Eighth Semester B. Tech. [ELECTRICAL] Degree Examination

(2013 Scheme- April/May 2017)

13.805.5 NON-LINEAR SYSTEMS (E) (Elective IV)

Time: 3 Hours | Max. Marks: 100

- ***Instruction:*** *Answer* ***all*** *questions from Part* ***A****.* ***One full*** *question from* ***each*** *Module of Part* ***B****.*

PART A (*Each carries 2 mark*)

1. List any 4 characteristics of Non-linear systems.
2. State local existence and uniqueness theorem.
3. Find out whether the given function is Locally lipschiz and globally lipschitz
   $f(x) = \tan x$
4. Graphically explain Lyapnov's asymptotic stability.
5. For the system given below find out the value of a for the system to be positive definite
   $V(x) = a x_1^2 + 2 x_1 x_3 + a x_2^2 + 4 x_2 x_3 + a x_3^2$

   Find out the value of a for the system to be positive definite
6. Briefly explain Region of attraction.
7. What are the advantages of Gain Scheduling?
8. Briefly explain how stability can be found out by popov criterion
9. Define Tracking
10. Differentiate Input state linearization and input output Linearization

PART B

MODULE 1

11.a) With the help of neat diagrams, explain different types of equilibrium points

(10)

b) Determine and classify the singularities for the system given below,

(10)

$\acute{y} - (1 - y^2)\acute{y} + y = 0$

OR

12. a) Draw the phase portrait of the

(10)

$\acute{x}+\acute{x}+|x|=0$

(10)

b) For the function, $f(x)=\begin{bmatrix}-x_1+x_1x_2\\ x_2-x_2x_1\end{bmatrix}$, find out the Lipschitz constant L PTC **(5)**

c) Consider the Linear system, $\acute{x}=A(t)x+g(t)=f(t,x)$ prove that the system has a unique solution $\forall\, t\geq t_0$ **(5)**

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MODULE 2

13. Explain in detailed about the variable gradient method of generating a Lyapnov function for non-linear systems and hence construct a Lyapnov function for the system given below **(10+10)**

$\acute{x}_1=x_2$

$\acute{x}_2=-x_1^3-x_2$

OR

14. a) Determine the stability of the system $\acute{x}=Ax$ where $A=\begin{bmatrix}0 & 1\\ -2 & -3\end{bmatrix}$ **(10)**

by Lyapnov's theorem and hence determine a suitable Lyapnov function

b) Explain centre manifold theorem and hence investigate the stability of the following system at origin

(10)

$\acute{x}_1 = -2x_1 - 3x_2 + x_3 + x_3^3$

$\acute{x}_2 = x_1 + x_1^2 + x_2$

$\acute{x}_3 = x_1^2$

MODULE 3

15. a) Explain how state feedback stabilization via linearization can be applied to a linear system. **(10)**

b) For the system $\acute{\theta} = -a\sin\theta - b\acute{\theta} + cT$, Design a state feedback control to stabilise the system at an angle $\theta = \delta$. T is the torque applied to the system. a and b are constants. **(10)**

PTO

OR

16. a) Explain in detailed about how stability can be analysed using circle criterion **(10)**

b) Invesstigate the stability of the given system using circle criterion **(10)**

$$G(s) = \frac{4}{(s+1)\left(\frac{1}{2}s+1\right)\left(\frac{1}{3}s+1\right)}$$

MODULE 4

17. a) Briefly explain state feedback control **(5)**

b) Consider the system **(15)**

$\acute{x}_1 = -x_1 + x_2 - x_3$

$\acute{x}_2 = -x_1 x_3 - x_2 + u$

$\acute{x}_3 = -x_1 + u$

Find a feedback control law and change of variables that linearize the state equation

OR

18. a) Explain Input-output linearization (8)

b) Consider the system

$\dot{x}_1 = -x_1 + x_2 - x_3$

$\dot{x}_2 = -x_1 x_3 - x_2 + u$

$\dot{x}_3 = -x_1 + u$

$y = x_3$

i. Is the system input-output linearizable? **(2)**

ii. If yes, transform it into normal form. **(8)**

iii. Is the system minimum phase? **(2)**