

R-51PB USER'S GUIDE

**Version 2.0
June 2003**

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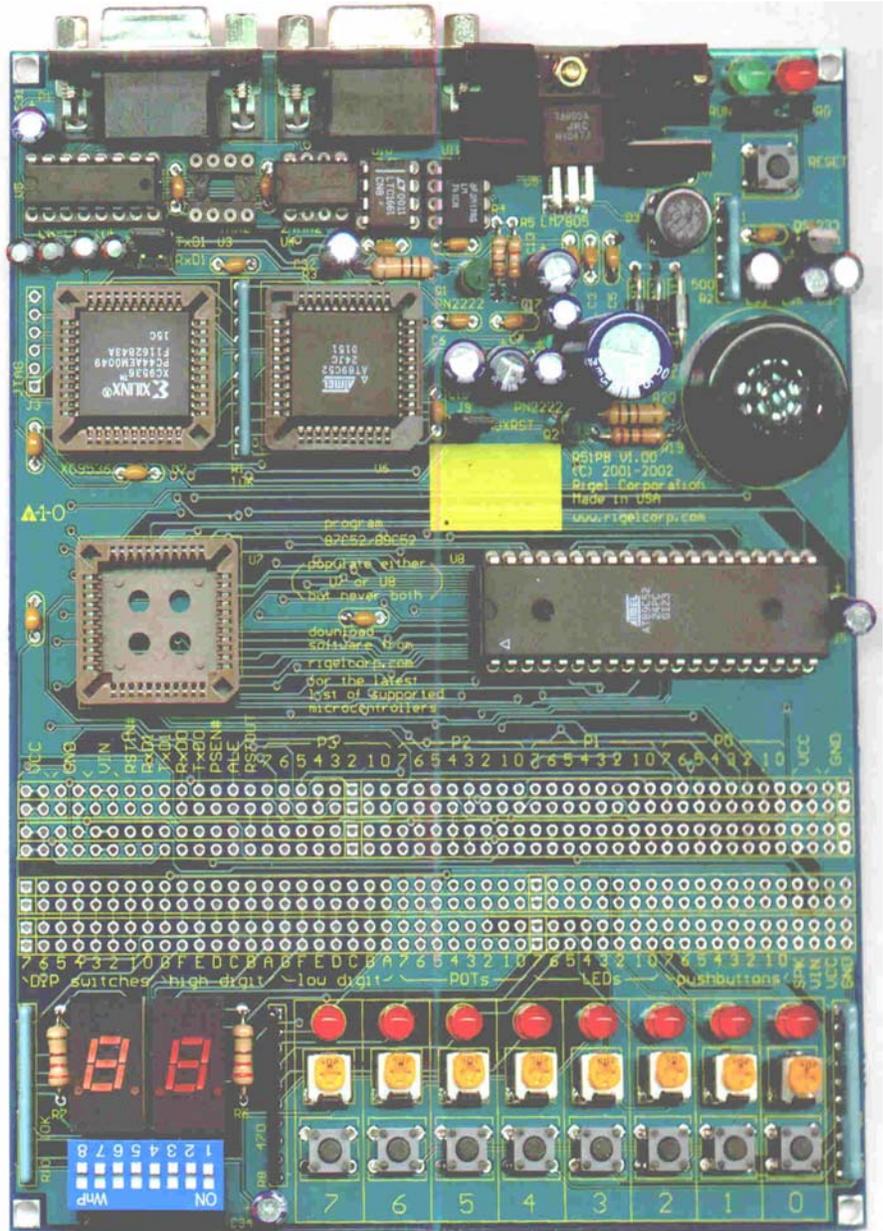
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1 OVERVIEW

The R-51PB is designed as a low-cost flexible platform for educational and code development purposes. Typically, the R-51PB is populated with a FLASH microcontroller and the code is repeatedly programmed and erased as the software development progresses. Although EPROM versions of the 8051 may be programmed, a special EPROM eraser is required to erase the memory before the chip may be reprogrammed. Moreover, only the EPROM version of the microcontrollers with a window may be erased. (The EPROM erasers use high-energy ultraviolet light.) Manufacturers also provide windowless versions of these microcontrollers, called OTP (one-time-programmable) versions. OTP versions may be programmed but not erased. In this respect, they are more appropriately used after the code is fully developed and ready to be placed in the final product.

The R-51PB board is a “smart” board. It uses another 8052 microcontroller, called the service processor, to carry out its functions. It also has a software-controlled voltage regulator to generate a variety of programming voltages. These features allow the R-51PB to program both 5V and 12V (12.5V, 12.75V) EPROM and FLASH devices. Firmware resides in the service processor. Future firmware upgrades may be implemented by simply programming a new service processor using the R-51PB.

The R-51PB has two sockets for the target microcontroller. One is a 40-pin DIP socket, and the other, a 44-pin PLCC socket. **Only one of these must be populated at a time.**



1.1 Currently Supported Microcontrollers

The following microcontrollers are supported by V1.0 firmware.

Atmel

AT89C51 (both 5V and 12V) 4K FLASH

AT89C52 (both 5V and 12V) 8K FLASH

Dallas Semiconductor (www.maxim-ic.com)

DS87C520 12.75 Volts 16K EPROM

DS89C420

Phillips 87C51 and 89C52 processors.

2 SOFTWARE SETUP

2.1 System Requirements

All of Rigel's software is designed to work with an IBM PC or compatible, Pentium 120MHz or better, running Windows 95, 98, 2000, ME, or Windows NT. The newest versions of our software are always available to download off our web site, www.rigelcorp.com. We encourage you to check our web site often to keep up-to-date.

2.2 Software Installation

If you receive a CD from Rigel, follow these steps:

- Place the CD-ROM in your drive.
- Go to the **Rigel Products | 8051 Software** and click on the .exe file you wish to install. The program will then install in your system. Follow the standard install directions.

If you download Rigel software from the web, (www.rigelcorp.com), follow these steps:

- Click on the.exe file you downloaded.
- The program will then install in your system. Follow the standard install directions.

2.3 rP51

The rP51 environment is a Windows program that communicates with the R-51PB to carry out the various programming and verification functions. Besides programming a user program, the microcontroller's various security features, such as the lock bits and encryption array, may also be programmed.

The program rP51 is used to program the microcontrollers. It may be invoked directly from the Reads51 environment using the menu command **Tools | Launch rP51**.

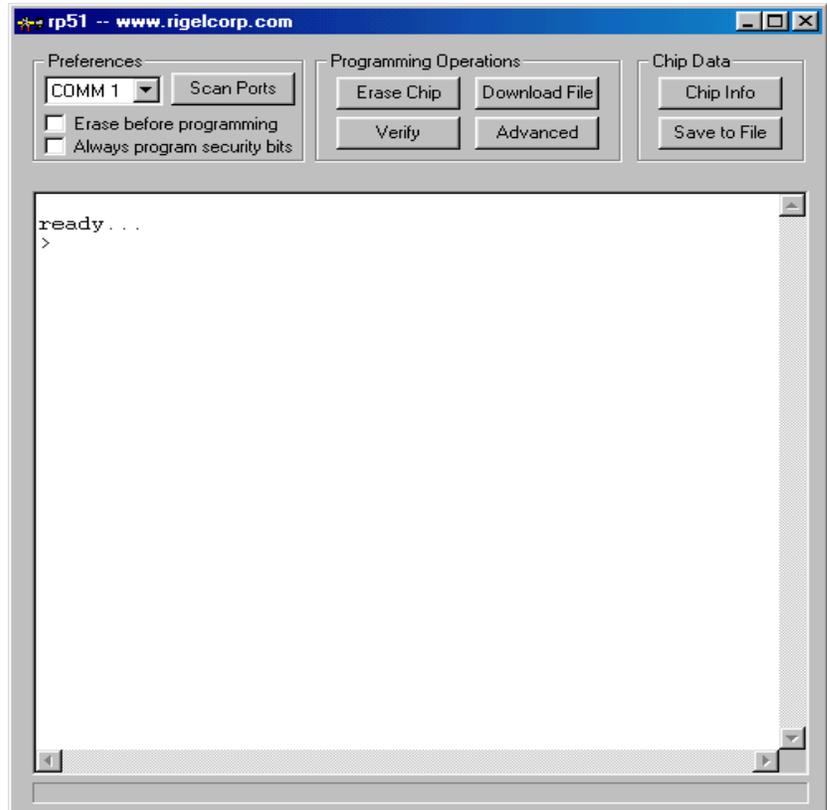
The rP51 is a "message-oriented" environment. A large output (console) window gives relatively detailed reports on the commands and their outcomes. This reduces the learning process as well as the need for extensive help schemes.

See section 5 for a tutorial on rP51.

2.4 Reads51

Reads51 is an integrated development environment (IDE) that has a source code editor, an assembler, a Small-C compatible compiler, and an OMF-51 linker. Reads51 now supports code development for the single-chip mode. Refer to the various Reads51 manuals, documentation, and tutorials for further information.

The single-chip mode refers to the use of the microcontroller where code memory is the on-chip ROM and the data memory is the 128 or 256-byte internal RAM (register memory). Note that some microcontrollers have XDATA-type RAM in addition to the register type internal RAM. For instance, the DS89C420 has 1K of XDATA RAM. Although it sounds like a contradiction, these microcontrollers have on-chip external data memory! Of course, the external in XDATA is more of a logical designation to differentiate the memory space. It really is not a physical location specifier. These microcontrollers may run code that use external memory. The single-chip mode issues discussed below apply only to cases where the data memory is the 128 or 256-byte internal RAM (register memory).



2.4.1 Programming for the Single-Chip Mode

Most of the examples given in the Reads51 work directory assume the microcontroller has access to external data and code memory. The R-51PB board runs the microcontroller in the single-chip mode. That is, only on-chip code memory and on-chip data (register) memory are used. A few things should be kept in mind when running the examples written for the external memory mode.

1. The size of the code memory is limited to that of the on-chip ROM. For example, the Atmel AT89C52 has 8K of code memory. If you try to download a program larger than the size of on-chip ROM, the rP51 programming software will issue an error.
2. The 8051-type microcontrollers have 128 bytes of internal RAM, while the 8052-type devices have 256 bytes of internal RAM. Most of the newer derivatives of the family have 256 bytes of RAM. This memory is used by the register banks and the bit-addressable memory. In addition, it is also used to store return addresses during function calls, global variables, local variables, and an expression stack. The program cannot support large data structures. For example, an array of 256 bytes would use all available memory.
3. The Reads51 C compiler generates code differently for the single-chip mode. (Rather than using external RAM, only internal RAM is used.) Libraries compiled for the external memory mode cannot work in the single-chip mode. If you have your own libraries already compiled for the external memory mode, you must recompile them for the single-chip mode. Many of the libraries in the include directory are compiled both ways. For example, the serial I/O library (including the functions such as printf()) is compiled for the external mode cSio51.lib, as well as for the single-chip mode cSio51i.lib. The suffix 'i' implies the "internal memory" mode. Note that, while many examples in the work directory use cSio51.lib, the example Hello_00 uses cSio51i.lib.

2.4.2 Memory Map for the Single-Chip Mode

The amount of memory set aside for the various uses can be adjusted by selecting the various parameters within the Reads51 options dialogs.

In the table below, three parameters are used.

SP: This is the initial value of the stack pointer as set in ci0.src in the include directory. You may change the value of SP in the assignment statement. The default value is 2Fh.

DATA: The linker uses this value to establish the starting address of the data segment. It is specified in the under the "Linker Options" tab in the "Project build options | Assembly Options" dialog. The default is 20h.

BASE: This is the starting address of the C stack used by the compiler. This stack holds both the local variables and the expression stack. It is specified under the "Memory" tab in the "Project Build Options | Compiler Options" dialog. The default is 40h.

Range	Use	Remarks
0..1Fh	MCS-51 register banks	
20h..SP	not used by the C compiler	20h..2Fh is bit addressable memory
SP..DATA	call/return stack	default SP is 2Fh
DATA..BASE	global variables	default DATA is 20h
BASE..	local variables and expression stack	default BASE is 40h

The default parameters may be used if global variables are not used. If global variables are used, modify the parameters DATA and BASE. For example, DATA=40 and BASE=60 allows 32 bytes (60-40=20 hex) of global variable space.

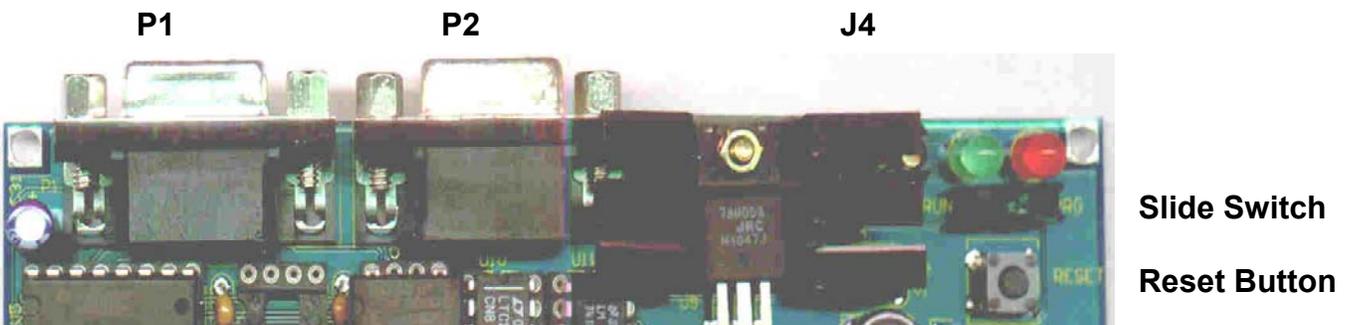
3 OPERATING NOTES

3.1 Overview

The R-51PB is a programming and prototyping board for 8051 family microcontrollers with on-chip ROM. User code may be developed in Rigel's Reads51 environment and downloaded to the microcontroller on the R-51PB board using the rP51 programming software. The code is programmed into the internal ROM of the microcontroller. A slide switch determines the mode of operation. In the PRG (program) mode, the board is used to program the microcontroller. In the RUN mode, the programmed code is executed. User input/output devices such as push buttons, dip switches, potentiometers, LEDs and seven-segment LEDs are provided to interact with the user code.

3.2 Power

A wall transformer is used to power the R-51PB. The wall transformer may be an AC or a DC type. Connect the wall transformer output (secondary side) to the terminal block marked J4. The voltage should not exceed 15 Volts. The wall transformer voltage should be at least a few volts greater than the programming voltage of the microcontroller. A 9 Volt wall transformer is sufficient for a 5V FLASH microcontroller. A 12.75V EPROM microcontroller will require a wall transformer with an output of at least 14 Volts. You may use a higher voltage transformer than these minimum values. For example, a 14 Volt transformer will work with a 5V FLASH microcontroller.



3.3 Serial Port

P1 of the R-51PB is a DB-9 female connector used to connect the board to an IBM compatible PC. A straight-through modem cable may be used. That is, a cable connecting pin 2 of the R-51PB to pin 2 of the host, and similarly pin 3 to pin 3, and pin 5 to pin 5. A second DB9 port, P2 is provided to support microcontrollers with a second serial port, such as the DS87C520.

Only the transmit, receive and ground lines of the DB9 connector are used. A minimal serial port is constructed with just 3 lines: transmit, receive, and ground, disregarding all hardware handshake signals. That is, only pins 2, 3, and 5 of P1 need be connected to the same pins on the PC side.

3.4 Clock Frequency

The R-51PB uses two clock oscillators. Both are in the industry standard 8-pin DIP format. The oscillator in socket U3 is fixed at 5MHz. It provides the clock input to the microcontroller during programming. (Most microcontrollers specify a clock frequency of 4MHz to 6MHz during programming.) The second oscillator is placed in U4. It is used when the board is placed in the RUN mode. The factory default is 24MHz for use with an AT89C52. If you want your microcontroller to run at a different frequency, you may replace the oscillator in U4.

The position of the slide switch determines the clock source for the microcontroller. The usual operating practice is to move the slide switch to the RUN position and press reset. The microcontroller clock is then determined by U4. If you now move the slide switch back to PRG but **not** press reset, the microcontroller clock is provided by U3 (5MHz). Pressing reset in this position would cause the service processor to take control over the microcontroller and expect to communicate with rP51.

3.5 Switches

The R-51PB has one reset button and one slide switch. The pushbutton resets the board. The slide switch selects the operating mode of the board.

3.5.1 Slide Switch

The slide switch at the top-right corner of the board determines the operating mode. Move the switch to the PRG (program) position to program the microcontroller. The red LED is lit in the PRG mode. The rP51 software must be run on the PC to communicate with the board.

Once the code is programmed into the microcontroller, move the slide switch to the RUN position. The green LED is lit in this mode. The service processor is disengaged, and the user code in the microcontroller is executed. The same serial port connection through P1 may now be used by the downloaded code to communicate with the PC.

3.5.2 Reset Switch

A reset button is provided to initialize the board in both modes. After moving the slide switch, press the reset button to fully initialize both processors (the service processor and the target processor) in the newly selected mode.

3.6 LEDs

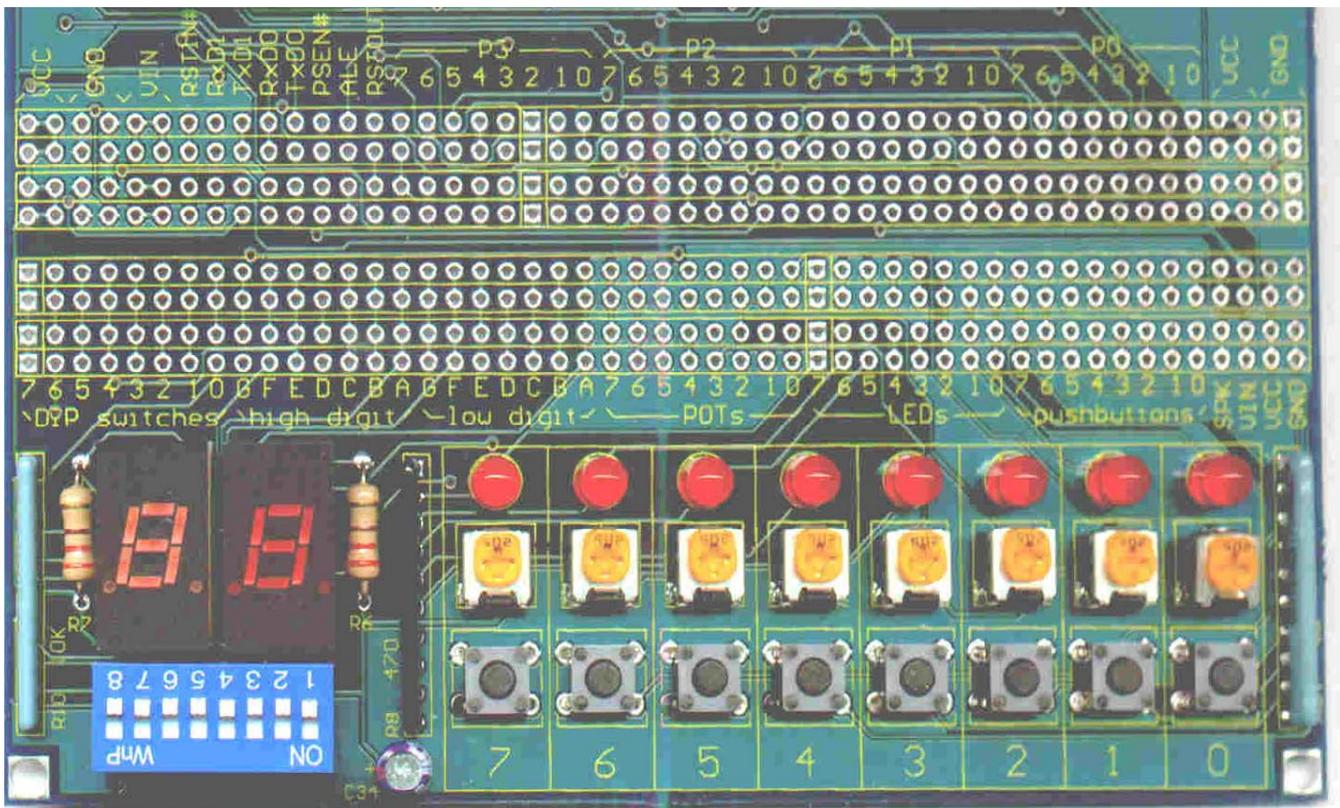
There are two LEDs on the R-51PB. The LEDs indicate the current operating mode of the board. They also provide visual confirmation that power is applied.

3.7 Jumpers, J1 and J2

J1 and J2 are the jumpers that activate the second serial port on the board. These jumpers should be populated when you wish to use the second serial port on processors such as the DS87C520. The second serial port is directed to the second DB9 connector P2. Remove J1 and J2 if the microcontroller does not have a second serial port, or if the second serial port is not used.

3.8 UIOD - User Input/Output Devices

There is a variety of I/O devices available on the R-51PB board including LEDs, push buttons, seven segment displays, potentiometers, toggle switches, and a speaker. These components are referred to as the User Input Output Devices (UIOD).



3.8.1 LEDs

The output LEDs are in a common anode configuration, meaning that their anodes are connected to +5 Volts (VCC) by current-limiting resistors. There are several ways the LEDs may be turned on and off. The LED may be turned on and off by connecting the corresponding position on the strip to the corresponding position for a push button and then pressing the button. The LED may be turned on by connecting the corresponding position on the strip to the ground (0 Volts). The ground is available on the strip at the position marked GND. The LED may also be switched on by applying a logic LOW signal to the LED positions 0-7.

3.8.2 Push Buttons, Dip Switches

There are 16 switches that may be used as digital input devices. Each switch has one terminal connected to ground, and the other available on header J5/J6. The 8 push button switches terminate at the positions marked PB 0-7. Similarly, the 8 toggle switches which are implemented by an 8 contact DIP switch marked DIP TS, are terminated on the strip at the posts marked TS 7-0.

Output devices sink current, and are therefore appropriate to drive the microcontrollers input ports. As a simple demonstration, connect LED 0 to Pushbutton 7. Observe that LED 0 lights when push button 7 is pressed.

Care should be taken not to connect the push buttons or DIP switches to the power post VCC, or VSS. If connected, closing (making contact) the corresponding switch will short power to ground.

3.8.3 Seven-Segment Displays

The 14 posts for the seven segment displays on the strip are grouped into 2 sets marked HG-A and LG-A. Each display has segments with the standard designations A to G. The output devices are in a common anode configuration, meaning that their anodes are connected to +5 Volts (VCC) by current-limiting resistors. An output device, say segment D of DISPLAY LOW, may be turned on by connecting the corresponding position on the strip to ground (0 Volts).

3.8.4 Potentiometers

In addition to the digital input devices, the UIODs contain 8 potentiometers, marked POT0 to POT7. Each potentiometer has one fixed terminal connected to +5 Volts (VCC), the other fixed terminal to 0 Volts (the ground GND), and its wiper terminal available on the header J6 marked POT7-0.

3.8.5 Speaker

There is a speaker built into the R-51PB board. It may be used to produce sounds directly from the ports. The speaker is connected to VCC through a capacitor. Simply connect a port pin to the speaker. Pulse the port bit to produce a tone.

4 HEADERS

4.1 Processor I/O, J7 / J8

Headers J7 and J8 placed side by side. Collectively, there are 50 posts on the headers. They are connected to the microcontroller ports as well as some of the control and power signals. These signals may be connected to the user input/output devices, or to external circuitry. It is convenient to use a solderless breadboard to build external circuitry. The circuitry may then be connected to the microcontroller signals through J7 / J8 posts.

Individual signals of these headers are listed below. They are also marked on the board silkscreen. The position refers to the location of the post from the left.

The posts are populated with SIP sockets. You may insert wires into the sockets for quick access to the signals. Worn sockets may be replaced one at a time using a soldering iron. Alternatively, you may insert a second row of sockets and simply replace the top row if excessive wear is detected.

POSITION	SIGNAL	REMARK
1	VCC	Regulated 5V supply
2	VCC	
3	GND	Ground
4	GND	
5	VIN	Unregulated DC supply
6	VIN	
7	RSTIN#	Active low reset input.
8	RX1	Serial Port 1 receive (RxD)
9	TX1	Serial Port 1 transmit (TxD)
10	RX0	Serial Port 0 receive (RxD)
11	TX0	Serial Port 0 transmit (TxD)
12	PSEN#	Microcontroller output
13	ALE	Microcontroller output
14	RSTOUT	Inverted RSTIN#
15	P3.7	Microcontroller port
16	P3.6	
17	P3.5	
18	P3.4	
19	P3.3	
20	P3.2	
21	P3.1	
22	P3.0	
23	P2.7	
24	P2.6	
25	P2.5	
26	P2.4	
27	P2.3	
28	P2.2	
29	P2.1	
30	P2.0	
31	P1.7	
32	P1.6	
33	P1.5	
34	P1.4	
35	P1.3	
36	P1.2	
37	P1.1	
38	P1.0	
39	P0.7	
40	P0.6	
41	P0.5	
42	P0.4	
43	P0.3	
44	P0.2	
45	P0.1	
46	P0.0	
47	VCC	Regulated 5V supply
48	VCC	Ground
49	GND	
50	GND	

4.2 User I/O, J5 and J6

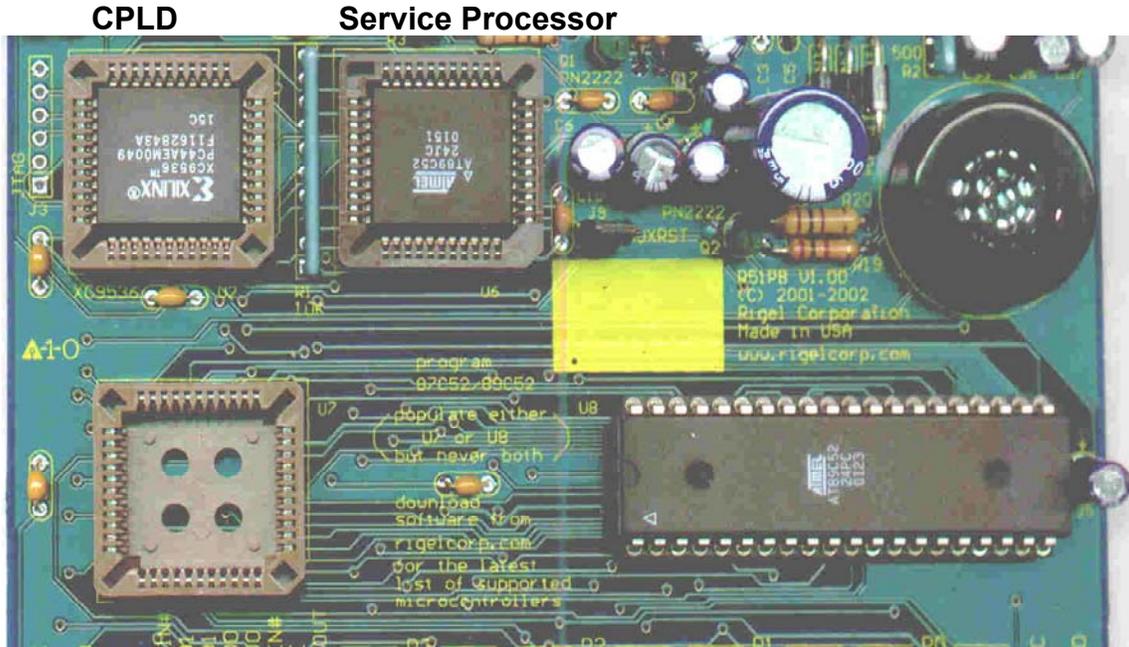
POSITION	SIGNAL	REMARK
1	DIP Switch 7	Toggle switches
2	DIP Switch 6	
3	DIP Switch 5	
4	DIP Switch 4	
5	DIP Switch 3	
6	DIP Switch 2	
7	DIP Switch 1	
8	DIP Switch 0	
9	High Digit G	Seven-segment display high digit segments
10	High Digit F	
11	High Digit E	
12	High Digit D	
13	High Digit C	
14	High Digit B	
15	High Digit A	
16	Low Digit G	Seven-segment display low digit segments
17	Low Digit F	
18	Low Digit E	
19	Low Digit D	
20	Low Digit C	
21	Low Digit B	
22	Low Digit A	
23	Potentiometer 7	0 to 5V DC
24	Potentiometer 6	
25	Potentiometer 5	
26	Potentiometer 4	
27	Potentiometer 3	
28	Potentiometer 2	
29	Potentiometer 1	
30	Potentiometer 0	
31	LED 7	LEDs
32	LED 6	
33	LED 5	
34	LED 4	
35	LED 3	
36	LED 2	
37	LED 1	
38	LED 0	
39	Push Button 7	Push buttons
40	Push Button 6	
41	Push Button 5	
42	Push Button 4	
43	Push Button 3	
44	Push Button 2	
45	Push Button 1	
46	Push Button 0	
47	Speaker	
48	VIN	Unregulated DC supply
49	VCC	Regulated 5V supply
50	GND	Ground

5 TUTORIAL

The following steps illustrate programming an Atmel AT89C52 microcontroller.

5.1 Setting Up The R-51PB

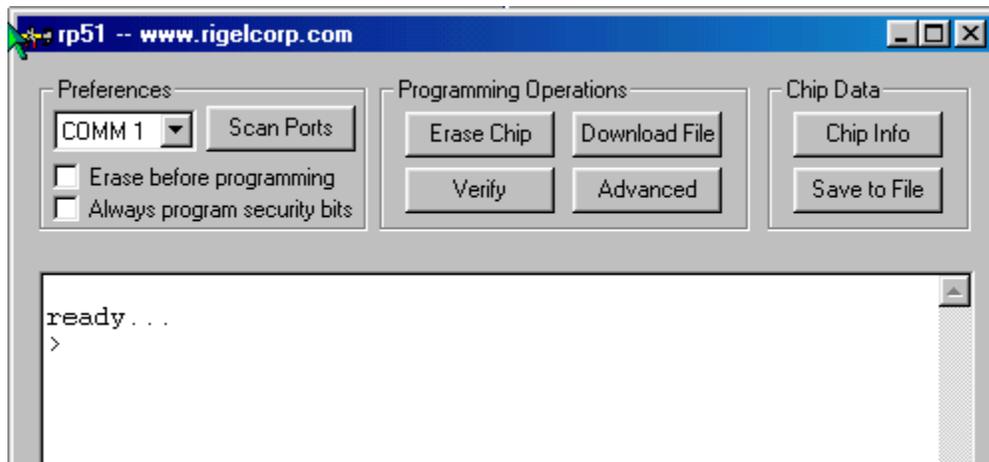
Place a 44-pin PLCC microcontroller in socket U7 or a 40-pin DIP microcontroller in socket U8. **Never populate both of these sockets at the same time.** The microcontroller must be one that is supported by the current firmware.



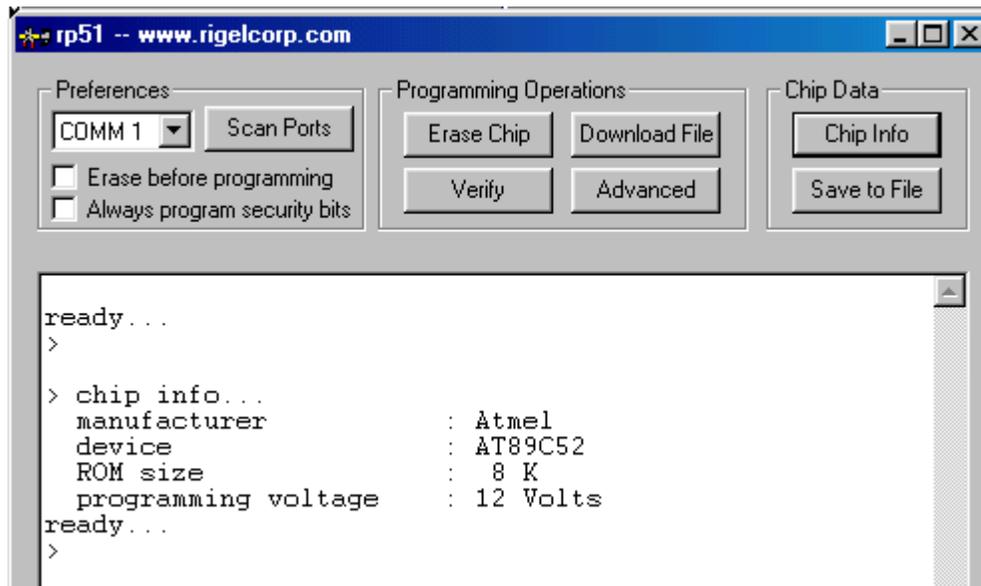
U7, Chip to be Programmed, U8, Chip to be Programmed
Do Not Populate U7 and U8 at the Same Time

5.2 Programming the Microcontroller

Start rP51 and select the COMM port connected to the R-51PB. The “ready” prompt is seen when the PC is connected to the R-51PB initialized in the PRG mode. If you power up the R-51PB after starting the rP51, press the reset button on the board to get the “ready” prompt.

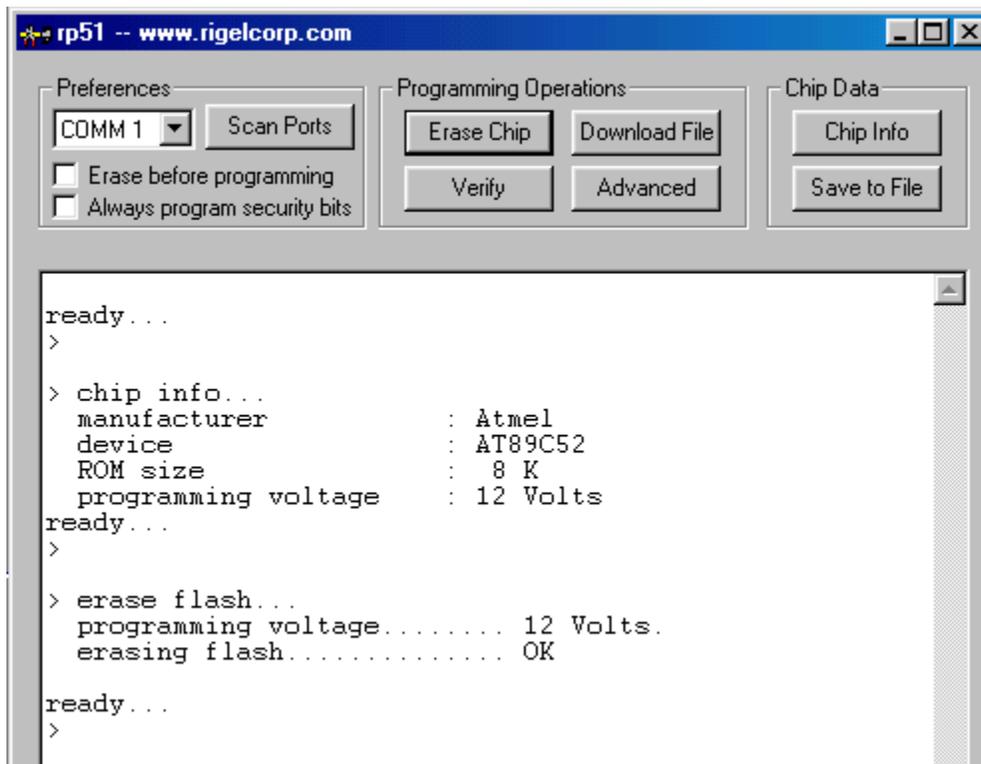


The software is designed to automatically inspect the microcontroller being programmed before each operation. This is done by reading the so-called signature bytes. Click on the “Chip Info” button to manually invoke this check.

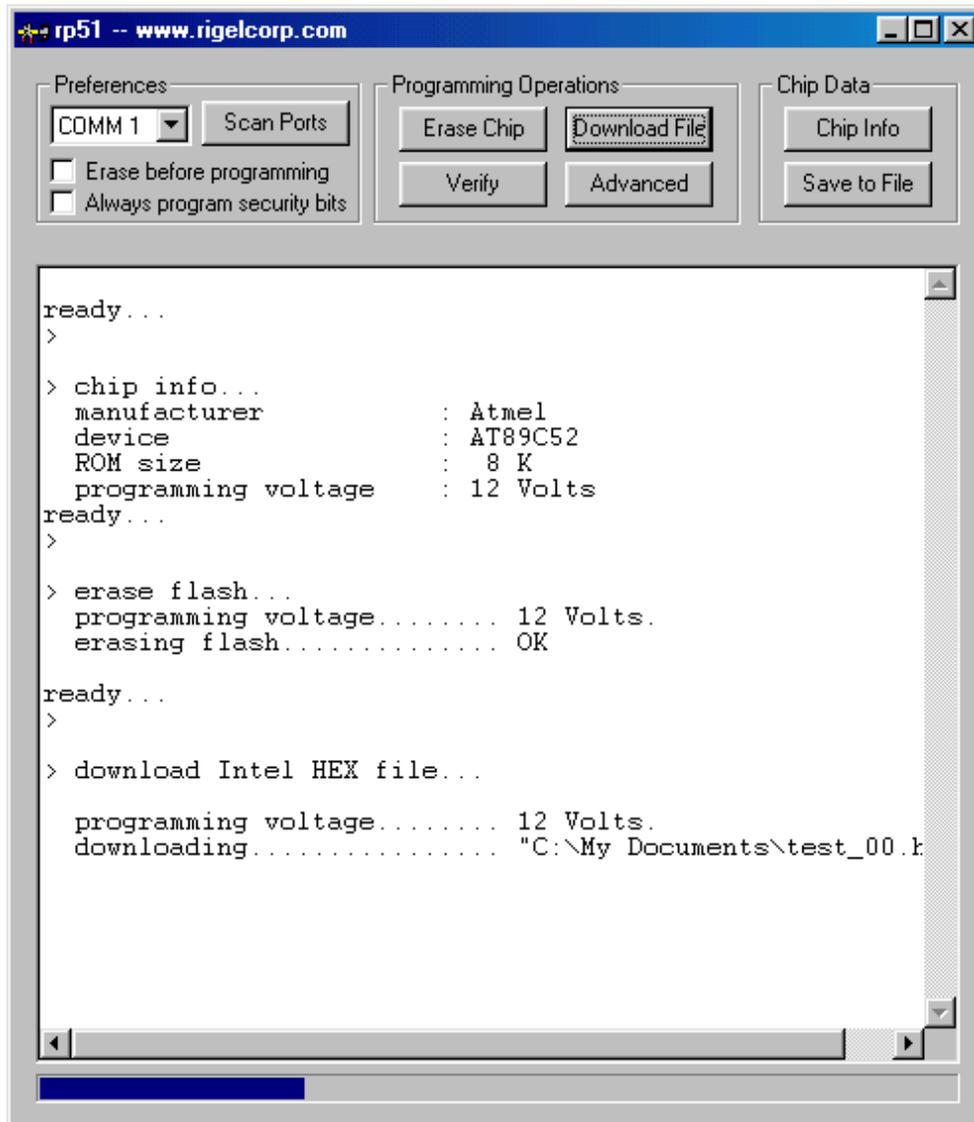


The Atmel AT89C52 is a FLASH microcontroller with 8K of memory. Being FLASH, its memory may be electrically erased. Click on the “erase” button to invoke this function. You may also check the “erase before programming” box in the preferences group to automatically call the erase function before each download.

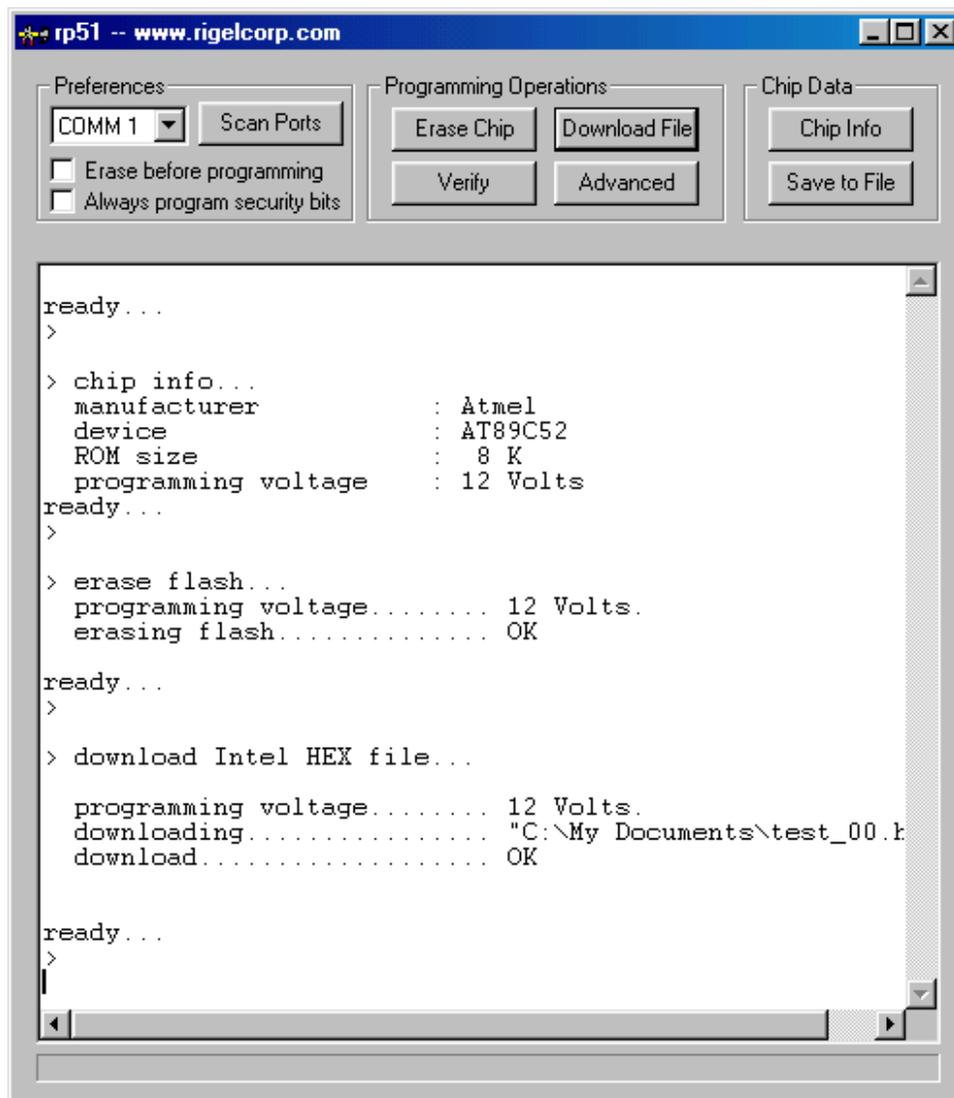
The erase function may take a few seconds to actually erase the microcontroller and subsequently verify that the memory is actually erased.



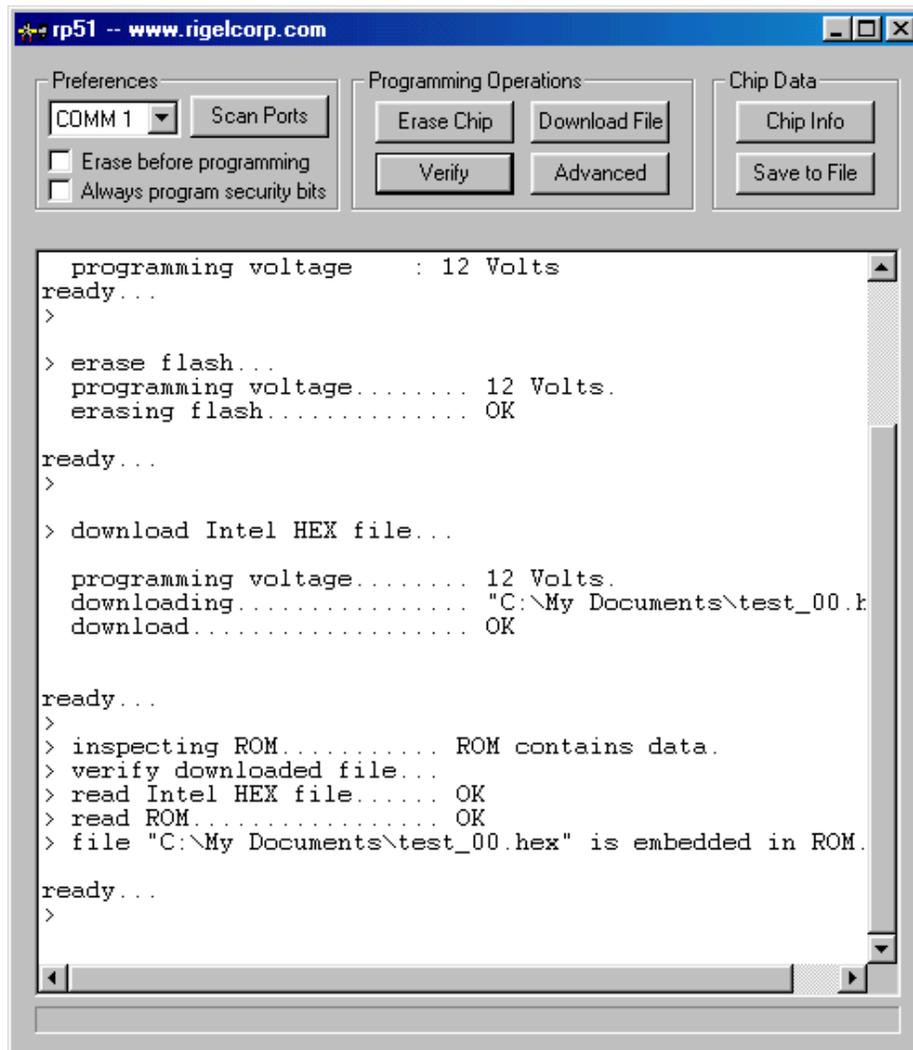
Now that the memory is erased, we may download a program. Click the "Download file" button and select the Intel Hex file to be downloaded. (Note that if the "erase before programming" box is checked, the memory is erased before this download.) The file is read and sent to the R-51PB to be programmed. The progress is shown by a bar at the bottom of the dialog.



The result of the operation is reported at the end of the download operation.

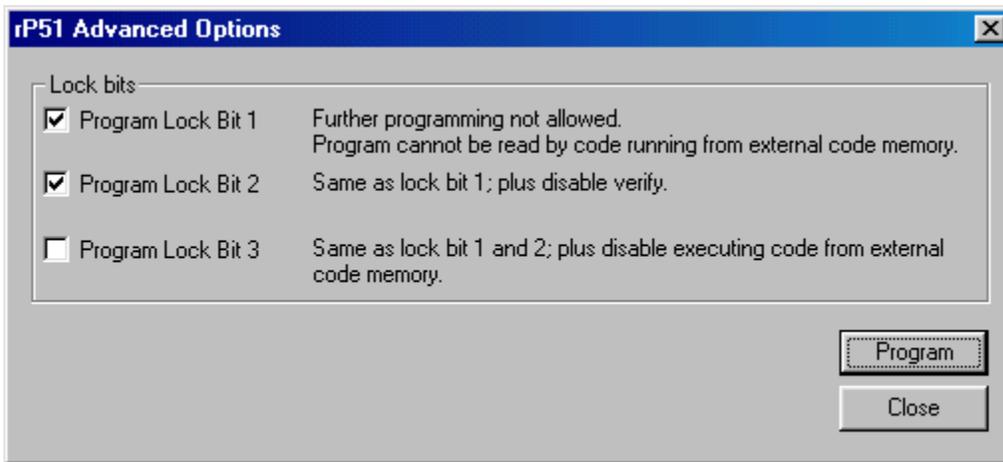


At a later time, you may verify that a file has been programmed into the memory by clicking the “Verify” button. Once clicked, the memory is inspected. If the memory is erased (or never programmed), that is reported. Otherwise, you are prompted to select a file. The contents of the memory are then checked against the file.



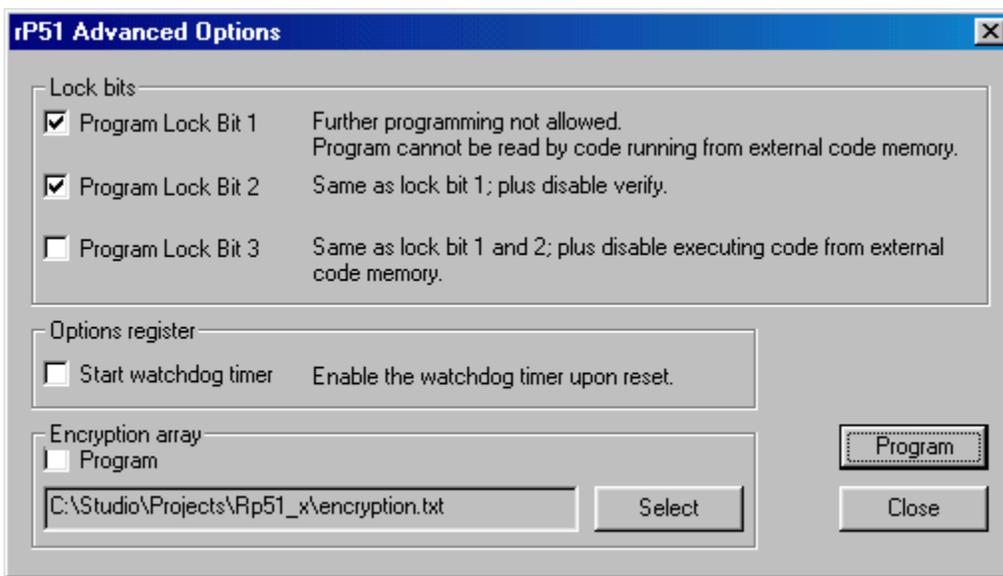
Note that the microcontrollers have various security features that prevent reading its memory. If the security bits are programmed, for example, it is not possible to read the contents of memory, and hence, not possible to verify such downloads. If an encryption array is used (refer to the microcontroller's data sheets), the verify function attempts to first compare the contents in its raw form. If the contents do not match the file, the contents are once again compared to the file, this time using the encryption array.

The AT89C52 does not have an encryption array, but it has three lock bits. Click the "Advanced" button to view the security features of the microcontroller. Note that this dialog may be different for other microcontrollers.



Click “Program” to program the lock bits. You may also click “Close” to exit the dialog without programming the selected bits. In either case, your choices are saved. If you check the box “Always program security bits” in the main dialog, these saved choices are programmed after each download.

The DS87C520 has a 64-byte encryption array. It also features an options register. Bit 3 of this register is programmed if you want the watchdog timer to be activated upon reset.



Click the “Select” button to specify the file containing the encryption array. This file is a list of numbers. If the file contains more than the needed number of bytes, the extra bytes are ignored. Similarly, if the file contains fewer bytes than needed, the file is rewound and the bytes are read from the beginning. For example, if only 60 bytes are specified, the first four bytes are used over again for bytes 61 to 64. Bytes may be written in hexadecimal or in decimal. Hexadecimal numbers may be in the C-language format or in the assembly-language format. Bytes may be separated by commas, spaces, or tabs. Similar to the assembly-language syntax, lines that start with a semicolon are treated as comments. In the example below, 64 encryption bytes are specified. The bytes are simply the numbers from 0 to 63.

```

; This is an encryption table file.
; =====

; hex numbers in C-language syntax:
; separated by spaces or tabs

0x00 0x01 0x02 0x03 0x04 0x05 0x06 0x07

```

```
; hex numbers in C-language syntax:
; separated by commas

0x08,0x09,0x0A,0x0B,0x0C,0x0D,0x0E,0x0F

; hex numbers in assembly-language syntax
; separated by spaces or tabs

10h 11h 12h 13h 14h 15h 16h 17h

; hex numbers in assembly-language syntax
; separated by commas

18h, 19h, 1Ah, 1Bh, 1Ch, 1Dh, 1Eh, 1Fh

; decimal numbers

32 33 34 35 36 37 38 39
40, 41, 42, 43, 44, 45, 46, 47

; mixed syntax

48,0x31 50, 51 0x34,0x35 0x36, 55
56, 57,0x3A 0x3B 60, 61 62,0x3F
```

6 R-51PB PARTS LIST

Quantity	Part	Digikey Part Number	Designator	Type
20	BP	1206PHTR-ND		Axial Capacitor
4	1uF, 50V	P993-ND	C8-C11	Small Radial Capacitor
1	10uF, 25V	P6248-ND	C16	Radial Capacitor
6	22uF- 47uF, 16V	P6226 (47uF)	C31-37	Radial Capacitor
3	47uF - 100uF, 16V	P5138 (100uF)	C13, 14, 15	Radial Capacitor
1	1000uF, 25V	P5156	C12	Radial Capacitor
3	100 Ohm, 1/2W	100H-ND	R3, R19, R20	5% Carbon Resistor
2	220 Ohm, 1/2W	220H-ND	R6, R7	5% Carbon Resistor
1	470 Ohm	770-61-R470-ND	R2	6 Position Gang
1	1K, 1/4W	1KQBK-ND	R4	5% Carbon Resistor
1	2.7K, 1/4W	2.7KQBK-ND	R5	5% Carbon Resistor
1	470 Ohm	770-61-R470-ND	R8	10 Position Gang
3	10K	770-101-R10K-ND	R1, 9, 10	10 Position Gang
8	Pot	D4AA53-ND	R11-R18	5K Potentiometers
1	Varisiter	P7288-ND	V1	
3	IN4001	1N4001GICT-ND	D4 -D6	Diode
9	Red Led	160-1087	D1, D10-D17	1 ¼ Red LED
1	Green Led	160-1089	D2	1 ¼ Green LED
1	Bridge	W005GDI-ND	D3	Full Bridge Diode
2	PN2222	PN2222	Q1, Q2	Transistor
9	PushButtons	P8007S-ND	P3-P11	6mm button
1	Slide Switch	EG1903-ND	S1	
2	DB9	DB09SRS	P1, P2	
1	Terminal Block	281-1400	J4	3.5 mm Terminal Block
1	Dip Switch	8 Position	S2	
2	7-Segment Display		D8, D9	
1	Speaker		SP1	
1	Heat Sink		U9	
1	1x6 Header		J3	100mil spacing
1	2x2 Header		J1/J2	100mil spacing
1	1x2 Header		J9	100mil spacing
4	8 Pin Dips	ED3108	U3, U4, U10, U11	Socket
2	14 Pin Dips	ED3114	D8, D9	Socket
2	16 Pin Dips	ED3116	U5, S2	Socket
1	40 Pin Dip	ED3140	U8	Socket
3	44 PLCC	ED80024	U2, U6, U7	Socket
4	Sip Sockets		J7, J8	Socket

1	40 ZIF	A348		Optional ZIF Socket
1	MAX232		U5	
1	LTC1661	LTC1661CN8	U10	
1	LT1637CN8	LT1637CN8	U11	
1	XC9536	XC9536-15PC44C	U2	
1	AT89C52-24PC	AT89C52-24JC	U6	
1	7805	LM340T-5.0-ND	U9	
1	DS1233-10		U1	
1	5MHz Clock	SE1205	U3	
1	24MHz Clock	SE1213	U4	