Circuit Theorms
Part : 02

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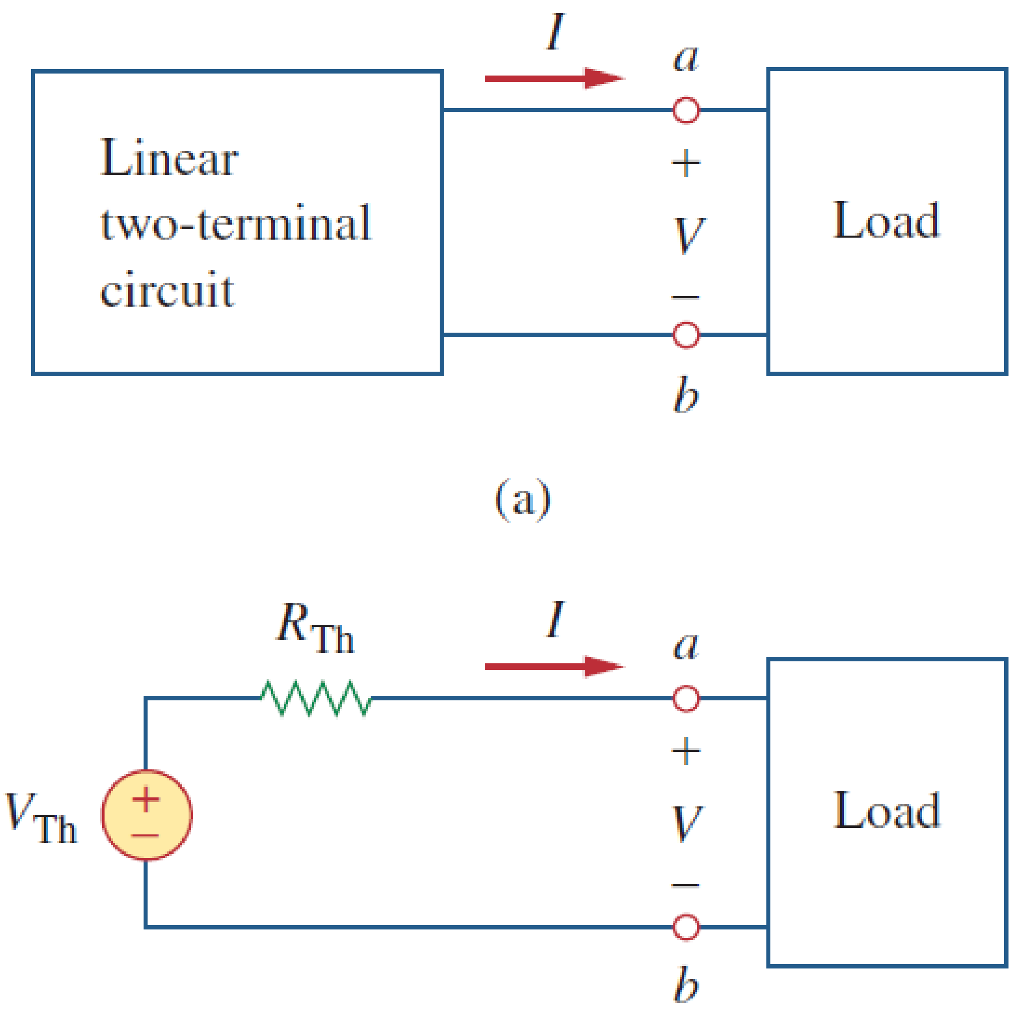
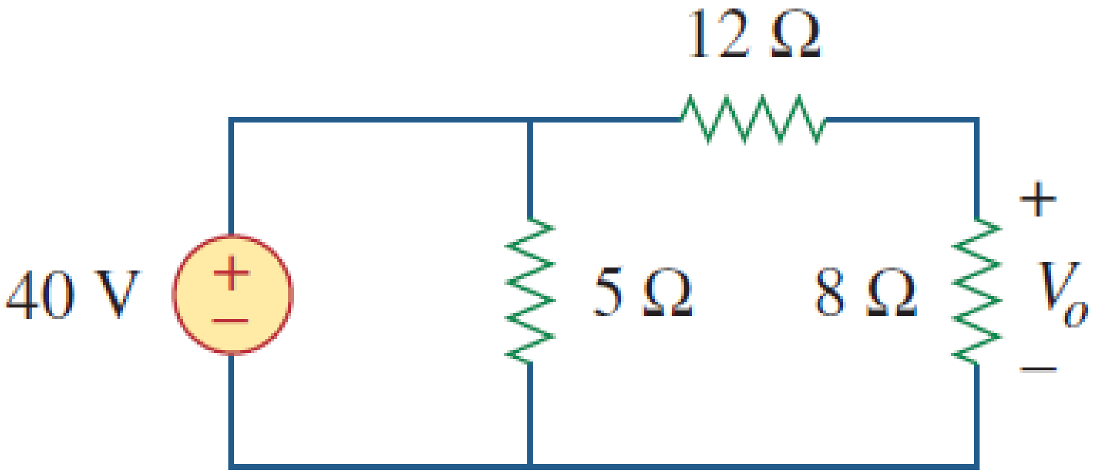
Thevenin Theorm

Thevenin's theorem states that a linear two-terminal circuit can be replaced by an equivalent circuit consisting of a voltage source V_{Th} in series with a resistor R_{Th}, where V_{Th} is the open-circuit voltage at the terminals and R_{Th} is the input or equivalent resistance at the terminals when the independent sources are turned off.

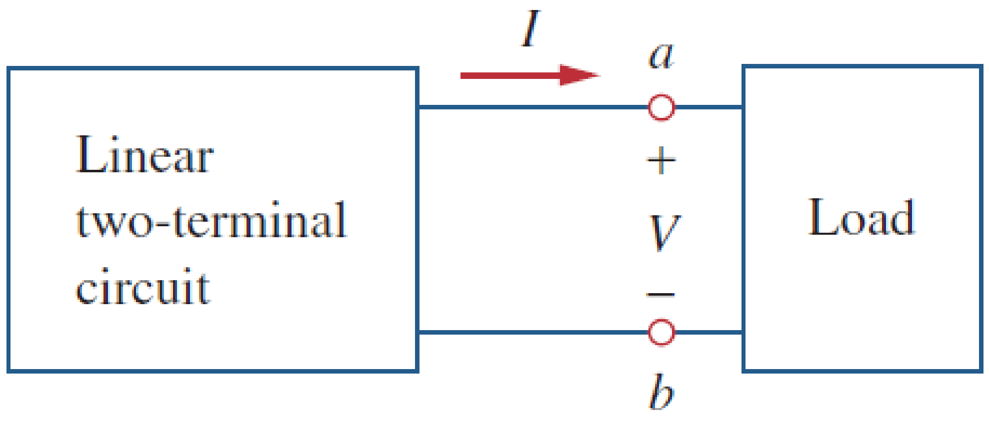
- A **linear circuit** is one whose output is linearly related (or directly proportional) to its input.

Thevenin Theorm



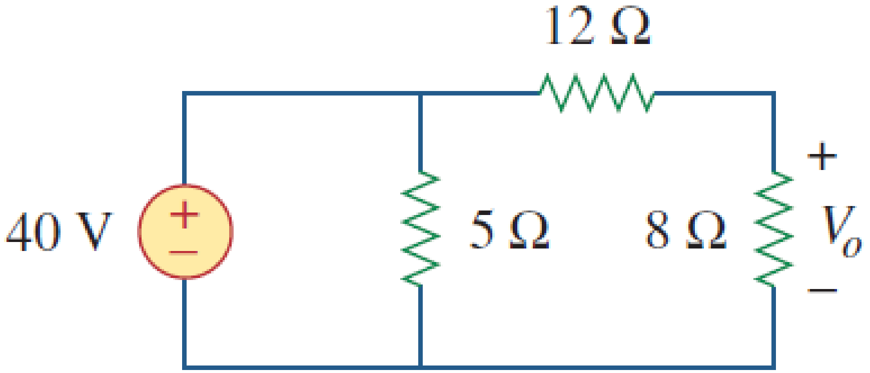


Thevenin Resistance R_{Th}

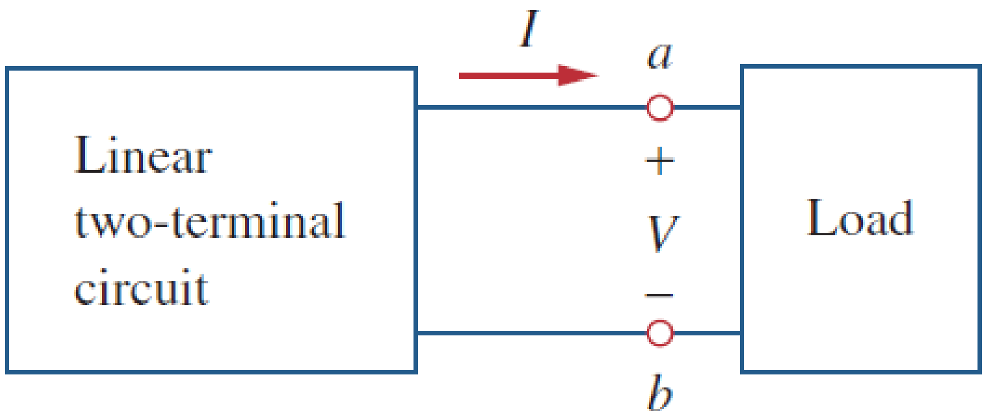


CASE-1 : No dependent Sources in the Network

If the network has no dependent sources, we turn off all independent sources. R_{Th} is the input resistance of the network looking between terminals a and b .

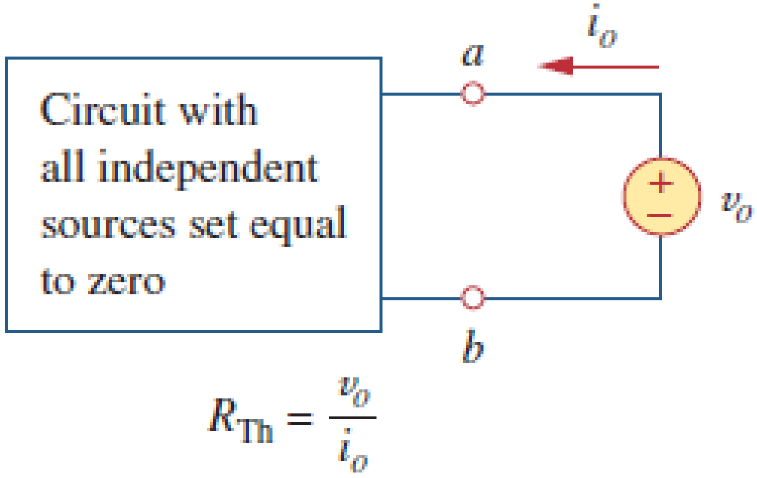


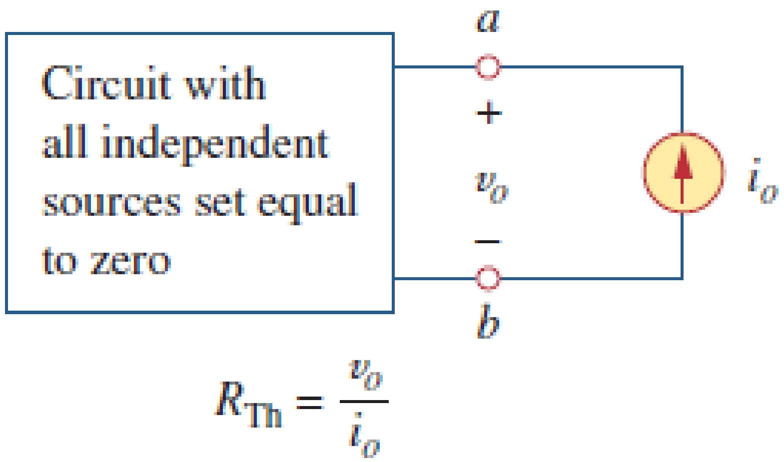
Thevenin Resistance R_{Th}



CASE-2 : Dependent Sources are present in the Network

If the network has dependent sources, we turn off all independent sources.





Thevenin Theorm

Find the Thevenin equivalent circuit of the circuit shown in Fig. 4.27, to the left of the terminals *a*-*b*. Then find the current through $R_L = 6, 16,$ and 36 Ω.

Example 4.8

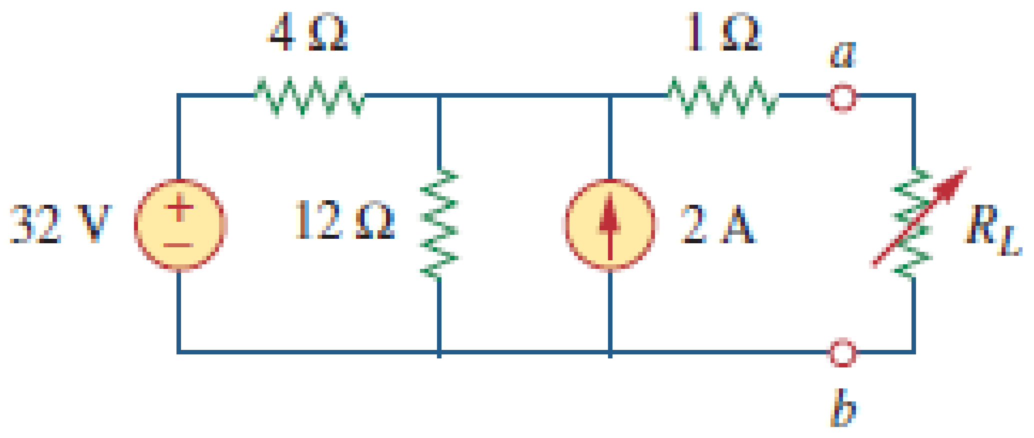
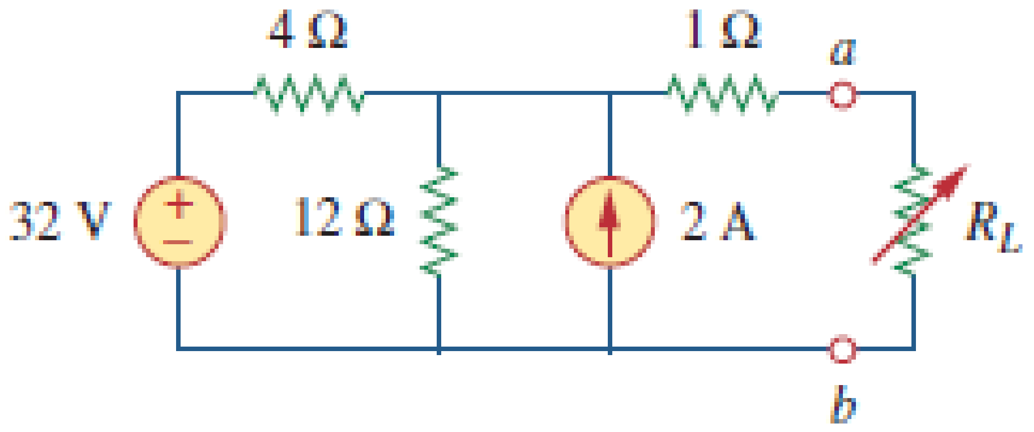
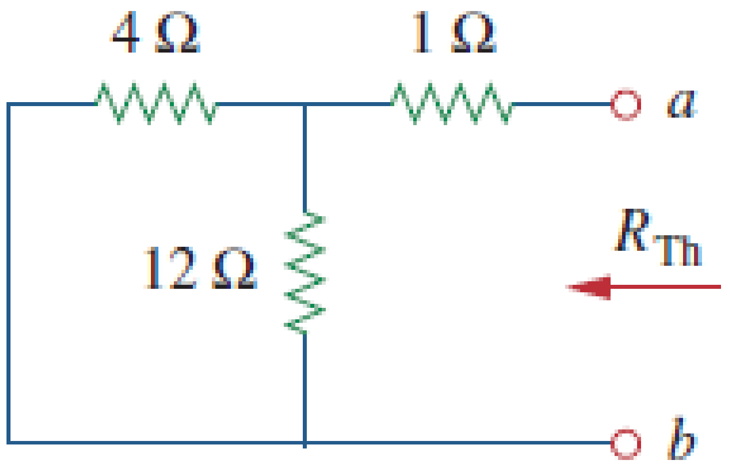


Figure 4.27
For Example 4.8.

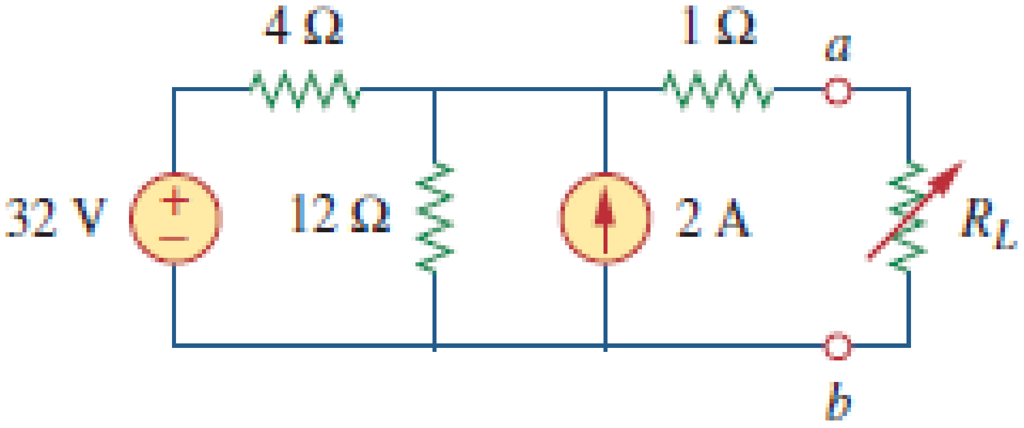
Thevenin Theorm

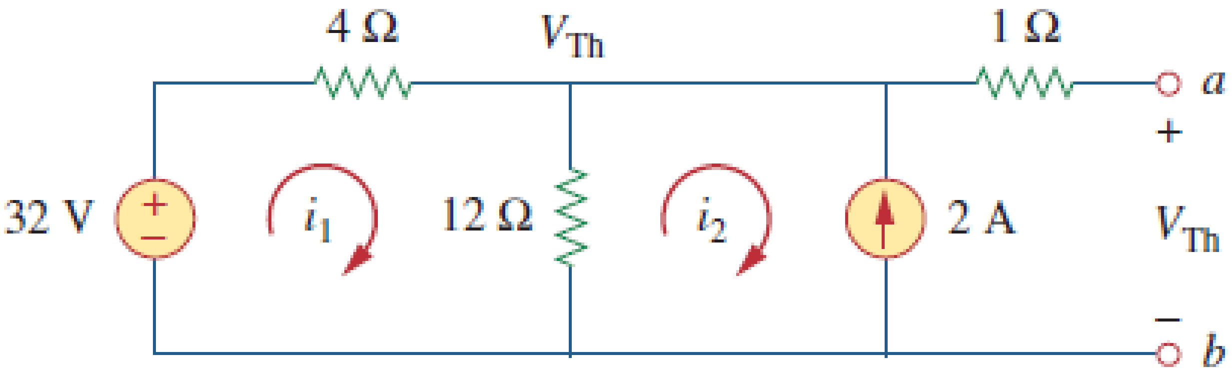




$$R_{\text{Th}} = 4 \parallel 12 + 1 = \frac{4 \times 12}{16} + 1 = 4\ \Omega$$

Thevenin Theorm





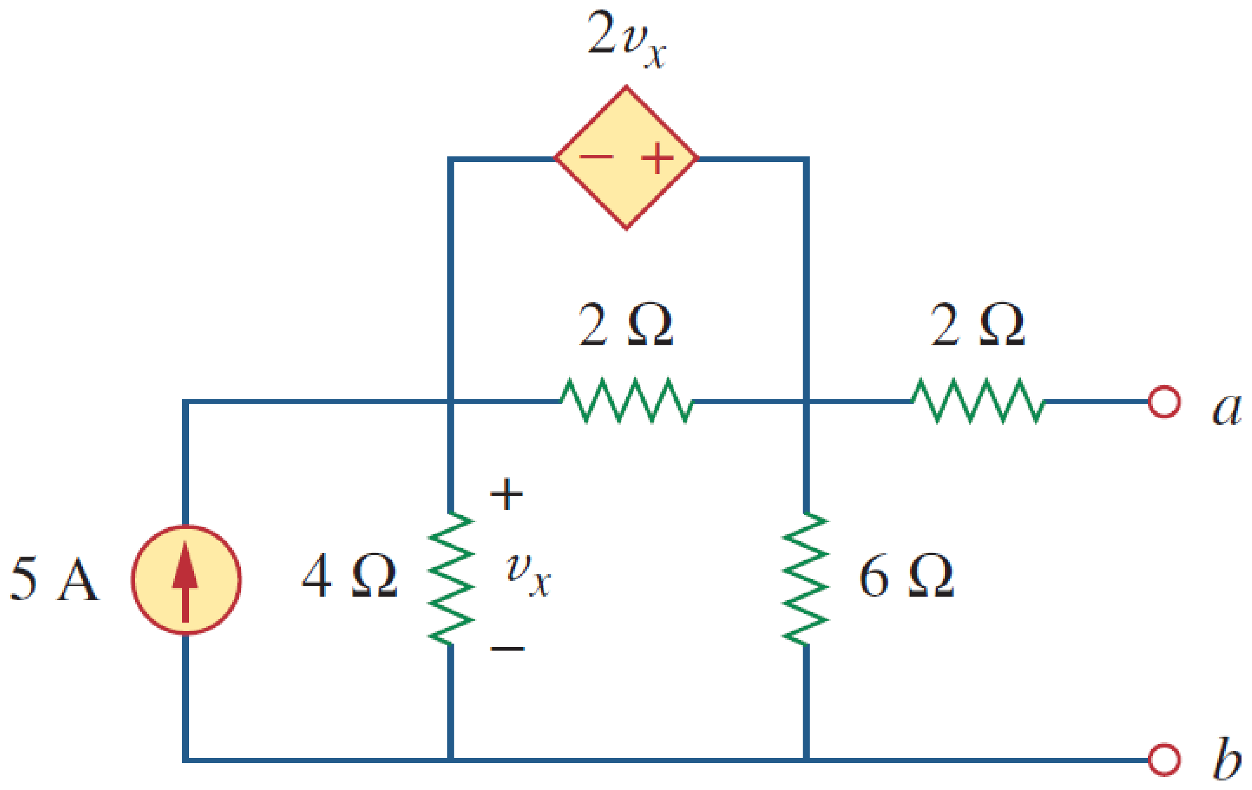
$$-32 + 4i_1 + 12(i_1 - i_2) = 0, \qquad i_2 = -2\ \text{A}$$

Solving for i_1, we get $i_1 = 0.5$ A. Thus,

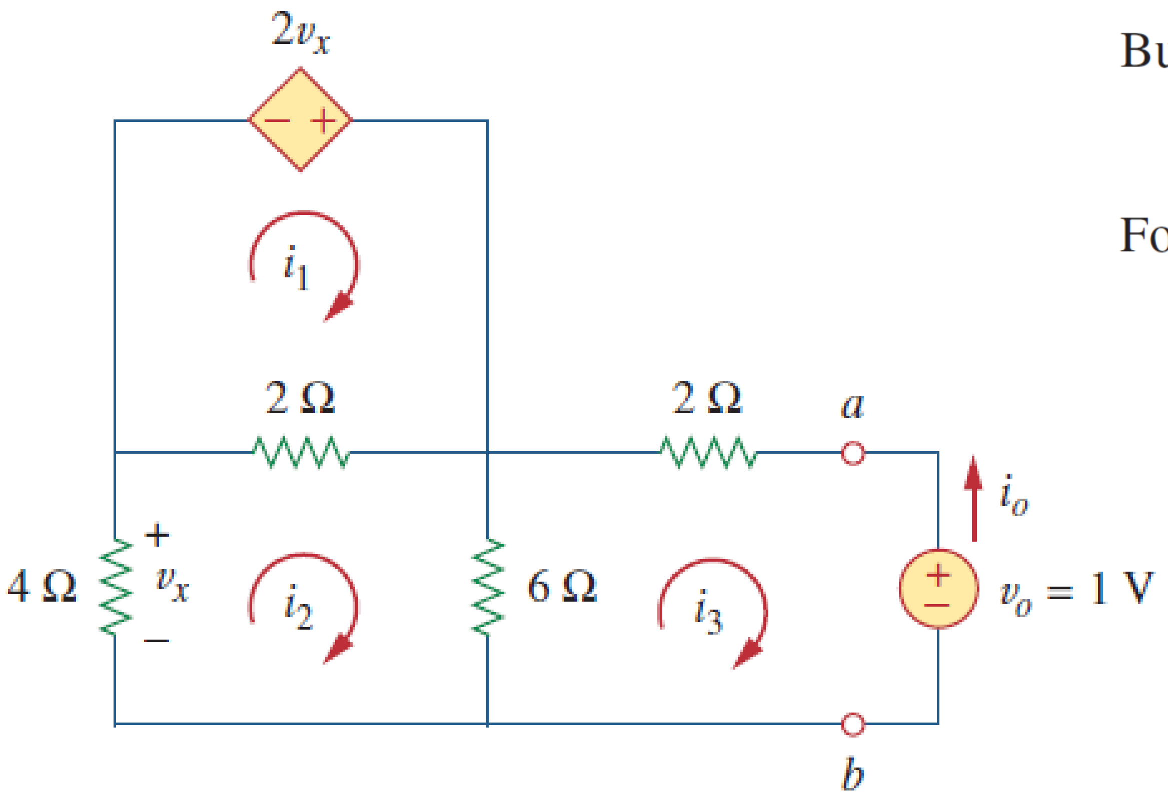
$$V_{Th} = 12(i_1 - i_2) = 12(0.5 + 2.0) = 30\ \text{V}$$

Thevenin Theorm

Example 4.9 Find the Thevenin equivalent of the circuit in Fig. 4.31 at terminals *a*-*b*.



Thevenin Theorm



$$-2v_x + 2(i_1 - i_2) = 0 \qquad \text{or} \qquad v_x = i_1 - i_2$$

But $-4i_2 = v_x = i_1 - i_2$; hence,

$$i_1 = -3i_2$$

For loops 2 and 3, applying KVL produces

$$4i_2 + 2(i_2 - i_1) + 6(i_2 - i_3) = 0$$

$$6(i_3 - i_2) + 2i_3 + 1 = 0$$

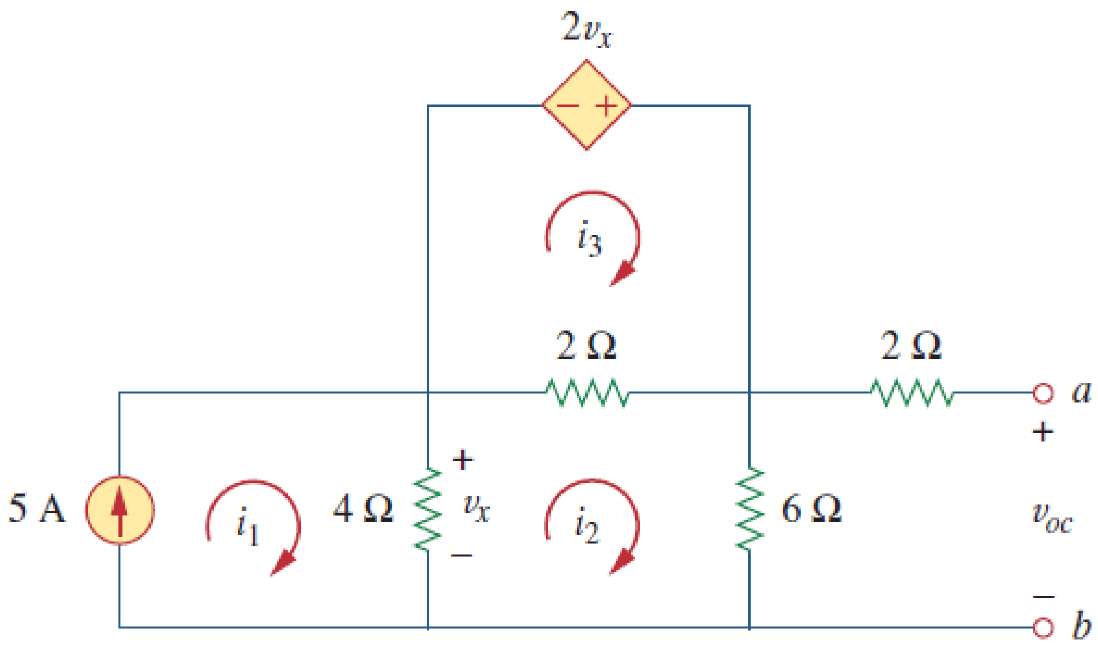
Solving these equations gives

$$i_3 = -\frac{1}{6} \text{ A}$$

But $i_o = -i_3 = 1/6$ A. Hence,

$$R_{\text{Th}} = \frac{1 \text{ V}}{i_o} = 6\ \Omega$$

Thevenin Theorm



$$i_1 = 5 \qquad \textbf{(4.9.4)}$$

$$-2v_x + 2(i_3 - i_2) = 0 \quad \Rightarrow \quad v_x = i_3 - i_2 \qquad \textbf{(4.9.5)}$$

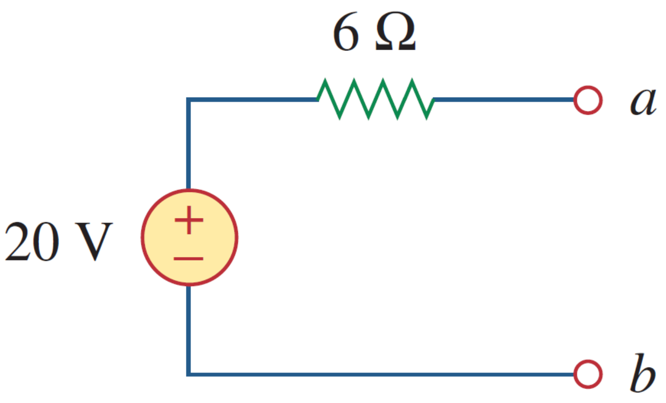
$$4(i_2 - i_1) + 2(i_2 - i_3) + 6i_2 = 0$$

or

$$12i_2 - 4i_1 - 2i_3 = 0 \qquad \textbf{(4.9.6)}$$

But $4(i_1 - i_2) = v_x$. Solving these equations leads to $i_2 = 10/3$. Hence,

$$V_{Th} = v_{oc} = 6i_2 = 20 \text{ V}$$

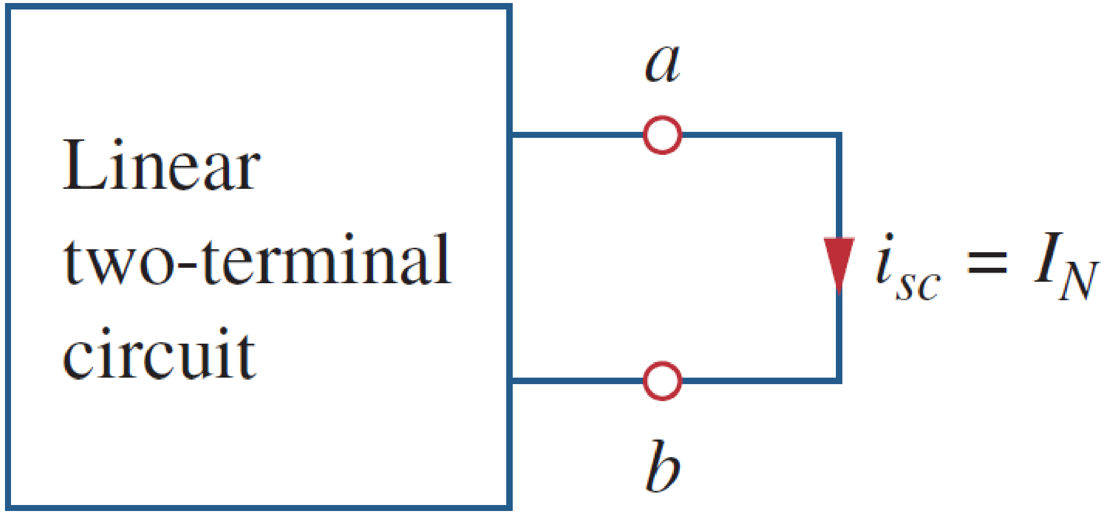


Norton Theorm

Norton's theorem states that a linear two-terminal circuit can be replaced by an equivalent circuit consisting of a current source I_N in parallel with a resistor R_N, where I_N is the short-circuit current through the terminals and R_N is the input or equivalent resistance at the terminals when the independent sources are turned off.

The Thevenin and Norton equivalent circuits are related by a source transformation.

Norton Theorm



$$V_{Th} = v_{oc}$$

$$I_N = i_{sc}$$

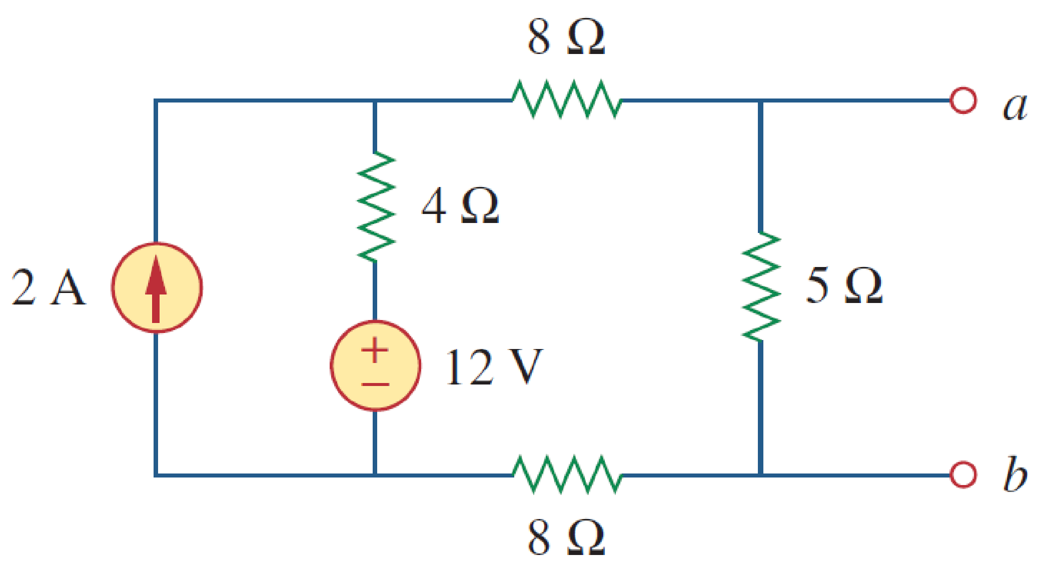
$$R_{Th} = \frac{v_{oc}}{i_{sc}} = R_N$$

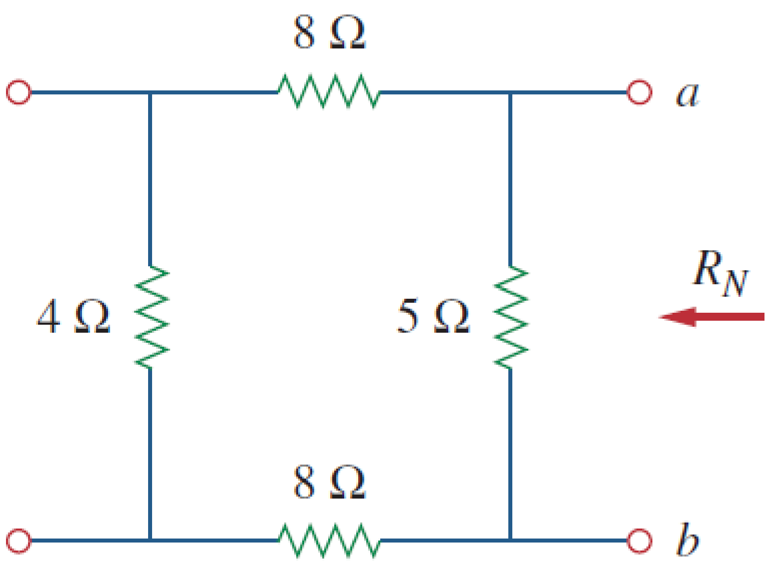
$$I_N = \frac{V_{Th}}{R_{Th}}$$

Norton Theorm

Example 4.11

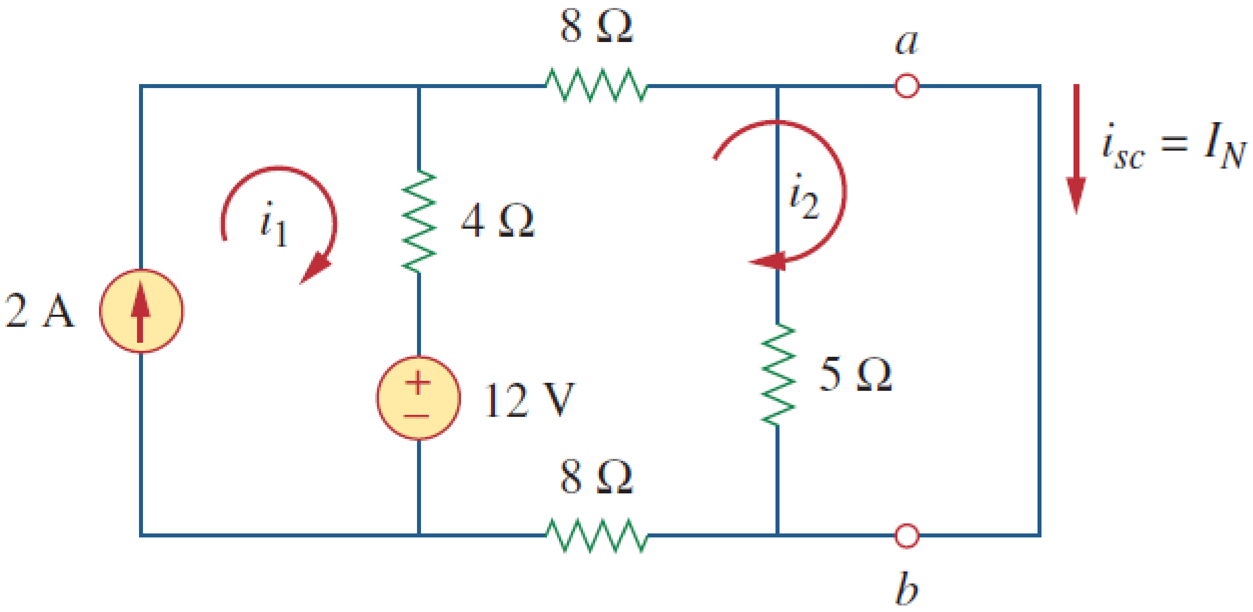
Find the Norton equivalent circuit of the circuit in terminals *a*-*b*.





$$R_N = 5 \parallel (8 + 4 + 8) = 5 \parallel 20 = \frac{20 \times 5}{25} = 4\ \Omega$$

Norton Theorm



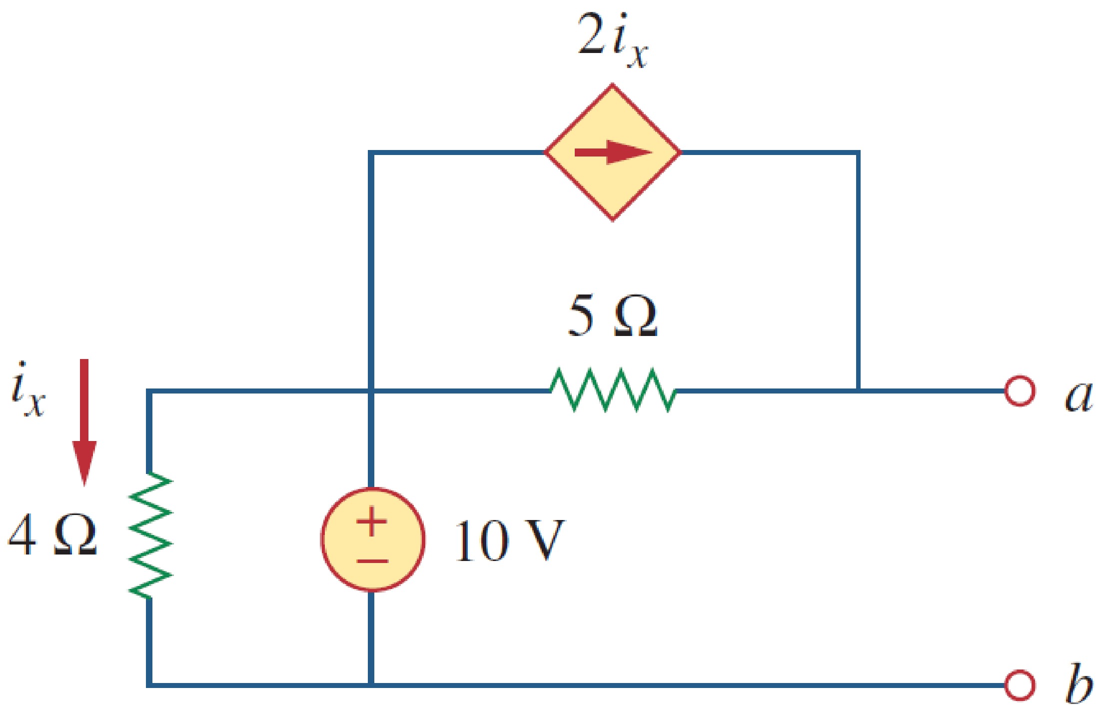
$$i_1 = 2 \text{ A}, \qquad 20i_2 - 4i_1 - 12 = 0$$

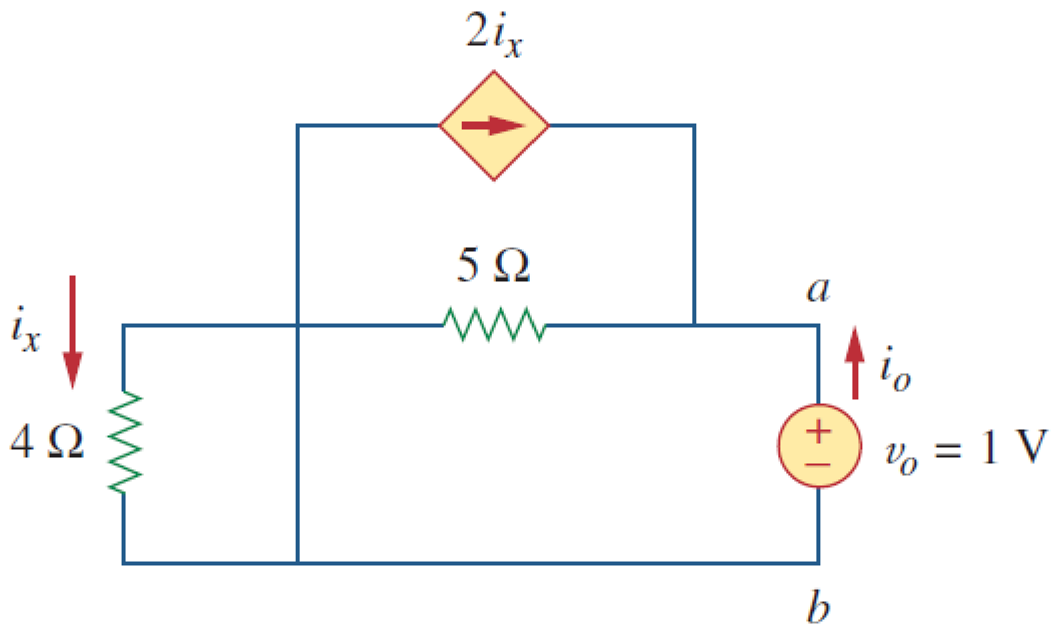
From these equations, we obtain

$$i_2 = 1 \text{ A} = i_{sc} = I_N$$

Norton Theorm

Using Norton's theorem, find R_N and I_N of the circuit in terminals a-b.

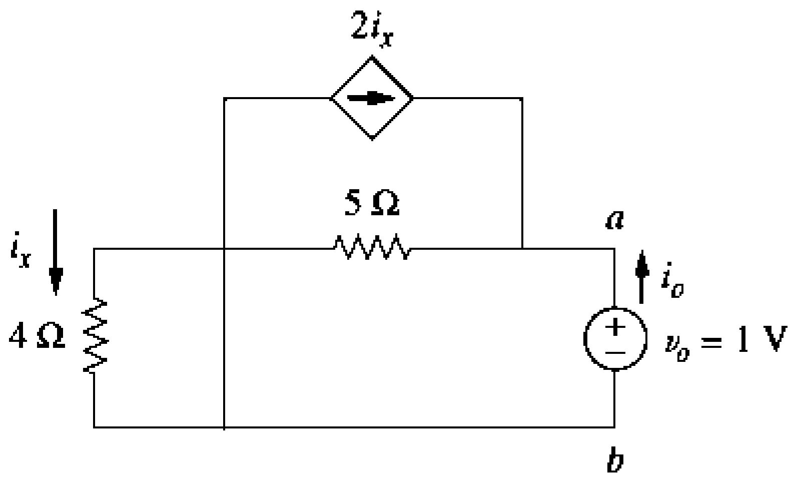


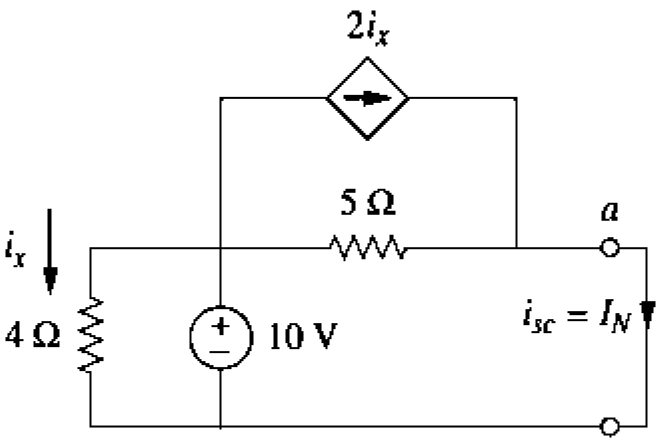


Hence, $i_x = 0$. At node a, $i_o = \frac{1v}{5\Omega} = 0.2$ A, and

$$R_N = \frac{v_o}{i_o} = \frac{1}{0.2} = 5\ \Omega$$

Norton Theorm





$$i_x = \frac{10}{4} = 2.5 \text{ A}$$

At node *a*, KCL gives

$$i_{sc} = \frac{10}{5} + 2i_x = 2 + 2(2.5) = 7 \text{ A}$$

Thus,

$$I_N = 7 \text{ A}$$

Maximum Power Transfer theorm

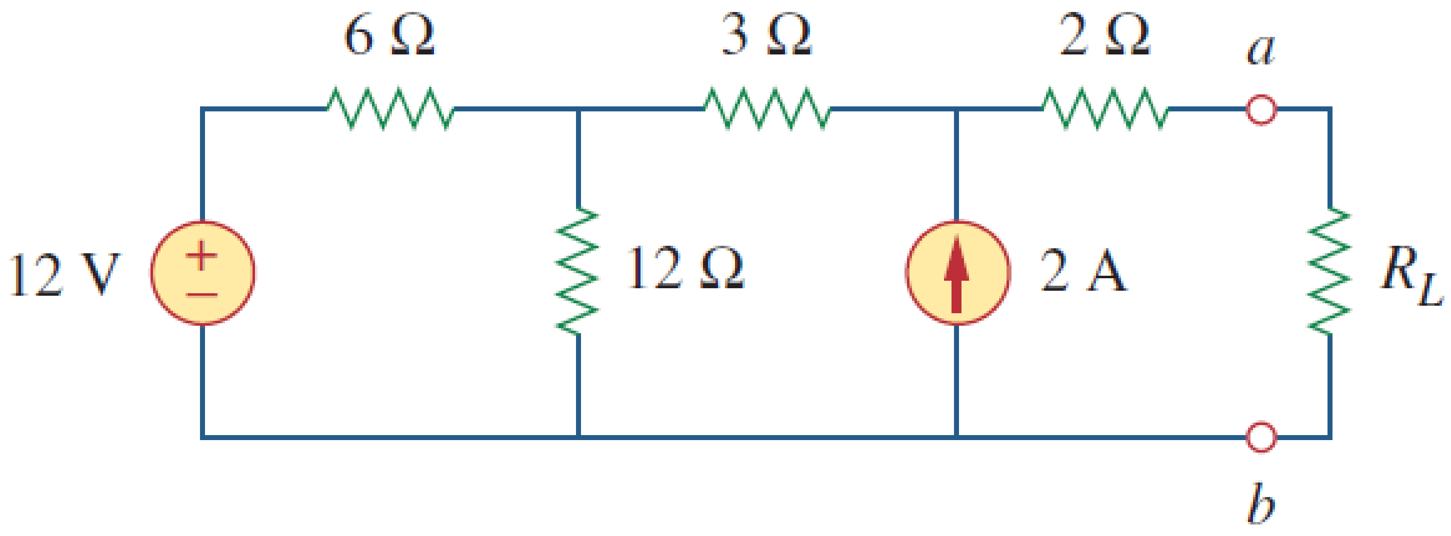
Maximum power is transferred to the load when the load resistance equals the Thevenin resistance .

$$R_L = R_{\text{Th}}$$

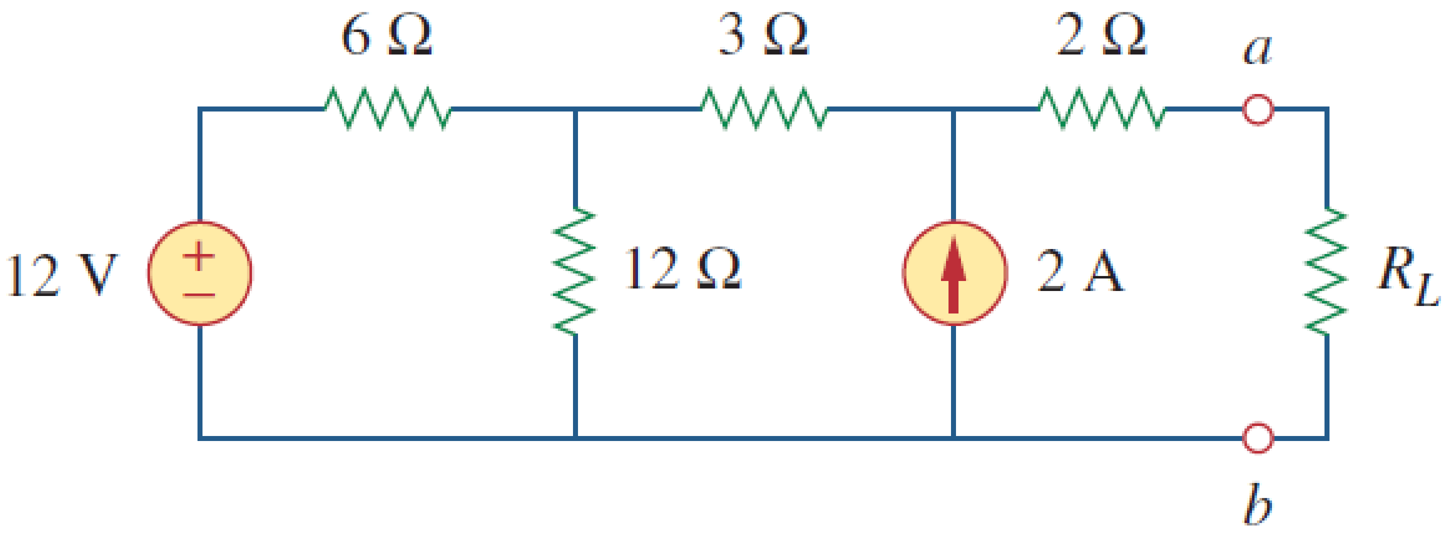
$$p_{\text{max}} = \frac{V_{\text{Th}}^2}{4R_{\text{Th}}}$$

Maximum Power Transfer theorm

Find the value of R_L for maximum power transfer in the circuit of Fig. 4.50. Find the maximum power.



Maximum Power Transfer theorm



$$R_{Th} = 9\ \Omega$$

$$V_{Th} = 22\ V$$

$$p_{\max} = \frac{V_{\mathrm{Th}}^2}{4R_L} = \frac{22^2}{4 \times 9} = 13.44\ \mathrm{W}$$

Thank You