Code :R7420203

IV B.Tech II Semester(R07) Regular Examinations, April 2011
DIGITAL CONTROL SYSTEMS
(Electrical & Electronics Engineering)

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

Answer any FIVE questions
All questions carry equal marks

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1. (a) With the help of a neat block schematic, explain the working of a digital control system.
   (b) Explain the need for Analog to digital and digital to analog conversions.

2. (a) What is primary strip? How does it map into the Z-plane? Explain.
   (b) Obtain the z-transform of
   $X(s) = \frac{s}{(s+1)^2(s+2)}$ by using
      i. The partial fraction expansion method,
      ii. The residue method.

3. Derive the pulse transfer function of a digital PID controller in positional form.

4. (a) What do you understand by 'state Transition Matrix'? What are its properties?
   (b) Obtain the discrete-time state-space representation for $G(s) = \frac{Y(s)}{U(s)} = \frac{1}{s+a}$ by first writing the continuous-time state space representation and then discretizing it.

5. Determine the stability of the system described by
   $y(k) - 0.6y(K-1) - 0.81y(K-2) + 0.67y(K-3) - 0.12y(K-4) = x(K)$
   Where x(k) is the input and y(k) is the output of the system.

6. (a) Describe the steps involved in the procedure for design of a digital controller in the W-plane.
   (b) Explain the important transient response specifications for a unit-step input.

7. A digital control system is described by
   $\bar{x}(K+1) = \bar{G}\,\bar{x}(k) + \bar{H}\,u(K)$
   $y(K) = \bar{c}\,\bar{x}(k)$
   Where $\bar{G} = \begin{bmatrix} 1 & T \\ 0 & 1 \end{bmatrix}$; $\bar{H} = \begin{bmatrix} \frac{T^2}{2} \\ T \end{bmatrix}$; $\bar{C} = \begin{bmatrix} 1 & 0 \end{bmatrix}$
   and T is the sampling period Design a state observer for this system assuming the standard block schematic for observer configuration. Design such that the error vector has dead beat response.

8. Write a note on the following:
   (a) Controllability, Observability, Duality.
   (b) Design of state feedback controller through pole placement.

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Code :R7420203 **2**

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1. (a) Draw the block schematic of any one example for digital control systems and explain the working.
   (b) Derive the transfer function of Zero-order Hold.
2. (a) Obtain the inverse Z-transform of $x(z) = \frac{Z+2}{(z-2)z^2}$
   (b) Obtain the Z-transform of $t^2 e^{-at}$.
3. (a) Solve the difference equation:
   $x(K+2) - x(K+1) + 0.25x(K) = u(k+2)$
   Where $x(0) = 1$ and $x(1) = 2$
   The input function u(K) is given by $u(K) = 1,\ K = 0, 1, 2, ...$
   (b) What are complementary strips ? Explain.
4. (a) Obtain a state-space representation of the following pulse-transfer-function system in the controllable canonical form
   $\frac{y(z)}{U(z)} = \frac{z^{-1}+2z^{-2}}{1+4z^{-1}+3z^{-2}}$
   (b) Obtain a state-space representation of the following pulse-transfer-function system in the observable canonical form
   $\frac{y(z)}{U(z)} = \frac{z^{-2}+4z^{-3}}{1+6z^{-1}+11z^{-2}+6z^{-3}}$
5. (a) Explain the concept of 'controllability'
   (b) State and prove duality between controllability and observability.
6. (a) Explain how the imaginary axis of the s-plane maps into the z-plane.
   (b) Draw constant damping-ratio loci in the s-plane and z-plane and explain the correspondence.
7. (a) Obtain the expression for static position error constant of discrete-time linear time-invariant systems.
   (b) How is bilinear transformation useful for design ? Explain.
8. Consider the system defined by $\bar{x}(K+1) = \bar{G}\,\bar{X}(K) + \bar{H}\,u(K)$
   $y(K) = \bar{C}\,\bar{X}(K)$
   $u(K) = \bar{K}_0\, r(K) - \bar{K}\,\bar{X}(K)$
   Where
   $\bar{G} = \begin{bmatrix} 0 & 1 \\ -0.16 & -1 \end{bmatrix};\ \bar{H} = \begin{bmatrix} 0 \\ 1 \end{bmatrix};\ \bar{C} = \begin{bmatrix} 1 & 0 \end{bmatrix}$
   Design a control system such that the desired closed-loop poles of the characteristic equation are at
   $Z_1 = 0.5 + j0.5$
   $Z_2 = 0.5 - j0.5$

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Code :R7420203 **3**

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1. (a) Enumerate the merits and demerits of digital control systems.
   (b) Explain the terms 'Quantization' 'Quantization level' and 'Quantization error' with reference to 3-bit conversion.

2. (a) Determine the final value $x(\infty)$ of $x(z) = \frac{1}{1-z^{-1}} - \frac{1}{1-e^{-aT}z^{-1}}, a > 0$. By using the appropriate theorem of z-transforms.
   (b) Find x(K) for K=0,1,2,3, and 4 when x(Z) is given by $x(z) = \frac{10z+5}{(z-1)(z-0.2)}$

3. (a) Obtain the expression for x(K) by solving the following difference equation: $x(K + 2) + 3x(K + 1) + 2x(K) = 0, x(0) = 0, x(1) = 1$.
   (b) Explain how the jw-axis of the s-plane maps into the z-plane.

4. Obtain the state transition matrix of the following discrete-time system:
   $\bar{x}(K + 1) = \bar{G}\,\bar{X}(K) + \bar{H}\,u(K)$
   $y(K) = \overline{CX}(K)$
   $Where\ \overline{G} = \begin{bmatrix} 0 & 1 \\ -0.16 & -1 \end{bmatrix}; \overline{H} = \begin{bmatrix} 1 \\ 1 \end{bmatrix}; \overline{C} = \begin{bmatrix} 1 & 0 \end{bmatrix}$
   Then obtain the state $\bar{x}(K)$ and the output y(k) when the input u(K)=1 for $K = 0, 1, 2, ...$ assume that the initial state is given by $\bar{x}(0) = \begin{bmatrix} x_1(0) \\ x_2(0) \end{bmatrix} = \begin{bmatrix} 1 \\ -1 \end{bmatrix}$

5. A unity-feedback discrete-time control system (with sampling period T=1 sec) has the open-loop transfer function given by
   $G(z) = \frac{K(0.3679z+0.2642)}{(z-0.3679)(z-1)}$
   Determine the range of gain K for stability by use of the jury stability test. Also find the frequency of sustained oscillations.

6. Obtain the expression for steady state error to a unit-ramp input $r(t) = t1(t)$ given to the system shown in fig.1

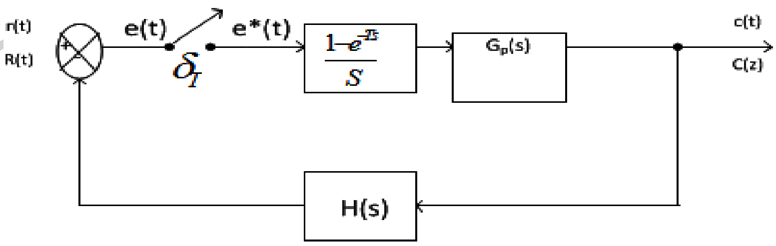

Figure 1

7. (a) How is a state feedback controller used for pole placement ? Explain with the help of a block schematic.
   (b) Derive the necessary condition for pole placement.

8. Write a note on the following:
   (a) State observers-full order and reduced order.
   (b) Tests for controllability and observability.

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1. (a) Compare and contrast analog control systems and digital control systems.
   (b) Explain the need for 'Sample' and 'Hold' operations.
2. (a) State and prove complex translation theorem of z-transforms.
   (b) Obtain the pulse transfer function of the closed-loop system shown in fig.1.

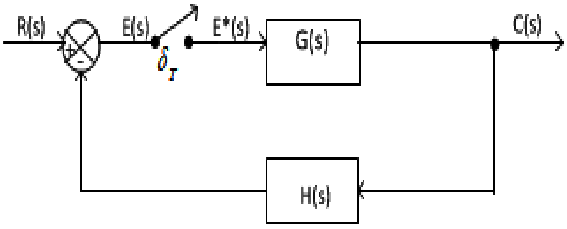

Figure 1

3. (a) What does the unit circle in z-plane represent in the s-plane? Explain its importance in detail.
   (b) Find the z-transforms of unit step functions that are delayed by 1 sampling period, and 4 sampling periods.
4. Given $\frac{y(s)}{u(s)} = \frac{w^2}{s^2+w^2}$ obtain the continuous time state-space representation of the system. Then discretize the system and obtain the discre-time state-space representation. Also obtain the pulse transfer function of the discretized system.
5. (a) Explain the concept of 'Observability'.
   (b) State and prove duality between 'Observability' and 'Controllability'.
6. (a) Explain how the right-half of the s-plane maps into the z-plane.
   (b) Draw and explain the correspondence between the constant frequency loci, of the s-plane and the z-plane.
7. For the digital control system shown in Fig. 2, the plant transfer function is $\frac{1}{s^2}$. Design a digital controller in the w-plane such that the phase margin is 50^0 and the gain margin is at least 10dB. The sampling period is 0.1sec.

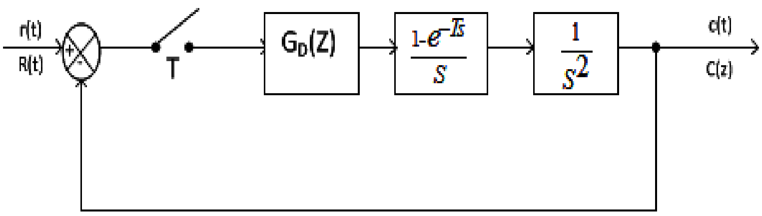

Figure 2

8. (a) Explain the concept of 'Pole placement'.
   (b) Derive Ackerman's formula.

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