NEW SCHEME

EE52

Reg. No.

Fifth Semester B.E. Degree Examination, January/February 2006

Electrical & Electronics Engineering

Modern Control Theory

Time: 3 hrs.) (Max.Marks : 100

Note: *Answer any FIVE full questions.*

1. (a) Explain the concepts of state variable, state and state model of a linear system. **(6 Marks)**

(b) Linearize the following equation in the neighbourhood of the origin

$$\frac{d^2\theta}{dt^2} = tan^{-1}\, 2\theta - 3\, sin\, \theta + 2ue^{u/2} + u^3$$

Obtain the approximate response $\theta(t)$ for $u = 0.02$, with the system initially at equilibrium. **(6 Marks)**

(c) Choosing appropriate physical variables as state variables, obtain the state model for the electric circuit shown in Fig. 1. **(8 Marks)**

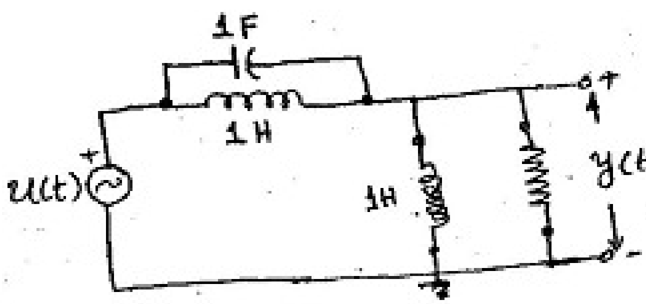


Fig. 1

2. (a) For the transfer function $\frac{Y(s)}{R(s)} = \frac{s(s+2)(s+3)}{(s+1)^2\,(s+4)}$

Obtain the state model in

i) Phase variable cannonical form

ii) Jordan Cannonical form **(4+4=8 Marks)**

(b) Consider the matrix

$$A = \begin{bmatrix} 2 & -2 & 3 \\ 1 & 1 & 1 \\ 1 & 3 & -1 \end{bmatrix}$$

i) Find the eigen values and eigen vectors of A

ii) Write the modal matrix

iii) Show that the modal matrix indeed diagonalizes A. **(12 Marks)**

3. (a) List at least three important properties of the state transition matrix. **(3 Marks)**

(b) Consider the homogeneous equation $\dot{X} = AX$. Where A is a 3 × 3 matrix. The following three solutions for three different initial conditions are available

$$\begin{bmatrix} e^{-t} \\ -e^{-t} \\ 2e^{-t} \end{bmatrix}, \begin{bmatrix} e^{-2t} \\ -2e^{-2t} \\ 0 \end{bmatrix}, \begin{bmatrix} 2e^{-3t} \\ -6e^{-3t} \\ 0 \end{bmatrix}$$

i) Identify the initial conditions

ii) Find the state transition matrix

iii) Hence or otherwise find the system matrix A **(10 Marks)**

(c) Given the state model $\dot{X} = AX + bu$, $y = cX$

Where $A = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -1 & -2 & -3 \end{bmatrix}$, $b = \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix}$ and $c = [1 \ 0 \ 0]$

i) Simulate and find the transfer function $\frac{Y(s)}{U(s)}$ using Mason's gain formula.

ii) Determine the transfer function from the state model formulation. **(7 Marks)**

4. (a) Obtain the time response $y(t)$, of the system given below by first transforming the state model into a 'Cannonical model'.

$$\dot{X} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -6 & -11 & -6 \end{bmatrix} X + \begin{bmatrix} 0 \\ 0 \\ 2 \end{bmatrix} u, \quad y = [1 \ 0 \ 0]x$$

u is a unit step function and $X^T(0) = [0 \ 0 \ 2]$ **(12 Marks)**

(b) Write the state and output equations for the system shown in Fig. 2. Determine whether the system is completely controllable and completely observable. **(8 Marks)**

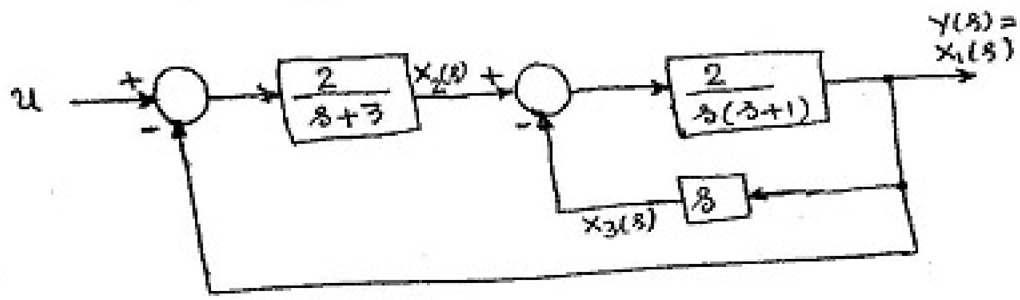


Fig 2.

5. A regulator system has the plant

$$\dot{X} = \begin{bmatrix} 0 & 0 & -6 \\ 1 & 0 & -11 \\ 0 & 1 & -6 \end{bmatrix} X + \begin{bmatrix} 1 \\ 0 \\ 0 \end{bmatrix} u, \quad y = [0 \ 0 \ 1]X$$

i) Compute K so that the control law $u = -KX + r(t)$, $r(t)$ = reference input, places the closed loop poles at $-2 \pm j\sqrt{12}$, -5. **(8 Marks)**

ii) Design an observer such that the eigen values of the observer are located at $-2 \pm j\sqrt{12}, \ -5$. **(6 Marks)**

iii) Draw a block diagram implementation of the control configuration. **(3 Marks)**

iv) Obtain the state model of the observer based state feed back control system. **(3 Marks)**

6. (a) Using Lyapunovs direct method, find the range of K to guarantee stability of the system shown in Fig. 3 **(14 Marks)**

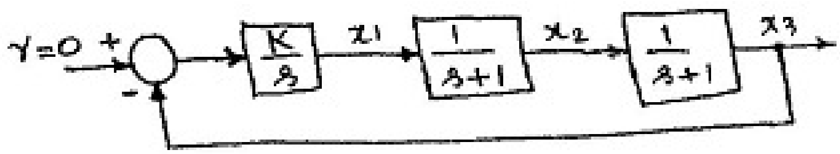


Fig 3

(b) Choose an appropriate Lyapunov function and check the stability of the equilibrium state of the system described by

$$\dot{x}_1 = x_2$$
$$\dot{x}_2 = -x_1 - x_1^2 x_2$$

(6 Marks)

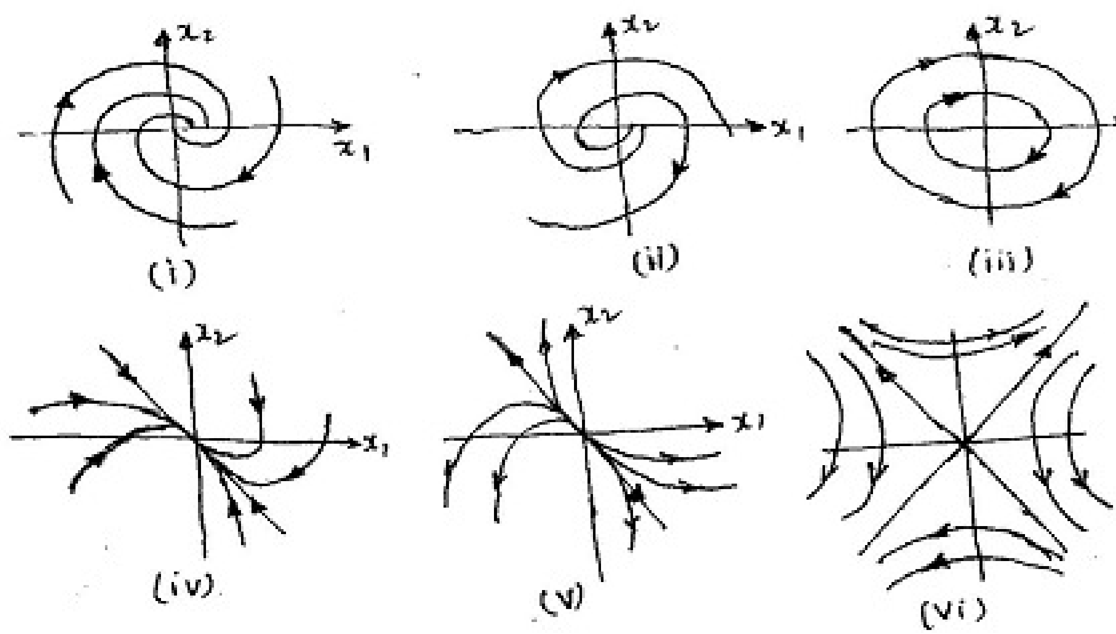
7. (a) Discuss the basic features of the following non linearities

i) Non linear friction

ii) On-off controllers

iii) Back lash **(9 Marks)**

(b) Fig. 4 shows phase portraits for type - 0 systems. Classify them into the categories. Stable focus, stable node and so-on. **(6 Marks)**



(c) Explain the concept of jump resonance with a suitable example. **(5 Marks)**

8. **(a)** Explain the delta method of constructing phase trajectories **(7 Marks)**

(b) Using Isocline method, draw the phase trajectory for the system

$$\frac{d^2x}{dt^2} + 0.6\frac{dx}{dt} + x = 0$$

with $x = 1$ and $\frac{dx}{dt} = 0$ as initial condition. **(8 Marks)**

(c) Sketch a suitable phase trajectory and explain the 'Dither phenomenon'. **(5 Marks)**

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