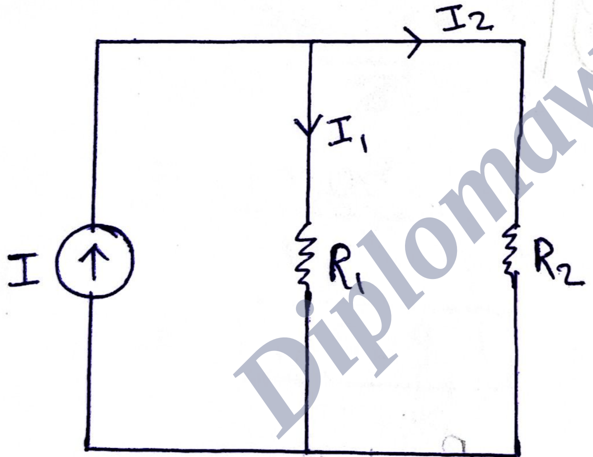
Unit :- 01

Network Theorem

Date :- 26.11.24 Day :- Tuesday

→ Basic

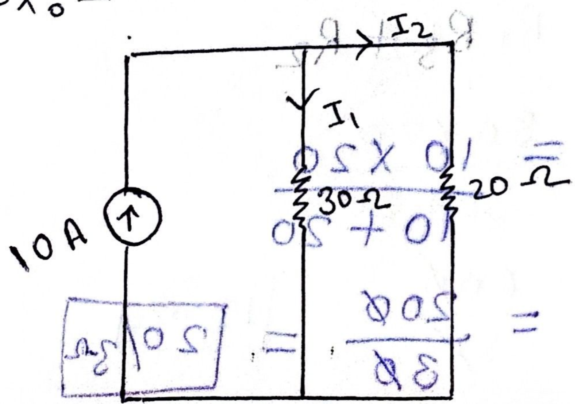
Current Division Rule :-



$$\frac{\text{Total current} \times \text{Opposite Resistance}}{\text{Total Resistance}}$$

$$I_1 = \frac{I \times R_2}{R_1 + R_2}, \quad I_2 = \frac{I \times R_1}{R_1 + R_2}.$$

→ Ex :-



$$I_1 = \frac{10 \times 20}{30 + 20}$$

$$= \frac{20\cancel{0}}{5\cancel{0}}$$

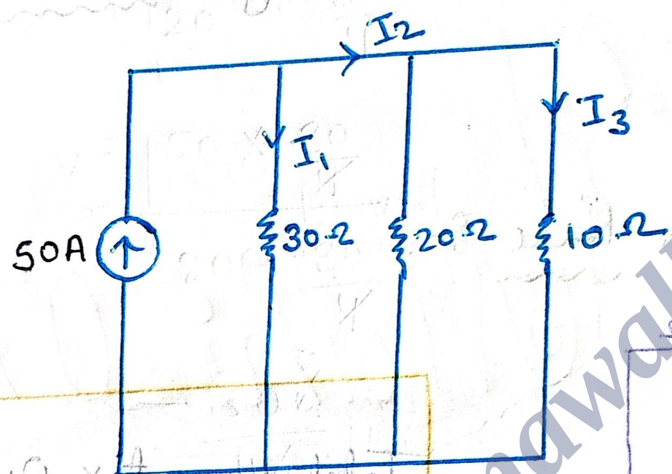
$$= \boxed{4\,A}$$

$$I_2 = \frac{10 \times 30}{30 + 20}$$

$$= \frac{30\cancel{0}}{5\cancel{0}}$$

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

Ex:- Find the value of I_1, I_2 & I_3



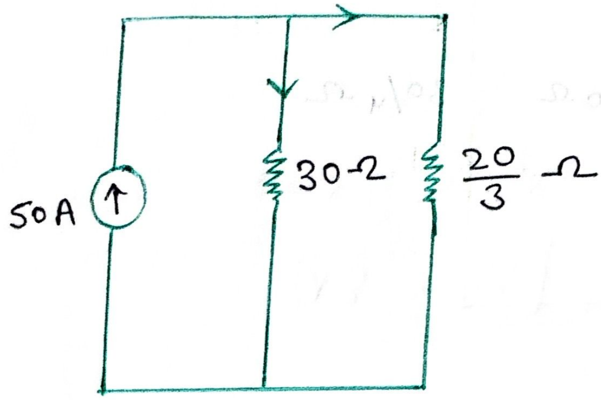
1.) $I_1 = R_2 \parallel R_3$

$R_2 \parallel R_3$ $\quad \frac{1}{R_{eq}} = \frac{1}{R_2} + \frac{1}{R_3} = \frac{R_3 + R_2}{R_3 \times R_2}$

$$R_{eq} = \frac{R_3 \times R_2}{R_3 + R_2}$$

$$R_{eq} = \frac{10 \times 20}{10 + 20}$$

$$R_{eq} = \frac{20\cancel{0}}{3\cancel{0}} = \boxed{20/3\,\Omega}$$



$$R_{eq} = \frac{50 \times \frac{20}{3}}{30 + \frac{20}{3}}$$

$$= \frac{50 \times \frac{20}{\cancel{3}}}{\frac{90+20}{\cancel{3}}}$$

$$= \frac{100\cancel{0}}{11\cancel{0}}$$

$$I_1 = \boxed{9.909\ A}$$

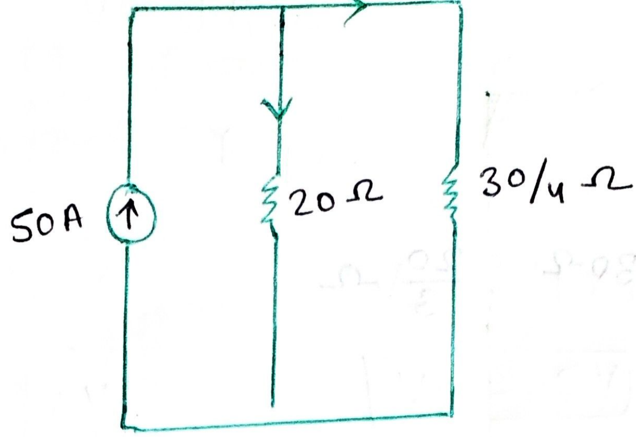
2.) $I_2 = \underbrace{R_1 \parallel R_3}$

$R_1 \parallel R_3$ $\quad \frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_3} = \frac{R_1 + R_3}{R_1 \times R_3}$

$$R_{eq} = \frac{R_1 \times R_3}{R_1 + R_3}$$

$$R_{eq} = \frac{10 \times 30}{10 + 30}$$

$$R_{eq} = \frac{30\cancel{0}}{4\cancel{0}} = \boxed{30/4\ \Omega}$$



$$Req = \frac{50 \times \frac{30}{4}}{20 + \frac{30}{4}}$$

$$= \frac{50 \times \frac{30}{\cancel{4}}}{\frac{80 + 30}{\cancel{4}}}$$

$$= \frac{150\cancel{0}}{11\cancel{0}}$$

$$I_2 = \boxed{13.6A}$$

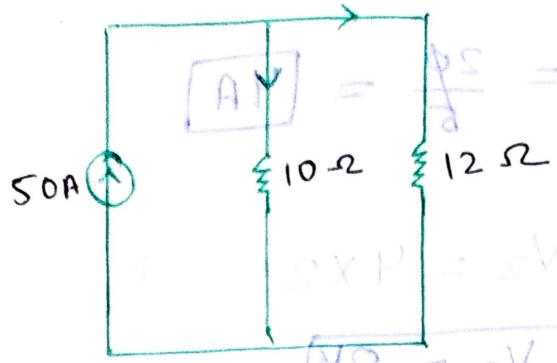
3) $I_3 = R_1 \parallel R_2$

$R_1 \parallel R_2$ $\quad \frac{1}{Req} = \frac{1}{R_1} + \frac{1}{R_2} = \frac{R_1 + R_2}{R_1 \times R_2}$

$$Req = \frac{R_1 \times R_2}{R_1 + R_2}$$

$$Req = \frac{30 \times 20}{30 + 20}$$

$$Req = \frac{60\cancel{0}}{5\cancel{0}} = \boxed{12\Omega}$$



$$Req = \frac{50 \times 12}{10 + 12}$$

$$= \frac{600}{22}$$

$$I_3 = \boxed{27.27\ A}$$

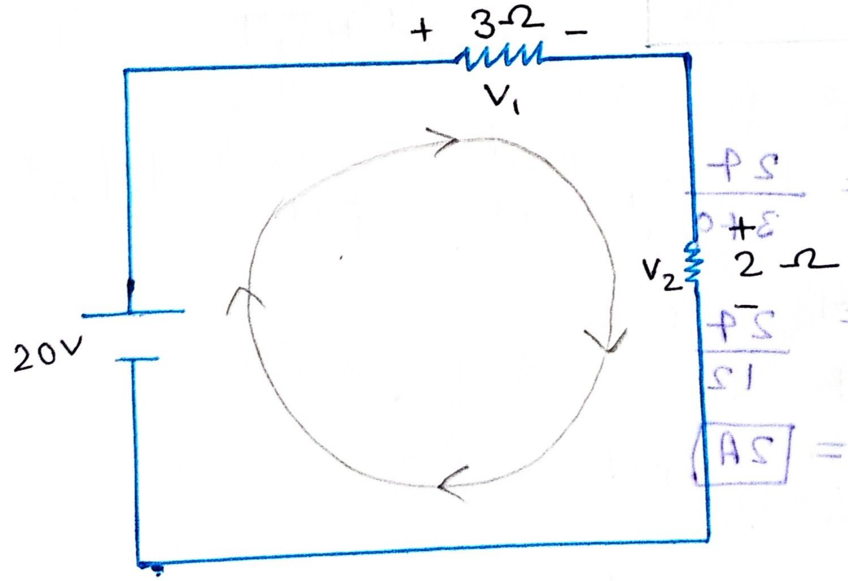
$\therefore \quad I_1 + I_2 + I_3$

$9.90 + 13.6 + 27.27$

$= \boxed{50.77}$ Proved

Voltage Division Current :-

1.)



$$V = IR$$

$$I = \frac{V}{R_{eq}} = \frac{2\cancel{0}}{\cancel{5}} = \boxed{4A}$$

$\rightarrow$ $V_1 = 4 \times 3$

$\boxed{V_1 = 12V}$

$V_2 = 4 \times 2$

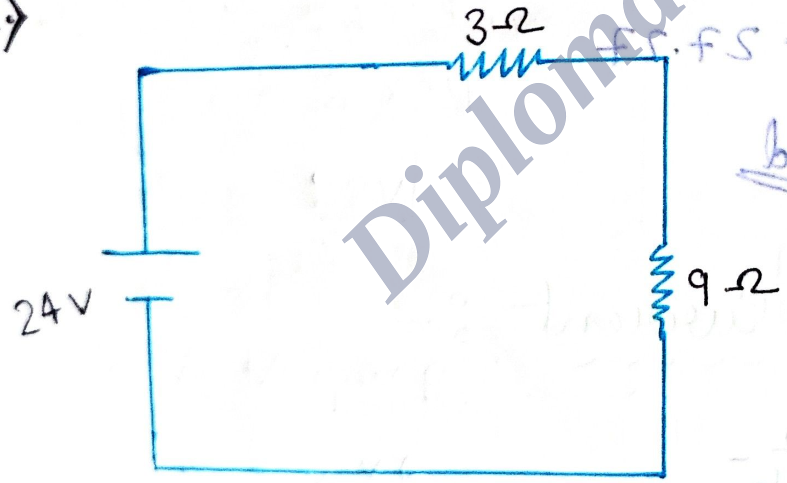
$\boxed{V_2 = 8V}$

$\rightarrow$ $V = V_1 + V_2$

$= 12 + 8$

$V = \boxed{20V}$ Proved

2)



$$I = \frac{V}{R_{eq}} = \frac{24}{3+9}$$

$$= \frac{24}{12}$$

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

$\rightarrow V_1 = 2 \times 3$

$\boxed{V_1 = 6V}$

$V_2 = 2 \times 9$

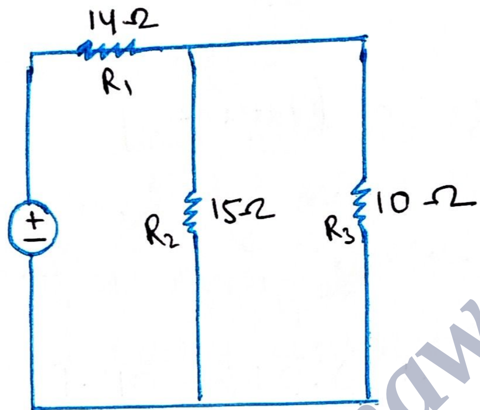
$\boxed{V_2 = 18V}$

$V = V_1 + V_2$

$= 6v + 18v$

$= \boxed{24V}$ Proved.

③ Example :-



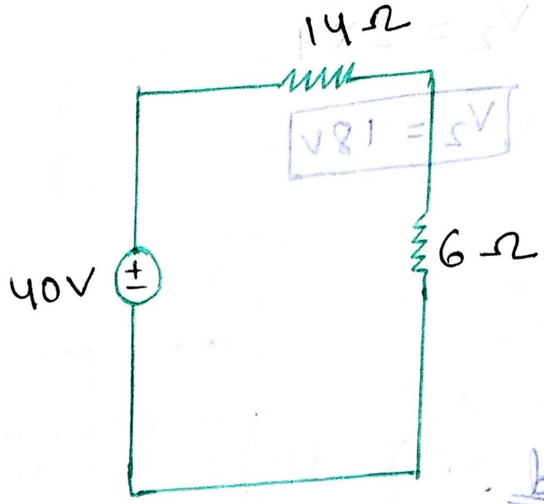
$$Req = R_2 \parallel R_3 = \frac{1}{R_2} + \frac{1}{R_3} = \frac{R_2 + R_3}{R_2 \times R_3}$$

$$Req = \frac{R_2 \times R_3}{R_2 + R_3}$$

$$Req = \frac{15 \times 10}{15 + 10}$$

$$Req = \frac{150}{25}$$

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



$V = IR$

$$I = \frac{40}{14+6}$$

$$I = \frac{40}{20}$$

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

$\rightarrow V_1 = i_1 \times R_1$

$= 2 \times 14$

$\boxed{V_1 = 28V}$

$\rightarrow V_2 = i_1 \times R_2$

$= 2 \times 6$

$\boxed{V_2 = 12V}$

$\therefore V = V_1 + V_2$

$= 28 + 12$

$\boxed{V = 40V}$ Proved

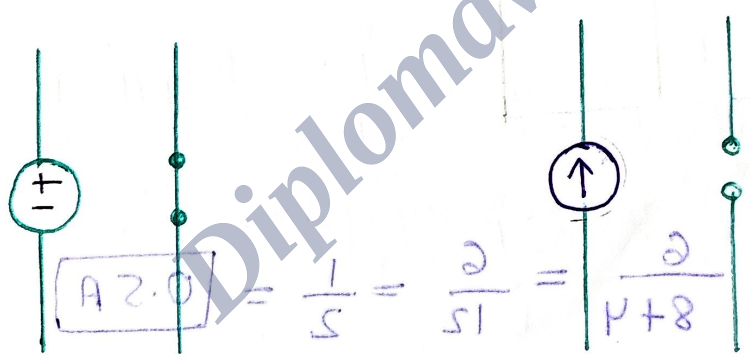
▷ Superposition Theorem :-

Statement :-

The voltage across (or current through) an element in a linear circuit is the algebraic sum of the voltage across (or current through) that element due to each independent source acting alone.

Turned off :-

It means all the independent source are replaced by there internal resistance i.e we replace every voltage source by zero volt and every current source by zero ampere.

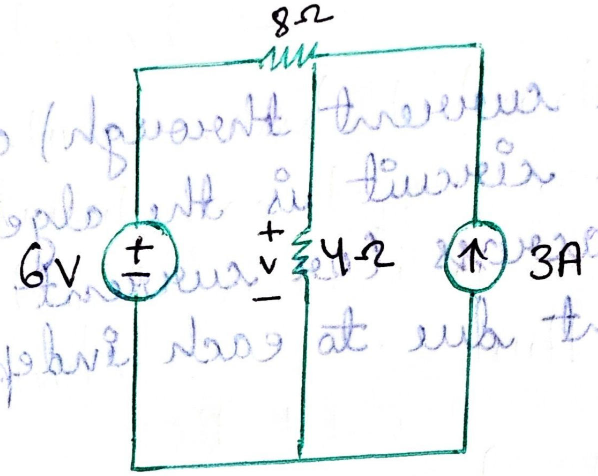


Short Circuit Open Circuit

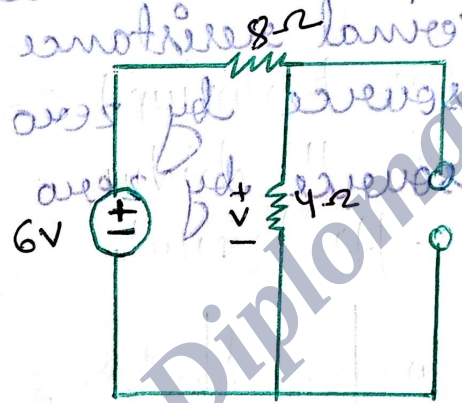
- The dependent source are left as they are
- The superposition theorem is not valid in case of non-linear circuit.

Example :-

Find voltage in the given circuit.



Step 1 :- Consider 6 volt as a source.



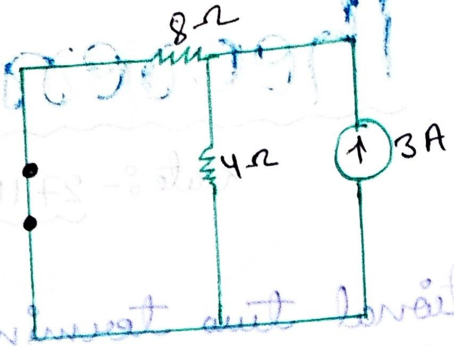
$V = IR$

$I = \frac{V}{Req} = \frac{6}{8+4} = \frac{6}{12} = \frac{1}{2} = \boxed{0.5\,A}$

$V_2 = 4 \times 0.5$

$= \boxed{2V}$

Step 2 :- Consider 3A as a source.



$$I_2 = \frac{3 \times 8}{8+4}$$

$$= \frac{24}{12}$$

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

$\therefore$ $V = I_2 \times R_2$

$= 2 \times 4$

$= \boxed{8V}$

Total voltage $= V_1 + V_2 = 2V + 8V$
$= 10V$ } From Superposition Theorem.

▷ Thevenins Theorem

Date :- 27.11.24

Statement :-

A linear and bidirectional two terminal network can be replaced by an equivalent network consists of a voltage source (V_{th}) connects in series with a resistor (R_{th}).

$V_{th} \rightarrow$ Open circuit voltage at (Thevenins voltage) terminals.

$R_{th} \rightarrow$ Equivalent resistance at the terminal which the independent source are turned off.

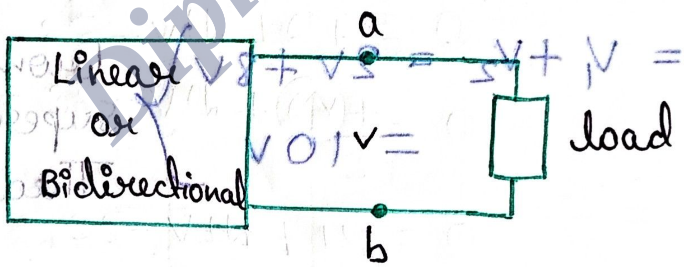
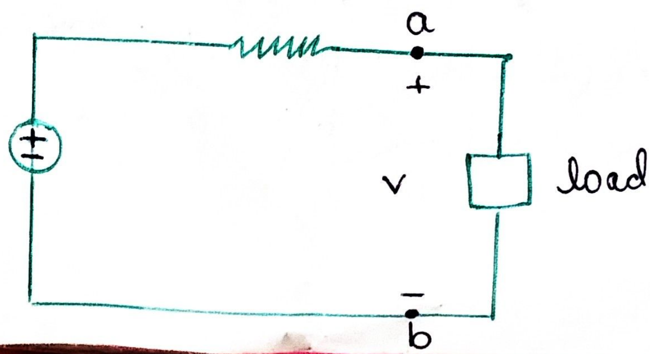


Fig :- Black diagram of Thevenins Theorem

→ Equivalent Circuit :-



Procedure :-

1.) Remove the resistor and mark the terminals.

2.) Find the open circuit voltage (V_{th}) using KVL.

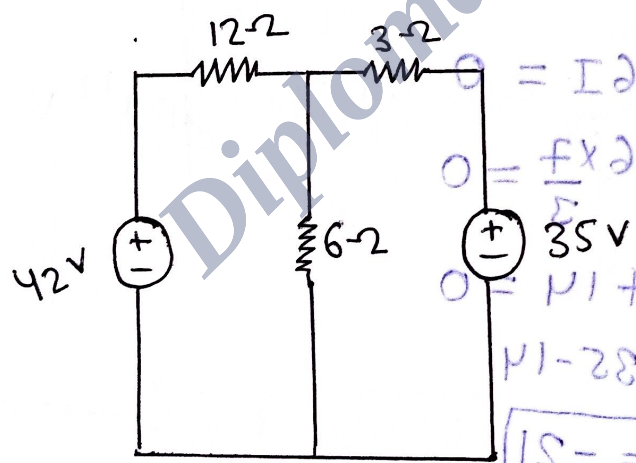
3.) Deactivate all independent sources and find R_{th}.

4.) Produce the thevenins equivalent circuit reconnecting the load resistance.

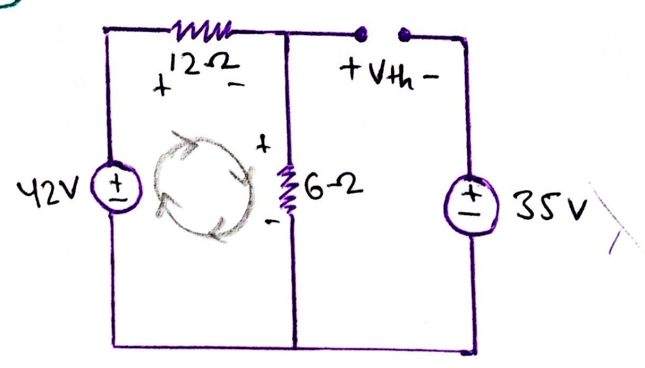
5.) Find the current through resistor.

→ Example :-

Q. Find V_{th}, R_{th} and current flowing through the 3 Ω resistor in the below circuit.



Step :- 1



$$V = IR$$

$$I = \frac{V}{R_{eq}}$$

$$I = \frac{42}{12+6}$$

$$I = \frac{42}{18} = \frac{7}{3} = \boxed{2.33\,A}$$

→ Loop Process :-

$$-42 + 12I + 6I = 0$$

$$-42 + 12 + 6 = 0$$

$$18I = 42$$

$$I = \frac{\cancel{42}}{\cancel{18}} = \boxed{\frac{7}{3}\,A}$$

Step :- 2

$$-35 - V_{th} + 6I = 0$$

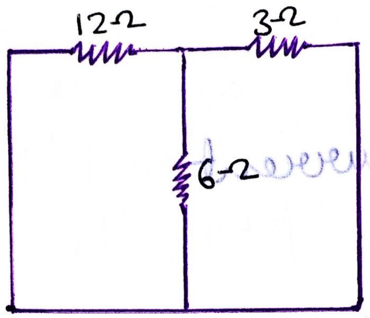
$$-35 - V_{th} + 6 \times \frac{7}{3} = 0$$

$$-35 - V_{th} + 14 = 0$$

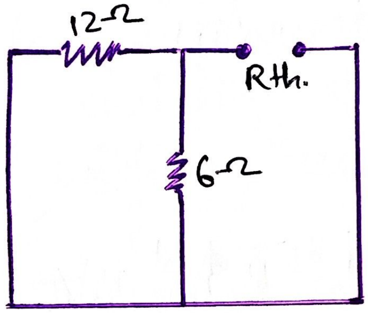
$$-V_{th} = 35 - 14$$

$$\boxed{V_{th} = -21}$$

Step :- 3



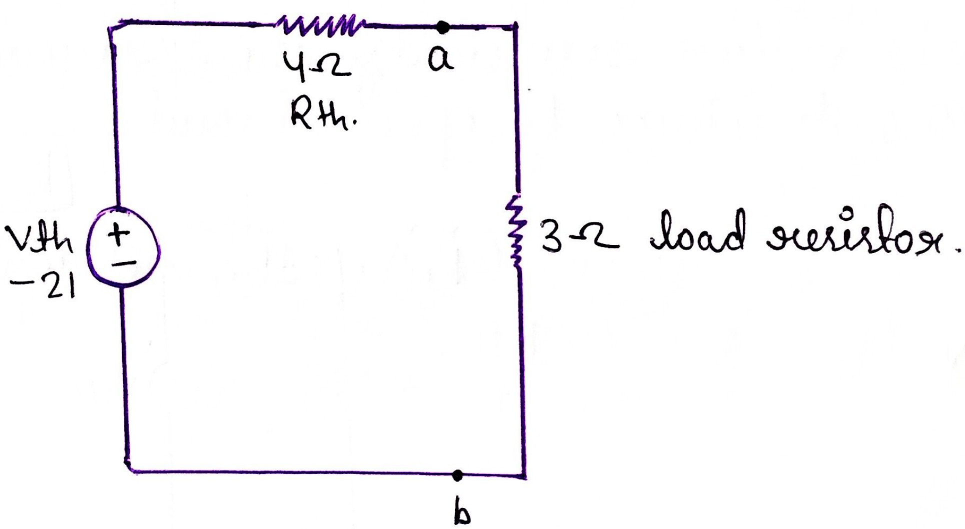
Step :- 4



$$R_{th} = \frac{12 \times 6}{12+6} = \frac{72}{18} = 4$$

$$\boxed{R_{th} = 4\Omega}$$

Step :- 5



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

$$= \frac{-21}{7}$$

$\boxed{I = -3A}$ → Total current.

→ Current will be same Across 3Ω.

→ Loop Process :-

$$+21 + 4I + 3I = 0$$

$$7I = -21$$

$$I = \frac{-21}{7}$$

$$\boxed{I = -3A}$$

Norton's Theorem

Invented in 1946

who had invented → American Engineer
Edward Lawry Norton
on Bell laboratory.

Statement :-

A linear and bidirectional two terminal network can be replaced by an equivalent circuit consisting of a current source I_N in parallel with a resistor R_N.

I_N :- The short circuit current through the terminals.

R_N :- Equivalent resistance at the terminal when independent sources are turned off.

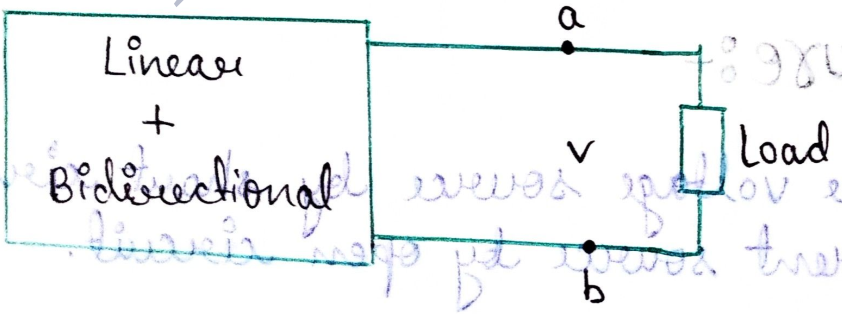


Fig :- Black diagram of Norton's Theorem.

→ Equivalent circuit:

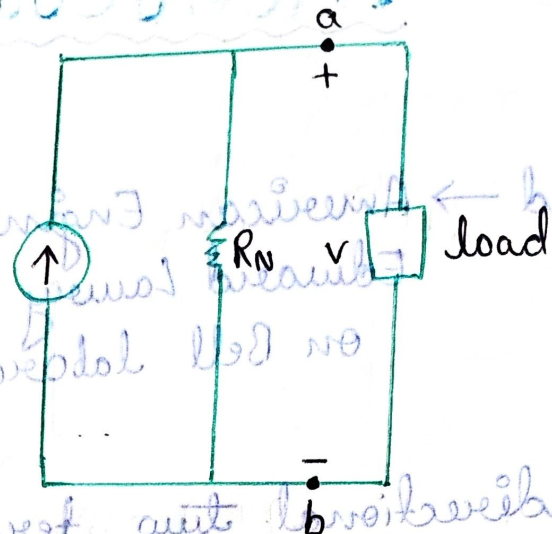


Fig:- Norton's Equivalent circuit

Note:- $V = IR$ $\therefore R_{Th} = R_N$

$V = I_N R_{Th}$

$V = I_N \times R_N$

$= I_N = \frac{V_{Th}}{R_N}$

Procedure:-

1.) Remove the voltage source by short circuit and current source by open circuit.

2.) Next, Find the resistance (R_N) of the network. It is exactly same as R_{Th}.

3.) After finding R_N, short the resistance across where to find and put short circuit current across them.

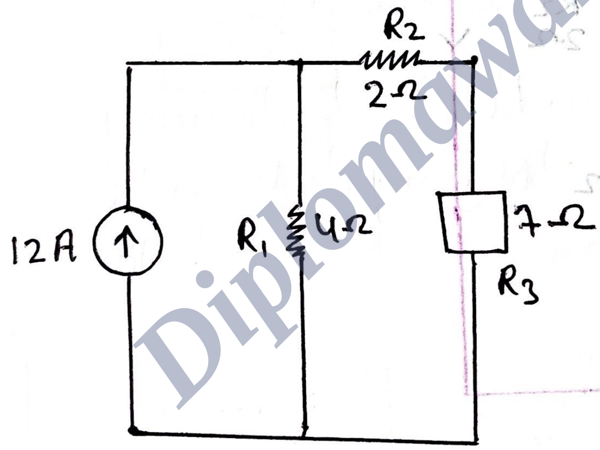
4.) Compute the short circuit current $I_{sc} = I_N$

$\boxed{I_{sc} = I_N}$ sc = short circuit.

5.) The current source (I_{sc} or I_N) joined in parallel across R_N between the two terminals given in equivalent circuit.

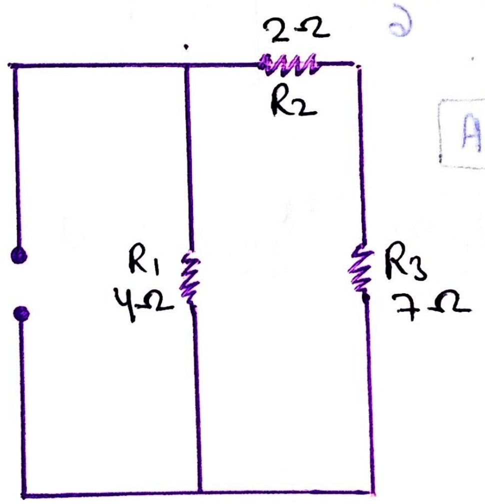
Example :-

Q. Find the current through 7Ω resistor using Norton's Theorem.

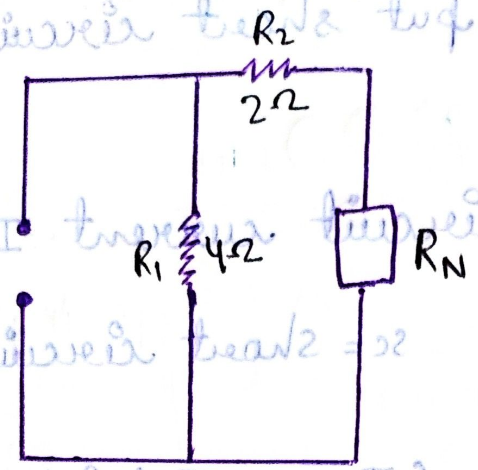


Soln :-

Step :- 1

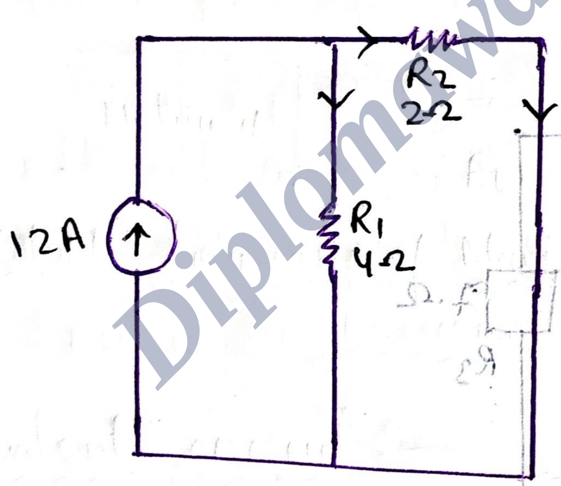


Step :- 2



$$R_N = R_1 + R_2$$
$$= 4 + 2$$
$$\boxed{R_N = 6\,\Omega}$$

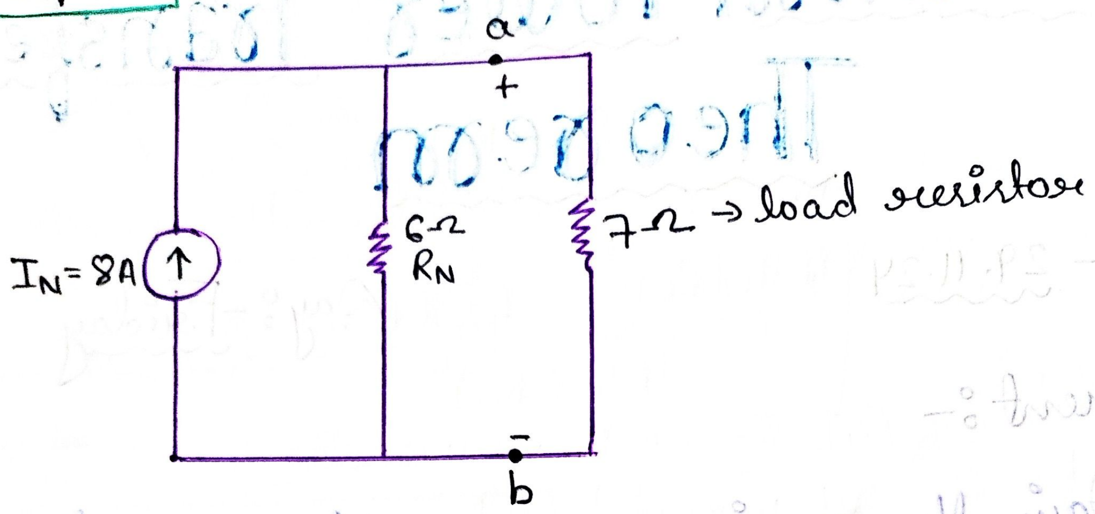
Step :- 3



$$I_N = \frac{12 \times 4}{4+2} = \frac{48}{6}$$

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

Step :- 4



$$= 8 \times \frac{6}{6+7}$$

$$= 8 \times \frac{6}{13}$$

$$= \frac{48}{13}$$

$$= \boxed{3.69\,A}$$

▷ Maximum Power Transfer Theorem

Date :- 29.11.24 Day :- Friday

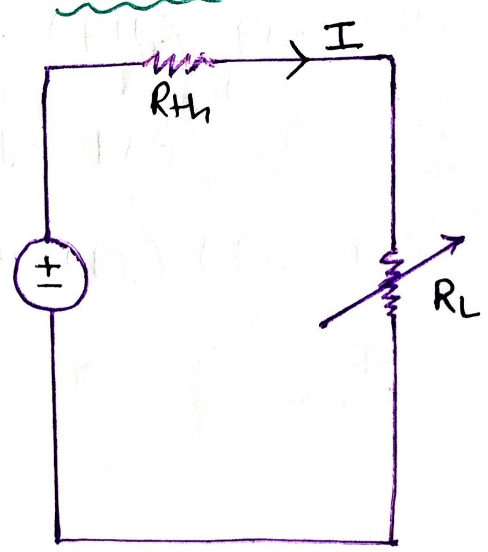
Statement :-

To obtain the maximum power for a network the resistance of the load must be equal to the Thevenin's resistance of the network.

$$\boxed{R_L = R_{Th}}$$

Fig :- Black diagram of Maximum Power transfer Theorem

Equivalent circuit :-



→ To prove,

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

$$\boxed{I = \frac{V_{th}}{R_{th} + R_L}}$$

→ Power

$$P = I^2 R_L$$

$$\boxed{P = \left(\frac{V_{th}}{R_{th} + R_L}\right)^2 \times R_L} \text{ ——— (i)}$$

→ To find the maximum power we will differenciate with respect to R_L.

$$\boxed{\frac{dp}{dR_L} = 0}$$

$$\frac{dp}{dR_L} = \frac{\left(\frac{V_{th}}{R_{th} + R_L}\right)^2 \times R_L}{dR_L} = 0$$

$$\Rightarrow \frac{d \cdot \frac{(V_{th})^2}{(R_{th} + R_L)^2} \times R_L}{dR_L}$$

$$\left\{ \frac{V \cdot \frac{du}{dx} - u \cdot \frac{dv}{dx}}{(V)^2} \right.$$

$$\Rightarrow \frac{d \cdot V_{th}^2 \left[\frac{R_L}{(R_{th} + R_L)^2}\right]}{dR_L}$$

$$\Rightarrow d\, V_{th}^2 \left[\frac{(R_{th}+R_L)^2 \times \frac{d(R_L)}{dR_L} - R_L \, d(R_{th}+R_L)^2}{\left\{(R_{th}+R_L)^2\right\}^2} \right]$$

$$\Rightarrow d\, V_{th}^2 \left[\frac{(R_{th}+R_L)^2 - 2R_L(R_{th}+R_L)}{(R_{th}+R_L)^4} \right]$$

$$\Rightarrow V_{th}^2 \left[\frac{R_{th}^2 + \cancel{2R_{th} \cdot R_L} + R_L^2 - \cancel{2R_L R_{th}} - 2R_L^2}{(R_{th}+R_L)^4} \right]$$

$$\Rightarrow \frac{V_{th}^2 (R_{th}^2 - R_L^2)}{(R_{th}+R_L)^4}$$

$$\Rightarrow \frac{V_{th}^2 (R_{th}^2 - R_L^2)}{(R_{th}+R_L)^4} = 0$$

$$\Rightarrow V_{th}^2 (R_{th}^2 - R_L^2) = 0$$

$$\Rightarrow (R_{th}^2 - R_L^2) = 0$$

$$\Rightarrow (R_{th}+R_L)(R_{th}-R_L) = 0$$

$$\Rightarrow R_{th} - R_L = 0$$

$$\Rightarrow R_{th} = R_L$$

Date :- 02/12/24 Day :- Monday

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

$$P = I^2 \times R$$

$\rightarrow P = I^2 R$

$$P_{max} = \left(\frac{V_{th}}{R_{th}+R_L}\right)^2 \times R_L$$

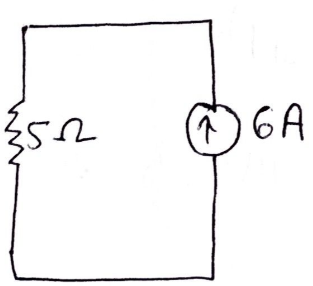
$$P_{max} = \frac{V_{th}^2}{(R_{th}+R_L)^2} \times R_L$$

$$= \frac{V_{th}^2}{(2R_{th})^2} \times R_{th}$$

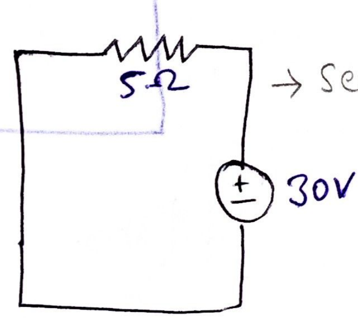
$$= \frac{V_{th}^2}{4R_{th}^{\cancel{2}}} \times \cancel{R_{th}}$$

$$\boxed{P_{max} = \frac{V_{th}^2}{4R_{th}}}$$

Source Transformation :-



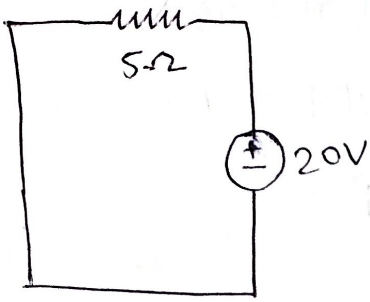
$= V = I \times R$
$= 6 \times 5$
$= 30$



→ Series

↓

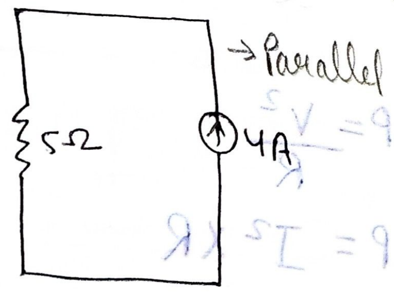
Voltage Transformation



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

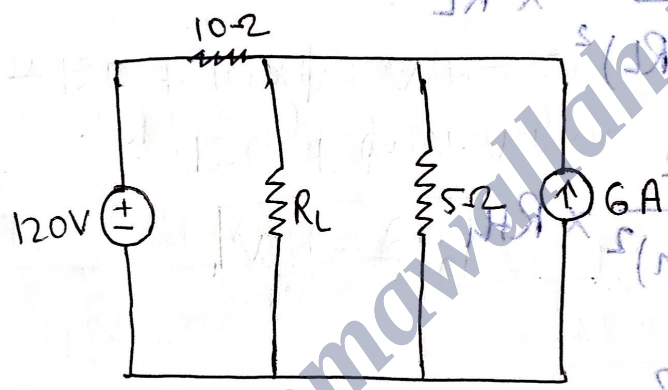
$$= \frac{20}{5}$$

$$= \boxed{4A}$$



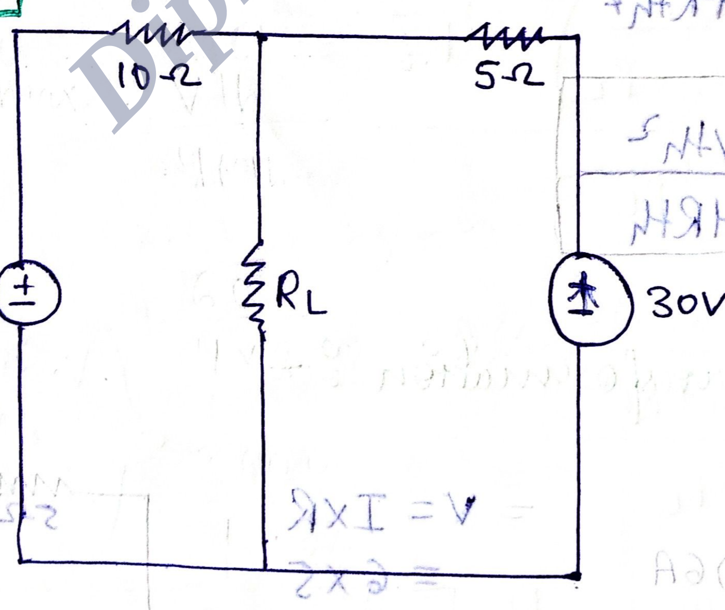
Example :-

Q. Calculate the value of R_L which will absorb maximum power from the circuit.

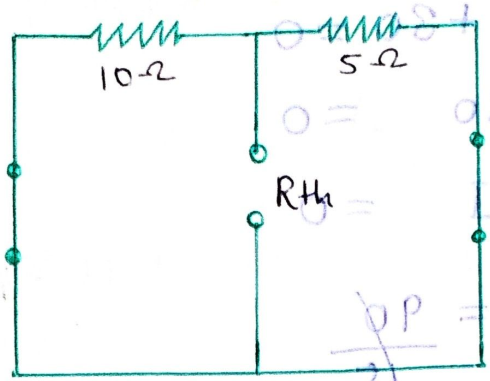


Step: 1

Soln:- (1)



Step : 2



$10\Omega \parallel 5\Omega$

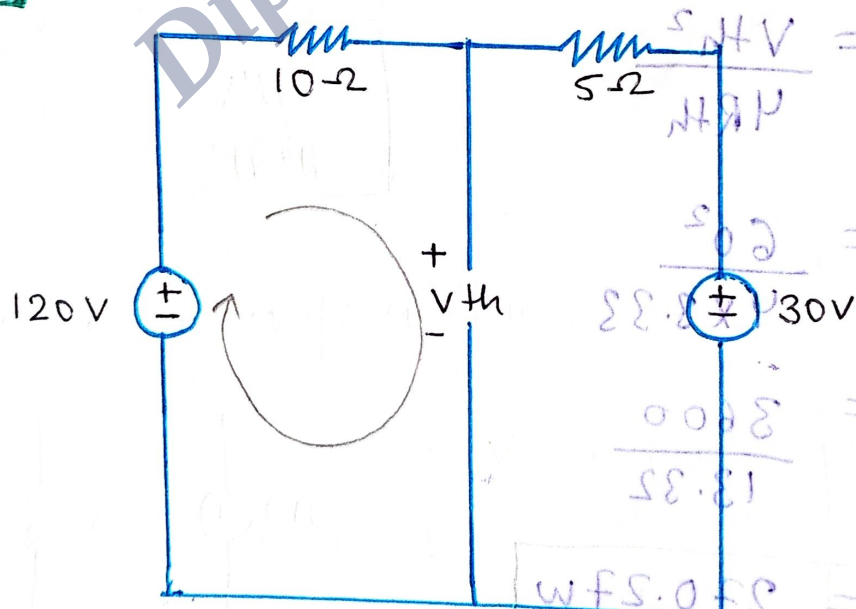
$$R_{th} = \frac{10 \times 5}{10+5}$$

$$= \frac{50}{15}$$

$$= \frac{10}{13}$$

$$\boxed{R_{th} = 3.33}$$

Step : 3



$$-120 + 10I + 5I + 30 = 0$$

$$-120 + 15I + 30 = 0$$

$$-90 + 15I = 0$$

$$I = \frac{9\cancel{0}}{\cancel{1}5}$$

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

Step: 3

$$-120 + 10 \times 6 + V_{th} = 0$$

$$-120 + 60 + V_{th} = 0$$

$$\boxed{V_{th} = 60}$$

Step: 4

$$P_{max} = \frac{V_{th}^2}{4R_{th}}$$

$$= \frac{60^2}{4 \times 3.33}$$

$$= \frac{3600}{13.32}$$

$$\boxed{P_{max} = 270.27 w}$$