NCERT SOLUTIONS
CLASS-XII PHYSICS
CHAPTER-7
ALTERNATING CURRENT

Question 7.1 :

A resistor of 100 Ω is being connected to a supply of 220 V, 50 Hz

(a) Calculate the rms value of current in the connection

(b) Calculate the total power being consumed over an entire cycle

Answer 7.1 :

Given :

Given that, Resistance R = 100 Ω

Source voltage , V = 220 V

Frequency of the supply given: f = 50 Hz

a) To determine the rms value of the current in the connection, we use the following formula :

à $I = \frac{V}{R}$

$I = \frac{220}{100}$ = 2.20 A

b) To calculate the total power being consumed over an entire cycle , we use the following formula

à P = V x I = 220 x 2.2 = 484 W

Question 7.2 :
a) An AC supply has a peak voltage of 300 V. calculate the rms voltage

b) 10 A is the rms value of current in an AC circuit. Calculate the peak current
Answer 7.2 :

a) peak voltage = V_0 = 300 V

we know that ,

à rms : $V = \frac{V_0}{\sqrt{2}}$

$V = \frac{300}{\sqrt{2}}$ = 212.2 V

b) as given in the question, rms value of current , I = 10 A

we know that,

peak current is formulated as

à $I_0 = \sqrt{2}I = \sqrt{2} \times 10 = 14.1A$

Question 7.3 :

A inductor of 44 mH has been connected to an AC supply of 220 V and a frequency of 50 Hz.

Calculate the rms value of the current in the network.

Answer 7.3:

As given : Inductance of inductor, L = 44 m H = 44 × 10^{-3} H

Voltage of source , V = 220 V

Frequency of source , v = 50 Hz

Angular frequency of source , ω = 2 π v

à Inductive reactance, $X_L = \omega_L$ = 2 π v L = 2π × 50 × 44 × 10^{-3} Ω

We know that :

Rms value of current :

à $I = \frac{V}{X_L} = \frac{220}{2\pi \times 50 \times 44 \times 10^{-3}}$ = 15.92 A

Question 7.4 :

A capacitor of 60 μF is connected to an AC supply of 110 V and 60 Hz ac. Calculate the rms current value in the network.

Answer 7.4 :

Given that , Capacitance of the capacitor in the circuit , C = 60 μ F = 60 × 10^{-6} F

source voltage, V = 110 V

Frequency of the source , v = 60 Hz

à Angular frequency, ω = 2πv

Capacitive reactance in the circuit :

We know that ,

à $X_C = \frac{1}{\omega C} = \frac{1}{2\pi\nu C} = \frac{1}{2\pi \times 60 \times 60 \times 10^{-6}}$ Ω

Rms value of current is given as :

à $I = \frac{V}{X_C} = \frac{220}{2\pi \times 60 \times 60 \times 10^{-6}} = 2.49A$

Therefore, the rms current is calculated as 2.49 A.

Question 7.5 :

In question numbers 7.3 and 7.4 , calculate the total power absorbed by each circuit over a full cycle. justify your answer.

Answer 7.5 :

Given that : Inductive network

In the above circuit we have :

rms current value, I = 15.92 A

rms voltage value, V = 220 V

Therefore, the total power taken in can be derived by the following equation :

à P = VI cos Φ

Here ,

Φ = Phase difference between V and I.

We know that, the difference in phase of alternating voltage and alternating current is 90° , in case of a pure inductive circuit

i.e., Φ = 90°.

Therefore, P = 0

i.e., the total power is zero.

In case of the capacitive network,

The value of rms current is given by , I = 2.49 A

The value of rms voltage is given by , V = 110 V

Thus , the total power taken in can be derived from the following equation :

à P = VI Cos Φ

For a pure capacitive circuit, the phase difference between alternating Voltage and alternating current is 90°

i.e., Φ = 90°.

Thus , P = 0

i.e., the net power is zero.

Question 7.6 :

Determine the resonant frequency ωr of a series LCR circuit with L = 2.0 H, C = 32 μF and R = 10 Ω. Calculate the Q – value of this circuit ?

Answer 7.6 :

Given Inductance of the inductor , L = 2.0 H

Given Capacitance of the capactitor, C = 32 μF = 32 × 10 $^{-6}$ F

Given Resistance of the resistor , R = 10 Ω

We know that , resonant frequency can be calculated by the following relation,

à $\omega_r = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{2\times32\times10^{-6}}} = \frac{1}{8\times10^{-3}} = 125\frac{rad}{sec}$

Now , Q – value of the circuit can be calculated as follows :

à $Q = \frac{1}{R}\sqrt{\frac{L}{C}} = \frac{1}{10}\sqrt{\frac{2}{32\times10^{-6}}} = \frac{1}{10\times4\times10^{-3}} = 25$

Thus , the Q – Value of the above question is 25.

Question 7.7 :

A 30 μF capacitor which is fully charged is connected to an inductor of 27 m H value. Calculate the angular frequency of free oscillations of the above connection ?

Answer 7.7 :

Given Capacitance value of the capacitor , C = 30 μF = 30 × 10 $^{-6}$ F

Given Inductance value of the charged inductor, L = 27 mH = 27 × 10 $^{-3}$ H

Angular frequency is given as :

à $\omega_r = \frac{1}{\sqrt{LC}}$

à $\omega_r = \frac{1}{\sqrt{27\times10^{-3}\times30\times10^{-6}}} = \frac{1}{9\times10^{-4}} = 1.11\times10^{3}\frac{rad}{sec}$

Therefore , the calculated angular frequency of free oscillation of the connection is 1.11 x 10 ^{3} rad / s

Question 7.8 :

Assuming that the charge initially on the capacitor in question 7.7 is 6 mC. Calculate the net energy stored initially in the circuit. Also calculate the net energy at later time.

Answer 7.8:

Given Capacitance value of the capacitor, C = 30 μF = 30 × 10 $^{-6}$ F

Inductance of the inductor, L = 27 mH = 27 × 10 $^{-3}$ H

Charge on the capacitor, Q = 6 mC = 6 × 10 $^{-3}$ C

Total energy stored in the capacitor can be calculated as :

à $E = \frac{1}{2}\times\frac{Q^2}{C} = \frac{1}{2}\frac{(6\times10^{-3})^2}{30\times10^{-6}} = \frac{6}{10} = 0.6J$

Total energy at a later time will remain the same because energy is shared between the capacitor and the inductor.

Question 7.9:

A LCR circuit with resistors, capacitors and inductors connected in series have the following values R = 20 Ω, L = 1.5 H and C = 35 μ F. This combination of LCR series circuit has been connected to a variable frequency and a supply voltage of 200 V ac supply. Calculate the average power that is transferred to the above connection in the entire cycle , when the supply frequency and the natural frequency are equal.

Answer 7.9 :

The supply frequency and the natural frequency are equal at resonance condition in the circuit.

Given Resistance of the resistor, R = 20 Ω

Given Inductance of the inductor, L = 1.5 H

Given Capacitance of the capacitor , C = 35 μF = 30 × 10 $^{-6}$ F

An AC source with a voltage of V = 200 V is connected to the LCR circuit,

We know that the Impedance of the above combination can be calculated by the following relation

We know that the impedance of the above combination can be calculated by the following relation,

à $Z = \sqrt{R^2 + (X_L - X_C)^2}$

At resonant condition in the circuit , $X_L = X_C$

Therefore , Z = R = 20 Ω

We know that Current in the network is given by the relation :

à $I = \frac{V}{Z} = \frac{200}{20} = 10A$

Therefore , the average power that is being transferred to the circuit in one full cycle :

V I = 200 x 10 = 2000 W

Question 7.10:

A radio transmitter has the ability to tune over the frequency of range of a portion of MW broadcast band : (800 kHz to 1200 kHz). Calculate the range of the variable capacitor, when LC network has an effective inductance of value 200 μH

[Hint : The condition for tuning is that the natural frequency which is the frequency of free oscillations of the LC network must be of the same value as the radio wave frequency]

Answer 7.10:

Given the frequency range of (v) of a radio is 800 kHz to 1200 kHz.

Given that the Lower tuning frequency of the circuit is , v 1 = 800 kHz = 800 × 10 3 Hz

Given that the Upper tuning frequency of the circuit is, v 2 = 1200 kHz = 1200 × 10 3 Hz

Given that the Effective inductance of the inductor in the circuit is L = 200 μH = 200 × 10^{-6} H

We know that, Capacitance of variable capacitor for v 1 can be calculated as follows :

à $C_1 = \frac{1}{\omega_1^2 L}$

Here the variables are ,

ω_1 = Angular frequency for capacitor C_1

à $\omega_1 = 2 \pi v_1$

à $\omega_1 = 2\pi \times 800 \times 10^3$ rad/s

therefore,

$$C_1 = \frac{1}{(2\pi \times 800 \times 10^3)^2 \times 200 \times 10^{-6}} = 1.9809 \times 10^{-10} F = 198pF$$

Variable capacitor for v 2 has capacitance of :

$C_2 = \frac{1}{\omega_2^2 L}$

Here the variables are ,

ω_2 = Angular frequency for capacitor C_2

à $\omega_2 = 2 \pi v_2$

à $\omega_2 = 2\pi \times 1200 \times 10^3$ rad/s

Therefore,

$$C_2 = \frac{1}{(2\pi \times 1200 \times 10^3)^2 \times 200 \times 10^{-6}} = 0.8804 \times 10^{-10} F = 88pF$$

Thus , the variable capacitor has a range from 88.04 pF to 198.1 pF.

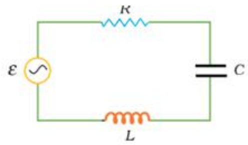
Question 7.11:

In the Figure given below, series LCR circuit is shown which is connected to a source of variable frequency and a voltage of 230 V. The values of the inductor, capacitor and resistor are given below :

L = 5.0 H,

C = 80 μF,

R = 40 Ω



(a) Calculate the source frequency that drives the circuit in resonant condition.

(b) derive the impedance of the network and the amplitude of current at the frequency obtained at resonance .

(c) Calculate the rms potential drops across the resistor, inductor and capacitor given in the network. Also, prove that at resonating frequency the potential drop encountered across the LC combination has a value equal to zero .

Answer 7.11 :

Given that the Inductance of the inductor in the circuit is , L = 5.0 H

Given that the Capacitance of the capacitor in the circuit is , C = 80 μH = 80 × 10^{-6} F

Given that Resistance of the resistor in the circuit , R = 40 Ω

Value of Potential of the variable voltage supply, V = 230 V

(a) We know that the Resonance angular frequency can be obtained by the following relation :

à $\omega_r = \frac{1}{\sqrt{LC}}$

\(\omega _{ r } = \frac{ 1 }{ \sqrt{ 5 x 80 x 10 $^{-6}$ }}\) $\omega_r = \frac{10^3}{20} = 50 rad/sec$

Thus, the circuit encounters resonance at a frequency of 50 rad/s.

(b) We know that the Impedance of the circuit can be calculated by the following relation :

à $Z = \sqrt{R^2 + (X_L - X_C)^2}$

At resonant condition ,

$X_L = X_C$

Z = R = 40 Ω

At resonating frequency amplitude of the current can be given by the following relation :

à $I_0 = \frac{V_0}{Z}$

Where,

à V_0 = peak voltage = $\sqrt{2}V$

Therefore,

à $I_0 = \frac{\sqrt{2}V}{Z} = \frac{\sqrt{2} \times 230}{40} = 8.13A$

Thus, at resonant condition , the impedance of the circuit is calculated to be 40 Ω and the amplitude of the current is found to be 8.13 A

c) rms potential drop across the inductor in the circuit ,

à $(V_L)_{rms}$ = I x ω_r L

Where,

$I_{rms} = \frac{I_0}{\sqrt{2}} = \frac{\sqrt{2}V}{\sqrt{2}Z} = \frac{230}{40} = \frac{23}{4}A$

Therefore, $(V_L)_{rms}$

$\frac{23}{4} \times 50 \times 5 = 1437.5V$

We know that the Potential drop across the capacitor can be calculated with the following relation :

à $(V_c)_{rms} = I \times \frac{1}{\omega_r C} = \frac{23}{4} \times \frac{1}{50 \times 80 \times 10^{-6}} = 1437.5V$

We know that the Potential drop across the resistor can be calculated with the following relation :

à $(V_R)_{rms} = IR = \frac{23}{4} \times 40 = 230V$

Now, Potential drop across the LC connection can be obtained by the following relation :

à $V_{LC} = I(X_L - X_C)$

At resonant condition ,

à $X_L = X_C$

à $V_{LC} = 0$

Therefore, it has been proved from the above equation that the potential drop across the LC connection is equal to zero at a frequency at which resonance occurs.