

ENGR 210 Lab1


Ohm's Law

Background

In the class lectures we have discussed the fundamental electrical quantities of voltage, current and resistance. Since these quantities are so important there are specialized instruments to measure these individually. One of the most useful instruments that can measure all three quantities (as well as quite a few more) is called a digital multimeter (usually abbreviated to DMM). This lab uses a computer simulation (really an animation) which will carry you through the process of using the Digital Multimeter and a voltage source (a power supply) to measure voltage, current and resistance to verify Ohm's Law.

Resistors

Real resistors like the ones you will use in the lab are cylindrical objects which are about 1/8-th of an inch in diameter and 1/2 inch long with a wire lead coming out of each end of the cylindrical body. The wires are for connecting the resistor into your circuit. The actual size of the resistor will depend upon its power handling capability — the resistors you will be using in the physical lab are typically rated at 1/8-th watt. A resistor's value is labeled on the cylindrical body using a color code as indicated in Figure 1.



BLACK	0	0	x	1
BROWN	1	1	x	10
RED	2	2	x	100
ORANGE	3	3	x	1,000
YELLOW	4	4	x	10,000
GREEN	5	5	x	100,000
BLUE	6	6	x	1,000,000
VIOLET	7	7	x	10,000,000
GRAY	8	8	x	100,000,000
WHITE	9	9	x	-

AN OPTIONAL FOURTH BAND INDICATES TOLERANCE (ACCURACY)
GOLD= $\pm 5\%$ SILVER= $\pm 10\%$ NO BAND INDICATED $\pm 20\%$

Figure 1, Resistor Color Code

Protoboards and clip leads

Aside from using a DMM and power supply, you will also need to learn how to make electrical circuits. In this course, you will use clip leads to connect the lab equipment to your circuits, which will be constructed on protoboards. Of course, these will be simulated in this lab and there are some differences between the simulation and the real thing. Real clip leads like you will use in the lab have a spring-loaded clip to hold a wire just like that shown in Figure 2. To operate the clip lead you typically hold the clip between your thumb and forefingers and squeeze the clip in the direction shown below. When you do this a wire hook comes out of the tip. This hook can be put around a wire and, when you release your

fingers, the spring-loaded clip pulls the wire against the plastic body of the clip lead providing a reliable electrical connection. (NOTE: These clip leads are really handy to have and you might want to consider purchasing some of your own. These and other tools can be purchased for your personal use from Electronic Stores in Glennan 309.)

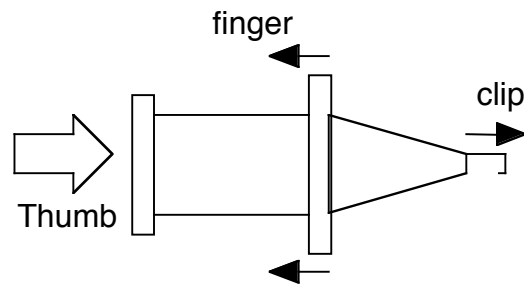


Figure 2. Spring-loaded test clip (sometimes called an EZ Clip)

The actual toolboxes you will use in the lab usually have alligator clips which slip onto banana plugs as shown Figure 3. Note that an alligator clip is so-called because it has teeth which can be used to grip a wire. The alligator clips you have in your lab toolbox slip onto the ends of the banana clip as shown in Figure 3. A banana plug is so called because it roughly has the shape of a banana. This shape was mechanically designed to give a good slip-fitting electrical connection. Banana plugs are often stacking which means that there is a jack built into the lead opposite the plug in which another banana plug can be inserted so that you can make electrical circuits with banana plugs and alligator clips.

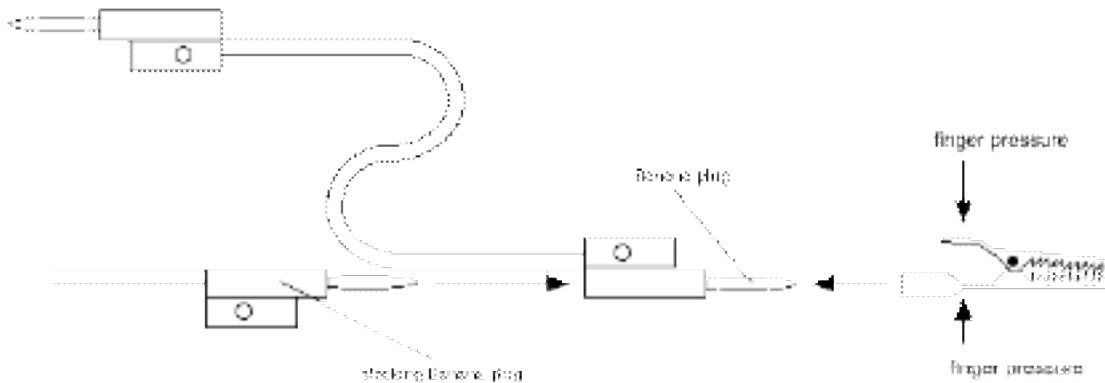


Figure 3. Alligator clips/banana plug leads

You will also use a variety of protoboards to construct your circuits in this class. A protoboard consists of many holes into which you can insert electrical components and wires to quickly make an electrical circuit without doing any soldering. A typical protoboard layout is shown below. The center section is used to connect your electrical components and integrated circuits; the two outer sections are typically used to make power supply connections. The holes in protoboards are normally 0.1-inch apart since this is a standard size for leads in integrated circuits. The holes are electrically connected internally by metal electrodes as shown below. Note that these electrical connections are not necessarily apparent on all protoboards. To help you out, some of the electrical connections are often shown with colored (red or blue) lines scribed on the protoboard which is typically all white plastic. The electrical connections for a typical protoboard are shown as straight lines in the drawing below. These are under the plastic and are not apparent from the surface of the protoboard.

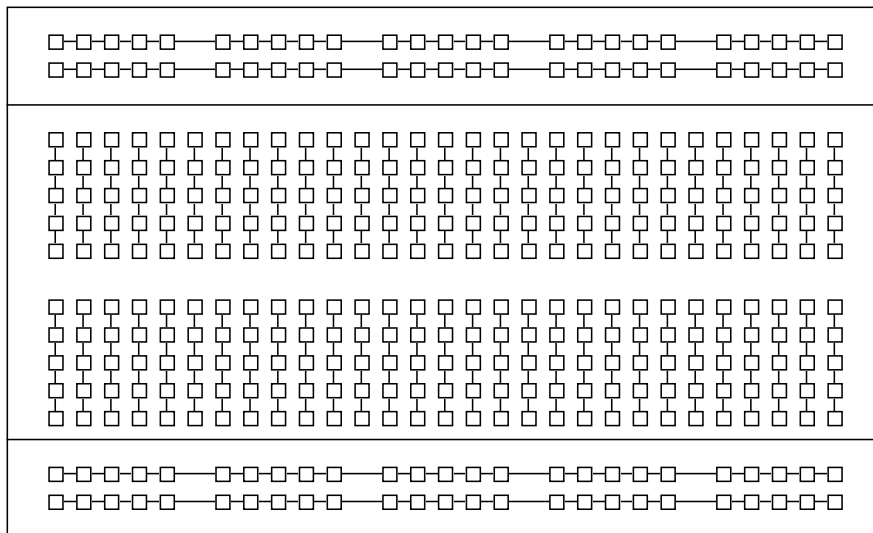


Figure 4. Protoboard found in lab simulation.

In a real protoboard you must be careful of the size of the wires you push into the holes. If the wire diameter is too large it can permanently damage the electrical connector in that hole.

Some protoboards also have a set of binding posts at their edge which can be used to hold wires for connecting to a separate power supply. These are called 5-way binding posts because they can hold wires, connectors or plugs in a variety of ways. Note that the color red always indicates a positive (+) lead and black a negative(-) or ground lead. On some protoboards these binding posts are electrically connected to the long sections of the protoboard to allow you to quickly make power supply connections. These are often indicated on the protoboard by colored dots or lines which correspond to the color of the connected binding post.

The computer simulation that you will run for this lab is available for download online at <http://www.educatorscorner.com/>. Under the Educator’s Corner banner, select Experiments, then click the Interactive Experiments in the first paragraph. Under the Interactive Simulations section, look in the DC Circuits subsection for the simulation entitled “Ohm’s Law.” Find the file type appropriate for your machine, download the file, run it to extract the simulation, then run the extracted file.

DATA AND REPORT SHEET FOR LAB 1

Part 1: Ohm's Law

Student Name (Print): _____ Student ID: _____

Student Signature: _____ Date: _____

While running the software simulation labeled "Ohms_Law" please take notes and answer the following questions. Note: To make an electrical connection drag the connector with your mouse. The clip will turn blue when you are at the connection point.

1. Describe the procedure for turning on and using the E3631A power supply. Just turning on the power is an unacceptable answer.
 2. Describe the procedure for turning on and using the HP 34401A multimeter to measure voltage. Just turning on the power is an unacceptable answer.
 3. Draw the electrical schematic of the circuit you have made with the resistor, power supply and multimeter. Be sure to show the polarity and magnitude of the measured voltage across the resistor.
Measured $V_R =$ _____
 4. Describe the procedure for using the HP 34401A multimeter to measure current. Note that you have to break the previous connection from the resistor to the negative (ground) side of the power supply to make a current measurement.
Measured $I_R =$ _____
 5. Use Ohm's Law for the previous V_R and I_R measurements to predict the actual resistance value.
 6. Describe the procedure for using the HP 34401A to measure resistance.
 7. What was the measured resistance? We will call this resistance R2 because it will be used later.
Measured R2= _____
- VOLTAGE DIVIDER**
8. What was the measured resistance? We will call this resistance R1 because it will be used later.
Measured R1= _____
 9. R1 is nominally a 10k Ω resistor. What is the color code for a 10k resistor?
 10. What was the measured value for resistor R3?
Measured R3= _____
 11. For Kirchoff's Voltage Law experiment what were the measured values of V_{r1} , V_{r2} and V_{r3} ?

Measured V_{r1} = _____

Measured V_{r2} = _____

Measured V_{r3} = _____

12. What are the calculated voltages (V_{r1} , V_{r2} and V_{r3}) using the measured resistance values and the measured value of the voltage source?

Calculated V_{r1} = _____

Calculated V_{r2} = _____

Calculated V_{r3} = _____

13. Calculate the % error between the measured value V_{r3} and the calculated value.

NOTE: % Error = $100\% * (\text{Measured_value} - \text{Calculated_value}) / \text{Calculated_value}$

14. What was your calculated current through the circuit composed of R_1 , R_2 and R_3 ?

15. What was your measured current through the circuit composed of R_1 , R_2 and R_3 ?

CURRENT DIVIDER

16. For the KCL experiment what was the measured value of current going through resistors R_1 , R_2 and R_3 ?

Measured I_{r1} = _____

Measured I_{r2} = _____

Measured I_{r3} = _____

17. What were the calculated currents through R_2 and R_3 ? Show your calculations.

NOTE: Don't do the % error calculations the simulation asks you to do.

18. Calculate the equivalent resistance of $R_2 || R_3$? Show your calculations.

19. Using the equivalent resistance for $R_2 || R_3$ what is the calculated voltage across R_1 ? Show your calculations.