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Question Paper Code : 91535

B.E./B.Tech. DEGREE EXAMINATION, NOVEMBER/DECEMBER 2014.

Sixth Semester

Electrical and Electronics Engineering

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

(Common to Instrumentation and Control Engineering)

(Regulation 2008/2010)

Time : Three hours Maximum : 100 marks

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. Define state of a system.
2. What is the disadvantage of phase variable formation?
3. Write down the Duffing's equation and list out the frequency behavior of the system based on the equation.
4. What is a phase portrait?
5. How will you determine the stability of a system due to non-linearity?
6. What is meant by describing function method of analysis?
7. Define a globally asymptotically stable system.
8. Briefly explain Lure's transformation.
9. What are the two approaches for minimizing the performance index?
10. What is meant by optimal estimation?

PART B — (5 × 16 = 80 marks)

11. (a) Consider a control system with state model as follows: (16)

$$\begin{bmatrix}\dot{x}_1\\ \dot{x}_2\end{bmatrix}=\begin{bmatrix}0 & 1\\ -2 & -3\end{bmatrix}\begin{bmatrix}x_1\\ x_2\end{bmatrix}+\begin{bmatrix}0\\ 2\end{bmatrix}u; \quad \begin{bmatrix}x_1(0)\\ x_2(0)\end{bmatrix}=\begin{bmatrix}0\\ 1\end{bmatrix}; \text{ u=unit step}$$

Compute the state transition matrix and there from, find the state response $x(t); t > 0$.

Or

(b) (i) Define controllability. Explain the different methods of testing controllability of a system in detail. (8)

(ii) Examine the observability of the given system:

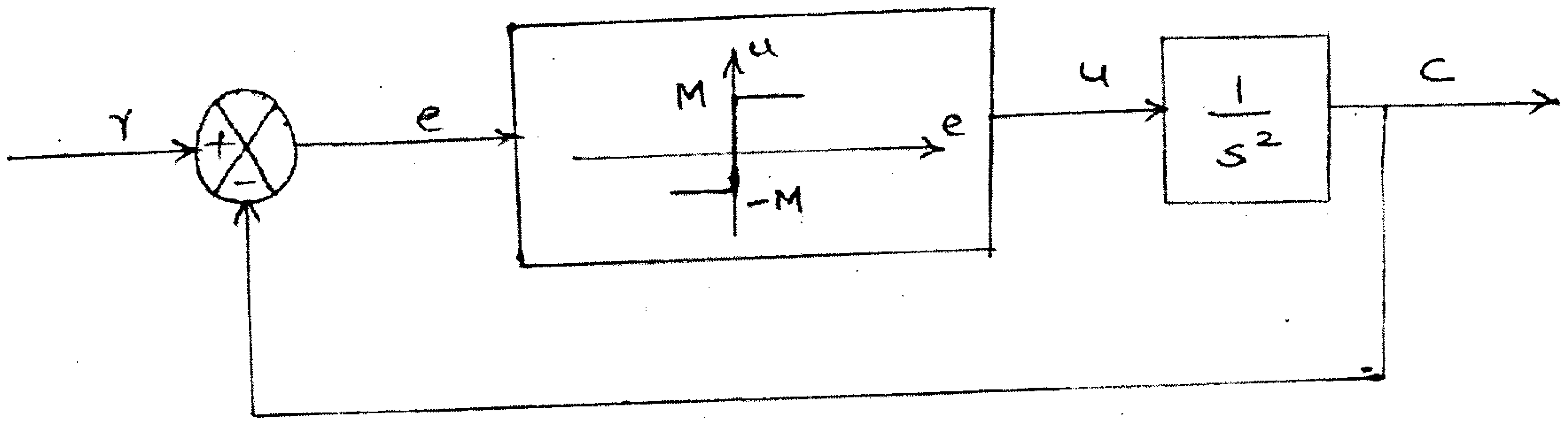
$$\begin{bmatrix}\dot{x}_1\\ \dot{x}_2\\ \dot{x}_3\end{bmatrix}=\begin{bmatrix}0 & 1 & 0\\ 0 & 0 & 1\\ 0 & -2 & -3\end{bmatrix}\begin{bmatrix}x_1\\ x_2\\ x_3\end{bmatrix}+\begin{bmatrix}0\\ 0\\ 1\end{bmatrix}u, \; y=\begin{bmatrix}3 & 4 & 1\end{bmatrix}\begin{bmatrix}x_1\\ x_2\\ x_3\end{bmatrix}.$$ (8)

12. (a) (i) Explain in detail any four of the basic features of common physical non-linearities. (8)

(ii) Explain about the classification of singular points based on eigen values of system matrix with their phase portraits. (8)

Or

(b) Consider a system with an ideal relay as shown below:

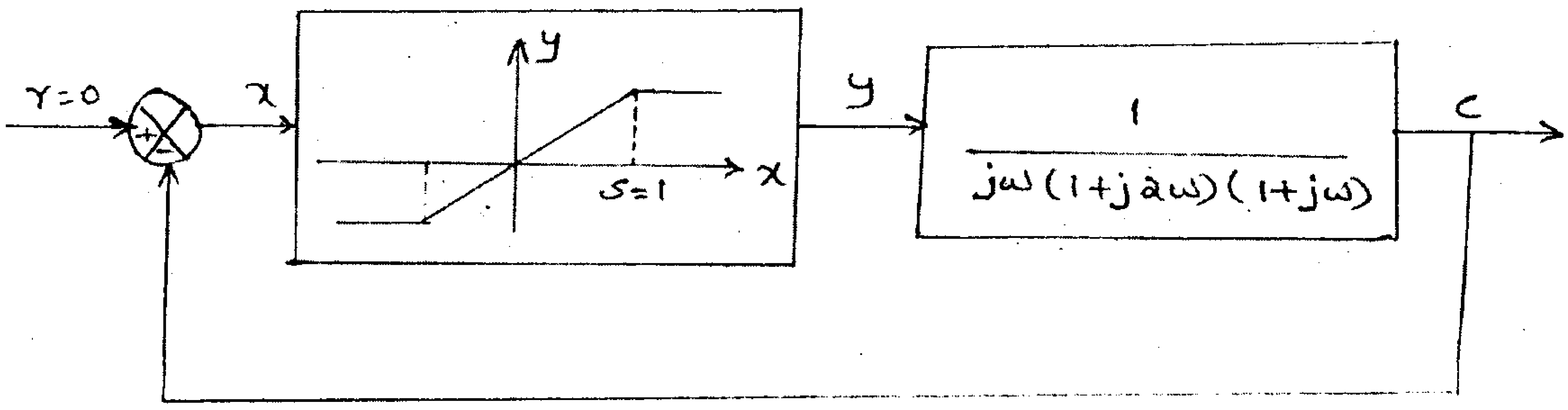


Determine the singular point. Construct the phase trajectories corresponding to initial conditions (1) c(0) = 2, c (0) = 1 and (2) c(0)= 2, c (0)= 15. Take r = 2volts and M= 1.2 volts. (16)

13. (a) Solve the describing function for backlash non-linearity. (16)

Or

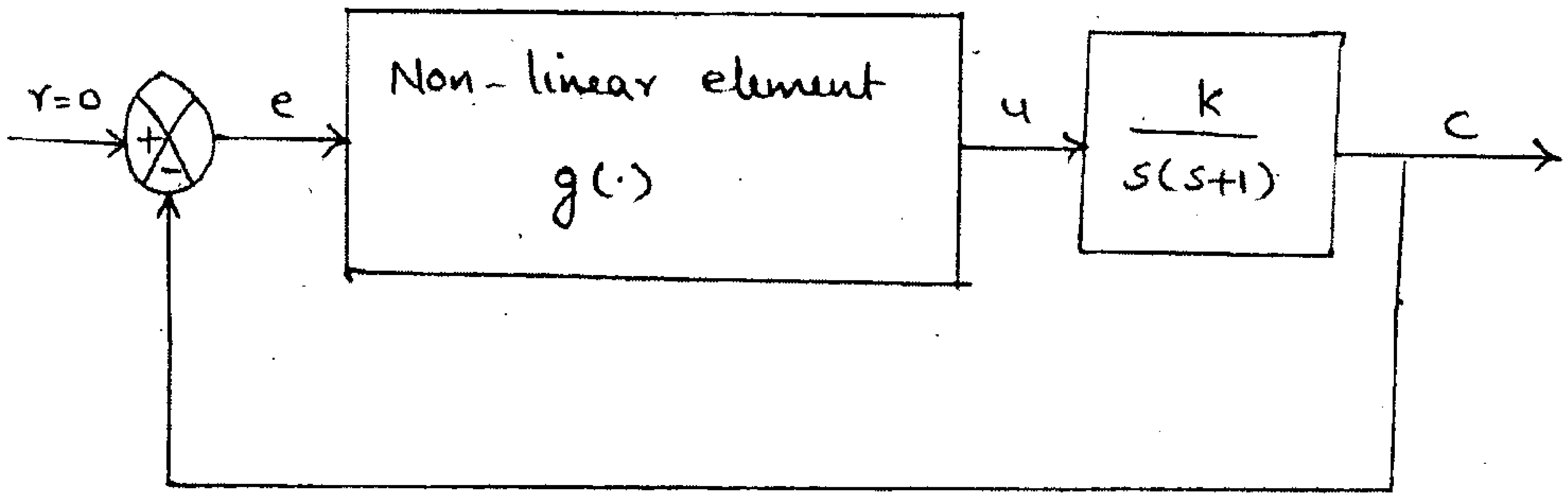
(b) Consider a third order system with a saturating amplifier having gain K in its linear region. (16)



Determine the largest value of gain K for the system to stay stable.

14. (a) (i) State and prove the Direct method of Liapunov. (8)

(ii) Find out the stability analysis of the following non-linear system. (8)



Or

(b) (i) State and prove any four theorems of Liapunov's method. (8)

(ii) Determine the stability of a system described by : (8)

$$\dot{x} = Ax, A = \begin{bmatrix} -1 & -2 \\ 1 & -4 \end{bmatrix}$$

15. (a) (i) Explain the optimal control problem based on transfer function approach with an example. (8)

(ii) Derive the control law which minimizes the performance index $j = \int_0^\infty (x_1^{\ 2} + u^2)dt$ for the system as follows. (8)

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ 0 & 0 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u.$$

Or

(b) Explain the LQR steady state optimal control problem with a suitable example. (16)