DC Circuits Laboratory **Lab # 2**

Series Circuits and KVL

Lab Objectives

When this lab exercise is completed, the student should be able to:

1. Measure voltages across and currents through elements in a series circuit built on a protoboard.
2. Take measurement data for use in creating an I-V characteristic curve graph.
3. Create a standard graph neatly and correctly.
4. Use the I-V Characteristic curve to determine resistance at a point of interest.
5. Use data taken to demonstrate Ohm's Law and Kirchhoff's Voltage Law.
6. Build a series circuit on a protoboard in such a way that others can easily recognize the components, and take measurements.

Pre-Laboratory Preparation

Prior to your scheduled laboratory meeting time the following items need to be completed. The pre-lab quiz will be based on this preparation.

1. **Research**
   a. On the internet, find a 1 page article or app note that explains Ohm's Law. Read it and bring it to lab - *You may refer to this article when taking the prelab quiz.*
   b. Repeat 1a for Kirchhoff's Voltage Law.
2. **On Line Learning**
   a. Click on this link and watch the video on Ohm's Law: http://www.youtube.com/watch?v=-mHLvtGjum4
   b. Click on this link and watch the video on Kirchhoff's Voltage Law: https://www.youtube.com/watch?v=Bt6V7D5av9A
   c. If either video doesn't load, search YouTube for a short introduction on either topic and don't forget, your text is also a great resource.
3. Preparation for quiz: The prelab quiz will be on the following topics:
   a. Calculating voltages and currents using Ohm's Law and KVL in a series circuit
   b. Understanding the I-V characteristic curve
   c. Measuring voltage and current in a series circuit.
   d. Identifying the nodes in a series circuit.

DC Circuits Lab Procedure - Part 1: Ohm's Law

Ohms Law relates voltage, current, and resistance in a linear component like a resistor.

1. Obtain a 1.2kΩ resistor from the supply drawer (verify the color code).
2. Install it in the proto-board and connect it to the power supply so you can use 2 DMMs at once; one to measure the voltage **(V_1)** across the resistor, and one to measure the current **(I_1)** through it. (see fig. 1)

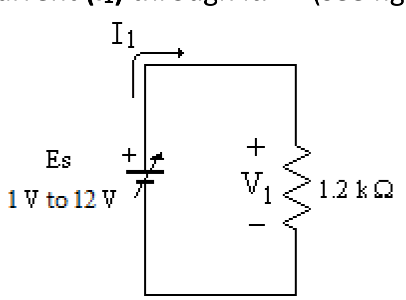


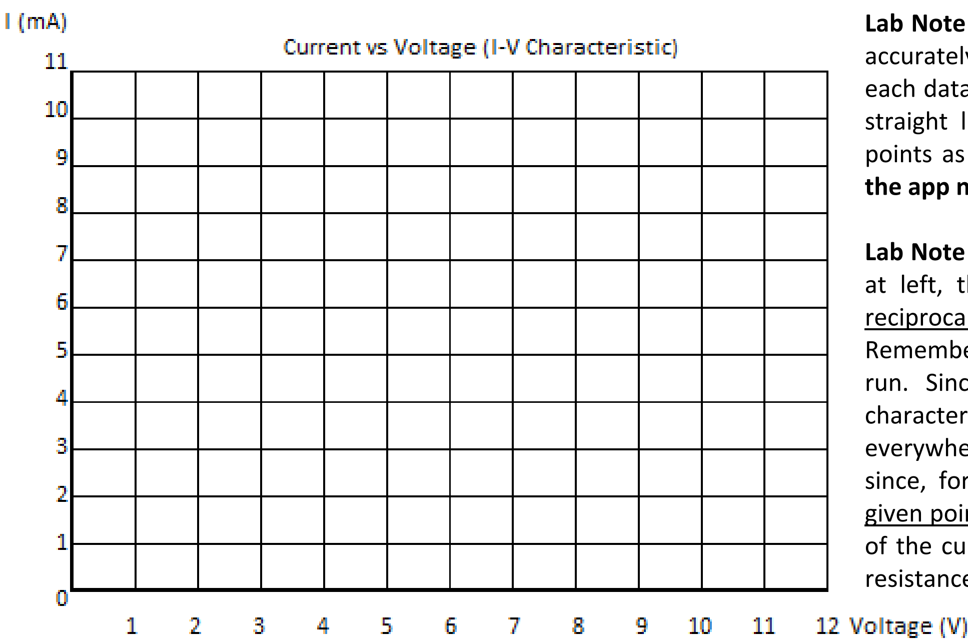
fig. 1

3. While measuring the voltage across the resistor (not at the power supply), set the voltage, E_S to 1.0V.
4. Read the voltage across the resistor and the current through it. Record this data in Data Table 1.
5. Repeat steps 3 and 4 for 1V increments of Es (i.e. E_S = 2V, 3V, 4V,...12V).
6. Answer the questions below Table 1.
7. Get an instructor sign off, and continue to part 2.

Data Table 1, Ohm's Law: R1 = 1.2kΩ								
Es	V_1	I_1	Es	V_1	I_1	Es	V_1	I_1
1V			**5V**			**9V**		
2V			**6V**			**10V**		
3V			**7V**			**11V**		
4V			**8V**			**12V**		

Questions:

1. Use the data from Table 1 above to plot the I-V characteristic curve for the 1.2kΩ resistor below:



Lab Note 1: A good sketch, done by hand, starts with accurately plotting the data points on the axes, circling each data point, then running the curve (in this case a straight line) so that it comes as close to as many points as possible (best fit). Do that in this case. **See the app notes for more graphing tips.**

Lab Note 2: In an I-V Characteristic Curve like the one at left, the slope of the curve at any point is the reciprocal of the resistance at that point (Ohm's Law). Remember from algebra, the slope is the rise over the run. Since Ohm's law predicts a straight line I-V characteristic for any resistor, the slope is the same everywhere. This is not true for all I-V curves, but since, for any curve, you can find the slope at any given point (using calculus), the reciprocal of the slope of the curve at that operating point is the equivalent resistance of the device at that operating point.

2. Use Lab Note 2 to calculate the resistance represented by the I-V Characteristic Curve shown above. Show your work below:

Part 2: Series Circuits and KVL

Refer to the circuit in fig. 2

1. Obtain the resistors needed from the supply drawers (verify proper color code) and build the circuit shown in fig. 2
2. Measure the voltages shown in fig.2 and record these in Table 2. Use the correct units.
3. Measure the currents shown in fig.2 and record them in Table 2. Use the correct units.
4. Answer the questions following Table 2. Have your instructor sign off on this work.

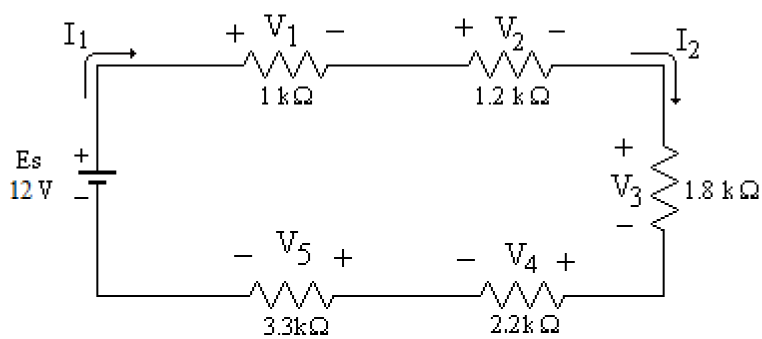


fig. 2

Data Table 2, Series Circuit							
Es	V_1	V_2	V_3	V_4	V_5	I_1	I_2
12V							

Questions:

3. In Lab: Using your measured data, calculate the sum of the voltages: $V_1 + V_2 + V_3 + V_4 + V_5 =$_____________.

4. In one or two sentences, describe how this verifies Kirchhoff's Voltage Law. Was the sum exactly equal to the applied voltage? Explain where any error might have come from:

5. Was there a difference in the value of I_1 and I_2? In one or two sentences explain why or why not:

Post Lab Requirements and additional Lab notes:

After lab, **during a time specified by your instructor**, take the post lab quiz. You may use the prelab work, the lab data and answers to the lab questions as reference material for this quiz.

Submit your completed documentation at the beginning of next week's lab before you take that week's prelab quiz. The submission package will be graded and returned with comments. Submit the following (stapled together and in the following order):

1) Your team cover sheet, complete with signatures, filled-in by each team member, one per team.
2) The page containing Data Table 1, completed including your plot (Q1) and answer/calculations for Q2, one per team
3) The page containing Data Table 2, completed including your answers to Q3, Q4 and Q5, one per team

*** Do NOT submit extraneous information or forget to answer the questions or your grade will be reduced ***
*** Your submission packet is due at the start of lab and will not be accepted after that time (automatic zero) ***

If you have any questions about your submission, please ask your instructor for clarification.

Lab Note 3: Graphing an I-V Characteristic from Data taken in a Lab exercise:

The I-V Characteristic curve is used to show the current through a two terminal device as a response to an applied voltage. It's a graph of Current through a device as a function of the voltage across a device (or I vs V). Like the graph of any function, the horizontal axis is the independent variable, and the vertical axis the dependent or functional variable. (The dependent variable is the function of the independent variable.) The term versus is occasionally used in a graph's title. The vertical function value vs. the horizontal variable.

Creating the graph is straightforward. Start with a set of axes, and decide on the scale you want to use. In general, the graph should fill the axes, so make the scales range slightly higher than the maximum values (i.e. in this lab, the axes should range from 0 - 12V and 0 - 10 or 11 mA. It makes it easier to read the graph if the line doesn't hug one of the axes. Once the axes are set up, plot the data points. Circling the data points allows them to be found even if the graph crosses them exactly. Once the data points are plotted, use a straightedge (for linear graphs) to draw a line that comes as close as possible to as many points as possible. This is the line of best fit. Interpolate the endpoints. If you know that the graph starts at the origin, start it there. Continue the best fit line to the edge of the field.

Every graph should have a Title, titled axes, and well labeled data. Label the curve. The labels should indicate all points of interest. In addition, every graph should have the data table, and the circuit diagram on the same page. Knowing where the data came from is very important. Finally, make sure that the labels used in the Table, the labels in the Circuit diagram, and graph labels all match. The Data table should have data in a labeled column (i.e. I_1), and the circuit diagram should have a parameter (voltage or current value) that matches (again I_1).
If the graph is an I-V Characteristic, the curve should have a label that tells the name of the device it represents.
That's how a professional creates a graph.

Lab Note 4: What's the difference between a graph (or plot) and the *sketch* of a graph?

When you're asked to "sketch" a graph, what should you do? A graph (or plot) is a line or curve on a set of axes that is accurate enough to use a ruler to actually measure a value on. A sketch, on the other hand, is a drawing that shows the essential "shape" of the graph, but is usually done free hand, and is not that accurate. A sketch communicates to the reader the idea of what the function is doing, but can be quickly drawn. When sketching a graph, neatness still counts, so use a straightedge to draw the axes, and the function if it linear. Since you cannot use the axis scales to find a value, you must clearly label your sketch with the values of interest. A label is just a number or a name that has a line pointed to the spot on the curve that you are labeling. If you are showing an I-V Characteristic, for example, and wish to show the slope, all the information (i.e. the rise ΔI and the run ΔV) must be shown as labels. Data points of interest must be indicated by adding a label for each one. With practice a neat sketch that includes labels will show precisely what the author wants to communicate. Just remember to be neat and complete.

Series Circuits and KVL

Team Name and Lab Section:… ....

Team Members Present (printed)

First Name, Last Name	Role This Lab	RIT Program

TEAM LABORATORY GRADE

(all work done neatly, legible, complete and organized including answering the questions, completed on time, all signoffs in place, no missing or extraneous information)

Instructor Signature, Part 1 ________	**/10**
Data Table 1, Q1-Q2..........................	**/20**
Instructor Signature, Part 2 ________	**/10**
Data Table 2, Q3-Q5..........................	**/20**
Final Team Grade..............................	**/60**

Instructor comments: