USC Viterbi School of Engineering

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EE 459Lx - Embedded Systems Design Laboratory

EE459 Lab Assignment 1
Power Connections

1 Introduction

The purpose of this assignment is to install the necessary components on the project board so that power is available for running the other components that will be installed on the board later. The circuit to be constructed is shown in Fig. 1. It consists of wires with banana plugs to connect to a power supply, a terminal block to connect the wires to the board, a toggle switch to turn the power to the board on and off, a capacitor for reducing noise on the power, and an LED that lights up when power it turned on. There is no point in installing other items on the board until there is reliable and stable power for them.

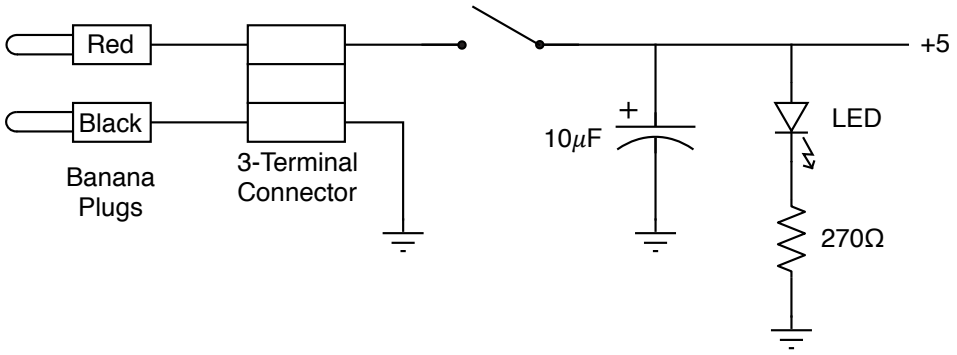

Figure 1: Wiring diagram for power components

2 Components

Each team will be provided with the following components:

- $8'' \times 6''$ prototyping board
- 3 position terminal block
- Red and black banana plugs
- Red and black wire for power connection
- Single-pole, double-throw (SPDT) panel-mount toggle switch.
- 10μF electrolytic capacitor
- LED
- 270Ω resistor

- Two header pins (or one long one that can be cut in half)
- Bus strip same length as the header pins

Teams will also receive their toolkit containing a collection of tools that can be used throughout the semester. Please try to keep the tools together and not leave them lying around in the lab.

- Needle-nose pliers
- Wire strippers
- Diagonal cutters
- Unwrapping tool for wire-wrap connections
- IC removal tool
- Small screwdriver
- Set of 5 micro-hook clip leads
- Key to the EE459 storage locker
- Padlock for the team locker
- USBtiny programming module and USB cable

3 Assembly

The first thing you want to do with your project board is to identify the component side and the wiring side of the board. The wiring side has little metal pads around each hole. The component side has white lines forming a grid pattern, and letters and numbers along the edges. All the components (modules, IC's, resistors, capacitors, etc.) will be mounted on the component side with their pins or leads poking through holes to the wiring side. All the wiring connections between pins and leads is done on the wiring side. Some components like the toggle switch used in this assignment are mounted so part of it is on the component side and part is on the wiring side.

3.1 Legs

The next thing to do is to install screws in the holes in the corners of the board to act as legs for the board. The screws, nuts and lock washers are in a plastic box in the supply cabinet. Install a 3/4" long #4 screw with the top of the screw on the component side and most of it extending out on the wiring side. Place a lock washer and nut on each screw as shown in Fig. 2 and use a $1/4''$ nutdriver from the tool chest to tighten it.

3.2 Power Terminals

The blue 3 position terminal block for connecting power cables can be installed anywhere but the recommended place is near one side of the board. In the terminal block the three openings for wire to be inserted should be facing out from the center of the board. Press the block against the component side of the board when soldering it to pads on the wiring side to make sure it is flush against the board.

Note: Sometimes the pins on the terminal block are too big to fit through the holes on the board. If this is the case, use the drill press in the lab and a #56 drill bit to widen the diameter of the three holes. If you are not comfortable doing the drilling yourself, mark on the board which holes to expand and ask the instructor to drill the holes.

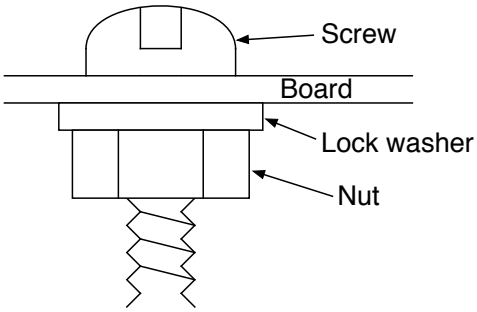

Figure 2: Installation of screws

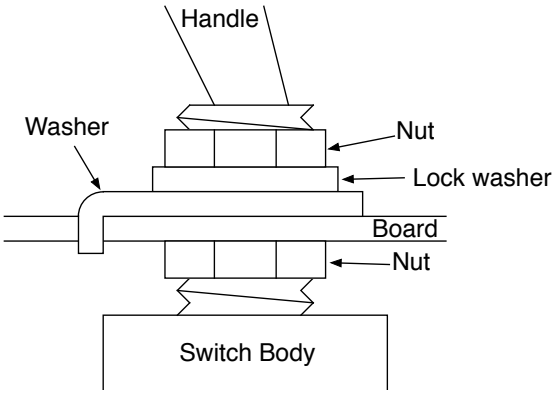

Figure 3: Toggle switches

3.3 Header Pins

It's likely that many of the components you eventually install on the project board will require connections to power and ground. To make it easy to do this we want to provide multiple places that wires can be connected to for power and ground, not just single point. For this reason your Lab 1 components included two sets of header pins (or one longer strip that can be cut in half) to be installed on the board. Once installed on the board one will be for power connections, and the other for ground connections.

The two header pins can be placed anywhere on the board, but putting them near one of the edges keeps the rest of the board free for installing other project components. If you put the header pins in the middle of board they may block the space for larger components to be installed so it's highly recommended that both be installed along the edge of the board. Once the header pins are installed, all the pins in one will be connected together so that connections for power or ground can be made to any of the pins in the group. Fig. 4 shows one possible way to lay out the power components.

If necessary use the wire cutters to cut the header to the length needed. Insert it through the holes in the board so the plastic part that holds the pins together is on the component side and the long part of the pin is going through the hole so it sticks out on the wiring side. Solder the two pins on each end of the header to the pad around their hole to hold the header in place. Don't solder all the pins to the pads. We just want to solder two so the header pins are attached to the board.

To connect all the pins in one header together, a metal "bus strip" was include with your parts. The bus strip (see Fig. 5) has holes in it at the same spacing as the header and can be pushed down over the header pins. Using your wire cutter, cut the bus strip to the proper length so when pushed down over the header, all the header pins will be poking through a hole in the bus strip.

Once the bus strip has been installed over the header and pushed down as far possible against the board, use the soldering iron to solder each header pin to the metal of the bus strip. Make sure to do that for all the pins so they will all be connected together. It's very important that a good solder joint is made between the header pin and the bus strip at each position.

Test it! Use one of the the bench DMMs to check for continuity between all the pins in each group. If you press the "CONT" switch on the front of the DMM, it will make a beep is there is continuity between the two test points. This makes testing go a lot faster than using the normal resistance mode and having to look up at the display to check the reading.

The Lab Notes handout has more information on installing the header strips.

3.4 Toggle Switch

The toggle switch is installed in a hole with the body of the switch on the wiring side of the board and the lever on the component side. If you examine the switch and its associated hardware you will see that there are two nuts, a lock washer and a flat washer on the shaft as shown in Fig. 3. The bottom nut can be adjusted to make the top of the shaft flush with the surface of the board when the top nut is tightened down.

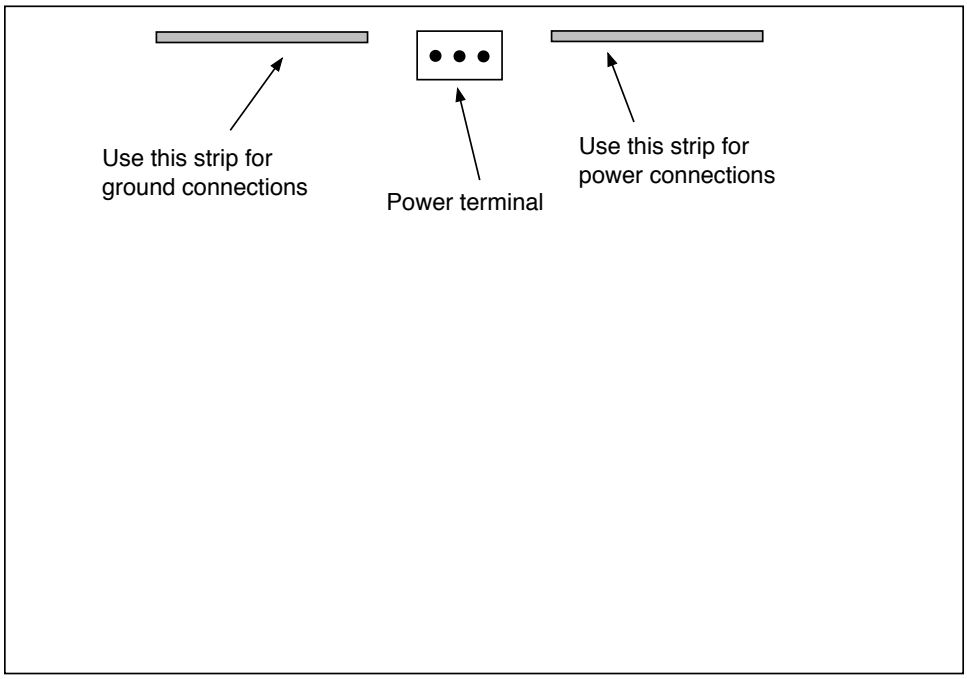

Figure 4: Location of bus strips and power terminal

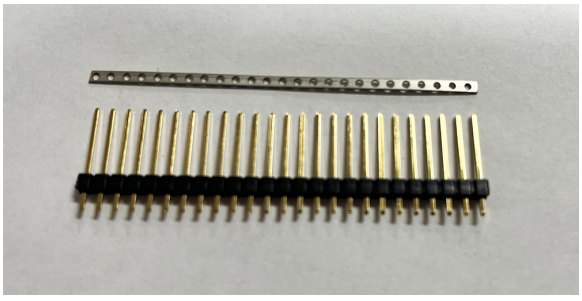

Figure 5: Header pins and bus strip

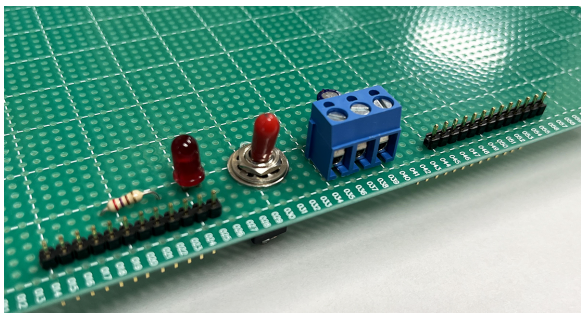

Figure 6: Component side of board

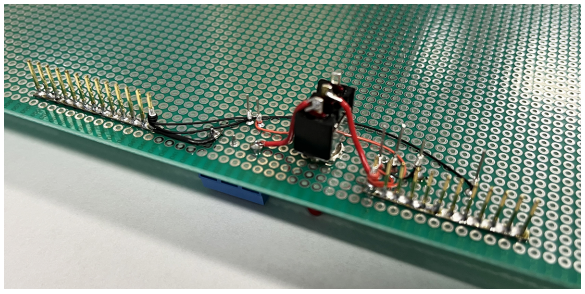

Figure 7: Wiring side of board

Look closely at the washer and note that it has a small prong in the inside of the washer's hole, and on the outside of the washer a small tab is bent at a 90° angle. The switch will be mounted with the right-angle tab poking into a hole on the board. The combination of the tab and the groove in the shaft of the switch that engages the prong on the washer is used to prevent the switch from rotating in case it comes loose.

Drill a $1/4''$ diameter hole for the toggle switch shaft and then using a smaller drill bit, make a small hole next to the first one for the tab on the washer. Insert the toggle switch through from the wiring side of the board and place the washer on the shaft on the component side so the tab goes into the small hole. Put the lock washer and nut on the switch and use a $5/16''$ nutdriver to tighten them down. If the shaft is sticking up too far, loosen the top nut and adjust the bottom nut to make it fit better.

4 Wiring the Electronic Components

The components on the board are wired up as shown in the schematic in Fig. 1. Figures 6 and 7 show both sides of a protoboard that has had the various components installed.

The electrical connections between the components can be made using wire from the spools in the lab. All wiring between capacitors, resistors and LEDs should be made using wire-wrapping as shown in Fig. 7. Wire-wrapping connections should be done with the thinner 30-gauge wire available in the lab. Connections that go to a solder terminal on a switch or power connector can be made using the 22-gauge hook-up wire. If some of the components are close together you can just bend their leads together and solder them without using any additional wire.

On the terminal block you can select which of the three terminals will be used for the $+5V$ power and which will be used for ground.

The toggle switch is a double-throw switch. Depending on which position the lever is in, the center terminal is connected to one of the two outside terminals. Use the center terminal and one of the outside terminals to make a power switch for the board. Make a connection from the $+5V$ position on the terminal block to one of the outside terminals on the switch. Connect the center terminal of the switch to your $+5V$ bus strip.

Install the capacitor, resistor and LED on the board as shown in the schematic. In Fig. 6 the top of the capacitor can be seen behind the terminal block. It does not have be installed there, you can install it wherever you like. The capacitor is used to help filter out noise on the $+5V$ line coming from either the power supply or from components that will be added later to the board. The capacitor is polarized so it is a good idea to mount it on the board in such a way that you can read the polarization marking after it's installed.

The leads of the resistor should be bent 90°, pushed through two holes of the board and then soldered to the pads to keep it in place.

The LED can be installed sticking straight up. The anode (+) lead of the LED is slightly longer than the cathode (−) lead. In addition the cathode of the LED is marked by a flat spot on the edge of the LED and this side should go towards ground.

Once you have installed the capacitor, LED and resistor on the board, cut the leads of these components

so they are not sticking up too high. When you place the board on the workbench so it's sitting on the four screws you installed above, none of the component leads should be touching the workbench.

The banana plugs are installed on the ends of the power wires using the small screw in the side of the banana plug. Strip about $1/4''$ of the insulation from both ends of the wire. To make a more solid connection, the stripped wire on both ends should be "tinned" by melting some solder into the strands of the wire to make a single solid wire. This will allow the screws that holds the wire into the banana plug and terminal block to hold the wire more securely. On the banana plug, loosen the screw, insert the wire into the barrel of the plug as far as it will go and then tighten the screw. For the blue terminal strip, use the screwdriver to open up the terminal block connector so the wire can be inserted. Insert the wire and tighten the screw. Give a tug on the wires to make sure they are securely fastened.

There should be no bare wire exposed. If you can see bare wire, either where the wire goes into the banana plug or where it goes into the power block, remove the wire and cut off enough of the wire so no bare wire is exposed when the wires are inserted into the plug or block.

5 Testing

Once all the components are installed on the board and wired together, plug it in to the bench power supply and turn on the power supply. Turning the switch on the board on and off should make the LED go on and off. Use the multimeter to confirm that there is $+5V$ present on **all** the pins of the power bus when the switch is on.

While the board is turned on and the multimeter is measuring the voltage level, bang the board on the bench top a few times (not too hard) and watch to make sure the power stays on. If the power flicks off and back on at all then something is loose on the board and you'll need to find the loose connection and fix it. You want the power connections to be rock solid so you don't have to worry about getting stable power to the rest of the circuit.