EE1025-Independent Project
Thevenin's theorem, Norton's theorem Superposition

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Abstract

Simplification is necessary!Solving large and complicated circuits involve theoretical approach using theorem's **Thevenin**,**Norton**,**Superposition**.Before directly applying the mathematical equations to the circuits one must know the limitations of these theorems.Each of these theorems have specific conditions and applicable in different situations!

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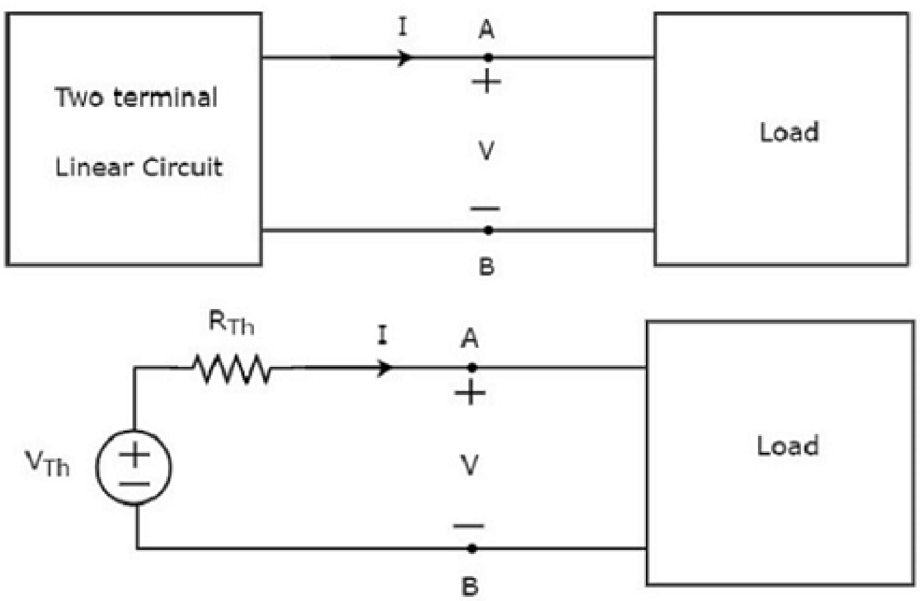
Contents

1 Aim

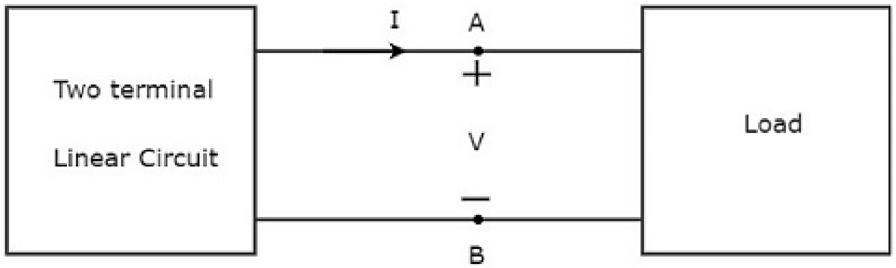
- In this experiment,Thevinin,Norton,Superposition theorem are explained.
- Understang the importance of each theorem and how to simplify complicated circuits.
- Know the conditions of Applicablity.
- Solve equations theoretically,and compare with experimental results.
- Then verify the experimental and theoretical values.

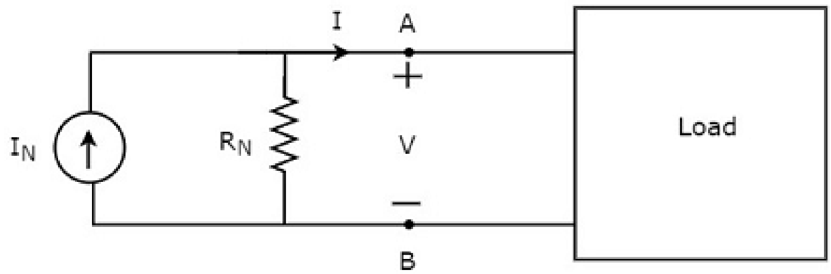
2 Introduction

Thevenin Theorem:- Thevenins Theorem states that Any linear circuit containing several voltages and resistances can be replaced by just one single voltage in series with a single resistance connected across the load

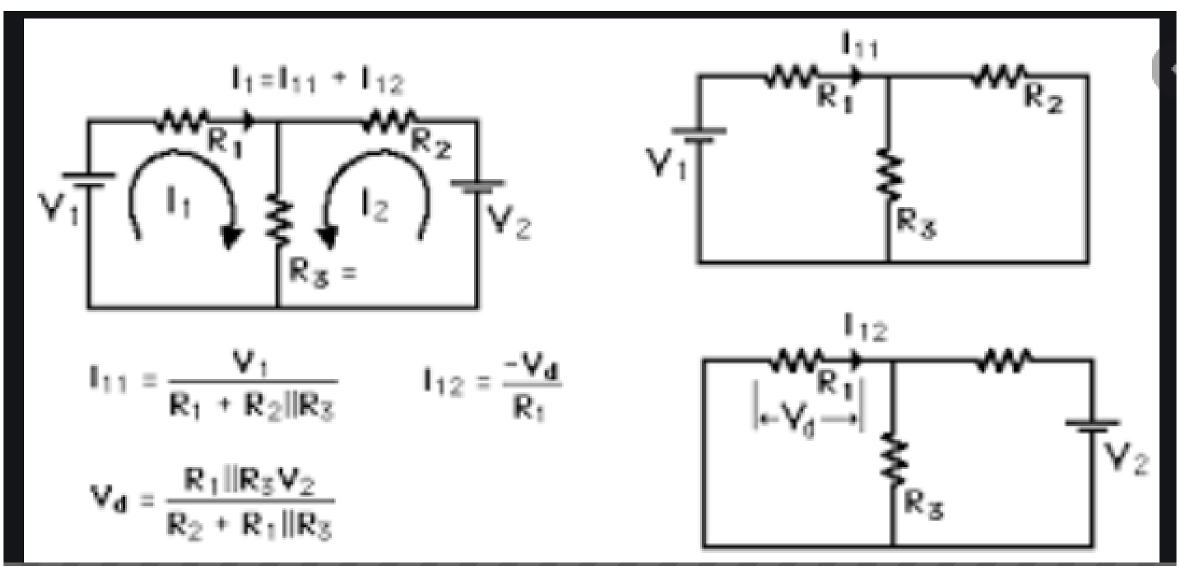


Norton Theorem:- Nortons Theorem states that Any linear circuit containing several energy sources and resistances can be replaced by a single Constant Current generator in parallel with a Single Resistor.





Superposition Theorem:- Superposition theorem is based on the concept of linearity between the response and excitation of an electrical circuit. It states that the response in a particular branch of a linear circuit when multiple independent sources are acting at the same time is equivalent to the sum of the responses due to each independent source acting at a time.



3 Apparatus

DC power supply,multimeter,resistors(47Ω , 100 Ω, 1000Ω)

4 Theoretical Background

4.1 Thevenin Theorem

- Thevenins theorem states that a linear two-terminal circuit can be replaced by an equivalent

  circuit consisting of a voltage source VTh in series with a resistor RTh, where VTh is the open- circuit voltage at the terminals and RTh is the input or equivalent resistance at the terminals

  when the independent sources are turned off.

- As far as the load resistor RL is concerned, any complex one-port network consisting of multiple resistive circuit elements and energy sources can be replaced by one single equivalent resistance Rs and one single equivalent voltage Vs. Rs is the source resistance value looking back into the circuit and Vs is the open circuit voltage at the terminals.

- It's applicable on both dependent and independent sources.

- It doesn't apply to non-linear circuit elements like transitors,diodes,etc.

4.2 Norton Theorem

- Nortons theorem states that a linear two-terminal circuit can be replaced by an equivalent cir- cuit consisting of a current source IN in parallel with a resistor RN , where IN is the short-circuit

  current through the terminals and RN is the input or equivalent resistance at the terminals when the independent sources are turned off.

- As far as the load resistance, RL 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.

- It's applicable on both dependent and independent sources.

- It doesn't apply to non-linear circuit elements like transitors,diodes,etc.

4.3 Superposition Theorem

- Superposition theorem is based on the concept of linearity between the response and excitation of an electrical circuit. It states that the response in a particular branch of a linear circuit when multiple independent sources are acting at the same time is equivalent to the sum of the responses due to each independent source acting at a time.

- This theorem cannot be used to measure power and is not applicable to unbalanced bridge circuits.
- Applicable only to linear circuits.

5 Procedures

5.1 Thevenin Theorem

- Step 1 Consider the circuit diagram by opening the terminals with respect to which, the Thevenins equivalent circuit is to be found.

- Step 2 Find Thevenins voltage $V_{Th} acrosstheopenterminalsoftheabovecircuit.$

- Step 3-If dependent sources are not present the R_{Th} *can be found switching off all the independent sour*
*Step*4*Find the short circuit current* I_{SC} *by shorting the two opened terminals of the above circuit.*

- Step 5 Find Thevenins resistance RTh by using the following formula.

- It's applicable of both dependent and independent sources.

$$R_{Th} = \frac{V_{Th}}{I_{SC}}$$

(1)

5.2 Norton Theorem

- Step 1 Consider the circuit diagram by opening the terminals with respect to which the Nortons equivalent circuit is to be found.

- Step 2 Find the open circuit voltage V_{OC} *across the open terminals of the above circuit.*
*Step*3 *Find the Nortons current* I_N *by shorting the two opened terminals of the above circuit.*

- Step 4-If dependent sources are not present the R_{Th} *can be found switching off all the independent sour*

- Step 5 Find Nortons resistance R_N *by using the following formula.*

- It's applicable of both dependent and independent sources.

$$R_N = \frac{V_{OC}}{I_N} \tag{2}$$

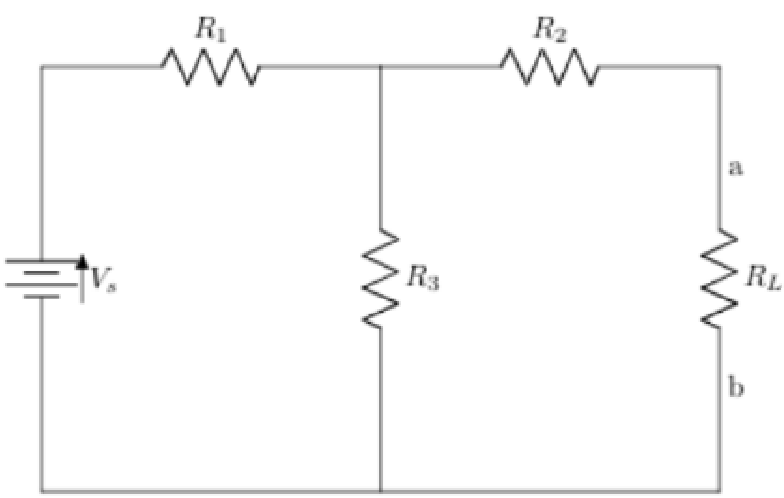
5.3 Superposition Theorem

- Step 1 Find the response in a particular branch by considering one independent source and eliminating the remaining independent sources present in the network.

- Step 2 Repeat Step 1 for all independent sources present in the network.

- Step 3 Add all the responses in order to get the overall response in a particular branch when all independent sources are present in the network.

5.4 Task -1



The R_1, R_2, R_3 *are respectively,*
Considering V_s *as* $11.5V$
We will use the current division and voltage division rules to explicitly find the following results.
The first step is to find the effective resistance since no dependent source is present hence we can direc
Shorting V_s *we get* $R_1//R_3 + R_2$
$R_{eff} = \dfrac{R_1 \times R_3}{R_1 + R_3} + R_2(3)$
Next the voltage V_Th
could be found by open circuiting terminals a and b.
Hence voltage across R_3 *would be same as the load* R_L.

$V_Th = \dfrac{V_S}{\dfrac{R_3 \times R_1}{R_1 + R_3}} \times R_3 (4)$
Next step is to find the I$_N$,
$it\, can\, be\, done\, by\, short\, circuiting\, a\, and\, b\, terminals\, ,\, the\, current\, through\, the\, terminals\, is\, same\, as\, the\, cur$
$I_N = \dfrac{V_S}{R_1 + \dfrac{R_2 \times R_3}{R_2 + R_3}} \times \dfrac{R_3}{R_2 + R_3} (5)$
Therefore the voltage drop across the load is when V$_Th\, and\, R_{eff}\, are\, in\, series\, with\, the\, R_L.$
$V_L = \dfrac{V_s}{\dfrac{R_1 \times R_3}{R_1 + R_3} + R_2 + R_L} \times R_L (6)$
And the current is given by

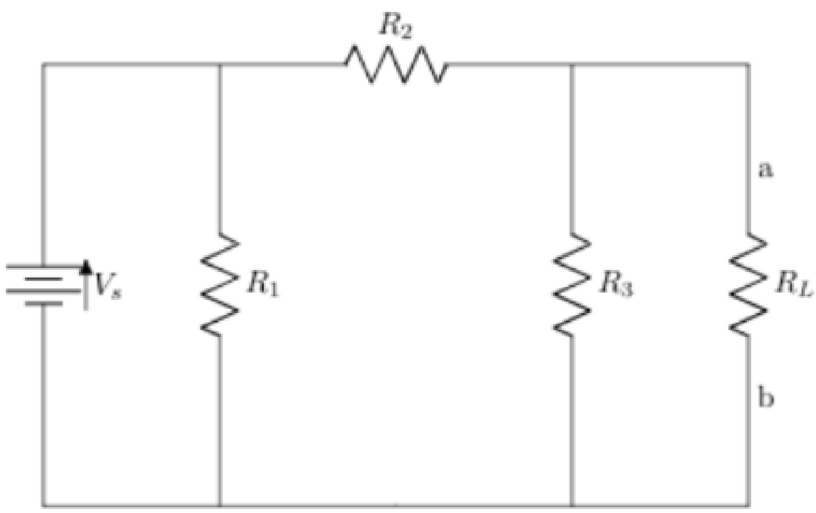
$$I_L = V_T h / R_L + R_{eff} \tag{7}$$

The current through Norton's method :

$$I_L = \frac{R_{eff}}{R_L + R_{eff}} \times I_N \tag{8}$$

We conclude that I$_N \times R_{eff} = V_{Th}$.

5.5 Task -2



The R$_1, R_2, R_3$ $1000\Omega,\ 47\Omega,\ 100\Omega$ $are\ respectively,$
$Considering V_s as 11.5V$
$We\, will\, use\, the\, current\, division\, and\, voltage\, division\, rules\, to\, explicitly\, find\, the\, following\, results.$
$The\, first\, step\, is\, to\, find\, the\, effective\, resistance\, since\, no\, dependent\, source\, is\, present\, hence\, we\, can\, direc$
$Shorting\ V_s\ we\ get\ R_2//R_3$

$R_{eff} = \dfrac{R_2 \times R_3}{R_3 + R_2}(9)$
Next the voltage $V_T h$
could be found by open circuiting terminals a and b.
Hence voltage across R_3 would be same as the load R_L.
$V_{Th} = \dfrac{V_s}{\dfrac{R_1 \times (R_2 + R_3)}{R_1 + R_2 + R_3}}_3 \;(10)$
Next step is to find the I_N,
it can be done by short circuiting a and b terminals , the current through the terminals is same as the cur
$I_N = \dfrac{V_s}{\dfrac{R_2 \times R_1}{R_2 + R_1}} \times \dfrac{R_1}{R_2 + R_1}(11)$
Therefore the voltage drop across the load is when $V_T h$ *and* R_{eff} *are in series with the* R_L.
$V_L = \dfrac{V_{Th}}{\dfrac{R_2 \times R_3}{R_3 + R_2} + R_L}_L \;(12)$
And the current is given by

$$I_L = V_{Th}/R_L + R_{eff} \tag{13}$$

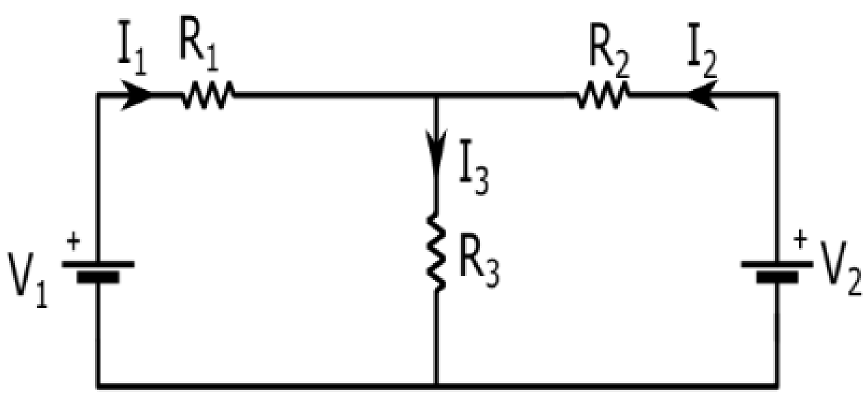
The current through Norton's method :

$$I_L = \frac{R_{eff}}{R_L + R_{eff}} \times I_N \tag{14}$$

We conclude that $I_N \times R_{eff} = V_{Th}$.

5.6 Task 3

The values of $R_1, R_2, R_3 are 100\Omega, 100\Omega, 1000\Omega respectively.$
$And V_1 and V_2 are 5V each.$



When source-1 is excited

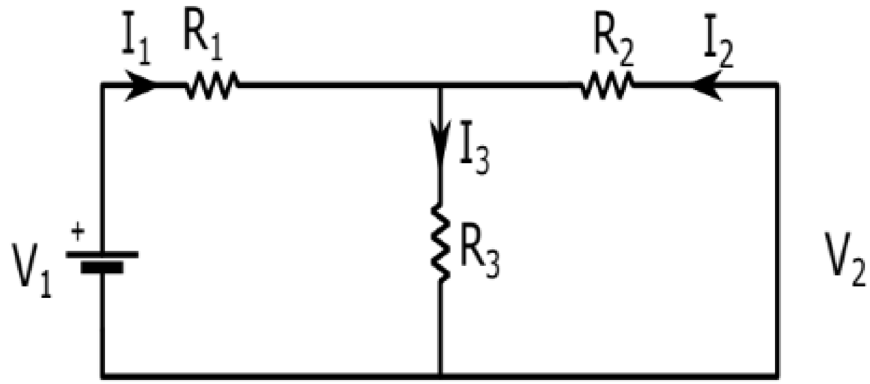


Figure 10: With source-1

$$I_1' = V_1 \frac{R_2 + R_3}{R_1R_2 + R_2R_3 + R_3R_1}$$
$$I_2' = V_1 \frac{R_3}{R_1R_2 + R_2R_3 + R_3R_1}$$
$$I_3' = V_1 \frac{R_2}{R_1R_2 + R_2R_3 + R_3R_1}$$

When source-2 is excited

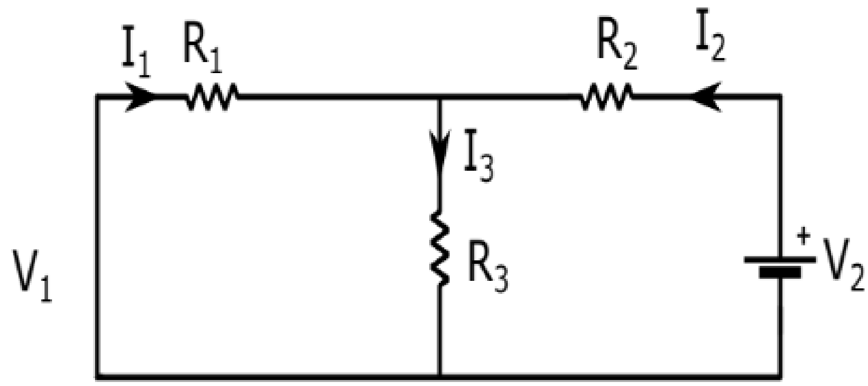


Figure 11: with source-2

$$I_2^{''} = V_2 \frac{R_1 + R_3}{R_1R_2 + R_2R_3 + R_3R_1}$$
$$I_1^{''} = V_1 \frac{R_3}{R_1R_2 + R_2R_3 + R_3R_1}$$
$$I_3^{''} = V_1 \frac{R_1}{R_1R_2 + R_2R_3 + R_3R_1}$$

Total Response is the combination of above two responses.

$$I_1 = I_1^{'} + I_1^{''}$$
$$I_2 = I_2^{'} + I_2^{''}$$
$$I_3 = I_3^{'} + I_3^{''}$$

6 Analysis

6.1 Task-1

Table 1: Thevenin's and Norton's results

Parameters	Theoretical values	Experimental values
1.$R_{Th} or R_N$	147Ω	146.6Ω
2.V_{Th}	11 V	10.97V
3.I_N	74.5mA	73.9mA
4.V_L	4.5V	4.48V
5.I_L	44mA	43.8mA

6.2 Task-2

Table 1: Norton's and Thevenin's results

Parameters	Theoretical values	Experimental values
1.$R_{Th} or R_N$	33.5Ω	33.2Ω
2.V_{Th}	7.66V	7.77V
3.I_N	0.246A	0.24A
4.V_L	5.86V	5.83V
5.I_L	56.9mA	57.6mA

6.3 Task-3

Table 2: Superposition results

Parameters	Theoretical values	Experimental values
1.V_3	4.75V	4.76V
2.V_2	0.25V	0.26V
3.V_{13}	2.375V	2.36V
4.V_{23}	2.375V	2.38V
5.V_{12}	-2.35V	-2.36V
6.V_{22}	2.6v	2.63V
7.I_3	4.6mA	4.59mA
8.I_2	2.45mA	2.45mA
9.I_{13}	2.3mA	2.38mA
10.I_{23}	2.3mA	2.37mA
11.I_{12}	-23.45mA	23.3mA
12.I_{22}	25mA	25.7mA

7 Conclusions

We verified the Thevenin ,Norton and Superposition theorem.
By connecting the resistors according to the circuit ,we found the currents and voltages through load resistor theoretically and experimentally.
) Reasons for variation in the values:

- Due to heating effect.
- Even it may be because of negligence of resistance of multimeter.
- Because of variations of voltages from DC power supply.

In Thevenin and Norton thorems, power dissipation may not be same as the theoritical values and valid only for a linear range.
Source Modelling and resistance measuring are some of the pratical applications.
Superposition theorem is not used for power calculations and not valid for time-varying resistances.