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Reg No.:_______________ Name:_______________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

Sixth Semester B.Tech Degree Regular and Supplementary Examination July 2021

Course Code: EE304

Course Name: ADVANCED CONTROL THEORY

Max. Marks: 100 Duration: 3 Hours

PART A

Answer all questions, each carries 5 marks.

Marks

1	Sketch the realisation of a phase lead compensator and derive its transfer function.	(5)
2	Identify the dominant poles of the unity feedback system with open loop transfer function $G(s) = \frac{168}{(s+2)(s+5)(s+15)}$.	(5)
3	Compute the solution to the state equation $\dot{x} = \begin{bmatrix} -1 & 0 \\ 0 & -2 \end{bmatrix} x,\ x(0) = \begin{bmatrix} 1 \\ 1 \end{bmatrix}$	(5)
4	Sketch the block schematic of a system controlled by a digital controller and list the additional components that appears in a system with digital controller.	(5)
5	Distinguish between inherent and intentional nonlinearities. Give examples	(5)
6	Define describing function? What is the assumption that makes the application of describing function analysis?	(5)
7	List the characteristics that are observed in nonlinear system.	(5)
8	Identify the equilibrium points for the system $\dot{x_1} = x_2,\ \dot{x}_2 = -0.5x_2 - sin(x_1)$.	(5)

PART B

Answer any two full questions, each carries 10 marks.

9	Design a suitable compensator for the unity feedback system with transfer function $G(s) = \frac{1}{s(s+1)}$ to satisfy the following specifications so that the gain cross over frequency is approximately 1 rad/s. Velocity error constant atleast $10s^{-1}$. Phase margin greater than 40^{o}.	(10)
10	Design a suitable compensator for the system $G(s) = \frac{3}{s(s+3)}$ to achieve an overshoot less than 20%, settling time less tnan 1.5s for unit step input. Velocity error constant atleast $5s^{-1}$.	(10)

11	a)	Design a P, PI and PID controller for the system with transfer function $G(s) = \frac{20}{s(s+2)(s+10)}$ by applying Zeigler-Nichols tuning method.	(6)
	b)	Draw the realisation of PID controller and explain its working.	(4)

PART C

Answer any two full questions, each carries 10 marks.

12	a)	Convert the system $\dot{x} = \begin{bmatrix} -1 & 0 \\ 0 & -2 \end{bmatrix} x + \begin{bmatrix} 1 \\ 2 \end{bmatrix} u, y = [1 \quad 1]x$ into controllable cannonical form by applying similarity transformation.	(5)
	b)	Determine the stability of the system $\dot{x} = \begin{bmatrix} -3 & 7 & 9 \\ 2 & 1 & 3 \\ -4 & -3 & -8 \end{bmatrix} x + \begin{bmatrix} 1 \\ 2 \\ 3 \end{bmatrix} u, \; y = [1 \quad 1 \quad 0]x.$	(5)
13	a)	Design a state feedback controller for the system $\dot{x} = \begin{bmatrix} 1 & 1 \\ 2 & 2 \end{bmatrix} x + \begin{bmatrix} 1 \\ 0 \end{bmatrix} u, \; y = [0 \quad 1]x$ to place the eigen values of the closed loop system matrix at -2$\pm$j2.	(5)
	b)	Derive the transfer function of the system $\dot{x} = \begin{bmatrix} -1 & 1 \\ -3 & -2 \end{bmatrix} x + \begin{bmatrix} 1 \\ 0 \end{bmatrix} u, y = [0 \quad 1]x$ when the initial state of the system is zero.	(5)
14	a)	Determine the stability of the system with characteristic equation $z^4 + 0.6z^3 + 0.63z^2 - 0.37z + 0.065 = 0$	(6)
	b)	Write the structure of state space representation of an nth ordered SISO system in digital domain and specify the dimensions of each matrix.	(4)

PART D

Answer any two full questions, each carries 10 marks.

15	Identify the stability of limit cycle exhibited by the unity feedback system with forward transfer function $G(s) = \frac{100}{s(s+2)(s+5)}$ when controlled by an amplifier (P-controller) having gain 2 and it saturates when its output reaches $\pm$2. Also determine the frequency and approximate amplitude of limit cycle.	(10)
16	Sketch the phase trajectory for the system $\dot{x_1} = x_2, \dot{x_2} = u, where\ u = \lvert -x_1 \rvert$ starting from (0,1).	(10)
17	Apply lyapunov stability to determine the stability of the autonomous system $\dot{x} = \begin{bmatrix} 5 & -12 \\ 7 & -14 \end{bmatrix} x$	(10)

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