

EECS 40

Introduction to Basic Electronics

Experiment Guide

1. Objectives

The purpose of this first experiment is to introduce you to:

- a. Resistors
- b. Simple Circuits
- c. Breadboards
- d. Multimeter
- e. Power supplies

2. Theory

Before we go on to study the equipment, let us review some basic concepts on voltages, currents, resistors and circuits.

a. Resistor

A resistor is schematically shown in Fig. 1. Its characteristic equation or “terminal relation” is given by Ohm’s Law:

$$V = IR$$

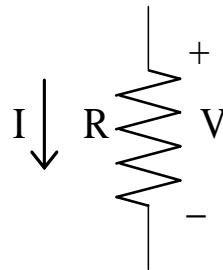


Figure 1

A potentiometer (pot) is a variable resistor. It has a constant resistance between pins 1 & 3 (see Figure 2) and the knob controls the resistance between pins 1 & 2 and 2 & 3.

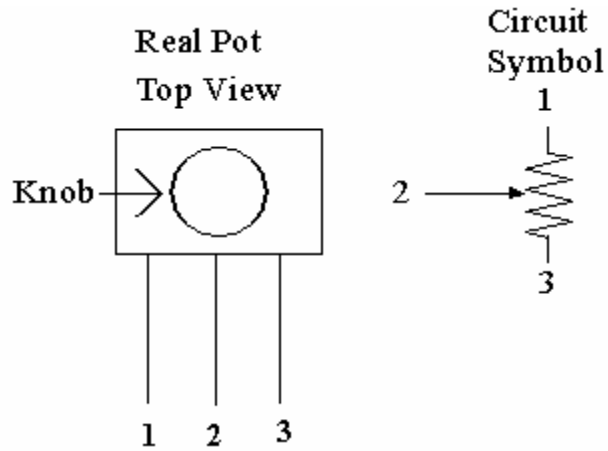


Figure 2

b. Voltage source

The circuit symbol for an ideal voltage source is shown in Figure 3. Its one characteristic is that the voltage across its terminals is always V volts, no matter what the current going through it is.

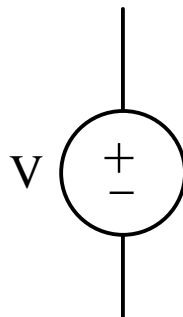


Figure 3

c. Current source

The circuit symbol for an ideal current source is shown in Figure 4. Its one characteristic is that the current through it is always I amps, no matter what the voltage across it is.

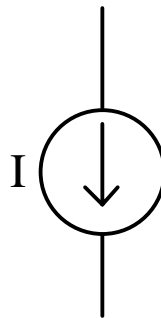


Figure 4

d. Series and Parallel connection (see Figure 5 and Figure 6 respectively):

This is when the devices are connected in such a way that both devices have the same current flowing through them.

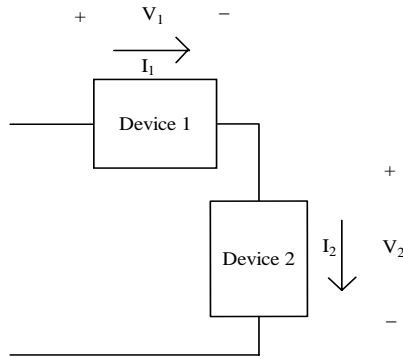


Figure 5

$$I_1 = I_2$$

Parallel connection is when the devices are connected in such a way that they have the same voltage across them.

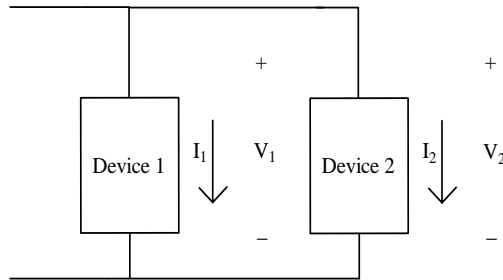


Figure 6

$$V_1 = V_2$$

f. Resistors connected in series (see Figure7):

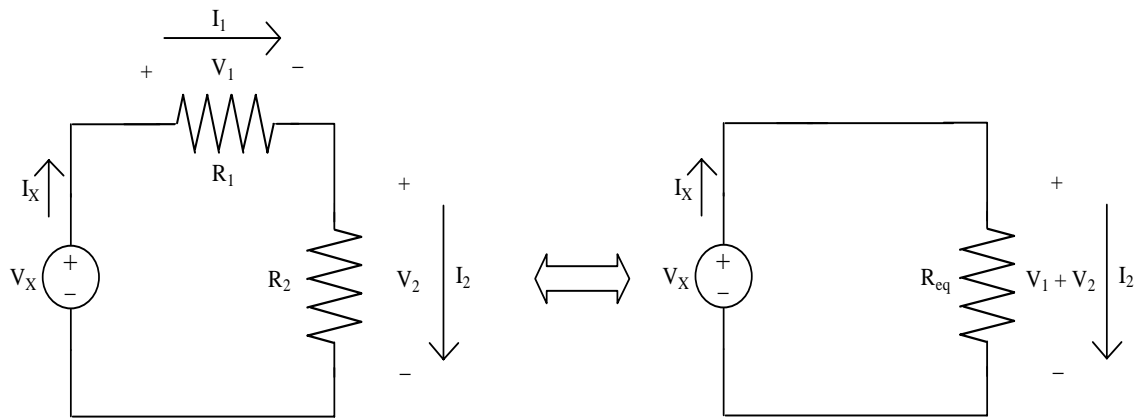


Figure 7

$$I_x = I_1 = I_2$$

$$V_x = i_x R_1 + i_x R_2$$

$$\frac{V_x}{i_x} = R_{eq} = R_1 + R_2$$

g. Resistors connected in parallel (see Figure8):

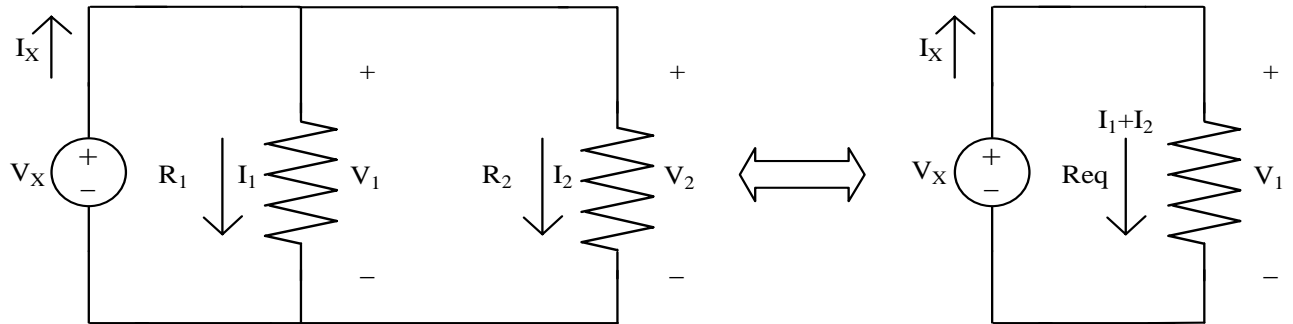


Figure 8

$$i_1 = \frac{V_x}{R_1}, i_2 = \frac{V_x}{R_2}$$

$$i_x = i_1 + i_2$$

$$i_x = \frac{V_x}{R_1} + \frac{V_x}{R_2}$$

$$\frac{1}{R_1} + \frac{1}{R_2} = \frac{i_x}{V_x} = \frac{1}{R_{eq}}$$

h. Voltage divider (see Figure 7):

$$V_x = i_x R_1 + i_x R_2$$

$$V_1 = i_x R_1, V_2 = i_x R_2$$

$$\frac{V_2}{V_x} = \frac{i_x R_2}{i_x (R_1 + R_2)}$$

$$V_2 = V_x \frac{R_2}{R_1 + R_2}$$

$$V_1 = V_x \frac{R_1}{R_1 + R_2}$$

Before we move to the experiment, we will talk about the some of the equipment in your lab.

a. The Power Supply

A photograph of the HP E3631A triple output DC power supply is shown in figure 9.

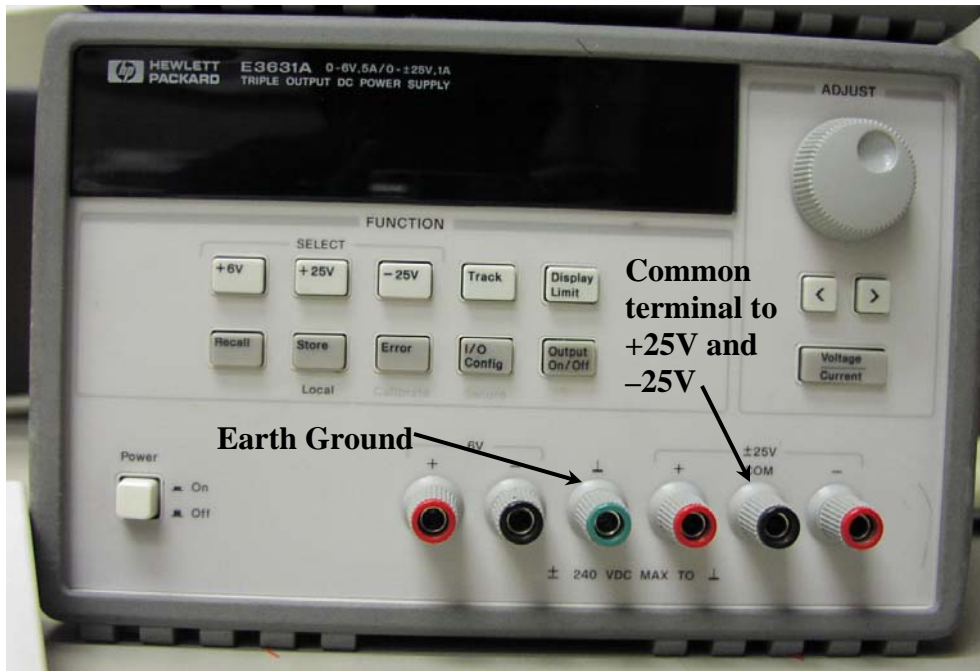


Figure 9

Like a battery, a DC power supply provides a constant voltage for powering electronic circuits. But, unlike a battery, the power supply will provide continuous power as long as it is connected to a wall outlet. Furthermore, you can set the voltage of the supply and set the maximum current (the current limit feature) that can be drawn from it. The multimeter will NOT output a value of current greater than the set limit. It may adjust the output voltage to match this maximum value of current. This is useful when you know beforehand that your circuit cannot tolerate more than a certain current or power. Setting current limits is described further below.

The HP E3631A triple output DC power supply contains three variable voltage sources, with maximum voltage values of +6V, +25V, and -25V. The 6V supply operates independently of the +25V and -25V supplies, which share a common terminal. (Look at figure 8 and try to spot the buttons for the three voltage settings). To a certain limit, all three voltage sources can be connected independent of earth ground, which is actually connected through the building wiring to the earth.

The concept of “ground” is **VERY IMPORTANT**. A ground node means the potential at that node is 0 volts. Since voltages are always differences in electric potential, “236 volts” means 236 volts with respect to a ground node. In figure 9 above, there is only ONE true ground (the green earth ground terminal). None of these terminals is automatically functioning as a ground in your circuit unless you explicitly connect one of

these to all the ground connections indicated in your schematic. Schematics often use implied ground references, so until you become accustomed to them, you may redraw the schematic with all wiring explicitly shown by lines. A schematic view of the terminals in figure 9 above is shown in figure 10 below.

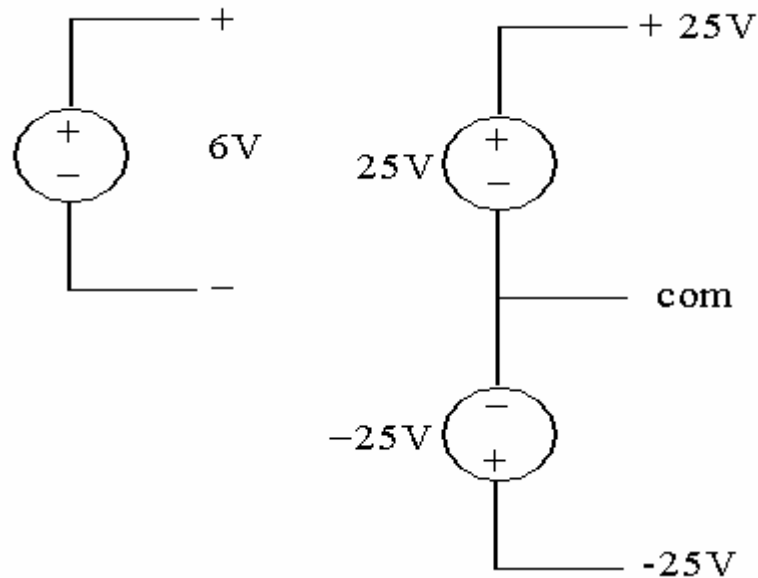


Figure 10

To set a voltage source:

1. Disconnect the power supply from a circuit and turn it on.
2. Make sure that the supply's output is off. This can be toggled by hitting the output on/off key. The display will say OUTPUT OFF when it is off or it will display the output voltage and current.
3. Select which source you would like to set, the +25V, the -25V or the +6V by hitting the corresponding key on the supply. The supply you have selected will be displayed along the bottom of the display screen.
4. Now, you set the voltage and current limits. Hit the display limit key. You will know that you are changing the limit because LMT will be displayed along the bottom of the display.
4. Select to set the voltage or current limit by hitting the voltage/current key. The one that is blinking is the one that you are editing.
5. When done setting the limits, hit the display limit key again to return to displaying the actual output.
6. Turn the output on once you have connected the supply to the circuit.

b. The breadboard

A photograph of a section of the breadboard (or protoboard) is shown in figure 11 below.

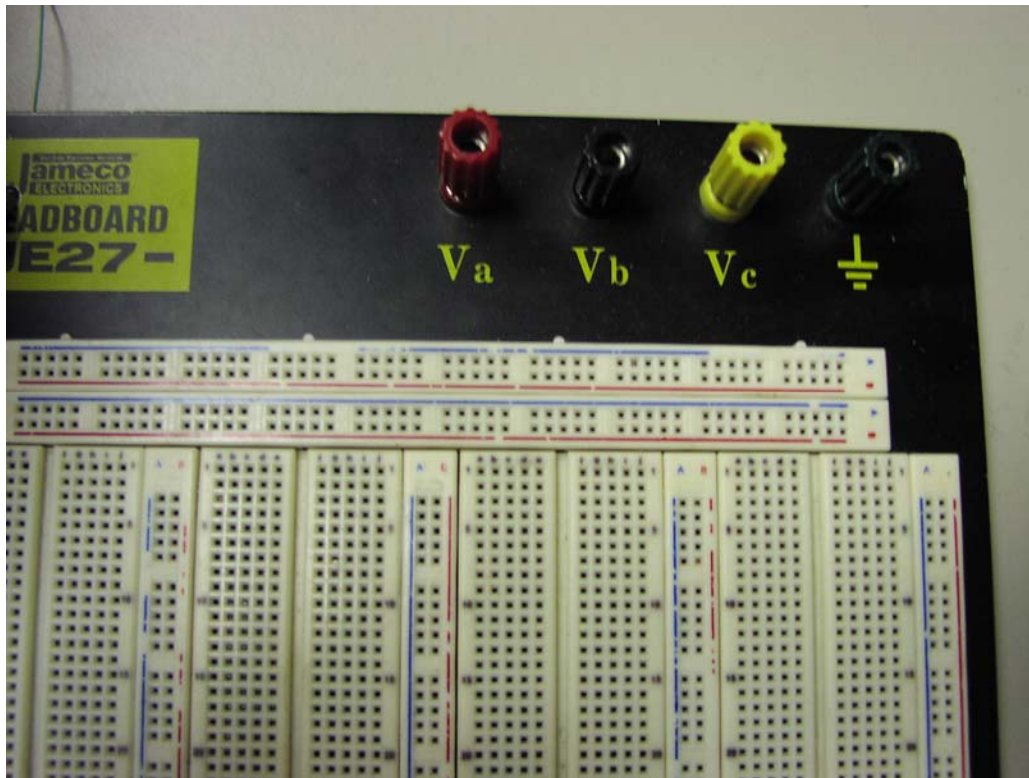


Figure 11

This type of breadboard is very useful for prototyping circuits that use integrated circuits in DIP packages. The IC will straddle the white line between columns e and f. Underneath the breadboard are pieces of metal that will serve as wires in your circuits. In the main section, these wires connect rows of five: from columns a through e, and separately columns f through j. The other useful type of wiring is called “bus wiring”. A bus wire runs the whole way along the blue line (A) and another separate wire runs the whole way along the red line (B). Use these “buses” for ground, power, and any other signal that must be accessed from many parts of the circuit.

There are also four binding posts at the top of the board that are not connected to anything yet...you must route a wire from the breadboard to the post and use the post to connect that node to other devices like the power supply, meters, or signal generator. These are provided for your convenience; always look for ways to make your life easier in the lab by using the available connectors, probes, and equipment.

c. The Multimeter

The HP 3401A is a digital multimeter (DMM) that will be extremely handy in making basic electrical measurements including voltage, current, resistance, and continuity.

When you first turn on the DMM, it is set to measure DC voltage across the two input terminals labeled V (figure 12). Other measurement functions are accessed from the front panel buttons and many functions are available using the blue-gray shift key (figure 12).

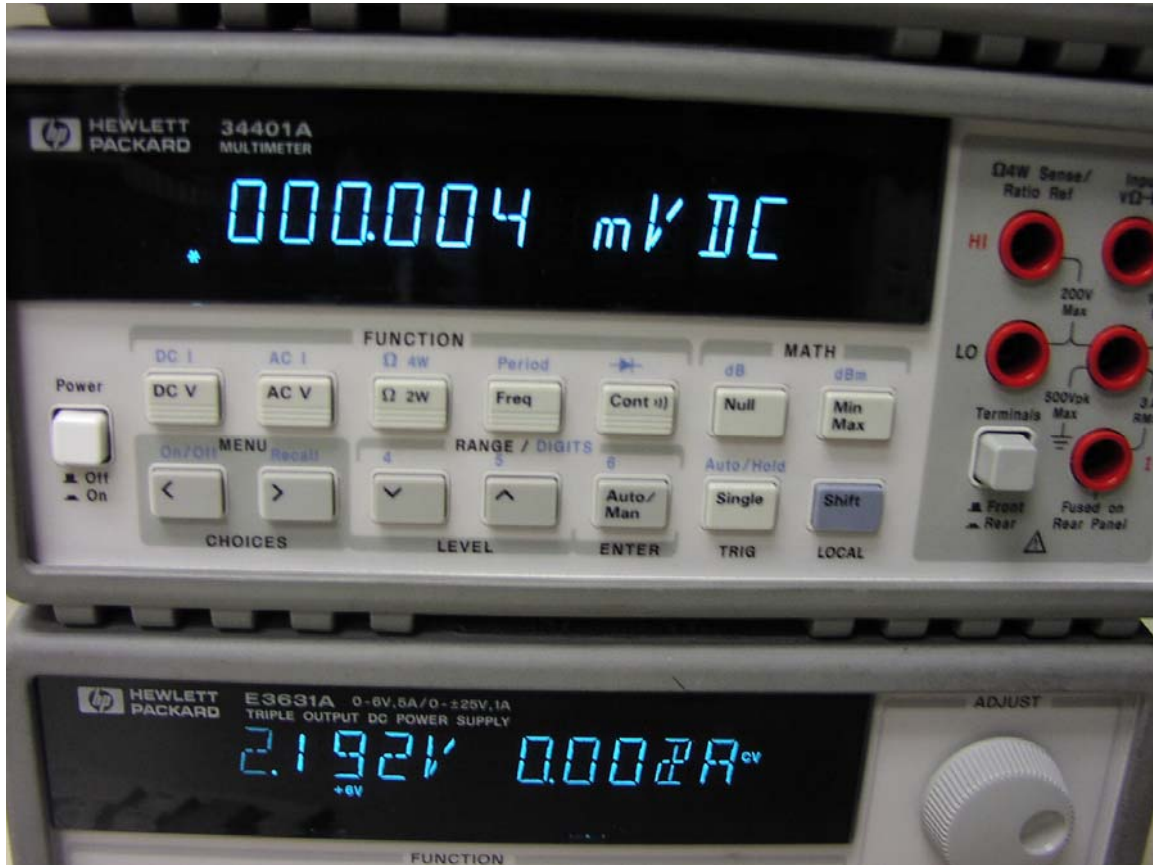


Figure 12

Here are some rules on how to use the multimeter. However, this is not an exhaustive list. If we try to do that, we will be rewriting the multimeter User's Guide. So, while you might be able to figure out how to use most features of the multimeter yourself, the User's Guide will come in handy for understanding some of its other less-known capabilities.

1. When measuring resistors (fixed resistors or variable “pots”), you must first unplug the component from the circuit. The reason is Thevenin's theorem and you will learn this later.
2. When measuring voltage (DC and AC) across an item, the measurement is made with the meter in PARALLEL with the item (the DUT or Device Under Test in figure 12(b) below). The multimeter is said to be acting as a “voltmeter” (see figure 12(b) below). When measuring current (DC and AC) through an item, the circuit must be broken open

and the meter placed in **SERIES** with that item. The multimeter is said to be acting as an “ammeter” (see figure 12 (b) below).

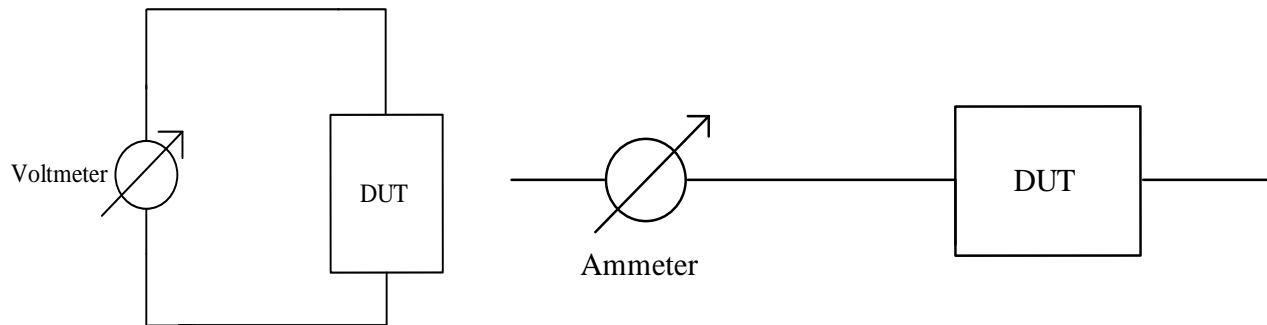
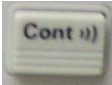


Figure 12 (b)

The concept of connecting the ammeter in series is very important. The ammeter has a very small resistance inside it and the current you want to measure flows through this resistor. The ammeter measures the voltage across this known resistance and then uses Ohm’s law to calculate the current. The key point to note here is that the resistance is low. If it were comparable to the resistance of the DUT you would then be changing the value of the current in the circuit.

3. Your multimeter is equipped with a continuity tester. It checks if two nodes in your circuit are connected or not. Your multimeter will emit a high-pitched beeping noise if the resistance between the two nodes falls below a 50 Ω indicating a potential short

circuit. To access this feature, hit the  button.

3. Hands on

a. Components Checklist

Make sure you have the following components on your workbench BEFORE you begin the experiment.

1. Wires
2. Alligator clips or Banana plugs
3. Two 1 k resistors
4. One 10 k potentiometer

b. Experiment

i. Understanding the breadboard connections.

- a. Stick two wires into the breadboard as shown in figure 13. You may need to strip them using the wirestrippers on your workbench. Use the continuity tester in the multimeter to determine if the two wires are connected.

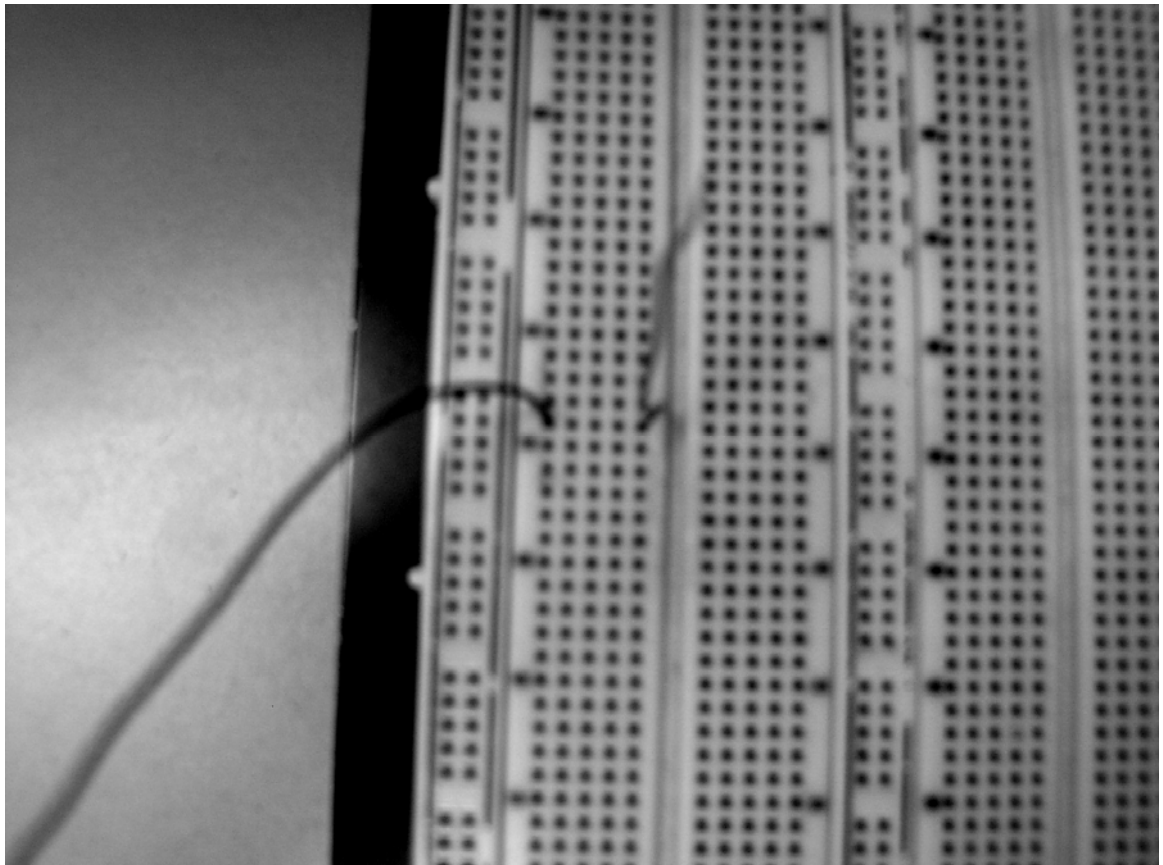


Figure 13

- b. Repeat part (a) for figure 14.

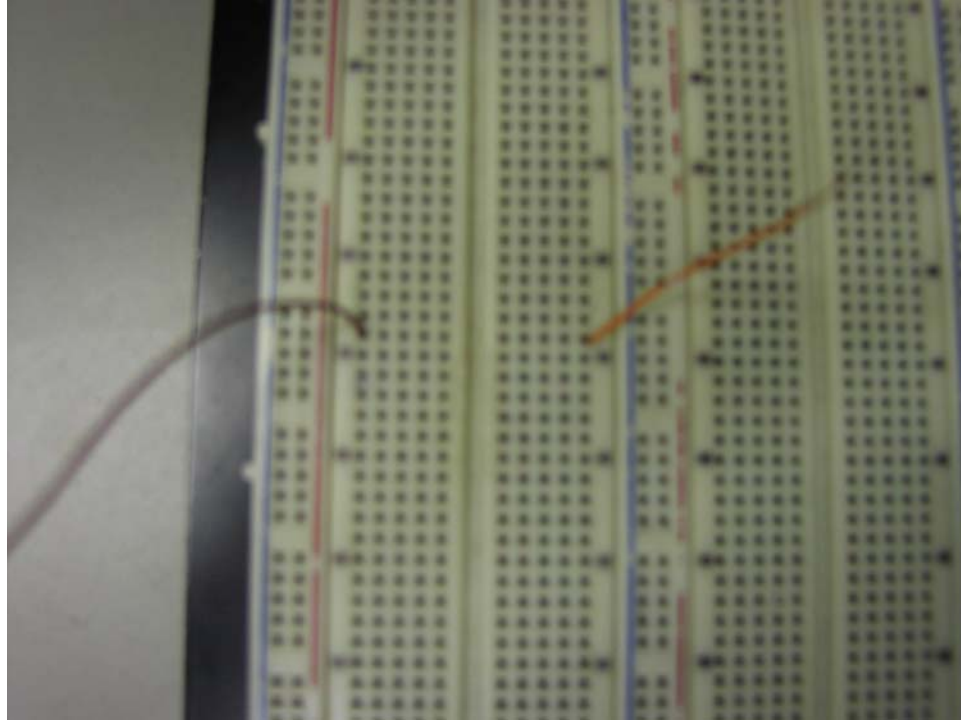


Figure 14

c. Repeat part (a) for figure 15.

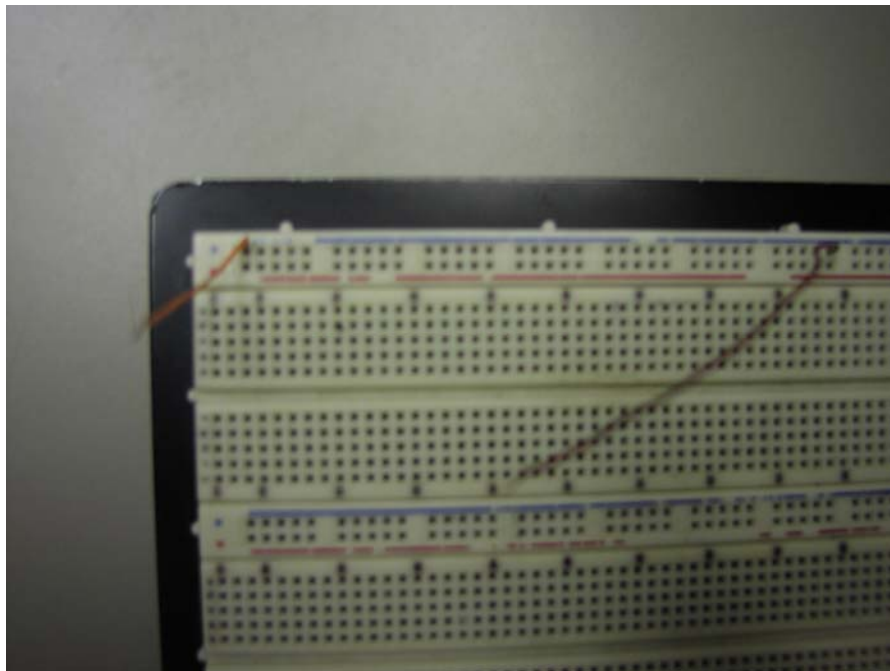


Figure 15

ii. Use multimeter to measure power supply voltages.

- a. Turn on the power supply and the your multimeter. Set your multimeter to measure DC voltage. Adjust your power supply to output 5 V and 14 V.
 - b. Measure the two voltage values using your multimeter.
- iii. Use multimeter to measure some resistors and pots.
- a. Measure the resistance of your 1 k resistor using your multimeter.
 - b. Measure the resistance between the outer two legs of your potentiometer using your multimeter.
 - c. Measure the resistance between the middle leg and any of the outer two legs of your potentiometer using your multimeter.
- iv. Simple series circuit.
- a. Build the circuit shown in figure 16 on your breadboard. Set V_x to be 5 V and $R_1 = R_2 = 1$ k.

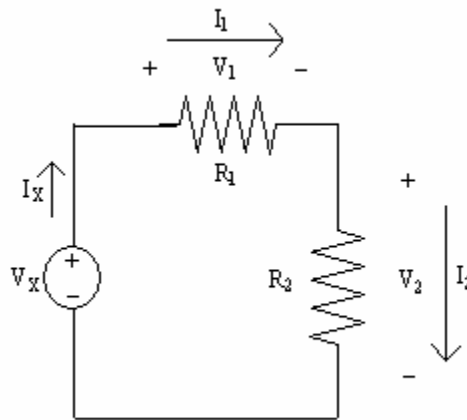


Figure 16

- b. Measure the voltage across and the current through R_1 .
- v. Simple parallel circuit.
- a. Build the circuit shown in figure 17. Set V_x to be 7 V and $R_1 = R_2 = 1$ k.

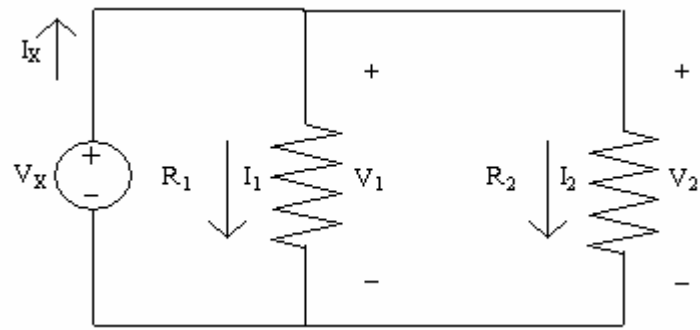


Figure 17

- b. Measure the voltage across and the current through R_2 .