LAB 3: RESISTIVITY

Texas A&M University
College Station, TX 77843, US.

Abstract: *This lab covers the fundamental theory of resistance and resistivity. Voltage and current can be measured by running an electric current through the conductive wire. In order to determine the resistivity of the wires, the student must insert the measured values into Ohm's law. Then the student can determine the uncertainty associated with this measurement. Therefore, every wire's composition can be calculated based on the resistivity values.*

Keywords: *Voltage Drop, Current, Ohm's Law, Resistivity, Resistance*

1. Introduction

The goal of this lab is to utilize what the student knows about resistance and resistivity in order to determine the composition of the different wires across the board. This can be calculated by using Ohms Law. Ohm's Law, suggests that the electric currents are directly proportional to voltage and inversely proportional to the resistance. The wire is considered to be Ohmic material when the wire's resistance over a range of voltages is constant. This is one of many to determine the resistivity related to the wire and its material composition. Throughout this lab, the student will examine several relationships between electrical and physical properties. They will also determine unknown components utilizing what's found through natural laws.

2. Experimental Procedure

The setup to perform this lab is quite simple, as it consists of 3 parallel wires that have the same length, are stretched across the resistivity board, and are held by binding posts on both ends. A meter stick is placed along with the board. The setup also includes a power supply, two banana cables, a BNC-to-banana cable, a test clip, and the DAQ. The BNC-to-banana cable is plugged into channel 0 of the DAQ and is attached to one end of the test clip. Both ends of the banana cables are plugged into channel 1 of the power supply and the opposing end is plugged to the corresponding bring clip for whichever wire is tested.

For the beginning stages of the first data collection, the current is first set to 0.1A and the voltage is sent to the maximum value of 6V. The voltage and current readings are stored in an excel datasheet when the power supply is turned on. The same process is then repeated one more time but the current is set to 0.09A and the readings are recorded. The process repeats and reading are stored in excel until the current reaches 0A. Finally, this process is repeated from 0.1A to 0A for the other two wires as well. This ends the data collections process for current vs voltage.

The next part of this lab to perform is to collect data for voltage over length. To begin the current setting is put to 0.1A. The black cable from the DAQ is attached at the binding post to the black cable coming from the power supply. The test clip is placed on the wire. This is placed very close to the black cable itself thus the length of it is zero. In the terminal, the student utilizes a script called 'daq_to_csv_with_input.py' which is under */examples/daq/*. It is used to perform measurements from eh DAQ corresponding to the user's input for the length. Changing is a few parameters within the script is key. This included *CHANNELS* which should be set to the DAQ channel being used, which is 0. *POINTS* is another one that should be set to 14 since the wire is 700mm long and is measured in 50mm intervals. Finally, *FILENAME,* which is given as "v_vs_l_wire_1" for wire one and "v_vs_l_wire_2" for wire two, etc. When the user launches these scripts, it requires the user to input the length at each data reading until the wire is completed. This starts at 0, then 50, then 100, and so on. These steps are then repeated for the other two wires.

The last part to complete the performance of this lab is data analysis and visualization. Using excel, the written data from the first part of this lab, and the data collected by the DAQ in the second part of this lab are used to create graphs of the voltage with respect to current, and another graph made for voltage as a function of length. As a result, there are a total of 3 graphs for each of the two sections.

In this lab, the student also had to determine the composition of each wire. In order to do that, they must calculate the resistivity, utilizing 2 equations:

Equation 1:

$$R = \frac{V}{I}\ (Ohm's\ Law)$$

Equation 2:

$$\rho = \frac{RA}{L}$$

R is the *resistance,* A is the *cross-sectional area,* L is *length* and ρ is the *resistivity*. On the graphs, the students can create a line of best fit, using the data points. The slope will determine the resistance on the voltage vs current graph. The cross-sectional area is determined by the given diameters of each wire. This gives the student enough data to calculate resistivity. The uncertainty of the slope or R is calculated by a function in excel called LINEST.

The lecture slides provide a list of materials and their resistivity to compare the results of this experiment to determine the material composition of wires.

3. Results and Analysis

wire 1 (ΔV) as a function of current (I)

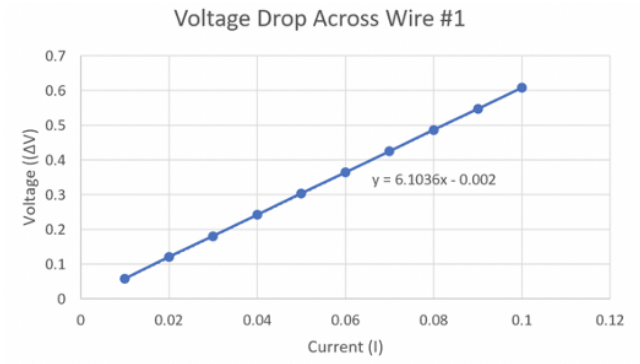


Figure 1: plot for voltage drop across the board

wire 2 (ΔV) as a function of current (I)

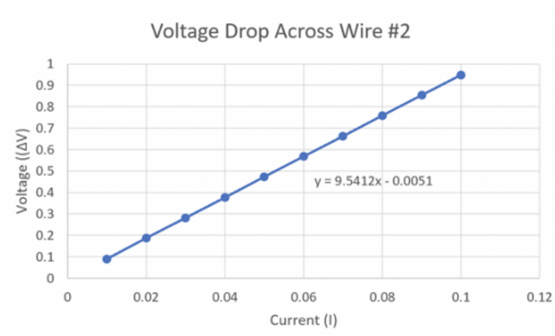


Figure 2: plot for the voltage drop across the board

wire 3 (ΔV) as a function of current (I)

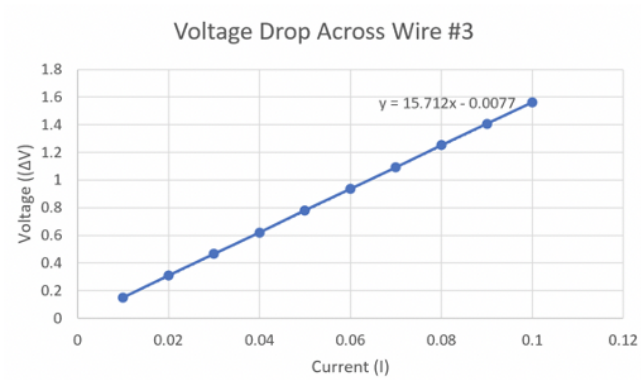


Figure 3: plot for the voltage drop across the board

The first 3 figures represent the relationship between current and voltage and the slope of the graphs signifies the resistance of the wires. Figures 1-3 all plot the current which is shown to be directly proportional to the voltage. Because of this data, the student can determine that the wires are made from Ohmic Material. This can be confirmed with Ohm's law.

Resistance for every wire with its uncertainty:
Wire1: 6.1036 +/- 0.0072
Wire2: 9.5412 +/- 0.011
Wire3: 15.712 +/- 0.017

wire 1 (ΔV) as a function of the length (l)

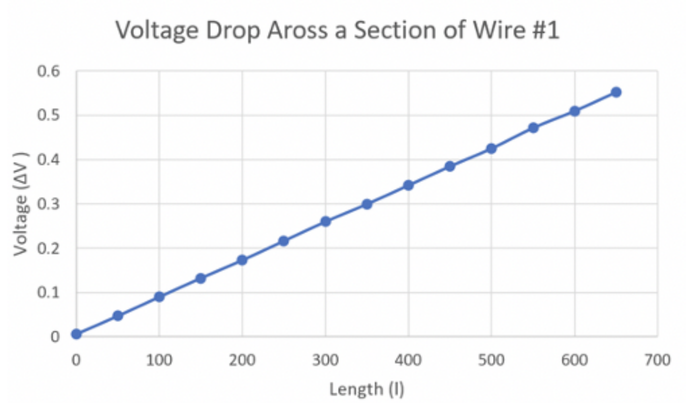


Figure 4: plot of the voltage drop across a section section

wire 2 (ΔV) as a function of the length (l)

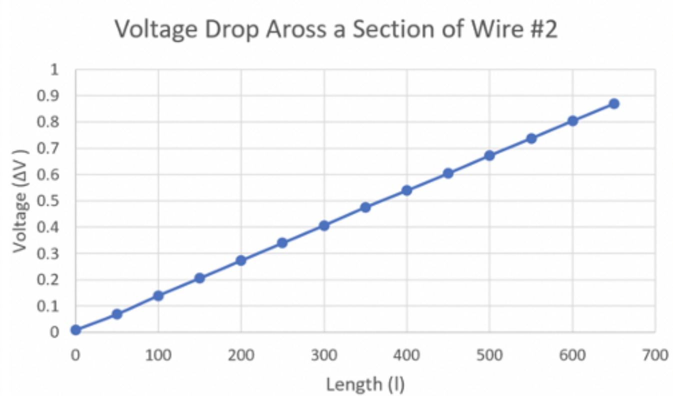
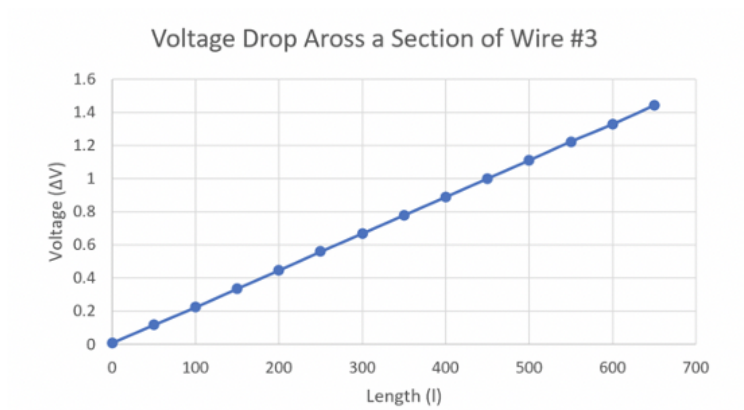


Figure 5: A plot of the voltage drop across a

wire 3 (ΔV) as a function of the length (l)



The 3 figure above, from 4-6, shows the voltage drop at a constant rate as length is increasing. The voltage drops mean that there is a decrease in electric potential along the path of current flowing in the electrical circuit. The longer the wire the higher the resistance.

Figure 6: A plot of voltage drop across a section

Diameter of the Wires:
Wire1: 0.42 ± 0.01 mm
Wire2: 0.34 ± 0.01 mm
Wire3: 0.27 ± 0.01 mm
The lenght for all of them was L = 705 ± 5 mm.
Plugging in these values into the second equation determines the resistivity of the wires.
Wire1: 1.21×10^{-8} +/- 1.1×10^{-9} $\Omega \cdot$ m
Wire2: 1.24×10^{-8} +/- 1.4×10^{-9} $\Omega \cdot$ m
Wire3: 1.29×10^{-8} +/- 1.7×10^{-9} $\Omega \cdot$ m
Based on the resistivity tables, the student can determine the material of the wire based on the calculations of the data.
Wire 1: Silver
Wire 2: Copper
Wire 3: Aluminum

4. Conclusions

This lab increased the understanding of Ohm's Law, as the three wires' resistivity was calculated by Ohm's Law. We were able to determine that the wires were made out of Ohmic material because the relationship between voltage and current and voltage and length was proportional. Using the equation to calculate resistance, showed that the larger resistivity and longer wire will have a higher resistance. Whereas, if the cross-sectional area of the wire increases then the resistance of the wire decreases. Analyzing the data and calculating resistivity for every wire showed that one wire corresponded to a type of material compared to the others. Hence, resistivity is a key component in determining the materials of every wire.