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APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

FIRST SEMESTER M.TECH DEGREE EXAMINATION, JULY 2021

Branch: Electrical and Electronics Engineering

Stream(s):

1.Control Systems

2.Guidance and Navigational Control

3. Electrical Machines

4. Power System and Control

5. Power Control and Drives

6. Power Electronics and Drives

01EE6101: DYNAMICS OF LINEAR SYSTEMS

Duration: 3 hrs — Max. Marks: 60

Answer any two full questions from each PART

Limit answers to the required points.

PART A (Modules I and II)

1. (a) Explain how steady state accuracy varies with the type of a system for different input signals. (4)

   (b) Design a compensating network for the system $G(s) = \frac{K}{(s(0.2s+1)(0.01s+1))}$ so that its phase margin is atleast 40^0 and the steady state error will not exceed 2% of the final value. (5)

2. (a) Derive the overall transfer function of a lag lead compensator network in pole-zero form. (4)

   (b) The forward transfer function of a unity feedback system is $G(s) = \frac{K}{(s(s+3)(s+5))}$. Design a suitable lag compensator so that the system will have a damping ratio of 0.5 and the steady state error will be limited to 0.125 for a unit ramp input. (5)

3. (a) Explain the need of anti-windup circuit in an integral controller. (3)

   (b) Consider a unity feedback system with an open loop transfer function $G(s) = \frac{25}{(s+1)(s+2)(s+3)}$. Design a PID controller, so that the phase margin of the system is 50^0 at a frequency of $2rad/sec$ and the steady state error for unit ramp input is 0.1 (6)

PART B (Modules III and IV)

4. (a) Obtain the controller canonical representation for the system whose transfer function is given by $\frac{20s^2+40s+100}{s^4+3s^3+5s^2+6s+7}$. (4)

   (b) A regulator system has a plant transfer function given by $G(s) = \frac{10}{(s+1)(s+2)(s+3)}$ Design a state feedback controller such that the closed loop poles are located at $-10, -2 \pm j2\sqrt{3}$. (5)

5. (a) Define the terms reachability, constructability and stabilizability. (3)

(b) Consider the system represented by (6)

$$\dot{x} = \begin{pmatrix} 1 & 1 & 0 \\ 0 & 1 & 1 \\ 0 & 0 & -1 \end{pmatrix} x + \begin{pmatrix} 0 \\ 1 \\ 0 \end{pmatrix} u$$

Check the controllability of the system and comment on the stabilizability of the system using controllable decomposition procedure.

6. (a) What is the significance of a observability gramian matrix. Derive the expression for the observability gramian matrix of a linear system. (4)

(b) Comment on the controllability of the system, $\dot{x} = Ax + Bu$ where (5)

$$A = \begin{pmatrix} 1 & 0 \\ 0 & 2 \end{pmatrix}, \quad B = \begin{pmatrix} e^t \\ e^{2t} \end{pmatrix}$$

with $x_0 = \begin{pmatrix} x_{10} \\ x_{20} \end{pmatrix}$ and obtain the general solution.

PART C(Modules V and VI)

7. (a) Explain the different companion forms for MIMO systems. (4)

(b) Consider the system $\dot{x} = Ax + Bu$, $y = Cx$ where, (8)

$$A = \begin{pmatrix} 0 & 0 & -6 \\ 1 & 0 & -11 \\ 0 & 1 & -6 \end{pmatrix}, \quad B = \begin{pmatrix} 1 \\ 0 \\ 0 \end{pmatrix}, \quad C = \begin{pmatrix} 0 & 0 & 1 \end{pmatrix}$$

Design a reduced order observer so that the observer poles are at $s = -2 \pm j3.46$

8. (a) Derive the transfer function of a combined observer controller configuration. (4)

(b) Consider the system $\dot{x} = Ax + Bu$, $y = Cx$ where, (8)

$$A = \begin{pmatrix} 1 & 0 \\ 0 & 0 \end{pmatrix}, \quad B = \begin{pmatrix} 1 \\ 1 \end{pmatrix}, \quad C = \begin{pmatrix} 2 & -1 \end{pmatrix}$$

Using transfer function approach design a full order observer-controller that makes the estimation error to decay at least as fast as e^{-10t} and the closed loop poles at $s = -1 \pm j1$

9. (a) Explain in detail the optimality criteria for choosing observer poles. (4)

(b) Given the system $\dot{x} = Ax + Bu$, $y = Cx$ where (8)

$$A = \begin{pmatrix} 1 & 0 & 0 \\ 0 & -1 & 0 \\ 0 & 0 & 2 \end{pmatrix} \textit{ and } B = \begin{pmatrix} 1 & 0 \\ 0 & 1 \\ 0 & 0 \end{pmatrix} \quad C = \begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 1 \end{pmatrix}$$

Obtain the observable canonical form realization.