SUPERPOSITION THEOREM

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Superposition Theorem

- It is used to find the solution to networks with two or more sources that are not in series or parallel
- The current through, or 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.
- For a two-source network, if the current produced by one source is in one direction, while that produced by the other is in the opposite direction through the same resistor, the resulting current is the difference of the two and has the direction of the larger
- If the individual currents are in the same direction, the resulting current is the sum of two in the direction of either current

Superposition Theorem

- The total power delivered to a resistive element must be determined using the total current through or the total voltage across the element and cannot be determined by a simple sum of the power levels established by each source

For applying Superposition theorem:-

- Replace all other independent voltage sources with a short circuit (thereby eliminating difference of potential. i.e. V=0, internal impedance of ideal voltage source is ZERO (short circuit)).
- Replace all other independent current sources with an open circuit (thereby eliminating current. i.e. I=0, internal impedance of ideal current source is infinite (open circuit).

Example:- Determine the branches current using Superposition theorem.

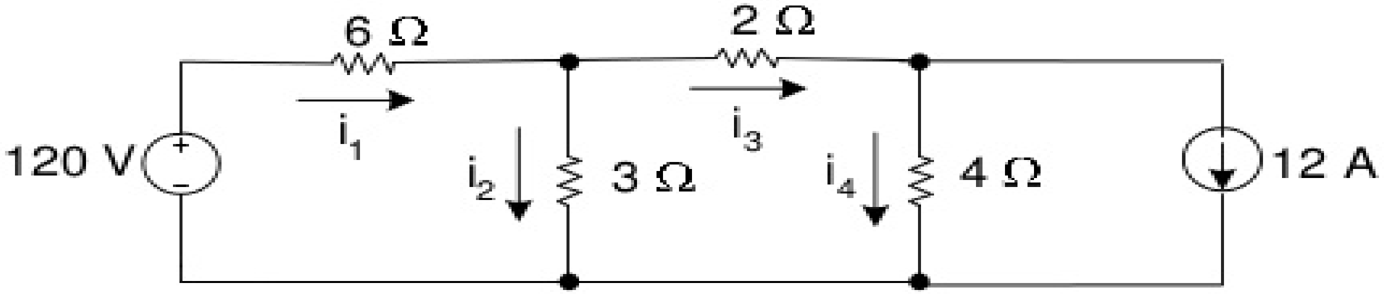


Figure 1

Solution:

- The application of the superposition theorem is shown in Figure 1, where it is used to calculate the branch current. We begin by calculating the branch current caused by the voltage source of 120 V. By substituting the ideal current with open circuit, we deactivate the current source, as shown in Figure 2.

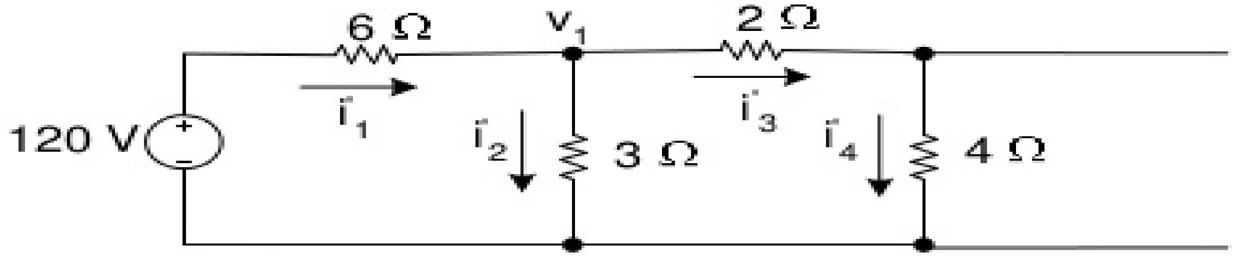


Figure 2

- To calculate the branch current, the node voltage across the 3Ω resistor must be known. Therefore

$$\frac{v_1 - 120}{6} + \frac{v_1}{3} + \frac{v_1}{2+4} = 0$$

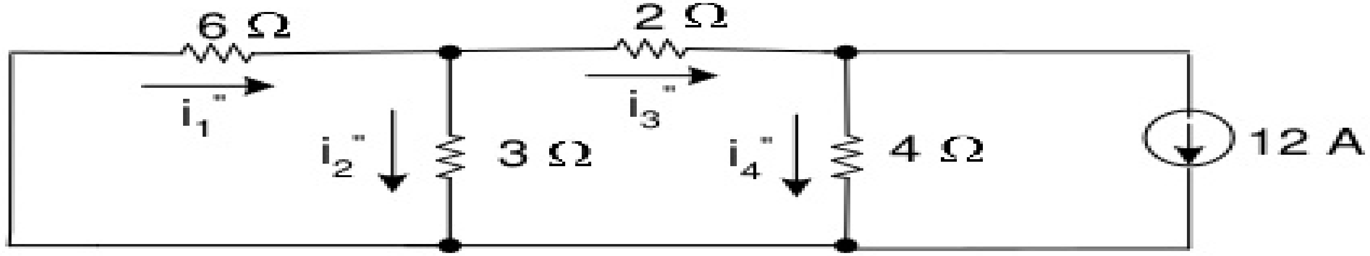
where $v_1 = 30\ \text{V}$

The equations for the current in each branch,

$$i'_1 = \frac{120-30}{6} = 15\ A$$

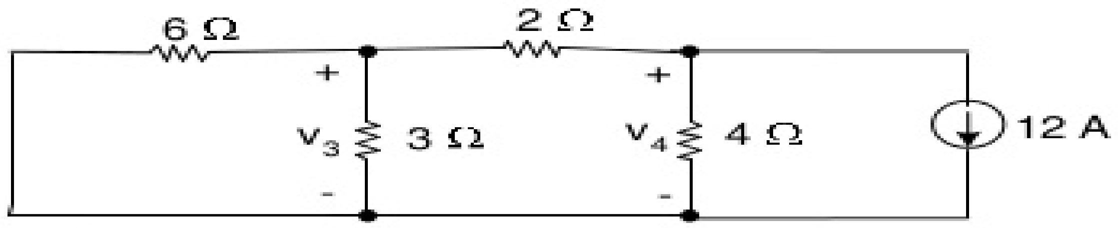
$$i'_2 = \frac{30}{3} = 10\ A$$

$$i'_3 = i'_4 = \frac{30}{6} = 5\ A$$



In order to calculate the current cause by the current source, we deactivate the ideal voltage source with a short circuit, as shown

To determine the branch current, solve the node voltages across the 3Ω dan 4Ω resistors as shown in Figure 4



$$\frac{v_3}{3} + \frac{v_3}{6} + \frac{v_3 - v_4}{2} = 0$$

$$\frac{v_4 - v_3}{2} + \frac{v_4}{4} + 12 = 0$$

The two node voltages are

- By solving these equations, we obtain

$v_3 = -12\ V$

$v_4 = -24\ V$

Now we can find the branches current,

$$i_1'' = \frac{-v_3}{6} = \frac{12}{6} = 2A$$
$$i_2'' = \frac{v_3}{3} = \frac{-12}{3} = -4A$$
$$i_3'' = \frac{v_3 - v_4}{2} = \frac{-12 + 24}{2} = 6A$$
$$i_4'' = \frac{v_4}{4} = \frac{-24}{4} = -6A$$

To find the actual current of the circuit, add the currents due to both the current and voltage source,

$$i_1 = i'_1 + i''_1 = 15 + 2 = 17\,A$$

$$i_2 = i'_2 + i''_2 = 10 - 4 = 6\,A$$

$$i_3 = i'_3 + i''_3 = 5 + 6 = 11\,A$$

$$i_4 = i'_4 + i''_4 = 5 - 6 = -1\,A$$