EX/PG/NUE/ T/128A / 2018

MASTER OF NUCLEAR ENGINEERING EXAMINATION, 2018
(2nd Semester)
Nonlinear and Adaptive Control

Time: Three hours **Full Marks: 100**

Answer any five questions

1. (a). Derive Describing Function of a nonlinear amplifier whose input-output characteristics is as shown in Fig.1 . Draw all necessary diagrams. 12

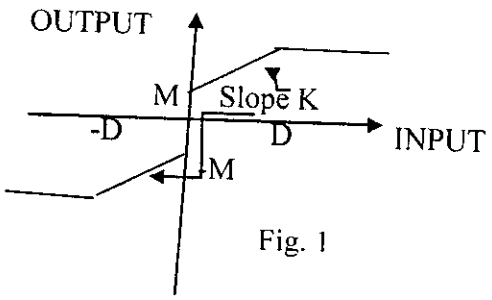

Fig. 1

(b). Obtain Describing Function of a system whose input x(t)-output y(t) relationship is represented by the expression 08

$$y(t) = (dx/dt)^3 + x^2 (dx/dt) + x^3$$

Justify the assumptions considered.

2. Consider the unity feedback system in which $G(s) = K e^{0.1s} / [s(s+2)]$ is driven by a Bang-bang controller with dead zone of 0.5 value and saturation value of 10,

(a) Draw the block diagram of the system.
(b) Investigate the stability of the system using Describing Function technique.
(c) Will this system be made oscillatory for any value of K? If so, find the amplitude and frequency of the oscillation.

02+12+06

3. (a). Consider a simple pendulum with length L, mass M which is evenly distributed with center of mass at L/2 and T, the torque applied in Θ direction.

Draw the necessary diagrams and illustrate the steps to develop small signal model of the system.

10

(b). Investigate singularities for the nonlinear system represented by following equations 10

$$x' = x^2y + 3xy - 10y$$

$$y' = xy - 4x$$

Sketch the phase portrait and comment on the stability of the system at each equilibrium point.

4. (a) Consider the system represented by the dynamic equation

$$\Theta'' + 2\Theta' + 0.5 \operatorname{Sin}\Theta = 0$$

Draw the phase portrait of the system using isocline method. Comment on the stability of the system. 14

(b) Plot phase trajectory for the system represented by

$$x' + 9x - x^3 = 0$$

Comment on stability conditions.

06

5. (a) Investigate stability of a Spring-mass-damper system using Lyapunov's first method. Can this method be extended for analyzing stability of the system with nonlinear spring ? Justify your comments. 06+04

(b) A system is represented by

$$x' = - x + 2x^2 + y^2$$

$$y' = - y + y^2$$

Investigate stability of the system constructing candidate Lyapunov Function. Comment on the region of stability. 07+03

6. (a) For a given system

$$x_1' = x_2 - 3x_3 - x_1(x_2 - 2x_3)^2$$
$$x_2' = - 2x_1 + 3x_3 - x_2(x_1 + x_3)^2$$
$$x_3' = 2x_1 - x_2 - x_3$$

Can $V(X) = 2x_1^2 + x_2^2 + 3x_3^2$ be a Lyapunov Function?
Investigate stability of the system. Explain the theorem applied for investigation. 10

(b) An autonomous system represented by $X' = A\,X$

Where $A = \begin{bmatrix} 0 & 1 \\ -12 & -8 \end{bmatrix}$

Construct Lyapunov Function and investigate stability of the system.

04+06

7. (a) A system is represented by

$$x_1' = -6x_1 + 2x_2$$
$$x_2' = 2x_1 - 6x_2 - 2x_2^3$$

Construct the candidate Lyapunov Function and investigate stability of the system.

10

(b) Construct Lyapunov Function and prove that the equilibrium state origin of the given system represented by

$$f(X) = [\, x_2 \qquad -x_1 - x_1^2 x_2 \,]^T$$

is asymptotically stable in the large.

10

8. Explain adaptive control system with block diagram.

Explain the principle of gain scheduling in adaptive control. Discuss advantages and drawbacks of gain scheduling.

What is Self-Tuning Regulator (STR) in adaptive control applications?

Explain Model Reference Adaptive Control (MRAC) approach with suitable diagram.

Explain the steps to formulate adaptive control problems.

03+06+04+04+03