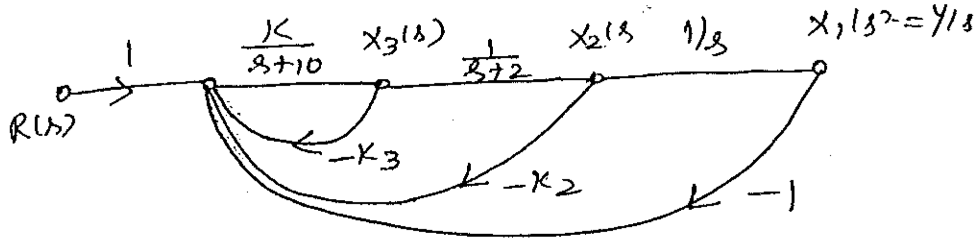
Assume that the states x_1 and x_2 are not accessible for feedback. Design an observer system to reconstruct X.



Design the feedback matrix G so that $X - \hat{X}$ will decay as fast as e^{-10t}. (8)

15. (a) Consider a nonlinear system described by the equations

$\dot{x}_1 = x_2$

$\dot{x}_2 = -(1 - |x_1|)(x_2 - x_1)$

Find the region in the state plane for which the equilibrium state of the systems is asymptotically stable. [Liapunov function $V = x_1^2 + x_2^2$]

Or

(b) Consider a nonlinear system described by the equations

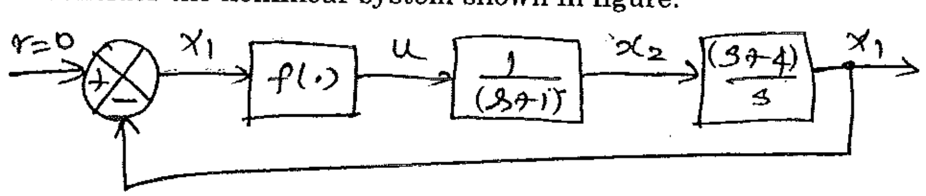
$\dot{x}_1 = -3x_1 + x_2$

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

Investigate the stability of equilibrium state using Kvasovskii's method.

PART C — (1 × 15 = 15 marks)

16. (a) Consider the nonlinear system shown in figure.



The system is described by the state equation

$\dot{x}_1 = -3x_2 - f(x_1)$

$\dot{x}_2 = -x_2 + f(x_1)$

Check the stability of the system.

Or

(b) Check the stability of the system described by

$\dot{x}_1 = x_2$; $\dot{x}_2 = -x_1 - b_1 x_2 - b_2 x_2^2$; $b_1, b_2 > 0$. Use variable gradient method to check the stability of the system.

Reg. No. : [ ][ ][ ][ ][ ][ ][ ][ ][ ][ ][ ][ ]

Question Paper Code : 40694

M.E./M.Tech. DEGREE EXAMINATION, NOVEMBER/DECEMBER 2018.

First Semester

Control and Instrumentation Engineering

IN 5152 — SYSTEM THEORY

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

(Regulations 2017)

Time : Three hours | Maximum : 100 marks

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. Define state of a system.

2. List the properties of the state transition matrix.

3. Draw the block diagram representation of the state model of a linear multi input-multi-output system.

4. What are the properties of Jordan canonical matrix?

5. Define controllability and observability of the system.

6. What is duality property of a given system?

7. Obtain the transfer function from a linear difference equation with state model.

8. How is the state transition matrix computed?

9. Consider a nonlinear system governed by the equation

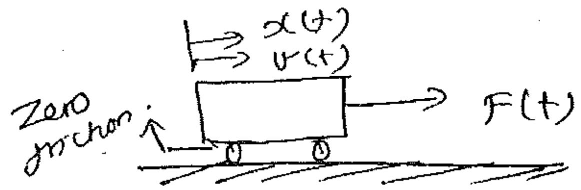
$\dot{x}_1 = -x_1 + 2x_1^2 x_2$

$\dot{x}_2 = -x_2$. Check the stability of the system using Lyapunov method.

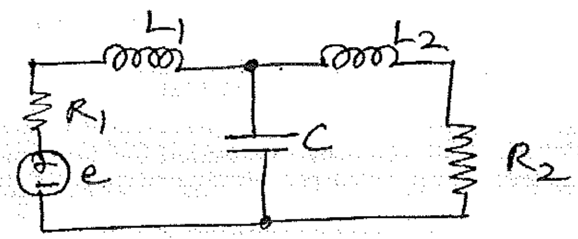
10. What is the procedure to formulate a Lyapunov function to check the stability of the system?

PART B — (5 × 13 = 65 marks)

11. (a) (i) Obtain the state variable model for the system given in figure. (6)



(ii) For the given network, obtain the state space representation using physical variables. (7)



Or

(b) A feedback system has a closed loop transfer function $\frac{C(s)}{U(s)} = \frac{10(s+4)}{s(s+1)(s+3)}$. Construct three different state models for this system and give block diagram representation for each state model. (13)

12. (a) For a system represented by the state equation $\dot{x}(t) = Ax(t)$ the response is $x(t) = \begin{bmatrix} e^{-2t} \\ -2e^{-2t} \end{bmatrix}$ when $x(0) = \begin{bmatrix} 1 \\ -2 \end{bmatrix}$ and $x(t) = \begin{bmatrix} e^{-t} \\ -e^{-t} \end{bmatrix}$ when $x(0) = \begin{bmatrix} 1 \\ -1 \end{bmatrix}$.

Determine the system matrix A and the state transition matrix.

Or

(b) A linear time-invariant system is characterized by the homogenous state equation

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ 1 & 1 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$$

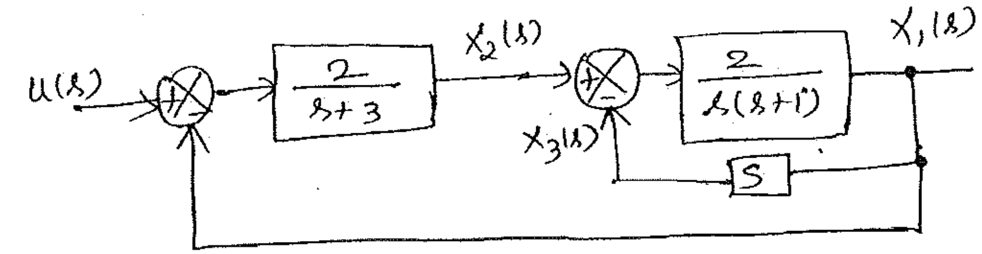
(i) Compute the solution of the homogeneous equation, assuming the initial state vector $X_0 = \begin{bmatrix} 1 \\ 0 \end{bmatrix}$. (6)

(ii) Consider now that the system has a forcing function and is represented by the following non homogenous state equation

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ 1 & 1 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u$$

where u is a unit step function. Compute the solution of this equation assuming initial condition of $X_0 = \begin{bmatrix} 1 \\ 0 \end{bmatrix}$. (7)

13. (a) Write the state equation of the system in figure in which x_1, x_2 and x_3 constitute the state vector. Determine whether the system is completely controllable and observable.



Or

(b) Consider the given system

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \\ \dot{x}_3 \end{bmatrix} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -6 & -11 & -6 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} u$$

Check the controllability of the system by Kalman's test.

14. (a) (i) Draw and explain a linear system with state observer with the help of a block diagram. (5)

(ii) Design a state observer for the given linear system described by the equation. (8)

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

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

Or

(b) (i) Discuss in detail about pole placement by state feedback for both SISO and MIMO systems. (5)

(ii) Consider a linear system

$$\dot{X} = \begin{bmatrix} 0 & 1 \\ 0 & -5 \end{bmatrix} X + \begin{bmatrix} 0 \\ -100 \end{bmatrix} u$$

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

The feedback controller for the system is given by

$$u = \begin{bmatrix} -K_1 & -K_2 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + r$$