Chapter 24

Alternating Current

Alternating Quantities (*i* or *V*)

(1) An alternating quantity (current *i* or voltage *V*) is one whose magnitude changes continuously with time between zero and a maximum value and whose direction reverses periodically.

(2) Some graphical representation for alternating quantities

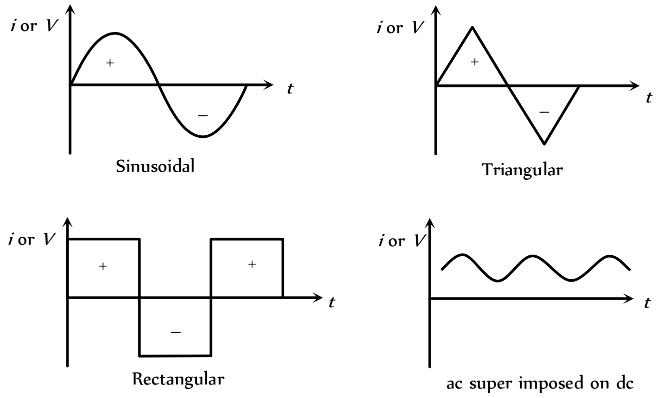


Fig. 24.1

(3) **Equation for *i* and *V* :** Alternating current or voltage varying as sine function can be written as

$$i = i_0 \sin \omega t = i_0 \sin 2\pi \nu t = i_0 \sin \frac{2\pi}{T} t$$

and $$V = V_0 \sin \omega t = V_0 \sin 2\pi \nu t = V_0 \sin \frac{2\pi}{T} t$$

where *i* and *V* are Instantaneous values of current and voltage,

i_0 and V_0 are peak values of current and voltage

ω = Angular frequency in *rad/sec*, ν = Frequency in *Hz* and *T* = time period

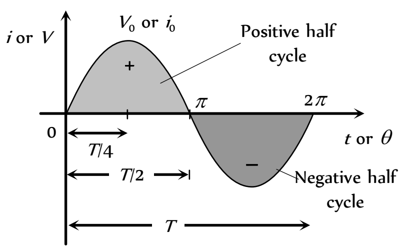


Fig. 24.2

(i) The time taken to complete one cycle of variations is called the periodic time or time period.

(ii) Alternating quantity is positive for half the cycle and negative for the rest half. Hence average value of alternating quantity (*i* or *V*) over a complete cycle is zero.

(iii) The value of alternating quantity is zero or maximum 2ν times every second. The direction also changes 2ν times every second.

(iv) Generally sinusoidal waveform is used as alternating current/voltage.

(v) At $t = \frac{T}{4}$ from the beginning, *i* or *V* reaches to their maximum value.

Important Values of Alternating Quantities

(1) **Peak value (i_0 or V_0) :** The maximum value of alternating quantity (i_0 or V_0) is defined as peak value or amplitude.

(2) **Mean square value ($\overline{V^2}$ or $\overline{i^2}$) :** The average of square of instantaneous values in one cycle is called mean square value. It is always positive for one complete cycle. *e.g.* $\overline{V^2} = \frac{1}{T}\int_0^T V^2 dt = \frac{V_0^2}{2}$ or $\overline{i^2} = \frac{i_0^2}{2}$

(3) **Root mean square (r.m.s.) value :** Root of mean of square of voltage or current in an *ac* circuit for one complete cycle is called *r.m.s.* value. It is denoted by V_{rms} or i_{rms}

$$i_{rms} = \sqrt{\frac{i_1^2 + i_2^2 + ...}{n}} = \sqrt{\overline{i^2}} = \sqrt{\frac{\int_0^T i^2 dt}{\int_0^T dt}} = \frac{i_0}{\sqrt{2}} = 0.707\, i_0 = 70.7\%\ i_0$$

Similarly $V_{rms} = \frac{V_0}{\sqrt{2}} = 0.707\, V_0 = 70.7\%$ of V_0

$$\left[\langle \sin^2(\omega t)\rangle = \langle \cos^2(\omega t)\rangle = \frac{1}{2}\right]$$

(i) The *r.m.s.* value of alternating current is also called virtual value or effective value.

(ii) In general when values of voltage or current for alternating circuits are given, these are *r.m.s.* value.

(iii) ac ammeter and voltmeter are always measure *r.m.s.* value. Values printed on *ac* circuits are *r.m.s.* values.

(iv) In our houses *ac* is supplied at 220 *V*, which is the *r.m.s.* value of voltage. It's peak value is $\sqrt{2} \times 200 = 311V$.

(v) *r.m.s.* value of *ac* is equal to that value of *dc*, which when passed through a resistance for a given time will produce the same amount of heat as produced by the alternating current when passed through the same resistance for same time.

(4) **Mean or Average value (i_{av} or V_{av}) :** The average value of alternating quantity for one complete cycle is zero.

The average value of *ac* over half cycle (t = 0 to $T/2$)

$$i_{av} = \frac{\int_0^{T/2} i\,dt}{\int_0^{T/2} dt} = \frac{2i_0}{\pi} = 0.637 i_0 = 63.7\% \text{ of } i_0$$

Similarly $V_{av} = \frac{2V_0}{\pi} = 0.637V_0 = 63.7\%$ of V_0

(5) **Peak to peak value :** It is equal to the sum of the magnitudes of positive and negative peak values

$\therefore$ Peak to peak value = $V_0 + V_0 = 2V_0$

$$= 2\sqrt{2}\, V_{rms} = 2.828\, V_{rms}$$

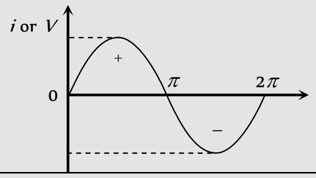
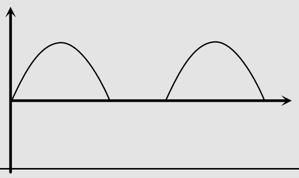
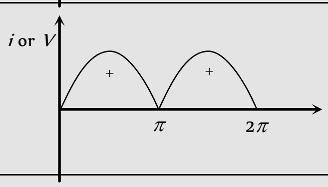
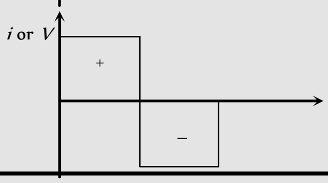
(6) **Form factor and peak factor :** The ratio of *r.m.s.* value of *ac* to it's average during half cycle is defined as form factor. The ratio of peak value and *r.m.s.* value is called peak factor

Phase

Physical quantity which represents both the instantaneous value and direction of alternating quantity at any instant is called it's phase. It's a dimensionless quantity and it's unit is radian.

If an alternating quantity is expressed as $X = X_0 \sin(\omega t \pm \phi_0)$ then the argument of $\sin(\omega t + \phi)$ is called it's phase. Where ωt = instantaneous phase (changes with time) and ϕ_0 = initial phase (constant *w.r.t.* time)

Table 24.1 : Some important values

Nature of wave form	Wave form	*r.m.s.* value	average value	Form factor $R_f = \frac{\text{r.m.s. value}}{\text{Average value}}$	Peak factor $R_p = \frac{\text{Peak value}}{\text{r.m.s. value}}$
Sinusoidal		$\frac{i_0}{\sqrt{2}}$	$\frac{2}{\pi} i_0$	$\frac{\pi}{2\sqrt{2}} = 1.11$	$\sqrt{2} = 1.41$
Half wave rectified		$\frac{i_0}{2}$	$\frac{i_0}{\pi}$	$\frac{\pi}{2} = 1.57$	2
Full wave rectified		$\frac{i_0}{\sqrt{2}}$	$\frac{2i_0}{\pi}$	$\frac{\pi}{2\sqrt{2}}$	$\sqrt{2}$
Square or Rectangular		i_0	i_0	1	1

(1) **Phase difference** (Phase constant) : The difference between the phases of currents and voltage is called phase difference. If alternating voltage and current are given by $V = V_0 \sin(\omega t + \phi_1)$ and $i = i_0 \sin(\omega t + \phi_2)$ then phase difference $\phi = \phi_1 - \phi_2$ (relative to current) or $\phi = \phi_2 - \phi_1$ (relative to voltage)

(2) **Time difference :** If phase difference between alternating current and voltage is ϕ then time difference between them is given as

$$\text{T.D.} = \frac{T}{2\pi} \times \phi$$

(3) **Phasor diagram :** A diagram representing alternating current and alternating voltage (of same frequency) as vectors (phasors) with the phase angle between them is called a phasor diagram.

While drawing phasor diagram for a pure element (*e.g.* *R*, *L* or *C*) either of the current or voltage can be plotted along *X*-axis.

But when phasor diagram for a combination of elements is drawn then quantity which remains constant for the combination must be plotted along *X*-axis so we observe that

(i) In series circuits current has to be plotted along *X*-axis.

(ii) In parallel circuits voltage has to be plotted along *X*-axis.

Measurement of Alternating Quantities

Alternating current shows heating effect only, hence meters used for measuring ac are based on heating effect and are called hot wire meters (Hot wire ammeter and hot wire voltmeter)

Table 24.2 : Measurement of ac and dc

ac measurement	*dc* measurement
(1) All ac meters read *r.m.s.* value.	(1) All dc meters read average value
(2) All ac meters are based on heating effect of current.	(2) All dc meters are based on magnetic effect of current
(3) Deflection in hot wire meters $\theta \propto i_{rms}^2$  (non-linear scale)	(3) Deflection in *dc* meters $\theta \propto i$  (Linear scale)

Impedance, Reactance, Admittance and Susceptance

(1) **Impedance (*Z*) :** The opposition offered by ac circuits to the flow of ac through it is defined it's impedance. It's unit is *ohm*(Ω).

(2) **Reactance (*X*) :** The opposition offered by inductor or capacitor or both to the flow of ac through it is defined as reactance. It is of following two type

(i) **Inductive reactance (*X*)** : Offered by inductive circuit $X_L = \omega L = 2\pi\nu L$ $\nu_{dc} = 0$ so for dc, $X_L = 0$.

Capacitive reactance (*X*) : Offered by capacitive circuit $X_C = \frac{1}{\omega C} = \frac{1}{2\pi\nu C}$ for dc $X_C = \infty$.

(3) **Admittance (*Y*) :** $Z = \frac{V_0}{i_0} = \frac{V_{rms}}{i_{rms}}$ Reciprocal of impedance is known as admittance $\left(Y = \frac{1}{Z}\right)$. It's unit is *mho*

(4) **Susceptance (*S*) :** the reciprocal of reactance is defined as susceptance $\left(S = \frac{1}{X}\right)$. It is of two type

(i) inductive susceptance $S_L = \frac{1}{X_L} = \frac{1}{2\pi\nu L}$ and

(ii) Capacitive susceptance, $S_C = \frac{1}{X_C} = \omega C = 2\pi\nu C$.

Power in ac Circuits

In dc circuits power is given by $P = Vi$. But in ac circuits, since there is some phase angle between voltage and current, therefore power is defined as the product of voltage and that component of the current which is in phase with the voltage.

Thus $\boldsymbol{P = V\,i\cos\phi}$; where *V* and *i* are *r.m.s.* value of voltage and current.

(1) **Instantaneous power :** Suppose in a circuit $V = V_0 \sin\omega t$ and $i = i_0 \sin(\omega t + \phi)$ then $P_{\text{instantaneous}} = Vi = V_0 i_0 \sin\omega t \sin(\omega t + \phi)$

(2) **Average power (True power) :** The average of instantaneous power in an ac circuit over a full cycle is called average power. It's unit is *watt i.e.*

$$P_{av} = V_{rms} i_{rms} \cos\phi = \frac{V_0}{\sqrt{2}} \cdot \frac{i_0}{\sqrt{2}} \cos\phi = \frac{1}{2} V_0 i_0 \cos\phi = i_{rms}^2 R = \frac{V_{rms}^2 R}{Z^2}$$

(3) **Apparent or virtual power :** The product of apparent voltage and apparent current in an electric circuit is called apparent power. This is always positive $P_{app} = V_{rms} i_{rms} = \frac{V_0 i_0}{2}$

Power Factor

(1) It may be defined as cosine of the angle of lag or lead (*i.e.* $\cos\phi$)

(2) It is also defined as the ratio of resistance and impedance (*i.e.* $\frac{R}{Z}$)

(3) The ratio $\frac{\text{True power}}{\text{Apparent power}} = \frac{W}{VA} = \frac{kW}{kVA} = \cos\phi$

Resistive Circuit (*R*-Circuit)

(1) Current : $i = i_0 \sin\omega t$

(2) Peak current : $i_0 = \frac{V_0}{R}$

(3) Phase difference between voltage and current : $\phi = 0$

(4) Power factor : $\cos\phi = 1$

(5) Power : $P = V_{rms} i_{rms} = \frac{V_0 i_0}{2}$

(6) Time difference : T.D. = 0

(7) Phasor diagram : Both are in same phase

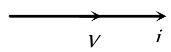
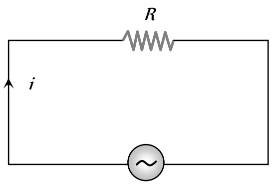


Fig. 24.4



$V = V_0 \sin\omega t$

Fig. 24.3

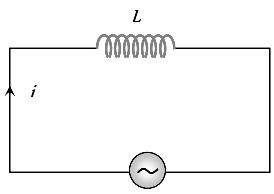
Inductive Circuit (*L*-Circuit)

(1) Current : $i = i_0 \sin\left(\omega t - \frac{\pi}{2}\right)$

(2) Peak current :

$$i_0 = \frac{V_0}{X_L} = \frac{V_0}{\omega_L} = \frac{V_0}{2\pi\nu L}$$

(3) Phase difference between



$V = V_0 \sin\omega t$

Fig. 24.5

voltage and current $\phi = 90^o$ (or $+\frac{\pi}{2}$)

(4) Power factor : $\cos\phi = 0$

(5) Power : $P = 0$

(6) Time difference : $\text{T.D.} = \frac{T}{4}$

(7) Phasor diagram : Voltage leads the current by $\frac{\pi}{2}$

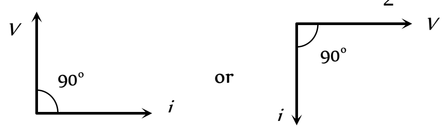


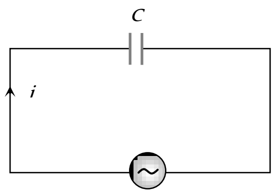
Fig. 24.6

Capacitive Circuit (*C*-Circuit)

(1) Current : $i = i_0 \sin\left(\omega t + \frac{\pi}{2}\right)$

(2) Peak current :

$$i_0 = \frac{V_0}{X_C} = V_0 \omega C = V_0 (2\pi \nu C)$$



$V = V_0 \sin\omega t$

Fig. 24.7

(3) Phase difference between

voltage and current : $\phi = 90^o$ (or $-\frac{\pi}{2}$)

(4) Power factor : $\cos\phi = 0$

(5) Power : $P = 0$

(6) Time difference : $\text{TD} = \frac{T}{4}$

(7) Phasor diagram : Current leads the voltage by $\pi/2$

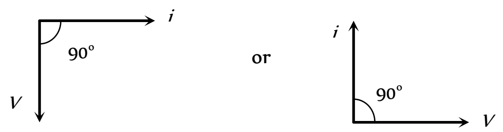
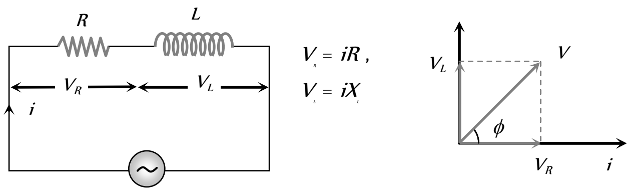


Fig. 24.8

Resistive, Inductive Circuit (*RL*-Circuit)



$V = V_0 \sin\omega t$

Fig. 24.9

(1) Applied voltage : $V = \sqrt{V_R^2 + V_L^2}$

(2) Impedance : $Z = \sqrt{R^2 + X_L^2} = \sqrt{R^2 + \omega^2 L^2} = \sqrt{R^2 + 4\pi^2 \nu^2 L^2}$

(3) Current : $i = i_0 \sin(\omega t - \phi)$

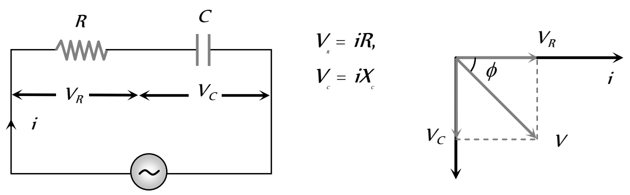
(4) Peak current $i_0 = \frac{V_0}{Z} = \frac{V_0}{\sqrt{R^2 + X_L^2}} = \frac{V_0}{\sqrt{R^2 + 4\pi^2 \nu^2 L^2}}$

(5) Phase difference : $\phi = \tan^{-1}\frac{X_L}{R} = \tan^{-1}\frac{\omega L}{R}$

(6) Power factor : $\cos\phi = \frac{R}{\sqrt{R^2 + X_L^2}}$

(7) Leading quantity : Voltage

Resistive, Capacitive Circuit (*RC*-Circuit)



$V = V_0 \sin\omega t$

Fig. 24.10

(1) Applied voltage : $V = \sqrt{V_R^2 + V_C^2}$

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

(3) Current : $i = i_0 \sin(\omega t + \phi)$

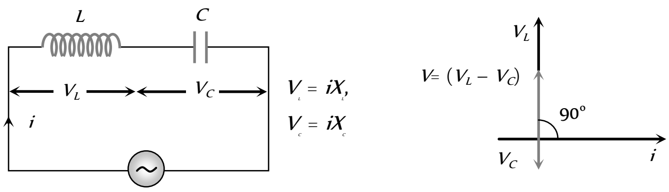
(4) Peak current : $i_0 = \frac{V_0}{Z} = \frac{V_0}{\sqrt{R^2 + X_C^2}} = \frac{V_0}{\sqrt{R^2 + \frac{1}{4\pi^2 \nu^2 C^2}}}$

(5) Phase difference : $\phi = \tan^{-1}\frac{X_C}{R} = \tan^{-1}\frac{1}{\omega CR}$

(6) Power factor : $\cos\phi = \frac{R}{\sqrt{R^2 + X_C^2}}$

(7) Leading quantity : Current

Inductive, Capacitive Circuit (*LC*-Circuit)



$V = V_0 \sin\omega t$

Fig. 24.11

(1) Applied voltage : $V = V_L - V_C$

(2) Impedance : $Z = X_L - X_C = X$

(3) Current : $i = i_0 \sin\left(\omega t \pm \frac{\pi}{2}\right)$

(4) Peak current : $i_0 = \frac{V_0}{Z} = \frac{V_0}{X_L - X_C} = \frac{V_0}{\omega L - \frac{1}{\omega C}}$

(5) Phase difference : $\phi = 90^\circ$

(6) Power factor : $\cos\phi = 0$

(7) Leading quantity : Either voltage or current

Series *RLC*-Circuit

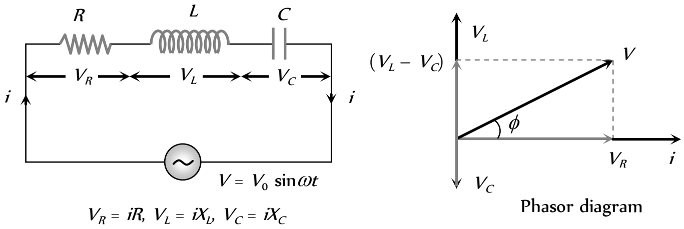


Fig. 24.12

(1) **Equation of current :** $i = i_0 \sin(\omega t \pm \phi)$; where $i_0 = \dfrac{V_0}{Z}$

(2) **Equation of voltage :** From phasor diagram

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

(3) **Impedance of the circuit :**

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

(4) **Phase difference :** From phasor diagram

$$\tan\phi = \frac{V_L - V_C}{V_R} = \frac{X_L - X_C}{R} = \frac{\omega L - \frac{1}{\omega C}}{R} = \frac{2\pi\nu L - \frac{1}{2\pi\nu C}}{R}$$

(5) **If net reactance is inductive :** Circuit behaves as *LR* circuit

(6) **If net reactance is capacitive :** Circuit behave as *CR* circuit

(7) **If net reactance is zero :** Means $X = X_L - X_C = 0$

$\Rightarrow X_L = X_C$. This is the condition of resonance

(8) **At resonance** (series resonant circuit)

(i) $X_L = X_C \Rightarrow Z_{min} = R$ *i.e.* circuit behaves as resistive circuit

(ii) $V_L = V_C \Rightarrow V = V_R$ *i.e.* whole applied voltage appeared across the resistance

(iii) Phase difference : $\phi = 0° \Rightarrow$ p.f. = cos ϕ = 1

(iv) Power consumption $P = V_{rms} i_{rms} = \dfrac{1}{2} V_0 i_0$

(v) Current in the circuit is maximum and it is $i_0 = \dfrac{V_0}{R}$

(vi) These circuit are used for voltage amplification and as selector circuits in wireless telegraphy.

(9) **Resonant frequency** (Natural frequency)

At resonance $X_L = X_C \Rightarrow \omega_0 L = \dfrac{1}{\omega_0 C} \Rightarrow \omega_0 = \dfrac{1}{\sqrt{LC}} \dfrac{rad}{sec}$

$$\Rightarrow \nu_0 = \frac{1}{2\pi\sqrt{LC}} Hz \text{ (or } cps)$$

(Resonant frequency doesn't depend upon the resistance of the circuit)

(10) **Half power frequencies and band width :** The frequencies at which the power in the circuit is half of the maximum power (The power at resonance), are called half power frequencies.

(i) The current in the circuit at half power frequencies (HPF) is $\dfrac{1}{\sqrt{2}}$ or 0.707 or 70.7% of maximum current (current at resonance).

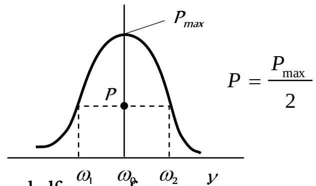


Fig. 24.13

(ii) There are two half power frequencies

(a) $\omega_1 \rightarrow$ called lower half power frequency. At this frequency the circuit is capacitive.

(b) $\omega_2 \rightarrow$ called upper half power frequency. It is greater than ω_0. At this frequency the circuit is inductive.

(iii) Band width $(\Delta\omega)$: The difference of half power frequencies ω_1 and ω_2 is called band width $(\Delta\omega)$ and $\Delta\omega = \omega_2 - \omega_1$. For series resonant circuit it can be proved $\Delta\omega = \left(\dfrac{R}{L}\right)$

(11) **Quality factor (*Q*-factor) of series resonant circuit**

(i) The characteristic of a series resonant circuit is determined by the quality factor (Q - factor) of the circuit.

(ii) It defines sharpness of i - ν curve at resonance when Q - factor is large, the sharpness of resonance curve is more and vice-versa.

(iii) Q - factor also defined as follows

$$Q\text{ - factor} = 2\pi \times \frac{\text{Max. energy stored}}{\text{Energy dissipation}}$$

$$= \frac{2\pi}{T} \times \frac{\text{Max. energy stored}}{\text{Mean power dissipated}} = \frac{\text{Resonant frequency}}{\text{Band width}} = \frac{\omega_0}{\Delta\omega}$$

(iv) Q - factor $= \dfrac{V_L}{V_R}$ or $\dfrac{V_C}{V_R} = \dfrac{\omega_0 L}{R}$ or $\dfrac{1}{\omega_0 CR}$

$$\Rightarrow Q\text{ - factor} = \frac{1}{R}\sqrt{\frac{L}{C}}$$

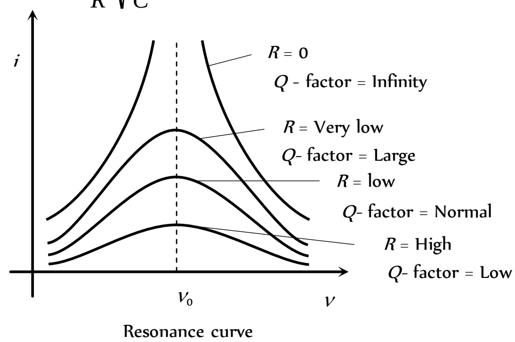


Fig. 24.14

Parallel *RLC* Circuits

$$i_R = \frac{V_0}{R} = V_0 G$$

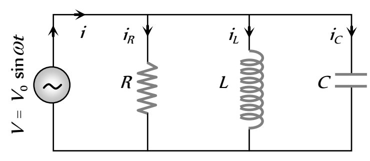


Fig. 24.15

$i_L = \frac{V_0}{X_L} = V_0 S_L$

$i_C = \frac{V_0}{X_C} = V_0 S_C$

(1) **Current and phase difference :** From phasor diagram current $i = \sqrt{i_R^2 + (i_C - i_L)^2}$ and phase difference $\phi = \tan^{-1}\frac{(i_C - i_L)}{i_R} = \tan^{-1}\frac{(S_C - S_L)}{G}$

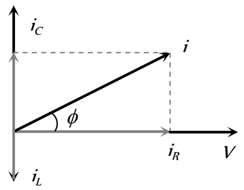


Fig. 24.16

(2) **Admittance (Y) of the circuit :** From equation of current

$$\frac{V_0}{Z} = \sqrt{\left(\frac{V_0}{R}\right)^2 + \left(\frac{V_0}{X_L} - \frac{V_0}{X_C}\right)^2}$$

$$\Rightarrow \frac{1}{Z} = Y = \sqrt{\left(\frac{1}{R}\right)^2 + \left(\frac{1}{X_L} - \frac{1}{X_C}\right)^2} = \sqrt{G^2 + (S_L - S_C)^2}$$

(3) **Resonance :** At resonance (i) $i_C = i_L \Rightarrow i_{\min} = i_R$

(ii) $\frac{V}{X_C} = \frac{V}{X_L} \Rightarrow S_C = S_L \Rightarrow \Sigma S = 0$

(iii) $Z_{\max} = \frac{V}{i_R} = R$

(iv) $\phi = 0 \Rightarrow$ p.f. $= \cos\phi = 1 =$ maximum

(v) Resonant frequency $\Rightarrow \nu = \frac{1}{2\pi\sqrt{LC}}$

(4) **Parallel *LC* circuits :** If inductor has resistance (*R*) and it is connected in parallel with capacitor as shown

(i) **At resonance**

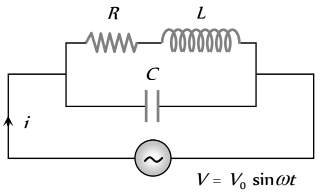


Fig. 24.17

(a) $Z_{\max} = \frac{1}{Y_{\min}} = \frac{L}{CR}$

(b) Current through the circuit is minimum and $i_{\min} = \frac{V_0 CR}{L}$

(c) $S_L = S_C \Rightarrow \frac{1}{X_L} = \frac{1}{X_C} \Rightarrow X = \infty$

(d) Resonant frequency $\omega_0 = \sqrt{\frac{1}{LC} - \frac{R^2}{L^2}}\ \frac{rad}{sec}$ or

$\nu_0 = \frac{1}{2\pi}\sqrt{\frac{1}{LC} - \frac{R^2}{L^2}}\ Hz$ (Condition for parallel resonance is $R < \sqrt{\frac{L}{C}}$)

(e) Quality factor of the circuit $= \frac{1}{CR}\cdot\frac{1}{\sqrt{\frac{1}{LC} - \frac{R^2}{L^2}}}$. In the state of resonance the quality factor of the circuit is equivalent to the current amplification of the circuit.

(ii) **If inductance has no resistance :** If $R = 0$ then circuit becomes parallel *LC* circuit as shown

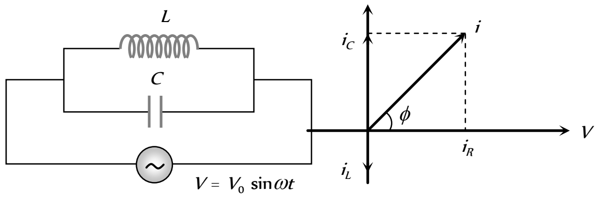


Fig. 24.18

Condition of resonance : $i_C = i_L \Rightarrow \frac{V}{X_C} = \frac{V}{X_L}$

$\Rightarrow X_C = X_L$. At resonance current *i* in the circuit is zero and impedance is infinite. Resonant frequency : $\nu_0 = \frac{1}{2\pi\sqrt{LC}}\ Hz$

Wattless Current

In an ac circuit $R = 0 \Rightarrow \cos\phi = 0$ so $P = 0$ *i.e.* in resistance less circuit the power consumed is zero. Such a circuit is called the wattless circuit and the current flowing is called the wattless current.

or

The component of current which does not contribute to the average power dissipation is called wattless current

(i) The average of wattless component over one cycle is zero

(ii) Amplitude of wattless current $= i \sin\phi$

and *r.m.s.* value of wattless current $= i_{rms}\sin\phi = \frac{i_0}{\sqrt{2}}\sin\phi$.

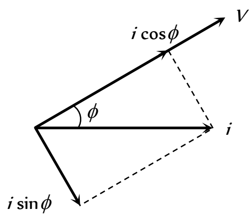


Fig. 24.19

It is quadrature (90) with voltage.

Choke Coil

Choke coil (or ballast) is a device having high inductance and negligible resistance. It is used to control current in ac circuits and is used in fluorescent tubes. The power loss in a circuit containing choke coil is least.

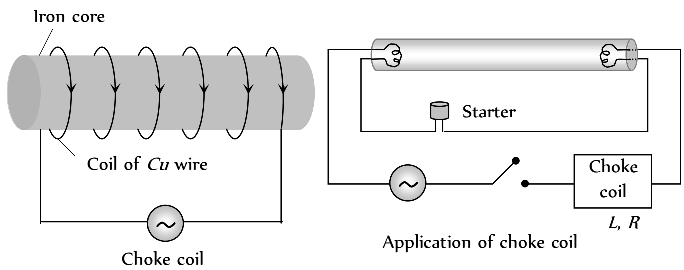


Fig. 24.20

(1) It consist of a *Cu* coil wound over a soft iron laminated core.

(2) Thick *Cu* wire is used to reduce the resistance (R) of the circuit.

(3) Soft iron is used to improve inductance (L) of the circuit.

(4) The inductive reactance or effective opposition of the choke coil is given by $X_L = \omega L = 2\pi\nu L$

(5) For an ideal choke coil $r = 0$, no electric energy is wasted *i.e.* average power $P = 0$.

(6) In actual practice choke coil is equivalent to a $R - L$ circuit.

(7) Choke coil for different frequencies are made by using different substances in their core.

For low frequency L should be large thus iron core choke coil is used. For high frequency ac circuit, L should be small, so air cored choke coil is used.

Tips & Tricks

☞ If ac is produced by a generator having a large number of poles then it's frequency

$$\nu = \frac{\text{Number of poles} \times \text{rotation per second}}{2} = \frac{P \times n}{2}$$

Where P is the number of poles; n is the rotational frequency of the coil.

✍ Alternating current in electric wires, bulbs etc. flows 50 times in one direction and 50 times in the opposite direction in 1 *second*. Since in one cycle the current becomes zero twice, hence a bulb lights up 100 times and is off 100 times in one second (50 cycles) but due to persistence of vision, it appears lighted continuously.

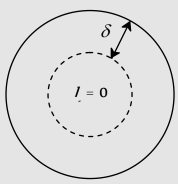
✍ ac is more dangerous than dc.

✍ The rate of change of ac is minimum at that instant when they are near their peak values.

✍ ac equipments such as electric motors, are more durable and convenient compared to dc equipments.

✍ **Skin Effect**

A direct current flows uniformly throughout the cross-section of the conductor. An alternating current, on the other hand, flows mainly along the surface of the conductor. This effect is known as skin effect. the reason is that when alternating current flows through a conductor, the flux changes in the inner part of the conductor are higher. Therefore the inductance of the inner part is higher than that of the outer part. Higher the frequency of alternating current, more is the skin effect.



The depth upto which ac current flows through a wire is called skin depth (δ).

Ordinary Thinking

Objective Questions

Alternating Current, Voltage and Power

1. The power is transmitted from a power house on high voltage ac because **[CPMT 1984, 85]**

(a) Electric current travels faster at higher *volts*

(b) It is more economical due to less power wastage

(c) It is difficult to generate power at low voltage

(d) Chances of stealing transmission lines are minimized

2. The potential difference V and the current i flowing through an instrument in an ac circuit of frequency f are given by $V = 5\cos\omega t$ *volts* and $I = 2\sin\omega t$ *amperes* (where $\omega = 2\pi f$). The power dissipated in the instrument is

[CPMT 1977, 80; MP PET 1999]

(a) Zero (b) 10 W

(c) 5 W (d) 2.5 W

3. In an ac circuit, V and I are given by

$V = 100\sin(100t)$ *volts*, $I = 100\sin\left(100t + \frac{\pi}{3}\right) mA$. The power dissipated in circuit is

[MP PET 1989; RPET 1999; MP PMT 1999, 2002]

(a) 10^{4} *watt* (b) 10 *watt*

(c) 2.5 *watt* (d) 5 *watt*

4. Alternating current can not be measured by dc ammeter because

(a) ac cannot pass through dc ammeter

(b) Average value of complete cycle is zero

(c) ac is virtual

(d) ac changes its direction

5. The resistance of a coil for dc is in ohms. In ac, the resistance

(a) Will remain same (b) Will increase

(c) Will decrease (d) Will be zero

6. If instantaneous current is given by $i = 4\cos(\omega t + \phi)$ *amperes*, then the *r.m.s.* value of current is **[RPET 2000]**

(a) 4 amperes (b) $2\sqrt{2}$ amperes

(c) $4\sqrt{2}$ amperes (d) Zero amperes

7. In an ac circuit, peak value of voltage is 423 *volts*. Its effective voltage is **[JIPMER 1997]**

(a) 400 *volts* (b) 323 *volts*

(c) 300 *volts* (d) 340 *volts*

8. In an ac circuit $I = 100\sin 200\pi t$. The time required for the current to achieve its peak value will be **[DPMT 2003]**

(a) $\frac{1}{100} sec$ (b) $\frac{1}{200} sec$

(c) $\frac{1}{300} sec$ (d) $\frac{1}{400} sec$

9. The peak value of an Alternating current is 6 *amp*, then *r.m.s.* value of current will be

(a) 3 A (b) $3\sqrt{3}\ A$

(c) $3\sqrt{2}\ A$ (d) $2\sqrt{3}\ A$

10. A generator produces a voltage that is given by $V = 240\sin 120t$, where t is in seconds. The frequency and *r.m.s.* voltage are **[MP PET 1993; MP PMT 1990]**

(a) 60 Hz and 240 V (b) 19 Hz and 120 V

(c) 19 Hz and 170 V (d) 754 Hz and 70 V

11. If E_0 represents the peak value of the voltage in an ac circuit, the *r.m.s.* value of the voltage will be

[CPMT 1972; MP PMT 1996]

(a) $\frac{E_0}{\pi}$ (b) $\frac{E_0}{2}$

(c) $\frac{E_0}{\sqrt{\pi}}$ (d) $\frac{E_0}{\sqrt{2}}$

12. The peak value of 220 *volts* of ac mains is

[CPMT 1990; MP PMT 1999; MP PET 2000; RPET2001]

(a) 155.6 *volts* (b) 220.0 *volts*

(c) 311.0 *volts* (d) 440 *volts*

13. A sinusoidal ac current flows through a resistor of resistance R. If the peak current is I_p, then the power dissipated is

[MP PMT 1991]

(a) $I_p^2 R\cos\theta$ (b) $\frac{1}{2} I_p^2 R$

(c) $\frac{4}{\pi} I_p^2 R$ (d) $\frac{1}{\pi} I_p^2 R$

[AIEEE 2004]

14. A 40 Ω electric heater is connected to a 200 V, 50 Hz mains supply. The peak value of electric current flowing in the circuit is approximately **[MP PET 1992]**

(a) 2.5 A (b) 5.0 A

(c) 7 A (d) 10 A

15. The frequency of ac mains in India is

[CPMT 1987]

[NCERT 1974; MP PMT/PET 1988; RPMT 1997; RPET 2000]

(a) 30 *c/s* or Hz (b) 50 *c/s* or Hz

(c) 60 *c/s* or Hz (d) 120 *c/s* or Hz

16. The *r.m.s.* value of an ac of 50 Hz is 10 *amp*. The time taken by the alternating current in reaching from zero to maximum value and the peak value of current will be

[MP PET 1993; KCET 2003]

(a) 2×10^{-2} *sec* and 14.14 *amp*

(b) 1×10^{-2} *sec* and 7.07 *amp*

(c) 5×10^{-3} *sec* and 7.07 *amp*

(d) 5×10^{-3} *sec* and 14.14 *amp*

17. The root mean square value of the alternating current is equal to

(a) Twice the peak value

(b) Half the peak value

(c) $\frac{1}{\sqrt{2}}$ times the peak value

(d) Equal to the peak value

18. The peak value of an alternating e.m.f. E is given by $E = E_0\cos\omega t$ is 10 *volts* and its frequency is 50 Hz. At time $t = \frac{1}{600} sec$, the instantaneous e.m.f. is

[MP PMT 1990; MP PET 2004]

(a) 10 V (b) $5\sqrt{3}\ V$

(c) 5 V (d) 1 V

19. If a current I given by $I_0\sin\left(\omega t - \frac{\pi}{2}\right)$ flows in an ac circuit across which an ac potential of $E = E_0\sin\omega t$ has been applied, then the power consumption P in the circuit will be

[CPMT 1986; Roorkee 1992; SCRA 1996; MP PMT 1994; RPET 2001; MP PET 2001, 02]

(a) $P = \frac{E_0 I_0}{\sqrt{2}}$ (b) $P = \sqrt{2}E_0 I_0$

(c) $P = \frac{E_0 I_0}{2}$ (d) $P = 0$

20. In an ac circuit, the instantaneous values of e.m.f. and current are $e = 200 \sin 314\, t$ *volt* and $i = \sin\left(314t + \frac{\pi}{3}\right)$ *ampere*. The average power consumed in *watt* is [NCERT 1990; RPMT 1997]

(a) 200 (b) 100
(c) 50 (d) 25

21. An ac generator produced an output voltage $E = 170 \sin 377\, t\, volts$, where t is in seconds. The frequency of ac voltage is [MP PET 1994]

(a) 50 *Hz* (b) 110 *Hz*
(c) 60 *Hz* (d) 230 *Hz*

22. In general in an alternating current circuit [MP PMT 1994]

(a) The average value of current is zero
(b) The average value of square of the current is zero
(c) Average power dissipation is zero
(d) The phase difference between voltage and current is zero

23. An alternating current is given by the equation $i = i_1 \cos \omega t + i_2 \sin \omega t$. The *r.m.s.* current is given by [MP PMT 1994]

(a) $\frac{1}{\sqrt{2}}(i_1 + i_2)$ (b) $\frac{1}{\sqrt{2}}(i_i + i_2)^2$
(c) $\frac{1}{\sqrt{2}}(i_1^2 + i_2^2)^{1/2}$ (d) $\frac{1}{2}(i_1^2 + i_2^2)^{1/2}$

24. In an ac circuit, the current is given by $i = 5 \sin\left(100\, t - \frac{\pi}{2}\right)$ and the ac potential is $V = 200 \sin(100) volt$. Then the power consumption is [CBSE PMT 1995; MH CET 1999; CPMT 2002]

(a) 20 *watts* (b) 40 *watts*
(c) 1000 *watts* (d) 0 *watt*

25. An electric lamp is connected to 220 *V*, 50 *Hz* supply. Then the peak value of voltage is [AFMC 1996]

(a) 210 V (b) 211 *V*
(c) 311 V (d) 320 *V*

26. In a circuit, the value of the alternating current is measured by hot wire ammeter as 10 *ampere*. Its peak value will be [MP PET 1996; AMU (Med.) 1999; KCET (Engg./Med.) 2000; CPMT 2003]

(a) 10 *A* (b) 20 *A*
(c) 14.14 *A* (d) 7.07 *A*

27. The voltage of domestic ac is 220 *volt*. What does this represent

(a) Mean voltage
(b) Peak voltage
(c) Root mean voltage
(d) Root mean square voltage

28. The *r.m.s.* voltage of domestic electricity supply is 220 *volt*. Electrical appliances should be designed to withstand an instantaneous voltage of

(a) 220 *V* (b) 310 *V*
(c) 330 *V* (d) 440 *V*

29. The process by which ac is converted into dc is known as

(b) Purification (b) Amplification
(c) Rectification (d) Current amplification

30. In an ac circuit with voltage *V* and current *I*, the power dissipated is [CBSE PMT 1997]

(a) *VI*
(b) $\frac{1}{2}VI$
(c) $\frac{1}{\sqrt{2}}VI$
(d) Depends on the phase between *V* and *I*

31. For an ac circuit $V = 15 \sin \omega t$ and $I = 20 \cos \omega t$ the average power consumed in this circuit is [RPET 1999]

(a) 300 *Watt* (b) 150 *Watt*
(c) 75 *Watt* (d) zero

32. A bulb is connected first with dc and then ac of same voltage then it will shine brightly with [RPET 2000]

(a) AC
(b) DC
(c) Brightness will be in ratio 1/1.4
(d) Equally with both

33. An ac supply gives 30 *V r.m.s.* which passes through a 10 Ω resistance. The power dissipated in it is [AMU (Med.) 2001]

(a) $90\sqrt{2}\, W$ (b) $90\, W$
(c) $45\sqrt{2}\, W$ (d) $45\, W$

34. The frequency of an alternating voltage is 50 *cycles/sec* and its amplitude is 120 *V*. Then the *r.m.s.* value of voltage is [BHU 1999; MH CET (Med.) 2001; KCET (Med.) 2001; MH CET 2003]

(a) 101.3 *V* (b) 84.8 *V*
(c) 70.7 *V* (d) 56.5 *V*

35. A resistance of 20 *ohms* is connected to a source of an alternating potential $V = 220 \sin(100\pi t)$. The time taken by the current to change from its peak value to *r.m.s* value is [MP PET 2001]

(a) 0.2 *sec* (b) 0.25 *sec*
(c) 25×10^{-3} *sec* (d) 2.5×10^{-3} *sec*

36. Voltage and current in an ac circuit are given by $V = 5 \sin\left(100\pi t - \frac{\pi}{6}\right)$ and $I = 4 \sin\left(100\pi t + \frac{\pi}{6}\right)$ [MP PMT 1996] [Kerala PET 2001]

(a) Voltage leads the current by 30^o
(b) Current leads the voltage by 30^o
(c) Current leads the voltage by 60^o
(d) Voltage leads the current by 60^o

37. If an ac main supply is given to be 220 *V*. What would be the average e.m.f. during a positive half cycle [MH CET 2002]

(a) 198 *V* (b) 386 *V*

(c) 256 *V* (d) None of these

38. In an ac circuit, the *r.m.s.* value of current, I_{rms} is related to the peak current, I_0 by the relation [AFMC 2002]

(a) $I_{rms} = \frac{1}{\pi} I_0$ (b) $I_{rms} = \frac{1}{\sqrt{2}} I_0$

(c) $I_{rms} = \sqrt{2} I_0$ (d) $I_{rms} = \pi I_0$

39. An alternating voltage is represented as $E = 20\sin 300t$. The average value of voltage over one cycle will be

[MP PMT 2002]

(a) Zero (b) 10 *volt*

(c) $20\sqrt{2}$ *volt* (d) $\frac{20}{\sqrt{2}}$ *volt*

40. The ratio of peak value and *r.m.s* value of an alternating current is

(a) 1 (b) $\frac{1}{2}$

(c) $\sqrt{2}$ (d) $1/\sqrt{2}$

41. A 280 *ohm* electric bulb is connected to 200 *V* electric line. The peak value of current in the bulb will be

[MP PET 2002]

(a) About one ampere (b) Zero

(c) About two ampere (d) About four ampere

42. An ac source is rated at 220 *V*, 50 *Hz*. The time taken for voltage to change from its peak value to zero is

[Orissa JEE 2003]

(a) 50 *sec* (b) 0.02 *sec*

(c) 5 *sec* (d) 5×10^{-3} *sec*

43. If the value of potential in an ac, circuit is 10 *V*, then the peak value of potential is [CPMT 2003]

(a) $\frac{10}{\sqrt{2}}$ (b) $10\sqrt{2}$

(c) $20\sqrt{2}$ (d) $\frac{20}{\sqrt{2}}$

44. A lamp consumes only 50% of peak power in an a.c. circuit. What is the phase difference between the applied voltage and the circuit current [MP PMT 2004]

(a) $\frac{\pi}{6}$ (b) $\frac{\pi}{3}$

(c) $\frac{\pi}{4}$ (d) $\frac{\pi}{2}$

45. If an alternating voltage is represented as

$E = 141\sin(628\,t)$, then the *rms* value of the voltage and the frequency are respectively [Kerala PET 2005]

(a) $141V, 628Hz$ (b) $100V, 50Hz$

(c) $100V, 100Hz$ (d) $141V,\ 100Hz$

46. The maximum value of a.c. voltage in a circuit is 707 *V*. Its *rms* value is [MP PET 2005]

(a) 70.7 *V* (b) 100 *V*

(c) 500 *V* (d) 707 *V*

ac Circuits

1. Choke coil works on the principle of [MP PET/PMT 1988]

(a) Transient current (b) Self induction

(c) Mutual induction (d) Wattless current

2. A choke coil has [RPET 1999; AIIMS 1999]

(a) High inductance and low resistance

(b) Low inductance and high resistance

(c) High inductance and high resistance

(d) Low inductance and low resistance

3. Choke coil is used to control [CPMT 1984]

(a) ac (b) dc

(c) Both ac and dc (d) Neither ac nor dc

4. Current in the circuit is wattless, if

(a) Inductance in the circuit is zero

(b) Resistance in the circuit is zero

[MP PMT 2002]

(c) Current is alternating

(d) Resistance and inductance both are zero

5. The phase angle between e.m.f. and current in *LCR* series ac circuit is [MP PMT/PET 1998]

(a) 0 to $\pi/2$ (b) $\pi/4$

(c) $\pi/2$ (d) π

6. A choke coil is preferred to a rheostat in ac circuit as

(a) It consumes almost zero power

(b) It increases current

(c) It increases power

(d) It increases voltage

7. An alternating e.m.f. is applied to purely capacitive circuit. The phase relation between e.m.f. and current flowing in the circuit is **or**

In a circuit containing capacitance only

[MP PET 1996; AIIMS 1997]

(a) e.m.f. is ahead of current by $\pi/2$

(b) Current is ahead of e.m.f. by $\pi/2$

(c) Current lags behind e.m.f. by π

(d) Current is ahead of e.m.f. by π

8. An ac source is connected to a resistive circuits. Which of the following is true [CPMT 1985]

(a) Current leads the voltage and both are in same phase

(b) Current lags behind the voltage and both are in same phase

(c) Current and voltage are in same phase

(d) Any of the above may be true depending upon the value of resistance

9. The average power dissipated in a pure inductor of inductance *L* when an ac current is passing through it, is

[CPMT 1974; RPMT 1997; MP PET 1999]

(a) $\frac{1}{2}LI^2$ (b) $\frac{1}{4}LI^2$

(c) $2\,Li^2$ (d) Zero

(Inductance of the coil *L* and current *I*)

10. An alternating current of frequency $'f'$ is flowing in a circuit containing a resistance R and a choke L in series. The impedance of this circuit is

[CPMT 1978; MP PMT 1993; MP PET 1999; AIIMS 2000; Pb. PET 2004; RPET 2001, 03]

(a) $R + 2\pi fL$ (b) $\sqrt{R^2 + 4\pi^2 f^2 L^2}$

(c) $\sqrt{R^2 + L^2}$ (d) $\sqrt{R^2 + 2\pi fL}$

11. A resonant ac circuit contains a capacitor of capacitance $10^{-6} F$ and an inductor of $10^{-4} H$. The frequency of electrical oscillations will be

(a) $10^5 Hz$ (b) 10 *Hz*

(c) $\frac{10^5}{2\pi} Hz$ (d) $\frac{10}{2\pi} Hz$

12. Power delivered by the source of the circuit becomes maximum, when [DCE 2004]

(a) $\omega L = \omega C$ (b) $\omega L = \frac{1}{\omega C}$

(c) $\omega L = -\left(\frac{1}{\omega C}\right)^2$ (d) $\omega L = \sqrt{\omega C}$

13. An alternating voltage is connected in series with a resistance R and an inductance L If the potential drop across the resistance is 200 *V* and across the inductance is 150 *V*, then the applied voltage is

(a) 350 *V* (b) 250 *V*

(c) 500 *V* (d) 300 *V*

14. An inductive circuit contains resistance of 10 Ω and an inductance of 20 *H*. If an ac voltage of 120 *V* and frequency 60 *Hz* is applied to this circuit, the current would be nearly

(a) 0.32 *amp* (b) 0.016 *amp*

(c) 0.48 *amp* (d) 0.80 *amp*

15. Same current is flowing in two alternating circuits. The first circuit contains only inductance and the other contains only a capacitor. If the frequency of the e.m.f. of ac is increased, the effect on the value of the current will be [MP PET 1993]

(a) Increases in the first circuit and decreases in the other

(b) Increases in both the circuits

(c) Decreases in both the circuits

(d) Decreases in the first circuit and increases in the other

16. A capacitor is a perfect insulator for

(a) Alternating currents (b) Direct currents

(c) Both ac and dc (d) None of these

17. In a circuit containing an inductance of zero resistance, the e.m.f. of the applied ac voltage leads the current by

[CPMT 1990]

(a) 90 (b) 45

(c) 30 (d) 0

18. In a pure inductive circuit or In an ac circuit containing inductance only, the current

[MP PMT 1993; CPMT 1996; Kerala PET 2002]

(a) Leads the e.m.f. by 90

(b) Lags behind the e.m.f. by 90

(c) Sometimes leads and sometime lags behind the e.m.f.

(d) Is in phase with the e.m.f.

19. A 20 *volts* ac is applied to a circuit consisting of a resistance and a coil with negligible resistance. If the voltage across the resistance is 12 *V*, the voltage across the coil is

[MP PMT 1989; RPMT 1997]

(a) 16 *volts* (b) 10 *volts*

(c) 8 *volts* (d) 6 *volts*

20. A resistance of 300 Ω and an inductance of $\frac{1}{\pi}$ henry are connected in series to a ac voltage of 20 *volts* and 200 *Hz* frequency. The phase angle between the voltage and current is

(a) $\tan^{-1}\frac{4}{3}$ (b) $\tan^{-1}\frac{3}{4}$

(c) $\tan^{-1}\frac{3}{2}$ (d) $\tan^{-1}\frac{2}{5}$

21. The power factor of *LCR* circuit at resonance is

[MP PMT 1991; RPMT 1999; RPET 2001; UPSEAT 1999]

(a) 0.707 (b) 1

(c) Zero (d) 0.5

22. An inductance of 1 *mH* a condenser of 10 μF and a resistance of 50 Ω are connected in series. The reactances of inductor and condensers are same. The reactance of either of them will be [CPMT 1990]

(a) 100 Ω (b) 30 Ω

(c) 3.2 Ω (d) 10 Ω

23. The natural frequency of a *L-C* circuit is equal to

[CPMT 1978, 97]

(a) $\frac{1}{2\pi}\sqrt{LC}$ (b) $\frac{1}{2\pi\sqrt{LC}}$

(c) $\frac{1}{2\pi}\sqrt{\frac{L}{C}}$ (d) $\frac{1}{2\pi}\sqrt{\frac{C}{L}}$

24. An alternating voltage $E = 200\sqrt{2}\sin(100\,t)$ is connected to a 1 *microfarad* capacitor through an ac ammeter. The reading of the ammeter shall be [NCERT 1984; MNR 1995; MP PET 1999; RPET 1999; UPSEAT 2000]

(a) 10 *mA* (b) 20 *mA*

(c) 40 *mA* (d) 80 *mA*

25. An ac circuit consists of an inductor of inductance 0.5 *H* and a capacitor of capacitance 8 μF in series. The current in the circuit is maximum when the angular frequency of ac source is

(a) 500 *rad/sec* (b) 2 × 10 *rad/sec*

(c) 4000 *rad/sec* (d) 5000 *rad/sec*

26. The average power dissipation in a pure capacitance in ac circuit is [DPMT 198

(a) $\frac{1}{2}CV^2$ (b) CV^2

(c) $\frac{1}{4}CV^2$ (d) Zero

27. In a region of uniform magnetic induction $B = 10^{-2}\, tesla$, a circular coil of radius 30 *cm* and resistance π *ohm* is rotated about an axis which is perpendicular to the direction of *B* and which forms

a diameter of the coil. If the coil rotates at 200 *rpm* the amplitude of the alternating current induced in the coil is

(a) 4π *mA* (b) 30 *mA*
(c) 6 *mA* (d) 200 *mA*

28. An inductive circuit contains a resistance of 10 *ohm* and an inductance of 2.0 *henry*. If an ac voltage of 120 *volt* and frequency of 60 *Hz* is applied to this circuit, the current in the circuit would be nearly [CPMT 1990; MP PET 2002]

(a) 0.32 *amp* (b) 0.16 *amp*
(c) 048 *amp* (d) 0.80 *amp*

29. In a *LCR* circuit having L = 8.0 *henry*, C = 0.5 μF and R = 100 *ohm* in series. The resonance frequency in *per second* is

(a) 600 *radian* (b) 600 *Hz*
(c) 500 *radian* (d) 500 *Hz*

30. In *LCR* circuit, the capacitance is changed from C to $4C$. For the same resonant frequency, the inductance should be changed from L to [MP PMT 1986; BHU 1998]

(a) $2L$ (b) $L/2$
(c) $L/4$ (d) $4L$

31. A 120 *volt* ac source is connected across a pure inductor of inductance 0.70 henry. If the frequency of the source is 60 *Hz*, the current passing through the inductor is

[MP PET 1994]

(a) 4.55 *amps* (b) 0.355 *amps*
(c) 0.455 amps (d) 3.55 amps

32. The impedance of a circuit consists of 3 *ohm* resistance and 4 *ohm* reactance. The power factor of the circuit is

[MP PMT 1994]

(a) 0.4 (b) 0.6
(c) 0.8 (d) 1.0

33. L, C and R denote inductance, capacitance and resistance respectively. Pick out the combination which does not have the dimensions of frequency [MP PMT 1994]

(a) $\frac{1}{RC}$ (b) $\frac{R}{L}$
(c) $\frac{1}{\sqrt{LC}}$ (d) $\frac{C}{L}$

34. The power factor of a good choke coil is [MP PMT 1994]

(a) Nearly zero (b) Exactly zero
(c) Nearly one (d) Exactly one

35. If resistance of 100 Ω, inductance of 0.5 *henry* and capacitance of $10\times10^{-6}F$ are connected in series through 50 *Hz* ac supply, then impedance is [BHU 1995]

(a) 1.876 (b) 18.76
(c) 189.72 (d) 101.3

36. An alternating current source of frequency 100 *Hz* is joined to a combination of a resistance, a capacitance and a coil in series. The potential difference across the coil, the resistance and the capacitor is 46, 8 and 40 *volt* respectively. The electromotive force of alternating current source in *volt* is

[MP PET 1995]

(a) 94 (b) 14
(c) 10 [CBSE PMT 1990] (d) 76

37. A 10 *ohm* resistance, 5 *mH* coil and 10 μF capacitor are joined in series. When a suitable frequency alternating current source is joined to this combination, the circuit resonates. If the resistance is halved, the resonance frequency [MP PET 1995]

(a) Is halved (b) Is doubled
(c) Remains unchanged (d) In quadrupled

38. L, C and R represent physical quantities inductance, capacitance and resistance respectively. The combination representing dimension of frequency is
[CPMT 1990] [MP PET 1995; DCE 2001]

(a) LC (b) $(LC)^{-1/2}$
(c) $\left(\frac{L}{C}\right)^{-1/2}$ (d) $\frac{C}{L}$

39. In a series circuit R = 300 Ω, L = 0.9 H, C = 2.0 μF and ω = 1000 *rad/sec*. The impedance of the circuit is

(a) 1300 Ω (b) 900 Ω
(c) 500 Ω (d) 400 Ω

40. In a *L-R* circuit, the value of L is $\left(\frac{0.4}{\pi}\right)$ *henry* and the value of R is 30 *ohm*. If in the circuit, an alternating *e.m.f.* of 200 *volt* at 50 cycles per sec is connected, the impedance of the circuit and current will be [MP PET 1996; DPMT 2003]

(a) $11.4\,\Omega, 17.5\,A$ (b) $30.7\,\Omega, 6.5\,A$
(c) $40.4\,\Omega, 5\,A$ (d) $50\,\Omega, 4\,A$

41. The reactance of a coil when used in the domestic ac power supply (220 *volt*, 50 *cycles*) is 100 *ohm*. The self inductance of the coil is nearly [MP PMT 1996]

(a) 3.2 *henry* (b) 0.32 *henry*
(c) 2.2 *henry* (d) 0.22 *henry*

42. In a series *LCR* circuit, operated with an ac of angular frequency ω, the total impedance is [MP PET 1996]

(a) $[R^2+(L\omega-C\omega)^2]^{1/2}$

(b) $\left[R^2+\left(L\omega-\frac{1}{C\omega}\right)^2\right]^{1/2}$

(c) $\left[R^2+\left(L\omega-\frac{1}{C\omega}\right)^2\right]^{-1/2}$

(d) $\left[(R\omega)^2+\left(L\omega-\frac{1}{C\omega}\right)^2\right]^{1/2}$

43. The reactance of a $25\,\mu F$ capacitor at the ac frequency of 4000 *Hz* is

(a) $\frac{5}{\pi}$ *ohm* (b) $\sqrt{\frac{5}{\pi}}$ *ohm*
(c) 10 *ohm* (d) $\sqrt{10}$ *ohm*

44. The frequency for which a $5\,\mu F$ capacitor has a reactance of $\frac{1}{1000}$ *ohm* is given by [MP PET 1997]

(a) $\frac{100}{\pi} MHz$ (b) $\frac{1000}{\pi} Hz$

(c) $\frac{1}{1000} Hz$ (d) 1000 *Hz*

45. An e.m.f. $E = 4\cos(1000t)$ *volt* is applied to an LR-circuit of inductance 3 *mH* and resistance 4 *ohms*. The amplitude of current in the circuit is [MP PMT 1997]

(a) $\frac{4}{\sqrt{7}} A$ (b) 1.0 *A*

(c) $\frac{4}{7} A$ (d) 0.8 *A*

46. In an ac circuit, a resistance of R *ohm* is connected in series with an inductance *L*. If phase angle between voltage and current be 45°, the value of inductive reactance will be

[MP PMT/PET 1998]

(a) $\frac{R}{4}$

(b) $\frac{R}{2}$

(c) R

(d) Cannot be found with the given data

47. A coil of inductance L has an inductive reactance of X_L in an AC circuit in which the effective current is *I*. The coil is made from a super-conducting material and has no resistance. The rate at which power is dissipated in the coil is

[MP PMT 1999]

(a) 0 (b) IX_L

(c) I^2X_L (d) IX_L^2

48. The phase difference between the current and voltage of *LCR* circuit in series combination at resonance is

[CPMT 1999; Pb. PET 2001]

(a) 0 (b) $\pi/2$

(c) π (d) $-\pi$

49. In a series resonant circuit, the ac voltage across resistance *R*, inductance *L* and capacitance *C* are 5 *V*, 10 *V* and 10 *V* respectively. The ac voltage applied to the circuit will be

[KCET 1994]

(a) 20 *V* (b) 10 *V*

(c) 5 *V* (d) 25 *V*

50. When 100 *volt* dc is applied across a coil, a current of 1 *amp* flows through it. When 100 volt ac at 50 cycle s^{-1} is applied to the same coil, only 0.5 ampere current flows. The impedance of the coil is

(a) $100\,\Omega$ (b) $200\,\Omega$

(c) $300\,\Omega$ (d) $400\,\Omega$

51. The coefficient of induction of a choke coil is 0.1*H* and resistance is $12\,\Omega$. If it is connected to an alternating current source of frequency 60 *Hz*, then power factor will be

[RPET 1997]

(a) 0.32 (b) 0.30

(c) 0.28 (d) 0.24

52. For series *LCR* circuit, wrong statement is [RPMT 1997]

(a) Applied e.m.f. and potential difference across resistance are in same phase

(b) Applied e.m.f. and potential difference at inductor coil have phase difference of $\pi/2$

(c) Potential difference at capacitor and inductor have phase difference of $\pi/2$

(d) Potential difference across resistance and capacitor have phase difference of $\pi/2$

53. In a purely resistive *ac* circuit, the current [Roorkee 1992]

(a) Lags behind the e.m.f. in phase

(b) Is in phase with the e.m.f.

(c) Leads the e.m.f. in phase

(d) Leads the e.m.f. in half the cycle and lags behind it in the other half

54. If an $8\,\Omega$ resistance and $6\,\Omega$ reactance are present in an ac series circuit then the impedance of the circuit will be

[MP PMT 2003]

(a) 20 *ohm* (b) 5 *ohm*

(c) 10 *ohm* (d) $14\sqrt{2}$ *ohm*

55. A 12 *ohm* resistor and a 0.21 henry inductor are connected in series to an ac source operating at 20 *volts*, 50 cycle/second. The phase angle between the current and the source voltage is

(a) 30° (b) 40°

(c) 80° (d) 90°

56. What will be the phase difference between virtual voltage and virtual current, when the current in the circuit is wattless

[RPET 1996]

(a) 90° (b) 45°

(c) 180° (d) 60°

57. The resonant frequency of a circuit is *f*. If the capacitance is made 4 times the initial values, then the resonant frequency will become

(a) $f/2$ (b) $2f$

(c) f (d) $f/4$

58. In the non-resonant circuit, what will be the nature of the circuit for frequencies higher than the resonant frequency

[RPET 1996]

(a) Resistive (b) Capacitive

(c) Inductive (d) None of the above

59. In an ac circuit, the potential difference across an inductance and resistance joined in series are respectively 16 *V* and 20 *V*. The total potential difference across the circuit is

[Bihar MEE 1995] [AFMC 1998; BHU 1999]

(a) 20.0 *V* (b) 25.6 *V*

(c) 31.9 *V* (d) 53.5 *V*

60. A 220 *V*, 50 *Hz* ac source is connected to an inductance of 0.2 *H* and a resistance of 20 *ohm* in series. What is the current in the circuit [MNR 1998; JIPMER 2001, 02]

(a) 10 *A* (b) 5 *A*

(c) 33.3 *A* (d) 3.33 *A*

61. An *LCR* circuit contains *R* = 50 Ω , *L* = 1 *mH* and *C* = 0.1 *μF*. The impedance of the circuit will be minimum for a frequency of [Bihar MEE 1995]

(a) $\frac{10^5}{2\pi}s^{-1}$ (b) $\frac{10^6}{2\pi}s^{-1}$

(c) $2\pi\times10^5 s^{-1}$ (d) $2\pi\times10^6 s^{-1}$

62. In a series *LCR* circuit, resistance $R=10\Omega$ and the impedance $Z=20\Omega$. The phase difference between the current and the voltage is [KCET (Engg./Med.) 1999]

(a) 30^o (b) 45^o

(c) 60^o (d) 90^o

63. A series ac circuit consist of an inductor and a capacitor. The inductance and capacitance is respectively 1 *henry* and $25\mu F$. If the current is maximum in circuit then angular frequency will be

(a) 200 (b) 100

(c) 50 (d) 200/2 π

64. An alternating e.m.f. of frequency $\nu\left(=\frac{1}{2\pi\sqrt{LC}}\right)$ is applied to a series *LCR* circuit. For this frequency of the applied e.m.f.

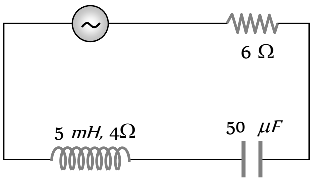
(a) The circuit is at resonance and its impedance is made up only of a reactive part

(b) The current in the circuit is in phase with the applied e.m.f. and the voltage across *R* equals this applied emf

(c) The sum of the p.d.'s across the inductance and capacitance equals the applied e.m.f. which is 180^o ahead of phase of the current in the circuit

(d) The quality factor of the circuit is $\omega L/R$ or $1/\omega CR$ and this is a measure of the voltage magnification (produced by the circuit at resonance) as well as the sharpness of resonance of the circuit

65. In the circuit shown below, the ac source has voltage $V=20\cos(\omega t)$ volts with ω = 2000 *rad/sec*. the amplitude of the current will be nearest to [AMU (Engg.) 2000]



(a) $2A$

(b) $3.3A$

(c) $2/\sqrt{5}A$

(d) $\sqrt{5}A$

66. The value of the current through an inductance of $1H$ and of negligible resistance, when connected through an ac source of 200 *V* and 50 *Hz*, is [AFMC 2000]

(a) 0.637 *A* (b) 1.637 *A*

(c) 2.637*A* (d) 3.637 *A*

67. The quality factor of *LCR* circuit having resistance (*R*) and inductance (*L*) at resonance frequency (ω) is given by [AFMC 2000; CBSE PMT 2000]

(a) $\frac{\omega L}{R}$ (b) $\frac{R}{\omega L}$

(c) $\left(\frac{\omega L}{R}\right)^{1/2}$ (d) $\left(\frac{\omega L}{R}\right)^2$

68. Power factor is maximum in an *LCR* circuit when [RPET 2000]

(a) $X_L=X_C$ (b) $R=0$

(c) $X_L=0$ (d) $X_C=0$

69. In an ac circuit the reactance of a coil is $\sqrt{3}$ times its resistance, the phase difference between the voltage across the coil to the current through the coil will be [KCET (Engg.) 2000]

(a) $\pi/3$ (b) $\pi/2$

(c) $\pi/4$ (d) $\pi/6$

70. The capacity of a pure capacitor is 1 *farad*. In dc circuits, its effective resistance will be [MP PMT 2000]

(a) Zero (b) Infinite

(c) 1 *ohm* (d) 1/2 *ohm*

71. In an ac circuit the current lags behind the voltage by $\pi/3$. The components in the circuit are [RPMT 1999] [MP PMT 2000]

(a) *R* and *L* (b) *R* and *C*

(c) *L* and *C* (d) Only *R*

72. The reactance of a coil when used in the domestic ac power supply (220 *volts*, 50 cycles per second) is 50 *ohms*. The inductance of the coil is nearly [Roorkee 1999] [MP PMT 2000]

(a) 2.2 *henry* (b) 0.22 *henry*

(c) 1.6 *henry* (d) 0.16 *henry*

73. In an ac circuit, the power factor [Roorkee 2000]

(a) Is zero when the circuit contains an ideal resistance only

(b) Is unity when the circuit contains an ideal resistance only

(c) Is zero when the circuit contains an ideal inductance only

(d) Is unity when the circuit contains an ideal inductance only

74. A resistance of 40 *ohm* and an inductance of 95.5 *millihenry* are connected in series in a 50 *cycles/second* ac circuit. The impedance of this combination is very nearly [MP PET 2000]

(a) 30 *ohm* (b) 40 *ohm*

(c) 50 *ohm* (d) 60 *ohm*

75. For high frequency, a capacitor offers [CPMT 1999; CBSE PMT 1999; AFMC 2001; Pb. PET 2001; J & K CET 2004]

(a) More reactance (b) Less reactance

(c) Zero reactance (d) Infinite reactance

76. The coil of choke in a circuit [AIIMS 2001]

(a) Increases the current

(b) Decreases the current

(c) Does not change the current

(d) Has high resistance to dc circuit

77. In a circuit, the current lags behind the voltage by a phase difference of $\pi/2$. The circuit contains which of the following

(a) Only *R* (b) Only *L*

(c) Only *C* (d) *R* and *C*

78. The inductive reactance of an inductor of $\frac{1}{\pi}$ *henry* at 50 *Hz* frequency is [MP PET 2001, 02]

(a) $\frac{50}{\pi}$ *ohm* (b) $\frac{\pi}{50}$ *ohm*

(c) 100 *ohm* (d) 50 *ohm*

79. An oscillator circuit consists of an inductance of 0.5mH and a capacitor of 20 μF . The resonant frequency of the circuit is nearly

(a) 15.92 *Hz* (b) 159.2 *Hz*

(c) 1592 *Hz* (d) 15910 *Hz*

80. Reactance of a capacitor of capacitance $C\mu F$ for ac frequency $\frac{400}{\pi}$ *Hz* is 25Ω. The value *C* is **[MH CET 2002]**

(a) $50\mu F$ (b) $25\mu F$

(c) $100\mu F$ (d) $75\mu F$

81. The power factor of an ac circuit having resistance (*R*) and inductance (*L*) connected in series and an angular velocity ω is

(a) $R/\omega L$ (b) $R/(R^2+\omega^2L^2)^{1/2}$

(c) $\omega L/R$ (d) $R/(R^2-\omega^2L^2)^{1/2}$

82. A circuit has a resistance of 11Ω, an inductive reactance of 25Ω and a capacitative resistance of 18Ω. It is connected to an ac source of 260 *V* and 50*Hz*. The current through the circuit (in amperes) is

(a) 11 (b) 15

(c) 18 (d) 20

83. A 0.7 *henry* inductor is connected across a 120 *V* – 60 *Hz* ac source. The current in the inductor will be very nearly **[MP PMT 2002]**

(a) 4.55 *amp* (b) 0.355 *amp*

(c) 0.455 *amp* (d) 3.55 *amp*

84. There is a 5Ω resistance in an ac, circuit. Inductance of 0.1*H* is connected with it in series. If equation of ac e.m.f. is $5\sin 50t$ then the phase difference between current and e.m.f. is

(a) $\frac{\pi}{2}$ (b) $\frac{\pi}{6}$

(c) $\frac{\pi}{4}$ (d) 0

85. An inductor of inductance *L* and resistor of resistance *R* are joined in series and connected by a source of frequency ω. Power dissipated in the circuit is **[AIEEE 2002; RPET 2003]**

(a) $\frac{(R^2+\omega^2L^2)}{V}$ (b) $\frac{V^2R}{(R^2+\omega^2L^2)}$

(c) $\frac{V}{(R^2+\omega^2L^2)}$ (d) $\frac{\sqrt{R^2+\omega^2L^2}}{V^2}$

86. In a ac circuit of capacitance the current from potential is **[CPMT 2003]**

(a) Forward

(b) Backward

(c) Both are in the same phase

(d) None of these

87. A coil of 200Ω resistance and 1.0 *H* inductance is connected to an ac source of frequency $200/2\pi\ Hz$. Phase angle between potential and current will be **[MP PMT 2003]**

(a) 30° (b) 90°

(c) 45° (d) 0°

88. In a *LCR* circuit the pd between the terminals of the inductance is 60 *V*, between the terminals of the capacitor is 30 *V* and that between the terminals of resistance is 40 *V*. the supply voltage will be equal to ...... **[KCET 2004]**

(a) 50 *V* (b) 70 *V*

[Kerala PET 2002]

(c) 130 *V* (d) 10 *V*

89. Radio frequency choke uses core of **[AFMC 2004]**

(a) Air (b) Iron

(c) Air and iron (d) None of these

90. In a *LCR* circuit capacitance is changed from *C* to 2*C*. For the resonant frequency to remain unchanged, the inductance should be change from *L* to **[AIEEE 2004]**

(a) 4*L* (b) 2*L*

(c) *L*/2 (d) *L*/4

[AIEEE 2002; MP PET 2000]

91. In an *LCR* series ac circuit, the voltage across each of the components, *L*, *C* and *R* is 50 *V*. the voltage across the *LC* combination will be **[AIEEE 2004]**

(a) 50 *V* (b) $50\sqrt{2}\ V$

(c) 100 *V* (d) 0 *V* (zero)

92. A coil has *L* = 0.04 *H* and $R = 12\,\Omega$. When it is connected to 220 *V*, 50*Hz* supply the current flowing through the coil, in amperes is **[Kerala PMT 2004]**

[Kerala PMT 2002]

(a) 10.7 (b) 11.7

(c) 14.7 (d) 12.7

93. The current in series *LCR* circuit will be maximum when ω is **[Kerala PMT 2004]**

(a) As large as possible

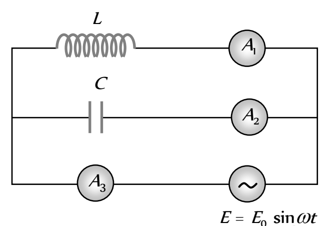
(b) Equal o natural frequency of *LCR* system

(c) $\sqrt{LC}$

(d) $\sqrt{1/LC}$

[RPET 2003]

94. An inductor *L* and a capacitor *C* are connected in the circuit as shown in the figure. The frequency of the power supply is equal to the resonant frequency of the circuit. Which ammeter will read zero ampere **[DCE 2002]**



(a) A_1 (b) A_2

(c) A_3 (d) None of these

95. Which of the following components of a *LCR* circuit, with ac supply, dissipates energy **[DCE 2004]**

(a) *L* (b) *R*

(c) *C* (d) All of these

96. In a circuit L, C and R are connected in series with an alternating voltage source of frequency f. The current leads the voltage by 45°. The value of C is **[CBSE PMT 2005]**

(a) $\frac{1}{2\pi f(2\pi fL+R)}$

(b) $\dfrac{1}{\pi f(2\pi fL+R)}$

(c) $\dfrac{1}{2\pi f(2\pi fL-R)}$

(d) $\dfrac{1}{\pi f(2\pi fL-R)}$

97. In an *A.C.* circuit the current [CPMT 2005]

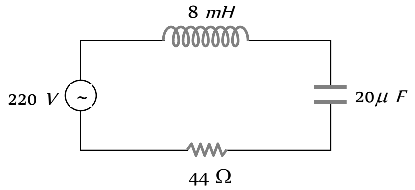
(a) Always leads the voltage

(b) Always lags behind the voltage

(c) Is always in phase with the voltage

(d) May lead or lag behind or be in phase with the voltage

98. For the series LCR circuit shown in the figure, what is the resonance frequency and the amplitude of the current at the resonating frequency [Kerala PET 2005]



(a) $2500\,rad-s^{-1}$ and $5\sqrt{2}\,A$

(b) $2500\,rad-s^{-1}$ and $5A$

(c) $2500\,rad-s^{-1}$ and $\dfrac{5}{\sqrt{2}}A$

(d) $25\,rad-s^{-1}$ and $5\sqrt{2}\,A$

Critical Thinking

Objective Questions

1. When 100 *volts* dc is supplied across a solenoid, a current of 1.0 amperes flows in it. When 100 *volts* ac is applied across the same coil, the current drops to 0.5 ampere. If the frequency of ac source is 50 *Hz*, then the impedance and inductance of the solenoid are

(a) 200 Ω and 0.55 *henry* (b) 100 Ω and 0.86 *henry*

(c) 200 Ω and 1.0 *henry* (d) 100 Ω and 0.93 *henry*

2. In an *LR*-circuit, the inductive reactance is equal to the resistance R of the circuit. An e.m.f. $E=E_0\cos(\omega t)$ applied to the circuit. The power consumed in the circuit is [MP PMT 1997]

(a) $\dfrac{E_0^2}{R}$ (b) $\dfrac{E_0^2}{2R}$

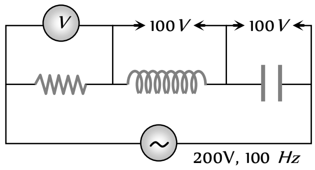
(c) $\dfrac{E_0^2}{4R}$ (d) $\dfrac{E_0^2}{8R}$

3. One 10 *V*, 60 *W* bulb is to be connected to 100 *V* line. The required induction coil has self inductance of value $(f=50\,Hz)$

(a) 0.052 *H* (b) 2.42 *H*

(c) 16.2 *mH* (d) 1.62 *mH*

4. In the circuit given below, what will be the reading of the voltmeter



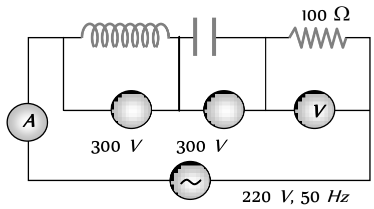
(a) 300 *V*

(b) 900 *V*

(c) 200 *V*

(d) 400 *V*

5. In the circuit shown below, what will be the readings of the voltmeter and ammeter [RPMT 1996]



(a) 800 *V*, 2*A* (b) 300 *V*, 2*A*

(c) 220 *V*, 2.2 *A* (d) 100 *V*, 2*A*

6. A bulb and a capacitor are connected in series to a source of alternating current. If its frequency is increased, while keeping the voltage of the source constant, then [Roorkee 1999]

(a) Bulb will give more intense light

(b) Bulb will give less intense light

(c) Bulb will give light of same intensity as before

(d) Bulb will stop radiating light

7. An alternating e.m.f. of angular frequency ω is applied across an inductance. The instantaneous power developed in the circuit has an angular frequency [Roorkee 1999]

(a) $\dfrac{\omega}{4}$ (b) $\dfrac{\omega}{2}$

(c) ω (d) 2ω

8. The voltage of an ac source varies with time according to the equation $V=100\sin 100\pi t\cos 100\pi t$ where t is in seconds and V is in volts. Then [MP PMT 1996; 2000]

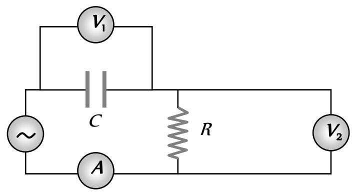
(a) The peak voltage of the source is 100 *volts*

(b) The peak voltage of the source is 50 *volts*

(c) The peak voltage of the source is $100/\sqrt{2}$ *volts*

(d) The frequency of the source is 50 *Hz* [CPMT 1990]

9. The diagram shows a capacitor C and a resistor R connected in series to an ac source. V_1 and V_2 are voltmeters and A is an ammeter



Consider now the following statements

I. Readings in A and V_2 are always in phase

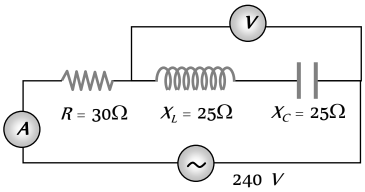
II. Reading in V_1 is ahead in phase with reading in V_2 [RPET 1997]

III. Readings in A and V_1 are always in phase which of these statements are/is correct [AMU (Med.) 2001]

(a) I only (b) II only

(c) I and II only [RPET 1996] (d) II and III only

10. In the circuit shown in figure neglecting source resistance the voltmeter and ammeter reading will respectively, will be [KCET (Engg.) 2001]

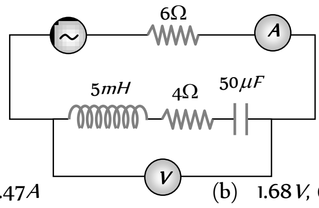


(a) 0 V, 3A (b) 150 V, 3A
(c) 150 V, 6A (d) 0 V, 8A

11. The voltage of an ac supply varies with time (t) as $V = 120\sin 100\pi t \cos 100\pi t$. The maximum voltage and frequency respectively are [MP PMT 2001; MP PET 2002]

(a) 120 *volts*, 100 *Hz* (b) $\frac{120}{\sqrt{2}}$ *volts*, 100 *Hz*
(c) 60 *volts*, 200 *Hz* (d) 60 *volts*, 100 *Hz*

12. In the circuit shown in the figure, the ac source gives a voltage $V = 20\cos(2000\,t)$. Neglecting source resistance, the voltmeter and ammeter reading will be [KCET (Engg.) 2002]



(a) 0 V, 0.47A (b) 1.68 V, 0.47A
(c) 0 V, 1.4 A (d) 5.6 V, 1.4 A

13. A telephone wire of length 200 *km* has a capacitance of 0.014 *μF* per *km*. If it carries an ac of frequency 5 *kHz*, what should be the value of an inductor required to be connected in series so that the impedance of the circuit is minimum

(a) 0.35 *mH* (b) 35 *mH*
(c) 3.5 *mH* (d) Zero

14. In a certain circuit current changes with time according to $i = 2\sqrt{t}$. *r.m.s.* value of current between $t = 2$ to $t = 4s$ will be

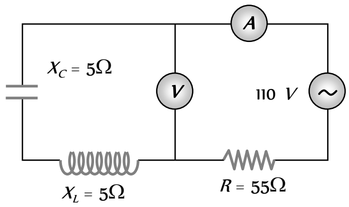
(a) $3A$ (b) $3\sqrt{3}A$
(c) $2\sqrt{3}A$ (d) $(2-\sqrt{2})A$

15. Match the following

Currents		*r.m.s.* values	
(1)	$x_0 \sin\omega t$	(i)	x_0
(2)	$x_0 \sin\omega t \cos\omega t$	(ii)	$\frac{x_0}{\sqrt{2}}$
(3)	$x_0 \sin\omega t + x_0 \cos\omega t$	(iii)	$\frac{x_0}{(2\sqrt{2})}$

(a) 1. (i), 2. (ii), 3. (iii) (b) 1. (ii), 2. (iii), 3. (i)
(c) 1. (i), 2. (iii), 3. (ii) (d) None of these

16. The reading of ammeter in the circuit shown will be



(a) 2A
(b) 2.4 A
(c) Zero
(d) 1.7 A

17. An ac source of angular frequency ω is fed across a resistor r and a capacitor C in series. The current registered is *I*. If now the frequency of source is changed to $\omega/3$ (but maintaining the same voltage), the current in then circuit is found to be halved. Calculate the ratio of reactance to resistance at the original frequency ω [Roorkee 1996]

(a) $\sqrt{\frac{3}{5}}$ (b) $\sqrt{\frac{2}{5}}$
(c) $\sqrt{\frac{1}{5}}$ (d) $\sqrt{\frac{4}{5}}$

18. An *LCR* series circuit with a resistance of 100 *ohm* is connected to an ac source of 200 *V* (*r.m.s.*) and angular frequency 300 *rad/s*. When only the capacitor is removed, the current lags behind the voltage by 60^o. When only the inductor is removed the current leads the voltage by 60^o. The average power dissipated is

(a) 50 *W* (b) 100 *W*
(c) 200 *W* (d) 400 *W*

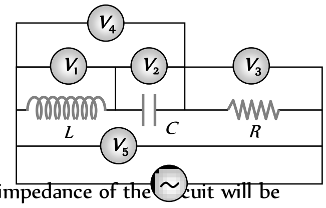
19. A virtual current of 4*A* and 50 *Hz* flows in an ac circuit containing a coil. The power consumed in the coil is 240 *W*. If the virtual voltage across the coil is 100 *V* its inductance will be

(a) $\frac{1}{3\pi}H$ (b) $\frac{1}{5\pi}H$
(c) $\frac{1}{7\pi}H$ (d) $\frac{1}{9\pi}H$

20. For a series *RLC* circuit $R = X_L = 2X_C$. The impedance of the circuit and phase difference (between) *V* and *i* will be

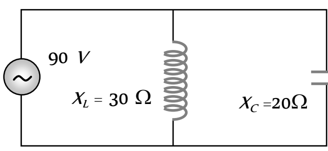
(a) $\frac{\sqrt{5}R}{2}, \tan^{-1}(2)$ (b) $\frac{\sqrt{5}R}{2}, \tan^{-1}\left(\frac{1}{2}\right)$
(c) $\sqrt{5}X_C, \tan^{-1}(2)$ (d) $\sqrt{5}R, \tan^{-1}\left(\frac{1}{2}\right)$

21. In the adjoining ac circuit the voltmeter whose reading will be zero at resonance is



(a) V_1
(b) V_2
(c) V_3
(d) V_4

22. In the adjoining figure the impedance of the circuit will be

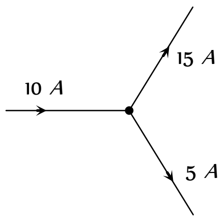


(a) 120 *ohm*
(b) 50 *ohm*
(c) 60 *ohm*
(d) 90 *ohm*

23. If $i = t^2 \quad 0 < t < T$ then *r.m.s.* value of current is

(a) $\frac{T^2}{\sqrt{2}}$ (b) $\frac{T^2}{2}$
(c) $\frac{T^2}{\sqrt{5}}$ (d) None of these

24. Is it possible



(a) Yes
(b) No

(c) Cannot be predicted

(d) Insufficient data to reply

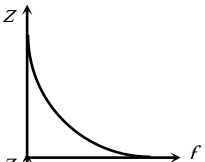
25. In a series circuit $C = 2\mu F, L = 1mH$ and $R = 10\,\Omega$, when the current in the circuit is maximum, at that time the ratio of the energies stored in the capacitor and the inductor will be

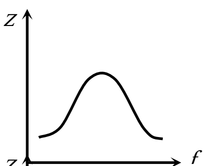
(a) 1 : 1 (b) 1 : 2

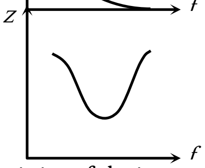
(c) 2 : 1 (d) 1 : 5

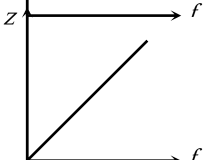
GQ Graphical Questions

1. Which one of the following curves represents the variation of impedance (Z) with frequency f in series LCR circuit

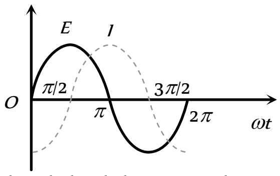
(a)


(b)


(c)


(d)


2. The variation of the instantaneous current (I) and the instantaneous emf (E) in a circuit is as shown in fig. Which of the following statements is correct



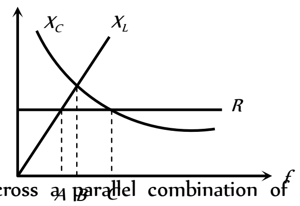
(a) The voltage lags behind the current by $\pi / 2$

(b) The voltage leads the current by $\pi / 2$

(c) The voltage and the current are in phase

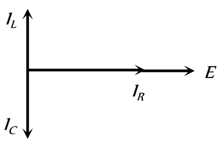
(d) The voltage leads the current by π

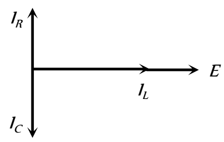
3. The figure shows variation of R, X_L and X_C with frequency f in a series L, C, R circuit. Then for what frequency point, the circuit is inductive

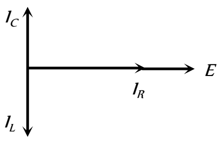


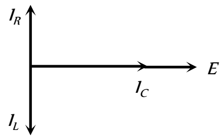
(a) A
(b) B
(c) C
(d) All points

4. An alternating emf is applied across a parallel combination of a resistance R, capacitance C and an inductance L. If I_R, I_L, I_C are the currents through R, L and C respectively, then the diagram which correctly represents, the phase relationship among I_R, I_L, I_C and source emf E, is given by

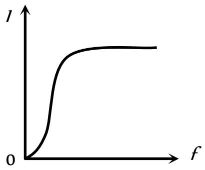
(a)


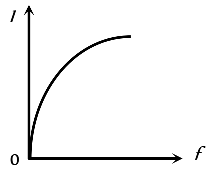
(b)


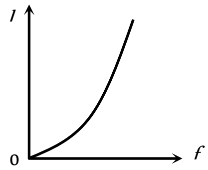
(c)


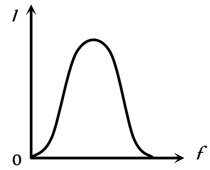
(d)


5. An ac source of variable frequency f is connected to an LCR series circuit. Which one of the graphs in figure. represents the variation of current of current I in the circuit with frequency f

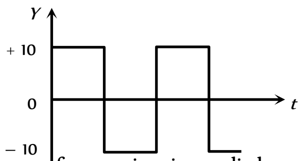
(a)


(b)


(c)


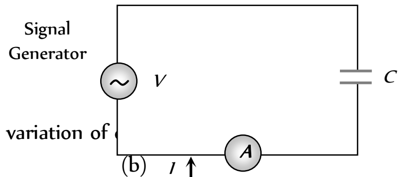
(d)


6. The $r.m.s.$ voltage of the wave form shown is

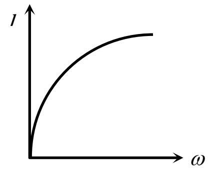


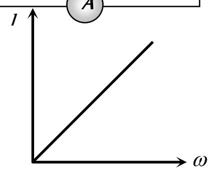
(a) 10 V
(b) 7 V
(c) 6.37 V
(d) None of these

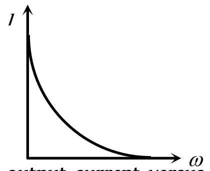
7. A constant voltage at different frequencies is applied across a capacitance C as shown in the figure. Which of the following graphs

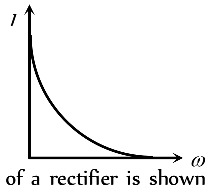


Correctly depicts the variation of

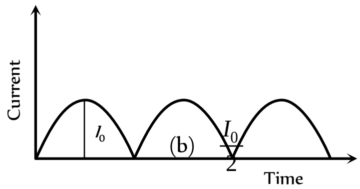
(a)


(b)


(c)


(d)


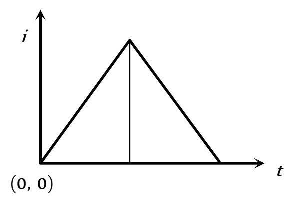
8. The output current versus time curve of a rectifier is shown in the figure. The average value of output current in this case is



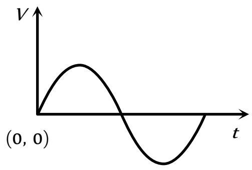
(a) 0 (b) $\frac{I_0}{2}$

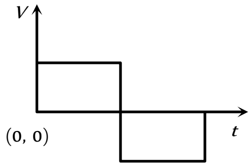
(c) $\frac{2I_0}{\pi}$ (d) I_0

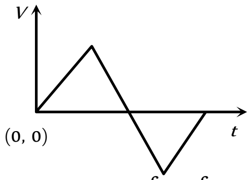
9. The current 'i' in an inductance coil varies with time 't' according to following graph

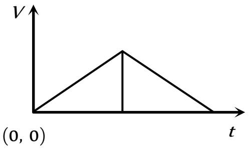


Which one of the following plots shows the variations of voltage in the coil [CBSE PMT 1994]

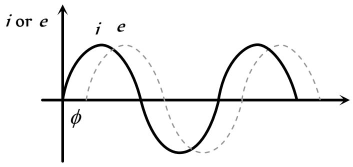
(a) 

(b) 

(c) 

(d) 

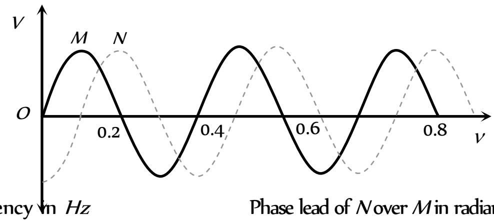
10. When an ac source of e.m.f. $e = E_0 \sin(100\,t)$ is connected across a circuit, the phase difference between the e.m.f. e and the current i in the circuit is observed to be $\pi/4$, as shown in the diagram. If the circuit consists possibly only of RC or LC in series, find the relationship between the two elements



(a) $R = 1k\Omega, C = 10\mu F$ (b) $R = 1k\Omega, C = 1\mu F$

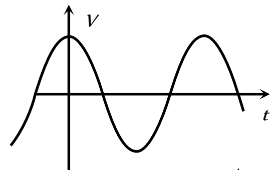
(c) $R = 1k\Omega, L = 10H$ (d) $R = 1k\Omega, L = 1H$

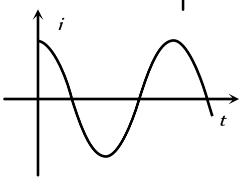
11. Two sinusoidal voltages of the same frequency are shown in the diagram. What is the frequency, and the phase relationship between the voltages

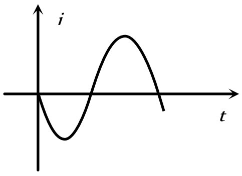


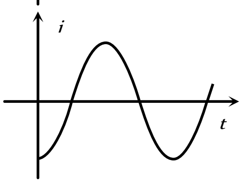
Frequency in Hz	Phase lead of N over M in radians
(a) 0.4	$-\pi/4$
(b) 2.5	$-\pi/2$
(c) 2.5	$+\pi/2$
(d) 2.5	$-\pi/4$

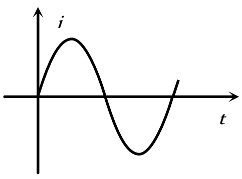
12. The voltage across a pure inductor is represented by the following diagram. Which one of the following diagrams will represent the current [MP PMT 1995]



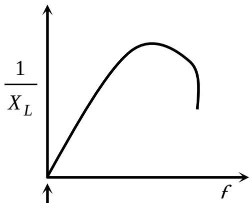
(a) 

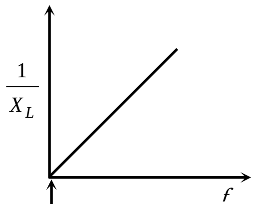
(b) 

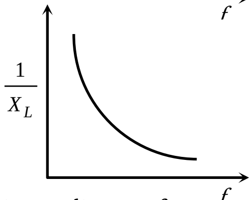
(c) 

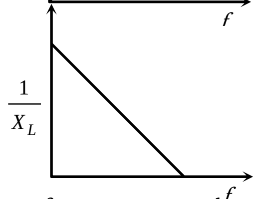
(d) 

13. In pure inductive circuit, the curves between frequency f and reciprocal of inductive reactance $1/X_L$ is

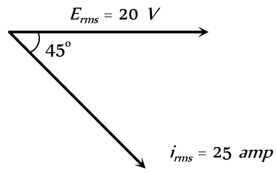
(a) 

(b) 

(c) 

(d) 

14. The (vector) diagram of current and voltage for a circuit is as shown. The components of the circuit will be [IIT-JEE (Screening) 2003]



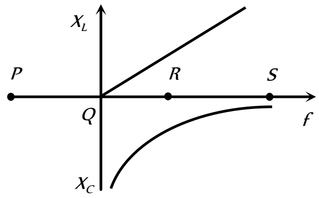
(a) LCR

(b) LR

(c) LCR or LR

(d) None of these

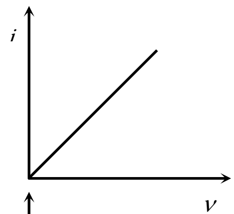
15. The resonance point in $X_L - f$ and $X_C - f$ curves is

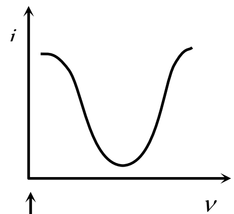


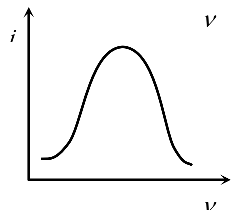
(a) P (b) Q

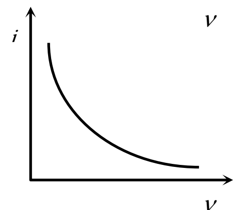
(c) R (d) S

16. The i - V curve for anti-resonant circuit is

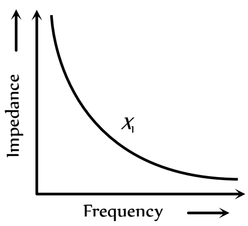
(a) 

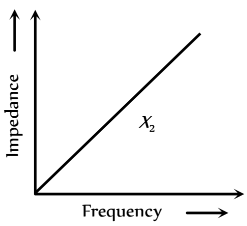
(b) 

(c) 

(d) 

17. The graphs given below depict the dependence of two reactive impedances X_1 and X_2 on the frequency of the alternating e.m.f. applied individually to them. We can then say that [Haryana CEE 1996; RPMT 2004]





(a) X_1 is an inductor and X_2 is a capacitor

(b) X_1 is a resistor and X_2 is a capacitor

(c) X_1 is a capacitor and X_2 is an inductor

(d) X_1 is an inductor and X_2 is a resistor

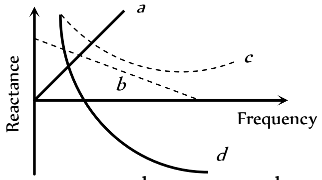
18. Which of the following plots may represent the reactance of a series LC combination [MP PMT 1999]

(a) a

(b) b

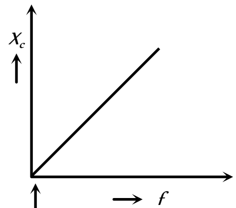
(c) c

(d) d

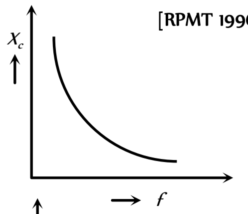


19. Which of the following curves correctly represents the variation of capacitive reactance X_c with frequency f [RPMT 1996]

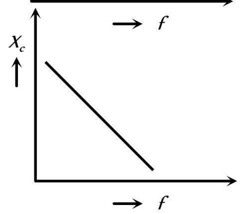
(a)



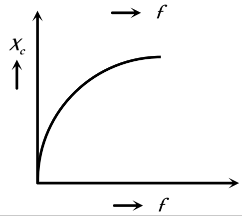
(b)



(c)



(d)



AR Assertion & Reason

For AIIMS Aspirants

Read the assertion and reason carefully to mark the correct option out of the options given below:

(a) *If both assertion and reason are true and the reason is the correct explanation of the assertion.*

(b) *If both assertion and reason are true but reason is not the correct explanation of the assertion.*

(c) *If assertion is true but reason is false.*

(d) *If the assertion and reason both are false.*

(e) *If assertion is false but reason is true.*

1. Assertion : In series LCR circuit resonance can take place.

Reason : Resonance takes place if inductance and capacitive reactances are equal and opposite.

[AIIMS 1998]

2. Assertion : The alternating current lags behind the e.m.f. by a phase angle of $\pi/2$, when ac flows through an inductor.

Reason : The inductive reactance increases as the frequency of ac source decreases.

3. Assertion : Capacitor serves as a block for dc and offers an easy path to ac.

Reason : Capacitive reactance is inversely proportional to frequency.

4. Assertion : When capacitive reactance is smaller than the inductive reactance in LCR current, e.m.f. leads the current .

Reason : The phase angle is the angle between the alternating e.m.f. and alternating current of the circuit.

5. Assertion : Chock coil is preferred over a resistor to adjust current in an ac circuit.

Reason : Power factor for inductance is zero.

6. Assertion : If the frequency of alternating current in an ac circuit consisting of an inductance coil is increased then current gets decreased.

Reason : The current is inversely proportional to frequency of alternating current.

7. Assertion : A bulb connected in series with a solenoid is connected to ac source. If a soft iron core is introduced in the solenoid, the bulb will glow brighter.

Reason : On introducing soft iron core in the solenoid, the inductance increases.

8. Assertion : An alternating current does not show any magnetic effect.

Reason : Alternating current varies with time.

9. Assertion : The dc and ac both can be measured by a hot wire instrument.

Reason : The hot wire instrument is based on the principle of magnetic effect of current.

10. Assertion : ac is more dangerous than dc

Reason : Frequency of ac is dangerous for human body.

11. Assertion : Average value of ac over a complete cycle is always zero.

Reason : Average value of ac is always defined over half cycle.

12. Assertion : The division are equally marked on the scale of ac ammeter.

Reason : Heat produced is directly proportional to the current.

13. Assertion : When ac circuit contain resistor only, its power is minimum.

Reason : Power of a circuit is independent of phase angle.

14. Assertion : An electric lamp connected in series with a variable capacitor and ac source, its brightness increases with increase in capacitance.

Reason : Capacitive reactance decrease with increase in capacitance of capacitor.

15. Assertion : An inductance and a resistance are connected in series with an ac circuit. In this circuit the current and the potential difference across the resistance lag behind potential difference across the inductance by an angle $\pi/2$.

Reason : In *LR* circuit voltage leads the current by phase angle which depends on the value of inductance and resistance both.

16. Assertion : A capacitor of suitable capacitance can be used in an ac circuit in place of the choke coil.

Reason : A capacitor blocks dc and allows ac only.

Answers

Alternating Current, Voltage and Power

1	b	2	a	3	c	4	b	5	b
6	b	7	c	8	d	9	c	10	c
11	d	12	c	13	b	14	c	15	b
16	d	17	c	18	b	19	d	20	c
21	c	22	a	23	c	24	d	25	c
26	c	27	d	28	b	29	c	30	d
31	d	32	d	33	b	34	b	35	d
36	c	37	a	38	b	39	a	40	c
41	a	42	d	43	b	44	b	45	c
46	c								

ac Circuits

1	b	2	a	3	a	4	b	5	a
6	a	7	b	8	c	9	d	10	b
11	c	12	b	13	b	14	b	15	d
16	b	17	a	18	b	19	a	20	a
21	b	22	d	23	b	24	b	25	a
26	d	27	c	28	b	29	c	30	c
31	c	32	b	33	d	34	a	35	c
36	c	37	c	38	b	39	c	40	d
41	b	42	b	43	a	44	a	45	d
46	c	47	a	48	a	49	c	50	b
51	b	52	c	53	b	54	c	55	c
56	a	57	a	58	b	59	b	60	d
61	a	62	c	63	a	64	bd	65	a
66	a	67	a	68	a	69	a	70	b
71	a	72	d	73	bc	74	c	75	b
76	b	77	b	78	c	79	c	80	a
81	b	82	d	83	c	84	c	85	b
86	a	87	c	88	a	89	a	90	c
91	d	92	d	93	d	94	c	95	b
96	a	97	d	98	b				

Critical Thinking Questions

1	a	2	c	3	a	4	c	5	c
6	a	7	d	8	b	9	b	10	d
11	d	12	d	13	a	14	c	15	b
16	c	17	a	18	d	19	b	20	b
21	d	22	c	23	c	24	a	25	d

Graphical Questions

1	c	2	b	3	c	4	c	5	d
6	a	7	b	8	c	9	b	10	a
11	b	12	d	13	c	14	c	15	c
16	b	17	c	18	d	19	b		

Assertion and Reason

1	a	2	c	3	a	4	b	5	a
6	a	7	e	8	b	9	c	10	a
11	b	12	d	13	d	14	a	15	b
16	b								

Answers and Solutions

Alternating Current, Voltage and Power

1. (b) Power loss $\propto \dfrac{1}{(\text{Voltage})^2}$

2. (a) $V = 5\cos\omega t = 5\sin\left(\omega t + \dfrac{\pi}{2}\right)$ and $i = 2\sin\omega t$

Power $= V_{r.m.s.} \times i_{r.m.s.} \times \cos\phi = 0$

(Since $\phi = \dfrac{\pi}{2}$, therefore $\cos\phi = \cos\dfrac{\pi}{2} = 0$)

3. (c) $P = V_{r.m.s.} \times i_{r.m.s.} \times \cos\phi = \dfrac{100}{\sqrt{2}} \times \dfrac{100\times 10^{-3}}{\sqrt{2}} \times \cos\dfrac{\pi}{3}$

$= \dfrac{10^4 \times 10^{-3}}{2} \times \dfrac{1}{2} = \dfrac{10}{4} = 2.5\ watt$

4. (b) In *dc* ammeter, a coil is free to rotate in the magnetic field of a fixed magnet.

If an alternating current is passed through such a coil, the torque will reverse it's direction each time the current changes direction and the average value of the torque will be zero.

5. (b) The coil having inductance *L* besides the resistance *R*. Hence for ac it's effective resistance $\sqrt{R^2 + X_L^2}$ will be larger than it's resistance *R* for dc.

6. (b) $i_{r.m.s.} = \dfrac{i_o}{\sqrt{2}} = \dfrac{4}{\sqrt{2}} = 2\sqrt{2}\ ampere$

7. (c) Effective voltage $V_{r.m.s.} = \dfrac{V_o}{\sqrt{2}} = \dfrac{423}{\sqrt{2}} = 300\ V$

8. (d) The current takes $\frac{T}{4}$ *sec* to reach the peak value.

In the given question $\frac{2\pi}{T} = 200\pi \Rightarrow T = \frac{1}{100} sec$

$\therefore$ Time to reach the peak value $= \frac{1}{400} sec$

9. (c) $i_{r.m.s} = \frac{6}{\sqrt{2}} = 3\sqrt{2}\ A$

10. (c) $\nu = \frac{\omega}{2\pi} = \frac{120\times 7}{2\times 22} = 19\ Hz$

$V_{r.m.s.} = \frac{240}{\sqrt{2}} = 120\sqrt{2} \approx 170\ V$

11. (d)

12. (c) Peak value = $220\sqrt{2} = 311\ V$

13. (b) Power $= I^2R = \left(\frac{I_p}{\sqrt{2}}\right)^2 R = \frac{I_p^2 R}{2}$

14. (c) $i_{r.m.s.} = \frac{V_{r.m.s.}}{R} = \frac{200}{40} = 5\ A \Rightarrow i_0 = i_{r.m.s.}\sqrt{2} = 7.07\ A$

15. (b)

16. (d) Time taken by the current to reach the maximum value $t = \frac{T}{4} = \frac{1}{4\nu} = \frac{1}{4\times 50} = 5\times 10^{-3} sec$

and $i_o = i_{rms}\sqrt{2} = 10\sqrt{2} = 14.14\ amp$

17. (c)

18. (b) $E = E_0 \cos\omega t = E_0 \cos\frac{2\pi t}{T}$

$= 10\cos\frac{2\pi\times 50\times 1}{600} = 10\cos\frac{\pi}{6} = 5\sqrt{3}\ volt.$

19. (d) Phase angle $\phi = 90^o$, so power $P = Vi\cos\phi = 0$

20. (c) $V_{rms} = \frac{200}{\sqrt{2}},\ i_{rms} = \frac{1}{\sqrt{2}}$

$\therefore P = V_{rms}\ i_{rms}\ \cos\phi = \frac{200}{\sqrt{2}}\frac{1}{\sqrt{2}}\cos\frac{\pi}{3} = 50\ watt$

21. (c) $2\pi\nu = 377 \Rightarrow \nu = 60.03\ Hz$

22. (a)

23. (c) $i_{rms} = \sqrt{\frac{i_1^2 + i_2^2}{2}} = \frac{1}{\sqrt{2}}(i_1^2 + i_2^2)^{1/2}$

24. (d) $P = Vi\cos\phi$

Phase difference $\phi = \frac{\pi}{2} \Rightarrow P = zero$

25. (c) $V_0 = V_{rms}\times\sqrt{2} = 220\times\sqrt{2} = 310$

26. (c) Hot wire ammeter reads *rms* value of current. Hence its peak value $= i_{rms}\times\sqrt{2} = 14.14\ amp$

27. (d)

28. (b) Peak voltage $= \sqrt{2}\times 220 = 311\ V$

29. (c)

30. (d) $\because P = Vi\cos\phi,\ \therefore P \propto \cos\phi$

31. (d) $P = V_{rms} I_{rms} \cos\phi$; since $\phi = 90^o$. So $P = 0$

32. (d) Brightness $\propto P_{consumed} \propto \frac{1}{R}$ for Bulb, $R_{ac} = R_{dc}$, so brightness will be equal in both the cases.

33. (b) $P = \frac{V_{rms}^2}{R} = \frac{(30)^2}{10} = 90\ W$

34. (b) $V_{rms} = \frac{V_0}{\sqrt{2}} = \frac{120}{1.414} = 84.8\ V$

35. (d) Peak value to *r.m.s.* value means, current becomes $\frac{1}{\sqrt{2}}$ times.

So from $i = i_0 \sin 100\pi t \Rightarrow \frac{1}{\sqrt{2}}\times i_0 = i_0 \sin 100\pi t$

$\Rightarrow \sin\frac{\pi}{4} = \sin 100\pi t \Rightarrow t = \frac{1}{400} sec = 2.5\times 10^{-3} sec.$

36. (c) Phase difference $\Delta\phi = \phi_2 - \phi_1 = \frac{\pi}{6} - \left(\frac{-\pi}{6}\right) = \frac{\pi}{3}$

37. (a) $V_{av} = \frac{2}{\pi}V_0 = \frac{2}{\pi}\times(V_{rms}\times\sqrt{2}) = \frac{2\sqrt{2}}{\pi}.V_{rms}$

$= \frac{2\sqrt{2}}{\pi}\times 220 = 198\ V$

38. (b)

39. (a)

40. (c)

41. (a) $i_{rms} = \frac{200}{280} = \frac{5}{7}A$. So $i_0 = i_{rms}\times\sqrt{2} = \frac{5}{7}\times\sqrt{2} \approx 1A.$

42. (d) Required time $t = T/4 = \frac{1}{4\times 50} = 5\times 10^{-3} sec$

43. (b) $V_0 = \sqrt{2}\ V_{rms} = 10\sqrt{2}$

44. (b) $P = \frac{1}{2}V_o i_o \cos\phi \Rightarrow P = P_{Peak}.\cos\phi$

$\Rightarrow \frac{1}{2}(P_{peak}) = P_{peak}\cos\phi \Rightarrow \cos\phi = \frac{1}{2} \Rightarrow \phi = \frac{\pi}{3}$

45. (c) $E = 141\sin(628\, t)$,

$E_{rms} = \frac{E_0}{\sqrt{2}} = \frac{141}{1.41} = 100V$ and $2\pi f = 628$

$\Rightarrow f = 100Hz$

46. (c) $E_{rms} = \frac{E_0}{\sqrt{2}} = \frac{707}{1.41} = 500V$

ac Circuits

1. (b)

2. (a)

3. (a) The choke coil can be used only in ac circuits, not in *dc* circuits, because for dc (ω = 0) the inductive reactance $X_L = \omega L$ of the coil is zero, only the resistance of the coil remains effective which too is almost zero.

4. (b) Because power $= i^2 R$, if $R = 0$, then $P = 0$.

5. (a)

6. (a) A choke coil contains high inductance but negligible resistance, due to which power loss becomes appreciably small.

7. (b) For purely capacitive circuit $e = e_0 \sin\omega t$

$i = i_o \sin\left(\omega t + \frac{\pi}{2}\right)$ *i.e.* current is ahead of emf by $\frac{\pi}{2}$

8. (c)

9. (d)

10. (b) $Z = \sqrt{R^2 + X_L^2}$, $X_L = \omega L$ and $\omega = 2\pi f$

$\therefore Z = \sqrt{R^2 + 4\pi^2 f^2 L^2}$

11. (c) $\nu = \frac{1}{2\pi\sqrt{LC}} = \frac{1}{2\pi\sqrt{10^{-6} \times 10^{-4}}} = \frac{10^5}{2\pi} Hz$

12. (b)

13. (b) The applied voltage is given by $V = \sqrt{V_R^2 + V_L^2}$

$V = \sqrt{(200)^2 + (150)^2} = 250\ volt$

14. (b) $i = \frac{V}{\sqrt{R^2 + \omega^2 L^2}} = \frac{120}{\sqrt{100 + 4\pi^2 \times 60^2 \times 20^2}} = 0.016\ A$

15. (d) For the first circuit $i = \frac{V}{Z} = \frac{V}{\sqrt{R^2 + \omega^2 L^2}}$

$\therefore$ Increase in ω will cause a decrease in *i*.

For the second circuit $i = \frac{V}{\sqrt{R^2 + \frac{1}{\omega^2 C^2}}}$

$\therefore$ Increase in ω will cause an increase in *i*.

16. (b) $X_C = \frac{1}{\omega C} = \frac{1}{2\pi\nu C}$; For dc $\nu = 0$, $\therefore X_C = \infty$

17. (a) In a pure inductor (zero resistance), voltage leads the current by 90^o *i.e.* $\pi/2$.

18. (b)

19. (a) The voltage across a *L–R* combination is given by

$V^2 = V_R^2 + V_L^2$

$V_L = \sqrt{V^2 - V_R^2} = \sqrt{400 - 144} = \sqrt{256} = 16\ volt.$

20. (a) Phase angle $\tan\phi = \frac{\omega L}{R} = \frac{2\pi \times 200}{300} \times \frac{1}{\pi} = \frac{4}{3}$

$\therefore \phi = \tan^{-1}\frac{4}{3}$

21. (b) At resonance, *LCR* circuit behaves as purely resistive circuit, for purely resistive circuit power factor = 1

22. (d) Given $\omega L = \frac{1}{\omega C} \Rightarrow \omega^2 = \frac{1}{LC}$

or $\omega = \frac{1}{\sqrt{10^{-3} \times 10 \times 10^{-6}}} = \frac{1}{\sqrt{10^{-8}}} = 10^4$

$X_L = \omega L = 10^4 \times 10^{-3} = 10\,\Omega$

23. (b)

24. (b) Reading of ammeter $= i_{rms} = \frac{V_{rms}}{X_C} = \frac{V_0 \omega C}{\sqrt{2}}$

$= \frac{200\sqrt{2} \times 100 \times (1 \times 10^{-6})}{\sqrt{2}} = 2 \times 10^{-2} A = 20\ mA$

25. (a) Current will be maximum at the condition of resonance. So resonant frequency $\omega_0 = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{0.5 \times 8 \times 10^{-6}}}$

= 500 *rad/s*

26. (d) Average power in ac circuits is given by $P = V_{rms} i_{rms} \cos\phi$

For pure capacitive circuit $\phi = 90^o$ so $P = 0$

27. (c) Amplitude of $ac = i_0 = \frac{V_0}{R} = \frac{\omega NBA}{R} = \frac{(2\pi\nu)NB(\pi r^2)}{R}$

$\Rightarrow i_0 = \frac{2\pi \times \frac{200}{60} \times 1 \times 10^{-2} \times \pi \times (0.3)^2}{\pi^2} = 6\ mA$

28. (b) $Z = \sqrt{R^2 + X_L^2} = \sqrt{10^2 + (2\pi \times 60 \times 2)^2} = 753.7$

$\therefore i = \frac{120}{753.7} = 0.159\ A$

29. (c) Resonance frequency in *radian/second* is

$\omega = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{8 \times 0.5 \times 10^{-6}}} = 500\ rad/sec$

30. (c) $\omega = \frac{1}{\sqrt{L_1 C_1}} = \frac{1}{\sqrt{L_2 C_2}} \Rightarrow L_2 = \frac{L_1}{4}$

31. (c) $Z = X_L = 2\pi \times 60 \times 0.7$

$\therefore i = \frac{120}{Z} = \frac{120}{2\pi \times 60 \times 0.7} = 0.455\ ampere$

32. (b) $Z = \sqrt{R^2 + X^2} = \sqrt{4^2 + 3^2} = 5$

$\therefore \cos\phi = \frac{R}{Z} = \frac{3}{5} = 0.6$

33. (d)

34. (a) $\cos\phi = \frac{R}{Z}$. In choke coil $\phi \approx 90°$ so $\cos\phi \approx 0$

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

$= \sqrt{100^2 + \left(0.5 \times 100\pi - \frac{1}{10 \times 10^{-6} \times 100\pi}\right)^2} = 189.72\Omega$

36. (c) $V_L = 46\,volts$, $V_C = 40\,volts$, $V_R = 8\,volts$

E.M.F. of source $V = \sqrt{8^2 + (46 - 40)^2} = 10\,volts$

37. (c) Resonant frequency $= \frac{1}{2\pi\sqrt{LC}}$ does not depend on resistance.

38. (b) Frequency $= \frac{1}{2\pi\sqrt{LC}}$

So the combination which represents dimension of frequency is $\frac{1}{\sqrt{LC}} = (LC)^{-1/2}$

39. (c) For series *R-L-C* circuit, $Z = \sqrt{R^2 + (X_L - X_C)^2}$

$= \sqrt{(300)^2 + \left(1000 \times 0.9 - \frac{10^6}{1000 \times 2}\right)^2} = 500\Omega$

40. (d) $Z = \sqrt{R^2 + X^2} = \sqrt{R^2 + (2\pi fL)^2}$

$= \sqrt{(30)^2 + \left(2\pi \times 50 \times \frac{0.4}{\pi}\right)^2} = \sqrt{900 + 1600} = 50\Omega$

$i = \frac{V}{Z} = \frac{200}{50} = 4\, ampere$

41. (b) Reactance $= 2\pi\nu L \Rightarrow 100\,\Omega = 2 \times \frac{22}{7} \times 50 \times L$

$\therefore\ L = 0.32\ henry$

42. (b)

43. (a) $X_C = \frac{1}{2\pi\nu C} = \frac{1}{2\pi \times 4000 \times 25 \times 10^{-6}} = \frac{5}{\pi}\Omega$

44. (a) $X_C = \frac{1}{2\pi\nu C} \Rightarrow \frac{1}{1000} = \frac{1}{2\pi \times \nu \times 5 \times 10^{-6}}$

$\Rightarrow \nu = \frac{100}{\pi} MHz$

45. (d) $i = \frac{V}{Z} = \frac{4}{\sqrt{4^2 + (1000 \times 3 \times 10^{-3})^2}} = 0.8\ A$

46. (c) $\tan\phi = \frac{X_L}{R} \Rightarrow \tan 45^o = \frac{X_L}{R} = 1 \Rightarrow X_L = R$

47. (a) For purely L-circuit $P = 0$

48. (a) At resonance LCR series circuit behaves as pure resistive circuit. For resistive circuit $\phi = 0^o$

49. (c) $V = \sqrt{V_R^2 + (V_L - V_C)^2} = \sqrt{(5)^2 + (10-10)^2} = 5\ Volt$

50. (b) When dc is supplied $R = \frac{V}{i} = \frac{100}{1} = 100\,\Omega$

When ac is supplied $Z = \frac{V}{i} = \frac{100}{0.5} = 200\,\Omega$

51. (b) $\cos\phi = \frac{R}{Z} = \frac{R}{\sqrt{R^2 + \omega^2 L^2}}$

$= \frac{12}{\sqrt{(12)^2 + 4 \times \pi^2 \times (60)^2 \times (0.1)^2}} \Rightarrow \cos\phi = 0.30$

52. (c)

53. (b)

54. (c) Impedance $Z = \sqrt{R^2 + X^2} = \sqrt{(8)^2 + (6)^2} = 10\Omega$

55. (c) $\tan\phi = \frac{\omega L}{R} = \frac{2\pi \times 50 \times 0.21}{12} = 5.5 \Rightarrow \phi = 80^o$

56. (a) If the current is wattless then power is zero. Hence phase difference $\phi = 90^o$

57. (a) $f = \frac{1}{2\pi\sqrt{LC}} \Rightarrow f \propto \frac{1}{\sqrt{C}}$

58. (b) In non resonant circuits impedance $Z = \frac{1}{\sqrt{\frac{1}{R^2} + \left(\omega C - \frac{1}{\omega L}\right)^2}}$, with rise in frequency Z decreases *i.e.* current increases so circuit behaves as capacitive circuit.

59. (b) $V = \sqrt{V_R^2 + V_L^2} = \sqrt{(20)^2 + (16)^2} = \sqrt{656} = 25.6\ V$

60. (d) $i = \frac{220}{\sqrt{(20)^2 + (2 \times \pi \times 50 \times 0.2)^2}} = \frac{220}{66} = 3.33\ A$

61. (a) Impedance of LCR circuit will be minimum at resonant frequency so $\nu_0 = \frac{1}{2\pi\sqrt{LC}} = \frac{1}{2\pi\sqrt{1 \times 10^{-3} \times 0.1 \times 10^{-6}}}$

$= \frac{10^5}{2\pi} Hz$

62. (c) $\cos\phi = \frac{R}{Z} = \frac{10}{20} = \frac{1}{2} \Rightarrow \phi = 60^o$

63. (a) Current in LC circuit becomes maximum when resonance occurs. So

$\omega = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{1 \times 25 \times 10^{-6}}} = \frac{1000}{5} = 200\, rad/\sec$

64. (b, d)

65. (a) $R = 6 + 4 = 10\,\Omega$

$X_L = \omega L = 2000 \times 5 \times 10^{-3} = 10\,\Omega$

$X_C = \frac{1}{\omega C} = \frac{1}{2000 \times 50 \times 10^{-6}} = 10\,\Omega$

$\therefore Z = \sqrt{R^2 + (X_L - X_C)^2} = 10\,\Omega$

Amplitude of current $= i_0 = \frac{V_0}{Z} = \frac{20}{10} = 2A$

66. (a) $i = \frac{V}{X_L} = \frac{200}{\omega L} = \frac{200}{2\pi \times 50 \times 1} = 0.637\ A$

67. (a)

68. (a) In LCR circuit; in the condition of resonance $X_L = X_C$ *i.e.* circuit behaves as resistive circuit. In resistive circuit power factor is maximum.

69. (a) $\tan\phi = \frac{X_L}{R} = \frac{\sqrt{3}\,R}{R} = \sqrt{3} \Rightarrow \phi = 60^o = \pi/3$

70. (b) $X_C = \frac{1}{2\pi\nu C} = \frac{1}{0} = \infty$

71. (a)

72. (d) $X_L = 2\pi\nu L \Rightarrow L = \frac{X_L}{2\pi\nu} = \frac{50}{2 \times 3.14 \times 50} = 0.16\ H$

73. (b, c)

74. (c) $Z = \sqrt{R^2 + (2\pi\nu L)^2}$

$= \sqrt{(40)^2 + 4\pi^2 \times (50)^2 \times (95.5 \times 10^{-3})^2} = 50\ ohm$

75. (b) $X_C = \frac{1}{2\pi\nu C} \Rightarrow X_C \propto \frac{1}{\nu}$

76. (b)

77. (b)

78. (c) $X_L = 2\pi\nu L = 2\times\pi\times 50\times\frac{1}{\pi} = 100\,\Omega$

79. (c) $\nu_0 = \frac{1}{2\pi\sqrt{LC}} = \frac{1}{2\times 3.14\sqrt{5\times 10^{-4}\times 20\times 10^{-6}}}$

$\nu_0 = \frac{10^4}{6.28} = 1592\,Hz$

80. (a) $X_C = \frac{1}{2\pi\nu C} \Rightarrow C = \frac{1}{2\pi\nu X_C} = \frac{1}{2\times\pi\times\frac{400}{\pi}\times 25} = 50\,\mu F$

81. (b) $\cos\phi = \frac{R}{Z} = \frac{R}{(R^2+\omega L^2)^{1/2}}$

82. (d) $Z = \sqrt{R^2+(X_L-X_C)^2} = \sqrt{(11)^2+(25-18)^2} = 13\,\Omega$

Current $i = \frac{260}{13} = 20\,A$

83. (c) $i = \frac{V}{X_L} = \frac{120}{2\times 3.14\times 60\times 0.7} = 0.455\,A$

84. (c) $\cos\phi = \frac{R}{Z} = \frac{R}{\sqrt{R^2+\omega^2L^2}} = \frac{5}{\sqrt{25+(50)^2\times(0.1)^2}}$

$= \frac{5}{\sqrt{25+25}} = \frac{1}{\sqrt{2}} \Rightarrow \phi = \pi/4$

85. (b) $P = Vi\cos\phi = V\left(\frac{V}{Z}\right)\left(\frac{R}{Z}\right) = \frac{V^2R}{Z^2} = \frac{V^2R}{(R^2+\omega^2L^2)}$

86. (a)

87. (c) $\tan\phi = \frac{X_L}{R} = \frac{2\pi\nu L}{R} = \frac{2\pi\times\frac{200}{2\pi}\times 1}{200} = 1 \Rightarrow \phi = 45^o$

88. (a) $V = \sqrt{V_R^2+(V_L-V_C)^2} = \sqrt{(40)^2+(60-30)^2} = 50\,V$

89. (a)

90. (c) $\nu_0 = \frac{1}{2\pi\sqrt{LC}}$

If C changes to $2C$ then for keeping ν constant L must change to $L/2$.

91. (d) Net voltage across LC combination $= V_L - V_C = 0\ V$

92. (d) Impedance $Z = \sqrt{R^2+4\pi^2\nu^2L^2}$

$= \sqrt{(12)^2+4\times(3.14)^2\times(50)^2\times(0.04)} = 17.37\ A$

Now current $i = \frac{V}{Z} = \frac{220}{17.37} = 12.7\Omega$

93. (d) At resonant frequency current in series LCR circuit is maximum.

94. (c)

95. (b)

96. (a) $\tan\phi = \frac{X_C - X_L}{R} \Rightarrow \tan 45^o = \frac{\frac{1}{2\pi fC} - 2\pi fL}{R}$

$\Rightarrow C = \frac{1}{2\pi\, f(2\pi fL + R)}$

97. (d)

98. (b) Resonance frequency

$\omega = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{8\times 10^{-3}\times 20\times 10^{-6}}} = 2500\ rad/\sec$

Resonance current $= \frac{V}{R} = \frac{220}{44} = 5A$

Critical Thinking Questions

1. (a) For dc, $R = \frac{V}{i} = \frac{100}{1} = 100\ \Omega$

For ac, $Z = \frac{V}{i} = \frac{100}{0.5} = 200\ \Omega$

$\because Z = \sqrt{R^2 + (\omega L)^2} \Rightarrow 200 = \sqrt{(100)^2 + 4\pi^2 (50)^2 L^2}$

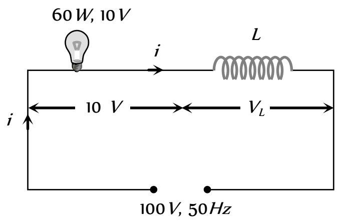
$\therefore L = 0.55\ H$

2. (c) $P = E_{rms} i_{rms} \cos\phi = \frac{E_0}{\sqrt{2}} \times \frac{i_0}{\sqrt{2}} \times \frac{R}{Z}$

$\Rightarrow \frac{E_0}{\sqrt{2}} \times \frac{E_0}{Z\sqrt{2}} \times \frac{R}{Z} \Rightarrow P = \frac{E_0^2 R}{2Z^2}$

Given $X_L = R$ so, $Z = \sqrt{2}R \Rightarrow P = \frac{E_0^2}{4R}$

3. (a) Current through the bulb $i = \frac{P}{V} = \frac{60}{10} = 6A$



$V = \sqrt{V_R^2 + V_L^2}$

$(100)^2 = (10)^2 + V_L^2 \Rightarrow V_L = 99.5\ Volt$

Also $V_L = iX_L = i \times (2\pi\nu L)$

$\Rightarrow 99.5 = 6 \times 2 \times 3.14 \times 50 \times L \Rightarrow L = 0.052\ H$

4. (c) $V^2 = V_R^2 + (V_L - V_C)^2$

Since $V_L = V_C$ hence $V = V_R = 200\ V$

5. (c) $V^2 = V_R^2 + (V_L - V_C)^2 \Rightarrow V_R = V = 220\ V$

Also $i = \frac{220}{100} = 2.2\ A$

6. (a) When a bulb and a capacitor are connected in series to an ac source, then on increasing the frequency the current in the circuit is increased, because the impedance of the circuit is decreased. So the bulb will give more intense light.

7. (d) The instantaneous values of emf and current in inductive circuit are given by $E = E_0 \sin\omega t$ and $i = i_0 \sin\left(\omega t - \frac{\pi}{2}\right)$ respectively.

So, $P_{inst} = Ei = E_0 \sin\omega t \times i_0 \sin\left(\omega t - \frac{\pi}{2}\right)$

$= E_0 i_0 \sin\omega t\left(\sin\omega t \cos\frac{\pi}{2} - \cos\omega t \sin\frac{\pi}{2}\right)$

$= E_0 i_0 \sin\omega t \cos\omega t$

$= \frac{1}{2} E_0 i_0 \sin 2\omega t$ $\quad(\sin 2\omega t = 2\sin\omega t \cos\omega t)$

Hence, angular frequency of instantaneous power is 2ω.

8. (b) $V = 50 \times 2 \sin 100\pi t \cos 100\pi t = 50 \sin 200\pi t$

$\Rightarrow V_0 = 50\ Volts$ and $\nu = 100 Hz$

9. (b) In RC series circuit voltage across the capacitor leads the voltage across the resistance by $\frac{\pi}{2}$

10. (d) The voltage V_L and V_C are equal and opposite so voltmeter reading will be zero.

Also $R = 30\,\Omega$, $X_L = X_C = 25\Omega$

So $i = \frac{V}{\sqrt{R^2 + (X_L - X_C)^2}} = \frac{V}{R} = \frac{240}{30} = 8\ A$

11. (d) $V = 120 \sin 100\pi t \cos 100\pi t \Rightarrow V = 60 \sin 200\pi t$

$V_{max} = 60V$ and $\nu = 100Hz$

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

$R = 10\,\Omega$, $X_L = \omega L = 2000 \times 5 \times 10^{-3} = 10\,\Omega$

$X_C = \frac{1}{\omega C} = \frac{1}{2000 \times 50 \times 10^{-6}} = 10\,\Omega$ *i.e.* $Z = 10\,\Omega$

Maximum current $i_0 = \frac{V_0}{Z} = \frac{20}{10} = 2A$

Hence $i_{rms} = \frac{2}{\sqrt{2}} = 1.4\ A$

and $V_{rms} = 4 \times 1.41 = 5.64\ V$

13. (a) Capacitance of wire

$C = 0.014 \times 10^{-6} \times 200 = 2.8 \times 10^{-6} F = 2.8\mu F$

For impedance of the circuit to be minimum $X_L = X_C \Rightarrow$

$2\pi\nu L = \frac{1}{2\pi\nu C}$

$\Rightarrow L = \frac{1}{4\pi^2\nu^2 C} = \frac{1}{4(3.14)^2 \times (5 \times 10^3)^2 \times 2.8 \times 10^{-6}}$

$= 0.35 \times 10^{-3} H = 0.35\, mH$

14. (c) $\overline{i^2} = \frac{\int i^2 dt}{\int dt} = \frac{\int_2^4 (4t) dt}{\int_2^4 dt} = \frac{4\int_2^4 t\, dt}{2} = 2\left[\frac{t^2}{2}\right]_2^4 = \left[t^2\right]_2^4 = 12$

$\Rightarrow i_{rms} = \sqrt{\overline{i^2}} = \sqrt{12} = 2\sqrt{3}\ A$

15. (b) 1. *rms* value $= \frac{x_0}{\sqrt{2}}$

2. $x_0 \sin\omega t \cos\omega t = \frac{x_0}{2}\sin 2\omega t \Rightarrow rms$ value$= \frac{x_0}{2\sqrt{2}}$

3. $x_0 \sin\omega t + x_0 \cos\omega t \Rightarrow rms$ value$= \sqrt{\left(\frac{x_0}{\sqrt{2}}\right)^2 + \left(\frac{x_0}{\sqrt{2}}\right)^2}$

$= \sqrt{x_0^2} = x_0$

16. (c) Given $X_L = X_C = 5\Omega$, this is the condition of resonance. So $V_L = V_C$, so net voltage across L and C combination will be zero.

17. (a) At angular frequency ω, the current in RC circuit is given by

$$i_{rms} = \frac{V_{rms}}{\sqrt{R^2 + \left(\frac{1}{\omega C}\right)^2}} \quad ......(i)$$

Also $\frac{i_{rms}}{2} = \frac{V_{rms}}{\sqrt{R^2 + \left(\frac{1}{\frac{\omega}{3}C}\right)^2}} = \frac{V_{rms}}{\sqrt{R^2 + \frac{9}{\omega^2 C^2}}}$ ......(ii)

From equation (i) and (ii) we get

$$3R^2 = \frac{5}{\omega^2 C^2} \Rightarrow \frac{\frac{1}{\omega C}}{R} = \sqrt{\frac{3}{5}} \Rightarrow \frac{X_C}{R} = \sqrt{\frac{3}{5}}$$

18. (d) $\tan\phi = \frac{X_L}{R} = \frac{X_C}{R} \Rightarrow \tan 60^o = \frac{X_L}{R} = \frac{X_C}{R}$

$\Rightarrow X_L = X_C = \sqrt{3}\ R$

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

So average power $P = \frac{V^2}{R} = \frac{200 \times 200}{100} = 400\ W$

19. (b) $R = \frac{P}{i_{rms}^2} = \frac{240}{16} = 15\Omega$

$Z = \frac{V}{i} = \frac{100}{4} = 25\Omega$

Now $X_L = \sqrt{Z^2 - R^2} = \sqrt{(25)^2 - (15)^2} = 20\Omega$

$\therefore 2\pi\nu L = 20 \Rightarrow L = \frac{20}{2\pi \times 50} = \frac{1}{5\pi}\ Hz$

20. (b) $X_L = R,\ X_C = R/2$

$\therefore \tan\phi = \frac{X_L - X_C}{R} = \frac{R - \frac{R}{2}}{R} = \frac{1}{2}$

$\Rightarrow \phi = \tan^{-1}(1/2)$

Also $Z = \sqrt{R^2 + (X_L - X_C)^2} = \sqrt{R^2 + \frac{R^2}{4}} = \frac{\sqrt{5}}{2}R$

21. (d) At resonance net voltage across L and C is zero.

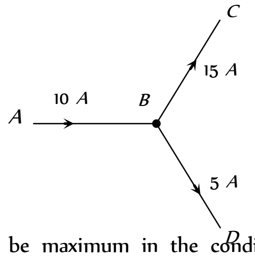
22. (c) $i_L = \frac{90}{30} = 3\ A,\quad i_C = \frac{90}{20} = 4.5\ A$

Net current through circuit $i = i_C - i_L = 1.5\ A$

$\therefore Z = \frac{V}{i} = \frac{90}{1.5} = 60\Omega$

23. (c) $i_{rms} = \sqrt{\frac{1}{T}\int_0^T i^2 dt} = \frac{T^2}{\sqrt{5}}$

24. (a) Yes, in AC if branch AB has R, BC has a capacitor C, and BD has a pure inductance L



25. (d) Current will be maximum in the condition of resonance so $i_{max} = \frac{V}{R} = \frac{V}{10}A$

Energy stored in the coil $W_L = \frac{1}{2}Li_{max}^2 = \frac{1}{2}L\left(\frac{E}{10}\right)^2$

$= \frac{1}{2} \times 10^{-3}\left(\frac{E^2}{100}\right) = \frac{1}{2} \times 10^{-5}E^2\ joule$

$\therefore$ Energy stored in the capacitor

$W_C = \frac{1}{2}CE^2 = \frac{1}{2} \times 2 \times 10^{-6}E^2 = 10^{-6}E^2\ joule$

$\therefore \frac{W_C}{W_L} = \frac{1}{5}$

Graphical Questions

1. (c) $Z = \sqrt{R^2 + \left(2\pi fL - \frac{1}{2\pi fC}\right)^2}$

From above equation at $f = 0 \Rightarrow z = \infty$

When $f = \frac{1}{2\pi\sqrt{LC}}$ (resonant frequency) $\Rightarrow Z = R$

For $f > \frac{1}{2\pi\sqrt{LC}} \Rightarrow Z$ starts increasing.

i.e., for frequency 0 – f, Z decreases

and for f to ∞, Z increases. This is justified by graph c.

2. (b) At $t = 0$, phase of the voltage is zero, while phase of the current is $-\frac{\pi}{2}$ i.e., voltage leads by $\frac{\pi}{2}$

3. (c) At $A : X_C > X_L$

At $B : X_C = X_L$

At $C : X_C < X_L$

4. (c) I_L lags behind I_R by a phase of $\frac{\pi}{2}$, while I_C leads by a phase of $\frac{\pi}{2}$.

5. (d) As explained in solution (1) for frequency $0 - f_r$, Z decreases hence $(i = V / Z)$, increases and for frequency $f_r - \infty$, Z increases hence i decrees.

6. (a) $V_{rms} = \sqrt{\frac{1}{T}\int_0^T 10^2\, dt} = 10\ V$

7. (b) For capacitive circuits $X_C = \frac{1}{\omega C}$

$\therefore i = \frac{V}{X_C} = V\omega C \Rightarrow i \propto \omega$

8. (c) $I_{av} = \frac{\int_0^{T/2} i\, dt}{\int_0^{T/2} dt} = \frac{\int_0^{T/2} I_0 \sin(\omega t) dt}{T/2}$

$$= \frac{2I_0}{T}\left[\frac{-\cos\omega t}{\omega}\right]_0^{T/2} = \frac{2I_0}{T}\left[-\frac{\cos\left(\frac{\omega T}{2}\right)}{\omega} + \frac{\cos 0^o}{\omega}\right]$$

$$= \frac{2I_0}{\omega T}[-\cos\pi + \cos 0^o] = \frac{2I_0}{2\pi}[1+1] = \frac{2I_0}{\pi}$$

9. (b) (1) For time interval $0 < t < T/2$

$I = kt$, where k is the slope

For inductor as we know, induced voltage $V = -L\frac{di}{dt}$

$\Rightarrow V_1 = -KL$

(2) For time interval $\frac{T}{2} < t < T$

$I = -Kt \Rightarrow V_2 = KL$

10. (a) As the current i leads the voltage by $\frac{\pi}{4}$, it is an RC circuit, hence

$\tan\phi = \frac{X_C}{R} \Rightarrow \tan\frac{\pi}{4} = \frac{1}{\omega CR}$

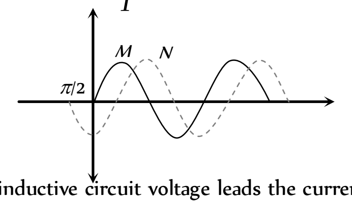
$\Rightarrow \omega CR = 1$ as $\omega = 100\ rad/sec$

$\Rightarrow CR = \frac{1}{100} sec^{-1}$.

From all the given options only option (a) is correct.

11. (b) From the graph shown below. It is clear that phase lead of N over M is $-\frac{\pi}{2}$. Since time period (*i.e.* taken to complete one cycle) = 0.4 *sec*.

Hence frequency $\nu = \frac{1}{T} = 2.5\ Hz$



12. (d) In purely inductive circuit voltage leads the current by 90°.

13. (c) $X_L = 2\pi fL \Rightarrow X_L \propto f \Rightarrow \frac{1}{X_L} \propto \frac{1}{f}$

i.e., graph between $\frac{1}{X_L}$ and f will be a hyperbola.

14. (c) From phasor diagram it is clear that current is lagging with respect to E. This may be happen in LCR or LR circuit.

15. (c) At resonance $X_L = X_C$

16. (b) For anti-resonant circuit current is minimum at resonant frequency and at frequencies other than resonant frequency current rises with frequency.

17. (c) We have $X_C = \frac{1}{C \times 2\pi f}$ and $X_L = L \times 2\pi f$

18. (d) Reactance $X = X_L - X_C = 2\pi fL - \frac{1}{2\pi fC}$

19. (b) $X_C = \frac{1}{\omega C} = \frac{1}{2\pi fC}$ *i.e.* $X_C \propto \frac{1}{f}$

Assertion and Reason

1. (a) At resonant frequency, $X_L = X_C \;\therefore\; Z = R$ (minimum) there for current in the circuit is maximum.

2. (c) When ac flows through an inductor current lags behind the *emf.*, by phase of $\pi/2$, inductive reactance, $X_L = \omega L = \pi.2f.L$, so when frequency increases correspondingly inductive reactance also increases.

3. (a) The capacitive reactance of capacitor is given by

$$X_C = \frac{1}{\omega C} = \frac{1}{2\pi fC}$$

So this is infinite for dc ($f = 0$) and has a very small value for ac. Therefore a capacitor blocks dc.

4. (b) The phase angle for the LCR circuit is given by

$$\tan\phi = \frac{X_L - X_C}{R} = \frac{\omega L - 1/\omega C}{R}$$

Where X_L, X_C are inductive reactance and capacitive reactance respectively when $X_L > X_C$ then $\tan\phi$ is positive *i.e.* ϕ is positive (between 0 and $\pi/2$). Hence emf leads the current.

5. (a) If resistor is used in controlling ac supply, electrical energy will be wasted in the form of heat energy across the resistance wire. However, ac supply can be controlled with choke without any wastage of energy. This is because, power factor ($\cos\phi$) for resistance is unity and is zero for an inductance. $[P = EI\cos\phi]$.

6. (a) When frequency of alternating current is increased, the effective resistance of the inductive coil increases. Current $(X_L = \omega L = 2\pi f L)$ in the circuit containing inductor is given by $I = \frac{V}{X_L} = \frac{V}{2\pi f L}$. As inductive resistance of the inductor increases, current in the circuit decreases.

7. (e) On introducing soft iron core, the bulb will glow dimmer. This is because on introducing soft iron core in the solenoid, its inductance L increases, the inductive reactance, $X_L = \omega L$ increases and hence the current through the bulb decreases.

8. (b) Like direct current, an alternating current also produces magnetic field. But the magnitude and direction of the field goes on changing continuously with time.

9. (c) Both ac and dc produce heat, which is proportional to square of the current. The reversal of direction of current in ac is immaterial so far as production of heat is concerned.

10. (a) The effect of ac on the body depends largely on the frequency. Low frequency currents of 50 to 60 *Hz* (*cycles/sec*), which are commonly used, are usually more dangerous than high frequency currents and are 3 to 5 times more dangerous than dc of same voltage and amperage (current). The usual frequency of 50 *cps* (or 60 *cps*) is extremely dangerous as it corresponds to the fibrillation frequency of the myocardium. This results in ventricular fibrillation and instant death.

11. (b) The mean average value of alternating current (or emf) during a half, cycle is given by $I_m = 0.636\, I_0$ (or $E_m = 0.636 E_0$)

During the next half cycle, the mean value of ac will be equal in magnitude but opposite in direction.

For this reason the average value of ac over a complete cycle is always zero. So the average value is always defined over a half cycle of ac.

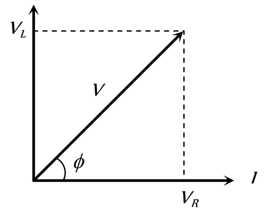
12. (d) An ac ammeter is constructed on the basics of heating effect of the electric current. Since heat produced varies as square of current $(H = I^2 R)$. Therefore the division marked on the scale of ac ammeter are not equally spaced.

13. (d) The power of a ac circuit is given by $P = EI\cos\phi$

where $\cos\phi$ is power factor and ϕ is phase angle. In case of circuit containing resistance only, phase angle is zero and power factor is equal to one. Therefore power is maximum in case of circuit containing resistor only.

14. (a) Capacitive reactance $X_C = \frac{1}{\omega C}$. When capacitance (C) increases, the capacitive reactance decreases. Due to decrease in its values, the current in the circuit will increases $\left(I = \frac{E}{\sqrt{R^2 + X_C^2}}\right)$ and hence brightness of source (or electric lamp) will also increases.

15. (b) As both the inductance and resistance are joined in series, hence current through both will be same. But in case of resistance, both the current and potential vary simultaneously, hence they are in same phase. In case of an inductance when current is zero, potential difference across it is maximum and when current reaches maximum (at $\omega t = \pi/2$), potential difference across it becomes zero *i.e.* potential difference leads the current by $\pi/2$ or current lags behind the potential difference by $\pi/2$, Phase angle in case of LR circuit is given as $\phi = \tan^{-1}\left(\frac{\omega L}{R}\right)$.



16. (b) We can use a capacitor of suitable capacitance as a chock coil, because average power consumed per cycle in an ideal capacitor is zero. Therefore, like a choke coil, a condenser can reduce ac without power dissipation.

Alternating Current

SET Self Evaluation Test - 24

1. A bulb and a capacitor are in series with an ac source. On increasing frequency how will glow of the bulb change

(a) The glow decreases (b) The glow increases
(c) The glow remain the same (d) The bulb quenches

2. The *r.m.s.* current in an ac circuit is 2 *A*. If the wattless current be $\sqrt{3}A$, what is the power factor

(a) $\frac{1}{\sqrt{3}}$ (b) $\frac{1}{\sqrt{2}}$
(c) $\frac{1}{2}$ (d) $\frac{1}{3}$

3. $\frac{2.5}{\pi}\mu F$ capacitor and 3000-*ohm* resistance are joined in series to an ac source of 200 *volt* and $50 sec^{-1}$ frequency. The power factor of the circuit and the power dissipated in it will respectively

(a) 0.6, 0.06 *W* (b) 0.06, 0.6 *W*
(c) 0.6, 4.8 *W* (d) 4.8, 0.6 *W*

4. The self inductance of a choke coil is 10 *mH*. When it is connected with a 10 *V* dc source, then the loss of power is 20 *watt*. When it is connected with 10 *volt* ac source loss of power is 10 *watt*. The frequency of ac source will be

(a) 50 *Hz* (b) 60 *Hz*
(c) 80 *Hz* (d) 100 *Hz*

5. In an *LCR* circuit $R = 100$ *ohm*. When capacitance *C* is removed, the current lags behind the voltage by $\pi/3$. When inductance *L* is removed, the current leads the voltage by $\pi/3$. The impedance of the circuit is

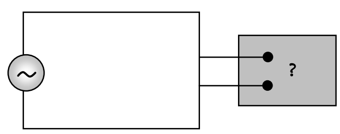
(a) 50 *ohm* (b) 100 *ohm*
(c) 200 *ohm* (d) 400 *ohm*

6. A group of electric lamps having a total power rating of 1000 *watt* is supplied by an ac voltage $E = 200\sin(310t + 60°)$. Then the *r.m.s.* value o the circuit current is

(a) 10 *A* (b) $10\sqrt{2}\ A$
(c) 20 *A* (d) $20\sqrt{2}\ A$

7. Following figure shows an ac generator connected to a "block box" through a pair of terminals. The box contains possible *R*, *L*, *C* or their combination, whose elements and arrangements are not known to us. Measurements outside the box reveals that

e = 75 sin (sin ωt) *volt*, i = 1.5 sin (ωt + 45°) *amp* then, the wrong statement is



(a) There must be a capacitor in the box
(b) There must be an inductor in the box
(c) There must be a resistance in the box
(d) The power factor is 0.707

8. A resistor *R*, an inductor *L* and a capacitor *C* are connected in series to an oscillator of frequency *n*. if the resonant frequency is n_r, then the current lags behind voltage, when

(a) $n = 0$ (b) $n < n_r$
(c) $n = n_r$ (d) $n > n_r$

9. If power factor is 1/2 in a series *RL* circuit $R = 100\,\Omega$. ac mains is used then *L* is

(a) $\frac{\sqrt{3}}{\pi}$ *Henry* (b) π *Henry*
(c) $\frac{\pi}{\sqrt{3}}$ *Henry* (d) None of these

10. What will be the self inductance of a coil, to be connected in a series with a resistance of $\pi\sqrt{3}\,\Omega$ such that the phase difference between the emf and the current at 50 *Hz* frequency is 30°

(a) 0.5 *Henry* (b) 0.03 *Henry*
(c) 0.05 *Henry* (d) 0.01 *Henry*

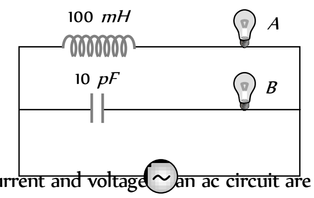
11. The phase difference between the voltage and the current in an ac circuit is $\pi/4$. If the frequency is 50 *Hz* then this phase difference will be equivalent to a time of

(a) 0.02 *s* (b) 0.25 *s*
(c) 2.5 *ms* (d) 25 *ms*

12. The instantaneous values of current and emf in an ac circuit are $I = 1/\sqrt{2}\sin 314\,t$ *amp* and $E = \sqrt{2}\sin(314\,t - \pi/6)V$ respectively. The phase difference between *E* and *I* will be

(a) $-\pi/6$ *rad* (b) $-\pi/3$ *rad*
(c) $\pi/6$ *rad* (d) $\pi/3$ *rad*

13. If *A* and *B* are identical bulbs which bulbs glows brighter



(a) *A*
(b) *B*
(c) Both equally bright
(d) Cannot say

14. The instantaneous values of current and voltage in an ac circuit are $i = 100\sin 314\,t\,amp$ and $e = 200\sin(314\,t + \pi/3)V$ respectively. If the resistance is 1Ω then the reactance of the circuit will be

(a) $-200\sqrt{3}\,\Omega$ (b) $\sqrt{3}\,\Omega$
(c) $-200/\sqrt{3}\,\Omega$ (d) $100\sqrt{3}\,\Omega$

15. What is the *r.m.s.* value of an alternating current which when passed through a resistor produces heat which is thrice of that produced by a direct current of 2 amperes in the same resistor

(a) 6 *amp* (b) 2 *amp*
(c) 3.46 *amp* (d) 0.66 *amp*

AS Answers and Solutions

(SET -24)

1. (b) This is because, when frequency ν is increased, the capacitive reactance $X_C = \frac{1}{2\pi\nu C}$ decreases and hence the current through the bulb increases.

2. (c) $i_{WL} = i_{rms} \sin\phi \Rightarrow \sqrt{3} = 2\sin\phi \Rightarrow \sin\phi = \frac{\sqrt{3}}{2}$

$\Rightarrow \phi = 60^o$ so p.f. $= \cos\phi = \cos 60^o = \frac{1}{2}$.

3. (c) $Z = \sqrt{R^2 + \left(\frac{1}{2\pi\nu C}\right)^2} = \sqrt{(3000)^2 + \frac{1}{\left(2\pi \times 50 \times \frac{2.5}{\pi} \times 10^{-6}\right)^2}}$

$\Rightarrow Z = \sqrt{(3000)^2 + (4000)^2} = 5 \times 10^3 \Omega$

So power factor $\cos\phi = \frac{R}{Z} = \frac{3000}{5 \times 10^3} = 0.6$ and power

$P = V_{rms} i_{rms} \cos\phi = \frac{V_{rms}^2 \cos\phi}{Z} \Rightarrow P = \frac{(200)^2 \times 0.6}{5 \times 10^3} = 4.8 W$

4. (c) With dc : $P = \frac{V^2}{R} \Rightarrow R = \frac{(10)^2}{20} = 5\,\Omega$;

With ac : $P = \frac{V_{rms}^2 R}{Z^2} \Rightarrow Z^2 = \frac{(10)^2 \times 5}{10} = 50\,\Omega^2$

Also $Z^2 = R^2 + 4\pi^2\nu^2 L^2$

$\Rightarrow 50 = (5)^2 + 4(3.14)^2 \nu^2 (10 \times 10^{-3})^2 \Rightarrow \nu = 80\,Hz.$

5. (b) When C is removed circuit becomes RL circuit hence

$\tan\frac{\pi}{3} = \frac{X_L}{R}$ .....(i)

When L is removed circuit becomes RC circuit hence

$\tan\frac{\pi}{3} = \frac{X_C}{R}$ .....(ii)

From equation (i) and (ii) we obtain $X_L = X_C$. This is the condition of resonance and in resonance $Z = R = 100\Omega$.

6. (b) $P = \frac{1}{2} V_0 i_0 \cos\phi \Rightarrow 1000 = \frac{1}{2} \times 200 \times i_0 \cos 60^o$

$\Rightarrow i_0 = 20 A \Rightarrow i_{rms} = \frac{i_0}{\sqrt{2}} = \frac{20}{\sqrt{2}} = 10\sqrt{2} A.$

7. (b) Since voltage is lagging behind the current, so there must be no inductor in the box.

8. (d) The current will lag behind the voltage when reactance of inductance is more than the reactance of condenser. Thus,

$\omega L > \frac{1}{\omega C}$ or $\omega > \frac{1}{\sqrt{LC}}$

or $n > \frac{1}{2\pi\sqrt{LC}}$ or $n > n_r$ where n_r = resonant frequency.

9. (a) $\cos\phi = \frac{1}{2} \Rightarrow \phi = 60^o$ $\tan 60^o = \frac{\omega L}{R} \Rightarrow L = \frac{\sqrt{3}}{\pi} H$

10. (d) $\tan\phi = \frac{X_L}{R} = \frac{2\pi\nu L}{R} \Rightarrow \tan 30^o = \frac{2\pi \times 50 \times L}{\pi\sqrt{3}} = 0.01\,H.$

11. (c) Time difference $= \frac{T}{2\pi} \times \phi = \frac{(1/50)}{2\pi} \times \frac{\pi}{4} = \frac{1}{400} s = 2.5\, m\text{-}s$

12. (a) Phase difference relative to the current

$\phi = (314\,t - \frac{\pi}{6}) - (314\,t) = -\frac{\pi}{6}$

13. (a) $\because (X_C) >> (X_L)$

14. (b) $V_0 = i_0 Z \Rightarrow 200 = 100\, Z \Rightarrow Z = 2\Omega$

Also $Z^2 = R^2 + X_L^2 \Rightarrow (2)^2 = (1)^2 + X_L^2 \Rightarrow X_L = \sqrt{3}\Omega$

15. (c) Heat produced by ac = 3 × Heat produced by dc

$\therefore i_{rms}^2 Rt = 3 \times i^2 Rt \Rightarrow I_{rms}^2 = 3 \times 2^2$

$\Rightarrow i_{rms} = 2\sqrt{3} = 3.46\,A$

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