Physics Department

Physics 112

Experiment #3

NETWORK ANALYSIS I THE SUPERPOSITION PRINCIPLE AND KIRCHHOTFS LAWS

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Date:14/3/2017

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1. abstract:

A.The aim of the experiment: *is to prove experimentally the superposition principle (SPP) and Kirchoff's laws (loop theorem and junction theorem).*

B.The method used: *is by directly measuring the currents and the voltage differences through the carbon resistors using digital multi-meter*

c. The main results:

Kirchoff's Results:

$I_1 = 2.09$ mA

$I_2 = 0.82$ mA

$I_3 = 1.27$ mA

SPP's Results:

$I_1 = 2.1$ mA

$I_2 = 0.81$ mA

$I_3 = 1.28$ mA

Theoretically: $I_1 = 2.13$ mA $I_2 = 0.84$ mA

$I_3 = 1.29$ mA $I_{13} = 1.1$ mA

$I_{23} = 0.17$ mA

$I_3 = I_{13} + I_{23}$

$I_3 = 1.27$ mA

$I_3 = I_{31} + I_{32}$

$I_3 = 1.88$ mA

Theory:

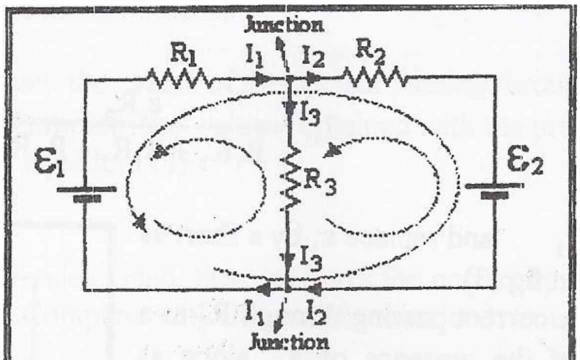
Applying Ohm's law and the simple parallel and series connection rules on electric networks is of no particular help, because electric networks consists of many circuit components connected in a complicated way.

Some of the laws that we can use in such cases are; Kirchoff's law and the superposition principle.

Kirchoff's law:

1. ***Loop theorem:*** *it stats that:* ***"The algebraic sum of the voltage drops and electromotive forces (emf's) in a closed electric circuit is always zero."*** *And that means that the power generated by voltage sources is totally consumed through the closed circuit.*
   $\sum_i V_i = 0$,
   or $\sum_k \varepsilon_k = \sum_j I_j R_j$,
   where we have accounted for the opposite signs of voltage drops and emf's.
2. ***Junction theorem:*** *it stats that:* ***"The algebraic sum of currents passing through any circuit junction is always zero."*** *Symbolically,*
   $\sum_j I_j = 0$
   where the currents entering a junction have opposite signs to those leaving it.
3.

If we took the circuit shown in fig.1 as an example, we will find that applying the previous laws on it gives the following:



Fig(1)

1. *There is two junctions in the circuit and applying the junction theorem both will*

give us the same equation:

$I_1 + I_2 - I_3 = 0$

2. Three circuit loops exist, but only two independent equations could be formed:

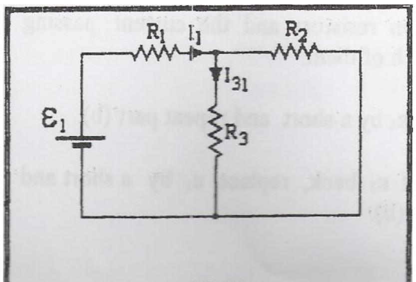
$\varepsilon_1 = I_1 R_1 + I_3 R_3$

$\varepsilon_2 = I_2 R_2 + I_3 R_3$

the third equation which is from the large loop is the sum of the previous two equations. Solving these three linear equations with three unknowns is straight forward and gives the values of the currents passing through the three resistors.

The Superposition Principle (SPP):

If circuit equations are linear, then the mathematical superposition principle is applicable. And it stats that: **"The response (a desired current or voltage) at any point in a linear circuit having more than one source can be obtained as the sum of the responses caused by each of the independent sources acting alone."**



Fig(2)

For example if we want to find the current passing through the third resistor we can follow the following steps:

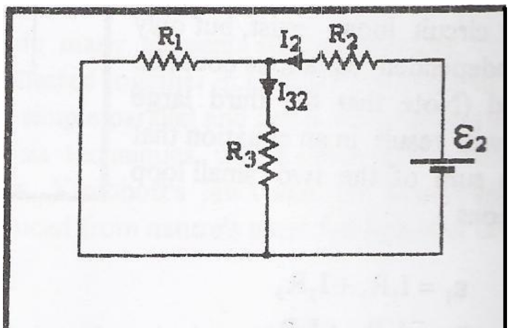
1. Keep **ε₁** and replace **ε₂** with a short circuit as in fig.2.
2. Find the current passing through **R₃** as a result of the presence of **ε₁** alone, as follows:

$$I_1 = \frac{\varepsilon_1}{R_1 + (R_2 \parallel R_3)},$$

and $I_{31} R_3 = (I_1 - I_{31}) R_2$.

Thus, $I_{31} = \dfrac{\varepsilon_1 R_2}{R_1 R_2 + R_1 R_3 + R_2 R_3}$

3. Keep **ε₂** and replace **ε₁** by a short as shown in fig.3 .
4. Find the current passing through **R₃** as a result of the presence of **ε₂** alone as follows:



Fig(3)

$$I_2 = \frac{\varepsilon_2}{R_2 + (R_1 \parallel R_3)},$$

and $I_{32}R_3 = (I_2 - I_{32})R_1$.

Those give: $I_{32} = \dfrac{\varepsilon_2 R_1}{R_1R_2 + R_2R_3 + R_1R_3}$

5. *Add both currents to find the total current passing through* ***R_3.***

$I_3 = I_{31} + I_{32}$

Analysis of results:

As we saw previously, using SPP we found that the sum of the current passing through R_3 when each source is acting alone equals the value of the current that passes through R_3 when the two sources act together. And the experimental values are around the theoretical ones.

And also as we found using Kirchoff's laws, the values that we've got theoretically are around the experimental values.

The two methods which we used to get I_3 , have given us the same values for it.

And finally there were some errors, which were occurred because we ignored the resistance of the equipments (the wires and the multi-meter), and this affect our result.