CLASS – 12

WORKSHEET- ALTERNATING CURRENT

A. RMS AND AVERAGE VALUES OF ALTERNATING CURRENT EMF & POWER

(1 Mark Questions)

1. The instantaneous current and voltage of an ac circuit are given by: i = 10 sin 314t A and v = 50 sin 314t V. What is the power dissipation in the circuit?

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2. If the rms current in a 50 Hz ac circuit is 5 A, the value of the current 1/300 seconds after its value becomes zero is
(a) $5\sqrt{2}$ A (b) 5 $\sqrt{3/2}$ A (c) 5/6 A (d) 5/ $\sqrt{2}$ A

3. Can the instantaneous power output of an ac source ever be negative? Can the average power output be negative?

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(2 Marks Questions)

4. The electric mains in a house are marked 220V, 50Hz. Write down the equation for instantaneous voltage. [Ans. 311 sin 314t volt]

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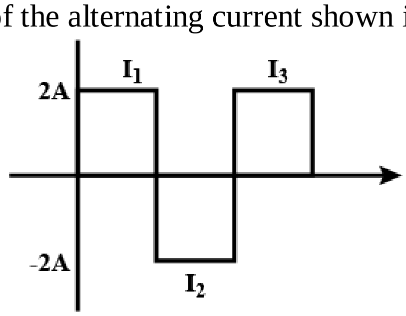
5. Calculate the rms value of the alternating current shown in figure.



[Ans. 2A]

6. Define peak value and root mean value of an alternating current. Derive an expression for the root mean square value of alternating current.

7. (a) The peak voltage of an ac supply is 300 V. What is the rms voltage?
(b) The rms value of current in an ac circuit is 10 A. What is the peak current?
[Ans. 212.1 V, 141.14A]

8. Explain the significance of phasor diagram.

(3 Marks Questions)

9. Derive the average power in ac circuit and explain the term power factor.

B. RESISTIVE CIRCUIT

(1 Mark Questions)

1. What is the maximum value of power factor? When does it occur?

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(2 Marks Questions)

2. An alternating voltage given by V = 140 sin314t is connected across a pure resistor of 50Ω. Find (i) the frequency of the source (ii) the rms current through the resistor.

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3. The peak value of an alternating voltage applied to a 50Ω resistance is 10V. Find the rms current, if the voltage frequency is 100Hz, write the equation for the instantaneous current. [Ans. 141.4 mA, 200 sin 200 πt mA]

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4. A 100 Ω resistor is connected to a 220 V, 50 Hz ac supply.
(a) What is the rms value of current in the circuit?
(b) What is the net power consumed over a full cycle?

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(3 Marks Questions)

5. (a) For a given ac, $i = i_m \sin \omega t$, show that the average power dissipated in a resistor R over a complete cycle is $\frac{1}{2} i^2_m R$. (b) A light bulb is rated at 100W for a 220V ac supply. Calculate the resistance of the bulb.

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(5 Marks Questions)

6. A resistance of 40Ω is connected to an ac source of 220V, 50Hz. Find (i) the rms current (ii) the maximum instantaneous current in the resistor and (iii) the time taken by the current to change from its maximum value to the rms value. [Ans. 5.5A, 7.8A, 2.5 ms]

C. CAPACITIVE CIRCUIT

(1 Mark Questions)

1. What is the impedance of a capacitor of capacitance C in an ac circuit using source of frequency ν Hz?

2. Define capacitive reactance. Write its SI units.

3. What is the minimum value of power factor? When does it occur?

4. How much average power, over a complete cycle, does an a.c. source supply to a capacitor?

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(2 Marks Questions)

5. An ac source of emf $V = V_0 \sin \omega t$ is connected to a capacitor of capacitance C, Deduce the expression for the current (I) flowing in it. Plot the graph of (i) V vs ωt, and (ii) I vs ωt.

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6. What is the inductive reactance of a coil if current through it is 800mA and the voltage across it is 40V? [Ans. 50Ω]

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7. A 60 μF capacitor is connected to a 110 V, 60 Hz ac supply. Determine the rms value of the current in the circuit. [Ans. 2.49A]

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D. INDUCTIVE CIRCUIT

(1 Mark Questions)

1. When an ac source is connected across an inductor, show on graph, the nature of variation of the voltage and the current over one complete cycle.

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2. Define Inductive Reactance.

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3. Draw the variation of Inductive Reactance with frequency of EMF source.

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(2 Marks Questions)

4. Prove that an ideal inductor does not dissipate power to an ac circuit.

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5. A 44 mH inductor is connected to 220 V, 50 Hz ac supply. Determine the rms value of the current in the circuit. [Ans. 15.9 A]

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(5 Marks Questions)

6. Show that an ideal inductor does not dissipate power in an ac circuit.

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7. Show that in an ac circuit containing a pure inductor, the voltage is ahead of current by $\pi/2$ in phase.

E. SERIES LCR CIRCUIT AND RESONANCE

(1 Mark Questions)

1. The selectivity of a series LCR a.c. current is large, when
   (a) L is large and R is large (b) L is small and R is small
   (c) L is large and R is small (d) LR

2. The power factor of a series LCR circuit at resonance will be
   (a) 1 (b) 0 (c) ½ (d) $1/\sqrt{2}$

3. Answer the following questions. [1 mark each]
   (a) In any ac circuit, is the applied instantaneous voltage equal to the algebraic sum of the instantaneous voltages across the series elements of the circuit? Is the same true for rms voltage?

   (b) A capacitor is used in the primary circuit of an induction coil.

   (c) An applied voltage signal consists of a superposition of a dc voltage and an ac voltage of high frequency. The circuit consists of an inductor and a capacitor in series. Show that the dc signal will appear across C and the ac signal across L.

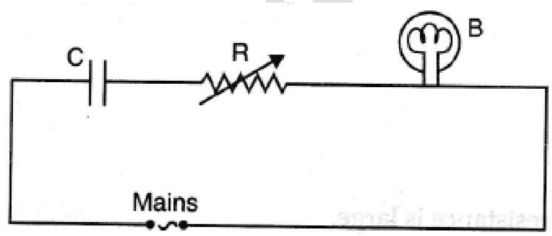
   (d) A choke coil in series with a lamp is connected to a dc line. The lamp is seen to shine brightly. Insertion of an iron core in the choke causes no change in the lamp's brightness. Predict the corresponding observations if the connection is to an ac line.

(e) Why is choke coil needed in the use of fluorescent tubes with ac mains? Why can we not use an ordinary resistor instead of the choke coil?

(2 Marks Questions)

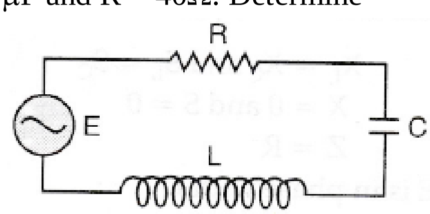
4. Explain the term 'sharpness of resonance' in ac circuit.

5. A capacitor, 'C', a variable resistor 'R' and a bulb 'B' are connected in series to the ac mains in circuits as shown. The bulb glows with some brightness.



How will the glow of the bulb change if (i) a dielectric slab is introduced between the plates of the capacitor, keeping resistance R to be the same; (ii) the resistance R is increased keeping the same capacitance?

6. The figure shows a series LCR circuit connected to a variable frequency 200V source with L = 50mH, C = 80 μF and R = 40Ω. Determine



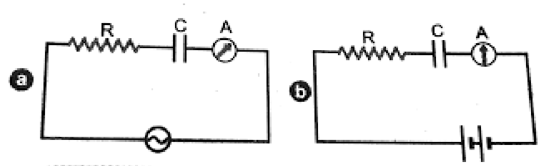
(i) the source frequency which derives the circuit in resonance; (ii) the quality factor (Q) of the circuit.

7. A series LCR circuit is connected to an ac source (200V, 50Hz). The voltages across the resistor, capacitor and inductor are respectively 200V, 250V and 250V.
(i) The algebraic sum of the voltages across the three elements is greater than the voltage of the source. How is this paradox resolved? (ii) Given the value of the resistance of R is 40Ω, calculate the current in the circuit.

8. In a series LCR circuit, $V_L = V_C \neq V_R$. What is the value of power factor for this circuit?

9. Voltage across L and C in series are 180° out of phase. Comment.

10. The hot wire ammeter in Fig (a) shows some deflection but not in fig (b). Why?



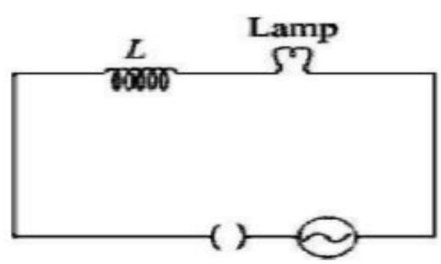
11. Obtain the resonant frequency ω_r of a series LCR circuit with L = 2.0H, C = 32 μF and R = 10 Ω. What is the Q-value of this circuit? [Ans. 25]

12. A charged 30 μF capacitor is connected to a 27 mH inductor. What is the angular frequency of free oscillations of the circuit? [Ans. 1.1×10^3 rad s^{-1}]

13. Suppose the initial charge on the capacitor in Question 38 is 6 μC. What is the total energy stored in the circuit initially? What is the total energy at a later time? [Ans. 0.6J]

(3 Marks Questions)

14. (i) When an AC source is connected to an ideal inductor show that the average power supplied by the source over a complete cycle is zero.
(ii) A lamp is connected in series with an inductor and an AC source. What happen in the brightness of the lamp when the key is plugged in and an iron rod is inserted inside the inductor? Explain.



15. A resistor R and an inductor L are connected in series to a source $V = V_0 \sin \omega t$. Find the (a) peak value of the voltage drops across R and across L. (b) phase difference between the applied voltage and current. Which of them is ahead?

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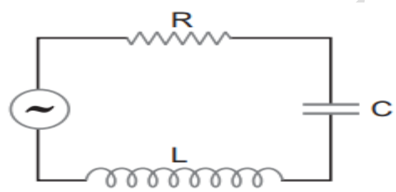
16. The figure shows a series LCR circuit with L = 10.0H, C = 40 μF, R = 60Ω connected to a variable frequency 240V source, calculate (i) the angular frequency of the source which derives the circuit at resonance. (ii) the current at the resonating frequency, (iii) the rms potential drop across the inductor at resonance.



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17. A voltage $V = V_0 \sin\omega t$ is applied to a series LCR circuit. Derive the expression for the average power dissipated over a cycle. Under what condition is (i) no power dissipated even though the current flows through the circuit (ii) maximum power dissipated in the circuit?

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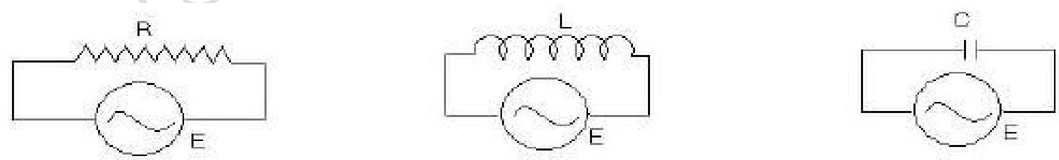
18. A bulb of resistance 10Ω connected to an inductor of inductance L, is in series with an ac source marked 100V, 50Hz. If the phase angle between the voltage and current is $\pi/4$ radian, calculate the value of L. [Ans. 0.0318H]

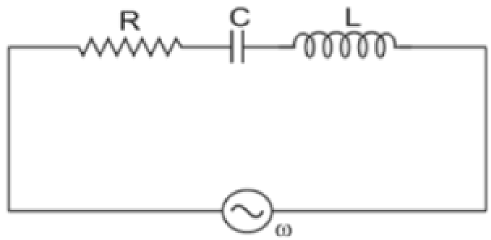
19. A circuit of a resistance of 10Ω and a capacitance of 0.1 μF. If an alternating emf of 100V, 50Hz is applied, find the current in the circuit. [Ans. 3.14 mA]

20. A resistor of 50 ohm, an inductor of (20/π) H and a capacitor of (5/π)μF are connected in series to a voltage source 230V, 50Hz. Find the impedance of the circuit.

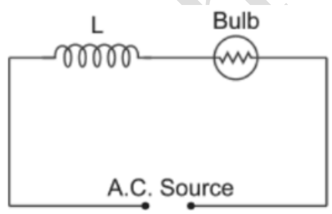
21. Figure (a), (b) and (c) show three a.c. circuits in which equal currents are flowing. If the frequency of emf be increased, how will the current be affected in these circuits? Give reasons for your answer.



22. In the circuit shown in fig, R represents an electric bulb. If the frequency of the supply is doubled, how should the values of C and L be changed so that the glow in the bulb remains unchanged?



23. An inductor 'L' of reactance X_L is connected in series with a bulb 'B' to an a.c. source as shown in figure.



Briefly explain how does the brightness of the bulb change, when (i) number of turns of the inductor is reduced and (ii) a capacitor of reactance $X_C = X_L$ is included in series in the same circuit.

24. A series LCR circuit with R = 20 Ω, L = 1.5 H and C = 35 μF is connected to a variable-frequency 200 V ac supply. When the frequency of the supply equals the natural frequency of the circuit, what is the average power transferred to the circuit in one complete cycle? [Ans. 2000W]

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25. A radio can tune over the frequency range of a portion of MW broadcast band: (800 kHz to 1200 kHz). If its LC circuit has an effective inductance of 200 μH, what must be the range of its variable capacitor? [Ans. 198 pF,88pF]

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26. A coil of inductance 0.50 H and resistance 100 Ω 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?
[Ans. 1.82A, 3.2 ms]

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27. Obtain the answers (a) and (b) in Q. 56, if the circuit is connected to a high frequency supply (240 V, 10 kHz). Hence, explain the statement that at very high frequency, an inductor in a circuit nearly amounts to an open circuit. How does an inductor behave in a dc circuit after the steady state? [Ans. 1.08×10^{-2}A]

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28. A 100 μF capacitor in series with a 40 Q resistance is connected to a 110 V, 60 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?
[Ans. 3.24A, 1.55 ms]

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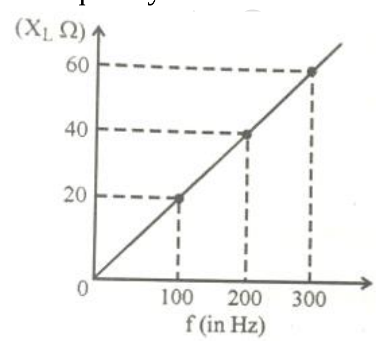
29. Obtain the answer to (a) and (b) in Q.58 if the circuit is connected to a 110 V, 12 kHz supply? Hence, explain the statement that a capacitor is a conductor at very high frequencies. Compare this behaviour with that of a capacitor in a dc circuit after the steady state. [Ans. 3.89A, 2.75A]

(5 Marks Questions)

30. The variation of inductive resistance (X_L) of an inductor with the frequency (f) of the ac source of 100V and variable frequency is shown in the fig.



(i) Calculate the self inductance of the inductor.

(ii) When this inductor is used in series with a capacitor of unknown value and a resistor of 10Ω at 300s^{-1}, maximum power dissipation occurs in the circuit. Calculate the capacitance of the capacitor.

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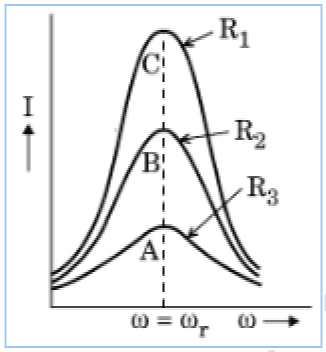
31. (a) What do you understand by 'sharpness of resonance' for a series LCR resonant circuit? How it is related with the quality factor 'Q' of the circuit? Using the graphs given in the diagram, explain the factors which affect it. For which graph is the resistance (R) minimum?



(b) A 2μF capacitor, 100Ω resistor and 8H inductor are connected in series with an ac source. Find the frequency of the ac source for which the current drawn in the circuit is maximum. If the peak value of emf of the source is 200V, calculate the (i) maximum current and, (ii) inductive and capacitive resistance of the circuit at resonance.

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32. Explain (i) Resistance (ii) Reactance and (iii) Impedance (iv) Admittance.

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33. A resistance of 2ohms, a coil of inductance 0.01H are connected in series with a capacitor, and put across a 200volt, 50Hz supply. Calculate: (i) the capacitance of the capacitor so that the circuit resonates. (ii) the current and voltage across the capacitor at resonance (take $\pi = 3$) [Ans.11×10^{-4}F, 303.03V]

34. An inductor 200mH, capacitor 500 μF, resistor 10Ω are connected in series with a 100V, variable frequency a.c. source. Calculate the (i) frequency at which the power factor of the circuit is unity. (ii) current amplitude at this frequency, (iii) Q factor.

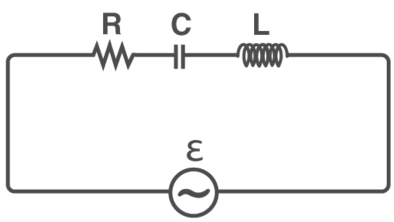
[Ans. (i)$50/\pi$ Hz, (ii) 141.14 A, (iii) 2]

35. (i) Draw the graphs showing variation of inductive reactance and capacitive reactance with frequency of applied ac source (ii) Can the voltage drop across the inductor or the capacitor in a series LCR circuit be greater than the applied voltage of the a.c. source? Justify your answer.

36. Derive an expression for the impedance of an ac circuit with an inductor L and a resistor R in series. Also obtain the expression for average power in the circuit.

37. A series LCR circuit is connected to an ac source having voltage $V = V_m \sin \omega t$. Derive the expression for the instantaneous current I and its phase relationship to the applied voltage. Obtain the condition for resonance to occur. Define 'power factor'. State the conditions under which it is (i) maximum and (ii) minimum.

38. Figure below shows a series LCR circuit connected to a variable frequency 230 V source. L = 5.0 H, C = 80μF, R = 40 Ω.



(a) Determine the source frequency which drives the circuit in resonance.
(b) Obtain the impedance of the circuit and the amplitude of current at the resonating frequency.
(c) Determine the RMS potential drops across the three elements of the circuit. Show that the potential drop across the LC combination is zero at the resonating frequency.

[Ans. (a)50 rad s^{-1},(b) 40Ω, 8.1A, (c) 230V]

39. An LC circuit contains a 20 mH inductor and a 50 μF capacitor with initial charge of 10 mC. The resistance of the circuit in negligible. Let the instant the circuit is closed be t = 0.
(a) What is the total energy stored initially? Is it conserved during LC oscillations?
(b) What is the natural frequency of the circuit?
(c) At what time is the energy stored

- completely electrical (i.e., stored in the capacitor)?
- completely magnetic (i.e., stored in the inductor)?

(d) At what times is the total energy shared equally between the inductor and capacitor?
(e) If a resistor is inserted in the circuit, how much energy is eventually dissipated as heat?

[Ans. (a)1J, (b) 159Hz, (c)(i) t=n/2T (ii)6.3ms, (d) t=(4n+3) T/8, (e) 1J]

40. A circuit containing a 80 mH inductor and a 60 μF capacitor in series is connected to a 230 V, 50 Hz supply. The resistance of the circuit is negligible.
(a) Obtain the current amplitude and rms values.
(b) Obtain the rms values of potential drops across each element.
(c) What is the average power transferred to the inductor?
(d) What is the average power transferred to the capacitor.
(e) What is the total average power absorbed by the circuit? ['Average 'implies' averaged over one cycle']. [Ans. (a) 8.24A,11.7A (b) 207V,437V, (c) 0 (d) 0 (e) 0]

41. Suppose the circuit in previous question has a resistance of 15 Ω. Obtain the average power transferred to each element of the circuit and the total power absorbed.
[Ans. 789.5W]

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F. TRANSFORMER

(1 Mark Questions)

1. Laminated iron sheets are used to minimize _______ currents in the core of a transformer.

2. What is the function of a step up transformer?

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3. The output of a step-down transformer is measured to be 24 V when connected to a 12 watt light bulb. The value of the peak current is

(a) $1/\sqrt{2}$ A. (b) $\sqrt{2}$ A. (c) 2 A. (d) $2\sqrt{2}$ A

(2 Marks Questions)

4. State the underlying principle of a transformer. How is the large scale transmission of electric energy over long distances done with the use of transformers?

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5. A transformer has 300 primary turns and 2400 secondary turns. If the primary supply voltage is 230V, what is the secondary voltage? [Ans. 1.84kV]

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6. What are the various energy losses in a transformer? How can they be reduced?

(3 Marks Questions)

7. Give two disadvantages of transmitting a.c. over long distances at low voltage and high current.

8. At a hydroelectric power plant, the water pressure head is at a height of 300m and the water flow available is 100 m^3s^{-1}. If the turbine generator efficiency is 60%, estimate the electric power available from the plane ($g = 9.8\ ms^{-2}$) [Ans. 176 mW]

9. A power transmission line feeds input power at 2300 V to a step down transformer with its primary windings having 4000 turns. What should be the number of turns in the secondary in order to get output power at 230 V? [Ans. 400 turns]

10. At a hydroelectric power plant, the water pressure head is at a height of 300 m and the water flow available is 100 m^3s^{-1}. If the turbine generator efficiency is 60%, estimate the electric power available from the plant (g = 9.8 ms^{-2}). [Ans. 176 MW]

(5 Marks Questions)

11. With the help of a labeled diagram, explain the working of a step up transformer. Give reasons to explain the following: (i) the core of the transformers is laminated (ii) thick copper wire is used in windings.

12. (a) Draw a labeled diagram of a step up transformer. Obtain the ratio of secondary to primary voltage in terms of number of turns and currents in the two coils. (b) A power transmission line feeds input power at 2200V to a step down transformer with its primary windings having 3000 turns. Find the number of turns in the secondary to get the power output to 220V.

G. CHALLENGING PROBLEMS

1. Keeping the source frequency equal to the resonating frequency of the series LCR circuit, if the three elements, L, C and R are arranged in parallel, show that the total current in the parallel LCR circuit is minimum at this frequency. Obtain the current rms value in each branch of the circuit for the elements of frequency. Source has emf 230 V and L = 5.0 H, C = 80 μF, ff = 40 Ω. [Ans. 0.92 A]

2. Obtain the resonant frequency and Q-factor of a series LCR circuit with L = 3.0 H, C= 27 μF, and R = 7.4 fl. It is desired to improve the sharpness of the resonance of the circuit by reducing its 'full width at half maximum' by a factor of 2. Suggest a suitable way. [Ans. 111 rad s^{-1}, 45]

3. A series LCR circuit with L = 0.12 H, C = 480 μF, R = 23 Ω is connected to a 230 V variable frequency supply.
(a) What is the source frequency for which current amplitude is maximum? Obtain this maximum value.
(b) What is the source frequency for which average power absorbed by the circuit is maximum? Obtain the value of this maximum power.
(c) For which frequencies of the source is the power transferred to the circuit half the power at resonant frequency? What is the current amplitude at these frequencies?
(d) What is the Q-factor of the given circuit?
[Ans. (a) 663Hz, 1.41A (b) 2300W, (c)15Hz, 648Hz & 678Hz (d) 21.7]

4. A small town with a demand of 800 kW of 1 electric power at 220 V is situated 15 km away from an electric plant generating power at 440V. The resistance of the two wire line carrying power is 0.5 Q per km. The town gets 1 power from the line through a 4000-220 V step- down transformer at a sub station in the town.
(a) Estimate the line power loss in the form of heat.
(b) How much power must the plant supply, assuming there is negligible power loss due to leakage?
(c) Characterize the step up transformer at the plant.
[Ans. 600kW, 1400 kW, 440-7000V]

5. Repeat the same exercise as in the previous question with the replacement of the earlier transformer by a 40,000-220 V step down transformer. (Neglect, as before, leakage losses through this may not be a good assumption any longer because of the very high voltage transmission involved). Hence, explain why high voltage transmission is preferred?

[Ans. 6 kW, 806 kW, 300V]

SPACE FOR ROUGH WORK

SPACE FOR NOTES