Single Phase AC Circuits

Power is consumed in R only, but not in L or C.

I_C leads V_C by $\frac{\pi}{2}$.

I_L lags V_L by $\frac{\pi}{2}$.

$$\boxed{P_{avg} = V \cdot I \cos\phi}$$

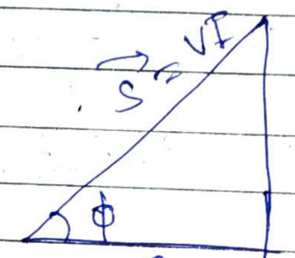
$$\vec{S} = \vec{V} \cdot \vec{I}^{*} = V\angle 0^{\circ} \cdot I\angle\phi$$

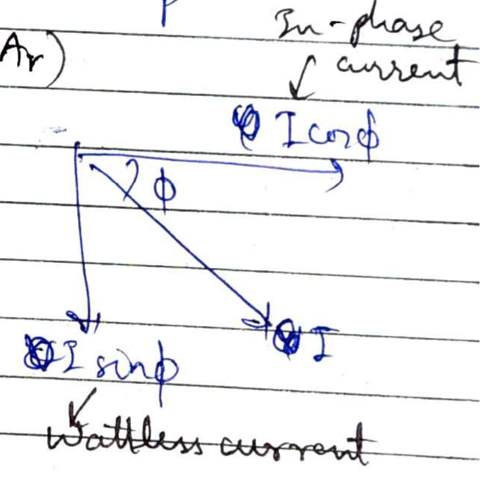
$$\vec{S} = VI\cos\phi + j\,VI\sin\phi$$

power (in VA) $\vec{S} = P + jQ$

P: Active Power (W)

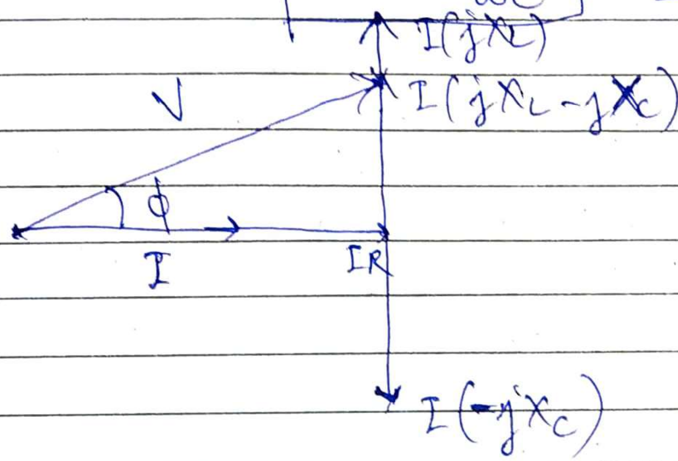
Q: Reactive Power (VAr)





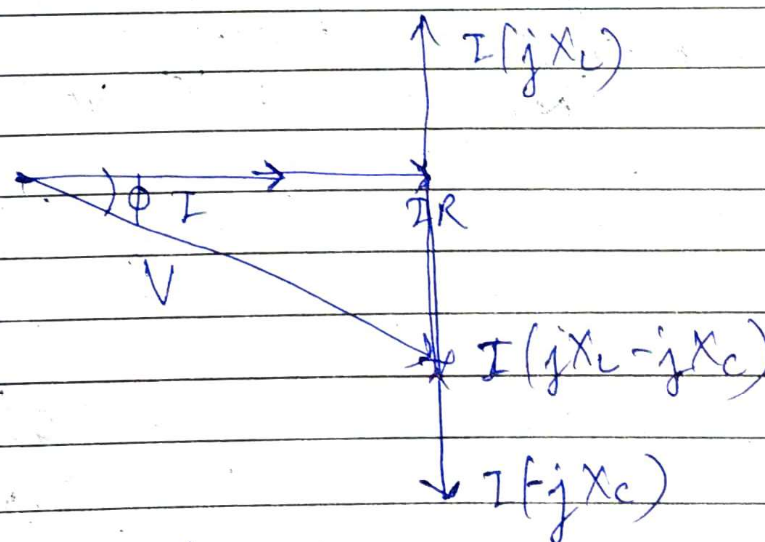
Series R-L-C Circuits

(i) **Inductive** : $\boxed{\omega L > \frac{1}{\omega C}}$ Current lags vol[tage] by ϕ.



(ii) **Capacitive** :- $\boxed{\frac{1}{\omega C} > \omega L}$

Current ~~lags~~ leads voltage by ϕ.



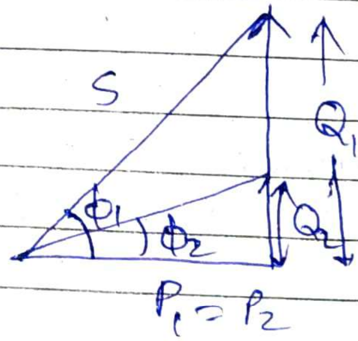
(iii) **Resonance** :- $\boxed{\omega L = \frac{1}{\omega C}}$

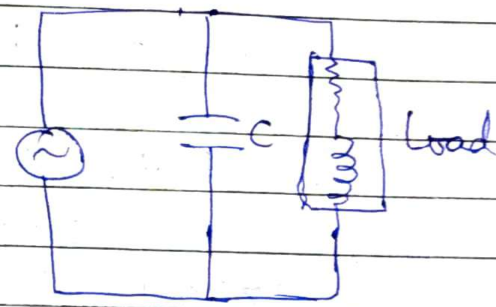
$\Rightarrow$ $i \to max^m$ } For Series Resona[nce]

$\Rightarrow$ $Z \to min$ & $\boxed{Z = R}$ }

Parallel R-L-C Circuit

In ∥ circuit, Active Power does not change upon adding a capacitor in parallel.





$$Q_C = \Delta Q = Q_1 - Q_2$$
$$= P_1 \tan\phi_1 - P_2 \tan\phi_2$$
$$\boxed{Q_C = P(\tan\phi_1 - \tan\phi_2) = \frac{V^2}{X_C}}$$

Resonance

Quality Factor = $\frac{\text{Voltage drop}}{\text{Supply voltage}}$

$$\boxed{Q = \frac{\omega_0 L}{R} = \frac{1}{R}\sqrt{\frac{L}{C}}}$$

If $I = \frac{I_m}{\sqrt{2}} \Rightarrow P = \frac{1}{2} I_m^2 R$ & $\boxed{Z = \sqrt{2}R}$

The frequencies corresponding to this current a called Half power frequencies.

∴ Band width = $\boxed{\Delta f = f_2 - f_1 = \frac{R}{2\pi L}}$

where $f_1 = f_0 - \frac{\Delta f}{2}$ & $f_2 = f_0 + \frac{\Delta f}{2}$

To improve Q of the coil, it must be designed to have its resistance R as low as possible. It results in reduction of bandwidth & losses.

Parallel Resonant Circuits :-

For || circuits at Resonance, the current i is minimum & Z is maximum and

$|Z| = R$

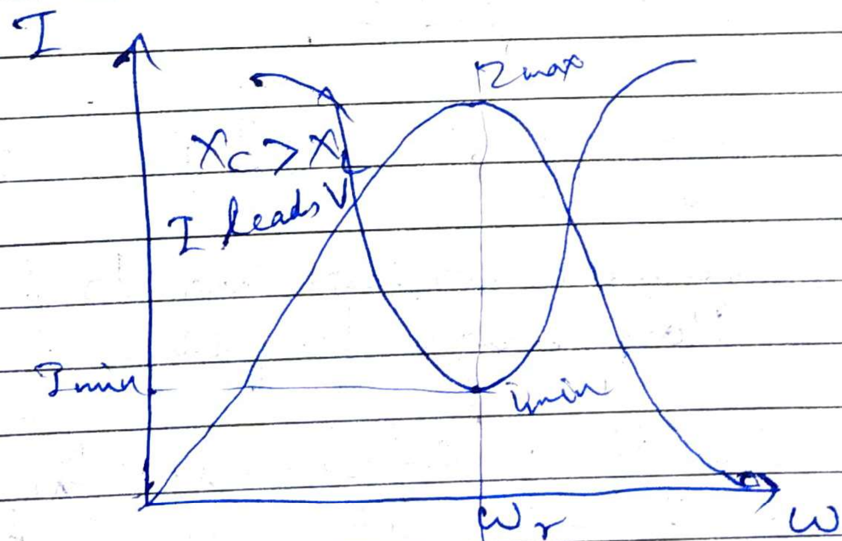
$\phi = 0$ & $\boxed{\cos\phi = 1}$

$$\boxed{f_0 = \frac{1}{2\pi\sqrt{LC}} \sqrt{\frac{R_L^2 - L/C}{R_C^2 - L/C}}}$$

nant
quency

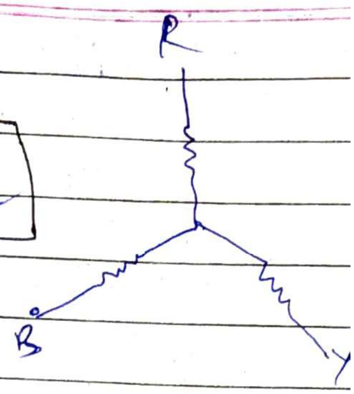
At $f < f_0$ ⇒ Capacitor acts as an open circuit
⇒ Net circuit is Inductive

At $f > f_0$ ⇒ Inductor acts as an open circuit
⇒ Net circuit is Capacitive



3ϕ

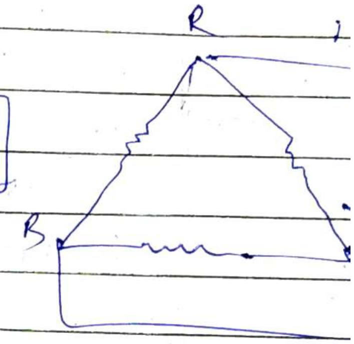
For Star (Y) connection :-



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

⇒ V_L leads V_{ph} by $30°$.

For Delta Connection :-



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

Power in 3ϕ AC :-

Active Power & $P = 3 V_{ph} I_{ph} \cos\phi$ (watts)

Reactive Power $Q = 3 V_{ph} I_{ph} \sin\phi$ (VAR)

Apparent Power $S = 3 V_{ph} I_{ph}$ (VA)

For both star & Delta Connection

Star	Delta
$I_L = I_{ph}$	$V_L = V_{ph}$
$V_L = \sqrt{3}\, V_{ph}$	$I_L = \sqrt{3}\, I_{ph}$
$P_{ph} = 3 V_{ph} I_{ph} \cos\phi$	$P_{ph} = 3 V_{ph} I_{ph} \cos\phi$
$P_{line} = \sqrt{3} \times \frac{V_L}{\cancel{\sqrt{3}}} \times I_L \cos\phi$	$P_{line} = \sqrt{3} \times \frac{I_L}{\cancel{\sqrt{3}}} \cos\phi$
$\boxed{P_{line} = \sqrt{3}\, V_L I_L \cos\phi}$	$\boxed{P_{line} = \sqrt{3}\, V_L I_L \cos\phi}$

$P = \sqrt{3} V_L I_L \cos\phi$ (watt)

$Q = \sqrt{3} V_L I_L \sin\phi$ (VAR)

$S = \sqrt{3} V_L I_L$ (V·A)

} For Both Star & Delta Connection.

Numericals

Assume all quantities (V, I, P) to be line quantities until & unless they are specified as phase quantities (for both Star & Delta)

Z is always in terms of phase.

$\boxed{I_{ph} = \frac{V_{ph}}{Z_{ph}}}$ If V_{ph} & Z_{ph} are given then calculate first I_{ph}
After that, $I_L = \sqrt{3} I_{ph}$ (Delta) or $I_L = I_{ph}$ (Star)

→ For phasor, we need V_m, I_m & ϕ

$V_m = \sqrt{2} V_{rms} = \sqrt{2} V_L$

$I_m = \sqrt{2} I_L$

› For Star connected lagging P.f load :-

$P = W_1 + W_2 = \sqrt{3} V_L I_L \cos\phi$

$W_1 - W_2 = V_L I_L \sin\phi$

$$\boxed{\tan\phi = \sqrt{3}\left[\frac{W_1 - W_2}{W_1 + W_2}\right]}$$

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

$\cos\phi =$ ✓