

ELECTRICAL ENGINEERING (Paper II)

Time Allowed : Three Hours

Maximum Marks : 300

QUESTION PAPER SPECIFIC INSTRUCTIONS

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

There are TWELVE questions divided in three Sections – A, B and C.

Candidate has to attempt FIVE questions in all, from Section A and either Section B or Section C.

Question No. 1 is compulsory, together with Question No. 5 (for candidates choosing Section B) or Question No. 9 (for candidates choosing Section C).

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. Select any three of the following statements, read them carefully and identify the correct and incorrect ones. Justify your answer using not more than 200 words in each case. **20×1=60**
- (a) State equations are first order differential equations that can be applied to portray only the linear time-invariant systems.
- (b) By adding a pole to the closed loop transfer function, the maximum overshoot increases and the effect is opposite to that of adding a pole to the open loop transfer function.
- (c) For a closed-loop system to be asymptotically stable, there is no restriction on the location of the poles and zeros of the loop transfer function $F(s)$, but the poles of the closed loop transfer function must all be located in the left half of S-plane.
- (d) A vacuum tube oscillator has small power outputs high at frequencies and is less efficient compared to SCR.
2. (a) Describe a simple position control system. A certain position control system is driven by 100:1 gear by a motor whose torque characteristics is of the form $(10V_m - 0.3N) 10^{-4}$ N-m, where N is the speed in R.P.M. and V_m is the voltage supplied by the amplifier. If the synchros produce 1 V/ degree error and if the steady state error should be 5° for a speed input of 20 RPM, calculate the required amplifier gain. Viscous friction at the motor shaft is 60×10^{-6} Nm-sec. **20**
- (b) Distinguish between open-loop and closed-loop system. Convert the system of Fig. 1 into a unity feedback system.
[Figure: Fig. 1: Block diagram: input R enters summing point 1 (+); its output splits into two parallel paths, one through block $(1+j\omega)/(1+0.5j\omega)$ and the other through block 10, which are added at summing point 2 (both +); the sum passes through block $6/(j\omega)^2$ [?] to the output C; C is fed back through block 3 [?] to summing point 1 (-)] **20**
- (c) Obtain the state equations in (i) the controller form, and (ii) and observer form for the transfer function $G(s)$ given by $G(s) = (3s^2 + 5s + 7)/(s^4 + 5s^3 + 18s^2 + 29s + 35)$ **20**
3. (a) What do you mean by Root-locus of a system? Give properties of the root-locus. A unity feedback system has a forward path transfer function $G(s) = K/(s(s+4)(s+5))$ Sketch the locus of the poles of the transfer function of the closed-loop system as 'K' varies from zero to infinity, explaining all the steps involved. **20**
- (b) What is a servomotor? Give the characteristics of a 2-phase servomotor and obtain its transfer function. A 50 Hz, 2-phase, ac. servomotor has the following parameters: Starting torque = 0.186 N-m Rotor inertia = 1×10^{-5} kg m² Supply voltage = 120 V No-load angular **20**

velocity = 304 rad/sec Assuming straight line torque-angular speed characteristics of the motor and zero viscous friction derive the transfer function.

- (c) A system is described by $\dot{X}=AX+BU$ $Y=CX$ where $A=\begin{bmatrix} 0 & 1 & -8 \\ 1 & 0 & -5 \\ 0 & 2 & -6 \end{bmatrix}$; $B=\begin{bmatrix} 2 \\ 1 \\ 0 \end{bmatrix}$ and $C=\begin{bmatrix} 1 & 2 & 1 \end{bmatrix}$ Determine whether the system is stable. 20
4. (a) Describe with a neat sketch a step up chopper and discuss its merits and demerits. 20
- (b) Explain the principle of electric welding. Describe with the help of a neat diagram the principle of operation of a timer circuit used for electric welding. 20
- (c) Fig. 2 shows a circuit used for self-commutation by resonance. (i) With the thyristor in blocking state, what is steady state capacitor voltage and load current? (ii) Derive an expression for the load current, thyristor current and $V_c(t)$ after a thyristor is triggered at $t=0$. (iii) Calculate the time when the thyristor would stop conducting.
- [Figure: Fig. 2: Battery $V_{dc} = 200$ V (+ at top) between a top line and a bottom line. From the top line, capacitor $C = 100$ μ F goes down to one end of inductor 0.1 H, whose other end joins node X; a thyristor is connected from the top line down to node X (in parallel with the series C–L branch); load resistor $R_L = 100$ Ω from node X to the bottom line, carrying load current i_L ; bottom line returns to the battery] 20

SECTION 'B'

5. Comment with justification on the correctness or otherwise of any three of the following statements, restricting your answer to within 200 words for each. 20×3=60
- (a) Single phase induction motors with auxiliary winding neither develop starting torque nor the running torque.
- (b) For EHV transmission lines, it is dangerous to use bundle conductors from the viewpoint of sub-synchronous resonance.
- (c) Sudden loss of load may cause severe disturbance in the operation of a power system.
- (d) Self-excitation of an induction generator requires the machine to be run at super synchronous speed.
6. (a) Derive an expression for the charge (complex) value per meter length of conductor 'A' of untransposed 3-phase line shown in Fig. 3. The applied voltage is balanced 3-phase, 50 Hz. Take the voltage of phase 'A' as reference phasor. All conductors have the same radii. Also find the charging current of phase A'. Neglect the effect of ground.
- [Figure: Fig. 3: Three conductors A, B and C of equal radius in a horizontal row; spacing A–B = p, B–C = q, A–C = r; p = q = D] 20
- (b) Discuss briefly different methods used for Load-Flow studies. Give their merits and demerits. 20
- (c) A single-phase, 50 Hz generator supplies an inductive load of 5 MW at a p.f. of 0.707 lagging by means of an overhead line 20 km long. The line R and L are 0.0195 Ω /km and 0.63 mH/km. The voltage at the receiving end is required to be kept constant at 10 kV. Find (i) the sending end voltage regulation of the line, (ii) the value of the capacitors to be placed in parallel with the load such that the regulation is reduced to 50% of that obtained in part (i), (iii) transmission efficiencies in both the cases. 20
7. (a) Discuss the behaviour of a 3-phase induction motor on single-phasing. Compare its characteristics, rating and efficiency with that under balanced 3-phase supply. 20
- (b) Give the constructional features, principle of operation and applications of a variable reluctance stepper motor. 20
- (c) A salient-pole synchronous motor has $x_d=0.85$ p.u and $x_q=0.55$ pu. It is connected to bus-bars of 1.0 p.u. voltage, while its excitation is adjusted to 1.2 p.u. Calculate the maximum power output that the motor can supply without loss of synchronism. Compute the minimum p.u. excitation that is necessary for the machine to stay in synchronism while 20

supplying the full-load torque.

8. (a) Explain the principle and applications of (i) induction heating, and (ii) dielectric heating. Discuss the range of frequencies used in these systems of heating. **20**
- (b) Discuss the electrical, mechanical and economic characteristics to be considered in selecting a motor for a given drive. What are the special features required for selecting electrical equipment for mines with fire hazard? **20**
- (c) An 11 kV, 1-MVA, Y-connected generator has a reactance of 4.2 ohms/phase. The generator neutral is grounded through a resistance of 22 ohms. Determine what percent of the generator winding remains unprotected by the percentage differential relaying. Assume for simplicity that the percentage differential relay operates when out-of-balance current exceeds 25% of the full-load current. **20**

SECTION 'C'

9. Select any three of the following statements and indicate with justification whether they are correct or incorrect. Your answer must not exceed 200 words for each statement. **20×3=60**
- (a) Modern communication system is concerned with development of transmission and not with the sorting, processing and storing of information.
- (b) AM is more likely to be affected by noise than is FM.
- (c) In comparison with wave-guides and co-axial lines, strip line has reduced bulk, lower bandwidth, higher power-handling capability and components made of it are readily adjustable.
- (d) The conical scanning method of tracking an acquired target is an improvement over lobe switching.
10. (a) (i) What are the three main systems of SSB generation? Give the salient characteristics of each system. (ii) Prove that the balanced modulator produces an output consisting of side bands only, with the carriers removed. **20**
- (b) What is an RF amplifier? Give its advantages. What do you understand by image frequency and its rejection ratio? In a broadcast super-heterodyne receiver having no RF amplifier, the loaded Q of the antenna coupling circuit (at the input to the mixer) is 100. If the intermediate frequency is 555 KHz, calculate (i) the image frequency and its rejection ratio at 1000 KHz, and (ii) the image frequency and its rejection ratio at 25 MHz. **20**
- (c) Give the properties of paraboloid reflectors. Explain why an antenna using a paraboloid reflector is likely to be a highly directive receiving antenna. Describe the Cassegrain method of feeding a paraboloid reflector. Give some shortcomings and difficulties associated with the method. **20**
11. (a) What is the importance of impedance matching in RF transmission lines? Explain single stub-matching and double stub-matching. A loss-less line has a characteristic impedance of 75 ohms and is terminated in a load of 300 ohms. The line is energised by a generator which has an open circuit voltage of 20 V (r.m.s) and output impedance of 75 ohms. The line is assumed to be $2\frac{1}{4}$ wavelengths long. Determine: (i) the input impedance (ii) the magnitude of instantaneous load voltage, and (iii) the instantaneous power delivered to the load. **20**
- (b) (i) What is meant by saying that colour TV must be compatible? (ii) Explain what is meant by the Y, I and Q signals in colour TV, and why they are generated. With the help of circuit diagram of a simplex matrix, explain how the I, Q and Y signals are generated in a colour TV transmitter. **20**
- (c) Give the advantages and disadvantages of submarine cables and communication satellites for intercontinental telephone and television. Show how the two media may be **20**

complementary. Explain what is done to ensure that intercontinental telephone calls are not misrouted.

12. (a) What do you understand by S-parameters of a 2-port network? Why are these parameters preferred to H, Y and Z parameters for operation in microwave range of frequencies? Show that the S-matrix of a directional coupler may be reduced to the form $S = \begin{bmatrix} 0 & p & 0 & jq \\ p & 0 & jq & 0 \\ 0 & jq & 0 & p \\ jq & 0 & p & 0 \end{bmatrix}$ 20
- (b) With the help of a schematic diagram, explain a four-cavity klystron amplifier. A four-cavity klystron amplifier has the following parameters: Beam voltage: $V_0 = 20$ kV Beam current: $I_0 = 2$ A Operating frequency: $f = 10$ GHz d.c. charge density: $\rho_0 = 10^{-6}$ C/m² RF charge density: $\rho = 10^{-8}$ C/m² Velocity perturbation: $v = 10^5$ m/s Determine (i) The d.c. electron velocity (ii) The d.c. phase constant (iii) The plasma frequency (iv) The reduced plasma frequency for $R = 0.5$ (v) The d.c. beam current density (vi) The instantaneous beam current density 20
- (c) Explain what you understand by: (i) MMIC (ii) MOSFET (iii) NMOS Growth (iv) CMOS Development (v) RAM Device (vi) SRAM Cell (vii) DRAM Cell 20