B.E.-Instrumentation Engineering Sem VI

IN603 - Control System Design

P. Pages : 2 **GUG/S/18/5388**

Time : Three Hours Max. Marks : 80

Notes :
1. Same Answer book must be used for all questions.
2. All questions carry marks as indicated.
3. Due credit will be given to neatness and adequate dimensions.
4. Assume suitable data wherever necessary.
5. Illustrate your answers wherever necessary with the help of neat sketches.

1. A unity feedback system with open loop transfer function is given as **16**

$$G(s) = \frac{K}{s^2 (s+1.5)}$$

Design a cascade lead compensator to meet following specifications.

i) Settling time, $t_s < 5\,\text{sec}$

ii) Damping ratio, $\xi = 0.45$

iii) Undamped natural frequency $w_n = 2.2\ \text{rad/sec}$.

OR

2. a) Give the realization of lead compensator by using electrical network. Also derive its frequency of maximum phase lead and value of maximum phase lead. **10**

b) Differentiate in between cascade compensation and feed back compensation. **6**

3. Consider unity feedback system with open loop transfer function is **16**

$$G(s) = \frac{K}{s(0.1\,s+1)\,(0.2\,s+1)}$$

Design a phase lag compensator to meet the following specifications.

i) Velocity error constant $K_v = 30$

ii) Phase margin $\phi_m \ge 50^\circ$

iii) Bandwidth $w_b = 12\text{rad/sec}$

OR

4. a) Illustrate the steps required to design lag compensator using Bode plot. **6**

b) The open loop transfer function of a control system is, **10**

$$G(s)H(s) = \frac{10}{s(1+0.5s)\,(1+0.1s)}$$

Draw the bode plot and determine

i) gain cross over frequency. ii) Phase margin iii) gain margin

5. a) Test the controllability of the following by both Gilbert's and Kalman's method. **10**

$$\left|\begin{array}{ccc} \dot{} & 4 & 3 \\ \dot{} & 20 & 16 \\ \dot{} & -25 & -20 \end{array}\right| \left|\begin{array}{c} x_1 \\ x_2 \\ x_3 \end{array}\right| + \left|\begin{array}{c} -1 \\ 3 \\ 0 \end{array}\right| u$$

b) Determine controllability and observability of the following system **6**

$$A = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -6 & -11 & -6 \end{bmatrix}; \; b = \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} \quad c = [4 \quad 5 \quad 1]$$

OR

6. a) A control system has a state model **12**

$$\dot{x} = \begin{bmatrix} 1 & 0 & 0 \\ & 2 & 0 \\ 0 & 0 & -3 \end{bmatrix} x + \begin{bmatrix} 1 \\ 1 \\ 1 \end{bmatrix} y \quad y = [1 \quad 1 \quad 1] x$$

i) Comment on stability of system.

ii) If the system is not stable, is it possible to stabilize the system using state feedback compensator.

iii) Obtain suitable feedback gain matrix, so that eigen values of the close loop system are located at –1, –2, –3.

b) Explain state observer in short. **4**

7. a) A unity feedback position control system has a forward path transfer function. **10**

$$G(s) = \frac{K}{s}$$

for unit step input, compute the value of 'K' that minimizes ISE.

b) What are performance indices? Discuss significance of ISE as the optimization criteria. **6**

OR

8. a) Differentiate in between optimal and non optimal control system. **6**

b) Using ISE as an objective function how the gain setting of the PID controllers can be optimized? Explain in detail using Parseval's theorem. **10**

9. Obtain the describing function for **16**

i) Ideal relay ii) Relay with dead zone.

OR

10. a) Consider the nonlinear system **8**

$\dot{x}$

$\dot{x}$ x_1^2x2

Identify the singular point of linearized system about the origin.

b) Discuss Lyapunov's stability criterion. **8**

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