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

IV B.Tech II Semester Regular/Supplementary Examinations, April - 2018

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) Define the following fundamental parameters of an sample and hold element
(i) Acquisition time (ii) Aperture time (iii) Droop rate [3]
b) Obtain the Z-transform of $x(t) = \frac{1}{a}(1 - e^{-at})$, where 'a' is a constant [4]
c) Write about the Jordan canonical form. [3]
d) Determine the stability of the characteristic equations by using Jury's stability tests $5z^2 - 2z + 2 = 0$. [4]
e) What do understand by primary strip and complimentary strips? [4]
f) Enumerate the design steps for pole placement. [4]

PART–B *(3x16 = 48 Marks)*

2. a) Discuss the mathematical model of sample and hold operations with neat sketch? [8]
b) Explain the conditions to be satisfied for reconstruction of sampled signal into continuous signals? [8]

3. a) Given the z transform $X(z) = \frac{(1-e^{-aT})}{(z-1)(z-e^{-aT})}$ Where a is a constant and T is the sampling period, determine the inverse z transform x(kT) by use of the partial fraction expansion method. [8]
b) The input output of a sampled data system is described by the difference equation $y(k+2) + 3y(k+1) + 4y(k) = r(k)$. Determine the pulse transfer function, the initial conditions are $y(0) = 0, y(1) = 1$. [8]

4. Consider the discrete control system represented by the following transfer function $G(z) = \frac{1+0.8z^{-1}}{1-z^{-1}+0.5z^{-2}}$. Obtain the state representation of the system in the observable canonical form. Also find its state transition matrix. [16]

5. a) How do you map constant damping loci from s-plane to z-plane? [6]
b) Construct the Jury stability table for the following characteristic equation
$P(z) = a_0z^4 + a_1z^3 + a_2z^2 + a_3z + a_4$ Where $a_0 > 0$. Write the stability conditions. [10]

6. The closed loop transfer function for the digital control system is given as

$$\frac{C(z)}{R(z)} = \frac{z + 0.5}{3(z^2 - z + 0.5)}$$

Find the steady state errors and error constants due to step input. [16]

7. Control a system, defined by $\dot{X} = Ax + Bu \quad Y = Cx$
$Where\ A = \begin{bmatrix} 0 & 1 \\ -2 & -3 \end{bmatrix}, B = \begin{bmatrix} 0 \\ 2 \end{bmatrix}, C = [1 \quad 0]$, It is desired to have eigen values at -3.0 and -5.0 by using a state feedback control u = - KX. Determine the necessary feedback gain matrix k and the control signal u. [16]

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

IV B.Tech II Semester Regular/Supplementary Examinations, April - 2018

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 offered by digital control? [4]
   b) Obtain the Z-transform of $x(t) = t^2 e^{-at}$ where 'a' is constant. [4]
   c) Write about the observable canonical form. [3]
   d) Determine the stability of the characteristic equations by using Jury's stability tests $z^3 - 0.2z^2 - 0.25z + 0.05 = 0$. [4]
   e) Write brief note on design procedure in the w-plane. [5]
   f) Write the sufficient condition for arbitrary pole placement. [2]

PART–B *(3x16 = 48 Marks)*

2. a) State and explain the theorem required to satisfy to recover the signal e(t) from the samples e*(t). [8]
   b) Explain how the reconstructing the input signal by hold circuits. [8]

3. Obtain the inverse Z-transform of the following in the closed form.
   (i) $F_1 = \frac{0.368z^2+0.478z+0.154}{z^2(z-1)}$ (ii) $F_2 = \frac{2z^3+z}{(z-1)^2 (z-1)}$ (iii) $F_3 = \frac{z+2}{z^2(z-2)}$ [16]

4. a) Explain any one method of evaluation of state transition matrix. [6]
   b) Investigate the controllability and observability of the following system.
   $$\begin{pmatrix} x_1(k+1) \\ x_2(k+1) \end{pmatrix} = \begin{pmatrix} 1 & -2 \\ 1 & -1 \end{pmatrix} \begin{pmatrix} x_1(k) \\ x_2(k) \end{pmatrix} + \begin{pmatrix} 1 & -1 \\ 0 & 0 \end{pmatrix} u(k)$$
   $$\begin{pmatrix} y_1(k) \\ y_2(k) \end{pmatrix} = \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix} \begin{pmatrix} x_1(k) \\ x_2(k) \end{pmatrix}$$ [10]

5. a) Discuss the stability analysis of discrete control system using modified Routh stability. [8]
   b) Using Jury's stability criterion, determine the stability of the following discrete time systems (i) $z^3 + 3.3z^2 + 4z + 0.8 = 0$ (ii) $z^3 - 1.1z^2 - 0.1z + 0.2 = 0$ [8]

6. a) Consider the transfer function system shown in figure 6(a). The sampling period T is assumed to be 0.1 sec. obtain G(w).

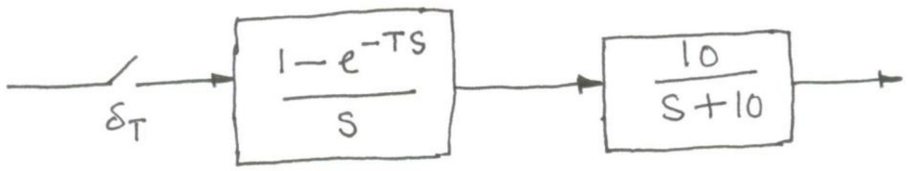

Figure 6 (a) [8]

b) List out the transient response specifications and explain in brief. [8]

7. A discrete time regulator system has the plant equation

$$X(k+1) = \begin{bmatrix} 2 & -1 \\ -1 & 1 \end{bmatrix} X(k) + \begin{bmatrix} 4 \\ 3 \end{bmatrix} u(k)$$
$$Y(k) = [1 \quad 1]X(k) + 7u(k)$$

Design a state feedback control algorithm with u(k)=-KX(k) which places the closed loop characteristic root at $\pm j0.5$. [16]

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

IV B.Tech II Semester Regular/Supplementary Examinations, April - 2018

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) Illustrate the step motor control system examples of discrete data control systems. [4]
   b) Find the z-transforms of f(t) = t sin(ωt). [4]
   c) State the state transition matrix. [3]
   d) Determine the stability of the characteristic equations by using Jury's stability tests $z^4 - 1.7z^3 + 1.04z^2 - 0.268z + 0.024 = 0$. [4]
   e) Write the design procedure of lag compensator in w-plane. [4]
   f) What do you mean by state feedback controller? [3]

PART–B *(3x16 = 48 Marks)*

2. a) Explain the examples of data control systems of the following
   (i) Microprocessor controlled system
   (ii) A digital computer controlled rolling mill regulating system. [8]
   b) Draw the frequency domain characteristics of zero order hold? Explain with necessary mathematical equations. [8]

3. a) Obtain the inverse z-transform of the following
   $(i)\ X(z) = \frac{z^{-3}}{(1-z^{-1})(1-0.2z^{-1})}$ *and* $(ii)\ X(z) = \frac{z^{-1}(1-z^{-2})}{(1+z^{-2})^2}$ [8]
   b) Write the difference equation governing the system for $G(s) = \frac{1}{s+1}$ as shown in figure.3 (b)

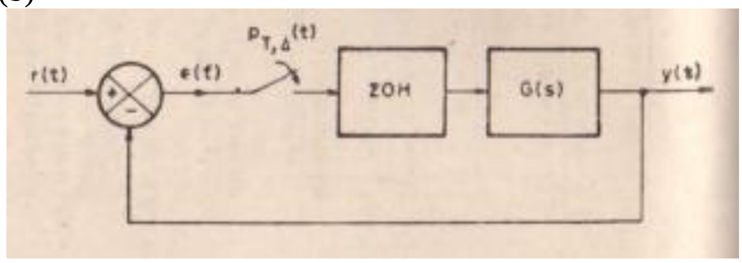

Figure.3 (b) [8]

4. a) Obtain the Jordan canonical form realization for the following transfer function
   $$G(z) = \frac{3z^2-4z+6}{(z-\frac{1}{3})^3}.$$ [8]
   b) Consider the following pulse transfer function
   $\frac{Y(z)}{U(z)} = \frac{z+0.2}{(z+0.8)(z+0.2)}$. Check this system is completely state controllable or not? [8]

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5. Consider the sample-data system shown in Figure.5 and assume its sampling period is 0.4 Sec. Find the range of K, so that the closed - loop system for which stable.

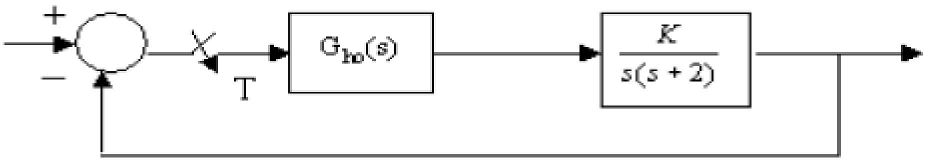

Figure.5 [16]

6. The open loop transfer function of a unity - feedback digital control system is given as $(z) = \frac{K(z^2+0.8z+0.5)}{(z-1)(z^2-z+0.2)}$. Sketch the root loci of the system for 0< K < ∞. Indicate all important information on the root loci. [16]

7. Consider the system defined by

$$\dot{X} = Ax + Bu$$

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

by using the state feedback control u = -Kx, it is desired to have the closed loop poles at s = -2 ± j 4 and s= -10. Determine the state feedback gain matrix K. [16]

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

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Answer ALL sub questions from Part-A
Answer any THREE questions from Part-B

*****

PART–A *(22 Marks)*

1. a) Explain the digital controller for a turbine and generator examples of discrete data control systems. [4]
   b) Find the z transform of $x(k) = \sum_{h=0}^{k} a^h$ where ‘a’ is a constant. [4]
   c) Write about the controllable canonical form. [3]
   d) Enumerate the conclusions from the general mapping between the s and z planes by the z transform. [4]
   e) Write the design procedure of lead compensator in w-plane. [4]
   f) Write the necessary conditions for arbitrary pole placement. [3]

PART–B *(3x16 = 48 Marks)*

2. a) Draw the magnitude and phase curves of the zero order hold and compare these curves with those of the ideal low pass filter? [8]
   b) Explain the problems encountered in reconstructing e(t) from its samples. [8]

3. a) By using the inversion integral method, obtain the inverse z transform of

$$X(k) = \frac{1 + 6z^{-2} + z^{-3}}{(1 - z^{-1})(1 - 0.2z^{-1})}$$ [8]

   b) Write the difference equation governing the system for $G(s) = \frac{1}{s^2}$ as shown in figure.3 (b).

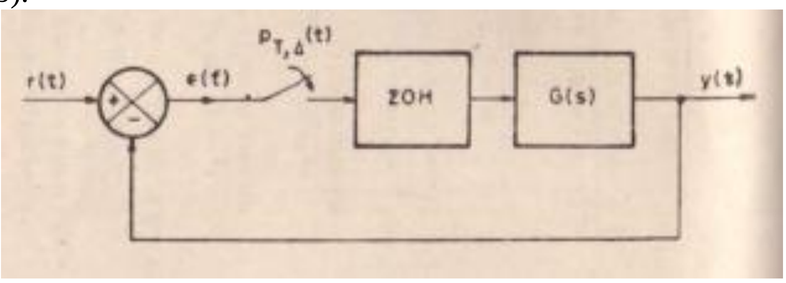

Figure.3(b) [8]

4. a) Write the following state space representation of discrete time systems
   (i) Observable canonical form (ii) Jordan canonical form [6]
   b) Obtain the state transition matrix of the following discrete time system

$x(k+1) = Gx(k) + Hu(k)$

$y(k) = Cx(k)$ Where $G = \begin{bmatrix} 0 & 1 \\ -0.16 & -1 \end{bmatrix}$, $H = \begin{bmatrix} 1 \\ 1 \end{bmatrix}$, $C = [1 \quad 0]$

Then obtain the state x(k) and output y(k) when the input u(k)=1 for k=0,1,2,….. [10]

5. a) Determine $F(z)|_{z=e^{sT}}$ in terms of F(s). Using this result, explain the relationship between the z-plane and the s-plane. [8]

   b) Use the Routh-Hurwitz criterion to find the stable range of K for the closed loop unity feedback system with loop gain $F(z)=\dfrac{K(z-1)}{(z-0.1)(z-0.8)}$. [8]

6. Consider the digital control system shown in figure 6, plot the root loci as the gain K is varied from 0 to ∞. Determine the critical value of gain K for stability. The sampling period is 0.1 sec, or T=0.1. What value of gain K will yield a damping ratio ζ of the closed loop poles equal to 0.5? With gain K set to yield ζ=0.5, determine the damped natural frequency ω_d and the number of samples per cycle of damped sinusoidal oscillation.

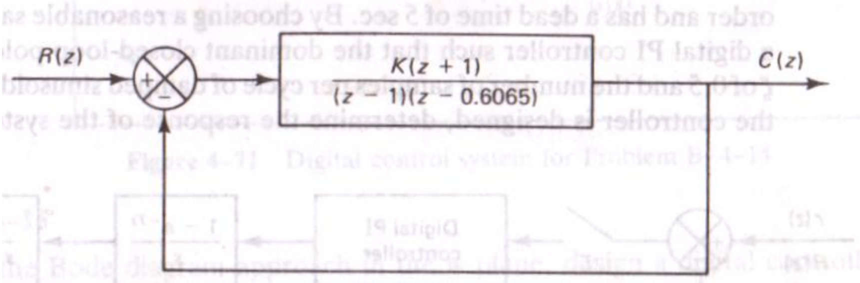

Figure.6 [16]

7. a) Discuss the necessary conditions for design of state feedback controller through pole placement. [9]

   b) Prove Ackermann's formula for the determination of the state feedback gain. [7]