

# ASSEMBLY OF THE QWIKFLASH BOARD

## A1.1 PREAMBLE

Construction of the QwikFlash board will provide you with a tool to support your learning as well as arm you with a low-cost vehicle for development work for any of the many opportunities to put intelligence into a product. This appendix identifies the parts you need to purchase to populate the QwikFlash board included in the back of this first printing of the book. The board is provided, gratis, by Jim Carreker, a friend and former student of the author. In addition to these parts, you will need to purchase, or obtain access to, appropriate tools to build the board.

The lowest-cost route to development makes use of the QwikBug debugger described in Appendix A4 and programmed into the PIC18F452 microcontroller on the QwikFlash board. Before you can take advantage of this debugger, you will need to program its code into the PIC18F452. If you have access to Microchip's ICD2 in-circuit debugger, it can be used for this step, as described in Section A4.3. An ICD2 module should be available in a college or university environment supporting a course organized around this book. Alternatively, you can use the low-cost "hobby" programmer described in Section A4.4.

You will also want access to a PIC18F452 chip programmed with QFPV, a QwikFlash Performance Verification program developed by Dave Desrochers and Michael Cheng and described in Section A1.10. Both the QwikBug code and the QFPV code are available at [www.picbook.com](http://www.picbook.com).

Before undertaking the assembly of the QwikFlash board, you might want to consider the alternative of purchasing from MICRODESIGNS Inc. ([www.microdesignsinc.com](http://www.microdesignsinc.com)) a fully functioning QwikFlash board, complete with the QwikBug monitor and the QFPV code already programmed into the chip as well as a "wall wart" power supply and a serial cable. MICRODESIGNS is a small company in the Atlanta area that has gained a reputation for quality, innovative design work over their 25 years of existence. Bill Kaduck and Dave Cornish, the principals, want to support the potential impact of this book

written by their friend. They will sell the package from their web site and hope to price it at \$99 plus shipping and handling.

## A1.2 MICROCHIP'S ICD2 MODULE

As an alternative to the use of the QwikBug debugger, the purchase of Microchip's ICD2 will provide you with the only development tool you will ever need for working with the PIC18F452. You will be able to develop and debug program code as well as program the features of the chip controlled by the configuration options. For example, you will be able to select the chip's high-speed, phase-locked loop clock to make the board run with a 10 MHz clock rather than the 2.5 MHz clock utilized by the QwikBug debugger.

The in-circuit debugger module is available in any of three configurations. Microchip's Part Number DV164005 (\$159) is just the "hockey puck" module of Figure 4-4 together with a USB cable to supply both power and communications to the ICD2 module from the PC. Part Number DV164006 (\$209) comes with a DB-9 serial cable, power supply, and demonstration board. A serial cable is the connection of choice for computers without a USB port and is illustrated in Figure 4-4. Part Number DV164007 (\$188) is the same as the DV164006 but without the demonstration board. For users with the QwikFlash board serving as a demonstration board and with the QFPV program serving as a demonstration program, either the DV164005 or the DV164007 unit are the parts of choice.

The module has been designed so that the firmware can be upgraded with a download from Microchip's Web site. Consequently, even early adopters of the unit need have no fear that a later revision will be a better revision.

## A1.3 PARTS LIST

Figure A1-1 lists the parts needed to populate the QwikFlash board. The Digi-Key phone number for ordering parts on a credit card is 1-800-344-4539. They have set up the single identifying "kit" number, 18F452-KIT, which acts as an alias for the one-by-one enumeration of each part listed in Figure A1-1. Simplicity and accuracy in placing the order as well as significantly reduced parts cost are the result. Check the author's Web site, [www.picbook.com](http://www.picbook.com), for possible further information.

If you do not have a serial cable available for your PC, and if you are planning to use the QwikBug on-chip monitor program, then you can either pick one up at any computer store or add Digi-Key Part Number AE1020 (\$5.35) to your order. This is a standard serial cable with a male DB-9 connector on one end and a female DB-9 connector on the other end.

You may also want to add to your Digi-Key order a seven-position terminal block (Part Number 277-1252) if you want to make connections of individual wires to the board (e.g., for the wires to a stepper motor) without having the permanence of soldered connections. This terminal block can be mounted in the large holes along the top right edge of the board.

The parts list includes a 3"-long, two-conductor flex cable with two uses. First, it supports the performance testing of the on-board digital-to-analog converter, both when the board construction has been completed and later if either the Maxim DAC or the PIC18F452's ADC does not seem to be working correctly. Second, it supports the use of the board in its QwikFlash instrument role, discussed in Section 4.3, to measure the performance of code running on another QwikFlash board.

Quantity	Part number	Distributor	Part Description	Board designation	Manufacturer	Manufacturer's part number	Price each	Minimum quantity	Total price
13(20)*	1210PHCT	Digi-Key	0.1 uf ceramic capacitor	C1,2,3,4,6,7,8,9,10,11,15,16,17	BC	A104M15Z5UFVWVN		10 for 1.15	2.30
2	P835	Digi-Key	33uf @ 35V polarized electrolytic capacitor	C5,14	Panasonic	ECE-A1VKA330	0.34		0.68
2	399-1890	Digi-Key	22 pf ceramic radial capacitor	C12,13	Kemet	C315C220J2G5CA	0.28		0.56
1	A9049	Digi-Key	Modular connector - side entry, 6 position	CON1	AMP	520470-3	0.72	1	0.72
1	A23303	Digi-Key	DB-9 female serial cable connector	CON2	AMP	747844-4	1.94	1	1.94
1	CP-202A	Digi-Key	Power supply connector - 2.1 mm barrel connector	CON3	CUI Stack	PJ-202A	0.38	1	0.38
4(10)*	1839K	Digi-Key	0.25" dia. 0.625" long cylindrical threaded standoff	Corners	Keystone	1839		10 for 2.50	2.50
1 pkg.*	H342	Digi-Key	Five Phillips panhead machine screws, 4-40 X 1/4"	Corners	Building Fasteners	PMS 440 0025 PH		100 for 1.11	1.11
5	P403	Digi-Key	Red LED, high brightness, T-1 package	D1, 2, 4, 5, 6	Panasonic	LN28RAL(US)	0.38	1	1.90
1	1N4001DICT	Digi-Key	Diode rectifier	D3	Diodes Inc.	1N4001-T	0.26	1	0.26
2	1N4148DICT	Digi-Key	Switching diode	D7, 8	Diodes Inc.	1N4148-T	0.23	1	0.46
1	S1011-36	Digi-Key	Header, single row, straight solder tail, 36 pins	J1, H1, 3, LCD1S	Sullins	PZC36SAAN	1.28	1	1.28
1(10)*	929950-00	Digi-Key	Shunt	J1S	3M	929950-00		10 for 1.46	1.46
1	S2011-36	Digi-Key	Header, dual row, straight solder tail, 80 contacts	LCD1S	Sullins	PZC36DAAN	2.37	1	2.37
1	73-1106	Digi-Key	LCD module, 8X2, high contrast	LCD1	Optrex America	DMC-50448N	9.79	1	9.79
1	T402-P5P	Digi-Key	9 VDC@200 mA wall transformer, 2.1 mm barrel conn.	Plugs into CON3	CUI Stack	DPD090020-P5P	4.65	1	4.65
1	P4D2502	Digi-Key	5 kilohm thumbwheel one-turn potentiometer	POT1	Panasonic	EVL-HFAA06B53	2.07	1	2.07
3(5)*	470QBK	Digi-Key	470 ohm, 5%, 1/4W resistor	R1, 3, 15	Yageo	CFR-25JB-470R		5 for 0.28	0.28
1(5)*	3.3KQBK	Digi-Key	3.3 kilohm, 5%, 1/4W resistor	R14	Yageo	CFR-25JB-3K3		5 for 0.28	0.28
6(10)*	1.0KQBK	Digi-Key	1.0 kilohm, 5%, 1/4W resistor	R2, 5, 6, 7, 8, 12	Yageo	CFR-25JB-1K0		5 for 0.28	0.56
2(5)*	47KQBK	Digi-Key	47 kilohm, 5%, 1/4W resistor	R4, 11	Yageo	CFR-25JB-47K		5 for 0.28	0.28
3(5)*	10KQBK	Digi-Key	10 kilohm, 5%, 1/4W resistor	R9, 10, 13	Yageo	CFR-25JB-10K		5 for 0.28	0.28
1	LM340T-5.0	Digi-Key	Voltage regulator - 5V @ 1A - TO-220 package	REG1	National Semi.	LM340T-5.0	0.59	1	0.59
1 pkg.*	H216	Digi-Key	One 4-40 hex nut	REG1N	Building Fasteners	HNZ440		100 for 0.93	0.93
1	3315C-1-006	Digi-Key	RPG - Encoder 9mm, square, right angle	RPG1	Bourns	3315C-001-006	2.59	1	2.59
1	8554K	Digi-Key	RPG knob with 1/8" diameter hole and set screws	RPG1K	Keystone	8554	3.38	1	3.38
1	EG2447	Digi-Key	SPDT toggle switch	SW1	E-Switch	200MSP1T1B1M2QE	3.31	1	3.31
2	P8006S	Digi-Key	Pushbutton switch	SW2, 3	Panasonic	EVQ-PAC04M	0.29	1	0.58
1	LM34DZ	Digi-Key	Temperature sensor - TO-92 package	TMP1	National Semi.	LM34DZ	2.33	1	2.33
1	MAX232ACPE	Digi-Key	RS-232 interface chip - 16-pin DIP	U1	Maxim	MAX232ACPE	4.88	1	4.88
1	ED3116	Digi-Key	16-pin DIP socket	U1S	Mill-Max	110-99-316-41-001	0.65	1	0.65
1	MAX522CPA	Digi-Key	Dual 8-bit DAC with SPI input - 8-pin DIP	U2	Maxim	MAX522CPA	6.04	1	6.04
1	ED3108	Digi-Key	8-pin DIP socket	U2S	Mill-Max	110-99-308-41-001	0.32	1	0.32
1	PIC18F452-I/P	Digi-Key	PIC microcontroller with flash memory - 40-pin DIP	U3	Microchip	PIC18F452-I/P	9.38	1	9.38
1	ED3740	Digi-Key	40-pin DIP socket	U3S	Mill-Max	110-99-640-41-001	1.62	1	1.62
1	X443	Digi-Key	10 MHz crystal	Y1	ECS	ECS-100-18-4	0.80	1	0.80
1	A9BBG-0203F	Digi-Key	3"-long 2-conductor flex cable	H3	AMP	A9BBG-0203F	2.99	1	2.99
*designates the minimum quantity that may be ordered. This is more than the number needed for one QuikFlash board.									<b>Total = 76.50</b>
Digi-Key (1-800-344-4539) For latest price and description, go to <a href="http://www.digikey.com">www.digikey.com</a> and enter the Digi-Key part number into the search box. Then, to see the actual catalog page, click on Technical/Catalog Information.									

**Figure A1-1** QwikFlash board parts and prices

## A1.4 CONSTRUCTION SUPPLIES NEEDED

**Mat**—An old towel or smooth placemat to work on that has been washed with a fabric softener like Downy or dried with a fabric softener like Bounce (to help keep down dangerous static). (We spray the carpet in my laboratory with half a cup of scent-free Downy in three gallons of water every couple of months to help with this same potential problem. It works well and seems to harm nothing.)

**Solder**—Either rosin-core solder or water-soluble-core solder is acceptable. Kester and Multicore are fine brands. I suggest thin solder (0.02" or 0.025" diameter, also known as 25 or 22 gauge) because it is easier to control the amount of solder used to form a solder joint. Either 63/37 (tin/lead) alloy solder with a melting point of 361°F or 60/40 alloy solder with a melting point of 361–374°F is fine.

**Soldering iron**—I am partial to using a soldering iron that has its temperature controlled by a temperature sensor built into its tip rather than by a dial, since I get the same reasonable temperature every time I turn it on. Weller's WTCPT soldering station with a 1/16" (0.06") screwdriver, 700°F tip (Weller Model PTA7 tip) is an excellent choice for a laboratory. For an individual, a 25–35 watt iron with an 0.06" screwdriver tip and a stand to hold the hot iron and a wet sponge to clean the tip should work fine.

**Desoldering braid**—To remove solder that shorts two adjacent pins together or to help remove a badly placed part or remove solder from the hole on the board from which a part has been removed, I suggest that you get 0.1"-wide desoldering braid. Popular brand names are Soder-Wick and Chem-Wik. The rosin in the braid wets the connection to the solder and the capillary action of the braid sucks up the solder.

**Tools**—If you are building your board in a college lab, you should have the tools you need available to you. Otherwise you can go to Radio Shack and see what you are getting before you make your purchases. Alternatively, Digi-Key sells everything you'll need. See the note at the bottom of the parts list in Figure A1-1 for checking their Web site catalog pages.

**Miniature pliers**—For forming leads to fit through the PC board holes, it is useful to have a pair of miniature pliers. My favorite, available from Digi-Key (#232-1017), is made by Swanstrom. It is 5"-long with a 1"-long "slim nose and smooth jaw." The key parameter is its slim nose. The smooth jaw actually handles leads better than a serrated jaw.

**Flush-cutting diagonal cutter**—This is used to remove the soft excess leads of a component after they have been soldered to the board. I like Radio Shack's low-cost Archer 5" Nippy Cutters (Cat. No. 64-1833C). A flush-cutting cutter will result in a smooth cut at the top of the solder blob used to join the component to the pad on the board. However, the cutting edges are so fragile that you will ding the edges if you try to cut anything hard. For example, if I have to remove a resistor from a board, I like to cut it in half first so that I can individually remove each lead from its pad. For that, I use a regular diagonal cutter, not a flush-cutting diagonal cutter.

**Other miscellaneous tools**—You'll need a few other tools, but only sporadically. If you don't have them, find someone who does rather than buying them. You'll need a Phillips screwdriver to tighten the machine screw that clamps the voltage regulator to the board and to tighten the corner feet on the board. You'll need a 5/16" nut driver or a small crescent wrench to tighten the nut that clamps the RPG1 to the board. You'll need a tiny 3/64" Allen wrench to tighten the knob onto the shaft of RPG1.

**Resistor color code**—It is helpful to be able to read the resistor values. A resistor has three color bars, possibly followed by a gold or silver tolerance bar. The color bars represent two digits plus an exponent. The colors are

0 — black	5 — green	no tolerance bar — 20%
1 — brown	6 — blue	silver tolerance bar — 10%
2 — red	7 — violet	gold tolerance bar — 5%
3 — orange	8 — gray	
4 — yellow	9 — white	

For example, a 10 k $\Omega$  resistor is marked with a brown bar at one end followed by a black bar followed by an orange bar. A handy calculator is found at many Internet sites, including <http://www.dannyg.com/javascript/res2/resistor.htm>.

## A1.5 SOLDERING TECHNIQUE

When you are ready to solder the pin or the lead of a part that you have inserted onto the board, unwind enough solder from its spool to position the end so that it touches both the pin and the pad on the board. Lightly press this joint with the tip of the hot soldering iron so that the solder flows onto both the pin and the pad. Once this flow happens, remove the iron.

Leaving the iron in place too long can have the deleterious consequence of breaking the bond between the pad and the PC board. Leaving it in place even longer can destroy the part, particularly a LED or a diode. Removing the soldering iron tip before this flow occurs onto both the pad and the component's lead can produce what is called a "cold solder joint." A cold solder joint can also form if the lead moves in the hole on the board as it cools down. The connection may be good immediately but will fail as the board ages. I lean in the direction of heating a joint too long, not too little, since I cannot remember the last time I destroyed a part by overheating it.

## A1.6 BOARD CONSTRUCTION

Figure A1-2 is the schematic of the board. It may be helpful to you as you build the board, giving some insight into the role of each part.

Figure A1-3 shows the board's "pads and top silk" artwork. This may be helpful, particularly after you have stuffed components and thereby obscured the labeling of a component (e.g., R3–R8).

Figure A1-4 provides a suggested sequence in which the parts might be "stuffed." As you carry out each step, you might check it off so as to ensure not missing any steps. The suggested sequence will have you stuffing the many low-profile parts first so that the board continues to lie flat (so you do not have to deal with a rocking board prematurely).

As you begin, you might insert all resistors of one value (e.g., R1, R3, and R15—the three 470 $\Omega$  resistors) into the board, bend the leads to hold them snug to the board, solder them, and then cut the excess leads off. Then check off the item in Figure A1-4 before proceeding to the next item in that chart.

If you have to remove a part (e.g., a resistor soldered in the wrong place), try breaking it so that each lead can be removed one at a time. Heavy-duty diagonal cutters are good for this. Don't use the flush-cutting diagonal cutters because you'll ding the sharp edges.

There are several two-terminal components that are labeled as being "polarized" (i.e., the diodes, LEDs, and electrolytic capacitors). If these are inserted into the board with the pins reversed from what is intended, they will not work correctly. Each of these will be specifically discussed.

When soldering a multiple-pin component (e.g., the 40-pin socket or the LCD display), hold it so that it is flat and then solder just one corner pin. Check that the component is really flat on the board before soldering the opposite corner. Then check it one final time before soldering the remaining pins.

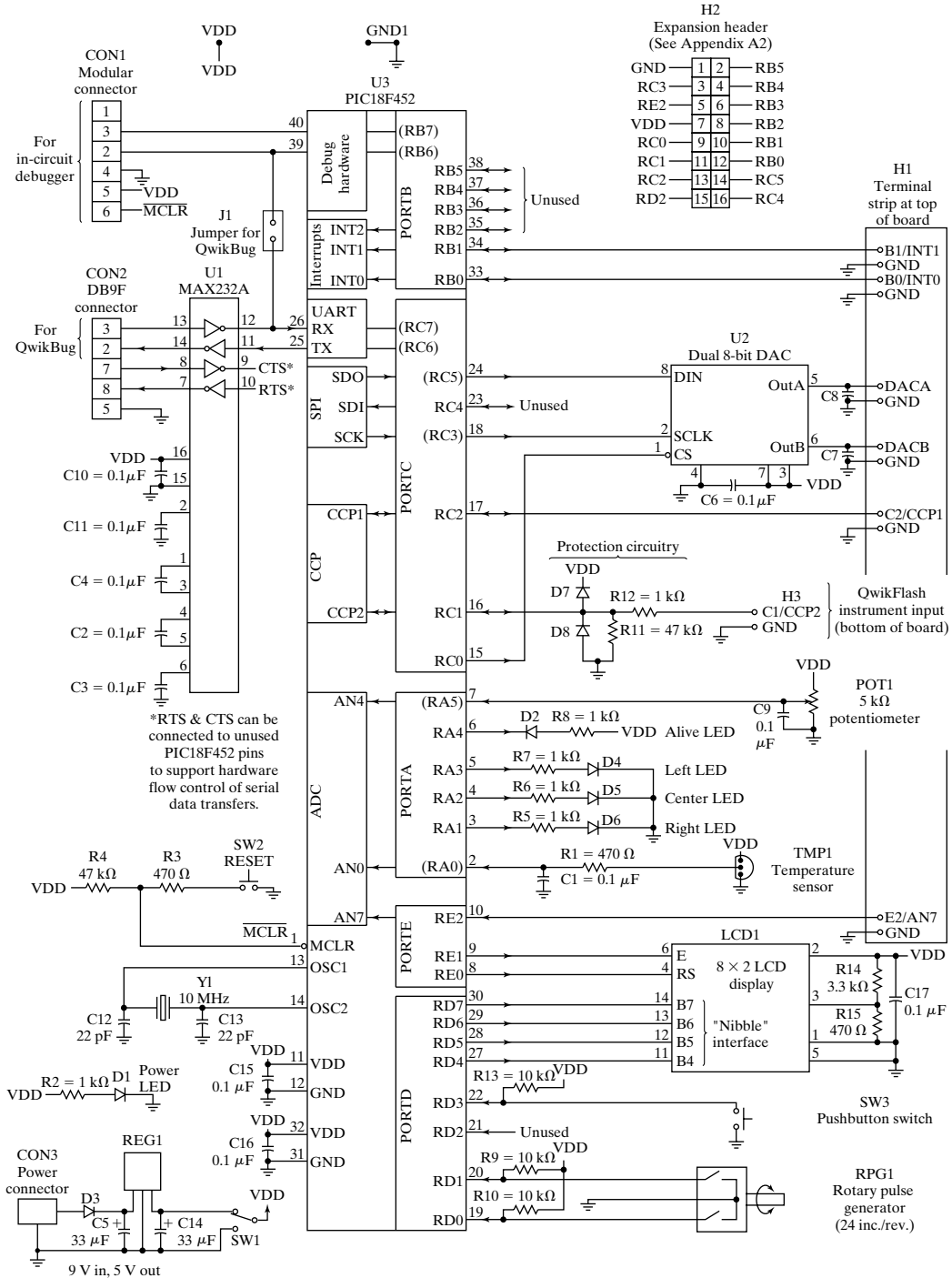


Figure A1-2 QwikFlash board schematic



Checkoff	Board designation	Description
	R1, 3, 15	470 ohm, 5%, 1/4W resistor (yellow-violet-brown)
	R2, 5, 6, 7, 8, 12	1.0 kilohm, 5%, 1/4W resistor (brown-black-red)
	R14	3.3 kilohm, 5%, 1/4W resistor (orange-orange-red)
	R9, 10, 13	10 kilohm, 5%, 1/4W resistor (brown-black-orange)
	R4, 11	47 kilohm, 5%, 1/4W resistor (yellow-violet-orange)
	C12, 13	22 pF ceramic radial capacitor
	C1, 2, 3, 4, 6, 7, 8, 9, 10, 11, 15, 16, 17	0.1 $\mu$ F ceramic axial capacitor
	Y1	10 MHz crystal
	D7, 8	1N4148 switching diode (polarized)
	D3	1N4001 diode rectifier (polarized)
	GND1	Ground grabber — #18 wire
	SW2, 3	Pushbutton switch
	POT1	5 kilohm thumbwheel one-turn potentiometer
	TMP1	LM34DZ temperature sensor — TO-92 package
	REG1	LM340T-5.0 voltage regulator — 5 V @ 1 A - TO-220 package
	SW1	Toggle switch
	CON3	Power supply connector — 2.1 mm barrel connector
	D1, 2, 4, 5, 6	Red LED, high brightness, T-1 package (polarized)
	U3S	40-pin DIP socket
	U1S	16-pin DIP socket
	U2S	8-pin DIP socket
	C5, 14	33 $\mu$ F electrolytic capacitor (polarized)
	CON2	DB-9 female serial cable connector
	CON1	Modular connector — side entry, 6 position
	RPG1	RPG — Bourns 3315C-1-006
	RPG1-knob	RPG knob with 1/8" diameter hole and set screws
	J1, H3	Two 1 $\times$ 2 headers, cut from S1011-36
	H1	One 1 $\times$ 12 header, cut from S1011-36
	LCD1S	2 $\times$ 7 header, cut from S2011-36
	LCD1S	Two 1 $\times$ 1 headers, cut from S1011-36
		WASH FLUX RESIDUE FROM BOARD
	LCD1	LCD module, 8 $\times$ 2, high contrast
	Corners	Four 0.25" dia $\times$ 0.625" threaded standoffs and four 4-40 $\times$ 1/4" machine screws

**Figure A1-4** Suggested sequence for stuffing parts.



D3, the 1N4001 rectifier, is another polarized component. Don't cut the leads until after it has been inserted in the board and soldered in place. Save the excess leads for possible use with the GND1 (ground grabber) pads discussed in the next step. The rectifier has a bar at one end, as does the silkscreen on the board. Just insert it the same way. Its role is to keep the board from frying if a wall wart with power and ground reversed is plugged into the power jack. It is cheap insurance. The specified wall wart (Digi-Key No. T402-P5P) is neither helped nor hurt by this rectifier's presence.

The two holes labeled GND1 located above the 40-pin DIP pattern, U3, are intended to be stuffed with a piece of bare #18 AWG heavy solid wire bent into the shape of a U. After it has been soldered into the two GND1 pads, it should rise about 1/4" above the board. It serves as a "ground grabber" for an oscilloscope's ground clip. If you have no #18 wire, use one of the excess leads left over from the rectifier, D3, discussed in the previous step. Solder each end of the wire in place on both the top and bottom pads to add sturdiness to the wire. Cut off any extra length from the wires beneath the board using a flush-cutting diagonal cutter.

The LM34DZ temperature sensor, TMP1, is mounted in the three holes in the upper left-hand corner of the board. You might mount the sensor so that its cylindrical back lies flat against the board and the "LM34" lettering is right-side up. To do this, first bend the middle lead away from the flat surface that holds the lettering, about 1/16" away from the body of the part. Then bend the two outer leads parallel to that lead but about 1/8" away from the body of the part. Insert it onto the board and solder just the middle lead. Now, rock the part until it is positioned with its flat surface parallel to the surface of the board and then solder the remaining two leads. Cut off the excess leads.

When you insert REG1, the 5 V voltage regulator, note that if you bend the leads in the right place, the hole in the regulator will line up with the hole in the board sufficiently closely to clamp it to the board with a 1/4"-long machine screw and nut. Do the clamping first and the soldering second so as not to stress the leads.

Mount the power switch, SW1, soldering just one pin and then looking from the top of the board to see that all four of its tiny plastic feet are in contact with the board. If not, then align the switch so that they are. If care is not taken, this is the one component on the board that can easily be askew after it has been soldered in place.

Mount the power supply connector, CON3. The holes for CON3 will require a lot of solder to fill up. However, the way the connector is built, you should not have trouble with solder slipping between the board and the connector and shorting the pins together.

Looking at the schematic of Figure A1-2, you will see that the power switch is located on the output of the voltage regulator. This is done for two reasons. First, when turning on power to the board, the input from the switch is already at 5 V, giving a fast risetime to the VDD input. This is one of the requirements for reliable startup. Second, when turning off power to the board, VDD is driven to ground, assuring the resetting of the PIC18F452 in spite of parasitic power coming in from a serial port connection to a PC.

Plug in the wall wart power supply (Digi-Key No. T402-P5P), turn on the power switch, and check that VDD is +5 V ( $\pm 10\%$ ) relative to GND on the board. Remove the wall wart's plug from the board as you add parts to the board.

Be very careful with the insertion of the (polarized) LEDs, D1, D2, D4, D5, and D6. I suggest that you insert the power indicator LED, D1, first without soldering it in (yet). The long lead of the LED (the anode) should go in the hole closer to the top of the board. Before soldering it, apply power and turn on the power switch by toggling it toward the top of the board. Wiggle the LED if necessary to get it to light up. If it doesn't, reverse the leads and try again.

The remaining LEDs are driven by the PIC, so they won't light up without a little help. For every one of them, the long lead should go in the hole closer to the top of the board.

- To light up D2, short the PIC's A4 pin to GND.
- To light up D4, short the PIC's A3 pin to VDD.
- To light up D5, short the PIC's A2 pin to VDD.
- To light up D6, short the PIC's A1 pin to VDD.

Once again, check that  $VDD = 5\text{ V}$ . If you don't have a voltmeter available, just check that the power LED turns on when power is applied and the power switch is turned on. This is an important check before stuffing the 40-pin DIP socket because a short to ground beneath the socket is hard to see. If the power LED doesn't turn on after stuffing the 40-pin socket, you want to know that it did turn on before stuffing the socket and therefore the problem has to do with the soldering associated with the socket and not something you did earlier. This really shouldn't happen since the socket stands off from the board. But check it. In fact, you really should give everything a visual check. The green solder mask is designed to prevent bridging between adjacent pins, but a visual check is worth your while.

Note that all three DIP sockets have a notch at one end. The notched end should be located closest to the top of the board, aligning with the notch shown in the silkscreened DIP socket outline on the board. The notch is there to guide the insertion of the IC itself, with the IC's notch aligned with the notch on the DIP socket.

The two electrolytic capacitors, C5 and C14, are polarized. Put the side marked with the “—” in the hole closest to the bottom of the board.

Add the DB-9 connector, CON2, next. The DB-9 connector has two spring-loaded feet that help avoid strain on the actual pins. After inserting the connector in place, solder the feet to the pads that surround them. Then solder the 9 pins. This connector is used for a serial cable to a PC, for use by the QwikBug debugger program.

The modular connector, CON1, has two plastic strain-relief feet. These are hard to get through the holes. I suggest that you put the board down flat on the mat and put the 9 pins in their respective holes. Then, inclining the connector a little so that the pins remain in the holes, press hard on the top of the connector until it just snaps in place. Check that all of the pins made it through the holes. Then solder them in place. The modular connector just requires that you make sure it is flush to the board after soldering one pin and before soldering the rest. This connector is used by Microchip's ICD2, their low-cost, in-circuit debugger.

The RPG, RPG1, has a plastic pin on one side that must be put through the second hole on the board. It is designed to keep the RPG from turning and stressing the leads if the nut is a little loose. You'll have to bend the leads toward the rotating shaft of the RPG and almost to a right angle. Tighten the nut with a wrench, but not very tight. The shaft of the RPG is plastic and will break off if tightened too much. Just tighten it casually tight. If it ever seems loose, you can tighten it again, but tighter. The specified knob is a first-class knob in that it fits so well, shrouding most of the protruding shaft of the RPG. You will need a small 3/64" Allen wrench to tighten the knob onto the shaft. Don't tighten too tight. You won't damage the knob, but you can easily round the edges of the Allen wrench so that it no longer will tighten anything. Be sure to solder each of the three RPG leads from the *back* of the board, where the soldering iron tip can come into contact with the RPG lead and the pad to which it is being soldered. I must have soldered all of the RPG leads for the boards in my lab from the front, because, one by one, the RPGs have failed with cold solder joints. Resoldering from the back cured each one, a solution that should have been carried out in the first place.

Install the single-row and dual-row headers next. There is a header, H2, inside the 40-pin DIP socket outline that you will not stuff. It is there to support the use of the QwikFlash board with additional QwikProto boards to build a college laboratory with peripheral chips and circuitry beyond that of the QwikFlash board itself. (For more information, see Appendix A2.)

There are two other headers that you may choose not to stuff. If you will be using Microchip's in-circuit debugger for the PIC18F452 and not the QwikBug debugger program, don't bother to stuff J1 with a 2-pin header. A jumper on that header lets QwikBug regain control when a user program is being executed. The pressing of any key on the PC will stop the running of the user program and return control to the QwikBug monitor program.

The other header that you may choose not to stuff is H3 at the bottom of the board. Unless you will be using your board together with another QwikFlash board, you won't be using the QwikFlash instrument option, for which this header serves as its input pins.

If you are stuffing J1 and/or H3, the optional 2-pin headers discussed above, then cut a 2-pin section from the single-row header strip. Insert the short-sided pins of the header into J1 or H3 **from above the board**. Holding the header in place with a towel (serving as a hot pad to keep your finger from being burned), solder one pin. Check the alignment carefully and fix it before soldering the other pin.

Cut a 12-pin section from a single-row header strip. Insert the short-sided pins of the header into H1 **from above the board**. Solder one end pin. Then, with the soldering iron on the same pin, make sure the pins are perpendicular to the board. (Don't leave the iron on the pin longer than is needed to loosen the solder.) Solder the other end of the strip and check the perpendicularity again. Then solder all of the pins, including the very first pin soldered (to forestall a possible cold solder joint).

If you have purchased the optional seven-position terminal block mentioned in Section A1.3, then solder it into the seven holes located at the top of the board with the seven openings for add-on wire connections directed out from the board. This terminal block supports the easy connection of external devices (e.g., a magnetic card reader or a stepper motor) to the board. Leave the excess length of the pins intact, to simplify the additional wiring needed to connect a terminal to the PIC18F452 or to a component on the QwikFlash board.

Use the flush-cutting diagonal cutters to cut off a  $2 \times 7$  section of the dual-row header strip. The  $2 \times 7$  pattern of holes for LCD1, the LCD display, is to be stuffed with the short-sided pins of the header **from beneath the board**. Solder a corner pin and ensure that the header is flush with the board before continuing with the opposite corner followed by another check. Then solder the remaining pins.

Cut two 1-pin sections from the single-row header strip. These will be used in the mounting of the LCD display's two bottom corners. Mount them **from beneath the board** in the same way as was done for the  $2 \times 7$  dual-row header already installed for the LCD display.

## A1.7 FLUX REMOVAL

Before the last construction step of mounting the LCD display, you need to clean the excess flux off both the front and the rear of the board. If you have used resin-core solder, clean the board with isopropyl alcohol, a low-cost solvent from your grocery store or drugstore. Pour some alcohol over the the rear of the board, where most of the excess flux is concentrated. Rub all contacts with an old toothbrush. Do the same on the front of the board. Pour some more alcohol over the back of the board and scrub again, to wash away as much of the dissolved flux as possible. Finally, if you have a bread pan or other small container that the board will fit into, put  $1/4$ " inch of alcohol in it and slosh the board around in it. You are again trying to remove the dissolved flux and make the surface of the board presentable and no longer tacky. Finally, wash the board with water under a faucet. To speed up drying, you can use a hair dryer without fear of hurting anything on the board with that amount of heat.

If you have used water-soluble-core solder such as Kester's Flux 331, the cleanup is much easier, but no less important since the residue is conductive. Just wash it under a faucet, rubbing all contacts with a toothbrush. The rubbing is very important because while the residue is water soluble, it can use

a little help from you. Again, a hair dryer will speed up the drying process. Until the board is dry, it probably won't run a test program.

## A1.8 PERFORMANCE VERIFICATION BEFORE LCD INSTALLATION

Before going on to mount the LCD display or to insert any of the integrated circuits, it is time to check the board for functionality. First apply power and check that you have +5 V on the pad labeled VDD in the upper left-hand corner (to the right of the TMP1 temperature sensor) relative to the GND1 ground grabber. This is really one last check against a short to ground, but you also don't want to power up the PIC18F452 if the supply voltage is anything other than +5 V. (The unregulated supply voltage coming onto the board from the "9 V" unregulated wall wart may actually be as high as 13 V or so and is higher than you want to apply accidentally to the PIC18F452's VDD pins.)

With power turned off, insert a PIC18F452 programmed with the QFPV performance verification code mentioned in Section A1.1 into the U3 socket. Make sure that the notch at one end of the chip is oriented toward the top of the board (i.e., toward the GND1 ground grabber). Also make sure that each pin of the IC is centered on its socket hole so that as you insert the IC into the socket, each pin drops down into its socket hole rather than doing a "deep-knee bend" above the socket hole. Power up the board. The "Alive" LED should blink on for 2.5 seconds, off for 2.5 seconds, on for 2.5 seconds, etc. Turning the RPG should cause the D4 and D5 LEDs to count up or down in binary, depending on the direction of turning. Each press and release of the pushbutton switch in the lower right-hand corner should change the state of the D6 LED.

Remove power from the board and then remove the PIC microcontroller chip with a small screwdriver inserted from the bottom of the board. (Be careful to get between the chip and the socket and not between the socket and the board.) Twist the screwdriver to raise the bottom edge of the chip. Being careful to slide the screwdriver along the back side of the chip so as not to break a rib of the socket, twist it until the chip is loose.

## A1.9 LCD INSTALLATION

Remove the piece of plastic film from the front of the LCD display. Fit the LCD display over the pins **from beneath the board**. Solder a corner pin of the  $2 \times 7$  header and check the alignment. Then solder the diagonally opposite pin at the bottom of the LCD display, filling the mounting hole completely. Check the alignment of the LCD display relative to the slot in the board into which it fits. If the gaps between the top and bottom edges of the LCD display and the board are not uniform from left to right, then touch one of the two soldered pins and rotate the LCD display appropriately. Then solder the remaining pins. Don't bother to wash these solder joints. Keep the LCD dry from now on.

Finally, add four feet to the four corners of the board, using four standoffs and four 1/4" -long machine screws.

## A1.10 PERFORMANCE VERIFICATION

Again, install the PIC18F452 coded with the QFPV program. If you do not have such a chip available to you (e.g., in a college lab), then carry out the QwikBug installation and verification process of Section A1.11 first, subsequently using QwikBug to download QFPV.hex to the QwikFlash board and to run it.

Insert the MAX522 DAC chip in the 8-pin socket, with its notch directed toward the top of the board. Power up your board. Each component should perform as follows.

**“Alive” LED**—It should blink on for 2.5 seconds, off for 2.5 seconds, on for 2.5 seconds, etc.

**RPG**—The RPG controls the state of a two-bit binary counter, displayed on two of the three LCDs above U3. CW turning should increment the counter while CCW turning should decrement the counter.

**Pushbutton switch, Potentiometer, and LCD**—Each press and release of the pushbutton switch, SW3, in the lower right-hand corner of the board should toggle the right LED, D6 (from on to off or from off to on). If the LED is off, then turning the pot from fully CCW to fully CW should change the hex number displayed in the lower right-hand corner of the LCD from 00 to FF. If the D6 LED is on, then just the opposite should happen; turning the pot from fully CCW to fully CW should change the hex number displayed in the lower right-hand corner of the LCD from FF to 00.

**Pot→DAC→ADC→LCD**—Connect the 3”-long, two-conductor flex cable mentioned in Section A1.3 between the DAC-A/GND pins at the left end of the top terminal strip to the E2-AN7/GND pins on the same strip. Press the SW3 pushbutton to turn off the D6 LED. The pot output is converted through the PIC18F452’s AN4 DAC input to the hex value displayed on the bottom row of the LCD display. It is also used to drive the DAC-A output that is fed back through the flex cable to the AN7 DAC input. The resulting value is what is displayed in the top row of the LCD display and should closely follow what is displayed on the bottom row as the potentiometer is turned. As the pot is turned from fully CCW to fully CW, the top number should track the bottom number (within a few counts) from 00 to FF.

Reconnect the flex cable between the DAC-B/GND pins and the E2-AN6/GND pins. Press the SW3 pushbutton to turn on the D6 LED. The pot output is converted through the PIC18F452’s AN4 DAC input *and complemented* to form the hex value displayed on the bottom row of the LCD display. This complemented value is also used to drive the DAC-B output that is fed back through the flex cable to the AN7 DAC input. The resulting value is what is displayed in the top row of the LCD display and should closely follow what is displayed on the bottom row as the potentiometer is turned. This time, as the pot is turned from fully CCW to fully CW, the top number should track the bottom number (within a few counts) from FF to 00.

**Temperature sensor verification**—The LM34 temperature sensor in the upper left-hand corner of the QwikFlash board should produce a display of the room temperature in the lower left-hand corner of the LCD display. Holding a warm finger on the LM34 should cause the displayed temperature to rise.

## A1.11 QWIKBUG PERFORMANCE VERIFICATION

With power turned off, put a PIC18F452 chip with the QwikBug monitor installed into socket U3. (The installation of the monitor into the PIC18F452 chip is discussed in Appendix A4 and requires access to an ICD2 in-circuit debugger or to the “hobby” PIC programmer discussed there.) Install a MAX232A chip in socket U1. Make sure that the chip has the “A” suffix because the original MAX232 chip will not work without much bigger capacitors for its dc-to-dc converters. (Refer to Figure 18-7.) Connect the QwikFlash board to the PC with a normal serial cable (with “straight through” connections of pins—2–2, 3–3, and 5–5—on the two DB-9 connectors).

Start up the Tera Term Pro terminal emulator utility as discussed in Section 5.8, with the serial port setup of Figure 5-8 (but note the comment about the “line delay” setup parameter in Section A4.5). Turn on the power to the QwikFlash board. You should see the PC display the QwikBug startup “help” message. Press the F1 key to see the “help” message rewritten. This will establish that serial communications are working in both directions.

Using the F3 key, send the QFPV.hex file to the board. Then reset the chip (F4 key) and run the QFPV program (F7 key). This will establish that you can load programs satisfactorily. As pointed out in Section A4.5, if you are using Tera Term Pro and the download is not completed successfully, increase Tera Term Pro’s line delay to “20 ms/line,” save this new setup, and try again. It is the author’s experience that Tera Term Pro was developed several years ago and does not handle the line delay accurately for a present-generation fast computer. A setting of “20 ms/line” on this computer produced a line delay that varied somewhat from line to line but that was always more than the required 10 ms/line.