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Fifth Semester B.E. Degree Examination, Aug./Sept.2020

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. Compare modern control theory with conventional control theory. **(05 Marks)**

b. Differential equation of dynamic system is $\ddot{c}_1 + \dot{c}_1 + 3c_1 - 5c_2 = r_1$, $\ddot{c}_2 + 2c_1 + c_2 = r_2$. Write state and output equation. **(07 Marks)**

c. A feedback system is characterized by the closed loop transfer function

$$T(s) = \frac{s^2 + 3s + 3}{s^3 + 2s^2 + 3s + 1}$$

Draw a suitable signal flow graph and obtain the state model. **(08 Marks)**

2 a. Obtain the state model in canonical form for the system described by the differential equation and write the block diagram $\dddot{y} + 6\ddot{y} + 11\dot{y} + 6y = \dddot{u} + 8\ddot{u} + 17\dot{u} + 8u$. **(10 Marks)**

b. A system is described by the following set of equations. Develop a block diagram for the system showing the transfer functions between different inputs and outputs.

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ -3 & -4 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 1 & 0 \\ 1 & 1 \end{bmatrix} \begin{bmatrix} u_1 \\ u_2 \end{bmatrix} \text{ and } \begin{bmatrix} y_1 \\ y_2 \end{bmatrix} = \begin{bmatrix} 1 & 2 \\ 1 & 0 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$$ **(10 Marks)**

3 a. Find the transformation matrix 'p' that transforms the matrix 'A' into diagonal or Jordan form where $A = \begin{bmatrix} 4 & 1 & -2 \\ 1 & 0 & 2 \\ 1 & -1 & 3 \end{bmatrix}$. **(10 Marks)**

b. What is state transition matrix? For $A = \begin{bmatrix} 0 & 1 \\ -2 & -3 \end{bmatrix}$ compute the state transition matrix e^{At} using Caley-Harmilton theorem. **(10 Marks)**

4 a. Determine the complete time response of the system given by $\overset{o}{X}(t) = \begin{bmatrix} 0 & 1 \\ -2 & 0 \end{bmatrix} X(t)$ where $X(0) = \begin{bmatrix} 1 \\ 1 \end{bmatrix}$ and $Y(t) = [1 \quad -1]X(t)$. **(10 Marks)**

b. Define controllability and observability and also write the condition for complete controllability and observability in the S-plane. **(04 Marks)**

c. Evaluate the controllability and observability of the following state model using Kalman's test.

$$A = \begin{bmatrix} -2 & 1 \\ 1 & -2 \end{bmatrix} \quad B = \begin{bmatrix} 1 \\ 0 \end{bmatrix} \quad C = [1 \quad -1]$$ **(06 Marks)**

PART – B

5 a. Describe the different methods for evolution of state feedback gain matrix 'K'. **(10 Marks)**

b. It is desired to place the closed loop poles of the following system at s = –3 and s = –4 by a state feedback controller with the control u = –Kx. Determine the state feedback gain matrix K and the control signal. Use transformation matrix (T) method.

$$\dot{x} = \begin{bmatrix} 0 & 1 \\ -1 & -3 \end{bmatrix} x + \begin{bmatrix} 0 \\ 2 \end{bmatrix} u \text{ and } y = \begin{bmatrix} 1 & 0 \end{bmatrix} x$$ **(10 Marks)**

6 a. Consider the system described by the state model $\dot{x} = Ax$, $y = Cx$ where $A = \begin{bmatrix} -1 & 1 \\ 1 & 2 \end{bmatrix}$, $C = \begin{bmatrix} 1 & 0 \end{bmatrix}$. Design a full order state observer. The desired eigen values for the observer matrix are $u_1 = -5$, $u_2 = -5$. Use direct substitution method. **(12 Marks)**

b. Mention the different types of inherent nonlinearities and explain Dead zone with suitable examples. **(08 Marks)**

7 a. What is singular point? Explain the different types of singular points in a non-linear control system based on the location of eigen values of the system. **(10 Marks)**

b. What is a phase plot? Describe delta method of drawing phase plane trajectories. **(10 Marks)**

8 a. 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 the large. **(08 Marks)**

b. Explain with an example:
(i) Liapunov main stability theorem
(ii) Liapunov second method
(iii) Krasovskii's theorem **(12 Marks)**

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