Sem-V / INST / CBGS / CSD / 27-05-16

Control System Design

Q.P. Code : 31178

(3 Hours) [Total Marks :80

N.B. : (1) Question No 1 is **compulsory**.

(2) Attempt any **three** questions from remaining **five** questions.

(3) Assume suitable data if needed.

(4) **Figures** to the **right** indicate **full** marks.

1. Attempt the following: 20

(a) Obtain a state space model of series R-L-C circuit.

(b) Explain the cascade and feedback compensators.

(c) Define controllability and observability.

(d) Describe n^{th} order system having m inputs and p outputs in state space form. State the dimensions of all matrices appropriately. What will be transfer function matrix for the same system?

2. (a) Give the steps in lag compensator design using Bode plot. 10

(b) Obtain the response of the system which is represented by the following state equation with given state vector : 10

$$\dot{x}(t) = \begin{bmatrix} 1 & 0 \\ 1 & 1 \end{bmatrix} x(t) + \begin{bmatrix} 1 \\ 0 \end{bmatrix} u(t)$$

$$x(0) = [1 \quad 0]^T$$

3. (a) Construct the state model for a system described by the following differential equation 10

(i) $\frac{d^2y}{dt^2} + 5\frac{dy}{dt} + 6y = \frac{du}{dt} + u$

(ii) $\frac{d^3y}{dt^3} + 4\frac{d^2y}{dt^2} + 2y = \frac{du}{dt} + u$

(b) Open loop transfer function of the uncompensated system is 10

$G(s) = \frac{k}{s(s+1)(s+2)}$. Design the lead compensator to meet the following specifications, damping ratio $\xi = 0.7$, undamped natural frequency $\omega_n = 1.5$ rad/sec and $k_v \leq 5$.

4\. (a) Check whether the following systems are completely controllable and observable. **15**

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

$y(t) = \begin{bmatrix} 1 & 0 \end{bmatrix} x(t)$

$\dot{x}(t) = \begin{bmatrix} 0 & 0 & 0 \\ 1 & 0 & -3 \\ 0 & 1 & -4 \end{bmatrix} x(t) + \begin{bmatrix} 40 \\ 10 \\ 0 \end{bmatrix} u(t)$

(ii) $y(t) = \begin{bmatrix} 0 & 0 & 1 \end{bmatrix} x(t)$

(b) Open loop transfer function of the plant is $G(s) = \frac{1}{s(s+1)(s+5)}$. Obtain the values of tuning parameters K_p, T_d and T_i using Zigler-Nichols method of PID tuning. **10**

5\. (a) Obtain the state feedback matrix K for the system of equation. **10**

$\dot{x}(t) = \begin{bmatrix} 0 & 1 \\ -2 & -5 \end{bmatrix} x(t) + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u(t)$

$y(t) = \begin{bmatrix} 1 & 0 \end{bmatrix} x(t)$

to place closed loop poles at $-1.5 \pm 1.5\,j$

(b) What is state transition matrix (STM). List the properties of STM. Compute the STM for a system matrix $A = \begin{bmatrix} 0 & 1 \\ -1 & -3 \end{bmatrix}$. **10**

6\. (a) The open loop transfer function of a unity feedback system is $G(s) = K/s^2$. Design a compensator such that the dominant closed loop poles are located at $s = -0.5 \pm 1.5j$. **10**

(b) Obtain transfer function of the following system. **10**

$\begin{bmatrix} \dot{x}_1(t) \\ \dot{x}_2(t) \end{bmatrix} = \begin{bmatrix} -1 & 0 \\ 0 & -2 \end{bmatrix} \begin{bmatrix} x_1(t) \\ x_2(t) \end{bmatrix} + \begin{bmatrix} 1 \\ 1 \end{bmatrix} u(t)$

$y(t) = \begin{bmatrix} 1 & 1 \end{bmatrix} x(t)$
