USN

10EE55

Fifth Semester B.E. Degree Examination, Dec.2014/Jan.2015

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. Define the following terms:
i) State ii) State variables iii) State vector iv) State space. **(04 Marks)**

b. Obtain the state model for the electrical circuit shown in Fig.Q1(b). **(08 Marks)**

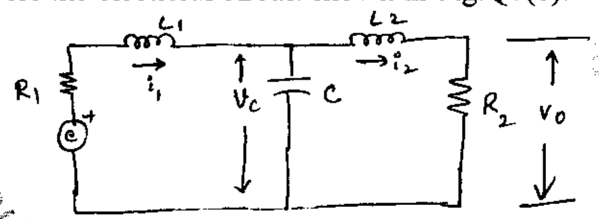

Fig.Q.1(b)

c. Derive the state model for the system described by the differential equation
$D^3y + 4D^2y + 5Dy + 2y = 2D^2u + 6Du + 5u$, where D = d/dt, in Jordan canonical form. **(08 Marks)**

2 a. Obtain the state model in first companion form for the system given by

$$\frac{d^3y}{dt^3} + 6\frac{d^2y}{dt^2} + 7\frac{dy}{dt} + 4y = 10u.$$ **(06 Marks)**

b. Fig.Q.2(b) shows block diagram of a control system using state variable feedback and integral control. State model of plant is

$$\begin{bmatrix}\dot{x}_1\\ \dot{x}_2\end{bmatrix} = \begin{bmatrix}-3 & 2\\ 4 & -5\end{bmatrix}\begin{bmatrix}x_1\\ x_2\end{bmatrix} + \begin{bmatrix}1\\ 0\end{bmatrix}r, \quad y = \begin{bmatrix}0 & 1\end{bmatrix}\begin{bmatrix}x_1\\ x_2\end{bmatrix}$$

Derive the state model of entire system. **(08 Marks)**

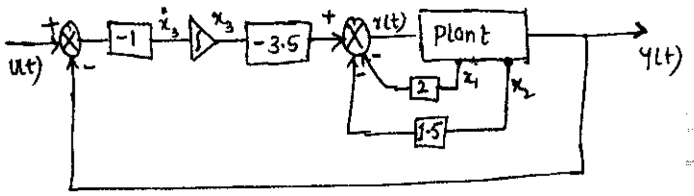

Fig.Q.2(b)

c. List out atleast one advantage and one disadvantage of selecting,
i) Physical variables; ii) Phase variable; iii) Canonical variables for state space formulation of control systems. **(06 Marks)**

3 a. Find eigen values, eigen vectors and modal matrix for

$$A = \begin{bmatrix}0 & 0 & 1\\ 2 & 0 & 0\\ 8 & 2 & -5\end{bmatrix}.$$ **(06 Marks)**

b. Convert the following state model into canonical form by diagonalising matrix 'A'.

$$\begin{bmatrix}\dot{x}_1\\ \dot{x}_2\end{bmatrix} = \begin{bmatrix}1 & -4\\ 3 & -6\end{bmatrix}\begin{bmatrix}x_1\\ x_2\end{bmatrix} + \begin{bmatrix}0\\ -1\end{bmatrix}u, \quad y = \begin{bmatrix}1 & 0\end{bmatrix}\begin{bmatrix}x_1\\ x_2\end{bmatrix}.$$ **(08 Marks)**

Important Note : 1. On completing your answers, compulsorily draw diagonal cross lines on the remaining blank pages.
2. Any revealing of identification, appeal to evaluator and /or equations written eg, 42+8 = 50, will be treated as malpractice.

c. Find the state transition matrix e^{At} for the system using Cayley-Hamilton method

$$A = \begin{bmatrix} 1 & 0 \\ 1 & 1 \end{bmatrix}.$$ **(06 Marks)**

4 a. Find the time response for unit step input of a system given by

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

$$y(t) = \begin{bmatrix} 0 & 1 \\ -2 & -3 \end{bmatrix} x(t) \quad \text{and} \quad x(0) = \begin{bmatrix} 1 \\ 0 \end{bmatrix}.$$ **(12 Marks)**

b. Evaluate controllability and observability of the following state model,

$$\dot{x} = \begin{bmatrix} 0 & 0 & 0 \\ 1 & 0 & -3 \\ 0 & 1 & -4 \end{bmatrix} x + \begin{bmatrix} 40 \\ 10 \\ 0 \end{bmatrix} u, \; y = \begin{bmatrix} 0 & 0 & 1 \end{bmatrix} x.$$ **(08 Marks)**

PART – B

5 a. "Any unstable system can be stabilized by complete state feedback if all the state variables are controllable". Comment on this statement and explain for the Fig.Q.5(a). **(06 Marks)**

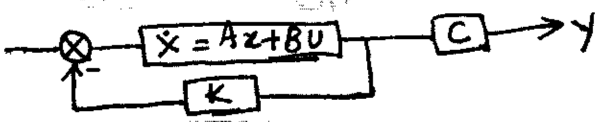

Fig.Q.5(a)

b. Consider the system defined by $\dot{x} = Ax + Bu$, $y = cx$ where

$$A = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -1 & -5 & -6 \end{bmatrix}, \; B = \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix}$$

By using the state feedback control u = -kx, it is desired to have the closed loop poles at s = -1 ± j2 and s = -10. Determine the state feedback gain matrix 'K' using Ackermann's formula. **(08 Marks)**

c. A regulator system has the plant.

$$\dot{x} = \begin{bmatrix} 0 & 0 & -6 \\ 1 & 0 & -11 \\ 0 & 1 & -6 \end{bmatrix} x + \begin{bmatrix} 1 \\ 0 \\ 0 \end{bmatrix} u, \; y = \begin{bmatrix} 0 & 0 & 1 \end{bmatrix} x$$

Design an observer such that the eigen values of the observer are located at $-2 \pm j\sqrt{12}$, -5. Use direct substitution method. **(06 Marks)**

6 a. Write a short note on P, PI and PID controllers. **(06 Marks)**

b. List the properties of nonlinear systems. **(06 Marks)**

c. Draw the input-output characteristics of following nonlinearities and explain in detail:
i) Dead zone ii) Backlash. **(08 Marks)**

7 a. Explain the phenomenon of jump resonance with respect to the nonlinear systems. **(06 Marks)**
b. Find out the singular points for the following: $\ddot{x} + 0.5\dot{x} + 2x = 0$. **(04 Marks)**
c. Draw the phase plane trajectory for the following equation using isocline method:
$\ddot{x} + 2\xi w_n \dot{x} + w_n^2 x = 0$. Given $\xi = 0.5$, w = 1, with x = 0 and $\frac{dx}{dt} = 1$ as initial condition. **(10 Marks)**

8 a. Define the following terms:
i) Positive definiteness.
ii) Positive semidefiniteness.
iii) Negative definiteness.
iv) Negative semidefiniteness.
Give one example to each. **(06 Marks)**
b. Explain the Liapunov second method and stability theorems. **(08 Marks)**
c. Use Krasovskii's theorem to show that the equilibrium state **x** = 0 of the system described by $\dot{x}_1 = -3x_1 + x_2$; $\dot{x}_2 = x_1 - x_2 - x_2^3$ is asymptotically stable in large. **(06 Marks)**

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