BE (sem. VII) / Advanced Control Systems

INST/04-12-15

QP Code : 5945

(3 Hours) **[Total marks : 80**

N.B.

1. Q.1 is ***compulsory***. Attempt ***any three*** from Q.2 to Q.6
2. Figures in ***right*** indicate ***full marks***.
3. Assume ***suitable data*** if necessary.

Q.1 Attempt ***any four*** **20**

(a) Define singular points of the system. How do you identify them in the phase portrait?

(b) Draw the sinusoidal response of saturation with dead zone nonlinearity. Write the response equations.

(c) Define positive definite matrix. What are the properties of the positive definite matrix if it is symmetric?

(d) Compute the 2-norm for the matrices

(i) $A=\begin{bmatrix}0 & 1\\ 3 & 5\end{bmatrix}$ (ii) $F=\begin{bmatrix}1 & 0\\ 0 & 5\end{bmatrix}$

(e) What are the limitations of plant inverse controllers ?

(f) Obtain the linear system matrix at the operating point $x_0^T=[1 \quad 0.5 \quad 0.5]$ for the system of equations.

$$\begin{bmatrix}\dot{x}_1\\ \dot{x}_2\\ \dot{x}_3\end{bmatrix}=\begin{bmatrix}x_2^2\\ x_3^2\\ -3x_1^2-11x_2^2-12x_3\end{bmatrix}$$

Comment whether the operating point is stable?

Q.2 (A) Draw the phase trajectory for the following system using delta method. Assume intial condition $x=1, \dot{x}=0$

$\ddot{x}+2\dot{x}+4x=0$ **10**

(B) Derive the describing function for relay with dead zone nonlinearity. **10**

Q.3 (A) Obtain via analytical method the solution of the following system and write the equation of trajectory. Assume initial condition $x_{10}=1, x_{20}=0$.

$\dot{x}_1=x_2$

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

What type of singular point the system will have? **10**

(B) Explain Lyapunov stability analysis with neat phase trajectories. **10**

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Q.4 (A) Design IMC controller for plant model

$\tilde{G}(s)=\frac{(-s+1)}{2s+1}$ in order to achieve the response with time constant of 1.5 sec. **10**

(B) (i) Explain choice of filters in IMC for step and ramp reference inputs. **5**

(ii) What is NMP system? Explain inverse response. **5**

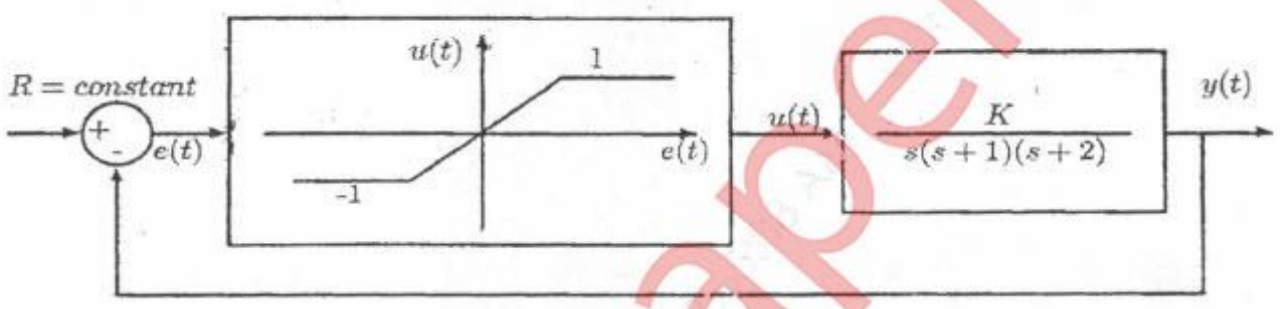
Q.5 (A) Design the optimal controller via Riccati equation for the system

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

to minimize the performance index $J=\int_0^\infty (x_1^2+x_2^2+u^2)\,dt.$ **10**

(B) Write the steps for constructing the Lyapunov function via Krasovskii method. **10**

Q.6 (A) Investigate stability of the given system using describing function method.



10

(B) Write steps for linearizing the nonlinear system using feedback linearization

$$\dot{x}=f(x)+g(x)u$$
$$y=h(x)$$

10
