Thevenin and Norton Equivalent Circuits

Materials:

- Digital Multimeter (DMM): DMM6500
- Direct current (DC) power supply: 2230 High Power Programmable Power Supply
- Resistors (6)
- Breadboard
- Jumper wires

Procedure:

Task 1: Original Circuit Measurements

Use the corresponding resistor values for Task 1:

$R_1 = 1\ k\Omega$ $R_2 = 2\ k\Omega$ $R_3 = 10\ k\Omega$ $R_4 = 5\ k\Omega$ $R_L = 1\ k\Omega$

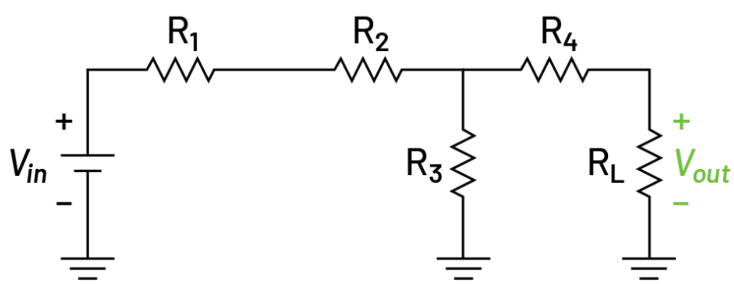

Figure 1. Circuit for Thevenin and Norton equivalent calculations.

1. Construct the circuit according to the diagram in Figure 1 using the corresponding resistor values for R_1, R_2, R_3, R_4, and R_L. This is the original circuit that will be converted into a Thevenin and Norton Equivalent. This experiment uses two input channels on the 2 Series MSO for analysis. Attach the Channel 1 probe to the input of the circuit (V_{in}) and the Channel 2 probe to the output of the circuit (V_{out}). Make sure both probes are connected to the common ground of the circuit.

2. Use the 2230 Power Supply to provide voltage to the circuit (V_{in}). Use one of the output channels on the power supply to output 5 V as V_{in}. This known voltage is used to take initial measurements of the load resistor R_L that will be used to compare later in this lab. Measure the voltage and current of R_L using the DMM and record those measurements in Table 1.

R_L Voltage	
R_L Current	

Table 1. Initial load measurements.

3. Now with the initial measurements completed, remove the load resistor (R_L) from the circuit. Use the DMM to measure the open circuit voltage across where R_L was. Record this value in Table 2. Next, use the DMM to measure the short circuit current across where R_L was and record. Tip: the open circuit voltage and short circuit current measurements are

done with the same probe configuration, just make sure to adjust the lead connects on the DMM when switching between measuring voltage and current. Lastly, short V_{in} (connect R_1 to ground) and remove the input source. Use the DMM to measure the resistance across the circuit. Record the resistance in Table 2.

Open Circuit Voltage (V_{OC})	
Short Circuit Current (I_{SC})	
Equivalent Resistance (R_{Eq})	

Table 2. Circuit measurements with load resistor (R_L) removed.

Task 2: Testing the Thevenin and Norton Equivalent Circuits

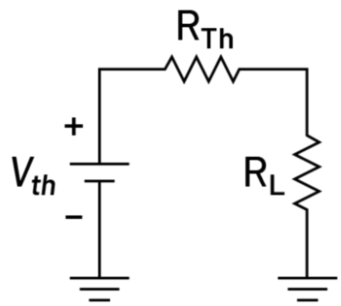

Figure 2. Thevenin equivalent circuit.

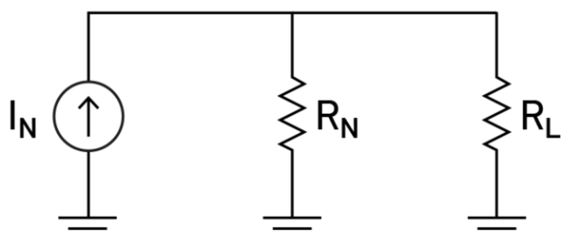

Figure 3. Norton equivalent circuit.

1. Build the Thevenin equivalent circuit as shown in Figure 2. R_L is the original load resistor used in the circuit in Figure 1. R_{Th} is the equivalent resistance measured and recorded in Table 2 and V_{Th} is the open circuit voltage. Tip: Using a combination of resistors in series can be used to achieve the R_{Th} resistance needed.
2. The Thevenin equivalent circuit uses a voltage source (V_{Th}) and a resistor (R_{Th}) to simulate the same voltage and current on the load resistor as the original circuit. Measure the voltage and current across the load resistor R_L. Record these values in Table 3. These values should be like the values recorded in Table 1.
3. Build the Norton equivalent circuit as shown in Figure 3. The power supply cannot act as a current source so use the following equation that combines the parallel resistors and applies ohm's law to find the Norton Voltage:

$$V_N = I_N * \frac{(R_{Th} * R_L)}{(R_{Th} + R_L)}$$

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Use the calculated Norton voltage in place of the current source (I_N). Repeat the voltage and current measurements in step 2 for the Norton equivalent circuit. Compare the measurements to the Thevenin equivalent circuit and the original circuit measurements. Which equivalent circuit's measurements were more accurate compared to the original circuit? Which equivalent circuit is easier to implement?

	Thevenin Equivalent	Norton Equivalent
R_L Voltage		
R_L Current		

Table 3. Thevenin and Norton equivalent circuit measurements.

Instructor's Notes:

Using the original resistor values, here are the measurements for each step of this experiment.

R_L Voltage	0.4638 V
R_L Current	0.4648 mA

Table 1. Initial load measurements (with V_{in}= 5V).

Open Circuit Voltage (V_{OC})	3.85 V
Short Circuit Current (I_{SC})	0.5283 mA
Equivalent Resistance (R_{Eq})	7.281 kΩ

Table 2. Circuit measurements with load resistor (R_L) removed.

The Norton voltage calculated: 0.463 V

	Thevenin Equivalent	Norton Equivalent
R_L Voltage	0.4646 V	0.4622 V
R_L Current	0.4655 mA	0.4588 mA

Table 3. Thevenin and Norton equivalent circuit measurements.