

NCERT 12.7 Q.13

EE23BTECH11203 - Adarsh A*

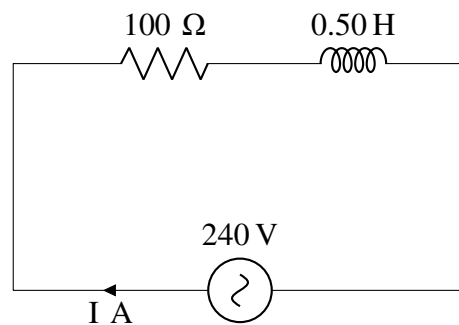
Question : A coil of inductance 0.50 H and resistance 100Ω is connected to a 240 V , 50 Hz ac supply.

- (a) What is the maximum current in the coil?
 (b) What is the time lag between the voltage maximum and the current maximum?

Parameter	Value	Description
V_{rms}	240 V	Effective voltage
f	50 Hz	Oscillations per unit time
R	100Ω	Resistance
L	0.50 H	Inductance
ϕ	-	Phase difference
t_1	-	Time of V_{max}
t_2	-	Time of I_{max}
Δt	$t_2 - t_1$	Time lag

Input Table

Solution:

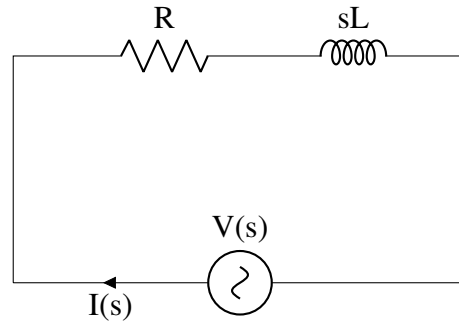


Given Circuit

(a) Peak voltage is given as,

$$V_0 = \sqrt{2}V_{rms} \quad (1)$$

$$= 240 \sqrt{2} \text{ V} \quad (2)$$



s-domain Circuit

Angular frequency is,

$$\omega = 2\pi f \quad (3)$$

$$= 100\pi \text{ rad/sec} \quad (4)$$

Magnitude of total impedance is,

$$Z = \sqrt{R^2 + (\omega L)^2} \quad (5)$$

$$= \sqrt{(100)^2 + (50\pi)^2} \quad (6)$$

$$= 186.21 \, \Omega \quad (7)$$

Now, maximum current is given by Ohm's law,

$$I_{max} = \frac{V_0}{Z} \quad (8)$$

$$= \frac{240 \sqrt{2}}{186.21} \quad (9)$$

$$I_{max} = 1.82 \text{ Amp} \quad (10)$$

\therefore The maximum current is 1.82 Amperes

(b) Equation of voltage is given as,

$$V = V_0 \cos(\omega t) \quad (11)$$

Equation of current is given as,

$$I = I_0 \cos(\omega t - \phi) \quad (12)$$

Maximum is obtained when,

$$V_{max} = V_0 \cos(0) \quad (13)$$

$$\implies \omega t_1 = 0 \quad (14)$$

$$\implies t_1 = 0 \quad (15)$$

Similarly,

$$I_{max} = I_0 \cos(0) \quad (16)$$

$$\Rightarrow \omega t_2 - \phi = 0 \quad (17)$$

$$\Rightarrow t_2 = \frac{\phi}{\omega} \quad (18)$$

Phase angle is given by the relation,

$$\tan \phi = \frac{\omega L}{R} \quad (19)$$

$$= \frac{50\pi}{100} \quad (20)$$

$$\phi = \frac{57.5\pi}{180} \text{ rad} \quad (21)$$

Time lag,

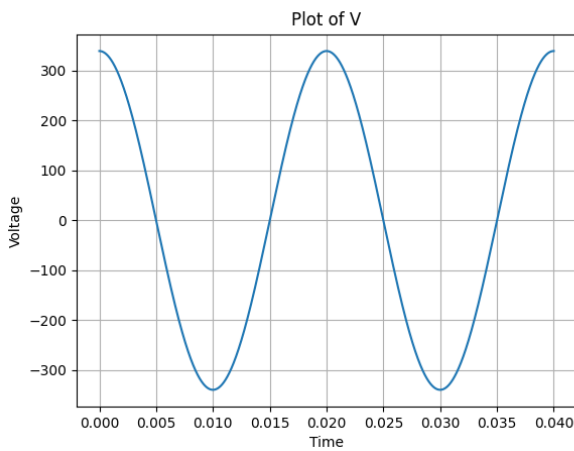
$$\Delta t = t_2 - t_1 \quad (22)$$

$$= \frac{\phi}{\omega} - 0 \quad (23)$$

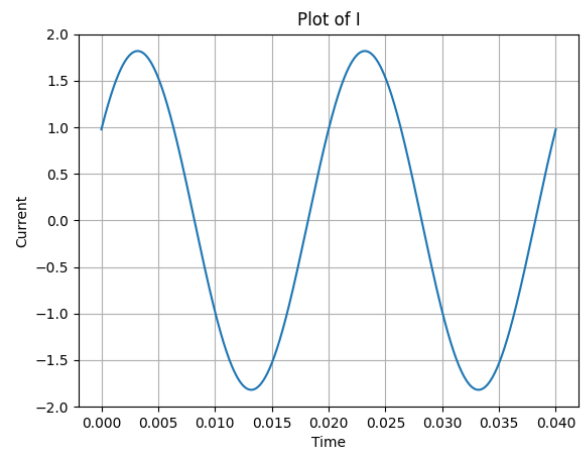
$$= \frac{57.5\pi}{(180)(100\pi)} \quad (24)$$

$$\Delta t = 3.2 \text{ ms} \quad (25)$$

\therefore The time lag between maximum voltage and maximum current is 3.2 ms



(a) Plot of V vs t



(b) Plot of I vs t