

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) In analog simulation of physical system, Integrators are used rather than Differentiators.
 - (b) Phase lead compensation decreases the band width of a system.
 - (c) Synchro error detectors are used in dc servo system.
 - (d) The required PIV capacity of diodes in single phase bridge rectifier is one half than that required in rectifier using centre tap transformer.
2.
 - (a) The roots of a second order system are located at $-1+j2$ and $-1-j2$. Determine the followings if the system is excited by unit step input: (i) Damping ratio (ii) Maximum % overshoot (iii) Natural frequency of oscillation (iv) Damped frequency of oscillation. **20**
 - (b) Discuss briefly the speed-torque characteristics of a 2ϕ ac servomotor and compare it with that of ordinary 3ϕ induction motor. Hence describe the laboratory method to obtain its speed-torque characteristic. **20**
 - (c) The unity feedback system has forward path transfer function $G(s)=K/(s(s+1)(s+2))$ Sketch the Nyquist diagram. If $K = 4$, determine whether the given system is stable or not. If the system is stable, determine its gain margin. What is the maximum value of K that will make its gain margin zero? **20**
3.
 - (a) Obtain the transfer function of phase lead network. Show that $\sin\phi_m = (a-1)/(a+1)$ and $\omega_m = 1/\sqrt{aT}$ where ϕ_m , ω , a and T have usual meanings. **20**
 - (b) The unity feedback system has forward path transfer function $G(s)=(S+1)/(s^2(s+2)(s+4))$ Determine steady state error coefficients K_p , K_v and K_a . Hence find the steady state error in output if (i) unit step input, (ii) unit ramp input and (iii) unit parabolic input are given. **20**
 - (c) The state equations for a system are given by $\dot{X}=\bar{A}X+\bar{B}u$, $\bar{Y}=\bar{C}X+\bar{D}u$ where $\bar{A}=\begin{bmatrix} -1 & 0 & 0 \\ 0 & -2 & 0 \\ 0 & 0 & -3 \end{bmatrix}$, $\bar{B}=\begin{bmatrix} 1 & -2 & 1 \end{bmatrix}$, $\bar{C}=\begin{bmatrix} 1 & 1 & 1 \end{bmatrix}$ and $\bar{D}=\begin{bmatrix} 0 & 0 & 0 \end{bmatrix}$ Determine the output response of a system to unit step input. **20**
4.
 - (a) Explain the working of a timer using general purpose OP AMP IC 741. Design such a timer for a time period of 60 seconds. **20**
 - (b) Obtain (i) average load voltage and (ii) rms load voltage in case of 3ϕ full wave rectifier. Hence calculate ripple factor. **20**

- (c) A simple voltage regulator circuit is shown in Fig 4(c). The zener voltage is given by $V_z = (10 + 0.20i_z)$ volts where i_z is in mA. For a given transistor, assume $\beta = 100$ and $V_{BE} = 0.3$ V (constant). Determine % load regulation if maximum load current of 500 mA is switched off.

[Figure: fig.4 (c): Series (emitter-follower) regulator: 20 V d.c. input between the + and – input terminals; NPN transistor ($\beta = 100$, $V_{BE} = 0.3$ V) with collector to the + input line and emitter to the load (load current 500 mA); 500 Ω resistor from the + input line to the base; zener diode (V_z) from the base to the – line (cathode at the base); the load block connected between the emitter and the – line]

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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) An amplidyne is an alternating current machine with a low gain.
- (b) Impedance relays used for transmission line protection work in conjunction with directional relays.
- (c) The power transfer capability of a transmission system can be enhanced by series-capacitor compensation.
- (d) An axial blast circuit breaker is not prone to current chopping.

6. (a) Explain the term “Critical clearing time” in the context of transient stability of a power system, as a sequel to a fault. A synchronous generator with an induced emf of E volts per phase is operating on constant-voltage, constant frequency bus bars, the bus-bar voltage being V volts per phase. If the impedance of the generator is Z ohms, obtain an expression for the maximum power generated.

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- (b) What are the factors affecting corona power loss in a transmission line? An inductance L connects two sections of a transmission line with surge impedances Z_1 , and Z_2 . A rectangular surge with a crest value “V” and of “t” microseconds travels along the line-section 1 towards the inductance. What is the maximum value of the transmitted wave?

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- (c) Explain the need for time-grading in the protective scheme for radial feeders. Explain how the multiplier setting, plug-setting affect the time of operation of the relay.

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7. (a) What are the most important requirements of a lightning arrester? A thyrite lightning arrester has a characteristic $RI^{0.7} = 72000$. Draw the Volt-ampere characteristic of the arrester. What is the ratio of the voltage appearing at the end of a line with a surge impedance of 500 ohms, due to a 500 kV surge when the line is open circuited to that when the line is terminated by the arrester?

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- (b) Explain with the help of a neat phasor diagram, the manner in which a synchronous condenser located at the receiving end of a short transmission line improves the power factor and maintains the voltages at both ends at the same level.

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- (c) Distinguish the characteristic features of alternators employed in Hydel and thermal power stations. A three-Phase 400 V, 6-pole, 50 Hz star-connected synchronous motor has a resistance and synchronous reactance of 0.5 Ω and 5 Ω per phase respectively. It takes a current of 15 A at Unity Power factor with a certain excitation. If the load torque is increased until the line current increases to 60A, with the excitation maintained constant, find the gross torque developed and the new power factor.

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8. (a) What are the essential requirements of motors employed in electric traction? A three-phase induction motor has a 4-pole, star- connected stator winding and runs on a 400 V 50 Hz supply. The rotor resistance is 0.1 Ω and reactance 0.9 Ω . The stator to rotor turns ratio is 1.75 and the full load slip is 5%. Calculate the full-load Horse-Power output. Determine also the maximum torque and the corresponding speed.

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- (b) Describe with the help of a neat diagram the operation of a reluctance-type stepper motor along with its characteristics. What are its possible applications? **20**
- (c) What are the limitations on the application of the “Equal area criterion” for examining transient stability? The maximum power that can be transmitted by a Synchronous Generator operating on to an infinite bus is 1.00 pu. The Generator initially was delivering under stable steady-state 0.4pu. What is the extra load that can be suddenly thrown on the generator for it to become critically stable? Ignore active resistance. **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) Pulse Code Modulation (PCM) systems for voice communication employ companding.
- (b) With a sinusoidal modulating signal and modulation indices of 0.1 each, the spectra of AM, FM and PM signals are identical.
- (c) The dominant mode of propagation in a rectangular waveguide is TEM.
- (d) For a given data rate, QPSK signals and BPSK signals require equal bandwidths.
10. (a) An antenna having a 10°K noise temperature feeds a low noise amplifier of 4°K noise temperature and 20 dB gain. This is followed by another amplifier of 4 dB noise figure and 30 dB gain. Find the overall noise figure and noise temperature of the system. **20**
- (b) Discuss the relative merits and shortcomings of BPSK and BFSK signals. **20**
- (c) Explain a scheme for demodulation of PPM signals. **20**
11. (a) Consider a DSB-SC signal corresponding to a modulating signal $x(t)$ of bandwidth B and a carrier signal $A\cos 2\pi f_c t$. This DSB-SC signal forms the input in Fig. 11(a). Find the output and comment on the result.
[Figure: Fig. 11(a): Input Signal applied to both inputs of a multiplier (X) (the input is split and fed to the multiplier twice); multiplier output to an LPF (Cut-off $2B$); LPF output to a square-root block ($\sqrt{\quad}$); its output is the Output] **20**
- (b) Draw the input impedance variation of an o.c. lossless line of characteristic impedance R_0 (purely resistive) when the length varies from zero to λ . Indicate the nature of the impedance at every 0.2λ separation. **20**
- (c) Describe a method of measuring impedance at microwave frequencies. **20**
12. (a) Discuss the significance of G/T ratio of an earth station. **20**
- (b) Give the frequency range of a gunn diode and order of available power. How many junctions does it have? **20**
- (c) Describe a DME system for measurement of distance. **20**