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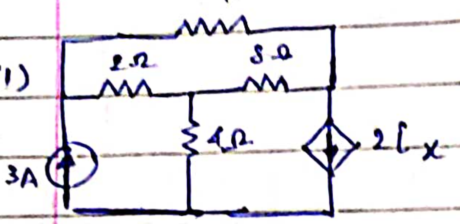
30/9/21

(1)



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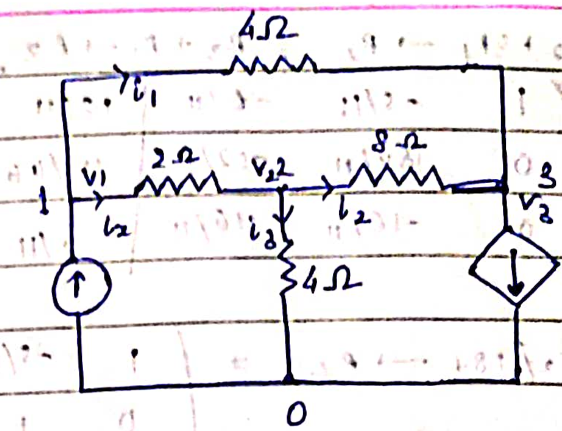


3 nodes

KCL at node 1 → $3 = i_1 + i_x$

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

$= 3v_1 - 2v_2 - V_3 = 12$ ⟶ (1)

KCL at node 2 →

$i_x = i_2 + i_3 \Rightarrow \frac{V_1 - V_2}{2} = \frac{V_2 - V_3}{8} + \frac{V_2 - 0}{4}$

$= -4v_1 + 7v_2 - V_3 = 0$ ⟶ (2)

KCL at node 3 →

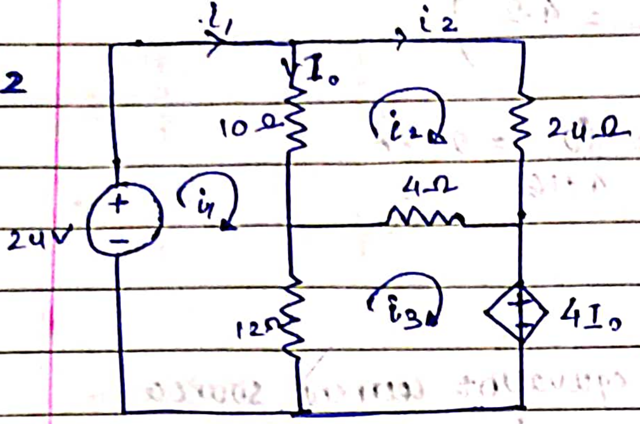
$i_1 + i_2 = 2i_x$

$\Rightarrow \frac{V_1 - V_3}{4} + \frac{V_2 - V_3}{8} = \frac{2V_1 - 2V_2}{2} \Rightarrow 2v_1 - 3v_2 + V_3 = 0$ ⟶ (3)

From (1), (2) and (3),

$V_1 = \frac{24}{5}$ V ; $V_2 = \frac{12}{5}$ V ; $V_3 = -\frac{12}{5}$ V

2



In Mesh 1, KVL

$-24 + 10(i_1 - i_2) + 12(i_1 - i_3) = 0$

$11i_1 - 5i_2 - 6i_3 = 12$

In mesh 2, KVL

$24i_2 + 4(i_2 - i_3) + 10(i_2 - i_1) = 0$

$-5i_1 + 19i_2 - 2i_3 = 0$

In mesh 3, $4I_o + 12(i_3 - i_1) + 4(i_3 - i_2) = 0$

at $I_o = I_1 - I_2$,

$4(i_1 - i_2) + 12(i_3 - i_1) + 4(i_3 - i_2) = 0$

$-i_1 - i_2 + 2i_3 = 0$

$$\begin{bmatrix} 11 & -5 & -6 \\ -5 & 19 & -2 \\ -1 & -1 & 2 \end{bmatrix} \begin{bmatrix} i_1 \\ i_2 \\ i_3 \end{bmatrix} = \begin{bmatrix} 12 \\ 0 \\ 0 \end{bmatrix}$$

by crammers rule;

$$\left(\begin{array}{ccc|c} 11 & -5 & -6 & 12 \\ -5 & 19 & -2 & 0 \\ -1 & -1 & 2 & 0 \end{array}\right)$$

$R_1/11 \longrightarrow R_1$

$$\left(\begin{array}{ccc|c} 1 & -5/11 & -6/11 & 12/11 \\ -5 & 19 & -2 & 0 \\ -1 & -1 & 2 & 0 \end{array}\right)$$

$R_2 + 5R_1 \rightarrow R_2 \; ; \; R_3 + R_1 \rightarrow R_3$

$$\left(\begin{array}{ccc|c} 1 & -5/11 & -6/11 & 12/11 \\ 0 & 184/11 & -52/11 & 15/46 \\ 0 & -16/11 & 16/11 & 12/11 \end{array}\right)$$

$R_2 / .184 \rightarrow R_2 \Rightarrow$

$$\left(\begin{array}{ccc|c} 1 & -5/11 & -6/11 & 12/11 \\ 0 & 1 & -13/46 & 15/46 \\ 0 & -16/11 & 16/11 & 12/11 \end{array}\right)$$

$R_1 + \frac{5}{11} R_2 \rightarrow R_1 \; ; \; R_3 + \frac{16}{11} R_2 \rightarrow R_3$

$$\left(\begin{array}{ccc|c} 1 & 0 & -31/46 & 57/46 \\ 0 & 1 & -13/46 & 15/46 \\ 0 & 0 & 24/23 & 36/23 \end{array}\right)$$

$R_3 / \frac{24}{23} \rightarrow R_3 \Rightarrow$

$$\left(\begin{array}{ccc|c} 1 & 0 & -31/46 & 57/46 \\ 0 & 1 & -13/46 & 15/46 \\ 0 & 0 & 1 & 1.5 \end{array}\right)$$

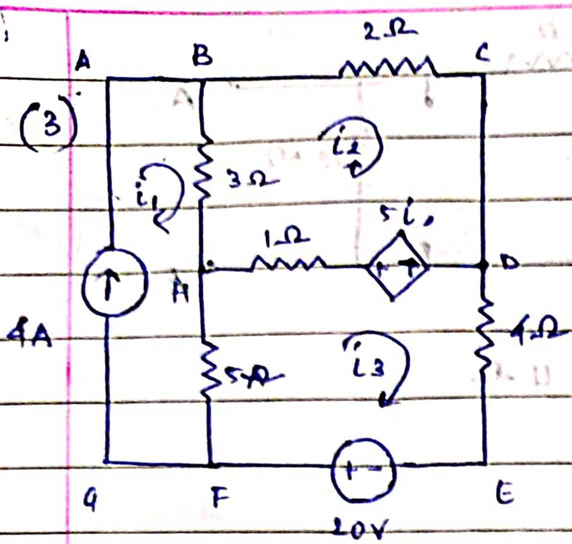
$R_1 + \frac{31}{46} R_3 \rightarrow R_1 \; ; \; R_2 + \frac{13}{46} R_3 \rightarrow R_2$

$$\left(\begin{array}{ccc|c} 1 & 0 & 0 & 2.25 \\ 0 & 1 & 0 & 0.75 \\ 0 & 0 & 1 & 1.5 \end{array}\right)$$

$\therefore \; i_1 = 2.25A \; , \; i_2 = 0.75A \; , \; i_3 = 1.5A$

Substituting in I_0, $I_0 = 1.5A$

(3)



$i_0 = i_0' + i_0''$

loop 1 → $i_1 = 4$ A

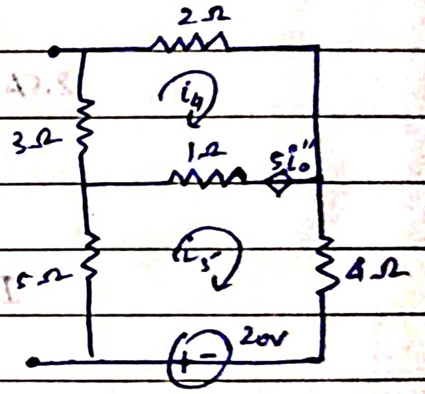
BCDHB

loop 2 → $-3i_1 + 6i_2 - i_3 - 5i_0' = 0$

HDEFH

loop 3 → $-5i - i_2 + 10i_3 + 5i_0' = 0$

Node at H → $i_3 = i_1 - i_0' = 4 - i_0'$



∴ loop 1 and node → $3i_2 - 2i_0' = 8$

loop 2 and loop 3 → $i_2 + 5i_0' = 20$

$i_0' = \frac{52}{17}$ A

For i_0'', turn off 4A current, For the big loop, KVL →

$6i_4 - i_5 - 5i_0'' = 0$

for loop 5 $-i_4 + 10i_5 - 20 + 5i_0'' = 0$

but $i_5 = -i_0''$ ∴ substituting in above eqns →

$6i_4 - 4i_0'' = 0$

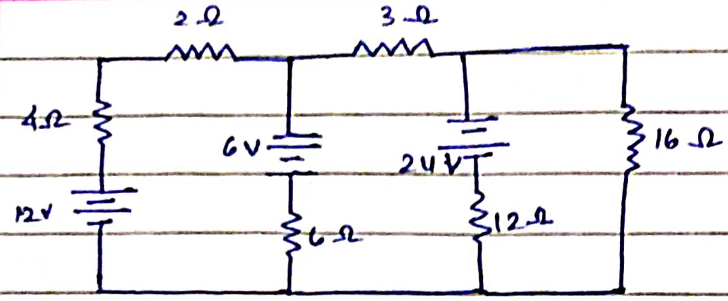
$i_4 + 5i_0'' = -20$

solving →

$i_0'' = -\frac{60}{17}$ A

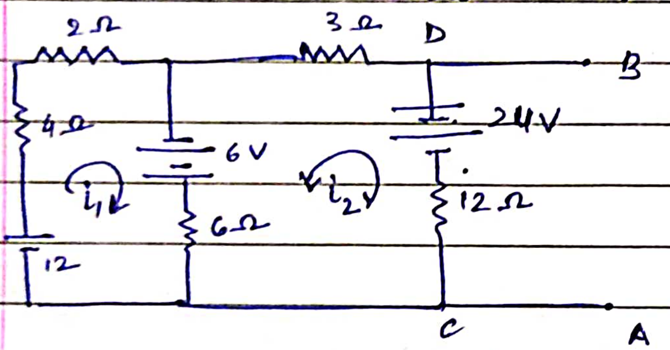
Substituting in $i_0 = i_0' + i_0''$ → $i_0 = -\frac{8}{17}$ A

4



Thevenin's Theorem ⇒

Remove the 16 Ω resistor and find V.



KVL in loop 1

$12 - 6I_1 + 6 - 6(I_1 + I_2) = 0$

$6(2I_1 + I_2) = 18$

$2I_1 + I_2 = 3 \longrightarrow (1)$

KVL in loop 2

$24 - 3I_2 + 6 - (I_1 + I_2)6 - 12I_2 = 0$

$21I_2 + 6I_1 = 30$

$2I_1 + 7I_2 = 10$

$2I_1 + I_2 = 3 \rightarrow (2)$

From (1) and (2), $6I_2 = 7$; $I_2 = \frac{7}{6}$ A

$\therefore I_1 = 3 - \frac{7}{6} = \frac{11}{12}$ A

$V_{CD} = -12I_2 + 24 = -12 \times \frac{7}{6} + 24 = 10V$

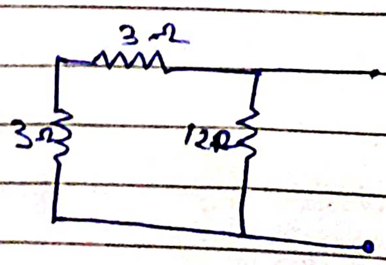
R_{th} ⇒ 4 and 2 in series = 6

6 and 6 in parallel → 3

3 and 3 in series = 6

6 and 12 in parallel → R_{th}

⇒

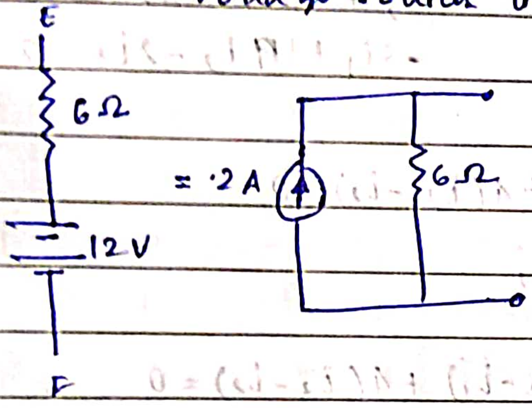


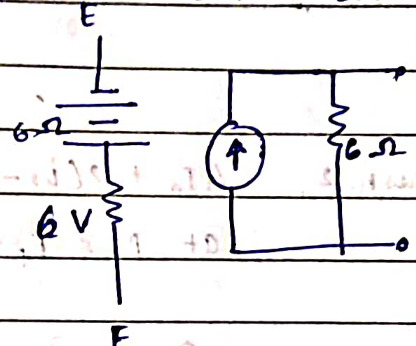
i through 16Ω ⇒ $\left(R_{th} = \dfrac{6 \times 12}{6+12} = 4\Omega \right)$

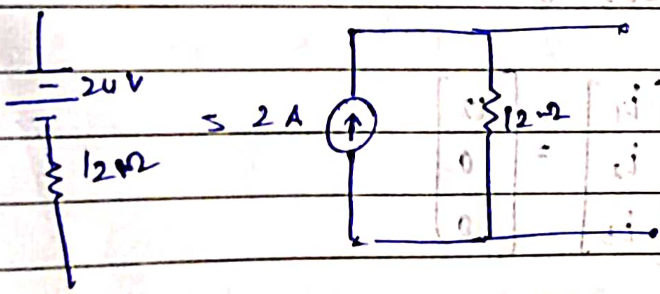
$$i = \frac{V}{R_{th}+16} = \frac{10}{4+16} = 0.5A$$

Norton's theorem ⇒

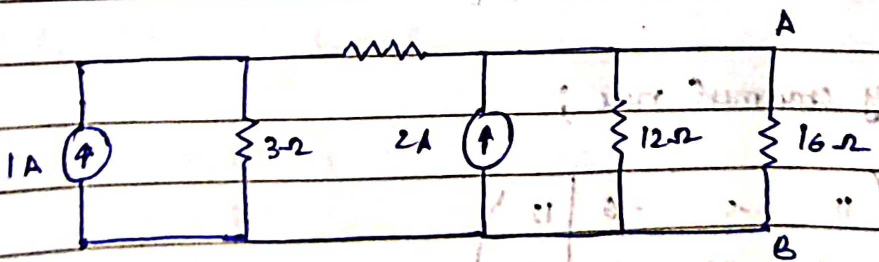
Convert the voltage source into equivalent current source.







∴ New ⇒



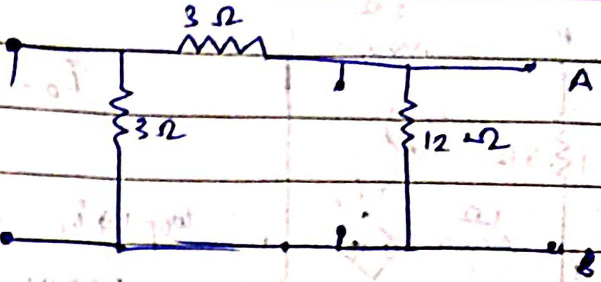
Short A B as 16Ω is removed.

$I_{sc} = 0.5A$ for first source.

$I_{sc} = 2A$ for second source.

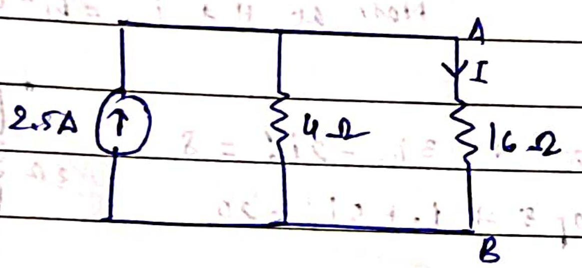
∴ $I_{sc} = 0.5 + 2 = 2.5A$

equivalent resistance →



$$R_{eq} = \frac{6 \times 12}{6 + 12} = \frac{72}{18} = 4\,\Omega$$

∴ Norton's equivalent circuit →



$$I = \frac{2.5 \times 4}{16 + 4} = \frac{10}{20} = \frac{1}{2} = 0.5\,A$$

∴ I for both Thevenin and Norton method is same.