BIRZEIT UNIVERSITY
Physics Department

Physics 112

Experiment No. 4

Network Analysis II
The Thevenin And Norton Techniques

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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:

by applying the equivalent circuit techniques of Thevenin and Norton. It also aims to confirm the accuracy of both techniques by comparing experimental and calculated results.
The main result we obtained was that both techniques proved to be correct methods for solving complicated electric networks

The Main Result :

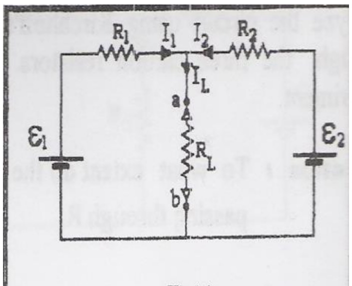
$R_{eq1} = 0.7674$
$\varepsilon_{eq1} = 10.60$
$I_{eq1} = 13.81$

<u>In Norton :</u>
$I_{eq} = 13.81$ mA
$I_{RL} = 1.52$ mA

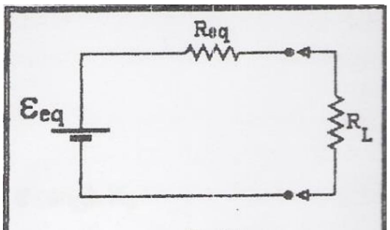
<u>In Thevenin :</u>
$I_{L3} = 1.52$mA

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)

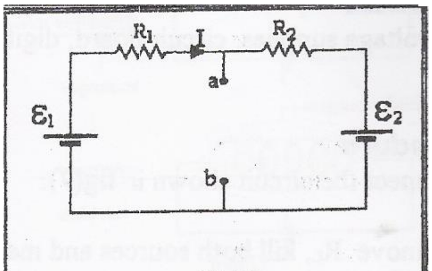


Fig(2)

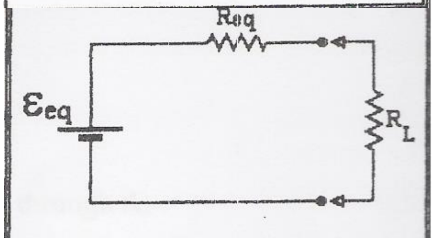
Norton and Thevenin's techniques are especially important in obtaining the current passing through and the voltage across any one resistor (**R_L**) in complicated networks. As an example if we took the circuit shown in fig.1 we can find the value of the current passing through (**R_L**) using Norton's and Thevenin's techniques and the values that we will have will be equal to those of Kirchoff.

Thevenin's:

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



Fig(6)

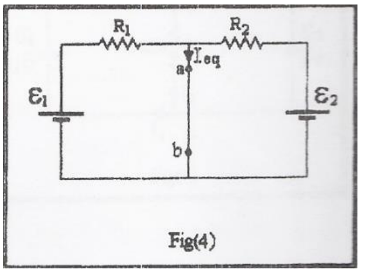


Fig(2)

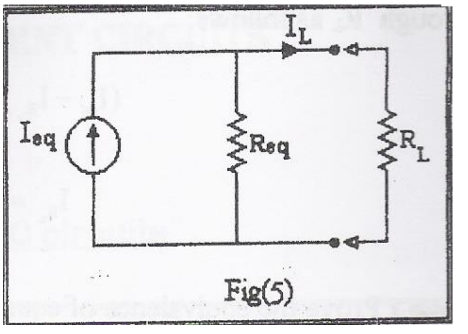
3. Construct Thevenin's equivalent as in fig.2 using the calculated values of **ε_{eq}** and **R_{eq}**. Now, you can find the current passing through **R_L** as follows:
   $$I_{R_L} = \frac{\varepsilon_{eq}}{R_{eq} + R_L}$$

Norton's:

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:*
$(I_{eq} - I_{R_L})R_{eq} = I_{R_L} R_L$,
$$I_{R_L} = \frac{I_{eq} R_{eq}}{R_{eq} + R_L}$$

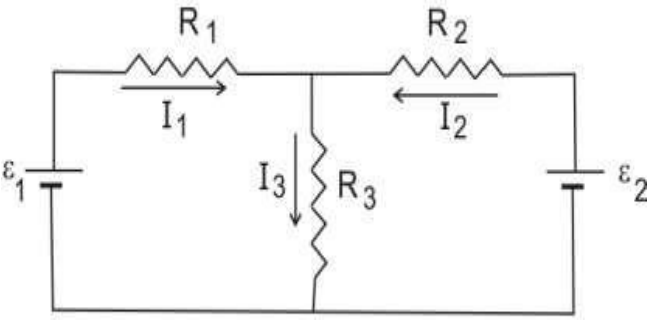


Procedure:

1. I_{eq}, R_{eq}, ε_{eq} are calculated as mentioned above.
2. Thevenin's circuit is connected, and I_3 is measured.
3. Norton's circuit is connected and I_3 is measured.

Data :

R1= 1 kΩ
R2= 3.3 kΩ
R3= 6.2 kΩ
ε1= 12 V
ε2= 6 V



in Northen the I_{L3} = 1.52 , in Thevenin the I_{L3} = 1.54

Measure the currents

	Experiment	Calculation
R_{eq1}	0.769 kΩ	0.7674
ε_{eq1}	10.63	10.60
I_{eq1}	13.60	13.81

Construct **Northen** equivalent circuit

	Experiment	Calculation
I_{L3} (mA)	1.52	1.52

Construct **Thevenin** equivalent circuit

	Experiment	Calculation
I_{L3} (mA)	1.54	1.52

Calculations :

$$R_{eq} = \frac{R_1\ R_2}{R_1 + R_2} = \frac{3.3}{4.3} = 0.7674\ \text{k}\ \Omega$$

$$\boldsymbol{\varepsilon}_{eq} = \boldsymbol{\varepsilon_1} - \frac{(\varepsilon_1 - \varepsilon_2)R_1}{R_1 + R_2} = 12 - \frac{12-6}{1+3.3} = 12 - 1.4 = 10.60\text{V}$$

$$\mathbf{I}_{eq} = \frac{\varepsilon_{eq}}{R_{eq}} = \frac{10.60}{0.7674} = 13.81$$

For Northen :

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

$$= \frac{\varepsilon_1}{R_1} + \frac{\varepsilon_2}{R_2} = \frac{12}{1} + \frac{6}{3.3} = 13.81\ \text{mA}$$

$$I_{RL} = \frac{I_{eq}\, R_{eq}}{(R_{eq} + R_L)} = \frac{13.81 * 0.7674}{(0.7674+6.2)} = 1.52 \text{ mA}$$

For Thevenin :

$$I_{L3} = \frac{\varepsilon_{eq}}{R_{eq}+R_L} = \frac{10.60}{(0.7674+6.2)} = 1.52\text{mA}$$

Conclusion :

We notice that the experimental values are very closed to the theoretical ,beside some values which are exactly the same as the theoretical values . In fact , the values which differ from the theoretical values as a result of many reasons :

1. we ignored the internal resistance of the power sources .
2. when we use the laws we assumed that the resistance of the wires is zero but there is a resistance for the wire even if it is so small.
3. even in the resistors there is some uncertainty that we can find it from the color code on the resistors.

- In this experiment we proof Thevenin's law and Norton's law by getting the values for circuits needed .
- In the two laws that we use here there is some conditions we have to be sure that they are available in the circuit in order to use these laws on it such as the resistors must be linear components that obey ohm’s law.
- The two techniques (Norton and Thevenin) that we used here are biased on the same aim which is that they aim to make all the power sources as one source and all of the resistors in one resistor even if the two methods use a different way.