B.E. Instrumentation Engineering (Model Curriculum) Semester-V

IN505M - Control System Design

P. Pages : 3 **GUG/W/23/14025**

Time : Three Hours * 7 6 1 2 * Max. Marks : 80

Notes :
1. All questions carry as indicated marks.
2. Due credit will be given to neatness and adequate dimensions.
3. Illustrate your answers wherever necessary with the help of neat sketches.

1. Consider a plant with transfer function $G(s)=\frac{4}{s(s+0.5)}$. Design a cascade lag-lead compensator to meet following specifications. **16**

i) amping factor, $\xi = 0.5$

ii) Undamped natural frequency, $W_n = 5$ rad/sec.

iii) Velocity error constant, $K_v = 80$ sec^{-1}.

OR

2. a) Give the realization of lead compensator by using electrical network. Also derive its frequency of maximum phase lead and value of the maximum phase lead. **8**

b) Write a short note on. **8**

i) Noise problem in lead/lag circuit.

ii) Effects of lead compensator.

3. a) Design a suitable lag compensator for the system whose transfer function is $G(s)=\frac{k}{s(s+2)(s+20)}$ to satisfy the following specifications. **16**

i) Velocity error constant $K_v = 20\sec^{-1}$

ii) Phase margin $\geq 35^o$

OR

4. a) Design phase lead compensator for the system whose transfer function is $G(s)=\frac{k}{s(s+1)}$ to satisfy the following specifications. **16**

i) Steady state error for unit ramp input $\leq 1/15$

ii) The gain phase margin of system $\geq 45^o$

iii) Steady crossover frequency of system must be less than 7.5 rad/sec.

5. a) Explain design procedure of PD/PI/PID controller in frequency domain. **8**

b) Consider a unity feedback system with open loop transfer function, **8**

$G(s) = \frac{5}{s(s+0.5)(s+1)}$. Design PD controller so that the phase margin of the system is 30º at frequency of 1.2 rad/sec.

OR

6. a) Consider a unity feedback system with open loop transfer function, **8**

$G(s) = \frac{75}{(s+1)(s+3)(s+8)}$ Design PID controller to satisfy the following specifications.

a) The steady state error for ramp input should be less than 0.08.

b) Damping ratio =0.8

c) Natural frequency of oscillation =2.5 rad/sec.

b) Consider a unity feedback system with open loop transfer function, **8**

$G(s) = \frac{100}{(s+1)(s+2)(s+5)}$. Design PI controller so that the phase margin of the system is 60º at frequency of 0.5 rad/sec.

7. a) Construct a state model for a system characterized by the differential equation. **8**

$\frac{d^3y}{dt^3} + 6\frac{d^2y}{dt^2} + 11\frac{dy}{dt} + 6y + u = 0$.

b) Derive the transfer function from state space model. **8**

OR

8. a) Give that $A = \begin{bmatrix} 1 & 0 \\ 1 & 1 \end{bmatrix}$ find state transition matrix. **8**

b) Obtain the state model of the electrical network shown in fig. 1 by choosing minimal no. of state variables. **8**

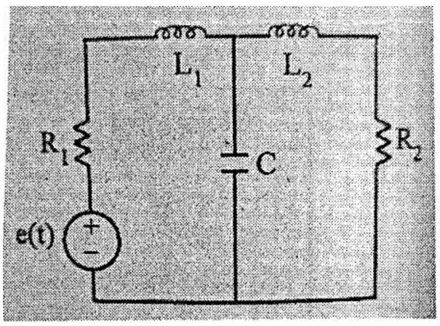

Fig.1

9. a) For the system represented by state model $\dot{x} = \begin{bmatrix} 1 & -1 \\ 0 & 1 \end{bmatrix} x + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u.$ **8**

Place the closed loop poles at $S = 3 \pm j$ by suitable state feedback gain matrix K. Determine K.

b) Design state observer for the system with state model $\dot{x} = \begin{bmatrix} 1 & -1 \\ 0 & 1 \end{bmatrix} x + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u, y = \begin{bmatrix} 1 & 0 \end{bmatrix} x$. **8**

Such that eigen values of observer error dynamics are $\mu_1 = 1 + j, \mu_2 = 1 - j$.

OR

10. a) Design a type 1 servo system when the plant transfer function has an integrator. Assume that the plant transfer function is given as $\frac{Y(s)}{U(s)} = \frac{1}{s(s+1)(s+2)}$. The desired closed loop poles are $S = 2 \pm j2\sqrt{3}$ and S = -10. **8**

b) What are the performance indices? List different types of performance indices. **8**

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