

**Faculty of Science**

**Physics Department**

**General Physics Lab 2 (PHYS112)**

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**{Report\_3 --> Experiment\_3}**

**<Network Analysis: The Superposition Principle, Kirchhoff’s Law>**

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# **Abstract**

1. **The aim of this experiment:** is to verify the Superposition Principle, Kirchhoff’s laws . And to find the current passing through a resistance, or the voltage between its terminals.
2. **The method used**:

* For Superposition Principle & Kirchhoff’s laws is by directly measuring the currents and the voltage differences through the carbon resistors using digital multi-meter.

1. **The main result:**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| I1 | 2.5 mA | I2 | 1.1 mA | I3 | 1.44 mA |
| VR1 | 2.5 V | **VR2** | 2.3 V | **VR3** | 7.3 V |

* Kirchhoff’s Results:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| I11 | 3.93 mA | I21 | 2.76 mA | I31 | 1.18 mA |
| I12 | 1.36 mA | **I22** | 1.61 mA | **I32** | 0.26mA |
| I1 | 2.57mA | **I**2 | 1.15mA | **I**3 | 1.44mA |

* SPP’s Results:

# **Theory**

Applying Ohm’s law and the simple parallel and series connection rules on electric networks is of no particular help, because electric networks consist of many circuit components connected in a complicated way. Some of the laws that we can use in such cases are; Kirchhoff’s law and the Superposition principle (SPP).

## **Kirchhoff’s law:**

1. Loop theorem: its 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.



Or



where we have accounted for the opposite signs of voltage drops and emf’s.

1. Junction theorem: its stats that: “The algebraic sum of currents passing through any circuit junction is always zero”. Symbolically,



where the currents entering a junction have opposite signs to

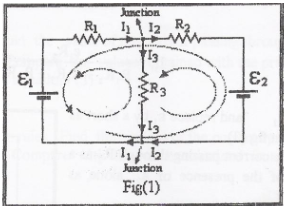
those leaving it.

Figure 1:Kirchhoff’s circuit

* If we took the circuit shown in

fig.1 as an example, we will find that

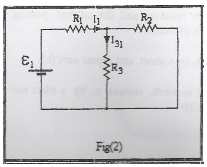
applying the previous laws on it gives the

following:

* There are two junctions in the circuit and applying the junction theorem both will give us the same equation: I1 +I2 – I3 = 0
* Three circuit loops exist, but only two independent equations could be formed:

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 its 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.”

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

Figure 2: SPP circuit

1. Keep ε 1 and replace ε 2 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:



And

Thus,

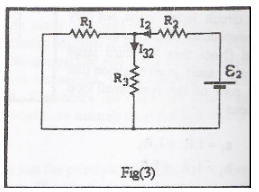
1. Keep ε 2 and replace ε 1 by a short as shown in fig.3.
2. Find the current passing through R 3 as a result of the presence of ε2 alone as follows:

Figure 3: SPP circuit



 And

 Those give

1. Add both currents to find the total current passing through R3

I3 = I31 + I32

# **Procedure & Data Discussion**

R 1 = 1kΩ, R 2 = 2.2 kΩ, R 3 =5.1 kΩ

The measurements which we took from the multi-meter (ε 1 =10 v, ε 2 =5 v): After performing the experiment, the following data were obtained:

Kirchhoff Rules

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| I1 | 2.5 mA | I2 | 1.1 mA | I3 | 1.44 mA |
| VR1 | 2.5 V | **VR2** | 2.3 V | **VR3** | 7.3 V |

Superposition Principle

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| I11 | 3.93 mA | I21 | 2.76 mA | I31 | 1.18 mA |
| I12 | 1.36 mA | **I22** | 1.61 mA | **I32** | 0.26mA |
| I1 | 2.57mA | **I**2 | 1.15mA | **I**3 | 1.44mA |

## Calculations:

And now, let’s apply these laws to our experiment; by setting up a circuit like the one shown in (figure 1) and applying the junction theorem to the circuit we get:

I1 -I2- I3 = 0

I1 = I2 + I3

By applying the loop theorem to the right closed part of the circuit we get:



and by applying the same theorem to the left part we get:



and by solving equations we find out that:

I1 = **2.5 mA** V1 = 2.5 Volt

I2 = **1.1 mA** V2 = 2.3 Volt

I3 = **1.44 mA** V3 = 7.3 Volt

Now if we look at the circuit shown in fig.2, we will find that it is a simple circuit on which we can use ohm’s law. (as shown in the theory (Superposition Principle)).

* **R 1** = 1kΩ, **R 2**= 2.2 kΩ, **R 3** =5.1 kΩ
* **ε 1** =10 v, **ε 2** =5 v



we get the following values: = 1.2 mA



= 0.29 mA

The values for I 31, I 32 (Theoretically):

I 31 = 1.2 mA

I 32 = 0.29 mA

Theoretically: I3 = I 31+I 32 = 1.49 mA

|  |  |  |
| --- | --- | --- |
|  | *Experimentally* | *Theoretically* |
| I31 | 1.18 mA | 1.19 mA |
| I32 | 0.26 mA | 0.29 mA |
| I3 | 1.44 mA | 1.49 mA |

# **Results and Conclusions**

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 Kirchhoff’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.

Finally, 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.