53 (IE 604) CNSY

2016

CONTROL SYSTEM-II

Paper : IE 604

Full Marks : 100

Time : Three hours

The figures in the margin indicate full marks for the questions.

Answer ***any five*** *questions out of* ***seven.***

1. *(a)* How the performances of a control system are specified? 2

(b) A system is designed by

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

Draw the root locus plot and determine the value of K to give a damping ratio of 0·5. And design a lead compensator when the undamped natural frequency $w_n = 2\, rad/sec$. 10

Contd.

(c) What is a lead compensator? Describe the lead compensator with a suitable circuit diagram. 4

(d) For a lead compensator prove that

$$\sin\phi_m = \frac{1-\alpha}{1+\alpha},$$

where, ϕ_m is the maximum phase lead caused by the compensator and

$\alpha = \frac{Zc}{Pc} < 1$. Zc and Pc are compensator Zero and Pole respectively. 4

2. (a) Derive the transfer function of the system

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ -3 & -2 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u$$

$$y = \begin{bmatrix} 1 & 2 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$$ 5

(b) A feedback system is characterized by the closed transfer function

$$\frac{Y(s)}{U(s)} = \frac{2s^2 + 3s + 1}{s^3 + 5s^2 + 6s + 7}$$

Obtain its state space model in 1st companion form. 5

(c) Consider the open loop transfer function

$$G(s) = \frac{1}{s(s+1)(0{\cdot}5s+1)}$$

It is desired to compensate the system so that the static velocity error constant Kv is 5 sec^{-1}, the phase margin and gain margin are at least 40° and 10dB respectively. 10

3. (a) Check the observability of the system given below :

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \\ \dot{x}_3 \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 2 & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} + \begin{bmatrix} 0 \\ 1 \\ 0 \end{bmatrix} u$$

$$y = \begin{bmatrix} 1 & 0 & 0 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix}$$

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(b) Find $x_1(t)$ and $x_2(t)$ of the system described by

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ -3 & -2 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$$

where the initial conditions are

$$\begin{bmatrix} x_1(0) \\ x_2(0) \end{bmatrix} = \begin{bmatrix} 1 \\ -1 \end{bmatrix}.$$

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(c) Consider the system defined by

$$\dot{x} = Ax + Bu$$

where, $$A = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -1 & -2 & -3 \end{bmatrix}; \quad B = \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix}$$

By using state feedback control $u = -kx$, it is desired to have the closed loop poles at $s = -1 \pm j2$ and $s = -4$. Determine the state feedback matrix k.

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4. *(a)* Find the *Z*-Transform of the following functions.

(i) e^{-at} , *(ii)* $\cos \omega t$ 6

(b) Determine the stability of a sample data control system having following characteristics polynomial.

$$2z^4 + 8z^3 + 12z^2 + 5z + 1 = 0$$ 4

(c) Determine the pulse transfer function of the system given in *Fig. (4.c)*. 10

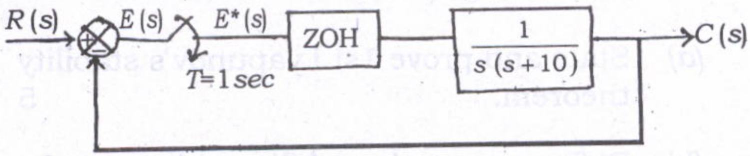

Fig. (4.c)

5. *(a)* What are the common non-linearities present in the systems.

Find the describing function for the nonlinear systems having characteristics as shown in *Fig. (5.a)*. 2+6

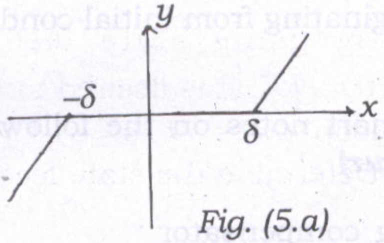

Fig. (5.a)

(b) Determine whether the system in *Fig. (5.b)* exhibits a self sustained oscillation. If so, determine the stability, frequency and amplitude of the oscillation. 12

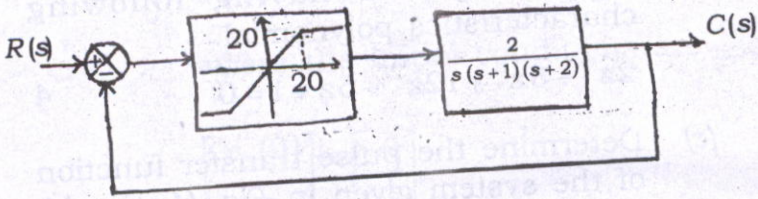

Fig. (5.b)

6. (a) State and prove 1st Lyapunov's stability theorem. 5

(b) Define asymtotic stability with example. 5

(c) For the system having a closed loop transfer function, $\dfrac{C(s)}{R(s)} = \dfrac{10}{s^2+2s+5}$.

Plot the phase plane trajectory originating from initial condition (−1, 0). 10

7. Write short notes on the following : 4×5
(any four)

(a) Lag compensator

(b) Backlash nonlinearity

(c) Eigenvalues and Eigenvector

(d) State space and State vector

(e) Frequency-amplitude dependency of a system.
