Name : .....

Roll No. : .....

Invigilator's Signature : .....

CS/M.Tech (CI)/SEM-2/CIM-201/2013

2013

CONTROL SYSTEM - II

Time Allotted : 3 Hours *Full Marks :* 70

The figures in the margin indicate full marks.

Candidates are required to give their answers in their own words as far as practicable.

Answer *all* questions in Group-A and any *four* questions selecting *two* from Group-B and *two* from Group-C.

GROUP – A

Answer *all* questions.

1. a) The ITSE quadratic performance index is given by

i) $\int_0^\infty te(t)^2 \, dt$

ii) $\int_0^\infty \left[e(t)^2 + u(t)^2 \right] dt$

iii) $\int_0^\infty \left[e(t)^2 + \lambda u(t)^2 \right] dt$

iv) None of these. 2

b) Compute the following performance indexes for the system given by $\frac{C(s)}{R(s)} = \frac{1}{s^2 + 2\xi s + 1}, \xi \geq 1$ and $R(s) = \frac{1}{s}$

i) $\int_0^\infty e(t)$

ii) $\int_0^\infty t\, e(t)\, dt$ 2 + 2

c) The phase portrait of a non-linear system is shown in the following figure. Here the origin is a

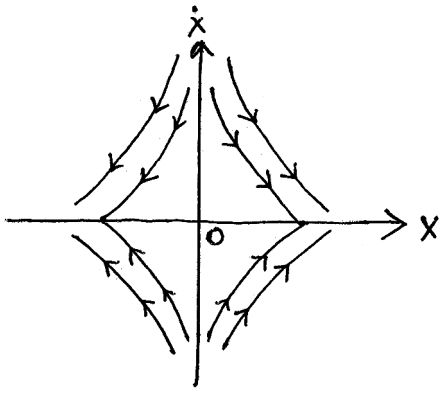
i) Stable focus

ii) Stable node

iii) Vortex

iv) Saddle point.

Justify your answer.



2

State whether the following sentences are *true* or *false*. Justify your answer. 3 × 2

d) Phase plane technique can be applied for up to third order linear system.

e) Liapunov's method is used for finding stability of non-linear system only.

f) System must have low pass filtering characteristic for stability analysis using describing function method.

GROUP – B

Answer any *two* of the following. 2 × 14 = 28

2. An altitude control system for the satellite that utilizes rate feedback is shown in Figure-1. $\theta(t)$ is the actual altitude, $\theta_r(t)$ is the reference attitude which is a step function, and $u(t)$ is the torque developed by the thrusters. Show whether the system is stable using optimal control law. The A, B, C matrix of the system is given below :

$$A = \begin{bmatrix} 0 & 1 \\ 0 & 0 \end{bmatrix}, B = \begin{bmatrix} 0 \\ 1 \end{bmatrix}, C = \begin{bmatrix} 1 & 0 \end{bmatrix}$$

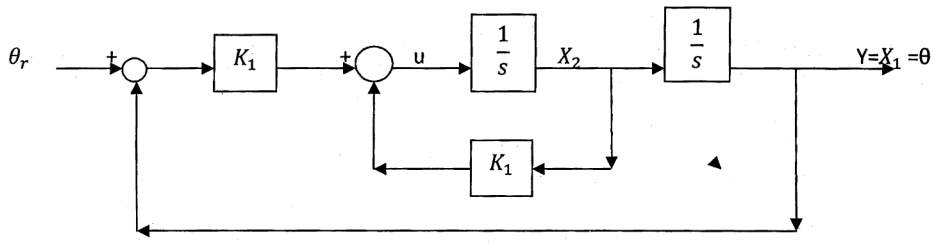


Figure-1

3. a) Derive the Riccati equation.

   b) Explain return difference. 11 + 3

4. a) Describe the δ_{SR} method for stability analysis.

   b) Consider a unity feedback system with open loop transfer function $G(s) = \frac{4 \cdot 5}{s(s+1)(s+2)}$. The parametric uncertainity of the coefficients in the characteristic equation is such that each coefficient has a variation ± 10% over its nominal value. Apply

Kharitnov's method to examine the stability of the system. 7+ 7

GROUP – C

Answer any *two* of the following. 2 × 14 = 28

5. a) The state equations of a non-linear system are available as

$$\dot{x} = x_2$$

$$\dot{x}_2 = -x_1^2 - x_2^2 - 2x_1 - 3x_2$$

Determine all points of equilibrium and investigate the nature of stability in the neighbourhood of these points.

b) Briefly illustrate the concept occurrence of stable and unstable limit cycles using describing function method.

Derive the describing function for a non-linear element with on-off non-linearity followed by dead zone. 7 + 7

6. a) Determine the stability using Lyapunov's second method when the system dynamics is given as :

$$\dot{x}_1 = x_2$$

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

Also validate the asymptotic stability using variable gradient method.

b) Draw the phase portrait of the system described by the equation

$$\ddot{e} + 2\xi w_n \dot{e} + w_n^2 e = 0$$

when $\xi = 0$, $W_n = 1$ rad/sec and $e(0) = 2$, $\dot{e}(0) = 0$.

7 + 7

7. a) What is limit cycle ? Illustrate the example of stable, unstable and semi-stable limit cycle-using phase plane trajectories. What is Bendixson theorem ?

b) A non-linear system with Hysteresis type non-linearity is shown in Figure-2. Determine whether the system exhibits limit cycle oscillations. Also determine the frequency of oscillation of such limit cycle, if any

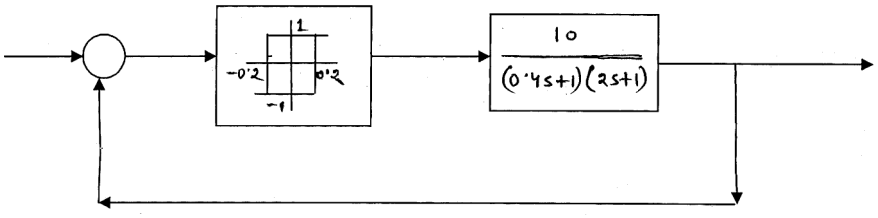


Figure-2

7 + 7