NORTON'S THEOREM

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

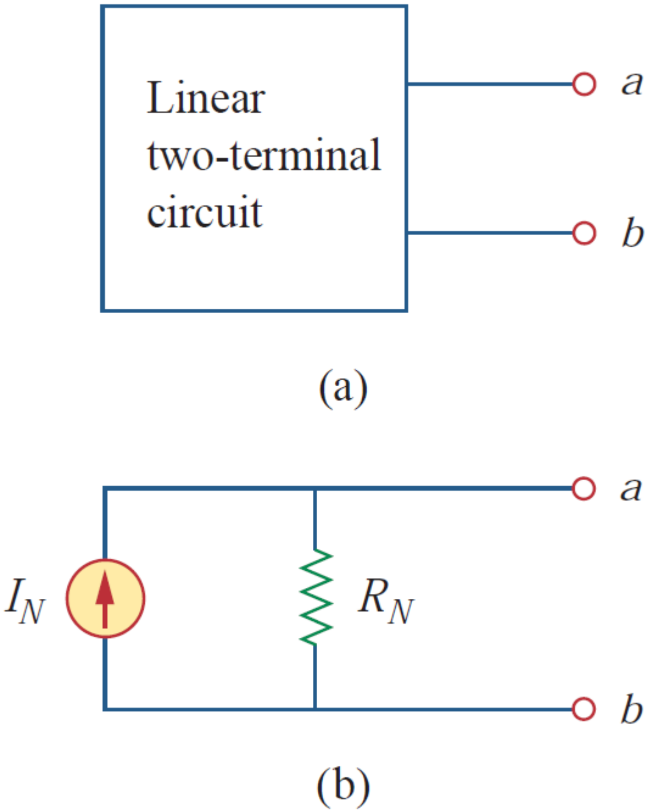

Figure 4.37
(a) Original circuit, (b) Norton equivalent circuit.

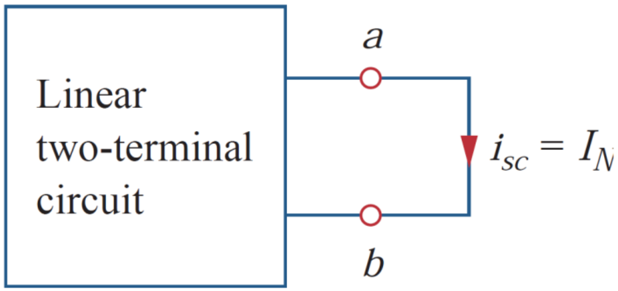

Figure 4.38
Finding Norton current I_N.

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

$$I_N = i_{sc}$$

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

Observe the close relationship between Norton's and Thevenin's theorems: $R_N = R_{\mathrm{Th}}$ as in Eq. (4.9), and

$$\boxed{I_N = \frac{V_{\mathrm{Th}}}{R_{\mathrm{Th}}}} \qquad \textbf{(4.11)}$$

This is essentially source transformation. For this reason, source transformation is often called Thevenin-Norton transformation.

Since V_{Th}, I_N, and R_{Th} are related according to Eq. (4.11), to determine the Thevenin or Norton equivalent circuit requires that we find:

- The open-circuit voltage v_{oc} across terminals a and b.
- The short-circuit current i_{sc} at terminals a and b.
- The equivalent or input resistance R_{in} at terminals a and b when all independent sources are turned off.

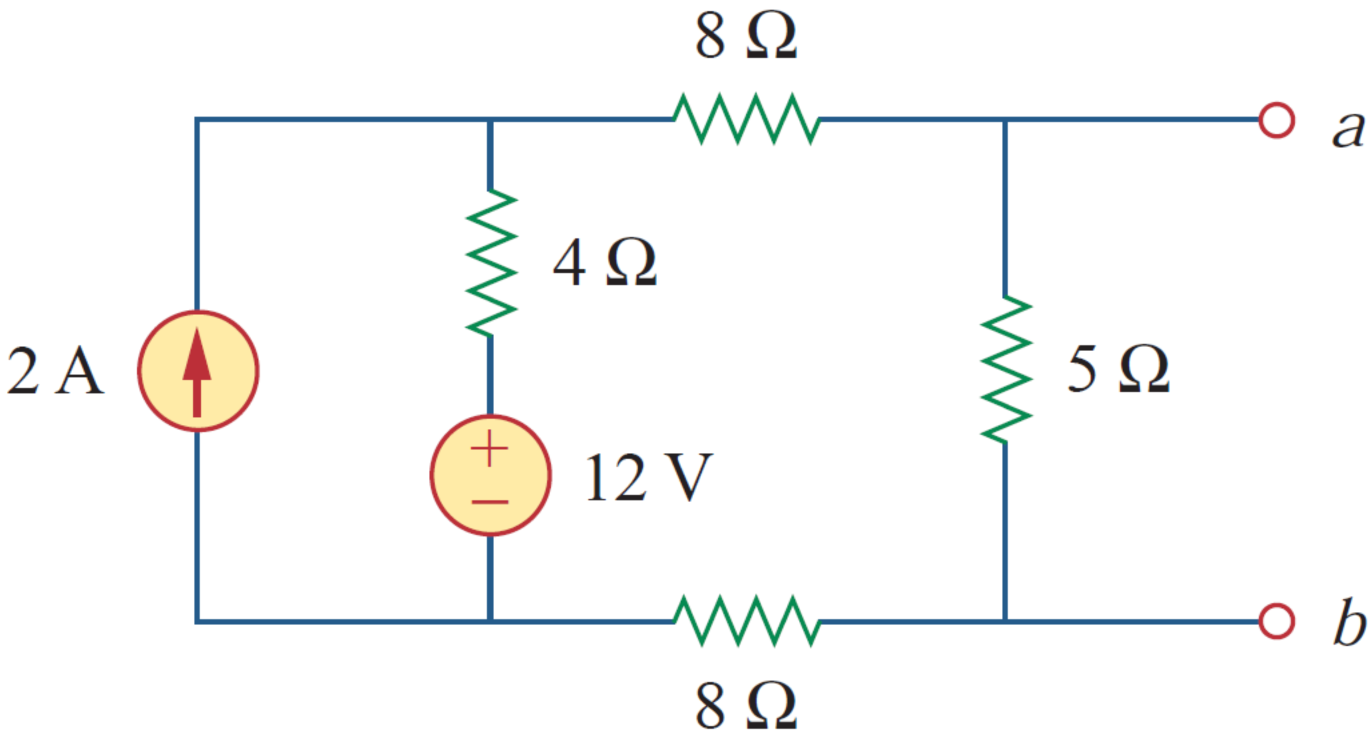

Figure 4.39
For Example 4.11.

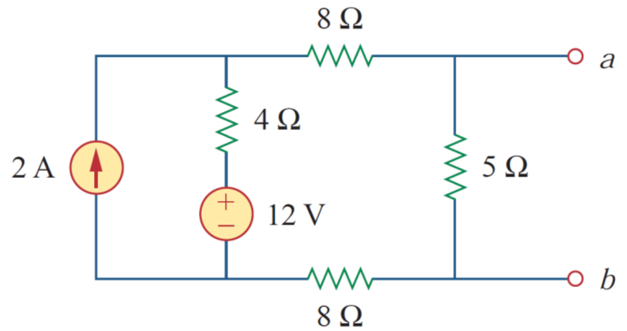

Figure 4.39
For Example 4.11

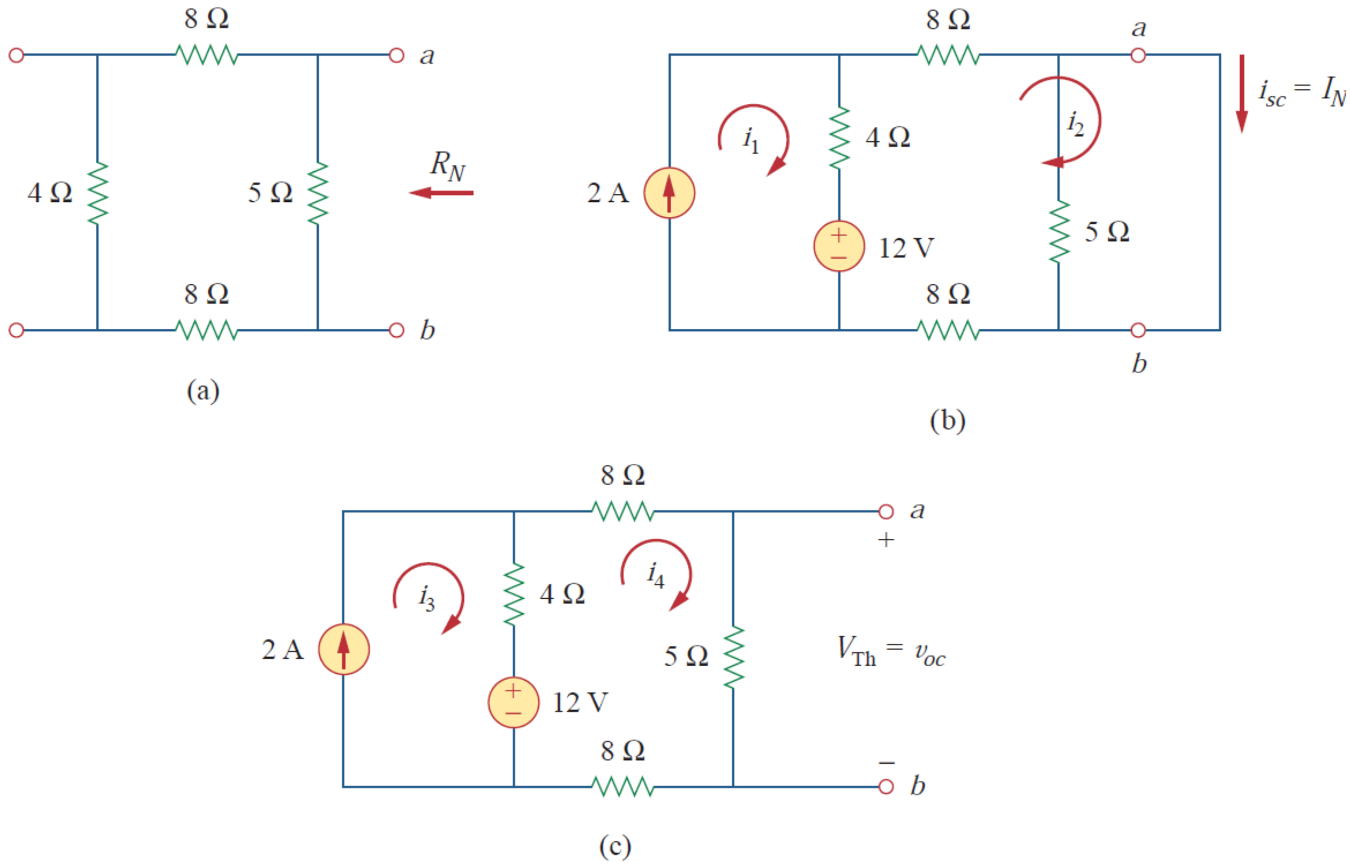

Figure 4.40
For Example 4.11; finding: (a) R_N, (b) $I_N = i_{sc}$, (c) $V_{Th} = v_{oc}$.

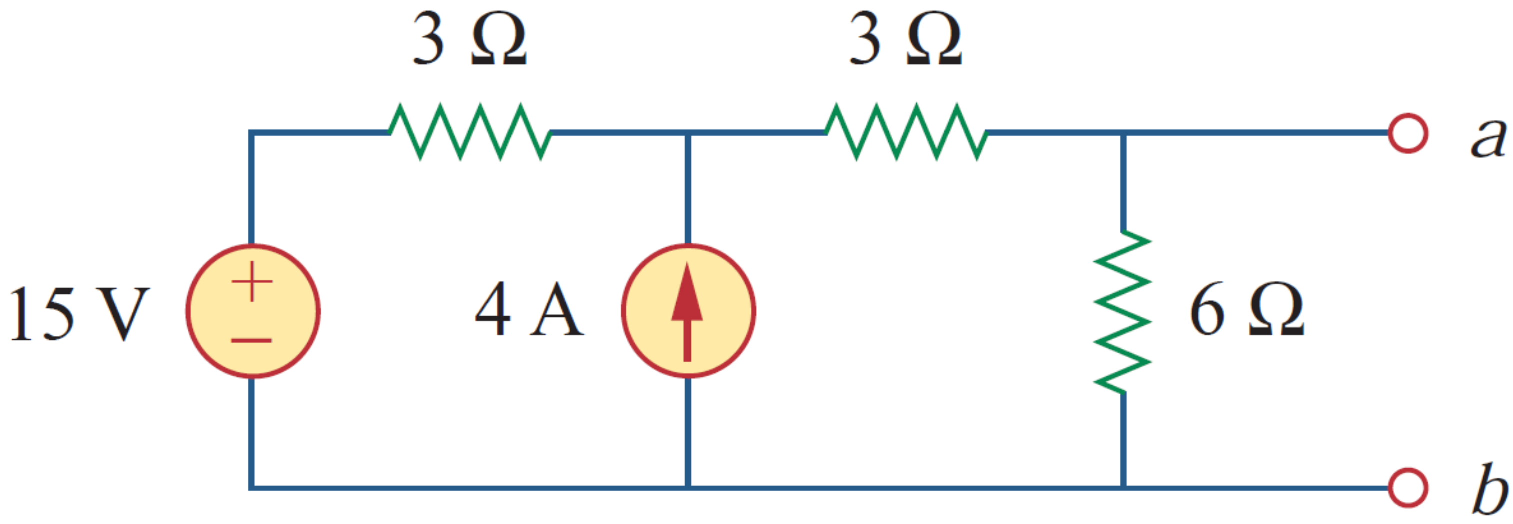

Figure 4.42
For Practice Prob. 4.11.

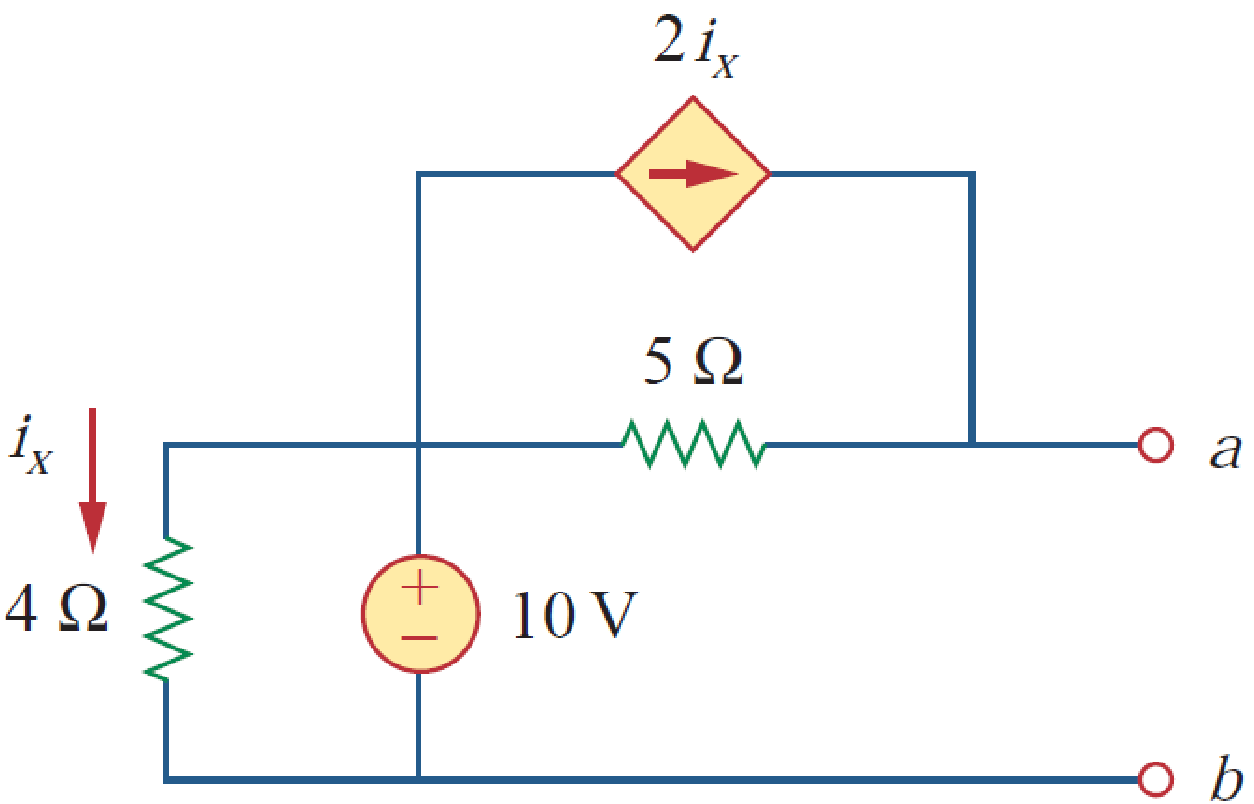

Figure 4.43
For Example 4.12.

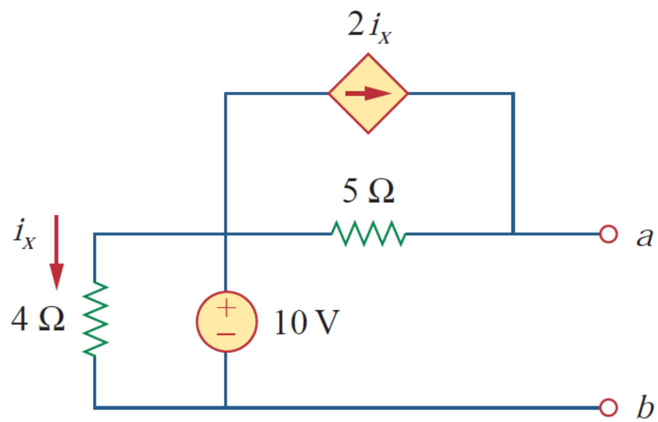

Figure 4.43
For Example 4.12.

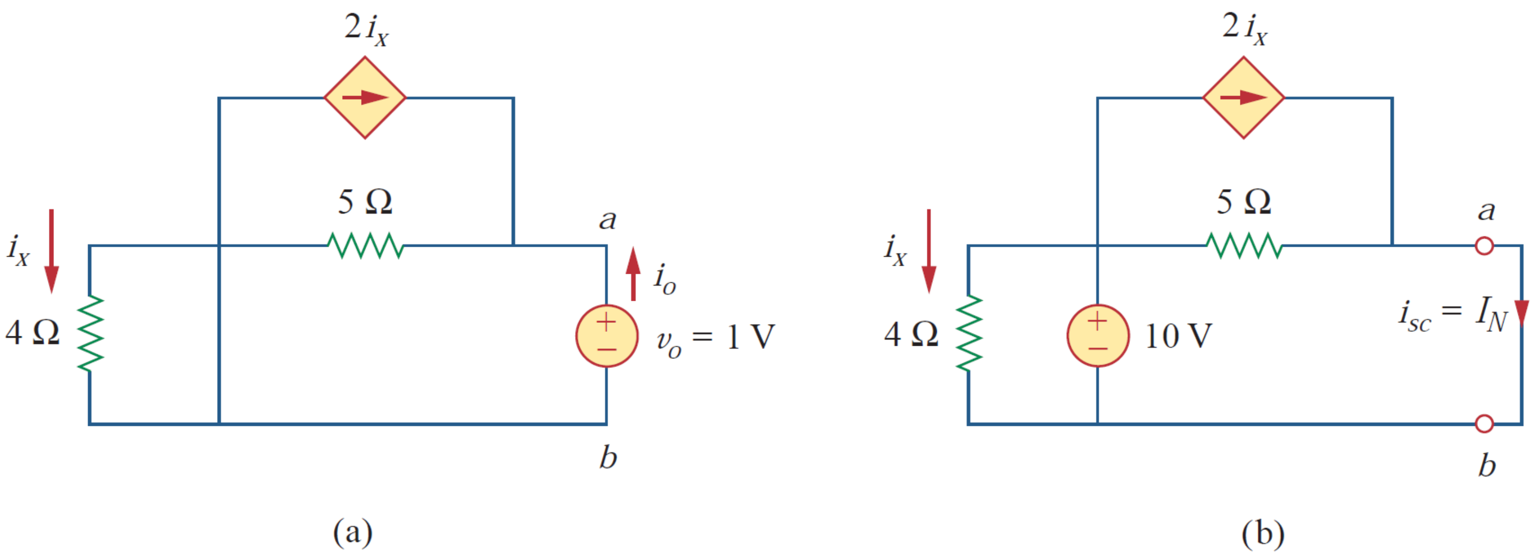

Figure 4.44
For Example 4.12: (a) finding R_N, (b) finding I_N.

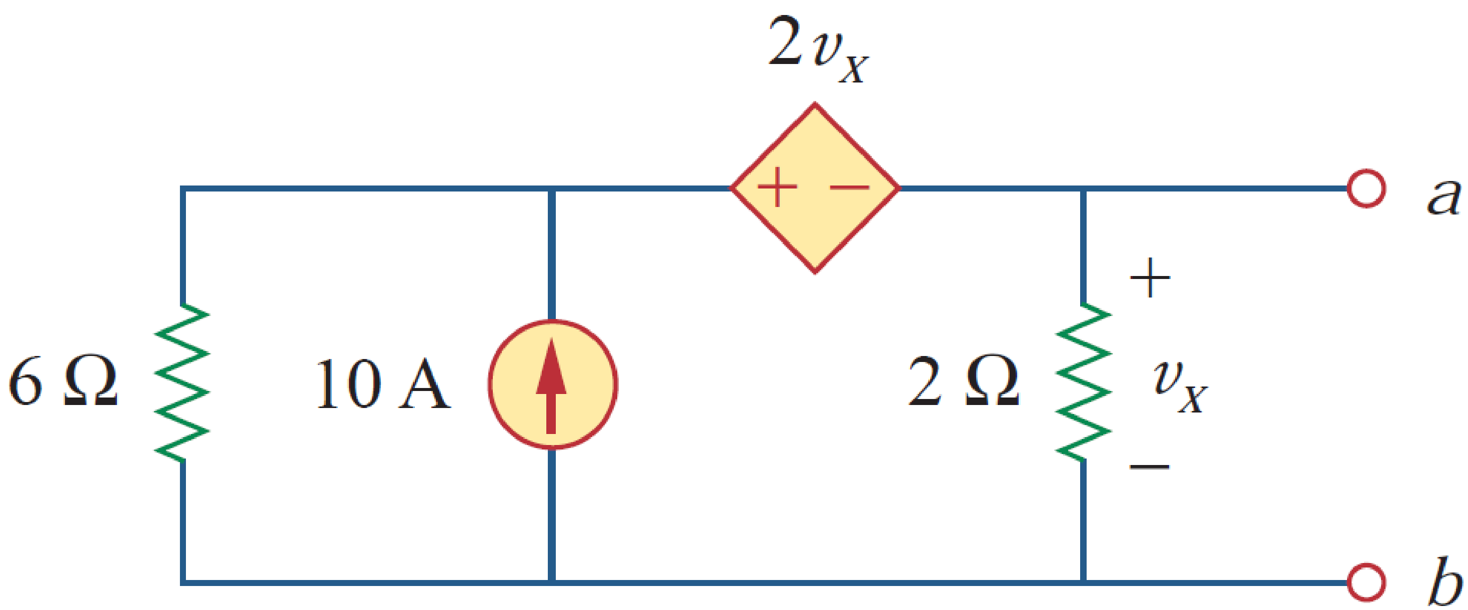

Figure 4.45
For Practice Prob. 4.12.

Derivations of Thevenin's and Norton's Theorems

- prove Thevenin's and Norton's theorems using the superposition principle

Maximum Power Transfer

There are applications in areas such as communications where it is desirable to maximize the power delivered to a load. We now address the problem of delivering the maximum power to a load when given a system with known internal losses.

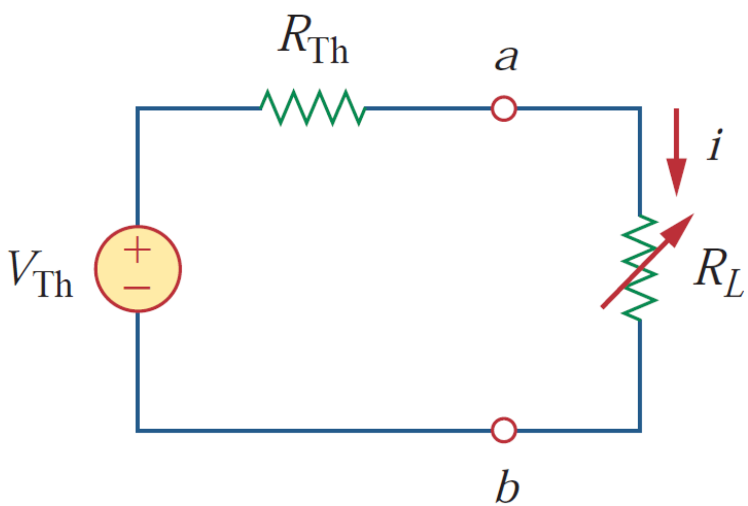

Figure 4.48
The circuit used for maximum power transfer.

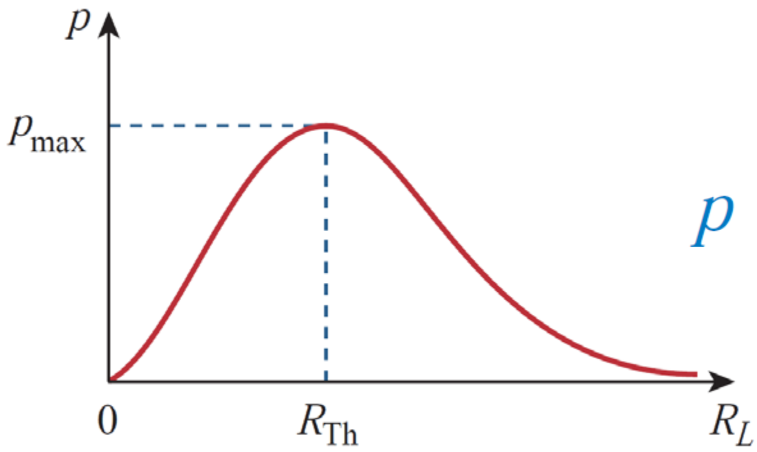

Figure 4.49
Power delivered to the load as a function of R_L.

$$p = i^2 R_L = \left(\frac{V_{Th}}{R_{Th} + R_L}\right)^2 R_L$$

$$\frac{dp}{dR_L} = V_{Th}^2\left[\frac{(R_{Th} + R_L)^2 - 2R_L(R_{Th} + R_L)}{(R_{Th} + R_L)^4}\right]$$

$$= V_{Th}^2\left[\frac{(R_{Th} + R_L - 2R_L)}{(R_{Th} + R_L)^3}\right] = 0$$

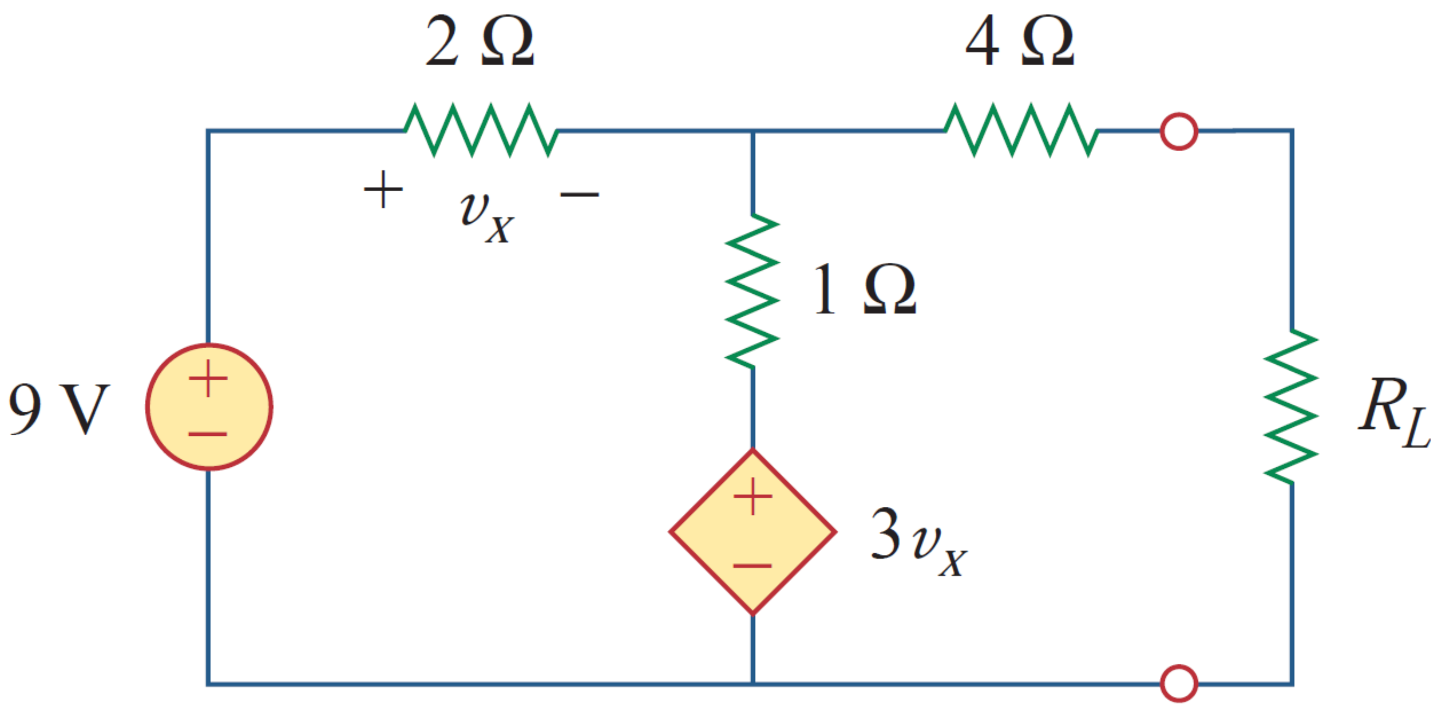

Figure 4.52
For Practice Prob. 4.13.

*4.60 For the circuit in Fig. 4.126, find the Thevenin and Norton equivalent circuits at terminals *a*-*b*.

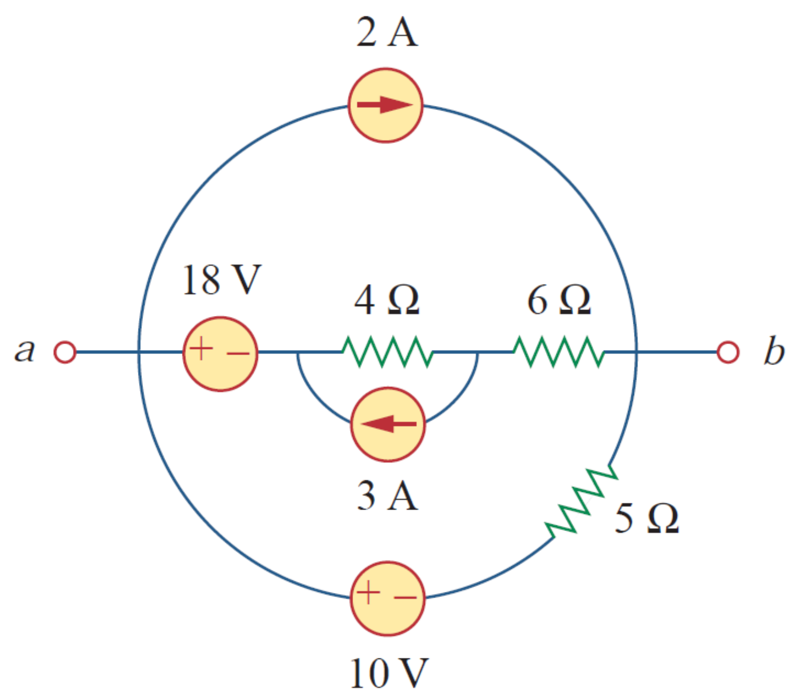

Figure 4.126
For Probs. 4.60 and 4.81.