EEEE 281 Experiment 3:

Thévenin's Equivalent Circuit

From: Christopher Larson, Computer Engineering
To: Section 2B TA: Ryan Tatu, Jorge Wang, and Liam Callaham
Date: Performed: 5 February 2019 Due: 12 February 2019
Subject: Lab 3-Thévenin Equivalent Circuits
Lab Partner(s): Thomas Mountford

Component	Percentage of Grade	Score	Comment
Report Formatting	20		
PSPICE: Setup Conditions	5		
PSPICE: Data and Figures	15		
PSPICE: Discussion of Simulation	15		
Hardware: Experimental Setup	10		
Hardware: Experimental Data and Tables	15		
Hardware: Discussion of Results	20		
Total Score:			
Graded By:			

Abstract

The abstract section should contain a summary of what was performed in the lab and should be approximately 200 words. This should succinctly rephrase the purpose of the laboratory. It should also refer to the data collected. **The abstract should specifically mentioned the Thévenin resistance and voltage obtained, as well as the various methods used.**

1 Introduction and Theory

Include 1-2 paragraphs that explains the scope of the experiment. Briefly introduce the concept of Thévenin's equivalent circuit. What was the primary purpose of the experiment? If the data collection has deviated in any way from the rest of your section (for example you had to come back to collect more data), explain this in a second paragraph. In particular, be sure to note if your data was acquired from a different lab than your classmates/using different equipment.

1.1 Theory: Circuit Topology

In this section, you should introduce the reader to the circuit investigated in the experiment, and demonstrate the theoretical value of the circuits.

- A figure of the circuit schematic should be included here. You can use a figure from PSPICE. Be sure to indicate what the load resistor is. Students using LaTeXmay ask Dr. Rommel permission to use the Circuitikz artwork used in the laboratory handout. Use of the artwork should be appropriately acknowledged as a citation and under the acknowledgements. If you do use Circuitikz, please let Dr. Rommel know what version you are using. Some recent updates (discovered while writing this handout/tempalte) have changed the way voltage polarity is presented. You will hae to edit the values of the resistors.
- Define the ground in the circuit and specific nodes.
- This description can be short (a few sentences in length).

1.2 Theory: PSPICE Simulation Summary

Begin by providing a 1 paragraph description of the PSPICE setup. Which **libraries** and **PSPICE elements** were used in the simulation? You can borrow from the text of your first tech memo here. If you do so, please be sure to cite the tech memo. Note the libraries used. You can find the information when you look at the properties of each element. There will be a reference to a ".olb" file. This is the library name.

Include a description of the resistor sweep. Specifically, what is the funcction of the **PARAMETER/SPECIAL** element? Also, what type of simluation was run? What were the start/stop resistor values? What was the step size, and was it linearly or logarithmically varied? Comment about the line fit in Excel (or whatever software was used to perform the linear regression).

The lab handout called for using parameters in the tutorial, which were edited during your prelab to match the resistors in this lab. What changes were made to the parameters? Also, why were unique names given for Net Aliases in each circuit?

1.2.1 Theory: PSPICE Schematic Diagram

Since the prelab called for having all 4 circuits on the same page, you may place two copies of the schematic here as listed in Figs. 1.2.1 and 1.2.2

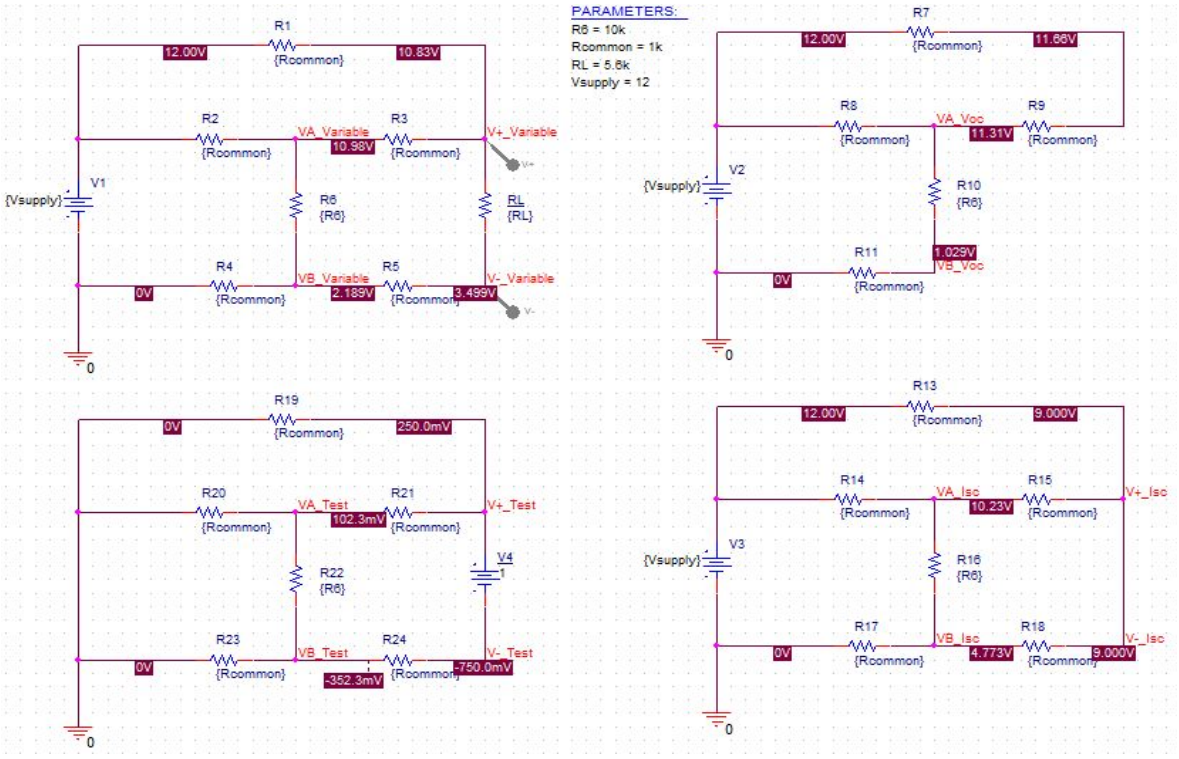


Figure 1.2.1: Screen shot of the PSPICE schematic with voltage markers.

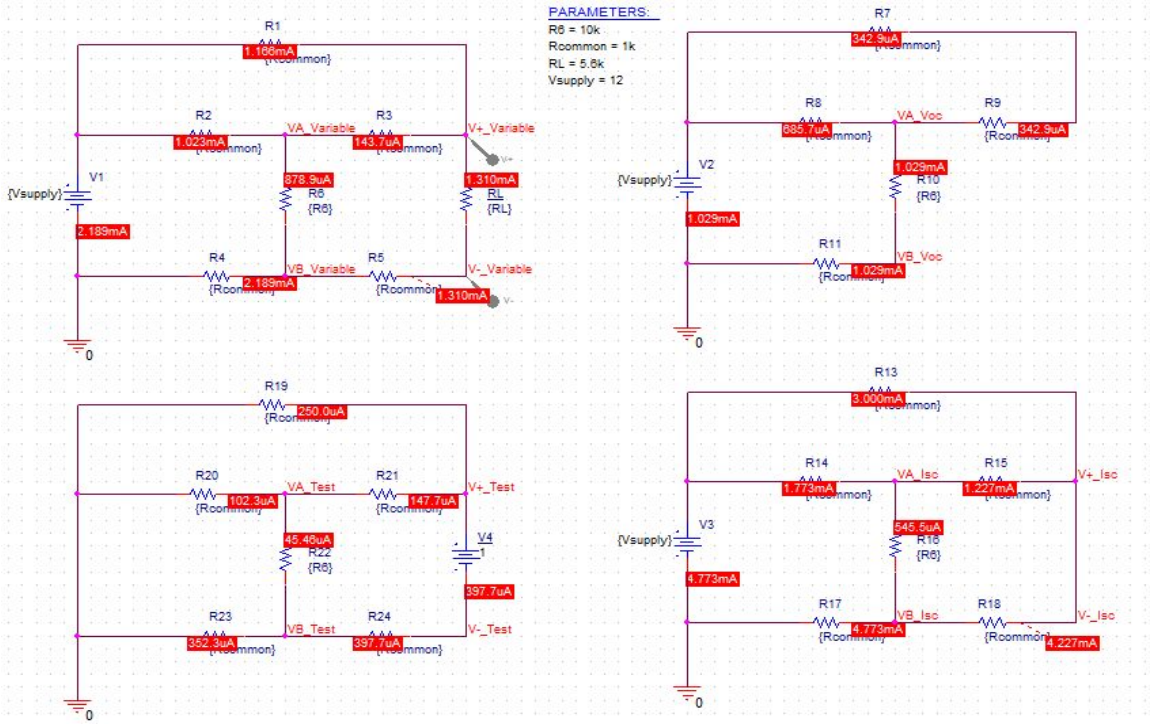


Figure 1.2.2: Screen shot of the PSPICE schematic with current markers.

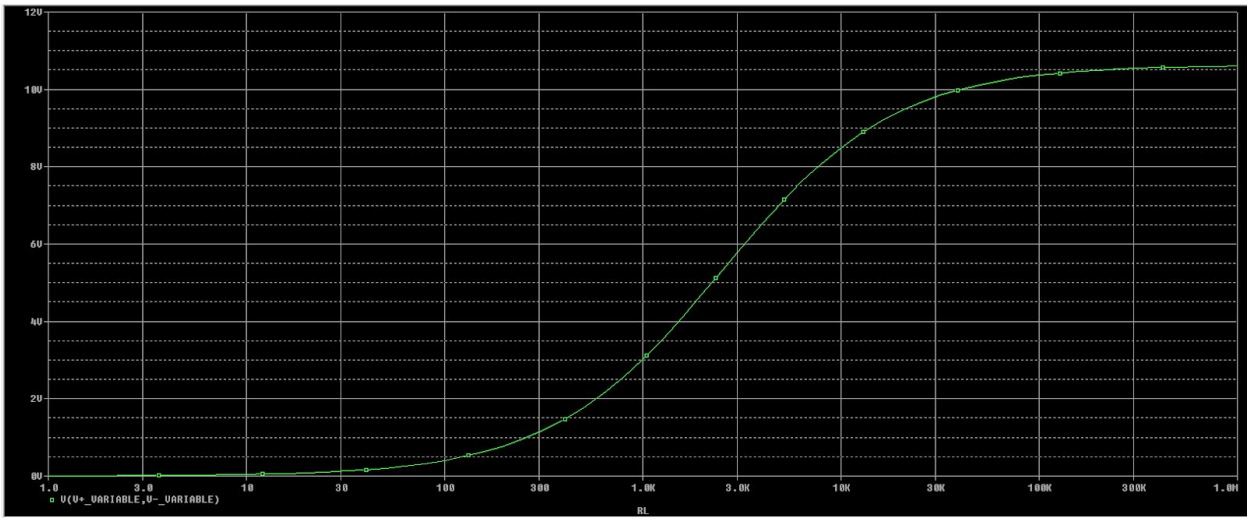
Include a brief description of the figures (which subcircuit is which-i.e., The upper right schematic diagram is the Variable Load).

The upper left circuit is the original circuit, it is a similar circuit to Lab 2 just this time parameters were used to hold values for the resistors and voltage source. The upper right circuit is the Variable Load, the resistance was found by removing the load resistor and determining the open-circuit voltage. The bottom right circuit is the Open Circuit/Short Circuit where the load resistor was removed but replaced by a wire to short-circuit the load and determine the current in the short-circuit. The bottom left circuit is the Test Signal.

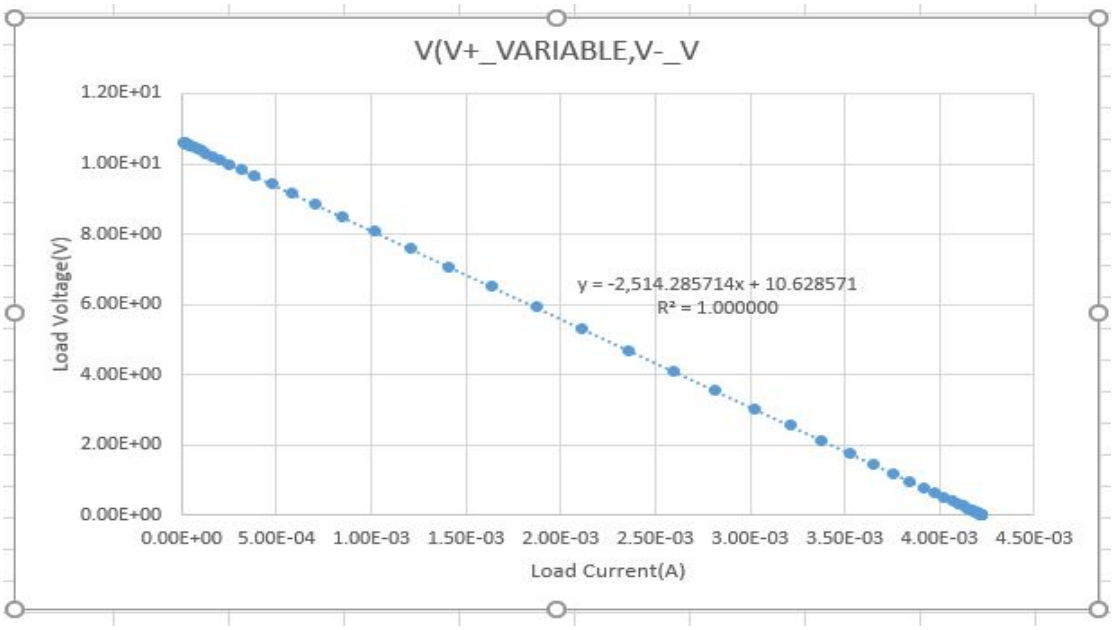
1.2.2 Theory: PSPICE Simulation Varying Load Circuit

In this section, include:

- A figure with the plot of R_L vs. V_L from PSPICE.



- A figure with the corresponding linear regression in Excel that illustrates the resulting scatter plot and extraction of R_{th}.



- Present the equation generated by Excel in the text of the report.

$$y = -2{,}514.285714x + 10.628571 \quad (0)$$

- Be sure to indicate the r^2 value with the equation. You may need to change the output precision of Excel if the r^2 value appears to be "1". Realistically simulation results will show a "1".
- Briefly comment about the results and include the extracted values of V_{th} and R_{th} in Table 1. This section should be a few sentences to a paragraph long.

The scatter plot graphed points of the Load Voltage and the Load Current which were found using DC Sweep which is a type of simulation. The trendline was taken from the graph and is shown as an equation in Equation 0. The slope of the line represents the R_{th} and the Y-intercept represents the $V_{th.}$

Table 1: Variable Load PSPICE test results.

V_{th} (V)	R_{th} (Ω)
10.631	2514

1.2.3 Theory: PSPICE Simulation Open Circuit/Short Circuit Test

In this section, include:

- Explain how the PSPICE schematic was altered for the open circuit voltage test and short circuit test. The entire discussion (including all bullets below) should be about 1 paragraph
- Refer to the Fig. 1.2.1 with a screen shot of the schematic in PSPICE with voltage markers for the V_{oc} test. As you likely have already placed this figure in your theory section, there is no need to do so a second time.

- Refer to Fig. 1.2.2 with a screen shot of the schematic in PSPICE with current markers for the I_{sc} test. As you likely have already placed this figure in your theory section, there is no need to do so a second time.
- Quotes the V_{oc}(V) and I_{sc}(A) values extracted from these figures in the text and report the values in Table 2. Provide a calculation of R_{th} that mirrors the tutorial. Subsequently, briefly comment about the results and whether they are in agreement with the Variable load test.

The open circuit voltage is found by taking the voltage difference between V+_Voc and VB_Voc as shown in Equation 1. The short circuit current is the current entering $R_1$7 resistor, which is 422.7 μA. The Thévenin resistance (R_{th}) was calculated using Equation 2, using the open circuit voltage and the short circuit current. All of the values agree with the Variable load test which shows that the test were performed correctly and the circuit was designed correctly.

$$V_{oc} = V_{+\_}V_{oc} - V_{B\_}V_{oc} = 11.66 \text{ V} - 1.029 \text{ V} = 10.631 \text{ V} \quad (1)$$

$$R_{th} = V_{oc} / I_{sc} = 10.631 \text{ V} / 422.7*10\text{^-}6 = 2514 \ \Omega \quad (2)$$

Table 2: PSPICE Open/Short Test Table.

V_{oc}(V)	I_{sc}(A)	R_{th} (Ω)
10.631	422.7*10^-6	2514

1.2.4 Theory: PSPICE Simulation Test Signal Method

In this section, include:

- Explain how the PSPICE schematic was altered for the open circuit voltage test and short circuit test. The entire discussion (including all bullets below) should be about 1 paragraph
- Refer to the Fig. 1.2.2 with a screen shot of the schematic in PSPICE with current markers for the Test signal. As you likely have already placed this figure in your theory section, there is no need to do so a second time.
- Briefly comment about the results and whether they agree the Voc/Isc approach and the Variable load. Include the results in Table 3.

The results from the Test Signal method agreed with the Variable Load test and the Open/Short Circuit test which further proves that the values are correct. The Thévenin resistance (R_{th}) was calculated using Equation 3, using the Test Signal voltage and the Test Signal current, which was found beneath the voltage source. The voltage at R5 was also recorded but not used in any equations.

$$R_{th} = \text{Test Signal} / I_{\text{Test Signal}} = 1 \text{ V} / 397.7*10\text{^-}6 = 2514 \ \Omega \quad (3)$$

Table 3: R_{th} from Test Signal.

Test Signal (V)	V_{R5} (V)	$I_{\text{Test Signal}}$ (A)	R_{th} (Ω)
1	-0.75	397.7*10^-6	2514

2 Hardware Experiment: Results and Discussion

This section of the report should present what was done in hardware. A reader should be able to recreate an experiment from the detail present. One section discusses the equipment used in the experiment. The remaining sections discuss the results for each circuit.

2.1 Equipment Used in the Laboratory

Write a short paragraph to detail the equipment used in the laboratory, and specific model numbers. Ideally, you should create a table of the equipment which should be referred to in text (See Table 4 as an example). The room location where the experiment was performed should be included. Note that this should be a part of all Tech Memos, as it is an essential piece for other users to replicate your experiment. **As you will be likely using the same equipment throughout the term, once the text/tables are established, you may reuse the information with the permission of your instructor/TA. Again, cite your first lab report as a reference.**

Table 4: Equipment/Software required for Lab 2.

Item	Tool	Room
Simulation	OrCAD Capture CIS	All Open EE Labs
DC Power Supply	Agilent E3630A	09-3170
DC Power Supply	Agilent E3631A	09-3200
Multimeter	Agilent E34401A	09-3170, 09-3200

2.2 Hardware Results/Discsussion Resistor Values

Begin the section by including the experimental values of the resistors as illustrated in Table 5. If you kept your lab 2 circuit wired up for lab 3, you can include the table (cut/paste), citing your lab 2 report. Briefly discuss.

Table 5: Resistors used in the laboratory.

Resistor	Exp. Value (Ω)
R_1	981
R_2	1000
R_3	993
R_4	990
R_5	985
R_6	9854

2.3 Hardware Results: Open/Short Extraction

Table 6: Hardware Open/Short Test Table.

V_{th}(V)	I_{sc} (A)	R_{th} (Ω)
10.619	427.9*10^-6	2481.6

Include the following discussion points in a paragraph:

- A table of the measured open circuit voltage and short circuit current (Table 6).
- Provide a discussion of how you implemented the technique in hardware (i.e., What did you change in the hardware circuit to measure the open circuit voltage? What did you change in the hardware circuit to measure the short circuit current?)
- For the short circuit current, you most likely extracted this by measuring a voltage across the R resistor in the lab handout. Include the Ohm's law calculation to back out the current as an inline equation.
- Discuss how the results agree with theory, and include an error analysis based on either the PSPICE or hand calculations.

2.4 Hardware Results: Direct Measurement of R_{th}

In this section, discuss the direct measurement of R_{th} in 1 paragraph.

- Provide a discussion of how you implemented the technique in hardware. What was done to the load resistor? What was done to the power supply? How was R_{th} measured?
- Record the value of R_{th} from direct measurement in Table 7.
- Discuss whether the results agree with theory.

Table 7: R_{th} direct measurement table

R_{th} (Ω)	2483

2.5 Hardware Results: Test Signal Extraction

In this section, discuss the test signal extraction measurement of R_{th} in 1 paragraph.

- Provide a discussion of how you implemented the technique in hardware. What was done to the load resistor? What was done to the power supply? Where did you hook up the test signal, and what was the magnitude of the test signal? How was R_{th} determined?
- Record the value of R_{th} from the test signal extraction in Table 8.
- Discuss whether the results agree with theory.
- Answer the following question: If the test signal was increase to 3 , would the final result change? Explain.

Table 8: R_{th} from Test Signal.

Test Signal (V)	V_{R5}	$I_{R5}=I_{Test}$ (A)	R_{th}(Ω)
0.998	0.397	397.7*10^-6	2513.8

2.6 Hardware Results: Varying Load Extraction

In this section, you should discuss the hardware results of the varying load extraction. Include the following:

- A table of the measured load voltage, and corresponding load current for each resistor (Table 9).
- A scatter plot of this data in Excel/Matlab/etc. showing the line fit extraction and corresponding Thévenin Resistance. As described in the prelab video, be sure to indicate the r^2 value with the equation. You may need to change the output precision of Excel if the r^2 value appears to be "1".
- Briefly discuss whether the results compare to the PSPICE theory.

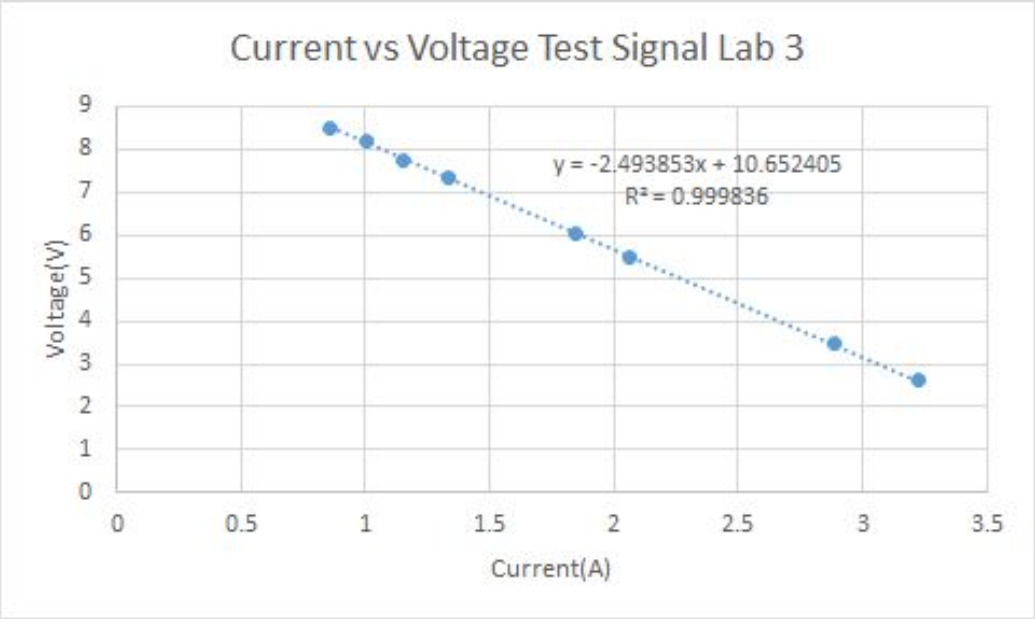


Table 9: Variable load resistor Table. Use Ohm's Law to determine the load current (I_L).

Resistor	Exp. Value (Ω)	V_{RL} (V)	I_{RL} (A)
R_{L1}	5493	7.317	1.332
R_{L2}	2630	5.507	2.062
R_{L3}	1200	3.460	2.883
R_{L4}	815	2.626	3.222
R_{L5}	3270	6.038	1.847
R_{L6}	6760	7.767	1.148
R_{L7}	9880	8.487	0.859
R_{L8}	8180	8.213	1.004

3 Conclusion

Provide a 1 paragraph summary of the laboratory experiment. What were the major conclusions for each part of the experiment? Also did the theory agree with the experiment? The conclusion is a revised version of the abstract. Has Thévenin's Theorem been experimentally validated? Discuss the effects of tolerances affecting the differences between measured results and simulated results.

4 Acknowledgments

Acknowledge **any** source of help received in the experiment/writing the report. This should certainly include your lab partner/teaching assistant/instructor. It may also include other classmates/study partners. State briefly what the nature of the help was.
Your report should include references to appropriate pages in the text, as well as any other sources, websites/etc. consulted in the preparation of the report.

References

[1] C.K. Alexander, and M.K.O. Sadiku, *Fundamentals of Electric Circuits, 4th Edition*, McGraw Hill, pp. xx-yy(EDIT), 2009.
[2] A. Student, *EEEE 281 Lab 1 Tech Memo*, page xx-yy, submitted Month, Day, 2015.
[3] S. Rommel, *EEEE 281 Lab 1 Lecture notes*, slides xx-yy, Spring 2015.