B

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APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

FIRST SEMESTER M.TECH DEGREE EXAMINATION, DECEMBER 2017

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

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.

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PART A *(Modules I and II)*

1. (a) Explain the effects of proportional and derivative gains of the PID controller on the system performance. (3)

   (b) Realize a suitable compensator using operational amplifiers for a unity feedback system whose open loop transfer function is $G(s) = \frac{1.06}{(s(s+1)(s+2))}$, so as to obtain a static velocity error constant $K_v \geq 5sec^{-1}$ without appreciably changing the location of the original closed loop poles. (6)

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

   (b) Design a phase lead compensator for the system whose transfer function is $G(s) = \frac{K}{(s(s+1))}$, to satisfy the following specifications. (6)

   - The phase margin of the system must be greater than 45^0.
   - Steady state error for a unit step input should be less than $\frac{1}{15}$ deg per deg/sec of the final output velocity.
   - The gain cross over frequency of the system must be less than 7.5 rad/sec.

3. (a) Realize a PID controller using operational amplifiers. (3)

   (b) Design a suitable compensator for the system with an open loop transfer function $G(s) = \frac{10^4}{(s+100)^2}$, to meet the following specifications, $e_{ss} \leq 10\%$, $\zeta = 0.707$, and $t_s < 40ms$ (6)

PART B *(Modules III and IV)*

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

   (b) Obtain the control signal if it exists, to transfer the system states from an initial value $x_0 = \begin{pmatrix} 0 \\ 0 \end{pmatrix}$ to a final state $x^* = \begin{pmatrix} x_1^* \\ x_2^* \end{pmatrix}$ for the system $\dot{x} = Ax + Bu$ where (5)

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

5. (a) Prove that a system is completely controllable if and only if its controllability matrix is full rank. (4)

   (b) Solve $\dot{x}(t) = A(t)x(t)$ where (5)

$$A(t) = \begin{pmatrix} 1 & 0 \\ 0 & 2t \end{pmatrix}$$

6. (a) Prove that zeros of a closed loop transfer function are unaffected with a state feedback controller. (4)

   (b) Determine the controllable and uncontrollable modes of the system represented by (5)

$$\dot{x} = \begin{pmatrix} -2 & 1 \\ 1 & -2 \end{pmatrix} x + \begin{pmatrix} 1 \\ 1 \end{pmatrix} u$$

$$y = \begin{pmatrix} 0 & 1 \end{pmatrix} x$$

   Also obtain the controllable sub realization of the system.

PART C*(Modules V and VI)*

7. (a) Explain the optimality criterion for choosing observer poles. (4)

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

$$A = \begin{pmatrix} 0 & 1 \\ 20.6 & 0 \end{pmatrix}, \quad B = \begin{pmatrix} 0 \\ 1 \end{pmatrix}, \quad C = \begin{pmatrix} 1 & 0 \end{pmatrix}$$

   By using state feedback control technique it is desired to have the closed loop poles at $s = -1.8 \pm j2.4$. Assume that the desired eigen values of the observer matrix are $\mu_1, \mu_2 = -8$. Design an observer-controller.

8. (a) With the help of a suitable example explain any one companion form for MIMO systems. (4)

   (b) Explain the direct transfer function design procedure of observer-controller. (8)

9. (a) Show that in an observed state feedback control system, the observer design and the state feedback design can be carried out independently. (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 $s = -2 \pm j3.46$.

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