# Thévenin and Norton Equivalents

The **Thévenin equivalent** method allows you to replace any circuit consisting of independent sources, dependent sources, and resistors with a simple circuit consisting of a single voltage source in series with a single resistor where the simple circuit is **equivalent** to the original circuit. This means that a resistor first attached to the original circuit and then attached to the simple circuit could not distinguish between the two circuits, since the resistor would experience the same voltage drop, the same current flow, and thus the same power dissipation. The Thévenin equivalent method can thus be used to reduce the complexity of a circuit and make it much easier to analyze. A **Norton equivalent** circuit consists of a single current source in parallel with a single resistor and can be constructed from a Thévenin equivalent circuit using source transformation. Thus in this section we will present a technique for calculating the component values for a Thévenin equivalent circuit; if you want the Norton equivalent circuit, you can calculate the Thévenin equivalent circuit and use source transformation.

There are three important quantities that make up a Thévenin equivalent circuit: the open-circuit voltage, $v_{\text{oc}}$, the short-circuit current, $i_{\text{sc}}$, and the Thévenin equivalent resistance, $\mathrm{R}_{\text{Th}}$. In the Thévenin equivalent circuit, the value of the voltage source is $v_{\text{oc}}$ and the value of the series resistor is $\mathrm{R}_{\text{Th}}$. In the Norton equivalent circuit, the value of the current source is $i_{\text{sc}}$ and the value of the parallel resistor is $\mathrm{R}_{\text{Th}}$. But it is not necessary to calculate all three quantities, since they are related by the following equation:

$$v_{\text{oc}} = \mathrm{R}_{\text{Th}} i_{\text{sc}}.$$

Thus we need to determine just two of these three quantities, and can use their relationship to find the third quantity, if desired.

In circuits containing only independent sources and resistors, our Thévenin equivalent method will determine the values of $v_{\text{oc}}$ and $\mathrm{R}_{\text{Th}}$. When a circuit also contains dependent sources we will modify the method and determine $v_{\text{oc}}$ and $i_{\text{sc}}$. In the examples and practice problems that follow we will calculate the Thévenin equivalent or Norton equivalent circuit as seen from a single load resistor. We will then reattach the load resistor to the Thévenin equivalent or Norton equivalent circuit and analyze this simplified circuit to determine a requested quantity.

The Thévenin equivalent method can be broken into the following steps:

1. First calculate the open-circuit voltage. Draw the circuit with the load resistor removed, which creates an open circuit where the resistor once was. Label this circuit with + and − polarity markings and the symbol $v_{\text{oc}}$. Then use any circuit analysis technique to determine the value of $v_{\text{oc}}$. In the examples we will usually use the mesh current method or the node voltage method.

2. Next calculate the Thévenin equivalent resistance if the circuit contains only independent sources and resistors, or the short-circuit current if the circuit also contains dependent sources. To calculate the Thévenin equivalent resistance, draw the circuit with the load resistor removed. From the perspective of the resulting open circuit, calculate the equivalent resistance. To do this, replace all voltage sources with short circuits and all current sources with open circuits. Then make series and parallel combinations of the remaining resistors until only one resistor remains. This is the Thévenin equivalent resistor. If there are dependent sources in the circuit, you cannot use the previous method to calculate the Thévenin equivalent resistance because you cannot remove the independent sources without changing the way the dependent sources behave. Therefore you must calculate the short-circuit current instead. To do this, draw the circuit the the load resistor removed and replaced by a short circuit (a wire). Label the current in the short circuit $i_{\text{sc}}$. Then use any circuit analysis technique to determine the value of $i_{\text{sc}}$. We usually employ the node voltage method or the mesh current method. Remember that we can use the open-circuit voltage and the short-circuit current to determine the Thévenin equivalent resistance with the equation
$$\mathrm{R}_{\mathrm{Th}} = \frac{v_{\text{oc}}}{i_{\text{sc}}}.$$

3. Now draw the Thévenin equivalent circuit, which consists of a voltage source with the value $v_{\text{oc}}$ in series with a resistor whose value is $\mathrm{R}_{\mathrm{Th}}$, or the Norton equivalent circuit, which consists of a current source with the value $i_{\text{sc}}$ in parallel with a resistor whose value is $\mathrm{R}_{\mathrm{Th}}$. Then attach the original load resistor to complete the circuit. Use any circuit analysis method to determine the requested voltage, current or power in this simplified circuit.

4. You can check your result by analyzing the original circuit using any appropriate circuit analysis technique. We will usually employ the node voltage method or the mesh current method.

The first example is a circuit without dependent sources. We consider circuits with dependent sources in the second example.

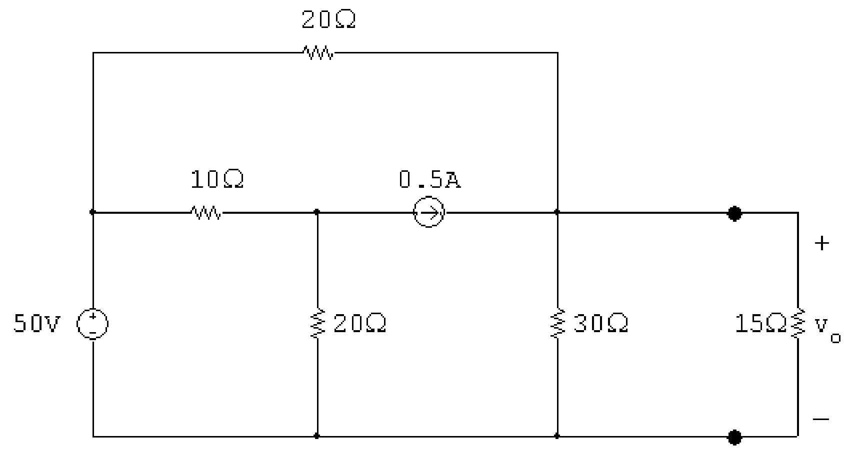


Figure 1: The circuit for Thévenin Equivalent Example 1

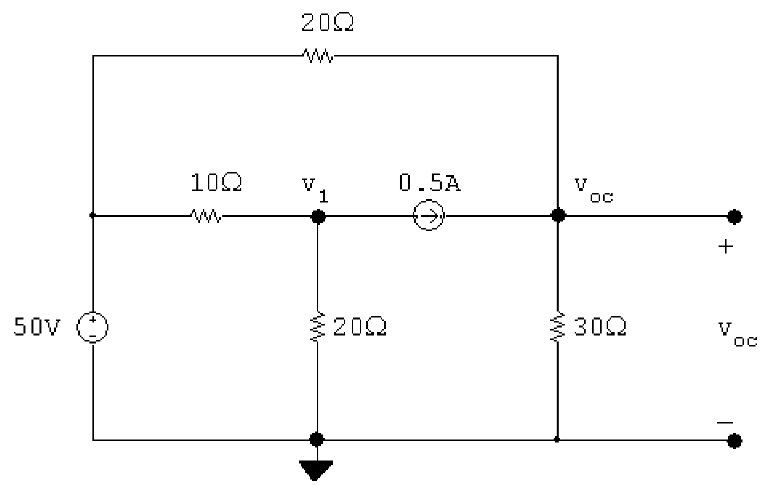


Figure 2: The circuit for Thévenin Equivalent Example 1, configured to determine the open-circuit voltage $v_{\text{oc}}$.

# Thévenin Equivalent Example 1

Find $v_o$ for the circuit in Fig. 1 by replacing the circuit to the left of the 15Ω resistor with its Thévenin equivalent and analyzing the resulting simplified circuit.

# Solution

1. Redraw the circuit in Fig. 1 with the 15Ω resistor replaced by an open circuit labeled $v_{\text{oc}}$ and calculate the value of $v_{\text{oc}}$. We will use the node voltage method to determine $v_{\text{oc}}$, so we have identified the reference node and labeled the remaining non-reference essential nodes with symbols if the voltage at the node is not known. The resulting circuit is shown in Fig. 2. The node voltage equations are

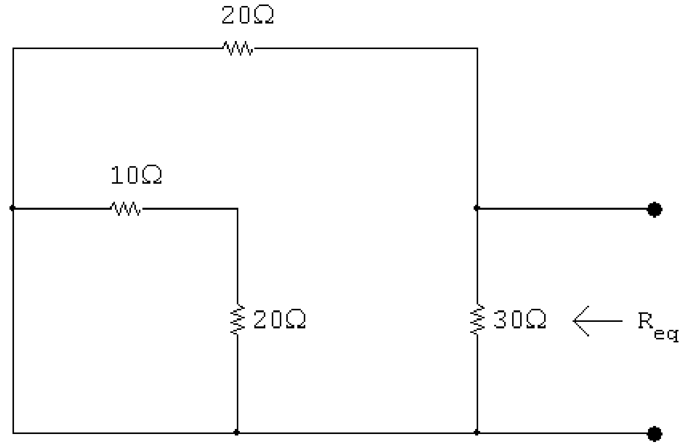


Figure 3: The circuit for Thévenin Equivalent Example 1, configured to determine the Thévenin equivalent resistance $R_{Th}$.

$$\begin{aligned} \text{At } v_1: \quad & \frac{v_1 - 50}{10} + \frac{v_1}{20} + 0.5 &= 0 \\ \text{At } v_{oc}: \quad & \frac{v_{oc} - 50}{20} + \frac{v_{oc}}{30} - 0.5 &= 0 \end{aligned}$$

Rewriting the node voltage equations in standard form we get

$$\begin{aligned} \text{At } v_1: \quad & \left(\frac{1}{10} + \frac{1}{20}\right) v_1 \quad + \quad (0)v_{oc} &= (50/10) - 0.5 \\ \text{At } v_{oc}: \quad & (0)v_1 \quad + \quad \left(\frac{1}{20} + \frac{1}{30}\right) v_{oc} &= (50/20) + 0.5 \end{aligned}$$

The calculator solution is

$$v_1 = 30 \text{ V}; \qquad v_{oc} = 36 \text{ V}.$$

2. Since there are no dependent sources in the circuit in Fig. 1 we can calculate the Thévenin equivalent resistance. To do this, redraw the circuit in Fig. 1, replacing the 15Ω resistor with an open circuit, the current source with an open circuit, and the voltage source with a short circuit. The resulting circuit is shown in Fig. 3. Notice that in Fig. 3 the 10Ω and 20Ω resistors in the lower left have been bypassed by a short circuit, and that the remaining 20Ω and 30Ω resistors are in parallel. Therefore, the equivalent resistance is given by

$$R_{Th} = 20 \| 30 = \frac{(20)(30)}{20 + 30} = 12\Omega.$$

3. Now draw the Thévenin equivalent circuit and attach the 15Ω resistor. The result is shown in Fig. 4. To find $v_o$ in this simple circuit, use voltage division:

$$v_o = \frac{15}{15 + 12}(36) = 20 \text{ V}$$

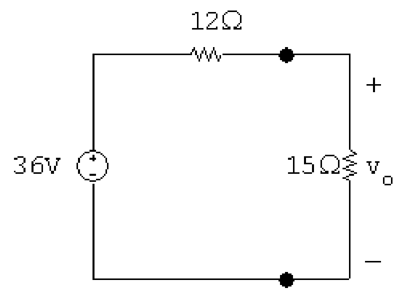


Figure 4: The circuit for Thévenin Equivalent Example 1, with the components to the left of the 15Ω resistor replaced by a Thévenin equivalent.

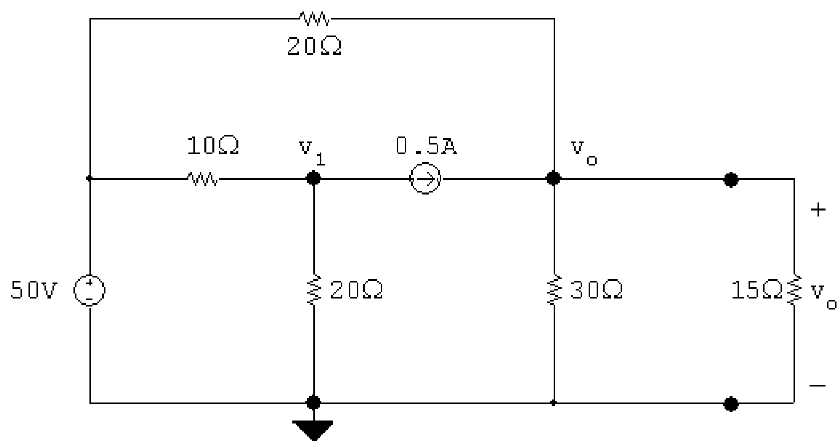


Figure 5: The circuit for Thévenin Equivalent Example 1, prepared for node voltage analysis.

4. We can check this result by analyzing the original circuit in Fig. 1 to find $v_o$. We choose the node voltage method for this analysis, and the circuit in Fig. 5 is configured for such analysis. The node voltage equations are

$$\begin{aligned} \text{At } v_1: \quad & \frac{v_1 - 50}{10} + \frac{v_1}{20} + 0.5 &= 0 \\ \text{At } v_o: \quad & \frac{v_o - 50}{20} + \frac{v_o}{30} + \frac{v_o}{15} - 0.5 &= 0 \end{aligned}$$

Rewriting the node voltage equations in standard form we get

$$\begin{aligned} \text{At } v_1: \quad & \left(\frac{1}{10} + \frac{1}{20}\right) v_1 \quad + \quad (0) v_{oc} &= (50/10) - 0.5 \\ \text{At } v_o: \quad & (0) v_1 \quad + \quad \left(\frac{1}{20} + \frac{1}{30} + \frac{1}{15}\right) &= (50/20) + 0.5 \end{aligned}$$

The calculator solution is

$$v_1 = 30 \text{ V}; \qquad v_o = 20 \text{ V}.$$

Thus the solution obtained with the Thévenin equivalent circuit is confirmed.

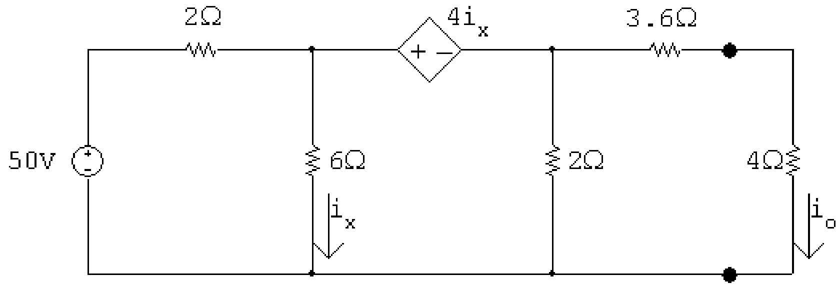


Figure 6: The circuit for Thévenin Equivalent Example 2

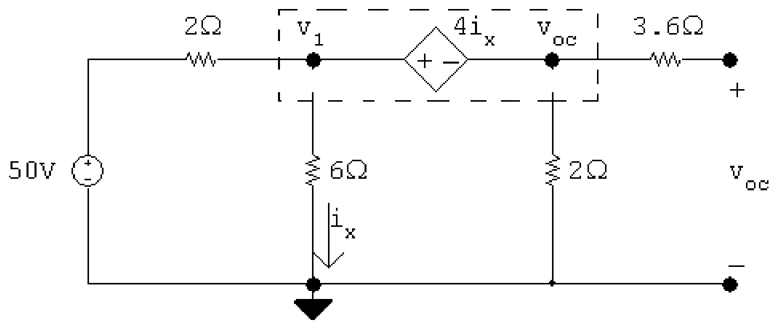


Figure 7: The circuit for Thévenin Equivalent Example 1, configured to determine the open-circuit voltage $v_{\text{oc}}$.

## Thévenin Equivalent Example 2

Find $i_o$ for the circuit in Fig. 6 by replacing the circuit to the left of the $4\Omega$ resistor with its Norton equivalent and analyzing the resulting simplified circuit.

## Solution

1. Redraw the circuit in Fig. 6 with the $4\Omega$ resistor replaced by an open circuit labeled $v_{\text{oc}}$ and calculate the value of $v_{\text{oc}}$. We will use the node voltage method to determine $v_{\text{oc}}$, so we have identified the reference node. The remaining non-reference essential nodes form a single supernode with the dependent source, so we label those nodes with symbols and identify the suprenode. The resulting circuit is shown in Fig. 7. The node voltage analysis equations consist of one supernode equation and two constraint equations, one for the supernode and one for the dependent source. The equations are

$$\begin{aligned}
\text{Supernode:} \quad & \frac{v_1 - 50}{2} + \frac{v_1}{6} + \frac{v_{\text{oc}}}{2} &= \quad & 0 \\
\text{Constraint:} \quad & v_1 - v_{\text{oc}} &= \quad & 4i_x \\
\text{Constraint:} \quad & \frac{v_1}{6} &= \quad & i_x
\end{aligned}$$

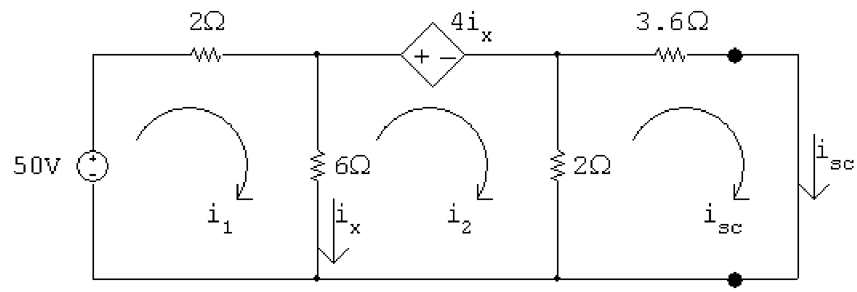


Figure 8: The circuit for Thévenin Equivalent Example 2, configured to determine the short-circuit current $i_{\text{sc}}$.

Rewriting the node voltage equations in standard form we get

$$\begin{array}{lccccccc}
\text{Supernode:} & \left(\frac{1}{2}+\frac{1}{6}\right)v_1 & + & \left(\frac{1}{2}\right)v_{\text{oc}} & + & (0)i_x & = & (50/2) \\
\text{Constraint:} & (1)v_1 & + & (-1)v_{\text{oc}} & + & (-4)i_x & = & 0 \\
\text{Constraint:} & \left(\frac{1}{6}\right)v_1 & + & (0)v_{\text{oc}} & + & (-1)i_x & = & 0
\end{array}$$

The calculator solution is

$$v_1 = 30\text{ V}; \qquad v_{\text{oc}} = 10\text{ V}; \qquad i_x = 5\text{ A}.$$

2. Since there is a dependent source in the circuit in Fig. 6 we must calculate the short-circuit current. To do this, redraw the circuit in Fig. 6, replacing the 4Ω resistor with short circuit and label the current in the short circuit $i_{\text{sc}}$. Since we want to find this short-circuit current the mesh current method is a good choice, so we also identify and label the mesh currents. The resulting circuit is shown in Fig. 8. We need three mesh current equations and a constraint equation for the dependent source. The equations are The equations are

$$\begin{array}{lccc}
\text{Left mesh:} & -50 + 8i_1 + 6(i_1 - i_2) & = & 0 \\
\text{Center mesh:} & 4i_x + 2(i_2 - i_{\text{sc}}) + 6(i_2 - i_1) & = & 0 \\
\text{Right mesh:} & 3.6i_{\text{sc}} + 2(i_{\text{sc}} - i_2) & = & 0 \\
\text{Constraint:} & i_1 - i_2 & = & i_x
\end{array}$$

Rewriting the mesh current equations in standard form we get

$$\begin{array}{lccccccccc}
\text{Left mesh:} & (8)i_1 & + & (-6)i_2 & + & (0)i_{\text{sc}} & + & (0)i_x & = & 50 \\
\text{Center mesh:} & (-6)i_1 & + & (8)i_2 & + & (-2)i_{\text{sc}} & + & (4)i_x & = & 0 \\
\text{Right mesh:} & (0)i_1 & + & (-2)i_2 & + & (5.6)i_{\text{sc}} & + & (0)i_x & = & 0 \\
\text{Constraint:} & (1)i_1 & + & (-1)i_2 & + & (0)i_{\text{sc}} & + & (-1)i_x & = & 0
\end{array}$$

The calculator solution is

$$i_1 = 11.5\text{ A}; \qquad i_2 = 7\text{ A}; \qquad i_{\text{sc}} = 2.5\text{ A}; \qquad i_x = 4.5\text{ A}.$$

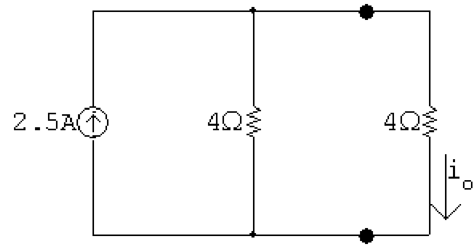


Figure 9: The circuit for Thévenin Equivalent Example 2, with the components to the left of the 4Ω resistor replaced by a Norton equivalent.

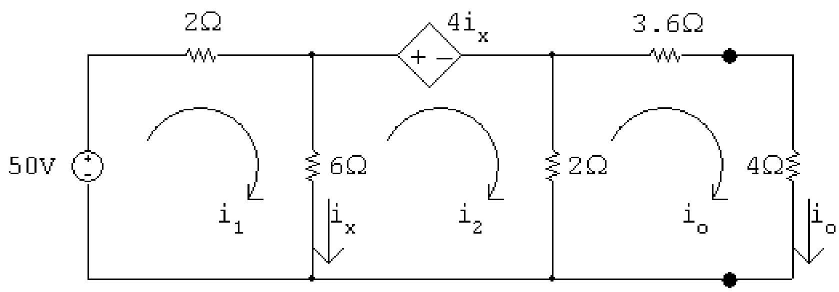


Figure 10: The circuit for Thévenin Equivalent Example 2, prepared for mesh current analysis.

3. Now draw the Norton equivalent circuit by placing a current source whose value is $i_{\text{sc}} = 2.5$A in parallel with a resistor whose value is $\text{r}_{\text{Th}} = v_{\text{oc}}/i_{\text{sc}} = 10/2.5 = 4\Omega$, attach the 4Ω load resistor. The result is shown in Fig. 9. To find $i_o$ in this simple circuit, use current division:

$$i_o = \frac{4}{4+4}(2.5) = 1.25 \text{ A}$$

4. We can check this result by analyzing the original circuit in Fig. 6 to find $i_o$. We choose the mesh current method for this analysis, and the circuit in Fig. 10 is configured for such analysis. We need three mesh current equations and one constraint equation, as shown below:

$$\begin{array}{lrcl}
\text{Left mesh:} & -50 + 8i_1 + 6(i_1 - i_2) & = & 0 \\
\text{Center mesh:} & 4i_x + 2(i_2 - i_o) + 6(i_2 - i_1) & = & 0 \\
\text{Right mesh:} & 3.6i_o + 4i_o + 2(i_o - i_2) & = & 0 \\
\text{Constraint:} & i_1 - i_2 & = & i_x
\end{array}$$

Rewriting the mesh current equations in standard form we get

$$\begin{array}{lccccccccc}
\text{Left mesh:} & (8)i_1 & + & (-6)i_2 & + & (0)i_o & + & (0)i_x & = & 50 \\
\text{Center mesh:} & (-6)i_1 & + & (8)i_2 & + & (-2)i_o & + & (4)i_x & = & 0 \\
\text{Right mesh:} & (0)i_1 & + & (-2)i_2 & + & (9.6)i_o & + & (0)i_x & = & 0 \\
\text{Constraint:} & (1)i_1 & + & (-1)i_2 & + & (0)i_o & + & (-1)i_x & = & 0
\end{array}$$

The calculator solution is

$$i_1 = 10.75 \text{ A}; \qquad i_2 = 6 \text{ A}; \qquad i_o = 1.25 \text{ A}; \qquad i_x = 4.75 \text{ A}.$$

Thus the solution obtained with the Norton equivalent circuit is confirmed.

Now try using the Thévenin equivalent method for each of the practice problems below.

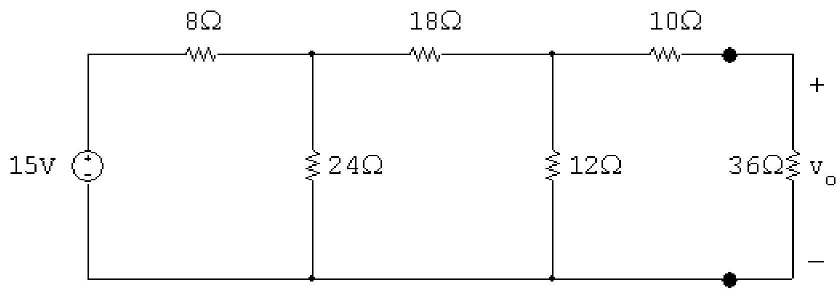


Figure 11: The circuit for Thévenin Equivalent Practice Problem 1.

## Thévenin Equivalent Practice Problem 1

Find $v_o$ for the circuit in Fig. 11 by replacing the circuit to the left of the 36Ω resistor with its Thévenin equivalent.

1. Redraw the circuit in Fig. 11, replacing the 36Ω resistor with an open circuit. Use this circuit to calculate $v_{\text{oc}}$.

2. Are there dependent sources in the circuit? If not, find the Thévenin equivalent resistor by redrawing the circuit in Fig. 11 with the load resistor removed, the voltage sources replaced by short circuits, and the current sources replaced with open circuits. Then make series and parallel combinations of resistors until a single equivalent resistor remains. If there are dependent sources in the circuit, find the short circuit current by redrawing the circuit in Fig. 11, replacing the $36\Omega$ resistor with a short circuit whose current is $i_{\text{sc}}$. Use this circuit to find $i_{\text{sc}}$.

3. Draw the Thévenin equivalent circuit and attach the $36\Omega$ resistor. Use this circuit to calculate $v_o$.

4. Check your solution by analyzing the original circuit in Fig. 11 to find $v_o$.

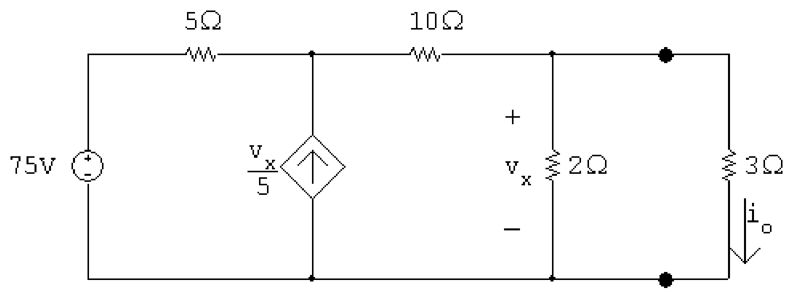


Figure 12: The circuit for Thévenin Equivalent Practice Problem 2.

# Thévenin Equivalent Practice Problem 2

Find $i_o$ for the circuit in Fig. 12 by replacing the circuit to the left of the 3Ω resistor with its Norton equivalent.

1. Redraw the circuit in Fig. 12, replacing the 3Ω resistor with an open circuit. Use this circuit to calculate $v_{\mathrm{oc}}$.

2. Are there dependent sources in the circuit? If not, find the Thévenin equivalent resistor by redrawing the circuit in Fig. 12 with the load resistor removed, the voltage sources replaced by short circuits, and the current sources replaced with open circuits. Then make series and parallel combinations of resistors until a single equivalent resistor remains. If there are dependent sources in the circuit, find the short circuit current by redrawing the circuit in Fig. 12, replacing the load resistor with a short circuit whose current is $i_{\mathrm{sc}}$. Use this circuit to find $i_{\mathrm{sc}}$.

3. Draw the Norton equivalent circuit and attach the $3\Omega$ resistor. Use this circuit to calculate $i_o$.

4. Check your solution by analyzing the original circuit in Fig. 12 to find $i_o$.

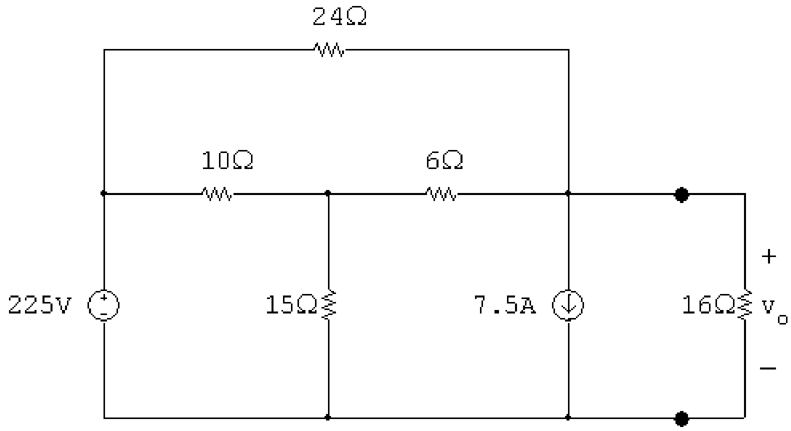


Figure 13: The circuit for Thévenin Equivalent Practice Problem 3.

## Thévenin Equivalent Practice Problem 3

Find $v_o$ for the circuit in Fig. 13 by replacing the circuit to the left of the 16Ω resistor with its Thévenin equivalent.

1. Redraw the circuit in Fig. 13, replacing the 16Ω resistor with an open circuit. Use this circuit to calculate $v_{\text{oc}}$.

2. Are there dependent sources in the circuit? If not, find the Thévenin equivalent resistor by redrawing the circuit in Fig. 13 with the load resistor removed, the voltage sources replaced by short circuits, and the current sources replaced with open circuits. Then make series and parallel combinations of resistors until a single equivalent resistor remains. If there are dependent sources in the circuit, find the short circuit current by redrawing the circuit in Fig. 13, replacing the load resistor with a short circuit whose current is $i_{\mathrm{sc}}$. Use this circuit to find $i_{\mathrm{sc}}$.

3. Draw the Thévenin equivalent circuit and attach the $16\Omega$ resistor. Use this circuit to calculate $v_o$.

4. Check your solution by analyzing the original circuit in Fig. 13 to find $v_o$.

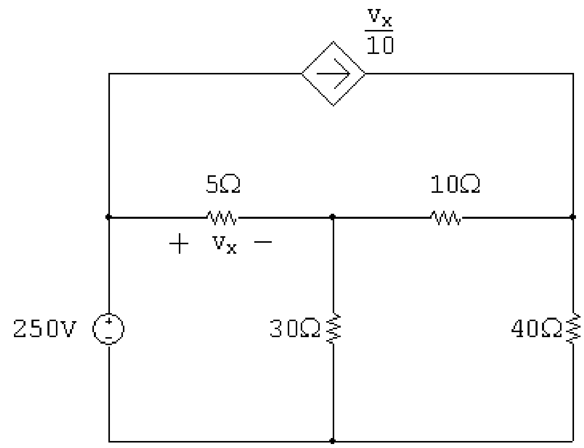


Figure 14: The circuit for Thévenin Equivalent Practice Problem 4.

## Thévenin Equivalent Practice Problem 4

Find power dissipated in the 40Ω resistor for the circuit in Fig. 14 by replacing the circuit to the left of the 40Ω resistor with its Thévenin equivalent.

1. Redraw the circuit in Fig. 14, replacing the 40Ω resistor with an open circuit. Use this circuit to calculate $v_{oc}$.

2. Are there dependent sources in the circuit? If not, find the Thévenin equivalent resistor by redrawing the circuit in Fig. 14 with the load resistor removed, the voltage sources replaced by short circuits, and the current sources replaced with open circuits. Then make series and parallel combinations of resistors until a single equivalent resistor remains. If there are dependent sources in the circuit, find the short circuit current by redrawing the circuit in Fig. 14, replacing the load resistor with a short circuit whose current is $i_{\mathrm{sc}}$. Use this circuit to find $i_{\mathrm{sc}}$.

3. Draw the Thévenin equivalent circuit and attach the $40\Omega$ resistor. Use this circuit to calculate the power dissipated by this $40\Omega$ resistor.

4. Check your solution by analyzing the original circuit in Fig. 14 to find $p_{40\Omega}$.

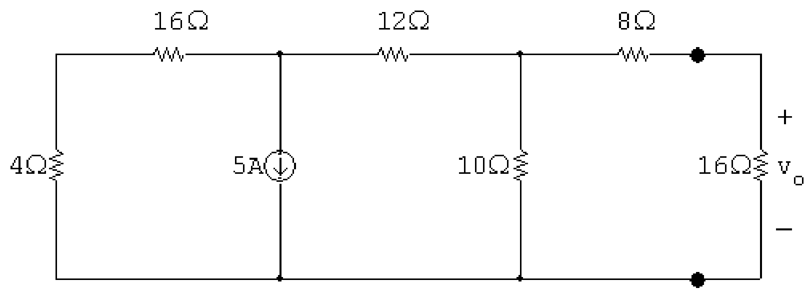


Figure 15: The circuit for Thévenin Equivalent Practice Problem 5.

## Thévenin Equivalent Practice Problem 5

Find $v_o$ for the circuit in Fig. 15 by replacing the circuit to the left of the 16Ω resistor with its Thévenin equivalent.

1. Redraw the circuit in Fig. 15, replacing the 16Ω resistor with an open circuit. Use this circuit to calculate $v_{\text{oc}}$.

2. Are there dependent sources in the circuit? If not, find the Thévenin equivalent resistor by redrawing the circuit in Fig. 15 with the load resistor removed, the voltage sources replaced by short circuits, and the current sources replaced with open circuits. Then make series and parallel combinations of resistors until a single equivalent resistor remains. If there are dependent sources in the circuit, find the short circuit current by redrawing the circuit in Fig. 15, replacing the load resistor with a short circuit whose current is $i_{\mathrm{sc}}$. Use this circuit to find $i_{\mathrm{sc}}$.

3. Draw the Thévenin equivalent circuit and attach the $16\Omega$ resistor. Use this circuit to calculate $v_o$.

4. Check your solution by analyzing the original circuit in Fig. 15 to find $v_o$.

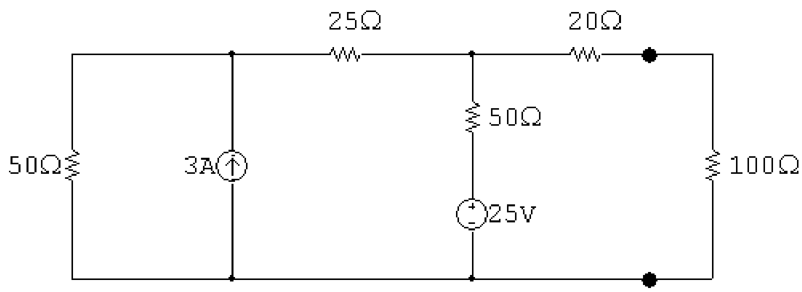


Figure 16: The circuit for Thévenin Equivalent Practice Problem 6.

# Thévenin Equivalent Practice Problem 6

Find the power dissipated in the 100Ω resistor for the circuit in Fig. 16 by replacing the circuit to the left of the 100Ω resistor with its Thévenin equivalent.

1. Redraw the circuit in Fig. 16, replacing the 100Ω resistor with an open circuit. Use this circuit to calculate $v_{\text{oc}}$.

2. Are there dependent sources in the circuit? If not, find the Thévenin equivalent resistor by redrawing the circuit in Fig. 16 with the load resistor removed, the voltage sources replaced by short circuits, and the current sources replaced with open circuits. Then make series and parallel combinations of resistors until a single equivalent resistor remains. If there are dependent sources in the circuit, find the short circuit current by redrawing the circuit in Fig. 16, replacing the load resistor with a short circuit whose current is $i_{\text{sc}}$. Use this circuit to find $i_{\text{sc}}$.

3. Draw the Thévenin equivalent circuit and attach the $100\Omega$ resistor. Use this circuit to calculate the power dissipated in this resistor.

4. Check your solution by analyzing the original circuit in Fig. 16 to find $p_{100\Omega}$.

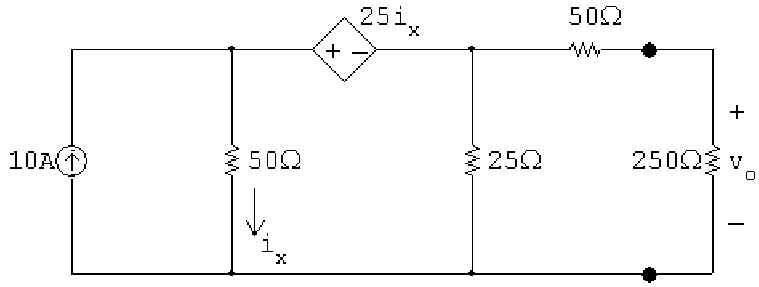


Figure 17: The circuit for Thévenin Equivalent Practice Problem 7.

# Thévenin Equivalent Practice Problem 7

Find $v_o$ for the circuit in Fig. 17 by replacing the circuit to the left of the 250Ω resistor with its Thévenin equivalent.

1. Redraw the circuit in Fig. 17, replacing the 250Ω resistor with an open circuit. Use this circuit to calculate $v_{\text{oc}}$.

2. Are there dependent sources in the circuit? If not, find the Thévenin equivalent resistor by redrawing the circuit in Fig. 17 with the load resistor removed, the voltage sources replaced by short circuits, and the current sources replaced with open circuits. Then make series and parallel combinations of resistors until a single equivalent resistor remains. If there are dependent sources in the circuit, find the short circuit current by redrawing the circuit in Fig. 17, replacing the load resistor with a short circuit whose current is $i_{\text{sc}}$. Use this circuit to find $i_{\text{sc}}$.

3. Draw the Thévenin equivalent circuit and attach the $250\Omega$ resistor. Use this circuit to calculate $v_o$.

4. Check your solution by analyzing the original circuit in Fig. 17 to find $v_o$.

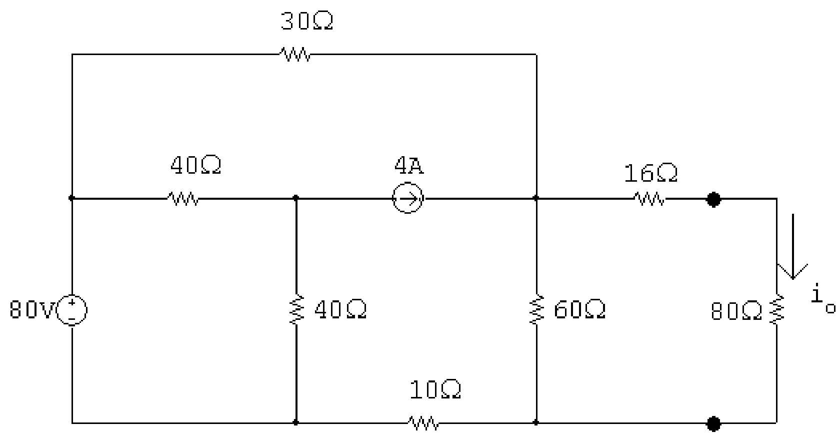


Figure 18: The circuit for Thévenin Equivalent Practice Problem 8.

## Thévenin Equivalent Practice Problem 8

Find $i_o$ for the circuit in Fig. 18 by replacing the circuit to the left of the $80\Omega$ resistor with its Norton equivalent.

1. Redraw the circuit in Fig. 18, replacing the $80\Omega$ resistor with an open circuit. Use this circuit to calculate $v_{\text{oc}}$.

2. Are there dependent sources in the circuit? If not, find the Thévenin equivalent resistor by redrawing the circuit in Fig. 18 with the load resistor removed, the voltage sources replaced by short circuits, and the current sources replaced with open circuits. Then make series and parallel combinations of resistors until a single equivalent resistor remains. If there are dependent sources in the circuit, find the short circuit current by redrawing the circuit in Fig. 18, replacing the load resistor with a short circuit whose current is $i_{\text{sc}}$. Use this circuit to find $i_{\text{sc}}$.

3. Draw the Norton equivalent circuit and attach the $80\Omega$ resistor. Use this circuit to calculate $i_o$.

4. Check your solution by analyzing the original circuit in Fig. 18 to find $i_o$.

## Reading

- in *Introductory Circuits for Electrical and Computer Engineering*:
  - Section 3.9 — Thévenin and Norton equivalents
  - Section 3.10 — more Thévenin and Norton equivalents
- in *Electric Circuits*, sixth edition:
  - Section 4.10 — Thévenin and Norton equivalents
  - Section 4.11 — more Thévenin and Norton equivalents
- Workbook section — Node Voltage Method
- Workbook section — Mesh Current Method

## Additional Problems

- in *Introductory Circuits for Electrical and Computer Engineering*:
  - 3.50 — 3.56
  - 3.58
- in *Electric Circuits*, sixth edition:
  - 4.58 — 4.62
  - 4.66
  - 4.69 — 4.70

## Solutions

- Thévenin Equivalent Practice Problem 1:

$$v_{\text{oc}} = 3.75 \text{ V} \qquad i_{\text{sc}} = 208.33 \text{ mA} \qquad \text{R}_{\text{Th}} = 18\Omega \qquad v_o = 2.5 \text{ V}.$$

- Thévenin Equivalent Practice Problem 2:

$$v_{\text{oc}} = 10 \text{ V} \qquad i_{\text{sc}} = 5 \text{ A} \qquad \text{R}_{\text{Th}} = 2\Omega \qquad i_o = 2 \text{ A}.$$

- Thévenin Equivalent Practice Problem 3:

$$v_{\text{oc}} = 105 \text{ V} \qquad i_{\text{sc}} = 13.125 \text{ A} \qquad \text{R}_{\text{Th}} = 8\Omega \qquad v_o = 70 \text{ V}.$$

- Thévenin Equivalent Practice Problem 4:

$$v_{\text{oc}} = 250 \text{ V} \qquad i_{\text{sc}} = 25 \text{ A} \qquad \text{R}_{\text{Th}} = 10\Omega \qquad p_{40\Omega} = 1 \text{ kW}.$$

- Thévenin Equivalent Practice Problem 5:

$$v_{\text{oc}} = -20 \text{ V} \qquad i_{\text{sc}} = -1.25 \text{ A} \qquad \text{R}_{\text{Th}} = 16\Omega \qquad v_o = -10 \text{ V}.$$

- Thévenin Equivalent Practice Problem 6:

$$v_{\text{oc}} = 75 \text{ V} \qquad i_{\text{sc}} = 1.5 \text{ A} \qquad \text{R}_{\text{Th}} = 50\Omega \qquad p_{100\Omega} = 25 \text{ W}.$$

- Thévenin Equivalent Practice Problem 7:

$$v_{\text{oc}} = 125 \text{ V} \qquad i_{\text{sc}} = 2 \text{ A} \qquad \text{R}_{\text{Th}} = 62.5\Omega \qquad v_o = 100 \text{ V}.$$

- Thévenin Equivalent Practice Problem 8:

$$v_{\text{oc}} = 120 \text{ V} \qquad i_{\text{sc}} = 3 \text{ A} \qquad \text{R}_{\text{Th}} = 40\Omega \qquad i_o = 1 \text{ A}.$$