

ELECTRICAL ENGINEERING

(Paper I)

Time Allowed : Three Hours
Maximum Marks : 250

QUESTION PAPER SPECIFIC INSTRUCTIONS

(Please read each of the following instructions carefully before attempting questions)

There are EIGHT questions divided in two Sections.

Candidate has to attempt FIVE questions in all.

Question Nos. 1 and 5 are compulsory and out of the remaining, any THREE are to be attempted choosing at least ONE question from each Section.

The number of marks carried by a question/part is indicated against it.

Wherever any assumptions are made for answering a question, they must be clearly indicated.

Word limit in questions, wherever specified, should be adhered to.

Attempts of questions shall be counted in sequential order. Unless struck off, attempt of a question shall be counted even if attempted partly. Any page or portion of the page left blank in the Question-cum-Answer Booklet must be clearly struck off.

SECTION 'A'

1. (a) For the circuit shown in Figure, evaluate the current through and the voltage across each element.
 [Figure: a.c. source $173.2 \angle 0^\circ$ V (+ at top) feeding, through a series 10Ω resistor (current I), node V_1 ; from V_1 two parallel branches to the bottom (return) wire: a 20Ω resistor carrying I_1 (downwards) and a capacitor of reactance $-j11.55 \Omega$ carrying I_2 (downwards)] 10
- (b) A voltage of a wave travelling in a non-magnetic medium is given by the equation $E = 4 \sin(2\pi \times 10^7 t - 0.8x) \hat{a}_z$ V/m. Find: (a) ϵ_r , η (b) The time-average power carried by the wave. 10
- (c) Derive the expressions for instantaneous and average power in a single-phase ac circuit. 10
- (d) In the Figure shown what is the function of R_0 and determine its value when $V_0 = -3V_1 - 2V_2$.
 [Figure: Op-amp summing amplifier: input V_1 through R_1 and input V_2 through R_2 to the inverting (-) input; feedback resistor $6 \text{ k}\Omega$ from the output V_0 to the inverting input; non-inverting (+) input connected through R_0 to the common bottom line, which runs between two open terminals (no ground symbol drawn)] 10
- (e) Find the efficiency of a class A amplifier shown in Figure. Given that the voltage drop across R_E is 1 V, the signal current swings from -0.5 A to $+0.5 \text{ A}$ and the DC current is 1 A.
 [Figure: Transformer-coupled class A amplifier: input applied to the base of a transistor; collector connected to one end of the primary winding of an output transformer (label "0.5 A" beside the primary); the other end of the primary goes to the supply marked 10 V, 1 A; secondary winding feeds a loudspeaker; emitter connected to ground through R_E (1 V across it) with a bypass capacitor in parallel with R_E] 10
2. (a) A 8-pole, 240 V lap-wound, series motor has armature and series field resistances of 0.2 ohm and 0.02 ohm respectively. There are 660 armature conductors. If the flux per pole is 0.03 Wb and the torque developed in the armature is 320 N-m, find the current taken by the motor and its speed. 20
- (b) A single-phase full converter is connected to RLE load. The source voltage is 230 V, 50 Hz. The average load current of 10 A is constant over the working range. For $R = 0.4 \Omega$ and $L = 2 \text{ mH}$, compute: (a) firing angle delay for $E = 120 \text{ V}$ and input power factor. (b) firing angle delay for $E = -120 \text{ V}$ and input power factor. 20
- (c) Find the z transform of: $f(t) = \sin \omega t$ for $t \geq 0$. 10
3. (a) Find the Laplace transform of the function: $f(t) = 2e^{-t} \cos 10t - t^4 + 6e^{-(t-10)}$ for $t > 0$. 20
- (b) A distortionless line has $z_0 = 60 \Omega$, $\alpha = 20 \text{ mNp/m}$, $u = 0.6 c$ where c is the velocity of the wave in vacuum. Find R , L , G , C and λ at 100 MHz. 20

- (c) A two-port network has $z_{11}=z_{12}=z_{21}=z_{22}=200\ \Omega$. Two such networks are connected in cascade. What are the overall z-parameters of the composite network? **10**
4. (a) Explain the speed enhancement gained in MOS device by using silicon-on-sapphire or spinel (SOS). What are the other good features of the process? Mention the drawbacks. **20**
- (b) In the network shown in Figure, determine the value of current through $1\ \Omega$ resistance connected between terminals A and B. Verify the answer using superposition theorem also.
[Figure: 4 V source (+ at top) on the left between the top wire and the bottom wire; $2\ \Omega$ resistor in the top wire from the source to the middle node; a 2 A current source (arrow pointing up) from the bottom wire to the middle node; $3\ \Omega$ resistor in the top wire from the middle node to terminal A; $1\ \Omega$ resistor between terminal A and terminal B, B being on the bottom wire] **20**
- (c) The transfer function of a system is given as:

$$C(s)/R(s)=((s+3))/(s(s+1)(s+2))$$
Find out the impulse response of the system. **10**

SECTION 'B'

5. (a) A single-phase full converter is supplied from 230 V, 50 Hz source as shown in Figure. The load consists of $R = 10\ \Omega$ and a large inductance so as to render the load current constant. For firing delay angle of 30° , determine: (a) average output voltage (b) average output current (c) average and rms values of thyristor current (d) input power factor.
[Figure: Single-phase fully controlled thyristor bridge: source $V_s = V_m \sin \omega t$ connected between the midpoints of the two legs; left leg T_1 (upper) and T_4 (lower), right leg T_3 (upper) and T_2 (lower); cathodes of T_1 and T_3 joined to the top (positive) rail, anodes of T_4 and T_2 joined to the bottom rail; load R in series with L connected between the top and bottom rails] **10**
- (b) A battery is charged through a resistor R as shown in Fig. For an ac source voltage of 230 V, 50 Hz find the value of average charging current for $R = 8\ \Omega$ and $E = 150\text{ V}$.
[Figure: Single loop: a.c. source $V_s = V_m \sin \omega t$; from its upper terminal a thyristor (drawn with gate; anode towards the source, cathode towards R) in series with resistor R to the + terminal of battery E; the - terminal of the battery returns to the lower terminal of the source] **10**
- (c) Prove that mechanical power developed by a self excited DC shunt motor is maximum when back e.m.f. is equal to half the applied voltage, if the field loss is neglected. **10**
- (d) Consider an incoming narrow-band signal of bandwidth 10 kHz, and mid frequency that may lie in the range of 0.535 to 1.605 MHz. It is desired to translate this signal to a fixed frequency band centered at 0.455 MHz. Determine the range of tuning that must be provided in the local oscillator to obtain the frequency band centered at 0.455 MHz. **10**
- (e) Obtain all the possible minimal functions for: $F = \Sigma(0,2,3,4,5,7)$. **10**
6. (a) A 440 V dc shunt motor has a no-load speed of 2000 rpm. It is running at 1000 rpm at full load torque, reduced armature voltage and full field current. If load torque is reduced to 50% of rated value with armature voltage and field voltage held constant at previous values, the speed increases to 1050 rpm. Find the armature voltage drop at full load. Neglect the effect of armature reaction. **20**
- (b) Divide by N counter is shown in the figure below. If initially $Q_0=0$, $Q_1=1$, $Q_2=0$, what is the value of N?
[Figure: Three JK flip-flops FF2, FF1, FF0 (left to right) with a common CLOCK to all C_K inputs. Connections: $J_2=\bar{Q}_1$, $K_2=Q_0$; $J_1=Q_2$, $K_1=\bar{Q}_2$; $J_0=Q_1$, $K_0=\bar{Q}_1$. Outputs Q_0 and $\bar{Q}_0$ brought out on the right] **20**
- (c) Draw the circuit for the speed control of a separately-excited dc motor from a single-phase source and explain it. **10**
7. (a) The efficiency of a 20 kVA, 2500/250 V, single-phase transformer at unity power factor is 98% both at rated load and half rated load. Determine: (i) the core loss and ohmic losses and (ii) the p.u. value of the equivalent resistance of the transformer. **20**
- (b) Discuss phase and frequency modulation. Explain, why in practice phase modulation is not favoured. **20**

- (c) An RLE load is operating in chopper circuit from a 500 V dc source as shown in Figure. For $R = 0$, $L = 0.064$ and constant E , the duty cycle is 0.2. Find the chopping frequency to limit the amplitude of load current excursion to 10 A.

[Figure: d.c. supply V_s (+ upper terminal, - lower terminal); a thyristor in the upper line from the + terminal (anode at the supply side) to the output node; a freewheeling diode from the lower line to the output node (cathode at the output node); load from the output node to the lower line: R , L and battery E (+ terminal towards L) in series; load current i_o and output voltage v_o across the diode/load marked]

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8. (a) A 3-phase, 12 pole alternator is coupled to an engine running at 500 r.p.m. The alternator supplies power to an induction motor which has a full-load speed of 1455 r.p.m. Find the slip and number of poles of the motor.

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- (b) Evaluate the maximum and minimum values of $V(t)$ of the amplitude-modulated voltage signal defined as: $V(t) = 10(1 + 0.5\cos\omega t + 0.2\cos 2\omega t)\cos\omega_0 t$.

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- (c) A separately excited dc motor, operating from a single-phase half controlled bridge (semi-converter) at a speed of 1440 rpm, has an input voltage of $330 \sin 314 t$ and back emf 80 V. The SCRs are fired symmetrically at $\alpha = 30^\circ$ in every half cycle and the armature has a resistance of 4Ω . Calculate the average armature current and the motor torque.

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