USN | | | | | | | | | | **10EE55**

Fifth Semester B.E. Degree Examination, May 2017

Modern Control Theory

Time: 3 hrs. Max. Marks: 100

Note: ***Answer any FIVE full questions, selecting atleast TWO questions from each part.***

PART – A

1 a. Mention any four advantages of state space analysis over frequency domain analysis. **(04 Marks)**

b. Obtain the state model for a single input single output continuous–time LTI system described by the following differential equation : $(D^n + a_1D^{n-1} + a_2D^{n-2} + - - - - - + a_n)y(t) = u(t)$. **(06 Marks)**

c. For the transfer function : $T(s) = \dfrac{s(s+2)(s+3)}{(s+1)^2(s+4)}$ obtain the state model in

i) Phase variable form using signal flow graph method

ii) Jordan's canonical form. **(10 Marks)**

2 a. Obtain the state model for the armature controlled DC motor. **(08 Marks)**

b. Obtain the state model for a system represented by the following function using canonical foster form. $T(s) = \dfrac{8s^2 + 17s + 8}{(s+1)(s^2 + 8s + 15)}$. **(06 Marks)**

c. Obtain the state model of a system by Gulleman's form (cascade programming) $T(S) = \dfrac{(s+2)(s+4)}{s(s+1)(s+3)}$. **(06 Marks)**

3 a. Obtain the transfer function of a linear time invariant system represented by the state model.

$\dot{x} = AX + BU; \quad y = CX + DU$. State the conditions for applying Lapalce transform. **(06 Marks)**

b. Obtain for the state model shown by equivalent transfer function :

$\dot{X} = \begin{bmatrix} -2 & -3 \\ 4 & 2 \end{bmatrix}\begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 3 \\ 5 \end{bmatrix}U \quad y = [1 \quad 1]X$. **(06 Marks)**

c. Consider a state model with matrix 'A' as $A = \begin{bmatrix} 0 & 2 & 0 \\ 4 & 0 & 1 \\ -48 & -34 & -9 \end{bmatrix}$. Prove that the transformation $M^{-1}AM$ results in a diagonal matrix, where 'M' is the model matrix. **(08 Marks)**

4 a. If $A = \begin{bmatrix} 0 & 1 \\ -2 & -3 \end{bmatrix}$ find A^{12} using Cayley-Hamilton theorem. **(06 Marks)**

b. A state–space representation of a system in the controllable canonical form is given as $\dot{X} = \begin{bmatrix} 0 & 1 \\ -0.4 & -1.3 \end{bmatrix}\begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 0 \\ 1 \end{bmatrix}U \quad Y = [0.8 \quad 1]\begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$.

Check for controllability and observability using Kalman's test. **(08 Marks)**

c. For a system the matrix 'A' is given by $A = \begin{bmatrix} 0 & 1 \\ -2 & -3 \end{bmatrix}$ compute the state transition matrix using Cayley-Hamiltion theorem. **(06 Marks)**

PART – B

5 a. With a neat diagram, explain a full-order state observer. **(06 Marks)**

b. A regulator plant is given by the matrices : $A = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -1 & -5 & -6 \end{bmatrix}$ $B = \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix}$. Design a feedback controller with the state feedback so that the closed loop poles are placed at –10, –2 + j4 and –2 –j4 using Ackerman's formula. **(08 Marks)**

c. The system is described by $\dot{X} = AX + BU$ and $y = CX$. Where $A = \begin{bmatrix} -1 & 1 \\ 1 & 2 \end{bmatrix}$ $C = [1 \quad 0]$ design a full order state observer. The desired eigen values are –5 and –5. Use Ackerman's formula. **(06 Marks)**

6 a. Explain a PI controller. **(06 Marks)**

b. Explain in detail the different types of non – linearities in a system. **(10 Marks)**

c. Define Jump resonance in a non – linear system. **(04 Marks)**

7 a. Draw the phase portraits of the following systems :

i) $\frac{d^2x}{dt^2} + 0.5\frac{dx}{dt} + 2x = 0$ ii) $\frac{d^2x}{dt^2} + \frac{3dx}{dt} + 2x = 0$ iii) $\frac{d^2x}{dt^2} + \frac{3dx}{dt} - 10 = 0$. **(09 Marks)**

b. Obtain all the singularities of the system represented by the equation :

$$\frac{d^2y}{dt^2} - \left\{0.1 - \frac{10}{3}\left(\frac{dy}{dt}\right)^2\right\}\frac{dy}{dt} + y + y^2 = 0 \ .$$ **(04 Marks)**

c. Construct a phase trajectory by Delta method for a non-linear system represented by the differential equation : $\ddot{x} + 4|\dot{x}|\dot{x} + 4x = D$. Choose the initial conditions as $x_1(0) = 1$ and $\dot{x}(0) = 0$. **(07 Marks)**

8 a. Define the terms : i) Local stability ii) global stability iii) positive definiteness iv) negative definiteness. **(04 Marks)**

b. Determine the stability of the system described by :

$$\dot{x}_1 = 3x_1 + x_2$$
$$\dot{x}_2 = x_1 - x_2 - x_2^3$$

using Krasovskii's method. **(08 Marks)**

c. Consider the second order system described by $\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ -1 & -1 \end{bmatrix}\begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$. Determine the stability of the system and also the Lyapunov function. **(08 Marks)**

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