Circuit

BASIC GUIDELINES

All experiments in this manual have been tried and proven and should give you little trouble in normal laboratory circumstances. However, a few guidelines will help you conduct the experiments quickly and successfully.

1. Each experiment has been written so that you follow a structured logical sequence meant to lead you to a specific set of conclusions. Be sure to follow the procedural steps in the order which they are written.
2. Read the entire experiment and research any required theory beforehand. Many times an experiment takes longer than one class period simply because a student is not well prepared.
3. Once the circuit is connected, if it appears "dead", spend few moments checking for obvious faults. Some common simple errors are: power not applied, switch off, faulty components, lose connection, etc. Generally the problems are with the operator and not the equipment.
4. When making measurements, check for their sensibility.
5. It's unethical to "fiddle" or alter your results to make them appear exactly consistent with theoretical calculations.

LAB INSTRUCTIONS

1. Each student is responsible in submitting 1 lab report upon completion of each experiment. The report must be submitted on the next lab.
2. The recorded data and observations from the lab manual need to be approved and signed by the lab instructor upon completion of each experiment.
3. Before beginning connecting up, it is essential to check that all sources of supply at the bench are switched off.
4. Start connecting up the experiment circuit by wiring up the main circuit path, then add the parallel branches as indicated in the circuit diagram.
5. After the circuit has been connected correctly, remove all unused leads from the experiment area, set the voltage supplies at the minimum value, and check the meters are set for the intended mode of operation.
6. When the experiment has been satisfactory completed and the results approved by the instructor, the students may disconnect the circuit and return the components and instruments to the locker tidily.

LAB REPORTS

a. Report format and Evaluation:

The following format should be adhered to by the students in all their laboratory reports:

(i)	Objective	(1 mark)
(ii)	Brief Theory	(2 marks)
(iii)	Results	(4 marks)
(iv)	Discussion & Conclusion	(4 marks)

(v) Problem (4 marks)

Of those listed above each section included in a report should be clearly mentioned with the appropriate heading. The information to be given in each section is outlined below:

(I) Objective
This should state clearly the objective of the experiment. It may be the verification of law, a theory or the observation of particular phenomena. Writing out the objective of the experiment is important to the student as it emphasizes the purpose for which the experiment is conducted.

(ii) Brief Theory
In this section, the related theory of the experiment must be discussed briefly. This section is important to assist student in making conclusion by comparing the experimental results to the theory.

(iii) Results
All experimental results which have been approved by the lab instructor (including graphs) must be attached in the report.

(iv) Discussion & Conclusion
Once the analysis of the results is complete, the student must write his/her own view about the experiment. Usually this involves mentioning whether the final results show that the aim of the experiment has been achieved or not, and if they verify some law or theory presented to the student during the lectures. Comments and comparison asked in the lab manual must be discussed in this section.

(v) Problem
There will be some problems or questions for the students to solve or answer after each experiment.

b. Presentation of Lab Reports:

All students are required to present their reports in accordance with the following instructions.

(i) Reports have to be **handwritten** for submission.

(ii) Writing should appear on one side of each sheet only.

(iii) All sections such as objective, brief theory and so on, should be titled on the left hand side of the working space of the page.

(iv)

- Each type of calculation in the experiment should be preceded by a brief statement indicating its objective.

- All calculations are to be shown in sufficient details to enable the reader to follow their procedure.
- All formulas used are to be written in correct symbols prior to the substitution of the known quantities.

(v) Necessary graphs are to be drawn on graph paper in blue or black ink. Other colors may be used for identification. The abscissa and ordinate are to be drawn in all times and scaled with the value clearly indicated at each major division. The quantity at each axis represents and the unit in which it is calibrated should be clearly indicated. Each graph is to be titled so as to indicate clearly what it represents.

(vi) The cover of the report must be as follows:

Metropolitan University, Sylhet
DEPARTMENT
OF
INFORMATION & COMMUNICATION
TECHNOLOGY (ICT)

Course Code :
Experiment No. :
Name of the Experiment :

Date of Performance :
Date of Submission :

Name :
ID :
Batch :

GRADING

The distribution of marks for Lab is as follows:

Attendance	10%
Lab Report	30%
Lab Performance	20%
Viva	40%
Total	**100%**

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EXPERIMENT NO. : 01
NAME OF THE EXPERIMENT:

TO VERIFY AND ANALYSES SERIES AND PARALLEL RESISTIVE NETWORK.

OBJECTIVE

Our objective is to-

- Know the relationship between current & voltage for a resistor.
- To know the characteristics of series & parallel resistive network.

PART A - SERIES CIRCUIT

THEORY

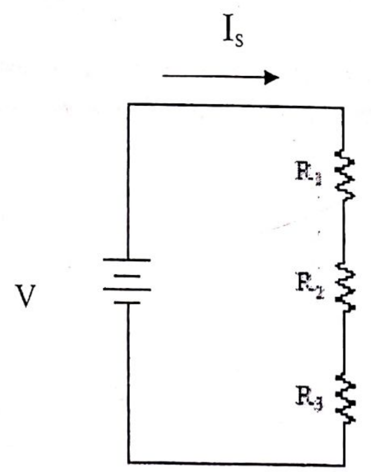
When resistors R_1, R_2 , and R_3 etc. are joined end to end, they are said to be connected in series. It can be proved that the equivalent resistance is equal to the sum of the three individual resistances. In this case,

- Current is the same through all the resistors.
- Different resistors have their individual voltage drops.
- Sum of the voltage drops is equal to the voltage applied across the three conductors.

APPARATUS

- Power supply
- Multi-meter
- 3 Resistors

CIRCUIT DIAGRAM



From figure, we can write equivalent resistance,

$$R_{eq} = R_1 + R_2 + R_3$$

Circuit current $I_s = V/R_{eq}$

$$= V/(R_1 + R_2 + R_3)$$

So,

voltage across $R_1 = V_1 = I_s R_1 = V R_1/R_{eq}$

voltage across $R_2 = V_2 = I_s R_2 = V R_2/R_{eq}$

voltage across $R_3 = V_3 = I_s R_3 = V R_3/R_{eq}$

PROCEDURE

- Select three resistors and measure the resistance of each one with an ohmmeter. Note these resistance values.
- Connect the three resistors in series and to the power supply, as shown in the circuit diagram.
- Measure the voltage of the power supply. It is advisable to measure the voltage while powering the resistor circuit because this voltage may differ slightly from a no-load condition.
- Use Ohm's Law ($I_s = V/R_{eq}$) to calculate circuit current, and then verify this calculated value by measuring current with an ammeter.
- Switch you multi-meter to the "voltage" mode and measure the voltage dropped across each resistor.
- Compare this measured voltages to the calculate values.
- If each resistor voltage drop becomes some fraction or percentage of the total voltage, then this circuit *will be called as voltage divider.*

OBSERVATIONS & RESULTS

No. of Observation	Supply Voltage (volt)	Resistance (kΩ)			Current (I)		Voltage (v)					
		R_1	R_2	R_3	Calculated	Measured	Calculated			Measured		
							V_1	V_2	V_3	V_1	V_2	V_3

PART B - PARALLEL CIRCUIT

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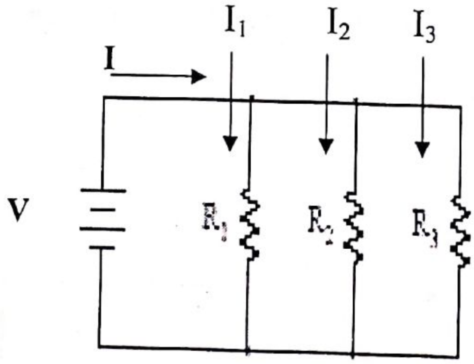
THEORY

When resistors R_1, R_2 , and R_3 etc. are joined as in fig.-3,then they are said to be connected in parallel. In this case voltages across all the resistors are same but current in each resistor is different and the total current is the sum of the separate currents.

APPARATUS

- Power supply
- Multi-meter
- 3 Resistors

CIRCUIT DIAGRAM



From figure, we get,

$$R_{eq} = R_1 R_2 R_3 / (R_1 R_2 + R_2 R_3 + R_3 R_1)$$

Circuit current,

$$I = V / R_{eq} = V(R_1 R_2 + R_2 R_3 + R_3 R_1) / R_1 R_2 R_3 \text{ (mA)}$$

Current across $R_1 = I_1 = I R_2 R_3 / (R_1 R_2 + R_2 R_3 + R_3 R_1)$ (mA)

Current across $R_2 = I_2 = I R_1 R_3 / (R_1 R_2 + R_2 R_3 + R_3 R_1)$ (mA)

Current across $R_3 = I_3 = I R_1 R_2 / (R_1 R_2 + R_2 R_3 + R_3 R_1)$ (mA)

PROCEDURE

- Select three resistors and measure the resistance of each one with an ohmmeter. Note these resistance values.
- Connect the three resistors in parallel and to the power supply, as shown in the circuit diagram.
- Measure the voltage of the power supply. It is advisable to measure the voltage while powering the resistor circuit because this voltage may differ slightly from a no-load condition.
- Switch you multi-meter to the "voltage" mode and measure the voltage dropped across each resistor. You'll see that, voltage is same for all resistors.
- Use Ohm's Law ($I = V / R_{eq}$) to calculate circuit current, and then verify this calculated value by measuring current with an ammeter.
- Measure currents through all the three resistors. Compare these values to the calculated values by equation.

OBSERVATIONS & RESULTS

No. of Observation	Supply Voltage (volt)	Resistance (kΩ)			Current (I)		Brunch Current (mA)					
		R_1	R_2	R_3	Calculated	Measured	Calculated			Measured		
							I_1	I_2	I_3	I_1	I_2	I_3

PROBLEMS

- Among which things the Ohm's Law gives us relationship?
- The input current to a transistor is 20μA. If the applied (input) voltage is 24mV, determine the input Resistance of the transistor?
- Plot "I" vs. "V" curve for Ohm's Law. Use the values, you got in the experiment.
- Will the currents through the resistors be same for Series Circuit? What will be the case for Parallel Circuit?
- Will the voltages across the resistors be same for Series Circuit? What will be the case for Parallel Circuit?

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EXPERIMENT NO. : 02
NAME OF THE EXPERIMENT:

TO VERIFY KIRCHHOFF'S VOLTAGE LAW (KVL) AND KIRCHHOFF'S CURRENT LAW (KCL).

OBJECTIVE

Our objective in this experiment is to know the nature of electric current. Moreover, from this experiment, we'll know-

- The relationship among voltage levels around any closed loop of a network.
- The relationship among current levels at any junction.

THEORY

KIRCHHOFF'S VOLTAGE LAW (KVL)

Kirchhoff's Voltage Law states that the algebraic sum of all the voltages around any closed path (loop or mesh) is zero.
Mathematically,

$$\sum_{k=1}^{n} V_k = 0$$

Here, *n* is the total number of voltages and V_k is the K^{th} voltage.

The algebraic sum is the sum which takes into account the polarities of the voltage drops. The sign of the voltage drop across a resistor depends on the direction of current through that resistor but is independent of the polarity of any other source of e.m.f. in the circuit under consideration. To determine this law we need to know the algebraic sign. When current flows from lower potential to higher potential it is considered positive. On the other hand when current flows from higher potential to lower potential it is considered negative.

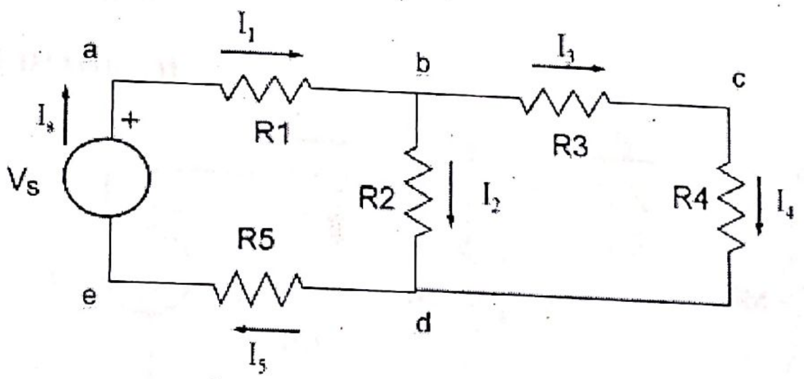


Figure 1

Applying Kirchhoff's voltage law to the first and the second loops in the circuit shown in Figure 1 yields:

Loop 1: $-V_s + V_1 + V_2 + V_5 = 0$........................ (1a)
Loop 2: $-V_2 + V_3 + V_4 = 0$ ....(1b)

KIRCHHOFF'S CURRENT LAW (KCL)

Kirchhoff's current law (KCL) states that in any electrical network, the algebraic sum of the currents meeting at a point (or junction) is zero. It simply means that the total current leaving a junction is equal to the total current entering that junction.

$$\sum_{k=1}^{n} I_k = 0$$

Here, n is the total number of currents flowing towards or away from the point and I_k is the K^{th} current.

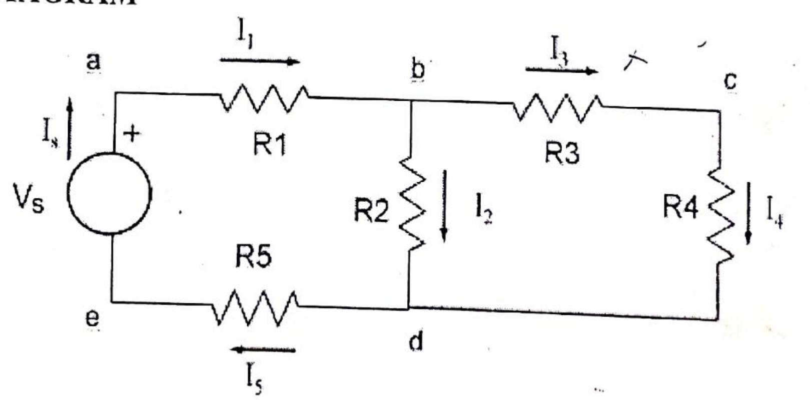
Applying Kirchhoff's current law to the first four nodes in the circuit shown in Figure1 yields the following equations;

Node a: $-I_s + I_1 = 0$ .... (2a)
Node b: $-I_1 + I_2 + I_3 = 0$............ (2b)
Node c: $-I_3 + I_4 = 0$ ....(2c)
Node d: $-I_2 - I_4 + I_5 = 0$ ....(2d)

APPARATUS

- Power supply
- 5 resistors
- Multi-meter
- Connecting wire

CIRCUIT DIAGRAM



PROCEDURE

- Make the connection as shown in the circuit diagram.
- Set the Variable Power Supply (Vs) to 5 Volts.
- Accurately measure all voltages and currents in the circuit using the Digital Multi-Meter (DMM).
- Record the measurements in a tabular form containing the measured voltage and current values.
- Verify KVL for the loops in the circuit using equations 1a and 1b.
- Verify KCL for the nodes in the circuit using equations 2a, 2b, 2c and 2d.

OBSERVATIONS & RESULTS (all are practical value)

Branch voltage	volts	Branch Current	mA	R	KΩ
V_s		I_s			
V_1		I_1		R_1	
V_2		I_2		R_2	
V_3		I_3		R_3	
V_4		I_4		R_4	
V_5		I_5		R_5	

PROBLEMS

- Theoretically calculate the voltages for each element in the circuit using ohm's law and compare them to the measured values.
- Theoretically calculate the currents for each element in the circuit using ohm's law and compare them to the measured values.
- Compute the percentage error (if any) in the two measurements and provide a brief explanation for the error.

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EXPERIMENT NO. : 03
NAME OF THE EXPERIMENT:

TO VERIFY THEVENIN'S THEORY FOR RESISTIVE NETWORK.

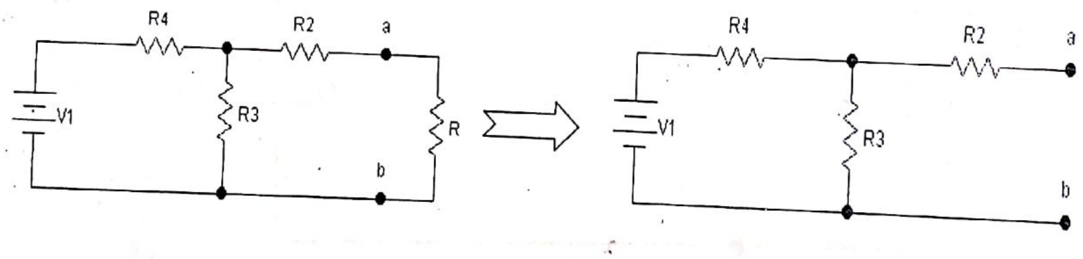
OBJECTIVE

It often occurs in practice that a particular element in a circuit is variable while other elements are fixed. Each time the variable element is changed, the entire circuit has to be analyzed all over again. Thevenin's theorem overcomes this problem. The objective of this experiment is to learn about this theorem and verify it.

THEORY

It 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).

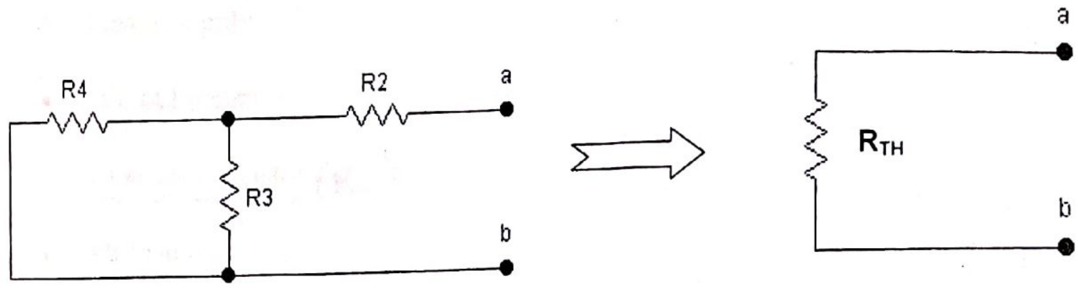
The first thing that one must do to use Thevenin's Theorem is remove the component over which one desires to measure the voltage. After this is done, the voltage is calculated across these wires as in the following diagram:



V_{th} is the Thevenin Equivalent Voltage [Thevenin's Equivalent Voltage (V_{th}) is the open circuit voltage between two points in a circuit] from point a to b. Note that no current flows through R_2, so there is no voltage drop across R_2.

$$V_{TH} = V_1 \frac{R_3}{R_3 + R_4}$$

The next step is to find the Thevenin Equivalent Resistance [Thevenin's Equivalent Resistance (R_{th}) is the total resistance appearing between two terminals] leading up to A and B. The voltage supply can be removed, or replaced by a resistor with the same internal resistance as the supply. An example of this is shown below:

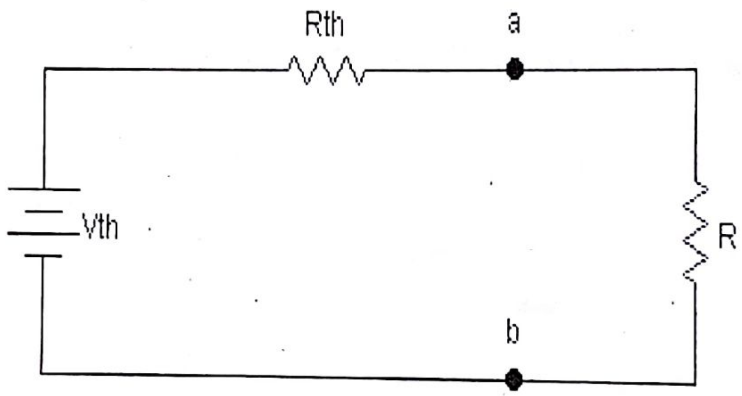


R_{th} can be calculated with the following equation (R3, R4 in parallel, R2 in series):

$$R_{TH} = \frac{R_3 R_4}{R_3 + R_4} + R_2$$

Next, we reattach R between a and b, put R_{th} in series with R, and place V_{th} on the circuit.

This looks like the following figure:



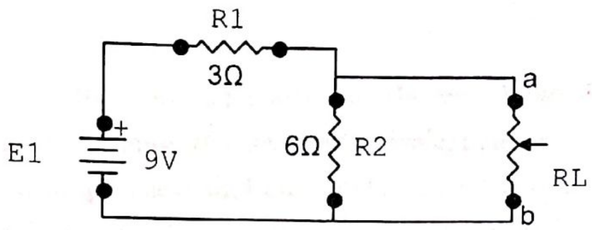
The resistance across R can be measured from our old circuit equations:

$$I_R = \frac{V_{TH}}{R_{TH} + R} \qquad V_R = IR = \frac{V_{TH} R}{R_{TH} + R}$$

APPARATUS

- Power supply
- 3Ω, 6Ω resistors
- 1 variable resistor (R_L)
- Multi-meter

CIRCUIT DIAGRAM



PROCEDURE

- At first we remove R_L from the terminals a and b. Obviously the terminals become open circuit.
- Then we calculate open circuit voltage V_{OC} that appears across terminals a and b when R_L is removed.
- Calculate R_{th} by setting all the sources to zero (voltage sources are replaced by short circuits and current sources by open circuits) and then measure the resultant resistance between a and b.
- Connect R_L back to its terminals a and b from where it was temporarily removed earlier. Measure current through R_L.
- Measure current flowing through R_L by the equation

  $$I_L = V_{th} / (R_{th} + R_L)$$

  and compare it with the measured value.
- Vary supply voltage and repeat the whole process.

OBSERVATIONS & RESULTS

No. of Observation	Supply Voltage (Volt)	Thevenin's Voltage V_{th} (volt)	Thevenin's Resistor R_{th} (KΩ)	I_L	
				Calculated	Measured

PROBLEM

- What is meant by the word "equivalent" in Thevenin Equivalent circuits?
- What is the practical value of Thevenin Equivalent circuits? Give several practical applications in which Thevenin Equivalent circuits are used.
- What will be the circuit diagram after removing R_L from the terminals a and b in the experimental circuit?
- Draw the thevenin equivalent circuit.

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EXPERIMENT NO. : 04

NAME OF THE EXPERIMENT:

TO VERIFY NORTON'S THEOREM FOR RESISTIVE NETWORK.

OBJECTIVE

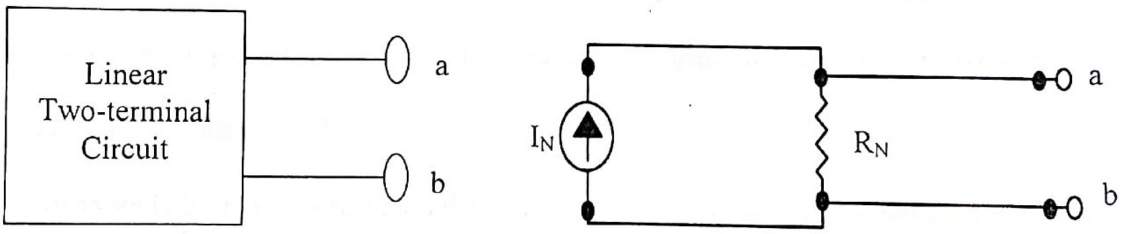
Every voltage source with a series internal resistance has a current source equivalent. The current source equivalent of the Thevenin network can be determined by Norton's theorem. Actually, Norton's theorem is an extension of Thévenin's theorem. Our objective is to know this theorem and verify it.

THEORY

This theorem is very useful to simplify a network in terms of currents instead of voltage. Norton's theorem for electrical networks states that-

"Any collection of voltage sources, current sources, and resistors with two terminals is electrically equivalent to an ideal current source in parallel with a single resistor."

For single-frequency AC systems the theorem can also be applied to general impedances, not just resistors. The Norton equivalent is used to represent any network of linear sources and impedances, at a given frequency. The circuit consists of an ideal current source in parallel with an ideal impedance (or resistor for non-reactive circuits).



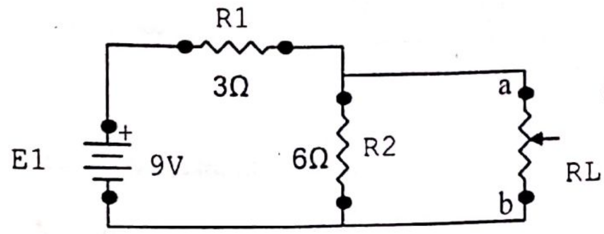
(a) (b)

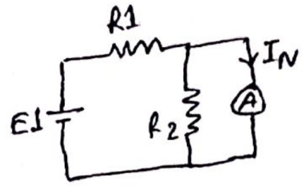
Here figure (a) is the original circuit and figure (b) is the Norton Equivalent Circuit.

APPARATUS

- Power supply
- 3Ω, 6Ω resistors
- 1 variable resistor
- Multi-meter

CIRCUIT DIAGRAM





PROCEDURE

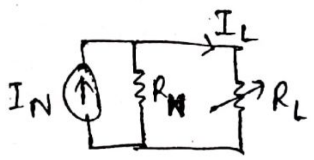
- Construct the circuit as shown in the diagram. Now measure I_L and V_L.
- Remove R_L from the terminals A and B. Obviously the terminals become open circuit.
- Then measure open circuit voltage V_{OC} that appears across terminals a and b when R_L is removed. Here $V_{OC} = V_{th}$
- First set all sources to zero (voltage sources are replaced by short circuits and current sources are replaced by open circuits) and then measure the equivalent resistance between terminal a and b.
- Measure I_N by first returning all the sources to their original places and then measuring the short-circuit current between the terminals a and b.
- Calculate $R_N = V_{OC} / I_N$ and compare it with the measured value.
- Calculate $I_N = V_{OC} / R_N$ and compare it with the measured value.

OBSERVATIONS & RESULTS

No. of Observation	Supply Voltage (Volt)	$V_{OC} = V_{th}$	I_N		R_N	
			Calculated (V_{OC}/R_N)	Measured	Calculated (V_{OC}/I_N)	Measured

PROBLEM

1. Draw the Norton equivalent circuit.
2. Draw a curve of V_{OC} vs. I_N.



$$I_L = I_N \frac{R_N}{R_L + R_N}$$

Supply Voltage	I_N	I_L calculated	I_L Measured

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EXPERIMENT NO. : 05
NAME OF THE EXPERIMENT:

· TO VERIFY MAXIMUM POWER TRANSFER THEOREM FOR RESISTIVE NETWORK.

OBJECTIVE

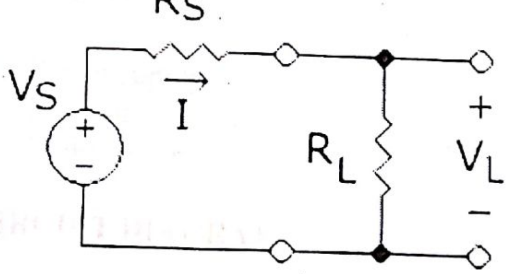
In many practical situations, a circuit is designed to provide power to a load. There are applications such as communications where it's desirable to maximize the power delivered to the load. Very often, problem rises with this as there may be internal losses. So the objective of this experiment is to verify the theorem and know how maximum power is transferred to the load.

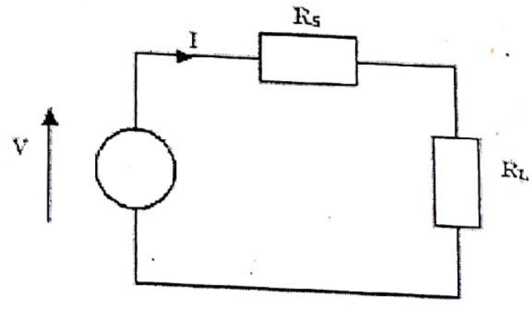
THEORY

The maximum power (transfer) theorem states that, to obtain maximum external power from a source with a finite internal resistance, the resistance of the load must be made the same as that of the source.

The theorem applies to maximum power, and not maximum efficiency. If the resistance of the load is made larger than the resistance of the source, then efficiency is higher, since most of the power is generated in the load, but the overall power is lower since the total circuit resistance goes up.

If the internal impedance is made larger than the load then most of the power ends up being dissipated in the source, and although the total power dissipated is higher, due to a lower circuit resistance, it turns out that the amount dissipated in the load is reduced.





In the diagram opposite, power is being transferred from the source, with voltage V and fixed source resistance R_S, to a load with resistance R_L, resulting in a current I. By Ohm's law, "I" is simply the source voltage divided by the total circuit resistance:

$$I = \frac{V}{R_S + R_L}$$

The power P_L dissipated in the load is the square of the current multiplied by the resistance:

$$P_L = I^2 R_L = \left(\frac{V}{R_S + R_L}\right)^2 R_L = \frac{V^2}{R_S^2/R_L + 2R_S + R_L}$$

We could calculate the value of R_L for which this expression is a maximum, but it is easier to calculate the value of R_L for which the denominator (R_S^2 / R_L + R_S + R_L) is a minimum. The result will be the same in either case. Differentiating with respect to is a minimum. The result will be the same in either case. Differentiating with respect to R_L :

$$\frac{d}{dR_L}\left(R_S^2/R_L + 2R_S + R_L\right) = -R_S^2/R_L^2 + 1$$

For a maximum or minimum, the first derivative is zero, so

$$R_S^2/R_L^2 = 1$$

or

$$R_L = \pm R_S$$

To find out whether this solution is a minimum or a maximum, we must differentiate again:

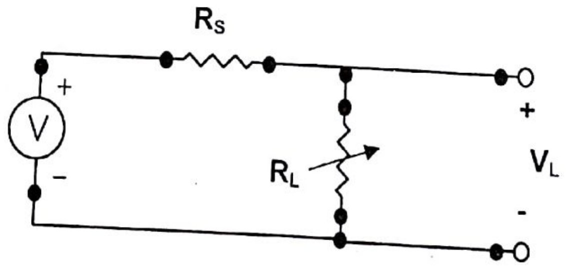
$$\frac{d^2}{dR_L^2}\left(R_S^2/R_L + 2R_S + R_L\right) = 2R_S^2/R_L^3$$

This is positive for positive values of R_S and R_L, showing that the denominator is a minimum, and the power is therefore a maximum, when $R_S = R_L$

APPARATUS

- Power supply
- Resistor
- Multi-meter

CIRCUIT DIAGRAM



PROCEDURE

- Construct the circuit as shown in the diagram.
- Internal resistance R_S is fixed and measure V_L (voltage across R_L) for different values of R_L.
- Calculate $V_L = R_L V / (R_L + R_S)$ and compare this value with the measured value.
- Measure I_L across R_L. Calculate $I_L = V / (R_L + R_S)$ and compare it with the measured value.
- Calculate $P_L = V_L I_L$ (use measured values of V_L & I_L). Now calculate $P_L = V^2 R_L / (R_S + R_L)$ and compare with the previously calculated value.

OBSERVATION & RESULT

No.of Observation	Load Resistance $R_L(\Omega)$	Load voltage, V_L		Load current, I_L		Power, P_L	
		Calculated	Measured	Calculated	Measured	Calculated	Measured

PROBLEM

1. Plot the curve P_L vs. R_L.
2. Plot the curve for V_L vs. R_L.
3. Plot the curve for I_L vs. R_L.

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EXPERIMENT NO. : 06

NAME OF THE EXPERIMENT:

TO VERIFY SUPERPOSITION THEOREM FOR RESISTIVE NETWORK.

OBJECTIVE

There are some powerful network theorems that allow us to easily analyze complex circuits. The Superposition Theorem allows us to determine a load voltage or current by analyzing the effects of each source acting independently. The purpose of this experiment is to verify this network theorem.

THEORY

The superposition theorem for electrical circuits states that the total current in any branch of a bilateral linear circuit equals the algebraic sum of the currents produced by each source acting separately throughout the circuit.

Let us consider the fig.-a, where I, I_1, and I_2 represents the value of currents which are due to the simultaneous action of the two source of e.m.f. in the network.

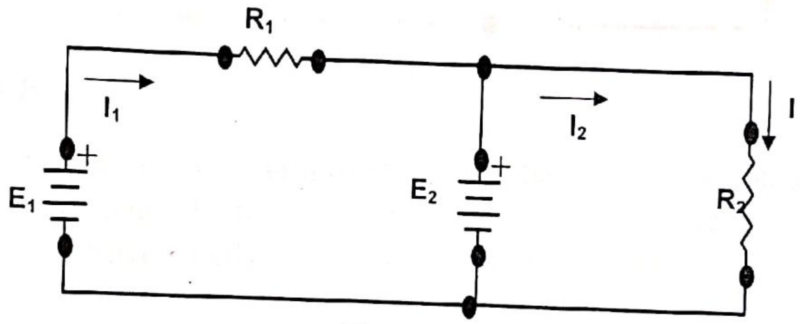


Figure- a

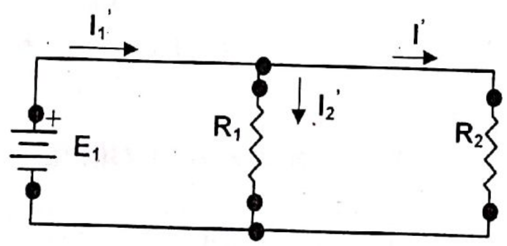


Figure- b

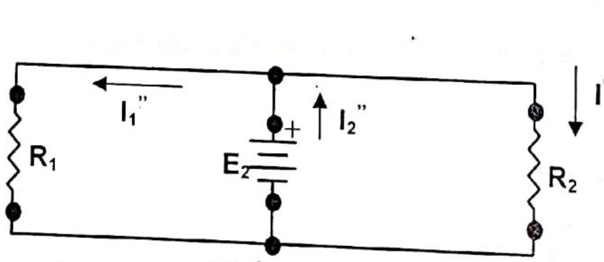


Figure- c

In fig- b the current values which would have obtained if left hand side battery dad acted alone. Similarly fig.-c represents conditions obtained when right hand side battery acted alone. By combining the current values of fig.- b and fig.- c the actual values of fig.- a can be obtained.

Obviously $I_1 = I'_1 - I''_1$

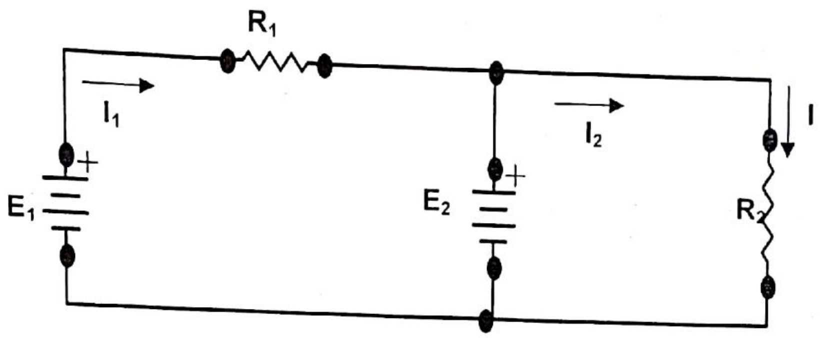
$$I_2 = I''_2 - I'_2$$

$$I = I' + I''$$

APPARATUS

- 2 voltage sources
- 2 resistors

CIRCUIT DIAGRAM



PROCEDURE

- At first, construct the circuit on the circuit board as shown in the diagram. Measure the branch current I, I_1, I_2 by multi-meter.
- Then the remove supply voltage E_2 and measure branch current I'_1, I'_2 and I.
- Now remove supply voltage E_1 and measure the branch current I''_1, I''_2 and I''.
- All the processes are repeated by changing the values of the sources of e. m. f.

OBSERVATION & RESULT

No. of observation	E_1	E_2	I	I'	I''	I_1	I'_1	I''_1	I_2	I'_2	I''_2

No. of observation	E_1	E_2	I		I_1		I_2	

PROBLEM

- Is the Superposition Theorem applicable for power levels?
- While removing voltage sources, what we'll do? Will it be an open circuit? What will be the case while removing current sources?