Class #2: Analog Discovery Board

Purpose: The objective of this experiment is to explore Ohm’s Law using a simple multi-meter and the Analog Discovery Board

Background: Before doing this experiment, students should be able to
- Measure the voltage across a component.
- Use Ohm’s Law to determine either I, V, or R when given the other two parameters.

Learning Outcomes: Students will be able to
- Plot the current through a resistor as a function of the voltage across the resistor and determine its resistance from the slope of this plot

Resources Required:
- Analog Discovery
- Protoboard (aka breadboard) from Parts Kit
- Resistors from Parts Kit

Helpful links for this experiment can be found on the course website under Class #2.

Pre-Lab

Required Reading: Before beginning the lab, at least one team member must read over and be generally acquainted with this document and the other required reading materials.

Required Viewing: Before beginning the lab, each team member must view the videos posted for this experiment.

Due: At the beginning of Class #4

Notes: For this experiment, it is a good idea to work with another student to compare and discuss results. If you have your own multimeter, you are encouraged to bring that to class and use it for making measurements.

You will be required to demonstrate some of your measurements to a TA or instructor and have them sign your report template. Your experiment must be running when you do this.

Background Theory.

As we saw in Class 1, the relationship between current and voltage in a resistor is defined by Ohm’s Law, \( V = IR \) (Voltage = Current*Resistance). This equation is a linear relationship, following the classic expression, \( y = mx + b \), where \( m \) is the slope of the line and \( b \) is the y-intercept. When considering Ohm’s Law, we can say the y-variable is the voltage, \( V \), and the x-variable is the current, \( I \). The slope of the line is then the resistance, with the y-intercept being zero.
Discovery Board
The following layout details the various connections available on the Discovery Board. In the laboratory description, the Waveform Generator (WaveGen) and Scope Channel connections will be used.
For This Experiment:

Analog Discovery Board signals and measurements.

1. On the Welcome tab, select Wavegen. To generate a 2V output, complete the following.
   a. Under the Channels drop down list, make sure a check mark is next to Channel 1. You can turn off Channel 2 for now (we will use it later).
   b. On the Channel 1 screen, select the Type drop down list and choose DC.
   c. Set the Offset value to 2V

Your screen should be similar to the following image.

2. Before clicking Run, we will want to wire up the circuit. Supplying power to a circuit before it is complete can be a little dangerous. The +2V output from Channel 1 on Wavegen will be the solid yellow wire (W1).

3. To make DC measurements (we will make other types of measurements later), select the Voltmeter option on the Welcome tab. A window will open with several measurement options. For now, we will be using Channel 1, DC measurements.

4. Measurement inputs are performing using Channel 1 (not the same thing as Channel 1 on the Wavegen tab). The two connections are the orange wire (1+) and the orange/white striped wire (1-).

5. To verify that Wavegen is producing a +2V signal, use a wire to connect the Wavegen Channel 1 output (W2) to the Voltmeter input (1+). The most accurate measurements use both inputs, so use a wire to connect any black ground wire (they are all the same) to the Voltmeter input (1-).

6. On the Wavegen page, click Run. A 2V output should now be applied on W2.

7. On the Voltmeter page, click Run. If the circuit is connected correctly, you should now see a value very close to 2V displayed in the Channel 1, DC box of the Voltmeter.
Your screen should be similar to the following image.
A. Determining Resistor Values
Select any resistor from your parts box. (It is a good idea to pick a resistor smaller than 1MΩ, 10^6Ω. The reason for this will be discussed in the next laboratory.)

1) In the template, write down the four color code for this resistor.
2) Using the following table, determine the resistance of the resistor you selected.

You can use an online resistor calculator to verify your calculation, a nice reference can be found at All About Circuits using the following link.

https://www.allaboutcircuits.com/tools/resistor-color-code-calculator/
B. Resistor I-V Plot – Part 1

1. Using the process described in the introduction, configure Wavegen Channel 1 as a DC source. The value of the DC source will be adjusted to make multiple measurements.

2. The source part of the circuit shown above is built using the Discovery Board connections. The yellow wire (W1) is the output of Wavegen Channel 1, our DC source that can produce voltages between -5V and +5V. The yellow wire with the white stripe (W2) is the output of Wavegen Channel 2. We will not be using it in this experiment. The source also needs a reference. We will use the black wire because it is a ground (0V).
   a. For a circuit similar (not exactly the same) to the one you built at the end of Class 1, connect Wavegen Channel 1 (W1) to the same protoboard node (hole) that was connected to the red lead of the battery.
   b. Connect a ground wire (Black) to the same protoboard node (hole) that was connected to the black lead of the battery.

3. To measure the voltage across the resistor R1, connect 1+ (orange wire) to one side of the resistor and 1- (orange/white wire) to the other side of the resistor.

4. Once you build your circuit, turn on Wavegen Channel 1 and the Voltmeter. Vary the offset voltage of Wavegen Channel 1 from 0V to 3V in 0.5V increments. For each source voltage increment, record the voltage measured across resistor R1. Apply Ohm’s Law to determine the current through the resistor

<table>
<thead>
<tr>
<th>Wavegen Voltage (V)</th>
<th>Resistor Voltage, V</th>
<th>Resistor Current, I</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td></td>
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<tr>
<td>0.5</td>
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5. Plot the current I (x-axis) vs the voltage V (y-axis). From the slope of your plot, verify that Ohm’s Law results in a linear relationship with a slope determined by the resistance value. 
   Note, the resistor current will have a linear relationship with the resistor voltage. However, the resistor current will not have a linear relationship with the Wavegen voltage. You might want to verify that yourself on a separate plot, but it is not required for the laboratory.
C. Resistor I-V Plot – Part 2

1. Remove the LED from the circuit.
2. Connect the Channel 2 Voltmeter leads, 2+ (blue) and 2- (blue/white), across resistor R2.
3. As in the previous part, step the source Wavegen voltage from 0.0 to 3.0V in 0.5V increments.
4. Using Voltmeter Channels 1 and 2, measure the voltage across R1 and R2. For each voltage, use Ohm’s Law to determine the current.

<table>
<thead>
<tr>
<th>Wavegen Voltage</th>
<th>R1 Voltage (measured)</th>
<th>R1 Current (calculated)</th>
<th>R2 Voltage (measured)</th>
<th>R2 current (calculated)</th>
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<tbody>
<tr>
<td>0</td>
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For both resistors, plot the V-I curves (voltage vs. current) on the same graph. From the slopes of your plots, verify that Ohm’s Law results in a linear relationship with a slope determined by the resistance value. Does the plot of the larger resistor have a steeper slope, as would be expected?