Code No: **R42021**

R10

Set No. 1

IV B.Tech II Semester Regular/Supplementary Examinations, April– 2015

DIGITAL CONTROL SYSTEMS

(Electrical and Electronics Engineering)

Time: 3 hours **Max. Marks: 75**

Answer any FIVE Questions
All Questions carry equal marks
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1 a) Find the even and odd components of the signal $x(t) = e^{-2t}$ Cos t. [6]

b) Differentiate between the continuous and discrete time signals? [9]

2 a) Obtain the z - transform of the following $x(k) = \sum_{h=0}^{k} a^h$ where a is a constant. [7]

b) Obtain the inverse z-transform of the following

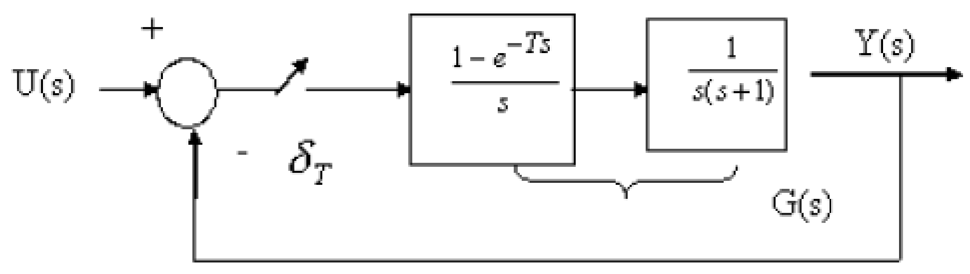
$$(i)\ X(z) = \frac{z^{-3}}{(1-z^{-1})(1-0.2z^{-1})} \quad and$$

$$(ii)\ X(z) = \frac{z^{-1}(1-z^{-2})}{(1+z^{-2})^2}$$ [8]

3 a) Draw the magnitude and phase curves of the zero order hold and compare these curves with those of the ideal low pass filter. [7]

b) With neat schematic, discuss the sample and hold operations. [8]

4 Obtain a state space representation of the system shown below in figure.4



[15]

Figure.4

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5 a) Develop relationship among controllability, observability and transfer function. [7]

b) Consider a discrete linear discrete - data control system, whose input - output relation is described by the difference equation $y(k+2)+2y(k+1)+y(k)=u(k+1)+u(k)$. Test for state controllable and output controllable. [8]

6 a) Prove that the bilinear transformation maps the left half of the s-plane into the unit circle in the z-plane. The transformation $z=e^{sT}$ also maps the left half of the s-plane into the unit circle in the z-plane. What is the difference between the two maps? [8]

b) Determine $F(z)|_{z=e^{sT}}$ in terms of F(s). Using this result, explain the relationship between the z-plane and the s-plane. [7]

7 a) Explain the design of the digital PID controller and PI controller in the Z-plane. [9]

b) What are the advantages of digital PID controller over digital PI or PD controller? [6]

8 Control a system, defined by $\dot{X} = Ax + Bu$

$$Y = Cx$$

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

It is desired to have eigenvalues at -3.0 and -5.0 by using a state feedback control u = - KX. Determine the necessary feedback gain matrix k and the control signal u. [15]

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Set No. 2

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(Electrical and Electronics Engineering)

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*****

1 a) Sketch the single sided and double sided spectra of the following signal x(t)=2Sin(10πt - π/6). [8]

b) Illustrate briefly about the causal systems. [7]

2 a) Given the discrete time system

$$y(k) - \frac{1}{\sqrt{2}}y(k-1) + \frac{1}{4}\,y(k-2) = u(k) + \frac{1}{3}u(k-2)$$

Determine the pulse transfer function. [8]

b) Solve for y(k) the equation $y(k) = r(k) - r(k-1) - y(k-1), k \geq 0$
$r(k) = 1; k\ even, r(k) = 0; k\ odd$, y(-1)=r(-1)=0 [7]

3 a) What are the advantages offered by digital control? [7]

b) State the sampling theorem. Discuss the principles of signal conversion. [8]

4 a) Enumerate the methods for computation of state transition matrix. [6]

b) Consider the discrete control system represented by the transfer function

$$G(z) = \frac{z^{-1}(1+z^{-1})}{(1+0.5z^{-1})(1-0.5z^{-1})}$$

Obtain the state space representation in the diagonal form. [9]

5 Consider the system defined by

$$\begin{bmatrix} x_1(k+1) \\ x_2(k+1) \end{bmatrix} = \begin{bmatrix} a & b \\ c & d \end{bmatrix} \begin{bmatrix} x_1(k) \\ x_2(k) \end{bmatrix} + \begin{bmatrix} 1 \\ 1 \end{bmatrix} u(k)$$

$$y(k) = \begin{bmatrix} 1 & 0 \end{bmatrix} \begin{bmatrix} x_1(k) \\ x_2(k) \end{bmatrix}$$

Determine the condition on a, b, c and d for complete state controllability and complete observability. [15]

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6 Determine the stability of the following characteristic equations by using suitable tests.
(a) $5z^2 - 2z + 2 = 0$
(b) $z^3 - 0.2z^2 - 0.25z + 0.05 = 0$
(c) $z^4 - 1.7z^3 + 1.04z^2 - 0.268z + 0.024 = 0$ [15]

7 What are PID controllers? Compare its performance with PI controllers and PD controllers. Explain digital PID controller in detail. [15]

8 A discrete time regulator system has the plant equation

$$X(k+1) = \begin{bmatrix} 2 & -1 \\ -1 & 1 \end{bmatrix} X(k) + \begin{bmatrix} 4 \\ 3 \end{bmatrix} u(k)$$
$$Y(k) = \begin{bmatrix} 1 & 1 \end{bmatrix} X(k) + 7u(k)$$

Design a state feedback control algorithm with u(k)=-KX(k) which places the closed loop characteristic root at $\pm j0.5$ [15]

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Set No. 3

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DIGITAL CONTROL SYSTEMS

(Electrical and Electronics Engineering)

Time: 3 hours **Max. Marks: 75**

Answer any FIVE Questions

All Questions carry equal marks

*****

1 a) Discuss about the shifting and scaling operator. [8]

b) Sketch the following signals $(i)\ \prod(\frac{t-1}{2}) + \prod(t-1)$

$(ii)\ \ f(t) = 3u(t) + tu(t) - (t-1)u(t-1) - 5u(t-1)$ [7]

2 Obtain the inverse Z-transform of the following in the closed form.

(i) $F_1 = \frac{0.368z^2+0.478z+0.154}{z^2(z-1)}$

(ii) $F_2 = \frac{2z^3+z}{(z-1)^{2\,(z-1)}}$

(iii) $F_3 = \frac{z+2}{z^2(z-2)}$ [15]

3 a) What do you mean by the problem of aliasing? How to overcome this problem? [7]

b) What is meant by zero order hold? Derive the transfer function of zero order hold device. [8]

4 Find state model for the following difference equation. Also find its state transition matrix $y(k+2) + 3y(k+1) + 2y(k) = 5u(k+1) + 3u(k)$. [15]

5 Define controllability and observability of discrete time systems. For the following system.

$$\frac{Y(z)}{U(z)} = \frac{z^{-1}(1+0.8z^{-1})}{1+1.3z^{-1}+0.4z^{-2}}$$

Determine whether the system is observable and controllable. [15]

6 a) State and explain Jury's stability test. [8]

b) Using Jury's stability criterion find the range of K, for which the characteristic equation $z^3 + Kz^2 + 1.5Kz - (K+1) = 0$ is closed loop stable. [7]

7 Explain the digital implementation of PI controller and lead lag controller in detail with suitable diagrams. [15]

8 a) Enumerate the design steps for pole placement. [7]

b) Prove Ackermann's formula for the determination of the state feedback gain [8]

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Set No. 4

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DIGITAL CONTROL SYSTEMS

(Electrical and Electronics Engineering)

Time: 3 hours **Max. Marks: 75**

Answer any FIVE Questions

All Questions carry equal marks

*****

1 a) What do you mean by periodic and aperiodic signals with neat sketch? [7]

b) Differentiate between the linear time invariant and causal systems. [8]

2 a) State and prove the following properties/theorems of z-transforms.

(i) Shifting theorem

(ii) Complex translation theorem

(iii) Complex differentiation and Partial differentiation theorem. [7]

b) Obtain the z-transform following:

(i) $X(s) = \frac{1}{S^2(S+1)}$ *and*

(ii) $f(t) = e^{-\alpha t}t^2$ [8]

3 a) With help of diagram explain the successive approximation analog to digital converter. [8]

b) Explain any two examples of digital control systems. [7]

4 The pulse transfer function of digital control systems is given by

$$G(z) = \frac{5z}{z^2 + 3z + 2}$$

Obtain a state space representation for the system. Find the complete solution to a unit step input and assume that, the initial conditions are zero. [15]

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5 Derive the necessary condition for the digital control system

$$X(k+1) = AX(k) + Bu(k)$$
$$Y(k) = CX(k) \ \ to\ be\ controllable.$$ [9]

Examine whether the discrete data system

$$X(k+1) = AX(k) + Bu(k)$$
$$Y(k) = CX(k)$$

Where

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

i) State controllable and ii) Observable. [6]

6 Consider the sample -data system shown in Figure 6 and assume its sampling period is 0.4 Sec. Find the range of K, so that the closed - loop system for which stable.

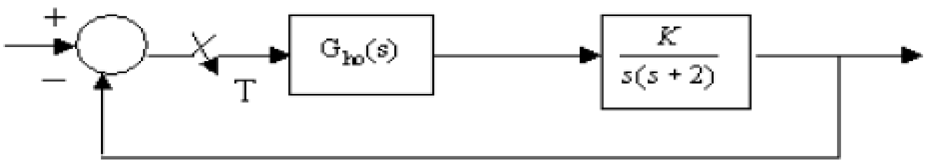

Figure.6 [15]

7 a) Explain the steady -state error analysis of continuous - data control and discrete data control systems. [8]

b) Explain the design of digital controllers through bilinear transformation. [7]

8 Consider the system defined by

$$\dot{X} = Ax + Bu$$

$$A = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -1 & -5 & -6 \end{bmatrix}, B = \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix}$$

by using the state feedback control u = -Kx, it is desired to have the closed loop poles at s = -2 ± j 4 and s= -10. Determine the state feedback gain matrix K. [15]