Total number of printed pages–7

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)* What is a lead compensator ? Why this type of compensator is connected to the control system ? 2+3

   (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 K_v is $5sec^{-1}$, the phase margin is 40° and gain margin is at least $10dB$. Obtain the suitable compensator. 10

Contd.

(c) 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 $\alpha = \frac{Z_c}{P_c} < 1$. Z_c and P_c are compensator zero and pole respectively. 5

2. (a) Consider the system shown in *Fig. (2.a)*. Design a suitable compensator for this system to meet the following specifications :

Damping ratio, $\xi = 0{\cdot}7$

Settling time, $t_s = 1{\cdot}4\,sec$

Velocity error constant, $K_v = 20\,sec^{-1}$. 10

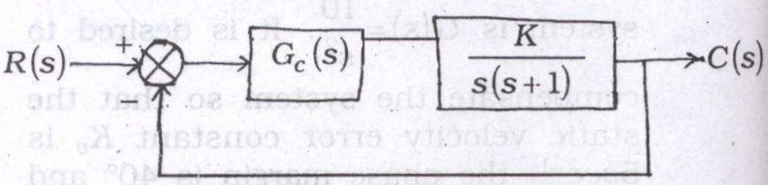

Fig. (2.a)

(b) Consider the system given by $\dot{x} = Ax + Bu$

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

The system is used as the state feedback $u = -Kx$. The desired closed loop poles are : $s = -2 \pm j4$, $s = -10$. Determine the state feedback gain matrix. 10

3. (a) Obtain the state space model of the electrical network shown in *Fig. (3.a)*. Select the suitable state variables and output variables. 5

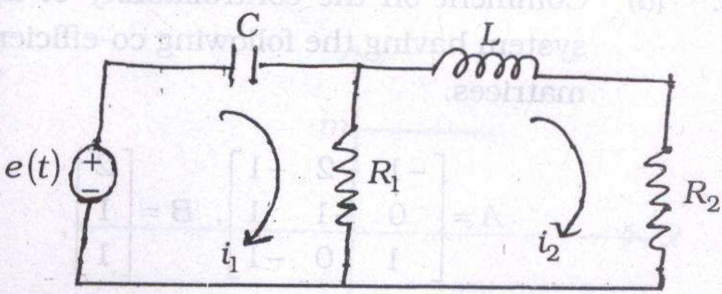

Fig. (3.a)

(b) 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

(c) 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 $x_1(0) = 1$ and $x_2(0) = -1$. 10

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

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

$$C = [1\ 0\ 1], D = 0.$$

5

(b) What is pulse transfer function ? Derive the pulse transfer function of a Zero Order Hold (ZOH) circuit.

2+3

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

10

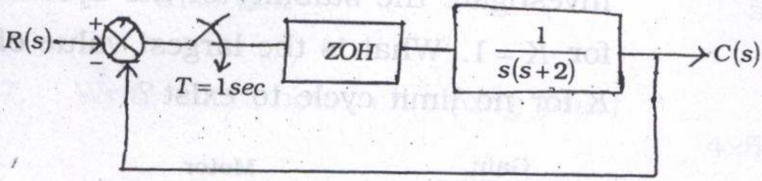

Fig. (4.c)

5. (a) Find the range of K for the stable system $F(z) = z^3 + z^2 + z + K = 0$. 4

(b) Find the describing function for the nonlinearity on shown in *Fig. (5.b)*.

6

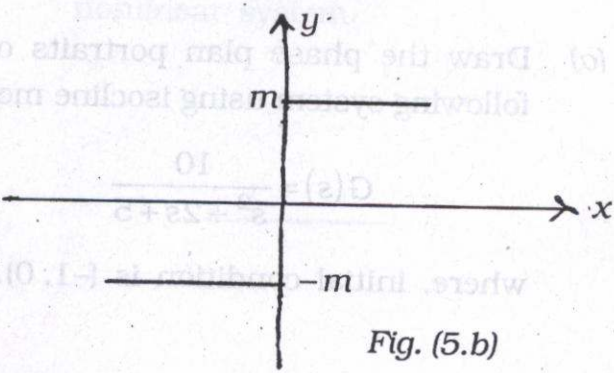

Fig. (5.b)

(c) A two phase servomotor is driven by an amplifier as shown in *Fig. (5.c)*. 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?

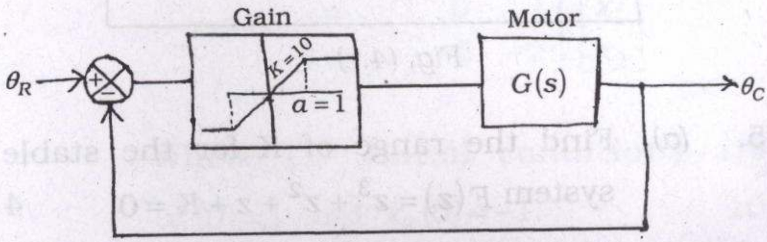

Fig. (5.c)

10

6. (a) Draw the phase plan portraits of the following system using isocline method.

$$G(s) = \frac{10}{s^2 + 2s + 5}$$

where, initial condition is (–1, 0).

10

(b) 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 asymtotically stable. 5

(c) State and prove 2nd Lyapunov's stability theorem. 5

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

(a) State space and state vector

(b) Lag compensator

(c) Saturation nonlinearity

(d) Eigenvalue and Eigenvector

(e) Frequency-amplitude dependancy of nonlinear system.