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

IN505M - Control System Design

P. Pages : 2 **GUG/S/23/14025**

Time : Three Hours Max. Marks : 80

* 2 7 6 2 *

Notes : 1. All questions carry as indicated marks.
2. Due credit will be given to neatness and adequate dimensions.
3. Assume suitable data wherever necessary.
4. Diagrams and Chemical equation should be given wherever necessary.

1. The open loop T.F. for unity closed-loop system given as: $G(s) = \frac{100}{s(s+9)}$. It is desired to have a damping factor $\zeta = 0.6$, natural undamped frequency $\omega_n = 12 \text{ rod/sec}$ and static velocity error constant $kv = 10.30 \sec^{-1}$. Design a lead compensator to satisfy above specifications. **16**

OR

2. a) Obtain the T. F. of "Op-Amp based electronic lag compensator". **8**

b) Write a short note on "Effects of addition of poles & zero's" **8**

3. The open loop T. F. for unity closed-loop system is given as $G(s) = \frac{1.06}{s(s+1)\,(s+2)}$. It is desired to have static velocity error constant $kv = 5\sec^{-1}$, without appreciably changing the location of dominant poles. Design a lag compensator to satisfy above specifications. **16**

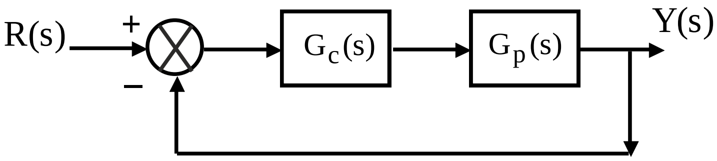
OR

4. a) Obtain a T. F. of "Mechanical type of Lead Compensator". **8**

b) Assume $k_C = 1$, $T = 1$ & $\alpha = 0.1$, Draw a Bode plot of Lead compensator. **8**

5. a) Derive the T.F. of "Electronic PI controller using Op-Amp. **8**

b) Derive the formula for $G_c(s)$ for system as shown in below figure, using direct synthesis. **8**

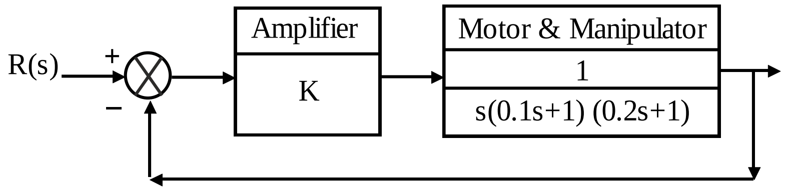


Also obtain $G_c(s)$ & its PID settings k_P, k_I, k_D;

If $G_P(s) = \frac{1}{(1+3s)\,(1+4s)}$, $Q(s) = \frac{1}{(1+10s)}$.

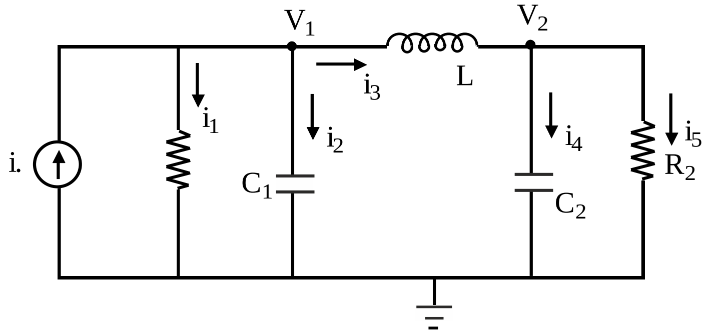
6. a) Explain how "PID controller introduces one pole at origin and two zero's that can be located any where in the left-hand s-plane". **8**

b) Consider the figure below, which uses a DC motor manipulator for laser. The amplifier gain "K" must be adjusted so that steady-state error for ramp input $r(t) = A \cdot t$ (where A = 1mm/s), is less than or equal to 0.1mm, while stable response is maintained. **8**



7. a) Explain the concept of "State space". Also define the terms state, state variables, state vector & state space. **8**

b) Obtain the state-space representation of following RLC network **8**



OR

8. a) Explain Properties of "State transition matrix (STM)" with proofs. **8**

b) Obtain the time response of the system described by: **8**

$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ -1 & -2 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 1 \\ -2 \end{bmatrix} u$ and $y = \begin{bmatrix} 0 & 1 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$ When u = 1 for $t \geq 0$ and

$\begin{bmatrix} x_1(0) \\ x_2(0) \end{bmatrix} = \begin{bmatrix} 0 \\ 1 \end{bmatrix}$

9. a) Define the controllability and derive the condition for controllability. **8**

b) Consider the system described by: **8**

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \\ \dot{x}_3 \end{bmatrix} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 0 \\ -6 & -11 & 6 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} u \text{ and } y = \begin{bmatrix} 1 & 0 & 0 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix}$$

By using state feedback control $u = -KX$, it is desired to have closed-loop poles at $s_1 = -2 + j2\sqrt{3}$, $s_2 = -2 - j2\sqrt{3}$ & $s_3 = -6$ Determine state feedback gain matrix K.

OR

10. a) Define the observability and derive the condition for observability. **8**

b) Consider the system described by: **8**

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \\ \dot{x}_3 \end{bmatrix} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -1 & -5 & -6 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} u$$

By using state feedback control $u = -KX$, it is desired to have closed-loop poles at $s_1 = -2 + j4$, $s_2 = -2 - j4$ & $s_3 = -10$. Determine state feedback gain matrix K.

****