Q. P. Code: 25159

Total Marks: 80

3 Hours

Instructions:

- **Q1** is compulsory
- Answer any **Three** out of remaining **Five** questions
- Assumptions made should be clearly stated
- Assume any suitable data wherever required but justify the same
- Figure to the right indicate gets full marks
- Illustrate answers with sketches wherever required

Q1. Answer the following. (20)

(a) Give classification of singular points. What is meant by limit cycle? Discuss the types of limit cycle with examples.

(b) How describing function method with Nyquist criteria will be used for prediction of limit cycle? Discuss the stable and unstable limit cycles with examples.

(c) What is nonminimum phase system? Explain invert response.

(d) List the uncertainties occur in the system. What are the methods to design the system with consideration of uncertainties.

(e) What is meant by optimal control problem formulation? What are its requirements? Discuss any one requirement with example.

Q2. (a) for the following system – (10)

$$\dot{x} = 2x - y - x^2$$
$$\dot{y} = x - 2y + y^2$$

has equilibrium at (0,0) and (1,1). Determine the singular point of the linearized system. Identify the singular point and draw phase portrait.

(b) Define performance measure. Discuss the performance measures for various optimal control problems. (10)

Q3. (a) Give definition of 1, 2 and ∞ norm. (05)

(b) Compute 2 – norm of the following – (05)

$$A = \begin{bmatrix} 0.8 & 0 \\ 0 & 1.7 \end{bmatrix}, \quad B = \begin{bmatrix} 1 & 0 \\ 0 & 5 \end{bmatrix}$$

(c) Obtain the control law which minimizes the performance index – (10)

$$J = \int_0^\infty (x_1^2 + u^2)dt$$

for the system

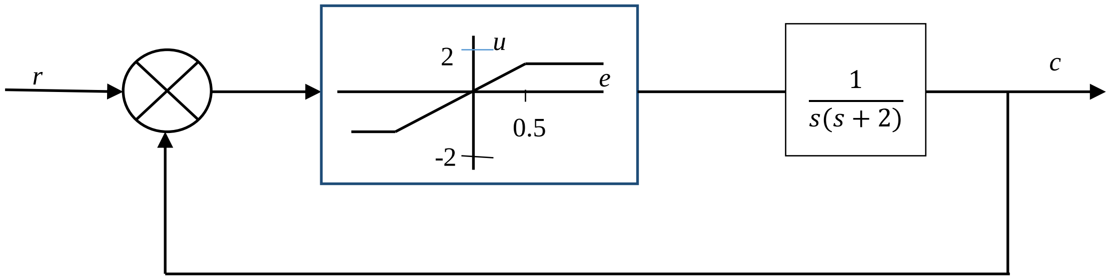
$$\dot{x} = \begin{bmatrix} 0 & 1 \\ 0 & 0 \end{bmatrix} x + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u$$

Q4. (a) Explain in detail the design procedure of IMC. Design IMC controller for plant model (10)

$$G(s) = \frac{(-s+1)}{(4s+1)}$$

in order to achieve the response with time constant of 1.2 sec.

(b) Draw the phase-plane trajectory for the following system. Assume $x_0 = (0,1)$ (10)



Q5. (a) Derive the Describing function for dead-zone nonlinearity. (10)

(b) Investigate the stability of a system having ON/OFF nonlinearity with amplitude ±1 and linear System – (10)

$G(s) = \frac{3}{s(1+2s)(1+s)}$. Determine amplitude and frequency of the limit cycle.

Q6. (a) Determine the definiteness of the following Lyapunov functions – (05)

$i)\ V(x) = x_1^2 + 4x_2^2 + x_3^2 + 2x_1x_2 - 6x_2x_3 - 2x_1x_3$

$ii)\ V(x) = x_1^2 - 3x_2^2 - 11x_3^2 + 2x_1x_2 - 4x_2x_3 - 2x_1x_3$

(b) Discuss the Jump resonance characteristics of nonlinear system with examples. (05)

(c) Examine the stability of equilibrium state of the following system using Krasovaskii method. (05)

$\dot{x}_1 = -x_1, \ \dot{x}_2 = x_1 - x_2 - x_2^3$

(d) Explain the stability of system in the sense of Lyapunov. Draw suitable trajectories. (05)