Reg. No. :

Question Paper Code : 31266

M.E./M.Tech. DEGREE EXAMINATIONS, NOVEMBER/DECEMBER 2022.

First Semester

Power Electronics and Drives

PS 4151 — SYSTEM THEORY

(Common to M.E. Power Systems Engineering)

(Regulations 2021)

Time : Three hours　　　　Maximum : 100 marks

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. For the system represented by a transfer function $\frac{Y(s)}{U(s)} = \frac{10(s+5)}{s^3+6s^2+5s+10}$. Obtain the state space model.
2. What are the advantages of state space modeling using physical variable?
3. For the autonomous system what is the state transition matrix?
4. How the Eigen vectors are calculated when Eigen values are distinct?
5. List the merits and demerits of observability test using Kalman's method.
6. What are the effects of pole zero cancellation in transfer function approach?
7. State the conditions under which the Describing Function method is justified in the analysis of Non-Linear systems.
8. Define the followings in the sense of Liapunov
   (a) stability in the small
   (b) asymptotically stable
   (c) unstable.
9. What is the need for state observer in a system?
10. Differentiate full order and reduced order observers.

PART B — (5 × 13 = 65 marks)

11. (a) Evaluate the state space model for the mechanical systems shown in Figure 11(a). Also find the transfer function from the state space model obtained.

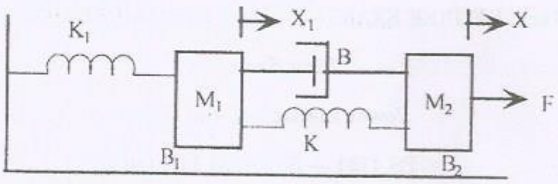

Fig 11 (a)

Or

(b) (i) State two important mode of classification of system. (5)

(ii) Show that the state variable representation of system is not unique. (8)

12. (a) Evaluate the state transition matrix and find $x(t)$ for a unit step input when $x(0) = \begin{bmatrix} 1 \\ -1 \end{bmatrix}$, $B = \begin{bmatrix} 1 \\ 0 \end{bmatrix}$ and $A = \begin{bmatrix} -3 & 1 \\ -2 & 0 \end{bmatrix}$

Or

(b) Explain the existence and uniqueness of solutions to continuous state equation.

13. (a) Prove that linear time invariant state model described by $\dot{x} = Ax + Bu$; $y = Cx$ is irreducible if and only if it is both controllable and observable.

Or

(b) For the system represented by state space model

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \\ \dot{x}_3 \end{bmatrix} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 0 \\ -1 & -5 & -6 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ 10 \end{bmatrix} u; \; y = \begin{bmatrix} 1 & 0 & 0 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix}.$$

Check whether the system is controllable and observable.

14. (a) (i) Deduce the describing function of a relay element with hysteresis, making necessary assumptions. (6)

(ii) How is the describing function technique used to the analyze the stability of non-linear system containing limit cycles (7)

Or

(b) Consider a non linear system described by the equation $\dot{x}_1 = -3x_1$; $\dot{x}_2 = x_1 - x_2 + x_2^3$, check the stability of equilibrium state using Krasovskii's method.

15. (a) Consider the system $\dot{X} = AX + BU$ and $Y = CX + DU$ where $A = \begin{bmatrix} -2 & -1 \\ 1 & 0 \end{bmatrix}$; $B = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$; $C = \begin{bmatrix} 0 & 1 \end{bmatrix}$ and $D = \begin{bmatrix} 2 & 0 \end{bmatrix}$. Design a full order state observer so that the estimation error will decay in less than 4 seconds.

Or

(b) For a system described by transfer function $G(s) = \dfrac{10}{S(S+1)(S+2)}$.

Design a feedback controller with a state feedback so that the closed loop poles are placed at $-2, -1 \pm j$.

PART C — (1 × 15 = 15 marks)

16. (a) (i) How the stability of non-linear system is determined using phase trajectories? (7)

(ii) For the given non-linear system $\ddot{X} + 0.5\dot{X} + 2X + X^3 = 0$. Find the singularities and their nature. (8)

Or

(b) A non linear system described by the following state equation $\dot{x}_1 = x_2 - x_1(x_1^2 + x_2^2)$; $\dot{x}_2 = -x_1 - x_2(x_1^2 + x_2^2)$. Determine the stability of the system using Lyapunov's Criterion.

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