



(Following Paper ID and Roll No. to be filled in your Answer Book)

**PAPER ID : 121655**

Roll No.

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## B. Tech.

(SEM. VI) THEORY EXAMINATION, 2014-15  
**DIGITAL CONTROL SYSTEM**

Time : 3 Hours]

[Total Marks : 100

Note : Attempt all questions.

1 Attempt any four parts of the following :  $5 \times 4 = 20$

- (a) Draw the basic digital control system and explain the function of each block. Also discuss the sampling effects.
- (b) Define an ideal sampler. Also explain the relationship between Z-transform and Laplace transform.
- (c) Predict the nature of the transient response of a discrete-time system whose characteristic equation is given by

$$Z^2 - 1.9Z + 0.9307 = 0$$

The sampling interval  $T = 0.02$  sec.

- (d) Obtain the companion first form realizations for the transfer function

$$\frac{Y(z)}{R(z)} = \frac{4z^3 - 12z^2 + 13z - 7}{(z-1)^2(z-2)}$$

- (e) Explain the suitable method for the stability of a discrete time system. Also explain the bilinear transformation.
- (f) What do you understand by performance measure ? Explain in view of optimal control problems.

2 Attempt any two parts of the following : 10×2=20

- (a) (i) If  $Z[f(t)] = F(z)$ , then prove that

$$Z[f(t+T)] = Z[F(z) - f(0)] \text{ where}$$

$$F(0) = f(0)$$

- (ii) Find  $z^{-1} \left[ \frac{z}{3z^2 - 4z + 1} \right]$

- (b) (i) Determine the pulse transfer function of the system shown in Fig. 1

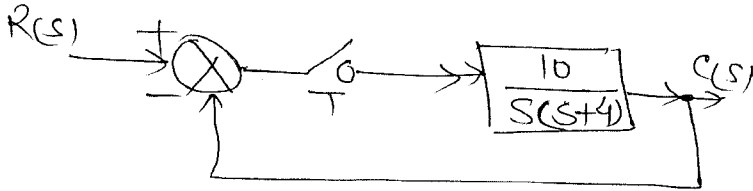


Fig. 1

- (ii) Solve the following difference equation :

$$y(k+2) + 3y(k+1) + 2y(k) = 0$$

$$y(-1) = -\frac{1}{2}, y(-2) = \frac{3}{4}$$

- (c) Consider the difference equation

$$y(k+2) + a_1y(k+1) + a_2y(k) = b_0r(k+2) + b_1r(k+1) + b_2r(k)$$

Assuming that the system is initially at rest, and  $r(k) = 0$

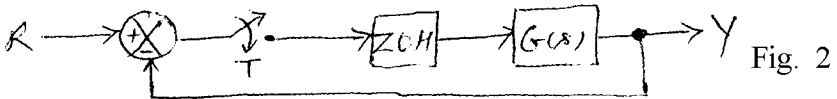
for  $k < 0$ , obtain the transfer function  $G(z) = \frac{Y(z)}{R(z)}$ .

3 Attempt any two parts of the following : 10×2=20

- (a) Discuss the transient and frequency domain specification that describe the performance of feedback control system in Z-plane.
- (b) A sampled data feedback control system is shown in fig. 2. The controlled process of the system is described by the transfer function

$$G(s) = \frac{k}{s(s+1)}; 0 \leq k < \infty$$

The sampling time period  $T = 1$  sec.



Sketch the root locus plot for the system on the Z-plane and from there obtain the value of 'k' that results in marginal stability.

- (c) Investigate the controllability and observability of the following system :

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

$$Y(k) = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} X(k)$$

4 Attempt any two parts of the following :  $10 \times 2 = 20$

- (a) Explain various methods available to investigate the controllability and observability.
- (b) A discrete - time regulator system has the plant

$$X(k+1) = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -4 & -2 & -1 \end{bmatrix} X(k) + \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} u(k)$$

Design a state feedback controller which will place the closed loop poles at  $-\frac{1}{2} \pm j\frac{1}{2}, 0$ . Also give a block diagram of the control configuration.

- (c) State and explain Lyapunov stability criterion in brief.

For the system

$$X_1(k+1) = 2X_1(k) + 0.5X_2(k) - 5$$

$$X_2(k+1) = 0.8X_2(k) + 2$$

Investigate the stability of the equilibrium state. Use the direct method of Lyapunov.

5 Attempt any two parts of the following :  $10 \times 2 = 20$

- (a) Using the Lyapunov's direct method, find the stability range for the gain 'K' of the system shown in Fig.3

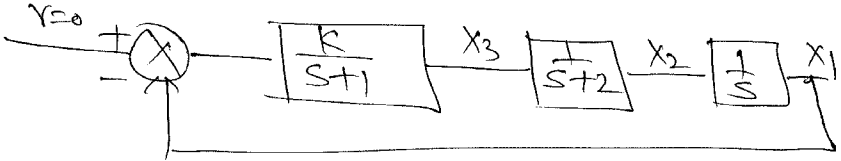


Fig. 3

- (b) Determine the optimal control law for the system

$$\dot{X} = \begin{bmatrix} 0 & 1 \\ 0 & 0 \end{bmatrix} X + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u$$

$$Y = \begin{bmatrix} 1 & 0 \\ 0 & 2 \end{bmatrix} X.$$

Such that the following performance index is minimized.

$$J = \int_0^{\infty} (y_1^2 + y_2^2 + u^2) dt$$

- (c) Write short notes on any two of the following :
- (i) Principle of optimality
  - (ii) Infinite regulator problem
  - (iii) Compensator design.