Problem-01: Find the source voltage, the voltage V_1, and current I_1 for the circuit in fig.

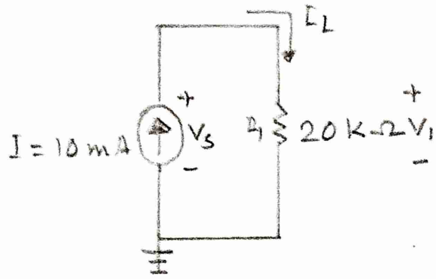


Fig:

Sol^n: Given,

$I = I_1 = 10 mA$

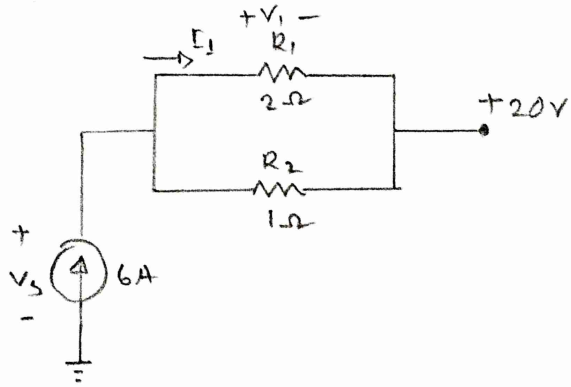
$R_1 = 20 k\Omega$

$\therefore V_S = V_1 = I_1 R_1 = (10 \times 20) V = 200V$

$\therefore$ Source voltage = Voltage, V_1 = 200V

(Ans.)

Problem-02: Determine the current I_1 and the voltage V_s for the network in fig.



Sol^n: Given,

$R_1 = 2\Omega$, $R_2 = 1\Omega$

$\therefore R_T = \left(\frac{1}{R_1} + \frac{1}{R_2}\right)^{-1} = \frac{2}{3}\Omega$

$I = 6A$

As C.D.R,

$$I_1 = \frac{R_T}{R_1} \cdot I = \frac{\frac{2}{3}}{2} \times 6 = 2A$$

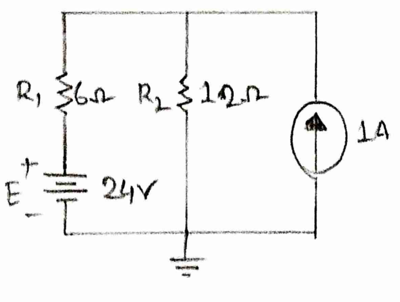
$\therefore$ voltage $V_1 = I_1 R_1 = 2 \times 2 = 4V$

As KVL,

$$V_S = V_1 + 20V = 4 + 20 = 24V$$

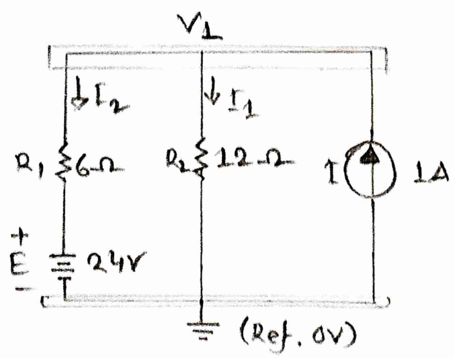
(Ans)

Problem - 03: Determine the node voltages for the network in Fig and calculate the current flow through 6Ω and 12Ω resistor.



Fig

Solⁿ:



Applying KCL at node V_1,

$$\frac{V_1 - 24}{6} + \frac{V_1 - 0}{12} - 1 = 0$$

$\Rightarrow 2V_1 - 48 + V_1 - 12 = 0$

$\Rightarrow 3V_1 = 60$

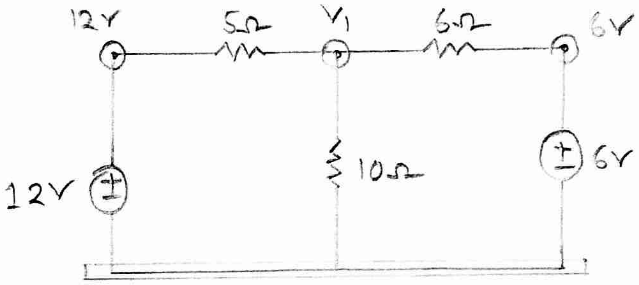
$\therefore V_1 = 20$

$$\therefore I_1 = \frac{V_1 - 24V}{6\Omega} = \frac{20V - 24V}{6\Omega} = -0.67\text{ A}$$

$$\therefore I_2 = \frac{V_1 - 0}{12\Omega} = \frac{20}{12} = 1.67\text{ A}$$

(Ans)

Problem-04: Determine the current through $10\,\Omega$ resistor using nodal analysis.



Fig

Applying KCL at node V_1,

$$\frac{V_1 - 12}{5} + \frac{V_1 - 0}{10} + \frac{V_1 - 6}{6} = 0$$

$$\Rightarrow 2V_1 - 24 + V_1 + \frac{10V_1 - 60}{6} = 0$$

$\Rightarrow 18V_1 - 144 + 10V_1 - 60 = 0$

$$\Rightarrow V_1 = \frac{204}{28} = 7.28\text{ V}$$

$$\therefore I_{10\Omega} = \frac{V_1 - 0}{10\Omega} = \frac{7.28V}{10\Omega} = 0.728\text{ A}.$$

(Ans)

Problem : 05 : Determine the node voltage of the network fig 5 and calculate the current flow through 8 Ω, 4 Ω and 10 Ω resistor.

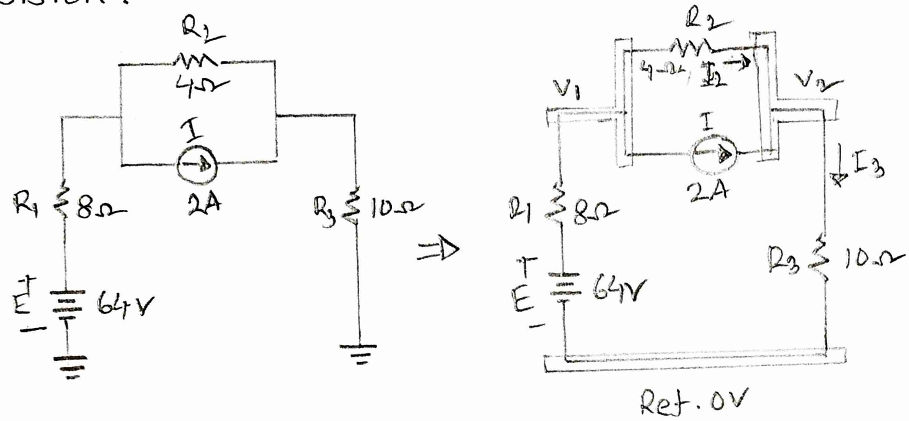


Fig : 05

Sol^n :

Apply KCL at node V_1,

$$\frac{V_1 - 64}{8} + \frac{V_1 - V_2}{4} + 2 = 0$$

$$\Rightarrow V_1 - 64 + 2V_1 - 2V_2 + 16 = 0$$

$$\Rightarrow 3V_1 - 2V_2 - 48 = 0 \quad \text{——— (1)}$$

Apply KCL at node V_2,

$$\frac{V_2 - 0}{10} + \frac{V_2 - V_1}{4} - 2 = 0$$

$$\Rightarrow 2V_2 + 5V_2 - 5V_1 - 40 = 0$$

$$\Rightarrow -5V_1 + 7V_2 - 40 = 0 \quad \text{——— (2)}$$

$$\{(1) \times 5 + (2) \times 3\} \Rightarrow 15V_1 - 10V_2 - 240 - 15V_1 + 21V_2 - 120 = 0$$

$$\Rightarrow 11V_2 = 360$$

$$\therefore V_2 = 32.73\ V$$

$$\therefore V_1 = (2V_2 + 48)/3 = (2 \times 32.73 + 48)/3 = 37.82\ V$$

$\therefore$ Current flow through 8Ω resistor, $I_{R_1} = \dfrac{V_1 - 64}{8}$

$$= \frac{37.82 - 64}{8}$$

$$= -3.27\ A$$

$\therefore$ Current flow through 4Ω resistor, $I_{R_2} = \dfrac{V_1 - V_2}{4}$

$$= \frac{37.82 - 32.73}{4}$$

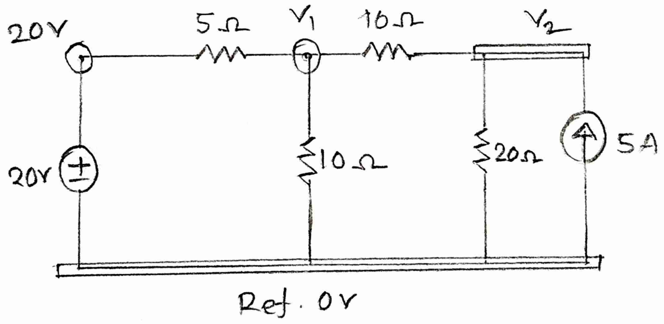
$$= 1.27\ A$$

$\therefore$ Current flow through 10Ω resistor, $I_{R_3} = \dfrac{V_2 - 0}{10}$

$$= \frac{32.73}{10} = 3.27A$$

(Ans.)

Problem-06: Find the node voltage in the following circuit and determine the current flow through 20Ω resistor.



Sol^n:

Apply KCL at node V_1,

$$\frac{V_1 - 20}{5} + \frac{V_1 - 0}{10} + \frac{V_1 - V_2}{10} = 0$$

$$\Rightarrow 2V_1 - 40 + V_1 + V_1 - V_2 = 0$$

$\Rightarrow 4V_1 - V_2 = 40$ ——— (1)

Apply KCL at node V_2,

$$\frac{V_2 - V_1}{10} + \frac{V_2 - 0}{20} - 5 = 0$$

$\Rightarrow 2V_2 - 2V_1 + V_2 - 100 = 0$

$\Rightarrow -2V_1 + 3V_2 = 100$ ——— (II)

$\{(1) + 2\times(II)\} \Rightarrow 4V_1 - V_2 - 4V_1 + 6V_2 = 40 + 200$

$\Rightarrow 5V_2 = 240$

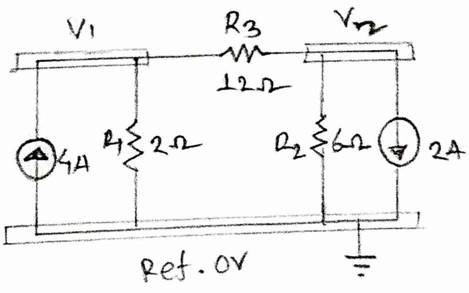
$\therefore V_2 = 48V$

$\therefore V_1 = (40 + V_2)/4 = (40+48)/4 = 22V$

current flow through 20Ω resistor, $I_{20\Omega} = \dfrac{V_2 - 0}{20\Omega} = \dfrac{48V}{20\Omega} = 2.4A.$

(Ans.)

Problem-07: Determine the nodal voltages for the network shown below.



Sol^n: Apply KCL at node V_1

$$-4 + \frac{V_1 - 0}{2} + \frac{V_1 - V_2}{12} = 0$$

$\Rightarrow -48 + 6V_1 + V_1 - V_2 = 0$

$\Rightarrow 7V_1 - V_2 = 48$ ——— (I)

Apply KCL at node V_2,

$$\frac{V_2 - V_1}{12} + \frac{V_2 - 0}{6} + 2 = 0$$

$\Rightarrow V_2 - V_1 + 2V_2 + 24 = 0$

$\Rightarrow 3V_2 - V_1 = -24$ ——— (II)

$\{(I) \times 3 + (II)\} \Rightarrow 21V_1 - 3V_2 + 3V_2 - V_1 = 144 - 24$

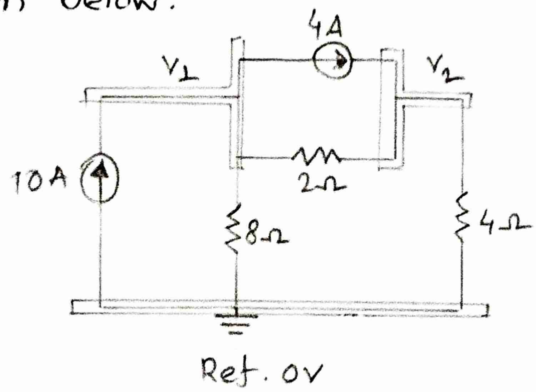
$\Rightarrow 20V_1 = 120$

$\therefore V_1 = 6\text{ V}$

$\therefore V_2 = 7V_1 - 48 = 42 - 48 = -6\text{ V}$

(Ans.)

Problem-08: Determine the node voltages in the following circuit shown below.



Apply KCL at node V_1,

$$-10 + 4 + \frac{V_1 - V_2}{2} + \frac{V_1 - 0}{8} = 0$$

$\Rightarrow -48 + V_1 + 4V_1 - 4V_2 = 0$

$\Rightarrow 5V_1 - 4V_2 = 48 \cdots \cdots \cdots \cdots$ (I)

Apply KCL at node V_2,

$$-4 + \frac{V_2 - V_1}{2} + \frac{V_2 - 0}{4} = 0$$

$\Rightarrow -16 + 2V_2 - 2V_1 + V_2 = 0$

$\Rightarrow -2V_1 + 3V_2 = 16 \cdots \cdots \cdots$ (II)

$\{(I) \times 2 + (II) \times 5\} \Rightarrow 10V_1 - 8V_2 - 10V_1 + 15V_2 = 96 + 80$

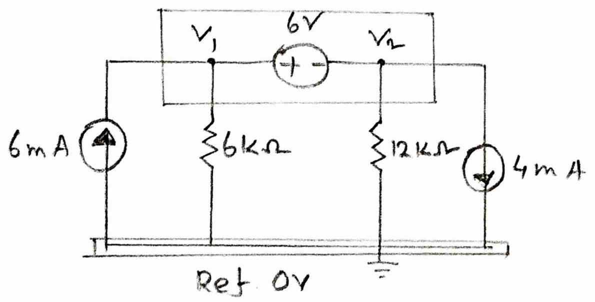
$\Rightarrow 7V_2 = 176$

$\therefore V_2 = 25.14$

$\therefore V_1 = (48 + 4V_2)/5 = (48 + 4 \times 25.14)/5 = 29.71 V$

(Ans.)

Problem-09: Determine the current I_0 in the network shown below.



Soln: Apply KCL at supernode

$$-6 + \frac{V_1 - 0}{6} + 4 + \frac{V_2 - 0}{12} = 0$$

$\Rightarrow 2V_1 + V_2 - 24 = 0$

$\Rightarrow 2V_1 + V_2 = 24$ ——— (1)

$$V_1 - V_2 = 6 \quad \text{——— (ii)}$$

$$\{(i) + (ii)\} \Rightarrow 2V_1 + V_2 + V_1 - V_2 = 24 + 6$$

$$\Rightarrow 3V_1 = 30$$

$$\Rightarrow V_1 = 10$$

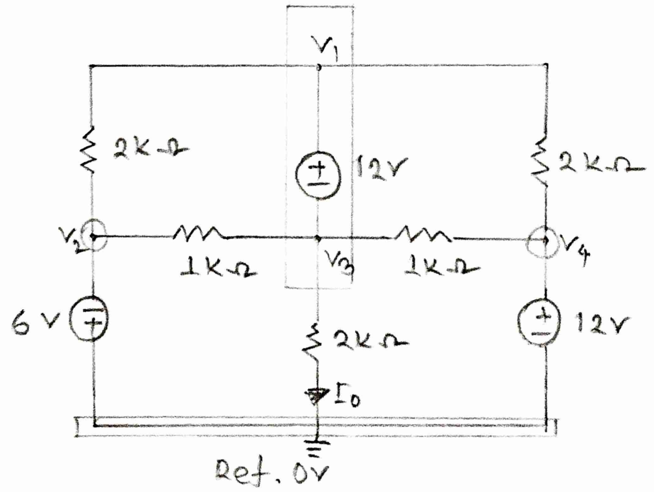
$$\therefore V_2 = V_1 - 6 = 10 - 6 = 4$$

$\therefore$ current flow through $6K\Omega$ resistor, $I_{6K\Omega} = \frac{V_1 - 0}{6\Omega} = \frac{10V}{6\Omega} = 1.67mA$

$\therefore$ current flow through $12K\Omega$ resistor, $I_{12K\Omega} = \frac{V_2 - 0}{12} = \frac{4}{12} = 0.33mA$

(Ans.)

Problem 10: Determine the current I_o in the network in the circuit shown below.



Sol^n:

From the circuit we can determine,

$$V_2 = -6V$$

$$V_4 = 12V$$

Apply KCL at supernode

$$\frac{V_3 - V_2}{1} + \frac{V_3 - 0}{2} + \frac{V_3 - V_4}{1} + \frac{V_1 - V_2}{2} + \frac{V_1 - V_4}{2} = 0$$

$$\Rightarrow V_3+6 + \frac{V_3}{2} + V_3 - 12 + \frac{V_1+6}{2} + \frac{V_1-12}{2} = 0$$

$$\Rightarrow 2V_3 + 12 + V_3 + 2V_3 - 24 + V_1 + 6 + V_1 - 12 = 0$$

$$\Rightarrow 2V_1 + 5V_3 = 18 \quad \text{——— (I)}$$

$$V_1 - V_3 = 12 \quad \text{——— (II)}$$

$\{(I) - (II)\times 2\} \Rightarrow 2V_1 + 5V_3 - 2V_1 + 2V_3 = 18 - 24$

$$\Rightarrow 7V_1 = -6$$

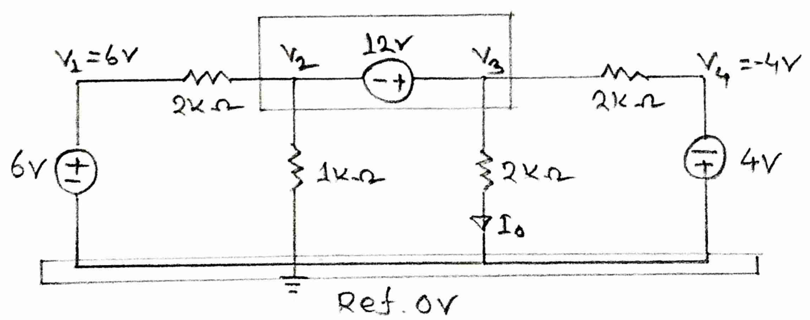
$$\therefore V_1 = -0.857\,V$$

current flow, $I_o = \frac{V_3 - 0}{2k\Omega}$

$$= -\frac{0.857\,V}{2k\Omega} = -0.4285\,mA.$$

(Ans)

Problem : 11 – Use nodal analysis to find I_o in the network in the figure below.



Applying KCL at supernode

$$\frac{V_2-6}{2} + \frac{V_2-0}{1} + \frac{V_3+4}{2} + \frac{V_3-0}{2} = 0$$

$$\Rightarrow V_2 - 6 + 2V_2 + V_3 + 4 + V_3 = 0$$

$\Rightarrow 2V_3 + 3V_2 = 2$ ——— (1)

$V_3 - V_2 = 12$ ——— (2)

$\{(1) + (2) \times 3\} \Rightarrow 2V_3 + 3V_2 + 3V_3 - 3V_2 = 2 + 36$

$\Rightarrow 5V_3 = 38$

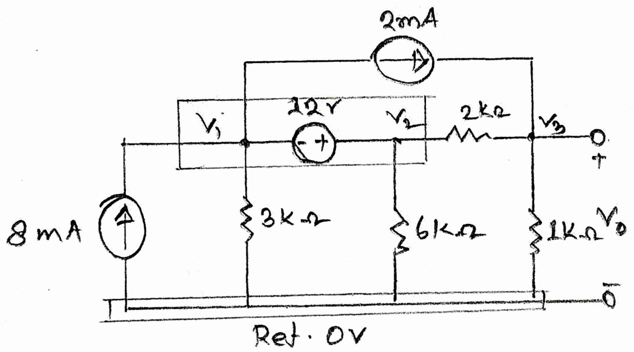
$\therefore V_3 = 7.6$

$\therefore V_2 = -4.4$

$$\therefore I_0 = \frac{V_3 - 0}{2} = \frac{7.6 - 0}{2} = 3.8\,mA$$

(Ans.)

Problem: 12 - Find V_o in figure below using nodal analysis.



Soln:

Applying KCL at supernode.

$$-8 + \frac{V_1 - 0}{3} + 2 + \frac{V_2 - V_3}{2} + \frac{V_2 - 0}{6} = 0$$

$\Rightarrow -36 + 2V_1 + 3V_2 - 3V_2 + V_2 = 0$

$\Rightarrow 2V_1 + 4V_2 - 3V_3 = 36$ ——— (1)

$V_2 - V_1 = 12$ ——— (2)

$\Rightarrow V_2 = 12 - V_1$ ——— (4)

Applying KCL at node V_3,

$$\frac{V_3 - V_2}{2} + \frac{V_3 - 0}{1} - 2 = 0$$

$\Rightarrow V_3 - V_2 + 2V_3 = 4$

$\Rightarrow 3V_3 - V_2 = 4$ ——— (3)

$\Rightarrow 3V_3 - (12 + V_1) = 4$ [From equ. (4)]

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

$\Rightarrow 3V_3 = 16 + V_1$ ——— (5)

$\therefore 2V_1 + 4V_2 - 3V_3 = 36$

$\Rightarrow 2V_1 + 4(12 + V_1) - (16 + V_1) = 36$

$\Rightarrow 2V_1 + 48 + 4V_1 - 16 - V_1 = 36$

$\Rightarrow 5V_1 = 4$

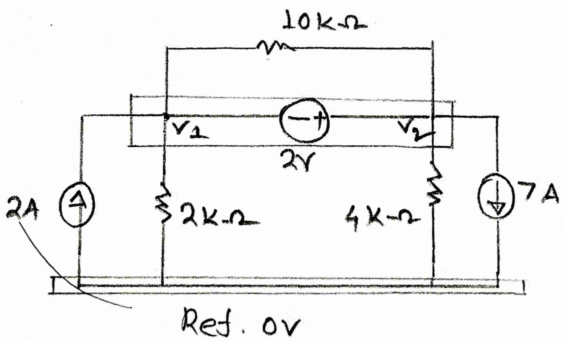
$\therefore V_1 = \frac{4}{5} = 0.8\,V$

$\therefore V_3 = (16 + V_1)/3$
$\quad = (16 + 0.8)/3 = 5.6\,V$

$\therefore V_2 = 12 + V_1 = 12.8\,V$

(Ans.)

Problem-13: For the circuit shown below find the node voltage.



Applying KCL at supernode

$$-2 + \frac{v_1 - 0}{2} + \frac{v_2 - 0}{4} + 7 = 0$$

$$\Rightarrow -8 + 2v_1 + v_2 + 28 = 0$$

$$\Rightarrow 2v_1 + v_2 = -20 \quad \text{------} \quad (1)$$

$$v_2 - v_1 = 2 \quad \text{------} \quad (2)$$

$$\{(1) - (2)\} \Rightarrow 2v_1 + v_2 - v_2 + v_1 = -20 - 2$$

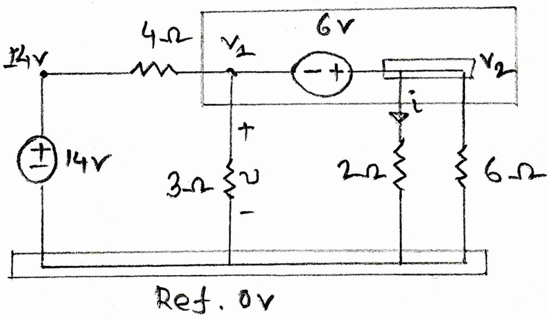
$$\Rightarrow 3v_1 = -22$$

$$\therefore v_1 = -22/3 = -7.33\ v$$

$$\therefore v_2 = 2 + v_1 = 2 - 7.33 = -5.33\ v$$

(Ans.)

Problem-14: Find v and I in the circuit below.



Sol^n:

Applying KCL at supernode

$$\frac{v_1 - 14}{4} + \frac{v_1 - 0}{3} + \frac{v_2 - 0}{2} + \frac{v_2 - 0}{6} = 0$$

$$\Rightarrow \frac{6v_1 - 84}{4} + 2v_1 + 3v_2 + v_2 = 0$$

$$\Rightarrow 6v_1 - 84 + 8v_1 + 16v_2 = 0$$

$$\Rightarrow 7V_1 + 8V_2 = 42 \quad \text{——— (1)}$$

$$V_2 - V_1 = 6 \quad \text{——— (2)}$$

$$\{(1) + (2) \times 7\} \Rightarrow 7V_1 + 8V_2 + 7V_2 - 7V_1 = 42 + 42$$

$$\Rightarrow 15V_2 = 84$$

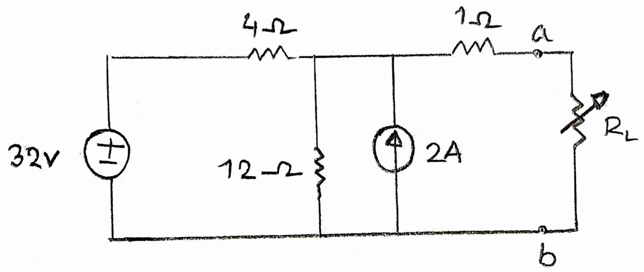
$$\therefore V_2 = 5.6\,V$$

$$\therefore V_1 = 5.6 - 6 = -0.4V$$

$$\therefore v = V_1 = -0.4V$$

$$\therefore i = \frac{V_2 - 0}{2} = \frac{5.6 - 0}{2} = 2.8\,mA \quad \text{(Ans.)}$$

Problem : 15 - Find the thevenin equivalent circuit of the circuit shown in the figure below, to the left of the terminal. Then find the current through $R_L = 6\Omega, 16\Omega, 36\Omega$



Sol^n:

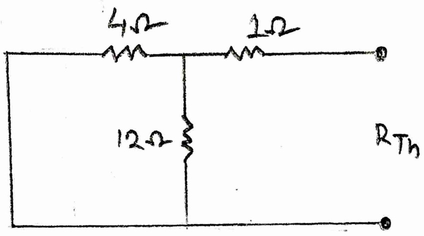


Fig: a

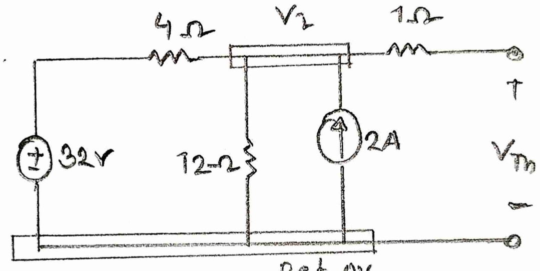


Fig: b

Find R_{Th},

We find by turning off the 32V voltage source (replacing it with a short circuit) and the 2-A current source (replacing it with an open circuit). The circuit becomes as fig: a.

$$\therefore R_{Th} = (4\Omega \parallel 12\Omega) + 1\Omega$$

$$= \left(\frac{1}{4} + \frac{1}{12}\right)^{-1} + 1 = 4\Omega$$

Find V_{Th},

Applying KCL at node V_1 in fig: b,

$$\frac{V_1 - 32}{4} + \frac{V_1 - 0}{12} - 2 = 0$$

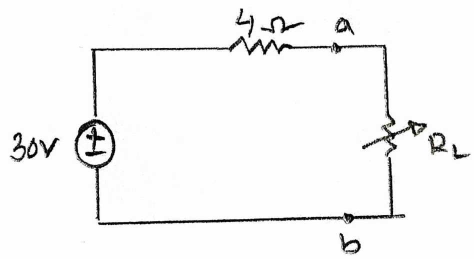
$$\Rightarrow 3V_1 - 96 + V_1 - 24 = 0$$

$$\Rightarrow 4V_1 = 120$$

$$\therefore V_1 = 30\text{ V}$$

$\because V_1 = V_{Th} = 30V$

$\therefore$ Thevenin equivalent circuit in fig: c



The current through R_L is $\Rightarrow I_L = \frac{V_{Th}}{R_{Th}+R_L}$

$= \frac{30}{4+R_L}$

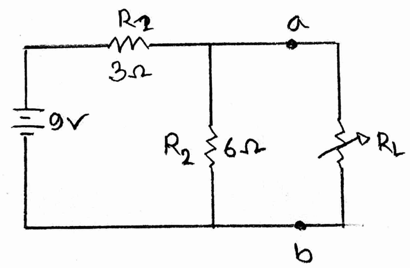
$\therefore$ when $R_L = 6\Omega$, $I_L = \frac{30}{4+6} = 3A$

$\therefore$ when $R_L = 16\Omega$, $I_L = \frac{30}{4+16} = 1.5A$

$\therefore$ when $R_L = 36\Omega$, $I_L = \frac{30}{4+36} = 0.75A$

(Ans.)

Problem-16: Find the thevenin equivalent circuit for for the network below in figure. Determine the current through RL for values of 2Ω, 10Ω, 100Ω



Find R_{Th},

We find by turning off the 9v voltage source, replacing it with a short circuit. The circuit becomes as fig:a.

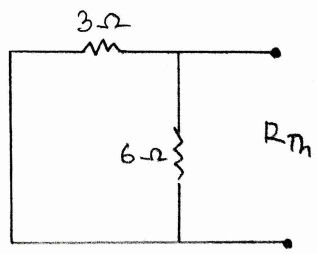
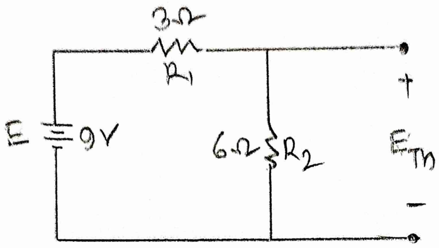


Fig: a

$\therefore R_{Th} = (3\Omega \,||\, 6\Omega) = 2\Omega$

Find. E_{Th},



∴ Open circuit voltage E_{Th} is same as voltage drop across the 6Ω resistor.

∴ Applying VDR,

$$E_{Th} = \frac{R_2}{R_T} \cdot V$$

$$= \frac{R_2}{R_1 + R_2} \cdot V = \frac{6}{9} \cdot 9 = 6V$$

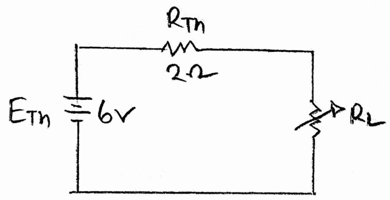


fig: b

Thevenin equivalent circuit in fig : b

The current through R_L is $\Rightarrow$ $I_L = \frac{E_{Th}}{R_{Th} + R_L}$

$$= \frac{6}{2 + R_L}$$

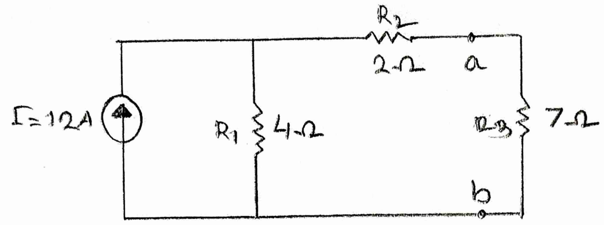
∴ when R_L is 2Ω, $I_L = \frac{6}{2+2} = 1.5\ A$

∴ when R_L is 10Ω, $I_L = \frac{6}{2+10} = 0.5A$

∴ when R_L is 100Ω, $I_L = \frac{6}{2+100} = 0.06\ A$

(Ans.)

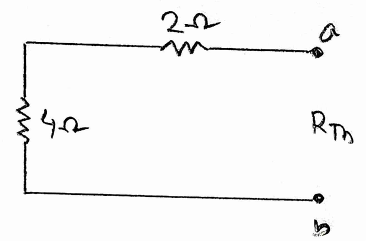
Proble 12: Find the Thevenin equivalent circuit and determine the current flow through R_L in the figure below.



Sol^n:

Find R_{Th},

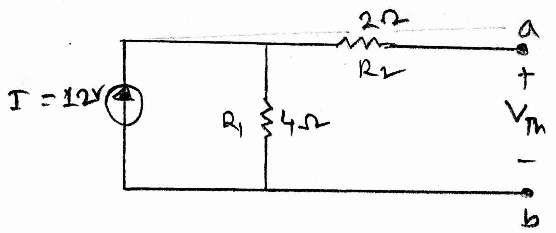
We find by turning off the current source (12 A) replacing with an open circuit.



$$\therefore R_{Th} = 2\Omega + 4\Omega = 6\Omega$$

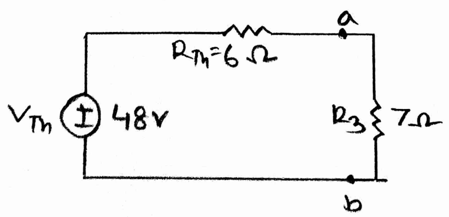
Find V_{Th}.

Open circuit voltage V_{Th} is same as voltage drop in 4Ω resistor



$$\therefore V_{Th} = IR_1 = 12 \times 4 = 48\,V$$

$\therefore$ Thevenin equivalent circuit.



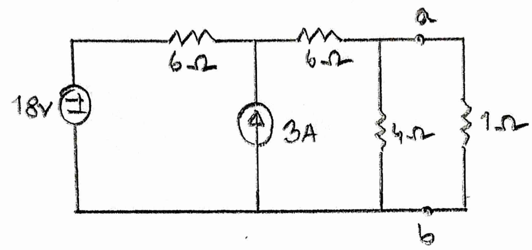
$\therefore$ Current through R_L is

$$I_L = \frac{V_{Th}}{R_{Th}+R_L}$$

$$= \frac{48}{6+7} = 3.69\,A$$

(Ans)

Problem - 18: Determine the thevenin equivalent circuit at terminal a-b. Find the current flow through 1Ω resistor.



Soln:

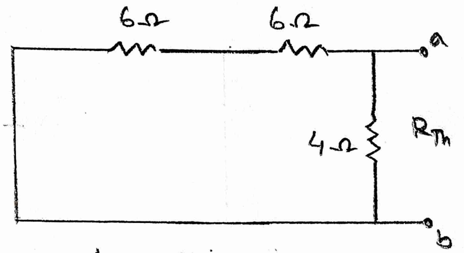


fig: (a)

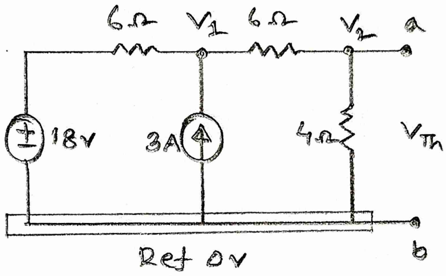


fig: (b)

Find R_{Th},

$$\therefore R_{Th} = (6\Omega + 6\Omega) \parallel 4\Omega = 3\Omega$$

Find V_{Th},

Apply KCL at node V_1 in fig: (b)

$$\frac{V_1 - 18}{6} - 3 + \frac{V_1 - V_2}{6} = 0$$

$$\Rightarrow V_1 - 18 - 18 + V_1 - V_2 = 0$$

$$\Rightarrow 2V_1 - V_2 = 36 \quad \text{——— (1)}$$

Apply KCL at node V_2 in fig (b);

$$\frac{V_2 - V_1}{6} + \frac{V_2 - 0}{4} = 0$$

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

$$\Rightarrow -2V_1 + 5V_2 = 0 \quad \text{——— (2)}$$

$\therefore$ Solving equation (1) and (2),

$$V_1 = 22.5\,V$$
$$V_2 = 9\,V$$

$$\therefore \quad V_{Th} = V_2 - 0 = 9 - 0 = 9\,V$$

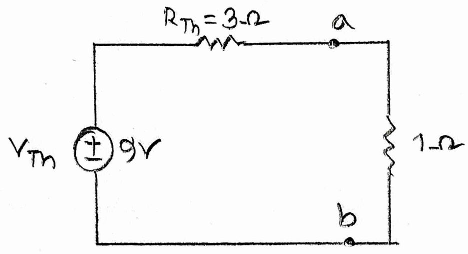


Fig: c

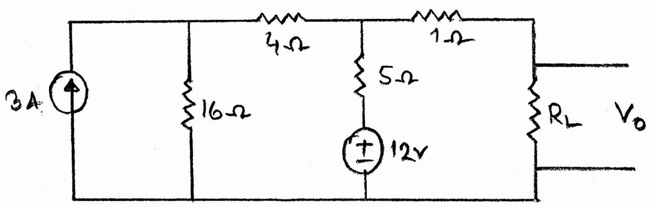
Thevenin equivalent circuit in fig: c

$\therefore$ current through R_L is, $I_L = \dfrac{V_{Th}}{R_{Th}+R_L}$

$$= \frac{9}{3+R_L}$$

When $R_L = 1\,\Omega$, $I_L = \dfrac{9}{3+1} = 2.25\,A$

Problem : 19 - Apply Thevenin theorem to find V_o when $R_L = 10\,\Omega$



Soln:

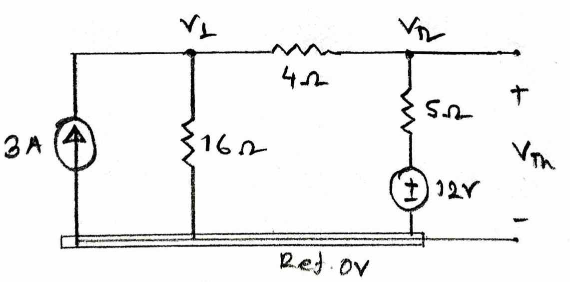


Fig: a

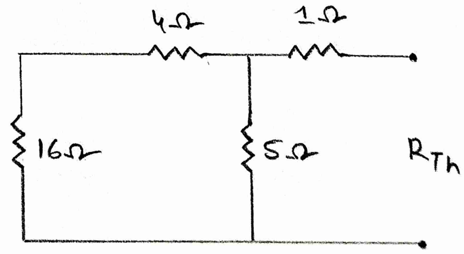


Fig: b

Find V_{Th}: (fig: a)

Applying KCL at node V_1,

$$-3 + \frac{V_1 - 0}{16} + \frac{V_1 - V_2}{4} = 0$$

$$\Rightarrow -48 + V_1 + 4V_1 - 4V_2 = 0$$

$$\Rightarrow 5V_1 - 4V_2 = 48 \quad \text{--------- (1)}$$

Applying KCL at node V_2,

$$\frac{V_2 - V_1}{4} + \frac{V_2 - 12}{5} = 0$$

$$\Rightarrow 5V_2 - 5V_1 + 4V_2 - 48 = 0$$

$$\Rightarrow -5V_1 + 9V_2 = 48 \quad \text{--------- (2)}$$

By solving equation (1) and (2)

$V_1 = 24.96\,V$

$V_2 = 19.2\,V$

$\therefore V_{Th} = V_2 - 0 = 19.2 - 0 = 19.2\,V$

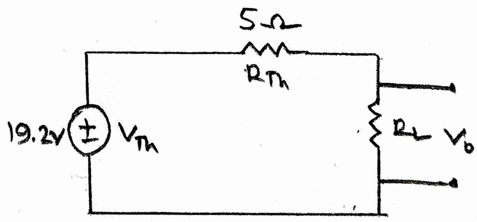
Find R_{Th}: (fig-b)

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

$$= 5\Omega$$

for $R_L = 10\Omega$,

$$\therefore V_o = \frac{R_L}{R_{Th} + R_L} \cdot V_{Th}$$



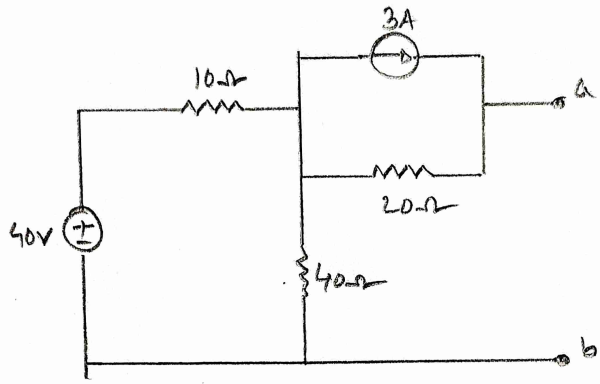
$$= \frac{10}{5 + 10} \cdot 19.2\,V$$

$$= 12.8\,V$$

(Ans.)

Problem-20: Design the thevenin equivalent circuit at terminal a-b for the circuit shown below.

Sol^n:



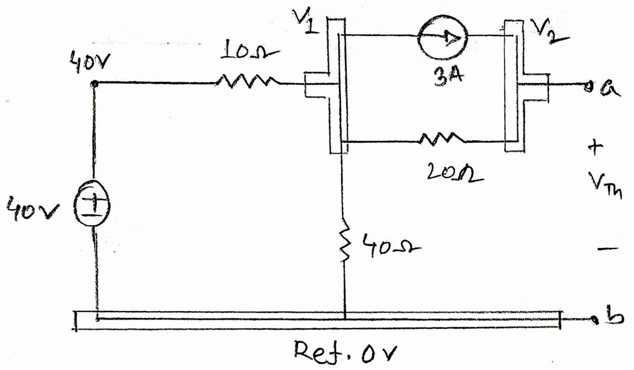


Fig: a

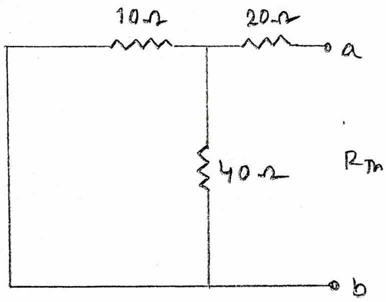


Fig: b

Find V_{Th} : (Fig-a)

Applying KCL at node V_1,

$$\frac{V_1 - 0}{40} + \frac{V_1 - 40}{10} + \frac{V_1 - V_2}{20} + 3 = 0$$

$$\Rightarrow V_1 - 4V_1 - 160 + 2V_1 - 2V_2 + 120 = 0$$

$$\Rightarrow 7V_1 - 2V_2 = 40 \quad \text{——— (1)}$$

Applying KCL at node V_2,

$$\frac{V_2 - V_1}{20} - 3 = 0$$

$$\Rightarrow V_2 - V_1 - 60 = 0$$

$$\Rightarrow -V_1 + V_2 = 60 \quad \text{——— (2)}$$

By solving equation ① and ②;

$$V_1 = 32V$$

$$V_2 = 92V$$

$$\therefore V_{Th} = V_2 - 0 = 92 - 0 = 92V$$

Find R_{Th} (Fig: b)

$$R_{Th} = (10\Omega \parallel 40\Omega) + 20\Omega$$

$$= 8\Omega + 20\Omega = 28\Omega$$

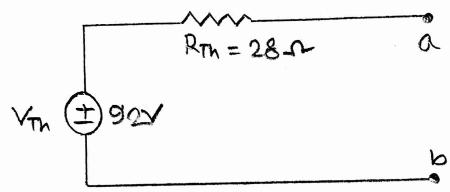
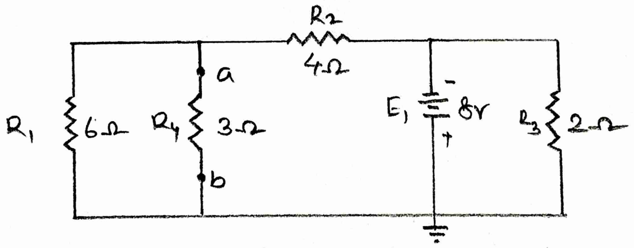


Fig: Thevenine Equivalent Circuit

Problem : 21 – Find the thevenin equivalent circuit at terminal a–b for the network shown in Figure below.



Soln:

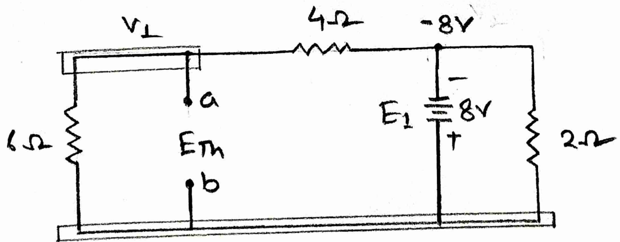


Fig : a

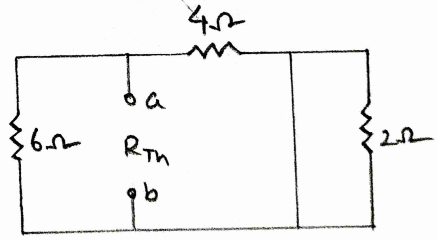


fig : b

Find E_{Th} (Fig: a)

Applying KCL at node V_1,

$$\frac{V_1 - 0}{6} + \frac{V_1 + 8}{4} = 0$$

$\Rightarrow 2V_1 + 3V_1 + 24 = 0$

$\Rightarrow 5V_1 = -24$

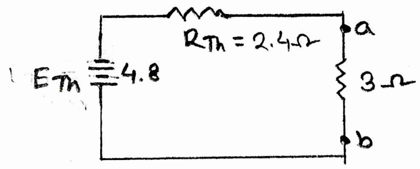
$\therefore V_1 = -4.8 \text{ V}$

$\therefore E_{Th} = (V_1 - 0)\text{V} = (-4.8\text{V} - 0\text{V}) = -4.8 \text{ V}$

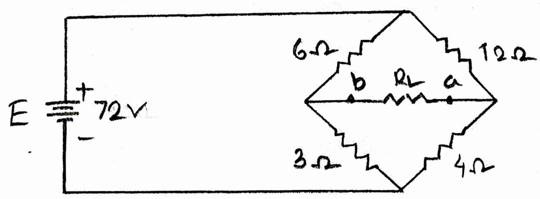
Find R_{Th} (Fig: b)

$$R_{Th} = 4\Omega \,||\, 6\Omega$$
$$= 2.4\,\Omega$$

$\therefore$ Thevenin equivalent circuit:



□ Problem - 22: Find the Thevenin equivalent circuit at terminal a-b for the network shown in the Figure below.



Find E_{Th}, (Fig a)

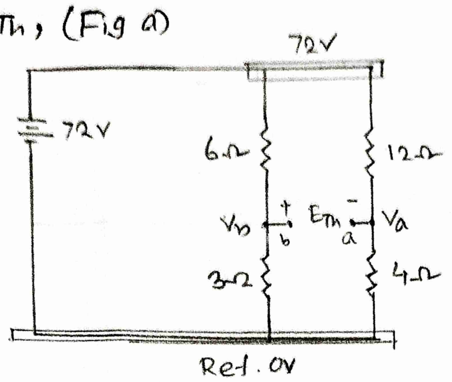


Fig : a

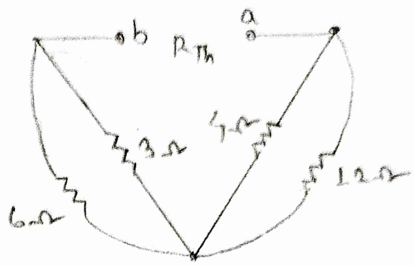


Fig : b

Applying KCL at node V_a,

$$\frac{V_a - 72}{12} + \frac{V_a - 0}{4} = 0$$

$\Rightarrow V_a - 72 + 3V_a = 0$

$\therefore V_a = 18\,V$

Applying KCL at node V_b,

$$\frac{V_b - 72}{6} + \frac{V_b - 0}{3} = 0$$

$\Rightarrow V_b - 72 + 2V_b = 0$

$\Rightarrow V_b = 24\,V$

$\therefore E_{Th} = V_b - V_a = 24 - 18 = 6\,V$

$\therefore R_{Th} = (6\Omega \parallel 3\Omega) + (4\Omega \parallel 12\Omega)$

$= 2\Omega + 3\Omega = 5\Omega$

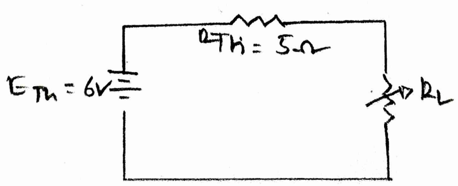
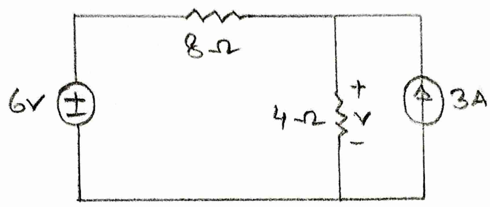


Fig: Thevenine equivalent circuit

Problem - 23: Use the superposition theorem to find v in the circuit of figure below.



Solⁿ:

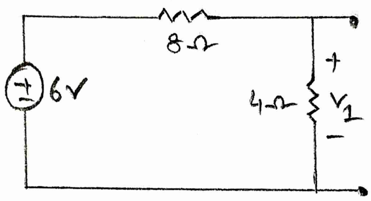


Fig (a)

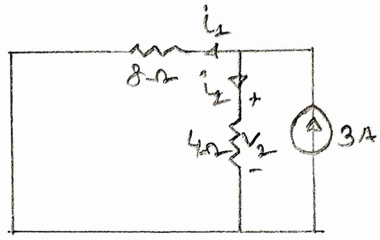


Fig (b)

Since there are two source, let $v = v_1 + v_2$

To obtain v_1 we replace 3A current source by an open circuit

∴ Applying vdr at fig (a).

$$V = \frac{4}{R_T} \cdot V_{supply} = \frac{4}{4+8} \times 6 = 2V$$

To obtain v_2 we replace 6V voltage source with a short circuit. Applying cdr at fig: b

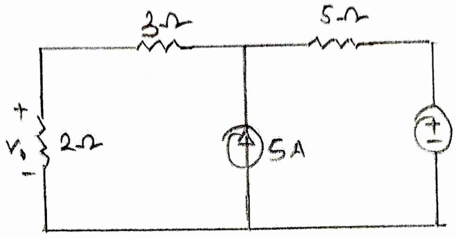
$$\therefore i_2 = \frac{R_T}{4} \cdot I = \frac{2.67}{4} \times 3 = 2A$$

$$\therefore v_2 = i_2 \times 4 = 2 \times 4 = 8V$$

$$\therefore V = V_1 + V_2 = 2V + 8V = 10V$$

(Ans.)

Problem : 24 - Using superposition theorem, find v_0 in the circuit of Figure below.



Sol^n: Since there are two power source, let $V_0 = V_1 + V_2$

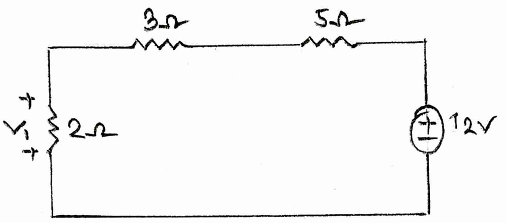


Fig: a

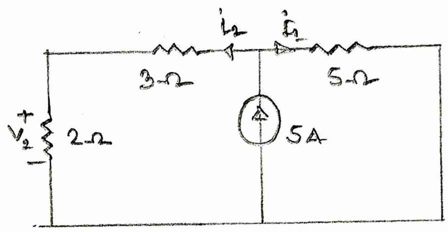


Fig: b

To obtain V_1 we replace 5A current source by an open circuit. Applying VDR at V_1 fig(a)

$$\therefore V_1 = \frac{2}{R_T} \cdot V_{supply} = \frac{2}{2+3+5} \times 12 = \frac{2}{10} \times 12 = 2.4V$$

To obtain V_2 we replace 12V voltage source by a shortcircuit

Applying CDR at (fig : b)

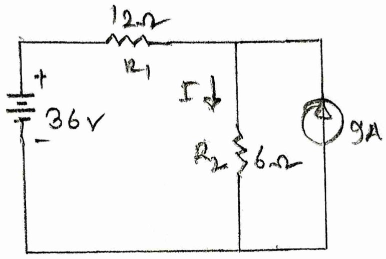
$$i_2 = \frac{R_T}{(2+3)} \cdot 5 = \frac{5/2}{5} \cdot 5 = 2.5A$$

$$\therefore V_2 = i_2 \times R = 2.5 \times 2 = 5V$$

$$\therefore V_0 = V_1 + V_2 = 2.4 + 5 = 7.4V$$

(Ans.)

Problem : 25 - Using the superposition theorem determine the current through resistor R_2 for the network in figure below.



Soln: Since there are two power source let, $I = I_1 + I_2$

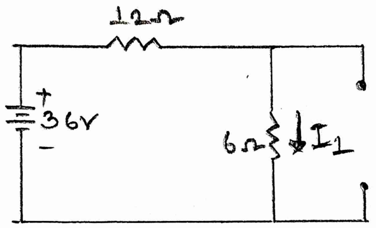


Fig : a

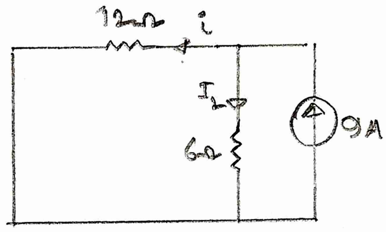


Fig : b

To obtain I_1 we replace 9A current source by an open circuit Applying VDR at 6Ω resistor in fig : a

$$V_{6\Omega} = \frac{6}{6+12} \cdot 36 = 12V$$

$$\therefore I_1 = \frac{V_{6\Omega}}{6\Omega} = \frac{12}{6} = 2A$$

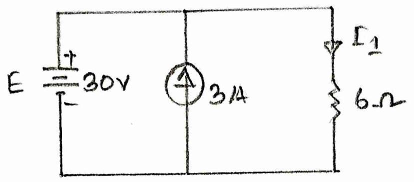
To obtain I_2 we replace 36V voltage source by a short circuit. Applying CDR at 6Ω resistor in fig : b

$$\therefore I_2 = \frac{R_T}{6} \cdot 9 = \frac{\left(\frac{1}{12}+\frac{1}{6}\right)^{-1}}{6} \cdot 9 = \frac{4}{6} \cdot 9 = 6A$$

$\therefore$ current flow in R_2 resistor $- I = I_1 + I_2 = 2 + 6 = 8A$

(Ans.)

Problem 26: Using the superposition theorem, determine current I_1 for the network in Figure below.



Soln: Since there is 2 power source, let $I_1 = i_a + i_b$

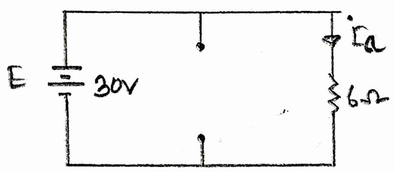


Fig: a

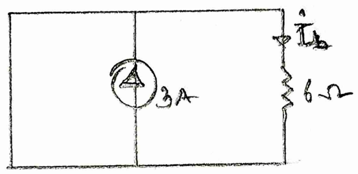


Fig: b

To obtain i_a we replace 3A current power source by an open circuit. in fig (a)

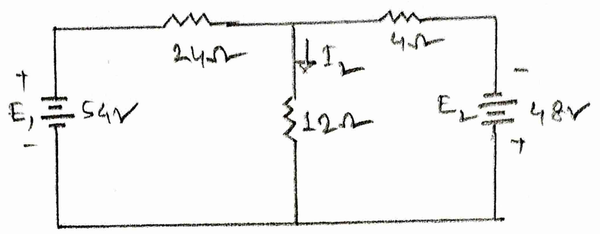
$$\therefore \; i_a = \frac{E}{6} = \frac{30}{6} = 5A$$

To obtain i_b we replace 30v voltage source by a short circuit. As the circuit shorted there will be no current flow through 6Ω resistor (Fig: b).

$$\therefore \; i_b = 0A$$

$\therefore$ current, $I_1 = i_a + i_b = 5 + 0 = 5A.$

Problem 27: Using the superposition theorem determine the current through 12Ω resistor in Figure below.



Solⁿ: Since there are 2 power source, Let $I_2 = i_a + i_b$

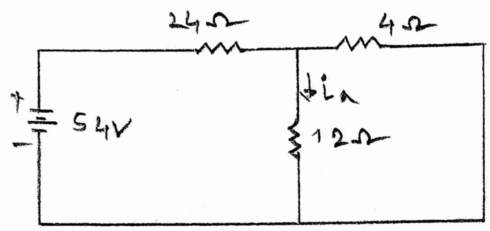


fig: a

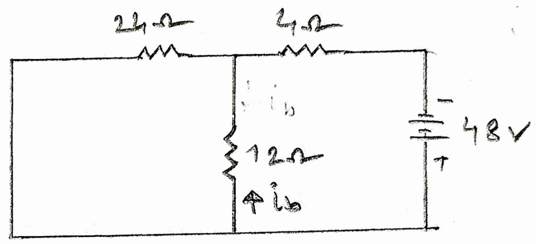


fig: b

To obtain i_a we replace 48V EMF source with an open circuit. (Fig: a). Applying VDR at 12Ω resistor,

$$V_{12\Omega} = \frac{\left(\frac{1}{12} + \frac{1}{4}\right)^{-1}}{R_T} \cdot E = \frac{3}{27} \times 54 = 6\,V$$

$$\therefore i_A = \frac{V_{12\Omega}}{12\Omega} = \frac{6}{12} = 0.5\,A$$

To Obtain i_b we replace 54V EMF source with a short circuit (Fig: b) Applying VDR at 12Ω resistor.

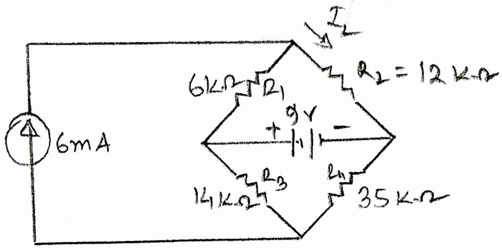
$$V_{12\Omega} = \frac{\left(\frac{1}{12} + \frac{1}{24}\right)^{-1}}{\left(\left(\frac{1}{12} + \frac{1}{24}\right)^{-1} + 4\right)} \times 48 = 32\,V$$

$$\therefore i_b = \frac{V_{12\Omega}}{12} = \frac{32}{12} = 2.67\,A$$

$$\therefore I_2 = i_a\downarrow + i_b\uparrow = i_b\uparrow - i_a\uparrow = 2.67 - 0.5 = 2.17\,A\,(\uparrow)$$

(Ans)

Problem 28 : Using the principle of superposition theorem find the current I_2 through the 12 kΩ resistor in Figure below



Solⁿ: since there is 2 power source let $I_2 = I_A + I_B$

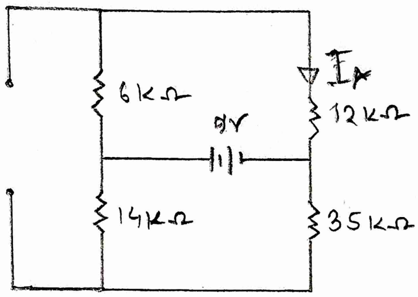


Fig: a

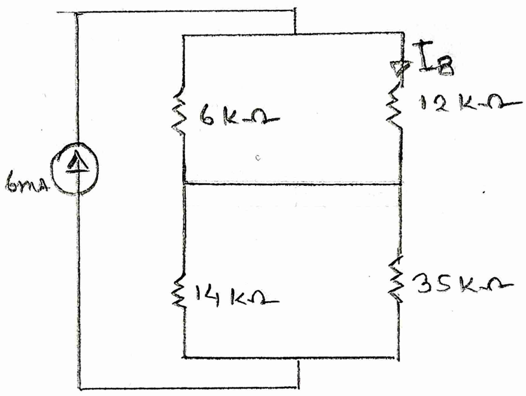


Fig: b

To determin I_a we replace 6mA current source with an open circuit (Fig: a).

as in parallel circuit voltage drop same and in series circuit current flow same.

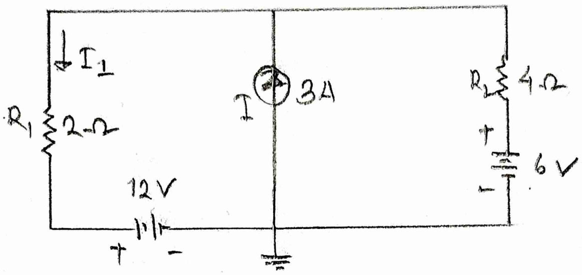
$$I_A = \frac{9}{6+12} = 0.5\,mA$$

To determine I_B we replace 9v EMF source with a short circuit (Fig: b). Applying CDR at 12kΩ resistor

$$\therefore I_B = \frac{12}{6+12} \cdot 6 = 2\,mA$$

∴ current through $I_2 = I_A + I_B = 0.5 + 2 = 2.5\,mA$

Problem 29: Find the current through the 2Ω resistor of the network in figure below.



Sol^n: Since there are 3 power source, Let $I_1 = I_A + I_B + I_C$

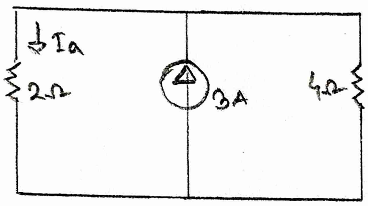


Fig: A

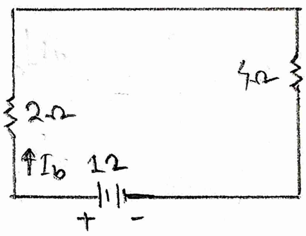


Fig: B

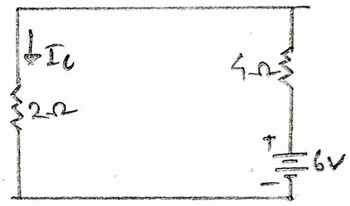


Fig: C

To determine I_A we replace 12v EMF source and 6v EMF source by short circuit. (Fig:A)

Applying CDR at 2Ω resistor,

$$I_a = \frac{R_T}{2\Omega} \times 3 = \frac{4}{2+4} \times 3 = 2A \downarrow$$

To determine I_B we replace 6v EMF source by short circuit and 3A current source by open circuit (Fig:B)

$$\therefore I_b = \frac{12v}{2\Omega + 4\Omega} = 2A \uparrow$$

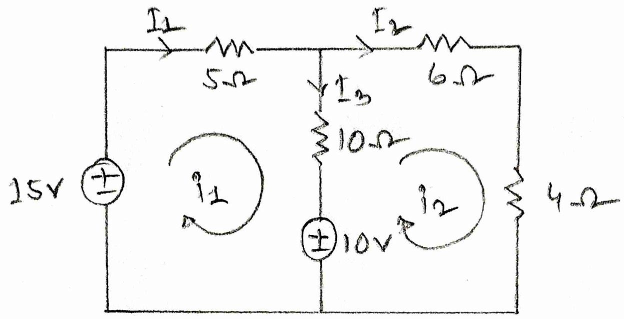
To determine I_C we replace 12v EMF source by short circuit and 3A current source by open circuit (Fig:C)

$$\therefore I_C = \frac{6}{2+4} = 1A \downarrow$$

$$\therefore I_1 = I_A\downarrow + I_B\uparrow + I_C\downarrow = (I_A - I_B + I_C)\downarrow = 2-2+1 = 1A\downarrow$$

(Ans)

⊞ Problem-30: For the circuit below find the branch currents I_1, I_2 and I_3 using mash analysis.



Sol^n:

Applying KVL at mesh i_1,

$$5i_1 + 10(i_1 - i_2) + 10 - 15 = 0$$

$$\Rightarrow 15i_1 - 10i_2 = 5$$

$$\Rightarrow 3i_1 - 2i_2 = 1 \text{ ——— } (1)$$

Applying KVL at mesh i_2,

$$6i_2 + 4i_2 - 10 + 10(i_2 - i_1) = 0$$

$$\Rightarrow 20i_2 - 10i_1 = 10$$

$$\Rightarrow 2i_2 - i_1 = 1 \text{ ——— } (2)$$

$\{(1)+(2)\} \Rightarrow 3i_1 - 2i_2 + 2i_2 - i_1 = 1+1$

$\Rightarrow 2i_1 = 2$

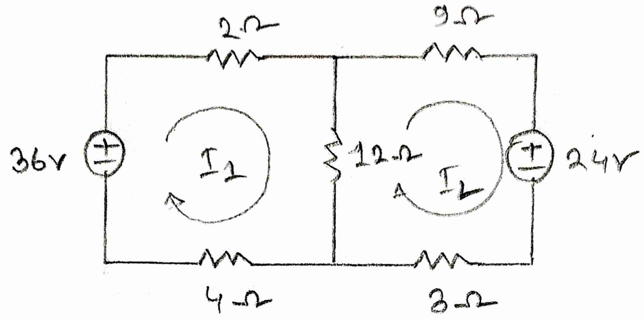
$\therefore i_1 = 1\,A \quad \therefore i_2 = 1\,A.$

$\therefore I_1 = 1\,A$

$\therefore I_2 = 1\,A$

$\therefore I_3 = i_1 - i_2 = 1 - 1 = 0\,A$ (Ans)

Problem - 31: Calculate the mesh current I_1 and I_2 of the circuit below.



Sol^n:

Applying KVL at mesh I_1,

$$2I_1 + 12(I_1+I_2) + 4I_1 - 36 = 0$$

$$\Rightarrow 18I_1 + 12I_2 = 36$$

$$\Rightarrow 3I_1 + 2I_2 = 6 \quad \text{------} \quad (1)$$

Applying KVL at mesh I_2,

$$9I_2 + 24 + 3I_2 + 12(I_2 - I_1) = 0$$

$$\Rightarrow 24I_2 - 12I_1 = -24$$

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

$$\{(1)-(2)\} \Rightarrow 3I_1 + 2I_2 - 2I_2 + I_1 = 6 + 2$$

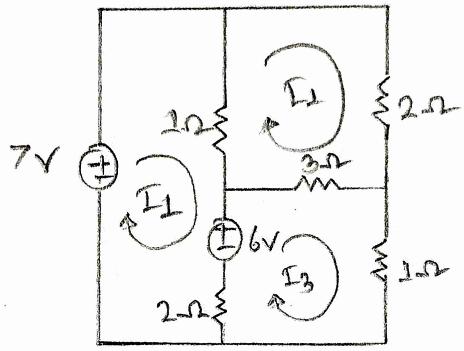
$$\Rightarrow 4I_1 = 8$$

$$\therefore I_1 = 2\text{ A}.$$

$$\therefore I_2 = (-2 + I_1)/2 = 0\text{ A}.$$

(Ans.)

Problem - 34: Use mesh analysis to determine the three mesh currents in the circuit below.



Soln:

Applying KVL at mesh I_1,

$$(I_1 - I_2) + 6 + 2(I_1 - I_3) - 7 = 0$$

$$\Rightarrow I_1 - I_2 + 2I_1 - 2I_3 = 1$$

$$\Rightarrow 3I_1 - I_2 - 2I_3 = 1 \quad \text{———} \quad (1)$$

Applying KVL at mesh I_2,

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

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

$$\Rightarrow -I_1 + 6I_2 - 3I_3 = 0 \quad \text{———} \quad (2)$$

Applying KVL at mesh I_3,

$$3(I_3 - I_2) + I_3 + 2(I_3 - I_1) - 6 = 0$$

$$\Rightarrow 3I_3 - I_2 + I_3 + 2I_3 - 2I_2 - 6 = 0$$

$$\Rightarrow -2I_1 - 3I_2 + 6I_3 = 6 \quad \text{———} \quad (3)$$

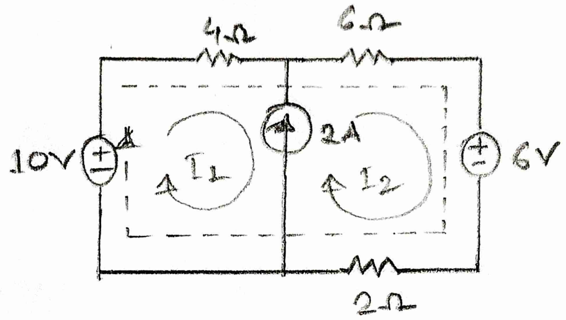
By solving equation 1, 2, 3

$I_1 = 3A$

$I_2 = 2A$

$I_3 = 3A.$

Problem 36 - In the circuit shown in figure below determine the current through 2Ω resistor.



Applying KVL at super-mesh,

$$4I_1 - 10 + 6I_2 + 6 + 2I_2 = 0$$

$$\Rightarrow 4I_1 + 8I_2 = 4$$

$$\Rightarrow I_1 + 2I_2 = 1 \quad \text{---------- (i)}$$

$$\therefore I_2 - I_1 = 2 \quad \text{---------- (ii)}$$

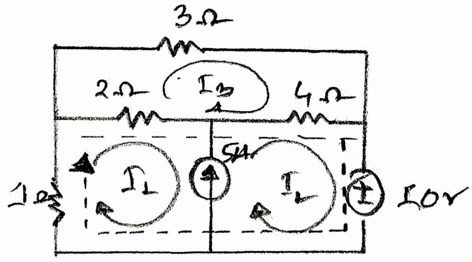
$$\{(i) + (ii)\} \Rightarrow I_1 + 2I_2 + I_2 - I_1 = 1 + 2$$

$$\Rightarrow 3I_2 = 3$$

$$\therefore I_2 = 1A$$

$$\therefore I_1 = I_2 - 2 = 1 - 2 = -1A \qquad \text{(Ans.)}$$

Problem 37 - In the circuit shown below determine all the loop currents.



Applying KVL at supermesh.

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

$$\Rightarrow 3I_1 + 4I_2 - 6I_3 = -10 \quad \text{---------- (1)}$$

$I_2 - I_1 = 5$ ———— (2)

Applying KVL at mesh I_3,

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

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

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

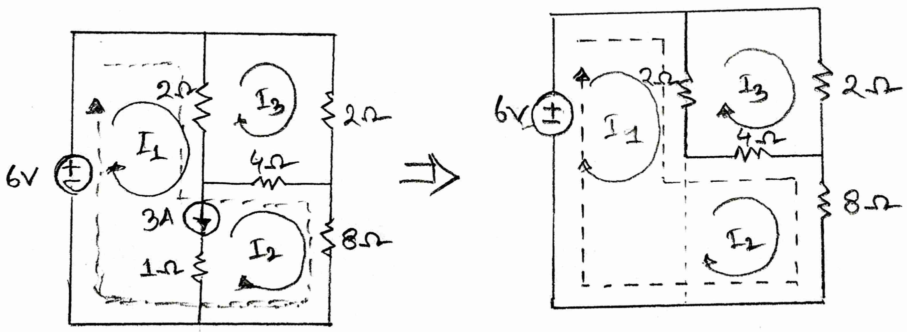
Solving the above equations,

$I_1 = -5.5556$ A

$I_2 = -0.5556$ A (Ans.)

$I_3 = -1.4815$ A

Problem: 38 – Use mesh analysis to determine all the mesh currents in the figure below.



Applying KVL at supermesh,

$$2(I_1 - I_3) + 4(I_2 - I_3) + 8I_2 - 6 = 0$$

$$\Rightarrow 2I_1 - 2I_3 + 4I_2 - 4I_3 + 8I_2 - 6 = 0$$

$$\Rightarrow 2I_1 + 12I_2 - 6I_3 = 6 \quad \text{———— (1)}$$

$$\therefore I_1 - I_2 = 3 \quad \text{———— (2)}$$

Applying KVL at mesh I_3,

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

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

$\Rightarrow -2I_1 - 4I_2 + 8I_3 = 0$ ——————— (3)

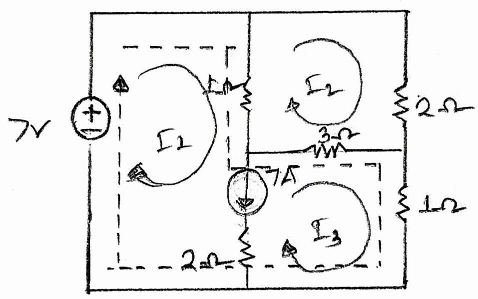
By solving equation (1); (2); (3),

$I_1 = 3.4737 A$

$I_2 = 0.4736 A$

$I_3 = 1.1052 A$ (Ans.)

Problem - 39: Determine the three mesh current in figure below.



Applying KVL at supermesh

$I_1 - I_2 + 3(I_2 - I_3) + I_3 - 7 = 0$

$\Rightarrow I_1 - I_2 + 3I_2 - 3I_3 + I_3 - 7 = 0$

$\Rightarrow I_1 - 4I_2 + 4I_3 = 7$ ——————— (1)

$I_1 - I_3 = 7$ ——————— (2)

Applying KVL at mesh I_2,

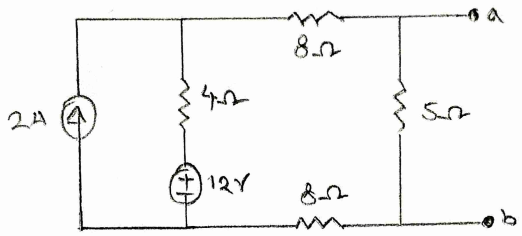
$2I_2 + 3(I_2 - I_3) + I_2 - I_1 = 0$

$\Rightarrow -I_1 + 6I_2 - 3I_3 = 0$ ——————— (3)

By solving above eqnations,

$I_1 = 9A$, $I_2 = 2.5A$, $I_3 = 2A$ (Ans.)

Problem - 40: Find the norton equivalent circuit of the circuit in the Figure shown below.



Soln:

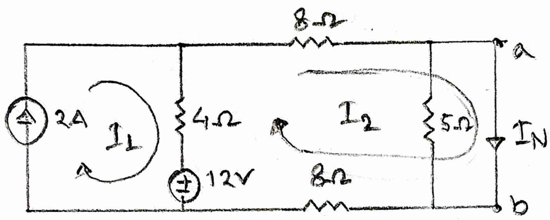


fig: a

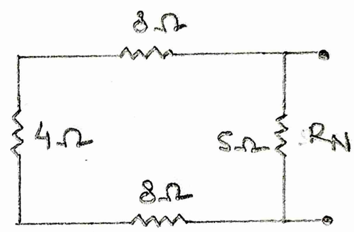


fig: b

Find I_N (Fig: a)

Applying KVL in I_2 mesh,

$$4(I_2 - I_1) + 8I_2 + 8I_2 - 12 = 0$$

$$\Rightarrow \quad -4I_1 + 20I_2 = 12$$

$$\Rightarrow \quad -4 \times 2 + 20I_2 = 12$$

$$\Rightarrow \quad I_2 = 20/20 = 1A$$

From mesh I_1,

$I_1 = 2A$

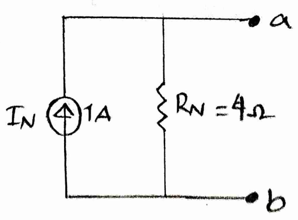
$$\therefore \; I_N = I_2 = 1A$$

Find R_N (Fig: b)

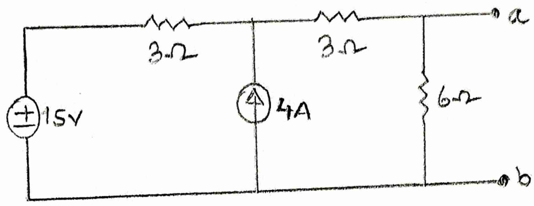
$$R_N = (8\Omega + 4\Omega + 8\Omega) \| 5\Omega$$

$$= 20\Omega \| 5\Omega = 4\Omega$$

∴ Norton Equivalent circuit:



Problem 41: Find the Norton equivalent circuit for the circuit in figure below at terminal a-b.



Soln:

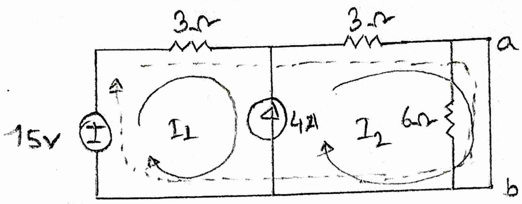


Fig : a

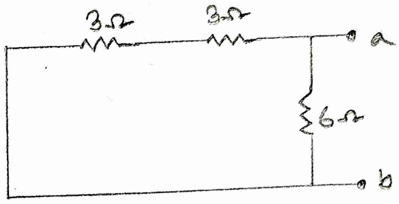


Fig : b

Find I_N (Fig:a)

Applying KVL at super mesh I_1,

$$3I_1 + 3I_2 - 15 = 0$$

$$\Rightarrow I_1 + I_2 = 5 \quad \text{--- (I)}$$

$$\therefore I_2 - I_1 = 4 \quad \text{--- (II)}$$

Solving equation (I) and (II)

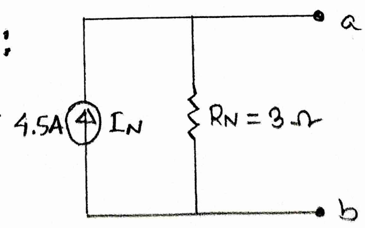
$$I_1 = 0.5 \text{ A}$$
$$I_2 = 4.5 \text{ A}$$

$$\therefore I_N = I_2 = 4.5 \text{ A}$$

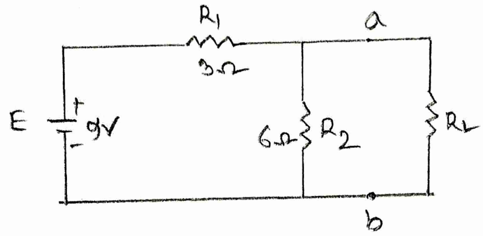
Find R_N (Fig: b)

$$R_N = (3\Omega + 3\Omega) \parallel 6\Omega$$
$$= 3\Omega$$

∴ Norton Equivalent Circuit :



Problem 42: Find the norton equivalent circuit for the network in the circuit below for point a-b.



Soln:

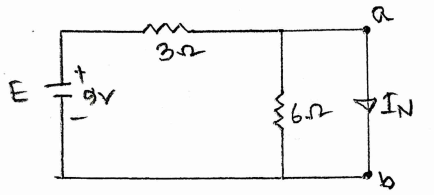


Fig: a

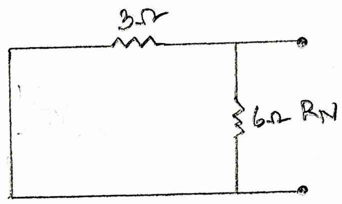


Fig: b

Find I_N (Fig: a)

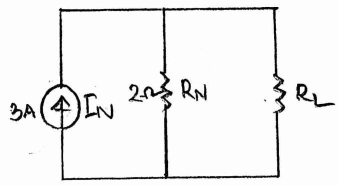
As this circuit shorted the current will only flow through 3Ω resistor.

$$\therefore I_N = \frac{9}{3} = 3A$$

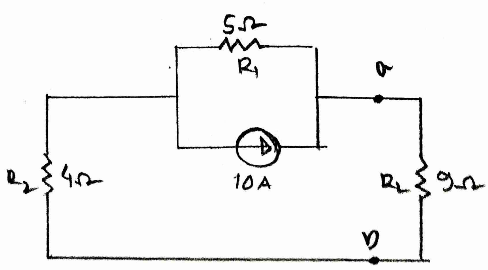
Find R_N (Fig: b)

$$\therefore R_N = 3\Omega \parallel 6\Omega = 2\Omega$$

∴ Norton Equivalent circuit:



Problem: 43: Find the Norton equivalent circuit for the network in point a-b to the 9Ω resistor.



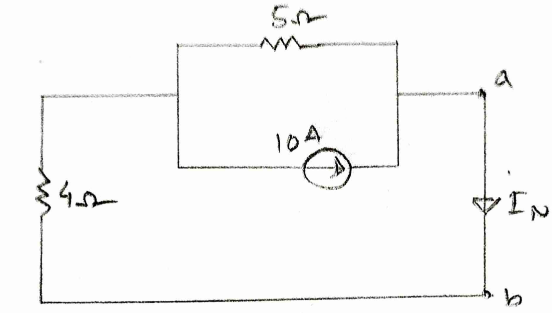


Fig: a

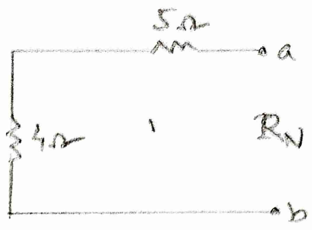


Fig: b

Find I_N (Fig: a)

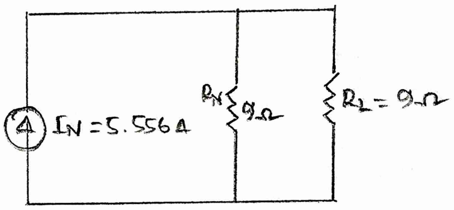
Applying CDR at 4Ω resistor,

$$I_N = \frac{\left(\frac{1}{4}+\frac{1}{5}\right)^{-1}}{4} \cdot 10 = 5.556\,A$$

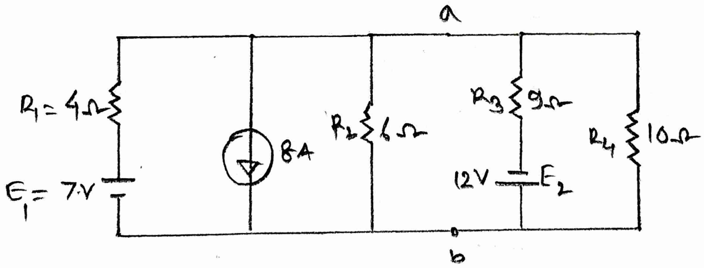
Find R_N (Fig: b)

$R_N = 5\Omega + 4\Omega = 9\Omega$

∴ Norton Equivalent circuit:



Problem 44: Find the norton equivalent circuit for the portion of network of a-b in the figure below.



Soln:

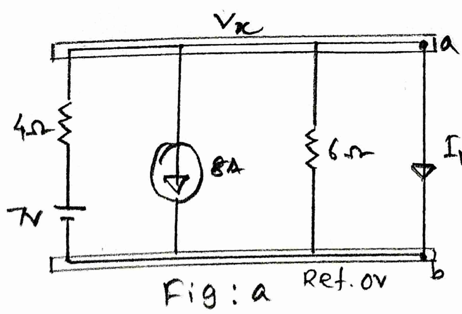


Fig: a

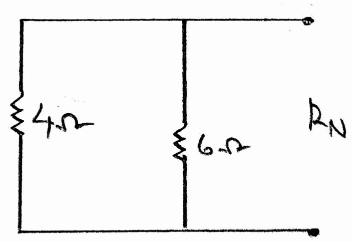


Fig: b

Find R_N (Fig: b)

$R_N = 4\Omega \parallel 6\Omega = 2.4\Omega$

Find I_N (Fig : a)

Applying KCL at node V_x,

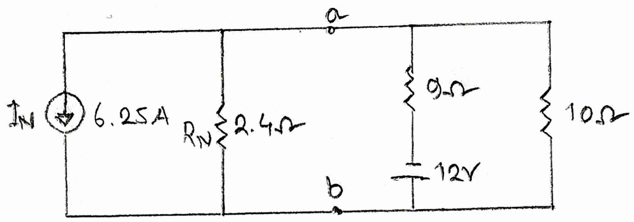
$$\frac{V_x - 7}{4} + 8 = 0$$

$$\Rightarrow V_x + 25 = 0$$

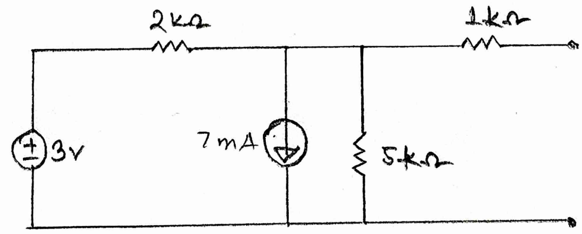
$$\Rightarrow V_x = -25$$

$$\therefore I_N = \frac{V_x}{R_T} = \frac{-25}{4} = -6.25A$$

∴ Norton equivalent circuit :



Problem : 45 – Determine the thevenine and Norton Equivalents of the circuit below.



Soln:

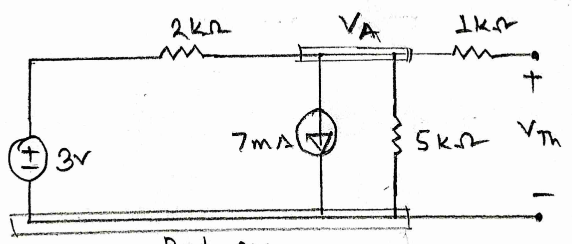


Fig : a

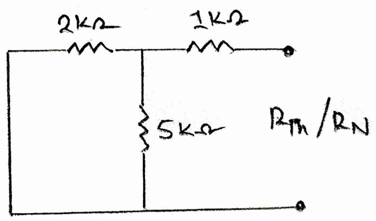


Fig : b

Find R_{Th}/R_N : (Fig b)

$$R_{Th} = R_N = (2k\Omega \parallel 5k\Omega) + 1k\Omega = 2.429k\Omega$$

Find V_{Th} (Fig: a)

Applying KCL at Node V_A,

$$\frac{V_A - 3}{2} + 7 + \frac{V_A - 0}{5} = 0$$

$$\Rightarrow 5V_A - 15 + 70 + 2V_A = 0$$

$$\Rightarrow 7V_A = -55$$

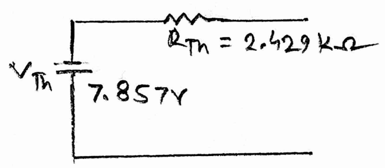
$$\therefore V_A = -7.857\,V$$

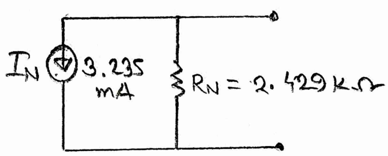
$$\therefore V_{Th} = V_A - 0 = -7.857\,V$$

We know,

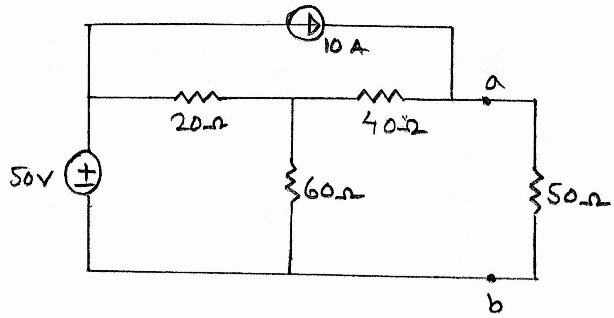
$$I_N = \frac{V_{Th}}{R_{Th}} = -\frac{7.857}{2.429} = -3.235\,mA$$

∴ Thevenine and Norton Equivalent circuit:





☐ Problem: 46 Find the norton equivalent circuit to a-b point/terminal in the shown figure below. Find the current through 50Ω resistor.



Sol^n:

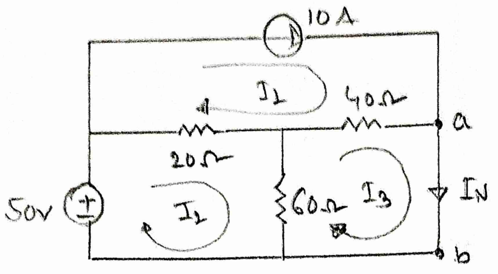


Fig: a

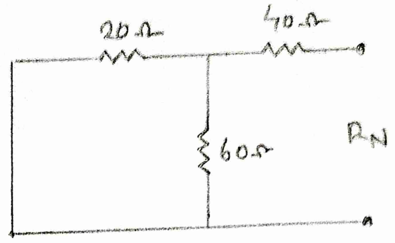


Fig: b

Finding I_N (Fig: a)

Applying KVL at mesh I_1,

$$I_1 = 10\,A$$

Applying KVL at mesh I_2,

$$20(I_2 - I_1) + 60(I_2 - I_3) - 50 = 0$$

$$\Rightarrow 20I_2 - 20I_1 + 60I_2 - 60I_3 - 50 = 0$$

$$\Rightarrow 80I_2 - 60I_3 = 250$$

$$\Rightarrow 8I_2 - 6I_3 = 25 \quad \text{———} \; (1)$$

Here, $I_1 = 10\,A$

Applying KVL at mesh I_3,

$$40(I_3 - I_1) + 60(I_3 - I_2) = 0$$

$$\Rightarrow 40I_3 - 40I_1 + 60I_3 - 60I_2 = 0$$

$$\Rightarrow -60I_2 + 100I_3 = 400$$

$$\Rightarrow -6I_2 + 10I_3 = 40 \quad \text{———} \; (2)$$

By solving equation (1) and (2)

$$I_2 = 11.136\,A$$

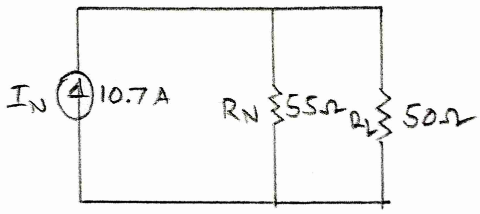
$$I_3 = 10.682\,A$$

$$\therefore I_N = I_3 = 10.682 \approx 10.7\,A$$

Finding R_N (Fig: b)

$$R_N = (20\Omega \parallel 60\Omega) + 40\Omega = 15\Omega + 40\Omega = 55\Omega$$

∴ Norton Equivalent circuit:



$$\therefore\ I_{R_L} = \frac{55}{55+50} \times 10.7 = 5.6\ A$$

(Ans.)