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Question Paper Code : 21687

B.E./B.Tech. DEGREE EXAMINATION, NOVEMBER/DECEMBER 2015.

Sixth Semester

Electrical and Electronics Engineering

IC 2351/IC 61/10133 IC 604 — ADVANCED CONTROL SYSTEM

(Common to Instrumentation and Control Engineering)

(Regulations 2008/2010)

Time : Three hours — Maximum : 100 marks

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. Check the controllability of the following system :

$$\dot{x} = \begin{bmatrix} 0 & 1 \\ -2 & 5 \end{bmatrix} x + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u$$

2. Obtain a state model for the following system :

$$G(s) = \frac{1}{s^2 + 5}$$

3. State two types of incidental non-linearity which may occur in physical system.

4. State the assumptions made in phase plane analysis.

5. Obtain the describing function of the following non-linearity

$$y = x^3$$

6. What are limit cycles?

7. State condition for asymptotic stability in the sense of Lyapunov.

8. What are the conditions to be imposed on a function to be qualified as Lyapunov's function?

9. State the LQR optimal control problem.

10. State the cost function of optimal estimation problem.

PART B — (5 × 16 = 80 marks)

11. (a) Consider the system whose state equation is given by

$$\dot{x} = \begin{bmatrix} 1 & 2 \\ 1 & 1 \end{bmatrix} x + \begin{bmatrix} 1 \\ 1 \end{bmatrix} u, y = [1 \;\; 0]\, u .$$

(i) Evaluate the state transition matrix. (6)

(ii) Determine the state and output response of the system for unit step input. (10)

Or

(b) Consider a system whose transfer function is given by

$$\frac{Y(s)}{U(s)} = G(s) = \frac{1}{s^4 + 3s + 5}$$

(i) Obtain the state model in controllable canonical form. (6)

(ii) Design a state feedback controller to place the closed Loop poles at –1, –2. (10)

12. (a) Obtain the trajectory and assess the stability of the system shown in figure 12 (a) when the states are initially at (1, 1). Let the controller gain be '1' and its output saturate at '1'. (16)

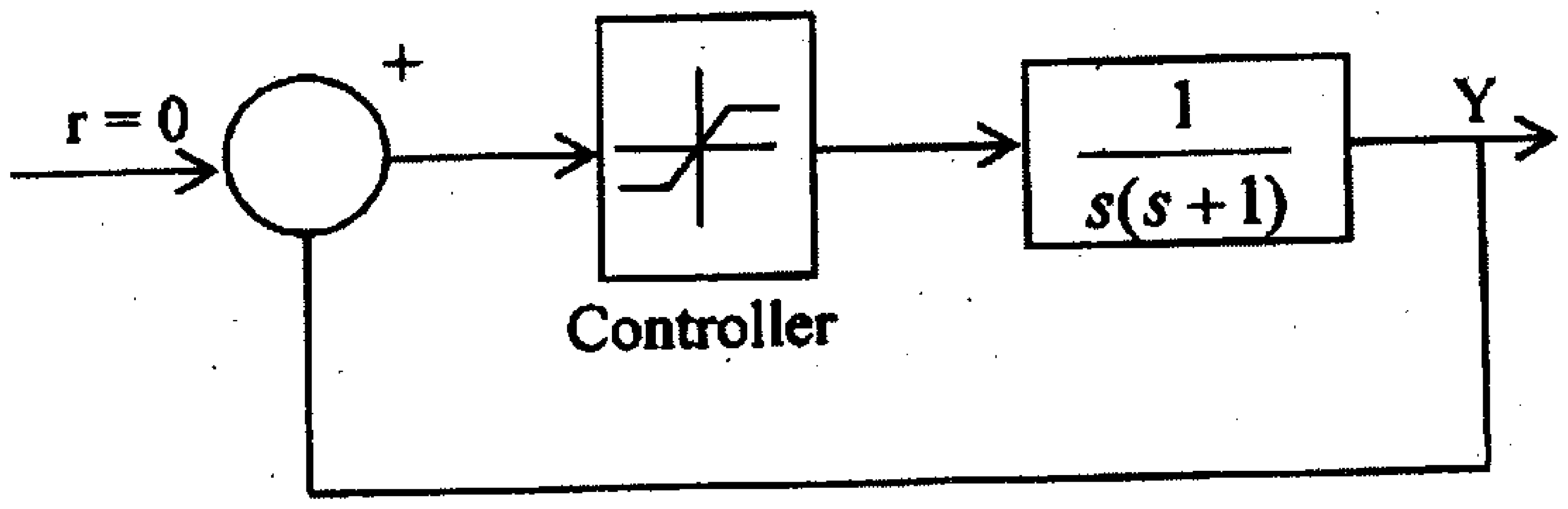

Figure 12 (a)

Or

(b) Consider the system shown in figure 12 (b). Show that infinite number of limit cycles occur for various initial conditions using phase portraits. Determine the magnitude and period of limit cycle when the trajectory starts at (1, 1). (16)

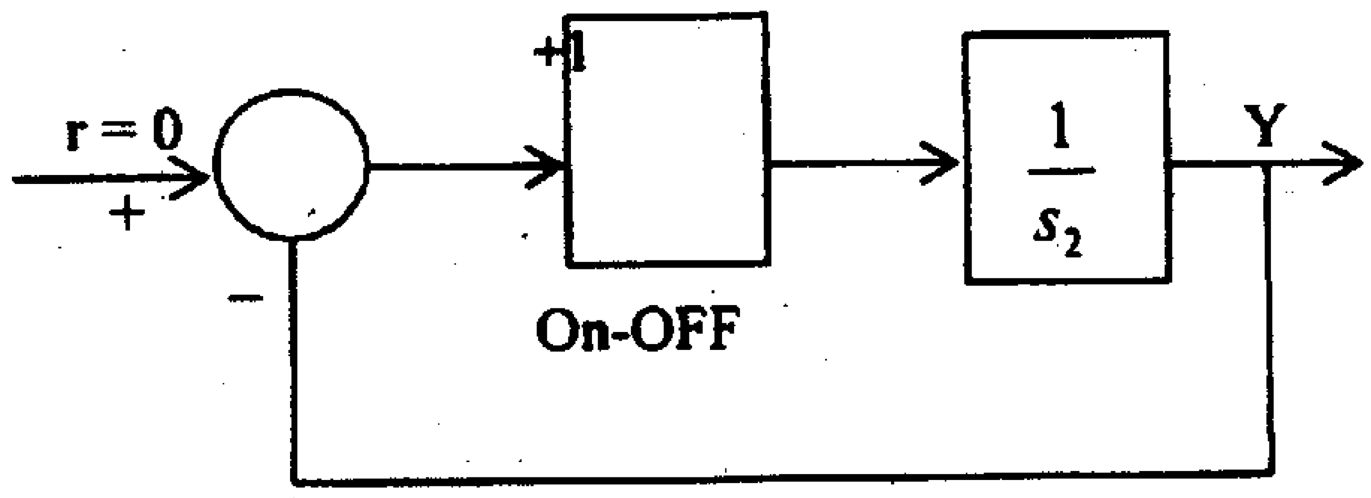

Figure 12 (b)

13. (a) Derive the describing function for the saturation non-linearity described in figure 12 (a) and asses the closed loop stability of the system. (16)

Or

(b) Analyse the closed loop performance of the system described in figure 12 (b) using describing function approach. (16)

14. (a) Consider the linear time invariant system whose state equation is given by $\dot{x} = \begin{bmatrix} 0 & 1 \\ -2 & -3 \end{bmatrix} x$

Assess the stability of the equilibrium point by constructing a Lyapunov's function. (16)

Or

(b) Construct a Lyapunov's function and assess the stability of the following system. (16)

$\dot{x} = -x_1 + (x_1 + x_2) x_2$

$\dot{x} = -x_1 + -2x_2$.

15. (a) Consider the following optimal control problem. (16)

$$\text{Min } J = \int_0^{\alpha} (x^2 + 2u^2)\, dt$$

Subject to $\dot{x} = -2x + u$

Determine the optimal control law.

Or

(b) Derive the Ricatti's equation as a solution of steady state optimal control problem. (16)