A **241B4** Total Pages: **4**

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SAINTGITS COLLEGE OF ENGINEERING (AUTONOMOUS)

(AFFILIATED TO APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY, THIRUVANANTHAPURAM)

SEVENTH SEMESTER B.TECH DEGREE EXAMINATION (S), FEBRUARY 2024
ELECTRICAL AND ELECTRONICS ENGINEERING
(2020 SCHEME)

Course Code : **20EET401**

Course Name: **Advanced Control Systems**

Max. Marks : **100** **Duration: 3 Hours**

Two normal Graph sheets are required for solving questions 17(b) and 19(a)

PART A

(Answer all questions. Each question carries 3 marks)

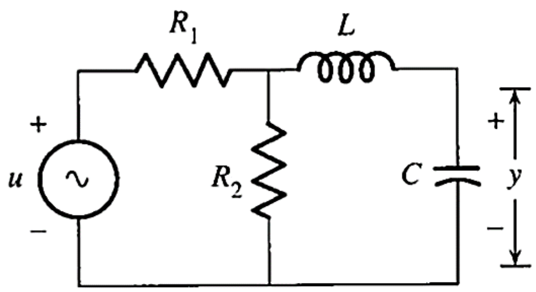
1. Explain the features of state space modelling
2. Obtain the state space model of given LTI continuous time system, whose differential equation is given by $\dddot{x} + 4\ddot{x} + 5\dot{x} + 2x + 7 = u$
3. Explain the significance of state transition matrix of LTI continuous time systems and mention its properties.
4. Obtain state transition matrix of given discrete time system, whose state matrix is given by $G = \begin{bmatrix} 0 & 1 \\ -0.16 & -1 \end{bmatrix}$.
5. Explain Duality property of a system.
6. Compare Full order and reduced order observer of continuous time system
7. Explain different types of incidental nonlinearities of the system.
8. Explain the relay nonlinearity and its describing function.
9. Determine given quadratic form is positive definite or not.
$V(x) = 10x_1^2 + 4x_2^2 + x_3^2 + 2x_1x_2 - 2x_2x_3 - 4x_1x_3$
10. Explain Lyapunov stability using suitable characteristics.

PART B

(Answer one full question from each module, each question carries 14 marks)

MODULE I

11. a) Select suitable state variables and write state equation and output equation of given electrical network. (4)



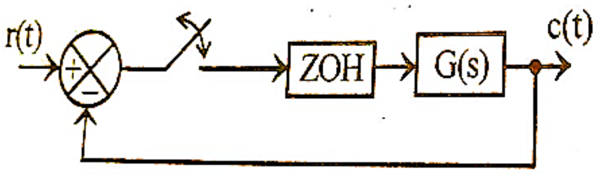
b) Obtain controllable canonical and observable canonical form of state space modelling of the given system. (10)

$$\frac{Y(s)}{X(s)} = \frac{2s^3 + s^2 + s + 2}{s^3 + 4s^2 + 5s + 2}$$

OR

12. a) Define pulse transfer function.
Find pulse transfer function of the system which produce response of $2^n u(n)$ to the unit step input u(n) (4)

b) Determine the pulse transfer function of the discrete time control system shown in figure for a sampling time of T=1 sec. Also find the response to unit step input. The transfer function of the system is G(s) = 1/(s+1). (10)



MODULE II

13. a) State and Explain Cayley Hamilton Theorem.
Find $F(A) = e^{At}$ using Cayley Hamilton Theorem if $A = \begin{bmatrix} 0 & 1 \\ 0 & -2 \end{bmatrix}$. (6)

b) Obtain transfer function of given LTI continuous time system, whose state model is given by (8)

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ -25 & -4 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 1 & 1 \\ 0 & 1 \end{bmatrix} \begin{bmatrix} u_1 \\ u_2 \end{bmatrix}$$

$$\begin{bmatrix} y_1 \\ y_2 \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 0 & 0 \\ 0 & 0 \end{bmatrix} \begin{bmatrix} u_1 \\ u_2 \end{bmatrix}$$

OR

14. a) Derive the solution of given continuous time autonomous system with initial condition X_0, whose state model is given by $\dot{X} = AX$ *and* $Y = CX$ (4)

b) A continuous system is represented by the following equations: (10)

$$\dot{X} = \begin{bmatrix} 0 & 2 \\ -2 & -5 \end{bmatrix} X + \begin{bmatrix} 0 \\ 1 \end{bmatrix} U \;;\; Y = \begin{bmatrix} 2 & 1 \end{bmatrix} X \;\; and \; X(0) = \begin{bmatrix} 1 & 2 \end{bmatrix}^T$$

Determine the state vector for time t and output y(t) for unit step input u(t)

MODULE III

15. a) Explain the significance of checking controllability of the system.

A linear dynamic system is described by $[\dot{X}] = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ 0 & -2 & -3 \end{bmatrix} X + \begin{bmatrix} 0 & 1 \\ 0 & 0 \\ 1 & 0 \end{bmatrix} U$; $where\ X = \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix}$ $and\ U = \begin{bmatrix} u_1 \\ u_2 \end{bmatrix}$

Check the controllability if (a) Input u_1 alone is acting (b) Input u_2 alone is acting (8)

b) Consider a system defined by $\dot{x} = \begin{bmatrix} 0 & 1 \\ -3 & 1 \end{bmatrix} x + \begin{bmatrix} 0 \\ 2 \end{bmatrix} u\ and\ \ y = [1 \quad 0]x$. Using state feedback control u=-Kx, it is desired to have the closed loop poles at s= -3 and s= -4, determine the state feedback gain matrix K. (6)

OR

16. a) Check whether given system is state observable. (4)

$$\dot{X} = \begin{bmatrix} -1 & -2 & -2 \\ 0 & -1 & 1 \\ 1 & 0 & -1 \end{bmatrix} X + \begin{bmatrix} 2 \\ 0 \\ 1 \end{bmatrix} U\ ; Y = [1\ 1\ 0]X$$

b) Consider the system described by,

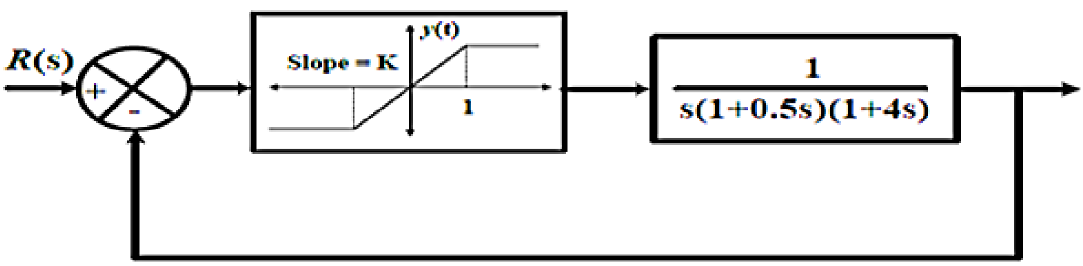
$$\dot{X} = AX + BU\ ; Y = CX \quad with\ A = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -6 & -11 & -6 \end{bmatrix} ; B = \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} ; C = [1 \quad 0 \quad 0]$$ (10)

Design an observer to place the eigen values at -2±3.46j and-6.

MODULE IV

17. a) Explain how the describing function analysis is used to determine the stability of a system with a neat diagram? (4)

b) A common form of an electronic oscillator is represented as shown in Figure. For what value of K, the possibility of limit cycle predicted? If K=3, determine amplitude and frequency of limit cycle. Also find the maximum value of K for the system is stable. (10)



OR

18. a) Explain characteristics of nonlinear system (6)

b) Derive the describing function of dead zone nonlinearity (8)

MODULE V

19. a) A linear second order system is described by $\ddot{e} + 2\delta w_n\,\dot{e} + w_n^2 e = 0$, where $\boldsymbol{\delta}$=0.15, w_n=1rad/sec, and e(0)=0. Determine the singular points and state stability by constructing the phase trajectory using method of isoclines. (14)

OR

20. a) A second order system is represented by $\dot{x} = Ax$, where $A = \begin{bmatrix} 0 & 1 \\ -2 & -3 \end{bmatrix}$ with Lyapunov theorem, determine the stability of the system and write the suitable Lyapunov function. (8)

b) Investigate the stability of the following system using Lyapunov direct method (6)

$$\dot{x}_1 = x_2$$
$$\dot{x}_2 = -x_1 - x_1^2 x_2$$

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