Code No: **R42021** **R10** **Set No. 1**

IV B.Tech II Semester Supplementary Examinations, July/Aug – 2015

DIGITAL CONTROL SYSTEMS

(Electrical and Electronics Engineering)

Time: 3 hours **Max. Marks: 75**

Answer any FIVE Questions
All Questions carry equal marks
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1 a) Consider an LTI system whose frequency response is $H(e^{j\omega}) = e^{-j\omega/2}, |\omega| < \pi$
Determine whether or not the system is causal. Show your reasoning. [7]

b) Consider the system in Figure. 1, where the subsystems S_1 and S_2 are LTI.

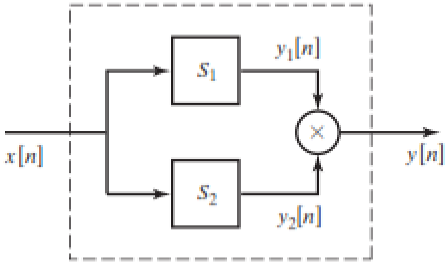

Figure. 1 [8]

2 a) Given the function

$$f(k) = (0.1)^k u_s(k) + 0.5k(0.1)^{k-1} u_s(k-1)$$

Find the z-transform of f(k), F(z). [8]

b) Find the inverse z-transform of

$$F(z) = \frac{z(z+1)}{(z-1)(z^2-z+1)}$$ by means of power series expansion. [7]

3 The following signals are sampled by an ideal sampler with sampling period T. Determine the sampling output f*(t), and evaluate the pulse transform F*(s) complex convolution method

a) $f(t) = 3te^{-at}$, where a is a real constant

b) $f(t) = \sin 2t$

c) $f(t) = t \sin \omega t$

d) $f(t) = e^{-at} \sin 2t$

e) $f(t) = e^{-2(t-T)} u_s(t-T)$, where $u_s(t)$ is a unit step function [15]

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4 Write about a) State Transition Matrix
b) Pulse Transfer Function Matrix
c) Discretization of continuous time state – space equations [15]

5 Explain the Duality between Controllability and Observability [15]

6 Define stability of digital control systems. Discuss the methods for investigating stability of such systems. Why is R-H criterion not directly applicable in stability analysis of such systems? Explain. [15]

7 Consider the digital control system shown in below figure 2. Design a digital controller in the w-plane such that the phase margin is 60^o, the gain margin is 12dB and static velocity error constant is 3 sec^{-1}. [15]

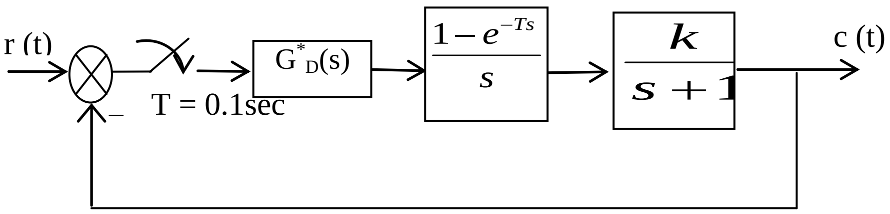

Figure 2

8 For the system described by $X(k+1)=\begin{bmatrix}0 & 1\\ -0.16 & -1\end{bmatrix}X(k)+\begin{bmatrix}0\\1\end{bmatrix}U(k)$

Design state feedback gain matrix K, such that the system will have closed loop poles located at z=0.5±j0.5 [15]

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1 a) Explain the shifting and scaling operator with suitable examples. [8]
b) Describe the linear time invariant and casual systems. [7]

2 Find the inverse z-transform f(kT) of the following functions

a. $F(z) = \frac{z}{z^2 + 1}$

b. $F(z) = \frac{10z}{z^2 - 1}$

c. $F(z) = \frac{1}{z(z - 0.2)}$ [15]

3 a) What is meant by sampling and hold operations? What are types of sampling operations? In case of an Ideal sampling show that L.T of sampled output, f*(t) is given by $F^*(s) = \sum_{n=0}^{\propto} f(nT)e^{-nsT}$, where T is sampling period. [8]
b) Explain about zero order hold device. [7]

4 What is State transition matrix and state its Properties. Also explain any two methods for Computation of State Transition Matrix. [15]

5 a) Derive relationships between controllability, observability and transfer function. [15]
b) A discrete-data control system is described is described by the state equation x(k+1) = A x(k) + B u(k) where A = $\begin{bmatrix} 0 & 0 & 0 \\ 0 & 0.5 & 0 \\ 1 & 0 & 2 \end{bmatrix}, B = \begin{bmatrix} 0 \\ 1 \\ 1 \end{bmatrix}$
Determine the state controllability of the system.

6 Consider the discrete time unity feedback control system (with sampling period T = 1 sec) whose open – loop pulse transfer function is given by

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

Determine the range of gain K for stability by use of the Jury stability test. Also, obtain the frequency of the sustained oscillations. [15]

7 a) What are digital compensators and how are they realized? Discuss. [8]

b) Given the transfer function of a digital controlled process as

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

The sampling period T is 0.1s. Determine the value of K, and design a cascade phase –lag digital controller with the transfer function

$$D(z) = K_c\,\frac{z-z_1}{z-p_1}$$

Where D(1)=1, so that the following design specifications are satisfied.

i) The ramp-error constant K_c =100.

ii) The phase margin is 60 degrees. [7]

8 Given a single input digital control system

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

Where x(k) is an n-vector and the pair [A, B] is completely controllable.

Let $A = \begin{bmatrix} 0 & 1 \\ -1 & 2 \end{bmatrix}$ $B = \begin{bmatrix} 0 \\ 1 \end{bmatrix}$

Find the state –feedback matrix G such that the eigen values of A-BG are at 0 and 0.3. [15]

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Set No. 3

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DIGITAL CONTROL SYSTEMS

(Electrical and Electronics Engineering)

Time: 3 hours **Max. Marks: 75**

Answer any FIVE Questions
All Questions carry equal marks
*****

1 Determine whether each of the following signals is periodic. If the signal is periodic, state its period.

a) $x[n] = e^{j(\pi n/6)}$

b) $x[n] = e^{j(3\pi n/4)}$

c) $x[n] = \left[\sin\left(\pi n / 5\right)\right] / \left(\pi / n\right)$

c) $x[n] = e^{j\pi n/\sqrt{2}}$ [15]

2 a) Solve the following difference equation using the z-transform method:

$c\left(k+2\right) - 0.1c\left(k+1\right) - 0.2c\left(k\right) = r\left(k+1\right) + r\left(k\right)$

Where $r\left(k\right) = u_s\left(k\right) \text{for } k = 0,1,2,...; c\left(0\right) = 0 \text{ and } c\left(1\right) = 0$ [8]

b) Find the inverse z-transform f(k) of the following function

$F\left(z\right) = \dfrac{2z+1}{(z-0.1)^2}$ [7]

3 a) Explain the conditions to be satisfied for reconstruction of sampled signal into continuous signal. [8]

b) What is hold operation? Derive the expression for transfer function of a sampled hold circuit. [7]

4 Find the state transition equations of the followings systems by means of state diagram method

$x\left(k+1\right) = Ax\left(k\right) + Bu\left(k\right)$

The initial states are given as $x\left(0\right)$.

$A = \begin{bmatrix} 0 & 1 \\ 0.5 & 0.3 \end{bmatrix} \quad B = \begin{bmatrix} 0 \\ 1 \end{bmatrix}$ [15]

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5 The input-output transfer function of a digital control system is

$$\frac{C(z)}{U(z)} = \frac{1.65(z+0.1)}{z^3+0.7z^2+0.11z+0.005}$$

a) Assign state variables to the system so that it is state controllable but not observable

b) Assign state variables to the system so that it is state observable but not controllable [15]

6 a) Compare and discuss the methods for investigating stability of such systems [8]

b) Explain the mapping between s-plane and z-plane. Also define primary and complimentary strips. [7]

7 Explain the design procedure of Digital Controllers using Bilinear Transformation methods. [15]

8 Discuss the design procedure of state feedback controller through pole placement technique. [15]

Code No: **R42021** **R10** **Set No. 4**

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DIGITAL CONTROL SYSTEMS

(Electrical and Electronics Engineering)

Time: 3 hours **Max. Marks: 75**

Answer any FIVE Questions
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*****

1 a) Consider the difference equation

$$y[n]-\frac{5}{6}y[n-1]+\frac{1}{6}y\left[n-2\right]=\frac{1}{3}x\left[n-1\right]$$

What are the impulse response, frequency response, and step response for the causal LTI system satisfying this difference equation? [7]

b) A causal LTI system is described by the difference equation

$$y\left[n\right]-5y\left[n-1\right]+6y\left[n-2\right]=2x\left[n-1\right]$$

Determine the impulse and step response of the system. [8]

2 a) Solve the difference equation with z-transform method

$$c\left(k+2\right)-1.5c\left(k+1\right)+c\left(k\right)=2u_s\left(k\right)$$

Where c(0)=0 and c(1)=1 [8]

b) Find the inverse z-transform f(k) of the following function [7]

$$F\left(z\right)=\frac{2z}{z^2-1.2z+0.5}$$

3 a) State and prove sampling theorem [7]

b) Find the maximum conversion time required to digitize a 1-kHz sinusoidal signal v(t)=Vsinωt to 10 bit resolution. [8]

4 The input –output transfer functions of linear discrete-data systems are as follows

(i). $\frac{C\left(z\right)}{R\left(z\right)}=\frac{z+0.5}{z^2+0.2z+0.1}$

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

a) Draw state diagrams for the systems

b) Write the dynamic equations of the systems [15]

5 a) Prove that the discrete-time control system defined by x[(k+1)T] = G x(kT), y(kT) = C x(kT) is complete observable. [8]

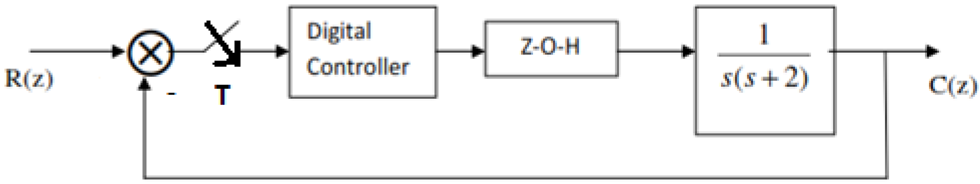
b) Show that the duality between controllability and observability. [7]

6 a) Explain the stability analysis of closed loop system in the z-planne. [7]

b) The characteristic equation of linear discrete data system is given by $Z^4+0.2z^3-0.25z^2-0.05z+k=0$. Determine the values of k for the system to be asymptotically stable. [8]

7 a) Explain the design procedure of Digital Controllers using frequency response methods [8]

b) For the digital control system shown below, design a digital controller such that the dominant closed loop poles have a damping ratio of 0.5 and a settling time of 2 sec. The sampling period is assumed to be 0.2 sec. [7]



8 Given the digital control system

$$A=\begin{bmatrix}0 & 1\\ -1 & -2\end{bmatrix} \quad B=\begin{bmatrix}1 & 0\\ 0 & 1\end{bmatrix}$$

Find the state feedback u(k) = -Gx(k) such that the eigen values of A-BG are at z=0,0. It is also required that feedback is bought only to $u_1(k)$ and not to $u_2(k)$ can this be achieved? [15]