اسس كهرباء

قسم هندسة تقنيات التبريد والتكييف

المرحلة الاولى

المحاضرة الخامسة

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4. Circuit Theorems

3.1 Superposition Theorem

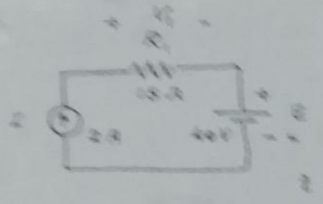
: The theorem states that: "the current through (or the voltage across) an element in a linear bilateral network is equal to the algebraic sum of the currents (or voltages) produced independently by each source."

* To apply this theorem to find the current (or voltage) in a certain part of a network, remove the sources of the network and find the current (or voltage) in the absence of only one source each time. The resultant current (or voltage) will be the algebraic sum of currents (or voltages) due to all sources when acting independently once a time.

* Removing the sources means: SHORT CIRCUITING the voltage source and OPEN CIRCUITING the current source.

Example

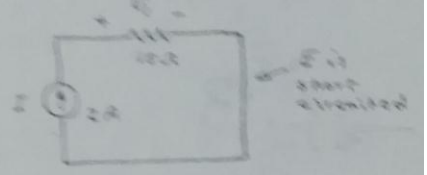
: Using the superposition theorem, determine V_0 for the network shown:



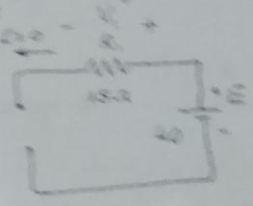
Solution

: * Due to the current source:

$$V_0' = IR_0$$
$$= (2)(8)$$
$$= 30\ V$$



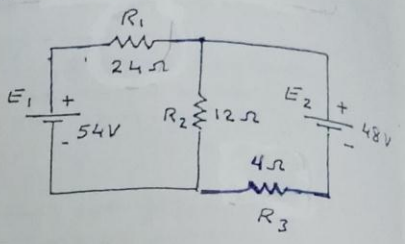
* Due to the voltage source:



$$V_0'' = I_1 R_1$$
$$= (0)(15)$$
$$= 0\ V$$

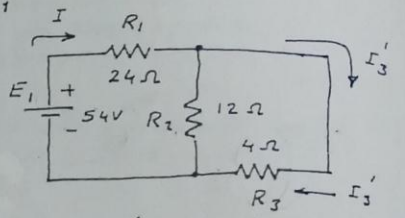
$$\therefore V_0 = V_0' + V_0''$$
$$= 30 + 0 = 30\ V$$

Example: Using the superposition theorem, determine the current through the 4-Ω resistor for the network shown.



Solution: Consider the effect of E_1

$$I = \frac{E_1}{R_T} = \frac{54}{27} = 2\ A$$

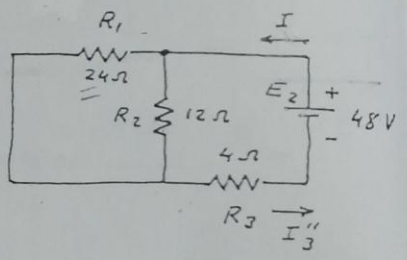


$$R_T = (R_2 // R_3) + R_1$$
$$= (12 // 4) + 24 = 3 + 24$$
$$= 27\ \Omega$$

Using the current division rule ∴

$$\therefore I_3' = I \frac{R_2}{R_2 + R_3}$$
$$= 2 \frac{12}{12 + 4} = \underline{1.5\ A}$$

* Consider the effect of E_2:



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

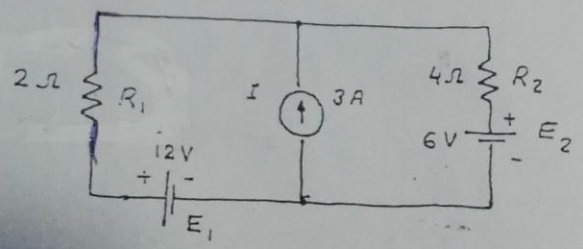
$$R_T = (24 // 12) + 4$$
$$= 8 + 4$$
$$= 12\ \Omega$$

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

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

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

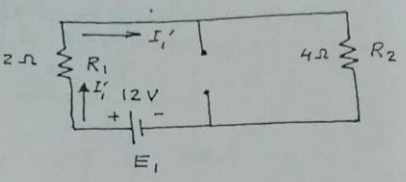
Example: Using the Superposition theorem, find the current through the 2-Ω resistor of the network shown.



Solution :

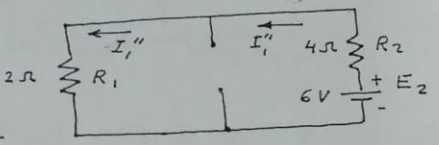
* The effect of E_1

Remove the voltage source E_2 (short circuited) and the current source I (open circuited); the network will be as shown:



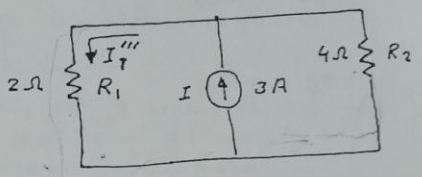
$$\therefore I_1' = \frac{E_1}{R_T} = \frac{12}{2+4}$$
$$= 2A$$

* The effect of E_2 : removing E_1 & I, the network will be as shown:



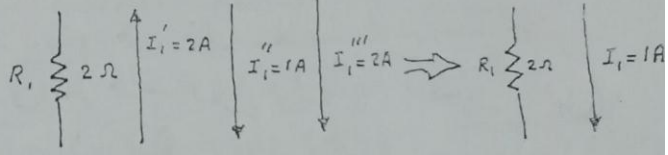
$$\therefore I_1'' = \frac{E_2}{R_T} = \frac{6}{2+4}$$
$$= 1\ A$$

* The effect of I : removing E_1 and E_2, the network will be as shown:



$$\therefore I_1''' = I \frac{R_2}{R_1 + R_2}$$
$$= (3)\frac{4}{4+2}$$
$$= 2\ A$$

$$\therefore I_1 = \underbrace{I_1'' + I_1'''}_{\text{same direction}} - \underbrace{I_1'}_{\text{opposite direction}} \Rightarrow I_1 = 1 + 2 - 1$$
$$= \underline{1\ A}$$



Resulting curr
in R_2