B.E. Instrumentation Engineering (MODEL CURRICULUM) Sem-V

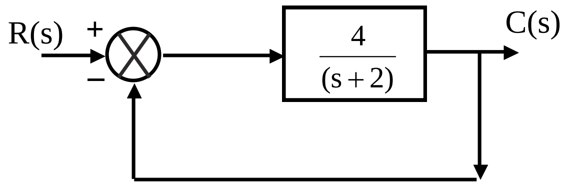
IN505M : Control System Design

P. Pages : 2 **GUG/W/22/14025**

Time : Three Hours Max. Marks : 80

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

1. Consider the system shown below. **16**



Design a Lead compensator to satisfy following specifications.

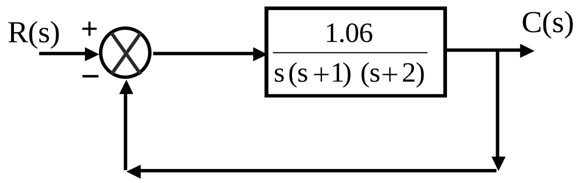
1) Damping factor $\xi = 0.5$

2) Undamped natural frequency $w_n = 4 \,{}^{rad}\!/_{sec}$

3) Velocity error constant $k_v = 5\sec^{-1}$

OR

2. Consider the system shown below. **16**



Design a Lag compensator to satisfy following specifications.

1) Damping ratio $\xi = 0.491$

2) Undamped natural frequency $w_n = 0.673 \,{}^{rad}\!/_{sec}$

3) Velocity error constant $k_v = 5.12\sec^{-1}$.

3. The given open loop T.F. is : $G(s) = \dfrac{4}{s(s+2)}$. Design a lead compensator for closed – loop system so that static velocity error constant $k_v = 20\sec^{-1}$, phase margin is at least 50°, and gain margin is at least 10 dB. **16**

OR

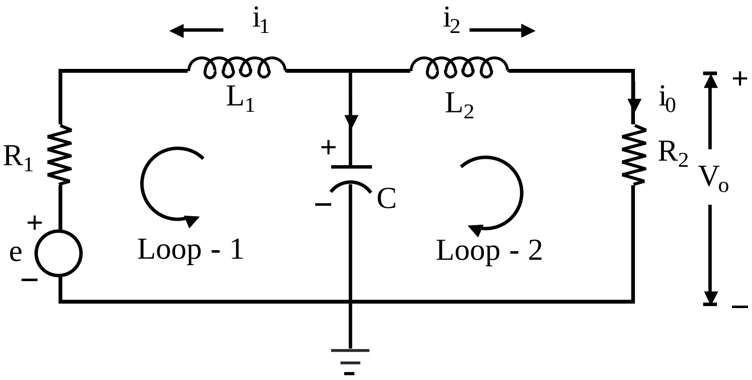
4. The given open – loop T.F. is : $G(s) = \dfrac{1}{s(s+1)(0.5s+1)}$. Design a lag compensator for closed – loop system so that static velocity error constant k_v is $5\sec^{-1}$, phase margin is at least 40°, and gain margin is at least 10 dB. **16**

5. a) Explain designing of PID controller using frequency response approach. **8**

b) A forward path T.F. of unity closed – loop system is $G(s) = \dfrac{100}{(s+1)(s+5)(s+10)}$, required $e_{ss} \le 0.08$ for a unit ramp and phase margin > 50° at a frequency of $6 \,{}^{rad}\!/_{sec}$. Determine a PID controller. **8**

OR

6.	a)	Derive the T.F. of electronic PI controller using Op-Amp.	**8**
	b)	Discuss the Ziegler – Nicholes PID controller tuning methods.	**8**
7.	a)	Obtain the state – space representation of Armature – controlled DC motor.	**8**
	b)	Obtain state – space representation of RLC network given below.	**8**



OR

8. a) Derive the solution of Homogeneous state equation. **8**

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

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

when $u=1$ for $t\ge 0$ and $\begin{bmatrix}x_1(0)\\ x_2(0)\end{bmatrix}=\begin{bmatrix}1\\ 0\end{bmatrix}$.

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

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

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

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 matrix K.

OR

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

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

$$\begin{bmatrix}\dot{x}_1\\ \dot{x}_2\\ \dot{x}_3\end{bmatrix}=\begin{bmatrix}0 & 1 & 0\\ 0 & 0 & 1\\ -2 & -3 & -5\end{bmatrix}\begin{bmatrix}x_1\\ x_2\\ x_3\end{bmatrix}+\begin{bmatrix}0\\ 0\\ 1\end{bmatrix}u \;\&\; y=\begin{bmatrix}1 & 0 & 0\end{bmatrix}\begin{bmatrix}x_1\\ x_2\\ x_3\end{bmatrix}$$

By using state feedback control $u=KX$, it is desired to have closed-loop poles at $S_1=-4.80+j3.60, S_2=-4.80-j3.60, S_3=-4.80$. Determine state feedback matrix.

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