

# Physics

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(Chapter 7)(Alternating Current)  
(Class 12)

It can be observed that  $I_0$  is very small in this case. Hence, at high frequencies, the inductor amounts to an open circuit.

In a dc circuit, after a steady state is achieved,  $\omega = 0$ . Hence, inductor  $L$  behaves like a pure conducting object.

## Question 7.15:

A  $100\ \mu\text{F}$  capacitor in series with a  $40\ \Omega$  resistance is connected to a  $110\ \text{V}$ ,  $60\ \text{Hz}$  supply.

(a) What is the maximum current in the circuit?

(b) What is the time lag between the current maximum and the voltage maximum?

## Answer 7.15:

Capacitance of the capacitor,  $C = 100\ \mu\text{F} = 100 \times 10^{-6}\ \text{F}$

Resistance of the resistor,  $R = 40\ \Omega$

Supply voltage,  $V = 110\ \text{V}$

(a) Frequency of oscillations,  $\nu = 60\ \text{Hz}$

Angular frequency,  $\omega = 2\pi\nu = 2\pi \times 60\ \text{rad/s}$

For a RC circuit, we have the relation for impedance as:  $Z = \sqrt{R^2 + \frac{1}{\omega^2 C^2}}$

Peak voltage,  $V_0 = V\sqrt{2} = 110\sqrt{2}$ . Maximum current is given as:

$$\begin{aligned} I_0 &= \frac{V_0}{Z} \\ &= \frac{V_0}{\sqrt{R^2 + \frac{1}{\omega^2 C^2}}} \\ &= \frac{110\sqrt{2}}{\sqrt{(40)^2 + \frac{1}{(120\pi)^2 \times (10^{-4})^2}}} \\ &= \frac{110\sqrt{2}}{\sqrt{1600 + \frac{10^8}{(120\pi)^2}}} = 3.24\ \text{A} \end{aligned}$$

(b) In a capacitor circuit, the voltage lags behind the current by a phase angle of  $\Phi$ . This angle is given by the relation:

$$\begin{aligned} \therefore \tan \phi &= \frac{\frac{1}{\omega C}}{R} = \frac{1}{\omega CR} \\ &= \frac{1}{120\pi \times 10^{-4} \times 40} = 0.6635 \\ \phi &= \tan^{-1}(0.6635) = 33.56^\circ \\ &= \frac{33.56\pi}{180}\ \text{rad} \\ \therefore \text{Time lag} &= \frac{\phi}{\omega} \\ &= \frac{33.56\pi}{180 \times 120\pi} = 1.55 \times 10^{-3}\ \text{s} = 1.55\ \text{ms} \end{aligned}$$

Hence, the time lag between maximum current and maximum voltage is  $1.55\ \text{ms}$ .

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