Chapter 4, Solution 1.

\[ 8 \parallel (5 + 3) = 4 \Omega, \quad i = \frac{1}{1 + 4} = \frac{1}{5} \]
\[ i_o = \frac{1}{2} i = \frac{1}{10} = \text{0.1A} \]

Chapter 4, Solution 2.

\[ 6 \parallel (4 + 2) = 3 \Omega, \quad i_1 = i_2 = \frac{1}{2} \text{A} \]
\[ i_o = \frac{1}{2} i_1 = \frac{1}{4}, \quad v_o = 2i_o = \text{0.5V} \]

If \( i_s = 1 \mu \text{A} \), then \( v_o = \text{0.5\muV} \)

Chapter 4, Solution 3.
(a) We transform the Y sub-circuit to the equivalent Δ.

\[ R \parallel 3R = \frac{3R^2}{4R} = \frac{3}{4}R, \frac{3}{4}R + \frac{3}{4}R = \frac{3}{2}R \]

\[ v_o = \frac{v_s}{2} \text{ independent of } R \]

\[ i_o = v_o/(R) \]

When \( v_s = 1 \text{V} \), \( v_o = 0.5 \text{V} \), \( i_o = 0.5 \text{A} \)

(b) When \( v_s = 10 \text{V} \), \( v_o = 5 \text{V} \), \( i_o = 5 \text{A} \)

(c) When \( v_s = 10 \text{V} \) and \( R = 10 \Omega \),

\[ v_o = 5 \text{V}, i_o = 10/(10) = 500 \text{mA} \]

**Chapter 4, Solution 4.**

If \( I_o = 1 \), the voltage across the 6Ω resistor is 6V so that the current through the 3Ω resistor is 2A.

\[ 3\|6 = 2\Omega, v_o = 3(4) = 12 \text{V}, i_1 = \frac{v_o}{4} = 3 \text{A}. \]

Hence \( I_s = 3 + 3 = 6 \text{A} \)

If \( I_s = 6 \text{A} \rightarrow I_o = 1 \)

\[ I_s = 9 \text{A} \rightarrow I_o = 6/(9) = 0.6667 \text{A} \]
Chapter 4, Solution 5.

If $v_o = 1\text{V}$, 

$$V_1 = \left(\frac{1}{3}\right) + 1 = 2\text{V}$$

$$V_s = 2\left(\frac{2}{3}\right) + v_1 = \frac{10}{3}$$

If $v_s = \frac{10}{3} \rightarrow v_o = 1$

Then $v_s = 15 \rightarrow v_o = \frac{3}{10} \times 15 = 4.5\text{V}$

Chapter 4, Solution 6

Let $R_T = R_2 \parallel R_3 = \frac{R_2R_3}{R_2 + R_3}$, then 

$$V_o = \frac{R_T}{R_T + R_1}V_s$$

$$k = \frac{V_o}{V_s} = \frac{R_T}{R_T + R_1} = \frac{\frac{R_2R_3}{R_2 + R_3}}{R_2 + R_3 + R_1} = \frac{R_2R_3}{R_1R_2 + R_2R_3 + R_3R_1}$$
Chapter 4, Solution 7

We find the Thevenin equivalent across the 10-ohm resistor. To find $V_{\text{Th}}$, consider the circuit below.

From the figure,

$V_x = 0, \quad V_{\text{Th}} = \frac{15}{15 + 5} (4) = 3V$

To find $R_{\text{Th}}$, consider the circuit below:

At node 1,

$$\frac{4 - V_1}{5} = 3V_x + \frac{V_1}{15} + \frac{V_1 - V_2}{5}, \quad V_x = 6 \times 1 = 6 \quad \rightarrow \quad 258 = 3V_2 - 7V_1 \quad (1)$$

At node 2,
1 + 3V_x + \frac{V_x - V_2}{5} = 0 \quad \Rightarrow \quad V_x = V_2 - 95 \quad (2)

Solving (1) and (2) leads to \( V_2 = 101.75 \text{ V} \)

\[
R_{Th} = \frac{V_2}{1} = 101.75\Omega, \quad P_{max} = \frac{V_{Th}^2}{4R_{Th}} = \frac{9}{4 \times 101.75} = 22.11 \text{ mW}
\]

Chapter 4, Solution 8.

Let \( i = i_1 + i_2 \),

where \( i_1 \) and \( i_L \) are due to current and voltage sources respectively.

\[
\begin{align*}
\text{(a)} & \quad 6 \Omega & 4 \Omega & 5 \text{ A} \\
\text{(b)} & \quad 6 \Omega & 20 \text{ V} & 4 \Omega
\end{align*}
\]

\[
i_1 = \frac{6}{6 + 4} (5) = 3 \text{ A}, \quad i_2 = \frac{20}{6 + 4} = 2 \text{ A}
\]

Thus \( i = i_1 + i_2 = 3 + 2 = 5 \text{ A} \)

Chapter 4, Solution 9.

Let \( i_x = i_{x_1} + i_{x_2} \)

where \( i_{x_1} \) is due to 15V source and \( i_{x_2} \) is due to 4A source,

\[
\begin{align*}
\text{(a)} & \quad 15 \text{ V} & 10 \Omega & 40\Omega \\
\text{(b)} & \quad 12\Omega & 10\Omega & 40\Omega
\end{align*}
\]
For iₙ₁, consider Fig. (a).

\[10 \parallel 40 = \frac{400}{50} = 8 \text{ ohms, } i = \frac{15}{12 + 8} = 0.75\]

\[i_{x1} = \frac{40}{40 + 10}i = \frac{4}{5} \times 0.75 = 0.6\]

For iₙ₂, consider Fig. (b).

\[12 \parallel 40 = \frac{480}{52} = \frac{120}{13}\]

\[i_{x2} = \frac{120/13}{120/13 + 10}(-4) = -1.92\]

\[i = 0.6 - 1.92 = -1.32 \text{ A}\]

\[p = vi = i^2R = (-1.32)^2 \times 10 = 17.43 \text{ watts}\]

**Chapter 4, Solution 10.**

Let \(v_{ab} = v_{ab1} + v_{ab2}\) where \(v_{ab1}\) and \(v_{ab2}\) are due to the 4-V and the 2-A sources respectively.

For \(v_{ab1}\), consider Fig. (a). Applying KVL gives,

\[-v_{ab1} - 3v_{ab1} + 10 \times 0 + 4 = 0, \text{ which leads to } v_{ab1} = 1 \text{ V}\]

For \(v_{ab2}\), consider Fig. (b). Applying KVL gives,

\[-v_{ab2} - 3v_{ab2} + 10 \times 2 = 0, \text{ which leads to } v_{ab2} = 5\]

\[v_{ab} = 1 + 5 = 6 \text{ V}\]
Chapter 4, Solution 11.

Let \( i = i_1 + i_2 \), where \( i_1 \) is due to the 12-V source and \( i_2 \) is due to the 4-A source.

\[
\begin{align*}
12V & \quad 6 \Omega \\
\downarrow & \quad \downarrow \\
2 \Omega & \quad 3 \Omega \\
\end{align*}
\]

(a)

For \( i_1 \), consider Fig. (a).

\[
\begin{align*}
2\|3 & = 2 \times \frac{3}{5} = \frac{6}{5}, \quad i_o = \frac{12}{(6 + \frac{6}{5})} = \frac{10}{6} \\
i_1 & = \left[\frac{3}{2 + 3}\right]i_o = \left(\frac{3}{5}\right) \times \left(\frac{10}{6}\right) = 1 \text{ A}
\end{align*}
\]

For \( i_2 \), consider Fig. (b), \( \frac{6}{3} = 2 \text{ ohm} \), \( i_2 = \frac{4}{2} = 2 \text{ A} \)

\[ i = 1 + 2 = 3 \text{ A} \]

Chapter 4, Solution 12.

Let \( v_o = v_{o1} + v_{o2} + v_{o3} \), where \( v_{o1}, v_{o2}, \) and \( v_{o3} \) are due to the 2-A, 12-V, and 19-V sources respectively. For \( v_{o1} \), consider the circuit below.

\[
\begin{align*}
\begin{array}{c}
2A \\
\hline
5 \Omega \\
\hline
6 \Omega \\
\hline
\end{array} & \quad \begin{array}{c}
\hline
5 \Omega \\
\hline
i_o \\
\hline
\end{array}
\end{align*}
\]

\[
\begin{align*}
\begin{array}{c}
2A \\
\hline
4 \Omega \\
\hline
3 \Omega \\
\hline
\end{array} & \quad \begin{array}{c}
\hline
5 \Omega \\
\hline
\downarrow \\
\hline
\end{array}
\end{align*}
\]

\[
\begin{align*}
\begin{array}{c}
12 \Omega \\
\hline
\downarrow \\
\hline
\end{array} & \quad \begin{array}{c}
\hline
5 \Omega \\
\hline
\downarrow \\
\hline
\end{array}
\end{align*}
\]

\[
\begin{align*}
\begin{array}{c}
6 \Omega \\
\hline
\downarrow \\
\hline
\end{array} & \quad \begin{array}{c}
\hline
\downarrow \\
\hline
\end{array}
\end{align*}
\]

\[
\begin{align*}
\begin{array}{c}
\hline
\downarrow \\
\hline
\end{array} & \quad \begin{array}{c}
\hline
\downarrow \\
\hline
\end{array}
\end{align*}
\]
6\|3 = 2 \text{ ohms}, \ 4\|12 = 3 \text{ ohms}. \text{ Hence,} \\
i_o = \frac{2}{2} = 1, \ v_{o1} = 5i_o = 5 \text{ V} \\

For \ v_{o2}, \text{ consider the circuit below.}

\[
\begin{align*}
\begin{array}{c}
\text{12V} \\
\hline
6 \Omega \\
\downarrow \\
3 \Omega \\
\downarrow \\
\frac{12}{3} \Omega \\
\downarrow \\
6 \Omega \\
\downarrow \\
3 \Omega \\
\downarrow \\
\frac{12}{3} \Omega \\
\downarrow \\
12 \Omega \\
\hline
\end{array}
\end{align*}
\]

3\|8 = 24/11, \ v_1 = \left[(\frac{24}{11})/(6 + 24/11)\right]12 = 16/5 \\

\[v_{o2} = (\frac{5}{8})v_1 = (\frac{5}{8})(16/5) = 2 \text{ V}\]

For \ v_{o3}, \text{ consider the circuit shown below.}

\[
\begin{align*}
\begin{array}{c}
\text{19V} \\
\hline
5 \Omega \\
\downarrow \\
4 \Omega \\
\downarrow \\
\frac{12}{3} \Omega \\
\downarrow \\
6 \Omega \\
\downarrow \\
3 \Omega \\
\downarrow \\
\frac{12}{3} \Omega \\
\downarrow \\
12 \Omega \\
\hline
\end{array}
\end{align*}
\]

7\|12 = (84/19) \text{ ohms}, \ v_2 = \left[(\frac{84}{19})/(4 + 84/19)\right]19 = 9.975 \\

\[v = (\frac{-5}{7})v_2 = -7.125\]

\[v_o = 5 + 2 - 7.125 = -125 \text{ mV}\]

Chapter 4, Solution 13

Let 
\[i_o = i_1 + i_2 + i_3,\]

where \ i_1, \ i_2, \ \text{and} \ i_3 \ \text{are the contributions to} \ i_o \ \text{due to} \ 30-\text{V}, \ 15-\text{V}, \ \text{and} \ 6-\text{mA sources} \ \text{respectively.} \ \text{For} \ i_1, \ \text{consider the circuit below.}
$3/5 = 15/8 = 1.875 \text{ kohm, } 2 + 3/5 = 3.875 \text{ kohm, } 1/3.875 = 3.875/4.875 = 0.7949 \text{ kohm.}$ After combining the resistors except the 4-kohm resistor and transforming the voltage source, we obtain the circuit below.

Using current division,

$$i_1 = \frac{0.7949}{4.7949} (30 \text{ mA}) = 4.973 \text{ mA}$$

For $i_2$, consider the circuit below.

After successive source transformation and resistance combinations, we obtain the circuit below:

Using current division,

$$i_2 = \frac{0.7949}{4.7949} (2.42 \text{ mA}) = -0.4012 \text{ mA}$$
For $i_3$, consider the circuit below.

After successive source transformation and resistance combinations, we obtain the circuit below:

Thus,

$$i_3 = -\frac{0.7949}{4.7949} (3.097\text{mA}) = -0.5134 \text{mA}$$

Thus,

$$i_o = i_1 + i_2 + i_3 = 4.058 \text{mA}$$

Chapter 4, Solution 14.

Let $v_o = v_{o1} + v_{o2} + v_{o3}$, where $v_{o1}$, $v_{o2}$, and $v_{o3}$, are due to the 20-V, 1-A, and 2-A sources respectively. For $v_{o1}$, consider the circuit below.

$$6 \|(4 + 2) = 3 \text{ ohms}, v_{o1} = (\frac{1}{2})20 = 10 \text{ V}$$
For $v_{o2}$, consider the circuit below.

\[ \frac{3||6}{6} = 2 \text{ ohms, } v_{o2} = \frac{2}{(4 + 2 + 2)} \times 4 = 1 \text{ V} \]

For $v_{o3}$, consider the circuit below.

\[ \frac{6||4 + 2}{3||6} = 3, \ v_{o3} = (-1)3 = -3 \]

\[ v_o = 10 + 1 - 3 = 8 \text{ V} \]

**Chapter 4, Solution 15.**

Let $i = i_1 + i_2 + i_3$, where $i_1$, $i_2$, and $i_3$ are due to the 20-V, 2-A, and 16-V sources. For $i_1$, consider the circuit below.
\[ 4|(3 + 1) = 2 \text{ ohms}, \quad \text{Then } i_o = \left[\frac{20}{2 + 2}\right] = 5 \text{ A, } i_1 = \frac{i_o}{2} = 2.5 \text{ A} \]

For \( i_3 \), consider the circuit below.

\[ 2|(1 + 3) = \frac{4}{3}, \quad v_o' = \left[\frac{4/3}{(4/3) + 4}\right](-16) = -4 \]

\[ i_3 = \frac{v_o'}{4} = -1 \]

For \( i_2 \), consider the circuit below.

\[ 2\|4 = \frac{4}{3}, \quad 3 + \frac{4}{3} = \frac{13}{3} \]

Using the current division principle.

\[ i_2 = \left[\frac{1}{(1 + 13/2)}\right]2 = \frac{3}{8} = 0.375 \]

\[ i = 2.5 + 0.375 - 1 = 1.875 \text{ A} \]

\[ p = i^2R = (1.875)^23 = 10.55 \text{ watts} \]
Chapter 4, Solution 16.

Let $i_o = i_{o1} + i_{o2} + i_{o3}$, where $i_{o1}$, $i_{o2}$, and $i_{o3}$ are due to the 12-V, 4-A, and 2-A sources. For $i_{o1}$, consider the circuit below.

\[
\begin{align*}
10 & || (3 + 2 + 5) = 5 \text{ ohms, } i_{o1} = \frac{12}{5 + 4} = \frac{12}{9} \text{ A}
\end{align*}
\]

For $i_{o2}$, consider the circuit below.

\[
\begin{align*}
2 + 5 + 4 & || 10 = 7 + \frac{40}{14} = \frac{69}{7} \\
i_1 & = \frac{3}{3 + 69/7} \times 4 = \frac{84}{90}, \quad i_{o2} = -\frac{10}{4 + 10} \times i_1 = -\frac{6}{9}
\end{align*}
\]

For $i_{o3}$, consider the circuit below.

\[
\begin{align*}
3 + 2 + 4 & || 10 = 5 + \frac{20}{7} = \frac{55}{7} \\
i_2 & = \frac{5}{5 + 55/7} \times 2 = \frac{7}{9}, \quad i_{o3} = -\frac{10}{10 + 4} \times i_2 = -\frac{5}{9}
\end{align*}
\]

\[
\begin{align*}
i_o & = \left(\frac{12}{9}\right) - \left(\frac{6}{9}\right) - \left(\frac{5}{9}\right) = \frac{1}{9} = 111.11 \text{ mA}
\end{align*}
\]
Chapter 4, Solution 17.

Let \( v_x = v_{x1} + v_{x2} + v_{x3} \), where \( v_{x1}, v_{x2}, \) and \( v_{x3} \) are due to the 90-V, 6-A, and 40-V sources. For \( v_{x1} \), consider the circuit below.

\[
\begin{align*}
&\begin{array}{c}
30 \, \Omega \\
60 \, \Omega \\
30 \, \Omega
\end{array} \\
&\begin{array}{c}
10 \, \Omega \\
+ \\
\text{vx1} \\
- \\
20 \, \Omega
\end{array} \\
&90V
\end{align*}
\]

\[
20 \parallel 30 = 12 \, \text{ohms, } 60 \parallel 30 = 20 \, \text{ohms}
\]

By using current division,

\[
i_o = \frac{[20/(22 + 20)]3}{60} = 60/42, \quad v_{x1} = 10i_o = 600/42 = 14.286 \, \text{V}
\]

For \( v_{x2} \), consider the circuit below.

\[
\begin{align*}
&\begin{array}{c}
10 \, \Omega \\
+ \\
\text{vx2} \\
- \\
6 \, \text{A}
\end{array} \\
&\begin{array}{c}
30 \, \Omega \\
60 \, \Omega \\
30 \, \Omega \\
20 \, \Omega
\end{array} \\
i_o' = \frac{12/(12 + 30)}{6} = 72/42, \quad v_{x2} = -10i_o' = -17.143 \, \text{V}
\]

For \( v_{x3} \), consider the circuit below.

\[
\begin{align*}
&\begin{array}{c}
10 \, \Omega \\
+ \\
\text{vx3} \\
- \\
40 \, \text{V}
\end{array} \\
&\begin{array}{c}
30 \, \Omega \\
60 \, \Omega \\
30 \, \Omega \\
20 \, \Omega
\end{array} \\
i_o'' = \frac{12/(12 + 30)}{2} = 24/42, \quad v_{x3} = -10i_o'' = -5.714 \, \text{V}
\]

\[
v_x = 14.286 - 17.143 - 5.714 = -8.571 \, \text{V}
\]
Chapter 4, Solution 18.

Let \( i_x = i_1 + i_2 \), where \( i_1 \) and \( i_2 \) are due to the 10-V and 2-A sources respectively. To obtain \( i_1 \), consider the circuit below.

\[
-10 + 10i_1 + 7i_1 = 0, \text{ therefore } i_1 = \frac{10}{17} \text{ A}
\]

For \( i_2 \), consider the circuit below.

\[
-2 + 10i_2 + 7i_o = 0, \text{ but } i_2 + 2 = i_o. \text{ Hence,}
\]

\[
-2 + 10i_2 + 7i_2 + 14 = 0, \text{ or } i_2 = -\frac{12}{17} \text{ A}
\]

\[v_x = 1xi_x = 1(i_1 + i_2) = \left(\frac{10}{17}\right) - \left(\frac{12}{17}\right) = -\frac{2}{17} = -117.6 \text{ mA}\]

Chapter 4, Solution 19.

Let \( v_x = v_1 + v_2 \), where \( v_1 \) and \( v_2 \) are due to the 4-A and 6-A sources respectively.
To find \( v_1 \), consider the circuit in Fig. (a).

\[
v_1/8 = 4 + (-4i_x - v_1)/2
\]

But, \(-i_x = (-4i_x - v_1)/2\) and we have \(-2i_x = v_1\). Thus,

\[
v_1/8 = 4 + (2v_1 - v_1)/8, \text{ which leads to } v_1 = -32/3
\]

To find \( v_2 \), consider the circuit shown in Fig. (b).

\[
v_2/2 = 6 + (4i_x - v_2)/8
\]

But \( i_x = v_2/2 \) and \( 2i_x = v_2 \). Therefore,

\[
v_2/2 = 6 + (2v_2 - v_2)/8 \text{ which leads to } v_2 = -16
\]

Hence,

\[
v_x = -(32/3) - 16 = -26.67 \text{ V}
\]

Chapter 4, Solution 20.

Transform the voltage sources and obtain the circuit in Fig. (a). Combining the 6-ohm and 3-ohm resistors produces a 2-ohm resistor \( (6||3 = 2) \). Combining the 2-A and 4-A sources gives a 6-A source. This leads to the circuit shown in Fig. (b).

From Fig. (b),

\[
i = 6/2 = 3 \text{ A}
\]

Chapter 4, Solution 21.

To get \( i_o \), transform the current sources as shown in Fig. (a).
From Fig. (a), \(-12 + 9i_o + 6 = 0\), therefore \(i_o = 666.7 \, \text{mA}\)

To get \(v_o\), transform the voltage sources as shown in Fig. (b).

\[
i = \left[\frac{6}{(3 + 6)}\right](2 + 2) = \frac{8}{3}
\]

\[
v_o = 3i = 8 \, \text{V}
\]

Chapter 4, Solution 22.

We transform the two sources to get the circuit shown in Fig. (a).

We now transform only the voltage source to obtain the circuit in Fig. (b).

\[
10||10 = 5 \, \text{ohms}, \quad i = \left[\frac{5}{(5 + 4)}\right](2 - 1) = \frac{5}{9} = 555.5 \, \text{mA}
\]
Chapter 4, Solution 23

If we transform the voltage source, we obtain the circuit below.

3/6 = 2-ohm. Convert the current sources to voltage sources as shown below.

Applying KVL to the loop gives
\[-30 + 10 + I(10 + 8 + 2) = 0 \quad \rightarrow \quad I = 1\,A\]

\[P = VI = I^2R = 8\,W\]
Chapter 4, Solution 24

Convert the current source to voltage source.

Combine the 16-ohm and 4-ohm resistors and convert both voltages sources to current Sources. We obtain the circuit below.

Combine the resistors and current sources.
\[ 20//5 = (20\times5)/25 = 4 \Omega, \quad 2.4 + 2.4 = 4.8 \text{ A} \]

Convert the current source to voltage source. We obtain the circuit below.

Using voltage division,
\[ V_o = \frac{10}{10 + 4 + 1}(19.2) = 12.8 \text{ V} \]
Chapter 4, Solution 25.

Transforming only the current source gives the circuit below.

![](image1.png)

Applying KVL to the loop gives,

\[(4 + 9 + 5 + 2)i - 12 - 18 - 30 - 30 = 0\]

\[20i = 90\] which leads to \(i = 4.5\)

\(v_o = 2i = 9\text{V}\)

Chapter 4, Solution 26.

Transform the voltage sources to current sources. The result is shown in Fig. (a),

\[30\parallel60 = 20\text{ ohms},\quad 30\parallel20 = 12\text{ ohms}\]

![](image2.png)

(a)

(b)
Combining the resistors and transforming the current sources to voltage sources, we obtain the circuit in Fig. (b). Applying KVL to Fig. (b),

$$42i - 60 + 96 = 0,$$
which leads to $i = -36/42$

$$v_x = 10i = -8.571 \text{ V}$$

**Chapter 4, Solution 27.**

Transforming the voltage sources to current sources gives the circuit in Fig. (a).

$$10\parallel 40 = 8 \text{ ohms}$$

Transforming the current sources to voltage sources yields the circuit in Fig. (b). Applying KVL to the loop,

$$-40 + (8 + 12 + 20)i + 200 = 0$$
leads to $i = -4$

$$v_x 12i = -48 \text{ V}$$
Transforming only the current sources leads to Fig. (a). Continuing with source transformations finally produces the circuit in Fig. (d).

Applying KVL to the loop in fig. (d),

\[-12 + 9i_o + 11 = 0, \text{ produces } i_o = \frac{1}{9} = 111.11 \text{ mA}\]
Chapter 4, Solution 29.

Transform the dependent voltage source to a current source as shown in Fig. (a). 2 || 4 = (4/3) k ohms

It is clear that i = 3 mA which leads to $v_o = 1000i = 3 \text{ V}$

If the use of source transformations was not required for this problem, the actual answer could have been determined by inspection right away since the only current that could have flowed through the 1 k ohm resistor is 3 mA.

Chapter 4, Solution 30

Transform the dependent current source as shown below.

Combine the 60-ohm with the 10-ohm and transform the dependent source as shown below.
Combining 30-ohm and 70-ohm gives $30/70 = 70 \times 30/100 = 21$-ohm. Transform the dependent current source as shown below.

Applying KVL to the loop gives

$$45i_x - 12 + 2.1i_x = 0 \quad \rightarrow \quad i_x = \frac{12}{47.1} = 254.8 \text{ mA}$$

**Chapter 4, Solution 31.**

Transform the dependent source so that we have the circuit in Fig. (a). $6||8 = (24/7)$ ohms. Transform the dependent source again to get the circuit in Fig. (b).
From Fig. (b),

\[ v_x = 3i, \text{ or } i = \frac{v_x}{3}. \]

Applying KVL,

\[
-12 + (3 + \frac{24}{7})i + \frac{(24/21)v_x}{3} = 0
\]

\[
12 = \left(\frac{21 + 24}{7}\right)v_x/3 + \left(\frac{8}{7}\right)v_x, \text{ leads to } v_x = \frac{84}{23} = 3.625 \text{ V}
\]

**Chapter 4, Solution 32.**

As shown in Fig. (a), we transform the dependent current source to a voltage source,
In Fig. (b), $50 \parallel 50 = 25$ ohms. Applying KVL in Fig. (c),

\[-60 + 40i_x - 2.5i_x = 0, \text{ or } i_x = 1.6 \text{ A}\]

**Chapter 4, Solution 33.**

(a) $R_{Th} = 10 \parallel 40 = \frac{400}{50} = 8 \text{ ohms}$

$V_{Th} = \frac{40}{40 + 10} \times 20 = 16 \text{ V}$

(b) $R_{Th} = 30 \parallel 60 = \frac{1800}{90} = 20 \text{ ohms}$

$2 + \frac{30 - v_1}{60} = \frac{v_1}{30}, \text{ and } v_1 = V_{Th}$

$120 + 30 - v_1 = 2v_1, \text{ or } v_1 = 50 \text{ V}$

$V_{Th} = 50 \text{ V}$

**Chapter 4, Solution 34.**

To find $R_{Th}$, consider the circuit in Fig. (a).

At node 1, \( \frac{40 - v_1}{10} = 3 + \left[ \frac{(v_1 - v_2)}{20} \right] + \frac{v_1}{40}, \text{ or } v_1 = 7v_1 - 2v_2 \) (1)

At node 2, \( 3 + \frac{(v_1 - v_2)}{20} = 0, \text{ or } v_1 = v_2 - 60 \) (2)

Solving (1) and (2), $v_1 = 32 \text{ V}, v_2 = 92 \text{ V}, \text{ and } V_{Th} = v_2 = 92 \text{ V}$
Chapter 4, Solution 35.

To find $R_{Th}$, consider the circuit in Fig. (a).

$$R_{Th} = R_{ab} = 6||3 + 12||4 = 2 + 3 = 5 \text{ ohms}$$

To find $V_{Th}$, consider the circuit shown in Fig. (b).

At node 1, 
$$2 + \frac{(12 - v_1)}{6} = \frac{v_1}{3}, \text{ or } v_1 = 8$$

At node 2, 
$$\frac{(19 - v_2)}{4} = 2 + \frac{v_2}{12}, \text{ or } v_2 = \frac{33}{4}$$

But, 
$$-v_1 + V_{Th} + v_2 = 0, \text{ or } V_{Th} = v_1 - v_2 = 8 - \frac{33}{4} = -0.25$$

$$V_{Th} = \frac{-1}{4}V$$

$$v_o = V_{Th}/2 = 0.25/2 = -125 \text{ mV}$$
Chapter 4, Solution 36.

Remove the 30-V voltage source and the 20-ohm resistor.

From Fig. (a), \( R_{Th} = \frac{10}{40} = 8 \) ohms

From Fig. (b), \( V_{Th} = \frac{40}{10 + 40} \times 50 = 40V \)

The equivalent circuit of the original circuit is shown in Fig. (c). Applying KVL,

\[ 30 - 40 + (8 + 12)i = 0, \text{ which leads to } i = 500mA \]
Chapter 4, Solution 37

R_N is found from the circuit below.

\[ R_N = \frac{12}{20 + 40} = 10 \Omega \]

I_N is found from the circuit below.

Applying source transformation to the current source yields the circuit below.

Applying KVL to the loop yields

\[ -120 + 80 + 60I_N = 0 \quad \rightarrow \quad I_N = \frac{40}{60} = 0.6667 \text{ A} \]
Chapter 4, Solution 38

We find Thevenin equivalent at the terminals of the 10-ohm resistor. For $R_{Th}$, consider the circuit below.

\[
R_{Th} = 1 + \frac{5}{(4 + 16)} = 1 + 4 = 5 \Omega
\]

For $V_{Th}$, consider the circuit below.

At node 1,
\[
3 = \frac{V_1}{16} + \frac{V_1 - V_2}{4} \quad \quad 48 = 5V_1 - 4V_2 \quad \quad (1)
\]

At node 2,
\[
\frac{V_1 - V_2}{4} + \frac{12 - V_2}{5} = 0 \quad \quad 48 = -5V_1 + 9V_2 \quad \quad (2)
\]

Solving (1) and (2) leads to
\[
V_{Th} = V_2 = 19.2
\]
Thus, the given circuit can be replaced as shown below.

Using voltage division,

\[ V_o = \frac{10}{10 + 5}(19.2) = 12.8 \text{ V} \]

**Chapter 4, Solution 39.**

To find \( R_{Th} \), consider the circuit in Fig. (a).

- \( -1 - 3 + 10i_o = 0, \text{ or } i_o = 0.4 \)

\[ R_{Th} = 1/i_o = 2.5 \text{ ohms} \]

To find \( V_{Th} \), consider the circuit shown in Fig. (b).

\[ [(4 - v)/10] + 2 = 0, \text{ or } v = 24 \]

But, \( v = V_{Th} + 3v_{ab} = 4V_{Th} = 24 \), which leads to \( V_{Th} = 6 \text{ V} \)

**Chapter 4, Solution 40.**

To find \( R_{Th} \), consider the circuit in Fig. (a).
\[ R_{Th} = 10\|40 + 20 = 28 \text{ ohms} \]

To get \( V_{Th} \), consider the circuit in Fig. (b). The two loops are independent. From loop 1,

\[ v_1 = (40/50)50 = 40 \text{ V} \]

For loop 2,

\[-v_2 + 20 \times 8 + 40 = 0, \text{ or } v_2 = 200 \]

But,

\[ V_{Th} + v_2 - v_1 = 0, \quad V_{Th} = v_1 = v_2 = 40 - 200 = -160 \text{ volts} \]

This results in the following equivalent circuit.

Chapter 4, Solution 41

To find \( R_{Th} \), consider the circuit below

\[ R_{Th} = 5 \| (14 + 6) = 4 \Omega = R_x \]

Applying source transformation to the 1-A current source, we obtain the circuit below.
At node a,
\[ \frac{14 + 6 - V_{Th}}{6 + 14} = 3 + \frac{V_{Th}}{5} \quad \rightarrow \quad V_{Th} = -8 \text{ V} \]

\[ I_N = \frac{V_{Th}}{R_{Th}} = (-8) / 4 = -2 \text{ A} \]

Thus,
\[ R_{Th} = R_N = 4 \Omega, \quad V_{Th} = -8 \text{ V}, \quad I_N = -2 \text{ A} \]

Chapter 4, Solution 42.

To find \( R_{Th} \), consider the circuit in Fig. (a).

\[
\begin{align*}
20 \parallel 20 &= 10 \text{ ohms. Transform the wye sub-network to a delta as shown in Fig. (b).} \\
10 \parallel 30 &= 7.5 \text{ ohms. } R_{Th} = R_{ab} = 30 \parallel (7.5 + 7.5) &= 10 \text{ ohms.}
\end{align*}
\]

To find \( V_{Th} \), we transform the 20-V and the 5-V sources. We obtain the circuit shown in Fig. (c).
For loop 1, $-30 + 50 + 30i_1 - 10i_2 = 0$, or $-2 = 3i_1 - i_2$ \hspace{1cm} (1)

For loop 2, $-50 - 10 + 30i_2 - 10i_1 = 0$, or $6 = -i_1 + 3i_2$ \hspace{1cm} (2)

Solving (1) and (2), $i_1 = 0$, $i_2 = 2 \text{ A}$

Applying KVL to the output loop, $-v_{ab} - 10i_1 + 30 - 10i_2 = 0$, $v_{ab} = 10 \text{ V}$

$V_{Th} = v_{ab} = 10 \text{ volts}$

Chapter 4, Solution 43.

To find $R_{Th}$, consider the circuit in Fig. (a).

\[ R_{Th} = 10 || 10 + 5 = 10 \text{ ohms} \]
To find $V_{Th}$, consider the circuit in Fig. (b).

$$v_b = 2 \times 5 = 10 \text{ V}, \quad v_a = 20/2 = 10 \text{ V}$$

But, $-v_a + V_{Th} + v_b = 0$, or $V_{Th} = v_a - v_b = 0 \text{ volts}$

Chapter 4, Solution 44.

(a) For $R_{Th}$, consider the circuit in Fig. (a).

$$R_{Th} = 1 + 4\| (3 + 2 + 5) = 3.857 \text{ ohms}$$

For $V_{Th}$, consider the circuit in Fig. (b). Applying KVL gives,

$$10 - 24 + i(3 + 4 + 5 + 2), \text{ or } i = 1$$

$$V_{Th} = 4i = 4 \text{ V}$$

(b) For $R_{Th}$, consider the circuit in Fig. (c).

(d) For $V_{Th}$, consider the circuit in Fig. (d).
\[ R_{Th} = 5 \|(2 + 3 + 4) = \textbf{3.214 ohms} \]

To get \( V_{Th} \), consider the circuit in Fig. (d). At the node, KCL gives,

\[ [(24 - vo)/9] + 2 = vo/5, \text{ or } vo = 15 \]

\[ V_{Th} = vo = 15 \text{ V} \]

Chapter 4, Solution 45.

For \( R_N \), consider the circuit in Fig. (a).

For \( I_N \), consider the circuit in Fig. (b). The 4-ohm resistor is shorted so that 4-A current is equally divided between the two 6-ohm resistors. Hence,

\[ I_N = 4/2 = 2 \text{ A} \]

Chapter 4, Solution 46.

(a) \( R_N = R_{Th} = \textbf{8 ohms} \). To find \( I_N \), consider the circuit in Fig. (a).

\[ I_N = I_{sc} = 20/10 = 2 \text{ A} \]

(b) To get \( I_N \), consider the circuit in Fig. (b).

\[ I_N = I_{sc} = 2 + 30/60 = 2.5 \text{ A} \]
Chapter 4, Solution 47

Since \( V_{Th} = V_{ab} = V_x \), we apply KCL at the node a and obtain

\[
\frac{30 - V_{Th}}{12} = \frac{V_{Th}}{60} + 2V_{Th} \quad \rightarrow \quad V_{Th} = \frac{150}{126} = 1.19 \text{ V}
\]

To find \( R_{Th} \), consider the circuit below.

\[
\begin{align*}
12 \Omega & \quad V_x \quad a \\
& \quad 60 \Omega \\
& \quad 2V_x \\
1 \text{ A}
\end{align*}
\]

At node a, KCL gives

\[
1 = 2V_x + \frac{V_x}{60} + \frac{V_x}{12} \quad \rightarrow \quad V_x = \frac{60}{126} = 0.4762
\]

\[
R_{Th} = \frac{V_x}{1} = 0.4762 \Omega, \quad I_N = \frac{V_{Th}}{R_{Th}} = 1.19 / 0.4762 = 2.5
\]

Thus,

\[
V_{Th} = 1.19V, \quad R_{Th} = R_N = 0.4762 \Omega, \quad I_N = 2.5 \text{ A}
\]

Chapter 4, Solution 48.

To get \( R_{Th} \), consider the circuit in Fig. (a).

\[
\begin{align*}
\text{(a)} & \\
\text{(b)}
\end{align*}
\]

From Fig. (a), \( I_o = 1, \quad 6 - 10 - V = 0, \text{ or } V = -4 \)

\[
R_N = R_{Th} = V/1 = -4 \text{ ohms}
\]
To get $V_{Th}$, consider the circuit in Fig. (b),

\[
I_o = 2, \quad V_{Th} = -10I_o + 4I_o = -12 \, V
\]

\[
I_N = \frac{V_{Th}}{R_{Th}} = \frac{3A}{28 \, \text{ohms}}
\]

Chapter 4, Solution 49.

\[
R_N = R_{Th} = 28 \, \text{ohms}
\]

To find $I_N$, consider the circuit below,

At the node, \((40 - v_o)/10 = 3 + (v_o/40) + (v_o/20)\), or \(v_o = 40/7\)

\[
i_o = v_o/20 = 2/7, \text{ but } I_N = I_{sc} = i_o + 3 = 3.286 \, A
\]

Chapter 4, Solution 50.

From Fig. (a), \(R_N = 6 + 4 = 10 \, \text{ohms}\)

From Fig. (b), \(2 + (12 - v)/6 = v/4\), or \(v = 9.6 \, V\)

\[-I_N = (12 - v)/6 = 0.4, \text{ which leads to } I_N = -0.4 \, A
\]

Combining the Norton equivalent with the right-hand side of the original circuit produces the circuit in Fig. (c).
Chapter 4, Solution 51.

(a) From the circuit in Fig. (a),
\[ R_N = 4\parallel(2 + 6\parallel3) = 4\parallel4 = 2 \text{ ohms} \]

For \( I_N \) or \( V_{Th} \), consider the circuit in Fig. (b). After some source transformations, the circuit becomes that shown in Fig. (c).

Applying KVL to the circuit in Fig. (c),
\[-40 + 8i + 12 = 0 \text{ which gives } i = \frac{7}{2} \]
\[ V_{Th} = 4i = 14 \text{ therefore } I_N = \frac{V_{Th}}{R_N} = \frac{14}{2} = 7 \text{ A} \]
(b) To get $R_N$, consider the circuit in Fig. (d).

\[ R_N = 2\|(4 + 6\|3) = 2\|6 = 1.5 \text{ ohms} \]

To get $I_N$, the circuit in Fig. (c) applies except that it needs slight modification as in Fig. (e).

\[ i = 7/2, \ V_{Th} = 12 + 2i = 19, \ I_N = V_{Th}/R_N = 19/1.5 = 12.667 \text{ A} \]

Chapter 4, Solution 52.

For $R_{Th}$, consider the circuit in Fig. (a).

For Fig. (a), $I_o = 0$, hence the current source is inactive and

\[ R_{Th} = 2 \text{ k ohms} \]
For $V_{Th}$, consider the circuit in Fig. (b).

$$I_o = \frac{6}{3k} = 2 \text{ mA}$$

$$V_{Th} = (-20I_o)(2k) = -20 \times 2 \times 10^{-3} \times 2 \times 10^3 = -80 \text{ V}$$

**Chapter 4, Solution 53.**

To get $R_{Th}$, consider the circuit in Fig. (a).

From Fig. (b),

$$v_o = 2 \times 1 = 2V, \quad -v_{ab} + 2 \times (1/2) + v_o = 0$$

$$v_{ab} = 3V$$

$$R_N = \frac{v_{ab}}{1} = 3 \text{ ohms}$$

To get $I_N$, consider the circuit in Fig. (c).

$$[(18 - v_o)/6] + 0.25v_o = (v_o/2) + (v_o/3) \text{ or } v_o = 4V$$

But, \( (v_o/2) = 0.25v_o + I_N \), which leads to \( I_N = 1 \text{ A} \)
Chapter 4, Solution 54

To find $V_{Th} = V_x$, consider the left loop.

$$-3 + 1000i_o + 2V_x = 0 \quad \rightarrow \quad 3 = 1000i_o + 2V_x \quad (1)$$

For the right loop, 

$$V_x = -50 \times 40i_o = -2000i_o \quad (2)$$

Combining (1) and (2),

$$3 = 1000i_o - 4000i_o = -3000i_o \quad \rightarrow \quad i_o = -1\text{mA}$$

$$V_x = -2000i_o = 2 \quad \rightarrow \quad V_{Th} = 2$$

To find $R_{Th}$, insert a 1-V source at terminals a-b and remove the 3-V independent source, as shown below.

\[ V_x = 1, \quad i_o = -\frac{2V_x}{1000} = -2\text{mA} \]

\[ i_x = 40i_o + \frac{V_x}{50} = -80\text{mA} + \frac{1}{50} \text{A} = -60\text{mA} \]

\[ R_{Th} = \frac{1}{i_x} = -1/0.060 = -16.67\Omega \]

Chapter 4, Solution 55.

To get $R_N$, apply a 1 mA source at the terminals a and b as shown in Fig. (a).
We assume all resistances are in k ohms, all currents in mA, and all voltages in volts. At node a,

\[(v_{ab}/50) + 80I = 1\]  \hspace{1cm} (1)

Also,

\[-8I = (v_{ab}/1000), \text{ or } I = -v_{ab}/8000\]  \hspace{1cm} (2)

From (1) and (2), \[(v_{ab}/50) - (80v_{ab}/8000) = 1, \text{ or } v_{ab} = 100\]

\[R_N = v_{ab}/I = \textbf{100 k ohms}\]

To get \(I_N\), consider the circuit in Fig. (b).

Since the 50-k ohm resistor is shorted,

\[I_N = -80I, \text{ or } v_{ab} = 0\]

Hence,

\[8i = 2 \text{ which leads to } I = (1/4) \text{ mA}\]

\[I_N = \textbf{-20 mA}\]

Chapter 4, Solution 56.

We first need \(R_N\) and \(I_N\).
To find $R_N$, consider the circuit in Fig. (a).

$$R_N = 1 + 2||4 = (7/3) \text{ ohms}$$

To get $I_N$, short-circuit ab and find $I_{sc}$ from the circuit in Fig. (b). The current source can be transformed to a voltage source as shown in Fig. (c).

$$\frac{20 - v_o}{2} = \frac{(v_o + 2)/1 + (v_o + 16)/4}{1} \text{, or } v_o = 16/7$$

$$I_N = \frac{(v_o + 2)/1}{1} = \frac{30}{7}$$

From the Norton equivalent circuit in Fig. (d),

$$i = \frac{R_N}{R_N + 3}, \quad I_N = \left[\frac{(7/3)/(7/3 + 3)}{30/7}\right] = \frac{30}{16} = 1.875 \text{ A}$$

Chapter 4, Solution 57.

To find $R_{Th}$, remove the 50V source and insert a 1-V source at a – b, as shown in Fig. (a).

We apply nodal analysis. At node A,

$$i + 0.5v_x = (1/10) + (1 - v_x)/2, \text{ or } i + v_x = 0.6 \quad (1)$$

At node B,

$$\frac{1 - v_o}{2} = \frac{v_x}{3} + \frac{v_x}{6}, \text{ and } v_x = 0.5 \quad (2)$$
From (1) and (2), \( i = 0.1 \) and

\[
R_{Th} = \frac{1}{i} = 10 \text{ ohms}
\]

To get \( V_{Th} \), consider the circuit in Fig. (b).

At node 1, \( \frac{50 - v_1}{3} = \frac{v_1}{6} + \frac{v_1 - v_2}{2} \), or \( 100 = 6v_1 - 3v_2 \) (3)

At node 2, \( 0.5v_x + \frac{v_1 - v_2}{2} = \frac{v_2}{10}, v_x = v_1, \) and \( v_1 = 0.6v_2 \) (4)

From (3) and (4),

\[
v_2 = V_{Th} = 166.67 \text{ V}
\]

\[
I_N = \frac{V_{Th}}{R_{Th}} = 16.67 \text{ A}
\]

\[
R_N = R_{Th} = 10 \text{ ohms}
\]

Chapter 4, Solution 58.

This problem does not have a solution as it was originally stated. The reason for this is that the load resistor is in series with a current source which means that the only equivalent circuit that will work will be a Norton circuit where the value of \( R_N = \text{infinity} \). \( I_N \) can be found by solving for \( I_{sc} \).

Writing the node equation at node \( v_0 \),

\[
i_b + \beta i_b = \frac{v_0}{R_2} = (1 + \beta) i_b
\]
But
\[ i_b = \frac{(V_s - v_o)}{R_1} \]

\[ v_o = V_s - i_b R_1 \]

\[ V_s - i_b R_1 = (1 + \beta)R_2 i_b, \text{ or } i_b = \frac{V_s}{(R_1 + (1 + \beta)R_2)} \]

\[
I_{sc} = I_N = -\beta i_b = -\beta \frac{V_s}{(R_1 + (1 + \beta)R_2)}
\]

Chapter 4, Solution 59.

\[ R_{Th} = \frac{(10 + 20)}{(50 + 40)} \frac{30}{90} = 22.5 \text{ ohms} \]

To find \( V_{Th} \), consider the circuit below.

\[ i_1 = i_2 = \frac{8}{2} = 4, \quad 10i_1 + V_{Th} - 20i_2 = 0, \text{ or } V_{Th} = 20i_2 - 10i_1 = 10i_1 = 10 \times 4 \]

\[ V_{Th} = 40V, \text{ and } I_N = \frac{V_{Th}}{R_{Th}} = \frac{40}{22.5} = 1.7778 \text{ A} \]

Chapter 4, Solution 60.

The circuit can be reduced by source transformations.
Chapter 4, Solution 61.

To find $R_{Th}$, consider the circuit in Fig. (a).

Let $R = 2\|18 = 1.8 \text{ ohms}$, $R_{Th} = 2R|R = (2/3)R = 1.2 \text{ ohms}$.

To get $V_{Th}$, we apply mesh analysis to the circuit in Fig. (d).
This leads to the following matrix form for (1), (2) and (3),

\[
\begin{bmatrix}
7 & -3 & -3 \\
-3 & 7 & -3 \\
-3 & -3 & 7 \\
\end{bmatrix}
\begin{bmatrix}
i_1 \\
i_2 \\
i_3 \\
\end{bmatrix}
= 
\begin{bmatrix}
12 \\
-12 \\
0 \\
\end{bmatrix}
\]
\[
\Delta = \begin{vmatrix}
7 & -3 & -3 \\
-3 & 7 & -3 \\
-3 & -3 & 7 \\
\end{vmatrix} = 100, \quad \Delta_2 = \begin{vmatrix}
7 & 12 & -3 \\
-3 & -12 & -3 \\
-3 & 0 & 7 \\
\end{vmatrix} = -120
\]

\[i_2 = \frac{\Delta}{\Delta_2} = \frac{-120}{100} = -1.2 \text{ A}\]

\[V_{Th} = 12 + 2i_2 = 9.6 \text{ V}, \text{ and } I_N = \frac{V_{Th}}{R_{Th}} = 8 \text{ A}\]

**Chapter 4, Solution 62.**

Since there are no independent sources, \(V_{Th} = 0 \text{ V}\)

To obtain \(R_{Th}\), consider the circuit below.

At node 2,

\[i_x + 0.1i_o = (1 - v_1)/10, \text{ or } 10i_x + i_o = 1 - v_1 \quad (1)\]

At node 1,

\[(v_1/20) + 0.1i_o = [(2v_o - v_1)/40] + [(1 - v_1)/10] \quad (2)\]

But \(i_o = (v_1/20)\) and \(v_o = 1 - v_1\), then (2) becomes,

\[1.1v_1/20 = [(2 - 3v_1)/40] + [(1 - v_1)/10]\]

\[2.2v_1 = 2 - 3v_1 + 4 - 4v_1 = 6 - 7v_1\]

or

\[v_1 = 6/9.2 \quad (3)\]

From (1) and (3),

\[10i_x + v_1/20 = 1 - v_1\]

\[10i_x = 1 - v_1 - v_1/20 = 1 - (21/20)v_1 = 1 - (21/20)(6/9.2)\]

\[i_x = 31.52 \text{ mA}, \quad R_{Th} = 1/i_x = 31.73 \text{ ohms.}\]
Chapter 4, Solution 63.

Because there are no independent sources, \( I_N = I_{sc} = 0 \, A \)

\( R_N \) can be found using the circuit below.

![Circuit Diagram](image)

Applying KCL at node 1, \( 0.5v_o + (1 - v_1)/3 = v_1/30 \), but \( v_o = (20/30)v_1 \)

Hence, \( 0.5(2/3)(30)v_1 + 10 - 10v_1 = v_1 \), or \( v_1 = 10 \) and \( i_o = (1 - v_1)/3 = -3 \)

\( R_N = 1/i_o = -1/3 = -333.3 \, \text{m ohms} \)

Chapter 4, Solution 64.

With no independent sources, \( V_{Th} = 0 \, V \). To obtain \( R_{Th} \), consider the circuit shown below.

![Circuit Diagram](image)

\[
i_x = [(1 - v_o)/1] + [(10i_x - v_o)/4], \text{ or } 2v_o = 1 + 3i_x \quad (1)
\]

But \( i_x = v_o/2 \). Hence,

\[
2v_o = 1 + 1.5v_o, \text{ or } v_o = 2, \text{ i}_o = (1 - v_o)/1 = -1
\]

Thus, \( R_{Th} = 1/i_o = -1 \, \text{ohm} \)
Chapter 4, Solution 65

At the terminals of the unknown resistance, we replace the circuit by its Thevenin equivalent.

\[ R_{Th} = \frac{2 + 4}{12} = 2 + 3 = 5 \, \Omega, \quad V_{Th} = \frac{12}{12 + 4} (32) = 24 \, V \]

Thus, the circuit can be replaced by that shown below.

![Circuit Diagram](image)

Applying KVL to the loop,

\[-24 + 5I_o + V_o = 0 \quad \rightarrow \quad V_o = 24 - 5I_o\]

Chapter 4, Solution 66.

We first find the Thevenin equivalent at terminals a and b. We find \( R_{Th} \) using the circuit in Fig. (a).

![Circuit Diagram](image)

\[ R_{Th} = \frac{2 \parallel (3 + 5)}{2 \parallel 8} = 1.6 \, \text{ohms} \]

By performing source transformation on the given circuit, we obtain the circuit in (b).
We now use this to find $V_{Th}$.

$$10i + 30 + 20 + 10 = 0, \text{ or } i = -5$$

$$V_{Th} + 10 + 2i = 0, \text{ or } V_{Th} = 2 \text{ V}$$

$$p = \frac{V_{Th}^2}{4R_{Th}} = \frac{(2)^2}{4(1.6)} = \textbf{625 m watts}$$

**Chapter 4, Solution 67.**

We need to find the Thevenin equivalent at terminals a and b.

From Fig. (a),

$$R_{Th} = \frac{4 || 6 + 8 || 12}{12} = 2.4 + 4.8 = \textbf{7.2 ohms}$$

From Fig. (b),

$$10i_1 - 30 = 0, \text{ or } i_1 = 3$$

$$20i_2 + 30 = 0, \text{ or } i_2 = 1.5, \text{ } V_{Th} = 6i_1 + 8i_2 = 6 \times 3 - 8 \times 1.5 = \textbf{6 V}$$

For maximum power transfer,

$$p = \frac{V_{Th}^2}{4R_{Th}} = \frac{(6)^2}{4(7.2)} = \textbf{1.25 watts}$$
Chapter 4, Solution 68.

This is a challenging problem in that the load is already specified. This now becomes a "minimize losses" style problem. When a load is specified and internal losses can be adjusted, then the objective becomes, reduce $R_{\text{Th}}$ as much as possible, which will result in maximum power transfer to the load.

Removing the 10 ohm resistor and solving for the Thevenin Circuit results in:

$$R_{\text{Th}} = \frac{R \times 20}{R + 20} \text{ and } V_{\text{oc}} = V_{\text{Th}} = 12\times\frac{20}{R + 20} + (-8)$$

As $R$ goes to zero, $R_{\text{Th}}$ goes to zero and $V_{\text{Th}}$ goes to 4 volts, which produces the maximum power delivered to the 10-ohm resistor.

$$P = vi = v^2/R = \frac{4 \times 4}{10} = 1.6 \text{ watts}$$

Notice that if $R = 20$ ohms which gives an $R_{\text{Th}} = 10$ ohms, then $V_{\text{Th}}$ becomes -2 volts and the power delivered to the load becomes 0.1 watts, much less that the 1.6 watts.

It is also interesting to note that the internal losses for the first case are $12^2/20 = 7.2$ watts and for the second case are $= 12$ watts. This is a significant difference.

Chapter 4, Solution 69.

We need the Thevenin equivalent across the resistor $R$. To find $R_{\text{Th}}$, consider the circuit below.

Assume that all resistances are in k ohms and all currents are in mA.
\[10 \parallel 40 = 8, \text{ and } 8 + 22 = 30\]

\[1 + 3v_o = \left(\frac{v_1}{30}\right) + \left(\frac{v_1}{30}\right) = \left(\frac{v_1}{15}\right)\]

\[15 + 45v_o = v_1\]

But \(v_o = \left(\frac{8}{30}\right)v_1\), hence,

\[15 + 45\left(\frac{8}{30}\right)v_1, \text{ which leads to } v_1 = 1.3636\]

\[R_{Th} = \frac{v_1}{1} = -1.3636 \text{ k ohms}\]

To find \(V_{Th}\), consider the circuit below.

\[(100 - v_o)/10 = \left(\frac{v_o}{40}\right) + \left(\frac{v_o - v_1}{22}\right) \quad (1)\]

\[((v_o - v_1)/22) + 3v_o = \left(\frac{v_1}{30}\right) \quad (2)\]

Solving (1) and (2),

\[v_1 = V_{Th} = -243.6 \text{ volts}\]

\[p = \frac{V_{Th}^2}{4R_{Th}} = \frac{(243.6)^2}{4(-1363.6)} = 10.882 \text{ watts}\]
Chapter 4, Solution 70

We find the Thevenin equivalent across the 10-ohm resistor. To find $V_{Th}$, consider the circuit below.

From the figure,

$$V_x = 0, \quad V_{Th} = \frac{15}{15 + 5} (4) = 3V$$

To find $R_{Th}$, consider the circuit below:

At node 1,

$$\frac{4 - V_1}{5} = 3V_x + \frac{V_1}{15} + \frac{V_1 - V_2}{5}, \quad V_x = 6 \times 1 = 6 \quad \rightarrow \quad 258 = 3V_2 - 7V_1 \quad (1)$$
At node 2, 
\[1 + 3V_x + \frac{V_1 - V_2}{5} = 0 \quad \rightarrow \quad V_1 = V_2 - 95\]  
(2)

Solving (1) and (2) leads to \(V_2 = 101.75\) V

\[R_{th} = \frac{V_2}{I} = 101.75\Omega, \quad P_{max} = \frac{V_{th}^2}{4R_{th}} = \frac{9}{4\times101.75} = 22.11\text{ mW}\]

Chapter 4, Solution 71.

We need \(R_{Th}\) and \(V_{Th}\) at terminals a and b. To find \(R_{Th}\), we insert a 1-mA source at the terminals a and b as shown below.

Assume that all resistances are in k ohms, all currents are in mA, and all voltages are in volts. At node a,

\[
1 = \frac{v_a}{40} + \frac{(v_a + 120v_o)}{10}, \quad \text{or} \quad 40 = 5v_a + 480v_o \quad (1)
\]

The loop on the left side has no voltage source. Hence, \(v_o = 0\). From (1), \(v_a = 8\) V.

\[R_{Th} = \frac{v_a}{1 \text{ mA}} = 8 \text{ kohms}\]

To get \(V_{Th}\), consider the original circuit. For the left loop,

\[v_o = \frac{1}{4}8 = 2 \text{ V}\]

For the right loop, \(v_R = V_{Th} = (40/50)(-120v_o) = -192\)

The resistance at the required resistor is

\[R = R_{Th} = 8 \text{ kohms}\]

\[p = \frac{V_{Th}^2}{4R_{Th}} = \frac{(-192)^2}{4\times8\times10^3} = 1.152 \text{ watts}\]
Chapter 4, Solution 72.

(a) \( R_{Th} \) and \( V_{Th} \) are calculated using the circuits shown in Fig. (a) and (b) respectively.

From Fig. (a), \( R_{Th} = 2 + 4 + 6 = 12 \text{ ohms} \)

From Fig. (b), \(-V_{Th} + 12 + 8 + 20 = 0\), or \( V_{Th} = 40 \text{ V} \)

![Circuit Diagram](image)

(b) \( i = V_{Th}/(R_{Th} + R) = 40/(12 + 8) = 2 \text{A} \)

(c) For maximum power transfer, \( R_L = R_{Th} = 12 \text{ ohms} \)

(d) \( p = V_{Th}^2/(4R_{Th}) = (40)^2/(4 \times 12) = 33.33 \text{ watts} \).

Chapter 4, Solution 73

Find the Thevenin’s equivalent circuit across the terminals of R.

![Circuit Diagram](image)

\[ R_{Th} = 10 // 20 + 25 // 5 = 325 / 30 = 10.833 \Omega \]
\[ V_a = \frac{20}{30} \times 60 = 40, \quad V_b = \frac{5}{30} \times 60 = 10 \]

\[ -V_a + V_{Th} + V_b = 0 \quad \Rightarrow \quad V_{Th} = V_a - V_b = 40 - 10 = 30 \text{ V} \]

\[ P_{max} = \frac{V_{Th}^2}{4R_{Th}} = \frac{30^2}{4 \times 10.833} = 20.77 \text{ W} \]

**Chapter 4, Solution 74.**

When \( R_L \) is removed and \( V_s \) is short-circuited,

\[ R_{Th} = R_1||R_2 + R_3||R_4 = [R_1 R_2/(R_1 + R_2)] + [R_3 R_4/(R_3 + R_4)] \]

\[ R_L = R_{Th} = \frac{(R_1 R_2 R_3 + R_1 R_2 R_4 + R_1 R_3 R_4 + R_2 R_3 R_4)/((R_1 + R_2)(R_3 + R_4))}{(R_2/(R_1 + R_2) - [R_4/(R_3 + R_4)]) V_s = \{(R_2 R_3) - (R_1 R_4)/[(R_1 + R_2)(R_3 + R_4)]\} V_s} \]

\[ P_{max} = V_{Th}^2/(4R_{Th}) \]

\[ = \{(R_2 R_3) - (R_1 R_4)^2/[4(R_1 + R_2)(R_3 + R_4)]\} V_s^2[(R_1 + R_2)(R_3 + R_4)/4(a)] \]

where \( a = (R_1 R_2 R_3 + R_1 R_2 R_4 + R_1 R_3 R_4 + R_2 R_3 R_4) \)

\[ P_{max} = \]

\[ [(R_2 R_3) - (R_1 R_4)^2]V_s^2/[4(R_1 + R_2)(R_3 + R_4)] (R_1 R_2 R_3 + R_1 R_2 R_4 + R_1 R_3 R_4 + R_2 R_3 R_4) \]
Chapter 4, Solution 75.

We need to first find $R_{th}$ and $V_{th}$.

Consider the circuit in Fig. (a).

\[
\frac{1}{R_{th}} = \frac{1}{R} + \frac{1}{R} + \frac{1}{R} = \frac{3}{R}
\]

\[R_{th} = \frac{R}{3}\]

From the circuit in Fig. (b),

\[
\left(\frac{1-v_o}{R}\right) + \left(\frac{2-v_o}{R}\right) + \left(\frac{3-v_o}{R}\right) = 0
\]

\[v_o = 2 = V_{th}\]

For maximum power transfer,

\[R_L = R_{th} = \frac{R}{3}\]

\[P_{max} = \left[\frac{V_{th}^2}{4R_{th}}\right] = 3 \text{ mW}\]

\[R_{th} = \left[\frac{V_{th}^2}{4P_{max}}\right] = \frac{4}{4xP_{max}} = \frac{1}{P_{max}} = \frac{R}{3}\]

\[R = \frac{3}{(3\times10^{-3})} = 1 \text{ k ohms}\]

Chapter 4, Solution 76.

Follow the steps in Example 4.14. The schematic and the output plots are shown below. From the plot, we obtain,
$V = 92 \text{ V} \quad [i = 0, \text{ voltage axis intercept}]$

$R = \text{Slope} = \frac{(120 - 92)}{1} = \textbf{28 ohms}$
Chapter 4, Solution 77.

(a) The schematic is shown below. We perform a dc sweep on a current source, I1, connected between terminals a and b. We label the top and bottom of source I1 as 2 and 1 respectively. We plot $V(2) - V(1)$ as shown.

\[
V_{Th} = 4 \, \text{V} \quad \text{[zero intercept]}
\]

\[
R_{Th} = \frac{7.8 - 4}{1} = 3.8 \, \text{ohms}
\]
(b) Everything remains the same as in part (a) except that the current source, I₁, is connected between terminals b and c as shown below. We perform a dc sweep on I₁ and obtain the plot shown below. From the plot, we obtain,

\[ V = 15 \text{ V} \] [zero intercept]

\[ R = \frac{18.2 - 15}{1} = 3.2 \text{ ohms} \]
Chapter 4, Solution 78.

The schematic is shown below. We perform a dc sweep on the current source, I1, connected between terminals a and b. The plot is shown. From the plot we obtain,

\[ V_{Th} = -80 \text{ V} \text{ [zero intercept]} \]

\[ R_{Th} = \frac{(1920 - (-80))}{1} = 2 \text{ k ohms} \]
Chapter 4, Solution 79.

After drawing and saving the schematic as shown below, we perform a dc sweep on I1 connected across a and b. The plot is shown. From the plot, we get,

\[ V = 167 \, \text{V} \quad \text{[zero intercept]} \]

\[ R = \frac{(177 - 167)}{1} = 10 \, \text{ohms} \]
Chapter 4, Solution 80.

The schematic in shown below. We label nodes a and b as 1 and 2 respectively. We perform dc sweep on I1. In the Trace/Add menu, type \( v(1) - v(2) \) which will result in the plot below. From the plot,

\[
V_{Th} = 40 \text{ V} \quad \text{[zero intercept]}
\]

\[
R_{Th} = \frac{40 - 17.5}{1} = 22.5 \text{ ohms} \quad \text{[slope]}
\]
Chapter 4, Solution 81.

The schematic is shown below. We perform a dc sweep on the current source, $I_2$, connected between terminals a and b. The plot of the voltage across $I_2$ is shown below. From the plot,

$$V_{Th} = 10 \text{ V} \quad \text{[zero intercept]}$$

$$R_{Th} = \frac{(10 - 6.4)}{1} = 3.4 \text{ ohms}.$$
Chapter 4, Solution 82.

\[ V_{Th} = V_{oc} = 12 \text{ V}, \quad I_{sc} = 20 \text{ A} \]

\[ R_{Th} = \frac{V_{oc}}{I_{sc}} = \frac{12}{20} = 0.6 \text{ ohm}. \]

\[ i = \frac{12}{2.6}, \quad p = i^2R = \left(\frac{12}{2.6}\right)^2(2) = 42.6 \text{ watts} \]

Chapter 4, Solution 83.

\[ V_{Th} = V_{oc} = 12 \text{ V}, \quad I_{sc} = I_N = 1.5 \text{ A} \]

\[ R_{Th} = \frac{V_{Th}}{I_N} = 8 \text{ ohms}, \quad V_{Th} = 12 \text{ V}, \quad R_{Th} = 8 \text{ ohms} \]
Chapter 4, Solution 84

Let the equivalent circuit of the battery terminated by a load be as shown below.

For open circuit,

\[ R_L = \infty, \quad V_{th} = V_{oc} = V_L = 10.8 \text{ V} \]

When \( R_L = 4 \text{ ohm}, \) \( V_L = 10.5, \)

\[ I_L = \frac{V_L}{R_L} = 10.8/4 = 2.7 \text{ A} \]

But

\[ V_{th} = V_L + I_L R_{Th} \quad \rightarrow \quad R_{Th} = \frac{V_{th} - V_L}{I_L} = \frac{12 - 10.8}{2.7} = 0.4444 \Omega \]

Chapter 4, Solution 85

(a) Consider the equivalent circuit terminated with R as shown below.

\[ V_{ab} = \frac{R}{R + R_{Th}} V_{Th} \quad \rightarrow \quad 6 = \frac{10}{10 + R_{Th}} V_{Th} \]

or

\[ 60 + 6R_{Th} = 10V_{Th} \quad \text{(1)} \]

where \( R_{Th} \) is in k-ohm.
Similarly,
\[ 12 = \frac{30}{30 + R_{Th}} V_{Th} \quad \longrightarrow \quad 360 + 12R_{Th} = 30V_{Th} \quad (2) \]

Solving (1) and (2) leads to

\[ V_{Th} = 24 \text{ V, } R_{Th} = 30k\Omega \]

(b) \[ V_{ab} = \frac{20}{20 + 30} (24) = 9.6 \text{ V} \]

Chapter 4, Solution 86.

We replace the box with the Thevenin equivalent.

\[ V_{Th} = v + iR_{Th} \]

When \( i = 1.5, \ v = 3 \), which implies that \( V_{Th} = 3 + 1.5R_{Th} \) \quad (1)

When \( i = 1, \ v = 8 \), which implies that \( V_{Th} = 8 + 1xR_{Th} \) \quad (2)

From (1) and (2), \( R_{Th} = 10 \) ohms and \( V_{Th} = 18 \text{ V.} \)

(a) When \( R = 4, \ i = V_{Th}/(R + R_{Th}) = 18/(4 + 10) = 1.2857 \text{ A} \)

(b) For maximum power, \( R = R_{TH} \)

\[ P_{max} = (V_{Th})^2/4R_{Th} = 18^2/(4x10) = 8.1 \text{ watts} \]

Chapter 4, Solution 87.

(a) \( i_m = 9.975 \text{ mA} \)

(b) \( i_m = 9.876 \text{ mA} \)
From Fig. (a),
\[ v_m = R_m i_m = 9.975 \text{ mA} \times 20 = 0.1995 \text{ V} \]
\[ I_s = 9.975 \text{ mA} + \left( \frac{0.1995}{R_s} \right) \quad (1) \]

From Fig. (b),
\[ v_m = R_m i_m = 20 \times 9.876 = 0.19752 \text{ V} \]
\[ I_s = 9.876 \text{ mA} + \left( \frac{0.19752}{2k} \right) + \left( \frac{0.19752}{R_s} \right) \]
\[ = 9.975 \text{ mA} + \left( \frac{0.19752}{R_s} \right) \quad (2) \]

Solving (1) and (2) gives,
\[ R_s = 8 \text{ k ohms}, \quad I_s = 10 \text{ mA} \]

(b)

\[ 8k || 4k = 2.667 \text{ k ohms} \]
\[ i_m' = \frac{2667}{(2667 + 20)}(10 \text{ mA}) = 9.926 \text{ mA} \]

Chapter 4, Solution 88

To find \( R_{Th} \), consider the circuit below.

\[ R_{Th} = 30 + 10 + 20 \parallel 5 = 44 \text{k} \Omega \]
To find $V_{Th}$, consider the circuit below.

![Circuit Diagram]

$$V_A = 30 \times 4 = 120, \quad V_B = \frac{20}{25} (60) = 48, \quad V_{Th} = V_A - V_B = 72 \text{ V}$$

**Chapter 4, Solution 89**

It is easy to solve this problem using Pspice.

(a) The schematic is shown below. We insert IPROBE to measure the desired ammeter reading. We insert a very small resistance in series IPROBE to avoid problem. After the circuit is saved and simulated, the current is displaced on IPROBE as $99.99 \mu A$.

(b) By interchanging the ammeter and the 12-V voltage source, the schematic is shown below. We obtain exactly the same result as in part (a).
Chapter 4, Solution 90.

\[ R_x = \left( \frac{R_3}{R_1} \right) R_2 = \left( \frac{4}{2} \right) R_2 = 42.6, \quad R_2 = 21.3 \]

which is \((21.3\text{ohms/100ohms})\% = 21.3\%\)

Chapter 4, Solution 91.

\[ R_x = \left( \frac{R_3}{R_1} \right) R_2 \]

(a) Since \(0 < R_2 < 50 \text{ ohms}\), to make \(0 < R_x < 10 \text{ ohms}\) requires that when \(R_2 = 50 \text{ ohms}\), \(R_x = 10 \text{ ohms}\).

\[ 10 = \left( \frac{R_3}{R_1} \right) 50 \quad \text{or} \quad R_3 = \frac{R_1}{5} \]

so we select \(R_1 = \underline{100 \text{ ohms}}\) and \(R_3 = \underline{20 \text{ ohms}}\)

(b) For \(0 < R_x < 100 \text{ ohms}\)

\[ 100 = \left( \frac{R_3}{R_1} \right) 50, \quad \text{or} \quad R_3 = 2R_1 \]

So we can select \(R_1 = \underline{100 \text{ ohms}}\) and \(R_3 = \underline{200 \text{ ohms}}\)
Chapter 4, Solution 92.

For a balanced bridge, $v_{ab} = 0$. We can use mesh analysis to find $v_{ab}$. Consider the circuit in Fig. (a), where $i_1$ and $i_2$ are assumed to be in mA.

![Circuit Diagram](image)

\[ 220 = 2i_1 + 8(i_1 - i_2) \quad \text{or} \quad 220 = 10i_1 - 8i_2 \quad (1) \]

\[ 0 = 24i_2 - 8i_1 \quad \text{or} \quad i_2 = (1/3)i_1 \quad (2) \]

From (1) and (2), $i_1 = 30 \text{ mA}$ and $i_2 = 10 \text{ mA}$

Applying KVL to loop 0ab0 gives

\[ 5(i_2 - i_1) + v_{ab} + 10i_2 = 0 \text{ V} \]

Since $v_{ab} = 0$, the bridge is balanced.

When the 10 k ohm resistor is replaced by the 18 k ohm resistor, the bridge becomes unbalanced. (1) remains the same but (2) becomes

\[ 0 = 32i_2 - 8i_1, \quad \text{or} \quad i_2 = (1/4)i_1 \quad (3) \]

Solving (1) and (3),

\[ i_1 = 27.5 \text{ mA}, \quad i_2 = 6.875 \text{ mA} \]

\[ v_{ab} = 5(i_1 - i_2) - 18i_2 = -20.625 \text{ V} \]

\[ V_{Th} = v_{ab} = -20.625 \text{ V} \]

To obtain $R_{Th}$, we convert the delta connection in Fig. (b) to a wye connection shown in Fig. (c).
\( R_1 = \frac{3 \times 5}{2 + 3 + 5} = 1.5 \text{ k ohms}, \quad R_2 = \frac{2 \times 3}{10} = 600 \text{ ohms}, \)

\( R_3 = \frac{2 \times 5}{10} = 1 \text{ k ohm}. \)

\( R_{Th} = R_1 + (R_2 + 6)|| (R_3 + 18) = 1.5 + 6.6||9 = 6.398 \text{ k ohms} \)

\( R_L = R_{Th} = 6.398 \text{ k ohms} \)

\( P_{max} = \frac{(V_{Th})^2}{4R_{Th}} = \frac{(20.625)^2}{4 \times 6.398} = 16.622 \text{ mWatts} \)

Chapter 4, Solution 93.

\[-V_s + (R_s + R_o)i_x + \beta R_o i_x = 0 \]

\[i_x = \frac{V_s}{R_s + (1 + \beta)R_o} \]
Chapter 4, Solution 94.

(a) \[ V_o/V_g = \frac{R_p}{R_g + R_s + R_p} \]  
\[ R_{eq} = \frac{R_p}{R_g + R_s} = R_g \]

\[ R_g = \frac{R_p(R_g + R_s)}{R_g + R_s + R_p} \]

\[ R_g R_p + R_g^2 + R_g R_s = R_p R_g + R_p R_s \]

\[ R_p R_s = R_g(R_g + R_s) \]

From (1), \[ \frac{R_p}{\alpha} = R_g + R_s + R_p \]

\[ R_g + R_s = R_p(1/\alpha - 1) = R_p(1 - \alpha)/\alpha \] \hspace{1cm} (1a)

Combining (2) and (1a) gives,

\[ R_s = [(1 - \alpha)/\alpha]R_{eq} \]

\[ = (1 - 0.125)(100)/0.125 = 700 \text{ ohms} \]

From (3) and (1a),

\[ R_p(1 - \alpha)/\alpha = R_g + [(1 - \alpha)/\alpha]R_g = R_g/\alpha \]

\[ R_p = \frac{R_g}{1 - \alpha} = \frac{100}{1 - 0.125} = 114.29 \text{ ohms} \]

(b)

\[ V_{Th} = V_s = 0.125V_g = 1.5 \text{ V} \]

\[ R_{Th} = R_g = 100 \text{ ohms} \]

\[ I = \frac{V_{Th}}{R_{Th} + R_L} = \frac{1.5}{150} = 10 \text{ mA} \]
Chapter 4, Solution 95.

Let \( 1/\text{sensitivity} = 1/(20 \text{ k ohms/volt}) = 50 \mu\text{A} \)

For the 0 – 10 V scale,
\[
R_m = V_{fs}/I_{fs} = 10/50 \mu\text{A} = 200 \text{ k ohms}
\]

For the 0 – 50 V scale,
\[
R_m = 50(20 \text{ k ohms/V}) = 1 \text{ M ohm}
\]

![Circuit Diagram]

\[
V_{Th} = I(R_{Th} + R_m)
\]

(a) A 4V reading corresponds to
\[
I = (4/10)I_{fs} = 0.4 \times 50 \mu\text{A} = 20 \mu\text{A}
\]
\[
V_{Th} = 20 \mu\text{A} \times R_{Th} + 20 \mu\text{A} \times 250 \text{ k ohms}
\]
\[
= 4 + 20 \mu\text{A} \times R_{Th}
\]

(b) A 5V reading corresponds to
\[
I = (5/50)I_{fs} = 0.1 \times 50 \mu\text{A} = 5 \mu\text{A}
\]
\[
V_{Th} = 5 \mu\text{A} \times R_{Th} + 5 \mu\text{A} \times 1 \text{ M ohm}
\]
\[
V_{Th} = 5 + 5 \mu\text{A} \times R_{Th}
\]

From (1) and (2)
\[
0 = -1 + 15 \mu\text{A} \times R_{Th} \quad \text{which leads to} \quad R_{Th} = 66.67 \text{ k ohms}
\]

From (1),
\[
V_{Th} = 4 + 20 \times 10^{-6} \times (1/(15 \times 10^{-6})) = 5.333 \text{ V}
\]
Chapter 4, Solution 96.

(a) The resistance network can be redrawn as shown in Fig. (a),

\[ R_{Th} = 10 + 10 + 60||((8 + 8 + 10)||40) = 20 + 60||24 = 37.14 \text{ ohms} \]

Using mesh analysis,

\[
\begin{align*}
-9 + 50i_1 - 40i_2 &= 0 \\
116i_2 - 40i_1 &= 0 \quad \text{or} \quad i_1 = 2.9i_2
\end{align*}
\]

From (1) and (2), \( i_2 = 9/105 \)

\[ V_{Th} = 60i_2 = 5.143 \text{ V} \]

From Fig. (b),

\[ V_o = \left[\frac{R}{R + R_{Th}}\right]V_{Th} = 1.8 \]

\[ \frac{R}{R + 37.14} = 1.8/5.143 \text{ which leads to } R = 20 \text{ ohms} \]

(b) \( R = R_{Th} = 37.14 \text{ ohms} \)

\[ I_{max} = \frac{V_{Th}}{2R_{Th}} = \frac{5.143}{2 \times 37.14} = 69.23 \text{ mA} \]

Chapter 4, Solution 97.
\[ R_{Th} = R_1 || R_2 = 6 || 4 = 2.4 \text{ k ohms} \]

\[ V_{Th} = \frac{R_2}{R_1 + R_2} V_s = \frac{4}{(6 + 4)}(12) = 4.8 \text{ V} \]

**Chapter 4, Solution 98.**

The 20-ohm, 60-ohm, and 14-ohm resistors form a delta connection which needs to be connected to the wye connection as shown in Fig. (b),

\[ R_1 = \frac{20 \times 60}{20 + 60 + 14} = \frac{1200}{94} = 12.97 \text{ ohms} \]

\[ R_2 = \frac{20 \times 14}{94} = 2.98 \text{ ohms} \]

\[ R_3 = \frac{60 \times 14}{94} = 8.94 \text{ ohms} \]

\[ R_{Th} = R_3 + R_1 || (R_2 + 30) = 8.94 + 12.77 || 32.98 = 18.15 \text{ ohms} \]

To find \( V_{Th} \), consider the circuit in Fig. (c).
$I_T = \frac{16}{(30 + 15.74)} = 350 \text{ mA}$

$I_1 = \frac{20}{(20 + 60 + 14)}I_T = 94.5 \text{ mA}$

$V_{Th} = 14I_1 + 30I_T = 11.824 \text{ V}$

$I_{40} = \frac{V_{Th}}{(R_{Th} + 40)} = \frac{11.824}{(18.15 + 40)} = 203.3 \text{ mA}$

$P_{40} = I_{40}^2R = 1.654 \text{ watts}$