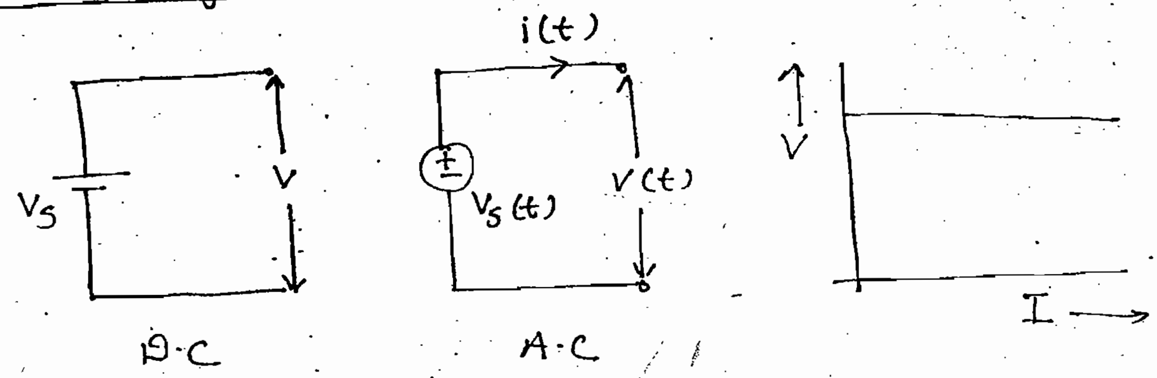
Lecture - 2

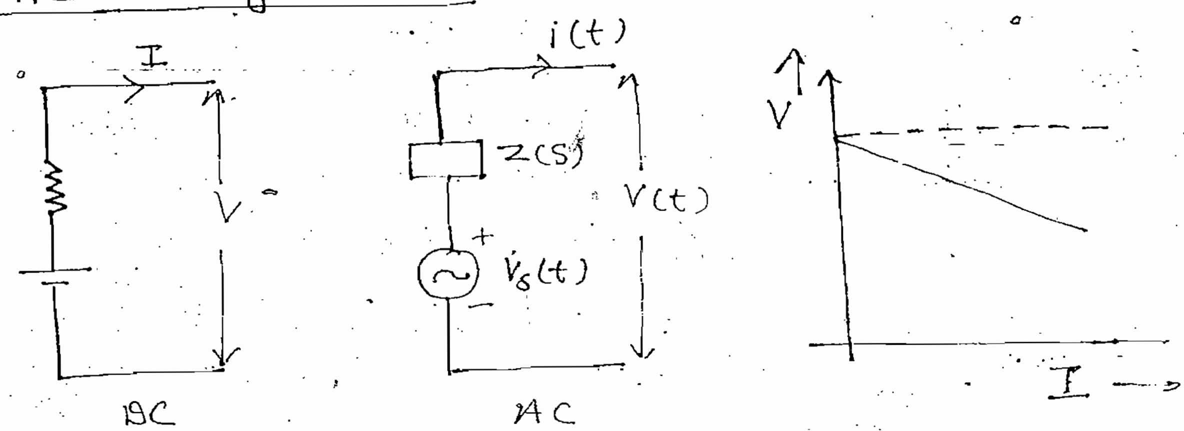
Ideal Voltage Source :-



→ $R_S = 0$

→ $V_S(t)$ → either AC or DC if t → specify then AC

Practical Voltage Source :-



$$V_S = V + IR_S$$

$$V = V_S - IR_S$$

→ Ideal voltage source delivers energy at specify voltage (V) it is independent on current deliver by a source

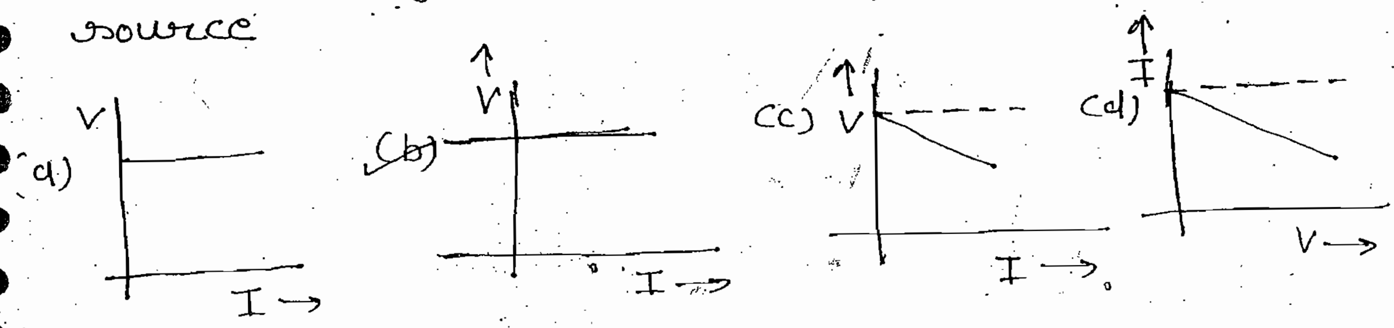
→ Internal resistance of ideal voltage source is zero

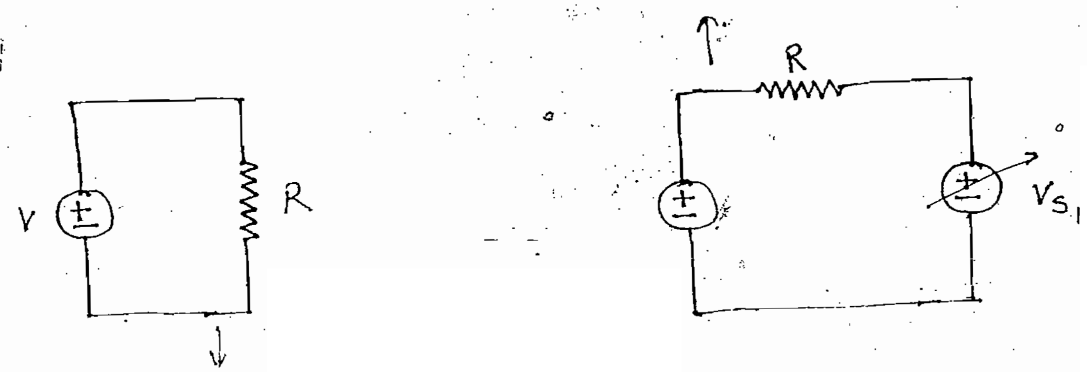
→ Practical voltage source delivers energy at specified voltage (V) which depends on current deliver by the source.

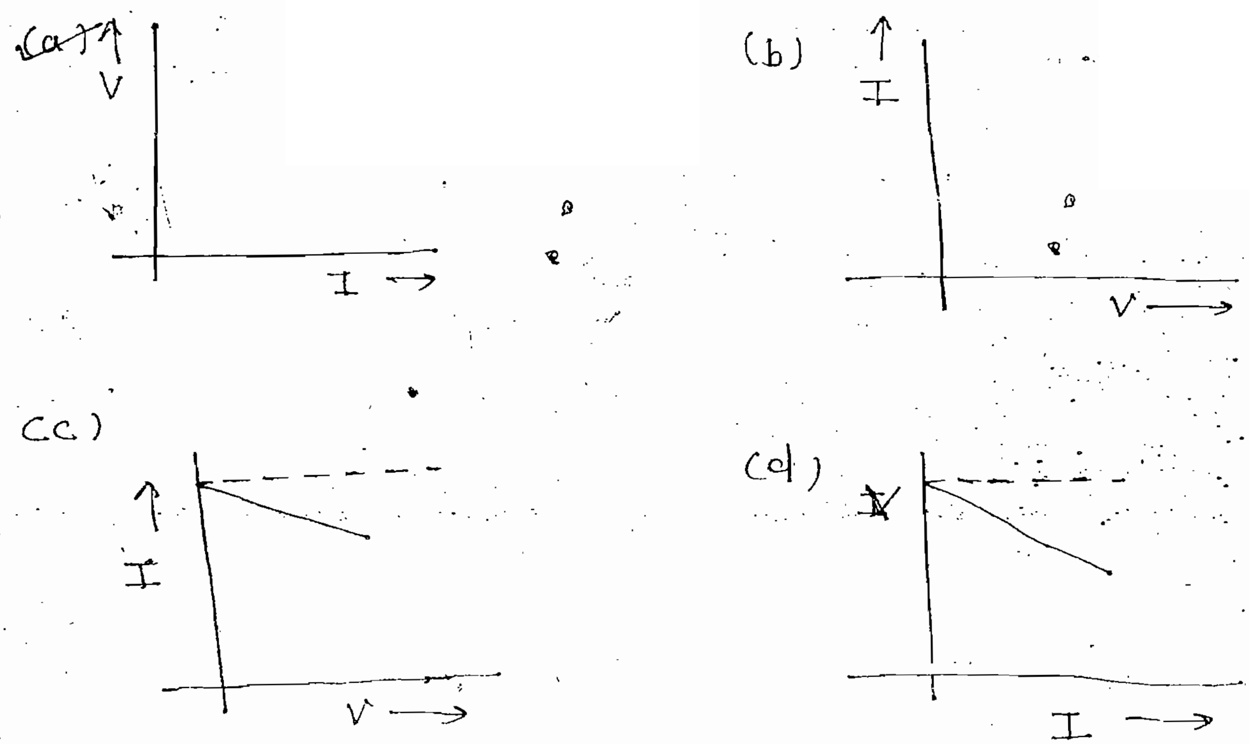
→ Linear → characteristic passes through origin and inc. linearly

→ Independent voltage source does not obey the Ohm's law. since V–I characteristic is non-linear.

Ques:- Identify V–I characteristic of ideal voltage source

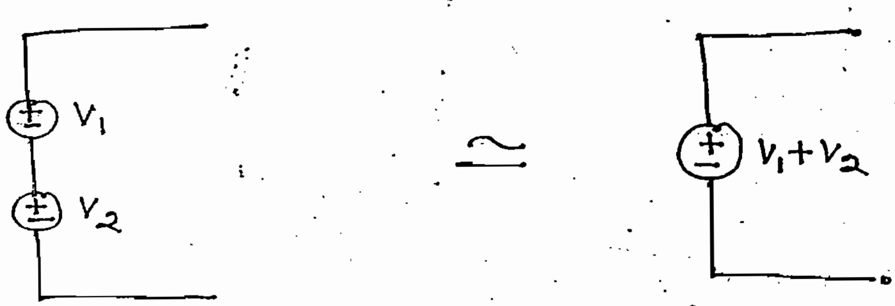




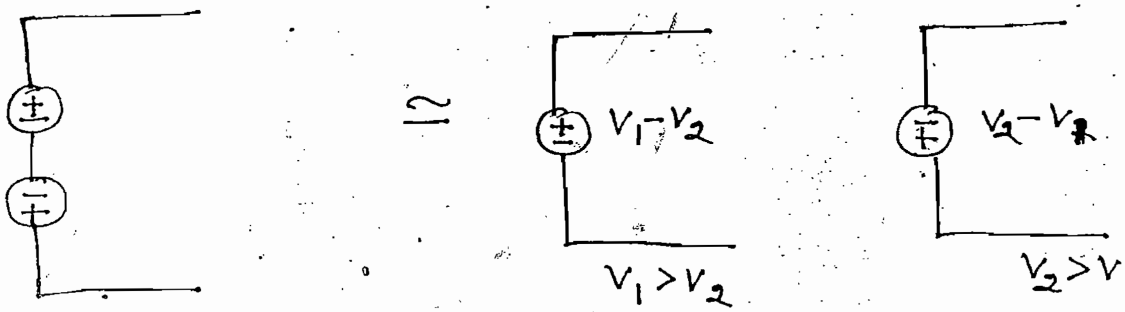


Note :-

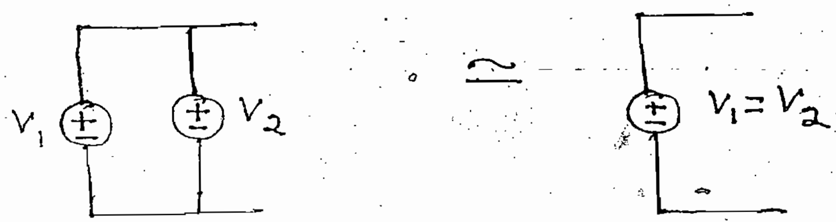
(I)



(II)

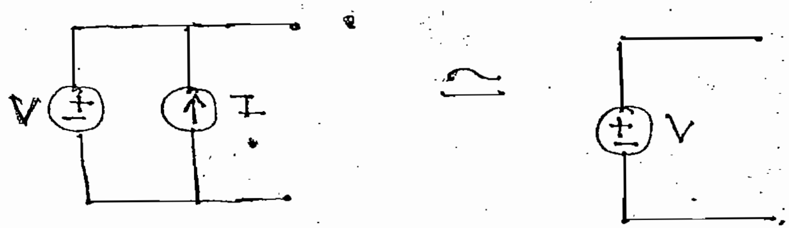


(III)



(IV)

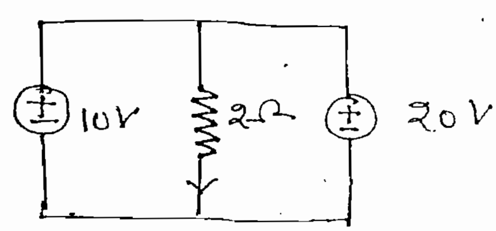
(V)



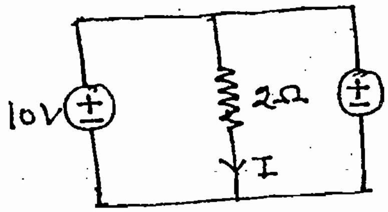
Ques:- Find current in the 2Ω resistor

(a) 5A (b) 10A

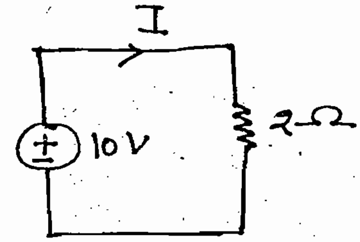
(c) 15A) (d) None or Not satisfying KVL



Note:-



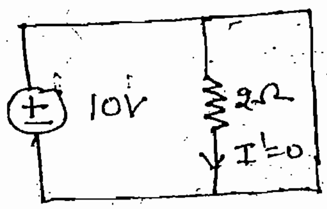
$\simeq$



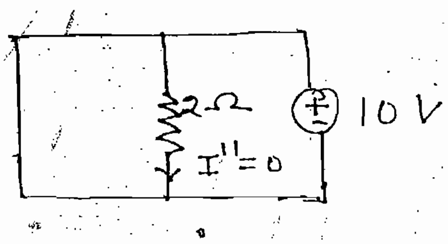
$I = 5A$

By using superposition theorem

Case - I



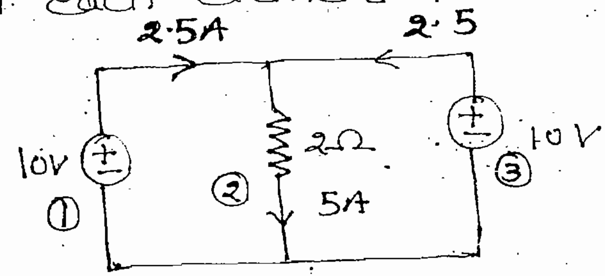
Case - II



$$I = I' + I'' = 0$$

→ For the above circuit superposition theorem can't be applied since case-(I) & case-(II) circuits are not satisfying KVL

Ques:- Find power of each element in the circuit given below



Soln:-

$P_1 = 10 \times 2.5 = 25\ W$ (Delivering)

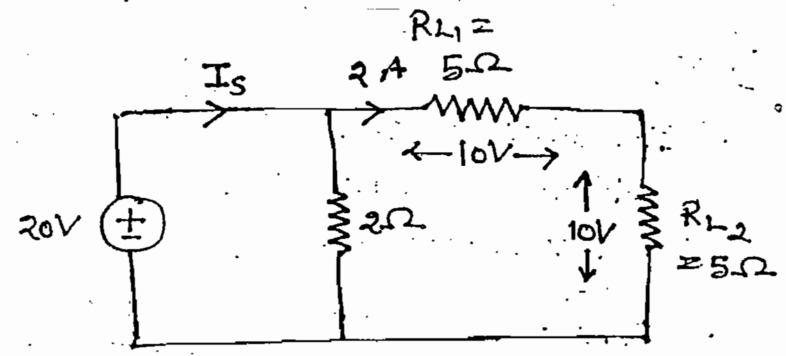
$P_3 = 10 \times 2.5 = 25\ W$ (Del.)

$P_2 = I^2 R = 5^2 \times 2 = 50\ W$ (Absorbing)

Note:-

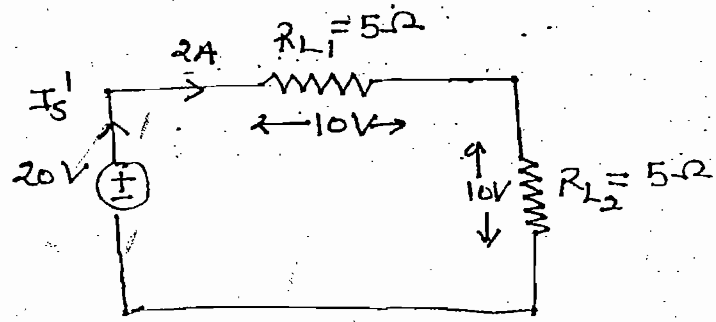
$I_S = 10+2 = 12A$

$P_S = 20 \times 12 = 240W$



$I_S' = 2A$

$P_S' = 20 \times 2 = 40W$



→ In the above circuit 2Ω resistance can be neglected while calculating either load current or load voltages

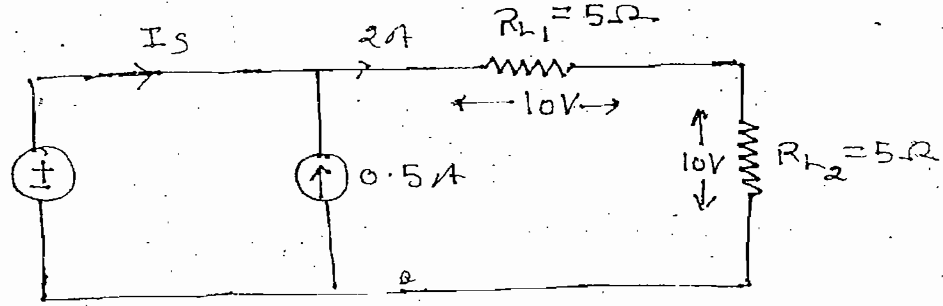
→ In the above circuit 2Ω resistance can't be neglected while calculating either source current or source power

$I_S + 0.5 = 2$

$\Rightarrow I_S = 1.5A$

$P_S = 20 \times 1.5$

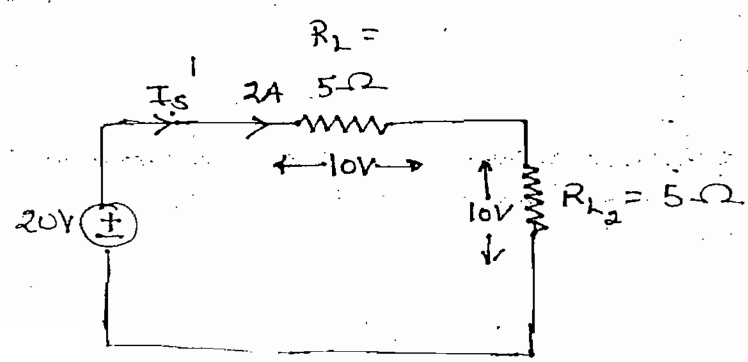
$= 30W$



$I_S' = 2A$

$P_S' = 20 \times 2$

$= 40W$

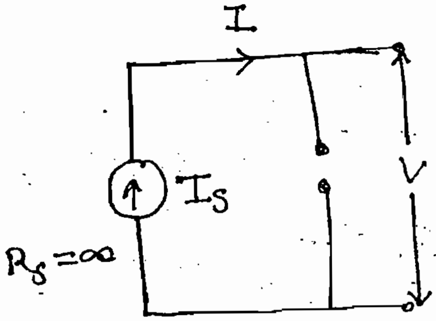


Note:-

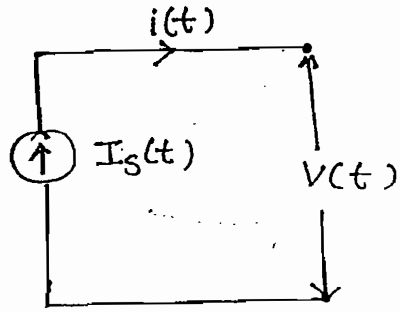
→ In the above circuit current source can be neglected while calculating either load current or load voltage

→ In the above circuit current source can't be neglected while calculating either voltage source current or voltage source power

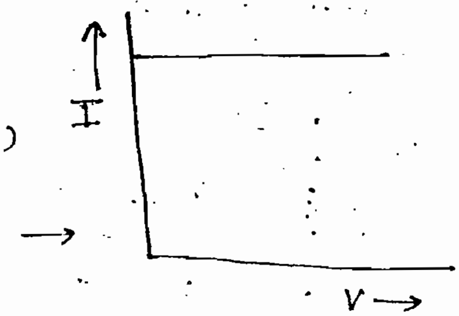
Current (I) :-



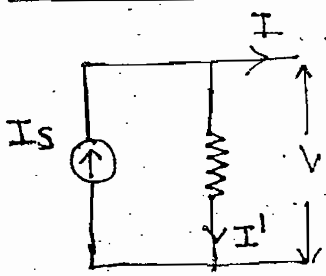
Ideal DC current source

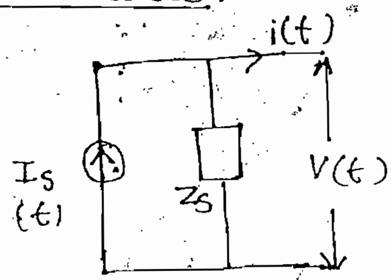


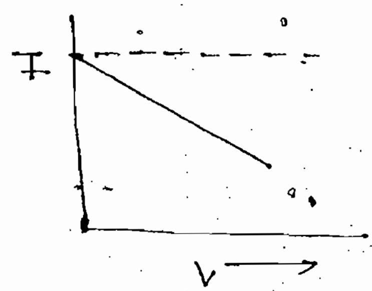
Ideal AC current source



Practical current source :-







$$I_s = I + I'$$

$$I = I_s - I'$$

$$I = I_s - \frac{V}{R_s}$$

→ Ideal current source deliver energy at specified current (I) which is independent on voltag across source

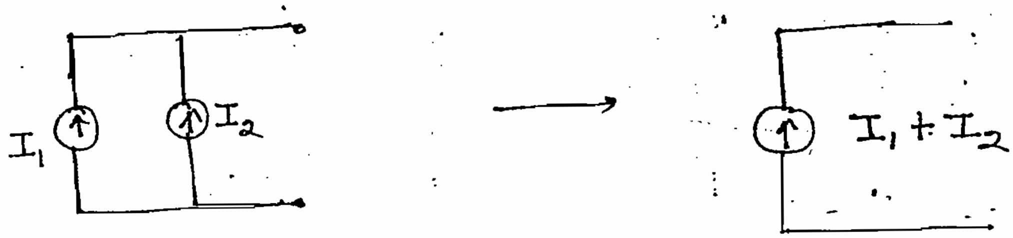
→ Internal resistance of ideal current source = ∞

→ Practical current source deliver energy at specified current (I) which depends on voltage across source

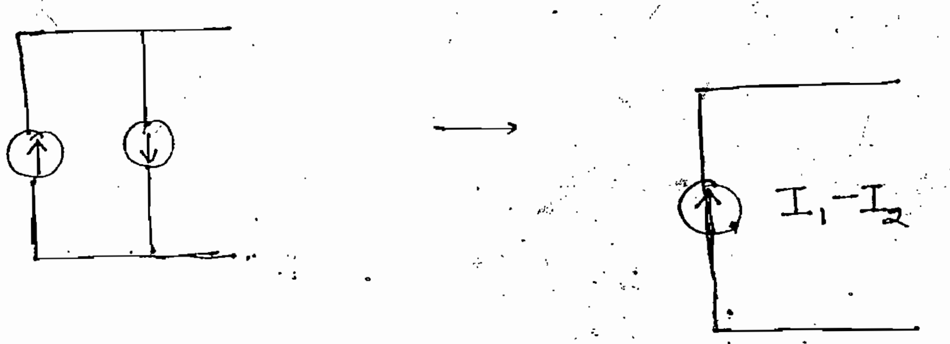
→ Independent current source doesn't obey the ohm's law since $V/_I$ V-I characteristics are non-linear

→ In the practical system no independent current source are exist but dependent current source are exist.

(I)

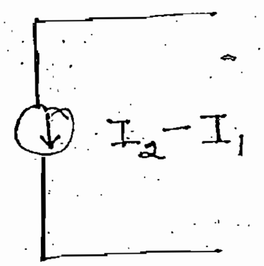


(II)



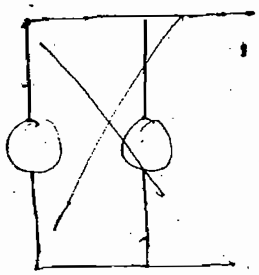
$I_1 > I_2$

OR

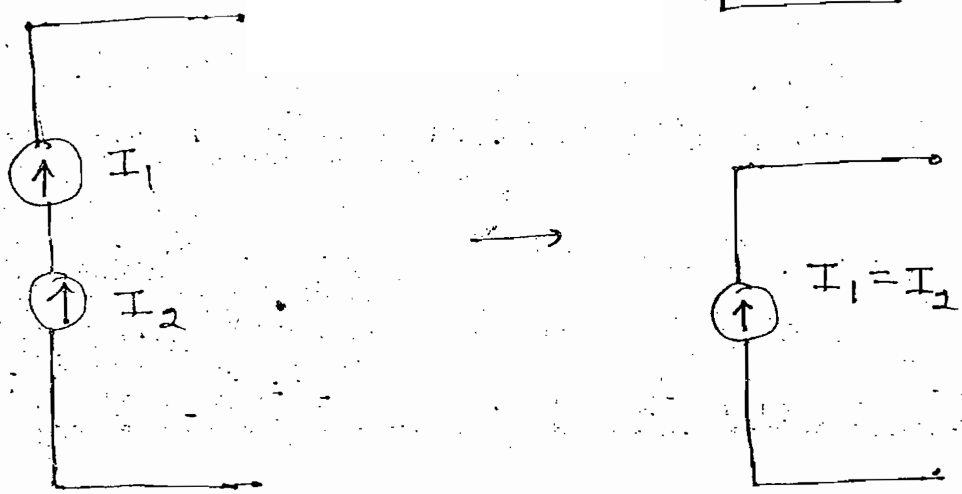


$I_2 > I$

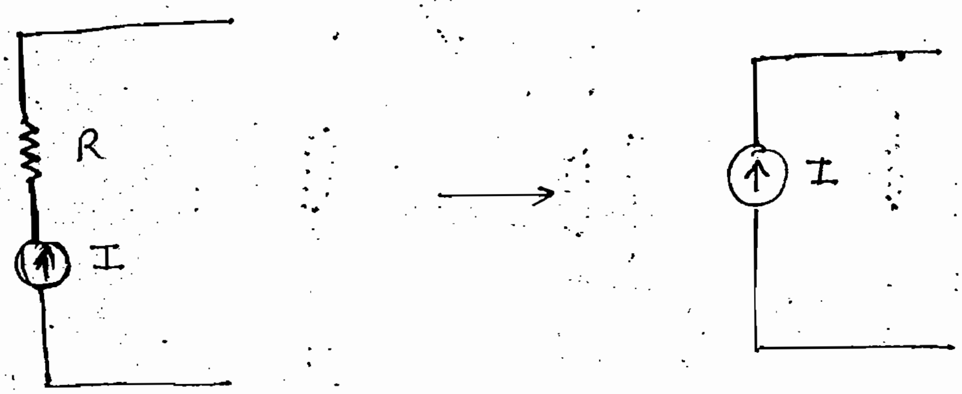
(III)



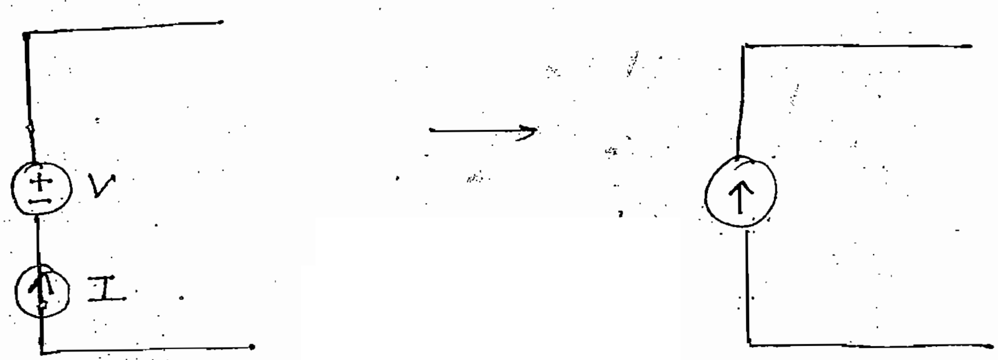
(III)



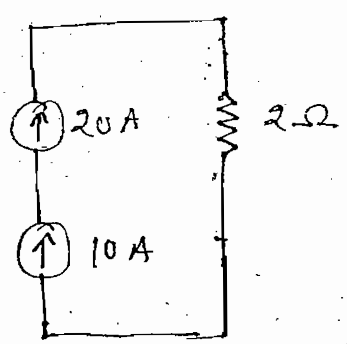
(IV)



(V)



Ques:-



(a) 10 A

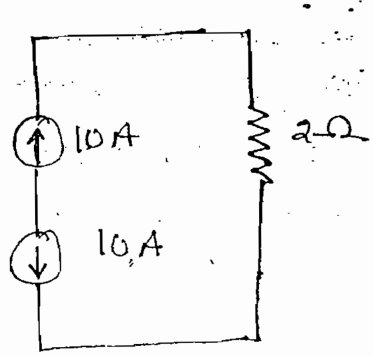
(b) 20 A

(c) 30 A

(d) None of these OR Not satisfied KCL

Note:-
With respect to KCL current flowing through all the series element should be equal

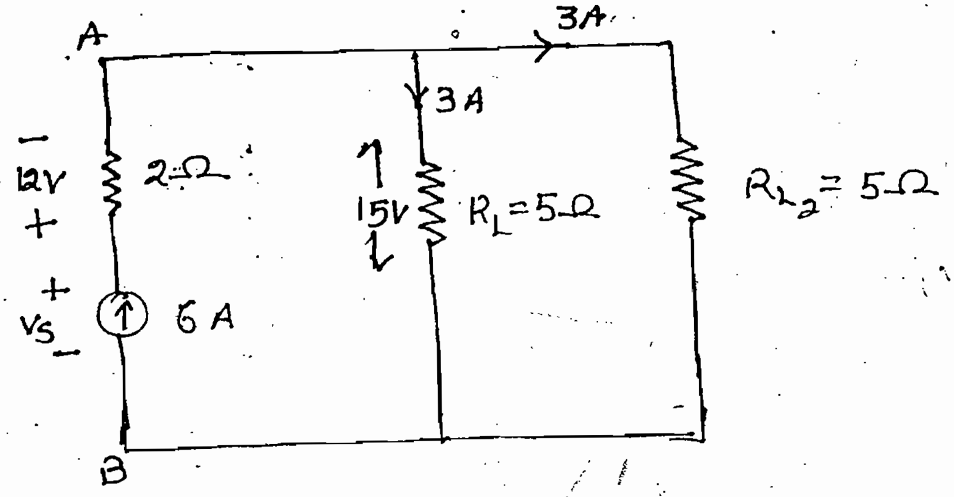
Ques:-



What is the current through 2Ω resistor?

Sol^n:- Not satisfied KCL bec. polarities are opposite.

→

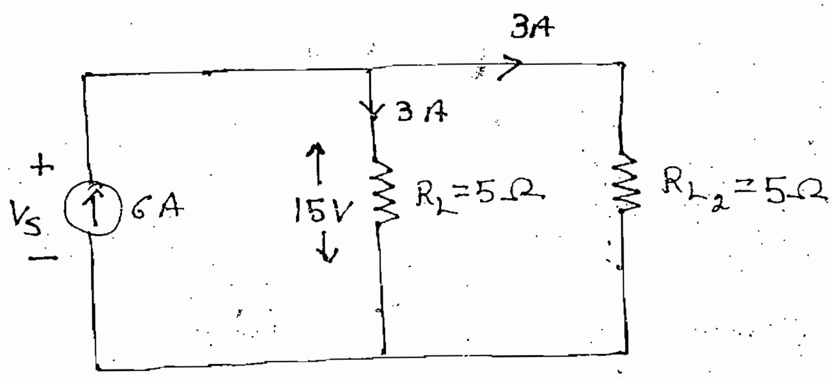


$$V_{AB} = V_S - 12$$

$$\Rightarrow 15 = V_S - 12$$

$$\Rightarrow V_S = 27$$

$$\& \quad P_S = 27 \times 6 = 162\,W$$



$V_S' = 15\,V$ $\qquad P_S' = 15 \times 6 = 90\,W.$

Note:-

→ In the above circuit 2Ω resistance can be neglecting either by calculating load current or load voltage.

→ In the above circuit 2Ω resistance cann't be neglected by calculating either voltage across current source or power of the current source.

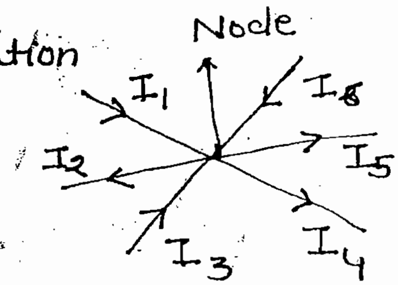
Note:-

→ In above circuit voltage source can be neglected by calculating either load current or load voltage

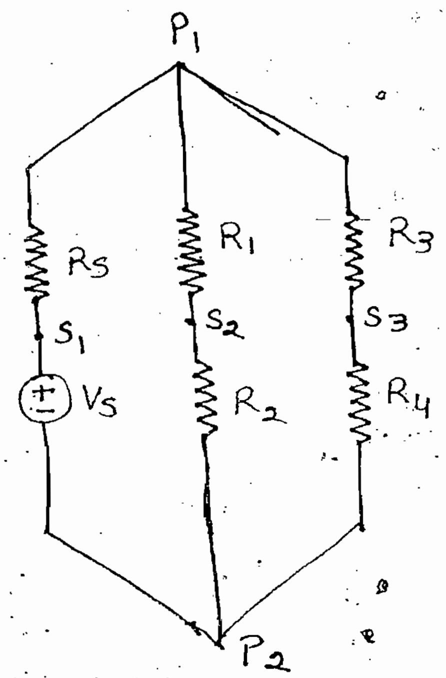
→ In the above circuit voltage source cannot be neglected ~~to~~ either calculating voltage across current source or power of the current source

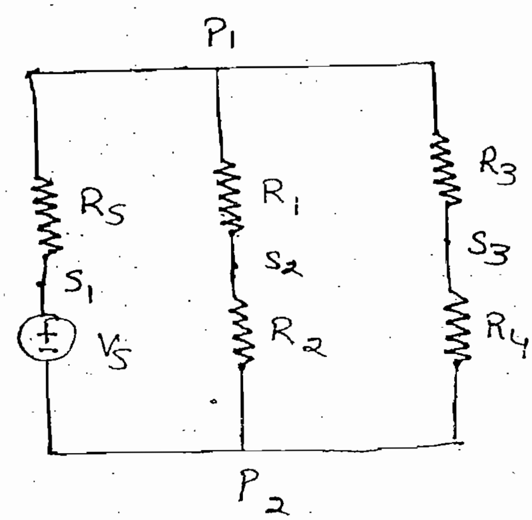
KCL:-

→ Based on law of conservation of charge



$$I_1 + I_3 + I_6 = I_2 + I_4 + I_5$$





→ KCL states that algebraic sum of currents meeting at a point is equal to zero.

→ When two elements are connected together then common point is called as simple node

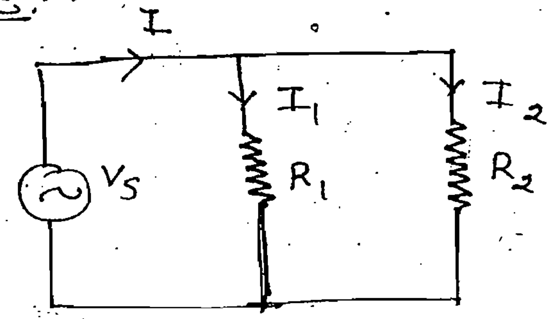
→ When more than two elements are connected together then common point is called as principal node.

Current division technique:-

$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2}$$

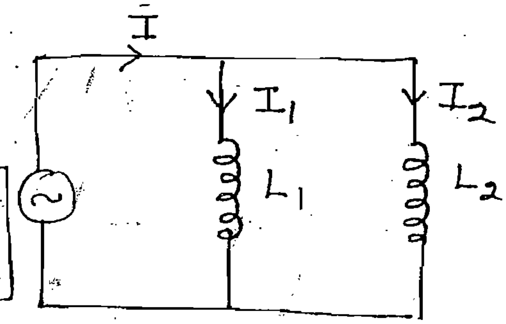
$$\boxed{I_1 = I \frac{R_2}{R_1+R_2}}$$

$$\boxed{I_2 = I \frac{R_1}{R_1+R_2}}$$



$$\frac{1}{L_{eq}} = \frac{1}{L_1} + \frac{1}{L_2}$$

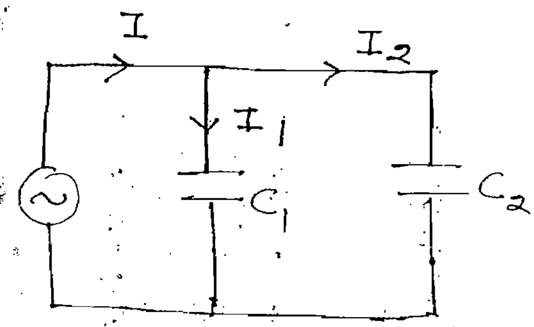
$$\boxed{I_1 = I \frac{L_2}{L_1+L_2}} \quad \boxed{I_2 = I \frac{L_1}{L_1+L_2}}$$



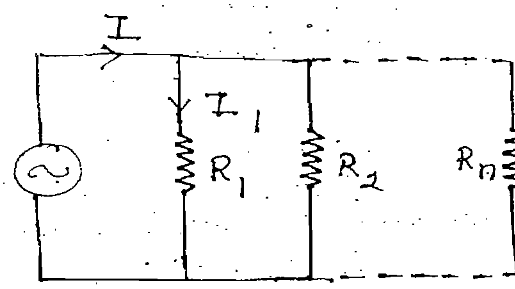
$$C_{eq} = C_1 + C_2$$

$$\boxed{I_1 = I \frac{C_1}{C_1+C_2}}$$

$$\boxed{I_2 = I \frac{C_2}{C_1+C_2}}$$



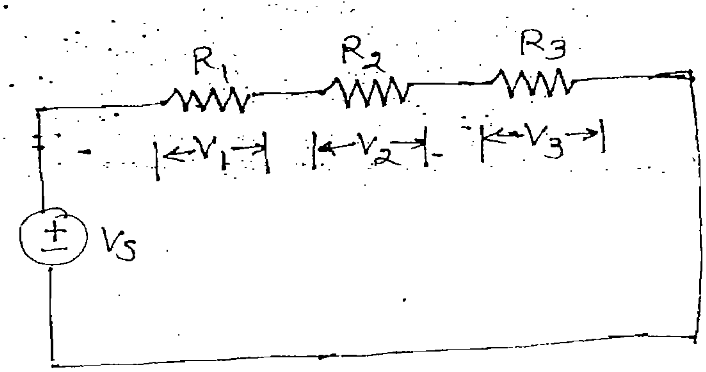
$$\boxed{I_1 = I \frac{1/R_1}{\frac{1}{R_1} + \frac{1}{R_2} + \cdots + \frac{1}{R_n}}}$$



KVL :-

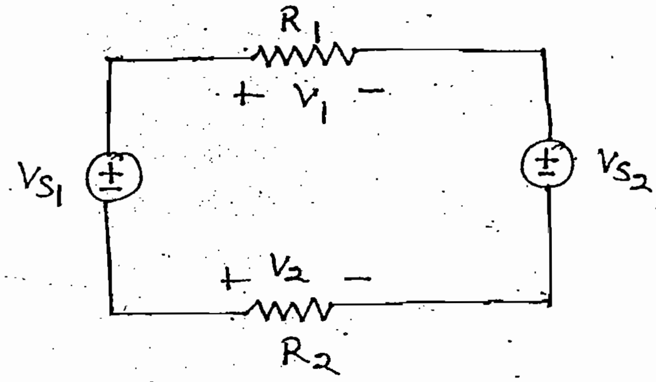
→ KVL works based on the principle of law of conservation of energy

$$V_1 + V_2 + V_3 - V_S = 0$$



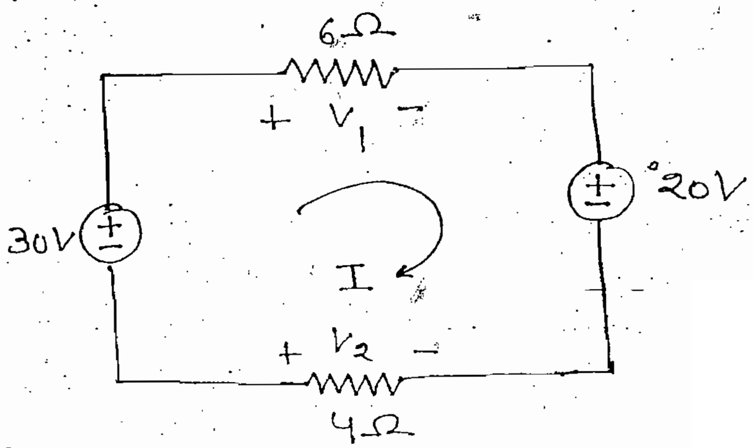
$$V_{S_1} - V_1 - V_{S_3} + V_2 = 0$$

$$V_{S_1} + V_2 = V_1 + V_{S_3}$$



→ KVL states that algebraic sum of voltages in a closed loop is equal to zero

Ques:- Find V_1 & V_2 of the circuit shown



Soln:- $V_1 = 6I \qquad V_2 = -4I$

$$30 - V_1 + 20 - V_2 = 0$$

$$\Rightarrow -30 + 6I + 20 - (-4I) = 0$$

$$\Rightarrow I = 1A$$

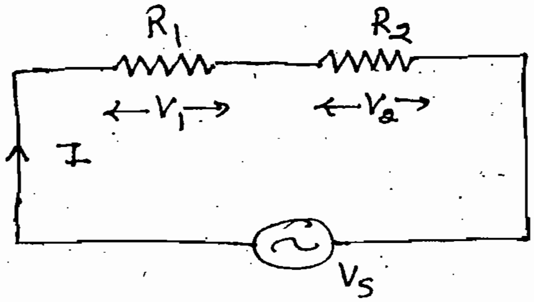
$$V_1 = 6V \quad \& \quad V_2 = -4V$$

Voltage Division Technique :-

$$R_{eq} = R_1 + R_2$$

$$\boxed{V_1 = V_S \frac{R_1}{R_1+R_2}}$$

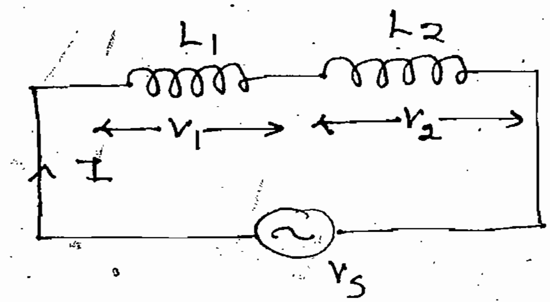
$$\boxed{V_2 = V_S \frac{R_2}{R_1+R_2}}$$



$$L_{eq} = L_1 + L_2$$

$$\boxed{V_1 = V_S \frac{L_1}{L_1+L_2}}$$

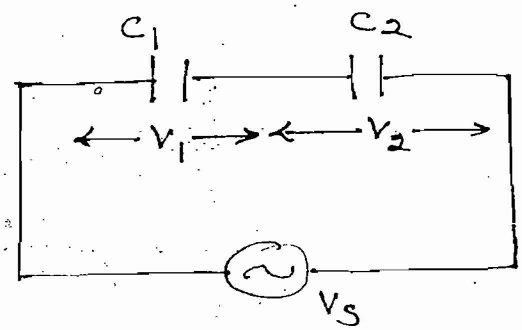
$$\boxed{V_2 = V_S \frac{L_2}{L_1+L_2}}$$



$$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2}$$

$$\boxed{V_1 = V_S \frac{C_2}{C_1+C_2}}$$

$$\boxed{V_2 = V_S \frac{C_1}{C_1+C_2}}$$



Conclusions :-

Field Theory → Low frequency

Field Theory → High frequency

Network Theory → Low frequency

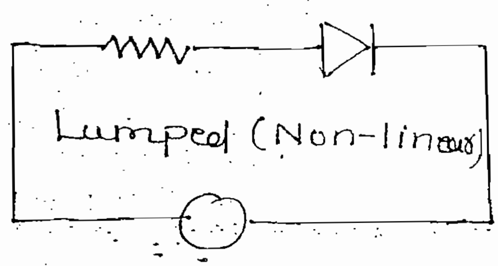
→ Field theory can be applied for low or high frequency application

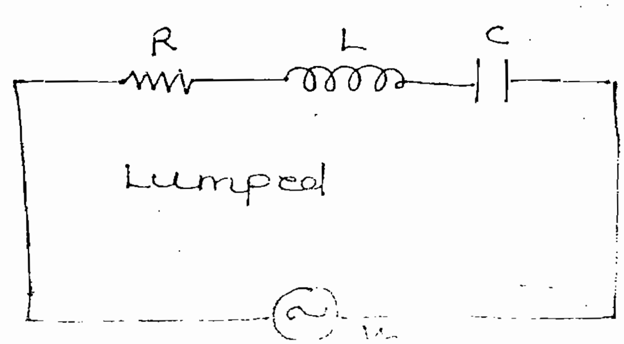
→ In field theory accurate results are obtain. but developing mathematical equation is complex

→ Network theory is applied only for low frequency applications

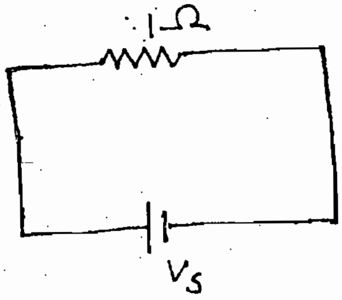
→ In the network theory approximate results are obtained and developing mathematical equation is simple

→ KVL and KCL fails for high frequencies application

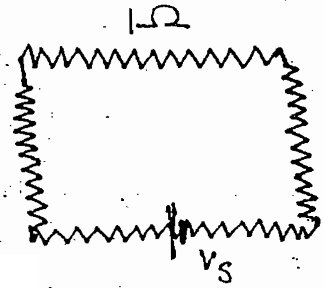




$$V_S = iR + L\frac{di}{dt} + \frac{1}{C}\int i\,dt$$

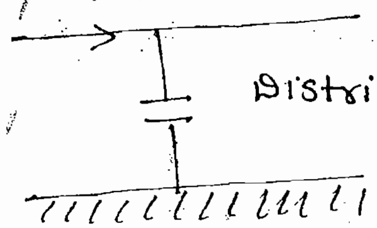


Lumped
(Linear)



Distributed

Transmission Line.



Distributed

$J = \sigma E$
(Ohm's Law

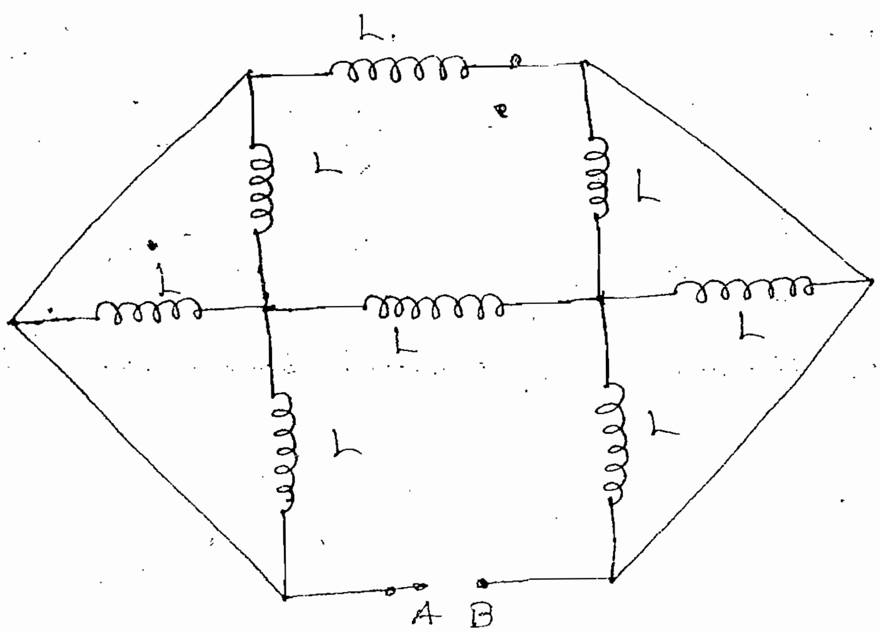
→ Ohm's law can be applied lumped (linear) and distributed parameters

→ KVL and KCL fails for distributed parameters since in the distributed parameters electrically it is not possible to separate resistance, inductance and capacitance effects

→ KVL and KCL are applied for lumped parameters (Linear, non-linear, uni-directional, bi-directional, time variant and invariant elements)

Ques:-

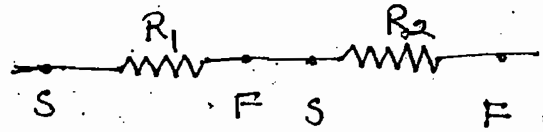
$L_{eq} = ?$



Note :-

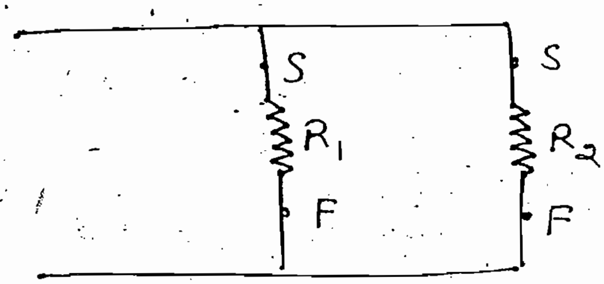
(I) one joint

(II) $I \rightarrow$ same

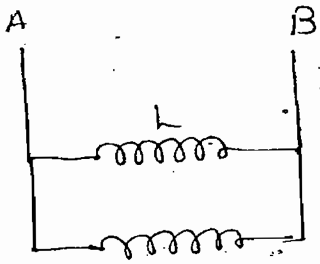


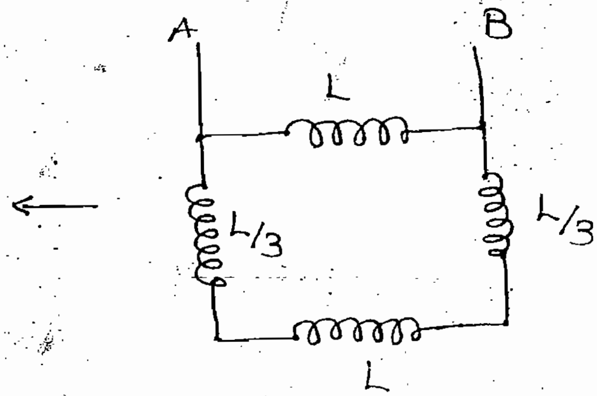
(I) Twice

(II) $V \rightarrow$ same



Soln:-





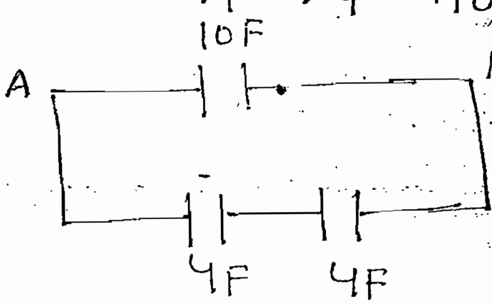
$$\frac{L}{3} + L + \frac{L}{3} = \frac{5L}{3}$$

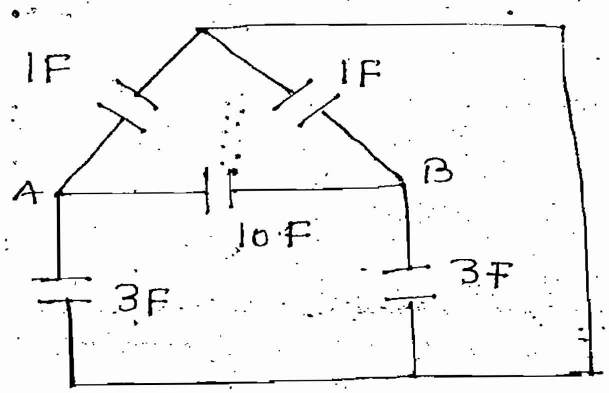
$$L_{eq} = \frac{L_1 L_2}{L_1 + L_2} = \frac{5L}{8}, \text{Ans}$$

Ques:- Find equivalent capacitance w.r.t A & B

Soln:-

$$\cancel{q_{eq}} = \cancel{\frac{1}{4}} + \cancel{\frac{1}{4}} + \cancel{\frac{1}{10}}$$

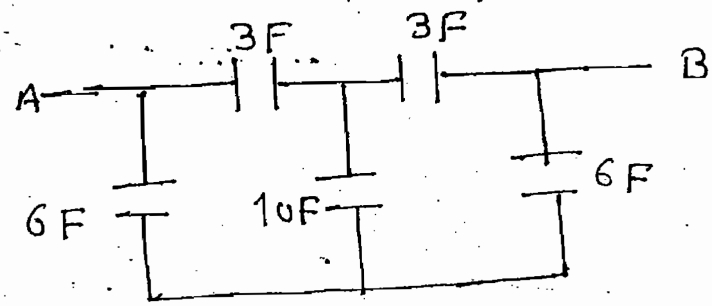




$$C_{eq} = 10 + 2 = 12\,F$$

ro

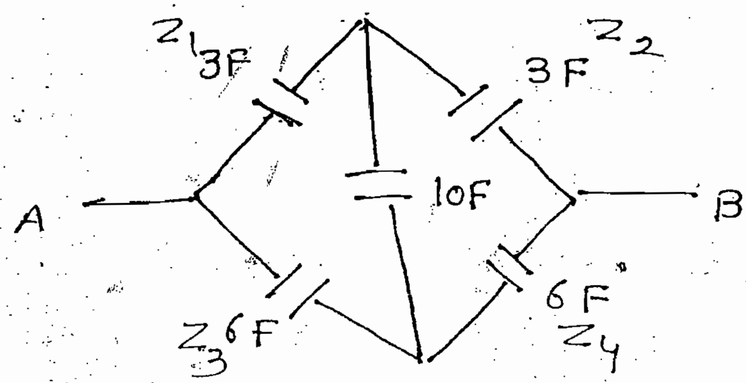
Ques:- Find equivalent capacitance w.r.t A & B



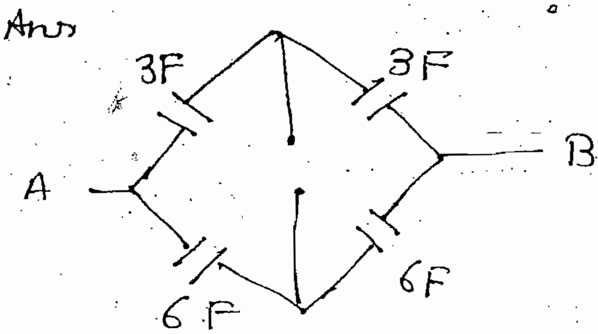
Soln:-

Balanced bridge

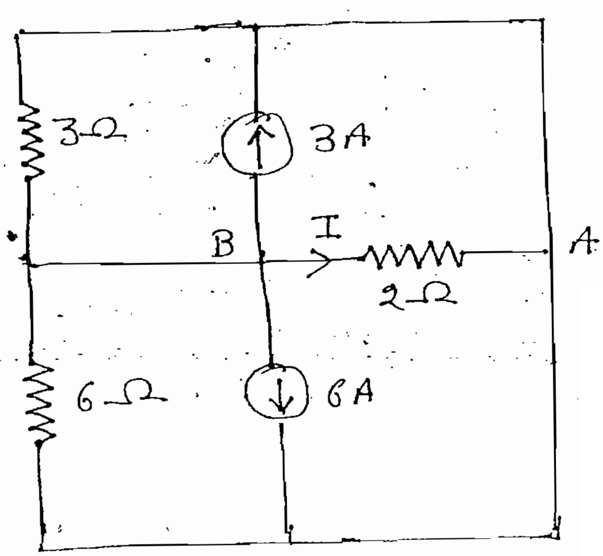
$Z_1 Z_4 = Z_2 Z_3$



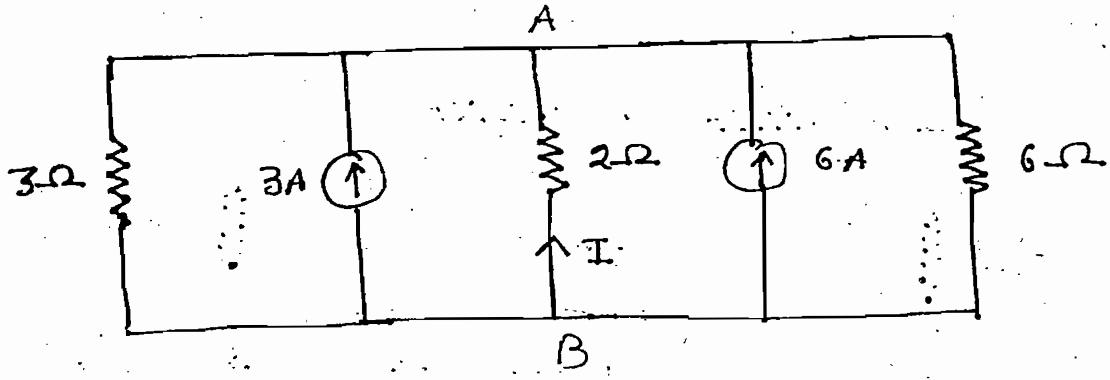
$C_{eq} = 3 + 1.5 = 4.5F$, Ans



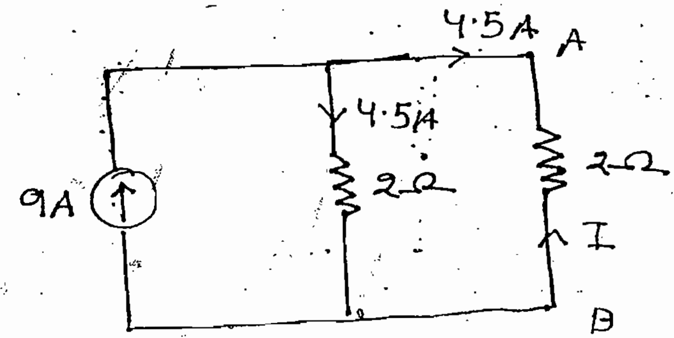
Ques:- Find I of the circuit shown



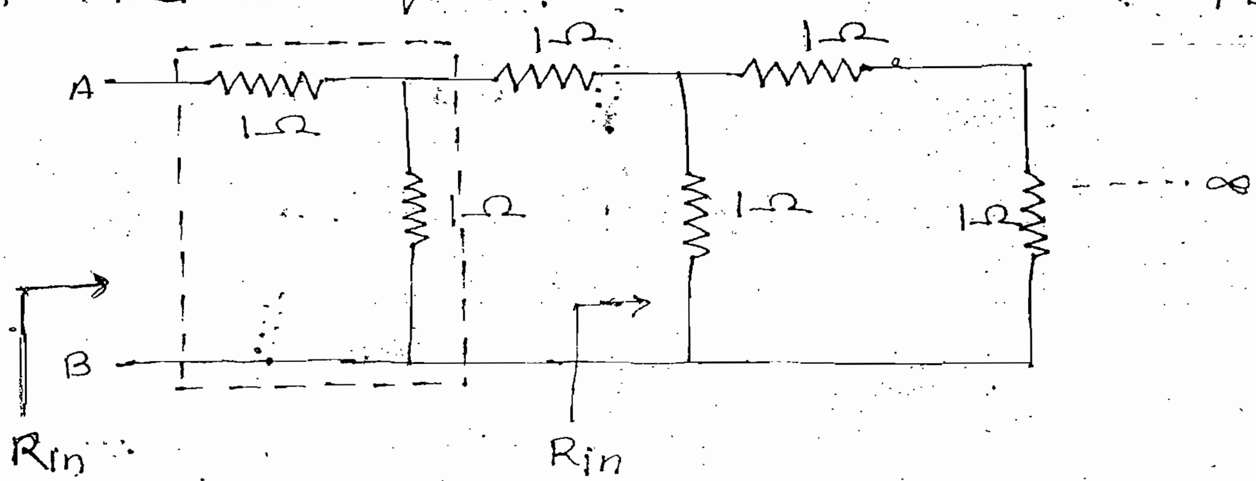
Solⁿ :-



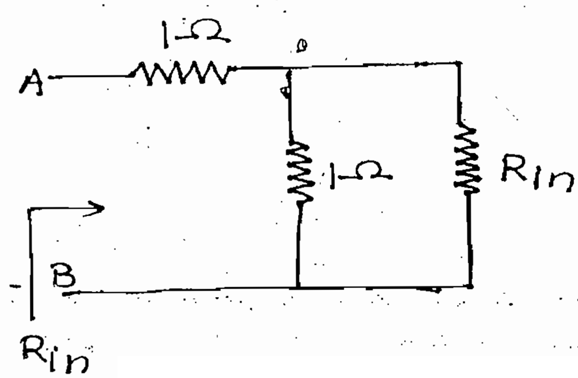
$\boxed{I = -4.5\,A}$



Ques:- Find the equivalent resistance w.r.t A & B



Solⁿ:-



$$R_{in} = 1 + \frac{1 \times R_{in}}{1 + R_{in}}$$

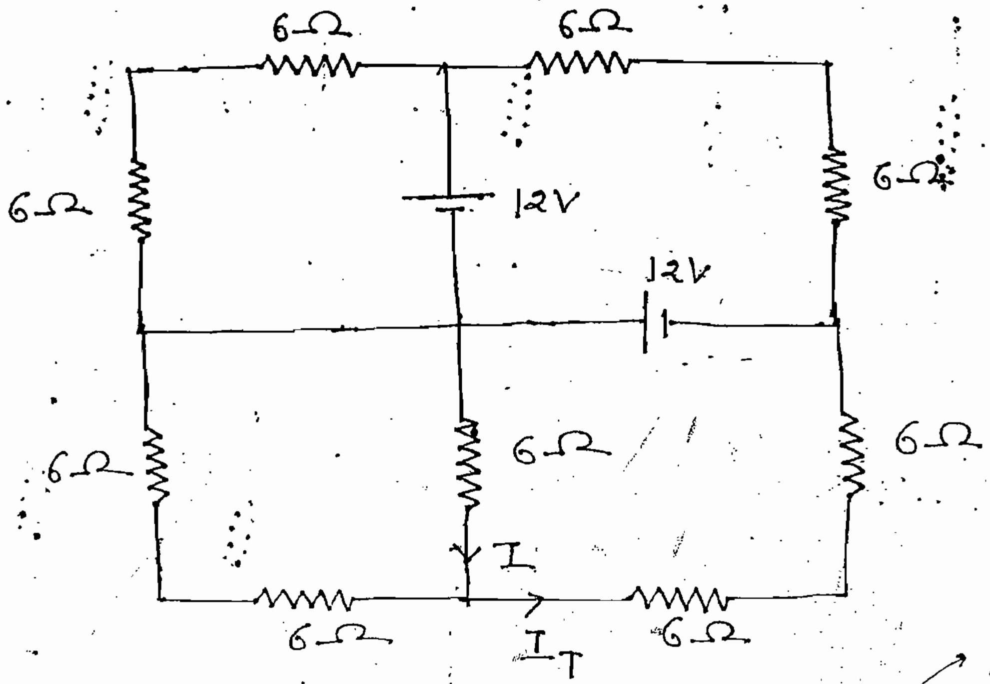
$$R_{in} = \frac{1 + R_{in} + R_{in}}{1 + R_{in}}$$

$$\Rightarrow R_{in}^2 - R_{in} - 1 = 0$$

$$\boxed{R_{in} = \frac{1 + \sqrt{5}}{2}}$$

, Ans

Ques:- Find I of the circuit shown



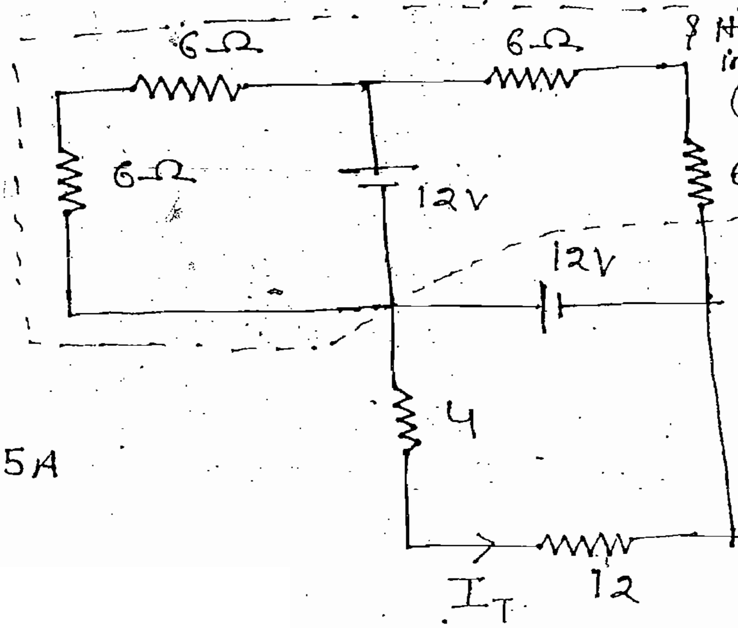
Not effect in cal: I_T ($\because$ V→ideal) & its in parallel (||)

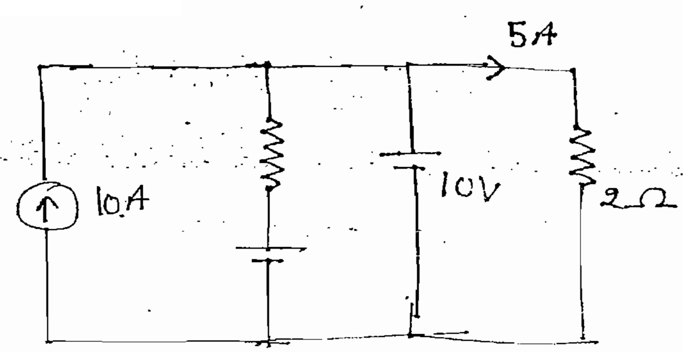
Soln:-

$$I_T = \frac{12}{4+12}$$

$$I = I_T \, \frac{12}{12+6}$$

$$= \frac{12}{16} \times \frac{12}{18} \approx 0.5A$$

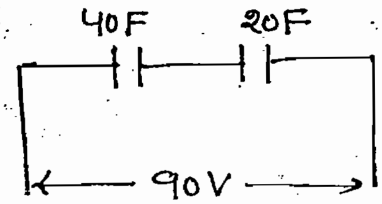




Ques:- When two capacitance 40F & 20F are connected in series with a source voltage 90V. When two capacitor charged fully then they are connected in parallel. Find voltage across capacitor in parallel branch.

(a) 40V (b) 60V (c) 45V (d) 30V

Soln:-

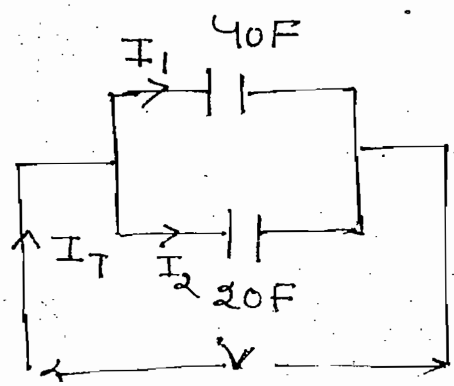


$$C_{eq} = \frac{40\times20}{40+20} = \frac{40}{3}$$

$$Q = C_{eq}V = \frac{40}{3}\times 90$$

$$= \cancel{90}\ 1200C$$

$$Q_T = 1200 + 1200 = 2400C$$



$$Q_T = 2400$$

$$C_{eq} = 40+20 = 60$$

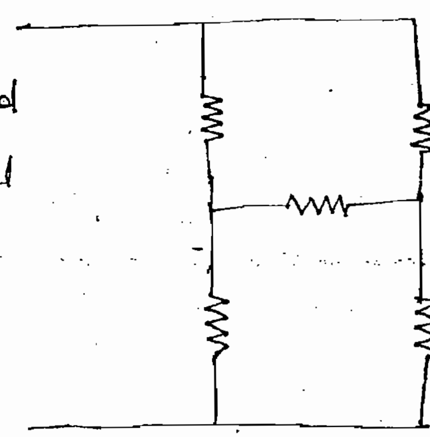
$$V = \frac{Q_T}{C_{eq}} = \frac{2400}{60}$$

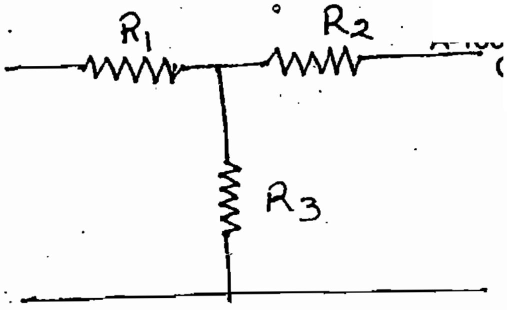
$$= 40V \text{ , Ans}$$

~~Ques~~:-

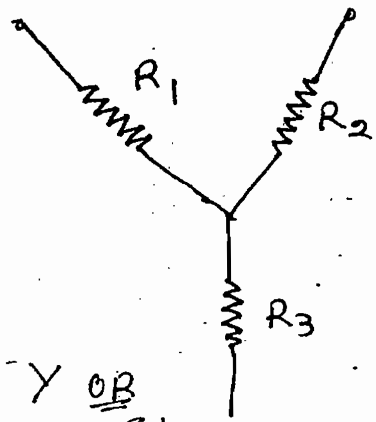
Note:-

When elements are connected not in series nor in parallel network is reduced by Star-delta transformation

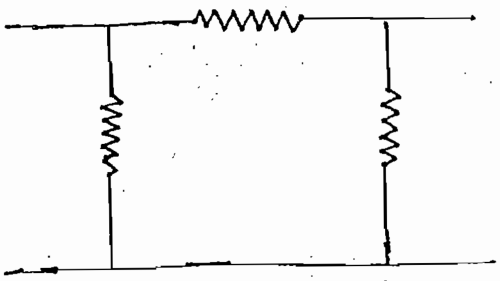




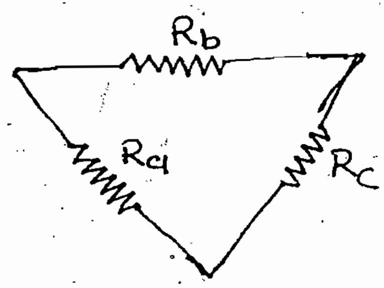
T



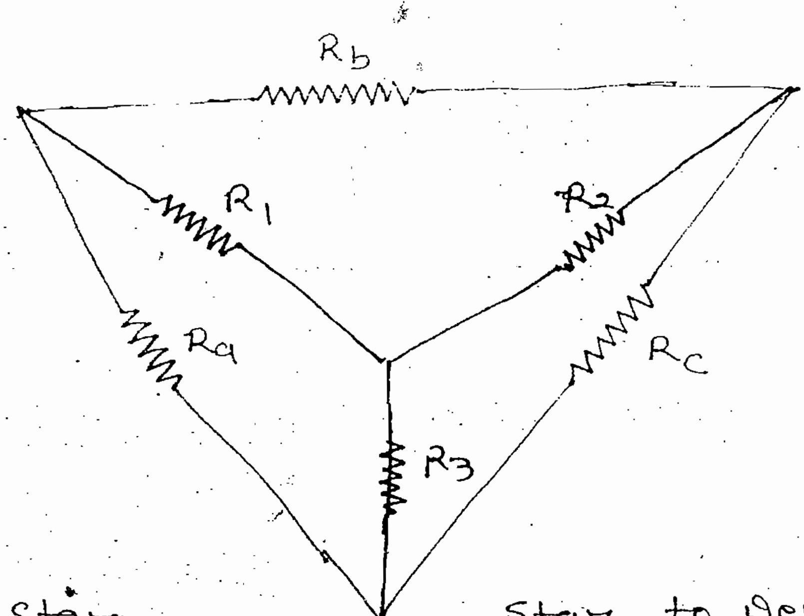
Y OR Star



π



Delta or Mesh



Delta to Star

$$R_1 = \frac{R_a R_b}{R_a + R_b + R_c}$$

$$R_2 = \frac{R_b R_c}{R_a + R_b + R_c}$$

$$R_3 = \frac{R_a R_c}{R_a + R_b + R_c}$$

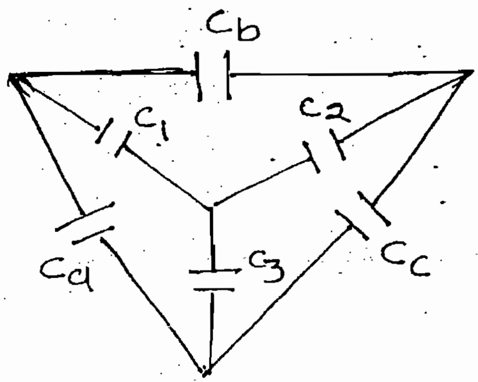
Star to Delta

$$R_a = \frac{R_1 R_2 + R_2 R_3 + R_3 R_1}{R_2}$$

$$R_b = \frac{R_1 R_2 + R_2 R_3 + R_3 R_1}{R_3}$$

$$R_c = \frac{R_1 R_2 + R_2 R_3 + R_3 R_1}{R_1}$$

→ The procedure of transformation either from delta to star or star to delta for the resistor, inductor and impedance is same



Delta to Star :-

$$\frac{1}{C_1} = \frac{\frac{1}{C_a} \cdot \frac{1}{C_b}}{\frac{1}{C_a} + \frac{1}{C_b} + \frac{1}{C_c}}$$

$$\frac{1}{C_2} = \frac{\frac{1}{C_b} \cdot \frac{1}{C_c}}{\frac{1}{C_a} + \frac{1}{C_b} + \frac{1}{C_c}}$$

$$\frac{1}{C_3} = \frac{\frac{1}{C_a} \cdot \frac{1}{C_c}}{\frac{1}{C_a} + \frac{1}{C_b} + \frac{1}{C_c}}$$

Star to Delta :-

$$\frac{1}{C_a} = \frac{\frac{1}{C_1}\frac{1}{C_2} + \frac{1}{C_2}\frac{1}{C_3} + \frac{1}{C_3}\frac{1}{C_1}}{1/C_2}$$

$$\frac{1}{C_b} = \frac{\frac{1}{C_1}\frac{1}{C_2} + \frac{1}{C_2}\frac{1}{C_3} + \frac{1}{C_3}\frac{1}{C_1}}{1/C_3}$$

$$\frac{1}{C_c} = \frac{\frac{1}{C_1}\frac{1}{C_2} + \frac{1}{C_2}\frac{1}{C_3} + \frac{1}{C_3}\frac{1}{C_1}}{1/C_1}$$