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كلية التكنولوجيا
Faculty of Technology
قسم الهندسة الكهربائية و قسم الإلكترونيك
Department of Electrical Engineering and Department of Electronics
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University year: 2024/2025 — السنة الجامعية: 2024 /2025
2nd year Electrical Engineering and Electronics — السنة الثانية هندسة كهربائية و إلكترونيك
Applied Work in Fundamentals of Electronics 1 — أعمال تطبيقية في الالكرونيك الأساسية 1
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PW n°02: Superposition Theorem

Duration: 1^{h}30.

Date of the experiment: ………. /……../………….. .

Report prepared by:

Last Name	**First Name**	**Group**	**S/Group**	**Final Note**
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Instructions :

- **Internal laboratory regulations must be observed.**
- **You must wear a lab coat.**
- **Attendance is compulsory and will be monitored. Any unjustified absence or failure to hand in a report will result in a mark of 0/20.**
- **Have your assemblies checked before connecting the voltage source.**
- **It is strictly forbidden to move equipment from one station to another. In the event of a breakdown or faulty equipment, contact the teacher.**
- **The report must be written by a maximum of four students.**
- **The report must be handed in at the beginning of the next session.**
- **The report must include the following sections:**
  - **TP cover page.**
  - **The date of the practical session.**
  - **Last Name and first name of the main writer.**
  - **Last Names and first names of the WP participants.**
  - **Preparation and work in manuscript.**

Person in charge of practical work: Dr ROUABHI.R

***PW n°02:* Phases Superposition Theorem**

1. **Objective of the Experiment**

This experiment aims to analyze circuits containing multiple voltage or current sources by isolating the effect of each source individually. This method simplifies the problem-solving process, providing a clear understanding of how each source influences the overall circuit behavior.

2. **Theoretical Background**

2.1. **Superposition Theorem**

The superposition theorem provides a systematic way to analyze complex circuits by considering one energy source at a time while deactivating the others. The results from each individual source are then combined to determine the overall voltage or current.

-**Statement 1**: The total voltage between two points in a circuit with multiple sources equals the algebraic sum of the individual voltages produced by each source acting alone.

- **Statement 2**: The total current in a branch with multiple energy sources equals the algebraic sum of the individual currents generated by each source acting independently.

2.1.1. Principle of Superposition

According to the principle of superposition, the total current (I) in a branch or voltage (U) across two points is the algebraic sum of the contributions from each source, assuming that only one source is active at a time. To implement this theorem:

1. Deactivate all sources except one, replacing voltage sources with short circuits and current sources with open circuits.

2. Calculate the resulting current or voltage for the active source.

3. Repeat this process for each source, then sum the individual contributions to obtain the total current or voltage.

For a circuit with (N) generators:

- **State 1**: All sources are deactivated except generator 1 → Compute (I_1).
- **State 2:** All sources are deactivated except generator 2 → Compute (I_2).
- **State N**: All sources are deactivated except generator (N) → Compute (I_N).

The overall **voltage** between two points is:

$$U=U_1+U_2+\cdots+U_N$$

Similarly, the total **current** in a branch is:

$$I=I_1+I_2+\cdots+I_N$$

This method ensures accurate analysis by accounting for the effect of each source individually, making it particularly effective for circuits with complex configurations.

Remark:

<u>***PW n°02:* Phases Superposition Theorem**</u>

Deactivating a generator refers to the process of treating it as non-operational:

- For a voltage source: This involves setting the voltage across its terminals to zero, which effectively means replacing the ideal voltage source with a short circuit.

- For a current source: This entails considering the output current to be zero, accomplished by replacing the current source with an open circuit.

These procedures are essential for accurately applying the superposition theorem, enabling a detailed analysis of each generator's contribution to the overall behavior of the circuit.

Example: Consider the circuit illustrated below:

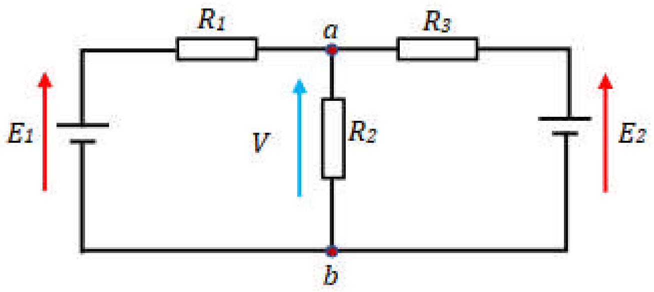

Figure.1

In this example, we will apply the superposition theorem to analyze the contributions of each generator independently.

According to the superposition theorem, the voltage V between points a and b is: $\mathbf{V=V_1+V_2}$

Where:

- V1 is the voltage between points a and b when E1 acts alone (with E2 neutralized).
- V2 is the voltage between points a and b when E2 acts alone (with E1 neutralized).

a. Calculate V1

By neutralizing E2, the circuit in Figure 1 will appear as follows:

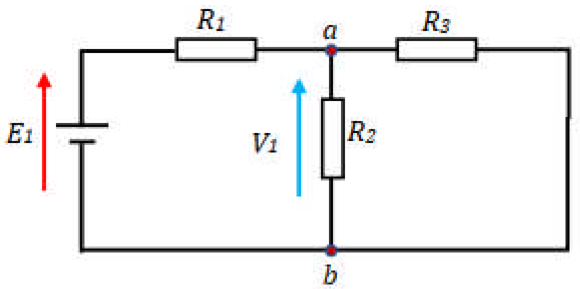

Figure.2

In this configuration, you can now calculate the voltage **V1** across points points a and b based on the remaining components in the circuit.

To calculate the voltage **V1**, we must first determine the equivalent resistance between the two points a and b (the equivalent resistance of the two resistors R2 and R3 which are in parallel):

$$\frac{1}{Req1} = \frac{1}{R2} + \frac{1}{R3}$$

Once $Req1$ is calculated, you can proceed to determine V1using the appropriate voltage division or Ohm's Law techniques.

Thus, the circuit can be simplified to the following:

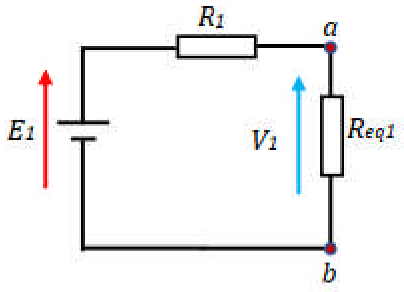

Figure.3

By using the concept of a voltage divider, we find that:

$$V1 = E1\frac{Req1}{Req1 + R1}$$

b. Calculate V2

By neutralizing E1, the circuit in Figure 1 will appear as follows:

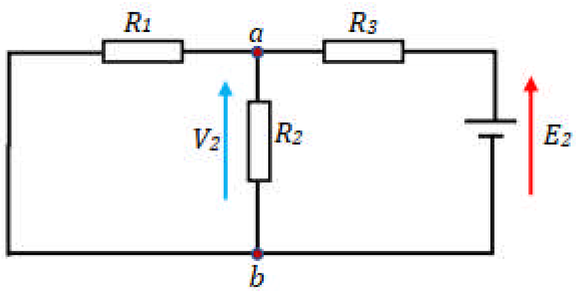

Figure.4

To calculate the voltage **V2**, we must first determine the equivalent resistance between the two points a and b (the equivalent resistance of the two resistors R1 and R2 which are in parallel):

$$\frac{1}{Req2} = \frac{1}{R1} + \frac{1}{R2}$$

Once $Req2$ is calculated, you can proceed to determine V2using the appropriate voltage division or Ohm's Law techniques.

Thus, the circuit can be simplified to the following:

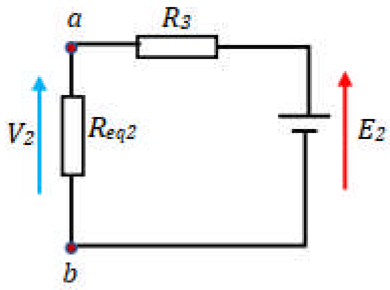

Figure.5

By using the concept of a voltage divider, we find that:

$$V2 = E2\frac{Req2}{Req2 + R3}$$

Finally, the voltage **V** between the two points a and b is equal to the algebraic sum of the two voltages **V1** and **V2:**

$$V = V1 + V2 = E1\frac{Req1}{Req1 + R1} + E2\frac{Req2}{Req2 + R3}$$

3. Experiment Procedure

3.1. Individual Work

a. Using Proteus (see Appendix E), construct the circuit shown below:

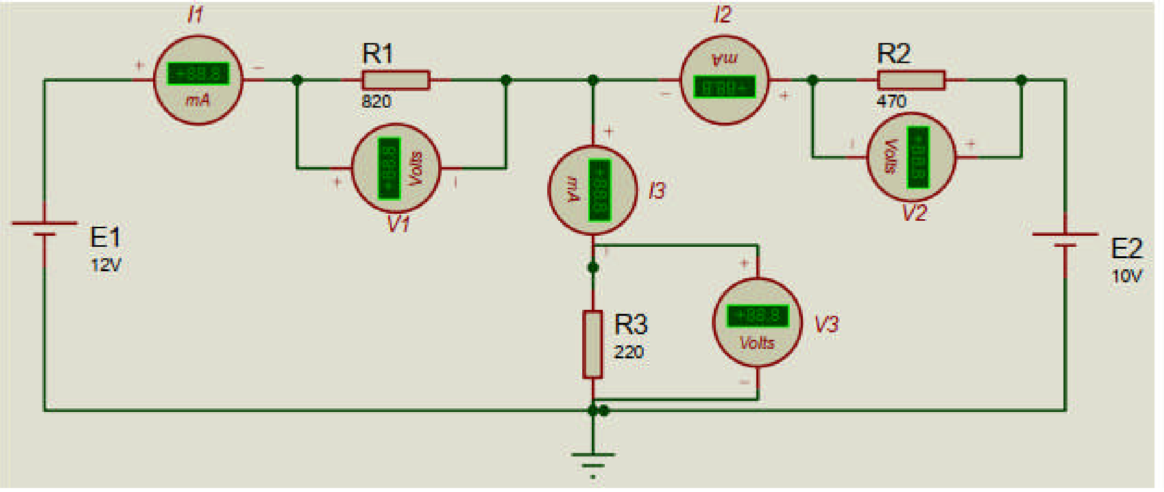

Figure.6

b. Conduct the circuit simulation and complete the table below:

V1 (V)	V2 (V)	V3 (V)	I1(mA)	I2 (mA)	I3 (mA)

c. Short-circuit the voltage source E2 to obtain the following circuit:

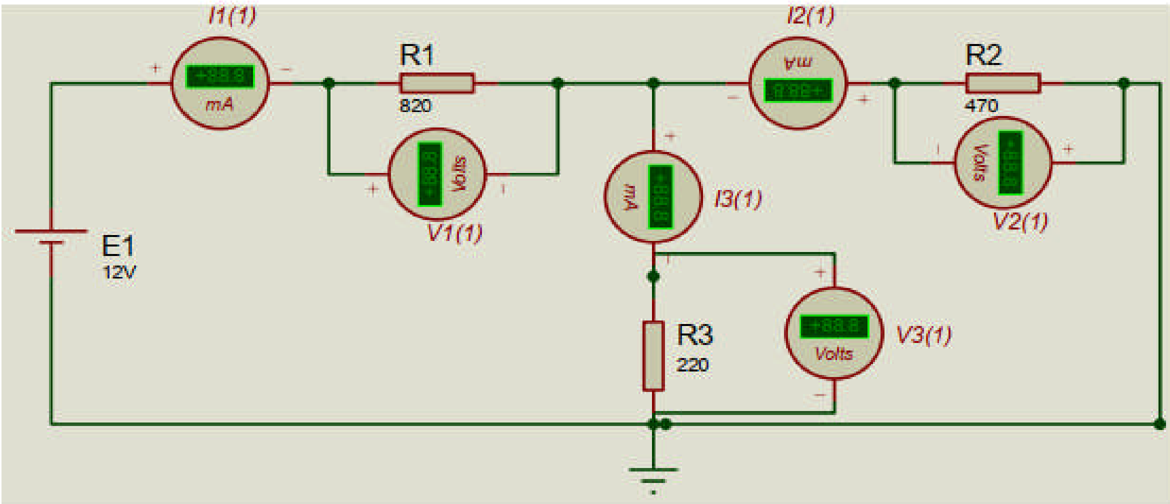

Figure.7

d. Simulate this circuit and complete the table below:

***V1(1)* (V)**	***V2* (1) (V)**	***V3* (1) (V)**	***I1* (1)(mA)**	***I2* (1) (mA)**	***I3*(1) (mA)**

e. Short-circuit the voltage source E1 to obtain the circuit shown below:

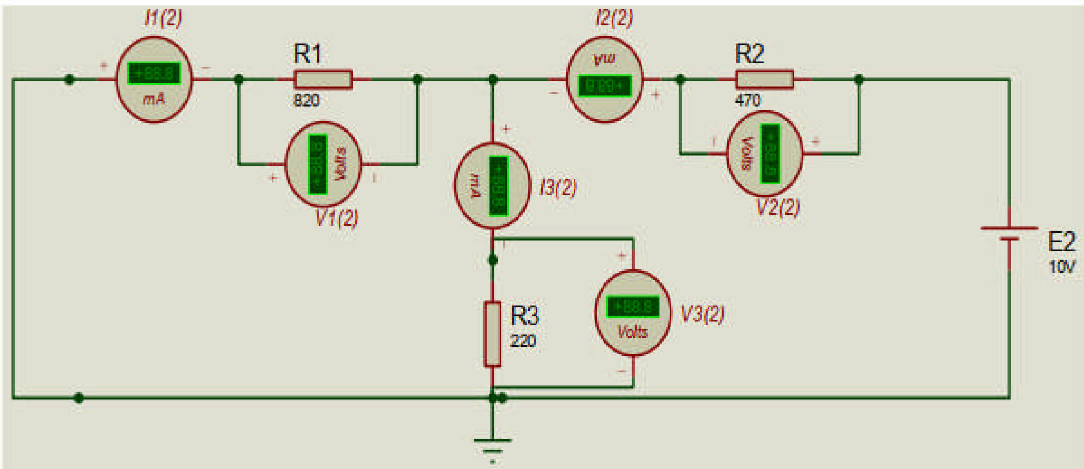

Figure.8

f. Simulate this circuit and complete the table below:

V1(2) (V)	V2 (2) (V)	V3 (2) (V)	I1 (2)(mA)	I2 (2) (mA)	I3(2) (mA)

g. Verify that:

$$Vn = Vn(1) + Vn(2) \qquad 1 \leq n \leq 3$$

And

$$In = In(1) + In(2) \qquad 1 \leq n \leq 3$$

3.2. In-Person Activity

3.2.1. Circuit Construction

a. Construct the circuit illustrated below:

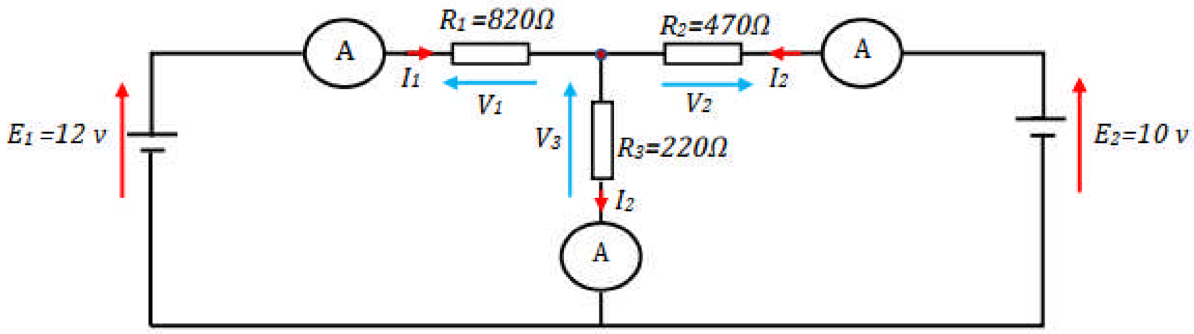

Figure.9

b. Record the various current and voltage measurements in the table below:

V1	V2	V3	I1	I2

c. We will now attempt to measure the currents and voltages in the previous circuit using the superposition theorem.

1.**Step 1**: E1 Alone, E2 Deactivated:

- Draw and assemble the circuit.
- Record the various current and voltage measurements in the table below:

V'1	V'2	V'3	I'1	I'2	I'3

2. Step 2: E2 Alone, E1 Deactivated:

- Draw and assemble the circuit.
- Record the various current and voltage measurements in the table below:

V''1	V''2	V''3	I''1	I''2	I''3

3.2.2. Tasks to Complete

a. What equipment is required to set up these circuits?

b. Theoretically calculate the voltages across the resistors R1, R2, and R3 using the superposition theorem.

c. Theoretically calculate the current intensities in all branches using the superposition theorem.

d. Based on the voltage values obtained earlier (both measured practically and calculated theoretically), can we confirm that the superposition theorem holds for these voltages? Why or why not?

e. Based on the current values obtained earlier (both measured practically and calculated theoretically), can we confirm that the superposition theorem holds for these currents? Why or why not?

f. The power dissipated in a resistor is given by the relationship:

$P = I^2 * R = I * V$, Verify whether the superposition theorem is applicable for calculating the power dissipated by a resistor (R1, R2, and R3). In other words, does the relationship P = P' + P'' hold true?