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2 YL Physics (S3), 2024-2025

PW N° 4 : Superposition theorem

1. The purpose of the manipulation

The goal of this lab is to study circuits with several generators (voltage or current) by considering the influence of each generator independently of the others, which will greatly simplify most of the problems.

2. Theoretical background 2.1. Superposition theorem

a. Statement 1: The voltage between two points in an electrical circuit containing several energy sources (generator) is equal to the algebraic sum of the voltages between these two points when each energy source acts alone.

b. Statement 2: The current intensity in a branch in an electrical circuit contains several currents (generator) is equal to the algebraic sum of the currents in that branch when each energy source acts alone.

2.1.1. Principle of superposition

The current I in a complete circuit branch (or the voltage U) is equal to the algebraic sum of the currents (or voltages) that would be imposed by each of the generators, the others being passivated (or neutralized). So to apply the superposition theorem, it is enough to successively short-circuit each generator.

So in a circuit of N generators:

➢State 1: all generators are passivated except for No. 1→ calculation of I_1.

➢State 2: all generators are passivated except for No. 2 → calculation of I_2.

➢State N: all generators are passivated except for No. N → calculation of I_N.

➢Current calculation I: $I = \sum I_n$

Same principle with tensions: $U = \sum U_n$

Remark:

To passivate a generator is to consider that it is inoperative:

- ✓ For a voltage generator, it means considering that the voltage across its terminals is zero, i.e. replacing the ideal voltage generator with a short circuit.

✓ For a current generator, it is considered that the current flowed is zero.

Example:

Let us consider the circuit below:

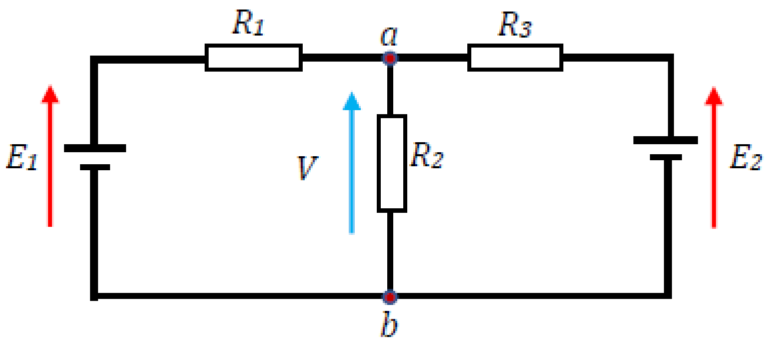


Figure. 1

According to the superposition theorem, the voltage V between the two points a and b is:

$$V=V_1+V_2 \tag{1}$$

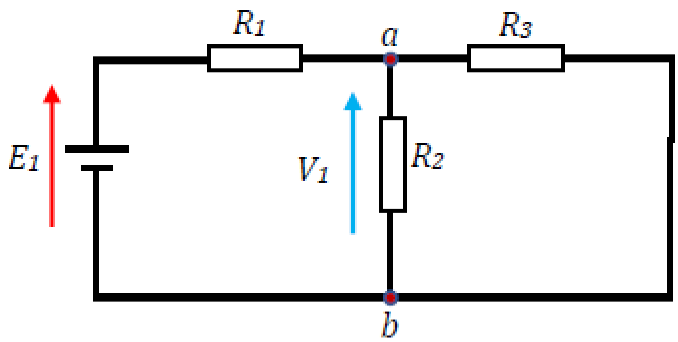
With:

• V_1 is the voltage between the two points a and b when E_1 acts alone (when E_2 is neutralized).

• V_2 is the voltage between the two points a and b when E_2 acts alone (when E_1 is neutralized).

a. Calculate V_1

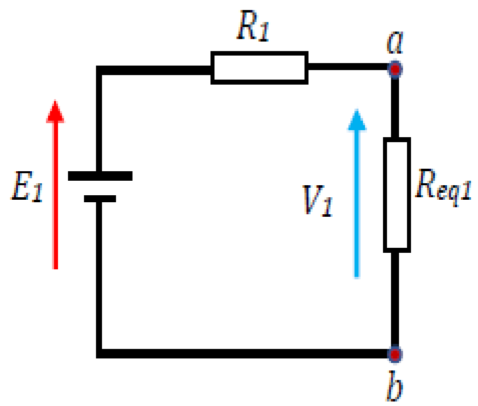
By neutralizing E_2 the circuit of the figure. 1 will be as follows:



To calculate the voltage V_1 we must first calculate the equivalent resistance between the two points a and b (the equivalent resistance of the two resistors R_2 and R_3 which are in parallel):

$$\frac{1}{R_{eq1}} = \frac{1}{R_2} + \frac{1}{R_3} \tag{2}$$

So the circuit is reduced to the following:

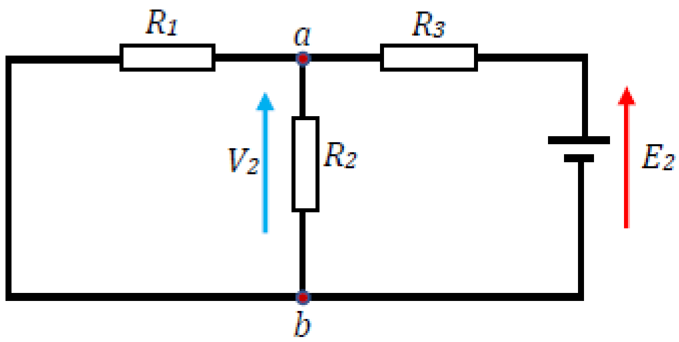


Using the notion of voltage divider, we find that:

$$V_1 = \frac{R_{eq1}}{R_{eq1}+R_1} E_1 \tag{3}$$

b. Calculate V_2

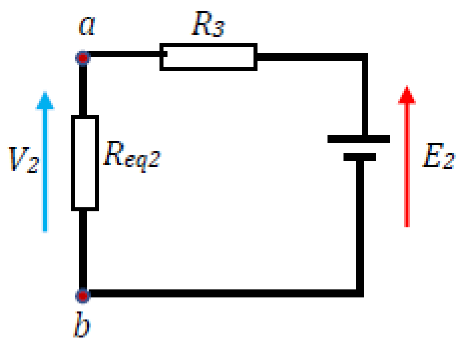
By neutralizing E1 the circuit of the figure. 1 will be as follows:



To calculate the voltage V_2, we must first calculate the equivalent resistance between the two points a and b (the equivalent resistance of the two resistors R_1 and R_3 which are in parallel):

$$\frac{1}{R_{eq2}} = \frac{1}{R_1} + \frac{1}{R_2} \tag{4}$$

So the circuit is reduced to the following:



Using the notion of voltage divider, we find that:

$$V_2 = \frac{R_{eq2}}{R_{eq2}+R_2} E_2 \tag{5}$$

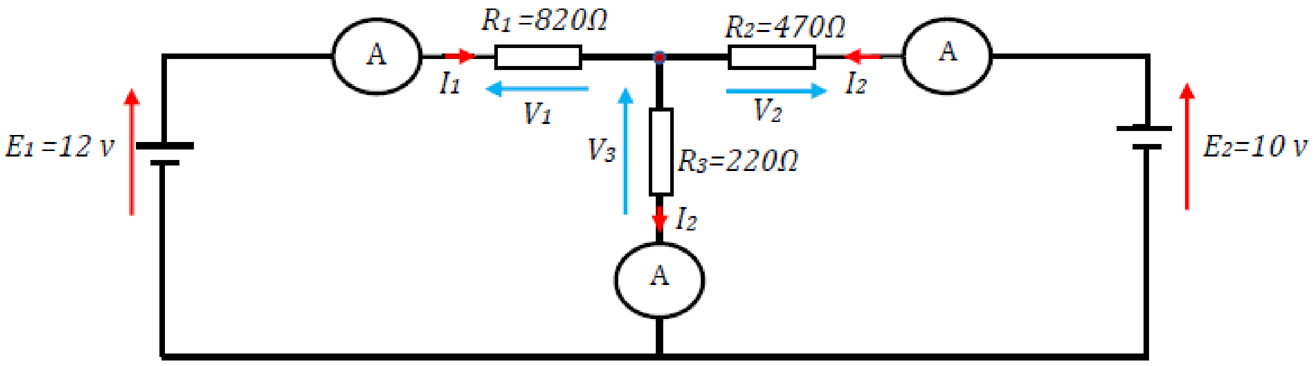
Finally, the voltage V between the two points a and b is equal to the algebraic sum of the two voltages V_1 and V_2:

$$V = V_1 + V_2 = \frac{R_{eq1}}{R_{eq1}+R_1} E_1 + \frac{R_{eq2}}{R_{eq2}+R_2} E_2 \tag{6}$$

3. Handling

3.1. Implementation

a. Make the following circuit:



b. Note the different measurements of currents and voltages on the following table:

Tableau. 1

V_1	V_2	V_3	I_1	I_2	I_3

c. Nous allons essayer maintenant de mesurer les courants et les tensions du circuit précédent en utilisant le théorème de superposition.

1. Step 1: E_1 alone, E_2 neutralized:

- Draw and do the Editing?
- Take note of the different measurements of currents and voltages on the following table

Tableau. 2

V'_1	V'_2	V'_3	I'_1	I'_2	I'_3

2. Step 2: E_2 alone, E1 neutralized:
Draw and Edit?

Note the different measurements of currents and voltages on the following table

Tableau. 3

V''_1	V''_2	V''_3	I''_1	I''_2	I''_3

3.2. Work to be done

a. What is the equipment used to make these montages?

b. Theoretically calculate the terminal voltages of the resistors R_1, R_2 and R_3 using the superposition theorem.

c. Theoretically calculate the currents in all branches using the superposition theorem.

d. From the values of the voltages found previously (practically measuring and calculating theoretically), can we say that the superposition theorem is verified in the case of these voltages? What for?

e. From the currents found previously (practically measuring and calculating theoretically), can we say that the superposition theorem is verified in the case of currents? What for?

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

$P = I_2 * R = VI$. Verified whether or not the superposition theorem can be used to calculate the power dissipated by a resistor (R_1, R_2 and R_3) (i.e.: is $P = P' + P''$ or not).