Exam Date & Time: 21-May-2022 (10:00 AM - 01:00 PM)

MANIPAL ACADEMY OF HIGHER EDUCATION

SIXTH SEMESTER B.TECH END SEMESTER EXAMINATIONS, MAY 2022

DIGITAL CONTROL SYSTEMS [ICE 4051]

Marks: 50 **Duration: 180 mins.**

A

Answer all the questions.

Instructions to Candidates:

Answer ALL questions Missing data may be suitably assumed

1) Using the method of sampled-signal flow graph, determine the overall pulse transfer function of the discrete-time system shown in Fig.1.

A)

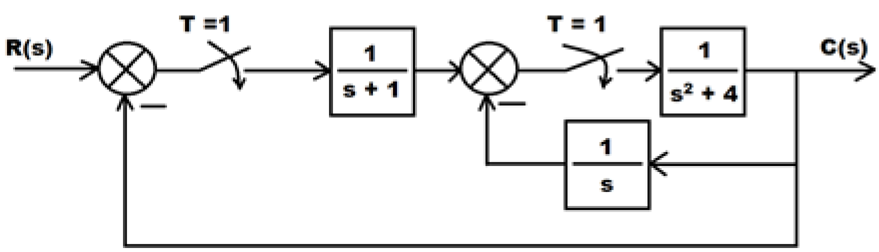

Fig. 1

(5)

B) Using block diagram reduction technique, obtain the pulse transfer function of the system shown in Fig.2.

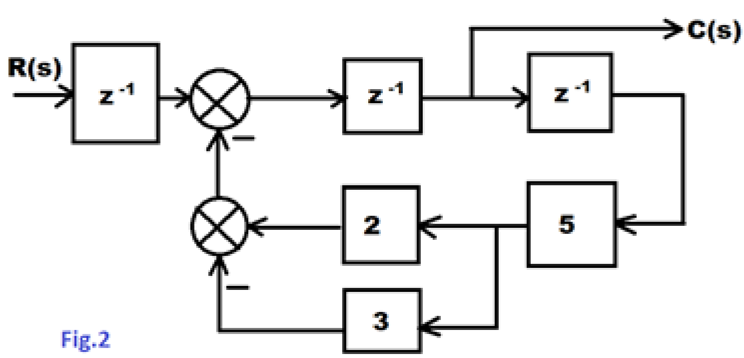

Fig.2

(3)

C) Determine the initial and final values of the pulse transfer function:

$$F(z) = \frac{6z^3 - 5z^2 + 8z}{(z-1)(z-0.5)^2}$$

(2)

2) A discrete-time control system (with unity-gain negative feedback) has an open-loop transfer function: (5)

A) $$G(z) = \frac{K(z + 0.7181)}{(z - 1)(z - 0.3679)}$$

Sketch the root-locus for the forward open loop system. Also, determine the range of gain K for which the given system remains stable? Assume that the sampling time-period T = 1s.

B) For the characteristic polynomial of a given system (as below),

$$\Delta(z) = z^4 - 0.9z^3 + 0.14z^2 + 0.216z + 0.032$$ (3)

determine the stability of the system using Jury's Test.

C) For the following open-loop system with unity-gain negative feedback,

$$G(z) = \frac{0.2385(z + 0.876)}{(z - 1)(z - 0.2644)}$$ (2)

determine the steady-state errors for unit step and unit ramp inputs. Assume that the sampling time-period, T = 0.2s

3) Consider the following discrete-time autonomous system. Compute the state-transition matrix using Z-transform method.

A) $$x(k+1) = \begin{bmatrix} 1 & 0 & 0 \\ 1 & -2 & 3 \\ 2 & 1 & 4 \end{bmatrix} x(k)$$ (4)

B) Diagonalize the given matrix $A = \begin{bmatrix} 1 & 1 & 0 \\ 1 & 0 & 1 \\ -2 & -1 & -4 \end{bmatrix}$ (3)

C) For the following discrete-time state-space model,

$$x(k+1) = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 3 & 5 \\ -1 & 2 & 4 \end{bmatrix} x(k) + \begin{bmatrix} 1 \\ 0 \\ 2 \end{bmatrix} u(k)$$ (3)

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

obtain the pulse transfer function of the system. Assume all initial conditions to be zero.

4) Consider a system described below. Using Lyapunov stability criteria, determine the stability of the equilibrium state of the system.

A) $$x_1(k+1) = x_1(k) + 0.2\,x_2(k) + 0.4$$ (4)
$$x_2(k+1) = 0.5\,x_1(k) - 0.5$$

B) A discrete-time plant-model is given as below: (3)

$$x(k+1) = \begin{bmatrix} 1 & 0.0952 \\ 0 & 0.905 \end{bmatrix} x(k) + \begin{bmatrix} 0.00484 \\ 0.0952 \end{bmatrix} u(k)$$

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

Assuming that the sampling frequency is 10Hz, design a full order state feedback controller such that the closed loop system poles are located at z = 0.888 ± j0.173.

C) Assume the following state-matrices,

$$F = \begin{bmatrix} 0.5 & 1 & 0 \\ -1 & 0 & 1 \\ 0 & 0 & 0 \end{bmatrix} \text{ and } C = \begin{bmatrix} 1 & 0 & 0 \end{bmatrix}$$ (3)

Check for the state-observability of the given discrete-time system.

5) The pulse transfer function of a system is given as follows :

A) $$\frac{Y(z)}{U(z)} = \frac{3}{(2z+1)(z+1)^2}$$ (4)

Obtain the state space model for the given system.

B) Construct the S.V.D for the rectangular matrix,

$$A = \begin{bmatrix} 1 & 1 & 0 \\ 0 & 1 & 1 \end{bmatrix}.$$ (4)

C) Check for sign-definiteness of the following quadratic form:

$$Q(x_1, x_2) = -x_1^2 - 2x_2^2 - 4x_3^2 + 4x_1x_2 + 6x_2x_3 + 2x_1x_3$$ (2)

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