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

IV B.Tech I Semester Examinations,MAY 2011
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. Draw a typical block diagram of a digital control system with state observer and explain the same. Write the equation for the control signal in terms of reference signal and observed state vector. [16]

2. Show that geometrically the patterns of the poles near z = 1 in the z-plane are similar to the patterns of poles in the s-plane near the origin. [16]

3. The input and output of a sampled data system is described by the difference equation
c(n + 2) + 3c(n + 1) + 4c(n) = r(n + 1) - r(n)
Determine the Z - transfer function. [16]

4. (a) Explain:
   i. Continuous time analog signal.
   ii. Continuous time quantized signal.
   iii. Sampled data signal.
   iv. Digital signal.

   (b) Explain any two different methods of D/A conversion? [8+8]

5. (a) Write short notes on primary and complementary strips.

   (b) Consider the digital system shown in figure 1. [8+8]

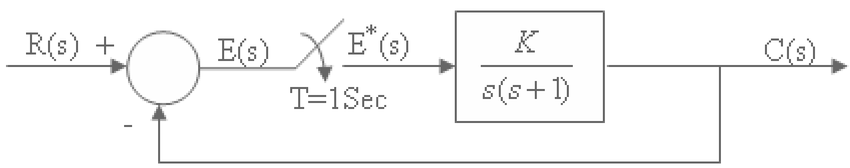

Figure 1:

6. A block diagram of a digital control system is shown in Figure 2. Design a compensator D(z) to meet the following specifications:

   (a) Velocity error constant, Kv ≥ 4 Sec.,
   (b) Phase margin ≥ 400 and
   (c) Band width =1.5 rad./sec. [16]

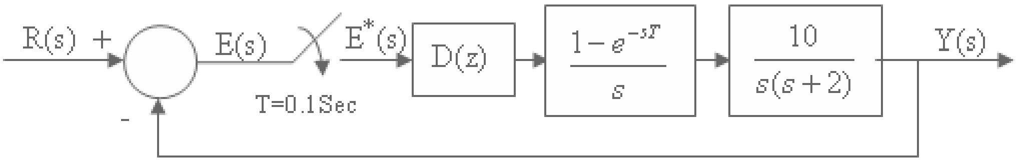

Figure 2:

7. Find the state variable models for the following system represented by the difference equation
   (a) y(k+3)+5y(k+2)+7y(k+1)+3y(k)=0.
   (b) y(k+2)+3y(k+1)+2y(k)=5r(k+1)+3r(k). [8+8]

8. (a) State and explain the state controllability and observability of time invariant systems.
   (b) A discrete data control system is described by the state equation where
   $x(k+1) = A\,x(k) + B\,u(k)$; Where $A = \begin{bmatrix} 0 & 0 & 0 \\ 0 & 0.5 & 0 \\ 0 & 0 & 2 \end{bmatrix}$, $B = \begin{bmatrix} 1 \\ 0 \\ 1 \end{bmatrix}$
   Determine the state controllability of the system. [8+8]

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

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DIGITAL CONTROL SYSTEMS
Electronics And Instrumentation Engineering

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

Answer any FIVE Questions
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1. A discrete time system is described the following difference equation
   y(k+2)+5y(k+1)+6y(k)=u(k).
   y(0)=y(1)=0, T=1 sec.
   (a) Determine the state model in canonical form.
   (b) Find the state transition matrix.
   (c) For input u(k) =1, k >=1, find the output y(k). [16]

2. Show that the transfer function U(s) / E(s) of the PID controller shown below is
   $\frac{U(s)}{E(s)} = K_0 \frac{T_1+T_2}{T_2}\left[1 + \frac{1}{T_1+T_2} + \left(\frac{T_1T_2.s}{T_1+T_2}\right)\right]$
   Assume the gain K is very large compared with unity, or K >> 1 as shown in the figure 3.
   [16]

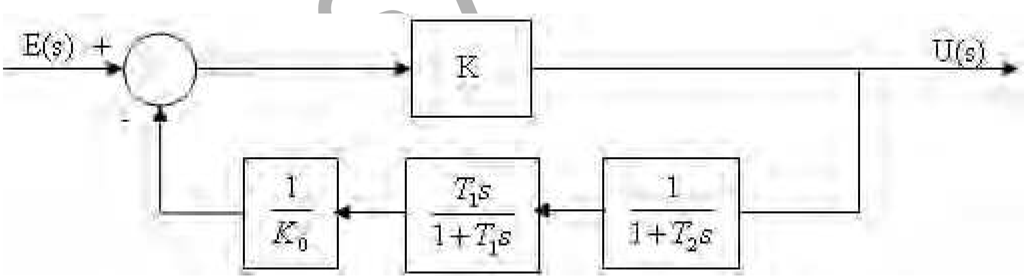

Figure 3:

3. (a) Find the inverse Z-transform of the following:
   i. x(z) = (z(z+2))/$(z-1)^2$
   ii. (2 Z+ Z)^3/((Z - 2)^2(Z-1)).
   (b) Explain different properties and theorems of Z-transforms. [8+8]

4. (a) Discuss about stability analysis of a closed loop system?
   (b) Find the range of K for the system shown in figure 4 to be stable using Jury's test. [6+10]

5. Obtain the solution of the following difference equation in terms of x(0) and x(1):
   x(k + 2) + (a + b) x(k + 1) + abx(k) = 0
   where a and b are constants and k = 0, 1, 2,..... [16]

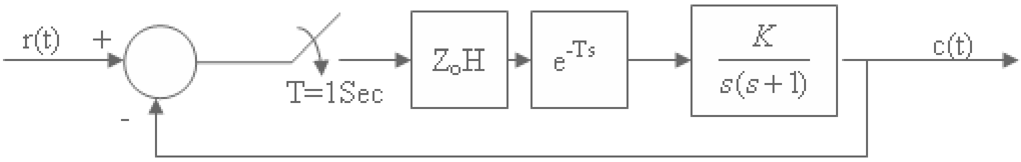

Figure 4:

6. Consider the digital process with the sate 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]

7. (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]

8. Consider the following continuous control system
   $$\begin{bmatrix} \dot{x}_1(t) \\ \dot{x}_2(t) \end{bmatrix} = \begin{bmatrix} -1 & 1 \\ 0 & -1 \end{bmatrix} \begin{bmatrix} x_1(t) \\ x_2(t) \end{bmatrix} + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u(t)$$
   $y(t) = x_1(t)$
   The control signal u(k) is now generated by processing the signal u(t) through a sampler and zero order hold. Study the controllability and observability properties of the system under this condition. Determine the values of the sampling period for which the discretised system may exhibit hidden oscillation. [16]

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

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1. Explain the steady -state error analysis of continuous - data control and discrete - data control systems. [16]

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

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

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

3. (a) Explain the conditions for complete state controllability and complete state observability in the z - plane.

   (b) Investigate the controllability and observability of the following system

$$\begin{bmatrix} x_1(k+1) \\ x_2(k+1) \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ -0.4 & -1.3 \end{bmatrix} \begin{bmatrix} x_1(k) \\ x_2(k) \end{bmatrix} + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u(k)$$

$$\begin{bmatrix} y_1(k) \\ y_2(k) \end{bmatrix} = \begin{bmatrix} 0.8 & 1 \end{bmatrix} \begin{bmatrix} x_1(k) \\ x_2(k) \end{bmatrix}$$

[6+10]

4. (a) State and explain the theorem required to satisfy to recover the signal e(t) from samples e*(t).

   (b) What are the advantages and disadvantages of digital control system over analog control system.

   (c) State different types of sampling operations [6+6+4]

5. Consider the digital control system X[(k+1)T] =AX(kT)+Bu(kT) where A = $\begin{bmatrix} 0 & 1 \\ -1 & -1 \end{bmatrix}$; B = $\begin{bmatrix} 0 \\ 1 \end{bmatrix}$.
   The state feedback control is described by u(kT) = -KX(kT) where K = $[K_1 K_2]$. Find the values K_1 and K_2 so that the roots of the characteristic equation of the closed loop system are at 0.5 and 0.7. [16]

6. Given the difference equation y(k+2) - 1.3y(k+1) + 0.4y(k) = u(k) with y(k) = 0, k<0 and y(0) = -1, y(1) = 1, obtain the solution if

   (a) $u(k) = \begin{cases} 0 & if \quad k < 0 \\ 1 & if \quad k \geq 0 \end{cases}$

   (b) $u(k) = \begin{cases} 1 & if \quad k = 0 \\ 0 & if \quad k \neq 0 \end{cases}$ [16]

7. (a) State the properties of state transition matrix.

   (b) Given the following state model of the system.

   $$X(K+1) = \begin{pmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -1 & -4 & -3 \end{pmatrix} X(K) + \begin{pmatrix} 1 & 0 \\ 0 & 1 \\ -1 & 1 \end{pmatrix} u(K)$$

   $$Y(K) = \begin{pmatrix} 0 & 1 & -1 \\ 1 & 2 & 1 \end{pmatrix} X(K)$$

   Obtain the

   i. State transition matrix
   ii. X(Z), given X(0) = $[1 \ \ 1 \ \ 1]^T$ Consider zero input condition. [4+12]

8. (a) Discuss about stability analysis of a closed loop system?

   (b) Consider the system described by y(k+2) = 2y(k+1)- 5y(k) + 10r(k+2) - 3r(k+1) + 4r(k). Where r(k) is the input and y(k) is the out put of the system. Determine the stability of the system. [6+10]

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

Answer any FIVE Questions
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1. Determine the discrete state variable representation for the pulse transfer functions given below:
   (a) $G(Z) = \frac{2 + Z^{-1}}{1 + Z^{-1}}$.
   (b) $G(Z) = \frac{5Z}{Z^2 + 2Z + 1}$. [8+8]

2. Explain the necessity of sampling and its applications in detail. [16]

3. The input and output of a sampled data system is described by the difference equation.
   c(n+2) + 3c(n+1) +4c(n) = r (n+1) - r(n)
   Determine the Z-transfer function. Also obtain the weighting sequence (discrete impulse response) of the system. [16]

4. Consider the system define by
   $$X(k+1) = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -0.5 & -0.2 & 1.1 \end{bmatrix} X(k) + \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} U(k).$$
   Determine the state feed back gain matrix K such that when the control signal is given by u(k)=-K x(k), the closed loop system will exhibit the dead beat response to any initial state X(0). [16]

5. Consider the system shown in Figure 5 and design lead compensator G_C(z) in w'-plane for this system to meet the following specifications:
   (a) damping ratio =0.7,
   (b) Settling time, t_s=1.4 sec., and
   (c) Velocity error constant $K_v = 2sec^{-1}$. [16]

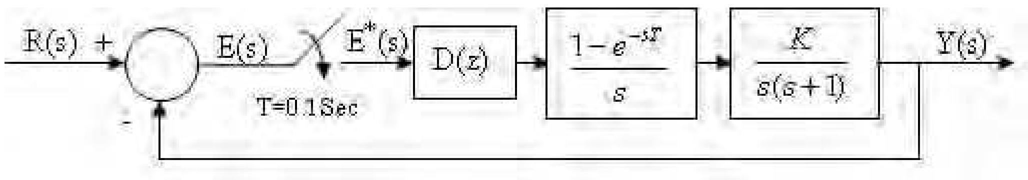

Figure 5:

6. Investigate the controllability and observability of the following systems:

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

$y(k) = \begin{bmatrix} 1 & 1 \end{bmatrix} X(k)$

(b) $X(k+1) = \begin{bmatrix} 1 & -2 \\ 1 & -1 \end{bmatrix} X(k) + \begin{bmatrix} 1 & 0 \\ 0 & -1 \end{bmatrix} u(k)$

$y(k) = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} X(k).$ [16]

7. Solve the following difference equation by Z transform method.
x(k + 2) = x(k + 1) + x(k)
Given that x(0) = 0 and
x(1) = 1. [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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