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APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

Seventh Semester B.Tech Degree (S, FE) Examination May 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

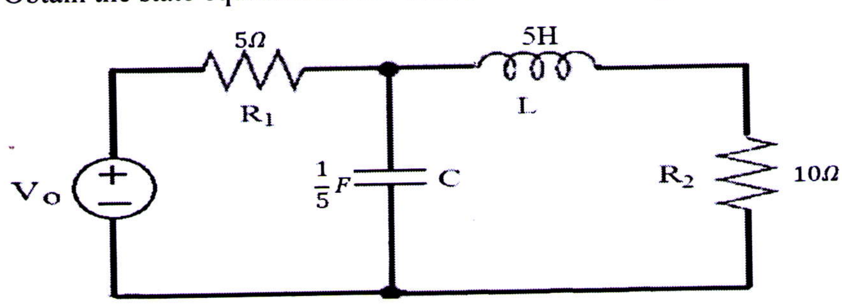
1	Summarize the advantages of state space method over transfer function approach.	(3)
2	What are phase variables? What are the advantages of choosing phase variables for state space modelling?	(3)
3	Derive a relation between state model and transfer function of LTI system.	(3)
4	Write the properties of state transition matrix of discrete time system.	(3)
5	Define controllability. Explain how can we check the controllability of a system using Kalman's test.	(3)
6	Illustrate the concept of duality referred to controllability and observability.	(3)
7	Describe the phenomenon of frequency entrainment in nonlinear systems.	(3)
8	Derive the describing function of ideal relay nonlinearity.	(3)
9	Explain what is phase trajectory and phase portrait.	(3)
10	Determine whether the given quadratic form is positive definite. $x_1^2 + 3x_2^2 + 11x_3^2 - 2x_1x_2 + 4x_2x_3 + 2x_1x_3$	(3)

PART B

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

Module I

11 a) Obtain the state equation for the network shown in Fig. (7)



b) Derive the state model of field-controlled dc servo motor. (7)

OR

12 a) Develop the state space representation of the system with differential equation $\frac{d^3y}{dt^3} + 6\frac{d^2y}{dt^2} + 11\frac{dy}{dt} + 10y = 8u(t)$. (7)

b) Determine the diagonal canonical representation of the system with transfer function (7)

$$T(S) = \frac{2(s+5)}{(s+2)(s+3)(s+4)}$$

Module II

13 a) A system is described by following state equation. Find the solution of the state equation. $\begin{bmatrix}\dot{x}_1\\ \dot{x}_2\end{bmatrix} = \begin{bmatrix}0 & 1\\ -6 & -5\end{bmatrix}\begin{bmatrix}x_1\\ x_2\end{bmatrix}$ $X(0) = \begin{bmatrix}1\\ 0\end{bmatrix}$ (7)

b) A discrete time system has the transfer function $\frac{Y(z)}{U(z)} = \frac{4z^3-12z^2+13z-7}{(z-1)^2(z-2)}$ (7)

Determine the state model of the system in phase variable form.

OR

14 a) Find the state transition matrix using Cayley-Hamilton theorem for the system matrix given below $A=\begin{bmatrix}0 & 1\\ 0 & -2\end{bmatrix}$ (8)

b) Write the transfer function of the system whose state model is given by (6)

$\dot{x} = \begin{bmatrix}-3 & 1\\ -2 & 0\end{bmatrix}x + \begin{bmatrix}0\\ 1\end{bmatrix}u$, $y = [1 \quad 0]\, x$

Module III

15 a) Check whether the given system is observable using Gilbert's test. (10)

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

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

b) What you mean by full order and reduced order observer? Explain. (4)

OR

16 a) Evaluate the controllability and observability of the state model using PBH test. (8)

$\dot{x} = \begin{bmatrix}-5 & 1\\ -8 & 1\end{bmatrix}x + \begin{bmatrix}0\\ 1\end{bmatrix}u$

$y = [2 \quad 0]\, x$

b) Illustrate the pole placement technique used for control system design. (6)

Module IV

17 a) Define Describing function. Explain how describing function can be used for stability analysis of nonlinear systems. (6)

b) Develop the describing function of relay with dead zone nonlinearity. (8)

OR

18 a) Explain any three types of non-linearities that occur in electrical systems. (6)

b) Derive the describing function of saturation nonlinearity. (8)

Module V

19 a) What are singular points? Write about the classification of singular points. (6)

b) Describe the Lyapunov's Stability criterion and investigate the stability of the following non-linear systems using Lyapunov's method. (8)

(a) $\dot{x}_1 = -3x_1 + x_2$,

(b) $\dot{x}_2 = -x_1 - x_2 - x_2^3$

OR

20 a) Determine the stability of the system described by (10)

$\dot{x} = Ax$, where A=$\begin{bmatrix} -1 & -2 \\ 1 & -4 \end{bmatrix}$

Solve for matrix P in the equation $A^TP+PA = -Q$, assuming the matrix Q to be identity matrix

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

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