

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 the incorrect ones. Justify your answer using not more than 200 words in each case.

20×3=60

- (a) If a system is stable with unity feedback, the open loop system is also stable.
- (b) A two-phase a.c. Servomotor is similar in all respects to a conventional induction motor.
- (c) If in the state variable description of a system, A matrix is singular, then the system is unstable.
- (d) Commutation has to be specially taken care of, While using Thyristor-Chopper for motor speed control.

2. (a) Sketch the under-damped time response of a second order control system to a step input. Define clearly the “Delay time”, “Rise time”, “Peak time”, “Peak-overshoot”, “Settling time” and “Steady state error” and also show them in the sketch.

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- (b) A system is represented by the following equations:

$$\dot{x} = x_1 + 3u$$

$$\dot{x}_1 = -3x_1 + x_2 + 2u$$

$$\dot{x}_2 = -2x_1 + u$$

Find the transfer function $X(s)/U(s)$ by signal flow technique.

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- (c) State Nyquist Stability Criteria and investigate the stability of the closed loop system with the following open loop transfer function. $G(s)H(s) = (2(s+3))/(s(s-1))$ by drawing Nyquist plot. Wherever the Nyquist plot crosses the real or imaginary axis determine the frequency and the intercept value.

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3. (a) The response of an initially relaxed time invariant constant parameter system to a unit impulse applied at $t=0$ is $4e^{-2t}u(t)$. (i) Find through time domain analysis the response to the same system to an input $e^{-t}u(t)$ (ii) Find the time function which when applied to the system would yield a response $\sin 2t \cdot u(t)$.

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- (b) An open loop transfer function of unity feedback system is given by $G(s) = 25/(s(s+2))$. Determine the damping factor, undamped natural frequency, damped natural frequency and time response for a unit step input.

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- (c) What do you understand by the term controllability of a system? State the necessary and sufficient conditions to be satisfied by the coefficient matrices of a system, so that the system is completely controllable. Hence check the controllability of a system having for its

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state description, the matrices: $A = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -1 & 0.5 & -2 \end{bmatrix}$ $B = \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix}$

4. (a) Discuss the volt-ampere characteristic of a Triac. Explain its usefulness in speed control applications. 20
- (b) The above figure shows a chopper circuit operating at 100 Hz with a $K_d = 0.5$. The load current at steady state is continuous but varies between 3 amps and 10 amps. Sketch the wave shape of (i) the load current, i_L (ii) the current i_f through the free wheeling diode D_f (iii) the current i_C through the commutating capacitor
 [Figure: Thyristor chopper (sketch, partly unclear): main thyristor Th_1 from the supply line to the load node; a commutating circuit consisting of diode D_1 , capacitor C in series with inductor L (current i_C , double-headed arrow) and diode D_2 , with an auxiliary thyristor Th_2 ; the load (resistor and inductor in series, current i_L downwards) connected from the load node to the return line; free-wheeling diode D_f across the load (current i_f upwards)] 20
- (c) The load connected at the output of a single phase bridge inverter is a series combination of $R = 10 \Omega$ and $L = 0.05H$. Determine the load voltage and current waveforms for the first two half cycles with rectangular wave output at 50 Hz. The input of the inverter is $V_{dc} = 250 V$. Also find the expression for the steady state current in each half cycle. 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) Load frequency control is used to control the reactive power flow in a power system.
- (b) Ground wires protect transmission lines against direct lightning strokes.
- (c) Sequence networks are connected in parallel to represent a single line-to-ground fault.
- (d) The secondary of a current transformer should never be kept open circuited.
6. (a) Distinguish between Restriking voltage and Recovery voltage as applied in case of a circuit breaker. On what factors the Active Recovery voltage depends? What is the maximum value of the peak Restriking voltage transient? 20
- (b) With a neat sketch explain the working principle of an Axial blast circuit breaker. Explain why such a circuit breaker is prone to current chopping. What is the voltage expected across the contacts of the circuit breaker under such a condition? 20
- (c) A generator operating at 50Hz delivers 1 P.U. power to an infinite bus through a transmission circuit in which the resistance is ignored. A fault place reducing the maximum power transferable to 0.5 P.U., whereas before the fault this power was 2.0 P.U. and after the clearance of the fault it is 1.5 P.U. By the use of Equal Area criteria determine the critical clearing angle. 20
7. (a) Discuss the advantages and disadvantages of HVDC transmission over a.c. transmission. Explain with suitable circuit diagram how power flow in an HVDC transmission system neither direction facilitated. 20
- (b) A 2000 VA [?], 11 kV, 3-phase star-connected alternator has a resistance of 0.3 ohm and a reactance of 5 ohms per phase. It delivers full load current at a power factor of 0.8 lagging and normal rated voltage. Compute the terminal Voltage for the same excitation and load current at 0.8 p.f. leading. 20
- (c) What is a synchronous condenser? Distinguish between a synchronous condenser and a static var compensator. Why is static var compensation necessary in a power system? 20

8. (a) An electric train has an average speed of 42 kmph on a level track between stops 1400 m apart. It is accelerated at 1.7 kmph/s and is broken at 3.3 kmph/s. Draw the speed-time curve for the run. Estimate the energy consumption at the axle of the train per ton km. Take tractive resistance constant at 50 N/ton and allow 10 per cent for rotational inertia. 20

- (b) Explain the working principle of a time graded protective scheme for radial feeders. Explain further with a sketch of a ring main feeder, why the time graded protective scheme has to be supplemented by directional control. 20

- (c) An 11 kV, 3-phase radial feeder is equipped with two current transformers along with their associated I.D.M.T.L. relays at two different locations. The c.t. ratios are 600/5 and 200/5 respectively and the relay associated with each c.t. has the following characteristic,

Plug Setting Multiplier (PSM)	Times in secs
2	10
3	6
5	4.1
10	3.0
15	2.5
20	2.2

The relay on 200/5 c.t. has a 150% plug setting and 0.2 time multiplier setting. Determine the time of operation of this relay, if the fault current through the feeder is 3000amps. Also calculate the time setting and time of operation of the other relay connected to 600/5 c.t. assuming a plug setting of 200% and taking into consideration the adequate discrimination margin of 0.5 sec. 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) VHF band is most suited for communication between a ship and a submarine.
- (b) Round trip propagation time with geostationary satellites is very large and poses a peculiar problem for telephone service.
- (c) Colour, television transmitter has to transmit more information than black and white but has to manage within the same bandwidth.
- (d) FM broadcast systems use wide-band FM.

10. (a) An MTI radar operating at 6GHz is having a PEW [?] of 900 pps. Find the two lowest blind speeds for this radar. 20

- (b) Why is companding used in PCM Systems? Describe any one companding law. 20

- (c) A silica fibre has a large core diameter. The refractive indices of core and cladding are 1.49 and 1.46 respectively. Find the NA of the fibre, the acceptance angle in air and the critical angle at the core-cladding interface. 20

11. (a) How is stereophonic FM broadcast made compatible with a monophonic system? 20

- (b) What is a three-port circulator? Write its S-matrix. One of the ports of such a circulator is terminated in a load having a reflection coefficient ρ . If the system is now viewed as a two-port at the other pair of ports, find the scattering matrix of the two-port. 20

- (c) A deep space probe radar operating at 3 GHz is using a 64 m dish and peak pulse power of 20MW. The receiver noise figure is 1.0 dB, the target cross section is 1.5 m^2 and the receiver bandwidth 8kHz. Find the maximum range under threshold detection conditions. Take antenna noise temperature to be 290K. 20

12. (a) Find the required size of a cubic cavity resonator to have a dominant mode at 8 GHz. Name the dominant modes for this cavity. **20**
- (b) Describe a balanced off-resonant (slope) discriminator for FM signals. **20**
- (c) A broadside antenna array has 20 identical radiators, equally fed and spaced $\lambda/2$ apart. Find the directivity of the array and express it in decibels. **20**