Reg. No.										

MANIPAL INSTITUTE OF TECHNOLOGY
MANIPAL
A Constituent Institution of Manipal University

SECOND SEMESTER M.TECH. (CONTROL SYSTEMS)

END SEMESTER EXAMINATIONS, APRIL/MAY 2017

SUBJECT: NON-LINEAR CONTROL SYSTEMS [ICE 5221]

Time: 3 Hours MAX. MARKS: 50

Instructions to Candidates:

- Answer **ALL** the questions.
- Missing data may be suitably assumed.

1A. List any four important characteristics of the nonlinear system. **2**

1B. Investigate the stability of the following nonlinear system using direct method of Lyapunov **3**

$\dot{x}_1 = x_2$

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

1C. Consider a unity feedback system for the given transfer function having a saturating amplifier with gain K. Determine the maximum value of K for the system to stay stable. What would be the frequency and nature of limit cycle for a gain K=3? **5**

$$G(s) = \frac{K}{s(1+0.5s)(1+5s)}$$

2A. Define (i) Positive semidefinite and (ii) Indefinite with the conditions. **2**

2B. Explain Asymptotic Stability with its conditions. **3**

2C. Determine whether the following quadratic form is positive definite. **5**

$Q(x_1, x_2, x_3) = 10x_1^2 + 4x_2^2 + x_3^2 + 2x_1x_2 - 2x_2x_3 - 4x_1x_3$

3A. Brief the Sliding Model Controller with a neat sketch. **2**

3B. Write the final equations of the relay with only saturation nonlinearity. **3**

3C. Using Krasovskii's theorem, find the stability region of the equilibrium state at x=0 for the following **5**

$\dot{x}_1 = -x_1$

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

4A. What you can infer from the limit cycle analysis. **2**

4B. Explain the state feedback linearization with a neat block diagram and necessary expressions. **3**

4C. Consider the unity feedback system with r(t)=0, where an ideal relay is connected with a plant having $G(s) = \frac{1}{s(1+s)(2+s)}$. Determine whether a limit cycle exists and if exists, determine **5**

the amplitude and frequency of the limit cycle.

5A. Write the nonlinear PID controller equation and explain its principle of operation. **2**

5B. Explain the operation of MRAC with its neat sketch. **3**

5C. A linear second order servo is described by the equation **5**

$\ddot{e} + 2\xi\omega_n \dot{e} + \omega_n^2 e = 0$, where ξ =0.2, ω_n =1 rad/sec, e(0)=1.5 and $\dot{e}$ (0)=0

Determine the singular point. Construct the phase trajectory, using the method of isoclines.

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