ENGR 210/EEAP 240 Lab2 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 computer simulations (really animations) 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 and to determine the behavior of resistors connected in series and parallel.

Resistors

Real resistors like the ones you will use in the lab are physically 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.

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	\downarrow	¥	X	
BLACK	0	0	х	1
BROWN	1	1	х	10
RED	2	2	х	100
ORANGE	3	3	х	1,000
YELLOW	4	4	х	10,000
GREEN	5	5	х	100,000
BLUE	6	6	х	1,000,000
VIOLET	7	7	х	10,000,000
GRAY	8	8	х	100,000,000
WHITE	9	9	Х	-

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

Figure 1, Resistor Color Code

Notes:

- 6. A graphical resistor color code "Resistance Calculator" is available on the ENGR 210 Web page (http://129.22.56.221/engr210.html) under "Tools."
- 7. A more detailed explanation of resistors, including how they are built, can be found in Thomas & Rosa, 2/e.

Pictures of the real lab equipment, its technical specifications and a very good tutorial on how to use the equipment can be found at the ENGR210 Web page. Follow the Lab/Workbench links to get to detailed tutorials of how the digial multimeter and power

supply work. Links to these tutorials are found immediately to the right of the picture of the HP 34401 DMM.

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 the simulation and there are some differences between the simulation and the real lab. Real clips 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 tool boxes 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 electrical connected internally by metal electrodes as shown below. Note that these electrical connections are not necessarily apparent on all protoboards boards. To help you out some of the electrical connections are often shown with colored (red or blue) lines scribed on the 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.

0-0-0-0-0-0-0-0-0-0-0-0-0-0-0-0-0-0-0-

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 simulations are installed on the computers in the Circuits Lab in Glennan 308. Physical access to the lab is by your CWRUid card and the account you can use on the computers is "lab" with no password. Use the machines on your right as you enter the lab. For the next week or two while we are still enabling card access to the lab you can download the computer simulated labs from the ENGR 210 Web page to your computer and run them. Starting at the ENGR 210 web page the simulated labs are located in Class_Info\Lab. They can also be downloaded to your machine, the Smith computer lab or any other PC and run there.

DATA AND REPORT SHEET FOR LAB 2 Part 1: Ohm's Law

Student Name (Print):	Student ID:
Student Signature:	Date:
Student Name (Print):	Student ID:
Student Signature:	Date:
Student Name (Print):	Student ID:
Student Signature:	Date:
Lab Group:	

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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 <u>procedure</u> for turning on and <u>using</u> the E3631A power supply. Just turning on the power is an unacceptable answer.
- 2. Describe the <u>procedure</u> for turning on and using the HP 34401A multimeter to measure voltage. Just turning on the power is unacceptable answer.
- 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 <u>procedure</u> 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 $V_{\rm R}$ and $I_{\rm R}$ measurements to predict the actual resistance value.
- 6. Describe the <u>procedure</u> for using the HP 34401A to measure resistance.
- What was the measured resistance? We will call this resistance R2 because it will be used later. Measured R2=_____

VOLTAGE DIVIDER

- What was the measured resistance? We will call this resistance R1 because it will be used later. Measured R1=
- 9. R1 is nominally a $10k\Omega$ resistor. What is the color code for a 10k resistor?
- 10. What was the measured value for resistor R3? MeasuredR3=_____
- 11. For Kirchoff's Voltage Law experiment what were the measured values of Vr1, Vr2 and Vr3?

Measured Vr1=_	
Measured Vr2=_	
Measured Vr3=	

- 12. What are the calculated voltages (Vr1, Vr2 and Vr3) using the measured resistance values and the measured value of the voltage source?
 Calculated Vr1=_____
 Calculated Vr2=
 - Calculated Vr2=___ Calculated Vr3=
- 13. Calculate the % error between the measured value Vr3 and the calculated value. NOTE: % Error = 100% * (Measured_value - Calculated-value)/Calculated_value

14. What was your calculated current through the circuit composed of R1, R2 and R3?

15. What was your measured current through the circuit composed of R1, R2 and R3?

CURRENT DIVIDER

16.For the KCL experiment what was the measured value of current going through resistors R1, R2 and R3?

Measured Ir1=____

- Measured Ir2=____
- Measured Ir3=_____
- 17. What were the calculated currents through R2 and R3? Show your calculations. NOTE: Don't do the % error calculations the simulation asks you to do.
- 18. Calculate the equivalent resistance of R2||R3? Show your calculations.
- 19. Using the equivalent resistance for R2||R3 what is the calculated voltage across R1? Show your calculations.

Part 2: Resistors in Series and Parallel

In this part of the lab you will perform a simulated laboratory using a HP 34401A Digital Multimeter and various resistors to confirm the various laws governing series and parallel resistance While running the software simulation titled "Resistors" please take notes and answer the following questions.

- 20. What were the measured resistances of R1 and R2?
- 21. Resistor R1 is nominally a 150 Ω resistor. What is the color code for 150 Ω ?
- 22. Resistor R2 is nominally a 1500 Ω resistor. What is the color code for 1500 Ω
- 23. What is the measured value of R1 and R2 in series?

- 24. How does this compare to the calculated value of resistors R1 and R2 in series?
- 25. What is the measured resistance of R1 and R2 in parallel, i.e., R1||R2?
- 26. How does this compare with the measured value of the individual resistances?