Duration: 3 Hours Max. Marks 80

N.B.

1. **Q.1** is compulsory. Attempt **any three** from the remaining questions.
2. All questions carry equal marks.
3. Figures to the Right indicate full marks.
3. Assume suitable data if necessary

Q.1 Attempt **any four** 20

a. Explain block diagram of digital control system and show all the signal forms in it.

b. What are the limiting factors that may affect choice of sampling rate for a given system?

c. What will be the output of first order hold when an impulse at $t = 1$ is passed through it?

d. Derive expression for pulse transfer function matrix for a given system represented by state space model.

e. Explain use of bilinear transformation in stability analysis of discrete time systems.

f. What is principle of duality by Kalman?

Q.2 A. Derive transfer function of Zero order hold and explain its frequency response. 10

B. Discretize the given system using Zero order hold with transfer function 10

$$G(s) = \frac{5}{s(s+5)}$$

Assume sampling period T=0.1 sec.

Q.3 A. Obtain state transition matrix using Cayley Hamilton theorm for the system described by : 10

$$x(k+1) = \begin{bmatrix} 0 & 1 \\ -10 & -7 \end{bmatrix} x(k)$$

B. What is meant by completely controllable and completely observable systems? Check controllability of the following discrete time system : 10

$$x(k+1) = \begin{bmatrix} 0 & 0 & 0 \\ 0 & 0.5 & 0 \\ 0 & 0 & 2 \end{bmatrix} x(k) + \begin{bmatrix} 1 \\ 0 \\ 1 \end{bmatrix} u(k)$$

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Q.4 A. Explain digital PID controller in detail. 10

B. The discrete time control system is given by 10

$$x(k+1) = \begin{bmatrix} 0 & 1 \\ 20.6 & 0 \end{bmatrix} x(k) + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u(k)$$

$$y(k) = [1 \ 0]\, x(k)$$

Design a full order observer such that the response to observation error is deadbeat.

Q.5 A Obtain the discrete time state model of the following continuous time system with sampling time of 1 sec : 10

$$\dot{x}(t) = \begin{bmatrix} 0 & 0 & -0.25 \\ 1 & 0 & 0 \\ 0 & 1 & 0.5 \end{bmatrix} x(t) + \begin{bmatrix} 1 \\ 0 \\ 1 \end{bmatrix} u(t)$$

$$y(t) = [1 \ 0 \ 0]\, x(t)$$

B. Using Jury's stability criteria determine the range of K for asymptotic stability of the system given by characteristic equation 10

$$P(z) = z^3 + 0.5z^2 + Kz - K = 0$$

Q.6 A. Determine steady state error for unit step, ramp and acceleration inputs for a unity feedback system characterized by transfer function : 10

$$G_{ho}G(z) = \frac{1.266z + 0.5702}{z^2 - 1.082z + 0.08208}$$

B. Determine state feedback gain matrix K for the system given by : 10

$$x(k+1) = \begin{bmatrix} 1 & 0.2 \\ 0 & 1 \end{bmatrix} x(k) + \begin{bmatrix} 0.02 \\ 0.2 \end{bmatrix} u(k)$$

$$y(k) = [1 \ 0]\, x(k)$$

Place closed loop poles at $0.5 \pm 0.5j$.

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