ET304a
Laboratory 5
Thevenin's and Norton's Theorem and the Principle of Superposition

Purpose: Experimentally determine the Thevenin and Norton equivalent circuits by measuring the open circuit voltage and short circuit currents of the test circuits. Use the principle of superposition along with Thenvenin's and Norton's theorems to reduce complex circuits to simple voltage and current source models. Compute the theoretical equivalents and compare them to the experimental equivalents.

Objectives: Develop circuit construction skills. Develop dc circuit voltage and current measurement skills. Make lab measurements that verify the Thevenin and Norton theorems. Experimentally apply the principle of superposition in the laboratory.

Procedure

1.) Construct the circuit shown in Figure 1 and measure the voltage, V_{ab}, across the 10 kΩ resistor. Record the value of V_{ab} for future use in Table 1. Use a dc power supply for the battery

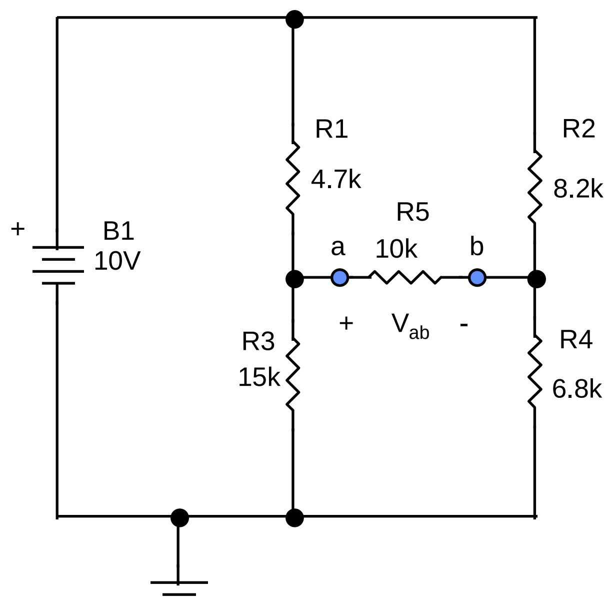

Figure 1. Test Circuit for Part 1of the Experiment.

2.) Remove the 10 kΩ resistor from the circuit in Figure 1 and measure the Thevenin's open circuit voltage, V_{oc}, for the remaining circuit. Figure 2 shows the circuit used to make the open circuit voltage measurements.

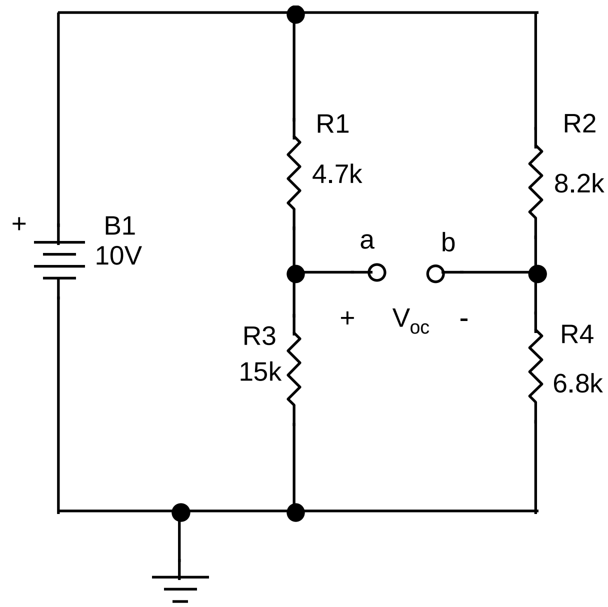

Figure 2. Circuit Connections for Measuring Thevenin's Open Circuit Voltage.

3.) Connect an ammeter between the points a and b as shown in Figure 3 and measure the short circuit current, I_{sc}. Record the value in Table 1 for future use. Note the positive direction of current flow.

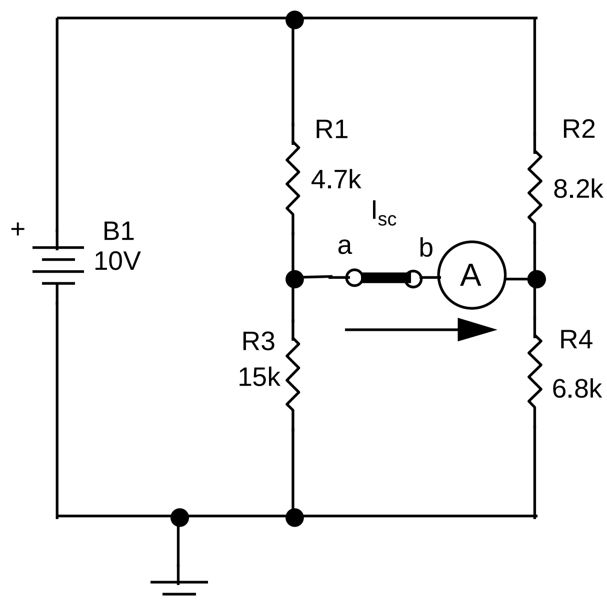

Figure 3. Short Circuit Current Measurement.

4.) From the measurements made in parts 2 and 3, calculate the Thevenin's equivalent resistance for the circuit. This is numerically equal to the Norton's equivalent resistance. Use the formula below to find these values.

$$R_{TH} = R_N = \frac{V_{oc}}{I_{sc}},$$

where: R_{TH} = the Thevenin's equivalent resistance
R_N = the Norton's equivalent resistance.

Record these values in Table 1.

5.) Calculate the theoretical values of R_{TH}, R_N, V_{oc}, and I_{sc} for the circuit above. Record the computed values in Table 1.

6.) Using the Thevenin's equivalent circuit, compute the value of V_{ab} with the 10 kΩ resistor attached to points a-b.

7.) Using the Norton's equivalent circuit, compute the value of V_{ab} with the 10 kΩ resistor attached to points a-b.

8.) Construct the circuit show in Figure 4 and measure the voltage across points a and b. Record this value in Table 2 for later use. Use dc power supplies for the batteries.

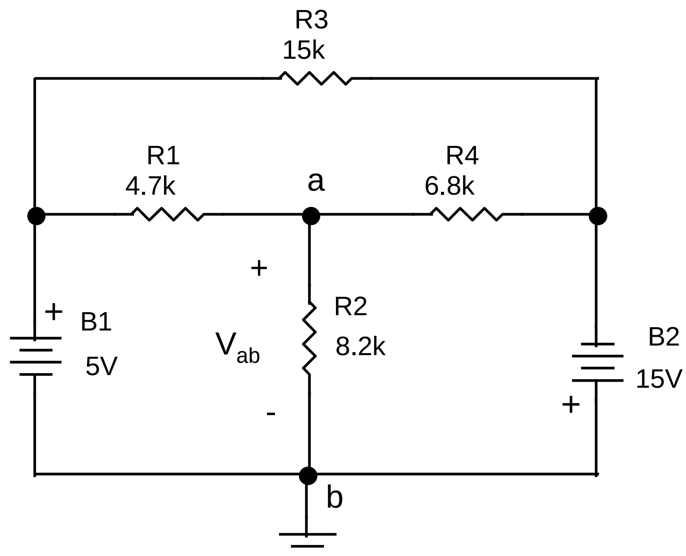

Figure 4. Circuit 2 Showing the Voltage V_{ab}.

9.) Use the principle of superposition to find the value of V_{ab} in Figure 4. To practically use superposition in the lab, sequentially disconnect each dc power supply from the circuit and replace them with short circuits in turn. DO NOT SHORT ACROSS THE TERMINALS OF THE POWER SUPPLY. Find the value of V_{ab} due solely to the 5 Vdc source and record the value in Table 2. Find the value of V_{ab} due solely to the –15 Vdc source and record the value in Table 2. Add these two measurements to find the total response and record it in Table 2.

10.) Remove the 8.2 kΩ resistor and measure the Thevenin's open circuit voltage

11.) Add a 10 ohm resistor and a ammeter between points a-b to measure, I_{sc}. Figure 5 shows this circuit. Record this reading in Table 2.

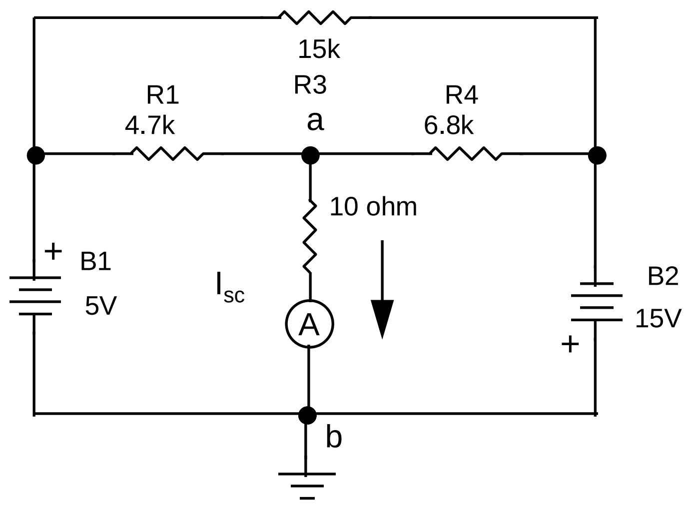

Figure 5. Circuit 2 Short Circuit Measurement Setup.

12.) Repeat steps 4 and 5 above for this circuit. Record the values in Table 2.

13.) Using the Thevenin's equivalent circuit, compute the value of V_{ab} with the 8.2 kΩ resistor attached to points a-b.

14.) Using the Norton's equivalent circuit, compute the value of V_{ab} with the 8.2 kΩ resistor attached to points a-b.

15.) Construct the circuit show in Figure 6 and measure the voltage across points a and b. Record this value in Table 3 for later use. Use dc power supplies for the batteries.

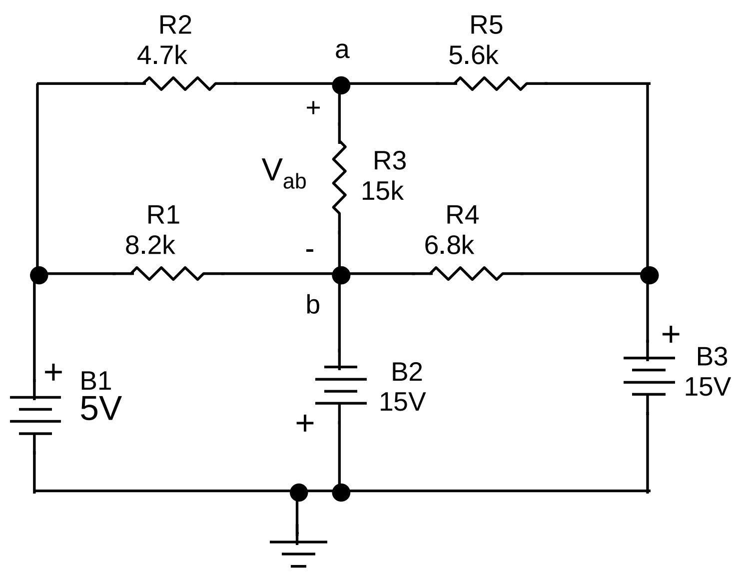

Figure 6. Circuit 3 Schematic.

16.) Use the principle of superposition to find the value of V_{ab} in Figure 6. To practically use superposition in the lab, sequentially disconnect each dc power supply from the circuit and replace them with short circuits in turn. DO NOT SHORT ACROSS THE TERMINALS OF THE POWER SUPPLY. Find the value of V_{ab} due solely to the 5 Vdc source and record the value in Table 3. Find the value of V_{ab} due solely to the –15 Vdc source and record the value in Table 3. Find the value of V_{ab} due solely to the +15 Vdc and record the value in Table 3. Add these three measurements to find the total response and record it in Table 3.

17.) Repeat steps 4 and 5 above for the circuits in Figures 6, 7, and 8. Record the values in Table 3.

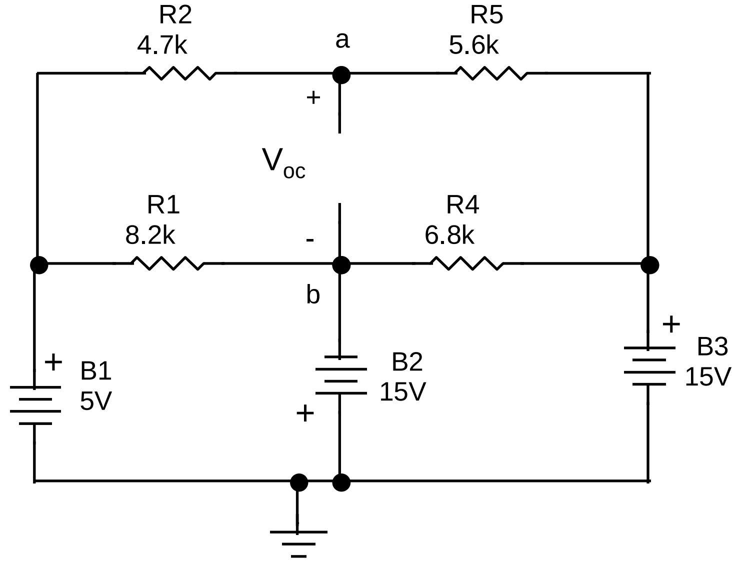

Figure 7. Open Circuit Voltage Measurement For Circuit 3.

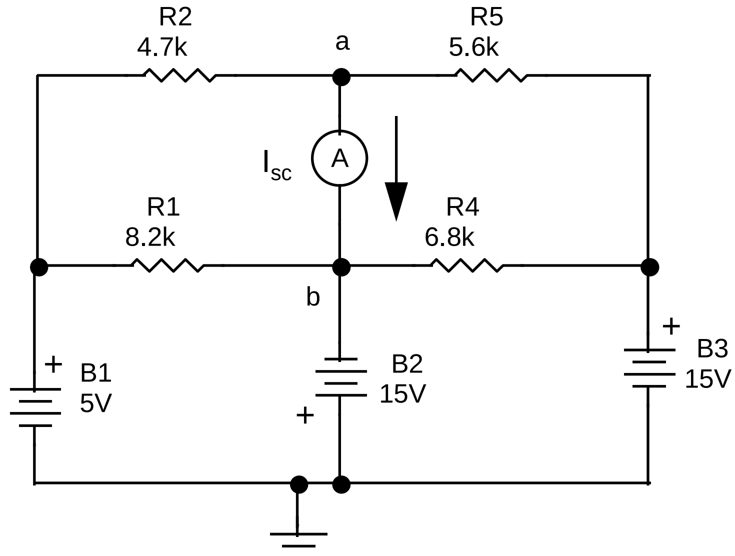

Figure 8. Short Circuit Current Measurement For Circuit 3.

18.) Using the Thevenin's equivalent circuit, compute the value of V_{ab} with the 15 kΩ resistor attached to points a-b.

19.) Using the Norton's equivalent circuit, compute the value of V_{ab} with the 15 kΩ resistor attached to points a-b.

Report:

1.) Follow the standard laboratory report procedures and format.
2.) Compute the theoretical values for all of the measured superposition values. Include drawings of the Thevenin and Norton equivalent circuits with all values labeled.
3.) Compare the theoretical values to the measured values by computing the percentage error between the theoretical and measured values. Use the formula below to compute the percentage error.

$$\%\text{error} = \frac{(\text{theoretical value} - \text{measured value})}{\text{theoretical value}} \times 100\%$$

Discuss the sources of the error.

Table 1- Figure 1 Circuit

Quantity	Value	
	Measured	Theoretical
V_{ab} (V)		
V_{oc} (V)		
I_{sc} (mA)		
R_{TH} (kΩ)		
R_N (kΩ)		
V_{ab} (Thevenin)		
V_{ab} (Norton)		

Table 2- Figure 4 Circuit

Quantity	Value	
	Measured	Theoretical
V_{ab} (V)		
V_{ab} (V) 5Vdc Source		
V_{ab} (V) –15Vdc Source		
V_{ab} (V) sum		
V_{oc} (V)		
I_{sc} (mA)		
R_{TH} (kΩ)		
R_N (kΩ)		
V_{ab} (Thevenin)		
V_{ab} (Norton)		

Table 3- Figure 6 Circuit

Quantity	Value	
	Measured	Theoretical
V_{ab} (V)		
V_{ab} (V) 5Vdc Source		
V_{ab} (V) –15Vdc Source		
V_{ab} (V) +15Vdc Source		
V_{ab} (V) sum		
V_{oc} (V)		
I_{sc} (mA)		
R_{TH} (kΩ)		
R_N (kΩ)		
V_{ab} (Thevenin)		
V_{ab} (Norton)		