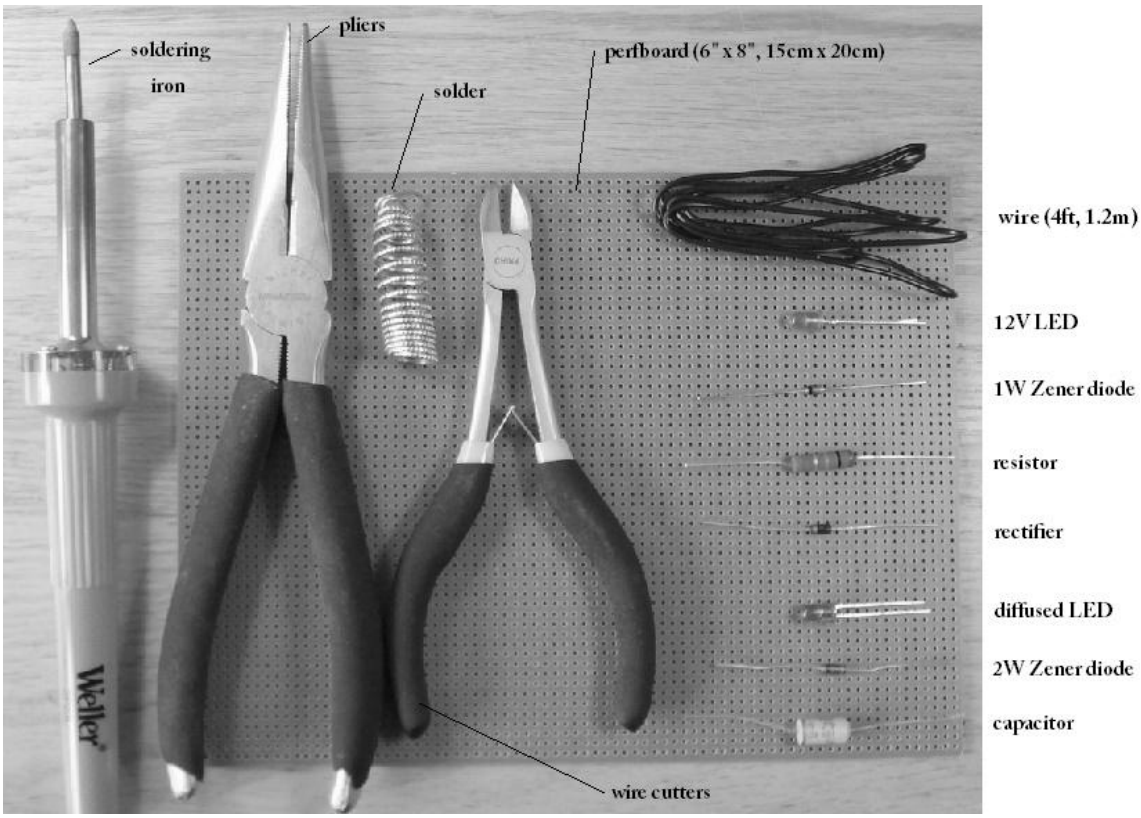
5 Building a Defibrillator Tester

5.1 Objective:

In this lab you will construct a device that tests the output of a defibrillator to ensure that it can deliver a sufficient shock to restart a heart. This circuit was designed by undergraduate students at Vanderbilt University.

5.2 Parts List:



12V 5mm LED	soldering iron
1W, 3.9V Zener diode	pliers
1.0M ohm, 3W resistor	solder
1A, 50V rectifier	perfboard, 15cm x 20cm
Diffused, round, long LED	wire cutters
2W, 15V Zener diode	super glue
63V, 4.7uF capacitor	wire, roughly 1.2m
permanent marker	multimeter

Figure 1: Parts for constructing the defibrillator tester.

5.3 Procedures

5.3.1 Introduction to Defibrillators

A monophasic defibrillator is capable of delivering a 10-350 Joule shock across two paddles or stick-on pads for a duration of about 40 milliseconds. Unlike popular culture's depictions of the machine, defibrillators are not the preferred choice of treatment when a patient is "flat-lining" or has no detectable heartbeat (continued administration of CPR is recommended in these cases). Rather, these devices serve as an electrical reset for the heart and will be most effective when the patient is undergoing ventricular fibrillation (uncoordinated heart muscle contractions). The jolt from the machine clears the random electrical firing causing the lack of coordination, essentially stopping the heart momentarily and allowing structures like the sinoatrial node to regain control of the contractions.

The powerful shock presents several safety issues: when using defibrillators, never allow the two paddles to touch each other; this could harm the operator and severely damage the device. In a real life use of a defibrillator, no one should be in contact with the patient being shocked. A small amount of gel should also be used on the paddles, lowering resistance of the body and helping limit burns where the paddles are placed.

5.3.2 Defibrillator tester design theory

The circuit you will construct is designed to output a visual signal based on the power of the defibrillator that is being tested. If, during the test, the defibrillator is outputting 11 Joules (equivalent to 388V across the grids) in this circuit or less, neither of the two LEDs will light. When a defibrillator's shock contains more than 11J but less than 150J (1410V), the 12V LED will turn on. Unless the parts list has been modified, this 12V LED is the green LED. A shock with more than 150J will activate both LEDs. The power values are relevant in understanding the functionality of the defibrillator being tested. The equivalent voltages, derived based on the circuit's construction, are relevant when the tester *itself* is being tested. Later in this lab, power supplies will be used to ensure the defibrillator testers are lighting up near the appropriate voltages.

5.3.3 Assembling the circuit

The circuit will be laid out on perfboard such that the electronic parts are in a central column. The paddles of the defibrillator will be placed onto bare-wire grids on either side of this column as show in the sketch below.

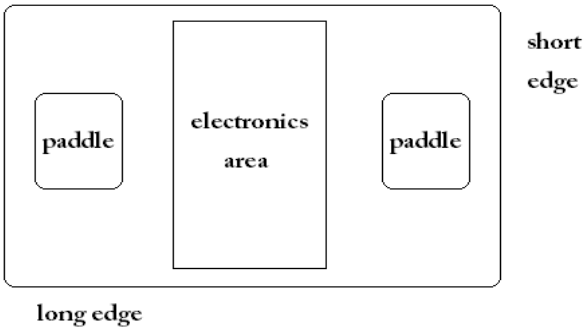


Figure 2: The general layout for the defibrillator tester.

You will begin by laying out and soldering the electronics area. Before beginning, ensure you keep track of the identity of each part during assembly. This is especially important for the 2W Zener diode and the rectifier as the two components appear very similar.

The circuit should be laid out in a similar manner to Figure 3. Notice that two imaginary columns of holes are visible in the perfboard and that the lead of every component falls into one or both of these columns. Also note the polarities indicated in the text to the right of the figure. The negative terminal of an LED is slightly shorter if the LED has never been clipped; the negative end may also be identified by a slight flat area near the bottom of the plastic case of the LED. Other diodes have their cathodes distinguished by a colored band.

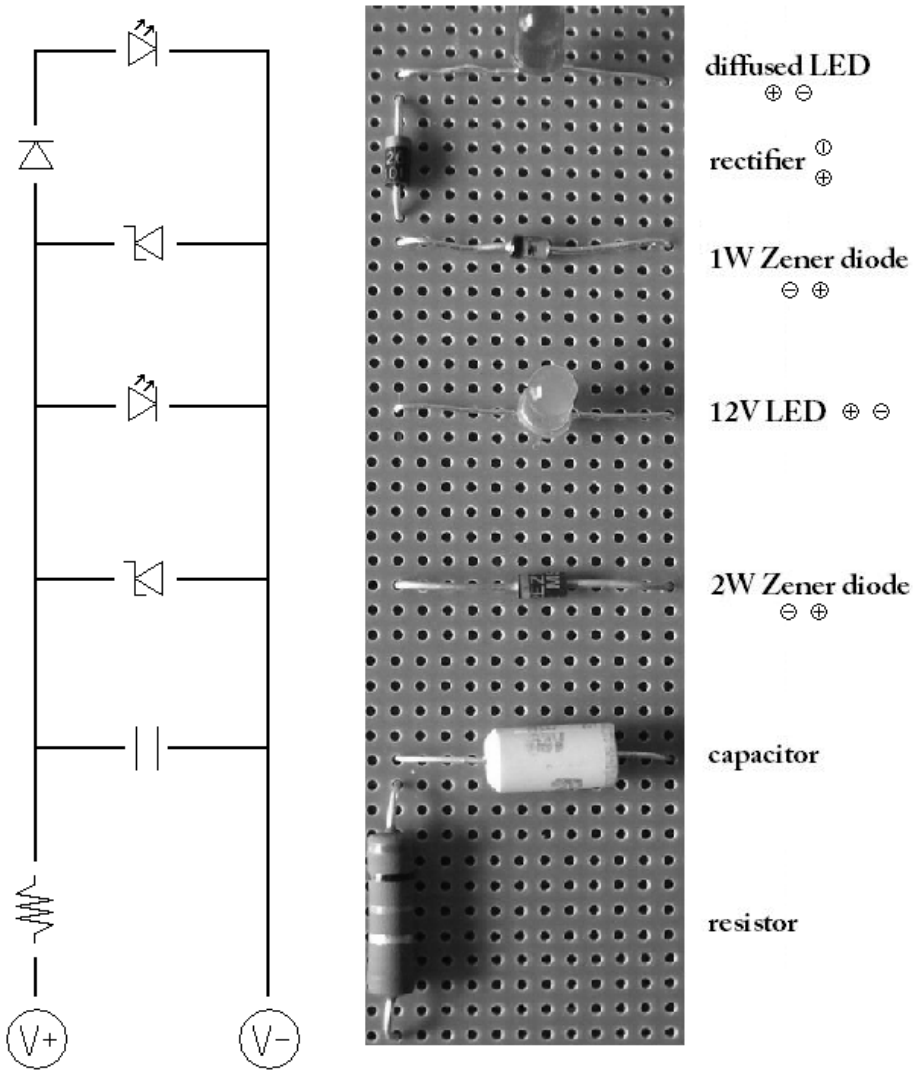


Figure 3: Top layout of the circuit. The + and – symbols indicate the polarity of each piece.

A soldering job like that performed in the soldering lab can be completed on three of the connections in the circuit. In these cases (seen for both leads of the rectifier and one lead of the resistor) connections from one component are being directly soldered to the leads of another

part. Be sure to use the hook and hook connection technique.

The other connections require small jumper wires. These can be made from the piece of wire in the parts list or they may be purchased. Seven small jumpers will be required. Figure 5 shows the completed “electronics column” from the top and bottom.

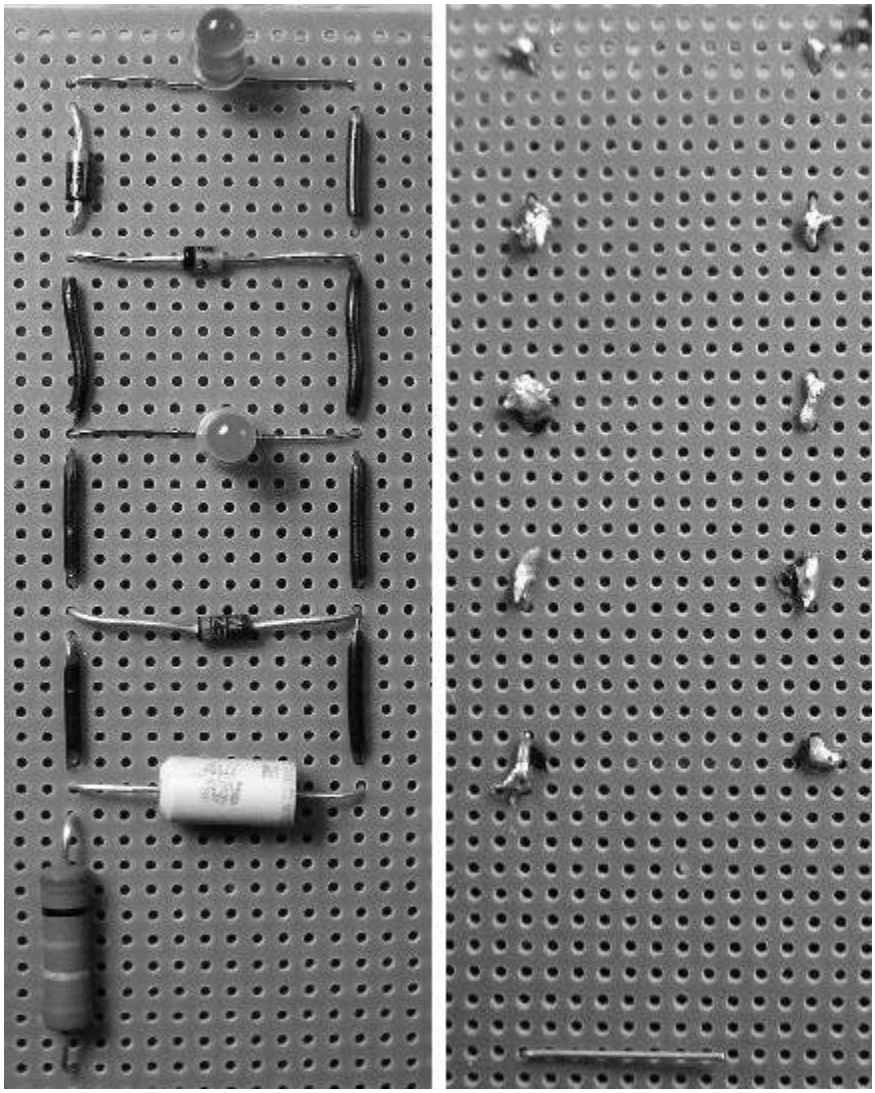


Figure 5: The front and back of the completed “electronics column.”

The circuit schematic in Figure 3 shows where power will enter the circuit. Two separate meshes of exposed wires will be made in this step and then electrically connected to the column of electronics. When a defibrillator is being examined, the paddles will be placed on the grids and then the shock will be administered.

You will first need to remove the insulation from approximately 1 meter of wire; it might be easier to do this with a knife rather than traditional wire strippers. Run the edge of the blade down the length of wire until you can barely see the metal beneath the plastic. If you're nimble, you should be able to pull back the plastic cover, separating it from the rest of the wire. Peel the

covering back to the start of the cut, slice the plastic off, and repeat the process until the entire wire is bare.

The mesh will be approximately 1.5” x 2.5” or 4cm x 6.5cm. To provide a more uniform contact area between the device and tester, the longer wires should be woven in between the shorter, horizontal wires. After the horizontal wires have been put in place, lay down the vertical wire such that it alternates passing above and below the horizontal ones. All intersections should be soldered together so the entire grid is electrically connected. A completed mesh can be seen in Figure 6; remember to make one on the left of the electronics column and another mesh for the right.

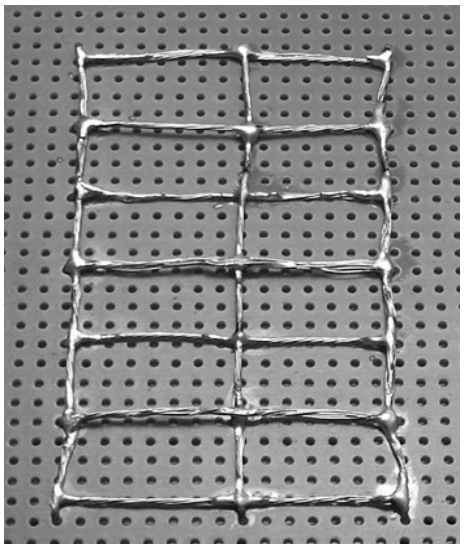


Figure 6: One of two completed meshes, the contact point for the defibrillator's paddles. Each intersection is soldered above the board. The corners are soldered below the board to keep the grid in place. The three vertical wires are woven among the seven horizontal wires to improve the contact area's uniformity.

Once the paddle meshes have each been made on the board, they will need to be connected to the electronics column. This is accomplished via two more small jumpers. So long as the schematic shown in Figure 3 is followed, the physical placement of the jumpers is irrelevant. Figure 7 depicts the completed defibrillator tester.

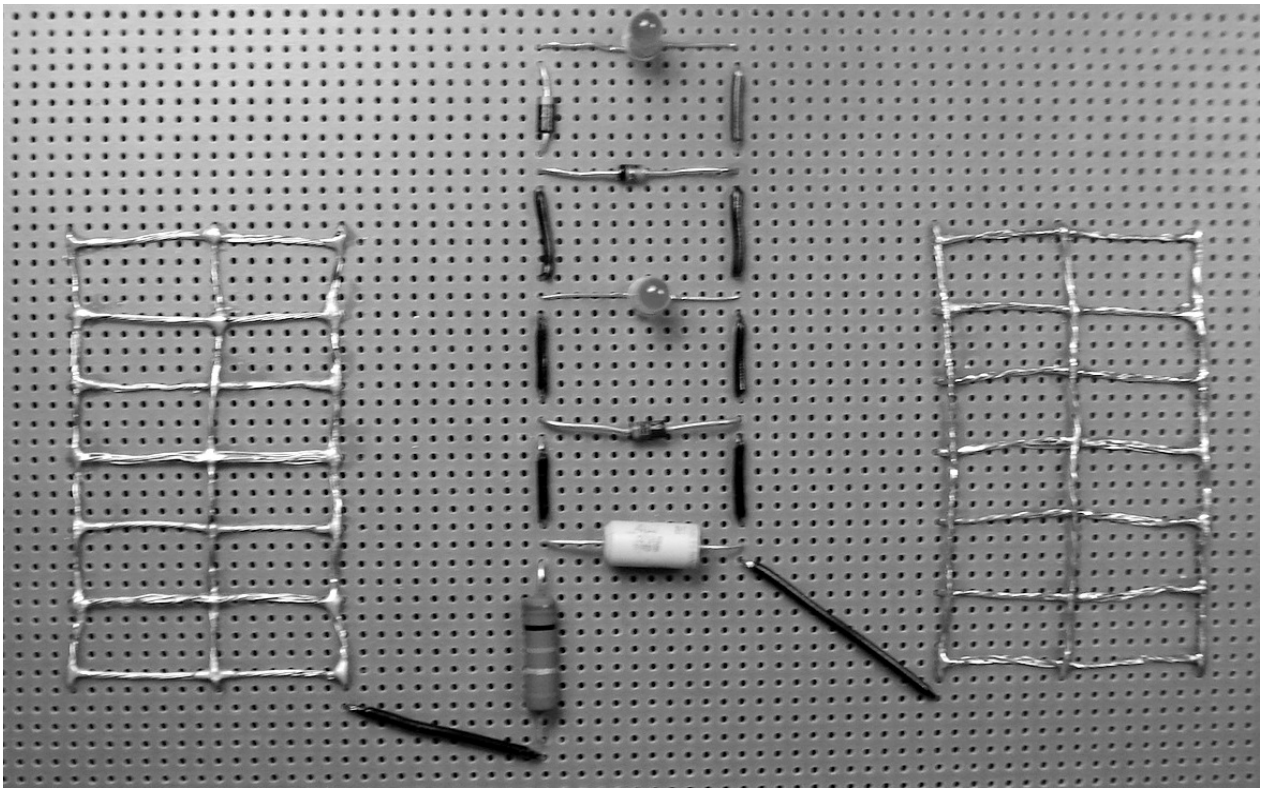


Figure 7: After the paddle-to-electronics jumpers are installed, the board is complete.

5.3.4 Testing the circuit

The device you just completed needs to be tested to ensure the LEDs light up at the correct voltages. If you have a defibrillator, simply check that the device lights up as expected (note that it won't necessarily work with the newer biphasic defibrillators).

If you don't have a defibrillator, you can still test your device. Two tests will be used, the first of which requires a completed power supply from another lab. If that section has not yet been covered, perform the alternate test first and return to this lab when the power supply is finished.

To verify that your tester works, take the negative lead of the power supply and place it on the grid of wires that directly connects to the capacitor. (This is the negative grid; it is on the right in Figure 7 and should be labeled with a negative symbol using a permanent marker. Also label the right grid with a plus sign.) Make sure the power supply is off. The positive lead should be placed on the capacitor's wire that is nearest the resistor (the left lead in Figure 7). While keeping the leads firmly in place, turn on the supply at 0 volts, then increase the voltage across the capacitor from 1V to around 25V. If the circuit is functioning correctly, the top LED should light up and remain on above a certain voltage level. With the voltage continuing to increase, the second LED should light as well.

The second test makes use of the multimeter. Measure the resistance between the lead of the capacitor nearest the resistor (this lead is on the left in Figure 7) and the positive grid on the tester. The measurement should be close to the impedance of the installed resistor, 1.0M ohms.

5.3.5 Instruction box

The image below should be cut out and super-glued to the back of your functional defibrillator tester.