EE52

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NEW SCHEME

Fifth Semester B.E. Degree Examination, July 2007
Electrical and Electronics Engineering
Modern Control Theory

Time: 3 hrs.] [Max. Marks:100

Note : *Answer any FIVE full questions.*

1 a. Define controller. Explain properties of P, P.I. and P.I.D controllers with the help of block diagram. (08 Marks)

b. List advantages of modern control theory over conventional control theory. (04 Marks)

c. Obtain the state model of the electrical network shown in fig. 1(c) selecting 'V', '$\dot{z}_1$' and '$\dot{z}_2$' as state variables and voltage across R_2 and current I_2 through R_2 are the output variables y_1 and y_2. (08 Marks)

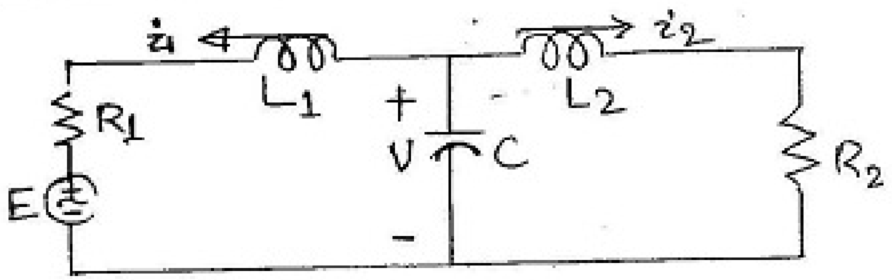

Fig. 1(c)

2 a. Obtain the observable phase variable state model of

$$\text{T.F} = \text{T}(s) = \frac{k(s)}{u(s)} = \frac{b_0 s^3 + b_1 s^2 + b_2 s + b_3}{s^3 + a_1 s^2 + a_2 s + a_3}$$

. Draw the signal flow graph of T(s). (08 Marks)

b. Obtain the controllable phase variable form of the transfer function given in question 2(a). (06 Marks)

c. Find the canonical state model for the following differential equation: (06 Marks)

$$\dddot{y} - 6\ddot{y} + 11\dot{y} + 6y = 6u$$

3 a. Determine the transfer function of the given state vector differential equation below: (08 Marks)

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \\ \dot{x}_3 \end{bmatrix} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ 0 & -4 & -5 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} + \begin{bmatrix} 1 \\ -1 \\ 5 \end{bmatrix} \text{u.}$$

b. Derive the equation of the vector model differential state equation. (02 Marks)

c. Obtain eigen values, eigen vectors and state model in canonical form for a system described by the following state model: (10 Marks)

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \\ \dot{x}_3 \end{bmatrix} = \begin{bmatrix} 0 & 1 & 0 \\ 3 & 0 & 2 \\ -12 & -7 & -6 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} + \begin{bmatrix} 1 \\ 0 \\ 2 \end{bmatrix} \text{u and y} = \begin{bmatrix} 1 & 0 & 0 \end{bmatrix} \begin{bmatrix} \bar{x}_1 \\ \bar{x}_2 \\ \bar{x}_3 \end{bmatrix}$$

4 a. Write and prove six properties of state transition matrix. **(06 Marks)**

b. Compute e^{At} for the given matrix :

$$\overline{A}_1 = \begin{bmatrix} 6 & 0 \\ 0 & 6 \end{bmatrix}; \overline{A}_2 = \begin{bmatrix} 0 & \omega \\ -\omega & 0 \end{bmatrix}; \overline{A} = \begin{bmatrix} 6 & \omega \\ -6 & \omega \end{bmatrix}$$ **(06 Marks)**

c. Obtain the time response of the following vector matrix differential equation.

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ -6 & -5 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u \text{ and } y = \begin{bmatrix} 1 & 0 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$$, where u(t) is an unit step input and the initial conditions are $x_1(0) = x_2(0) = 0$ **(08 Marks)**

5 a. Obtain state transition matrix for the given $\overline{A}$ using Caley – Hamilton method.

$$\overline{A} = \begin{bmatrix} 1 & 4 & 10 \\ 0 & 2 & 0 \\ 0 & 0 & 3 \end{bmatrix}$$ **(08 Marks)**

b. i) Define controllability and observability. **(06 Marks)**

ii) Explain the principle of duality between controllability and observability.

c. Examine the observability of the system given below

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \\ \dot{x}_3 \end{bmatrix} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ 0 & -2 & -3 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} u, \quad \dot{X} = \overline{A}\overline{x} + \overline{B}u$$

$$y = \begin{bmatrix} 3 & 4 & 1 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} = \overline{C}\overline{X}$$. Use Kalman's and Gilbert's test. **(06 Marks)**

6 a. A system is described by the following state space model.

$$\begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ 0 & -6 & -5 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} u.$$ **(10 Marks)**

Design a state feedback controller such that the poles are moved to $-1 \pm j$, -5.

b. Consider a linear system described by the equations.

$$\dot{\overline{X}} = \begin{bmatrix} 1 & 2 & 0 \\ 3 & -1 & 1 \\ 0 & 2 & 0 \end{bmatrix} \overline{X} + \begin{bmatrix} 2 \\ 1 \\ 1 \end{bmatrix} u = \overline{A}\overline{X} + \overline{B}u$$

$y = \begin{bmatrix} 0 & 0 & 1 \end{bmatrix} \overline{X} = \overline{C}\overline{X}$. Design a state observer so that eigen values of matrix (A-GC) are at -4, -3 $\pm$j1. **(10 Marks)**

7 a. Discuss the basic features of the following non-linearities with suitable figures :

i) Jump responses ii) Back lash **(08 Marks)**

b. Define : i) Stability ii) Asymptotic stability iii) Asymptotic stability in the large. **(06 Marks)**

c. Fig. 7(c) shows phase portraits for type–O systems, classify them into the categories – stable focus, stable node, saddlept and so on. **(06 Marks)**

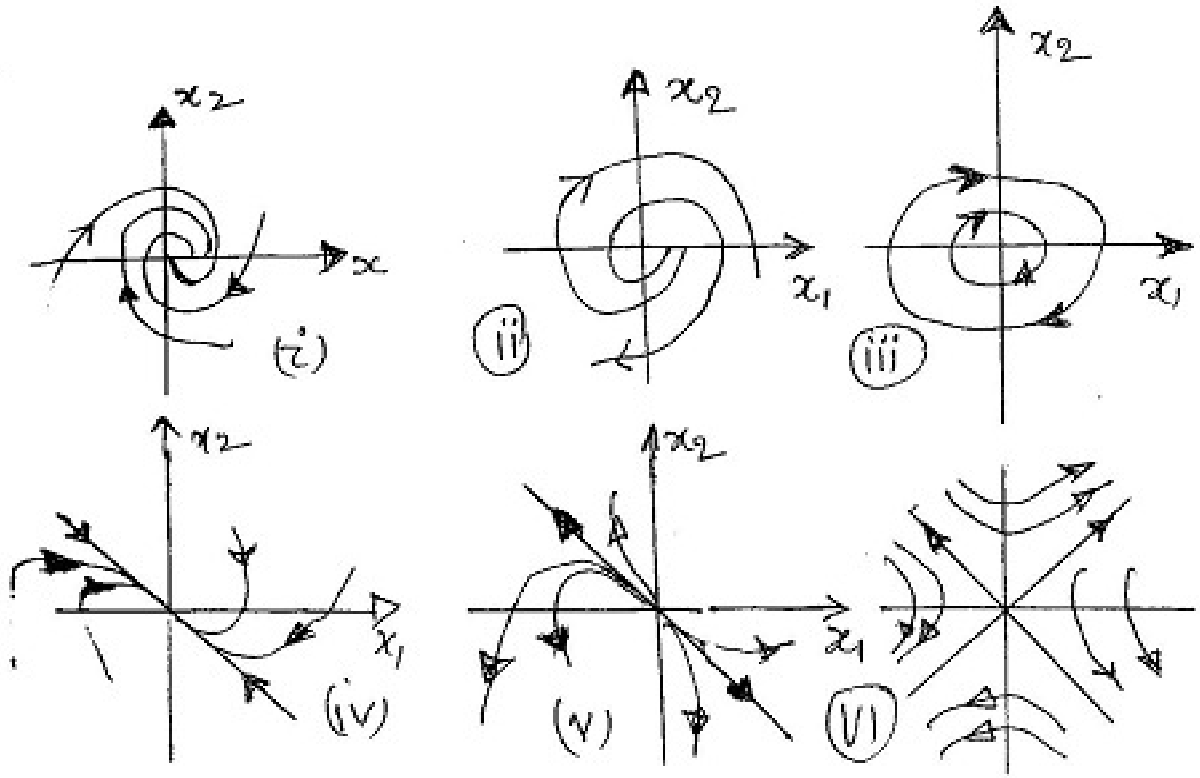

Fig. 7(c)

8. a. Explain Liapunov's stability criterion. **(06 Marks)**

b. Consider the system with differential equation.

$\ddot{e} + k\dot{e} + k_1 e^3 + e = 0$. Examine the stability by Liapunov's method, given that $K > 0$ and $K_1 > 0$. **(06 Marks)**

c. Examine the stability of the system described by the following equation by Krasovaskii's theorem.

$$\dot{X} = -x_1$$

$$\dot{X}_2 = x_1 - x_2 - x_2^3$$

(08 Marks)

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