CPUville 8-bit Processor Register Display Kit Instruction Manual

By Donn Stewart

If you find any errors in this manual, please let me know. Thanks.

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Introduction

Building Tips[1]

Thanks for buying a CPUville kit. Here is what you need to build it:

1. Soldering iron. I strongly recommend a pencil-tip type of iron, from 15 to 30 watts.
2. Solder. Use rosin core solder. Lead-free or lead-containing solders are fine. I have been using Radio Shack Standard Rosin Core Solder, 60/40, 0.032 in diameter. Use eye protection when soldering, and be careful, you can get nasty burns even from a 15-watt iron.
3. Tools. You will need needle nose pliers to bend leads. You will need wire cutters to cut leads after soldering, and possibly wire strippers if you want to solder power wires directly to the board. I find a small pen knife useful in prying chips or connectors from their sockets. A voltmeter is useful for testing continuity and voltage polarity. A logic probe is useful for checking voltages on IC pins while the computer is running, to track down signal connection problems.
4. De-soldering tool. Hopefully you will not need to remove any parts from the board, but if you do, some kind of desoldering tool is needed. I use a “Soldapullt”, a kind of spring-loaded syringe that aspirates melted solder quickly. Despite using this, I destroy about half the parts I try to take off, so it is good to be careful when placing the parts in the first place, so you don't have to remove them later.

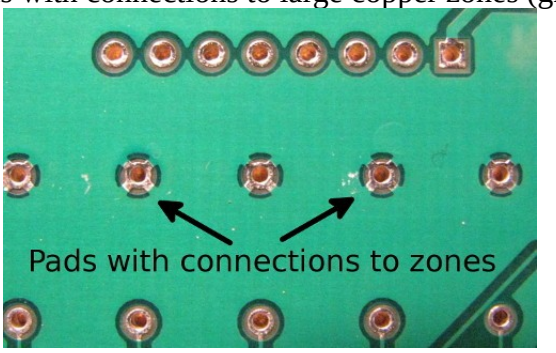
Soldering tips:

1. Before you plug in the iron, clean the tip with something mildly abrasive, like steel wool or a 3M Scotchbrite pad (plain ones, not the ones with soap in them).
2. Let the iron get hot, then tin the tip with lots of solder (let it drip off some). With a fresh coat of shiny solder the heat transfer is best.
3. Wipe the tinned tip on a wet sponge briefly to get off excess solder. Wipe it from time to time while soldering, so you don't get a big solder drop on it.
4. All CPUville kits have through-hole parts (no surface-mounted devices). This makes it easy for even inexperienced hobbyists to be successful.
5. The basic technique of soldering a through-hole lead is as follows:
    1. Apply the soldering iron tip so that it heats both the lead and the pad on the circuit board
    2. Wait a few seconds (I count to 4), then apply the solder.
    3. Apply only the minimum amount of solder to make a small cones around the leads, like this:

1 These are generic building tips that apply to all CPUville kits. The photos may not be from the same kit you have purchased.

This is only about 1/8th inch of the 0.032 inch diameter solder that I use. If you keep applying the solder, it will drip down the lead to the other side of the board, and you can get shorts. Plus, it looks bad.

4. Remove the solder first, wait a few seconds, then remove the soldering iron. Pull the iron tip away at a low angle so as not to make a solder blob.
5. There are some pads with connections to large copper zones (ground planes) like these:



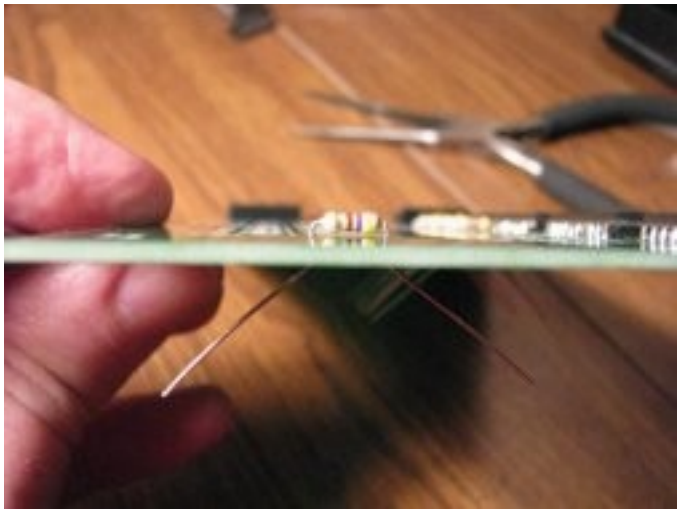
These require extra heat to make good connections, because the zones wick away the soldering iron heat. You will usually need to let a 15-watt iron rest on the pin and pad for more time before applying the solder (count to 10). You also can use a more powerful (30 watt) soldering iron.

6. The three main errors one might make are these:
    1. Cold joint. This happens when the iron heats only the pad, leaving the lead cold. The solder sticks to the pad, but there is no electrical connection with the lead. If this happens, you can usually just re-heat the joint with the soldering iron in the proper way (both the lead and the pad), and the electrical connection will be made.
    2. Solder blob. This happens if you heat the lead and not the pad, or if you pull the iron up the lead, dragging solder with it. If this happens, you can probably pick up the blob with the hot soldering iron tip, and either wipe it off on your sponge and start again, or carry it down to the joint and make a proper connection.
    3. Solder bridge. This happens if you use too much solder, and if flows over to another pad. This is bad, because it causes a short circuit, and can damage parts.

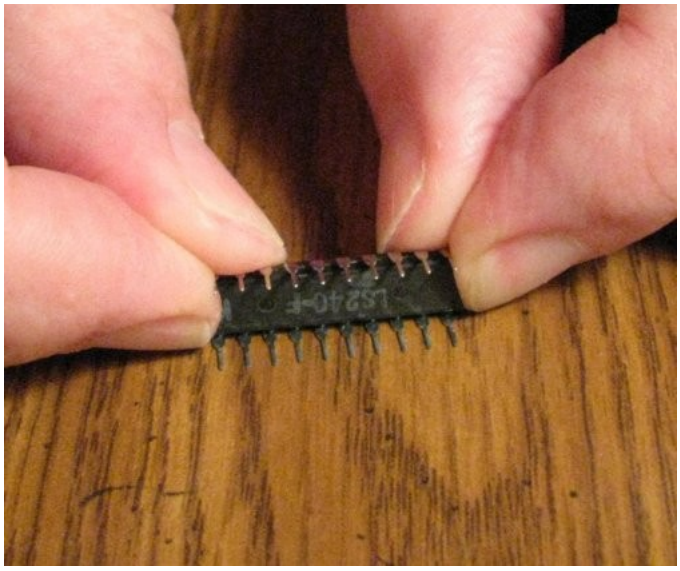
If this happens, you have to remove the solder with a desoldering tool, and re-do the joints.

Other tips:

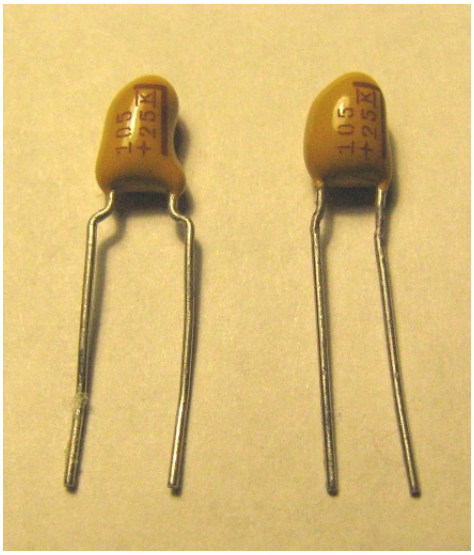
1. Be careful not to damage the traces on the board. They are very thin copper films, just under a thin plastic layer of solder mask (the green stuff). If you plop the board down on a hard surface that has hard debris on it (like ICs, screws etc.) it is easy to cut a trace. Such damage can be fixed, if you can find it, but try to avoid it in the first place.
2. When soldering multi-pin components, like the ICs or IC sockets, it is important to hold the parts against the board when soldering so they aren't “up in the air” when the solder hardens. The connections might work OK, but it looks terrible. If you make a lot of connections on a part while it is up in the air it is very difficult to get it to sit back down, because you cannot heat all the connections at the same time. To prevent this, I like to solder the lowest profile parts first, like resistors, because when the board is upside down they will be pressed against the top of the board by the surface of the table I am working on. Then, I solder the taller parts, like the LEDs, sockets, and capacitors. Sometimes, I need to put something beneath the component to support it while the board is upside down to be soldered, like a rolled-up piece of paper or the handle of a tool. Another technique is to put a tiny drop of solder on the tip of the iron, press the part against the board with one hand, and apply the drop of solder to one of the leads. When the solder hardens, it holds the chip in place. Solder the other leads, then come back and re-solder the one you used to hold it. It is good to re-solder it because the original solder drop will not have had any rosin in it. The rosin in the cold solder helps the electrical connection to be clean.
3. The components with long bendable leads (capacitors, resistors, and LEDs) can be inserted, and then the leads bent to hold them in place:



4. You might have to bend the leads on components, ICs or IC sockets to get them to fit into the holes on the boards. For an IC, place the part on the table and bend the leads all at once, like this:

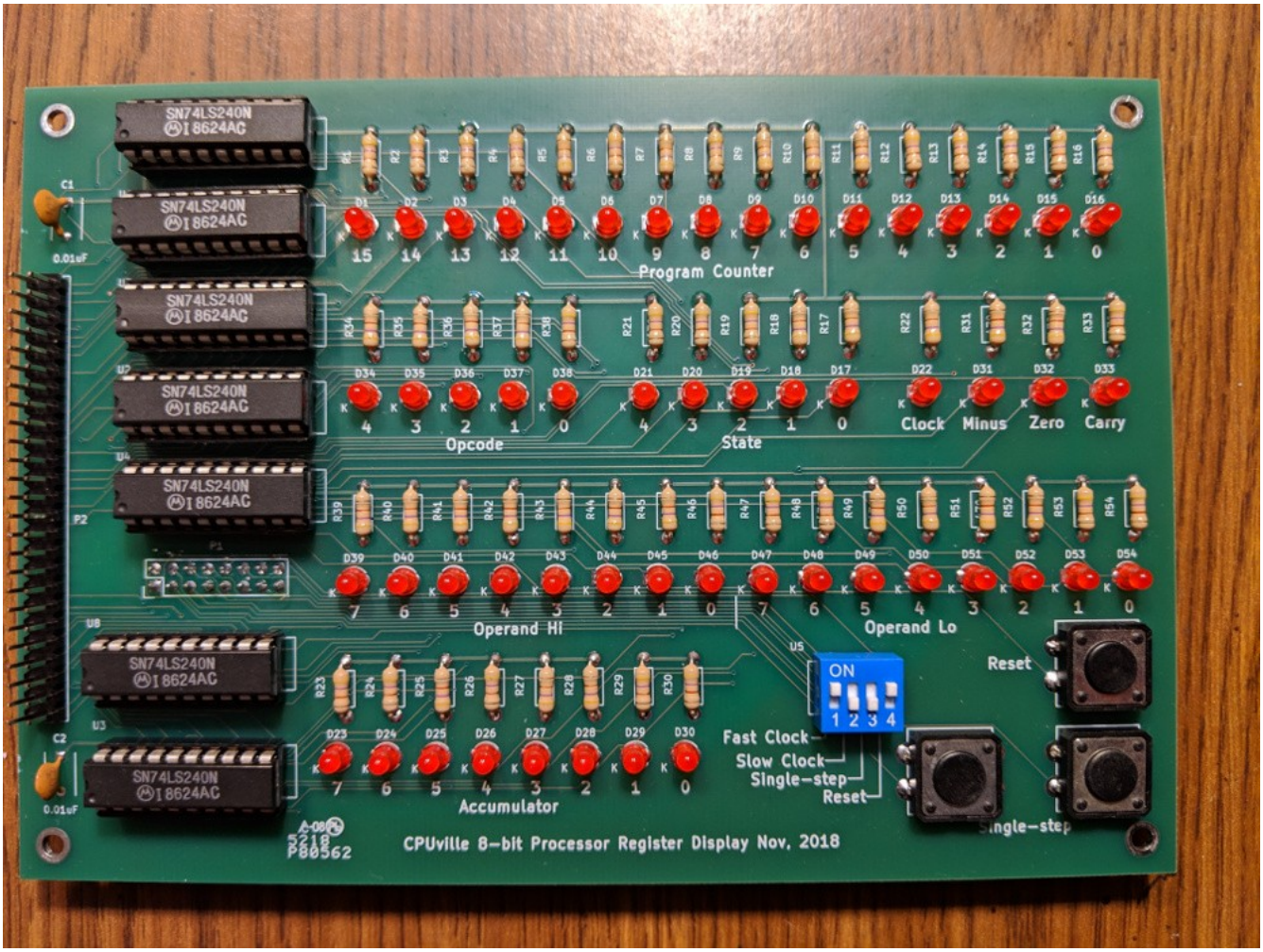


Bending the leads one-by-one or all together with the needle nose pliers doesn't work as well for some reason.
Also, some components have leads bent outward to fit in a certain printed circuit board footprint, but will fit a smaller footprint if you bend the leads in with a needle-nosed pliers. Here is a tantalum capacitor, one with wide leads, the other with narrow leads, from bending the wide leads in:

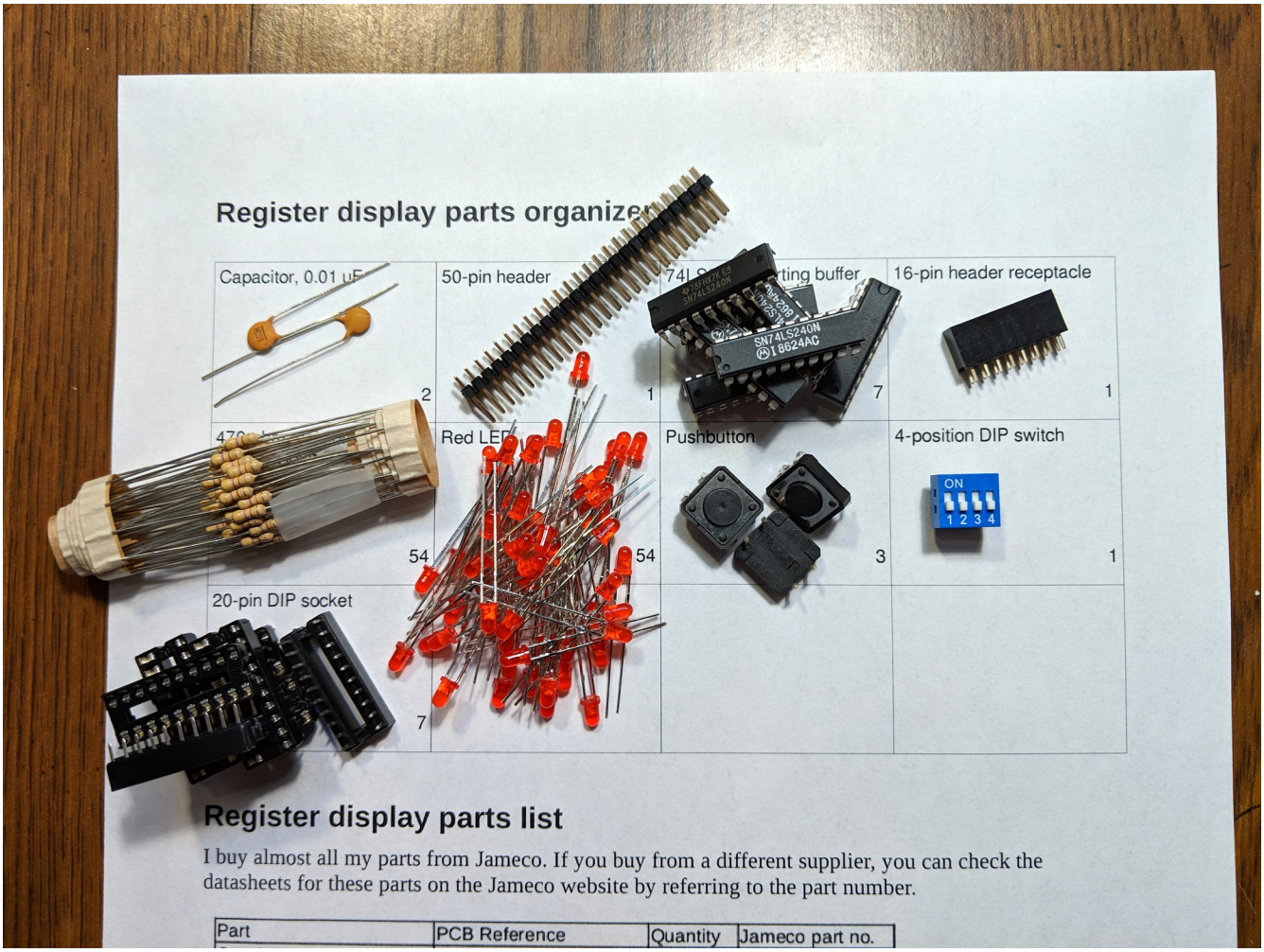


5. After you have soldered a row or two check the joints with a magnifying glass. These kits have small leads and pads, and it can be hard to see if you got the solder on correctly by naked eye. You can miss tiny hair-like solder bridges unless you inspect carefully. It is good to brush off the bottom of the board from time to time with something like a dry paintbrush or toothbrush, to get off any small solder drops that are sitting there.
6. Some connectors, like headers, have pins that are a little more massive than the IC socket or component pins. This means that more time, or perhaps more wattage, will be required to heat these pins with the soldering iron, to ensure good electrical connections.

Building the Register Display



Print out the Parts Organizer (page 14) and put the parts on the organizer to make sure you have them all, and to get familiar with them:

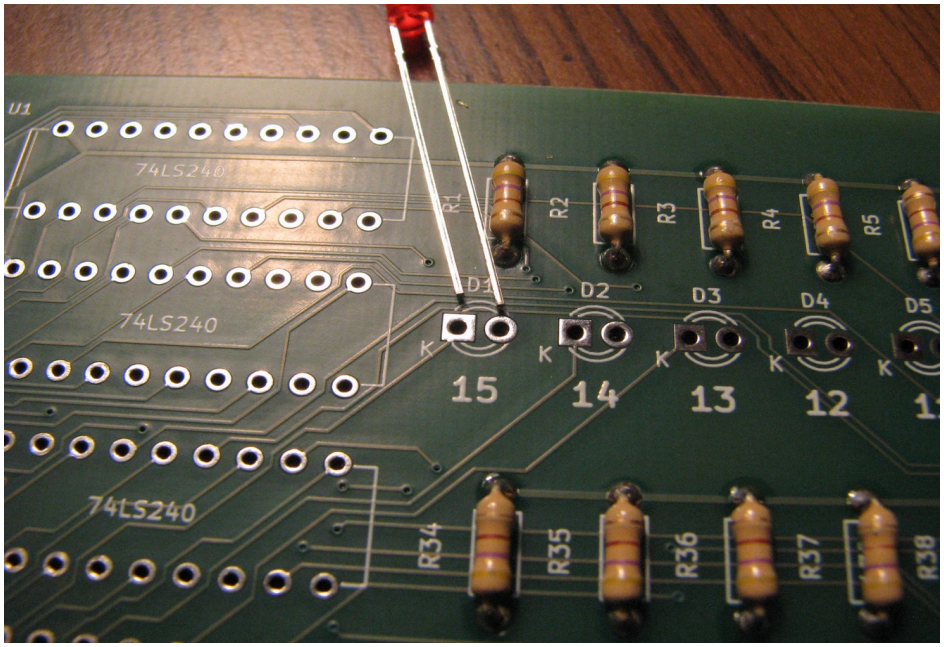


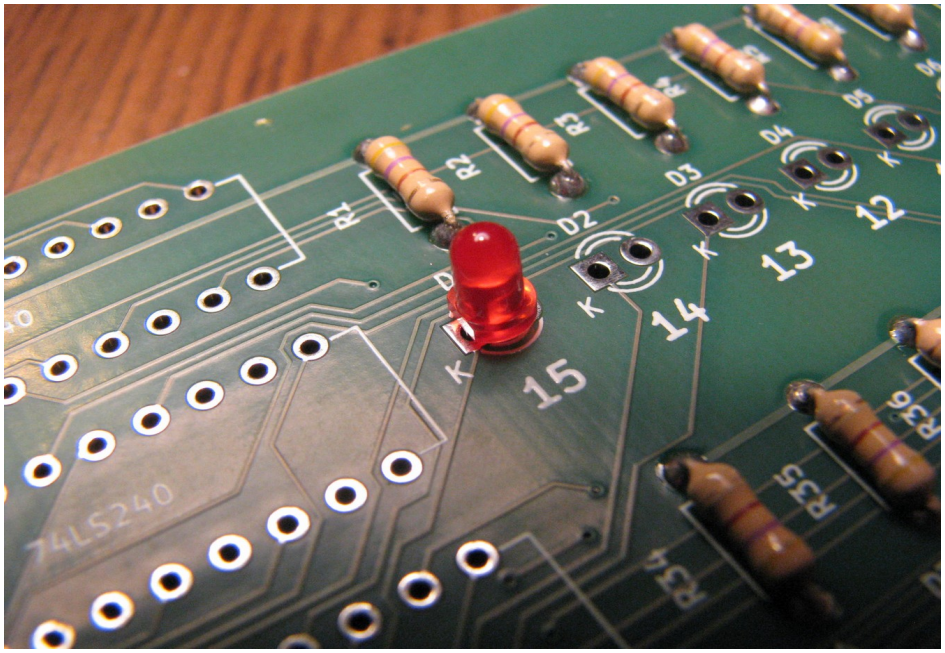
Once you have checked the parts you can start to solder them onto the circuit board.

The easiest way to solder the components is to start with the shortest (parts that lie closest to the board) and proceed to the tallest. The order is resistors, pushbutton switches, LEDs, IC sockets, capacitors, 4-position DIP switch, 50-pin connector. The 16-pin receptacle is then soldered to the back.

Some components need to be oriented properly, as described below.

1. The resistors can be soldered first. They do not have to be oriented.
2. The pushbutton switches are next. The pins have a bend in them that should make them snap into the holes before you solder them.
3. The LEDs are next. The cathode, which is side with the shorter lead, and the flat side of the plastic base, is oriented toward the left. There is a small “K” on the circuit board symbol by the cathode hole:

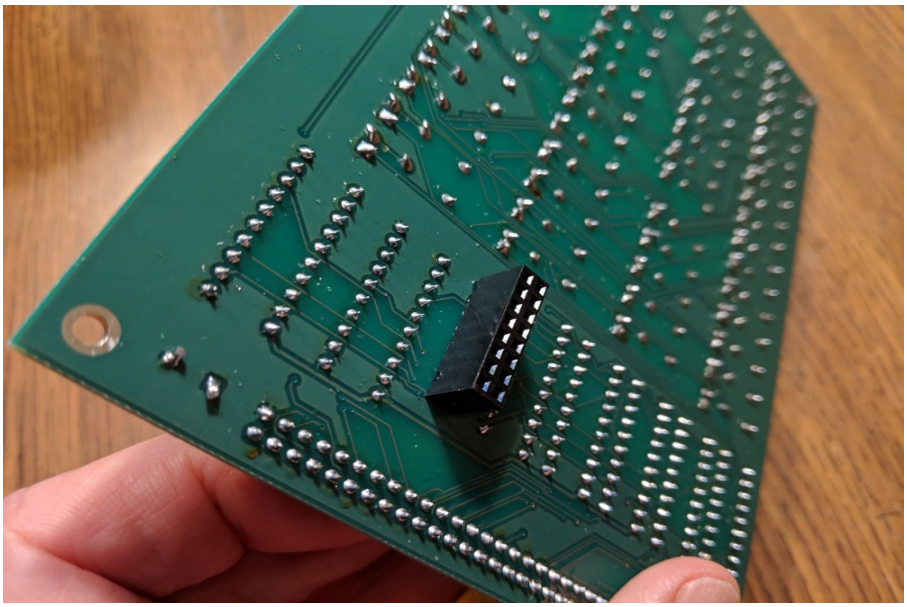




Here is a little trick for getting a long row of LEDs to line up nicely, that is, to stand up straight. The bottom of the LED base is flat, so go down a row, soldering only one lead of each LED while pressing down on the board. That way flat bottom of the base will help the LED to stand upright. Then, before soldering the other lead, bend each LED in the row to get them lined up well. Then solder the second lead.

4. The IC sockets are next. They do not need to be oriented.
5. The 50-pin display connector is next. No orientation is necessary, but it has fairly large leads and may require more time and/or soldering iron wattage to solder.

6. The 4-position DIP switch is soldered so ON is up (toward the rear of the board).
7. The 16-pin header receptacle is soldered on the back of the circuit board:



8. Once you have finished soldering all the parts on the computer, inspect the board to make sure there are no solder bridges or unsoldered pins. Lightly brush the back of the board with an old toothbrush or paintbrush to clear off loose debris or tiny solder hairs. You can also wipe the back of the board with a cloth soaked in alcohol to remove rosin flux spatters. Hold the finished board against a bright light. If you can see light coming through a pin hole, go back and solder it again, to make sure you have a good electrical connection. This does not apply to the vias, the plated holes where a trace goes from one side of the board to the other. These can be left open.

Testing and Using the Register Display

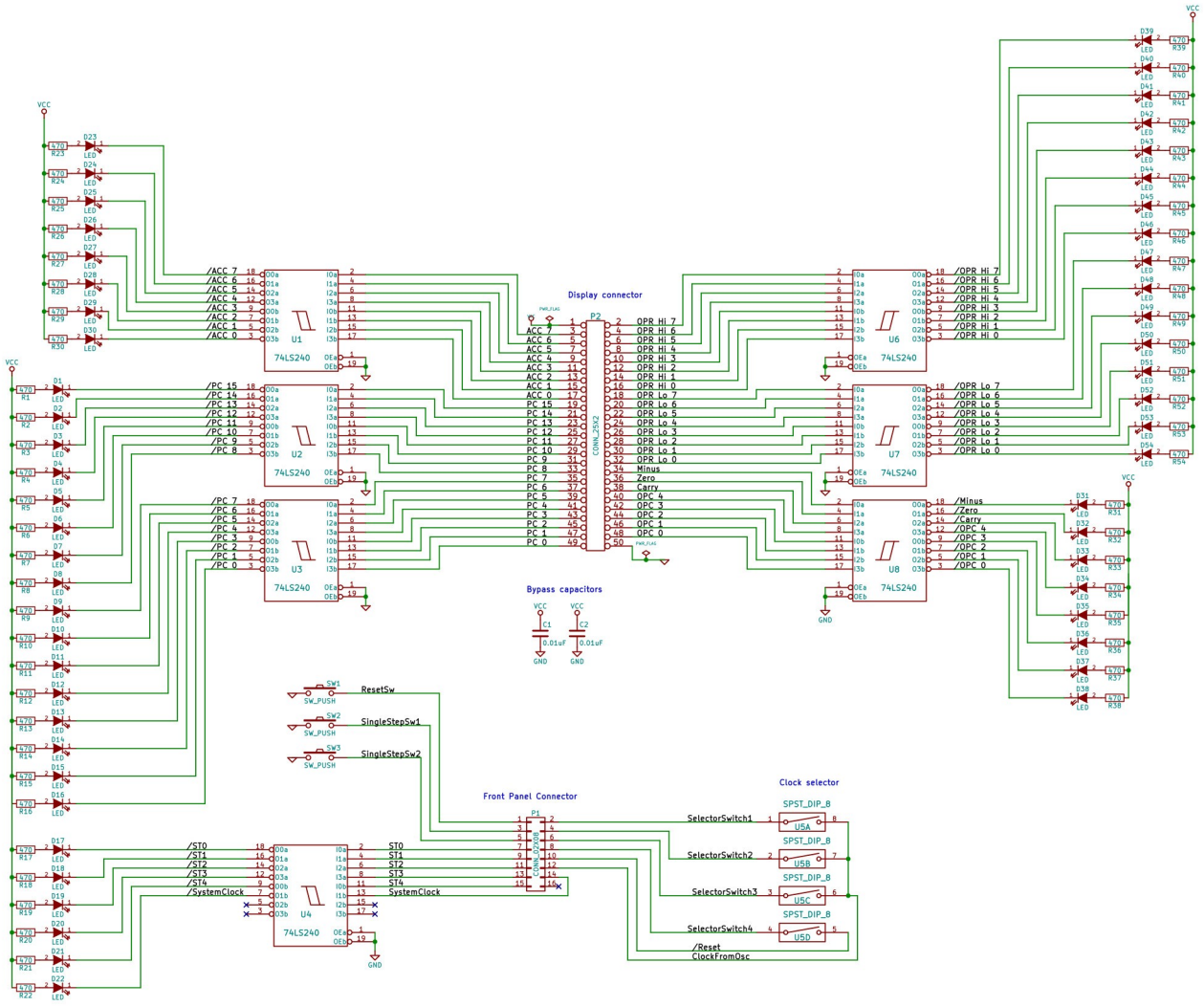
Plug the ICs into the sockets, being careful not to bend under any pins. A bent-under pin can look like a properly inserted pin from the top.

The register display can be tested by putting +5V and ground onto pins 1 and 50 of the display connector, respectively. Because the inputs to the buffers are not connected in this condition, they will assume a high level, and the LEDs will light. Then, you can ground the pins on the display connector one-by-one. The corresponding LED should go out. Pins 7, 9, 11, 13, 14 and 15 of the front panel connector can be tested in the same way. The clock selector switches connected to pins 2, 4 and 6 can be tested for continuity with pin 12 of the 16-pin front panel connector when closed. The switch connected to pin 8 can be tested for continuity with pin 10 when closed. The pushbuttons can be tested for grounding pins 1, 3, and 5 when closed (pressed).

To use the display, remove the control board from the processor stack and connect the 50-conductor ribbon cable to the display connector on the main board. Then replace the control board, being careful to line up the receptacle on the bottom of the control board with the control connector header on the main board. Turn **off** the switches on the control board, because you will be using the switches on the display board to control the computer. Place 0.5 inch male/female standoffs on the threads coming through the mounting holes on the control board. Then connect the 50-conductor cable to the display connector on the display board. Line up the front panel connector on the bottom of the display board with the 16-pin header on the control board. If lined up properly, the mounting holes will be in line with the standoffs on the control board. Put the female standoffs (nuts) onto the threads. The display board should show activity when the computer is powered up.

The switches and pushbuttons on the display board correspond to the switches and buttons on the control board, and are used the same way.

Register Display Schematic



The register display is simple. The register outputs and processor flags are brought to the inputs of the 74LS240 inverting buffers from the main board through the display connector. The state and system clock signals are brought in from the control board through the 16-pin front panel connector. The LEDs are connected to the buffer outputs so that the buffer “sinks” current from the LED, causing it to light when the buffer input is +5V (a logical 1). The pushbuttons and clock and reset switches are connected to their respective circuits on the control board through the front panel connector. The bypass capacitors filter out power line voltage spikes.

Register Display Parts Organizer

Capacitor, 0.01 uF 2	50-pin header 1	74LS240 inverting buffer 7	16-pin header receptacle 1
470-ohm resistor Yellow-Violet-Brown 54	Red LED 54	Pushbutton 3	4-position DIP switch 1
20-pin DIP socket 7			

Register Display Parts List

I buy almost all my parts from Jameco. If you buy from a different supplier, you can check the datasheets for these parts on the Jameco website by referring to the part number.

Part	PCB Reference	Quantity	Jameco part no.
Cap 0.01 uF	C1, C2	2	15229
4-position DIP switch	U5	1	38820
74LS240	U1,U2,U3,U4,U6,U7,U8	7	47141
50-pin header	P2	1	53560
16-pin header receptacle	P1	1	70721
20-pin socket		7	112248
Push button switch	SW1,SW2,SW3	3	122973
Resistor 470 ohm	R1-R54	54	690785
LED (red)	D1-D54	54	2081932