North South University
Department of Electrical & Computer Engineering

LAB REPORT

Course Code : EEE141L

Course Title: Electrical Circuit 1 Lab

Course Instructor: M Abu Obaidah (AbO)

Experiment Number: 06

Experiment Name:

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

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Experiment Name: Verification of Thevenin's, Norton's & Maximum Power Transfer Theorem

Objectives :-

The objectives of this experiment are as follows :-

- Experimentally perform thevenin's theorem, Norton's theorem and maximum power theorem
- Perform theoretical calculations
- verify the experimental values with theoretical values

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 ~~consists of a~~ with just a single ~~dc~~ voltage source ~~Referred to as~~ the and series Resistance connected to a load. The Thevenin equivalent circuit consists of a single dc source referred to as the thevenin voltage (V_{TH}) and a single fixed resistor called the thevenin resistance (R_{TH}).

Relationship between Thevenin & Norton Theorem

Both thevenin & Norton equivalent circuits are intended to behave the same as the original network in supplying voltage & current to the load resistor, having been derived from the same original network should behave identically.

This means that both Thevenin & Norton equivalent circuits should produce the same voltage across the load terminals with no load attached.

$$\Rightarrow R_{Thevenin} = R_{NORTON}$$

$$\Rightarrow V_{Thevenin} = I_{NORTON} R_{NORTON}$$

$$\Rightarrow I_{NORTON} = \frac{V_{Thevenin}}{R_{Thevenin}}$$

Applications of Thevenin, Norton & Maximum Power Transfer theorem :-

Thevenin's & Norton's theorem are used where the load can be varied. So basically these methods reduce the big linear circuit into one source & one resistor. Later we can put any kind of load & measure the variations of currents & voltages across the load. The load can be a fan, bulb etc, so we can determine the suitable one.

Also where maximum power is required from source, these theorem are used to calculate required load impedance or present source impedance for maximum power.

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).

Maximum Power Transfer Theorem

In electrical engineering, 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 equal the resistance of the source as viewed from its output terminals. 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. Formula given below:-

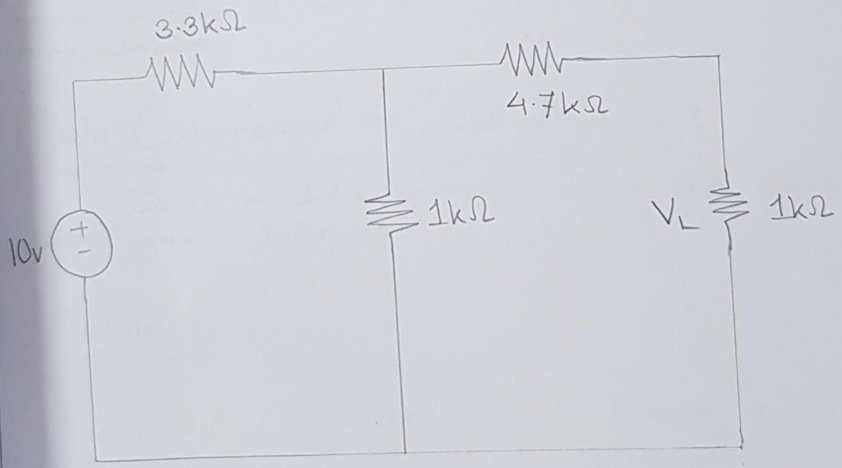
$$P_{max} = \frac{V_{TH}^2}{4R_{TH}}$$

Maximum Power will be delivered to the load when that load resistance is equal to the Thevenin resistance of the network supplying the power.

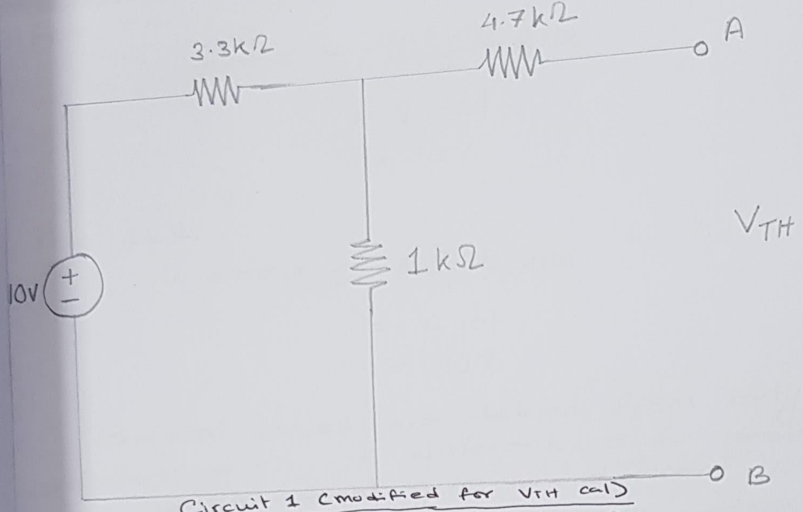
Apparatus List :-

i. Trainer Board
ii. one 3.3kΩ resistor
iii. one 4.7kΩ resistor
iv. two 1kΩ resistors
v. Digital Multimeter (DMM)
vi. Connecting wires

Circuit Diagram :-



Circuit 1



Circuit 1 (modified for VTH cal)

V_{TH} is calculated from the terminal at A and B removing the load resistance.

Data Collection & Result Analysis :-

Data & data analysis from the tables are given below:-

Table 1

Theoretical R	Measured R	% Error
5kΩ	4.9kΩ	2%
1kΩ	0.9kΩ	10%

For 5kΩ,

$$\% \text{ error} = \frac{4.9-5}{5} \times 100$$
$$= |-2|$$
$$= 2\%$$

For 1kΩ,

$$\% \text{ error} = \frac{0.9-1}{1} \times 100$$
$$= |-10|$$
$$= 10\%$$

Practical values are taken from only one resistors each. A different 5kΩ resister or 1kΩ resistor might give a different % error value. The % error for 1kΩ resistor came about 10% because the resistance is very small so a small change will give greater % error value.

Table 2:

Measurement	Measured	Calculated	% error
V_L	0.3V	0.359V	16.43%
I_L	0.36mA	0.359mA	0.27%

$$I_L = \frac{V_{TH}}{R_L+R_{TH}}$$
$$= \frac{2.3}{1+5.4}$$
$$= 0.359\text{ mA}$$

$$\% \text{ error} = \frac{0.36-0.359}{0.359} \times 100 = 0.27\%$$

$$V_L = I_L R_L$$
$$= 0.359 \times 1$$
$$= 0.359\text{V}$$

$$\% \text{ error} = \frac{0.3-0.359}{0.359} \times 100 = 16.43\%$$

Table 3

Measurement	Measured	Calculated	% error
V_{TH}	2.3	2.78V	17.3%
I_N	0.43 mA	0.426mA	0.94%
R_{TH}	5.4 kΩ	5.47kΩ	1.3%

$$R_{TH} = \frac{1}{\frac{1}{3.2} + 1} + 4.7$$

$$= 5.47\ k\Omega$$

$$\%\ error = \frac{5.4 - 5.47}{5.47} \times 100$$

$$= 1.3\%$$

From thevenin equivalence diagram

total resistance = 5.47kΩ + 1 kΩ

= 6.47kΩ

I_N = 0.43 mA

So,

$$V_{TH} = I_N \times R_N$$

$$= 0.43 \times 6.47$$

$$= 2.78V$$

$$\%\ error = \cancel{\frac{2.78 - 2.3}{2.3}} \times 100 \quad \frac{2.3 - 2.78}{2.78} \times 100$$

$$= 17.3\%$$

V_{TH} = 2.3V

R_{TH} = 5.4kΩ

So,

$$I_N = \frac{2.3}{5.4}$$

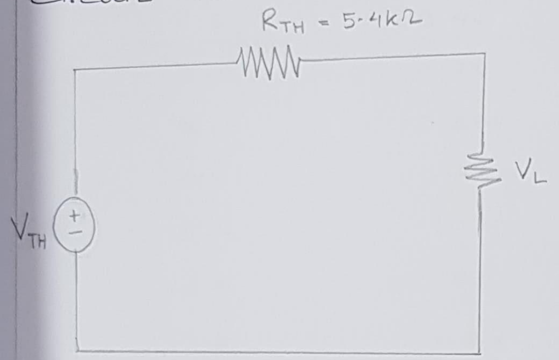
$$= 0.426$$

$$\%\ error = \frac{0.43 - 0.426}{0.426} \times 100$$

$$= 0.94\%$$

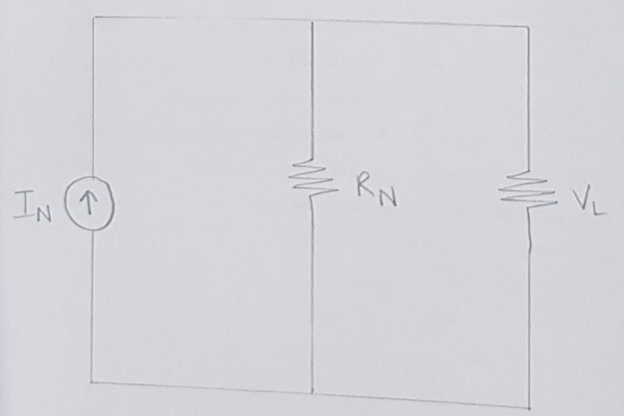
Table : 4

Thevenin's Equivalent circuit of the given circuit is drawn below :-



Thevenin's Equivalent Circuit

Norton's Equivalent Circuit is given below :-



Norton Equivalent Circuit

Table 5:

R_L (KΩ)	V_L (Experimental) (V)	P_L (Experimental) (mW)
1.0	0.4V	0.16
2.0	0.7V	0.245
3.0	0.83V	0.23
4.0	0.98V	0.24
5.0	1.13V	0.25
6.0	1.23V	0.245
7.0	1.3V	0.24
8.0	1.40V	0.24
9.0	1.46V	0.236
10.0	1.51V	0.228

Theoretical :- $P_{max} = V_{TH}^2 / 4R_{TH} = (2.7)^2/(4 \times 5.47) = 0.33$ mA

Result Analysis :-

From the above tables we saw that the % error differs by less number. At some points % error was greater than expected. It can occur due to internal resistance of DC power supply, resistance of the wires (as more wires give more resistance) or temperature at the time of the experiment.

In table-5 the voltage increases as resistance in the variable resistor was increased. Meanwhile, power tend to increase and at voltage 1.13V when resistance was 5kΩ the power was at highest (0.255mW). Then power ~~again~~ decreased ~~#~~ when resistance was increased after 5kΩ.

and replaced it with a short circuit. Then we calculated resistance at the terminals of the load resistor. This resistance is known was R_{TH}.

After that we again replaced the voltage source with ~~and~~ the short circuit, and this time ~~replacing~~ replaced the load resistance as short circuit. Then we measured the short circuit current. This current is known as I_N.

Then we replaced the load resistor with a variable load resistor, for table 5. At first we ~~p~~ faced some problems from where the variable resistor should be connected, but later with the help of the instructor it was solved. Then we ~~to~~ set the values in the variable resistor as given in table 5 and then measured voltages across them. Then using

$P = \frac{V_L^2}{R_L}$, we found power for each resistance.

At first we used too many wires. Later, as too many wires would increase the resistance, therefore we reduced it to a more perfect connection by connecting the resistors node by node. In this way we completed our experiment.

Discussion :-

We started our experiment by collecting the apparatus from the lab instructor. From the given resistors, we identified the resistors using colour codes of the resistors. We measured the resistance of 5kΩ and 1kΩ for table 1 and calculated their % error.

We formed circuit 1 in breadboard with one 3.3kΩ resistor, one 4.7kΩ resistor & two 1 kΩ resistor. As we had no power supply, we took the voltage from the trainer board. Before that we adjusted the voltage to 10v and measured it with DMM. The trainer board was giving the voltage of about 9.98v.

From Circuit 1 we measured voltage across the load ~~to~~ using DMM. Then we opened one side ~~the~~ of the load and connected DMM in series to measure current, more specifically to measure I_L (current passing throught the load).

Then to calculate V_{TH} we removed the load resistance, calculated the open-circuit voltage at the terminals of the load resistance. After that we removed the voltage source that we took from the trainer board, Graph Analysis :-

A P_L versus R_L graph is drawn from table 5 data. As we took practical values in ~~gr~~ table 5. Therefore the points might vary from the original values.

~~We~~ As we plotted the graph we saw that when R_L was 5kΩ, power was maximum which was 0.25 mW.

Our measured R_{TH} was 5.4kΩ. We know that when R_{TH} will be equal to the load resistance at that point maximum power will be delivered to the load. And from our graph we saw that it satisfies the maximum power theorem.

At 2kΩ the power came out to be 0.245 mW. As this point is far away from the graph this point might be an anomalous value.

In graph our highest peak occurred at 5kΩ. Therefore, we can say from the graph our R_{TH}/R_L is 5kΩ.