ST. LAWRENCE HIGH SCHOOL

A JESUIT CHRISTIAN MINORITY INSTITUTION

**STUDY MATERIAL : 8 (Part - 2)**

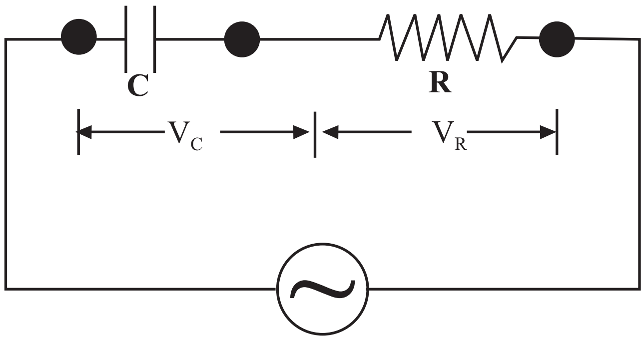
**Subject : PHYSICS**

**Topic : Alternating current**

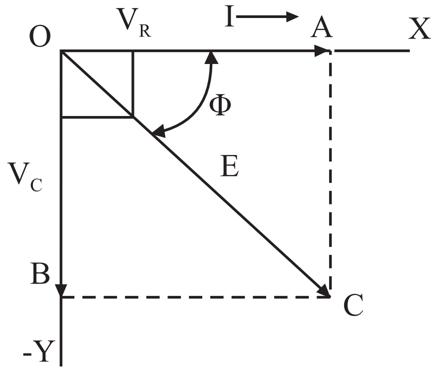
CLASS : XII

Date : 03.08.2020

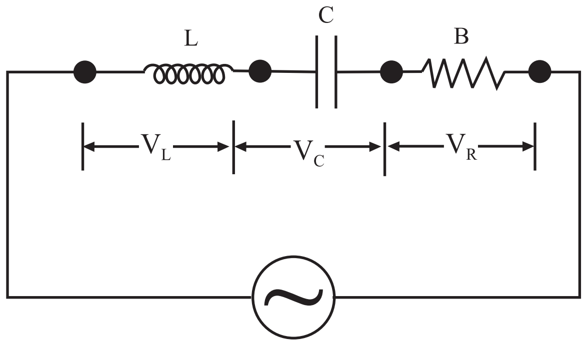
B 10. Let an alternating source of *e.m.f.* V ( r.m.s. value) be connected to a series combination of a capacitor of pure capacitance ( C ) and a resistor of resistance ( R ) as shown in figure




$V = V_0 \sin \omega t$

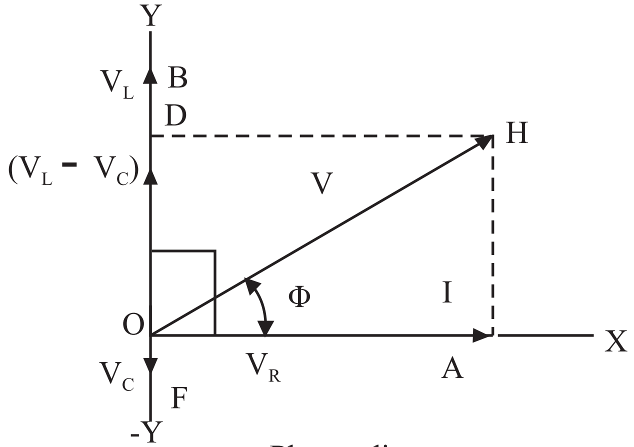



B 11. A circuit containing inductor of pure inductance (L), capacitor of pure capacitance ( C ) and resistor of resistance ( R ), all joined in series across an a.c. supply, is shown in figure. Let V be the r.m.s. value of the applied alternating *e.m.f.* to the LCR circuit.




$V = V_0 \sin \omega t$

B 12.

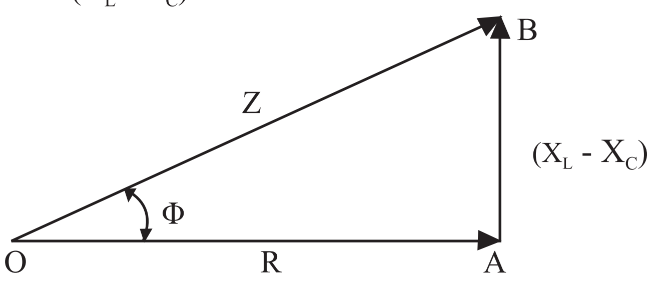



Phasor diagrm

B 13. ***The total effective opposition offered by LCR circuit to alternating current is known as Impedance.*** In general, impedance (Z) comprises of there parts *i.e.* resistance ( R ), inductive reactance ($X_L$) and capacitive reactance ($X_C$), where $X_L$ and $X_C$ are opposite to each other. In series LCR circuit, the total reactance is taken as $\pm$ ($X_L$ - $X_C$). ***Reciprocal of reactance is known as Susceptance.***

Impedance (Z) of *LCR circuit* can be represented diagrammatically by ***Impedance triangle*** as shown in Figure

$$Z = \sqrt{R^2 + \left(L\omega - \frac{1}{C\omega}\right)^2} = \sqrt{R^2 + (X_L - X_C)^2}$$




Phasor diagram

B 14. **Expression for resonant frequency**

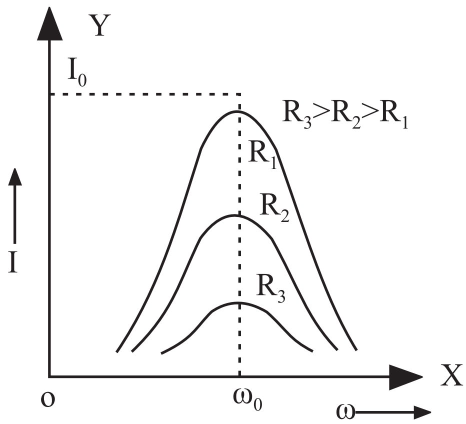
For electrical resonance, $X_L = X_C$

or $L\omega_0 = \frac{1}{C\omega_0}$ or $\omega_0 2 = \frac{1}{LC}$

or $\omega_0 = \frac{1}{\sqrt{LC}}$ or $(2\pi v_0) = \frac{1}{\sqrt{LC}}$

or $$\boxed{v_0 = \frac{1}{2\pi\sqrt{LC}}}$$

Eqn. is the expression for resonance frequency



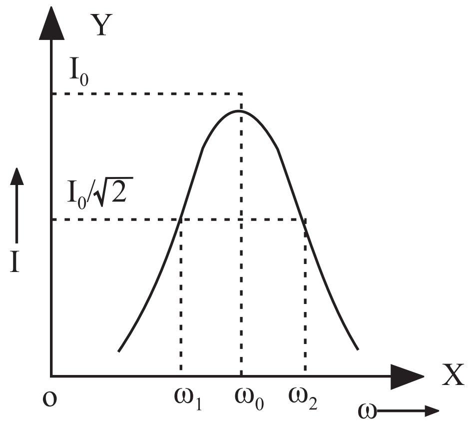

B 15. The Q- factor of the circuit is given by

$$Q = \frac{\omega_0}{2\Delta\omega} = \frac{\omega_0 L}{R}$$

Also $$\omega_0 = \frac{1}{\sqrt{LC}} \text{ or } L = \frac{1}{\omega_0^2 C}$$

Hence eqn. *(iv)* can be written as $$Q = \frac{1}{\omega_0 CR}$$

If Q-factor is large, the bandwidth ($2\Delta\omega$) is small and sharper is the resonance curve. It means the circuit is more selective. On the other hand, if Q-factor is small the bandwidth ($2\Delta\omega$) is large and resonance curve is less sharp. It means, the circuit is close to reconance for large range of frequencies and hence less selective.



B 16. **Power Factor of an A.C. Circuit**

*Ratio of true power and apparent power (virtual power) in an a.c. circuit is called as power factor of the circuit.*

*i.e.* Power factor, $\cos \Phi = \frac{P}{V_{rms} I_{rms}} = \frac{P}{P_{rms}}$

Power factor, ($\cos \Phi$) is always positive and not more than I

*(i) For circuit having pure resistor,* $\cos \Phi = I$ $(\because \Phi = 0)$

*(ii) For circuit having pure inductor or pure capacitor,* $\cos \Phi = 0$ $(\because \Phi = \frac{\pi}{2})$

*(iii) For RC circuit,* $\cos \Phi = \frac{R}{\sqrt{R^2 + \frac{I}{\omega^2 C^2}}}$ ........(*i*)

*(iv) For LR* circuit, $\cos \Phi = \frac{R}{\sqrt{R^2 + \omega^2 L^2}}$ .........*(ii)*

*(v) For LCR circuit,* $\cos \Phi = \frac{R}{Z}$ i.e., P.F. $= \frac{R}{\sqrt{R^2 + (L\omega - \frac{1}{C\omega})^2}}$ ..........*(iii)*

B 17. Wattless current is that component of the circuit current due to which the power consumed in the circuit is zero.

Wattful current is that component of current due to which power is consumed in the circuit.

In an a.c. circuit, the average power consumed over a complete cycle is given by

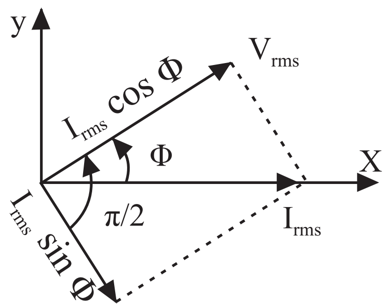
$P = V_{rms} I_{rms} \cos \Phi$

where $\Phi$ is the phase angle between $V_{rms}$ and $I_{rms}$

Resolving $I_{rms}$, we get two components

*(I)* $I_{rms} \cos \Phi$ along $V_{rms}$.

*(ii)* $I_{rms} \sin \Phi$ perpendicular to $V_{rms}$.




Now, the average power consumed in the circuit due to component ($I_{rms} \cos\Phi$) of current ($I_{rms}$) is given by

$P' = V_{rms} (I_{rms} \cos \Phi) \cos 0^0$

( *phase angle between* $V_{rms}$ and $I_{rms} \cos \Phi$ is zero)

$= V_{rms} (I_{rms} \cos \Phi)$

This component of current is called ***wattful component or wattful current.***

This average power consumed in the circuit due to component $I_{rms} \sin \Phi$ of current ($I_{rms}$) is given by

$P'' = V_{rms} (I_{rms} \sin \Phi) \cos \pi/2$

( *phase angle between* $V_{rms}$ and ( $I_{rms} \sin \Phi$ is $\pi/2$)

or $P'' = 0$

Thus, the average power consumed in the circuit due to ($I_{rms} \sin \Phi$) component of current is zero.

This component of current is known as ***wattless current.*** Power is consumed due to $I_{rms} \cos \Phi$ component so it is known as ***wattful component.***

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