

## CBSE Class-12 Physics Quick Revision Notes

### Chapter-07: Alternating Current

- Alternating Current:**

The current whose magnitude changes with time and direction reverses periodically is called alternating current. a) Alternating emf  $E$  and current  $I$  at any time are given by:

$$E = E_0 \sin \omega t$$

Where  $E_0 = NBA\omega$

$$I = I_0 \sin(\omega t - \phi)$$

Where  $I_0 = \frac{NBA\omega}{R}$

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

Where  $T$  is the time period.

- Values of Alternating Current and Voltage**

a) Instantaneous value:

It is the value of alternating current and voltage at an instant  $t$ .

b) Peak value:

Maximum values of voltage  $E_0$  and current  $I_0$  in a cycle are called peak values.

c) Mean value:

For complete cycle,

$$\langle E \rangle = \frac{1}{T} \int_0^T E dt = 0$$

$$\langle I \rangle = \frac{1}{T} \int_0^T I dt = 0$$

Mean value for half cycle:  $E_{mean} = \frac{2E_0}{\pi}$

d) Root - mean - square (rms) value:

$$E_{rms} = (\langle E^2 \rangle)^{1/2} = \frac{E_0}{\sqrt{2}} = 0.707 E_0 = 70.7\% E_0$$

$$I_{rms} = (\langle I^2 \rangle)^{1/2} = \frac{I_0}{\sqrt{2}} = 0.707 I_0 = 70.7\% I_0$$

RMS values are also called apparent or effective values.

- Phase difference Between the EMF (Voltage) and the Current in an AC Circuit**

a) For pure resistance:

The voltage and the current are in same phase i.e. phase difference  $\phi = 0$

b) For pure inductance:

The voltage is ahead of current by  $\frac{\pi}{2}$  i.e. phase difference  $\phi = +\frac{\pi}{2}$ .

c) For pure capacitance:

The voltage lags behind the current by  $\frac{\pi}{2}$  i.e. phase difference  $\phi = -\frac{\pi}{2}$

- Reactance:**

Reactance

a) 
$$X = \frac{E}{I} = \frac{E_0}{I_0} = \frac{E_{rms}}{I_{rms}} \pm \pi / 2$$

b) Inductive reactance

$$X_L = \omega L = 2\pi nL$$

Capacitive reactance

c) 
$$X_C = \frac{1}{\omega C} = \frac{1}{2\pi nC}$$

- Impedance:**

Impedance is defined as,

$$Z = \frac{E}{I} = \frac{E_0}{I_0} = \frac{E_{rms}}{I_{rms}} \phi$$

Where  $\phi$  is the phase difference of the voltage E relative to the current I.

a) For L – R series circuit:

$$Z_{RL} = \sqrt{R^2 + X_L^2} = \sqrt{R^2 + \omega L^2}$$

$$\tan \phi = \left( \frac{\omega L}{R} \right) \text{ or } \phi = \tan^{-1} \left( \frac{\omega L}{R} \right)$$

b) For R – C series circuit:

$$Z_{RC} = \sqrt{R^2 + X_C^2} = \sqrt{R^2 + \left( \frac{1}{\omega C} \right)^2}$$

$$\tan \phi = \frac{1}{\omega CR} \text{ Or } \phi = \tan^{-1} \left( \frac{1}{\omega CR} \right)$$

c) For L – C series circuit:

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

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

$$\tan \phi = \frac{\left( \omega L - \frac{1}{\omega C} \right)}{R} \text{ Or } \phi = \tan^{-1} \left( \frac{\omega L - \frac{1}{\omega C}}{R} \right)$$

- Conductance:**

Reciprocal of resistance is called conductance.

$$G = \frac{1}{R} \text{ mho}$$

- **Power in and AC Circuit:**

a) Electric power = (current in circuit) x (voltage in circuit)

$$P = IE$$

b) Instantaneous power:

$$P_{\text{inst}} = E_{\text{inst}} \times I_{\text{inst}}$$

c) Average power:

$$P_{\text{av}} = \frac{1}{2} E_0 I_0 \cos \phi = E_{\text{rms}} I_{\text{rms}} \cos \phi$$

d) Virtual power (apparent power):

$$= \frac{1}{2} E_0 I_0 = E_{\text{rms}} I_{\text{rms}}$$

- **Power Factor:**

a) Power factor

$$\cos \phi = \frac{P_{\text{av}}}{P_v} = \frac{R}{Z}$$

b) For pure inductance

$$\text{Power factor, } \cos \phi = 1$$

c) For pure capacitance

$$\text{Power factor, } \cos \phi = 0$$

d) For LCR circuit

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

$$X = \left( \omega L - \frac{1}{\omega C} \right)$$

- **Wattless Current:**

The component of current differing in phase by  $\frac{\pi}{2}$  relative to the voltage, is called wattless current.

- **The rms value of wattless current:**

$$= \frac{I_0}{\sqrt{2}} \sin \phi$$

$$= I_{\text{rms}} \sin \phi = \frac{I_0}{\sqrt{2}} \left( \frac{X}{Z} \right)$$

- **Choke Coil:**

- An inductive coil used for controlling alternating current whose self- inductance is high and resistance is negligible, is called choke coil.
- The power factor of this coil is approximately zero.

- **Series Resonant Circuit**

- When the inductive reactance ( $X_L$ ) becomes equal to the capacitive reactance ( $X_C$ ) in the circuit, the total impedance becomes purely resistive ( $Z=R$ ).
- In this state, the voltage and current are in same phase ( $\phi = 0$ ), the current and power are maximum and impedance is minimum. This state is called resonance.
- At resonance,

$$\omega_r L = \frac{1}{\omega_r C}$$

Hence, resonance frequency is,

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

- In resonance, the power factor of the circuit is one.

- **Half – Power Frequencies:**

Those frequencies  $f_1$  and  $f_2$  at which the power is half of the maximum power (power at resonance), i.e.,  $f_1$  and  $f_2$  are called half – power frequencies.

$$P = \frac{1}{2} P_{\max}$$

$$I = \frac{I_{\max}}{\sqrt{2}}$$

$$\therefore P = \frac{P_{\max}}{2}$$

- **Band – Width:**

- The frequency interval between half – power frequencies is called band – width.

$$\therefore \text{Bandwidth } \Delta f = f_2 - f_1$$

- For a series LCR resonant circuit,

$$\Delta f = \frac{1}{2\pi} \frac{R}{L}$$

- **Quality Factor (Q):**

$$Q = 2\pi \times \frac{\text{Maximum energy stored}}{\text{Energy dissipated per cycle}}$$

$$= \frac{2\pi}{T} \times \frac{\text{Maximum energy stored}}{\text{Mean power dissipated}}$$

Or

$$Q = \frac{\omega_r L}{R} = \frac{1}{\omega_r C R} = \frac{f_r}{(f_2 - f_1)} = \frac{f_r}{\Delta f}$$