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) $\omega = 2\pi f = 100\pi$
$f = 50\text{ Hz}$.

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

(V) $V_{av} = \dfrac{2V_m}{\pi} = \dfrac{400\sqrt{2}}{\pi}$

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

(VII)
Form Factor $= \dfrac{V_{rms}}{V_{av}} = \dfrac{V_m/\sqrt{2}}{2V_m/\pi} = 1.11$

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.

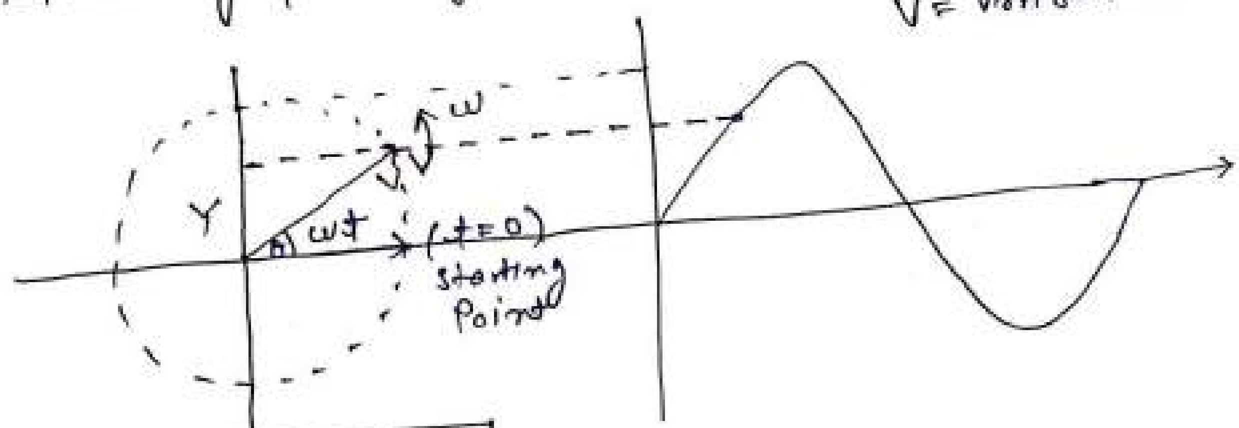
$$\text{Peak Factor} = \frac{\text{Maximum Value of A.C}}{\text{R.M.S Value of A.C.}}$$

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 Instantaneous Value of particular Alternating quantity. the starting point (t=0) of Phasor depend upon the equation of Alternating quantity "



$Y_{(t)} = V_m \sin \omega t$

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

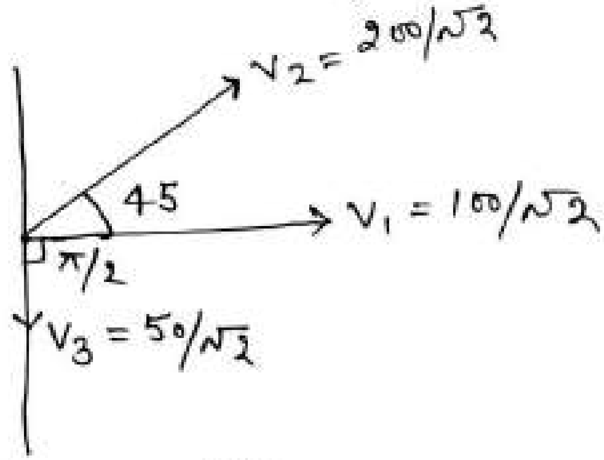
Que. 4 > Represent following Alternating quantities in phasor Form then Find the resultant of All.

$V_1 = 100 \sin 500t$
$V_2 = 200 \sin(500t + 45)$
$V_3 = -50 \cos 500t$

Ans. → For analysis all quantities must in phasorform

$V_1 = 100 \sin 500t$
$V_2 = 200 \sin(500t + 45)$
$V_3 = 50 \sin(500t - \pi/2)$

Phasor Representation >



Addition >

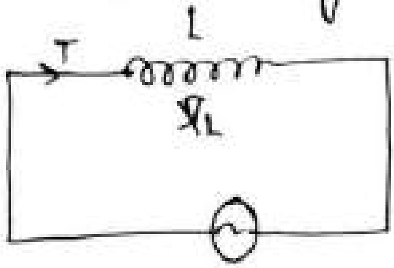
	V_x	V_y
V_1	100/[illegible]	0
V_2	$100\sqrt{2}$	141.42
V_3	0	− 50
V_R	241.42	91.42

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

$\tan\phi = \dfrac{91.42}{241.42}$ $\quad \phi =$

Ans. 5 > Prove that in purely Inductive & Capacitive ckt Power consumed is zero.

Ans. > (i) Purely Inductive ckt →



$V = V_m \sin \omega t$

⇒ 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. appose 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

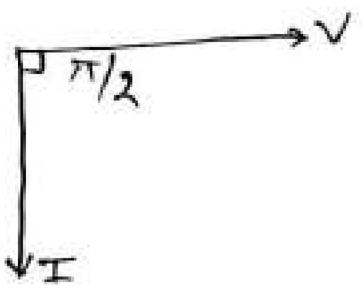
$$\int di = \int \frac{V}{L} dt$$

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

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

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

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



Now Instantaneous Power is

$$P_{in} = V I$$

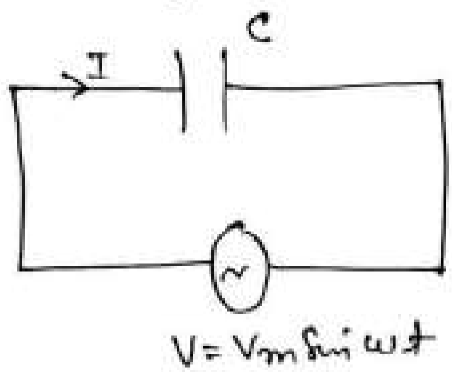
$$= V_m \sin \omega t \; I_m \sin(\omega t - \pi/2)$$

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

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

because average value of $\sin 2\omega t$ 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

$$P_{in} = VI$$

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

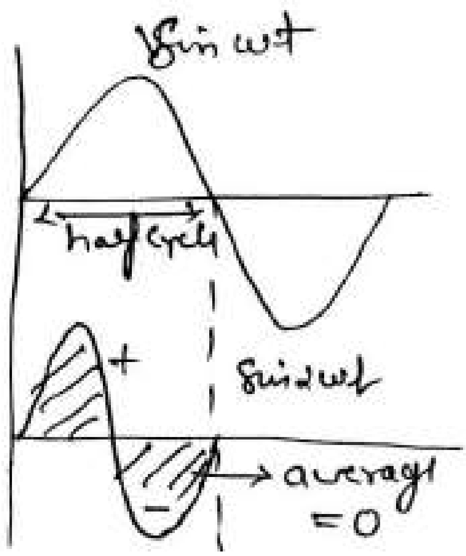
$$= \frac{V_m I_m}{2}(2 \sin \omega t \cos \omega t)$$

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

+ now average power →

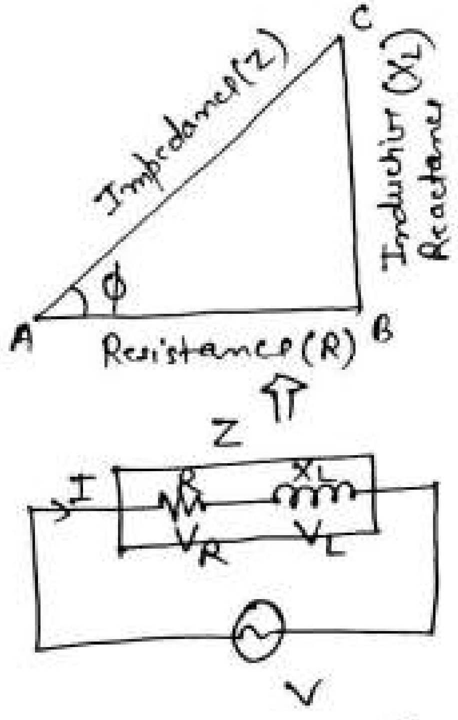
$$P_{av} = 0 \longrightarrow$$

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.



$$AB = \frac{V_R}{I} = R$$

$$BC = \frac{V_L}{I} = X_L$$

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

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

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

* $\cos\phi$ 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.

$$P_a = VI$$

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

$$P_T = VI\cos\phi$$

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.

$$P_R = VI\sin\phi$$

unit VA or KVAR (Volt-Ampere Reactive)

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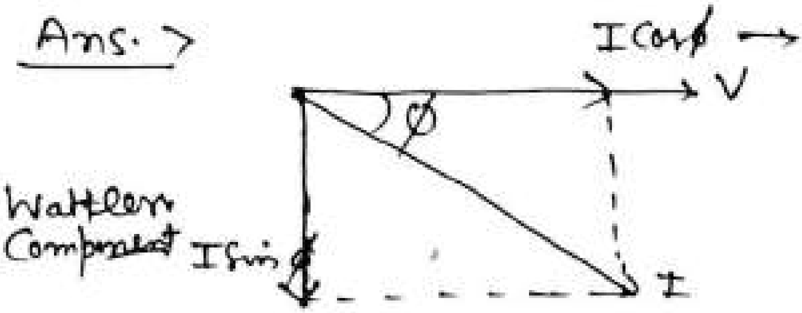
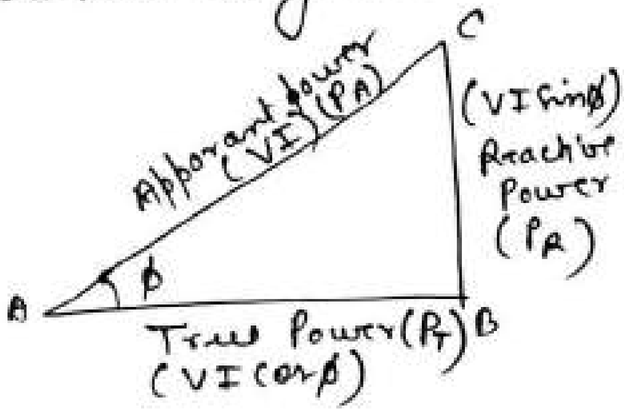
Que 8 → Explain Power Triangle then Discuss about Watt and Wattless Component of current.

Ans. →



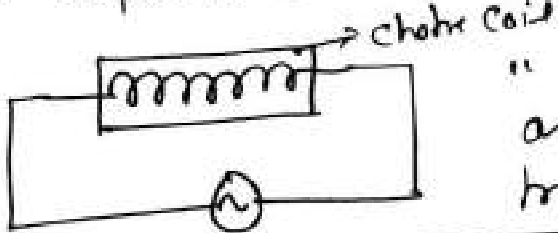
* The Component of current in phase with Voltage is known as active component or is Watt Component of Current because It is Responsible for Power Consumption
* Wattless Component → The Component of current quadrature To Voltage is called Watt-less Component It does not consume any Power.



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

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

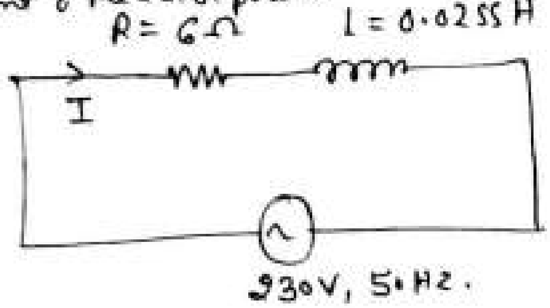
Q Factor → Reciprocal of Power Factor is known as quality Factor

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

" 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. →



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

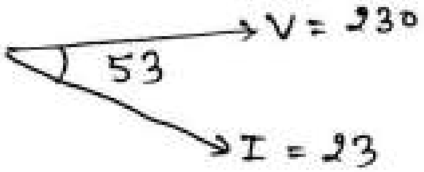
(i) $Z = \sqrt{R^2 + X_L^2} = \sqrt{6^2 + 8^2} = 10 \Omega$

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

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

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

(v)



$V = 230\sqrt{2} \sin \omega t$

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

(vi) Apparent & Reactive Power

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

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

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

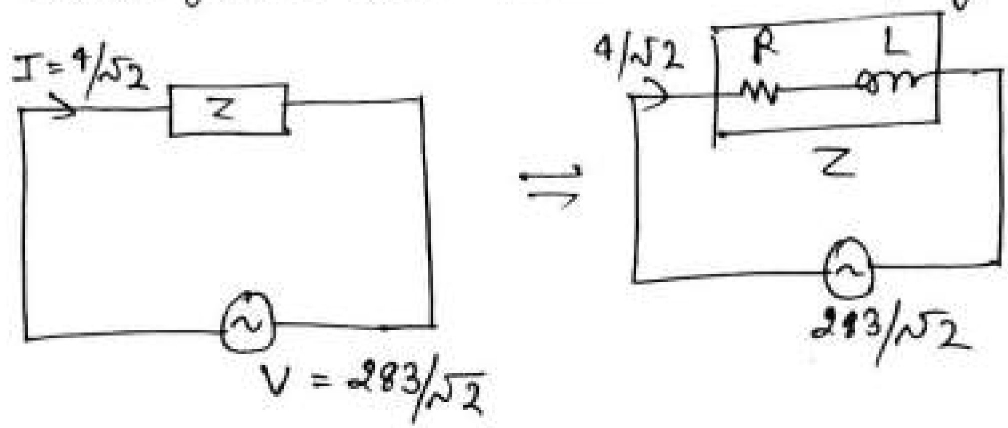
$V = 283 \sin 314t$

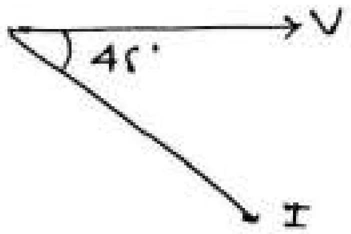
$I = 4 \sin(314t - 45°)$

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

$$Z = V/I = \frac{283/\sqrt{2}}{4/\sqrt{2}} = 70.75\Omega \text{ Ans}$$

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

$= 70.75 \cos 45$

$= 50\Omega$

$X_L = Z\sin\phi$

$= 50\Omega$

$2\pi f L = 50\Omega \Rightarrow L = 50/2\pi f = 0.159\,H$ Ans

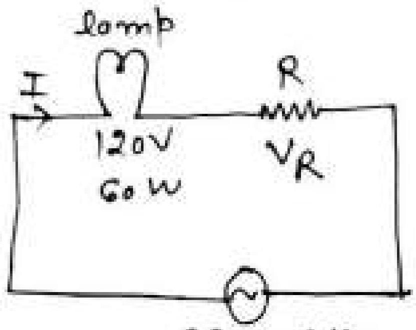
(ii) Power Factor $\Rightarrow \cos\phi = \cos 45 = 0.707$ (lagging)

$P = VI\cos\phi$

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

Q.71> A, 60 W, 120 V lamp connected across 220V, 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)



220V, 50 Hz.

" lamp to be considered as pure Resistor "

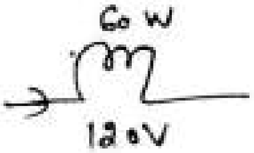
$V_R + 120 = 220$

$V_R = 100\ V$

$IR = 100\ V$

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

for lamp

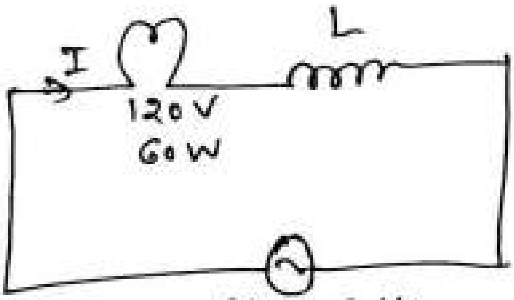


$P = VI$

$I = 60/120$

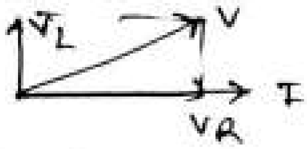
$= 0.5 A$

(ii) for Inductor →



220V, 50 Hz.

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



$V_R^2 + V_L^2 = V$

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

$IX_L = 184.4$

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

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

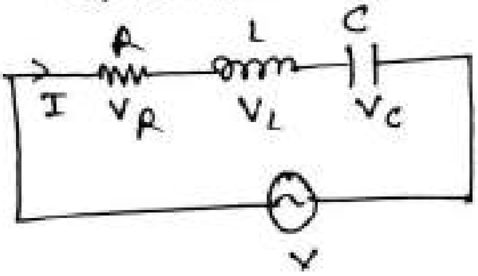
Ques.12> What is Resonance?

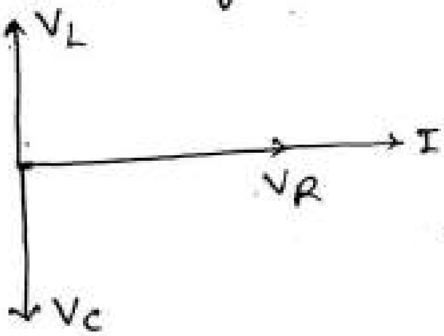
Ans.> The Resonance is a phenomenon which takes place in the circuit containing two types of Energy storing element (like Inductor & Capacitor) such that Energy can interchange b/w them.

"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

$$V_L = V_C$$

$$IX_L = IX_C$$

$$X_L = X_C$$

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

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

$$V_L = IX_L$$

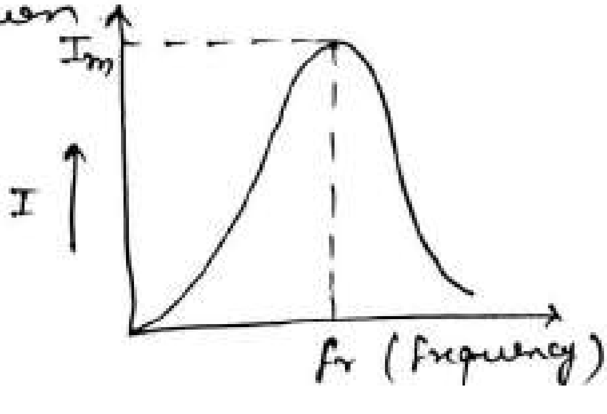
$$V_C = IX_C$$

$$V_R = IR$$

Ques.14> What is Resonance curve.

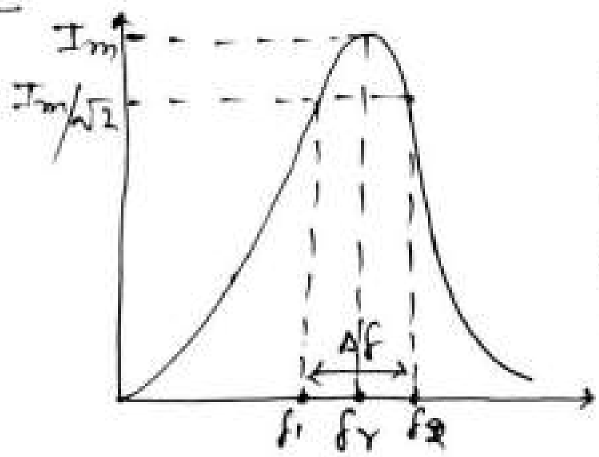
Ans.> The Curve Drawn b/w Current & frequency for Series R-L-C ckt is known as Resonant Curve

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



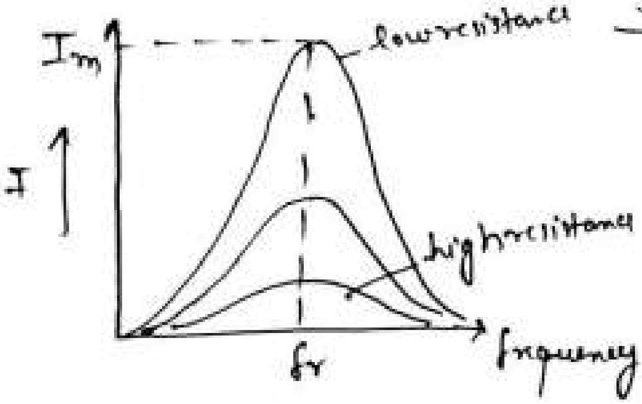
Que. 15 > Explain Selectivity & Bandwidth.

Ans. >



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

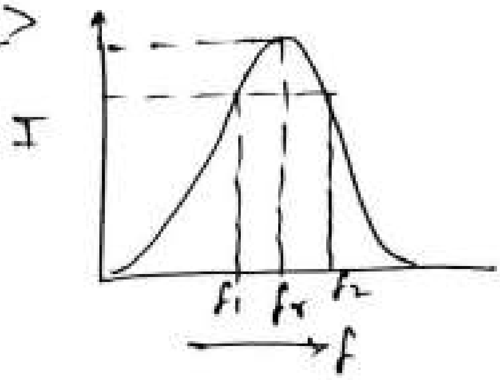
$$\boxed{\Delta f = f_2 - f_1}$$ bandwidth



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 $I = I_m/\sqrt{2} = \dfrac{V}{\sqrt{2}R}$

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 →

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

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

- Dividing whole eq. by LC

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

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

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

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

Discarding Negative frequency

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

* for upper cut off 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 $\omega_1 \omega_2 = \alpha^2 + \omega_r^2 - \alpha^2$

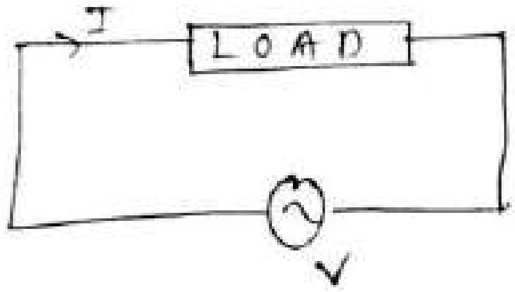
$$\omega_1 \omega_2 = \omega_r^2$$

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

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

Qus.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

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

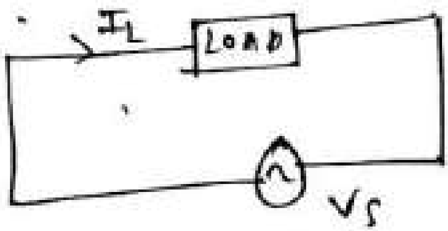
- If $\cos\phi$ is low then current is high which result following Disadvantages →

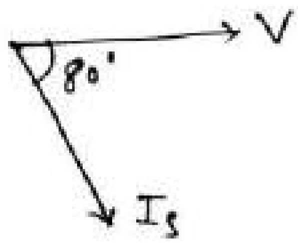
(i) Rating of generator's and Transformer's are proportional to their output current hence inversly proportional to Power factor.

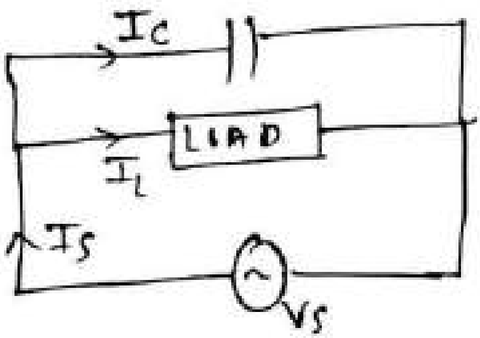
(ii) The Conducting material required is proportional to current so large Conducting material required for transmission of Power at low power Factor.

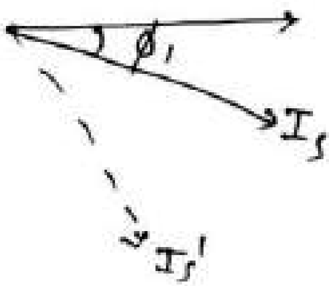
(iii) copper loss is propotional to current so low power Factor Result High Copper-loss (I^2R).

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





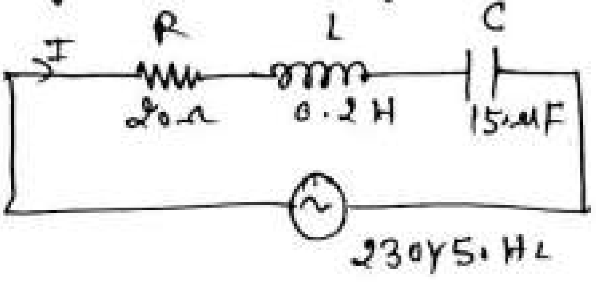




(ii) by using Induction motor with Phase advancer.

Qus. 18> A Series R-L-C Circuit Consisting $R = 20\Omega$, Inductance 0.2H and a Capacitance of 150μF is Connected across a 230V, 50 Hz. 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 $Z = \sqrt{R^2 + (X_L - X_C)^2}$

$= \sqrt{(20)^2 + (62.83 - 21.22)^2}$

$Z = 46.167\Omega$

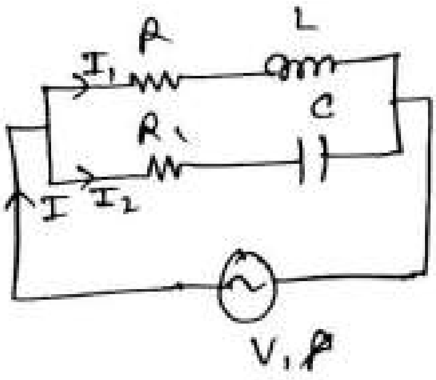
(ii) $I = V/Z = \frac{230}{46.167} = 4.98\,A$

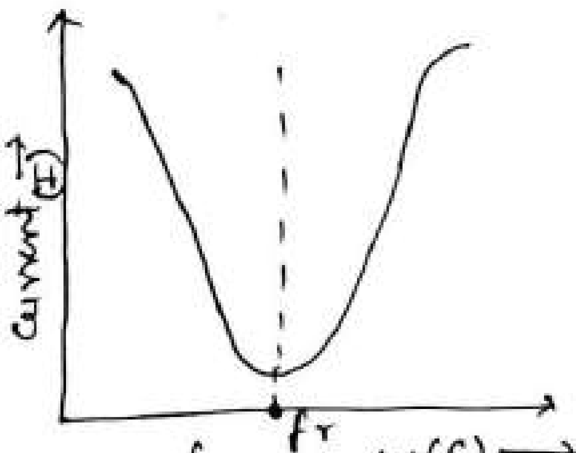
(iii) $\cos\phi = R/Z = \frac{20}{46.167} = 0.4332$ logging

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

Qus. 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 $\quad \phi = \tan^{-1} B/G = \tan^{-1} 1 = 45^\circ$

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

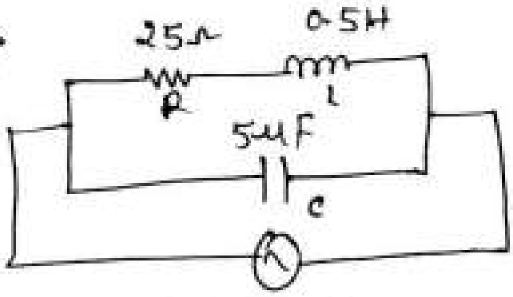
now $\quad I_C = 2\pi f_r CV$

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

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

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

Qu. 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 $Z = L/CR = 4000\,\Omega$

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

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