B.E-VIII / CBGS / INST / VIII / 12-05-2017

Digital Control System

Q.P.Code:13429

(3 Hours) Total Marks: 100

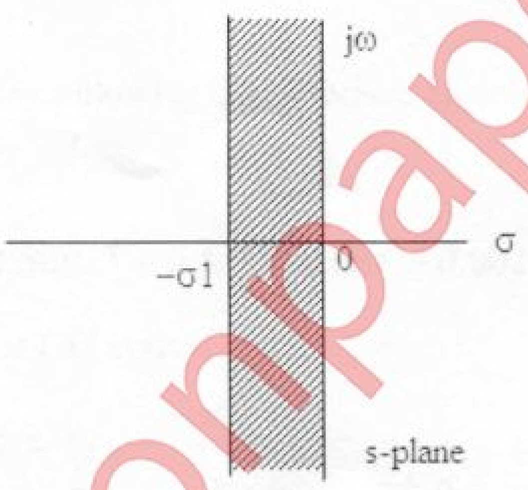
N.B.: 1) Question No. 1 is compulsory.
2) Attempt any three questions from the remaining questions.
3) Figures to the right indicate full marks.
4) Assume suitable data if necessary.

Q1. Answer any four from the following: 20

(a) Obtain state space representation of the following system in controllable canonical form

$$\frac{Y(z)}{R(z)} = \frac{-2z^3 + 2z^2 - z + 2}{z^3 + z^2 - z - \frac{3}{4}}$$

(b) Obtain the image of the shaded region in the z plane.



(c) What is a pulse transfer function? A first order discrete time LTI system is represented by the state model

$$x(k+1) = e^{-aT} x(k) + \frac{1 - e^{-aT}}{a} u(k)$$

$$y(k) = x(k)$$

Obtain its pulse transfer function.

(d) Define controllability, stabilizability, observability and detectability

(e) Explain 1-DOF (degree of freedom) and 2-DOF feedback controller.

Turn Over

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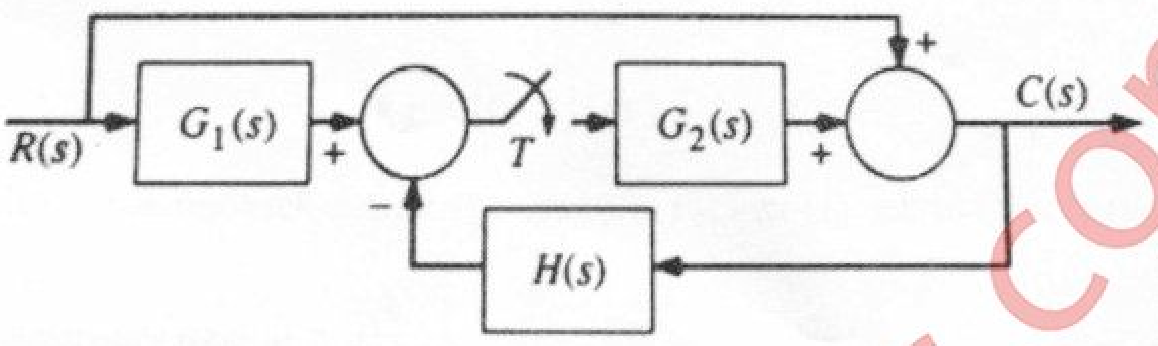
Q2. (a) Find the pulse transfer function of the following system using sampled signal flow graph approach. 10



(b) Explain how an analog signal can be reconstructed from the sampled data using extrapolation? Derive the transfer function of first order hold. 10

Q3. (a) Check if all the roots of the following characteristic equations lie within the unit circle in the plane: 10

$$z^4 - 1.368z^3 + 0.4z^2 + 0.08z + 0.002 = 0$$

(b) Consider the discrete time LTI system

$$\begin{bmatrix} x_1(k+1) \\ x_2(k+1) \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ -0.24 & -1 \end{bmatrix} \begin{bmatrix} x_1(k) \\ x_2(k) \end{bmatrix}$$

i. Obtain the state transition matrix 7

ii. Find the solution to the state equation for initial condition $\begin{bmatrix} x_1(0) \\ x_2(0) \end{bmatrix} = \begin{bmatrix} 1 \\ 1 \end{bmatrix}$ 2

iii. From the nature of the solution, comment whether the unforced system is stable or unstable. 1

Turn Over

Q4. (a) A discrete time regulator system has the plant 10

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

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

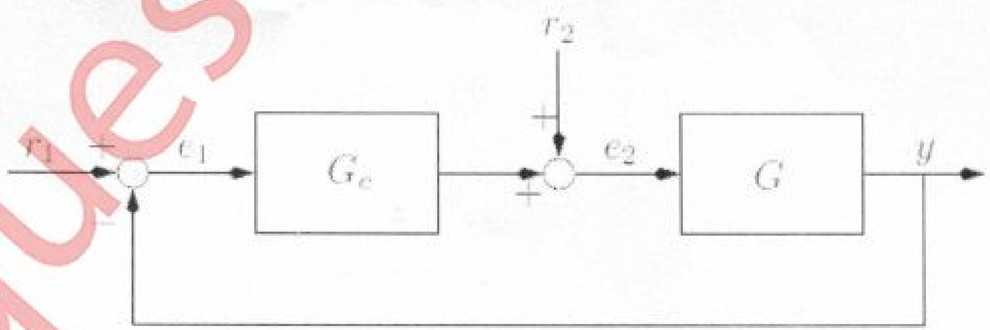
Design a state feedback control algorithm $u(k) = -Kx(k)$ which places the closed loop characteristics roots at $\pm j\frac{1}{2}$

(b) Define static position, velocity and acceleration error coefficient for a discrete time LTI system and find the steady state error for step, ramp and parabolic input for a unity feedback system characterized by the open loop transfer function

$$G_{h0}G(z) = \frac{0.2385(z + 0.8760)}{(z-1)(z-0.2644)}$$

The sampling period is T=0.2 sec. 10

Q5. (a) What do you mean by internal stability? How is it different from bounded input bounded output (BIBO) stability? For the system shown in the block diagram:



Determine the internal stability if $G = \frac{1}{z-1}$ and $G_c = \frac{1.5z-1}{z-1}$. 10

Turn Over

(b) A PID controller is described by the following relation between input e(t) and output u(t): 10

$$u(t) = k_p\left(e(t) + \frac{1}{T_I}\int_0^t e(t)dt + T_D\frac{de(t)}{dt}\right)$$

Using the trapezoidal rule for integration and backward-difference approximation for the derivative, obtain the difference equation model of the PID algorithm. . Also obtain the transfer function U (z)/ E (z)

Q6. (a) Consider system defined by continuous time state and output equations

$$\dot{x}(t) = Ax(t) + Bu(t)$$

$$y(t) = Cx(t) + Du(t)$$

If this system is sampled at T sec, derive its discrete time equivalent. Assume hold to be zero order. 10

(b) Design a full order state observer so that observer poles are located at - 0.2 and - 0.4 for the system 10

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

$$y(k) = [0 \quad 1]\, x(k)$$
