C 30138 (Pages : 3) Name.....................

Reg. No.....................

SEVENTH SEMESTER B.TECH. (ENGINEERING) DEGREE [2014 SCHEME] EXAMINATION, NOVEMBER 2017

Electrical and Electronics Engineering

EE 14 702—MODERN CONTROL THEORY

Time : Three Hours Maximum : 100 Marks

Part A

Answer any **eight** *questions.*
Each question carries 5 marks.

1. Find the transfer function for the system which is represented in state space as follows :

$$\begin{bmatrix} \dot{X}_1 \\ \dot{X}_2 \\ \dot{X}_3 \end{bmatrix} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -2 & -4 & -3 \end{bmatrix} \begin{bmatrix} X_1 \\ X_2 \\ X_3 \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ 2 \end{bmatrix} u$$

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

2. Find $f(A) = A^{10}$ for $A = \begin{bmatrix} 0 & 1 \\ -2 & -3 \end{bmatrix}$.

3. Construct the state model for a system characterized by the differential equation :

$$\frac{d^3y}{dt^3} + 6\frac{d^2y}{dt^2} + 11\frac{dy}{dt} + 6y + u = 0.$$

4. What are singular points ? Explain the different singular points with respect to stability of a non-linear system.

5. Explain the construction of a phase trajectory either by isocline method or by delta method.

6. Briefly explain the concept of equilibrium points and the stability definitions.

7. Investigate the stability of the non-linear system using direct method of Liapunov :

$$\dot{x}_1 = x_2$$
$$\dot{x}_2 = -x_1 - x_1^2 x_2.$$

Turn over

8. Examine the controllability and observability of the system given below :

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

$$y = [10 \quad 5 \quad 1] x.$$

9. Discuss in detail the design procedure of full order observer and reduced order observer with necessary equations.

10. Consider the following state space model :

$$\dot{x} = \begin{bmatrix} 0 & 1 \\ -2 & -3 \end{bmatrix} x + \begin{bmatrix} 0 \\ 2 \end{bmatrix} u(t) \, ; y = [1 \quad 0] x.$$

For the desired observed poles at – 1 and – 4, determine the observer gain matrix K using direct substitution method.

(8 × 5 = 40 marks)

Part B

Answer **all** *questions.*
Each question carries 15 *marks.*

1. (a) A feedback system is characterized by the closed loop transfer function :

$$\frac{C(s)}{U(s)} = \frac{10(s+4)}{s(s+1)(s+3)}.$$

Construct the canonical state model for this system and give the block diagram representation.

Or

(b) A linear time invariant system is described by the following state model :

$$\begin{bmatrix} \dot{X}_1 \\ \dot{X}_2 \\ \dot{X}_3 \end{bmatrix} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -6 & -11 & -6 \end{bmatrix} \begin{bmatrix} X_1 \\ X_2 \\ X_3 \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ 2 \end{bmatrix} u$$

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

Compute the state transition matrix e^{At} using similarity transformation method.

2. (a) (i) Explain the delta method of constructing phase trajectories. (7 marks)

(ii) Using isocline method, draw the phase trajectory for the system :

$$\frac{d^2x}{dt^2}+0.6\frac{dx}{dt}+x=0 \text{ with } x=1 \text{ and } \frac{dx}{dt}=0 \text{ as initial condition.}$$

(8 marks)

Or

(b) Determine the describing function of a combined dead zone and saturation type non-linearity.

3. (a) (i) Describe briefly about variable gradient method and Krasovskii's method of generating Liapunov functions.

(8 marks)

(ii) Consider the non-linear system described by the state equations given by :

$$x_1 = x_2$$

$$x_2 = -x_1 - b_1x_2 - b_2x_2^3;\ b_1, b_2 > 0.$$

Check the stability of the system.

(7 marks)

Or

(b) (i) State and explain the basic Liapunov's stability theorems. (7 marks)

(ii) Using direct method of Liapunov, determine the stability of the system given by :

$$x(t) = Ax(t) \text{ where } A = \begin{bmatrix} -1 & -2 \\ 1 & -4 \end{bmatrix}.$$

(8 marks)

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

$$\begin{bmatrix} \dot{X}_1 \\ \dot{X}_2 \\ \dot{X}_3 \end{bmatrix} = \begin{bmatrix} -1 & 0 & 0 \\ 1 & -2 & 0 \\ 2 & 1 & -3 \end{bmatrix} \begin{bmatrix} X_1 \\ X_2 \\ X_3 \end{bmatrix} + \begin{bmatrix} 10 \\ 1 \\ 0 \end{bmatrix} u.$$

Design a state feedback controller which will give closed loop poles at $-1 \pm j2, -6$.

Or

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

$$\dot{x} = Ax \quad \text{where } A = \begin{bmatrix} -1 & 1 \\ 1 & -2 \end{bmatrix} \text{ and } C = [1 \quad 0]$$

$$y = Cx.$$

Design a full order state observer. The desired Eigen values for the observer matrix are $\mu_1 = -5$ and $\mu_2 = -5$.

[4 × 15 = 60 marks]