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

Fifth Semester B.E. Degree Examination, Dec.2013/Jan.2014
Modern Control Theory

Time: 3 hrs. Max. Marks:100

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

PART – A

1 a. Using the Taylor's series, linearize the state equation $\dot{x}(t) = f(x, U)$ for small deviations about an equilibrium point (x_0, U_0). Neglect second and higher order terms. **(06 Marks)**

b. Obtain the state diagram of SISO system represented by equations

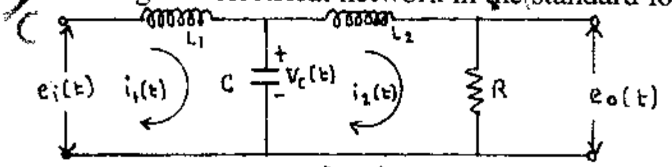
$\dot{x}_1(t) = a_1 x_1(t) + b_1 U(t)$

$\dot{x}_2(t) = a_2 x_1(t) + a_3 x_2(t) + b_2 U(t)$ and

$y(t) = c_1 x_1(t) + c_2 x_2(t)$. **(06 Marks)**

c. Obtain the state model of the given electrical network in the standard form. **(08 Marks)**

Fig.Q.1(c)



2 a. A feedback system is characterized by the closed loop transfer function $T(s) = \dfrac{s^2 + 3s + 3}{s^3 + 2s^2 + 3s + 1}$. Draw a suitable signal flow graph and obtain state model. The matrix 'A' should be in phase variable form. **(07 Marks)**

b. Obtain the state model of a system by Gullemin's form whose transfer function is

$T(s) = \dfrac{Y(s)}{U(s)} = \dfrac{(s+2)(s+4)}{S(s+1)(s+3)}$ **(06 Marks)**

c. Consider a two-input, two-output system $\dfrac{d^2y_1}{dt^2} + \dfrac{2dy_1}{dt} + \dfrac{3dy_2}{dt} + y_1 = u_1 + u_2$; $\dfrac{d^2y_2}{dt^2} + \dfrac{2dy_2}{dt} + \dfrac{5dy_1}{dt} + y_2 = 2u_1 + 3u_2$. Derive a state model of the system. **(07 Marks)**

3 a. Derive a transfer function from standard state model for linear time invariant system. **(06 Marks)**

b. Given the state model $\dot{x} + Ax + Bu$, $y = cx$ where

$$A = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -1 & -2 & -3 \end{bmatrix} \; B = \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} \text{ and } C = [1 \quad 0 \quad 0].$$

Find the transfer function $\dfrac{Y(s)}{U(s)}$ using Mason's gain formula. **(06 Marks)**

c. Consider the matrix

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

i) Find Eigen values and Eigen vectors of A; ii) Write the modal matrix ; iii) Show that the modal matrix indeed diagonalizes A. **(08 Marks)**

4 a. Find the state transition matrix for $A = \begin{bmatrix} 0 & -1 \\ 2 & -3 \end{bmatrix}$ using Cayley Hamilton theorem. **(06 Marks)**

b. Mention the conditions for complete controllability and observability. Using these, explain principle of duality between controllability and observability. **(06 Marks)**

c. Use controllability and observability matrices to determine whether the system represented by the signal flow graph shown in Fig.Q.4(c) is completely controllable and completely observable. Use Kalman's test. **(08 Marks)**

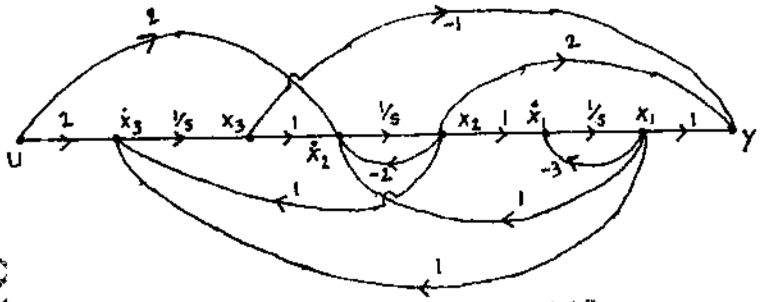


Fig.Q.4(c)

PART – B

5 a. With a neat block diagram, explain the fill order state observer. **(08 Marks)**

b. An observable system is described by

$$\dot{x} = \begin{bmatrix} 1 & 2 & 0 \\ 3 & -1 & 1 \\ 0 & 2 & 0 \end{bmatrix} x + \begin{bmatrix} 2 \\ 1 \\ 1 \end{bmatrix} u \quad y = [0 \ \ 0 \ \ 1]x$$

Design a state observer so that eigen values are at -4; $-3 \pm j1$. **(12 Marks)**

6 a. With a block diagram, explain P-1 controller. **(07 Marks)**

b. Explain the properties of non-linear systems. **(07 Marks)**

c. Classify the nonlinearities. Explain any two nonlinearities (inherent). **(06 Marks)**

7 a. Explain the delta method of constructing the phase trajectory. **(06 Marks)**

b. Sketch the different phase portraits for type '0' system. **(08 Marks)**

c. Determine the singular point for the following: $\ddot{y} + 3\dot{y} - 10 = 0$. **(06 Marks)**

8 a. Using Liapunov's direct method, find the range of 'K' to guarantee the stability of the system shown in Fig.Q.8(a). **(12 Marks)**

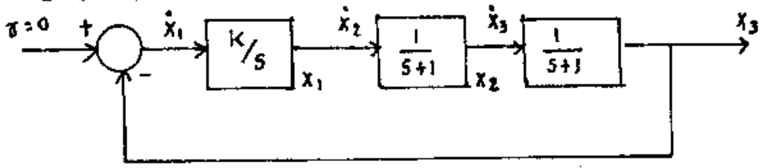


Fig.Q.8(a)

b. Determine whether or not following quadratic form is positive definite:

$V(x) = 8x_1^2 + x_2^2 + 4x_3^2 + 2x_1x_2 - 4x_1x_3 - 2x_2x_3$. **(08 Marks)**

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