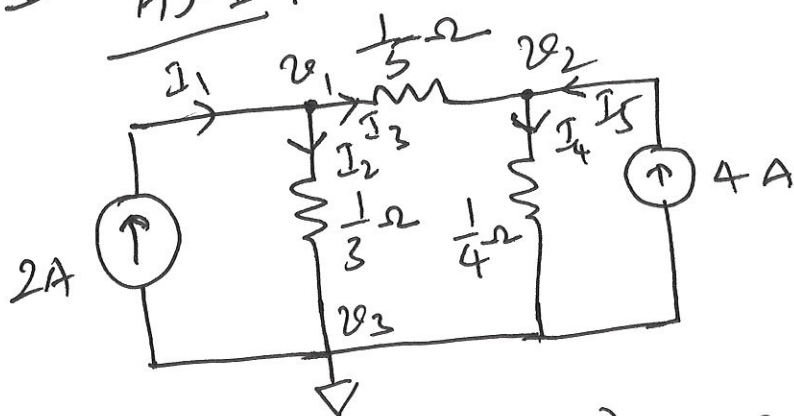


1. Fig. 1:



$$v_3 = 0$$

$$I_1 = I_2 + I_3$$

$$I_3 + I_5 = I_4$$

$$\frac{v_1}{Y_3} + \frac{(v_1 - v_2)}{Y_5} = 2 \quad \text{--- (1)}$$

$$\frac{v_2}{Y_4} + \frac{v_2 - v_1}{Y_5} = 4 \quad \text{--- (2)}$$

$$\begin{bmatrix} 8 & -5 \\ -5 & 9 \end{bmatrix} \begin{bmatrix} v_1 \\ v_2 \end{bmatrix} = \begin{bmatrix} 2 \\ 4 \end{bmatrix}$$

$$v_1 = 0.8085 \text{ V}$$

$$v_2 = 0.8936 \text{ V}$$

Current through $Y_5 \Omega$ resistor = -0.4255 A

Current through $Y_3 \Omega$ resistor = 2.4258 A

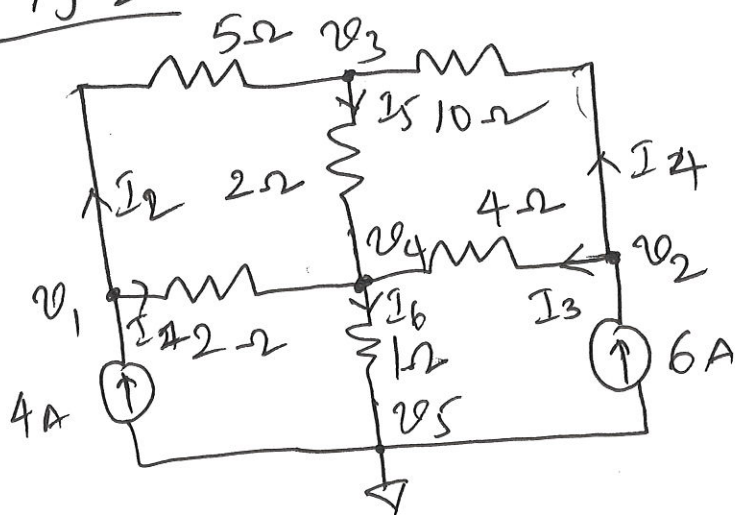
Current through $Y_4 \Omega$ resistor = 3.5744 A

Voltage across $Y_3 \Omega$ resistor = 0.8085 V

Voltage across $Y_4 \Omega$ resistor = 0.8936 V

Voltage across $1/5 \Omega$ resistor = $(0.8085 - 0.8936)$
 $= -0.0851 \text{ V}$

Fig. 2



$$\begin{aligned} \left(\frac{1}{2} + \frac{1}{5}\right)v_1 - \frac{1}{5}v_3 - \frac{1}{2}v_4 &= 4 \quad \text{KCL at node } v_1 \\ \left(\frac{1}{4} + \frac{1}{10}\right)v_2 - \frac{1}{10}v_3 - \frac{1}{4}v_4 &= 6 \quad \text{KCL at node } v_2 \\ -\frac{1}{5}v_1 - \frac{1}{10}v_2 + \left(\frac{1}{5} + \frac{1}{2} + \frac{1}{10}\right)v_3 - \frac{1}{2}v_4 &= 0 \quad \text{KCL at node } v_3 \\ -\frac{1}{2}v_1 - \frac{1}{4}v_2 - \frac{1}{2}v_3 + v_4 \left(\frac{1}{2} + \frac{1}{2} + 1 + \frac{1}{4}\right) &= 0 \quad \text{KCL at node } v_4 \end{aligned}$$

$$0.7v_1 + 0.0v_2 - 0.2v_3 - 0.5v_4 = 4$$

$$0.35v_2 - 0.1v_3 - 0.25v_4 = 6$$

$$-0.2v_1 - 0.10v_2 + 0.8v_3 - 0.50v_4 = 0$$

$$-0.5v_1 - 0.25v_2 - 0.5v_3 + 2.25v_4 = 0$$

$$\begin{bmatrix} 0.7 & 0 & -0.2 & -0.5 \\ 0 & 0.35 & -0.1 & -0.25 \\ -0.2 & -0.10 & 0.8 & -0.5 \\ -0.5 & -0.25 & -0.5 & 2.25 \end{bmatrix} \begin{bmatrix} v_1 \\ v_2 \\ v_3 \\ v_4 \end{bmatrix} = \begin{bmatrix} 4 \\ 6 \\ 0 \\ 0 \end{bmatrix}$$

(3)

$$v_1 = 16.8571 \text{ V}$$

$$v_2 = 28.2857 \text{ V}$$

$$v_3 = 14 \text{ V}$$

$$v_4 = 10 \text{ V}$$

$$I_1 = \frac{1}{2} (v_1 - v_4) = 3.43 \text{ A}$$

$$I_2 = \frac{1}{5} (v_1 - v_3) = 0.57 \text{ A}$$

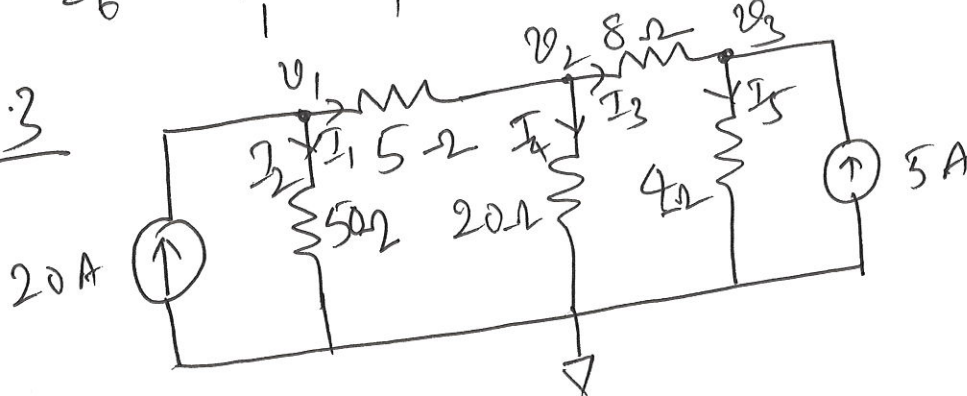
$$I_3 = \frac{1}{4} (v_2 - v_4) = 4.57 \text{ A}$$

$$I_4 = \frac{1}{2} (v_2 - v_3) = 2 \text{ A}$$

$$I_5 = \frac{1}{2} (v_3 - v_4) = 2 \text{ A}$$

$$I_6 = \frac{1}{1} v_4 = 10 \text{ A}$$

Fig. 3



At node v_1 $I_1 + I_2 = 20 \text{ A}$

$$\left(\frac{1}{5} + \frac{1}{50}\right)v_1 - \frac{1}{5}v_2 = 20 \quad \text{--- (1)}$$

At node v_2 $I_1 = I_3 + I_4$

$$-\frac{1}{5}v_1 + \left(\frac{1}{5} + \frac{1}{8} + \frac{1}{20}\right)v_2 - \frac{1}{8}v_3 = 0 \quad \text{--- (2)}$$

At node v_3

$$I_3 + I_4 = 5$$

$$-\frac{1}{8}v_2 + \left(\frac{1}{4} + \frac{1}{8}\right)v_3 = 5 \quad (3)$$

$$\begin{bmatrix} 0.22 & -0.2 & 0 \\ -0.2 & 0.375 & 0.125 \\ 0 & -0.125 & 0.375 \end{bmatrix} \begin{bmatrix} v_1 \\ v_2 \\ v_3 \end{bmatrix} = \begin{bmatrix} 20 \\ 0 \\ -5 \end{bmatrix}$$

$$v_1 = 190 \text{ V} \quad v_2 = 109 \text{ V} \quad v_3 = 23 \text{ V}$$

$$I_1 = 16.2 \text{ A} \quad I_2 =$$

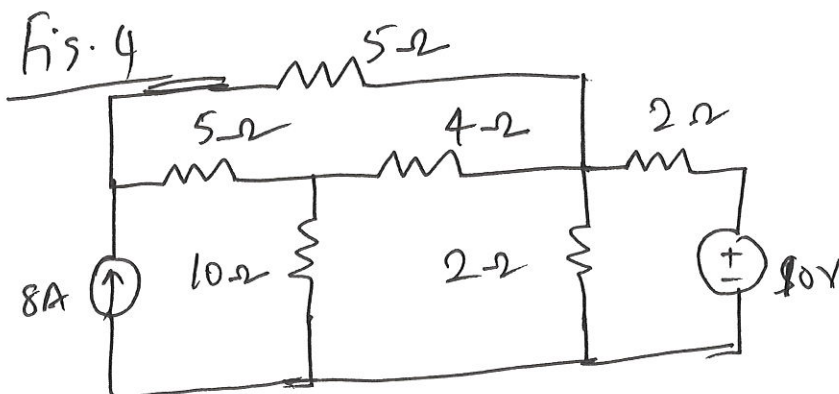
$$I_1 = \frac{v_1 - v_2}{5} = \frac{190 - 109}{5} = 16.2 \text{ A}$$

$$I_2 = \frac{v_1}{50} = \frac{190}{50} = 3.8 \text{ A}$$

$$I_3 = \frac{v_2 - v_3}{8} = \frac{109 - 23}{8} = 10.75 \text{ A}$$

$$I_4 = \frac{v_2}{20} = \frac{109}{20} = 5.45 \text{ A}$$

$$I_5 = \frac{v_3}{4} = \frac{23}{4} = 5.75 \text{ A}$$

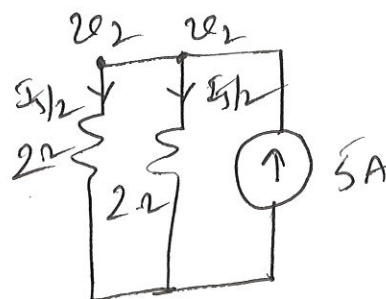
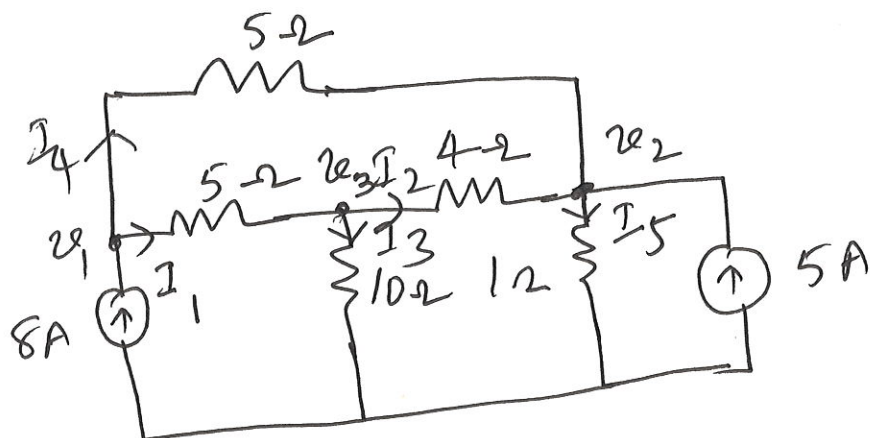


Using Source transformation

$$I_{S1} = \frac{10}{2} = 5 \text{ A}$$

$$2\Omega // 2\Omega = 1\Omega$$

5



$$\left(\frac{1}{5} + \frac{1}{5}\right)v_1 - \frac{1}{5}v_2 - \frac{1}{5}v_3 = 8 \quad - (1)$$

$$-\frac{1}{5}v_1 + \left(\frac{1}{4} + \frac{1}{5}\right)v_2 - \frac{1}{4}v_3 = 5 \quad - (2)$$

$$-\frac{1}{5}v_1 - \frac{1}{4}v_2 + \left(\frac{1}{5} + \frac{1}{10} + \frac{1}{4}\right)v_3 = 0 \quad - (3)$$

$$\begin{bmatrix} 0.4 & -0.2 & -0.2 \\ -0.2 & 1.45 & -0.25 \\ -0.2 & -0.25 & 0.55 \end{bmatrix} \begin{bmatrix} v_1 \\ v_2 \\ v_3 \end{bmatrix} = \begin{bmatrix} 8 \\ 5 \\ 0 \end{bmatrix}$$

$$v_1 = 34.43 \text{ V} \quad v_2 = 11.24 \text{ V} \quad v_3 = 17.63 \text{ V}$$

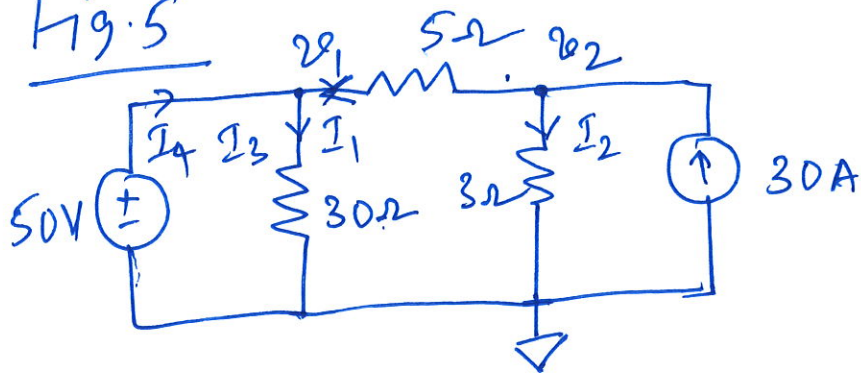
$$I_1 = \frac{v_1 - v_3}{5} = 3.36 \text{ A} \quad I_2 = \frac{v_3 - v_2}{4} = 1.5975 \text{ A}$$

$$I_3 = \frac{v_3}{10} = 1.763 \text{ A} \quad I_4 = \frac{v_1 - v_2}{5} = 4.838 \text{ A}$$

$$I_5 = \frac{v_2}{2} = \frac{11.24}{2} = 5.62 \text{ A}$$

$$\frac{I_5}{2} = \underline{5.62 \text{ A}} \quad (\text{Current through } 2\text{-}\Omega \text{ resistor})$$

Fig. 5



At node v_1 , $v_1 = 50 \text{ V}$.

At node v_2 , $I_1 + I_2 = 30$

$$\frac{v_2 - v_1}{5} + \frac{v_2}{3} = 30$$

$$v_1 = 50 \quad \left(\frac{1}{5} + \frac{1}{3}\right) v_2 = 40$$

$$v_2 = 75 \text{ V}$$

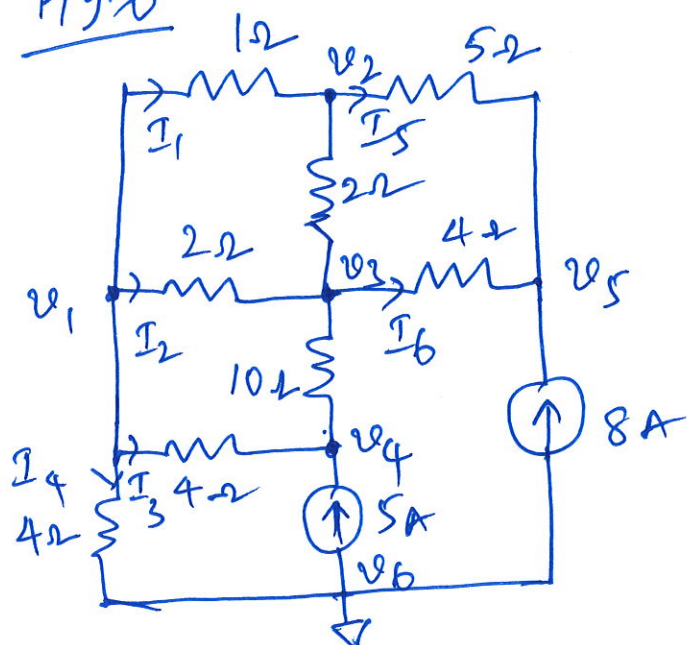
$$I_2 = \frac{75}{3} = 25 \text{ A}$$

$$I_1 = \frac{75 - 50}{5} = 5 \text{ A}$$

$$I_3 = \frac{v_1}{30} = \frac{50}{30} = 1.67 \text{ A}$$

$$I_1 + I_4 = I_3 \Rightarrow I_4 = I_3 - I_1 = \underline{\underline{3.33 \text{ A}}}$$

Fig. 6



$$\left(\frac{1}{1} + \frac{1}{2} + \frac{1}{4} + \frac{1}{4}\right)v_1 - \frac{1}{1}v_2 - \frac{1}{2}v_3 - \frac{1}{4}v_4 = 0$$

$$-\frac{1}{1}v_1 \quad \left(\frac{1}{1} + \frac{1}{2} + \frac{1}{5}\right)v_2 - \frac{1}{2}v_1 - \frac{1}{5}v_5 = 0$$

$$-\frac{1}{2}v_1 - \frac{1}{2}v_2 + \left(\frac{1}{2} + \frac{1}{2} \cdot \frac{1}{4} + \frac{1}{10}\right)v_3 - \frac{1}{10}v_4 - \frac{1}{4}v_5 = 0$$

$$-\frac{1}{4}v_1 - \frac{1}{10}v_3 + \left(\frac{1}{4} + \frac{1}{10}\right)v_4 = 5$$

$$-\frac{1}{5}v_2 - \frac{1}{4}v_3 + \left(\frac{1}{5} + \frac{1}{4}\right)v_5 = 8$$

$$\begin{bmatrix} 2 & -1 & -0.5 & -0.25 & 0 \\ -1 & 1.7 & -0.5 & 0 & -0.2 \\ -0.5 & -0.5 & 1.35 & -0.1 & -0.25 \\ -0.25 & 0 & -0.1 & 0.35 & 0 \\ 0 & -0.2 & -0.25 & 0 & 0.45 \end{bmatrix} \begin{bmatrix} v_1 \\ v_2 \\ v_3 \\ v_4 \\ v_5 \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 5 \\ 8 \end{bmatrix}$$

$$v_1 = 52 \text{ V} \quad v_2 = 57.09 \text{ V} \quad v_3 = 59.60 \text{ V}$$

$$v_4 = 68.46 \text{ V} \quad v_5 = 76.26 \text{ V}$$

$$I_1 = \frac{v_1 - v_2}{1} = -5.09 \text{ A}$$

$$I_5 = \frac{v_2 - v_5}{5} = -3.834 \text{ A} \quad (8)$$

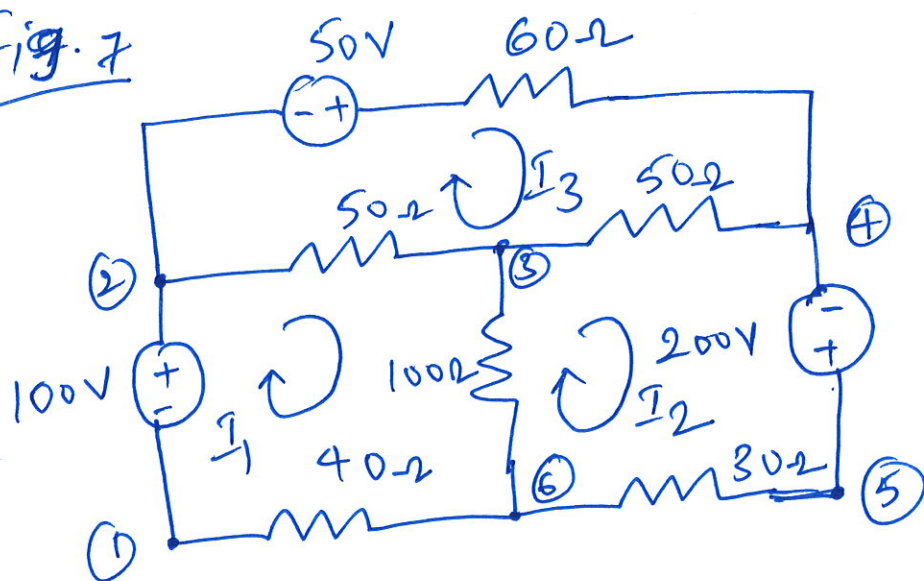
$$I_2 = \frac{v_1 - v_3}{2} = -3.8 \text{ A}$$

$$I_6 = \frac{v_3 - v_5}{4} = -4.165 \text{ A}$$

$$I_3 = \frac{v_1 - v_4}{4} = -4.115 \text{ A}$$

$$I_4 = \frac{v_1}{4} = 13 \text{ A}$$

Fig. 7



Applying KVL to mesh 1-2-3-6-1

$$40I_1 + 50(I_1 - I_3) + 100(I_1 - I_2) = 100$$

$$190I_1 - 100I_2 - 50I_3 = 100 \quad (1)$$

Applying KVL to mesh 6-3-4-5-6

$$30I_1 + 100(I_2 - I_1) + 50(I_2 - I_3) = 200$$

$$-100I_1 + 180I_2 - 50I_3 = 200 \quad (2)$$

Applying KVL to mesh 2-4-3-2

$$50(I_3 - I_1) + 60I_3 + 50(I_3 - I_2) = 50$$

$$-50 I_1 - 50 I_2 + 160 I_3 = 50 \quad (3)$$

(9)

$$\begin{bmatrix} 190 & -100 & -50 \\ -100 & 180 & -50 \\ -50 & -50 & 160 \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \\ I_3 \end{bmatrix} = \begin{bmatrix} 100 \\ 200 \\ 50 \end{bmatrix}$$

$$I_1 = 2.873 \text{ A} \quad I_2 = 3.33 \text{ A} \quad I_3 = 2.252 \text{ A}$$

$$I_{40\Omega} = 2.873 \text{ A} \quad V_{40\Omega} = 114.92 \text{ V}$$

$$I_{100\Omega} = I_1 - I_2 = -0.46 \text{ A} \quad V_{100\Omega} = -46 \text{ V}$$

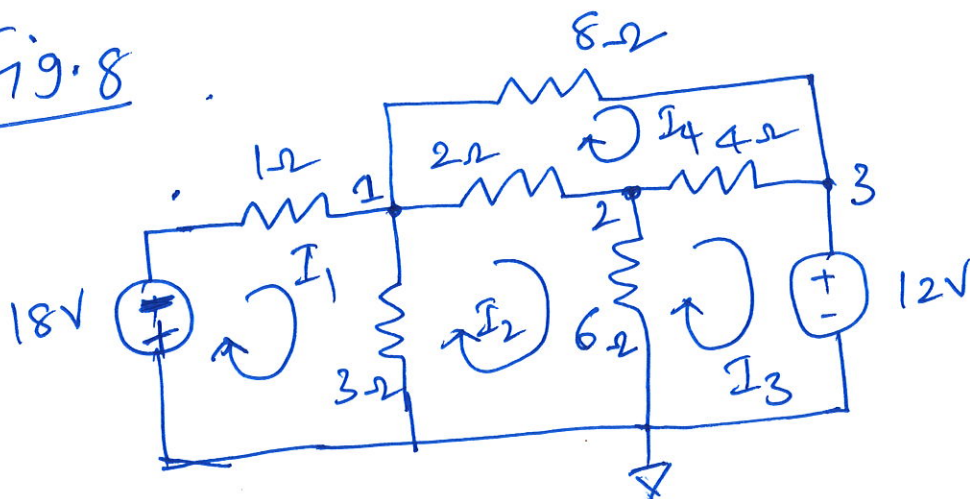
$$I_{60\Omega} = 2.252 \text{ A} \quad V_{60\Omega} = 135.12 \text{ V}$$

$$I_{50\Omega} = I_3 - I_2 = -1.081 \text{ A} \quad V_{50\Omega} = -54.05 \text{ V}$$

$$I_{50\Omega} = I_3 - I_1 = -0.621 \text{ A} \quad V_{50\Omega} = -31.05 \text{ V}$$

$$I_{30\Omega} = 3.333 \text{ A} \quad V_{30\Omega} = 100 \text{ V}$$

Fig. 8



$$\text{Mesh 1: } 4I_1 - 3I_2 = -18 \quad (1)$$

$$\text{Mesh 2: } -3I_1 + 11I_2 - 6I_3 - 2I_4 = 0 \quad (2)$$

$$\text{Mesh 3: } -6I_2 + 10I_3 - 4I_4 = -12 \quad (3)$$

Mesh 4:

(10)

$$-2I_2 - 4I_3 + 14I_4 = 0 \quad - (4)$$

$$\begin{bmatrix} 4 & -3 & 0 & 0 \\ -3 & 11 & -6 & -2 \\ 0 & -6 & 10 & -4 \\ 0 & -2 & -4 & 14 \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \\ I_3 \\ I_4 \end{bmatrix} = \begin{bmatrix} -18 \\ 0 \\ -12 \\ 0 \end{bmatrix}$$

$$I_1 = -9.182 \text{ A} \quad I_2 = -6.243 \text{ A}$$

$$I_3 = -5.987 \text{ A} \quad I_4 = -2.602 \text{ A}$$

$$I_{1\Omega} = -9.182 \text{ A} \quad V_{1\Omega} = -9.182 \text{ V}$$

$$V_{3\Omega} = I_1 - I_2 = -2.939 \text{ A} \quad V_{3\Omega} = -8.817 \text{ V}$$

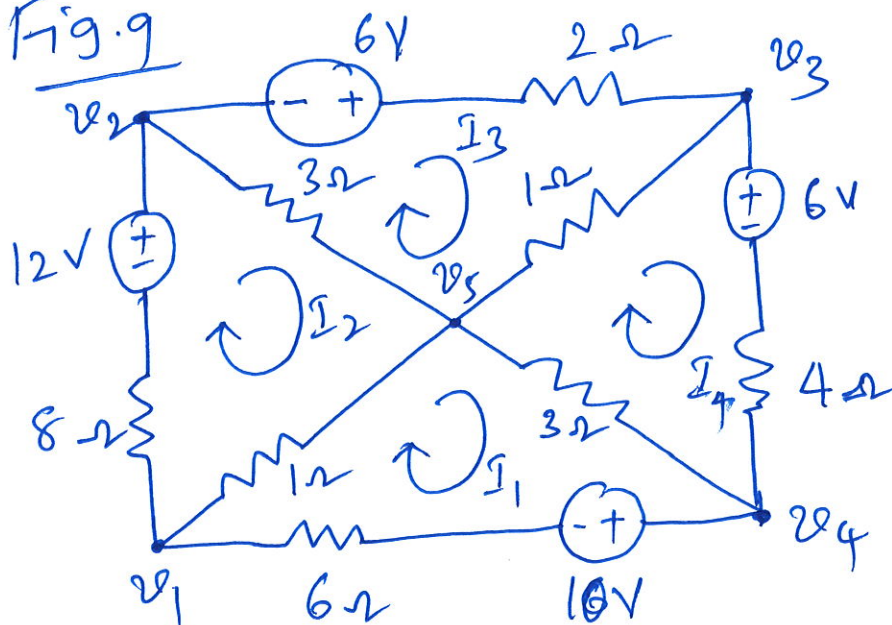
$$I_{6\Omega} = I_2 - I_3 = -0.256 \text{ A} \quad V_{6\Omega} = -1.536 \text{ V}$$

$$I_{8\Omega} = -2.602 \text{ A} \quad V_{8\Omega} = -20.816 \text{ V}$$

$$I_{2\Omega} = I_4 - I_2 = +3.641 \text{ A}, \quad V_{2\Omega} = +9.884 \text{ V}$$

$$I_{4\Omega} = I_4 - I_3 = 3.385 \text{ A} \quad V_{4\Omega} = 13.54 \text{ V}$$

Fig. 9



Mesh 1: $10I_1 - I_2 - 3I_4 = -10$

Mesh 2: $-I_1 + 12I_2 - 3I_3 = 12$

Mesh 3: $-3I_2 + 6I_3 - I_4 = 6$

Mesh 4: $-3I_1 - I_3 + 8I_4 = -6$

$$\begin{bmatrix} 10 & -1 & 0 & -3 \\ -1 & 12 & -3 & 0 \\ 0 & -3 & 6 & -1 \\ -3 & 0 & -1 & 8 \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \\ I_3 \\ I_4 \end{bmatrix} = \begin{bmatrix} -10 \\ 12 \\ 6 \\ -6 \end{bmatrix}$$

$I_1 = -1.1754 \text{ A}$ $I_2 = 1.2687 \text{ A}$ $I_3 = 1.4664 \text{ A}$

$I_4 = -1.0075 \text{ A}$

$I_{6\Omega} = -1.1754 \text{ A}$ $V_{6\Omega} = -7.0524 \text{ V}$

$I_{8\Omega} = 1.2687 \text{ A}$ $V_{8\Omega} = 10.1496 \text{ V}$

$I_{2\Omega} = 1.4664 \text{ A}$ $V_{2\Omega} = 2.9328 \text{ V}$

$I_{4\Omega} = -1.0075 \text{ A}$ $V_{4\Omega} = -4.03 \text{ V}$

$I_{1\Omega} = I_1 - I_2 = -2.4441 \text{ A}$ $V_{1\Omega} = -2.4441 \text{ V}$

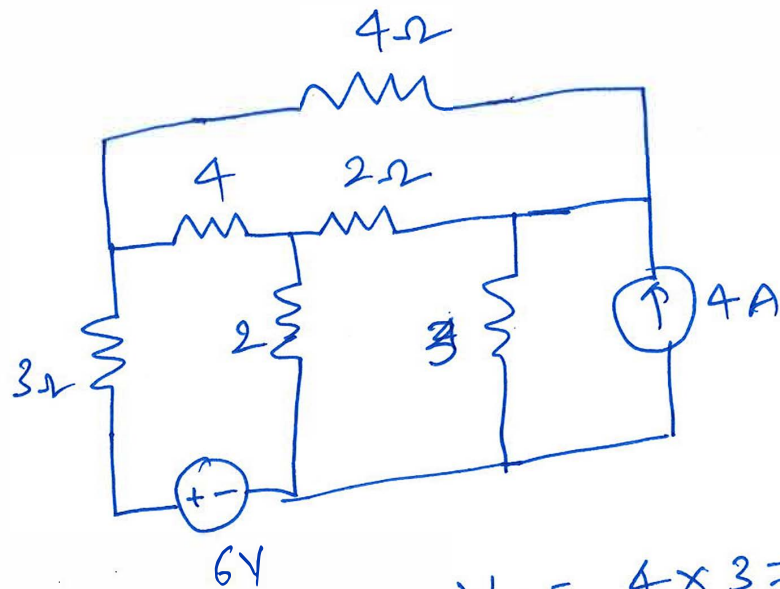
$I_{1\Omega} = I_3 - I_4 = 2.4739 \text{ A}$ $V_{1\Omega} = 2.4739 \text{ V}$

$I_{3\Omega} = I_2 - I_3 = -0.1977 \text{ A}$ $V_{3\Omega} = -0.5931 \text{ V}$

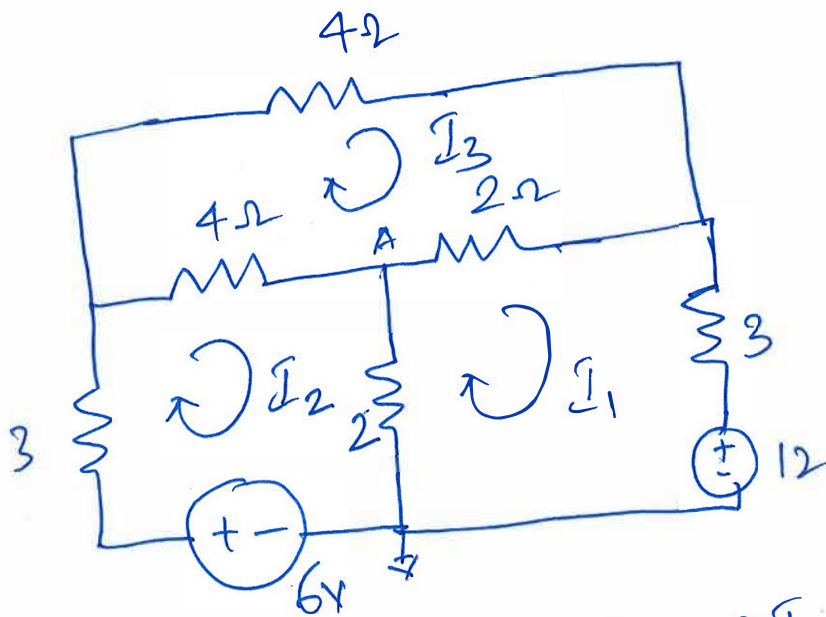
$I_{3\Omega} = I_1 - I_4 = -0.1679 \text{ A}$ $V_{3\Omega} = -0.5037 \text{ V}$

Fig. 10

(12)



Using Source transformation, $V_s = 4 \times 3 = 12V$



In mesh 1: $7I_1 - 2I_2 - 2I_3 = -12$ — (1)

Mesh 2: $-2I_1 + 9I_2 - 4I_3 = 6$ — (2)

Mesh 3: $-2I_1 - 4I_2 + 10I_3 = 0$ — (3)

$$\begin{bmatrix} 7 & -2 & -2 \\ -2 & 9 & -4 \\ -2 & -4 & 10 \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \\ I_3 \end{bmatrix} = \begin{bmatrix} -12 \\ 6 \\ 0 \end{bmatrix}$$

$$I_1 = -1.7561 \text{ A} \quad I_2 = 0.1463 \text{ A} \quad I_3 = -0.2927 \text{ A} \quad (13)$$

$$I_{3\Omega} = -1.756 \text{ A} \quad V_{3\Omega} = -5.268 \text{ V}$$

$$I_{2\Omega} = I_1 - I_2 = -1.9023 \text{ A} \quad V_{2\Omega} = -3.8046 \text{ V}$$

$$I_{2\Omega} = I_1 - I_3 = -1.4634 \text{ A} \quad V_{2\Omega} = -2.9268 \text{ V}$$

$$I_{3\Omega} = I_2 = 0.1463 \text{ A}$$

$$V_{3\Omega} = 0.4369 \text{ V}$$

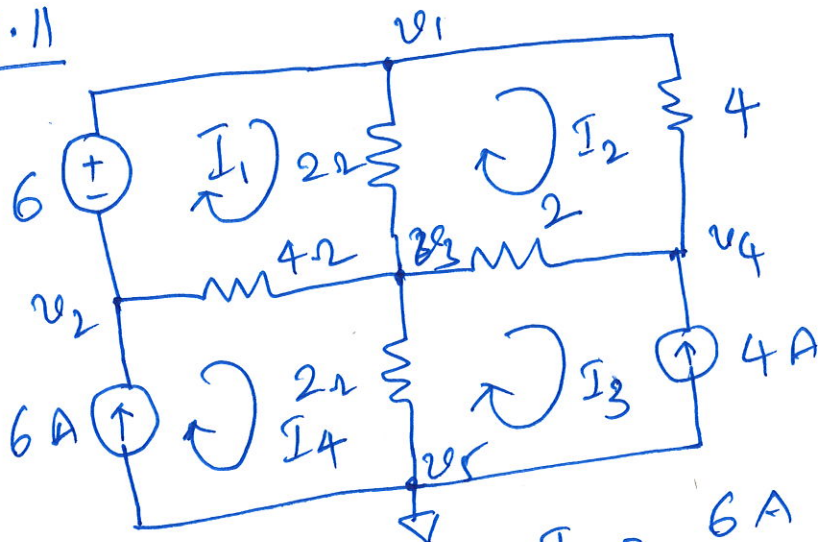
$$I_{4\Omega} = I_2 - I_3 = 0.439 \text{ A}$$

$$V_{4\Omega} = 1.756 \text{ V}$$

$$I_{4\Omega} = I_3 = -0.2927 \text{ A}$$

$$V_{4\Omega} = -1.1708 \text{ V}$$

Fig. 11



$$I_3 = -4 \text{ A} \quad I_4 = 6 \text{ A}$$

$$\begin{aligned} \text{In Mesh I: } 6I_1 - 2I_2 - 4I_4 &= 6 \\ 6I_1 - 2I_2 &= 30 \quad - (1) \end{aligned}$$

$$\begin{aligned} \text{In Mesh II: } -2I_1 + 8I_2 - 2I_3 &= 0 \\ -2I_1 + 8I_2 &= -8 \quad - (2) \end{aligned}$$

$$\text{Solving, } I_1 = 5.09 \text{ A} \quad I_2 = 0.273 \text{ A}$$

(14)

$$I_{2\Omega} = I_4 = 5.09A \quad V_{2\Omega} = 10.18V$$

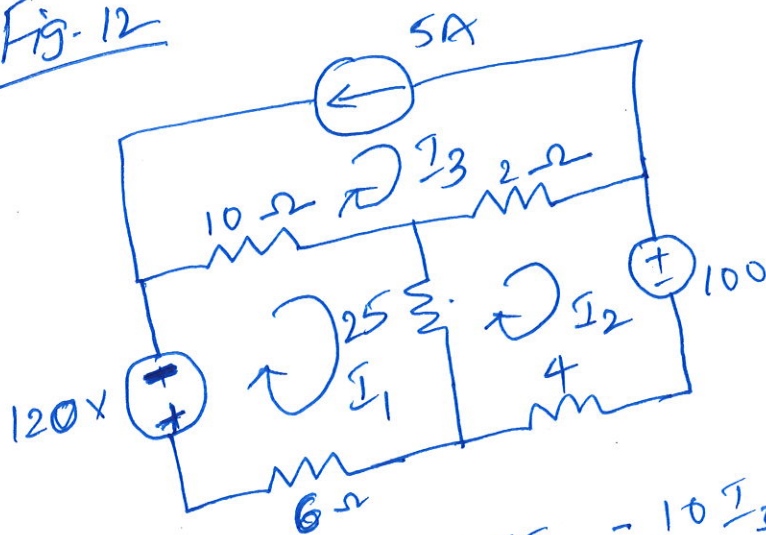
$$I_{4\Omega} = I_1 - I_4 = -0.91A \quad V_{4\Omega} = -3.64V$$

$$I_{4\Omega} = I_2 = 0.273A \quad V_{4\Omega} = 1.092V$$

$$I_{2\Omega} = I_2 - I_3 = 4.273A \quad V_{2\Omega} = 8.546V$$

$$I_{2\Omega} = I_4 - I_3 = 10A \quad V_{2\Omega} = 20V$$

Fig. 12



$$I_3 = -5A$$

$$\text{Mesh 1: } 4I_1 - 25I_2 - 10I_3 = -120 \quad \text{--- (1)}$$

$$\text{Mesh 2: } -25I_1 + 31I_2 - 2I_3 = +100 \quad \text{--- (2)}$$

$$\text{Simplify for}$$

$$4I_1 - 25I_2 = -170$$

$$-25I_1 + 31I_2 = 90$$

$$\text{Solving } I_1 = -4.675A \quad I_2 = -0.867A$$

$$I_{10\Omega} = I_3 - I_1 = -0.325A \quad V_{10\Omega} = -3.25V$$

$$I_{2\Omega} = I_3 - I_2 = -4.132A \quad V_{2\Omega} = -8.266V$$

$$I_{4\Omega} = I_2 = -0.867A \quad V_{4\Omega} = -3.468V$$

$$I_{25\Omega} = I_1 - I_2 = -3.808 \text{ A} \quad V_{25\Omega} = -95.2 \text{ V}$$

(15)

$$I_{6\Omega} = I_4 = -4.675 \text{ A} \quad V_{6\Omega} = -28.05 \text{ V}$$