Ref. No.: **Ex/EE/PE/B/T/414A/2024(S)**

B.E. ELECTRICAL ENGINEERING FOURTH YEAR FIRST SEMESTER SUPPLEMENTARY EXAM – 2024

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 sequential order.

1.a) Consider the system described by the following mathematical model:

$$y(k)-0.7y(k-1)-0.75y(k-2)+0.6y(k-3)-0.25y(k-4)=x(k)$$

Where *x(k)* is the input and *y(k)* is the output of the system. Test the stability of the system employing Jury's Stability test.

b) Is there any other way to test the stability of the system given above?

[14+2=16]

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

$$G(z)=\frac{Kz}{(z-1.6)}\cdot\frac{(1-e^{-T})}{(z-e^{-T})}$$

Where K is the variable gain of the controller. Draw the Root-locus diagram for the above system for T=0.1 sec, T= 0.5 sec, and T= 1.0 sec and comment on the Root-locus that you have drawn for these values of T.

[12+4=16]

3. Derive the steady-state errors of Type-0, Type-1 and Type-2 LTI discrete-time control systems in response to standard test signals. Comment on the nature of the error constants.

[12+4=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.

[10+6=16]

[Turn over

5. Write short notes on (***any two***): [8+8=16]

a) Selection of sampling frequency in digital control systems.

b) Necessity of Sample and Hold circuit in discrete-time control systems.

c) Various signals associated with closed-loop digital control systems.

d) W-plane Transformation in discrete-time control systems.

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B. E. ELECTRICAL ENGINEERING 4TH YEAR 1ST SEMESTER

SUPPLEMENTARY EXAMINATION, 2024

Subject: DIGITAL CONTROL TECHNIQUES **Time: Three Hours** **Full Marks: 100**

Part II (50 marks)

Question No.	***Question 1*** is compulsory Answer ***Any Two*** questions from the rest (2×20)	Marks
Q1	*Answer **any TWO** Questions* (2 × 5=10)	
(a)	Given a pulse transfer of a discrete-time system, show that the state-space representation of the system is not unique.	5
(b)	Derive the solution of the linear-time-invariant discrete-time state equation $$\boldsymbol{x}(k+1) = \boldsymbol{A}\,\boldsymbol{x}(k)$$ in terms of the state transition matrix.	5
(c)	What is Similarity Transformation? Show that the Pulse Transfer Function is invariant under Similarity Transformation.	5
(d)	Briefly discuss the principles of "Full-Order", "Reduced-Order" and "Minimum-Order" State Observers.	5
Q2 (a)	Derive, using the "Nested Programming Method", the state space representation of the system defined by the pulse transfer function $$\frac{Y(z)}{U(z)} = \frac{z+5}{z^2+4z+3}$$	10
(b)	Define State Transition Matrix for a discrete-time system. Obtain the State Transition Matrix for the discrete-time system given by $$\boldsymbol{x}(k+1) = \begin{bmatrix} 0 & 1 \\ -0.21 & -1 \end{bmatrix} \boldsymbol{x}(k) + \begin{bmatrix} 0 \\ 1 \end{bmatrix} (-1)^k \quad x(0) = \begin{bmatrix} 1 \\ 0 \end{bmatrix}$$ $$y(k) = x_2(k)$$	2+8
Q3 (a)	Find the pulse transfer function for the system described by the state equations $$\boldsymbol{x}(k+1) = \begin{bmatrix} 1.35 & 0.55 \\ -0.45 & 0.35 \end{bmatrix} \boldsymbol{x}(k) + \begin{bmatrix} 0.5 \\ 0.5 \end{bmatrix} u(k)$$ $$\mathrm{y(k)} = [1 \quad -1]\boldsymbol{x}(k)$$	8
(b)	Consider the system $$\begin{bmatrix} x_1(k+1) \\ x_2(k+1) \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ -2 & -3 \end{bmatrix} \begin{bmatrix} x_1(k) \\ x_2(k) \end{bmatrix} + \begin{bmatrix} 0 \\ 1 \end{bmatrix} (-1)^k$$ with, $x_1(0) = x_2(0) = 1$ and $y(k) = x_1(k)$. Find the expression for $y(k)$ for $k \geq 1$.	8
(c)	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. Obtain the state-variable model in Diagonal Canonical Form.	4

Q4 (a) Define Complete State Controllability and Observability for a Linear Discrete-Time-Invariant system. 2+2

(b) State and derive the Necessary and Sufficient condition for complete state controllability of a discrete-time system. 8

(c) Consider an asymptotically stable continuous-time system

$$\begin{bmatrix} \dot{x}_1(t) \\ \dot{x}_2(t) \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ -2 & -3 \end{bmatrix} \begin{bmatrix} x_1(t) \\ x_2(t) \end{bmatrix} + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u(t)$$

$$y(t) = x_1(t)$$

Obtain the state equation for the discrete-time system, assuming that the input to the system is held constant between consecutive sampling instants of 1 sec. 8

Q5 (a) What is State Observer? Why is it necessary? 2+2

(b) Draw the block diagram for Observer-based state-feedback control system.
Show that for such a control scheme the pole-placement design and the observer design are independent of each other. 4+4

(c) What is Deadbeat Response? Explain how it can be achieved for a discrete-time system. 2+6