Al-Mustaqbal University
College Of Engineering Technology
Department Of Cyber Security Techniques Engineering
Class: 1st
Subject: fundamental of electrical engineering
Lecturer: Dr. Rami Qays Malik
1st term – Lecture: 6- Superposition Method

الكلية التقنية الهندسية

قسم هندسة تقنيات الامن السيبراني

Lecture: 6- Superposition Method

Email: rami.qays@uomus.edu.iq

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Introduction:

According to the Superposition Theorem, the response (voltage or current) at any point in a linear electrical network with multiple independent sources can be calculated by calculating the individual contributions of each source while assuming the other sources are "turned off" or replaced by their internal resistances.

The Superposition Theorem allows you to analyze a circuit with multiple voltage or current sources by considering the effect of each source separately while treating the others as inactive.

The Superposition Theorem can significantly simplify the analysis of complex circuits, especially when there are many independent sources

The current through, or voltage across, any element of a network is equal to the algebraic sum of the currents or voltages produced independently by each source.

When removing a voltage source from a network schematic, replace it with a direct connection (short circuit) of zero ohms. Any internal resistance associated with the source must remain in the network.

When removing a current source from a network schematic, replace it by an open circuit of infinite ohms. Any internal resistance associated with the source must remain in the network.

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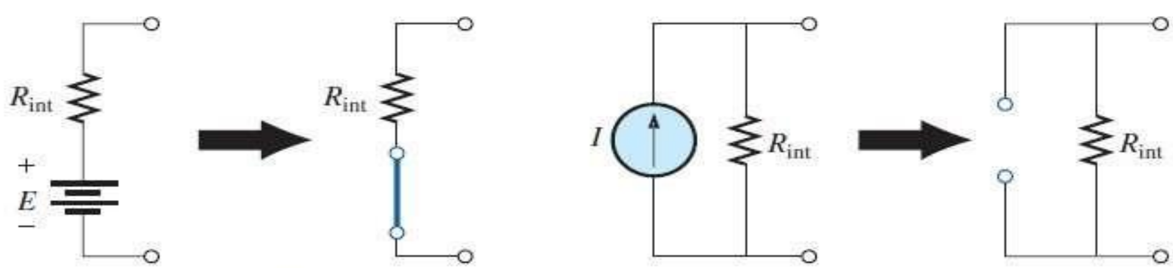
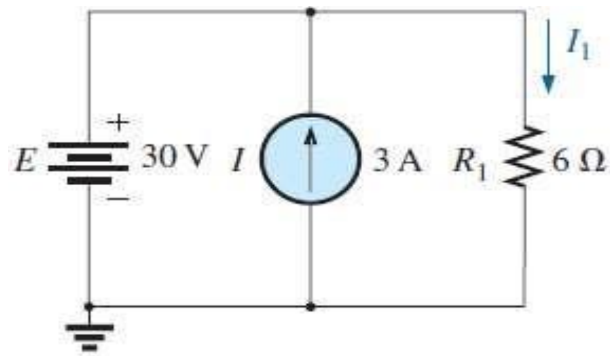
Guidelines While Using the Superposition Theorem

- All the components must be linear with the circuit voltage and current, whenever using the superposition theorem.
- Since power is not a linear quantity, it should not be used with power.
- Ideal voltage source should be removed.
- Ideal current source should be removed so that it can be replaced with an open circuit.
- Real voltage source should be removed , to replace with the internal resistance.
- Consider one source at a time from the various multiple sources.
- Replace all the other (except the selected source) impedances with their internal resistance.
- Calculate the current flowing through the source and the voltage drop across it.
- Repeat the above steps by taking the individual sources one by one.
- Take the algebraic sum once all the current sources and voltage drops have been calculated.

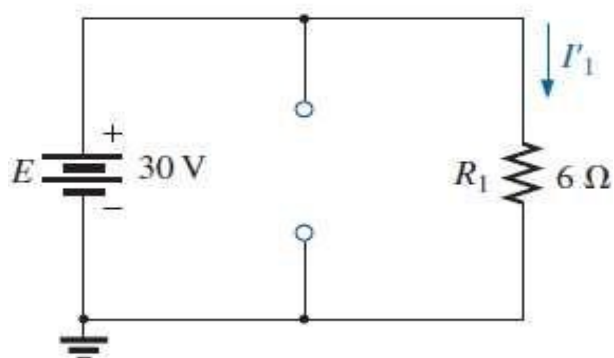


Removing a voltage source and a current source to permit the application of the superposition theorem.

EXAMPLE: 1 Using the superposition theorem, determine current *I1* for the network in Fig.

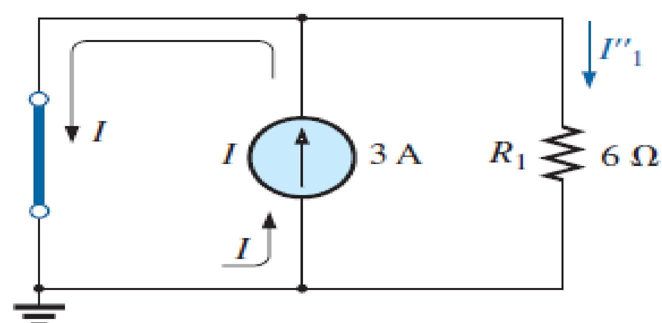


$$I'_1 = \frac{V_1}{R_1} = \frac{E}{R_1} = \frac{30\ \text{V}}{6\ \Omega} = 5\ \text{A}$$



$$I''_1 = \frac{R_{sc}I}{R_{sc} + R_1} = \frac{(0\ \Omega)I}{0\ \Omega + 6\ \Omega} = 0\ \text{A}$$

$$I_1 = I'_1 + I''_1 = 5\ \text{A} + 0\ \text{A} = 5\ \text{A}$$



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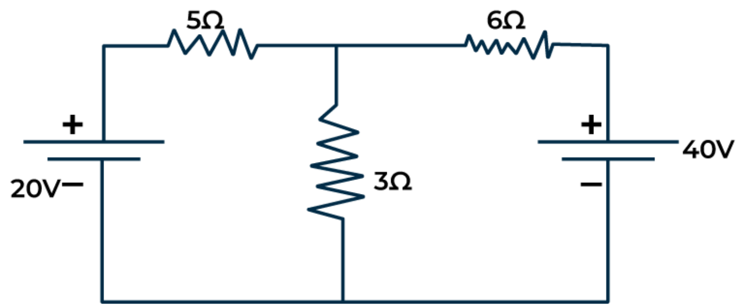
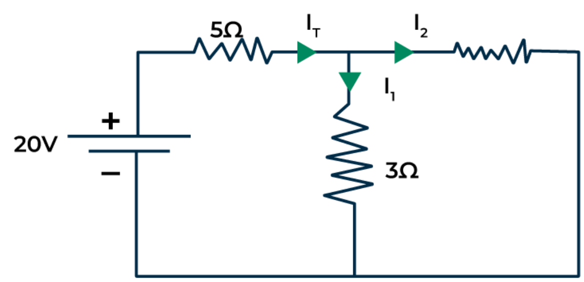
Example : 2. Find the current through 3 Ω resistor using superposition theorem.



- **Step 1: To find I1.**

Consider the 20 V voltage source alone. Short circuit the other voltage source.



To find the current through 3 Ω resistor, it is necessary to determine the total current supplied by the source (I_T).
If we observe the circuit, 3 Ω and 6 Ω resistors are in parallel with each other. This parallel combination is connected in series with a 5 Ω resistor. The equivalent or total resistance is obtained as below,

*⇒RT = 5 + (3*6/9) = 7 Ω*

By applying Ohm's law,

⇒$I_T = V/R_T$ = 20/7 = 2.857 A

Now, the current through 3 Ω resistor is determined by using current division rule. It is given by,

⇒$I_1 = I_T$*(6/6+3) = 2.857*0.667 = 1.904 A

- **Step 2: To find I_2.**

Consider the 40 V voltage source alone. Short circuit the other voltage source.

Now, to find the current through 3 Ω resistor, it is necessary to determine the total current supplied by the source (IT).

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If we observe the circuit, 3 Ω and 5 Ω resistors are in parallel with each other. This parallel combination is connected in series with a 6 Ω resistor. Hence the equivalent or total resistance is obtained as below,

$\Rightarrow R_T = 6 + [(3*5)/(3+5)] = 7.875\ \Omega$

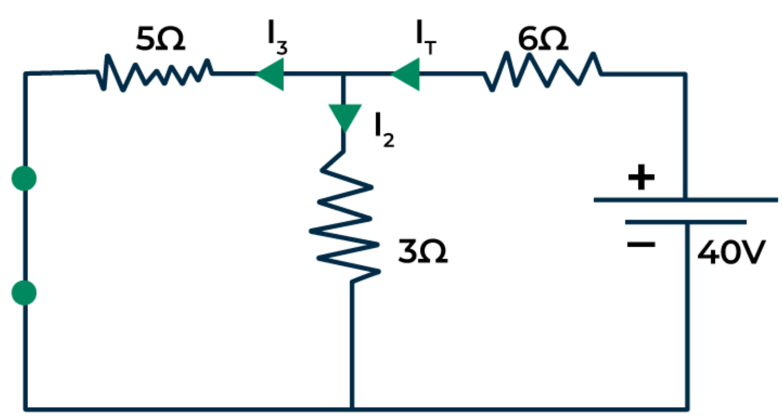
By applying Ohm's law,

$\Rightarrow I_T = V/R_T = 40/7.875 = 5.079\ A$

Now, the current through 3 Ω resistor is determined by using current division rule. It is given by,

$\Rightarrow I_2 = I_T*(5/5+3) = 5.079*0.625 = 3.174\ A$

The below figure shows the resultant circuit, which depicts the currents produced because of two voltage sources 20 V and 40 V acting individually.



By superposition theorem, the total current is determined by adding the individual currents produced by 20 V and 40 V.

Therefore, the current through 3 Ω resistor is :

$I_1 + I_2 = 1.904 + 3.174 = 5.078\ A$

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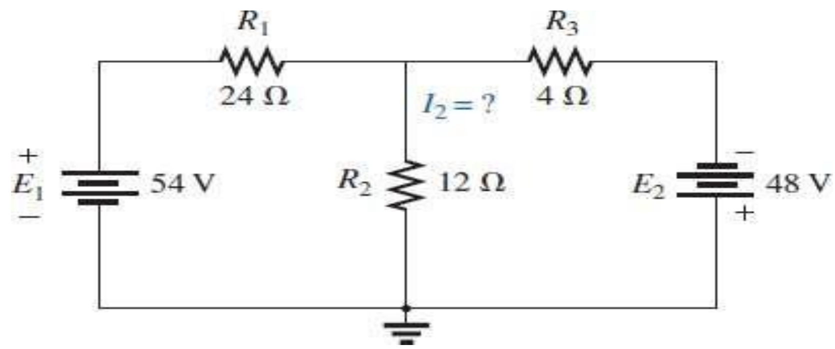
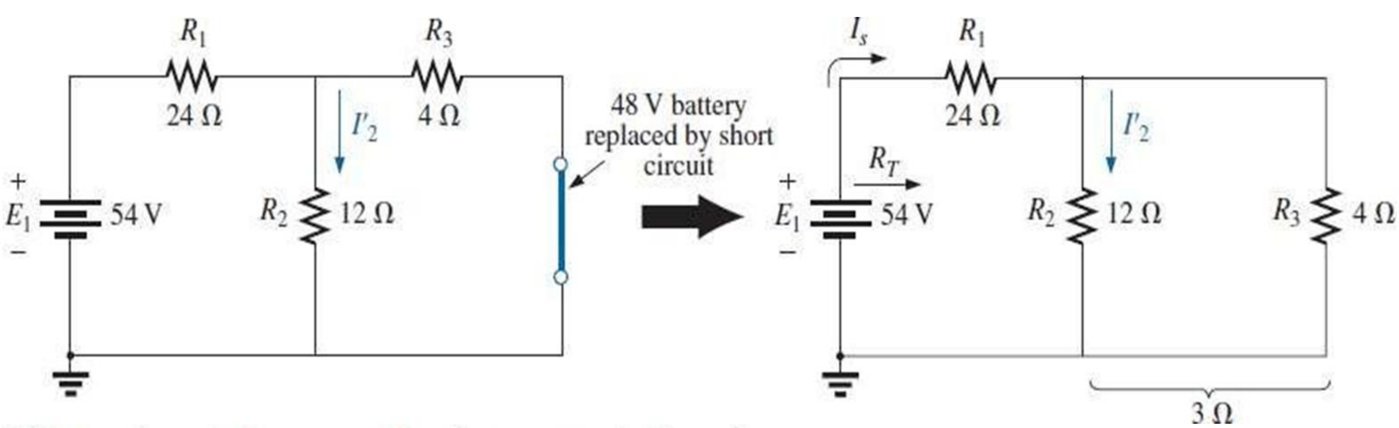
EXAMPLE :3 Using the superposition theorem, determine the current through the 12 Ω resistor in Fig. Note that this is a two-source network





The total resistance seen by the source is therefore

$$R_T = R_1 + R_2 \parallel R_3 = 24\ \Omega + 12\ \Omega \parallel 4\ \Omega = 24\ \Omega + 3\ \Omega = 27\ \Omega$$

and the source current is

$$I_s = \frac{E_1}{R_T} = \frac{54\ \text{V}}{27\ \Omega} = 2\ \text{A}$$

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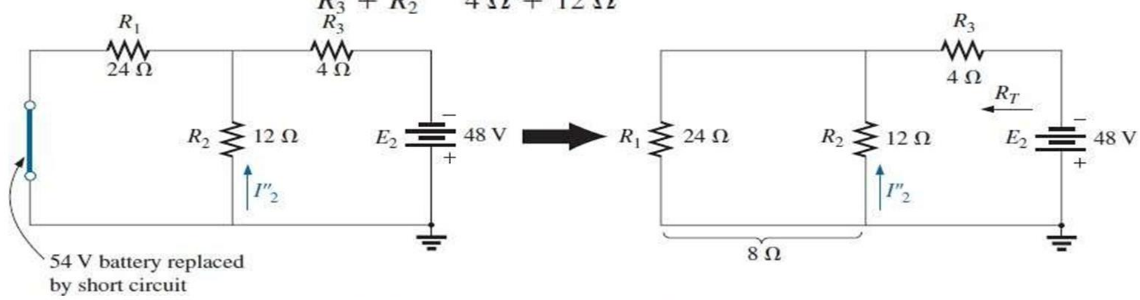
Using the current divider rule results in the contribution to I_2 due to the 54 V source:

$$I'_2 = \frac{R_3 I_s}{R_3 + R_2} = \frac{(4\ \Omega)(2\ \text{A})}{4\ \Omega + 12\ \Omega} = 0.5\ \text{A}$$



Therefore, the total resistance seen by the 48 V source is

$$R_T = R_3 + R_2 \| R_1 = 4\ \Omega + 12\ \Omega \| 24\ \Omega = 4\ \Omega + 8\ \Omega = 12\ \Omega$$

and the source current is

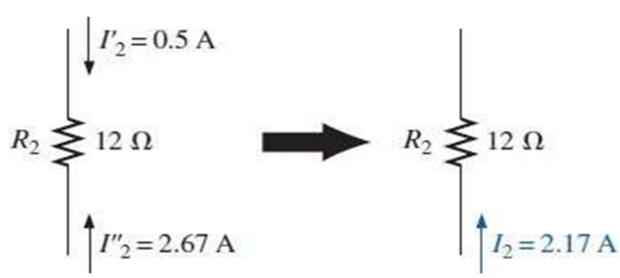
$$I_s = \frac{E_2}{R_T} = \frac{48\ \text{V}}{12\ \Omega} = 4\ \text{A}$$

Applying the current divider rule results in

$$I''_2 = \frac{R_1(I_s)}{R_1 + R_2} = \frac{(24\ \Omega)(4\ \text{A})}{24\ \Omega + 12\ \Omega} = 2.67\ \text{A}$$

It is now important to realize that current *I2 due to each source has a* different direction, as shown in Fig. The net current therefore is the difference of the two and the direction of the larger as follows:

$$I_2 = I''_2 - I'_2 = 2.67\ \text{A} - 0.5\ \text{A} = \mathbf{2.17\ A}$$



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