Digital Electronics
&
Chip Design

Lab Manual I: The Utility Board

© 1999 David Harris

The objective of this lab is to assemble your utility board. This board, containing LED displays, switches, and a clock, will be used during each of the succeeding hardware labs so that you do not have to rebuild inputs and outputs every week. Therefore, a careful job assembling the board this week will save hours of trouble in future weeks. This week is an exception from the norm because you will just be following instructions, not doing your own design and understanding the project. However, over the next few weeks you will learn about the capabilities of the board and will find out how it operates.

Before beginning, skim through Lab Manual I to get an idea of the steps involved. Then go through each step in order, checking off the step as you proceed. Ask for help if you have questions or encounter trouble. You may also find that borrowing an additional hand or two to hold components may save you trouble in some places.

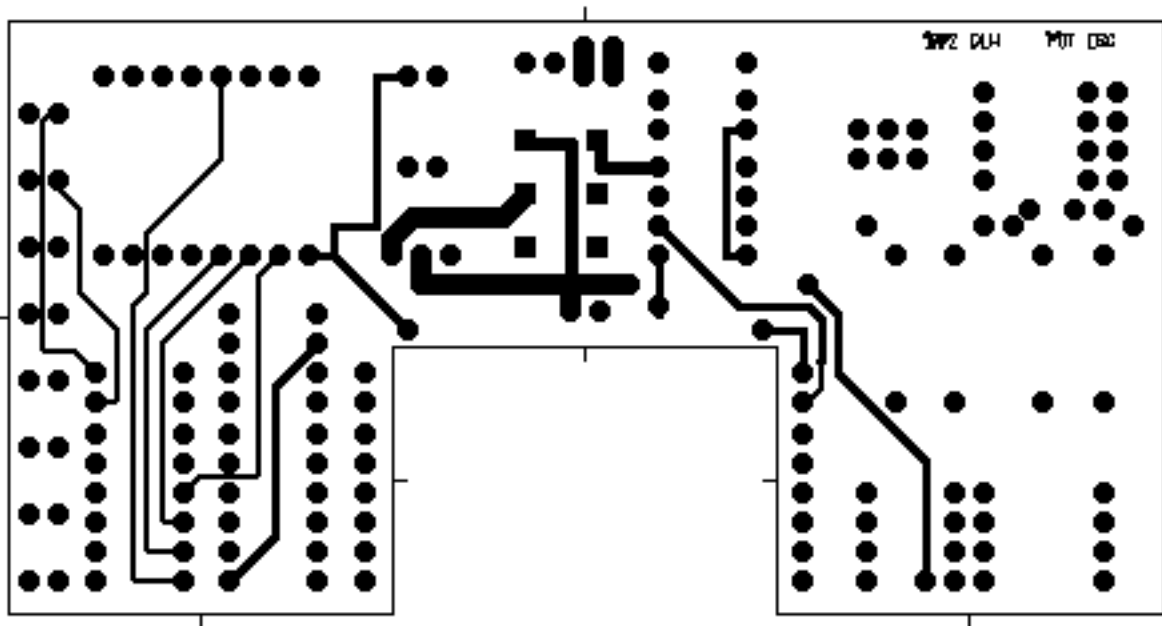✝ **Identify the component side of your circuit board.**

Figure 1: Component side

Your utility board has two sides: the component side and the solder side. All the components must be placed on the component side or you will be very unhappy. All soldering should be done on the solder side of the board. On this board, the component side is the one with just a few traces showing and text in the upper right corner (shown in Figure 1), while the solder side is the one with more traces and text in the upper left.

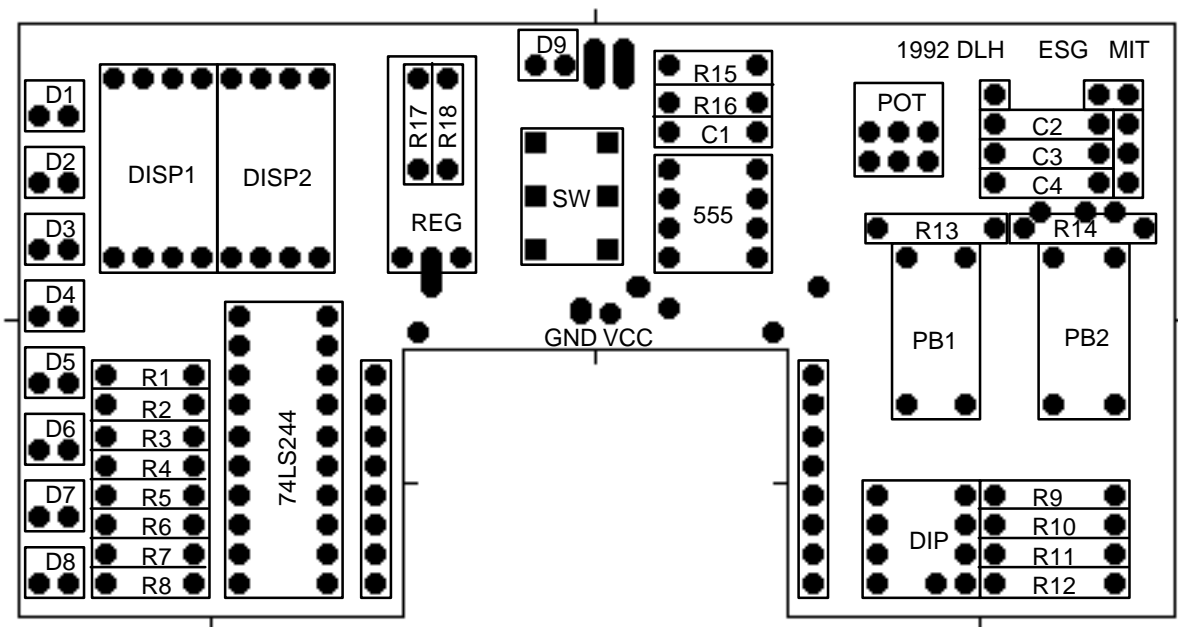Refer to Figure 2 for placement of the various components. Not all components will be used.

Figure 2: Component Placement

✝ **Place the resistors.**

There are 18 resistors to place on the circuit board that set defaults on switches and limit current to LEDs. Resistors are labeled with four bands; the first three indicate the value; the fourth (usually gold) is separated by a bit more space and indicates the precision of the resistor. We can ignore the precision for this class. Resistors do not have polarity; i.e., they can be inserted in either direction.

Bend the leads and insert in the diagram in the positions shown. Be sure to pull the leads all the way through the board. Bend the leads outward to hold each resistor in place, then solder. Clip the leads off when done.

R1 through R8 and R18 are 390 ? resistors (orange white brown).

R9 through R12 are 10 K? resistors (brown black orange).

R13, R14, and R16 are 1 K? resistors (brown black red).

R15 is a 2 K? resistor (red black red).

R17 will not be used.

✝ **Place the sockets.**
You will be placing sockets for the chips to prevent damaging the chips via overheating. There are two sockets; one is has 20 pins, the second has 8 pins. By custom, sockets are placed with the notch facing up.

Insert the 20 pin socket in the space labeled 74LS244 on the diagram. Have a foolish volunteer hold it while you solder two diagonally opposite corners to keep the socket in place. Then solder the remaining 18 pins.

Insert and solder the 8 pin socket in the space labeled 555.

✝ **Place the potentiometer.**
The 100 K? variable resistor (also known as a potentiometer) is used to adjust the frequency of your clock generator circuit. It is a small square with an adjustable knob and three pins. There are six holes in the board in the area marked POT; each column of 2 is connected together already. Place the pins such that one is in a left hole, one is in a middle hole, and one is in a right hole. Hold it down and solder.

✝ **Place the pushbutton switches.**
The utility board has two pushbutton switches. These are the black square switches and go in the areas marked PB1 and PB2. Unfortunately, due to a foul-up with the company making the drill holes, the holes are slightly too small for the legs of the switches. Just insert the legs as far as they go, have somebody hold them in place, and let solder run into the hole to make the contact and hold the switch in place. If this doesn't work, you may need to solder from the top side of the board.

✝ **Place the Light Emitting Diodes (LEDs).**
You have 9 LEDs to place on the board. LEDs have polarity; i.e., they only function in one direction. One edge of every LED has a notch and a slightly shorter lead. This indicates the negative end.

Place D1 through D8. These are red LEDs used as outputs for future projects. They are in small transparent packages. Insert all of the LEDs with the negative end facing the edge of the board, bending the legs to keep them in place. Make sure that the LED is sitting straight up. Then solder each LED and trim the extra leads.

Place D9. This is a green LED that is the power indicator for the utility board. Insert it with the negative end facing away from the red LEDs and solder.

✝   **Place the DIP switches.**
Find your DIP (dual inline package) switches. Find a victim to hold the switch in place, then solder. The direction does not matter.

✝   **Place a jumper wire.**
Your board could be configured to allow many clock frequencies by moving a jumper between several capacitors, but we will not need that feature. Therefore, we will hardwire the clock to one capacitor. Strip about 0.75" off one end of your white wire. Locate the three holes directly above R14. Stick the wire down through the rightmost hole and back up through the left (it's too hard to snake it through the middle hole, so we won't bother). Pull the wire as flat as possible to prevent accidentally shorting other components. Solder both holes and cut off any excess wire. Strip about 0.25" off of the other end of the wire. Solder it into the hole just right of C2.

✝   **Place the capacitors.**
There are two capacitors used in the clock circuit. Each one looks different and will be treated separately.

C1 is a 0.01 ?F ceramic disk capacitor. It is the smaller brown disk-shaped widget labeled 103. Place it, bend the legs to hold it in place, and solder.

C2 is a 4.7 ?F cylindrical electrolytic capacitor. Electrolytic capacitors have polarity. If they are inserted in the wrong way, they may explode.😵   There are two kinds of electrolytic capacitors: radial and axial. Radial capacitors have two leads sticking out of the bottom. An arrow with a minus sign points to one; solder it into the board with the negative terminal toward the edge.

If you have an axial capacitor, you should see leads coming out both ends. One end is marked with a notch; this is the positive end. An arrow points to the negative end. Bend the leads as shown so that the capacitor can sit vertically without interfering with the holes for C3. Insert the capacitor with the negative end toward the edge of the board, bend the legs to hold it in place, and solder.
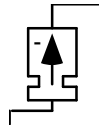
C3 and C4 will not be used.

✝   **Place the power switch.**
Locate your large power switch. This switch will go in the area marked SW. The legs are too big for the holes. Use a file to thin the legs. This may take filing across all three legs for a minute or two. Insert the switch into the leftmost column of three holes and solder.

✝ **Place the voltage regulator.**
The voltage regulator is used in the power supply part of the utility board to produce a clean 5 volt signal from the noisy six volts coming from the wall transformer. The regulator is a black device with three legs and a metal tang at the top. It sits on top of the resistors in the area marked REG. Bend the legs 90 degrees at the point where they thin and place the regulator so that it rests on top of the resistors with the numbered side facing up. Inserting the leads may require some force. Hold it in place and solder the terminals.

✝ **Locate the Hexadecimal Display mounts.**
This utility board is designed to support two fancy hexadecimal readouts in the slots marked DISP. Unfortunately the displays are very expensive and we were not able to get any, so this portion of the board will not be used.

✝ **Connect the power supply wires.**
Take your red and black pieces of wire. Strip about 0.75" of insulation off of one end of each. Find the two pairs of holes beside D9. Insert the stripped end of the black wire up through the top left hole, bend it, and pull it down into the bottom left hole. This should prevent you from accidentally ripping out your wires with excessive force. Pull tight so that very little wire is exposed on top of the board. Solder the bottom side of each hole. Repeat the process using the red wire in the right pair of holes. Cut off the extra wire coming through the bottom holes and be certain that the exposed pieces of wire do not touch near the top holes. Then twist the two wires together, leaving about 1.5" at the other end. Strip 0.5" of insulation from those ends.

✝ **Place the male header.**
You will be using three pieces of male header to connect your utility board to the breadboard. Find the two strips of 8 pins. Solder one to each of the 8 rows of holes such that the black plastic rests below the board, the long legs point down, and the solder goes on the component side of the board. Be careful not to melt your DIP switches with the side of the soldering iron. Then solder the strip of 2 pins in the pair of holes directly below the power switch.

✝ **Place the chips.**
You are now done with the soldering part of this assembly and can place the chips without risk of heat damage. Find your 74LS244 chip. Place it with the notch facing the top of the board in the 20 pin socket. Find your 555 timer chip. Again, place it with the dot facing up in the 8 pin socket.

✝ **Prepare the transformer.**
Locate the transformer in your kit. With your wire cutters, snip off the socket at the end. We will not be using the socket. The power cord is made of two wires, one carrying ground and the other carrying 6 or so volts. Slice the insulation carefully to separate the two wires for about 1.5". Trim 0.5" of insulation from the end of each wire, being careful not to cut the copper inside. Twist the exposed

copper strands together so that they do not fray and tin the strands with a thin coat of solder. The positive transformer wire is usually marked with a white line.

✝ **Assemble your breadboard.**
Now you are finally ready to put your breadboard together. Remove the board from its package and find the two posts that come with the board. Mount the red post in the hole marked Vb and the black post in the hold marked Va.

Place the utility board such that the GND and VCC header pins go in the topmost blue and red-lined holes, respectively, and the 16 other header pins fit in holes in rows 5-12.

Under this setup, all of the large number of holes along the blue line are connected to ground and all of the adjacent holes along the red line are connected to five volts. These sets of holes are called the ground and power busses, respectively. Along any given row, the five pins labeled a-e are connected and the five pins labeled f-j are connected).

If you loosen the top of each mounting post, you should see a hole drilled through horizontally. Stick the red power supply wire and the positive transformer wire into the red post and the black supply wire and negative transformer wire into the black post, then tighten down the tops again. Double check with a TA that your connections are correct; otherwise, you may blow out your voltage regulator.

Finally, write your name on the back of your breadboard.

✝ **Insert the bypass capacitor.**
The original design of the utility board omitted a bypass capacitor that is helpful in maintaining the 5 volt power supply. Find the 10 ?F cylindrical electrolytic capacitor in your kit. Bend the legs, then cut them so that it fits flushly into the breadboard with the positive end in the power bus and the negative end in the ground bus.

✝

✝ **Test the power supply.**
Plug in the transformer. Turn off the power switch and make sure no lights are on. Turn on the power switch and check that the green power indicator LED and all of the red LEDs turn on. Check with a voltmeter that the VCC pin is at 5 volts.

✝ **Test the LEDs.**
Take a piece of wire and strip off 1/2" of insulation from each end. Put one end in a hole horizontally adjacent to the topmost header pin on the left side (i.e. row 5, column g, h, i, or j), corresponding to the topmost LED. Put the other end in a hole on the ground bus. Check that the LED turns off. Switch the same end to the power bus. Check that the LED turns back on. Repeat the process for each of the 7 other LEDs (rows 6-12).

✝ **Test the clock.**
Now we will check that the clock generator works correctly. Take the wire that you used to test the LEDs. Connect one end to a row with the LED pins; connect the other end to a hole in row 6 on the right side of the board (corresponding to the second pin from the top on the right side, the clock output). Turn the potentiometer with a screwdriver and check that the LED blinks. Observe that you can vary the frequency by adjusting the position of the potentiometer.

✝ **Test the switches.**
The last components to test are the switches. The two pushbuttons connect to rows 7 and 8 on the right part of the breadboard; the four DIP switches connect to rows 9 through 12. Connect an LED to each switch and check that you can turn on and off the LED by pushing or flipping the switch.

✝ **Go home!**