Reg. No.										

MANIPAL INSTITUTE OF TECHNOLOGY
Manipal University

SECOND SEMESTER M.Tech. (I & C E) DEGREE END SEMESTER EXAMINATION
May 2016
SUBJECT: NONLINEAR CONTROL SYSTEMS (ICE - 558)

TIME: 3 HOURS **MAX. MARKS: 50**

Instructions to candidates
- Answer **ANY FIVE** full questions.
- Missing data may be suitably assumed.

1A. Explain the Intentional and Dynamic Nonlinearities.

1B. Consider the second order system with differential equation $\ddot{y}+2\xi\omega_n\dot{y}+\omega_n^2 y=0$. Given $\xi=0.5$ and $\omega_n=1$. Let constant 'N' be the slope of $\frac{dx_2}{dx_1}$. Construct the phase plot for ranges from [0 1 2 3 -1 -2 -3 -4].

(3+7 Marks)

2A. Derive the describing function for relay with saturation nonlinearity.

2B. Define three different types of spring nonlinearity with its equations.

(7+3 Marks)

3A. Consider the closed loop system with relay and saturation non-linearity with $G(s)=\frac{1}{s(s+1)(s+2)}$. Determine whether the limit cycles exists in the system, if exists what is the frequency of the limit cycle

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

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

(6+4 Marks)

4A. Briefly explain the describing function analysis of nonlinear systems. Explain the concept of enclosure with the illustration of stable and unstable limit cycles.

4B With a neat sketch brief the Asymptotic stability.

4C Define Jump response.

(5+3+2 Marks)

5A. Determine the sign definiteness of the quadratic form $Q=10x_1^2+4x_2^2+x_3^2+2x_1x_2-2x_2x_3-4x_3x_1$. Use Sylverster's criteria.

5B. Write short note on Lyapunov's second method.

5C. What is singular points. What is the use of it in nonlinear system analysis.

(5+3+2 Marks)

6A. Briefly explain the sliding mode controller with its control law. List the merits and demerits.

6B. The closed loop system with ideal relay is cascaded with $G(s) = \frac{(s+1)}{(s+2)(s+3)}$. Determine whether a limit cycle exist, if exist determine the amplitude and frequency of the limit cycle.

(5+5)

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