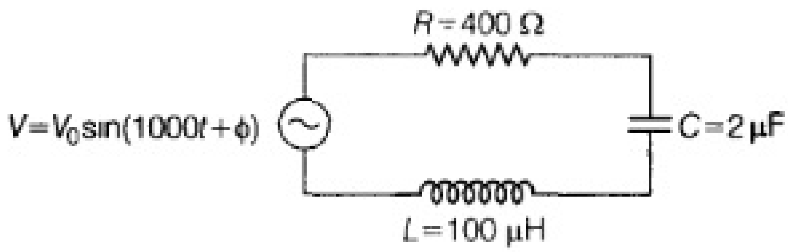
CBSE Test Paper-03

Class - 12 Physics (Alternating Current)

1. Domestic power supply in India is:
   a. 416 V 60 Hz
   b. 110 V 60 Hz
   c. 24 V DC
   d. 220 V 50 Hz
2. If the current is halved in a coil then the energy stored is how much times the previous value:
   a. $\frac{1}{2}$
   b. 1/4
   c. 2
   d. 4
3. If V_m and I_m are peak voltage and current, Impedance Z in an AC circuit is
   a. $\frac{v_m}{2i_m}$
   b. $v_m i_m$
   c. $\frac{2v_m}{i_m}$
   d. $\frac{v_m}{i_m}$
4. The rms current I_{rms} is related to the peak current I_o as
   a. $I_{rms} = 0.787\ I_o$
   b. $I_{rms} = 0.9\ I_o$
   c. $I_{rms} = 0.707\ I_o$
   d. $I_{rms} = 0.5\ I_o$
5. A power transmission line feeds input power at 2300 V to a step-down transformer with its primary windings having 4000 turns. Number of turns in the secondary in order to get output power at 230 V is
   a. 325
   b. 380
   c. 425
   d. 400

6. A power transmission line feeds input power at 2200V to a step-down transformer with its primary windings having 3000 turns. Find the number of turns in the secondary winding to get the power output at 220 V.
7. Is a motor starter a variable R or L?
8. The number of turns in the secondary coil of a transformer is 500 times that in primary. What power is obtained from the secondary when power fed to the primary is 10 W?
9. Mention various energy losses in a transformer.
10. An alternating voltage given by V = 140 sin 314t is connected across a pure resistor of 50Ω. Find
    i. the frequency of the source.
    ii. the rms current through the resistor.
11. An electric lamp having coil of negligible inductance connected in series with a capacitor and an AC source is glowing with certain brightness. How does the brightness of the lamp change on reducing the
    i. capacitance, and
    ii. the frequency? Justify your answer.
12. A $100\mu F$ capacitor in series with a 40Ω resistance is connected to a 110 V, 60 Hz supply.
    a. What is the maximum current in the circuit?
    b. What is the time lag between current maximum and voltage maximum?
13. An inductor $200\mu H$, capacitor $500\mu F$, resistor 10Ω are connected in series with a 100 V, variable frequency a.c. source.
    Calculate:
    i. frequency at which the power factor of the circuit is unity
    ii. current amplitude at this frequency
    iii. Q-factor
14. i. Determine the value of phase difference between the current and the voltage in the given series L-C-R circuit.



ii. Calculate the value of additional capacitor which may be joined suitably to the capacitor C that would make the power factor of the circuit unity.

15. A resistor of 400 Ω, an inductor of $\frac{5}{\pi}$ H and a capacitor of $\frac{50}{\pi} \mu F$ are connected m series across a source of alternating voltage of 140 sin $100\pi t\, V$. Find the voltage (rms) across the resistor, the inductor and the capacitor. Is the algebraic sum of these voltages more than the source voltage? If yes, resolve the paradox.
(Given, $\sqrt{2} = 1.414$)..

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Answers

1. d. 220 V 50 Hz

   Explanation: In INDIA domestic power supply is at 220V and 50Hz .

2. b. 1/4

   Explanation: $E=\frac{1}{2}Li^2$

   $\frac{E_1}{E_2}=\left(\frac{i_1}{i_2}\right)^2$

   $i_2=\frac{i_1}{2}$

   $\frac{E_1}{E_2}=\left(\frac{i_1}{\frac{i_1}{2}}\right)^2=4$

   $E_2=\frac{E_1}{4}$

3. d. $\frac{v_m}{i_m}$

   Explanation: Impedance refers to the overall obstruction offered by a circuit containing different components to the passage of current. Also Z has unit same as resistance.

   So, drawing an analogy with the ohm's law, we get the above relation

4. c. I_{rms} = 0.707 I_o

   Explanation: Average value of i^2 over a complete cycle is given by

   $\bar{i}^2=\frac{1}{T}\int_0^T i^2 dt$

   $i=i_o\sin\omega t$

   $T=\frac{2\pi}{\omega}$

   $\bar{i}^2=\frac{\omega}{2\pi}\int_0^{2\pi/\omega} {i_o}^2\sin^2\omega t dt=\frac{\omega}{2\pi}i_0^2\int_0^{2\pi/\omega}\frac{(1-\cos 2\omega t)}{2}dt$

   $\bar{i}^2=\frac{\omega}{2\pi}\frac{{i_o}^2}{2}\left[t-\frac{\sin 2\omega t}{2\omega}\right]_0^{2\pi/\omega}=\frac{\omega}{2\pi}\frac{{i_o}^2}{2}\left(\frac{2\pi}{\omega}\right)$

   $\bar{i}^2=\frac{i_0^2}{2}$

   the root-mean-square value of the alternating current is

   $i_{rms}=\sqrt{\bar{i}^2}=\frac{i_0}{\sqrt{2}}$

   i_{rms} = 0.707i_0

5. d. 400

   Explanation: N_p = no. of turns in primary coil = 4000

   N_s = no. of turns in primary coil

   V_p = input voltage = 2300 V

   V_s = output voltage = 230 V

   $\frac{V_s}{V_p} = \frac{N_s}{N_p}$

   $\frac{230}{2300} = \frac{N_s}{4000}$

   N_s = 400
6. Given, input voltage (V1) = 2200 V

   Number of turns (n_1) = 3000

   Output voltage (V2) = 220 V

   As, $\frac{V_2}{V_1} = \frac{n_2}{n_1} \Rightarrow \frac{220}{2200} = \frac{n_2}{3000}$

   $\Rightarrow n_2 = \frac{220}{2200} \times 3000$

   n_2 = 300
7. Variable R
8. If there is no loss of energy, then the output power will be 10 W.
9. For energy losses in transformer.
   - Copper Losses (Winding Resistance) Core or Iron Losses
   - Hysteresis Losses
   - Eddy Current Losses
10. An alternating voltage given by V = 140 sin 315 t, R = 50Ω

    Comparing it with V = V_0 sin ωt

    i. Here, $\omega = 314 \mathrm{rad/s}$

       i.e. $2\pi v = 314$

       $\Rightarrow \quad v = 314/2\pi$

       $v = \frac{314}{2\times3.14}$

       = 50 Hz

    ii. As, $I_{\mathrm{rms}} = \frac{V_{\mathrm{rms}}}{R}$ and $V_{\mathrm{rms}} = \frac{V_0}{\sqrt{2}}$

       Here, $V_0 = 140\mathrm{V}$

       $V_{\mathrm{rms}} = \frac{140}{\sqrt{2}} \times \frac{\sqrt{2}}{\sqrt{2}} = 70\sqrt{2}\mathrm{V}$

$\therefore \quad I_{\text{rms}} = \frac{70\sqrt{2}}{R} = \frac{70\sqrt{2}}{50} = 1.9\text{A}$

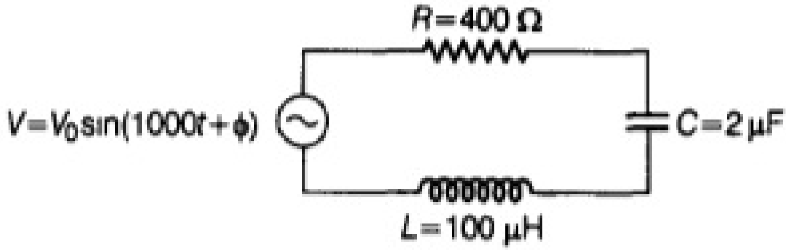
11. When AC source is connected, the capacitor offers capacitive reactance $X_C = \frac{1}{\omega C} = \frac{1}{2\pi v_0 C}$. The current flows in the circuit and the lamp glows.
    i. By *reducing the capacitance*, the capacitive reactance will *increase*. So the *bulb brightness* will *decrease.*
    ii. On reducing frequency, X_C increases so current in the circuit decrease. Therefore, the brightness of the bulb decrease.
12. Here, $C = 100\mu F = 100 \times 10^{-6} F = 10^{-4} F,\ R = 40\Omega$
    $E_v = 110 volt,\ E_0 = \sqrt{2},\ E_v = \sqrt{2} \times 110V$ v = 60 Hz,
    $\omega = 2\pi v = 120\pi rad/s$ I_0 =?
    In RC circuit as $Z = \sqrt{R^2 + X_L^2} = \sqrt{R^2 + \frac{1}{\omega^2 C^2}}$
    $\therefore I_0 = \frac{E_0}{\sqrt{R^2 + \frac{1}{\omega^2 C^2}}} = \frac{\sqrt{2} \times 110}{\sqrt{1600 + \frac{1}{(120\pi \times 10^{-4})^2}}}\ I_0 = 3.24\ amp$
    In RC circuit, voltage lags behind the current by phase angle .ϕ
    where $\tan\phi = \frac{\frac{1}{\omega C}}{R} = \frac{1}{\omega CR} = \frac{1}{120\pi \times 10^{-4} \times 40} = 0.6628$
    $\phi = \tan^{-1}(0.6625) = 33.5^\circ = \frac{33.5\pi}{180} rad$ Time lag
    $= \frac{\phi}{\omega} = \frac{33.5\pi}{180 \times 120\pi} = 1.55 \times 10^{-3}$sec
13. i. Power factor
    $\cos\theta = \frac{R}{Z} = 1$
    R = Z
    $R = \sqrt{R^2 + \left(\omega L - \frac{1}{\omega C}\right)^2}$
    $R^2 = R^2 + \left(\omega L - \frac{1}{\omega C}\right)^2$
    $\omega L = \frac{1}{\omega C}$
    $\omega^2 = \frac{1}{LC}$ or $\omega = \frac{1}{\sqrt{LC}}$
    $2\pi v = \frac{1}{\sqrt{LC}}$
    $\nu = \frac{1}{2\pi\sqrt{LC}}$
    $\omega_0 = \frac{1}{2\pi\sqrt{LC}}$
    $= \frac{1}{\sqrt{200 \times 10^{-6} \times 500 \times 10^{-6}}}$
    $= 3.16 \times 10^{-3}\ rad\ s^{-1}$

$\omega_0 = 3.16 \times 10^{-3} rad/s$

ii. The current amplitude at this frequency, $I_0 = \frac{V}{R} = \frac{100}{10} = 10A$

iii. The Q-factor, $Q = \frac{X_L}{R} = \frac{\omega_0 L}{R}$

$= \frac{3.16 \times 10^{-3} \times 200 \times 10^{-6}}{10} = 6.32 \times 10^{-8}$

14. i. 

Given

$V = V_0 \sin(1000t + \phi) \Rightarrow \omega = 1000\text{Hz}$

$R = 400\Omega C = 2\mu F, L = 100\text{mH}$

$\because$Capacitive reactance, $X_c = \frac{1}{\omega C}$

$\Rightarrow \quad X_C = \frac{1}{1000 \times 2 \times 10^{-6}}$

$\Rightarrow \quad X_c = \frac{10^3}{2} \Rightarrow X_c = 500\Omega$

$\because$ Inductive reactance, $X_L = \omega L$

$\Rightarrow \quad X_L = 1000 \times 100 \times 10^{-3} \Rightarrow X_L = 100\Omega$

So $X_c > X_L$

$\Rightarrow \tan\phi$ is negative.

Hence, the voltage lags behind the current by a phase angle ϕ .

$\because$ Phase difference, tanϕ = $= \frac{X_L - X_C}{R}$

$\tan\phi = \frac{100-500}{400} \Rightarrow \tan\phi = \frac{-400}{400}, \tan\phi = -1$

$\Rightarrow \quad \tan\phi = -\tan\left(\frac{\pi}{4}\right) \Rightarrow \phi = -\frac{\pi}{4}$

This is the required value of the phase difference between the current and the voltage in the given series L-C-R circuit.

As, cos$\phi < 1$

ii. Suppose, new capacitance of the circuit is C'. Thus, to have power factor unity

$\cos\phi' = 1 = \frac{R}{\sqrt{R^2 + (X_L - X_C)^2}}$

$\Rightarrow \quad R^2 = R^2 + \left(X_L - X'_C\right)^2$

$\Rightarrow \quad X_L = X'_C = \frac{1}{\omega C'}$ or $\quad \omega L = \frac{1}{\omega C'}$

$\Rightarrow \omega^2 = \frac{1}{LC'}$ or $(1000)^2 = \frac{1}{LC'}$ $(\because \omega = 1000)$

$\Rightarrow \quad C' = \frac{1}{L \times 10^6} = \frac{1}{100 \times 10^{-3} \times 10^6}$

$= \frac{10}{10^6} = \frac{1}{10^5} = 10^{-5}$

$\Rightarrow \quad C' = 10^{-5}\text{F} = 10 \times 10^{-6}\text{F} = 10\mu\text{F}$

As, C' >C. Hence, we have to add an additional capacitor of capacitance $8\mu F(10\mu F - 2\mu F)$ in parallel with previous capacitor.

15. It can be calculated with the help of formula of phase difference.

As applied voltage, $V = 140 \sin 100\pi t$

$C = \frac{50}{\pi}\mu F, L = \frac{5}{\pi}H, R = 400\Omega$

Comparing it with $V = V_0 \sin \omega t$,

$V_0 = 140\text{V}, \omega = 100\pi$

Inductive reactance, $X_L = \omega L$

$X_L = 100\pi \times 5/\pi = 500\Omega$

Capacitive reactance, $X_C = \frac{1}{\omega C}$

$X_c = \frac{1}{100\pi \times \frac{50}{\pi} \times 10^{-6}} = 200\Omega$

Impedance of the AC circuit,

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

$= \sqrt{1409^2 + (500 - 200)^2}$

$Z = \sqrt{1600 + 900} = 500\Omega$

Maximum current in the circuit,

$I_0 = \frac{V_0}{Z} = \frac{140}{500}$

$I_{\text{rms}} = \frac{I_0}{\sqrt{2}} = \frac{140}{500 \times \sqrt{2}} = 0.2\text{A}$

V_{rms} across resistor R, $V_{rms} = I_{rms}R$

$V_{rms} = 0.2 \times 400 = 80\text{V}$

V_{rms} across inductor, $V_L = I_{\text{ms}}X_L$

$V_L = 0.2 \times 500 = 100\text{V}$

V_{rms} across capacitor, $V_C = I_{\text{rms}}X_C$

$V_C = 0.2 \times 200 = 40\text{V}$

Here, $V < V_R + V_L + V_C$

Because V_L and V_R are not in same phase,

$\therefore V = \sqrt{V_K^2 + (V_L - V_C)^2}$