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

FE102-2 / PEC-4.2 - Control System Design

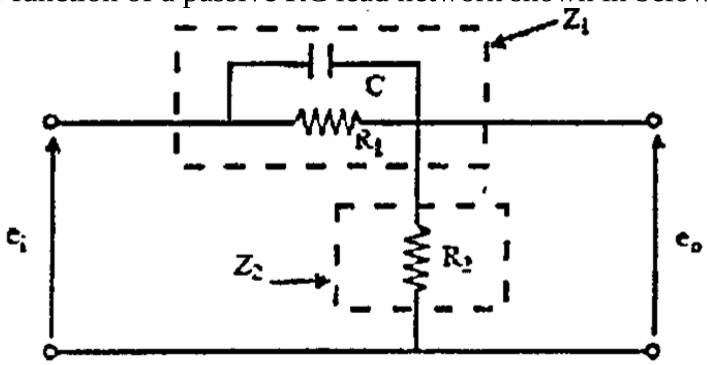
P. Pages : 3 **GUG/S/25/14241**

Time : Three Hours 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.
7. Answer **any five** questions are per internal given choice.

1. a) Derive the transfer function of Lag Compensator and Draw its Bode Plot. **8**

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



OR

2. a) Derive the expression for maximum lead angle frequency of lead compensator and maximum lag angle frequency of lag compensator. **8**

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

3. a) For a system $\dot{X} = AX$, $X(t) = \begin{bmatrix} e^{-2t} \\ -2e^{-2t} \end{bmatrix}$ when $X(0) = \begin{bmatrix} 1 \\ -2 \end{bmatrix}$ and **8**

$$X(t) = \begin{bmatrix} e^{-r} \\ -e^{-r} \end{bmatrix} \text{ for } X(0) = \begin{bmatrix} 1 \\ -1 \end{bmatrix}$$

Determine the system matrix A.

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.

OR

4. a) A linear time invariant system is described by the following state model **8**

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \\ \dot{x}_3 \end{bmatrix} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -6 & -11 & -6 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ 2 \end{bmatrix} u$$

Transform this state model into a canonical state model.

b) Find the state transition matrix of the state equation **8**

$$\begin{bmatrix} x_1 \\ x_2 \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ 1 & 1 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 1 \\ 1 \end{bmatrix} U$$

Using the inverse transform method.

5. a) Check for controllability and observability of a system having following coefficient matrices. **8**

$$A = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -6 & -11 & -6 \end{bmatrix}, B = \begin{bmatrix} 1 \\ 0 \\ 1 \end{bmatrix} \text{ and } C^T = \begin{bmatrix} 10 \\ 5 \\ 1 \end{bmatrix}$$

b) Given the transfer function, **8**

$$\frac{Y(s)}{U(s)} = \frac{1}{(s+5)\,(s+4)}$$

It is desired that the closed-loop poles are to be placed at $s = (-1 \pm j2)$. Determine the feedback gain matrix K.

OR

6. a) Consider the system. **8**

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

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

i) Determine the stability of the system.

ii) Comment on controllability and observability of the system.

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

$$\dot{x} = Ax + Bu$$

$$y = Cx$$

Where

$$A = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -5 & -6 & 0 \end{bmatrix}, \quad B = \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix}, \quad C = \begin{bmatrix} 1 & 0 & 0 \end{bmatrix}$$

Design a full-order state observer, assuming that the desired poles for the observer are located at $s = -10$, $s = -10$, $s = -15$

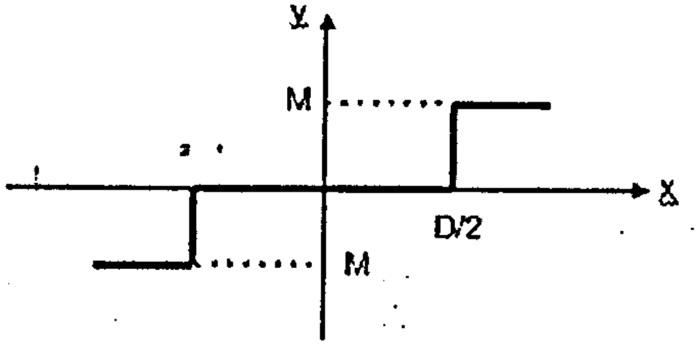
7. a) Explain the significance of the “singular points’ in the phase plane method of analysing non-linear system. **8**

b) Write short note on: **8**
Phenomenon of JUMP RESONANCE in the behaviour of non-linear element.

OR

8. a) Write a short note on Stability analysis of Describing function method. **8**

b) The characteristics of a relay with dead zone is show in fig. **8**



Derive the describing function of this non linearity.

9. a) Explain the formulation of optimal control problem. **8**

b) Find the extremals of the following functional. **8**

$$J(x) = \int_{0}^{\pi/4} (x^2 - \dot{x}^2)\,dt; \; x(0) = 0, x\left(\frac{\pi}{4}\right) \text{ is free}$$

OR

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

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

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