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Phys 330 – Electronics

Thevenin's Theorem and Diodes

Abstract:

In this lab, I tested my ability to create and understand voltage dividers in the first half. In the second part, I ran experiments on diodes and potentiometers. During the first part, I verified the commonly used voltage divider equation and created a circuit representing my Thevenin voltage, resistance, and short-circuit current. During the second part, I struggled to fully understand my equipment but eventually came to a proper understanding of how diodes affect the voltage and current of a system by changing resistance.

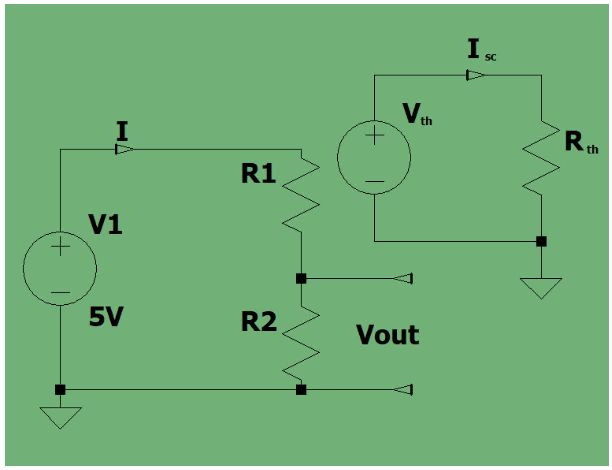
Background & Theory:

Thevenin's Theorem is one of the most fundamental concepts in analyzing electrical circuits. It simplifies complex linear circuits, allowing engineers to focus on components in a circuit. Thevenin's Theorem states that any linear electrical network with voltage and current sources and resistances can be reduced to a single voltage source in series with a single equivalent resistance. Eq 1. Shows how I found my Thevenin voltage and short circuit current for my given circuit found in Figure 1.

Eq. 1

$$\left| V_{out} = \frac{R_2}{R_1 + R_2} * V_{in} = V_{th} \right| \left| R_{th} = \left(\frac{1}{R_1} + \frac{1}{R_2}\right)^{-1} \right| \left| I_{sc} = \frac{V_{th}}{R_{th}} \right|$$

Figure 1. (Circuit diagram plus my Thevenin circuit with blank values that can be found below)

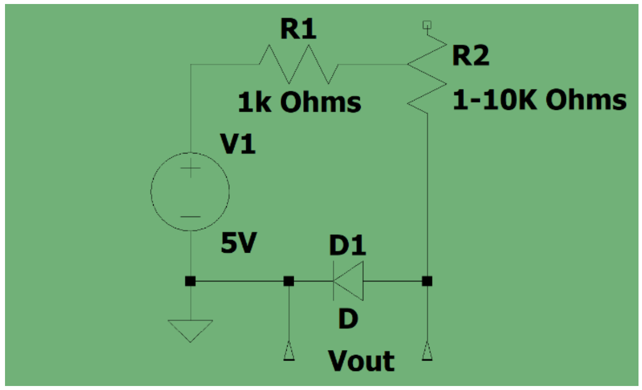


R1, R2 = 20k ohms, Vth = 2.5 V, Rth = 10k ohms, Isc = 25mA

You can use a voltage divider to find the Thevenin resistance then if you remove the source voltage and find your equivalent resistance for your system you can find Thevenin resistance. After you have resistance and voltage you can use Ohms Law to find the current you should be getting during testing. Both Thevenin circuits and voltage dividers are critical tools in circuit analysis and design. Thevenin's theorem simplifies complex networks into manageable parts, while the voltage divider allows for controlled voltage output across resistors in a series circuit.

For part 2 of the lab, I needed to familiarize myself with Potentiometers, Diodes, and the waveform generator we were using for our testing. Potentiometers are variable resistors with a simple mechanism that lets you induce a higher resistance by turning a knob. Diodes act as one-way current gates that can change the current of your system concerning resistance. Figure 2 below shows the Electrical circuit Diagram I was using for my testing and experimentation.

Figure 2. (R1 is my initial resistor to protect my system as I lower my potentiometer the Diode, I was using was a 1N 4001 Diode a link to the datasheet is found in my sources$_1$)



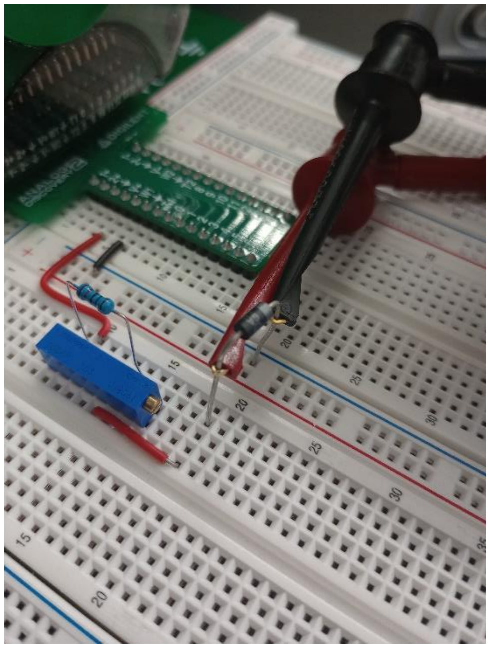
Diodes do not obey the typical equation for Ohm's Law, so I needed to discover what relation voltage had alongside current. To do this, I would use the potentiometer and Waveform technology I had on hand to aid in my testing.

Procedure:

The procedure for part 1 was very straightforward. First, I needed to calculate What my Short circuit current should be using me equations found above in Eq.1. This provided me with the values you can find at the bottom of Figure 1. To validate these assumptions, I needed to establish the circuit and use a volt meter to test the current on both ends of my second resistor. After taking that reading I could compare it to my expected value and see whether my equations held up.

Part 2 of the lab was a little trickier. Figure 3 below shows my final circuit and how I connected my voltmeter to get viable readings. Some of the problems I ran into here can be found in my Lab notebook, however, most of my issues came from an improper understanding of my equipment and how I was to take measurements.

Figure 3.
I attempted to hookup my potentiometer in a way that when I needed to change the resistance I wouldn't be hitting the wires. This resulted in a more complex-looking circuit.



For this procedure, I took a roundabout way of taking value because I could not find a way to do it using my tools. I found the bounds of my potentiometer and then counted the number of turns needed to move it from its minimum resistance to its maximum. After finding that number I divided the total change in resistance by the total number of turns to find roughly 1 rotation of the knob was a 400 ohm increase in resistance. I used this constant to help measure my voltage and current consistently. This also let me make two more graphs to maybe give me a better understanding of what I was doing. I recorded my results in my notebook and created plots based on the data I found.

Data Analysis:

Part 1 of the lab was an utter success. My reading was giving me about 26mA, and my projection was 25mA, so I was very happy to find little error in my experimentation and calculation. My notebook can be found below for any questions regarding my analysis.

Part 2 was a bit challenging. I was able to find a relationship between voltage and current, but I struggled to quantify the said relationship. In Figure 4 you can find my graphs for Current V.S. Resistance and Voltage V.S. Resistance. The relationship each shared with Resistance made it a lot easier for me to understand as I could see a direct relationship. In Figure 5 you can see my Current V.S. Voltage graph, and this is where it starts to get away from me. The lab recommended making a log graph to aid in understanding the goings on with this experiment and although I did it, I did not benefit from it as much as I had hoped. The graph for this can be found in Figure 6.

Figure 4. The graphs show how both Current and Voltage responded to an increase in Resistance

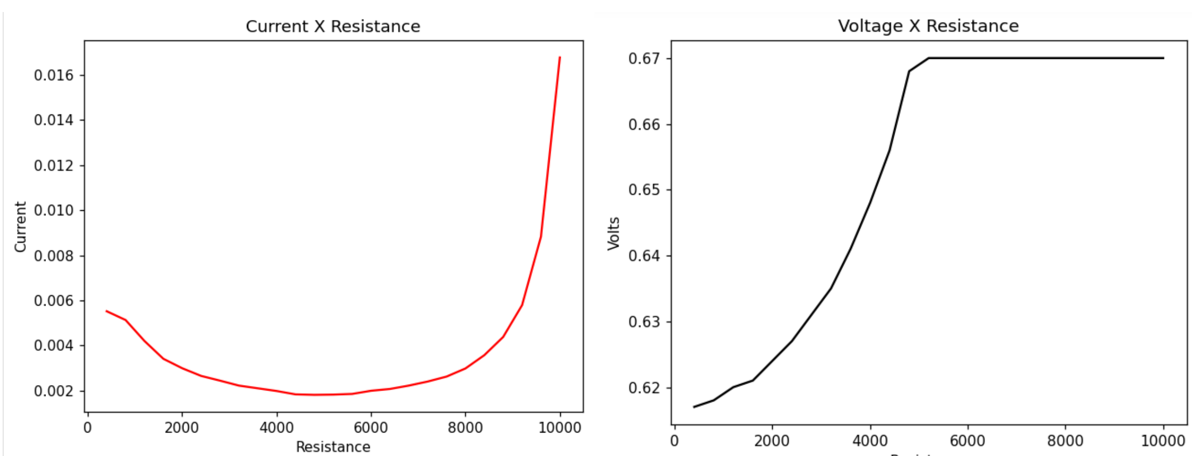


Figure 5. The below graph shows how current and voltage relate to one another.

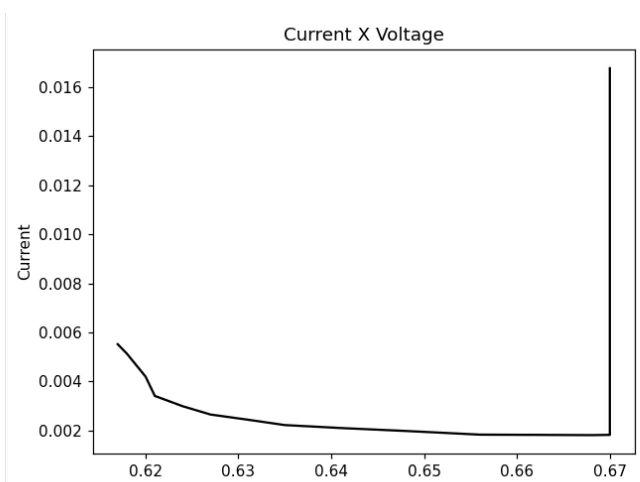
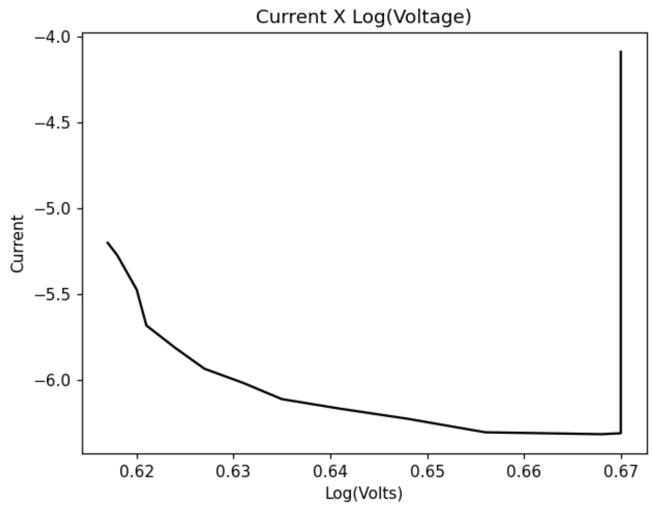


Figure 6. The below Graph is my attempt at making a graph that can be interpreted using the log method.



Although my data collecting and graphing did not go as I had initially hypothesized. I did learn a lot from this experiment. It seems that Diodes have both a minimum peak and high-end resistance threshold that they can go to for current which can be seen in my current V.S. resistance graph in Figure 4. It also seems like the Voltage will reach a certain maximum while the Current will continue to change, and that maximum seems to be at the same point as the diode's minimum current.

Conclusion:

Both parts of this lab we complicated in their way. Part 1 involved new concepts that were easy to learn but important to memorize. Part 2 involved a more complicated understanding of the tools I was using and helped me learn more about Diodes and potentiometers which will be ever-present in circuit analysis. I found a pliable relationship between voltage and Current in a diode and I was able to verify a very useful tool with Thevenin's Theorem. If I had to repeat this lab and correct any errors, I would become more familiar with waveform and see if there could be a more consistent way to take data.

Sources

https://www.onlinecomponents.com/en/datasheet/1n4004-42844393/--1N 4001 Diode Datasheet

Lab1 Electronics.pdf

Lab2.pdf