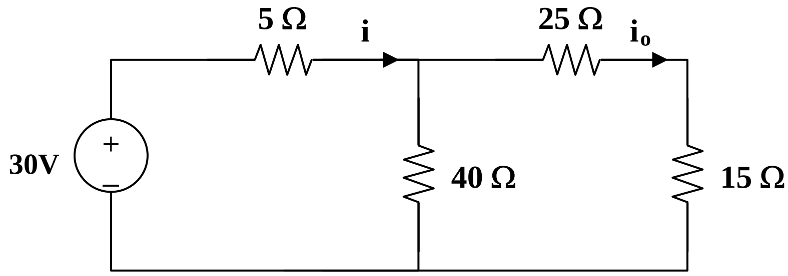
Chapter 4, Solution 1.



$40 \| (25+15) = 20\Omega$, i = [30/(5+20)] = 1.2 and i_o = i20/40 = **600 mA**.

Since the resistance remains the same we get can use linearity to find the new value of the voltage source = (30/0.6)5 = **250 V**.

4.2 Using Fig. 4.70, design a problem to help other students better understand linearity.

Although there are many ways to work this problem, this is an example based on the same kind of problem asked in the third edition.

Problem

Find v_o in the circuit of Fig. 4.70. If the source current is reduced to 1 μA, what is v_o?

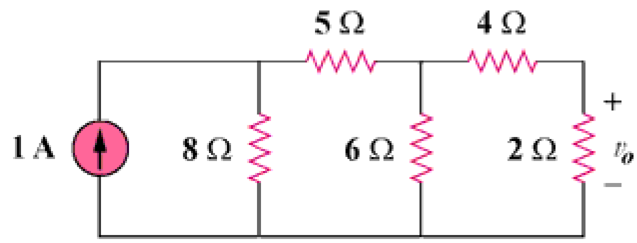
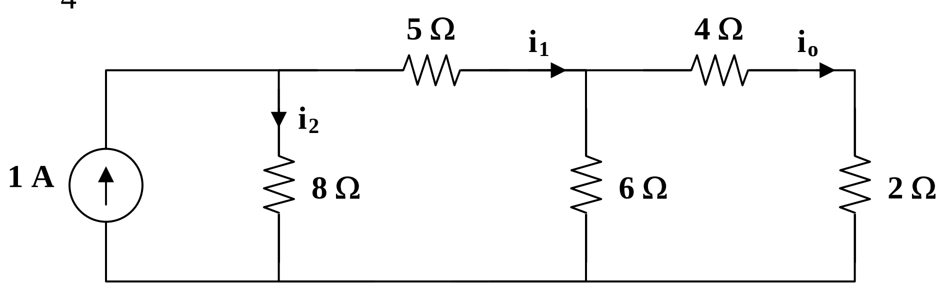


Figure 4.70

Solution

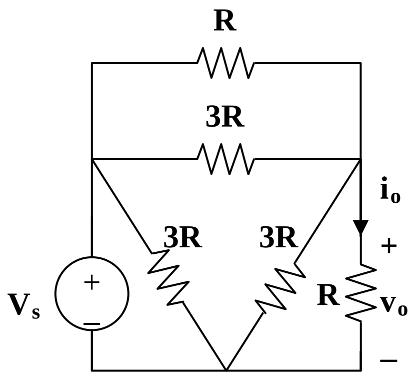
$$6\|(4+2) = 3\Omega, \quad i_1 = i_2 = \frac{1}{2}\text{A}$$

$$i_o = \frac{1}{2}i_1 = \frac{1}{4}, \quad v_o = 2i_o = \underline{\mathbf{0.5V}}$$

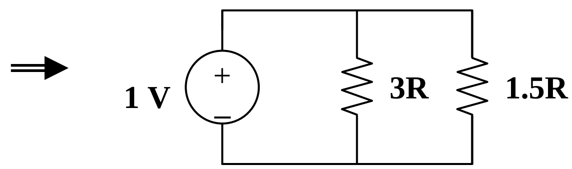


If i_s = 1µA, then v_o = **0.5µV**

Chapter 4, Solution 3.



(a)



(b)

(a) We transform the Y sub-circuit to the equivalent Δ.

$$R \| 3R = \frac{3R^2}{4R} = \frac{3}{4}R, \quad \frac{3}{4}R + \frac{3}{4}R = \frac{3}{2}R$$

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

$i_o = v_o/(R)$

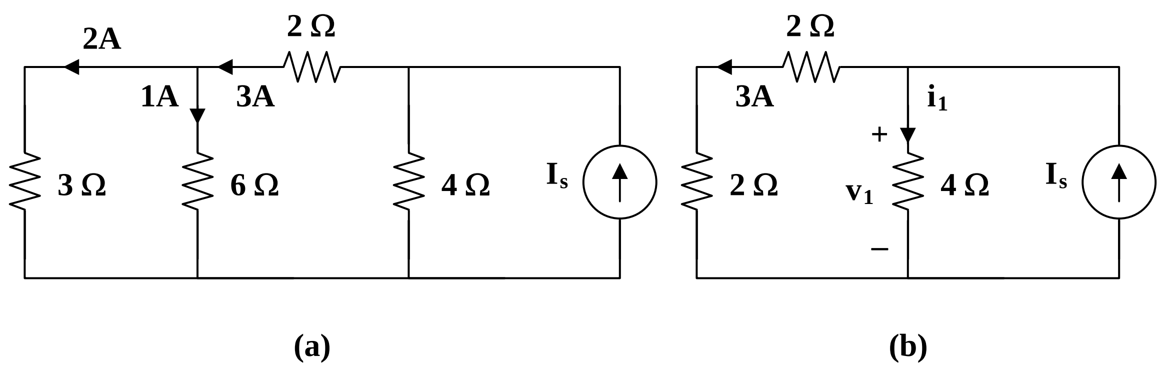
When $v_s = 1V$, $v_o =$ **0.5V**, $i_o =$ **0.5A**

(b) When $v_s = 10V$, $v_o =$ **5V**, $i_o =$ **5A**

(c) When $v_s = 10V$ and $R = 10\Omega$,
$v_o =$ **5V**, $i_o = 10/(10) =$ **500mA**

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.



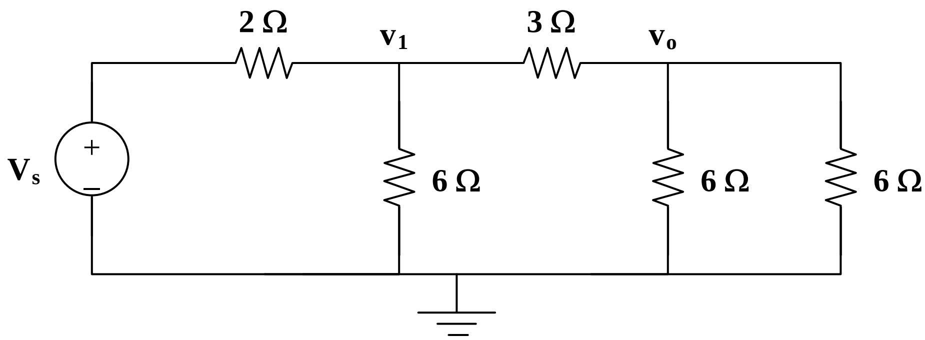
$3 \| 6 = 2\Omega$, $v_o = 3(4) = 12V$, $i_1 = \frac{v_o}{4} = 3A.$

Hence $I_s = 3 + 3 = 6A$

If $\quad I_s = 6A \longrightarrow I_o = 1$

$\quad\quad I_s = 9A \longrightarrow I_o = 9/6 = \mathbf{1.5A}$

Chapter 4, Solution 5.



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

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

If $v_s = \frac{10}{3}$ ⟶ $v_o = 1$

Then v_s = 15 ⟶ $v_o = \frac{3}{10} x15 =$ **4.5V**

Chapter 4, Solution 6.

Due to linearity, from the first experiment,

$$V_o = \frac{1}{3} V_s$$

Applying this to other experiments, we obtain:

Experiment	V_s	V_o
2	48	16 V
3	1 V	0.333 V
4	-6 V	-2V

Chapter 4, Solution 7.

If V_o = 1V, then the current through the 2-Ω and 4-Ω resistors is ½ = 0.5. The voltage across the 3-Ω resistor is ½ (4 + 2) = 3 V. The total current through the 1-Ω resistor is 0.5 +3/3 = 1.5 A. Hence the source voltage

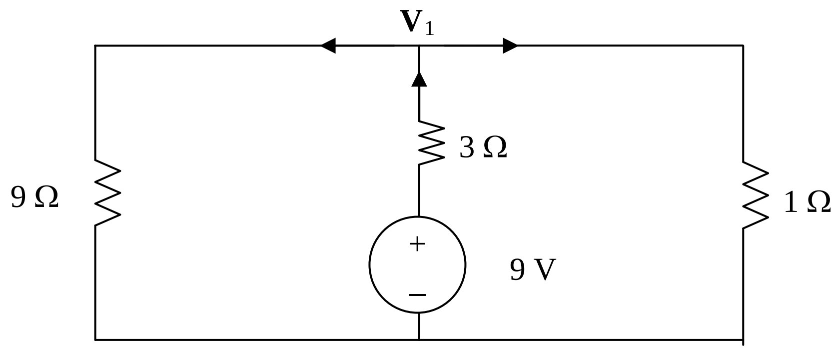
$$v_s = 1x1.5 + 3 = 4.5 \text{ V}$$

If $v_s = 4.5 \longrightarrow 1V$

Then $v_s = 4 \longrightarrow \frac{1}{4.5}x4 = \underline{0.8889 \text{ V}}$ = **888.9 mV**.

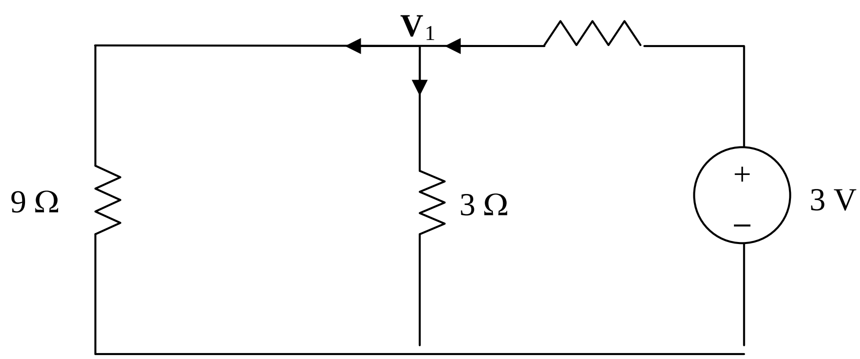
Chapter 4, Solution 8.

Let $V_o = V_1 + V_2$, where V_1 and V_2 are due to 9-V and 3-V sources respectively. To find V_1, consider the circuit below.



$$\frac{9-V_1}{3} = \frac{V_1}{9} + \frac{V_1}{1} \longrightarrow V_1 = 27/13 = 2.0769$$

To find V_2, consider the circuit below.

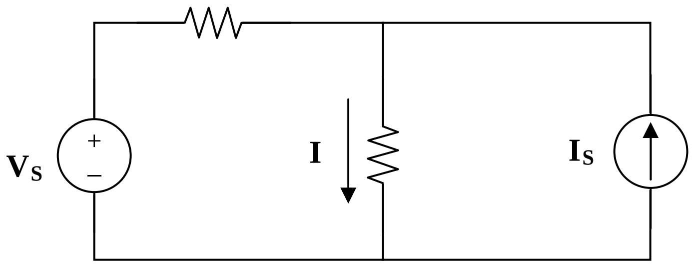


$$\frac{V_2}{9} + \frac{V_2}{3} = \frac{3-V_2}{1} \longrightarrow V_2 = 27/13 = 2.0769$$

$V_o = V_1 + V_2 =$ **4.1538 V**

Chapter 4. Solution 9.

Given that I = 4 amps when V_s = 40 volts and I_s = 4 amps and I = 1 amp when V_s = 20 volts and I_s = 0, determine the value of I when V_s = 60 volts and I_s = –2 amps.



At first this appears to be a difficult problem. However, if you take it one step at a time then it is not as hard as it seems. The important thing to keep in mind is that it is linear!

If I = 1 amp when V_s = 20 and I_s = 0 then I = 2 amps when V_s = 40 volts and I_s = 0 (linearity). This means that I is equal to 2 amps (4–2) when I_s = 4 amps and V_s = 0 (superposition). Thus,

$$I = (60/20)1 + (-2/4)2 = 3-1 = \mathbf{2\ amps}.$$

Chapter 4, Solution 10.

Using Fig. 4.78, design a problem to help other students better understand superposition. Note, the letter *k* is a gain you can specify to make the problem easier to solve but must not be zero.

Although there are many ways to work this problem, this is an example based on the same kind of problem asked in the third edition.

Problem

For the circuit in Fig. 4.78, find the terminal voltage V_{ab} using superposition.

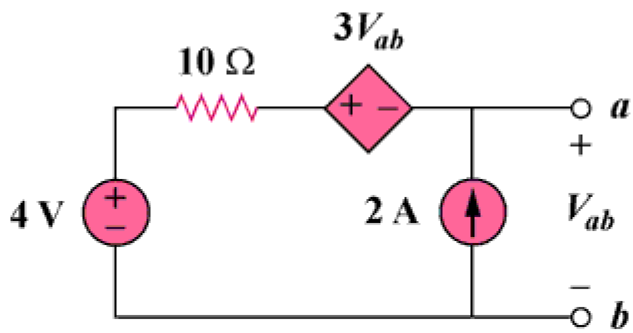
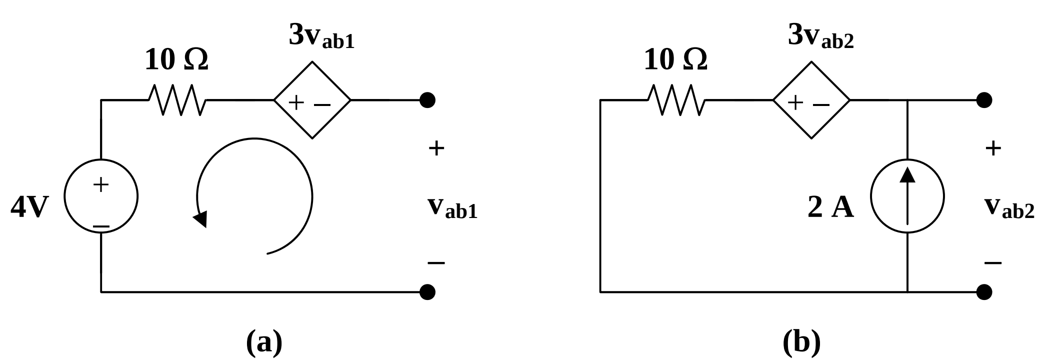


Figure 4.78
For Prob. 4.10.

Solution

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,

$$- v_{ab1} - 3\,v_{ab1} + 10x0 + 4 = 0, \text{ which leads to } v_{ab1} = 1 \text{ V}$$

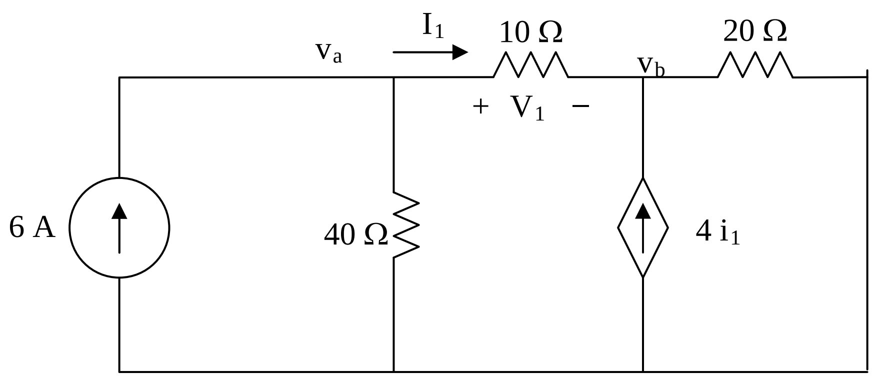
For v_{ab2}, consider Fig. (b). Applying KVL gives,

$$-v_{ab2} - 3v_{ab2} + 10x2 = 0, \text{ which leads to } v_{ab2} = 5$$

$$v_{ab} = 1 + 5 = \mathbf{6\ V}$$

Chapter 4, Solution 11.

Let $v_o = v_1 + v_2$, where v_1 and v_2 are due to the 6-A and 80-V sources respectively. To find v_1, consider the circuit below.



At node a,

$$6 = \frac{v_a}{40} + \frac{v_a - v_b}{10} \longrightarrow 240 = 5v_a - 4v_b \qquad (1)$$

At node b,

$$-I_1 - 4I_1 + (v_b - 0)/20 = 0 \text{ or } v_b = 100I_1$$

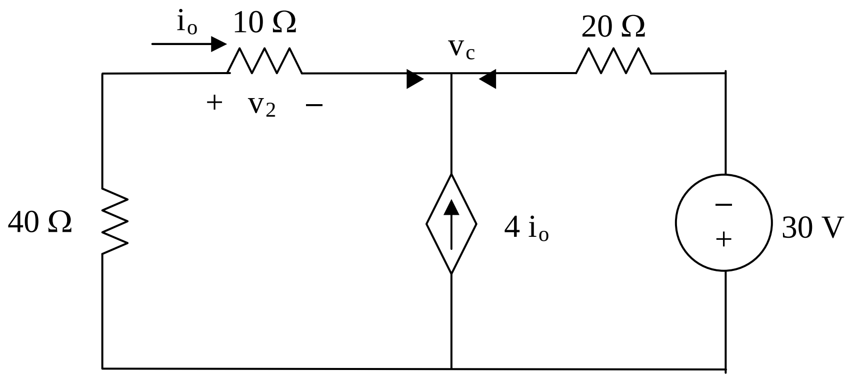
But $i_1 = \dfrac{v_a - v_b}{10}$ which leads to $100(v_a - v_b)10 = v_b$ or $v_b = 0.9091v_a$ (2)

Substituting (2) into (1),

$$5v_a - 3.636v_a = 240 \text{ or } v_a = 175.95 \text{ and } v_b = 159.96$$

However, $v_1 = v_a - v_b = 15.99$ V.

To find v_2, consider the circuit below.



$$\frac{0-v_c}{50}+4i_o+\frac{(-30-v_c)}{20}=0$$

But $i_o=\dfrac{(0-v_c)}{50}$

$$-\frac{5v_c}{50}-\frac{(30+v_c)}{20}=0 \longrightarrow v_c=-10\text{ V}$$

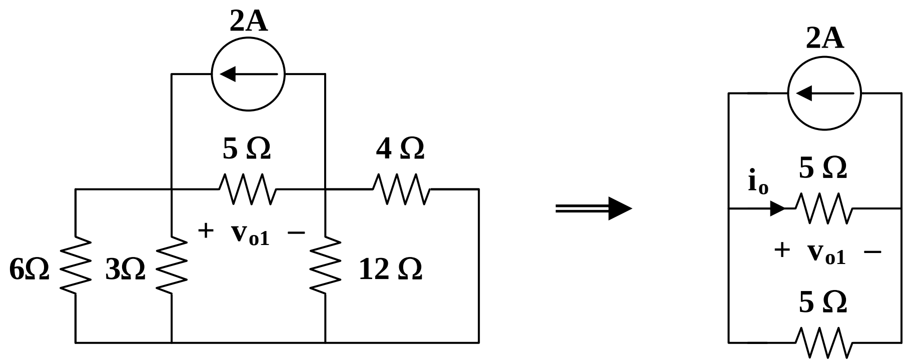
$$i_2=\frac{0-v_c}{50}=\frac{0+10}{50}=\frac{1}{5}$$

$$v_2=10i_2=2\text{ V}$$

$v_o = v_1 + v_2$ =15.99 + 2 = **17.99 V** and $i_o = v_o/10$= **1.799 A**.

Chapter 4, Solution 12.

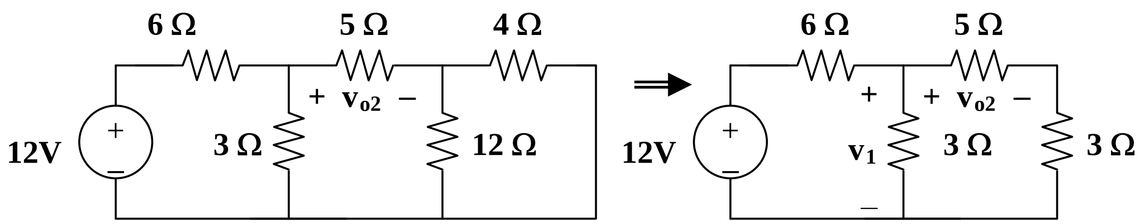
Let $v_o = v_{o1} + v_{o2} + v_{o3}$, where v_{o1}, v_{o2}, and v_{o3} are due to the 2-A, 12-V, and 19-V sources respectively. For v_{o1}, consider the circuit below.



$$6||3 = 2 \text{ ohms}, \; 4||12 = 3 \text{ ohms. Hence,}$$

$$i_o = 2/2 = 1, \; v_{o1} = 5io = 5 \text{ V}$$

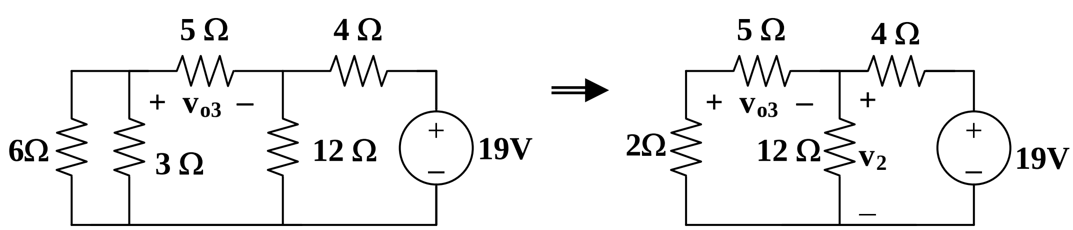
For v_{o2}, consider the circuit below.



$$3||8 = 24/11, \; v_1 = [(24/11)/(6 + 24/11)]12 = 16/5$$

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

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



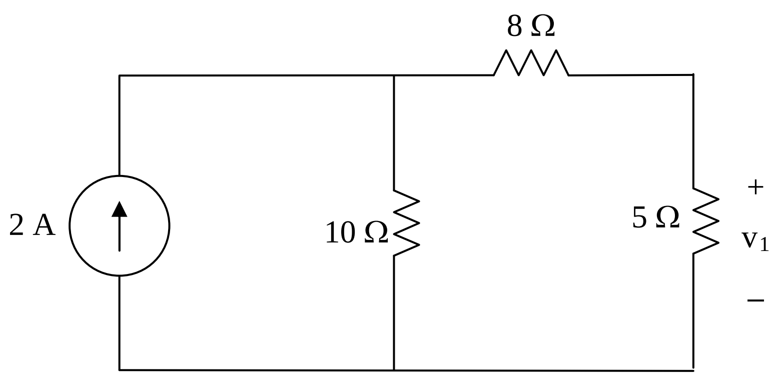
$$7||12 = (84/19) \text{ ohms}, \; v_2 = [(84/19)/(4 + 84/19)]19 = 9.975$$

$$v = (-5/7)v2 = -7.125$$

$$v_o = 5 + 2 – 7.125 = \mathbf{-125 \text{ mV}}$$

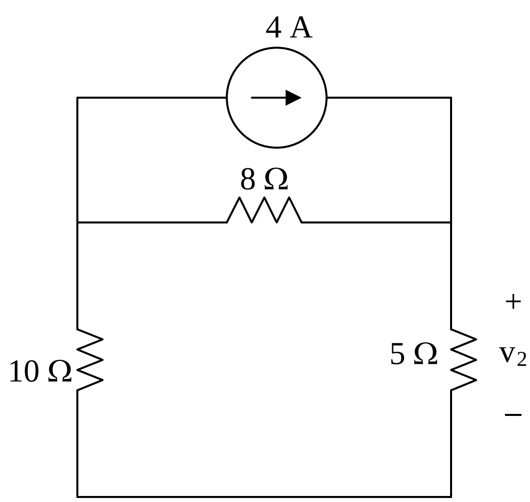
Chapter 4, Solution 13.

Let $v_o = v_1 + v_2 + v_3$, where v_1, v_2, and v_3 are due to the independent sources. To find v_1, consider the circuit below.



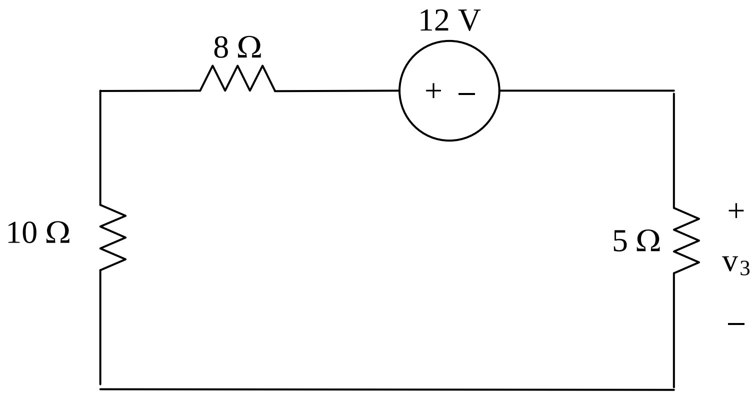
$$v_1 = 5x\frac{10}{10+8+5}x2 = 4.3478$$

To find v_2, consider the circuit below.



$$v_2 = 5x\frac{8}{8+10+5}x4 = 6.9565$$

To find v_3, consider the circuit below.

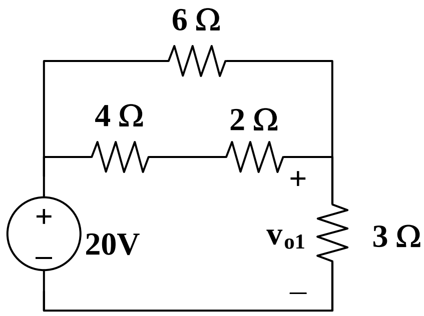


$$v_3 = -12\left(\frac{5}{5+10+8}\right) = -2.6087$$

$$v_o = v_1 + v_2 + v_3 = \underline{8.6956\ \text{V}} = \mathbf{8.696V}.$$

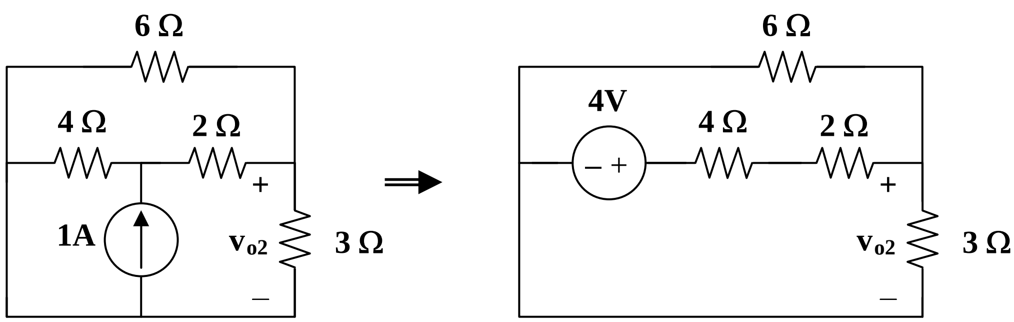
Chapter 4, Solution 14.

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.



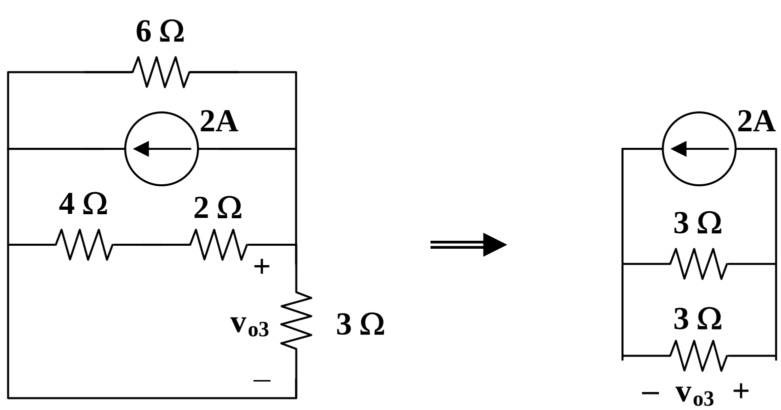
$$6||(4 + 2) = 3 \text{ ohms}, \; v_{o1} = (½)20 = 10 \text{ V}$$

For v_{o2}, consider the circuit below.



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

For v_{o3}, consider the circuit below.

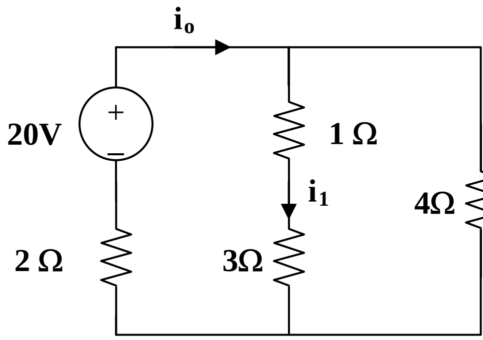


$$6||(4 + 2) = 3, \; v_{o3} = (-1)3 = –3$$

$$v_o = 10 + 1 – 3 = \mathbf{8 \text{ V}}$$

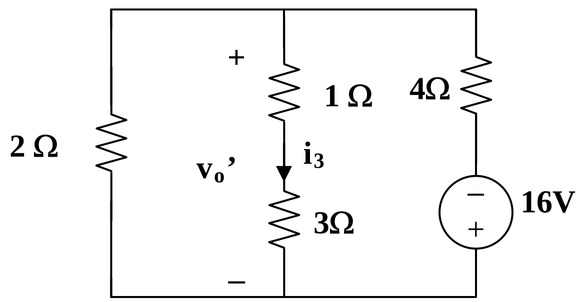
Chapter 4, Solution 15.

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.



$$4||(3 + 1) = 2 \text{ ohms, Then } i_o = [20/(2 + 2)] = 5 \text{ A, } i_1 = i_o/2 = 2.5 \text{ A}$$

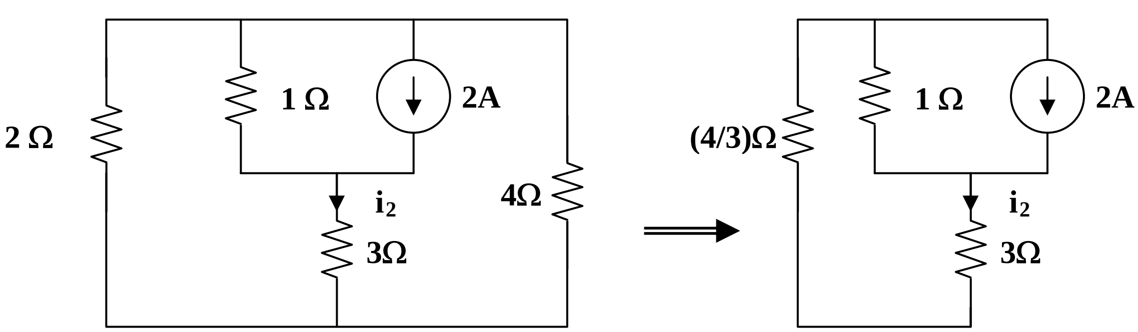
For i_3, consider the circuit below.



$$2||(1 + 3) = 4/3, \quad v_o' = [(4/3)/((4/3) + 4)](-16) = -4$$

$$i_3 = v_o'/4 = -1$$

For i_2, consider the circuit below.



$$2||4 = 4/3, \quad 3 + 4/3 = 13/3$$

Using the current division principle.

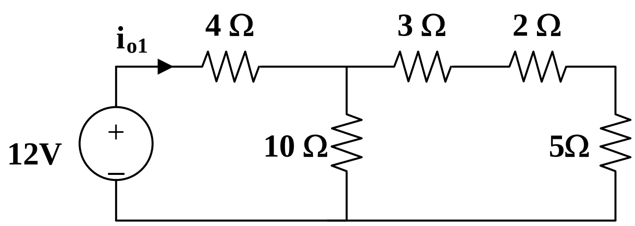
$$i_2 = [1/(1 + 13/2)]2 = 3/8 = 0.375$$

$$i = 2.5 + 0.375 - 1 = \mathbf{1.875\ A}$$

$$p = i^2R = (1.875)^2 3 = \mathbf{10.55\ watts}$$

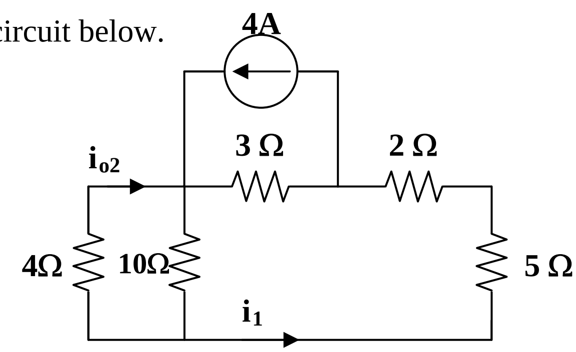
Chapter 4, Solution 16.

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.



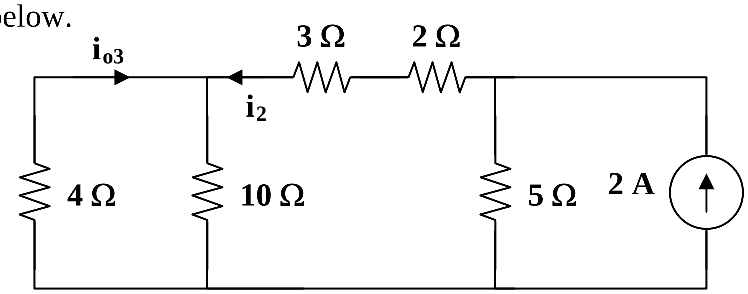
$$10||(3 + 2 + 5) = 5 \text{ ohms}, \quad i_{o1} = 12/(5 + 4) = (12/9) \text{ A}$$

For i_{o2}, consider the circuit below.



$$2 + 5 + 4||10 = 7 + 40/14 = 69/7$$
$$i_1 = [3/(3 + 69/7)]4 = 84/90, \quad i_{o2} = [-10/(4 + 10)]i_1 = -6/9$$

For i_{o3}, consider the circuit below.



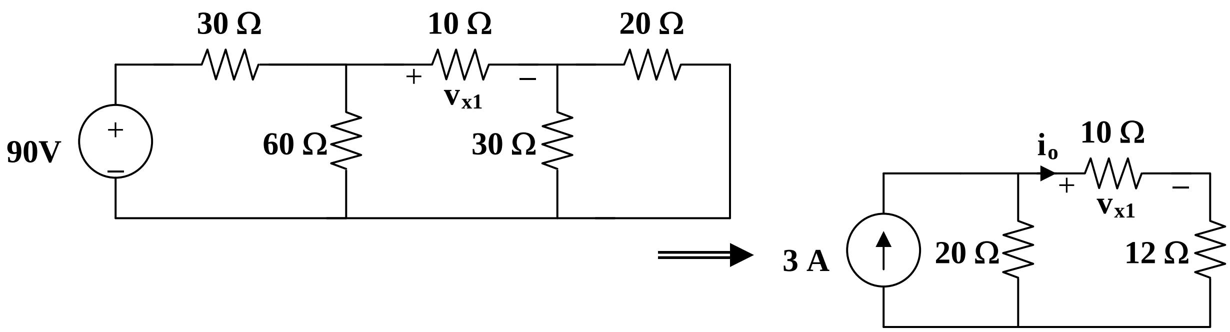
$$3 + 2 + 4||10 = 5 + 20/7 = 55/7$$

$$i_2 = [5/(5 + 55/7)]2 = 7/9, \quad i_{o3} = [-10/(10 + 4)]i_2 = -5/9$$

$$i_o = (12/9) – (6/9) – (5/9) = 1/9 = \mathbf{111.11\ mA}$$

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.

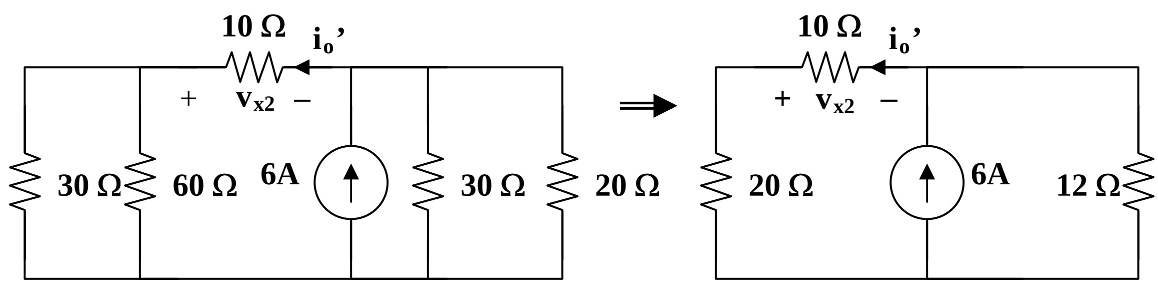


$$20||30 = 12 \text{ ohms}, \quad 60||30 = 20 \text{ ohms}$$

By using current division,

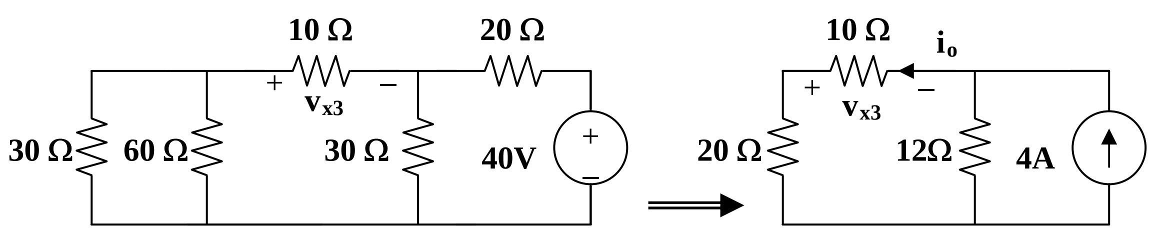
$$i_o = [20/(22 + 20)]3 = 60/42, \quad v_{x1} = 10i_o = 600/42 = 14.286 \text{ V}$$

For v_{x2}, consider the circuit below.



$$i_o' = [12/(12 + 30)]6 = 72/42, \quad v_{x2} = -10i_o' = -17.143 \text{ V}$$

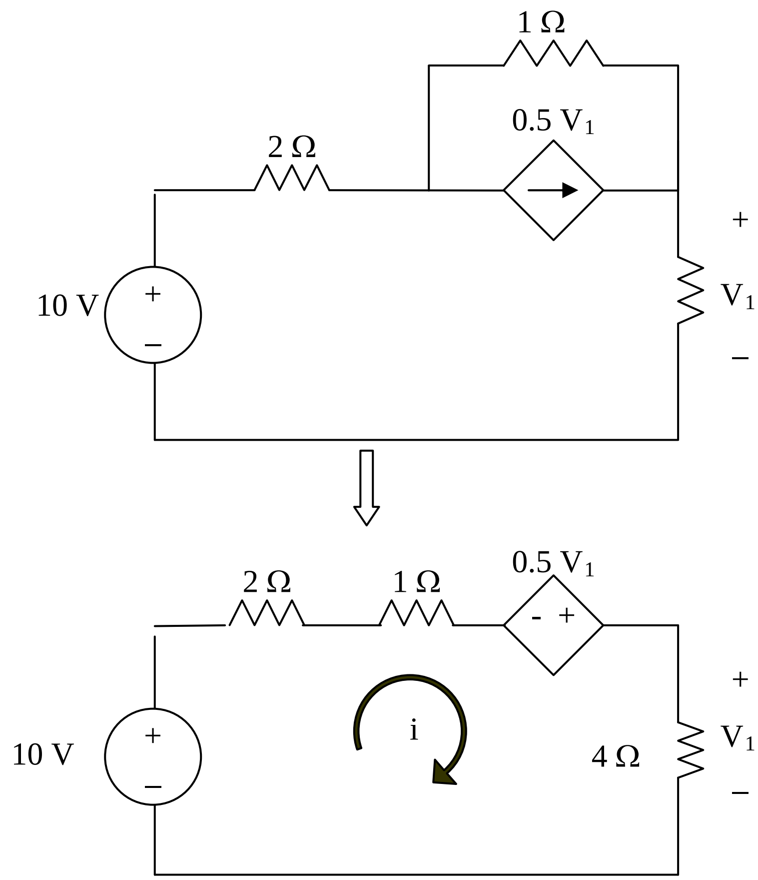
For v_{x3}, consider the circuit below.



$$i_o'' = [12/(12 + 30)]2 = 24/42, \quad v_{x3} = -10i_o'' = -5.714 = [12/(12 + 30)]2 = 24/42,$$
$$v_{x3} = -10i_o'' = -5.714$$
$$= [12/(12 + 30)]2 = 24/42, \quad v_{x3} = -10i_o'' = -5.714$$
$$v_x = 14.286 - 17.143 - 5.714 = \mathbf{-8.571\ V}$$

Chapter 4, Solution 18.

Let $V_o = V_1 + V_2$, where V_1 and V_2 are due to 10-V and 2-A sources respectively. To find V_1, we use the circuit below.

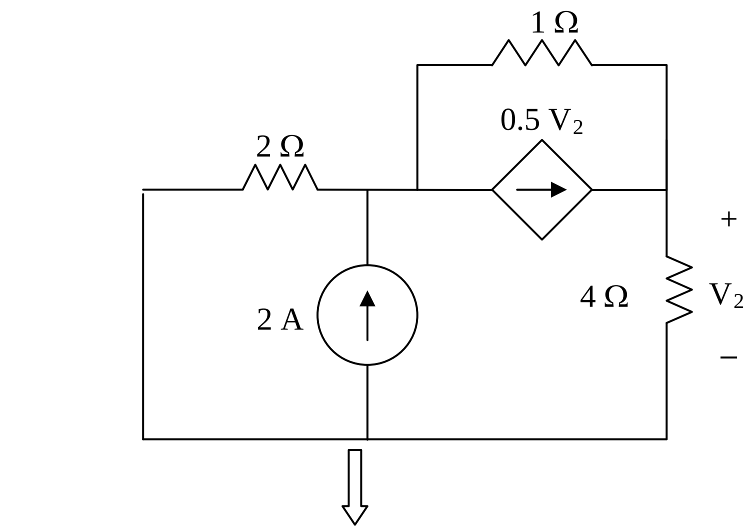


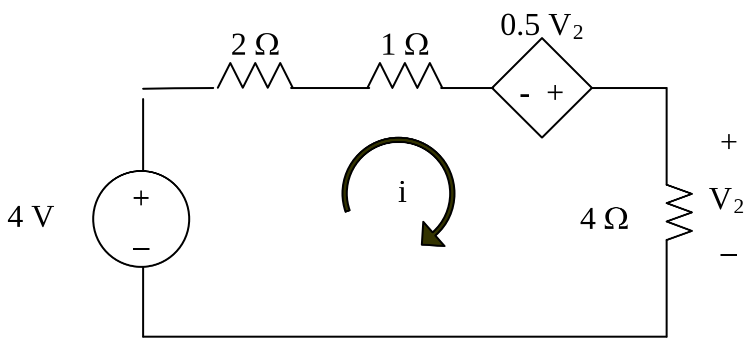
$$-10 + 7i - 0.5V_1 = 0$$

But $V_1 = 4i$

$$`10 = 7i - 2i = 5i \longrightarrow i = 2, \quad V_1 = 8 \text{ V}$$

To find V_2, we use the circuit below.





$- 4 + 7i – 0.5V_2 = 0$

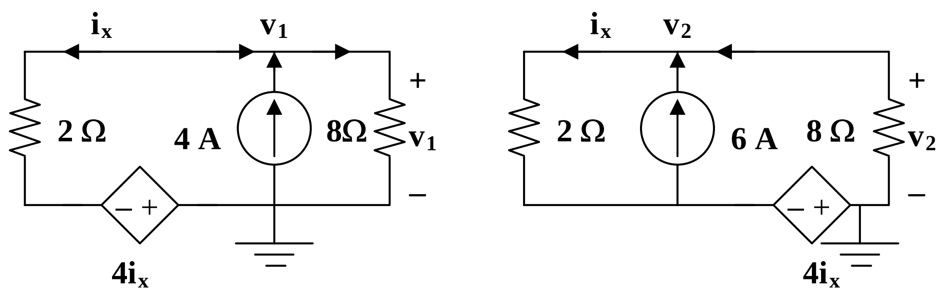
But $V_2 = 4i$

$4 = 7i - 2i = 5i \longrightarrow i = 0.8, \quad V_2 = 4i = 3.2$

$V_o = V_1 + V_2 = 8 + 3.2 = \mathbf{11.2\ V}$

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.



(a) **(b)**

To find v_1, consider the circuit in Fig. (a).

$$v_1/8 - 4 + (v_1 - (-4i_x))/2 = 0 \text{ or } (0.125+0.5)v_1 = 4 - 2i_x \text{ or } v_1 = 6.4 - 3.2i_x$$

But, $i_x = (v_1 - (-4i_x))/2$ or $i_x = -0.5v_1$. Thus,

$$v_1 = 6.4 + 3.2(0.5v_1), \text{ which leads to } v_1 = -6.4/0.6 = -10.667$$

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

$$v_2/8 - 6 + (v_2 - (-4i_x))/2 = 0 \text{ or } v_2 + 3.2i_x = 9.6$$

But $i_x = -0.5v_2$. Therefore,

$$v_2 + 3.2(-0.5v_2) = 9.6 \text{ which leads to } v_2 = -16$$

Hence, $v_x = -10.667 - 16 =$ **-26.67V**.

Checking,

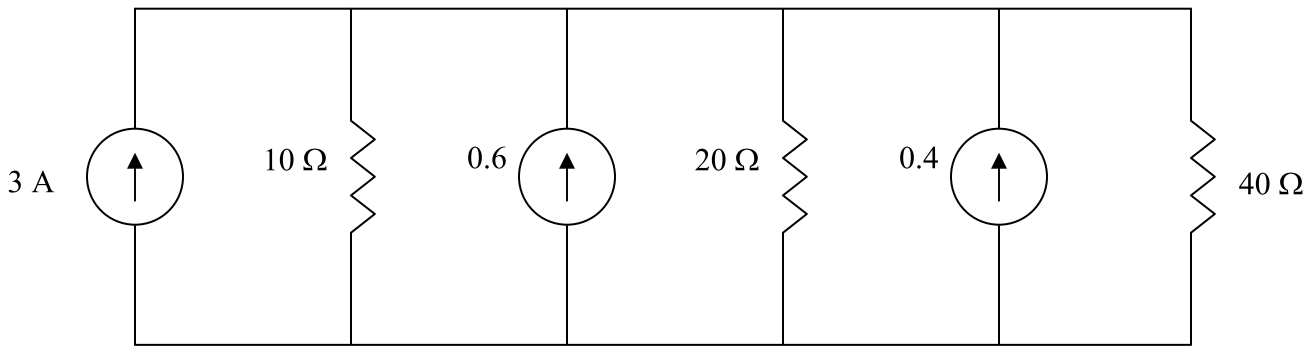
$$i_x = -0.5v_x = 13.333\text{A}$$

Now all we need to do now is sum the currents flowing out of the top node.

$$13.333 - 6 - 4 + (-26.67)/8 = 3.333 - 3.333 = 0$$

Chapter 4, Solution 20.

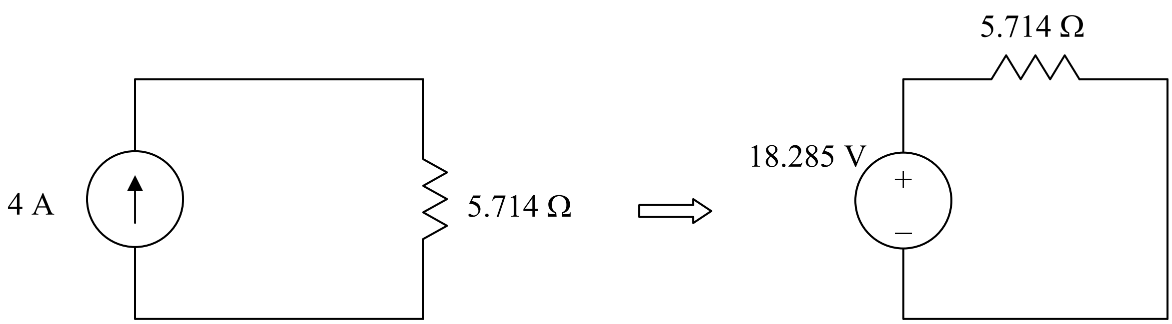
Convert the voltage sources to current sources and obtain the circuit shown below.



$$\frac{1}{R_{eq}} = \frac{1}{10} + \frac{1}{20} + \frac{1}{40} = 0.1 + 0.05 + 0.025 = 0.175 \longrightarrow R_{eq} = 5.714\ \Omega$$

$I_{eq} = 3 + 0.6 + 0.4 = 4$

Thus, the circuit is reduced as shown below. Please note, we that this is merely an exercise in combining sources and resistors. The circuit we have is an equivalent circuit which has no real purpose other than to demonstrate source transformation. In a practical situation, this would need some kind of reference and a use to an external circuit to be of real value.



4.21 Using Fig. 4.89, design a problem to help other students to better understand source transformation.

Although there are many ways to work this problem, this is an example based on the same kind of problem asked in the third edition.

Problem

Apply source transformation to determine v_o and i_o in the circuit in Fig. 4.89.

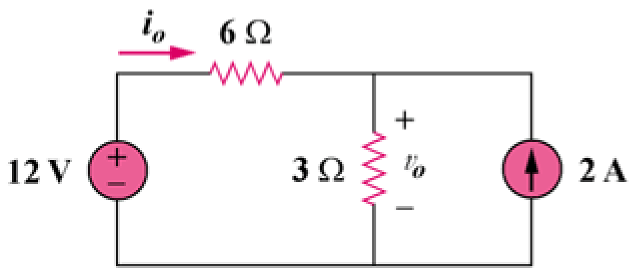
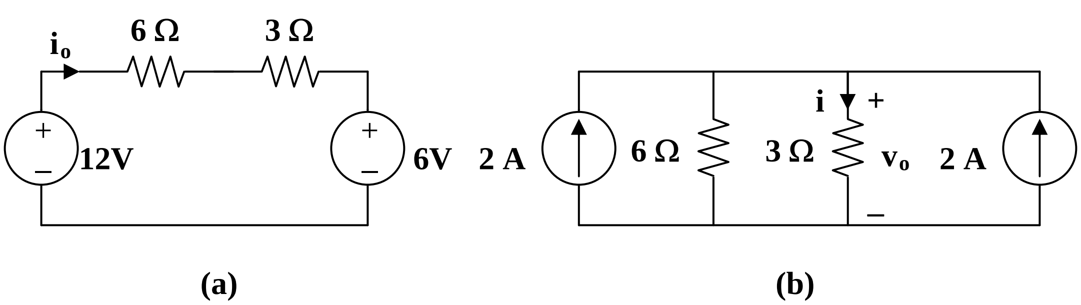


Figure 4.89

Solution

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 mA**

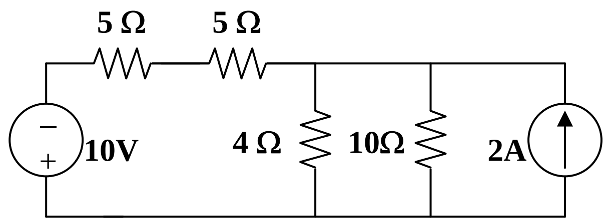
To get v_o, transform the voltage sources as shown in Fig. (b).

$$i = [6/(3 + 6)](2 + 2) = 8/3$$

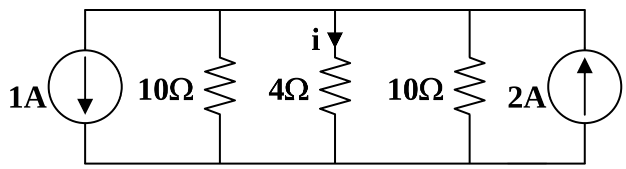
$$v_o = 3i = \mathbf{8\ V}$$

Chapter 4, Solution 22.

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



(a)



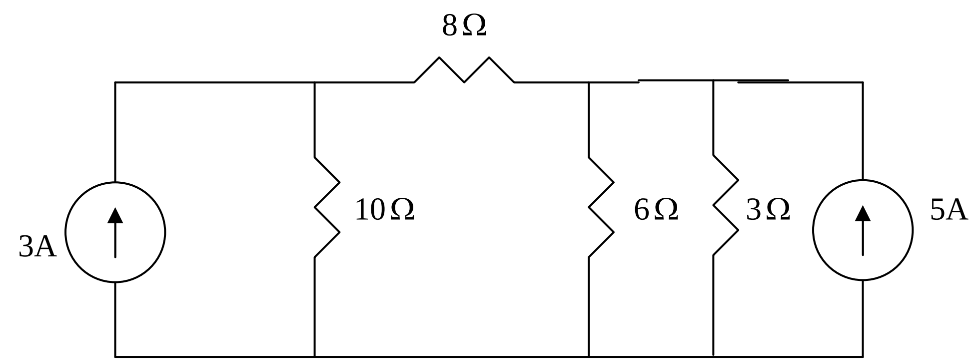
(b)

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

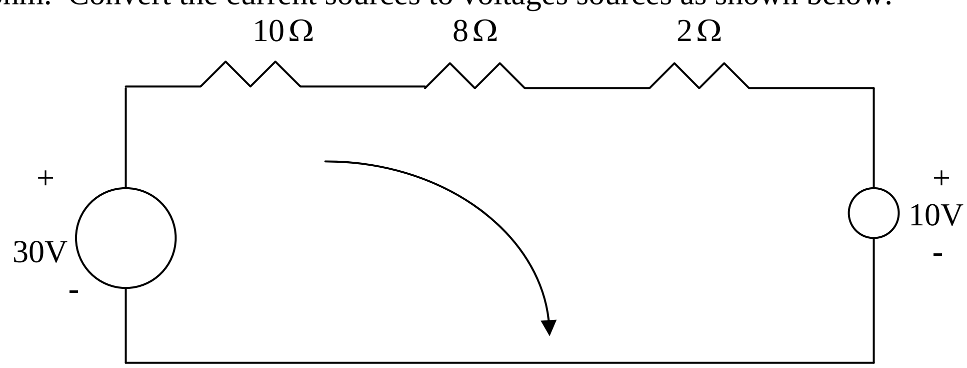
$$10||10 = 5 \text{ ohms}, \quad i = [5/(5 + 4)](2 - 1) = 5/9 = \mathbf{555.5\ mA}$$

Chapter 4, Solution 23

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



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



Applying KVL to the loop gives

$-30+10+I(10+8+2)=0 \qquad \longrightarrow \qquad$ I = **1 A**

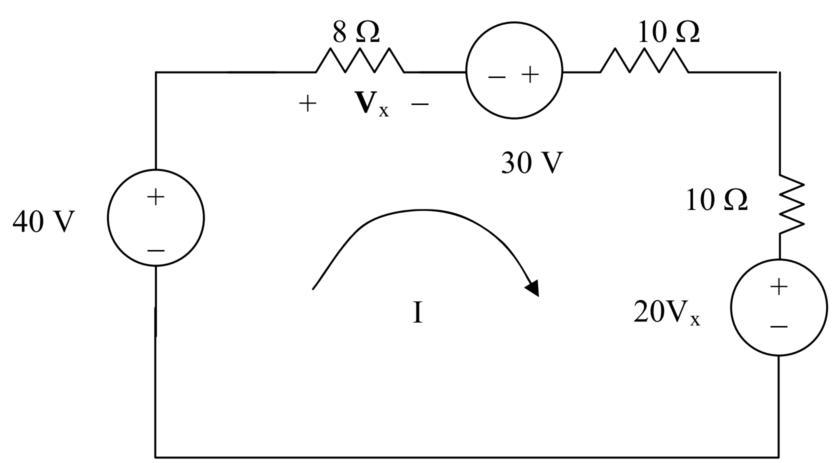
$$p = VI = I^2R = \ \mathbf{8\ W}$$

Chapter 4, Solution 24.

Transform the two current sources in parallel with the resistors into their voltage source equivalents yield,

> a 30-V source in series with a 10-Ω resistor and a $20V_x$-V sources in series with a 10-Ω resistor.

We now have the following circuit,

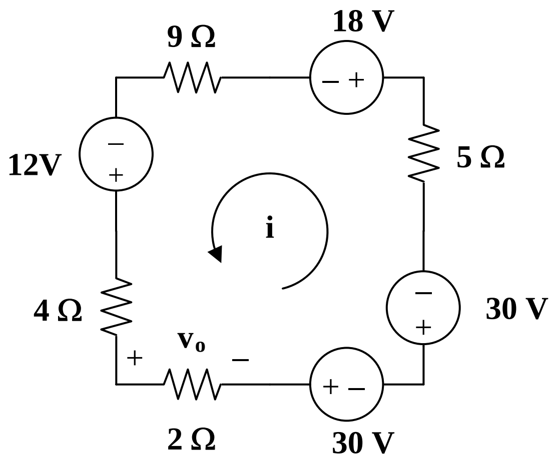


We now write the following mesh equation and constraint equation which will lead to a solution for V_x,

> $28I - 70 + 20V_x = 0$ or $28I + 20V_x = 70$, but $V_x = 8I$ which leads to
>
> $28I + 160I = 70$ or $I = 0.3723$ A or $V_x =$ **2.978 V**.

Chapter 4, Solution 25.

Transforming only the current source gives the circuit below.



Applying KVL to the loop gives,

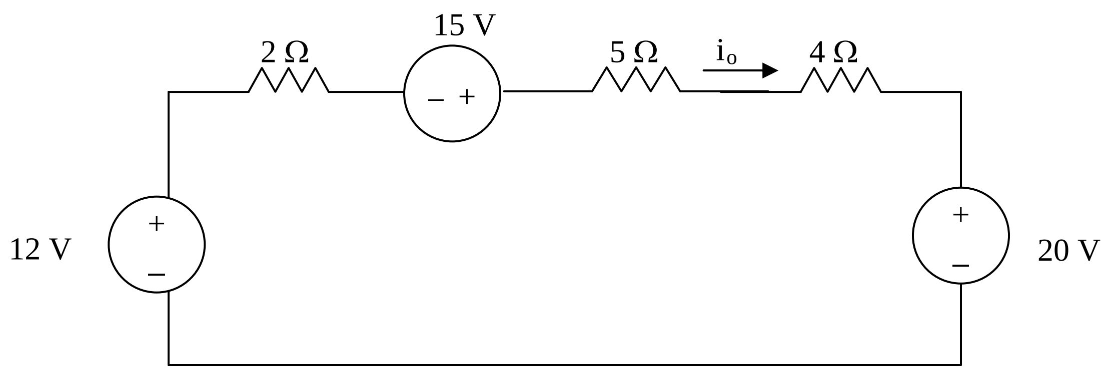
$$-(4 + 9 + 5 + 2)i + 12 - 18 - 30 - 30 = 0$$

$$20i = -66 \text{ which leads to } i = -3.3$$

$v_o = 2i =$ **–6.6 V**

Chapter 4, Solution 26.

Transforming the current sources gives the circuit below.



$-12 + 11i_o - 15 + 20 = 0$ or $11i_o = 7$ or $i_o =$ **636.4 mA**.

Chapter 4, Solution 27.

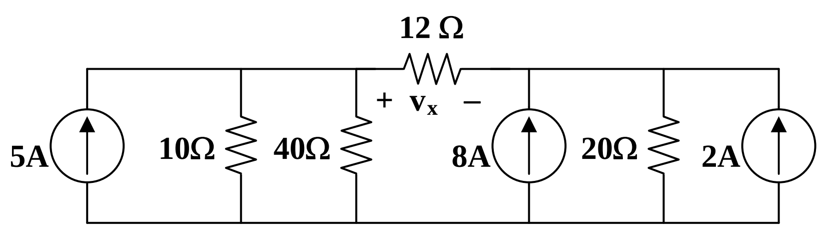
Transforming the voltage sources to current sources gives the circuit in Fig. (a).

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

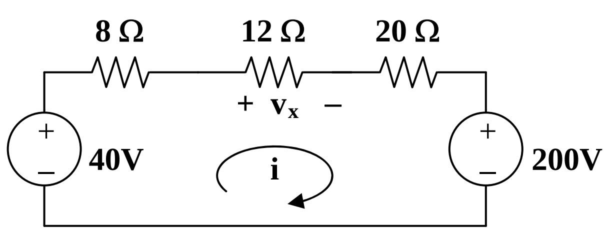
Transforming the current sources to voltage sources yields the circuit in Fig. (b). Applying KVL to the loop,

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

$$v_x \;\; 12i = \mathbf{-48\ V}$$



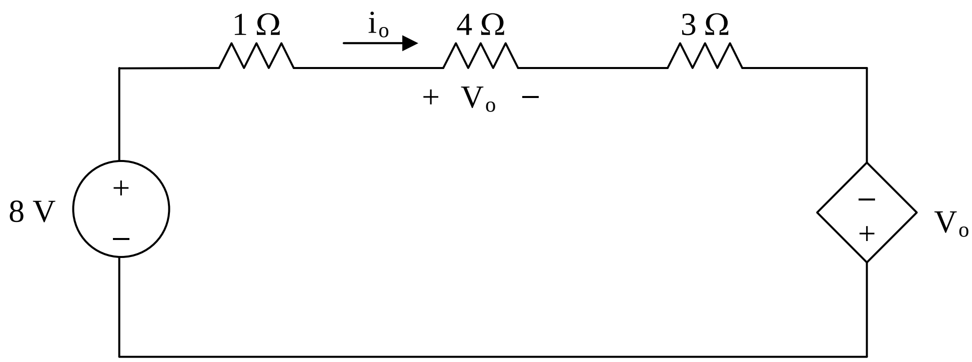
(a)



(b)

Chapter 4, Solution 28.

Convert the dependent current source to a dependent voltage source as shown below.



Applying KVL,

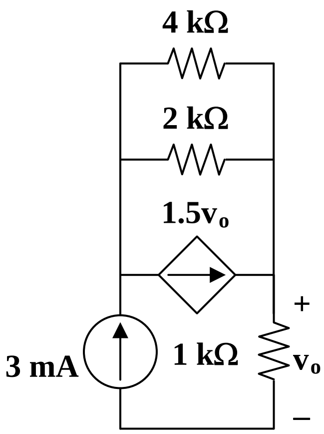
$$-8 + i_o(1 + 4 + 3) - V_o = 0$$

But $V_o = 4i_o$

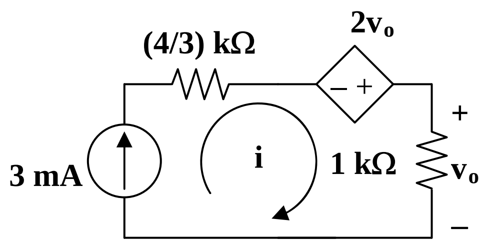
$$-8 + 8i_o - 4i_o = 0 \quad \longrightarrow \quad i_o = \underline{2 \text{ A}}$$

Chapter 4, Solution 29.

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



(a)



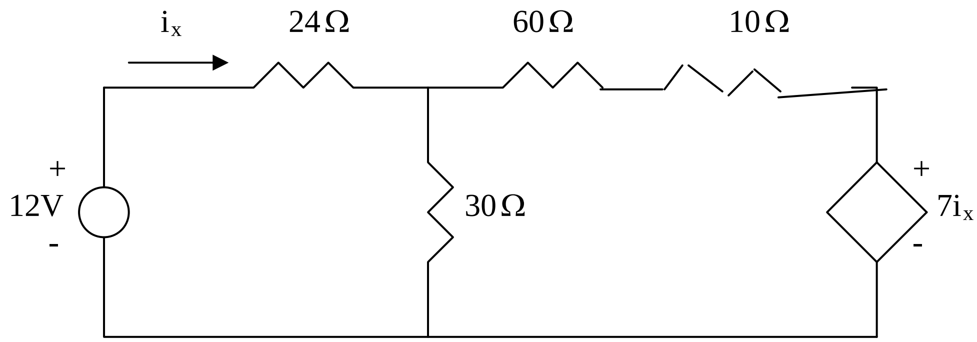
(b)

It is clear that i = 3 mA which leads to v_o = 1000i = **3 V**

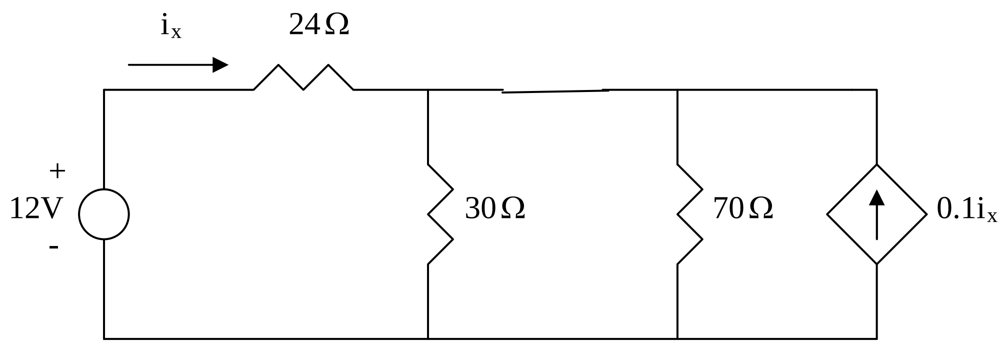
If the use of source transformations was not required for this problem, the actual answer could have been determined by inspection right away since the only current that could have flowed through the 1 k ohm resistor is 3 mA.

Chapter 4, Solution 30

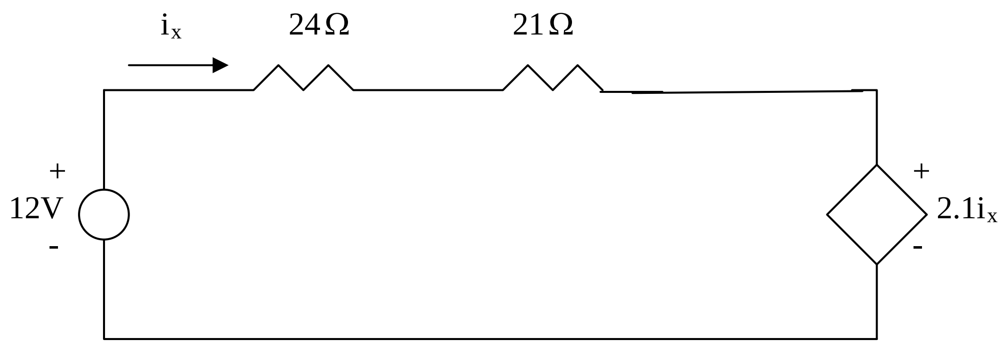
Transform the dependent current source as shown below.



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 = 70x30/100 = 21-ohm. Transform the dependent current source as shown below.

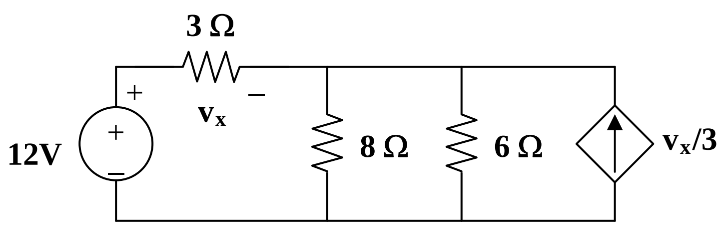


Applying KVL to the loop gives

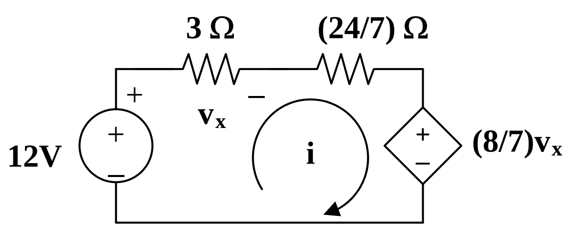
$$\mathbf{45}\boldsymbol{i_x} - \mathbf{12} + \mathbf{2.1}\boldsymbol{i_x} = \mathbf{0} \quad \longrightarrow \quad \boldsymbol{i_x} = \frac{\mathbf{12}}{\mathbf{47.1}} = \mathbf{254.8\ mA}.$$

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).



(a)



(b)

From Fig. (b),

$$v_x = 3i, \text{ or } i = v_x/3.$$

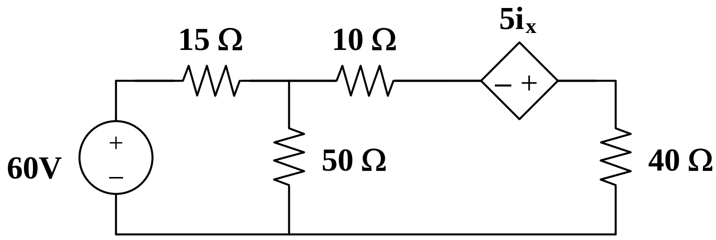
Applying KVL,

$$-12 + (3 + 24/7)i + (24/21)v_x = 0$$

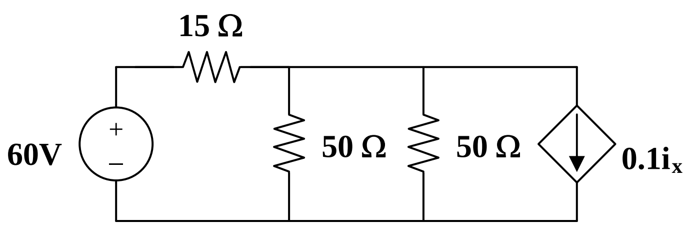
$$12 = [(21 + 24)/7]v_x/3 + (8/7)v_x, \text{ leads to } v_x = 84/23 = \mathbf{3.652\ V}$$

Chapter 4, Solution 32.

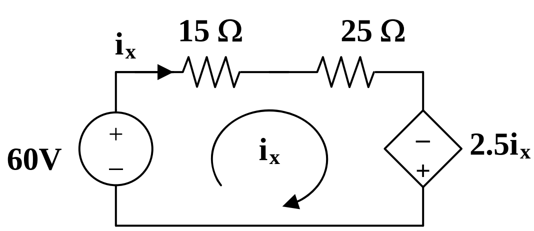
As shown in Fig. (a), we transform the dependent current source to a voltage source,



(a)



(b)



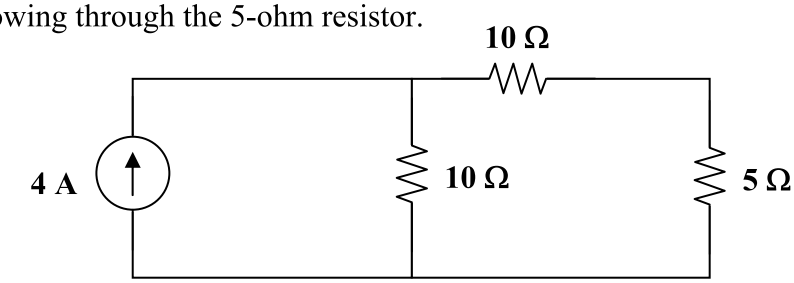
(c)

In Fig. (b), $50||50 = 25$ ohms. Applying KVL in Fig. (c),

$-60 + 40i_x - 2.5i_x = 0$, or $i_x =$ **1.6 A**

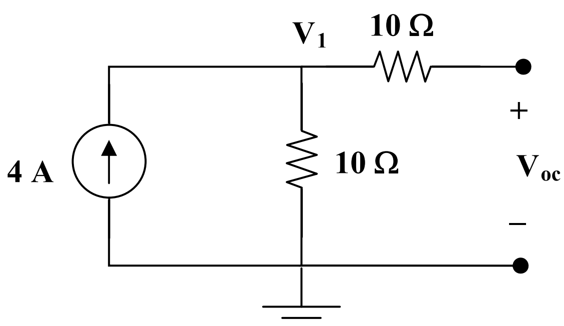
Chapter 4, Solution 33.

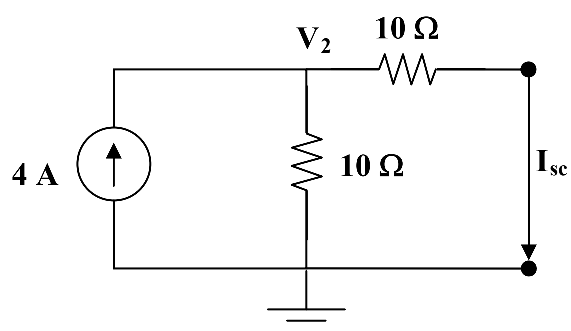
Determine the Thevenin equivalent circuit as seen by the 5-ohm resistor. Then calculate the current flowing through the 5-ohm resistor.



Solution

Step 1. We need to find V_{oc} and I_{sc}. To do this, we will need two circuits, label the appropriate unknowns and solve for V_{oc}, I_{sc}, and then R_{eq} which is equal to V_{oc}/I_{sc}.





Note, in the first case $V_1 = V_{oc}$ and the nodal equation at 1 produces $-4+(V_1-0)/10 = 0$. In the second case, $I_{sc} = (V_2-0)/10$ where the nodal equation at 2 produces, $-4+[(V_2-0)/10]+[(V_2-0)/10] = 0$.

Step 2. $0.1V_1 = 4$ or $V_1 =$ **40 V** $= V_{oc} = V_{Thev}$. Next, $(0.1+0.1)V_2 = 4$ or $0.2V_2 = 4$ or $V_2 = 20$ V. Thus, $I_{sc} = 20/10 = 2$ A. This leads to $R_{eq} = 40/2 =$ **20 Ω**. We can check our results by using source transformation. The 4-amp current source in parallel with the 10-ohm resistor can be replaced by a 40-volt voltage source in series with a 10-ohm resistor which in turn is in series with the other 10-ohm resistor yielding the same Thevenin equivalent circuit. Once the 5-ohm resistor is connected to the Thevenin equivalent circuit, we now have 40 V across 25 Ω producing a current of **1.6 A**.

4.34 Using Fig. 4.102, design a problem that will help other students better understand Thevenin equivalent circuits.

Although there are many ways to work this problem, this is an example based on the same kind of problem asked in the third edition.

Problem

Find the Thevenin equivalent at terminals ***a-b*** of the circuit in Fig. 4.102.

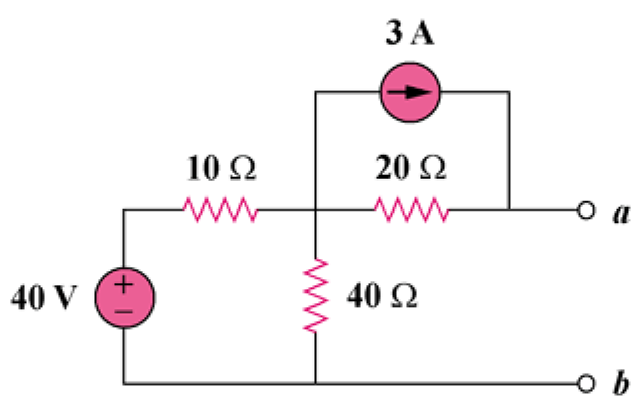
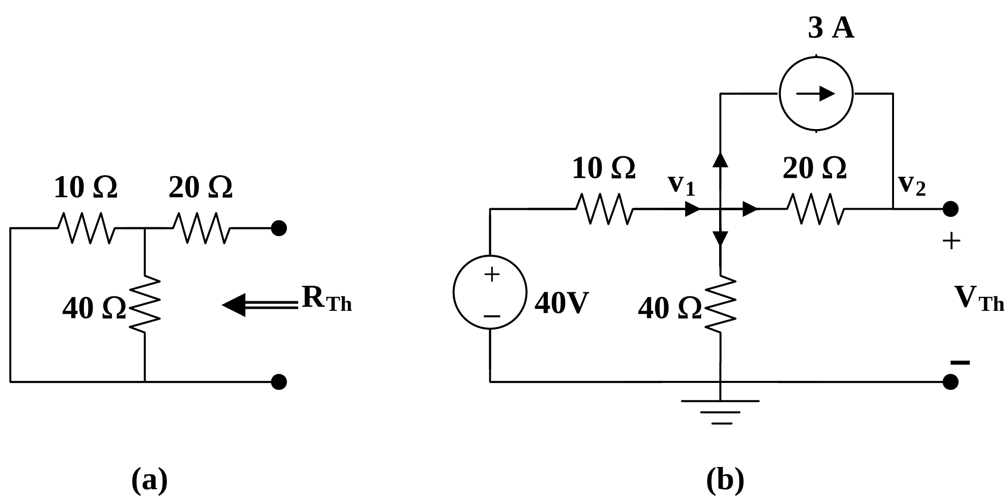


Figure 4.102

Solution

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



$$R_{Th} = 20 + 10||40 = 20 + 400/50 = \mathbf{28\ ohms}$$

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

At node 1, $(40 - v_1)/10 = 3 + [(v_1 - v_2)/20] + v_1/40$, $40 = 7v_1 - 2v_2$ (1)

At node 2, $3 + (v1 - v2)/20 = 0$, or $v1 = v2 - 60$ (2)

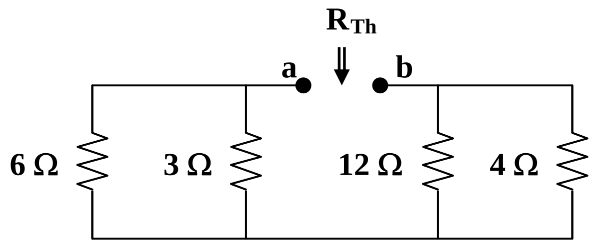
Solving (1) and (2), $v_1 = 32$ V, $v_2 = 92$ V, and $V_{Th} = v_2 =$ **92 V**

Chapter 4, Solution 35.

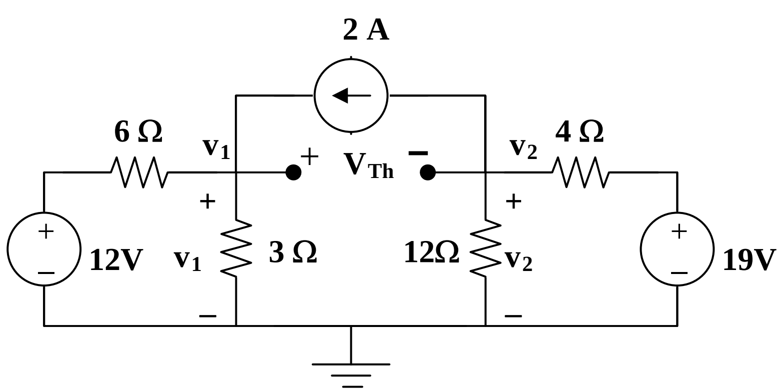
To find R_{Th}, consider the circuit in Fig. (a).

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

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



(a)

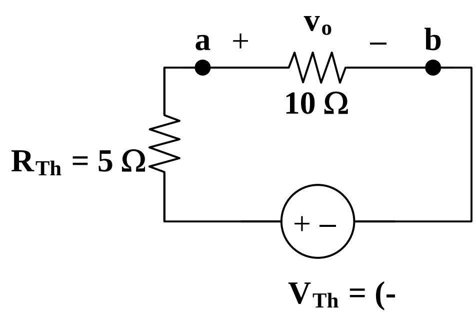


(b)

At node 1, $2 + (12 - v_1)/6 = v_1/3$, or $v_1 = 8$

At node 2, $(19 - v_2)/4 = 2 + v_2/12$, or $v_2 = 33/4$

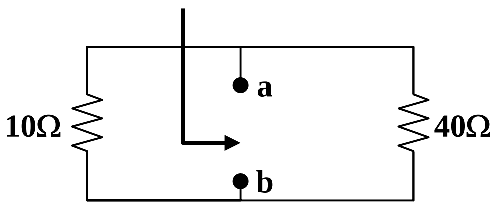
But, $-v_1 + V_{Th} + v_2 = 0$, or $V_{Th} = v_1 - v_2 = 8 - 33/4 = -0.25$



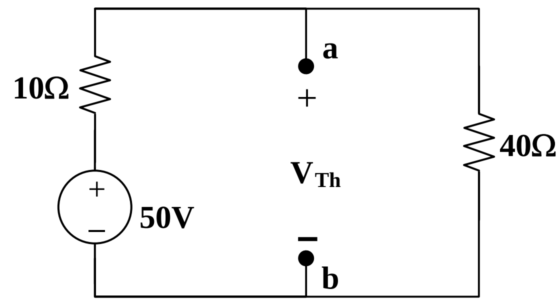
v_o = $V_{Th}/2$ = -0.25/2 = **–125 mV**

Chapter 4, Solution 36.

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



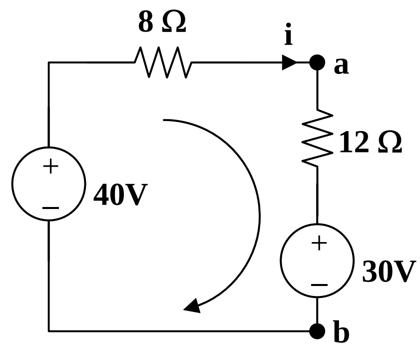
(a)



(b)

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

From Fig. (b), $V_{Th} = (40/(10 + 40))50 = 40V$



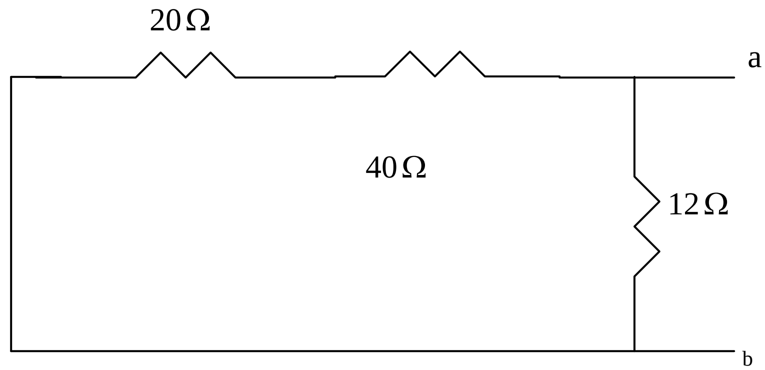
(c)

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

30 – 40 + (8 + 12)i = 0, which leads to i = **500mA**

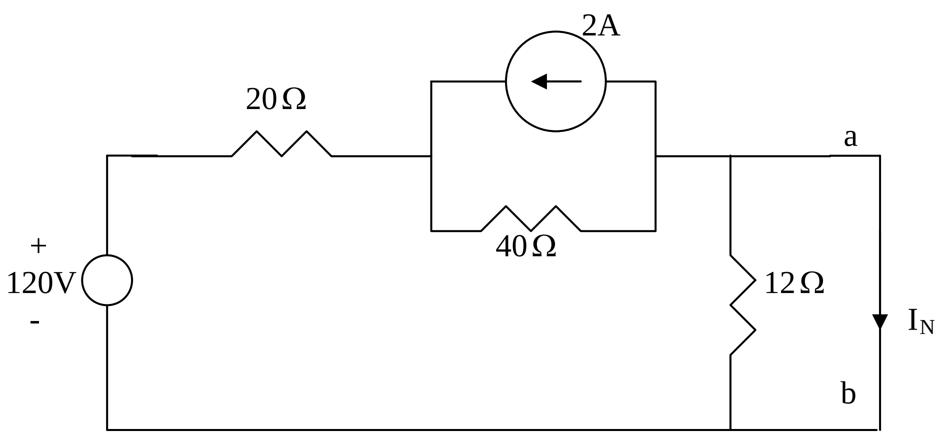
Chapter 4, Solution 37

R_N is found from the circuit below.

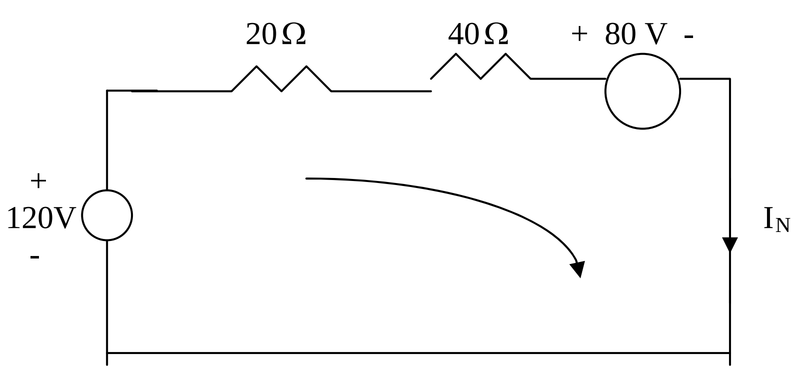


$R_N = 12//(20+40) = \mathbf{10\ \Omega}$.

I_N is found from the circuit below.



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

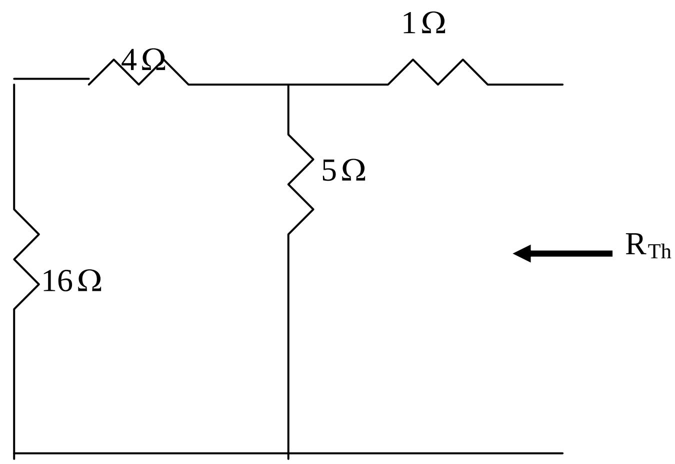


Applying KVL to the loop yields

$-120 + 80 + 60I_N = 0 \quad \longrightarrow \quad I_N = 40/60 = \mathbf{666.7\ mA}$.

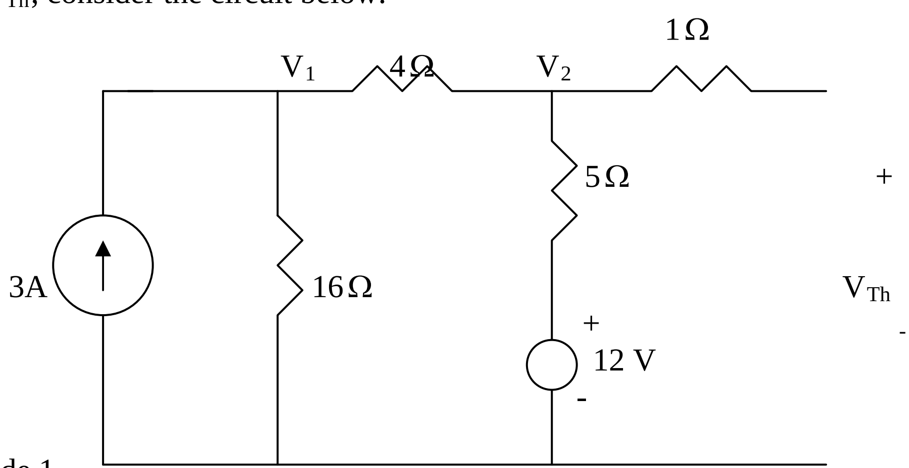
Chapter 4, Solution 38

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



$$R_{Th} = 1 + 5//(4+16) = 1 + 4 = 5\Omega$$

For V_{Th}, consider the circuit below.



At node 1,

$$3 = \frac{V_1}{16} + \frac{V_1 - V_2}{4} \quad \longrightarrow \quad 48 = 5V_1 - 4V_2 \qquad (1)$$

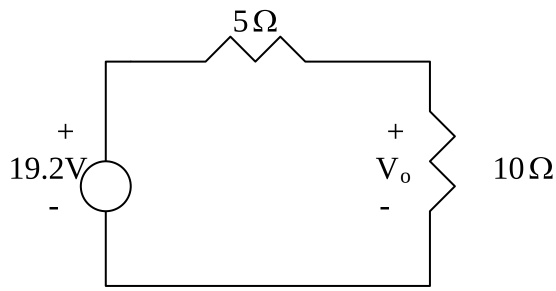
At node 2,

$$\frac{V_1 - V_2}{4} + \frac{12 - V_2}{5} = 0 \quad \longrightarrow \quad 48 = -5V_1 + 9V_2 \qquad (2)$$

Solving (1) and (2) leads to

$V_{Th} = V_2 = 19.2$

Thus, the given circuit can be replaced as shown below.

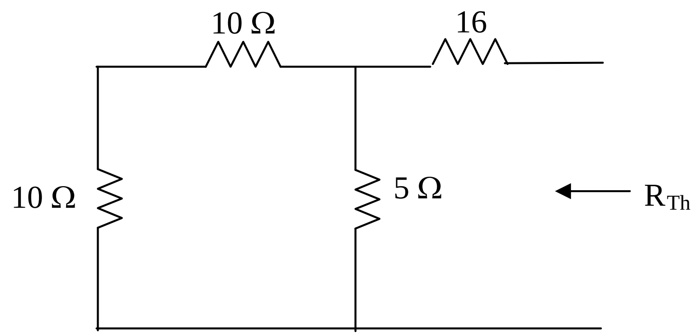


Using voltage division,

$$\boldsymbol{V_o = \frac{10}{10+5}(19.2) = 12.8\ \text{V}}.$$

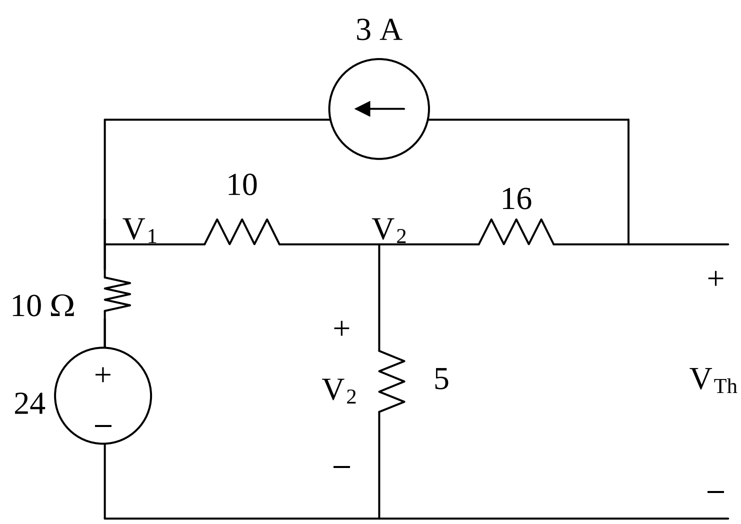
Chapter 4, Solution 39.

We obtain R_{Th} using the circuit below.



$$R_{Thev} = 16 + (20||5) = 16 + (20x5)/(20+5) = \mathbf{20\ \Omega}$$

To find V_{Th}, we use the circuit below.



At node 1,

$$\frac{24 - V_1}{10} + 3 = \frac{V_1 - V_2}{10} \longrightarrow 54 = 2V_1 - V_2 \qquad (1)$$

At node 2,

$$\frac{V_1 - V_2}{10} = 3 + \frac{V_2}{5} \longrightarrow 60 = 2V_1 - 6V_2 \qquad (2)$$

Substracting (1) from (2) gives

$$6 = -5V_2 \text{ or } V_2 = -1.2 \text{ V}$$

But

$$-V_2 + 16x3 + V_{Thev} = 0 \text{ or } V_{Thev} = -(48 + 1.2) = \mathbf{-49.2\ V}$$

Chapter 4, Solution 40.

To obtain V_{Th}, we apply KVL to the loop.

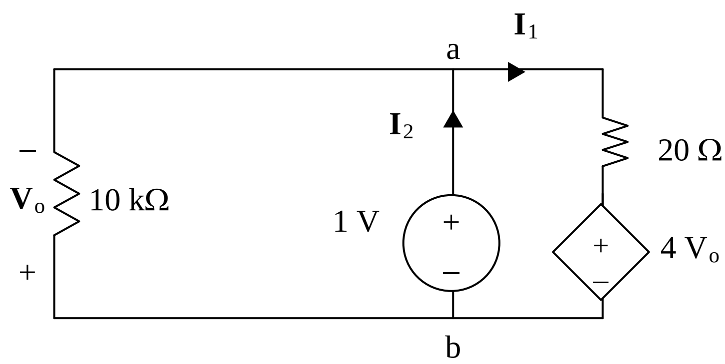
$$-70 + (10 + 20)kI + 4V_o = 0$$

But $V_o = 10kI$

$$70 = 70kI \longrightarrow I = 1mA$$

$$-70 + 10kI + V_{Th} = 0 \longrightarrow V_{Th} = \underline{60\ \text{V}}$$

To find R_{Th}, we remove the 70-V source and apply a 1-V source at terminals a-b, as shown in the circuit below.



We notice that $V_o = -1$ V.

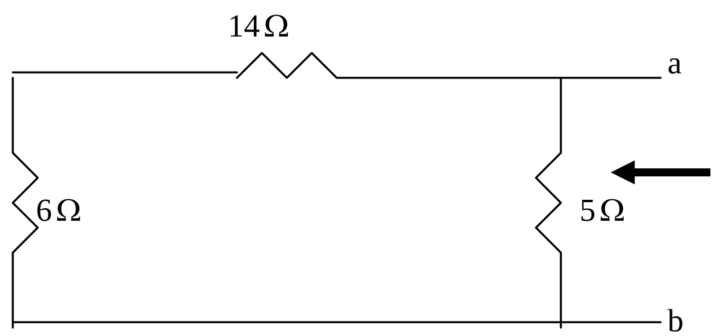
$$-1 + 20kI_1 + 4V_o = 0 \longrightarrow I_1 = 0.25\ \text{mA}$$

$$I_2 = I_1 + \frac{1V}{10k} = 0.35\ \text{mA}$$

$$R_{Th} = \frac{1V}{I_2} = \frac{1}{0.35}k\Omega = \underline{2.857\ \text{k}\Omega}$$

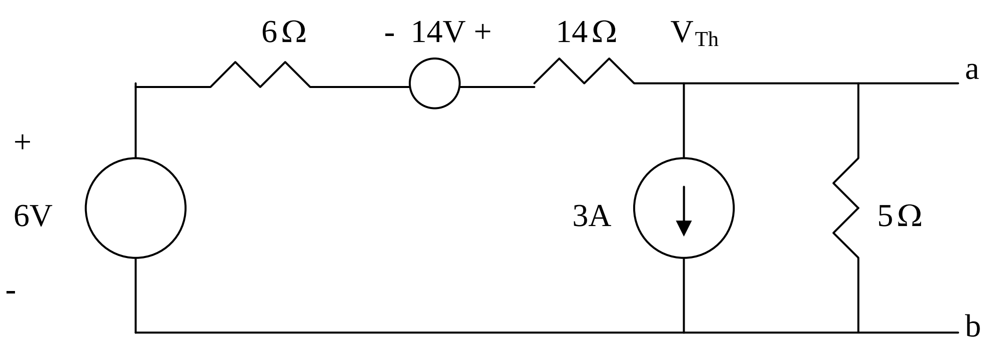
Chapter 4, Solution 41

To find R_{Th}, consider the circuit below



$$R_{Th} = 5//(14+6) = 4\Omega = R_N$$

Applying source transformation to the 1-A current source, we obtain the circuit below.



At node a,

$$\frac{14+6-V_{Th}}{6+14} = 3 + \frac{V_{Th}}{5} \longrightarrow V_{Th} = -8\text{ V}$$

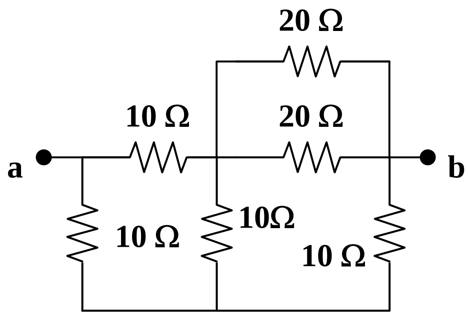
$$I_N = \frac{V_{Th}}{R_{Th}} = (-8)/4 = -2\text{ A}$$

Thus,

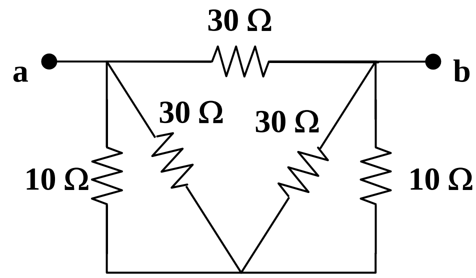
$$\underline{\boldsymbol{R_{Th} = R_N = 4\Omega, \quad V_{Th} = -8\text{V}, \quad I_N = -2\text{ A}}}$$

Chapter 4, Solution 42.

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



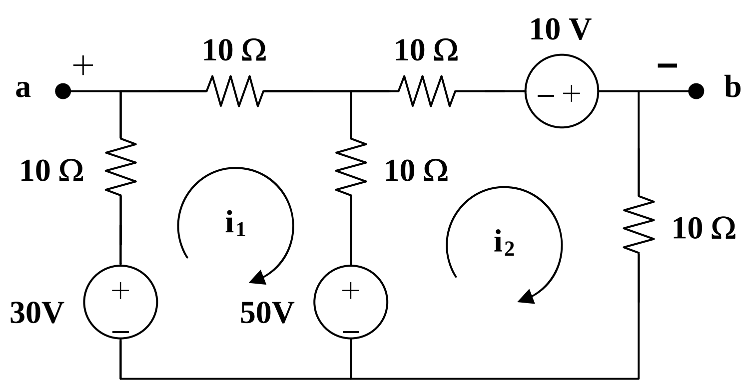
(a)



(b)

$20||20 = 10$ ohms. Transform the wye sub-network to a delta as shown in Fig. (b).
$10||30 = 7.5$ ohms. $R_{Th} = R_{ab} = 30||(7.5 + 7.5) =$ **10 ohms**.

To find V_{Th}, we transform the 20-V (to a current source in parallel with the 20 Ω resistor and then back into a voltage source in series with the parallel combination of the two 20 Ω resistors) and the 5-A sources. We obtain the circuit shown in Fig. (c).



(c)

For loop 1, $-30 + 50 + 30i_1 - 10i_2 = 0$, or $-2 = 3i_1 - i_2$ (1)

For loop 2, $-50 - 10 + 30i_2 - 10i_1 = 0$, or $6 = -i_1 + 3i_2$ (2)

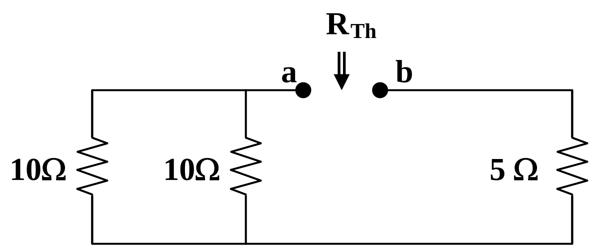
Solving (1) and (2), $i_1 = 0$, $i_2 = 2$ A

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

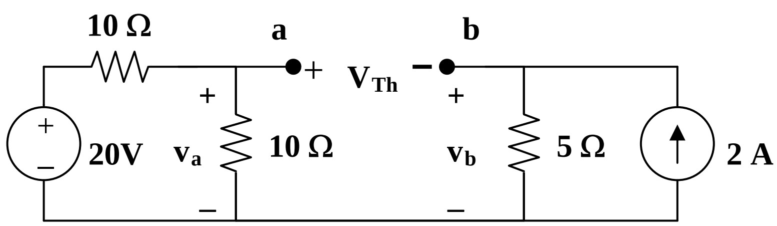
$$V_{Th} = v_{ab} = \textbf{10 volts}$$

Chapter 4, Solution 43.

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



(a)



(b)

$$R_{Th} = 10\|10 + 5 = \mathbf{10\ ohms}$$

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

$$v_b = 2x5 = 10 \text{ V}, \quad v_a = 20/2 = 10 \text{ V}$$

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

Chapter 4, Solution 44.

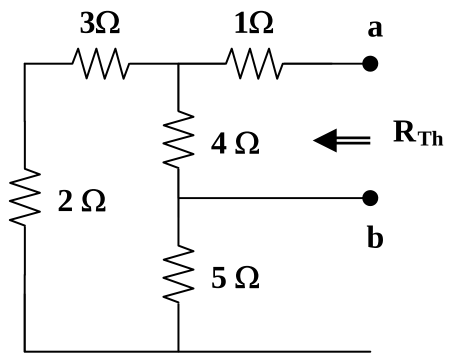
(a) For R_{Th}, consider the circuit in Fig. (a).

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

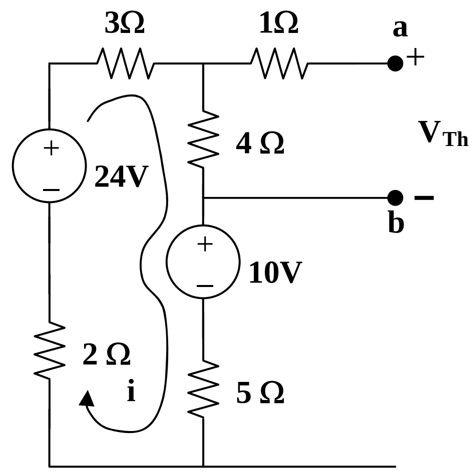
For V_{Th}, consider the circuit in Fig. (b). Applying KVL gives,

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

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

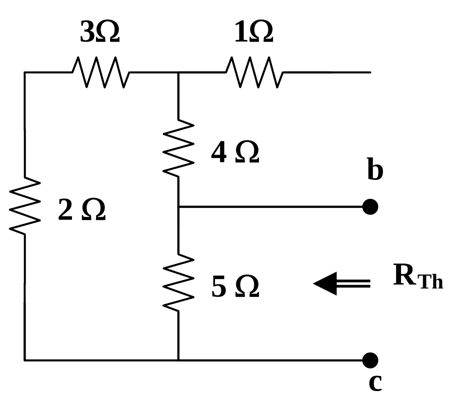


(a)

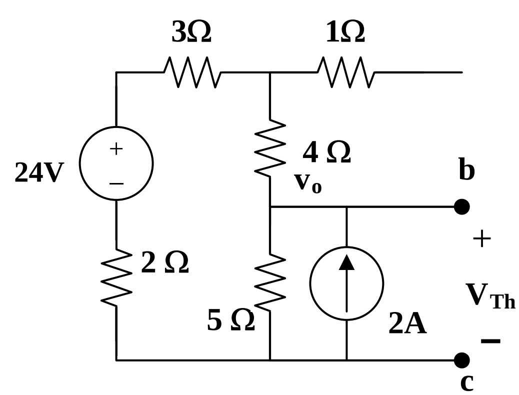


(b)

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



(c)



(d)

$$R_{Th} = 5||(2 + 3 + 4) = \mathbf{3.214\ ohms}$$

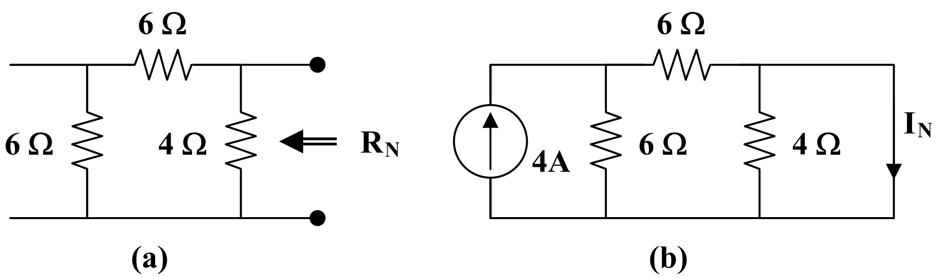
To get V_{Th}, consider the circuit in Fig. (d). At the node, KCL gives,

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

$$V_{Th} = vo = \mathbf{15\ V}$$

Chapter 4, Solution 45.

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



$$R_N = (6 + 6)||4 = \mathbf{3\ \Omega}$$

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,

$$I_N = 4/2 = \mathbf{2\ A}$$

Chapter 4, Solution 46.

Using Fig. 4.113, design a problem to help other students better understand Norton equivalent circuits.

Although there are many ways to work this problem, this is an example based on the same kind of problem asked in the third edition.

Problem

Find the Norton equivalent at terminals a-b of the circuit in Fig. 4.113.

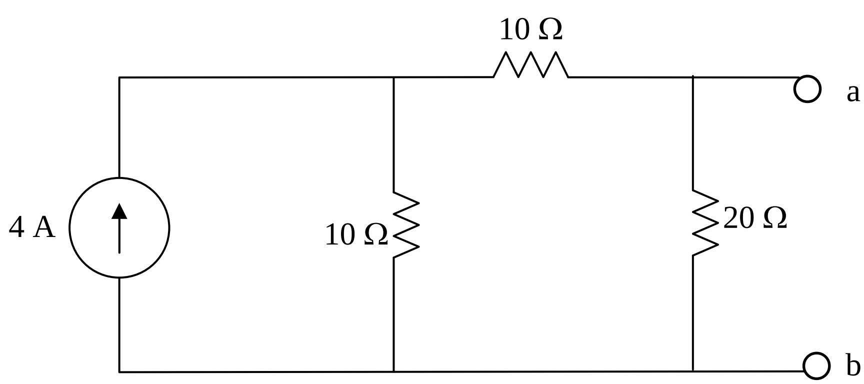
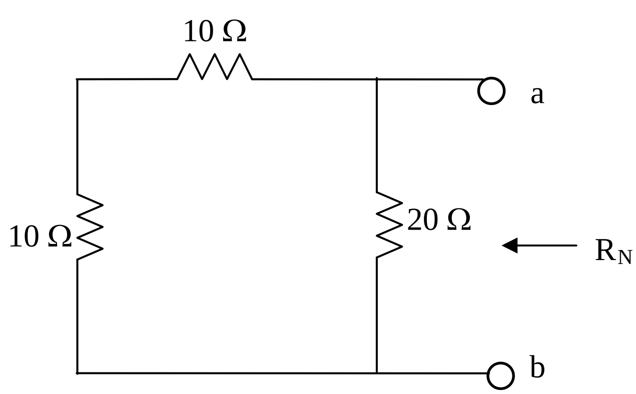


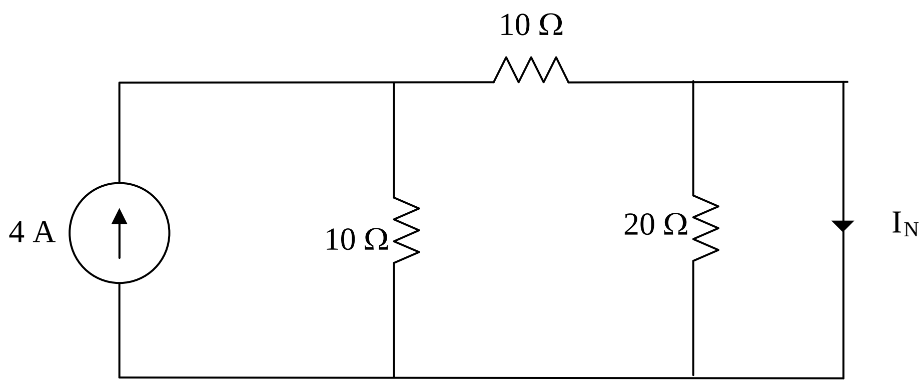
Figure 4.113 For Prob. 4.46.

Solution

R_N is found using the circuit below.



$R_N = 20//(10+10) = 10\ \Omega$
To find I_N, consider the circuit below.



The 20-Ω resistor is short-circuited and can be ignored.

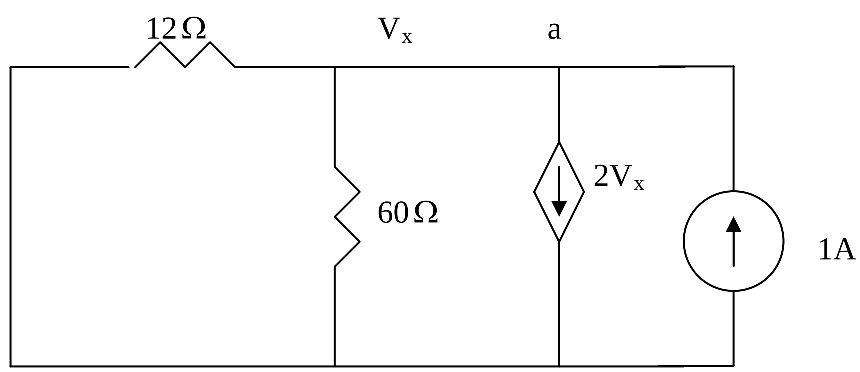
$$I_N = \tfrac{1}{2} \times 4 = \mathbf{2\ A}$$

Chapter 4, Solution 47

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

$$\frac{30 - V_{Th}}{12} = \frac{V_{Th}}{60} + 2V_{Th} \longrightarrow V_{Th} = 150/126 = 1.1905\text{ V}$$

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



At node a, KCL gives

$$1 = 2V_x + \frac{V_x}{60} + \frac{V_x}{12} \longrightarrow V_x = 60/126 = 0.4762$$

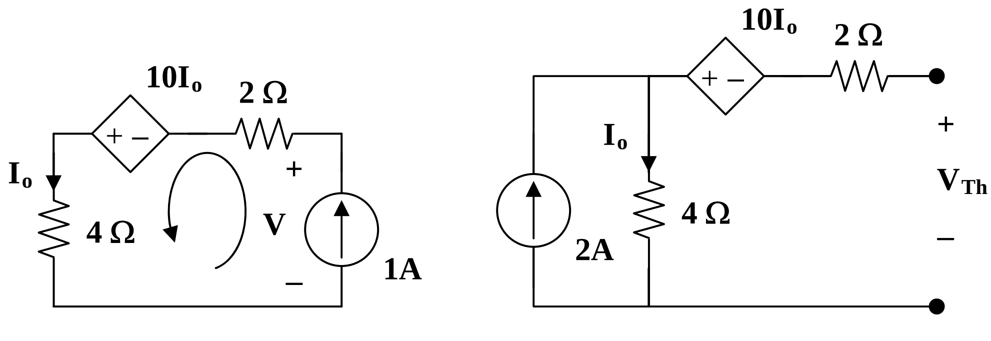
$$R_{Th} = \frac{V_x}{1} = 0.4762\Omega, \qquad I_N = \frac{V_{Th}}{R_{Th}} = 1.19/0.4762 = 2.5$$

Thus,

V_{Thev} = **1.1905 V**, R_{eq} = **476.2 mΩ**, and I_N = **2.5 A**.

Chapter 4, Solution 48.

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



(a)　　　　　　　　(b)

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

$$R_{eq} = V/1 = \mathbf{-4\ ohms}$$

Note that the negative value of R_{eq} indicates that we have an active device in the circuit since we cannot have a negative resistance in a purely passive circuit.

To solve for I_N we first solve for V_{Th}, consider the circuit in Fig. (b),

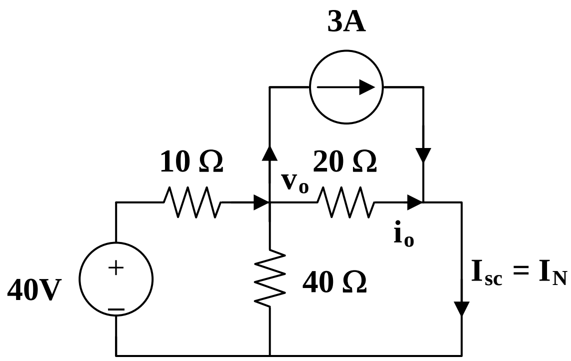
$$I_o = 2, \; V_{Th} = -10I_o + 4I_o = -12 \text{ V}$$

$$I_N = V_{Th}/R_{Th} = \mathbf{3A}$$

Chapter 4, Solution 49.

$R_N = R_{Th} =$ **28 ohms**

To find I_N, consider the circuit below,

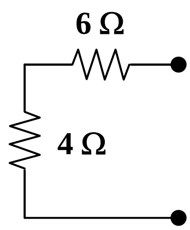


At the node, $(40 - v_o)/10 = 3 + (v_o/40) + (v_o/20)$, or $v_o = 40/7$

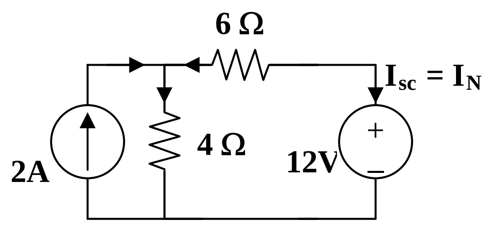
$i_o = v_o/20 = 2/7$, but $I_N = I_{sc} = i_o + 3 =$ **3.286 A**

Chapter 4, Solution 50.

From Fig. (a), $R_N = 6 + 4 = $ **10 ohms**



(a)

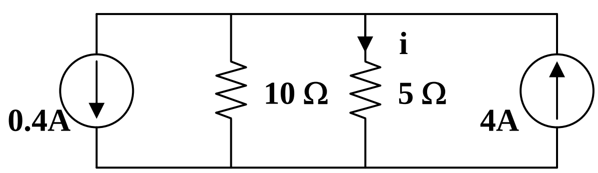


(b)

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

$-I_N = (12 - v)/6 = 0.4$, 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).



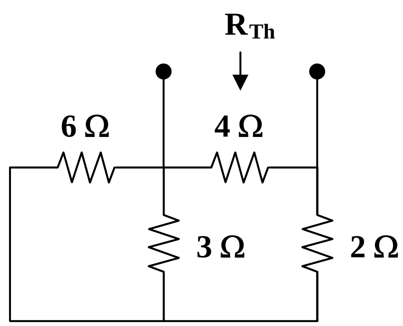
(c)

$i = [10/(10 + 5)]\,(4 - 0.4) = $ **2.4 A**

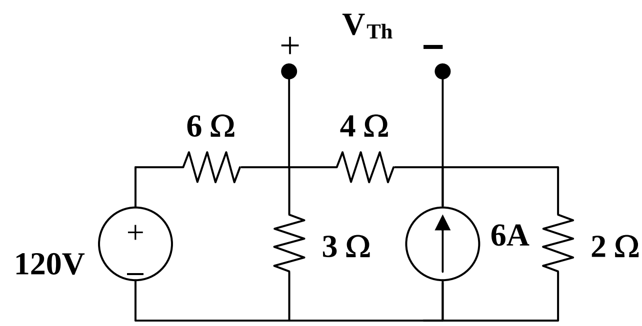
Chapter 4, Solution 51.

(a) From the circuit in Fig. (a),

$$R_N = 4||(2 + 6||3) = 4||4 = \mathbf{2\ ohms}$$

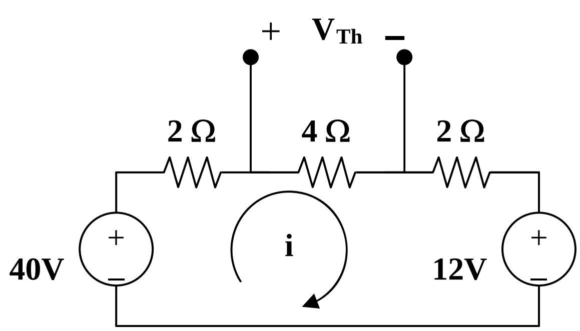


(a)



(b)

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



(c)

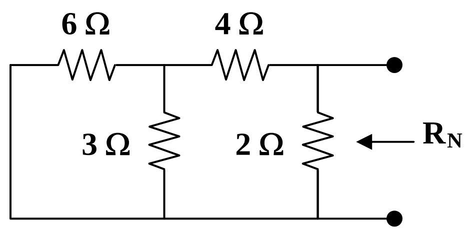
Applying KVL to the circuit in Fig. (c),

$$-40 + 8i + 12 = 0 \text{ which gives } i = 7/2$$

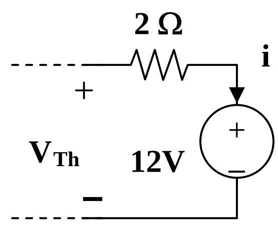
$$V_{Th} = 4i = 14 \text{ therefore } I_N = V_{Th}/R_N = 14/2 = \mathbf{7\ A}$$

(b) To get R_N, consider the circuit in Fig. (d).

$$R_N = 2||(4 + 6||3) = 2||6 = \mathbf{1.5\ ohms}$$



(d)



(e)

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

$$i = 7/2, \quad V_{Th} = 12 + 2i = 19, \quad I_N = V_{Th}/R_N = 19/1.5 = \mathbf{12.667\ A}$$

Chapter 4, Solution 52.

For the transistor model in Fig. 4.118, obtain the Thevenin equivalent at terminals ***a-b***.

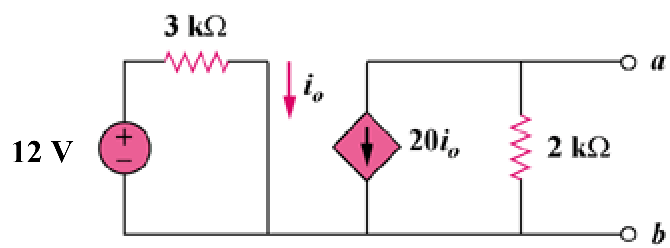
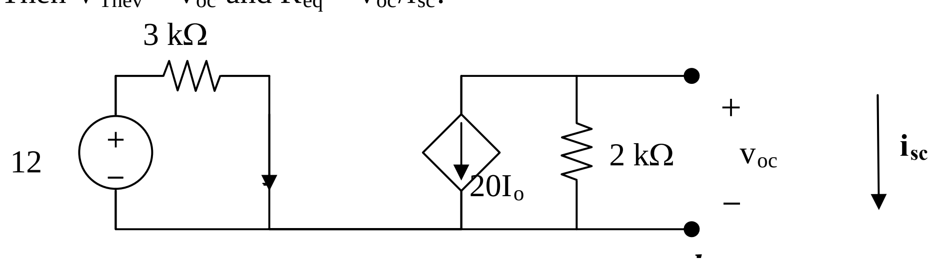


Figure 4.118
For Prob. 4.52.

Solution

Step 1. To find the Thevenin equivalent for this circuit we need to find v_{oc} and i_{sc}. Then $V_{Thev} = v_{oc}$ and $R_{eq} = v_{oc}/i_{sc}$.



For v_{oc}, $I_o = (12–0)/3k = 4$ mA and $20I_o + (v_{oc}–0)/2k = 0$.

For i_{sc}, $i_{sc} = –20I_o$.

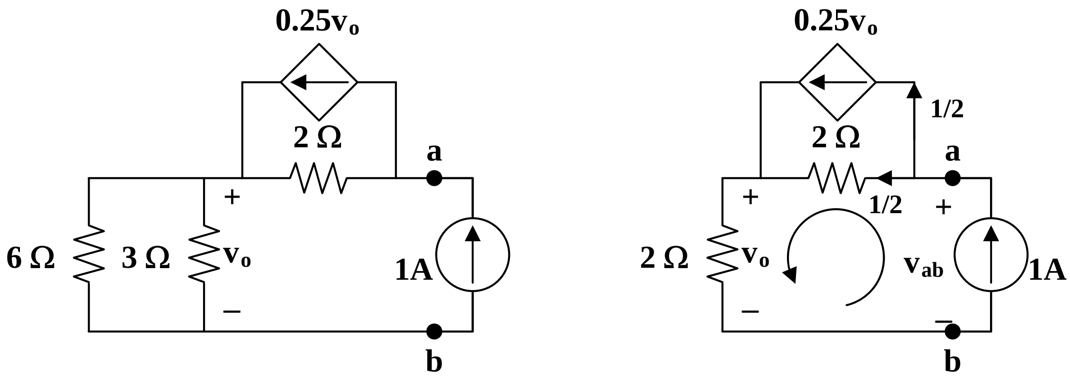
Step 2. $v_{oc} = –2k(20I_o) = –40x4 =$ **–160 volts** $= V_{Thev}$

$i_{sc} = –20x4x10^{–3} = –80$ mA or

$R_{eq} = –160/(80x10^{–3}) =$ **2 kΩ**.

Chapter 4, Solution 53.

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



(a) (b)

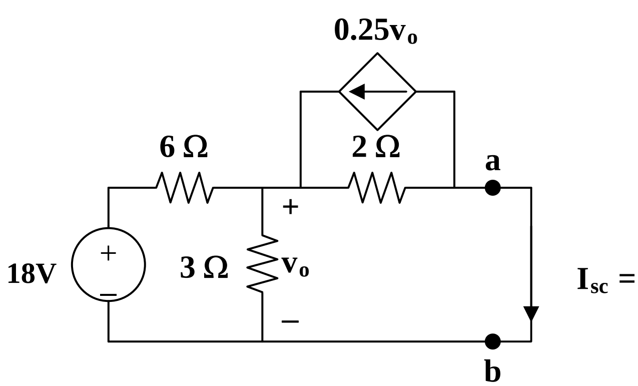
From Fig. (b),

$$v_o = 2x1 = 2V, \quad -v_{ab} + 2x(1/2) + v_o = 0$$

$$v_{ab} = 3V$$

$$R_N = v_{ab}/1 = \mathbf{3\ ohms}$$

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



(c)

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

But, $(v_o/2) = 0.25v_o + I_N$, which leads to $I_N = \mathbf{1\ A}$

Chapter 4, Solution 54

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

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

For the right loop,

$$V_x = -50x40 i_o = -2000 i_o \quad (2)$$

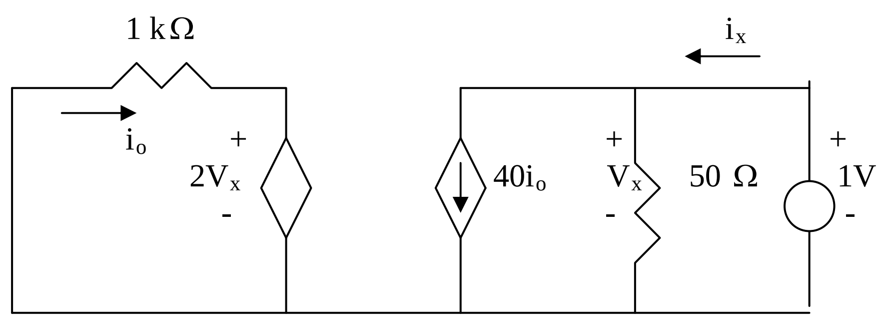
Combining (1) and (2),

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

$$V_x = -2000 i_o = 2 \longrightarrow \underline{V_{Th} = 2}$$

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

.



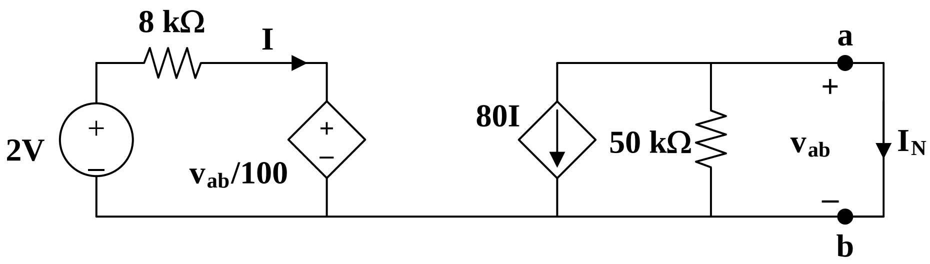
$$V_x = 1, \quad i_o = -\frac{2V_x}{1000} = -2\text{mA}$$

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

$$R_{Th} = \frac{1}{i_x} = -1/0.060 = \underline{-16.67\Omega}$$

Chapter 4, Solution 55.

To get R_N, apply a 1 mA source at the terminals a and b as shown in Fig. (a).



(b)

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

$$(v_{ab}/50) + 80I = 1 \qquad (1)$$

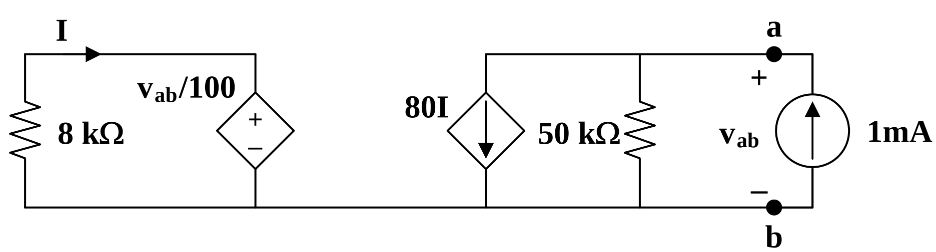
Also,

$$-8I = (v_{ab}/1000), \text{ or } I = -v_{ab}/8000 \qquad (2)$$

From (1) and (2), $(v_{ab}/50) - (80v_{ab}/8000) = 1$, or $v_{ab} = 100$

$R_N = v_{ab}/1 =$ **100 k ohms**

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



(a)

Since the 50-k ohm resistor is shorted,

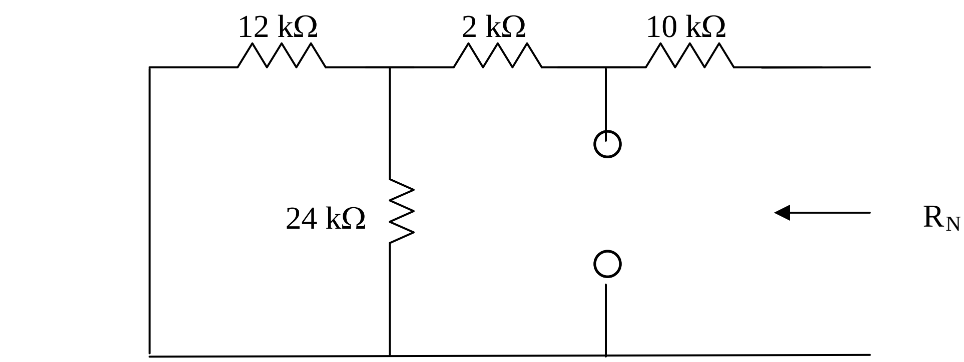
$$I_N = -80I, \ v_{ab} = 0$$

Hence, $8i = 2$ which leads to $I = (1/4)$ mA

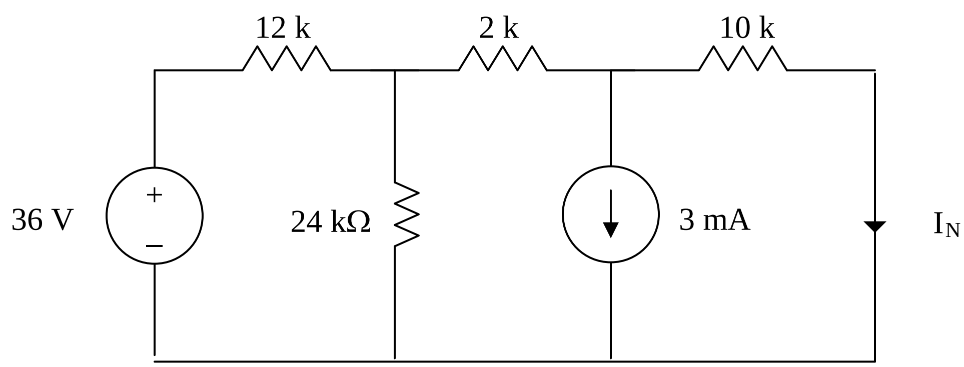
$I_N =$ **-20 mA**

Chapter 4, Solution 56.

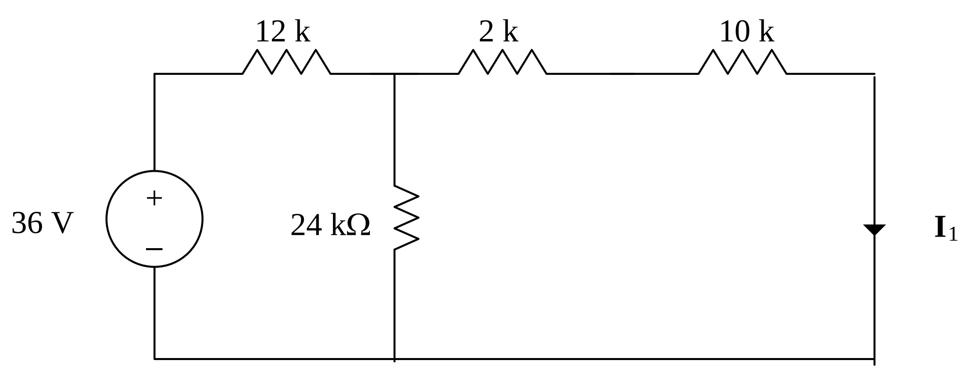
We remove the 1-kΩ resistor temporarily and find Norton equivalent across its terminals. R_{eq} is obtained from the circuit below.



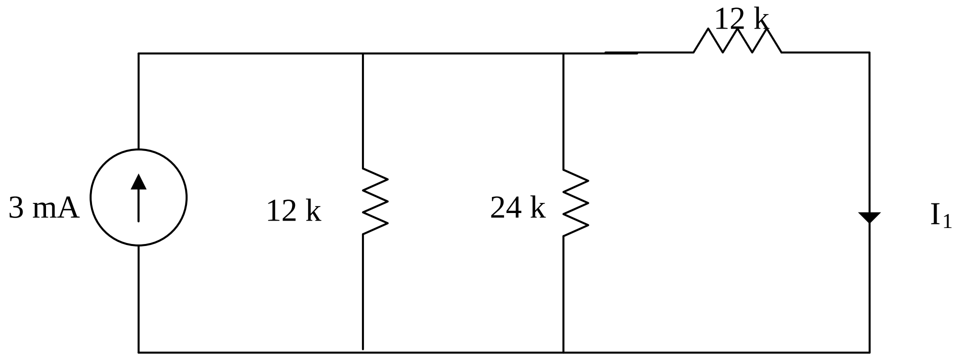
R_{eq} = 10 + 2 + (12//24) = 12+8 = 20 kΩ
I_N is obtained from the circuit below.



We can use superposition theorem to find I_N. Let $I_N = I_1 + I_2$, where I_1 and I_2 are due to 16-V and 3-mA sources respectively. We find I_1 using the circuit below.



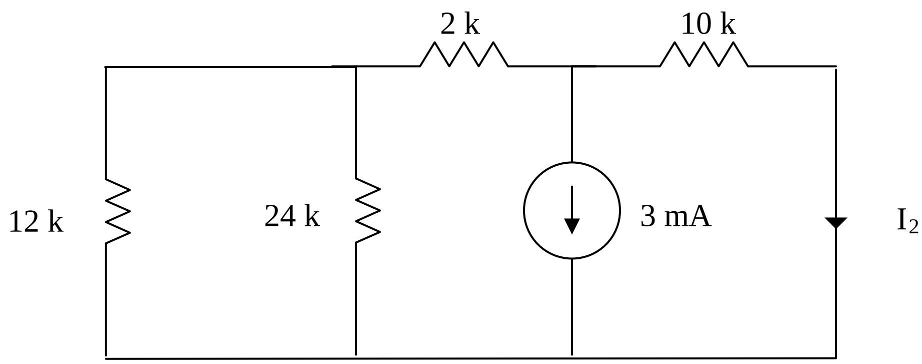
Using source transformation, we obtain the circuit below.



12//24 = 8 kΩ

$$I_1 = \frac{8}{8+12}(3mA) = 1.2 \text{ mA}$$

To find I_2, consider the circuit below.

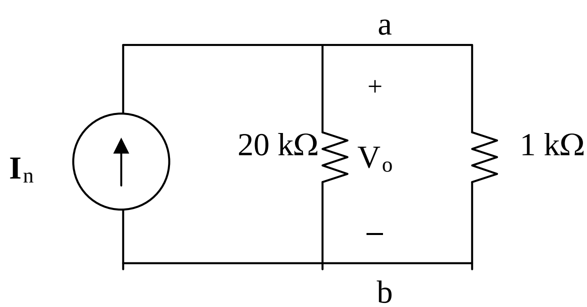


2k + 12k//24 k = 10 kΩ

I_2=0.5(-3mA) = -1.5 mA

I_N = 1.2 –1.5 = -0.3 mA

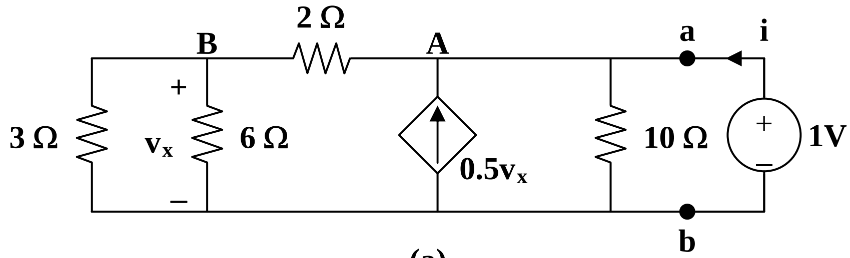
The Norton equivalent with the 1-kΩ resistor is shown below



V_o = 1k(20/(20+1))(-0.3 mA) = **-285.7 mV**.

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).



(a)

We apply nodal analysis. At node A,

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

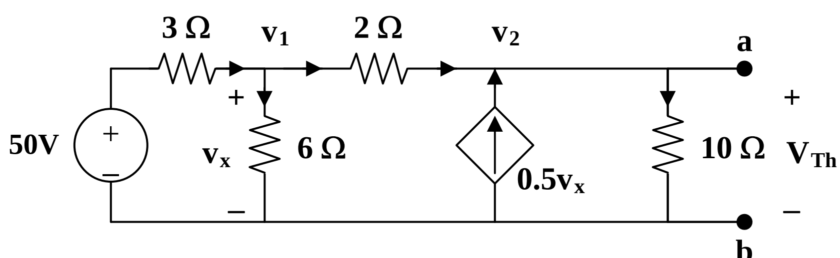
At node B,

$$(1 - v_o)/2 = (v_x/3) + (v_x/6), \text{ and } v_x = 0.5 \qquad (2)$$

From (1) and (2), $i = 0.1$ and

$$R_{Th} = 1/i = \mathbf{10\ ohms}$$

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



(b)

At node 1, $(50 - v_1)/3 = (v_1/6) + (v_1 - v_2)/2$, or $100 = 6v_1 - 3v_2$ (3)

At node 2, $0.5v_x + (v_1 - v_2)/2 = v_2/10$, $v_x = v_1$, and $v_1 = 0.6v_2$ (4)

From (3) and (4),

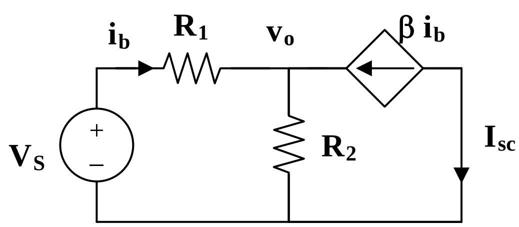
$$v_2 = V_{Th} = \mathbf{166.67\ V}$$

$$I_N = V_{Th}/R_{Th} = \mathbf{16.667\ A}$$

$$R_N = R_{Th} = \mathbf{10\ ohms}$$

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 = **infinity**. I_N can be found by solving for I_{sc}.



Writing the node equation at node vo,

$$i_b + \beta i_b \ = \ v_o/R_2 \ = \ (1 + \beta)i_b$$

But $$i_b \ = \ (V_s - v_o)/R_1$$

$$v_o \ = \ V_s - i_bR_1$$

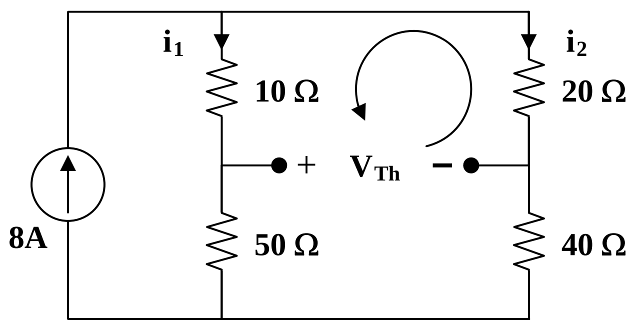
$$V_s - i_bR_1 \ = \ (1 + \beta)R_2i_b, \ \text{or} \ \ i_b \ = \ V_s/(R_1 + (1 + \beta)R_2)$$

$$I_{sc} \ = \ I_N \ = \ -\beta i_b \ = \ \mathbf{-\beta V_s/(R_1 + (1 + \beta)R_2)}$$

Chapter 4, Solution 59.

R_{Th} = (10 + 20)||(50 + 40) 30||90 = **22.5 ohms**

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

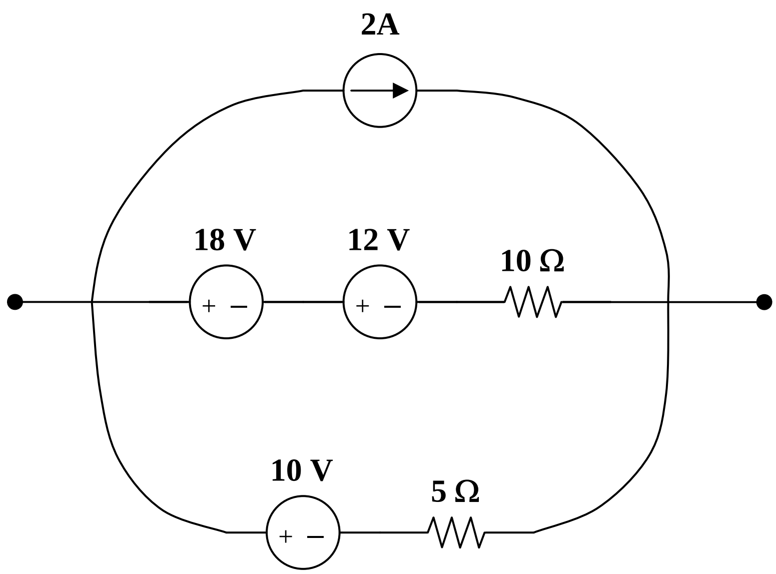


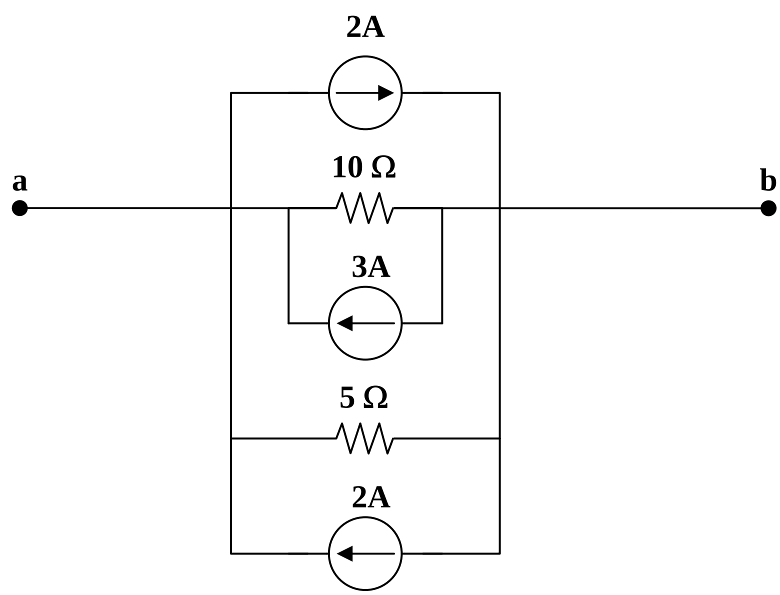
$i_1 = i_2 = 8/2 = 4$, $10i_1 + V_{Th} - 20i_2 = 0$, or $V_{Th} = 20i_2 - 10i_1 = 10i_1 = 10x4$

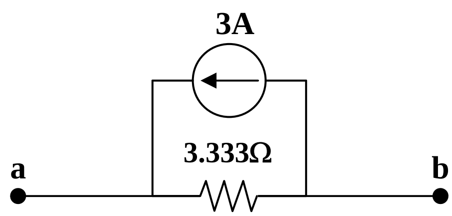
V_{Th} = **40V**, and $I_N = V_{Th}/R_{Th} = 40/22.5 =$ **1.7778 A**

Chapter 4, Solution 60.

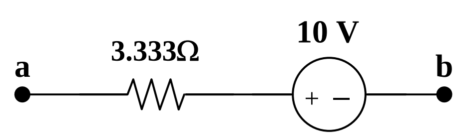
The circuit can be reduced by source transformations.







Norton Equivalent Circuit



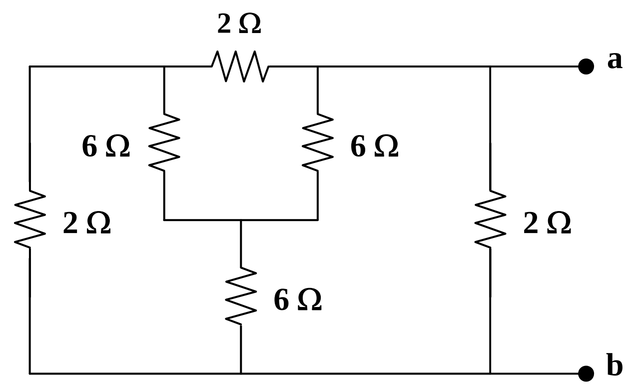
Thevenin Equivalent Circuit

Chapter 4, Solution 61.

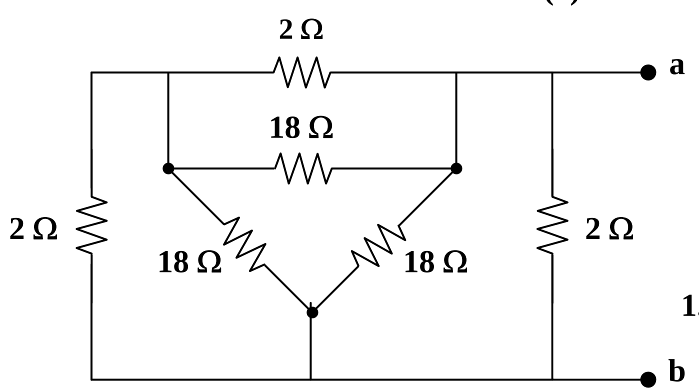
To find R_{Th}, consider the circuit in Fig. (a).

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

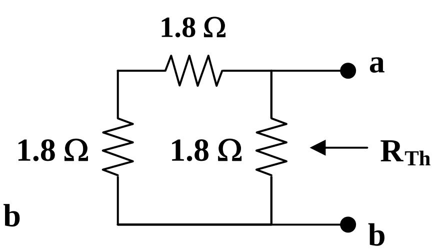
To get V_{Th}, we apply mesh analysis to the circuit in Fig. (d).



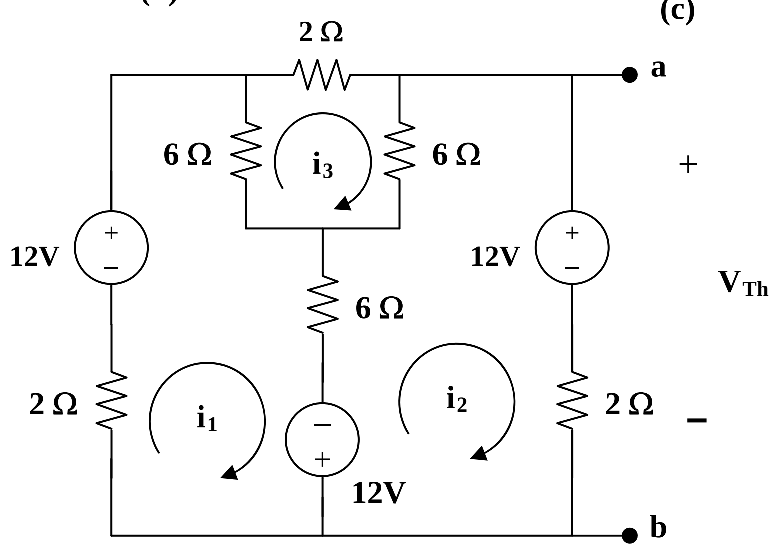
(a)



(b)



(c)



(d)

$-12 - 12 + 14i_1 - 6i_2 - 6i_3 = 0$, and $7 i_1 - 3 i_2 - 3i_3 = 12$ (1)

$12 + 12 + 14 i_2 - 6 i_1 - 6 i_3 = 0$, and $-3 i_1 + 7 i_2 - 3 i_3 = -12$ (2)

$14 i_3 - 6 i_1 - 6 i_2 = 0$, and $-3 i_1 - 3 i_2 + 7 i_3 = 0$ (3)

This leads to the following matrix form for (1), (2) and (3),

$$\begin{bmatrix} 7 & -3 & -3 \\ -3 & 7 & -3 \\ -3 & -3 & 7 \end{bmatrix}\begin{bmatrix} i_1 \\ i_2 \\ i_3 \end{bmatrix} = \begin{bmatrix} 12 \\ -12 \\ 0 \end{bmatrix}$$

$$\Delta = \begin{vmatrix} 7 & -3 & -3 \\ -3 & 7 & -3 \\ -3 & -3 & 7 \end{vmatrix} = 100, \qquad \Delta_2 = \begin{vmatrix} 7 & 12 & -3 \\ -3 & -12 & -3 \\ -3 & 0 & 7 \end{vmatrix} = -120$$

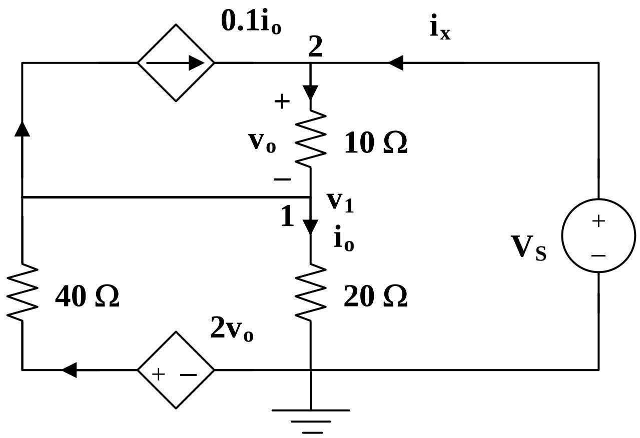
$$i_2 = \Delta/\Delta_2 = -120/100 = -1.2 \text{ A}$$

$V_{Th} = 12 + 2i_2 =$ **9.6 V**, and $I_N = V_{Th}/R_{Th} =$ **8 A**

Chapter 4, Solution 62.

Since there are no independent sources, $V_{Th} = 0$ 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),

$$10i_x + v_1/20 = 1 - v_1$$

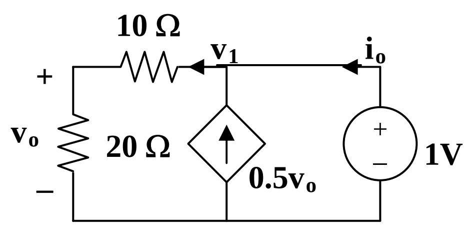
$$10i_x = 1 - v_1 - v_1/20 = 1 - (21/20)v_1 = 1 - (21/20)(6/9.2)$$

$$i_x = 31.52 \text{ mA}, \ R_{Th} = 1/i_x = \mathbf{31.73 \text{ ohms.}}$$

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.



Applying KCL at node 1, $v_1 = 1$, and $v_o = (20/30)v_1 = 2/3$

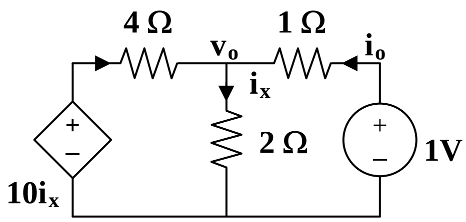
$i_o = (v_1/30) - 0.5v_o = (1/30) - 0.5x2/3 = 0.03333 - 0.33333 = -0.3$ A.

Hence,

$R_N = 1/(-0.3) = $ **–3.333 ohms**

Chapter 4, Solution 64.

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



$$i_x = [(1 - v_o)/1] + [(10i_x - v_o)/4], \text{ or } 5v_o = 4 + 6i_x \qquad (1)$$

But $i_x = v_o/2$. Hence,

$$5v_o = 4 + 3v_o, \text{ or } v_o = 2, \; i_o = (1 - v_o)/1 = -1$$

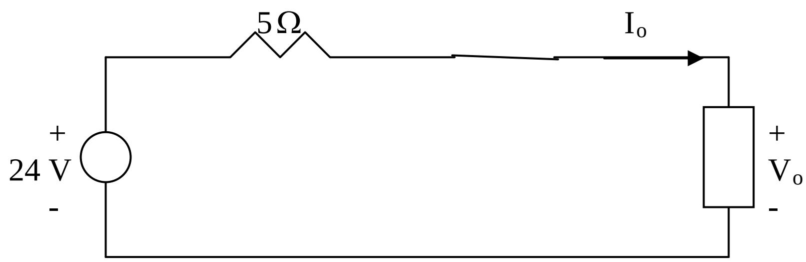
Thus, $R_{Th} = 1/i_o =$ **–1 ohm**

Chapter 4, Solution 65

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

$$R_{eq} = 2 + (4 \| 12) = 2 + 3 = 5\Omega, \qquad V_{Th} = \frac{12}{12+4}(32) = 24\text{ V}$$

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

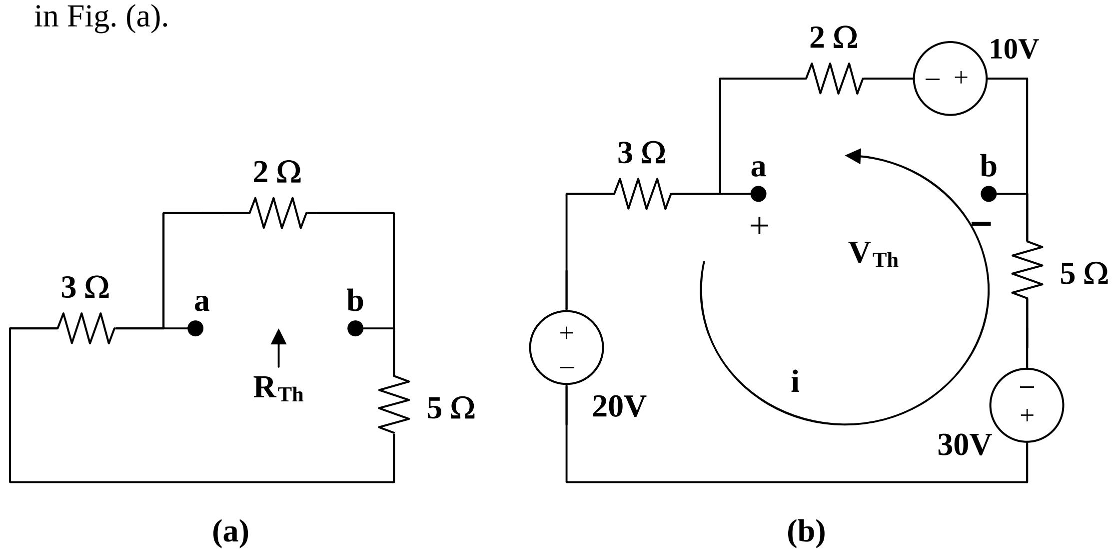


Applying KVL to the loop,

$$-24 + 5I_o + V_o = 0 \qquad \longrightarrow \qquad \mathbf{V_o = 24 - 5I_o.}$$

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).



$$R_{Th} = 2||(3 + 5) = 2||8 = \mathbf{1.6\ ohms}$$

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

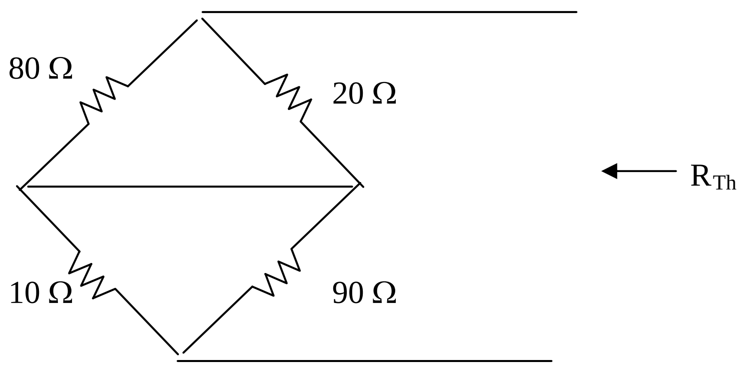
$$10i + 30 + 20 + 10 = 0, \text{ or } i = -6$$

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

$$p = V_{Th}^2/(4R_{Th}) = (2)^2/[4(1.6)] = \mathbf{625\ m\ watts}$$

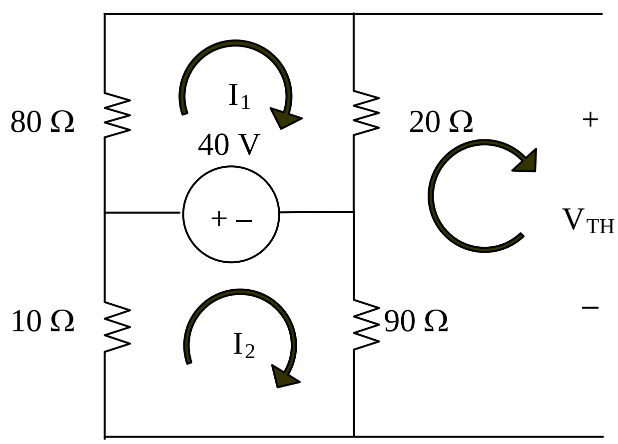
Chapter 4, Solution 67.

We first find the Thevenin equivalent. We find R_{Th} using the circuit below.



$$R_{Th} = 20//80 + 90//10 = 16 + 9 = 25\ \Omega$$

We find V_{Th} using the circuit below. We apply mesh analysis.



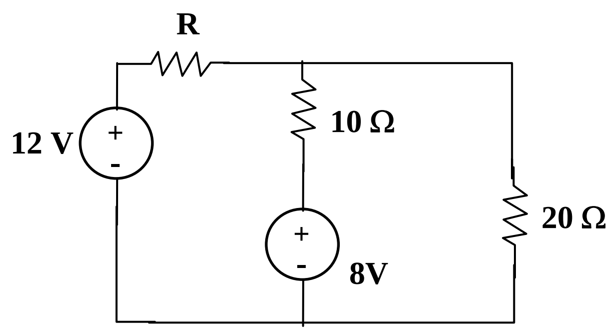
$$(80+20)i_1 - 40 = 0 \longrightarrow i_1 = 0.4$$
$$(10+90)i_2 + 40 = 0 \longrightarrow i_2 = -0.4$$
$$-90i_2 - 20i_1 + V_{Th} = 0 \longrightarrow V_{Th} = -28\ \text{V}$$

(a) R = R_{Th} = **25 Ω**

(b) $P_{\max} = \dfrac{V_{Th}^2}{4R_{Th}} = \dfrac{(28)^2}{100} = \underline{7.84\ \text{W}}$

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_{Thev} 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:

$$R_{Th} = (Rx20/(R+20)) \text{ and a } V_{oc} = V_{Th} = 12x(20/(R+20)) + (-8)$$

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

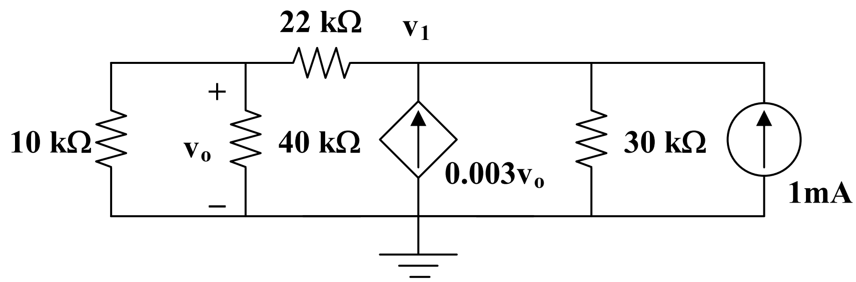
$$P = vi = v^2/R = 4x4/10 = 1.6 \text{ watts}$$

Notice that if R = 20 ohms which gives an R_{Th} = 10 ohms, then V_{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 = to 12 watts. This is a significant difference.

Chapter 4, Solution 69.

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



Assume that all resistances are in k ohms and all currents are in mA.

$$10||40 \;=\; 8, \;\text{and}\; 8 + 22 \;=\; 30$$

$$1 + 3v_o \;=\; (v_1/30) + (v_1/30) \;=\; (v_1/15)$$

$$15 + 45v_o \;=\; v_1$$

But $v_o \;=\; (8/30)v_1$, hence,

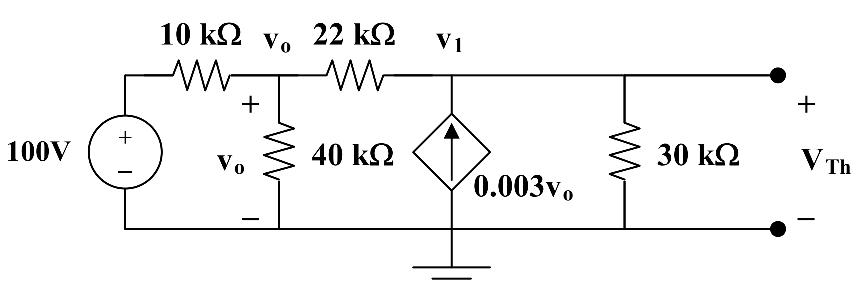
$$15 + 45x(8v_1/30)\;\; v_1, \;\text{which leads to}\; v_1 \;=\; 1.3636$$

$$R_{Th} \;=\; v_1/1 \;=\; -1.3636 \text{ k ohms}$$

R_{Th} being negative indicates an active circuit and if you now make R equal to 1.3636 k ohms, then the active circuit will actually try to supply infinite power to the resistor. The correct answer is therefore:

$$p_R = \left(\frac{V_{Th}}{-1363.6 + 1363.6}\right)^2 1363.6 = \left(\frac{V_{Th}}{0}\right)^2 1363.6 \;=\; \infty$$

It may still be instructive to find V_{Th}. Consider the circuit below.



$$(100 - v_o)/10 \;=\; (v_o/40) + (v_o - v_1)/22 \qquad (1)$$

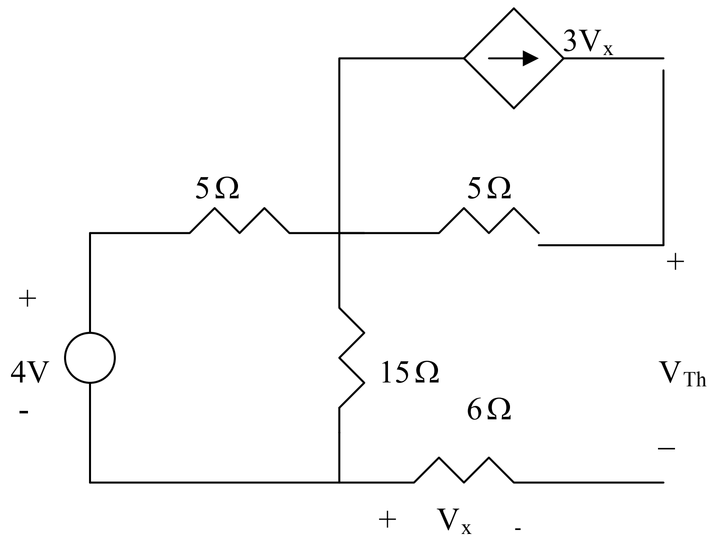
$$[(v_o - v_1)/22] + 3v_o = (v_1/30) \qquad (2)$$

Solving (1) and (2),

$$v_1 = V_{Th} = -243.6 \text{ volts}$$

Chapter 4, Solution 70

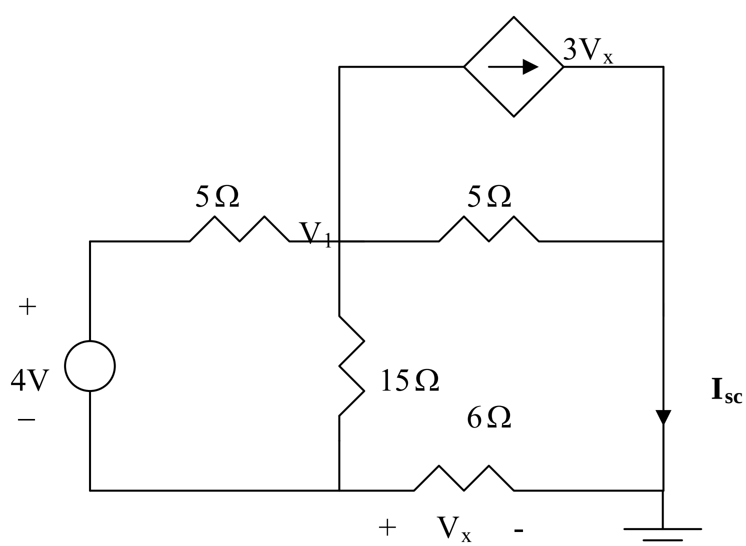
We find the Thevenin equivalent across the 10-ohm resistor. To find V_{Th}, consider the circuit below.



From the figure,

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

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



At node 1,

$$[(V_1–V_x)/15] + [(V_1–(4+V_x))/5] + [(V_1–0)/5] + 3V_x = 0 \text{ or}$$

$$0.4667V_1 + 2.733V_x = 0.8 \qquad (1)$$

At node x,

$[(V_x–0)/6] + [((V_x+4)–V_1)/5] + [(V_x–V_1)/15] = 0$ or
$–(0.2667)V_1 + 0.4333V_x = –0.8 \qquad (2)$

Adding (1) and (2) together lead to,

$(0.4667–0.2667)V_1 + (2.733+0.4333)V_x = 0$ or $V_1 = –(3.166/0.2)V_x = –15.83V_x$

Now we can put this into (1) and we get,

$0.4667(–15.83V_x) + 2.733V_x = 0.8 = (–7.388+2.733)V_x = –4.655V_x$ or $V_x = –0.17186$ V.

$I_{sc} = –V_x/6 = 0.02864$ and $R_{eq} = 3/(0.02864) = 104.75\ \Omega$

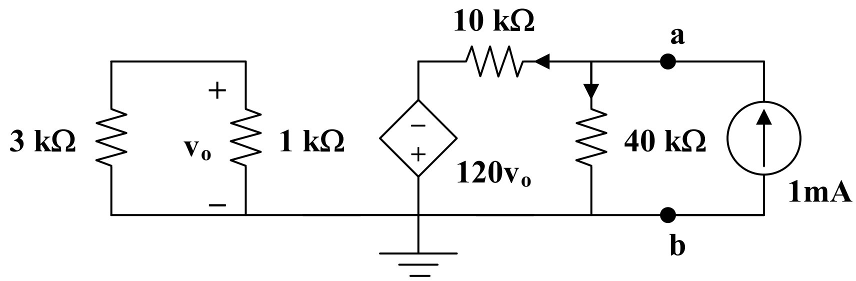
An alternate way to find R_{eq} is replace I_{sc} with a 1 amp current source flowing up and setting the 4 volts source to zero. We then find the voltage across the 1 amp current source which is equal to R_{eq}. First we note that $V_x = 6$ volts ;
$V_1 = 6+3.75 = –9.75$; $V_2 = 19x5 + V_1 = 95+9.75 = 104.75$ or $R_{eq} = 104.75\ \Omega$.

Clearly setting the load resistance to 104.75 Ω means that the circuit will deliver maximum power to it. Therefore,

$$p_{max} = [3/(2x104.75)]^2 x104.75 = \mathbf{21.48\ mW}$$

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,

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

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

$$R_{Th} = v_a/1\text{ mA} = 8 \text{ kohms}$$

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

$$v_o = (1/4)8 = 2 \text{ V}$$

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

The resistance at the required resistor is

$$R = R_{Th} = \mathbf{8\ k\Omega}$$

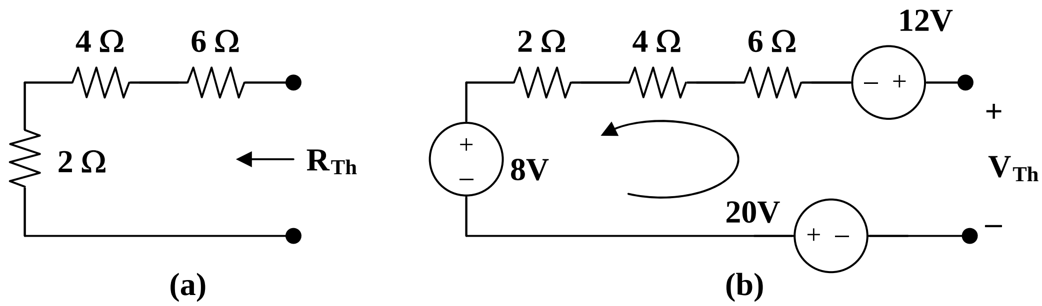
$$p = V_{Th}^2/(4R_{Th}) = (-192)^2/(4\text{x}8\text{x}10^3) = \mathbf{1.152\ watts}$$

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 ohms**

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



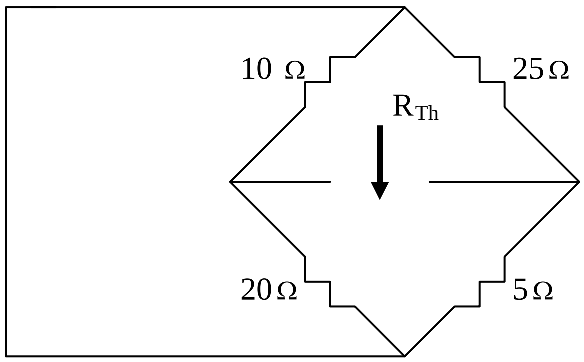
(b) $i = V_{Th}/(R_{Th} + R) = 40/(12 + 8) =$ **2A**

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

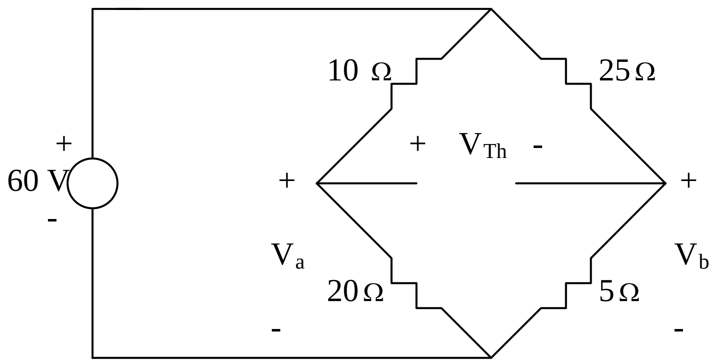
(d) $p = V_{Th}^2/(4R_{Th}) = (40)^2/(4x12) =$ **33.33 watts**.

Chapter 4, Solution 73

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



$$R_{Th} = 10 // 20 + 25 // 5 = 325 / 30 = 10.833\Omega$$



$$V_a = \frac{20}{30}(60) = 40, \qquad V_b = \frac{5}{30}(60) = 10$$

$$-V_a + V_{Th} + V_b = 0 \longrightarrow V_{Th} = V_a - V_b = 40 - 10 = 30 \text{ V}$$

$$\boldsymbol{p_{\max} = \frac{V_{Th}{}^2}{4R_{Th}} = \frac{30^2}{4x10.833} = 20.77 \text{ W}}.$$

Chapter 4, Solution 74.

When R_L is removed and V_s is short-circuited,

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

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

When R_L is removed and we apply the voltage division principle,

$$V_{oc} = V_{Th} = v_{R2} - v_{R4}$$

$$= ([R_2/(R_1 + R_2)] - [R_4/(R_3 + R_4)])V_s = \{[(R_2R_3) - (R_1R_4)]/[(R_1 + R_2)(R_3 + R_4)]\}V_s$$

$$p_{max} = V_{Th}^2/(4R_{Th})$$

$$= \{[(R_2R_3) - (R_1R_4)]^2/[(R_1 + R_2)(R_3 + R_4)]^2\}V_s^2[(R_1 + R_2)(R_3 + R_4)]/[4(a)]$$

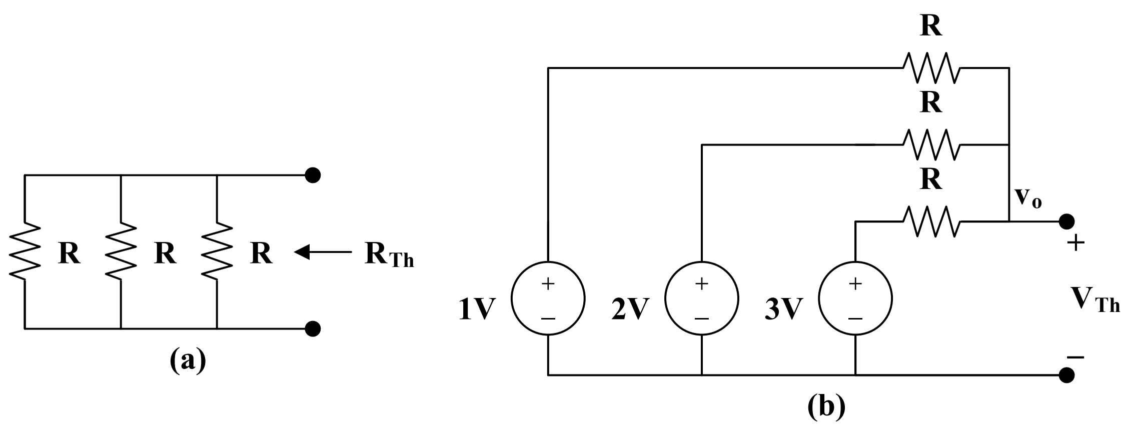
$$\text{where } a = (R_1 R_2 R_3 + R_1 R_2 R_4 + R_1 R_3 R_4 + R_2 R_3 R_4)$$

$$p_{max} =$$

$$\mathbf{[(R_2R_3) - (R_1R_4)]^2V_s^2/[4(R_1 + R_2)(R_3 + R_4) (R_1 R_2 R_3 + R_1 R_2 R_4 + R_1 R_3 R_4 + R_2 R_3 R_4)]}$$

Chapter 4, Solution 75.

We need to first find R_{Th} and V_{Th}.



Consider the circuit in Fig. (a).

$$(1/R_{eq}) = (1/R) + (1/R) + (1/R) = 3/R$$

$$R_{eq} = R/3$$

From the circuit in Fig. (b),

$$((1 - v_o)/R) + ((2 - v_o)/R) + ((3 - v_o)/R) = 0$$

$$v_o = 2 = V_{Th}$$

For maximum power transfer,

$$R_L = R_{Th} = R/3$$

$$P_{max} = [(V_{Th})^2/(4R_{Th})] = \mathbf{3\ mW}$$

$$R_{Th} = [(V_{Th})^2/(4P_{max})] = 4/(4xP_{max}) = 1/P_{max} = R/3$$

$$R = 3/(3x10^{-3}) = \mathbf{1\ k\Omega}$$

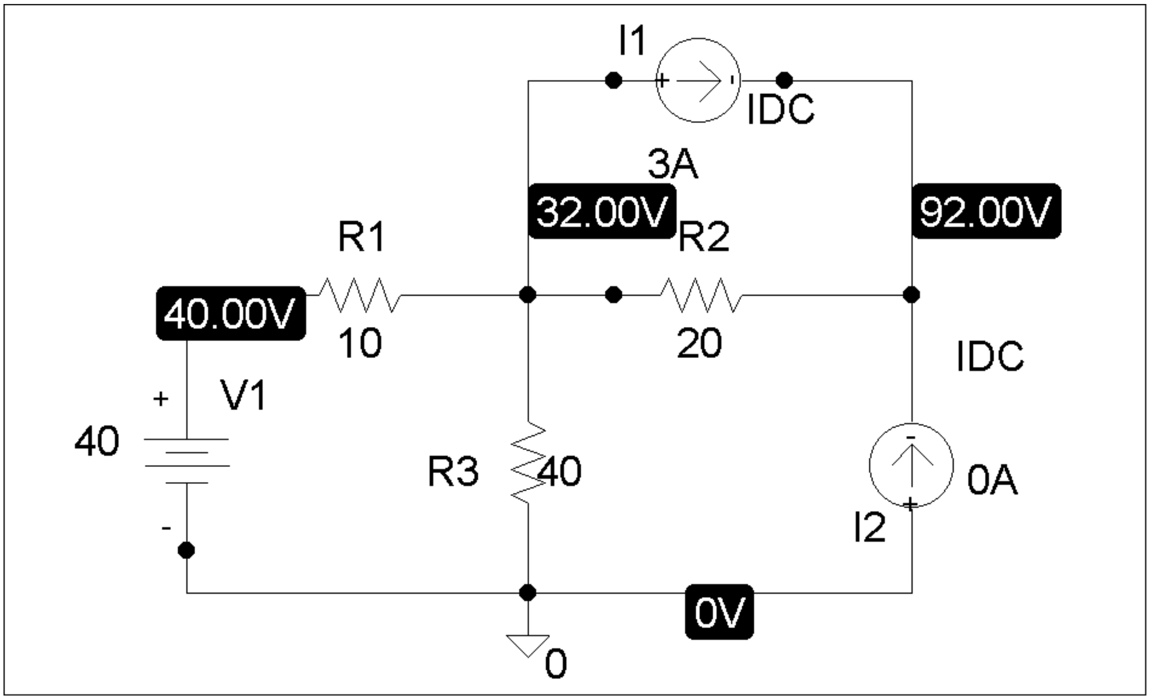
1 kΩ, 3 mW

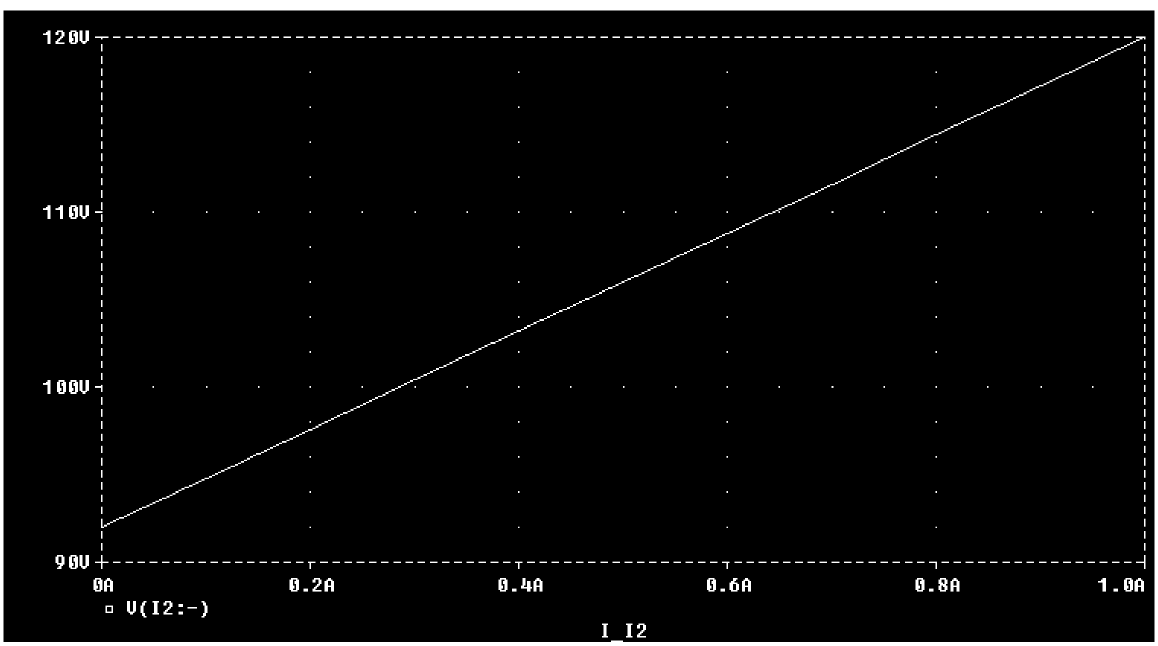
Chapter 4, Solution 76.

Follow the steps in Example 4.14. The schematic and the output plots are shown below. From the plot, we obtain,

$$V = \mathbf{92\ V} \text{ [i = 0, voltage axis intercept]}$$

$$R = \text{Slope} = (120 - 92)/1 = \mathbf{28\ ohms}$$



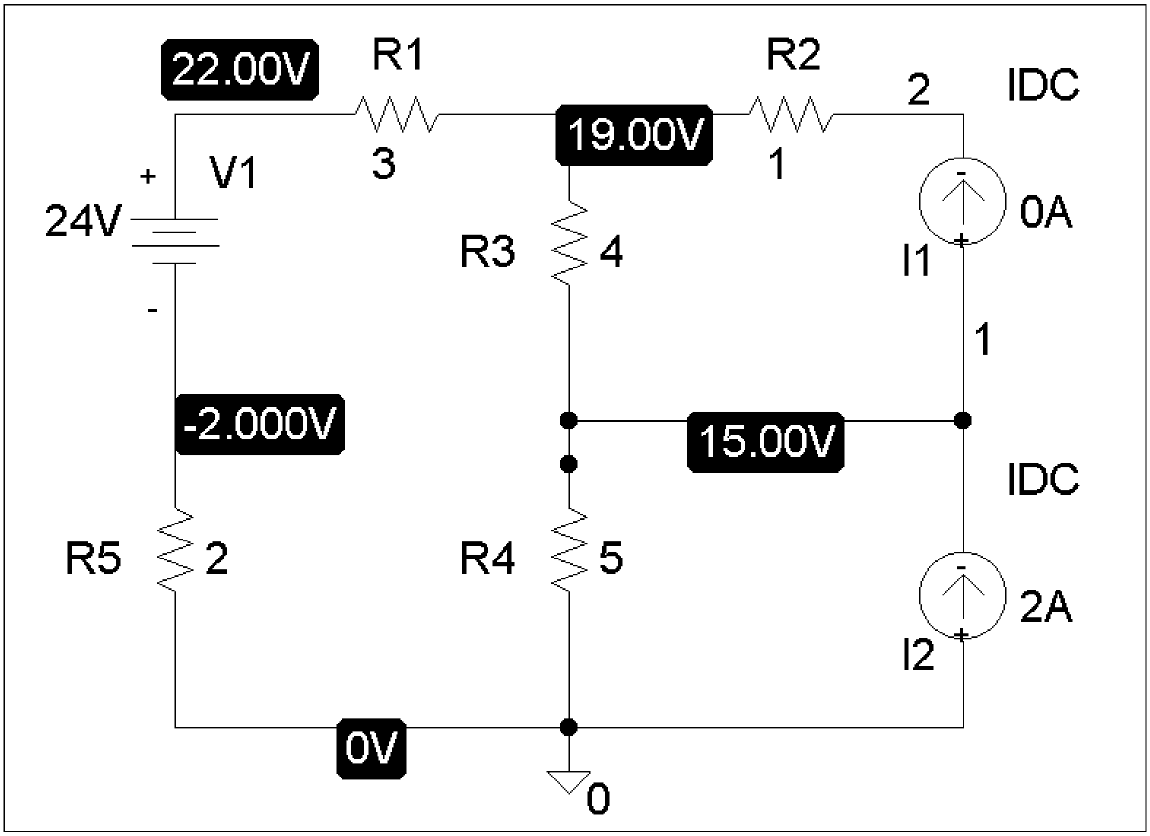


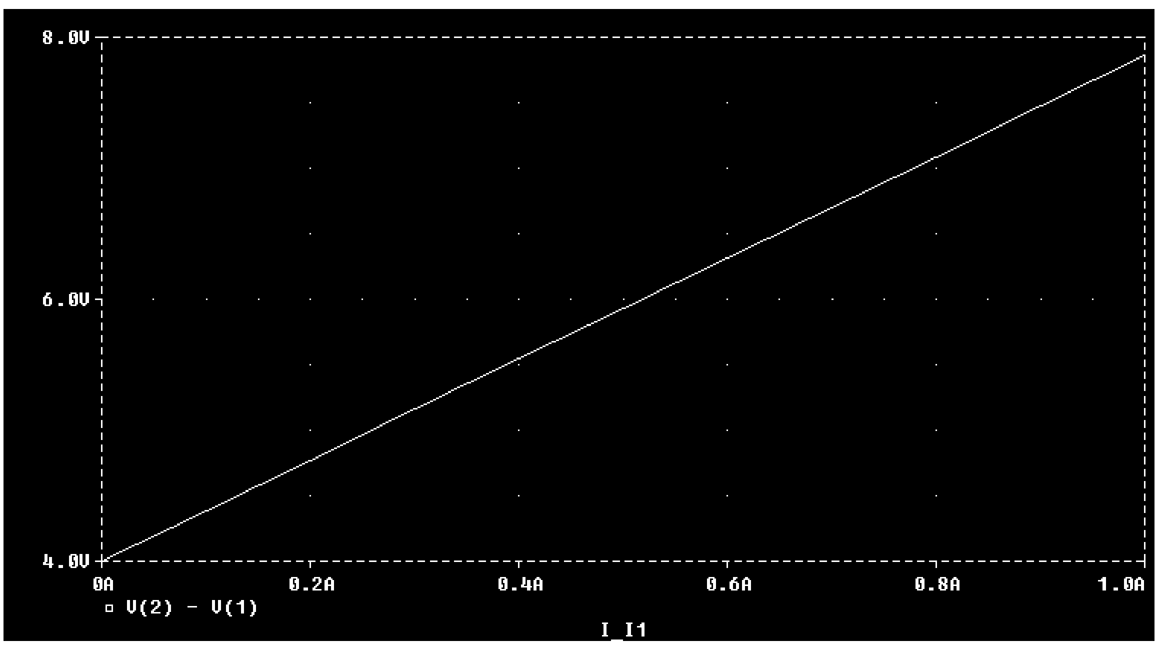
Chapter 4, Solution 77.

(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.

$$V_{Th} = \mathbf{4\ V} \text{ [zero intercept]}$$

$$R_{Th} = (7.8 - 4)/1 = \mathbf{3.8\ ohms}$$

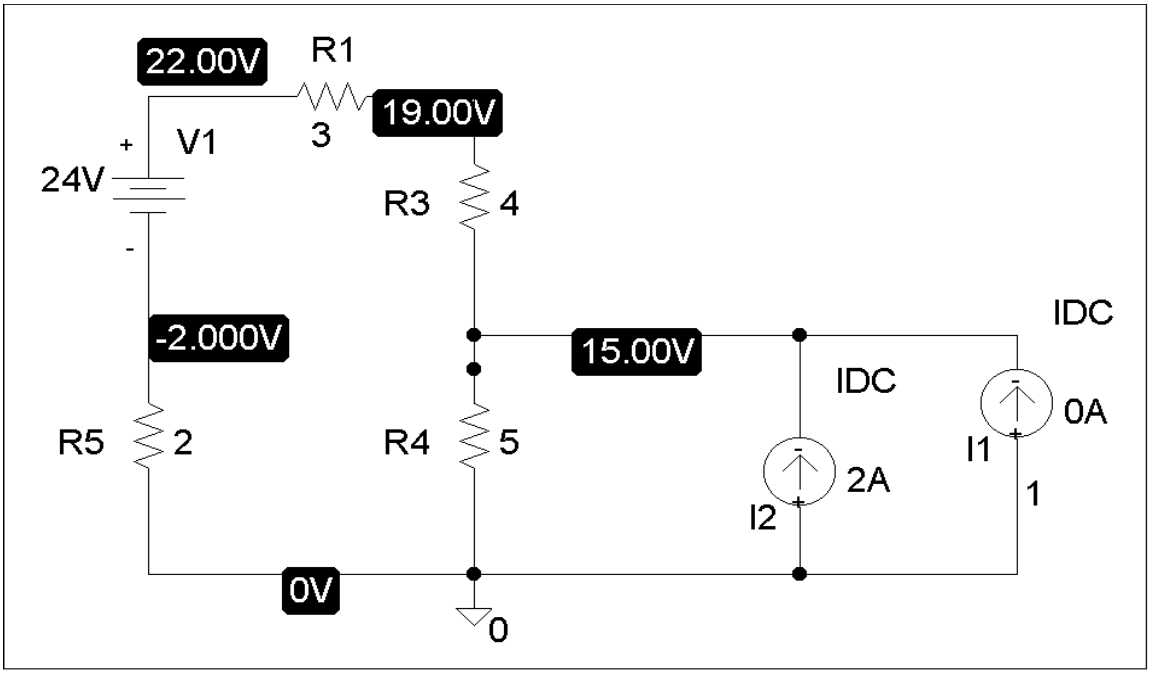


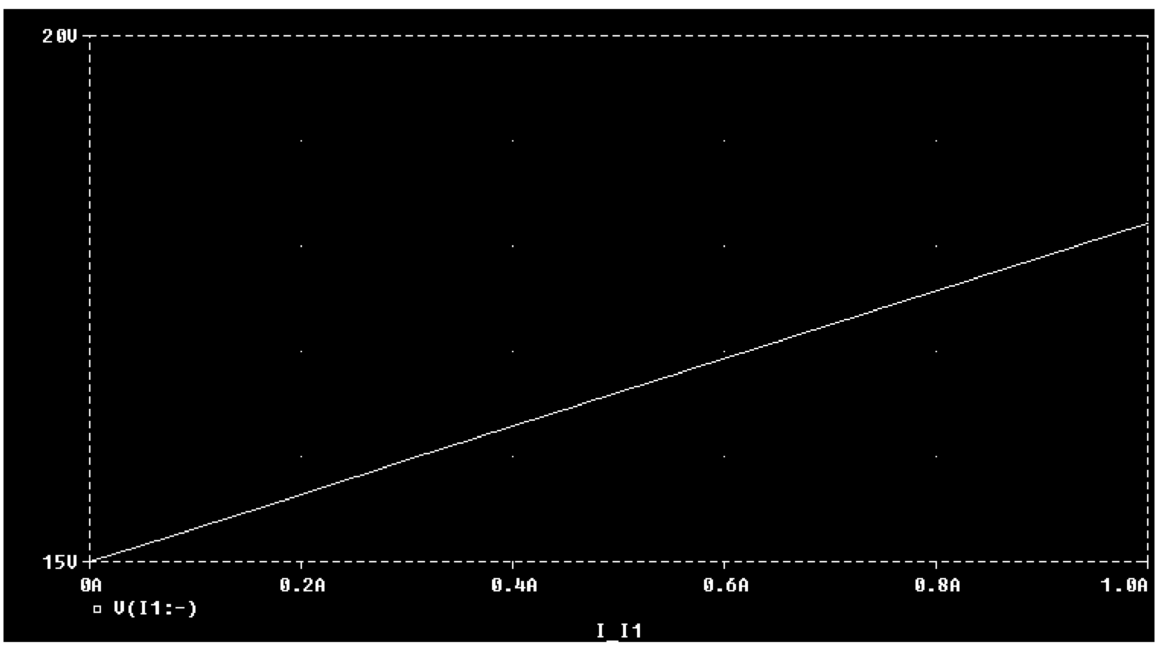


(b) Everything remains the same as in part (a) except that the current source, I1, is connected between terminals b and c as shown below. We perform a dc sweep on I1 and obtain the plot shown below. From the plot, we obtain,

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

$$R = (18.2 - 15)/1 = \mathbf{3.2\ ohms}$$



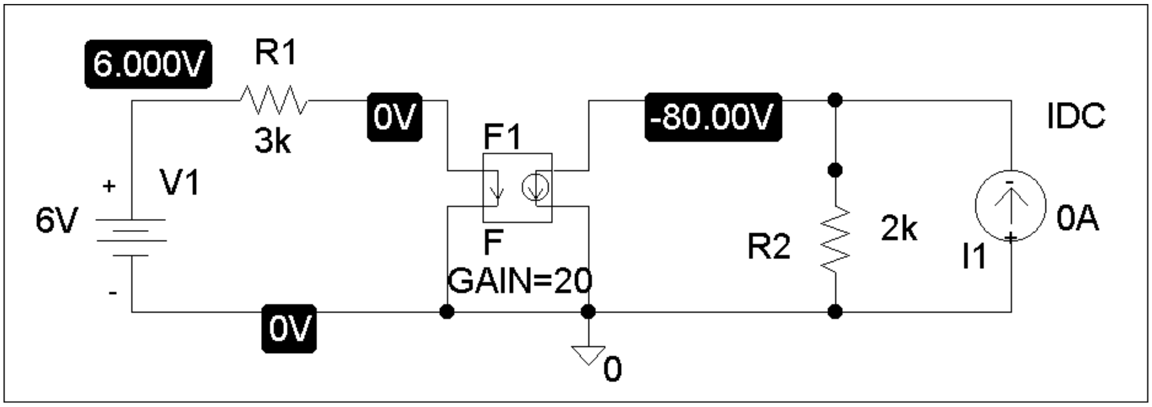


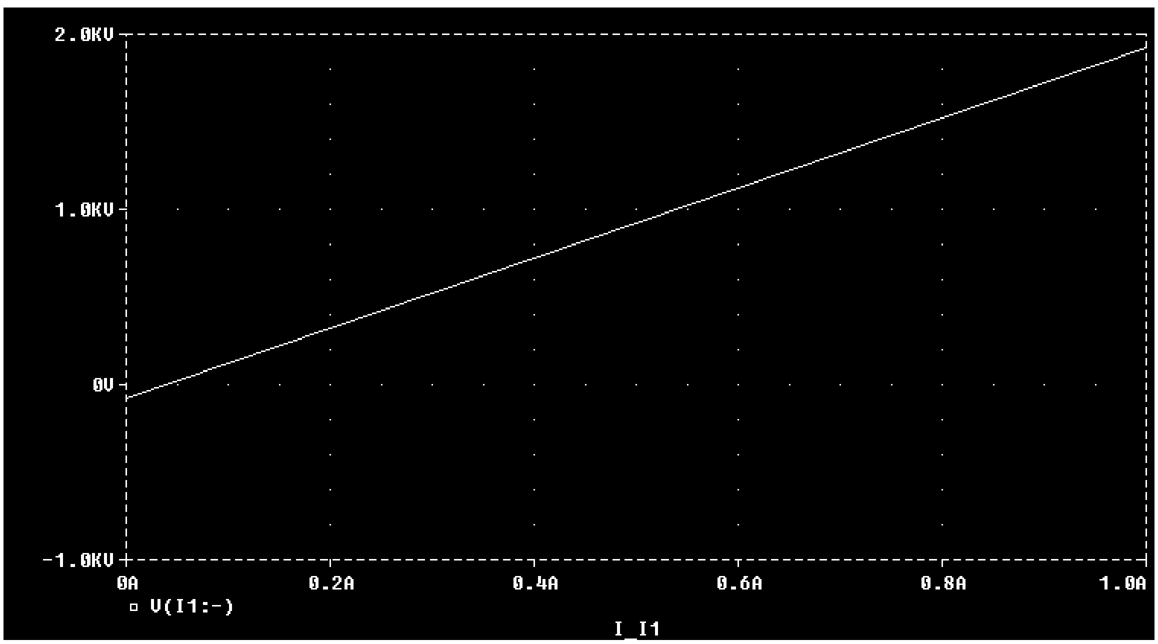
Chapter 4, Solution 78.

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,

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

$$R_{Th} = (1920 - (-80))/1 = \mathbf{2\ k\ ohms}$$



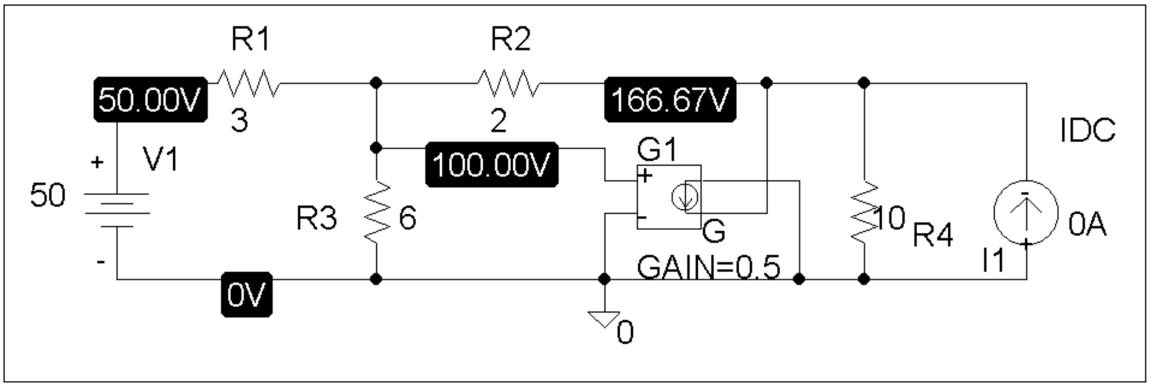


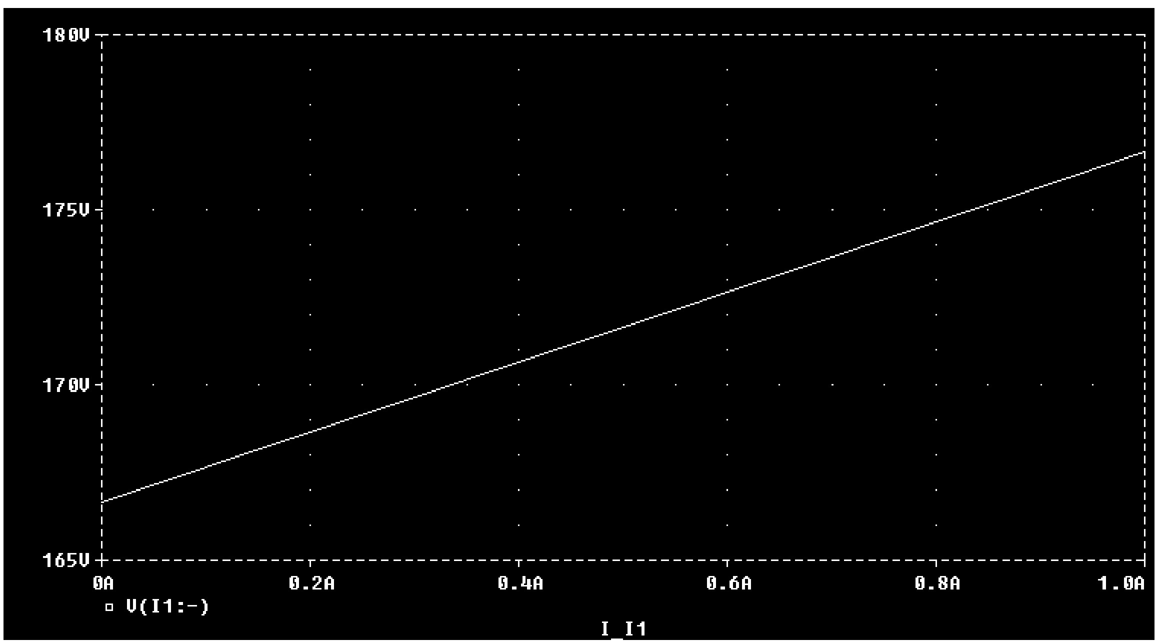
Chapter 4, Solution 79.

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,

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

$$R = (177 - 167)/1 = \mathbf{10\ ohms}$$



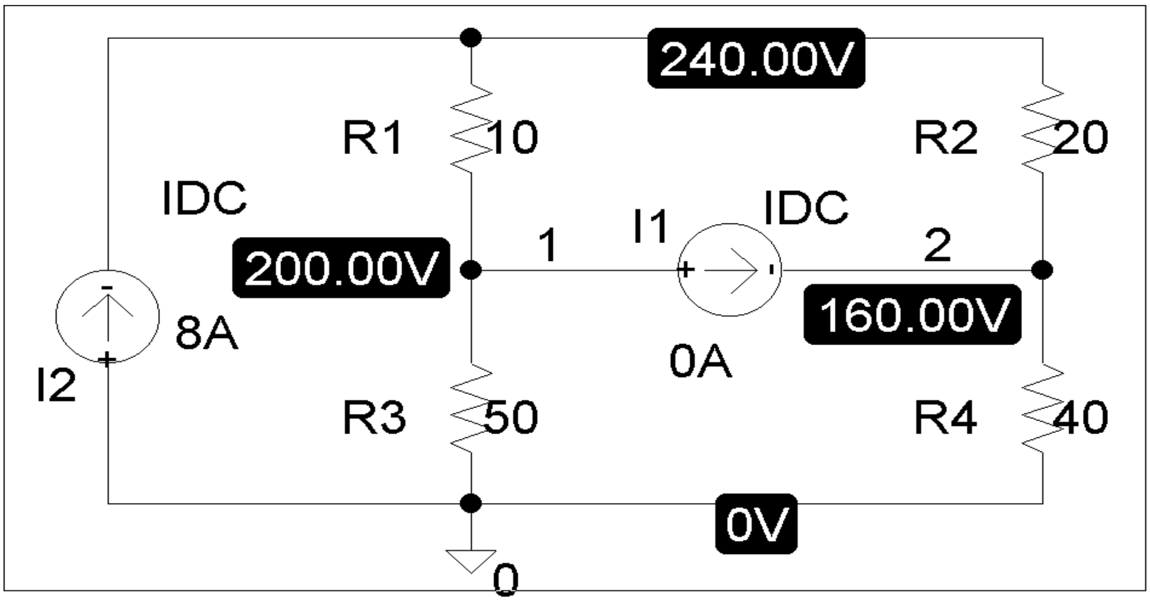


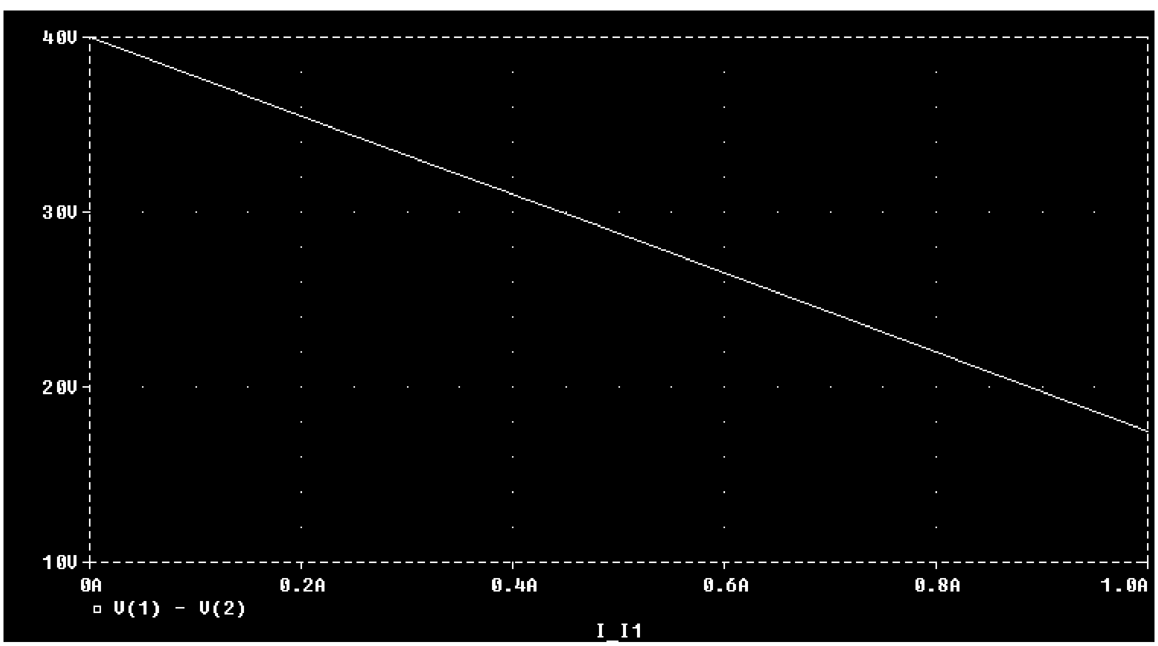
Chapter 4, Solution 80.

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,

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

$$R_{Th} = (40 - 17.5)/1 = \mathbf{22.5\ ohms} \quad \text{[slope]}$$



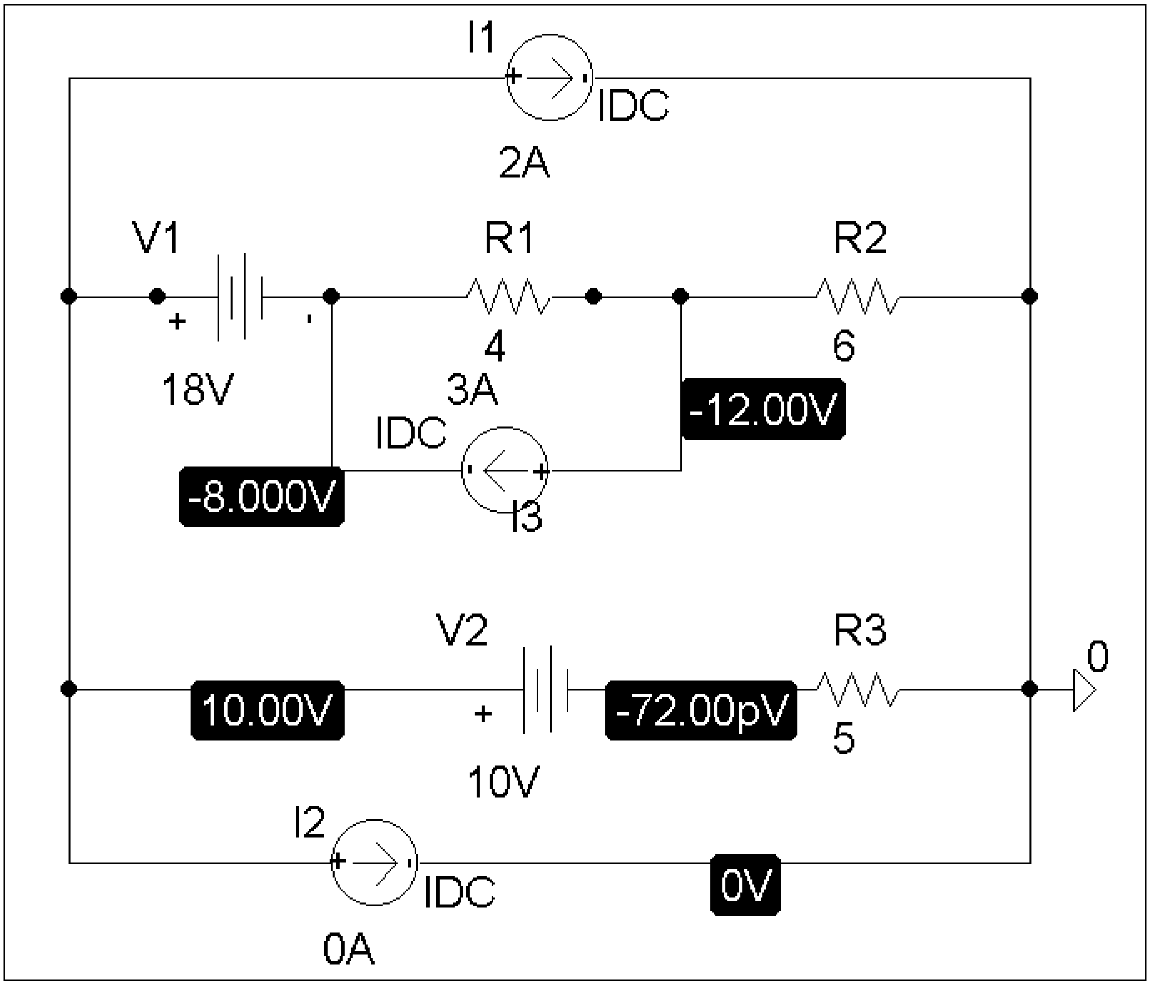


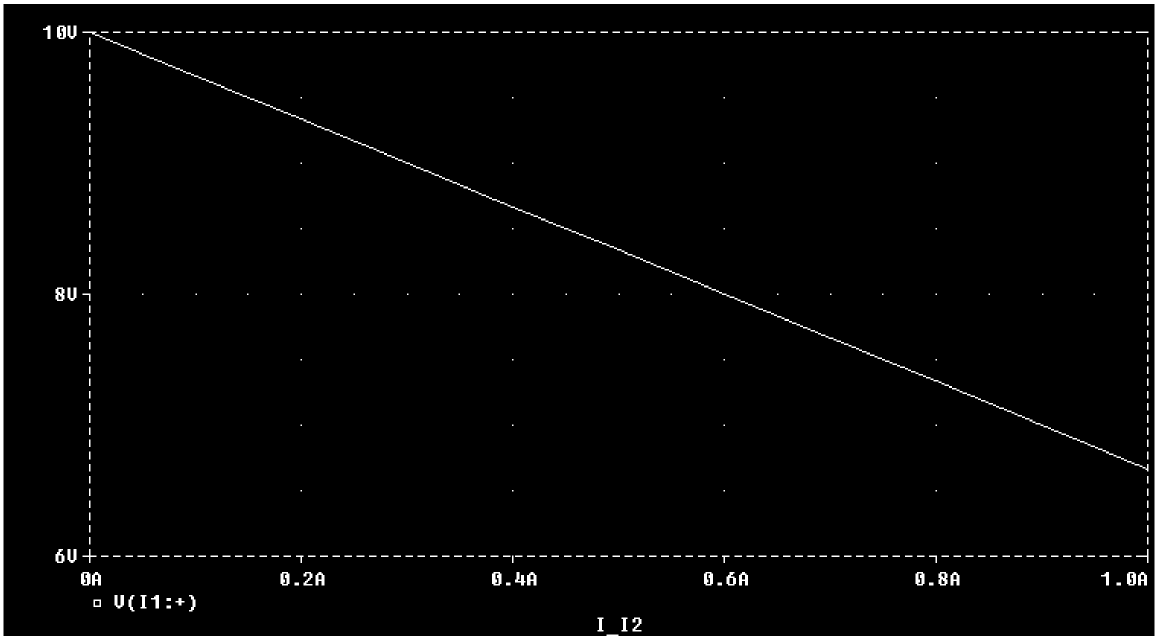
Chapter 4, Solution 81.

The schematic is shown below. We perform a dc sweep on the current source, I2, connected between terminals a and b. The plot of the voltage across I2 is shown below. From the plot,

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

R_{Th} = (10 – 6.7)/1 = **3.3 ohms**. Note that this is in good agreement with the exact value of 3.333 ohms.

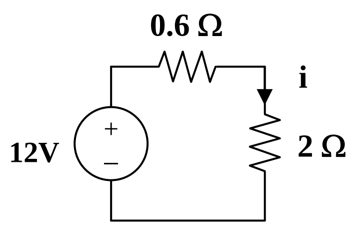



10V
8V
6V
0A
0.2A
0.4A
0.6A
0.8A
1.0A
V(I1:+)
I_I2

Chapter 4, Solution 82.

$V_{Th} = V_{oc} = 12$ V, $I_{sc} = 20$ A

$$R_{Th} = V_{oc}/I_{sc} = 12/20 = 0.6 \text{ ohm.}$$



$i = 12/2.6$, $p = i^2R = (12/2.6)^2(2) =$ **42.6 watts**

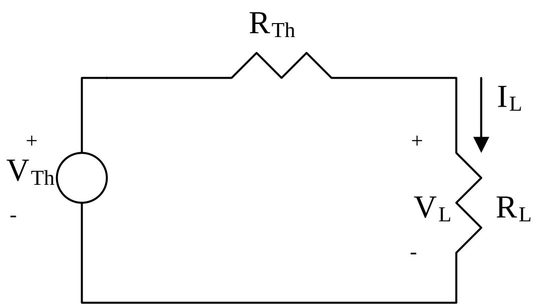
Chapter 4, Solution 83.

$V_{Th} = V_{oc} = 12$ V, $I_{sc} = I_N = 1.5$ A

$$R_{Th} = V_{Th}/I_N = 8 \text{ ohms}, \quad V_{Th} = \mathbf{12\ V}, \quad R_{Th} = \mathbf{8\ ohms}$$

Chapter 4, Solution 84

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



For open circuit,

$$R_L = \infty, \quad \longrightarrow \quad V_{Th} = V_{oc} = V_L = \underline{10.8\ \text{V}}$$

When R_L = 4 ohm, V_L=10.5,

$$I_L = \frac{V_L}{R_L} = 10.8/4 = 2.7$$

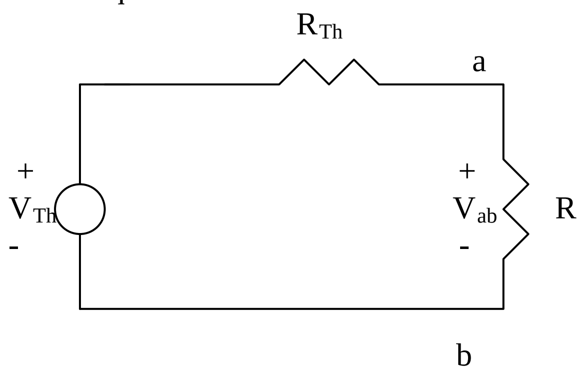
But

$$V_{Th} = V_L + I_L R_{Th} \quad \longrightarrow \quad R_{Th} = \frac{V_{Th} - V_L}{I_L} = \frac{12 - 10.8}{2.7} = \underline{0.4444\Omega}$$

= **444.4 mΩ**.

Chapter 4, Solution 85

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



$$V_{ab} = \frac{R}{R+R_{Th}} V_{Th} \longrightarrow 6 = \frac{10}{10+R_{Th}} V_{Th}$$

or

$$60 + 6R_{Th} = 10V_{Th} \qquad (1)$$

where R_{Th} is in k-ohm.

Similarly,

$$12 = \frac{30}{30+R_{Th}} V_{Th} \longrightarrow 360 + 12R_{Th} = 30V_{Th} \qquad (2)$$

Solving (1) and (2) leads to

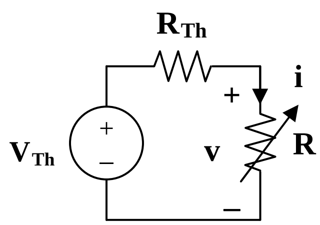
$$\underline{\boldsymbol{V_{Th} = 24\,\text{V},\ R_{Th} = 30k\Omega}}$$

(b)

$$\boldsymbol{V_{ab} = \frac{20}{20+30}(24) = \underline{9.6\ \text{V}}}$$

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 $V_{Th} = 3 + 1.5R_{Th}$ (1)

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

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

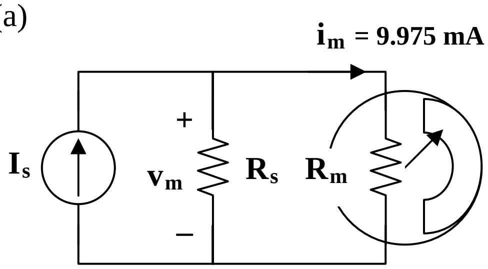
(a) When $R = 4$, $i = V_{Th}/(R + R_{Th}) = 18/(4 + 10) =$ **1.2857 A**

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

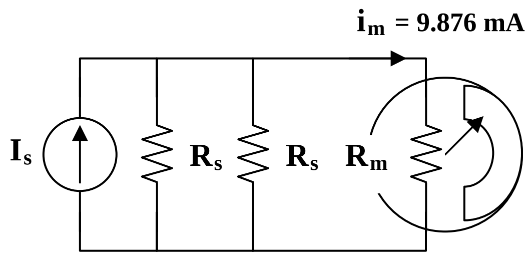
$$\text{Pmax} = (V_{Th})^2/4R_{Th} = 18^2/(4x10) = \textbf{8.1 watts}$$

Chapter 4, Solution 87.

(a)



(a)



(b)

From Fig. (a),

$$v_m = R_m i_m = 9.975 \text{ mA x } 20 = 0.1995 \text{ V}$$

$$I_s = 9.975 \text{ mA} + (0.1995/R_s) \qquad (1)$$

From Fig. (b),

$$v_m = R_m i_m = 20x9.876 = 0.19752 \text{ V}$$

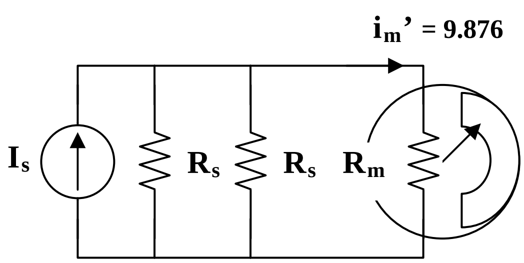
$$I_s = 9.876 \text{ mA} + (0.19752/2k) + (0.19752/R_s)$$

$$= 9.975 \text{ mA} + (0.19752/R_s) \qquad (2)$$

Solving (1) and (2) gives,

R_s = **8 k ohms**, I_s = **10 mA**

(b)



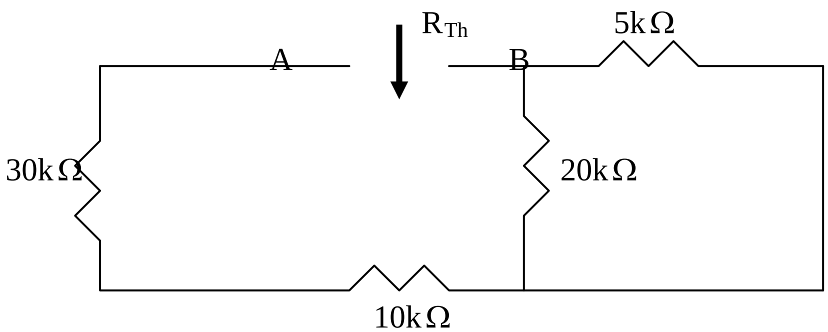
(b)

$$8k||4k = 2.667 \text{ k ohms}$$

i_m’ = [2667/(2667 + 20)](10 mA) = **9.926 mA**

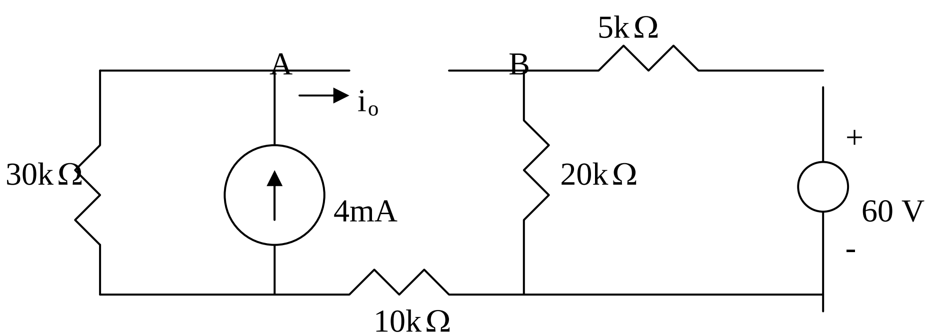
Chapter 4, Solution 88

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



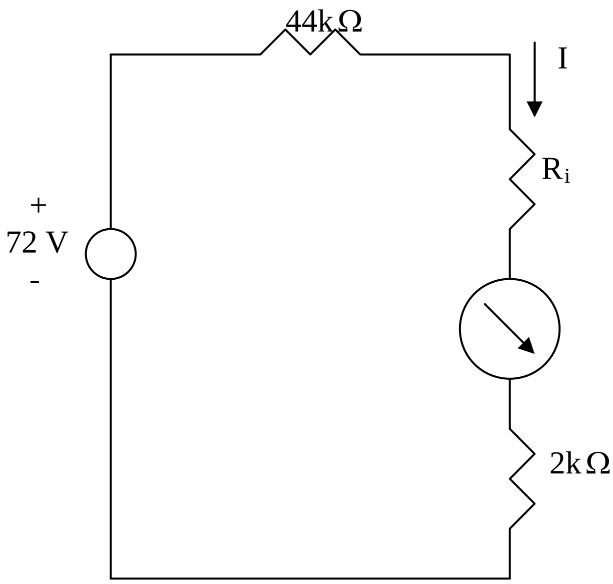
$$R_{Th} = 30 + 10 + 20 // 5 = 44k\Omega$$

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



$$V_A = 30x4 = 120, \quad V_B = \frac{20}{25}(60) = 48, \quad V_{Th} = V_A - V_B = 72 \text{ V}$$

The Thevenin equivalent circuit is shown below.



$$I = \frac{72}{44 + 2 + R_i} \text{ mA}$$

assuming R_i is in k-ohm.

(a) When $R_i = 500\Omega$,

$$\boldsymbol{I = \frac{72}{44 + 2 + 0.5} = \underline{1.548\text{ mA}}}$$

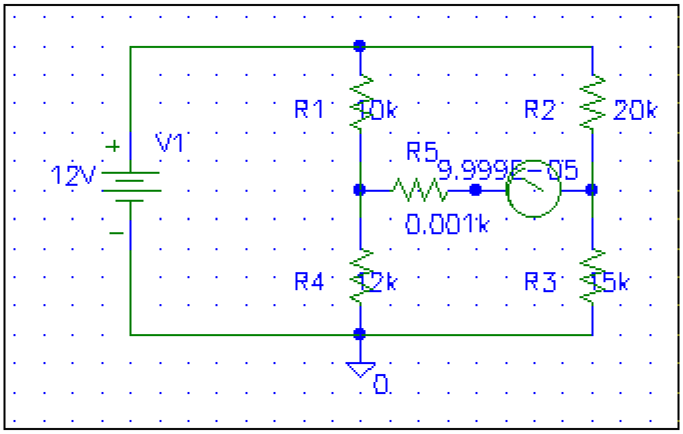
(b) When $R_i = 0\Omega$,

$$\boldsymbol{I = \frac{72}{44 + 2 + 0} = \underline{1.565\text{ mA}}}$$

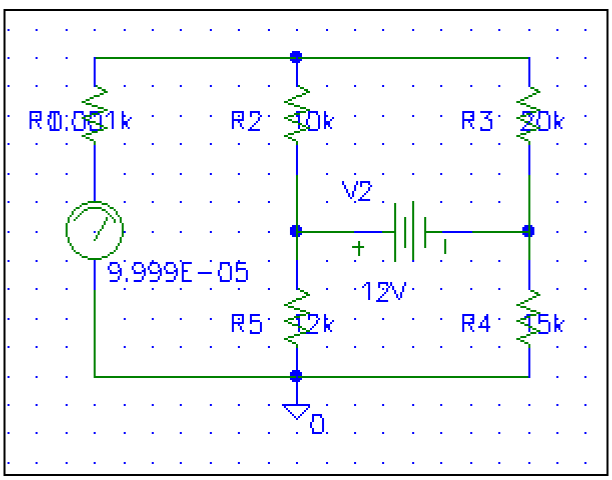
Chapter 4, Solution 89

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 $\mathbf{99.99\mu A}$.



(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.

$R_x = (R_3/R_1)R_2 = (4/2)R_2 = 42.6, R_2 = 21.3$

which is (21.3ohms/100ohms)% = **21.3%**

Chapter 4, Solution 91.

$R_x = (R_3/R_1)R_2$

(a) Since $0 < R_2 < 50$ ohms, to make $0 < R_x < 10$ ohms requires that when $R_2 = 50$ ohms, $R_x = 10$ ohms.

$$10 = (R_3/R_1)50 \text{ or } R_3 = R_1/5$$

so we select R_1 = **100 ohms** and R_3 = **20 ohms**

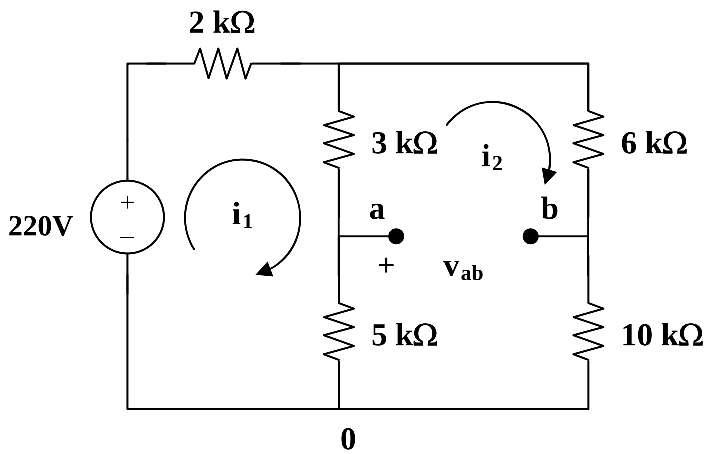
(b) For $0 < R_x < 100$ ohms

$$100 = (R_3/R_1)50, \text{ or } R_3 = 2R_1$$

So we can select R_1 = **100 ohms** and R_3 = **200 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.



(a)

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

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

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 gridge becomes unbalanced. (1) remains the same but (2) becomes

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

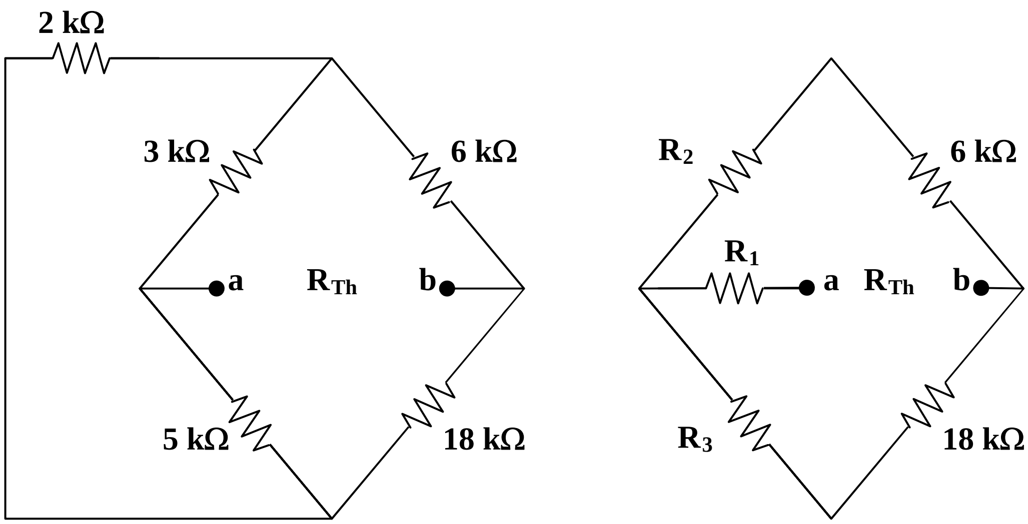
Solving (1) and (3),

$$i_1 = 27.5 \text{ mA}, \ i_2 = 6.875 \text{ mA}$$

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

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

To obtain R_{Th}, we convert the delta connection in Fig. (b) to a wye connection shown in Fig. (c).



(b) (c)

$$R_1 = 3\text{x}5/(2 + 3 + 5) = 1.5 \text{ k ohms}, \quad R_2 = 2\text{x}3/10 = 600 \text{ ohms},$$

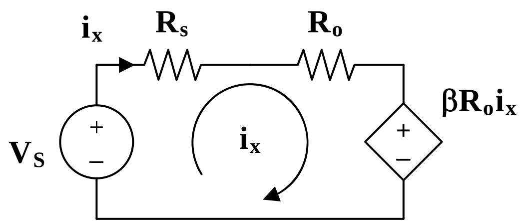
$$R_3 = 2\text{x}5/10 = 1 \text{ k ohm}.$$

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

$$R_L = R_{Th} = \mathbf{6.398\ k\ ohms}$$

$$P_{max} = (V_{Th})^2/(4R_{Th}) = (20.625)^2/(4\text{x}6.398) = \mathbf{16.622\ mWatts}$$

Chapter 4, Solution 93.



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

$$i_x = \mathbf{V_s/(R_s + (1 + \beta)R_o)}$$

Chapter 4, Solution 94.

(a) $$V_o/V_g = R_p/(R_g + R_s + R_p) \qquad (1)$$

$$R_{eq} = R_p||(R_g + R_s) = R_g$$

$$R_g = R_p(R_g + R_s)/(R_p + R_g + R_s)$$

$$R_gR_p + R_g^2 + R_gR_s = R_pR_g + R_pR_s$$

$$R_pR_s = R_g(R_g + R_s) \qquad (2)$$

From (1), $$R_p/\alpha = R_g + R_s + R_p$$

$$R_g + R_s = R_p((1/\alpha) - 1) = R_p(1 - \alpha)/\alpha \qquad (1a)$$

Combining (2) and (1a) gives,

$$R_s = [(1 - \alpha)/\alpha]R_{eq} \qquad (3)$$

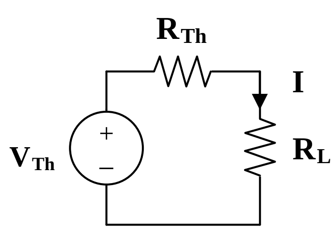
$$= (1 - 0.125)(100)/0.125 = \mathbf{700\ ohms}$$

From (3) and (1a),

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

$$R_p = R_g/(1 - \alpha) = 100/(1 - 0.125) = \mathbf{114.29\ ohms}$$

(b)



$$V_{Th} = V_s = 0.125V_g = 1.5\ V$$

$$R_{Th} = R_g = 100\ ohms$$

$$I = V_{Th}/(R_{Th} + R_L) = 1.5/150 = \mathbf{10\ mA}$$

Chapter 4, Solution 95.

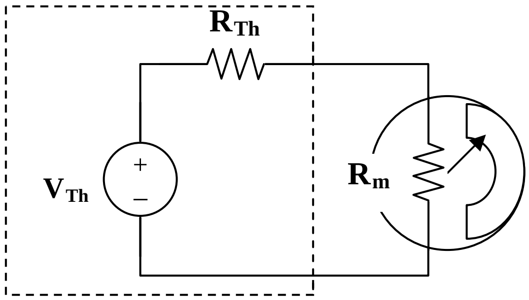
Let 1/sensitivity = 1/(20 k ohms/volt) = 50 μA

For the 0 – 10 V scale,

$$R_m = V_{fs}/I_{fs} = 10/50\ \mu A = 200 \text{ k ohms}$$

For the 0 – 50 V scale,

$$R_m = 50(20 \text{ k ohms/V}) = 1 \text{ M ohm}$$



$$V_{Th} = I(R_{Th} + R_m)$$

(a) A 4V reading corresponds to

$$I = (4/10)I_{fs} = 0.4x50\ \mu A = 20\ \mu A$$

$$V_{Th} = 20\ \mu A\ R_{Th} + 20\ \mu A\ 250 \text{ k ohms}$$

$$= 4 + 20\ \mu A\ R_{Th} \qquad (1)$$

(b) A 5V reading corresponds to

$$I = (5/50)I_{fs} = 0.1 \text{ x } 50\ \mu A = 5\ \mu A$$

$$V_{Th} = 5\ \mu A \text{ x } R_{Th} + 5\ \mu A \text{ x } 1 \text{ M ohm}$$

$$V_{Th} = 5 + 5\ \mu A\ R_{Th} \qquad (2)$$

From (1) and (2)

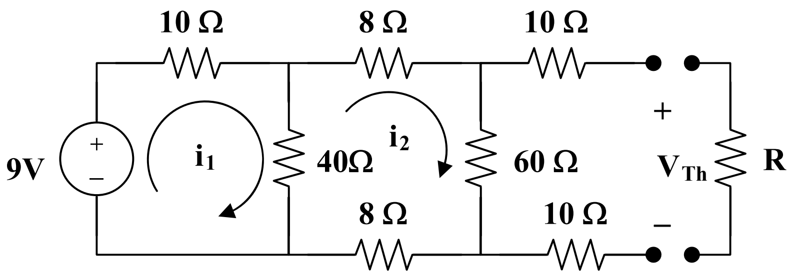
$$0 = -1 + 15\ \mu A\ R_{Th} \text{ which leads to } R_{Th} = \mathbf{66.67 \text{ k ohms}}$$

From (1),

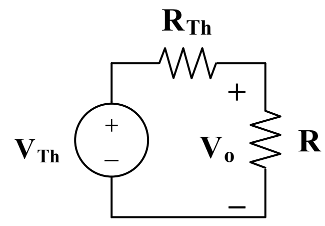
$$V_{Th} = 4 + 20x10^{-6}x(1/(15x10^{-6})) = \mathbf{5.333\ V}$$

Chapter 4, Solution 96.

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



(a)



(b)

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

Using mesh analysis,

$$-9 + 50i_1 - 40i_2 = 0 \qquad (1)$$
$$116i_2 - 40i_1 = 0 \text{ or } i_1 = 2.9i_2 \qquad (2)$$

From (1) and (2), $i_2 = 9/105 = 0.08571$

$$V_{Th} = 60i_2 = 5.143 \text{ V}$$

From Fig. (b),

$$V_o = [R/(R + R_{Th})]V_{Th} = 1.8 \text{ V}$$

$$R/(R + 37.14) = 1.8/5.143 = 0.35 \text{ or } R = 0.35R + 13 \text{ or } R = (13)/(1–0.35)$$

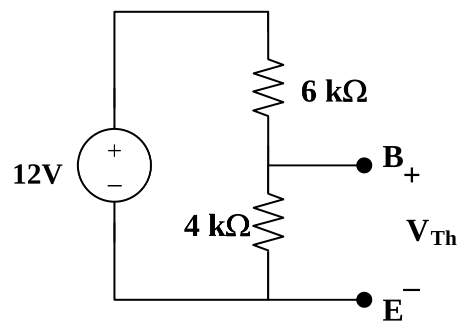
which leads to R = **20 Ω** (note, this is just for the V_o = 1.8 V)

(b) Asking for the value of R for maximum power would lead to $R = R_{Th}$ = **37.14 Ω**.

However, the problem asks for the value of R for maximum current. This happens when the value of resistance seen by the source is a minimum thus R = 0 is the correct value.

$$I_{max} = V_{Th}/(R_{Th}) = 5.143/(37.14) = \mathbf{138.48 \text{ mA}}.$$

Chapter 4, Solution 97.

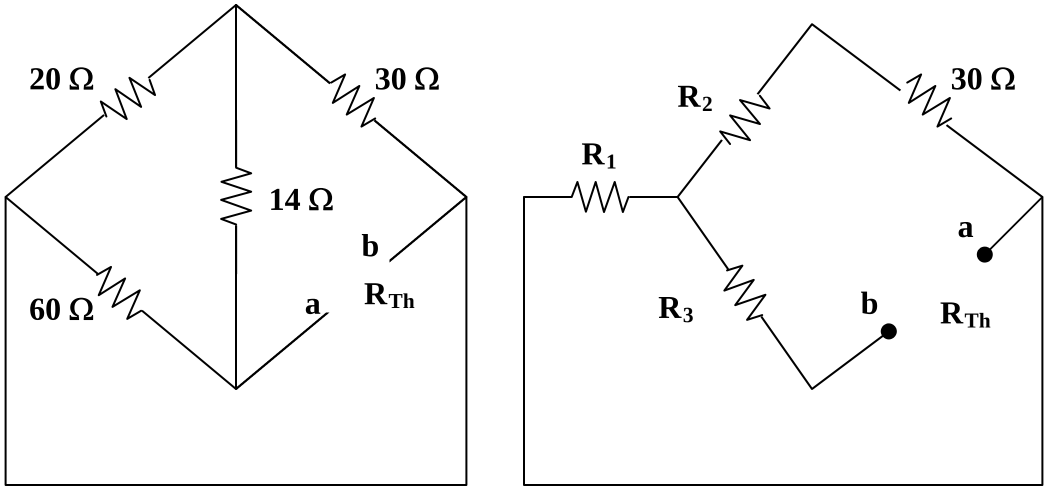


$$R_{Th} = R_1 || R_2 = 6||4 = \mathbf{2.4\ k\ ohms}$$

$$V_{Th} = [R_2/(R_1 + R_2)]v_s = [4/(6 + 4)](12) = \mathbf{4.8\ V}$$

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),



(a) (b)

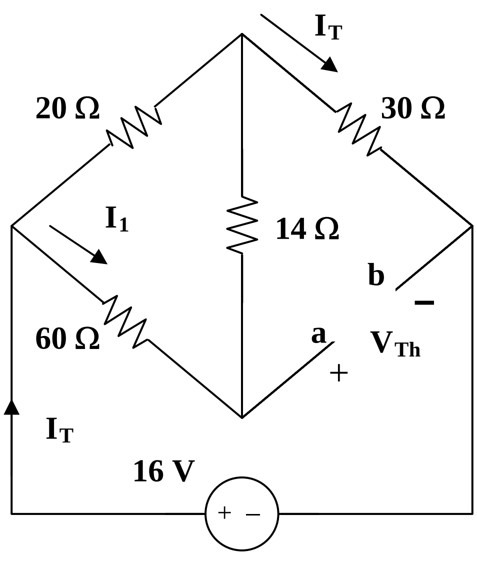
$$R_1 = 20x60/(20 + 60 + 14) = 1200/94 = 12.766 \text{ ohms}$$

$$R_2 = 20x14/94 = 2.979 \text{ ohms}$$

$$R_3 = 60x14/94 = 8.936 \text{ ohms}$$

$$R_{Th} = R_3 + R_1||(R_2 + 30) = 8.936 + 12.766||32.98 = 18.139 \text{ ohms}$$

To find V_{Th}, consider the circuit in Fig. (c).



(c)

$$I_T = 16/(30 + 15.745) = 349.8 \text{ mA}$$

$$I_1 = [20/(20 + 60 + 14)]I_T = 74.43 \text{ mA}$$

$$V_{Th} = 14I_1 + 30I_T = 11.536 \text{ V}$$

$$I_{40} = V_{Th}/(R_{Th} + 40) = 11.536/(18.139 + 40) = 198.42 \text{ mA}$$

$$P_{40} = I_{40}^2R = \mathbf{1.5748\ watts}$$