UNIVERSITY OF NORTH CAROLINA AT CHARLOTTE
Department of Electrical and Computer Engineering

EXPERIMENT 9 – THEVENIN & NORTON EQUIVALENT CIRCUITS

OBJECTIVES

The purpose of this experiment is to use Thevenin and Norton Theorems to calculate the current through or voltage across any one of several resistors in a circuit and verify the results by measurements.

MATERIALS/EQUIPMENT NEEDED

Digital Multimeter
DC Power Supply
Resistors: 1.2kΩ, 3.3kΩ, 10kΩ

INTRODUCTION

Sometimes in circuit analysis we want to concentrate on what happens at a specific pair of terminals. As an example, when we plug a mobile phone charger into an outlet, we are mostly interested in the voltage and current at the terminals of the charger. We have no interest in the effect of the charger on voltages or currents elsewhere in the circuit supplying the outlet. In this laboratory experiment we are going to take a look at Thevenin and Norton equivalent circuits, which are circuit simplifications techniques that focus on terminal behavior.

Thevenin's Theorem: Any combination of sources and resistances with two terminals can be replaced by a combination of a single voltage source (Thevenin voltage) in series with a single resistor (Thevenin resistance). The value of the Thevenin voltage is the open circuit voltage at the output terminals. The value of the Thevenin resistance is the equivalent resistance looking back into the network at the output terminals with all voltage sources replaced by a short and all current sources replaced by an open. In Figure 9-1 a particular driving circuit with output terminals a and b has been replaced by its Thevenin equivalent circuit, consisting of a Thevenin voltage source v_{TH} in series with the Thevenin resistance R_{TH}.

To find and apply the Thevenin equivalent circuit, follow the steps below:

1. Remove the resistor (often referred to as the load resistor, R_L) for which you wish to calculate the current and/or voltage. Label these terminals (where the resistor was removed) "a" and "b". Calculate the voltage across these open terminals. This is v_{TH}.
2. From the open terminals, ("a" and "b") calculate the resistance "looking back" into the circuit with all voltage sources removed and replaced by a short and all current sources removed and replaced by an open. The resistance obtained is R_{TH}.

3. Now, a circuit similar to Figure 9-1 can be put together to look for the current through and the voltage across R_L.

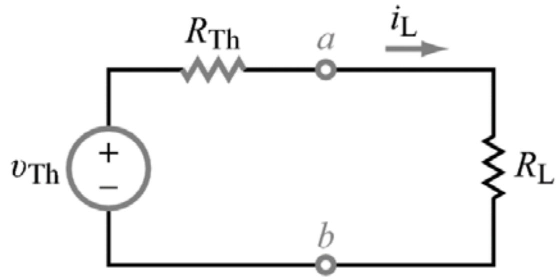

Figure 9-1 Thevenin equivalent circuit

Norton's Theorem: Any combination of sources and resistances with two terminals can be replaced by a combination of a single current source (Norton current) in parallel with a single resistor (Norton resistance). The value of the Norton current is the short circuit current at the at the output terminals. The value of the Norton resistance is the equivalent resistance looking back into the network at the output terminals with all voltage sources replaced by a short and all current sources replaced by an open. In Figure 9-2 a particular driving circuit with output terminals a and b has been replaced by its Norton equivalent circuit, consisting of a Norton current source i_N in parallel with the Norton resistance R_N.

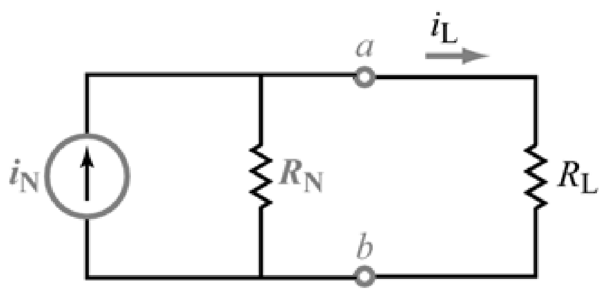

Figure 9-2 Norton equivalent circuit

One method for finding the Norton equivalent circuit is to find the Thevenin equivalent, and then perform a source transformation. Another way to find the Norton equivalent circuit is to;

1. Remove the resistor (often referred to as the load resistor, R_L) for which you wish to calculate the current and/or voltage. Label these terminals (where the resistor was removed) "a" and "b". Short these terminals together and determine the current that flows through this short. This short circuit current is i_N.
2. From the open terminals, ("a" and "b") calculate the resistance "looking back" into the circuit with all voltage sources removed and replaced by a short and all current sources removed and replaced by an open. The resistance obtained is R_N.
3. Now, a circuit similar to Figure 9-2 can be put together to look for the current through and the voltage across R_L.

PRELAB

1. Remove resistor R3 in the circuit of Figure 9-3;
   a. Find the Thevenin equivalent circuit. Please show all your work and draw the circuit.
   b. Find the Norton equivalent circuit. Please show all your work and draw the circuit.
2. Using your Thevenin equivalent circuit from part 1a of the prelab;
   a. Find the current through R3 if connected back into the terminals a and b of the Thevenin equivalent circuit (Record in Table 9-1).
   b. Find the voltage across R3 if connected back into the terminals a and b of the Thevenin equivalent circuit (Record in Table 9-1).
3. Using your Norton equivalent circuit from part 1b of the prelab;
   a. Find the current through R3 if connected back into the terminals a and b of the Norton equivalent circuit (Record in Table 9-1).
   b. Find the voltage across R3 if connected back into the terminals a and b of the Norton equivalent circuit (Record in Table 9-1).

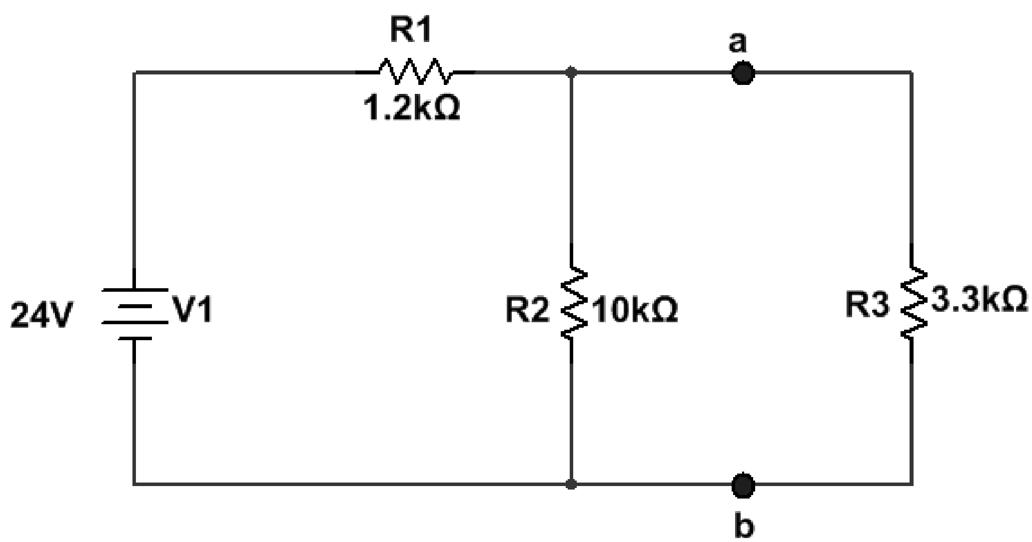

Figure 9-3 Circuit for Thevenin and Norton Analysis

PROCEDURE

1. Connect the circuit in Figure 9-3; measure and record in Table 9-3 the current through and voltage across R3.

Thevenin Equivalent Determination and Validation

2. Remove resistor R3; then measure and record the Thevenin voltage (the voltage across open terminals a and b) and in Table 9-2.
3. With R3 removed and the voltage source replaced by a short circuit; measure and record the Thevenin resistance (the resistance between terminals a and b) and in Table 9-2.
4. Using the results from the steps above (steps 2 and 3) connect the Thevenin equivalent circuit and connect resistor R3 between terminals a and b (should look similar to Figure 9-1).
5. Measure and record in Table 9-3 the current through and voltage across R3.

Norton Equivalent Determination and Validation

6. Build the circuit in Figuer 9-4, measure and record the Norton current (the short circuit current) in Table 9-2.
7. With the Ammeter replaced with an ohmmeter and the voltage source replaced by a short circuit; measure and record the Norton resistance (the resistance between terminals a and b) in Table 9-2.
8. Using the results from the steps above (steps 6 and 7) connect the Norton equivalent circuit and connect resistor R3 between terminals a and b (should look similar to Figure 9-2).
9. Measure and record in Table 9-3 the current through and voltage across R3.

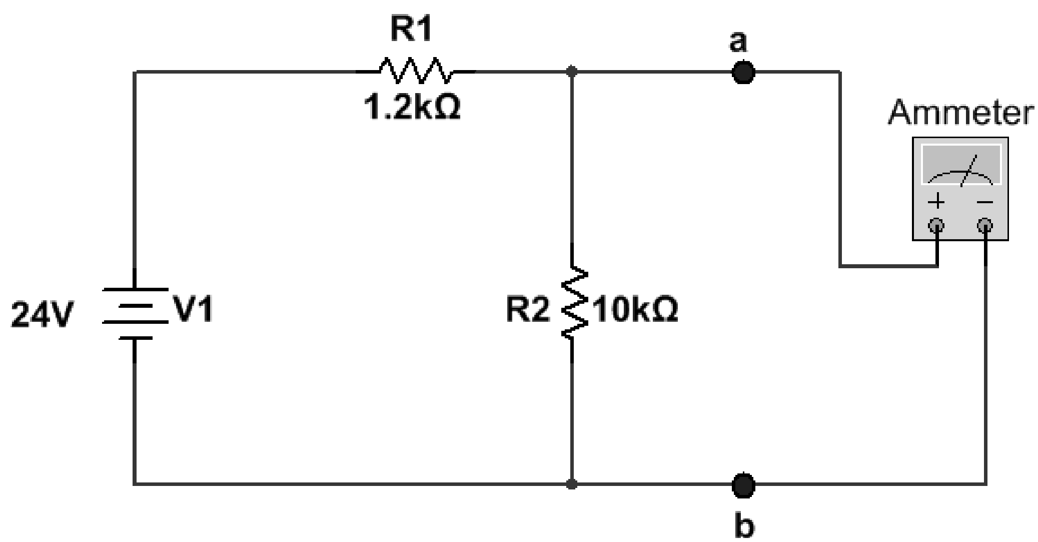

Figure 9-4 Circuit for Norton Analysis with R3 replaced by an Ammeter.

DATA/OBSERVATIONS

Table 9-1: Calculated Voltage and Current for Resistor R3

	Thevenin Equivalent	Norton Equivalent
I_{R3}		
V_{R3}		

Table 9-2: Measured Thevenin and Norton Equivalents

Thevenin Equivalent		Norton Equivalent	
v_{TH}		i_N	
R_{TH}		R_N	

Table 9-3: Measured Voltage and Current for Resistor R3

	Figure 9-3	Thevenin Equivalent	Norton Equivalent
I_{R3}			
V_{R3}			

INSTRUCTOR'S INITIALS: ________ DATE: ________

POST-LAB

1. From the data obtained in this experiment and prelab calculations simulations; discuss on
   a. Observations regarding the current through resistor R3.
   b. Observations regarding the voltage across resistor R3.
   c. Observations regarding the Thevenin equivalent.
   d. Observations regarding the Norton equivalent.

   Be sure to comment on the differences observed between calculated and measured values. If significant differences (not explainable by resistor tolerances and expected measurement errors) are observed, make your best effort to explain.

Be sure to include all items from the post-lab exercise above in your written lab report.