

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. **20×3=60**
 - (a) Real parts of the Eigen values of a stable system are always positive.
 - (b) Knowing the step response of a system the response to a ramp input cannot be deduced.
 - (c) Use of a free wheeling diode improves the quality of speed-torque characteristics of a thyristor controlled d.c. motor.
 - (d) State variable method of analysis can be applied both to linear and non-linear systems.
2.
 - (a) Sketch and explain the frequency-response characteristics of a second-order control system. What is the effect of damping ratio on the amplitude and phase of the steady state output? **20**
 - (b) The forward path transfer function of a position control system with velocity feedback is given by $G(s)=K/(s(s+p))$. Determine the sensitivity of the transfer function of the closed-loop system to changes in K, p and a for transfer function of the feedback path (i) $H(s)=1$, and (ii) $H(s)=(1+\alpha s)$. The nominal values of the parameters are $K=12$, $p=3$ and $\alpha=0.14$. **20**
 - (c) A linear feedback control system has an open-loop transfer function $A=(\mu(s+\alpha)^2)/(\alpha^2(1+s)s^3)$ where μ and α are adjustable parameters. Find the relation between μ and α so that the system is stable with unity feedback. **20**
3.
 - (a) What are Tachogenerators? Discuss with block diagram, their application to closed-loop control systems. **20**
 - (b) The block diagram of an electronic pacemaker is given in Fig 1, where $K=400$. (i) Calculate the output $c(t)$ for a unit step input. (ii) Calculate the integral of the square of the error between input and the output. (iii) Determine the steady-state error for a unit ramp input. (iv) Determine the value of K for which the steady-state error to a unit ramp will be 0.02.
[Figure: Fig. 1: Unity negative feedback loop: input $r(t)$ ("Desired heart rate") enters a summing point (+); its output passes through the "Pacemaker" block $K/(s+20)$ and then the "Heart" block $1/s$ to give the output $c(t)$ ("Actual heart rate"); $c(t)$ is fed back directly to the summing point (-)] **20**
 - (c) A linear control system is described by the following equations in state-space domain: $\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} -2 & 0 \\ 1 & -1 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u(t)$ $y = \begin{bmatrix} -1 & 2 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + 1 u(t)$ Find the transfer function of the system. **20**
4.
 - (a) What are the important ratings that specify an SCR? Compare the performance characteristics of a rectifier circuit using ordinary diodes with that of one using SCR's. **20**

- (b) A chopper circuit as shown in Fig 2 is inserted between a battery, $V_{dc}=150\text{ V}$ and a load resistance $R_L=10\ \Omega$. The turn-off time for the main thyristor Th_1 is $110\ \mu\text{s}$ and the maximum permissible current through it is 30A . Calculate the values of the commutating components L and C .

[Figure: Fig. 2: Battery (+ at top) between a top line and a bottom line. Main thyristor Th_1 in the top line (anode towards the battery, cathode towards the load) feeding node X; load current I_L flows from X through load resistor R_L to the bottom line and back to the battery. Commutation circuit: capacitor C from the anode side of Th_1 (top line) down to node Y (C marked - at the top plate and + at the bottom plate); auxiliary thyristor Th_2 from Y (anode) to X (cathode); inductor L in series with diode D also between Y and X, the diode's anode towards X and cathode towards L, so that it conducts from X through D and L to Y]

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- (c) A slab of material 2.5 cm thick and 200 sq. cm in area, having relative permittivity 5 and 0.05 is to be heated using dielectric heating. The power required is 200 watts at a frequency of 30 MHz . Determine the voltage required and the current that will flow through the material. If the voltage were to be limited to 600 V , what should be the frequency for the same power requirement?

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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) Lightning arrestor should be located as close to the transformer being protected as is physically possible.
- (b) Tap changing transformers are used in power systems primarily to control reactive volt-amperes.
- (c) The main purpose for which the damper bars are located in the rotor faces of a synchronous motor is to prevent hunting of the machines.
- (d) Economic operation of a power system requires that the incremental fuel cost of each plant multiplied by its penalty factor is the same for all plants of the system.

6. (a) Explain the concept of self GMD and mutual GMD in respect of 3-phase transmission lines. Indicate how these concepts are used in estimating the inductance and capacitance of 3-phase overhead lines.

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- (b) Discuss briefly the various methods adopted for improving the transient stability of a power system.

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- (c) A 3-phase, 50 Hz , transmission line is 400 km long. The voltage at the sending-end is 220 kV . The line parameters are: $R=0.125\ \Omega/\text{km}$, $X=0.4\ \Omega/\text{km}$, and $Y=2.8\times 10^{-6}\text{ S/km}$. Find, using approximate expressions for A, B, C, D constants of long lines, the following: (i) The sending-end current and receiving end voltage when there is no-load on the line. (ii) The minimum permissible line length if the receiving no-load voltage is not to exceed 235 kV . (iii) For part (i), the maximum permissible line frequency, if the no-load voltage is not to exceed 250 kV .

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7. (a) Explain the various reactances associated with a salient-pole synchronous machine when it is subjected to sudden short circuit at its armature terminals. How can these reactances be determined from the short circuit oscillograms of the machine?

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- (b) Briefly explain the various controls in a.c. drives. Why are such drives becoming increasingly more popular as compared to d.c. drives?

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- (c) A 4-pole, 3-phase, 400 V , 50 Hz , induction motor has the following per phase parameters for its circuit model (referred to the stator side): $r_1=1.2\ \Omega$, $x_1=1.16\ \Omega$, $r_2'=0.4\ \Omega$, $x_2'=1.16\ \Omega$. Find the slip and corresponding torque when the machine develops (i) maximum torque, and (ii) maximum power. The machine is Y-connected.

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8. (a) Discuss various types of electric traction used in India. Explain the characteristics of the motor used in any one such system. 15
- (b) Explain clearly with a flowchart, the computational procedure for load flow solution using Gauss-Seidel method when the power system contains all types of buses. 15
- (c) A 40 MVA, 3-phase, 345/34.5 kV transformer is star/delta connected. Select standard CT ratios on the two sides of the transformer for percentage differential protection of the transformer. Would an auto-transformer be required? If so, what should be its current ratio? 30

SECTION 'C'

9. Select any three of the following statement and indicate with justification whether they are correct or incorrect. Your answer must not exceed 200 words for each statement.

20×3=60

- (a) In PM, the frequency deviation is proportional to instantaneous amplitude of modulating voltage but not to the modulating frequency. 20
- (b) An ideal directional coupler must have infinite directivity. 20
- (c) Telecommunication carriers can increase the utilization of their existing cable ducts significantly if fibre-optic cables are substituted for copper. 20
- (d) Digital processing is used widely because it provides economic and rapid manipulation of data. 20
10. (a) Explain what you understand by shot noise, signal-to-noise ratio and noise figure. When might the noise-figure be a more suitable piece of information than the equivalent noise resistance? The first stage of a 2-stage amplifier has a voltage gain of 10, a 500 Ω input resistor, a 1500 Ω equivalent noise resistance and a 30 k ohm output resistance. For the 2nd stage these values are 20, 80 k Ω , 10 k Ω and 1 M Ω respectively. Calculate the equivalent input-noise resistance of the two-stage amplifier. 20
- (b) Give the differences between FM and AM receivers. How can the overall limiting performance of an FM receiver be improved? Explain the operation of AGC in addition to a limiter. 20
- (c) Explain, with the help of block diagram, the principle of operation of an ISB transmitter. 20
11. (a) What is resonator? Define and obtain expression for the Q-factor of a parallel plate resonator. The parallel plates of a resonator are 1.5 cm apart and have free space in between them. Find Q of the resonator for fundamental frequency of oscillations. For copper $\sigma=5.8 \times 10^7$ S/m, $\mu_0=4\pi \times 10^{-7}$ H/m. 20
- (b) What is MESFET? Give its characteristics. What are intrinsic and extrinsic parameters of a MESFET? What is the effect of increasing the channel doping to a value as high as possible? 20
- (c) Discuss the advantages and list applications of parametric amplifiers. Draw the circuit diagram of a TW parametric amplifier and explain briefly how it works. 20
12. (a) Compare and contrast the performance and advantages of co-axial cable and microwave links as broad band 'continental' transmission media. Draw and explain block diagram of a microwave link carrier chain. 20
- (b) What is a Modem? Draw and explain a Communication system using Modems. What is RS-232 interface? Explain its use for data transmission. 20
- (c) With the help of a block diagram, explain a Radio-telemetry transmitter using frequency-division multiplex with TDM for sub-communication. 20