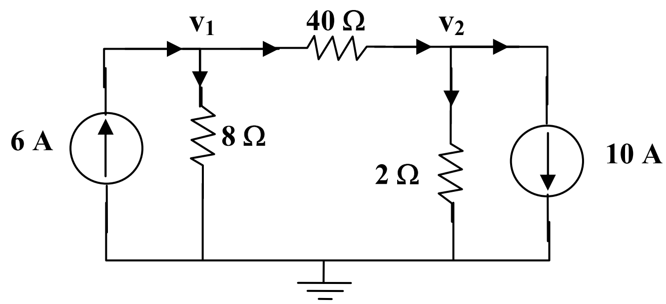
Chapter 3, Solution 1.



At node 1,

$$6 = v_1/(8) + (v_1 - v_2)/4 \longrightarrow 48 = 3v_1 - 2v_2 \qquad (1)$$

At node 2,

$$v_1 - v_2/4 = v_2/2 + 10 \longrightarrow 40 = v_1 - 3v_2 \qquad (2)$$

Solving (1) and (2),

$v_1 =$ **9.143V**, $v_2 =$ **-10.286 V**

$$P_{8\Omega} = \frac{v_1^2}{8} = \frac{(9.143)^2}{8} = \mathbf{10.45\ W}$$

$$P_{4\Omega} = \frac{(v_1 - v_2)^2}{4} = \mathbf{94.37\ W}$$

$$P_{2\Omega} = \frac{v_2^1}{2} = \frac{(=10.286)^2}{2} = \mathbf{52.9\ W}$$

Chapter 3, Solution 2

At node 1,

$$\frac{-v_1}{10} - \frac{v_1}{5} = 6 + \frac{v_1 - v_2}{2} \longrightarrow 60 = -8v_1 + 5v_2 \qquad (1)$$

At node 2,

$$\frac{v_2}{4} = 3 + 6 + \frac{v_1 - v_2}{2} \longrightarrow 36 = -2v_1 + 3v_2 \qquad (2)$$

Solving (1) and (2),

$v_1 =$ **0 V**, $v_2 =$ **12 V**

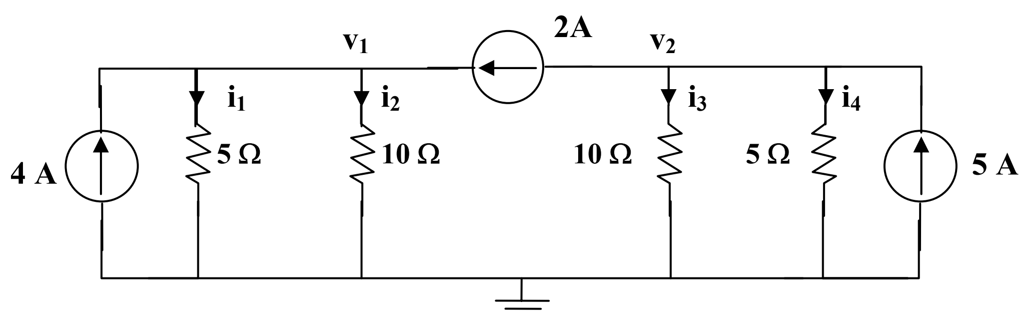
Chapter 3, Solution 3

Applying KCL to the upper node,

$$10 = \frac{v_0}{10} + \frac{v_o}{20} + \frac{v_o}{30} + 2 + \frac{v_0}{60} \longrightarrow v_0 = \underline{\mathbf{40\ V}}$$

$$i_1 = \frac{v_0}{10} = \underline{\mathbf{4\ A}},\ i_2 = \frac{v_0}{20} = \underline{\mathbf{2\ A}},\ i_3 = \frac{v_0}{30} = \underline{\mathbf{1.33\ A}},\ i_4 = \frac{v_0}{60} = \underline{\mathbf{67\ mA}}$$

Chapter 3, Solution 4



At node 1,

$$4 + 2 = v_1/(5) + v_1/(10) \longrightarrow v_1 = 20$$

At node 2,

$$5 - 2 = v_2/(10) + v_2/(5) \longrightarrow v_2 = 10$$

$i_1 = v_1/(5) = \underline{\mathbf{4\ A}}$, $i_2 = v_1/(10) = \underline{\mathbf{2\ A}}$, $i_3 = v_2/(10) = \underline{\mathbf{1\ A}}$, $i_4 = v_2/(5) = \underline{\mathbf{2\ A}}$

Chapter 3, Solution 5

Apply KCL to the top node.

$$\frac{30 - v_0}{2k} + \frac{20 - v_0}{6k} = \frac{v_0}{4k} \longrightarrow v_0 = \underline{\mathbf{20\ V}}$$

Chapter 3, Solution 6

$i_1 + i_2 + i_3 = 0 \qquad \frac{v_2 - 12}{4} + \frac{v_0}{6} + \frac{v_0 - 10}{2} = 0$

or v_0 = **8.727 V**

Chapter 3, Solution 7

At node a,

$$\frac{10 - V_a}{30} = \frac{V_a}{15} + \frac{V_a - V_b}{10} \longrightarrow 10 = 6V_a - 3V_b \qquad (1)$$

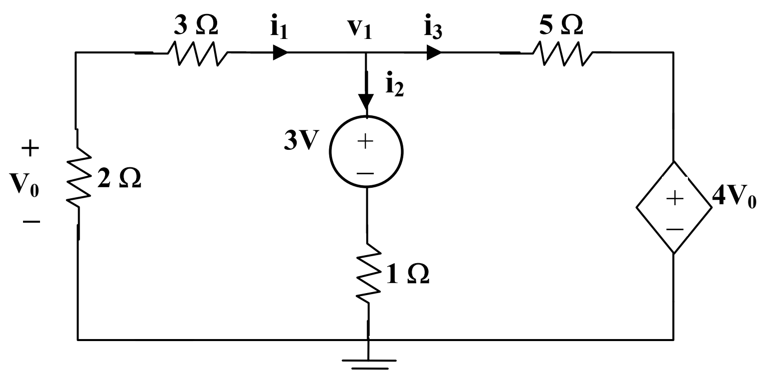
At node b,

$$\frac{V_a - V_b}{10} + \frac{12 - V_b}{20} + \frac{-9 - V_b}{5} = 0 \longrightarrow 24 = 2V_a - 7V_b \qquad (2)$$

Solving (1) and (2) leads to

V_a = -0.556 V, V_b = **-3.444V**

Chapter 3, Solution 8

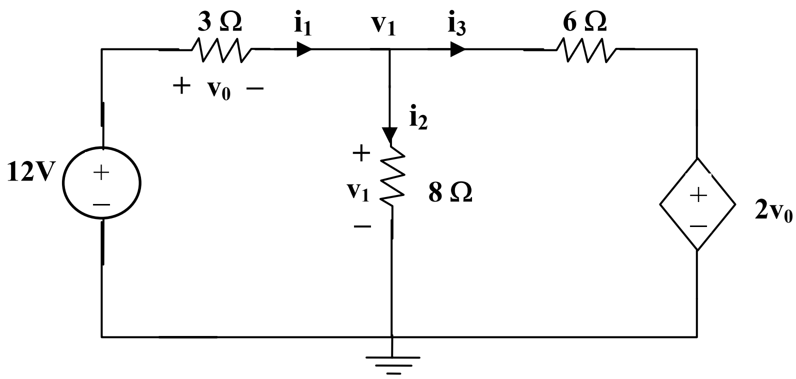


$$i_1 + i_2 + i_3 = 0 \longrightarrow \frac{v_1}{5} + \frac{v_1 - 3}{1} + \frac{v_1 - 4v_0}{5} = 0$$

But $v_0 = \frac{2}{5} v_1$ so that $v_1 + 5v_1 - 15 + v_1 - \frac{8}{5} v_1 = 0$

or $v_1 = 15x5/(27) = 2.778$ V, therefore $v_o = 2v_1/5$ = **1.1111 V**

Chapter 3, Solution 9



At the non-reference node,

$$\frac{12 - v_1}{3} = \frac{v_1}{8} + \frac{v_1 - 2v_0}{6} \qquad (1)$$

But

$$-12 + v_0 + v_1 = 0 \longrightarrow v_0 = 12 - v_1 \qquad (2)$$

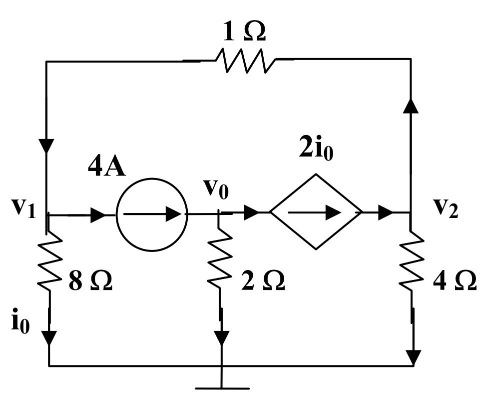
Substituting (2) into (1),

$$\frac{12 - v_1}{3} = \frac{v_1}{8} + \frac{3v_1 - 24}{6} \longrightarrow v_0 = \underline{\mathbf{3.652\ V}}$$

Chapter 3, Solution 10

At node 1,

$$\frac{v_2 - v_1}{1} = 4 + \frac{v_1}{8} \longrightarrow 32 = -v_1 + 8v_2 - 8v_0 \qquad (1)$$



At node 0,

$$4 = \frac{v_0}{2} + 2I_0 \text{ and } I_0 = \frac{v_1}{8} \longrightarrow 16 = 2v_0 + v_1 \qquad (2)$$

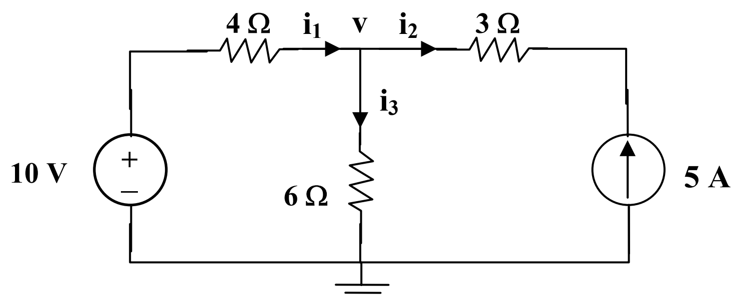
At node 2,

$$2I_0 = \frac{v_2 - v_1}{1} + \frac{v_2}{4} \text{ and } I_0 = \frac{v_1}{8} \longrightarrow v_2 = v_1 \qquad (3)$$

From (1), (2) and (3), $v_0 = 24$ V, but from (2) we get

$$i_o = \frac{4 - \frac{v_o}{2}}{2} = 2 - \frac{24}{4} = 2 - 6 = \underline{\mathbf{-4\ A}}$$

Chapter 3, Solution 11

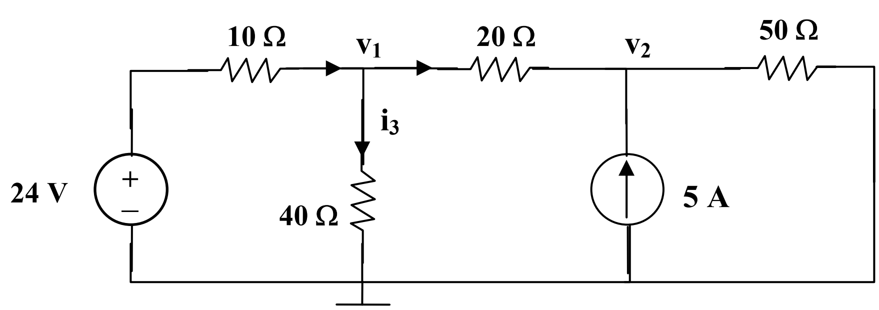


Note that $i_2 = -5$A. At the non-reference node

$$\frac{10 - v}{4} + 5 = \frac{v}{6} \longrightarrow v = 18$$

$$i_1 = \frac{10 - v}{4} = \underline{\mathbf{-2\ A}},\ i_2 = \underline{\mathbf{-5\ A}}$$

Chapter 3, Solution 12



At node 1, $\frac{24 - v_1}{10} = \frac{v_1 - v_2}{20} + \frac{v_1 - 0}{40}$ $\longrightarrow$ $96 = 7v_1 - 2v_2$ (1)

At node 2, $5 + \frac{v_1 - v_2}{20} = \frac{v_2}{50}$ $\longrightarrow$ $500 = -5v_1 + 7v_2$ (2)

Solving (1) and (2) gives,

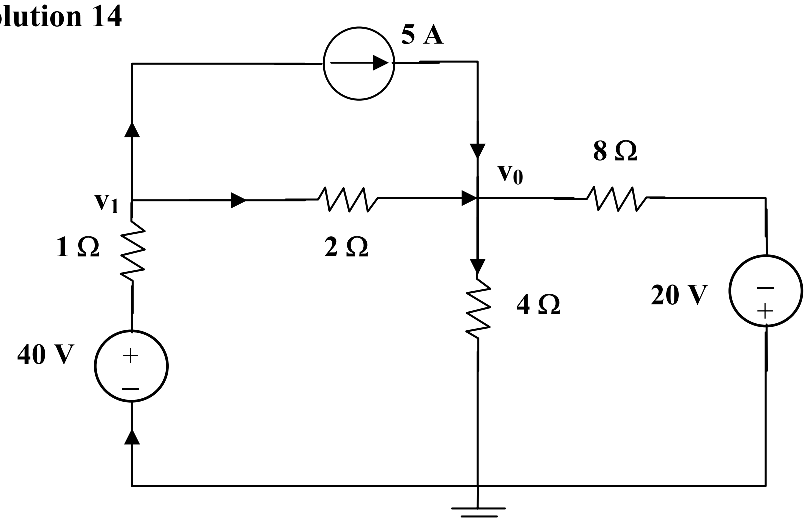
$v_1 = 42.87$ V, $v_2 = 102.05$ V

$i_1 = \frac{v_1}{40} =$ **<u>1.072 A</u>**, $v_2 = \frac{v_2}{50} =$ **<u>2.041 A</u>**

Chapter 3, Solution 13

At node number 2, $[(v_2 + 2) - 0]/10 + v_2/4 = 3$ or $v_2 =$ **<u>8 volts</u>**
But, $I = [(v_2 + 2) - 0]/10 = (8 + 2)/10 = 1$ amp and $v_1 = 8x1 =$ **<u>8volts</u>**

Chapter 3, Solution 14

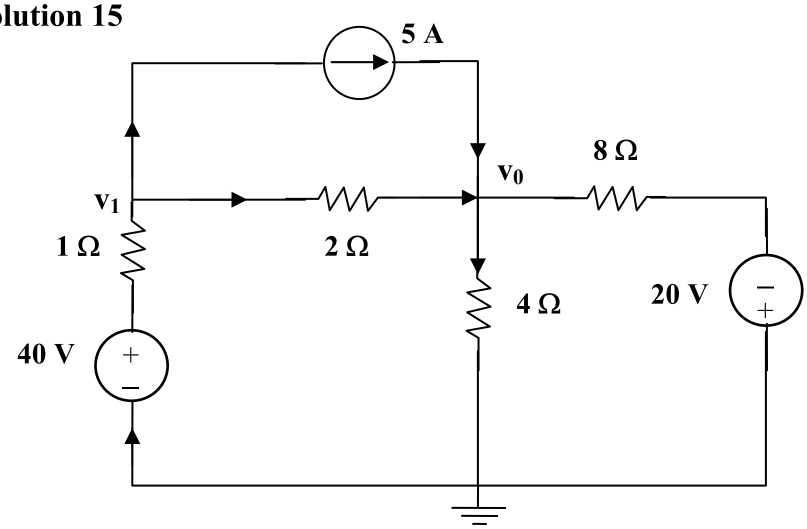


At node 1, $\frac{v_1 - v_0}{2} + 5 = \frac{40 - v_0}{1}$ $\longrightarrow$ $v_1 + v_0 = 70$ (1)

At node 0, $\frac{v_1 - v_0}{2} + 5 = \frac{v_0}{4} + \frac{v_0 + 20}{8}$ $\longrightarrow$ $4v_1 - 7v_0 = -20$ (2)

Solving (1) and (2), $v_0 =$ **<u>20 V</u>**

Chapter 3, Solution 15



Nodes 1 and 2 form a supernode so that $v_1 = v_2 + 10$ (1)

At the supernode, $2 + 6v_1 + 5v_2 = 3(v_3 - v_2) \longrightarrow 2 + 6v_1 + 8v_2 = 3v_3$ (2)

At node 3, $2 + 4 = 3(v_3 - v_2) \longrightarrow v_3 = v_2 + 2$ (3)

Substituting (1) and (3) into (2),

$$2 + 6v_2 + 60 + 8v_2 = 3v_2 + 6 \longrightarrow v_2 = \frac{-56}{11}$$

$$v_1 = v_2 + 10 = \frac{54}{11}$$

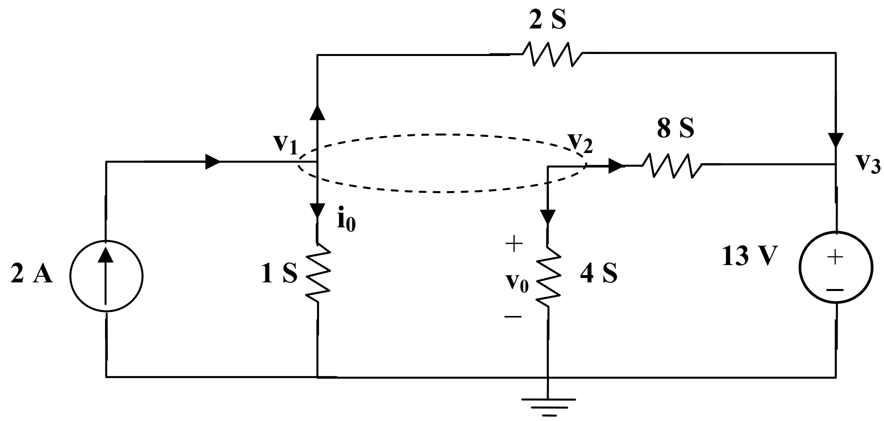
$$i_0 = 6v_i = \underline{\mathbf{29.45\ A}}$$

$$P_{65} = \frac{v_1^2}{R} = v_1^2 G = \left(\frac{54}{11}\right)^2 6 = \underline{\mathbf{144.6\ W}}$$

$$P_{55} = v_2^2 G = \left(\frac{-56}{11}\right)^2 5 = \underline{\mathbf{129.6\ W}}$$

$$P_{35} = (v_L - v_3)^2 G = (2)^2 3 = \underline{\mathbf{12\ W}}$$

Chapter 3, Solution 16



At the supernode,

$$2 = v_1 + 2\ (v_1 - v_3) + 8(v_2 – v_3) + 4v_2, \text{ which leads to } \ 2 = 3v_1 + 12v_2 - 10v_3 \qquad (1)$$

But

$v_1 = v_2 + 2v_0$ and $v_0 = v_2$.

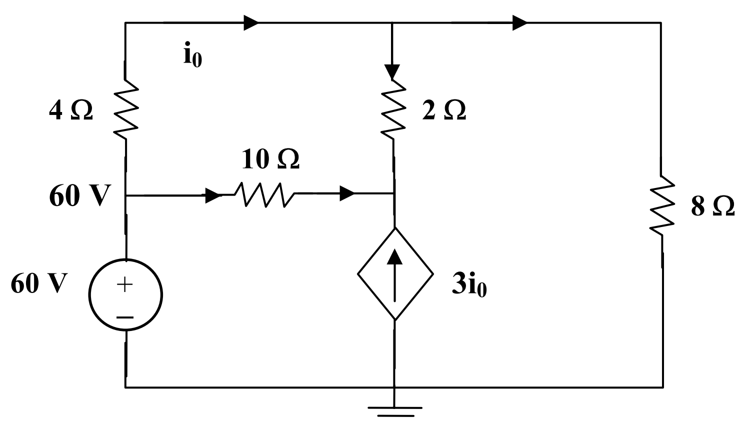
Hence

$$v_1 = 3v_2 \qquad (2)$$
$$v_3 = 13V \qquad (3)$$

Substituting (2) and (3) with (1) gives,

$v_1 =$ **18.858 V**, $v_2 =$ **6.286 V**, $v_3 =$ **13 V**

Chapter 3, Solution 17



At node 1, $\frac{60 - v_1}{4} = \frac{v_1}{8} + \frac{v_1 - v_2}{2}$ $\quad$ $120 = 7v_1 - 4v_2$ $\quad$ (1)

At node 2, $3i_0 + \frac{60 - v_2}{10} + \frac{v_1 - v_2}{2} = 0$

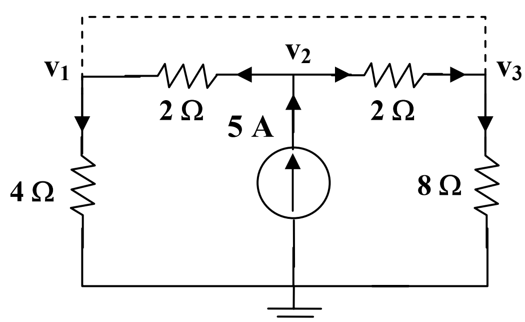
But $i_0 = \frac{60 - v_1}{4}$.

Hence

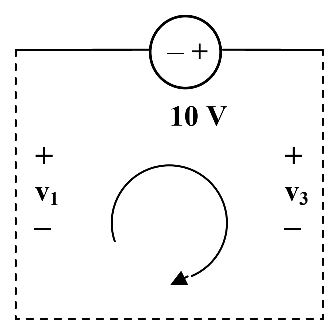
$$\frac{3(60 - v_1)}{4} + \frac{60 - v_2}{10} + \frac{v_1 - v_2}{2} = 0 \longrightarrow 1020 = 5v_1 - 12v_2 \qquad (2)$$

Solving (1) and (2) gives $v_1 = 53.08$ V. Hence $i_0 = \frac{60 - v_1}{4} =$ **1.73 A**

Chapter 3, Solution 18



(a)



(b)

At node 2, in Fig. (a), $5 = \frac{v_2 - v_1}{2} + \frac{v_2 - v_3}{2} \longrightarrow 10 = -v_1 + 2v_2 - v_3$ $\quad$ (1)

At the supernode, $\frac{v_2 - v_1}{2} + \frac{v_2 - v_3}{2} = \frac{v_1}{4} + \frac{v_3}{8} \longrightarrow 40 = 2v_1 + v_3$ $\quad$ (2)

From Fig. (b), $-v_1 - 10 + v_3 = 0 \longrightarrow v_3 = v_1 + 10$ $\quad$ (3)

Solving (1) to (3), we obtain $v_1 =$ **10 V**, $v_2 =$ **20 V** $= v_3$

Chapter 3, Solution 19

At node 1,

$$5 = 3 + \frac{V_1 - V_3}{2} + \frac{V_1 - V_2}{8} + \frac{V_1}{4} \longrightarrow 16 = 7V_1 - V_2 - 4V_3 \qquad (1)$$

At node 2,

$$\frac{V_1 - V_2}{8} = \frac{V_2}{2} + \frac{V_2 - V_3}{4} \longrightarrow 0 = -V_1 + 7V_2 - 2V_3 \qquad (2)$$

At node 3,

$$3 + \frac{12 - V_3}{8} + \frac{V_1 - V_3}{2} + \frac{V_2 - V_3}{4} = 0 \longrightarrow -36 = 4V_1 + 2V_2 - 7V_3 \quad (3)$$

From (1) to (3),

$$\begin{pmatrix} 7 & -1 & -4 \\ -1 & 7 & -2 \\ 4 & 2 & -7 \end{pmatrix} \begin{pmatrix} V_1 \\ V_2 \\ V_3 \end{pmatrix} = \begin{pmatrix} 16 \\ 0 \\ -36 \end{pmatrix} \longrightarrow AV = B$$

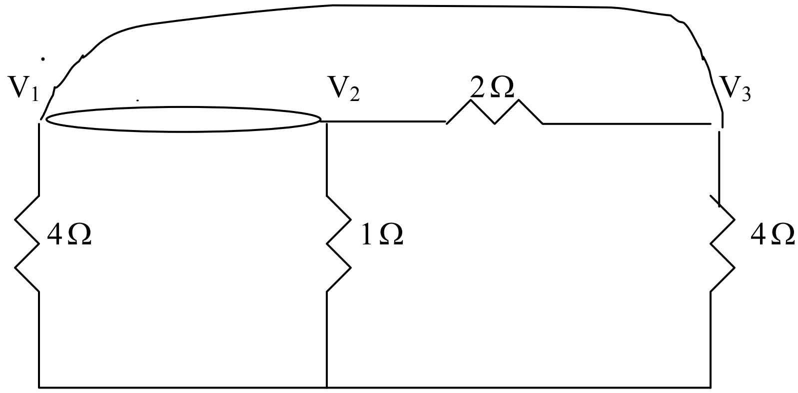
Using MATLAB,

$$V = A^{-1}B = \begin{bmatrix} 10 \\ 4.933 \\ 12.267 \end{bmatrix} \longrightarrow \underline{V_1 = 10\text{ V},\ V_2 = 4.933\text{ V},\ V_3 = 12.267\text{ V}}$$

Chapter 3, Solution 20

Nodes 1 and 2 form a supernode; so do nodes 1 and 3. Hence

$$\frac{V_1}{4} + \frac{V_2}{1} + \frac{V_3}{4} = 0 \longrightarrow V_1 + 4V_2 + V_3 = 0 \qquad (1)$$



Between nodes 1 and 3,

$$-V_1 + 12 + V_3 = 0 \quad \longrightarrow \quad V_3 = V_1 - 12 \qquad (2)$$

Similarly, between nodes 1 and 2,

$$V_1 = V_2 + 2i \qquad (3)$$

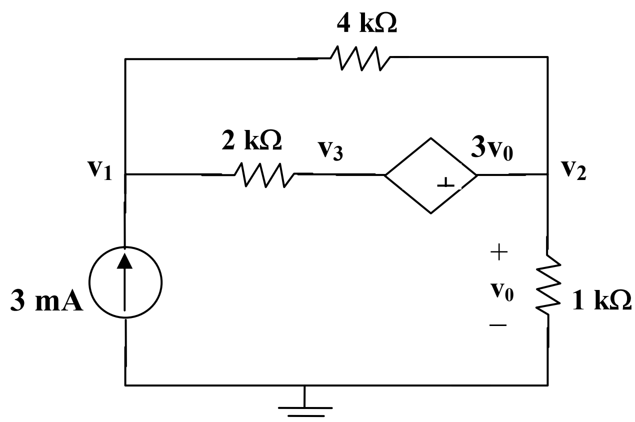
But $i = V_3 / 4$. Combining this with (2) and (3) gives

$$V_2 = 6 + V_1 / 2 \qquad (4)$$

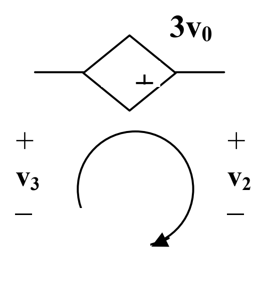
Solving (1), (2), and (4) leads to

$\underline{V_1 = -3\text{V}, \quad V_2 = 4.5\text{V}, V_3 = -15\text{V}}$

Chapter 3, Solution 21



(a)



(b)

Let v_3 be the voltage between the 2kΩ resistor and the voltage-controlled voltage source.
At node 1,

$$3\text{x}10^{-3} = \frac{v_1 - v_2}{4000} + \frac{v_1 - v_3}{2000} \longrightarrow 12 = 3v_1 - v_2 - 2v_3 \qquad (1)$$

At node 2,

$$\frac{v_1 - v_2}{4} + \frac{v_1 - v_3}{2} = \frac{v_2}{1} \longrightarrow 3v_1 - 5v_2 - 2v_3 = 0 \qquad (2)$$

Note that $v_0 = v_2$. We now apply KVL in Fig. (b)

$$- v_3 - 3v_2 + v_2 = 0 \longrightarrow v_3 = - 2v_2 \qquad (3)$$

From (1) to (3),

$v_1 = \underline{\textbf{1 V}}$, $v_2 = \underline{\textbf{3 V}}$

Chapter 3, Solution 22

At node 1, $\frac{12 - v_0}{2} = \frac{v_1}{4} + 3 + \frac{v_1 - v_0}{8} \longrightarrow 24 = 7v_1 - v_2$ (1)

At node 2, $3 + \frac{v_1 - v_2}{8} = \frac{v_2 + 5v_2}{1}$

But, $v_1 = 12 - v_1$

Hence, $24 + v_1 - v_2 = 8\ (v_2 + 60 + 5v_1) = 4$ V

$456 = 41v_1 - 9v_2$ (2)

Solving (1) and (2),

$v_1 =$ **<u>- 10.91 V</u>**, $v_2 =$ **<u>- 100.36 V</u>**

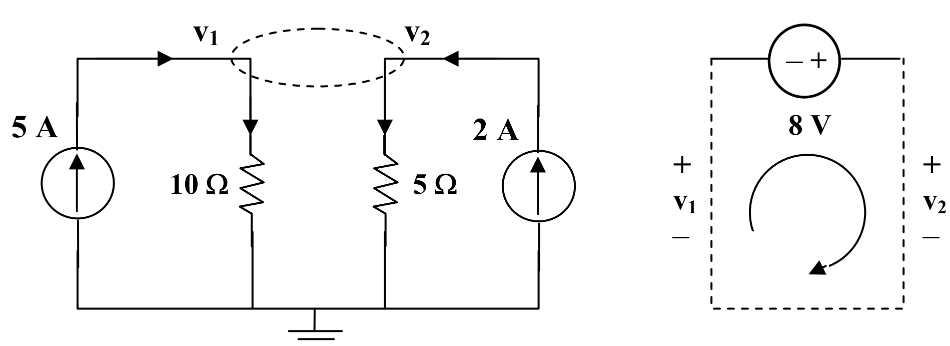
Chapter 3, Solution 23

At the supernode, $5 + 2 = \frac{v_1}{10} + \frac{v_2}{5} \longrightarrow 70 = v_1 + 2v_2$ (1)

Considering Fig. (b), $- v_1 - 8 + v_2 = 0 \longrightarrow v_2 = v_1 + 8$ (2)

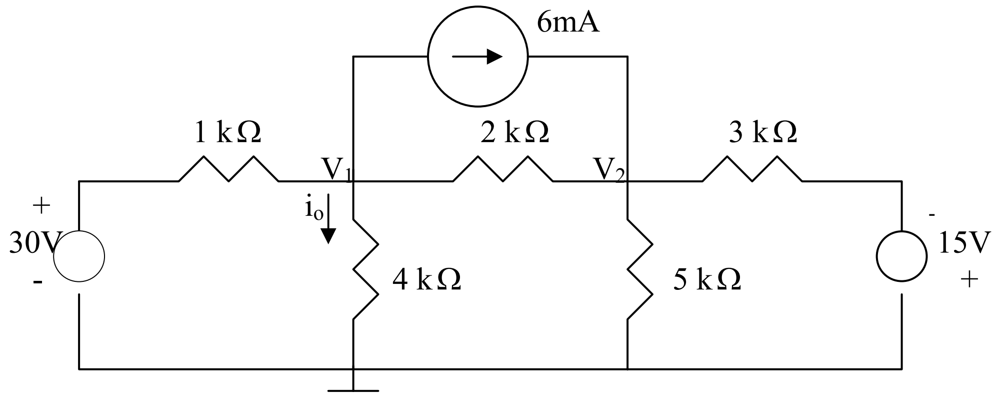
Solving (1) and (2),

$v_1 =$ **<u>18 V</u>**, $v_2 =$ **<u>26 V</u>**



(a) (b)

Chapter 3, Solution 24



At node 1,

$$\frac{30 - V_1}{1} = 6 + \frac{V_1}{4} + \frac{V_1 - V_2}{2} \longrightarrow 96 = 7V_1 - 2V_2 \qquad (1)$$

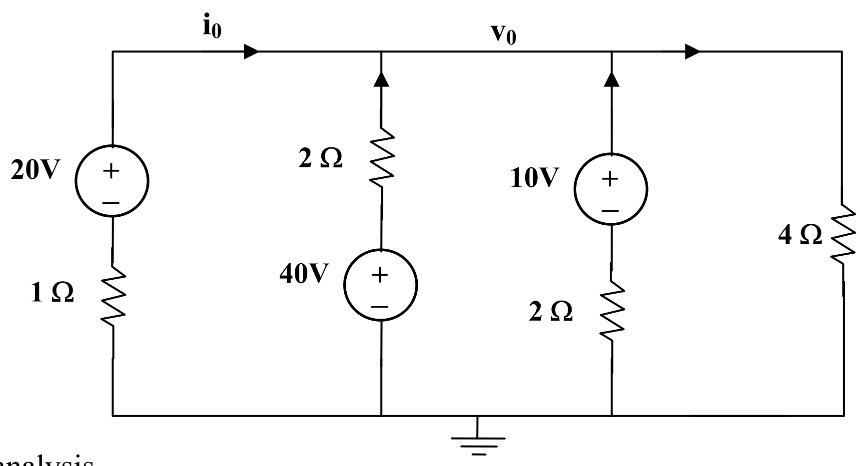
At node 2,

$$6 + \frac{(-15 - V_2)}{3} = \frac{V_2}{5} + \frac{V_2 - V_1}{2} \longrightarrow 30 = -15V_1 + 31V_2 \qquad (2)$$

Solving (1) and (2) gives V_1=16.24. Hence

$i_o = V_1/4$ = 4.06 mA

Chapter 3, Solution 25



Using nodal analysis,

$$\frac{20 - v_0}{1} + \frac{40 - v_0}{2} + \frac{10 - v_0}{2} = \frac{v_0 - 0}{4} \longrightarrow v_0 = \mathbf{20V}$$

$$i_0 = \frac{20 - v_0}{1} = \mathbf{0\ A}$$

Chapter 3, Solution 26

At node 1,

$$\frac{15-V_1}{20} = 3 + \frac{V_1 - V_3}{10} + \frac{V_1 - V_2}{5} \longrightarrow -45 = 7V_1 - 4V_2 - 2V_3 \quad (1)$$

At node 2,

$$\frac{V_1 - V_2}{5} + \frac{4I_o - V_2}{5} = \frac{V_2 - V_3}{5} \quad (2)$$

But $I_o = \dfrac{V_1 - V_3}{10}$. Hence, (2) becomes

$$0 = 7V_1 - 15V_2 + 3V_3 \quad (3)$$

At node 3,

$$3 + \frac{V_1 - V_3}{10} + \frac{-10 - V_3}{5} + \frac{V_2 - V_3}{5} = 0 \longrightarrow -10 = V_1 + 2V_2 - 5V_3 \quad (4)$$

Putting (1), (3), and (4) in matrix form produces

$$\begin{pmatrix} 7 & -4 & -2 \\ 7 & -15 & 3 \\ 1 & 2 & -5 \end{pmatrix} \begin{pmatrix} V_1 \\ V_2 \\ V_3 \end{pmatrix} = \begin{pmatrix} -45 \\ 0 \\ -10 \end{pmatrix} \longrightarrow AV = B$$

Using MATLAB leads to

$$V = A^{-1}B = \begin{pmatrix} -9.835 \\ -4.982 \\ -1.96 \end{pmatrix}$$

Thus,

$$\underline{V_1 = -9.835\text{ V},\ \ V_2 = -4.982\text{ V},\ V_3 = -1.95\text{ V}}$$

Chapter 3, Solution 27

At node 1,

$$2 = 2v_1 + v_1 - v_2 + (v_1 - v_3)4 + 3i_0, \quad i_0 = 4v_2. \text{ Hence,}$$

$$2 = 7v_1 + 11v_2 - 4v_3 \quad (1)$$

At node 2,

$$v_1 - v_2 = 4v_2 + v_2 - v_3 \longrightarrow 0 = -v_1 + 6v_2 - v_3 \quad (2)$$

At node 3,

$$2v_3 = 4 + v_2 - v_3 + 12v_2 + 4(v_1 - v_3)$$

or $$-4 = 4v_1 + 13v_2 - 7v_3 \qquad (3)$$

In matrix form,

$$\begin{bmatrix} 7 & 11 & -4 \\ 1 & -6 & 1 \\ 4 & 13 & -7 \end{bmatrix}\begin{bmatrix} v_1 \\ v_2 \\ v_3 \end{bmatrix} = \begin{bmatrix} 2 \\ 0 \\ -4 \end{bmatrix}$$

$$\Delta = \begin{vmatrix} 7 & 11 & -4 \\ 1 & -6 & 1 \\ 4 & 13 & -7 \end{vmatrix} = 176, \quad \Delta_1 = \begin{vmatrix} 2 & 11 & -4 \\ 0 & -6 & 1 \\ -4 & 13 & -7 \end{vmatrix} = 110$$

$$\Delta_2 = \begin{vmatrix} 7 & 2 & -4 \\ 1 & 0 & 1 \\ 4 & -4 & -7 \end{vmatrix} = 66, \quad \Delta_3 = \begin{vmatrix} 7 & 11 & 2 \\ 1 & -6 & 0 \\ 4 & 13 & -4 \end{vmatrix} = 286$$

$$v_1 = \frac{\Delta_1}{\Delta} = \frac{110}{176} = 0.625\text{V}, \quad v_2 = \frac{\Delta_2}{\Delta} = \frac{66}{176} = 0.375\text{V}$$

$$v_3 = \frac{\Delta_3}{\Delta} = \frac{286}{176} = 1.625\text{V}.$$

v_1 = **625 mV**, v_2 = **375 mV**, v_3 = **1.625 V**.

Chapter 3, Solution 28

At node c,

$$\frac{V_d - V_c}{10} = \frac{V_c - V_b}{4} + \frac{V_c}{5} \longrightarrow 0 = -5V_b + 11V_c - 2V_d \qquad (1)$$

At node b,

$$\frac{V_a + 45 - V_b}{8} + \frac{V_c - V_b}{4} = \frac{V_b}{8} \longrightarrow -45 = V_a - 4V_b + 2V_c \qquad (2)$$

At node a,

$$\frac{V_a - 30 - V_d}{4} + \frac{V_a}{16} + \frac{V_a + 45 - V_b}{8} = 0 \longrightarrow 30 = 7V_a - 2V_b - 4V_d \qquad (3)$$

At node d,

$$\frac{V_a - 30 - V_d}{4} = \frac{V_d}{20} + \frac{V_d - V_c}{10} \longrightarrow 150 = 5V_a + 2V_c - 7V_d \qquad (4)$$

In matrix form, (1) to (4) become

$$\begin{pmatrix} 0 & -5 & 11 & -2 \\ 1 & -4 & 2 & 0 \\ 7 & -2 & 0 & -4 \\ 5 & 0 & 2 & -7 \end{pmatrix} \begin{pmatrix} V_a \\ V_b \\ V_c \\ V_d \end{pmatrix} = \begin{pmatrix} 0 \\ -45 \\ 30 \\ 150 \end{pmatrix} \longrightarrow \quad AV = B$$

We use MATLAB to invert A and obtain

$$V = A^{-1}B = \begin{pmatrix} -10.14 \\ 7.847 \\ -1.736 \\ -29.17 \end{pmatrix}$$

Thus,

$$\underline{V_a = -10.14\text{ V},\ \ V_b = 7.847\text{ V},\ \ V_c = -1.736\text{ V},\ V_d = -29.17\text{ V}}$$

Chapter 3, Solution 29

At node 1,

$$5 + V_1 - V_4 + 2V_1 + V_1 - V_2 = 0 \quad \longrightarrow \quad -5 = 4V_1 - V_2 - V_4 \qquad (1)$$

At node 2,

$$V_1 - V_2 = 2V_2 + 4(V_2 - V_3) = 0 \quad \longrightarrow \quad 0 = -V_1 + 7V_2 - 4V_3 \qquad (2)$$

At node 3,

$$6 + 4(V_2 - V_3) = V_3 - V_4 \quad \longrightarrow \quad 6 = -4V_2 + 5V_3 - V_4 \qquad (3)$$

At node 4,

$$2 + V_3 - V_4 + V_1 - V_4 = 3V_4 \quad \longrightarrow \quad 2 = -V_1 - V_3 + 5V_4 \qquad (4)$$

In matrix form, (1) to (4) become

$$\begin{pmatrix} 4 & -1 & 0 & -1 \\ -1 & 7 & -4 & 0 \\ 0 & -4 & 5 & -1 \\ -1 & 0 & -1 & 5 \end{pmatrix} \begin{pmatrix} V_1 \\ V_2 \\ V_3 \\ V_4 \end{pmatrix} = \begin{pmatrix} -5 \\ 0 \\ 6 \\ 2 \end{pmatrix} \longrightarrow \quad AV = B$$

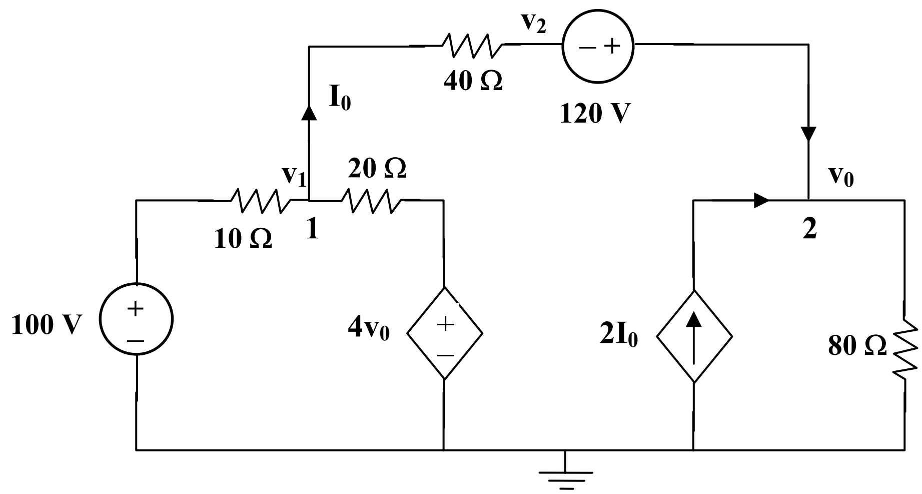
Using MATLAB,

$$V = A^{-1}B = \begin{pmatrix} -0.7708 \\ 1.209 \\ 2.309 \\ 0.7076 \end{pmatrix}$$

i.e.

$$\underline{V_1 = -0.7708\text{ V},\ V_2 = 1.209\text{ V},\ V_3 = 2.309\text{ V},\ V_4 = 0.7076\text{ V}}$$

Chapter 3, Solution 30



At node 1,

$$\frac{v_1 - v_2}{40} = \frac{100 - v_1}{10} + \frac{4v_o - v_1}{20} \qquad (1)$$

But, $v_o = 120 + v_2 \longrightarrow v_2 = v_o - 120$. Hence (1) becomes

$$7v_1 - 9v_o = 280 \qquad (2)$$

At node 2,

$$I_o + 2I_o = \frac{v_o - 0}{80}$$

$$3\left(\frac{v_1 + 120 - v_o}{40}\right) = \frac{v_o}{80}$$

or $$6v_1 - 7v_o = -720 \qquad (3)$$

from (2) and (3), $$\begin{bmatrix} 7 & -9 \\ 6 & -7 \end{bmatrix}\begin{bmatrix} v_1 \\ v_o \end{bmatrix} = \begin{bmatrix} 280 \\ -720 \end{bmatrix}$$

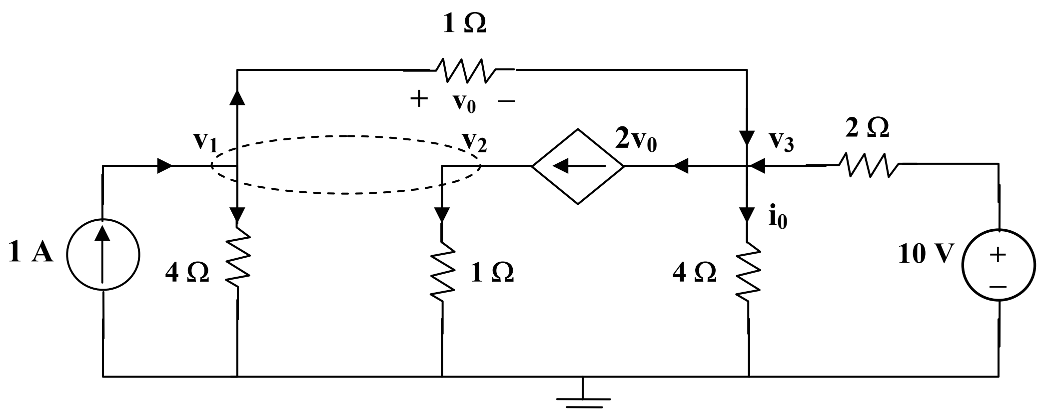
$$\Delta = \begin{vmatrix} 7 & -9 \\ 6 & -7 \end{vmatrix} = -49 + 54 = 5$$

$$\Delta_1 = \begin{vmatrix} 280 & -9 \\ -720 & -7 \end{vmatrix} = -8440, \quad \Delta_2 = \begin{vmatrix} 7 & 280 \\ 6 & -720 \end{vmatrix} = -6720$$

$$v_1 = \frac{\Delta_1}{\Delta} = \frac{-8440}{5} = -1688, \quad v_o = \frac{\Delta_2}{\Delta} = \frac{-6720}{5} - 1344V$$

I_o = **-5.6 A**

Chapter 3, Solution 31



At the supernode,

$$1 + 2v_0 = \frac{v_1}{4} + \frac{v_2}{1} + \frac{v_1 - v_3}{1} \qquad (1)$$

But $v_o = v_1 - v_3$. Hence (1) becomes,

$$4 = -3v_1 + 4v_2 + 4v_3 \qquad (2)$$

At node 3,

$$2v_o + \frac{v_2}{4} = v_1 - v_3 + \frac{10 - v_3}{2}$$

or

$$20 = 4v_1 + v_2 - 2v_3 \qquad (3)$$

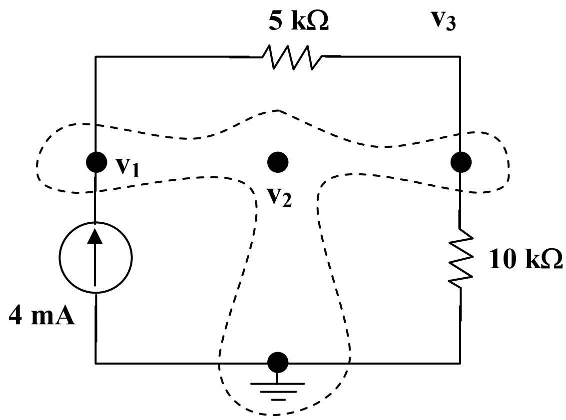
At the supernode, $v_2 = v_1 + 4i_o$. But $i_o = \frac{v_3}{4}$. Hence,

$$v_2 = v_1 + v_3 \qquad (4)$$

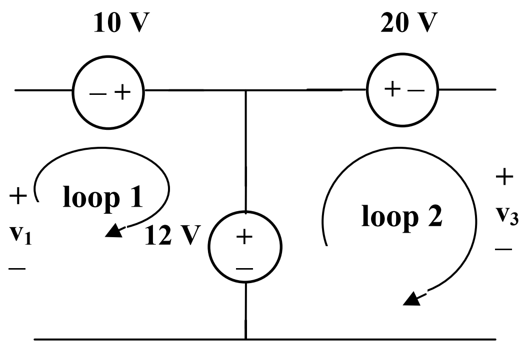
Solving (2) to (4) leads to,

v_1 = **4 V**, v_2 = **4 V**, v_3 = **0 V**.

Chapter 3, Solution 32



(a)



(b)

We have a supernode as shown in figure (a). It is evident that $v_2 = 12$ V, Applying KVL to loops 1and 2 in figure (b), we obtain,

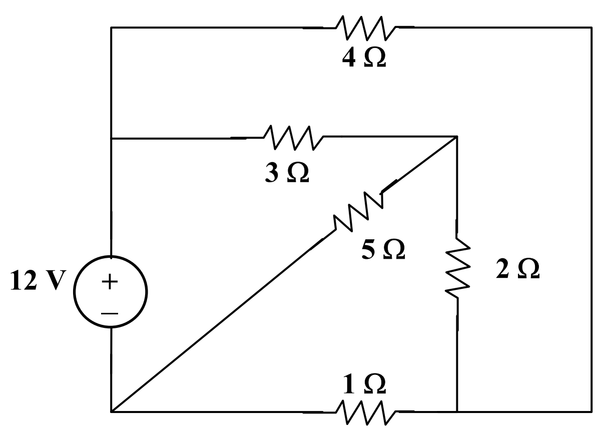
$$-v_1 - 10 + 12 = 0 \text{ or } v_1 = 2 \text{ and } -12 + 20 + v_3 = 0 \text{ or } v_3 = -8 \text{ V}$$

Thus, $v_1 = \underline{\textbf{2 V}}$, $v_2 = \underline{\textbf{12 V}}$, $v_3 = \underline{\textbf{-8V}}$.

Chapter 3, Solution 33

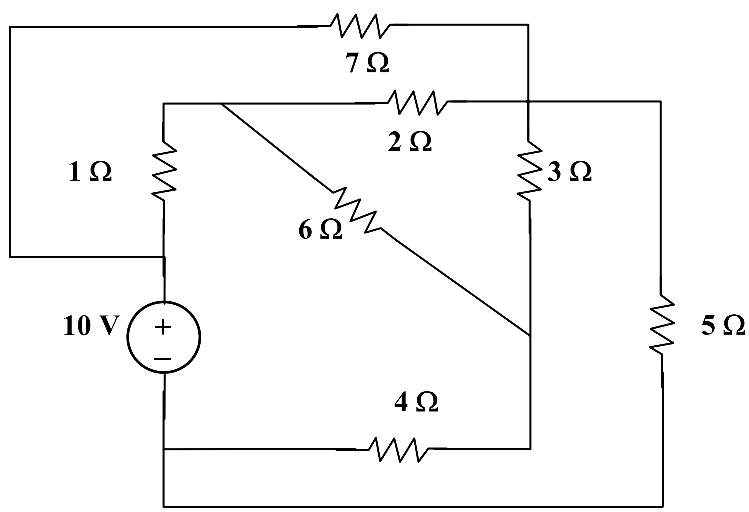
(a) This is a **non-planar** circuit because there is no way of redrawing the circuit with no crossing branches.

(b) This is a **planar** circuit. It can be redrawn as shown below.



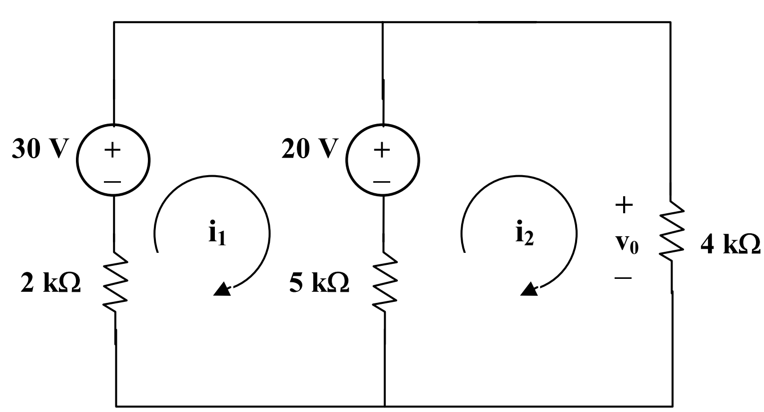
Chapter 3, Solution 34

(a) This is a **planar** circuit because it can be redrawn as shown below,



(b) This is a **non-planar** circuit.

Chapter 3, Solution 35



Assume that i_1 and i_2 are in mA. We apply mesh analysis. For mesh 1,

$$-30 + 20 + 7i_1 - 5i_2 = 0 \quad \text{or} \quad 7i_1 - 5i_2 = 10 \qquad (1)$$

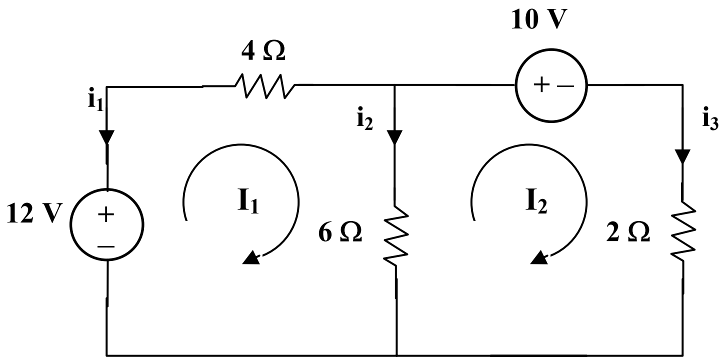
For mesh 2,

$$-20 + 9i_2 - 5i_1 = 0 \quad \text{or} \quad -5i_1 + 9i_2 = 20 \qquad (2)$$

Solving (1) and (2), we obtain, $i_2 = 5$.

$v_0 = 4i_2 =$ **20 volts**.

Chapter 3, Solution 36



Applying mesh analysis gives,

$$12 = 10I_1 - 6I_2$$

$$-10 = -6I_1 + 8I_2$$

or
$$\begin{bmatrix} 6 \\ -5 \end{bmatrix} = \begin{bmatrix} 5 & -3 \\ -3 & 4 \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \end{bmatrix}$$

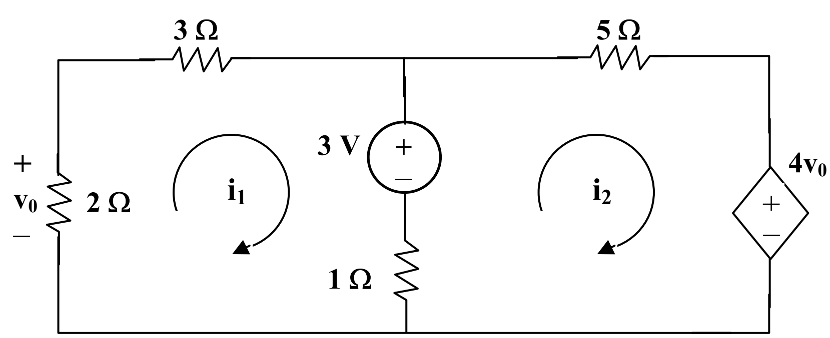
$$\Delta = \begin{vmatrix} 5 & -3 \\ -3 & 4 \end{vmatrix} = 11, \quad \Delta_1 = \begin{vmatrix} 6 & -3 \\ -5 & 4 \end{vmatrix} = 9, \quad \Delta_2 = \begin{vmatrix} 5 & 6 \\ -3 & -5 \end{vmatrix} = -7$$

$$I_1 = \frac{\Delta_1}{\Delta} = \frac{9}{11}, \quad I_2 = \frac{\Delta_2}{\Delta} = \frac{-7}{11}$$

$i_1 = -I_1 = -9/11 = -0.8181$ A, $i_2 = I_1 - I_2 = 10/11 = 1.4545$ A.

$v_o = 6i_2 = 6x1.4545 =$ <u>8.727 V</u>.

Chapter 3, Solution 37



Applying mesh analysis to loops 1 and 2, we get,

$6i_1 - 1i_2 + 3 = 0$ which leads to $i_2 = 6i_1 + 3$ (1)

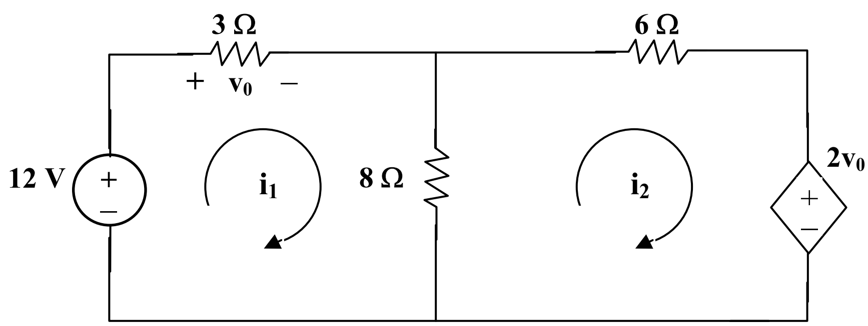
$-1i_1 + 6i_2 - 3 + 4v_0 = 0$ (2)

But, $v_0 = -2i_1$ (3)

Using (1), (2), and (3) we get $i_1 = -5/9$.

Therefore, we get $v_0 = -2i_1 = -2(-5/9) =$ **1.111 volts**

Chapter 3, Solution 38



We apply mesh analysis.

$12 = 3\ i_1 + 8(i_1 - i_2)$ which leads to $12 = 11\ i_1 - 8\ i_2$ (1)

$-2\ v_0 = 6\ i_2 + 8(i_2 - i_1)$ and $v_0 = 3\ i_1$ or $i_1 = 7\ i_2$ (2)

From (1) and (2), $i_1 = 84/69$ and $v_0 = 3\ i_1 = 3x89/69$

$v_0 =$ **3.652 volts**

Chapter 3, Solution 39

For mesh 1,

$$-10 - 2I_x + 10I_1 - 6I_2 = 0$$

But $I_x = I_1 - I_2$. Hence,

$10 = -12I_1 + 12I_2 + 10I_1 - 6I_2 \longrightarrow 5 = 4I_1 - 2I_2$ (1)

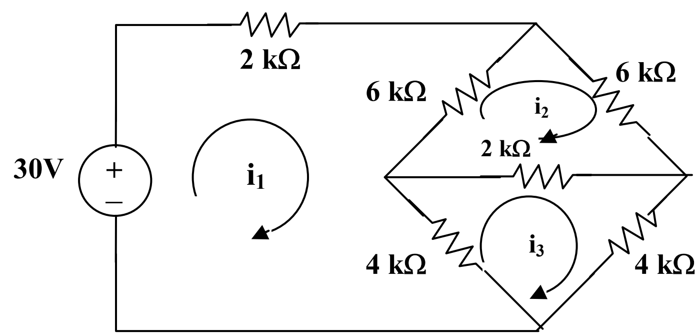
For mesh 2,

$12 + 8I_2 - 6I_1 = 0 \longrightarrow 6 = 3I_1 - 4I_2$ (2)

Solving (1) and (2) leads to

$\underline{I_1 = 0.8\text{ A},\ I_2 = \text{-0.9A}}$

Chapter 3, Solution 40



Assume all currents are in mA and apply mesh analysis for mesh 1.

$$30 = 12i_1 – 6i_2 – 4i_3 \longrightarrow 15 = 6i_1 – 3i_2 – 2i_3 \qquad (1)$$

for mesh 2,

$$0 = - 6i_1 + 14i_2 – 2i_3 \longrightarrow 0 = -3i_1 + 7i_2 – i_3 \qquad (2)$$

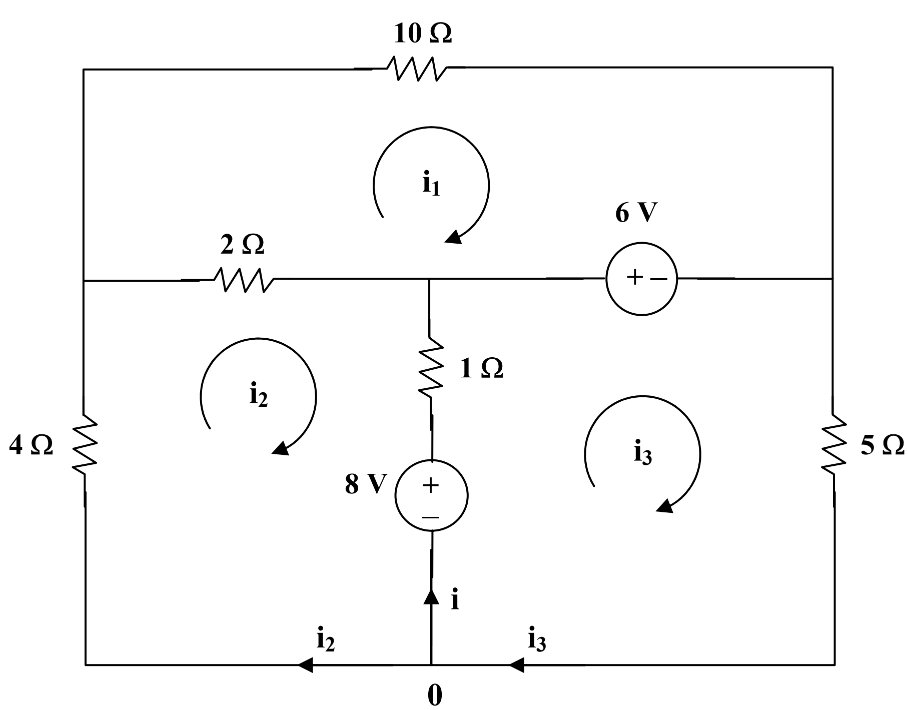
for mesh 2,

$$0 = -4i_1 – 2i_2 + 10i_3 \qquad 0 = -2i_1 – i_2 + 5i_3 \qquad (3)$$

Solving (1), (2), and (3), we obtain,

$i_o = i_1 =$ **4.286 mA**.

Chapter 3, Solution 41



For loop 1,

$$6 = 12i_1 - 2i_2 \longrightarrow 3 = 6i_1 - i_2 \qquad (1)$$

For loop 2,

$$-8 = 7i_2 - 2i_1 - i_3 \qquad (2)$$

For loop 3,

$$-8 + 6 + 6i_3 - i_2 = 0 \longrightarrow 2 = 6i_3 - i_2 \qquad (3)$$

We put (1), (2), and (3) in matrix form,

$$\begin{bmatrix} 6 & -1 & 0 \\ 2 & -7 & 1 \\ 0 & -1 & 6 \end{bmatrix} \begin{bmatrix} i_1 \\ i_2 \\ i_3 \end{bmatrix} = \begin{bmatrix} 3 \\ 8 \\ 2 \end{bmatrix}$$

$$\Delta = \begin{vmatrix} 6 & -1 & 0 \\ 2 & -7 & 1 \\ 0 & -1 & 6 \end{vmatrix} = -234, \quad \Delta_2 = \begin{vmatrix} 6 & 3 & 0 \\ 2 & 8 & 1 \\ 0 & 2 & 6 \end{vmatrix} = -240$$

$$\Delta_3 = \begin{vmatrix} 6 & -1 & 3 \\ 2 & -7 & 8 \\ 0 & -1 & 2 \end{vmatrix} = -38$$

At node 0, $i + i_2 = i_3$ or $i = i_3 - i_2 = \dfrac{\Delta_3 - \Delta_2}{\Delta} = \dfrac{-38 - 240}{-234} =$ **1.188 A**

Chapter 3, Solution 42

For mesh 1,

$$-12 + 50I_1 - 30I_2 = 0 \longrightarrow 12 = 50I_1 - 30I_2 \qquad (1)$$

For mesh 2,

$$-8 + 100I_2 - 30I_1 - 40I_3 = 0 \longrightarrow 8 = -30I_1 + 100I_2 - 40I_3 \qquad (2)$$

For mesh 3,

$$-6 + 50I_3 - 40I_2 = 0 \longrightarrow 6 = -40I_2 + 50I_3 \qquad (3)$$

Putting eqs. (1) to (3) in matrix form, we get

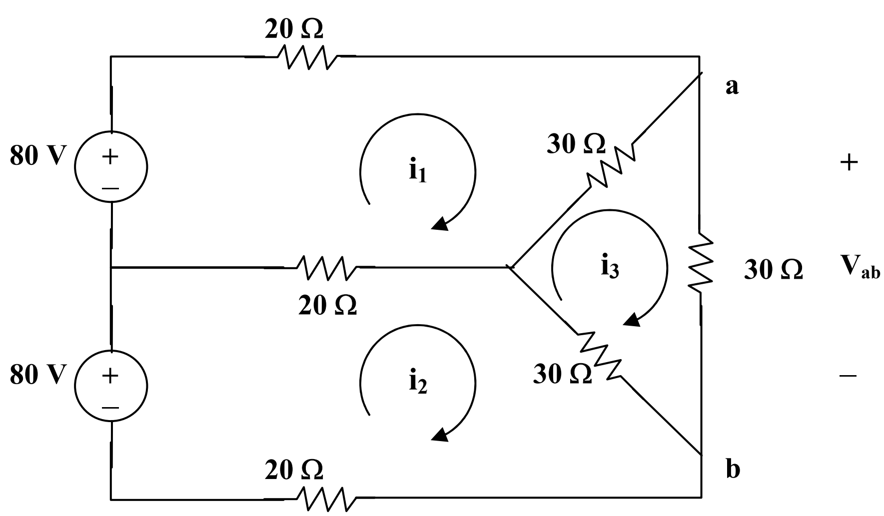
$$\begin{pmatrix} 50 & -30 & 0 \\ -30 & 100 & -40 \\ 0 & -40 & 50 \end{pmatrix}\begin{pmatrix} I_1 \\ I_2 \\ I_3 \end{pmatrix} = \begin{pmatrix} 12 \\ 8 \\ 6 \end{pmatrix} \longrightarrow AI = B$$

Using Matlab,

$$I = A^{-1}B = \begin{pmatrix} 0.48 \\ 0.40 \\ 0.44 \end{pmatrix}$$

i.e. $I_1 = 0.48$ A, $I_2 = 0.4$ A, $I_3 = 0.44$ A

Chapter 3, Solution 43



For loop 1,

$$80 = 70i_1 - 20i_2 - 30i_3 \longrightarrow 8 = 7i_1 - 2i_2 - 3i_3 \qquad (1)$$

For loop 2,

$$80 = 70i_2 - 20i_1 - 30i_3 \longrightarrow 8 = -2i_1 + 7i_2 - 3i_3 \qquad (2)$$

For loop 3,

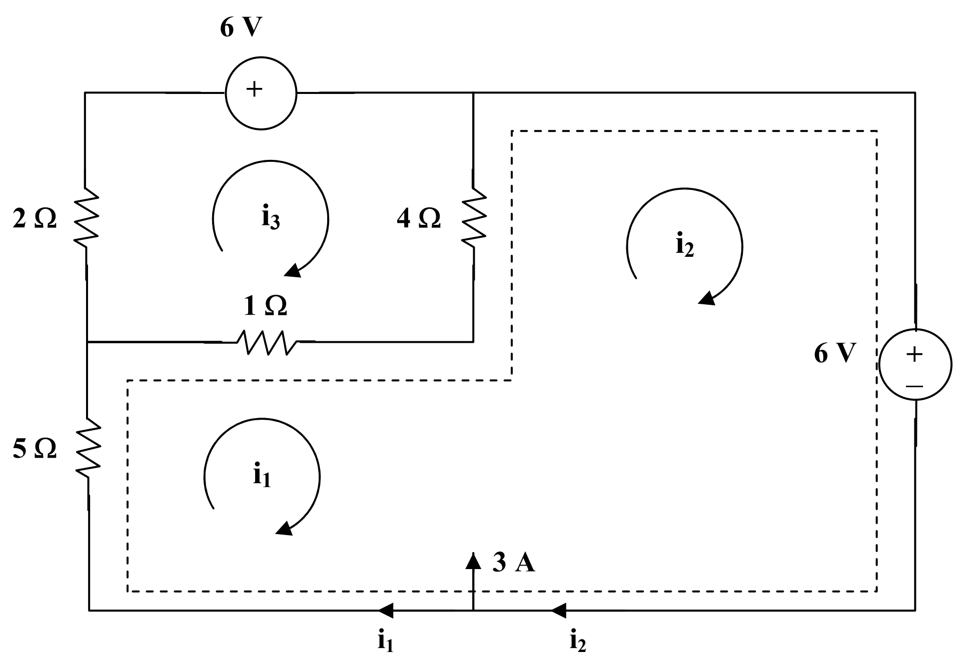
$$0 = -30i_1 - 30i_2 + 90i_3 \longrightarrow 0 = i_1 + i_2 - 3i_3 \qquad (3)$$

Solving (1) to (3), we obtain $i_3 = 16/9$

$$I_o = i_3 = 16/9 = \underline{\mathbf{1.778\ A}}$$

$V_{ab} = 30i_3 =$ **<u>53.33 V</u>**.

Chapter 3, Solution 44



Loop 1 and 2 form a supermesh. For the supermesh,

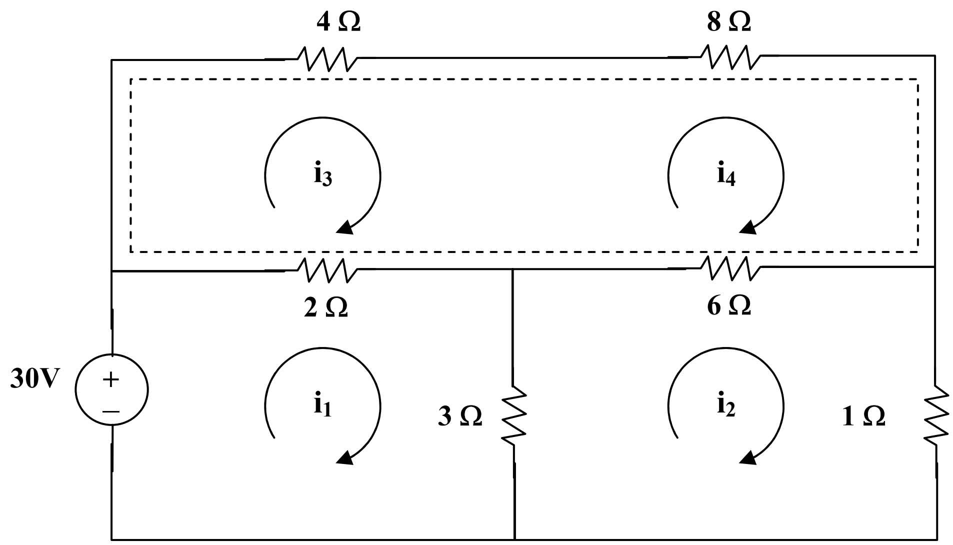
$$6i_1 + 4i_2 - 5i_3 + 12 = 0 \qquad (1)$$

For loop 3, $\quad -i_1 - 4i_2 + 7i_3 + 6 = 0 \qquad (2)$

Also, $\quad i_2 = 3 + i_1 \qquad (3)$

Solving (1) to (3), $i_1 = -3.067$, $i_3 = -1.3333$; $i_o = i_1 - i_3 =$ **<u>-1.7333 A</u>**

Chapter 3, Solution 45



For loop 1, $30 = 5i_1 - 3i_2 - 2i_3$ (1)

For loop 2, $10i_2 - 3i_1 - 6i_4 = 0$ (2)

For the supermesh, $6i_3 + 14i_4 - 2i_1 - 6i_2 = 0$ (3)

But $i_4 - i_3 = 4$ which leads to $i_4 = i_3 + 4$ (4)

Solving (1) to (4) by elimination gives $i = i_1 =$ **<u>8.561 A</u>**.

Chapter 3, Solution 46

For loop 1,

$-12 + 11i_1 - 8i_2 = 0 \longrightarrow 11i_1 - 8i_2 = 12$ (1)

For loop 2,

$-8i_1 + 14i_2 + 2v_o = 0$

But $v_o = 3i_1$,

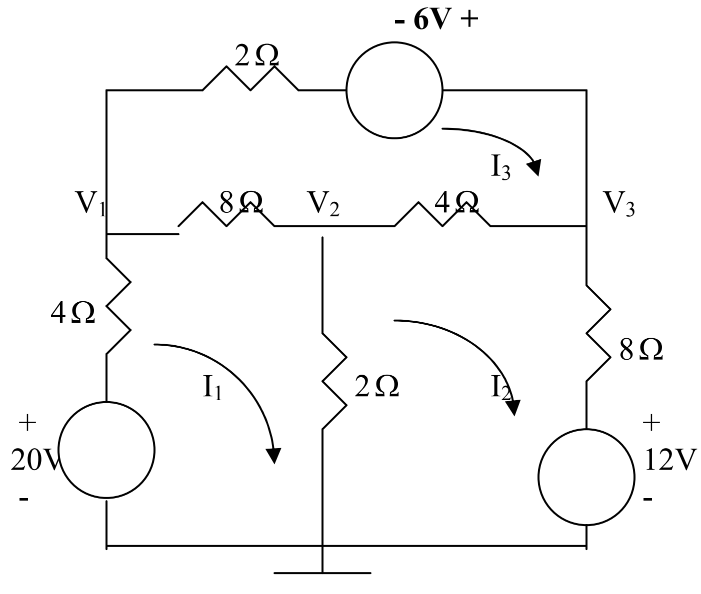
$-8i_1 + 14i_2 + 6i_1 = 0 \longrightarrow i_1 = 7i_2$ (2)

Substituting (2) into (1),

$77i_2 - 8i_2 = 12 \longrightarrow$ $\underline{i_2 = 0.1739}$ A and $\underline{i_1 = 7i_2 = 1.217}$ A

Chapter 3, Solution 47

First, transform the current sources as shown below.



For mesh 1,

$$-20+14I_1-2I_2-8I_3=0 \longrightarrow 10=7I_1-I_2-4I_3 \qquad (1)$$

For mesh 2,

$$12+14I_2-2I_1-4I_3=0 \longrightarrow -6=-I_1+7I_2-2I_3 \qquad (2)$$

For mesh 3,

$$-6+14I_3-4I_2-8I_1=0 \longrightarrow 3=-4I_1-2I_2+7I_3 \qquad (3)$$

Putting (1) to (3) in matrix form, we obtain

$$\begin{pmatrix} 7 & -1 & -4 \\ -1 & 7 & -2 \\ -4 & -2 & 7 \end{pmatrix}\begin{pmatrix} I_1 \\ I_2 \\ I_3 \end{pmatrix}=\begin{pmatrix} 10 \\ -6 \\ 3 \end{pmatrix} \longrightarrow AI=B$$

Using MATLAB,

$$I=A^{-1}B=\begin{bmatrix} 2 \\ 0.0333 \\ 1.8667 \end{bmatrix} \longrightarrow I_1=2.5,\ I_2=0.0333, I_3=1.8667$$

But

$$I_1=\frac{20-V}{4} \longrightarrow V_1=20-4I_1=\underline{10\text{ V}}$$

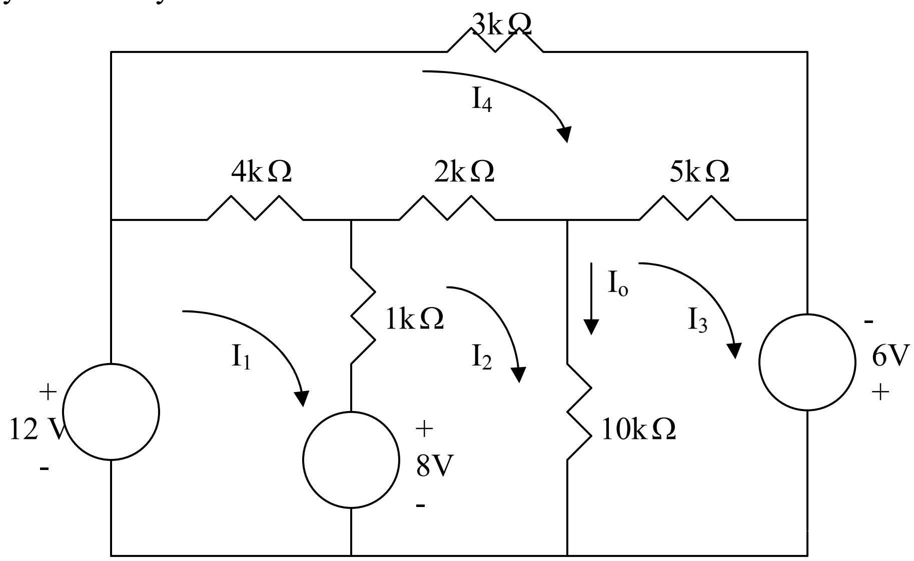
$$V_2=2(I_1-I_2)=\underline{4.933\text{ V}}$$

Also,

$$I_2=\frac{V_3-12}{8} \longrightarrow V_3=12+8I_2=\underline{12.267\text{V}}$$

Chapter 3, Solution 48

We apply mesh analysis and let the mesh currents be in mA.



For mesh 1,

$$-12+8+5I_1-I_2-4I_4=0 \longrightarrow 4=5I_1-I_2-4I_4 \qquad (1)$$

For mesh 2,

$$-8+13I_2-I_1-10I_3-2I_4=0 \longrightarrow 8=-I_1+13I_2-10I_3-2I_4 \qquad (2)$$

For mesh 3,

$$-6+15I_3-10I_2-5I_4=0 \longrightarrow 6=-10I_2+15I_3-5I_4 \qquad (3)$$

For mesh 4,

$$-4I_1-2I_2-5I_3+14I_4=0 \qquad (4)$$

Putting (1) to (4) in matrix form gives

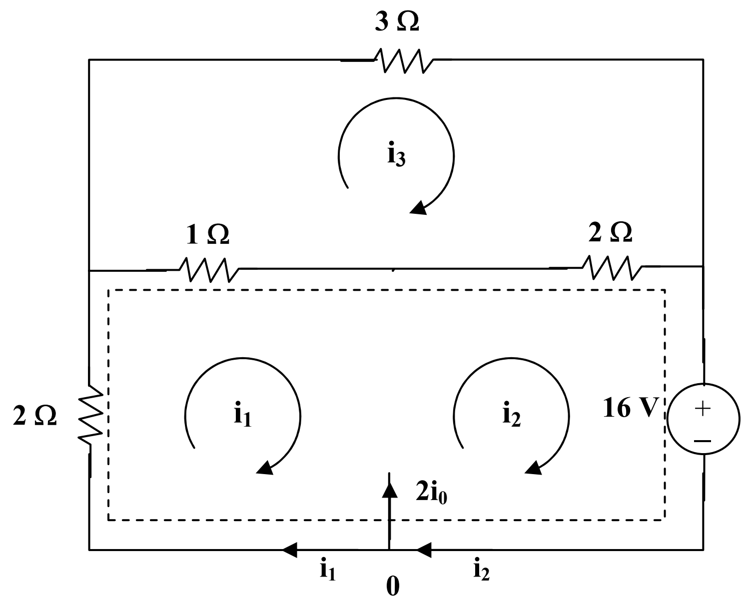
$$\begin{pmatrix} 5 & -1 & 0 & -4 \\ -1 & 13 & -10 & -2 \\ 0 & -10 & 15 & -5 \\ -4 & -2 & -5 & 14 \end{pmatrix}\begin{pmatrix} I_1 \\ I_2 \\ I_3 \\ I_4 \end{pmatrix}=\begin{pmatrix} 4 \\ 8 \\ 6 \\ 0 \end{pmatrix} \longrightarrow AI=B$$

Using MATLAB,

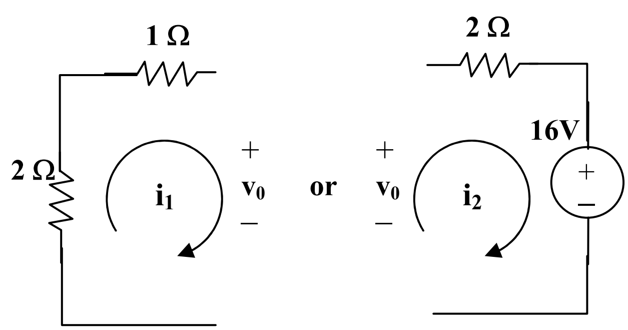
$$I=A^{-1}B=\begin{pmatrix} 7.217 \\ 8.087 \\ 7.791 \\ 6 \end{pmatrix}$$

The current through the 10kΩ resistor is $I_o = I_2 - I_3 =$ <u>0.2957 mA</u>

Chapter 3, Solution 49



(a)



(b)

For the supermesh in figure (a),

$$3i_1 + 2i_2 - 3i_3 + 16 = 0 \qquad (1)$$

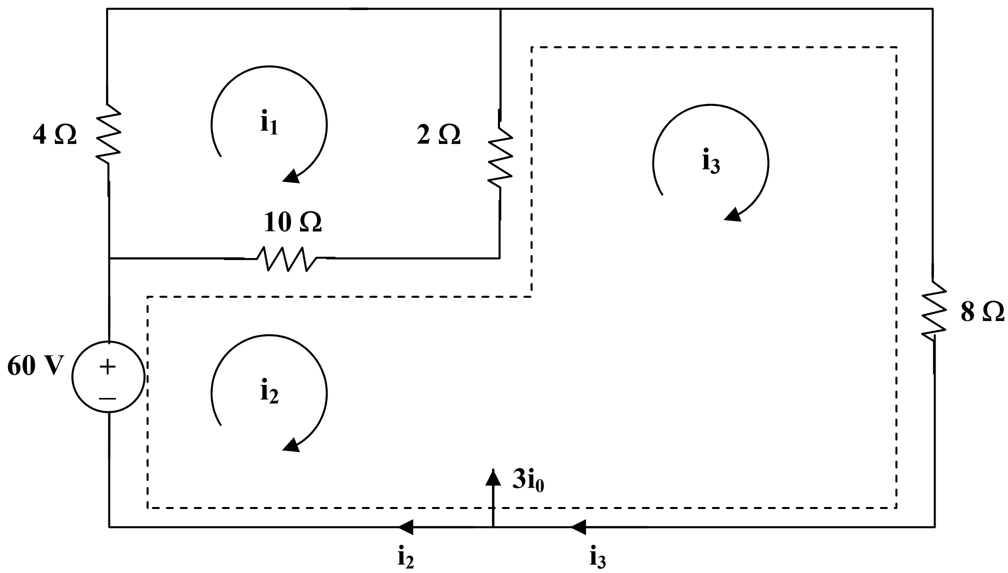
At node 0, $\quad i_2 - i_1 = 2i_0$ and $i_0 = -i_1$ which leads to $i_2 = -i_1$ (2)

For loop 3, $\quad -i_1 - 2i_2 + 6i_3 = 0$ which leads to $6i_3 = -i_1$ (3)

Solving (1) to (3), $i_1 = (-32/3)$A, $i_2 = (32/3)$A, $i_3 = (16/9)$A

$i_0 = -i_1 =$ **10.667 A**, from fig. (b), $v_0 = i_3 - 3i_1 = (16/9) + 32 =$ **33.78 V**.

Chapter 3, Solution 50



For loop 1, $16i_1 - 10i_2 - 2i_3 = 0$ which leads to $8i_1 - 5i_2 - i_3 = 0$ (1)

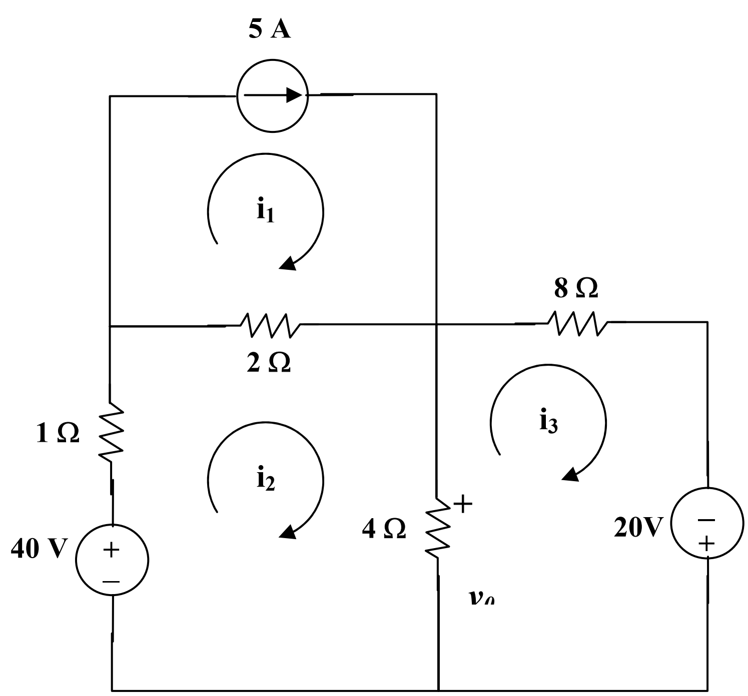
For the supermesh, $-60 + 10i_2 - 10i_1 + 10i_3 - 2i_1 = 0$

or $-6i_1 + 5i_2 + 5i_3 = 30$ (2)

Also, $3i_0 = i_3 - i_2$ and $i_0 = i_1$ which leads to $3i_1 = i_3 - i_2$ (3)

Solving (1), (2), and (3), we obtain $i_1 = 1.731$ and $i_0 = i_1 =$ **<u>1.731 A</u>**

Chapter 3, Solution 51



For loop 1, $i_1 = 5A$ (1)

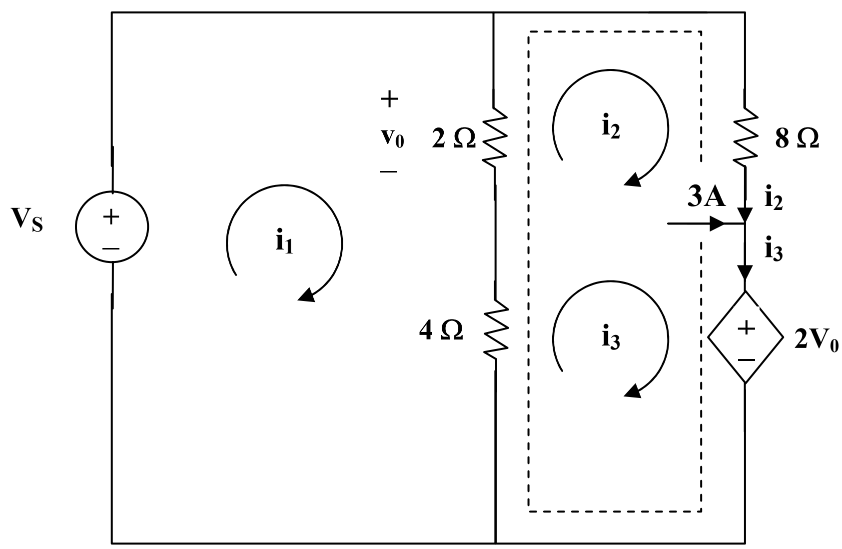
For loop 2, $-40 + 7i_2 - 2i_1 - 4i_3 = 0$ which leads to $50 = 7i_2 - 4i_3$ (2)

For loop 3, $-20 + 12i_3 - 4i_2 = 0$ which leads to $5 = - i_2 + 3\, i_3$ (3)

Solving with (2) and (3), $i_2 = 10$ A, $i_3 = 5$ A

And, $v_0 = 4(i_2 - i_3) = 4(10 - 5) =$ **20 V**.

Chapter 3, Solution 52



For mesh 1,

$$2(i_1 - i_2) + 4(i_1 - i_3) - 12 = 0 \text{ which leads to } 3i_1 - i_2 - 2i_3 = 6 \quad (1)$$

For the supermesh, $2(i_2 - i_1) + 8i_2 + 2v_0 + 4(i_3 - i_1) = 0$

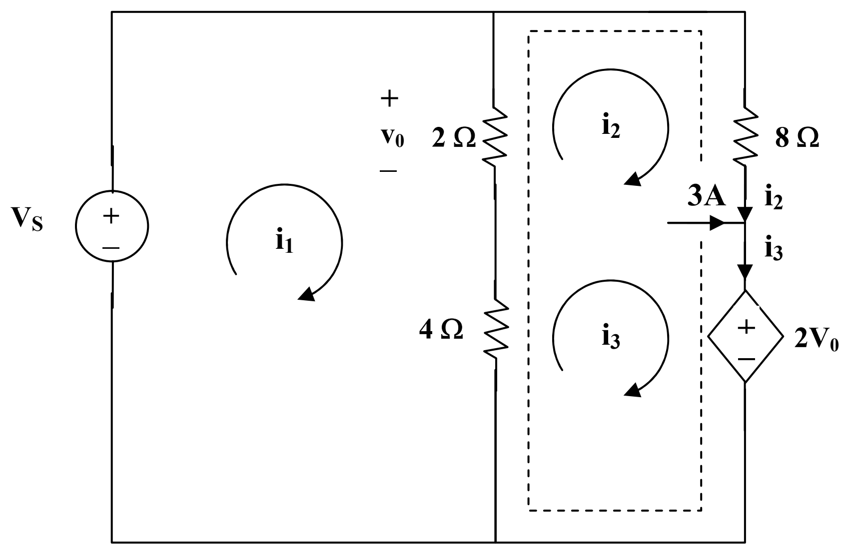
But $v_0 = 2(i_1 - i_2)$ which leads to $-i_1 + 3i_2 + 2i_3 = 0$ (2)

For the independent current source, $i_3 = 3 + i_2$ (3)

Solving (1), (2), and (3), we obtain,

$i_1 =$ **3.5 A**, $i_2 =$ **-0.5 A**, $i_3 =$ **2.5 A**.

Chapter 3, Solution 53



For mesh 1,

$$2(i_1 - i_2) + 4(i_1 - i_3) - 12 = 0 \quad \text{which leads to} \quad 3i_1 - i_2 - 2i_3 = 6 \qquad (1)$$

For the supermesh, $2(i_2 - i_1) + 8i_2 + 2v_0 + 4(i_3 - i_1) = 0$

But $v_0 = 2(i_1 - i_2)$ which leads to $-i_1 + 3i_2 + 2i_3 = 0$ (2)

For the independent current source, $i_3 = 3 + i_2$ (3)

Solving (1), (2), and (3), we obtain,

i_1 = **3.5 A**, i_2 = **-0.5 A**, i_3 = **2.5 A**.

Chapter 3, Solution 54

Let the mesh currents be in mA. For mesh 1,

$$-12+10+2I_1-I_2=0 \longrightarrow 2=2I_1-I_2 \quad (1)$$

For mesh 2,

$$-10+3I_2-I_1-I_3=0 \longrightarrow 10=-I_1+3I_2-I_3 \quad (2)$$

For mesh 3,

$$-12+2I_3-I_2=0 \longrightarrow 12=-I_2+2I_3 \quad (3)$$

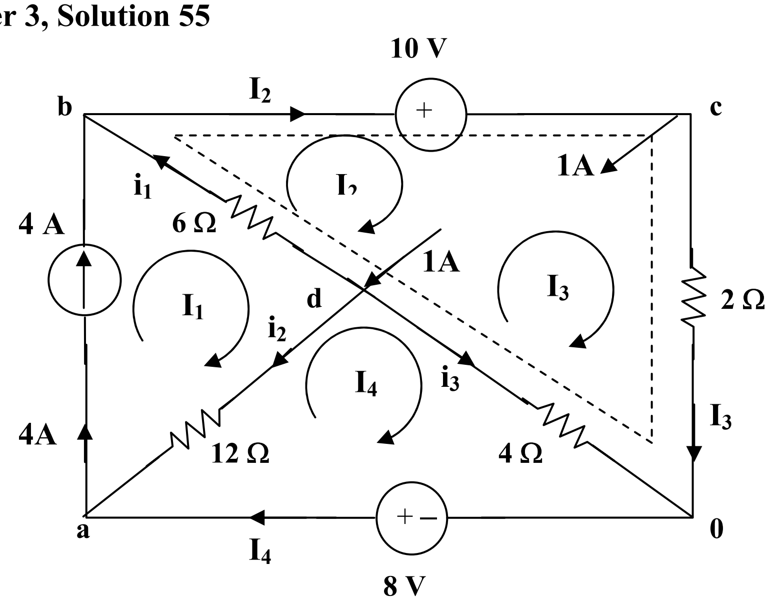
Putting (1) to (3) in matrix form leads to

$$\begin{pmatrix} 2 & -1 & 0 \\ -1 & 3 & -1 \\ 0 & -1 & 2 \end{pmatrix}\begin{pmatrix} I_1 \\ I_2 \\ I_3 \end{pmatrix}=\begin{pmatrix} 2 \\ 10 \\ 12 \end{pmatrix} \longrightarrow AI=B$$

Using MATLAB,

$$I=A^{-1}B=\begin{bmatrix} 5.25 \\ 8.5 \\ 10.25 \end{bmatrix} \longrightarrow \underline{I_1=5.25\,\text{mA},\ I_2=8.5\,\text{mA}, I_3=10.25\,\text{mA}}$$

Chapter 3, Solution 55



It is evident that $I_1 = 4$ (1)

For mesh 4, $12(I_4 - I_1) + 4(I_4 - I_3) - 8 = 0$ (2)

For the supermesh $6(I_2 - I_1) + 10 + 2I_3 + 4(I_3 - I_4) = 0$
or $-3I_1 + 3I_2 + 3I_3 - 2I_4 = -5$ (3)

At node c, $I_2 = I_3 + 1$ (4)

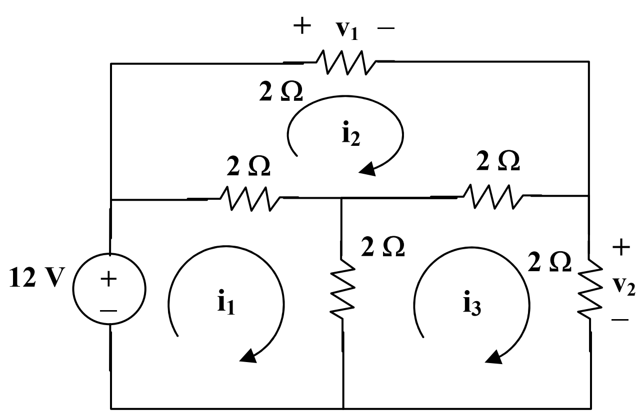
Solving (1), (2), (3), and (4) yields, $I_1 = 4A$, $I_2 = 3A$, $I_3 = 2A$, and $I_4 = 4A$

At node b, $i_1 = I_2 - I_1 =$ **-1A**

At node a, $i_2 = 4 - I_4 =$ **0A**

At node 0, $i_3 = I_4 - I_3 =$ **2A**

Chapter 3, Solution 56



For loop 1, $12 = 4i_1 - 2i_2 - 2i_3$ which leads to $6 = 2i_1 - i_2 - i_3$ (1)

For loop 2, $0 = 6i_2 - 2i_1 - 2i_3$ which leads to $0 = -i_1 + 3i_2 - i_3$ (2)

For loop 3, $0 = 6i_3 - 2i_1 - 2i_2$ which leads to $0 = -i_1 - i_2 + 3i_3$ (3)

In matrix form (1), (2), and (3) become,

$$\begin{bmatrix} 2 & -1 & -1 \\ -1 & 3 & -1 \\ -1 & -1 & 3 \end{bmatrix} \begin{bmatrix} i_1 \\ i_2 \\ i_3 \end{bmatrix} = \begin{bmatrix} 6 \\ 0 \\ 0 \end{bmatrix}$$

$$\Delta = \begin{vmatrix} 2 & -1 & -1 \\ -1 & 3 & -1 \\ -1 & -1 & 3 \end{vmatrix} = 8, \quad \Delta_2 = \begin{vmatrix} 2 & 6 & -1 \\ -1 & 3 & -1 \\ -1 & 0 & 3 \end{vmatrix} = 24$$

$$\Delta_3 = \begin{vmatrix} 2 & -1 & 6 \\ -1 & 3 & 0 \\ -1 & -1 & 0 \end{vmatrix} = 24 \text{ , therefore } i_2 = i_3 = 24/8 = 3\text{A},$$

$v_1 = 2i_2 =$ **6 volts**, $v = 2i_3 =$ **6 volts**

Chapter 3, Solution 57

Assume R is in kilo-ohms.

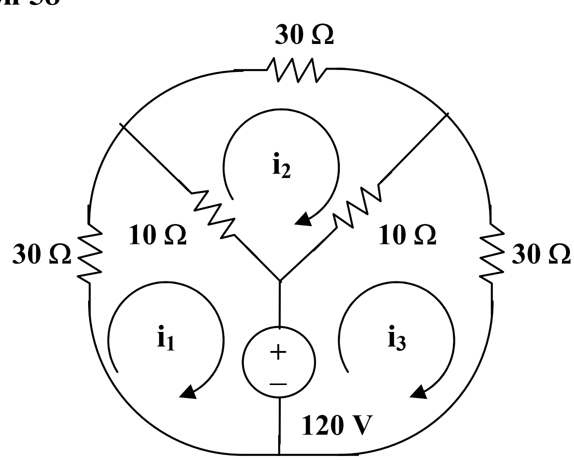
$V_2 = 4k\Omega x 18mA = \underline{72V}$, $\qquad V_1 = 100 - V_2 = 100 - 72 = \underline{28V}$

Current through R is

$i_R = \dfrac{3}{3+R} i_o, \qquad V_1 = i_R R \longrightarrow \qquad 28 = \dfrac{3}{3+R}(18)R$

This leads to R = 84/26 = $\underline{3.23\ k\Omega}$

Chapter 3, Solution 58



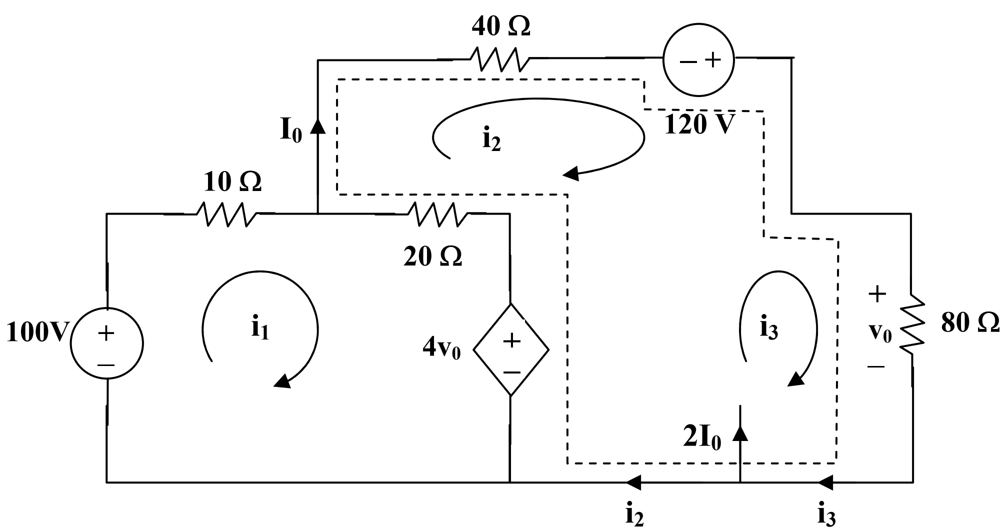
For loop 1, $120 + 40i_1 - 10i_2 = 0$, which leads to $-12 = 4i_1 - i_2$ (1)

For loop 2, $50i_2 - 10i_1 - 10i_3 = 0$, which leads to $-i_1 + 5i_2 - i_3 = 0$ (2)

For loop 3, $-120 - 10i_2 + 40i_3 = 0$, which leads to $12 = -i_2 + 4i_3$ (3)

Solving (1), (2), and (3), we get, $i_1 =$ **-3A**, $i_2 =$ **0**, and $i_3 =$ **3A**

Chapter 3, Solution 59



For loop 1, $-100 + 30i_1 - 20i_2 + 4v_0 = 0$, where $v_0 = 80i_3$
or $5 = 1.5i_1 - i_2 + 16i_3$ (1)

For the supermesh, $60i_2 - 20i_1 - 120 + 80i_3 - 4\,v_0 = 0$, where $v_0 = 80i_3$
or $6 = -i_1 + 3i_2 - 12i_3$ (2)

Also, $2I_0 = i_3 - i_2$ and $I_0 = i_2$, hence, $3i_2 = i_3$ (3)

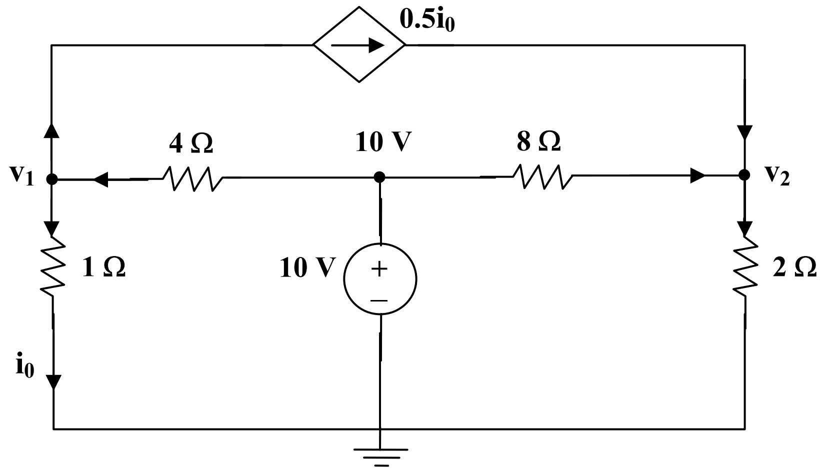
From (1), (2), and (3),
$$\begin{bmatrix} 3 & -2 & 32 \\ -1 & 3 & -12 \\ 0 & 3 & -1 \end{bmatrix}\begin{bmatrix} i_1 \\ i_2 \\ i_3 \end{bmatrix} = \begin{bmatrix} 10 \\ 6 \\ 0 \end{bmatrix}$$

$$\Delta = \begin{vmatrix} 3 & -2 & 32 \\ -1 & 3 & -12 \\ 0 & 3 & -1 \end{vmatrix} = 5,\ \Delta_2 = \begin{vmatrix} 3 & 10 & 32 \\ -1 & 6 & -12 \\ 0 & 0 & -1 \end{vmatrix} = -28,\ \Delta_3 = \begin{vmatrix} 3 & -2 & 10 \\ -1 & 3 & 6 \\ 0 & 3 & 0 \end{vmatrix} = -84$$

$I_0 = i_2 = \Delta_2/\Delta = -28/5 =$ **-5.6 A**

$v_0 = 8i_3 = (-84/5)80 =$ **-1344 volts**

Chapter 3, Solution 60



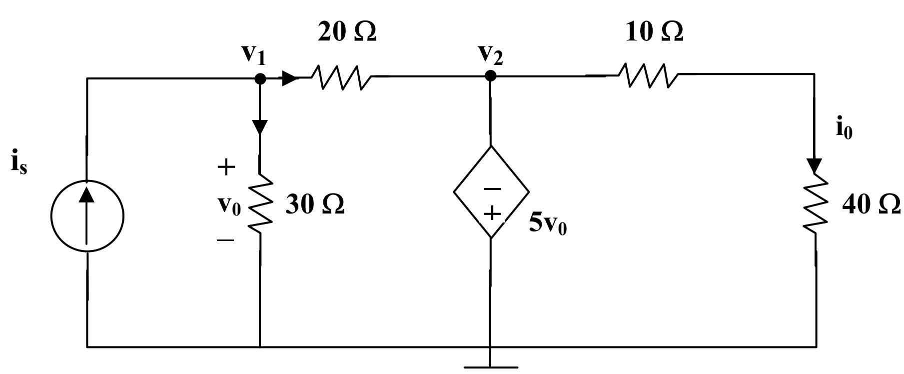
At node 1, $(v_1/1) + (0.5v_1/1) = (10 - v_1)/4$, which leads to $v_1 = 10/7$

At node 2, $(0.5v_1/1) + ((10 - v_2)/8) = v_2/2$ which leads to $v_2 = 22/7$

$P_{1\Omega} = (v_1)^2/1 =$ **2.041 watts**, $P_{2\Omega} = (v_2)^2/2 =$ **4.939 watts**

$P_{4\Omega} = (10 - v_1)^2/4 =$ **18.38 watts**, $P_{8\Omega} = (10 - v_2)^2/8 =$ **5.88 watts**

Chapter 3, Solution 61



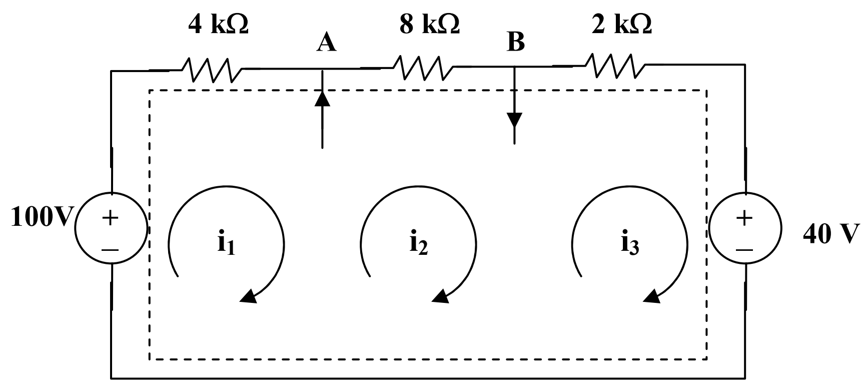
At node 1, $i_s = (v_1/30) + ((v_1 - v_2)/20)$ which leads to $60i_s = 5v_1 - 3v_2$ (1)

But $v_2 = -5v_0$ and $v_0 = v_1$ which leads to $v_2 = -5v_1$

Hence, $60i_s = 5v_1 + 15v_1 = 20v_1$ which leads to $v_1 = 3i_s$, $v_2 = -15i_s$

$i_0 = v_2/50 = -15i_s/50$ which leads to $i_0/i_s = -15/50 =$ **-0.3**

Chapter 3, Solution 62



We have a supermesh. Let all R be in kΩ, i in mA, and v in volts.

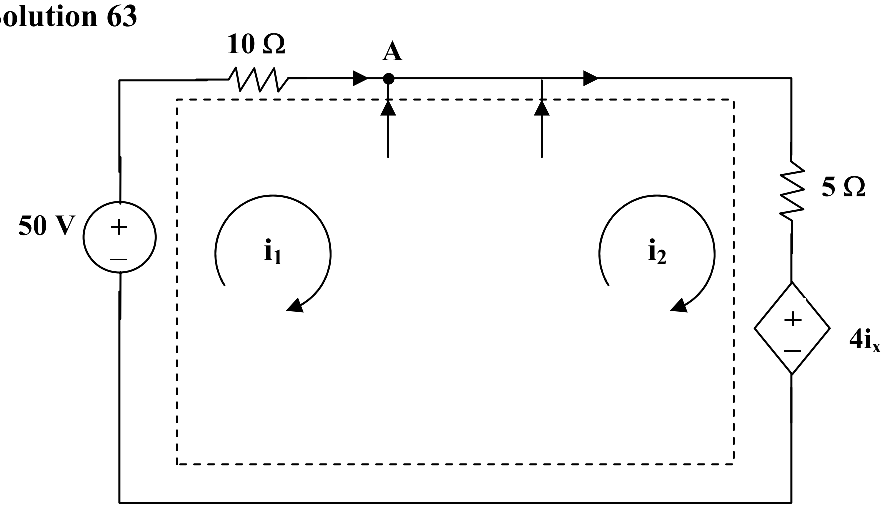
For the supermesh, $-100 + 4i_1 + 8i_2 + 2i_3 + 40 = 0$ or $30 = 2i_1 + 4i_2 + i_3$ (1)

At node A, $i_1 + 4 = i_2$ (2)

At node B, $i_2 = 2i_1 + i_3$ (3)

Solving (1), (2), and (3), we get i_1 = **2 mA**, i_2 = **6 mA**, and i_3 = **2 mA**.

Chapter 3, Solution 63



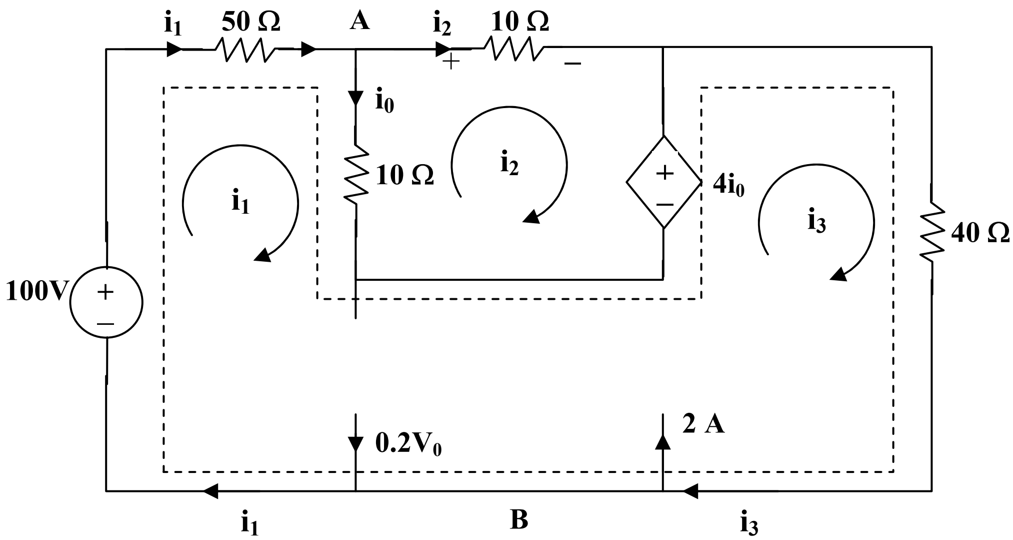
For the supermesh, $-50 + 10i_1 + 5i_2 + 4i_x = 0$, but $i_x = i_1$. Hence,

$$50 = 14i_1 + 5i_2 \quad (1)$$

At node A, $i_1 + 3 + (v_x/4) = i_2$, but $v_x = 2(i_1 - i_2)$, hence, $i_1 + 2 = i_2$ (2)

Solving (1) and (2) gives $i_1 = 2.105$ A and $i_2 = 4.105$ A
$v_x = 2(i_1 - i_2)$ = **-4 volts** and $i_x = i_2 - 2$ = **4.105 amp**

Chapter 3, Solution 64



For mesh 2, $20i_2 - 10i_1 + 4i_0 = 0$ (1)

But at node A, $i_o = i_1 - i_2$ so that (1) becomes $i_1 = (7/12)i_2$ (2)

For the supermesh, $-100 + 50i_1 + 10(i_1 - i_2) - 4i_0 + 40i_3 = 0$

or $50 = 28i_1 - 3i_2 + 20i_3$ (3)

At node B, $i_3 + 0.2v_0 = 2 + i_1$ (4)

But, $v_0 = 10i_2$ so that (4) becomes $i_3 = 2 - (17/12)i_2$ (5)

Solving (1) to (5), $i_2 = -0.674$,

$v_0 = 10i_2 =$ <u>**-6.74 volts**</u>, $i_0 = i_1 - i_2 = -(5/12)i_2 =$ <u>**0.281 amps**</u>

Chapter 3, Solution 65

For mesh 1, $12 = 12I_1 - 6I_2 - I_4$ (1)

For mesh 2, $0 = -6I_1 + 16I_2 - 8I_3 - I_4 - I_5$ (2)

For mesh 3, $9 = -8I_2 + 15I_3 - I_5$ (3)

For mesh 4, $6 = -I_1 - I_2 + 5I_4 - 2I_5$ (4)

For mesh 5, $10 = -I_2 - I_3 - 2I_4 + 8I_5$ (5)

Casting (1) to (5) in matrix form gives

$$\begin{pmatrix} 12 & -6 & 0 & 1 & 0 \\ -6 & 16 & -8 & -1 & -1 \\ 0 & -8 & 15 & 0 & -1 \\ -1 & -1 & 0 & 5 & -2 \\ 0 & -1 & -1 & -2 & 8 \end{pmatrix} \begin{pmatrix} I_1 \\ I_2 \\ I_3 \\ I_4 \\ I_5 \end{pmatrix} = \begin{pmatrix} 12 \\ 0 \\ 9 \\ 6 \\ 10 \end{pmatrix} \longrightarrow \quad AI = B$$

Using MATLAB leads to

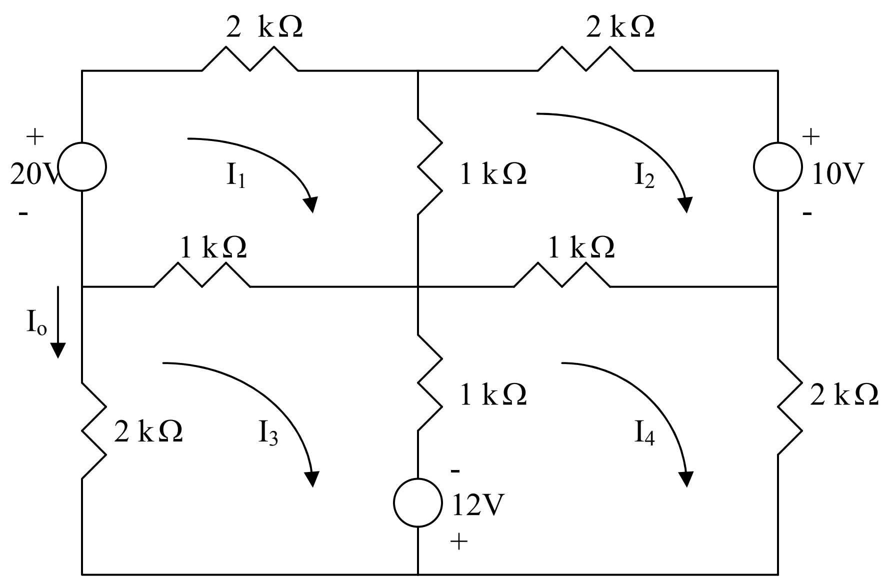
$$I = A^{-1}B = \begin{pmatrix} 1.673 \\ 1.824 \\ 1.733 \\ 2.864 \\ 2.411 \end{pmatrix}$$

Thus,

$$\underline{I_1 = 1.673\text{ A}, I_2 = 1.824\text{ A}, I_3 = 1.733\text{ A}, I_4 = 1.864\text{ A}, I_5 = 2.411\text{ A}}$$

Chapter 3, Solution 66

Consider the circuit below.



We use mesh analysis. Let the mesh currents be in mA.

For mesh 1, $\quad 20 = 4I_1 - I_2 - I_3 \qquad (1)$

For mesh 2, $\quad -10 = -I_1 + 4I_2 - I_4 \qquad (2)$

For mesh 3, $\quad 12 = -I_1 + 4I_3 - I_4 \qquad (3)$

For mesh 4, $\quad -12 = -I_2 - I_3 + 4I_4 \qquad (4)$

In matrix form, (1) to (4) become

$$\begin{pmatrix} 4 & -1 & -1 & 0 \\ -1 & 4 & 0 & -1 \\ -1 & 0 & 4 & -1 \\ 0 & -1 & -1 & 4 \end{pmatrix}\begin{pmatrix} I_1 \\ I_2 \\ I_3 \\ I_4 \end{pmatrix} = \begin{pmatrix} 20 \\ -10 \\ 12 \\ -12 \end{pmatrix} \longrightarrow \quad AI = B$$

Using MATLAB,

$$I = A^{-1}B = \begin{pmatrix} 5.5 \\ -1.75 \\ 3.75 \\ -2.5 \end{pmatrix}$$

Thus,

$$I_o = -I_3 = \underline{-3.75\,\text{mA}}$$

Chapter 3, Solution 67

$G_{11} = (1/1) + (1/4) = 1.25$, $G_{22} = (1/1) + (1/2) = 1.5$

$G_{12} = -1 = G_{21}$, $i_1 = 6 - 3 = 3$, $i_2 = 5\text{-}6 = -1$

Hence, we have, $\begin{bmatrix} 1.25 & -1 \\ -1 & 1.5 \end{bmatrix}\begin{bmatrix} v_1 \\ v_2 \end{bmatrix} = \begin{bmatrix} 3 \\ -1 \end{bmatrix}$

$$\begin{bmatrix} 1.25 & -1 \\ -1 & 1.5 \end{bmatrix}^{-1} = \frac{1}{\Delta}\begin{bmatrix} 1.5 & 1 \\ 1 & 1.25 \end{bmatrix}, \text{ where } \Delta = [(1.25)(1.5)\text{-}(-1)(-1)] = 0.875$$

$$\begin{bmatrix} v_1 \\ v_2 \end{bmatrix} = \begin{bmatrix} 1.7143 & 1.1429 \\ 1.1429 & 1.4286 \end{bmatrix}\begin{bmatrix} 3 \\ -1 \end{bmatrix} = \begin{bmatrix} 3(1.7143) - 1(1.1429) \\ 3(1.1429) - 1(1.4286) \end{bmatrix} = \begin{bmatrix} 4 \\ 2 \end{bmatrix}$$

Clearly v_1 = **<u>4 volts</u>** and v_2 = **<u>2 volts</u>**

Chapter 3, Solution 68

By inspection, $G_{11} = 1 + 3 + 5 = 8S$, $G_{22} = 1 + 2 = 3S$, $G_{33} = 2 + 5 = 7S$

$G_{12} = -1$, $G_{13} = -5$, $G_{21} = -1$, $G_{23} = -2$, $G_{31} = -5$, $G_{32} = -2$

$i_1 = 4$, $i_2 = 2$, $i_3 = -1$

We can either use matrix inverse as we did in Problem 3.51 or use Cramer's Rule. Let us use Cramer's rule for this problem.

First, we develop the matrix relationships.

$$\begin{bmatrix} 8 & -1 & -5 \\ -1 & 3 & -2 \\ -5 & -2 & 7 \end{bmatrix}\begin{bmatrix} v_1 \\ v_2 \\ v_3 \end{bmatrix} = \begin{bmatrix} 4 \\ 2 \\ -1 \end{bmatrix}$$

$$\Delta = \begin{vmatrix} 8 & -1 & -5 \\ -1 & 3 & -2 \\ -5 & -2 & 7 \end{vmatrix} = 34, \Delta_1 = \begin{vmatrix} 4 & -1 & -5 \\ 2 & 3 & -2 \\ -1 & -2 & 7 \end{vmatrix} = 85$$

$$\Delta_2 = \begin{vmatrix} 8 & 4 & -5 \\ -1 & 2 & -2 \\ -5 & -1 & 7 \end{vmatrix} = 109, \Delta_3 = \begin{vmatrix} 8 & -1 & 4 \\ -1 & 3 & 2 \\ -5 & -2 & -1 \end{vmatrix} = 87$$

$v_1 = \Delta_1/\Delta = 85/34 =$ **3.5 volts**, $v_2 = \Delta_2/\Delta = 109/34 =$ **3.206 volts**

$v_3 = \Delta_3/\Delta = 87/34 =$ **2.56 volts**

Chapter 3, Solution 69

Assume that all conductances are in mS, all currents are in mA, and all voltages are in volts.

$G_{11} = (1/2) + (1/4) + (1/1) = 1.75$, $G_{22} = (1/4) + (1/4) + (1/2) = 1$,
$G_{33} = (1/1) + (1/4) = 1.25$, $G_{12} = -1/4 = -0.25$, $G_{13} = -1/1 = -1$,
$G_{21} = -0.25$, $G_{23} = -1/4 = -0.25$, $G_{31} = -1$, $G_{32} = -0.25$

$i_1 = 20$, $i_2 = 5$, and $i_3 = 10 - 5 = 5$

The node-voltage equations are:

$$\begin{bmatrix} 1.75 & -0.25 & -1 \\ -0.25 & 1 & -0.25 \\ -1 & -0.25 & 1.25 \end{bmatrix} \begin{bmatrix} v_1 \\ v_2 \\ v_3 \end{bmatrix} = \begin{bmatrix} 20 \\ 5 \\ 5 \end{bmatrix}$$

Chapter 3, Solution 70

$G_{11} = G_1 + G_2 + G_4$, $G_{12} = -G_2$, $G_{13} = 0$,
$G_{22} = G_2 + G_3$, $G_{21} = -G_2$, $G_{23} = -G_3$,
$G_{33} = G_1 + G_3 + G_5$, $G_{31} = 0$, $G_{32} = -G_3$

$i_1 = -I_1$, $i_2 = I_2$, and $i_3 = I_1$

Then, the node-voltage equations are:

$$\begin{bmatrix} G_1 + G_2 + G_4 & -G_2 & 0 \\ -G_2 & G_1 + G_2 & -G_3 \\ 0 & -G_3 & G_1 + G_3 + G_5 \end{bmatrix} \begin{bmatrix} v_1 \\ v_2 \\ v_3 \end{bmatrix} = \begin{bmatrix} -I_1 \\ I_2 \\ I_1 \end{bmatrix}$$

Chapter 3, Solution 71

$R_{11} = 4 + 2 = 6$, $R_{22} = 2 + 8 + 2 = 12$, $R_{33} = 2 + 5 = 7$,
$R_{12} = -2$, $R_{13} = 0$, $R_{21} = -2$, $R_{23} = -2$, $R_{31} = 0$, $R_{32} = -2$

$v_1 = 12$, $v_2 = -8$, and $v_3 = -20$

Now we can write the matrix relationships for the mesh-current equations.

$$\begin{bmatrix} 6 & -2 & 0 \\ -2 & 12 & -2 \\ 0 & -2 & 7 \end{bmatrix} \begin{bmatrix} i_1 \\ i_2 \\ i_3 \end{bmatrix} = \begin{bmatrix} 12 \\ -8 \\ -20 \end{bmatrix}$$

Now we can solve for i_2 using Cramer's Rule.

$$\Delta = \begin{vmatrix} 6 & -2 & 0 \\ -2 & 12 & -2 \\ 0 & -2 & 7 \end{vmatrix} = 452, \Delta_2 = \begin{vmatrix} 6 & 12 & 0 \\ -2 & -8 & -2 \\ 0 & -20 & 7 \end{vmatrix} = -408$$

$i_2 = \Delta_2/\Delta = -0.9026$, $p = (i_2)^2 R =$ **<u>6.52 watts</u>**

Chapter 3, Solution 72

$R_{11} = 5 + 2 = 7$, $R_{22} = 2 + 4 = 6$, $R_{33} = 1 + 4 = 5$, $R_{44} = 1 + 4 = 5$,
$R_{12} = -2$, $R_{13} = 0 = R_{14}$, $R_{21} = -2$, $R_{23} = -4$, $R_{24} = 0$, $R_{31} = 0$,
$R_{32} = -4$, $R_{34} = -1$, $R_{41} = 0 = R_{42}$, $R_{43} = -1$, we note that $R_{ij} = R_{ji}$ for all i not equal to j.

$v_1 = 8$, $v_2 = 4$, $v_3 = -10$, and $v_4 = -4$

Hence the mesh-current equations are:

$$\begin{bmatrix} 7 & -2 & 0 & 0 \\ -2 & 6 & -4 & 0 \\ 0 & -4 & 5 & -1 \\ 0 & 0 & -1 & 5 \end{bmatrix} \begin{bmatrix} i_1 \\ i_2 \\ i_3 \\ i_4 \end{bmatrix} = \begin{bmatrix} 8 \\ 4 \\ -10 \\ -4 \end{bmatrix}$$

Chapter 3, Solution 73

$R_{11} = 2 + 3 + 4 = 9$, $R_{22} = 3 + 5 = 8$, $R_{33} = 1 + 4 = 5$, $R_{44} = 1 + 1 = 2$,
$R_{12} = -3$, $R_{13} = -4$, $R_{14} = 0$, $R_{23} = 0$, $R_{24} = 0$, $R_{34} = -1$

$v_1 = 6$, $v_2 = 4$, $v_3 = 2$, and $v_4 = -3$

Hence,

$$\begin{bmatrix} 9 & -3 & -4 & 0 \\ -3 & 8 & 0 & 0 \\ -4 & 0 & 6 & -1 \\ 0 & 0 & -1 & 2 \end{bmatrix} \begin{bmatrix} i_1 \\ i_2 \\ i_3 \\ i_4 \end{bmatrix} = \begin{bmatrix} 6 \\ 4 \\ 2 \\ -3 \end{bmatrix}$$

Chapter 3, Solution 74

$R_{11} = R_1 + R_4 + R_6$, $R_{22} = R_2 + R_4 + R_5$, $R_{33} = R_6 + R_7 + R_8$,
$R_{44} = R_3 + R_5 + R_8$, $R_{12} = -R_4$, $R_{13} = -R_6$, $R_{14} = 0$, $R_{23} = 0$,
$R_{24} = -R_5$, $R_{34} = -R_8$, again, we note that $R_{ij} = R_{ji}$ for all i not equal to j.

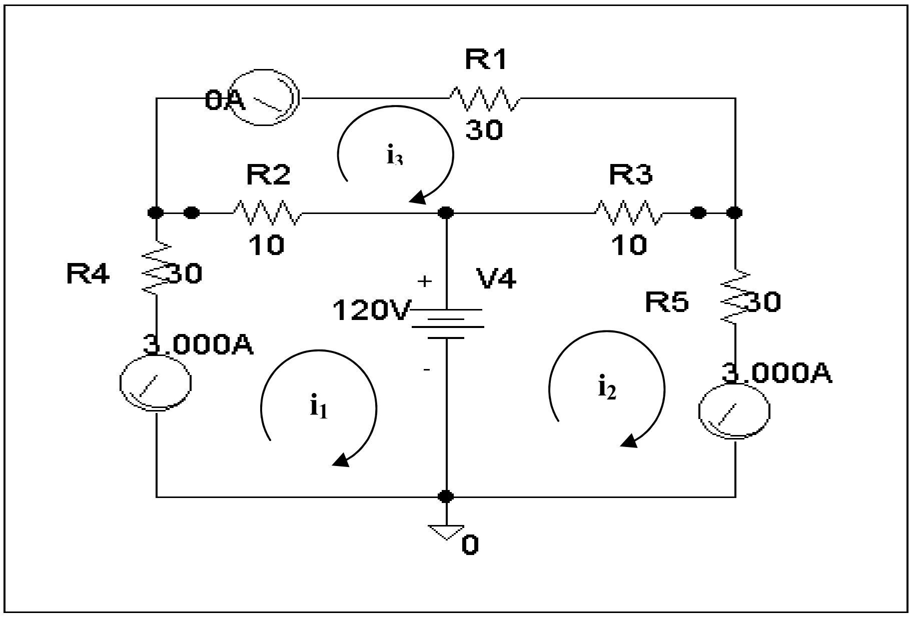
The input voltage vector is = $\begin{bmatrix} V_1 \\ -V_2 \\ V_3 \\ -V_4 \end{bmatrix}$

$$\begin{bmatrix} R_1 + R_4 + R_6 & -R_4 & -R_6 & 0 \\ -R_4 & R_2 + R_4 + R_5 & 0 & -R_5 \\ -R_6 & 0 & R_6 + R_7 + R_8 & -R_8 \\ 0 & -R_5 & -R_8 & R_3 + R_5 + R_8 \end{bmatrix} \begin{bmatrix} i_1 \\ i_2 \\ i_3 \\ i_4 \end{bmatrix} = \begin{bmatrix} V_1 \\ -V_2 \\ V_3 \\ -V_4 \end{bmatrix}$$

Chapter 3, Solution 75

```
* Schematics Netlist *

R_R4          $N_0002 $N_0001  30
R_R2          $N_0001 $N_0003  10
R_R1          $N_0005 $N_0004  30
R_R3          $N_0003 $N_0004  10
R_R5          $N_0006 $N_0004  30
V_V4          $N_0003 0 120V
v_V3          $N_0005 $N_0001 0
v_V2          0 $N_0006 0
v_V1          0 $N_0002 0
```

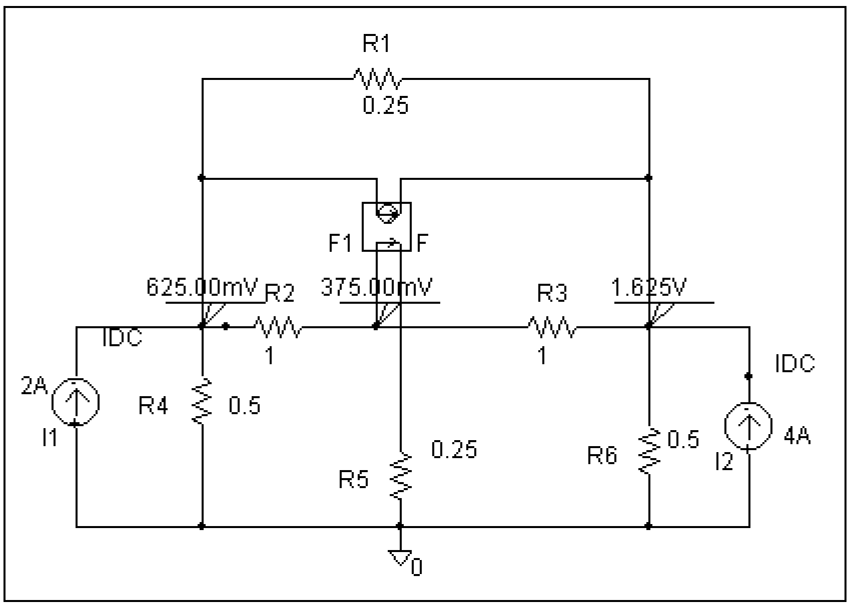


Clearly, i_1 = **-3 amps**, i_2 = **0 amps**, and i_3 = **3 amps**, which agrees with the answers in Problem 3.44.

Chapter 3, Solution 76

```
* Schematics Netlist *

I_I2          0 $N_0001 DC 4A
R_R1          $N_0002 $N_0001  0.25
R_R3          $N_0003 $N_0001  1
R_R2          $N_0002 $N_0003  1
F_F1          $N_0002 $N_0001 VF_F1 3
VF_F1         $N_0003 $N_0004 0V
R_R4          0 $N_0002  0.5
R_R6          0 $N_0001  0.5
I_I1          0 $N_0002 DC 2A
R_R5          0 $N_0004  0.25
```

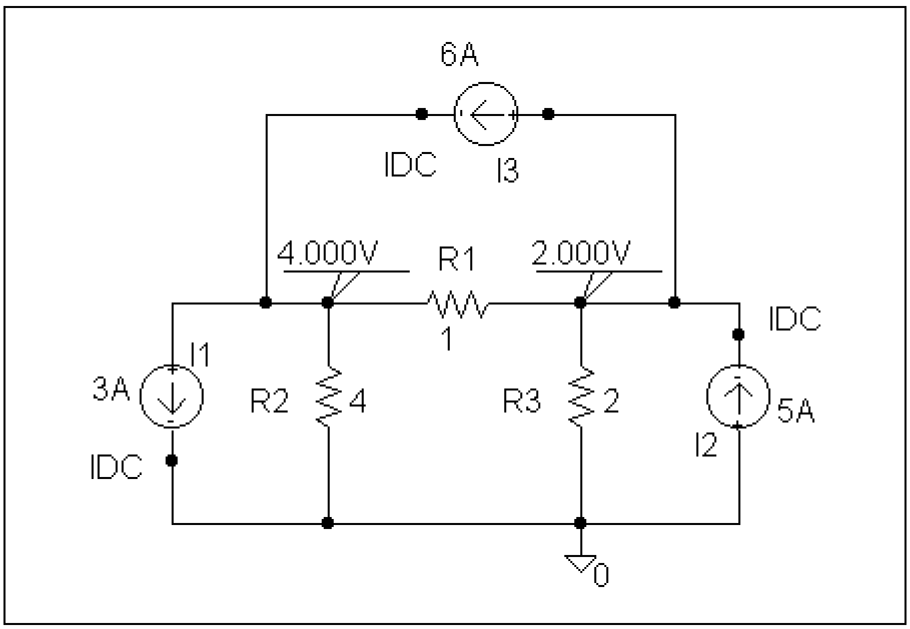


Clearly, v_1 = **<u>625 mVolts</u>**, v_2 = **<u>375 mVolts</u>**, and v_3 = **<u>1.625 volts</u>**, which agrees with the solution obtained in Problem 3.27.

Chapter 3, Solution 77

```
* Schematics Netlist *

R_R2          0 $N_0001  4
I_I1          $N_0001 0 DC 3A
I_I3          $N_0002 $N_0001 DC 6A
R_R3          0 $N_0002  2
R_R1          $N_0001 $N_0002  1
I_I2          0 $N_0002 DC 5A
```

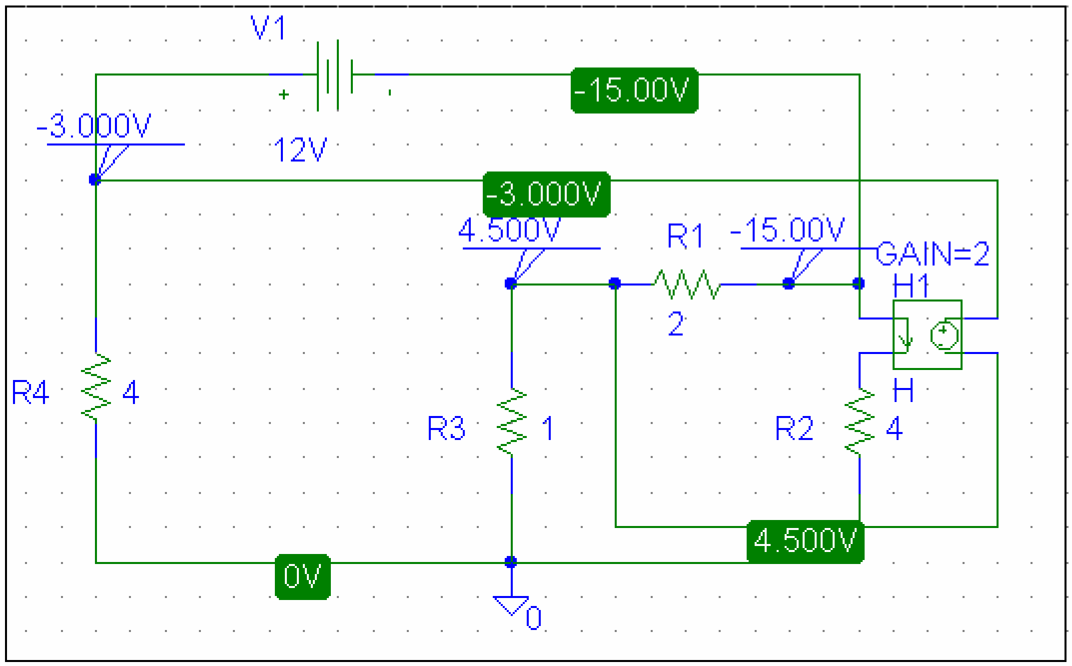


Clearly, v_1 = **<u>4 volts</u>** and v_2 = **<u>2 volts</u>**, which agrees with the answer obtained in Problem 3.51.

Chapter 3, Solution 78

The schematic is shown below. When the circuit is saved and simulated the node voltages are displaced on the pseudocomponents as shown. Thus,

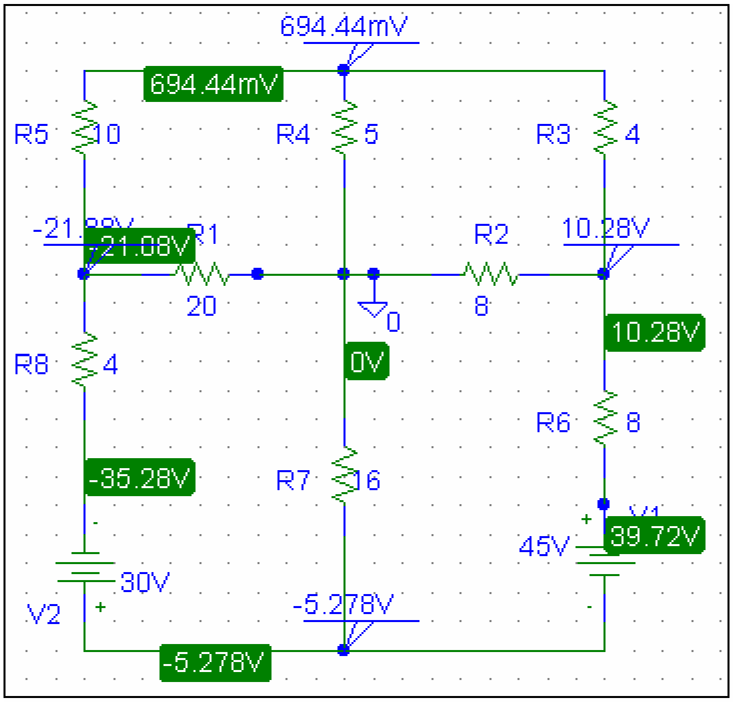
$V_1 = -3\text{V}, \quad V_2 = 4.5\text{V}, V_3 = -15\text{V},$



Chapter 3, Solution 79

The schematic is shown below. When the circuit is saved and simulated, we obtain the node voltages as displaced. Thus,

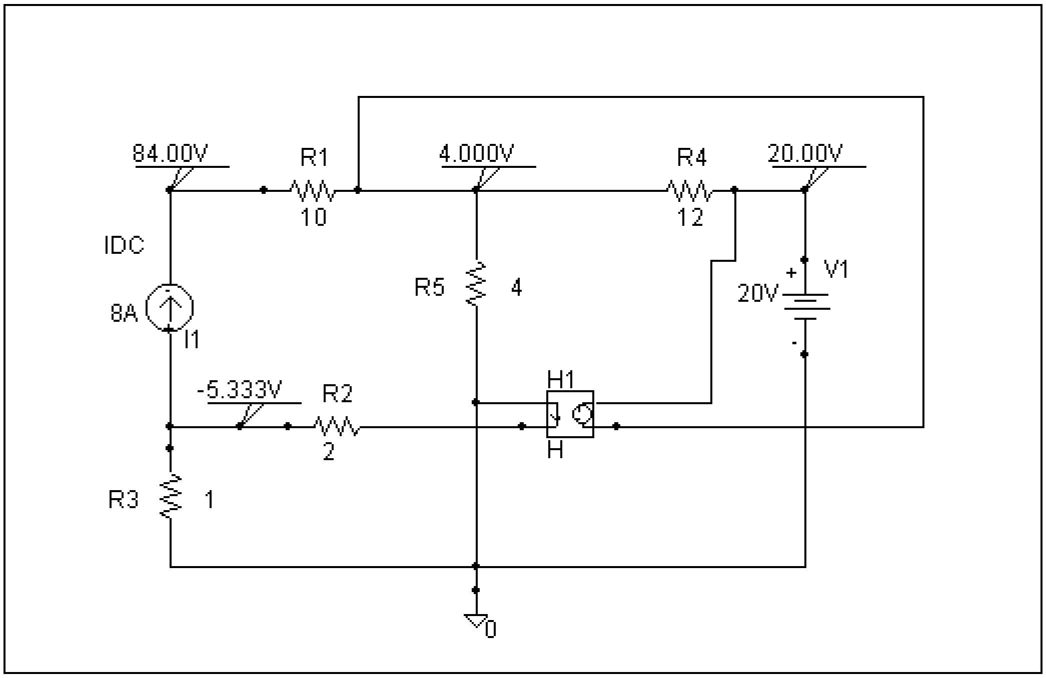
$$\underline{V_a = -5.278\text{ V},\ \ V_b = 10.28\text{ V},\ \ V_c = 0.6944\text{ V},\ \ V_d = -26.88\text{ V}}$$



Chapter 3, Solution 80

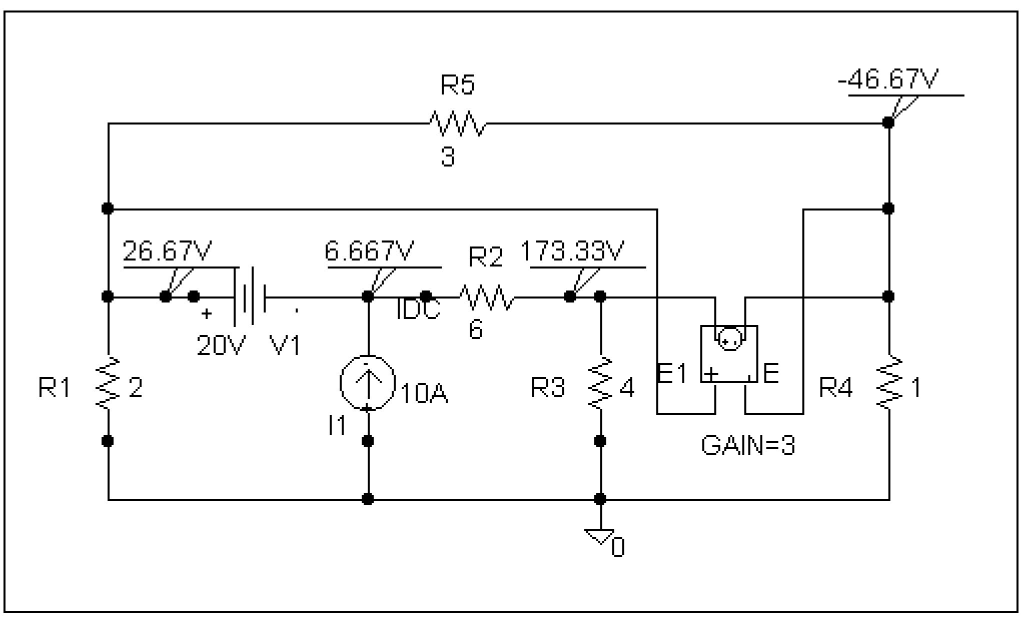
```
* Schematics Netlist *

H_H1          $N_0002 $N_0003 VH_H1 6
VH_H1         0 $N_0001 0V
I_I1          $N_0004 $N_0005 DC 8A
V_V1          $N_0002 0 20V
R_R4          0 $N_0003  4
R_R1          $N_0005 $N_0003  10
R_R2          $N_0003 $N_0002  12
R_R5          0 $N_0004  1
R_R3          $N_0004 $N_0001  2
```



Clearly, v_1 = **84 volts**, v_2 = **4 volts**, v_3 = **20 volts**, and v_4 = **-5.333 volts**

Chapter 3, Solution 81



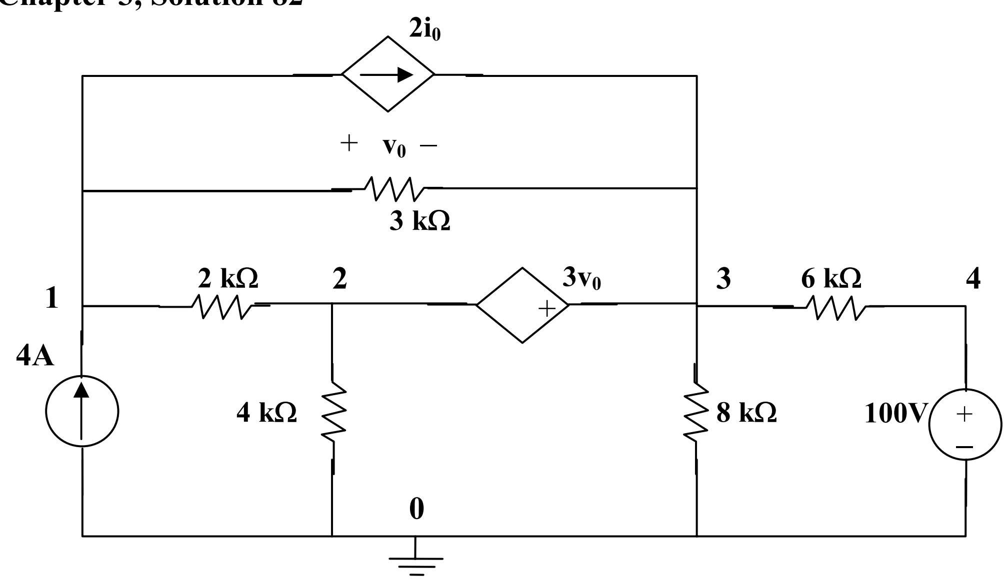
Clearly, v_1 = **26.67 volts**, v_2 = **6.667 volts**, v_3 = **173.33 volts**, and v_4 = **-46.67 volts** which agrees with the results of Example 3.4.

This is the netlist for this circuit.

```
* Schematics Netlist *

R_R1          0 $N_0001  2
R_R2          $N_0003 $N_0002  6
R_R3          0 $N_0002  4
R_R4          0 $N_0004  1
R_R5          $N_0001 $N_0004  3
I_I1          0 $N_0003 DC 10A
V_V1          $N_0001 $N_0003 20V
E_E1          $N_0002 $N_0004 $N_0001 $N_0004 3
```

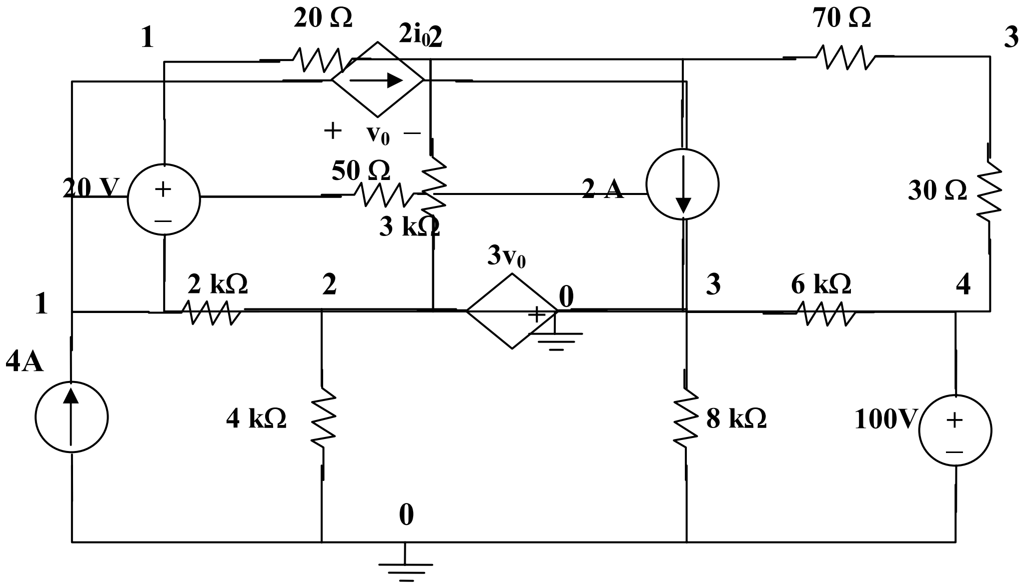
Chapter 3, Solution 82



This network corresponds to the Netlist.

Chapter 3, Solution 83

The circuit is shown below.



When the circuit is saved and simulated, we obtain v_2 = <u>-12.5 volts</u>

Chapter 3, Solution 84

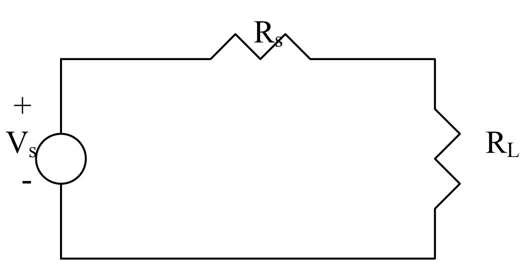
From the output loop, $v_0 = 50i_0 x20x10^3 = 10^6 i_0$ (1)

From the input loop, $3x10^{-3} + 4000i_0 - v_0/100 = 0$ (2)

From (1) and (2) we get, i_0 = **<u>0.5μA</u>** and v_0 = **<u>0.5 volt</u>**.

Chapter 3, Solution 85

The amplifier acts as a source.



For maximum power transfer,

$$R_L = R_s = \underline{9\Omega}$$

Chapter 3, Solution 86

Let v_1 be the potential across the 2 k-ohm resistor with plus being on top. Then,

$[(0.03 - v_1)/1k] + 400i = v_1/2k$ (1)

Assume that i is in mA. But, $i = (0.03 - v_1)/1$ (2)

Combining (1) and (2) yields,

$v_1 = 29.963$ mVolts and $i = 37.4$ nA, therefore,

$v_0 = -5000x400x37.4x10^{-9} =$ **-74.8 mvolts**

Chapter 3, Solution 87

$v_1 = 500(v_s)/(500 + 2000) = v_s/5$

$v_0 = -400(60v_1)/(400 + 2000) = -40v_1 = -40(v_s/5) = -8v_s$,

Therefore, $v_0/v_s =$ **-8**

Chapter 3, Solution 88

Let v_1 be the potential at the top end of the 100-ohm resistor.

$$(v_s - v_1)/200 = v_1/100 + (v_1 - 10^{-3}v_0)/2000 \qquad (1)$$

For the right loop, $v_0 = -40i_0(10,000) = -40(v_1 - 10^{-3})10,000/2000$,

$$\text{or,}\ \ v_0 = -200v_1 + 0.2v_0 = -4x10^{-3}v_0 \qquad (2)$$

Substituting (2) into (1) gives,

$(v_s + 0.004v_1)/2 = -0.004v_0 + (-0.004v_1 - 0.001v_0)/20$

This leads to $0.125v_0 = 10v_s$ or $(v_0/v_s) = 10/0.125 =$ **-80**

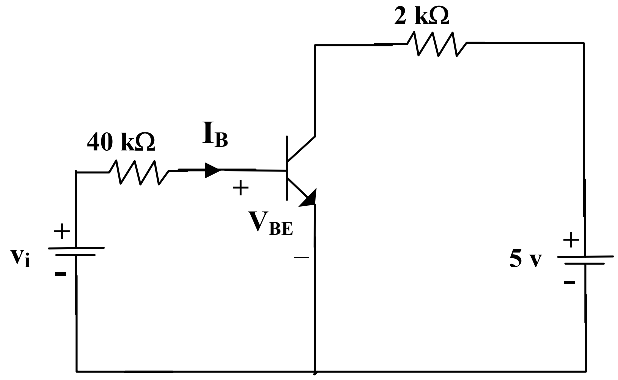
Chapter 3, Solution 89

$$v_i = V_{BE} + 40k\ I_B \qquad (1)$$

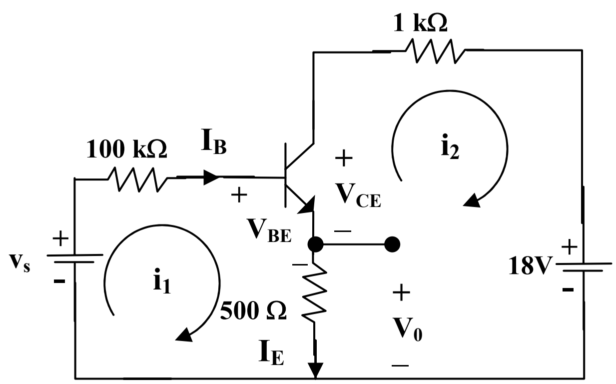
$$5 = V_{CE} + 2k\ I_C \qquad (2)$$

If $I_C = \beta I_B = 75I_B$ and $V_{CE} = 2$ volts, then (2) becomes $5 = 2 + 2k(75I_B)$ which leads to $I_B = 20\ \mu A$.

Substituting this into (1) produces, $v_i = 0.7 + 0.8 =$ **<u>1.5 volts</u>**.



Chapter 3, Solution 90



For loop 1, $-v_s + 10k(I_B) + V_{BE} + I_E\ (500) = 0 = -v_s + 0.7 + 10{,}000I_B + 500(1 + \beta)I_B$

which leads to $v_s + 0.7 = 10{,}000I_B + 500(151)I_B = 85{,}500I_B$

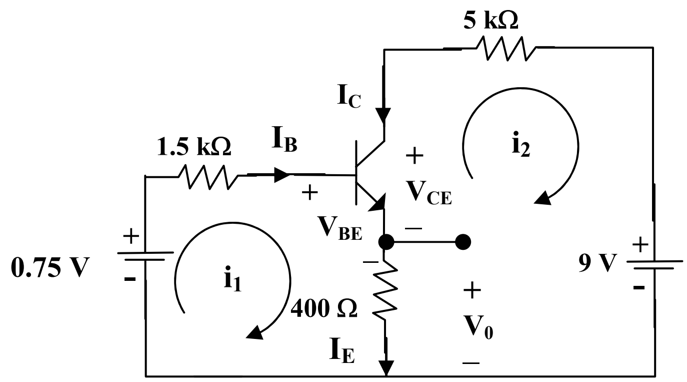
But, $v_0 = 500I_E = 500x151I_B = 4$ which leads to $I_B = 5.298x10^{-5}$

Therefore, $v_s = 0.7 + 85{,}500I_B =$ **<u>5.23 volts</u>**

Chapter 3, Solution 91

We first determine the Thevenin equivalent for the input circuit.

$R_{Th} = 6||2 = 6x2/8 = 1.5\ k\Omega$ and $V_{Th} = 2(3)/(2+6) = 0.75$ volts



For loop 1, $-0.75 + 1.5kI_B + V_{BE} + 400I_E = 0 = -0.75 + 0.7 + 1500I_B + 400(1 + \beta)I_B$

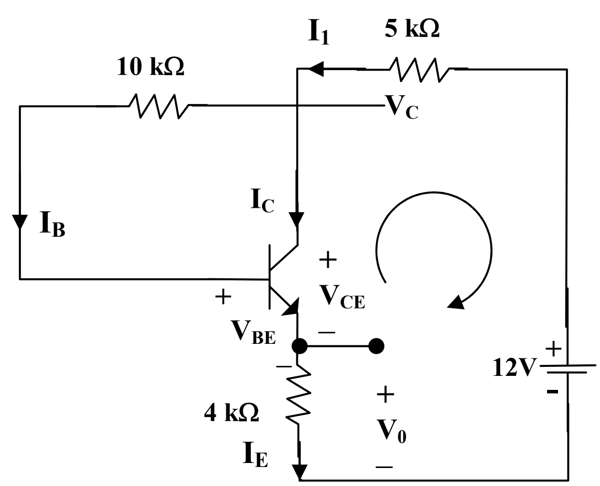
$I_B = 0.05/81{,}900 = \underline{\mathbf{0.61\ \mu A}}$

$v_0 = 400I_E = 400(1 + \beta)I_B = \underline{\mathbf{49\ mV}}$

For loop 2, $-400I_E - V_{CE} - 5kI_C + 9 = 0$, but, $I_C = \beta I_B$ and $I_E = (1 + \beta)I_B$

$V_{CE} = 9 - 5k\beta I_B - 400(1 + \beta)I_B = 9 - 0.659 = \underline{\mathbf{8.641\ volts}}$

Chapter 3, Solution 92



$I_1 = I_B + I_C = (1 + \beta)I_B$ and $I_E = I_B + I_C = I_1$

Applying KVL around the outer loop,

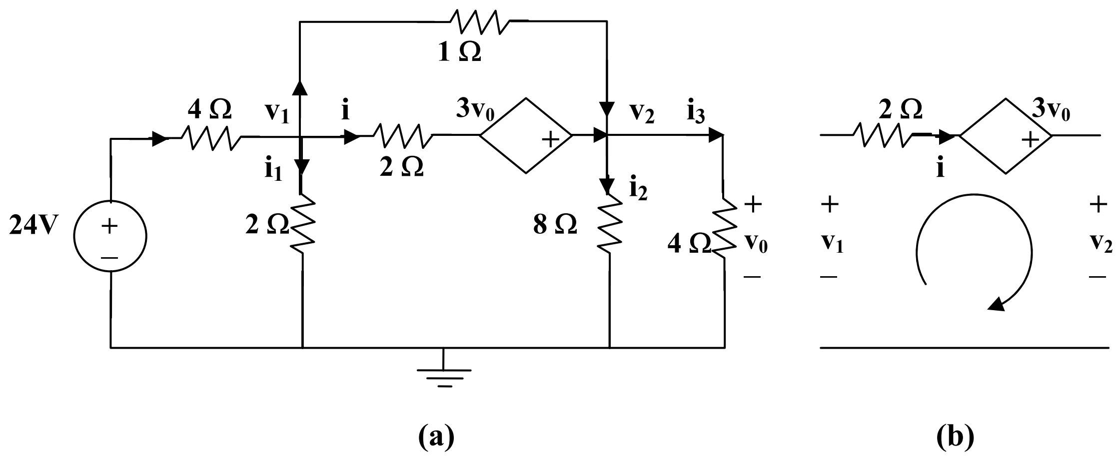
$$4kI_E + V_{BE} + 10kI_B + 5kI_1 = 12$$

$$12 – 0.7 = 5k(1 + \beta)I_B + 10kI_B + 4k(1 + \beta)I_B = 919kI_B$$

$$I_B = 11.3/919k = 12.296\ \mu A$$

Also, $12 = 5kI_1 + V_C$ which leads to $V_C = 12 – 5k(101)I_B =$ **<u>5.791 volts</u>**

Chapter 3, Solution 93



From (b), $-v_1 + 2i – 3v_0 + v_2 = 0$ which leads to $i = (v_1 + 3v_0 – v_2)/2$

At node 1 in (a), $((24 – v_1)/4) = (v_1/2) + ((v_1 +3v_0 – v_2)/2) + ((v_1 – v_2)/1)$, where $v_0 = v_2$

or $24 = 9v_1$ which leads to $v_1 =$ **<u>2.667 volts</u>**

At node 2, $((v_1 – v_2)/1) + ((v_1 + 3v_0 – v_2)/2) = (v_2/8) + v_2/4$, $v_0 = v_2$

$v_2 = 4v_1 =$ **<u>10.66 volts</u>**

Now we can solve for the currents, $i_1 = v_1/2 =$ **<u>1.333 A</u>**, $i_2 =$ **<u>1.333 A</u>**, and

$i_3 =$ **<u>2.6667</u>** A.