

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 x 10

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

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

Find its eigen values.

(b) What are the eigen vectors ? How these are useful in diagonalising 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 $A = \begin{bmatrix} 0 & 1 \\ -4 & -3 \end{bmatrix}$ and $B = \begin{bmatrix} 0 \\ 1 \end{bmatrix}$ obtain the states when $u(t)$ is a 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 :

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

Determine the corresponding :

- (i) state-space representation
- (ii) pulse transfer function

Is the system stable ?

5

4. Consider the second-order system :

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

$$\text{and } Y(t) = [0 \ 1] X(t).$$

The desired characteristic equation of the observer is given by

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

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

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

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

$s_1 = -2 + j4$, $s_2 = -2 - j4$ and $s_3 = -10$ using three methods.

- Comparison of coefficients
- Ackermann's formula
- Using Controller Canonical transformation form of the State-space representation
- 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 a sampling period of 2 seconds and obtain the discrete-time state space model of the system. 5

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

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

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