LABORATORY 4

Equivalent Circuits

Guide

Important Notes

- Please make sure the current limit set higher than the current required by the circuit but lower than 2 amps. This is to ensure that you provide your circuit with enough power without damaging the equipment.
- Always use measuring devices (DMM) to take your measurements. Do not depend on the power supply to report accurate voltage and current values.
- In this lab, you may use resistors 2.2kΩ; 1.2kΩ, 1kΩ, 670Ω, 220Ω, 100Ω, etc. For this lab, you can use resistor values are at within 5% of your theoretical value. If you require the use of other valued resistors, then your theoretical calculations are incorrect.
- These circuits are complicated. Good breadboard practice will be key in completing this lab.
- Before coming into the lab, you should use Multisim to build these circuits first, which also help use check your answer in the prelab.

Equivalent Resistor Networks

1. Build the circuit shown in Figure 1. To demonstrate the importance of a neat and orderly breadboard layout, use only the resistors and no extra wires (except those connecting the power supply) to build this circuit. Assuming a maximum of 10 volts, what is the maximum amount of current supplied by the power supply?
2. From your prelab, you calculated the theoretical resistance across **A** and **B**. Disconnect the circuit from the power supply and use the DMM to measure the actual resistance across terminals **A** and **B**.
3. Reconnect the power supply, and record $\mathbf{V_{AB}}$ and **I** for 5 different supply voltages (2V, 4V, 6V, 8V, 10V). Plot the IV curve of this circuit.

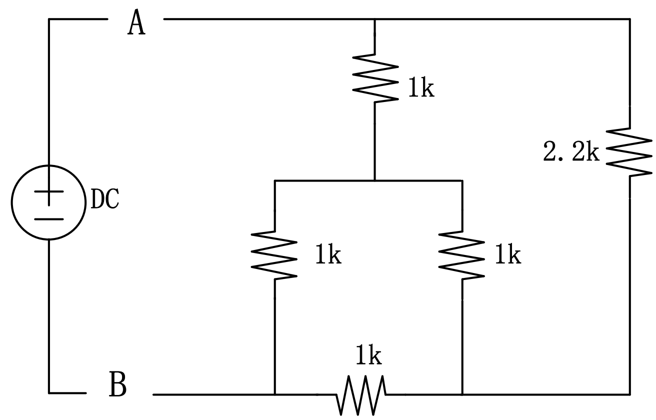


Figure 1

4. Build the circuit shown in Figure 2. Use the value of **R_{eq}** calculated in the prelab exercises and measured in step 2.

5. Using the power supply, record **V_{AB}** and **I** for 5 different supply voltages（2V， 4V，6V， 8V， 10V）. Plot the IV curve of this circuit.

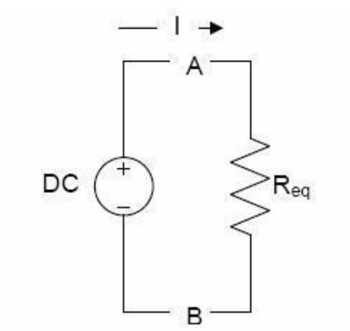


Figure 2

Thévenin's and Norton's Equivalence

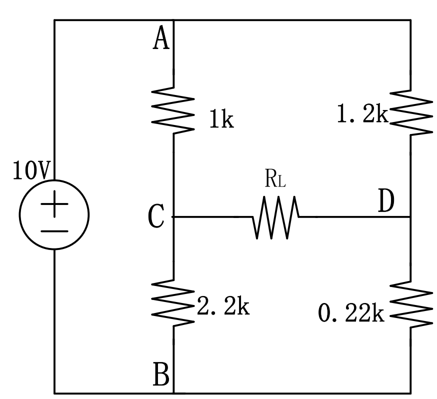


Figure 3

6. Build the circuit shown in Figure 3 leaving out the resistor labeled $\mathbf{R_L}$ for now. Again, use only the resistors and no extra wires to build this circuit. Measure the voltage across terminals **C** and **D**. This is your open circuit voltage ($\mathbf{V_{TH}}$) and should be the same as you calculated in your prelab.

7. Now measure the current flowing through terminals **C** and **D**. Remember, when measuring current using the DMM, there is 0-resistance across the probes. Then you are essentially measuring the short-circuit current ($\mathbf{I_{SC}}$) and should be the same as you calculated in your prelab.

8. Disconnect the power supply, and short terminals **A** and **B**. You killed the voltage source. Measure the resistance across terminals **C** and **D**. This is your Thévenin resistance ($\mathbf{R_{TH}}$) and should be the same as what you calculated in prelab.

9. Now, “un−short” terminals **A** and **B** and reconnect the power supply (thus restoring the circuit in figure 3). For 3 different values of R_L=220, 1.2k, and 2.2k, install the resistor and measure the voltage across and the current through $\mathbf{R_L}$.

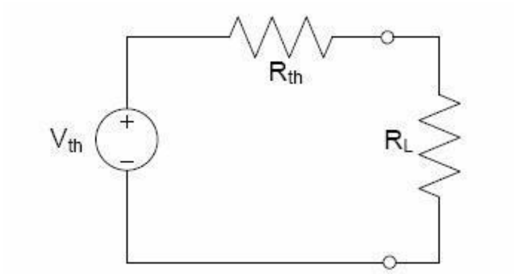


Figure 4

10. Build the circuit shown in Figure 4 with the appropriate values of $\mathbf{V_{TH}}$ and $\mathbf{R_{TH}}$ you calculated in your prelab and measured in steps 6 and 8.

11. For the three values of $\mathbf{R_L}$, measure the voltage across and current through $\mathbf{R_L}$.

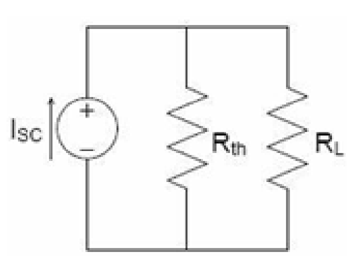


Figure 5

12. Build the circuit shown in Figure 5 with the appropriate values of I_{SC} and R_{TH} that you calculated in your prelab and measured in steps 7 and 8.
    Hint: to make a viable current source, connect a large (>>R_{TH}) resistor in series with the power supply and adjust the voltage of the power supply until the current through the resistor is I_{SC}.

13. For the three values of R_L, measure the voltage across and current through R_L.

Pure Resistive Networks and Frequency

14. Attach the oscilloscope channel across points **C** and **D** (on figure 3). This is the system output. Disconnect the power supply, and instead attach points A and B to the function generator. This will apply an AC, rather than DC input to the system. Attach a second oscilloscope channel across points **A** and **B**.

15. Output a 10 kilohertz 10Vp-p sinusoidal wave with function generator.

16. Observe both input and output waveforms together on the oscilloscope screen. Vary the frequency of the sine wave.

Circuit Simplification and Symmetry

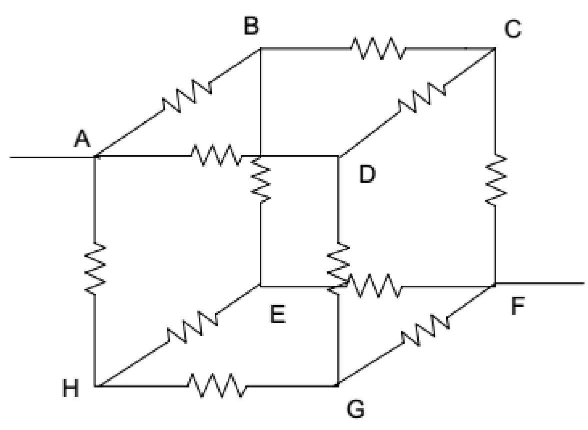


Figure 6

17. Build the circuit in Figure 6 on the breadboard. Make all resistor values 1k. As mentioned in the prelab, this circuit should be constructed in a neat and orderly fashion using only the resistors and no extra wires. (**Hint**: node **A** and **F** are the voltage source and ground respectively. Remember the breadboard configuration need not resemble the circuit's spatial configuration. Only the connections between nodes matters)

18. Measure $\mathbf{R_{eq}}$ between points **A** and **G**. Compare this to the value you calculated in the prelab.

19. Reconnect the power supply to points **A** and **F**. Adjust the voltage to 10V. Measure the current through the resistor between point **A** and **D**, **D** and **C**, **C** and **F**.

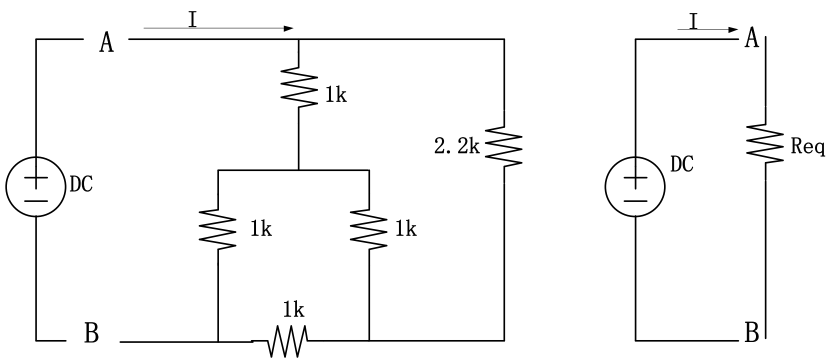
Lab4 Prelab

Name ____________________ TA ____________________

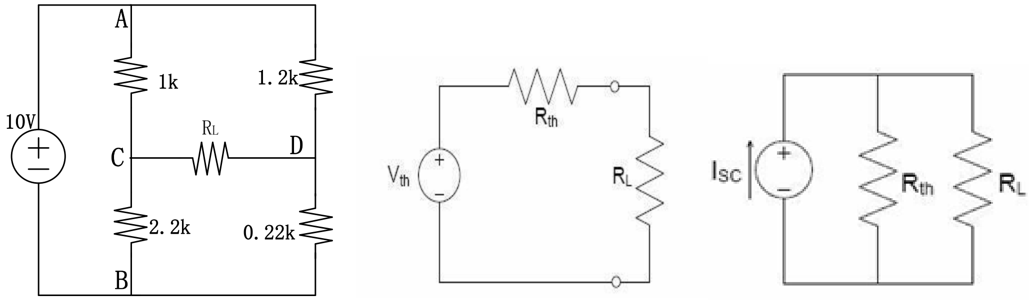
Teammate ____________________ Score ____________________

NOTE: Many of these theoretical values will be used in your lab. Please record your theoretical values in questions 2 and 5 of your lab report.

1) The two circuits given below are equivalent. What is $\mathbf{R_{eq}}$? **__/8pt**

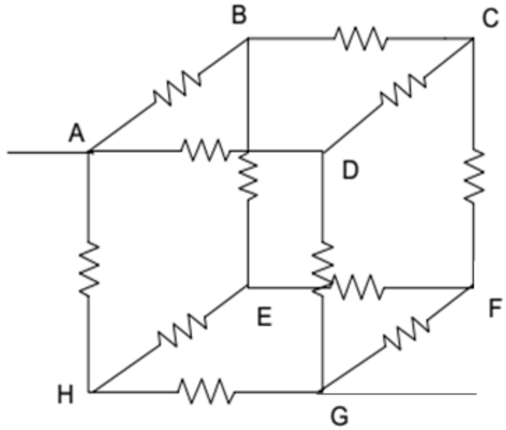


2) The three circuits given below are equivalent. **__/12pt**



a. What is the value of $\mathbf{R_{TH}}$?
b. What is the value of $\mathbf{I_{SC}}$?
c. What is the value of $\mathbf{V_{TH}}$?

3） In the circuit below, all resistor values 1k. What is $\mathbf{R_{eq}}$ between points **A** and **G**? **__/10pt**



Lab4 Report

Name ______________________ TA Checkoff ______________________

Teammate ______________________ Score ______________________

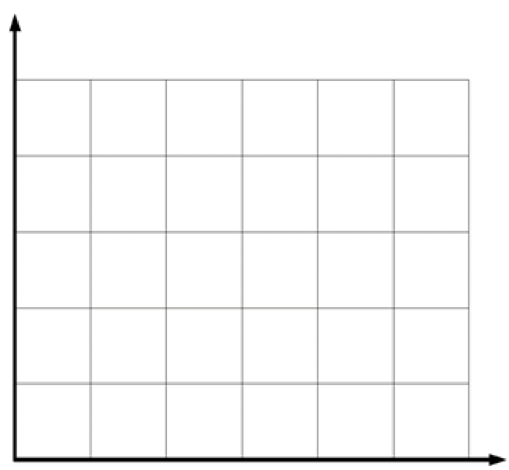
Equivalent Resistor Networks

Step 1: Max Current through resistor network: ______________________ **__/2pt**

Step 2: Resistance across **A** and **B**. Theory: _______ Measured: _______ **__/4pt**

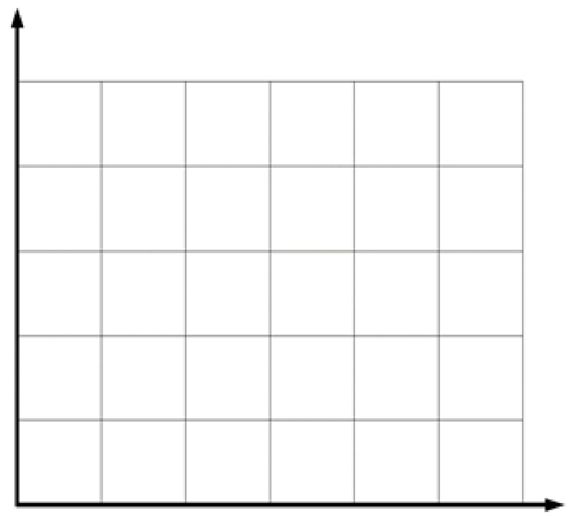
Step 3: **__/12pt**

V_{AB}	**I**



Step 5: **__/12pt**

V_{AB}	I



Step 6 - 8: measure V_{TH}, I_{SC}, and R_{TH}. The theoretical values should have been calculated in your prelab. **__/6pt**

	Theory	Actual
V_{TH}		
I_{SC}		
R_{TH}		

Step 9 - 13: **__/16pt**

	Original		**Thévenin**		**Norton**	
	V	**I**	**V**	**I**	**V**	**I**
220						
1.2k						
2.2k						

Step 14 - 16: **__/8pt**

What is the frequency of the output wave between terminal C and D?
Note the differences, if any, between the input and output wave forms
What can be said about the relationship of the input and output wave forms when a sinusoidal signal is passed through a purely resistive network?

Step 17-18: **__/4pt**

	Theory	**Measured**
$\mathbf{R_{eq}}$		

Step 19: **__/6pt**

	Current
A—D	
D—C	
C—F	

Reference

[1] UC Berkeley, course EE100, summer 2008.