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

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

P. Pages : 3 **GUG/W/24/14241**

Time : Three Hours * 5 7 2 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. Answer **any five** questions as per internal given choice.
7. Use of non-programmable calculator is permitted.

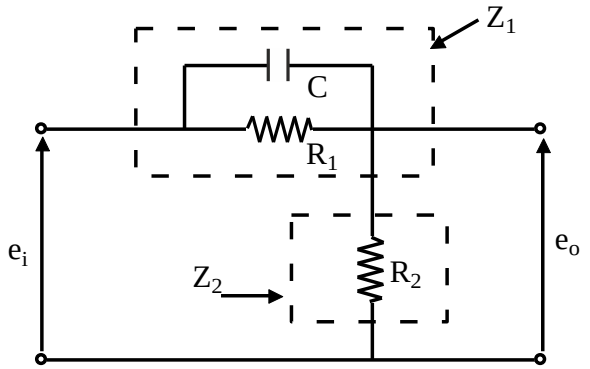
1. a) Derive the expression for Maximum Lead angle frequency of Lead Compensator and maximum Lag angle frequency of lag compensator. **8**

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

OR

2. 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**



3. a) Consider the matrix **8**

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

i) Find the eigen values and eigen vectors of A.
ii) Write the modal matrix
iii) Show that the modal matrix indeed diagonalizes A

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

$$\dot{X}(t) = \begin{bmatrix} 0 & 1 \\ -2 & 0 \end{bmatrix} X(t) \quad \text{where } X(0) = \begin{bmatrix} 1 \\ 1 \end{bmatrix}$$

And $Y(t) = \begin{bmatrix} 1 & -1 \end{bmatrix} X(t)$

OR

4. a) Find the state transition matrix of **8**

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

b) Consider the matrix **8**

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

i) Find the eigen values and eigen vectors of A
ii) Write the modal matrix
iii) Show that the modal matrix indeed diagonalizes A.

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) It is desired to place the closed loop poles of the following system at $s = -3$ and $s = -4$ by a state feedback controller with the control $u = -Kx$. Determine the Sate feedback gain Matrix K and the control signal. **8**

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

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

OR

6. a) Determine the controllability and observability of the following state model. **8**

$$\dot{X} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -6 & -11 & -6 \end{bmatrix} X + \begin{bmatrix} 1 \\ 0 \\ 1 \end{bmatrix} u$$

$$Y = \begin{bmatrix} 10 & 5 & 1 \end{bmatrix} X$$

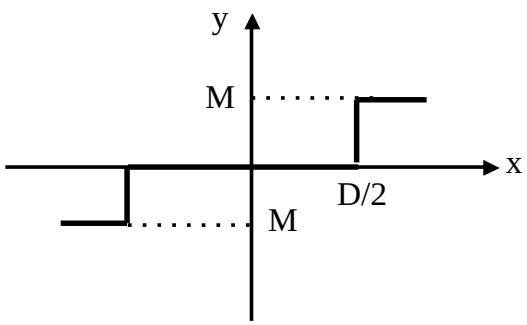
b) Consider the system represented by **8**

$$\dot{x} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -6 & -11 & -6 \end{bmatrix} x + \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} u$$

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

Design a full order observer such that the observer eigne values are at $-2 \pm j2\sqrt{3}$ and -5.

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



Derive the describing function of this non linearity.

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) Define and explain the following stabilities in reference to phase analysis of non-linear systems- **8**
a) Stable system
b) Asymptotically stable system
c) Globally asymptotically stable system

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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