Ministry of Higher Education and Scientific Research

Tikrit University

Engineering Collage –Al shirqat

FUNDAMENTALS OF ELECTRICAL ENGINEERING

LECTURE 6

SUPERPOSITION THEOREM

PREPARED BY
TEACHING ASSISTANT

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General Objectives:

- Enabling engineers and students to analyze complex electrical circuits that contain multiple sources of current or voltage.
- Helping students learn how to isolate and analyze the effect of each source in a circuit independently.
- Enhancing understanding of Kirchhoff's current (KCL) and voltage (KVL) laws by using them as a basis for circuit analysis.
- Enabling students to appreciate and understand the behavior of an electrical system under the influence of multiple sources.

Specific objectives:

- Teaching students how to deactivate other sources (voltage becomes an open circuit and current becomes a short circuit) and analyze the effect of one source at a time.
- Developing the ability to combine the effects of different sources to obtain the complete solution of the circuit.
- Enabling students to apply the superposition theorem in the design and analysis of power, communication, and control systems.
- Improving accuracy and reducing errors when solving complex electrical circuits.
- Equipping students with the necessary skills to analyze power systems and electronic circuits in practical life.

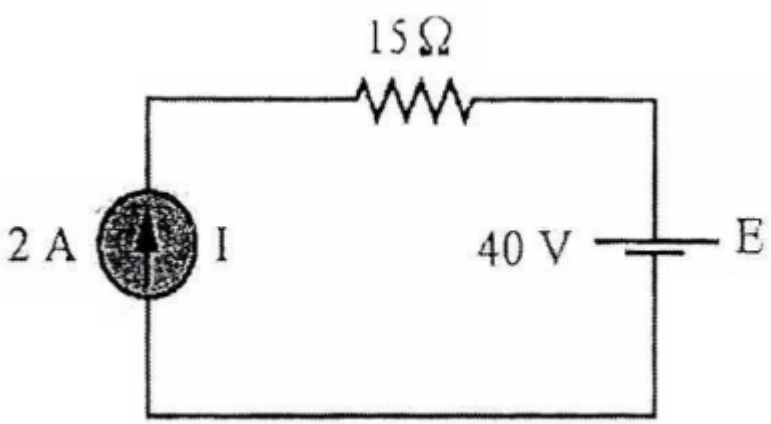
Introduction:

The **Superposition Theorem** is one of the fundamental theorems in electrical circuit analysis. It is used to understand the effect of each electrical source (current or voltage) independently of the other sources. The theorem is based on the principle of separating effects, where all other sources are deactivated when analyzing the effect of a single source. Ultimately, all the individual effects are summed to obtain the final result of the circuit. This theorem is highly useful in simplifying and analyzing complex multi-source circuits.

Superposition Theorem

Example1: Using the superposition theorem to find the voltage across the resistance in the following circuit

Solution:

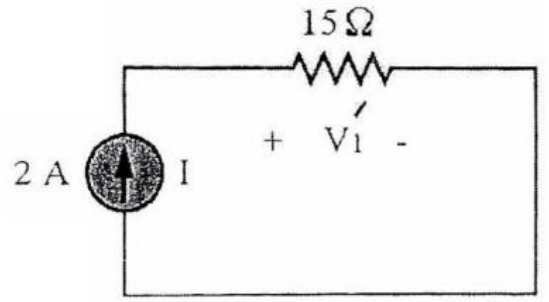


- The current source only (I):

$V'_1 = I \times R$

$V'_1 = 2 \times 15 = 30\ V$

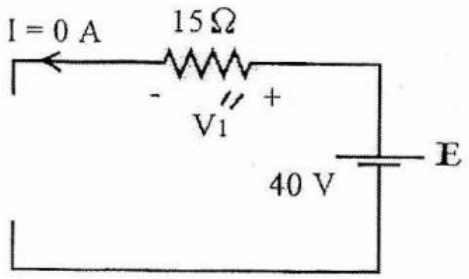
- The voltage source only (E):



$V''_1 = I \times R$

$V''_1 = 0 \times 15$

$V''_1 = 0\ V$



$\therefore V_1 = V'_1 - V''_1$

$V_1 = 30 - 0 = 30$ V (in the direction of V'_1)

Superposition Theorem

Example 2: Use the superposition theorem to find v in the circuit of Fig. 4.1.

Solution: Since there are two sources, let

$v = v_1 + v_2$

Applying KVL to the loop in Fig. 4.1(a) gives:

$-6+i_1(8+4) = 0 \quad \rightarrow \; 12i_1 = 6 \; \rightarrow \; i_1 = \frac{6}{12} = 0.5Amp.$

$v_1 = 4i_1 = 4 \times 0.5 = 2v$

We may also use voltage division to get by writing:

$$v_1 = v \times \frac{R_x}{R_T}$$

$$v_1 = 6 \times \frac{4}{4+8} = \frac{24}{12} = 2v$$

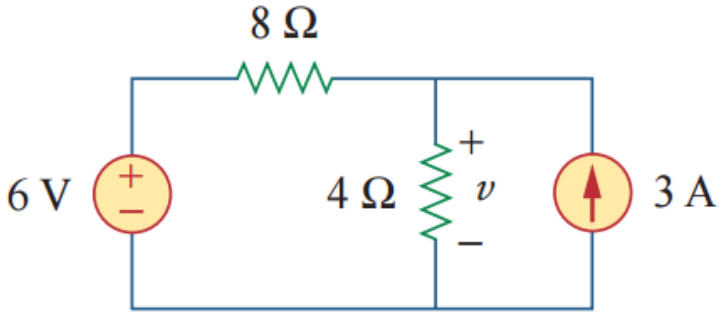
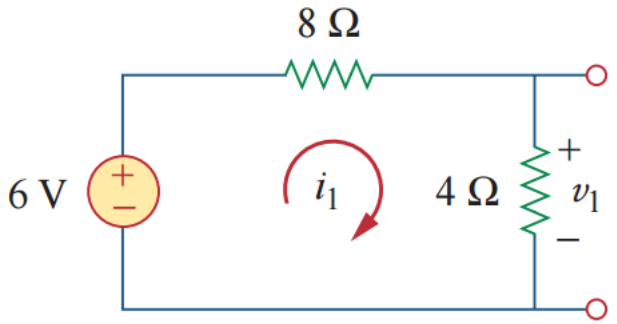


Figure 4-1 Equivalent circuit for Example 1



(a) calculating v_1

Superposition Theorem

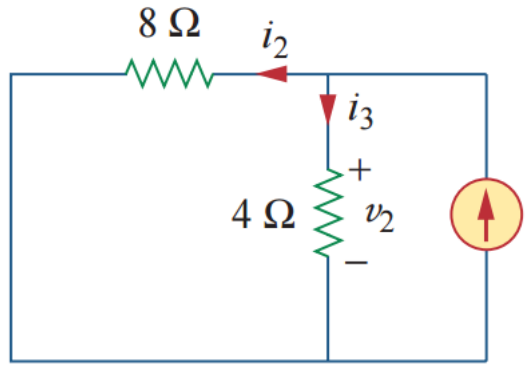
To get we set the voltage source to zero, as in Fig. 4.7(b). Using current division,

$$i_3 = i \times \frac{R_8}{R_8 + R_4}$$

$$i_3 = (3) \times \frac{8}{8+4} = 2\ Amp.$$

$$v_2 = 4i_3 = 4 \times 2 = 8\ \text{V}$$

$$v = v_1 + v_2 = 2 + 8 = 10\ \text{V}$$

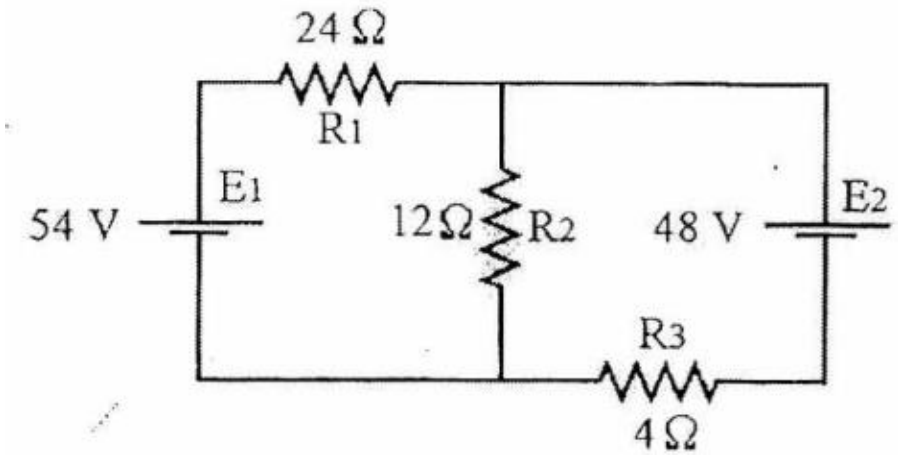


(b)

(b) calculating v_2

Superposition Theorem

Example 3: Using the superposition theorem, determine the current through the (4Ω) resistor in the following circuit



Solution:

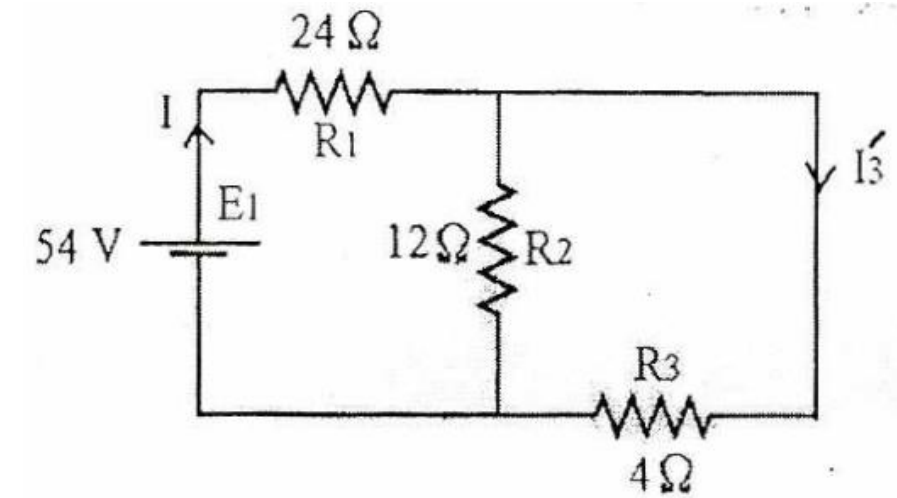
The voltage source only (E_1):

$$I = \frac{E_1}{R_T}$$

$$R_T = R_1 + (R_2 || R_3)$$

$$R_T = 24 + \frac{12 * 4}{12 + 4} = 27\Omega$$

$$\therefore I = \frac{54}{27} = 2\ A$$



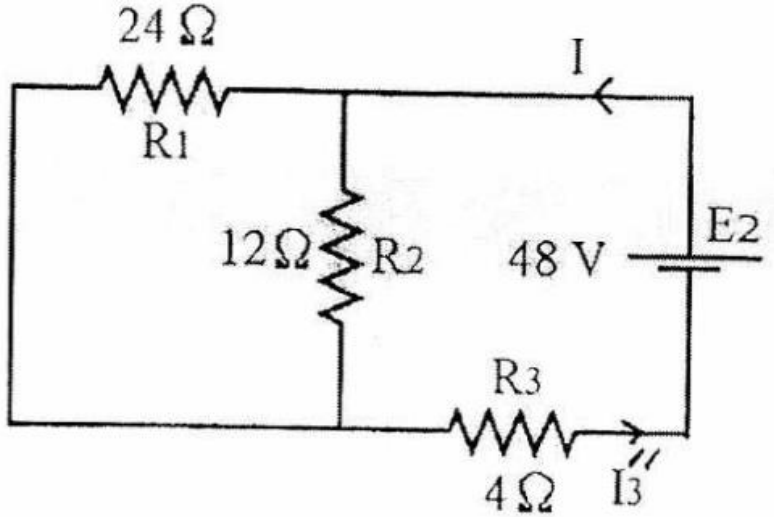
Using current divider rule :

$$I_3' = I \frac{R_2}{R_2 + R_3}$$

$$I_3' = 2 * \frac{12}{12 + 4} = 1.5\ A$$

Superposition Theorem

The voltage source only (E_2):



$$I_3'' = I = \frac{E_2}{R_T}$$

$$R_T = R_3 + (R_1 || R_2)$$

$$R_T = 4 + \frac{24 * 12}{24 + 12} = 12\ \Omega$$

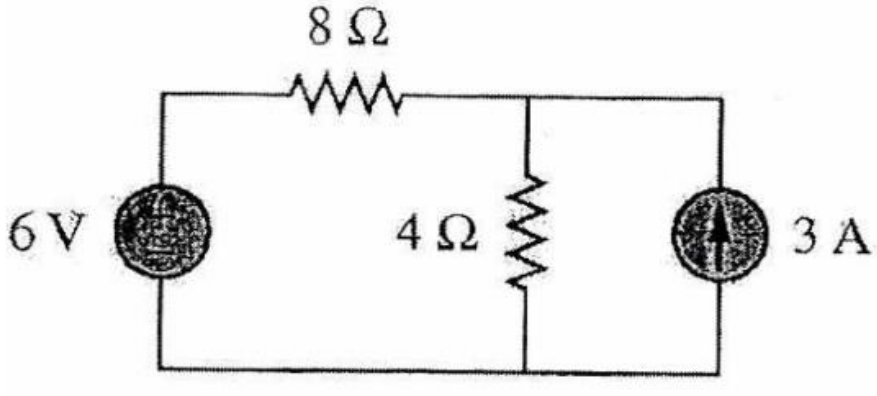
$$\therefore I_3'' = \frac{48}{12} = 4\ A$$

$$\therefore I_3 = I_3'' - I_3'$$

$$I_3 = 4 - 1.5 = 2.5\ A \text{ (in the direction of } I_3'')$$

Superposition Theorem

Example 4: Using the superposition theorem to find the current through the (4Ω) resistor for the circuit below

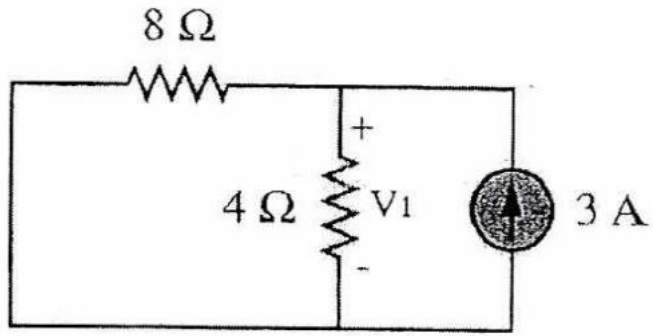


Solution: The current source only (*I*):

Using current divider rule :

$$I_{(4\Omega)} = 3 * \frac{8}{8+4} = 2\ A$$

$$\therefore V_1 = 2 * 4 = 8\ V$$



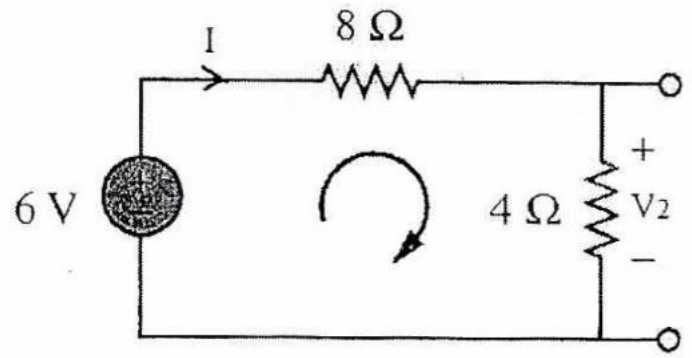
The voltage source only :

By KVL:

$$6 - 8I - 4I = 0$$

$$\Rightarrow I = 0.5\ A$$

$$\therefore V_2 = 0.5 * 4 = 2\ V$$



$$\therefore V_{(4\Omega)} = V_1 + V_2 = 8 + 2 = 10\ V$$

فيديو توضيحي لنظرية Superposition theorem

Thank you for listening