Experiment-3: Verification of Thevenin's Theorem and Norton's Theorem

AIM: Study and verifications of Thevenin's and Norton's Theorem.

APPARATUS REQUIRED: Bread-board, Multi-meter, Resistances, Voltage /Current Source, Connecting wires

THEORY: (a) Thevenin's Theorem: Thevenin's theorem states that "*Any linear circuit containing voltage and current sources, and resistances can be replaced by just one single voltage in series with a single resistance connected across the load.*" In other words, it is possible to simplify any electrical circuit, no matter how complex it is, to an equivalent two-terminal circuit with just a single constant voltage source in series with a resistance (or impedance) connected to a load as shown below.

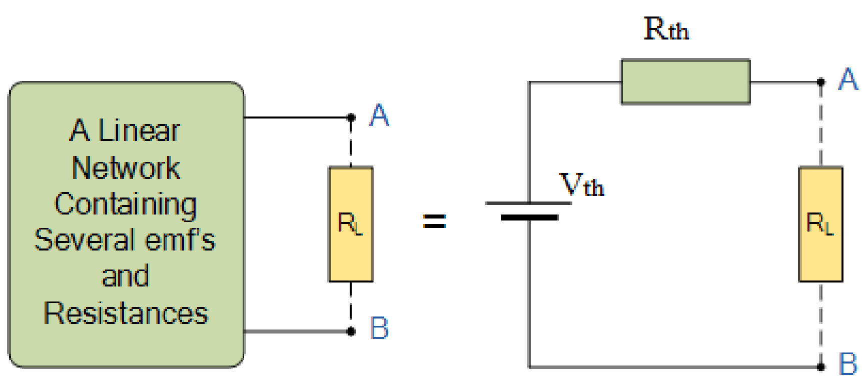


Fig. 3.1: Thevenin's Equivalent Circuit

Simple steps to analyze electronic circuit given in Fig. 3.2, through Thevenin's theorem

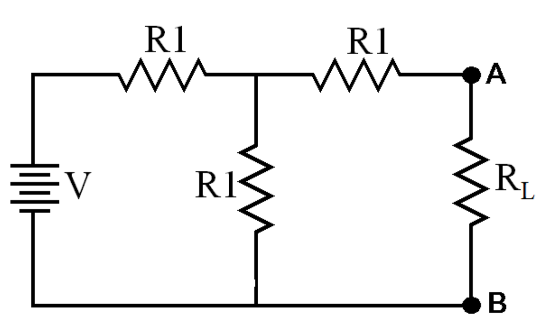
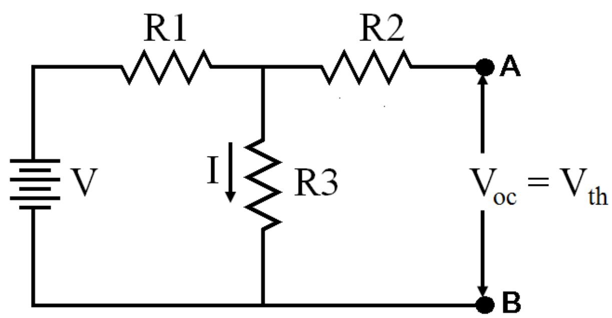


Fig. 3.2: An Electronic circuit to be analyzed using Thevenin's Theorem

1. Open the load resistor
2. Calculate/measure the open circuit voltage. This measured or calculated voltage is known as the Thevenin's voltage (V_{th})

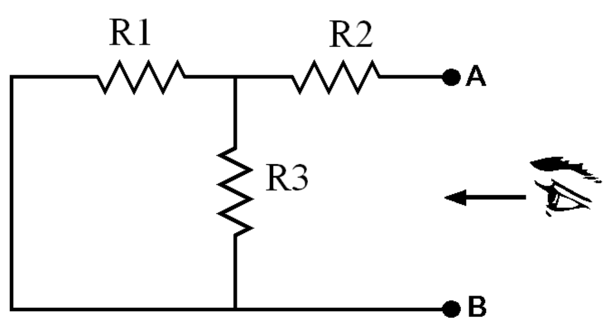


$$V_{OC} = IR_3 \tag{1}$$

$$I = \frac{V}{R_1 + R_3} \tag{2}$$

$$V_{th} = V_{OC} = V \times \frac{R_3}{R_1 + R_3} \tag{3}$$

3. Open current sources and short the voltage sources.
4. Calculate/measure the open circuit resistance. This measured or calculated resistance is known as the Thevenin's resistance (R_{th}).



$$R_{th} = R_2 + \frac{R_1 R_3}{R_1 + R_3} \tag{4}$$

5. Now, redraw the circuit with measured open circuit voltage (V_{th}) in step (2) as a voltage source and measured the open circuit resistance (R_{th}) in step (4) as series resistance and connect the load resistor which was removed in step (1). This new circuit is the equivalent Thevenin circuit of that linear electric network or complex circuit which had

to be simplified and analyzed by Thevenin's Theorem.

OBSERVATION TABLE:

S.NO.	**Thevenin's Voltage**		**Thevenin's Resistance**	
	Theoretical calculation	Practical or Measured	Theoretical calculation	Practical or Measured

(b) Norton's Theorem: It states that "*Any linear circuit containing several voltage and current sources and resistances can be replaced by a single Constant Current generator in parallel with a Single Resistor*". As far as the load resistance, R_L is concerned this single resistance, Rs is the value of the resistance looking back into the network with all the current sources open circuited and Is is the short circuit current at the output terminals as shown below.

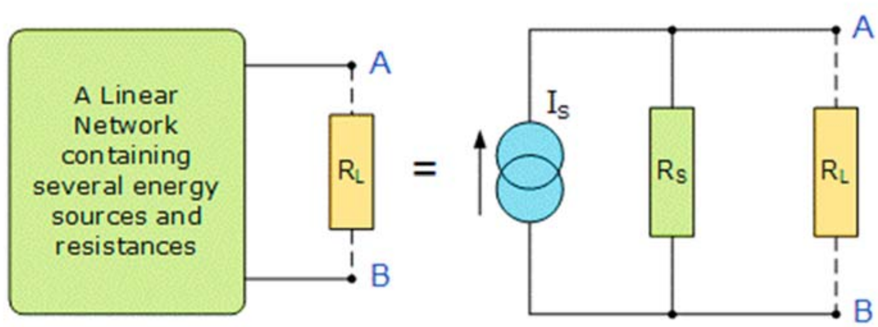
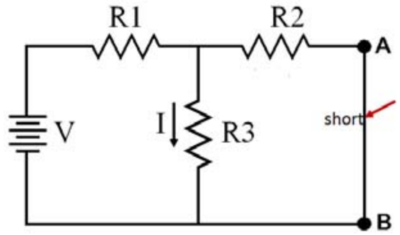


Fig. 3.3: Norton's Equivalent Circuit

Simple steps to analyze electronic circuit given in Figure 2, through Norton's theorem

1. Short the load resistor



2. Calculate/Measure the short circuit current. This measured or calculated current is known as Norton current (I_N)

We have shorted the *AB* terminals to determine the Norton current, I_N. The R_3 and R_2 are then in parallel, and this parallel combination of R_3 and R_2 are then in series with R_1.

The total resistance, R_{Total}, of the circuit to the source is given by

$$R_{Total} = R_1 + \left(R_3 \parallel R_2\right) = R_1 + \frac{R_2 R_3}{R_2 + R_3} \tag{5}$$

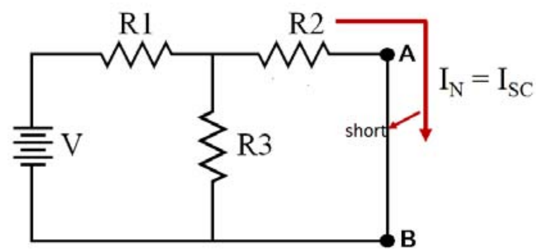
The total current in the circuit, I_{Total}, is given by

$$I_{Total} = \frac{V}{R_{Total}} \tag{6}$$

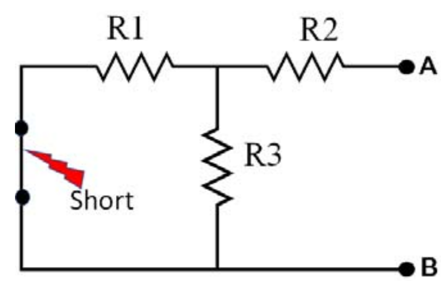
The short circuit current I_{SC}, is given by applying curret divison rule.

$$I_{SC} = I_{Total} \frac{R_3}{R_2 + R_3} \tag{7}$$

The Norton's current is given by $I_{SC} = I_N$.



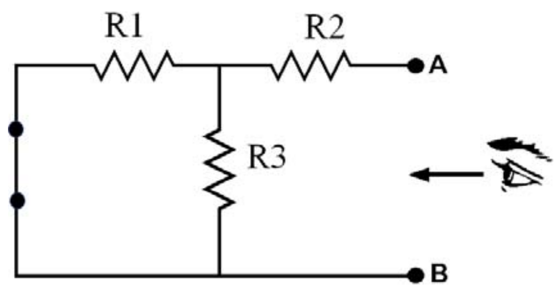
3. Open the current sources, short the voltage sources and open the load resistor



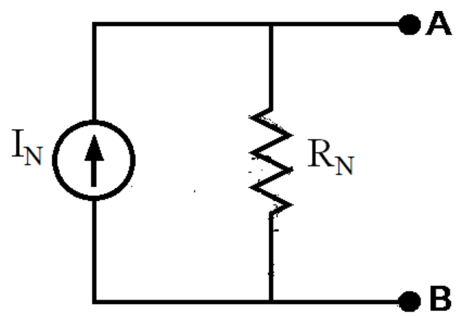
4. Calculate/Measure the open circuit resistance. This measured or calculated resistance is known as Norton resistance (R_N).

   We have reduced the DC source to zero is equivalent to replace it with a short in step (3), as shown in the above figure. We can see that the parallel combination of resistors R_3 and R_1 is in series with resistor R_2. Thus

$$R_N = R_2 + \frac{R_1 R_3}{R_1 + R_3} \tag{8}$$



5. Now, Redraw the circuit with measured short circuit current (I_N) in step (2) as a current source and measured open circuit resistance (R_N) in step (4) as parallel resistance and connect the load resistor which was removed in step (3). The resultant circuit is the equivalent Norton circuit of that linear electric network.



6. Now find the load current through and load voltage across the load resistor by using the current divider rule.

$$I_L = \frac{I_N}{\left(\frac{R_N}{R_N + R_L}\right)} \tag{9}$$

OBSERVATION TABLE:

	V	I_N	R_N	I_L
Theoretical values				
Practical values				

CONCLUSIONS: Thevenin's theorem and Norton's theorem are successfully.