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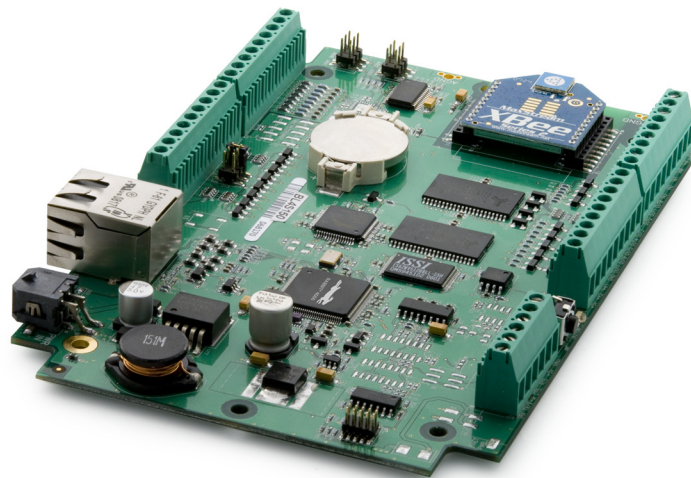
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# **BL4S100**

C-Programmable Single-Board Computer with Networking

## **User's Manual**

019-0172\_D

## **BL4S100 User's Manual**

Part Number 019-0172\_D • Printed in U.S.A.

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# 1. INTRODUCTION

The BL4S100 series of high-performance, C-programmable single-board computers offers built-in RS232, digital I/O and analog inputs combined with the 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<sup>®</sup> 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 website for up-to-date information about additional add-ons and features as they become available. The website 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.

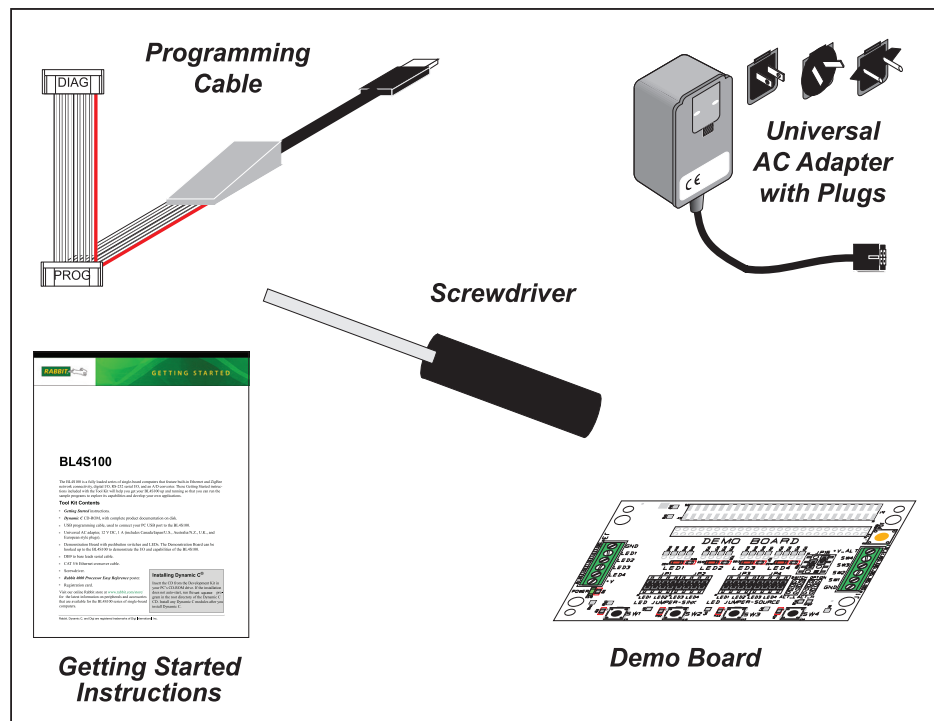


Figure 1. BL4S100 Tool Kit

### 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  $\mu$ C/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 website 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 website at [www.digi.com](http://www.digi.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 $\mu\text{V}/\text{m}$ at 10 m (40 dB relative to 1 $\mu\text{V}/\text{m}$ ) or 300 $\mu\text{V}/\text{m}$	More restrictive emissions requirement: 30 dB $\mu\text{V}/\text{m}$ at 10 m or 100 $\mu\text{V}/\text{m}$

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 website.



## 2. GETTING STARTED

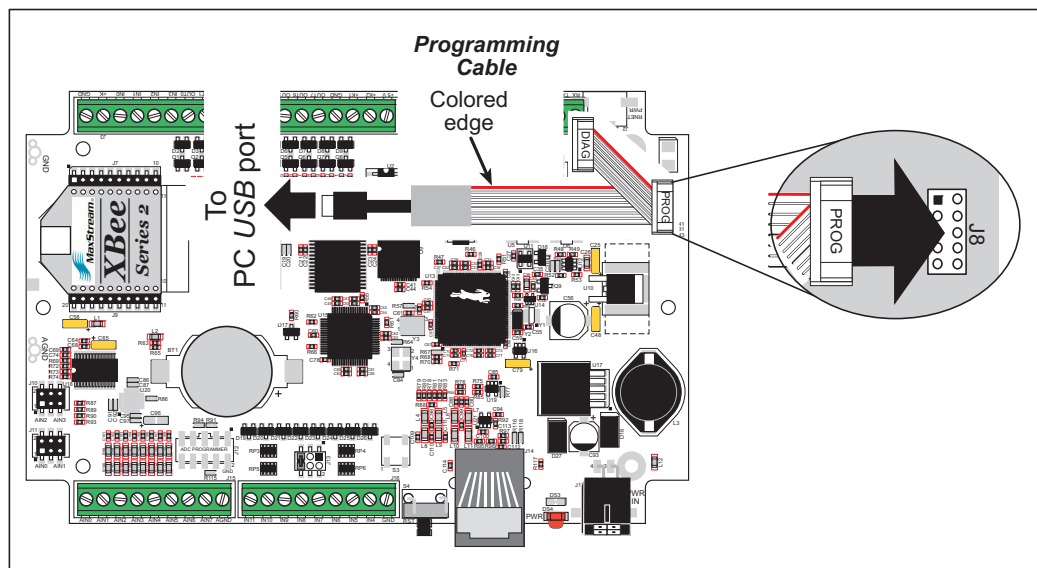
Chapter 2 explains how to connect the programming cable and power supply to the BL4S100.

## 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**

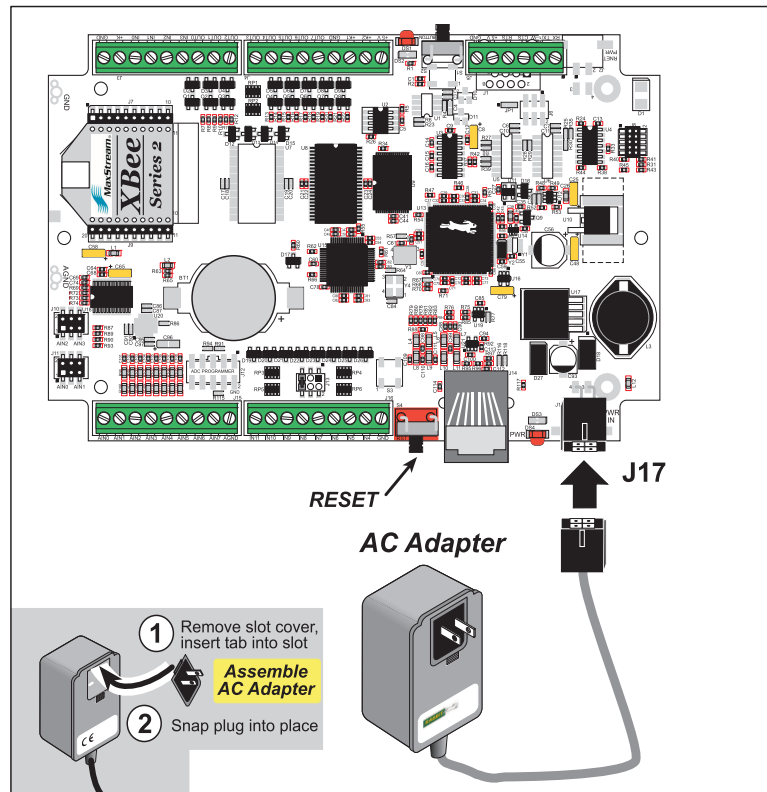
Your PC should recognize the new USB hardware, and the LEDs in the shrink-wrapped area of the USB programming cable will flash — if you get an error message, you will have to install USB drivers. Drivers for Windows XP are available in the Dynamic C **Drivers\Rabbit USB Programming Cable\WinXP\_2K** 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](http://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 websites 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.

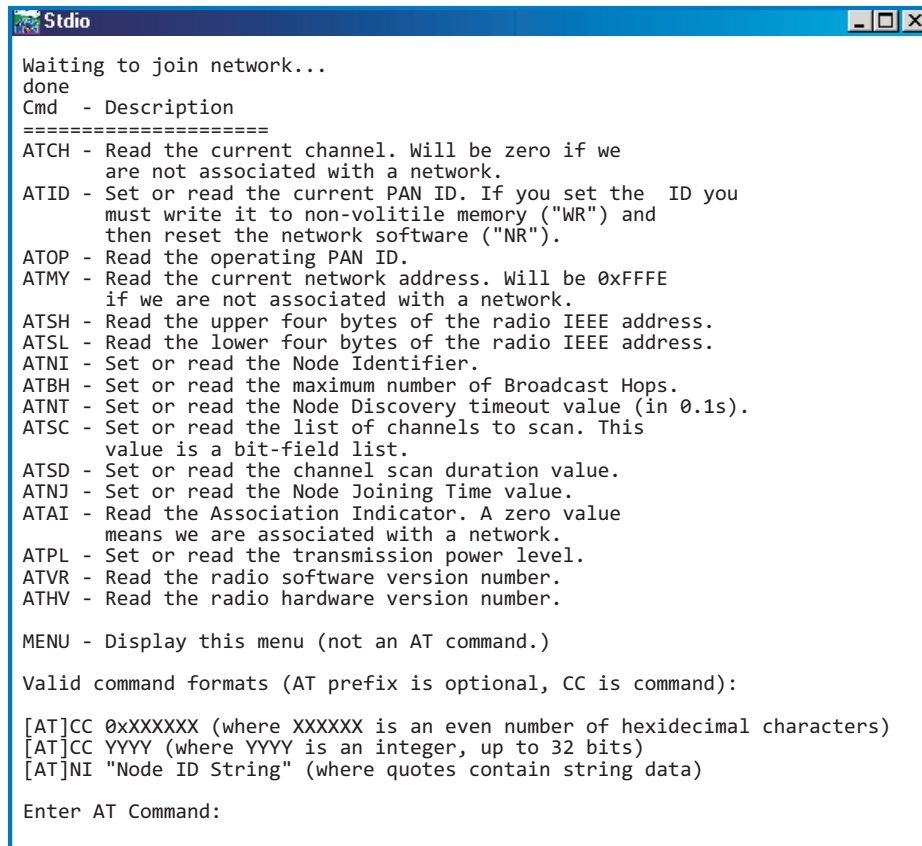
- Locate the **Serial Options** dialog on the “Communications” tab in the Dynamic C **Options > Project Options** menu. Choose a lower debug baud rate. Click **OK** to save.

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.



```
Stdio
Waiting to join network...
done
Cmd - Description
=====
ATCH - Read the current channel. Will be zero if we
are not associated with a network.
ATID - Set or read the current PAN ID. If you set the ID you
must write it to non-volatile memory ("WR") and
then reset the network software ("NR").
ATOP - Read the operating PAN ID.
ATMY - Read the current network address. Will be 0xFFFE
if we are not associated with a network.
ATSH - Read the upper four bytes of the radio IEEE address.
ATSL - Read the lower four bytes of the radio IEEE address.
ATNI - Set or read the Node Identifier.
ATBH - Set or read the maximum number of Broadcast Hops.
ATNT - Set or read the Node Discovery timeout value (in 0.1s).
ATSC - Set or read the list of channels to scan. This
value is a bit-field list.
ATSD - Set or read the channel scan duration value.
ATNJ - Set or read the Node Joining Time value.
ATAI - Read the Association Indicator. A zero value
means we are associated with a network.
ATPL - Set or read the transmission power level.
ATVR - Read the radio software version number.
ATHV - Read the radio hardware version number.

MENU - Display this menu (not an AT command.)

Valid command formats (AT prefix is optional, CC is command):

[AT]CC 0XXXXXX (where XXXXXX is an even number of hexadecimal characters)
[AT]CC YYYY (where YYYY is an integer, up to 32 bits)
[AT]NI "Node ID String" (where quotes contain string data)

Enter AT Command:
```

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.digi.com/support/](http://www.digi.com/support/) and at [www.digi.com/forum/support/rabbit](http://www.digi.com/forum/support/rabbit).
- Click [tech.support@digi.com](mailto:tech.support@digi.com) to send an email to Technical 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 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.

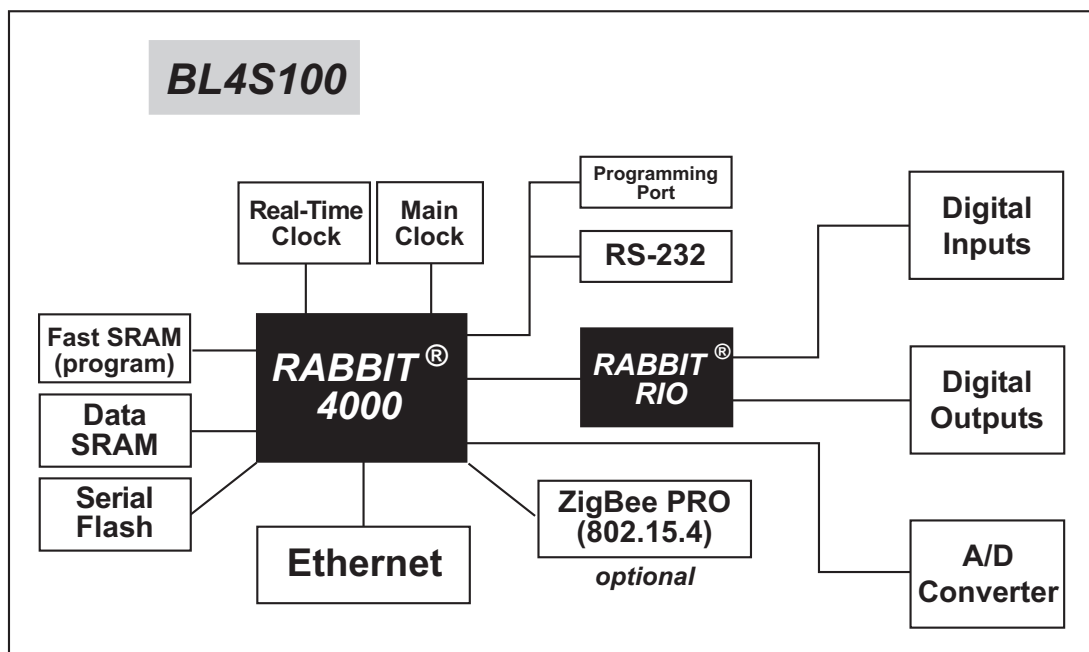


Figure 4. BL4S100 Subsystems

### 3.1 BL4S100 Pinouts

The BL4S100 pinouts are shown in Figure 5.

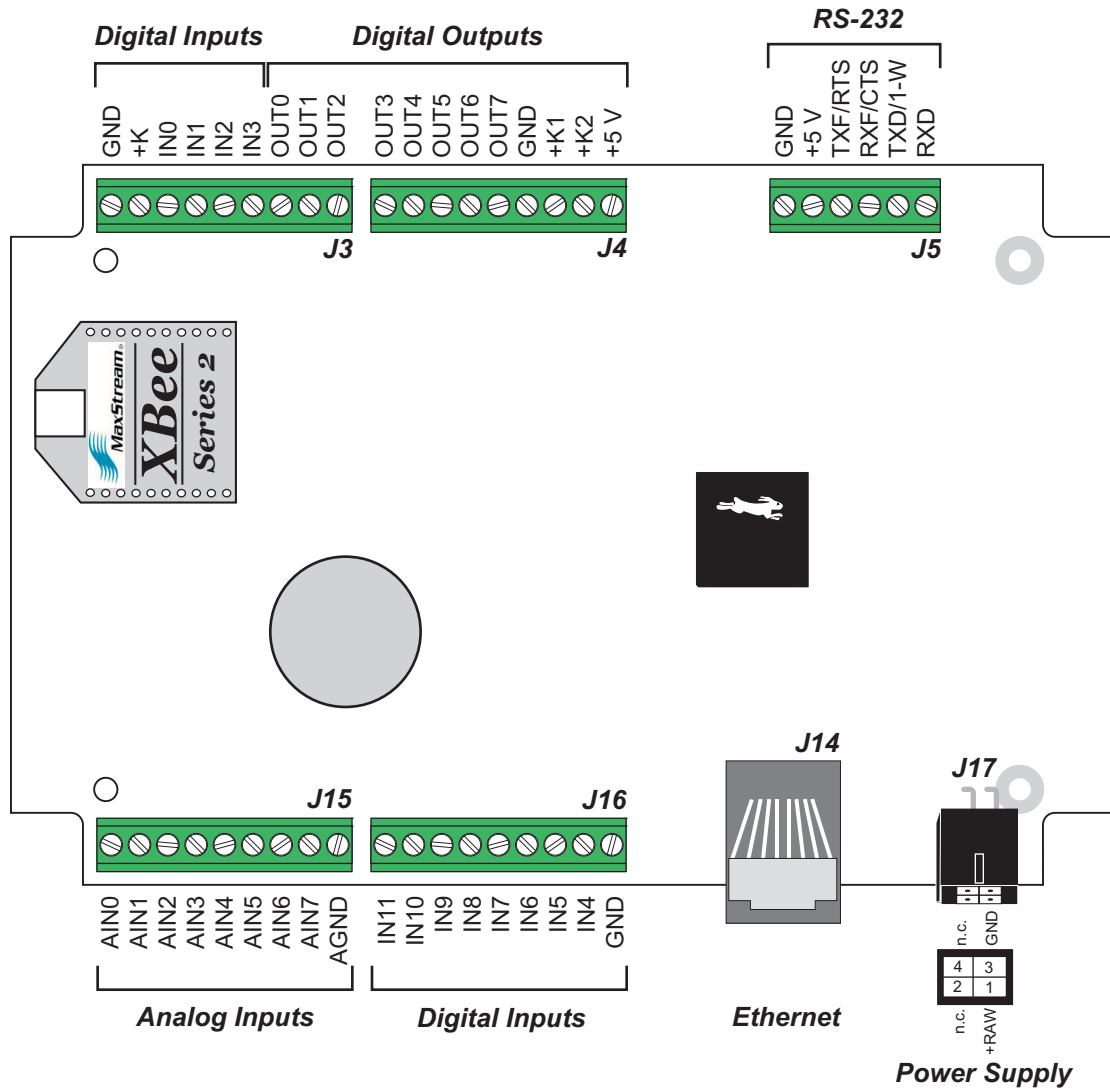


Figure 5. BL4S100 Pinouts

#### 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.

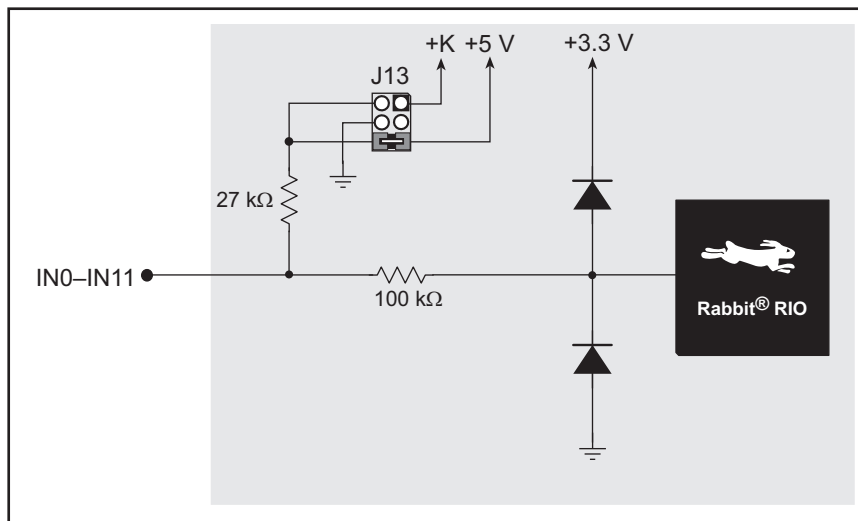
## 3.2 Digital I/O

### 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]**

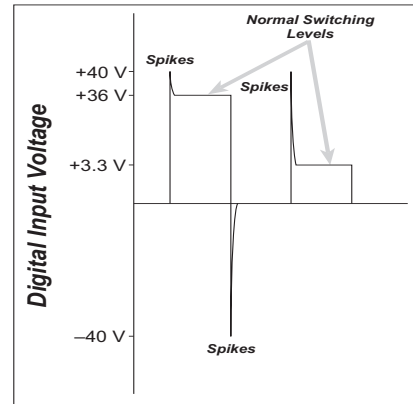
Table 2 summarizes the jumper settings.

**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  $\pm 40$  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  $\pm 36$  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.

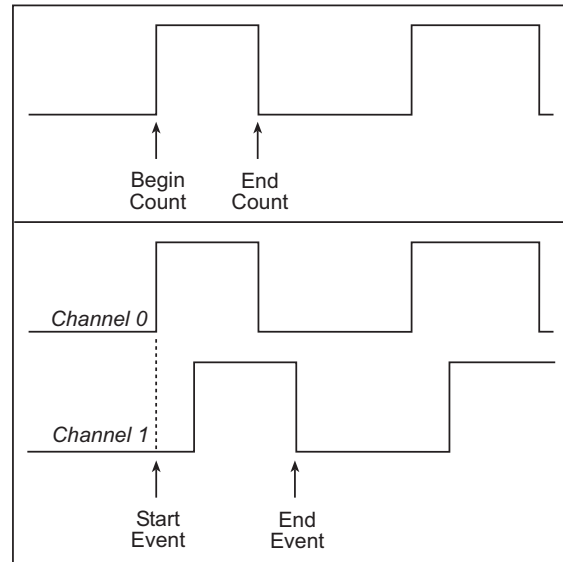
Sample programs in the **DIO** subdirectory in **SAMPLES\BL4S1xx** show how to set up and use digital inputs for interrupts, pulse capture, and quadrature decoders.

### 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.

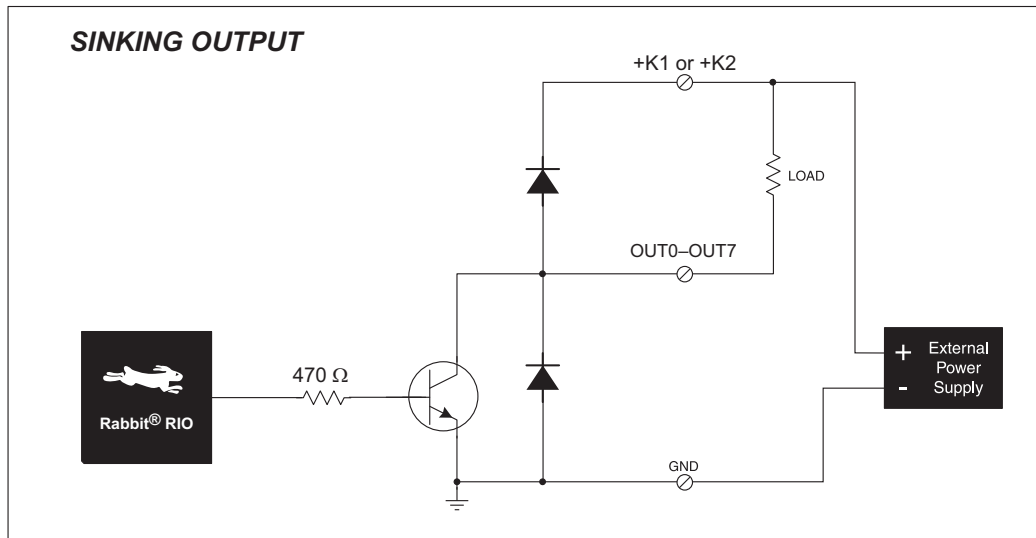


The counter readings can be obtained via the `getBegin ()` or `getEnd ()` function calls.



### 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.

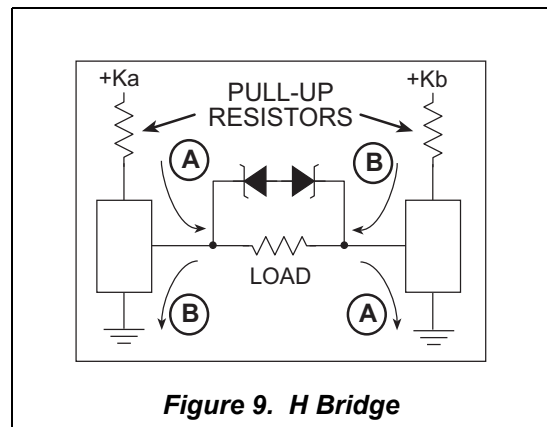


**Figure 8. BL4S100 Digital Outputs**

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.