Code No: RR420201 **Set No.1**

IV B.Tech. II Semester Regular Examinations, April/May -2006
DIGITAL CONTROL SYSTEMS
(Electrical & Electronic Engineering)

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

Answer any FIVE Questions
All Questions carry equal marks

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1. (a) What are the different types of sampling operations? Explain each of them. [6]
   (b) What do you mean by the problem of aliasing?. How to overcome this? [5]
   (c) Explain the advantages and disadvantages of digital control systems. [5]

2. (a) Obtain the z - transform of the following x(k) $x(k) = \sum_{h=0}^{k} a^h$ where a is a constant. [8]
   (b) Obtain the inverse z-transform of the following. [8]
      i. X(z)=$\frac{z^{-3}}{(1-z^{-1})(1-0.2z^{-1})}$ and
      ii. X(z) = $\frac{z^{-1}(1-z^{-2})}{(1+z^{-2})^2}$

3. (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 $z^3 + Kz^2$ + 1.5 Kz - (K+ 1) = 0 is closed loop stable. [8]

4. Compare the characteristics of time-domain responses of continuous - time and discrete time systems. [16]

5. 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]

6. A block diagram of a digital control system is shown in Figure 1. Design a compensator D(z) to meet the following specifications:
   (a) Velocity error constant, $K_v \geq 4$ Sec.,
   (b) Phase margin $\geq 40^o$ and
   (c) band width =1.5 rad./sec. The sampling frequency may be selected as 10 times of bandwidth. [16]

7. 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. [16]

8. (a) State and explain the Liapunov's stability theorem for linear digital systems. [6]

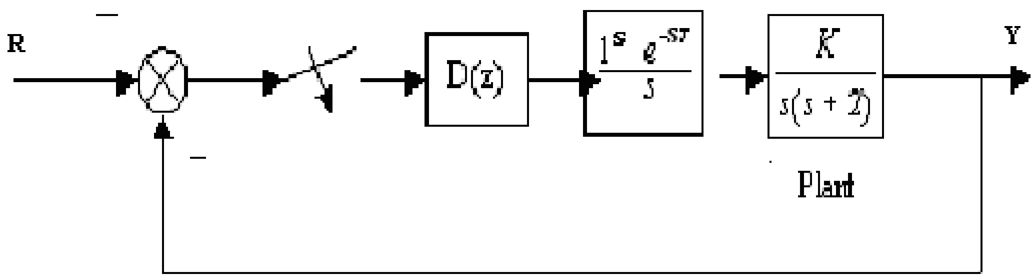

Figure 1:

(b) Given $X(k + 1) = \begin{bmatrix} 0.5 & 1 \\ -1 & -1 \end{bmatrix} X(k)$.
Solve for 'P' - matrix and justify, by using the Liapunov's theorem (Direct method). Show that the system is asymptotically stable. [10]

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1. (a) With suitable block diagram explain the general sampled data control system. [8]
   (b) State and explain the theorem required to satisfy to recover the signal e(t) from the samples e*(t). [8]
2. (a) Obtain the z - transform of the following x(t)
      i. x(t) $=\frac{1}{a}(1-e^{-at})$, and
      ii. $x(t) = t^2 e^{-at}$ where a is a constant. [8]
   (b) Obtain the inverse z-transform of the following.
      i. X(z)$=\frac{0.368z^2+0.478z+0.154}{(z-1)z^2}$ and
      ii. $X(z) = \frac{z}{z^2+1}$ [8]
3. The input-output of a sampled-data system is described by the difference equation y (k+2) + 3y (k+1) + 4y (k) = r (k+1) - r (k) Determine the pulse transfer function. Also obtain the unit-pulse response of the system. [16]
4. (a) Derive the steady state error due to a step function input and the corresponding step error constant of discrete- data control systems. [8]
   (b) Explain the root locations relations between the s-plane - and the z-plane. [8]
5. The open loop transfer function of a unity - feedback digital control system is given as $G(z) = \frac{K(z+0.5)(z+0.2)}{(z-1)(z-0.5)}$. Sketch the root loci of the system for $0 < K < \infty$. Indicate all important information on the root loci. [16]
6. Explain the control systems design specifications in terms of following:
   (a) Time Response [6]
   (b) Root locations [5]
   (c) Frequency response. [5]
7. Find the state space representation of the following system:
   y(k + 2) - 3y(k + 1) + 2y(k) = 4^k and y(0) = 0 ; y(1) = 1. Find the complete solution of the above system. [16]
8. (a) Develop relationship between controllability, observability and transfer functions.
   [6]

(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. [10]

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Code No: RR420201 **Set No.3**

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

Answer any FIVE Questions
All Questions carry equal marks
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1. (a) Describe the following parameters:
   i. Acquisition time
   ii. Aperture time and
   iii. Settling time. [6]

   (b) State and explain the sampling theorem. [5]

   (c) Derive the transfer function of zero order hold device. [5]

2. (a) State and prove the following properties/theorems of z-transforms. [8]
   i. Shifting theorem
   ii. Complex translation theorem
   iii. Complex differentiation and Partial differentiation theorem.

   (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. Consider the sample -data system shown in Figure 2 and assume its sampling period is 0.4 Sec.

   Find the range of K, so that the closed - loop system for which stable. [16]

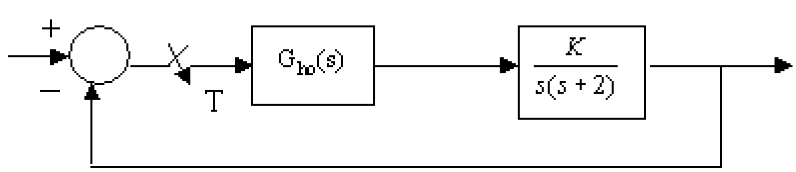

Figure 2:

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

5. The open loop transfer function of a unity - feedback digital control system is given as $G(z) = \frac{Kz}{(z-1)(z^2-z+0.5)}$. Sketch the root loci of the system for $0 < K < \infty$. Indicate all important information on the root loci. [16]

6. Derive the pulse transfer function of digital PID controller. Also the design procedure of PID controller. [16]

7. Find the complete response of the system. [16]

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

   if u(k) = 1 for k = 0,1,2,

8. (a) Derive the necessary condition for digital control system
   X(k+1 = G X(k)=Hu(k)
   Y(k) = C X(k) to be output controllable and observable. [10]

   (b) Examine whether the discrete data system

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

   i. Output controllable and
   ii. Observable. [6]

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Code No: RR420201 **Set No.4**

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DIGITAL CONTROL SYSTEMS
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Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions
All Questions carry equal marks

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1. (a) With help of diagram explain the successive approximation analog to digital converter. [8]
   (b) What do you mean by the problem of aliasing? How to overcome this problem? [8]

2. (a) Solve the difference equation by using z-transform method x(k+2) + 3x(k+1) + 2 x(k) = u(k) the initial conditions are x(0) = 0, x(1) = 1. [8]
   (b) Find the z-transform of the following :
      i. $F(s) = \frac{4}{s^2(s+2)}$ and
      ii. f(t) =e^{-t}sin(at). [8]

3. A sampler and ZOH are now introduced in the forward loop Figure 3 . Study the stability of the sampled-data system via bilinear transformation and show that the stable linear continuous time system becomes unstable upon the introduction of a sampler and ZOH. [16]

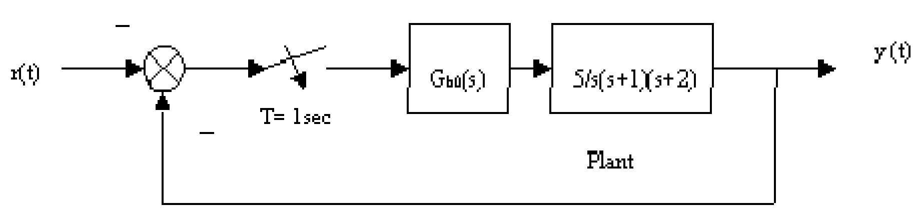

Figure 3:

4. Explain the correlation between time response and root locations in the s - plane and the z-plane. [16]

5. The open loop transfer function of a unity - feedback digital control system is given as $G(z) = \frac{K(z+0.5)(z+0.2)}{(z-1)(z^2-z+0.5)}$. Sketch the root loci of the system for $0 < K < \infty$. Indicate all important information on the root loci. [16]

6. (a) Explain the design procedure of digital controller through bilinear transformation. [8]

(b) Explain the digital PID controllers. [8]

7. Given the state equation X(k+1) = F X(k) + G u(k)

   where $F = \begin{pmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ 0 & -0.5 & 1.5 \end{pmatrix}; \quad G = \begin{bmatrix} 0 & 1 \\ 1 & 0 \\ 2 & 1 \end{bmatrix}$

   Find the state transition matrix φ (k) using

   (a) Cayley-Hamilton technique. [8]

   (b) Similarity transformation. [8]

8. (a) State and explain the Lyapunov's stability theorem for dynamical systems. [8]

   (b) A system is described by the following state model

   $X(k+1) = \begin{bmatrix} 2 & 2 \\ 0 & 0 \end{bmatrix} X(k) + \begin{bmatrix} 1 \\ 1 \end{bmatrix} u(k) \; and \quad \mathrm{Y(k)} = \begin{bmatrix} 1 & 1 \end{bmatrix} \mathrm{X(k)}$

   Test its

   i. State controllability,
   ii. Output Controllability and
   iii. Observability. [8]

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