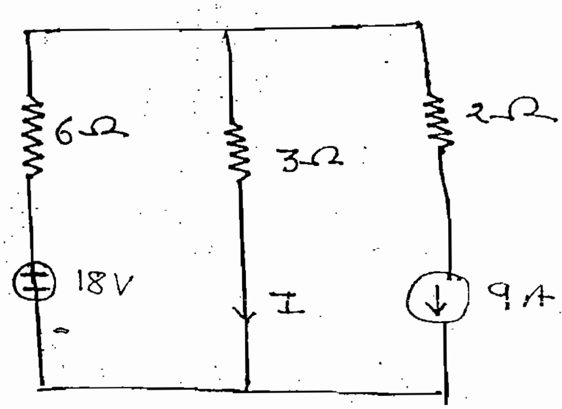
THEOREMS :—

When the N/w is having more no. of nodes and more no. of meshes, the response in any one of the branches can be easily obtained by using theorem

Superposition theorem:—

In any linear bidirectional circuit having more than one independent source the response in any of the branches is equal to algebraic sum of the responses caused by individual sources while rest of the sources are replaced by its internal resistances

Ques:— Find the value of I by using superposition theorem

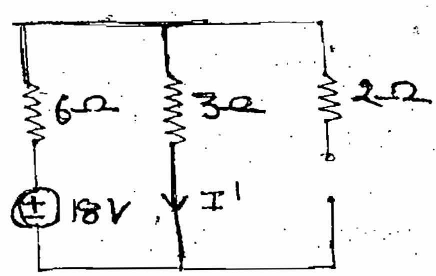


Soln:— Case-(I):—

Due to 18V

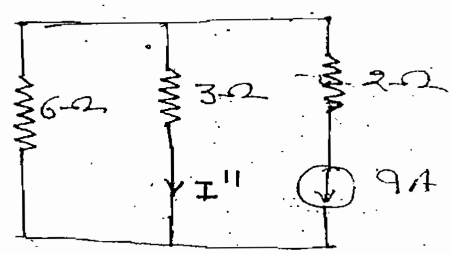
$I' = \frac{18}{6+3}$

$= 2A$



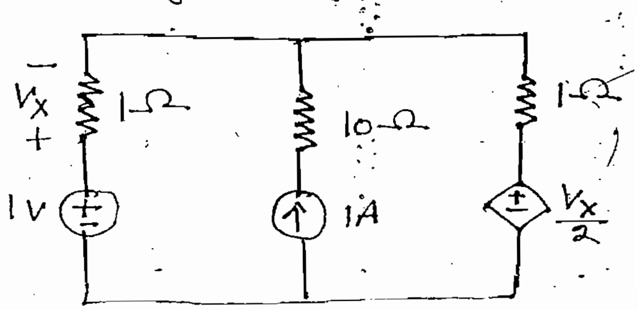
Case-(II):—

$I'' = -9\,\frac{6}{6+3} = -6$



$I = I' + I'' = 2-6 = -4$, Ans.

Ques:— Find V_x by using superposition theorem

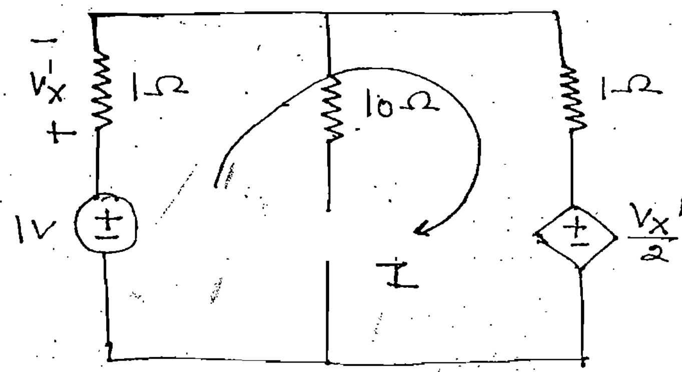


Note:-

In the above circuit while applying superposition theorem dependent sources neither replaced by open circuit nor S.C $ it remains as original ckt.

Soln:- Case-(I):-

$$I = \frac{1 - \frac{V_x'}{2}}{1+1}$$



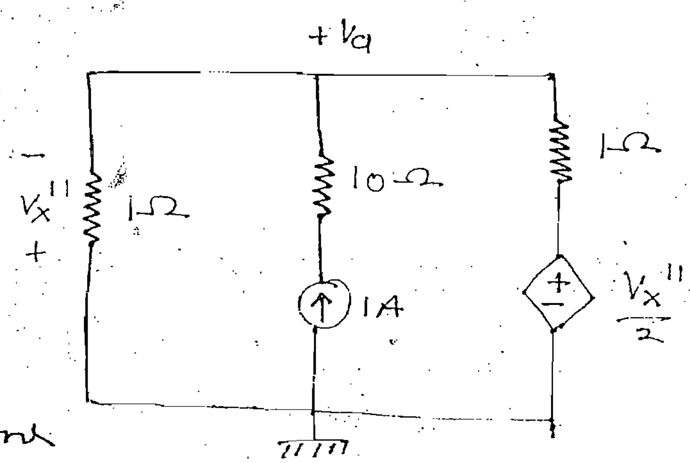
$$V_x' = 1 \times I = I$$

$$V_x' = \frac{2}{5}$$

Case-(II):-

$$V_a = -V_x''$$

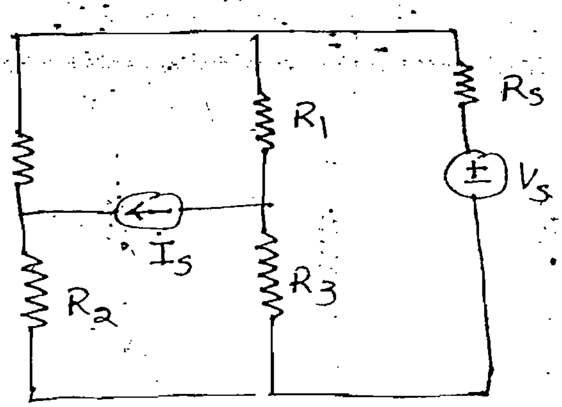
$$\frac{V_a}{1} + \frac{V_a - \frac{V_x''}{2}}{1} = 1$$



$$V_x'' = -\frac{2}{5}$$

$$V_x = V_x' + V_x'' = 0, \text{ Ans}$$

Ques:- In the circuit shown power dissipation in 1Ω resistor is 576 W when voltage source is acting along and power dissipation in 1Ω is resistor is 1W when current source is acting along. Find total power dissipation in 1 ohm resistor



Soln:–

$I = \pm I' \pm I''$ ✓

$V = \pm V' \pm V''$ ✓

$P = \pm P' \pm P''$ ✗

$P = I^2 R$ $\qquad P' = I'^2 R$

$I' = \sqrt{\frac{P'}{R}}$

$I'' = \sqrt{\frac{P''}{R}}$

$I = \pm I' \pm I''$

$\Rightarrow I = \pm \sqrt{\frac{P'}{R}} \pm \sqrt{\frac{P''}{R}}$

$P = I^2 R$

$\Rightarrow P = \left(\pm \sqrt{\frac{P'}{R}} \pm \sqrt{\frac{P''}{R}} \right)^2 R$

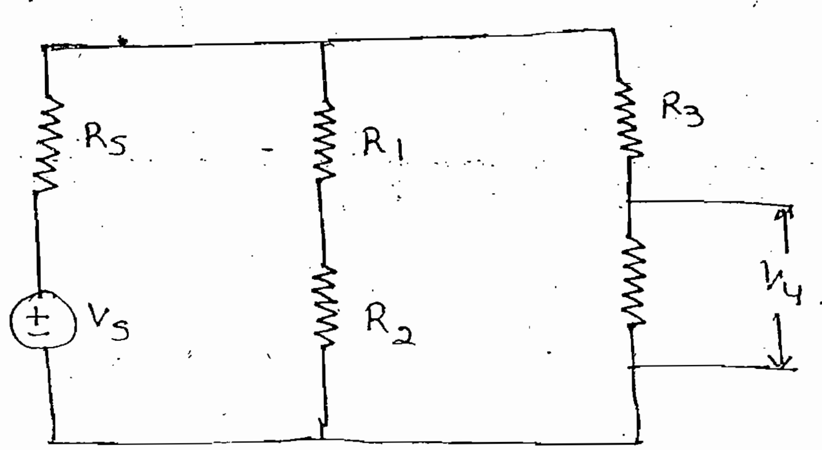
** $\Rightarrow \boxed{P = \left(\pm \sqrt{P'} \pm \sqrt{P''} \right)^2}$

$P = \left(+ \sqrt{P'} - \sqrt{P''} \right)^2$

$= \left(+ \sqrt{576} - \sqrt{1} \right)^2 = 529\,W$, Ans.

Ques:– In the circuit shown if the source voltage is increased by 10% then find variation of the power in the R_4 resistor

Soln:–



OL

Solⁿ:—

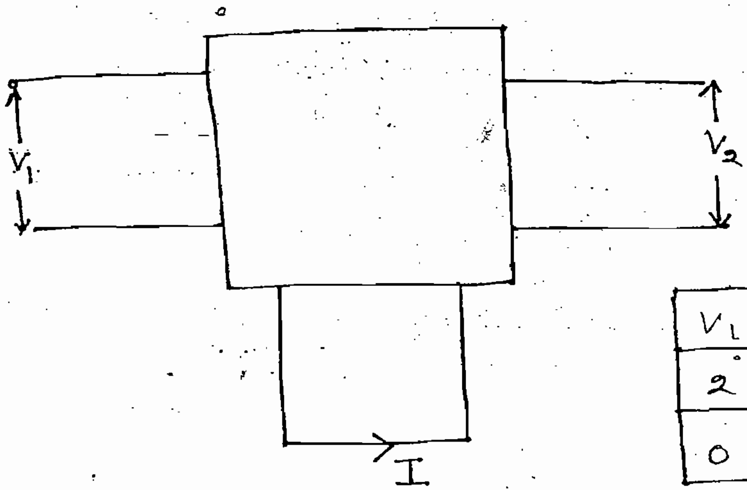
$$P_4 = \frac{V_4^2}{R_4}$$

$$P_4' = \frac{(1.1V_4)^2}{R_4} = 1.21\frac{V_4^2}{R_4} = 1.21 P_4$$

Inc by 21%

Note:—
When the N/w is having linear bidirectional element if excitation is particularly constant K the response of each element also multiplied by constant K (Homogenity Principle)

Ques:- In the circuit shown find I when $V_1 = 10V$ & $V_2 = -12V$



V_1	V_2	I
2	0	3A
0	3V	-4A

Solⁿ:- $V_1 = 2$ $I = 3A$

$V_1 = 10$ then $I' = 5\times3 = 15A$
(2×5)
5times ↑

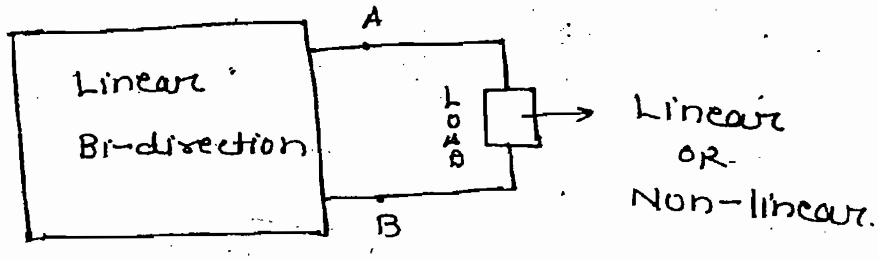
$V_2 = 3V$ $I = -4$

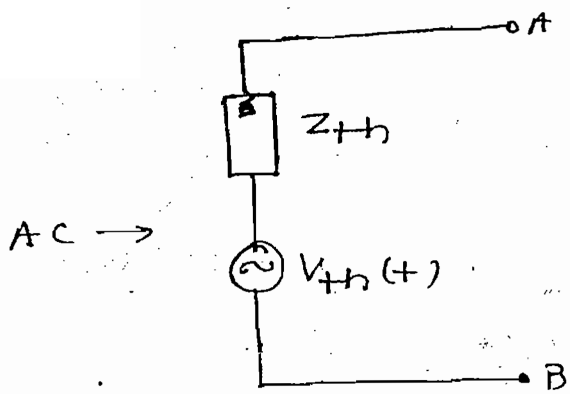
$V_2 = -12V$ then $I'' = (-4)(-4)$
(-4×3) $= 16$

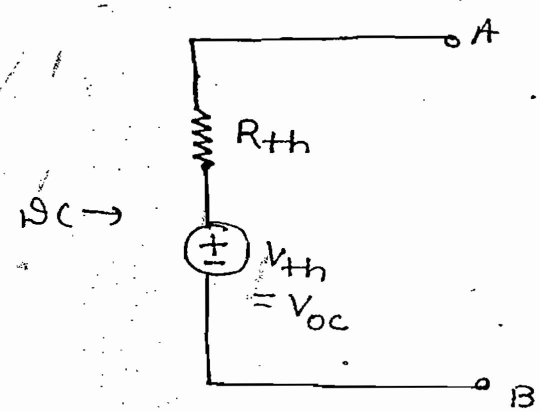
$I = I' + I''$

$I = 15+16 = 31A$, Ans

Thevenins Theorem :-

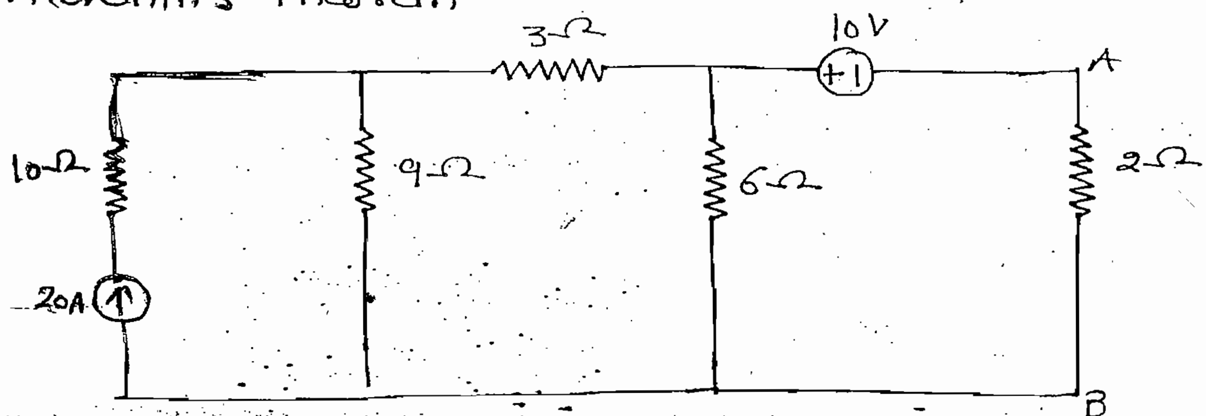






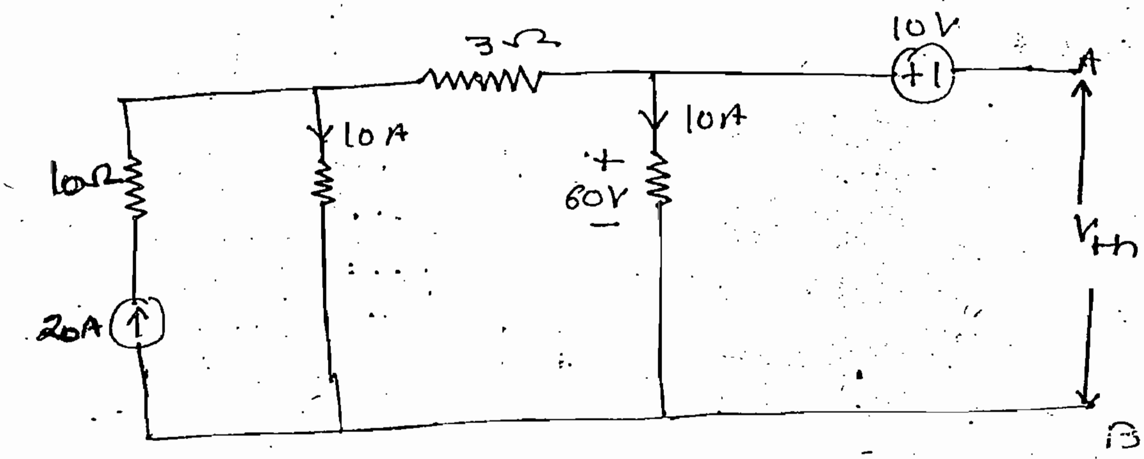
When N/w is having linear bidirectional elements and more no. of active and passive elements, it can be replaced by single equivalent circuit consisting of equivalent voltage source (V_{th}) in series with equivalent resistance (R_{th})

ques:- Find current in the 2Ω resistor by using thevenin's theorem



soln:- Case-(1) → (V_{th}) :-

Disconnect the load resistor and o.c voltage across the load terminals

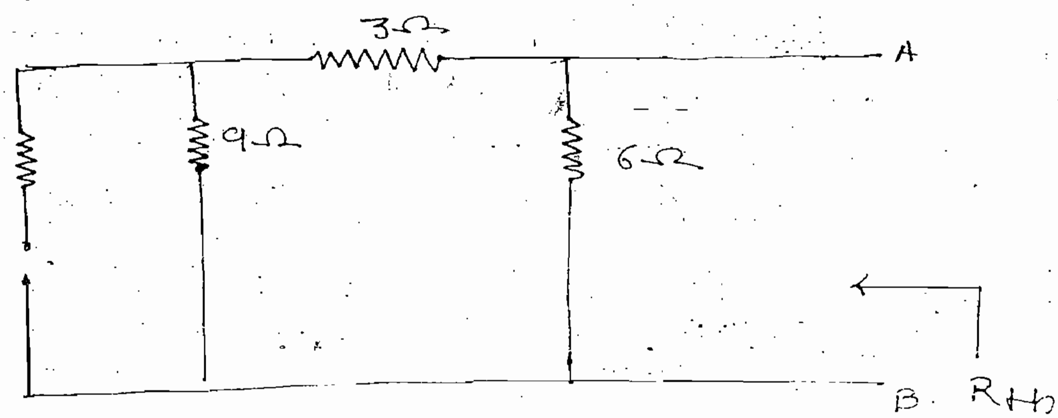


$$-60 + 10 + V_{th} = 0$$

$$\Rightarrow \quad V_{th} = 50V$$

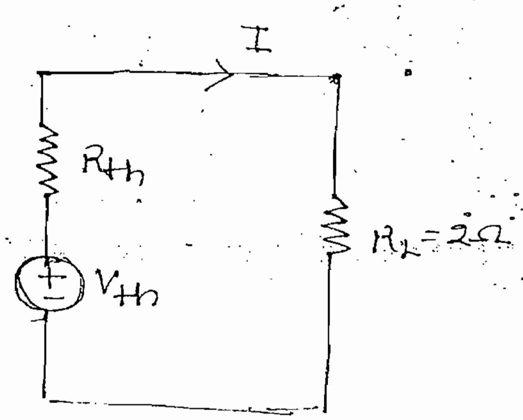
Case-(II) $\rightarrow$ (R_{th}) :-

Deactivate all the independent sources and find eq. resistance w.r.t. load terminals



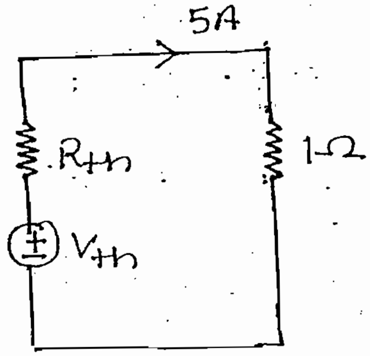
$$R_{th} = \frac{12 \times 6}{12+6} = 4\Omega$$

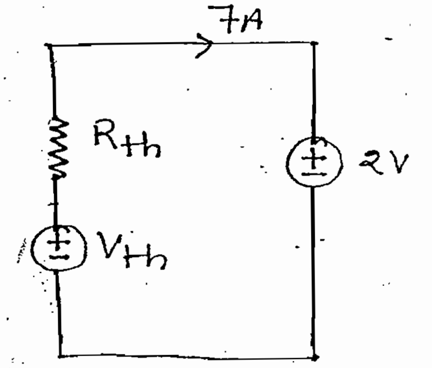
$$I = \frac{V_{th}}{R_{th} + R_L}$$



Ques:- When a battery charger connected to 1Ω resistor, current in the resistor is 5A. When same battery charger is connected for charging of ideal 2V battery at 7A rate. Find V_{th} & R_{th}

Soln:-



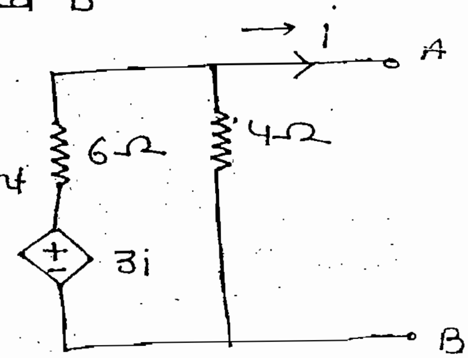


$$5 = \frac{V_{th}}{R_{th}+1} \quad -(I)$$

$$7 = \frac{V_{th}-2}{R_{th}} \quad -(II)$$

$\Rightarrow V_{th} = 12.5$ and $R_{th} = 1.5$

Ques:- Find V_{th} w.r.t A and B



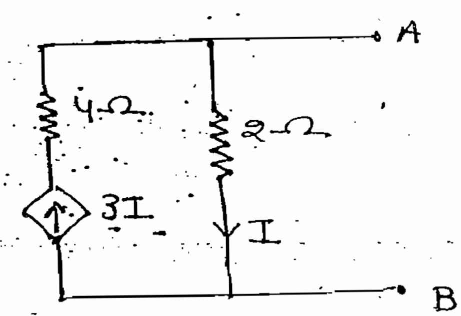
Note:-

In above N/w no independent source is present. Therefore $V_{th} = 0$

Ques:- Find V_{th} w.r.t A and B.

(a) 0 (b) 4 (c) 6

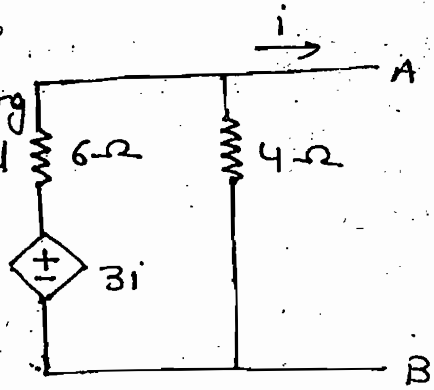
(d) None



Note:-

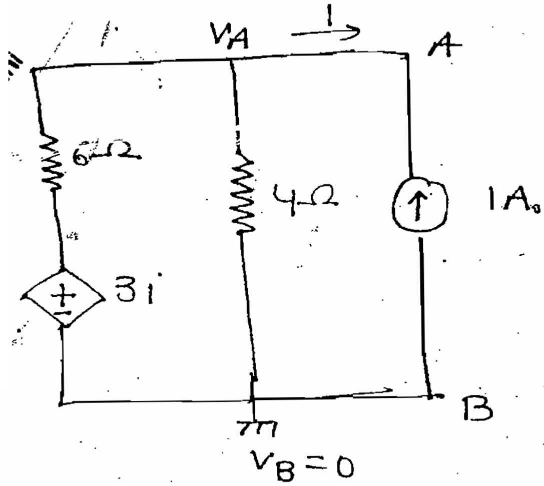
In the above ckt, it is not possible to find O.C voltage since it is not satisfying KCL

Ques:- Find R_{th} w.r.t A and B



Note:-
In above N/w while finding R_{th} dependent source is replaced by neither OC nor short ckt and it remains same as original ckt.

Soln:-



$$\frac{V_A - 3i}{6} + \frac{V_A}{4} = 1$$

$\Rightarrow \quad i = -1$

$V_A = 1.2$

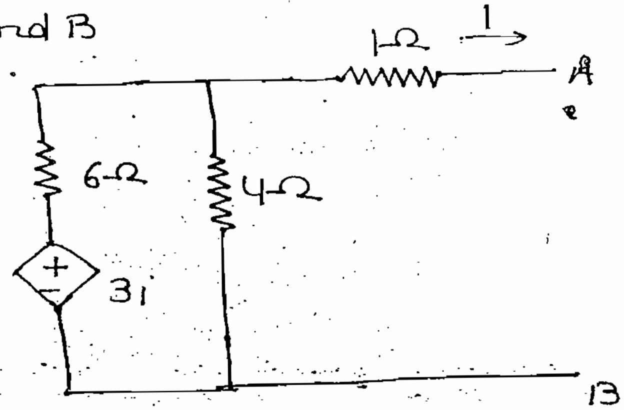
$V_{AB} = V_A - V_B$

$= 1.2 - 0 = 1.2$

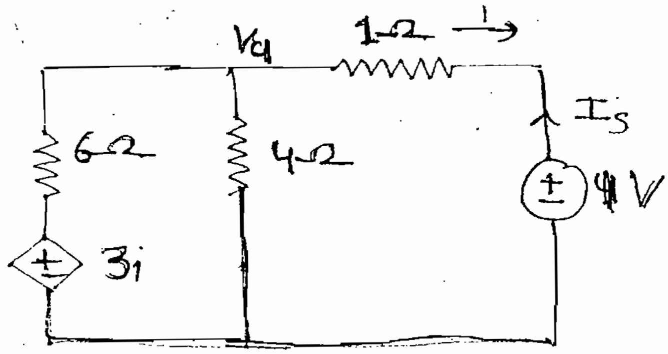
$$R_{th} = \frac{V_{AB}}{I_s} = \frac{1.2}{1} = 1.2\,\Omega \text{, Ans}$$

In parallel consider current source for simple calculation.

Ques:- Find R_{th} w.r.t A and B



Soln:- In series consider voltage source



$$\frac{V_1 - 3i}{6} + \frac{V_1}{4} + \frac{V_1 - 1}{1} = 0$$

$$i = \frac{V_1 - 1}{1} \Rightarrow \cancel{V_1 = \frac{6}{11}}$$

$$= -\frac{5}{11}$$

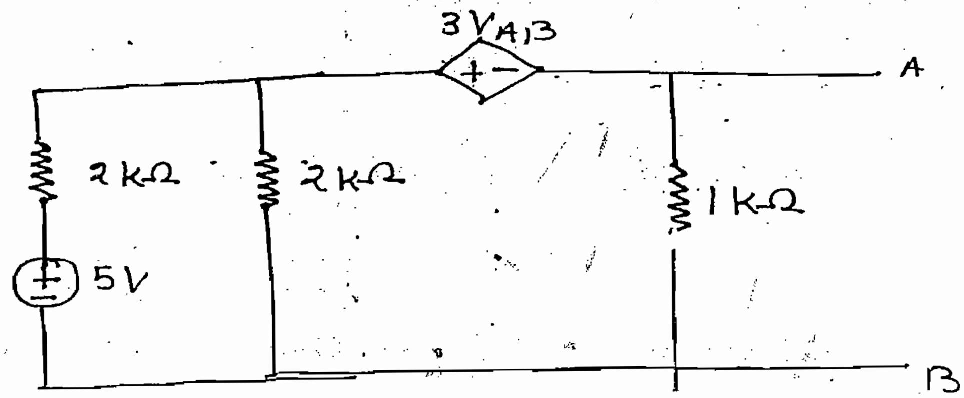
& $V_1 = \dfrac{6}{11}$

$$I_s = -i = -\left(-\frac{5}{11}\right) = \frac{5}{11}$$

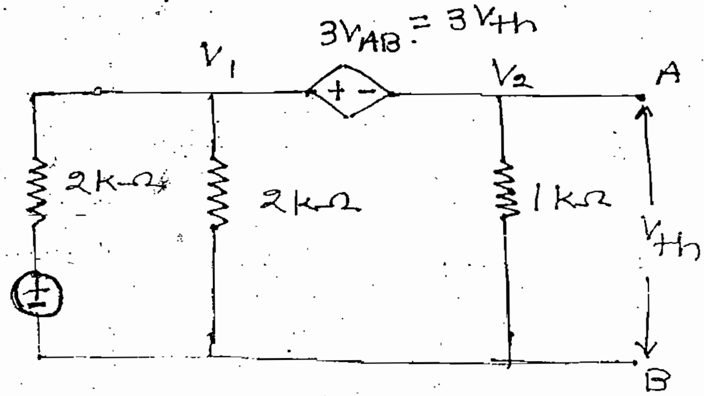
$$R_{th} = \frac{V_s}{I_s} = \frac{1}{5/11} = \frac{11}{5}\,\Omega \quad \text{, Ans}$$

$$= 2.2\,\Omega \quad \text{, Ans.}$$

Ques:- Find V_{th} and R_{th} w.r.t A and B



Soln:- Case-(I) :-



$$\frac{V_1 - 5}{2\times10^3} + \frac{V_1}{2\times10^3} + \frac{V_2}{1\times10^3} = 0 \quad \text{---(I)}$$

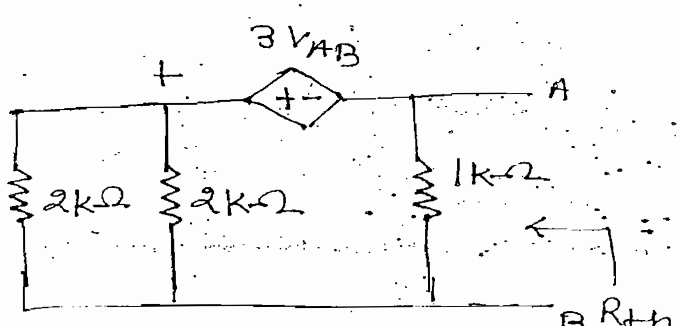
$$V_1 - V_2 = 3V_{th} \quad \text{---(II)}$$

$$V_2 = V_{th}$$

$$V_1 = 4\,V_{th}$$

$$V_{th} = 0.5\,V$$

Case-(II) :- For R_{th}



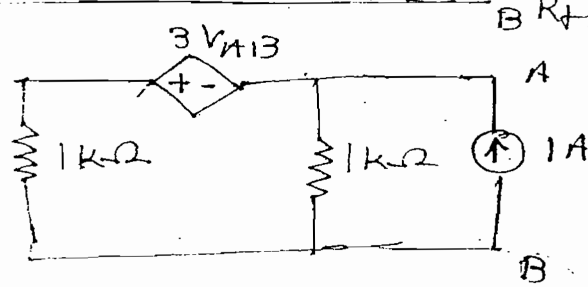
$$\frac{V_A + 3V_{AB}}{10^3} + \frac{V_A}{1\times10^3} = 1$$

$$V_{AB} = V_A - V_B = V_A$$

$$V_{AB} = 200$$

$$R_{th} = \frac{V_{AB}}{I_s} = \frac{200}{1} = 200\,\Omega$$

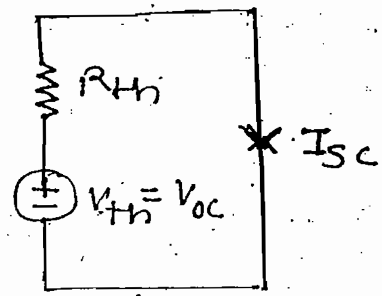
And



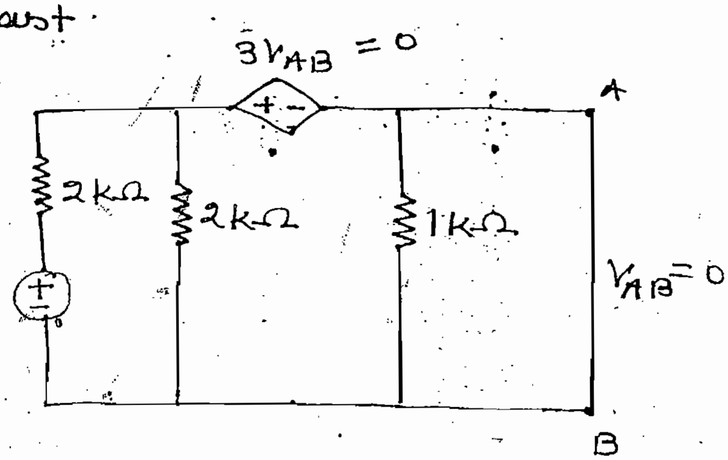
Verification:-

$$I_{sc} = \frac{V_{oc}}{R_{th}}$$

$$R_{th} = \frac{V_{oc}}{I_{sc}}$$



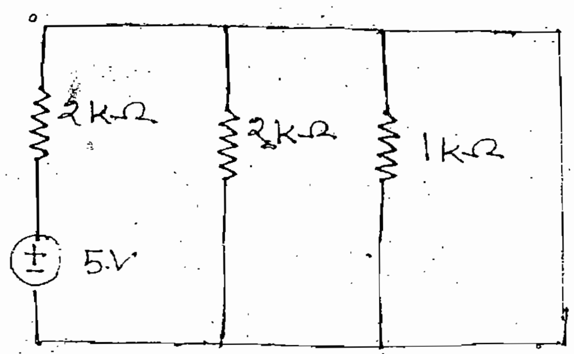
For this method atleast one independent source should be present



$$I_{sc} = \frac{5}{2\times10^3}$$

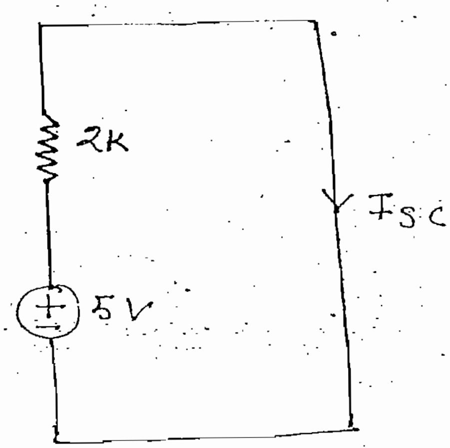
$$R_{th} = \frac{V_{oc}}{I_{sc}} = \frac{0.5}{5/2\times10^3}$$

$$= 200\Omega$$

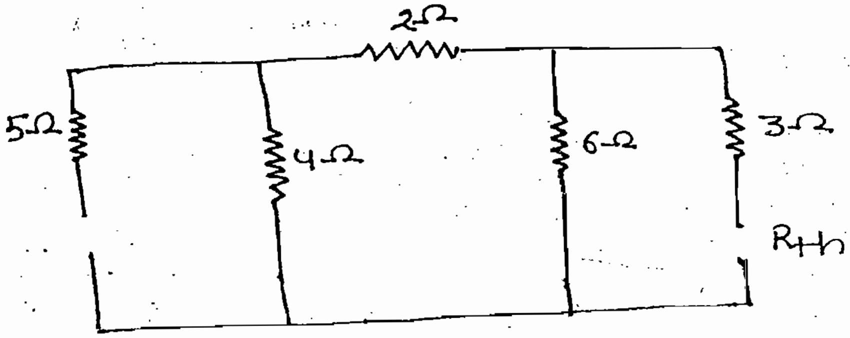


Note:-

The above method of R_{th} calculation can be done provided original N/w should consist of atleast one independent source.



Case - 2 (R_{th}):-

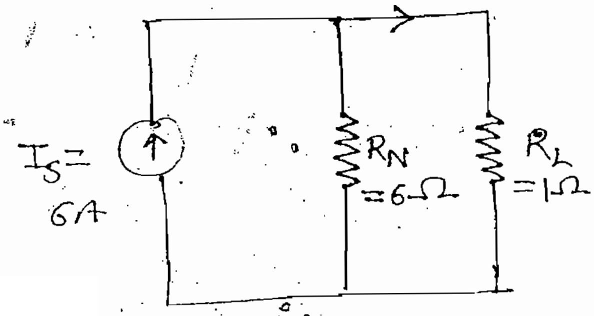


$R_{th} = R_N$

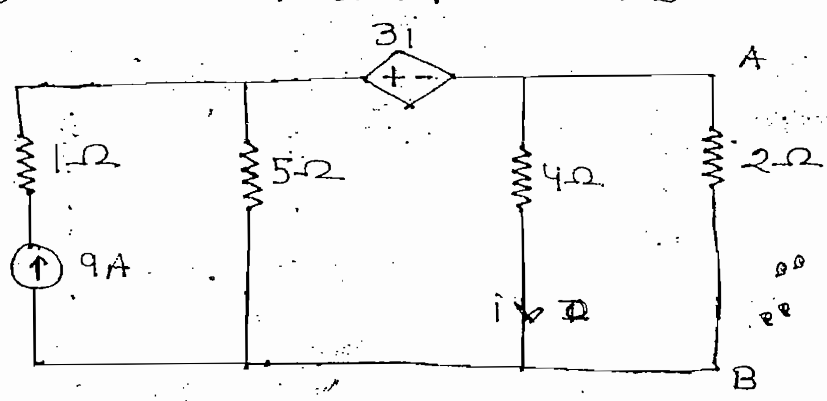
$$R_{th} = R_N = 6\Omega$$

$$I_L = 6 \times \frac{6}{6+1}$$

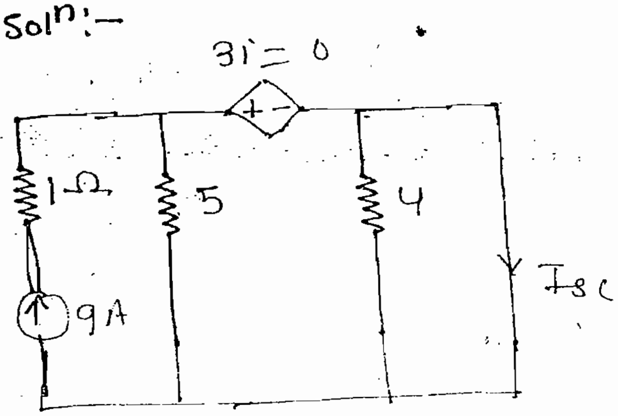
$$= \frac{36}{7} \text{ A} \quad \text{, Ans}$$



Ques:- Find s.c current w.r.t A and B



Soln:-



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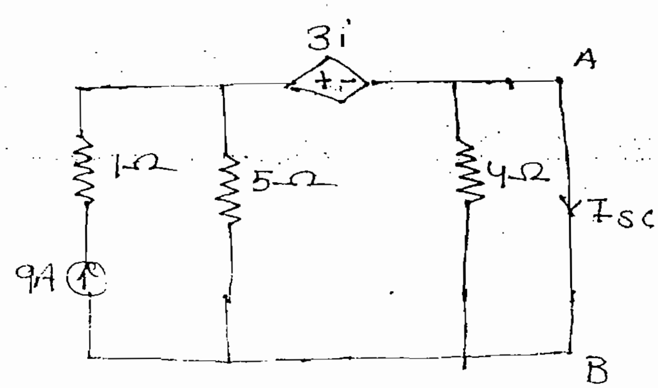
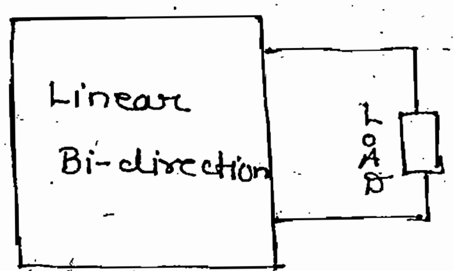
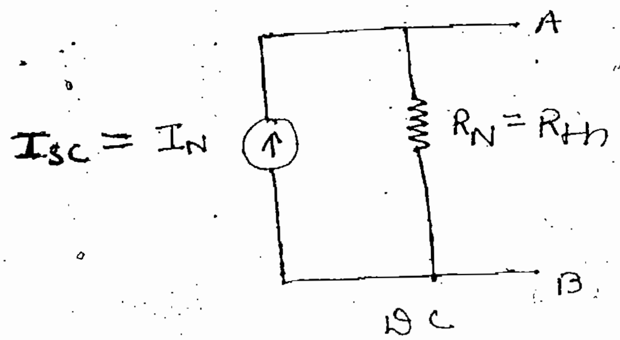


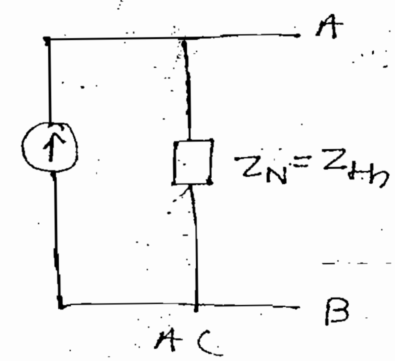
Lecture-7

Norton's theorem:-

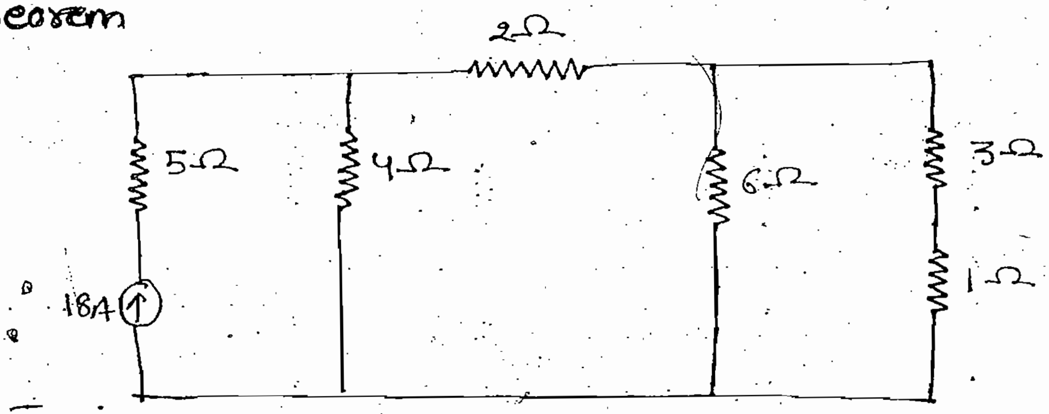
In any linear bidirection circuit having more no. of active and passive element, it can be replaced by single equivalent ckt consisting of equivalent current source (I_N) in parallel with equivalent resistance (R_N)







Ques:- Find current in 1Ω resistor using Norton's theorem



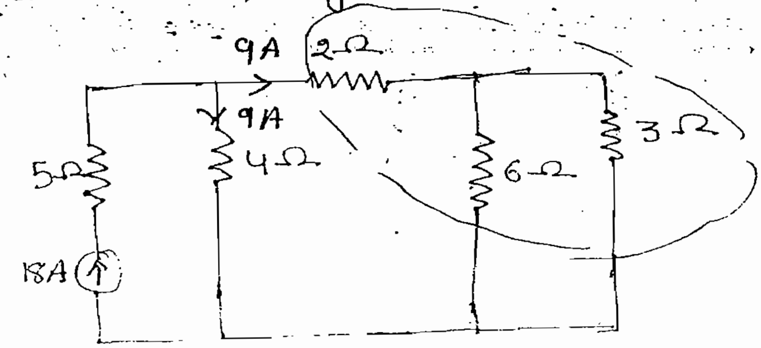
Soln:-

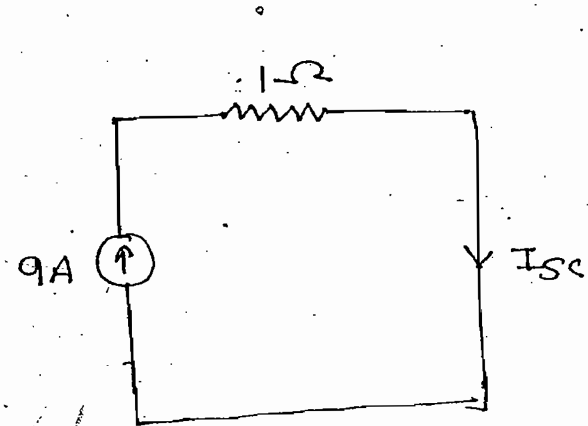
Case-(1):-

Replace the load resistor by S.C and find SC current

$$I_{SC} = 9 \times \frac{6}{6+3}$$

$$= 6A$$



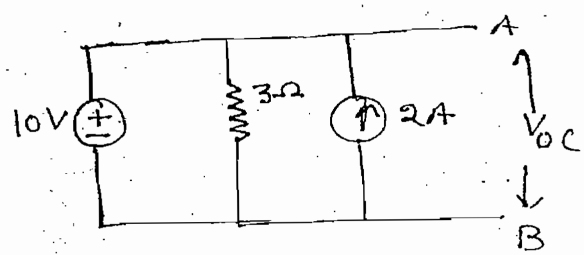


$I_{sc} = 9A$, Ans.

Ques:- Find O.C voltage and SC current w.r.t A & B

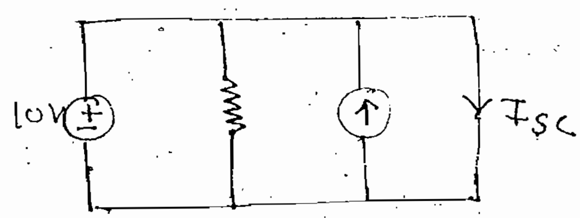
Soln:-

$V_{oc} = 10V$



For I_{sc}:-

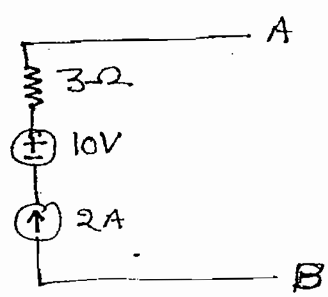
I_{sc} = not possible



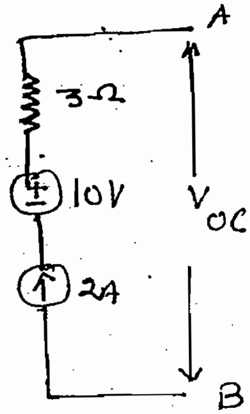
Note:-

In the above circuit it is not possible to find I_{sc} since it is not satisfying KVL

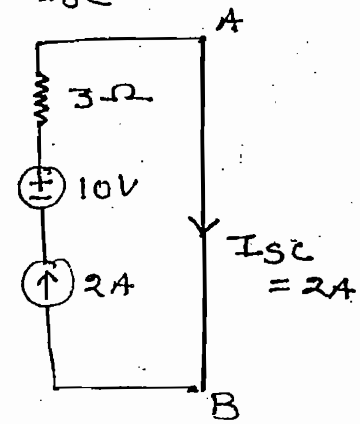
Ques:- Find V_{oc} and I_{sc} w.r.t A and B



V_{oc}:



I_{sc}

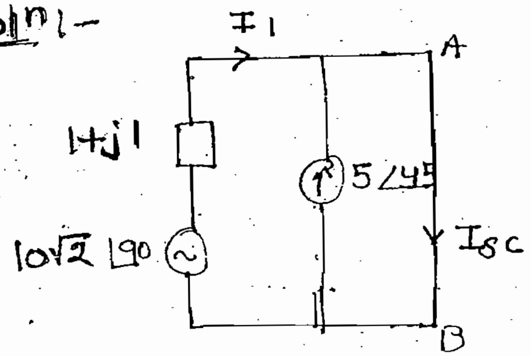


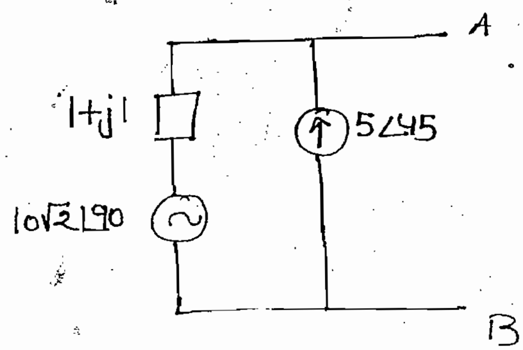
Note:-

In above circuit it is not possible to find o.c voltage since it is not satisfying KCL

Ques:- Find I_{sc} w.r.t A and B

Soln:-





$$I_1 = \frac{10\sqrt{2}\angle 90}{\sqrt{2}\angle 45} = 10\angle 45$$

$$I_1 + 5\angle 45 = I_{sc}$$

$$10\angle 45 + 5\angle 45 = I_{sc}$$

$$\Rightarrow \quad I_{sc} = 15\angle 45^\circ$$

Ques:- Find current in 4Ω resistor using the following data:

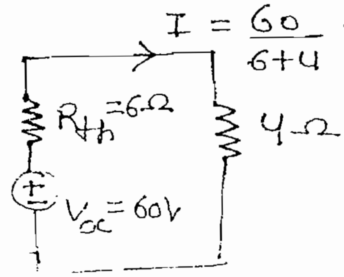
V	60	0
I	0	10A

Soln:- $V_{oc} = 60$

$I_{sc} = 10A$

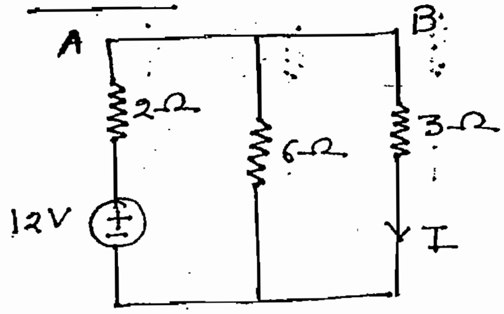
$$R_{th} = \frac{V_{oc}}{I_{sc}} = \frac{60}{10} = 6\Omega$$

$$I = \frac{60}{6+4} = 6A$$



Reciprocity theorem :-

Case-(i) :-



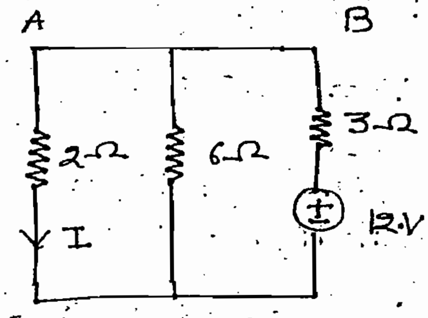
$$R_{eq} = 2 + \frac{6 \times 3}{6+3} = 4$$

$$I_T = \frac{12}{4} = 3A$$

$$I = 3 \frac{6}{6+3} = 2A$$

$$\frac{\text{Response}}{\text{Excitation}} = \frac{2}{12} = \frac{1}{6}$$

Case-(ii) :-



$$R_{eq} = 3 + \frac{6 \times 2}{6+2}$$

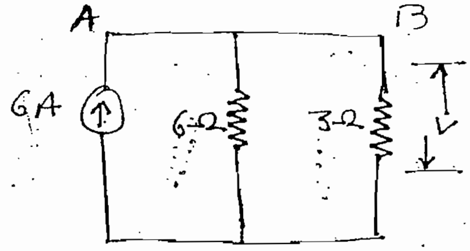
$$I_T' = \frac{12}{R_{eq}}$$

$$I = I_T' \frac{6}{6+2} = 2A$$

$$\frac{\text{Response}}{\text{Excitation}} = \frac{2}{12} = \frac{1}{6}$$

In above N/w after interchanging position of response and excitation the ratio of response to excitation is constant. Hence given N/w satisfy the reciprocity (Linear bi-directional element)

Ques:- Verify Reciprocity theorem of the circuit shown.

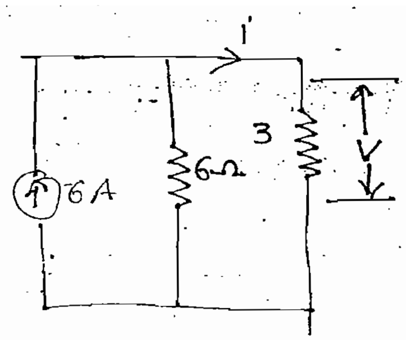


Soln:- Case-(i) :-

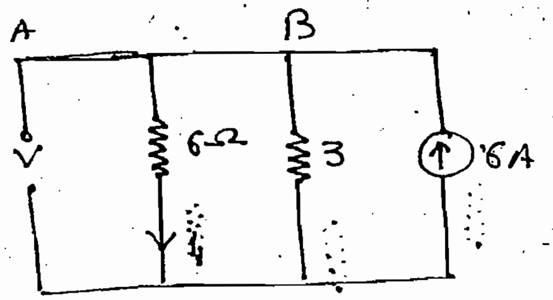
$$I' = 6 \times \frac{6}{6+3} = 4A$$

$$V = 3 \times 4 = 12$$

$$\frac{\text{Response}}{\text{Excitation}} = \frac{12}{6} = 2$$



Case-(II):-



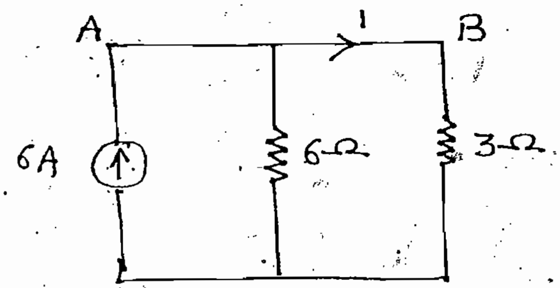
$i_1 = 6 \frac{3}{3+6} = 2A$

$V = 6 \times 2 = 12$

$\frac{\text{Response}}{\text{Excitation}} = \frac{12}{6} = 2$

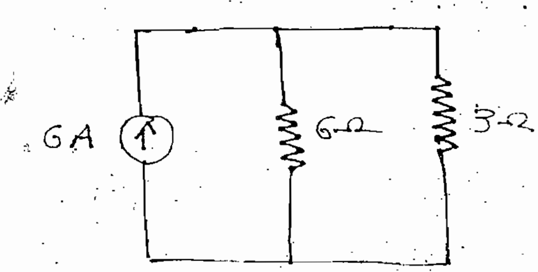
$\longrightarrow$ satisfy Reciprocity

Ques:- Verify Reciprocity theorem of the ckt shown:-



Soln:-

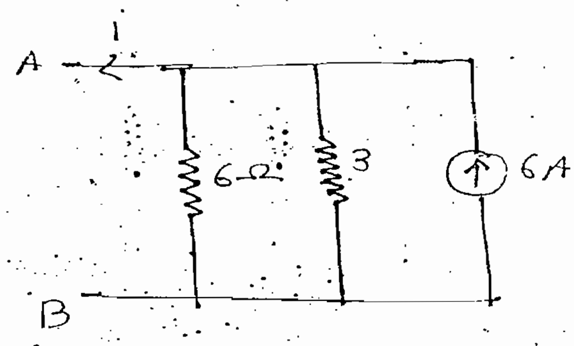
Case-(I)



$i = 6 \frac{6}{6+3} = 4A$

Case-(II)

$i = 0$



Note:- For above problem

(I) $\frac{\text{Response}}{\text{Excitation}} = \frac{I}{V_s} = \text{mho}$

(II) $\frac{\text{Response}}{\text{Excitation}} = \frac{V}{I_s} \longrightarrow \Omega$

(III) $\frac{\text{Response}}{\text{Excitation}} = i/I_s$

(IV) $\frac{\text{Response}}{\text{Excitation}} = \frac{V}{V_s}$

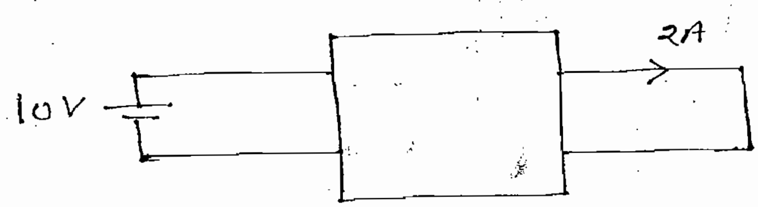
No units

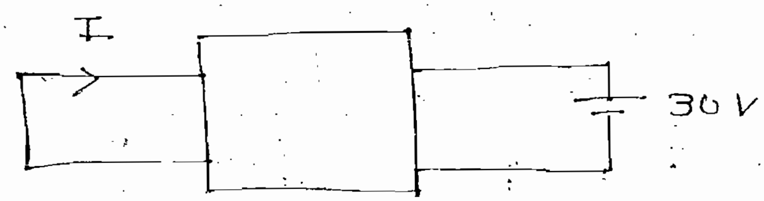
Note:-
For the above N/ω Reciprocity theorem can't be applied since unit of response to excitation should be neither mho or Ω

Note:-

1. To apply Reciprocity theorem unit of Res/Exc. should be either mho or ohm
2. While applying reciprocity theorem N/ω should consist of only one independent source
3. While applying reciprocity theorem N/ω should not consist of any dependent sources

Ques:- When given N/ω satisfy the Reciprocity then find the value of I

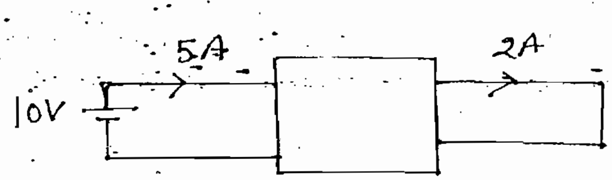


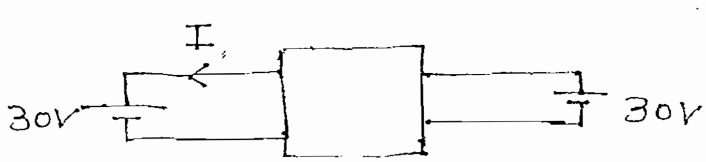


Soln:-

$$\frac{\text{Response}}{\text{Excitation}} = \frac{2}{10} = \frac{-I}{30} \Rightarrow I = -6A$$

Ques:- When given N/ω satisfy the Reciprocity then find the value of I



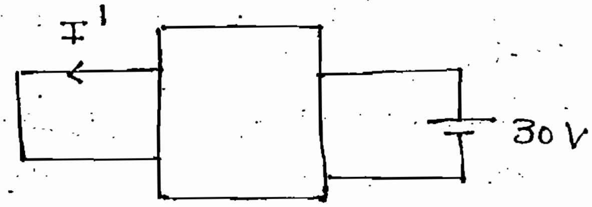


Sol^n:- Sol^n by using superposition & Reciprocity
($\because$ more than one independent sources are present)

Case-(I) (30V) :-

$$\frac{\text{Response}}{\text{Excitation}} = \frac{I'}{30} = \frac{2}{10}$$

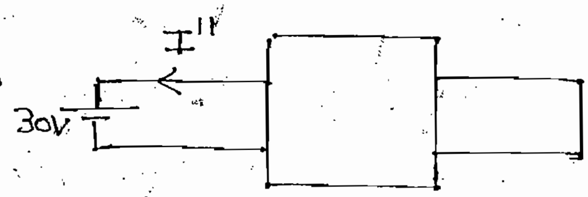
$$\Rightarrow I' = 6A$$



Case-(II) (30V) :-

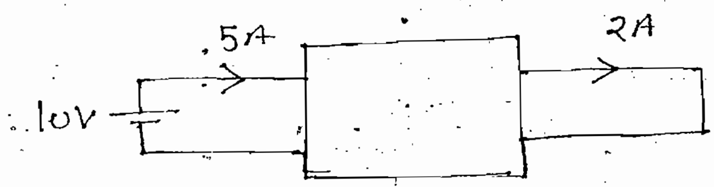
$$\frac{\text{Response}}{\text{Excitation}} = \frac{-I''}{30} = \frac{5}{10}$$

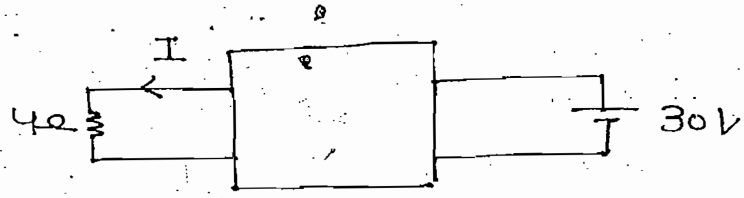
$$\Rightarrow I'' = -15$$



$$I = I' + I'' = 6 - 15 = -9A$$

Ques:- When given N/w satisfy the Reciprocity find the value of I

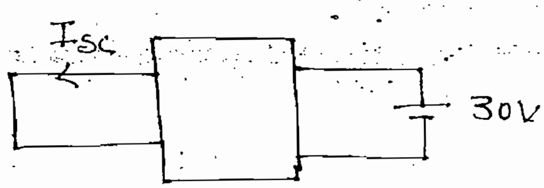




Sol^n:- Case-(I) (I_{sc}) :- (Norton's theorem)

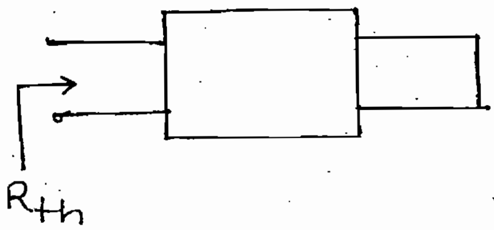
$$\frac{\text{Response}}{\text{Excitation}} = \frac{I_{sc}}{30} = \frac{2}{10}$$

$$I_{sc} = 6\ A$$

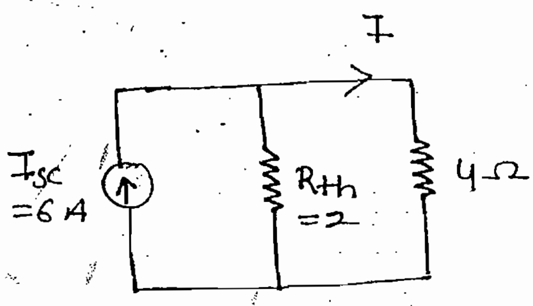


Case 2 (R_{th}) :-

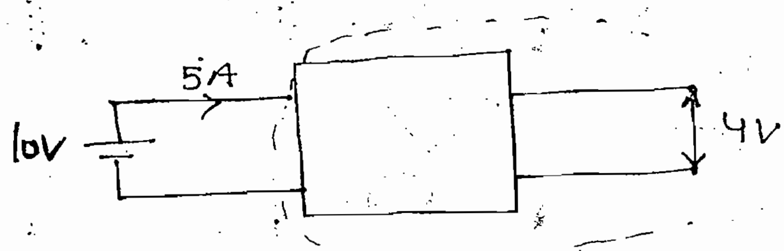
$$R_{th} = \frac{10}{5} = 2\Omega$$

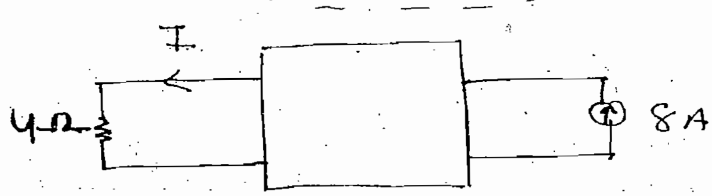


$$I = 6 \times \frac{2}{2+4} = 2A$$



Ques:- When given N/w satisfy the Reciprocity Find the value of I :

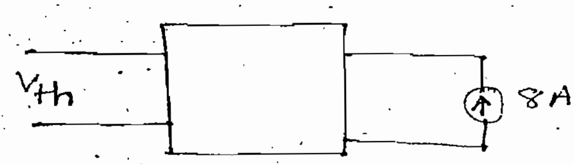




Sol(n):- Case (1) (V_{th}) :-

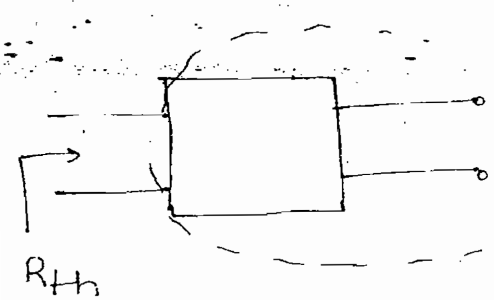
$$\frac{\text{Response}}{\text{Excitation}} = \frac{V_{th}}{8} = \frac{4}{5}$$

$$\Rightarrow V_{th} = \frac{32}{5}$$

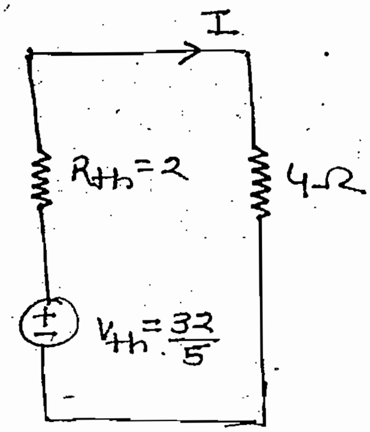


Case (II) (R_{th}) :-

$$R_{th} = \frac{10}{5} = 2\Omega$$



$$I = \frac{32/5}{2+4} = \frac{\overset{16}{\cancel{32}}}{5} \times \frac{1}{\underset{3}{\cancel{6}}} = \frac{16}{15} A$$



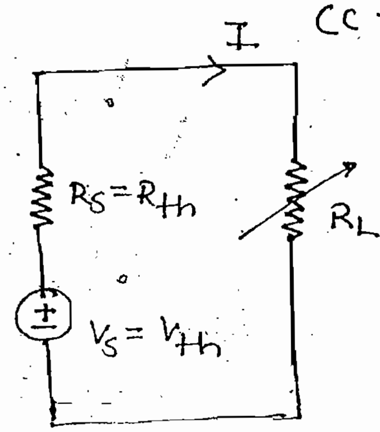
Maximum Power Transfer theorem :— ✓(variable = constant)

(C = V) X

$$I = \frac{V_S}{R_S + R_L}$$

$$P_L = I^2 R_L$$

$$\Rightarrow P_L = \left(\frac{V_S}{R_S + R_L}\right)^2 R_L \quad \text{—— (1)}$$



Diff eq—(1) w.r.t 'R_L' and equated to zero, we get

$$R_L = R_S$$

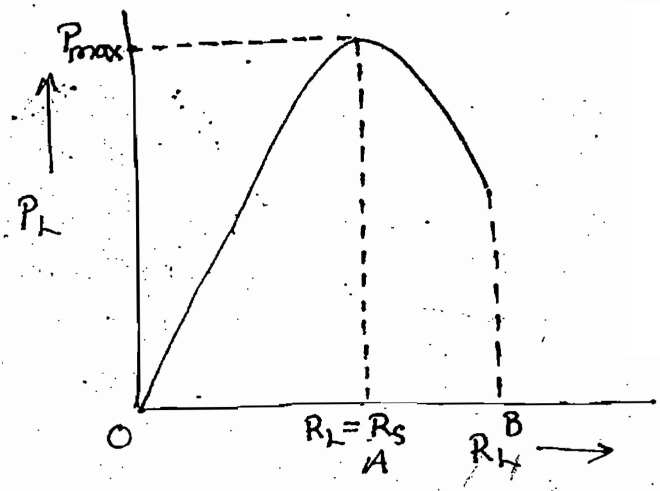
$$P_{max} = \frac{V_S^2}{(R_L + R_L)^2} R_L$$

$$\Rightarrow \boxed{P_{max} = \frac{V_S^2}{4R_L}}$$

$$\eta = \frac{o/p}{i/p} \times 100$$

$$\eta = \frac{I^2 R_L}{I^2 (R_L + R_S)} \times 100 \Rightarrow \eta = \frac{R_L}{R_L + R_L} \times 100$$

$$\Rightarrow \boxed{\eta = 50\%}$$



Case – (I) :–

OA $\Rightarrow$ $R_S > R_L$

$\boxed{\eta < 50\%}$

Case – (II) :–

At point A $\Rightarrow$ ~~R_S~~ $R_L = R_S$

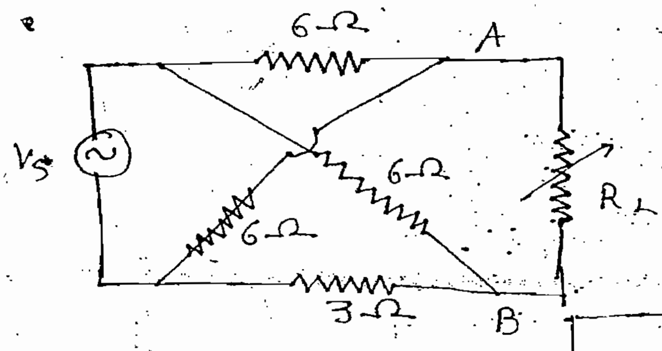
$\boxed{\eta = 50\%}$

Case – (III) :–

AB $\Rightarrow$ $R_L > R_S$

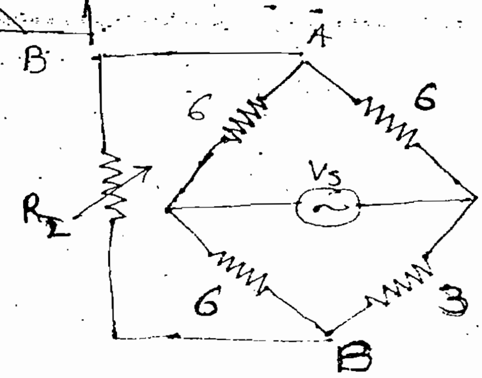
$\boxed{\eta > 50\%}$

Ques :– Find R_L to obtain max. power from source to load

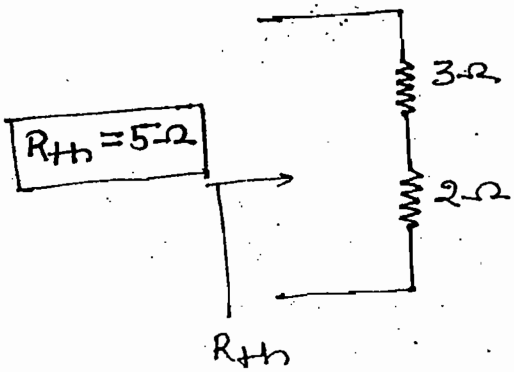


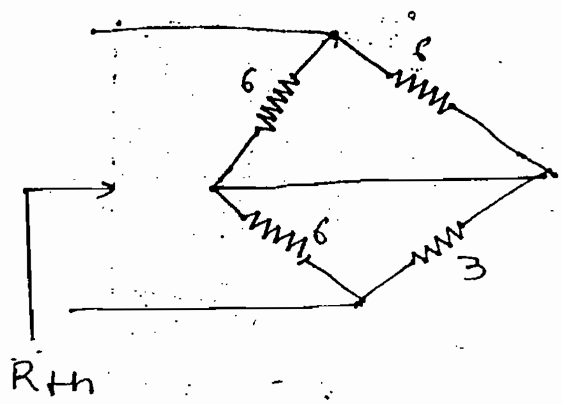
Soln :–

$\Rightarrow$



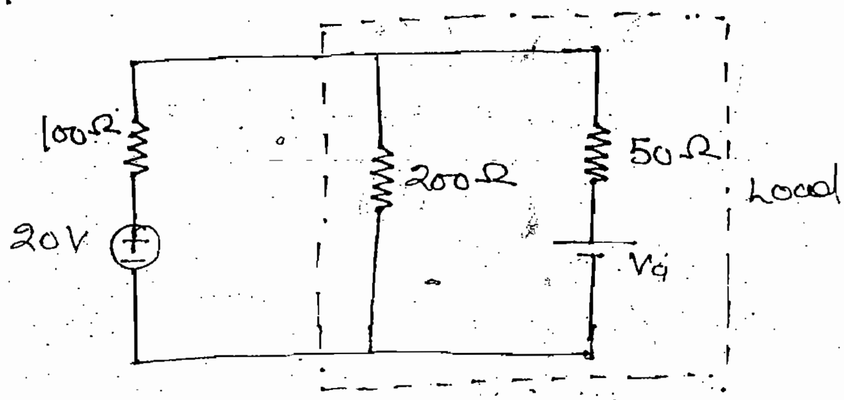
R_{th} :-



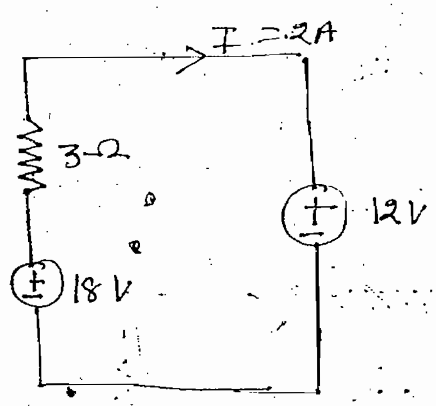


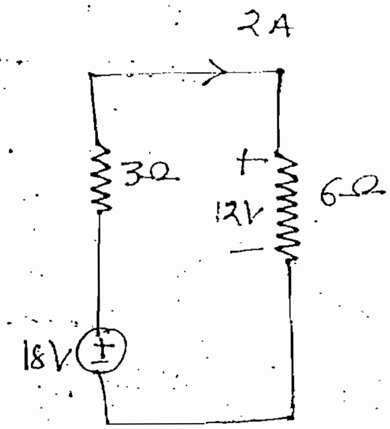
$$\boxed{R_L = R_{th} = 5\Omega}$$

Ques :- Find V_a to obtain max. power from source to load.



Note :-



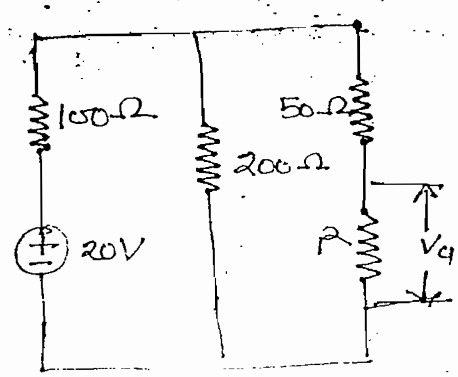


Soln :- $(R_{eq})_L = R_s = 100$

$$(R_{eq})_L = \frac{200\,(50+R)}{200+50+R}$$

$$\Rightarrow \quad 100 = \frac{200\,(50+R)}{250+R}$$

$$\Rightarrow \quad \boxed{R = 150\Omega}$$

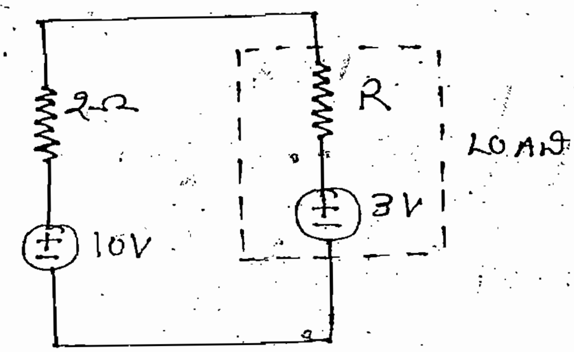


$$I_T = \frac{20}{R_S + (R_{eq.})_L}$$

$$I_T = \frac{20}{100+100} = \frac{1}{10} A$$

$$V_a = \frac{I_T}{2} R = 7.5 \text{ volts}, \text{ Ans}$$

Ques:- Find resistance R to obtain maximum power from source to load



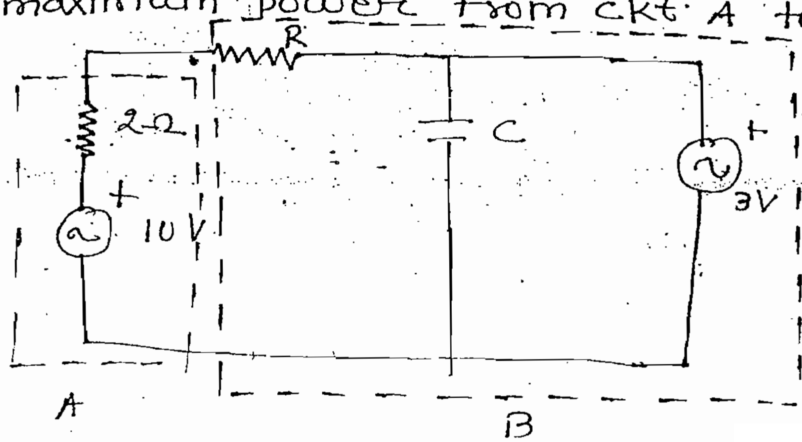
Soln:- $(R_{eq.})_L = R_S = 2\Omega$

$$I_T = \frac{10}{R_S + (R_{eq.})_L}$$

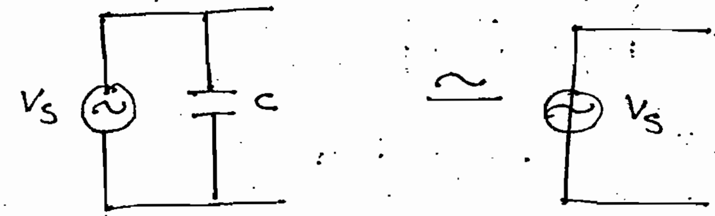
$$I_T = \frac{10}{2+2} = 2.5A$$

$$I_T = \frac{10-3}{2+R} = 2.5 \Rightarrow \boxed{R = 0.8\Omega} \text{ Ans}$$

Ques:- In the figure shown find resistance R to obtain maximum power from ckt. A to ckt. B

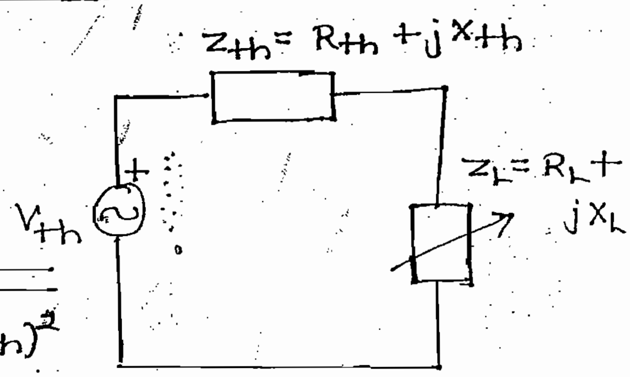


Note:-



Soln:- $R = 0.8\,\Omega$

Maximum Power Transfer theorem (For AC):-



$$i = \frac{V_{th}}{(R_L + R_{th}) + j(X_L + X_{th})}$$

$$i = \frac{V_{th}}{\sqrt{(R_L + R_{th})^2 + (X_L + X_{th})^2}}$$

$$P_L = i^2 R_L$$

$$P_L = \frac{V_{th}^2 R_L}{(R_L + R_{th})^2 + (X_L + X_{th})^2} \quad \text{—(1)}$$

→ Max Power transfer is applicable only for active power

Case (1):-

Both R_L & X_L are variable

(i) Diff. eq-(1) w.r.t R_L and equated to zero

(ii) Diff. eq-(ii) w.r.t X_L and equated to zero

we get

$$\boxed{\begin{aligned} R_L + jX_L &= R_{th} - jX_{th} \\ Z_L &= Z_{th}^* \end{aligned}}$$

Putting these values in eq-(1), we get

$$\boxed{\begin{aligned} P_{max} &= \frac{V_{th}^2}{4R_L} \\ \eta &= 50\% \end{aligned}}$$

Case (II) :—

Only R_L is variable $(X_L = \text{constant})$

→ Diff eq-(1) w.r.t R_L and equated to zero

$$R_L = |Z_{th} + jX_L| = |R_{th} + j(X_{th} + X_L)|$$

$$R_L = \sqrt{R_{th}^2 + (X_L + X_{th})^2}$$

$$\eta = \frac{R_L}{R_L + R_{th}} \times 100$$

$$\boxed{\eta \geq 50\%}$$

Case (III) :—

Load impedance is only resistive $(X_L = 0)$

$$P_L = \frac{V_{th}^2 R_L}{(R_L + R_{th})^2 + X_{th}^2} \quad \text{—(11)}$$

Diff eq-(11) w.r.t R_L and equated to zero, we g

$$R_L = \sqrt{R_{th}^2 + X_{th}^2}$$

$$R_L = |Z_{th}| \qquad R_L > R_{th}$$

$$\boxed{\eta > 50}$$

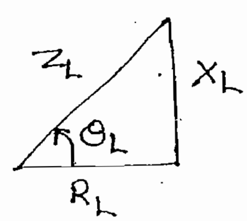
Case-(IV) :— Both R_L & X_L → Variable But load impedance angle → Cons-tant

$$Z_L = R_L + jX_L$$

load impedance angle $= \theta_L = \tan^{-1}\left(\frac{X_L}{R_L}\right) = \text{constant}$

$$R_L = Z_L \cos\theta_L$$

$$X_L = Z_L \sin\theta_L$$

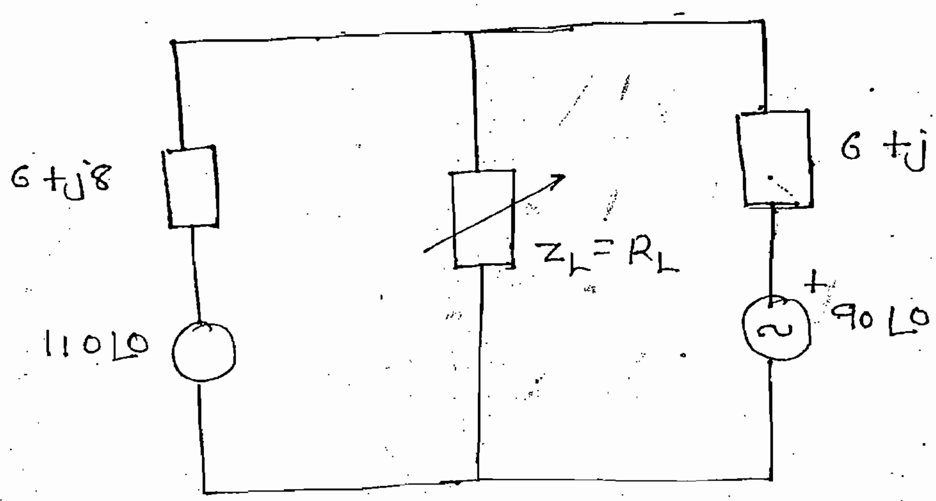


$$P_L = \frac{V_{th}^2 Z_L \cos\theta_L}{(Z_L\cos\theta_L + R_{th})^2 + (Z_L\sin\theta_L + X_{th})^2} \quad \text{--- (III)}$$

Diff. eq-(III) w.r.t Z_L and equated to zero, we get

$$\boxed{Z_L = Z_{th}}$$

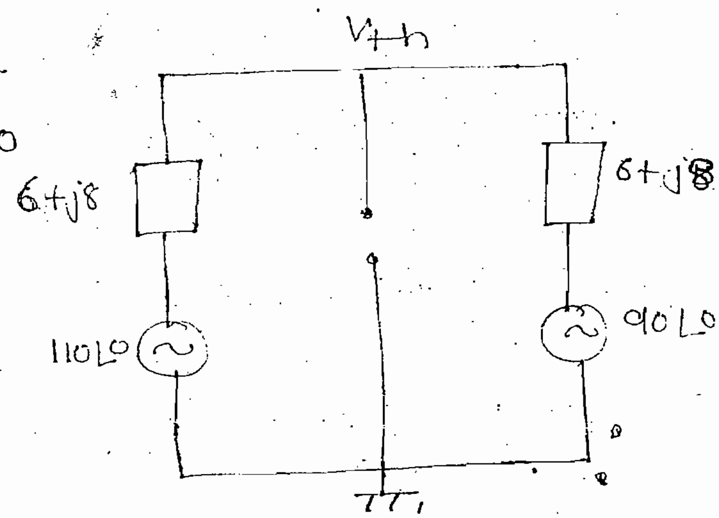
Ques:- Find max. power dissipation in load impedance



Soln:- Case-(I):- (V_{th})

$$\frac{V_{th} - 110\angle 0}{6+j8} + \frac{V_{th} - 90\angle 0}{6+j8} = 0$$

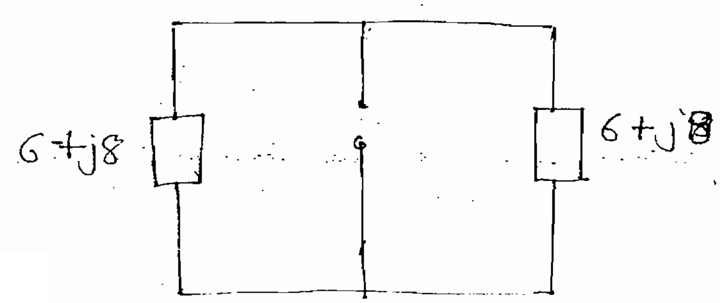
$$V_{th} = 100\angle 0$$



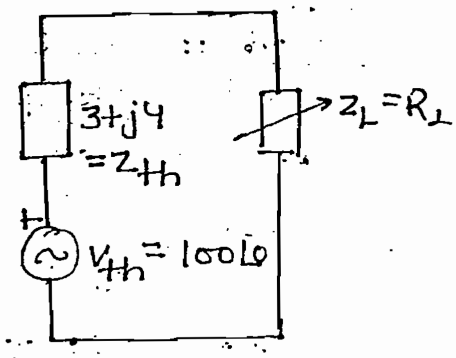
Case-(II) (Z_{th}):-

$$Z_{th} = \frac{6+j8}{2}$$

$$Z_{th} = 3+j4$$



$$R_L = \sqrt{R_{th}^2 + X_{th}^2} = \sqrt{3^2+4^2}$$
$$= 5$$

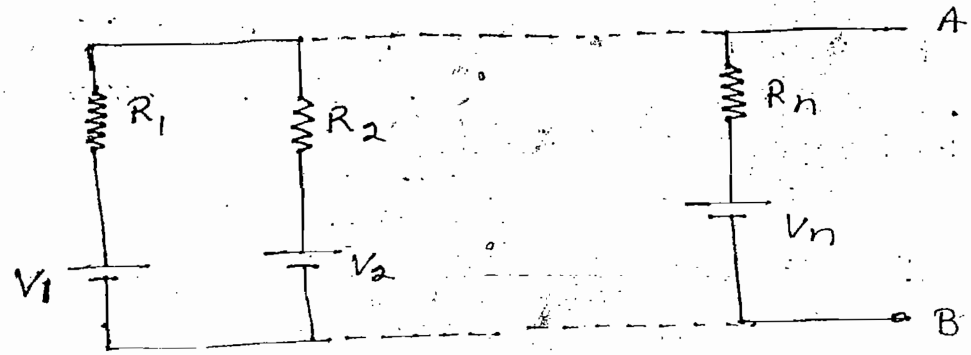


$$i = \frac{100\angle 0}{3+j4+5} = \frac{100}{8+j4}$$

$$= \frac{100}{\sqrt{8^2+4^2}}$$

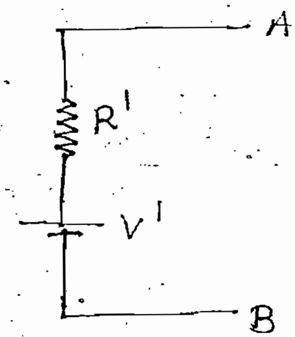
$$P_L = i^2 R_L \Rightarrow \boxed{P_L = 625\,W}$$

Millman's theorem :-



$$R' = R_{th}$$

$$\frac{1}{R'} = \frac{1}{R_1} + \frac{1}{R_2} + \cdots\cdots + \frac{1}{R_n}$$



$$\boxed{R' = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \cdots + \frac{1}{R_n}} \qquad R' = \frac{1}{G_1 + G_2 + \cdots\cdots + G_n}}$$

$$V_{th} = I_{sc} R_{th}$$

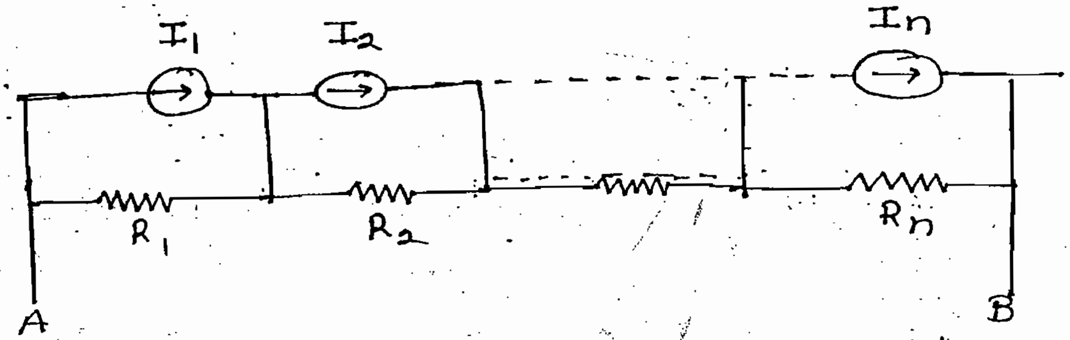
$$V' = I' R'$$

$$V' = \frac{V_1/R_1 + V_2/R_2 + \cdots\cdots + V_n/R_n}{1/R_1 + 1/R_2 + \cdots\cdots + 1/R_n}$$

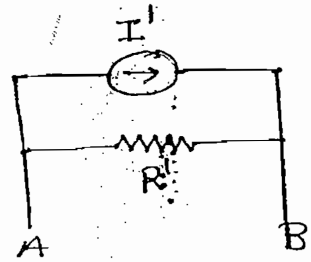
49

4A 49

$$\boxed{V' = \frac{V_1 G_1 + V_2 G_2 + \cdots + V_n G_n}{G_1 + G_2 + \cdots + G_n}}$$



$R' = R_{th}$



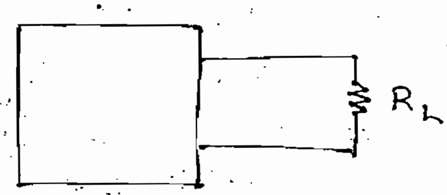
$$\boxed{R' = R_1 + R_2 + \cdots + R_{th}}$$

$$I_{sc} = \frac{V_{oc}}{R_{th}}$$

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

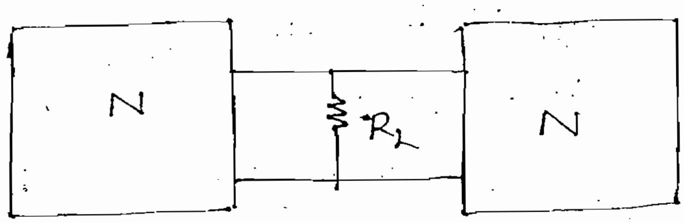
$$\boxed{I' = \frac{I_1 R_1 + I_2 R_2 + \cdots + I_n R_n}{R_1 + R_2 + \cdots + R_n}}$$

Ques:- When complex N/w of N is connected to load resistor power dissipation in the load resistor is P Watts. When two identical complex N/w of N are connected to same load resistor. Find power dissipation in the load resistor



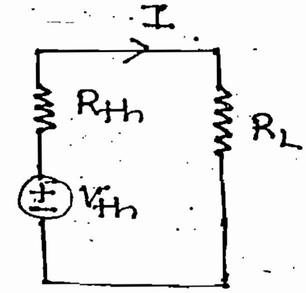
(a) P (b) 2P

(c) 4P (d) P to 4P



Soln:-

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

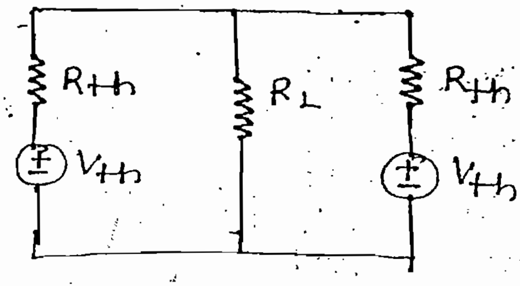


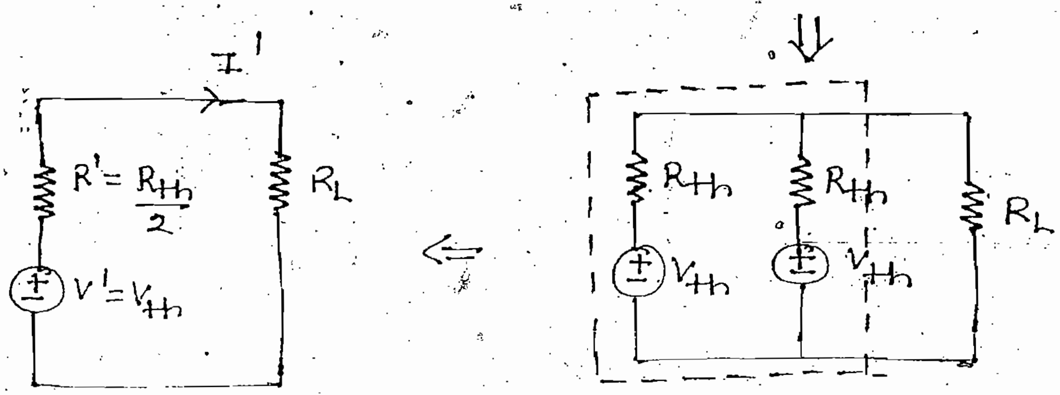
$$P = I^2 R_L$$

$$P = \left(\frac{V_{th}}{R_L + R_{th}}\right)^2 R_L \quad \text{— (1)}$$

$$V' = \frac{\frac{V_{th}}{R_{th}} + \frac{V_{th}}{R_{th}}}{\frac{1}{R_{th}} + \frac{1}{R_{th}}} = V_{th}$$

$$R' = \frac{1}{1/R_{th} + 1/R_{th}} = \frac{R_{th}}{2}$$



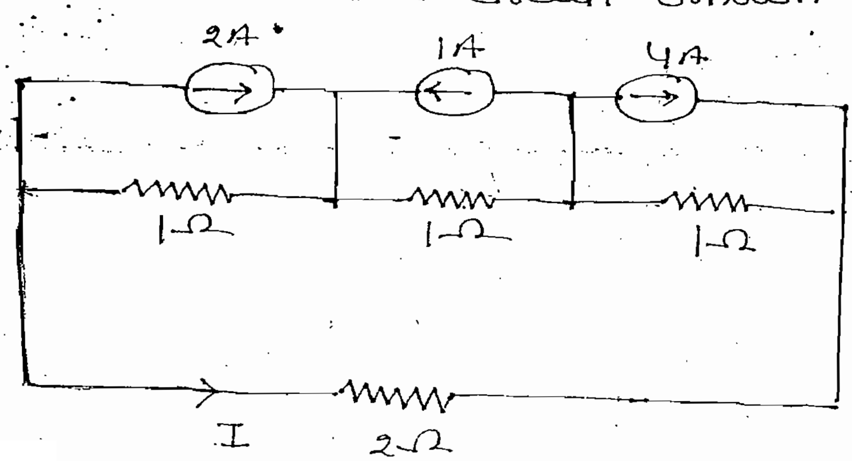


$$I' = \frac{V_{th}}{R_L + \frac{R_{th}}{2}} = \frac{2V_{th}}{2R_L + R_{th}}$$

$$P' = I'^2 R_L = \left(\frac{2V_{th}}{2R_L + R_{th}}\right)^2 R_L \quad \text{— (11)}$$

Comparing eq-(1) & (11) we get option-d

Ques:- Find I of the circuit shown

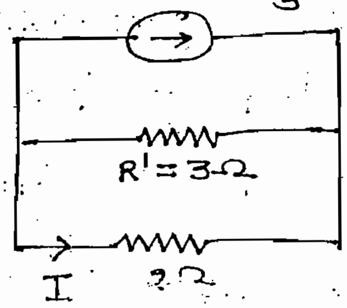


soln:-

$$I^1 = \frac{(2\times1)-(1\times1)+(4\times1)}{1+1+1} = \frac{5}{3}$$

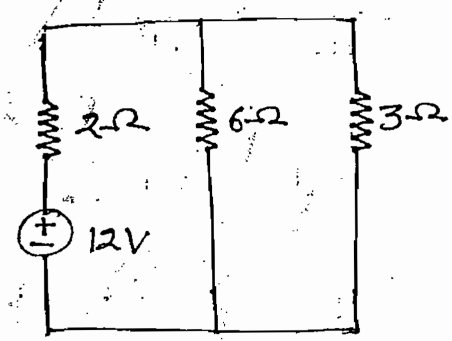
$$R^1 = 1+1+1 = 3\,\Omega$$

$$I = -\frac{5}{3}\,\frac{3}{3+2} = -1\,A$$



Tellegen's theorem:-

$$\sum_{k=1}^{n} V_k i_k = 0$$



Tellegen's theorem states that algebraic sum of the powers in any circuit at any instant is equal to zero (linear, non-linear, unidirectional, bidirectional, time variant and time invariant elements)

$$R_{eq} = 2+\frac{6\times3}{6+3} = 4$$

$$I_T = \frac{12}{4} = 3A$$

$$I_6 = 3\,\frac{3}{3+6} = 1A \qquad I_3 = 3-1 = 2A$$

$$V_2 = I_T\times2 = 6$$

$$V_6 = V_3 = 2\times3 = 6$$

$$V_2I_T + V_6I_6 + V_3I_3 - V_sI_T$$

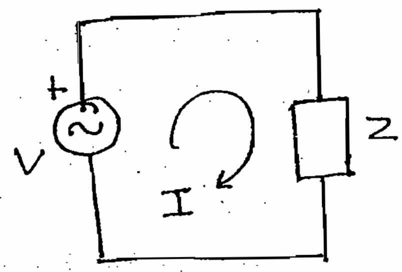
$$18+6+12-12\times3 = 0$$

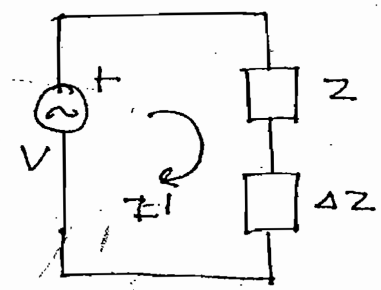
Note:-

→ Tellegen's theorem is verified by using KCL and KVL equations

→ Tellegen's theorem works based on the principle of law of conservation of energy.

Compensation theorem:-





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

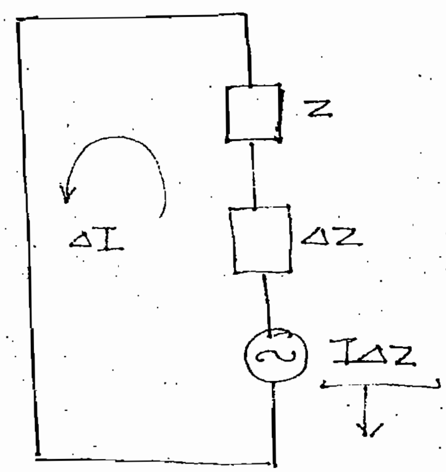
$$I' = \frac{V}{Z+\Delta Z}$$

$$\Delta I = |I - I'|$$

(Clockwise)

$$\boxed{\Delta I = \frac{-I\Delta Z}{Z+\Delta Z}}$$

Modified Circuit:-



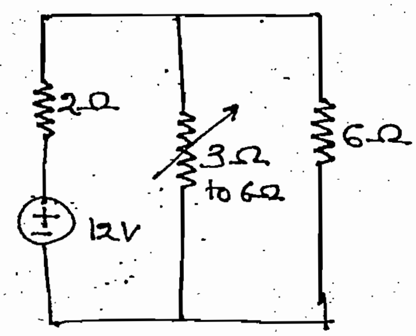
Compensation emf
or
opposing emf

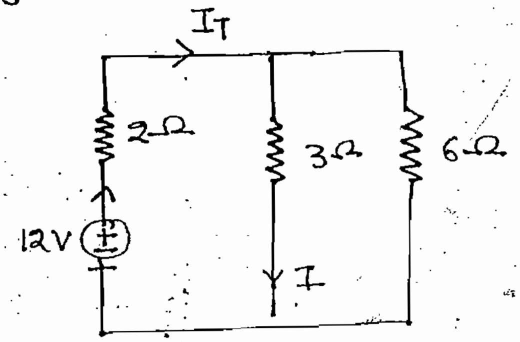
Lecture -

Ques:- Find change in current in the 2Ω and 6Ω resistor when resistance in the variable branch is changed from 3 to 6Ω

Soln:- Step-(I) :-

Find original current circulating in the variable branch





$$R_{eq} = 2 + \frac{6 \times 3}{6+3} = 4$$

$$I_T = \frac{12}{4} = 3A$$

$$I = 3\,\frac{6}{6+3} = 2A$$

Step-(II):-

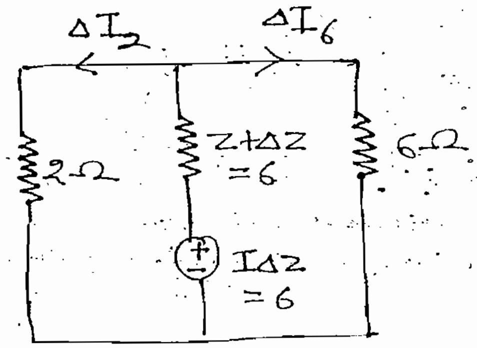
Find compensation emf

$$I\Delta Z = 2(6-3) = 6V$$

Step-(III):-

Develop modified ckt

→ While developing modified circuit deactivate all the original sources and connect the compensation emf in series to variable branch



$$R_{eq} = 6 + \frac{6 \times 2}{6+2}$$

$$I_T = \frac{6}{R_{eq}}$$

$$\Delta I_2 = I_T\,\frac{6}{6+2} = 0.6A$$

$$\Delta I_6 = I_T - \Delta I_2 = 0.2A$$

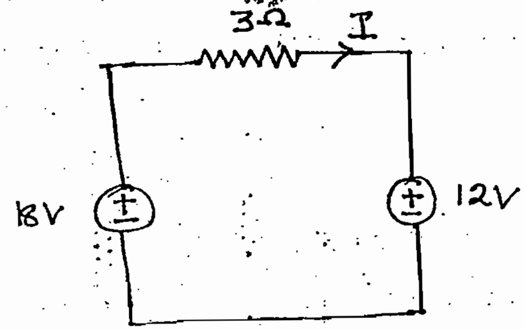
Note:-

In the bridge circuit by using compensation theorem condition for null deflection in the galvanometer is obtain

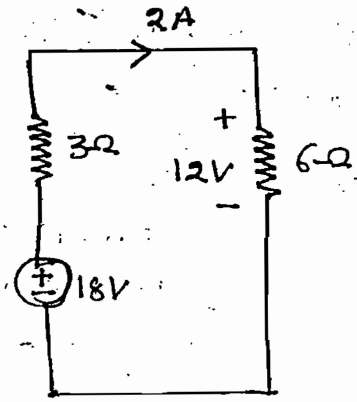
Application of comp. theorem

1V

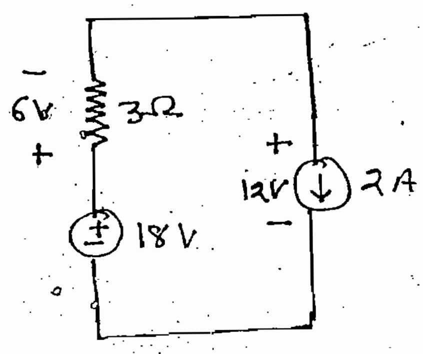
Substitution theorem :-

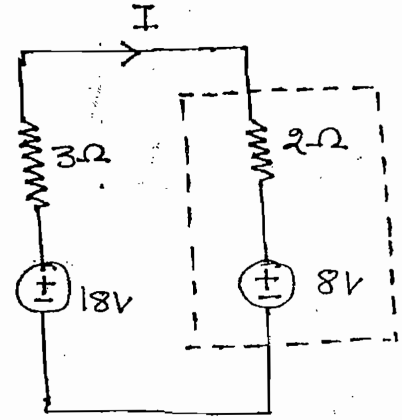


$$I = \frac{18-12}{3} = 2$$



$6\Omega \rightarrow 2\Omega + 4\Omega$

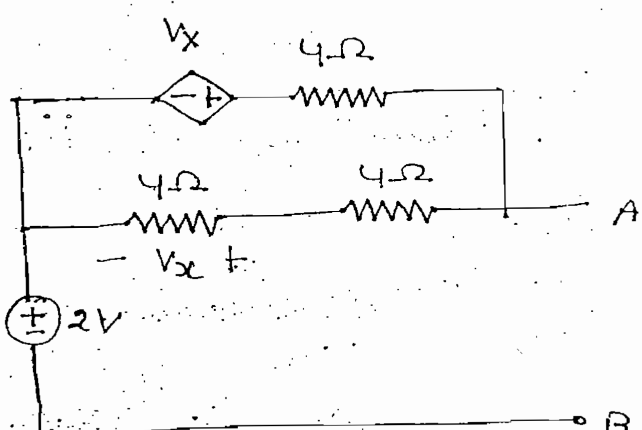




$$I = \frac{18-8}{3+2} = 2A$$

→ All circuits are equivalent

Ques:- Find R_{th} w.r.t A and B



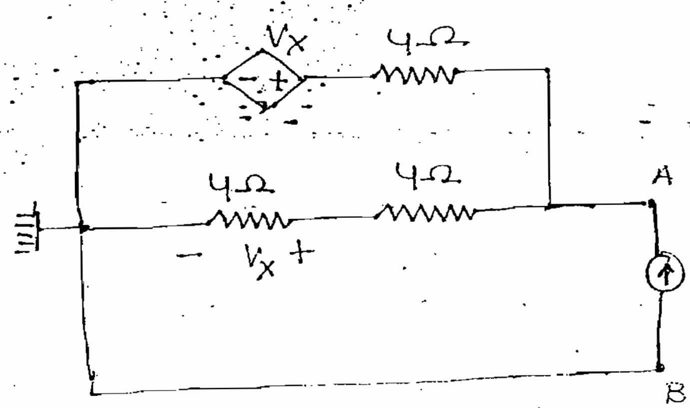
Soln:-

$$\frac{V_A}{8} + \frac{V_A - V_x}{4} = 1$$

$$V_x = \frac{V_A}{2}$$

$$V_A = 4V$$

$$R_{th} = \frac{V_A}{I_s} = \frac{4}{1} = 4\Omega$$



Alternate Way :-

By using substitution theorem

$$R_{th} = \frac{8 \times 8}{8+8} = 4$$