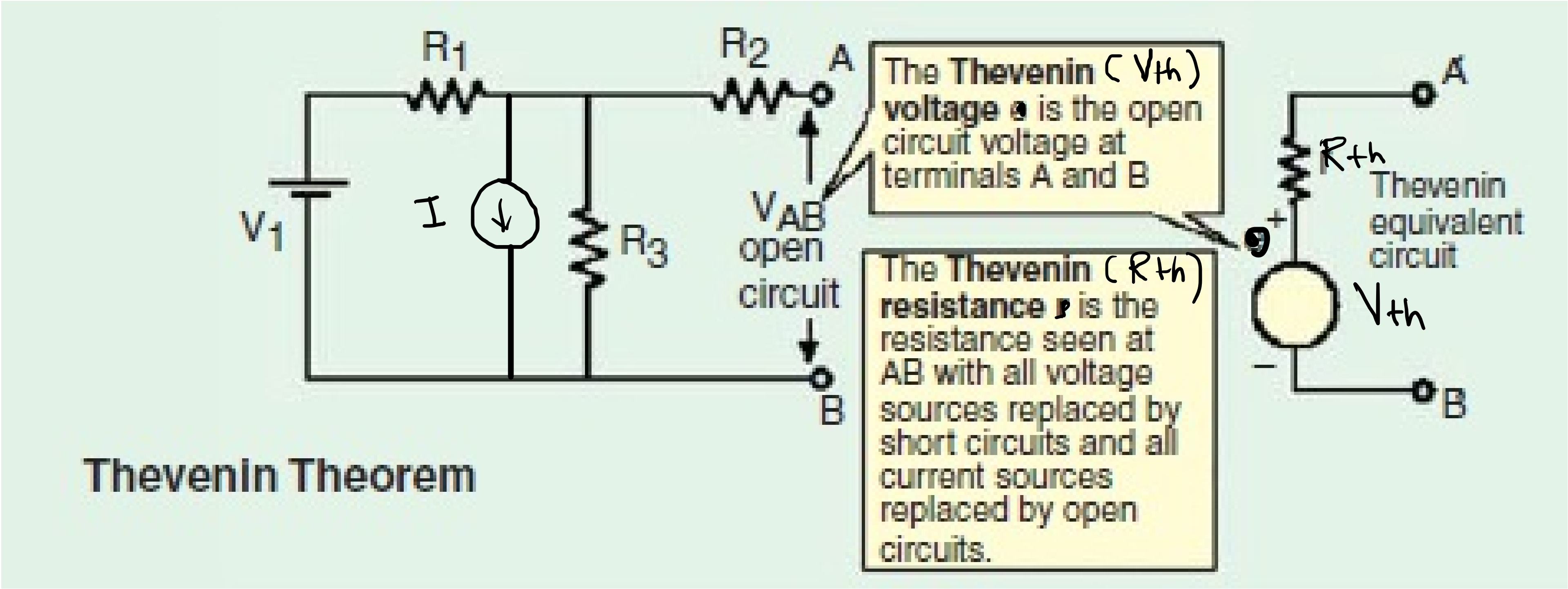
Thevenin's Theorem

Statement:

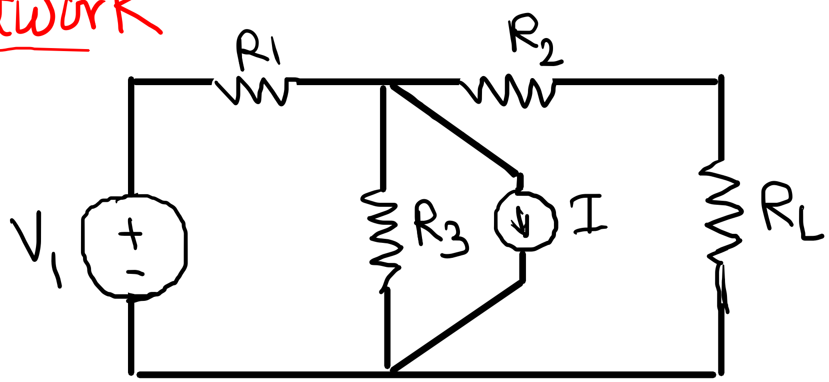
Any linear, active bilateral network can be replaced by a voltage source (Vth) in series with a resistance (Rth) where Vth is the open-circuit voltage (i.e. voltage across the two terminals when RL is removed) and Rth is the internal resistance of the network as viewed back into the open-circuited network from terminals A and B with all energy sources replaced by their internal resistance. (Ideal current sources by infinite resistance and Ideal voltage source by zero resistance.



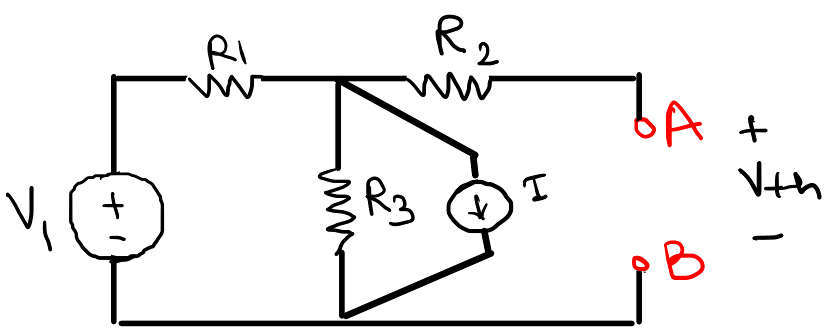
Thevenin's Theorem

Steps to analyse netwrk using Thevenin's Theorem

Given network

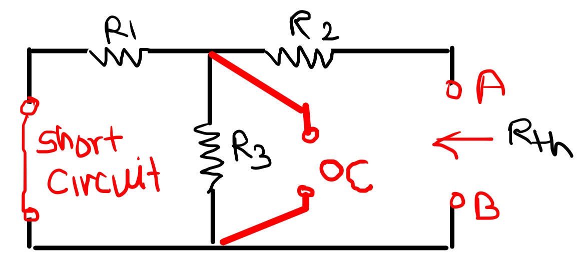


1. Remove load resistance RL from the given network



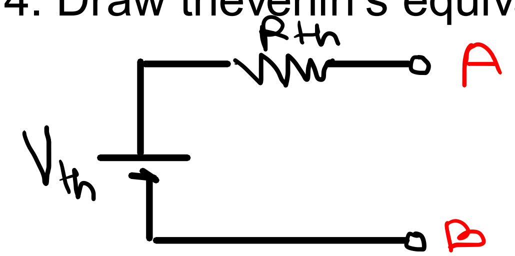
2. Find Vth i.e. the open circuit voltage between the terminals (A-B) from where the load is removed using any suitable method (mesh, nodal, source transformation etc..)

3. Find Rth i.e. resistance looking back into the network from the terminals (A-B) from where the load is removed and energy sources replaced by their internal resistances.

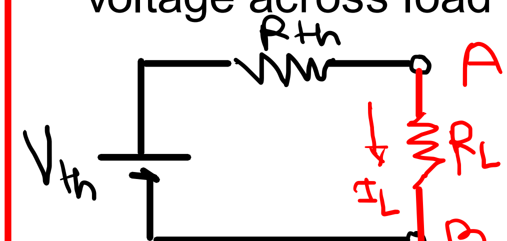


$$R_{th} = (R_1 || R_3) + R_2$$

4. Draw thevenin's equivalent circuit



5. Connect the load RL and find current/ voltage across load RL



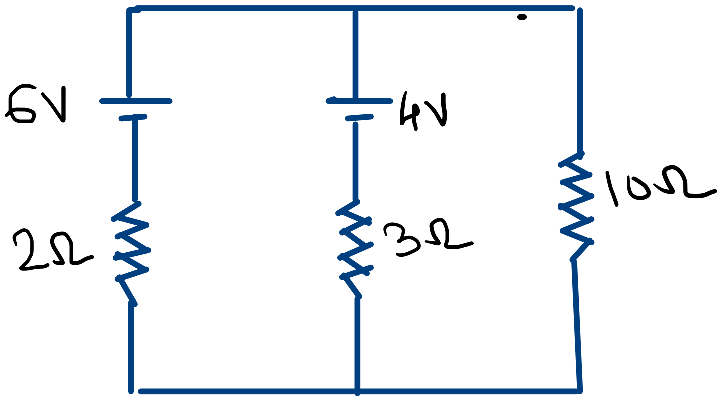
$$I_L = \frac{V_{th}}{R_{th} + R_L}$$

Voltage division $V_L = \frac{V_{th} \times R_L}{R_L + R_{th}}$

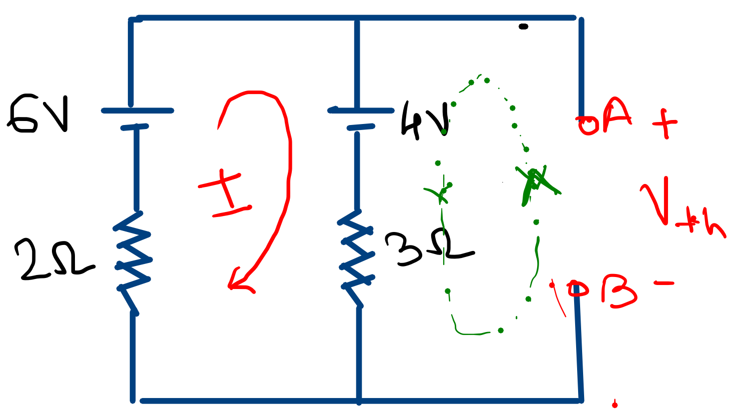
Thevenin's Theorem

Q.1 Find current flowing through 10 Ohm resistance using Thevenin's Theorem

$I_{10} = 0.464A$



① Remove Load $R_L = 10\Omega$



② Find V_{th}.

$V_{th} - 4 - V_{3\Omega} = 0$

$V_{th} = 4 + V_{3\Omega}$

KVL to loop to find I

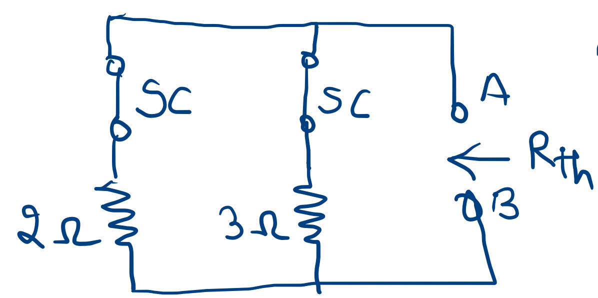
$-4 - 3I - 2I + 6 = 0$

$5I = 2 \quad \therefore I = \frac{2}{5} = 0.4A$

$V_{3\Omega} = 3 \times I = 3 \times 0.4 = 1.2V$

$V_{th} = 4 + 1.2 = 5.2V$

③ Find R_{Th}



$R_{Th} = 3 \| 2$

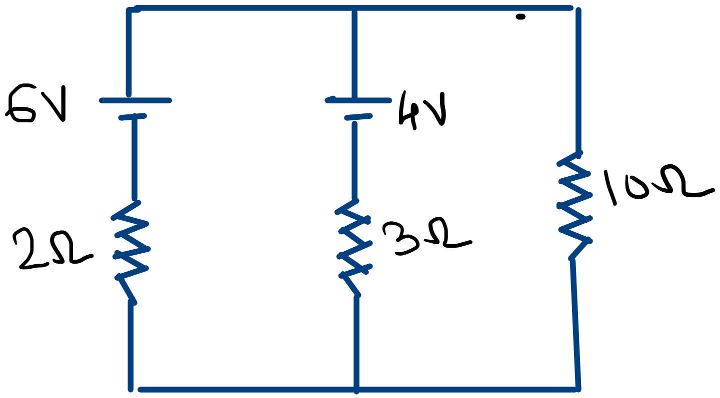
$= \frac{3 \times 2}{3 + 2}$

$R_{Th} = \frac{6}{5} = 1.2\Omega$

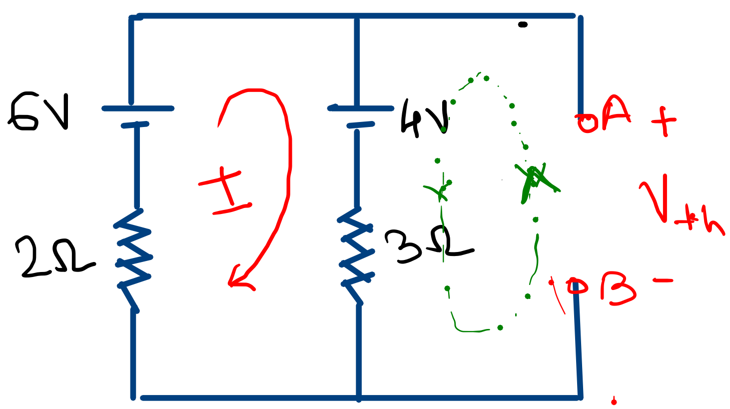
Thevenin's Theorem

Q.1 Find current flowing through 10 Ohm resistance using Thevenin's Theorem

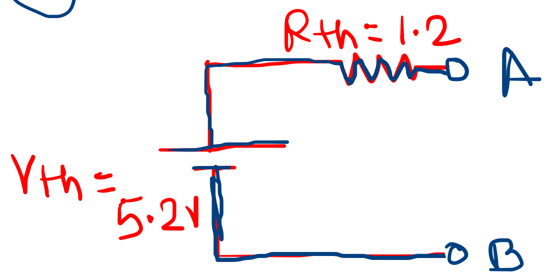
$I_{10} = 0.464A$



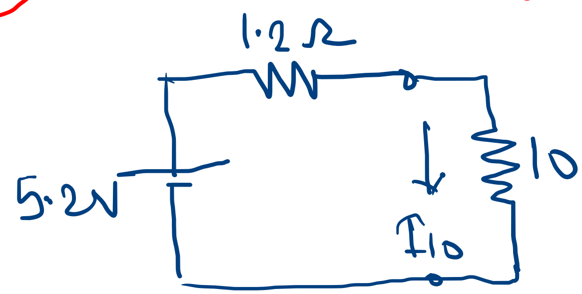
① Remove load $R_L = 10\Omega$



④ Draw Thevenin's Equivalent circuit



⑤ Connect the load & find current



$$I_{10} = \frac{5.2}{1.2 + 10} = 0.464A$$

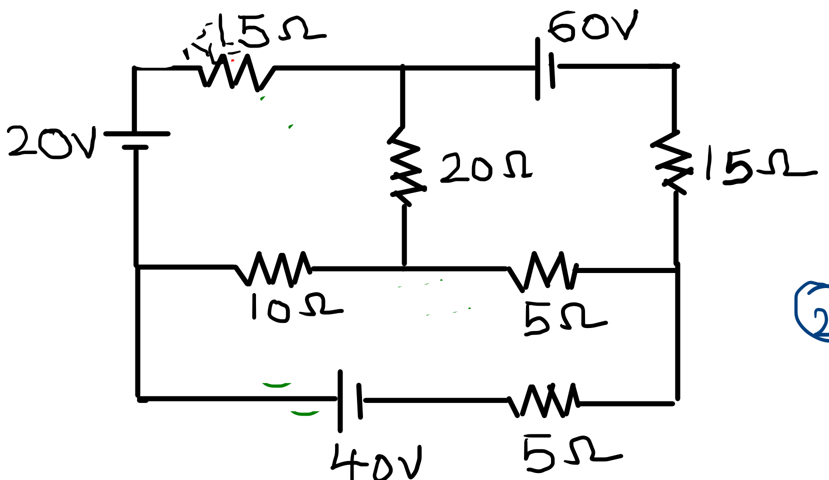
Thevenin's Theorem

Example:- 2. Find current through RL=15 Ohm resistor in the following network.

$V_{th} = 10.97$

$I_{15} : 0.40$

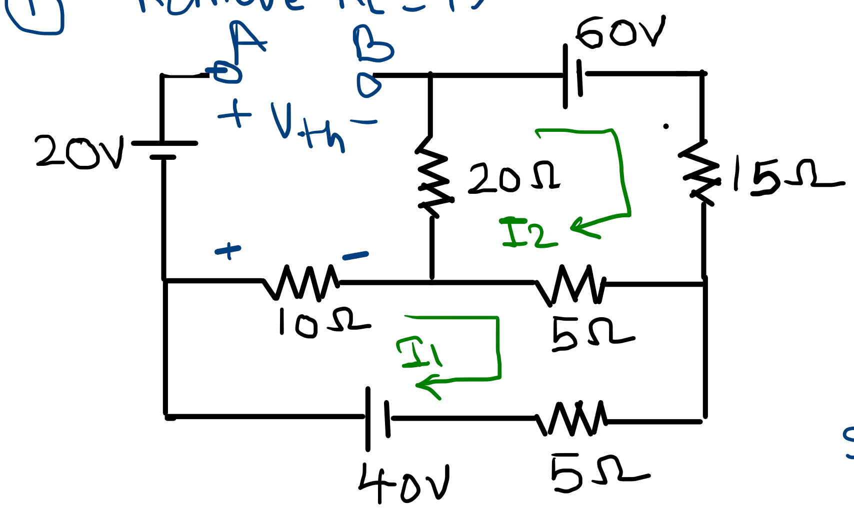
$R_{th} = 8.37\Omega$



$V_{th} - 20 - V_{10\Omega} - V_{20\Omega} = 0$

$V_{th} = 20 + V_{10\Omega} + V_{20\Omega}$

① Remove $R_L = 15\Omega$



② To find V_{th}

Solving using mesh Analysis

KVL to mesh (I)

$40 - 10I_1 - 5(I_1 - I_2) - 5I_1 = 0$

$20I_1 - 5I_2 = 40$ ---- (1)

KVL to mesh (II)

$-60 - 15I_2 - 5(I_2 - I_1) - 20I_2 = 0$

$5I_1 - 40I_2 = 60$ ---- (2)

Solving (1) & (2) $I_1 = 1.67A$ $I_2 = -1.29A$

Thevenin's Theorem

Example:- 2. ....

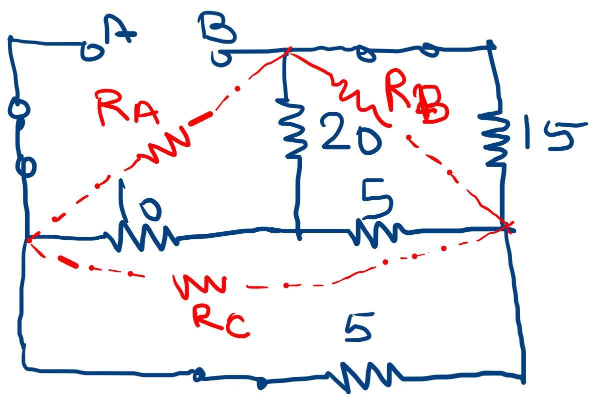
$V_{th} = 20 + V_{10\Omega} + V_{20\Omega}$

$V_{10\Omega} = 1.67 \times 10 = 16.7V$

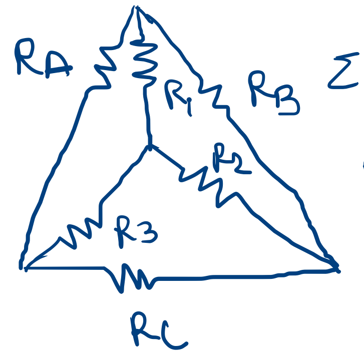
$V_{20} = -1.29 \times 20 = -25.8V$

$V_{th} = 20 + 16.7 - 25.8 = 10.9V$

(3) Find R_{Th}



Star to Delta Transformation



$\Sigma R = R_1R_2 + R_2R_3 + R_3R_1$

$R_A = \dfrac{\Sigma R}{R_2}$

$R_B = \dfrac{\Sigma R}{R_3}$

$R_C = \dfrac{\Sigma R}{R_1}$

$\Sigma R = 10 \times 20 + 20 \times 5 + 10 \times 5$

$\Sigma R = 200 + 100 + 50 = 350\Omega$

$R_A = \dfrac{350}{5} = 70\Omega$

$R_B = \dfrac{350}{10} = 35\Omega$

$R_C = \dfrac{350}{20} = 17.5\Omega$

$V_{th} = 10.97$

$I_{15} : 0.407$

$R_{th} = 8.37\Omega$

Thevenin's Theorem

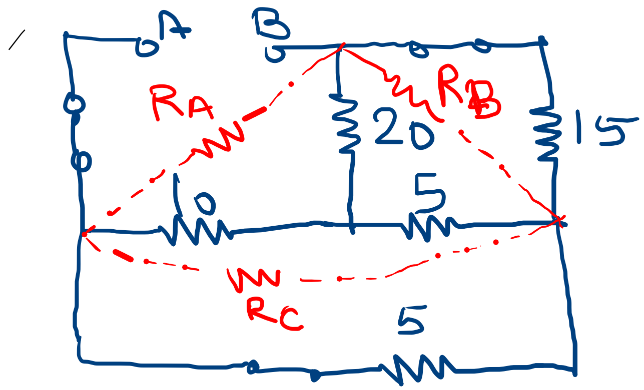
Example:- 2. .....

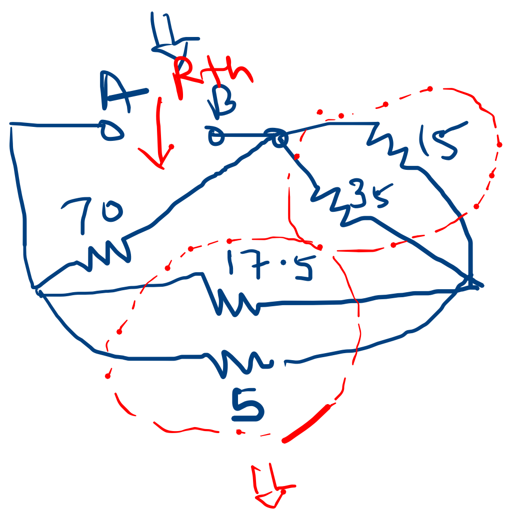
$V_{th} = 10.97$

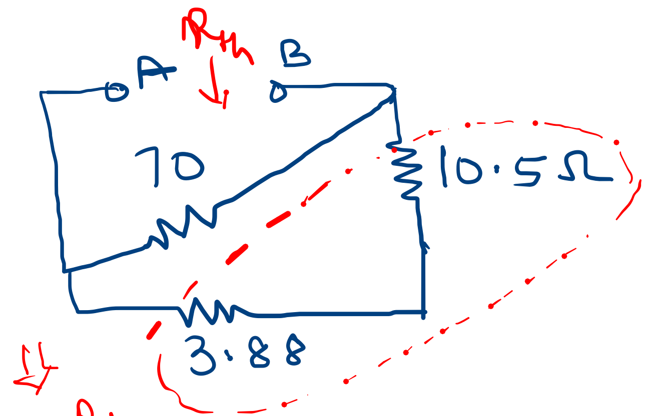
$I_{15} : 0.407$

$R_{th} = 8.37\Omega$

③ Find R_{Th}



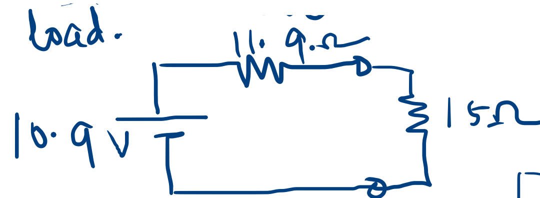




$R_{th} = 70 \| 14.38$

$R_{Th} = 11.9\ \Omega$

④ Draw Thevenin's equivalent circuit & Connect load.

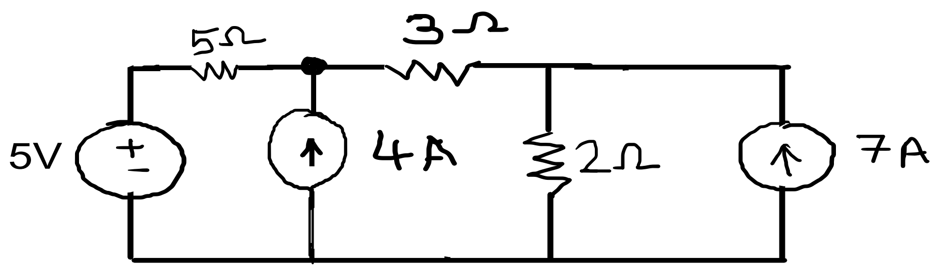


$I_{15} = \frac{10.9}{11.9+15}$

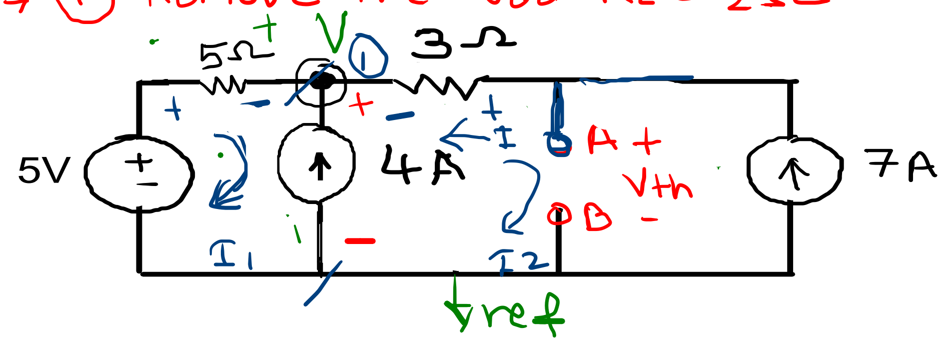
$\boxed{I_{15} = 0.4\ A}$

Thevenin's Theorem

Example:- 3. Find voltage across 2 Ohm resistor in the flowing network.



⇒ ① Remove the load $R_L = 2\Omega$



⇒ ② Find V_{th}

$V_{th} - 3I - V_{4A} = 0$

Using Nodal Analysis

KCL at node ①

$7 + 4 = \frac{V-5}{5}$

$11 = \frac{V-5}{5}$ OR $V - 5 = 55$

$V = 60V$. $V_{4A} = V = 60V$

$I = 7A$

$V_{th} = 3 \times I + V_{4A}$

$V_{th} = 3 \times 7 + 60 = 81V$

Using Mesh Analysis.

$I_2 = -7A$

$I_1 + 4 = I_2$ OR $I_1 = -7 - 4 = -11A$

$V_{4A} = 11 \times 5 + 5 = 60$

$V_{th} = 3 \times 7 + 60 = 81V$

$V_{th} = 81V$

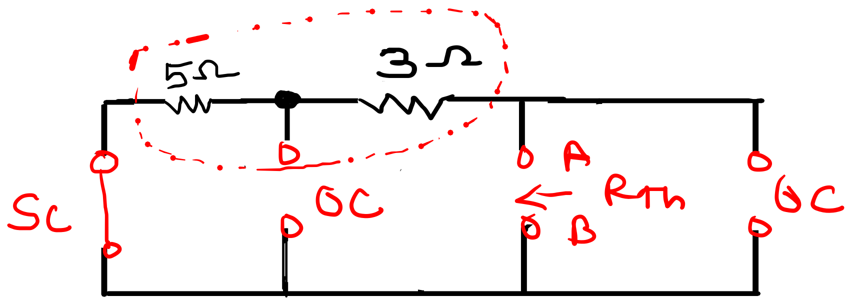
$R_{th} = 8\Omega$

$V_{2\Omega} = 16.2V$

Thevenin's Theorem

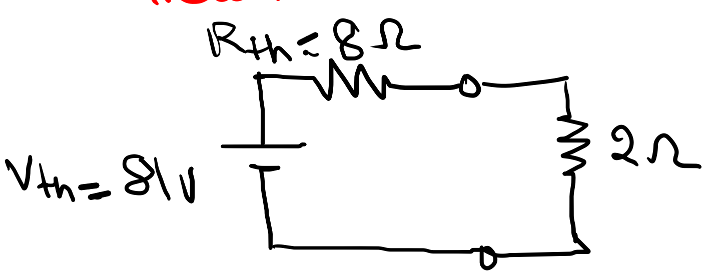
Example:- 3. ....

(3) Find R_{Th}



$R_{Th} = 5 + 3 = 8\,\Omega$

(4) Draw Thevenin's Equivalent Circuit & Connect load.



using voltage division formula

$$V_{2\Omega} = \frac{2 \times 81}{2+8}$$

$$V_{2\Omega} = \frac{2 \times 81}{10}$$

$$\boxed{V_{2\Omega} = 16.2\,V}$$

$V_{th} = 81\,V$

$R_{Th} = 8\,\Omega$

$V_{2\Omega} = 16.2\,V$