Reg. No.

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M.E./M.Tech. DEGREE EXAMINATIONS – NOV / DEC 2020

First/Third semester

Control and Instrumentation engineering

IN5152 SYSTEM THEORY

(Common to: Electrical Drives and Embedded Control/Instrumentation Engineering /Power Electronics and Drives/ Power System Engineering)

(Regulation 2017)

Time: 3 Hours | Answer ALL Questions | Max. Marks 100

PART- A (10 x 2 = 20 Marks)

1. Is the state variable representation of a given transfer function unique? Explain.
2. Consider a system which has two poles and one zero. What can be the order of the state model? And why?
3. A system has $A = [-1 \ \ 0;\ 2 \ -5]$, as its system matrix. Can the modes of the system be e^{-t} and e^{-6t} explain.
4. State two properties state transition matrix.
5. Does output controllability imply state controllability? Explain.
6. Distinguish the terms observability and detectability.
7. A third order system has two controllable and one uncontrollable mode. How many of these modes can be shifted by state feedback? Explain.
8. Can the estimator error dynamics be slower than system dynamics? Explain.
9. Does BIBO stability imply asymptotic stability? Explain.
10. The small signal model of a system has a zero eigenvalue when taken around an equilibrium point. What does it imply about the stability of equilibrium point? Explain.

PART- B (5 x 13 = 65 Marks)

11. a) Consider the physical system of your choice (minimum of second order). Derive the dynamic equations, transfer function and atleast two different state variable realizations for the system. (13)

OR

b) Consider the transfer function $G(s)=\frac{s+5}{(s+2)(s+3)(s+1)}$. Obtain three different state realizations for the system and show that all the system matrices have same set of eigenvalue. (13)

12. a) A system showed the following responses for zero input (13)

$$X(t)=\begin{bmatrix}1\\-3\\9\end{bmatrix}e^{-3t} \quad when\ X(0)=\begin{bmatrix}1\\-3\\9\end{bmatrix},$$

$$X(t)=\begin{bmatrix}1\\-2\\4\end{bmatrix}e^{-2t} \quad when\ X(0)=\begin{bmatrix}1\\-2\\4\end{bmatrix}, X(t)=\begin{bmatrix}1\\-5\\25\end{bmatrix}e^{-5t} \quad when\ X(0)=\begin{bmatrix}1\\-5\\25\end{bmatrix}.$$

Determine the response of the system for a unit step input and zero initial condition, assuming the system dynamics has no zeros and unity dc gain.

OR

b) Consider the transfer function $G(s)=\frac{s+5}{(s+2)(s+3)(s+1)}$. Obtain a diagonal realization of the system and determine the output responses of the system for the following inputs namely, (i) u(t)=1 for t≥0 and (ii) u(t)=e^{-5t} for t≥0. Comment on the modes present in the output. (13)

13. a) Consider the system whose dynamics is defined by the following equations

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

Show that the controllability grammian of the system is non-singular and determine the input that transforms the state from $x(0)=[1;-1]$ to $x(3)=[-1;1]$. (13)

OR

b) Consider the system whose dynamics is defined by the following equations

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

Derive necessary equations to determine the initial conditions for a given set of input and output observations. (13)

14. a) (i) Show that controllability is not affected by state feedback (5)

(ii) Design a State feedback controller to place the closed loop poles at -1 and -2 for the following system. (8)

$$\dot{x} = \begin{bmatrix} 0 & 4 \\ 1 & -3 \end{bmatrix} x + \begin{bmatrix} 1 \\ 1 \end{bmatrix} u$$

$$y = \begin{bmatrix} 1 & 0 \end{bmatrix} x$$

OR

b) (i) Derive conditions for transforming a system to controllable canonical form and obtain the state feedback solution for a given set of eigenvalues. (5)

ii) Design a state feedback controller so that the closed loop poles are placed at -1 and -2 by both the inputs. (8)

$$\dot{x} = \begin{bmatrix} 0 & 4 \\ 1 & -3 \end{bmatrix} x + \begin{bmatrix} 1 & 1 \\ 0 & 1 \end{bmatrix} u$$

$$y = \begin{bmatrix} 1 & 0 \end{bmatrix} x$$

15. a) Consider the linear system whose dynamic equation is given by

$$\dot{x} = \begin{bmatrix} 0 & 4 \\ 1 & -3 \end{bmatrix} x$$

State Lyapunov's stability definitions, and assess the stability of the equilibrium point of the system by constructing a Lyapunov's equation and Lyapunov's function. (13)

OR

b) Consider the non linear system whose dynamic equation is given by (13)

$$\dot{x} = \begin{bmatrix} -x_1 - 1 & -4 \\ 1 & -3x_2 - 2 \end{bmatrix} x$$

Determine and assess the stability of the equilibrium point.

PART- C (1 x 15 = 15 Marks)

16. a) Consider a system whose dynamic equations are given by

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

$$y = \begin{bmatrix} 1 & 0 & 1 \end{bmatrix} x$$

Show that the system dynamics cannot be made for faster than 1.0s (time constant) and the estimation error cannot be made faster than 0.5s (time constant) however best you try through design of state feedback controller and observer. Illustrate with necessary properties. (15)

OR

b) Consider a system whose dynamic equation are given by

$$\dot{x} = \begin{bmatrix} 0 & 1 \\ -x_1 & -3x_2 - x_1 \end{bmatrix} x + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u$$

Design a suitable controller so that the equilibrium point of the system is stable using the theory of Lyapunov functions. (15)

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