Chipsmall Limited consists of a professional team with an average of over 10 year of expertise in the distribution of electronic components. Based in Hongkong, we have already established firm and mutual-benefit business relationships with customers from,Europe,America and south Asia,supplying obsolete and hard-to-find components to meet their specific needs.

With the principle of "Quality Parts,Customers Priority,Honest Operation,and Considerate Service",our business mainly focus on the distribution of electronic components. Line cards we deal with include Microchip,ALPS,ROHM,Xilinx,Pulse,ON,Everlight and Freescale. Main products comprise IC,Modules,Potentiometer,IC Socket,Relay,Connector.Our parts cover such applications as commercial,industrial, and automotives areas.

We are looking forward to setting up business relationship with you and hope to provide you with the best service and solution. Let us make a better world for our industry!

## Contact us

# Fox (LP3500)

C-Programmable Single-Board Computer

## User's Manual

019–0111 • 081121–L

# Fox (LP3500) User's Manual

Digi International reserves the right to make changes and
improvements to its products without providing notice.

## Trademarks

Rabbit and Dynamic C are registered trademarks of Digi International Inc.

Rabbit 2000 and RabbitCore are trademarks of Digi International Inc.

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

## Digi International Inc.

www.rabbit.com

# TABLE OF CONTENTS

# 1. INTRODUCTION

The LP3500 is a low-power single-board computer with built-in analog and digital I/O. Although the LP3500 was designed specifically for low-power applications and data logging, it has a host of features that make it attractive for other applications as well. Low power is often required in portable equipment operating from batteries or from solar power. The LP3500 is ideal for monitoring equipment or processes that are far-removed from a power supply, remote telemetry (RTUs), pipeline control and monitoring, well-head monitoring; and use on mobile equipment such as refrigeration trucks. An optional plastic enclosure and an LCD/keypad module are available.

The Tool Kit has the essentials that you need to design your own low-power microprocessor-based system, and includes a complete Dynamic C software development system.

## 1.1 LP3500 Description

The LP3500 is a low-power single-board computer that incorporates the powerful and low-EMI Rabbit 3000 microprocessor, flash memory, static RAM, digital I/O ports, A/D converter inputs, PWM outputs, RS-232/RS-485 serial ports, and both parallel and serial interfaces that allow other devices to be connected to the LP3500.

All aspects of the LP3500 are designed for low power consumption and operates at a variety of power levels, including a power-save mode, to fit customer-specified conditions at any given time. The CPU runs at a nominal speed of 7.4 MHz, and operates at 2.8 V to conserve power. The LP3500 consumes less than 20 mA when fully operational, and less than 100 $\mu$A when in the power-save mode. A replaceable coin-type battery will allow the LP3500 to operate in sleep mode for over 3 years. The LP3500 is normally powered from an external battery or power supply. When the unit is in the power-save mode, it can be awakened by an internal timer, an RS-232 signal, or via polling of an external input. The LP3500 can be switched from the power-save mode to full operation and back under program control. In addition, various sections of circuitry (such as the RS-232 ports) can be switched off under program control to further conserve power when not in use.

## 1.2  LP3500 Features

- Rabbit 3000® microprocessor operating at up to 7.4 MHz.

- 512K/128K static RAM and 512K/256K flash memory options.

- 26 digital I/O: 16 protected digital inputs and 10 high-current digital outputs provide sinking and sourcing outputs.

- 8 single-ended or 4 differential analog channels with Vcc monitoring option: 11-bit single-ended or 12-bit differential channels.

- 3 PWM outputs.

- Six serial ports

    1 RS-485

    3 RS-232 (one 5-wire and one 3-wire or three 3-wire), jumper option for logic-level outputs; Serial Port E has a "listen" and "wake-up" capability

    1 logic-level serial interface for optional add-ons

    1 asynchronous clocked serial port dedicated for programming

- Battery-backed real-time clock.

- Watchdog supervisor.

Two LP3500 models are available. Their standard features are summarized in Table 1.

*Table 1.  LP3500 Models*

| Feature | LP3500 | LP3510 |
|---|---|---|
| Microprocessor | Rabbit 3000 running at 7.4 MHz | |
| Static RAM | 512K | 128K |
| Flash Memory | 512K | 256K |
| A/D Converter Inputs (ranges from 0–1 V DC to 0–20 V DC, 4 channels may be individually configured for 4–20 mA) | Yes | No |
| C-form Bistable Relay | Yes | No |

Appendix A provides detailed specifications.

The LP3500 can be mounted in two ways. It can be mounted to a panel or on a plastic-enclosure base, which allows I/O connections to be made using traditional connectors with 0.1" spacing. The LP3500 can also be inverted and mounted directly to mating connectors on a motherboard of the customer's design. The first approach is appropriate where I/O connections go directly to devices and switches. The second approach is appropriate where additional circuitry is incorporated on the motherboard.

## 1.3  Optional Add-Ons

- Plastic enclosure (can be wall-mounted or panel-mounted), which consists of a base and a cover for either the LP3500 by itself or an assembly made up of the LP3500 and the LP3500 Prototyping Board. The base is also available separately.

- The Prototyping Board included with the Tool Kit is a convenient means of interfacing to the LP3500 via the screw-terminal headers on the Prototyping Board. The Prototyping Board is also available for separate purchase.

- 4M and 8M SF1000 serial flash expansion cards.

- LCD/keypad module with  7-key keypad and seven LEDs.

Further details on the Prototyping Board, the plastic enclosure, and the LCD/keypad module are provided in Appendix B, Appendix C, and Appendix D.

Visit our 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 and schematics.

## 1.4 Development and Evaluation Tools

### 1.4.1 Tool Kit

A Tool Kit contains the hardware essentials you will need to develop applications with the LP3500 single-board computer. The items in the Tool Kit and their use are as follows.

- *LP3500 Getting Started* instructions.
- *Dynamic C* CD-ROM, with complete product documentation on disk.
- Programming cable, used to connect your PC serial port to the LP3500.
- Universal AC adapter, 12 V DC, 1 A (includes Canada/Japan/U.S., Australia/N.Z., U.K., and European style plugs). If you are using another power supply, it must provide 3 to 30 V DC.
- Prototyping Board with pushbutton switches, LEDs, and screw-terminal headers. The Prototyping Board can be hooked up to the LP3500 to demonstrate the I/O capabilities of the LP3500 and to provide a prototyping area for you to develop your own add-on circuits. The screw-terminal headers extend the LP3500's headers for development, and can also be used in a production environment.
- Plastic enclosure with four screws.
- Four standoffs with mounting screws.
- Screwdriver.
- *Rabbit 3000 Processor Easy Reference* poster.
- Registration card.
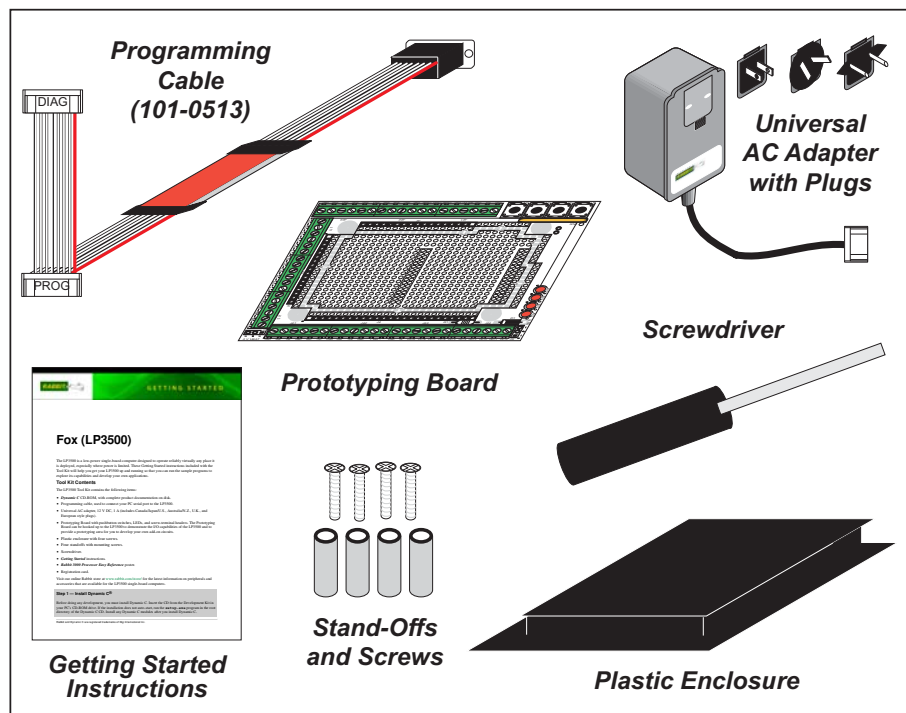


*Figure 1.  LP3500 Tool Kit*

## 1.4.2  Software

The LP3500 is programmed using version 7.26P or later of Rabbit's Dynamic C. A compatible version is included on the Tool Kit CD-ROM. Library functions provide an easy-to-use interface for the LP3500. Software drivers for digital and analog I/O, and for serial communication are included with Dynamic C. Web-based technical support is included at no extra charge.

Starting with Dynamic C version 9.60, 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.

## 1.5 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:<br>less than 40 dB µV/m at 10 m<br>(40 dB relative to 1 µV/m) or 300 µV/m | More restrictive emissions requirement:<br>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 LP3500 has been tested and was found to be in conformity with the following applicable immunity and emission standards. The LP3510 is also CE qualified as it is a sub-version of the LP3500. Boards that are CE-compliant have the CE mark.



> **NOTE:** Earlier versions of the LP3500 sold before 2003 that do not have the CE mark are *not* CE-complaint.

### Immunity

The LP3500 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 LP3500 series of single-board computers meets the following emission standards emission standards with the Rabbit 3000 spectrum spreader turned on and set to the normal mode.

- 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.

### 1.5.1  Design Guidelines

Note the following requirements for incorporating the LP3500 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 LP3500 to outdoor cables, the customer is responsible for providing CE-approved surge/lightning 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. Rabbit also recommends using properly shielded I/O cables in noisy electromagnetic environments.

**Safety**

- For personal safety, all inputs and outputs to and from the LP3500 must not be connected to voltages exceeding SELV levels (42.4 V AC peak, or 60 V DC). Damage to the Rabbit 3000 microprocessor may result if voltages outside the design range of 0 V to 40 V DC are applied directly to any of its digital inputs.

- The lithium backup battery circuit on the LP3500 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.

### 1.5.2  Interfacing the LP3500 to Other Devices

There are two versions of the LCD/keypad module that may be used with the LP3500: without a bezel (Part No. 101-0601), and a remote panel-mounted version with bezel (Part No. 101-0541). The cable used to connect the LCD/keypad module should be less than 30 cm (12") to maintain CE compliance. Appendix C provides complete information for mounting and using the LCD/keypad module.

Since the LP3500 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 LP3500.

## 2.1 LP3500 Connections

1. Use the 4-40 screws supplied with the Tool Kit to attach the metal standoffs to your LP3500 series board as shown in Figure 2.
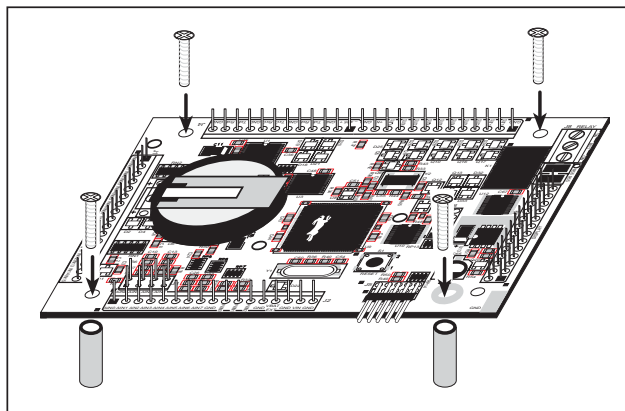


**Figure 2.  Attach Stand-Offs and Remove Battery Cap**

2. Attach the LP3500 main board to the Prototyping Board as shown in Figure 3.

Press the pins from the headers on the bottom side of the LP3500 board firmly into the corresponding header sockets located at J1, J2, and J4 on the Prototyping Board.

> **NOTE:** It is important that you line up the header pins on the LP3500 exactly with the corresponding header sockets J1, J2, and J4 on the Prototyping Board. The header pins may become bent or damaged if the pin alignment is offset, and the LP3500 will not work. Permanent electrical damage may also result if a misaligned LP3500 is powered up.



*Figure 3.  Attach LP3500 Main Board to Prototyping Board*

3. Connect the programming cable to download programs from your PC and to program and debug the LP3500.

> **NOTE:** Use only the programming cable that has a red shrink wrap around the RS-232 level converter (Part No. 101-0513), which is supplied with the LP3500 Tool Kit. Other Rabbit programming cables with clear or blue shrink wrap might not be voltage-compatible or their connector sizes may be different.
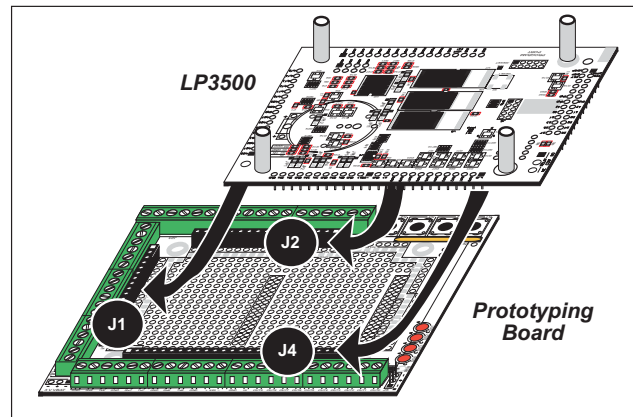
Connect the 10-pin **PROG** connector of the programming cable to header J5 on the LP3500 board. Ensure that the colored edge lines up with pin 1 as shown. There is a small dot on the circuit board next to pin 1 of header J5. (Do not use the **DIAG** connector, which is used for monitoring only.) Connect the other end of the programming cable to a COM port on your PC. Make a note of the port to which you connect the cable, as Dynamic C will need to have this parameter configured. Note that COM1 on the PC is the default COM port used by Dynamic C.
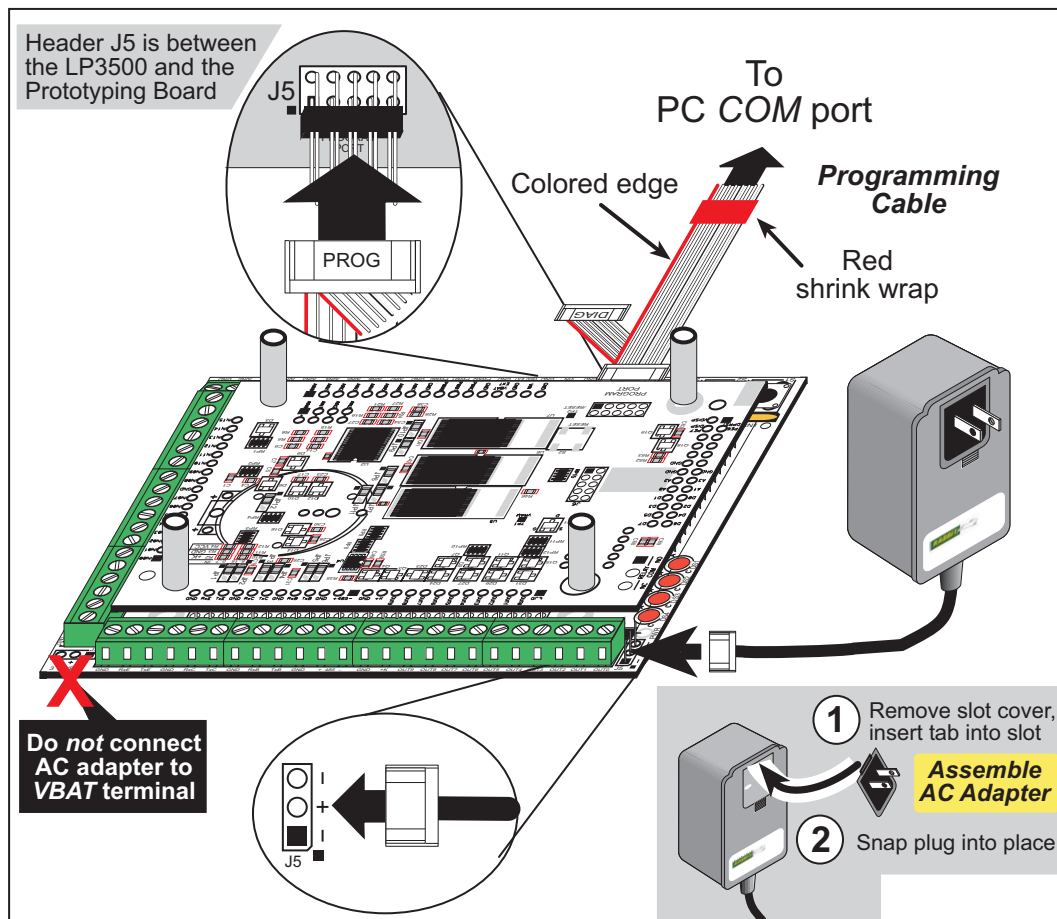


*Figure 4.  Programming Cable and Power Supply Connections*

> **NOTE:** Some PCs now come equipped only with a USB port. It may be possible to use an RS-232/USB converter (Part No. 20-151-0178) with the programming cable supplied with the LP3500 Tool Kit. Note that not all RS-232/USB converters work with Dynamic C.

4. Connect the power supply.

First, prepare the AC adapter for the country where it will be used by selecting the plug. The LP3500 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 4, then press down on the spring-loaded clip below the plug assembly to allow the plug assembly to click into place.

Hook up the connector from the wall transformer to header J5 on the Prototyping Board as shown in Figure 4. The orientation of this connector is not important since the VIN (positive) voltage is the middle pin, and GND is available on both ends of the three-pin header J5.

> NOTE: Do *not* connect the AC adapter to the **VBAT** terminal on the Prototyping Board. The **VBAT** terminal supplies the backup battery voltage of 3 V, and the LP3500 may be damaged if subjected to the raw DC voltage from the AC adapter through the **VBAT** terminal.

5. Apply power.

Plug in the AC adapter. If you are using your own power supply, it must provide 3 V to 30 V DC—voltages outside this range could damage the LP3500.

> NOTE: A hardware reset may be done by pressing the RESET switch on the LP3500. The LP3500 may also be reset by unplugging the AC adapter, then plugging it back in. However, when the LP3500 is operating in the power-save mode, the backup battery will provide sufficient voltage to prevent a reset from happening, in which case you will have to press the RESET switch on the LP3500.
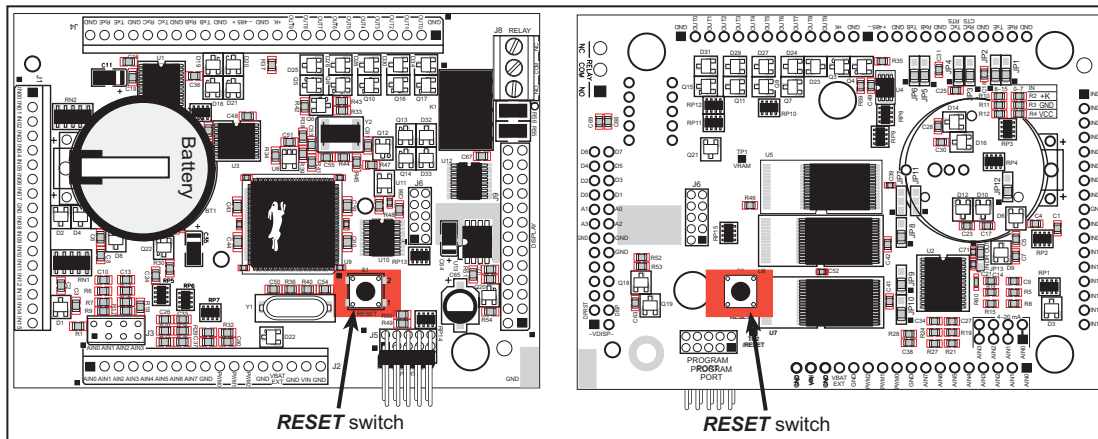


*Figure 5. Locations of LP3500 RESET Switches*

Reset switches are located on both sides of the LP3500 board.

## 2.2  Remove Battery Tab

The backup battery on the LP3500 has a plastic tab to protect the battery against discharging before the LP3500 is placed into service.
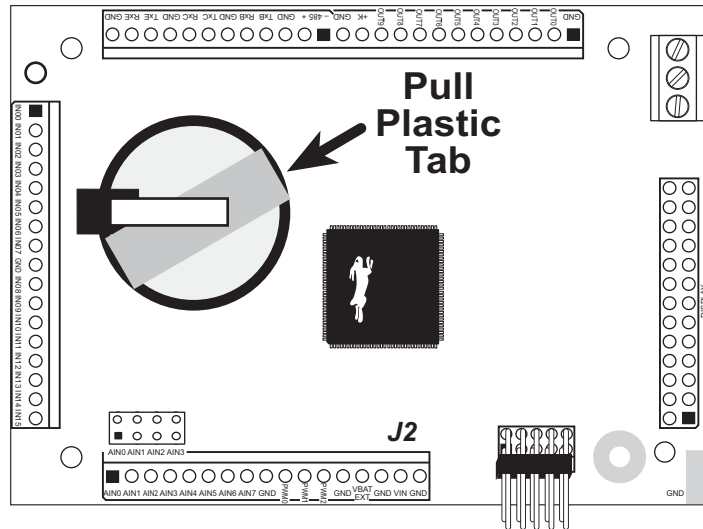


*Figure 6.  Remove Battery Tab*

> **NOTE:** Rabbit recommends that the battery tab not be removed until you are ready to place the LP3500 in normal service with regular power connected through header J2.

The backup battery protects the contents of the SRAM and keeps the real-time clock running when regular power to the LP3500 is interrupted. If you plan to use the real-time clock functionality in your application, you will need to set the real-time clock once you remove the plastic tab. Set the real-time clock using the onscreen prompts in the demonstration program. Alternatively, 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.

## 2.3  Installing Dynamic C

If you have not yet installed Dynamic C version 7.26P (or a later version), do so now by inserting the Dynamic C CD in your PC's CD-ROM drive. The CD will auto-install unless you have disabled auto-install on your PC.

If the CD does not auto-install, click **Start > Run** from the Windows **Start** button and browse for the Dynamic C **setup.exe** file on your CD drive. Click **OK** to begin the installation once you have selected the **setup.exe** file.

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

> **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.

## 2.4  Starting Dynamic C

Once the LP3500 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.

If you are using a USB port to connect your computer to the LP3500, choose **Options > Project Options** and select "Use USB to Serial Converter" on the **Communications** tab. Click **OK**.

Dynamic C assumes, by default, that you are using serial port COM1 on your PC when you are running a program. If you *are* using COM1, then Dynamic C should detect the LP3500 and go through a sequence of steps to cold-boot the LP3500 and to compile the BIOS. If the error message "Rabbit Processor Not Detected" appears, you have probably connected to a different PC serial port such as COM2, COM3, or COM4. You can change the serial port used by Dynamic C with the **OPTIONS** menu, then try to get Dynamic C to recognize the LP3500 by selecting **Reset Target/Compile BIOS** on the **Compile** menu. Try the different COM ports in the **OPTIONS** menu until you find the one you are connected to. If you still can't get Dynamic C to recognize the target on any port, then the hookup may be wrong or the COM port might not working on your PC.

Dynamic C automatically uses a maximum debug baud rate of 38,400 bps when an LP3500 series board is in use.

## 2.5  PONG.C

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

Find the file **PONG.C**, which is in the Dynamic C **SAMPLES** folder. To run the program, open it with the **File** menu (if it is not still open), then compile and run it by pressing **F9** or by selecting **Run** in the **Run** menu. The **STDIO** window will open and will display a small square bouncing around in a box.

This program shows that the CPU is working.

## 2.6  Where Do I Go From Here?

> **NOTE:**  If you purchased your LP3500 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 LP3500 features and develop your own applications.

Chapter 3, "Subsystems," provides a description of the LP3500's features, Chapter 4, "Software," describes the Dynamic C software libraries and introduces some sample programs. These sample programs can be used as templates for applications you may wish to develop.

# 3.  SUBSYSTEMS

Chapter 3 describes the principal subsystems for the LP3500.

- Power Modes
- Digital I/O
- Serial Communication
- A/D Converter Inputs (LP3500 only)
- PWM Outputs
- Relay Output Circuit (LP3500 only)
- Memory

Figure 7 shows these Rabbit-based subsystems designed into the LP3500.
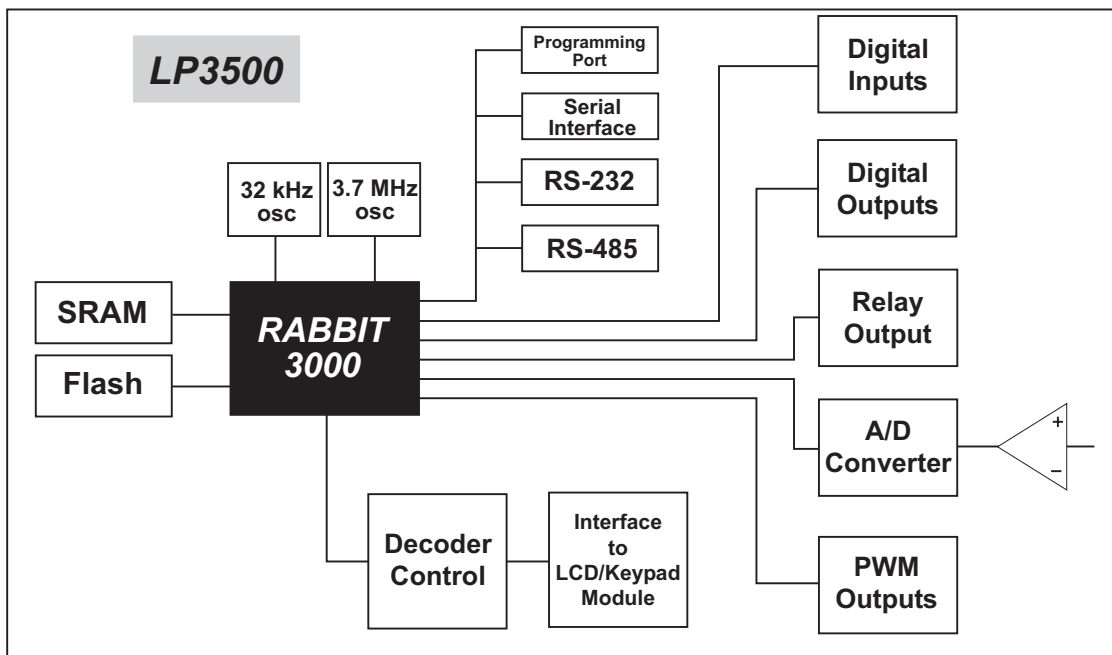


**Figure 7.  LP3500 Subsystems**

## 3.1  LP3500 Pinouts
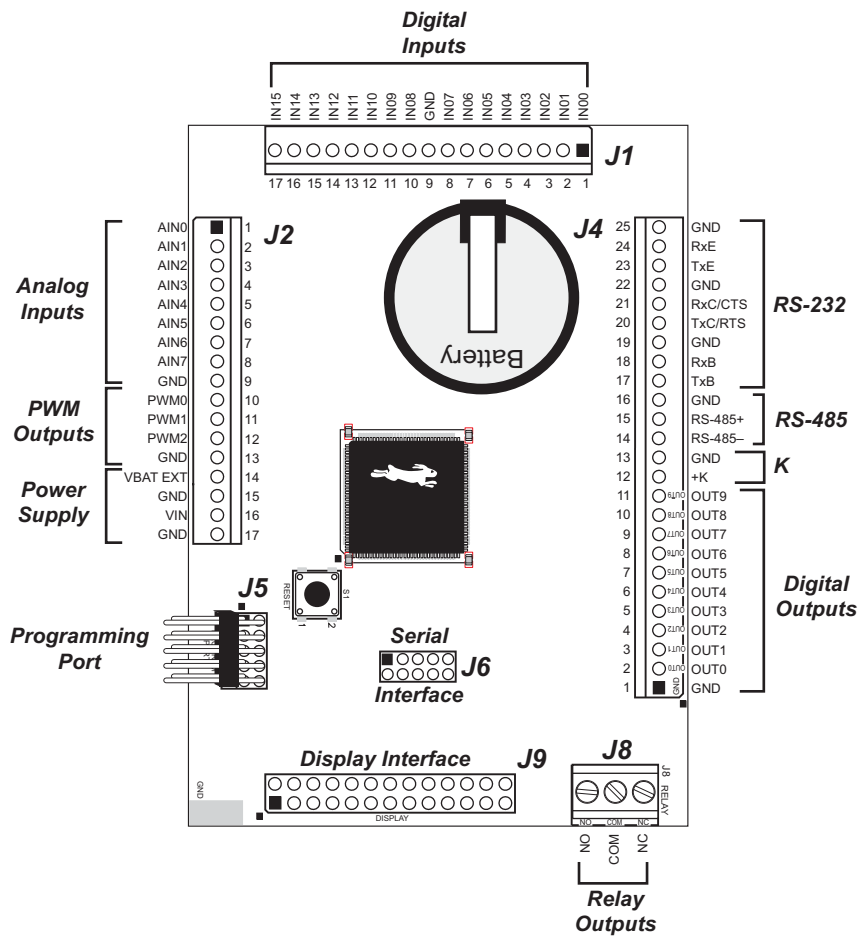
The LP3500 pinouts are shown in Figure 8.



**Figure 8.  LP3500 Pinouts**

> **NOTE:**  Although header J2 is installed on the LP3510, the associated analog I/O are not available on the LP3510. The relay screw-terminal header at J8 is also not installed on the LP3510. The power supply inputs on header J2 are still available.

### 3.1.1  Headers and Screw Terminals

Standard LP3500 models are equipped with two 1 × 17 headers (J1 and J2) with a pitch of 0.1", one 1 × 25 header (J4) with a pitch of 0.1", and one 1 × 3 screw terminal strip (J8). The Display Interface (J9) is a 2 × 13 header with a pitch of 0.1", and the Serial Interface is a 2 mm 2 × 5 socket.

A variety of commercially available connectors with a 0.1" pitch can be used to interface to the signals on headers J1, J2, and J4, or the Prototyping Board may be used to access these signals via screw-terminal headers.

*Table 2.  Software-Defined Power Modes*

| Mode | | Clock Frequency | Debug Capability | Code Restrictions | Power Source | Supports Relay Output | Supports Subsystems from Table 3 | Typical Current Consumption |
|---|---|---|---|---|---|---|---|---|
| 1 | Normal Modes | 7.3728 MHz | Normal | None | VIN | Yes | Yes | 16 mA ↓ 5 mA |
| 2 | | 3.6864 MHz | | | | | | |
| 3 | | 1.8423 MHz | | | | | | |
| 4 | | 1.2288 MHz | None | | | | | |
| 5 | | 0.9216 MHz | | | | | | |
| 6 | Low-Power Modes | 32.768 kHz | | | | | | 1.0 mA ↓ See note 140 μA |
| 7 | | 16.384 kHz | | | | | | |
| 8 | | 8.192 kHz | | | | | | |
| 9 | | 4.096 kHz | None | | | | | |
| 10 | | 2.048 kHz | | | | | | |
| Power-Save Mode | | 2.048 kHz | | See Section 3.2.1 and Section 3.2.2 | VIN or external battery | No | No | 140 μA |
| | | | | | External battery (with linear regulator turned off) | | | 70 μA |
| Processor halted | | | None | SRAM and RTC updates | Onboard battery or ext. battery | No | No | 46 μA |

**NOTE:**  The actual current consumption depends heavily on the SRAM writes in the user's program. See Section 3.2.2 for more information.