USN

10EE55

Ffith Semester B.E. Degree Examination, June/July 2018

Modern Control Theory

Time: 3 hrs. Max. Marks:100

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

PART – A

1 a. Mention five advantages of modern control theory (MCT), over classical control theory. **(05 Marks)**

b. Consider a system given by $G(s) = \dfrac{s+3}{s^2+3s+2}$, obtain the state space representation in:

i) Controllable canonical form

ii) Observable canonical form **(05 Marks)**

c. Write the state variable formulation of the network shown in Fig.Q1(c), where all components are of unity magnitude.

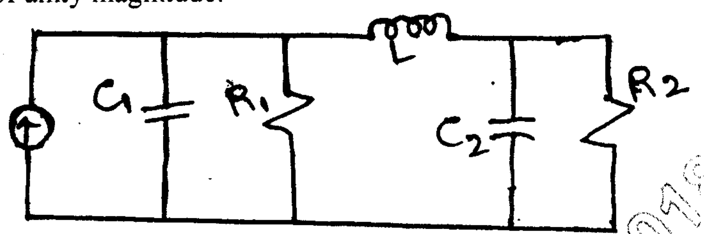

Fig.Q1(c) **(10 Marks)**

2 a. Derive the transfer function from state model. **(05 Marks)**

b. Consider a system having state model $\dot{X} = AX + BU$ and $Y = CX + DU$ where $A = \begin{bmatrix} -2 & -3 \\ 4 & 2 \end{bmatrix}$, $B = \begin{bmatrix} 3 \\ 5 \end{bmatrix}$, $C = [1 \;\; 1]$, $D = [0]$, obtain its transfer function. **(05 Marks)**

c. Reduce the given state model into its canonical form by diagonalising matrix A. $\dot{X} = AX + BU$; $Y = CX + DU$ where $A = \begin{bmatrix} 0 & 1 & -1 \\ -6 & -11 & 6 \\ -6 & -11 & 5 \end{bmatrix}$, $B = \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix}$, $C = [1 \;\; 0 \;\; 0]$, $D = [0]$. **(10 Marks)**

3 a. Diagonalize the matrix A where $A = \begin{bmatrix} 4 & 1 & -2 \\ 1 & 0 & 2 \\ 1 & -1 & 3 \end{bmatrix}$. **(06 Marks)**

b. For the transfer function T(S), obtain the state model in canonical form $T(S) = \dfrac{s(s+2)(s+3)}{(s+1)^2(s+4)}$ **(08 Marks)**

c. A system is described by the following differential equations. Represent the system in state space. $X^{(3)} + 3X^{(2)} + 4\dot{X} + 4X = U_1 + 3U_2 + 4U_3$ and the outputs are $Y_1 = 4\dot{X} + 3U_1$; $Y_2 = X^{(2)} + 4U_2 + U_3$. **(06 Marks)**

4 a. What is STM? State atleast five properties of STM. **(06 Marks)**

b. Find the STM of $A = \begin{bmatrix} 0 & 0 & -2 \\ 0 & 1 & 0 \\ 1 & 0 & 3 \end{bmatrix}$ by Caley Hamilton method. **(06 Marks)**

c. Given the state model of the system $\dot{X} = AX + BU$ and $Y = CX + DU$ where $A = \begin{bmatrix} 0 & 1 \\ -4 & -5 \end{bmatrix}$ $B = \begin{bmatrix} 0 \\ 1 \end{bmatrix}$ $C = [1 \ \ 0]$, $D = [0]$ with initial conditions $X(0) = \begin{bmatrix} 1 \\ 1 \end{bmatrix}$. Determine

i) The state transition matrix (STM).
ii) The state and output X(t) and Y(t) for a unit step input.
iii) Inverse state transition matrix. **(08 Marks)**

PART – B

5 a. Determine the controllability and observability of $\dot{X} = AX + BU$ and $Y = CX + DU$ where $A = \begin{bmatrix} -3 & 1 & 0 \\ 1 & -2 & 1 \\ 1 & 1 & 0 \end{bmatrix}$ $B = \begin{bmatrix} 0 \\ 2 \\ 2 \end{bmatrix}$ $C = [1 \ \ 2 \ \ -1]$, $D = [0]$ using (i) Kalman's test and (ii) Gilbert's test. **(10 Marks)**

b. For a homogeneous equation $\dot{X} = AX$ the following three different initial conditions are $\begin{bmatrix} e^{-t} \\ -e^{-t} \\ 2e^{-t} \end{bmatrix}$; $\begin{bmatrix} e^{-2t} \\ -2e^{-2t} \\ 0 \end{bmatrix}$; $\begin{bmatrix} -2e^{-3t} \\ -6e^{-3t} \\ 0 \end{bmatrix}$.

i) Identify the initial conditions ii) Find the system matrix A iii) Find STM. **(10 Marks)**

6 a. Consider a system defined by $\dot{X} = AX + BU$ where $A = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -1 & -5 & -6 \end{bmatrix}$; $B = \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix}$. It is desired to have closed loop poles at -1±j2 and -10. Determine the state feedback gain matrix K using (i) Direct substitution method and (ii) Ackerman's method. **(10 Marks)**

b. For a system defined by $\dot{X} = AX + BU$ and $Y = CX + DU$ where $A = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -6 & -11 & -6 \end{bmatrix}$; $B = \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix}$; $C = [1 \ \ 0 \ \ 0]$. Determine the observer gain matrix by (i) Direct substitution method and (ii) Ackerman's method. **(10 Marks)**

7 a. Mention five properties of non linear systems and explain (i) dead zone (ii) backlash. **(10 Marks)**

b. Explain the concept of limit cycles used in non linear systems. **(10 Marks)**

8 a. Determine the stability of a nonlinear system governed by the equations $\dot{X}_1 = -X_1 + 2X_1^2 X_2$, $\dot{X}_2 = -X_2$ using Lyapunov's method. **(08 Marks)**

b. Determine the stability of a system described by $A = \begin{bmatrix} -1 & 1 \\ -2 & -4 \end{bmatrix}$. **(08 Marks)**

c. Explain: i) Asymptotic stability, ii) Stability in the sense of Lyapunov. **(04 Marks)**