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APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

B.Tech Degree S7 (R, S) / S7 (PT) (R) Examination December 2023 (2019 Scheme)

Course Code: EET401

Course Name: ADVANCED CONTROL SYSTEMS

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

PART A

Answer all questions, each carries 3 marks. Marks

1 Define phase variables? List the advantages of choosing phase variables for state space modelling. (3)

2 Construct the state model for a system characterized by the differential equation $\frac{d^3y}{dt^3} + 6\frac{d^2y}{dt^2} + 11\frac{dy}{dt} + 6y + u = 0.$ (3)

3 Determine the transfer function of the system with state model

$$\begin{bmatrix}\dot{x_1}\\ \dot{x_2}\end{bmatrix} = \begin{bmatrix}-2 & 1\\ 0 & -2\end{bmatrix}\begin{bmatrix}x_1\\ x_2\end{bmatrix} + \begin{bmatrix}2\\ 0\end{bmatrix}u\ ; \qquad y = [1 \quad 0]\begin{bmatrix}x_1\\ x_2\end{bmatrix}$$ (3)

4 A linear time-invariant system is characterized by homogeneous state equation $\begin{bmatrix}\dot{x_1}\\ \dot{x_2}\end{bmatrix} = \begin{bmatrix}1 & 0\\ 1 & 1\end{bmatrix}\begin{bmatrix}x_1\\ x_2\end{bmatrix}$. Compute the solution of the homogeneous equation, assuming the initial state vector, $X_0 = \begin{bmatrix}1\\ 0\end{bmatrix}$. (3)

5 Define controllability and explain Kalman's method for determining controllability. (3)

6 Explain the significance of PBH test for observability. (3)

7 Explain the different non linearities with diagram. (3)

8 What is limit cycle? How will you determine stable and unstable limit cycle using phase portrait? (3)

9 Define singular points? Explain the types of singular points. (3)

10 State the condition/s for a scalar function V(x) to be (i) positive definite (ii) negative definite and (iii) indefinite. Give one example for each. (3)

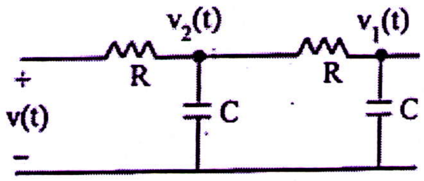
PART B

Answer any one full question from each module, each carries 14 marks.

Module I

11 a) From the basics, derive the state model of a Field controlled dc servo motor and draw the block diagram. (7)

b) Develop the state model of the electrical network shown in figure by choosing $V_1(t)$ and $V_2(t)$ as state variables. (7)



OR

12 a) A linear time invariant system is described by the following state model

$$\begin{bmatrix}\dot{x}_1\\ \dot{x}_2\\ \dot{x}_3\end{bmatrix} = \begin{bmatrix}0 & 1 & 0\\ 0 & 0 & 1\\ -6 & -11 & -6\end{bmatrix}\begin{bmatrix}x_1\\ x_2\\ x_3\end{bmatrix} + \begin{bmatrix}0\\ 0\\ 2\end{bmatrix}[u] \text{ and } y = [1 \ \ 0 \ \ 0]\begin{bmatrix}x_1\\ x_2\\ x_3\end{bmatrix}$$

. Transform this state model into a canonical state model. (10)

b) Summarize the advantages of state space method over transfer function approach. (4)

Module II

13 a) A discrete time system has the transfer function (7)

$$\frac{Y(Z)}{U(Z)} = \frac{4Z^3 - 12Z^2 + 13Z - 7}{(Z-1)^2(Z-2)}$$

Determine the state model of the system in Jordan Canonical form.

b) The system matrix A of a discrete system is given by $A = \begin{bmatrix}0 & 1\\ -2 & -3\end{bmatrix}$. Compute the state transition matrix A^k using Cayley-Hamilton theorem. (7)

OR

14 a) For a system represented by 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. (10)

b) Show that eigen values of state models are unique. (4)

Module III

15 a) Describe about state observers. (4)

b) Consider a linear system described by the transfer function (10)

$$\frac{Y(s)}{U(s)} = \frac{10}{s(s+1)(s+2)}$$

Design a feedback controller with a state feedback so that the closed loop poles are placed at -2, (-1+j1) and (-1-j1).

OR

16 a) Consider the system described by the state model $\dot{X} = AX$, y = CX where A $=\begin{bmatrix} -1 & 1 \\ 1 & -2 \end{bmatrix}$; C = [1 0]. Design a full-order state observer. The desired eigen values for the observer matrix are μ_1 = -5; μ_1 = -5; (10)

b) Explain the concept of duality referred to controllability. (4)

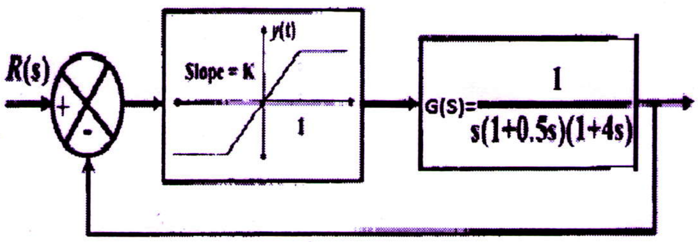
Module IV

17 a) Develop the describing function of relay nonlinearity. (6)

b) Define Describing function. Explain how describing function can be used for stability analysis of nonlinear systems. (8)

OR

18 a) Determine the value of K for an occurrence of limit cycle. Also determine the frequency, amplitude and stability of limit cycle. (10)



b) List any four properties of non linear systems. (4)

Module V

19 a) A linear second order system is described by the equation (10)

$\ddot{e} + 2\delta\omega_n\dot{e} + \omega_n^2 e = 0$, Where $\delta = 0.15$, ω_n = 1rad/sec, e(0)=1.5, and $\dot{e}(0) = 0$. Determine the singular point and state the stability by constructing the phase trajectory using the method of isoclines.

b) Differentiate between stable and unstable limit cycles. (4)

OR

20 a) Define the terms(i) stability (ii) asymptotic stability (iii) asymptotically stable in the large (iv) instability (4)

b) A second order system is represented by $\dot{X} = AX$ where A = $\begin{bmatrix} 0 & 1 \\ -1 & -1 \end{bmatrix}$. Assuming matrix Q to be identity matrix, solve for matrix P in the equation $A^TP+PA = -Q$. Use Lyapunov theorem and determine the stability of the system. Write the Lyapunov function V(x) (10)

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