Reg No.:_____ Name:_____

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

Fifth Semester B.Tech (Hons) Degree Examination December 2021 (2019 admission)

Course Code: MRT395

Course Name: ADVANCED CONTROL SYSTEMS

Max. Marks: 100 Duration: 3 Hours

PART A

(Answer all questions; each question carries 3 marks) Marks

1 Obtain the transfer function of a lag-lead compensator with the help of an electrical network. (3)

2 What is a PID controller? Explain its effects on the system performance? (3)

3 Explain the terms (i) state (ii) state vector (iii) and state space of a system. (3)

4 The system matrix of a system is given by $A=\begin{bmatrix} 0 & 1 \\ -8 & -6 \end{bmatrix}$. Determine the first element of the state transition matrix, using the properties of state transition matrix. (3)

5 Explain the different stability tests applicable to sampled data control system. (3)

6 With the help of a diagram explain the role of a state observer. (3)

7 Explain different nonlinearities with diagram. (3)

8 With a neat diagram explain how the describing function analysis is used to determine the stability of a system? (3)

9 What are singular point? Explain the types of singular point. (3)

10 Explain Liapunov direct method of stability for nonlinear systems. (3)

PART B

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

Module -1

11 a) The unity feedback control system with open loop transfer function given by $G(s)=\frac{1}{(0.2s+1)}$. Using frequency response methods, design a compensator to yield (i) the steady state error to unit ramp input less than 0.02 and (ii) Phase margin > 48^0. (10)

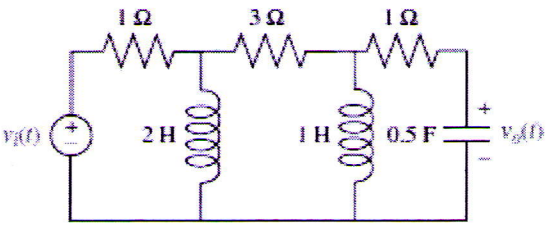
b) Explain the role of a lag compensator with the help of its pole-zero plot and frequency response characteristics. (4)

12 a) Design a suitable compensator for a unity feedback system with open loop transfer function $G(s)=\dfrac{K}{s(s+1)(s+2)(s+10)}$ to improve the steady-state error by a factor of 10 if the system is operating with a damping ratio of 0.174. (10)

b) What are the principal effect of a lead and lag compensation on a root locus? (4)

Module -2

13 a) Represent the electrical network shown in the following figure in state space, where $v_o(t)$ is the output. (6)



b) Given the system represented in state space by equations $\dot{x}=\begin{bmatrix}0 & 2\\ -3 & -5\end{bmatrix}x+\begin{bmatrix}0\\1\end{bmatrix}e^{-t}$; $y=\begin{bmatrix}1 & 3\end{bmatrix}x$; $x(0)=\begin{bmatrix}2\\1\end{bmatrix}$. (i) Solve for $y(t)$ using state-space and Laplace transform techniques. (ii) Find the eigenvalues of the system matrix. (8)

14 a) State Cayley-Hamilton Theorem. Find the state transition matrix for the system matrix $A=\begin{bmatrix}1 & 0\\ -2 & -3\end{bmatrix}$ using Cayley-Hamilton Theorem. (7)

b) Obtain the observable canonical form of the transfer function $\dfrac{C(s)}{R(s)}=\dfrac{s^2+7s+2}{s^3+9s^2+26s+24}$. (7)

Module -3

15 a) Derive the transfer function of a ZOH circuit. (4)

b) The characteristic polynomial of certain sampled data system is given by $P(z)=2z^4+7z^3+10z^2+4z+1$. Test the stability of the system using Jury's stability test. (10)

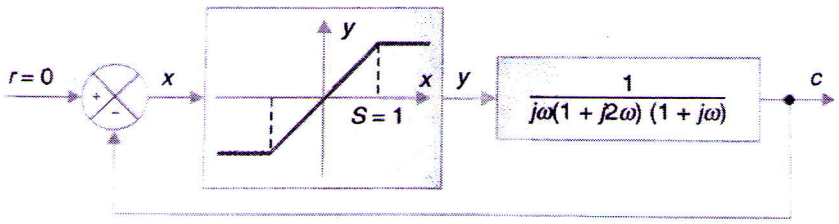
16 a) Consider a system defined by $\dot{x}=\begin{bmatrix}1 & 1\\ 1 & 2\end{bmatrix}x+\begin{bmatrix}1\\0\end{bmatrix}u$ and $y=\begin{bmatrix}1 & 0\end{bmatrix}x$. Design a feedback controller with a state feedback so that the closed loop poles are placed at -5, -6. (10)

b) Explain the concept of controllability and observability. Explain any method to check controllability and observability. (4)

Module -4

17 a) Derive the describing function of saturation with relay. (7)

b) Consider a third-order system with a saturating amplifier of figure having gain K in its linear region. Determine the largest value of gain K for the system to stay stable. What would be the frequency, amplitude and nature of the limit cycle for a gain of $K = 6$? (7)



18 a) Derive the describing function of relay with dead-zone. (7)

b) Assume that the input x to the nonlinearity is sinusoidal, i.e., $x = X\sin(\omega t)$. The output waveform of the nonlinear element is described as (7)

$$y = \begin{cases} 0 & ;0 \le \omega t \le \alpha \\ K\left(x - \dfrac{D}{2}\right) & ;\alpha \le \omega t \le (\pi - \alpha) \\ 0 & ;(\pi - \alpha) \le \omega t \le \pi \end{cases}$$

. Identify the nonlinearity and derive a describing function for the same.

Module -5

19 a) A second order system is represented by $\dot{x} = Ax$, where $A = \begin{bmatrix} 3 & -2 \\ 1 & -4 \end{bmatrix}$. (10)

Assuming matrix Q to be identity matrix, solve for matrix P in the equation $A^T P + PA = -Q$. Use Liapunov theorem and determine the stability of the system. Write the Liapunov function $V(x)$.

b) Explain different types of phase trajectories. (4)

20 a) A linear second order servo is described by the equation $\ddot{e} + 2\zeta\omega_n \dot{e} + \omega_n^2 e = 0$, (10)

where $\zeta = 0.2$, $\omega_n = 1$ rad/sec, $e(0)=1.5$, and $\dot{e}(0) = 0$. Determine the singular points and state the stability by constructing the phase trajectory using the method of isoclines.

b) Investigate the stability of the following non-linear system using Liapunov direct method (4)

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

$$\dot{x}_2 = -x_2$$

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