Reg. No. : | | | | | | | | | | | |

L 5054

M.E. DEGREE EXAMINATION, MAY/JUNE 2009.

First Semester

Control and Instrumentation

CI 131 — SYSTEM THEORY

(Common to M.E. Power Systems Engineering and M.E. Power Electronics and Drives)

(Regulation 2002)

Time : Three hours | Maximum : 100 marks

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. Consider a system whose transfer function matrix is given by

   $G(s) = \frac{6s}{(s+1)(s+2)(s+3)}$. Develop a state model in diagonal form.

2. Enlist the dynamic response specifications.

3. What is bandwidth? Explain.

4. State the conditions for controllability and observability.

5. Explain the role of left and right eigenvectors in the state response of a system.

6. State and prove the conditions for observability in linear time invariant systems.

7. What is an observer? Explain.

8. Explain the assumptions made in Phase plane and Describing function methods of analyzing non–linear systems.

9. What do you mean by dominant poles? Explain.

10. Explain Krasovski's method of deriving the Liapunov's function for assessment of stability of nonlinear system.

PART B — (5 × 16 = 80 marks)

11. (a) A single input system is described by the following state equation.

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \\ \dot{x}_3 \end{bmatrix} = \begin{bmatrix} -1 & 0 & 0 \\ 1 & -2 & 0 \\ 2 & 1 & -3 \end{bmatrix} \begin{bmatrix} 10 \\ 1 \\ 0 \end{bmatrix} u$$

Design a state feedback controller which will give closed – loop poles at $-1 \pm j2$ and -6. (16)

Or

(b) Consider the system described by the state model.

$$\dot{x} = Ax$$
$$y = Cx$$

Where $A = \begin{bmatrix} -1 & 1 \\ 1 & -2 \end{bmatrix}$; $C = [1\ 0]$.

Design a full order observer. The desired eigen values for the observer matrix are –5 and –5. (16)

12. (a) (i) A system is described by its transfer function

$$Y(s)/X(s) = 8(s+5)/(s^3 + 12s^2 + 44s + 48)$$

Determine the phase variable representation and state transition matrix. (8)

(ii) A system is described by the following state and output equation

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

$$y(t) = [1\ 0]\,x$$

with initial conditions $x(0) = \begin{bmatrix} x_1 & (0) \\ x_2 & (0) \end{bmatrix}$

and u as a unit–step function applied at $t = 0$, find the output $y(t)$. (8)

Or

(b) (i) A system is described by the state equation

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

with $u(t) = 0$, and $x_1(0) = x_2(0) = 10$. Determine $x_1(t)$ and $x_2(t)$. (8)

(ii) For a system represented by the state equation

$$x = Ax(t)$$

the response of $x(t) = \begin{bmatrix} e^{-2t} \\ -2e^{-2t} \end{bmatrix}$ when $x(0) = \begin{bmatrix} 1 \\ -2 \end{bmatrix}$

and $x(t) = \begin{bmatrix} e^{-t} \\ -e^{-t} \end{bmatrix}$ when $x(0) = \begin{bmatrix} 1 \\ -1 \end{bmatrix}$

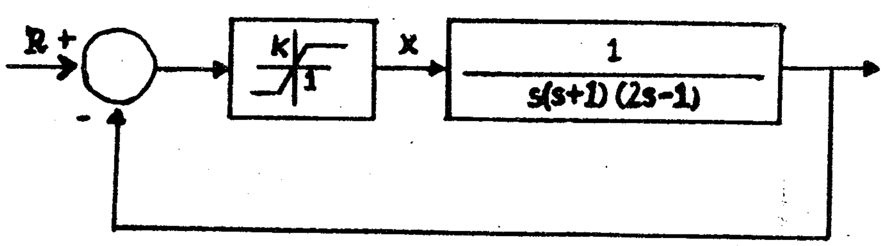
Determine the system matrix A and the state transition matrix. (8)

13. (a) (i) Derive the Describing function of relay with dead – zone and hysteresis type of non–linearity. (10)

(ii) Explain how Describing function is used in assessing the stability of non–linear systems. (6)

Or

(b) Consider a unity feedback system shown in fig. below with a saturating amplifier having gain K in its linear region. Determine the largest value of gain K for the system to remain stable. What would be the frequency, amplitude and the nature of limit cycle when $K = 3$. (16)



14. (a) (i) Show that the system defined in figure 14(a) will have limit cycle with an ON–OFF controller. (8)

(ii) Design a suitable controller to force the state trajectory approach origin. (8)

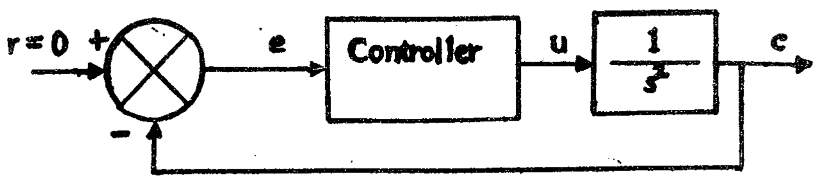


Figure 14 (a)

Or

(b) A linear second order servo is described by the equation.

$e + 2\delta\, w_n e + w_n^2 e = 0$

$\delta = 0.15, w_n = 1, e(0) = 1.5, e(0) = 0$

Determine the singular points. Construct the phase trajectory using method of isocline. (16)

15. (a) (i) Derive the Liapunov equation for testing the stability of linear time invariant systems. (8)

(ii) Check the stability of the system described by

$X = \begin{bmatrix} x_2 \\ -x_1 - b_1 x_2 - b_2 x_2^3 \end{bmatrix}$ for b_1 and $b_2 > 0$; Choose variable gradient method with $a_{12} = x_1 / x_2$ and $a_{21} = x_2 / x_1$. (8)

Or

(b) (i) Consider the dynamics of the system represented by

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ -1 & -1 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$$

Formulate the Liapunov function to test the asymptotic stability of the system. (8)

(ii) Determine the range of value of K by applying the Liapunov's second method for the given system dynamics.

$\dot{x}_1 = x_2$

$\dot{x}_2 = -x_2 + x_3$

$\dot{x}_3 = -Kx_1 - 4x_3$

and the scalar function $v(x) = 5Kx_1^2 + 2Kx_1x_2 + 20x_2^2 + 8x_2x_3 + x_3^2$. (8)
