BIRZEIT UNIVERSITY

Physics Department

Physics 112

Experiment #4

NETWORK ANALYSIS II THE THENENIN AND NORTON TECHNIQUES

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Section:- 18

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1. Abstract

The aim of the experiment: *is to examine and prove experimentally Thevenin's and Norton's techniques and compare the results with Kirchoff's laws.*
The method used: *is by using the equivalent circuit of Thevenin and Norton techniques.*

<u>The main results:</u>

<u>Experimentally:</u>

A) By THEVENIN:

I_{L1}=2.09 mA.. , I_{L2}=0.8 mA, I_{L3} = 1.26 mA

R(eg1)= $2.15k\Omega$ R(eq2)= $0.86\ k\Omega$ R(eq3)= $0.76\ k\Omega$

ε_1=6.67V ε_2=3.46V $\varepsilon3$=8.85V

B) By NORTON:

I_{L1}=2.11 mA.. , I_{L2}=0.84 mA, I_{L3} = 1.25 mA

<u>Theoretically:</u>

I_{L1}=6.74 mA.. , I_{L2}=0.868 mA, I_{L3} = 1.27 mA

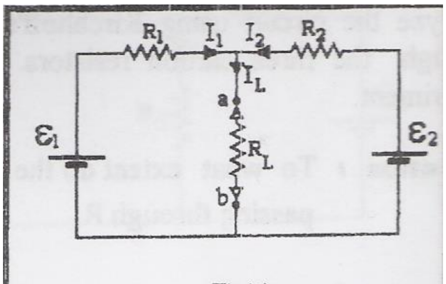
R(eg1)= $2.15k\Omega$ R(eq2)= $0.861\ k\Omega$ R(eq3)= $0.767\ k\Omega$

ε_1=6.74V ε_2=3. 6V $\varepsilon3$=8.84V

Theory:

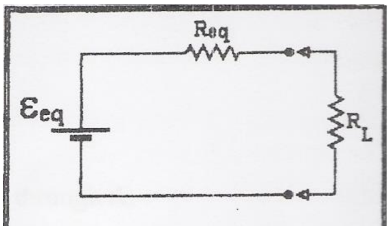
Dealing with fairly complicated networks, requires adequate methods such as the equivalent circuit techniques of Thevenin and Norton.

*Thevenin's theorem states that: "any network of resistors and supplies having two output terminals as in fig.1 can be replaced by a series combination of a voltage source **(ε_{eq})** and a resistor **(R_{eq})**, as in fig.2.*



Fig(1)

*Norton and Thevenin's techniques are especially important in obtaining the current passing through and the voltage across any one resistor **(R_L)** in complicated networks.*



Fig(2)

*As an example if we took the circuit shown in fig.1 we can find the value of the current passing through **(R_L)** using Norton's and Thevenin's techniques and the values that we will have will be equal to those of Kirchoff:*

<u>Thevenin's:</u>

1. *Remove **R_L**, kill both sources as in fig.4, and you will get:*

   $$R_{eq} = R_1 \parallel R_2 = \frac{R_1 R_2}{R_1 + R_2}$$

2. *Remove **R_L**, return both sources back to the circuit as in fig.6 and calculate **ε_{eq}** as follows: Using Kirchoff's loop theorem we get:*

   $$\varepsilon_1 - \varepsilon_2 = I(R_1 + R_2),$$

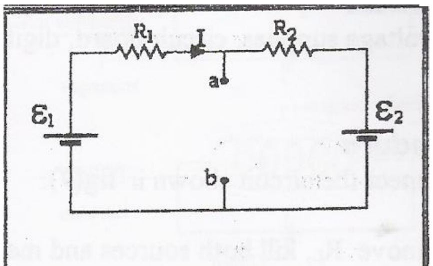
   $$\varepsilon_{eq} = \varepsilon_1 - IR,$$

   *eliminating **I** between the two equations, yields:*

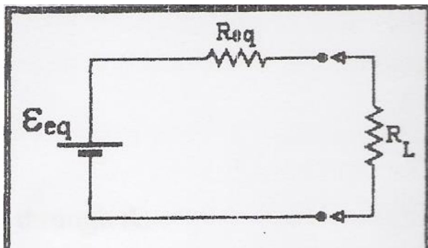
   $$\varepsilon_{eq} = \varepsilon_1 - \frac{(\varepsilon_1 - \varepsilon_2)R_1}{R_1 + R_2}$$

3. *Construct Thevenin's equivalent as in fig.2 using the calculated values of **ε_{eq}** and **R_{eq}**. Now, you can find the current passing through **R_L** as follows:*

   $$I_{R_L} = \frac{\varepsilon_{eq}}{R_{eq} + R_L}$$

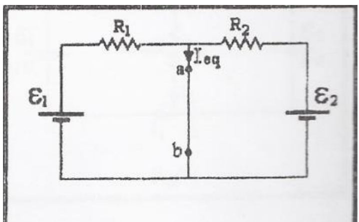


Fig(6)



Fig(2)

<u>Norton's:</u>



Fig(4)

1. *Replace* $\mathbf{R_L}$ *with a short circuit (a wire) as in fig.4, and calculate* $\mathbf{I_{eq}}$ *as follows:*

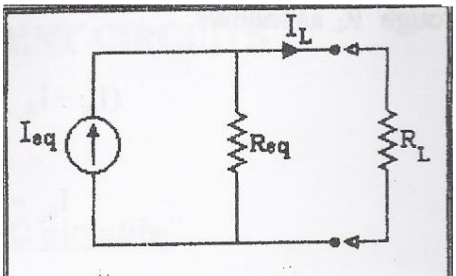
   $$I_{eq} = I_1 + I_2,$$

   $$I_{eq} = \frac{\varepsilon_1}{R_1} + \frac{\varepsilon_2}{R_2}$$

2. *Construct Norton's equivalent circuit, fig.5, and calculate the current passing through* $\mathbf{R_L}$ *as follows:*

   $$(I_{eq} - I_{R_L})R_{eq} = I_{R_L} R_L,$$

   $$I_{R_L} = \frac{I_{eq} R_{eq}}{R_{eq} + R_L}$$



Fig(5)

Conclusion:

After performing the experiment we come to the following conclusions:

- By comparing the values of the electric current obtained from the theoretically by solving the current Thevinin's and Norton's techniques, and the values obtained from the experiment we find that these techniques fit almost perfectly with a slight discrepancy that fall within the experimental error range. Which is not something strange since they are based on the natural laws of electricity.

- Results seem to be very close to the values in experiment #3 (we have used the same circuit). And that shows the application for Thevenin and Norton techniques.

- Thevinin's and Norton's techniques are among the circuit analyzing methods used with complicated circuits, when we have voltage sources connected in parallel, that is to say when Ohm's law is not applicable anymore.

- The difference in the values obtained and the theoretical ones are due to some kind of errors concerning the precision of the used apparatus, and maybe some systematic errors while setting the circuit. However, such errors don't affect our conclusion that our verification of the circuit has worked.