

**Fifth Semester B.E. Degree Examination, July/August 2021**  
**Modern Control Theory**

Time: 3 hrs.

Max. Marks: 100

**Note: Answer any FIVE full questions.**

- 1 a. What are the advantages of state variable analysis over classical control theory? (05 Marks)  
 b. For an electrical network shown in Fig Q1(b), obtain the state model. Choose the voltage across capacitor c as the output variable.

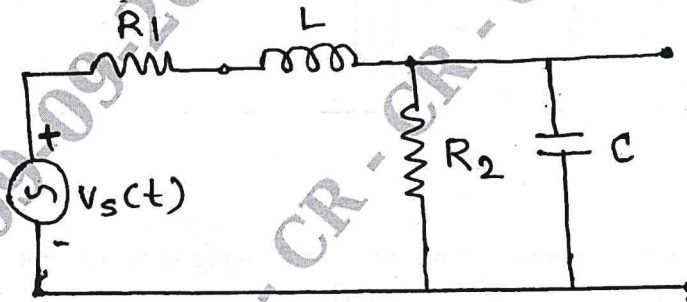


Fig Q1(b)

(07 Marks)

- c. Derive the state model of an armature controlled dc motor. (08 Marks)
- 2 a. A feedback system is characterized by the closed loop transfer function  $\frac{Y(s)}{U(s)} = \frac{(s^2 + 4)}{(s+1)(s+2)(s+3)}$ . Obtain the state model in canonical form (diagonal form). Also draw the block diagram. (08 Marks)  
 b. A feedback system is characterized by closed loop transfer function  $\frac{Y(s)}{U(s)} = \frac{(2s^2 + 6s + 7)}{(s+1)^2(s+2)}$ . Obtain the state model in Jordan canonical form. Also draw the block diagram. (08 Marks)  
 c. Discuss briefly about Linearization of state equation. (04 Marks)

- 3 a. For the system represented by the state equation

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \\ \dot{x}_3 \end{bmatrix} = \begin{bmatrix} -1 & 0 & 1 \\ 1 & -2 & 0 \\ 0 & 0 & 3 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} u(t)$$

$$y = \begin{bmatrix} 0 & 1 & 0 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix}$$

(08 Marks)

- b. What are the advantages of diagonalization techniques? (04 Marks)

- c. Given  $A = \begin{bmatrix} 0 & 2 & 0 \\ -1 & -3 & 0 \\ 0 & 2 & -4 \end{bmatrix}$ , find the eigen values and modal matrix of A. (08 Marks)

- 4 a. List the properties of state transition matrix. (04 Marks)  
 b. The state equation and initial state of a linear unforced system are given respectively by

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} 1 & 2 \\ 0 & 2 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix}; \quad \begin{bmatrix} x_1(0) \\ x_2(0) \end{bmatrix} = \begin{bmatrix} 1 \\ 2 \end{bmatrix}.$$

Obtain the state transition matrix of the system and hence obtain the solution (zero input response) (08 Marks)

- c. Check the observability of the system described by the following equations by  
 i) Kalman's test ii) Gilberts test

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \\ \dot{x}_3 \end{bmatrix} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ 0 & -2 & -3 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} u(t)$$

$$y = [3 \ 4 \ 1] \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix}$$

(08 Marks)

- 5 a. Consider a system described by the following state equation.

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \\ \dot{x}_3 \end{bmatrix} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -1 & -5 & -6 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} u(t)$$

By using the state feedback control  $U = -Kx$ , it is desired to have the closed loop poles at  $s = -1 \pm j2, s = -10$ . Determine the state feedback gain matrix by any two methods. (12 Marks)

- b. What are controllers? Explain the basic classification of controllers. Explain proportional control mode. (08 Marks)
- 6 a. What is a state observer? Explain briefly the concept of state observer. (08 Marks)  
 b. Explain the following types of non-linearities with relevant input-output characteristics.  
 i) Dead zone ii) Back lash iii) Friction. (12 Marks)
- 7 a. Explain isodine method for the construction of phase trajectory. (10 Marks)  
 b. Explain the following terms as referred to phase plane method  
 i) Singular point ii) Limit cycle. (10 Marks)
- 8 a. Define : i) Stability in the sense of Liapunov ii) Asymptotic stability (06 Marks)  
 b. Check for positive definiteness of the following quadratic form  
 i)  $v(X) = 8X_1^2 + X_2^2 + 4X_3^2 + 2X_2X_2 - 4X_1X_3 - 2X_2X_3$   
 ii)  $v(X) = 10X_1^2 + 4X_2^2 + X_3^2 + 2X_1X_2 - 2X_2X_3 - 4X_1X_3$  (08 Marks)  
 c. Explain Liapunov's direct method. (06 Marks)

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