Lab 6: Verification of Thevenin's, Norton's and Maximum Power Transfer Theorem

Objectives

- Experimentally perform Thevenin's theorem, Norton's theorem and Maximum Power theorem
- Perform theoretical calculations.
- Verify the experimental values with theoretical values.

List of Components:

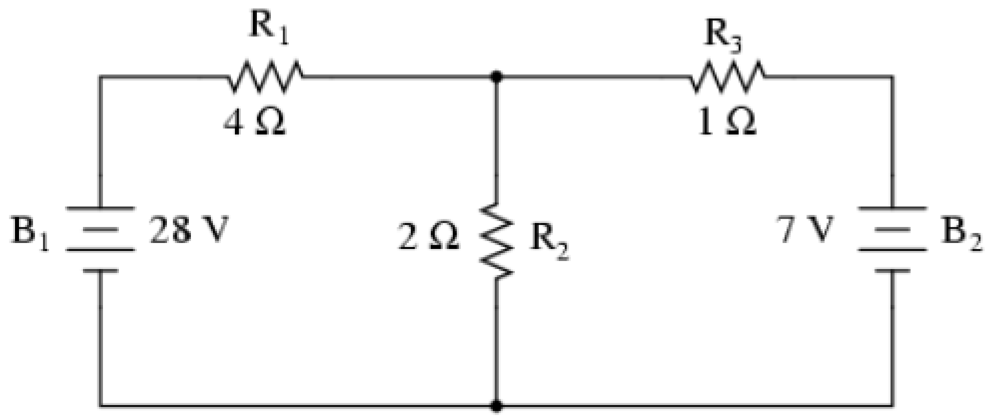
- Trainer board
- 1× 1K
- 2 × 10KΩ
- POT (10K)
- Digital Multimeter (DMM)
- Connecting Wire

Theory:

Thevenin's Theorem: Thevenin's Theorem states that it is possible to simplify any linear circuit, no matter how complex, to an equivalent circuit with just a single voltage source and series resistance connected to a load. The Thévenin equivalent circuit consists of a single dc source referred to as the Thévenin voltage (V_{TH}) and a single fixed resistor called the Thévenin resistance (R_{TH})

Norton's Theorem: Norton's Theorem states that it is possible to simplify any linear circuit, no matter how complex, to an equivalent circuit with just a single current source (I_N) and parallel resistance connected to a load (R_N)

Usefulness of Thevenin and Norton Theorem:



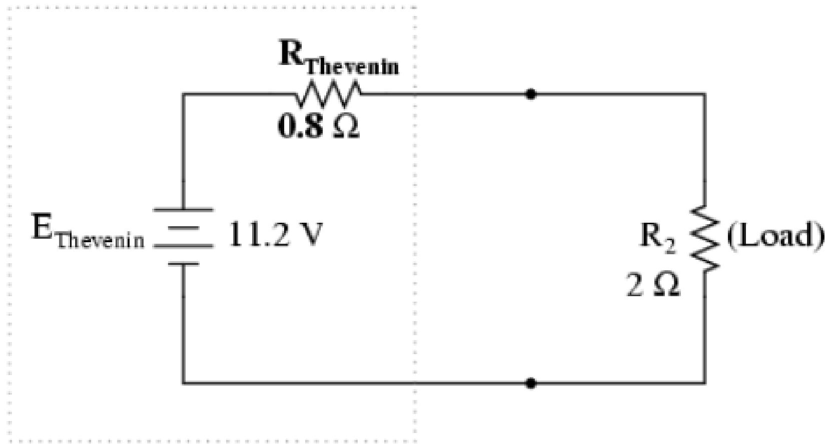
Let's consider R_2 as the load resistor. To find the voltage and current across this load resistor, you can follow superposition theorem. Now say your load resistance is subjected to change (i.e. it varies), then each time your resistor value changes, you need to apply superposition theorem and recalculate the current and voltages. This is time consuming.

Thevenin's or Norton's theorem makes this easy by temporarily removing the load resistance from the original circuit and reducing what's left to an equivalent circuit:

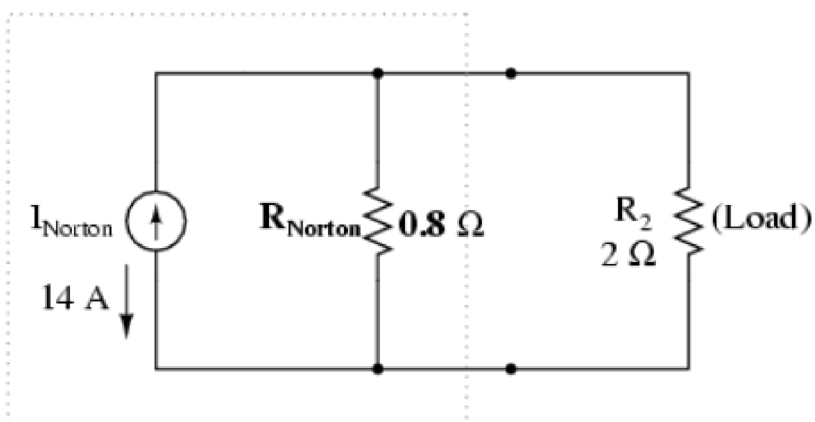
- Single voltage source and series resistance in case of Thevenin.
- Single current source and parallel resistance in case of Norton.

The load resistance can then be re-connected to this "equivalent circuit" and calculations carried out as if the whole network were nothing but a simple series circuit:

Thevenin Equivalent Circuit



Norton Equivalent Circuit



How to find E_{TH}?

- Remove the load resistance, calculate the open-circuit voltage at the terminals of the load resistance.

How to find R_{TH}?

- With the load resistance still removed, remove the independent voltage sources (replace them with a short circuit just like in superposition theorem) and calculate the resistance at the terminals of the load resistor.

How to find R_N?

- Methods for finding R_N is same as that for R_{TH}

How to find I_N?

- With voltage sources turned on, replace the load resistance as short circuit. Measure the short circuit current. This short circuit current is I_N.

Thevenin Norton Equivalence:

$$R_N = R_{TH}$$
$$E_{TH} = I_N \; R_{TH}$$

Maximum Power Theorem:

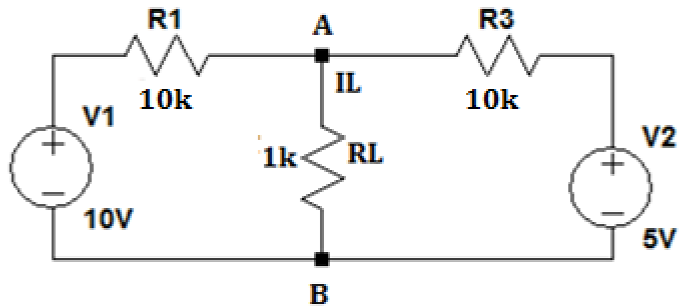
Maximum Power will be delivered to the load when that load resistance is equal to the Thevenin/Norton resistance of the network supplying the power. If the load resistance is lower or higher than the Thevenin/Norton resistance of the source network, its dissipated power will be less than maximum.

A load impedance that is too high will result in low power output. A load impedance that is too low will not only result in low power output

$I_L = V_{TH} \,/\, (R_{TH} + R_L)$
$\quad = V_{TH} \,/\, (R_{TH} + R_{TH})$
$\quad = V_{TH} \,/\, 2 \; R_{TH}$

Where, **Pmax** = $I_L{}^2 R_L$
$\qquad = V_{TH}{}^2 \,/\, 4 \, R_{TH}$

Circuit Diagram:



Procedure:

1. Measure the values of resistance using DMM.
2. Construct the Circuit-1
3. Measure $V_L$and I_L of R_L for circuit 1. Record in Table-2.
4. Remove R_L from the original circuit and measure the open circuit voltage Vth.
5. Measure the short circuit current I_N by placing an Ammeter between A and B. In this manner, the Ammeter will act as a short circuit.
6. Replace the voltage sources with short circuits. With RL removed from the circuit measure Rth using a multimeter (place DMM across A and B)
7. Record values in Table-3.
8. Draw the Thevenin and Norton Equivalent circuit in Table-4.
9. Construct the Thevenin equivalent circuit drawn in Table-4, measure I_L and V_L. Record readings in Table 2.
10. Now replace the load resistor with a POT, vary the load resistance and for each resistance value measure V_L. Fill in Table-5

Data Collection for Lab 6:

Group No. ________

Instructor's Signature __________

Table 1:

Theoretical R	Measured R	% Error
10K		
1K		

Table 2:

Value	Measured R	% Error
V_L		
I_L		

Table 3:

Measurement	Measured	Calculated	% Error
V_{TH}			
I_N			
R_{TH}			
V_L			
I_L			

Table 4:

THEVENIN'S EQUIVALENT CIRCUIT	NORTON'S EQUIVALENT CIRCUIT

Table 5:

R_L (kΩ)	V_L (Experimental)	P_L (Experimental)
1.0		
2.0		
3.0		
4.0		
5.0		
6.0		
7.0		
8.0		
9.0		
10		

Report Questions:

1. Calculate all the theoretical values of Table 2. **Show all steps**
2. Comparing experimental values to theoretical values, verify Thevenin and Norton theorem.
3. Prove Thevenin Norton equivalence.
4. In a graph paper, draw P_L vs R_L .
5. From the graph state the value of R_L for which maximum power is obtained.
6. Theoretically calculate the maximum power.
7. Verify the maximum power theorem