

ELECTRICAL ENGINEERING (Paper I)

Time Allowed : Three Hours

Maximum Marks : 300

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.

SECTION 'A'

1. Answer any three of the following
 - (a) Determine the relationship between R_1 , R_2 , L and C of the circuit shown below so that the poles of the function $V(s)/I(s)$ are complex.
 [Figure: Current source $I(s)$ (arrow pointing up) in the left vertical branch between the top and bottom wires; shunt branch from the top wire to the bottom wire: R_1 in series with L ; capacitor C in series along the top wire after this branch; then shunt resistor R_2 from the top wire to the bottom wire; output terminals at the right end of the top and bottom wires, $V(s)$ across them (i.e. across R_2).] 20
 - (b)
 - (b)(i) Justify that a thin sheet of a conducting material acts as a low-pass filter for electromagnetic waves. 10
 - (b)(ii) A radio signal at a frequency of 20 MHz is transmitted through sea-water having $\sigma=4$ Ω/m and $\epsilon_r=100$. Find the distance at which 80% of the wave amplitude is attenuated. 10
 - (c) Justify the statement Commentator in a d.c. machine keeps the armature mmf stationary in space along the interpolar axis even though the armature rotates. 20
 - (d)
 - (d)(i) What factors influence the performance of Yagi–Uda antenna? Explain it clearly with the help of a neat sketch showing the direction of e.m.w. 10
 - (d)(ii) Determine field strength at a distance of 50 km of a short vertical monopole radiating power of 20 kW at a frequency 1 MHz over ground with mean conductivity of 10 mS/metre 10
2. (a) The clock frequency of 1000 ns is connected to a 3-bit asynchronous counter with each flip-flop having 50 ns propagating delay. Which state will never occur in it, if the clock frequency is decreased to 100 ns? Explain it by drawing wave- shapes for 1000 ns and 100 ns clock frequencies separately. 20
- (b) A 230 V D.c. source feeds a separately-excited d.c. motor through a chopper operating at 400 Hz. The load torque at 1200 r.p.m. is 32.5 Nm. The motor has $r_a=0$, $L_a=3$ mH and $K_m=1.3$ V-s/rad. All motor and chopper losses are neglected. Calculate (i) the armature current excursion and (ii) the armature current expressions during on and off periods. 20
- (c) Draw the equivalent circuit of a 1-phase induction motor based on two-revolving field theory. Identify the various parameters involved in it. Prove, there from, that the forward flux wave is several times greater than the backward flux wave ϕ_b at normal rotor speed, but at standstill. $\phi_f=\phi_b$. 20

3. (a) Describe the principle of working of linearized model of phase lock loop shown in the figure given below and show that the output voltage is proportional to the change in frequency in the FM signal
 [Figure: PLL block diagram. FM input $v_i(t)$ enters a multiplier ($\otimes$); multiplier output to a LPF; the multiplier and LPF are enclosed in a dashed box labelled "Phase comparator". LPF output is $v_o(t)$, the "Demodulated output"; $v_o(t)$ is also fed back to a VCO, whose output $v_f(t)$ is applied to the second input of the multiplier.] **20**
- (b) Two transformers A and B, operating in parallel have equal voltage ratios and leakage impedances. Their reactance to resistance ratios are 10 and 4 respectively. Determine the ratio of the full-load kVA delivered by the parallel combination to the sum of their individual kVA ratings. Comment on the result. **20**
- (c) For the, circuit shown above, thyristor T is turned on at a triggering angle greater than that given by $\sin^{-1}(E/V_m)$. Draw waveforms for v_s , i_0 and v_T . Derive an expression for the average charging current I_0 . For supply voltage of 30 V, 50 Hz and constant battery e.m.f. of 6 V find the resistance to be inserted in series with the battery to limit the average charging current to 3 A in case thyristor T is turned on at a firing angle of 20° .
 [Figure (printed above the text): Battery-charging circuit: ac source $v_s = V_m \sin \omega t$ in series with thyristor T (voltage v_T marked across it, + on the anode side), resistor R and battery E , forming a single loop; charging current i_0 marked flowing from R towards the battery.] **20**
4. (a) Why do the maximum voltages across the inductance and capacitance in a series R - L - C resonant circuit occur at different values of frequencies? Explain. **20**
- (b) Calculate the quiescent collector current I_{CQ} or room temperature for the amplifier circuit shown in the figure given below.
 [Figure: Voltage-divider-biased npn transistor amplifier: supply (10 ± 1) V on the top line; 4.2 k from the supply to the base node and 0.4 k from the base node to ground (the base node connected to the base); collector resistor 0.3 k from the supply to the collector; emitter resistor $(100 \pm 10) \Omega$ from the emitter to ground.] **10**
- (b)(ii) Describe the applications of clipping and clamping circuits. **10**
- (c) What is the difference between TWT and Klystron? How TWT operates as microwave oscillator? Determine (i) the gain parameter; (ii) the power gain, and (iii) any two propagation constants in a traveling wave tube having the following parameters Beam voltage $V_0 = 2$ kV Beam current $I_0 = 20$ mA Frequency $f = 10$ GHz Characteristic impedance of helix $Z_0 = 10 \Omega$ Circuit length = 50 (wavelength) **20**

SECTION 'B'

5. Answer any three of the following
- (a) A non-sinusoidal current $i(t)$ as shown in the above figure is passed through a capacitance $C = 100 \mu\text{F}$. Determine the voltage across the capacitance when $\omega = 1000$ rad/sec.
 [Figure (printed above the text): Waveform of $i(t)$ against $\theta = \omega t$: triangular wave starting at $+I$ at $\theta = 0$, falling linearly through zero at $\pi/2$ to $-I$ at π , then rising linearly through zero at $3\pi/2$ to $+I$ at 2π .] **20**
- (b) Design a combinational circuit having 3 inputs and 6 outputs with the condition that the output number is square of the input number. **10**
- (b)(ii) A computer uses RAM chips of capacity 1024×1 . How many chips are required and how their address and data bus be connected to provide a memory capacity of 1024 bytes? How chips would be connected to provide memory of 16 K bytes? **10**
- (c) For a single-phase one-pulse controlled converter system, sketch waveforms for load voltage and load current for (i) RL load and (ii) RL load with freewheeling diode across RL. Compare these waveforms and discuss the advantages of using a freewheeling diode. State the assumptions made. **20**

- (d) Justify the statement pulse modulation is not digital whereas pulse code modulation is digital. Obtain the bandwidth for 128 quantization levels and 8 kHz sampling frequency of a practical PCM system consisting of 24 telephone channels, each band limited to 3.4 kHz in time division multiplexing. Deduce formulae used. **20**
6. (a) **10**
- (a)(i) Explain the phenomenon of attenuation in TE and TEM waves. **10**
- (a)(ii) Determine the guide wavelength to propagate a 20 GHz signal through a parallel plate waveguide having a plate separation of 5 cm. **10**
- (b) **10**
- (b)(i) Which type of communication system will you prefer for speech processing? Why? **10**
- (b)(ii) With the help of a suitable schematic diagram describe the working of a delta modulation system. Discuss its limitation. **10**
- (c) **10**
- (c)(i) Derive relationship between critical frequency and the maximum density of a layer N. **10**
- (c)(ii) Calculate skip distance for a wave of frequency 4.5 MHz when the maximum ionization in the E - region has value of 10^{10} electrons/m³ at a height of 105 km. **10**
7. (a) Obtain Z-parameters of the 2-port network given above and deduce Y-parameters from the result. **20**
- [Figure (printed above the text): Ladder two-port: from input terminal 1 (current I_1 entering, voltage V_1 across port 1) series resistor R to node A; shunt 2R from node A to the common bottom line; series 2R from node A to node B; shunt 2R from node B to the bottom line; series R from node B to output terminal 2 (current I_2 entering, voltage V_2 across port 2).]
- (b) **10**
- (b)(i) A n-type GaAs Gunn diode of length 10 μm , doping concentration $2 \times 10^{14}/\text{m}^3$ and threshold field 3 kV/cm operates at a frequency of 10 GHz with applied voltage of 3.5 kV/cm. Calculate electron drift velocity, current density and negative mobility of electron. **10**
- (b)(ii) A circular loop of 20 cm radius made of 3 mm dia. of copper wire is used as an antenna. Calculate its radiation resistance, ohmic resistance, input resistance and radiation efficiency at 1 MHz. **10**
- (c) A signal $v_i(t) = k\{1 + mf(t)\} \cos \omega_c t$ is applied to the input of an average (diode) detector with load resistance R. The diode is characterized as $i_b = 0$ for $v_b \leq 0$, $i_b = v_b / r_d$ for $v_b > 0$. Obtain an expression or low frequency component of the output voltage of the detector for $|mf(t)| < 1$. **20**
8. (a) Determine the output $c(t)$ at $t = 2$ sec for the system shown in the above figure. **20**
- [Figure (printed above the text): Sampled-data unity-feedback system: unit step input to a summing junction (+ input; - feedback from the output $c(t)$); error passes through a sampler with $T = 1$ sec, then a ZOH block, then a plant block $1/(s+2)$, whose output is $c(t)$. "ZOH: Zero Order Hold".]
- (b) A star - connected synchronous machine with $Z_s = 1 + j10$ ohm per phase, is synchronized with an infinite bus of 11 kV. The machine is made to operate at a leading power factor of 0.8 with an armature current of 50 A and with terminal voltage ahead of the excitation e.m.f. Calculate the magnitude of excitation e.m.f. How can this machine be made to operate at unity p.f.? Under this condition, find the armature current and load angle, **20**
- (c) A single-phase full bridge inverter feeds a load that allows load commutation. Explain how load commutation is achieved. Describe the conduction of various elements of the inverter circuit. **20**