O P JINDAL SCHOOL, SAVITRINAGAR

ASSIGNMENT

CLASS XII PHYSICS

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31 An alternating voltage of frequency f is applied across a series LCR circuit. Let f_r be the resonance frequency for the circuit. Will the current in the circuit lag, lead or remain in phase with the applied voltage when (i) $f > f_r$, (ii) $f < f_r$? Explain your answer in each case. 2

ANS: We know $X_L \propto f$ and $X_C \propto \frac{1}{f}$ As f increases X_C decreases and X_L increases. For a particular value of frequency called resonance frequency (f_r), X_L becomes equal to X_C. In case we keep on increasing frequency after this X_L becomes greater than X_C.

(i) Hence for $f >$ fr circuit turns inductive in nature and current lags behind the voltage by certain phase angle.

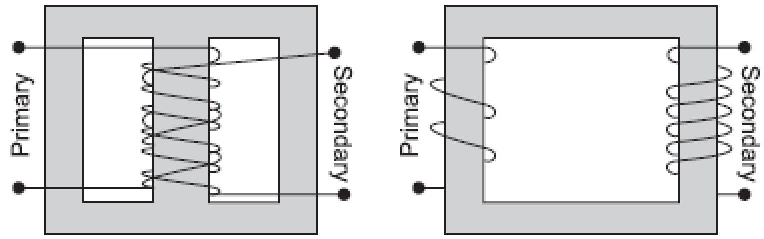
(ii) For $f < f_r$ circuit is capacitive in nature as $X_C > X_L$ and current leads the voltage by certain phase angle.

32 State the underlying principle of a transformer. How is the large scale transmission of electric energy over long distance done with the use of transformers ? 2

ANS: A transformer is based on the principle of mutual induction, i.e. when electric current in one coil changes, then emf in the neighbouring coil is induced. For a large distance transmission of electric energy, an alternating current is stepped up (i.e. at a given power voltage is increased). As a result, the current in the circuit gets reduced and hence reduces the power ($P = I^2R$) loss. At the receiving end, step down transformer lowers the voltage at the required power.

33 Draw two arrangements of primary and secondary windings in a transformer which arrangement will have higher efficiency and why? 2

ANS: The arrangement (a) will have a higher efficiency because the leakage of magnetic flux in this arrangement is almost zero.



(a) (b)

34 Write one use each of: (i) step down transformer, and (ii) step-up transformer. 2

ANS: (i) Step down transformer is used in battery chargers and battery eliminators.
(ii) Step-up transformer is used in transmission of electric power to distant places.

35 In a series *LCR* circuit, obtain the conditions under which (i) the impedance of the circuit is minimum, and (ii) wattless current flows in the circuit. 2

ANS: In case of a series *LCR* circuit, the impedance of the circuit is given by $Z = \sqrt{R^2 + (X_C - X_L)^2}$ (i) The impedance of the circuit is minimum when $X_C = X_L$, i.e. capacitive reactance = inductive reactance.
Under this condition, $X_C = X_L$ gives $Z = R$, i.e. the circuit is resistive.
(ii) When the circuit is purely capacitive or inductive, wattless current flows in the circuit.

36 Draw the graphs showing the variations of (i) inductive reactance, and (ii) capacitive reactance, with frequency of applied voltages in ac circuit. How do the values of (i) inductive, and (ii) capacitive reactance change, when the frequency of applied voltage is tripled? 2

ANS: (i) Graph: Refer to Point no. 4 [Important Terms, Definitions and Formulae]
(ii) Graph: Refer to Point no. 5 [Important Terms, Definitions and Formulae] When frequency of applied voltage is tripled:
(i) Inductive reactance also gets tripled because $X_L = 2\pi\nu L$, i.e. $X_L \propto \nu$.

(ii) Capacitive reactance reduces to onethird because $X_C = \frac{1}{2\pi\nu C}$, i.e. $X_C \propto \frac{1}{\nu}$

37 Define root mean square current. Also, obtain its expression. 3

ANS:

Rms current is that value of current which produces the same amount of heat as is produced by alternating current when flows through the same conductor for the same time period.

Let an instantaneous current $I = I_m \sin \omega t$ is passing through a resistor R. Let it be constant for a very short duration of time dt.

Then, very small amount of heat produced is given by

$$dH = I^2 R\, dt$$

Heat produced for one complete cycle is given by

$$H = \int_0^T dH = \int_0^T I^2 R dt$$

$$\therefore H = \int_0^T I_m^2 (\sin^2 \omega t) R dt = I_m^2 R \int_0^T \sin^2 \omega t\, dt = I_m^2 R \int_{t=0}^{T} \left(\frac{1-\cos 2\omega t}{2}\right) dt$$

$$H = \frac{I_m^2 R}{2}\left[\int_0^T dt - \int_0^T (\cos 2\omega t) dt\right] = \frac{I_m^2 R}{2}\left\{T - \left[\frac{\sin 2\omega t}{2\omega}\right]_0^T\right\}$$

As $\omega = 2\pi/T$

$$H = \frac{I_m^2 RT}{2} - \frac{I_m^2 R}{2}\left[\sin 2 \times \frac{2\pi}{T} \times T - \sin 0\right] \qquad (\because \sin 4\pi = \sin 0 = 0)$$

$$\therefore H = \frac{I_m^2 RT}{2} \qquad \ldots(i)$$

If I_{rms} is steady current flowing through the same circuit for the same time interval T producing the same amount of heat H, then the heat produced is

$$H = I_{rms}^2 RT \qquad \ldots(ii)$$

Equating (i) and (ii), we get

$$\frac{I_m^2 RT}{2} = I_{rms}^2 RT$$

$$\therefore \quad \frac{I_m}{\sqrt{2}} = I_{rms} \quad \text{or} \quad I_{rms} = 0.707\, I_m.$$

38 You are given three circuit elements *X*, *Y* and *Z*. When the element *X* is connected across an ac source of a given voltage, the current and the voltage are in the same phase. When the element *Y* is connected in series with *X* across the source, voltage is 3

ahead of the current in phase by π/4. But the current is ahead of the voltage in phase by π/4 when *Z* is connected in series with *X* across the source. Identify the circuit elements *X*, *Y* and *Z*.
When all the three elements are connected in series across the same source, determine the impedance of the circuit.
Draw a plot of the current versus the frequency of applied source and mention the significance of this plot.

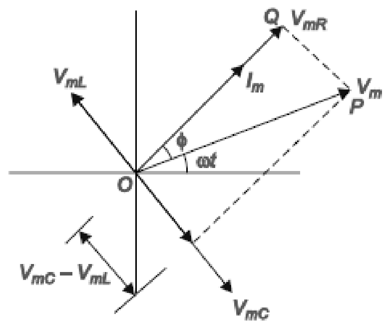
ANS:

X is resistor, because current and voltage are in phase.

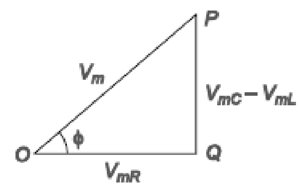
Y is inductor, because voltage is ahead of current in phase.

Z is capacitor, because current is ahead of voltage in phase.

When all the three elements are connected in series, the phasor diagram is as shown below.



We assume that circuit is capacitive in nature from the impedance triangle *OQP*, we get



$$V_m^2 = V_{mR}^2 + (V_{mC} - V_{mL})^2$$

where $V_{mR} = I_m R;\ \ V_{mC} = I_m X_C$ and

$$V_{mL} = I_m X_L$$

$$\therefore \quad V_m = I_m \sqrt{R^2 + (X_C - X_L)^2}$$

$$\frac{V_m}{I_m} = \sqrt{R^2 + (X_C - X_L)^2}$$

The impedance of the circuit is given by

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

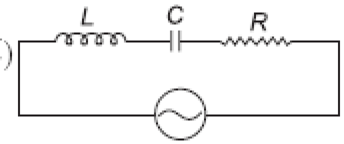
Diagram: Refer to page no. 384, point no. 9 (Important terms .....)

From the graph we come to know about the quality factor of the circuit, i.e. its selectivity.

39 A series *LCR* circuit is connected to an ac source. Using the phasor diagram, derive the expression for the impedance of the circuit. Plot a graph to show the variation of current with frequency of the source, explaining the nature of its variation. 3

Take the voltage of source

$$V = V_m \sin \omega t \qquad \ldots(i)$$



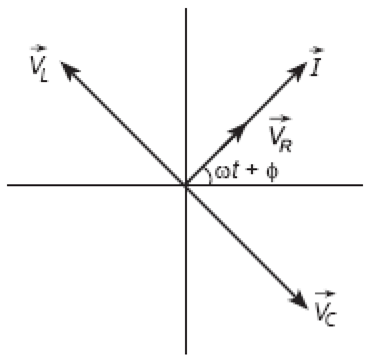
To determine the phase relation between current and voltage at any instant of time, we use a phasor technique.

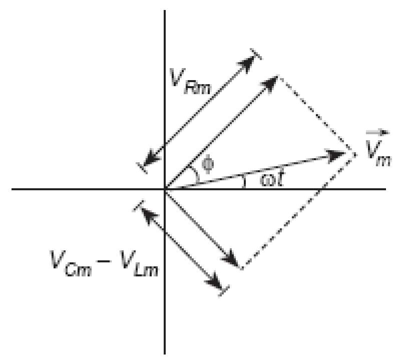
As all the three components are in series, the same amount of current flows through them at any instant of time. Let it be

$$I = I_m \sin (\omega t + \phi) \qquad \ldots(ii)$$

where ϕ is the phase difference between the voltage across the source and current.

We construct a phasor diagram.





ANS:

On applying Pythagoras theorem, we get

$$V_m^2 = V_{Rm}^2 + (V_{Cm} - V_{Lm})^2$$

Here $V_{Rm} = I_m R$, $V_{Cm} = I_m X_C$, $V_{Lm} = I_m X_L$

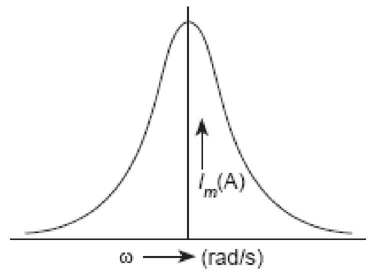
$$V_m = I_m \sqrt{R^2 + (X_C - X_L)^2}$$

$$V_m = I_m Z$$

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

Z is called the impedance of the circuit.

The variation of current with frequency of source is shown in the figure.



$$I_m = \frac{V_m}{Z}$$

We know $X_L = \omega L$ and $X_C = \frac{1}{\omega C}$

Thus, on increasing the frequency, X_L increases and X_C decreases. As a result, $X_C - X_L$ decreases.

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

So, Z also decreases and with this current increases.

For a particular value of frequency called resonant frequency (ω_r)

we find $$X_L = X_C$$

$\therefore$ $$Z = R$$

and $$I_m = I_m^{max}$$

After this frequency, $X_C - X_L$ again increases and I_m decreases.

Hence, we obtain bell-shaped graph.

40 An inductor L of inductance X_L is connected in series with a bulb B and an ac source. How would brightness of the bulb change when (i) number of turn in the inductor is reduced, (ii) an iron rod is inserted in the inductor and (iii) a capacitor of reactance $X_C = X_L$ is inserted in series in the circuit. Justify your answer in each case. 3

ANS: An inductor connected with a bulb in series and an ac source is an *L–R* circuit.
(i) Number of turns in inductor is reduced.

$$\text{We know} \qquad I_{rms} = \frac{E_{rms}}{Z} = \frac{E_{rms}}{\sqrt{X_L^2 + R^2}}$$

The brightness of bulb increases. where $X_L = \omega L$. As the number of turns decreases, therefore, L decreases and the impedance (Z) of the circuit also decreases. Hence, the current through the bulb increases/voltage across bulb increases. (ii) An iron rod is inserted in the inductor
The brightness of bulb decreases, as an iron rod increases the inductance which increases X_L. Hence, the current through the bulb decreases. (iii) A capacitor of reactance $X_C = X_L$ is inserted in series.
The brightness of the bulb increases.
Under the condition $X_C = X_L$, i.e. $Z = R$, the impedance is minimum and the current in the circuit is maximum. Hence, the brightness is maximum.