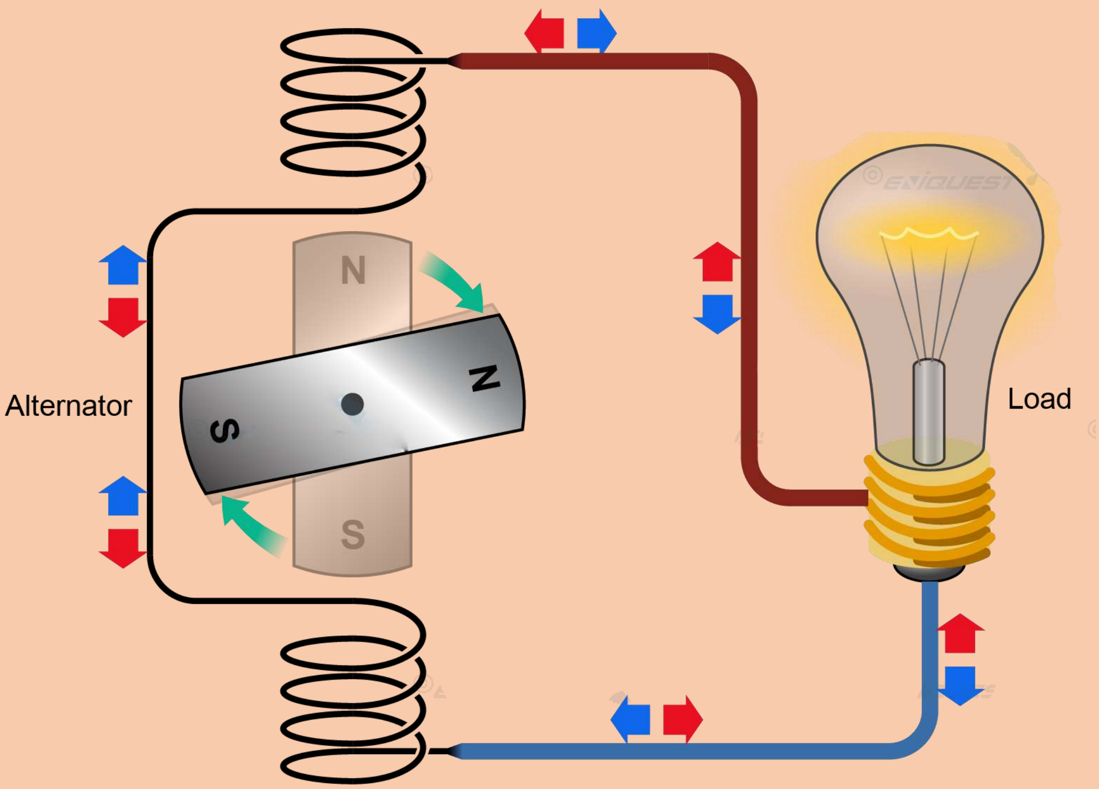
7.ALTERNATING CURRENT



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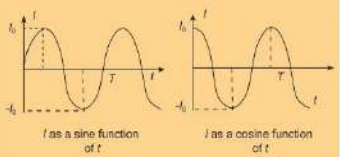
ALTERNATING CURRENT

ALTERNATING CURRENT AND VOLTAGE

When the magnitude and direction of current and voltage change continuously with time, then current or voltage is said to be alternating.



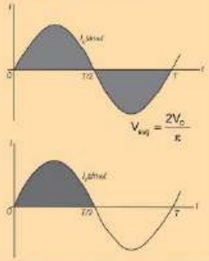
$I = I_0 \sin(\omega t + \phi)$ or
$I = I_0 \cos(\omega t + \phi)$

I = instantaneous values of current
I_0 = peak value or amplitude
ω = angular frequency
ϕ = initial phase.

Average or Mean Value

$I_{av} = \frac{2I_0}{\pi}$

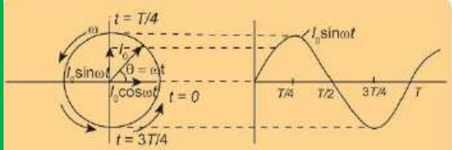
$V_{avg} = \frac{2V_0}{\pi}$



ROOT MEAN SQUARE VALUE

$I_{av} = \frac{2I_0}{\pi}$

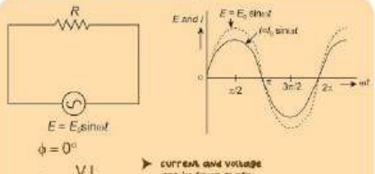
$V_{av} = \frac{2V_0}{\pi}$



- The projection phasor on x – axis or y – axis gives the instantaneous value of alternating current/voltage.
- A phase rotates with angular speed ω about the origin.
- Arrow length of this vector is equal to the peak value of alternating current/voltage.

AC SERIES CIRCUIT ANALYSIS

RESISTIVE CIRCUIT

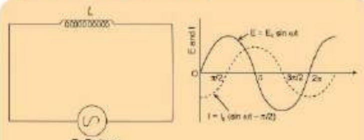


$\phi = 0^\circ$

$P_{av} = \frac{V_0 I_0}{2}$

➤ Current and voltage are in same phase.

INDUCTIVE CIRCUIT



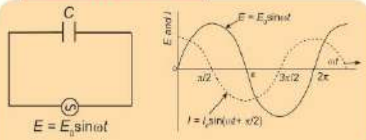
➤ $I = I_0 \sin(\omega t - \frac{\pi}{2})$

$\phi = \frac{\pi}{2}$

➤ Voltage leads current by $\frac{\pi}{2}$.

➤ $P_{av} = 0$

CAPACITIVE CIRCUIT



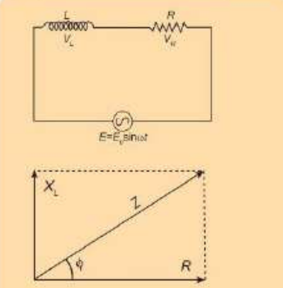
➤ $I = I_0 \sin(\omega t + \frac{\pi}{2})$

$\phi = -\frac{\pi}{2}$ or $\frac{\pi}{2}$

➤ Current leads voltage by $\frac{\pi}{2}$.

➤ $P_{av} = 0$

L – R CIRCUIT



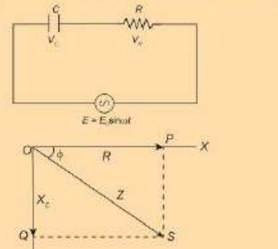
➤ $I = I_0 \sin(\omega t - \phi)$

➤ $Z = \sqrt{R^2 + X_L^2}$

➤ Inductive reactance, $X_L = \omega L$

➤ Phase angle $\phi = \tan^{-1}\left(\frac{X_L}{R}\right)$

R – C CIRCUIT



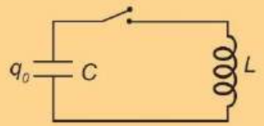
➤ $I = I_0 \sin(\omega t + \phi)$

➤ $Z = \sqrt{R^2 + X_C^2}$

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

➤ $\phi = \tan^{-1}\left(\frac{X_C}{R}\right)$

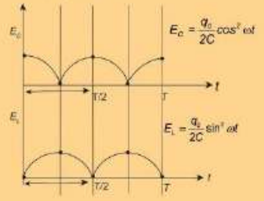
L C OSCILLATIONS



It is defined as the oscillation of energy between capacitor and inductor.

Frequency of Oscillation.

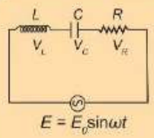
$f = \frac{1}{2\pi}\sqrt{\frac{1}{LC}}$

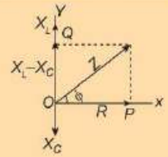


$E_C = \frac{q_0^2}{2C}\cos^2 \omega t$

$E_L = \frac{q_0^2}{2C}\sin^2 \omega t$

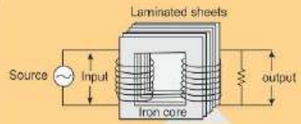
LCR CIRCUIT





- $I = I_0 \sin(\omega t \pm \phi)$
- $Z = \sqrt{R^2 + (X_L - X_C)^2}$
- $\phi = \tan^{-1}\left(\frac{X_L - X_C}{R}\right)$

TRANSFORMER



➤ Transformer ratio.

$K = \frac{N_s}{N_p} = \frac{\text{No. of turns in Secondary}}{\text{No. of turns in Primary}}$

ASSUMPTIONS

➤ No magnetic flux leakage.

$\frac{E_s}{E_p} = \frac{N_s}{N_p}$

➤ No power loss. efficiency (n) = 100%.

$n = \frac{P_{Out}}{P_{in}} \times 100\%$, $P_{in} = P_{Out}$

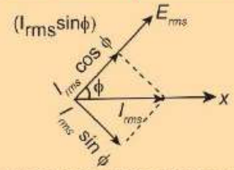
$\frac{I_p}{I_s} = \frac{E_s}{E_p} = \frac{N_s}{N_p}$

POWER CONSUMED IN AC CIRCUIT

➤ Average Power dissipation, $\langle P \rangle = E_{rms}\ I_{rms}\ \cos\phi$

➤ Power factor, $\cos\phi = \frac{\text{Average Power}}{\text{rms Power}} = \frac{R}{Z}$

Wattless Current



➤ When the power consumption in AC circuit is zero, then current is said to be wattless current.

➤ Wattless current is a sine component of current.

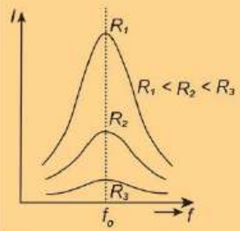
Half Power Frequency

➤ Frequency at which power becomes half of its maximum value.

➤ At half power frequency.

$\cos\phi = \frac{1}{2}$ or $\phi = 60^\circ$

Quality Factor



➤ It represents sharpness curve (I vs f).

➤ It is unitless and dimensionless.

➤ $Q = \frac{\omega_0 L}{R} = \frac{1}{R}\sqrt{\frac{L}{C}}$

➤ $Q = \frac{f_0}{\text{band width } (\Delta f)}$

➤ Sharpness $\propto$ Q

RESONANCE IN SERIES LCR CIRCUIT

Conditions for resonance

- $Z_{min} = R$
- $I_{max} = \frac{E}{Z_{min}} = \frac{E}{R}$
- $X_L = X_C$
- $V_L = V_C$
- $\cos\phi = 1$
- $\phi = 0^\circ$

Resonant frequency.

$f_0 = \frac{1}{2\pi\sqrt{LC}}$

Variation of Z with f

1) $f < f_0$, $X_L < X_C$ ➤ ϕ (negative)

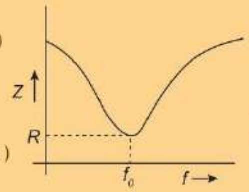
➤ Capacitive in nature.

2) $f = f_0$, $X_L = X_C$ ➤ $\phi = 0$

➤ Resistive in nature

3) $f > f_0$, $X_L > X_C$ ➤ ϕ (Positive)

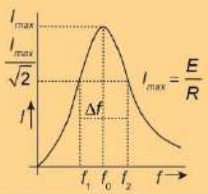
➤ Inductive in nature.



Variation of I with f

➤ As frequency (f) increases current (I) decreases

➤ Band width. $\Delta f = f_2 - f_1$



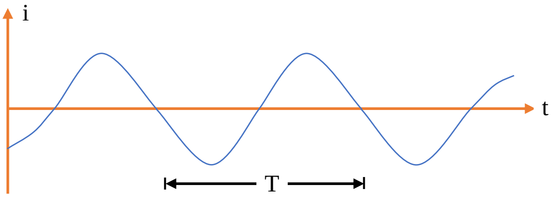
Alternating Current

AC Circuits

In the previous chapters, various circuits we have analysed were all direct current circuits. The source which drives the current in dc circuits is a battery. The main element which controls the current through the circuit is the resistance. It is a well known fact that almost all household and industrial power-distribution systems operate with alternating current (ac) and not direct currents (dc). To drive an ac through a circuit a source of alternating emf or voltage is required.

In this chapter we only study the ac that varies sinusoidally with time. Such an alternating current is given by

$i = i_o \sin(\omega t + \phi)$ ... (1)



In equation (1), 'i' gives instantaneous value of current i.e. magnitude of current at any instant of time t and i_0 the peak value or maximum value of ac. This is also called amplitude of ac. ω is the angular frequency of ac.

Further, $\omega = \frac{2\pi}{T} = 2\pi f$,

where T is the time period of ac. It is equal to the time taken by the ac to go through one complete cycle of variation (zero to maximum, maximum to zero; zero to maximum in opposite direction and finally maximum to zero). Again, f is the frequency of ac. It is equal to the number of complete cycles of variation gone through by the ac per second.

A dc flows from +ve terminal to –ve through the external resistor. Magnitude of dc also remains almost constant. But ac through a resistor changes its direction alternatively.

Characteristics of ac

Instantaneous current

This is given by $i = i_0 \sin(\omega t + \phi)$ at any time t.

Average current or mean current

The alternating current (ac) varies with time. Its mean value over a time interval o to t is given by

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

This, on integrating turns out to be

$$\bar{i} = -\frac{i_0}{T_\omega}[\cos(2\pi + \varphi) - \cos\varphi] = 0$$ for a time period t = T and ωT = 2π

Mean square current

At every instant of time i^2 is +ve. The average of i^2 over a time period is given by

$$\bar{i}^2 = \frac{\int_0^T i^2\,dt}{\int_0^T dt} \Rightarrow = \frac{i_0^2}{2T}\left[T - \frac{\sin(4\pi + 2\varphi) - \sin 2\varphi}{2\omega}\right] = \left(\frac{i_0^2}{\sqrt{2}}\right)$$

Root mean square current

Square root of mean square current is called root mean square current or rms current

ic = $i_0 \sin(\omega t + \phi)$ and is given by $i_{rms} = \sqrt{\overline{i}^2} = \frac{i_0}{\sqrt{2}}$

The equations for mean square current and root-mean-square current are obtained for one time period. They are also valid if the average is calculated over a long period of time.

An alternating voltage which drives ac through a circuit (potential difference) may be written as

$V = V_0 \sin(\omega t + \phi)$.

This gives the instantaneous voltage. The mean value $\overline{V}$ over a complete cycle is zero, the mean square voltage over a cycle is $\frac{V_0^2}{2}$ and the root-mean-square voltage (rms voltage or virtual voltage) is $\frac{V_0}{\sqrt{2}}$.

The importance of rms current and rms voltage can be shown by considering a resistor of resistance R carrying a current i

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

The voltage across the resistor is $V = Ri = (i_0 R) \sin(\omega t + \phi)$

The thermal energy developed in the resistor during the time t to t + dt is

$i^2 R\, dt = i_0^2 R \sin^2(\omega t + \phi)dt$.

The thermal energy developed in one time period is

$$U = \int_0^T i^2 R\, dt = R\int_0^T i_0^2 \sin^2(\omega t + \varphi)dt = RT\left[\frac{1}{T}\int_0^T i_0^2 \sin^2(\omega t + \varphi)dt\right] = i_{rms}^2 RT .$$

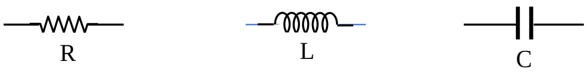
Thus, if we pass a direct current, i_{rms} passes through the resistor, it will produce the same thermal energy in a time period as that produced when the alternating current I passes through it. Similarly, a constant voltage V_{rms} applied across a resistor produces the same thermal energy as that produced by the voltage

$V = V_0 \sin(\omega t + \phi)$.

Circuit elements in ac circuit

In dc circuits except in special cases, only resistance R can control the current in the circuit, as inductor acts as short circuit while capacitor acts as open circuit.

However in case of ac circuits, resistance R, inductance L and capacitance C, or any combination of these can control the current in the circuit. Resistance R, inductance L and capacitance C are referred to as circuit elements and are shown in figure below.



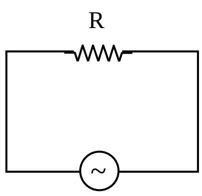
We consider the following cases to understand how R, L and C control the current in an ac circuit

(a) A Resistor in an ac circuit

If an alternating voltage $E = E_0 \sin \omega t$ is applied across a resistance as shown in figure. Kirchhoff's loop-rule at any time t, gives

$E = IR$ i.e., $I = \frac{E}{R}$

or $I = \frac{E_0}{R} \sin \omega t$ [as $E = E_0 \sin \omega t$]



$E = E_0 \sin \omega t$
circuit

From this it is evident that

1. The frequency of current in the circuit is ω and is same as that of the applied voltage.

2. In a resistance, applied voltage and the resulting current are in phase.
3. Current in the circuit is independent of frequency and decreases with increase in R (similar to that in dc circuits)

(b) An inductor in an ac circuit

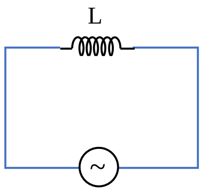
If an emf $E = E_0 \sin \omega t$ is applied across an inductor of inductance L as shown, applying Kirchhoff's loop rule we have,

$$E - L\frac{dI}{dt} = 0 \quad \text{or,} \quad L\frac{dI}{dt} = E_0 \sin \omega t$$

$$\text{or,} \quad \frac{dI}{dt} = \frac{E_0}{L}\sin \omega t$$

which on integration gives, $I = -\frac{E_0}{L\omega}\cos \omega t$

i.e., $I = I_0 \sin\left(\omega t - \frac{\pi}{2}\right)$ with $I_0 = \frac{E_0}{\omega L}$



$E = E_0 \sin \omega t$

From this expression it is evident that

1. The frequency of current in the circuit is same as that of applied emf but current in an inductor 'lags' the applied voltage by (π/2) [or voltage leads the current by (π/2)]
2. As we have $I_0 = (E_0/\omega L)$, the quantity ωL has the dimensions of resistance as,

$$[\omega L] = \left[\frac{\text{rad}}{\text{sec}} \times \text{H}\right] = \left[\frac{\text{rad}}{\text{sec}} \times \text{ohm} \times \text{sec}\right] = [\text{ohm}]$$

This quantity is referred to as 'inductive-reactance' and is represented by X_L and represents the opposition of a coil to ac, i.e., $X_L = \omega L = 2\pi f L$

(c) A capacitor in an ac circuit

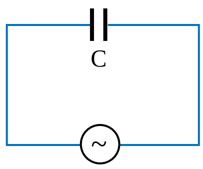
If $E = E_0 \sin \omega t$ is applied across a capacitor as shown, applying Kirchhoff's loop rule

we have, $E - \frac{q}{C} = 0$

or, $q = CE_0 \sin \omega t$ (as $E = E_0 \sin \omega t$)

or, $I = \frac{dq}{dt} = C\omega E_0 \cos \omega t$

or, $I = I_0 \sin\left(\omega t + \frac{\pi}{2}\right)$ with $I_0 = E_0 C\omega$



$E = E_0 \sin \omega t$

From this expression it is evident that

1. Current in the circuit has same frequency as the applied voltage but leads it by (π/2) [or voltage across a capacitor lags the current by (π/2)]
2. As $I_0 = C\omega E_0 = \frac{E_0}{X_C}$ where $X_C = \frac{1}{\omega C}$. $(1/\omega C)$ has dimensions of resistance,

as we have $\left[\frac{1}{\omega C}\right] = \left[\frac{1}{\text{rad}\,\text{s}^{-1}} \times \frac{\text{V}}{\text{coul}}\right] = \left[\frac{\text{V}}{\text{A}}\right] = \text{ohm}$

and so it represents the opposition due to capacitor to the flow of ac through it and is called 'capacitive reactance'.

Impedance

The peak current and the peak emf in all the three circuits discussed are related by

$i_0 = \frac{\varepsilon_0}{Z}$, where Z is called the impedance of circuit.

Z = R for a purely resistive circuit $Z = \frac{1}{\omega C}$ for a purely capacitive circuit and $Z = \omega L$ for a purely inductive circuit.

The peak current and the peak emf are related to each other for any series circuit (one-loop circuit) having an ac source. The general name for Z is impedance.

Phase factor

We have seen that the current and the emf are in general, not in phase in an ac circuit. If the emf is $\varepsilon = \varepsilon_0 \sin \omega t$, the corresponding current may be written as $I = i_0 \sin(\omega t + \phi)$.

For a purely resistive circuit, $\phi = 0$; for a purely capacitive circuit, $\phi = \frac{\pi}{2}$ and for a purely inductive circuit, $\phi = -\frac{\pi}{2}$. Constant ϕ is referred to as the phase factor.

Impedance Triangle

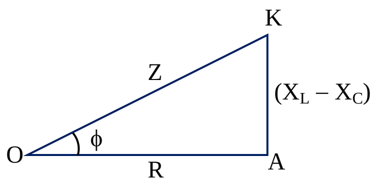
As already stated, R stands for ohmic resistance. It results an account of material of the conductor ($R = \rho\, l/a$).

The reactance (X) is the resistance that arises due to opposing e.m.f. induced due to change in the strength of current. The inductive reactance $X_L = \omega L$ is the resistance offered by the inductor coil. The capacitative reactance $X_C = 1/\omega C$ is the resistance due to the capacitor. As voltage across the inductor leads the current by a phase angle of 90° and voltage across the capacitor lags behind the current by a phase angle of 90°, X_L and X_C have opposite signs. Total reactance can be taken to be $\pm(X_L - X_C)$.

The net opposition to the flow of current offered by the RLC circuit is referred to as impedance. It is represented by Z.

From the three phasors, $\vec{V}_R = \vec{I}_0 R; \vec{V}_L = \vec{I}_0 X_L$ and $\vec{V}_C = \vec{I}_0 X_C$, we define, what is known as *impedance triangle*.

The base OA of this triangle represents ohmic resistance R, the normal AK represents reactance $(X_L - X_C)$ and diagonal OK represents the impedance (Z) of the ac circuit. $A\hat{O}K = \phi$ is the angle by which voltage leads the current in the circuit and called phase angle.

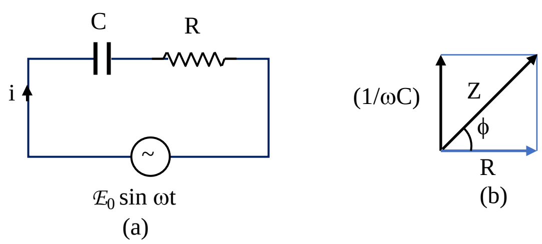


The reciprocal of reactance is called *susceptance* of the ac circuit and reciprocal of impedance is called the admittance. Both, the susceptance and admittance are measured in mho i.e., ohm^{-1}.

Behavior of CR, LR and LCR circuits

CR circuits

The current in a CR circuit can be found by using the vector method. The circuit and the corresponding vector diagram are shown in figure. The resistance is represented by a vector of magnitude R along the x-axis and the capacitive reactance by a vector of magnitude $1/\omega C$ along the positive y-axis. The impedance of the circuit is hence given by the magnitude of the resultant of these two. It is



$$Z = \sqrt{R^2 + \left(\frac{1}{\omega C}\right)^2} \quad \ldots (1)$$

and hence the peak current is $i_0 = \frac{E_0}{Z} = \frac{E_0}{\sqrt{R^2 + \left(\frac{1}{\omega C}\right)^2}}$

The direction of the resultant makes an angle φ with the x-axis where

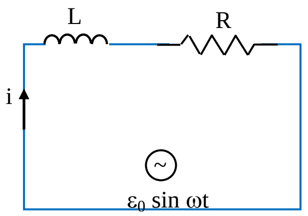
$$\tan\phi = \frac{1}{\omega CR} \qquad \ldots (2)$$

The steady state current in the circuit is $i = \frac{E_0}{Z}\sin(\omega t + \varphi)$

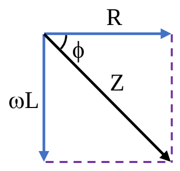
where Z and φ are given by equations (1) and (2).

The reactance of the circuit is $\frac{1}{\omega C}$. It is seen that the current leads the emf.

LR circuit



(a)



(b)

An inductor, a resistor and an ac source connected in series together with its sector diagram is shown above. The resistance is represented by a vector of magnitude R along the X-axis and the inductive reactance by a vector of magnitude ωL along the negative Y- axis. The impedance of the circuit is equal to the magnitude of the resultant of these two.

Its value is

$$Z = \sqrt{R^2 + \omega^2 L^2} \qquad \ldots (1)$$

The resultant is at an angle φ below the X-axis where

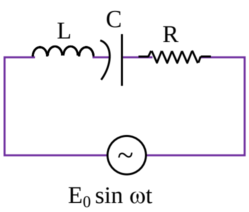
$$\tan\phi = \frac{\omega L}{R}.$$

The current in steady state is given by

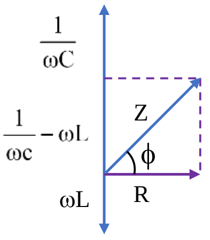
$$i = \frac{\varepsilon_0}{\sqrt{R^2 + \omega^2 L^2}}\sin(\omega t - \phi).$$

where φ is given by equation (ii). The reactance of the circuit is ωL. We see that the current lags behind the emf.

LCR Circuit



(a)



(b)

In this case an inductor, a capacitor and a resistor are connected in series with an AC source and the vector diagram to find the steady-state current is also given.

The resultant of 1/ωC and ωL,

i.e., $X = X_c - X_L = \left(\frac{1}{\omega C} - \omega L\right)$ is along the positive Y-axis

This is the net reactance of the circuit.

The resultant of R and the reactance $\left(\frac{1}{\omega C} - \omega L\right)$ which has a magnitude given by

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

This is the impedance of the circuit. This resultant makes an angle φ with the X-axis given by

$$\tan\phi = \frac{\frac{1}{\omega C} - \omega L}{R}\,. \qquad \ldots (2)$$

ϕ is the phase angle by which the current leads the voltage

The steady –state current in the circuit is given by

$$i = \frac{\varepsilon_0}{\sqrt{R^2 + \left(\frac{1}{\omega C} - \omega L\right)^2}}\sin(\omega t + \phi) \qquad \ldots (3)$$

Power in AC Circuits

Power = voltage × current

The average power delivered by an ac source is

The average power delivered by the source is, therefore,

$$P = \frac{W}{T} = \frac{1}{2}E_0 i_0 \cos\phi = \left(\frac{E_0}{\sqrt{2}}\right)\left(\frac{i_0}{\sqrt{2}}\right)(\cos\phi)$$

$$= E_{rms} i_{rms} \cos\phi \qquad \ldots (1)$$

This equation is obtained for the average power in a complete cycle. It also represents the average power in a complete cycle in a long time.

The term cos φ is called the power factor for the circuit. For a purely resistive circuit, $\varphi = 0$ so that cos $\varphi = 1$ and P = $E_{rms} i_{rms}$. For purely reactive circuits (no resistance, only capacitance and /or inductance), $\phi = \pi/2$ 0r $-\pi/2$. In these cases, cos $\varphi = 0$ and hence no power is absorbed in such circuits.

Wattless current

The current flowing in a circuit with pure inductance and capacitance but with zero resistance, results in zero power consumption and hence called wattles current.

Series resonance circuit

A circuit in which inductance L, capacitance C and resistance R are connected in series, and the circuit allows maximum current corresponding to a given frequency of ac to flow through and is called series resonance circuit.

The impedance (Z) of an RLC circuit is given by

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

At very low frequencies, inductive reactance $X_L = \omega L$ can be neglected, but capacitative reactance ($X_C = 1/\omega C$) is considerable.

As frequency of alternating emf applied to the circuit is increased, X_L goes on increasing and X_C goes on decreasing. For a particular value of ω (= ω_r, say)

we have $X_L = X_C$ i.e., $\omega_r L = \frac{1}{\omega_r C}$ or $\omega_r = \frac{1}{\sqrt{LC}}$

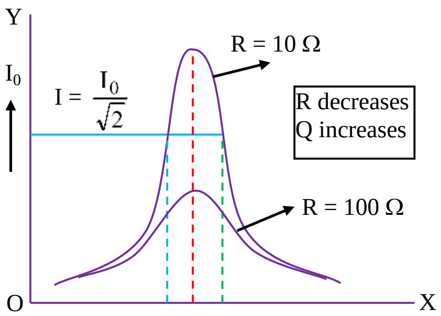
$$2\pi f_r = \frac{1}{\sqrt{LC}} \text{ or } f_r = \frac{1}{2\pi\sqrt{LC}}$$

At this particular frequency f_r, as $X_L = X_C$, therefore, from (1) the impedance becomes

$Z = \sqrt{R^2 + 0} = R$ which is minimum.

When impedance of RLC circuit is minimum the current $I_0 = \frac{E_0}{Z} = \frac{E_0}{R}$ becomes maximum. The corresponding frequency is called resonance frequency. $\frac{1}{2\pi\sqrt{LC}}$ is called the natural frequency of oscillation of an LC circuit containing no resistance.

The variation of circuit current with the changing frequency of applied voltage is shown in figure. It is clear that for frequencies greater than or less than ω_r the values of current are less than the maximum value I_0 of the current.



Further, when $\omega = \omega_r$, maximum current is inversely proportional to R. For lower R values, I_0 is large and vice-versa.

As series resonance circuit allows maximum current to pass through it at a particular frequency, it is called acceptor circuit. The commercial application of series resonance circuit is in radio and TV receiver sets. When signals of several frequencies from different transmitting stations are available, the receiver set picks up signal of that frequency only which matches with the natural frequency of the set.

Quality factor or sharpness of resonance

The characteristic of a series resonant circuit is decided by the Q factor or quality factor of the circuit which defines sharpness of tuning at resonance.

The Q factor of series resonant circuit is the ratio of the voltage developed across the inductance or capacitance at resonance to the impressed voltage, which is the voltage applied across R.

i.e., $Q = \frac{\text{voltage across L or C}}{\text{applied voltage}(=\text{voltage across R})}$

$Q = \frac{(\omega_r L)I}{RI} = \frac{\omega_r L}{R}$ or $Q = \frac{(1/\omega_r C)I}{RI} = \frac{1}{RC\omega_r}$

Using $\omega_r = \frac{1}{\sqrt{LC}}$, we get

$Q = \frac{L}{R}\frac{1}{\sqrt{LC}} = \frac{1}{R}\sqrt{\frac{L}{C}}$ or $Q = \frac{1\sqrt{LC}}{RC} = \frac{1}{R}\sqrt{\frac{L}{C}}$

Thus $Q = \frac{1}{R}\sqrt{\frac{L}{C}}$ … (1)

It is easy to see that Q is just a number.

Thus Q factor can also be taken as voltage multiplication factor of the circuit.

As R is increased, Q factor of the circuit should decrease. The electronic circuits with high Q values would respond to a very narrow range of frequencies and vice-versa. The values of Q usually vary from 10 to 100. However, there are electronic circuits which may have Q = 200. It should be clearly understood that higher the value of Q, the narrower and sharper is the resonance.

LC oscillations

If the resistance R in an LCR circuit is zero, the peak current at resonance is, $i = \frac{E}{\text{zero}}$.

Meaning, there can be a finite current in the pure LC circuit even without any applied emf. This is the case when a charged capacitor is connected to a pure inductor. There is a current in the circuit at frequency $f = \frac{1}{2\pi}\sqrt{\frac{1}{LC}}$.

The capacitor gets discharged driving a current in the inductor and induced emf in the inductor charges the capacitor again. Thus, the energy oscillates between electric field energy in the capacitor and magnetic field energy in the inductor. This phenomenon is called LC oscillation. In practice, these oscillations cannot continue indefinitely because there will always be some resistance in the circuit.

	Mechanical system	Electrical system
1.	Displacement, x	Electric charge, q
2.	Velocity, $v = \frac{dx}{dt}$	Electric current, $I = \frac{dq}{dt}$
3.	Acceleration, $a = \frac{d^2x}{dt^2}$	Rate of variation of electric current $= \frac{d^2q}{dt^2}$
4.	$\frac{d^2x}{dt^2} + \left(\frac{k}{m}\right)x = 0$	$\frac{d^2q}{dt^2} + \left(\frac{1}{LC}\right)q = 0$
5.	Frequency of oscillation, $f = \frac{1}{2\pi}\sqrt{\frac{k}{m}}$	Frequency of oscillation, $f = \frac{1}{2\pi\sqrt{LC}}$
6.	Mass, m	Inductance, L
7.	Spring constant, k	Inverse of capacitance, $\frac{1}{C}$
8.	K.E. stored in mass = $\frac{1}{2}mv^2$	Magnetic energy stored in the inductor $= \frac{1}{2}LI^2$
9.	PE stored in spring $= \frac{1}{2}kx^2$	Electrostatic energy stored in the capacitor $= \frac{1}{2}\frac{q^2}{C}$
10.	Instantaneous displacement, $x = A \sin \omega t$	Instantaneous charge, $q = q_0 \sin \omega t$
11.	Instantaneous velocity, $v = A\omega \cos \omega t$	Instantaneous current in the inductor $I = q_0\omega \cos \omega t$
12.	Maximum velocity of the mass = $A\omega$	Maximum current in the inductor = $q_0\omega$
13.	The law of conservation of energy: $\frac{1}{2}mv^2 + \frac{1}{2}kx^2$ = constant.	The law of conservation of energy: $\frac{1}{2}LI^2 + \frac{1}{2}\frac{q^2}{C}$ = constant.

Electric Generator

An electric generator or a dynamo is a device that converts mechanical energy into electrical energy.
It is based on the principle of electromagnetic induction.

Principle of a Generator

Consider a planar coil of a conducting wire held in a uniform magnetic field $\vec{B}$, with the normal to its plane making an angle θ with $\vec{B}$. The area of the coil is represented by area vector A. If there are N turns in the coil, the magnetic flux linked with the coil is

$$\phi = NAB\cos\theta \qquad \dots (1)$$

When the coil is rotated (about an axis perpendicular to $\vec{B}$) with an angular velocity ω, then at a time t, $\theta = \omega t$

The emf induced in the coil is

$$e = -\frac{d\varphi}{dt} = +NAB\omega \sin \omega t \qquad \dots (2)$$

The voltage across the terminals of the coil is

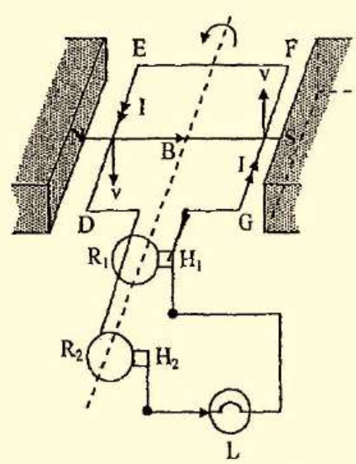
$$V = V_0 \sin \omega t \qquad \dots (3)$$

where $V_0 = NAB\omega$ is the maximum value of voltage developed. From equation (3), we see that an alternating voltage of frequency $f = \frac{\omega}{2\pi}$ and amplitude $V_0 = NAB\omega$ is developed in the coil.

The rotational mechanical energy given to the coil is converted into electrical energy. This voltage is maximum when θ = 90° or the plane of the coil is parallel to the magnetic field.

AC Generator

An ac generator consists of a coil of insulated copper wire wound over a hollow soft iron cylinder (called the armature) is mounted in between the pole pieces N and S of a powerful permanent magnet. The ends of the coil are attached to two rings R_1 and R_2 called slip - rings. Small blocks of carbon H supported by springs make contacts with rings R_1 and R_2. When the coil is rotated from mechanical energy supplied from outside an emf is developed in the coil. When the portion ED is going down, and FG is going up, then according to Flemings right - hand rule (dynamo rule) the induced current flows in the direction GFED, so that R_1 is at a + ve potential and R_2 is at a –ve potential. In the other half of the cycle, R_1 becomes –ve and R_2 becomes +ve. Thus an alternating voltage of frequency equal to that of rotation of the coil is developed between the ends of the coil. If external load of resistance R_L is connected to the contact heads H_1 and H_2 an alternating current flows through the load.



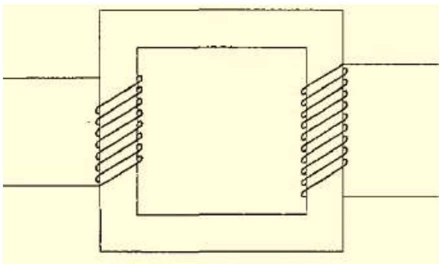
Coil horizontal v 90° to B

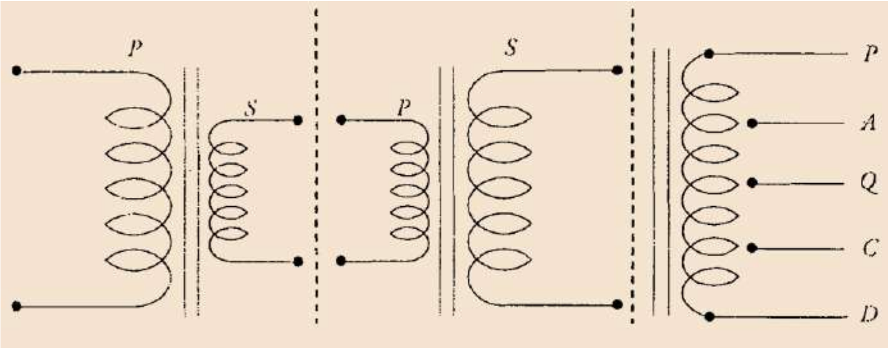
If V_0 is the emf developed in the coil in open circuit and R_a is the resistance of the armature, maximum current drawn from the generator is $I = \frac{v_a}{R_a}$.

Transformer

A transformer is a device to step-up or step-down ac voltage. It works on the principle of mutual induction.

A transformer consists of two coils of insulated wire wound separately over a laminated iron core. The ac voltage to be altered is fed to the primary and the altered ac voltage is obtained across the secondary.


The transformer



(a) Step-down transformer (b) step-up transformer (c) auto transformer

When an alternating current flows in the primary, it sets up a changing magnetic flux which gets linked with the secondary. Let N_S and N_P be the number of turns in the secondary and the primary respectively. 'Then the induced secondary voltage V_S is related to the primary voltage V by the relation.

$$\frac{V_S}{V_P} = \frac{N_S}{N_P} \qquad \ldots (1)$$

The ratio $\frac{N_S}{N_P} = T$ and T is called the turns ratio.

For a step-up transformer, T > 1 as $N_S > N_P$. Hence $V_S > V_P$.

For a step-down transformer, T < 1 as $N_S < N_P$. Hence $V_S < V_P$.

At a power generating station, the voltage is stepped-up using a step-up transformer, while a step- down transformer

is used when power is to be delivered to the consumer.

In an ideal case, assuming that there is no loss of energy in a transformer,

output power = input power

$$I_S V_S = I_P V_P \text{ or } \frac{V_S}{V_S} = \frac{I_P}{I_S} \qquad \ldots (2)$$

Thus, as the voltage across the secondary increases, the current in it falls proportionately.

Energy loss in a transformer

The equation $\frac{V_S}{V_P} = \frac{I_P}{I_S}$ holds good only in the case of an ideal transformer, in which there is no loss of energy. But in an actual transformer, there will be loss of energy due to several reasons.

1. **Loss of energy due to resistance of the windings:** The wires used for the primary and secondary coils have some resistance. Hence some energy is lost due to heat produced in the wire. This loss can be minimised by using wires of proper thickness.
2. **Flux Leakage:** All the magnetic flux from the primary may not pass through the secondary due to improper coupling. This results in some energy loss. This can be minimised by increasing coupling between the coils.
3. **Hysteresis:** As the ferromagnetic core of the transformer is subjected to repeated cycles of magnetisation, some energy is lost due to hysteresis. This can be minimised by using a core material which has low hysteresis loss.
4. **Eddy currents:** The core of the transformer is placed in a region of varying magnetic flux. This results in surface currents known as eddy currents which contribute to some energy loss. This is can be minimised by using a laminated core.

Efficiency of a transformer

A measure of energy loss is done by determining the efficiency of a transformer.

Efficiency = $\eta = \dfrac{\text{Power output}}{\text{Power input}} = \dfrac{V_S I_S}{V_P I_P}$

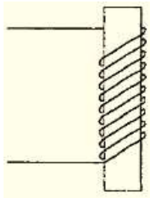
For an ideal transformer, $\eta = 1$

$\therefore V_S I_S = V_P I_P$

For a practical transformer, $\eta < 1$

$\therefore V_S I_S = \eta V_P I_P$.

Choke

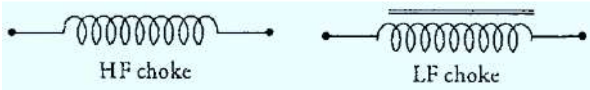

Choke

A choke is an inductance coil of negligible resistance used to control current in ac circuits. It is based on the principle of self induction. A choke coil consists of several turns of a insulated conducting wire of material of low resistivity wound over a laminated soft iron core as in the figure.

The power consumed by a choke is given by $P = V_{rms}\, I_{rms} \cos\phi$ where and V_{rms} and I_{rms} are the rms values of voltage and current respectively and ϕ is the phase difference between V_{rms} and I_{rms}.

In the case of a choke, $\phi \approx \dfrac{\pi}{2}$; $\cos\varphi \approx 0$ i.e., $P \approx 0$. Thus, choke **regulates** the current in AC circuits with minimum power loss. Hence, **chokes are preferred to resistors to limit alternating currents.**

Types of chokes



HF and LF Chokes

A choke of high inductance offers high reactance to the low frequency currents and is called low frequency (LF) choke. LF chokes are usually soft iron core coils.

A variable choke is one whose self inductance can be varied, by changing the length of the soft iron core inside the coil.

The reactance of the choke to the flow of ac is given by $X_L = 2\pi fL$. It depends both on frequency of ac and inductance of the choke. Thus, a choke of small inductance offers high reactance to the flow of high frequency currents is called high frequency (HF) choke. HF chokes are usually air core coils.

Uses of chokes

Chokes are used

1. to control alternating currents, in ac circuits.
2. to separate audio frequency signals from radio waves.
3. as filters in electronic power supply units.
4. to generate high voltage required for working of sodium and mercury vapour lamps.
5. in fluorescent lamps.
6. in tuner circuits in communications.

Illustrations

1. If the voltage applied to an ac circuit is represented by the equation $V = 220\sqrt{2}\sin(314t - \phi)$ the peak value and rms value of the voltage respectively are

(A) 311 V, 220 V (B) 220 V, 311 V (C) 622 V, 220 V (D) 220 V, 622V

Ans (A)

Given equation is $V = 220\sqrt{2}\sin(314t - \phi)$. Comparing this with the equation $V = V_0 \sin(\omega t - \phi)$, peak value is $V_0 = 220\sqrt{2}\,V = 311\,V$

$$V_{rms} = \frac{V_0}{\sqrt{2}} = \frac{220\sqrt{2}}{\sqrt{2}} = 220\ V$$

2. A resistance of 200 Ω and a capacitance of 15.0 μF are connected in series to a 220 V, 50 Hz source. The current in the circuit is

(A) 0.707 A (B) 0.755 A (C) 0.523 A (D) 0.100 A

Ans (B)

$V_{rms} = 220$ V, $\nu = 50$ Hz, $R = 200\ \Omega$, $C = 15\ \mu F$

$i_{rms} = \frac{V_{rms}}{|Z|}$; $\omega = 2\pi\nu = 100\pi$ rad s^{-1}

$X_C = \frac{1}{\omega C} = \frac{1}{100\pi \times 15 \times 10^{-6}} = 212\,\Omega$,

$Z = \sqrt{200^2 + 212^2} = 291.5\ \Omega$; $i_{rms} = \frac{220}{291.5} = 0.755$ A

3. A pure inductance of 1 H is connected across 110 V, 70 Hz source. Find the reactance, and the peak value of current.

(A) 439.6 Ω, 0.354 A (B) 489.7 Ω, 0.423 A (C) 391.2 Ω, 0.372 A (D) 350.0 Ω, 0.472 A

Ans (A)

$L = 1$ H $V_{rms} = 110$ V, $\nu = 70$ Hz ; $\omega = 2\pi\nu = 439.6$ rad s^{-1}

$X_L = \omega L = 439.6 \times 1 = 439.6\ \Omega$

$i_{rms} = \frac{V_{rms}}{X_L} = \frac{110}{439.6} = 0.25\,A$ $\Rightarrow$ $i_0 = i_{rms}\left(\sqrt{2}\right) = 0.354$ A

4. When 100 volt dc is applied across a coil, a current of 1A flows through it. When 100 volt ac of 50 Hz is applied to the same coil 0.5 A flows. The inductance of the coil is

(A) 0.75 H (B) 10.65 H (C) 0.55 H (D) 10.45 H

Ans (C)

When dc is applied $R = \frac{V}{i} = \frac{100}{1} = 100\ \Omega$

When ac is applied, $Z = \frac{V}{i} = \frac{100}{1/2} = 200\ \Omega$

$Z = \sqrt{R^2 + (\omega L)^2} \Rightarrow R^2 + \omega^2 L^2 = Z^2$

$(100)^2 + (2\pi \times 50)^2 L^2 = (200)^2 \Rightarrow L = 0.55$ H

5. A 50 W, 100 V electric lamp is to be operated on 200 V, 50 Hz electric mains. The capacitance required in series with the lamp is

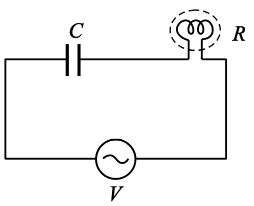
(A) 7.2 μF (B) 8.2 μF (C) 9.2 μF (D) 10.2 μF

Ans (C)

$V^2 = V_R^2 + V_C^2 \Rightarrow V_C = \sqrt{V^2 - V_R^2} = \sqrt{200^2 - 100^2}$ or $V_C = 100\sqrt{3}$ V

In series combination current is same.

Current through the circuit is $i = \frac{P}{V} = \frac{50\text{ W}}{100\text{ V}} = 0.5\,A$



$X_C = \frac{V_C}{i} = \frac{100\sqrt{3}}{0.5} = 200\sqrt{3}\ \Omega$

$X_C = \frac{1}{\omega C} = \frac{1}{2\pi f C} \Rightarrow C = \frac{1}{2\pi f X_C} = \frac{1}{2\pi(50)\left(200\sqrt{3}\right)} = 9.2\ \mu F$

6. An alternating emf of frequency 50 Hz is applied to a series circuit of resistance 20 Ω, an inductance of 100 mH and a capacitance of 30 μF. Then

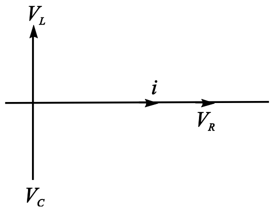
(A) voltage leads the current by $\tan^{-1}$ (3.73) (B) current leads the applied voltage by $\tan^{-1}$ (3.73)

(C) voltage leads the current by $\tan^{-1}(1.73)$ (D) current leads the applied voltage by $\tan^{-1}(1.73)$

Ans (B)

$$X_L = \omega L = 2\pi\nu L = 2\pi\times 50\times 0.1 = 31.4\ \Omega$$

$$X_C = \frac{1}{\omega C} = \frac{1}{2\pi\nu C} = \frac{1}{2\pi\times 50\times 30\times 10^{-6}} = 106.1\ \Omega$$



$X_C > X_L \quad \therefore V_C > V_L$

$\therefore V_{net}$ is lagging behind current I, $X = X_C - X_L = 74.7\ \Omega$

$$\phi = \tan^{-1}\left(\frac{X}{R}\right) = \tan^{-1}\left(\frac{74.7}{20}\right) = \tan^{-1}(3.73)$$

7. A capacitor of 10 μF and an inductor of 1H are joined in series. An ac of 50 Hz is applied to this combination. The impedance of the combination is

(A) 5.67 Ω (B) 4.16 Ω (C) 7.02 Ω (D) 3.21 Ω

Ans (B)

$X_L = \omega L = 2\pi\nu L = 2\pi \times 50 \times 1 = 100\pi\ \Omega$

$$X_C = \frac{1}{\omega C} = \frac{1}{2\pi\nu C} = \frac{1}{2\pi\times 50\times 10\times 10^{-6}} = 318.31\ \Omega$$

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

$$= \sqrt{0^2 + (100\pi - 318.31)^2} = 4.16\ \Omega$$

8. A 60 Hz, 230 V rms voltage is applied on an inductance of 0.265 H. At t = 0, voltage is also zero. The equation for voltage is

(A) 230 sin 12 πt (B) $230\sqrt{2}\sin 60\pi t$ (C) $\frac{230}{\sqrt{2}}\sin 60\pi t$ (D) $230\sqrt{2}\sin 120\pi t$

Ans (D)

$$V_0 = \sqrt{2}\ V_{rms} = 230\sqrt{2}\ V$$

$$\omega = 2\pi\nu = 2\pi(60) = 120\pi \text{ rad s}^{-1}$$

$$V = V_0\sin\omega t = 230\sqrt{2} \sin 120\ \pi t \text{ volt}$$

9. An LCR series circuit with 100 Ω resistance is connected to an ac source of 200 V and angular frequency 300 rad s^{-1}. When only the capacitance is removed, the current lags behind the voltage by 60°. When only the inductance is removed, the current leads the voltage by 60°. Calculate the current in LCR circuit

(A) 2 A (B) 2.5 A (C) 3 A (D) 1.75 A

Ans (A)

When capacitance is removed, the circuit becomes L – R circuit

$$\tan\phi_1 = \frac{X_L}{R} \Rightarrow X_L = R\tan\phi_1 = 100\sqrt{3}\ \Omega$$

When inductance is removed, the circuit becomes C – R circuit

$$\tan\phi_2 = \frac{X_C}{R} \Rightarrow X_C = R\tan\phi_2 = 100\sqrt{3}\ \Omega$$

$X_L = X_C \Rightarrow$ the LCR circuit is in resonance

$$\therefore i_{rms} = \frac{V_{rms}}{Z} = \frac{V_{rms}}{R} = \frac{200}{100} = 2\text{ A}$$

10. A series LCR circuit containing a resistance of 120 Ω has resonance frequency 4×10^5 rad s^{-1}. The voltages, at resonance, across resistance and inductance are 60 V and 40 V respectively. The values of L and C respectively are

(A) 0.3 mH, 0.0195 μF (B) 0.1 mH, 0.4525 μF

(C) 0.2 mH, 0.03125 μF (D) 0.4 mH, 0.5125 μF

Ans (C)

At resonance $X_L = X_C, i = \frac{V_R}{R} = \frac{60}{120} = 0.5A$

$$V_L = iX_L = i\omega_0 L \Rightarrow L = \frac{V_L}{i\omega_0} = \frac{40}{0.5\times4\times10^5} = 0.2\text{ mH}$$

$$\omega_0 = \frac{1}{\sqrt{LC}} \Rightarrow C = \frac{1}{L\omega_0^2} = \frac{1}{0.2\times10^{-3}\times(4\times10^5)^2}$$

$$= \frac{1}{32}\mu F = 0.03125\ \mu F$$

11. An LCR circuit has inductance 10 mH resistance 3 Ω and capacitance 1 μF connected in series to a source of V = 15 cos ωt volt. The current amplitude, at a frequency that is 10 % lower than the resonance frequency, is

(A) 0.611 A (B) 0.523 A (C) 0.704 A (D) 0.821 A

Ans (C)

$$\omega_0 = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{10^{-2}\times10^{-6}}} = 10^4\text{ rad s}^{-1}$$

$$\therefore \omega = \omega_0 - 10\%\text{ of }\omega_0 = 10^4 - \frac{10}{100}\times10^4$$

$$= 9\times10^3\text{ rad s}^{-1}$$

$X_L = \omega L = 9\times10^3\times10^{-2} = 90\ \Omega$ and ; $X_C = \frac{1}{\omega C} = \frac{1}{9\times10^3\times10^{-6}} = 111.11\ \Omega$

$X = X_C - X_L = 111.11 - 90 = 21.11\ \Omega$

$Z = \sqrt{R^2 + X^2} = \sqrt{3^2 + (21.11)^2} = 21.32\ \Omega$; $i_0 = \frac{V_0}{Z} = \frac{15}{21.32} = 0.704$ A

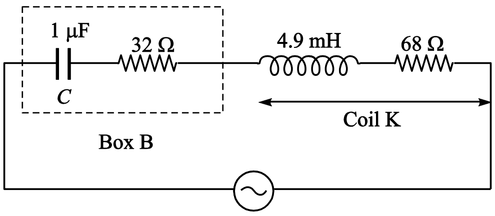
12. A box B and a coil K are connected in series, with an ac source of variable frequency. The peak emf of source is constant and 10 V. Box B contains a capacitance of 1 μF in series with a resistance of 32 Ω. Coil K has self inductance 4.9 mH and a resistance of 68 Ω. The frequency is adjusted so that the maximum current flows in B and K. Find the impedance of B at this frequency

(A) 88 Ω (B) 99 Ω (C) 66 Ω (D) 77 Ω

Ans (D)

In this LCR circuit, current is maximum. Hence it is in resonance.

$$\therefore \omega = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{4.9\times10^{-3}\times1\times10^{-6}}} = \frac{10^5}{7}\text{ rad s}^{-1}$$



$\therefore$ Impedance of B is $Z_B = \sqrt{R_1^2 + \left(\frac{1}{\omega C}\right)^2}$

or $Z_B = \sqrt{(32)^2 + \left(\frac{7}{10^5\times10^{-6}}\right)^2} = 77\ \Omega$

13. A current 4 A flows in a coil when connected to a 12 V dc source. If the same coil is connected to a 12 V ac source ($\omega = 50$ rad s^{-1}) a current of 2.4 A flows in the circuit. The inductance of the coil is

(A) 80 mΩ (B) 90 mΩ (C) 60 mΩ (D) 72 mΩ

Ans (A)

$Z = \sqrt{R^2 + \omega^2 L^2}$ and $i = \frac{V}{Z} \Rightarrow i = \frac{V}{\sqrt{R^2 + \omega^2 L^2}}$

When dc is applied $i = \frac{V}{R}$ [$\because$ ω = 0]

i.e., $R = \frac{12}{4} = 3\Omega$

When ac is applied $Z = \frac{V}{i} = \frac{12}{2.4} = 5\Omega$

$R^2 + \omega^2L^2 = Z^2 \Rightarrow 3^2 + (50)^2L^2 = 5^2$

$\Rightarrow L = 0.08\ \Omega = 80\ m\Omega$

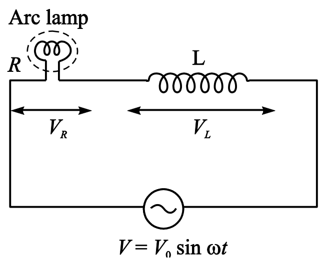
14. A choke coil is needed to operate an arc lamp at 160 V (rms) and 50 Hz. The arc lamp has an effective resistance of 5 Ω when running at 10 A (rms). The inductance of the choke coil is

(A) 67.8 mH (B) 48.4 mH (C) 71.2 mH (D) 53.5 mH

Ans (B)

For lamp $V_R = 10 \times 5 = 50$ V

When lamp is connected to 160 V ac source through a choke in series,



$V^2 = V_R^2 + V_L^2 \Rightarrow V_L = \sqrt{160^2 - 50^2} = 152$ V

$V_L = iX_L = i(2\pi\nu)L$

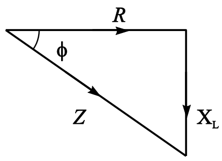
$\Rightarrow L = \frac{V_L}{i \times 2\pi\nu} = \frac{152}{10 \times 2\pi \times 50} = 0.0484$ H

15. An ac circuit draws 550 W power from a 220 V, 50 Hz source. The power factor is 0.8, with the current lagging behind the applied voltage. The capacitance required to be connected in series with this circuit, to increase the power factor to 1.0, is

(A) 85.4 μF (B) 75.4 μF (C) 65.4 μF (D) 55.4 μF

Ans (B)

$P = V_{rms}\ i_{rms}\ \cos\phi = \frac{V_{rms}^2}{Z}\cos\phi$



$Z = \frac{V_{rms}^2}{P}.\cos\phi = \frac{(220)^2}{(550)}(0.8)$

$Z = 70.4\ \Omega$

$\cos\phi = 0.8$, so $\sin\phi = \sqrt{1-(0.8)^2} = 0.6$

$X_L = Z\sin\phi = 70.4 \times 0.6 = 42.24\ \Omega$

For the power factor to become 1.0, new phase angle $\phi' = 0$. This can be achieved by introducing a suitable capacitive reactance X_C, such that $X_C = X_L$.

$\therefore X_C = \frac{1}{\omega C} = 42.24\ \Omega \Rightarrow C = \frac{1}{2\pi(50)(42.24)} = 75.4\ \mu F$

16. A 750 Hz, 20 V source is connected to a resistance of 100 Ω, an inductance of 0.1803 H and a capacitance of 10 μF all in series. If thermal capacity of resistor is 2 J°C^{-1}, the time in which the resistor will get heated by 10 °C is

(A) 5.8 min (B) 6.8 min (C) 4.8 min (D) 7.8 min

Ans (A)

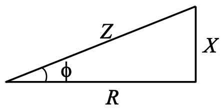
$X_L = \omega L = 2\pi\nu L = 2\pi \times 750 \times 0.1803 = 849.2\ \Omega$

$X_C = \frac{1}{\omega C} = \frac{1}{2\pi\nu C} = \frac{1}{2\pi \times 750 \times 10 \times 10^{-6}} = 21.23\ \Omega$

$X = X_L - X_C = 849.2 - 21.23 = 828\ \Omega$

$\therefore Z = \sqrt{R^2 + X^2} = \sqrt{(100)^2 + (828)^2} = 834\ \Omega$

In case of ac, $P_{av} = V_{rms}\ i_{rms}\ \cos\phi$



or $P_{av} = V_{rms}\left(\frac{V_{rms}}{Z}\right)\left(\frac{R}{Z}\right) = \left(\frac{V_{rms}}{Z}\right)^2.R$

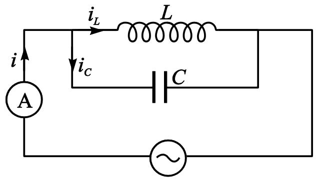
or $P_{av} = \left(\frac{20}{834}\right)^2 \times 100 = 0.0575$ W

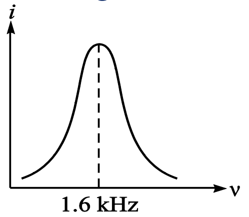
Thermal capacity is mc = 2 J °C^{-1} and Q = Pt

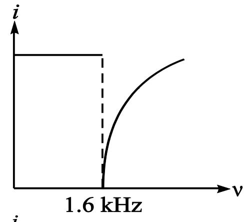
$\Rightarrow$ mc $\Delta\theta$ = Pt

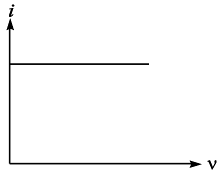
$$t = \frac{mc\Delta\theta}{P} = \frac{2\times 10}{0.0575} = 348\,s = 5.8\,\text{min}$$

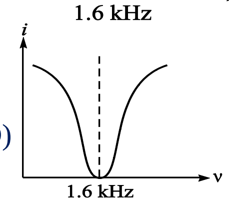
17. An L – C circuit (L = 0.01 H, C = 1 μF) is connected to a variable frequency source as shown in the figure. The best sketch that represents the current variation as the frequency is changed from 1 kHz to 2 kHz is



(A)


(B)


(C)


(D)


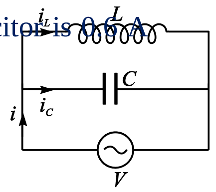
Ans (D)

Here, L and C are connected in parallel to the ac source, so resonance frequency is

$$\nu = \frac{1}{2\pi\sqrt{LC}} = \frac{1}{2\pi\sqrt{0.01\times 10^{-6}}} = 1.6\,\text{kHz}$$

In case of parallel resonance, current in LC circuit at resonance is zero.

18. For the circuit shown in figure, current in the inductor is 0.8 A and in the capacitor is 0.6 A (both peak values). The current (peak) drawn from the source is



(A) 0.1 A (B) 0.2 A

(C) 0.3 A (D) 0.4 A

Ans (B)

$$i_L = \frac{V}{X_L}\sin\left(\omega t - \frac{\pi}{L}\right) = -0.8\cos\omega t \text{ and}$$

$$i_C = \frac{V}{X_C}\sin\left(\omega t + \frac{\pi}{2}\right) = +0.6\cos\omega t$$

So the current drawn from the source is $i = i_L + i_C = -0.2\cos\omega t$

$\therefore |i_0| = 0.2A$

19. A series LCR circuit contains a 50 Ω resistance, $\frac{2}{\pi}$H inductance and $\frac{800}{19\pi}$ μF capacitance connected across a 220 V, 50 Hz ac source. The net reactance of the circuit is

(A) 200 Ω (B) 237.5 Ω (C) 37.5 Ω (D) 50 Ω

Ans (C)

$$X_L = \omega L = 2\pi\nu L = (100\pi)\left(\frac{2}{\pi}\right) = 200\ \Omega$$

$$X_C = \frac{1}{\omega C} = \frac{19\pi}{2\pi\times 50\times 800\times 10^{-6}} = 237.5\ \Omega$$

Net reactance is $X = X_C - X_L = 237.5 - 200 = 37.5\ \Omega$

20. The transformer ratio $\left(\frac{N_S}{N_P}\right)$ of a transformer is 50. The input power across the primary at 220 V is 17.6 kW. The resistance of the secondary coil is 3.7 Ω. If the efficiency is 80%, the rate of heat loss in the secondary is

(A) 4.06 W (B) 7.06 W (C) 5.06 W (D) 6.06 W

Ans (D)

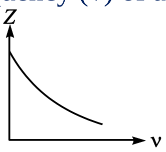
Output power across secondary coil = 80% of 17.6 kW = 14.08 kW

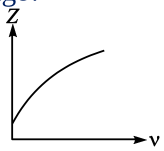
Output voltage is $V_S = \frac{N_S}{N_P}.V_P = 50 \times 220 = 11000$ V

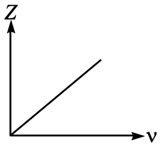
Current through the secondary is $i_S = \frac{\text{output power}}{V_S} = \frac{14.08 \times 10^3}{11000} = 1.28$ A

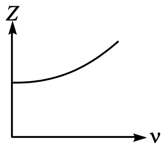
Rate of heat loss = $i_S^2 R_S = (1.28)^2 (3.7) = 6.06$ W

21. Which of the following graphs shown, correctly represents the variation of impedance Z of an L – R circuit with frequency (ν) of applied voltage?

(A) 

(B) 

(C) 

(D) 

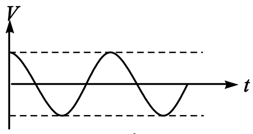
Ans (D)

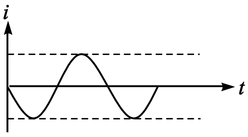
$$Z = \sqrt{R^2 + X_L^2} = \sqrt{R^2 + (2\pi\nu)^2 L^2}$$

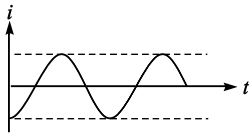
$$Z^2 - 4\pi^2\nu^2L^2 = R^2 \Rightarrow \frac{Z^2}{R^2} - \frac{\nu^2}{\left(\frac{R^2}{4\pi^2L^2}\right)} = 1 \quad \Rightarrow \frac{Z^2}{(R)^2} - \frac{\nu^2}{\left(\frac{R}{2\pi L}\right)^2} = 1$$

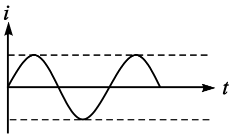
This is the equation of a hyperbola

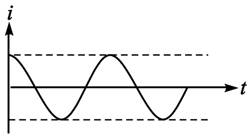
22. The variation of voltage across a pure capacitor with time is represented in figure. Which of the graphs shown represents variation of current with time?



(A) 

(B) 

(C) 

(D) 

Ans (A)

From the graph given, $V = V_0 \cos \omega t$.

$$q = CV = CV_0 \cos\omega t \Rightarrow \frac{dq}{dt} = -V_0 C\omega \sin\omega t$$

or $$i = -\frac{V_0}{\left(\frac{1}{\omega C}\right)} \sin\omega t$$

∴ correct option is (A)

23. The equations of voltage and current corresponding to a series L–C–R circuit are V = 141.4 sin (3000 t) volt and i = $5\ \cos\left(3000t-\frac{\pi}{4}\right)$ ampere respectively. If the inductance is 10 mH, the resistance is

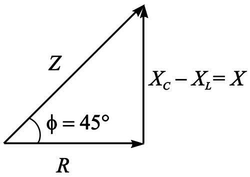
(A) 20 Ω (B) 10 Ω (C) 30 Ω (D) 40 Ω

Ans (A)

$$i=5\ \sin\left[3000t-\frac{\pi}{4}+\frac{\pi}{2}\right]=5\sin\left[3000t+\frac{\pi}{4}\right]$$

$$V=141.4\sin(3000\,t)$$

$\therefore$ Phase difference, $\phi=\frac{\pi}{4}$



Impedance triangle is

From figure $X=R;\ \therefore Z=\sqrt{R^2+R^2}=R\sqrt{2}$

Also $Z=\frac{V_0}{i_0}=\frac{141.4}{5}=20\sqrt{2}\,\Omega\ \therefore\ R\sqrt{2}=20\sqrt{2}\Rightarrow R=20\ \Omega$

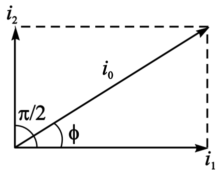
24. A current depends on time (t) as

$i = i_1 \sin \omega t + i_2 \cos \omega t$. What is its rms value for one complete cycle?

(A) $\sqrt{i_1 i_2}$ (B) $\sqrt{\frac{i_1^2+i_2^2}{2}}$ (C) $\sqrt{\frac{i_1^2+i_2^2}{3}}$ (D) $\sqrt{\frac{i_1^2-i_2^2}{2}}$

Ans (B)

$$i=i_1\sin\omega t+i_2\sin\left(\omega t+\frac{\pi}{2}\right)$$



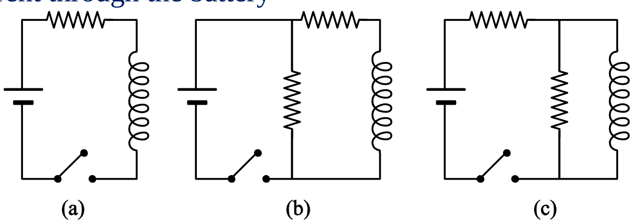
$$i_0=\sqrt{i_1^2+i_2^2+2i_1i_2\cos\frac{\pi}{2}}=\sqrt{i_1^2+i_2^2}$$

$$\phi=\tan^{-1}\left(\frac{i_2}{i_1}\right)\quad \therefore i=i_0\sin(\omega t+\phi);\ i^2=i_0^2\sin^2(\omega t+\phi)$$

Average value of $\sin^2(\omega t+\phi)$ for one complete cycle is $\frac{1}{2}\ \therefore\langle i^2\rangle=i_0^2\left(\frac{1}{2}\right)=\frac{i_1^2+i_2^2}{2}$

$$i_{rms}=\sqrt{\langle i^2\rangle}=\sqrt{\frac{i_1^2+i_2^2}{2}}$$

25. The figure shows three circuits with identical batteries, inductors (L), and resistors (R). Rank the circuit in the decreasing order, of the current through the battery



(i) Just after the switch is closed and

(ii) A long time after the switch is closed

(A) (i) $i_b>i_c>i_a(i_a=0)$ (ii) $i_b>i_c=i_a$ (B) (i) $i_b>i_c<i_a(i_a\neq0)$ (ii) $i_b>i_c>i_a$

(C) (i) $i_b=i_c=i_a(i_a=0)$ (ii) $i_b<i_c<i_a$ (D) (i) $i_b=i_c>i_a(i_a\neq0)$ (ii) $i_b>i_c>i_a$

Ans (A)

(a) Initially $i_a=0$ and after a long time $i_a=\frac{\varepsilon}{R}$

(b) Initially $i_b = \frac{\varepsilon}{R}$ and after a long time $i_b = \frac{\varepsilon}{\left(\frac{R}{2}\right)}$

(c) Initially $i_c = \frac{\varepsilon}{2R}$ and after a long time $i_c = \frac{\varepsilon}{R}$

26. In an oscillating LC circuit [L = 50 mH and C = 4 μF], the current is initially maximum. How long will it take before the capacitor is fully discharged for the first time?

(A) 0.5 ms (B) 0.6 ms (C) 0.7 ms (D) 0.8 ms

Ans (C)

$$T = 2\pi\sqrt{LC} = 2\pi\sqrt{50\times10^{-3}\times4\times10^{-6}} = 28\times10^{-4}s$$

Required time $= \frac{T}{4} = 7\times10^{-4}s$

Each of the following questions consists of a statement–I and a Statement–II. Examine both of them and select one of the options using the following codes

(A) Statement-I and Statement-II are true and Statement-II is the correct explanation of Statement-I.

(B) Statement-I and Statement-II are true, but Statement-II is not the correct explanation of Statement -I

(C) Statement-I is true, but Statement -II is false

(D) Statement-I is false, but Statement -II is true

1. **Statement I:** An alternating current is the current in which the magnitude of the current changes alternately.

Statement II: An alternating current is the current in which both the magnitude and direction of current changes alternately.

Ans (D)

2. **Statement I:** In a pure inductive circuit the current lags behind the applied ac emf by $\pi/2$.

Statement II: In a pure capacitive circuit the current lags behind the applied ac emf by $\pi/2$.

Ans (C)

3. **Statement I:** The average power dissipated through a pure inductor is zero.

Statement II: The inductive reactance is directly proportional to the frequency of ac.

Ans (B)

4. **Statement I:** With the increase in frequency of ac the impendence of a series LCR circuit first decreases, reaches a minimum and then increases.

Statement II: With the increase in frequency of ac the impendence of a series LCR circuit first increases, reaches a maximum and then decreases.

Ans (C)

5. **Statement I:** An ac circuit has a resistance and a high inductance. Its power factor is high.

Statement II: An ac circuit has a resistance and a high inductance. Its power factor is low.

Ans (D)

6. **Statement I:** At low frequencies, an inductor offers high resistance to the flow of ac.

Statement II: At low frequencies, an inductor offers low resistance to the flow of ac.

Ans (D)

7. **Statement I:** The potential difference across an inductor depends on the current passing through it.

Statement II: The potential difference across an inductor depends on the rate of change of current passing through it.

Ans (D)

8. **Statement I:** In a LC oscillating system, the capacitance is the electrical analogue of spring.

Statement II: In an LC oscillating system, the inductor is the electrical analogue of spring.

Ans (C)

NCERT LINE BY LINE QUESTIONS

1. A $\frac{10}{\pi}\mu F$ capacitor is connected to a 200 V, 50 Hz ac source. The capacitive reactance of the circuit is [NCERT Pg. 242]

(1) 1000 Ω (2) 500 Ω (3) 212 Ω (4) 100 Ω

2. A light bulb is rated at 100 W for a 220 V, 50 Hz supply. The rms current through the bulb is [NCERT Pg. 236]

(1) $\frac{5}{110}$ A (2) $\frac{5}{11}$ A (3) $\frac{3}{11}$ A (4) $\frac{4}{11}$ A

3. An ac signal (sinusoidal) output from a device is shown in the figure. The average value and rms value respectively in the given case are [NCERT Pg. 235]

(1) $\frac{I_0}{\pi}, \frac{I_0}{\sqrt{2}}$ (2) $\frac{2I_0}{\pi}, \frac{I_0}{\sqrt{2}}$ (3) $\frac{2I_0}{\pi}, \frac{I_0}{2}$ (4) $\frac{I_0}{\pi}, \frac{I_0}{2}$

4. The instantaneous values of alternating current and voltage in an ac circuit are given $i = \frac{1}{\sqrt{2}}\sin(100\pi t)A$ and $\varepsilon = \sqrt{2}\sin\left(100\pi t + \frac{\pi}{3}\right)V$. The average power dissipated through the circuit is (NCERT Pg. 252]

(1) $\frac{\sqrt{3}}{2}$ W (2) $\frac{1}{4}$ W (3) $\frac{1}{8}$ W (4) $\frac{\sqrt{3}}{4}$ W

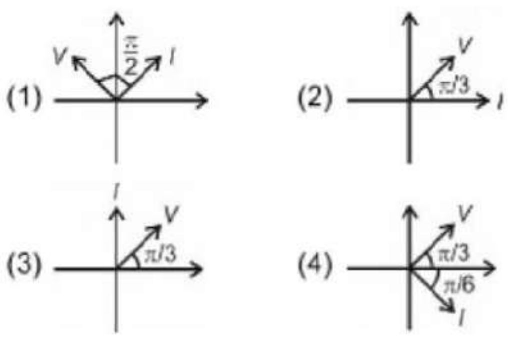
5. For a series LCR circuit, the power dissipated at resonance is [NCERT Pg 252]

(1) $\frac{v^2}{(X_L - X_C)}$ (2) $I^2\omega L$ (3) $I^2(X_L - X_C)$ (4) $I_{rms}^2 R$

6. The primary winding of a transformer has 200 turns whereas its secondary winding has 2000 turns. If the primary is connected to an ac Source of 20 V and 60 Hz, then secondary will have output of [NCERT Pg. 261]

(1) 200 V and 6 Hz (2) 2 V and 60 Hz
(3) 200 V and 60 Hz (4) 2 V and 6 Hz

7. An ac supply is connected across a series LCR circuit. If capacitor is removed then which of the following phasor diagram may be correct? [NCERT Pg. 245]



8. The analogue of displacement x in mechanical system (spring block) is P in electrical system (LC oscillation). Then P is [NCERT Pg. 257]

(1) Inductance (L) (2) Charge (q)
(3) Current (I) (4) Capacitance (C)

9. A capacitor (C), initially charged upto q_m is connected to an inductor (L). The differential equation of LC oscillator is (NCERT Pg. 255]

(a) $\frac{d^2q}{dt^2}+q=0$ (b) $\frac{dq}{dt}+q=0$

(c) $\frac{dq}{dt}+\frac{q}{LC}=0$ (d) $\frac{d^2q}{dt^2}+\frac{q}{LC}=0$

10. For pure resistive ac circuit the phase angle between voltage and current and power factor are respectively. [NCERT Pg. 252]

(1) 0°,1 (2) 0°,0 (3) 90°, 1 (4) 90°, 0

11. A resistor of $100\,\Omega$ is connected in series with series combination of inductor and capacitor. If X_L and Xc are the reactances of inductor and capacitor respectively, then reactance of circuit will be [NCERT Pg. 245]

(1) $|X_L+X_C|$ (2) $|X_L-X_C|$ (3) $\sqrt{X_L^2+X_C^2}$ (4) $\sqrt{X_L X_C}$

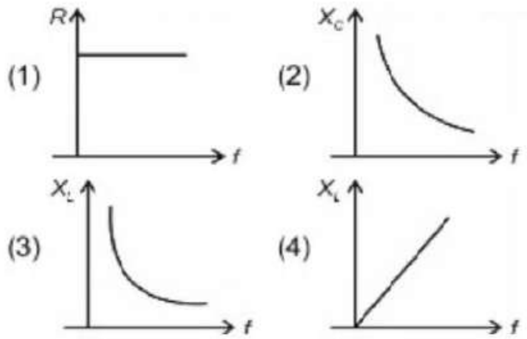
12. The quantity which measures the sharpness of resonance is [NCERT Pg, 249]

(1) Quality factor (2) Peak factor (3) Form factor (4) Ripple factor

13. A steady current of 2 A flowing through a resistor produces a heat of 100 W. To produce a heat of 400 W by supplying an ac current through the same circuit, the value of peak current will be [NCERT Pg. 235]

(1) 4 A (2) 5.6 A (3) 2.8 A (4) 8 A

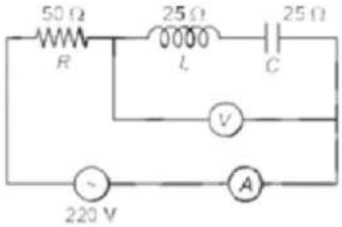
14 The variation of impedance of an ac circuit (having one of the element) with frequency of source is given for different elements. Choose the incorrect plot. (NCERT Pg. 246)



15. Consider a series LCR circuit in which reactance and resistance are 100 each. When the circuit is connected to ac source 220 V, 50 Hz, then current drawn from the source is (NCERT Pg. 245)

(1) $2.2\sqrt{2}$A (2) $1.1\sqrt{2}$A (3) $3.3\sqrt{2}$A (4) 2.2A

16. In the circuit shown in the figure. The voltmeter and ammeter reading will respectively be (source, voltmeter and ammeter are ideal) (NCERT Pg. 245]



1) $0V, 2\sqrt{2}A$ 2) $0V, 4.4A$ 3) $110V, 2\sqrt{2}A$ 4) $110V, 3A$

17. In an oscillating L-C circuit, Q_m is the maximum charge on the capacitor. If at any time, the energy stored in capacitor and Inductor are equal, then charge stored on the capacitor at that instant is [NCERT Pg. 256]

1) $\frac{Q_m}{\sqrt{2}}$ 2) $\frac{Q_m}{2}$ 3) $\frac{Q_m}{3}$ 4) $\frac{Q_m}{\sqrt{3}}$

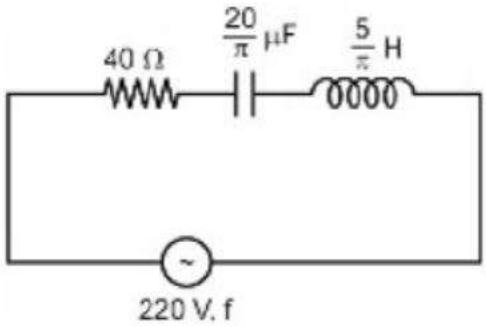
18. For an ideal transformer, which of the following option is correct?
(Symbols have their usual meaning) [NCERT Pg. 261]

1) $\frac{I_S}{I_P}=\frac{N_S}{N_P}$ 2) $\frac{I_S}{I_P}=\frac{V_S}{V_P}$ 3) $V_SI_S=V_PI_P$ 4) $\frac{V_S}{V_P}=\frac{N_P}{N_S}$

19. A radio can tune over the frequency range (800 - 1200) kHz. If LC circuit has an effective inductance of 200 μH- What should be the range of its variable capacitor? [NCERT Pg. 266]

(1) 100 pF - 280 pF (2) 88 pF - 198 pF
(3) 4C pF - 80 pF (4) 200 pF - 400 pF

20. The figure shows a series *LCR* circuit connected to a variable frequency and 220 V source. The source frequency which drives the circuit in resonance will be [NCERT Pg. 248]



(1) 25Hz (2) 100Hz
(3) 50 Hz (4) 80Hz

NCERT BASED PRACTICE QUESTIONS

1. r.m.s. value of A.C. is defined in terms of

(1) heating effect of current (2) chemical effect of current
(3) magnetic effect of current (4) none of these

2. An applied voltage signal consists of a superposition of a d.c. voltage and an a.c. voltage of high frequency. The circuit consists of an inductor and a capacitor in series, then :

(1) d.c. signal will appear across L and C
(2) d.c. signal will appear across C and a.c. signal across L.
(3) d.c. signal will appear across L and a.c. signal across C
(4) across L and C a.c. signal will appears

3. Which is true for a.c.

(1) r.m.s value is non-zero (2) average values is zero
(3) instantaneous values may be zero (4) All of above

4. Circuits used for transporting electric power, requires :

(1) low power factor (2) high power factor
(3) zero power factor (4) any values of power factor

5. More selective a.c. circuit should have :

(1) low R, high L (2) low R, low L (3) high R, high L (4) high R, low L

6. Metal detector works on principle of
(1) Newton's third law
(2) Resonance in a.c. circuit
(3) heating effect of current
(4) electrostatic shielding effect

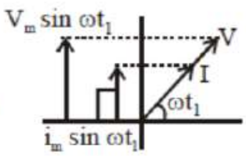
7. Which is true for series R-L-C circuit :
(1) The power rating of an element used in a.c. circuit refers to its average power rating.
(2) The power consumed in an a.c. circuit is never negative
(3) The power factor in a R-L-C circuit is a measure of how close the circuit is to expanding the maximum power.
(4) All

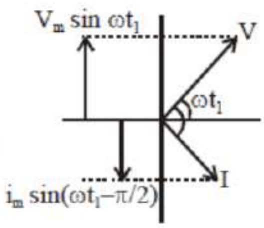
8. A choke coil is used for limiting current in
(1) dc circuit only
(2) ac circuit only
(3) in both ac and dc
(4) electronic valves

9. Ohm's law expressed as V = IR
(1) may never be applied to ac
(2) applied to ac in the same manner as to dc.
(3) always applies to ac circuits when z is substituted for R
(4) tell us that $V_{eff} = 0.707\ V_{max}$ for ac

10. To express AC power in the same from as DC power, a special value of current is defined and used, is called
(1) root mean square current (Irms)
(2) effective current
(3) induced current
(4) both (1) and (2)

11. Which of the following figure shows that the current phasor I is $\frac{\pi}{2}$ behind the voltage phasor V.

(1)


(2)


(3) Both (1) and (2)
(4) Neither (1) nor (2)

12. Equation $\frac{di}{dt} = \frac{V}{L} = \frac{V_m}{L} \sin \omega t$ implies that the equation for i(t), the current as a function of time, must be such that
(1) its slope $\frac{di}{dt}$ is a sinusoidally varying quantity with the same phase as the source voltage
(2) an amplitude given by $\frac{V_m}{\omega L}$
(3) Both (1) and (2)

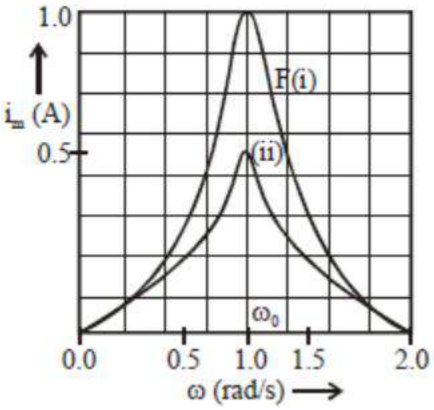
(4) Neither (1) nor (2)

13. The phenomenon of resonance is common among system that have a tendency

(1) to oscillate at a particular frequency (2) to get maximum amplitude

(3) Both (1) and (2) (4) Neither (1) and (2)

14. Figure shows the variation of i_m with ω in a



(1) R–L–C circuit (2) R–L circuit (3) R–C circuit (4) None of these

15. In tuning we vary the capacitance of a capacitor in the tuning circuit such that the resonant frequency of the circuit becomes nearly equal to the frequency of the radio signal received. When this happens, the ......A...... with the frequency of the signal of the particular radio station in the circuit is maximum. Here, A refers to

(1) Resonant frequency (2) Impedance

(3) Amplitude of the current (4) Reactance

16. An alternating emf of frequency $v = \left(\frac{1}{2\pi\sqrt{LC}}\right)$ is applied to a series L–C–R circuit. For the frequency of the applied emf

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

(2) The current in the circuit is in phase with the applied emf and voltage across R equals the applied emf.

(3) the sum of the potential difference across the inductance and capacitance equals the applied emf which is 180° ahead of phase of the current in the circuit

(4) the quality factor of the circuit is $\frac{\omega L}{R}$ or $\frac{1}{\omega CR}$ and this is measure of the voltage magnification (produced by the circuit) at resonance as well as the sharpness of resonance of the circuit

17. A value of w for which the current amplitude is $\frac{1}{\sqrt{2}}$ times its maximum value. At this value the power dissipated by the circuit becomes

(1) double (2) one-fourth (3) one-third (4) half

18. When a capacitor (initially charged) is connected to a inductor, the change on the capacitor and the current in the circuit exhibit the phenomenon of

(1) electrical oscillations (2) induction

(3) power factor (4) All of these

19. Choose the incorrect

(1) Phasor diagram say nothing about the initial condition

(2) Any arbitrary value of t, draw different phasor which show the relative angle between different phasors. The solution, so obtained is called the steady-state solution

(3) We do have a transient solution which exists even for v = 0. The general solution is the sum of transient solution and the steady state solution

(4) None of the above

20. Choose the **INCORRECT** options

(1) If the resonance is less sharp, not only is the maximum current less, the circuit is close to resonance for a larger range of frequencies and the tuning of the circuit will not be good.

(2) Less sharp the resonance less is the selectivity of the circuit or vice-versa

(3) If quality factor is large i.e. R is low or L is large the circuit is more selective

(4) None of the above

21. L–C oscillation is not realistic for the following reasons. Which of following reasons is **INCORRECT**?

(1) Every inductor has some resistance

(2) The effect of resistance is to introduce a damping effect on the charge and current in the circuit and the oscillations finally dies away.

(3) Even if the resistance is zero, the total energy of the system would not remain constant. It is radiated away from the system in the form of electromagnetic waves

(4) None of the above

22. Same current is flowing in two alternating circuits. The first circuit contains only inductance and the other circuit contains only a capacitance. If the frequency of the e.m.f. of A.C. is increased, the effect on the value of the current will be

(1) increase in the first circuit and decrease in the other

(2) increased in both circuits

(3) decrease in both circuits

(4) decrease in the first circuit and increase in the other

23. Non-resonant circuit, what will be the nature of circuit for frequencies higher them the resonant frequency ?

(1) Resistive (2) Capacitive (3) Inductive (4) None of these

24. A choke is preferred over a resistance for limiting current in AC circuit because

(1) choke is cheap (2) there is no wastage of power

(3) choke is compact in size (4) choke is a good absorber of heat

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

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

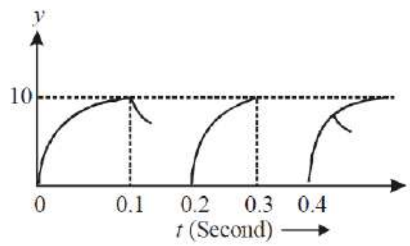
(1) Assertion is correct, reason is correct; reason is a correct explanation for assertion.

(2) Assertion is correct, reason is correct; reason is not a correct explanation for assertion

(3) Assertion is correct, reason is incorrect

(4) Assertion is incorrect, reason is correct.

26. The rms value of the function shown in figure if it is given that for $0 < t < 0.1$, $y = 10\,(1 - e{-}100t)$ and for $0.1 < t < 0.2$, $y = 10e{-}50(t{-}0.1)$ is

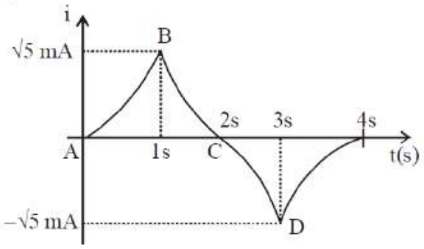


(1) 6.2 (2) 5.3 (3) 4.1 (4) 6.9

27. A sinusoidal voltage V(t) = 100 sin (500t) is applied across a pure inductance of L = 0.02 H. The current through the coil is:

(1) 10 cos (500 t) (2) –10 cos (500t) (3) 10 sin (500t) (4) –10 sin (500t)

28. Figure shows one cycle of an alternating current with the segments AB, BC, CD, DE being symmetrical and parabolic. The root mean square value of this current over one cycle is x mA, find x.



(1) 1 mA (2) 2 mA (3) 3 mA (4) 4 mA

29. An A.C. source is connected to a resistive circuit. Which of the following is true?

(1) Current leads ahead of voltage in phase
(2) Current lags behind voltage in phase
(3) Current and voltage are in same phase
(4) Any of the above may be true depending upon the value of resistance.

30. With increase in frequency of an A.C. supply, the inductive reactance

(1) decreases
(2) increases directly with frequency
(3) increases as square of frequency
(4) decreases inversely with frequency

31. The capacitive reactance in an A.C. circuit is

(1) effective resistance due to capacity (2) effective wattage
(3) effective voltage (4) None of these

32. In which of the following circuits the maximum power dissipation is observed?

(1) Pure capacitive circuit (2) Pure inductive circuit
(3) Pure resistive circuit (4) None of these

33. In an L.C.R. series a.c. circuit, the current

(1) is always in phase with the voltage (2) always lags the generator voltage
(3) always leads the generator voltage (4) None of these

34. If an LCR series circuit is connected to an ac source, then at resonance the voltage across

(1) R is zero (2) R equals the applied voltage
(3) C is zero (4) L equals the applied voltage

35. Of the following about capacitive reactance which is correct?

(1) The reactance of the capacitor is directly proportional to its ability to store charge
(2) Capacitive reactance is inversely proportional to the frequency of the current
(3) Capacitive reactance is measured in farad
(4) The reactance of a capacitor in an A.C. circuit is similar to the resistance of a capacitor in a D.C. circuit

36. The power factor in a circuit connected to an A.C. The value of power factor is

(1) unity when the circuit contains an ideal inductance only
(2) unity when the circuit contains an ideal resistance only
(3) zero when the circuit contains an ideal resistance only
(4) unity when the circuit contains an ideal capacitance Only

37. In series combination of R, L and C with an A.C. source at resonance, if R = 20 ohm, then impedence Z of the combination is

(1) 20 ohm (2) zero (3) 10 ohm (4) 400 ohm

38. In an LCR series a.c. circuit, the voltage across each of the components, L, C and R is 50V. The voltage across the LC combination will be

(1) 100 V (2) 50 2 V (3) 50 V (4) 0 V

39. **Assertion :** When the frequency of the AC source in an LCR circuit equals the resonant frequency, the reactance of the circuit is zero, and so there is no current through the inductor or the capacitor.

Reason : The net current in the inductor and capacitor is zero.

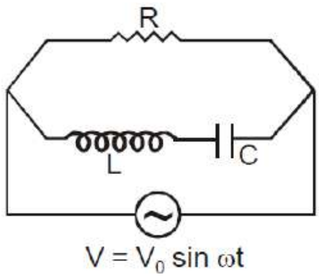
(1) Assertion is correct, reason is correct; reason is a correct explanation for assertion.

(2) Assertion is correct, reason is correct; reason is not a correct explanation for assertion

(3) Assertion is correct, reason is incorrect

(4) Assertion is incorrect, reason is correct.

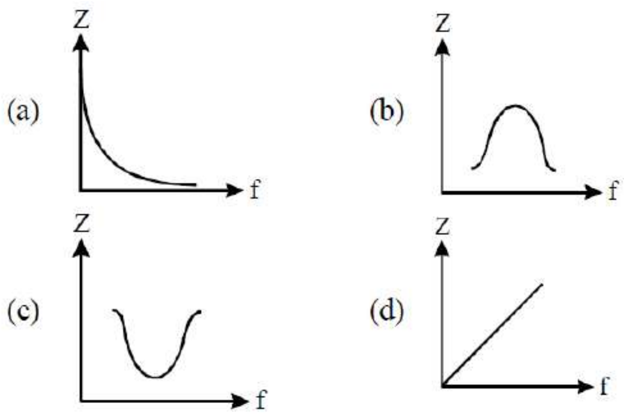
40. The current in resistance R at resonance is



(1) zero (2) minimum but finite

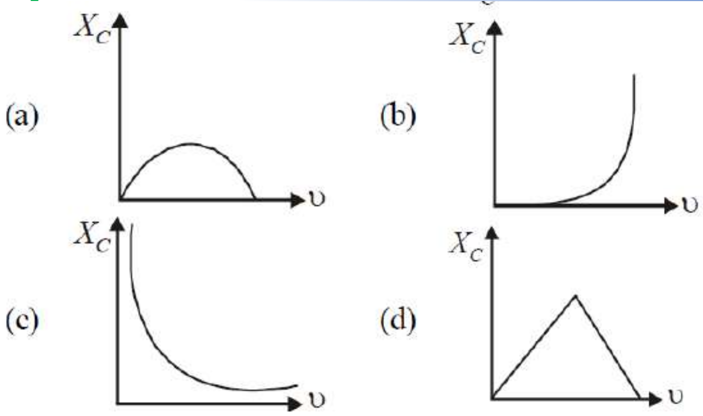
(3) maximum but finite (4) infinite

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



(1) a (2) b (3) c (4) d

42. Which of the following graphs represents the correct variation of capacitive reactance *XC* with frequency υ?



(1) a (2) b (3) c (4) d

43. A coil of 40 henry inductance is connected in series with a resistance of 8 ohm and the combination is joined to the terminals of a 2 volt battery. The time constant of the circuit is

(1) 20 seconds (2) 5 seconds (3) 1/5 seconds (4) 40 seconds

44. A current of 4A flows in a coil when connected to a 12V dc source. If the same coil is connected to a 12V, 50 rad/s a.c. source, a current of 2.4A flows in the circuit. Determine the inductance of the coil.

(1) 0.08 H (2) 0.04 H (3) 0.02 H (4) 1 H

45. Which of the following statements is/are correct?

I. In LCR series ac circuit, as the frequency of the source increases, the impedence of the circuit first decreases and then increases.

II. If the net reactance of an LCR series ac circuit is same as its resistance, then the current lags behind the voltage by 45°.

III. Below resonance, voltage leads the current while above it, current leads the voltage.

(1) I only (2) II only (3) I and III (4) I and II

46. **Assertion :** In series LCR resonance circuit, the impedance is equal to the ohmic resistance.

Reason: At resonance, the inductive reactance exceeds the capacitive reactance.

(1) Assertion is correct, reason is correct; reason is a correct explanation for assertion.

(2) Assertion is correct, reason is correct; reason is not a correct explanation for assertion

(3) Assertion is correct, reason is incorrect

(4) Assertion is incorrect, reason is correct.

47. An inductance of negligible resistance whose reactance is 22 Ω at 200 Hz is connected to 200 volts, 50 Hz power line. The value of inductance is

(1) 0.0175 henry (2) 0.175 henry (3) 1.75 henry (4) 17.5 henry

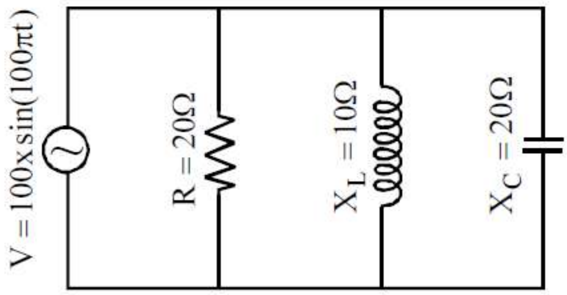
48. An inductive circuit contains resistance of 10 ohms and an inductance of 2 henry. If an A.C. voltage of 120 Volts and frequency 60 Hz is applied to this circuit, the current would be nearly

(1) 0.32 A (2) 0.16 A (3) 0.48 A (4) 0.80 A

49. An inductive coil has a resistance of 100 Ω. When an a.c. signal of frequency 1000 Hz is fed to the coil, the applied voltage leads the current by 45°. What is the inductance of the coil ?

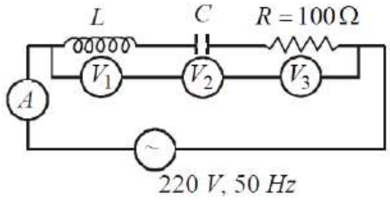
(1) 10 mH (2) 12 mH (3) 16 mH (4) 20mH.

50. In the given circuit, the current drawn from the source is



(1) 20 A (2) 10 A (3) 5 A (4) $5\sqrt{2}$ A

51. In the given circuit the reading of voltmeter V_1 and V_2 are 300 volt each. The reading of the voltmeter V_3 and ammeter A are respectively



(1) 150 V and 2.2 A (2) 220 V and 2.0 A (3) 220 V and 2.0 A (4) 100 V and 2.0 A

52. **Assertion :** The power is produced when a transformer steps up the voltage.
Reason : In an ideal transformer VI = constant.
(1) Assertion is correct, reason is correct; reason is a correct explanation for assertion
(2) Assertion is correct, reason is correct; reason is not a correct explanation for assertion
(3) Assertion is correct, reason is incorrect
(4) Assertion is incorrect, reason is correct.

TOPIC WISE PRACTICE QUESTIONS

Topic 1: Alternating Current, Voltage and Power

1. A.C. power is transmitted from a power house at a high voltage as
(1) the rate of transmission is faster at high voltages
(2) it is more economical due to less power loss
(3) power cannot be transmitted at low voltages
(4) a precaution against theft of transmission lines

2. In an ac circuit, peak value of voltage is 423 volts. Its effective voltage is
(1) 400 Volts (2) 323 Volts (3) 300 Volts (4) 340 Volts

3. The ratio of mean value over half cycle to r.m.s. value of A.C. is
(1) $2 : \pi$ (2) $2\sqrt{2} : \pi$ (3) $\sqrt{2} : \pi$ (4) $\sqrt{2} : 1$

4. The heat produced in a given resistance in a given time by the sinusoidal current $I_0 \sin \omega t$ will be the same as that of a steady current of magnitude nearly
(1) 0.71 I_0 (2) 1.412 I_0 (3) I_0 (4) $\sqrt{I_0}$

5. The sinusoidal A.C. current flows through a resistor of resistance R. If the peak current is I_p, then power dissipated is
(1) $I_p^2 R \cos\theta$ (2) $\frac{1}{2} I_p^2 R$ (3) $\frac{4}{\pi} I_p^2 R$ (4) $\frac{1}{\pi^2} I_p^2 R$

6. The average power dissipated in a pure inductor is

(1) $\frac{1}{2}LI^2$ (2) 2 LI (3) $LI^2 / 4$ (4) zero

7. A. C. measuring instrument measures its

(1) rms value (2) peak value (3) average value (4) square of current

8. The current I passed in any instrument in alternating current circuit is $I = 2 \sin\omega t$ amp and potential difference applied is given by $V = 5 \cos\omega t$ volt then power loss in instrument is

(1) 2.5 watt (2) 5 watt (3) 10 watt (4) zero

9. 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

(1) 120 volt, 100 Hz (2) $\frac{120}{\sqrt{2}}$ volt, 100 Hz (3) 60 volt, 200 Hz (4) 60 volt, 100 Hz

10. 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

(1) $\frac{\omega}{4}$ (2) $\frac{\omega}{2}$ (3) ω (4) 2ω

11. Power delivered by the source in the circuit is maximum, when

(1) $\omega L = \omega C$ (2) $\omega L = 1/\omega C$ (3) $\omega L = \omega C^2$ (4) $\omega L = \sqrt{\omega C}$

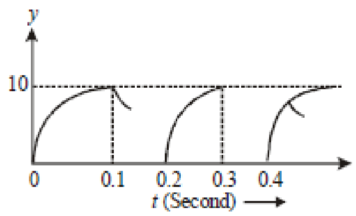
12. An alternating current is given by $i = i_1 \cos\omega t + i_2 \sin\omega t$. The rms current is given by

(1) $\frac{i_1 + i_2}{\sqrt{2}}$ (2) $\frac{|i_1 + i_2|}{\sqrt{2}}$ (3) $\sqrt{\frac{i_1^2 + i_2^2}{2}}$ (4) $\sqrt{\frac{i_1^2 + i_2^2}{\sqrt{2}}}$

13. In an A.C. circuit, the current flowing in inductance is $I = 5 \sin(100t - \pi/2)$ amperes and the potential difference is $V = 200 \sin(100t)$ volts. The power consumption is equal to

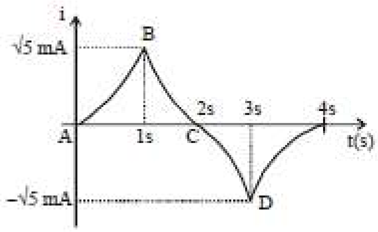
(1) 1000 watt (2) 40 watt (3) 20 watt (4) Zero

14. The rms value of the function shown in figure if it is given that for $0 < t < 0.1$, $y = 10(1 - e^{-100t})$ and for $0.1 < t < 0.2$, $y = 10e^{-50(t-0.1)}$ is



(1) 6.2 (2) 5.3 (3) 4.1 (4) 6.9

15. Figure shows one cycle of an alternating current with the segments AB, BC, CD, DE being symmetrical and parabolic. The root mean square value of this current over one cycle is x mA, find x.



(1) 1 mA (2) 2 mA (3) 3 mA (4) 4 mA

16. A resistance of 20 ohm is connected to a source of an alternating potential $V = 200 \cos(100\pi t)$. The time taken by the current to change from its peak value to rms value α is

(1) 2.5×10^{-3} s (2) 25×10^{-3} s (3) 0.25 s (4) 0.20 s

17. Determine the rms value of the emf given by E (in volt) = $8 \sin(\omega t) + 6\sin(2\omega t)$

(1) $5\sqrt{2}$ V (2) $7\sqrt{2}$ V (3) 10 V (4) $10\sqrt{2}$ V

18. An AC voltage source has an output of $V = 200 \sin 2\pi ft$. This source is connected to a 100 Ω resistor. RMS current in the resistance is

(1) 1.41 A (2) 2.41 A (3) 3.41 A (4) 0.71 A

19. The r.m.s value of an a.c. 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

(1) 2×10^{-2} sec and 14.14 amp

(2) 1×10^{-2} sec and 7.07 amp

(3) 5×10^{-3} sec and 7.07 amp

(4) 5×10^{-3} sec and 14.14 amp

20. Using an A.C. voltmeter the potential difference in the electrical line in a house is read to be 234 volt. If the line frequency is known to be 50 cycles/second, the equation for the line voltage is

(1) $V = 165 \sin (100\pi t)$

(2) $V = 331 \sin (100\pi t)$

(3) $V = 220 \sin (100\pi t)$

(4) $V = 440 \sin (100\pi t)$

Topic 2: A.C. Circuits and Power Factor

21. In an L.C.R. series a.c. circuit, the current

(1) is always in phase with the voltage

(2) always lags the generator voltage

(3) always leads the generator voltage

(4) None of these

22. An inductor, a resistor and a capacitor are joined in series with an AC source. As the frequency of the source is slightly increased from a very low value, the reactance of the

(1) inductor increases

(2) resistor increases

(3) capacitor increases

(4) circuit increases

23. In a LCR circuit at resonance which of these will effect the current in circuit

(1) R only (2) L and R only (3) R and C only (4) all L, C and R

24. An alternating voltage of frequency ω is induced in electric circuit consisting of an inductance L and capacitance C, connected in parallel. Then across the inductance coil the

(i) current is maximum when $\omega^2 = 1/(LC)$

(ii) current is minimum when $\omega^2 = 1/(LC)$

(iii) voltage is minimum when $\omega^2 = 1/(LC)$

(iv) voltage is maximum when $\omega^2 = 1/(LC)$

(1) (i) and (iii) are correct

(2) (i) and (iv) are correct

(3) (ii) and (iii) are correct

(4) (ii) and (iv) are correct

25. If the frequency of an A.C. is made 4 times of its initial value, the inductive reactance will

(1) be 4 times (2) be 2 times (3) be half (4) remain the same

26. Two coils A and B are connected in series across a 240 V, 50 Hz supply. The resistance of A is $5\,\Omega$ and the inductance of B is 0.02 H. The power consumed is 3 kW and the power factor is 0.75. The impedance of the circuit is

(1) $0.144\,\Omega$ (2) $1.44\,\Omega$ (3) $14.4\,\Omega$ (4) $144\,\Omega$

27. With increase in frequency of an A.C. supply, the impedance of an L-C-R series circuit

(1) remains constant

(2) increases

(3) decreases

(4) decreases at first, becomes minimum and then increases.

28. A coil of inductance 300 mH and resistance $2\,\Omega$ is connected to a source of voltage 2V. The current reaches half of its steady state value in

(1) 0.1 s (2) 0.05 s (3) 0.3 s (4) 0.15 s

29. An ideal coil of 10H is connected in series with a resistance of $5\,\Omega$ and a battery of 5V. 2second after the connection is made, the current flowing in ampere in the circuit is

(1) $(1 - e^{-1})$ (2) $(1 - e)$ (3) e (4) e^{-1}

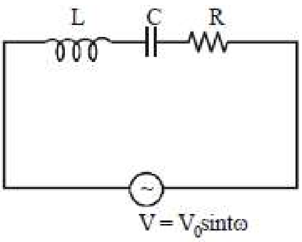
30. In an LR-circuit, the inductive reactance is equal to the resistance R of the circuit. An e.m.f. $E = E_0 \cos(\omega t)$ applied to the circuit. The power consumed in the circuit is

(1) $\frac{E_0^2}{R}$ (2) $\frac{E_0^2}{2R}$ (3) $\frac{E_0^2}{4R}$ (4) $\frac{E_0^2}{8R}$

31. An inductance L having a resistance R is connected to an alternating source of angular frequency ω. The quality factor Q of the inductance is

(1) $\frac{R}{\omega L}$ (2) $\left(\frac{\omega L}{R}\right)^2$ (3) $\left(\frac{R}{\omega L}\right)^{1/2}$ (4) $\frac{\omega L}{R}$

32. For the LCR circuit, shown here, the current is observed to lead the applied voltage. An additional capacitor C', when joined with the capacitor C present in the circuit, makes the power factor of the circuit unity. The capacitor C', must have been connected in :



(1) series with C and has a magnitude $\frac{C}{(\omega^2 LC - 1)}$

(2) series with C and has a magnitude $\frac{1 - \omega^2 LC}{\omega^2 L}$

(3) parallel with C and has a magnitude $\frac{1 - \omega^2 LC}{\omega^2 L}$

(4) parallel with C and has a magnitude $\frac{C}{(\omega^2 LC - 1)}$

33. In a series combination of R, L and C to an A.C. source at resonance if R = 200 hm, then impedance Z of the combination is

(1) 200 hm (2) zero (3) 10 hm (4) 4000 hm

34. A coil of 40 henry inductance is connected in series with a resistance of 8 ohm and the combination is joined to the terminals of a 2 volt battery. The time constant of the circuit is

(1) 20 seconds (2) 5 seconds (3) 1/5 seconds (4) 40 seconds

35. For a series RLC circuit R = X_L = $2X_C$. The impedance of the circuit and phase difference between V and I respectively will be

(1) $\frac{\sqrt{5}R}{2}, \tan^{-1}(2)$ (2) $\frac{\sqrt{5}R}{2}, \tan^{-1}(1/2)$ (3) $\sqrt{5}X_C, \tan^{-1}(2)$ (4) $\sqrt{5}R, \tan^{-1}(1/2)$

36. A current of 4A flows in a coil when connected to a 12V dc source. If the same coil is connected to a 12V, 50 rad/s a.c. source, a current of 2.4A flows in the circuit. Determine the inductance of the coil.

(1) 0.08 H (2) 0.04 H (3) 0.02 H (4) 1 H

37. In series L-C circuit, the voltage across E and C are respectively 200 V and 300 V. The voltage E of the ac source is :

(1) 150 Volt (2) 200 Volt (3) 100 Volt (4) 250 Volt

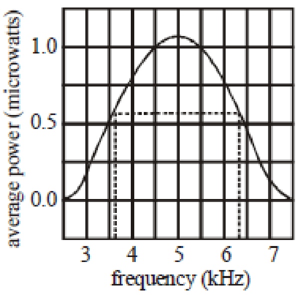
38. An e.m.f. of 15 volt is applied in a circuit containing 5 henry inductance and 10 ohm resistance. The ratio of the currents at time t= ∞ and at t = 1 second is

(1) $\frac{e^{1/2}}{e^{1/2-1}}$ (2) $\frac{e^2}{e^{2-1}}$ (3) $1-e^{-1}$ (4) e^{-1}

39. 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

(1) 350 V (2) 250 V (3) 500 V (4) 300 V

40. The plot given below is of the average power delivered to an LRC circuit versus frequency. The quality factor of the circuit is :



(1) 5.0 (2) 2.0 (3) 2.5 (4) 0.4

41. In an L-C-R series circuit connected to an AC source, V = $V_0 \sin\left(100\pi t + \frac{\pi}{6}\right)$. Given V_R = 40V, V_L = 10V and V_C = 10V. Resistance R = 4Ω. Peak value of current in the circuit is

(1) $10\sqrt{2}$ A (2) $15\sqrt{2}$ A (3) $20\sqrt{2}$ A (4) $25\sqrt{2}$ A

42. In series L-C-R circuit, the voltages across R, L and C are V_R, V_L and V_C respectively. Then the voltage of applied a.c. source must be

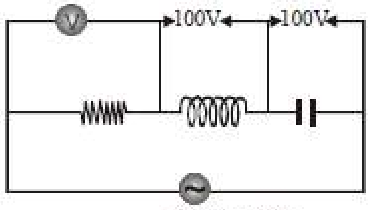
(1) $V_R + V_L + V_C$

(2) $\sqrt{\left[(V_R)^2 + (V_L - V_C)^2\right]}$

(3) $V_R + V_C - V_L$

(4) $\left[(V_R + V_L)^2 + (V_C)^2\right]^{1/2}$

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



(1) 300 V (2) 900 V (3) 200 V (4) 400 V

44. 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 bulb will
(1) give more intense light
(2) give less intense light
(3) give light of same intensity before
(4) stop radiating light

45. The power factor in a circuit connected to an A.C. The value of power factor is
(1) unity when the circuit contains an ideal inductance only
(2) unity when the circuit contains an ideal resistance only
(3) zero when the circuit contains an ideal resistance only
(4) unity when the circuit contains an ideal capacitance only

46. An ac source of angular frequency w 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 the circuit is found to be halved. Calculate the ratio of reactance to resistance at the original frequency ω

(1) $\sqrt{\frac{3}{5}}$ (2) $\sqrt{\frac{2}{5}}$ (3) $\sqrt{\frac{1}{5}}$ (4) $\sqrt{\frac{4}{5}}$

47. A coil of inductive reactance $31\,\Omega$ has a resistance of $8\,\Omega$. It is placed in series with a condenser of capacitive reactance $25\,\Omega$. The combination is connected to an a.c. source of 110 volt. The power factor of the circuit is
(1) 0.64 (2) 0.80 (3) 0.33 (4) 0.56

48. In an A.C. 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
(1) R/4 (2) R/2 (3) R (4) cannot be found with given data

49. A coil has an inductance of 0.7 henry and is joined in series with a resistance of $220\,\Omega$. When the alternating emf of 220 V at 50 Hz is applied to it then the phase through which current lags behind the applied emf and the wattles component of current in the circuit will be respectively
(1) 30°, 1 A (2) 45°, 0.5 A (3) 60°, 1.5 A (4) None of these

50. The power factor of an AC circuit having resistance (R) and inductance (L) connected in series and an angular velocity ω is
(1) $R/\omega L$ (2) $R/(R^2+\omega^2L^2)^{1/2}$ (3) $\omega L/R$ (4) $R/(R^2-\omega^2L^2)^{1/2}$

51. A resistor of resistance *R*, capacitor of capacitance *C* and inductor of inductance *L* are connected in parallel to AC power source of voltage $\varepsilon_0 \sin\omega t$. The maximum current through the resistance is half of the maximum current through the power source. Then value of R is

(1) $\frac{\sqrt{3}}{\left|\omega C-\frac{1}{\omega L}\right|}$ (2) $\sqrt{3}\left|\frac{1}{\omega C}-\omega L\right|$ (3) $\sqrt{5}\left|\frac{1}{\omega C}-\omega L\right|$ (4) None of these

Topic 3: Transformers and LC Oscillations

52. A transformer is employed to
(1) convert A.C. into D.C.
(2) convert D.C. into A.C.
(3) obtain a suitable A.C. voltage
(4) obtain a suitable D.C. voltage

53. The transformer voltage induced in the secondary coil of a transformer is mainly due to
(1) a varying electric field
(2) a varying magnetic field
(3) the vibrations of the primary coil
(4) the iron core of the transformer

54. Eddy currents in the core of transformer can't be developed by
(1) increasing the number of turns in secondary coil
(2) taking laminated transformer
(3) making step down transformer
(4) using a weak a.c. at high potential

55. A transformer is used to light a 140 W, 24 V bulb from a 240 V a.c. mains. The current in the main cable is 0.7 A. The efficiency of the transformer is
(1) 63.8 % (2) 83.3 % (3) 16.7 % (4) 36.2 %

56. A generator supplies 100V to the primary-coil of a transformer of 50 turns. If the secondary coil has 500 turns, then the secondary voltage is
(1) 100V (2) 550V (3) 500V (4) 1000V

57. A transistor-oscillator using a resonant circuit with an inductor L (of negligible resistance) and a capacitor C in series produce oscillations of frequency f. If L is doubled and C is changed to 4C, the frequency will be
(1) 8f (2) $f / 2\sqrt{2}$ (3) f/2 (4) f/4

58. A capacitor in an *LC* oscillator has a maximum potential difference of 17 V and a maximum energy of 160 μJ. When the capacitor has a potential difference of 5V and an energy of 10 μJ, what is the energy stored in the magnetic field?
(1) 10 μJ (2) 150 μJ (3) 160 μJ (4) 170 μJ

59. In an oscillating *LC* circuit with L = 50 mH and C = 4.0 μF, the current is initially a maximum. How long will it take before the capacitor is fully discharged for the first time :
(1) 7×10^{-4} s (2) 14×10^{-4} s (3) 28×10^{-4} s (4) none

60. An alternating current emf device has a smaller resistance than that of the resistive load, to increase the transfer of energy from the device to the load, a transformer will be connected between two. Then
(1) N_S should be greater than N_P
(2) N_S should be less than N_P
(3) $N_S = N_P$
(4) none

61. A choke coil and capacitor are connected in resides and the current through the combination is maximum for AC of frequency n. If they are connected in parallel, at what frequency the current through the combination is minimum?
(1) n (2) n/2 (3) 2n (4) 5n

62. In an oscillation of L-C circuit, the maximum charge on the capacitor is Q. The charge on the capacitor, when the energy is stored equally between the electric and magnetic field is

(1) $\frac{Q}{2}$ (2) $\frac{Q}{\sqrt{2}}$ (3) $\frac{Q}{\sqrt{3}}$ (4) $\frac{Q}{3}$

63. If the total charge stored in the *LC* circuit is Q_0, then for $t \geq 0$

(1) The charge on the capacitor is $Q = Q_0 \cos\left(\frac{\pi}{2} + \frac{t}{\sqrt{LC}}\right)$

(2) The charge on the capacitor is $Q = Q_0 \cos\left(\frac{\pi}{2} - \frac{t}{\sqrt{LC}}\right)$

(3) The charge on the capacitor is $Q = -LC\frac{d^2Q}{dt^2}$

(4) The charge on the capacitor is $Q = \frac{1}{\sqrt{LC}}\frac{d^2Q}{dt^2}$

64. A transformer is used to light a 140 W, 24 V bulb from a 240 V a.c. mains. The current in the main cable is 0.7 A. The efficiency of the transformer is

(1) 63.8 % (2) 83.3 % (3) 16.7 % (4) 36.2 %

65. In an ideal transformer, the voltage and the current in the primary coil are 200 V and 2 A, respectively. If the voltage in the secondary coil is 2000 V, the value of current in the secondary coil will be

(1) 0.2 A (2) 2 A (3) 10 A (4) 20 A

66. The tuning circuit of a radio receiver has a resistance of 50 Ω, an inductor of 10 mH and a variable capacitor. A 1 MHz radio wave produces a potential difference of 0.1 mV. The values of the capacitor to produce resonance is (Take $\pi^2 = 10$)

(1) 2.5 pF (2) 5.0 pF (3) 25 pF (4) 50 pF

67. A step down transformer is connected to 2400 volts line and 80 amperes of current is found to flow in output load. The ratio of the turns in primary and secondary coil is 20 : 1. If transformer efficiency is 100%, then the current flowing in the primary coil will be

(1) 1600 amp (2) 20 amp (3) 4 amp (4) 1.5 amp

68. The primary winding of a transformer has 100 turns and its secondary winding has 200 turns. The primary is connected to an A.C. supply of 120 V and the current flowing in it is 10 A. The voltage and the current in the secondary are

(1) 240 V, 5 A (2) 240 V, 10 A (3) 60 V, 20 A (4) 120 V, 20 A

69. A transformer has an efficiency of 80%. It works at 4 kW and 100 V. If secondary voltage is 240 V, the current in primary coil is

(1) 0.4 A (2) 4 A (3) 10 A (4) 40 A

70. The output of a step-down transformer is measured to be 24V when connected to a 12 W light bulb. The value of the peak current is

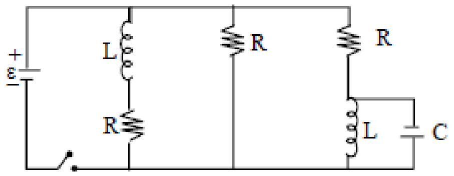
(1) $1/\sqrt{2}$ A (2) $\sqrt{2}$ A (3) 2 A (4) $2\sqrt{2}$ A

NEET PREVIOUS YEARS QUESTIONS

1. An inductor 20 mH, a capacitor 100 μF and a resistor 50 Ω are connected in series across a source of emf, V = 10 sin 314 t. The power loss in the circuit is **[2018]**

(1) 0.79 W (2) 0.43 W (3) 1.13 W (4) 2.74 W

2. Figure shows a circuit that contains three identical resistors with resistance R = 9.0 Ω each, two identical inductors with inductance L = 2.0 mH each, and an ideal battery with emf ε = 18 V. The current 'i' through the battery just after the switch closed is **[2017]**



(1) 0.2 A (2) 2 A (3) 0 (4) 2 mA

3. A small signal voltage V(t) = V_0 sin ωt is applied across an ideal capacitor C : **[2016]**

(1) Current I (t), lags voltage V(t) by 90°.

(2) Over a full cycle the capacitor C does not consume any energy from the voltage source.

(3) Current I (t) is in phase with voltage V(t).

(4) Current I (t) leads voltage V(t) by 180°.

4. An inductor 20 mH, a capacitor 50 μF and a resistor 40 Ω are connected in series across a source of emf V = 10 sin 340 t. The power loss in A.C. circuit is : **[2016]**

(1) 0.51 W (2) 0.67 W (3) 0.76 W (4) 0.89 W

5. A resistance 'R' draws power 'P' when connected to an AC source. If an inductance is now placed in series with the resistance, such that the impedance of the circuit becomes 'Z', the power drawn will be **[2015]**

(1) $P\sqrt{\frac{R}{Z}}$ (2) $P\left(\frac{R}{Z}\right)$ (3) P (4) $P\left(\frac{R}{Z}\right)^2$

6. A series R-C circuit is connected to an alternating voltage source. Consider two situations: **[2015]**

(1) When capacitor is air filled.

(2) When capacitor is mica filled.

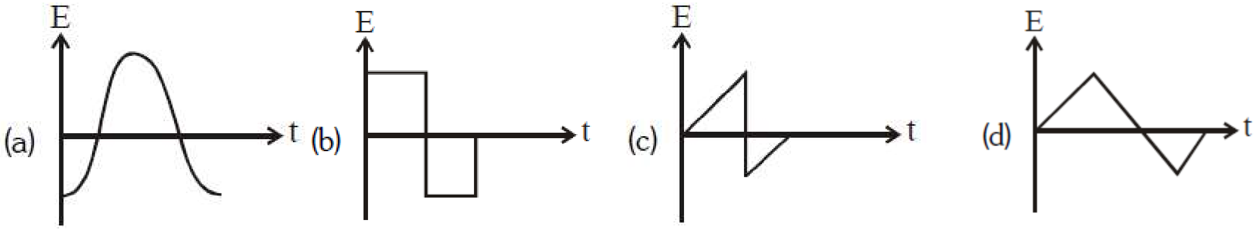
Current through resistor is i and voltage across capacitor is V then :

(1) $V_a > V_b$ (2) $i_a > i_b$ (3) $V_a = V_b$ (4) $V_a < V_b$

7. A transformer having efficiency of 90% is working on 200V and 3kW power supply. If the current in the secondary coil is 6A, the voltage across the secondary coil and the current in the primary coil respectively are : **[2014]**

(1) 300 V, 15A (2) 450 V, 15A (3) 450V, 13.5A (4) 600V, 15A

8. The variation of EMF with time for four types of generators are shown in the figures. Which amongst them can be called AC ? **[NEET – 2019 (ODISSA)]**



(1) and (4) (2) (1), (2), (3) and (4)

(3) (1) and (2) (4) only (1)

9. A circuit when connected to an AC source of 12 V gives a current of 0.2 A. The same circuit when connected to a DC source of 12 V, gives a current of 0.4 A. The circuit is **[NEET – 2019 (ODISSA)]**

(1) series LR (2) series RC (3) series LC (4) series LCR

10. A 40 μF capacitor is connected to a 200V-50 Hz ac supply. The rms value of the current in the circuit is, nearly: **[NEET-2020 (CODE-H4)]**

1) 25.1A 2) 1.7A 3) 2.05A 4) 2.5A

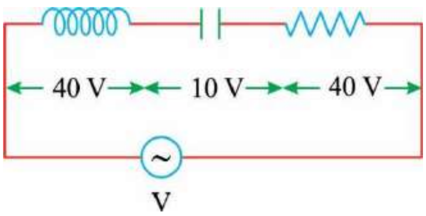
11. A series LCR circuit is connected to an ac voltage source. When L is removed from the circuit, the phase difference between current and voltage is $\frac{\pi}{3}$. If instead C is removed from the circuit, the phase difference is again $\frac{\pi}{3}$ between current and voltage. The power factor of the circuit is **[NEET-2020 (CODE-H4)]**

1) – 10 2) zero 3) 0.5 4) 1.0

12. A capacitor of capacitance 'C', is connected across an ac source of voltage V, given by $V = V_0 \sin \omega t$ The displacement current between the plates of the capacitor, would then be given by **[NEET-2021]**

1) $I_d = \frac{V_0}{\omega C} \cos \omega t$ 2) $I_d = \frac{V_0}{\omega C} \sin \omega t$ 3) $I_d = V_0 \omega C \sin \omega t$ 4) $I_d = V_0 \omega C \cos \omega t$

13. An inductor of inductance L, a capacitor of capacitance C and a resistor of resistance 'R' are connected in series to an ac source of potential difference 'V' volts as shown in figure. Potential difference across L, C and R is 40 V, 10 V and 40 V, respectively. The amplitude of current flowing through LCR series circuit is $10\sqrt{2}A$. The impedance of the circuit is **[NEET-2021]**



1) $5/\sqrt{2}\,\Omega$ 2) 4Ω 3) 5Ω 4) $4\sqrt{2}\,\Omega$

14. A series LCR circuit containing 5.0 H inductor , $80\,\mu F$ capacitor and 40Ω resistor is connected to 230 V variable frequency ac source . The angular frequencies of the source at which power transferred to the circuit is half the power at the resonant angular frequency are likely to be : **[NEET-2021]**

1. 50 rad/s and 25 rad/s
2. 46 rad/s and 54 rad/s
3. 42 rad/s and 58 rad/s
4. 25 rad/s and 75 rad/s

15. A step down transformer connected to an ac mains supply of 220 V is made to operate at 11 V , 44 W lamp. Ignoring power losses in the transformer, what is the current in the primary circuit ? **[NEET-2021]**

1) $0.4A$ 2) $2A$ 3) $4A$ 4) $0.2A$

16. A series LCR circuit with inductance 10 H, capacitance 10 μF, resistance 50Ω is connected to an ac source of voltage, V = 200 sin(100 t) volt. If the resonant frequency of the LCR circuit is v_0 and the frequency of the ac source is v, then : **[NEET-2022]**

1) $v_0 = v = 50Hz$ 2) $v_0 = v = \frac{50}{\pi}Hz$ 3) $v_0 = \frac{50}{\pi}Hz, v = 50Hz$ 4) $v = 100Hz, v_0 = \frac{100}{\pi}Hz$

NCERT LINE BY LINE QUESTIONS – ANSWERS

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

1) 1	2) 2	3) 4	4) 2	5) 1	6) 2	7) 4	8) 2	9) 3	10) 4
11) 2	12) 3	13) 1	14) 1	15) 3	16) 2	17) 4	18) 1	19) 4	20) 4
21) 4	22) 4	23) 3	24) 2	25) 2	26) 4	27) 2	28) 1	29) 3	30) 2
31) 1	32) 3	33) 4	34) 2	35) 2	36) 2	37) 1	38) 4	39) 4	40) 3
41) 3	42) 3	43) 2	44) 1	45) 4	46) 3	47) 1	48) 2	49) 3	50) 4
51) 2	52) 1								

NCERT BASED PRACTICE QUESTIONS – ANSWERS

TOPIC WISE PRACTICE QUESTIONS - ANSWERS

1) 2	2) 3	3) 2	4) 1	5) 2	6) 4	7) 1	8) 4	9) 4	10) 4
11) 2	12) 3	13) 4	14) 4	15) 1	16) 1	17) 1	18) 1	19) 4	20) 2
21) 4	22) 1	23) 1	24) 4	25) 1	26) 3	27) 4	28) 1	29) 1	30) 3
31) 4	32) 3	33) 1	34) 2	35) 2	36) 1	37) 3	38) 2	39) 2	40) 2
41) 1	42) 2	43) 3	44) 1	45) 2	46) 1	47) 2	48) 3	49) 2	50) 2
51) 1	52) 3	53) 2	54) 2	55) 2	56) 4	57) 2	58) 2	59) 1	60) 1
61) 1	62) 2	63) 3	64) 2	65) 1	66) 1	67) 3	68) 1	69) 4	70) 1

NEET PREVIOUS YEARS QUESTIONS-ANSWERS

1) 1	2) 2	3) 2	4) 1	5) 4	6) 1	7) 2	8) 2	9) 1
10) 4	11) 4	12) 4	13) 3	14) 2	15) 4	16) 2		

TOPIC WISE PRACTICE QUESTIONS - SOLUTIONS

1. **(2)** To reduce the energy loss which occur in long distance transmission.

2. **(3)** Effective voltage $V_{rms}=\frac{V_0}{\sqrt{2}}=\frac{423}{\sqrt{2}}=300V$

3. **(2)** We know that $I_{rms}=I_0/\sqrt{2}$ and $I_m=2I_0/\pi$

$\therefore \frac{I_m}{I_{rms}}=\frac{2\sqrt{2}}{\pi}$

4. **(1)** $I_{rms}=\frac{I_0}{\sqrt{2}}=0.707I_0$

5. **(2)** The value of r.m.s current is $I_{rms}=\frac{I_P}{\sqrt{2}}$

so power dissipated is $P=I_{rms}^2R=\frac{1}{2}I_P^2R$

6. (4) We know that in pure inductive circuit, current is lagging behind the voltage by 90^0 i.e. phase difference (ϕ) between voltage and current is 90^0.

Average power dissipated, $P_{avg}=\frac{v_o i_o}{2}\cos\phi$

$\therefore P_{avg}=\frac{v_o i_o}{2}\cos 90^0=0 \qquad (\because \cos 90^0=0)$

7. (1) AC is measured using half wave rectifier using diodes, which measures the rms value of the AC.

8. **(4)** $I = 2\sin\omega t$

$V=5\cos\omega t=5\sin\left(\frac{\pi}{2}-\omega t\right)$

Since, there is a phase difference of $\frac{\pi}{2}$ between the current and voltage

$\therefore$ Average power over a complete cycle is zero.

9. **(4)** $V = 120\sin 100\,\pi t\cos 100\,\pi t \Rightarrow V = 60\sin 200\,\pi t$

$V_{max} = 60V$ and $v = 100Hz$

10. (4) The instantaneous values of emf and current in inductive circuit are given by
[E=E_0sinωt] and [i=$i_0$sin(ωt−π/2)] respectively.

So, [P_{inst}=E_i=E_0sinωt×$i_0$sin(ωt− π/2)]

[=$E_0 i_0$sinωt(sinωt cos π/2−cosωt sin π/2)]

[=$E_0 i_0$ sinωt cosωt]

[=$\frac{1}{2}$ $E_0 i_0$sin2ωt]

[(sin2ωt=2sinωt cosωt)]

Hence, angular frequency of instantaneous power is [2ω].

11. (2) As we know,
power delivered by the source of the circuit becomes maximum when, load resistance equals to source resistance.
we know, in L-C-R circuit, load resistance is inductive reactance and source resistance is reactance of capacitor.

e.g., X_L=X_C or, $\omega L = \frac{1}{\omega C}$

hence, Power delivered by the source of the circuit becomes maximum, when , $\omega L = \frac{1}{\omega C}$

12. (3) i=i_1 cosωt+i_2 sinωt

Let i_1= I sinθ...(1)

i_2=Icosθ...(2)

I = I sinθ cosωt +I cosθ sinωt

form equation (1) and (2)

$i_1^2 + i_2^2$ = $I^2(\sin^2\theta+\cos^2\theta)$

or $I = \sqrt{i_1^2 + i_2^2}$

$$I_{rms} = \frac{I}{\sqrt{2}} = \sqrt{\frac{i_1^2 + i_2^2}{2}}$$

13. **(4)** Power, $P = I_{r.m.s} \times V_{r.m.s} \times \cos\phi$
In the given problem, the phase difference between voltage and current is p/2. Hence
$P = I_{r.m.s} \times V_{r.m.s} \times \cos(\pi / 2) = 0$

14. **(4)** Find $\frac{dy}{dx}$, if $y = 12(1 - \cos t), x = 10(t - \sin t), -\frac{\pi}{2} < t < \frac{\pi}{2}$

15. **(1)** RMS value over one cycle = RMS value over AB.
$0 \le t \le 15$

$$i(t) = \sqrt{5}\, t^2 c \quad i_{rms} = \sqrt{< i^2 >} = \sqrt{\frac{5\int_0^1 t^4 dt}{\int_0^1 dt}} = 1\text{mA}$$

16. **(1)** The current and potential difference are in phase with the resistance. So, the time taken would be same as time for voltage to change from (t = 0) that is peak value to rms value.

Time taken by voltage to achieve its rms value of $\frac{200}{\sqrt{2}}$

$$\frac{200}{\sqrt{2}} = 200\cos(100\pi t)$$

$$\Rightarrow \cos(100\pi t) = \frac{1}{\sqrt{2}} = \cos\left(\frac{\pi}{4}\right)$$

$t = \frac{1}{400}$ second = 2.5×10^{-3} sec

17. **(1)** $E = 8\sin\omega t + 6\sin 2\omega t$

$$\Rightarrow E_{peak} = \sqrt{8^2 + 6^2} = 10V \Rightarrow E_{rms} = \frac{10}{\sqrt{2}} = 5\sqrt{2}V$$

18. (1) On comparing the given source voltage with $V = V_o \sin wt$

We get, $V_o = 200$ volts

Rms voltage of source $V_{rms} = \frac{V_o}{\sqrt{2}} = \frac{200}{\sqrt{2}} = 100\sqrt{2}$ volts

Thus rms current $I_{rms} = \frac{V_{rms}}{R}$ where $R = 100\Omega$

$$\Rightarrow I_{rms} = \frac{100\sqrt{2}}{100} = \sqrt{2} = 1.41A$$

19. (4) Time taken by alternating current to reach maximum from zero is $\frac{T}{4}$.

where T is the time period of the AC function.

$T = \frac{1}{f}$, Frequency (f)=50 Hz.

So time taken to reach maximum $= \frac{T}{4} = \frac{1}{4f} = \frac{1}{4 \times 50} = 5 \times 10^{-3}$ sec

$I_{RMS} = \frac{I_0}{\sqrt{2}}, I_0 =$ Peak value of current

Peak value of current $I_0 = \sqrt{2} \times I_{RMS} = \sqrt{2} \times 10 = 14.14A$

20. **(2)** $V = V_0 \sin\omega t$

Voltage in r.m.s. value

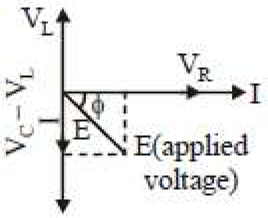
$V_0 = \sqrt{2} \times 234$ V = 331 volt

and $\omega t = 2\pi nt = 2\pi \times 5 \times t = 100\pi t$

Thus, the equation of line voltage is given by $V = 331 \sin(100\pi t)$

21. **(4)** $\tan\phi = \frac{V_C - V_L}{V_R} (\text{if } V_C > V_L)$

$$= \frac{V_L - V_C}{R} \ (\text{if } V_L > V_C)$$



where ϕ is angle between current & applied voltage.

22. **(1)** The reactance of inductor, $X_L = \omega L$

The reactance of capacitor, $X_C = \dfrac{1}{\omega C}$

where $\omega = 2\pi n$ & n is the frequency of A.C source.

23. (1) At resonance, $\omega L = \dfrac{1}{\omega C}$

Hence the impedance of the circuit would be just equal to R (minimum). In other words, the LCR-series circuit will behave as a purely resistive circuit. Due to this the current is maximum. This condition is known as resonance

$\therefore Z = R,$ Current $= \dfrac{V}{R}$

24. (4) In parallel LC circuits, current is minimum when, $\omega = \sqrt{\dfrac{1}{LC}}$

Also, current and voltage are at angle of 90 degrees.

Hence, voltage is maximum when current is minimum.

25. (1) inductive reactance $= 2\pi fL$

therefore when f is made 4 times, inductive reactance also becomes 4 times.

26. (3) $P = \dfrac{E_V^2 \cos\phi}{Z}$

$$P = 3000 = \frac{(240)^2 (0.75)}{Z} d \Rightarrow Z = 14.4\Omega$$

27. (4) We have the formula for Impedance

$$Z = \sqrt{R^2 + (X_1 - X_C)^2}$$

$X_C = \dfrac{1}{\omega C}$; $X_1 = \omega L$

And from the graph it can be easily seen that is Decreases first and then Increases.

28. (1) The charging of inductance given by,

$$i = i_0\left(1 - e^{-\frac{Rt}{L}}\right) \quad \frac{t_0}{2} = i_0\left(1 - e^{-\frac{Rt}{L}}\right) \Rightarrow e^{\frac{Rt}{L}} = \frac{1}{2}$$

Taking log on both the sides,

$$-\frac{Rt}{L} = \log 1 - \log 2$$

$$\Rightarrow t = \frac{L}{R}\log 2 = \frac{300 \times 10^{-3}}{2} \times 0.69 = 0.1\text{sec}$$

29. **(1)** $I = I_0\left(1 - e^{-\frac{Rt}{L}}\right)$

(When current is in growth in *LR* circuit)

$$= \frac{E}{R}\left(1 - e^{-\frac{Rt}{L}}\right) = \frac{5}{5}\left(1 - e^{-\frac{5}{10}\times 2}\right) = \left(1 - e^{-1}\right)$$

30. **(3)** $P = e_{rms} i_{rms} \cos\phi = \dfrac{E_0}{\sqrt{2}} \times \dfrac{I_0}{\sqrt{2}} \times \dfrac{R}{Z}$

$$\Rightarrow \frac{E_0}{\sqrt{2}} \times \frac{E_0}{Z\sqrt{2}} \times \frac{R}{Z} \Rightarrow P = \frac{E_0^2 R}{2Z^2}$$

Given $X_L = R$ so $Z = \sqrt{2}R \Rightarrow P = \frac{E_0^2 R}{4R^2} = \frac{E_0^2}{4R}$

31. **(4)** Quality factor $= \frac{V_L}{V_R} = \frac{I\omega L}{IR} = \frac{\omega L}{R}$

32. **(3)** Power factor

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

On solving we get,

$$\omega L = \frac{1}{\omega(C+C')}$$

$$C' = \frac{1-\omega^2 LC}{\omega^2 L}$$

33. (1) At resonance, impedance Z=R

So, Z=R=20 ohm

34. (2) Time constant is L/R

Given, L = 40H & R = 8 Ω

$\therefore \tau$ = 40/8 = 5 sec.

35. **(2)** $R = X_L = 2X_C$

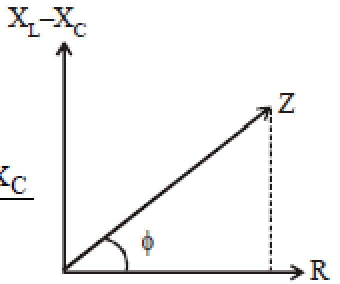
$$Z = \sqrt{R^2 + (X_L - X_C)^2} = \sqrt{(2X_C)^2 + (2X_C - X_C)^2}$$

$$= \sqrt{4X_C^2 + X_C^2}$$

$$= \sqrt{5}X_C = \frac{\sqrt{5}R}{2}$$

$$\tan\phi = \frac{X_L - X_C}{R} = \frac{2X_C - X_C}{2X_C}$$

$$\tan\phi = \frac{1}{2} \;;\; \phi = \tan^{-1}\left(\frac{1}{2}\right)$$



36. **(1)** A coil consists of an inductance (L) and a resistance (R).

In dc only resistance is effective. Hence,

$$R = \frac{V}{i} = \frac{12}{4} = 3\Omega$$

$$\text{In ac, } i_{rms} = \frac{V_{rms}}{Z} = \frac{V_{rms}}{\sqrt{R^2 + \omega^2 L^2}}$$

$$\Rightarrow L = \frac{1}{\omega}\sqrt{\left(\frac{V_{rms}}{i_{rms}}\right)^2 - R^2} = \frac{1}{50}\sqrt{\left(\frac{12}{2.4}\right)^2 - (3)^2}$$

$$= 0.08 \text{ henry}$$

37. (3) we know that the voltage of C & L are always in Opposite phase

So Net voltage i.e., V_L & V_C & resultant will be

$$\sqrt{(V_L - V_C)^2} = \sqrt{(300-400)^2} \Rightarrow V = 100V$$

This formula is directed from

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

38. **(2)** $i = i_0 (1-e^{-Rt/L})$

$i_o = \frac{E}{R}$(Steady current) when $t = \infty$

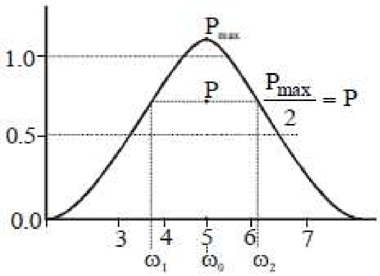
$i_\infty = \frac{E}{R}(1-e^{-\infty}) = \frac{15}{10} = 1.5$

$i_1 = 1.5(1-e^{-R/L}) = 1.5(1-e^{-2})$

$\Rightarrow \frac{i_\infty}{i_1} = \frac{1}{1-e^{-2}} = \frac{e^2}{e^2-1}$

39. **(2)** $V = \sqrt{V_R^2 + V_L^2} = \sqrt{200^2 + 150^2} = 250V$

40. **(2)**



Quality factor of the circuit

$= \frac{\omega_0}{\omega_2 - \omega_1} = \frac{5}{2.5} = 2.0$

41. **(1)** $V_{rms} = \sqrt{V_R^2 + (V_L - V_C)^2}$ = 40 Volt

$V_0 = V_{rms} \times \sqrt{2} = 40\sqrt{2}$ Volt

$Z = R$ (Purely resistance)

$= 4\Omega$ (Resonance)

$\therefore i_0 = \frac{V_0}{Z} = \frac{40\sqrt{2}}{4} = 10\sqrt{2}A$

42. **(2)** $V = V_R + (V_L - V_C)$

So value of apply voltage $V = \sqrt{V_R^2 + (V_L - V_C)^2}$

43. **(3)** $V = V_R + (V_L - V_C)$

Since $V_L = V_C$ hence $V = V_R = 200V$

44. **(1)** give more intense light

45. **(2)** $\cos\phi = R/Z$, where Z is the impedance &

$Z = \sqrt{R^2 + (X_L - X_C)^2}$, if there is only resistance then

$Z = R \Rightarrow \cos\phi = 1$

46. **(1)** $i = \frac{V}{\sqrt{R^2 + \left(\frac{1}{\omega C}\right)^2}}$

$I = \frac{V}{\sqrt{R^2 + \frac{1}{\omega^2 C^2}}}$ -------------(i)

and $\frac{I}{2} = \frac{V}{\sqrt{R^2 + \frac{\omega^2 C^2}{9}}}$ -------(ii)

On simplifying above equations, we get

$$\frac{X_L}{R}=\frac{\omega L}{R}=\sqrt{\frac{3}{5}}$$

47. **(2)** Power factor $\phi=\dfrac{R}{\sqrt{\left(\omega L-\frac{1}{\omega C}\right)^2+R^2}}$

$$=\frac{8}{\sqrt{(31-25)^2+8^2}}=\frac{8}{\sqrt{6^2+8^2}}=\frac{8}{10}=0.8$$

48. **(3)** $\tan\phi=\dfrac{\omega L}{R}=\dfrac{X_L}{R}$

Given $\phi=45°$. Hence $X_L = R$.

49. **(2) L=0.7H, R=220Ω, ε0=220V, v=50Hz**

This is an L - R circuit

Phase difference,

$$\tan\phi=\frac{X_L}{R}=\frac{\omega L}{R}=\frac{2\pi vL}{R}$$

$$\left[X_L=2\pi vL=2\times\frac{22}{7}\times 50\times 0.7=220\Omega\right]$$

$=\dfrac{220}{220}=1$ **or** $\phi=45^0$

50. **(2) Reactance due to inductor = ωL**

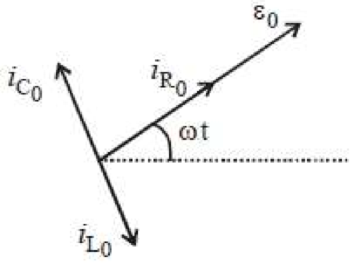
$$Z=\sqrt{R^2+\omega L^2}$$

Power factor : $\cos\phi=\dfrac{R}{Z}$

$$\cos\phi=\frac{R}{\sqrt{R^2+\omega L^2}}$$

51. **(1)** $\dfrac{iR_0}{\sqrt{(iR_0)^2+\left(i_{C_0}-i_{L_0}\right)^2}}=\dfrac{1}{2}$

$$\Rightarrow \frac{\varepsilon_0/R}{\sqrt{(\varepsilon_0/R)^2+\left(\varepsilon_0\omega C-\frac{\varepsilon_0}{\omega L}\right)^2}}=\frac{1}{2}$$



$$\Rightarrow R=\frac{\sqrt{3}}{\left(\omega C-\frac{1}{\omega L}\right)}$$

52. (3) A transformer is a device that is used to either raise or lower voltage, and currents in an electric circuit. Thereby, we can suitably obtain the voltage and current.

53. (2) A varying induced magnetic field which is generated by primary coil

54. (2) Eddy currents are locally generated current loops in the transformer core. This happens because transformer core is in close proximity of the varying magnetic field of the primary.Eddy current is a loss. To reduce this loss, core is made from bundle of thin laminated sheets.

55. (2) Power of source = EI = 240 × 0.7 = 166

$$\Rightarrow \text{Efficiency} = \frac{140}{166} \Rightarrow \eta = 83.3\%$$

56. **(4)** $V_s = V_p\left(\frac{N_s}{N_p}\right) = (100V)\left(\frac{500}{50}\right) = 1.00\times10^3 V$

57. **(2)** We know that frequency of electrical oscillation in L.C. circuit is

$$f = \frac{1}{2\pi}\sqrt{\frac{1}{LC}}$$

Now, L = 2L & C = 4C

$$f^{|} = \frac{1}{2\pi}\sqrt{\frac{1}{2L.4C}} = \frac{1}{2\pi}\sqrt{\frac{1}{LC}}\times\frac{1}{2\sqrt{2}} \Rightarrow f^{|} = \frac{1}{2\sqrt{2}}\times f$$

58. **(2)** $U_e + U_m = 160$

$\therefore U_m = 160 - U_e$

$= 160 - 10 = 150\mu J$

59. **(1)** Time period, $T = 2\pi\sqrt{LC} = 2\pi\sqrt{(50\times10^{-3})\times4\times10^{-6}} = 28\times10^{-4}$ s

Time taken by capacitor to charge fully,

$$t = \frac{T}{4} = 7\times10^{-4}s$$

60. **(1)** To increase transfer of energy, V_s and hence N_s should be greater than N_p.

61. **(1)** When the X_L is in resonance with X_C then the current is minimum and the frequency is given as

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

We have been given series frequency as

$$f = \frac{\omega}{2\pi\sqrt{LC}} = n$$

By substituting the value in above equation we get

$$f = n\sqrt{LC}$$

The current through a parallel LC circuit is given as

$$I = \frac{V}{Z}$$

When the impedance is maximum the current through a circuit is minimum.

Hence the frequency will be n

62. **(2)** If q is the required charge, then

$$\frac{q^2}{2C} = \frac{1}{2}\frac{Q^2}{2C};\ \therefore q = \frac{Q}{\sqrt{2}}$$

63. **(3)** If Q is the instantaneous charge on the capacitor, then

$$\frac{Q^2}{2C}+\frac{1}{2}Li^2=\frac{Q_0{}^2}{2C} \quad \text{or} \quad \frac{d}{dt}\left[\frac{Q^2}{2C}+\frac{1}{2}Li^2\right]=0$$

$$\text{or } \frac{2Q}{2C}\frac{dQ}{dt}+\frac{L}{2}\times 2i\times\frac{di}{dt}=0 \quad \therefore \; Q=-LC\frac{d^2Q}{dt^2}.$$

64. **(2)** Power of source

$=EI=240\times 0.7=166$

$\Rightarrow \text{Efficiency } =\frac{140}{166}\Rightarrow \eta=83.3\%$

65. **(1)** The relation for the current in the secondary coil is

$\frac{V_S}{V_P}=\frac{i_p}{i_s}\Rightarrow\frac{2000}{200}=\frac{2}{i_s}=\frac{2\times 200}{2000}=0.2A$

66. **(1)** L = 10 mHz = 10^{-2} Hz

f = 1MHz = 10^6 Hz

$f=\frac{2}{2\pi\sqrt{LC}}\Rightarrow f^2=\frac{1}{4\pi^2 LC}$

$\Rightarrow C=\frac{1}{4\pi^2 f^2 L}=\frac{1}{4\times 10\times 10^{-2}\times 10^{12}}=\frac{10^{-12}}{4}=2.5pF$

67. **(3)** $\frac{I_s}{I_p}=\frac{n_p}{n_s};\ \frac{80}{I_p}=\frac{20}{1}$ or $I_p=4\,\text{amp}$

68. **(1)** $\frac{E_s}{E_p}=\frac{n_s}{n_p}$ or $E_s=E_p\times\left(\frac{n_s}{n_p}\right)$

$\therefore E_s=120\times\left(\frac{200}{100}\right)=240V$

$\frac{I_p}{I_s}=\frac{n_s}{n_p}$ or $I_s=I_p\left(\frac{n_p}{n_s}\right) \quad \therefore I_s=10\left(\frac{100}{200}\right)=5\,\text{amp}$

69. **(4)** As $E_p I_p=P_i$

$\therefore I_p=\frac{P_i}{E_p}=\frac{4000}{100}=40A$

70. **(1)** As given that,

Secondary voltage (V_S) is :

V_S = 24 Volt

Power associated with secondary is :

P_S = 12 Watt

As we know that $P_S = V_S I_S$

$I_S=\frac{P_S}{V_S}=\frac{12}{24}=\frac{1}{2}A=0.5\,\text{amp}$

Peak value of the current in the secondary

$I_0=I_S\sqrt{2}=0.5\sqrt{2}=\frac{5}{10}\sqrt{2}\left[I_0=\frac{1}{\sqrt{2}}\text{Amp}\right]$

NEET PREVIOUS YEARS QUESTIONS-EXPLANATIONS

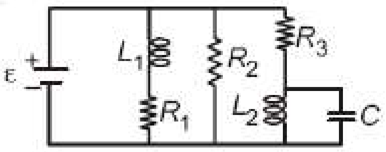
1. **(1)** Power dissipated in an LCR series circuit connected to an a.c. source of emf E

$$P = E_{rms} i_{rms} \cos\phi = \frac{E_{rms}^2 R}{Z^2} = \frac{E_{rms}^2 R}{R^2 + \left(\omega L - \frac{1}{C\omega}\right)}$$

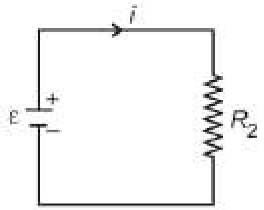
$$= \frac{\left(\frac{10}{\sqrt{2}}\right)^2 \times 50}{(50)^2 + \left(314 \times 20 \times 10^{-3} - \frac{1}{314 \times 100 \times 10^{-6}}\right)^2}$$

Solving we get, P = 0.79 W

2. **(2)**



At t = 0, no current flows through R_1 and R_3



Current through battery just after the switch closed is

$$i = \frac{\varepsilon}{R_2} = \frac{18}{9} = 2A$$

3. **(2)** As we know, power $P = V_{rms}.I_{rms} \cos\phi$

as $\cos\phi = 0 \,(\because \phi = 90°)$

$\therefore$ Power consumed = 0 (in one complete cycle)

4. **(1)** Given: L = 20 mH; C = 50 μF ; R = 40 Ω

V = 10 sin 340 t

$$\therefore V_{runs} = \frac{10}{\sqrt{2}}$$

$$X_C = \frac{1}{\omega C} = \frac{1}{340 \times 50 \times 10^{-6}} = 58.8\Omega$$

$$X_L = \omega L = 340 \times 20 \times 10^{-3} = 6.8\Omega$$

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

$$= \sqrt{40^2 + (58.8 - 6.8)^2} = \sqrt{4304}\,\Omega$$

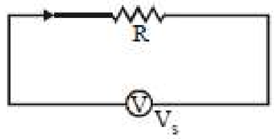
Power loss in A.C. circuit,

$$P = i_{rms}^2 R = \left(\frac{V_{rms}}{Z}\right)^2 R$$

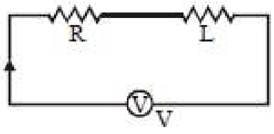
$$= \left(\frac{10/\sqrt{2}}{\sqrt{4304}}\right)^2 \times 40 = \frac{50 \times 40}{4304} = 0.51W$$

5. **(4)**

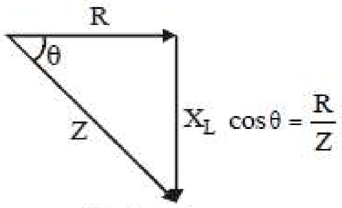
Pure resistor



L-R series circuit



Phasor diagram



Z = impedance

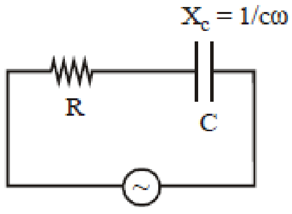
For pure resistor circuit, power

$$P = \frac{V^2}{R} \Rightarrow V^2 = PR$$

$$P^| = \frac{V^2}{Z}\cos\theta = \frac{V^2}{Z}.\frac{R}{Z} = \frac{PR}{Z^2}.R = P\left(\frac{R}{Z}\right)^2$$

6. **(1)** For series R – C circuit, capacitive reactance,

$$Z_c = \sqrt{R^2 + \left(\frac{1}{C\omega}\right)^2}$$



AC Source

Current $i = \frac{V}{Z_c} = \frac{V}{\sqrt{R^2 + \left(\frac{1}{C\omega}\right)^2}}$

$$V_c = iX_c = \frac{V}{\sqrt{R^2 + \left(\frac{1}{C\omega}\right)^2}} \times \frac{1}{C\omega}$$

$$V_c = \frac{V}{\sqrt{(RC\omega)^2 + 1}}$$

If we fill a di-electric material like mica instead of air then capacitance $C \uparrow \Rightarrow V_c \downarrow$

So, $V_a > V_b$

7. **(2)** Efficiency $\eta = \frac{V_s I_s}{V_p I_p} \Rightarrow 0.9 = \frac{V_s(6)}{3 \times 10^3} \Rightarrow V_s = 450V$

As $V_p I_p = 3000$ so

$$I_p = \frac{3000}{V_p} = \frac{3000}{200}A = 15A$$

8. Changing polarity is termed as AC

9. $Z = \frac{12}{0.2} = 60\,\Omega$ and $R = \frac{12}{0.4} = 30\,\Omega$

10. $i_{rms} = \dfrac{E_{rms}}{X_C} = \dfrac{E_{rms}}{(\omega C)}$

$i_{rms} = E_{rms} \times (2\pi fc)$

$= 200 \times 2 \times 3.14 \times 50 \times 40 \times 10^{-6} = 2.5\text{A}$

11. When L removed $\tan\dfrac{\pi}{3} = \dfrac{X_C}{R}$

When C removed $\tan\dfrac{\pi}{3} = \dfrac{X_L}{R}$

$\dfrac{X_C}{R} = \dfrac{X_L}{R} \Rightarrow$ The circuit is in resonance and Z = R

$\cos\phi = \dfrac{R}{Z} = \dfrac{R}{R} = 1$

12. $i_d = \epsilon_0 \cdot \dfrac{d}{dt}(\phi_E)$; $\quad = \epsilon_0 \cdot \dfrac{d}{dt}(EA) \qquad E = \dfrac{\sigma}{\epsilon_0} = \dfrac{q}{A\epsilon_0} = \dfrac{CV}{A\epsilon_0}$

$= \epsilon_0 \times \dfrac{d}{dE}\left(\dfrac{CV}{A\epsilon_0}.A\right)$

$= \dfrac{\epsilon_0 C}{\epsilon_0} \cdot \dfrac{d}{dt}(V)$

$= C \times \dfrac{d}{dt}(V_0 \sin wt)$

$= C \times V_0 \cos wt \times w$

$= cwV_0 \cos wt$

13. Supply voltage, $\text{V} = \sqrt{(\text{V}_\text{L} - \text{V}_\text{C})^2 + \text{V}_\text{R}^2}$

$\Rightarrow \text{V} = \sqrt{(40-10)^2 + 40^2}\,\text{volt} = 50\,\text{volt}$

So, peak value of supply voltage $= 50\sqrt{2}$ volt

$\therefore \text{Z} = 50\sqrt{2}/10\sqrt{2} = 5\Omega$; $\therefore \text{Z} = 5\Omega$

14. For half power frequency

$i = \dfrac{i_0}{\sqrt{2}} = \dfrac{1}{\sqrt{2}} \times \dfrac{V}{R}$

$\dfrac{V}{\sqrt{R^2 + (X_L - X_C)^2}} = \dfrac{1}{\sqrt{2}} \times \dfrac{V}{R}$

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

$(X_L - X_C)^2 = R^2$

$X_L - X_C = R$

$X_C - X_L = R \qquad \omega L - \dfrac{1}{\omega C} = R$

$\dfrac{1}{\omega C} - \omega L = R$

15.

$P = V_p I_p$

$44 = 220\left(I_p\right)$

$I_p = 0.2A$

16. $W = 100$

$2\pi r = 100$

$r = \frac{50}{\pi}$

$$r_0 = \frac{1}{2\pi\sqrt{LC}} = \frac{1}{2\pi\sqrt{10\times10^{-6}\times10}} = \frac{1}{2\pi\sqrt{10^{-4}}} = \frac{50}{\pi}$$