Appendix

A2

LABORATORY DEVELOPMENT WITH THE QWIKPROTO ADD-ON BOARD

A2.1 BOARD AND PARTS

In addition to the QwikFlash board described in Appendix A1, there is also a QwikProto board available for expanding I/O resources, as would be helpful for setting up a college laboratory around the PIC18F452 microcontroller. For information on how to get this board for setting up a college laboratory, check *www.microdesignsinc.com*, or contact the author at jpeatman@mindspring.com.

Figure A2-1 shows the board's "pads and top silk" artwork. The board is exactly the same 4″ × 4″ size as the QwikFlash board. It is connected to the QwikFlash board via a 16-conductor ribbon cable extending from the H2 header mounted beneath the PIC18F452 socket to a similar H1 header mounted beneath the QwikProto board, as illustrated in Figure A2-2. Additional QwikProto boards can be daisy-chained together with short jumper ribbon cables extending from the H3 header mounted beneath one board to the H1 header mounted beneath the next. In this way, a variety of laboratory projects can be "mixed and matched" together.

Figure A2-3 identifies parts that can be used to stuff the board and to implement the ribbon-cable connection between the QwikFlash board and the QwikProto board. An "IDC crimping tool" is included for squeezing the ribbon-cable connectors onto the ribbon cable. A bench vise can serve the same purpose. Cover the jaws of the vise with masking tape so as not to score the connector as you squeeze it onto the end of a piece of ribbon cable. For a lab, get lots of the 2 × 8 headers and connectors. Then, even if some are destroyed in the process of crimping the ribbon cable into a connector, others will be available. The wirewrap wire is for making connections between the H2 header and the components to
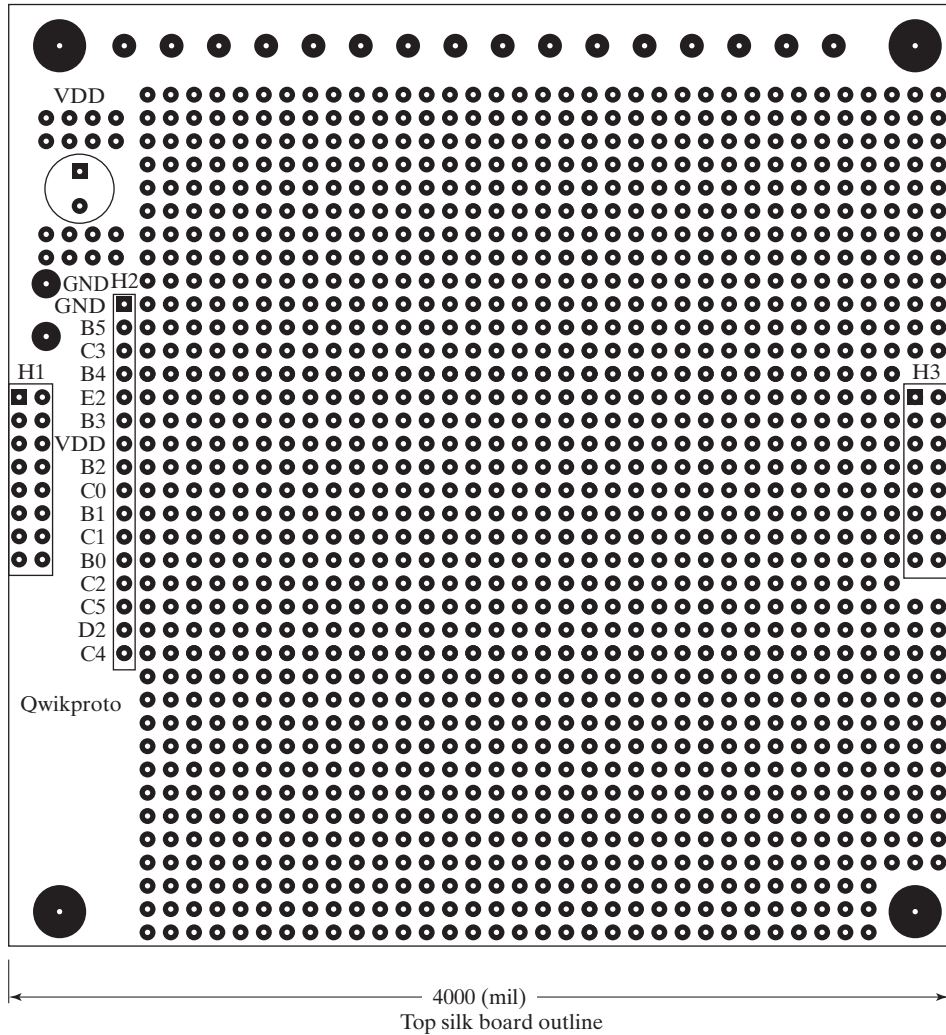
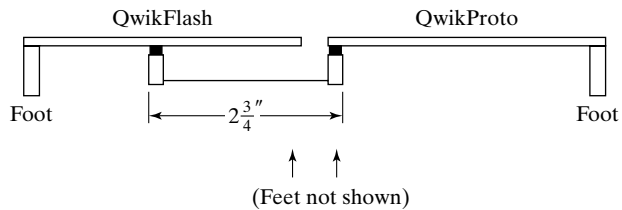**Figure A2-1** QwikProto board's "pads and top silk" artwork

Figure A2-2 Board interconnection.

Quantity	Part number	Distibutor	Part description	Board designation	Price each	Minimum quantity	Total price
2	109567	Jameco	2 × 8 pin male header	H1 to QwikFlash	0.29	1	0.58
2	119466	Jameco	2 × 8 pin socket connector	H1 to QwikFlash	0.35	1	0.70
1	37671	Jameco	10 feet of 16-conductor gray ribbon cable	H1 to QwikFlash	1.75	10 feet	1.75
1	73251	Jameco	IDC crimping tool	H1 sockets	11.95	1	11.95
1	22664	Jameco	100 feet of white 30 AWG wirewrap wire		3.95	100 feet	3.95
1	P835	Digi-Key	33 uf @ 35V polarized electrolytic capacitor	VDD to GND	0.34	1	0.34
						Total =	19.27
Jameco - for price and availability information, go to www.jameco.com - add $5.00 for orders under $20.							

Figure A2-3 QwikProto board parts and prices

be added to the board. For stripping the ends of wirewrap wire, I like Radio Shack's wire-wrapping tool No. 276-1570 ($7.49). It includes an excellent little stripper stored in its handle.

A2.2 CONSTRUCTION

Before you can add the 2 × 8 header beneath the QwikFlash board, you will have to remove the two middle ribs of the 40-pin socket so that you can reach the 2 × 8 array of pins with a soldering iron. I use a soldering iron to melt a gap in the rib and then use a flush-cutting diagonal cutter to finish removing the entire rib. Just cutting the rib without first melting the gap puts a stress on the other ribs that may cause them to break. (This is not a serious problem, but it is an avoidable one.)

A2.3 CONSTRAINTS PLACED ON PIN USE

Figure A2-4 lists the pins brought over to this board from the QwikFlash board as well as any constraints on their use. Thus, the three pins used by the digital-to-analog converter on the QwikFlash board can all be used by further expansion circuitry as either inputs or outputs. Since the DAC does not *drive* any of these three pins, at most the only consequence of their arbitrary further use will be erratic output voltages appearing on the DAC outputs. Such erratic behavior is not even a possibility if only the SPI/I^{2}C pins are used, and not the RC0 pin. Thus, the full expansion possibilities of either the SPI bus or the I^{2}C bus can be exploited.

The RC0/T1OSO and RC1/T1OSI pins can be used to explore the possibilities of using a 32,768 Hz crystal as the external clock for Timer1 and thereby the clock for the chip itself, as discussed in conjunction with Figures 20-10 through 20-12. Doing this requires the removal of the DAC from the board (or rewiring its connection from RC0 to an alternative undedicated pin).

An interesting feature of the PIC18F452 is its use of either its RB3 pin or its RC1 pin as the alternative function, CCP2. The choice is made with the CCP2MX bit in one of the configuration bytes for

PIN	QwikFlash connections	Usage comments
RB0/INT0	H1 header	
RB1/INT1	H1 header	
RB2/INT2		
RB3/CCP2		Optional CCP2 pin
RB4		
RB5		
RC0/T1OSO/T1CKI	Chip select for DAC	
RC1/T1OSI/CCP2	H3 header	Optional CCP2 pin
RC2/CCP1	H1 header	
RC3/SCK/SCL	SPI clock out to DAC	OK for SPI/I^{2}C use
RC4/SDI/SDA		OK for SPI/I^{2}C use
RC5/SDO	SPI data out to DAC	OK for SPI use
RD2		Best used as input, not output (because of LCD) — see text
RE2/AN7	H1 header	
VDD	Most of 200 ma supply current available here	
GND		

Figure A2-4 QwikFlash connections and usage comments

the chip (refer to Figure 20-1). If RC0 and RC1 are used as 32,768 Hz crystal inputs to Timer1, the CCP2 function can be moved to the RB3 pin so as not to lose *its* functionality.

Figure A2-4 also lists RD2 as best serving as an input, not an output. The rationale for this statement lies in the use of RD4 . . . 7 as outputs to the LCD display. The other three pins of PORTD serve as dedicated inputs from the RPG and the pushbutton. As presently written, the routines that write to the LCD display blindly write to PORTD as if all four lower bits are inputs and will not be affected if garbage is written to them. Should RD2 be set up as an output, then the LCD display routines would need to be rewritten so as not to affect the output on RD2.

A2.4 PROJECT IDEAS

Several project ideas have been considered in earlier chapters, including the stepper motor drive of Figure 16-5. The stepper motor and its drive chip can be mounted on the QwikProto board, as shown in Figure A2-5, with connections made to the PIC18F452 through the ribbon-cable connection to the Qwik-Flash board.

The Analog Devices' 3-pin TMP04 temperature sensor circuit of Figure 13-14 is also shown in Figure A2-5. It provides a vehicle for using CCP1 or CCP2 to capture input time intervals, converting them to either Fahrenheit or Centigrade temperature, with arbitrary resolution, with the help of the math subroutines of Chapter 14.

Agilent Technologies' HLCP-J100, ten-segment, low-current bar graph display and a 1 kΩ SIP resistor pack driven from two 74HC595 double-buffered shift registers provide a good example of SPI use.

The QwikProto board can serve as the home for a second PIC18F452 (or the 28-pin PIC18F252) connected to the PIC18F452 on the QwikFlash board using the SPI in a master–slave relationship. The slave PIC microcontroller can decipher a keypad into keycodes using the circuit of Figure 19-11 and returning the keycode of a newly pressed key in response to periodic queries from the master PIC microcontroller. This serves as a fine example of master–slave interactions on the SPI bus.

Sharp Microelectronics' IS1U60 is a low-cost, three-terminal device for demodulating the 38 kHz output of a TV/VCR/etc. remote into 5 V pulses that can be deciphered by the CCP1 or CCP2 capture input of the PIC18F452. It makes an interesting keypad input to the PIC microcontroller and uses only a single pin to do so. A digital scope can capture the IS1U60 output for each of the digit keys on the remote so that you know what you are trying to do to distinguish one pattern from another. The inner tube from a paper towel roll slid over the end of the remote can be used to confine the IR output to a single QwikFlash board and prevent the output from being picked up by other QwikFlash boards in a lab.
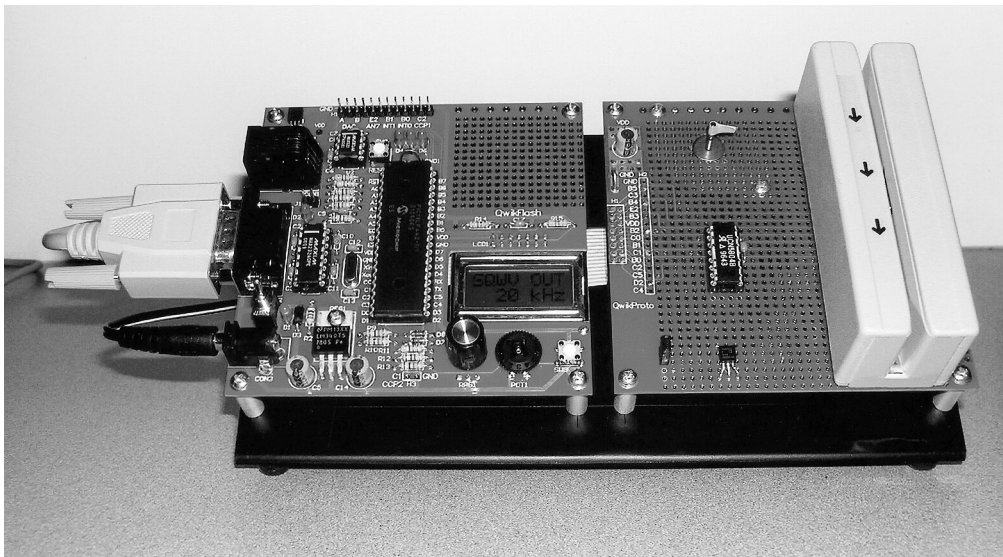

Figure A2-5

For short-range wireless control using RF data transmission, RF Modulation (www.rfm.com) makes low-cost transmitters and receivers. Check their TX5003 and RX5003 303.825 MHz transmitter and receiver modules. Also check Microchip's rfPIC12C509 "AF Enhanced Microcontroller with UHF ASK/FSK Transmitter" and related parts just being introduced as this book is being completed.

Another low-cost, interesting device is the Model 1490 eight-direction digital compass sensor made by Dinsmore Instrument Company.

A search for "robotics" and "RC control" on a search engine like www.google.com will turn up a variety of low-cost devices.

The same Jameco mail-order distributor and source of the materials of Figure A2-3 is also a good source of miscellaneous kits and parts for getting a head start on some project ideas.

Two other sources of unusual I/O devices at relatively low cost are B. G. Micro, www.bgmicro.com and Marlin P. Jones & Assoc., Inc., www.mpja.com. These companies buy surplus electronic parts that companies sell before the end of their fiscal year to reduce their year-end tax on inventory. Thus, for example, the Magtek magnetic card reader discussed in Section 16.2 was a $5 surplus item from B. G. Micro.

A2.5 THE AUTHOR'S LABORATORY STATIONS

For our instructional laboratory at Georgia Tech, we have mounted a QwikFlash board and a QwikProto board side by side on the little stand shown in Figure A2-5. The stand is formed from an $8\frac{1}{4}''$ wide $\times$ $8\frac{1}{2}''$ sheet of aluminum with eight $\frac{1}{8}''$-diameter mounting holes, four for each of the boards and drilled so as to align each board with an upper corner of the stand. The aluminum has been folded on a line $4\frac{1}{2}''$ from the top, with an angle of about $45°$. Finally, the stand has been commercially anodized to give it a black finish. Four rubber feet (Digi-Key No. SJ5523) on the bottom give the stand a solid feel.

The $0.625''$ standoffs listed in Figure A1-1 provide sufficient clearance for the connectors used with the ribbon cable between the two boards. If any other holes are needed (e.g., to provide clearance for a stepper motor that is deeper than the $0.625''$ allowed by the standoffs), these are most easily punched out before the aluminum has been folded.

My favorite add-on device is a stepper motor. With the drive circuit of Figure 16-5, it is easy to add to the QwikProto board. It provides a range of lab projects, starting with stepping it once per loop time (i.e., 100 steps/second), then reversing direction with each push of the pushbutton. CCP1 or CCP2 "compare" interrupts can be used to step the motor at a variable rate set in with the RPG, up to the point where the motor drops out and dithers without stepping. It can be stepped down to just one step per second by using the 24-bit version of Timer1/CCP1 (or Timer3/CCP2), discussed in Section 16.5, to support an interrupt handler that pulses the driver chip's "step" input at the end of each timer-derived step period.

The driver chip of Figure 16-5 will handle stepper motors with four unipolar windings. In contrast to a stepper motor with two bipolar windings (that requires an "H-bridge" controller to be able to reverse the direction of current in each winding), a stepper motor with four unipolar windings only requires the driver to drive each winding to ground. The UCN5804B driver chip can handle a wide range of motor voltages and motor currents. With luck, 5 V unipolar stepper motors appear on the pages of surplus distributors like Marlin P. Jones & Assoc., Inc. (www.mpja.com). I found some listed at $1.95 each. Since the surplus market leads to "here today, gone tomorrow" (they had 403 of the motors in stock), I asked about price breaks and was given a price of $0.50 each for 100 units. So I bought 100 units! One of these is shown in exploded form in Figure A2-6.

This motor's winding resistance of 20 ohms means that the motor will draw 250 mA from the power supply. I use the motor with the "full-step, wave-drive sequence" shown in Figure 16-5 so as to limit the draw on the power supply to just 250 mA, rather than the 500 mA resulting from either of the other two
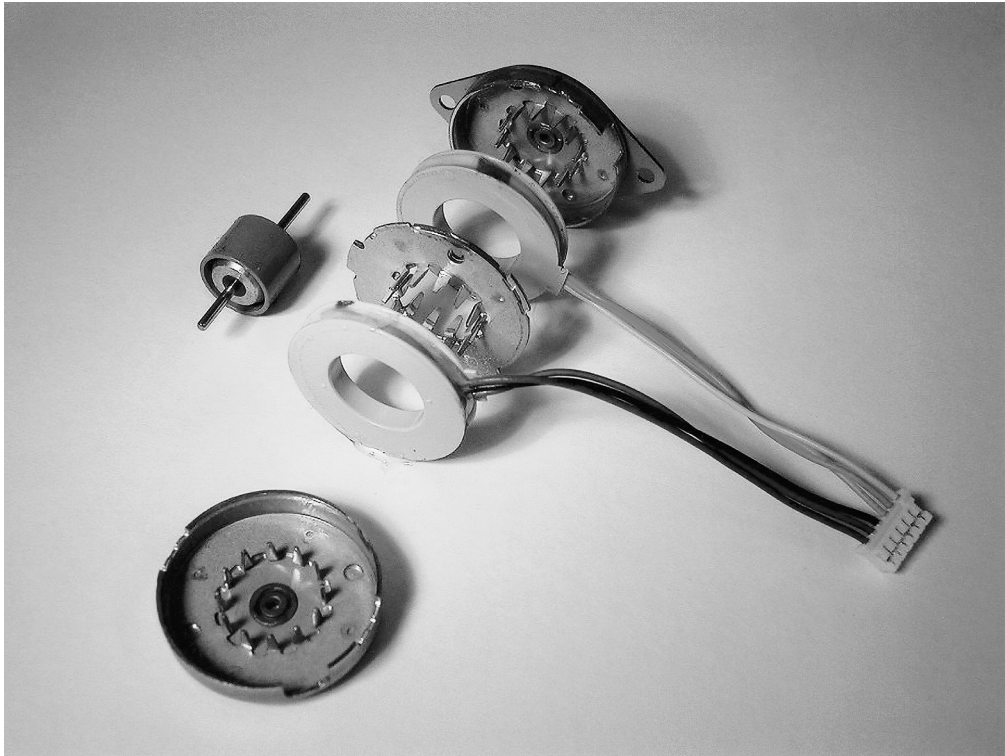
Figure A2-6

operating modes of that figure. I also have changed from the 9 V @ 200 mA wall transformer of Figure A1-1 to a 9 V @ 300 mA wall transformer (Mouser No. 412-109034). A heavier-duty wall transformer might be used (e.g., 9 V @ 500 mA) since the voltage regulator on the board is rated for up to 1 ampere.

To find a source for the Allegro Microsystems UCN5804B stepper motor translator/driver chip, go to www.findchips.com and enter UCN5804B. This is a wonderful Web site for finding distributors for any chip and for being steered to each distributor's pricing and availability information. (Newark Electronics should be listed as one of the sources.)

Also shown in Figure A2-5 is the magnetic card reader of Figure 16-1, with the simple connections to the PIC18F452 microcontroller shown in Figure 16-2. Once again, these card readers were obtained from a surplus distributor—B. G. Micro in this case (www.bgmicro.com)—and for less than $5.00 each. The card reader affords the opportunity to retrieve characters bit by bit under interrupt control. The little 8 × 2 LCD can be used to display eight characters at a time:

```
MCR    1
;1234567
```

The RPG can be used to cycle among five groups of eight characters making up the card's contents of up to 40 characters. Alternatively, the PIC18F452's UART can be used to display each successive character in sequence on the PC's monitor. As a character is formed into ASCII code in **WREG**, a call of the following **TXbyte** subroutine will send it to the PC's monitor. At 19,200 baud, the transmission of each character takes only about half a millisecond. The example magnetic card scan of Figure 16-2c takes

about 6.5 milleseconds to read in each character, so this subroutine will keep up with the input rate of new characters without requiring buffering.

```
TXbyte
        REPEAT_
        UNTIL_  PIR1,TX1F    ;Wait, if necessary, on previous transfer
        movwf  TXREG         ;Send character
        return
```

Be sure to include in the **Initial** subroutine the initialization of the UART, as described in Chapter 18.