Total No. of printed pages = 6

EI 181402

Roll No. of candidate

2023

B.Tech. 4th Semester End-Term Examination

CONTROL SYSTEMS

(New Regulation (w.e.f 2017 – 18) & New Syllabus (w.e.f. 2018 – 19))

Full Marks – 70

Time – Three hours

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

Answer Question No. 1 and any *four* from the rest.

1. Choose the correct answer from the following multiple choice questions : (10 × 1 = 10)

(i) A control system cannot be classified on the basis of the

(a) number of feedback

(b) number of input and output terminals

(c) order of the equations

(d) type of damping

(ii) The transfer function of a control system, assuming zero initial condition, is the Laplace transform of the output response of the system for

(a) unit step input

(b) unit impulse input

(c) unit parabolic input

(d) unit ramp input

[Turn over

(iii) The open loop transfer function of a unity feedback control system is given by $G(S) = \frac{0.4s+1}{s(s+0.6)}$

The closed loop system has

(a) a pair of complex poles

(b) a pair of real poles

(c) a pair of complex zeroes

(d) a pair of real zeroes

(iv) The time response of a control system is

$c(t) = 1 - e^{-10t}$ *for* $t > 0$

The closed loop transfer function of the system for a unit step input is

(a) $\frac{1}{s+10}$

(b) $\frac{s+9}{s+10}$

(c) $\frac{10}{s(s+10)}$

(d) $\frac{10}{s+10}$

(v) The characteristic equation of a second order control system is given by $s^2 + 3s + 8 = 0$

The system is

(a) an under-damped system

(b) a critically-damped system

(c) an over-damped system

(d) an un-damped system

(vi) The steady state error of a control system subjected to a unit ramp input with zero static error coefficient is

(a) zero

(b) infinity

(c) one

(d) greater than zero but less than one

(vii) The characteristic equation of a control system is given by

$s^5 + 4s^4 + s^2 + s + 2 = 0$, the system is

(a) stable

(b) marginally stable

(c) unstable

(d) absolutely stable

(viii) The root locus always starts at the

(a) open-loop poles (b) open-loop zeros

(c) closed-loop poles (d) closed-loop zeros

(ix) For the Bode plot of transfer function

$G(S) = \dfrac{K}{s+10}$ the corner frequency is

(a) 10 (b) K/10

(c) 0.01 (d) 0.1

(x) The system with 0 dB Gain Margin is a

(a) stable system

(b) unstable system

(c) conditionally stable system

(d) marginally stable system

2. (a) Derive transfer function $\dfrac{E_0(s)}{E_1(s)}$ for the systems shown in Fig. 1 (7)

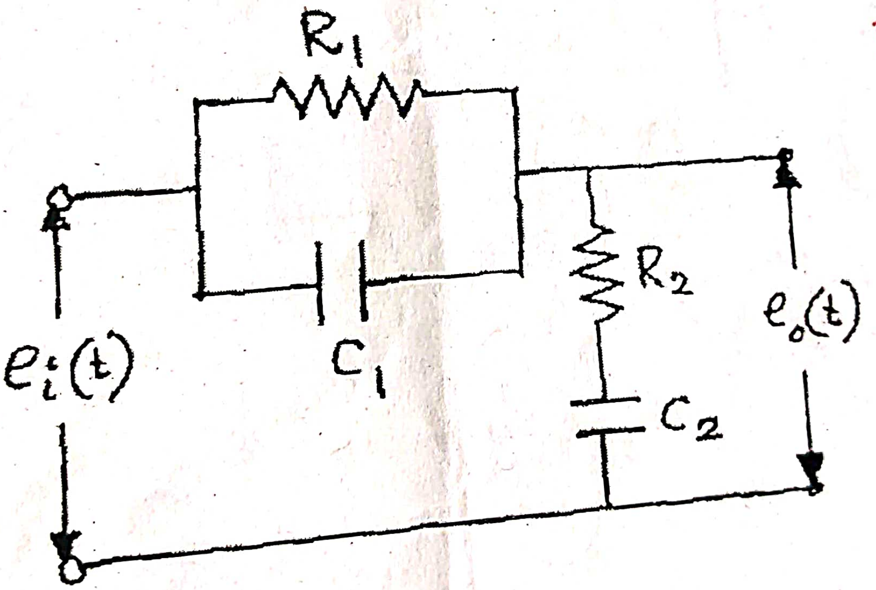

Fig. 1

(b) The following differential equation represents a linear time invariant system, where $x(t)$ denotes the input, and $y(t)$ the output. Determine the closed loop transfer function, characteristic equation and closed loop poles for the system. (4)

$$\frac{d^2y(t)}{dt^2} + 3\frac{dy(t)}{dt} + 8y(t) = 8x(t)$$

[Turn over

(c) Explain the working principle of any one of the following control system components : (4)

(i) DC Servomotor

(ii) Synchros

3. (a) Determine transfer function $\frac{C(s)}{R(s)}$ using reduction technique for the block diagram shown in Fig. 2. (7)

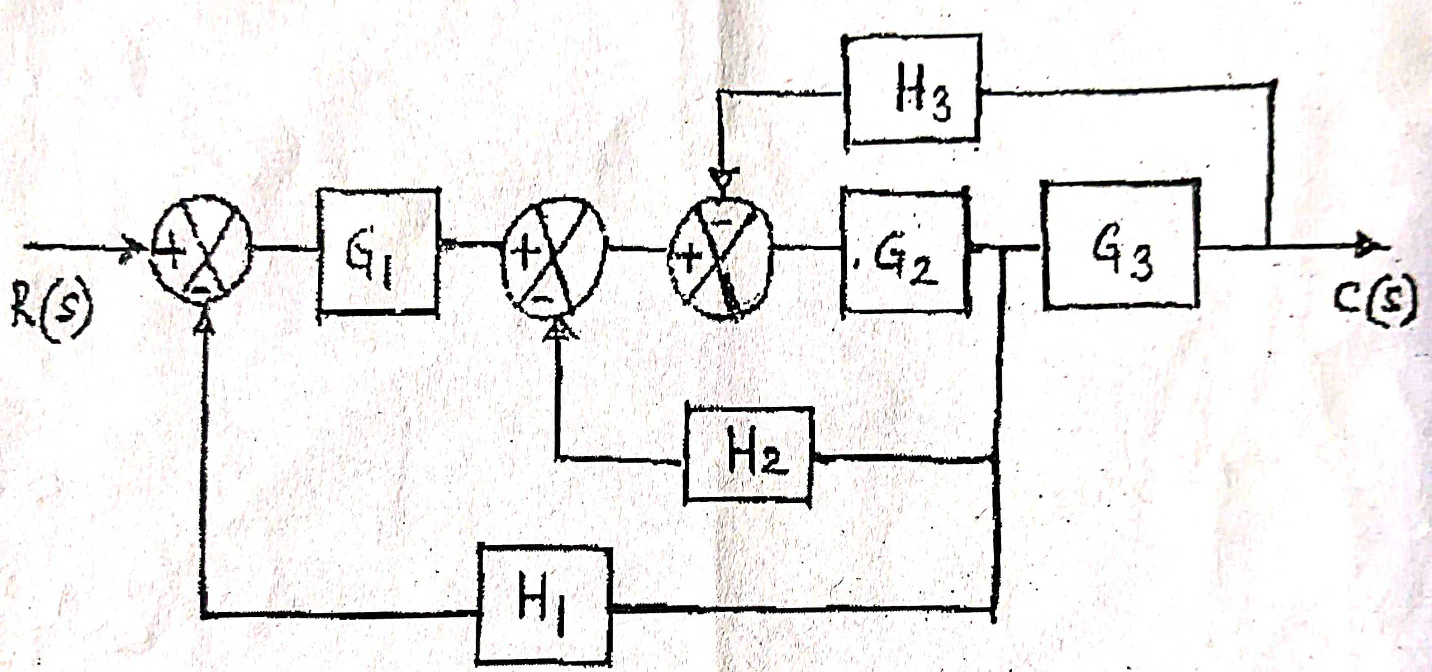

Fig. 2

(b) Draw signal flow graph for the block diagram shown in Fig. 2 and determine transfer function $\frac{C(s)}{R(s)}$ using gain formula. (8)

4. (a) Demonstrate graphically the rise time, peak time, maximum overshoot and settling time in a transient response of a second order control system subjected to a unit step input. (5)

(b) The closed-loop poles of a second-order control system are $(-4+j2)$ and $(-4-j2)$. Determine damping ratio, natural frequency and settling time (2% tolerance) for the system subjected to a unit step input. (5)

(c) A unity feedback system has open-loop transfer function

$$G(S) = \frac{2}{s(s+1)(0.1s+1)}$$

and the input to the system is $r(t) = 10t$. Determine the steady state error of the system. (5)

5. (a) The characteristic equation of a system is given by

$$s^4 + 4s^3 + 13s^2 + 36s + K = 0$$

Determine the range of values of K for the system to be stable. Can the system be marginally stable? If so, find the required value of K and the frequency of sustained oscillation. (7)

(b) A unity feedback control system has an open loop transfer function

$$G(S) = \frac{K}{s(s^2 + 4s + 13)}, K > 0$$

Sketch the complete root locus of the system. (8)

6. Answer either (a) OR (b):

(a) The open-loop transfer function of a control system is given by

$$GH(S) = \frac{20}{s(s+4)(s+6)}.$$

Sketch Nyquist plot and using Nyquist stability criterion examine the stability of the system. (15)

OR

(b) The open-loop transfer function of a control system is given by

$$GH(j\omega) = \frac{10}{(j\omega)(1+j0.2\omega)(1+j0.02\omega)}$$

Sketch Bode magnitude and phase angle plot in a semi-log graph paper and from the plots determine the gain margin and phase margin. (15)

[Turn over

7. Answer the following questions :

(a) What is meant by a compensator? (3)

(b) Illustrate two types of compensation with the help of block diagrams. (4)

(c) What is the basis for the selection of a particular compensator? (4)

(d) How do you realize a compensator by an electric circuit? (4)

$$\frac{d^2y(t)}{dt^2} + \frac{3\,dy(t)}{dt} + 8\,y(t) = 8x(t)$$

$$\Rightarrow s^2Y(s) + 3sY(s) + 8Y(s) = 8X(s)$$

$$\Rightarrow \frac{Y(s)}{X(s)} = \frac{8}{s^2+3s+8}$$

$$s^2+3s+16=0$$

$$\frac{-3 \pm \sqrt{9-64}}{2}$$