American International University- Bangladesh
Department of Electrical and Electronic Engineering
Introduction to Electrical Circuits Laboratory

Title: Study of Thevenin's Theorem and Maximum Power Transfer Theorem

Introduction:

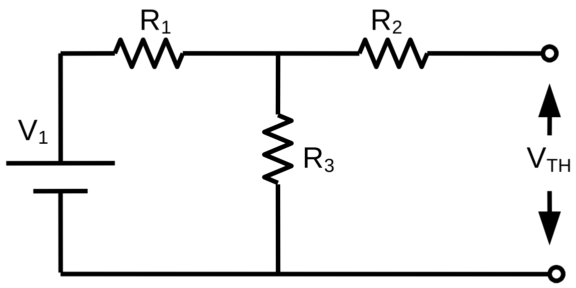
Thevenin's theorem is a very powerful circuit analysis technique. It can convert complex circuit to a simpler series equivalent circuit for easier analysis. Analysis involves removing part of the circuit across two terminals to aid calculation, later combining the circuit with the Thevenin equivalent circuit.

The purpose of this experiment is to-

1. find the Thevenin equivalent circuit
2. measure the load voltage and load current from the given network
3. Verification of maximum power transfer theorem.
4.

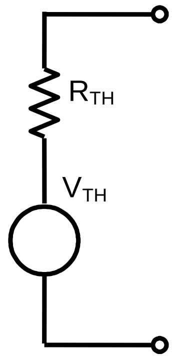
Theory and Methodology:

The Thevenin Theorem is a process by which a complex circuit is reduced to an equivalent series circuit consisting of a single voltage source, V_{TH}, a series resistance R_{TH} and a load resistance, R_L. After creating the Thevenin equivalent circuit, you may then easily determine the load voltage V_L and the load current I_L.



The Thevenin voltage V_{TH} is the open circuit voltage at terminals A and B

The Thevenin resistance R_{TH} is the resistance seen at AB with all voltage sources replaced by short circuits and all current sources are replaced by open circuits



Maximum power Transfer Theorem

The Maximum power transfer theorem is not so much a means of analysis as it is an aid to system design. Simply stated, the maximum amount of power will be dissipated by a load resistance when that load resistance is equal to the Thevenin / Norton resistance of the network supplying the power. If the load resistance lower or higher than the Thevenin /Norton resistance of the source network, its dissipated power will be less than maximum.

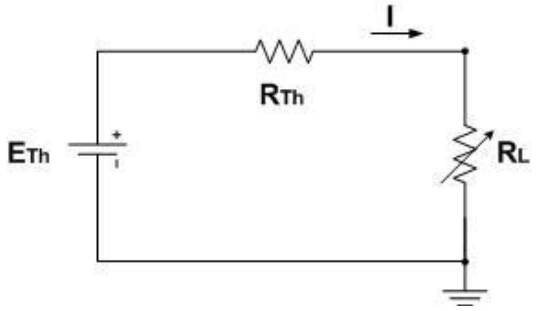


Fig. 1

For the network of Fig. 1, maximum power will be delivered to the load when

$$R_L = R_{Th}$$

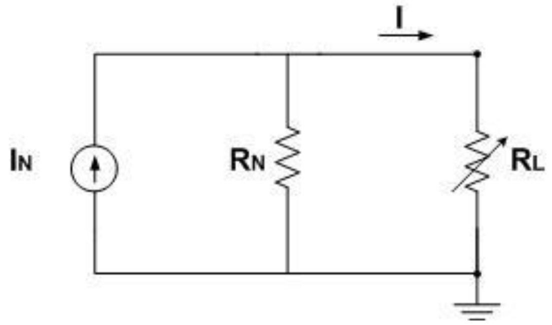


Fig.2

For the network of Fig. 1, maximum power will be delivered to the load when

$$R_L = R_N$$

$$I = \frac{E_{Th}}{R_{Th} + R_L}$$

$$P_L = I^2 R_L = (\frac{E_{Th}}{R_{Th} + R_L})^2 \times R_L$$

$$P_L = \frac{E_{Th}^2 R_L}{(R_{Th} + R_L)^2}$$

The power delivered to R_L under maximum power conditions ($R_L = R_{Th}$) is

$$I = \frac{E_{Th}}{R_{Th} + R_L} = \frac{E_{Th}}{2R_{Th}}$$

$$P_L = I^2 R_L = (\frac{E_{Th}}{2R_{Th}})^2 \times R_{Th} = \frac{E_{Th}^2 R_{Th}}{4R_{Th}^2}$$

$$\boldsymbol{P_{Lmax} = \frac{E_{Th}^2}{4R_{Th}}}$$

For the Norton Circuit of fig. 2:

$$\boldsymbol{P_{Lmax} = \frac{I_N^2 R_N}{4}}$$

Pre-Lab Homework:

Study Thevenin's Theorem from any book or websites; perform the simulation using Multisim and MUST present the simulation results to the instructor before the start of the experiment.

Apparatus:

1. Trainer Board
2. Voltmeter
3. Ammeter
4. AVO meter or Multimeter
5. DC source
6. Resistors :1kΩ [2 pcs], 2kΩ[2 pcs], 3kΩ [2 pcs]

Precautions:

i) Do not short any connections. Short connection can produce heat (due to high current flow) which is harmful for the components.
ii) Carefully connect the ammeter in series.

Experimental Procedure:

1. Remove the portion of the circuit for which Thevenin's equivalent circuit will be determined.
2. Remove the voltage source by a short circuit and replace the current source by an open circuit
3. Determine the Thevenin equivalent resistance R_{TH} for the load.
4. Now return the sources to their original position and determine the open circuit voltage between the terminals A and B.
5. Verify the Thevenin's theorem

Simulation and Measurement:

For Thevenins Theorem:

Compare the simulation results with your experimental data and comment on the differences (if any).

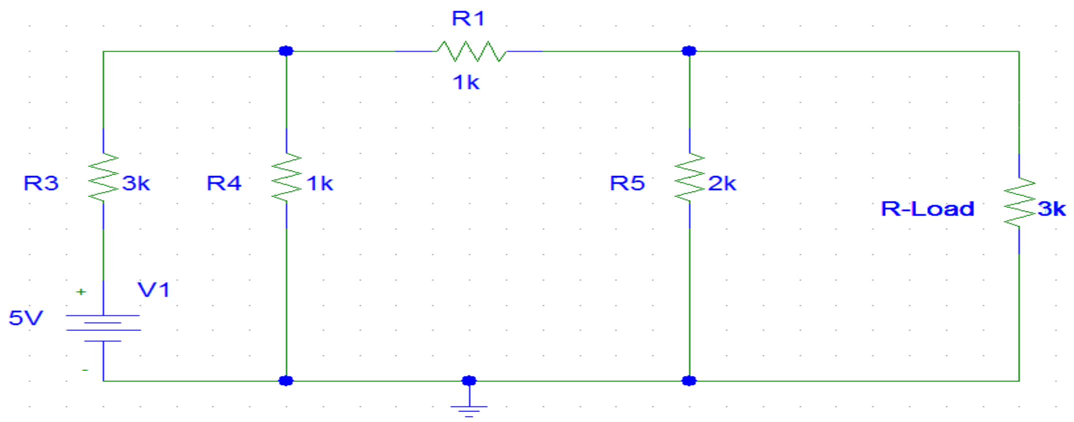


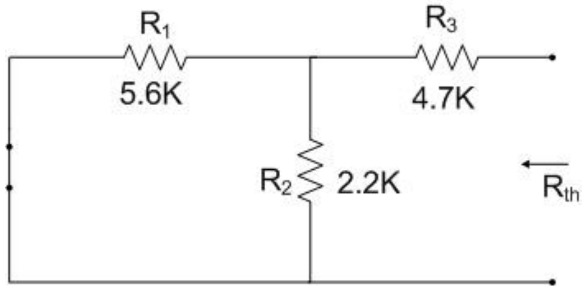
Fig: A

Data Table:

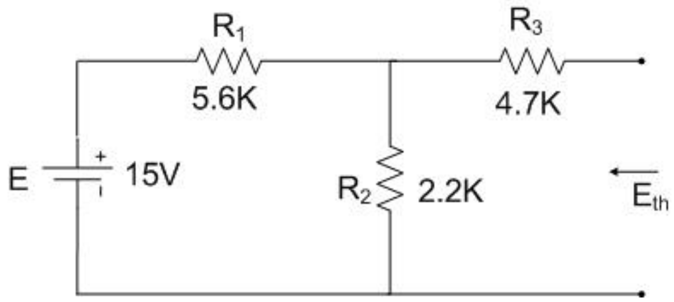
Thevenin Equivalent Voltage (E_{th})		Thevenin Equivalent Resistance (R_{th})	
MeasuredValue (Experimental)	Calculated Value/ Simulate Value	MeasuredValue (Experimental)	Calculated Value/ Simulated Value

For Maximum Power Transfer Theorem:

1. At first, remove the voltage source and make a short circuit at that terminal. Then open the Load resistance and look through this terminal, measure the total resistance (Thevenin Equivalent Resistance).



2. Now connect the voltage source again in the previous place (Load resistance will remain removed).



3. Measure the voltage across the load terminal. This is the Thevenin Equivalent voltage.
4. A tabulation of P_L for a range of values of R_L yields Table 1. A plot of P_L versus R_L using the data of Table 1 should be done in a Graph paper.

Serial	***R_L (ohm)***	$\boldsymbol{I_L}$	$\boldsymbol{V_L}$
1	500		
2	1000		
3	1500		
4	1580		
5	1650		
6	2000		
7	3500		
8	4000		
9	4500		

Note, in particular, that P_L is, in fact, a maximum when $R_L = R_{th}$. The power curve increases more rapidly toward its maximum value than it decreases after the maximum point, clearly revealing that a small change in load resistance for levels of R_L below R_{th} will have a more dramatic effect on the power delivered than similar changes in R_L above R_{th} level.

Results and Discussion:

Reference(s):

1. Robert L. Boylestad, ”Introductory Circuit Analysis”, Prentice Hall, 12th Edition, New York, 2010, ISBN 9780137146666.

