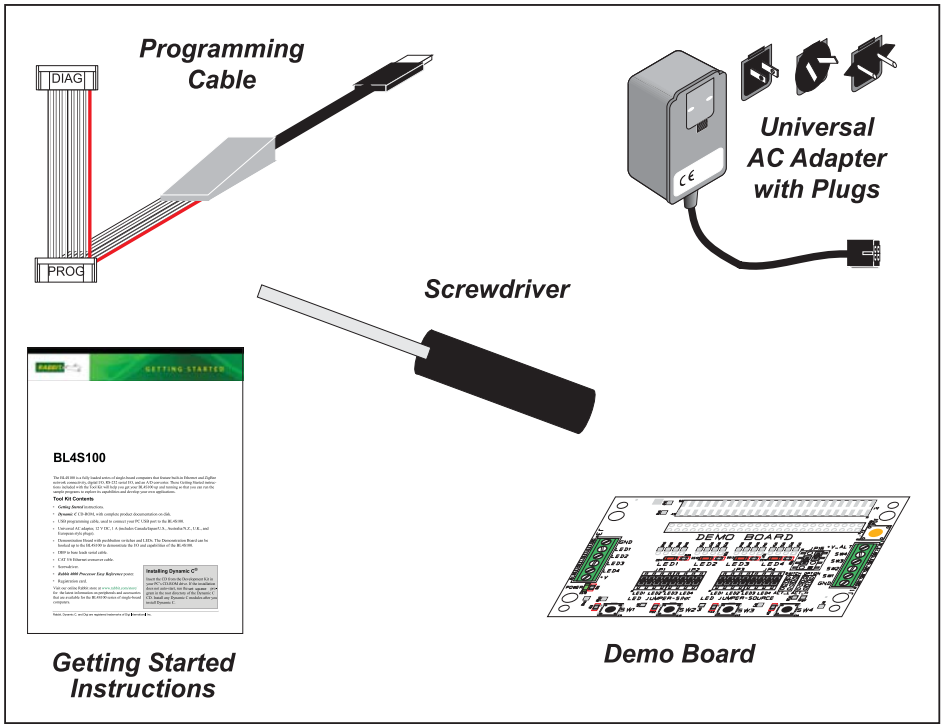


Figure 1. BL4S100 Tool Kit

1.3.2 Software

The BL4S100 is programmed using version 10.44 or later of Rabbit's Dynamic C. A compatible version is included on the Tool Kit CD-ROM. This version of Dynamic C includes the popular µC/OS-II real-time operating system, point-to-point protocol (PPP), FAT file system, RabbitWeb, and other select libraries.

Rabbit also offers for purchase the Rabbit Embedded Security Pack featuring the Secure Sockets Layer (SSL) and a specific Advanced Encryption Standard (AES) library. In addition to the Web-based technical support included at no extra charge, a one-year telephone-based technical support subscription is also available for purchase. Visit our Web site at www.rabbit.com for further information and complete documentation, or contact your Rabbit sales representative or authorized distributor.

1.3.3 Optional Add-Ons

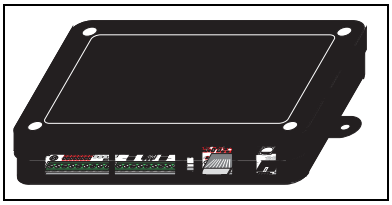
Rabbit has a plastic enclosure and a Mesh Network Add-On Kit available for the BL4S100.

- Mesh Network Add-On Kit (Part No. 101-1272)
  - ▶ Digi® XBee USB (used as ZigBee coordinator)
  - ▶ XBee Series 2 RF module
  - ▶ RF Interface module

  The XBee Series 2 RF module is installed on the RF Interface module, which can be connected via an RS-232 serial connection to a Windows PC for setup. The Mesh Network Add-On Kit enables you to explore the wireless capabilities of BL4S100 models that offer a ZigBee network interface.

- Plastic enclosure (Part No. 181-0041)

  Further details on the plastic enclosure are provided in Appendix E.



Visit our Web site at www.rabbit.com or contact your Rabbit sales representative or authorized distributor for further information.

1.4 CE Compliance

Equipment is generally divided into two classes.

CLASS A	CLASS B
Digital equipment meant for light industrial use	Digital equipment meant for home use
Less restrictive emissions requirement: less than 40 dB µV/m at 10 m (40 dB relative to 1 µV/m) or 300 µV/m	More restrictive emissions requirement: 30 dB µV/m at 10 m or 100 µV/m

These limits apply over the range of 30–230 MHz. The limits are 7 dB higher for frequencies above 230 MHz. Although the test range goes to 1 GHz, the emissions from Rabbit-based systems at frequencies above 300 MHz are generally well below background noise levels.

The BL4S100 single-board computer has been tested and was found to be in conformity with the following applicable immunity and emission standards. The BL4S110, BL4S150, and BL4S160 single-board computers are also CE qualified as they are sub-versions of the BL4S100 single-board computer. Boards that are CE-compliant have the CE mark.

Immunity

The BL4S100 series of single-board computers meets the following EN55024/1998 immunity standards.

- 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.

Emissions

The BL4S100 series of single-board computers meets the following emission standards.

- EN55022:1998 Class B
- FCC Part 15 Class B

Your results may vary, depending on your application, so additional shielding or filtering may be needed to maintain the Class B emission qualification.

1.4.1 Design Guidelines

Note the following requirements for incorporating the BL4S100 series of single-board computers into your application to comply with CE requirements.

General

- The power supply provided with the Tool Kit is for development purposes only. It is the customer's responsibility to provide a CE-compliant power supply for the end-product application.
- When connecting the BL4S100 single-board computer to outdoor cables, the customer is responsible for providing CE-approved surge/lighting protection.
- Rabbit recommends placing digital I/O or analog cables that are 3 m or longer in a metal conduit to assist in maintaining CE compliance and to conform to good cable design practices.
- When installing or servicing the BL4S100, it is the responsibility of the end-user to use proper ESD precautions to prevent ESD damage to the BL4S100.

Safety

- All inputs and outputs to and from the BL4S100 series of single-board computers must not be connected to voltages exceeding SELV levels (42.4 V AC peak, or 60 V DC).
- The lithium backup battery circuit on the BL4S100 single-board computer has been designed to protect the battery from hazardous conditions such as reverse charging and excessive current flows. Do not disable the safety features of the design.

1.4.2 Interfacing the BL4S100 to Other Devices

Since the BL4S100 series of single-board computers is designed to be connected to other devices, good EMC practices should be followed to ensure compliance. CE compliance is ultimately the responsibility of the integrator. Additional information, tips, and technical assistance are available from your authorized Rabbit distributor, and are also available on our Web site at www.rabbit.com.

2. GETTING STARTED

Chapter 2 explains how to connect the programming cable and power supply to the BL4S100.

2.1 BL4S100 Connections

Step 1 — Connect Programming Cable

The programming cable connects the BL4S100 to the PC running Dynamic C to download programs and to monitor the BL4S100 module during debugging.

Connect the 10-pin **PROG** connector of the programming cable to header J8 on the BL4S100. Ensure that the colored edge lines up with pin 1 as shown. (Do not use the **DIAG** connector, which is used for monitoring only.) Connect the other end of the programming cable to an available USB port on your PC or workstation.

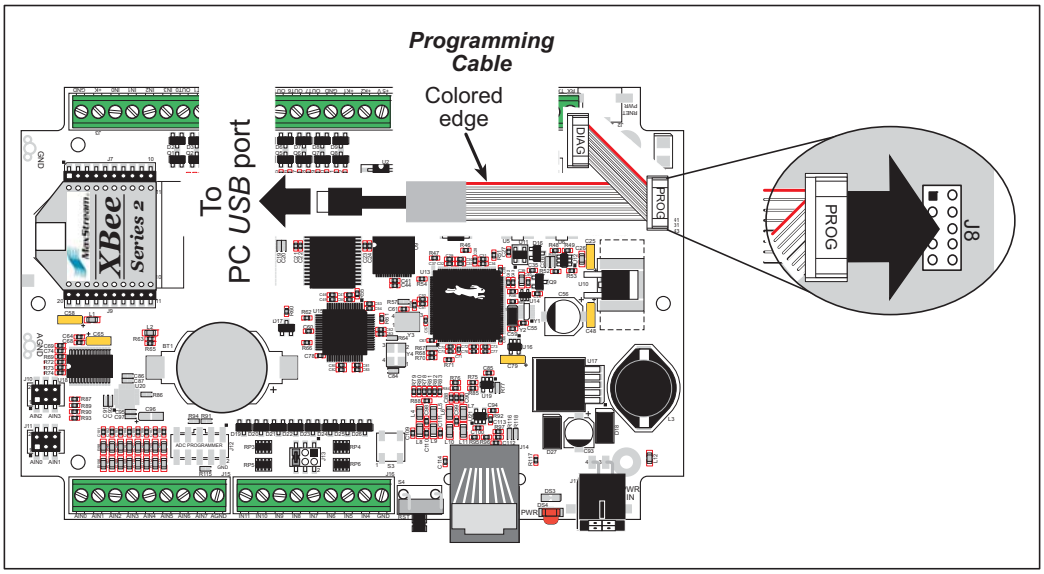


Figure 2. Programming Cable Connections

Your PC should recognize the new USB hardware, and the LEDs in the shrink-wrapped area of the USB programming cable will flash — if you get an error message, you will have to install USB drivers. Drivers for Windows XP are available in the Dynamic C **`Drivers\Rabbit USB Programming Cable\WinXP_2K`** folder — double-click **`DPInst.exe`** to install the USB drivers. Drivers for other operating systems are available online at www.ftdichip.com/Drivers/VCP.htm.

Step 2 — Connect Power Supply

Once all the other connections have been made, you can connect power to the BL4S100.

First, prepare the AC adapter for the country where it will be used by selecting the plug. The Tool Kit presently includes Canada/Japan/U.S., Australia/N.Z., U.K., and European style plugs. Snap in the top of the plug assembly into the slot at the top of the AC adapter as shown in Figure 3, then press down on the spring-loaded clip below the plug assembly to allow the plug assembly to click into place. Release the clip to secure the plug assembly in the AC adapter.

Connect the power supply to header J17 on the BL4S100 as shown in Figure 3. Be sure to match the latch mechanism with the top of the connector to header J17 on the BL4S100 as shown. The Micro-Fit® connector will only fit one way.

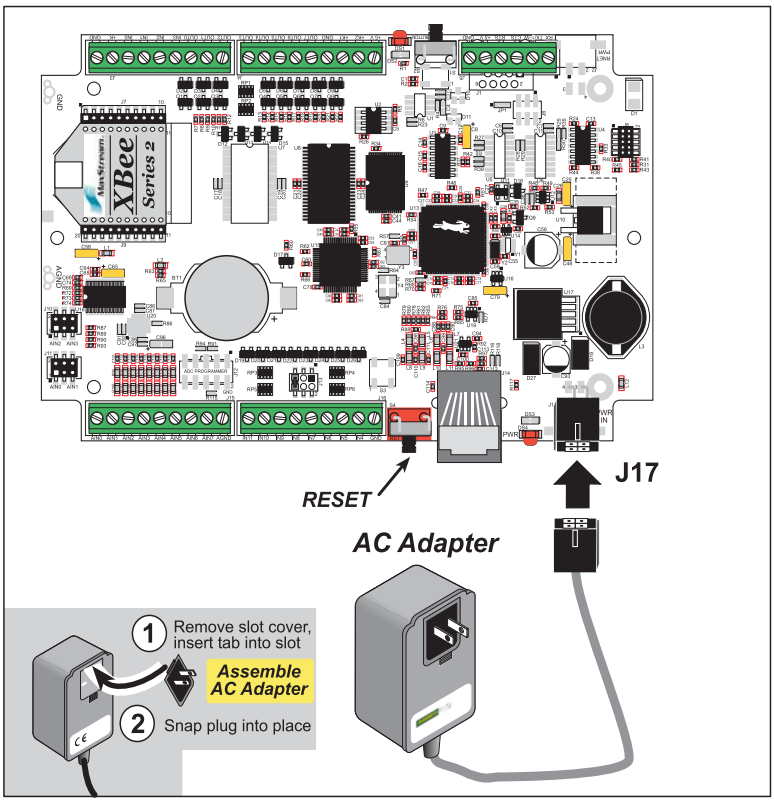


Figure 3. Power Supply Connections

Plug in the AC adapter. The red LED next to the power connector at J17 should light up. The BL4S100 is now ready to be used.

CAUTION: Unplug the power supply while you make or otherwise work with the connections to the headers. This will protect your BL4S100 from inadvertent shorts or power spikes.

2.1.1 Hardware Reset

A hardware reset is done by unplugging the power supply, then plugging it back in, or by pressing the **RESET** button located next to the Ethernet jack.

2.2 Installing Dynamic C

If you have not yet installed Dynamic C version 10.44 (or a later version), do so now by inserting the Dynamic C CD from the BL4S100 Tool Kit in your PC's CD-ROM drive. If autorun is enabled, the CD installation will begin automatically.

If autorun is disabled or the installation does not start, use the Windows **Start | Run** menu or Windows Disk Explorer to launch **setup.exe** from the root folder of the CD-ROM.

The installation program will guide you through the installation process. Most steps of the process are self-explanatory.

> **NOTE:** If you have an earlier version of Dynamic C already installed, the default installation of the later version will be in a different folder, and a separate icon will appear on your desktop.

The online documentation is installed along with Dynamic C, and an icon for the documentation menu is placed on the workstation's desktop. Double-click this icon to reach the menu. If the icon is missing, create a new desktop icon that points to **default.htm** in the **docs** folder, found in the Dynamic C installation folder. The latest versions of all documents are always available for free, unregistered download from our Web sites as well.

The ***Dynamic C User's Manual*** provides detailed instructions for the installation of Dynamic C and any future upgrades.

Once your installation is complete, you will have up to three icons on your PC desktop. One icon is for Dynamic C, one opens the documentation menu, and the third is for the Rabbit Field Utility, a tool used to download precompiled software to a target system.

If you have purchased any of the optional Dynamic C modules, install them after installing Dynamic C. The modules may be installed in any order. You must install the modules in the same directory where Dynamic C was installed.

2.3 Starting Dynamic C

Once the BL4S100 is connected to your PC and to a power source, start Dynamic C by double-clicking on the Dynamic C icon on your desktop or in your **Start** menu. Select **Store Program in Flash** on the "Compiler" tab in the Dynamic C **Options > Project Options** menu. Then click on the "Communications" tab and verify that **Use USB to Serial Converter** is selected to support the USB programming cable. Click **OK**.

You may have to select the COM port assigned to the USB programming cable on your PC. In Dynamic C, select **Options > Project Options**, then select this COM port on the "Communications" tab, then click **OK**. You may type the COM port number followed by **Enter** on your computer keyboard if the COM port number is outside the range on the dropdown menu.

2.4 Run a Sample Program

You are now ready to test your set-up by running a sample program.

Use the **File** menu to open the sample program **PONG.C**, which is in the Dynamic C **SAMPLES** folder. Press function key **F9** to compile and run the program. The **STDIO** window will open on your PC and will display a small square bouncing around in a box.

This program shows that the CPU is working. The sample program described in Section 5.2.3, "Run the PINGME.C Demo," tests the TCP/IP portion of the board.

2.4.1 Troubleshooting

If you receive the message **No Rabbit Processor Detected**, the programming cable may be connected to the wrong COM port, a connection may be faulty, or the target system may not be powered up. First, check to see that the red power LED next to header J5 is lit. If the LED is lit, check both ends of the programming cable to ensure that it is firmly plugged into the PC and the programming header on the BL4S100 with the marked (colored) edge of the programming cable towards pin 1 of the programming header.

If Dynamic C appears to compile the BIOS successfully, but you then receive a communication error message when you compile and load a sample program, it is possible that your PC cannot handle the higher program-loading baud rate. Try changing the maximum download rate to a slower baud rate as follows.

- Locate the **Serial Options** dialog on the "Communications" tab in the Dynamic C **Options > Project Options** menu. Select a slower Max download baud rate. Click **OK** to save.

If a program compiles and loads, but then loses target communication before you can begin debugging, it is possible that your PC cannot handle the default debugging baud rate. Try lowering the debugging baud rate as follows.

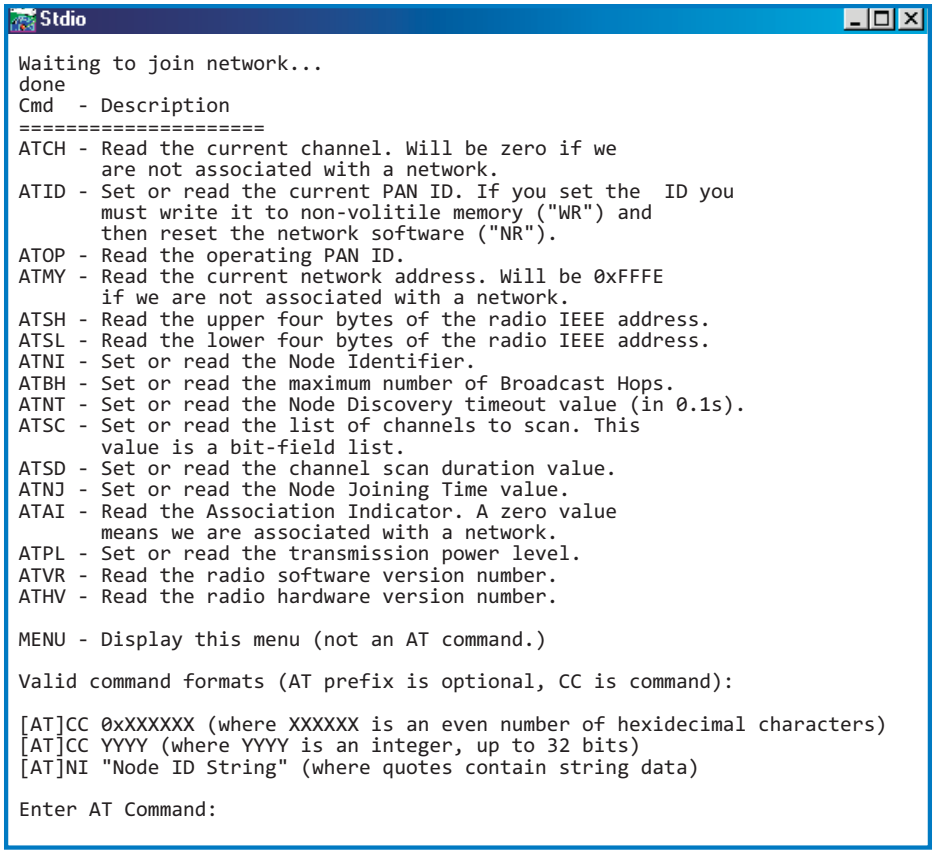
- Locate the **Serial Options** dialog on the "Communications" tab in the Dynamic C **Options > Project Options** menu. Choose a lower debug baud rate. Click **OK** to save.

Press **<Ctrl-Y>** to force Dynamic C to recompile the BIOS. You should receive a **Bios compiled successfully** message once this step is completed successfully.

2.4.2 Run a ZigBee Sample Program (BL4S100/BL4S150 only)

This section explains how to run a sample program in which the BL4S100/BL4S150 is used in its default setup as a router and the Digi® XBee USB is used as the ZigBee coordinator.

1. Connect the Digi® XBee USB acting as a ZigBee coordinator to an available USB port on your PC or workstation. Your PC should recognize the new USB hardware.
2. Find the file **AT_INTERACTIVE.C**, which is in the Dynamic C **SAMPLES\XBee** folder. To run the program, open it with the **File** menu, then compile and run it by pressing **F9**. The Dynamic C **STDIO** window will open to display a list of AT commands. Type **MENU** to redisplay the menu of commands.



Appendix F provides additional configuration information if you experience conflicts while doing development simultaneously with more than one ZigBee coordinator, or if you wish to upload new firmware.

2.5 Where Do I Go From Here?

NOTE: If you purchased your BL4S100 through a distributor or Rabbit partner, contact the distributor or partner first for technical support.

If there are any problems at this point:

- Use the Dynamic C **Help** menu to get further assistance with Dynamic C.
- Check the Rabbit Technical Bulletin Board and forums at www.rabbit.com/support/bb/ and at www.rabbit.com/forums/.
- Use the Technical Support e-mail form at www.rabbit.com/support/.

If the sample program ran fine, you are now ready to go on to explore other BL4S100 features and develop your own applications.

When you start to develop an application involving the analog inputs, run **USERBLOCK_READ_WRITE.C** in the **SAMPLES\UserBlock** folder to save the factory calibration constants before you run any other sample programs in case you inadvertently write over them while running another sample program.

Chapter 3, "Subsystems," provides a description of the BL4S100's features, Chapter 4, "Software," describes the Dynamic C software libraries and introduces some sample programs, and Chapter 5, "Using the Ethernet TCP/IP Features," explains the TCP/IP features.

3. SUBSYSTEMS

Chapter 3 describes the principal subsystems for the BL4S100.

- Digital I/O
- Serial Communication
- A/D Converter Inputs
- Memory

Figure 4 shows these Rabbit-based subsystems designed into the BL4S100.

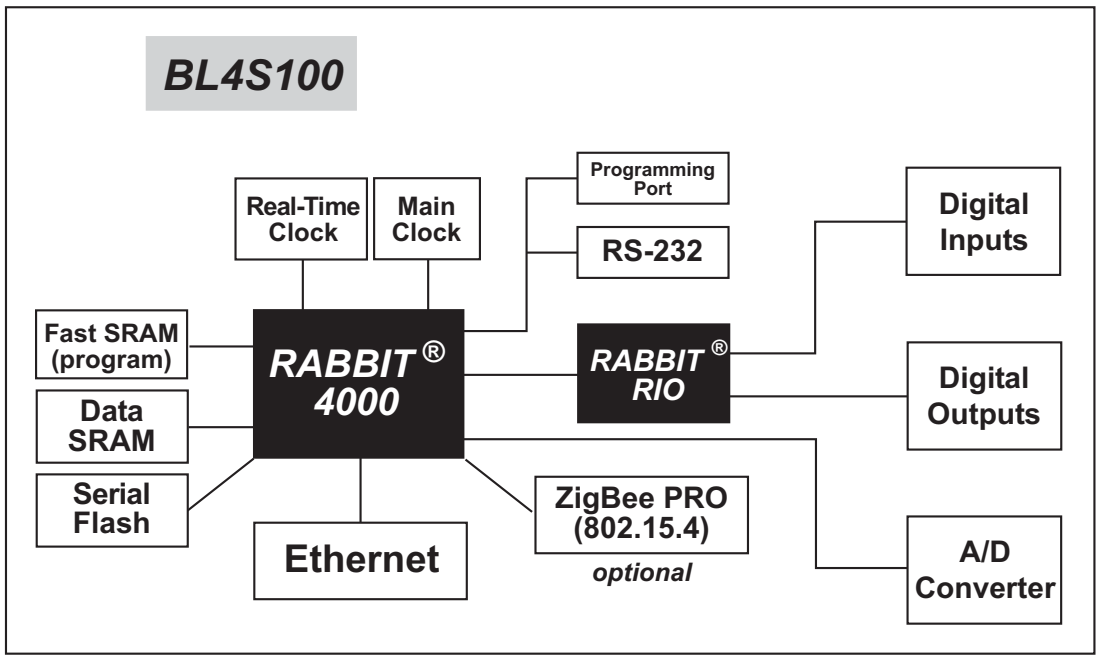


Figure 4. BL4S100 Subsystems

3.1 BL4S100 Pinouts

The BL4S100 pinouts are shown in Figure 5.

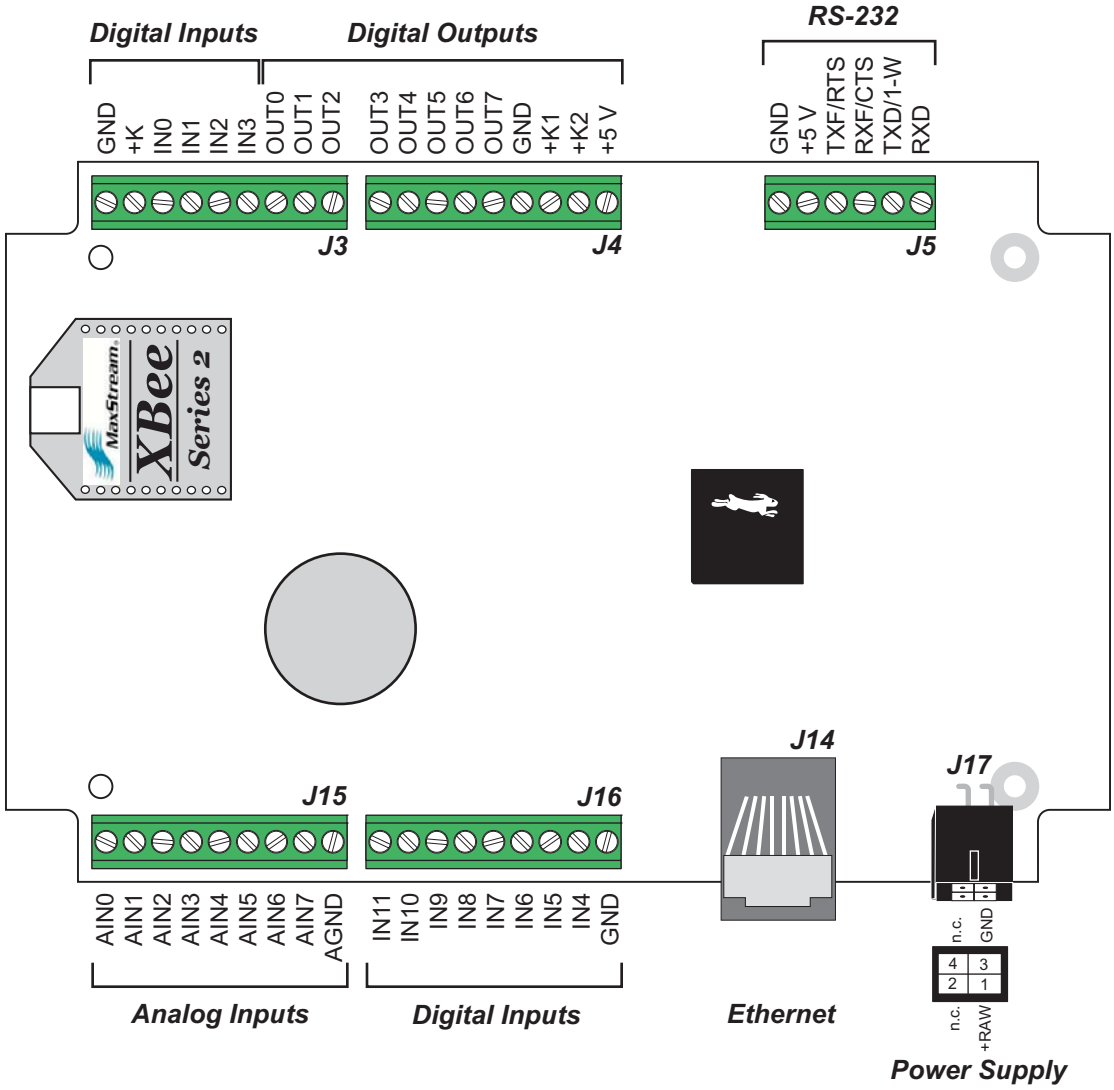


Figure 5. BL4S100 Pinouts

3.1.1 Connectors

Standard BL4S100 models are equipped with an RJ-45 Ethernet jack, four 1 × 9 screw-terminal headers and one 1 × 6 screw-terminal header for the I/O and RS-232 signals. The polarized 2 × 2 Micro-Fit® connector at J17 is for the power supply connection.

3.2 Digital I/O

3.2.1 Digital Inputs

The BL4S100 has 12 digital inputs, IN0–IN11, each of which is protected over a range of –36 V to +36 V. The inputs are factory-configured to be pulled up to +5 V, but they can also be pulled up to +K or pulled down to 0 V by changing a jumper as shown in Figure 6.

CAUTION: Do not simultaneously jumper more than one setting when configuring the pull-up or pull-down options.

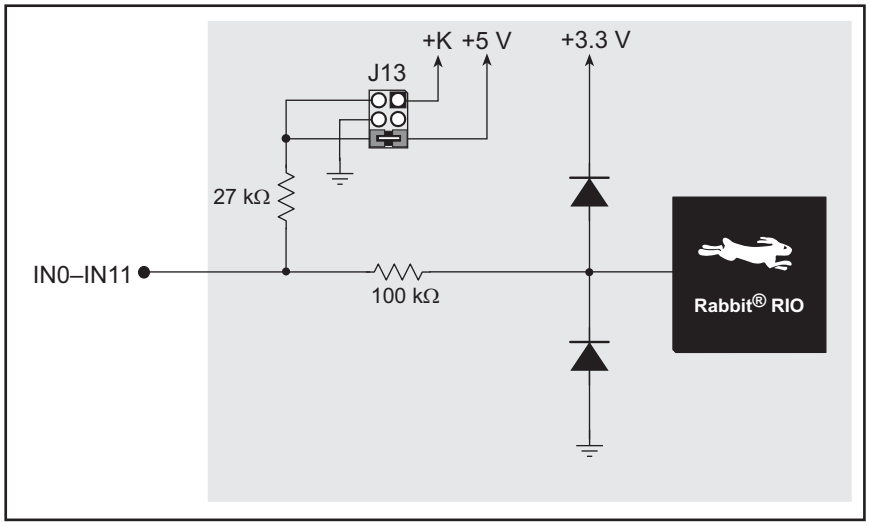


Figure 6. BL4S100 Digital Inputs IN0–IN11 [Pulled Up to +5 V—Factory Default]

Table 2 summarizes the jumper settings.

Table 2. BL4S100 Digital Input Pull-Up/Pull-Down Jumper Settings

Pins Jumpered	Pulled Up/Pulled Down
1–2	Inputs pulled up to +K
2–4 or 4–6	Inputs pulled down to GND
5–6	Inputs pulled up to +5 V

The actual switching threshold is approximately 1.40 V. Anything below this value is a logic 0, and anything above 1.90 V is a logic 1. The digital inputs are each fully protected over a range of -36 V to +36 V, and can handle short spikes of ±40 V.

NOTE: If the inputs are pulled up to +K, the voltage range over which the digital inputs are protected changes to +K – 36 V to +36 V.

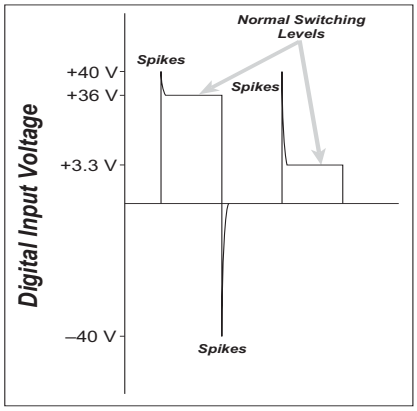


Figure 7. BL4S100 Digital Input Protected Range

CAUTION: Do not allow the voltage on a digital input pin to exceed ±36 V to avoid damaging the input.

Individual digital input channels may be also used for counters, synching, interrupts, input capture, or as quadrature decoder inputs. The use of these channels for interrupts, input capture, and as quadrature decoders is described below.

Blocks of digital input pins are associated with counters/timers on the Rabbit RIO chip. Table 3 provides complete details for these associations.

Table 3. Counter/Timer Associations for BL4S100 Digital Input Pins

Configurable I/O Pin(s)	Counter/Timer Blocks	Block Shared With
IN0–IN2	0	XBee RF module
IN3–IN5	1	—
IN6–IN7	2	OUT0–OUT1
IN8–IN9	3	OUT2–OUT3
IN10	6	—
IN11	7	—

Appendix D provides further details on the blocks and pins associated with the Rabbit RIO chip to facilitate configuring each block consistently and to identify misconfigured pins when a software function call returns a *Mode Conflict* error code.

Keep the following guidelines in mind when selecting special uses for the digital input pins.

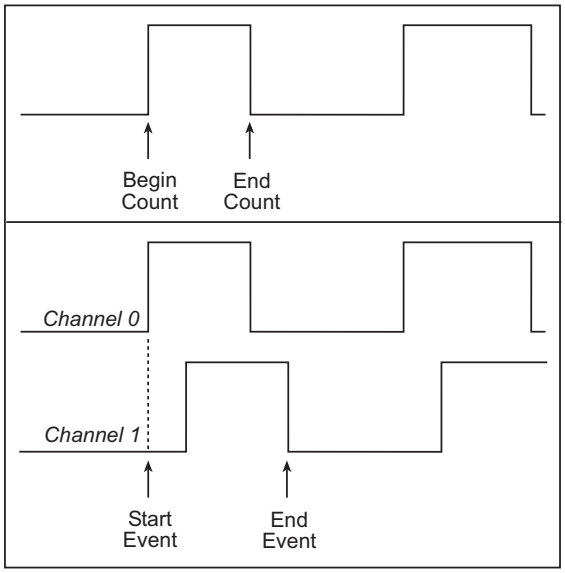
- Interrupts, event counters, and input capture are available on any digital input pin.
- Each Quadrature Decoder channel requires at least two digital input pins associated with the same counter/timer block; three digital input pins associated with the same counter/timer block are needed if you need indexing. Quadrature Decoder channels are configured using the **`setDecoder()`** function call.

Sample programs in the **`DIO`** subdirectory in **`SAMPLES\BL4S1xx`** show how to set up and use digital inputs for interrupts, pulse capture, and quadrature decoders.

3.2.1.1 Interrupt, Counter, and Event Capture Setup

External interrupts on the BL4S100 digital input pins are configured using the **`setExtInterrupt()`** function call. The interrupt can be set up to occur on a rising edge, a falling edge, or either edge.

An input channel may be set up to count events, with the count incrementing or decrementing, using the rising edge, falling edge, or either edge as triggers to start/end the count. This feature is configured using the **`setCounter()`** function call.



A more extensive use of the timing abilities of the BL4S100 inputs can be realized through the event capture function call, **`setCapture()`**. Here the count of a particular clock cycle is noted at the start of the event and at the end of the event so that the time between them can be determined. This can be set up on one or two input channels. The event counter can be reset with the **`resetCounter()`** function call.

The counter readings can be obtained via the **`getBegin()`** or **`getEnd()`** function calls.

3.2.2 Digital Outputs

The BL4S100 has eight digital outputs, OUT0–OUT7, which can each sink up to 200 mA. Figure 8 shows a wiring diagram for using the sinking digital outputs.

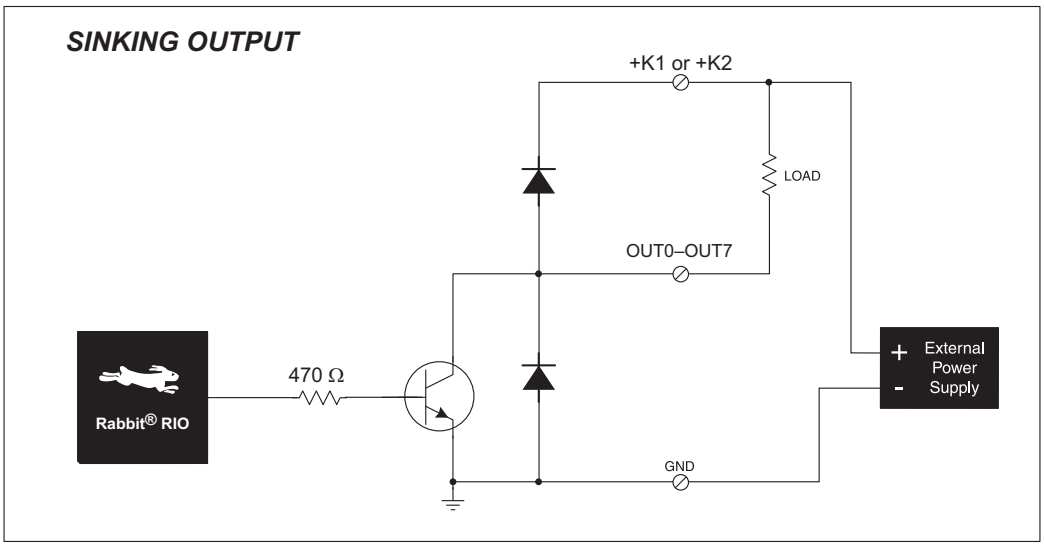


Figure 8. BL4S100 Digital Outputs

OUT0–OUT3 are powered by +K1, and OUT4–OUT7 are powered by +K2. +K1 and +K2 can each be up to 36 V. They don't have to be the same. All the sinking current, which could be up to 1.6 A, is returned through the GND pin. Be sure to use a suitably sized ground wire and keep the distance to the power supply as short as possible.

All the digital outputs sink actively. They can be used as low-side drivers, or as an H-bridge driver. When the BL4S100 is first powered up or reset, all the outputs are disabled, that is, at a high-impedance state.

For the H bridge, which is shown in Figure 9, Ka and Kb ***should be the same***. This is most easily accomplished by using outputs from the same bank on one connector.

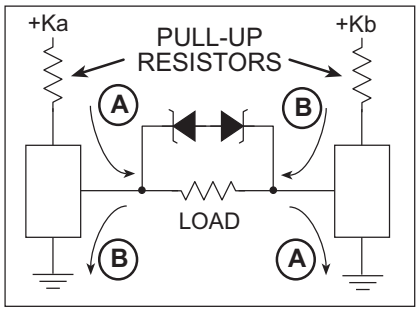


Figure 9. H Bridge

Individual digital output channels may be used for PWM/PPM outputs.The use of these channels for PWM/PPM is described in Section 3.2.2.1.

Blocks of digital output pins are associated with counters/timers on the Rabbit RIO chip. Table 4 provides complete details for these associations.

Table 4. Counter/Timer Associations for BL4S100 Digital Output Pins

Configurable I/O Pin(s)	Counter/Timer Blocks	Block Shared With
OUT0–OUT1	2	IN6–IN7
OUT2–OUT3	3	IN8–IN9
OUT4–OUT5	4	RabbitNet (reserved for future use)
OUT6–OUT7	5	A/D converter

Appendix D provides further details on the blocks and pins associated with the Rabbit RIO chip to facilitate configuring each block consistently and to identify misconfigured pins when a software function call returns a *Mode Conflict* error code.

Keep the following guidelines in mind when selecting special uses for the digital output pins.

- When using digital output pins for PWM/PPM outputs, the output pins can only share the same RIO block if they are using the same period or frequency.

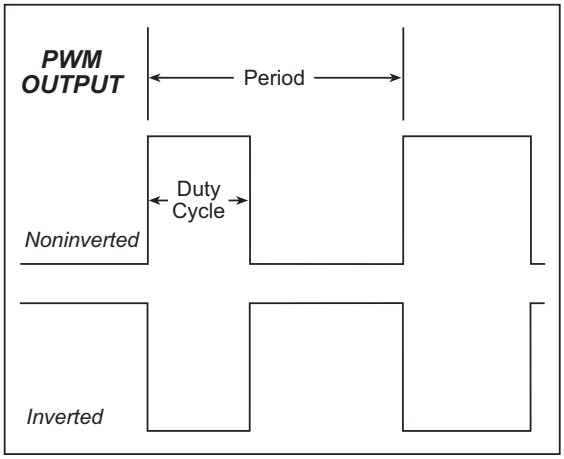
  The **PWM.C** and the **PPM.C** sample programs in the **DIO** subdirectory in **SAMPLES\BL4S1xx** show how to set up and use the PWM/PPM outputs.

3.2.2.1 PWM/PPM Outputs Setup

A PWM output is described as *noninverted* when it starts high, remains high for a duty cycle that is a fraction of the period, then goes low for the remainder of the period.

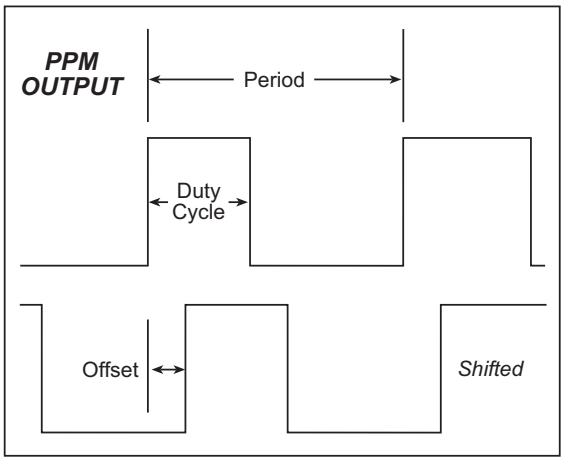
Similarly, an *inverted* PWM output starts low, remains low for a duty cycle that is a fraction of the period, then goes high for the remainder of the period.

A PWM output is normally set up to start when triggered by an event, and may be set up so that the leading and trailing edges of several PWM outputs are aligned as long as the all the PWM outputs are on the same block of a particular Rabbit RIO chip.



A PPM ouput is similar to a PWM output, except it is *shifted* by an *offset* relative to the event that triggered the start of the PPM output.

A PPM output is either inverted or noninverted, based on whether it starts high or low, and may be set up so that their leading and trailing edges of several PPM outputs are aligned as long as the all the PPM outputs are on the same block of a particular Rabbit RIO chip



PWM and PPM outputs on the BL4S100 are configured using the **`setPWM()`** and **`setPPM()`** function calls.

3.3 Serial Communication

The BL4S100 has two RS-232 serial ports, which can be configured as one RS-232 serial channel (with RTS/CTS) or as two RS-232 (3-wire) channels using the **serMode()** software function call. Table 5 summarizes the options.

Table 5. Serial Communication Configurations

Mode	Serial Port	
	D	F
0	RS-232, 3-wire	RS-232, 3-wire
1	RS-232, 5-wire	CTS/RTS

The BL4S100 also has one CMOS serial channel that serves as the programming port.

All three serial ports operate in an asynchronous mode. An asynchronous port can handle 7 or 8 data bits. A 9th bit address scheme, where an additional bit is sent to mark the first byte of a message, is also supported. Serial Port A, the programming port, can be operated alternately in the clocked serial mode. In this mode, a clock line synchronously clocks the data in or out. Either of the two communicating devices can supply the clock. The BL4S100 boards supports standard asynchronous baud rates up to 115,200 bps.

3.3.1 RS-232

The BL4S100 RS-232 serial communication is supported by an RS-232 transceiver. This transceiver provides the voltage output, slew rate, and input voltage immunity required to meet the RS-232 serial communication protocol. Basically, the chip translates the Rabbit microprocessor's CMOS signals to RS-232 signal levels. Note that the polarity is reversed in an RS-232 circuit so that a +3.3 V output becomes approximately -10 V and 0 V is output as +10 V. The RS-232 transceiver also provides the proper line loading for reliable communication.

RS-232 can be used effectively at the BL4S100's maximum baud rate for distances of up to 15 m.

3.3.2 Programming Port

The BL4S100 has a 10-pin programming header. The programming port uses the Rabbit 4000 Serial Port A for communication, and is used for the following operations.

- Programming/debugging
- Cloning

The programming port is used to start the BL4S100 in a mode where the BL4S100 will download a program and then execute the program. The programming port transmits information to and from a PC while a program is being debugged.

The Rabbit 4000 startup-mode pins (SMODE0, SMODE1) are presented to the programming port so that an externally connected device can force the BL4S100 to start up in an

external bootstrap mode. The BL4S100 can be reset from the programming port via the **/RESET_IN** line.

The Rabbit microprocessor status pin is also presented to the programming port. The status pin is an output that can be used to send a general digital signal.

> **NOTE:** Refer to the ***Rabbit 4000 Microprocessor User's Manual*** for more information related to the bootstrap mode.

3.3.3 Ethernet Port

Figure 10 shows the pinout for the Ethernet port (J4). Note that there are two standards for numbering the pins on this connector—the convention used here, and numbering in reverse to that shown. Regardless of the numbering convention followed, the pin positions relative to the spring tab position (located at the bottom of the RJ-45 jack in Figure 10) are always absolute, and the RJ-45 connector will work properly with off-the-shelf Ethernet cables.

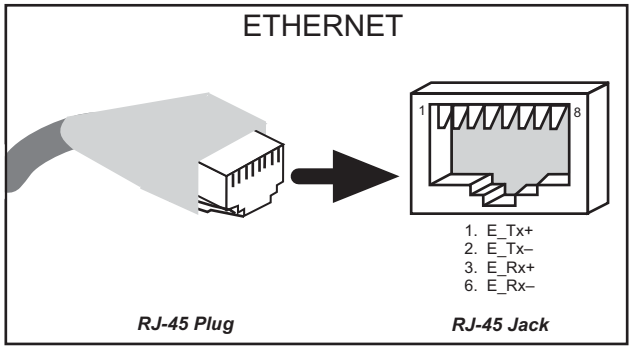


Figure 10. RJ-45 Ethernet Port Pinout

Two LEDs on the RJ-45 Ethernet jack indicate an Ethernet link (green **LNK**) and Ethernet activity (yellow **ACT**).

The grounded RJ-45 connector is shielded to minimize EMI effects to/from the Ethernet signals.

3.4 A/D Converter Inputs

The single A/D converter chip used in the BL4S100 has a resolution of 12 bits (11 bits for the value and one bit for the polarity). The A/D converter chip has a programmable-gain amplifier. Each external input has circuitry that provides scaling and filtering. All 8 external inputs are scaled and filtered to provide the user with an input impedance of 1 MΩ and a variety of single-ended unipolar, and differential bipolar ranges as shown in Table 6.

Figure 11 shows a pair of A/D converter input circuits. The resistors form an approx. 10:1 attenuator, and the capacitors filter noise pulses from the A/D converter inputs.

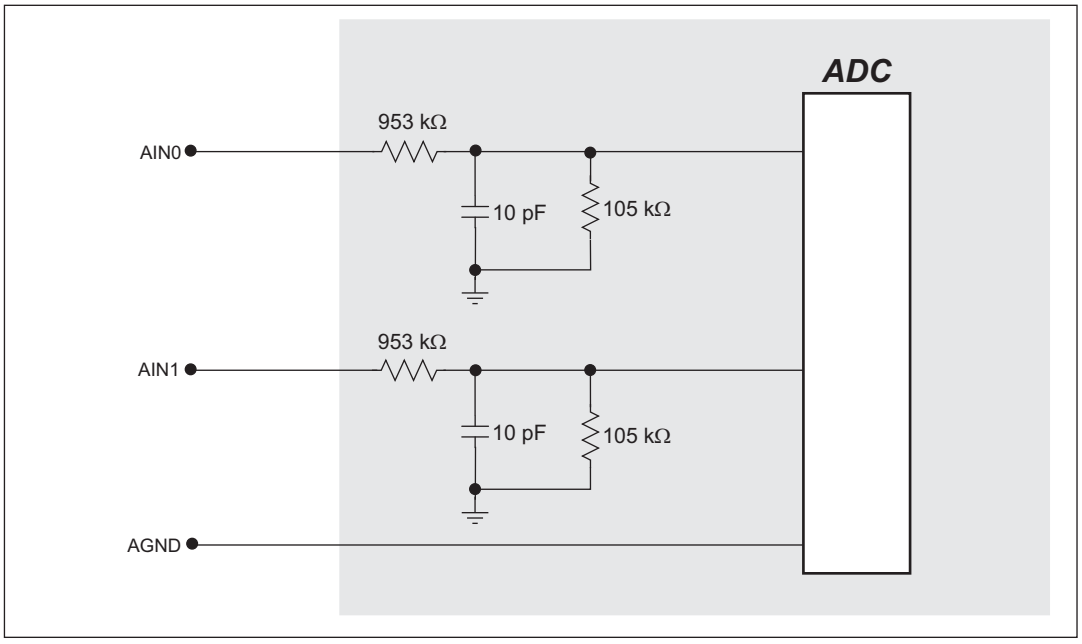


Figure 11. Buffered A/D Converter Inputs

The A/D converter chip can only accept positive voltages. By pairing the analog inputs, differential bipolar measurements are possible, and can be configured for each channel pair with the **`opmode`** parameter in the **`anaInConfig()`** software function call. The available voltage ranges are listed in Table 6.

Table 6. A/D Converter Input Voltage Ranges

Amplifier Gain	Voltage Range	
	Single-Ended Unipolar	Differential Bipolar
1	0–20 V	± 20 V
2	0–10 V	± 10 V
4	0–5 V	± 5 V
5	0–4 V	± 4 V
8*	0–2.5 V	± 2.5 V
10	0–2 V	± 2 V
16	0–1.25 V	± 1.25 V
20	0–1 V	± 1 V

* 4–20 mA operation is available with an amplifier gain of 8

In the differential mode, each individual channel is limited to half the total voltage—for example, the range for a gain code of 1 is ±20 V, but each channel is limited to 0–20 V.

Note that while the differential bipolar mode can return a negative value, this negative value can only indicate negative with respect to the two differential voltages since the A/D converter cannot handle a voltage below -0.2 V.

When using channels AIN0–AIN3 for current measurements, remember to set the corresponding jumper(s) on headers J10 and J11. The current measurements are realized by actually measuring the voltage drop across a 100 Ω resistor.

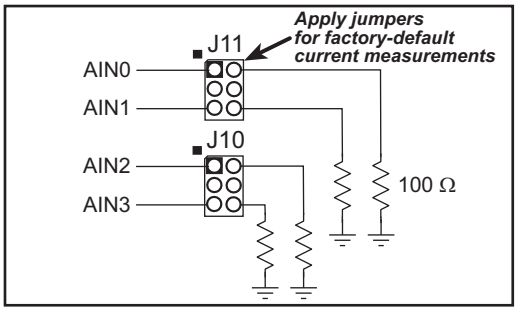


Figure 12. Analog Current Measurements

The A/D converter inputs are factory-calibrated, and the calibration constants are stored in the user block.

3.4.1 A/D Converter Calibration

When you start to develop your application, run **USERBLOCK_READ_WRITE.C** in the **SAMPLES\UserBlock** folder to save the factory calibration constants in case you inadvertently write over them while running the sample programs.

To get the best results from the A/D converter, it is necessary to calibrate each mode (single-ended, differential, and current) for each of its gains. It is imperative that you calibrate each of the A/D converter inputs in the same manner as they are to be used in the application. For example, if you will be performing floating differential measurements or differential measurements using a common analog ground, then calibrate the A/D converter in the corresponding manner. The calibration table in software only holds calibration constants based on mode, channel, and gain. ***Other factors affecting the calibration must be taken into account by calibrating using the same mode and gain setup as in the intended use.***

Sample programs are provided to illustrate how to read and calibrate the various A/D inputs for the three operating modes.

Mode	Read	Calibrate
Single-Ended, unipolar	**ADC_RD_SE_UNIPOLAR.C**	**ADC_CAL_SE_UNIPOLAR.C**
Differential, bipolar	**ADC_RD_DIFF.C**	**ADC_CAL_DIFF.C**
4–20 mA	**ADC_RD_MA.C**	**ADC_CAL_MA.C**

These sample programs are found in the **ADC** subdirectory in **SAMPLES\BL4S1xx**. See Section 4.2.3 for more information on these sample programs and how to use them.

3.5 USB Programming Cable

The USB programming cable is used to connect the serial programming port of the BL4S100 to a PC USB port. The programming cable converts the voltage levels used by the PC USB port to the CMOS voltage levels used by the Rabbit microprocessor.

When the **PROG** connector on the programming cable is connected to the programming header on the BL4S100, programs can be downloaded and debugged over the serial interface.

The **DIAG** connector of the programming cable may be used on the programming header on the BL4S100 with the BL4S100 operating in the Run Mode. This allows the programming port to be used as a regular serial port.

3.5.1 Changing Between Program Mode and Run Mode

The BL4S100 is automatically in Program Mode when the **PROG** connector on the programming cable is attached, and is automatically in Run Mode when reset with no programming cable is attached or the **DIAG** connector is attached. When the Rabbit microprocessor is reset, the operating mode is determined by the status of the SMODE pins. When the programming cable's **PROG** connector is attached, the SMODE pins are pulled high, placing the Rabbit microprocessor in the Program Mode. When the programming cable's **PROG** connector is not attached, the SMODE0 pin is pulled low and the SMODE1 pin is high so that the Rabbit 4000 powers up in the clocked serial bootstrap mode to load the program from the serial flash when the BL4S100 is operating in the Run Mode.

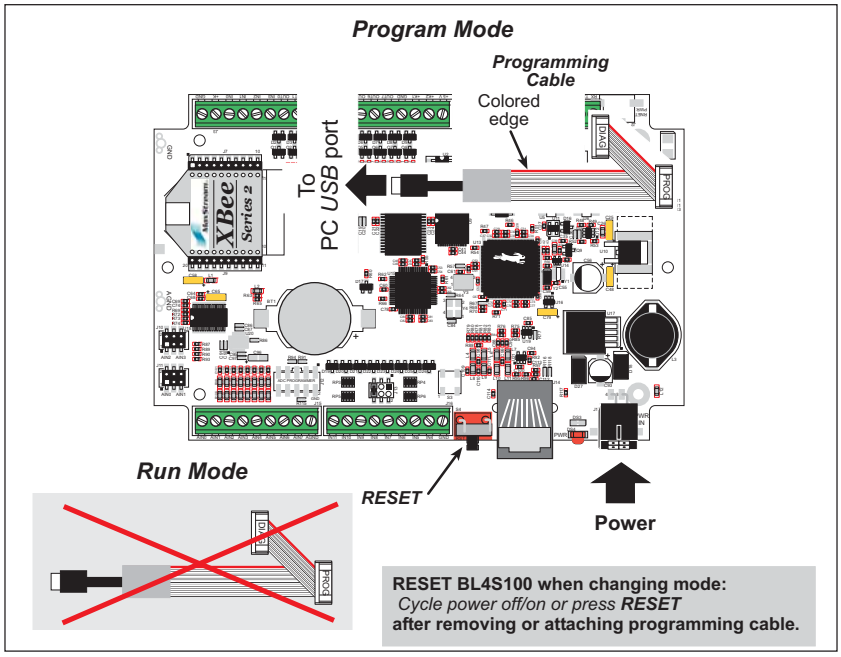


Figure 13. BL4S100 Program Mode and Run Mode Setup

A program "runs" in either mode, but can only be downloaded and debugged when the BL4S100 is in the Program Mode.

Refer to the ***Rabbit 4000 Microprocessor User's Manual*** for more information on the programming port and the programming cable.

3.6 Other Hardware

3.6.1 Clock Doubler

The BL4S100 takes advantage of the Rabbit microprocessor's internal clock doubler. A built-in clock doubler allows half-frequency crystals to be used to reduce radiated emissions.

The clock doubler may be disabled if the higher clock speeds are not required. Disabling the clock doubler will reduce power consumption and further reduce radiated emissions. The clock doubler is disabled with a simple configuration macro as shown below.

1. Select the "Defines" tab from the Dynamic C **Options > Project Options** menu.
2. Add the line **CLOCK_DOUBLED=0** to always disable the clock doubler.

   The clock doubler is enabled by default, and usually no entry is needed. If you need to specify that the clock doubler is always enabled, add the line **CLOCK_DOUBLED=1** to always enable the clock doubler.
3. Click **OK** to save the macro. The clock doubler will now remain off or on according to your setting whenever you are using the project file where you defined the macro.

3.6.2 Spectrum Spreader

The Rabbit microprocessors features a spectrum spreader, which help to mitigate EMI problems. By default, the spectrum spreader is on automatically, but it may also be turned off or set to a stronger setting. The means for doing so is through a simple configuration macro as shown below.

1. Select the "Defines" tab from the Dynamic C **Options > Project Options** menu.
2. Normal spreading is the default, and usually no entry is needed. If you need to specify normal spreading, add the line

   ```
   ENABLE_SPREADER=1
   ```

   For strong spreading, add the line

   ```
   ENABLE_SPREADER=2
   ```

   To disable the spectrum spreader, add the line

   ```
   ENABLE_SPREADER=0
   ```

   NOTE: The strong spectrum-spreading setting is not recommended since it may limit the maximum clock speed or the maximum baud rate. It is unlikely that the strong setting will be used in a real application.
3. Click **OK** to save the macro. The spectrum spreader will be set according to the macro value whenever a program is compiled using this project file.

   NOTE: Refer to the ***Rabbit 4000 Microprocessor User's Manual*** for more information on the spectrum-spreading settings and the maximum clock speed.

3.7 Memory

3.7.1 SRAM

All BL4S100 boards have 512KB of battery-backed data SRAM, and 512KB–1MB of fast program execution SRAM.

3.7.2 Flash Memory

BL4S100 boards have 1MB—2MB of serial flash memory.

Writing to arbitrary flash memory addresses at run time is also discouraged. Instead, define a "user block" area to store persistent data. The functions **`writeUserBlock()`** and **`readUserBlock()`** are provided for this.

3.7.3 VBAT RAM Memory

The tamper detection feature of the Rabbit microprocessor can be used to detect any attempt to enter the bootstrap mode. When such an attempt is detected, the VBAT RAM memory in the Rabbit microprocessor is erased. The serial bootloader on the BL4S100 boards uses the bootstrap mode to load the SRAM, which erases the VBAT RAM memory on any reset, and so it cannot be used for tamper detection.

4. SOFTWARE

Dynamic C is an integrated development system for writing embedded software. It runs on an IBM-compatible PC and is designed for use with single-board computers and other devices based on the Rabbit microprocessor.

Chapter 4 provides the libraries, function calls, and sample programs related to the BL4S100.

4.1 Running Dynamic C

Since the BL4S100 has a serial flash memory, all software development must be done in the static SRAM. The flash memory and SRAM options are selected with the **Options > Program Options > Compiler** menu. Select **Store Program in Flash** on the "Compiler" tab for the program to run normally.

For debugging purposes, you may select **Store Program in RAM** on the "Compiler" tab so that download speed is as fast as possible. Note that programs stored in RAM will be lost when the BL4S100 is reset, so this option should be used only for debugging.

Developing software with Dynamic C is simple. Users can write, compile, and test C and assembly code without leaving the Dynamic C development environment. Debugging occurs while the application runs on the target. Alternatively, users can compile a program to an image file for later loading. Dynamic C runs on PCs under Windows NT and later—see Rabbit's Technical Note TN257, *Running Dynamic C® With Windows Vista®*, for additional information if you are using a Dynamic C under Windows Vista. Programs can be downloaded at baud rates of up to 460,800 bps after the program compiles.

Dynamic C has a number of standard features:

- Full-feature source and/or assembly-level debugger, no in-circuit emulator required.
- Royalty-free TCP/IP stack with source code and most common protocols.
- Hundreds of functions in source-code libraries and sample programs:
  - Exceptionally fast support for floating-point arithmetic and transcendental functions.
  - RS-232 and RS-485 serial communication.
  - Analog and digital I/O drivers.
  - I^2C, SPI, GPS, file system.
  - LCD display and keypad drivers.
- Powerful language extensions for cooperative or preemptive multitasking
- Loader utility program to load binary images into Rabbit targets in the absence of Dynamic C.
- Provision for customers to create their own source code libraries and augment on-line help by creating "function description" block comments using a special format for library functions.
- Standard debugging features:
  - Breakpoints—Set breakpoints that can disable interrupts.
  - Single-stepping—Step into or over functions at a source or machine code level, µC/OS-II aware.
  - Code disassembly—The disassembly window displays addresses, opcodes, mnemonics, and machine cycle times. Switch between debugging at machine-code level and source-code level by simply opening or closing the disassembly window.
  - Watch expressions—Watch expressions are compiled when defined, so complex expressions including function calls may be placed into watch expressions. Watch expressions can be updated with or without stopping program execution.
  - Register window—All processor registers and flags are displayed. The contents of general registers may be modified in the window by the user.
  - Stack window—shows the contents of the top of the stack.
  - Hex memory dump—displays the contents of memory at any address.
  - **STDIO** window—**`printf`** outputs to this window and keyboard input on the host PC can be detected for debugging purposes. **`printf`** output may also be sent to a serial port or file.

4.1.1 Upgrading Dynamic C

4.1.1.1 Patches and Updates

Dynamic C patches that focus on bug fixes and updates are available from time to time. Check the Web site at www.rabbit.com/support/ for the latest patches, workarounds, and updates.

The default installation of a patch or update is to install the file in a directory (folder) different from that of the original Dynamic C installation. Rabbit recommends using a different directory so that you can verify the operation of the patch or update without overwriting the existing Dynamic C installation. If you have made any changes to the BIOS or to libraries, or if you have programs in the old directory (folder), make these same changes to the BIOS or libraries in the new directory containing the patch. Do ***not*** simply copy over an entire file since you may overwrite an update; of course, you may copy over any programs you have written. Once you are sure the new patch or update works entirely to your satisfaction, you may retire the existing installation, but keep it available to handle legacy applications.

4.1.2 Add-On Modules

Starting with Dynamic C version 10.40, Dynamic C includes the popular µC/OS-II real-time operating system, point-to-point protocol (PPP), FAT file system, RabbitWeb, and other select libraries. Rabbit also offers for purchase the Rabbit Embedded Security Pack featuring the Secure Sockets Layer (SSL) and a specific Advanced Encryption Standard (AES) library.

In addition to the Web-based technical support included at no extra charge, a one-year telephone-based technical support subscription is also available for purchase.

Visit our Web site at www.rabbit.com for further information and complete documentation.

4.2 Sample Programs

Sample programs are provided in the Dynamic C **Samples** folder. The sample program **PONG.C** demonstrates the output to the **STDIO** window.

The various directories in the **Samples** folder contain specific sample programs that illustrate the use of the corresponding Dynamic C libraries.

The **SAMPLES\BL4S1xx** folder provides sample programs specific to the BL4S100. Each sample program has comments that describe the purpose and function of the program. Follow the instructions at the beginning of the sample program.

To run a sample program, open it with the **File** menu (if it is not still open), then compile and run it by pressing **F9**. The BL4S100 must be in **Program** mode (see Section 3.5, "USB Programming Cable,") and must be connected to a PC using the programming cable as described in Section 2.1, "BL4S100 Connections." See Appendix C for information on the power-supply connections to the Demonstration Board.

Complete information on Dynamic C is provided in the ***Dynamic C User's Manual***.

TCP/IP specific functions are described in the ***Dynamic C TCP/IP User's Manual***, which is included in the online documentation set. Information on using the TCP/IP features and sample programs is provided in Chapter 5, "Using the Ethernet TCP/IP Features."

ZigBee specific functions are described in ***An Introduction to ZigBee***, which is included in the online documentation set. Information on using the TCP/IP features and sample programs is provided in Chapter 6, "Using the ZigBee Features."

4.2.1 Digital I/O

The following sample programs are found in the **SAMPLES\BL4S1xx\DIO** subdirectory.

Figure 14 shows the signal connections for the sample programs that illustrate the use of the digital inputs.

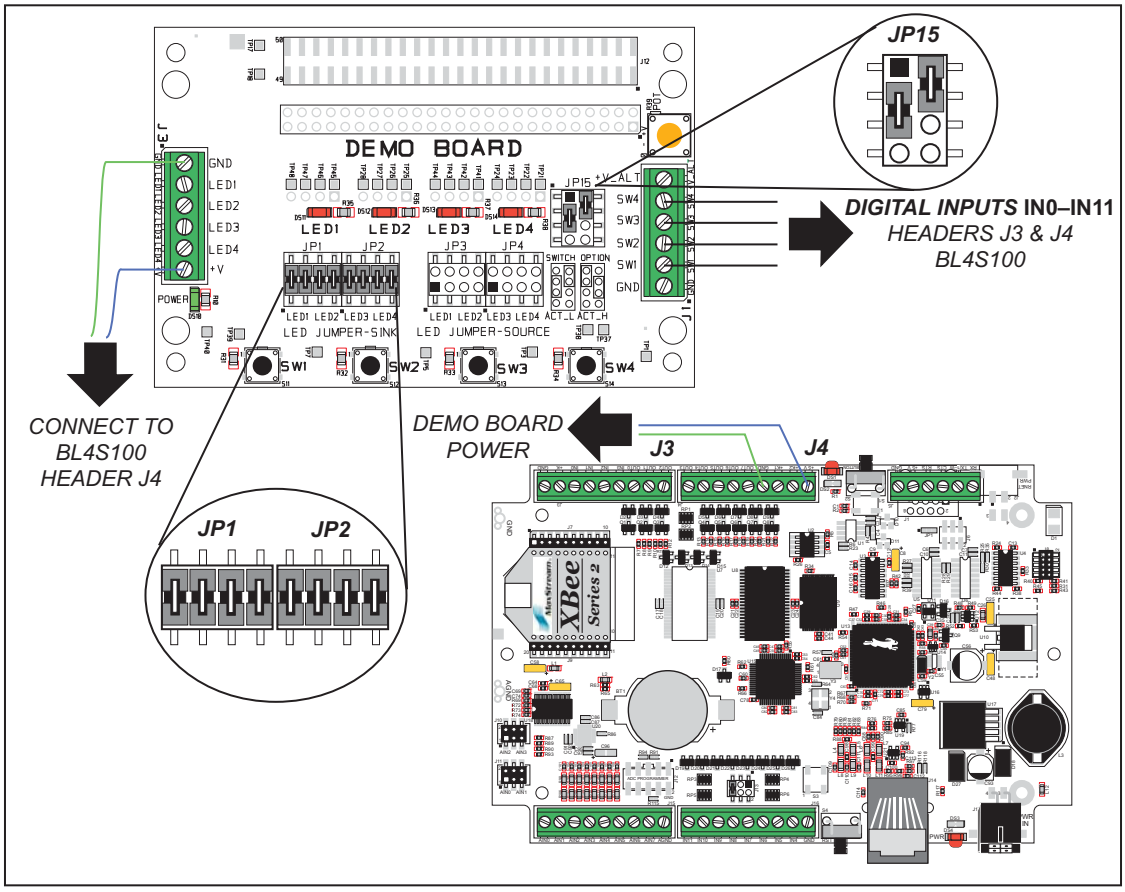


Figure 14. Digital Inputs Signal Connections

- **DIGIN.C**—Demonstrates the use of the digital inputs. Using the Demonstration Board, you can see an input channel toggle from HIGH to LOW in the Dynamic C **STDIO** window when you press a pushbutton on the Demonstration Board.
- **DIGIN_BANK.C**—Demonstrates the use of **digInBank()** to read digital inputs. Using the Demonstration Board, you can see an input channel toggle from HIGH to LOW in the Dynamic C **STDIO** window when you press a pushbutton on the Demonstration Board. The banking functions allow I/O banks to be input or output more efficiently.

Figure 15 shows the signal connections for the sample programs that illustrate the use of the digital outputs.

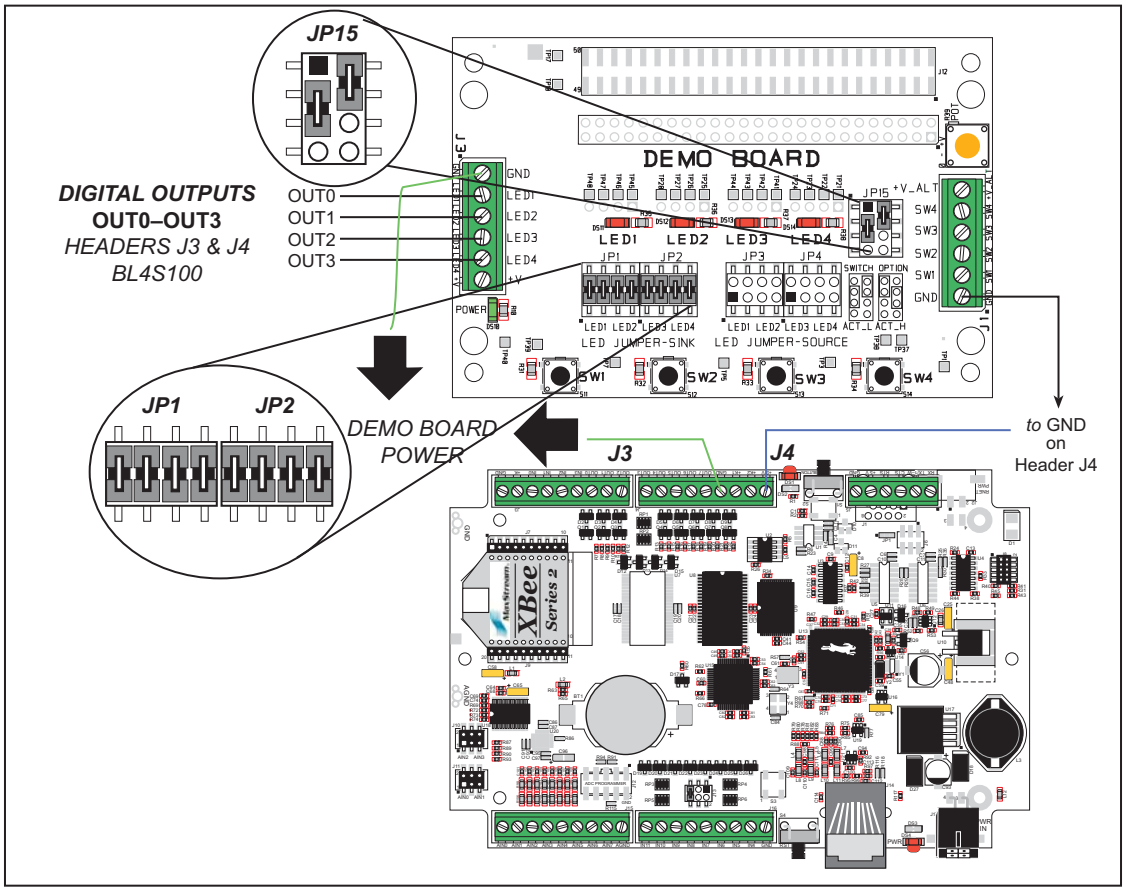


Figure 15. Digital Outputs Signal Connections

- **`DIGOUT.C`**—Demonstrates the use of the sinking digital outputs. Using the Demonstration Board, you can see an LED toggle on/off via a sinking output that you selected via the Dynamic C **STDIO** window.
- **`DIGOUT_BANK.C`**—Demonstrates the use of **`digOutBank()`** to control the sinking digital outputs. Using the Demonstration Board, you can see an LED toggle on/off via a sinking output that you selected via the Dynamic C **STDIO** window. The banking functions allow I/O banks to be input or output more efficiently.

- **INTERRUPTS.C**—Demonstrates the use of the Rabbit RIO interrupt service capabilities. Set up the Demonstration Board as shown in Figure 14 with IN0 connected to SW1.

  The sample program sets up two interrupt sources, an external interrupt tied to pushbutton switch SW1, and a rollover interrupt tied to a timer that is producing a PWM output. The Dynamic C **STDIO** window will show a count of rollovers that have occurred since the PWM signal was started. The window will also display *Button Pressed* each time the pushbutton switch is pressed. Each time the button is pressed, the timeout timer that removes the message is reset, so you can keep the message on the screen indefinitely by pressing the button repeatedly.

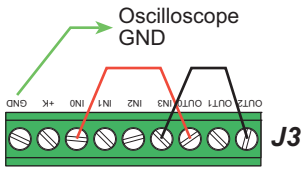
- **PPM.C**—Demonstrates the use of up to eight PPM channels on the digital output pins on headers J3 and J4. The PPM signals are set for a frequency of 200 Hz, with the duty cycle adjustable from 0 to 100% and an offset adjustable from 0 to 100% by the user. These pins can be connected to an oscilloscope to view the waveform being generated. The overall frequency can be adjusted in the **#define PPM_FREQ** line. Follow these instructions when running this sample program.

  1. The digital outputs on the BL4S100 do not have an internal pull-up resistor and will not register on the oscilloscope without a pull-up resistor. The Demonstration Board has pull-up resistors—connect OUT0–OUT3 on the BL4S100 to SW1–SW4 on header J1 of the Demonstration Board.
  2. Connect the oscilloscope probe to digital output pins OUT0–OUT3 on headers J3 or J4. Remember to connect the oscilloscope ground to GND on header J4.

  Once you compile and run the sample program, change the duty cycle and offsets for a given PPM channel via the Dynamic C **STDIO** window and watch the change in waveforms on the oscilloscope. Signals on OUT0 and OUT1 will all be synchronized with each other as they share the same overall counter block that sets the cycle frequency. The same is true for PPM signals on OUT2 and OUT3 (and the remaining digital outputs when you connect them to J1 on the Demonstration Board instead of those already connected). The two blocks may have a phase shift from each other, but will run at the same frequency.

- **PULSE_CAPTURE.C**—Demonstrates the use of two input capture inputs tied to PPM channels on the digital I/O pins on header J3. The input capture feature allows the begin and end positions of a pulse to be measured in a given time window. We take advantage of the counter synchronization feature of the underlying Rabbit RIO chip to create capture windows and pulse modulation windows that are synchronized. This guarantees that we always catch the begin edge first on a quickly repeating waveform. This was done to create an interactive element to this sample program, but capturing real-world repetitive signals will usually not have this advantage. Refer to Appendix D for more information on how to use the input capture.feature. Follow the instructions below when running this sample program.

  1. Connect I/O pins IN0 and OUT0 together.
  2. Connect I/O pins IN3 and OUT2 together.
  3. Connect the oscilloscope ground to GND on header J3.
  4. Use the oscilloscope probes on the IN0 and the OUT0 pair or the IN3 and OUT2 pair to view the PPM signals.

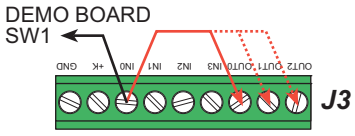


Once the connections have been made, compile and run this sample program. Change the offset and duty cycle for a given PPM channel via the Dynamic C **STDIO** window and watch the change to the begin and end counts measured on the input capture inputs. The PPM frequency can be changed in the **#define PPM_FREQ** line.

Rabbit recommends that you run and understand both the **INTERRUPTS.C** and the **PULSE_CAPTURE.C** sample programs before looking at **PULSE_CAPTURE_IRQ.C** since **PULSE_CAPTURE_IRQ.C** uses concepts covered in the simpler sample programs.

- **PULSE_CAPTURE_IRQ.C**—Demonstrates the use of an advanced pulse capture method using RIO interrupts.

  IN0 is configured as the pulse capture input, and OUT0–OUT7 are configured as PWM outputs of varying frequencies and duty cycles that provide signals to test the capture with. Connect IN0 and OUT0 together.

  If an external signal source is available, connect it to IN0 for capture.

  If an external signal source is not available, connect IN0 on the BL4S100 to SW1.

  Once you compile and run this sample program, press any key on your PC keyboard to pause or unpause the display—the capture will continue in the background. Change the IN0 connection to any of OUT0–OUT7 or an external source to capture a different signal.

  This sample program will continuously capture single pulses in an interrupt service request for display

- **PWM.C**—Demonstrates the use of the eight PWM channels on digital output pins OUT0–OUT7. The PWM signals are set for a frequency of 200 Hz with the duty cycle adjustable from 0 to 100% by the user. These pins can be connected to an oscilloscope to view the waveform being generated. The overall frequency can be adjusted in the **#define PWM_FREQ** line. Follow these instructions when running this sample program.

  1. The digital outputs on the BL4S100 do not have an internal pull-up resistor and will not register on the oscilloscope without a pull-up resistor. The Demonstration Board has pull-up resistors—connect OUT0–OUT3 on the BL4S100 to SW1–SW4 on header J1 of the Demonstration Board.
  2. Connect the oscilloscope probe to digital output pins OUT0–OUT3 on headers J3 or J4. Remember to connect the oscilloscope ground to GND on header J4.

  Once you compile and run the sample program, change the duty cycle for a given PWM output channel via the Dynamic C **STDIO** window and watch the change in waveforms on the oscilloscope. Signals on the same RIO counter block (OUT0 and OUT1 for example) will all be synchronized with each other. Different blocks may have a phase shift from each other, but will run at the same frequency.

  Global synchronization can be used to synchronize different block on the RIO, but this is not demonstrated in this sample program.

- **`QUADRATURE_DECODER.C`**—Demonstrates the use of quadrature decoders on the BL4S100. See Figure 16 for hookup instructions of the digital I/O pins on headers J3 and J4 with the Demonstration Board.

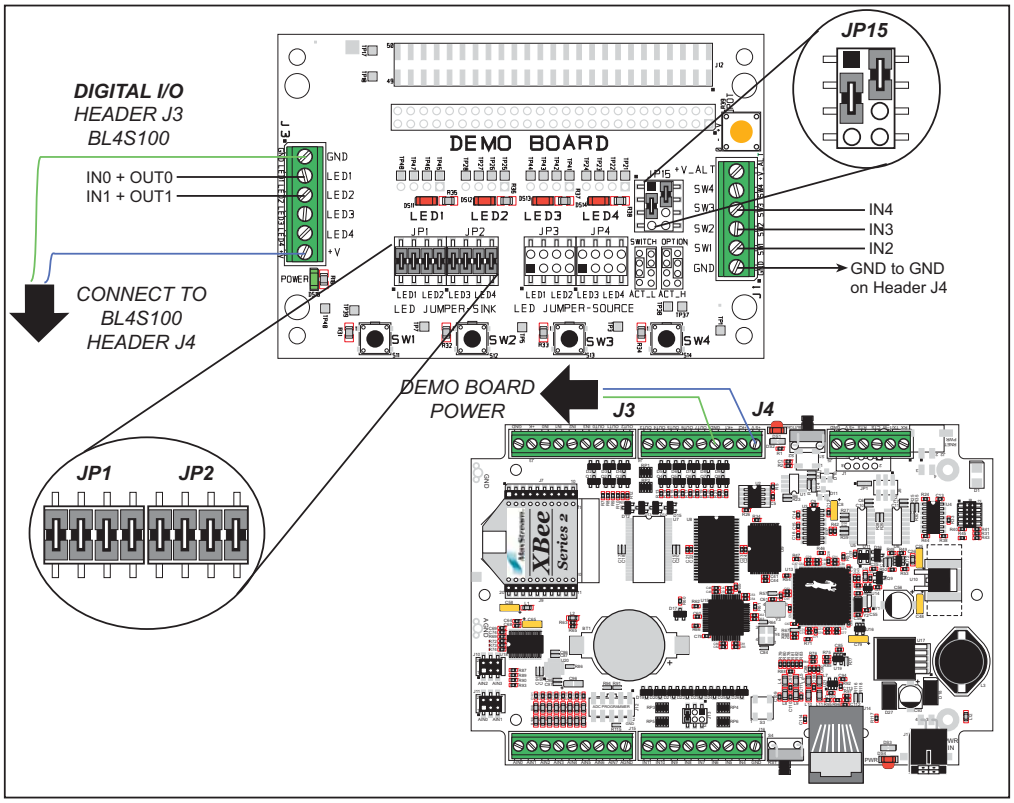
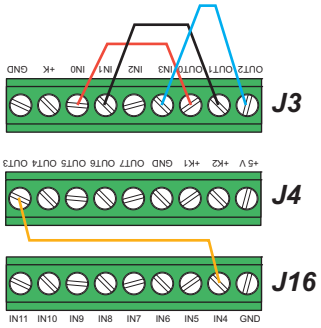


Figure 16. Quadrature Decoder Signal Connections

Once the connections have been made, compile and run this sample program. Press button SW1 on the Demonstration Board to decrement the quadrature counter, or press button SW2 on the Demonstration Board to increment the quadrature counter. The counter will continue to increment or decrement as you hold down the corresponding pushbutton. Press button SW3 on the Demonstration Board to reset the quadrature counter.

- **PPM_QUADRATURE_DECODER.C**—Demonstrates the use of two PWM and two PPM output channels connected back to four digital inputs to simulate two Quadrature Decoders feeding signals into the BL4S100. The PWM and PPM outputs are adjusted through a menu system to simulate the movement of a Quadrature Decoder. The results of the Quadrature Decoder inputs are displayed continuously to show the effects of the PWM and PPM outputs.

  The high-speed Quadrature Decoder counts the number of rollovers that occur (one per 1000 counts). The low-speed Quadrature Decoder displays the current count in the register.

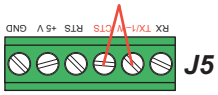
  Once the connections are made as shown, and you compile and run this sample program, change the frequency/direction for a given Quadrature Decoder via the Dynamic C **STDIO** window and watch the register counts on the low-speed channel and the register rollovers on the high-speed channel.

4.2.2 Serial Communication

The following sample programs are found in the **SAMPLES\BL4S1xx\RS232** subdirectory.

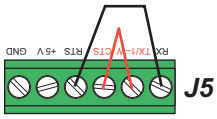
- **PARITY.C**—This sample program repeatedly sends byte values 0–127 from Serial Port D to Serial Port F. The program will cycle through parity types on Serial Port D. Serial Port F will always be checking parity, so parity errors should occur during most sequences. The results are displayed in the Dynamic C **STDIO** window.

  Connect Tx/1-W to CTS (RxF) on header J5 before compiling and running this sample program. You may wish to do **<Ctrl-Q>** to stop the program to see the data, which go by rather quickly.

  NOTE: For the sequence that does yield parity errors, the errors won't occur for each byte received. This is because certain byte patterns along with the stop bit will appear to generate the correct parity for the UART.

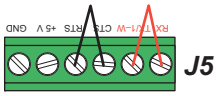
- **SIMPLE3WIRE.C**—This program demonstrates basic RS-232 serial communication using the Dynamic C **STDIO** window. Follow these instructions before running this sample program.

  Connect Tx/1-W to CTS (RxF), then connect Rx to RTS (TxF) before compiling and running this sample program.

- **SIMPLE5WIRE.C**—This program demonstrates 5-wire RS-232 serial communication using the Dynamic C **STDIO** window. Follow these instructions before running this sample program.

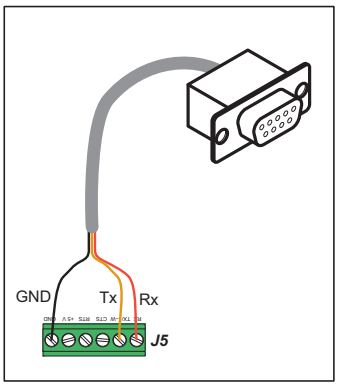
  Before you compile and run this sample program, connect Tx/1-W to Rx, then connect RTS to CTS.

  To test flow control, disconnect RTS from CTS while running this program. Characters should stop printing in the Dynamic C **STDIO** window and should resume when RTS and CTS are connected again.

- **COMPUTER_PARITY.C**—This sample program demonstrates using parity over a simple three-wire RS-232 connection. Parity is selected for the BL4S100 and for the serial terminal emulation program. Characters typed in either the Dynamic C **STDIO** window or in the serial terminal emulation program are echoed in both displays. Parity errors are counted and displayed by the Rabbit microprocessor on the BL4S100.

  Before you compile and run this sample program, use the long serial cable (Part No. 540-0094) to connect Tx (brown wire), Rx (red wire) and GND (black wire) on header J5 to a PC COM port.

  Open a Hyperterminal session (**Start > Accessories > Communications**). Select the PC COM port the cable is connected to and set the default serial parameters:

  Bits per second: 115200

  Data bits: 8

  Parity: None

Stop bits: 1

Flow control: None

Once you compile and run this program, configure the serial port using the following menu options in the Dynamic C **STDIO** window.

```
Menu
q - Quit
s - Send "Sample Text"
r - Reset Counters
n - Set No Parity
e - Set Even Parity
o - Set Odd Parity
```

Type in the Hyperterminal window to send characters to the sample program. The characters typed will be echoed in the terminal emulation program and will be displayed on the top of the Dynamic C **STDIO** window with a message displaying whether there was an error or not. There may be some differences for special characters such as new lines (enter key), delete, backspace, and others. Each character sent will also increment either the successful or the error counter, depending on the parity of both the BL4S100 and the terminal emulation program.

- **COMPUTER3WIRE.C**—This sample program demonstrates basic initialization for a simple three-wire RS-232 connection. Characters typed in either the Dynamic C **STDIO** window or in a serial terminal emulation program are echoed in both displays.

  The setup and run instructions are the same as for the **COMPUTER_PARITY.C** sample program.

- **COMPUTER5WIRE.C**—This sample program demonstrates basic initialization for a simple five-wire RS-232 connection. Characters typed in either the Dynamic C **STDIO** window or in a serial terminal emulation program are echoed in both displays.

  The setup and run instructions are the same as for the **COMPUTER_PARITY.C** sample program.

4.2.3 A/D Converter Inputs

The following sample programs are found in the **SAMPLES\BL4S1xx\ADC** subdirectory. You will need a separate power supply and a multimeter to use with these sample programs.

> **NOTE:** The calibration sample programs will overwrite the calibration constants set at the factory. Before you run these sample programs, run **USERBLOCK_READ_WRITE.C** in the **SAMPLES\UserBlock** folder to save the factory calibration constants in case you inadvertently write over them while running other sample programs.

> **NOTE:** For best results use a multimeter with a resolution of at least 4½ digits.

- **ADC_CAL_DIFF.C**—Demonstrates how to recalibrate a differential A/D converter channel using two measured voltages to generate two coefficients, gain and offset, which are rewritten into the user block. The voltage that is being monitored is displayed continuously.

  Once you compile and run this sample program, connect the power supply across a differential channel pair, then follow the instructions in the Dynamic C **STDIO** window.

- **ADC_CAL_MA.C**—Demonstrates how to recalibrate a milli-amp A/D converter channel using two measured currents to generate two coefficients, gain and offset, which are rewritten into the reserved user block. The current that is being monitored is displayed continuously.

  Before you compile and run this sample program, jumper pins 1–2 and 5–6 on headers J10 and J11. Then connect a current meter in series with the power supply connected to one of pins AIN0–AIN3 and AGND, then compile and run the sample program, and follow the instructions in the Dynamic C **STDIO** window.

- **ADC_CAL_SE_UNIPOLAR.C**—Demonstrates how to recalibrate a single-ended unipolar A/D converter channel using two measured voltages to generate two coefficients, gain and offset, which are rewritten into the reserved user block. The voltage that is being monitored is displayed continuously.

  Before you compile and run this sample program, connect the power supply (which should be OFF) between the pin (AIN0–AIN7) of the channel you are calibrating and AGND, then compile and run the sample program, and follow the instructions in the Dynamic C **STDIO** window.

- **ADC_AVERAGING_SE_UNIPOLAR.C**—Demonstrates how to read and display the average voltage of each of the single-ended analog input channels using a sliding window. The voltage is calculated from coefficients read from the display—the two calibration coefficients, gain and offset, in the Dynamic C **STDIO** window for each channel, and mode of operation.

  Before you compile and run this sample program, connect the power supply (which should be OFF) between the pin (AIN0–AIN7) of an analog input channel and AGND, then compile and run the sample program, and follow the instructions in the Dynamic C **STDIO** window.

- **ADC_RD_CALDATA.C**—Demonstrates how to display the two calibration coefficients, gain and offset, in the Dynamic C **STDIO** window for each channel and mode of operation.
- **ADC_RD_DIFF.C**—Demonstrates how to read and display voltage and equivalent values for a differential A/D converter channel using calibration coefficients previously stored in the user block. The user selects to display either the raw data or the voltage equivalent.

  Once you compile and run this sample program, connect the power supply across a differential channel pair, then follow the instructions in the Dynamic C **STDIO** window.
- **ADC_RD_MA.C**—Demonstrates how to read and display voltage and equivalent values for a milli-amp A/D converter channel using calibration coefficients previously stored in the user block.

  Before you compile and run this sample program, jumper pins 1–2 and 5–6 on headers J10 and J11. Then connect a current meter in series with the power supply connected to one of pins AIN0–AIN3 and AGND, then compile and run the sample program, and follow the instructions in the Dynamic C **STDIO** window as you vary the output from the power supply.
- **ADC_RD_SE_UNIPOLAR.C**—Demonstrates how to read and display the voltage of all single-ended analog input channels using calibration coefficients previously stored in the user block.

  Before you compile and run this sample program, connect the power supply (which should be OFF) between a pin (AIN0–AIN7) and AGND, then compile and run the sample program, and follow the instructions in the Dynamic C **STDIO** window. The voltage readings will be displayed for all the channels measured to that point.

4.2.4 Real-Time Clock

If you plan to use the real-time clock functionality in your application, you will need to set the real-time clock. You may set the real-time clock using the **SETRTCKB.C** sample program from the Dynamic C **SAMPLES\RTCLOCK** folder. The **RTC_TEST.C** sample program in the Dynamic C **SAMPLES\RTCLOCK** folder provides additional examples of how to read and set the real-time clock

4.2.5 TCP/IP Sample Programs

TCP/IP sample programs are described in Chapter 5.

4.2.6 ZigBee Sample Programs

ZigBee sample programs are described in Chapter 6.

4.3 BL4S100 Libraries

Two library directories provide libraries of function calls that are used to develop applications for the BL4S100.

- **`BL4S1xx`**—libraries associated with features specific to the BL4S100. The functions in the **`BL4S1xx.LIB`** library are described in Section 4.4, “BL4S100 Function Calls.”
- **`TCPIP`**—libraries specific to using TCP/IP functions on the BL4S100. Further information about TCP/IP is provided in Chapter 5, “Using the Ethernet TCP/IP Features.”
- **`ZigBee`**—libraries specific to using ZigBee functions on the BL4S100. Further information about ZigBee is provided in Chapter 6, “Using the ZigBee Features.”

4.4 BL4S100 Function Calls

4.4.1 Board Initialization

---

brdInit

```
void brdInit (void);
```

FUNCTION DESCRIPTION

Call this function at the beginning of your program. This function initializes Parallel Ports A–E, the Rabbit RIO chip, and the A/D converter.

The ports are initialized according to Table A-3 in Appendix A.

4.4.2 Digital I/O

setDigIn

```
int setDigIn(int channel);
```

FUNCTION DESCRIPTION

Sets an input channel to be a general digital input.

PARAMETERS

channel digital input channel, 0–11 (pins IN0–IN11)

RETURN VALUE

0 — success.

-EINVAL — invalid parameter value.

SEE ALSO

brdInit, digIn, digInBank

digIn

```
int digIn(int channel);
```

FUNCTION DESCRIPTION

Reads the state of a digital input channel.

PARAMETERS

channel digital input channel, 0–11 (pins IN0–IN11)

RETURN VALUE

The logic state of the specified channel.

0 — logic low
1 — logic high

-EINVAL — channel value is out of range.

-EPERM:— channel functionality does not permit this operation.

SEE ALSO

brdInit, setDigIn, digInBank

digInBank

```
int digInBank(int bank);
```

FUNCTION DESCRIPTION

Reads the state of the 12 digital input channels in banks of up to 8 input channels.

PARAMETER

bank digital input bank pins:

0 — IN0–IN7
1 — IN8–IN11

RETURN VALUE

Data read from the bank of digital inputs.

Data Bits		Bank 0	Bank 1
LSB	D0	IN0	IN8
	D1	IN1	IN9
	D2	IN2	IN10
	D3	IN3	IN11
	D4	IN4	not used
	D5	IN5	
	D6	IN6	
MSB	D7	IN7	

-EINVAL — invalid parameter value.

SEE ALSO

brdInit, digIn, setDigIn

setExtInterrupt

```
int setExtInterrupt(int channel, char edge, int handle);
```

FUNCTION DESCRIPTION

Sets the specified channel to be an interrupt. The interrupt can be configured as a rising edge, falling edge, or either edge.

PARAMETERS

channel	digital input channel to be configured as an interrupt channel, 0–11 (pins IN0–IN11)
edge	macro to set edge of the interrupt: **BL_IRQ_RISE** — interrupt event on rising edge **BL_IRQ_FALL** — interrupt event on falling edge **BL_IRQ_BOTH** — interrupt events on both edges
handle	handle for the ISR handler to service this interrupt

RETURN VALUE

0 — success.

-EINVAL — invalid parameter value.

-EPERM — pin type does not permit this function.

-EACCES — resource needed by this function is not available.

-EFAULT — internal data fault detected.

positive number — Mode Conflict — the positive number is a bitmap that corresponds to the pins on a particular block of a RIO chip that have not been configured to support this function call. Appendix D provides the details of the pin and block associations to allow you to identify the channels that need to be reconfigured to support this function call.

SEE ALSO

brdInit, digIn, setDigIn

setDecoder

```
int setDecoder(int channel_a, int channel_b, int channel_index,
   char index_polarity);
```

FUNCTION DESCRIPTION

Sets up Quadrature Decoder functionality on the specified channels. The Quadrature Decoder may optionally use an index channel.

PARAMETERS

`channel_a` channel to use as Input A (also known as in-phase or I), 0–11 (pins IN0–IN11)

`channel_b` channel to use as Input B (also known as quadrature or Q), 0–11 (pins IN0–IN11)

`channel_index` channel to use as index input (-1 if not used), 0–11 (pins IN0–IN11)

NOTE: The Quadrature Decoder count may still be reset by existing or new synch signals set up on the same block of a particular RIO chip.

`index_polarity` polarity of the index channel (not used when channel_index set to -1)

0 — index on low level
non-zero — index on high level

RETURN VALUE

0 — success.

`-EINVAL` — invalid parameter value.

`-EACCESS`— resource needed by this function is not available.

SEE ALSO

`brdInit, getCounter, resetCounter`

setCounter

```
int setCounter(int channel, int mode, int edge, word options);
```

FUNCTION DESCRIPTION

Sets up the channel as a counter input, with selectable modes and edge settings. The counter will increment or decrement on each selected edge event. Use **`getCounter()`** to read the current count and use **`resetCounter()`** to force a reset of the counter.

PARAMETERS

`channel` channel to use for the up count input, 0–11 (pins IN0–IN11)

`mode` macro to set the mode of the counter:

`BL_UP_COUNT` — continuous up count mode

`BL_DOWN_COUNT` — up/down count mode (uses 2 pins)

`BL_MATCH_ENABLE` — continuous up count mode with count stopping on any match event

`edge` edge setting macro for the up count event:

`BL_EDGE_RISE` — up count on rising edge

`BL_EDGE_FALL` — up count on falling edge

`BL_EDGE_BOTH` — up count on either edge

`options` options based on mode (N/A if the continuous up mode is selected):

`BL_EDGE_RISE` — down count on rising edge

`BL_EDGE_FALL` — down count on falling edge

`BL_EDGE_BOTH` — down count on either edge

If the up/down mode is selected, **`options`** has down count channel and event edge settings (these settings cannot be on the same pin as the up count) ORed together. The low 4 bits are the channel number for the down count input

If the **`BL_MATCH_ENABLE`** mode is selected, **`options`** has the match count to stop at (other match registers on the block are set to max.).

RETURN VALUE

0 — success.

-EINVAL — invalid parameter value or pin use.

-EPERM — pin type does not permit this function.

-EACCESS— resource needed by this function is not available.

-EFAULT — internal data fault detected.

positive number — Mode Conflict — the positive number is a bitmap that corresponds to the pins on a particular block of a RIO chip that have not been configured to support this function call. Appendix D provides the details of the pin and block associations to allow you to identify the channels that need to be reconfigured to support this function call.

SEE ALSO

brdInit, getCounter, resetCounter

setCapture

```
int setCapture(int channel, int mode, int edge, word options);
```

FUNCTION DESCRIPTION

Sets up the channel as an event capture input, with selectable modes and edge settings. The counter will run from a gated main or prescaled clock signal based on the run criteria of the selected mode, and begin/end events can be set to capture the count at the time of these events. Optionally, a second channel can be set (which shares the same RIO channel input block as **channel**) for two-signal begin/end event detection. Use **getBegin()** and **getEnd()** to read the captured count values and use **resetCounter()** to force a reset of the counter.

PARAMETERS

channel — channel to use for the begin event input for all modes except **BL_CNT_TIL_END**, then it specifies the end event input.,
0–11 (pins IN0–IN11)

mode — mode macro for the counter/timer:

BL_CNT_RUN — continuous count mode

BL_CNT_BEGIN_END — start count on begin event, continue to count until end event detected

BL_CNT_TIL_END — count until end event detected

BL_CNT_ON_BEGIN — count while begin signal is active

NOTE: If an end event occurs before the begin event, the count will begin then end immediately on the begin event, and the end count will be 1. The begin count will be 0 or 1 based on the edge that triggered the event (0 = rising, 1 = falling).

edge — edge/state macro setting for the begin event for all modes except **BL_CNT_TIL_END**, then it specifies the end event:

BL_EVENT_RISE — begin event on rising edge
BL_EVENT_FALL — begin event on falling edge
BL_EVENT_BOTH — begin event on any edge

The following two settings are only for the **BL_CNT_ON_BEGIN** mode:

BL_BEGIN_HIGH — begin active while signal is high
BL_BEGIN_LOW — begin active while signal is low

options options based on mode:

BL_CNT_TIL_END — begin input and edge can be selected
all others modes — end input and edge can be selected.

For all modes, the prescale clock and save limit flags can be used (OR in).

For input and edge selection, use:

low 5 bits for channel to use for begin/end input
BL_SAME_CHANNEL — begin and end both from same channel
BL_EVENT_RISE — begin/end event on rising edge
BL_EVENT_FALL — begin/end event on falling edge
BL_EVENT_BOTH — begin/end event on any edge

For clock and limit options use:

BL_PRESCALE — use prescaled clock
BL_SAVE_LIMIT — save current limit register value (otherwise limit set to 0xFFFF)

RETURN VALUE

0 — success.

-EINVAL — invalid parameter value.

-EPERM — pin type does not permit this function.

-EACCESS— resource needed by this function is not available.

-EFAULT — internal data fault detected.

positive number — Mode Conflict — the positive number is a bitmap that corresponds to the pins on a particular block of a RIO chip that have not been configured to support this function call. Appendix D provides the details of the pin and block associations to allow you to identify the channels that need to be reconfigured to support this function call.

SEE ALSO

brdInit, getBegin, getEnd, getCounter, resetCounter

getCounter

```
int getCounter(int channel, word *count);
```

FUNCTION DESCRIPTION

Reads the current count of the counter register within the counter block hosting the given channel.

PARAMETERS

channel	digital input channel that uses the desired counter block, 0–11 (pins IN0–IN11)
count	pointer to word variable to place count register reading

RETURN VALUE

0 — success.

-EINVAL — invalid parameter value.

SEE ALSO

brdInit, setCounter, setDecoder, setCapture, resetCounter

getBegin

```
int getBegin(int channel, word *begin);
```

FUNCTION DESCRIPTION

Reads the current value of the begin register within the counter block hosting the given channel.

PARAMETERS

channel	digital input channel that uses the desired counter block, 0–11 (pins IN0–IN11)
begin	pointer to word variable to place begin register reading

RETURN VALUE

0 — success.

-EINVAL — invalid parameter value.

-EPERM — pin type does not permit this function.

SEE ALSO

brdInit, setCapture, resetCounter, getEnd

getEnd

```
int getEnd(int channel, word *end);
```

FUNCTION DESCRIPTION

Reads the current value of the end register within the counter block hosting the given channel.

PARAMETERS

`channel` digital input channel that uses the desired counter block, 0–11 (pins IN0–IN11)

`begin` pointer to word variable to place end register reading

RETURN VALUE

0 — success.

`-EINVAL` — invalid parameter value.

`-EPERM` — pin type does not permit this function.

SEE ALSO

`brdInit, setCapture, resetCounter, getBegin`

resetCounter

```
int resetCounter(int channel);
```

FUNCTION DESCRIPTION

Resets the current count of the counter register within the counter block hosting the given channel.

PARAMETER

`channel` digital input channel that uses the desired counter block, 0–11 (pins IN0–IN11)

RETURN VALUE

0 — success.

`-EINVAL` — invalid parameter value.

`-EPERM` — pin type does not permit this function.

SEE ALSO

`brdInit, getCounter, setDecoder`

setLimit

```
int setLimit(int channel, word limit);
```

FUNCTION DESCRIPTION

Sets the value of the limit register within the counter block hosting the given channel. This new value will take effect on the next counter overflow or by resetting the counter via the **`resetCounter()`** function call.

PARAMETERS

`channel`	digital input channel that uses the desired counter block, 0–11 (pins IN0–IN11)
`limit`	new value for the limit register

RETURN VALUE

0 — success.

`-EINVAL` — invalid parameter value.

`-EPERM` — pin type does not permit this function.

SEE ALSO

`brdInit, setCapture, resetCounter`

setSyncIn

```
int setSyncIn(int channel, int source, int edge);
```

FUNCTION DESCRIPTION

Sets the synch for the block the digital input channel is associated with.

Note that when more than one block is synchronized to the same synch signal (global or external), each block has its own independent edge-detection circuit. These circuits will synch to the edge within plus or minus one count of the block's current clock source (main or prescale). This means synchronized blocks may have a small offset when compared to each other.

PARAMETERS

`channel` digital input channel that is on the block that will have its synch set, 0–11 (pins IN0–IN11)

`source` source of the synch signal.

-1 to use the RIO chip's Global Synch signal *or*
input-capable channel to use as an external synch signal

`edge` edge of the synch signal.

`BL_EDGE_RISE` — synchronize event on rising edge
`BL_EDGE_FALL` — synchronize event on falling edge
`BL_EDGE_BOTH` — synchronize events on both edges
`0` — disable the synch on this block (if the source of the external synch is given, it will be set to a digital input)

RETURN VALUE

0 — success.

`-EINVAL` — invalid parameter value.

`-EPERM` — pin type does not permit this function.

`-EACCES` — resource needed by this function is not available.

`-EFAULT` — internal data fault detected.

SEE ALSO

`brdInit, setSyncOut`

globalSync

```
int globalSync(void);
```

FUNCTION DESCRIPTION

Sends a single pulse to the global synch inputs of all RIO chips.

Note that when more than one block is synchronized to the same synch signal (global or external), each block has its own independent edge-detection circuit. These circuits will synch to the edge within plus or minus one count of the block's current clock source (main or prescale). This means synchronized blocks may have a small offset when compared to each other.

RETURN VALUE

0 — success.

`-EPERM` — **`brdInit()`** was not run before calling this function.

SEE ALSO

`brdInit`

setDigOut

```
int setDigOut(int channel, int state);
```

FUNCTION DESCRIPTION

Configures the output channel as a simple digital output. The output state of the channel is also initialized to logic 0 or logic 1 based on the **state** parameter. The digOut function should be used to control the output state after configuration as it is more efficient. This function is non-reentrant.

PARAMETERS

channel digital output channel, 0–7 (OUT0–OUT7)

state set output to one of the following states:

0 — connects the load to GND
1 — puts the output in a high-impedance state

RETURN VALUE

0 — success.

-EINVAL — invalid parameter value.

SEE ALSO

brdInit, digOut, digOutBank

digOut

```
void digOut(int channel, int state);
```

FUNCTION DESCRIPTION

Sets the state of a digital output channel to a logic 0 or a logic 1. This function will only allow control of pins that are configured by the **`setDigOut()`** function call.

PARAMETERS

`channel` digital output channel, 0–7 (OUT0–OUT7)

`state` set output to one of the following states:

0 — connects the load to GND
1 — puts the output in a high-impedance state.

RETURN VALUE

0 — success.

`-EINVAL` — invalid parameter value.

`-EPERM` — pin function was not set up as a digital output

SEE ALSO

`brdInit, setDigOut, digOutBank`

digOutBank

```
int digOutBank(char bank, char data);
```

FUNCTION DESCRIPTION

Sets the state (logic 0 or logic 1) of a bank of 8 digital output pins to the states contained in the **data** parameter. This function only updates the channels that are configured to be sinking digital outputs by the **setDigOut()** function call.

PARAMETERS

bank digital output bank pins:

0 — OUT0–OUT7

data data value to be written to the specified digital output bank; the data format and bitwise value are as follows:

Data Bits		Bank 0
LSB	D0	OUT0
	D1	OUT1
	D2	OUT2
	D3	OUT3
	D4	OUT4
	D5	OUT5
	D6	OUT6
MSB	D7	OUT7

Bitwise value:

0 — connects the load to GND
1 — puts the output in a high-impedance state.

RETURN VALUE

0 — success.

-EINVAL — invalid parameter value or board not initialized.

SEE ALSO

brdInit, digOut, setDigOut

setPWM

```
int setPWM(int channel, float frequency, float duty, int invert,
   int bind);
```

FUNCTION DESCRIPTION

Sets up a PWM output on the selected digital output channel with the specified frequency and duty cycle. The PWM output can be inverted. The PWM channel duty cycle can be bound to a PWM/PPM on another channel on the same RIO block so that they share an edge.

PARAMETERS

`channel` digital output channel being set up for PWM, 0–7 (OUT0–OUT7)

`frequency` PWM frequency in Hz (should be from 2 Hz to 50 kHz); use -1 to preserve the existing frequency on the RIO block

`duty` PWM duty cycle (should be from 0 to 100%); use -1 and **`bind`** parameter to use bound edge to set the duty cycle

`invert` whether the PWM output is inverted; the PWM output normally starts with the output high and inverted starts with the output low.

0 — noninverted
1 — inverted

`bind` use **`BL_BIND_LEAD`** or **`BL_BIND_TRAIL`** ORed with another digital output channel hosted by the same block to enable binding for the leading of the PWM output on this channel. Bindings allow PWM and PPM outputs to align their leading and trailing edges.

RETURN VALUE

0 — success.

-EINVAL — invalid parameter value.

-EPERM — pin type does not permit this function.

-EACCES — resource needed by this function is not available.

-EFAULT — internal data fault detected.

positive number — Mode Conflict — the positive number is a bitmap that corresponds to the pins on a particular block of a RIO chip that have not been configured to support this function call. Appendix D provides the details of the pin and block associations to allow you to identify the channels that need to be reconfigured to support this function call.

SEE ALSO

brdInit, setFreq, setDuty, setSyncIn, setSyncOut, pulseEnable, pulseDisable, setPPM

setPPM

```
int setPPM(int channel, float frequency, float offset,
   float duty, char invert, int bind_offset, int bind_duty);
```

FUNCTION DESCRIPTION

Sets up a PPM output on the selected digital output channel with the specified frequency and duty cycle. The PPM output of the PPM can be inverted. The offset and duty of the PPM can be bound to a PWM/PPM on another channel on the same RIO block so that they share an edge.

PARAMETERS

`channel` digital output channel being set up for PWM, 0–7 (OUT0–OUT7)

`frequency` PPM frequency in Hz (should be from 2 Hz to 50 kHz); use -1 to preserve the existing frequency on the RIO block

`offset` PPM offset (should be from 0 to 100%); use -1 and **`bind_offset`** parameter to use bound edge to set the offset

NOTE: A zero offset will produce the smallest offset possible, which is one count. If you must have a zero offset, use **`setPWM()`** instead of **`setPPM()`**.

`duty` PPM duty cycle (should be from 0 to 100%); use -1 and **`bind_duty`** parameter to use bound edge to set the duty cycle

NOTE: PPM will not wrap around the PPM period. If **`offset`** is set to 25%, the 75 to 100% duty cycle will have the same effect as **`offset`** = 25%, **`duty`** = 75%. The same waveform as a wrapped PPM can be created using an inverted PPM

`invert` whether the PPM output is inverted; the PPM output normally starts with the output low, goes high at the offset, and stays high for the remainder of the duty cycle; inverted will start with the output high, goes low at the offset, and stays low for the duration of the duty cycle.

0 — noninverted
1 — inverted

`bind_offset` use **`BL_BIND_LEAD`** or **`BL_BIND_TRAIL`** ORed with another digital output channel hosted by the same block to enable binding for the leading edge of the PPM output on this channel. Bindings allow PWM and PPM outputs to align their leading and trailing edges.

`bind_duty` use **`BL_BIND_LEAD`** or **`BL_BIND_TRAIL`** ORed with another digital output channel hosted by the same block to enable binding for the trailing edge of the PPM output on this channel. Bindings allow PWM and PPM outputs to align their leading and trailing edges

RETURN VALUE

0 — success.

-EINVAL — invalid parameter value.

-EPERM — pin type does not permit this function.

-EACCES — resource needed by this function is not available.

-EFAULT — internal data fault detected.

positive number — Mode Conflict — the positive number is a bitmap that corresponds to the pins on a particular block of a RIO chip that have not been configured to support this function call. Appendix D provides the details of the pin and block associations to allow you to identify the channels that need to be reconfigured to support this function call.

SEE ALSO

brdInit, setFreq, setOffset, setDuty, setSyncIn, setSyncOut, pulseEnable, pulseDisable, setPWM

setFreq

```
int setFreq(int channel, float frequency);
```

FUNCTION DESCRIPTION

Sets the frequency of all the PWM or PPM outputs on the same block as the channel. Will preserve the duty cycle and offset percentages for all of the channels on the same block.

Repeated calls to this function by itself may cause the duty cycle and offset values to drift. If this drift is of concern, call **`setOffset()`** and **`setDuty()`** to reset the duty cycle and offset to the desired value.

PARAMETERS

`channel` — all digital output channels on the same RIO chip and block as this channel (0–7, OUT0–OUT7) will have their frequency set. Duty cycle and offset percentages will be maintained.

`frequency` — frequency of the PWM and PPM outputs (should be from 2 Hz to 50 kHz). Use -1 to preserve the existing frequency on the RIO block.

RETURN VALUE

0 — success.

`-EINVAL` — invalid parameter value.

SEE ALSO

`brdInit, setPWM, setPPM, setOffset, setDuty, setSyncIn, setSyncOut, pulseEnable, pulseDisable`

setDuty

```
int setDuty(int channel, float duty);
```

FUNCTION DESCRIPTION

Sets the duty cycle of the PWM or PPM output on a digital output channel. Will affect any PWM/PPM that has been bound to this channel's PWM/PPM.

PARAMETERS

channel	digital output channel that is getting its duty cycle set, 0–7 (OUT0–OUT7)
duty	duty cycle of the PWM/PPM output (should be from 0 to 100%)

RETURN VALUE

0 — success.

-EINVAL — invalid parameter value.

-EPERM — channel function does not permit this operation.

SEE ALSO

brdInit, setPWM, setPPM, setOffset, setFreq, setSyncIn, setSyncOut, pulseEnable, pulseDisable

setOffset

```
int setOffset(int channel, float offset);
```

FUNCTION DESCRIPTION

Sets the offset of a PPM output on a digital output channel. This function call will not affect the position of the trailing edge of the PPM output and so will change the duty cycle percentage of the PPM output. If the offset is set past the current position of the trailing edge of the PPM output (set by the duty cycle), the PPM output will start at the offset and will wrap around to the position of what was the trailing edge.

PARAMETERS

`channel` digital output channel that is getting its offset set, 0–7 (OUT0–OUT79)

`offset` PPM offset (should be from 0 to 100%)

NOTE: A zero offset will produce the smallest offset possible, which is one count. If you must have a zero offset, use **`setPWM()`** instead of **`setOffset()`**.

RETURN VALUE

0 — success.

`-EINVAL` — invalid parameter value.

`-EPERM` — channel function does not permit this operation.

SEE ALSO

`brdInit, setPWM, setPPM, setFreq, setDuty, setSyncIn, setSyncOut, pulseEnable, pulseDisable`

pulseDisable

```
int pulseDisable(int channel, int state);
```

FUNCTION DESCRIPTION

Disables a PWM/PPM output and sets the output to **state**. The pin can be restored to the same PWM/PPM operation as before by calling **pulseEnable()**.

PARAMETERS

channel digital output channel that is getting its PWM/PPM disabled, 0–7 (OUT0–OUT7)

state state that the digital output will be set to (0 or 1)

RETURN VALUE

0 — success.

-EINVAL — invalid parameter value.

-EPERM — channel function does not permit this operation.

SEE ALSO

brdInit, setPWM, setPPM, pulseEnable

pulseEnable

```
int pulseEnable(int channel);
```

FUNCTION DESCRIPTION

Enables a disabled PWM/PPM output. The pin is restored to the same PWM/PPM operation it had before being disabled.

PARAMETER

channel digital output channel that is getting its PWM/PPM enabled, 0–7 (OUT0–OUT7)

RETURN VALUE

0 — success.

-EINVAL — invalid parameter value.

-EPERM — channel function does not permit this operation.

SEE ALSO

brdInit, setPWM, setPPM, pulseDisable

setSyncOut

```
int setSyncOut(int channel, int source, int edge);
```

FUNCTION DESCRIPTION

Sets the synch for the block the digital output channel is associated with.

Note that when more than one block is synchronized to the same synch signal (global or external), each block has its own independent edge-detection circuit. These circuits will synch to the edge within plus or minus one count of the block's current clock source (main or prescale). This means synchronized blocks may have a small offset when compared to each other.

PARAMETERS

`channel` digital output channel that is on the block that will have its synch set, 0–7 (OUT0–OUT7)

`source` source of the synch signal.

-1 to use the RIO chip's Global Synch signal *or*
input-capable channel to use as an external synch signal

`edge` edge of the synch signal.

`BL_EDGE_RISE` — synchronize event on rising edge
`BL_EDGE_FALL` — synchronize event on falling edge
`BL_EDGE_BOTH` — synchronize events on both edges
`0` — disable the synch on this block (if the source of the external synch is given, it will be set to a digital input)

RETURN VALUE

0 — success.

`-EINVAL` — invalid parameter value.

`-EPERM` — pin type does not permit this function.

`-EACCES` — resource needed by this function is not available.

`-EFAULT` — internal data fault detected.

SEE ALSO

`brdInit, setSyncIn`

getMatch

```
int getMatch(int channel, int source);
```

FUNCTION DESCRIPTION

Returns the block match register use for the given channel. May optionally be filtered to specific sources by the **source** parameter.

PARAMETERS

channel digital output channel about which to get match information, 0–7 (OUT0–OUT7)

source source filter:

BL_TRAIL_ONLY will filter only the *Trail* match register
BL_LEAD_ONLY will filter only the *Lead* match register

Note that counters will only use the *Trail* match register.

RETURN VALUE

Bit flags showing match use on success:

BL_IER_MATCH0 bit set if using Match Register 0
BL_IER_MATCH1 bit set if using Match Register 1
BL_IER_MATCH2 bit set if using Match Register 2
BL_IER_MATCH3 bit set if using Match Register 3

or

-EINVAL — invalid channel value.

SEE ALSO

brdInit, setPWM, setPPM, setCounter

4.4.3 Rabbit RIO Interrupt Handlers

addISRIn

```
int addISRIn(int channel, int ier, void (*handler)());
```

FUNCTION DESCRIPTION

Adds an interrupt handler for the interrupts specified in the **ier** parameter for the given RIO block hosting the given configurable I/O pin. The interrupt service routine (ISR) is always disabled when created. Call **enableISR()** to enable the interrupt service routine. The ISR handler function is responsible for clearing the interrupt(s) within the hosting RIO block when called.

PARAMETERS

channel digital input channel to bind to ISR, 0–11 (IN0–IN11)

ier bit mask of interrupt(s) this handler services

- **BL_IER_DQE** — decrement/quadrature/end
- **BL_IER_IIB** — increment/inphase/begin
- **BL_IER_ROLL_D** — counter rollover on decrement
- **BL_IER_ROLL_I** — counter rollover on increment
- **BL_IER_MATCH3** — Match 3 condition
- **BL_IER_MATCH2** — Match 2 condition
- **BL_IER_MATCH1** — Match 1 condition
- **BL_IER_MATCH0** — Match 0 condition

handler pointer to the interrupt service function

RETURN VALUE

Success — returns the handler ID number (**0..RSB_MAX_ISR-1**).

-EINVAL— Invalid parameter given.

-ENOSPC — No more room in ISR table (increase **RSB_MAX_ISR**).

SEE ALSO

addISROut, tickISR, enableISR, setIER

addISROut

```
int addISROut(int channel, int ier, void (*handler)());
```

FUNCTION DESCRIPTION

Adds an interrupt handler for the interrupts specified in the **ier** parameter for the given RIO block hosting the given digital output pin. The interrupt service routine (ISR) is always disabled when created. Call **enableISR()** to enable the ISR. The ISR handler given is responsible for clearing the interrupt(s) within the hosting RIO block.

PARAMETERS

channel digital output channel to bind to ISR, 0–7 (OUT0–OUT7)

ier bit mask of interrupt(s) this handler services:

- **BL_IER_DQE** — decrement/quadrature/end
- **BL_IER_IIB** — increment/inphase/begin
- **BL_IER_ROLL_D** — counter rollover on decrement
- **BL_IER_ROLL_I** — counter rollover on increment
- **BL_IER_MATCH3** — Match 3 condition
- **BL_IER_MATCH2** — Match 2 condition
- **BL_IER_MATCH1** — Match 1 condition
- **BL_IER_MATCH0** — Match 0 condition

handler pointer to the interrupt service function

RETURN VALUE

Success — returns the handler ID number (**0..RSB_MAX_ISR-1**).

-EINVAL— Invalid parameter given.

-ENOSPC — No more room in ISR table (increase **RSB_MAX_ISR**).

SEE ALSO

addISRIn, tickISR, enableISR, setIER

setIER

```
int setIER(int isr_handle, int ier);
```

FUNCTION DESCRIPTION

Sets the Interrupt Enable Register (IER) mask for an interrupt handler. Note that the interrupt handler must be currently disabled to set the IER value. Disabling the ISR can be done by calling **`enableISR()`** with a zero for the **`enable`** parameter.

PARAMETERS

`isr_handle`	index to the desired ISR
`ier`	bit mask of interrupts this handler services (bit positions match RIO Interrupt Enable and Status registers)

RETURN VALUE

0 — success

`-EINVAL`— Invalid parameter given.

`-EPERM` — Handler is enabled, can't change IER.

SEE ALSO

`addISRIn, addISROut, enableISR, tickISR`

enableISR

int enableISR(int isr_handle, int enable)

FUNCTION DESCRIPTION

Enables or disables an interrupt handler.

PARAMETERS

isr_handle	index to the desired ISR
enable	non-zero enables the ISR, zero disables the ISR

RETURN VALUE

0 — success.

-EINVAL— invalid parameter given.

SEE ALSO

addISRIn, addISROut, setIER, tickISR

tickISR

void tickISR(void)

FUNCTION DESCRIPTION

Polls the RIO chip(s) for ISR events if interrupts are not being used. Any enabled ISR events will be passed to the appropriate ISR handler.

RETURN VALUE

None.

SEE ALSO

addISRIn, addISROut, enableISR, setIER

4.4.4 Serial Communication

Library files included with Dynamic C provide a full range of serial communications support. The **RS232.LIB** library provides a set of circular-buffer-based serial functions. The **PACKET.LIB** library provides packet-based serial functions where packets can be delimited by the 9th bit, by transmission gaps, or with user-defined special characters. Both libraries provide blocking functions, which do not return until they are finished transmitting or receiving, and nonblocking functions, which must be called repeatedly until they are finished. For more information, see the ***Dynamic C User's Manual*** and Technical Note 213, ***Rabbit Serial Port Software***.

Use the following function calls with the BL4S100.

serMode

```
int serMode(int mode);
```

FUNCTION DESCRIPTION

This function call sets the serial interfaces used by your application program. Call this function after executing **serXopen()** and before using any other serial port function calls.

PARAMETER

mode the defined serial port configuration

Mode	Serial Port D	Serial Port F
0	RS-232, 3-wire	RS-232, 3-wire
1	RS-232, 5-wire	RTS/CTS

RETURN VALUE

0 if valid mode selected, **-EINVAL** if not.

4.4.5 A/D Converter Inputs

anaInConfig

```
void anaInConfig(int channel, int opmode);
```

FUNCTION DESCRIPTION

Configures an A/D converter input channel for a given mode of operation. This function must be called before accessing the A/D converter chip.

The channel pairs for the differential mode are listed below.

AIN0 and AIN1
AIN2 and AIN3
AIN4 and AIN5
AIN6 and AIN7

The modes of operation are as follows:

Single-ended unipolar 0–20 V
Differential bipolar ±20 V
4-20 mA operation

NOTE: When a pin in a differential pair is reconfigured as a nondifferential pin, the remaining paired pin is also reconfigured.

PARAMETERS

channel analog input channel, 0–7 (AIN0–AIN7)

opmode selects the mode of operation for the A/D converter channel pair. The values are as follows:

SE0_MODE — single-ended unipolar (0–20 V)
DIFF_MODE — differential bipolar (±20 V)
mAMP_MODE — 4–20 mA operation

RETURN VALUE:

0 — success.

-EINVAL — invalid parameter.

SEE ALSO

brdInit, anaInCalib, anaIn, anaInVolts, anaInmAmps, anaInDiff

anaInCalib

```
int anaInCalib(int channel, int opmode, int gaincode,
   int value1, float volts1, int value2, float volts2);
```

FUNCTION DESCRIPTION

Calibrates the response of a given A/D converter channel as a linear function using the two conversion points provided. Gain and offset constants are calculated and placed into the user block in the flash memory.

NOTE: The 10 and 90% points of the maximum voltage range are recommended when calibrating a channel.

PARAMETERS

channel analog input channel number (0 to 7) corresponding to AIN0–AIN7

channel	Single-Ended	Differential	4–20 mA
0	+AIN0	+AIN0 -AIN1	+AIN0
1	+AIN1	—	+AIN1
2	+AIN2	+AIN2 -AIN3	+AIN2
3	+AIN3	—	+AIN3
4	+AIN4	+AIN4 -AIN5	
5	+AIN5	—	
6	+AIN6	+AIN6 -AIN7	
7	+AIN7	—	

opmode the mode of operation for the specified channel. Use one of the following macros to set the mode for the channel being configured.

SE0_mode = single-ended unipolar (0–20 V)
DIFF_MODE = differential bipolar (±20 V)
mAMP_mode = 4–20 mA

gaincode the gain code of 0 to 7 (use the gain code macro **mAMP_GAINCODE** for 4–20 mA operation)

Gain Code	Macro	Voltage Range	
		Single-Ended Unipolar	Differential Bipolar
0	**GAIN_X1**	0–20 V	±20 V
1	**GAIN_X2**	0–10 V	±10 V
2	**GAIN_X4**	0–5 V	±5 V
3	**GAIN_X5**	0–4 V	±4 V
4	**GAIN_X8**	0–2.5 V	±2.5 V
5	**GAIN_X10**	0–2 V	±2 V
6	**GAIN_X16**	0–1.25 V	±1.25 V
7	**GAIN_X20**	0–1 V	±1 V

value1 the first A/D converter value

volts1 the voltage corresponding to the first A/D converter value

value2 the second A/D converter value

volts2 the voltage corresponding to the second A/D converter value

RETURN VALUE

0 — success.

-EINVAL — invalid parameter.

-ERR_ANA_CALIB — error writing calibration constants.

SEE ALSO

brdInit, anaInConfig, anaIn, anaInmAmps, anaInDiff, anaInVolts

anaIn

```
int anaIn(int channel, int gaincode);
```

FUNCTION DESCRIPTION

Reads the state of an A/D converter input channel.

PARAMETERS

channel analog input channel number (0 to 7) corresponding to AIN0–AIN7

channel	Single-Ended	Differential	4–20 mA
0	+AIN0	+AIN0 -AIN1	+AIN0
1	+AIN1	—	+AIN1
2	+AIN2	+AIN2 -AIN3	+AIN2
3	+AIN3	—	+AIN3
4	+AIN4	+AIN4 -AIN5	
5	+AIN5	—	
6	+AIN6	+AIN6 -AIN7	
7	+AIN7	—	

gaincode the gain code of 0 to 7 (use a gain code of 4 for 4–20 mA operation)

Gain Code	Macro	Value Range		Voltage Range
		Single-Ended Unipolar	Differential Bipolar	
0	**GAIN_X1**	0–20 V	± 20 V	0–20 V
1	**GAIN_X2**	0–10 V	± 10 V	0–10 V
2	**GAIN_X4**	0–5 V	± 5 V	0–5 V
3	**GAIN_X5**	0–4 V	± 4 V	0–4 V
4	**GAIN_X8**	0–2.5 V	± 2.5 V	0–2.5 V
5	**GAIN_X10**	0–2 V	± 2 V	0–2 V
6	**GAIN_X16**	0–1.25 V	± 1.25 V	0–1.25 V
7	**GAIN_X20**	0–1 V	± 1 V	0–1 V

RETURN VALUE

A value corresponding to the voltage on the analog input channel:

0–2047 for 11-bit A/D conversions,
or a value of **BL_ERRCODESTART** or less to indicate an error condition:

A/D converter operation errors (will not create run-time error):

BL_TIMEOUT
BL_OVERFLOW
BL_WRONG_MODE

System errors (can create run-time error unless disabled):

-ERR_ANA_CALIB — fault detected in reading calibration factor
-ERR_ANA_INVAL — invalid parameter value.

SEE ALSO

brdInit, anaInConfig, anaInCalib, anaInmAmps, anaInDiff, anaInVolts

anaInVolts

```
float anaInVolts(int channel, int gaincode);
```

FUNCTION DESCRIPTION

Reads the state of a single-ended A/D converter input channel and uses the previously set calibration constants to convert it to volts. The voltage ranges given in the table below are nominal ranges that will be returned. However, values outside these ranges can often be seen before the return of a **BL_OVERFLOW** error.

If the gain code for a given channel has changed from the previous cycle, the user block will be read to get the calibration constants for the new gain value.

PARAMETERS

channel analog input channel number (0 to 7) corresponding to AIN0–AIN7

gaincode the gain code of 0 to 7; the table below applies for single-ended modes only

Gain Code	Macro	Value Range		Voltage Range
		Single-Ended Unipolar	Differential Bipolar	
0	**GAIN_X1**	0–20 V	± 20 V	0–20 V
1	**GAIN_X2**	0–10 V	± 10 V	0–10 V
2	**GAIN_X4**	0–5 V	± 5 V	0–5 V
3	**GAIN_X5**	0–4 V	± 4 V	0–4 V
4	**GAIN_X8**	0–2.5 V	± 2.5 V	0–2.5 V
5	**GAIN_X10**	0–2 V	± 2 V	0–2 V
6	**GAIN_X16**	0–1.25 V	± 1.25 V	0–1.25 V
7	**GAIN_X20**	0–1 V	± 1 V	0–1 V

RETURN VALUE

A voltage on the analog input channel, or a value of **BL_ERRCODESTART** or less to indicate an error condition:

A/D converter operation errors (will not create run-time error):

BL_NOT_CAL — A/D converter is not calibrated for this channel/gain.
BL_OVERFLOW — A/D converter overflow.
BL_TIMEOUT — A/D converter timeout.
BL_WRONG_MODE — A/D converter is in wrong mode (run **anaInConfig()**).

System errors (can create run-time error unless disabled):

-ERR_ANA_CALIB — fault detected in reading calibration facto.r
-ERR_ANA_INVAL — invalid parameter value.

SEE ALSO

brdInit, anaInConfig, anaIn, anaInmAmps, anaInDiff, anaInCalib

anaInDiff

```
float anaInDiff(int channel, int gaincode);
```

FUNCTION DESCRIPTION

Reads the state of a differential A/D converter input channel and uses the previously set calibration constants to convert it to volts. Voltage ranges given in the table below are the nominal ranges that will be returned. However, values outside these ranges can often be seen before the return of a **BL_OVERFLOW** error.

If the gain code for a given channel has changed from the previous cycle, the user block will be read to get the calibration constants for the new gain value.

PARAMETERS

channel the analog input channel number (0, 2, 4, 6) as shown below

channel	Differential Inputs
0	+AIN0 -AIN1
2	+AIN2 -AIN3
4	+AIN4 -AIN5
6	+AIN6 -AIN7

gaincode the gain code of 0 to 7

Gain Code	Macro	Actual Gain	Differential Voltage Range	Actual Voltage Range
0	**GAIN_X1**	×1	± 20 V	0–20 V
1	**GAIN_X2**	×2	± 10 V	0–10 V
2	**GAIN_X4**	×4	± 5 V	0–5 V
3	**GAIN_X5**	×5	± 4 V	0–4 V
4	**GAIN_X8**	×8	± 2.5 V	0–2.5 V
5	**GAIN_X10**	×10	± 2 V	0–2 V
6	**GAIN_X16**	×16	± 1.25 V	0–1.25 V
7	**GAIN_X20**	×20	± 1 V	0–1 V

RETURN VALUE

A voltage on the analog input channel, or a value of **BL_ERRCODESTART** or less to indicate an error condition:

A/D converter operation errors (will not create run-time error):

BL_NOT_CAL — A/D converter is not calibrated for this channel/gain.
BL_OVERFLOW — A/D converter overflow.
BL_TIMEOUT — A/D converter timeout.
BL_WRONG_MODE — A/D converter is in wrong mode (run **anaInConfig()**).

System errors (can create run-time error unless disabled):

-ERR_ANA_CALIB — fault detected in reading calibration factor.
-ERR_ANA_INVAL — invalid parameter value.

SEE ALSO

brdInit, anaInConfig, anaIn, anaInmAmps, anaInVolts, anaInCalib

anaInmAmps

```
float anaInmAmps(int channel);
```

FUNCTION DESCRIPTION

Reads the state of a single-ended A/D converter input channel and uses the previously set calibration constants to convert it to a floating-point current value in milli amps. The nominal range is 0 mA to 20 mA, although it is possible to receive values outside this range before a **BL_OVERFLOW** error is returned.

PARAMETER

channel A/D converter input channel (0–3 corresponding to AIN0–AIN3)

RETURN VALUE

A current value corresponding to the current on the analog input channel, or a value of **BL_ERRCODESTART** or less to indicate an error condition:

A/D converter operation errors (will not create run-time error):

BL_NOT_CAL — A/D converter is not calibrated for this channel/gain.
BL_OVERFLOW — A/D converter overflow.
BL_TIMEOUT — A/D converter timeou.t
BL_WRONG_MODE — A/D converter is in wrong mode (run **anaInConfig()**).

System errors (can create run-time error unless disabled):

-ERR_ANA_CALIB — fault detected in reading calibration factor.
-ERR_ANA_INVAL — invalid parameter value.

SEE ALSO

brdInit, anaInConfig, anaIn, anaInDiff, anaInVolts, anaInCalib

anaInRdCalib

```
anaInRdCalib(int channel, int opmode, int gaincode,
   calib_t *pcal_data)
```

FUNCTION DESCRIPTION

Reads the calibration constants, gain and offset, from the user block on the flask.

PARAMETER

channel analog input channel number (0 to 7) corresponding to AIN0–AIN7

channel	Single-Ended	Differential	4–20 mA
0	+AIN0	+AIN0 -AIN1	+AIN0
1	+AIN1	—	+AIN1
2	+AIN2	+AIN2 -AIN3	+AIN2
3	+AIN3	—	+AIN3
4	+AIN4	+AIN4 -AIN5	
5	+AIN5	—	
6	+AIN6	+AIN6 -AIN7	
7	+AIN7	—	

opmode select the mode of operation for the A/D converter channel calibration data being read. Use one of the following macros.

SE0_mode = single-ended unipolar (0–20 V)
DIFF_MODE = differential bipolar (±20 V)
mAMP_mode = 4–20 mA

gaincode the gain code of 0 to 7 (use the gain code macro **mAMP_GAINCODE** for 4–20 mA operation)

Gain Code	Macro	Voltage Range	
		Single-Ended Unipolar	Differential Bipolar
0	**GAIN_X1**	0–20 V	±20 V
1	**GAIN_X2**	0–10 V	±10 V
2	**GAIN_X4**	0–5 V	±5 V
3	**GAIN_X5**	0–4 V	±4 V
4	**GAIN_X8**	0–2.5 V	±2.5 V
5	**GAIN_X10**	0–2 V	±2 V
6	**GAIN_X16**	0–1.25 V	±1.25 V
7	**GAIN_X20**	0–1 V	±1 V

pcal_data calibration structure pointer to gain and offset values

RETURN VALUE

0 — success.

-1 — invalid address or range.

-2 — no valid user block found (block version 3 or later)

-3 — flash read error

-EINVAL — invalid parameter

SEE ALSO

anaInCalib, _anaInAddr

anaInDriver

```
int anaInDriver(char cmd);
```

FUNCTION DESCRIPTION

Low-level driver to read the ADS7870 A/D converter chip. Reads the voltage of an analog input channel by serial clocking an 8-bit command to the ADS7870 by its Direct Mode method. **`anaInConfig()`** uses the Register Mode method. This function call assumes that Mode2 (least significant byte first) and the A/D converter oscillator have been enabled.

See anaInConfig() for additional setup information.

After the last data bit is transferred, the conversion begins immediately. An exception error will occur if Direct Mode bit D7 is not set.

PARAMETER

`cmd` The **`cmd`** parameter contains a gain code and channel code, and the MSB is set high for direct-mode access. The format is as follows:

D7	D6–D4	D3–D0
`1`	**`gain_code`**	**`channel_code`**

Use the following calculation and tables to determine **`cmd`**:

```
cmd = 0x80 | (gain_code<<4) + channel_code
```

gain_code	Multiplier
0	1
1	2
2	4
3	5
4	8
5	10
6	16
7	20

channel_code	Differential Input Lines	channel_code	Single-Ended Input Lines	mA Input Lines
0	+AIN0 -AIN1	8	+AIN0	+AIN0
1	+AIN2 -AIN3	9	+AIN1	+AIN1
2	+AIN4 -AIN5	10	+AIN2	+AIN2
3	+AIN6 -AIN7	11	+AIN3	+AIN3
4	Reserved	12	+AIN4	Reserved
5	Reserved	13	+AIN5	Reserved
6	Reserved	14	+AIN6	Reserved
7	Reserved	15	+AIN7	Reserved

RETURN VALUE

A value corresponding to the voltage on the analog input channel, which will be either in the range [-2048,2047], or an error code of **BL_ERRCODESTART** or less as follows:

BL_TIMEOUT — conversion incomplete, busy bit timeout
BL_OVERFLOW — overflow or out of range

System errors (can create run-time error unless disabled):

-ERR_ANA_INVAL — invalid parameter value

SEE ALSO

anaInConfig, anaIn, brdInit

4.4.6 SRAM Use

The BL4S100 has a battery-backed data SRAM and a program-execution SRAM. Dynamic C provides the **protected** keyword to identify variables that are to be placed into the battery-backed SRAM. The compiler generates code that maintains two copies of each protected variable in the battery-backed SRAM. The compiler also generates a flag to indicate which copy of the protected variable is valid at the current time. This flag is also stored in the battery-backed SRAM. When a protected variable is updated, the "inactive" copy is modified, and is made "active" only when the update is 100% complete. This assures the integrity of the data in case a reset or a power failure occurs during the update process. At power-on the application program uses the active copy of the variable pointed to by its associated flag.

The sample code below shows how a protected variable is defined and how its value can be restored.

```
protected nf_device nandFlash;
int main() {
   ...
   _sysIsSoftReset();    // restore any protected variables
```

The **bbram** keyword may also be used instead if there is a need to store a variable in battery-backed SRAM without affecting the performance of the application program. Data integrity is ***not*** assured when a reset or power failure occurs during the update process.

Additional information on **bbram** and **protected** variables is available in the ***Dynamic C User's Manual***.

5. USING THE ETHERNET TCP/IP FEATURES

Chapter 5 discusses using the Ethernet TCP/IP features on the BL4S100 boards.

5.1 TCP/IP Connections

Before proceeding you will need to have the following items.

- If you don't have Ethernet access, you will need at least a 10Base-T Ethernet card (available from your favorite computer supplier) installed in a PC.
- Two RJ-45 straight-through CAT 5/6 Ethernet cables and a hub, or an RJ-45 crossover CAT 5/6 Ethernet cable.

The CAT 5/6 Ethernet cables and Ethernet hub are available from Rabbit in a TCP/IP tool kit. More information is available at www.rabbit.com.

1. Connect the AC adapter and the programming cable as shown in Chapter 2, "Getting Started."
2. Ethernet Connections

If you do not have access to an Ethernet network, use a crossover CAT 5/6 Ethernet cable to connect the BL4S100 to a PC that at least has a 10Base-T Ethernet card.

If you have Ethernet access, use a straight-through CAT 5/6 Ethernet cable to establish an Ethernet connection to the BL4S100 from an Ethernet hub. These connections are shown in Figure 17.

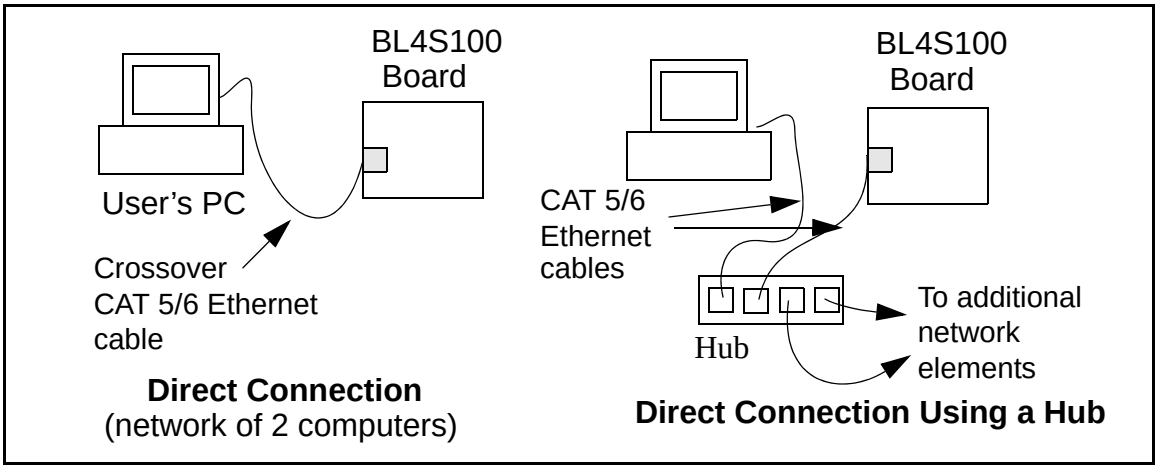


Figure 17. Ethernet Connections

The PC running Dynamic C through the serial programming port on the BL4S100 does not need to be the PC with the Ethernet card.

3. Apply Power

Plug in the AC adapter. The BL4S100 is now ready to be used.

> **NOTE:** A hardware RESET is accomplished by unplugging the AC adapter, then plugging it back in, or by pressing the **RESET** button located next to the Ethernet jack.

When working with the BL4S100, the green **LNK** light is on when a program is running and the board is properly connected either to an Ethernet hub or to an active Ethernet card. The orange **ACT** light flashes each time a packet is received.

5.2 TCP/IP Sample Programs

We have provided a number of sample programs demonstrating various uses of TCP/IP for networking embedded systems. These programs require that you connect your PC and the BL4S100 together on the same network. This network can be a local private network (preferred for initial experimentation and debugging), or a connection via the Internet.

5.2.1 How to Set IP Addresses in the Sample Programs

With the introduction of Dynamic C 7.30 we have taken steps to make it easier to run many of our sample programs. You will see a **TCPCONFIG** macro. This macro tells Dynamic C to select your configuration from a list of default configurations. You will have three choices when you encounter a sample program with the **TCPCONFIG** macro.

1. You can replace the **TCPCONFIG** macro with individual **MY_IP_ADDRESS**, **MY_NETMASK**, **MY_GATEWAY**, and **MY_NAMESERVER** macros in each program.
2. You can leave **TCPCONFIG** at the usual default of 1, which will set the IP configurations to **10.10.6.100**, the netmask to **255.255.255.0**, and the nameserver and gateway to **10.10.6.1**. If you would like to change the default values, for example, to use an IP address of **10.1.1.2** for the BL4S100 board, and **10.1.1.1** for your PC, you can edit the values in the section that directly follows the "General Configuration" comment in the **TCP_CONFIG.LIB** library. You will find this library in the **LIB\TCPIP** directory.
3. You can create a **CUSTOM_CONFIG.LIB** library and use a **TCPCONFIG** value greater than 100. Instructions for doing this are at the beginning of the **TCP_CONFIG.LIB** library in the **LIB\TCPIP** directory.

There are some other "standard" configurations for **TCPCONFIG** that let you select different features such as DHCP. Their values are documented at the top of the **TCP_CONFIG.LIB** library in the **LIB\TCPIP** directory. More information is available in the ***Dynamic C TCP/IP User's Manual***.

5.2.2 How to Set Up your Computer for Direct Connect

Follow these instructions to set up your PC or notebook. Check with your administrator if you are unable to change the settings as described here since you may need administrator privileges. The instructions are specifically for Windows 2000, but the interface is similar for other versions of Windows.

> **TIP:** If you are using a PC that is already on a network, you will disconnect the PC from that network to run these sample programs. Write down the existing settings before changing them to facilitate restoring them when you are finished with the sample programs and reconnect your PC to the network.

1. Go to the control panel (**Start > Settings > Control Panel**), and then double-click the Network icon.
2. Select the network interface card used for the Ethernet interface you intend to use (e.g., **TCP/IP Xircom Credit Card Network Adapter**) and click on the "Properties" button. Depending on which version of Windows your PC is running, you may have to select the "Local Area Connection" first, and then click on the "Properties" button to bring up the Ethernet interface dialog. Then "Configure" your interface card for a "10Base-T Half-Duplex" or an "Auto-Negotiation" connection on the "Advanced" tab.

   NOTE: Your network interface card will likely have a different name.

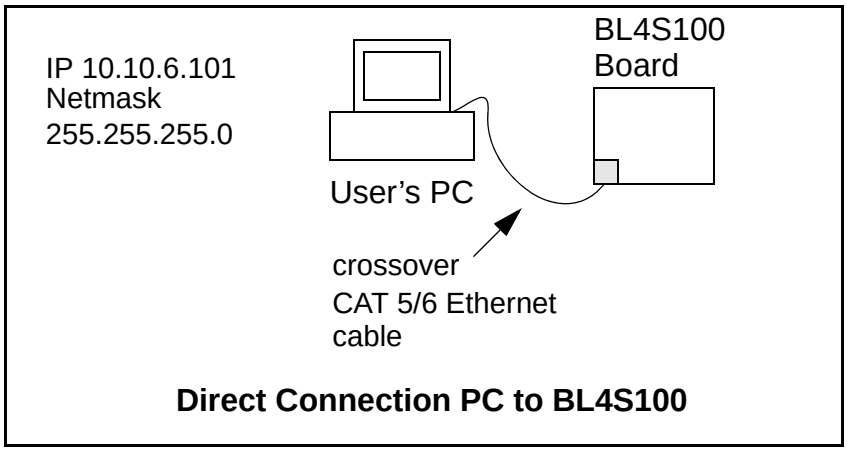
3. Now select the **IP Address** tab, and check **Specify an IP Address**, or select TCP/IP and click on "Properties" to assign an IP address to your computer (this will disable "obtain an IP address automatically"):

   IP Address : 10.10.6.101

   Netmask : 255.255.255.0

   Default gateway : 10.10.6.1

4. Click **<OK>** or **<Close>** to exit the various dialog boxes.



Direct Connection PC to BL4S100

5.2.3 Run the PINGME.C Demo

Connect the crossover cable from your computer's Ethernet port to the BL4S100's RJ-45 Ethernet connector. Open this sample program from the **SAMPLES\TCPIP\ICMP** folder, compile the program, and start it running under Dynamic C. When the program starts running, the green **LNK** light on the BL4S100 should be on to indicate an Ethernet connection is made. (Note: If the **LNK** light does not light, you may not have a crossover cable, or if you are using a hub perhaps the power is off on the hub.)

The next step is to ping the board from your PC. This can be done by bringing up the MS-DOS window and running the ping program:

```
ping 10.10.6.100
```

or by **Start** > **Run**

and typing the command

```
ping 10.10.6.100
```

Notice that the orange **ACT** light flashes on the BL4S100 Ethernet jack while the ping is taking place, and indicates the transfer of data. The ping routine will ping the board four times and write a summary message on the screen describing the operation.

5.2.4 Running More Demo Programs With a Direct Connection

The following sample programs are found in the **SAMPLES\BL4S1xx\TCPIP** folder.

Figure 18 shows the signal connections for the sample programs that illustrate the use of TCP/IP.

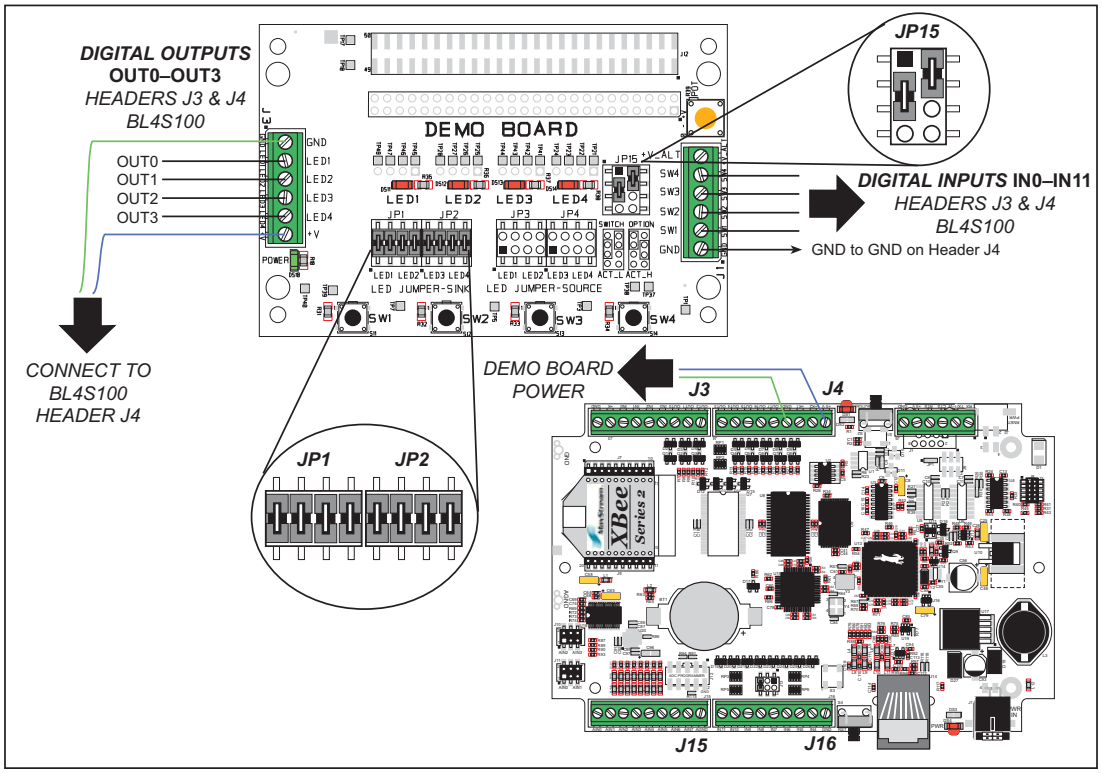


Figure 18. TCP/IP Sample Programs Demonstration Board Connections

- **PINGLED.C**—Demonstrates ICMP by pinging a remote host. The sample program will flash LED1 and LED2 on the Demonstration Board when a ping is sent and received.
- **RWEB_DIGITAL_OUTPUTS.C**—Demonstrates using the **digOut()** function call to control the sinking digital outputs on the BL4S100 to toggle the LEDs on the Demonstration Board on/off.

  Once the sample program is compiled and running, open your PC Web browser. As long as you have not modified the **TCPCONFIG 1** macro in the sample program, enter the following server address in your Web browser to bring up the Web page served by the sample program.

  http://10.10.6.100

- **RWEB_IO_SAMPLE.C**—Demonstrates using RabbitWeb to display the status of multiple I/O lines (analog and digital) in a Web browser, and allows the user to change the digital outputs by clicking the buttons on the page.

  The sample program uses an IFRAME (invisible frame) to refresh the I/O readings every two seconds. Since the Web browser does not have to re-render the entire page, updates are quick and flicker free.

  Once the sample program is compiled and running, open your PC Web browser. As long as you have not modified the **TCPCONFIG 1** macro in the sample program, enter the following server address in your Web browser to bring up the Web page served by the sample program.

  http://10.10.6.100

  Now use a wire to touch +5 V from header J4 on the BL4S100 to the various digital and analog inputs on header J3, J15, and J16

- **SMTP.C**—Uses the SMTP library to send an e-mail when a pushbutton switch on the Demonstration Board is pressed.

- **TELNET.C**—Allows you to communicate with the BL4S100 using the Telnet protocol. This program takes anything that comes in on a port and sends it out Serial Port D and displays the content in the Dynamic C **STDIO** window. It uses a digital input to indicate that the TCP/IP connection should be closed and a digital output to toggle an LED to indicate that there is an active connection.

  Once the sample program is compiled and running, start the Telnet program on your PC (**Start > Run** `telnet 10.10.6.100`). As long as you have not modified the **TCPCONFIG 1** macro in the sample program, the IP address is 10.10.6.100 as shown; otherwise use the TCP/IP settings you entered in the **TCP_CONFIG.LIB** library. Each character you type will be printed in Dynamic C's **STDIO** window, indicating that the board is receiving the characters typed via TCP/IP.

5.3 Where Do I Go From Here?

NOTE: If you purchased your BL4S100 through a distributor or Rabbit partner, contact the distributor or partner first for technical support.

If there are any problems at this point:

- Use the Dynamic C **Help** menu to get further assistance with Dynamic C.
- Check the Rabbit Technical Bulletin Board and forums at www.rabbit.com/support/bb/ and at www.rabbit.com/forums/.
- Use the Technical Support e-mail form at www.rabbit.com/support/questionSubmit.shtml.

If the sample programs ran fine, you are now ready to go on.

Additional sample programs are described in the ***Dynamic C TCP/IP User's Manual***.

Refer to the ***Dynamic C TCP/IP User's Manual*** to develop your own applications. ***An Introduction to TCP/IP*** provides background information on TCP/IP, and is available on the Web site.

6. USING THE ZIGBEE FEATURES

Chapter 6 discusses using the ZigBee features on the BL4S100 and the BL4S150 models. This networking feature is ***not*** available on other BL4S100 models.

6.1 Introduction to the ZigBee Protocol

The ZigBee PRO specification was ratified in April, 2007, and covers high-level communication protocols for small, low-power digital modems based on the IEEE 802.15.4 standard for wireless personal area networks (WPANs). The XBee RF module used by the BL4S100 and the BL4S150 operates in the 2.4 GHz industrial, scientific, and medical (ISM) radio band in most jurisdictions worldwide.

The ZigBee protocol is ideal for embedded-system applications that are characterized by low data rates and low power consumption. A network of devices using the ZigBee protocol works via a self-organizing mesh network that can be used for industrial control, embedded sensors, data collection, home security, and building automation. The power consumption of the individual device could be met for a year or longer using the originally installed battery.

A ZigBee device can be set up in one of three ways.

- As a *coordinator*: The coordinator serves as the root of the network tree. Each network can only have one coordinator. The coordinator stores information about the network and provides the repository for security keys. The coordinator starts a ZigBee network and then acts as a router once that network is started.
- As a *router*. Routers pass data from other devices.
- As an *end device*. End devices contain just enough functionality to talk to their parent node (either the coordinator or a router), and cannot relay data from other devices.

The XBee RF module used by the BL4S100 and the BL4S150 presently supports using them in a mesh network. BL4S100 and the BL4S150 boards are preconfigured with ZB router firmware; coordinator and end-device firmware are included in the Dynamic C installation along with a sample program to allow you to download the firmware.

The firmware used with the XBee RF modules on the BL4S100 and the BL4S150 is based on the API command set.

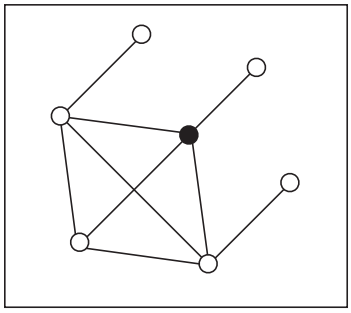


Figure 19. Mesh Network

An Introduction to ZigBee provides background information on the ZigBee protocol, and is available on the CD and on our Web site.

6.2 ZigBee Sample Programs

In order to run the sample programs discussed in this chapter and elsewhere in this manual,

1. Dynamic C must be installed and running on your PC.
2. The programming cable must connect the programming header on the BL4S100 or the BL4S150 to your PC.
3. Power must be applied to the BL4S100/Bl4S150.
4. The Digi® XBee USB used as the ZigBee coordinator must be connected to an available USB port on your PC if you are exercising the ZigBee protocol.

Refer to Chapter 2, "Getting Started," if you need further information on these steps.

> **NOTE:** The Digi XBee USB device is an optional accessory and is not a part of the standard BL4S200 Tool Kit. See section F.2 Digi® XBee USB Configuration for more information on the Digi XBee USB device.

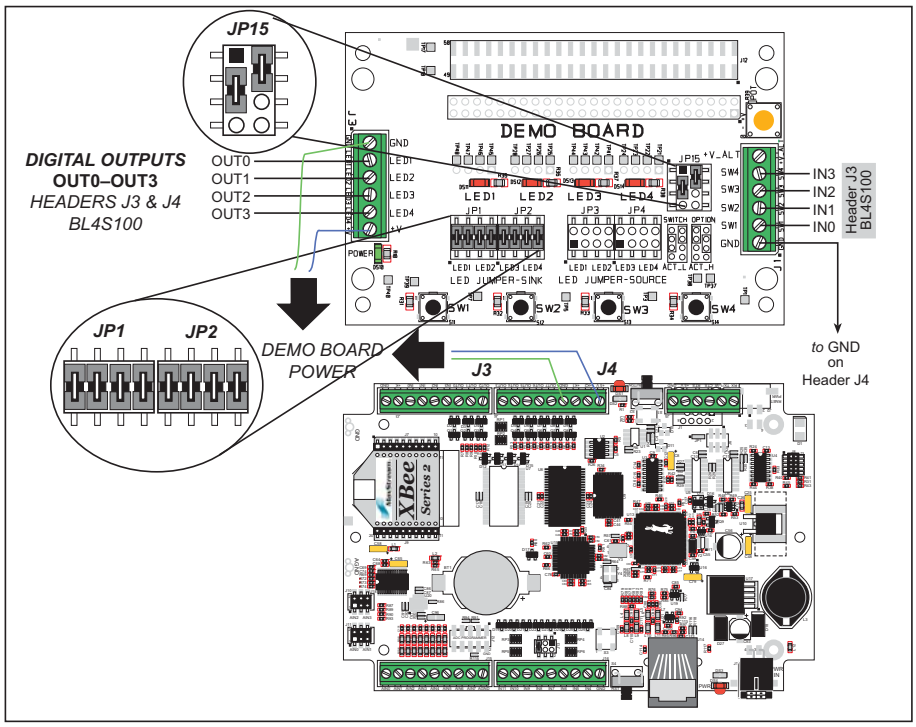
To run a sample program, open it with the **File** menu (if it is not still open), then compile and run it by pressing **F9**.

Each sample program has comments that describe the purpose and function of the program. Follow the instructions at the beginning of the sample program.

The sample programs in the Dynamic C **SAMPLES\XBee** folders illustrate the use of the ZigBee function calls.

6.2.1 Setting Up the Digi XBee USB Coordinator

1. Connect the Digi® XBee USB acting as a ZigBee coordinator to an available USB port on your PC or workstation. Your PC should recognize the new USB hardware.
2. Connect the Demonstration Board to the BL4S100 as shown below.



3. Compile and run the **`XBEE_GPIO_SERVER.C`** sample program in the Dynamic C **`SAMPLES\BL4S1xx\XBee`** folder.
4. Open the ZigBee Utility by double-clicking **`XBEE_GPIO_GUI.exe`** in the Dynamic C **`Utilities\XBee GPIO GUI`** folder — if you have problems launching the ZigBee Utility, install a .Net Framework by double-clicking **`dotnetfx.exe`** in the Dynamic C **`Utilities\dotnetfx`** folder. You may add a shortcut to the ZigBee Utility on your desktop.

5. Confirm the following hardware setup is displayed on the “PC Settings” tab.

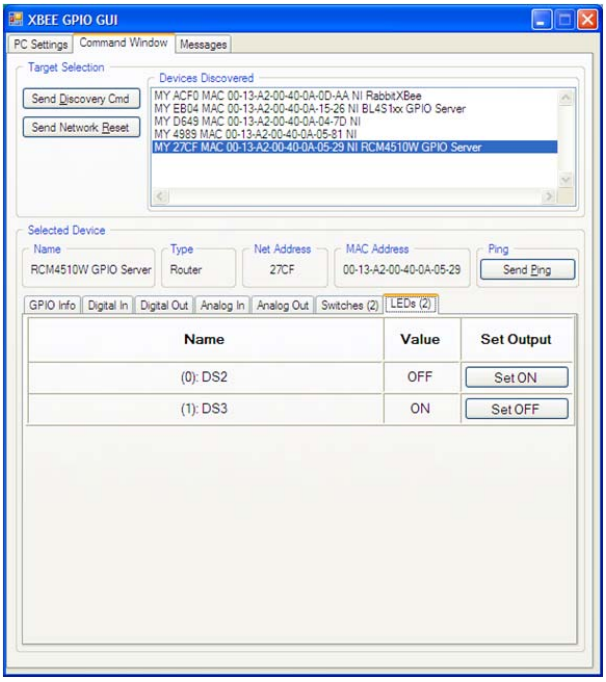
   - 115200 baud
   - Hardware flow control
   - 8 data bits
   - No parity
   - 1 stop bit

   Now select the COM port the Digi® XBee USB is connected to, and click the “Open Com Port” button. The message “Radio Found” is displayed to indicate that you selected the correct COM port. The ZigBee parameters (firmware version, operating channel, PAN ID) for the Digi® XBee USB will be displayed in the “Radio Parameters” box. Go to **Control Panel > System > Hardware > Device Manager > Ports** on your PC if you need help in identifying the USB COM port.

6. Any ZigBee devices discovered will be displayed in the “Devices Discovered” window to the right.

   If the utility times out and no ZigBee devices are displayed, you will have to reconfigure the Digi® XBee USB and recompile the sample program once you make sure the BL4S100/BL4S150 is powered up. The timeout may occur if you are doing development simultaneously with more than one ZigBee coordinator. Appendix F explains the steps to reconfigure the Digi® XBee USB.

7. Select a device with your mouse pointer and click on the selected device to select that device. This device will now be displayed in the “Selected Device” area.



8. You are now ready to interface with the BL4S100/BL4S150 via the ZigBee protocol. Try pinging the selected device by clicking the “Send Ping” button.

6.2.2 Setting up Sample Programs

The sample programs are set up so that the BL4S100/Bl4S150 you are using is a ZigBee router, coordinator, or end device. Uncomment the line corresponding to the role the BL4S100/Bl4S150 will have once it is running the sample program. The default in the sample programs is for the BL4S100/Bl4S150 to be a router.

```
// Set XBEE_ROLE to NODE_TYPE_COORD, NODE_TYPE_ROUTER or NODE_TYPE_ENDDEV
// to match your XBee's firmware.
#define XBEE_ROLE   NODE_TYPE_ROUTER
```

NOTE: Remember that the firmware loaded to the XBee RF module is different depending on whether the BL4S100/BL4S150 is a router (default), an end device, or a coordinator. See Appendix F, “Additional Configuration Instructions,” for information on how to download firmware to the BL4S100/BL4S150 to set it up as a coordinator or to resume its original configuration as a router.

There are several macros that may be changed to facilitate your setup. The macros can be included as part of the program code, or they may be put into the Program Options “Defines” on the “Defines” tab in the **Options > Program Options** menu.

Channel mask — defaults to 0x1FFE, i.e., all 16 possible channels via the macro in the Dynamic C **LIB\Rabbit4000\XBee\XBee_Firmware\XBEE_API.LIB** library. If you want to limit the channels used, all devices on your network should use the same channel mask.

```
#define DEFAULT_CHANNELS XBEE_DEFAULT_CHANNELS
```

Extended PAN ID — the 64-bit network ID. Defaults to **DEFAULT_PANID** if set in the Dynamic C **LIB\Rabbit4000\XBee\XBEE_API.LIB** library, otherwise defaults to **0x0123456789abcdef** to match the default used on the Digi® XBee USB.

If set to **0x00**, tells coordinators to "select a random extended PAN ID," and tells routers and end devices to "join any network."

Change the extended PAN ID if you are developing simultaneously with more than one ZigBee coordinator.

```
#define DEFAULT_EXTPANID "0x0123456789abcdef"
```

Node ID — the ID of your particular node via the macro in the Dynamic C **LIB\Rabbit4000\XBee\XBee_Firmware\XBEE_API.LIB** library. Each node should have a unique identifier.

```
#define NODEID_STR "RabbitXBee"
```

The XBee sample programs in the Dynamic C **SAMPLES\XBee** folder illustrate the use of the XBee function calls.

- **AT_INTERACTIVE.C**—This sample program shows how to set up and use AT commands with the XBee RF module.

  The program will print out a list of AT commands in the Dynamic C **STDIO** window. You may type in either "ATxx" or just the "xx" part of the command.

  - Use just the AT command to read any of the values.
  - Use [AT]xx yyyy (where the y is an integer up to 32 bits) to set any of the "set or read" values. (Note that this works for NI, the *node identifier*, where the data will be a Node ID.string in quotes — [AT]NI "Node ID string" where the quotes contain the string data)
  - Type "menu" to redisplay the menu of commands.
  - Press **F4** to exit and close the **STDIO** window.

- **AT_RUNONCE.C**—This sample program uses many of the most important and useful AT commands. Several commands can either set a parameter or read it. This sample program simply reads the parameters and displays the results.

  Compile and run this sample program. The program will display the results in the Dynamic C **STDIO** window.

The XBee sample programs in the Dynamic C **SAMPLES\BL4S1xx\XBee** folder illustrate the use of the XBee function calls.

- **SLEEP.C**—This sample program demonstrates having the XBee RF module wake the Rabbit up upon receipt of a packet.

  It also demonstrates conditional use of TCP/IP networking in low-power modes. The sample program illustrates how to respond to TCP/IP ping packets and also demonstrates pinging a remote host. It prints a message in the Dynamic C **STDIO** window when the ping response arrives here.

  Once the sample program is compiled and running, open your PC Web browser. As long as you have not modified the **TCPCONFIG 1** macro in the sample program, enter the following server address in your Web browser to bring up the Web page served by the sample program.

  http://10.10.6.100

  If **PING_WHO** is not defined, then it pings the default gateway.

  For this sample, the **XBEE_ROLE** macro must be defined as **NODE_TYPE_ENDDEV** since routers and coordinators cannot sleep.

- **XBEE_GPIO_SERVER.C**—This sample program shows how to set up and use endpoints and clusters. It is meant to be run with the Windows GUI client (installed in Dynamic C's **Utilities** directory) and a Digi USB XBee coordinator or with the GPIO client sample program (**SAMPLES/XBEE/XBEE_GPIO_CLIENT.C**) running on an RCM4510W RabbitCore module or on a single-board computer with an XBee RF module.

  Connect the BL4S100/BL4S150 to the Demonstration Board as explained in Section 6.2.1. Then compile and run this sample program on the BL4S100/BL4S150. Run the Windows GUI client (**XBEE_GPIO_GUI.exe** in the Dynamic C **Utilities\XBee GPIO GUI** folder) on your PC. Configure the GUI client to connect to the Digi USB XBee coordinator and scan for devices. Make sure the BL4S100/BL4S150 and the Digi USB XBee coordinator are configured with the same PAN ID.

  If you run the **XBEE_GPIO_CLIENT.C** sample program on another board with an XBee RF module, set the PAN IDs to match between the client and the server sample programs.

  Now select the GPIO server and use the GUI interface on the PC, or the command-line client on another XBee-equipped board to view the server's inputs and change its outputs. For example, you can toggle the LEDs on the Demonstration Board on/off.

- **XBEE_WEB_GATEWAY.C**—This sample program shows how to interact with nodes on a wireless ZigBee network through a Web interface.

  Before you compile and run this sample program, set up a ZigBee network based on boards with the XBee RF module. The sample program provides configuration recommendations for RF Interface Boards from the Mesh Network Add-On Kit and other boards. Use the X-CTU utility to configure these boards as end devices with the same PAN ID.

Once the sample program is compiled and running, open your PC Web browser. As long as you have not modified the **`TCPCONFIG 1`** macro in the sample program, enter the following server address in your Web browser to bring up the Web page served by the sample program.

http://10.10.6.100

The Web browser will display the network and the individual boards on the network. You can use the Web browser to control the boards. Note that the **`XB24-ZB_2x40`** firmware allows you to set digital outputs on all node types, but analog and digital inputs can only be read on end devices.

6.3 Dynamic C Function Calls

Function calls for use with the XBee RF modules are in the Dynamic C **LIB\Rabbit4000\XBee\XBEE_API.LIB** library. These ZigBee specific function calls are described in ***An Introduction to ZigBee***, which is included in the online documentation set.

6.4 Where Do I Go From Here?

NOTE: If you purchased your BL4S100/BL4S150 through a distributor or through a Rabbit partner, contact the distributor or partner first for technical support.

If there are any problems at this point:

- Use the Dynamic C **Help** menu to get further assistance with Dynamic C.
- Check the Rabbit Technical Bulletin Board and forums at www.rabbit.com/support/bb/ and at www.rabbit.com/forums/.
- Use the Technical Support e-mail form at www.rabbit.com/support/.

If the sample programs ran fine, you are now ready to go on.

An Introduction to ZigBee provides background information on the ZigBee protocol, and is available on the CD and on our Web site.

Digi's ***XBee™ Series 2 OEM RF Modules*** provides complete information for the XBee RF module used on the BL4S100/BL4S150, provides background information on the ZigBee PRO protocol, and is available at ftp1.digi.com/support/documentation/90000976_a.pdf.

APPENDIX A. SPECIFICATIONS

Appendix A provides the specifications for the BL4S100.

A.1 Electrical and Mechanical Specifications

Figure A-1 shows the mechanical dimensions for the BL4S100.

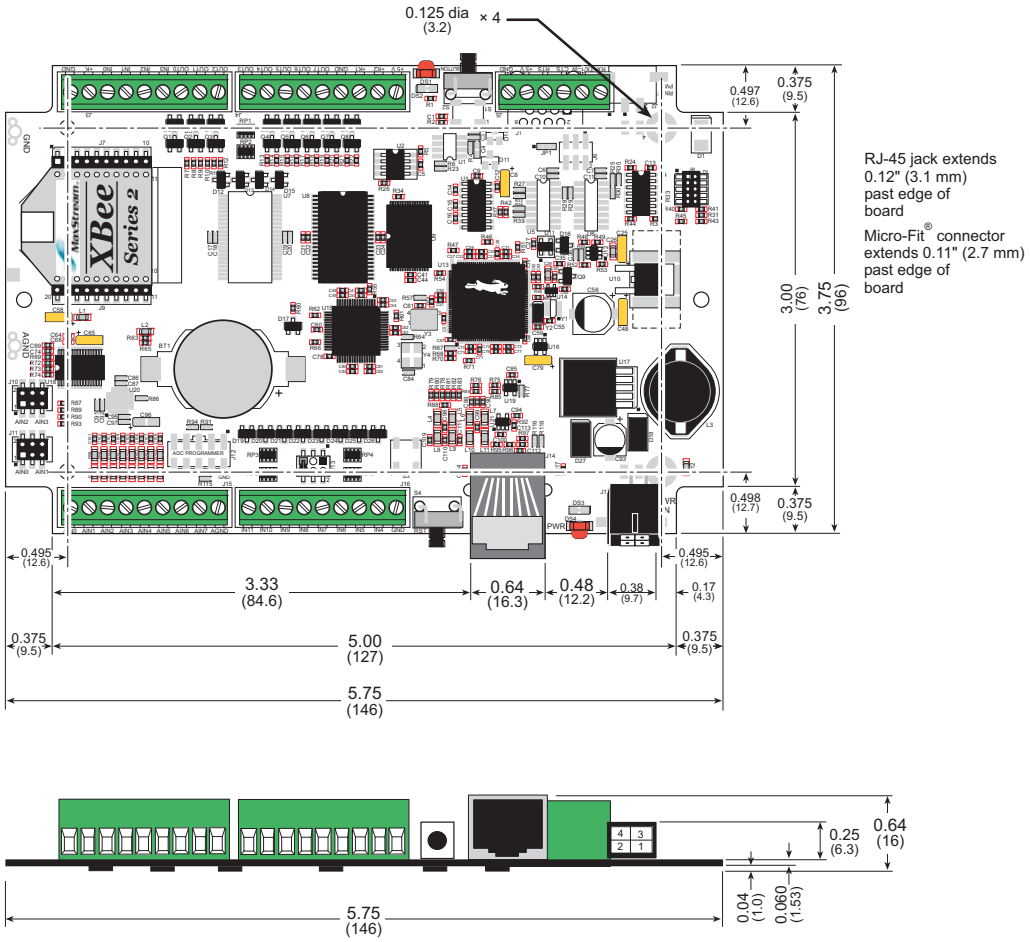


Figure A-1. BL4S100 Dimensions

NOTE: All measurements are in inches followed by millimeters enclosed in parentheses. All dimensions have a manufacturing tolerance of ±0.01" (0.25 mm).

Table A-1 lists the electrical, mechanical, and environmental specifications for the BL4S100.

Table A-1. BL4S100 Specifications

Feature	BL4S100	BL4S110	BL4S150	BL4S160
Microprocessor	Rabbit 4000® at 40.00 MHz			
Ethernet Interface	10Base-T			
ZigBee Interface	ZigBee PRO (802.15.4)	—	ZigBee PRO (802.15.4)	—
Serial Flash Memory (program)	1MB		2MB	
Program Execution SRAM	512KB		1MB	
Data SRAM	512KB			
Backup Battery	Panasonic CR2032 or equivalent 3 V lithium coin type, 235 mA·h standard, socket-mounted			
Digital Inputs	12: protected to ±36 V DC, switching threshold 1.4 V/1.9 V typical			
Digital Outputs	8: sink up to 200 mA each, 36 V DC max.			
Analog Inputs	Eight 11-bit res. channels, software-selectable ranges unipolar/differential bipolar: 1, 2, 2.5, 5, 10, 20 V DC; 4 channels can be hardware-configured for 4–20 mA; 1 MΩ input impedance, up to 4,100 samples/s			
Serial Ports	3 serial ports: • two RS-232 or one RS-232 (with CTS/RTS) • one serial port dedicated for programming/debug			
Serial Rate	Max. asynchronous rate = 250kbps, Max. synchronous rate = 1 MB/s			
Hardware Connectors	Micro-Fit® connector: one polarized 2 × 2 with 3 mm pitch (power) Screw-terminal connectors (accept up to 14 AWG/1.5 mm^2 wire): four 1 × 9 (I/O), one 1 × 6 (serial) Programming port: 2 × 5 IDC, 1.27 mm pitch			
Ethernet Network Connector	One RJ-45 Ethernet			
Real-Time Clock	Yes			
Timers	Ten 8-bit timers (6 cascadable, 3 reserved for internal peripherals), one 10-bit timer with 2 match registers			
Watchdog/Supervisor	Yes			
Power	9–36 V DC, 2 W max.			
Operating Temperature	-40°C to +85°C			

Table A-1. BL4S100 Specifications (continued)

Feature	BL4S100	BL4S110	BL4S150	BL4S160
Humidity	5–95%, noncondensing			
Board Size	3.75" × 5.75" × 0.64" (96 mm × 146 mm × 16 mm)			
ZigBee RF Module				
RF Module	Digi XBee® Series 2			
Compliance	ZigBee PRO (802.15.4)			

A.1.1 Exclusion Zone

It is recommended that you allow for an “exclusion zone” of 0.25" (6 mm) around the BL4S100 in all directions when the BL4S100 is incorporated into an assembly that includes other components. This “exclusion zone” that you keep free of other components and boards will allow for sufficient air flow, and will help to minimize any electrical or EMI interference between adjacent boards. An “exclusion zone” of 0.12" (3 mm) is recommended below the BL4S100. Figure A-2 shows this “exclusion zone.”

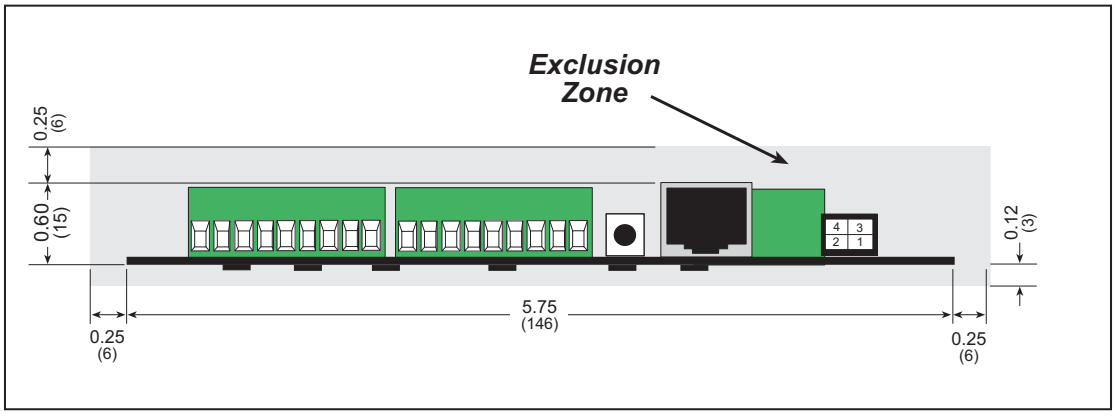


Figure A-2. BL4S100 “Exclusion Zone”

A.1.2 Headers

The BL4S100 has a 3 mm Micro-Fit® connectors at J17 for power-supply connections. There are four 1 × 9 screw-terminal headers for the various analog inputs and digital I/O. One 1 × 6 screw-terminal header handles to RS-232 signals.

A.2 Jumper Configurations

Figure A-3 shows the header locations used to configure the various BL4S100 options via jumpers.

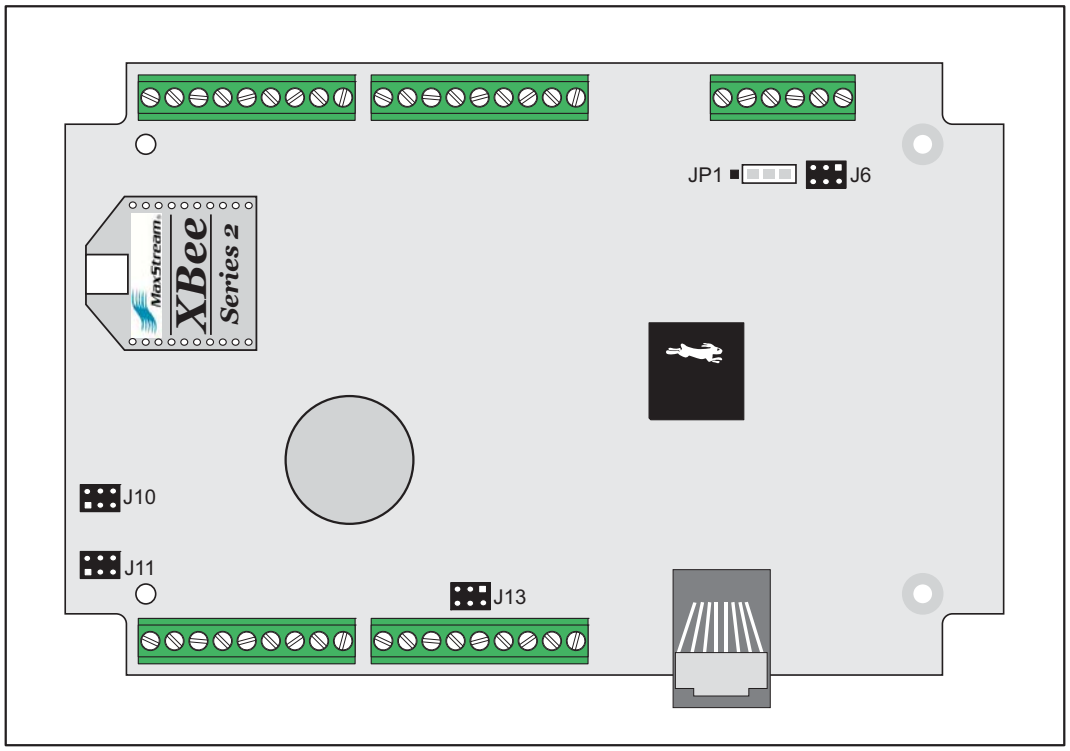


Figure A-3. Location of BL4S100 Configurable Positions

Table A-2 lists the configuration options.

Table A-2. BL4S100 Jumper Configurations

Header	Description	Pins Connected		Factory Default
JP1	Serial Communication Configuration Options (not stuffed)	None	J1 is configured for RS-232	✕
		1–2	J1 is configured for RabbitNet	
		2–3	J1 configured for 1-Wire serial	
J6	Serial Communication Configuration Options (not stuffed)	None	J1 is configured for RS-232 or RabbitNet	✕
		1–3 4–6	J1 is configured for alternate 1-Wire serial pinout	
		2–4	J1 is configured for Digi 1-Wire serial pinout	

Table A-2. BL4S100 Jumper Configurations (continued)

Header	Description	Pins Connected		Factory Default
J10	A/D Converter Voltage/Current Measurement Options	None	Voltage Option	✕
		1–2	AIN2 4–20 mA option	
		5–6	AIN3 4–20 mA option	
J11	A/D Converter Voltage/Current Measurement Options	None	Voltage Option	✕
		1–2	AIN0 4–20 mA option	
		5–6	AIN1 4–20 mA option	
J13	Digital Inputs (IN0–IN11) Pull-Up Options	1–2	Inputs pulled up to +K	
		4–6	Inputs pulled down to GND	
		5–6	Inputs pulled up to +5 V	✕

The location at J1 provides a stuffing option to support an RJ-45 jack instead of the screw-terminal header at J5. This option is reserved for future use.

A.3 Use of Rabbit Microprocessor Parallel Ports

Table A-3 lists the Rabbit microprocessor parallel ports and their use in the BL4S100 boards.

Table A-3. Use of Rabbit Microprocessor Parallel Ports

Port	I/O	Signal		Initial State
PA0–PA7	I/O	Rabbit RIO D0–D7		Bus data line
PB0	Output	PB0/SCLKB		Inactive high
PB1	Input	PB1/SCLKA		Driven by U12
PB2	Output	Rabbit RIO PI		Bus address line
PB3–PB5	Output	Rabbit RIO CH0–CHA2		
PB6	Output	Rabbit RIO /CS		
PB7	Output	Rabbit RIO G//B		
PC0	Output	TXD	Serial Port D	Inactive high
PC1	Input	RXD		Pulled up
PC2	Output	TXC (A/D converter)	Serial Port C	Inactive high
PC3	Input	RXC (A/D converter)		Pulled up
PC4	Output	TXB (serial flash)	Serial Port B	Inactive high
PC5	Input	RXB (serial flash)		Pulled up
PC6	Output	TXA programming port	Serial Port A	Low
PC7	Input	RXA programming port		Pulled up
PD0	Output	RabbitNet CLK		Clock signal
PD1	Input	XBee 1-button		
PD2	Output	SCLKC (A/D converter)		
PD3	Input	XBee reduce power		
PD4	Output	Rabbit RIO GS		Low
PD5	Input	XBee /CTS		
PD6	Output	TXE (XBee Tx)	Serial Port E	Inactive high
PD7	Input	RXE (XBee Rx)		Pulled up
PE0	Output	A20		Bus address line
PE1	Input	RIO interrupt input		Pulled up
PE2	Output	TXF (RTS)	Serial Port F	Low
PE3	Input	RXF (CTS)		Inactive high

Table A-3. Use of Rabbit Microprocessor Parallel Ports (continued)

Port	I/O	Signal	Initial State
PE4	Output	Serial Flash /CS	Inactive high
PE5	Output	Ethernet LINK	Inactive high (LED off)
PE6	Output	XBee /RTS	Low
PE7	Output	Ethernet ACT	Inactive high (LED off)
BUFEN	Output	/CS (A/D converter)	Inactive high
CLK	Output	CLK to Rabbit RIO	CPU clock

APPENDIX B. POWER SUPPLY

Appendix B describes the power circuitry provided on the BL4S100.

B.1 Power Supplies

Power is supplied to the BL4S100 boards via the Micro-Fit® connector at J17. The BL4S100 is protected against reverse polarity by a diode at D27 as shown in Figure B-1.

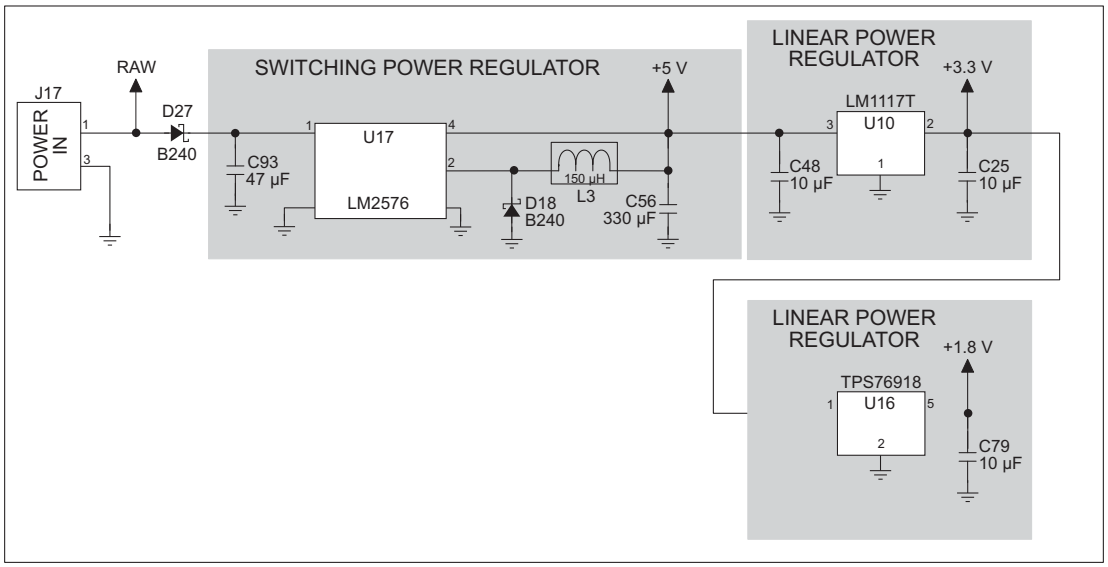


Figure B-1. BL4S100 Power Supply

The input voltage range is from 9 V to 36 V. A switching power regulator is used to provide +5 V for the BL4S100 logic circuits. In turn, the regulated +5 V DC power supply is used to drive regulated +1.8 V and +3.3 V power supplies.

The digital ground and the analog ground share a single split ground plane on the board, with the analog ground connected at a single point to the digital ground by a 0 Ω resistor (R63). This is done to minimize digital noise in the analog circuits and to eliminate the possibility of ground loops. External connections to analog ground are made on a screw-terminal header at J15.

B.2 Batteries and External Battery Connections

The SRAM and the real-time clock on the BL4S100 modules have battery backup. Power to the SRAM and the real-time clock (VRAM) is provided by two different sources, depending on whether the main part of the BL4S100 is powered or not. When the BL4S100 is powered normally, and the +3.3 V supply is within operating limits, the SRAM and the real-time clock are powered from the +3.3 V supply. If power to the board is lost or falls below 2.93 V, the VRAM and real-time clock power will come from the battery. The reset generator circuit controls the source of power by way of its **/RESET** output signal.

A replaceable 235 mA·h lithium battery provides power to the real-time clock and SRAM when external power is removed from the circuit board. The drain on the battery is typically less than 10 µA when there is no external power applied to the BL4S100, and so the expected shelf life of the battery is

$$\frac{235\ \text{mA}\cdot\text{h}}{10\ \mu\text{A}} = 2.7\ \text{years}.$$

The actual battery life in your application will depend on the current drawn by components not on the BL4S100 and on the storage capacity of the battery. The BL4S100 does not drain the battery while it is powered up normally.

B.2.1 Replacing the Backup 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 CR2032 or equivalent replacement battery, and insert it into the battery holder with the + side facing up.

NOTE: The SRAM contents and the real-time clock settings will be lost if the battery is replaced with no power applied to the BL4S100. Exercise care if you replace the battery while external power is applied to the BL4S100.

CAUTION: There is an explosion danger if the battery is short-circuited, recharged, or replaced incorrectly. Replace the battery only with the same type or an equivalent type recommended by the battery manufacturer. Dispose of used batteries according to the battery manufacturer's instructions.

Cycle the main power off/on after you install a backup battery for the first time, and whenever you replace the battery. This step will minimize the current drawn by the real-time clock oscillator circuit from the backup battery should the BL4S100 experience a loss of main power.

Rabbit's Technical Note TN235, ***External 32.768 kHz Oscillator Circuits***, provides additional information about the current draw by the real-time clock oscillator circuit.

APPENDIX C. DEMONSTRATION BOARD

Appendix C explains how to use the Demonstration Board with the BL4S100 sample programs.

C.1 Connecting Demonstration Board

Before running sample programs based on the Demonstration Board, you will have to connect the Demonstration Board from the BL4S100 Tool Kit to the BL4S100 board. Proceed as follows.

1. Use wires to connect screw-terminal header J3 on the Demonstration Board to header J4 on the BL4S100. The connections are shown in Figure C-1, with the green wire to GND and the blue wire to +V.
2. Make sure that your BL4S100 is connected to your PC via the programming cable and that the power supply is connected to the BL4S100 and plugged in as described in Chapter 2, “Getting Started.”

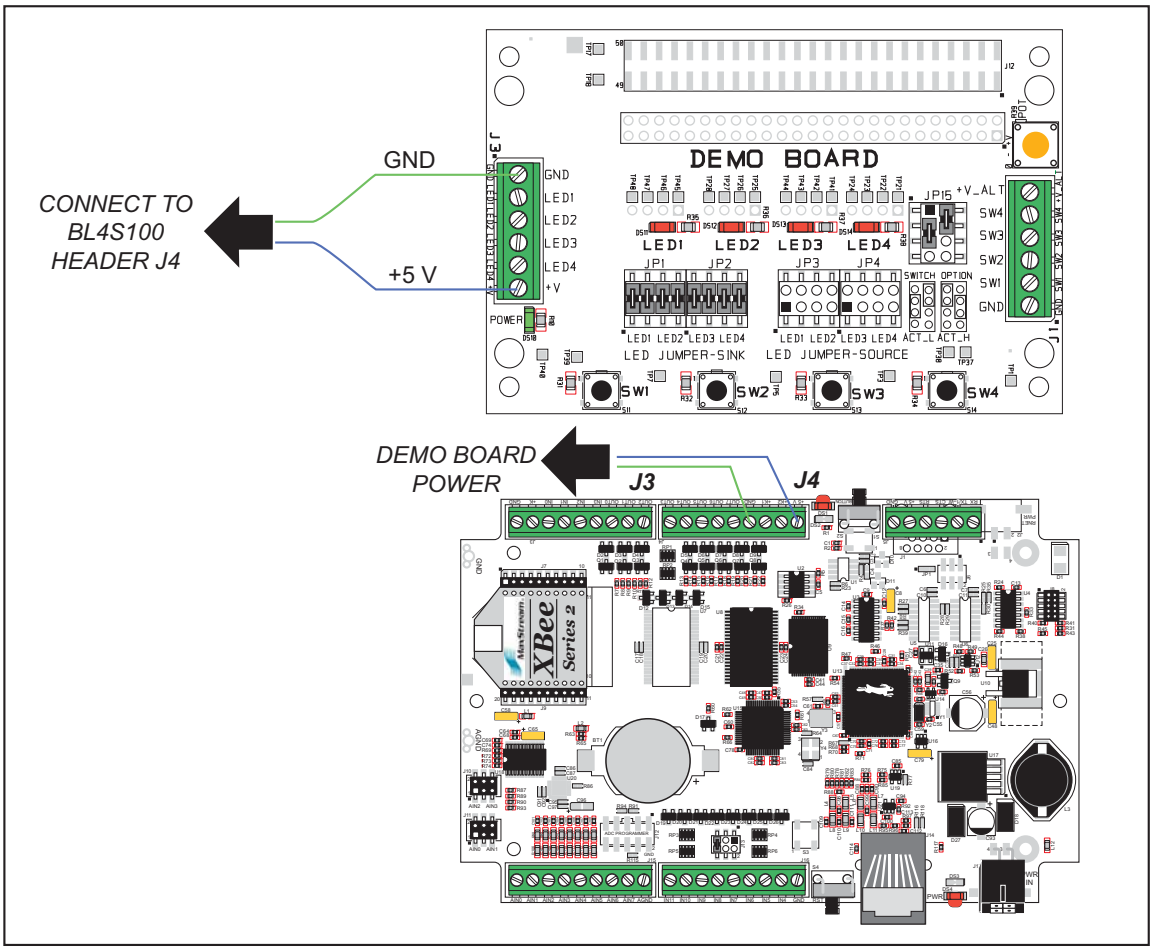


Figure C-1. Power Supply Connections Between BL4S10 and Demonstration Board

CAUTION: If you are using your own power supply with the Demonstration Board, note that the maximum power supply input voltage the Demonstration Board can handle is + 12 V DC. Do not use a higher power supply voltage.

C.2 Demonstration Board Features

The Demonstration Board can be used to illustrate I/O activity via LEDs and pushbutton switches.

C.2.1 Pinout

Figure C-2 shows the pinouts for the input signals on screw-terminal header J1 and the outputs on screw-terminal header J3.

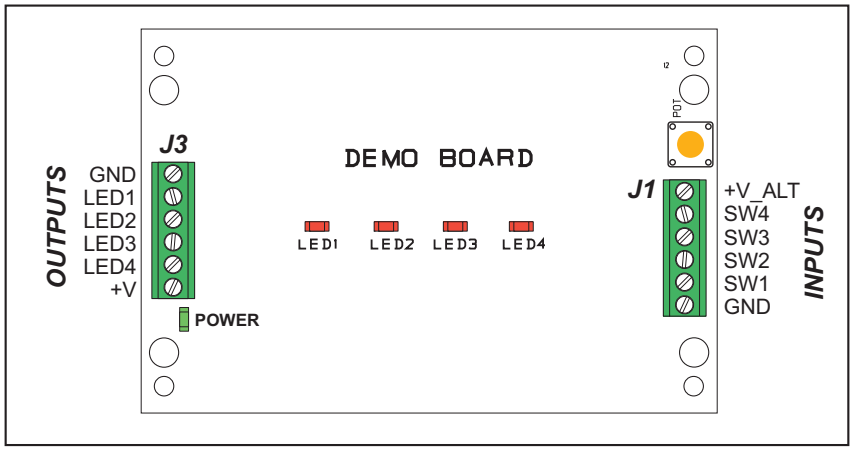


Figure C-2. Demonstration Board Pinout

C.2.2 Configuration

The pushbutton switches may be configured active high or active low via jumper settings on header JP15.

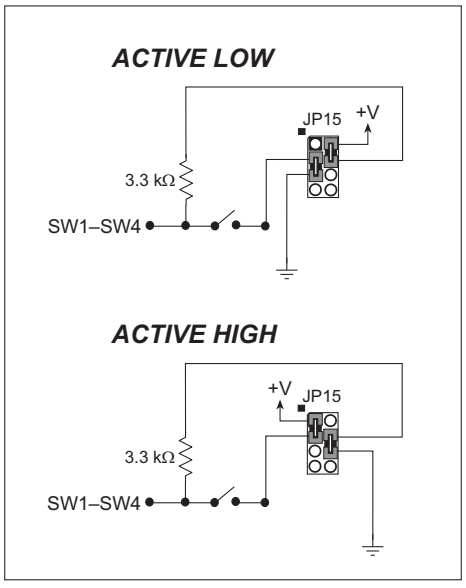


Figure C-3. Pushbutton Switch Configuration

The four LED output indicators can be configured as sinking outputs or as sourcing outputs via jumpers on headers JP1–JP4 as shown in Figure C-4.

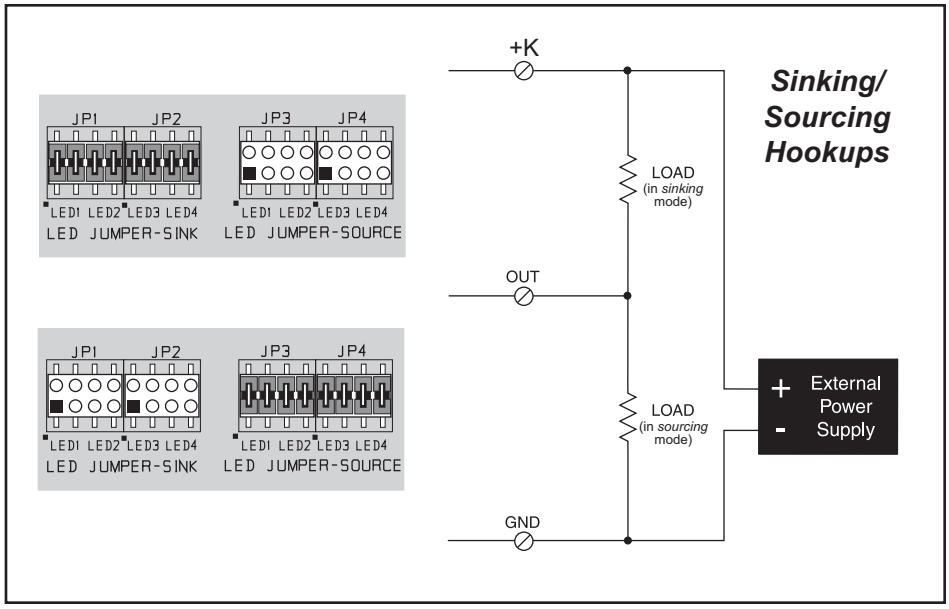


Figure C-4. LED Output Indicators Sinking or Sourcing Configuration

NOTE: Disconnect power *before* changing any jumper settings.

The power supply voltage input at +V on screw-terminal header J3 is available as +V_ALT on screw-terminal header J1. There is a potentiometer immediately above the +V_ALT location to allow you to vary the voltage at +V_ALT from 0 V to +V.

Figure C-5 shows the location of the adjustable output voltage and the potentiometer.

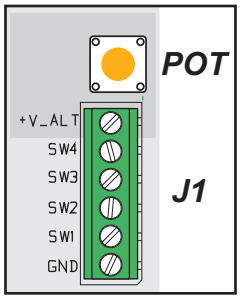


Figure C-5. Location of Adjustable Output Voltage

APPENDIX D. RABBIT RIO RESOURCE ALLOCATION

Appendix D provides the pin and block associations on the Rabbit RIO chip with their corresponding I/O on the BL4S100 boards. The main shared resource within the RIO chips are the counter/timer blocks — the RIO chip has eight counter/timer blocks. A given block is defined by the block number. The tables in this appendix provide a quick reference of which block is used by each input and/or output pin on the BL4S100 board.

D.1 Digital I/O Pin Associations

Table D-1. Digital I/O Pin Associations

I/O Pin	Block	Pin
IN0	0	0
IN1		1
IN2		2
IN3	1	0
IN4		1
IN5		2
IN6	2	0
IN7		1
OUT0		2
OUT1		3
IN8	3	0
IN9		1
OUT2		2
OUT3		3
OUT4	4	2
OUT5		3
OUT6	5	2
OUT7		3
IN10	6	0
IN11	7	0

D.2 Interpreting Error Codes

Some BL4S100 function calls may return a *Mode Conflict* error code. This error code is a 4-bit value that identifies other pins using the same counter/timer block on a RIO chip that require this block to be in a mode that conflicts with the functionality that has already been requested — the additional functionality requested cannot be supported. The error code also helps you identify the other pins whose functionality needs to change to possibly allow the latest function call to succeed.

The bit values in the *Mode Conflict* error codes have the following meanings.

- Bits [7:4] don't matter, will always be zero
- Bit 3 — Pin 3 of this block has a mode conflict
- Bit 2 — Pin 2 of this block has a mode conflict
- Bit 1 — Pin 1 of this block has a mode conflict
- Bit 0 — Pin 0 of this block has a mode conflict

By looking at the table in this appendix, you can identify the other pins that share the RIO counter/timer block with the pin(s) that returned the *Mode Conflict* error code. For example, if you already configured IN0 and IN1 as Quadrature Decoder inputs, then try to set IN2 as a counter input, the function call will return a *Mode Conflict* error code of 3.

This error code is a 4-bit value that identifies other pins using the same counter/timer block that conflict with the requested function. In this case, 3 is 0011, which indicates that pin 1 and pin 2 of the block used by IN2 have the conflicts — they are using the counter/timer in a way that conflicts with setting IN2 as a counter input. Looking at Table D-1, you find IN2 is using block 0 on RIO chip 0, and pin 0 and pin 1 of this block are used by IN0 and IN1. Therefore you cannot use IN2 as a counter input unless you remove the Quadrature Decoder inputs from this block. This illustrates how the *Mode Conflict* error code can be used to identify the pin functions that cannot mix together on the same RIO block.

The tables in this appendix are useful for both finding the cause of mode conflicts, and for planning which pins to use for which functions to avoid conflicts in the first place.

Notice that there is a pattern to the block sharing of certain I/O pins. The first six digital input pins, IN0—IN5, have blocks shared across four inputs. These are the only pins that can support functions such as Quadrature Decoder inputs with an independent index-based reset. The next group of eight digital I/O pins (IN6–IN9 and OUT0–OUT3) share blocks among their digital I/O pairs, bringing both the input and output functionality of these pins into the same block. This allows PWM or PPM outputs that can be used with an external synchronization signal. It would also allow synchronization of a pulse capture response to a PWM-based output pulse. The last remaining I/O pins have nonshared RIO blocks available for both the input and output functionality, making these pins ideal for single-pin functions requiring a counter/timer.

Table D-2 shows all counter/timer modes of the RIO block and which functions can use the given modes. The use of synch signals is allowed with all the functions, but does affect the timer/counter so it may have an adverse affect on functions marked with * or #.

Table D-2. RIO Counter/Timer Block Mode Summary

	Up Count	Count Until Match	Up/Down Count	Free-Running Timer	Count Until End	Count from Begin to End	Count While Begin Is Active
Digital Input	×	×	×	×	×	×	×
Digital Output	×	×	×	×	×	×	×
Event Counter Input	*	*	*				
Event Capture Input				#	*	*	*
Quad. Decoder Input			*				
Ext. Interrupt Input	×	×	×	×	×	×	×
External Synch Input	×	×	×	×	×	×	×
PWM/PPM Output				#			

× — I/O are compatible with the given mode, and can work with any other function using that mode.

* — I/O cannot share the block with any other * or # marked function without possible conflicts.

— I/O can generally share the timer, but will be affected by settings of the limit value (value at which the timer rolls over) or resetting of the counter, either directly or through synch signals.

APPENDIX E. PLASTIC ENCLOSURE

The plastic enclosure provides a secure way to protect your BL4S100. The enclosure itself may be mounted on any flat surface.

The complete plastic enclosure consists of a base and a cover. The base alone is a convenient surface on which to mount the BL4S100, and also provides a means to mount the BL4S100 on any flat surface. The base and cover are sold together.

Appendix E describes how to mount the BL4S100 inside the plastic enclosure, and provides details on mounting the assembly.

E.1 Assembly Instructions

1. Attach the BL4S100 board to the plastic enclosure base.

Position the BL4S100 board over the plastic enclosure base as shown below in Figure E-1. Attach the BL4S100 to the base using the four 4-40 × ¼ screws supplied with the enclosure base.

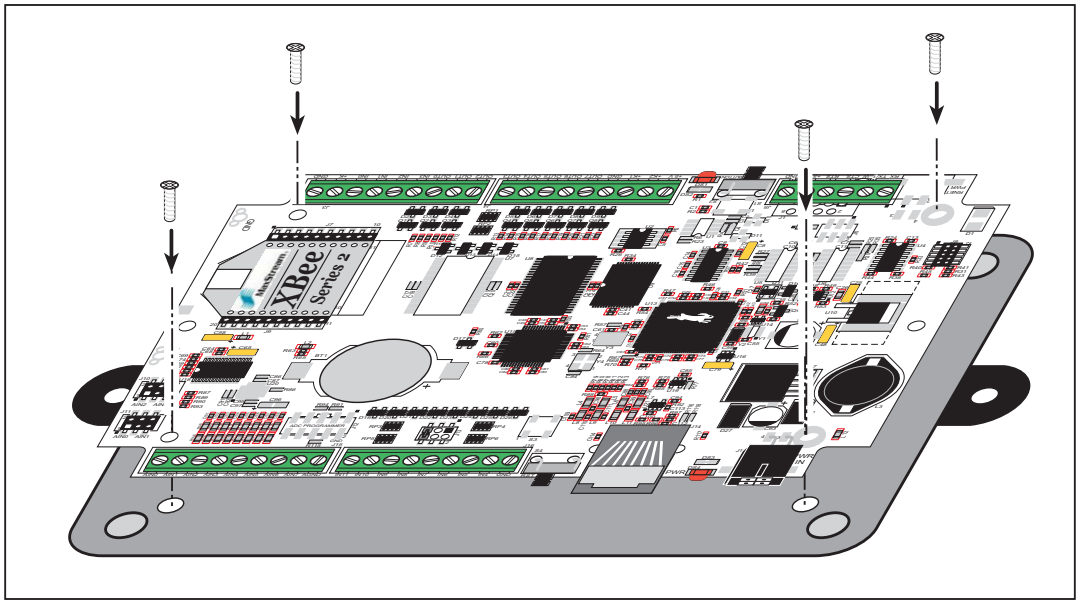


Figure E-1. Attach BL4S100 to Plastic Enclosure Base

2. Mount plastic enclosure (optional).

Use two #10 screws to attach the plastic enclosure at the two outer side mounting holes to the surface on which it will be mounted.

3. Attach the enclosure cover to the base.

Position the cover over the plastic enclosure base as shown below in Figure E-2. Attach the cover to the base using the four 4-40 × ½ screws supplied.

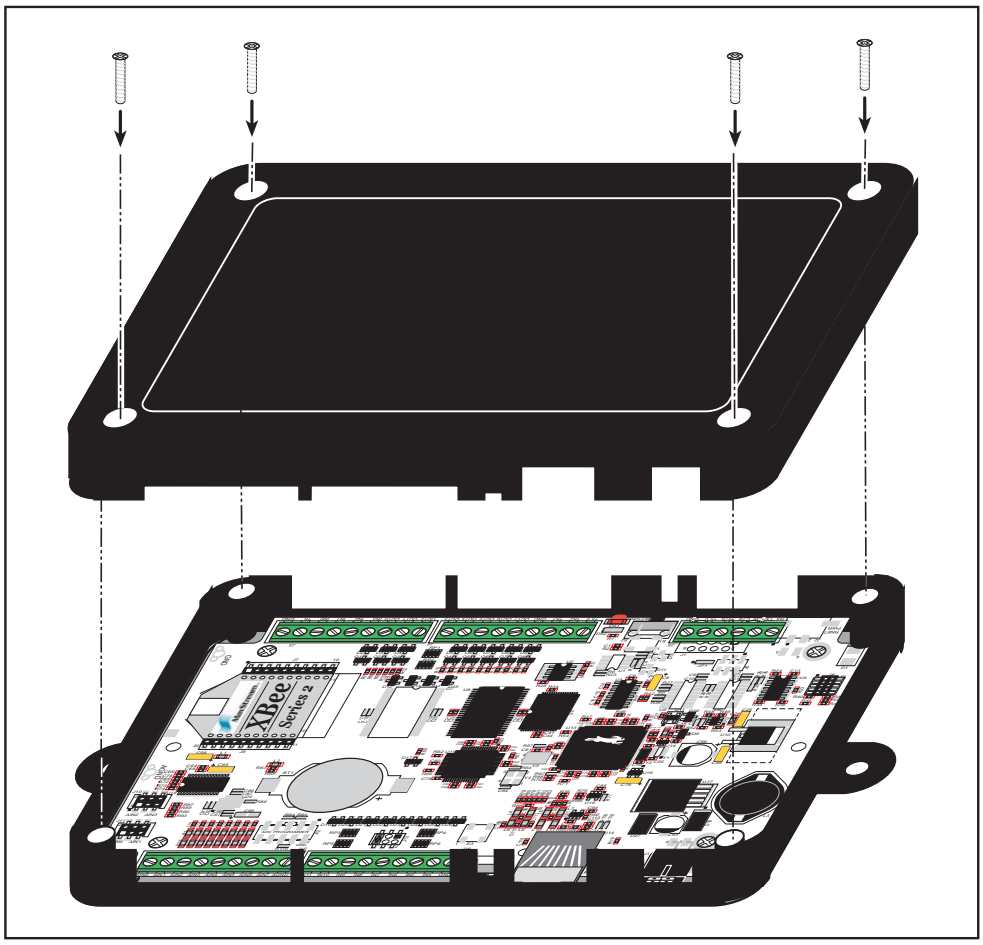


Figure E-2. Attach Enclosure Top

E.2 Dimensions

Figure E-3 shows the dimensions for the plastic enclosure.

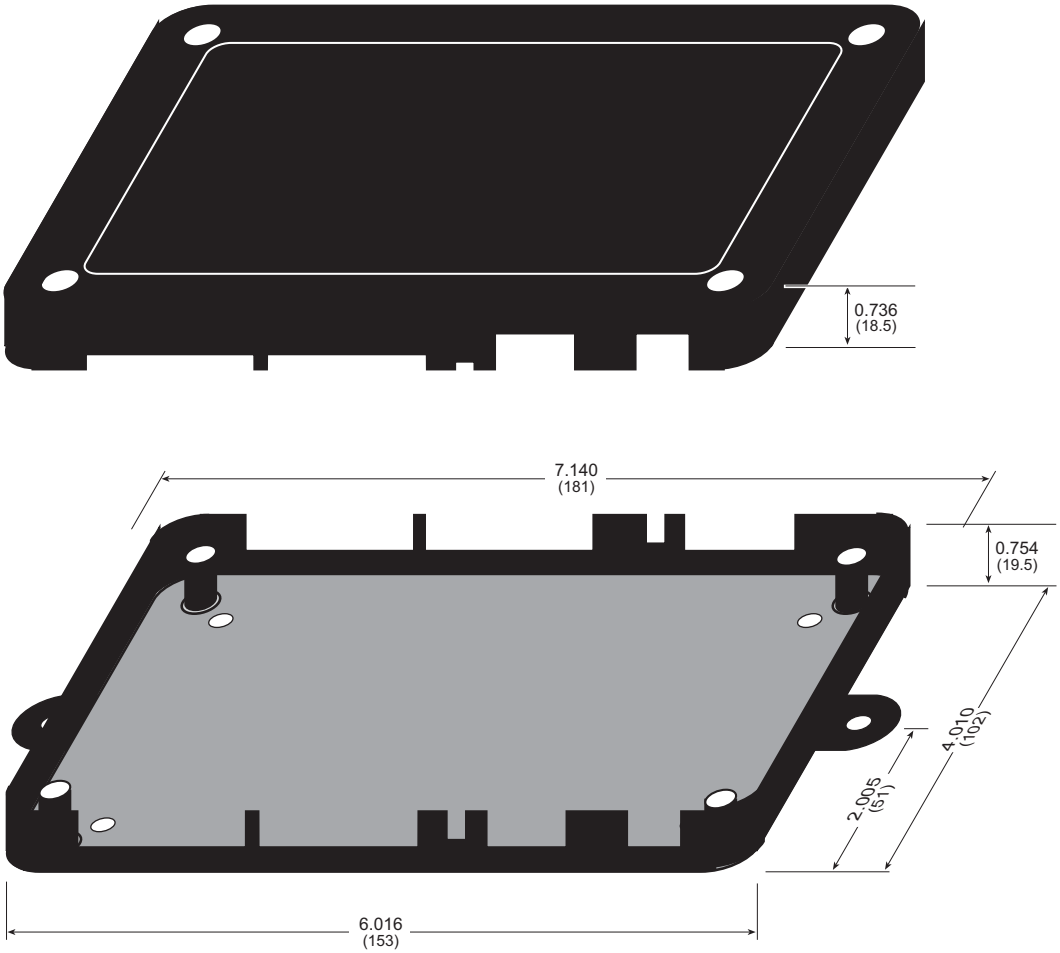


Figure E-3. Plastic Enclosure Dimensions

When fully assembled, the total height of the plastic enclosure will be 1.5" (38 mm).

NOTE: All measurements are in inches followed by millimeters enclosed in parentheses. All dimensions have a manufacturing tolerance of ±0.01" (0.25 mm).

APPENDIX F. ADDITIONAL CONFIGURATION INSTRUCTIONS

Appendix F provides information on how to find the latest firmware for the XBee RF module and the Digi® XBee USB used as the ZigBee coordinator, and how to install the firmware.

F.1 XBee Module Firmware Downloads

By default, the BL4S100/BL4S150 is shipped from the factory with firmware to operate as a router in a mesh network. You will need to run the **MODEMFWLOAD.C** sample program in the Dynamic C **SAMPLES\XBEE** folder to download the firmware needed to operate the BL4S100/BL4S150 as a coordinator or as an end device.

NOTE: You can verify the firmware version by running the **AT_INTERACTIVE.C** sample program in the Dynamic C **SAMPLES\XBEE** folder and by entering the command ATVR **<Enter>** to get the version number displayed in the Dynamic C **STDIO** window.

CAUTION: Different firmware versions are likely to interact with the Dynamic C libraries in different ways. Rabbit has tested the firmware associated with a particular version of Dynamic C for correct operation, and only this version is included on the Dynamic C CD-ROM — do not use any other firmware versions with that version of Dynamic C.

Once you have successfully loaded the firmware, compile and run another sample program to make sure the **MODEMFWLOAD.C** sample program does not inadvertently reload (or partially reload) the firmware.

If you are uploading firmware because you upgraded to a more recent Dynamic C release, remember to recompile your applications using the new version of Dynamic C once you have uploaded the new firmware.

F.1.1 Dynamic C v. 10.44 and Later

Encrypted libraries have been created within Dynamic C for the firmware. The three libraries are in the **LIB\Rabbit4000\XBee\XBee_Firmware\ZigBee** folder.

- A Dynamic C library of the type **XB24-ZB_21….LIB** is used for a coordinator BL4S100/BL4S150.
- A Dynamic C library of the type **XB24-ZB_23….LIB** is used for a router BL4S100/BL4S150.
- A Dynamic C library of the type **XB24-ZB_29….LIB** is used for an end-device BL4S100/BL4S150.

Make the following modifications to the **MODEMFWLOAD.C** sample program.before you run it according to whether you will be using the BL4S100/BL4S150 as a coordinator, a router, or an end device.

- Select the XBee role macro according to whether the BL4S100/BL4S150 is being used as a coordinator, a router or an end-device.

```
#define XBEE_ROLE NODE_TYPE_COORD
#define XBEE_ROLE NODE_TYPE_ROUTER
#define XBEE_ROLE NODE_TYPE_ENDDEV
```

- Some Rabbit boards use the ZNet 2.5 protocol. The BL4S100/BL42150 use the ZB protocol. Make sure the **#define** statement calls for the ZB protocol.

```
#define XBEE_PROTOCOL XBEE_PROTOCOL_ZB
```

F.2 Digi® XBee USB Configuration

The Digi XBee USB device is an optional accessory and is available as a part of the Mesh Networking Add on Kit (101-1272), or for separate purchase (101-1286). It is not a part of the standard BL4S200 Tool Kit.

You may experience difficulty when you use the ZigBee sample programs and the Digi® XBee USB with the default settings if you are working simultaneously with more than one ZigBee coordinator.

Section 6.2.2 explains how to set up the BL4S100/BL4S150 configuration patterns for the sample programs via macros in the Dynamic C **LIB\Rabbit4000\XBee\XBEE_API.LIB** library folder.

Channel mask — defaults to 0x1FFE, i.e., all 16 possible channels via the macro in the Dynamic C **LIB\Rabbit4000\XBee\XBEE_API.LIB** library.

```
#define DEFAULT_CHANNELS ZB_DEFAULT_CHANNELS
```

For example, to limit the channels to three channels, the macro would read as follows.

```
#define DEFAULT_CHANNELS 0x000E
```

Extended PAN ID — the 64-bit network ID. Defaults to **DEFAULT_PANID** if set in the Dynamic C **LIB\Rabbit4000\XBee\XBEE_API.LIB** library, otherwise defaults to **0x0123456789abcdef** to match the default used on the Digi® XBee USB.

If set to **0x00**, tells coordinators to "select a random extended PAN ID," and tells routers and end devices to "join any network."

Change the extended PAN ID if you are developing simultaneously with more than one ZigBee coordinator.

```
#define DEFAULT_EXTPANID "0x0123456789abcdef"
```

The same configurations must then be applied to the Digi® XBee USB via Digi's X-CTU utility. If you have not previously used this utility, install it from the Dynamic C **Utilities\X-CTU** folder by double-clicking **Setup_x-ctu.exe**,

Continue the following steps with the Digi® XBee USB connected to your PC's USB port. Since the ZigBee Utility **XBEE_GPIO_GUI.exe** will conflict with X-CTU, first close the ZigBee Utility if it is running.

1. Start X-CTU from the desktop icon and set the "PC Settings" tab to **115200** baud, **HARDWARE** flow control, **8** data bits, parity **NONE**, **1** stop bit.
2. On the "PC Settings" tab, check the "Enable API" box under "Host Setup."
3. On the "PC Settings" tab, select the "USB Serial Port" corresponding to the USB serial port the Digi® XBee USB is connected to and click "Test/Query." You should see a response showing the Modem Type (XB 24-B) and the firmware version. Click **OK**.

   Note that several USB serial ports could be listed. If you select a serial port without the Digi® XBee USB connected, the X-CTU response to "Test/Query." will be "communication with modem … OK," but the modem type will be unknown, and the firmware version will be blank.

   If you a get a message that X-CTU is unable to open the COM port, verify that you selected the COM port with the "USB Serial Port," then try unplugging the Digi® XBee USB from the USB slot and plugging it back in. Now click "Test/Query" again.
4. Under the "Modem Configuration" tab click the "Read" button. X-CTU will now display the networking and I/O parameters for the Digi® XBee USB being used as the ZigBee coordinator.

   Modem: XBEE XB24-ZB

   Function Set: ZIGBEE COORDINATOR API (do not select other settings)

   Version: the version of the firmware included with the version of Dynamic C you are using (should be of the type **21…**)
5. Now set the networking parameters in your project defines or in the sample program to match the parameters in the Dynamic C **LIB\Rabbit4000\XBee\XBEE_API.LIB** library.

   Networking

   (D) CH - Operating Channel — this is the operating channel you could see when you ran the **AT_INTERACTIVE.C** sample program in the Dynamic C **SAMPLES\XBEE** folder by entering the command ATCH <**Enter**>. This channel information cannot be changed from the X-CTU utility.

   (0123456789ABCDEF) ID - Extended Pan ID — set the new extended PAN ID that follows 0x to match the **DEFAULT_EXTPANID** macro.

   (1FFE) SC - Scan Channels - set the new value for the channels to scan, E, for example, to match the new setting in the macro.

   ```
   #define DEFAULT_CHANNELS 0x000E
   ```
6. Finish by clicking the "Write" button.

F.2.1 Additional Reference Information

Check Digi's Web site for the latest information and documentation on the XBee Series 2 module, the X-CTU utility, and the Digi® XBee USB. Note that the XBee™ and the XBee

PRO™ RF modules are presently not compatible with the XBee Series 2 module used with the BL4S100/BL4S150, but the general documentation about ZigBee and the use of AT commands for the XBee™ and the XBee PRO™ RF modules is relevant.

F.2.2 Update Digi® XBee USB Firmware

The firmware version used by the Digi® XBee USB must correspond to the firmware version installed on the BL4S100/BL4S150. If you have updated the BL4S100/BL4S150 firmware (or you have a need to re-install the firmware on the Digi® XBee USB), the corresponding firmware for the Digi® XBee USB is in the Dynamic C **Utilities\X-CTU\MODEMFW** folder.

- Remember to record the extended PAN ID, NI, and other parameters you are using.
- Firmware of the type **XB24-ZB_21….zip** is used for the Digi® XBee USB coordinator.

> **CAUTION:** Different firmware versions are likely to interact with the Dynamic C libraries in different ways. Rabbit has tested the firmware associated with a particular version of Dynamic C for correct operation, and only this version is included on the Dynamic C CD-ROM — do not use any other firmware versions with that version of Dynamic C.

1. Start X-CTU from the desktop icon and set the "PC Settings" tab to **115200** baud, **HARDWARE** flow control, **8** data bits, parity **NONE**, **1** stop bit.
2. On the "PC Settings" tab, check the "Enable API" box under "Host Setup."
3. On the "PC Settings" tab, select the "USB Serial Port" and click "Test/Query." You should see a response showing the Modem Type (XB 24-B) and the firmware version. Click **OK**.

   Note that several USB serial ports could be listed. If you select a serial port without the Digi® XBee USB connected, the X-CTU response to "Test/Query." will be "communication with modem … OK," but the modem type will be unknown, and the firmware version will be blank.

   If you a get a message that X-CTU is unable to open the COM port, verify that you selected the COM port with the "USB Serial Port," then try unplugging the Digi® XBee USB from the USB slot and plugging it back in. Now click "Test/Query" again.
4. Under the "Modem Configuration" tab click the "Read" button. X-CTU will now display the networking and I/O parameters for the Digi® XBee USB.

   Modem: XBEE XB24-ZB

   Function Set: ZIGBEE COORDINATOR API (do not select other settings)

   Version: the version of the firmware included with the version of Dynamic C you are using
5. Under the "Modem Configuration" tab click the "Download new versions…" button, select "File," and browse to the **Utilities\X-CTU\MODEMFW** subfolder, then click "Open" when you have selected the firmware. (Do *not* select "Web," which will allow you to find the file on a Web site.) Remember to select firmware of the type **XB24-ZB_21….zip** that is used for a coordinator.

   The X-CTU utility will display an Update Summary box. Click "OK," and then click "Done."
6. Click the "Read" button, select XB24-B as the Modem type; select ZIGBEE COORDINATOR API as the Function Set, and 21… as the Version, then click "Write."
7. When the process is complete set the PANID, NI, and other parameters to the values you were using before the firmware was upgraded.

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SCHEMATICS

090-0265 BL4S100 Schematic

www.rabbit.com/documentation/schemat/090-0265.pdf

090-0252 USB Programming Cable Schematic

www.rabbit.com/documentation/schemat/090-0252.pdf

090-0272 Rabbit Demonstration Board

www.rabbit.com/documentation/schemat/090-0272.pdf

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

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