

IV B.Tech II Semester Regular Examinations, Apr/May 2008
DIGITAL CONTROL SYSTEMS
(Electrical & Electronic Engineering)

Time: 3 hours

Max Marks: 80

Answer any FIVE Questions
 All Questions carry equal marks

1. (a) What are the different types of sampling operations? Explain each of them.
 (b) What do you mean by the problem of aliasing? How to overcome this?
 (c) Explain the advantages and disadvantages of digital control systems. [6+5+5]
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.
 (b) Find the inverse Z-Transform of the $F(z) = \frac{3z^2+2z+1}{(z^2-3z+2)}$
 (c) Show that $z^{-1} \left[\frac{z^{-2}}{(1-az^{-1})^2} \right] = \begin{cases} (k-1)a^{k-2} & k = 1, 2, 3.. \\ 0 & k \leq 0 \end{cases}$ [6+5+5]
3. (a) State and explain Jury's stability test.
 (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. [8+8]
4. Explain the correlation between time response and root locations in the s - plane and the z-plane. [16]
5. Draw root locus in the z-plane for the system shown in Figure 5 for $0 < K < \infty$. Consider the sampling period $T = 4$ sec. [16]

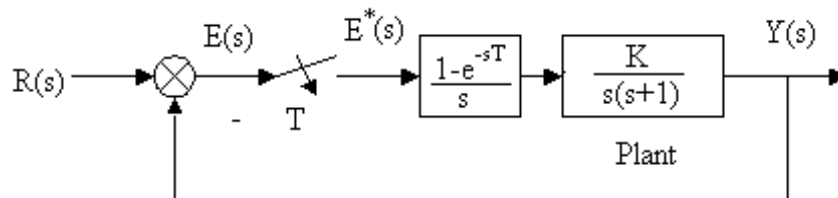


Figure 5

6. Derive the pulse transfer function of digital PID controller. Also the design procedure of PID controller. [16]
7. Obtain a state space representation of the system given in Figure 7. The sampling period T is 1 sec. Also obtain the state transition matrix. [16]

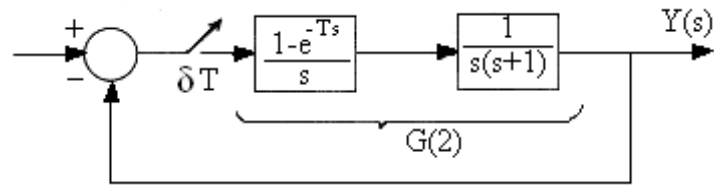


Figure 7

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

(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. [6+10]

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1. (a) With suitable block diagram explain the general sampled data control system.
 (b) State and explain the theorem required to satisfy to recover the signal $e(t)$ from the samples $e^*(t)$. [8+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.
 (b) Find the inverse Z-Transform of the $F(z) = \frac{3z^2+2z+1}{(z^2-3z+2)}$
 (c) Show that $z^{-1} \left[\frac{z^{-2}}{(1-az^{-1})^2} \right] = \begin{cases} (k-1)a^{k-2} & k = 1, 2, 3.. \\ 0 & k \leq 0 \end{cases}$ [6+5+5]
3. The block diagram representation of digital control system is given in the Figure 3.

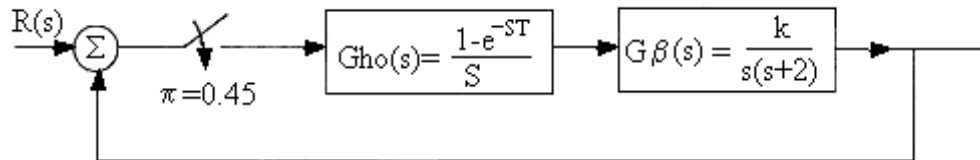


Figure 3

Using Jury's criterion, find the range of values of K for which the system is stable. [16]

4. The block diagram of a discrete - data control system is shown in Figure 4, in which $G_p(s) = \frac{20}{s(s+5)}$ and $T = 0.5$ sec. Compute and plot the unit step response $c^*(t)$ of the system. Find $c_{\max}^*$ and the sampling instant at which it occurs. [16]

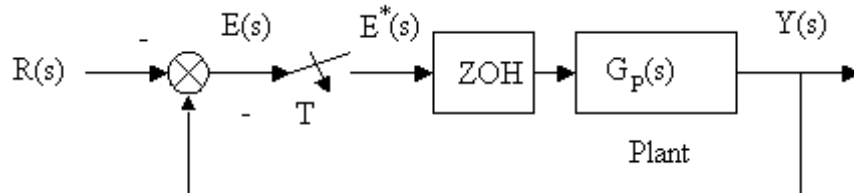


Figure 4

5. Sketch the root locus of a digital system indicating all the component information on the root loci, given with $G(z) = \frac{K(z^2+0.5z+0.2)}{(z-1)(z^2-z+0.5)}$. [16]

6. Derive the pulse transfer function of digital PID controller. Also the design procedure of PID controller. [16]
7. The pulse transfer function of a digital control system is given by
$$\frac{Y(z)}{R(z)} = \frac{z^3 + 2z^2 + z + 2}{z^3 + 3z^2 + 2z + 1}$$
obtain a state space representation for the system and draw the state diagram. Also obtain the pulse transfer matrix. [16]
8. (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]

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1. (a) What are the different types of sampling operations? Explain each of them.
 (b) What do you mean by the problem of aliasing? How to overcome this?
 (c) Explain the advantages and disadvantages of digital control systems. [6+5+5]
2. (a) Find the inverse Z-Transform of the following:
 - i. $F(z) = \frac{(1-e^{-\omega T})z}{(z-1)(z-e^{-\omega T})}$ 'ω' is a positive constant; and T is the sampling period
 - ii. $F(z) = \frac{3z^2+2z+1}{(z^2-3z+2)}$.
 (b) Explain the properties of Z-transforms (at least four). [8+8]
3. The block diagram of a digital control system is shown in Figure 3, where $G_p(s) = \frac{K}{s(s+5)}$.

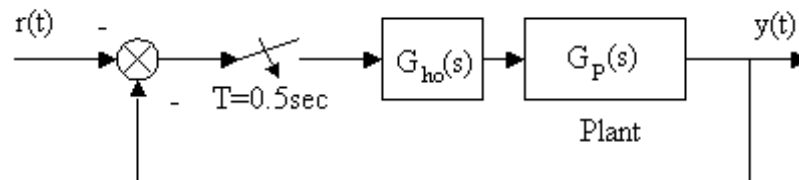


Figure 3

Determine the range of K for the system to be asymptotically stable.

4. The block diagram of a discrete - data control system is shown in Figure 4, in which $G_p(s) = \frac{2(s+1)}{s(s+2)}$ and $T = 0.5$ sec. Compute and plot the unit step response $c^*(t)$ of the system. Find $c_{\max}^*$ and the sampling instant at which it occurs. [16]

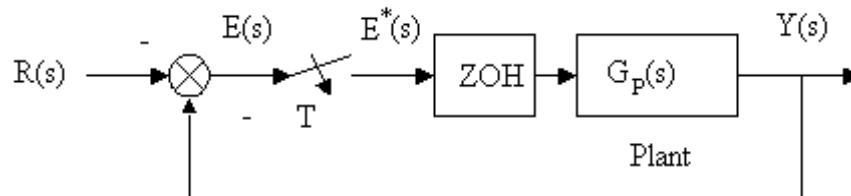


Figure 4

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. (a) Explain the design procedure of digital controller through bilinear transformation.
 (b) Explain the digital PID controllers. [8+8]
7. Obtain a state space representation of the system given in Figure 7. The sampling period T is 1 sec. Also obtain the state transition matrix. [16]

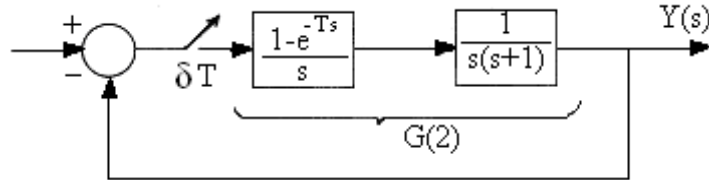


Figure 7

8. Investigate the controllability and observability of the following systems.

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

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

What can you say about controllability and observability of the state model in part (a) without making any further calculations? [8+8]

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1. (a) With help of schematic diagram explain the principal operation of digital to analog conversion.
 (b) Explain the conditions to be satisfied for reconstruction of sampled signal into continuous signal.
 (c) Explain zero order hold device. [5+5+6]
2. (a) Given the function $f(k) = (0.1)^k u_s(k) + 0.5k(0.1)^k u_s(k)$. Find the z-transform of f(k), F(z).
 (b) Find the inverse z-transform of the following functions:
 i. $F(z) = \frac{10z}{z^2-1}$ and
 ii. $F(z) = \frac{1}{z(z-0.2)}$ [8+8]
3. (a) Explain the procedure for obtaining the pulse transfer function of a closed loop transfer function.
 (b) Find $Y(z)/R(z)$ for the following sample-data closed - loop systems shown in Figure 3. [6+10]

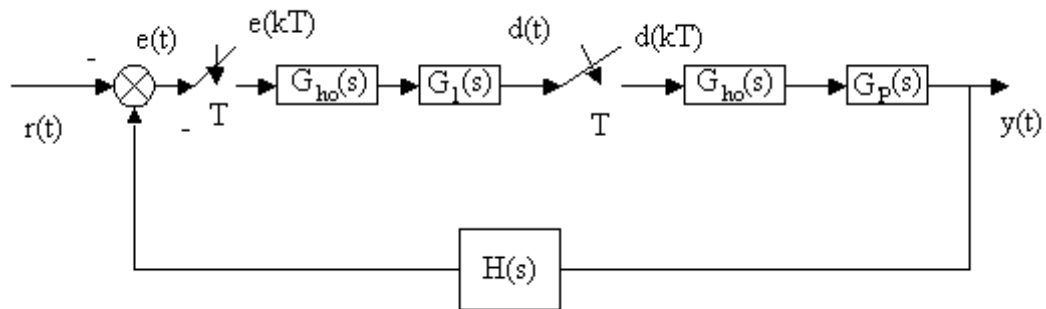


Figure 3

4. Consider the closed - loop transfer function of the system is given by

$$\frac{C(z)}{R(z)} = \frac{0.4986(z+0.7453)}{z^2-1.262z+0.5235}$$
 Draw the pole - zero configurations of the given system. Also find the maximum overshoot and peak time. [16]
5. Consider the digital control system whose transfer function is given by

$$GH(z) = \frac{0.0952Kz}{(z-1)(z-0.905)}$$
 Draw the Nyquist plot and determine its stability. [16]
6. A block diagram of a digital control system is shown in Figure 6. Design a compensator D(z) to meet the following specifications:

- (a) Velocity error constant, $K_v \geq 4$ Sec.,
- (b) Phase margin $\geq 40^\circ$ and
- (c) band width = 1.5 rad./sec.

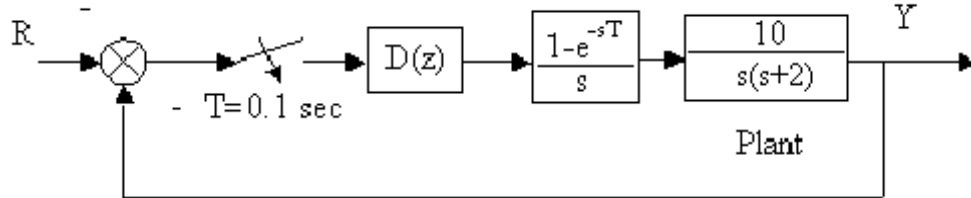


Figure 6

7. Find state model for the following difference equation. Also find its state transition matrix.

$$y(k+2) + 3y(k+1) + 2y(k) = 5u(k+1) + 3u(k). \quad [16]$$

8. (a) Derive the necessary condition for the digital control system

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

$$Y(k) = CX(k) \text{ to be Controllable.}$$

- (b) Examine whether the discrete data system

$$X(k+1) = AX(k) + BU(k)$$

$$Y(k) = CX(k) \text{ where } A = \begin{bmatrix} 1 & -2 \\ 1 & -1 \end{bmatrix}, B = \begin{bmatrix} 1 & 0 \\ 0 & -1 \end{bmatrix}, C = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} \text{ is}$$

i. State controllable and

ii. Observable.

[10+6]
