EEE 141
ELECTRICAL CIRCUITS

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CIRCUIT THEOREMS

Linearity Property

Superposition

Thevenin's Theorem

Norton's Theorem

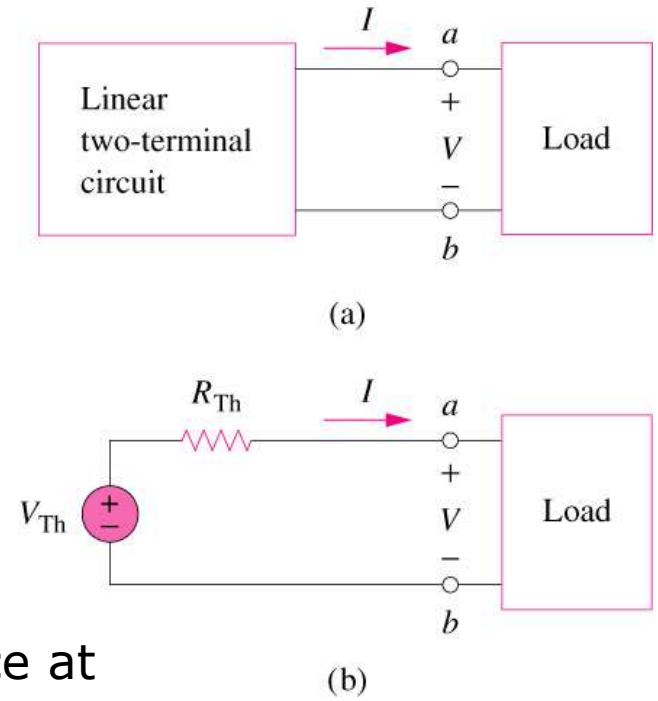
Maximum Power Transfer

THÉVENIN'S THEOREM

- In general, the theorem can be used to do the following:
  - ***Analyze networks with sources that are not in series or parallel.***
  - ***Reduce the number of components required to establish the same characteristics at the output terminals.***
  - ***Investigate the effect of changing a particular component on the behavior of a network without having to analyze the entire network after each change.***

THEVENIN'S THEOREM

It states that a linear two-terminal circuit (Fig. a) can be replaced by an equivalent circuit (Fig. b) consisting of a voltage source V_{TH} in series with a resistor R_{TH},

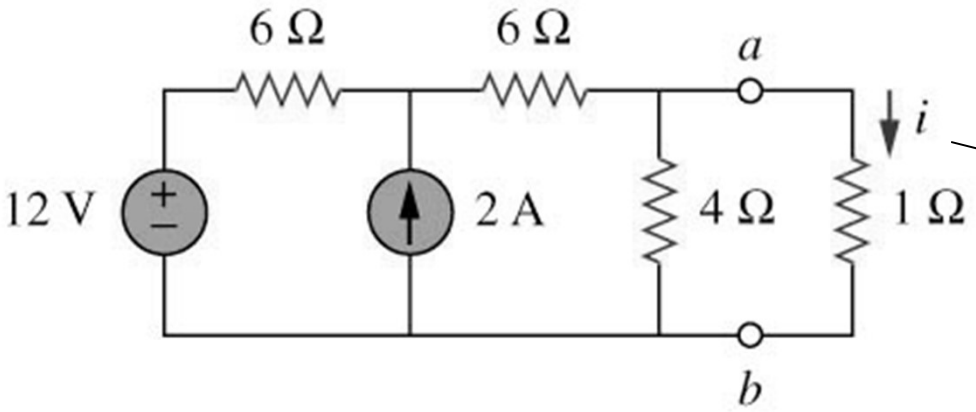


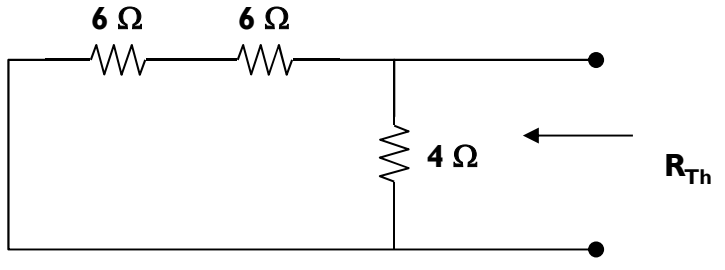
where

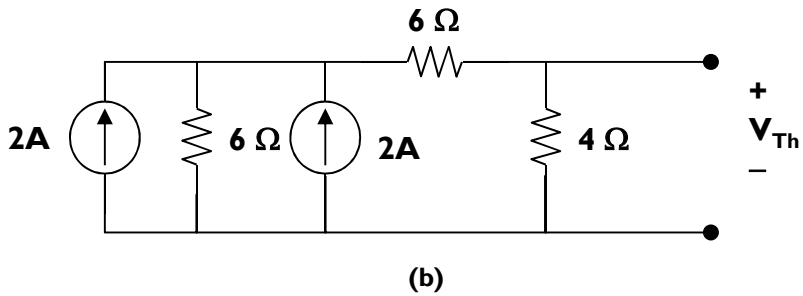
- V_{TH} is the open-circuit voltage at the terminals.
- R_{TH} is the input or equivalent resistance at the terminals when the independent sources are turned off.

EXAMPLE

Using Thevenin's theorem, find the equivalent circuit to the left of the terminals in the circuit shown below. Hence find i.







*Refer to in-class illustration, textbook, answer V_{TH} = 6V, R_{TH} = 3Ω, i = 1.5A

EXAMPLE

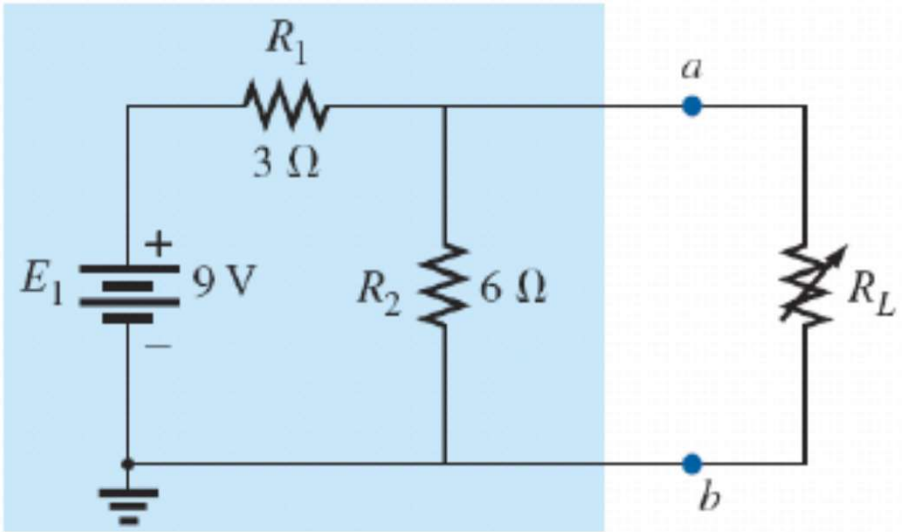


FIG. 9.26 *Example 9.6.*

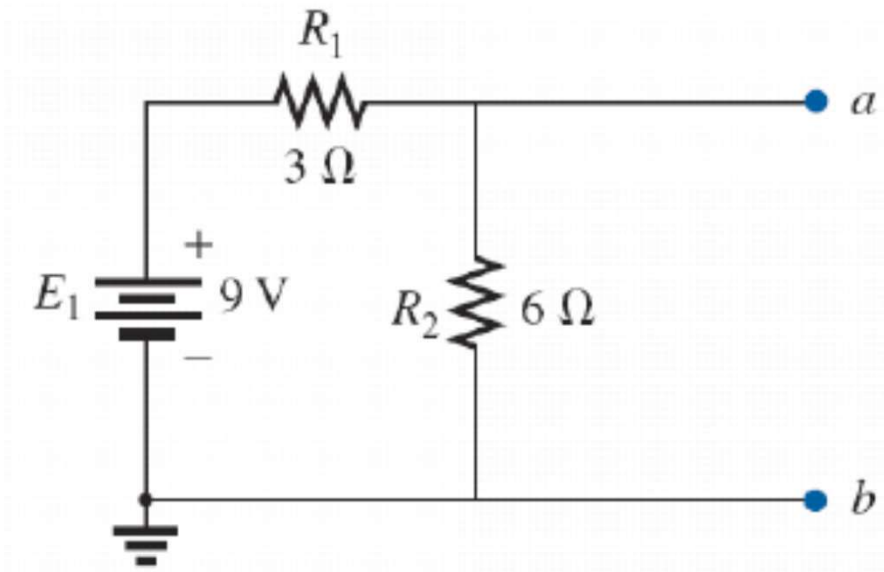


FIG. 9.27 *Identifying the terminals of particular importance when applying Thévenin's theorem.*

SOLUTION

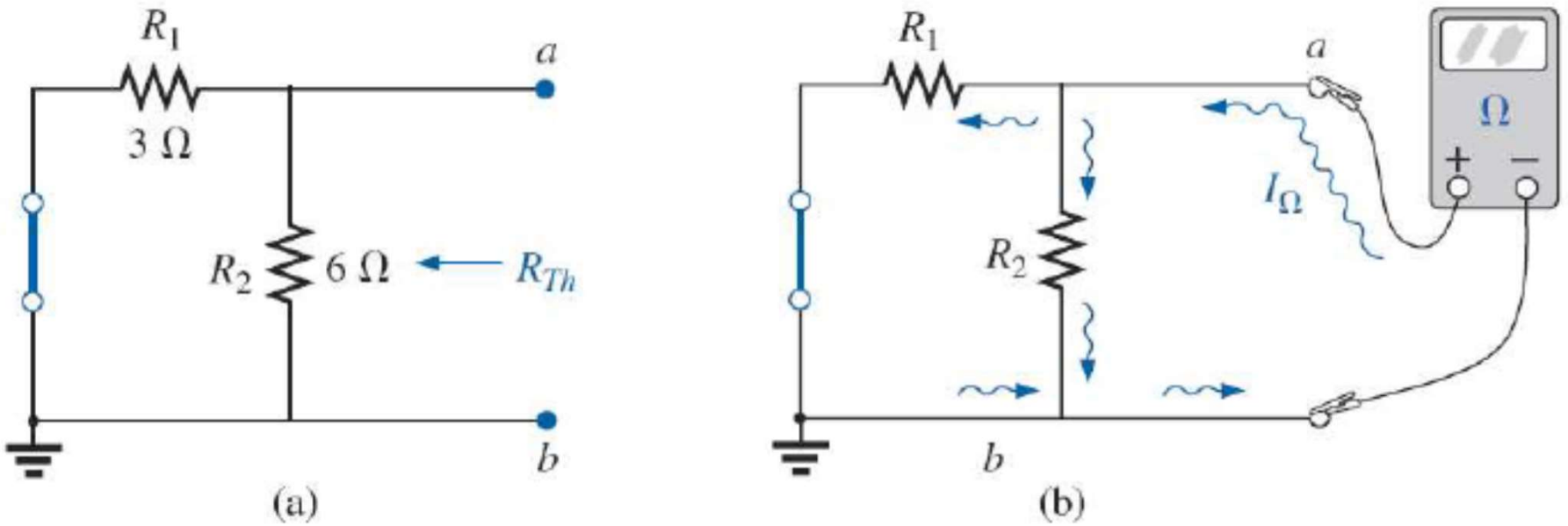


FIG. 9.28 *Determining R_{Th} for the network in Fig. 9.27.*

SOLUTION

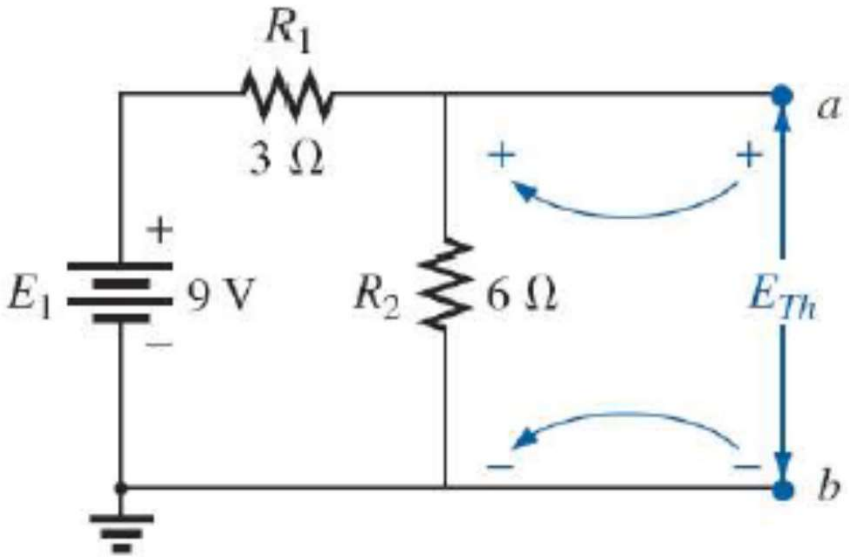


FIG. 9.29 *Determining E_{Th} for the network in Fig. 9.27.*

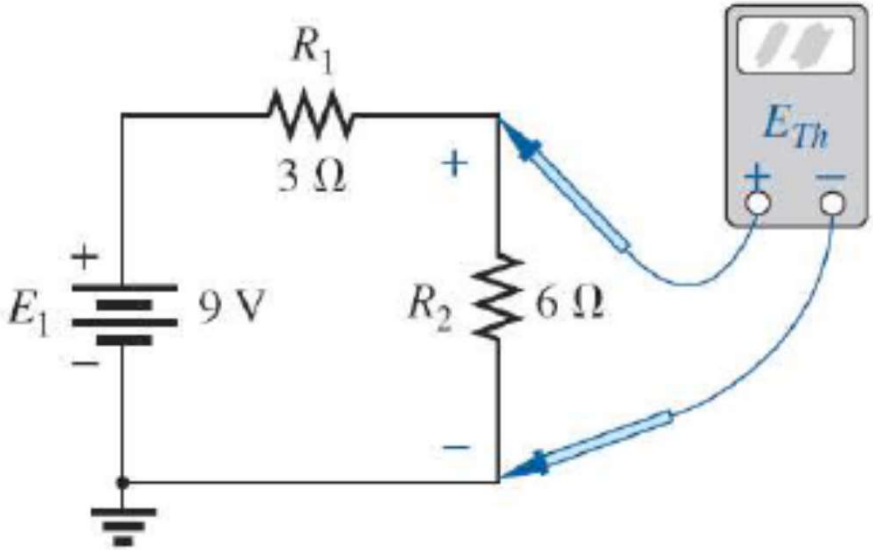


FIG. 9.30 *Measuring E_{Th} for the network in Fig. 9.27.*

SOLUTION

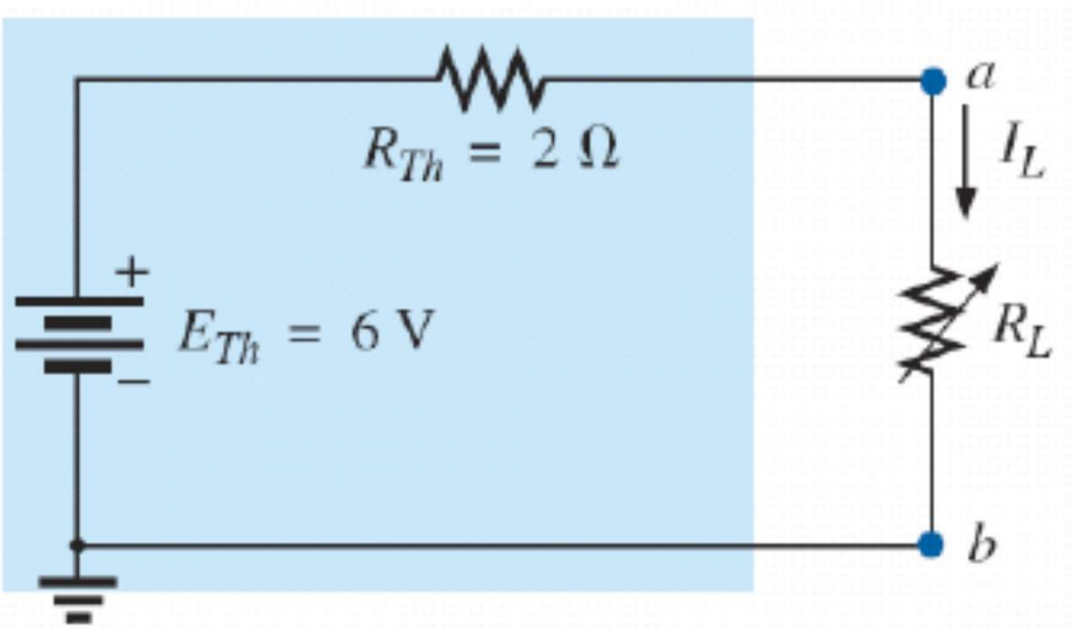


FIG. 9.31 *Substituting the Thévenin equivalent circuit for the network external to R_L in Fig. 9.26.*

EXAMPLE

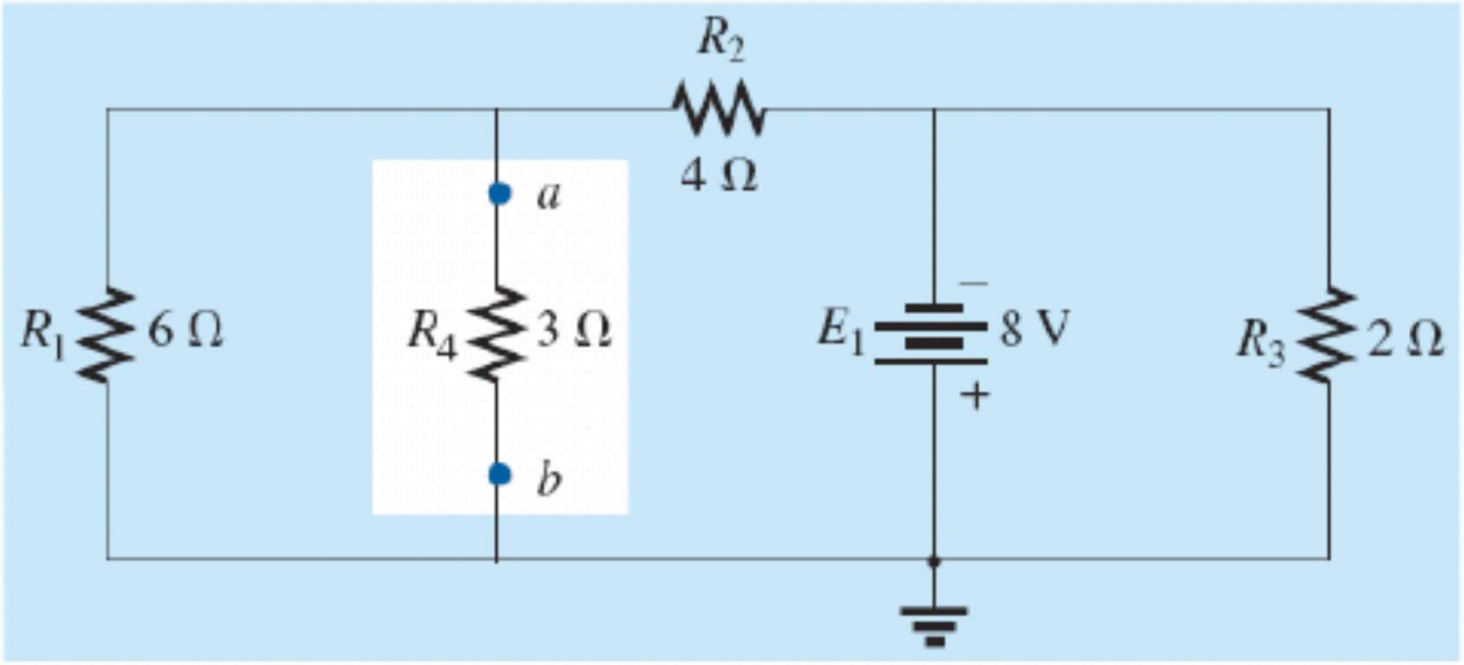


FIG. 9.37 *Example 9.8.*

SOLUTION

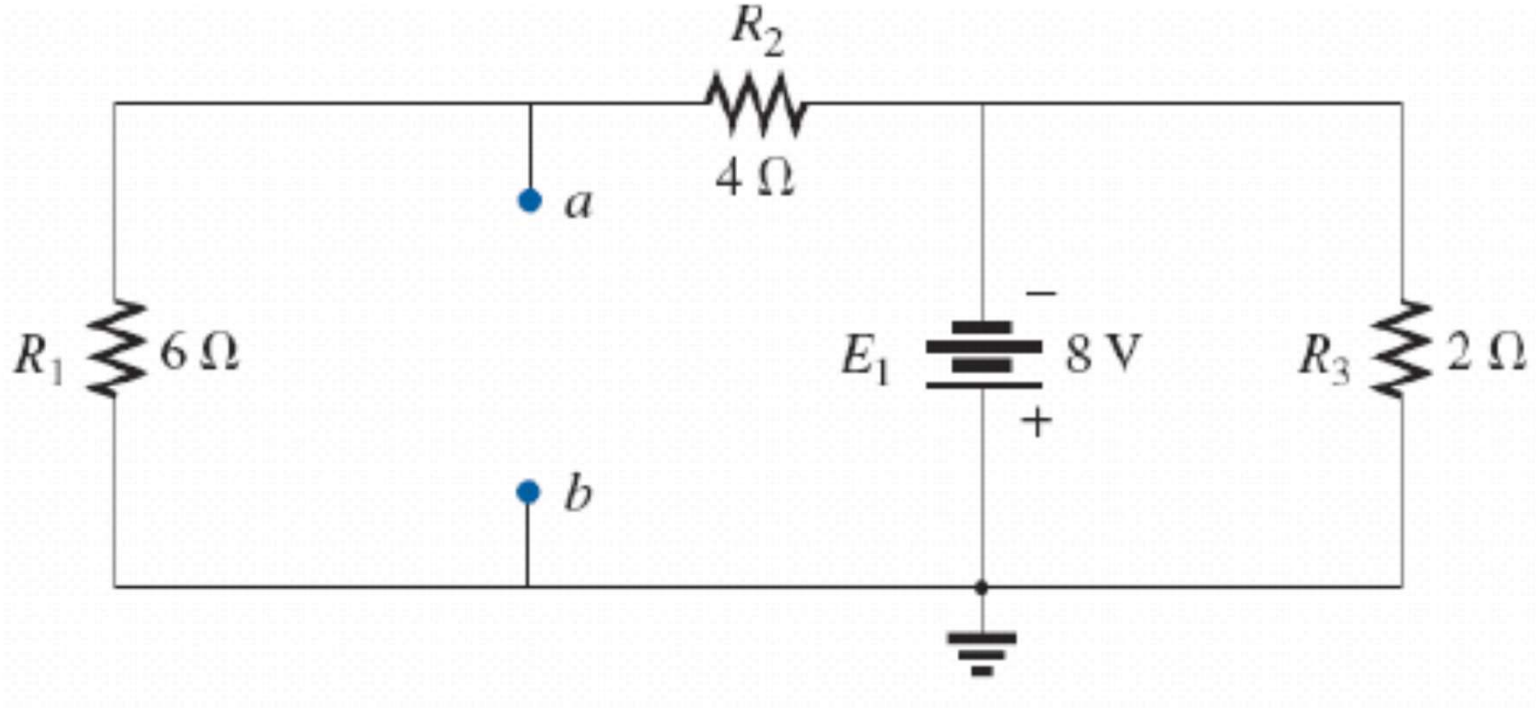


FIG. 9.38 *Identifying the terminals of particular interest for the network in Fig. 9.37.*

SOLUTION

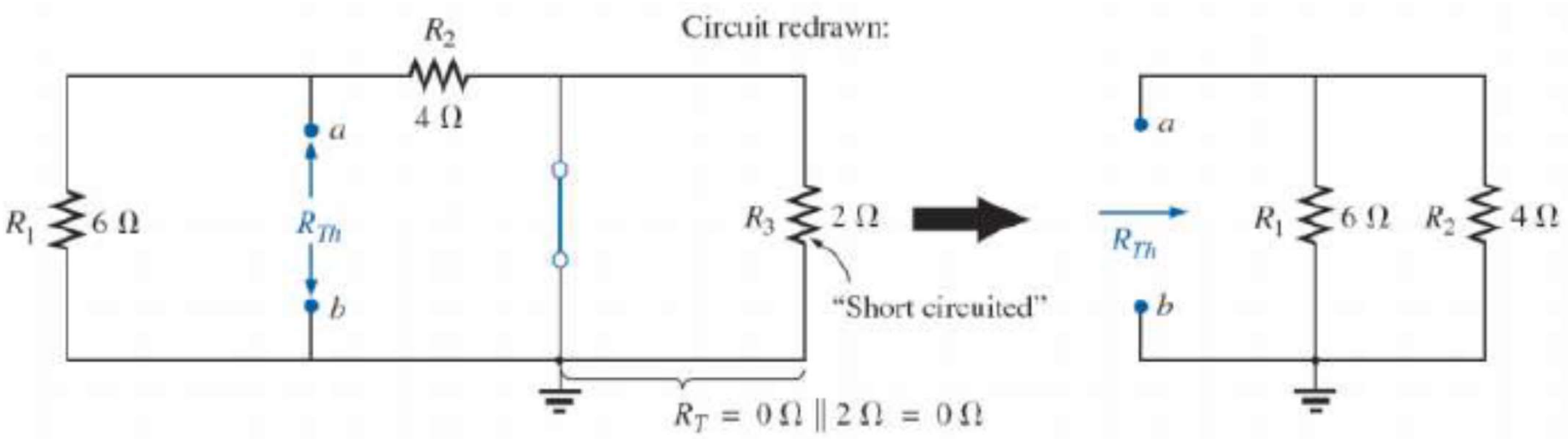


FIG. 9.39 *Determining R_{Th} for the network in Fig. 9.38.*

SOLUTION

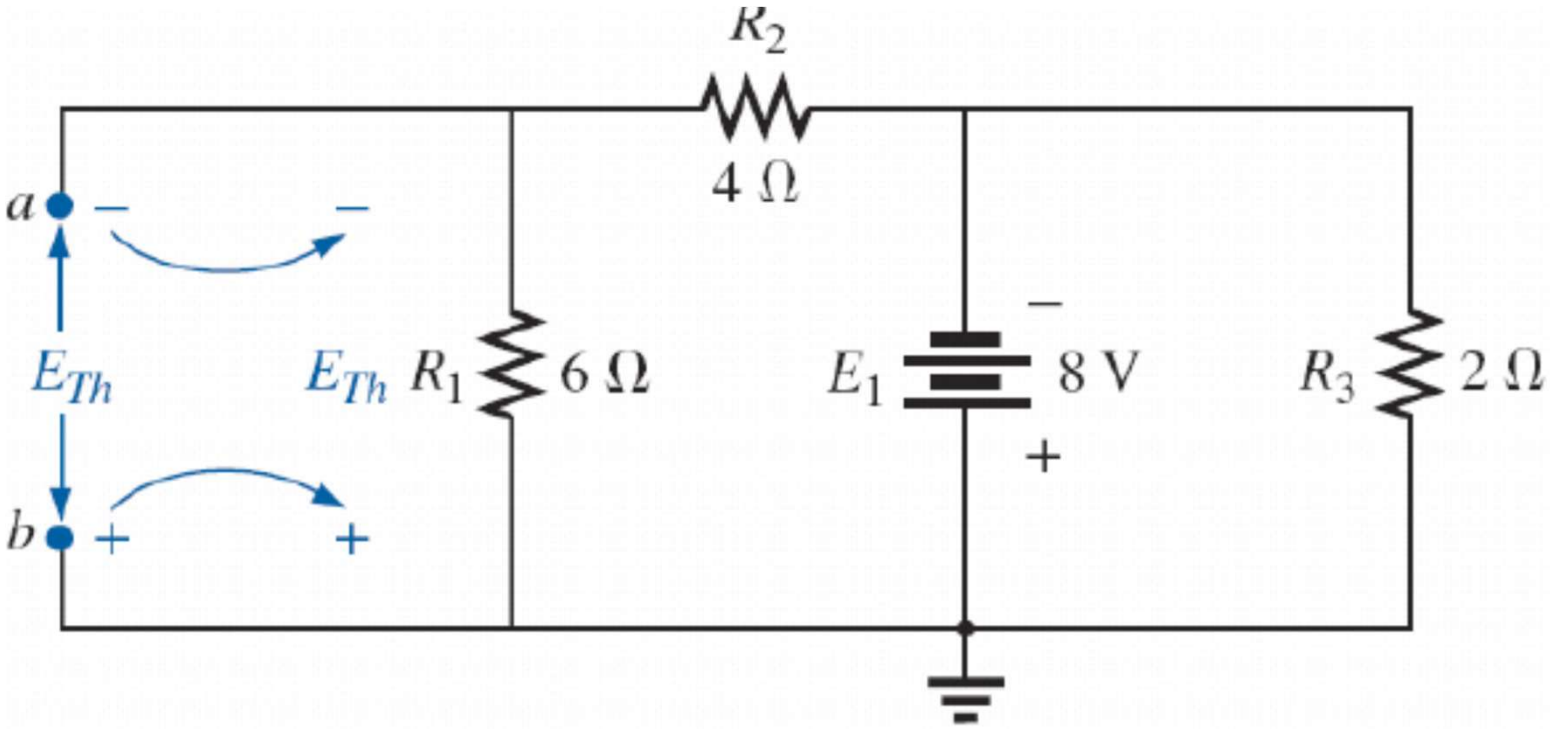


FIG. 9.40 *Determining E_{Th} for the network in Fig. 9.38.*

SOLUTION

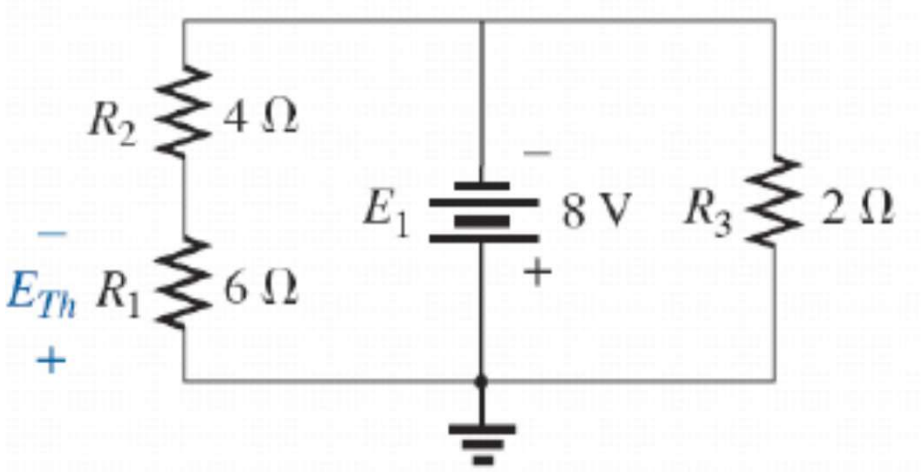


FIG. 9.41 *Network of Fig. 9.40 redrawn.*

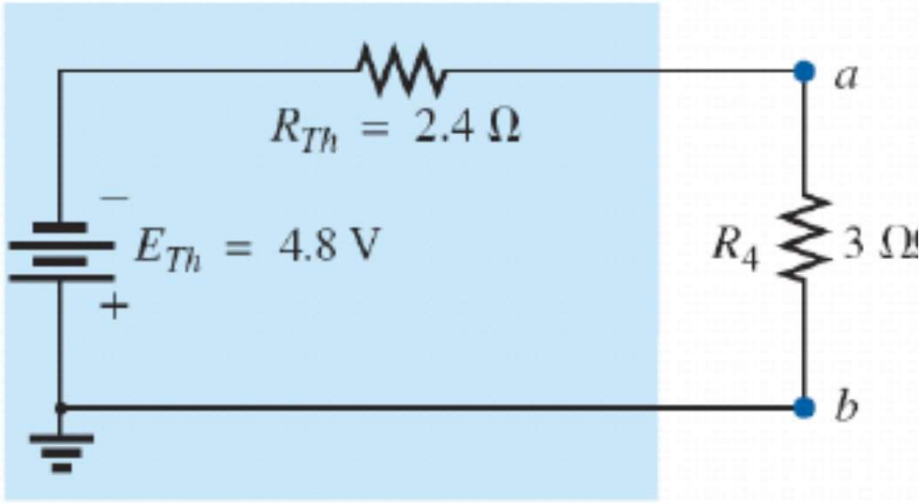


FIG. 9.42 *Substituting the Thévenin equivalent circuit for the network external to the resistor R_4 in Fig. 9.37.*

EXAMPLE

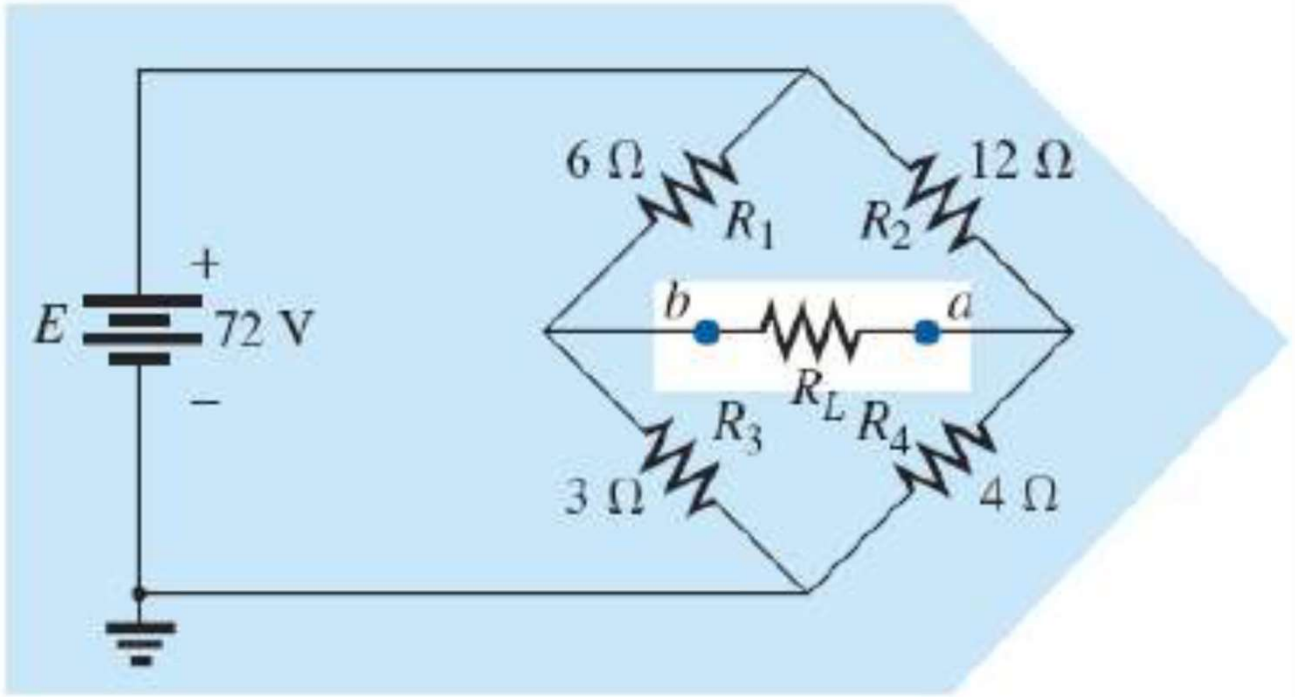


FIG. 9.43 *Example 9.9.*

SOLUTION

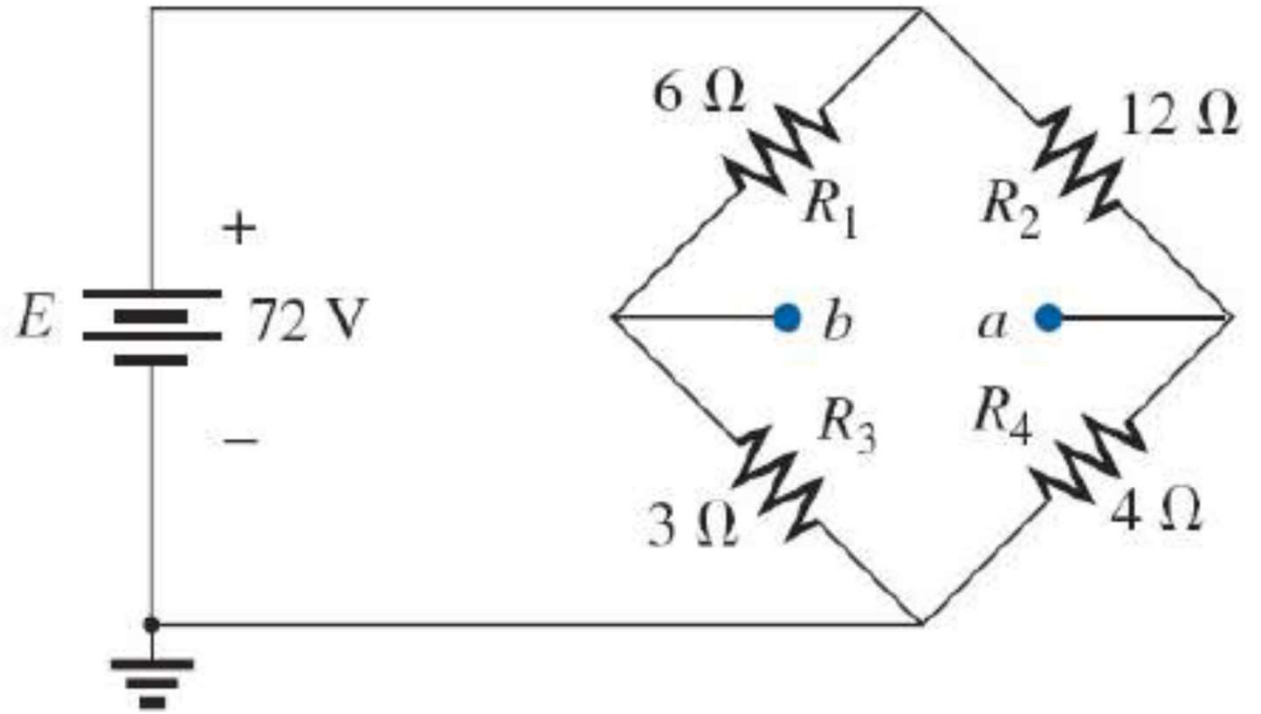


FIG. 9.44 *Identifying the terminals of particular interest for the network in Fig. 9.43.*

SOLUTION

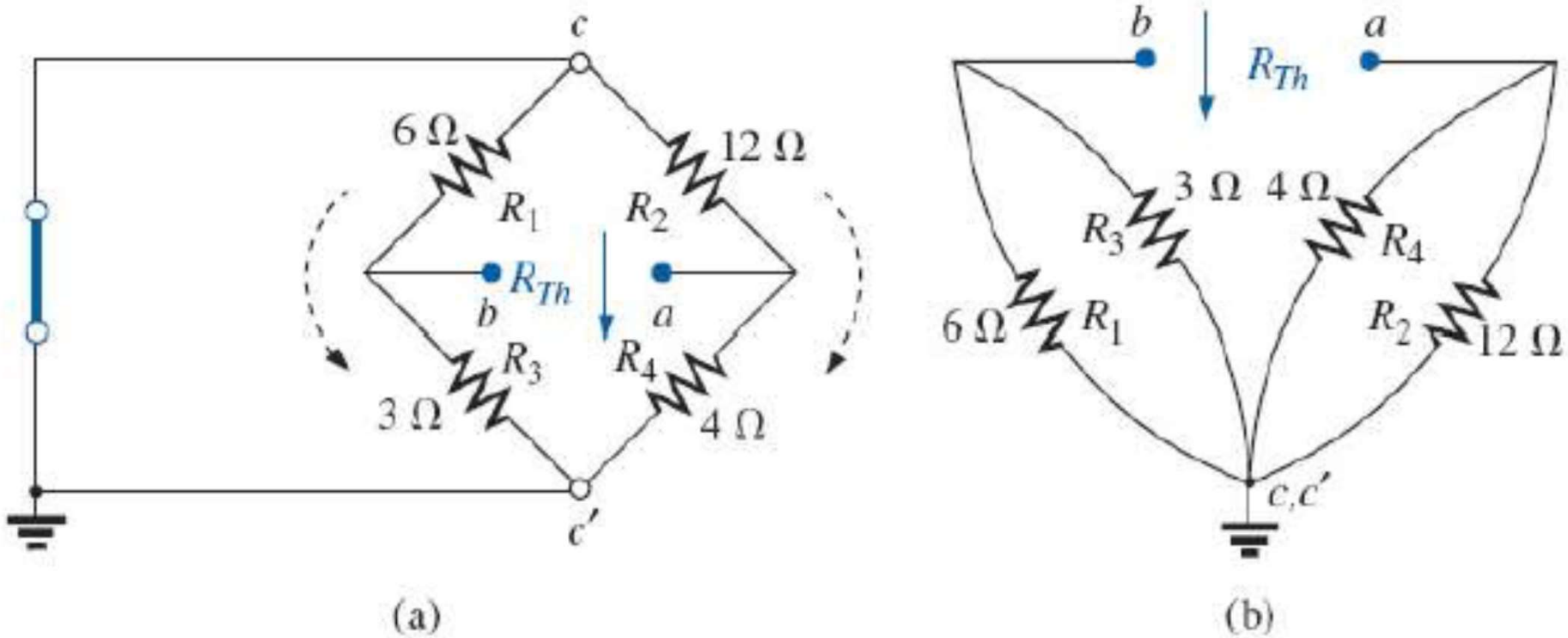


FIG. 9.45 *Solving for R_{Th} for the network in Fig. 9.44.*

SOLUTION

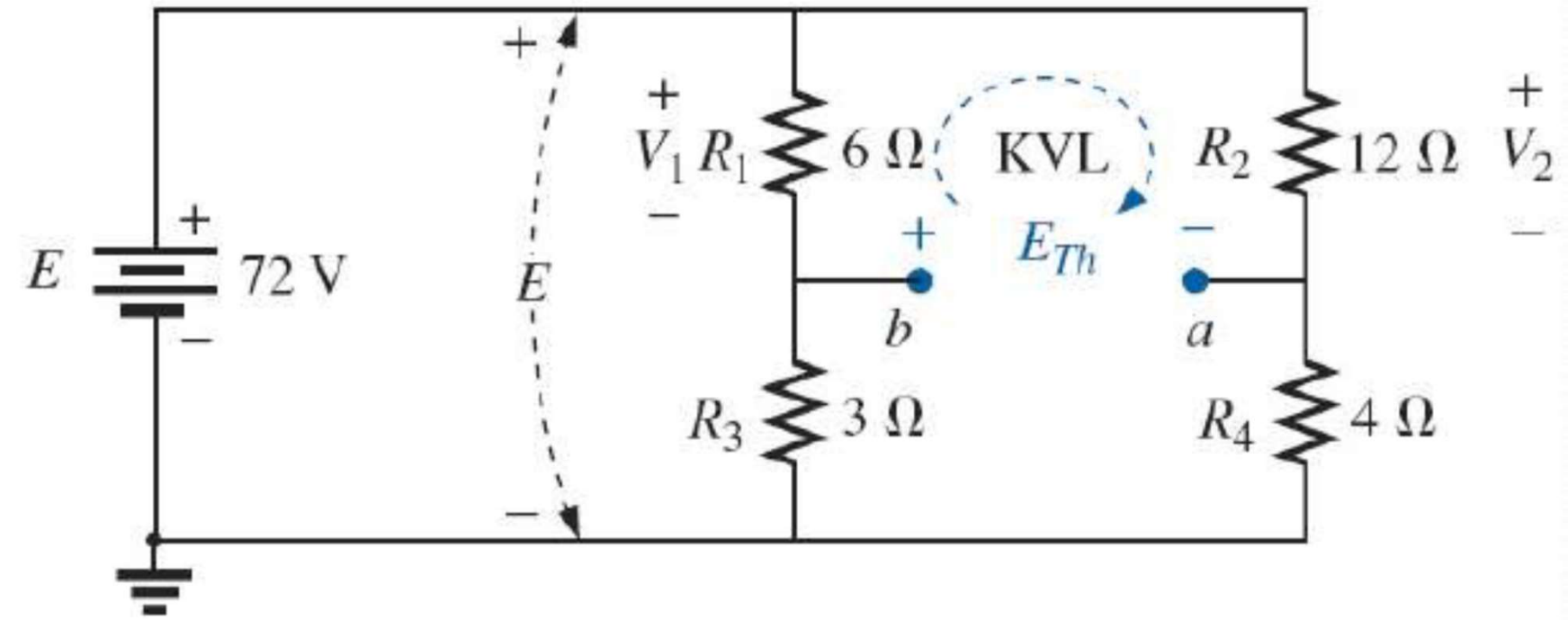


FIG. 9.46 *Determining ET_h for the network in Fig. 9.44.*

SOLUTION

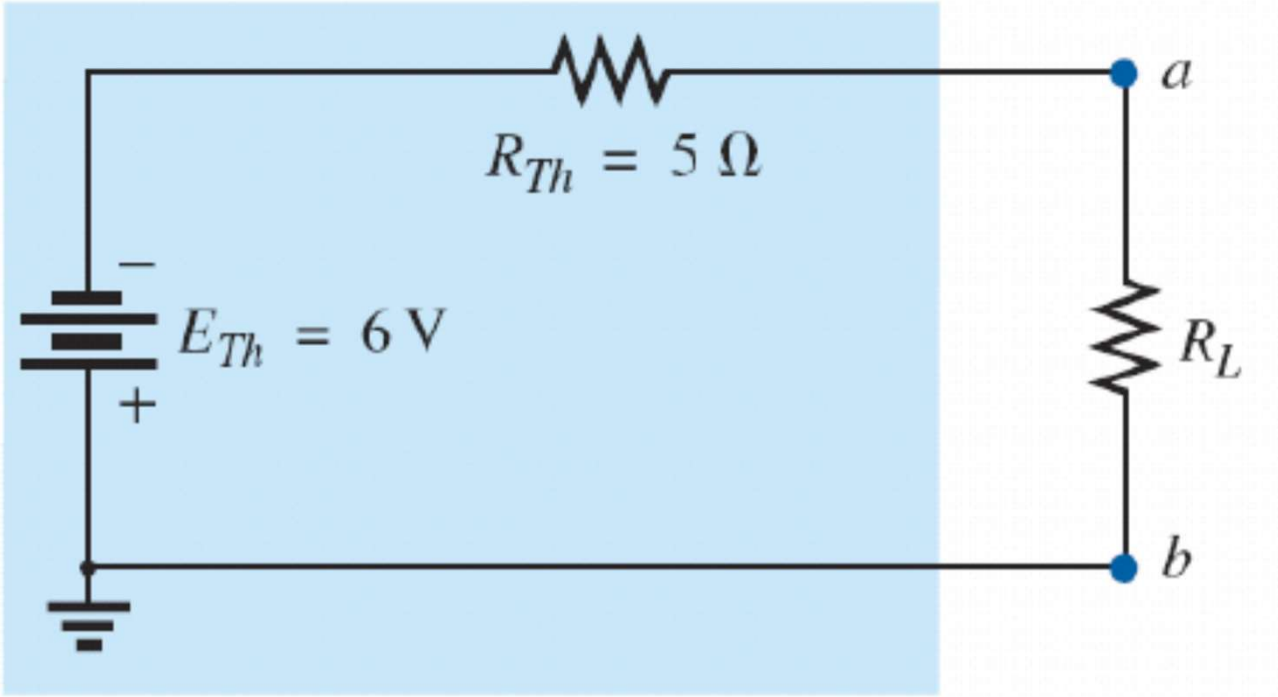


FIG. 9.47 *Substituting the Thévenin equivalent circuit for the network external to the resistor RL in Fig. 9.43.*

EXAMPLE

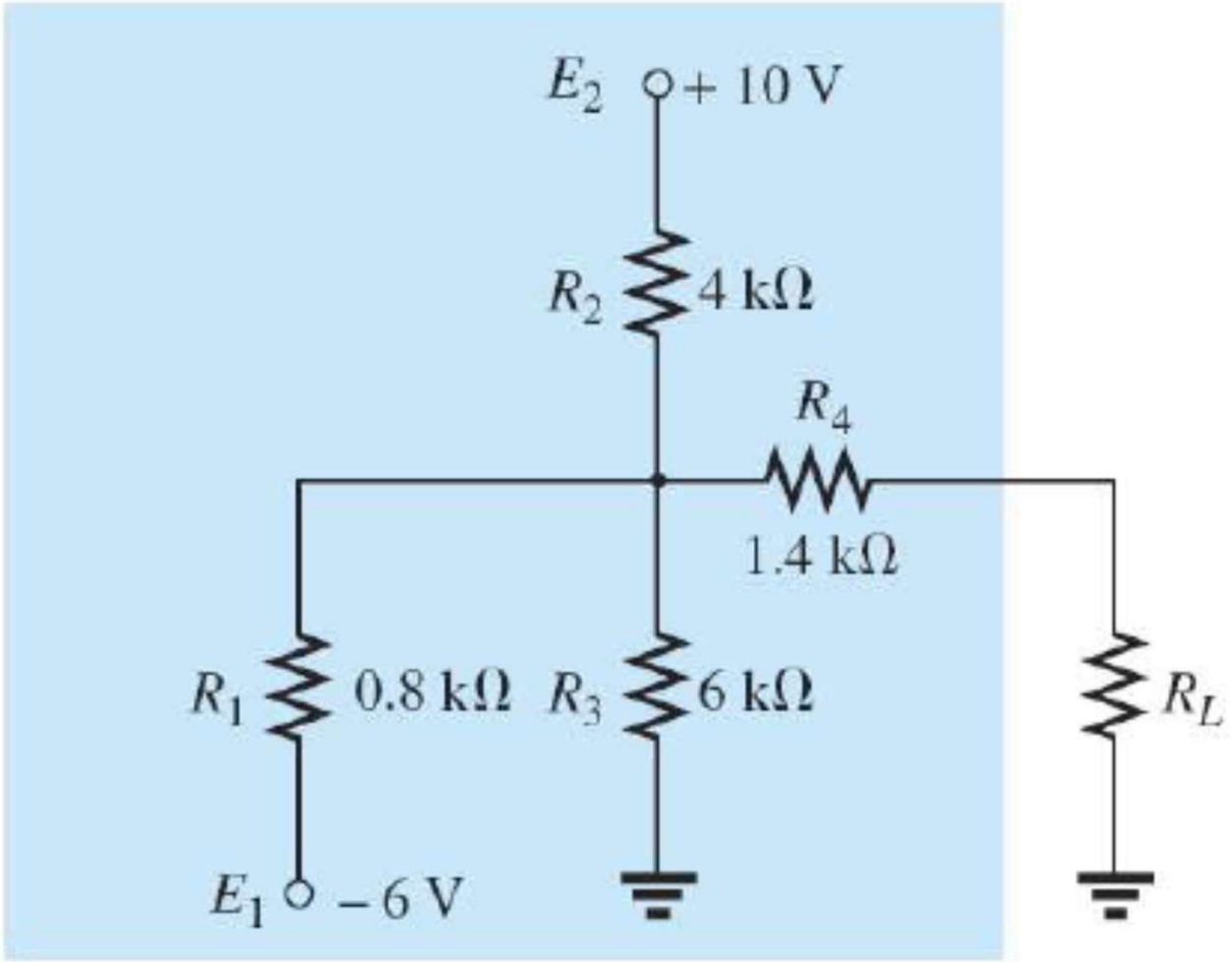


FIG. 9.48 *Example 9.10.*

SOLUTION

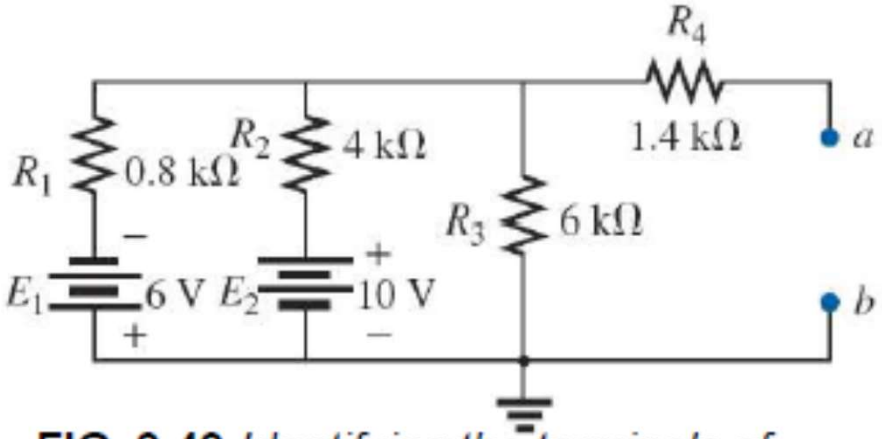


FIG. 9.49 *Identifying the terminals of particular interest for the network in Fig. 9.48.*

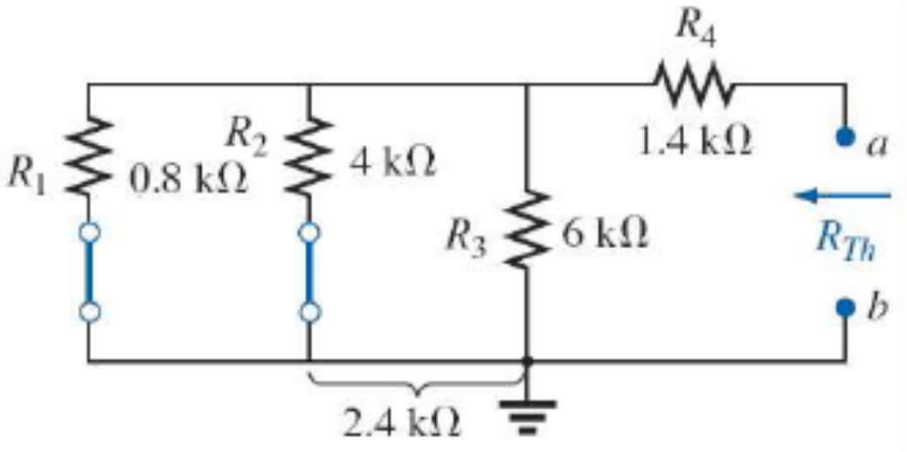


FIG. 9.50 *Determining R_{Th} for the network in Fig. 9.49.*

SOLUTION

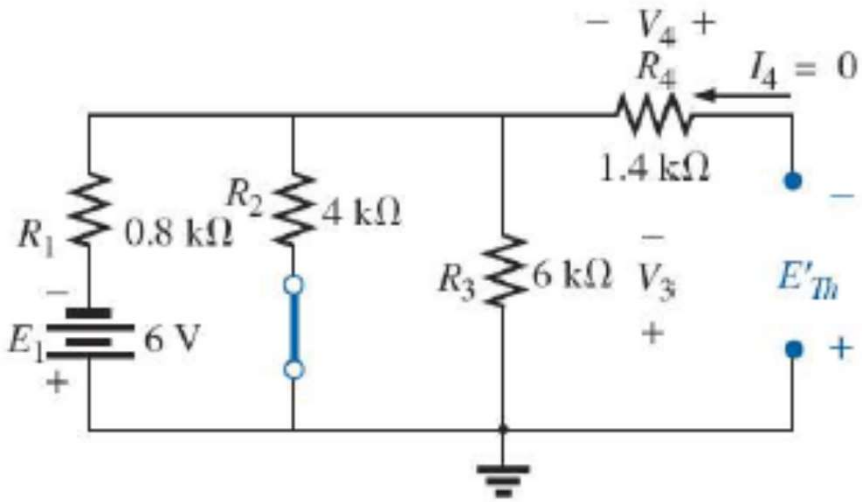


FIG. 9.51 *Determining the contribution to E_{Th} from the source E_1 for the network in Fig. 9.49.*

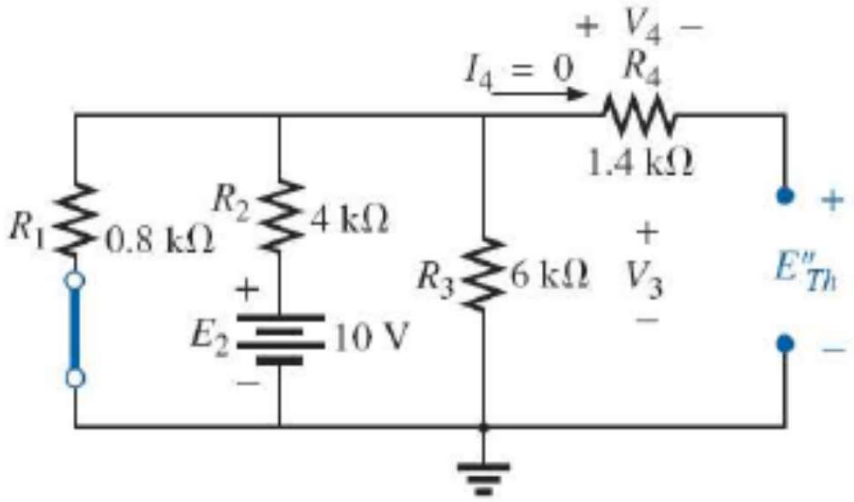


FIG. 9.52 *Determining the contribution to E_{Th} from the source E_2 for the network in Fig. 9.49.*

SOLUTION

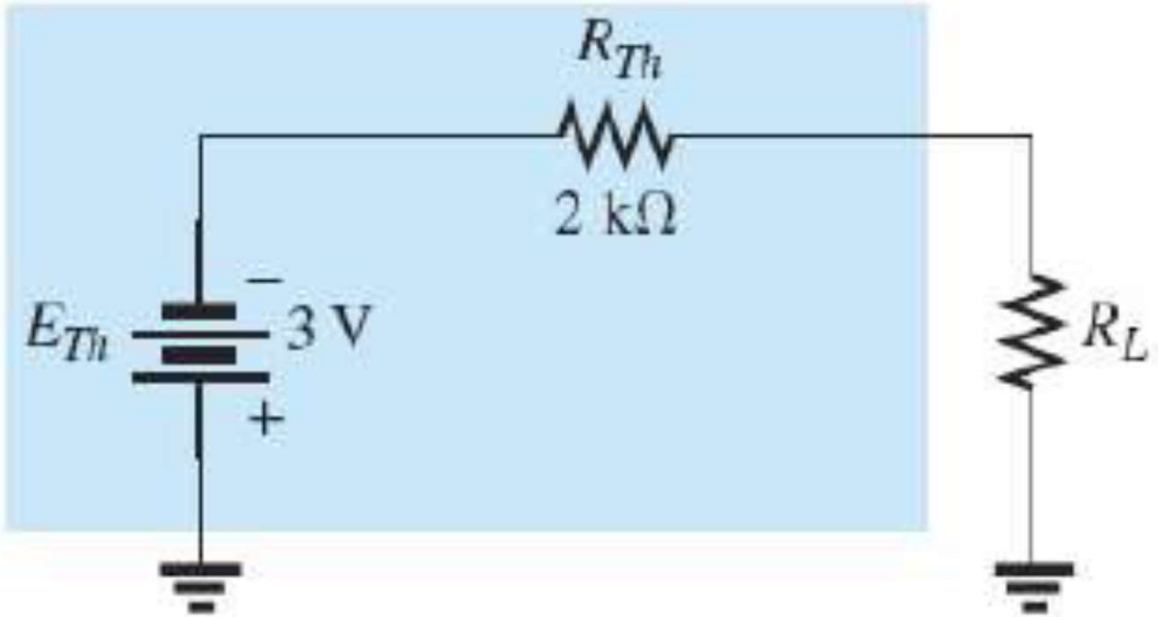


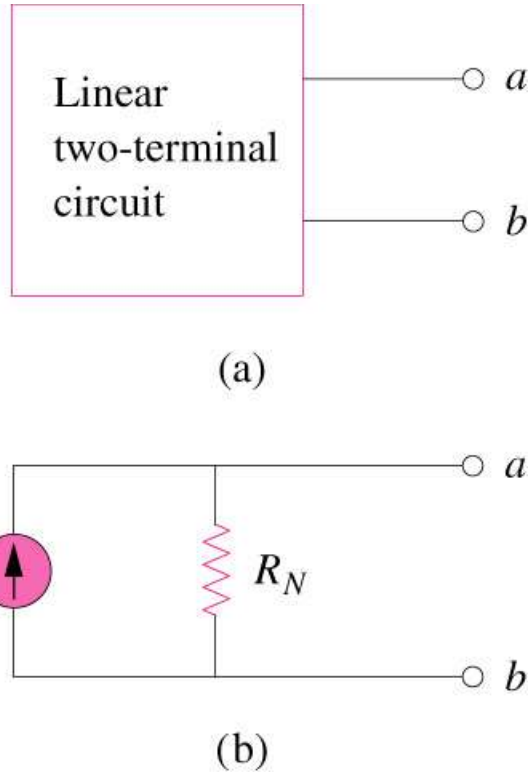
FIG. 9.53 *Substituting the Thévenin equivalent circuit for the network external to the resistor R_L in Fig. 9.48.*

NORTON'S THEOREM

It states that a linear two-terminal circuit can be replaced by an equivalent circuit of a current source I_N in parallel with a resistor R_N,

Where

- I_N is the short circuit current through the terminals.
- R_N is the input or equivalent resistance at the terminals when the independent sources are turned off.



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

EXAMPLE

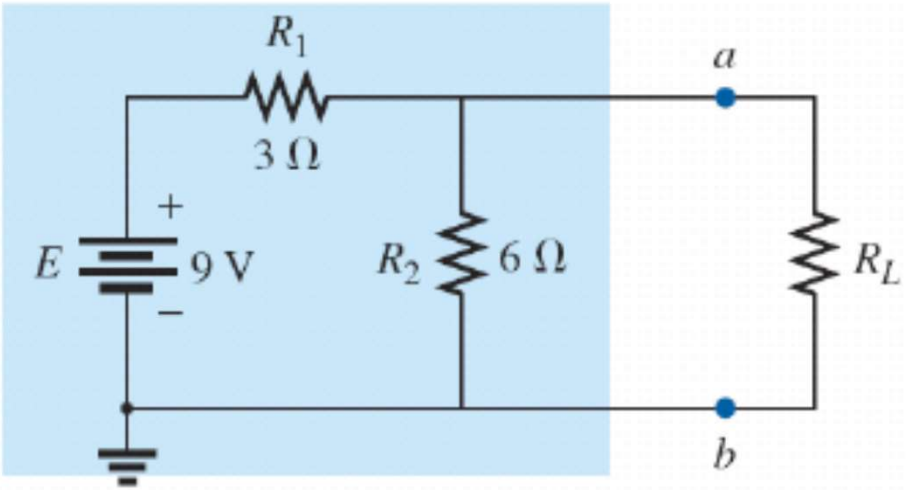


FIG. 9.61 *Example 9.11.*

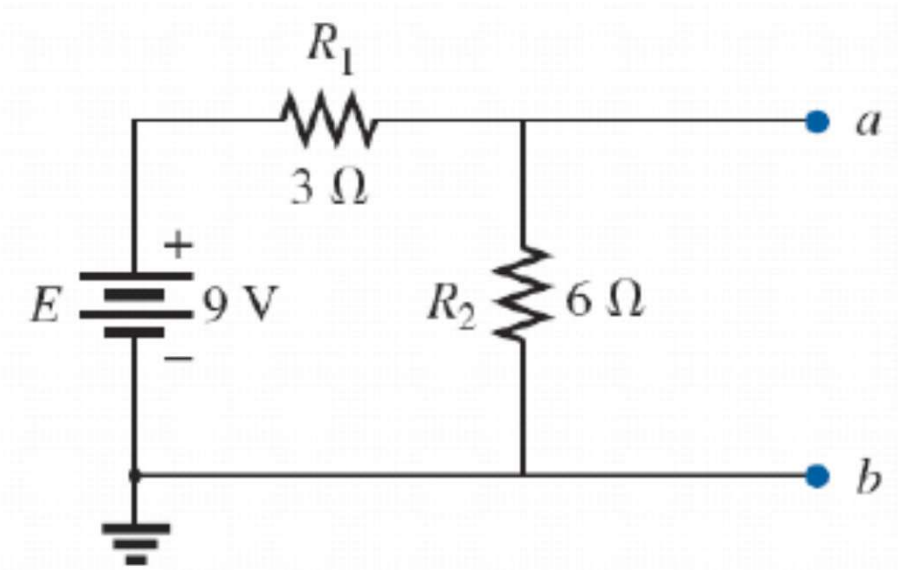


FIG. 9.62 *Identifying the terminals of particular interest for the network in Fig. 9.61.*

SOLUTION

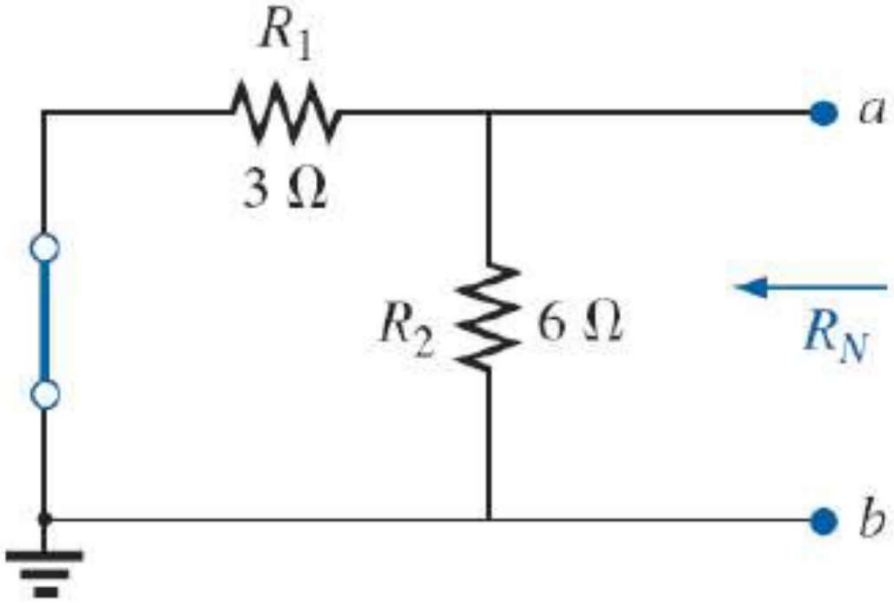


FIG. 9.63 *Determining R_N for the network in Fig. 9.62.*

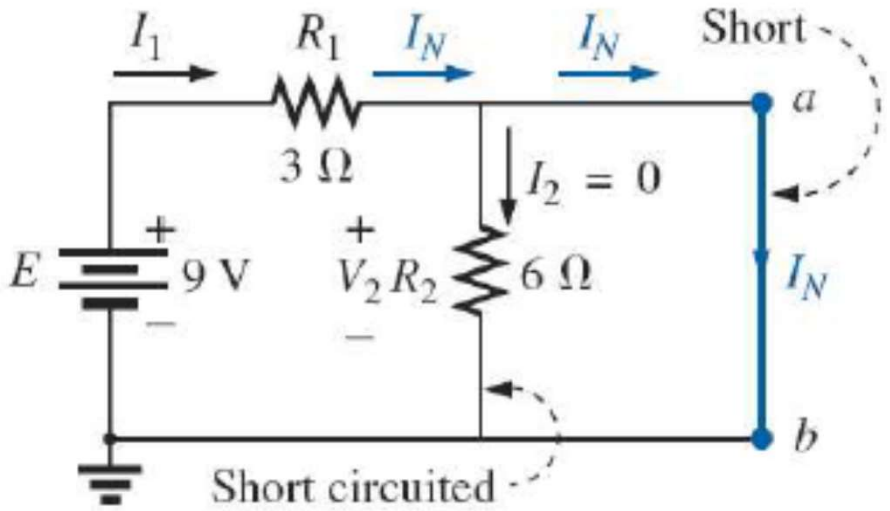


FIG. 9.64 *Determining I_N for the network in Fig. 9.62.*

SOLUTION

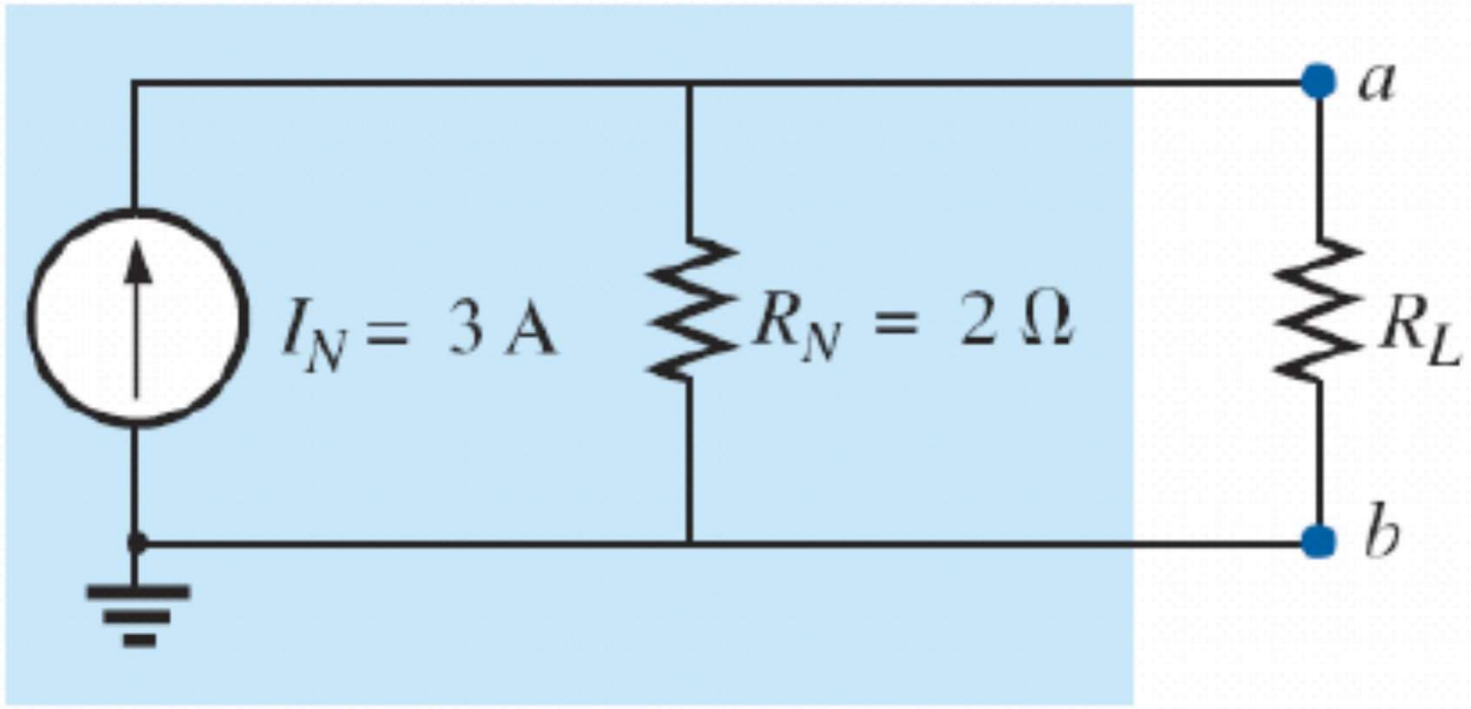


FIG. 9.65 *Substituting the Norton equivalent circuit for the network external to the resistor R_L in Fig. 9.61.*

EXAMPLE

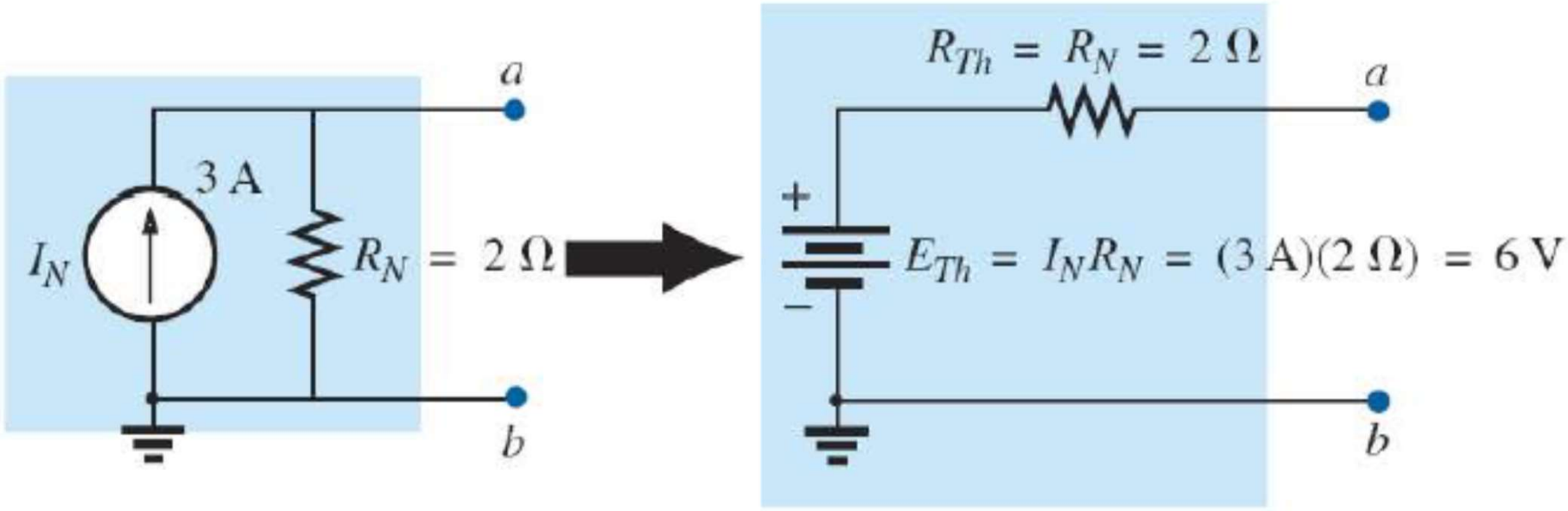


FIG. 9.66 *Converting the Norton equivalent circuit in Fig. 9.65 to a Thévenin equivalent circuit.*