R·I·T

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EEEE 281 Lab 2 Circuits 1

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To: Section 2 TA: LJ Boone, Harrison Keats
Date: Performed: 2/11/20 Due: 2/18/20
Subject: Lab 2-Loop and Nodal Analysis
Lab Partner(s): N/A

Table 1: Grading Table

Component	Percentage of Grade	Score	Comment
Report Formatting	20 %		
Hand Calc.: Nodal or Mesh Analysis	10 %		
PSPICE: Simulation Summary	5 %		
PSPICE: Simulation and Data	10 %		
PSPICE Discussion	20 %		
Hardware: Experimental Setup	5 %		
Hardware: Experimental Results/Data	10 %		
Hardware: Discussion	20 %		
Total Score:			
Graded By:			

Abstract

The purpose of this lab was to reinforce student's knowledge of Capture CIS. By designing a more complex circuit and performing a simulation, students were familiarized more with the program. The hardware portion of the lab also helped students become more comfortable with the lab equipment by having students analyze more complex circuits. The concept of nodal analysis and mesh analysis were used to calculate the differential voltage drop between $V_{out,+}$ and $V_{out,-}$ across the load resistor R_L. A complex circuit was built using different resistors in a pattern described below. Potentials relative to ground were measured at all of the nodes and compared to the nodal voltages in the PSPICE simulation.

1 Introduction and Theory

The purpose of this exercise was to reinforce skills with circuit design software and simulation as well as give students a better understanding over the lab equipment.
The data collection did not deviate from that of the simulation. All hand calculations could be done with the resistances measured in lab.

1.1 Theory: Circuit Topology

The circuit investigated in lab consisted of 6 $1\,k\Omega$ resistors and a $10\,k\Omega$. A 12 V voltage source was connected to power the circuit.

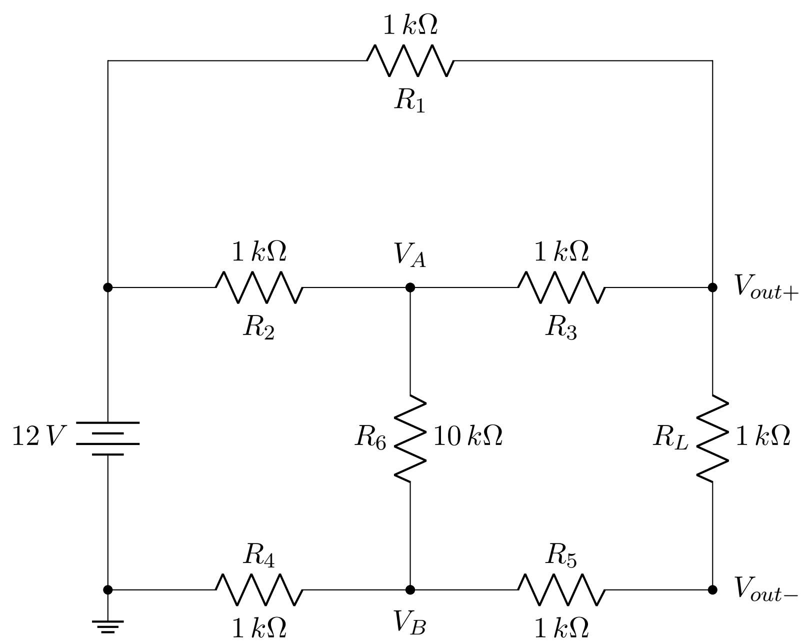

Figure 1: Circuit investigated in lab

There are four unknown nodes in Figure 1. V_{out+} and V_{out-} are defined across R_L or the load resistor. The other two nodes, V_A and V_B and across the $10\,k\Omega$ resistor. Ground is defined as the negative poll on the voltage source. A 12 V voltage source is connected to the circuit.

1.2 Theory: Nodal or Mesh Analysis (hand calculations)

In this section, you should integrate the hand calculations into the text of the report. You are required to perform either nodal or mesh analysis calculations.
To start the mesh analysis, an equation representing each mesh must be shown. i_1 was defined as the top-most mesh, i_2 the bottom left and i_3 the bottom right.

$$(3\,k\Omega)i_1 - (1\,k\Omega)i_2 - (1\,k\Omega)i_3 = 0 \tag{1}$$

$$-(1\,k\Omega)i_1 + (12\,k\Omega)i_2 - (10\,k\Omega)i_3 = 12 \tag{2}$$

$$-(1\,k\Omega)i_1 - (10\,k\Omega)i_2 + (13\,k\Omega)i_3 = 0 \tag{3}$$

Each equation was set up by assuming a clockwise mesh current. The effective voltage drop for each of the currents were added together. Following the set up, a matrix can be solved.

$$\begin{bmatrix} 3 & -1 & -1 & 0 \\ -1 & 12 & -10 & 12 \\ -1 & -10 & 13 & 0 \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 2.244 \\ 0 & 1 & 0 & 3.710 \\ 0 & 1 & 1 & 3.024 \end{bmatrix} \tag{4}$$

The matricies in equation 4 used the coefficients in $k\Omega$ and therefore the reduced echilon form shows answers in mA. The voltage across R_L can be calculated using i_3.

$$V_{out} = (3.024\,mA) \cdot (1\,k\Omega) = 3.024\text{V} \tag{5}$$

The voltage at each node can be traced back to ground through multiple resistors. The sum of the voltage drop across each resistor will indicate the voltage at the node.

$$V_A = i_2 \cdot (10\,k\Omega) + i_2 \cdot (1\,k\Omega) - i_3 \cdot (10\,k\Omega) = 10.57\text{V} \tag{6}$$

$$V_B = i_2 \cdot (1\,k\Omega) = 3.707\text{V} \tag{7}$$

$$V_{out+} = i_3 \cdot (1\,k\Omega) + i_3 \cdot (1\,k\Omega) + i_2 \cdot (1\,k\Omega) = 9.756\text{V} \tag{8}$$

$$V_{out-} = i_3 \cdot (1\,k\Omega) + i_2 \cdot (1\,k\Omega) = 6.732\text{V} \tag{9}$$

1.3 Theory: PSPICE Simulation Summary

The PSPICE simulation began with a design of the circuit. A voltage supply along with three resistors were placed. A 5% tolerance was added to each of the resistors. The resistance was set for each element. The nodes V_A, V_B, V_{out+}, and V_{out-} were named as such. A ground was placed according to the circuit diagram in figure. The PSPICE setup used the libraries imported from the Circuits 1 library from the lab computer. The libraries were called **analog.olb**, **opamp.olb**, **source.olb**, and **special.olb**. The components used were "R/ANALOG" from the **analog.olb** for the resistors, "VDC/SOURCE" from the **source.olb** for the voltage source and "O/CAPSYM" from the **special.olb** for ground.

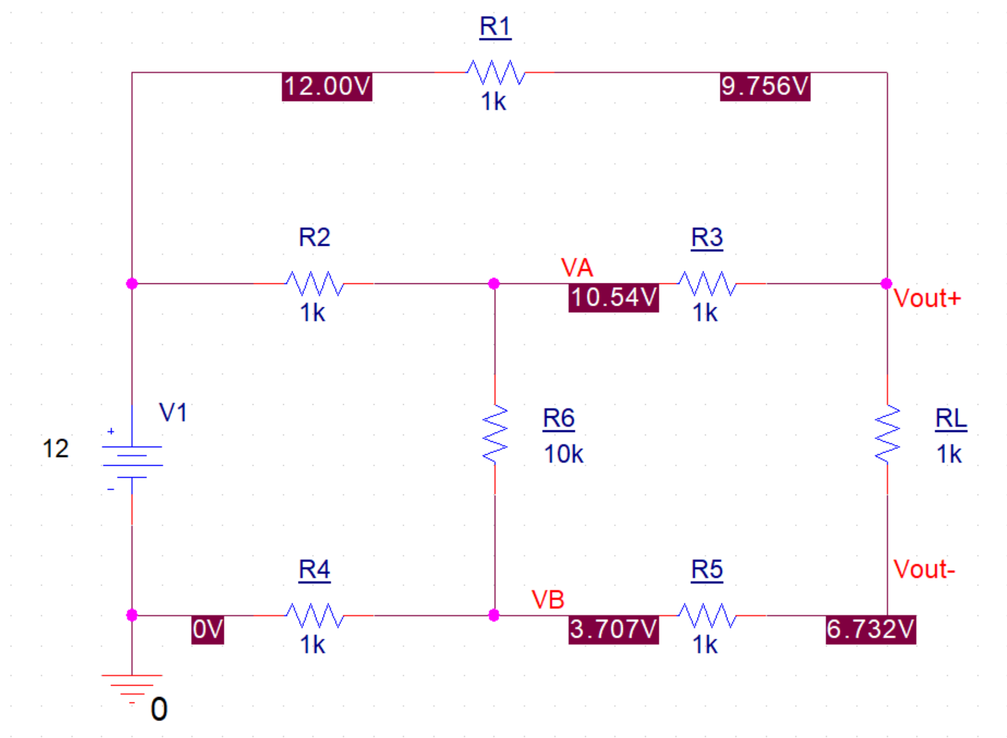

Figure 2: PSPICE simulation with voltage markers.

1.3.1 PSPICE: DC Simulation

In Figure 2 the circuit shows the results of the PSPICE simulation and all of the nodal voltages. The nodal voltage at V_A and V_B were 10.54 V and 3.707 V respectively. The voltage at nodes V_{out+} and V_{out-} were measured at 9.756 V and 6.732 V respectively giving V_{out} a voltage of 3.024 V. These perfectly aligned with the hand calculations done in the previous section.

2 Hardware Experiment: Results and Discussion

The hardware portion of this exercise consisted of reading the resistances of each of the seven resistors and building the circuit. A measurement on each of the unknown nodes was taken using a multimeter.

2.1 Equipment Used in the Laboratory

Table 2: Equipment/Software required for Lab 1.

Item	Tool	Room
Simulation	OrCAD Capture CIS	09-3200
DC Power Supply	Agilent E3631A	09-3200
Multimeter	Agilent 34401A	09-3200

PSPICE Capture CIS was used to create the circuit and the perform the simulation. The DC Power Supply shown in Table 2 was used in the hardware portion to power the circuit. The multimeter shown was used to measure the voltage and resistances across each of the resistors.

2.2 Hardware Results/Discussion

The resistances of all seven resistors were measured and recorded using the resistance tool on the multimeter.

Table 3: Resistor Table

Resistor	Nominal Value (kΩ)	Measured Value (kΩ)	Tolerance (%)
R_1	1	0.983	5
R_2	1	0.983	5
R_3	1	0.987	5
R_4	1	0.981	5
R_5	1	0.982	5
R_6	10	9.95	5
R_L	1	0.986	5

The small variance from nominal and measured values are due to phyiscal variations in the resistors. They are all within specified tolerances.

2.3 Hardware Results Summary

The voltages relative to ground were measured for each of the unknown nodes, V_A, V_B, V_{out+}, and V_{out-}. The equivalent resistance accross the power supply was measured to be $3.231\,k\Omega$. The equivalent resistance accross R_L was measured at $0.915\,k\Omega$.

Table 4: Summary of nodal voltages for Lab 2.

Voltage	Hand Calculations (V)	PSPICE (V)	Hardware (V)	Percent Error With Hand Calc. (%)
V_A	10.54	10.54	10.54	0
V_B	3.707	3.707	3.697	0.27
V_{out+}	9.756	9.756	9.764	0.08
V_{out-}	6.732	6.732	6.723	0.13
$\Delta V_{out} = V_{out+} - V_{out-}$	3.024	3.024	3.040	0.53

Table 4 shows a very slight error in the measured voltages of the unknown nodes. This is due to the fact that the equipment used provided very little room for error.

3 Conclusion

This laboratory experiement made students more comfortable with PSPICE Capture CIS software and simulation by having students design and simulate a more complex circuit. The simulation in PSPICE was compared to hand calculations. Hand calculation were obtained through nodal analysis or mesh analysis. Finally the circuit was constructed on a bread board and the unknown nodes were measured using a multimeter. Results were compared to the calculation obtained in the prelab.

4 Acknowledgments

- wikibooks.org helped with the LaTeX code.
- tex.stackexchange.com helped with the circuit diagram in LaTeX.

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.