Total number of printed pages–7

53 (IE 604) CNSY-II

2015

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)* What is lead compensator ? Describe the lead compensator with a proper circuit diagram and necessary Bode plot. 5

Contd.

(b) The open loop transfer function of a system is given by $G(s)\,H(s)=\frac{k}{s^2}$. It is desired to compensate the system as to meet the following transient response specifications.

setting time ≤ 4 sec.

peak overshoot for step input $\leq 20\%$.

Design a suitable lead compensator and sketch the root locus plot of the uncompensated and compensated systems. 10

(c) A lag compensator is designed to compensate the system,

$G(s)=\frac{1}{s\,(s+1)\,(0\cdot 5s+1)}$, so that the static velocity error constant k_v is $5\,sec^{-1}$, the phase margin is 50° and gain margin is at least $10dB$. Find the maximum phase lag produced by the compensator. Find also the frequency where the maximum phase lag occurs. 5

2. (a) What is state space? Why the state space representation is advantageous than transfer function representation? 1+2

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

$$\frac{C(s)}{R(s)} = \frac{s^2+3s+3}{s^3+2s^2+3s+1}$$

Obtain its state space model. 5

(c) Consider the system defined by

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

$$y = Cx$$

where,

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

Obtain the transfer function $Y(s)/U(s)$. 7

(d) What is observability ? Is the following system completely observable ?

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_3 \\ \dot{x}_3 \end{bmatrix} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -6 & -11 & -6 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} u$$

$$y = \begin{bmatrix} 20 & 9 & 1 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix}$$

5

3. *(a)* A regulator system has a plant

$$\frac{Y(s)}{U(s)} = \frac{10}{(s+1)(s+2)(s+3)}$$

By use of the state-feedback control $u = -kx$, it is desired to place the closed-loop poles at $s = -2 + j2\sqrt{3}$, $s = -2 - j2\sqrt{3}$, $s = -10$.

Determine the necessary state-feedback gain matrix k. 10

(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

$$\begin{bmatrix} x_1(0) \\ x_2(0) \end{bmatrix} = \begin{bmatrix} 1 \\ -1 \end{bmatrix}$$ 10

4. *(a)* What is pulse transfer function? Determine the pulse transfer function of the system given in *Fig.*(4.*a*) 1+4

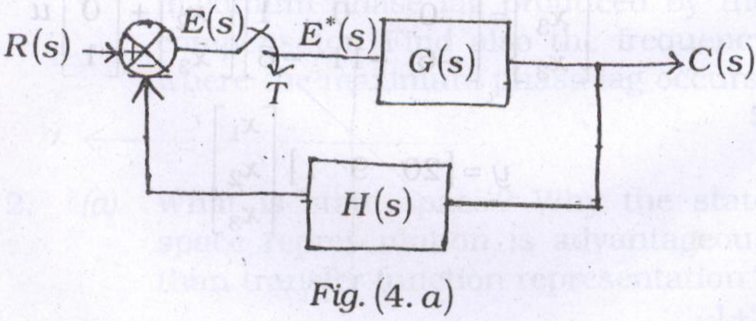

Fig. (4. *a*)

(b) Find the Z-Transform of the following functions. 6

(i) $t \cdot e^{-at}$

(ii) $e^{-at} \cos \omega t$

(c) What is the transfer function expression for ZOH circuit ?
Find the range of k for which the system of Fig. (4.c) will be stable. 1+8

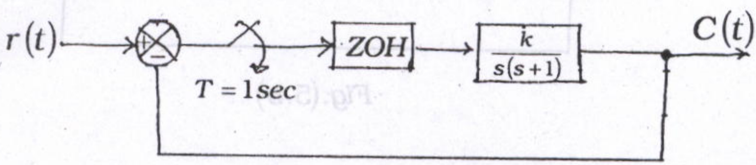

Fig. (4. c)

5. (a) What is describing function ?
Find the describing function for the nonlinear system having characteristics as shown in Fig. 5(a). 2+8

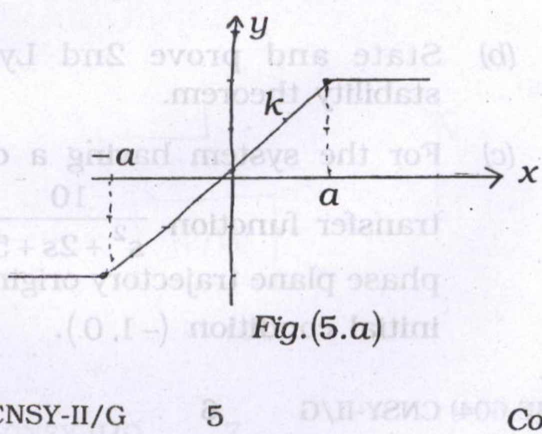

Fig.(5.a)

(b) Consider the nonlinear system of *Fig.* (5.*b*). Determine the largest k which preserves the stability of the system. If $k = 2k_{max}$, find the amplitude and frequency of the self-sustained oscillation. 10

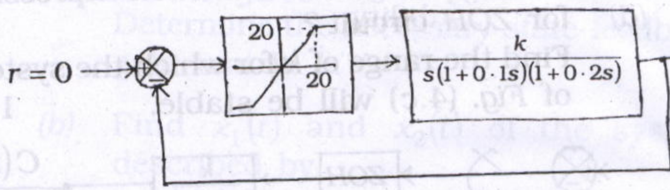

Fig.(5.*b*)

6. (a) For the following systems, find the equilibrium points and determine their stability.

(i) $\dot{x} = -x^3 + sin^4 x$

(ii) $\dot{x} = (5 - x)^5$ 6

(b) State and prove 2nd Lyapurnov's stability theorem. 4

(c) For the system having a closed loop transfer function $\frac{10}{s^2 + 2s + 5}$, plot the phase plane trajectory originating from initial condition $(-1, 0)$. 10

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

(a) Back lash nonlinearity

(b) Lag-lead compensator

(c) Frequency-amplitude dependency

(d) Controllability

(e) Jury's stability test.
