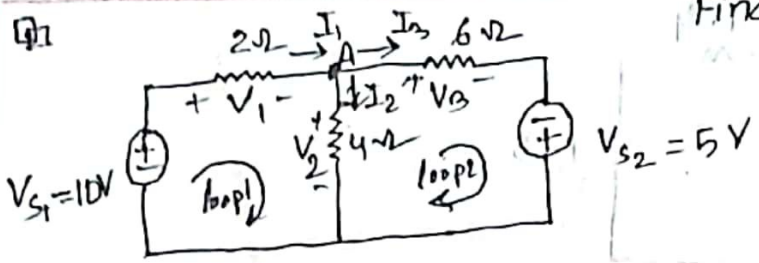
Loop Analysis 2

Date : 02-07-2025

Find $I_1, I_2, I_3, V_1, V_2, V_3$

Q1



Using KVL in loop 1,

$-10 + 2I_1 + 4I_2 = 0$

$\Rightarrow 2I_1 + 4I_2 = 10$ ——— (1)

KVL in loop 2,

$-4I_2 + 6I_3 - 5 = 0$

$\Rightarrow 6I_3 - 4I_2 = 5$ ——— (II)

Using KCL, in node A,

$I_1 = I_2 + I_3$ ——— (III)

(III) in (I) $\Rightarrow$

$2I_2 + 2I_3 + 4I_2 = 10$

$\Rightarrow 6I_2 + 2I_3 = 10$

$\Rightarrow 3I_2 + I_3 = 5$ ——— (IV)

eq(II) $\times 3$ + eq(IV) $\times 4 \Rightarrow$

$-I_2 12 + I_3 18 = 15$

$I_2 12 + I_3 4 = 20$

$22 I_3 = 35$

$\therefore I_3 = \frac{35}{22} = 1.59\ A$

Putting $I_3 = 1.59A$ in eq (II)

$-I_2 4 + (1.59) \times 6 = 5$

$\therefore I_2 = 1.136\ A$

$\therefore I_1 = 1.136 + 1.59$

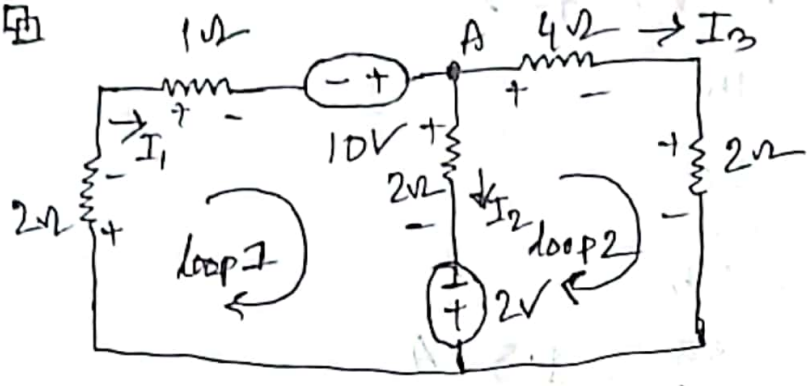
$= 2.73\ A$

Using ohm's Law,

$V_1 = I_1 2 = 2.73 \times 2 = 5.46\ V$

$V_2 = I_2 4 = 1.136 \times 4 = 4.5\ V$

$V_3 = I_3 6 = 1.59 \times 6 = 9.5\ V$



Using KVL in loop 1,

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

$$\Rightarrow 3I_1 + 2I_2 = 12 \quad \text{---(I)}$$

Using KVL in loop 2,

$$2 - 2I_2 + 4I_3 + 2I_3 = 0$$

$$\Rightarrow -2I_2 + 6I_3 + 2 = 0$$

$$\Rightarrow 2I_2 - 6I_3 = 2 \quad \text{---(II)}$$

Using KCL in node A,

$$I_1 = I_2 + I_3 \quad \text{---(III)}$$

(III) in (I) $\Rightarrow$

$$3I_2 + 3I_3 + 2I_2 = 12$$

$$\Rightarrow 5I_2 + 3I_3 = 12 \quad \text{---(IV)}$$

eq (ii) + eq (iv) × 2 ⇒

$$2I_2 - 6I_3 = 2$$

$$+10I_2 + 6I_3 = 24$$

$$12I_2 = 26$$

$$\Rightarrow I_2 = \frac{26}{12} = 2.17\,A$$

$I_2 = 2.17A$ in eq (ii) ⇒

$$2(2.17) - 6I_3 = 2$$

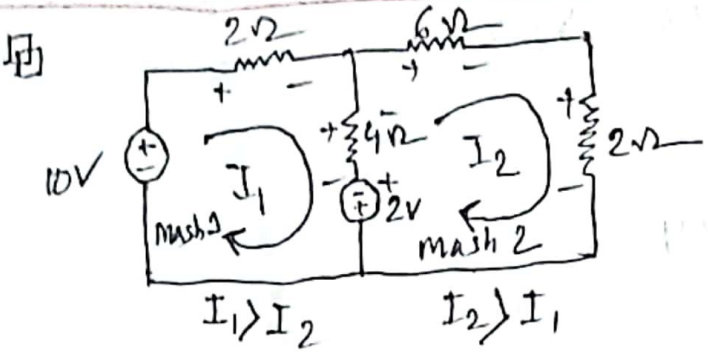
$$\Rightarrow 4.34 - 6I_3 = 2$$

$$\Rightarrow I_3 = \frac{2.34}{6} = 0.39\,A$$

$$\therefore I_1 = 2.17 + 0.39$$

$$= 2.56\,A$$

Mesh Analysis 4



Applying KVL in mesh 1,

$$-10 + 2I_1 + 4(I_1 - I_2) - 2 = 0$$

$$\Rightarrow -10 + 2I_1 + 4I_1 - 4I_2 - 2 = 0$$

$$\Rightarrow 6I_1 - 4I_2 = 12 \quad \text{---(I)}$$

Applying KVL in mesh 2,

$$2 + 4(I_2 - I_1) + 6I_2 + 2I_2 = 0$$

$$\Rightarrow 2 + 4I_2 - 4I_1 + 6I_2 + 2I_2 = 0$$

$$\Rightarrow -4I_1 + 12I_2 = -2$$

$$\Rightarrow 4I_1 - 12I_2 = 2 \quad \text{---(II)}$$

Type-1

(I) × 3 − (II) ⇒

$$18I_1 - 12I_2 = 36$$

$$4I_1 - 12I_2 = 2$$

(−) (+) (−)

$$14I_1 = 34$$

$$\therefore I_1 = 2.4\ A$$

$I_1 = 2.4$ in eq (11) $\Rightarrow$

$4(2.4) - 12I_2 = 2$

$\Rightarrow I_2 = \frac{7.6}{12}$

$\therefore I_2 = 0.6\ A$

Type-2 Using Cramer's rule,

$$\begin{bmatrix} 3 & -2 \\ -2 & 6 \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \end{bmatrix} = \begin{bmatrix} 6 \\ -1 \end{bmatrix}$$

$$\Delta = \begin{bmatrix} 3 & -2 \\ -2 & 6 \end{bmatrix} = 14$$

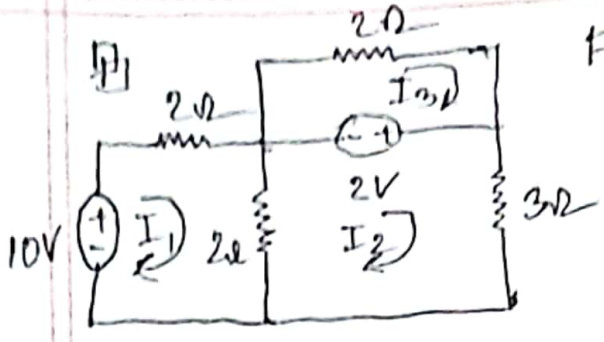
$$\Delta_1 = \begin{bmatrix} 6 & -2 \\ -1 & 6 \end{bmatrix} = 34$$

$$\Delta_2 = \begin{bmatrix} 3 & 6 \\ -2 & -1 \end{bmatrix} = 9$$

$$I_1 = \frac{\Delta_1}{\Delta} = \frac{34}{14} = 2.4$$

$$I_2 = \frac{\Delta_2}{\Delta} = \frac{9}{34} = 0.26$$

Find mesh current and power across 3Ω resistor.



Using KVL in mesh 1,

$$-10 + 2I_1 + 2(I_1 - I_2) = 0$$

$$\Rightarrow -10 + 2I_1 + 2I_1 - 2I_2 = 0$$

$$\Rightarrow 4I_1 - 2I_2 = 10 \quad \text{——(I)}$$

Using KVL in mesh 2,

$$2(I_2 - I_1) - 2 + 3I_2 = 0$$

$$\Rightarrow 2I_2 - 2I_1 - 2 + 3I_2 = 0$$

$$\Rightarrow -2I_1 + 5I_2 - 2 = 0$$

$$\Rightarrow 2I_1 - 5I_2 = -2 \quad \text{——(II)}$$

eq(I) − eq(II) × 2 ⇒

$$4I_1 - 2I_2 = 10$$

$$4I_1 - 10I_2 = -2$$

(−) (+) (+)

$$8I_2 = 12$$

$$\therefore I_2 = 1.5\,A$$

Using KVL in mesh 3,

$2 + 2I_3 = 0$

$\Rightarrow I_3 = -1$

$I_2 = 1.5A$ in eq (1) $\Rightarrow$

$4I_1 - 2(1.5) = 10$

$\Rightarrow 4I_1 = 13$

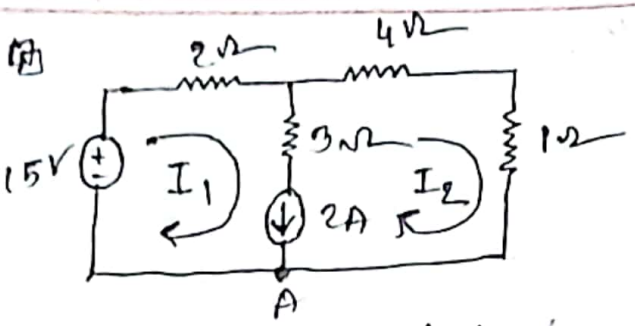
$\therefore I_1 = 3.25$ A

$P = I_2^2 R$

$= (1.5)^2 \times 3$

$=$

→ current

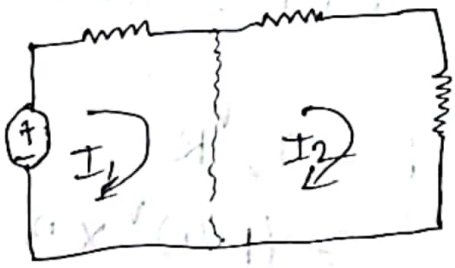


Using KVL in mesh 1,

$$-15 + 2I_1 + 3(I_1 - I_2) + 2 = 0$$

$$\Rightarrow -15 + 2I_1 + 3I_1 - 3I_2 + 2 = 0$$

$$\Rightarrow 5I_1 - 3I_2 = 13 \quad \text{---(i)}$$



Using KVL in supermesh,

$$-15 + 2I_1 + 4I_2 + I_2 = 0$$

$$\Rightarrow 2I_1 + 5I_2 = 15 \quad \text{---(ii)}$$

Applying KCL in node A,

$$I_1 = 2 + I_2 \quad \text{---(iii)}$$

$I_1 = 2 + I_2$ in eq (i) $\Rightarrow$

$$2(2 + I_2) + 5I_2 = 15$$

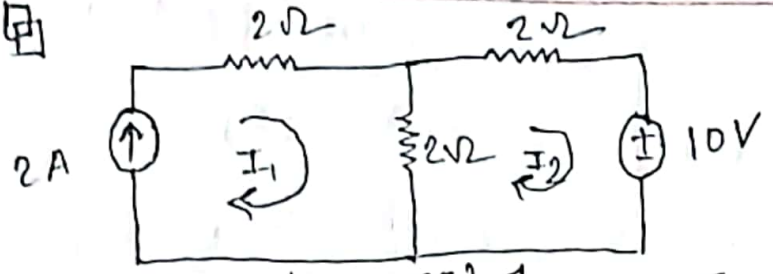
$$\Rightarrow 4 + 2I_2 + 5I_2 = 15$$

$$\Rightarrow 7I_2 = 11$$

$$\therefore I_2 = 1.57A$$

$$\therefore I_1 = 2 + 1.57$$

$$= 3.57A$$



Using KVL in mesh 1

$$2I_1 + 2(I_1 - I_2) = 0$$

$$\Rightarrow 2I_1 + 2I_1 - 2I_2 = 0$$

$$\Rightarrow 4I_1 - 2I_2 = 0 \quad \text{---(1)}$$

From mesh 1,

$$I_1 = 2A$$

Using KVL in mesh 2,

$$10 + 2(I_2 - I_1) + 2I_2 = 0$$

$$\Rightarrow 10 + 2I_2 - 2I_1 + 2I_2 = 0$$

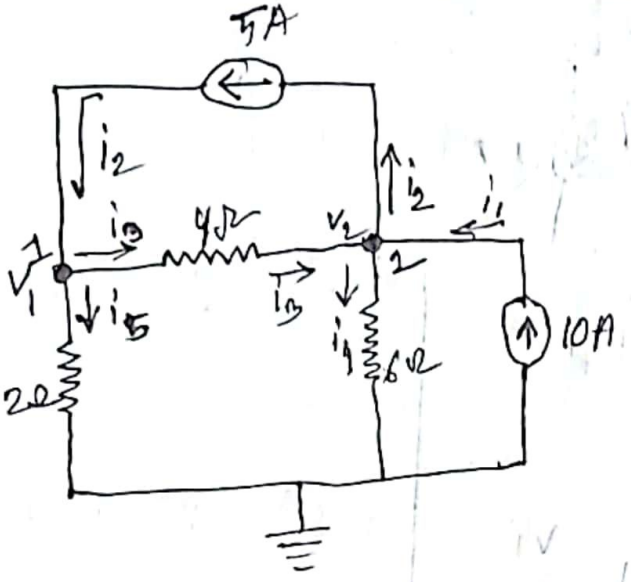
$$\Rightarrow 4I_2 - 2I_1 = -10$$

$$\Rightarrow 4I_2 = -6$$

$$\Rightarrow I_2 = -\frac{6}{4} = -1.5\,A$$

Practice

Nodal Analysis 6



$$i_3 = \frac{V_1 - V_2}{4}$$

$i_2 = 5A$

$i_1 = 10A$

$$i_4 = \frac{V_2}{6}$$

$$i_5 = \frac{V_1}{2}$$

Applying KCL in node 1,

$$i_2 = i_3 + i_5$$

$$\Rightarrow 5 = \frac{V_1 - V_2}{4} + \frac{V_1}{2}$$

$$\Rightarrow 5 = \frac{V_1}{4} - \frac{V_2}{4} + \frac{V_1}{2}$$

$$\Rightarrow 5 = \frac{1}{4}(V_1 - V_2 + 2V_1)$$

$$\Rightarrow 5 = \frac{1}{4}(3V_1 - V_2)$$

$$\Rightarrow 3V_1 - V_2 = 20 \quad \text{---(1)}$$

Applying KCL in node 2,

$$i_1 + i_3 = i_2 + i_4$$

$$\Rightarrow 10 + \frac{V_1 - V_2}{4} = 5 + \frac{V_2}{6}$$

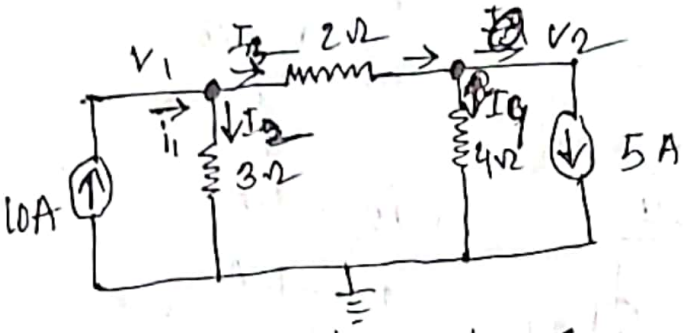
$$\Rightarrow$$

$$\Rightarrow 3V_1 - 5V_2 = -60 \quad \text{---(2)}$$

$\therefore$ eq (solve) $\Rightarrow V_1 = 13.33V$

$V_2 = 20V$

Determine the node voltage.



Applying KCL in node 1,

$$i_1 = i_2 + i_3$$

$$\Rightarrow 10 = \frac{V_1 - V_2}{2} + \frac{V_1}{3}$$

$$\Rightarrow 10 = \frac{V_1}{2} - 10 + \frac{V_1}{3}$$

$$\Rightarrow \frac{2V_1}{6} = 20 \Rightarrow V_1 = 60$$

Applying KCL in node 2,

$$i_2 = I_4 + 5$$

$$\Rightarrow 10 = \frac{V_2}{4} + 5$$

$$\Rightarrow \frac{V_2}{4} = 10 - 5$$

$$\Rightarrow V_2 = 20\,V$$

$i_1 =$

Applying KCL in node 1,

$i_1 = i_2 + i_3$

$\Rightarrow 10 = \frac{V_1}{3} + \frac{V_1 - V_2}{2}$

$\Rightarrow 5V_1 - 3V_2 = 60$ ——— (I)

$i_1 = 10\,A$

$i_2 = \frac{V_1}{3}$

$i_3 = \frac{V_1 - V_2}{2}$

$i_4 = \frac{V_2}{4}$

$i_5 = 5\,A$

Applying KCL at node 2,

$i_3 = i_4 + i_5$

$\Rightarrow \frac{V_1 - V_2}{2} = \frac{V_2}{4} + 5$

$\Rightarrow \frac{V_1}{2} - \frac{V_2}{2} - \frac{V_2}{4} = 5$

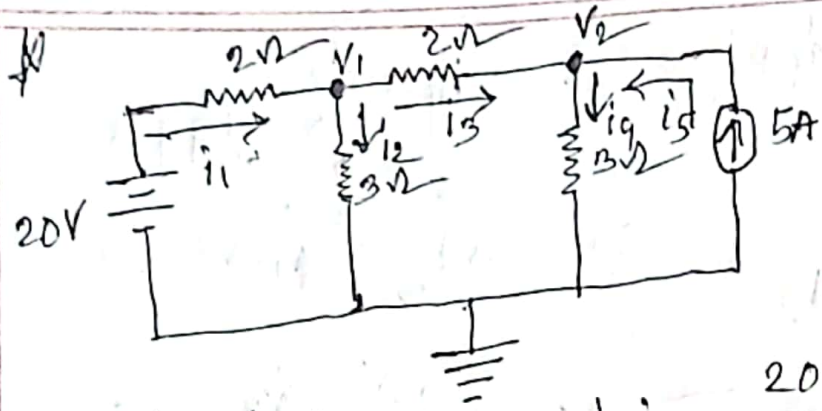
$\Rightarrow \frac{1}{4}(2V_1 - 2V_2 - V_2) = 5$

$\Rightarrow 2V_1 - 3V_2 = 20$ ——— (II)

eq (solve) $\Rightarrow$

$V_1 =$?

$V_2 =$?



KCL at node 1,

$i_1 = i_2 + i_3$

$\Rightarrow \frac{20 - V_1}{2} = \frac{V_1}{3} + \frac{V_1 - V_2}{2}$

$\Rightarrow 10 = \frac{V_1}{2} + \frac{V_1}{3} + \frac{V_1}{2} - \frac{V_2}{2}$

$\Rightarrow 10 = \frac{1}{6}(3V_1 + 2V_1 + 3V_1 - 3V_2)$

$\Rightarrow 60 = 8V_1 - 3V_2$ — (1)

$i_1 = \frac{20 - V_1}{2}$

$i_2 = \frac{V_1}{3}$

$i_3 = \frac{V_1 - V_2}{2}$

$i_4 = \frac{V_2}{3}$

$i_5 = 5A$

KCL at node 2,

$i_3 + i_5 = i_4$

$\Rightarrow \frac{V_1 - V_2}{2} + 5 = \frac{V_2}{3}$

$\Rightarrow \frac{V_1}{2} - \frac{V_2}{2} + 5 = \frac{V_2}{3}$

$\Rightarrow \frac{V_1}{2} - \frac{V_2}{2} - \frac{V_2}{3} + 5 = 0$

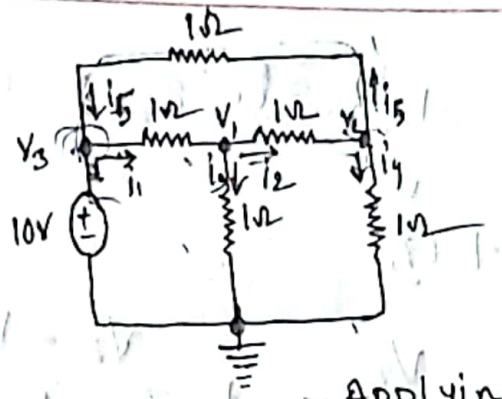
$\Rightarrow \frac{1}{6}(3V_1 - 3V_2 - 2V_2) = -5$

$\Rightarrow 3V_1 - 5V_2 = -30$ — (2)

$V_1 = 12.58\ V$

$V_2 = 13.55\ V$

Q1



$V_3 = 10\ V$

Applying KCL at node 3,

$$i_1 = i_5$$

$$\Rightarrow \frac{V_3 - V_1}{1} = \frac{V_2 - V_3}{1}$$

$$\Rightarrow V_3 - V_1 = V_2 - V_3$$

$$\Rightarrow 10 - V_1 = V_2 - 10$$

$$\Rightarrow -V_1 - V_2 = -10 - 10$$

$$\Rightarrow V_1 + V_2 = 20 \quad \text{— (I)}$$

Applying KCL at node1,

$$i_1 = i_2 + i_3$$

$$\Rightarrow \frac{V_3 - V_1}{1} = \frac{V_1 - V_2}{1} + \frac{V_1}{1}$$

$$\Rightarrow 10 - V_1 = V_1 - V_2 + V_1$$

$$\Rightarrow 3V_1 - V_2 = 10 \quad \text{— (II)}$$

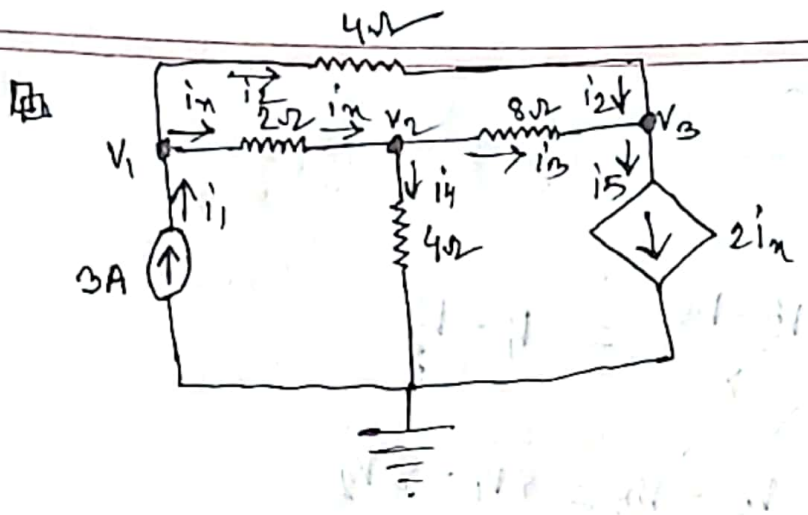
Applying KCL at node 2,

$$i_2 = i_4 + i_5$$

$$\Rightarrow \frac{V_1 - V_2}{1} = \frac{V_2}{1} + \frac{V_2 - V_3}{1}$$

$$\Rightarrow V_1 - V_2 = V_2 + V_2 - 10$$

$$\Rightarrow V_1 - 3V_2 = -10 \quad \text{---} \quad (iii)$$



$i_1 = 3A$

$i_x = \frac{v_1 - v_2}{2}$

$i_2 = \frac{v_1 - v_3}{4}$

$i_4 = \frac{v_2}{4}$

$i_3 = \frac{v_2 - v_3}{8}$

$i_5 = 2i_x$

$= 2\,\frac{v_1 - v_2}{2}$

$\therefore i_5 = v_1 - v_2$

Applying KCL in node-1,

$i_1 = i_2 + i_x$

$\Rightarrow 3 = \frac{v_1 - v_3}{4} + \frac{v_1 - v_2}{2}$

$\Rightarrow 12 = v_1 - v_3 + 2v_1 - 2v_2$

$\Rightarrow 12 = 3v_1 - 3v_2$

$\Rightarrow v_1 - v_2 = 4$ ——— (I)

$\Rightarrow 3v_1 - 2v_2 - v_3 = 12$ ——— (I)

Applying KCL in node-2,

$i_x = i_3 + i_4$

$\Rightarrow \frac{v_1 - v_2}{2} = \frac{v_2 - v_3}{8} + \frac{v_2}{4}$

$\Rightarrow 4v_1 - 4v_2 = v_2 - v_3 + 2v_2$

$\Rightarrow 4v_1 - 4v_2 - v_2 + v_3 - 2v_2 = 0$

$\Rightarrow 4v_1 - 7v_2 + v_3 = 0$ ——— (II)

KCL at node-3

$i_2 + i_3 = i_5$

$\Rightarrow \frac{V_1 - V_3}{4} + \frac{V_2 - V_3}{8} = V_1 - V_2$

$\Rightarrow 2V_1 - 2V_3 + V_2 - V_3 = 8V_1 - 8V_2$

$\Rightarrow 2V_1 - 2V_3 + V_2 - V_3 - 8V_1 + 8V_2 = 0$

$\Rightarrow 2V_1 - 3V_2 + V_3 = 0$ ——— (III)

Using Cramer's rule,

$$\begin{bmatrix} 3 & -2 & -1 \\ 4 & -7 & 1 \\ 2 & -3 & 1 \end{bmatrix} \begin{bmatrix} V_1 \\ V_2 \\ V_3 \end{bmatrix} = \begin{bmatrix} 12 \\ 0 \\ 0 \end{bmatrix}$$

$$\Delta = \begin{bmatrix} 3 & -2 & -1 \\ 4 & -7 & 1 \\ 2 & -3 & 1 \end{bmatrix} =$$

$$\Delta_1 = \begin{bmatrix} 12 & -2 & -1 \\ 0 & -7 & 1 \\ 0 & -3 & 1 \end{bmatrix} = -48$$

$$\Delta_2 = \begin{bmatrix} 3 & 12 & -1 \\ 4 & 0 & 1 \\ 2 & 0 & 1 \end{bmatrix} = -24$$

$$\Delta_3 = \begin{bmatrix} 3 & -2 & 12 \\ 4 & -7 & 0 \\ 2 & -3 & 0 \end{bmatrix} = 24$$

$= 3(0-0) + 2(0) + 12(-12+14)$

$\Delta = 3(-7+3) + 2(4-2) - 1(-12+14)$

$= -12 + 4 - 2$

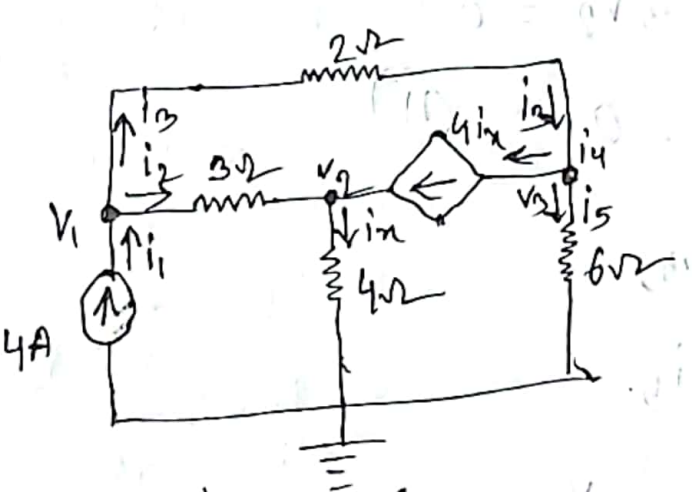
$= -10$

$$V_1 = \frac{\Delta_1}{\Delta} = \frac{-48}{-10} = 4.8\,V$$

$$V_2 = \frac{\Delta_2}{\Delta} = \frac{-24}{-10} = 2.4\,V$$

$$V_3 = \frac{\Delta_3}{\Delta} = \frac{24}{-10} = -2.4\,V$$

(4)



Applying KCL in node 1,

$$i_1 = i_2 + i_3$$

$$\Rightarrow 4 = \frac{V_1 - V_2}{3} + \frac{V_1 - V_3}{2}$$

$$\Rightarrow 24 = 2V_1 - 2V_2 + 3V_1 - 3V_3$$

$$\Rightarrow 24 = 5V_1 - 2V_2 - 3V_3$$

$$\Rightarrow 5V_1 - 2V_2 - 3V_3 - 24 = 0 \quad \text{---(1)}$$

$$i_1 = 4\,A$$

$$i_2 = \frac{V_1 - V_2}{3}$$

$$i_3 = \frac{V_1 - V_3}{2}$$

$$i_4 = 4i_x = 4 \cdot \frac{V_2}{4} = V_2$$

$$i_x = \frac{V_2}{4}$$

$$i_5 = \frac{V_3}{6}$$

KCL in node-2,

$i_2 + i_4 = i_x$

$\Rightarrow \frac{v_1 - v_2}{3} + v_2 = \frac{v_2}{4}$

$\Rightarrow 4v_1 - 4v_2 + 12v_2 - 3v_2 = 0$

$\Rightarrow 4v_1 + 8v_2 - 3v_2 = 0$

$\Rightarrow 4v_1 + 5v_2 = 0$ ——— (II)

KCL in node-3,

$i_3 = i_4 + i_5$

$\Rightarrow \frac{v_1 - v_3}{2} = v_2 + \frac{v_3}{6}$

$\Rightarrow 3v_1 - 3v_3 = 6v_2 + v_3$

$\Rightarrow 3v_1 - 3v_3 - 6v_2 - v_3 = 0$

$\Rightarrow 3v_1 - 6v_2 - 4v_3 = 0$ ——— (III)

$$\Delta = \begin{bmatrix} 5 & -2 & -3 \\ 4 & 5 & 0 \\ 3 & -6 & -4 \end{bmatrix} \begin{bmatrix} V_1 \\ V_2 \\ V_3 \end{bmatrix} = \begin{bmatrix} 24 \\ 0 \\ 0 \end{bmatrix}$$

$$\Delta = \begin{bmatrix} 5 & -2 & -3 \\ 4 & 5 & 0 \\ 3 & -6 & -4 \end{bmatrix} \quad \begin{aligned} &= 5(-20) + 2(-16) - 3(-24-15) \\ &= -100 - 32 + 117 \\ &= -15 \end{aligned}$$

$$\Delta_1 = \begin{bmatrix} 24 & -2 & -3 \\ 0 & 5 & 0 \\ 0 & -6 & -4 \end{bmatrix} \quad \begin{aligned} &= 24(-20) + 2(0) - 3(0) \\ &= -480 \end{aligned}$$

$$\Delta_2 = \begin{bmatrix} 5 & 24 & -3 \\ 4 & 0 & 0 \\ 3 & 0 & -4 \end{bmatrix} \quad \begin{aligned} &= 5(0) - 24(-16) - 3(0) \\ &= 384 \end{aligned}$$

$$\Delta_3 = \begin{bmatrix} 5 & -2 & 24 \\ 4 & 5 & 0 \\ 3 & -6 & 0 \end{bmatrix} \quad \begin{aligned} &= 5(0) + 2(0) + 24(-24-15) \\ &= -936 \end{aligned}$$

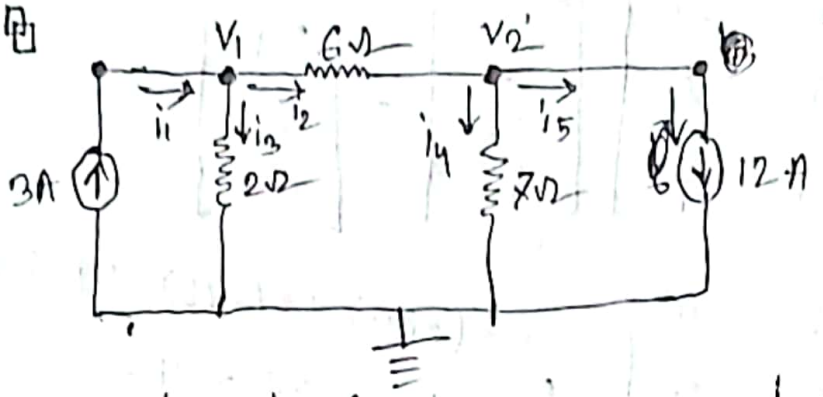
$$V_1 = \frac{\Delta_1}{\Delta} = \frac{-480}{-15} = 32$$

$$V_2 = \frac{\Delta_2}{\Delta} = \frac{384}{-15} = -25.6$$

$$V_3 = \frac{\Delta_3}{\Delta} = \frac{-936}{-15} = 62.4$$

$1 + \frac{6}{7}$

$\Rightarrow \frac{13}{7}$



KCL at node 1,

$i_1 = i_2 + i_3$

$\Rightarrow 3 = \frac{V_1 - V_2}{6} + \frac{V_1}{2}$

$\Rightarrow 18 = V_1 - V_2 + 3V_1$

$\Rightarrow 4V_1 - V_2 = 18$ —— (1)

KCL at node 2,

$i_2 = i_4 + i_5$

$\Rightarrow \frac{V_1 - V_2}{6} = \frac{V_2}{7} + 12$

$\Rightarrow V_1 - V_2 = \frac{6}{7} V_2 + 72$

$\Rightarrow V_1 - V_2 - \frac{6}{7} V_2 = 72$

$\Rightarrow V_1 - \frac{13}{7} V_2 = 72$

$i_1 = 3A$

$i_2 = \frac{V_1 - V_2}{6}$

$i_3 = \frac{V_1}{2}$

$i_4 = \frac{V_2}{7}$

~~$i_5 = V_2 - V_3$~~

$i_5 = 12A$

~~KCL at node 3,~~

$$\Delta = \begin{bmatrix} 4 & -1 \\ 1 & -\frac{13}{2} \end{bmatrix} \begin{bmatrix} V_1 \\ V_2 \end{bmatrix} = \begin{bmatrix} 18 \\ 72 \end{bmatrix}$$

$$\Delta = \begin{bmatrix} 4 & -1 \\ 1 & -\frac{13}{2} \end{bmatrix} = -2 \cdot 4 + 1 = -6.4$$

$$\Delta_1 = \begin{bmatrix} 18 & -1 \\ 72 & -\frac{13}{2} \end{bmatrix} = -33.4 + 72 = 38.6$$

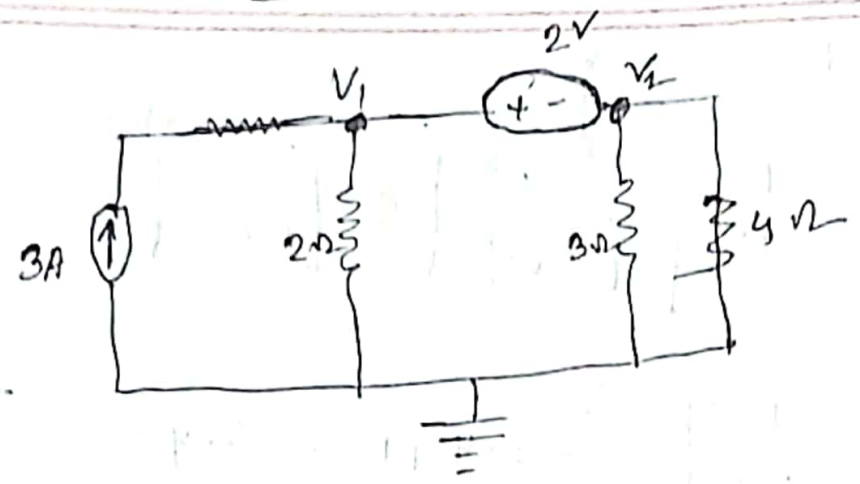
$$\Delta_2 = \begin{bmatrix} 4 & 18 \\ 1 & 72 \end{bmatrix} = 288 - 18 = 270$$

$$V_1 = \frac{\Delta_1}{\Delta} = \frac{38.6}{-6.4} = -6\ V$$

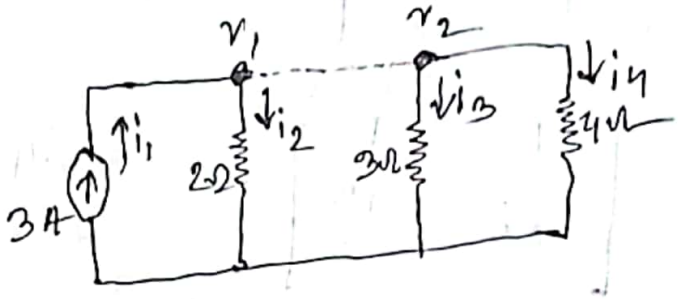
$$V_2 = \frac{\Delta_2}{\Delta} = \frac{270}{-6.4} = -42.2\ V$$

Supper Node

[1]



Solve



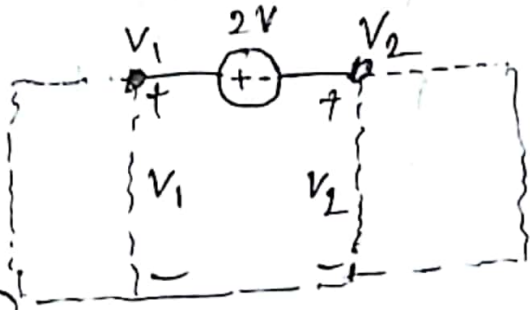
Applying KCL at supper node,

$$I_1 = i_2 + i_3 + i_4$$

$$\Rightarrow 3 = \frac{V_1}{2} + \frac{V_2}{3} + \frac{V_2}{4}$$

$$\Rightarrow 6V_1 + 7V_2 = 36 \quad \text{(I)}$$

Applying KVL,

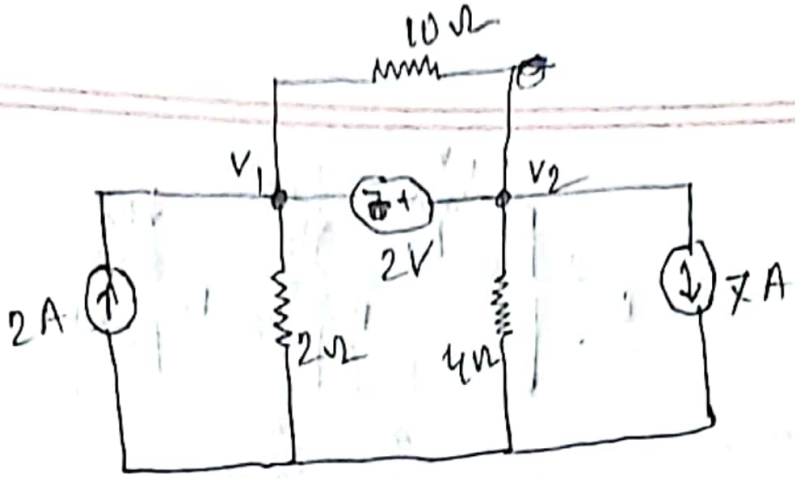


$$-V_1 + 2 + V_2 = 0$$

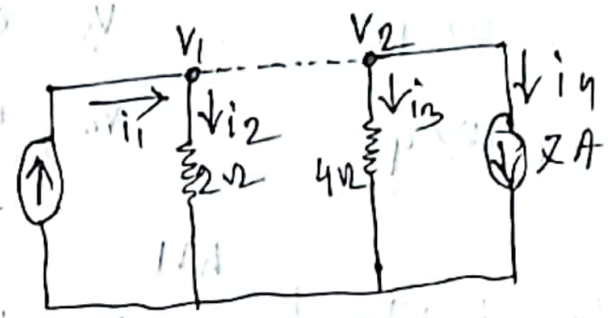
$$\Rightarrow V_1 - V_2 = 2 \quad \text{(II)}$$

$$V_1 = 3.84V$$

$$V_2 = 1.82V$$



Solve



Applying KCL at super node,

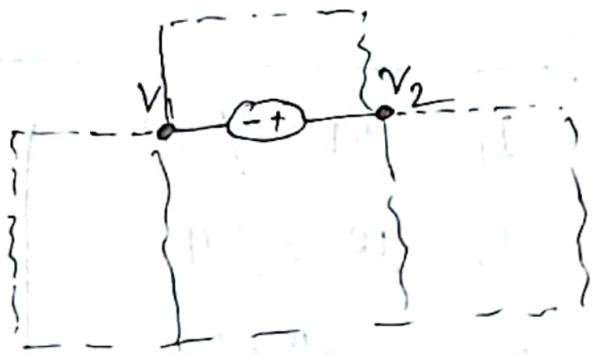
$$i_1 = i_2 + i_3 + i_4$$

$$\Rightarrow 2 = \frac{V_1}{2} + \frac{V_2}{4} + \frac{}{7}$$

$$\Rightarrow 8 = 2V_1 + V_2 + \frac{}{7} \Rightarrow 2V_1 + V_2 = -20 \quad \text{—(1)}$$

$$\Rightarrow 56 = 14V_1 + 7V_2 + 4V_2$$

$$\Rightarrow 14V_1 + 11V_2 = 56 \quad \text{—(1)}$$



Applying KVL,

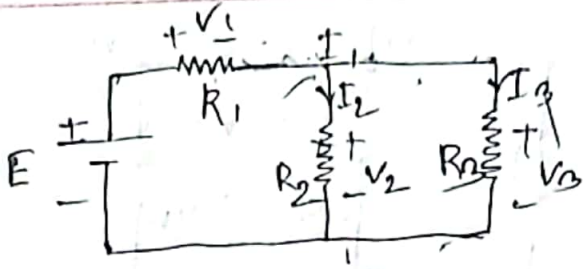
$$-V_1 + 2 + V_2 = 0$$

$$\Rightarrow V_2 - V_1 = -2$$

$$V_1 = -7.34$$

$$V_2 = -5.3$$

$V = 3^V$



$R_1 = 97.88$

$R_2 = 98.9$

$R_3 = 48.2$

$I_1 = 30 / 18$ (5 / 3)

$I_2 = 7 / 10$

$I_3 = 12 / 4$

$V_1 = 2.3 / 3.7$ (3 / 5)

$V_2 = 0.9 / 1.3$

$V_3 = 0.7 / 1.1$

$I_1 = I_2 + I_3$

$\Rightarrow 18 \neq 14$

$\Rightarrow 30 \neq 19$

KVL

$-E + \,'$

$I_1 = 22\,mA$ (3) | 24 25 (5)

$I_2 = 7\,mA$ | 16

$I_3 = 13\,mA$ | 18 23

$I_1 = 33 / 34$

$I_2 = 11$

$I_3 = 20$

$I_1 = 31$

$I_2 = 10$

$I_3 = 29$

$I_1 = 22 / 33$

$I_2 = 7 / 11$

$I_3 = 13 / 20$

$V_1 = 2.3 / 3.7$

$V_2 = 0.9 / 1.3$

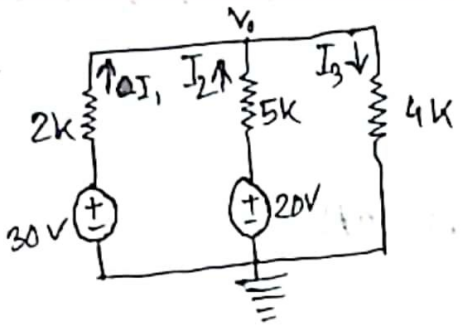
$V_3 = 0.7 / 1.1$

$R_1 = 97.8$

$R_2 = 98.9$

$R_3 = 48.2$

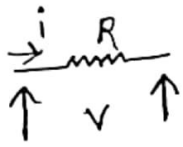
Date: 14-07-2025

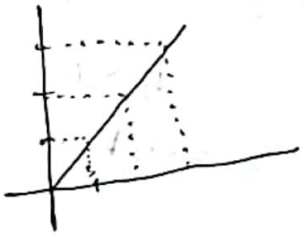


Applying KCL,

$I_1 + I_2 = I_3$

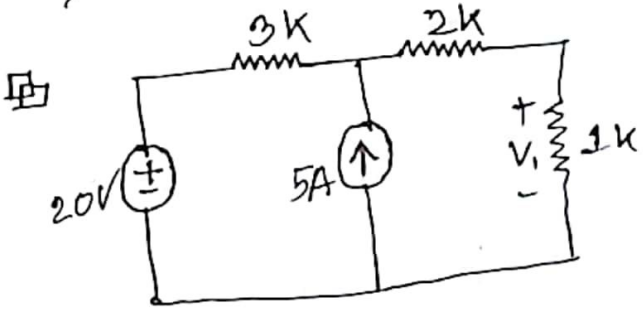
Super Position Theorem 5





$V = iR$ [R=2Ω]

$\Rightarrow V = 2i$



$[V_1 = V_1' + V_1'']$

[current – open
voltage – sort] বন্ধ

Solve

Fig - 1 using VDR,

$V_1' = \frac{20 \times 1}{3+2+1} = 3.3V$

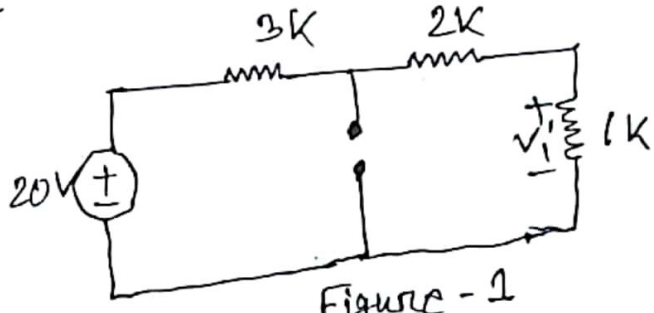


Figure - 1

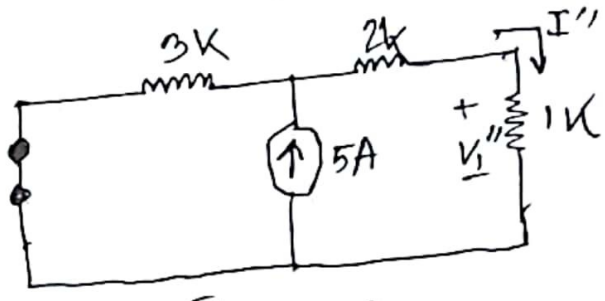


Figure - 2

Fig-2

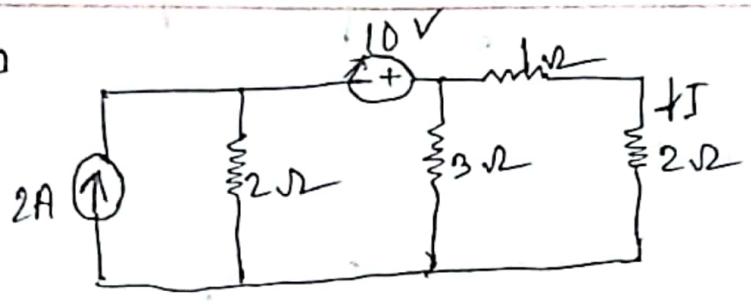
Using CDR,

$$I'' = \frac{5 \times (2+1)}{3+(2+1)} = 2.5\ mA$$

Using ohm's Law,

$$V_1'' = I'' \times 1k$$
$$= 2.5 \times 1$$
$$= 2.5V$$

$$V_1 = V_1' + V_1''$$
$$= 3.3 + 2.5$$
$$= 5.8\ V$$



solve

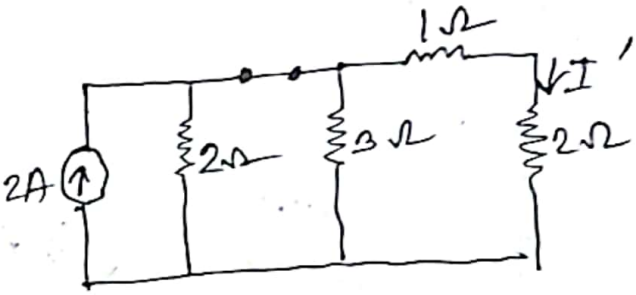


Fig-1,

Using CDR,

$$I' = \frac{2 \times 3}{3+(2+1)}$$

$$= \frac{6}{6} = 1A$$

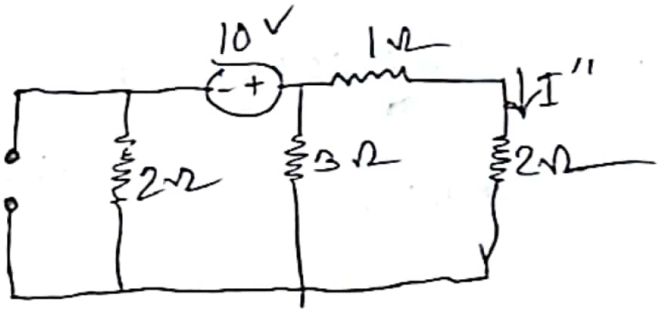


Fig-2,

Using CDR,

$I'' =$

Using VDR,

V

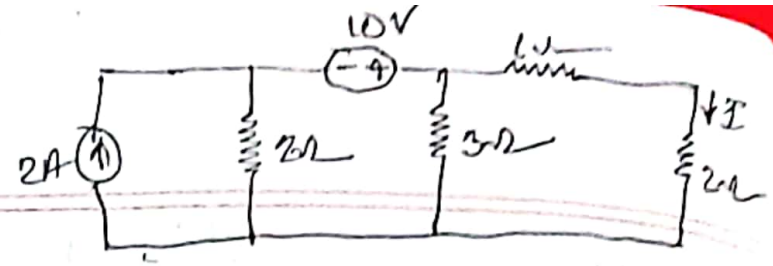
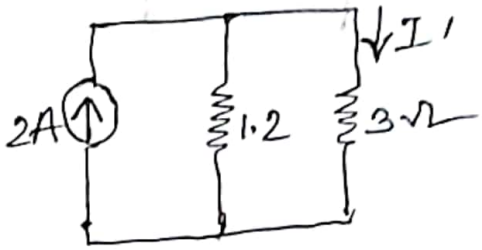


Fig-1

$(2 \| 3) = \frac{2 \times 3}{2+3} = 1.2\Omega$

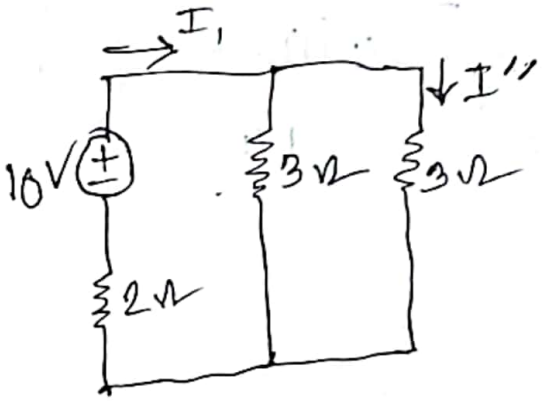
$(1+2)\Omega = 3\Omega$



Using CDR,

$$I' = \frac{2 \times 1.2}{1.2+3} = 4/7\ A$$

Fig-2



Using ohm's Law,

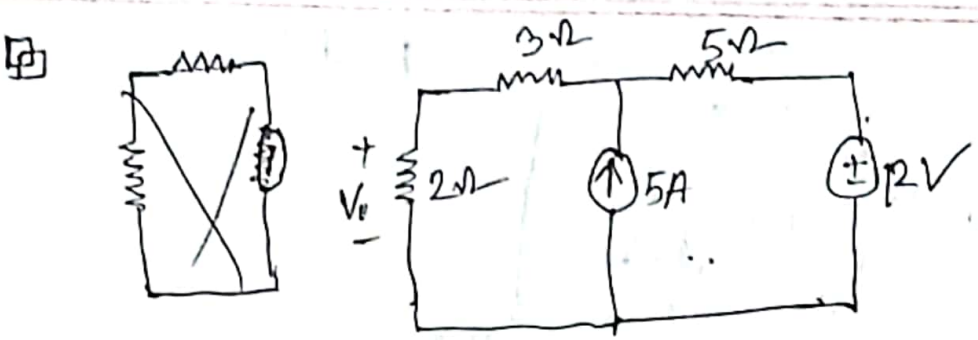
$(3 \| 3) = \frac{3 \times 3}{3+3} = 1.5\Omega$

$$I_1 = \frac{10}{2+1.5} = 2.86A$$

$$I'' = \frac{I_1 \times 3}{3+3} = \frac{2.86 \times 3}{3+3}$$

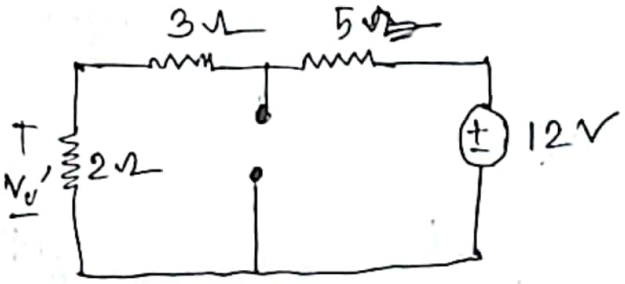
$$= 1.43A$$

$$I = I' + I''$$
$$= 4/7 + 1.43$$
$$= 2A$$



Solve

Fig-1

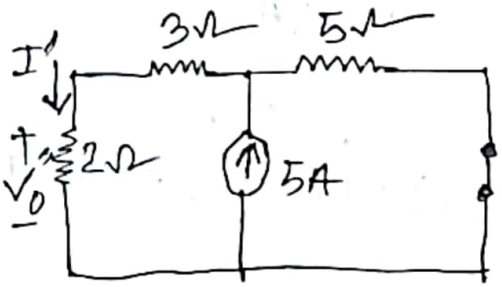


Using VDR,

$$V_o' = \frac{12 \times 2}{2+3+5} = \frac{24}{10}$$

$$= 2.4V$$

Fig-2



Using CDR,

$$I' = \frac{5 \times 5}{(3+2)+5}$$

$$= \frac{25}{10}$$

$$= 2.5$$

$$V_o'' = I \times 2$$

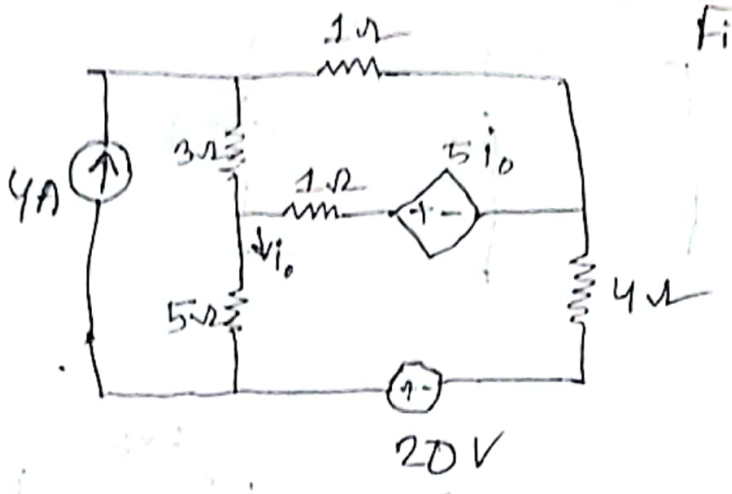
$$= 2.5 \times 2$$

$$= 5$$

$\therefore$ $V = V_o' + V_o''$

$= 2.4 + 5 = 7.4V$

[1]L



Find I_o

Solve

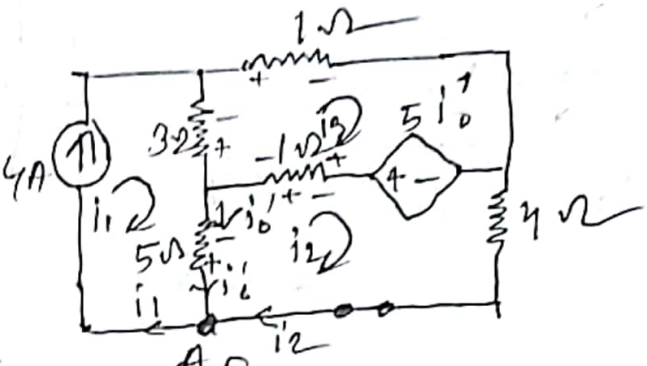


Fig -1

Using KCL,

$i_o' + i_2 = i_1$

$\therefore i_o' = i_1 - i_2 = 4 - i_2$

$= 4 - 0.94$

$= 3.06A$

Mash-1 : $i_1 = 4A$ —(1)

Mash-2 using KVL,

$5(i_2 - i_1) + 1(i_2 - i_3) + 5i_o + 4i_2 = 0$

$\Rightarrow 5(i_2 - 4) + i_2 - i_3 + 5(4 - i_2) + 4i_2 = 0$

$\Rightarrow 5i_2 - 20 + i_2 - i_3 + 20 - 5i_2 + 4i_2 = 0$

$\Rightarrow 5i_2 - i_3 = 0$ —(II)

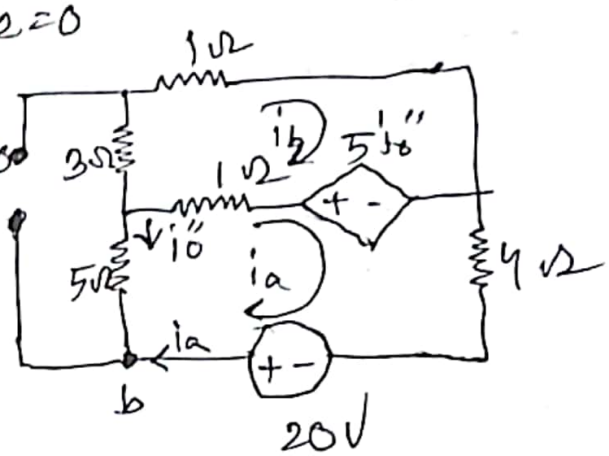


Fig - 2

Fig-2

KCL node-b

$i_a + i_0'' = 0$

$\therefore i_0'' = -i_a$

KVL in mash-3

$3(i_3 - 4) + 2i_3 - 5(4 - i_2) + 1(i_3 - i_2) = 0$

$\Rightarrow 3i_3 - 12 + 2i_3 - 20 + 5i_2 + i_3 - i_2 = 0$

$\Rightarrow 4i_2 + 6i_3 - 32 = 0$

$\Rightarrow 2i_2 + 3i_3 = 16$ ——— (III)

eq (I) & (III) $\Rightarrow$

$15i_2 - 3i_3 = 0$

$2i_2 + 3i_3 = 16$

$17i_2 = 16$

$\therefore i_2 = 0.94A$

KCL mesh-2,

$3i_b + 2i_b - 5i_0'' + 1(i_b - i_a) = 0$

$\Rightarrow 3i_b + 2i_b - 5(-i_a) + i_b - i_a = 0$

$\Rightarrow 4i_a + 6i_b = 0$ ——— (II)

eq solving,

$i_a = 3.5A$

$i_0'' = -3.5A$

$i_0 = i_0' + i_0''$

$= 3.06 - 3.5$

$= -0.4A$

Fig-2

KCL node-b,

$i_a + i_0'' = 0$

$\Rightarrow i_0'' = -i_a$

Applying KVL, mesh-1,

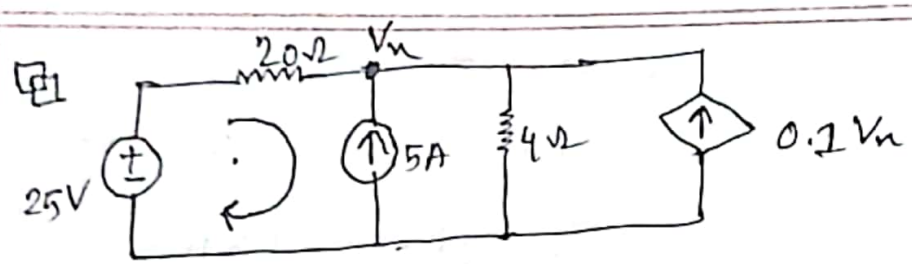
$5i_a + 1(i_a - i_b) + 5i_0'' + 4i_a + 20 = 0$

$\Rightarrow 5i_a + i_a - i_b + 5(-i_a) + 4i_a + 20 = 0$

$\Rightarrow 5i_a + i_a - i_b - 5i_a + 4i_a + 20 = 0$

$\Rightarrow 5i_a - i_b = 20$ ——— (I)

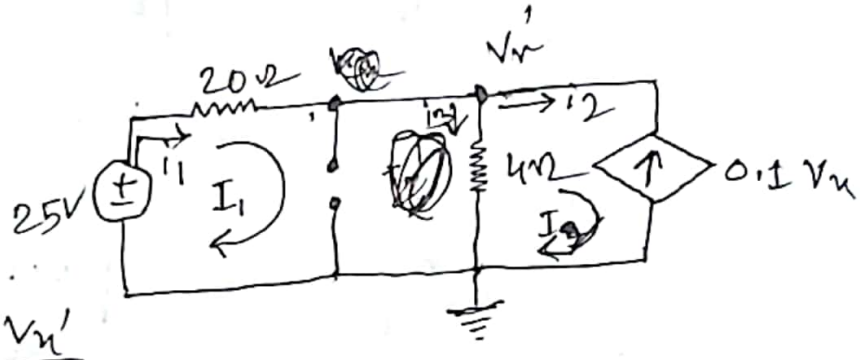
Ex1



Find V_n

Solve

Using nodal Analysis,



$$i_1 + i_2 = i_3$$

$$\Rightarrow \frac{25 - V_n'}{20} + 0.1V_n = \frac{V_n'}{4}$$

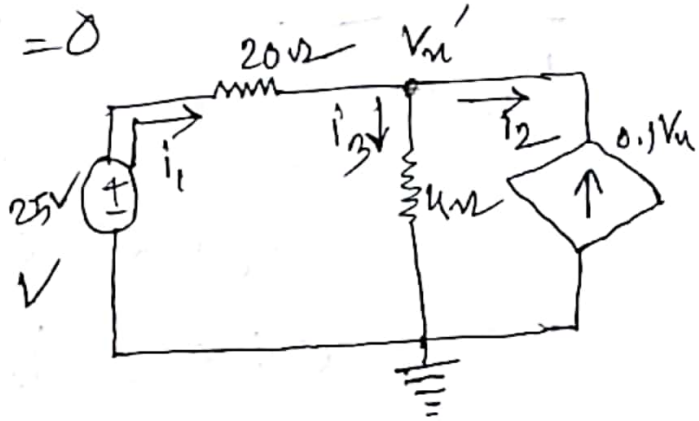
$$\therefore \cancel{V_n'}$$

$$\Rightarrow \frac{25}{20} - \frac{V_n'}{20} + 0.1V_n - \frac{V_n'}{4} = 0$$

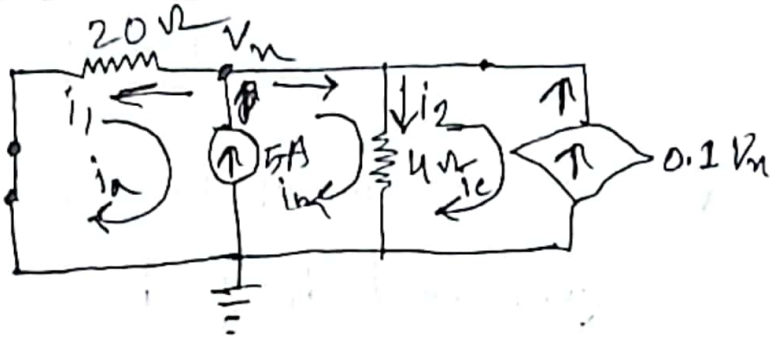
$$\Rightarrow 25 - V_n' + 2V_n - 5V_n' = 0$$

$$\Rightarrow 25 - 6V_n' = 0$$

$$\Rightarrow V_n' = \frac{25}{4} = 6.25\ V$$



MTD



Applying KCL,

$5 + 0.1V_x'' = i_1 + i_2$

$\Rightarrow 5 + 0.1V_x'' = \frac{V_x''}{20} + \frac{V_x''}{4}$

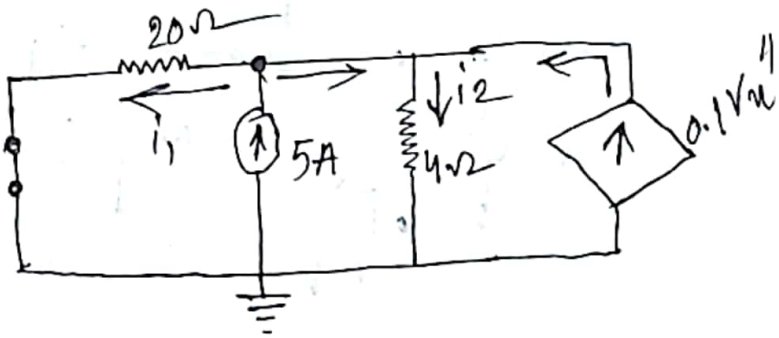
$\Rightarrow \frac{V_x''}{20} + \frac{V_x''}{4} = 0.1V_x'' + 5$

$\Rightarrow V_x'' + 5V_x'' = 2V_x'' + 100$

$\Rightarrow V_x'' + 5V_x'' - 2V_x'' - 100 = 0$

$\Rightarrow 4V_x'' = 100$

$\therefore V_x'' = 25V$



$V_x = V_x' + V_x''$

$= 6.25 + 25$

$= 31.25\,V$

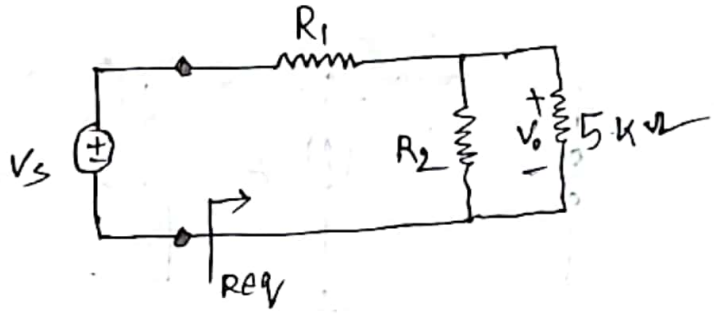
Date : 16-07-2025

Practice

(1) In a certain application, the circuit in the following figure must designed to meet this two criteria :

a) $\frac{V_o}{V_s} = 0.05$ b) $R_{eq} = 40k\Omega$

If the load resistor ~~meet the criteria~~ $5k\Omega$ is fixed, find R_1 and R_2 to meet the criteria.



Solve

$\frac{V_o}{V_s} = 0.05$

$R_{eq} = 40k\Omega$

KVL in loop 1,

$-V_s + IR_1 + I_1R_2 = 0$

KVL in loop 2,

$+5I$

Using VDR,

$$V_o = \frac{V_s\,(R_2 \| 5k\Omega)}{R_1 + (R_2 \| 5)}$$

$$\Rightarrow \frac{V_o}{V_s} = \frac{R_2 \| 5}{R_1 + R_2 \| 5}$$

$$\Rightarrow 0.05 = \frac{R_2 \| 5}{R_{eq}}$$

$$\Rightarrow 0.05 = \frac{R_2 \| 5}{40}$$

$$\Rightarrow R_2 \| 5 = 0.05 \times 40$$

$$\Rightarrow \frac{R_2 \times 5}{R_2 + 5} = 0.05 \times 40$$

$$\Rightarrow R_2 \times 5 = (0.05 \times 40)(R_2 + 5)$$

$$\Rightarrow R_2 \times 5 = (0.05 \times 40) R_2 + (0.05 \times 40 \times 5)$$

$$\Rightarrow (R_2 \times 5) - (0.05 \times 40) R_2 = 0.05 \times 40 \times 5$$

$$\Rightarrow R_2 (5 - 0.05 \times 40) = 0.05 \times 40 \times 5$$

$$\Rightarrow R_2 = \frac{0.05 \times 40 \times 5}{5 - 0.05 \times 40}$$

$$\therefore R_2 = 3.33 \ k\Omega$$

$$\therefore Req = R_1 + (R_2 \| 5K)$$

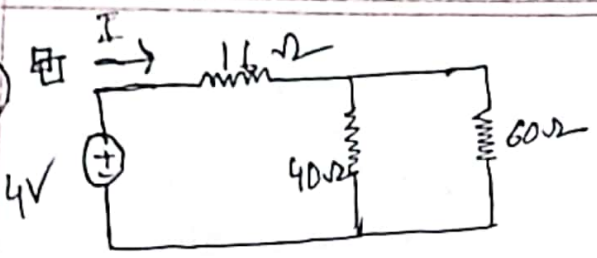
$$\Rightarrow 40 = R_1 + \frac{R_2 \times 5}{R_2 + 5}$$

$$\Rightarrow 40 = R_1 + \frac{3.33 \times 5}{3.33 + 5}$$

$$\Rightarrow 40 = R_1 + \frac{16.65}{8.33}$$

$$\Rightarrow R_1 = 40 - \frac{16.65}{8.33} = 38.001 \ k\Omega$$

(2)



a) Find the current I

b) An ammeter with an internal resistance of 1Ω is inserted in the network to measure the current through 16Ω resistor

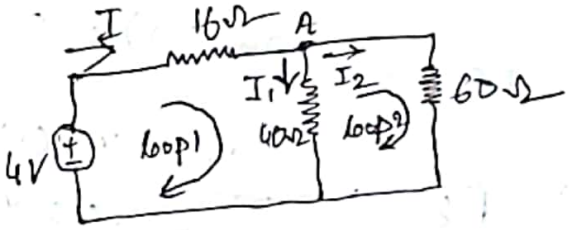
c) calculate the percent error introduced by the meter as $\left|\frac{I-I'}{I}\right| \times 100\%$.

Solve

a) Applying KCL in node-A,

$I = I_1 + I_2$

Applying KVL in loop-1,

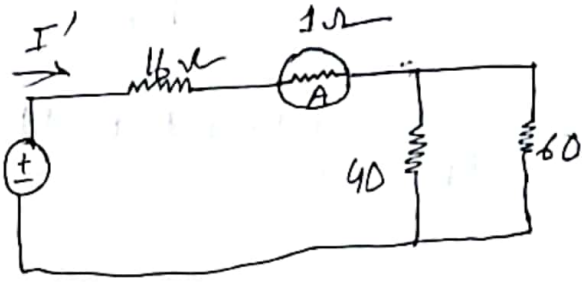


a) $(40 \| 60) = \frac{40 \times 60}{40+60} = 24\Omega$

Using Ohm's Law,

$$I = \frac{4}{16+24} = 0.1\,A$$

b)



$$Req = (16+1) + (40 \| 60)$$

$$= 17 + \frac{40 \times 60}{40+60}$$

$$= 41\Omega$$

Using ohm's Law,

$$I' = \frac{4}{41} = 0.098\,A$$

c) Percent of error,

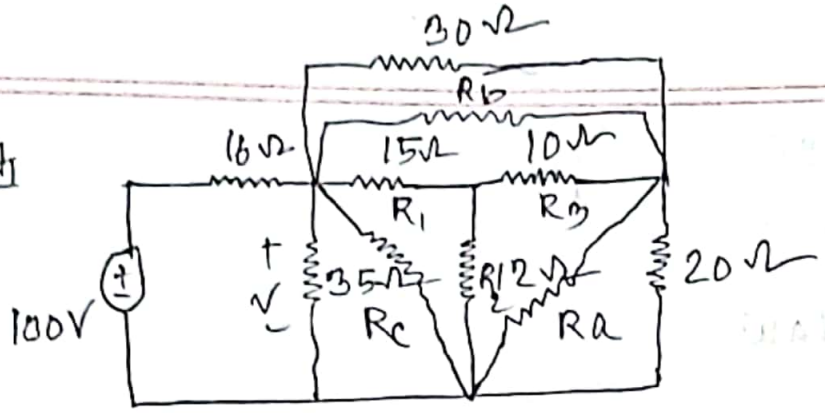
$$\left| \frac{I - I'}{I} \right| \times 100\%$$

$$= \left| \frac{0.1 - 0.098}{0.1} \right| \times 100\%$$

$$= 2\%$$

30
37.5
45

(B)

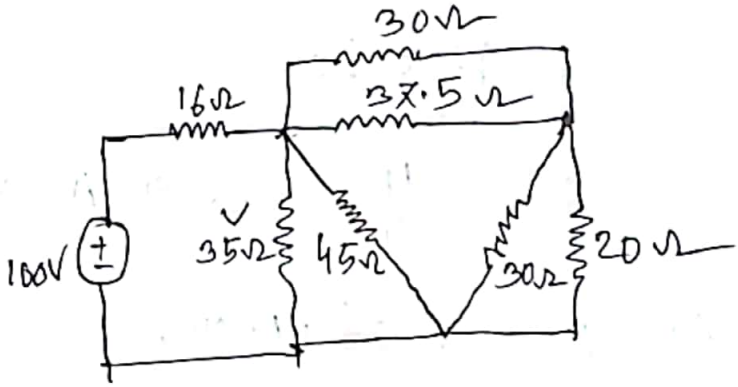


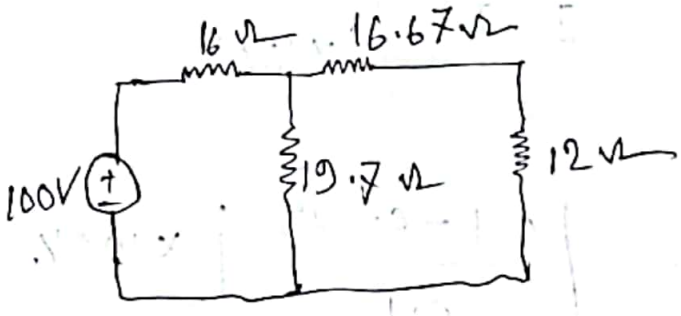
* V (use Y→Δ)

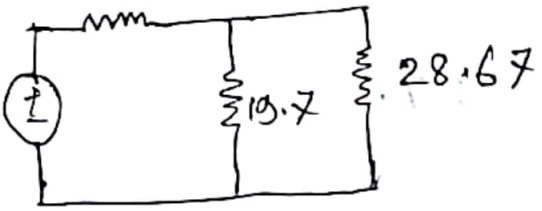
$$R_a = \frac{R_1R_2 + R_2R_3 + R_3R_1}{R_1} = 30$$

$$R_b = \frac{R_1R_2 + R_2R_3 + R_3R_1}{R_2} = 37.5$$

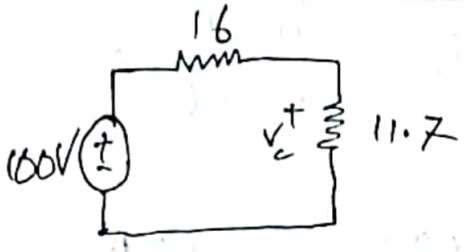
$$R_c = \frac{R_1R_2 + R_2R_3 + R_3R_1}{R_3} = 45$$







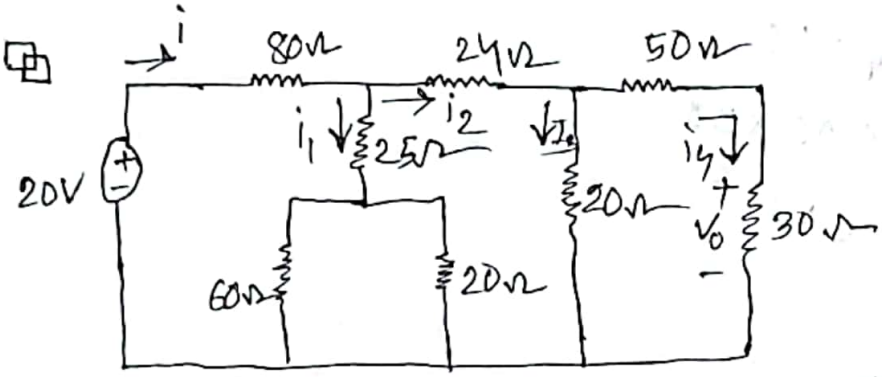
Using VDR,



$$V = \frac{V_s \times 11.7}{16 + 11.7}$$

$$= 42.24\ V$$

(4)



Find I and V_0.

$(50 + 30) = 80\Omega$

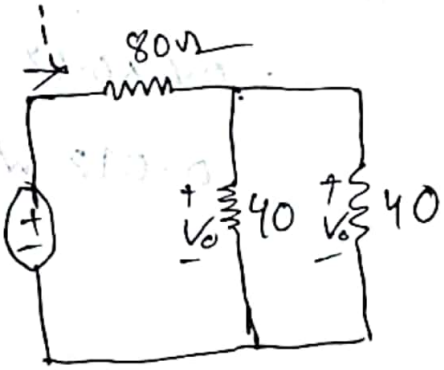
$(80 \| 20) = \frac{80 \times 20}{80 + 20} = 16\Omega$

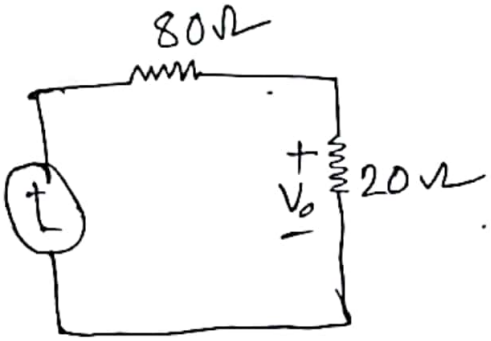
$(16 + 24) = 40$

$(60 \| 20) = \frac{60 \times 20}{60 + 20} = 15\Omega$

$(15 + 25) = 40\Omega$

$(40 \| 40) = \frac{40 \times 40}{40 + 40} = 20\Omega$





Using VDR,

$$V_0 = \frac{20 \times 20}{80 + 20} = 4V$$

Using Ohm's Law,

$$I = \frac{20}{80} = 0.2A$$

Using CDR, $i_2 = \frac{i_1 40}{40+40} = \frac{0.2}{2} = 0.1A$

$i_4 = \frac{i_2 \times 20}{20+8} = 0.02A$

Using ohm's Law,

$V_0 = i_4 \times 30$

$= 0.02 \times 30$

$= 0.6V$

$P_{30\Omega} = V_0 i_4$

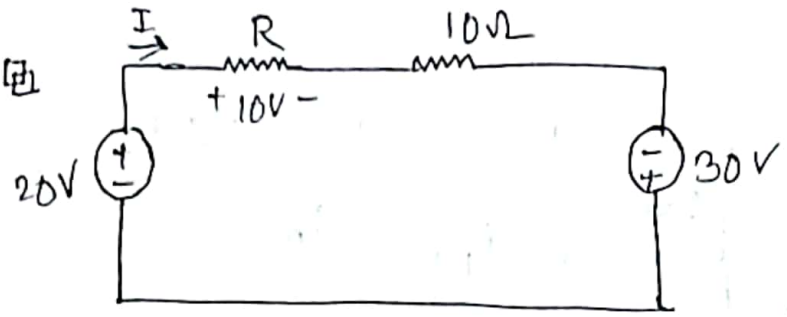
$= 0.6 \times 0.02$

$= 0.012 W$

$V = IR$

$\Rightarrow R = \frac{V}{I}$

(5)



* Find R ?

Solve

$-20 + IR + 10 - 30 = 0$

$\Rightarrow IR = 40 \quad \Rightarrow I = \frac{40}{10} = 4\,A$

$\Rightarrow R = \frac{40}{I}$

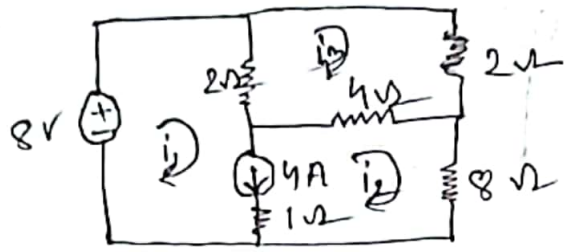
Using ohm's Law,

$V = IR$

$\Rightarrow 10 = 4R$

$\Rightarrow R = \frac{10}{4} = 2.5\,\Omega$

(6)

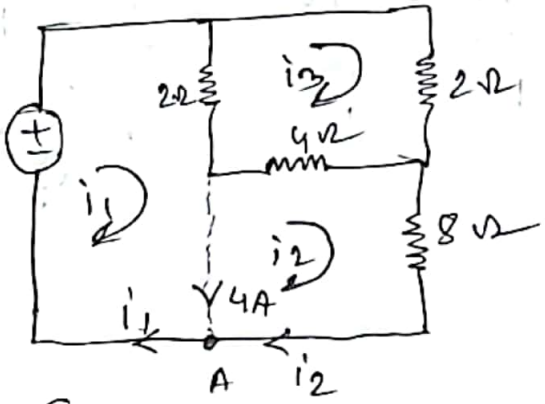


Use mesh analysis

I_1, i_2, I_3

Solve

Applying KVL in super mesh,



$$-8 + 2(i_1 - i_3) + 4(i_2 - i_3) + 8i_2 = 0$$

$$\Rightarrow -8 + 2i_1 - 2i_3 + 4i_2 - 4i_3 + 8i_2 = 0$$

$$\Rightarrow 2i_1 + 12i_2 - 6i_3 = 8$$

$$\Rightarrow i_1 + 6i_2 - 3i_3 = 4 \quad \text{——— (I)} \times 2$$

Applying KVL in mesh-3,

$$2(i_3 - i_1) + 2i_3 + 4(i_3 - i_2) = 0$$

$$\Rightarrow -i_1 - 2i_2 + 4i_3 = 0 \quad \text{——— (II)}$$

$$\Rightarrow i_1 + 2i_2 - 4i_3 = 0$$

Applying KCL in node-A,

$$i_1 = 4 + i_2 \quad \text{——— (V)}$$

14 Days Left

MID 30 July

(i) × 4 − (ii) × 3

$4I_1 + 24$

eq (i) ⇒

$4 + i_2 + 6i_2 - 3i_3 = 4$

$\Rightarrow 7i_2 - 3i_3 = 0$ ——— (iii)

eq (ii)

$4 + i_2 + 2i_2 - 4i_3 = 0$

$\Rightarrow 3i_2 - 4i_3 + 4 = 0$ ——— (iv)

(iii) × 4 − (iv) × 3

$28i_2 - 12i_3 = 0$

$9i_2 - 12i_3 + 12 = 0$

(−) (+) (−)

$19i_2 - 12 = 0$

$\Rightarrow i_2 = \frac{12}{19} = 0.63$

i_2 in eq (v) ⇒

$i_1 = 4 + 0.63$

$= 4.63$

i_2 in eq (iii)

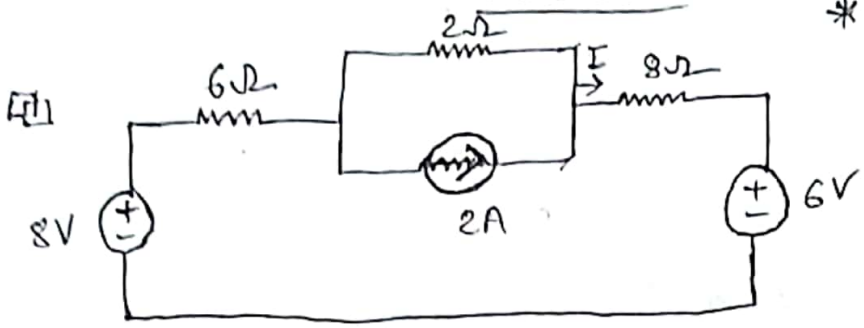
$(7 \times 0.63) - 3i_3 = 0$

$\Rightarrow i_3 = \frac{4.41}{3} = 1.47$ A

Date: 23-07-2025

Practice

(1)

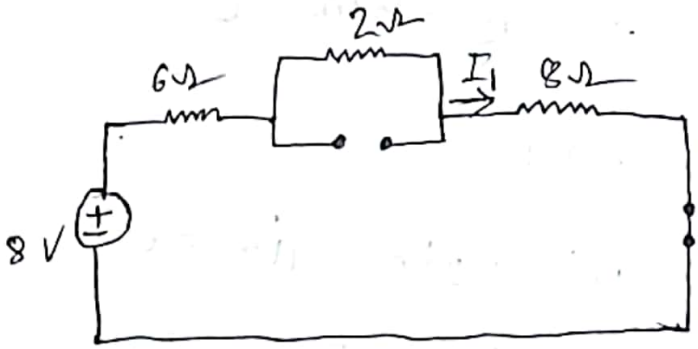


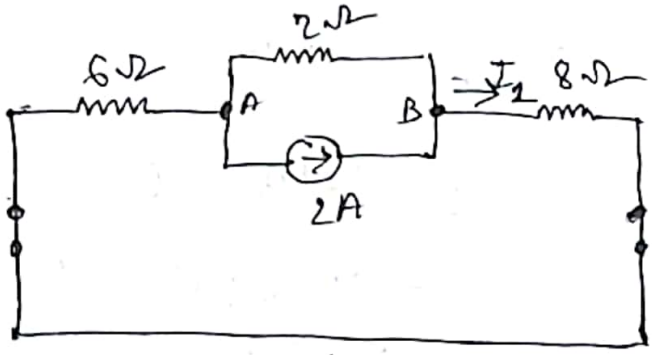
* Find I using Superposition theorem.

Solve

Using Ohm's Law,

$$I_1 = \frac{8}{6+2+8} = 0.5A$$

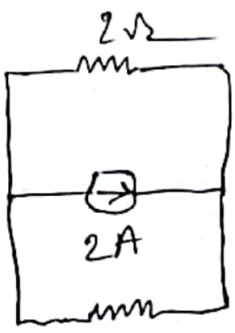




Using CDR,

$$I_2 = \frac{2 \times 2}{2+14}$$

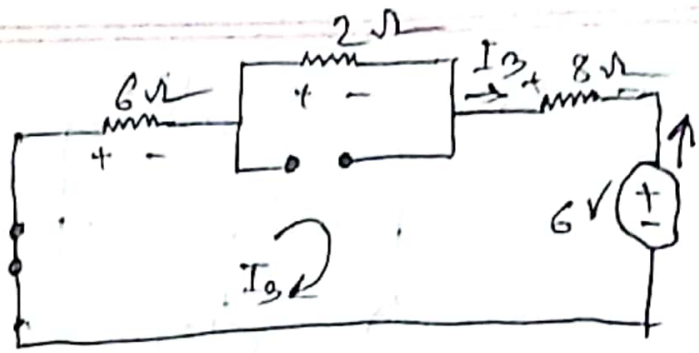
$$= 0.25A$$



6+8 = 14Ω

mid → Q-5

120/5



Using ~~ohms law~~; KVL,

$$I_3 6 + 2I_3 + 8I_3 + 6 = 0$$

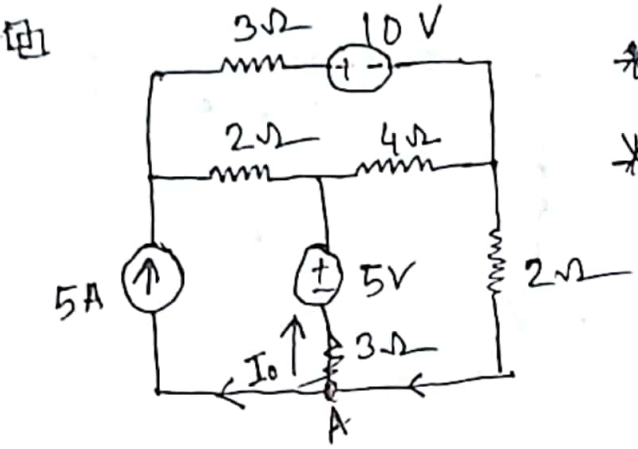
$$\Rightarrow I_3 = -\frac{6}{6+2+8} = -0.375\,A$$

$$I = I_1 + I_2 + I_3$$

$$= 0.5 + 0.25 - 0.375$$

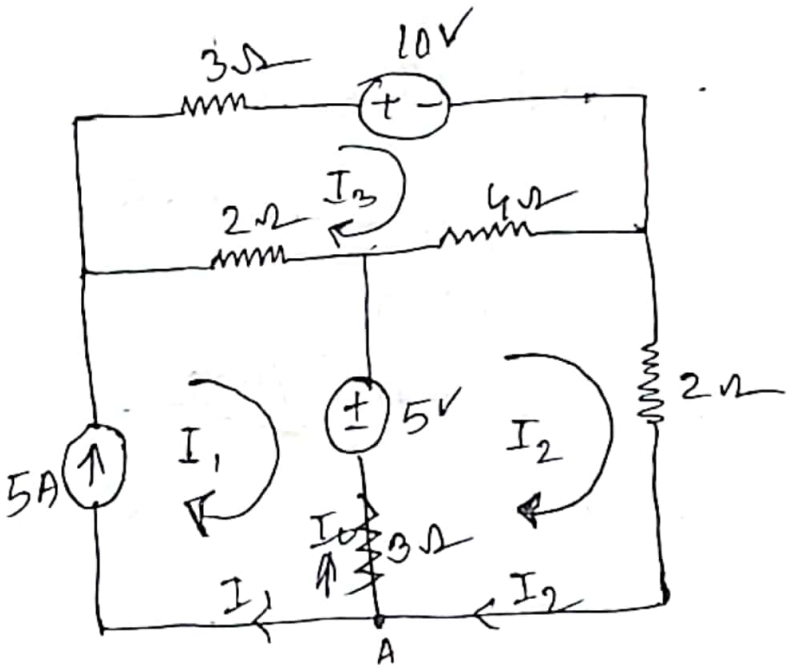
$$= 0.375\,A$$

$$= 375\,mA$$ ~~Ans:~~

(8) 

* Find the mesh currents.
* Find the current I_o.

Solve



From mesh 1,

$I_1 = 5A$

Applying KVL in mesh 2,

$$3(I_2 - I_1) - 5 + 4(I_2 - I_3) + 2I_2 = 0$$

$$\Rightarrow 3I_2 - 3I_1 - 5 + 4I_2 - 4I_3 + 2I_2 = 0$$

$$\Rightarrow -3I_1 + 9I_2 - 4I_3 = 5$$

$$\Rightarrow (-3 \times 5) + 9I_2 - 4I_3 = 5$$

$$\Rightarrow 9I_2 - 4I_3 = 20 \quad \text{---------- (1)}$$

Applying KVL in mesh 3,

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

$$\Rightarrow 4I_3 - 4I_2 + 2I_3 - 2I_1 + 3I_3 + 10 = 0$$

$$\Rightarrow -2I_1 - 4I_2 + 9I_3 + 10 = 0$$

$$\Rightarrow (-2 \times 5) - 4I_2 + 9I_3 + 10 = 0$$

$$\Rightarrow -4I_2 + 9I_3 = 0 \quad \text{——— (II)}$$

solving eq (I) & (II) $\Rightarrow$

$I_2 = 2.8\,A$

$I_3 = 1.23\,A$

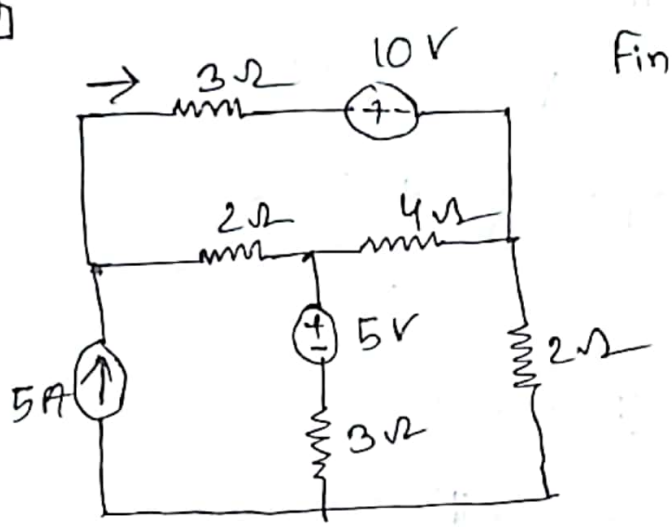
Applying KCL at node A,

$$I_1 + I_0 = I_2$$

$$\Rightarrow I_0 = 2.8 - 5$$

$$\therefore I_0 = -2.2\,A$$

(9) 中



Find I using super position theorem.

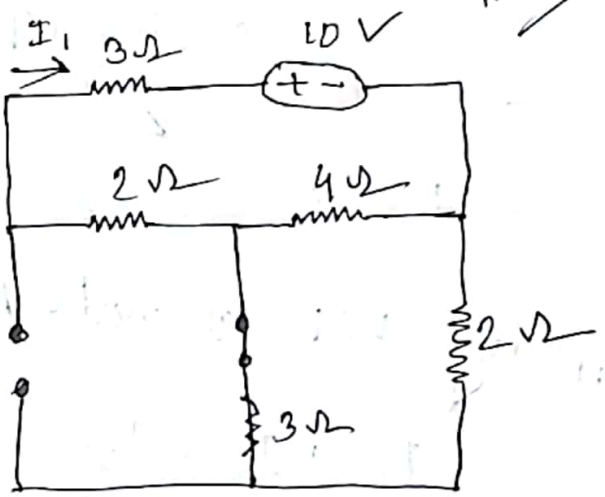
Solve $4\|2 = \frac{4\times2}{6+2} = 1.5$

Using ohms Law,

$$I_1 = \frac{10}{\frac{4\times2}{4+2} + \frac{1.5\times3}{1.5+3}}$$

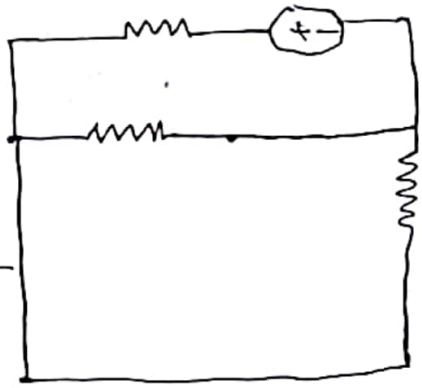
$= 10\ A$

modal Analysis



$$2\|3 = \frac{2\times3}{2+3} = 0.75$$

$$0.75\|4 = \frac{0.75\times4}{0.75+4} = 0.63\Omega$$



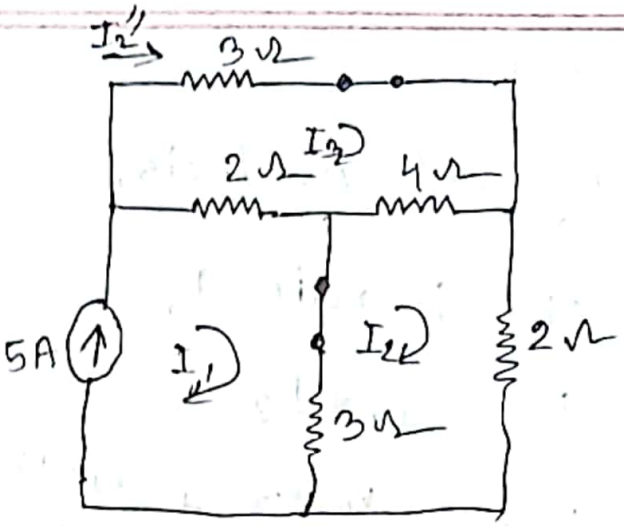
$$0.63\|2 = \frac{0.63\times2}{0.63+2} = 0.48\Omega$$

Using ohms Law, $I_1 = \frac{10}{\frac{0.48\times3}{0.48+3}} = 24.17A$

Using-

From mesh 1,

$I_1 = 5A$



(mesh-2) using KVL,

$$3(I_2 - I_1) + 4(I_2 - I_3) + 2I_2 = 0$$

$$\Rightarrow 3I_2 - 3I_1 + 4I_2 - 4I_3 + 2I_2 = 0$$

$$\Rightarrow -3I_1 + 9I_2 - 4I_3 = 0$$

$$\Rightarrow (-3 \times 5) + 9I_2 - 4I_3 = 0$$

$$\Rightarrow 9I_2 - 4I_3 = 10 \quad \text{---(1)}$$

(mesh-3) using KVL,

$$4(I_3 - I_2) + 2(I_3 - I_1) + 3I_3 = 0$$

$$\Rightarrow 4I_3 - 4I_2 + 2I_3 - 2I_1 + 3I_3 = 0$$

$$\Rightarrow -2I_1 - 4I_2 + 9I_3 = 0$$

$$\Rightarrow -4I_2 + 9I_3 = 10$$

$I_1 = 5A$
$I_2 = 2A$
$I_3 = 2A$

$\therefore I_2'' = 2 + 2 = 4A$

Start

2nd circuit

Using nodal Analysis,

KCL in node-1,

$I_3 = I_1 + I_2$

$\Rightarrow 5 = \frac{V_1 - V_3}{3} + \frac{V_1 - V_2}{2}$

$\Rightarrow 30 = (V_1 - V_3)2 + (V_1 - V_2)3$

$\Rightarrow 5V_1 - 3V_2 - 2V_3 = 30$ ——— (1)

Applying KCL in node 2,

$I_2 = I_4 + I_5$

$\Rightarrow \frac{V_1 - V_2}{2} = \frac{V_2}{5} + \frac{V_2 - V_3}{4}$

$\Rightarrow 6V_1 - 13V_2 + 3V_3 = 0$ ——— (11)

KCL in node 3,

$I_1 + I_5 = I_6$

$\Rightarrow \frac{V_1 - V_3}{3} + \frac{V_2 - V_3}{4} = \frac{V_3}{2}$

$\Rightarrow 4V_1 + 3V_2 - 13V_3 = 0$ ——— (111)

Using Cramer's rule,

$$\begin{bmatrix} 5 & -3 & -2 \\ 6 & -13 & 3 \\ 4 & 3 & -13 \end{bmatrix} \begin{bmatrix} V_1 \\ V_2 \\ V_3 \end{bmatrix} = \begin{bmatrix} 30 \\ 0 \\ 0 \end{bmatrix}$$

$$\Delta = \begin{bmatrix} 5 & -3 & -2 \\ 6 & -13 & 3 \\ 4 & 3 & -13 \end{bmatrix} = 3190$$

$$\Delta_1 = \begin{bmatrix} 30 & -3 & -2 \\ 0 & -13 & 3 \\ 0 & 3 & -13 \end{bmatrix} = 4800$$

$$\Delta_2 = \begin{bmatrix} 5 & 30 & -2 \\ 6 & 0 & 3 \\ 4 & 0 & -13 \end{bmatrix}$$

$$\Delta_3 = \begin{bmatrix} 5 & -3 & 30 \\ 6 & -13 & 0 \\ 4 & 3 & 0 \end{bmatrix} = 2100$$

$$V_1 = \frac{\Delta_1}{\Delta} = \frac{4800}{3190} = 15.05 \quad 12.3\text{V}$$

$$V_2 = \frac{\Delta_2}{\Delta} =$$

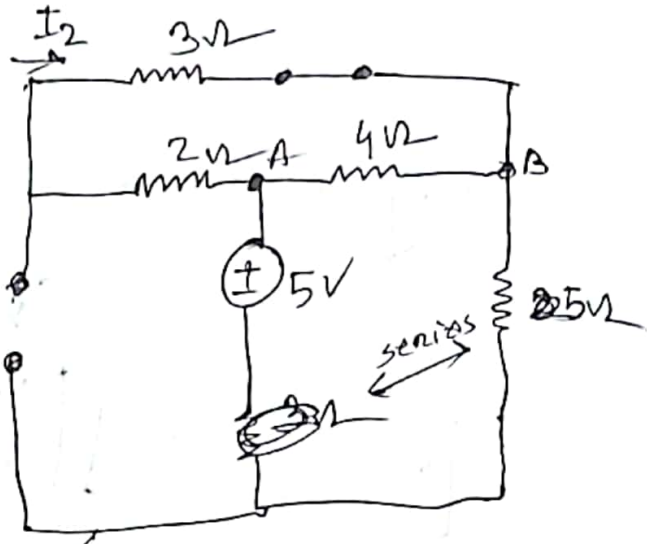
$$V_3 = \frac{\Delta_3}{\Delta} = \frac{2100}{3190} = 9.5 \quad 5.38\text{V}$$

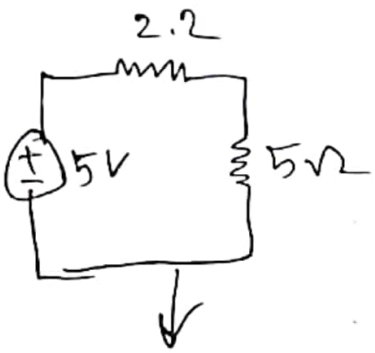
$$I_1 = \frac{V_1 - V_3}{3}$$

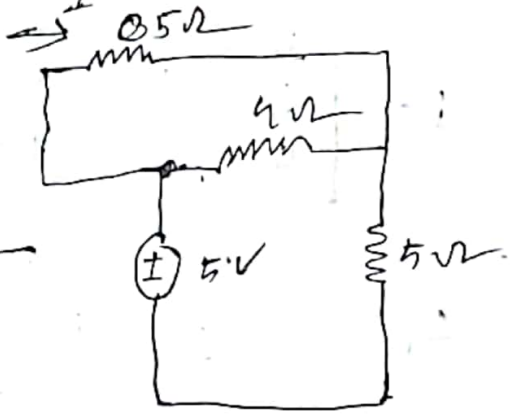
$$= 2.30$$

$(3+2) = 5\Omega$

$5 \| 4 = \frac{5 \times 4}{5+4} = 2.2\Omega$

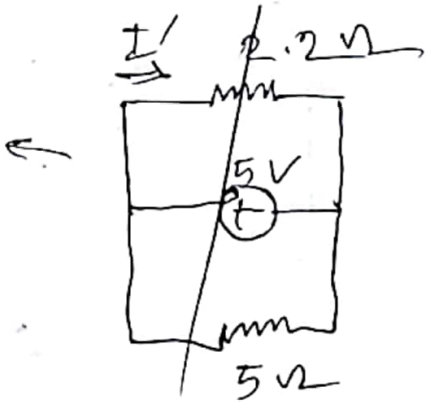


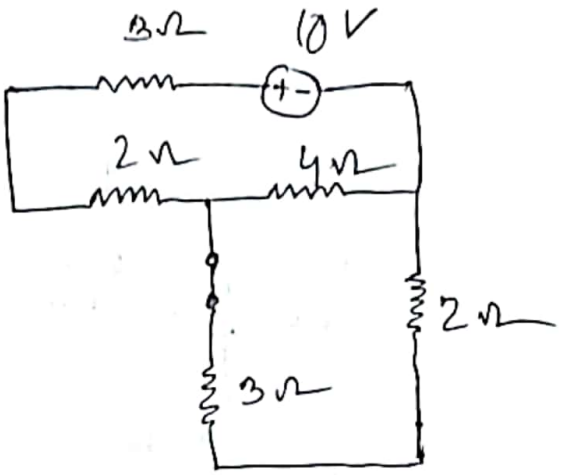


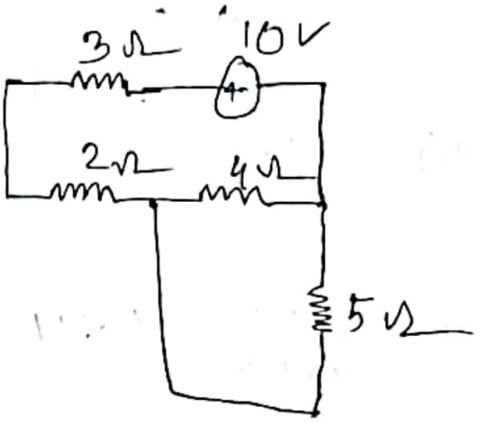


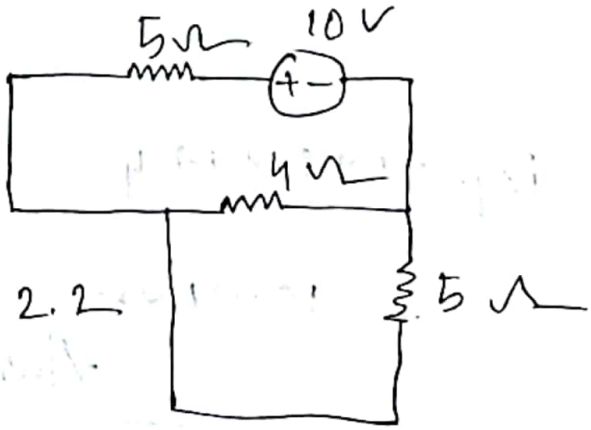
Using ohms Law

$I' = \frac{5}{5+2.2} = 0.69$









$$4 \| 5 = \frac{4 \times 5}{4+5} = \frac{20}{9} = 2.2$$

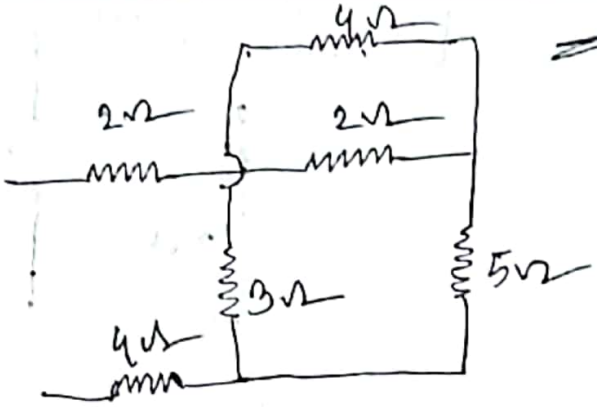
$$I_3 = -\frac{10}{5+2.2} = -1.39\ A$$

$$I = I_1 + I_2 + I_3$$

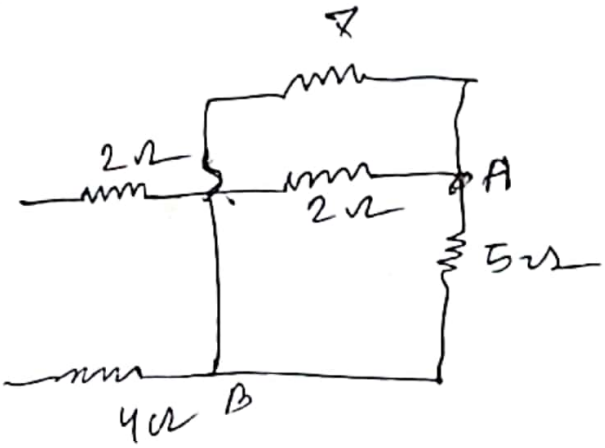
$$= 2.3 + 0.306 - 1.38$$

$$= 1.226\ A$$ Ans:

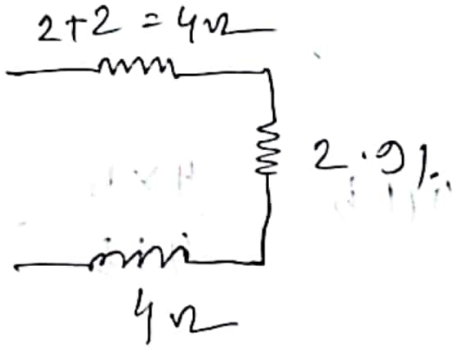
(10) Find the Req.



$(3+4) = 7\Omega$



$5 \| 7 = \frac{5 \times 7}{5+7} = 2.91$



$Req = 4 + 2.917 + 4$

$= 10.91\Omega$

Ans;

conductance,

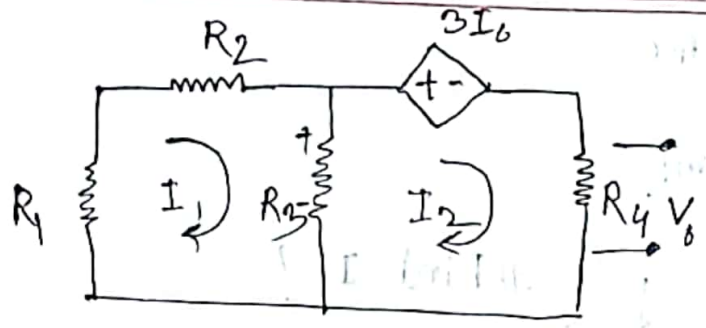
$$G_{eq} = \frac{1}{Req}$$

$$= \frac{1}{10.91}$$

$$= 0.09 \text{ S}$$

$$P = VI = I^2R = \frac{V^2}{R}$$

(11)



Find V_0 ?

Ans:-

Since there is no independent source

$I_0 = 0A$

$V_0 = 0V$

Solve

Using kVL in ~~loop-1~~ mesh-1,

~~$I_1R_1 + I_1R_2 + I_1R_3 = 0$~~

$I_1R_1 + I_1R_2 + R_3(I_1 - I_2) = 0$

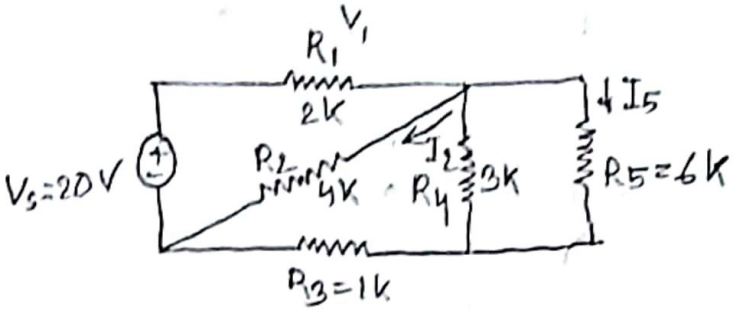
~~Using kVL in loop-2,~~

$I_1R_1 + I_1R_2 + I_1R_3 - I_2R_3 = 0$

$\Rightarrow$

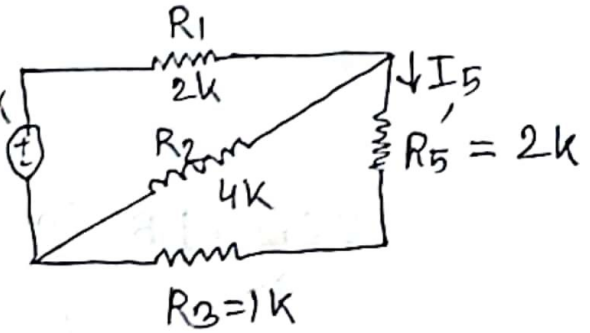
[Date: 28-07-2025]

12 Q: Determine the current I_2, I_5, V_1 & the power across R_4 resistor.

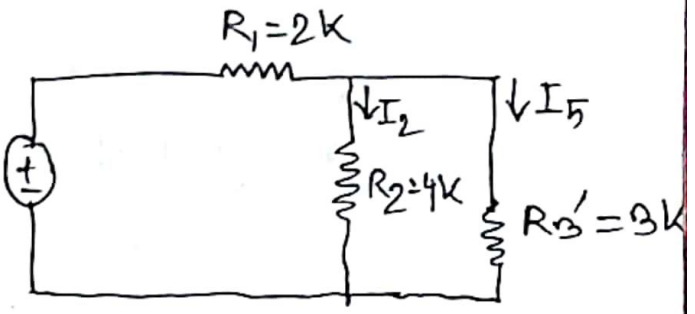


Solve

$$3||6 = \frac{3\times 6}{3+6} = \frac{18}{9} = 2K$$

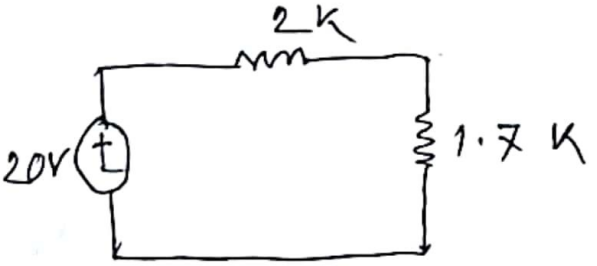


$$R_3' = R_5' + R_3 = 2+1 = 3K$$



$$4||3 = \frac{12}{7} = 1.7K$$

$$I_5 = \frac{20}{2+1.7} = 5.4mA$$



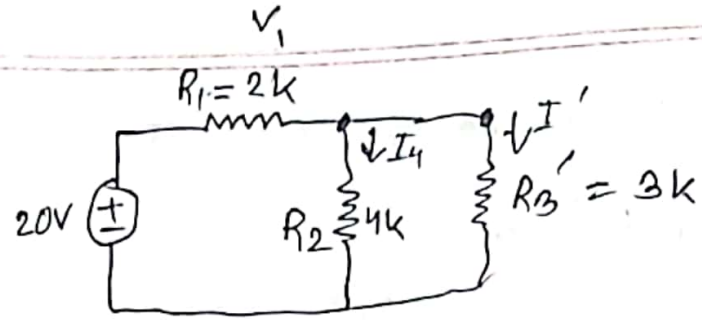
$$I_5 = \frac{5.4\times 4}{3+4} = 3.1\ mA$$

$$I_2 = \frac{5.4\times 3}{4+3} = 2.3\ mA$$

$V_1 = I_S R_1$

$= 5.4 \times 2$

$= 10.8\ V$



Applying KCL,

$I_S = I_2 + I'$

$\Rightarrow I' = I_S - I_2 = 5.4 - 2.3 = 3.1$

Using CDR in I_5,

$$I_5 = \frac{I' R_4}{R_4 + R_5} = \frac{3.1 \times 3}{3+6} = 1.13mA$$

Applying KCL,

$I_4 = I' - I_5$

$= 3.1 - 1.13$

$= 1.97$

Power, $P_4 = I_4^2 R_4$

$= (1.97)^2 \times 3$

$= 11.65\ W$

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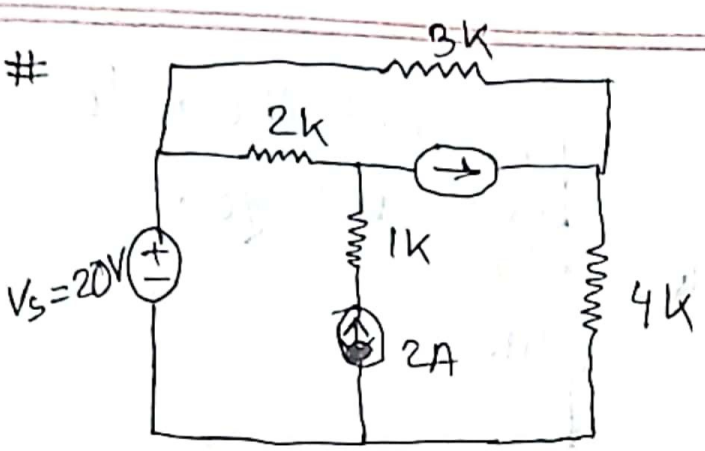
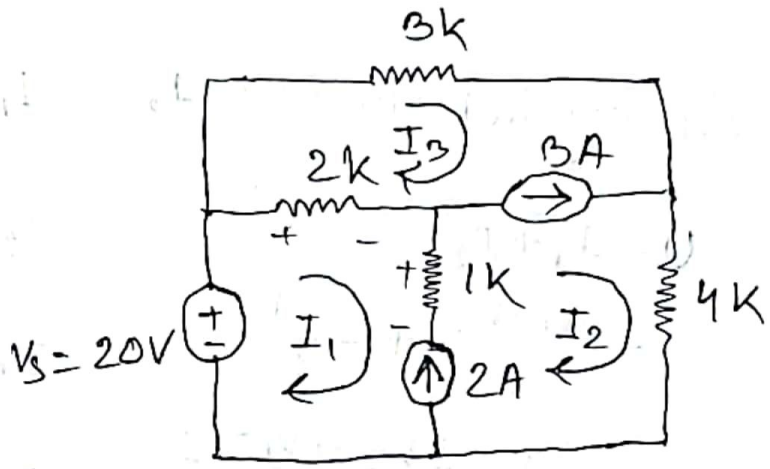


find the mesh current.

Solve

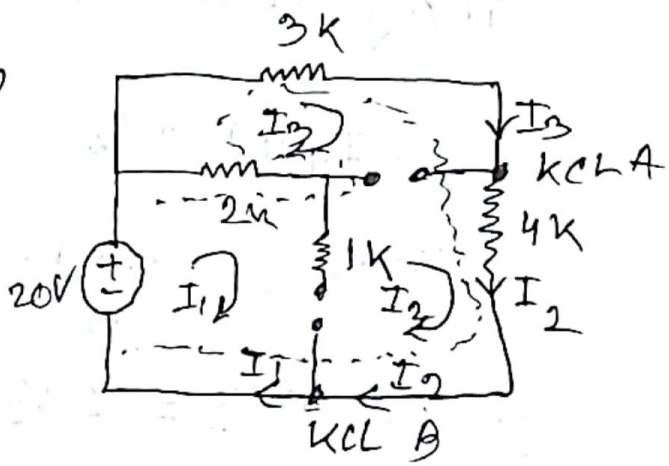


Applying KVL in mesh-1,

$$-20 + 2(I_1 - I_3) + 1(I_1 - I_2)$$

KVL in supermesh,

$$-V_s + I_1 2k + I_3 3k + I_2 4k = 0$$



KCL in node - A, B

$$I_1 + 2 = I_2$$

$$3 + I_3 = I_2$$

* Mesh
* Nodal
* ~~Super mesh~~
* superposition

* Normal
*

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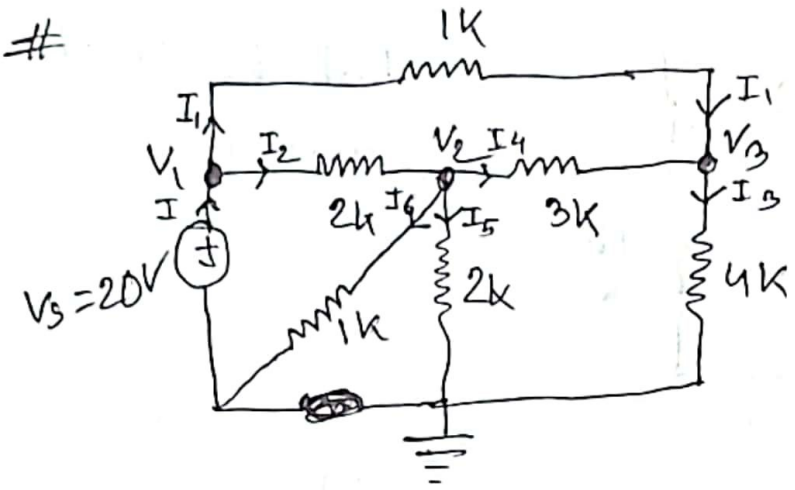

And the node voltage.

Applying KCL in node-1,

$$I_1 = \frac{V_1 - V_3}{1}$$

$$I_2 = \frac{V_1 - V_2}{2}$$

$$I_3 = \frac{V_3}{4}$$

$$I_4 = \frac{V_2 - V_3}{3}$$

$$I_5 = \frac{V_2}{2}$$

$$I_6 = \frac{V_2}{1}$$

$$I = I_1 + I_2$$

$$= \frac{V_1 - V_3}{1} + \frac{V_1 - V_2}{2}$$

$$0 = 2V_1 - 2V_3 + V_1 - V_2$$

$$\Rightarrow 3V_1 - V_2 - 2V_3 = 0$$

$$\Rightarrow 60 - V_2 - 2V_3 = 0 \quad \text{---(i)}$$

Applying KCL in node-2,

$$I_2 = I_4 + I_5 + I_6$$

$$\Rightarrow \frac{V_1 - V_2}{2} = \frac{V_2 - V_3}{3} + \frac{V_2}{2} + V_2$$

$$\Rightarrow 3V_1 - 3V_2 = 2V_2 - 2V_3 + 3V_2 + 6V_2 = 0$$

$$\Rightarrow 60 - 3V_2 - 2V_2 + 2V_3 - 3V_2 - 6V_2 = 0$$

$$\Rightarrow -14V_2 + 3V_3 + 60 = 0 \quad \text{---(ii)}$$

Applying KCL in node-3,

$$I_3 = I_4 + I_1$$

$$\Rightarrow \frac{V_3}{4} = \frac{V_2 - V_3}{3} + \frac{V_{21} - V_3}{1}$$

$$\Rightarrow 3V_3 = 4V_2 - 4V_3 + 12V_1 - 12V_3$$

$$\Rightarrow 3V_3 - 4V_2 + 4V_3 - (12 \times 20) + 12V_3 = 0$$

$$\Rightarrow -4V_2 + 19V_3 - 240 = 0 \quad \text{---(III)}$$

eq (I) (II) (III) solve $\Rightarrow$

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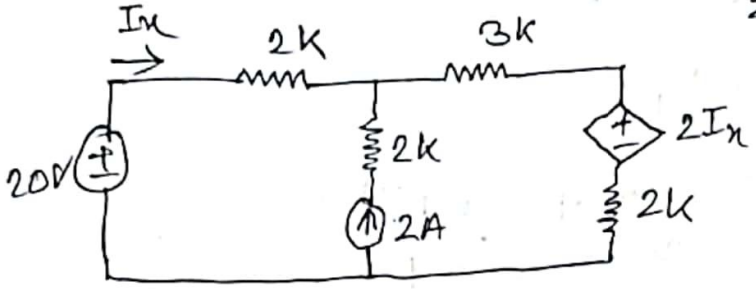
Using super position theorem find I_x



Solve

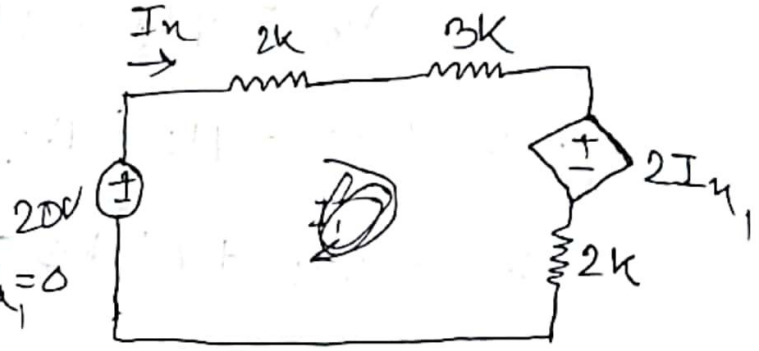


Fig-1

Applying KVL in loop-1

$-20 + 2I_{x_1} + 3I_{x_1} + 2I_{x_1} + 2I_{x_1} = 0$

$\Rightarrow -20 + 7I_{x_1} + 2I_{x_1} = 0$

$\Rightarrow -20 + 9I_{x_1} = 0$

$\therefore I_{x_1} = 2.2A$

Using nodal Analysis,

Using supper mesh - KVL

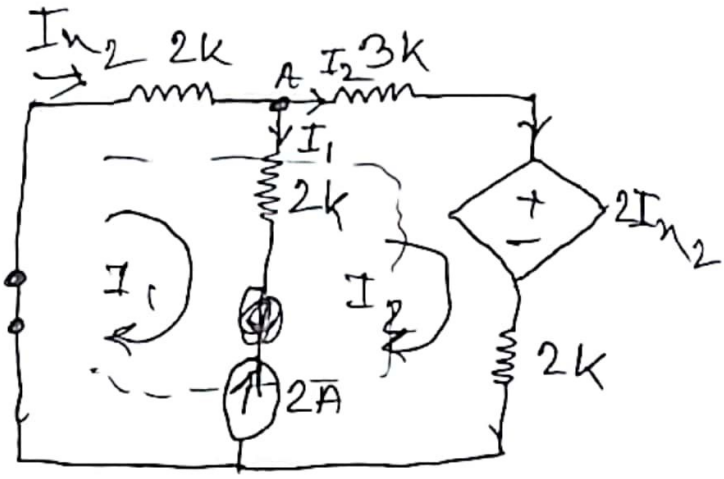


Fig-2

$2I_1 + 3I_2 + 2I_{x_2} + 2I_2 = 0$

$\Rightarrow 2I_{x_2} + 3I_2 + 2I_{x_2} + 2I_2 = 0$

$\Rightarrow 4I_{x_2} + 5I_2 = 0$ ——(1)

KCL in Node-A

$$I_{n_2} + 2 = I_2 \quad \text{---(ii)}$$

$$\Rightarrow I_{n_2} - I_2 + 2 = 0$$

eq solve $\Rightarrow$

$$I_{n_2} = -1.1 \text{ mA}$$

$$I_n = I_{n_1} + I_{n_2}$$

$$= 2.2 - 1.1$$

$$= 1.1 \text{ mA} \quad \underline{\text{Ans.}}$$