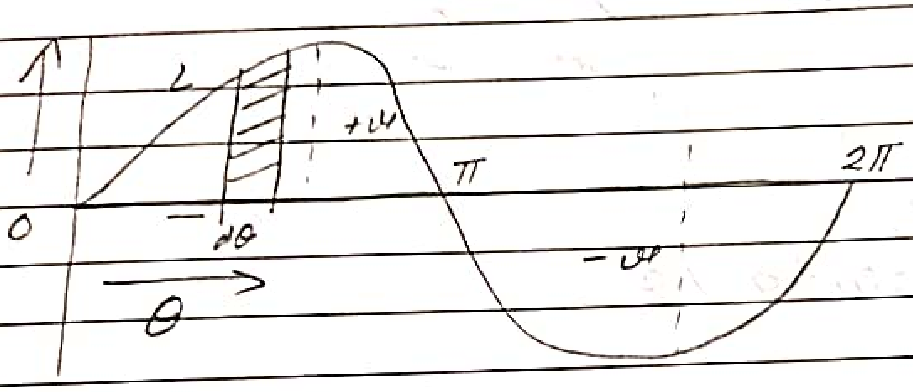
AC Circuits

Averge value sinsucr

The altarnating current varies sinusoidaly as shown in fig 1.



Area of elementry

(i) $i = I_m \sin\theta$ —— (1)

Consider an elementry strip of thickness the θ in the +ve half cycle has been tak

Area of half cycle will be $(A) = \int_0^{\pi} i\, d\theta$

$(A) = \int_0^{\pi} i \sin\theta\, d\theta$

$(A) = i_m \int_0^{\pi} \sin\theta\, d\theta \Rightarrow i_m(-\cos(\pi) - \cos 0$

$= i_m (1+1) \Rightarrow i_m(2) \Rightarrow 2 I_m$

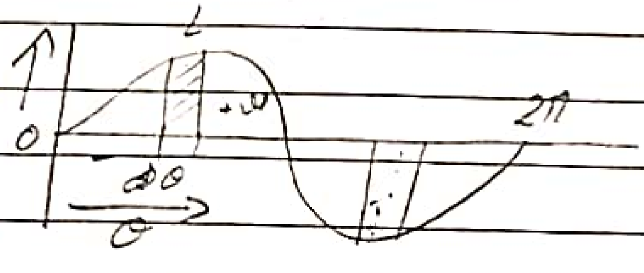
Average value of current is

$I_{av} = \frac{\text{Area of altanaties}}{\text{base}}$

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

$$I_{av} = \frac{2I_m}{3.14} = 0.637\,m$$

RMS value of current :-



$$I_m^2 \int_0^{\pi} \sin^2\theta \, d\theta$$

$$= I_m^2 \int_0^{\pi} \frac{1-\cos 2\theta}{2} \, d\theta$$

$$= \frac{I^2 m}{2} \int_0^{\pi} (1-\cos 2\theta) \, d\theta$$

$$\boxed{\cancel{= \frac{I^2 m}{2} \left[1 - \left(\frac{\sin 2\theta}{2} \right) \right]_0^{\pi} d\theta}}$$

$$= \frac{I^2 m}{2} \left[\theta - 0 \right]_0^{\pi} \qquad \cos 2\theta = 0$$

$$= \frac{I^2 m}{2} \left[\pi - 0 \right]$$

$$= \frac{\pi I^2 m}{2} \Rightarrow 3.14 \times \frac{I^2 m}{2}$$

$$I_{RMS} = \sqrt{\frac{\frac{\pi I_m^2}{2}}{\pi}} \Rightarrow \frac{I_m}{\sqrt{2}} = 0.707\, I_{mV}$$ [max value]

Form Facture:-

It is the ratio of R.M.S value to average value of alternating ~~quality~~ of quantity is called form factor.

$$\frac{I_{rms}}{I_{av}} = \frac{I_m/\sqrt{2}}{2I_m/\pi}$$

$$\frac{I_{rms}}{I_{av}} = \frac{\cancel{I_m}}{\sqrt{2}} \times \frac{\pi}{2\cancel{I_m}}$$

$$\frac{I_{rms}}{I_{av}} = \frac{\pi}{2\sqrt{2}}$$

$$\frac{I_{rms}}{I_{av}} = 1.11$$

Peak Factor:-

It is the ratio of maximum value to rms value of an alternating quanting is called peak factor.

$$P.f = \frac{I_m}{I_m/\sqrt{2}}$$

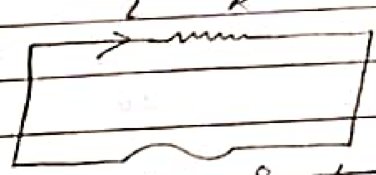
$$P.f = \frac{\cancel{I_m}}{\cancel{I_m}} \times \sqrt{2}$$

$$P.F = \sqrt{2}$$

$$P.F = 1.414$$

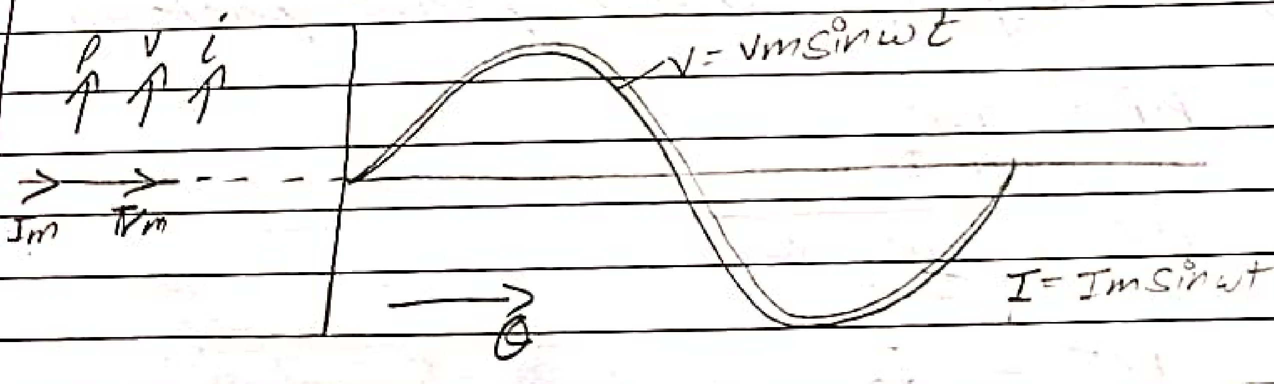
→ Condudence
→ impedence
→ ~~Avafidence~~ Ampedence

⟹ AC circuit having resistance only:- let an alte-rting voltage applied across the surface circuit is given by $V = V_m \sin\omega t$
The current can be defing by equation number (ii)



$V = V_m \sin\omega t$ — (i)
$i = I_m \sin\omega t$ — (ii)

$$P = Vi$$
$$= \frac{V_m I_m 2\sin^2\omega t}{2}$$
$$= \frac{V_m}{\sqrt{2}} \frac{I_m}{\sqrt{2}} (1 - \cos 2\omega t)$$
$$\frac{V_m}{\sqrt{2}} \frac{I_m}{\sqrt{2}} - \frac{V_m}{\sqrt{2}} \frac{I_m}{\sqrt{2}} \cos 2\omega t \qquad \because \cos 2\omega t = 0$$
$$= \frac{V_m}{\sqrt{2}} \frac{I_m}{\sqrt{2}}$$



- In case of resistance their is no ~~phace~~ difference b/w voltage & current and the power obtained is maximum.

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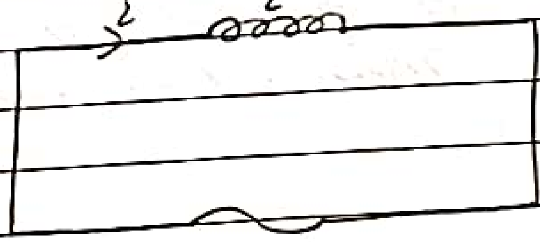
⇒ **AC circuit having inductor** :— let the alternating voltage applied across a circuit is given by

$V = V_m \sin\omega t$ — (I)

As a result an alternating current I flo[ws] through the inductance which induse an EMF that is given by $e = -L\frac{di}{dt}$ — (II)

as per lens know this induced emf is equal and opposite to that of applied vol[tage]

from eq (II)



$V = -e$

$V = -\left(-L\frac{di}{dt}\right)$

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

or

$\int di = \int \frac{V_m}{L}\sin\omega t\, dt$ — (III)

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

$i = \frac{V_m}{X_L}\left(\sin\omega t - \frac{\pi}{2}\right)$ — (IV) $\quad \therefore \frac{V_m}{X_L} = I$

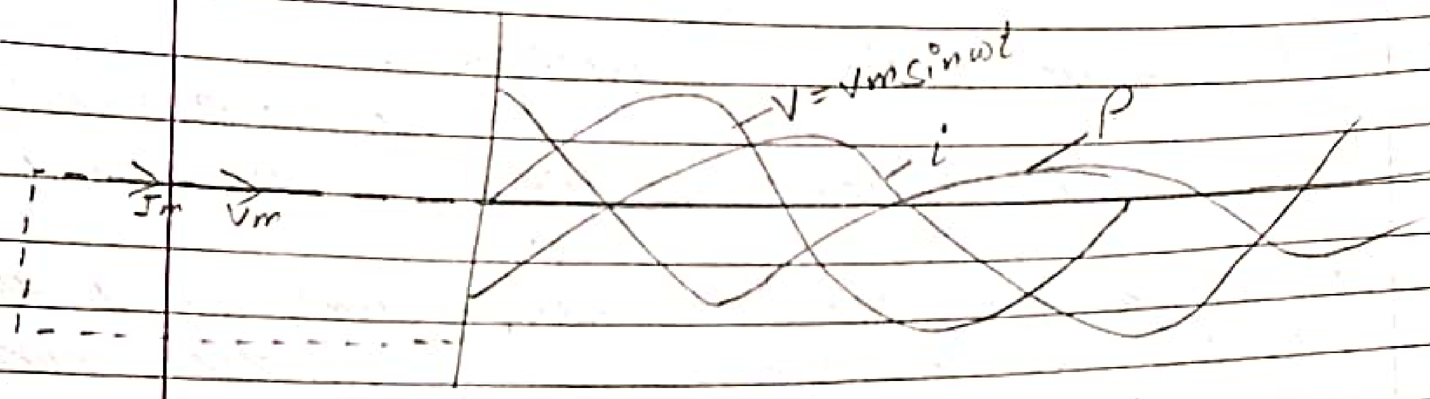
$i = I_m \sin\left(\omega t - \frac{\pi}{2}\right)$ — (V)

$P = VI$

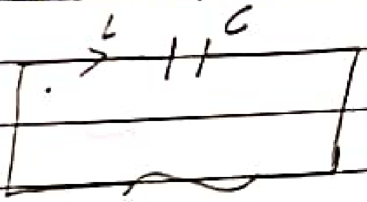
$P = V_m \sin\omega t \times I_m \sin\left(\omega t - \frac{\pi}{2}\right)$

$= \frac{V_m I_m}{2} \times 2\sin\omega t + \cos\omega t$

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



⟹ AC circuit having pure ~~conductor~~ capacitor only :- let the alternating voltage applied across the circuit is given by same. charge on the capacitor is given by equation (II)
current flowing to the circuit $i = \frac{dq}{dt}$



$V = V_m \sin \omega t$ —(I)

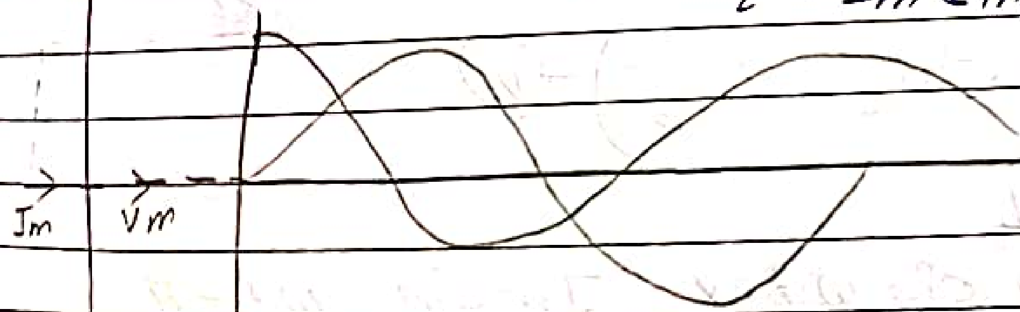
$q = CV$ —(II)

$i = \frac{dq}{dt}$ —(III)

$i = \frac{d(CV)}{dt} \Rightarrow \frac{dC\, V_m \sin \omega t}{dt}$

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

$i = I_m \sin(\omega t + \frac{\pi}{2})$ —(VI)



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Numerical :-

Ans :- An AC circuit consist of a pure resistance of 10 ohm(Ω) and is connected across a supply of 230 V, 50 Hz calculate :- 1) the current 2) power consume and (3) expression, (4) voltage and current.

$$V = IR$$

$$\frac{V}{R} = I \Rightarrow I = \frac{230}{10} \Rightarrow \underline{\underline{23 A}}$$

(i) = $I = 23 A$

(ii) $P = VI$

$P = 230 \times 23$

$P = 529 W$

$\cancel{(iii)\ V_{rms} = \sqrt{2}V}$

$\cancel{\Rightarrow 1.414 \times 230} = \cancel{\text{[illegible]}}$

(iii) $V_m = \sqrt{2} V$

$= 1.41 \times 230 = 325.2 V$

(iv) $\omega = 2\pi f = 2 \times 3.14 \times 50 = 314$

$V = V_m \sin \omega t$

$= 325.2 \sin(314)$

$= -0.7 \times 325.2$

$= -233.9$

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Ques:- An inductive coil having negligible resistence 0.1 Henery inductance is connected across 200V, 60 Hz supply. find

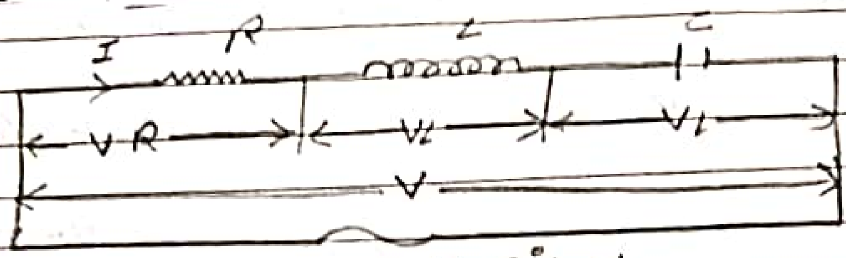
a.) Inductive Reactance
b.) RMS value of current
c.) Power
d.) Expression for voltage and current

$L = 0.1\,H$
$V = 200\,V$
$\nu = 50\,H.$

(a) $X_L = \omega L$
$= 2\pi \nu L$
$= 2\pi \times 50 \times 0.1 = 31.41\,\Omega$
$X_L = 31.41\,\Omega$

(b) $I_{rms} = \frac{V_{rms}}{X_L} = \frac{200}{31.4} = 6.36$

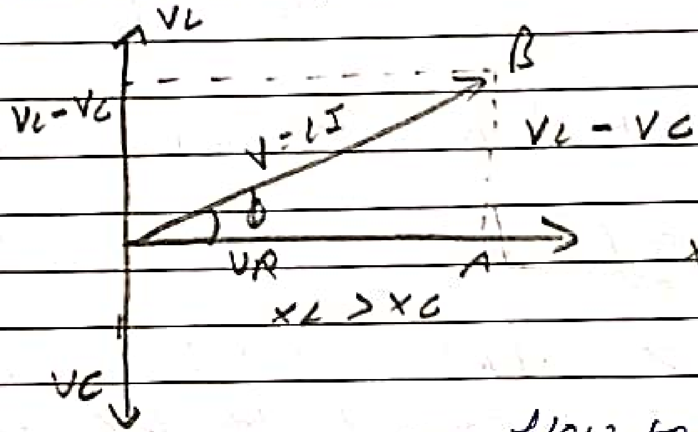
RLC series circuit :-



$V_R = IR$
$V_L \Rightarrow I X_L$
$V_C \Rightarrow I X_C$

$V = V_m \sin \omega t$

A circuit which have a pure resistance of R Ω, a pure inductance of ~~H~~ L Henery and a pure capacitor of capacitance and come are connected in series is known as RLC series circuit.



$X_L > X_C$

$X_L = \omega L = 2\pi f L$

$X_C = \frac{1}{\omega C} = \frac{1}{2\pi f C}$

When a resulting current I ~~close to the~~ flow to the circuit the voltage across each component will be.
The phaser diagram is show in Fig = 2 their current is taken as the reference pha since voltage across inductance V_L leads th current I by 90° and voltage across capa-tance V_C lags the current by 90°.
If V_L is greather then V_C the circuit beh as an inductive circuit but when ~~V_L~~ is les then V_C the inductive circuit behave as a capacitive

circuit. From the phaser diagram the circuit is consider for the inductive circuit.

$$V = \sqrt{(V_R)^2 + (V_L - V_C)^2} \leftarrow \text{from phaser diagram.}$$

$$V = \sqrt{(IR)^2 + (IX_L - IX_C)^2}$$

$V_R = IR$ — (i)

$V_L \Rightarrow IX_L$ — (ii)

$V_C = IX_C$ — (iii)

$$V = \sqrt{I^2\left((R)^2 + (X_L - X_C)^2\right)}$$

$X_L = \omega L = 2\pi f L$

$X_C = \frac{1}{\omega C} = \frac{1}{2\pi f C}$

$$\boxed{V = I\sqrt{R^2 + (X_L - X_C)^2}}$$

$$\alpha \quad \boxed{V = I\sqrt{R^2 + \left(2\pi f L - \frac{1}{2\pi f C}\right)^2}}$$

$$V = I\sqrt{R^2 + (X_L - X_C)^2}$$

$$\boxed{V = IZ}$$

where $Z = \sqrt{R^2 + (X_L - X_C)^2}$ it is the total appoqition offered to the flow of alternating current by an RLC ~~[illegible]~~ series circuit and it known as inpidence of the circuit.

formula:- $\phi = \tan^{-1}\left(\frac{V_L - X_C}{R}\right)$

⇒ Three Cases of RLC series circuit

i) When X_L is greater than X_C the phase angle is $+ve$. In this case the circuit current leads behind the applied voltage and power factor is lacking the equation for the current will be $I = I_m \sin(\omega t - \phi)$

2) When X_L is less then X_C
angle is -ve in this case circuit behave an RC series circuit. The circuit current leads the applied voltage and power fecture is leading and it this case the equation of current is $i = I_m \sin(\omega t + \phi)$

$\phi = \pi/2$

3) When X_L is equal to X_C the phase angl is zero and the circuit behaves as a pure resistive circuit in this case the circuit curre is in phase with the applied voltage and th equation of current will be ~~high~~

$i = I_m \sin \omega t - R$

current change every time in each case.

⇒ Series resonance:- In an RLC series cir -cuit when circuit curren is in phase with the applied voltage the ci is said to be series resonance and X_L

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

$$Z_r = \sqrt{R^2} \Rightarrow Z_r = R$$

$$(I_r = V/Z_r)$$

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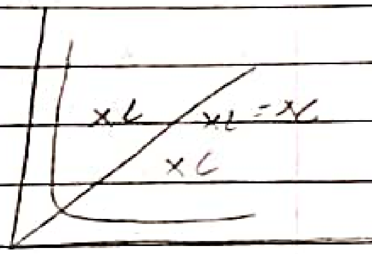
$\Rightarrow$ **Resonance frequency:-** The value of X_L and X_C this ~~applied sup~~ supply ~~apply~~ can be change by changing the frequency. so that the series resonance frequency will be



$$X_L = X_C$$

$$2\pi f_r L = \frac{1}{2\pi f_r C}$$

$$(2\pi f_r L)\, 2\pi f_r C = 1$$

$$4\pi^2 f_r^2 LC = 1$$

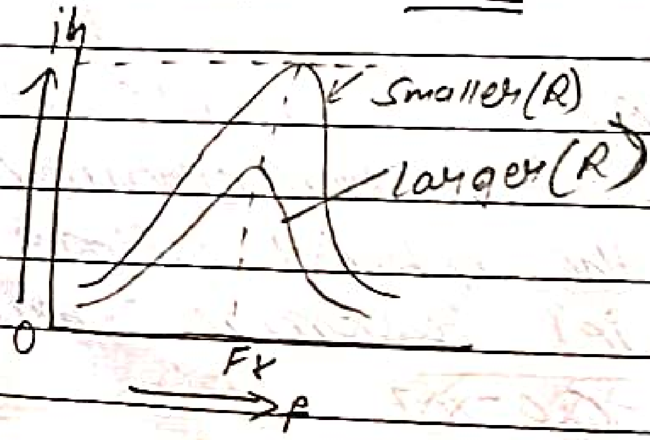
$$f_r^2 LC = \frac{1}{4\pi^2}$$

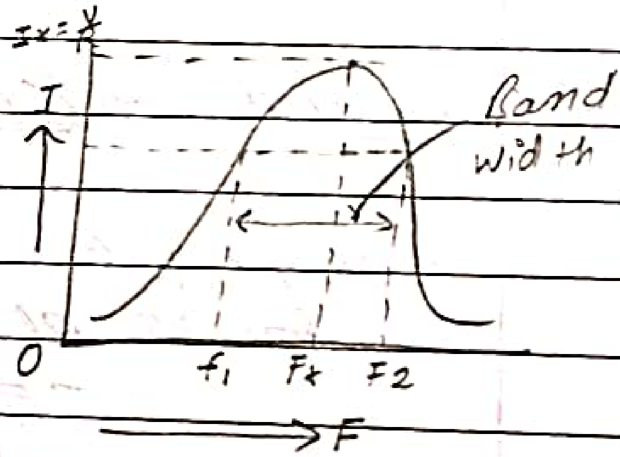
$$f_r^2 = \frac{1}{4\pi^2 LC}$$

$$f_r = \sqrt{\frac{1}{4\pi^2 LC}}$$

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

$\Rightarrow$ **Resonance Curve:-**





Quality factor or Q factor :-

The factor by which the potential difference across L or C rises to that off applied voltage is called Q factor of the series resonant circuit.

$$Q \text{ factor} \Rightarrow \frac{I_r X_L}{I_r R} = \frac{\omega_r L}{R}$$

$$= 2\pi f_r \frac{L}{R}$$

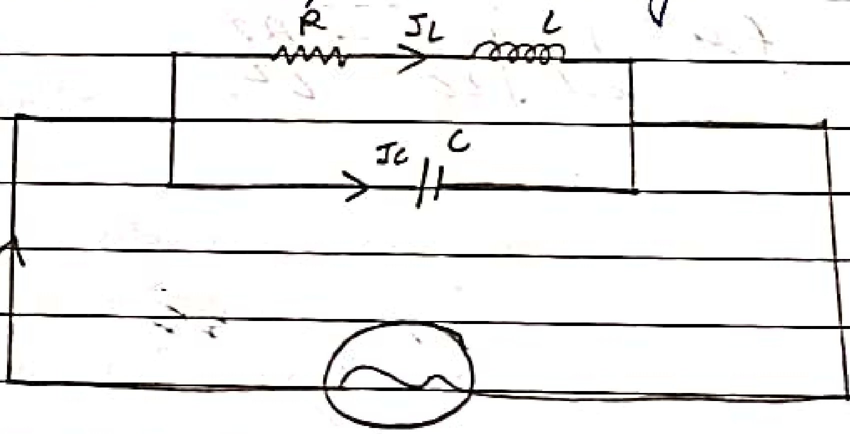
$$\because f_r = \frac{1}{2\pi\sqrt{LC}}$$

$$= 2\pi \times \frac{L}{2\pi R\sqrt{LC}}$$

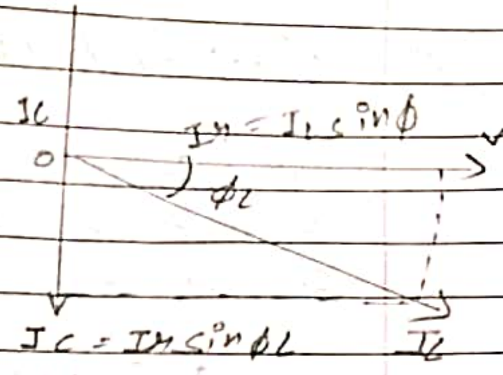
$$= \frac{1}{R\sqrt{LC}}$$

Parallel resonance :-

An AC circuit having an inductor & capacitor in parallel is set to be parallel resonance when the circuit current in phase with the applied voltage.



The circuit current I_R will be in phase with the supply voltage when $I_C = I_L \sin\phi$



$$V = I_C X_C$$
$$V = I_L Z_L$$

$$\sin\phi_L = \frac{X_L}{Z_L}$$

$$\frac{V}{X_C} = \frac{V}{Z_L} \times \frac{X_L}{Z_L}$$

or

$$X_L X_C = Z_L^2$$

$$\frac{\omega L}{\omega C} = Z_L^2 = \left(R^2 + X_L^2\right)$$

$$\frac{L}{C} = R^2 + (2\pi f_r L)^2$$

$$2\pi f_r L = \sqrt{\frac{L}{C} - R^2}$$

$$f_r = \frac{1}{2\pi L}\sqrt{\frac{L}{C} - R^2}$$

$$f_r = \frac{1}{2\pi}\sqrt{\frac{1}{LC} - \frac{R^2}{L^2}}$$

⇒ Comparison of Series & Parallel Resonance ckts :-

Sr. no	Particulars	Series circuit	Parallel circuit
1	Impedence	Minimum i.e $Z_r = R$	Maximum i.e $Z_r = L/CR$
2	current	Maximum i.e $I_r = V/R$	Minimum i.e $I_r = V/Z_r$
3	Resonant frequency (f_r)	$f_r = \frac{1}{2\pi\sqrt{LC}}$	$f_r = \frac{1}{2\pi}\sqrt{\frac{1}{LC} - \frac{R^2}{L^2}}$
4	Power factor (P.f)	unity	unity
5	Q factor	X_L/R	X_L/R
6	Amplification	It amplifies voltage	It aimplefers current

Numerical:-

Ques find the empidence current and power fact of the following circuit and draw the phas diagram for? (i) R A L

(ii) R A C

(iii) R, L, C

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in each case the applied voltage is 200 V frequency is 50 Hz resistance is 10Ω. Value of L (circumstance) ~~50~~ henry and capacitance ~~100~~ 100 uF.

Solution =)

$V = 200\,V$

$R = 10\,\Omega$

$f = 50\,Hz$

$C = 100\,\mu F$

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

(i)

$2\pi f L = 2 \times \pi \times 50 \times 50$

$= 5000\pi \times 10^{-3}$

$= 15700 \times 10^{-3}$

$= 15.7$

$Z = \sqrt{R^2 + (\omega L)^2}$

$= \sqrt{100 + (15.7)^2}$

$= \sqrt{100 + 246.49}$

$= \sqrt{346.49} = 18.61$

$V = ZI$

$I = \frac{V}{Z} = \frac{200}{18.61} = 10.74$

$\cos\phi = \frac{R}{Z} = \frac{10}{18.61} = 0.54$

⇒ Three phase (ϕ) Balanced circuits :- Star / Delta

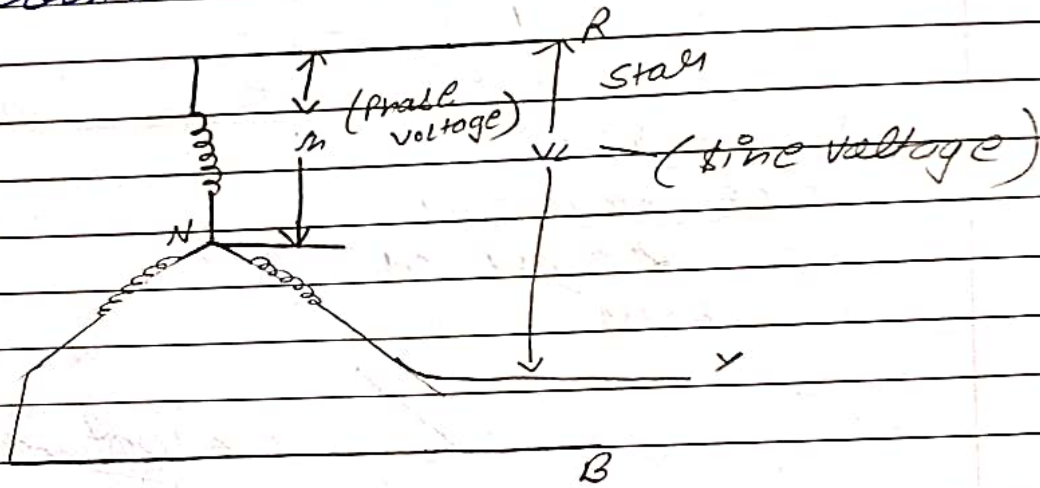
⇒ Advantages of 3 phase(ϕ) over 1 phase(ϕ) system

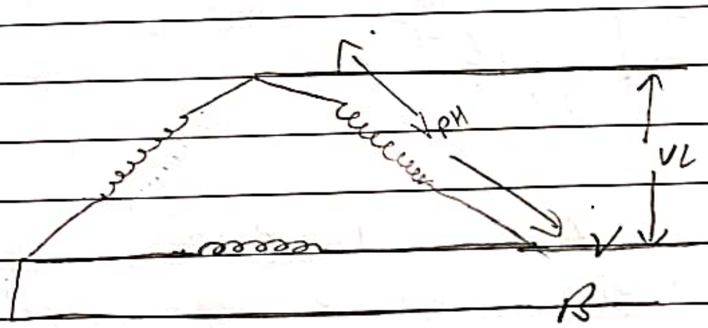
1:> Constant Power
2:> Higher Rating
3:> Power Transmisson Economies

⇒ In start conection the similar end (either start or finish of the three winding are connected to a comman point called start or Neutral point

$V_{ph} = V_L/\sqrt{3}$

$I_{ph} = I_L$





$I_{ph} = I_L/\sqrt{3}$

$V_{ph} = V_L$

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Unit = III

P.N Junction

Important Energy bands:-

1.) Valance band:- The electrons in the outmost orbit of an atom are knows as valance electron under normal condition of the Atom valance band contains the e^- of heigest energy. This band may be filled completely or paltially.

2.) Conduction gap :- In some of the materials for example :- matels the valance e^- are attached to the neclus can be reattached very easily. These e^- are knows as free e^- and a responsible for the conduction of current.

3.) forbidden energy gap:- The energy gap b/w the valance band and conduction band is knows as forbidden energy gap.

HOL :- A vacancy left in the valance ba[nd] because of lifting of electron from valance band to conduction band is cal[led] HOL.