Electrical Engineering in India

Introduction:— Electrical Engineering begin at the end of 19th Century

* Power Supply Start in "Darjeeling" at 1897
* Start Shivasamudra Hydro Plant in 1902 in Karnataka
* Total Capacity of Electrical Power = 1,18,419 MW (31 March 2015)
  2,74,818 MW (30 June 2015)
  = 1400 MW (1947)
* Total Capacity of Electrical Power in UP = 4120 MW
* Per person Electrical power = 130 kwh (2002-03)
* There is 1,25000 villages where is not Electric Supply
* Nuclear Power in India = 4120 MW
* Electric Track of Railway = 17500 km 28% (31 March 2...)
* Total Reactor in India = 14

Mohd Munfaid
Power System

② Molecules

↕

Atom —centre→ Nucleus → Proton + Electron; Nucleus → Neutron

Combination of similiar Atom → Element

" " dissimilier " → Compound

Total No. of element – 106

Compound → ∞

Current :→ Transfer of charge from one point to other is termed as Electric Current.

Net motion of Electron

1 electron charge → 1.6021×10^{-19} Coulomb

1.6021×10^{-19} coulomb charge have – 1 electron

1 " " " $= \dfrac{1}{1.6021 \times 10^{-19}}$

$= 6.24 \times 10^{18}$

Time rate of flow of free electron

Current $I(t) = \dfrac{d}{dt} q(t) = \dfrac{\text{Coulomb}}{\text{Second}} =$ Ampere (A)

Termed in honour of The French Physicist Andre Marie Ampere (1775 – 1836)

French word intensite(I) = Current

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Voltage / Potential difference :→ Time derivative of the flux ϕ:

$$V(t) = \frac{d}{dt}\phi(t) = \frac{\text{Weber}}{\text{Second}} = \text{volts (V)}$$

Termed in honour of italian Physicist Allessandro Volta (1745-1827)

* Power :- Product of instantaneous value of voltage and current

$$P(t) = V(t)\, i(t) = \text{Power} \Rightarrow \text{watt.}$$

British Inventor James watt (1738-1819)

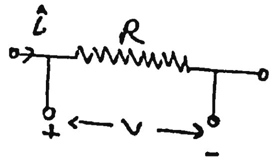
* Energy Delivered :-

$$E(t_0 - t) = \int_{t_0}^{t} P(x)\,dx = \int_{t_0}^{t} V(x)\, i(t)\,dx = \text{watt second}$$

Joule

British Scientist J.P. Joule (1818 – 1869)

Resistance :- (R)



$V = Ri$ (ohm law)

The property of a material which oppose the flow of electron is called resistance

George Simon Ohm (1787-1854). German mathematician

By experiment

$$R \propto \frac{l}{A} \equiv R = \rho \frac{l}{A}$$

ρ = specific resistance or resistivity

A = Area of conductor

l = length of conductor

Conductance $(G) = \frac{1}{R}$

$R = \rho \frac{l}{A}$

$G = \frac{1}{\rho}\frac{A}{l} = \sigma \frac{A}{l}$

σ = Conductivity

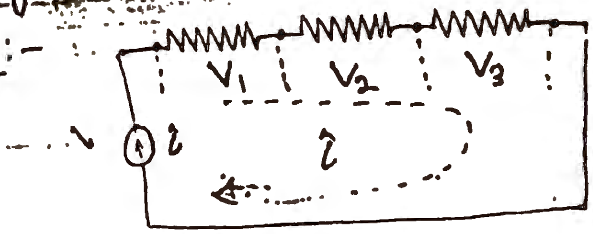
Temperature effect

$R_t = R_0(1 \pm \alpha t)$

α = Temperature coefficient

Combination of Resistance:-

In Series:-



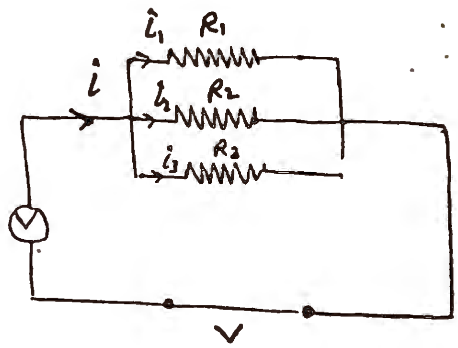
Current Same
Voltage difference

$$V = V_1 + V_2 + V_3 \qquad V = IR$$

$$IR = IR_1 + IR_2 + IR_3$$

$$\boxed{R = R_1 + R_2 + R_3}$$

In Parallel:-



Voltage Same
Current different

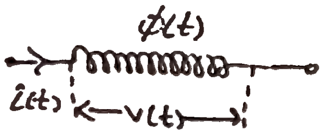
$$I = I_1 + I_2 + I_3$$

$$\frac{V}{R} = \frac{V}{R_1} + \frac{V}{R_2} + \frac{V}{R_3}$$

$$\boxed{\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}}$$

* **Inductance (L):** → It is the property of the material (Conductor) by virtue of which it oppose the change in direction or magnitude of current.

~~$L \propto \phi$~~ $\frac{}{I}$



$$L = \frac{N\phi}{I}$$

N = Number of turns
ϕ = flux in weber
I = Current

Current flow ⟶ change in flux ⟶ Voltage Induced

Scond ... difference

$\therefore V \propto \frac{di}{dt}$

1)

$V = L\frac{di}{dt} \Rightarrow L = \frac{V}{\frac{di}{dt}} = \frac{V\,dt}{di} = \frac{d\phi}{di}$

$V = L\frac{di}{dt} = L\frac{d}{dt}(I_m \sin\omega t)$

$\Rightarrow L I_m \omega \cos\omega t = I_m \omega L \sin(\omega t + \pi/2)$

$V = \omega I_m L \sin(\omega t + \pi/2)$

$V = \omega L\, I_m \sin(\omega t + \pi/2)$ X_L = Inductive reactance in Ohm

$V_m = X_L I_m$

$\boxed{X_L = \omega L}$

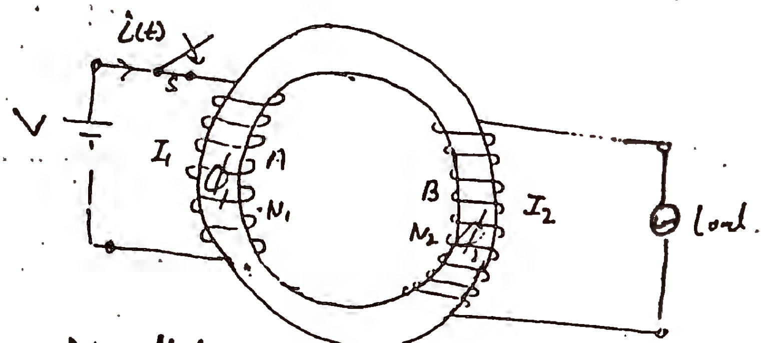
By experiment $L = \frac{\mu_0 \mu_r N^2 A}{l}$ = Henry $\mu_0 \mu_r$ = Permiability

Combination of Inductance:—

In Series:— $L = L_1 + L_2 + L_3 + L_4 + \ldots\ldots$

in Parallel: $\frac{1}{L} = \frac{1}{L_1} + \frac{1}{L_2} + \frac{1}{L_3} + \frac{1}{L_4} + \ldots\ldots$

Mutual Inductance



$M = \frac{\mu_0 \mu_r N_1 N_2 A}{l}$

$M = K\sqrt{L_1 L_2}$

$M = \frac{N_1 N_2}{S}$

$\boxed{M = K\sqrt{L_1 L_2}}$

S = Relectance of the coil

Energy Store $= \frac{1}{2} L I^2$

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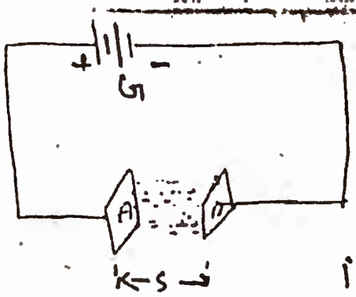
Capacitance (C) :- Farad

A.C. Through Resistance only



$Q \propto V$

$Q = CV$

$C = \frac{Q}{V}$ Farad

in honour Michael Faraday

- The reciprocal of Capacitance is called Elastance

$C = \frac{\epsilon_0 \epsilon_r A}{d}$ Farad

↙ dielectric

$q \propto v \Rightarrow q = cv \Rightarrow c = \frac{q}{v}$

$i = \frac{dq}{dt} = c\frac{dv}{dt} \Rightarrow i = c\left(\frac{dv}{dt}\right) \Rightarrow \int dv = \frac{1}{c}\int i\,dt$

$$v(t) = \frac{1}{c}\int_0^t i(t)\,dt + \left(\frac{q(0)}{c}\right)$$

$v = V_m \sin \omega t$

$i = c\left(\frac{dv}{dt}\right) = c\frac{d}{dt}(V_m \sin \omega t) = cV_m \omega \cos \omega t$

$i = I_m \sin(\omega t + \pi/2)$

$V_m = \frac{I_m}{\omega c} = I_m X_c$

$$X_c = \frac{1}{\omega c}$$

Energy Store $= \frac{1}{2}cv^2$

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A.C. Through Resistance, Inductance, Capacitance only:--

Resistance only:- $V = V_m \sin\theta = V_m \sin\omega t$ $\quad V = IR$

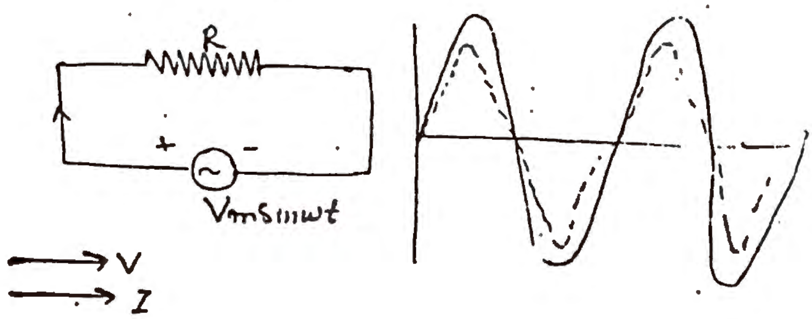
$V = IR$

$IR = V_m \sin\omega t$

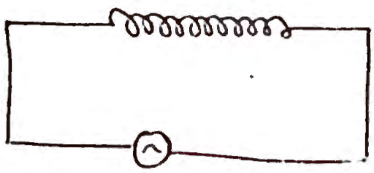
$i = \frac{V_m}{R} \sin\omega t \Rightarrow \hat{i} = \frac{V_m}{R}$ while $\sin\omega t$ is unity

$\hat{i} = \frac{V_m}{R}$

$\boxed{i = I_m \sin\omega t}$



Inductance only:→

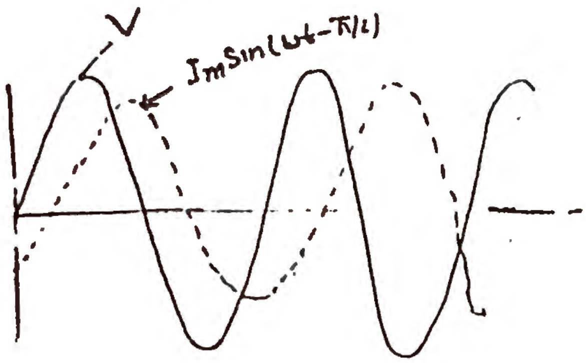


$V = L\frac{di}{dt}$

$V = V_m \sin\omega t \quad \ldots\ldots (I)$

$L\frac{di}{dt} = V_m \sin\omega t$

$di = \frac{V_m}{L} \sin\omega t \, dt$



Integrating on both side

$i = \frac{V_m}{L}\int \sin\omega t \, dt$

$= \frac{V_m}{\omega L}(-\cos\omega t)$

$i = \frac{V_m}{\omega L}\sin(\omega t - \pi/2)$

$i = I_m \sin(\omega t - \pi/2) \quad \ldots (II)$

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Capacitance only:- it charged first in one direction and then in the opposite direction.

$q = CV$

$q = CV_m \sin\omega t$

$i = \frac{dq}{dt} = \frac{d}{dt}(CV_m \sin\omega t) = \omega C V_m \sin\omega t$

$i = \frac{V_m}{1/\omega C} \cos\omega t = \frac{V_m}{1/\omega C} \sin(\omega t + \pi/2)$

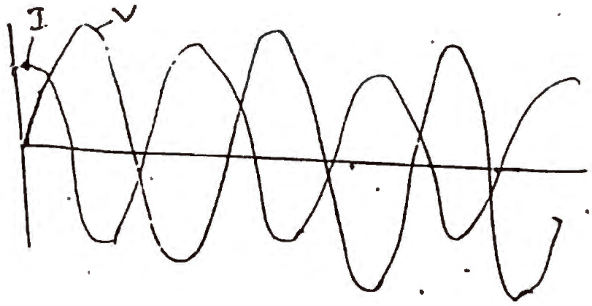
$I_m = \frac{V_m}{1/\omega C} = \omega C V_m$

$i = I_m \sin(\omega t + \pi/2)$

$$\boxed{X_C = \frac{1}{\omega C}}$$

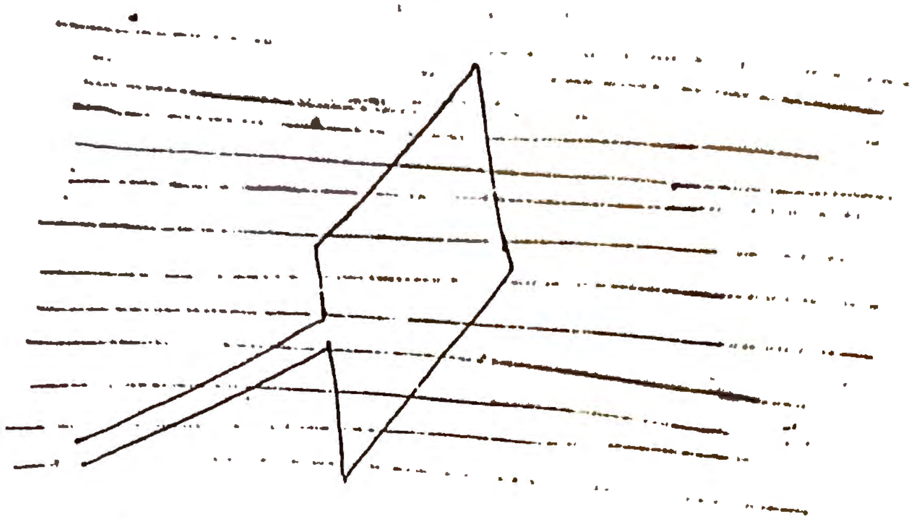
$V = V_m \sin\omega t$

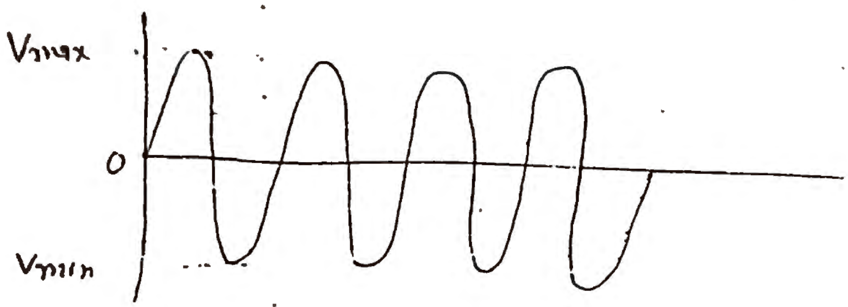
$i = I_m \sin(\omega t + \pi/2)$



A.C. Fundamental:-

H





When a rectangular coil of area $A\,m^2$ rotates in a flux density of B Tesla at an angular frequency (ω) radian per second. Therefore then the emf induced in that coil

$$e = \omega BA \sin\theta$$

if there are N turns then

$$e = \omega NBA \sin\theta$$

$$e = E_{max} \sin\theta$$

$$e = E_{max} \sin\omega t$$

For Phase difference (ϕ)

$$i = I_{max} \sin(\omega t \pm \phi)$$

$$e = E_{max} \sin(\omega t \pm \phi)$$

R.M.S value $I_{rms} = \sqrt{\dfrac{I_1^2 + I_2^2 + I_3^2 \ldots}{n}}$

220 volt

$I_{rms} = \dfrac{I_0}{\sqrt{2}}$ $V_{rms} = \dfrac{V_0}{\sqrt{2}}$ 310 volt

Average value $I_{avg} = \frac{I_1 + I_2 + I_3 + \dots I_n}{n}$

For sinusoidal current

$$I_{rms} = \frac{I_m}{\sqrt{2}}$$

$$I_{avg} = \frac{2I_m}{\pi}$$

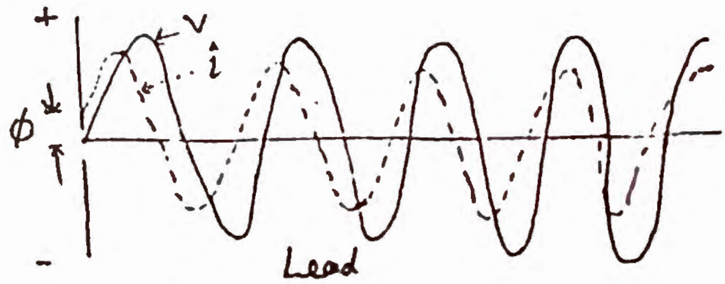
* Frequency of voltage & current is same in A.C. current

Form factor = $\frac{\text{r.m.s. value}}{\text{Average Value}}$

Peak factor = $\frac{\text{Maximum Value}}{\text{r.m.s. Value}}$

Power = $V_{rms} \times I_{rms} = VI\cos\phi$

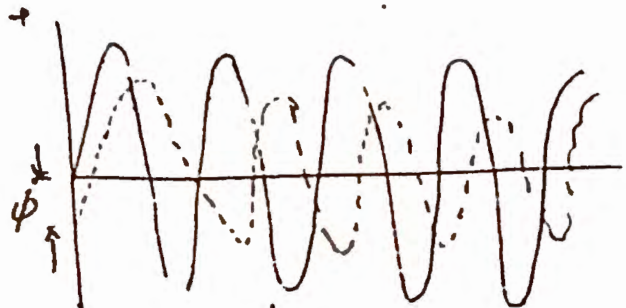
Phase difference :→ ϕ



Lead

$V = V_0 \sin\omega t$

$i = I_0 \sin(\omega t + \phi)$



lag

$V = V_0 \sin\omega t$

$i = I_0 \sin(\omega t - \phi)$

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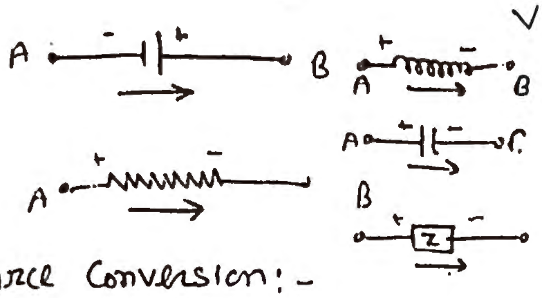
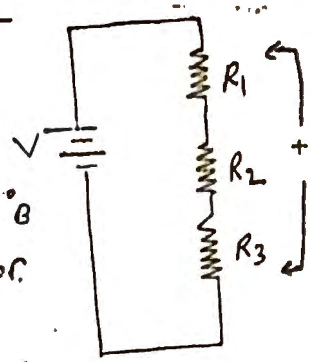
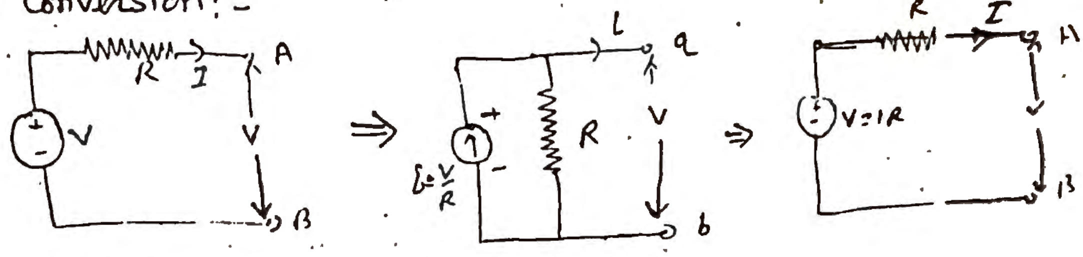
Voltage Divider formula:-



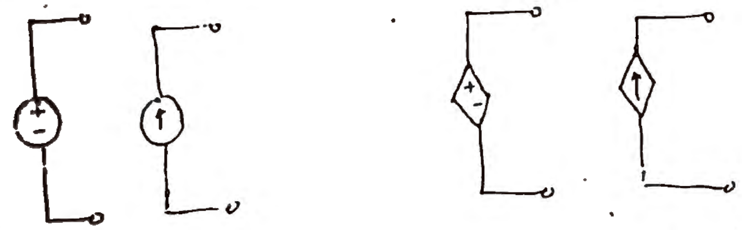


$V_1 = V \frac{R_1}{R}$

Source Conversion:-



Independent Source   Dependent Source



Absolute Permeability $\mu = \frac{B}{H} = \frac{\text{Flux density}}{\text{Magnetising Force}}$

Relative Permeability $\mu_r = \frac{\text{Flux density in the media}}{\text{Flux density in the vaccum}}$

Susceptibility $(K) = \frac{I}{H}$

Reluctance:- Property of a material which opposes the creation of magnetic flux

$\text{Reluctance} = \frac{l}{\mu_0 \mu_r A} = \frac{l}{\mu A}$

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Network Theorem

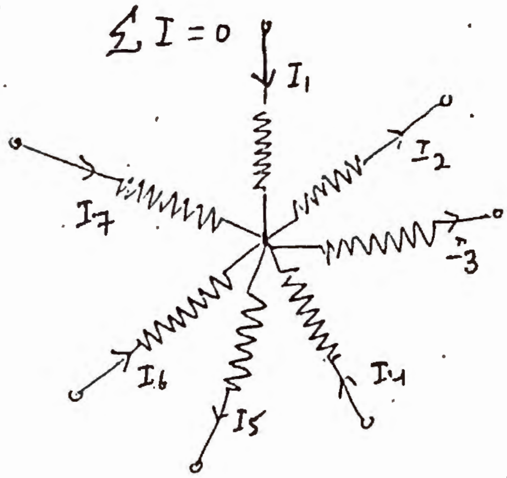
Network Theorem are used for solving various network it save time and Considerably reduce the laborious Mathematical work.

Kirchhoff's laws:-

(i) Kirchhoff's first law or Point law or Current law (KCL)

Statement:- The algebric sum of the current meeting at a Point (or junction) is zero

$\Sigma I = 0$



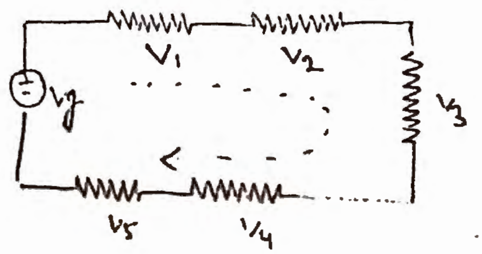
$I_1 + (-I_2) + (-I_3) + I_4 + (-I_5) + I_6 + I_7 = 0$

जो दूर जा रहा है (−)

(ii) Kirchhoff's Second law or Mesh law or voltage law (KVL)

Statement:- The algebric sum of all branch voltage around ~~and~~ any closed loop of a network is zero at all direction instant of it.

$\Sigma V = 0$

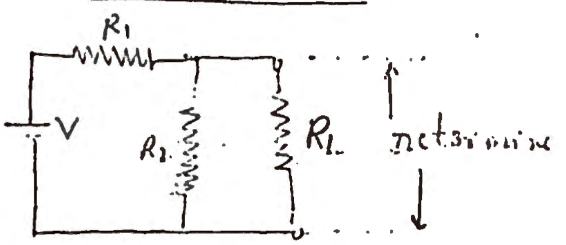


$-V_g + V_1 + V_2 + V_3 + V_4 + V_5 = 0$

(1) Superposition Theorem:- The Statement of Superposition Theorem is that
" The response in any element of linear, bilateral network containing more than one sources is the sum of the response produced by the sources each acting independently"
it is aplicable for those network which contain more than one voltage and current sources.

(2). Tievenin Theorem:- " Any two terminal network when viewed from its any two point can be replaced by a single voltage sources in series with a single resistance".
The equivalent voltage source is designated by V_{Th} and the equivalent resistance R_{th}

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



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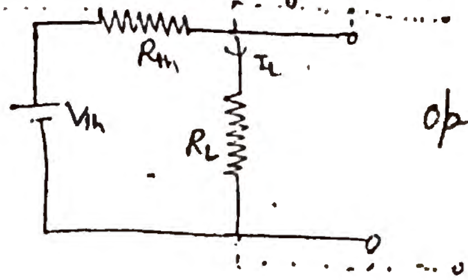
Step 1:- Remove the RL from the circuit terminals ...



open circuit Vth

Step 2:→ Determine open circuit voltage of

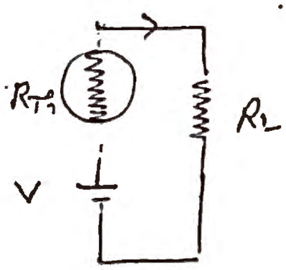
$$I = \frac{V}{R_1+R_2}$$

$$V_{Th} = \frac{V}{R_1+R_2} \cdot R_2$$

Step 3:- Remove the battery from the circuit and determine the Rth from A and B

$$R_{Th} = R_1 \parallel R_2 \Rightarrow \frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} = \frac{R_1+R_2}{R_1 R_2} \Rightarrow R = \frac{R_1 R_2}{R_1+R_2}$$

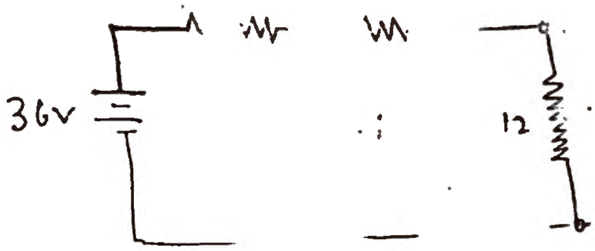
Step 4:→ Determine I



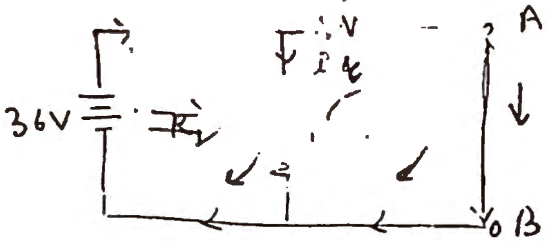
$$I = \frac{V_{Th}}{R_{Th}+R_L}$$

Norton Theorem:→ Any two terminal linear network containing energy sources and impedance can be replaced by a simple two terminal network consisting of a single current source I_N in parallel with impedance Z_N

$$I = I_N \times \frac{Z_N}{Z_N + Z}$$



Step 1:- Short ... which the current is to b... ...t



$$-36 + 3I_1 + 6(I_1 - I_2) = 0$$

$$4I_2 + 6(I_2 - I_1) = 0$$

$$9I_1 - 6I_2 = 36 \cdots (1)$$

$$-6I_1 + 10I_2 = 0 \cdots (2)$$

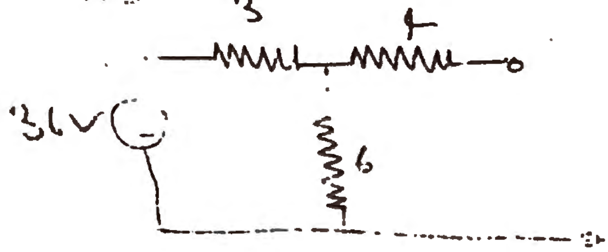
$$I_2 = 4$$

$$R = 3 + 4 \| 6$$

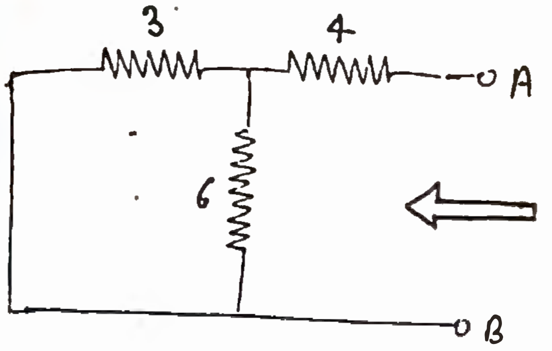
$$= 3 + \frac{4 \times 6}{4+6} = 3 + \frac{24}{10} = 3 + 2.4 = 5.4\Omega$$

$$I = \frac{36}{5.4} = \frac{20}{3} A$$

Step 2:- Remove the short circuit terminal from AB



Step 3:- Remove the Battery and Determine R_N from it



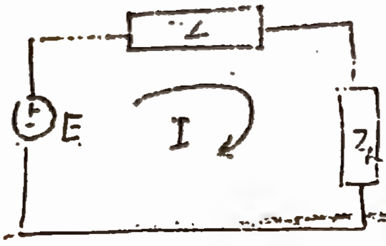
$$R_N = 4 + 3 \parallel 6 = 4 + \frac{3 \times 6}{3+6} = 4 + \frac{18}{9} = 4+2 = 6\Omega$$

Step 4:- Determine I from formula

$$I = I_N \cdot \frac{Z_N}{Z_N + Z_L} = 4 \cdot \frac{6}{6+12} = \frac{24}{18} = \underline{1.33 A}$$

Maximum Power Transfer Theorem:- The statement is as

Maximum power will be delivered by a network to a Impedance Z_R if the impedance of Z_R is the Complex Conjugate of the impedance Z of the network, Measured looking back into the terminal of the Network.



$$I = \frac{E}{Z + Z_R} = \frac{E}{(R + R_L)}$$

Power delivered to the load is

$$P = \frac{(E)^2 R_R}{(R_R+R)^2 + (X_R+X)^2}$$

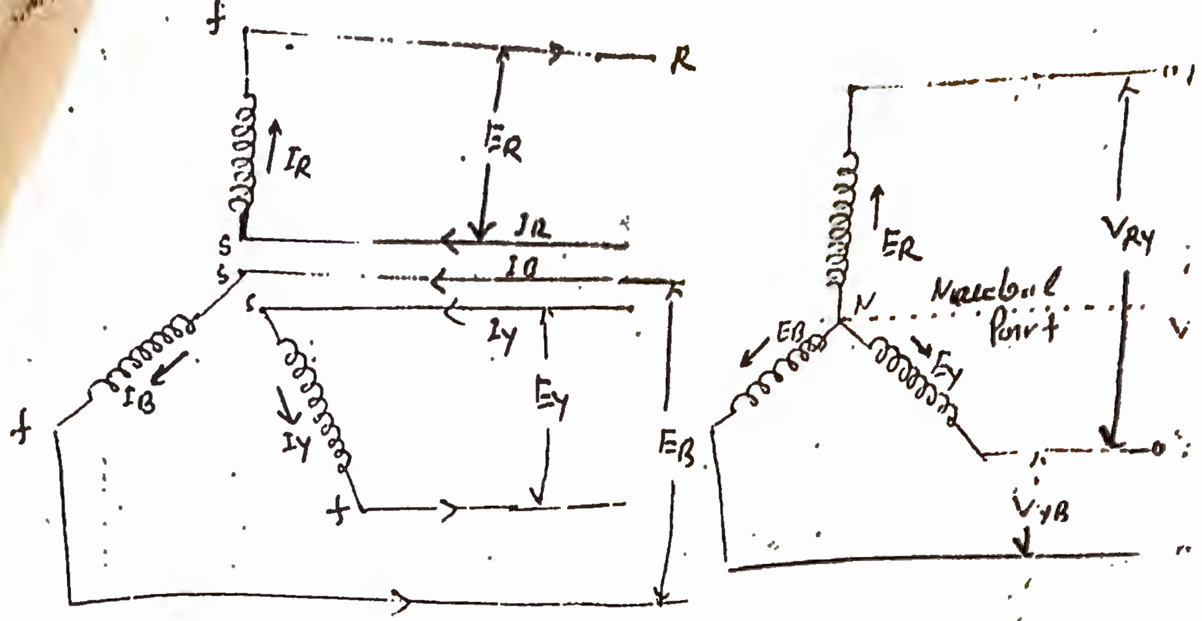
$Z = R + jX$

$Z_R = R_R + jX_R$

$$\boxed{P = \frac{E^2}{4 R_R}}$$

Three Phase A.C. circuit

Star or wye (Y) Connected System:-



The voltage between any line and the neutral Point means voltage across the Phase winding is called phase Voltage.

The voltage between any two outer is called line voltage. The neutral point is usually earth connected. The Positive direction of emf taken from Star Point outer.

Assume $V_R = V_Y = V_B = V_{ph}$

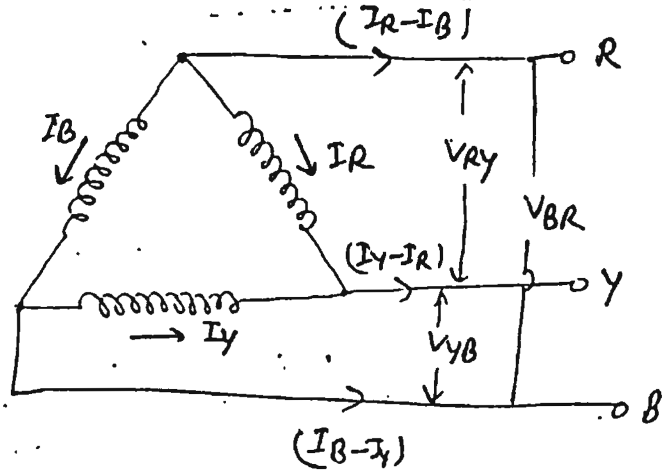
$V_{RY} = V_{YB} = V_{BR} =$ line voltage V_L

$$V_L = \sqrt{3}\, V_{ph}$$ $$I_L = I_{phase}$$

Total Active Power $= \sqrt{3}\, V_L I_L \cos\phi$

Reactive " $= \sqrt{3}\, V_L I_L \sin\phi$

[illegible] connected System:-



When the starting end of one coil is connected to the finishing end of another coil then Delta connection is obtained

$V_L = V_{ph}$

$I_L = \sqrt{3}\, I_{PH}$

Total active Power / Phase

$= V_P I_P \cos\phi$

Total $P = \sqrt{3}\, V_L I_L \cos\phi$

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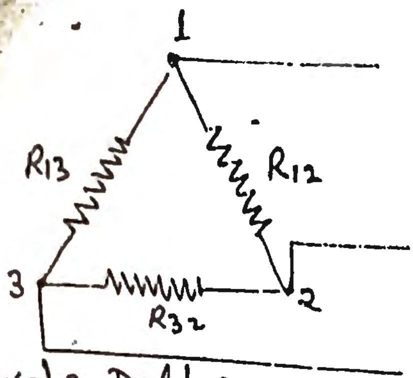
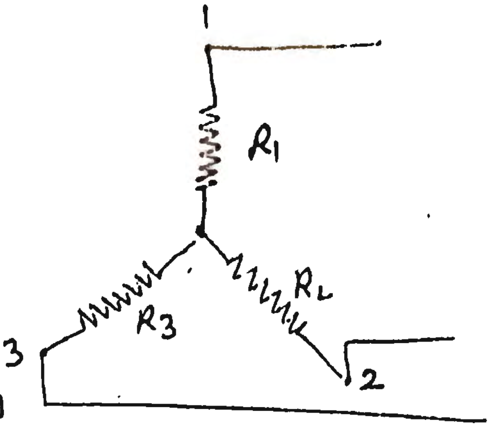
Delta Transformation:-





Star to Delta Transformation

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

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

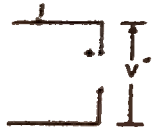
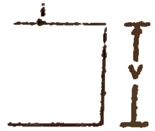
$$R_{13} = R_1 + R_3 + \frac{R_1 R_3}{R_2}$$

Δ To Start Transformation

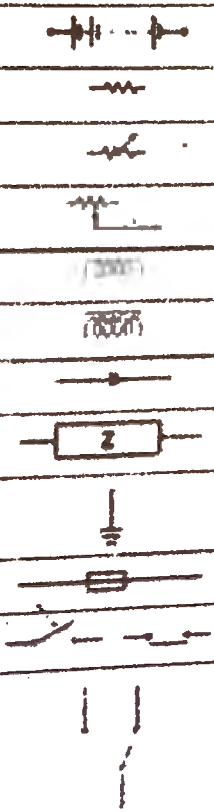
$$R_1 = \frac{R_{12} R_{13}}{R_{12} + R_{23} + R_{13}}$$

$$R_2 = \frac{R_{23} R_{12}}{R_{12} + R_{23} + R_{13}}$$

$$R_3 = \frac{R_{13} R_{23}}{R_{12} + R_{23} + R_{13}}$$

8. *Open circuit*		*I is zero for all v*
9. *Short circuit*		*V is zero for all i*

Quantity	Symbol
10. Battery	
11. Fixed resistor	
12. Variable resistor	
13 Voltage divider	
14. Inductor	
15. Inductor with iron core	
16. Capacitor	
17. Impedance	
18. Earth	
19. Fuse	
20. Switch contacts (general)	
21. Change-over switch	



23. Lamp or Bulb	
24 Transformer with iron core	
25. Auto-transformer	
26 Three-phase transformer, star-delta connections	
27. DC generator, DC motor	
28. AC generator, AC motor	
29. DC generator, separately excited	
30 DC shunt generator	
31 DC series motor	
32. DC compound motor	

Units of Length, Volume, Mass and Time

Quantity	Unit	Symbol
Length	metre	m
	kilometre	km
Volume	cubic metre	m^3
	litre (0.001 m^3)	l