# RabbitCore 2000

**C-Programmable Core Module**

## User's Manual

**001004 - C**

## RabbitCore 2000 User’s Manual

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# Table of Contents

## About This Manual

This manual provides instructions for installing, testing, configuring, and interconnecting the RabbitCore 2000 (RCM 2000) and the RCM 2000 Prototyping Board.

## Assumptions

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

- Ability to design and engineer the target system that a RabbitCore 2000 will control.
- Understanding of the basics of operating a software program and editing files under Windows on a PC.
- Knowledge of basic assembly language and architecture for controllers.

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

***The C Programming Language*** by Kernighan and Ritchie (published by Prentice-Hall).

and/or

***C: A Reference Manual*** by Harbison and Steel (published by Prentice-Hall).

- Knowledge of basic assembly language and Rabbit microprocessor architecture.

For more information on the Rabbit 2000 microprocessor, refer to the ***Rabbit 2000 Microprocessor user's Guide***.

## Acronyms

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

***Table 1. Acronyms***

| Acronym | Meaning |
|---|---|
| EPROM | Erasable Programmable Read-Only Memory |
| EEPROM | Electronically Erasable Programmable Read-Only Memory |
| NMI | Nonmaskable interrupt |
| PIO | Parallel Input/Output<br>(Individually programmable input/output) |
| PRT | Programmable Reload Timer |
| RAM | Random Access Memory |
| RTC | Real-Time Clock |
| SRAM | Static Random Access Memory |
| UART | Universal Asynchronous Receiver Transmitter |

## Conventions

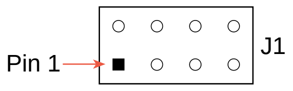
Table 2 lists and defines the typographic conventions that may be used in this manual.

***Table 2. Typographic Conventions***

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

### Pin Number 1

A black square indicates pin 1 of all headers.



### Measurements

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

## Application Notes

The CD contains application notes and technical notes that will enhance your use of Rabbit-based products and provide information about the latest product enhancements. These notes are also available on the Web sites.

www.zworld.com

or

www.rabbitsemiconductor.com

# 1. INTRODUCTION

The RabbitCore 2000 is a microprocessor core module designed to be the heart of your own controller built around the plug-in module.  Data processing is done by a Rabbit 2000 microprocessor operating at 25.8 MHz (RCM2000 and RCM2010).

The RabbitCore 2000 has a Rabbit 2000 microprocessor, a static RAM, a flash memory, two quartz crystals (main oscillator and timekeeping), and the circuitry necessary for reset and management of battery backup of the Rabbit 2000's internal real-time clock and the static RAM.  Two 40-pin headers bring out the Rabbit 2000 I/O bus, address lines, data lines, parallel ports, and serial ports.

The RabbitCore 2000 receives its +5 V power from the user board on which it is mounted. The RabbitCore 2000 can interface will all kinds of digital devices through the user board.

The RabbitCore 2000 Development Kit comes with a Prototyping Board that can be used to demonstrate the operation of the RabbitCore 2000 and to prototype new circuits.

## 1.1 Features

- Small size: 1.90" × 2.30" (48.3 mm × 58.4 mm)
- Microprocessor: Rabbit 2000 running at 25.8 MHz (RCM2000 and RCM2010)
- 40 CMOS-compatible parallel I/O lines grouped in five 8-bit ports (shared with serial ports)
- 8 data lines (D0–D7)
- 13 address lines (A0–A12)
- I/0 read, write, buffer enable
- Status, watchdog and clock outputs
- Two startup mode inputs for master/slave configuration
- External reset input
- Reset output
- Five 8-bit timers, two 10-bit timers; five timers are cascadable in pairs
- 256K flash EPROM, 512K SRAM
- Real-time clock
- Watchdog supervisor
- Provision for customer-supplied backup battery via connections on header J2
- Four CMOS-compatible serial ports: maximum asynchronous baud rate of 806,400 bps, maximum synchronous baud rate of 6.45 Mbps.  Two ports are configurable as clocked ports.

Appendix A, "Specifications," provides detailed specifications for the RabbitCore 2000.

Three versions of the RabbitCore 2000 are available.  Their standard features are summarized in Table 1.

*Table 1. RabbitCore 2000 Features*

| Model | Features |
|---|---|
| RCM2000 | Full-featured controller. |
| RCM2010 | RCM2000 with 128K SRAM |
| RCM2020 | RCM2000 with 18.432 MHz clock and 128K SRAM |

## 1.2 Advantages of Using the RabbitCore 2000

- Fast design time since the basic core has already been designed and built.
- Competitive pricing compared with purchasing and assembling the individual components.
- Easy programming, including production installation of a program.
- Generous memory size allows large C programs with tens of thousands of lines of code, and substantial data storage.

## 1.3 Development and Evaluation Tools

### 1.3.1 Development Kit

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

The items in the Development Kit and their use are as follows:

- CD-ROM with Dynamic C® software, RabbitCore 2000, and Rabbit™ 2000 microprocessor documentation. You may install this software by inserting the disk into your CD-ROM drive. If it doesn't start automatically, click on "setup.exe." This software runs under Windows '95, Windows '98, and Windows NT. We suggest taking the option to load the documentation to your hard disk. The documentation is in both HTML and Adobe PDF format, and may be viewed with a browser.
- RabbitCore 2000 (RCM2020 model). This is a complete controller board that includes a Rabbit 2000 processor, 256K of flash memory, 128K of SRAM.
- Prototyping Board. The RabbitCore 2000 can be plugged into this board. The Prototyping Board includes a 5 V supply for powering the RabbitCore 2000, and various accessories such as pushbutton switches, and LEDs. In addition, you can add your own circuitry using through-hole or surface mount parts in the prototyping space provided.
- Programming cable. The programming cable is used to connect your PC serial port directly to the RabbitCore 2000 to write and debug C programs that run on the Rabbit 2000.
- AC adapter. The AC adapter is used to power the Prototyping Board and the RabbitCore 2000. The wall transformer is supplied only for Development Kits sold for the North American market. The Prototyping Board can also be powered from any DC voltage source between 7.5 V and 25 V. The linear regulator becomes rather hot for voltages above 15 V.

### 1.3.2 Documentation

- Our documentation is provided in paperless form on the CD-ROM included in the Development Kit. (A paper copy of the "Getting Started" page *is* included.) Most documents, including this comprehensive ***RabbitCore 2000 User's Manual***, are provided in two formats: HTML and PDF. HTML documents can be viewed with an Internet browser, either *Netscape Navigator* or *Internet Explorer*. HTML documents are very convenient because all the documents are hyperlinked together, and it is easy to navigate from one place to another. PDF documents can be viewed using the Adobe Acrobat reader, which is automatically invoked from the browser. The PDF format is best suited for documents requiring high resolution, such as schematics, or if you want to print the document. Don't print a hard copy from the HTML version because the HTML version has no page numbers and the cross-references and table of contents links only work if viewed on line. The PDF versions contain page number references to allow navigation when reading a paper version of the manual. To view the online documentation with a browser, open the file **`default.htm`** in the **`docs`** folder.

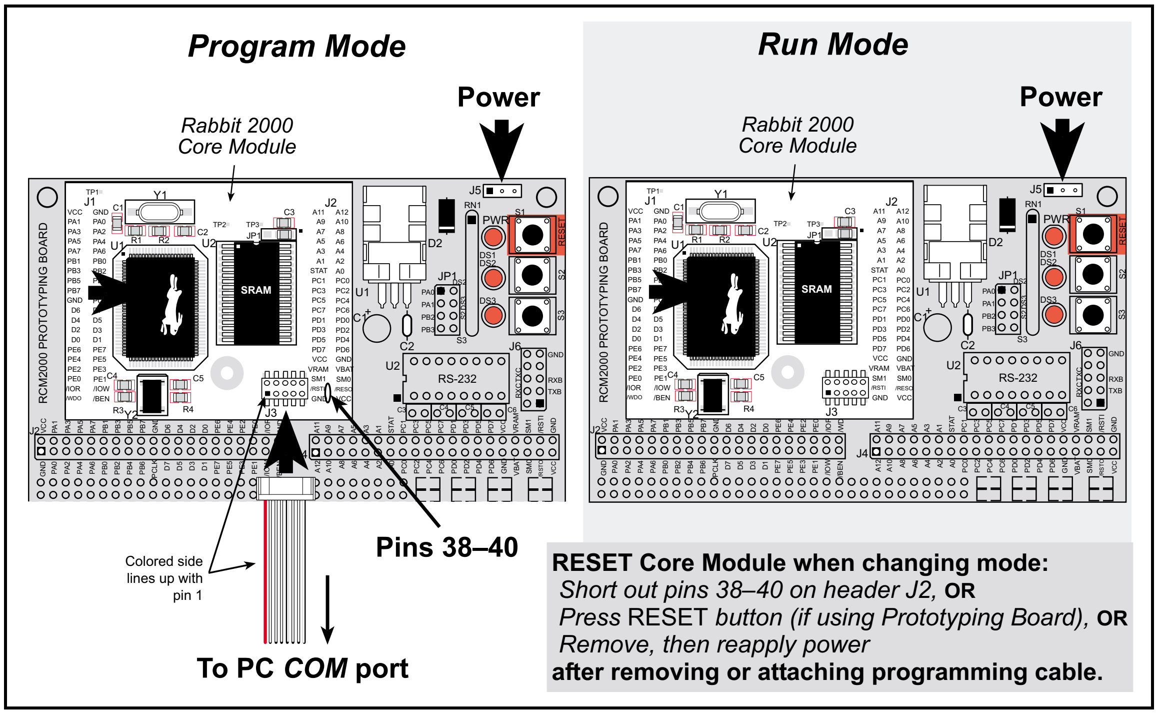
# 2. SUBSYSTEMS

Chapter 2 describes the principal subsystems for the RabbitCore 2000.

- Switching Between Program Mode and Run Mode
- Rabbit 2000 Core Module Digital Inputs and Outputs
- Serial Communication
- Memory

## 2.1 Switching Between Program Mode and Run Mode

The RabbitCore 2000 is automatically in Program Mode when the programming cable is attached, and is automatically in Run Mode when no programming cable is attached. See Figure 1.



Program Mode
Run Mode
Power
Power
Rabbit 2000 Core Module
Rabbit 2000 Core Module
Colored side lines up with pin 1
Pins 38–40
To PC COM port
RESET Core Module when changing mode:
Short out pins 38–40 on header J2, OR
Press RESET button (if using Prototyping Board), OR
Remove, then reapply power
after removing or attaching programming cable.

*Figure 1. RabbitCore 2000 Program Mode and Run Mode Setup*

### 2.1.1 Detailed Instructions: Changing from Program Mode to Run Mode

1. Disconnect the programming cable from header J3 of the RabbitCore 2000.
2. Reset the RabbitCore 2000. You may do this as explained in Figure 1. Figure 2 shows the location of the RESET button on the Prototyping Board.

The RabbitCore 2000 is now ready to operate in the Run Mode.

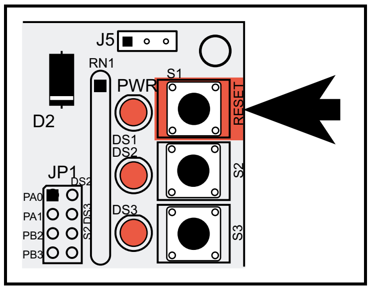


*Figure 2. Location of Prototyping Board Reset Button*

### 2.1.2 Detailed Instructions: Changing from Run Mode to Program Mode

3. Attach the programming cable to header J3 on the RabbitCore 2000.
4. Reset the RabbitCore 2000. You may do this as explained in Figure 1. Figure 2 shows the location of the RESET button on the Prototyping Board.

The RabbitCore 2000 is now ready to operate in the Program Mode.

## 2.2 RabbitCore 2000 Digital Inputs and Outputs

Figure 3 shows the subsystems designed into the RabbitCore 2000.

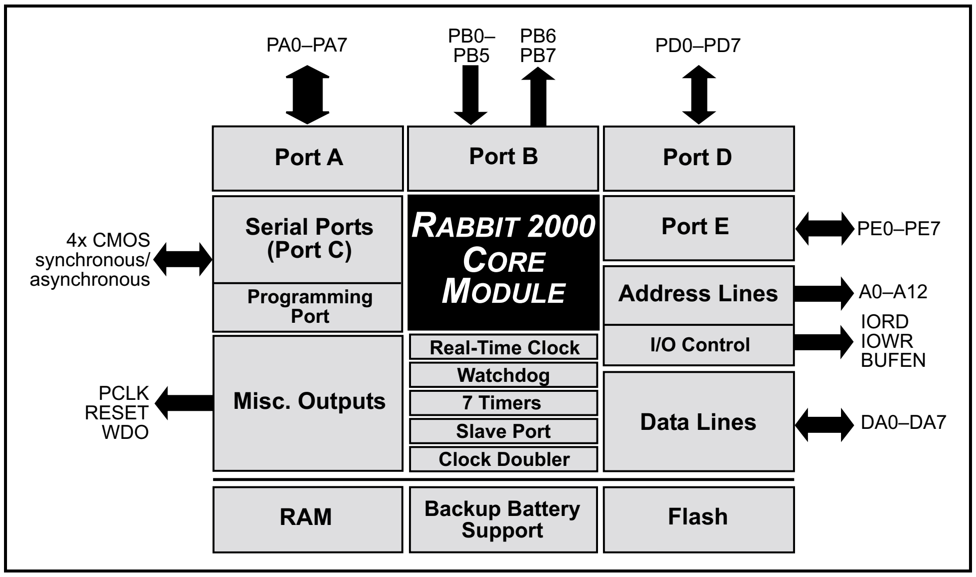


*Figure 3. RabbitCore 2000 Subsystems*

The RabbitCore 2000 has 40 parallel I/O lines grouped in five 8-bit ports available on headers J1 and J2. The 24 bidirectional I/O lines are located on pins PA0–PA7, PD0-PD7, and PE0-PE7. The pinouts for headers J1 and J2 are shown in Figure 4.

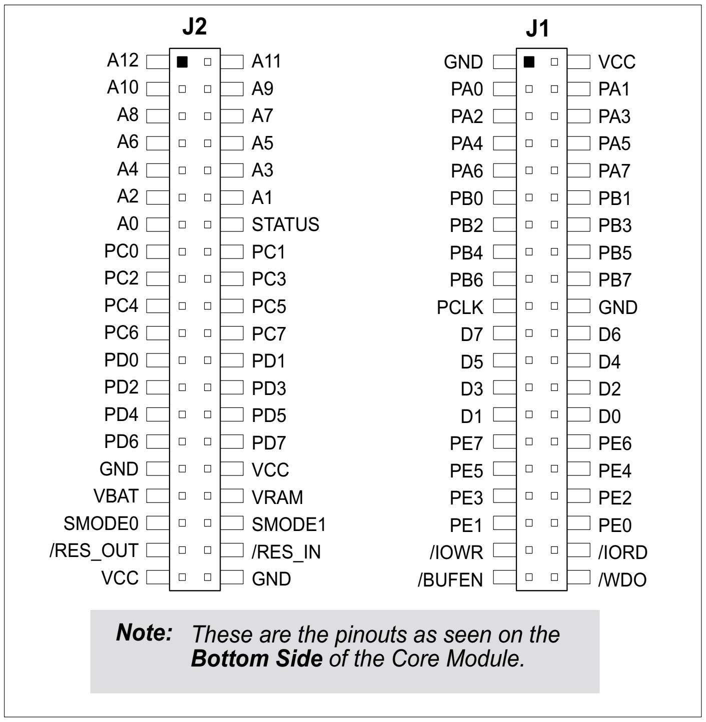


*Figure 4. RabbitCore 2000 I/O Pins*

The ports on the Rabbit 2000 microprocessor used in the RabbitCore 2000 are configurable, and so the factory defaults can be reconfigured.  Table 2 lists the Rabbit 2000 factory defaults and the alternate configurations.

***Table 2.  RabbitCore 2000 Pinout Configurations***

| Pin | | Pin Name | Default Use | Alternate Use | Notes |
|---|---|---|---|---|---|
| Header J1 | 1, 20 | GND | | | |
| | 2 | VCC | | | |
| | 3–10 | PA[0:7] | Parallel I/O | Slave port data bus SD0–SD7 | |
| | 11 | PB0 | Input | Serial port clock CLKB | |
| | 12 | PB1 | Input | Serial port clock CLKA | CLKA is connected to programming port (header J3, pin 3) |
| | 13 | PB2 | Input | Slave port write /SWR | |
| | 14 | PB3 | Input | Slave port read /SRD | |
| | 15 | PB4 | Input | SA0 | Slave port address lines |
| | 16 | PB5 | Input | SA1 | |
| | 17 | PB6 | Output | | |
| | 18 | PB7 | Output | Slave port attention line /SLAVEATTN | |
| | 19 | PCLK | Output (Internal Clock) | Output | Disable by removing R27 |
| | 21–28 | D[7:0] | Input/Output | | Rabbit 2000 data bus |
| | 29 | PE7 | Bitwise or parallel programmable I/O | I7 output or slave port chip select /SCS | |
| | 30 | PE6 | | I6 output | |
| | 31 | PE5 | | I5 output or INT1B input | |
| | 32 | PE4 | | I4 output or INT0B input | |
| | 33 | PE3 | | I3 output | |
| | 34 | PE2 | | I2 output | |
| | 35 | PE1 | | I1 output or INT1A input | |
| | 36 | PE0 | | I0 output or INT0A input | |
| | 37 | /IOWR | Output (I/O write strobe) | | |
| | 38 | /IORD | Output (I/O read strobe) | | |
| | 39 | /BUFEN | Output (I/O buffer enable) | | |
| | 40 | /WDO | Output (Watchdog output) | May also be used to output a 30 µs pulse | Outputs a pulse when the internal watchdog times out |

*Table 2. RabbitCore 2000 Pinout Configurations (continued)*

| Pin | | Pin Name | Default Use | Alternate Use | Notes |
|---|---|---|---|---|---|
| Header J2 | 1–13 | A[12:0] | Output | | Rabbit 2000 address bus |
| | 14 | STAT | Output (Status) | Output | |
| | 15 | PC0 | Output | TXD | |
| | 16 | PC1 | Input | RXD | |
| | 17 | PC2 | Output | TXC | |
| | 18 | PC3 | Input | RXC | |
| | 19 | PC4 | Output | TXB | |
| | 20 | PC5 | Input | RXB | |
| | 21 | PC6 | Output | TXA | |
| | 22 | PC7 | Input | RXA | |
| | 21 | PC6 | Output | TXA | Connected to programming port |
| | 22 | PC7 | Input | RXA | |
| | 23–26 | PD[0:3] | Bitwise or parallel programmable I/O, can be driven or open-drain output | | 16 mA sourcing and sinking current at full AC switching speed |
| | 27 | PD4 | | ATXB output | |
| | 28 | PD5 | | ARXB input | |
| | 29 | PD6 | | ATXA output | |
| | 30 | PD7 | | ARXA input | |
| | 31, 40 | GND | | | |
| | 32, 39 | VCC | | | |
| | 33 | VBATR | 3 V battery input | | |
| | 34 | VRAM | 2.1 V output | | 100 kΩ minimum load |
| | 35–36 | SMODE0, SMODE1 | (0,0)—start executing at address zero | | No programming cable attached |
| | | | SMODE0 =1, SMODE1 = 1 Cold boot from asynchronous serial port A at 2400 bps (programming cable connected) | (0,1)—cold boot from slave port (1,0)—cold boot from clocked serial port A | With programming cable attached |
| | 37 | /RES_OUT | Reset Output | | |
| | 38 | /RES_IN | Reset Input | | |

As shown in Table 2, pins PA0–PA7 can be used to allow the Rabbit 2000 to be a slave to another processor.  PE0, PE1, PE4, and PE5 can be used as external interrupts INT0A, INT1A, INT0B, and INT1B.  Pins PB0 and PB1 can be used to access the clock on Serial Port B and Serial Port A of the Rabbit microprocessor.  Pins PD4 and PD6 can be programmed to be optional serial outputs for Serial Ports B and A.  PD5 and PD7 can be used as alternate serial inputs by Serial Ports B and A.

### 2.2.1 Dedicated Inputs

PB0 and PB1 are designated as inputs because the Rabbit 2000 is operating in an asynchronous mode.  Four of the input-only pins are located on PB2–PB5.  These pins are used for the slave port.  PB2 and PB3 are slave write and slave read strobes, while PB4 and PB5 serve as slave address lines SA0 and SA1, and are used to access the slave registers (SD0–SD7), which is the alternate assignment for parallel port A.  When Port C is used as a parallel port,  PC1, PC3, PC5, and PC7 are inputs only.  These pins can alternately be selectively enabled to serve as the serial data inputs for Serial Ports D, C, B, and A.

### 2.2.2 Dedicated Outputs

Two of the output-only pins are located on PB6–PB7.  PB7 can also be used with the slave port as the /SLAVEATTN output.  This configuration signifies that the slave is requesting attention from the master.  When Port C is used as a parallel port,  PC0, PC2, PC4 and PC6 are outputs only.  These pins can alternately serve as the serial data outputs for Serial Ports D, C, B, and A.

## 2.3 Memory I/O Interface

Thirteen of the Rabbit 2000 address lines (A0–A12) and all the data lines (D0–D7) are available as outputs on the RabbitCore 2000. I/0 write (/IOWR), I/0 read (/IORD), buffer enable (/BUFEN), and Watchdog Output (/WDO) are also available for interfacing to external devices.

The STATUS output has three different programmable functions:

1. It can be driven low on the first op code fetch cycle.
2. It can be driven low during an interrupt acknowledge cycle.
3. It can also serve as a general-purpose output.

The output clock is available on the PCLK pin. The primary function of PCLK is as a peripheral clock or a peripheral clock ÷ 2, but PCLK can instead be used as a digital output. PCLK can also be disabled by removing R27 if there is a need to reduce radiated emissions. Removing R27 will disable the PCLK output on pin 19 of header J1.

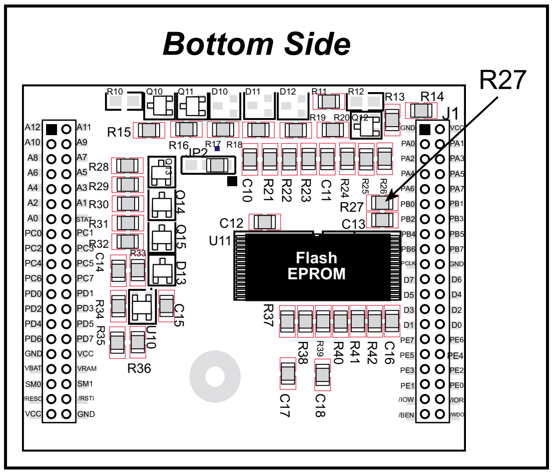


*Figure 5. Location of R27*

### 2.3.1 Additional I/0

Two status mode pins, SMODE0 and SMODE1, are available as inputs. The logic state of these two pins determines the startup procedure after a reset. /RES_IN is an external input used to reset the Rabbit 2000 microprocessor and RabbitCore 2000 memory. /RES_OUT is an output from the reset circuitry that can be used to reset other peripheral devices.

## 2.4 Serial Communication

The RabbitCore 2000 does not have an RS-232 or an RS-485 transceiver directly on the RabbitCore 2000 board. However, the Prototyping Board does support a industry standard RS-232 transceiver chip. See Appendix B, “Prototyping Board,” for more information.

### 2.4.1 Serial Ports

There are four serial ports designated as Serial Ports A, B, C, and D. All four serial ports can operate in an asynchronous mode up to the baud rate of the system clock divided by 32. 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 ports A and B 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. When the Rabbit provides the clock, the baud rate can be up to 1/4 of the system clock frequency, or more than 6.45 Mbps for a 25.8 MHz clock speed.

### 2.4.2 Programming Port

Serial Port A has special features that allow it to cold-boot the system after reset. Serial Port A is also the port that is used for software development under Dynamic C.

The RabbitCore 2000 has a 10-pin program header labeled J3. The Rabbit 2000 startup-mode pins (SMODE0, SMODE1) are presented to the programming port so that an externally connected device can force the RabbitCore 2000 to start up in an external bootstrap mode. ***The Rabbit 2000 Microprocessor User’s Manual*** provides more information related to the bootstrap mode.

The programming port is used to start the RabbitCore 2000 in a mode where it will download a program from the port and then execute the program. The programming port transmits information to and from a PC while a program is being debugged.

The RabbitCore 2000 can be reset from the programming port via the /RESET_IN line.

The Rabbit 2000 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.

The clock line for Serial Port A is presented to the programming port, which makes fast serial communication possible.

## 2.5 Clock Doubler

The RabbitCore 2000 takes advantage of the Rabbit 2000 microprocessor's internal clock doubler. A built-in clock doubler allows half-frequency crystals to be used to reduce radiated emissions. The 25.8 MHz (RCM 2000 and RCM2010) and 18.4 MHz (RCM 2020) frequencies are generated using 12.9 MHz and 9.2 MHz crystals. The clock doubler is disabled automatically in the BIOS for crystals with a frequency above 12.9 MHz.

The clock doubler can be disabled if 25.8 MHz or 18.4 MHz clock speeds are not required. Disabling the Rabbit 2000 microprocessor's internal clock will reduce power consumption and further reduce radiated emissions. The clock doubler is disabled with a simple change to the BIOS as described below.

1. Open the BIOS source code file, **`RABBITBIOS.C`** in the **`BIOS`** directory.
2. Change the line

   ```
   #define CLOCK_DOUBLED 1    // set to 1 to double the clock if XTAL<=12.9MHz,
   ```

   to read as follows.

   ```
   #define CLOCK_DOUBLED 0    // set to 1 to double the clock if XTAL<=12.9MHz,
   ```
3. Change the serial baud rate to 57,600 bps when the RabbitCore 2000 is operated at 12.9 MHz or 9.2 MHz.
4. Save the change using **File > Save**.

## 2.6 Memory

### 2.6.1 SRAM

The RabbitCore 2000 is designed to accept 32K to 512K of SRAM packaged in an SOIC case.

The existing standard models of the RabbitCore 2000 come with 128K or 512K of SRAM. Figure 6 shows the locations and the jumper settings for the jumpers at JP1 used to set the SRAM size. The "jumpers" are 0 Ω surface-mounted resistors.

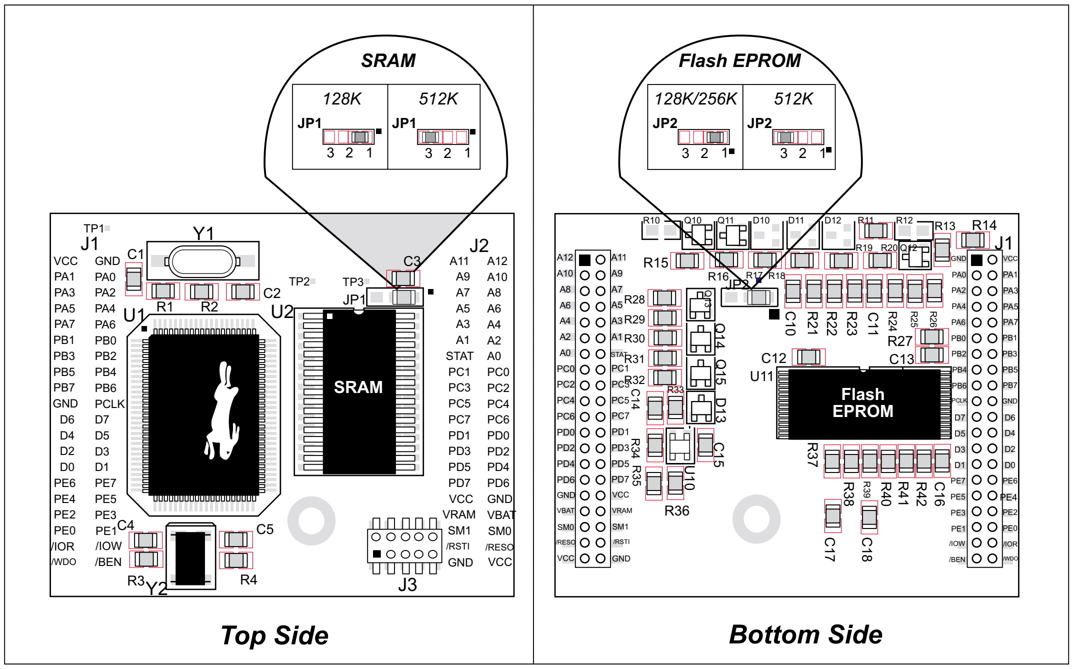


*Figure 6. RabbitCore 2000 Jumper Settings for SRAM and Flash EPROM Size*

### 2.6.2 Flash EPROM

The RabbitCore 2000 is also designed to accept 128K to 512K of flash EPROM packaged in a TSOP case.

The existing standard models of the RabbitCore 2000 come with 256K of flash EPROM. Figure 6 shows the locations and the jumper settings for the jumpers at JP2 used to set the flash EPROM size. The "jumpers" are 0 Ω surface-mounted resistors.

Z-World recommends that any customer applications should not be constrained by the sector size of the flash EPROM since it may be necessary to change the sector size in the future.

### 2.6.3 Dynamic C BIOS Source Files

The Dynamic C BIOS source files handle different standard RAM and flash EPROM sizes automatically.

# 3. SOFTWARE REFERENCE

## 3.1 More About Dynamic C

Dynamic C has been in use worldwide since 1989. Dynamic C is specially designed for programming embedded systems. Dynamic C features quick compile and interactive debugging in the real environment. A complete reference to Dynamic C is contained in the ***Dynamic C Reference Manual***.

Dynamic C for Rabbit™ processors uses the standard Rabbit programming interface. This is a 10-pin connector that connects to the Rabbit serial port A. It is possible to reset and cold-boot a Rabbit processor via the programming port. No software needs to be present in the target system. More details are available in the ***Rabbit 2000 Microprocessor User's Manual***.

Dynamic C cold-boots the target system and compiles the BIOS. The BIOS is a basic program of a few thousand bytes in length that provides the debugging and communication facilities that Dynamic C needs. Once the BIOS has been compiled, the user can compile his own program and test it. If the BIOS fails because the program stops running, a new cold boot and BIOS compile can be done at any time.

The BIOS can be customized by using **`#define`** options.

Dynamic C does not use **`include`** files, rather it has libraries that are used for the same purpose, that is, to supply function prototypes to programs before they are compiled. Libraries are much easier to use compared to **`include`** files.

Dynamic C supports assembly language, either as separate functions or as fragments embedded in C programs. Interrupt routines may be written in Dynamic C or in assembly language.

### 3.1.1 Operating System Framework

Dynamic C does not include an operating system in the usual sense of a complex software system that is resident in memory. The user has complete control of what is loaded as a part of his program, other than those routines that support loading and debugging (which are inactive at embedded run time). However, certain routines are very basic and normally should always be present and active.

- Periodic interrupt routine. This interrupt routine is driven by the Rabbit periodic interrupt facility, and when enabled creates an interrupt every 16 ticks of the 32.768 kHz oscillator, or every 488 µs. This routine drives three long global variables that keep track of the time: **`SEC_TIMER`**, **`MS_TIMER`**, and **`TICK_TIMER`** that respectively count seconds, milliseconds, and 488 µs ticks. These variables are needed by virtually all functions that measure time. The **`SEC_TIMER`** is set to seconds elapsed since 1 Jan 1980, and thus also keeps track of the time and date. The periodic interrupt routine must be disabled when the microprocessor enters sleepy mode and the processor clock is operating at 32.768 kHz. The interrupt routine cannot complete at this slow speed before the next tick of the periodic interrupt. In this situation, the hardware real-time clock can be read directly to provide the time.

- Watchdog support routines. Although the Rabbit watchdog can be disabled, this is not recommended since the watchdog is an essential facility for recovering when a program stops running. Very few systems are crash-free in real life.

### 3.1.2 Using Dynamic C

You have a choice of doing your software development in the flash memory or in the static RAM. There are 256K bytes of flash and 128K SRAM memory. The advantage of working in RAM is to save wear on the flash, which is limited to about 100,000 writes.

Note that an application can be developed in RAM, but cannot run standalone from RAM after the programming cable is disconnected. All applications can only run from flash.

Do not depend on the flash sector size for debugging. Due to the volatility of the flash market, the RabbitCore 2000 and Dynamic C were designed to accommodate flash devices with various sector sizes.

When using flash EPROM, the compile to a file is followed by a download to the flash EPROM. The disadvantage of using flash EPROM is that interrupts must be disabled for approximately 5 ms whenever a break point is set in the program. This can crash fast interrupt routines that are running while you stop at a break point or single-step the program. Flash EPROM or RAM is selected with the Dynamic C **Options** > **Compiler** menu.

## 3.2 I/O

The RabbitCore 2000 was designed to interface with other systems, and so there are no drivers written specifically for this purpose. The general Dynamic C read and write functions allow you to customize the parallel I/O to meet your specific needs. For example, use

```
WrPortI(PEDDR, &PEDDRShadow, 0x00);
```

to set all the port E bits as inputs, or use

```
WrPortI(PEDDR, &PEDDRShadow, 0xFF);
```

to set all the port E bits as outputs.

The sample programs in the Dynamic C **SAMPLES** directory provide further examples.

## 3.3 Serial Communication Drivers

The Prototyping Board has room for an RS-232 chip for which the Rabbit serial library, **`RSERIAL.LIB`**, provides users with a set of functions that send and receive entire blocks of data without yielding to other tasks, a set of single-user cofunctions that send and receive data but yield to other tasks, and a set of circular buffer functions.

The naming convention is **`serXfn`**:

ser - serial

X - the port being used: A, B, C, or D

fn - the function being implemented

For example, **`serBgetc()`** is the serial port B function **`getc()`**, which returns a character.

The Rabbit serial functions are listed in the following groups.

Open and Close Functions

Non-Cofunction Blocking Input Functions

Non-Cofunction Blocking Output Functions

Single-User Cofunction Input Functions

Single-User Cofunction Output Functions

Circular Buffer Functions

### 3.3.1 Open and Close Functions

The open and close functions enable and disable serial communication over the specified port.

**`int serXopen (long baud);`**

Currently only 8N1 transmission (8 data bits, no parity, 1 stop bit) is supported. The **`open`** function sets up the interrupt service routine vector.

#### Parameters

`baud`—desired baud rate in bits per second

#### Return Value

1—The baud rate set on the Rabbit is the same as the input baud rate.

0—The baud rate set on the rabbit does not match the input baud rate.

**`int serXclose ( );`**

Disables the serial port interrupt service routine.

#### Parameters

None.

#### Return Value

1

### 3.3.2 Non-Cofunction Blocking Input Functions

These are simple functions that do not use Dynamic C costatements. If no input data are available when called, they return immediately with appropriate status information in their return value. Once they begin to receive characters, they do not yield to other tasks until they complete their operation or until a character-to-character time-out period elapses.

```
int serXgetc ( );
```

Gets a single character. Always returns immediately, either with the next available input byte, or with –1 if none is available.

#### Parameters

None

#### Return Value

An integer with return character in the low byte. No character is represented by a return of –1.

```
int serXread (void *data, int length, unsigned long tmout);
```

Reads a block of characters. Returns the number of bytes read from an input serial stream. The stream is considered to be ended when all **`length`** bytes have been read or when the timeout period elapses waiting for data to appear in the input buffer.

#### Parameters

**`data`**—Destination data structure. The user must ensure data is allocated for at least length bytes.

**`length`**—The number of bytes to read.

**`tmout`**—The number of milliseconds to wait for receipt of each byte before timing out.

#### Return Value

The number of bytes read into data until timed out or until all length bytes have been read.

### 3.3.3 Non-Cofunction Blocking Output Functions

These are simple functions that do not use Dynamic C costatements. They immediately begin to perform their task, not yielding to other tasks until all characters have been written.

```
int serXputc (char c);
```

Writes a character to the serial port.

#### Parameters

`c`—Character to write

#### Return Value

1 for success, 0 if the character could not be written to the port.

```
int serXputs (char *s);
```

Calls `serXwrite (s, strlen (s))`.

#### Parameters

`s`—Null-terminated character string source to write to the serial port.

#### Return Value

The number of characters written.

```
int serXwrite (void *data, int length);
```

Writes a block of `length` bytes to the serial port.

#### Parameters

`data`—Destination data structure. The user must ensure data is allocated for at least length bytes.

`length`—The number of bytes to read.

#### Return Value

The number of bytes written to the serial port.

### 3.3.4 Single-User Cofunction Input Functions

These are Dynamic C cofunctions. If the input buffer they use is locked or becomes full during the course of their operation, they yield to other tasks, but do not return to execute the next statement within their own costatement block until they have completed their operation.

#### `scofunc int cof_serXgetc ( );`

Reads a single character from the serial port, yielding when not successful, and only returning when a character is successfully read.

**Parameters**

None

**Return Value**

An integer with the character read in the low byte.

#### `scofunc int cof_serXgets(char *s, int length, unsigned long tmout);`

Reads a null-terminated string, completes its execution when a carriage return is read, **`length`** number of characters are read, or the character to character time-out period elapses after the first character is read. It yields to other tasks while the input buffer is locked or becomes empty during its execution, and only returns control to the following statement in its own costatement block when it completes.

**Parameters**

**`data`**—Destination data structure. The user must ensure data is allocated for at least length bytes.

**`length`**—The number of bytes to read.

**`tmout`**—The number of milliseconds to wait for each character after the first character is read.

**Return Value**

1—CR or **`length`** bytes read into **`s`**.

0—Function times out before reading CR or **`length`** bytes.

#### `scofunc int cof_serXread(void *data, int length, unsigned long tmout);`

Reads a block of characters, completes its execution when **`length`** number of characters are read, or the character-to-character time-out period elapses after the first character is read. It yields to other tasks while the input buffer is locked or becomes empty during its execution and only returns control to the following statement in its own costatement block when it completes.

**Parameters**

**`data`**—Destination data structure. The user must ensure data is allocated for at least length bytes.

**`length`**—The number of bytes to read.

**`tmout`**—The number of milliseconds to wait for each character after the first.

**Return Value**

The number of bytes read.

### 3.3.5 Single-User Cofunction Output Functions

These are Dynamic C cofunctions. If the output buffer they use is locked or becomes empty during the course of their operation, they yield to other tasks, but do not return to execute the next statement within their own costatement block until they have completed their operation.

#### `scofunc void cof_serXputc (char c);`

Writes a single character to the serial port, yielding to other tasks when unsuccessful, and returning only when the character is successfully written.

**Parameters**

`c`—Character to write to the serial port.

**Return Value**

None

#### `scofunc void cof_serXputs(char *s);`

Writes a null-terminated character string to the serial port, yielding to other tasks when unsuccessful or whenever the buffer is full, returning only when the string is successfully written.

**Parameters**

`s`—Null-terminated character string written to the serial port.

**Return Value**

None

#### `scofunc void cof_serXwrite (void *data, int length);`

Writes a block of characters to the serial port, yielding to other tasks when unsuccessful or whenever the buffer is full, returning only when all the data is successfully written.

**Parameters**

`data`—Source data structure to write to the serial port.

`length`—Number of characters in data to write.

**Return Value**

None

### 3.3.6 Circular Buffer Functions

These functions act on or report status of the circular transmit/receive buffers.

Macro definitions are used to establish the buffer sizes:

> **`xINBUFSIZE`**—read buffer size, where **`x`** is A, B, C, or D
>
> **`xOUTBUFSIZE`**—write buffer size where **`x`** is A, B, C, or D

The user must define each buffer size for each port being used to be a power of 2 minus 1 with a macro. The size of 2^n - 1 enables masking for fast rollover calculations. If no value or an illegal value is defined, a default size of 31 will be used and a compiler warning will be given. When using cofunctions, smaller buffer sizes can yield more frequently to other tasks, but have the risk of a large input data stream overrunning the buffer and losing data if the other task executes for too long relative to the baud rate.

**`int serXpeek ( );`**

Returns the first character in the receive buffer, if any are available, without removing it from the buffer.

**Parameters**

None

**Return Value**

An integer with return character in the low byte. No character is represented by a return of –1.

**`void serXrdFlush ( );`**

Flushes the serial port receive buffer.

**Parameters**

None

**Return Value**

None

**`void serXwrFlush ( );`**

Flushes the serial port transmit buffer.

**Parameters**

None

**Return Value**

None

## `int serXrdFree ( );`

Calculates the free space in the serial port receive buffer.

### Parameters

None

### Return Value

The number of characters the serial port receive buffer can accept before becoming full.

## `int serXwrFree ( );`

Calculates the free space in the serial port transmit buffer.

### Parameters

None

### Return Value

The number of characters the serial port transmit buffer can accept before becoming full.

## `int serXrdUsed ( );`

Calculates the number of characters ready to read from the serial port receive buffer.

### Parameters

None

### Return Value

The number of characters currently in the serial port receive buffer.

# APPENDIX A. SPECIFICATIONS

## A.1 Electrical and Mechanical Specifications

Figure A-1 shows the mechanical dimensions for the RabbitCore 2000.

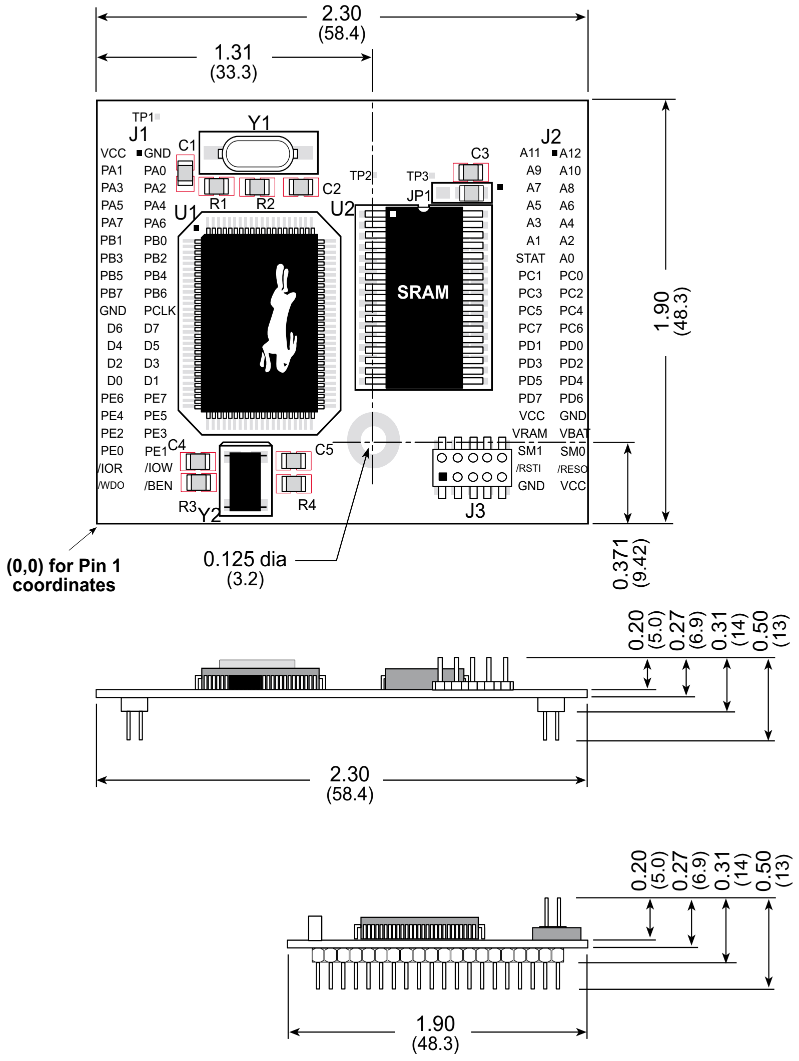


*Figure A-1. RabbitCore 2000 Dimensions*

Table A-1 provides the pin 1 locations for the RabbitCore 2000 headers viewed from the top side (as in Figure A-1).

*Table A-1. Jackrabbit Header Pin 1 Locations*

| Header | Description | Pin 1 (x,y) Coordinates (Inches) |
|---|---|---|
| J1 | RabbitCore 2000 subsystems | (0.221, 1.675) |
| J2 | RabbitCore 2000 subsystems | (2.181, 1.675) |
| J3 | Programming port | (1.600, 0.214) |

Table A-2 lists the electrical, mechanical, and environmental specifications for the Rabbit-Core 2000.

***Table A-2. RCM2000 Specifications***

| Parameter | Specification |
|---|---|
| Board Size | 1.90" × 2.30" × 0.50"<br>(48.3 mm × 58.4 mm × 12.7 mm) |
| Operating Temperature | –40°C to +85°C |
| Storage Temperature | –55°C to +125°C |
| Humidity | 5% to 95%, noncondensing |
| Input Voltage | 4.75 V to 5.25 V DC |
| Current | 58 mA at 9.216 MHz, 5 V DC<br>74 mA at 12.9024 MHz, 5 V DC<br>98 mA at 18.432 MHz, 5 V DC<br>130 mA at 25.8048 MHz, 5 V DC |
| Standby Current | 16 µA (typical), 50 µA (maximum) |
| General-Purpose I/O | 40 parallel I/0 lines grouped in five 8-bit ports:<br>24 bidirectional, 10 inputs only, 6 outputs only |
| Memory, I/O Interface | 13 address lines, 8 data lines, I/O read/write, buffer enable, status, clock |
| Additional Digital Inputs | 2 startup mode (for master/slave), reset in |
| Additional Digital Outputs | Watchdog output, reset out |
| Microprocessor | Rabbit 2000 |
| Clock | 25.8048 MHz (18.432 MHz option) |
| SRAM | 512K (supports 32K–512K) |
| Flash EPROM | 256K (supports 128K–512K) |
| Timers | Five 8-bit timers cascadable in pairs, one 10-bit timer with 2 match registers that each have an interrupt |
| Serial Ports | Four CMOS-compatible ports. Two ports are configurable as clocked ports, one is configurable as RS-232 programming port. |
| Serial Rate | CMOS<br>maximum asynchronous 806,400 bps<br>maximum synchronous 6.45 Mbps |
| Watchdog/Supervisor | Yes |
| Time/Date Clock | Yes |

*Table A-2. RCM2000 Specifications (continued)*

| Parameter | Specification |
|---|---|
| Socket Strip (for connection to headers J1 and J2) | Pinrex 2x20, 2 mm pitch (PS2S-2X20GOB) |
| Recommended Standoff (to attach RabbitCore 2000 to user board) | 9/32” (7.14) with 4-40 screw |
| Backup Battery | Provision for user-supplied backup battery (2.85 V to 3.15 V) via connections on header J2 |

### A.1.1 Headers

The RabbitCore 2000 uses headers at J1, J2, and J3 for physical connection to other boards. J1 and J2 are 2 × 20 SMT headers with a 2 mm pin spacing. J3 is a 2 × 5 header with a 2 mm pin spacing.

Figure A-2 shows the layout of another board for the RabbitCore 2000 to be plugged in to. These values are relative to the header connectors.

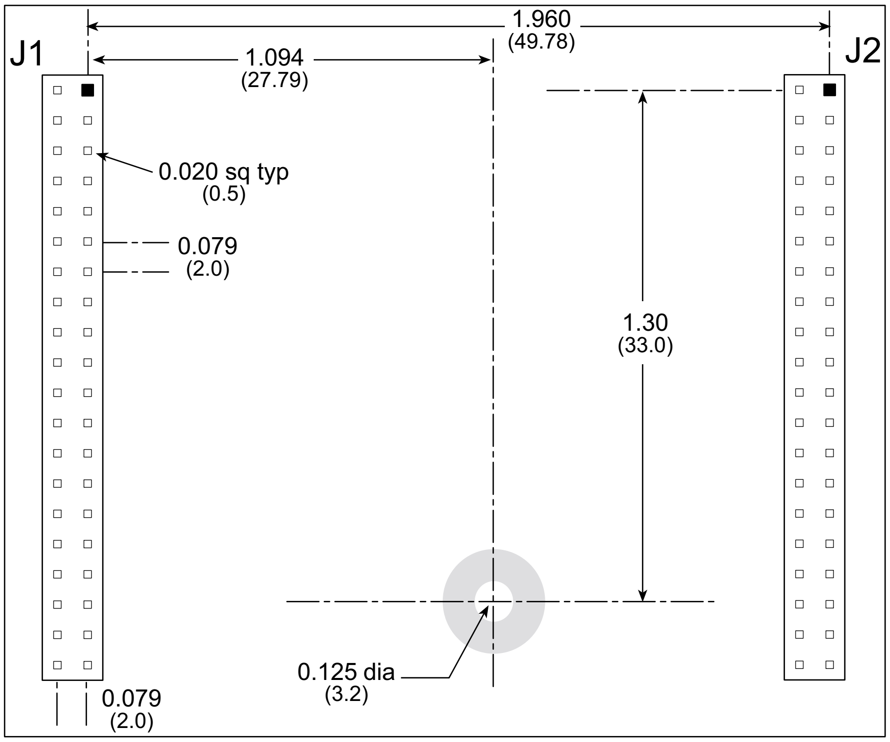


*Figure A-2. J1 and J2 Header Layout (Top View)*

## A.2 Bus Loading

When designing an interface to the RabbitCore 2000, careful attention must be paid to bus loading. This section provides bus loading of external devices.

Table A-3 lists the capacitance for the various RabbitCore 2000 I/O ports.

***Table A-3. Capacitance of Rabbit 2000 I/O Ports***

| I/O Ports | Input Capacitance (pF) | Output Capacitance (pF) |
|---|---|---|
| Parallel Ports A to E | 12 | 14 |
| Data Lines D0–D7 | 30 | 32 |
| Address Lines A0–A12 | 30 | 32 |

Table A-4 lists the external capacitive bus loading for the various Rabbit 2000 output ports. Be sure to add the loads for the devices you are using in your custom system and verify that they do not exceed the values in Table A-4.

***Table A-4. External Capacitive Bus Loading -40°C to +85°C***

| Output Port | Clock Speed (MHz) | Maximum External Capacitive Loading (pF) |
|---|---|---|
| A[12:1]<br>D[7:1] | 25.8 | 50 |
| A[12:1]<br>D[7:1] | 18.4 | 55 for 90 ns flash<br>100 for 55 ns flash* |
| A0<br>D0 | 25.8, 18.4 | 100 |
| PD[3:0] | 25.8, 18.4, | 100 |
| PA[7:0]<br>PB[7,6,1,0]<br>PC[6,4,2,0]<br>PD[7:4]<br>PE[7:0] | 25.8, 18.4 | 90 |
| All data, address, and I/O lines with clock doubler disabled | 12.9, 9.2 | 100 |

* The RCM2020 operating at 18.4 MHz will typically come with a flash EPROM whose access time is 55 ns. Because of the volatility of the memory market, a 90 ns flash EPROM could be used on the RCM2020.

The values from the table above are derived using 55 ns (25.8 MHz version) and 90 ns (18.4 MHz version) memory access times. External capacitive loading can be improved by 10 pF for commercial temperature ranges, but do not exceed 100 pF. See the AC timing specifications in the ***Rabbit 2000 Users Manual*** for more information.

Figure A-3 shows a typical timing diagram for the Rabbit 2000 microprocessor memory read and write cycles.

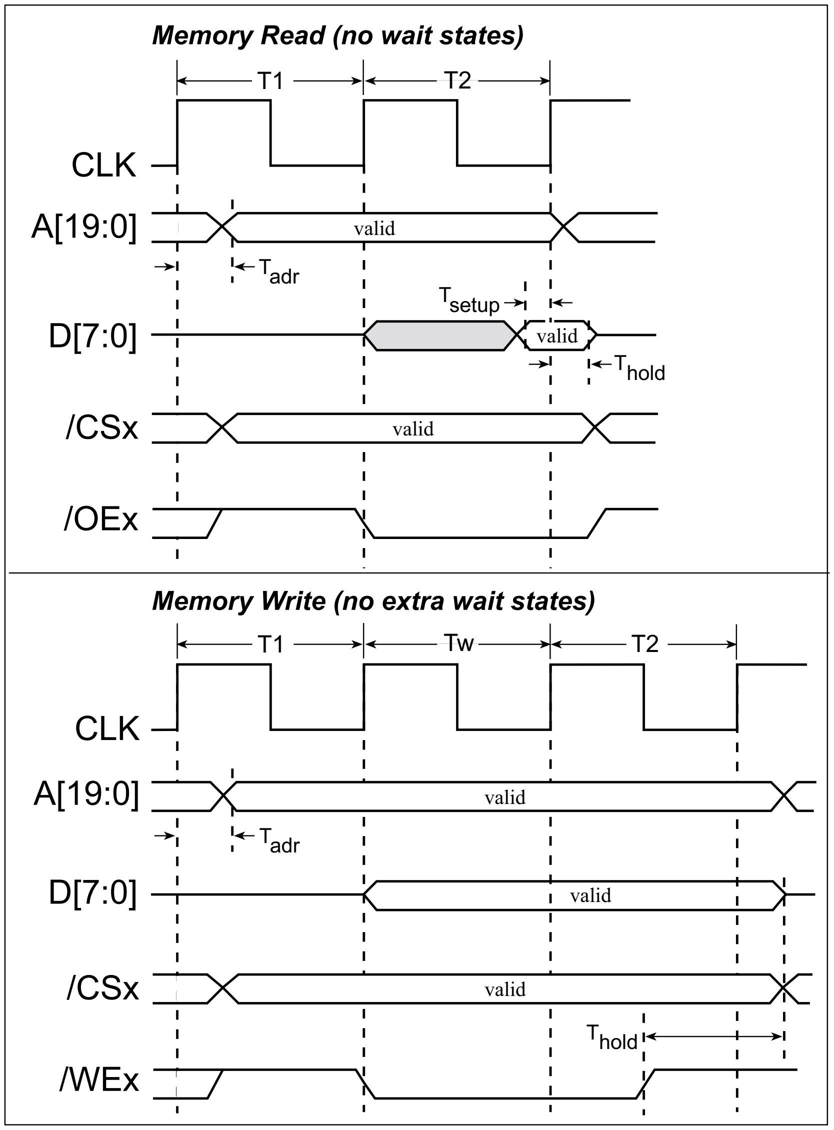


***Figure A-3. Memory Read and Write Cycles***

$T_{adr}$ is the time required for the address output to reach 0.8 V. This time depends on the bus loading. A0 has a stronger driver and can handle larger capacitive loads than the other address lines. $T_{setup}$ is the data setup time relative to the clock. Tsetup is specified from 30%/70% of the $V_{DD}$ voltage level. Add 1.5 ns to $T_{adr}$ for each 10 pF of additional bus loading above 70 pF.

## A.3 Rabbit 2000 DC Characteristics

Table A-5 outlines the DC characteristics for the Rabbit 2000 at 5.0 V over the recommended operating temperature range from $T_a$ = –40°C to +85°C, $V_{DD}$ = 4.5 V to 5.5 V.

***Table A-5. 5.0 Volt DC Characteristics***

| Symbol | Parameter | Test Conditions | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|
| $I_{IH}$ | Input Leakage High | $V_{IN} = V_{DD}$, $V_{DD}$ = 5.5 V | | | 10 | µA |
| $I_{IL}$ | Input Leakage Low (no pull-up) | $V_{IN} = V_{SS}$, $V_{DD}$ = 5.5 V | -10 | | | µA |
| $I_{OZ}$ | Output Leakage (no pull-up) | $V_{IN} = V_{DD}$ or $V_{SS}$, $V_{DD}$ = 5.5 V | -10 | | 10 | µA |
| $V_{IL}$ | CMOS Input Low Voltage | | | | 0.3 x $V_{DD}$ | V |
| $V_{IH}$ | CMOS Input High Voltage | | 0.7 x $V_{DD}$ | | | V |
| $V_T$ | CMOS Switching Threshold | $V_{DD}$ = 5.0 V, 25°C | | 2.4 | | V |
| $V_{OL}$ | CMOS Output Low Voltage | $I_{OL}$ = See Table A-6 (sinking) $V_{DD}$ = 4.5 V | | 0.2 | 0.4 | V |
| $V_{OH}$ | CMOS Output High Voltage | $I_{OH}$ = See Table A-6 (sourcing) $V_{DD}$ = 4.5 V | 0.7 x $V_{DD}$ | 4.2 | | V |

## A.4 I/O Buffer Sourcing and Sinking Limit

Unless otherwise specified, the Rabbit I/O buffers are capable of sourcing and sinking 8 mA of current per pin at full AC switching speed. Full AC switching assumes a 25.8 MHz CPU clock and capacitive loading on address and data lines of less than 100 pF per pin. Address pin A0 and data pin D0 are rated at 16 mA each. Pins A1–A12 and D1–D7 are each rated at 8 mA. The absolute maximum operating voltage on all I/O is $V_{DD}$ + 0.5 V, or 5.5 V.

Table A-6 shows the AC and DC output drive limits of the parallel I/O buffers when the Rabbit 2000 is used in the RabbitCore 2000.

***Table A-6. I/O Buffer Sourcing and Sinking Capability***

| **Pin Name** | **Output Drive Sourcing*/Sinking† Limits (mA)** | |
|---|---|---|
| *Output Port Name* | *Full AC Switching* SRC/SNK | *Maximum‡ DC Output Drive* SRC/SNK |
| PA [7:0] | 8/8 | 12/12 |
| PB [7, 1, 0] | 8/8 | 12/12 |
| PC [6, 4, 2, 0] | 8/8 | 12/12 |
| PD [7:4] | 8/8 | 12/12 |
| PD [3:0]** | 16/16 | 12/25 |
| PE [7:0] | 8/8 | 12/12 |

* The maximum DC sourcing current for I/O buffers between $V_{DD}$ pins is 112 mA.

† The maximum DC sinking current for I/O buffers between $V_{SS}$ pins is 150 mA.

‡ The maximum DC output drive on I/O buffers must be adjusted to take into consideration the current demands made my AC switching outputs, capacitive loading on switching outputs, and switching voltage.

***The current drawn by all switching and nonswitching I/O must not exceed the limits specified in the first two footnotes.***

** The combined sourcing from Port D [7:0] may need to be adjusted so as not to exceed the 112 mA sourcing limit requirement specified in the first footnote.

Some of the values listed are different from those listed in the ***Rabbit 2000 Microprocessor User's Manual*** to take into account external loading of the Rabbit 2000 while it is part of the RabbitCore 2000. Loads that exceed the values listed above need to be buffered.

# APPENDIX B. PROTOTYPING BOARD

Appendix B describes the features and accessories of the Prototyping Board, and explains the use of the Prototyping Board to demonstrate the RabbitCore 2000 and to build prototypes of your own circuits.

## B.1 Mechanical Dimensions and Layout

Figure B-1 shows the mechanical dimensions and layout for the RabbitCore 2000 Prototyping Board.

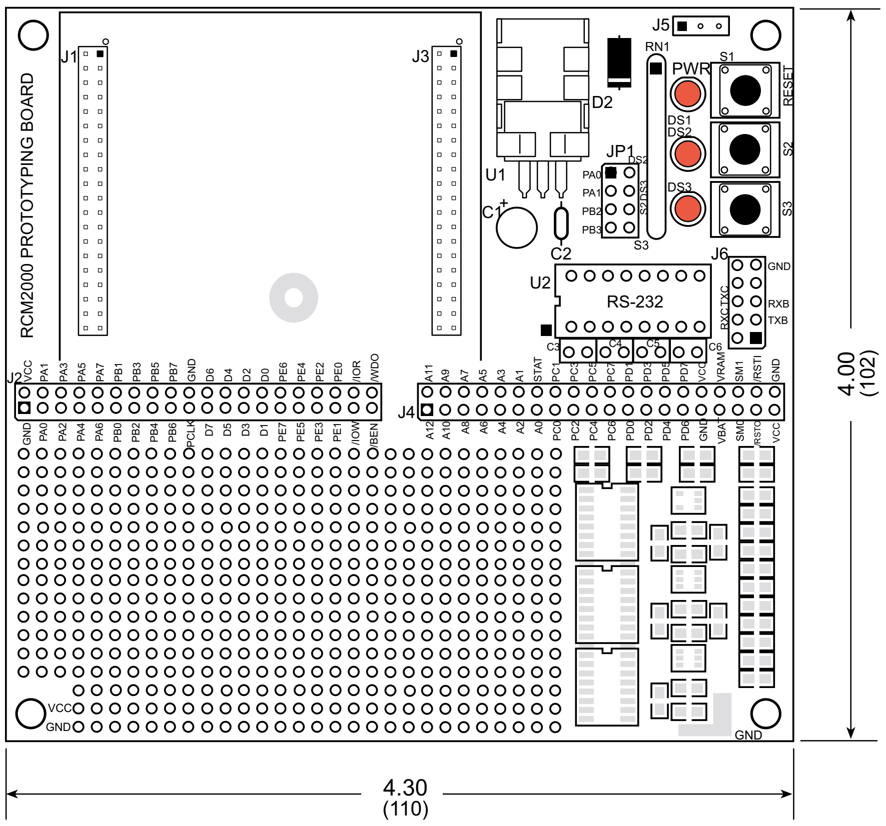


*Figure B-1. RabbitCore 2000 Prototyping Board Dimensions*

Table B-1 lists the electrical, mechanical, and environmental specifications for the Prototyping Board..

*Table B-1. Prototyping Board Specifications*

| Parameter | Specification |
|---|---|
| Board Size | 4.00" × 4.30" × 1.19" (102 mm × 110 mm × 30 mm) |
| Operating Temperature | –40°C to +70°C |
| Humidity | 5% to 95%, noncondensing |
| Input Voltage | 7.5 V to 25 V DC |
| Maximum Current Draw (including user-added circuits) | 1 A at 12 V and 25°C, 0.7 A at 12 V and 70ºC |
| Prototyping Area | 2" × 3" (51 mm × 76 mm) throughhole, 0.1" spacing |
| Standoffs/Spacers | 4, accept 6-32 x 3/8 screws |

## B.2 Power Supply

The RabbitCore 2000 requires a regulated 5 V ± 0.25 V dc power source to operate. Depending on the amount of current required by the application, different regulators can be used to supply this voltage.

The Prototyping Board has an onboard LM340-T5 or equivalent. The LM340-T5 is an inexpensive linear regulator that is easy to use. Its major drawback is its inefficiency, which is directly proportional to the voltage drop across it. The voltage drop creates heat and wastes power.

A switching power supply may be used in applications where better efficiency is desirable. The LM2575 is an example of an easy-to-use switcher. This part greatly reduces the heat dissipation of the regulator. The drawback in using a switcher is the increased cost.

The Prototyping Board itself is protected against reverse polarity by a Shottky diode at D2 as shown in Figure B-2.

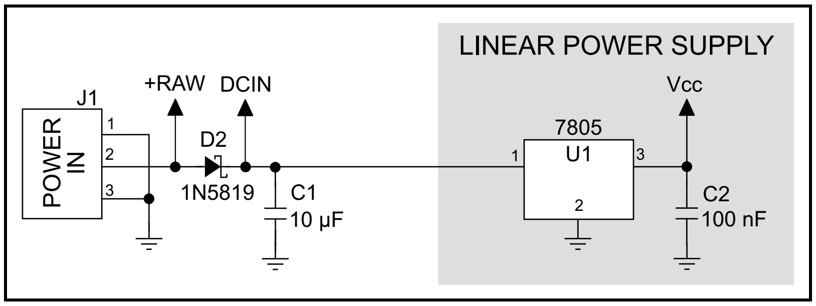


***Figure B-2. Prototyping Board Power Supply***

Capacitor C1 provides surge current protection for the voltage regulator, and allows the external power supply to be located some distance away.

## B.3 Using the Prototyping Board

The Prototyping Board is actually both a demonstration board and a prototyping board. As a demonstration board, it can be used to demonstrate the functionality of the RabbitCore 2000 right out of the box without any modifications to either board. There are no jumpers or dip switches to configure or misconfigure on the Prototyping Board so that the initial setup is very straightforward.

The Prototyping Board comes with the basic components necessary to demonstrate the operation of the RabbitCore 2000. Two LEDs (DS2 and DS3) are connected to PA0 and PA1, and two switches (S2 and S3) are connected to PB2 and PB3 to demonstrate the interface to the Rabbit 2000 microprocessor. Reset switch S1 is the hardware reset for the RabbitCore 2000.

To maximize the availability of RabbitCore 2000 resources, the demonstration hardware (LEDs and switches) on the Prototyping Board may be disconnected. This is done by cutting the traces below the silk-screen outline of header JP1 on the bottom side of the Prototyping Board. Figure B-3 shows the four places where cuts should be made. An exacto knife would work nicely to cut the traces. Alternatively, a small standard screwdriver may be carefully and forcefully used to wipe through the PCB traces.

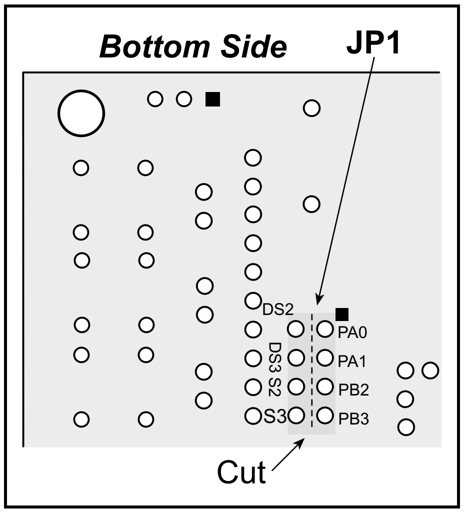


***Figure B-3. Where to Cut Traces to Permanently Disable Demonstration Hardware on Prototyping Board***

The power LED (PWR) and the RESET switch remain connected. Jumpers across the appropriate pins on header JP1 can be used to reconnect specific demonstration hardware later if needed.

***Table B-1. Prototyping Board Jumper Settings***

| Header JP2 | |
|---|---|
| **Pins** | **Description** |
| 1–2 | PA0 to LED DS2 |
| 3–4 | PA1 to LED DS3 |
| 5–6 | PB2 to Switch S2 |
| 7–8 | PB3 to Switch S3 |

Note that the pinout at location JP1 on the bottom side of the Prototyping Board (shown in Figure B-3) is a mirror image of the top side pinout.

The Prototyping Board provides the user with RabbitCore 2000 connection points brought out conveniently to labeled points at headers J2 and J4 on the Prototyping Board. Small to medium circuits can be prototyped using point-to-point wiring with 20 to 30 AWG wire between the prototyping area and the holes at locations J2 and J4. The holes are spaced at 0.1" (2.5 mm), and 40-pin headers or sockets may be installed at J2 and J4. The pinouts for locations J1 and J3, which correspond to J2 and J4, are shown in Figure B-4.

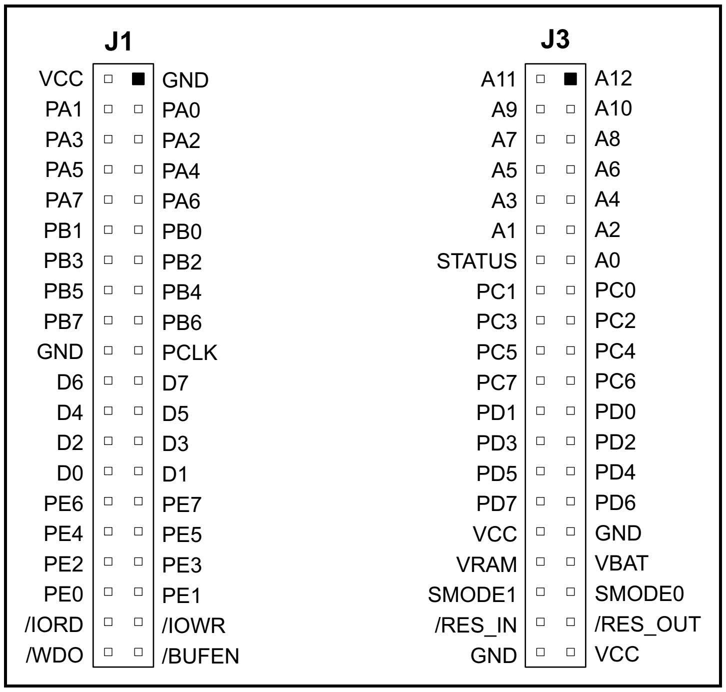


***Figure B-4. RabbitCore 2000 Prototyping Board Pinout (Top View)***

A pair of small holes capable of holding 30 AWG wire appears to the side of each hole pair at locations J2 and J4 for convenience of point-to-point wiring when headers are installed. The signals are those of the adjacent pairs of holes at J2 and J4. These small holes are also provided for the components that may be installed below location J4.

There is an additional 2" × 3" of through-hole prototyping space available on the Prototyping Board. VCC and GND traces run along the edge of the Prototyping Board for easy access. A GND pad is also provided at the lower right for alligator clips or probes.

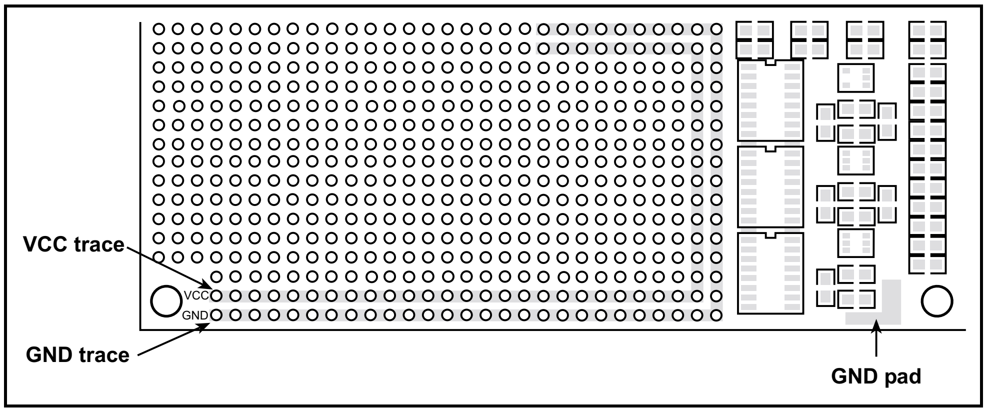


***Figure B-5. VCC and GND Traces Along Edge of Prototyping Board***

### B.3.1 Adding Other Components

There is room on the Prototyping Board for a user-supplied RS-232 transceiver chip at location U2 and a 10-pin header for serial interfacing to external devices at location J6. A Maxim MAX232 transceiver is recommended. When adding the MAX232 transceiver at position U2, you must also add 100 nF charge storage capacitors at positions C3–C6 as shown in Figure B-6.

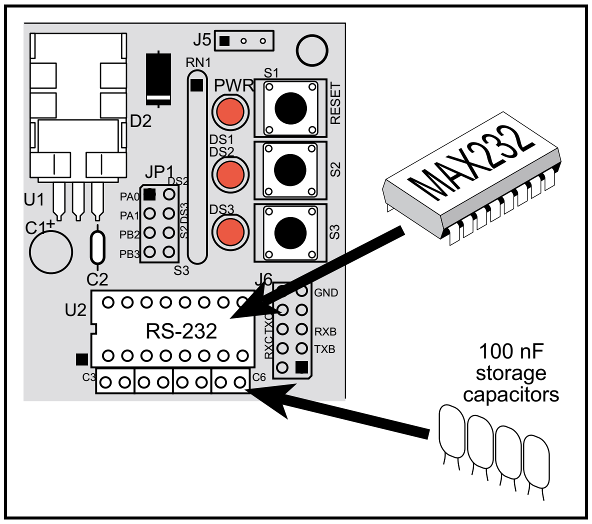


***Figure B-6. Location for User-Supplied RS-232 Transceiver and Charge Storage Capacitors***

There are two sets of pads that can be used for surface mount prototyping SOIC devices. The silk screen layout separates the rows into six 16-pin devices (three on each side). However, there are pads between the silk screen layouts giving the user two 52-pin (2x26) SOIC layouts with 50 mil pin spacing. There are six sets of pads that can be used for 3- to 6-pin SOT23 packages. There are also 60 sets of pads that can be used for SMT resistors and capacitors in an 0805 SMT package. Each component has every one of its pin pads connected to a hole in which a 30 AWG wire can be soldered (standard wire wrap wire can be soldered in for point-to-point wiring on the Prototyping Board). Because the traces are very thin, carefully determine which set of holes is connected to which surface mount pad.

# APPENDIX C. POWER MANAGEMENT

## C.1 Power Supplies

The RabbitCore 2000 requires a regulated 5 V ± 0.25 V DC power source.

A RabbitCore 2000 with no loading at the outputs operating at 18.432 MHz typically draws 98 mA, and a RabbitCore 2000 operating at 25.8048 MHz typically draws 130 mA. The RabbitCore 2000 will consume 13 mA to 15 mA of additional current when the programming cable is used to connect J3 to a PC.

### C.1.1 Batteries and External Battery Connections

The RabbitCore 2000 does not have a battery, but there is provision for a customer-supplied battery to back up SRAM and keep the internal Rabbit 2000 real-time clock running.

Header J2, shown in Figure C-1, allows access to the external battery. This header makes it possible to connect an external 3 V power supply. This allows the SRAM and the internal Rabbit 2000 real-time clock to retain data with the RabbitCore 2000 powered down.

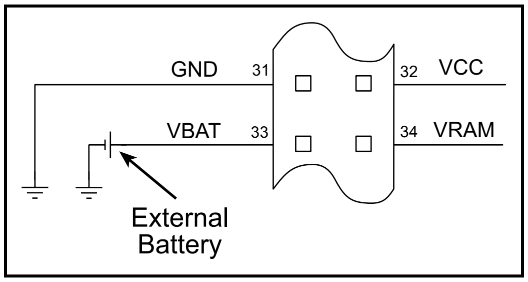


*Figure C-1. External Battery Connections at Header J2*

A lithium battery with a nominal voltage of 3 V and a minimum capacity of 165 mA·h is recommended. A lithium battery is strongly recommended because of its nearly constant nominal voltage over most of its life.

The drain on the battery by the RabbitCore 2000 is typically 16 µA when no other power is supplied. If a 950 mA·h battery is used, the battery can last more than 6 years:

$$\frac{950\ \text{mA·h}}{16\ \mu\text{A}} = 6.8\ \text{years.}$$

The actual life in your application will depend on the current drawn by components not on the RabbitCore 2000 and the storage capacity of the battery. Note that the shelf life of a lithium battery is ultimately 10 years.

### C.1.2 Battery Backup Circuit

The battery-backup circuit serves two purposes:

- It reduces the battery voltage to the real-time clock, thereby reducing the current consumed by the real-time clock and lengthening the battery life.
- It ensures that current can flow only ***out*** of the battery to prevent charging the battery.

Figure C-2 shows the RabbitCore 2000 battery backup circuitry.

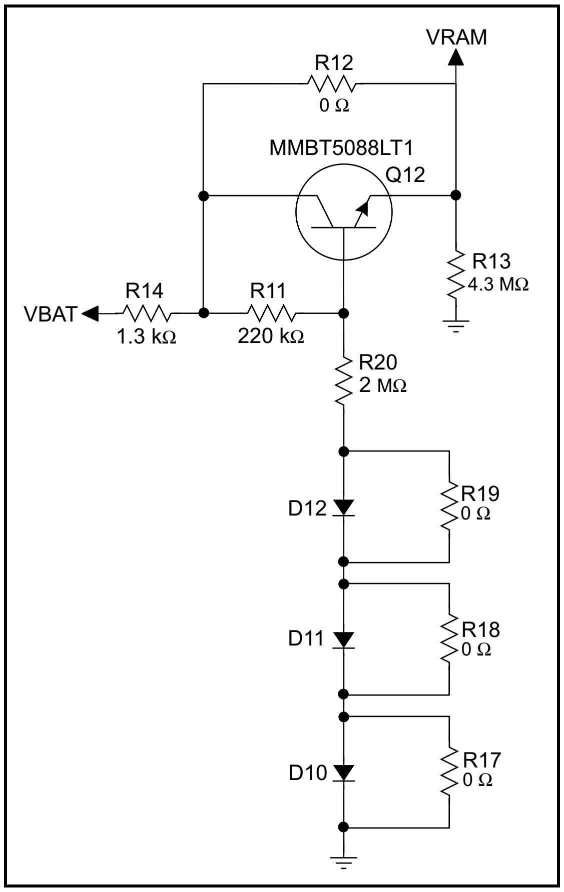


***Figure C-2. RabbitCore 2000 Battery Backup Circuit***

Resistor R12, shown in Figure C-2, is typically not stuffed on the RabbitCore 2000. VRAM and Vcc are nearly equal (<100 mV, typically 10 mV) when power is supplied to the RabbitCore 2000. R14 prevents any catastrophic failure of Q12 by limiting current from the customer-supplied battery.

Resistors R11 and R20 make up a voltage divider between the battery voltage and the temperature-compensation voltage at the anode of diode D12. This voltage divider biases the base of Q12 to about 0.9 × VBAT. $V_{BE}$ on Q12 is about 0.55 V. Therefore, VRAM is about 0.9 × VBAT - 0.55 V, or about 2.15 V for a 3 V battery.

These voltages vary with temperature. VRAM varies the least because temperature-compensation diodes D10–D12 will offset the variation with temperature of Q12’s $V_{BE}$. R17–R19 may be stuffed instead of the corresponding D10–D12 to provide the optimum temperature compensation.

Resistor R13 provides a minimum load to the regulator circuit.

VRAM is also available on pin 34 of header J2 to facilitate battery backup of the external circuit. Note that the recommended minimum resistive load at VRAM is 100 kΩ, and new battery life calculations should be done to take external loading into account.

### C.1.3 Power to VRAM Switch

The VRAM switch, shown in Figure C-3, allows a customer-supplied external battery to provide power when the external power goes off. The switch provides an isolation between Vcc and the battery when Vcc goes low. This prevents the Vcc line from draining the battery.

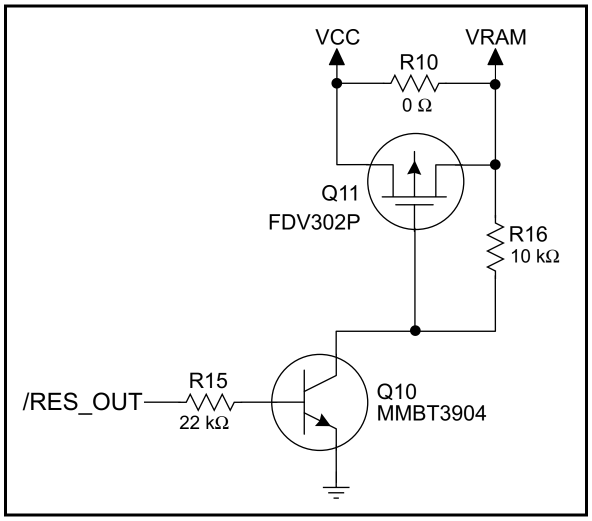


*Figure C-3. VRAM Switch*

Transistor Q11 is needed to provide a very small voltage drop between Vcc and VRAM (<100 mV, typically 10 mV) so that the processor lines powered by Vcc will not have a significantly different voltage than VRAM.

When the RabbitCore 2000 is not resetting (pin 2 on U10 is high), the /RES_OUT line will be high. This turns on Q10, causing its collector to go low. This turns on Q11, allowing VRAM to nearly equal Vcc.

When the RabbitCore 2000 is resetting, the /RES_OUT line will go low. This turns off Q10 and Q11, providing an isolation between Vcc and VRAM.

The battery backup circuit keeps VRAM from dropping below 2 V.

### C.1.4 Reset Generator

The RabbitCore 2000 uses a reset generator, U10, to reset the Rabbit 2000 microprocessor when the voltage drops below the voltage necessary for reliable operation. The reset occurs between 4.50 V and 4.75 V, typically 4.63 V. The RabbitCore 2000 has a reset output, pin 37 on header J3, presented to the headers. The reset generator has a reset input, pin 38 on header J3, that can be used to force the RabbitCore 2000 to reset.

## C.2 Chip Select Circuit

Figure C-4 shows a schematic of the chip select circuit.

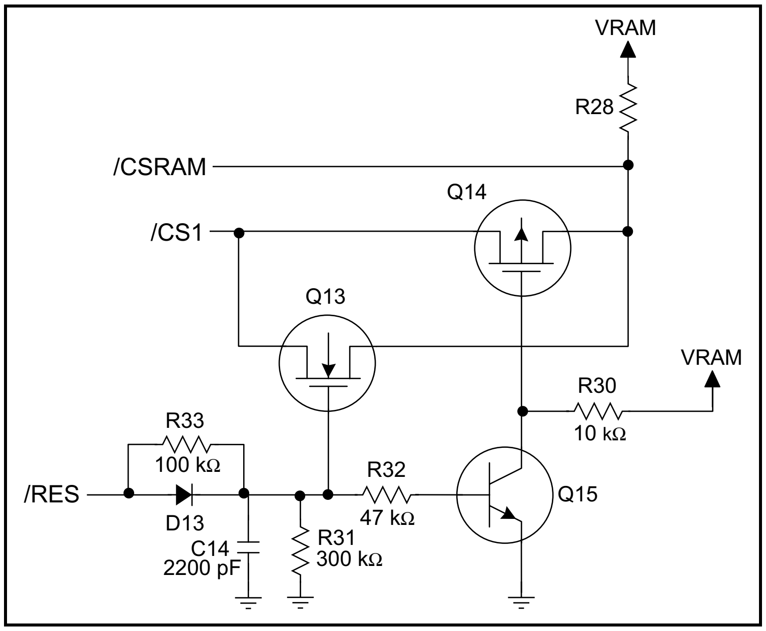


*Figure C-4. Chip Select Circuit*

The current drain on the battery in a battery-backed circuit must be kept at a minimum. When the RabbitCore 2000 is not powered, the battery keeps the SRAM memory contents and the real-time clock (RTC) going. The SRAM has a powerdown mode that greatly reduces power consumption. This powerdown mode is activated by raising the chip select (CS) signal line. Normally the SRAM requires Vcc to operate. However, only 2 V is required for data retention in powerdown mode. Thus, when power is removed from the circuit, the battery voltage needs to be provided to both the SRAM power pin and to the CS signal line. The CS control circuit accomplishes this task for the CS signal line.

In a powered-up condition, the CS control circuit must allow the processor's chip select signal /CS1 to control the SRAM's CS signal /CSRAM. So, with power applied, /CSRAM must be the same signal as /CS1, and with power removed, /CSRAM must be held high (but only needs to be battery voltage high). Q13 and Q14 are MOSFET transistors with opposing polarity. They are both turned on when power is applied to the circuit. They allow the CS signal to pass from the processor to the SRAM so that the processor can periodically access the SRAM. When power is removed from the circuit, the transistors will turn off and isolate /CSRAM from the processor. The isolated /CSRAM line has a 100 kΩ pullup resistor to VRAM (R28). This pullup resistor keeps /CSRAM at the VRAM voltage level (which under no power condition is the backup battery’s regulated voltage at a little more than 2 V).

Transistors Q13 and Q14 are of opposite polarity so that a rail-to-rail voltages can be passed. When the /CS1 voltage is low, Q13 will conduct. When the /CS1 voltage is high, Q14 will conduct. It takes time for the transistors to turn on, creating a propagation delay. This delay is typically very small, about 10 ns to 15ns.

The signal that turns the transistors on is a high on the processor’s reset line, /RES_OUT. When the RabbitCore 2000 is not in reset, the reset line will be high, turning on n-channel Q13 and Q15. Q15 is a simple inverter needed to turn on Q14, a p-channel MOSFET. When a reset occurs, the /RES_OUT line will go low. This will cause C14 to discharge through R31 and R33. This small delay (about 160 µs) ensures that there is adequate time for the processor to write any last byte pending to the SRAM before the processor puts itself into a reset state. When coming out of reset, CS will be enabled very quickly because D13 conducts to charge capacitor C14.

# APPENDIX D. SAMPLE CIRCUITS

Appendix D provides these sample circuits that incorporate the RabbitCore 2000.

- RS-232/RS-485 Serial Communication
- Keypad and LCD Connections
- LCD Connections
- LCD Connections
- D/A Converter

## D.1 RS-232/RS-485 Serial Communication

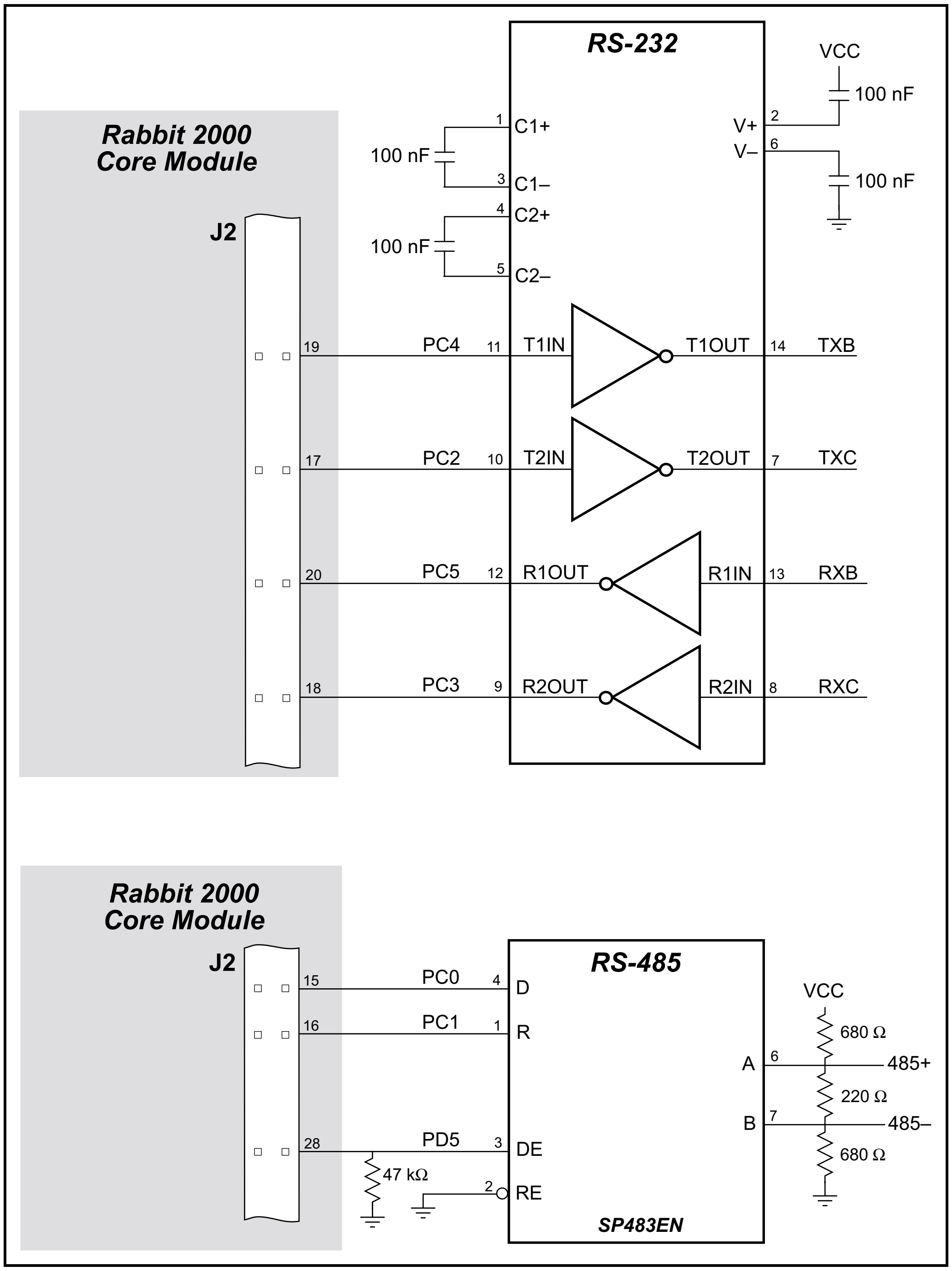


*Figure D-1. Sample RS-232 and RS-485 Circuits*

Sample Program: **PUTS.C** in **SAMPLES/SERIAL**.

## D.2 Keypad and LCD Connections

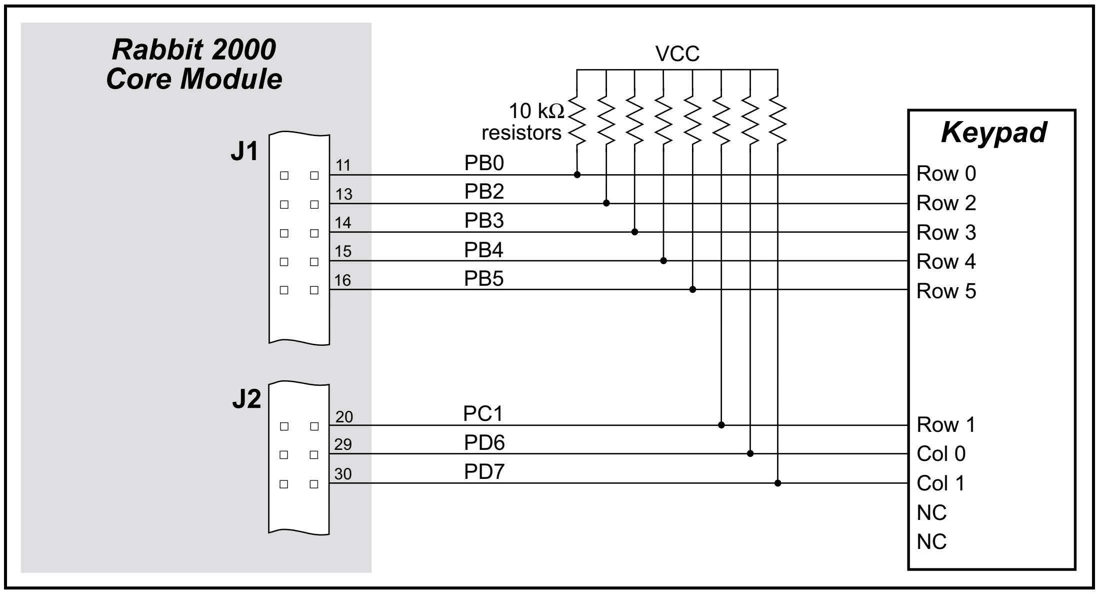


*Figure D-2. Sample Keypad Connections*

Sample Program: **`KEYLCD.C`** in **`SAMPLES/COREMODULE`**.

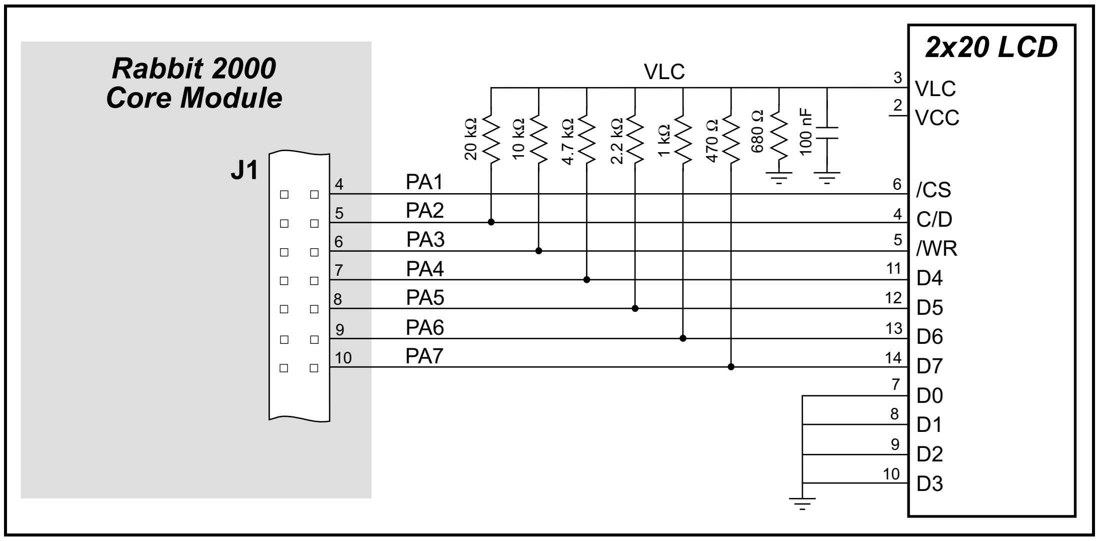


*Figure D-3. Sample LCD Connections*

Sample Program: **`KEYLCD.C`** in **`SAMPLES/COREMODULE`**.

## D.3 LCD Connections

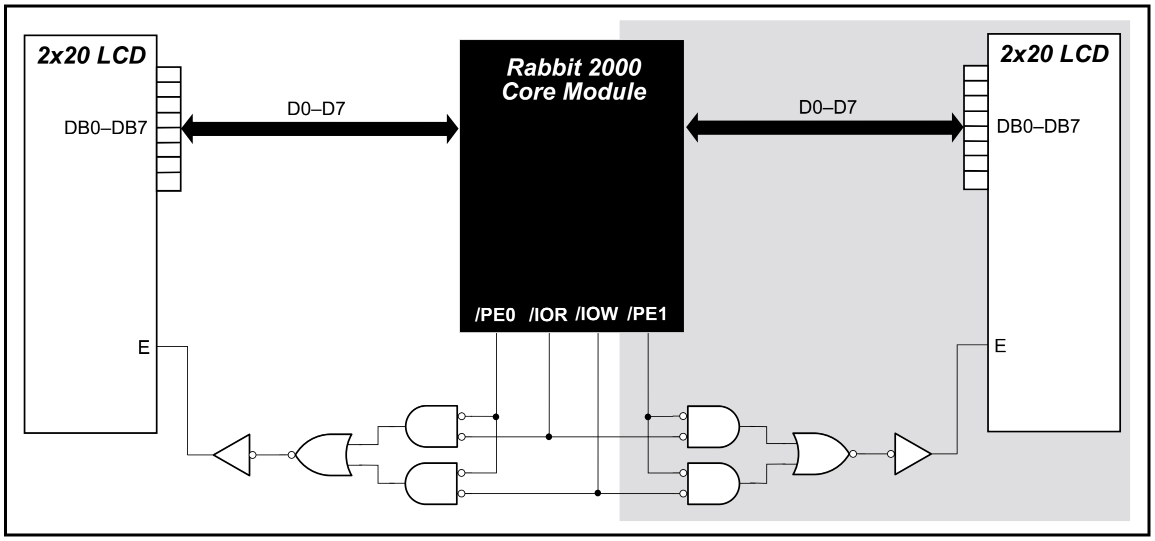


*Figure D-4. Sample LCD Connections*

Sample Program: **`LCD_DEMO.C`** in **`SAMPLES/COREMODULE`**.

The shaded part of the circuit in Figure D-4 can be used to drive a second LCD, but additional software not included in **`LCD_DEMO.C`** will have to be written.

## D.4 External Memory

The sample circuit can be used with an external 64 Kbit memory device. Larger SRAMs can be written to using this scheme by using other available Rabbit 2000 ports (parallel ports A to E) as address lines.

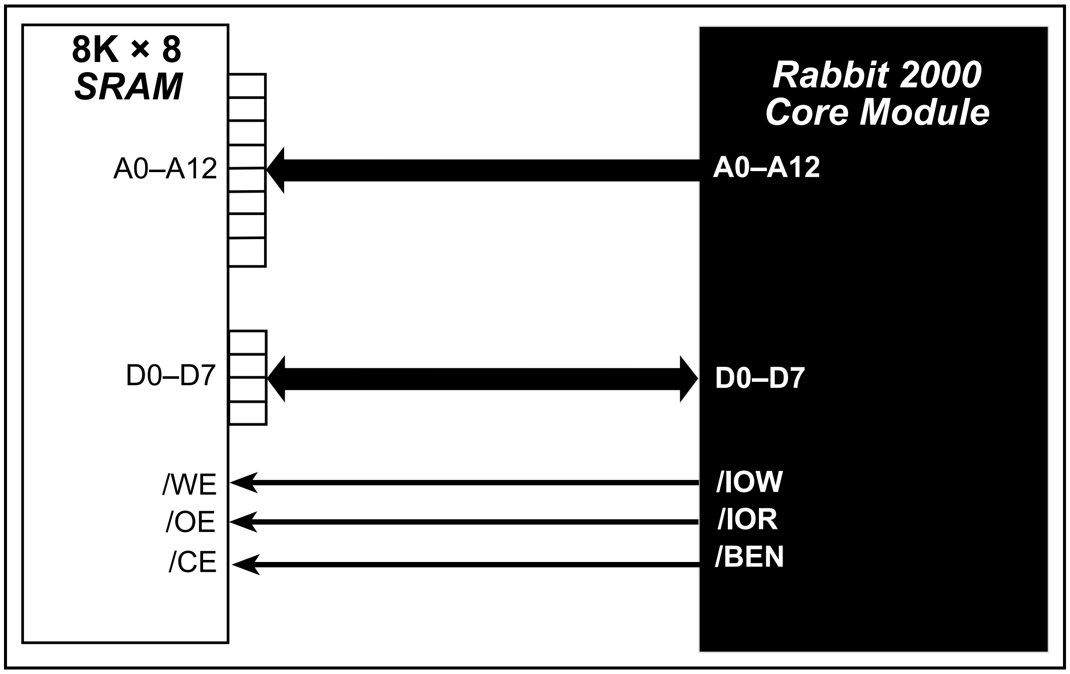


***Figure D-5. Sample External Memory Connections***

Sample Program: `EXTSRAM.C` in `SAMPLES/COREMODULE`.

## D.5 D/A Converter

The output will initially be 0 V to -10.05 V after the first inverting op-amp, and 0 V to +10.05 V after the second inverting op-amp. All lows produce 0 V out, FF produces 10 V out. The output can be scaled by changing the feedback resistors on the op-amps. For example, changing 5.11 kΩ to 2.5 kΩ will produce an output from 0 V to -5 V. Op-amps with a very low input offset voltage are recommended.

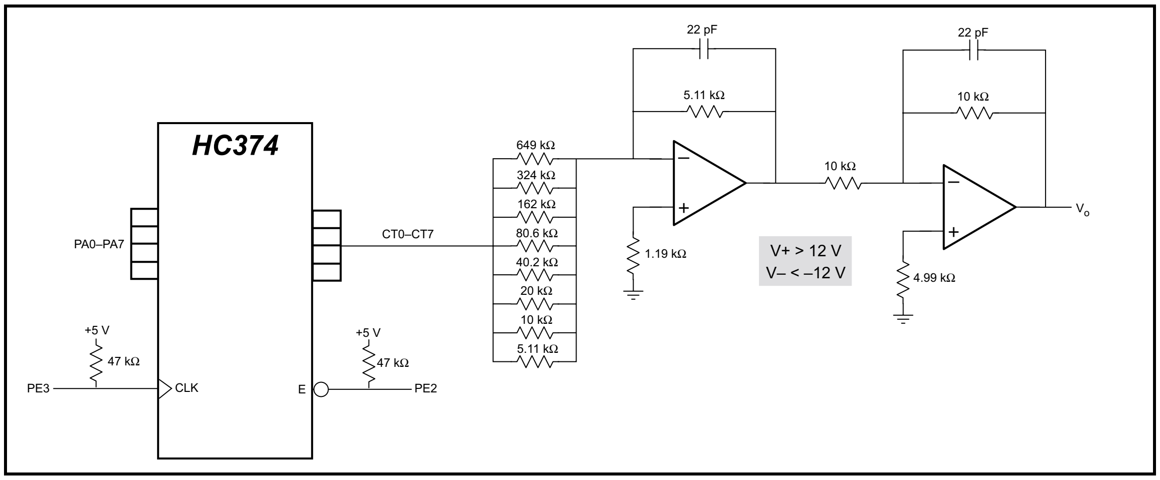


***Figure D-6. Sample D/A Converter Connections***

# SCHEMATICS