53 (IE 604) CNSY

2017

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)* A unity feedback system is characterized by the open-loop transfer function

$$G(s)=\frac{k}{s(s+3)(s+9)}$$

Design a cascade compensator for the system. If 20% overshoot to a step input is desired find the value of k. Also velocity error constant, $kv \geq 20$ should be maintained. 10

(b) The open loop transfer function of a system is $G(s)=\frac{10}{s^2}$. It is desired to compensate the system so that the static velocity error constant kv is $5sec^{-1}$, the phase margin is 40° and gain margin is at least $10dB$. 10

2. (a) What is lag-lead compensator? Why this type of compensator is connected to the control system? 3+2

(b) If the transfer function of lead compensator is $G_e(s)=\frac{s+1/e}{s+1/\alpha e}$, show that the maximum phase lead by the compensator be $\phi_m = sin^{-1}\frac{1-\alpha}{1+\alpha}$ at the frequency of $w_m=\frac{1}{e\sqrt{\alpha}}$. 5

(c) Determine the transfer function from the data given below

$$A=\begin{bmatrix}-3 & 1\\ 0 & -1\end{bmatrix}, B=\begin{bmatrix}1\\1\end{bmatrix}, C=[1\ \ 1],\ D=0.$$

5

(d) Obtain the state space model of the electrical network shown in *Fig. 2. (d)*. Select suitable state variables and output variables. 5

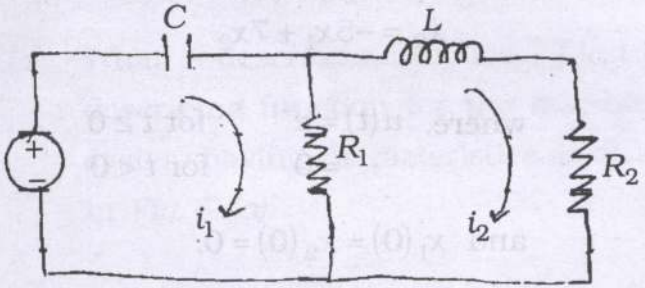

Fig. 2. (d)

3. (a) Consider the system given by $\dot{x} = Ax + Bu$. Where,

$$A = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -1 & -5 & -6 \end{bmatrix}, \quad B = \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix}$$

The system uses the state feedback $u = -kx$. The desired closed loop poles at

$$s = -2 \pm j4, \quad s = -10.$$

Determine the state feedback gain matrix. 10

(b) Using Laplace transform method, determine time response of a system having state model as .....

$$\dot{x}_1 = x_2 + u(t)$$
$$\dot{x}_2 = -5x_1 + 7x_2$$

where, $u(t) = e^{-t}$ for $t \geq 0$
$= 0$ for $t < 0$

and $x_1(0) = x_2(0) = 0$: 10

4. (a) Find the closed loop transfer function in Z domain of the system in *Fig. 4. (a)*. 10

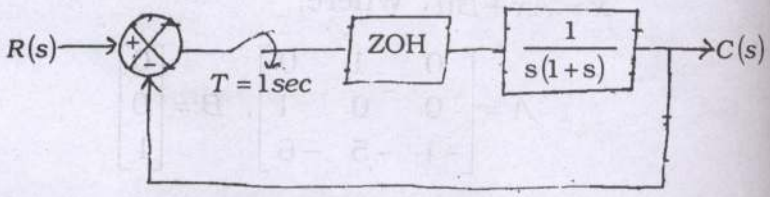

Fig. 4. (a)

(b) Check the stability of the system having characteristics equation — 5

$$p(z) = z^4 - 1{\cdot}2z^3 + 0{\cdot}07z^2 + 0{\cdot}3z - 0{\cdot}08 = 0$$

(c) What is pulse transfer function ? Derive the pulse transfer function of Zero Order Hold (ZOH) circuit. 2+3

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

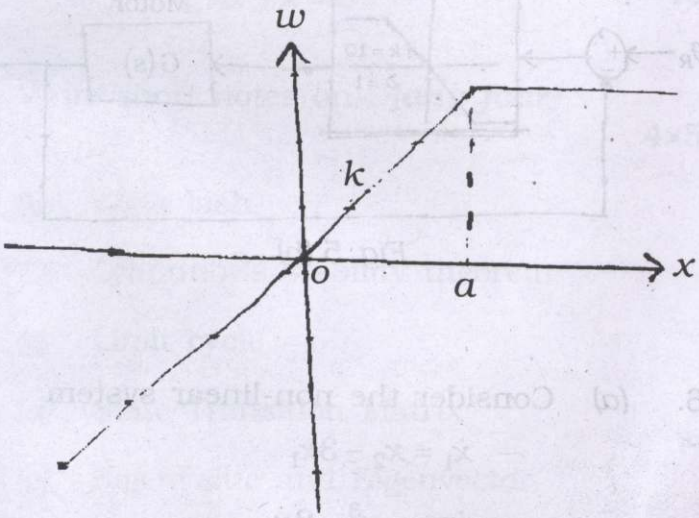

Fig. 5. (a)

(b) A two phase servomotor is driven by an amplifier as shown in *Fig. 5.(b)*. The transfer function of the motor is

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

Investigate the stability of the system for $k = 1$. What is the largest value of k for no limit cycle to exist? 10

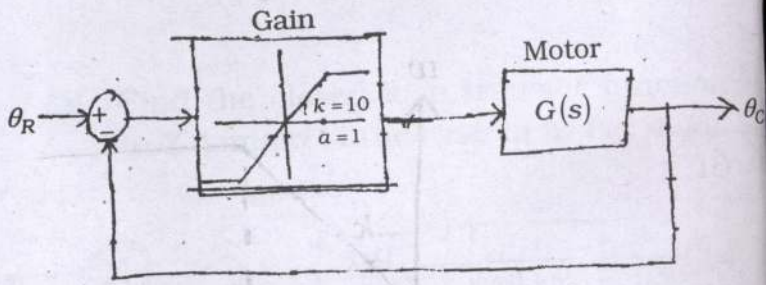

Fig. 5.(b)

6. (a) Consider the non-linear system

$$\dot{x}_1 = x_2 - 3x_1$$

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

Prove that the system is asymptotically stable.

(b) Comment on the controllability of the system having following co-efficient matrices.

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

$$C = [1\ 0\ 0], \quad D = 0$$ 5

(c) Draw the phase plane portraits of the following system, using isocline method.

$$\ddot{x} + \dot{x} + x = 0$$ 10

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

(a) Back lash

(b) Lyapunov's stability theorem

(c) Limit cycle

(d) State Transition Matrix

(e) Eigenvalue and Eigenvector.
