Total number of printed pages–6

53 (IE 506) CTTH

2021

CONTROL THEORY

Paper : IE 506

Full Marks : 100

Time : Three hours

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

Answer ***any five*** *questions.*

1. *(a)* What is closed-loop control system ? Discuss with proper diagram. 5

   (b) Find the Laplace transform of the following function : 5

   $f(t) = 0 \quad \text{for} \quad t = 0$

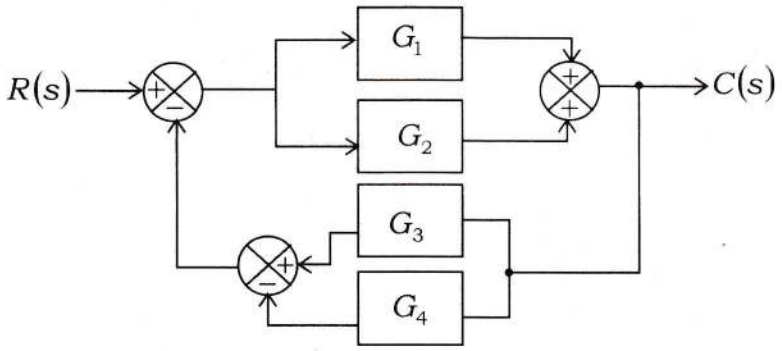
   $= 3\sin(5t + 45^\circ)$

   (c) Find the inverse Laplace transform of

   $$F(s) = \frac{s+1}{s(s^2+s+1)}.$$ 10

Contd.

2. *(a)* Simplify the block diagram shown below : 5



(b) Consider the system described by

$$\dddot{y} + 3\ddot{y} + 2\dot{y} = u$$

Derive the state-space representation of the system. 5

(c) Consider the system described by

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} -4 & -1 \\ 3 & -1 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 1 \\ 1 \end{bmatrix} u$$

Obtain the transfer function of the system. 10

3. *(a)* Determine the range of K for stability of a unity-feedback control system whose open-loop transfer function is 5

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

(b) Obtain the unit-impulse response of a unity-feedback system whose open transfer function is $G(s)=\frac{2s+1}{s^2}$. 5

(c) Consider the closed-loop system given by

$$\frac{C(s)}{R(s)}=\frac{\omega_n^2}{s^2+2\zeta\omega_n s+\omega_n^2}.$$

Determine the value of ζ and ω_n so that the system responds to a step-input with approximately 5% overshoot and with a settling time of 2 *sec* (use the 2% criterion). 10

4. *(a)* What is root-locus? 5

(b) Plot the root loci for a closed-loop control system with

$$G(s)=\frac{K(s+9)}{s\left(s^2+4s+1\right)},\quad H(s)=1$$

Locate the closed-loop poles on the root loci such that the dominant closed-loop poles have a damping ratio equal to 0·5. Determine the corresponding value of gain *K*. 10+5=15

5. *(a)* What is Bode diagram? 5

(b) Draw Bode diagram of $(s)^{-1}$. 5

(c) Plot a Bode diagram of

$$G(s)=\frac{10\left(s^2+0.4s+1\right)}{s\left(s^2+0{\cdot}8s+9\right)}.$$ 10

6. *(a)* Draw a Nyquist locus for the unity-feedback control system with the open-loop transfer function

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

Using the Nyquist stability criterion, determine the stability of the closed-loop system. 10

(b) Consider a unity-feedback control system with the open-loop transfer function —

$$G(s)=\frac{K}{s\left(s^2+s+4\right)}$$

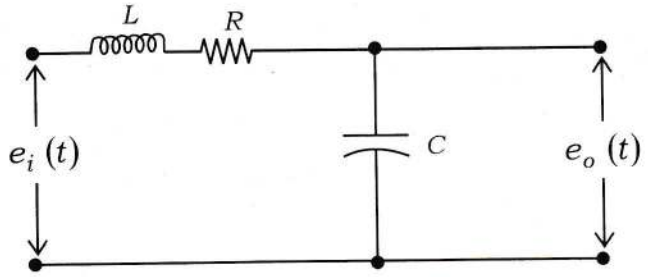
Determine the value of the gain K such that the phase margin is 50°. What is the gain margin of this system with this gain K ? 10

7. *(a)* Define the terms : 5

(a) Transfer function

(b) Mason's Gain Formula.

(b) The RLC circuit is shown in the figure. Obtain the transfer function. 5



(c) Consider the unit-step response of a unity-feedback control system whose open-loop transfer function is

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

Obtain the rise time, peak time, maximum overshoot and settling time. 10