

ECET 102/CPET101
Lab 11
Thevenin and Norton Circuit Lab

Required Devices and Equipment

Resistors: 1k, 2.2k, 3.3k, 3.9k, 10k, and a 5k potentiometer

Objectives:

1. Calculate the Thevenin equivalent circuit.
2. Find the Norton equivalent circuit from the Thevenin equivalent circuit.
3. Construct the original circuit and the Thevenin equivalent circuit and measure circuit voltages and currents to verify Thevenin's theorem.

General Information:

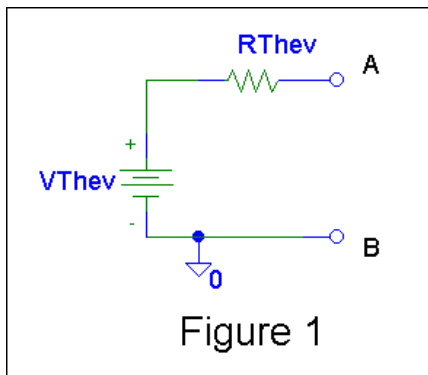
Basic steps to find a Thevenin Equivalent Circuit:

(There are other methods)

1. First combine any elements that are in series and any elements that are in parallel.
2. Mark terminals where you must calculate the Thevenin equivalent circuit.
3. Remove the load (any elements between the terminals where you will be calculating the Thevenin equivalent circuit)

Note that either step 4 or step 5 can be done first.

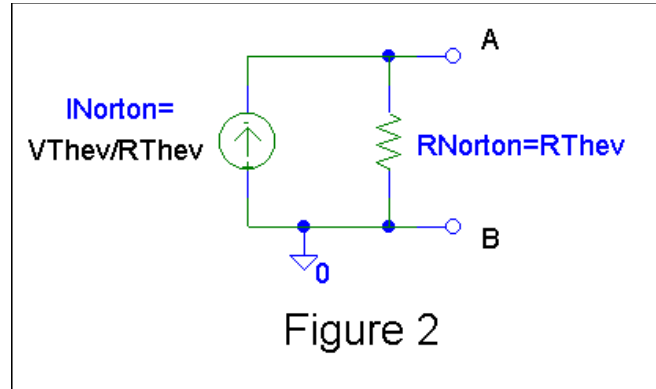
4. To find Thevenin equivalent resistance:
 - a. Replace voltage sources with short circuits
 - b. Replace current sources with open circuits
 - c. Combine resistors in series- parallel to find equivalent resistance between the Thevenin terminals
5. Find the Open-Circuit voltage between the Thevenin terminals. This is the Thevenin voltage.
6. Draw the Thevenin equivalent circuit which always looks like the circuit shown in Figure 1:



To find a Norton equivalent circuit from a Thevenin equivalent circuit:

1. The Norton resistance is the same as the Thevenin resistance
2. The Norton current is the Thevenin voltage divided by the Thevenin resistance.
3. Draw the Norton equivalent circuit which always looks like the circuit shown in Figure 2:

All voltages and currents at or outside the terminals A & B are the same for a Thevenin or Norton Equivalent Circuit as they were for the original circuit between points A & B.



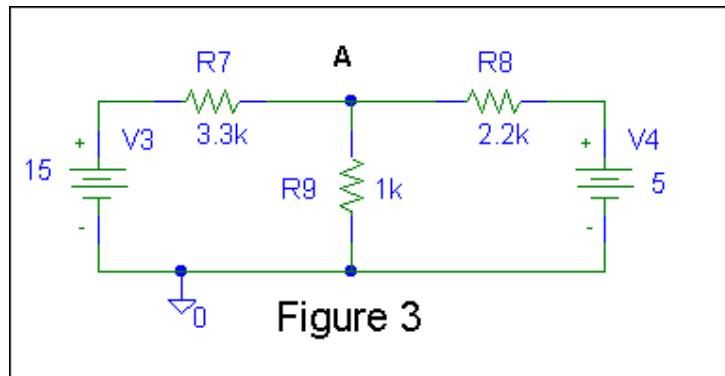
Procedure:

Part 1: Find the Thevenin and Norton equivalent circuits, construct the Thevenin equivalent circuit and measure the Voltage across and current through the load.

1. The circuit you built and measured for the source conversion and superposition lab is shown in Figure 3.

a. Calculate the following and sketch the Thevenin equivalent circuit between node A and ground.

Show your work and write the calculated values below:



$V_A =$ _____

$I_{1k} =$ _____ (current through 1k resistor)

$V_{Thev} =$ _____ $R_{Thev} =$ _____

Sketch the Thevenin equivalent circuit:

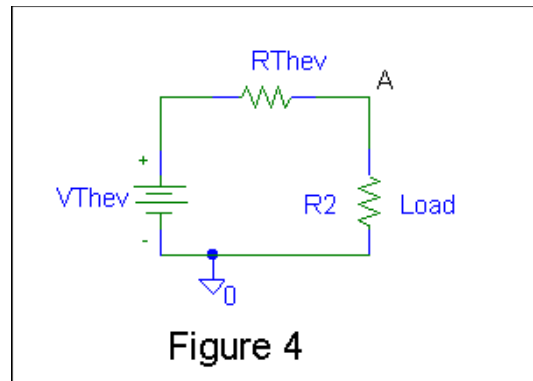
b. Construct the Thevenin equivalent circuit shown in Figure 4 based on the above calculations. Use the 5k potentiometer to set the **exact** Thevenin equivalent resistance

Measure the voltage at node A and the current through the 1k resistor.

$V_A =$ _____

$I_{1k} =$ _____

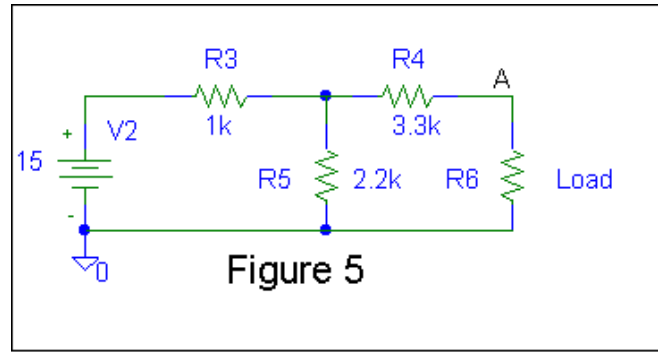
Are these the same values you calculated above? Comment below on any differences.



Part 2. Thevenin calculations for a new circuit and direct measurement of Thevenin voltage and resistance for the circuit.

For the circuit shown in Figure 5:

- a. **Calculate** the Thevenin voltage and resistance seen by the load and **record** these values below:



$V_{Thev} =$ _____

$R_{Thev} =$ _____

- b. **Sketch** the Thevenin equivalent circuit seen by the load below:

- c. **Calculate** the current through the load and voltage across the load for the three load resistances shown below and record your results: (Use your Thevenin equivalent circuit for these calculations.)

$V_{1k} =$ _____ $V_{3.9k} =$ _____ $V_{10k} =$ _____

$I_{1k} =$ _____ $I_{3.9k} =$ _____ $I_{10k} =$ _____

- d. **Direct measurement of Thevenin voltage and resistance** (using the circuit shown above).

- 1) **Remove** the load resistor and **measure** the voltage from node A to ground/common (V_A). This is the Thevenin equivalent voltage. **Record** this measured value below.
- 2) **Connect** the potentiometer as the load resistor and vary the resistance until V_A is $\frac{1}{2}$ of V_{Thev} (that you just measured). **Measure** the resistance of the potentiometer (out of the circuit of course). This resistance is the Thevenin equivalent resistance of the circuit seen by the load. **Record** this value below.

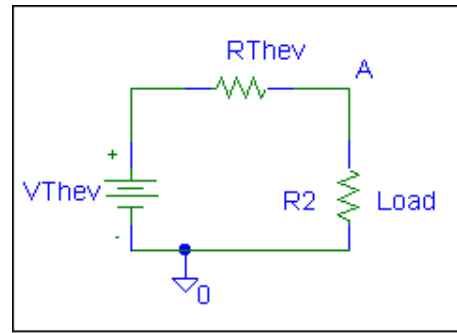
$V_{Thev} =$ _____

$R_{Thev} =$ _____

- 3) Do the measured voltage and resistance match the calculated values in part 2a? **Comment**

- e. **Construct** the following equivalent circuit seen by the load using values from part d and using a 5k potentiometer as the Thevenin resistance.

Measure the Voltage at node A and the current through the load for 1k, 4k, and 10k loads and record the results below. **Measure using 3 significant figures on the DMM.**



$$V_{1k} = \underline{\hspace{2cm}} \quad V_{3.9k} = \underline{\hspace{2cm}} \quad V_{10k} = \underline{\hspace{2cm}}$$

$$I_{1k} = \underline{\hspace{2cm}} \quad I_{3.9k} = \underline{\hspace{2cm}} \quad I_{10k} = \underline{\hspace{2cm}}$$

Compare these results with the calculations on page 2. **Comment:**

Part 3. Maximum power transfer.

Maximum power is transferred to a load when the load resistance equals the source resistance. A source is normally represented by a Thevenin equivalent circuit. The load is matched to the Thevenin resistance of the source to ensure maximum power to the load.

Use the voltage measurements that you recorded above (on this page) to **calculate** the power to each load resistor and record your calculations below:

Ensure that your units are correct:

$$P_{1k} = \underline{\hspace{2cm}} \quad P_{3.9k} = \underline{\hspace{2cm}} \quad P_{10k} = \underline{\hspace{2cm}}$$

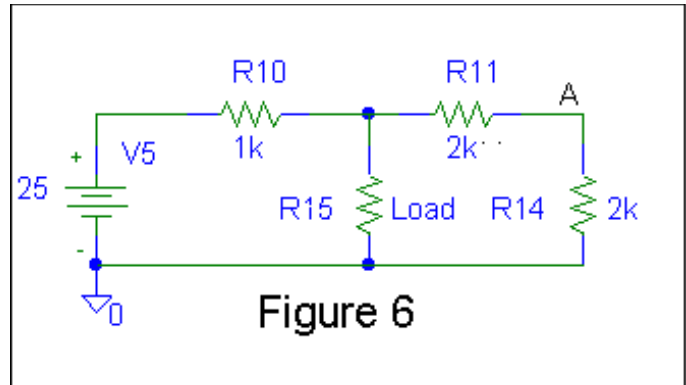
Comment on which load resistor dissipates the most power.

Does this verify the maximum power transfer theorem? Explain.

Part 4: Problem

For the circuit shown in
Figure 6

- a. Sketch the Thevenin and Norton equivalent circuits seen by the load below:



- b. Determine the load resistance that will produce maximum power transfer to the load and write the value below.

$$R_{\text{Load}}(\text{for maximum power to the load}) = \underline{\hspace{2cm}}$$

- c. Calculate the power to the load for maximum power transfer and write the value below.

$$P_{\text{Load}}(\text{maximum power transfer}) = \underline{\hspace{2cm}}$$

- d. Calculate the power produced by the battery (in the Thevenin circuit) for maximum power transfer to the load and write the value below.

$$P_{\text{Battery}}(\text{For maximum power transfer to the load}) = \underline{\hspace{2cm}}$$

- e. Determine what percentage of the power that is being produced by the battery is being dissipated in the load resistor and write the value below.

$$\text{Percentage of power produced that is dissipated in the load} = \underline{\hspace{2cm}}\%$$