Code No: **RT42021** **R13** **Set No. 1**

**IV B.Tech II Semester Regular Examinations, April/May - 2017**

# DIGITAL CONTROL SYSTEMS

**(Electrical and Electronics Engineering)**

**Time: 3 hours** **Max. Marks: 70**

***Question paper consists of Part-A and Part-B***
***Answer ALL sub questions from Part-A***
***Answer any THREE questions from Part-B***

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## PART–A *(22 Marks)*

1. a) What are the advantages of sampling process in control systems? [4]
   b) What is the property of linearity of Z-transforms? [4]
   c) What are the different ways of state space representation? [4]
   d) Write about the mapping of left half of the *s*-plane into the *z*-plane? [4]
   e) How a pulse transfer function in z-plane is converted into a rational function w-plane? [3]
   f) What is Ackermann's formula? [3]

## PART–B *(3x16 = 48 Marks)*

2. a) What are the advantages and disadvantages of digital control systems? [8]
   b) Give any one typical example of digital control systems and explain its operation? [8]

3. a) Define Z transform. Calculate the Z-transform of the system having transfer function, F(s); subject to a step input sampled at 3 Hz.

   $$F(s) = \frac{1}{1+2s}$$ [8]

   b) Solve the following differential equation using Z transform method $x(k+2) + 5x(k+1) + 6x(k) = 0$
   Given that $x(0) = 0, x(1) = 1$ [8]

4. a) A linear time invariant system is represented by vector-matrix difference equation
   $X(k+1) = AX(k) + BU(k)$
   Obtain X(k) by Z transform method. [8] b) For a homogenous system given by

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

   Obtain state transition matrix $\psi(k)$ [8]



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5. a) Explain about the relation between location of closed loop poles in the z-plane and system stability? [8]

   b) Consider the discrete - time unity feedback control system (with sampling period T=1 sec) whose open loop pulse transfer function is given by [8]

$$G(z) = \frac{K\,(0.3679z + 0.2642)}{(z - 0.3679)(z - 1)}$$

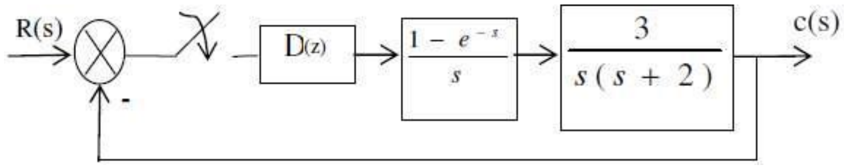
   Determine the range of gain K for stability by using Jury stability test.

6. A block diagram of a digital control system is shown in the figure. Design a compensation D(z) to meet the following specifications. [16]

   i) Velocity error constant, $K_v \geq 3\sec^{-1}$

   ii) Phase Margin $\geq 50^0$

   iii) Band Width = $1.1 rad/\sec$




7. a) Enumerate the design steps for pole placement [8]

   b) Prove Ackermann's formula for the determination of the state feedback gain matrix K. [8]

Code No: **RT42021** **R13** **Set No. 2**

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***Answer any THREE questions from Part-B***

*****

### PART–A *(22 Marks)*

1. a) What are the advantages of digital control systems? [4]
   b) What are the limitations of Z-transforms? [4]
   c) Write the discrete time state equations of a pulse transfer function? [4]
   d) Write about the primary and complimentary strips? [4]
   e) What is bilinear transformation? [3]
   f) What are the necessary and sufficient conditions in design via pole placement? [3]

### PART–B *(3x16 = 48 Marks)*

2. a) Explain about the frequency-domain characteristics of zero-order hold? [8]
   b) With suitable block diagram explain the sample and hold circuit. [8]

3. a) Obtain the Z-transform of the following function

$$F(s) = \frac{s+2}{s^2\left(s^2+2s+3\right)}$$ [8]

   b) Solve for *y(k)* the equation

$$y(k) = r(k) - r(k-1) - y(k-1),\ k \geq 0,$$
$$r(k) = 1;\ k\ even,\ r(k) = 0;\ k\ odd,\ y(-1) = r(-1) = 0$$ [8]

4. a) Explain the concepts of controllability and observability? [6]
   b) Find the state model for the following difference equation and also find its state transition matrix.
   *y(k+2) + 3y(k+1) + 2y(k) = 2u(k+1) + u(k)* Assume initial conditions are zero. [10]

5. a) State and explain Jury's stability test [8]

   b) Using Jury's stability criterion, find the range of 'M' $z^3 + Mz^2 + 3Mz + M - 2 = 0$ [8]

6. a) Explain the design procedure in the ω - plane of lag compensator. [8]

   b) State the rules for the construction of root loci of a sampled data control system. [8]

7. A discrete-time regulator system has the plant equation

$$x(k+1) = \begin{bmatrix} 2 & -1 \\ -1 & 1 \end{bmatrix} x(k) + \begin{bmatrix} 4 \\ 3 \end{bmatrix} u(k)$$

$$y(k) = \begin{bmatrix} 1 & 1 \end{bmatrix} x(k) + 7u(k)$$

Design a state feedback control system with $u(k) = -Kx(k)$ to place the closed loop poles at 0.5 ± j0.5. [16]

Code No: **RT42021** **R13** **Set No. 3**

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## DIGITAL CONTROL SYSTEMS

**(Electrical and Electronics Engineering)**

**Time: 3 hours** **Max. Marks: 70**

***Question paper consists of Part-A and Part-B***
***Answer ALL sub questions from Part-A***
***Answer any THREE questions from Part-B***

*****

**<u>PART–A</u>** ***(22 Marks)***

1. a) What are the different types of sampling operations? [4]
   b) State and explain the shifting theorem of Z transforms [4]
   c) What is the concept of observability [4]
   d) State the Jury's stability criterion [4]
   e) What are the time response specifications [3]
   f) Draw the block schematic of a closed loop control system (state space model) using a state feedback controller? [3]

**<u>PART–B</u>** ***(3x16 = 48 Marks)***

2. a) State and explain the sampling theorem for data reconstruction? [8]
   b) Describe the operation of zero-order hold circuit? Obtain its frequency-domain characteristics? [8]

3. a) Obtain the Z-transform of the following function

   $x(k) = \sum_{h=0}^{k} a^{h}$, where '$a$' is a constant. [8]

   b) Obtain the inverse Z-transform of the following in the closed form.

   (i) $F(z) = \dfrac{3z^2 + 2z + 1}{z^2 - 3z + 2}$ and (ii) $F(z) = \dfrac{z}{z^2\ 0.3z + 0.02}$ [8]

4. a) A discrete time system is described by the differential equation [8]

   *y(k+2) + 3y(k+1) + 4y(k) = u(k)*

   *y(0) =1, y(1) = 1, T = 0.8 sec*

   Determine a state model in canonical form.

   b) Explain the computation of state transition matrix. [8]

5. a) Explain bounded - input, bounded - output stability of a system [8]

   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 output of the system. Determine the stability of the system. [8]

6. 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 < ∞. Indicate all important information on the root loci [16]

7. A discrete-time regulator system has the plant equation

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

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

   The state feedback control is described by $u(k) = -Kx(k)$ where $K = \begin{bmatrix} K_1 & K_2 \end{bmatrix}$. Find the values K1 and $K_2$ so that the roots of the characteristic equation of the closed loop system are at 0.5 and 0.7. [16]

Code No: **RT42021** **R13** **Set No. 4**

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**(Electrical and Electronics Engineering)**

**Time: 3 hours** **Max. Marks: 70**

***Question paper consists of Part-A and Part-B***
***Answer ALL sub questions from Part-A***
***Answer any THREE questions from Part-B***

*****

**PART–A** ***(22 Marks)***

1. a) Explain the principle of operation of zero-order hold? [4]
   b) State initial and final value theorems of Z transforms? [4]
   c) What is the concept of controllability? [4]
   d) State the conditions for the Jury's stability? [4]
   e) Show that the steady-state error of a Type-1 system is zero for step-input? [3]
   f) Why is pole-placement design necessary? Explain? [3]

**PART–B** ***(3x16 = 48 Marks)***

2. a) What are the advantages of sampling process in control systems? Give the mathematical description of ideal sampling process. [8]
   b) Explain the advantages and disadvantages of digital control systems. [8]

3. a) Given the discrete time system

$$y(k) - \frac{1}{\sqrt{2}}y(k-1) + \frac{1}{4}y(k-2) = u(k) + \frac{1}{3}u(k-2)$$

   Determine the pulse transfer function. [8]
   b) Obtain the inverse Z-transform of the following in the closed form.

$$F(z) = \frac{0.368z^2 + 0.478z + 0.154}{z^2(z-1)}$$ [8]

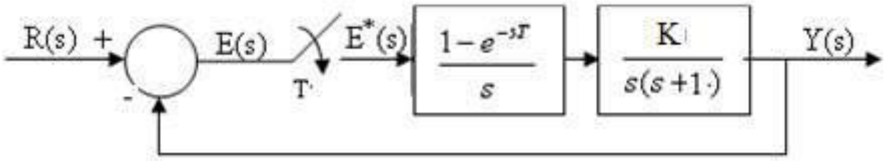
4. a) Given a state equation in continuous-time, how is it discretized to obtain the equivalent discrete-time state model? Describe? [8]
   b) Consider the discrete control system represented by the transfer function. [8]

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

   Obtain the state space representation in the diagonal form.

5. a) How are primary and complementary strips formed? Discuss? [8]
   b) Consider the following characteristic equation $P(z) = z^4 - 1.368z^3 + 0.4z^2 + 0.08z + 0.002 = 0.$ Determine whether or not any of the roots of the characteristic equation lie outside the unit circle in the z - plane. [8]

6. Draw the root locus in the z-plane for the system shown in figure for 0 < K < ∞. Consider the sampling period T = 2sec.




[16]

7. Consider system described by

$$x(k+1) = Ax(k) + Bu(k)$$
$$y(k) = Cx(k)$$

with $A = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -1 & -5 & -6 \end{bmatrix}$, $B = \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix}$ and $C = \begin{bmatrix} 0 & 0 & 1 \end{bmatrix}$

Compute K so that the control law $u(k) = -Kx(k)$ places the closed loop poles at $-0.2 \pm j0.5$ and -0.8. [16]