CHAPTER NO. 16(ALTERNATING CURRENT)

Question 16.1:- An alternating current is represented by the equation I = 20 sin 100πt. Compute its frequency and the maximum and rms values of current.

Solution:- Given representation of alternating current source I = 20 sin 100πt

Standard representation of alternating current source $I = I_o \sin 2\pi ft$

Comparing both equations gives $I_o = 20$ A and 2πft = 100πt

Frequency = f = 50 Hz

Maximum value = I_o = 20 A

Root mean square value of current = $I_{rms} = I_o/\sqrt{2} = 20/1.414$

I_{rms} = 14 A

Question 16.2:- A sinusoidal A.C. has a maximum value of 15 A. What is its rms value? If the time is recorded from the instant the current is zero and is becoming positive, what is the instantaneous value of the current after 1/300 s, given the frequency is 50 Hz.

Solution:- Peak value of current = I_o = 15 A

Root mean square value of current = $I_{rms} = I_o/\sqrt{2} = 15/1.414$

I_{rms} = 10.6 A

Time instant = t = 1/300 s

Frequency = f = 50 Hz

Instantaneous value of current = $I = I_o \sin 2\pi ft = (15) \sin 2\pi(50)(\frac{1}{300})$

$I = 15 \sin \frac{\pi}{3} = 15 \sin 60^o = 15\ (0.866)$

I = 13.0 A

Question 16.3:- Find the rms value of current and the inductive reactance when A.C. voltage of 220 V at 50 Hz is passed through an inductor of 10 H.

Solution:- Root mean square value of alternating voltage = V_{rms} = 220 V

Frequency = f = 50 Hz

Inductance of inductor = L = 10 H

Inductive reactance of inductor = $X_L = \omega L = 2\pi f L$

$X_L = 2\ (3.14)\ (50)\ (10)$

X_L = 3140 Ω

Root mean square value of current = $I_{rms} = V_{rms}/X_L$

$I_{rms} = 220/3140$

I_{rms} = 0.07 A

Question 16.4:- A circuit has an inductance of 1/π H and resistance of 2000 Ω. A 50 Hz A.C. is supplied to it. Calculate the reactance and impedance offered by the circuit.

Solution:- Inductance of the inductor = L = 1/π H

Resistance = R = 2000 Ω

Frequency = f = 50 Hz

Reactance = X_L = ω L = 2 π f L = 2 (π) (50) (1/π)

X_L = 100 Ω

Impedance offered by RL circuit = Z = $\sqrt{R^2 + X_L{}^2} = \sqrt{(2000)^2 + (100)^2}$

Z = 2002.5 Ω

Question 16.5:- An inductance of pure inductance 3/π H is connected in series with a resistance of 40.0 Ω. Find (i) the peak value of the current (ii) The rms value, and (iii) the phase difference between the current and the applied voltage V = 350 sin (100 πt).

Solution:- Inductance of inductor = L = 3/π H

Resistance = R = 40.0 Ω

Given representation of alternating voltage is V = 350 sin (100 πt)

Standard representation of alternating voltage is V = V_o sin 2πft

Comparing both equation gives **V_o = 350 V** and 2πft = 100πt

f = 50 Hz

Reactance of the inductor = X_L = 2 π f L = 2 π (50) (3/π) = 300 Ω

Impedance offered by RL circuit = Z = $\sqrt{R^2 + X_L{}^2} = \sqrt{(40)^2 + (300)^2}$ = 302.65 Ω

(i) Peak value of current = I_o = V_o/Z = 350/302.65

I_o = 1.16 A

(ii) Root mean square value of current = I_{rms} = $I_o/\sqrt{2}$ = 1.16/1.414

I_{rms} = 0.81 A

(iii) Phase angle = θ = $\tan^{-1}$ (X_L/R) = $\tan^{-1}$ (300/40)

θ = $\tan^{-1}$ (7.5)

θ = 81.4°

Question 16.6:- A 10 mH, 20 Ω coil is connected across a 240 V and 180/π Hz source. How much power does it dissipate?

Solution:- Inductance of the coil = L = 10 mH = 0.010 H

Resistance of the coil = R = 20 Ω

Root mean square voltage = V_{rms} = 240 V

Frequency of the source = f = 180/π Hz

Power dissipated = P = V_{rms} I_{rms} cos θ

Reactance of the coil = $X_L = 2\pi f L = 2\pi (180/\pi)(0.010) = 3.6\ \Omega$

Impedance of RL circuit = $Z = \sqrt{R^2 + X_L{}^2} = \sqrt{(20)^2 + (3.6)^2} = 20.32\ \Omega$

Phase angle = $\theta = \tan^{-1}(X_L/R) = \tan^{-1}(3.6/20)$

$\theta = \tan^{-1}(0.18)$

$\theta = 10.2^o$

$I_{rms} = V_{rms}/Z = 240/20.32 = 11.81$ A

$P = V_{rms} I_{rms} \cos\theta = (240)(11.81)\cos(10.2^o) = 240 \times 11.81 \times 0.98$

P = 2778 W

Question 16.7:- Find the value of current flowing through a capacitor 0.5 μF when connected to a source of 150 V at 50 Hz.

Solution:- Capacitance of the capacitor = C = 0.5 μF = 0.5×10^{-6} F

Root mean square voltage = V_{rms} = 150 V

Frequency = f = 50 Hz

Capacitive reactance of capacitor = $X_C = 1/\omega C = 1/2\pi fC = 1/(2)(3.14)(50)(0.5 \times 10^{-6})$

$X_C = 0.006369 \times 10^6\ \Omega = 6369\ \Omega$

Root mean square current = $I_{rms} = V_{rms}/X_C = 150/6369$

I_{rms} = 0.024 A

Question 16.8:- An alternating source of emf 12 V and frequency 50 Hz is applied to a capacitor of capacitance 3 μF in series with a resistance of 1 kΩ. Calculate the phase angle.

Solution:- Root mean square voltage = V_{rms} = 12 V

Frequency = f = 50 Hz

Capacitance of the capacitor = C = 3 μF

Resistance = R = 1 kΩ = 1000 Ω

Capacitive reactance = $X_C = 1/\omega C = 1/2\pi fC = 1/(2)(3.14)(50)(3 \times 10^{-6})$

$X_C = 0.001061 \times 10^6\ \Omega$

$X_C = 1061\ \Omega$

Phase angle = $\theta = \tan^{-1}(X_C/R) = \tan^{-1}(1061/1000)$

$\theta = \tan^{-1}(1.061)$

$\theta = 46.7^o$

Question 16.9:- What is the resonance frequency of a circuit which includes a coil of inductance 2.5 H and capacitance 40 μF?

Solution:- Capacitance of the capacitor = C = 40 μF = 40×10^{-6} F

Inductance of the coil = L = 2.5 H

Resonant frequency = $f_o = \frac{1}{2\pi\sqrt{LC}} = \frac{1}{2(3.14)\sqrt{(2.5)(40 \times 10^{-6})}}$

$f_o = \frac{1}{(6.28)(10\ x\ 10^{-3})}$ Hz

<u>f_o = 15.9 Hz</u>

Question 16.10:- An inductor of inductance 150 μH is connected in parallel with a variable capacitor whose capacitance can be changed from 500 pF to 20 pF. Calculate the maximum frequency and minimum frequency for which the circuit can be tuned.

Solution:- Inductance of the inductor = L = 150 μH = 150 x 10^{-6} H

Minimum value of capacitance = C_{min} = 20 pF = 20 x 10^{-12} F

Maximum value of capacitance = C_{max} = 500 pF = 500 x 10^{-12} F

Maximum resonant frequency = $f_{max} = \frac{1}{2\pi\sqrt{LC_{min}}} = \frac{1}{2(3.14)\sqrt{(150\ x\ 10^{-6})(20\ x\ 10^{-12})}}$

$f_{max} = \frac{1}{(6.28)(54.77\ x\ 10^{-9})}$ = 2.91 x 10^6 Hz

<u>f_{max} = 2.91 MHz</u>

Minimum resonant frequency = $f_{min} = \frac{1}{2\pi\sqrt{LC_{max}}} = \frac{1}{2(3.14)\sqrt{(150\ x\ 10^{-6})(500\ x\ 10^{-12})}}$

$f_{min} = \frac{1}{(6.28)(273.86\ x\ 10^{-9})}$ = 5.814 x 10^5 Hz

<u>f_{min} = 0.58 MHz</u>