B.E. Electrical (Electronics & Power) Engineering (MODEL CURRICULUM) Semester-VII

FE102-PEC-4- 2 - Control System Design

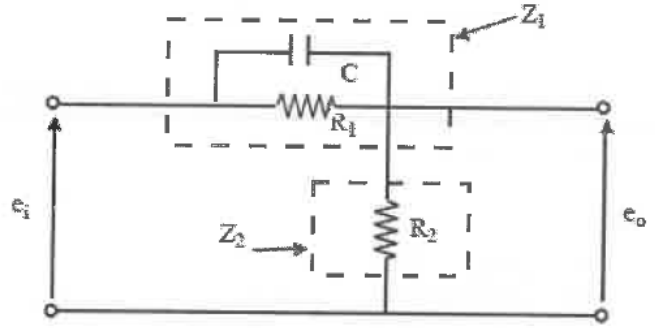
P. Pages : 3 **GUG/W/22/14241**

Time : Three Hours * 3 5 4 1 * 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.

1. a) Compare and justify the selection of lag and lead compensator for **8**
i) Speed of response ii) Signal to noise ratio at o/p
iii) Relative stability iv) Type of system

b) Derive the transfer function of a passive RC lead network shown in below fig. **8**



OR

2. a) Draw & explain Bode plot of lead compensator & derive the expression for maximum phase lead frequency. **8**

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

3. a) Comment whether the given matrix can reduce to its canonical form (i.e. diagonal). If not obtain Jordan canonical form. **8**

$$A = \begin{bmatrix} 4 & 1 & -2 \\ 1 & 0 & 2 \\ 1 & -1 & 3 \end{bmatrix}$$

b) For the given system matrix $A = \begin{bmatrix} 0 & 1 \\ -2 & -3 \end{bmatrix}$, using Caley Hamilton theorem determine: **8**

a) STM b) $[A]^{10}$

OR

4. a) Use diagonalization of matrix A to determine the time response of the system. **8**

$$\begin{bmatrix}\dot{X}_1\\ \dot{X}_2\end{bmatrix}=\begin{bmatrix}0 & 1\\ -6 & -5\end{bmatrix}\begin{bmatrix}X_1\\ X_2\end{bmatrix}+\begin{bmatrix}0\\ 1\end{bmatrix}[U] \text{ and}$$

$[Y]=[6 \quad 1]$, given that $X(0)=\begin{bmatrix}1\\ 0\end{bmatrix}$. Assume unit step input i.e $U(\tau)=1$

b) Find the STM of the following system using laplace transform method & Inverse of STM at t = 2. **8**

$$\begin{bmatrix}\dot{X}_1\\ \dot{X}_2\end{bmatrix}=\begin{bmatrix}0 & 2\\ -1 & 3\end{bmatrix}\begin{bmatrix}X_1\\ X_2\end{bmatrix}$$

5. a) Explain Gilbert's & Kalman's test for controllability & observability. **8**

b) Consider the system **8**

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

$$[Y]=[1 \quad 0 \quad 0][X]$$

a) Determine the stability of the system.
b) Comment on controllability and observability of the system.

OR

6. a) Transfer function of the system is given by $\frac{Y(s)}{U(s)}=\frac{10}{s(s+1)(s+2)}$ design a suitable feedback such that eigen values are placed at $-2,-1\pm j$. **8**

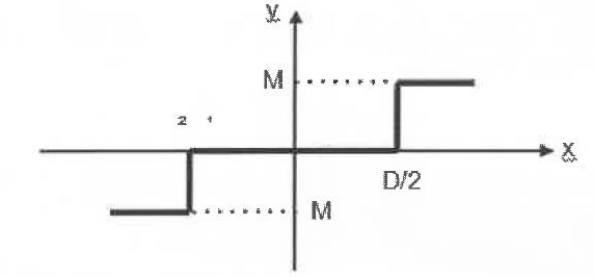
b) A linear time invariant system is given by **8**

$$[\dot{X}]=\begin{bmatrix}1 & 0 & 0\\ 0 & -2 & 0\\ 0 & 0 & -3\end{bmatrix}[X]+\begin{bmatrix}b_1\\ b_2\\ b_3\end{bmatrix}[U];\ [Y]=[c_1 \quad c_2 \quad c_3][X]$$

Find the condition (in term of system parameters) such that the system is stable & controllable.

7. a) Explain how describing function can be used in the analysis of non-linear system. **6**

b) The characteristics of a relay with dead zone is show in fig. **10**



Derive the describing function of this non linearity.

OR

8. a) Define and explain the following stabilities in reference to phase plane analysis of non-linear systems- **8**

a) Stable system
b) Asymptotically stable system
c) Globally asymptotically stable system

b) What are the different types of singular point, draw approximate shape of trajectory near it. **8**

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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