

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 correct and incorrect ones. Justify your answer using not more than 200 words in each case: **20×3=60**
 - (a) For a stable system, the gain margin and phase margin should be positive.
 - (b) Shaft encoders are extremely useful for the measurement of singular displacement.
 - (c) An SCR is derated when it handles pulsed anode current.
 - (d) An operation amplifier has features suitable for radio frequency timers.
2. (a) What is Bode-plot? Discuss how a Bode-plot can be drawn. Derive the step response of a second order system expressed by: $ad_2\theta/dt+bd\theta/dt+c\theta=F(t)$. **20**
 - (b)(i) Enumerate the salient features of phase-lead and phase lag networks. **10**
 - (b)(ii) Design an astable multivibrator with LM 555. Calculate also the duty cycle and frequency of oscillation. **10**
 - (c)(i) The pole-zero configuration of a closed-loop control system is given by $(s_1, s_2) = -2 \pm j2$. Calculate the undamped resonance frequency and the damping ratio. **10**
 - (c)(ii) Explain Hurwitz stability criteria. The characteristic equation of a system is represented by $4s^3 + 3s^2 + 2s + 3 = 0$. Verify the stability of the system through expansion by confined fraction. **10**
3. (a) Fig. 3(a) shows a circuit employing class-C commutation. The circuit is initially relaxed. Sketch the waveform for V_{T1} , V_{T2} , i_c , i_{T1} , v_c and i_{T2} for one cycle for explaining the commutation process of both the thyristors. **20**

[Figure: Fig. 3 (a): d.c. supply V_S (+ at the top rail, – at the bottom rail); R_1 from the top rail to the anode of thyristor T1, R_2 from the top rail to the anode of thyristor T2; cathodes of T1 and T2 connected to the bottom rail; commutating capacitor C connected between the anodes of T1 and T2, with voltage v_c marked – at the T1 side and + at the T2 side and current i_c marked (arrow towards the capacitor from the T2 side); thyristor voltages V_{T1} and V_{T2} (+ at anode) and currents i_{T1} , i_{T2} (downwards) marked]

 - (b) Describe the working of a 3-phase full converter when connected to a resistive load. The firing angle is approximately 70° . Derive an expression for its average output voltage in terms of firing angle, input supply voltage. **20**
 - (c) A fixed frequency chopper feeds a separately-excited dc motor supplied from 80 V dc source. The rated speed is 900 rpm and the rated armature current is 40 A. Armature circuit resistance is 0.25Ω . Find the duty cycle of the chopper at half the rated motor torque for a speed of 300 rpm ignoring the current pulsations. **20**

4. (a) Enumerate states and state variable representation of a dynamic system. Determine, by Routh array, whether a system represented by characteristic equation. $s^3+4s^2+8s+11=0$ is stable or not. 20
- (b) Discuss the principle of working of a 3-phase bridge inverter with an appropriate circuit. Draw phase and line voltage waveforms on the assumption that each thyristor conducts for 180° and the resistive load is star connected. Indicate the sequence of firing for thyristors as well. 25
- (c) Explain the mechanism for the dissipation of stored energy in a SCR during its commutation process. 15

SECTION 'B'

5. Select any three of the following statements and justify the correctness or otherwise of them, restricting your answer to within 200 words for each: **3×20=60**
- (a) Restriking transients can be damped by connecting a resistance across the contacts of a circuit breaker.
- (b) Gauss-Siedel method is preferred for load flow studies of large power system due to its quadratic convergence.
- (c) An electrical machine has cylindrical stator and salient- pole rotor. Reluctance torque is produced when exciting winding is on the rotor.
- (d) If the rotor of a 3-phase induction motor is assumed purely inductive, the electromagnetic torque would be optimum with load angle equal to 90° .
6. (a) Which type of distance relay is preferred for EHV transmission lines? Discuss its principle of operation with its salient features. 20
- (b) Develop necessary equations and explain the Newton-Raphson method in polar co-ordinates for solving the load flow problem when both load and voltage-controlled buses are present in the system. 20
- (c) A 3-phase, 4-pole, 50 Hz, star-connected induction motor, during short circuit test, took 100 A and 30 kW. In case stator resistance is equal to equivalent standstill rotor resistance, calculate the starting torque. 20
7. (a) An overhead transmission line, with a surge impedance of 500Ω , has a load comprising of a 10 kilo-ohm resistor in parallel with a $0.005 \mu\text{F}$ capacitor connected across the far end. A surge voltage of 10 kV magnitude and unit step travels along the line. Determine an expression for the time variation of the voltage across the load and calculate this voltage $5 \mu\text{s}$ after the arrival of the wave front of the surge. State any assumptions made. 20
- (b) A 3-phase generator, an open circuit, is excited to give a voltage of 2200 V between lines. The absolute values of fault currents for various types of faults are: (i) 3-phase fault: 127.0 Amps (ii) L–L fault: 129.5 Amps (iii) L–G fault: 190.0 Amps Find the positive, negative and zero-sequence reactances of the generator. Assume the resistance to be negligible. 20
- (c) Explain how the power factor of a 3-phase induction motor is controlled by static capacitors. Show that for a constant capacitance, the degree of power factor correction is not the same at different loads. 20
8. (a) Describe the constructional features and working of a 2-phase, 4/6 pole hybrid stepping motor. Discuss its torque-displacement characteristics also. 20
- (b) A salient-pole synchronous motor, with $r_a=0$, $X_d=1.0$ pu and $X_q=0.5$ pu, is operated on infinite bus-bar of 1.00 pu voltage. Show that for one per-unit synchronous power, the excitation voltage is given by $E_1=\text{cosec } \delta - \cos \delta$. Also derive the condition for load angle 20

when synchronous power is maximum.

- (c) The generalized constants A and B of a transmission line are $0.96 \angle 1^\circ$ and $100 \angle 80^\circ$ respectively. If the line to line voltages at the sending and receiving ends are both 110 kV and phase angle between them is 30° , find the receiving end power factor and current. With the sending end voltage maintained at 110 kV, if the load is suddenly thrown off, find the corresponding receiving end voltage.

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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 statements:

20×3=60

- (a) The characteristic of a twin-T network is similar to that of a notch filter in audio frequency range. 30
- (b) The transposition of telephone lines is desirable. 10
- (c) Magnetrons are capable of delivering low pulsed power output. 20
- (d) Only one kind of dielectric substrate is used in microwave integrated circuits (MICs). 20
10. (a) Define spectral density and auto-correlation function for the measurement of noise. Find out the spectral density and auto-correlation function of the output when white noise with spectral density η is applied to a low pass RC filter. Derive the expressions used. 30
- (b) Discuss the microwave spectrum in satellite communication. 10
- (c) Describe the technique of making stereophonic FM broadcast compatible with monophonic system. 20
11. (a) Discuss the realization techniques, with circuit diagrams, for inductor and capacitor in microwave communication. 20
- (b) Derive the equivalent circuits and find out 'Q' factor of the inductor and capacitor. State any assumptions made. 20
- (c) Enumerate the salient features of wave guides with diagrams based on band width and power handling capabilities. 20
12. (a) Describe the relative merits of single mode and multimode fibres used in communication system. 20
- (b) Describe the schematic arrangement of pulse-code modulation by using optical fibre. 20
- (c) Draw a schematic diagram and discuss how the thickness of foil can be measured by microwave sensors. 20