Total number of printed pages – 7

B. Tech

CPEE 5305

Sixth Semester Examination – 2008

ADVANCED CONTROL SYSTEM ENGINEERING

Full Marks – 70

Time : 3 Hours

Answer Question No. 1 which is compulsory and any ***five*** *from the rest.*

The figures in the right-hand margin indicate marks.

1. Answer the following questions : 2×10

(a) What is the importance of eigen values of a system ? Given a system matrix

$$A = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -6 & -11 & -6 \end{bmatrix}.$$

Find its eigen values.

P.T.O.

(b) What are the eigen vectors ? How these are useful in diagnonalising a system matrix ?

(c) What are the different models used to describe a discrete-time system ?

(d) State Shanon's sampling theorem. What is its importance ?

(e) Draw the frequency response characteristics of a zero-order hold device.

(f) What is the condition of BIBO stability for Discrete-time system ?

(g) What is condition for output controllability ?

(h) Define Describing Function.

(i) What is limit cycle ?

(j) What is signal stabilization ?

2. (a) Prove that eigen values remain invariant under the similarity transformation. 5

(b) For the given system $\dot{X}(t) = AX(t) + Bu(t)$ where $A = \begin{bmatrix} 0 & 1 \\ -2 & -3 \end{bmatrix}$ and $B = \begin{bmatrix} 0 \\ 1 \end{bmatrix}$ obtain the states when u(t) is an unit step input. 5

3. (a) Let the pulse train {f(k)} has the z-transform F(z). Prove using the definition of the z-transform that $z\{f(k+1)\} = zF(z) - zf(0)$. Use this result and further prove that $z\{f(k+2)\} = z^2F(z) - z^2f(0) - zf(1)$. 5

(b) Consider the difference equation :

$y(k+2) - 1.3\,y(k+1) + 0.4y(k) = u(k+1) - 0.4\,u(k)$

Determine the corresponding :

(i) state-space representation

(ii) pulse transfer function

Is the system stable ? 5

4. Consider the second-order system :

$$\dot{X}(t) = \begin{bmatrix} 2 & 3 \\ -1 & 4 \end{bmatrix} X(t) + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u(t)$$

and $Y(t) = [0 \quad 1]\, X(t)$.

The desired characteristic equation of the observer is given by

$\phi(s) = s^2 + 2\xi\omega_n s + \omega_n^2$ where $\xi = 0.8$ and $\omega_n = 10$.

Design a full-state observer such that the desired performance specifications for the observer are satisfied using. 10

(i) Comparison of coefficients methods

(ii) Ackermann's formula

(iii) Derive the formulas used in step (i) and (ii).

5. Design a state feedback control law for the plant given by

$$\dot{X}(t) = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -1 & -5 & -6 \end{bmatrix} X(t) + \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} u(t)$$

such that the performances specifications can be met by placing the poles at the desired locations as follows : 10

$s_1 = -2 + j4$, $s_1 = -2 - j4$ and $s_3 = -10$ using three methods.

(a) Comparison of coefficients

(b) Ackermann's formuls

(c) Using Controller Canonical transformation form of the State-space representation

(d) Derive the formulas used in steps (a), (b) and (c).

6. (a) Given a state space description of a system in continuous system $\dot{X}(t) = AX(t) + Bu(t)$. Discretize the state equations. 5

(b) Discretize the given system with an sampling period of 2 seconds and obtain the discrete-time state space model of the system. 5

$$\dot{X}(t) = \begin{bmatrix} 0 & 1 \\ 0 & -2 \end{bmatrix} \cdot X(t) + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u(t).$$

7. (a) Derive the condition for complete state controllability of a continuous system. 5

(b) Verify whether the following system is completely state controllable : 5

$$\dot{X}(t) = \begin{bmatrix} 1 & 1 \\ 2 & -1 \end{bmatrix} X(t) + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u(t).$$

8. (a) Draw the phase-plane portrait of the system. 5

$$\dot{x}_1 = x_1 + x_2$$

$$\dot{x}_2 = 2x_1 + x_2$$

(b) Derive the describing function of a dead-zone and saturation nonlinearity. 5