**A green tree on a black background

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BIRZEIT UNIVERSITY

Physics Department

## Physics 112

**Experiment No. 3**

**NETWORK ANALYSIS 1 : THE**

**SUPERPOSITION PRINCIPLE AND**

**KIRCHHO’FS LAWS**

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* Abstract :

1. **The aim of the experiment** :

is to prove experimentally the superposition principle (SPP) and Kirchoff’s laws (loop theorem and junction theorem).

1. **The method used :**

is by directly measuring the currents and the voltage differences through the carbon resistors using digital multi-meter.

* 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 thepower generated by voltage sources is totally consumed through the closed circuit.

∑ Vi = 0

Or ∑ k = ∑ Ij Rj .

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,

∑ Ij = 0

where the currents entering a junction have opposite signs to those leaving it.

3.If we took the circuit shown , we will find that applying the previous laws on it gives the following:

1. There is two junctions in the circuit and applying the junction theorem both will give us the same equation:

I1 + I2 – I3=0

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

ε1 = I1 R1 + I3 R3

ε2 = I2 R2 + I3 R3

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.**”For example if we want to find thecurrent passing through the third resistor we can follow the followingsteps:

1. Keep ε1 and replace ε2 with a short circuit .

2. Find the current passing through R3 as a result of the presence of **ε1** alone, as follows:

I1 =

And I31R3 = (I1 – I31)R2

Thus I31 =

3. Keep ε2 and replace ε1 by a short.

4. Find the current passing through R3 as a result of the presence of ε2 alone as follows:

I2 =

And I32R3 = (I2 – I32)R1

Thus I31 =

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

I3 = I31 I32 .

* Data :

1. Kirchoff’s Results :

Connect the circuit shown

A diagram of a circuit

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A number of numbers and symbols

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|  |  |  |
| --- | --- | --- |
|  |  |  |
|  | 2.55 | 2.56 |
|  | 1.03 | 1.04 |
|  | 1.52 | 1.52 |

1. Superposition Principle :
2. A diagram of a circuit

   Description automatically generatedConnect the circuit shown



|  |  |  |
| --- | --- | --- |
|  |  |  |
| I11 | 3.78 | 3.8 |
| I21(mA) | 2.47 | 2.47 |
| I31 | 1.32 | 1.31 |

1. Connect the circuit shown

A diagram of a circuit

Description automatically generated



|  |  |  |
| --- | --- | --- |
|  |  |  |
| I12 | 1.23 | 1.24 |
| I22 (mA) | 1.43 | 1.44 |
| I32 | 0.19 | 0.2 |

1. Find the current :

|  |  |  |
| --- | --- | --- |
|  | Kirchoff’s | Superposition |
|  | 2.56 | 2.56 |
|  | 1.04 | 1.03 |
|  | 1.52 | 1.51 |

* Calculations :

For kirchoff’s :

1. ε1 – I 1R1 -I3R3 = 0 3) 12 = I1 + 6.2 (I1 +I2)

12 – I1 – 6.2 I3  = 0 12 = I1 + 6.2 I1 + 6.2 I2

12 = I1 + 6.2 I3 ….1 12 = 7.2 I1 + 6.2 I2 ……1

-6 = - I1 + 3.3 I2 …….2

1. ε2 – I2R2 – I3R3  = 0 = => I2 =

6 – 3.3 I2 – 6.2 I3 = 0 12 = 7.2 I1 + 6.2 ( )

6 = 3.3 I2 + 6.2 I3 12 = 7.2 I1  + 1.878 I1 - 11.272

6 = 3.3 I2 + 12 – I1 9.078 I1 = 23.272 => I1=2.56

-6 = 3.3 I2 - I1 …..2 I2 = => I2 = - 1.04

I3 = -1.04 + 2.56 => I3 = 1.52

For Superposition :

1. R23 =

Itotal  = = 2) R13 =

Itotal = I11 = I1(23) = 3.8 Itotal  = =

V23 = I23 R 23  Itotal = I22 = I2(13) = 1.44 mA

V23 = 3.8 \* 2.15 = 8.17 V V13 = I2(13)  R(13)

V 23 = V31 = V21 V13 = 1.4 \* 0.86 = 1.24 Volt

8.17 = I­31 \* 6.2 = I21 \* 3.3 V13 = V12 = V32

I31 = 1.31 | I21 = 2.47 1.24 = I12 \*R = I32 \* R3

1.24 = I12 = 6.2 I32

I12  = 1.24mA | I32 = 0.2mA

I1  = 2.56

I2  = I21  - I22 = 2.47 – 1.44 = 1.03

I3  = I31 + I32 = 1.31 + 0.2 = 1.51

* Analysis of results:

As we saw previously, using SPP we found that the sum of the current passing through R3 when each source is acting alone equals the value of the current that passes through R3 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 I3 , 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.