

EE 43/100
Introduction to Basic Electronics
Experiment Guide

1. Objectives

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

- a. Resistors
- b. Basic circuit measurements
- c. Breadboards
- d. Multimeter (DMM)
- 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:

$$V = IR$$

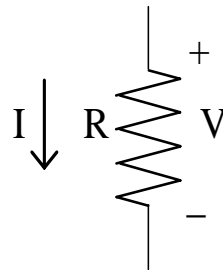


Figure 1

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.

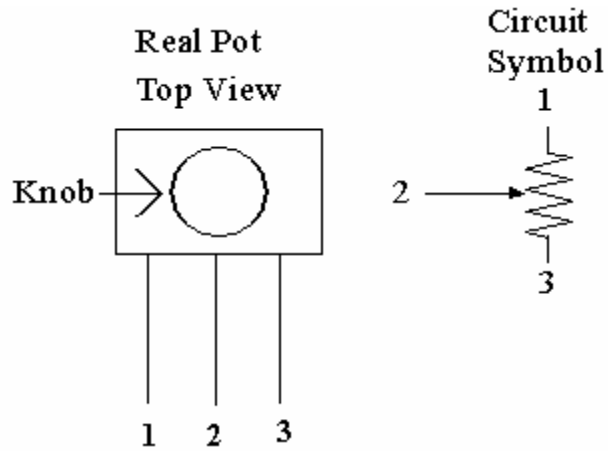


Figure 2

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.

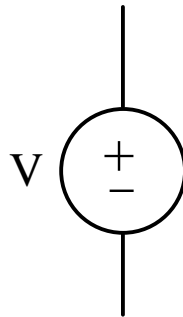


Figure 3

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.

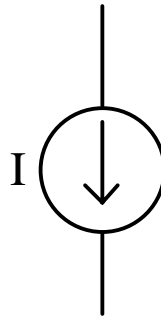


Figure 4

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.

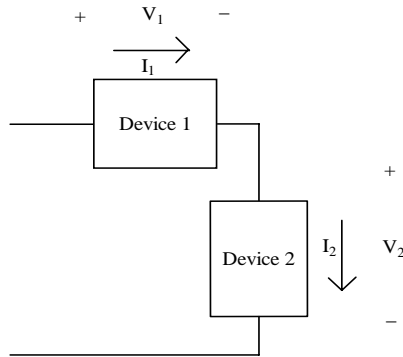


Figure 5

$$I_1 = I_2$$

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

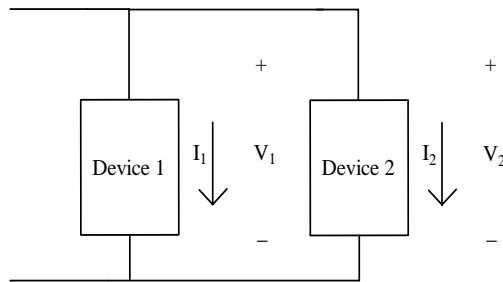


Figure 6

$$V_1 = V_2$$

f. Resistors connected in series (see Figure7):

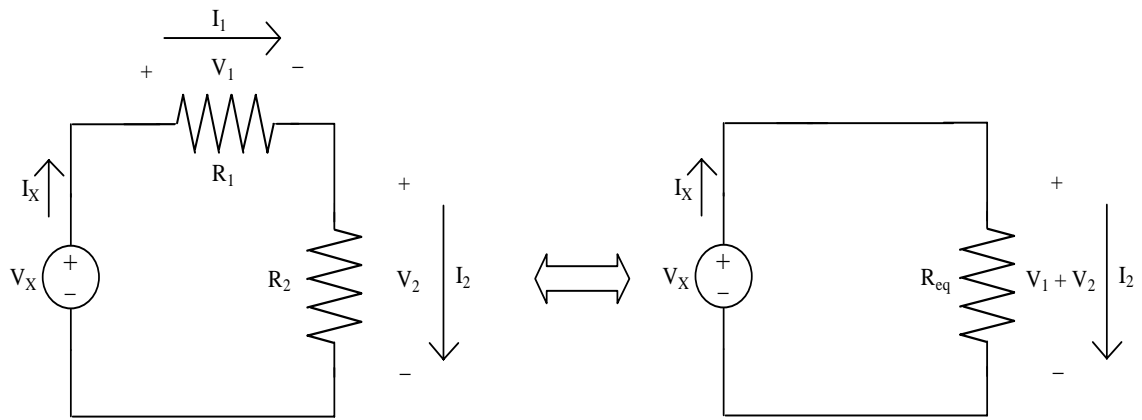


Figure 7

$$I_x = I_1 = I_2$$

$$V_x = i_x R_1 + i_x R_2$$

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

g. Resistors connected in parallel (see Figure8):

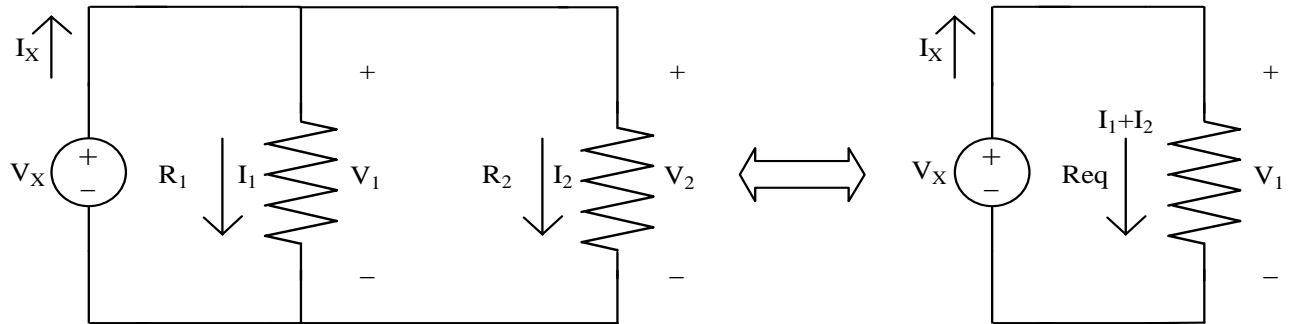


Figure 8

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

$$i_x = i_1 + i_2$$

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

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

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.

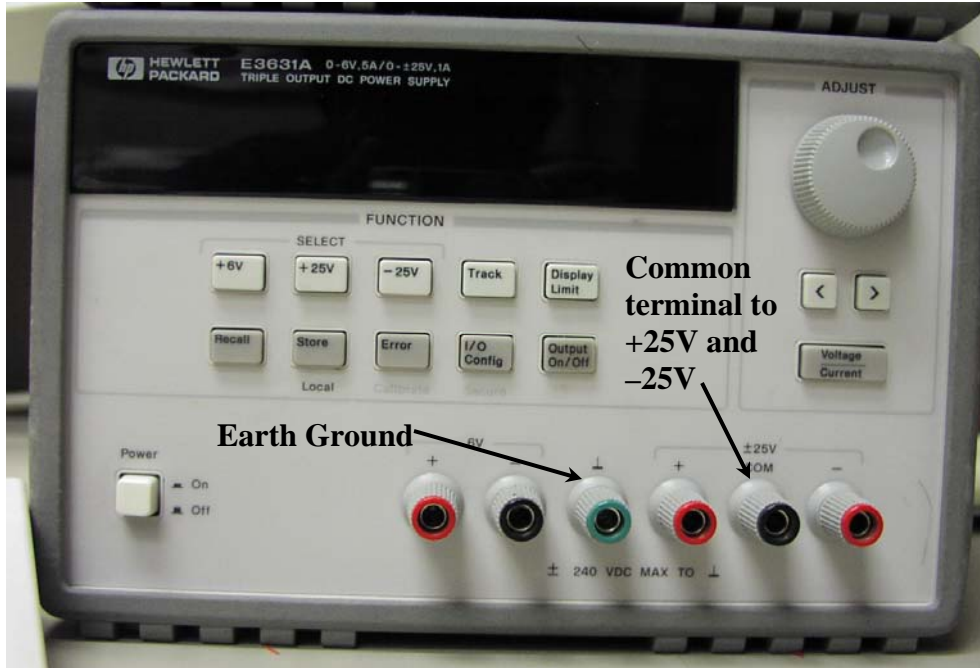


Figure 9

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 is a piece of wire designated by a human to be the voltage reference for other nodes. Thus, with reference to itself, the ground node is at 0 volts. If a node is at “236 volts”, we must assume it is 236 volts above the 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.

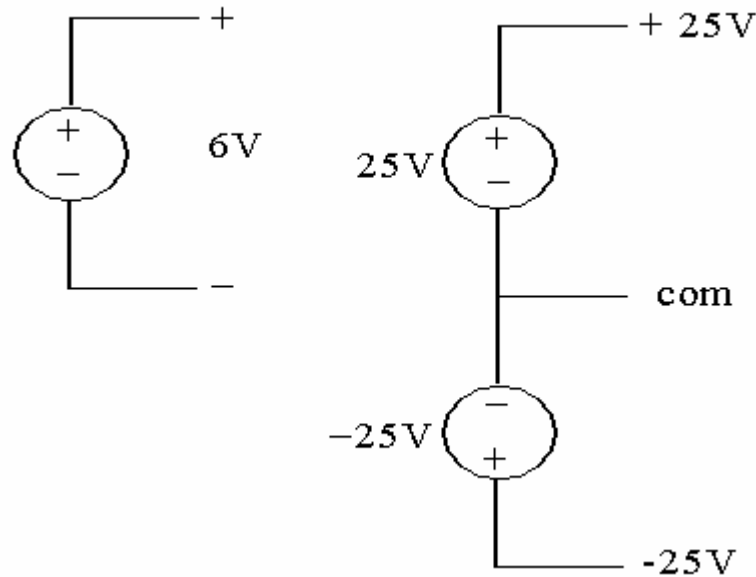


Figure 10

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.

Follow the above steps to power a very simple circuit: a short circuit. Take a wire with banana plug ends and put end into the +25 V output; put the other into Common. Set the

voltage limit to 5 V and current limit to 100 mA. Turn the output on and explain why the current and voltage are limited.

b. The breadboard

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

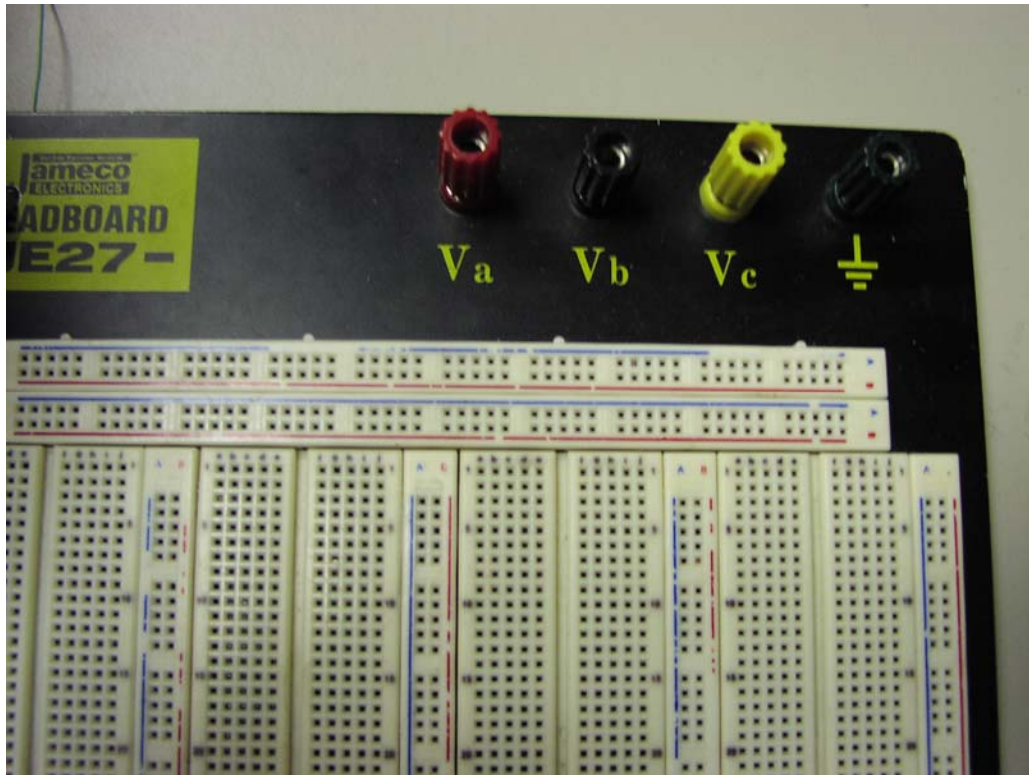


Figure 11

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).

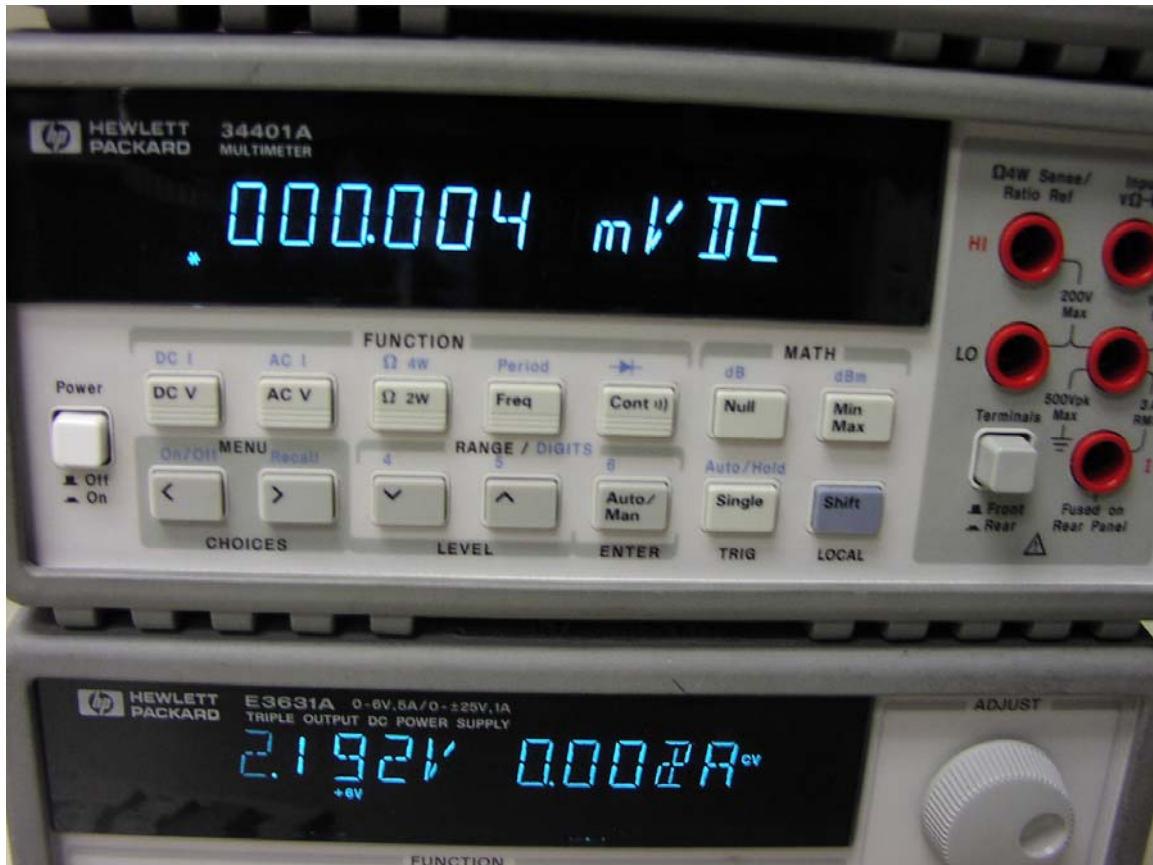


Figure 12

Here are some rules on how to use the DMM. However, this is not an exhaustive list. If we try to do that, we will be rewriting the DMM User's Guide. So, while you might be able to figure out how to use most features of the DMM 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. Otherwise, some of the DMM probe current will also run through circuit paths other than the resistor. 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 DMM 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 DMM is said to be acting as an “ammeter” (see figure 12 (b) below).

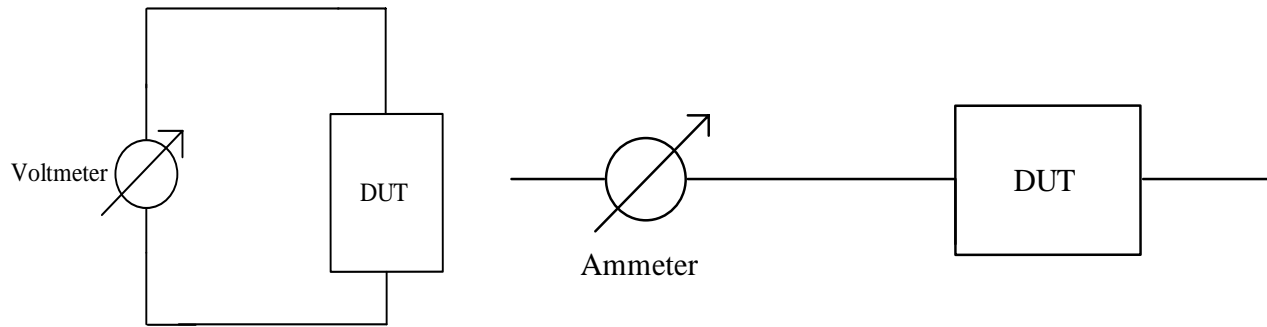



Figure 12 (b)

3. When measuring current (DC and AC) through a circuit wire, the wire must be replaced by the DMM in ammeter mode. Ideally, ammeters have zero resistance and the exact current you want to measure flows through it. Some ammeters measure the voltage across a known near-zero internal resistor and use Ohm’s law to compute 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. Since ammeters have low-resistance, please do not put an ammeter in series with a voltage supply.

4. The DMM is equipped with a continuity tester. It checks if two nodes in your circuit are connected (short circuit) or not. The DMM 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. Try touching the probes together.

3. Hands on

a. Components Checklist

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

1. Wires for the breadboard
2. Wires with 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 DMM to determine if the two wires are connected.

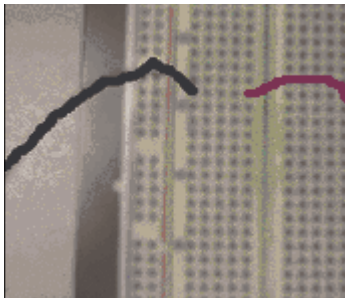


Figure 13

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

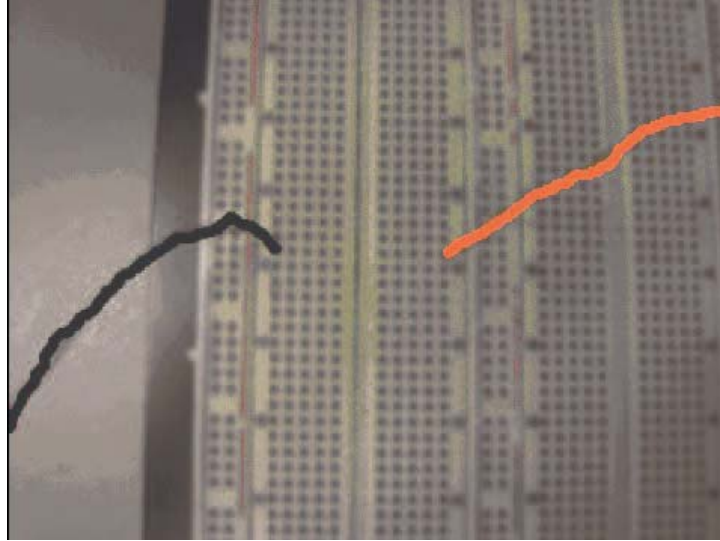


Figure 14

- c. Repeat part (a) for figure 15.

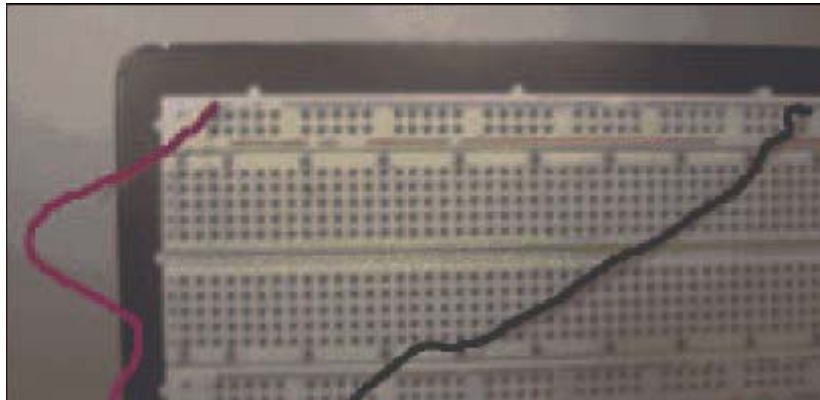


Figure 15

- ii. Use the DMM to measure power supply voltages.
 - a. Turn on the power supply and the DMM. Set the DMM to measure DC voltage. Adjust the 6 V output to 5 V, then adjust the +25 V output to 14 V.
 - b. Measure the two voltage values using the DMM.
- iii. Use the DMM and breadboard to measure some resistors and pots.
 - a. Plug the ends of the resistor in the breadboard such that the resistor is not shorted. Measure the resistance of your 1 k resistor using the DMM.
 - b. Plug the wires of the pot anywhere into the breadboard where they will not be shorted. Measure the resistance between the outer two legs of the potentiometer using the DMM.

- c. Measure the resistance between the middle leg and any of the outer two legs of the potentiometer using the DMM.

iv. Simple series circuit.

- a. Build the circuit shown in figure 16 on your breadboard.
Set V_x to be 5 V and $R_1 = R_2 = 1\text{ k}$.

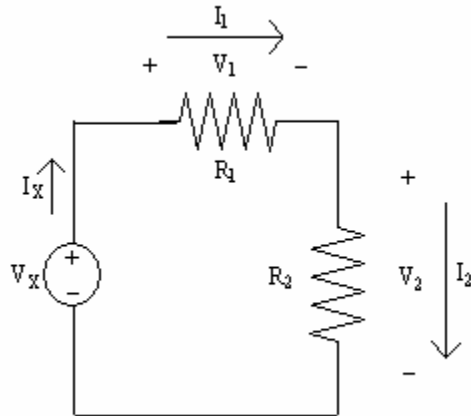


Figure 16

- d. Measure the voltage across R_1 . Then replace the wire comprising the node shared by V_x and R_1 with the DMM as ammeter. Measure 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 $R_1 = R_2 = 1\text{ k}$.

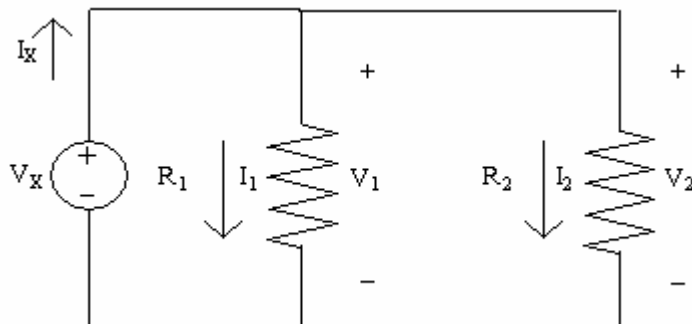


Figure 17

- b. Measure the voltage across R_2 . Then measure the current through R_2 using the DMM. Remember to insert the DMM in series with R_2 .