53 (IE 604) CNSY-II

2019

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.*

1. *(a)* Draw and explain the Bode plot for a phase lead network. 5

   (b) Design a suitable lead compensation network for $G(s)=\frac{K}{s(s+2)(s+10)}$ to meet the following specifications :
   Velocity error constant, $K_V = 25 sec^{-1}$, phase margin (PM) $\geq 25°$. Assume the margin of safety = 5°. 15

2. *(a)* Define the describing function. 4

   (b) Determine the describing function for a practical relay. 16

Contd.

3. *(a)* Explain the phase portraits for a mass spring system. 10

(b) How time can be determined from the phase plane trajectory ? 10

4. *(a)* Using the z-transformation, find $x(z)$ when $x(k)=a^k$ for $k=0, 1, 2, 3...$ 6

(b) Prove $Z[f(k+m)]=z^m F(z)-z^m f(0)-z^{m-1} f(1) - z^{m-2} f(2)...-z f(m-1)$. 10

(c) State initial and final value theorem for z-transformation. 4

5. *(a)* Define state variable and state vector. 6

(b) A system is described by the differential equation

$$\frac{d^3y}{dt^3}+3\frac{d^2y}{dt^2}+4\frac{dy}{dt}+4y=u_1(t)+2u_2(t)$$

where $y(t)$ is the output and $u_1(t)$ and $u_2(t)$ are the inputs to the system. Obtain the state space representation of the system. 14

6. *(a)* For the given transfer function, obtain the state model :

$$G(s)=\frac{y(s)}{u(s)}=\frac{K}{s^3+2s^2+3s+4}$$ 12

(b) What is transfer matrix and state transition matrix ? 8

7. *(a)* Using the properties of state transition matrices, prove that 8

$$\phi(t_2-t_1)\phi(t_1-t_0)=\phi(t_2-t_0) = \phi(t_1-t_0)\phi(t_2-t_1)$$

(b) A single input single output (SISO) system is represented as

$$\dot{x}(t)=\begin{bmatrix}-1 & 0 & 0\\ 0 & -3 & 0\\ 0 & 0 & -4\end{bmatrix}x(t)+\begin{bmatrix}1\\1\\0\end{bmatrix}u(t) \text{ and}$$

$$y(t)=[1\cdot0\ 2]x(t).$$

Test the controllability and observability of this SISO system. 12

8. Write short notes on ***any two*** of the following : 10×2=20

(a) Phase lag networks

(b) Stability analysis with describing function

(c) Describing function for saturation type of non-linearity

(d) Kalman's test for controllability and observability.
