

ENGR 120 LAB #2 – Electronic Tools and Ohm’s Law

Objectives

Understand how to use a digital multi-meter, power supply and proto board and apply that knowledge to constructing circuits to demonstrate ohm’s law.

Material

- 1) Introduction to ECSE textbook
- 2) Course website: www.EngrCS.com
- 3) Instruments: Power Supply and Multi-meter
- 4) Supplies:
 - a) Electrical Tool Box
 - b) Proto Board
 - c) Power Extension, Probes & Connecting Cables
 - d) Available Resistors

Procedure

- 1) Find a partner to form a team of two. In the case of an odd number of people in the class, one team of three can be formed. Keeping the team small will allow everyone a chance to participate more effectively. Keep in mind when forming teams:
 - a) Shared Objectives and complementary learning styles
 - b) Common time available to work together during open lab times

To find a partner, use the beginning/end of class time, the Moodle forum or the instructor.

- 2) Record your team and claim an electronics kit
 - a) Print each of your names on the list posted on the supply cabinet
 - b) The list will indicate which electronics kit you will use, each kit is numbered
- 3) Lab experiments
 - a) Read through the lab prior to arriving in the lab. The labs provide background information or design that can be done prior to arriving in the lab. Good preparation can minimize the time spent in the lab room and lead to a more enjoyable lab!
 - b) Perform each experiment listed in the lab.
 - c) Record your results and/or observations for each experiment.
- 4) Report
Reports must be created ***individually***. All reports must be computer printed (Formulas and Diagrams may be hand drawn) and at minimum include:

- a) Header:

<p>Your name Lab # Date Team member names</p> <p>Experiment #1: ...</p>

- b) For each experiment:
 - i. Clear problem statement; specify items given (if any) and to be found
 - ii. Document the resulting circuit design, tables, diagrams, calculations and other results
- c) For the report as a whole:
 - i. Lessons learned from the experiments
 - ii. Content/format improvement suggestions and reasons for the suggestions
 - iii. Estimated time spent on the lab (value is not graded – used to improve labs)

Experiment 1. Digital Multimeter operation

The digital multimeter, just as the name implies, is a tool to make various types of electronic measurements. Some meters do more and some do less. The basic measurements that most DMMs (Digital Multimeters) perform are:

- AC/DC Voltage
- AC/DC Current
- Resistance

Many of the DMMs found in the lab have capability to perform many more measurements.

DMMs have three major components:

1. Display
2. Controls
3. Input jacks

The display is where the readings of the measurements are displayed. The reading can be a value (a valid number) or a partial value or symbol ('OL' for some meters) to indicate an out of bounds reading. More on this later. The units **may** also be displayed (Amps, volts...) and the scale (nano, micro, milli, kilo...) and any special mode indicators.

The control section sets the type of measurement to be made and if needed, the expected range of values for the reading. The type of measurement would select current, voltage, or resistance types of measurements. Or it may select special functions such as continuity (measuring resistance with an audible beep when the DMM measures 0 or near 0 resistance). In Figure 1, the continuity (or audible mode) is with the 200 Ω setting and is indicated by a speaker symbol. The diode test mode is shown by the diode symbol and is used to test diodes.

The control section sometimes also selects the expected range of values to read. The controls could select micro (u), milli (m), mega (M) or whole units. (M is not the same as m.) Or it may have numbers indicating values up to this number it can measure. For example, 20 V_{DC} could measure up to 20 V (19.999 V). If the measurement value is larger than what can be displayed, then an out of bounds reading is displayed.

The proper measurement technique is to use the smallest range that produces a valid reading. This ensures the best precision. If the value is too large, then select the next larger scale.

Some DMMs have an autoranging feature that selects the best scale for the current measurement.

Test leads (wires that connect the DMM to the device to measure) plug into the input jacks. Depending on the DMM and the type of measurement to make, the jacks will plug into different locations. The black test lead will typically plug into the COM (common) jack. For the DMM in Figure 1, the red lead would be in the right jack for voltage or resistance measurements and one of the left jacks for current. The two current jacks allow for high or low current measurements.

The www.engr.cs.com website has the link for the Extech 470 User Manual with an excellent description of various measurements and important user warnings.



Figure 1 DMM

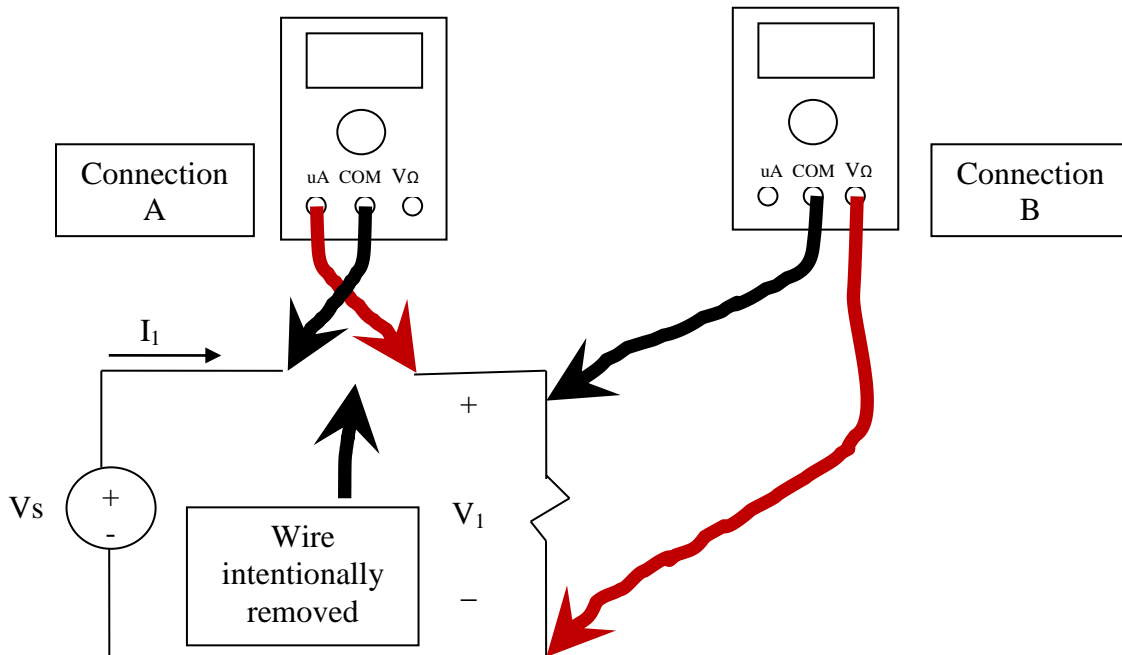
***** WARNING: *****

When measuring current, the DMM acts as a short circuit and can create excessive currents if not connected properly. Normally the ammeter function of the DMM should be in series with the rest of the circuit.

For the DMM in Figure 1, fill in the following chart indicating the settings and connections to perform the following measurements. NOTE: You do not need to make the measurements, only complete the table with the DMM settings and which jacks the test leads would be connected:

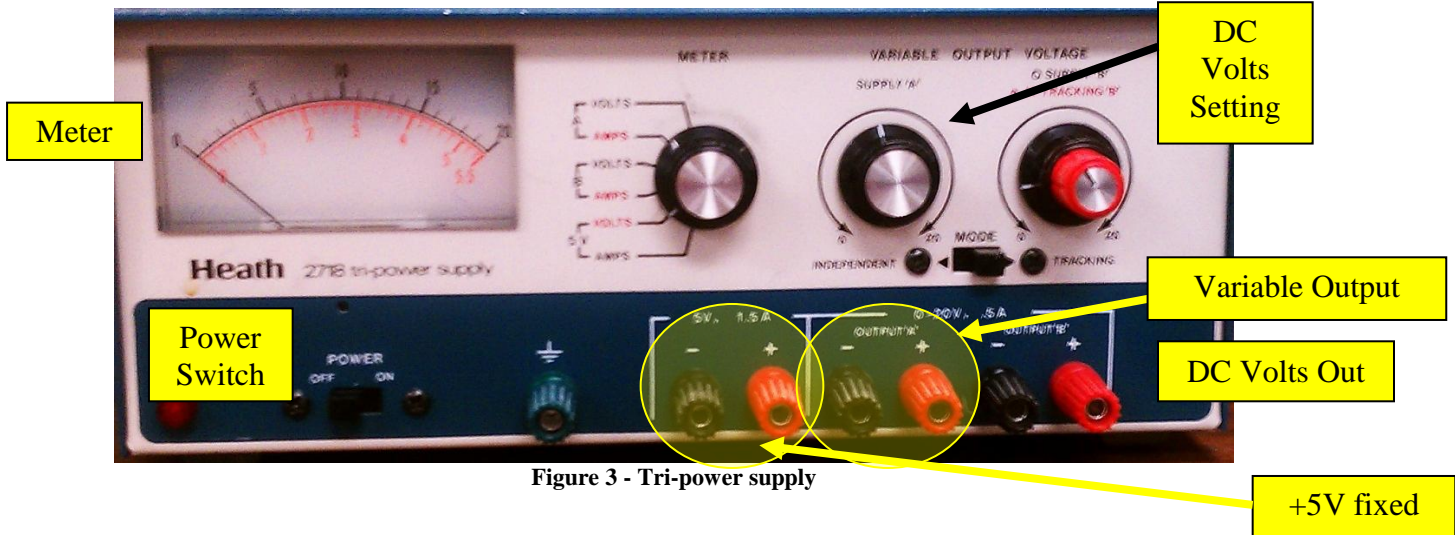
Use “Red” for the red test lead, “Black” for the black test lead and N/C for no connection. The first row is an example to measure a 10 Ω resistor.

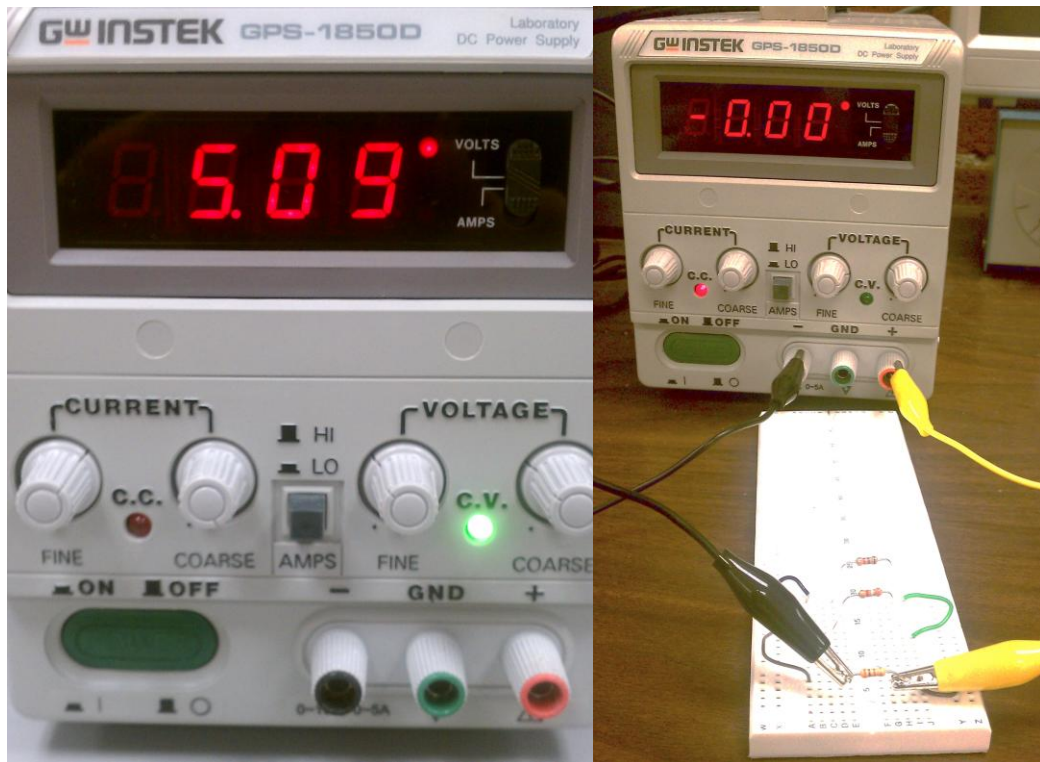
Test	Measuring	Expected value	Dial		Connection Type (A or B)
			Function	Scale	
Ex	Resistance	10 Ω	Ω	200	B
1	Connectivity/Beep	Near 0 Ω			
2	DC voltage	10 to 18 V			
3	DC voltage	100 to 150 mV			
4	DC Current	5 to 10 mA			
5	DC Current	25 to 30 A			
6	DC Current	160 μA			
7	Resistance	1.7 kΩ			
8	Resistance	1 Ω			



Experiment 2. Power Supplies

Power supplies can supply direct current (DC) or alternating current (AC). For ENGR/CSE 120, we will just use the DC current. Another aspect of power supplies is that they can have a fixed voltage output (typically +5V) or they can be variable. The lab has both types available and some supplies can supply both a fixed voltage output and a variable voltage output. Here are some of the supplies in the lab:





In general, the power supply jacks will be black for the ground (or 0V) output and red for the positive voltage output. In some instances, there will also be a green earth ground that we will not use for the ENGR/CSE 120 class. Power to the circuits for this class will use the black jack for the ground or 0V signal and the red jack for the positive power. Check the data sheet for the devices to determine the voltage needed for the circuit.

All of the supplies shown here have a variable voltage output that is adjusted by a round knob. (The supply in Figure 3 - Tri-power supply has an additional variable voltage output labeled output "B" which we will not use.) The supplies also have a meter to show the current voltage or current as selected by either a DC Meter switch (Figure 2) or a Meter knob (Figure 3). The supply in Figure 3 also has a fixed +5V output. Most of the power supply operation can be determined by reading the front panel. And the third supply shown with the digital readout has the voltage adjustment knobs on the right. There is a fine adjustment knob, which changes the voltage slowly, and a coarse adjustment to change the voltage rapidly. There is also a set of current adjustment knobs to limit the amount of current the supply can deliver to your circuit. These are very useful and you will learn more about these later. **But for now, you need to know that if the read light is on by CC (Constant Current indicator), the power supply is probably not delivering the voltage you want. So turn the coarse and/or fine knob clockwise until the light goes out.**

If you notice on the supplies, the outputs generally have a voltage range (or value) that they can supply and a current rating. If you were to short the positive and negative leads together, the supply is protected so that it will not damage the supply. However the circuit that it is connected to may be damaged. So be careful.

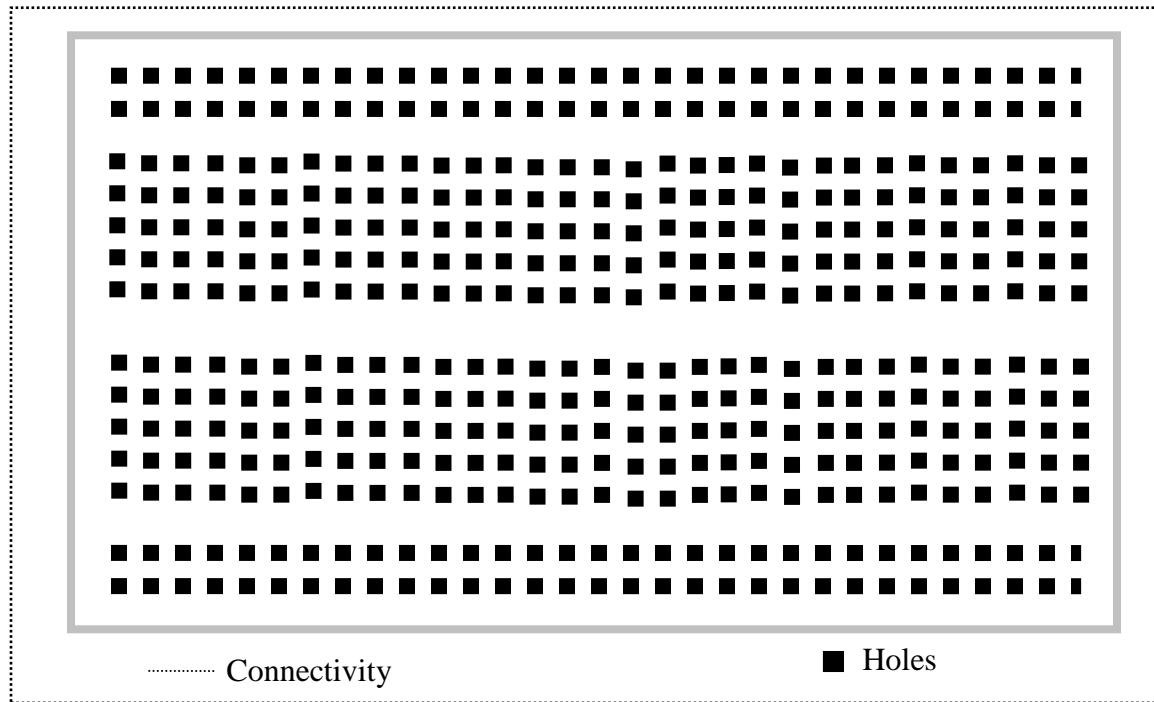
The normal technique for using power supplies is to use a DMM to ensure the voltage is set to the correct value BEFORE connecting the supply to the circuit and turning on the power. Yes, there is a built in meter, but it is always a better idea to use a DMM to ensure the meter is reading the correct terminals.

Take some time to set the power supply to various voltages and measure the voltages with the DMM. Check that the internal meter is reading the same value as the DMM.

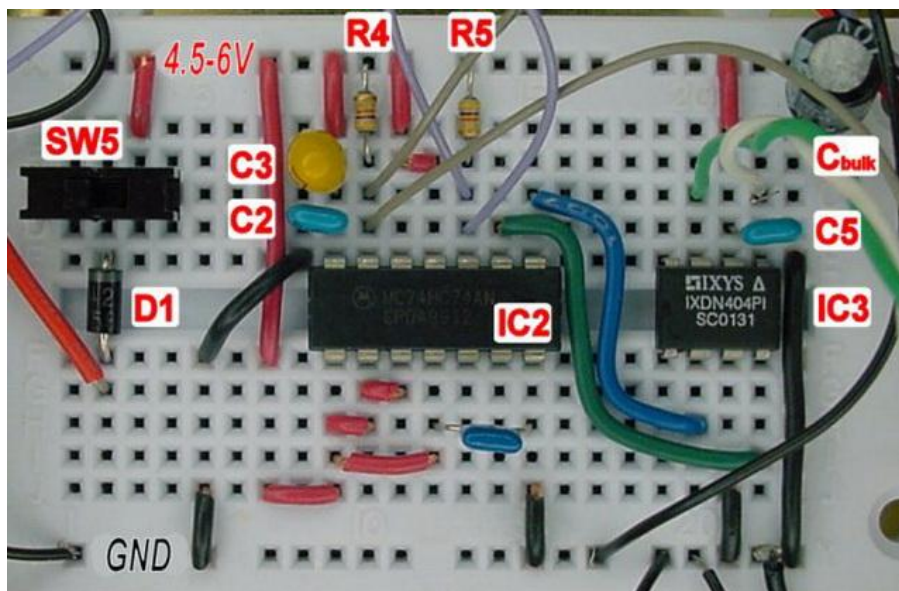
For this experiment, there is nothing to include in the lab report. Just get familiar with the supplies and DMMs.

Experiment 3. Proto board Connectivity

Circuit proto boards are used for building experimental circuits for evaluation purposes. Electronic components such as resistors, IC's (integrated circuits which perform logic functions), switches, LED's, etc. are placed on the protoboard. The board makes electrical connection between these devices to enable them to operate as designed. Select a proto board and describe connectivity between the proto board holes. You may use the Multimeter's ohmmeter capability to determine connectivity. Select the connectivity mode on the meter which generates an audible beep if the holes are connected together. **Then draw a line between the connected holes on the diagram below.**



The following image illustrates a protoboard with a number of components. This circuit is easy to access in case we need to use a multi-meter or any other electronic diagnostic tool to probe for problems. The IC's (IC2) does not have any wires over it, so if it needs to be replaced, additional wires or devices do not need to be removed also. The wires are short and out of the way.



Experiment 4. Resistor Colors

Identify the value of three resistors in your lab box using the color coding on the resistors and verify the reading by using the multimeter. Fill in the following chart:

Resistor Color Bands 1 st 2 nd 3 rd 4 th	Nominal Resistance	Tolerance +/- Ohms	Minimum Valid Resistance	Max Valid Resistance	Measured Value

Resistor Value Color Bands

Band Colors	Value Bands, 1 st & 2 nd	Multiplier Color Band, 3 rd
BLACK	0	x1
BROWN	1	x10
RED	2	x100
ORANGE	3	x1,000 or 1K
YELLOW	4	x10,000 or 10K
GREEN	5	x100,000 or 100K
BLUE	6	x1,000,000 or 1M
VIOLET	7	x10,000,000 or 10M
GRAY	8	x100,000,000 or 100M
WHITE	9	x1000,000,000 or 1G

Note: If third band is gold then divide by 10 and if silver divide by 100.

Resistor Tolerance Color Bands

Band Colors	Tolerance Color Band, 4 th
GOLD	5%
SILVER	10%
NONE	20%

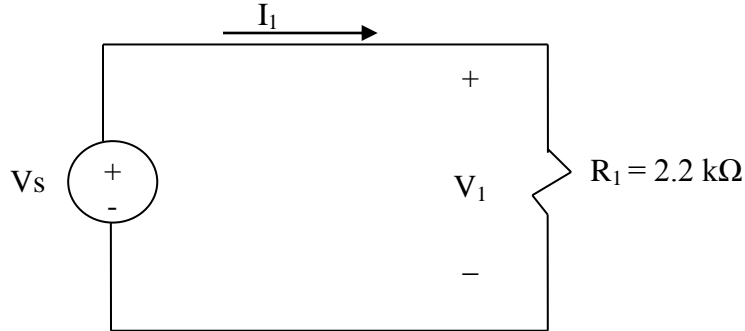
Example (1.0 K Ω or 1000 Ω resistor with $\pm 5\%$)

Brown	Black	Red	Gold
1	0	2	5%

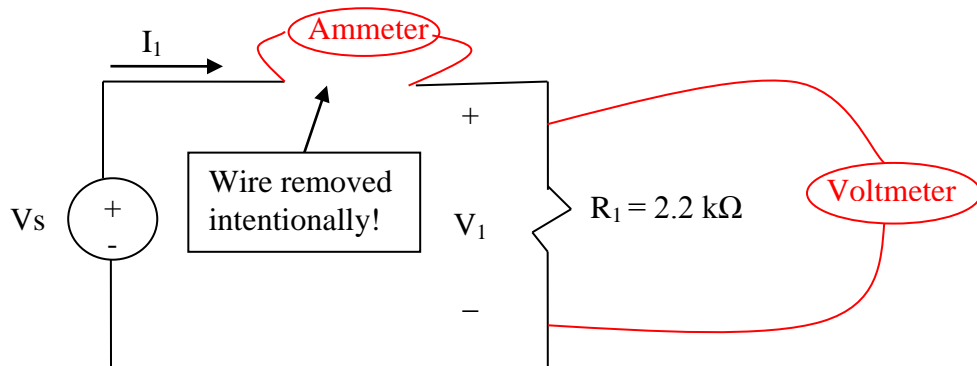
10 x 10²

Experiment 5. Application of Ohm's Law and KVL

a) Implement the following circuit:



- b) Write equations that describe the relationships between I_1 , R_1 , V_1 , and V_s in the above circuit.
- c) **Plot** V_1 vs. I_1 as the value of V_s changes from 1 to 5 volts in 0.5 volt steps using the relationship derived in part b. **Volts on the vertical axis and current on the horizontal axis.**
- d) Using Voltmeter and Ammeter functionality of the Multimeter, measure values of I_1 and V_1 as supply voltage, V_s , is changed from 1 to 5 volts in 0.5 volt steps. **Plot the results on the same graph** as the plot from part c.



Warning: Ammeter is seen as a short ($R=0$) so the Ammeter must be inserted in the circuit to measure the current. If Ammeter is connected as Voltmeter, it will result in blown fuse and damage to Ammeter.

If your ammeter returns values that look incorrect, check the fuse or get a different ammeter!

- e) Based on the components used, what is the expected average slope of plots in parts c and d? Explain any differences observed between expected slope and value calculated/measured in parts c and d.