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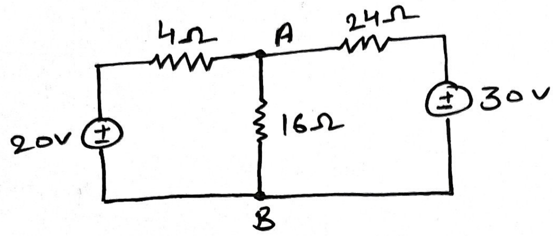
13122003004S

Assignment 1 [Electrical Science]

Ques 1 Find Thevenin Equivalent Circuit and Norton Equivalent Circuit.

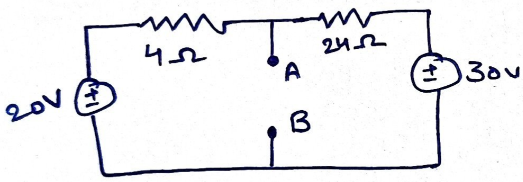


Ans:

Thevenin

Load Resistance $\boxed{R_L = 16\,\Omega}$

Step 1: Remove R_L and calculate V_{Th}



$I = \frac{V}{R} = \frac{30-20}{24+4} = \frac{10}{28}$

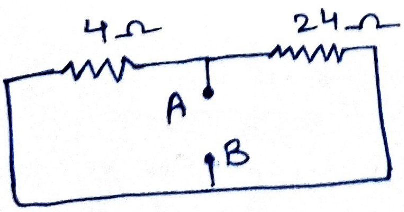
$\boxed{I = 0.357\ A}$

Voltage Drop [V_{Th}]

$V_{Th} = 30 - [24 \times 0.357]$

$\boxed{V_{Th} = 21.4\ V}$

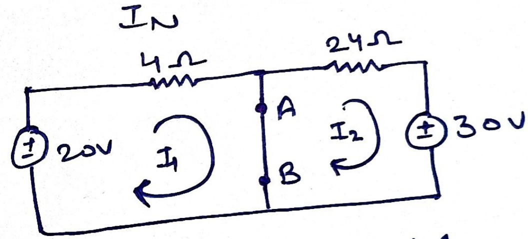
Step 2: Remove R_L and replace all active sources with their internal resistances



Norton

Load Resistance $\boxed{R_L = 16\,\Omega}$

Step 1: Replace R_L with short circuit branch and calculate I_N



Applying KVL in Mesh 1

$20 - 4I_1 = 0$

$I_1 = 5A$

Applying KVL in Mesh 2

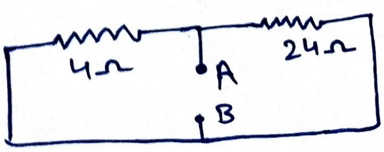
$-30 - 24I_2 = 0$

$I_2 = -1.25\ A$

$I_N = I_1 - I_2 = 5 - (-1.25)$

$\boxed{I_N = 6.25\ A}$

Step 2: Remove R_L and replace all active sources with their internal resistances

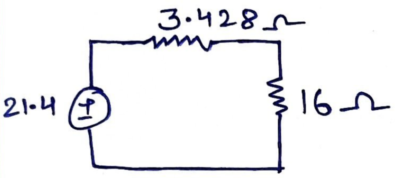


Step 3 : Calculate R_{Th}

$$R_{Th} = \frac{4 \times 24}{4+24}$$

$$\boxed{R_{Th} = 3.428\Omega}$$

Step 4 : Draw Thevenin's Equivalent Circuit

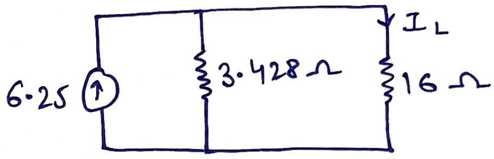


Step 3: Calculate R_N

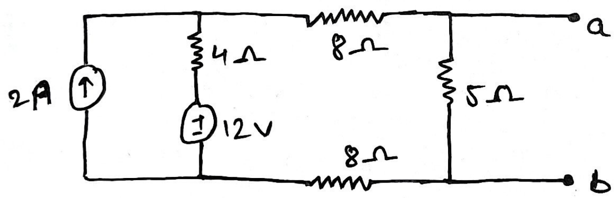
$$R_N = \frac{4 \times 24}{4+24}$$

$$\boxed{R_N = 3.428\Omega}$$

Step 4 : Draw Norton's Equivalent Circuit



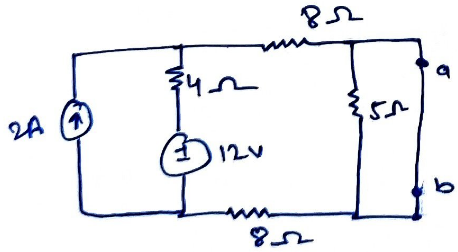
Ques 2 : Find the Norton equivalent circuit at terminals a-b of the electrical circuit given below.



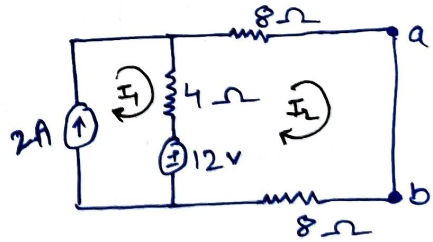
Ans : Step 1 : Identify Load Terminals

$\boxed{\text{Load Terminal : a-b}}$

Step 2 : Replace R_L with short circuit branch and calculate I_N



5 Ω will be short circuited ⇒



Apply KVL in Mesh ①

$$\boxed{I_1 = 2A}$$

Apply KVL in Mesh ②

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

$$12 - 20I_2 + 4I_1 = 0$$

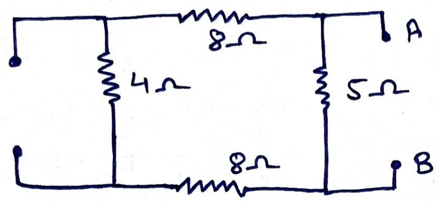
$$-20I_2 = -20$$

$$\boxed{I_2 = 1A}$$

$I_N = I_2 = 1A$

$$\boxed{I_N = 1A}$$

step 3: Remove R_L and replace all active sources with their internal resistances.



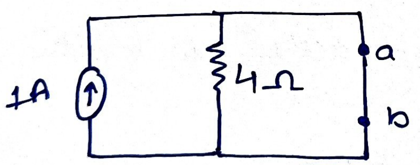
step 4: Calculate R_N

$$R_N = (8+8+4) \parallel 5$$

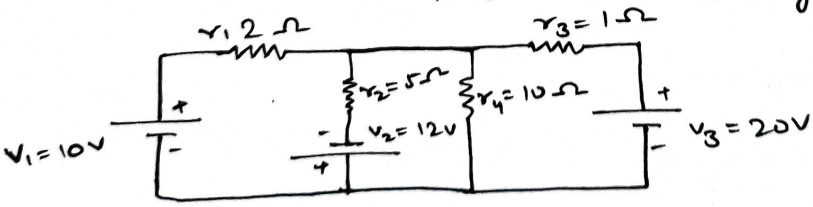
$$= \frac{20 \times 5}{20+5} = 4$$

$$\boxed{R_N = 4\Omega}$$

step 5: Draw Norton's Equivalent Circuit



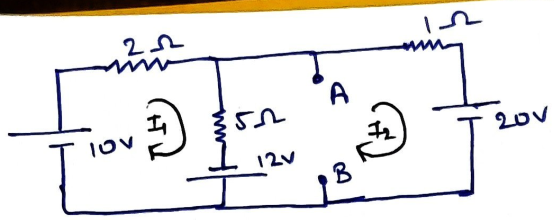
Ques 3: Find the current through the 10 ohm resistor using Thevnin's ~~Resis~~ Theorem in circuit given below.



Ans: **step 1**: Identify Load Resistance

$$\boxed{R_L = 10\Omega}$$

step 2: Remove R_L and calculate V_{Th}



apply KVL in Mesh ①

$$12+10-2I_1-5(I_1-I_2)=0$$
$$22-2I_1-5I_1+5I_2=0$$
$$22-7I_1+5I_2=0$$
$$\boxed{7I_1-5I_2=22} \quad \text{— (i)}$$

apply KVL in Mesh ②

$$-20-12-5(I_2-I_1)-1I_2=0$$
$$-22-5I_2+5I_1-I_2=0$$
$$-22-6I_2+5I_1=0$$
$$\boxed{5I_1-6I_2=32} \quad \text{— (ii)}$$

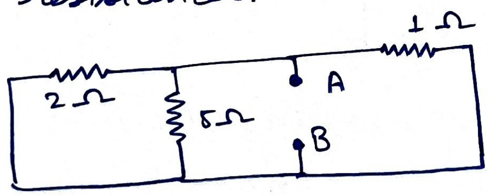
From (i) & (ii)

$$\boxed{I_1=-1.64A} \qquad \boxed{I_2=-6.70A}$$

Voltage Drop $= 20+(-6.70\times1)$
$= 13.3$

$$\boxed{V_{Th}=13.3V}$$

step 3: Remove R_L and replace all active soures with their internal resistances.



step 4: Calculate R_{th}

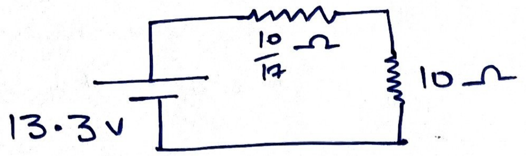
$$R_{Th}=R_{eq}$$

$$\frac{1}{R_{eq}} = \frac{1}{2}+\frac{1}{5}+\frac{1}{10} = \frac{5+2+10}{5\times2}$$

$$R_{eq} = \frac{10}{17}\,\Omega$$

$$\boxed{R_{th}=\frac{10}{17}\,\Omega}$$

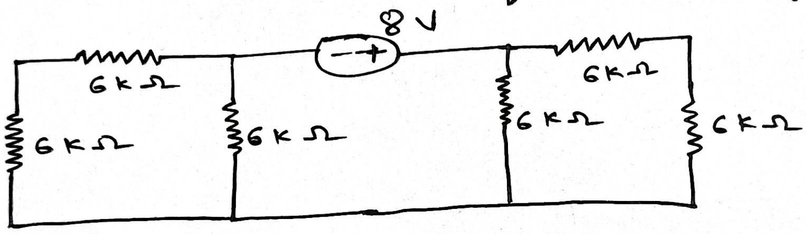
Step 5 : Draw Thevnin's Equivalent circuit



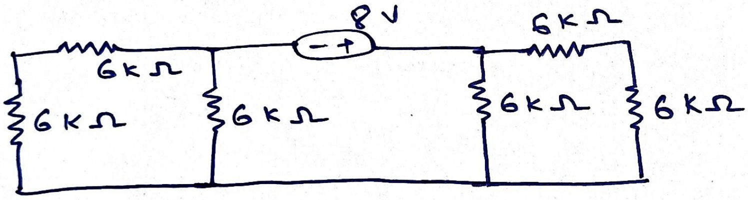
$$I_L = \frac{13.3}{\frac{10}{17}+10} = 1.25\,A$$

Current through $10\,\Omega$ resistor $= 1.25\,A$

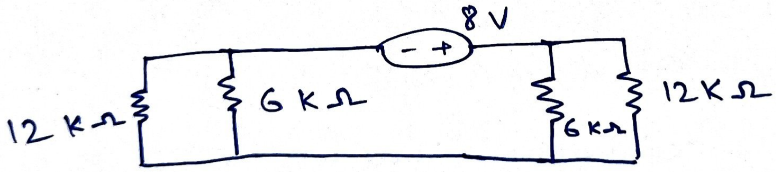
Ques 4: Find the current I of the circuit given below



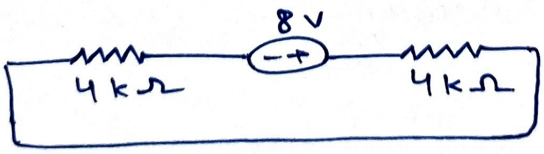
Ans:



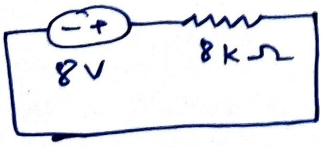
$6\,k\Omega + 6\,k\Omega = 12\,k\Omega$ $\qquad$ $6\,k\Omega + 6\,k\Omega = 12\,k\Omega$



$$R_{eq} = \frac{12\times 6}{12+8} = 4\,k\Omega \qquad R_{eq} = \frac{12\times 6}{12+6} = 4\,k\Omega$$



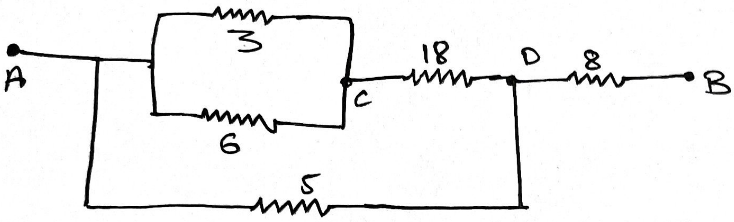
$R_{eq} = 8\,k\Omega$



$$I = \frac{8\,V}{8\,K}$$

$$\boxed{I = 1\,mA}$$

Ques 5: Calculate the effective resistance of the following combination of resistances in ohm and the voltage drop across each resistance when a P.D. of 60V is applied across AB.



Ans: Resistance between AC = $6 \| 3 = 2\,\Omega$

Resistance between ACD = $18 + 2 = 20\,\Omega$

Resistance between AD = $20 \| 5 = 4\,\Omega$

$\therefore$ Resistance between AB = $4 + 8 = 12\,\Omega$

Total current = $\frac{60}{12} = \underline{5A}$

Current through $5\,\Omega$ resistance = $5 \times \frac{20}{25} = 4A$

Current in Branch ACD = $5 \times \frac{5}{25} = 1A$.

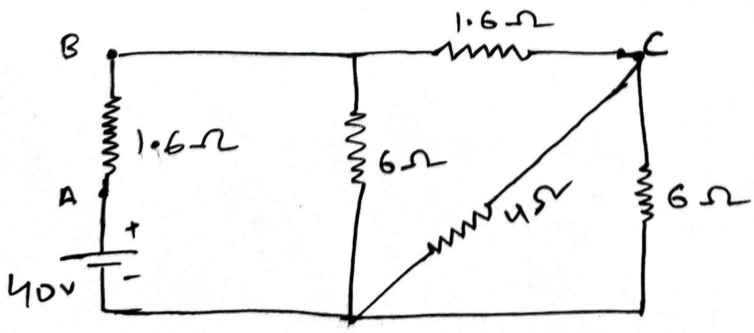
$\therefore$ PD across $3\,\Omega$ and $6\,\Omega$ resistors = $1 \times 2 = 2V$

PD across $18\,\Omega$ resistors = $1 \times 18 = 18V$

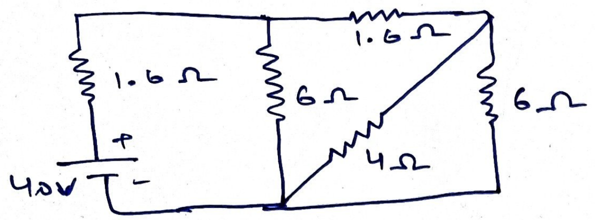
PD across $5\,\Omega$ resistors = $4 \times 5 = 20V$

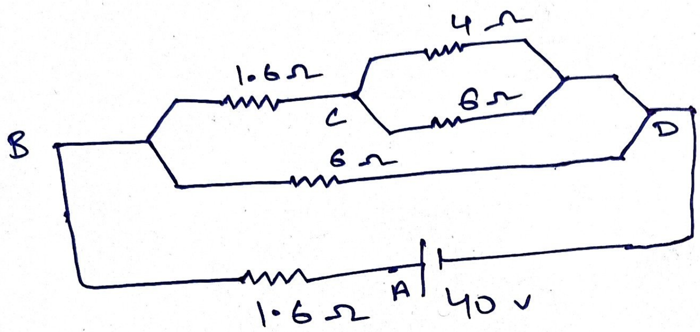
PD across $8\,\Omega$ resistors = $5 \times 8 = 40V$

Ques 6: Find current through $4\,\Omega$ resistance of the circuit.



Ans :





Resistance b/w CD = 4||6 = 2.4 Ω

Total Resistance b/w BCD = 1.6 + 2.4 = 4 Ω

Total Resistance b/w BD = 4||6 = 2.4 Ω

Total Resistance in the circuit = 2.4 + 1.6 = 4 Ω

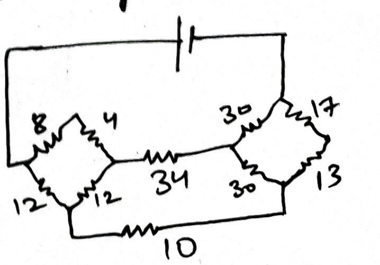
Current = $\frac{40}{4}$ = 10 A

Current in Branch BCD = $\frac{10 \times 6}{6+4}$ = 6 A

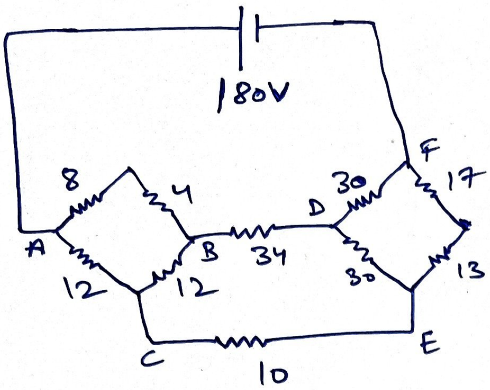
Current in 4 Ω resistor = $\frac{6 \times 6}{6+4}$ = 3.6 A

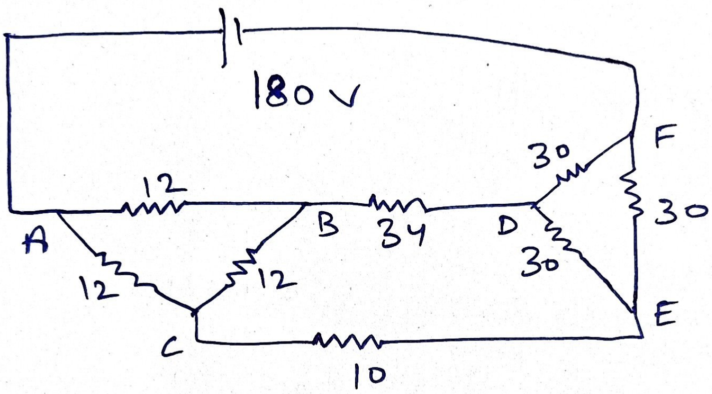
$\boxed{\text{Current} = 3.6\text{ A}}$

Ques 7 : Calculate the current flowing through the 10 Ω resistor by using any method.



Ans:





Converting Delta ABC to star

$\cancel{R_A = R_B = R_C = \frac{30\times30}{30+30+30}}$

$\cancel{\boxed{R_D = R_E = R_F = 10}}$

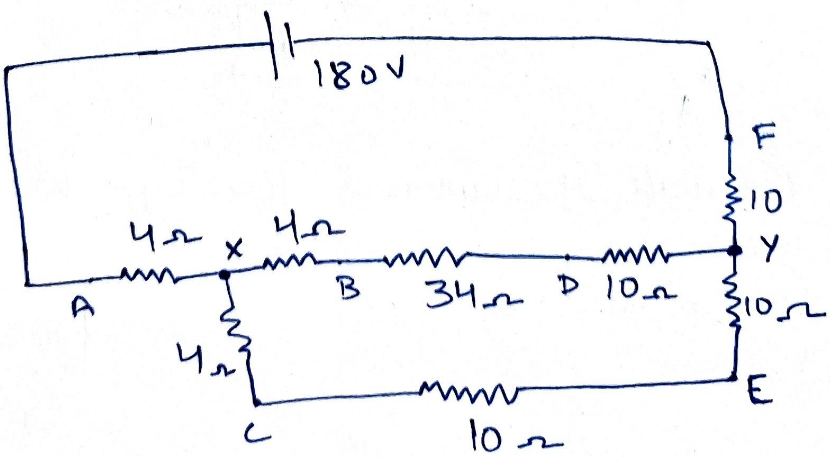
$$R_A = R_B = R_C = \frac{12\times12}{12+12+12}$$

$$\boxed{R_A = R_B = R_C = 4\,\Omega}$$

Converting Delta DEF to star

$$R_D = R_E = R_F = \frac{30\times30}{30+30+30}$$

$$\boxed{R_D = R_E = R_F = 10\,\Omega}$$



Resistance b/w XBDY $= 4+34+10 = 48\,\Omega$

Resistance b/w XCEY $= 4+10+10 = 24\,\Omega$

Resistance b/w XY $= 48 \| 24 = 16\,\Omega$

Total Resistance b/w AF $= 4+16+10 = 30\,\Omega$

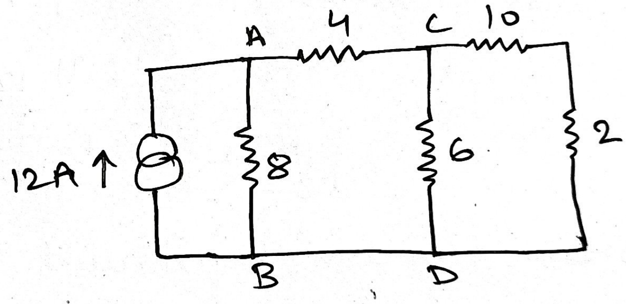
Current $= \dfrac{180}{30} = 6A$

$$\boxed{I = 6A}$$

Current in Branch XCEY $= \dfrac{6 \times 48}{48+24} = 4A$

$$\boxed{\text{Current in } 10\,\Omega \text{ Resistor} = 4A}$$

Ques 8: Using Norton's Theorem calculate current in the $6\,\Omega$ resistor

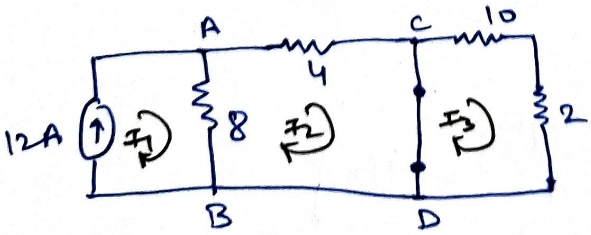


Ans: Using Norton's Theorem

Step 1: Identify Load Resistor

$$\boxed{R_L = 6\,\Omega}$$

Step 2: Replace R_L with short circuit branch and calculate I_N



→ I_3 was short circuited so, $\boxed{I_3 = 0}$

Applying KVL in Mesh ①

$$\boxed{12\,A = I_1}$$

Applying KVL in Mesh ②

$$-8[I_2 - I_1] - 4I_2 = 0$$

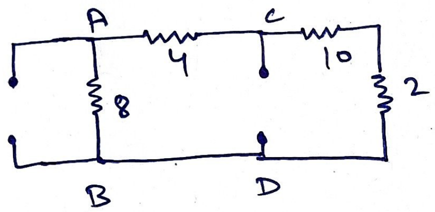
$$-12I_2 + 8I_1 = 0$$

$$-12I_2 = -96\,A$$

$$\boxed{I_2 = 8\,A}$$

$$\boxed{I_N = I_2 = 8\,A}$$

Step 3 : Remove R_L and replace all active sources with their internal resistances. Calculate R_N

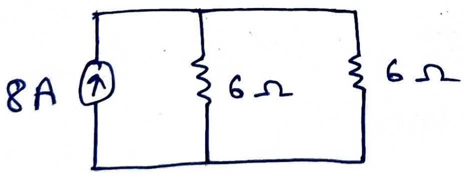


Total Resistance $= (8+4) \,||\, (10+2)$

$= 12 \,||\, 12$

$$\boxed{R_N = 6\,\Omega}$$

Step 4 : Draw Norton's equivalent circuit and calculate I_L



$$I_L = \frac{8 \times 6}{6+6}$$

$$I_L = 4A$$

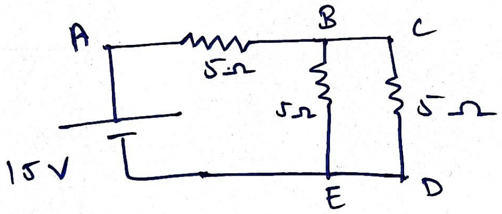
$$\boxed{\text{Current through } 6\,\Omega \text{ Resistance} = 4A}$$

Ques 9: State Thevnin's Theorem and Norton's Theorem and verify it by Illustration.

ans: Thevnin Theorem: According to Thevnin's Theorem, any linear network irrespective of its complexity can be reduced into a thevnin equivalent circuit having thevnin voltage or open circuit voltage [V_{TH}], thevnin / Equivalent Total Resistance [R_{TH}] with load resistance [R_L] connected in series with [R_{TH}].

Norton's Theorem: According to Norton's Theorem, any linear electric network irrespective of its complexities can be reduced into a Norton's Equivalent circuit having a Norton's short circuit current in parallel with Norton's equivalent resistance R_N with parallel load resistor R_L.

Illustration:



using Ohm's law:

$$R_{eq} = 5 + 5 \| 5$$
$$= 5 + 2.5$$
$$\boxed{R_{eq} = 7.5\,\Omega}$$

$$I = \frac{15}{7.5} = 2$$
$$\boxed{I = 2A}$$

Current in Branch $BE = \frac{2 \times 5}{5+5} = 1$

current in BE = 1A

Thevnin

step 1: Identify load resistance

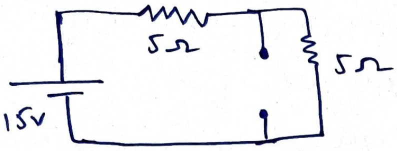
$\boxed{R_L = 5\,\Omega}$

~~Illustra~~ Norton

step 1: Identify load resistance

$\boxed{R_L = 5\,\Omega}$

Step 2: Remove R_L and calculate V_{Th}

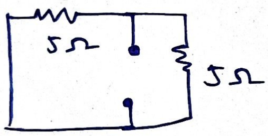


$$I = \frac{15}{10} = 1.5A$$

$$V_{Th} = 5 \times 1.5$$

$$\boxed{V_{Th} = 7.5V}$$

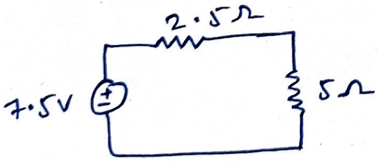
Step 3: Remove R_L and replace all active sources with their internal resistances.



$$R_{Th} = \frac{5 \times 5}{5+5}$$

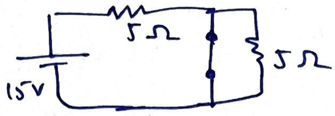
$$\boxed{R_{Th} = 2.5\Omega}$$

Step 4: Draw Thevenin's equivalent circuit



$\underline{I = 1A}$

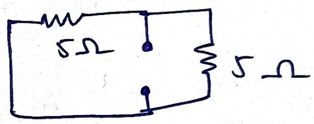
Step 2: Replace R_L with short circuit branch and calculate I_N



$$I = \frac{15}{5} = 3A$$

$$\boxed{I_N = 3A}$$

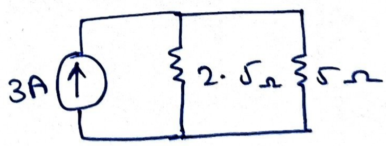
Step 3: Remove R_L and replace all active sources with their internal resistances



$$R_N = \frac{5 \times 5}{5+5}$$

$$\boxed{R_N = 2.5\Omega}$$

Step 4: Draw Norton's equivalent circuit

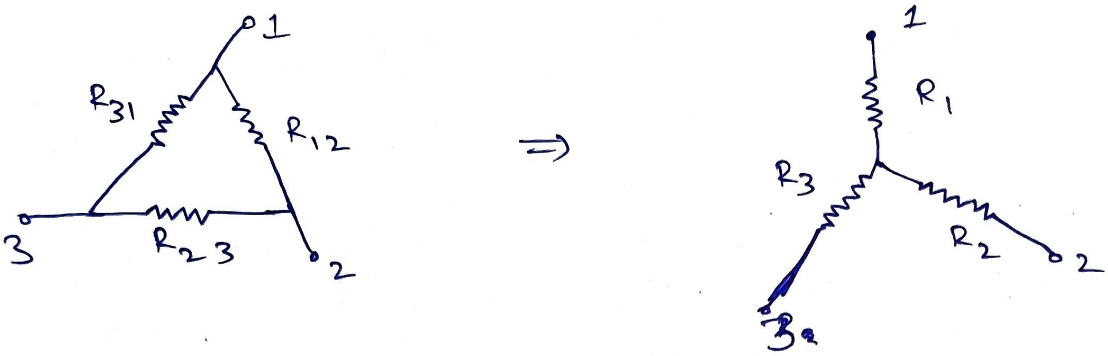


$\underline{I = 1A}$

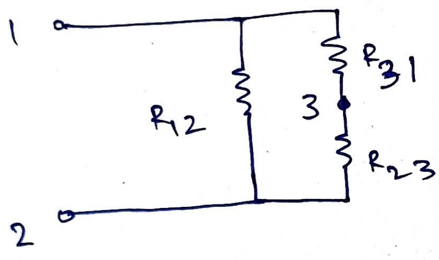
As all the three calculated values are same. Hence, verified.

Ques 10: Give the derivation for Star to Delta and Delta to Star transformation.

Ans: <u>Delta to Star Transformation</u>



Equivalent circuit between ① & ②

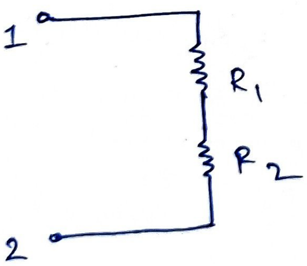


$$R_{eq} = R_{12} \parallel (R_{31} + R_{23})$$

$$\left.R_{eq}\right)_{12} = \frac{R_{12}(R_{31} + R_{23})}{R_{12} + R_{31} + R_{23}}$$

Similarly,

$$\left.R_{eq}\right)_{23} = \frac{R_{23}(R_{12} + R_{31})}{R_{12} + R_{23} + R_{31}} \qquad \left.R_{eq}\right)_{31} = \frac{R_{31}(R_{12} + R_{23})}{R_{12} + R_{23} + R_{31}}$$



$$\left.R_{eq}\right)_{12} = R_1 + R_2$$

Similarly,

$$\left.R_{eq}\right)_{23} = R_2 + R_3 \qquad \cancel{R_3+} \left.R_{eq}\right)_{31} = R_3 + R_1$$

$$R_1 + R_2 = \frac{R_{12}(R_{23} + R_{31})}{R_{12} + R_{23} + R_{31}} \quad \text{—— ①}$$

$$R_2 + R_3 = \frac{R_{23}(R_{31} + R_{12})}{R_{12} + R_{23} + R_{31}} \quad \text{—— (II)} \qquad R_3 + R_1 = \frac{R_{31}(R_{23} + R_{12})}{R_{12} + R_{23} + R_{31}} \quad \text{—— (III)}$$

(I) − (II) ⇒

$$R_1 - R_3 = \frac{R_{12} \cdot R_{23} + R_{12} \cdot R_{31} - R_{23} \cdot R_{31} - R_{23} \cdot R_{12}}{R_{12} + R_{23} + R_{31}}$$

$$R_1 - R_3 = \frac{R_{12} \cdot R_{31} - R_{23} \cdot R_{31}}{R_{12} + R_{23} + R_{31}} \quad \text{—— (IV)}$$

(IV) + (III),

$$2R_1 = \frac{R_{12} \cdot R_{31} - \cancel{R_{23} \cdot R_{31}} + R_{31} \cdot R_{12} + \cancel{R_{31} \cdot R_{23}}}{R_{12} + R_{23} + R_{31}}$$

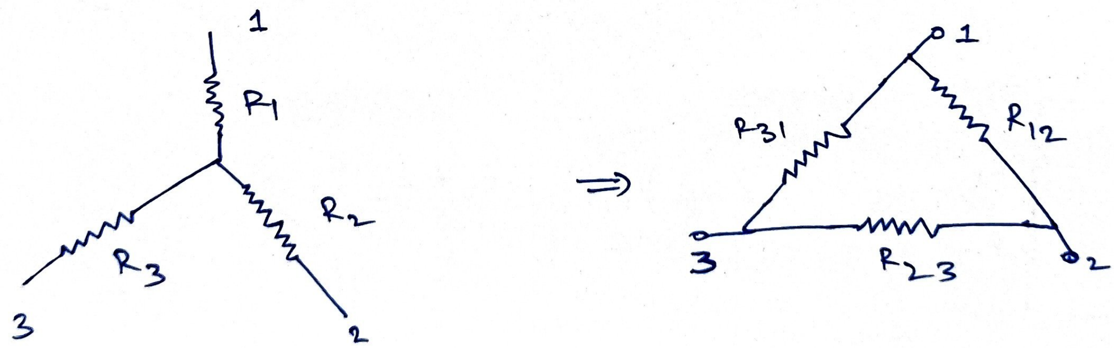
$$2R_1 = \frac{2\, R_{12} \cdot R_{31}}{R_{12} + R_{23} + R_{31}}$$

$$R_1 = \frac{R_{12} \cdot R_{31}}{R_{12} + R_{23} + R_{31}}$$

Similarly,

$$R_2 = \frac{R_{23} \cdot R_{12}}{R_{12} + R_{23} + R_{31}} \qquad R_3 = \frac{R_{31} \cdot R_{23}}{R_{12} + R_{23} + R_{31}}$$

Star to Delta Transformation



$$R_1 = \frac{R_{12} \cdot R_{31}}{R_{12} + R_{23} + R_{31}} \quad \text{—— (I)}$$

$$R_2 = \frac{R_{23} \cdot R_{12}}{R_{12} + R_{23} + R_{31}} \quad \text{—— (II)}$$

$$R_3 = \frac{R_{31} + R_{23}}{R_{12} + R_{23} + R_{31}} \quad \text{—— (III)}$$

$$R_1 \cdot R_2 = \frac{(R_{12} \cdot R_{31})(R_{23} \cdot R_{12})}{(R_{12}+R_{23}+R_{31})^2} = \frac{R_{12}^2 \cdot R_{23} \cdot R_{31}}{(R_{12}+R_{23}+R_{31})^2} \quad \text{—— (4)}$$

$$R_2 \cdot R_3 = \frac{R_{23}^2 \cdot R_{12} \cdot R_{31}}{(R_{12}+R_{23}+R_{31})^2} \quad \text{—— (5)}$$

$$R_3 \cdot R_1 = \frac{R_{13}^2 \cdot R_{12} \cdot R_{31}}{(R_{12}+R_{23}+R_{31})^2} \quad \text{—— (6)}$$

(4) + (5) + (6)

$$R_1 \cdot R_2 + R_2 \cdot R_3 + R_3 \cdot R_1 = \frac{R_{12} \cdot R_{23} \cdot R_{31} \cancel{(R_{12}+R_{23}+R_{31})}}{(R_{12}+R_{23}+R_{31})^{\cancel{2}}}$$

$$R_1 \cdot R_2 + R_2 \cdot R_3 + R_3 \cdot R_1 = \frac{R_{12} \cdot R_{23} \cdot R_{31}}{R_{12}+R_{23}+R_{31}} \quad \text{—— (7)}$$

using (7) & (1)

$$R_1 \cdot R_2 + R_2 \cdot R_3 + R_3 \cdot R_1 = R_1 \cdot R_{23}$$

$$R_{23} = \frac{R_1 \cdot R_2 + R_2 \cdot R_3 + R_3 \cdot R_1}{R_1}$$

Similarly,

$$R_{31} = \frac{R_1 \cdot R_2 + R_2 \cdot R_3 + R_3 \cdot R_1}{R_2}$$

$$R_{12} = \frac{R_1 \cdot R_2 + R_2 \cdot R_3 + R_3 \cdot R_1}{R_3}$$