Lecture (06)

Circuit Theorems (1)

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Agenda

- Linearity Property
- Super position
- Source transformation

Linearity Property

- Linearity is the property of an element describing a linear relationship between cause and effect.
- The homogeneity property requires that if the input (also called the *excitation*) is multiplied by a constant, then the output (also called the *response*) is multiplied by the same constant

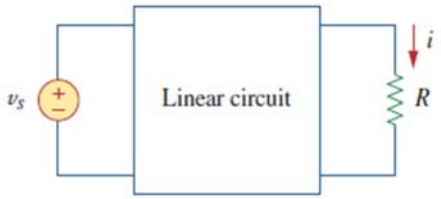
$$v = iR$$

- In general, a circuit is linear if it is both additive and homogeneous.

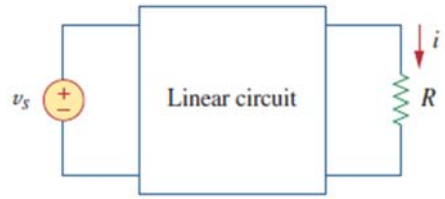
$$p = i^2R = v^2/R$$

- the relationship between power and voltage (or current) is nonlinear
- Therefore, the theorems covered in this lecture are not applicable to power

- consider the linear circuit shown in Fig
- The linear circuit has no independent sources inside it.
- It is excited by V_s a voltage source which serves as the input.
- The circuit is terminated by a load *R*.
- We may take the current *i* through *R* as the output.

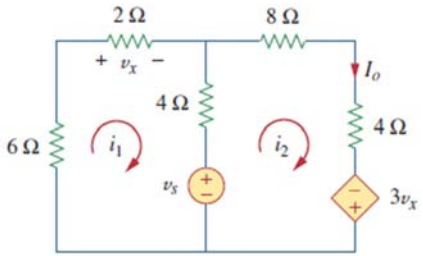


- If Vs = 10 volt and I = 2 Amp
- So according to linearity priciple
- If Vs become 1 Volt then I = 0.2 Amp



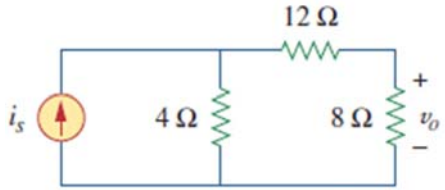
Example 01

For the circuit in Fig. 4.2, find I_o when $v_s = 12$ V and $v_s = 24$ V.



Example 02

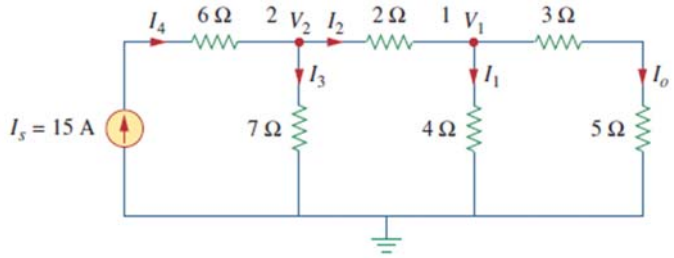
For the circuit in Fig. 4.3, find v_o when $i_s = 30$ and $i_s = 45$ A.



Answer: 40 V, 60 V.

Example 03

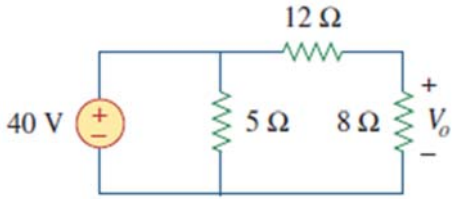
Assume $I_o = 1$ A and use linearity to find the actual value of I_o in the circuit of Fig. 4.4.



$I_o = 3$ A

Example 04

Assume that $V_o = 1$ V and use linearity to calculate the actual value of V_o in the circuit of Fig. 4.5.



Answer: 16 V.

Superposition

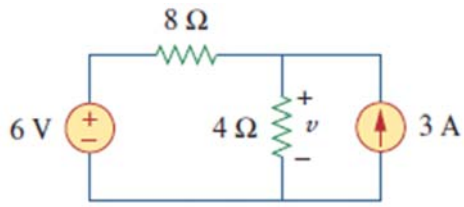
- The superposition principle states that the voltage across (or current through) an element in a linear circuit is the algebraic sum of the voltages across (or currents through) that element due to each independent source acting alone.

Steps to Apply Superposition Principle:

1. Turn off all independent sources except one source. Find the output (voltage or current) due to that active source using the techniques covered in Chapters 2 and 3.
2. Repeat step 1 for each of the other independent sources.
3. Find the total contribution by adding algebraically all the contributions due to the independent sources.

Example 05

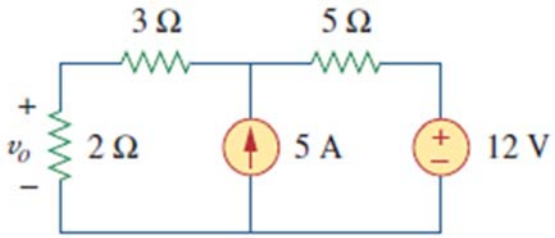
- Use the superposition theorem to find *v* in the circuit of Fig.



10 V

Example 06

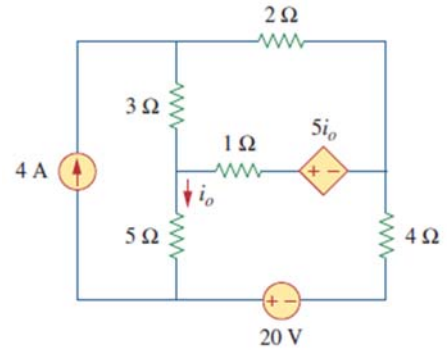
Using the superposition theorem, find v_o in the circuit of Fig.



Answer: 7.4 V.

Example 07

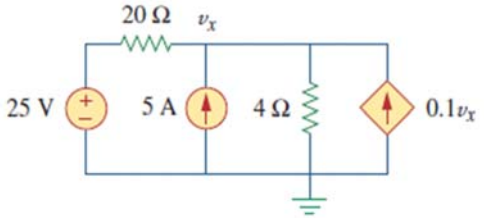
Find i_o in the circuit of Fig.



$$i_o = -\frac{8}{17} = -0.4706 \text{ A}$$

Example 08

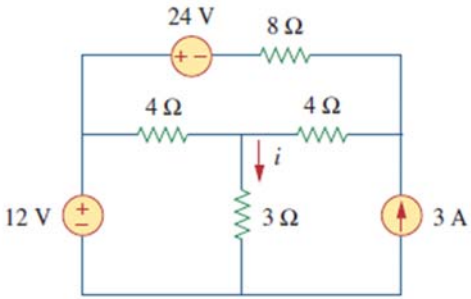
Use superposition to find v_x in the circuit of Fig.



$v_x = 31.25$ V.

Example 09

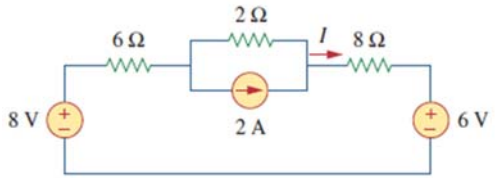
For the circuit in Fig. 4.12, use the superposition theorem to find i.



$$i = i_1 + i_2 + i_3 = 2 - 1 + 1 = 2 \text{ A}$$

Example 10

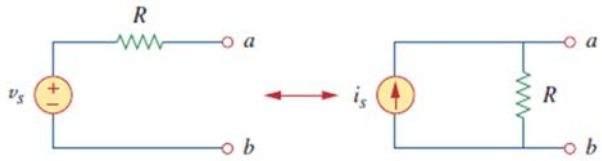
Find I in the circuit of Fig. 4.14 using the superposition principle.



Answer: 375 mA.

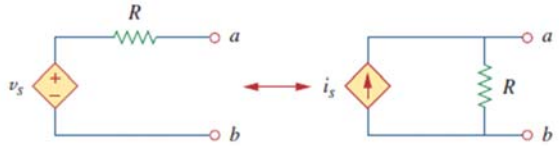
Source Transformation

- substitute a voltage source in series with a resistor for a current source in parallel with a resistor, or vice versa, as shown in Fig.



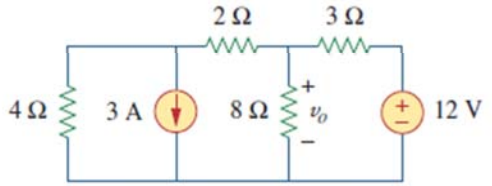
A **source transformation** is the process of replacing a voltage source v_s in series with a resistor R by a current source i_s in parallel with a resistor R, or vice versa.

- Source transformation also applies to dependent sources, provided we carefully handle the dependent variable



Example 11

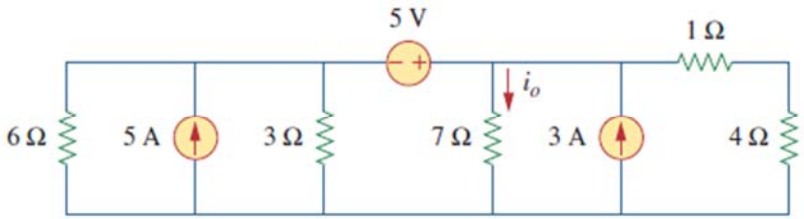
Use source transformation to find v_o in the circuit of Fig.



$= 3.2$ V

Example 12

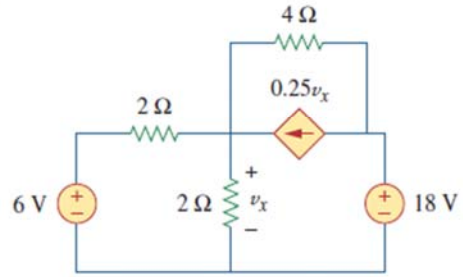
Find i_o in the circuit of Fig. 4.19 using source transformation.



Answer: 1.78 A.

Example 13

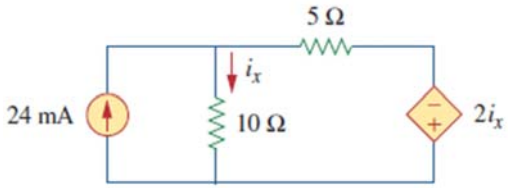
Find v_x in Fig. 4.20 using source transformation.



$v_x = 3 - i = 7.5$ V.

Example 14

Use source transformation to find i_x in the circuit shown in Fig.



Answer: 7.059 mA.