DCAM classes

Dynamic Classes for Academic Mastery

Physics

NCERT Exemplar Problems

Chapter 7

Alternationg Current

Answers

7.1 (b)

7.2 (c)

7.3 (c)

7.4 (b)

7.5 (c)

7.6 (c)

7.7 (a)

7.8 (a), (d)

7.9 (c), (d)

7.10 (a), (b), (d)

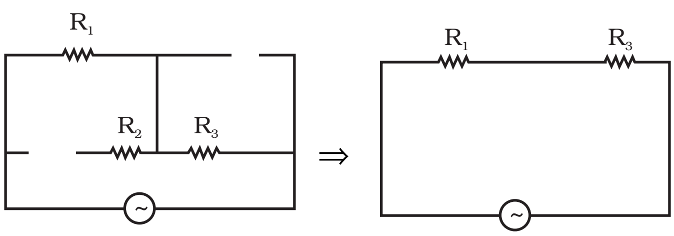
7.11 (a), (b), (c)

7.12 (c), (d)

7.13 (a), (d)

7.14 Magnetic energy analogous to kinetic energy and electrical energy analogous to potential energy.

7.15 At high frequencies, capacitor ≈ short circuit (low reactance) and inductor ≈ open circuit (high reactance). Therefore, the equivalent circuit $Z \approx R_1 + R_3$ as shown in the Fig.



7.16 (a) Yes, if rms voltage in the two circuits are same then at resonance, the rms current in *LCR* will be same as that in *R* circuit.

(d) No, because $R \leq Z, \text{so}\, I_a \geq I_b$.

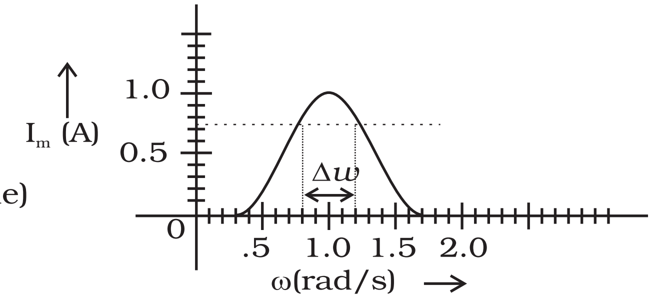
7.17 Yes, No.

7.18 Bandwidth corresponds to frequencies at which $I_m = \frac{1}{\sqrt{2}} I_{max}$

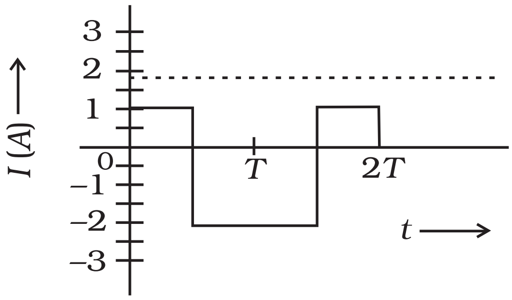
$\approx 0.7 I_{max}$.

It is shown in the Fig.

$\Delta\omega = 1.2 - 0.8 = 0.4$ rad/s



7.19 I_{rms} = 1.6A (shown in Fig. by dotted line)



7.20 From negative to zero to positive; zero at resonant frequency.

7.21 (a) A

(b) Zero

(c) L or C or LC

7.22 An a.c current changes direction with the source frequency and the attractive force would average to zero. Thus, the a.c 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 a.c.

7.23 $X_L = \omega L = 2pfL$

$= 3.14\Omega$

$Z = \sqrt{R^2 + L^2}$

$= \sqrt{(3.14)^2 + (1)^2} = \sqrt{10.86}$

; 3.3Ω

$$\tan\phi = \frac{\omega L}{R} = 3.14$$

$\phi = \tan^{-1}(3.14)$

; $72°$

; $\dfrac{72\times\pi}{180}$ rad.

$$\text{Timelag } \Delta t = \frac{\phi}{\omega} = \frac{72\times\pi}{180\times 2\pi\times 50} = \frac{1}{250}\text{s}$$

7.24 $P_L = 60\text{W},\ I_L = 0.54\text{A}$

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

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

$$i_p = \frac{1}{2} \times I_2 = 0.27\text{A}.$$

7.25 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 $1/\omega C$.

7.26 An inductor opposes flow of current through it by developing a back 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.

7.27 Power $P = \frac{V^2}{Z} \Rightarrow \frac{50,000}{2000} = 25 = Z$

$$Z^2 = R^2 + (X_C - X_L)^2 = 625$$

$$\tan\phi = \frac{X_C - X_L}{R} = -\frac{3}{4}$$

$$625 = R^2 + \left(-\frac{3}{4}R\right)^2 = \frac{25}{16}R^2$$

$$R^2 = 400 \Rightarrow \text{R} = 20\Omega$$

$$X_C - X_L = -15\Omega$$

$$I = \frac{V}{Z} = \frac{223}{25} \approx 9\text{ A}.$$

$$I_M = \sqrt{2} \times 9 = 12.6\text{ A}.$$

If R, X_C, X_L are all doubled, $\tan\phi$ does not change.

Z is doubled, current is halfed.

Power drawn is halfed.

7.28 (i) Resistance of Cu wires, R

$$= \rho\frac{l}{A} = \frac{1.7\times10^{-8}\times20000}{\pi\times\left(\frac{1}{2}\right)^2\times10^{-4}} = 4\Omega$$

I at 220 V: $VI = 10^6$ W ; $I = \dfrac{10^6}{220} = 0.45\times10^4$ A

RI^2 = Power loss

$= 4 \times (0.45)^2 \times 10^8$ W

$> 10^6$ W

This method cannot be used for transmission

(ii) $V'I' = 10^6$ W $= 11000\ I'$

$$I' = \frac{1}{1.1}\times10^2$$

$$RI'^2 = \frac{1}{1.21}\times4\times10^4 = 3.3\times10^4 \text{ W}$$

Fraction of power loss $= \dfrac{3.3\times10^4}{10^6} = 3.3\%$

7.29 $Ri_1 = v_m \sin\omega t \quad i_1 = \dfrac{v_m \sin\omega t}{R}$

$$\frac{q_2}{C} + L\frac{dq_2^2}{dt^2} = v_m \sin\omega t$$

Let $q_2 = q_m \sin(\omega t + \phi)$

$$q_m\left(\frac{\cancel{q_m}}{C} - L\omega^2\right)\sin(\omega t + \phi) = v_m \sin\omega t$$

$$q_m = \frac{v_m}{\frac{1}{C} - L\omega^2}, \phi = 0; \frac{1}{C} - \omega^2 L > 0$$

$$v_R = \frac{v_m}{Lw^2 - \dfrac{1}{C}}, \phi = \pi\, L\omega^2 - \frac{1}{C} > 0$$

$$i_2 = \frac{dq_2}{dt} = \omega q_m \cos(\omega t + \phi)$$

i_1 and i_2 are out of phase. Let us assume $\dfrac{1}{C} - \omega^2 L > 0$

$$i_1 + i_2 = \frac{v_m \sin\omega t}{R} + \frac{v_m}{L\omega - \dfrac{1}{c\omega}} \cos\omega t$$

Now A sin ωt + B cos ωt = C sin (ωt + ϕ)

C cos ϕ = A, C sin ϕ = B; $C = \sqrt{A^2 + B^2}$

Therefore, $i_1 + i_2 = \left[\dfrac{{v_m}^2}{R^2} + \dfrac{{v_m}^2}{[\omega l - 1/\omega C]^2}\right]^{\frac{1}{2}} \sin(\omega t + \phi)$

$$\phi = \tan^{-1}\frac{R}{X_L - X_C}$$

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

7.30 $Li\dfrac{di}{dt} + Ri^2 + \dfrac{qi}{c} = vi$; $Li\dfrac{di}{dt} = \dfrac{d}{dt}\left(\dfrac{1}{2}Li^2\right)$ = rate of change of energy stored in an inductor.

Ri^2 = joule heating loss

$\dfrac{q}{C}i = \dfrac{d}{dt}\left(\dfrac{q^2}{2C}\right)$ = rate of change of energy stored in the capacitor.

vi = rate at which driving force pours in energy. It goes into (i) ohmic loss and (ii) increase of stored energy.

$$\int_0^T dt \frac{d}{dt}\left(\frac{1}{2}i^2 + \frac{q^2}{C}\right) + \int_0^T Ri^2 dt = \int_0^T vidt$$

$$0+(+ve)=\int_0^T vidt$$

$\int_0^T vidt > 0$ if phase difference, a constant is acute.

7.31 (i) $L\frac{d^2q}{dt^2}+R\frac{dq}{dt}+\frac{q}{C}=v_m \sin \omega t$

Let $q = q_m \sin(\omega t + \phi) = - q_m \cos(\omega t + \phi)$

$i = i_m \sin(\omega t + \phi) = q_m\, \omega \sin(\omega t + \phi)$

$$i_m=\frac{v_m}{Z}=\frac{v_m}{\sqrt{R^2+(X_C-X_L)^2}};\phi=\tan^{-1}\left(\frac{X_C-X_L}{R}\right)$$

(ii) $U_L=\frac{1}{2}Li^2=\frac{1}{2}L\left[\frac{v_m}{\sqrt{R^2+X_C-X_L)^2{}_0}}\right]^2\sin^2(\omega t_0+\phi)$

$$U_C=\frac{1}{2}\frac{q^2}{C}=\frac{1}{2C}\left[\frac{v_m}{\sqrt{R^2+(X_C-X_L)^2}}\right]^2\frac{1}{\omega^2}\cos^2(\omega t_0+\phi)$$

(iii) Left to itself, it is an LC oscillator. The capacitor will go on discharging and all energy will go to L and back and forth.