Ref. No. : Ex/ET/PC/B/T/312/2025

B.E. ELECTRONICS AND TELE-COMMUNICATION ENGINEERING THIRD YEAR FIRST SEMESTER – 2025

CONTROL ENGINEERING

Time: 3 Hour **Marks:** 100

Answer any FOUR questions.

1. a) Draw the block diagram of an Armature Controlled DC motor, and obtain its transfer function.

b) Develop a block diagram of a DC position-control system using the above motor. Simplify the block diagram and evaluate the closed-loop transfer function of the position control system.

c) Synthesize the above DC position-control system using a signal-flow graph, and also evaluate the transfer function using Mason's gain formula. [5+10+10]

2. a) How does a Servomotor differ from an Induction motor?

b) Evaluate the transfer function of an AC Servomotor.

c) Show that the Synchro transmitter response from the three stator coils always remain at same phase independent of the rotor input.

d) Draw a position control loop using Synchro as an error-detector i) without and ii) with tacho feedback. What is the benefit of tacho-feedback? [4+6+5+10]

3. a) Draw the polar plot of $G(s)= K/s(1+Ts)$.

b) State the principles of Argument used in Complex Algebra. Also state how principles of argument transform to Nyquist Criteria?

c) Draw the Nyquist plot of $G(s)= K/s(1+Ts)$.

d) Infer stability of the system given from the Nyquist plot. [8+ 4+10+3]

4. a) Construct the root locus of $G(s)= K/s(s+3)\ (s^2+ 2s +2)$ with $H(s)=1$ explaining computation of all relevant parameters of the locus.

b) Determine DC gain K at s =-2.3 and angle of departure at a complex pole. [15+10]

6. a) Given the plant transfer function $G_p(s)= K/s(s+1)$. Draw the magnitude Bode plot of $G_p(s)$, and hence determine the phase margin.

b) Suppose, the uncompensated phase-margin of a plant is 15°. To attain 45° phase-margin, use a Phase-lead network to provide an extra 30° phase-margin. Now, suppose the uncompensated plant has

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a gain -4.7 dB at w= 100 rad/sec. Verify that w= 100 rad/sec is the new gain crossover frequency of the compensated plant. Also design the phase-lead network transfer function.

c) Explain when you should go for phase-lag and phase-lead network as a compensator in a control system? [10+10+5]

7. a) Define controllability and observability of a system. Draw state diagrams demonstrating controllability and observability of a system.

b) Let a system be described by dX/dt = AX(t)+ Bu(t) and Y(t)= CX(t), where

$$A = \begin{bmatrix} 0 & 1 \\ -2 & -3 \end{bmatrix},$$

B= $[0 \quad 1]^T$ and C= $[1 \quad 1]^T$. Test controllability and observability of the system.

c) For the given A matrix and B and C vectors, determine the State-Transition Matrix (STM), and also the system states. Presume X(0)= $[1 \quad 2]^T$ and u(t) is a unit step function. [7+ 6+12]

8. a) Determine the unit step response of a second order transfer function, and hence obtain an expression for the peak overshoot.

b) Define type of a system. What would be steady-state error of a type 2 system with unit step, unit ramp and a unit parabola input?

c) The peak-overshoot of a second-order system is 0.02. Find its damped natural frequency, when natural frequency is 4 rad/sec. [10+10+5]

9. Write a technical essay on a typical control system of an aircraft/missile/ship/thermal process or any other process of your interest, highlighting a) the variable you like to control, b) the plant dynamics, c) type of controller used and its motivation, d) stability issues of the overall system, and e) method of stability analysis you will undertake for your proposed system. [25]

10. Compare any FIVE of the following groups of phrases with examples, if needed:

a) Regulatory and Tracking Control,
b) Classical Transfer Function based system and state-space system,
c) Time- and frequency domain stability analysis techniques,
d) DC and AC position control,
e) Autonomous and Non-autonomous systems,
f) Transfer function of Delay with and without attenuation,
g) Synchro transmitter and Receiver. [5 x 5]