Code No: 07A7EC36 **R07** **Set No. 2**

IV B.Tech I Semester Examinations November 2010

DIGITAL CONTROL SYSTEMS

Electronics And Instrumentation Engineering

Time: 3 hours Max Marks: 80

Answer any FIVE Questions

All Questions carry equal marks

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1. Given the transfer functions:
   (a) $F_1(s) = \frac{s+1}{(s+2)(s+3)}$.
   (b) $F_2(s) = \frac{1-e^{4s}}{s} \quad \frac{s+1}{(s+2)^2}$.
   Obtain the pulse transfer functions by two different methods. [16]

2. (a) Explain the mapping between S-plane, Z-plane and ω-plane with suitable dagrams.
   (b) Explain the design procedure of digital controller in ω -plane using frequency response method. [8+8]

3. (a) Consider the following characteristic equation P(z) = $z^3 + 2.1z^2$ +1.44z + 0.32 = 0. Determine whether or not any of the roots of the characteristic equation lie outside the unit circle in the z - plane. Use the bilinear transformation and routh stability criterion.
   (b) Explain the following conditions for discrete time systems.
      i. Stability
      ii. Instability
      iii. Critical stability. [10+6]

4. a) Find the Z-transform of the following:
   (i) X(S) = 5 /s(s^2+4).
   (ii) F(S) = 2/s^2(s+2).
   b)State the properties of Z-transforms. [12+4]

5. Solve the following difference equation X(k+2) - X(K+1) + 0.25 X(K) = U(K+2) where x(0)=1, x(1) =2. the input function u(k),is given by

   U(k) = 1, k =0,1,2 − − −−. [16]

6. (a) Consider the system
   X(k+1) = GX(k) + Hu(k)
   Y(k) = CX(k)
   where G = $\begin{bmatrix} 0 & -0.16 \\ 1 & -1 \end{bmatrix}$; H = $\begin{bmatrix} 0 \\ 1 \end{bmatrix}$; C= $\begin{bmatrix} 0 & 1 \end{bmatrix}$. Design a full-order observer. The desired eigenvalues of the observer matrix are $\lambda_1; \lambda_2 = 0.5 \pm j0.5$.

(b) Describe the reduced-order observed with suitable diagram. [8+8]

7. (a) Given the system:

$$\dot{x} = \begin{bmatrix} -1 & 0 & 0 \\ 0 & -2 & 0 \\ 0 & 0 & -3 \end{bmatrix} x(k) + \begin{bmatrix} 0 & 1 \\ 2 & 0 \\ 0 & 1 \end{bmatrix} u(k)$$

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

Determine the controllability and observability?

(b) Determine the state controllability for the systems, whose system matrix and input matrices given as:

i. $A = \begin{bmatrix} 2 & 1 \\ 0 & -1 \end{bmatrix}$; $B = \begin{bmatrix} 1 \\ 0 \end{bmatrix}$

ii. $A = \begin{bmatrix} 0 & 1 \\ -1 & 0 \end{bmatrix}$; $B = \begin{bmatrix} 0 \\ 1 \end{bmatrix}$. [10+6]

8. (a) Explain the digital implementation of analog controllers in detail.

(b) Describe the three digital integration rules used for the digital implementation of controllers and explain bilinear transformation briefly. [8+8]

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Code No: 07A7EC36 **R07** **Set No. 4**

IV B.Tech I Semester Examinations November 2010

DIGITAL CONTROL SYSTEMS
Electronics And Instrumentation Engineering

Time: 3 hours Max Marks: 80

Answer any FIVE Questions
All Questions carry equal marks
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1. A discrete system is described by the difference equation
   y(k + 2) + 3y(k + 1) + 2y(k) = u(k) and u(k) = 1 $\forall$ k $\geq$ 0
   given y(0) = y(1) = 1 solve the difference equation. [16]

2. Explain the procedure for discretization of continuous time state space equations. [16]

3. (a) What are PID controllers?
   (b) Compare the performance of PID controller with PI controllers and PD controllers.
   (c) Explain digital PID controller in detail. [4+8+4]

4. (a) Develop relationship between controllability, observability and transfer functions.
   (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. [6+10]

5. Investigate the stability of the following system as shown in figure 1 and calculate the range of K, over which the system is stable. Select the sampling period T = 0.4 sec. [16]

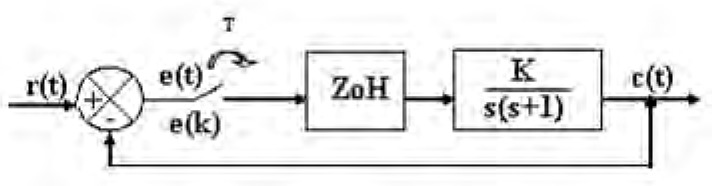

Figure 1:

6. (a) Obtain the Z-transform of :
   i. $f_1(t) = \frac{1}{a}\left(1 - e^{-at}\right)$ where 'a' is a positive constant.
   ii. $f_2(t) = 9k\left(2^{k-1}\right) - 2^k + 3 \qquad k \geq 0.$
   (b) Show that
   $z\left[k\left(k-1\right).....\left(k-h+1\right)a^{k-h}\right] = \frac{(h!)z}{(z-a)^{h+1}}.$ [4+4+8]

7. Consider the digital process with the state equations described by
   $x(k+1) = A\,x(k) + B\,u(k)$

   $C(k) = D\,X(k)$

   Where $A = \begin{bmatrix} 0 & 1 \\ -1 & 1 \end{bmatrix}$ $B = \begin{bmatrix} 0 \\ 1 \end{bmatrix}$ $D = \begin{bmatrix} 2 & 0 \end{bmatrix}$
   Design a full order observer which will observe the states x1(k) and x2(k) from the output C(k), having dead beat response. Write the dynamic equation for the observer. [16]

8. Explain the following with respect to digital control system configuration:
   (a) A/D and D/A conversion.
   (b) Sample and hold circuit.
   (c) Transducer.
   (d) Different types of sampling operations. [16]

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Code No: 07A7EC36 **R07** **Set No. 1**

IV B.Tech I Semester Examinations November 2010
DIGITAL CONTROL SYSTEMS
Electronics And Instrumentation Engineering

Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions
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1. What are the two basic transformations used to convert an analog system transfer function to a digital system transfer function? Explain each procedure. [16]

2. (a) Determine the Z- transform of the following sequence:

$$f(k) = \begin{cases} 1 & k = 0,\ and\ even\ \text{integers} \\ -1 & k =\ odd\ \text{integers} \end{cases}$$

   (b) State Z - transform and obtain the relation between Z- plane and S- plane transformations. [8+8]

3. (a) Explain the effects of the discretization of a continuous -time control system on controllability and observability.

   (b) Examine whether the discrete data system:

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

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

   is complete state controllable and complete state observable. [8+8]

4. For the following discrete control system represented by

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

   Obtain the state representation of the system in the controllable canonical form. Also find its state transition matrix. [16]

5. (a) What is the necessary and sufficient condition for state observation?

   (b) Consider the system

$$x(k+1) = G\,x(k) + H\,u(k)$$
$$y(k) = C\,x(k)$$

   Where $G = \begin{bmatrix} 0 & -0.16 \\ 1 & -1 \end{bmatrix}$; $H = \begin{bmatrix} 0 \\ 1 \end{bmatrix}$ and $C = \begin{bmatrix} 0 & 1 \end{bmatrix}$. Determine a full-order state observer, such that the desired eigen values of the obsever matrix are z = 0.5 ± j0.5. [8+8]

6. Consider the difference equation
   x(k+2) - 1.3679x(k+1) + 0.3679x(k) = 0.3679u(k+1) + 0.2642u(k).
   where x(k) is the output and x(k) = 0 for k≤ 0 and where u(k) is the input and is given by u(k) = 0, k≤0.
   u(0) = 1, u(1) = 0.2142; u(2) = -0.2142

u(k) = 0, k = 3,4,5 − − − − −
Determine the output x(k). [16]

7. The open loop transfer function of a unity - feedback digital control system is given as G(z) $=\frac{Kz}{(z-1)(z-0.5)}$. Sketch the root loci of the system for $0 < K < \infty$. Indicate all important information on the root loci. [16]

8. (a) Consider the discrete - time unity feedback control system (with sampling period T=1 sec) whose open loop pulse transfer function is given by $G(z) = \frac{K(0.3679z+0.2642)}{(z-0.3679)(z-1)}$. Determine the range of gain K for stability by using the Jury stability test.

   (b) What is bilinear transformation? Explain briefly the stability analysis using bilinear transformation and Routh stability? [10+6]

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Code No: 07A7EC36 **R07** **Set No. 3**

IV B.Tech I Semester Examinations November 2010

DIGITAL CONTROL SYSTEMS

Electronics And Instrumentation Engineering

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Answer any FIVE Questions

All Questions carry equal marks

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1. Obtain the discrete time state and output equations and the pulse transfer function (when the sampling period T=1) of the following continuous time system G(S) = Y(S) /U(S) = 1/S(S+2). [16]

2. Using Jury's stability criterion find the range of K, for which the following characteristic equations:
   (a) z^2 + 1.5 z + K = 0 and
   (b) z^2 - K z + 0.5 = 0 is closed loop stable. [8+8]

3. Derive the state transition equation of a discrete time systems. [16]

4. The closed loop transfer function for the digital control system is given as $\frac{c(z)}{R(z)} = \frac{z+0.5}{3(z^2 - z + 0.5)}$ .Find the maximum overshoot and the normalized peak time T_{max} / T of the step response.

5. A regulator system has the plant characterized by
   X(k+1) = AX(k)+Bu(k)
   Y(k) = CX(k)
   with $A = \begin{bmatrix} 0 & 0 & 6 \\ 1 & 0 & -11 \\ 0 & 1 & -6 \end{bmatrix}$ $B = \begin{bmatrix} 1 \\ 0 \\ 0 \end{bmatrix}$ $C = \begin{bmatrix} 0 & 0 & 1 \end{bmatrix}$
   Compute K so that the control law u(k) = -K(X) places the closed loop poles at -2 + j3.464, -2 - j3.464, -5. Give the state variable model of the closed loop system. [16]

6. Develop a mathematical model of sample and hold circuit. Show that an ideal sampler is an impulse modulator. [16]

7. (a) Obtain the Z-transform of :

   i. f1 (t) $=\frac{1}{a}\left(1-e^{-at}\right)$ where 'a' is a constant.

   ii. f2 (t) $= 9k\left(2^{k-1}\right)-2^k+3 \qquad k \geq 0.$

   (b) Find the inverse Z-transform of the following function:
   $F_2(z)=\frac{1+6z^{-2}+z^{-3}}{(1-z^{-1})(1-0.2z^{-1})}$. [16]

8. Show that the following system

$$\begin{bmatrix} x_1(k+1) \\ x_2(k+1) \\ x_3(k+1) \end{bmatrix} = \begin{bmatrix} -1 & -2 & 0 \\ 0 & -3 & 1 \\ 1 & 0 & -1 \end{bmatrix} \begin{bmatrix} x_1(k) \\ x_2(k) \\ x_3(k) \end{bmatrix} + \begin{bmatrix} 1 \\ 0 \\ 1 \end{bmatrix} u(k)$$

$$y(k) = \begin{bmatrix} 1 & 1 & 0 \end{bmatrix} \begin{bmatrix} x_1(k) \\ x_2(k) \\ x_3(k) \end{bmatrix}$$

is completely state controllable and observable. [16]

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