B.E. Electrical (Electronics & Power) Engineering (Model Curriculum) Semester-VII

PEC-4-2 / FE102-2 - Control System Design

P. Pages : 3 **GUG/W/23/14241**

Time : Three Hours * 7 8 0 6 * Max. Marks : 80

Notes :
1. All questions carry equal marks.
2. Due credit will be given to neatness and adequate dimensions.
3. Assume suitable data wherever necessary.
4. Illustrate your answers wherever necessary with the help of neat sketches.
5. Use of slide rule, Logarithmic tables, Steam tables, Mollier's chart, Drawing instruments, Thermodynamic tables for moist air, Psychrometric charts and Refrigeration charts is permitted.
6. Use of Non-programmable calculator is permitted.

1. a) Derive the transfer function of lag compensator and the expression for maximum value of phase lag. **8**

b) Draw and explain the bode plot of lag lead compensator. **8**

OR

2. a) Draw & explain the bode plot of lag-lead compensator. State the condition when lag-lead compensator are used. **8**

b) Derive the transfer function of a passive lead network. State its advantages & disadvantages. **8**

3. a) What is state transition matrix? Also describe its properties and computation of same. **8**

b) Derive the expression for the solution of non-homogeneous state equation. **8**

OR

4. a) Obtain the transfer function of the system defined by following state model- **8**

$$\begin{bmatrix} \dot{X}_1 \\ \dot{X}_2 \\ \dot{X}_3 \end{bmatrix} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -5.008 & -25.1026 & -5.03241 \end{bmatrix} \begin{bmatrix} X_1 \\ X_2 \\ X_3 \end{bmatrix} + \begin{bmatrix} 0 \\ 25.04 \\ -121.005 \end{bmatrix} [U]$$

$$\& \ [Y] = [1 \quad 0 \quad 0] \begin{bmatrix} X_1 \\ X_2 \\ X_3 \end{bmatrix}.$$

b) For the system matrix. **8**

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

Find model matrix $[M]$ and comment on stability of systems.

5. a) State the advantages & disadvantages of state variable feedback compensation. **6**

b) Consider the system. **10**

$$\begin{bmatrix}\dot{X}\end{bmatrix}=\begin{bmatrix}1 & 1 & 0\\ 0 & -2 & 1\\ 0 & 0 & -1\end{bmatrix}\begin{bmatrix}X\end{bmatrix}+\begin{bmatrix}0\\ 1\\ -2\end{bmatrix}\begin{bmatrix}U\end{bmatrix}$$

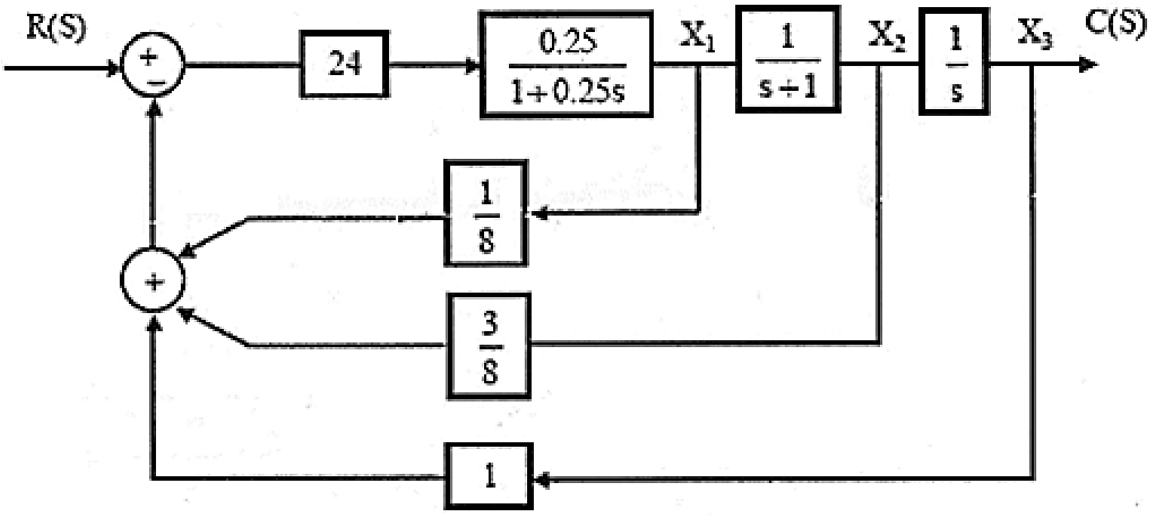
$$\begin{bmatrix}Y\end{bmatrix}=\begin{bmatrix}1 & 0 & 0\end{bmatrix}\begin{bmatrix}X\end{bmatrix}$$

i) Determine the stability of the system.

ii) Comment on controllability and observability of the system.

OR

6. a) Examine controllability and observability of the system shown in below fig. **8**



b) The system is described by the following state model. **8**

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

$$y=\begin{bmatrix}0 & 1 & 3\\ 0 & 2 & 4\end{bmatrix}x$$

Comment on the controllability and observability of the system.

7. a) Explain how a stable system may have an unstable limit cycle. **8**

b) Define and explain the following stabilities in reference to phase plane analysis of non-linear system- **8**

i) Stable system

ii) Asymptotically stable system

iii) Globally asymptotically stable system.

OR

8. a) Explain the significance of the "singular points" in the phase plane method of analysing non-linear system. **4**

b) Construct the phase trajectory using δ method for system described by- **12**

$3\ddot{x} + 12|x|\dot{x} + 12x = 0$

Given : x(0) = 1 : x(0) = 0

9. a) For the optimal control to find performance criteria explain the state regulator problem. **8**

b) Explain the formulation of optimal control problem. **8**

OR

10. a) Explain the concept of parameter optimization. **8**

b) Explain & derive the infinite time linear quadratic regulators. **8**

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