

B.E. ELECTRICAL ENGINEERING FOURTH YEAR FIRST SEMESTER - 2025
DIGITAL CONTROL TECHNIQUES

Time : 3 hours

Full Marks : 100
(50 marks for each part)

Use separate answer-scripts for each parts.

Part-I

Answer ANY THREE questions. Two marks reserved for neatness.

Answer all parts of a question in the sequential order.

1.a) Explain with suitable example, what will happen if A/D conversion is attempted for a time varying signal containing arbitrary frequency components without deploying a hold circuit?

b) Derive the transfer function of a Zero Order Hold.

[10+6=16]

2.a) State and explain Jury's Stability test for a discrete-time closed-loop system.

b) Consider the system described by following mathematical model:

$$y(k) - 0.7y(k-1) - 0.72y(k-2) + 0.69y(k-3) - 0.25y(k-4) = x(k)$$

Where $x(k)$ is the input and $y(k)$ is the output of the system. Test the stability of the system and comment on the result.

[8+8=16]

3. The feed-forward pulse transfer function of a unity gain (negative) feedback discrete-time control system is given as:

$$G(z) = \frac{Kz}{(z-1)} \cdot \frac{(1-e^{-T})}{(z-e^{-T})}$$

Where K is the variable gain of the controller. Draw the Root-locus diagram for the above system for $T=0.1$ sec and $T=1$ sec.

[16]

4. Derive the P-I-D controller equation for Position Algorithm of Direct Digital Control employing suitable numerical methods for calculating the integral and derivative terms. Hence, draw the flow chart of the same.

[12+4=16]

[Turn over

5. Write short notes on **ANY TWO** from the following:

- a) Advantages and Challenges of Velocity Algorithm of Direct Digital Control.
- b) Steady-state errors of Type-0, Type-1 and Type-2 LTI discrete-time control systems in response to standard test signals.
- c) The principle of mapping between s-plane and z-plane and interpretation of stability from z-plane.
- d) Selection of sampling frequency for a Digital Control System implementation.

[8+8=16]

B. E. ELECTRICAL ENGINEERING 4TH YEAR 1ST SEMESTER EXAMINATION, 2025**Subject: DIGITAL CONTROL TECHNIQUES****Time: Three Hours****Full Marks: 100****Part II** (50 marks)

Question No.	<u>Question 1 is compulsory</u> <u>Answer Any Two questions from the rest (2×20)</u>	Marks
Q1	Answer any TWO Questions (2 × 5=10)	
(a)	Given a pulse transfer function of a discrete-time system, show that the state-space representation of the system is not unique.	5
(b)	Define State Transition Matrix for a discrete-time system. Derive the solution of the following discrete-time state equation in terms of State Transition Matrix: $x(k+1) = A x(k)$	2+3
(c)	Define complete state controllability and observability for a discrete-time system.	5
(d)	What are State Observers? Briefly discuss the principles of “Full-Order”, “Reduced-Order” and “Minimum-Order” State Observers.	2+3
Q2	(a) Derive the Pulse Transfer Function for the n -th order state space representation $x(k+1) = A x(k) + B u(k)$ $y(k) = C x(k) + D u(k)$	4
	(b) What is Similarity Transformation? Show that the Pulse Transfer Function remains invariant under Similarity Transformation.	2+4
	(c) Given a Pulse Transfer Function $\frac{Y(z)}{U(z)} = \frac{z+5}{z^2+4z+3}$	
	(i) Obtain, describing the steps involved, the state space representation of the system using the “Nested Programming Method”.	8
	(ii) Draw the block diagram for the system showing all the state variables.	2
Q3	(a) For the sampled-data system with sampling period $T=1$ sec and $G_p(s) = \frac{1}{s(s+2)}$	
	(i) Obtain the discrete-time state-space model of the system.	6
	(ii) Derive the Pulse Transfer Function of the system.	4
	(b) What is Deadbeat Control ?	2
	Consider a SISO, Linear-Discrete-Time-Invariant (LDTI) system given by $x(k+1) = \begin{bmatrix} 0 & 1 \\ -0.16 & -1 \end{bmatrix} x(k) + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u(k)$	8
	Show that the state feedback gain matrix $K = [-0.16 \quad -1]$ would yield deadbeat response for any arbitrary initial condition $x(0)$.	

- Q4 (a) Consider the system described by the difference equation

$$y(k+2) = u(k) + 1.7y(k+1) - 0.72y(k)$$

where, $u(k)$ is the input and $y(k)$ is the output of the system.

- (i) Obtain the state-variable model in Diagonal Canonical Form. 4

- (ii) Draw the corresponding simulation/block diagram. 2

- (iii) Consider a linear transformation matrix given as

$$T = \begin{bmatrix} 1 & -1 \\ 1 & 1 \end{bmatrix}$$

6

Derive the state and output equations following the transformation $x(k) = Tw(k)$, $w(k)$ being the transformed domain state vector.

- (iv) Show that the characteristic equation remains unchanged following the given transformation. 2

- (b) Obtain the State Transition Matrix for the discrete-time system given by 6

$$x(k+1) = \begin{bmatrix} 0 & 1 \\ -0.21 & -1 \end{bmatrix} x(k) + \begin{bmatrix} 0 \\ 1 \end{bmatrix} (-1)^k \quad x(0) = \begin{bmatrix} 1 \\ 0 \end{bmatrix}$$

$$y(k) = x_2(k)$$

- Q5 (a) What are Current and Prediction Observers? 2

With the help of relevant equations depicting the dynamics of these types of observers discuss the differences between them. 2

- (b) Show that the pole placement and the observer design are independent of each other. 6

- (c) Consider a system given by the following state and output equations

$$x(k+1) = \begin{bmatrix} 0 & -0.16 \\ 1 & -1 \end{bmatrix} x(k) + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u(k)$$

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

- (i) Design a full order observer with the eigenvalues of the observer at $z = 0.5 \pm j0.5$. 6

- (ii) Draw the corresponding block diagram for observer-based state-feedback control. 4