Short Answer Questions – I (PYQ)

Q. 1. Define power factor. State the conditions under which it is (i) maximum and (ii) minimum. [CBSE Delhi 2010]

Ans. The power factor (cos φ) is the ratio of resistance and impedance of an ac circuit i.e.,

$$\text{Power factor, } \cos\varphi = \frac{R}{Z}$$

Maximum Power factor is 1 when Z = R i.e., when circuit is purely resistive. Minimum power factor is 0 when R = 0 i.e., when circuit is purely inductive or capacitive.

Q. 2. When an AC source is connected to an ideal inductor show that the average power supplied by the source over a complete cycle is zero. [CBSE (Central) 2016]

Ans. For an ideal inductor phase difference between current and applied voltage = π/2

$$\therefore \quad \text{Power, } P = V_{rms}\, I_{rms} \cos\varphi = V_{rms}\, I_{rms} \cos\frac{\pi}{2} = 0.$$

Thus the power consumed in a pure inductor is **zero**.

Q. 3. When an AC source is connected to an ideal capacitor, show that the average power supplied by the source over a complete cycle is zero. [CBSE (North) 2016]

Ans.

$$\text{Power dissipated in ac circuit, } P = V_{rms}\, I_{rms} \cos\varphi \text{ where } \cos\varphi = \frac{R}{Z}$$

$$\text{For an ideal capacitor } R = 0 \quad \therefore \cos\varphi = \frac{R}{Z} = 0$$

$$\therefore P = V_{rms}\, I_{rms} \cos\varphi = V_{rms}\, I_{rms} \times 0 = 0 \text{ (zero)}.$$

i.e., power dissipated in an ideal capacitor is zero.

Q. 4. The current flowing through a pure inductor of inductance 2 mH is i=15 cos 300t ampere. What is the (i) rms and (ii) average value of current for a complete cycle?
[CBSE (F) 2011]

Ans.

Peak value of current (i_0) = 15 A

i. $i_{rms} = \frac{i_0}{\sqrt{2}} = \frac{15}{\sqrt{2}} = \frac{15}{\sqrt{2}} \times \frac{\sqrt{2}}{\sqrt{2}} = 7.5\sqrt{2}\,A$

ii. $i_{av} = 0$

Q. 5. In a series LCR circuit with an ac source of effective voltage 50 V, frequency v =50/π Hz, R = 300Ω, C = 20 μF and L = 1.0 H. Find the rms current in the circuit. [CBSE (F) 2014]

Ans.

Given, $L = 1.0$ H; C = 20μF = 20×10^{-6}F

$R = 300\Omega; V_{rms} = 50V; \nu = \frac{50}{\pi}$Hz

Inductive reactance $X_L = \omega L = 2\pi\nu\, L = 2 \times \pi \times \frac{50}{\pi} \times 1 = 100\ \Omega$

Capacitive reactance, $X_C = \frac{1}{\omega C} = \frac{1}{2\pi\nu C} = \frac{1}{2\times\pi\times\frac{50}{\pi}\times20\times10^{-6}} = 500\Omega$

Impedance of circuit

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

$$= \sqrt{(300)^2 + (500 - 100)^2} = \sqrt{90000 + 160000} = \sqrt{250000} = 500\Omega$$

$$I_{rms} = \frac{V_{rms}}{z} = \frac{50}{500} = 0.1A$$

Q. 6. Calculate the quality factor of a series LCR circuit with L = 2.0 H, C= 2 μF and R = 10Ω. Mention the significance of quality factor in LCR circuit.
[CBSE (F) 2012]

Ans.

We have, $Q = \frac{1}{R}\sqrt{\frac{L}{C}}$

$$= \frac{1}{10}\sqrt{\frac{2}{2\times 10}} = 100$$

It signifies the sharpness of resonance.

Short Answer Questions – I (OIQ)

Q. 1. The instantaneous current in an ac circuit is i = 0.5 sin 314 t, what is (i) rms value and (ii) frequency of the current.

Ans.

Given $I = 0.5 \sin 314\, t$ ... (i)

Standard equation of current is $I = I_0 \sin \omega t$ ... (ii)

Comparing (i) and (ii), we get $I_0 = 0.5$ A, $\omega = 314$

∴ (i) rms value $I_{\text{rms}} = \frac{I_0}{\sqrt{2}} = \frac{0.5}{\sqrt{2}} A = 0.35\, A$

(ii) Frequency $\nu = \frac{\omega}{2\pi} = \frac{314}{2\times 3.14} = 50$ Hz

Q. 2. The instantaneous voltage from an ac source is given by E = 300 sin 314t; what is the rms voltage of the source.

Ans. Given equation is E = 300 sin 314 t

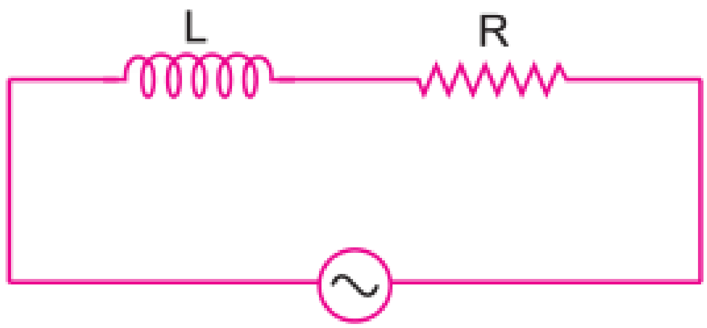
Comparing with standard equation $E = E_0 \sin \omega t$, we have

$E_0 = 300$ volt

So $E_{\text{rms}} = \frac{E_0}{\sqrt{2}} = \frac{300}{\sqrt{2}} = 150\sqrt{2}\,\text{volt} = 150 \times 1.414 = 212\, V$

Q. 3. In the given circuit, the potential difference across the inductor L and resistor R are 200 V and 150 V respectively and the rms. value of current is 5 A. Calculate (i) the impedance of the circuit and (ii) the phase angle between the voltage and the current.

Ans.



Voltage applied $$V = \sqrt{V_L^2 + V_R^2} = \sqrt{(200)^2 + (150)^2} = 250V$$

Impedance of circuit, $$Z = \frac{V}{I} = \frac{250}{5} = 50\ \Omega$$

Phase angle between voltage and current

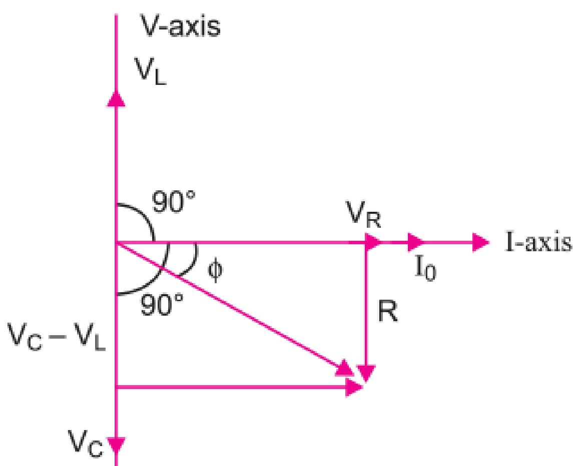
$$\tan\varphi = \frac{X_L}{R} = \frac{V_L}{V_R} = \frac{200}{150} = \frac{4}{3}$$

$$\varphi = \tan^{-1}\left(\frac{4}{3}\right) = 53^o$$

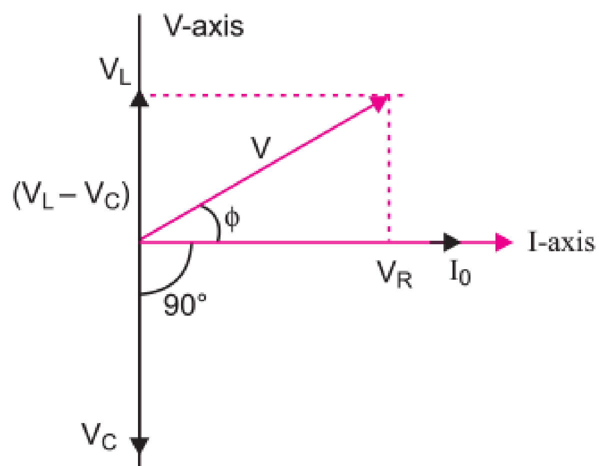
Q. 4. An AC source of voltage V = Vm sin ωt is applied across a series LCR circuit. Draw the phasor diagrams for this circuit, when

(i) Capacitive impedance exceeds the inductive impedance.
(ii) Inductive impedance exceeds capacitive impedance.

Ans. (i) When $X_C > X_L$; the phasor diagram is shown in fig. (a).



(a) $X_C > X_L$



(b) $X_L > X_C$

(ii) When $X_L > X_C$; the phasor diagram is shown in fig. (b).

Q. 5. In a series LCR circuit, R=1k Ω, C = 2μ F and voltage across R is 100 V. The resonant frequency of the circuit ω is 200 rad s^{-1}. Calculate the value of voltage across L at resonance.

Ans.

Current flowing in the circuit is

$$I = \frac{V_R}{R} = \frac{100}{1000} = 0.1\ A$$

∴ Also at resonance, $\omega L = \frac{1}{\omega C}$

$$\omega L = \frac{1}{200 \times 2 \times 10^{-6}} = 2500\ \Omega$$

∴ Voltage across, $L = I\left(\omega L\right) = 0.1 \times 2500 = \mathbf{250V}$

Q. 6. What is the power dissipated in an ac circuit in which voltage and current are given by $V = 230 \sin\left(\omega t + \frac{\pi}{2}\right)$ and $I = 10 \sin \omega t$?

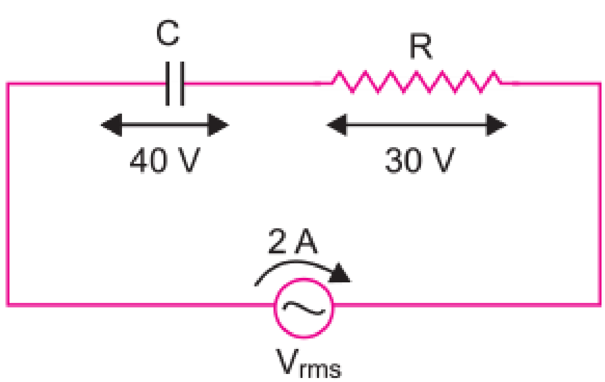
Ans.

Power dissipated $P = \frac{1}{2} V_0\ I_0 \cos\varphi$

Here $V_0 = 230V,\ I_0 = 10\ A,\ \varphi = \frac{\pi}{2}$

∴ $$P = \frac{1}{2} \times 230 \times 10 \cos\frac{\pi}{2} = 0.$$

Q. 7. Calculate the following:



(i) Impedance of the given ac circuit.
(ii) Wattless current of the given ac circuit.

Ans. (i)

Potential difference across capacitance, $V_C = X_C I$

∴ Capacitive reactance,

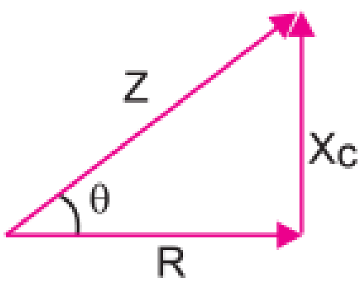
$X_C = \frac{V_C}{I} = \frac{40}{2} = 20\Omega$

Resistance, $R = \frac{V_R}{I} = \frac{30}{2} = 15\Omega$

Impedance, $Z = \sqrt{R^2 + X_C^2} = \sqrt{(15)^2 + (20)^2}$

$= \sqrt{225 + 400} = \sqrt{625}\Omega = 25\ \Omega$

(ii)



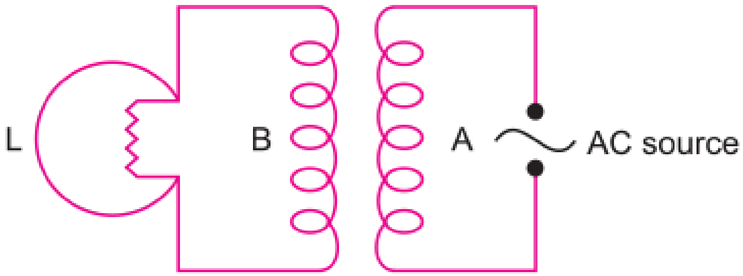
The phase lead (φ) of current over applied voltage is

$\varphi = \frac{X_C}{R}$

Wattless Current, $I_{\text{wattless}} = I \sin\ \varphi = I.\left(\frac{X_C}{Z}\right)$

$= 2 \times \frac{20}{25} A = 1.6\ A$

Q. 8. In the given diagram, a coil B is connected to low voltage bulb L and placed parallel to another coil A as shown. Explain the following observations:



(i) Bulb lights and
(ii) Bulb gets dimmer if the coil B moves upwards

Ans. (i) Bulb lights up due to induced current in B because of change in flux linked with it as a consequence of continuous variation of magnitude of alternative current flowing in A.

(ii) When coil B moves upward, the magnetic flux linked with B decreases and hence lesser current is induced in B.

Q. 9. In a series LCR circuit, the voltage across an inductor, a capacitor and a resistor are 30 V, 30 V and 60 V respectively. What is the phase difference between the applied voltage and current in the circuit?

Ans.

Given $V_L = 30\text{V},\ V_C = 30\text{V},\ V_R = 60\text{V}$

Phase difference (φ) in series LCR circuit is given by

$$\tan\varphi = \frac{X_C - X_L}{R} = \frac{V_C - V_L}{V_R} = \frac{30-30}{60} = 0$$

$$\Rightarrow \quad \varphi = 0 \ (\text{zero})$$

Q. 10. When a capacitor is connected in series LR circuit, the alternating current flowing in the circuit increases. Explain why.

Ans. Impedance of series LR circuit

$$Z_1 = \sqrt{R^2 + X_L^2}$$

When capacitor is also connected in circuit,

Then impedance

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

Clearly impedance of circuit decreases ($Z_2 < Z_1$), so the value of current $I = \frac{V}{Z} \propto \frac{1}{Z}$ in the circuit increases.

Q. 11. In India, Domestic power supply is at 220 V, 50 Hz; while in USA it is 110 V, 50 Hz. Give one advantage and one disadvantage of 220 V supply over 110 V supply.

Ans. Advantage: Line loss is low.

Disadvantage: High voltage is dangerous.

Q. 12. Distinguish between the terms 'effective value' and peak value of alternating current.

Ans. Alternating current changes in magnitude as well as direction. The maximum value of the alternating current is called the peak value. It is denoted by I_0. The square root of mean square value of current is called the 'effective value' or 'rms value' of current. The two are related by

$$\text{Effective value, } E_{\text{eff}} = \frac{I_0}{\sqrt{2}}$$

Q. 13. What is the power dissipated by an ideal inductor in ac circuit? Explain.

Ans. The power $P = V_{rms} I_{rms} \cos\varphi$

An ideal inductor is the one whose resistive component is zero.

$$\text{where } \cos\varphi = \frac{R}{Z}; \qquad \text{For ideal inductor } R = 0,$$

$$\therefore \cos\varphi = \frac{R}{Z} = 0$$

$\therefore P = V_{rms} I_{rms} \cos\varphi = 0$, i.e., power dissipated by an ideal inductor in ac circuit is zero.

Q. 14. Both alternating current and direct current are measured in amperes. But how is the ampere defined for an alternating current? [NCERT Exemplar]

Ans. An ac current changes direction with the source frequency and the attractive force would average to zero. Thus, the ac ampere must be defined in terms of some property that is independent of the direction of current. Joule's heating effect is such property and hence it is used to define rms value of ac.

Q. 15. A 60W load is connected to the secondary of a transformer whose primary draws line voltage. If a current of 0.54 A flows in the load, what is the current in

the primary coil? Comment on the type of transformer being used. [NCERT Exemplar]

Ans.

Here $P_L = 60$ W, $I_L = 0.54$ A

$$V_L = \frac{60}{0.54} = 110\ V$$

The transformer is step-down and have $\frac{1}{2}$ input voltage. Hence

$$i_p = \frac{1}{2} \times I_L = \frac{1}{2} \times 0.54 = 0.27\ A.$$

Q. 16. Explain why the reactance provided by a capacitor to an alternating current decreases with increasing frequency. [NCERT Exemplar]

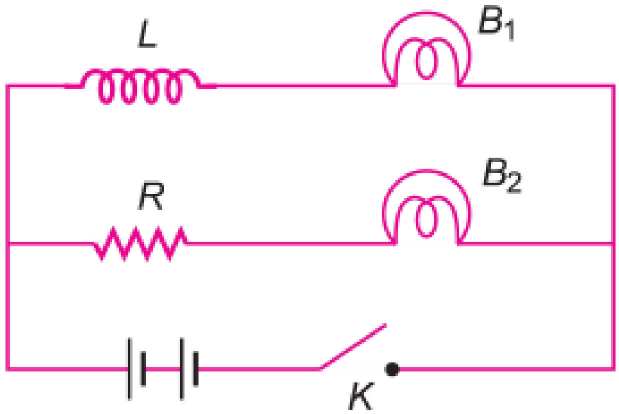
Ans. A capacitor does not allow flow of direct current through it as the resistance across the gap is infinite. When an alternating voltage is applied across the capacitor plates, the plates are alternately charged and discharged. The current through the capacitor is a result of this changing voltage (or charge). Thus, a capacitor will pass more current through it if the voltage is changing at a faster rate, i.e., if the frequency of supply is higher. This implies that the reactance offered by a capacitor is less with increasing frequency; it is given by $1/\omega C$.

Q. 17. Explain why the reactance offered by an inductor increases with increasing frequency of an alternating voltage. [NCERT Exemplar]

Ans. An inductor opposes flow of current through it by developing an induced emf according to Lenz's law. The induced voltage has a polarity so as to maintain the current at its present value. If the current is decreasing, the polarity of the induced emf will be so as to increase the current and vice versa. Since the induced emf is proportional to the rate of change of current, it will provide greater reactance to the flow of current if the rate of change is faster, i.e., if the frequency is higher. The reactance of an inductor, therefore, is proportional to the frequency, being given by ωL.

Q. 18. In the given circuit, the value of resistance effect of the coil L is exactly equal to the resistance R. Bulbs B_1 and B_2 are exactly identical.

Answer the following questions based on above information:



(i) Which one of the two bulbs lights up earlier, when key K is closed and why?
(ii) What will be the comparative brightness of the two bulbs after sometime if the key K is kept closed and why?

Ans. (i) Bulb B_2 lights up earlier. The self-induction effect due to coil L in bulb B1 arm does not allow the current to attain maximum value immediately on closing the circuit.

(ii) Since the resistance effect of the coil L is equal to R and the self-induction effect in coil L will disappear after sometime, the current in both the arms will be equal. Hence, both the bulbs will glow with equal brightness after sometime.