UNIT

1

< D.C Circuit Analysis >

Qus.1 > Explain Active and passive element

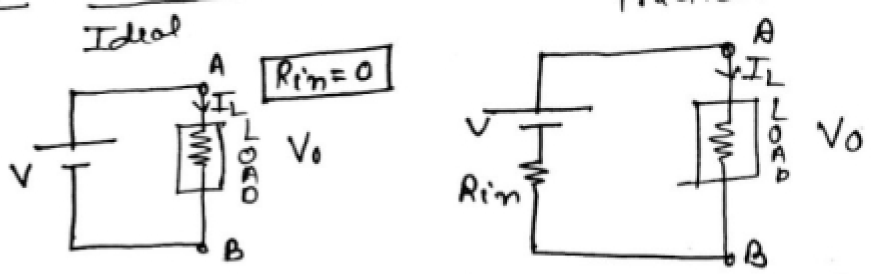
Ans.> The element which supply energy to Network are known as Active element
Ex.→ Voltage Source, current Source etc.
The elements which dissipate or store energy are known as passive element
Ex.→ Resistor, Inductor and Capacitor.

Qus.2> Define unilateral and bilateral elements.

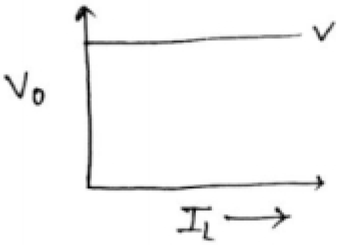
Ans> Unilateral→ The elements whose property Depend upon the Direction of current are known as Unilateral elements.
Ex.→ Diode, Transistor, etc.
Bilateral→ The elements whose properties Does not Depend upon the Direction of current are known as bilateral elements.
Ex.→ Resistor, Inductor and Capacitor

Qus.3> Explain Ideal and practical Voltage and current Source→

Ans.> Ideal & Practical Voltage Source >

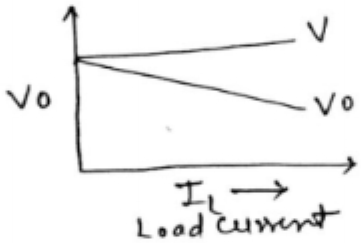


* The Source which maintain a Constant Voltage across the load irrespective of the load current. is known as Ideal Voltage Source.



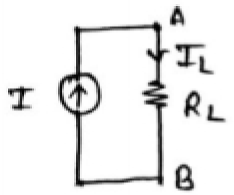
$$V_0 = V$$

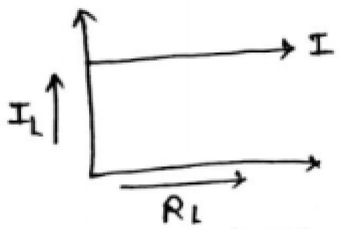
Practical Voltage Source → the Source whose output terminal Voltage Decreases as we Increase the load current is known as Practical Voltage Source



$$V_0 = V - I_L R_{in}$$

* Ideal Current Source → the Source which delivers Constant current to the load Irrespective of the load resistance

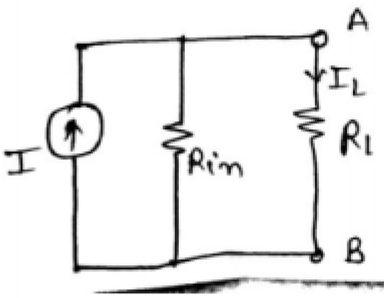


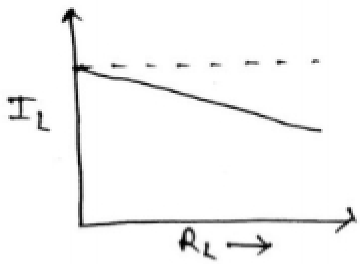


$$I_L = I$$

* Internal Resistance of Ideal Current Source is ∞

* Practical Current Source → The Source whose output current Decreases as we Increase the Load Resistance is known as Practical Current Source

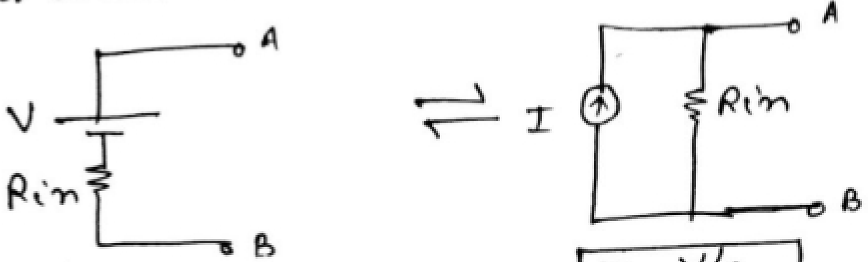




$$I_L = \frac{I R_{in}}{R_{in} + R_L}$$

Ques.3> What is Source Transformation?

Ans.→ For the Simplification of Complex Network and Practical Voltage Source can be Converted Into a Practical Current Source and Vice versa. This Conversion is known as Source Transformation.



$V = I R_{in}$ $I = V/R_{in}$

* for Conversion Internal Resistance remains unchanged
* $I = V/R_{in}$ for Voltage to Current Source Conversion.
* $V = I R_{in}$ for Current to Voltage Source Conversion

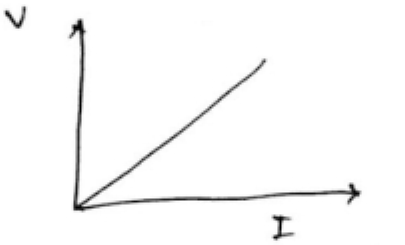
Ques.4> Explain Linear & Non linear elements.

Ans.→ The elements Whose V-I charachteristics is straight-line are known as Linear elements.

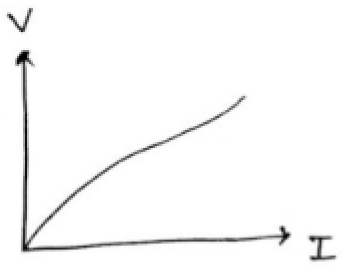
ex.→ Resistor, Inductor & Capacitor

The elements Whose V-I charachteristics is other than straight line is known as Non-linear elements

Ex.→ Diode



Linear elements



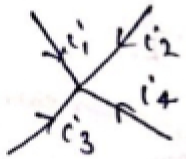
Non linear elements

Que.5 → Differentiate between Mesh & loop.

Ans. → Any closedpath in a given Network is known as loop.
The loop which does not contain any other loop whithin it is known as Mesh.

Que.6 → What is KCL & KVL Explain their limitation?

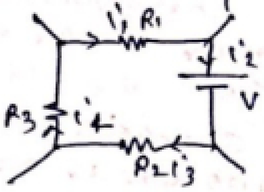
Ans. → (i) Kirchhoff's Current low → (KCL) → according to KCL Algebric sum of All the current entering or leaving at a Node is equal to zero.



$\Sigma I = 0$

$$\boxed{i_1 + i_2 + i_3 + i_4 = 0}$$

(ii) Kirchhoff's Voltage Law > (KVL) this law is applicable in a closed path (loop) according to this law algebraic sum of Voltage and Voltage drop in a closed path is equal to zero.



$i_1 R_1 + V + i_3 R_2 + i_4 R_3 = 0$

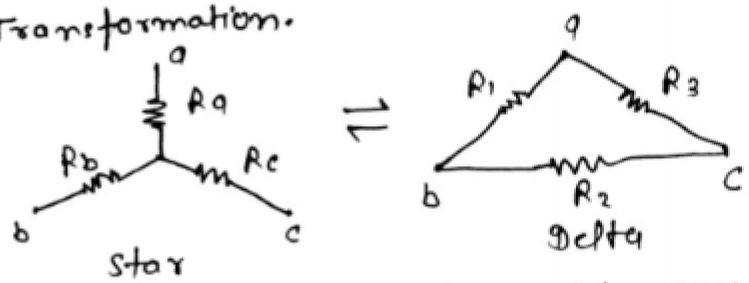
$$\boxed{\Sigma V + \Sigma I_i \cdot R_i = 0}$$

Limitations → (1) KCL & KVL both depend upon lumped element Model only.

(II) KCL, in its usual form is depend upon the assumption that current only flow in Conductor.

Ques.6 > Explain Star - Delta Transformation.

Ans. → For Solving the Complicated Circuits We have to Convert Star Network into Delta Network and Vice - Versa this Conversion is known as Star - Delta Transformation.



* For conversion eq. resistance b/w any two terminal of given Network must be same.

For star Network →

R_{ab_s} (eq. resistance b/w terminal a-b) = $R_a + R_b$

R_{bc_s} (" " " b-c) = $R_b + R_c$

R_{ac_s} (" " " a-c) = $R_a + R_c$

For Delta Network →

R_{ab_D} (eq. resistance b/w terminal a-b) = $R_1 \parallel (R_2 + R_3)$

R_{bc_D} (" " " b-c) = $R_2 \parallel (R_1 + R_3)$

R_{ac_D} (" " " a-c) = $R_3 \parallel (R_1 + R_2)$

⇒ Now for Conversion eq. resistance b/w given terminal of both the network must be same.

$$R_{a-b(S)} = R_{a-b(D)}$$
$$R_{b-c(S)} = R_{b-c(D)}$$
$$R_{a-c(S)} = R_{a-c(D)}$$

Now →

$$R_a + R_b = \frac{R_1(R_2 + R_3)}{R_1 + R_2 + R_3} \quad \text{——— (i)}$$

$$R_b + R_c = \frac{R_2(R_1 + R_3)}{R_1 + R_2 + R_3} \quad \text{——— (ii)}$$

$$R_a + R_c = \frac{R_3(R_1 + R_2)}{R_1 + R_2 + R_3} \quad \text{——— (iii)}$$

by Solving eq. (i) (ii) & (iii)

* For star to Delta →

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

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

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

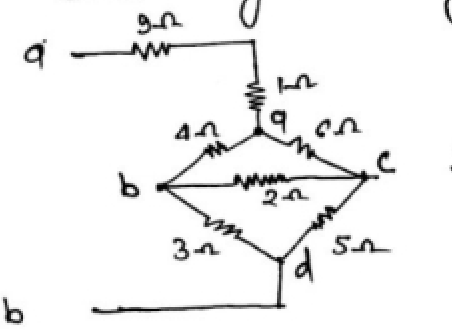
* For Delta to Star →

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

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

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

Que. → Solve the given ckt by star - Delta Transformation →



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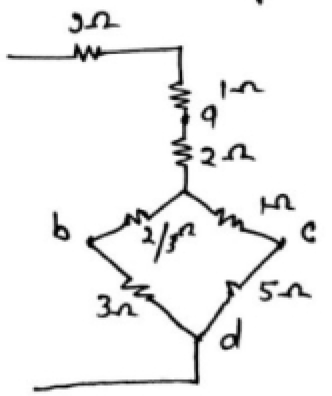

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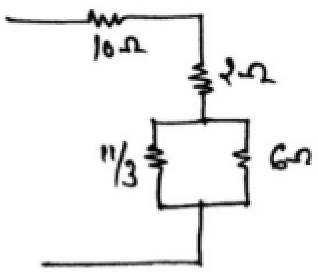


$R_{ab} = 16.276\,\Omega$ Ans

Ques. 7> Write the statement of following Theorem.
(i) Superposition Theorem (ii) Thevenin Theorem
(iii) Norton's Theorem

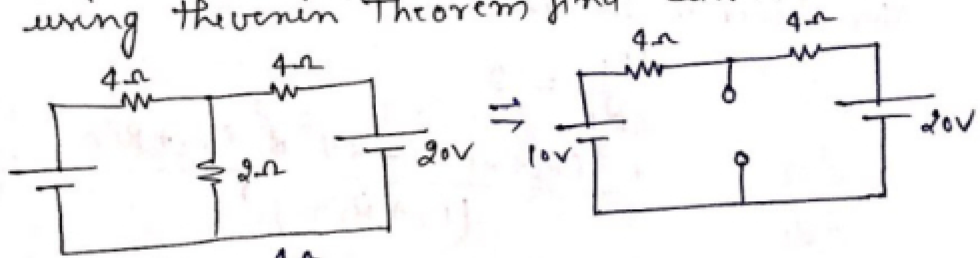
Ans. 7> (i) Superposition Theorem> according to this Theorem in a linear resistive network containing two or more voltage sources the current through any element may be determined by adding together algebraically the current produced by each source acting alone, when all other sources are deactivated.

(ii) Thevenin's Theorem> According to this Theorem any complicated two terminal electrical Network can be converted into a Voltage source (V_T) and resistance (R_T) in series.

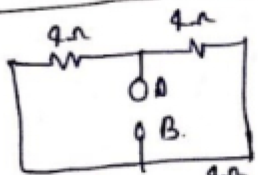
(iii) Norton's Theorem> According to this Theorem any complicated two terminal electrical Network can be converted into a current source (I_S) and Resistance (R_N) in Parallel.

Ques. 8> using thevenin Theorem find current in 2Ω.

Ans.>

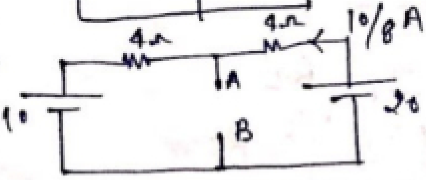


for R_T →



$R_T = 2Ω$

for V_T →



$V_T = V_{AB} = 4 \times 10/8 + 10$

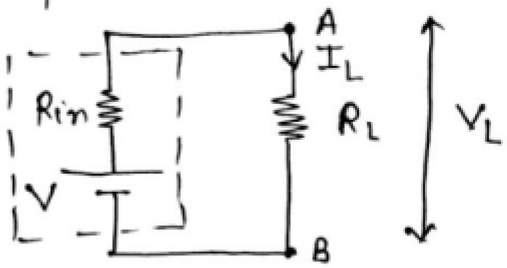
$V_T = 15\ V$

$I = 15/4\ A$ Ans

Que. 9 > State & Prove Max. Power Transfer Theorem

Ans → "According To this Theorem Max. Power is Delievered to the load by a Voltage Source when Internal Resistance of Voltage Source becomes equal to Load Resistance"

Prove →



* Current in load resistance is given by

$$I_L = \frac{V}{R_L + Rin}$$

Now Power Delievered to the load

$$P_L = I_L^2 R_L$$

$$P_L = \left(\frac{V}{R_L + Rin}\right)^2 R_L = \frac{V^2 R_L}{(R_L + Rin)^2}$$

For Power to be maximum

$$\frac{dP_L}{dR_L} = 0$$

$$\frac{dP_L}{dR_L} = \frac{V^2 (R_L + Rin)^2 - 2V^2 R_L (R_L + Rin)}{(R_L + Rin)^4} = 0$$

$$\boxed{R_L = Rin}$$

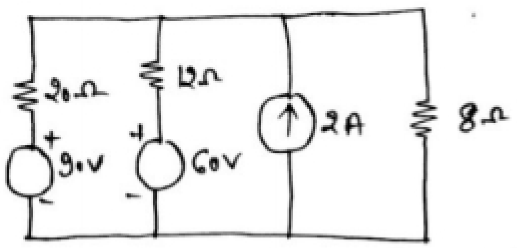
Value of Max. Power →

$$P_{Lmax} = I_L^2 R_L$$

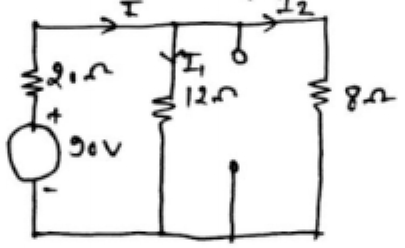
$$= \left(\frac{V}{2Rin}\right)^2 \cdot Rin$$

$$\boxed{P_{max} = \frac{V^2}{4Rin}}$$

Ques.12→ using Superposition Theorem find the current in 20Ω Resistor.

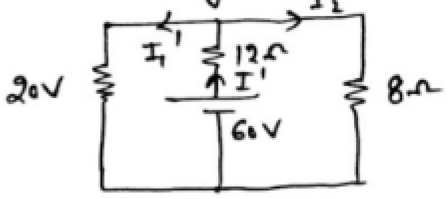


Ans.→ first taking 90V voltage source→



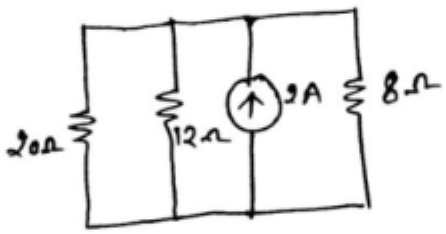
$$R = (12\|8)+20$$
$$= \frac{96}{20} + 20 = 24.8\Omega$$
$$I = \frac{90}{24.8} = 3.63A$$

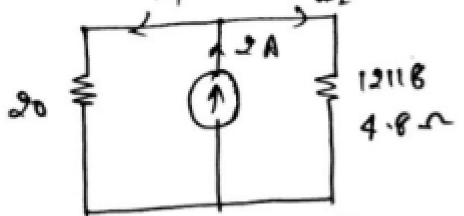
* Now taking 60V voltage source→



$$R = (20\|8) + 12$$
$$= \frac{160}{28} + 12 = 17.71\Omega$$
$$I' = \frac{60}{17.71} = 3.39A$$
$$I_1' = \frac{8}{28} \times I' = 0.97A$$

* Now taking 2A current source

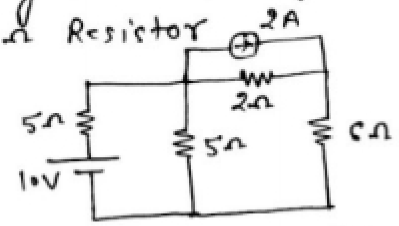




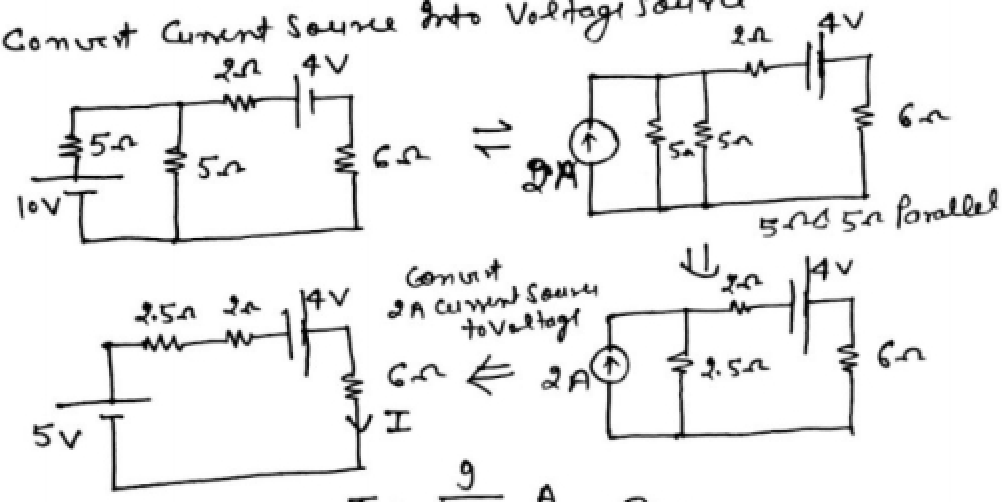
$$I_1'' = \frac{4.8}{24.8} \times 2 = 0.39A$$

total current in 20Ω = 3.63 − 0.97 − 0.39
= 2.27 Am

Que.10 → using Source Transformation find the current in 6Ω Resistor

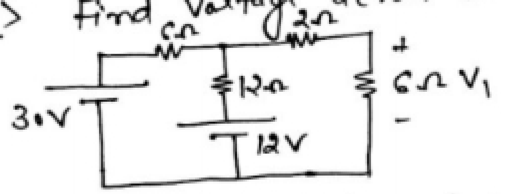


Ans. → Convert Current Source into Voltage Source

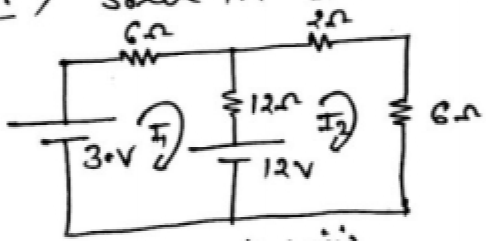


$$I = \frac{9}{10.5}\ A \quad \text{Ans}$$

Que.11 > Find Voltage across 6Ω resistor



Ans. > Solve the Circuit using Maxwell's theorem



apply KVL in loop (i)

$$6I_1 + 12(I_1 - I_2) + 12 - 30 = 0$$

$$3I_1 - 2I_2 = 3 \quad \text{---(i)}$$

apply KVL in loop (ii)

$$-12 + 12(I_2 - I_1) + 2I_2 + 6I_2 = 0$$

$$2I_1 - 3I_2 = -2 \quad \text{---(ii)}$$

Solve the eq. (i) & (ii)

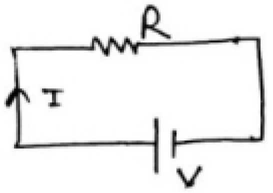
$$I_2 = 12/5 = 2.4\ A$$

Voltage across 6Ω $= 2.4 \times 6$

$= 14.4\ V$ Ans

Ques.12 > Explain R, L & C as a linear element.

Ans. > Resistor >



In case of Resistor ($V = IR$) which is a linear relationship so Resistor is linear element.

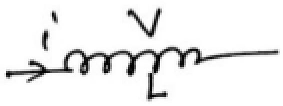
Inductor & Capacitor > both L & C voltage and current as function of time depend in a linear way on each other

Linearity means principal of superposition holds

$$f(ax + by) = a f(x) + b f(y)$$

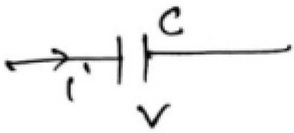
* So In case of Inductor

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



* Capacitor

$$V = \frac{1}{C} \int i \, dt$$



Intigeration & differentiation both follow principal of superposition.

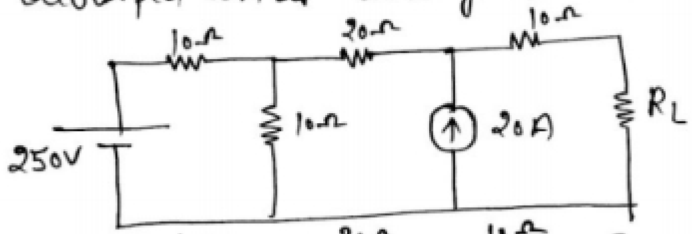
"So R, L, & C are be behaves as a linear element."

$$\boxed{V_1 + V_2 = L_1 \frac{di_1}{dt} + L_2 \frac{di_2}{dt}}$$

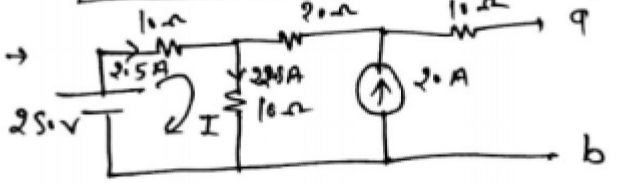
"Linear elements"

$$\boxed{I_1 + I_2 = C_1 \frac{dV}{dt} + C_2 \frac{dV}{dt}}$$

Ques.13> Find the Value of R_L so that Max. Power developed in it also find the Value of Max. Power

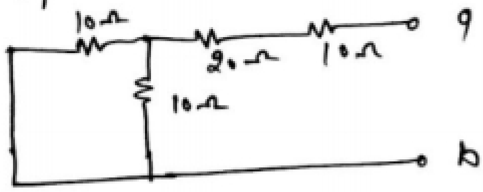


for $V_T \rightarrow$

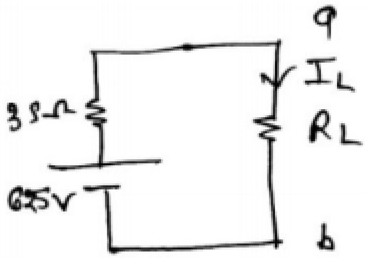


$$V_T = +400V + 225V = 625V$$

for $R_T \rightarrow$



$R_T = 35\Omega$



for Max power $R_L = R_{th}$

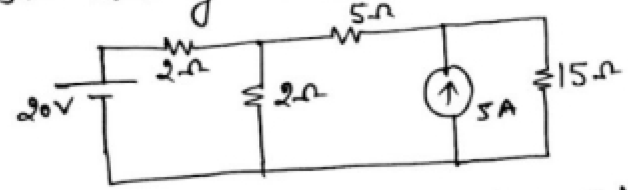
$R_L = 35\Omega$

$$I_L = \frac{625}{70} = 8.926\,A$$

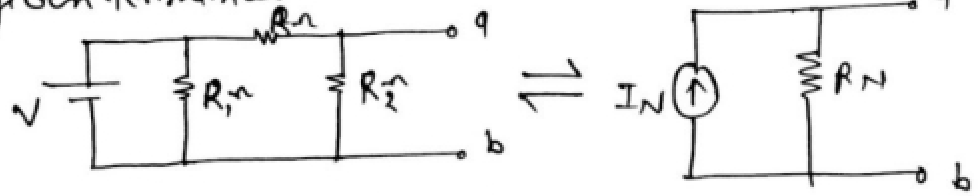
$$P_m = I_L^2 R_L = (8.926)^2 \cdot 35$$

$$\boxed{P_m = 2788.58\,W}$$

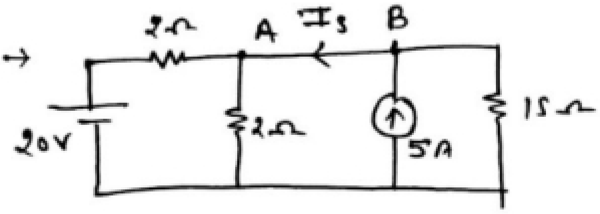
Ques. 14> State Norton's Theorem. Then find current in 5Ω using Norton's Theorem.



Ans. > "According to this Theorem Any linear active, resistive, complicated Network can be converted into a equivalent circuit containing a current Source with Resistance in parallel b/w the given terminal"

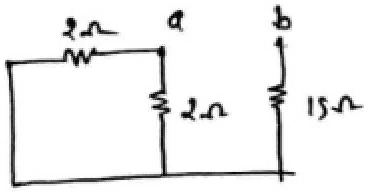


for $I_N \rightarrow$

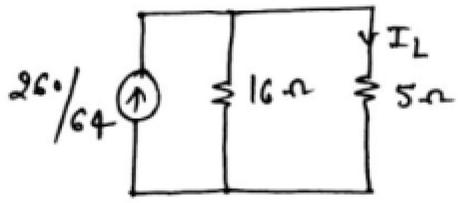


$I_S = 260/64 \text{ A}$

for $R_N \rightarrow$



$R_N = 16\Omega$



$$I_L = \frac{260/64 \times 16}{21}$$

$$\boxed{I_L = \frac{65}{21} \text{ A}}$$ Ans

UNIT

2

UNIT-2 (A.C. Circuits)

Qus.1> For a given A.C. Voltage

$V = 200\sqrt{2}\ \sin(100\pi t - 30^\circ)$

find (i) Max value (ii) r.m.s Value (iii) frequency (iv) Phase angle (v) average value (vi) Angular velocity (vii) Form & Peak Factor

Ans.> $V = 200\sqrt{2}\ \sin(100\pi t - 30^\circ)$

general eq. $V = V_m \sin(\omega t - \phi)$

on comparing → $V_m = 200\sqrt{2}$

$\omega = 100\pi$

$\phi = 30^\circ$

(i) Max Value $V_m = 200\sqrt{2}$

(ii) R.m.s. Value $V_{rms} = V_m/\sqrt{2} = 200$

(iii) $\omega = 2\pi f = 100\pi$

$f = 50\ Hz.$

(iv) $\phi = 30^\circ$ Phase angle $= 30^\circ$

(v) $V_{av} = \frac{2V_m}{\pi} = \frac{400\sqrt{2}}{\pi}$

(vi). angular velocity ⇒ $\omega = 100\pi$ rad/sec.

(vii)

Form Factor $= \frac{V_{rms}}{V_{av}} = \frac{V_m/\sqrt{2}}{2V_m/\pi} = 1.11$

Peak Factor $= 1.414$

Qus. 2> Explain form factor & Crest or Peak factor.

Ans.> (a) Form Factor → The ratio of Effective or R.M.S Value to Average Value is known as Form Factor

$$\text{Form Factor} = \frac{\text{R.M.S Value of A.C}}{\text{Average Value of A.C}}$$

(b) Peak Factor → The ratio of Max. Value to R.M.S. Value is known as peak or Crest Factor.

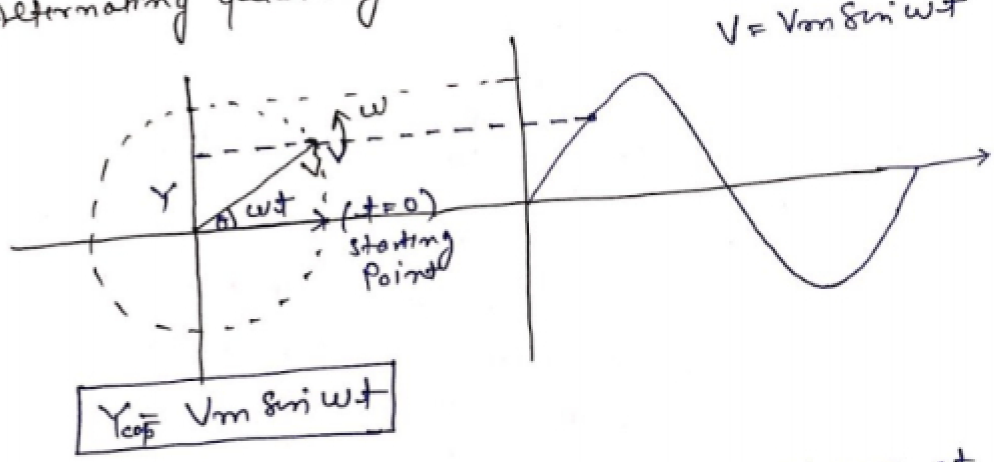
$$\text{Peak Factor} = \frac{\text{Maximum Value of A.C}}{\text{R.M.S Value of A.C.}}$$

Que.3> What is The Physical Significance of Phasor.

Ans.> As we know Alternating quantities change its Magnitude and Direction Continuously So Mathmatical analysis of A.C. is very Complicated For Representing A.C. we use Phasor Method for Simplicity of Mathmatical analysis

Phasor> Phasor is basically a Rotating line Whose Magnitude is equal to R.M.S value of alternating quantity and which is Rotating in anticlockwise direction with angular velocity ω.

" Y component of Phasor gives the Instantanious Value of particular Alternating quantity. the starting point (t=0) of Phasor depend upon the equation of Alternating quantity"



* For Mathmatical Analysis we represent Phasor at (t = 0) only and this is used for addition and Substraction of alternating quantities.

Ques 4> Represent following Alternating quantities in phasor form then Find the resultant of all.

$V_1 = 100 \sin 500t$

$V_2 = 200 \sin(500t + 45)$

$V_3 = -50 \cos 500t$

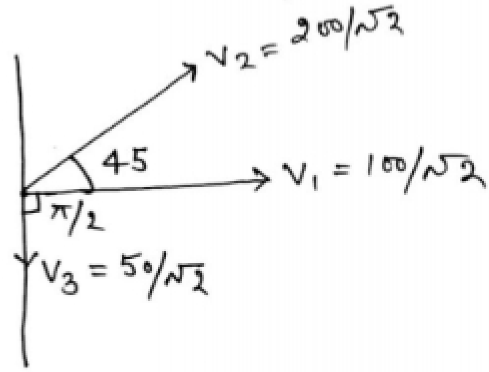
Ans.→ For analysis all quantities must in Phasor form

$V_1 = 100 \sin 500t$

$V_2 = 200 \sin(500t + 45)$

$V_3 = 50 \sin(500t - \pi/2)$

Phasor Representation>



Addition>

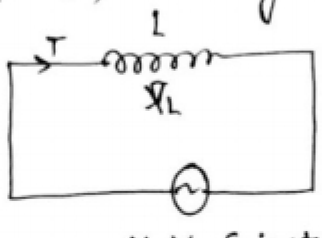
	V_x	V_Y
V_1	100/[illegible]	0
V_2	$100\sqrt{2}$	141.42
V_3	0	−50
V_R	241.42	91.42

$V_R = \sqrt{V_x^2 + V_Y^2} = V_{rmax} = 258.15\,V$

$\tan\phi = \frac{91.42}{241.42}$ $\qquad \phi =$

Que.5> Prove that in purely Inductive & Capacitive ckt Power Consumed is zero.

Ans.> (i) Purely Inductive ckt →



V= Vm Sin wt

⇒ When alternating current flow Through the Inductor an e.m.f. known as self Induced e.m.f. is Induced across the Inductor and this Induced e.m.f. oppose the applied Voltage and is given by

$$e_L = -L\frac{di}{dt}$$

$$V = -e_L$$

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

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

Integrating both sides

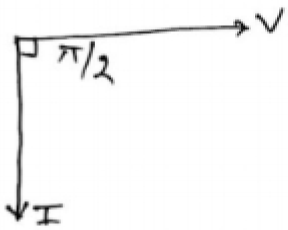
$$\int di = \int \frac{V}{L}\,dt$$

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

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

$$I = I_m \sin(\omega t - \pi/2)$$

$$I_m = \frac{V_m}{\omega L} = \frac{V_m}{X_L}$$



Now Instantaneous Power I

$$P_{in} = VI$$

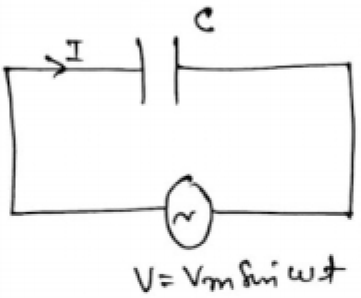
$$= V_m \sin \omega t\; I_m \sin(\omega t - \pi/2)$$

$$P_{in} = \frac{V_m I_m}{2}\sin 2\omega t$$

$$\boxed{P_{av} = 0}$$

because average Value of sin 2wt in half cycle is zero.

(ii) Purely Capacitive circuit >



at particular time charge stored in Capacitor is given by

$$\boxed{Q = CV}$$

$$Q = C V_m \sin \omega t$$

now.

$$I = \frac{dQ}{dt}$$

$$I = \frac{d}{dt}\left(C V_m \sin \omega t\right) = V_m \omega C \cos \omega t$$

$$I = V_m \omega C \sin(\omega t + \pi/2)$$

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

where $X_C \rightarrow$ Capacitive reactance

* Now Instantaneous power across Capacitor

$$P_{in} = V I$$

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

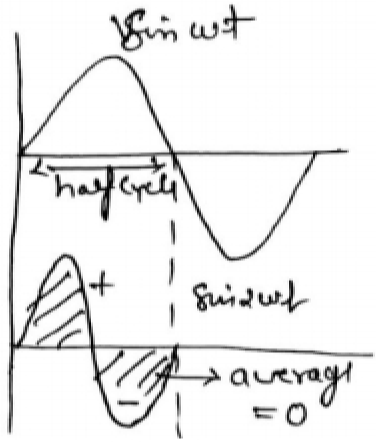
$$= \frac{V_m I_m}{2}(2 \sin \omega t \cos \omega t)$$

$$\boxed{P_{in} = \frac{V_m I_m}{2} \sin 2\omega t}$$

+ now average power →

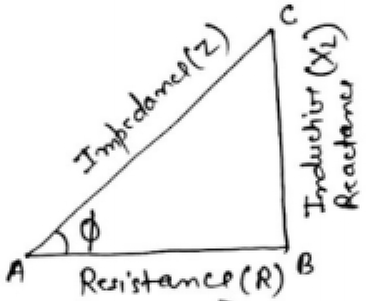
$$P_{av} = 0 \rightarrow$$

because average value of $\sin 2\omega t$ in half cycle is zero

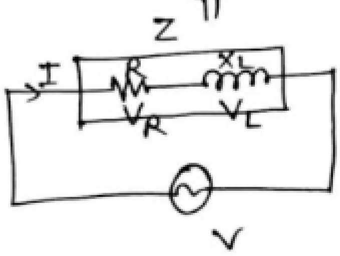


Que. 6 → Explain Impedance Triangle with Suitable Diagram.

Ans. → When Resistance, Inductance and Impedance are Represented by Three Sides of Right angle triangle Such a Triangle is known as Impedance Triangle.



$$\left.\begin{aligned} AB &= \frac{V_R}{I} = R \\ BC &= \frac{V_L}{I} = X_L \\ AC &= \frac{V}{I} = Z \end{aligned}\right\}$$



* the angle b/w AB & AC is known as Phase angle

$$\boxed{\cos\phi = R/Z}$$

* $\cos\phi$ is the Power Factor of the Circuit.

Que. 7 → Discuss about Apparent, True and Reactive Power.

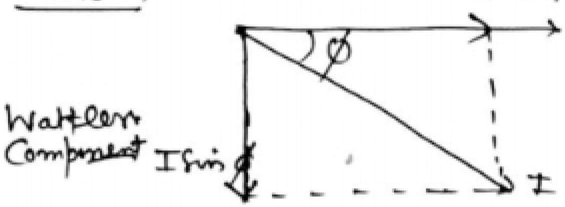
Ans. → (i) Apparent Power > The Product of r.m.s value of Voltage & current is known as apparent Power. $\boxed{P_a = VI}$ unit → V-A or KVA (Volt-Ampere)

(ii) True Power > When Apparent Power is Multiply by power Factor then This Product is known as True Power $\boxed{P_T = VI\cos\phi}$ unit W or KW (Watt) or (Kilowatt)

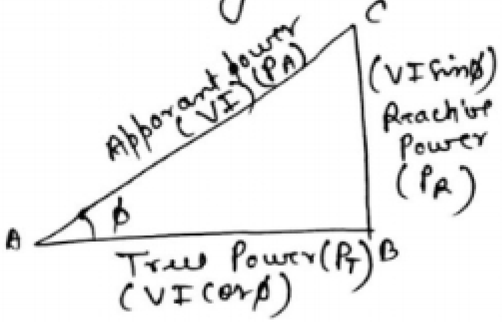
(iii) Reactive Power > The Product of apparent Power to the Sine of angle b/w Voltage and current is known as Reactive Power. $\boxed{P_R = VI\sin\phi}$ unit VA or KVAR (Volt-Ampere Reactive)

Que 8 → Explain Power Triangle the Discuss about Watt and Wattless Component of current.

Ans. >



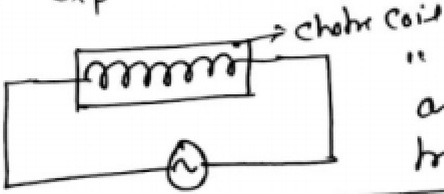
* The Component of current in phase with Voltage is known as active component or is Watt Component of Current because It is Responsible for Power Consumption
* Wattless Component → The Component of current quadrature To Voltage is called Watt-less Component It does not consume any Power.



$$P_A = \sqrt{P_T^2 + P_R^2}$$

Que. 9 > Explain Choke coil then define quality Factor.

Ans. >



" A Coil having high Inductance and low resistance is known as choke coil "

Power loss in choke coil = Iron loss + Copper loss

Q Factor → Reciprocal of Power Factor is known as quality Factor

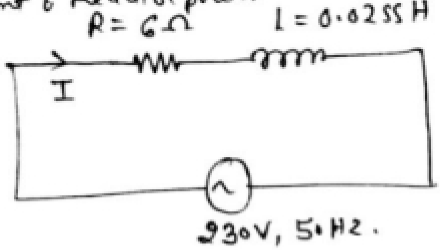
$$Q = 1/\cos\phi$$

" The quality Factor of choke Coil is very high "

because $\phi \to 90°$

Que. 9 → A coil having Resistance 6 Ω and Inductance 0.0255 H is Connected across 230V, 50 Hz. A.C. Supply Calculate.
(i) Impedance of coil (ii) Current in circuit (iii) Power factor (iv) Power Consume (v) Instantaneous Value of Voltage & Current (vi) Apparent & Reactive power

Ans. →



$X_L = 2\pi f L$
$= 2 \times 3.14 \times 50 \times 0.0255$
$= 8 \Omega$

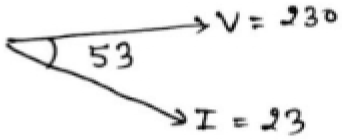
(i) $Z = \sqrt{R^2 + X_L^2} = \sqrt{6^2 + 8^2} = 10 \Omega$

(ii) $I = V/Z = \frac{230}{10} = 23\ A$

(iii) $\cos\phi = R/Z = 0.6 \qquad \phi = 53$

(iv) $P = VI\cos\phi$
$= 230 \times 23 \times 0.6 = 3174\ W$

(v)



$V = 230\sqrt{2}\sin\omega t$
$I = 23\sqrt{2}\sin(\omega t - 53)$

(vi) Apparent & Reactive Power

⇒ apparent $P_A = VI$
$= 230 \times 23 = 5290\ VA$
$\underline{5.290\ KVA}$ Ans

⇒ Reactive power $= VI\sin\phi$
$= 230 \times 23 \times 0.8$
$= 4232\ VAR$
$= \underline{4.232\ KVAR}$ Ans.

Que.10 → The Instantaneous Value of Voltage and current in particular circuit is given by

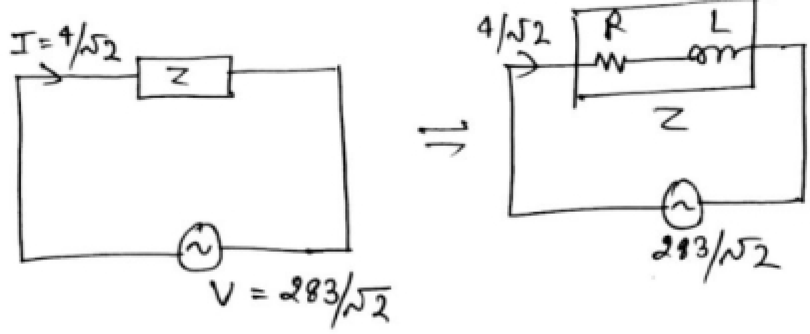
$V = 283 \sin 314t$

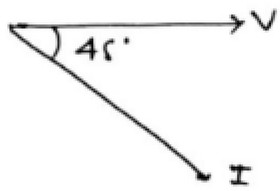
$I = 4 \sin(314t - 45^\circ)$

find (i) Circuit elements & their Value

(ii) Power factor and Power Consumed by ckt.

Ans. →





The current is lag behind the supply voltage by 45° so circuit contain R & L

now $Z = V/I = \dfrac{283/\sqrt{2}}{4/\sqrt{2}} = \underline{70.75\Omega}$ Ans

$\cos\phi = R/Z$ so $R = Z\cos\phi$

$= 70.75 \cos 45$

$= 50\Omega$

$X_L = Z\sin\phi$

$= 50\Omega$

$2\pi f L = 50\Omega \Rightarrow L = 50/2\pi f = \underline{0.159H}$ Ans

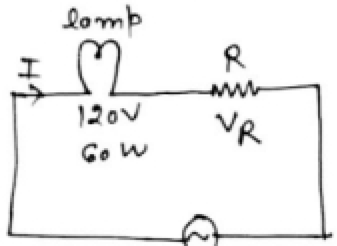
(ii) Power Factor $\Rightarrow \cos\phi = \cos 45 = 0.707$ (lagging)

$P = VI\cos\phi$

$= \dfrac{283}{\sqrt{2}} \times \dfrac{4}{\sqrt{2}} \times 0.707$

Q.71> A, 60 W, 120 V lamp connected across 220 V, 50 Hz A.C. supply find the value of (i) Resistor (ii) Inductor connected in series with the lamp so that lamp run on correct voltage.

Ans.> (i)

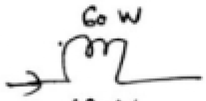


" lamp to be considered as pure Resistor "

$$V_R + 120 = 220$$

$$V_R = 100\,V$$

for lamp



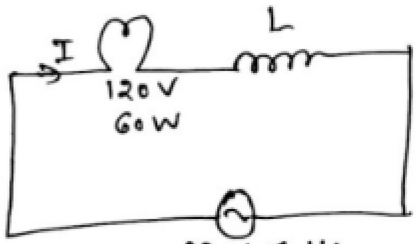
$$P = VI$$

$$I = 60/120 = 0.5\,A$$

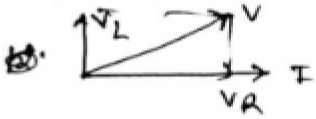
$$IR = 100\,V$$

$$\boxed{R = 200\,\Omega} \text{ Ans}$$

(ii) for Inductor →



• If Inductor is connected in series then ckt behave as like R-L circuit



$$V_R^2 + V_L^2 = V$$

$$(120)^2 + (IX_L)^2 = 220$$

$$IX_L = 184.4$$

$$X_L = \frac{184.4}{0.5}$$

$$\boxed{L = 1.174\,H} \text{ Ans}$$

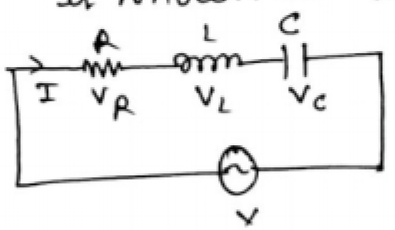
Ques. 12> What is Resonance ?

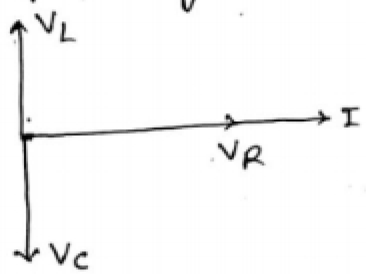
Ans. > The Resonance is a phenomenon which takes place in the Circuit Containing two types of Energy storing element (like Inductor & Capacitor) Such that Energy can Interchange b/w them.

" At Resonance the Voltage & Current of R-L-C ckt becomes in Same phase "

Ques. 13> Define Resonant frequency and Derive the expression for it. (for Series R-L-C ckt).

Ans. > The frequency at which Resonance takes place is known as Resonant frequency.





Resonance takes place when

$$V_L = V_C$$

$$IX_L = IX_C$$

$$X_L = X_C$$

$$2\pi f_r L = 1/2\pi f_r C$$

$$\boxed{f_r = \frac{1}{2\pi}\sqrt{\frac{1}{LC}}}$$

$$V_L = IX_L$$

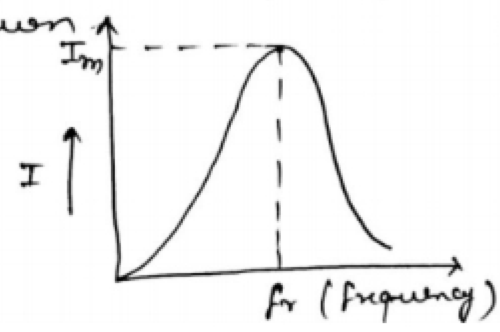
$$V_C = IX_C$$

$$V_R = IR$$

Ques. 14> What is Resonance curve.

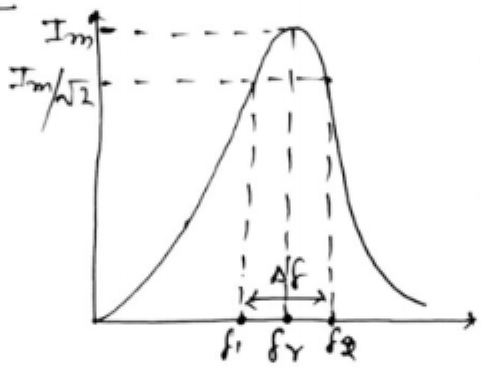
Ans. > The Curve Drawn b/w Current & frequency for Series R-L-C ckt is known as Resonant Curve

$f_r \rightarrow$ frequency at which Voltage & Current becomes in same phase.



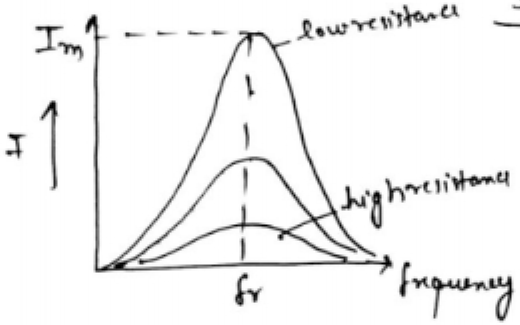
Que.15 > Explain Selectivity & Bandwidth.

Ans. >



Bandwidth → The band of frequencies either side of Resonance frequency where current becomes $1/\sqrt{2}$ times maximum current.

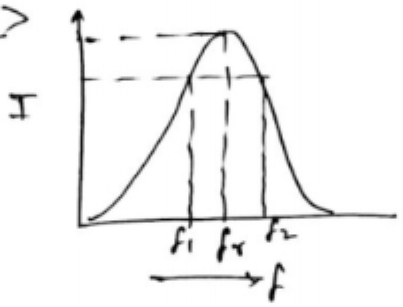
$$\boxed{\Delta f = f_2 - f_1} \text{ bandwidth}$$



Selectivity → If Resonant curve is highly peaked then it is high selective & if the curve is flat then it is low selective. Selectivity depend upon Resistance of ckt.

Que.16 > Derive the Expression for Bandwidth in Series R-L-C ckt >

Ans. >



ω_1 & ω_2 Corresponding frequencies of point where current is $I_m/\sqrt{2}$

* for maximum current

$$Z = R$$

\+ if $I = I_m/\sqrt{2} = \frac{V}{\sqrt{2}R}$

means $Z = \sqrt{2}R$

Now → $\sqrt{R^2 + (X_L - X_C)^2} = \sqrt{2}R$

$$X_L - X_C = \pm R$$

⇒ for lower cut off frequency ω_1 →

$$\omega_1 L - 1/\omega_1 C = -R$$

$$\omega_1^2 LC - 1 + R\omega_1 C = 0$$

- Deviding whole eq. by LC

$$\omega_1^2 + \frac{R}{L}\omega_1 - \frac{1}{LC} = 0$$

now

$$\omega_1 = \frac{-R/L \pm \sqrt{(R/L)^2 + 4/LC}}{2}$$

$$\omega_1 = -R/2L \pm \sqrt{\left(\frac{R}{2L}\right)^2 + \left(\frac{1}{\sqrt{LC}}\right)^2}$$

let $R/2L = \alpha$ $\qquad \omega_r = 1/\sqrt{LC}$

$$\omega_1 = -R/2L \pm \sqrt{(R/2L)^2 + (1/\sqrt{LC})^2}$$

$$\boxed{\omega_1 = -\alpha \pm \sqrt{\alpha^2 + \omega_r^2}}$$

Discarding negative frequency

$$\omega_1 = -\alpha + \sqrt{\alpha^2 + \omega_r^2}$$

* for upper cutoff frequency $\omega_2 \rightarrow$

$$X_L - X_C = +R$$

$$\omega_2 L - 1/\omega_2 C = R$$

$$\boxed{\omega_2 = +\alpha + \sqrt{\alpha^2 + \omega_r^2}}$$

now band width $\omega_2 - \omega_1 = 2\alpha$

$$f_2 - f_1 = \frac{R}{2\pi L}$$

$$\boxed{\Delta f = R/2\pi L}$$

also $\omega_1\omega_2 = \alpha^2 + \omega_r^2 - \alpha^2$

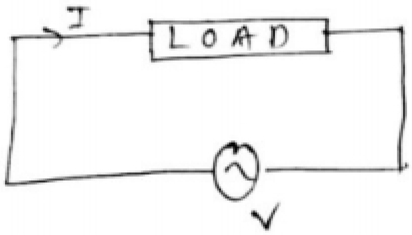
$$\omega_1\omega_2 = \omega_r^2$$

$$\omega_1\omega_2 = \omega_r^2$$

$$\boxed{f_1 f_2 = f_r^2}$$

Que.17) Write Down Disadvantages of low power factor How Can we Improve power factor.

Ans.)



The Current for a Given load Supplied at Constant Voltage is given by

$$I = \frac{P}{V\cos\phi}$$

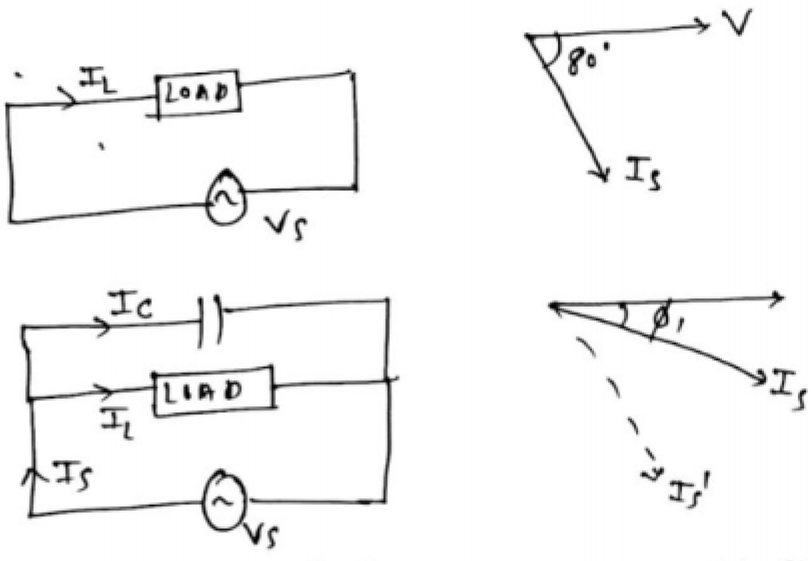
- If $\cos\phi$ is low then current is high which result following Disadvantages →

(i) Rating of generator's and Transformer's are proportional to their output current hence Inversly proportional to Power factor.

(ii) The Conducting material required is proportional to Current so large Conducting material required for transmission of Power at low power Factor.

(iii) copper loss is propotional to current so low power Factor Result High Copper-loss (I^2R).

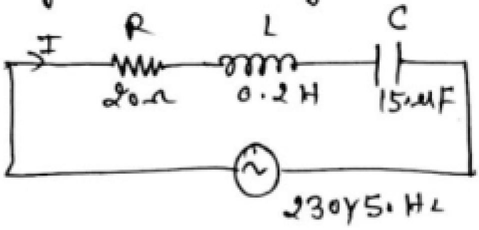
Power Factor Improvement → (i) by using capacitor with Parallel to load ↓



(ii) by using Induction motor with Phase advancer.

Que. 18> A Series R-L-C Circuit Consisting $R = 20\Omega$, Inductance 0.2H and a Capacitance of 150μF is Connected across a 230V, 50Hz. Source. Calculate.
(i) Impedance (ii) the current (iii) Power Factor (iv) Resonant frequency (V) Quality Factor.

Ans.>



$X_L = 2\pi f L$
$= 2 \times \pi \times 50 \times 0.2$
$= 62.83\Omega$

$X_C = 1/2\pi f C = 21.22\Omega$

(i) Impedance $Z = \sqrt{R^2 + (X_L - X_C)^2}$
$= \sqrt{(20)^2 + (62.83 - 21.22)^2}$

$Z = 46.167\Omega$

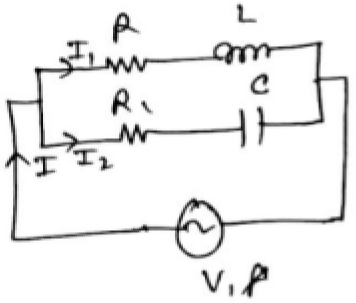
(ii) $I = V/Z = \frac{230}{46.167} = 4.98 A$

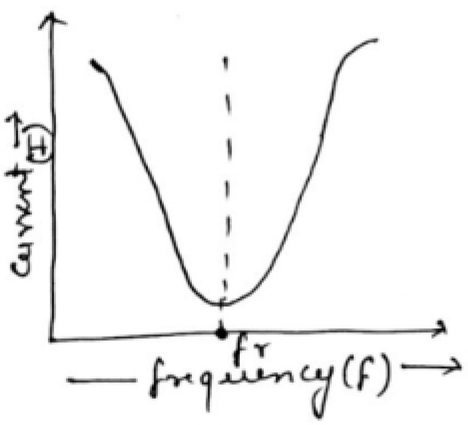
(iii) $\cos\phi = R/Z = \frac{20}{46.167} = 0.4332$ logging

(iv) $f_r = \frac{1}{2\pi}\sqrt{\frac{1}{LC}} = 29.06 Hz.$ (v) $Q = \frac{1}{R}\sqrt{\frac{L}{C}}$

Que. 19> Drive the Expression for band width in Parallel R-L-C. Circuit. (Current Resonance)

Ans.>





+ Current is minimum at Resonance.

in case of Parallel circuit at bandwidth frequencies the net Susceptance B is equal to conductance G So at frequency f_1 the Net Susceptance

$$B_{L_1} - B_{C_1} = G$$

at f_2 $\quad B_{C_2} - B_{L_2} = G$

Then $\quad Y = \sqrt{G^2 + B^2} = \sqrt{2}G$

and $\quad \phi = \tan^{-1} B/G = \tan^{-1} 1 = 45°$

Q Factor > $\quad Q = \dfrac{\text{Circulating Current b/w L \& C}}{\text{Line current}}$

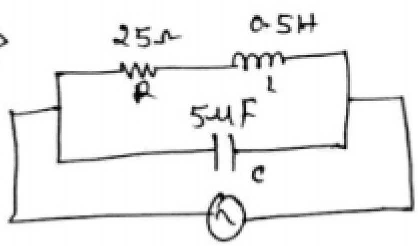
now $\quad I_C = 2\pi f_r C V$

$$I = V/_{L/CR} = VCR/L$$

$$Q = \frac{I_C}{I} = \frac{2\pi f_r L}{R} \quad \text{but } f_r = \frac{1}{2\pi}\sqrt{\frac{1}{LC}}$$

$$\boxed{Q = \frac{1}{R}\sqrt{\frac{L}{C}}}$$ neglecting R in f_r

Que. 20>



for the circuit find
(i) Resonant frequency
(ii) Impedance at Resonance
(iii) Bandwidth
(iv) Quality Factor

(i) $f_r = \dfrac{1}{2\pi}\sqrt{\dfrac{1}{LC} - \dfrac{R^2}{L^2}} = 100.34 \text{ Hz}.$

(ii) Impedance of ckt at Resonance $\quad Z = L/CR = 4000\,\Omega$

(iii) $\quad \Delta f = R/2\pi L = \dfrac{25}{2\pi \times 0.5} = 7.958 \text{ Hz}.$

(iv) Quality Factor $\quad Q = \dfrac{1}{R}\sqrt{\dfrac{L}{C}} = \dfrac{1}{25}\sqrt{\dfrac{0.5}{5\times10^{-6}}} = 12.65$

UNIT

3

<UNIT-3>

< Three phase A.C. Circuit <

Ques.1> Write down Merits & Demerits of poly phase system over single phase system.

Ans.1> (i) In a single phase system power delivered is pulsating even when current and voltage are in phase. The power is zero twice in a cycle. In case of heavy motor this cause vibration. This problem is resolved in three phase system.

(ii) The rating of given machine increases with the increase in no of phase.

(iii) Single phase motor (Induction) has no starting torque but three phase induction motor has starting torque.

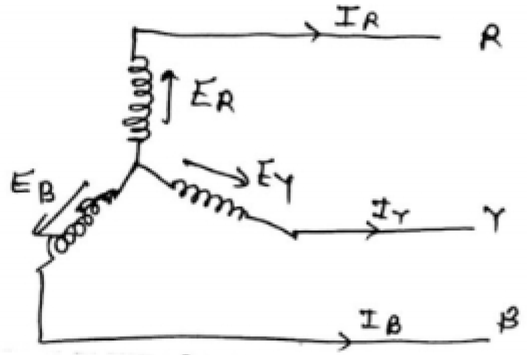
(iv) Power factor of single phase motor is lower than that of poly phase motor of same rating.

(V) Three phase system requires 3/4th weight of copper of that required in single phase system to transmit the same amount of power at given voltage over same distance.

(vi) Rotating magnetic field can be setup by poly phase system only.

Ques.2> Prove that for a star connected system the line voltage = $\sqrt{3}$ Phase voltage. ($V_L = \sqrt{3} V_P$).

Ans.>



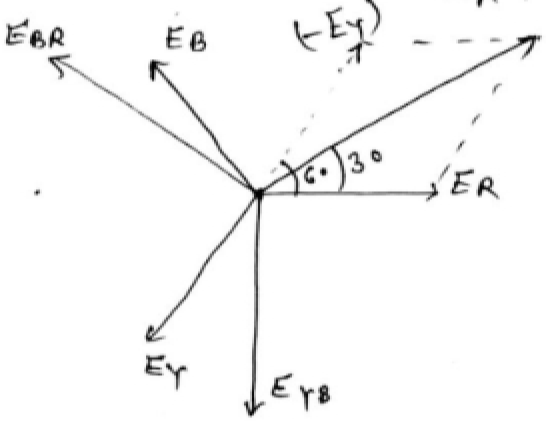
* Voltage b/w any two line is known as line voltage.

⇒ here the Phase Sequence is R, Y, B

Line Voltages are E_{RY}, E_{YB}, E_{BR}

now $E_{RY} = E_R - E_Y$

$= E_R + (-E_Y)$



now from phasor Diagram

$$E_{RY} = \sqrt{E_R^2 + E_Y^2 + 2 E_R E_Y \cos 60}$$

Let $E_R = E_Y = E_B =$ Phase Voltage (E_P)

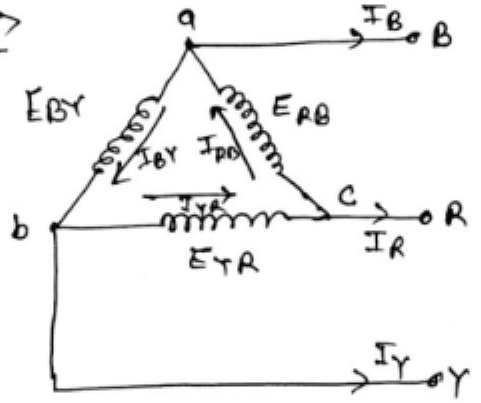
$E_{RY} = E_L$ (Line Voltage)

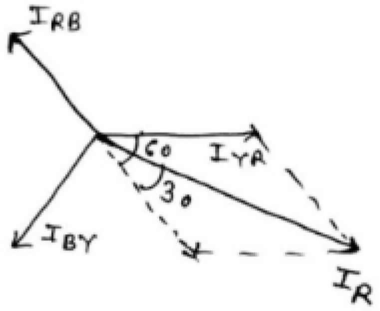
$$E_{RY} = \sqrt{E_P^2 + E_P^2 + 2E_P^2 \cos 60}$$

$$\boxed{E_L = \sqrt{3}\, E_P}$$

Ques.3> For Delta Connected System Prove that $I_L = \sqrt{3} I_P$.

Ans.>





from the figure we can say

line Voltage = Phase voltage

$$\boxed{E_L = E_P}$$

Now apply KCL at Node C →

$$I_R = I_{YR} - I_{RB}$$

$$I_R = I_{YR} + (-I_{RB})$$

the angle b/w I_{YR} & $-I_{RB}$ is 60°

So

$$I_R = \sqrt{I_{YR}^2 + I_{RB}^2 + 2 I_{YR} I_{RB} \cos 60}$$

now $I_{YR} = I_{RB} = I_{BY} = I_P$ (Phase Voltage)

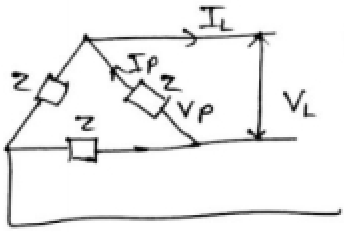
$$I_R = \sqrt{I_P^2 + I_P^2 + 2 I_P^2 \cos 60}$$

$$I_R = \sqrt{3}\, I_P$$

$$\boxed{I_L = \sqrt{3}\, I_P}$$

Que. 4> A balance Delta Connected load of $(12 + j9)\,\Omega$/phase is Connected to 3phase 400V supply find (i) line current (ii) Power factor (iii) Power Consume (iv) Reactive Power

Ans. > $R = 12\Omega$ $X_L = 9\Omega$



$I_L = \sqrt{3} I_P$

$V_P = V_L$

$$Z = \sqrt{R^2 + X_L^2}$$
$$= 15\Omega$$

$$\cos\phi = R/Z = 12/15$$

$$\phi = 36.87°$$

(i) Phase current $I_P = \frac{V_P}{Z} = \frac{400}{15} = 26.67\ A$

$I_L = \sqrt{3} I_P$ $I_L = 46.2\ A$

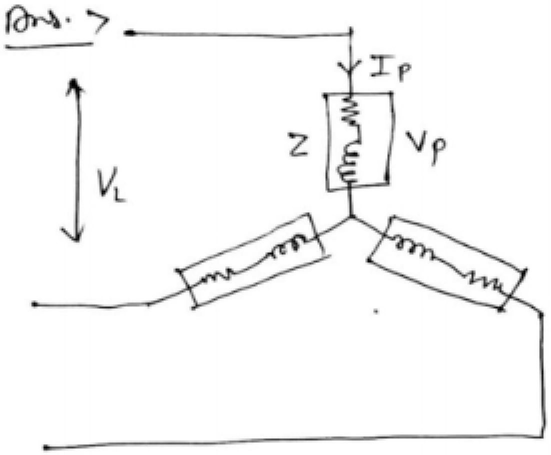
(ii) $\cos\phi = 12/15 = 0.8$ (lagging)

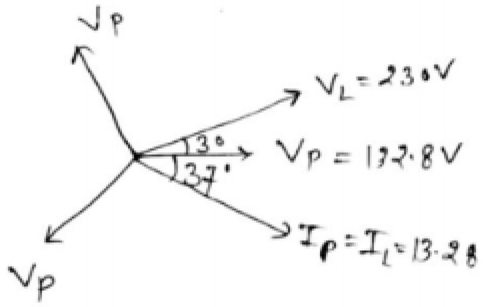
(iii) $P = 3 V_P I_P \cos\phi = 25600\ W$

(iv) $P_R = 3 V_P I_P \sin\phi = 3 \times 400 \times 26.67 \times 0.6 = 19200\ W$

Que. 5> A balance star connected load of $(8+j6)\,\Omega$ per phase is connected to 3 phase, 230V, 50 Hz. Supply. Find the line current, power factor, Volt ampere reactive. Draw the phasor Diagram for cht.

Ans. >





now given → $V_L = 230\,V$ $\quad Z = \sqrt{8^2+6^2} = 10\,\Omega$

$Z = 8+j6\,\Omega$ $\quad V_p = V_L/\sqrt{3} = 132.8\,V$

now

$$I_p = \frac{V_p}{Z} = \frac{132.8}{10} = 13.28\,A$$

(i) $I_L = I_p = 13.28\,A$

(ii) $\cos\phi = R/Z = 0.8$ and $\phi = 36.87$

(iii) $P = 3V_pI_p\cos\phi = 3\times 132.8\times 13.28\times 0.8 = 4.232\,kW$

(iv) $P_R = 3V_pI_p\sin\phi = 3\times 132.8\times 13.28\times 0.6 = 3.174\,kVAR$

Que. 6> A 3ϕ balance load draw 10 kW power from a 400V, 3 phase, supply at 0.8 lagging power factor. determine (i) line current (ii)

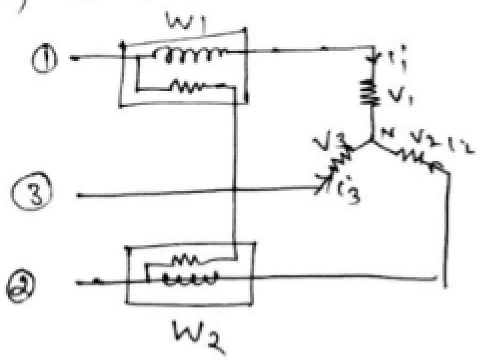
Ans. > $P = 10\,kW \quad V_L = 400\,V \quad \cos\phi = 0.8$

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

$\boxed{I_L = 18.04\,A}$ Ans

Que.7> Prove that Power Can be measured by two wattmeter method for Star & Delta Connected System.

(i) Star Connected System>



Total Power in ckt is given by

$$P = V_1 i_1 + V_2 i_2 + V_3 i_3 \quad \text{—(i)}$$

apply KCL at node N

$$i_1 + i_2 + i_3 = 0$$
$$i_3 = (-i_1 - i_2)$$

Put the Value of i_3 in eq. (i)

$$P = V_1 i_1 + V_2 i_2 - V_3(i_1 + i_2)$$
$$P = i_1(V_1 - V_3) + i_2(V_2 - V_3) \quad \text{—— (ii)}$$

* Now for Wattmeter reading.

(W_1) → the Current Coil having Current i_1 & Pressure Coil Voltage is $V_{13} = (V_1 - V_3)$ So Wattmeter reading is

$$W_1 = i_1(V_1 - V_3)$$

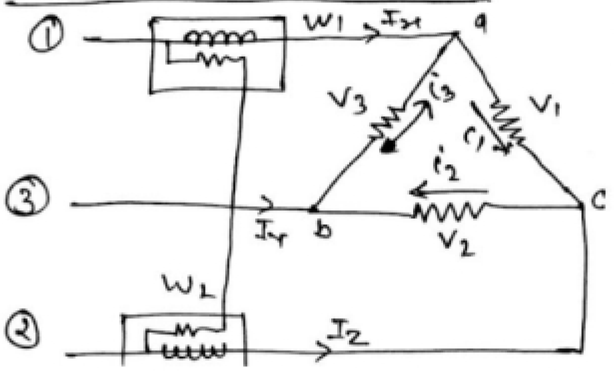
Similarly $W_2 = i_2(V_2 - V_3)$

by eq. (ii) total Power is now

$$\boxed{P = W_1 + W_2}$$

So total Power Can be measured by two wattmeter Method

(ii) Delta Connected System>



Total Power in Delta Connected System is

$$P = V_1 i_1 + V_2 i_2 + V_3 i_3 \quad (i)$$

apply KVL in loop abcb →

$$V_1 + V_2 + V_3 = 0$$
$$V_1 = -(V_2 + V_3)$$

Put the value of V_1 in eq. (1')

$P = V_1 i'_1 + V_2 i'_2 + V_3 i'_3$

$= -(V_2+V_3) i'_1 + V_2 i'_2 + V_3 i'_3$

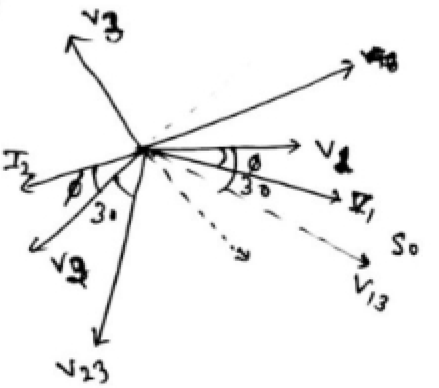
$P = -V_3(i'_1 - i'_3) + V_2(i'_2 - i'_1)$

Comparing with wattmeter reading →

$$P = W_1 + W_2$$

Que. 8> Derive the Expression for power factor by wattmeter reading.

Ans.>



Wattmeter readings are

$W_1 = i_1 (V_1 - V_3)$

$W_2 = i'_2 (V_2 - V_3)$

for Inductive load →

$W_1 = V_L I_L \cos(30 - \phi)$

$W_2 = V_L I_L \cos(30 + \phi)$

now $W_1 + W_2 = V_L I_L \cos(30 - \phi) + V_L I_L \cos(30 + \phi)$

$= \sqrt{3} V_L I_L \cos\phi$

$W_1 - W_2 = V_L I_L \cos(30 - \phi) - V_L I_L \cos(30 - \phi)$

$= V_L I_L [2 \sin 30 \sin\phi]$

$= V_L I_L \sin\phi$

$\frac{W_1 - W_2}{W_1 + W_2} = \frac{1}{\sqrt{3}} \tan\phi$

$\tan\phi = \sqrt{3}\left(\frac{W_1 - W_2}{W_1 + W_2}\right)$

$$\cos\phi = \cos \tan^{-1} \sqrt{3}\left(\frac{W_1 - W_2}{W_1 + W_2}\right)$$

Que.1> Explain Different type of Magnetic Material

Ans.> Magnetic Materials are basically three types

(i) Paramagnetic Material

(ii) Diamagnetic Material

(iii) Ferromagnetic Material

(i) Paramagnetic Materials > The materials which are not strongly attracted by a magnet are known as Paramagnetic material.

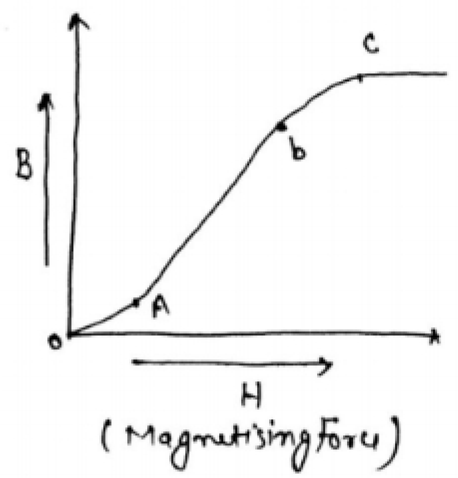
Ex.> aluminium, platinum, magnesium.

(ii) Diamagnetic Materials > The materials which are repelled by a magnet such as Zinc, mercury, lead are known as Diamagnetic materials.

(iii) Ferromagnetic Materials > The material which are strongly attracted by a magnet such as Iron, steel, Nickel are known as ferromagnetic materials.

Que.2> Explain B-H curve in detail >

Ans.> The Curve Drawn b/w Induction density B and Magnetising Force H is known as B-H curve or Magnetising curve.



* in region oA Increase in flux density is very small
* in region ab flux density is Directly proportional to Magnetising Force
* in Region bc again Increase in flux density is very small.
* beyond c there is no change in flux density on Increasing the Magnetising Force this Region is known as Magnetic Saturation.

Que.3 > Explain Ideal & Practical Transformer.

Ans. > For a Ideal Transformer we take following assumption's →

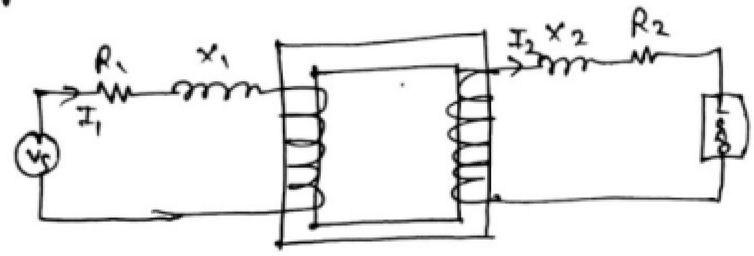
(i) No winding resistance → The primary & Secondary winding's have No resistance.

(ii) No magnetic leakage → There is No leakage Flux all the flux setup is confined to the core.

(iii) No Iron loss → There is No Hysteresis and eddy current loss

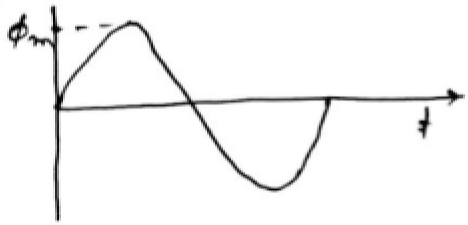
(iv) Zero magnetising current → The Core has Infinite Permeability and zero reluctance.

Practical Transformer > The Transformer which Not follow the assumption of Ideal Transformer is known as practical Transformer



Que.4 > Write down E.m.f. Equation of transformer

Ans. >



* Let flux associated with the Core is

$$\phi = \phi_m \sin \omega t$$

* N_1 & N_2 no of turn in Primary and Secondary winding.

* Now Induced e.m.f in Primary winding

$$e_1 = -N_1 \frac{d\phi}{dt} = -N_1 \omega \phi_m \cos \omega t$$

$$= N_1 \omega \phi_m \sin(\omega t - \pi/2)$$

Similarly

$$E_2 = -N_2 \frac{d\phi}{dt}$$

$$= -N_2 \frac{d}{dt}(\phi_m \sin \omega t)$$

$$= N_2 \omega \phi_m \sin(\omega t - \pi/2)$$

Now r.m.s. value of Induced e.m.f.

$$E_1 = \frac{N_1 \phi_m \omega}{\sqrt{2}}$$

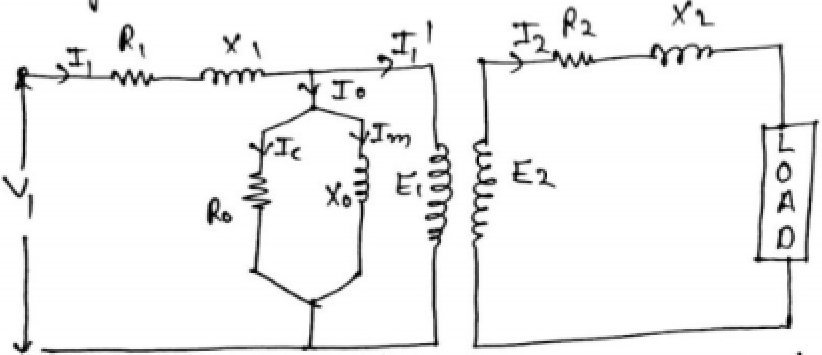
$$= \frac{N_1 \phi_m 2\pi f}{\sqrt{2}}$$

$$\boxed{E_1 = 4.44 f \phi_m N_1 \text{ Volt}}$$

$$\boxed{E_2 = 4.44 f \phi_m N_2 \text{ Volt}}$$

Que 5 > Draw and Explain Equivalent Circuit of Transformer.

Ans. >



Equivalent ckt of any device can be quit helpful in Predetermination of the behavior of the device under Various Condition of operation.

$R_1, X_1 \rightarrow$ Primary Resistance and Reactance

$R_2, X_2 \rightarrow$ Secondary Resistance and Reactance.

$I_1, I_2 \rightarrow$ Primary & Secondary current

$R_o, X_o \rightarrow$ No-load Parameter of Transformer.

$I_o \rightarrow$ No load Current

I_1' → Counter balancing current which Neutrilized the flux producted by Secondary current.

$$I_1 = I_0 + I_1'$$

$$\boxed{N_1 I_1 = N_2 I_2}$$

Que 6 → Explain Different type of loss Present in Transformer.

Ans. → There are two type of losses present in Transform

(i) Copper loss

(ii) Iron loss

Copper loss → Copper loss is basically due to Resistance and It takes place in primary & Secondary winding.

$$\boxed{P_c = I_1^2 R_1 + I_2^2 R_2}$$

Iron loss → Iron loss is also two types.

(i) Hysteresis loss

(ii) Eddy current loss.

(i) Hysteresis loss > When alternating flux Setup in the Core the Hysteresis loop is Traced out and area under Hysteresis loop represent Hysteresis loss. and it is given by

$$\boxed{P_h = \eta (B_{max})^x f V \text{ Joule}}$$

where η → Hysteresis cofficient

B_{max} → Max. flux density

f → Supply frequency

V → Volume of Core.

(ii) Eddy current loss > When Variable flux Setup in the Core the flux linkage with Iron core is change due to which a current is

Induced in the core this current is known as Eddy Current and result heating loss which is known as Eddy current loss. and is given by

$$P_e = K_e (B_{max})^2 f^2 t^2 V \text{ Watt}$$

Ques.7 → What is the efficiency of Transformer. Derive the expression for Max. efficiency.

Ans.7 The efficiency of any Machine is given by

$$\eta = \frac{\text{output}}{\text{Input}} = \frac{\text{output}}{\text{output} + \text{losses}}$$

for a fixed Input Voltage Iron loss is constant but Copper loss is depend upon Load current

$$\eta = \frac{\text{output}}{\text{output} + \text{Copper loss} + \text{Iron loss}}$$

let P_o → output Power at full load
P_i → Iron loss
P_c → Copper loss at full load

then efficiency at x load where x is fraction of full load →

$$\eta = \frac{x P_o}{x P_o + P_i + x^2 P_c}$$

for max. efficiency

$$\frac{d\eta}{dx} = 0 \quad \text{now} \quad \frac{d\eta}{dx} = \frac{(xP + x^2 P_c + P_i)P - xP(P + 2xP_c)}{(xP + P_i + x^2 P_c)^2}$$

$$P_i - x^2 P_c = 0$$

$$x = \sqrt{\frac{P_i}{P_c}}$$

Que. 8 → In a 25 KVA 2000V/200V Transformer The Iron and Copper losses are 200 W and 400 W respectively calculate the efficiency at half load 0.8 Power Factor lagging. also determine max. efficiency and corresponding load.

Ans. → $P_c = 400\,W = 0.4\,KW$

$P_i = 200\,W$

$P_o = \frac{1}{2} \times V \times I \times \cos\phi$

$= \frac{1}{2} \times 25 \times 0.8$

$= 10\,KW$

* Copper loss at half load $= \left(\frac{1}{2}\right)^2 \times 400 = 0.1\,KW$
* efficiency at half load →

$$\%\eta = \frac{10}{10 + 0.1 + 0.2} \times 100 = 97.08\%$$

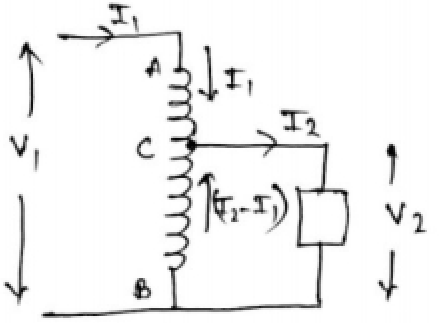
* for max efficiency $x = \sqrt{\frac{P_i}{P_c}}$ ⇒

Corresponding load $= 25 \times \sqrt{\frac{P_i}{P_c}} = 17.68\,KVA$

So max. efficiency $= \frac{17.68}{17.68 + 0.2 + 0.2} = 97.788\%$

Que. 9 > What is Auto Transformer. How Conducting Material Saved in Auto Transformer.

Ans. > The Auto Transformer has same principal as like Conventional two Winding transformer the only difference is that in auto transformer primary and Secondary windings are Interrelated.



$$\frac{V_2}{V_1} = \frac{E_{BC}}{E_{AB}} = \frac{N_2}{N_1} = \frac{I_1}{I_2} = K$$

Conducting Material → Conducting Material required is Directly Proportional to cross sectional area and length of Conductor so.

Conducting Material in ordinary Transformer

$$C_0 \propto (N_1 I_1 + N_2 I_2)$$

$$C_0 \propto 2N_1 I_1 \quad \text{because } N_1 I_1 = N_2 I_2$$

In auto Transformer

$$C_A \propto I_1 (N_1 - N_2) + N_2 (I_2 - I_1)$$

$$C_A \propto 2(N_1 - N_2) I_1$$

now

$$\frac{C_A}{C_0} = \frac{2(N_1 - N_2) I_1}{2 N_1 I_1} = 1 - \frac{N_2}{N_1} = 1 - K$$

$$\boxed{C_A = C_0 (1-K)}$$

Conducting Material Saved.

$$C_0 - C_A = C_0 - C_0 (1-K)$$

$$= C_0 K$$

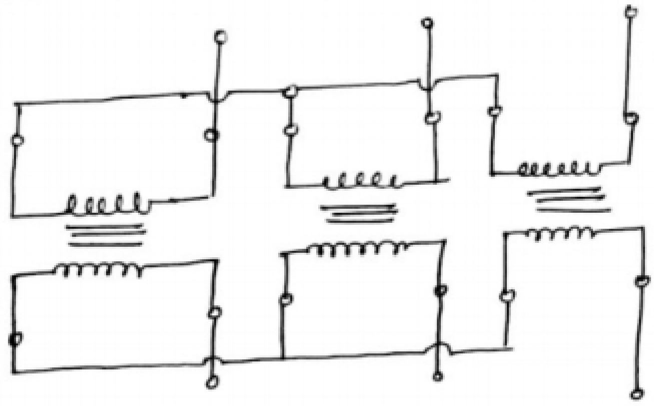
Saving = K × Conducting Material in Ordinary

Ques.10 > Explain Different type of Three phase Transformer Inter Connection.

Ans. > The Winding of Three phase Transformer are either Connected in Star or Delta. According To Primary & Secondary Winding Inter Connection there are four Method of Interconnection.

(i) Y-Y (Star-Star) Connection
(ii) Δ-Δ (Delta-Delta) Connection
(iii) Y-Δ (Star-Delta) Connection
(iv) Δ-Y (Delta-Star) Connection

(i). Y-Y (Star-star) Connection:

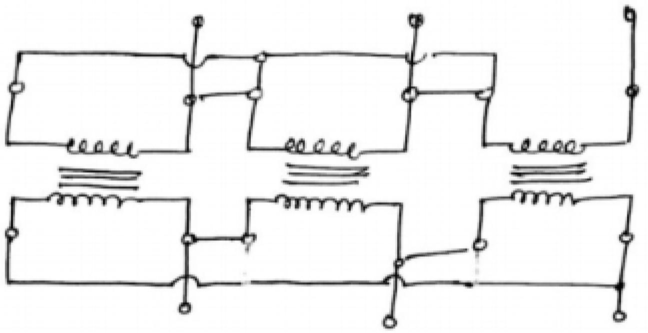


It gives line voltage √3 times phase voltage. It is economical for small rating, high voltage transformers as the number of turns per phase and the amount of insulation required is less.

$$\text{Voltage ratio} = \frac{V_{L2}}{V_{L1}} = \frac{\sqrt{3}\,V_{P2}}{\sqrt{3}\,V_{P1}} = \frac{N_2}{N_1}$$

$$\text{Current ratio} = \frac{I_{L2}}{I_{L1}} = \frac{I_{P2}}{I_{P1}} = \frac{N_1}{N_2}$$

(ii). Δ – Δ (Delta Delta Connections)

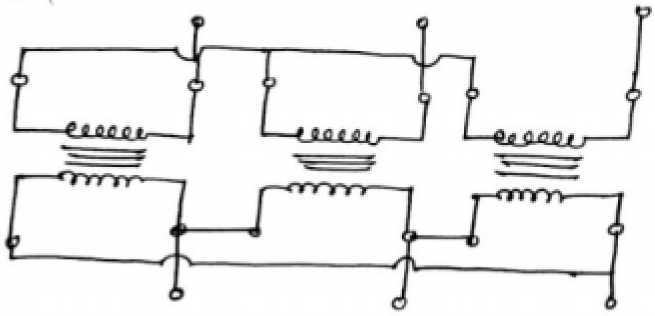


This arrangement is generally used in systems which carry large currents on low voltages. The conductor is required of smaller cross section as the phase current is $\frac{1}{\sqrt{3}}$ times the line current.

$$\text{Voltage ratio} = \frac{V_{L2}}{V_{L1}} = \frac{V_{P2}}{V_{P1}} = \frac{N_2}{N_1}$$

$$\text{Current ratio} = \frac{I_{L2}}{I_{L1}} = \frac{\sqrt{3}\, I_{P2}}{\sqrt{3}\, I_{P1}} = \frac{N_1}{N_2}$$

(iii). Y – Δ (star Delta Connection):

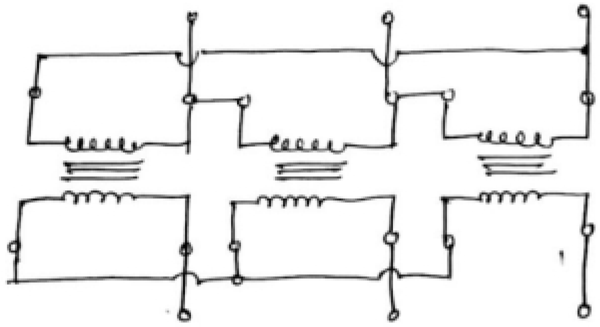


Such connections are used principally where the voltage is to be stepped down. The neutral of the primary winding is earthed.

$$\text{Voltage ratio} = \frac{V_{L2}}{V_{L1}} = \frac{V_{P2}}{\sqrt{3}\, V_{P1}} = \frac{1}{\sqrt{3}} \frac{N_2}{N_1}$$

$$\text{Current ratio} = \frac{I_{L2}}{I_{L1}} = \frac{\sqrt{3}\, I_{P2}}{I_{P1}} = \sqrt{3}\, \frac{N_1}{N_2}$$

(iv). Δ-Y (Delta star) Connections:



Such connections are used where it is necessary to step up the voltage.

$$\text{Voltage ratio} = \frac{V_{L2}}{V_{L1}} = \frac{\sqrt{3}\,V_{p2}}{V_{p1}} = \sqrt{3}\,\frac{N_2}{N_1}$$

$$\text{Current ratio} = \frac{I_{L2}}{I_{L1}} = \frac{I_{p2}}{\sqrt{3}\,I_{p1}} = \frac{N_1}{\sqrt{3}\,N_2}$$

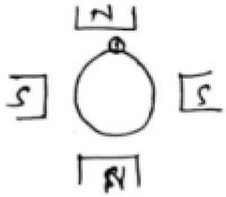
UNIT 4

< UNIT- 4 >

< Electrical Machine >

Que. 1 > Drive the Expression for e.m.f equation of D.C. Generator.

Ans. >



Let $\phi \rightarrow$ flux per pole

$N \rightarrow$ speed of ~~rotor~~ Generator in R.P.M.

$Z \rightarrow$ Total no of Conductor

$P \rightarrow$ no of Pole of Generator

* Flux cut by 1 Conductor in one revolution $= P\phi$
* Flux cut by conductor in one second $= P\phi \times N/60$

" now flux cut by conductor in one second is actually a average value of Induced e.m.f. because

$$e = \frac{d\phi}{dt} \quad \text{so average value is} \quad e = \frac{\Delta\phi}{\Delta t}$$

+ average value of Induced e.m.f per Conductor $= P\phi \times N/60$

now no. of conductor in series is given by

$$Z^* = \frac{Z}{A} \quad \text{where } A \rightarrow \text{no of parallel path}$$

+ Total Induced e.m.f. is given by $E = \phi P \times N/60 \times Z^*$

$$\boxed{E = \frac{\phi Z N P}{60 A}}$$

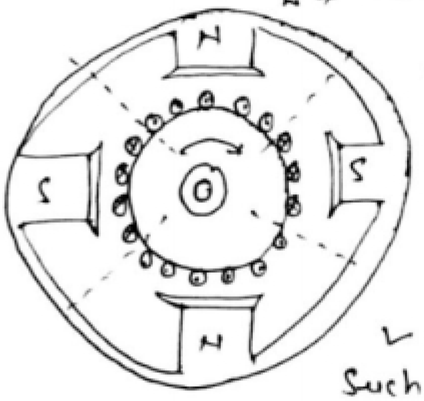
$A = 2$ for wave winding

$A = P$ for lape winding

Que.2> Explain working principal of D.C. Motor >

Ans. > D.C. Motor is based on the Principal that when a current carrying conductor placed in a magnetic field force is Experienced by the conductor and magnitude of Force is given by $\boxed{F = BIL}$

where B → magnetic field strength
I → current in Conductor
L → length of conductor



* When Motor is connected to D.C. supply current start to flow in Rotor Conductor through Commutator & Commutator Perform following Perpose.

✓ "It convert D.C current into A.C. Such that conductor under different pole have current in apposite direction. So by Flemings left hand rule Force in all conductor must in same direction and unidirectional Torque is produced and motor start to run in particular direction"

✓ also when particular Conductor comes influence of one pole to another pole the direction of current in it is reversed and Motor Continue to run in particular Direction.

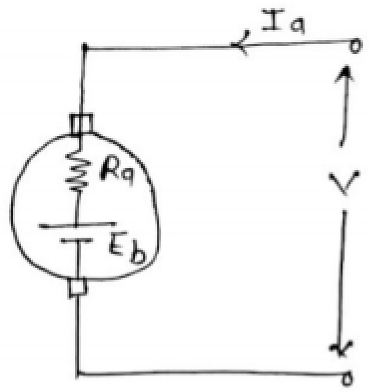
Que 3> What is back e.m.f.?

Ans. > When Rotor Conductor continue to run due To Motor action flux linkage with the Conductor is change so e.m.f is Induced in the conductor as like generator. this Induced e.m.f. oppose the supply Voltage and is known as back e.m.f.

$$\boxed{E_b = \frac{\phi Z N P}{60 A}}$$

Que.4> What is the Physical Significance of back e.m.f.

Ans.>



$$E_b = \frac{\phi Z N P}{60 A}$$

$$V = E_b + I_a R_a$$

$$I_a = \frac{V - E_b}{R_a}$$

* Without back e.m.f. the speed of D.C. motor is undefined because there is no opposing factor to supply.

* also back e.m.f. is responsible for producing variable Torque in motor according to applied load. So motor becomes self regulating.

* as the load is increases Motor reduce its speed so that E_b decreases and Torque increases.

Que.5> Drive the Torque equation of D.C. Motor.

Ans> let Motor is Running with speed N R.P.M. and Producing a Torque of T then

$$\text{Power devolped in Motor} = T\omega$$
$$= T\frac{2\pi N}{60} \text{ Watt}$$

Now this Mechanical Power is equivalent to electrical Power in armature ($E_b I_a$)

So

$$T \times \frac{2\pi N}{60} = E_b I_a$$

$$T = \frac{E_b I_a 60}{2\pi N} \quad \text{—— (i)}$$

now $E_b = \frac{\phi Z N P}{60A}$

Putting the Value of E_b in eq. (1')

$$T = 0.159 \phi Z P \frac{I_a}{A} \text{ Newton-meter}$$

$$T \propto \phi I_a$$

Que. 6> A 4 pole lap wound armature has 144 slots with two coil sides per slot each coil having two turns if flux per pole is 20 mWb and speed of armature is 720 RPM find Induced Voltage.

Ans.> Z = total slots × no of coil sides per slot × no of turns in each coil

= 144×2×2

Z = 576

$$E = \frac{\phi Z N P}{60 A} = \frac{20\times10^{-3} Wb \times 576 \times 720 \times 4}{60 \times 4}$$

$$E = 138.24V$$ Ans.

Que. 7> What is slip. Drive the expression for Rotor frequency in term of supply Frequency.

Ans.> The difference between Stator Field and Rotor speed is known as slip and denoted by s

$$S = \frac{N_s - N}{N_s}$$

* It is expressed as fraction of Synchronous speed.

* When Rotor is stationary the supply frequency and Rotor Frequency is same.

$$f = \frac{N_s P}{120 f}$$

but when Rotor start Rotating in the direction of Field Relative speed b/w Rotor & Stator Decreases so frequency also decreases.

$$f' = \frac{(N_s - N) P}{120 f}$$

$$= \frac{N_s - N}{N_s} \times \frac{N_s P}{120 f}$$

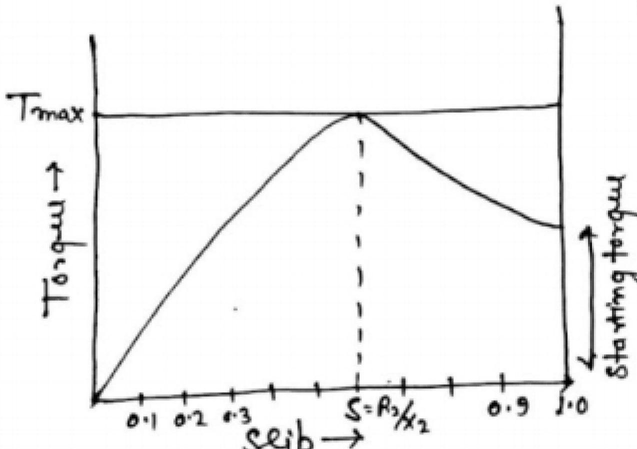
$$f' = S \times f \qquad \boxed{S = \frac{N_s - N}{N_s}}$$

$$\boxed{f' = SF}$$

Ques. 8 > "Explain Torque slip characteristics of three Phase Induction Motor."

Ans. > as we know Torque of Three Phase Induction Motor is given by

$$\boxed{T = \frac{K S R_2 E_2^2}{R_2^2 + S^2 X_2^2}}$$



* for starting slip is very small So we can Neglect the S^2 Term and

$$\boxed{T \propto S}$$

and curve is straightline on Increasing the slip Torque is also Increases upto Its become maximum at $\boxed{S = R_2/X_2}$

* after Max. torque if we further Increases the slip now slip is sufficient So we can not neglect the S^2 term and

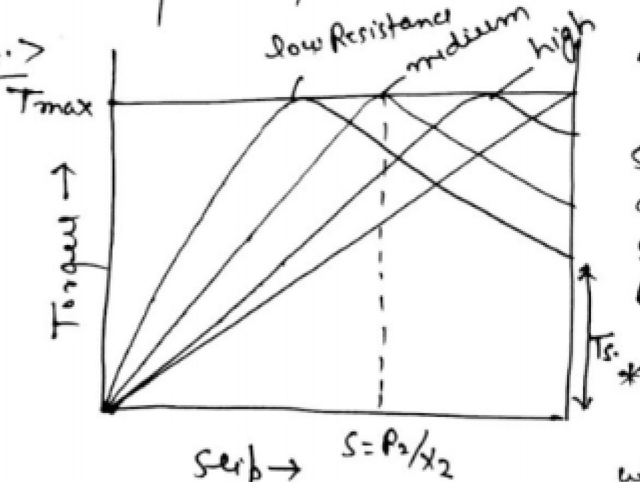
$$\boxed{T \propto 1/S}$$

Now increasing slip further Torque start decreasing. and curve is Rectangular hyperbola.

* If we further increase the slip Motor eventually stop and at this point Torque is equal To starting Torque.

Que.9> Explain the effect of Rotor Resistance on Torque slip characteristics.

Ans.>



* as we increase the Resistance the value of slip at which max torque occurs is also increases So curve shift towards Right as shown in figure.

* $$T_{max} = \frac{KE_2^2}{2X_2}$$

which is Independent of slip so Tmax Remains unchanged on changing the Resistance of Rotor.

Que.10> A 3phase 4-pole 50 Hz. Induction motor is running at 1455 r.p.m. find the slip.

Ans.> $N_s = 120f/P = \frac{120 \times 50}{4} = 1500$ r.p.m.

actual speed $N = 1455$

$$\text{slip}(S) = \frac{N_s - N}{N_s} = \frac{1500 - 1455}{1500} = .03$$

$\%S = .03 \times 100$

$\%S = 3\%$

Que. 11> A 3phase, 4-Pole Induction motor Connected to 3ϕ, 400V, 50 Hz. ac. supply. Calculate.

(i) Synchronous speed

(ii) Rotor speed at 4% slip

(iii) Rotor frequency when rotor speed is 600 r.p.m.

(iv) Rotor Induced e.m.f. when Rotor to stator turn ratio is 2:1 and Stator is star connected and rotor speed is 600 r.p.m.

Ans.> (i) $N_s = \frac{120f}{P} = \frac{120 \times 50}{4} = 1500$ r.p.m.

(ii) $\frac{N_s - N}{N_s} \times 100 = 4$

$\frac{1500 - N}{1500} = .04 \Rightarrow N = 1440$ r.p.m.

(iii) $N = 600$ $\quad S = \frac{1500 - 600}{1500} = 0.6$

$f' = Sf = 50 \times 0.6 = 3$ Hz.

(iv) $V_1 = 400/\sqrt{3}$ $\quad \frac{V_2}{V_1} = \frac{2}{1}$ $\quad V_2 = \frac{800}{\sqrt{3}}$

$V_2' = SV_2$

for $N = 600$

$S = 0.6$

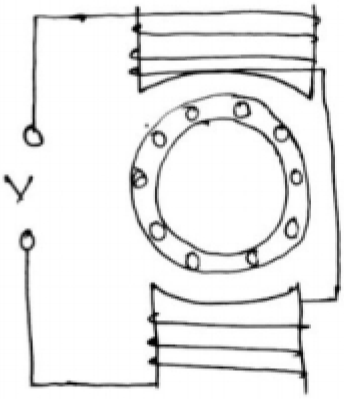
$V_2' = SV_2$

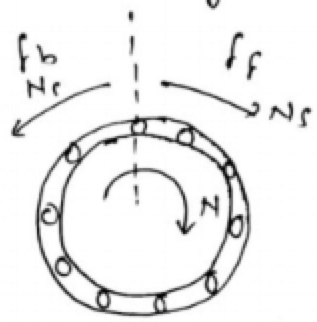
$= 0.6 \times 800/\sqrt{3}$

$\boxed{V_2' = 48/\sqrt{3} \text{ V}}$ Ans.

Que.12 > Explain operating principal of Single phase Induction Motor. also explain why it is not Selfstarting.

Ans. > The operation of Single phase Induction motor can be explain by "Double revolving Field" Theory.





Double revolving field theory

* When we give Single phase supply to Motor pulsating Magnetic field is produced this pulsating magnetic field can be resolved Into two Rotating Magnetic field of half Its amplitude and Rotating in apposite direction with synchronous speed.
* when Rotor is stationary both field produce equal and apposite Torque so Net torque is zero and motor is not self starting.
* now If we rotate rotor in particular lets in forword direction with speed N such that $N \approx N_s$

- slip due to forword field $S_f = \frac{N_s - N}{N_s} = S$
- slip due to backward field $S_b = \frac{N_s - (-N)}{N_s} = \frac{2N_s - (N_s - N)}{N_s}$

$$\boxed{S_b = 2 - S}$$

* Now because $2 - S >> S$

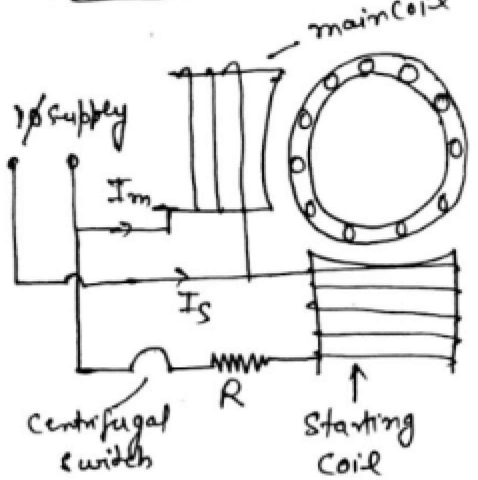
So current in Conductor due to backward field is very high so magnetic field produce in rotor Conductor due to backward field is also high and It Completely finish the backward field due to which only forward field remains and motor behave as like Three phase Induction motor and Continue to run in Forward Direction.

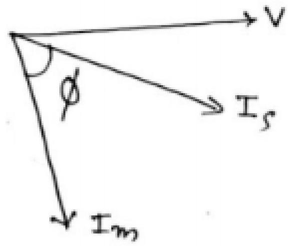
Que. 13> Explain starting Method of Single phase Induction Motor. why It is not Self starting.

Ans.> as we know there is No Torque in single Phase Induction motor at starting due to pulsating field. So we produce Rotating Magnetic field at starting with the help of Auxilary coil and as motor attend sufficiend speed for proper operation we remove auxilary coil with the help of Centrifugal switch. In starting Method we try to devolpe phase difference b/w main coil and auxilary coil near about (90° – 50°)

(i) Resistance start Single phase Induction motor
(ii) Capacitor start Single phase Induction motor
(iii) Capacitor start Capacitor run Single phase Induction motor
(iv) permanet capacitor Single phase Induction motor

(i) Resistance start>





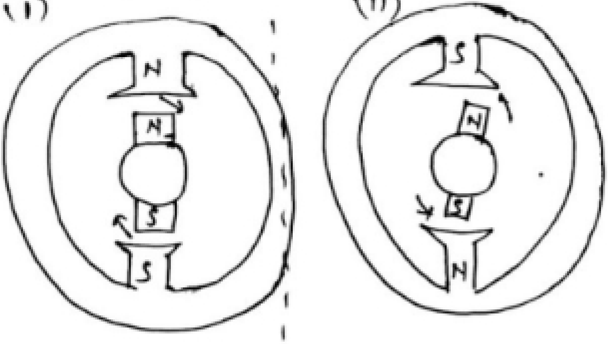
+ "Due to heavy resistor in starting coil a phase difference is devolped b/w main coil and auxilary coil, which is not 90° but sufficient to devolpe a Magnetic field (Rotating) which is capable for starting the low power Single phase Induction motor."

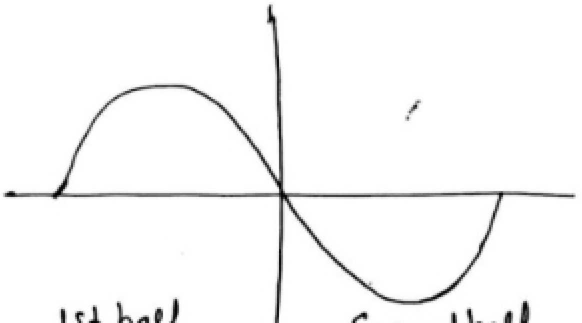
Que.14 > Explain operating Principal of Synchronous Motor. the Draw V-curve. Why It is not Self starting.

Ans. > Let Consider 3ϕ 2 pole Synchronous Machine is Three phase Synchronous Motor Stator windings are Connected to 3ϕ A.C. Supply by Rotor windings are Connected to D.C Supply.

- So Rotor pole Remains unchanged due to D.C. Supply.
- Stator pole change after each half cycle or half Time period N pole become S & S pole becomes N pole.

(i) (ii)





- let Condition(i) where North pole of stator repal North pole of Rotor So Torque is devolped in clock wise direction and motor try to rotate in this direction.
- but after half time period Stator North pole becomes South by Rotor Pole remains unchanged and Stator South pole attract the Rotor North pole hence Torque produced in anti clockwise Direction
- hence Torque is pulsating and motor Does not rotate in any direction and it is not Self starting.

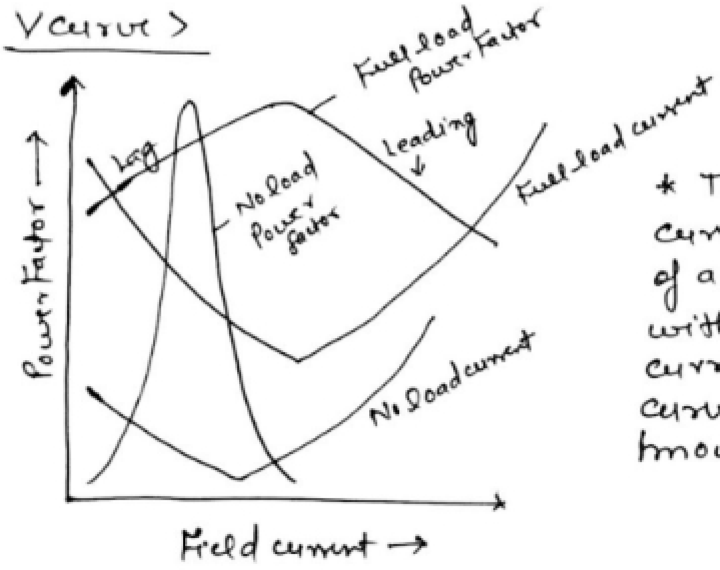
(iii)

Now if Rotate the Rotor with speed So that in half time Period is Comes from influence of one stator pole to adjacent stator pole and Now the Torque is Same as like figure(i) unidirectional Torque is porduced and Motor Start to Rotate in clockwise Direction.

· So Required speed is calculated by →

$$N_S = \frac{120f}{P}$$ known as synchronous speed

V curve >



* The variation between current and Power Factor of a synchronous Motor with variation of Field current is Represented by curve then curve are known as V-curve

Que.15 > Explain application of D.C. Motor.

Ans. > (i) D.C. Series Motor > It is variable speed motor and develope very high Torque at low speed. It has very high starting Torque therfor used in hoist, cranes, Trolley cars, conveyors, electric locomotive, elevator, etc.

(ii) D.C. Shunt Motor > It is constant speed Motor and has medium starting Torque and therfor used for constant speed application like centrifugal pump, reciprocating pump, Fans. blowers, conveyors, woodworking Machines, Machine tools, etc.

(iii) Compound Wound Motor's > Rarely used due to Poor Torque characterstics. It is basically used in machine which is subjected to sudden application of heavy load like rolling mills, Punching & Shearing Machine, lifts, mini hoists etc.

Ques.16> Explain application of Single phase Induction Motor and Threephase Synchronous Motor.

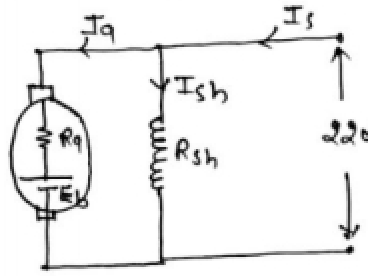
Ans.> (i) Three phase Synchronous Motor → It is Constant speed Motor hence used in -

- Power house and substations for Improving the Power Factor
- Regulate the Voltage at the end of Transmission line
- fans, blowers, dc generator, line shafts, Constant speed application.

(ii) Single phase Induction Motor > low load application like, home appliances like fan, Washing Machine, Mixy juicer, etc.

Ques.17> A 220V D.C. Shunt Motor have 4 pole and take a line current of 3A at no-load while running at 1500 r.p.m. determine the speed when motor take line current of 50A. assume field and armature resistances are 400Ω and 0.2Ω respectively.

Ans.>



Case (i) → $I_S = I_a + I_{sh}$

$$I_{sh} = \frac{220}{400} = 0.55A$$

$$I_{a_0} = 3 - 0.55 = 2.45A$$

$$E_b = V - I_a R_a$$
$$= 220 - (2.45 \times 0.2)$$
$$E_{b_0} = 219.51V$$

Case (ii) $I_S = 50A$

$$I_{a_1} = 50 - 0.55 = 49.45A$$

$$E_{b_1} = 210.11V = V - I_{a_1} R_a = 220 - (49.45 \times 0.2)$$
$$= 210.11V.$$

$$\therefore N_f = N_0 \times \frac{E_{b_1}}{E_{b_0}} = 1500 * \frac{210.11}{219.51} = 1436 \text{ r.p.m}$$

UNIT

5

1. Explain different types of wires and cables?

According to types of insulation, the cables are of the following types:

i. Vulcanized Indian Rubber (VIR) Cables:

VIR cable consists of either tinned copper conductor covered with a layer of vulcanized Indian rubber insulation. Over the rubber insulation cotton tape sheathed covering is provided with moisture resistant compound b1tumen wax or some other insulating material for making the cables moisture proof. The thickness of rubber insulation depends upon the voltage grade for which the cable is required.

The copper conductor is tinned to provide protection against corrosion due to presence of traces of sulphur, zinc oxide and other mineral ingredients in the VIR.

ii. Tough Rubber Sheathed (TRS) or Cab Tyre Sheathed (CTS) Cables:

These cables are available in 250/440 volt and 650/1, 100 volt grades and used in CTS (0r TRS) wiring. TRS cable is nothing but a vulcanized rubber insulated conductor with an outer protective covering of tough rubber, which provides additional insulation and protection against wear and tear. These cables are waterproof, hence can be used in wet conditions. These cables are available as single core, circular twin core, circular three core, flat three core, twin or three core with an earth continuity conductor (ECC). The cores are insulated from each other and covered with a common sheathing.

iii. Lead Sheathed Cables:

These cables are available in 240/415 volt grade. The lead sheathed cable is a vulcanized rubber insulated conductor covered with a continuous sheath of lead. The lead sheath provides very good protection against the absorption of moisture and sufficient protection against mechanical injury and so can be used without casing or conduit system. It is available as a single core, flat twin core, flat three core and flat twin or three cone with an earth continuity conductor.

iv. Polyvinyl Chloride (PVC) Insulated Cables:

These cables are available in 250/440 volt and 650/ 1.100 volt grades and are used in casing-capping, batten and conduit wiring system. In this type of cable conductor is insulated with PVC insulation. Since PVC is harder than rubber, PVC cable does not require cotton taping and braiding over it for mechanical and moisture protection.

v. Weather Proof Cables:

These cables are used for outdoor wiring and for power supply or industrial supply. These cables are either PVC insulated or vulcanized rubber insulated conductors being suitably taped (only in case of vulcanized rubber insulated cable) braided and then compounded with weather resisting material. These cables are available in 240/415 volt and 650/1,100 volt grades.

vi. Flexible Cords and Cables:

The flexible cords consist of wires silk/cotton/plastic covered. Plastic cover is popular as it is available in different pleasing colours. Flexible cords have tinned copper conductors. Flexibility and strength is obtained by using conductors having larger number of strands. These wires or cables are used as connecting wires for such purposes as from ceiling rose to lamp holder, socket outlet to portable apparatus such as radios, fans, lamps, heaters etc. The flexibility of such wires facilitates in handling the appliances and prevents the wires from breakage. These must not be used in fixed wiring.

vii. XLPE Cables:

PVC and XLPE cables are built of insulation made of polymers. Polymers are substances consisting of long macromolecules built up of small molecules or groups of molecules as repeated units. These are divided into homopolymers and copolymers. Homopolymers are built by reactions of identical monomers. Copolymers are built up of at least two different kinds of monomers.

The mechanical properties of the polymers e.g. tensile strength, elongation elasticity and resistance against cold depend upon chemical structure. Their resistance against external chemical influences, acids, bases or oils together with their electrical and thermal characteristics are the decisive factors for the usefulness of cables insulated and sheathed with these materials.

2. What is need of earthing. Explain different types of earthing method.

Earthing means connections of the neutral point of a supply system or the non-current carrying parts of electrical apparatus, such as metallic framework, metallic covering of cables, earth terminal of socket outlet, stay wires etc., to the general mass of earth in such a manner that at all times an immediate discharge of electrical energy takes place without danger.

Earthing is provided

1. to ensure that no current carrying conductor rises to a potential with respect to general mass of earth than its designed insulation.
2. to avoid electric shock to the human beings, and
3. to avoid risk of fire due to earth leakage current through unwanted path.

The various methods of earthing are

i. Strip or Wire Earthing:

In this system of earthing, strip electrodes of cross section not less than 25 mm 1.6 mm if of copper and 25 mm x 4 mm if of galvanised iron or steel are buried in horizontal trenches of minimum depth 0.5 metre. If round conductors are used, their cross-sectional area shall not be smaller than 3.0mm^2 if of copper and 6mm^2 if of galvanised iron or steel. The length of buried conductor shall be sufficient to give the required earth resistance. It shall, however be not less than 15 metres. The electrodes shall be as widely distributed as possible preferably in a single straight or circular trench or in a number of trenches radiating from a point. If conditions require use of more than one strip, they shall be laid either in parallel trenches or in radial trenches.

This type of earthing is used at places which have rocky soil earth bed because at such places excavation work of plate earthing is difficult.

ii. Rod Earthing:

In this system of earthing, 12.5 mm diameter solid rods of copper or 16 mm diameter solid rods of galvanised iron or steel or hollow section 25 mm GI pipes of length not less than 2.5 metres are driven vertically into the earth either manually or by pneumatic hammer. In order to increase the embedded length of electrodes under the ground, which is sometimes necessary to reduce the earth resistance to desired value, more than one rod sections are hammered one above the other.

This system of earthing is suitable for areas which are sandy in character. This system of earthing is very cheap as no excavation work is involved.

iii. Pipe Earthing:

This is the most common and best system of earthing as compared to other systems suitable for the same earth and moisture conditions.

In this method of earthing, a galvanised steel and perforated pipe of approved length and diameter is placed upright in a permanently wet soil.

The size of the pipe depends upon the current to be carried and type of soil. Usually the pipe used for this purpose is of diameter 40 mm and 2.5 metres in length for ordinary soil or of greater length in case of dry and rocky soil. The depth at which the pipe must be buried depends upon the moisture of the ground. The pipe is placed at a depth of 3.75 metres (minimum). The pipe is provided with a tapered casting at the lower end in Order to facilitate the driving. The pipe at the bottom is surrounded by broken pieces of coke or charcoal for a distance of about 15 cm around the pipe. Generally alternate layers of coke and salt are used to increase the effective area of the earth and to decrease the earth resistance respectively. Another pipe of 19 mm diameter and minimum length 1.25 metres is connected at the top of GI pipe through reducing socket.

iv. Plate Earthing:

This is another common system of earthing. In plate earthing an earthing plate either of copper of dimensions 60 cm X 60 cm X 3 mm or of galvanised iron of dimensions 6o cm X 60 cm X 6 mm is buried into the ground with its face vertical at a depth of not less than 3 metres from ground level.

3. What is the effect of electric shock on human body?

Bruner (1967) states that the threshold of perception of electric shock is about 1 mA. At this level u tingling sensation is felt by the subject when there is a contact with an electrified object through intact skin. With the increase in magnitude of ac. the sensation of tingling gives way to contraction of muscles. The muscular contractions increase as the current is increased and finally a value of current is reached at which the subject cannot release his grip on the current carrying conductor. The maximum current at which the subject is still capable of releasing a conductor by using muscles directly stimulated by the current is called "let go current". The value of this current is significant because an individual can withstand, without serious after effects, repeated exposures to his 'let go current' for at least the time required for him to release the conductor. Also currents slightly in excess of 'let go current' would not permit the individual to release his grip from the conductor supplying current.

Based on the experiments conducted on males and females, it is generally accepted that the safe 'let go current' could be taken approximately 9 mA and 6 mA for men and women respectively.

At current levels higher than the 'let go current' the subject loses ability to control his (m n muscle actions and he is unable to release his grip on the electrical conductor. Such currents are very painful and hard to bear. This type of accident is called 'hold-on-type' accident, and is caused by currents in the range 20-100 mA. These currents may also cause physical injury due to powerful contraction of the skeletal muscles. However, the heart and respiratory function usually continue because of uniform spread of current through the trunk of the body.

If current contacts contact skin and passed through the trunk, at about 100 mA and above, there is a likelihood of pulling the heart into ventricular fibrillation. In this condition, the rhythmic action of the heart ceases, pumping action stops and the pulse disappears. Ventricular fibrillation is a serious cardiac emergency because once it starts, it practically never stops spontaneously. It proves fatal unless corrected within minutes, since the brain begins to die 2 to 4 minutes after it is robbed of its supply of oxygenated blood.
At very high currents of the order of 6A and above, there is a danger of temporary respiratory paralysis and also of serious burns. However, if the shock duration is of only a very few seconds, there is a possibility of heart reverting to the normal rhythmic action.

The threshold of perception depends largely on the current density in the body tissues. It may vary widely depending upon the size of the current contact. At very small point contact, it is probable that even 0.3 mA current may be felt whereas a current in excess of perhaps 1 mA may not produce sensation if the contacts are somewhat larger. Similarly, depending on the size of contact, the threshold of pain may also be considerably above 1 mA, probably 10 mA if the contacts are large enough.
Besides the magnitude of current, the current duration and the relationship of current flow resistance are also important. Duration of less than 10 ms typically does not produce fibrillation whereas duration of 0.1 s or longer does. It has been found experimentally that the safe value of current in amperes (rms) which a human body can tolerate is given as

$$I = \frac{0.165}{\sqrt{t}}\, for\ t < 3s\ and\ I = 9mA\ for\ t > 3s$$

where t is the time duration in seconds of the flow of current.

Que.4> Explain Different Component of LT Switch Gear.

Ans.> In an electric Power System Switchgear is the combination of electrical Disconnect Switches, fuses or circuit breaker used to Control, Protect and Isolate electrical equipment. Following Component are used to perform above mentioned function.

(i) Fuses → Simplest and cheapest Device for break the electrical Connection under overload or short circuit Protection.
the action of Fuse is based on flow of current through fuse wire if current exceed beyond limit then heat develope in wire which is more then melting point of wire So Fuse break the electrical Connection. there are following types.
(i) Round type (ii) kitkat type fuse (iii) cartridge type
(iv) HRC (v) Semi conductor Fuse unit.

(ii) Miniature Circuit Breaker (MCB) > It is used to Protect wiring Installations and Sophisticated equipment against overcurrent and short ckt Faults. The operation is based on bimetallic strip which deflects when heated by over current flowing through it hence releases the electrical Connection. MCB are available with different current rating 0.5 to 160 A.

(iii) Earth leakage Circuit Breaker> [ELCB] > It is device that Provide Protection against earth leakage. there are of two types+
(i) Current operated earth leakage Circuit Breaker
(ii) Voltage operated earth leakage Circuit Breaker

– Current operated ELCB is used when the Product of the operating current in ampere and the earth loop Impedance in ohms does not exceed 40. $I_m Z_s < 40$

* Voltage operated ELCB is used when earth-loop Impedance exceeds the value applicable to fuses or other circuit breaker.

(iv) Molded Case Circuit Breaker (MCCB) > It is used to wide range of Voltage and frequency and have current rating upto 2500 A also trip setting is adjustable. also MCCB is larger then MCB. operating principal is based on bimetallic strip contact which expand and contracts in response to change in temp.

Que.3 > What is the Difference b/w MCCB & MCB

MCB	MCCB
(i) Current rating upto 160A	(i) Current rating upto 2500 Amper
(ii) Size is Small	(ii) Size is large in compare to MCB
(iii) trip setting is not adjustable	(iii) Tripping current is adjustable
(iv) Range of frequencies are Narrow	(iv) Range of Frequencies are wide.

Ques.5> Explain amper hour and Watt-hour efficiency.

Ans.> (i) Ampere-hour efficiency → ratio of Ampere hour of discharge to amper hour of charge.

$$\eta_{A\text{-}h} = \frac{I_d T_d}{I_c T_c} \times 100$$

(ii) Watt-hour efficiency → Ratio of energy delivered in Watt hour during Dis charge to energy Consume during charging.

$$\eta_{w\text{-}h} = \frac{V_d I_D T_d}{V_c I_c T_c} \times 100$$

V_d → Discharge Voltage
T_d → Discharge time
I_d → Dis charge Current
V_c → charging Voltage
T_c → charging time
I_c → charging current

Ques 6> A battery has taken charging current of 5.2 A for 24 hour at a Voltage 2.25V while Discharging it gave a current of 4.5 A for 24 hour at an average Voltage of 1.85V Calculate amper-hour and Watt hour efficiency.

Ans.> Given →

$I_c = 5.2\,A$ $\quad I_D = 4.5\,A$
$V_c = 2.25\,V$ $\quad V_D = 1.85\,V$
$T_c = 24$ hour $\quad T_D = 24$ hour

now

$$\eta_{A\text{-}h} = \frac{T_d I_D}{I_c T_c} \times 100 = \frac{4.5 \times 24}{5.2 \times 24} \times 100 = 86.54\%$$ Ans

$$\eta_{w\text{-}h} = \frac{V_d I_d T_d}{V_c I_c T_c} \times 100 = \frac{4.5 \times 1.85 \times 24}{5.2 \times 2.25 \times 24} \times 100 = 71.15\%$$ Ans