

Total Pages—6

(Set-R₁)

B.Tech-6th

Control System Engg.

Full Marks : 70

Time : 3 hours

Answer Q. No. 1 and any five from the rest

The figures in the right-hand margin indicate marks

Symbols carry usual meaning

1. Answer the following questions : 2 × 10

- (a) What are the advantages of closed-loop control systems ?
- (b) Determine the settling time for 2% band for a system with closed-loop transfer function

$$H(s) = \frac{9}{s^2 + 4s + 9}$$

- (c) What is the Routh's Stability criterion ?

(Turn Over)

(2)

- (d) What is the effect of addition of a pole to the system ?
- (e) What are the differences between PI and PD control ?
- (f) A system is described by the transfer function

$$H(s) = \frac{1}{s^3 + \alpha s^2 + ks + 3}$$

What are the constraints on α and k for the system to be stable ?

- (g) Define the state variable of a system.
- (h) What are the main problems associated with implementation of digital control ?
- (i) What is the Shannon's sampling theorem ?
- (j) State the final value theorem of the z-transform.

2. (a) Convert the block diagram of Fig. 1 to a signal flow-graph, and therefrom obtain the

(3)

input-output transfer function using Mason's
gain rule.

5

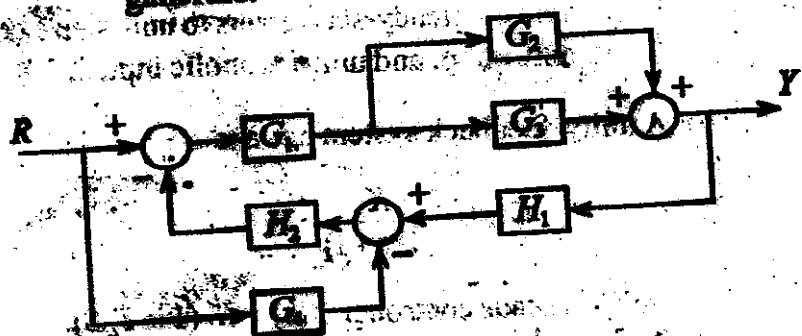


Fig. 1

(b) Then open-loop transfer function of a unity-feedback control system is given as

$$G(s) = \frac{K(s+1)}{s(s-1)(s^2+4s+16)}$$

Determine the value of K which causes sustained oscillation. Also determine the corresponding frequency of oscillation.

5

3. (a) A unity-feedback system is characterized by the open-loop transfer function

(4)

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

Determine the steady-state error for unit step input, unit-ramp, and unit-parabolic.

(5) Velocity-feedback system in a plane

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

with a cascade controller $-D(s) = -K_C s$.

Describe the effects of K_C and ζ on steady-state error, settling time, and peak overshoot of the system.

4. Plot the root locus of the closed-loop velocity feedback system when varying the forward function $G(s) = K/(s^2 + 2\zeta s + 1)$.

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

Locate the closed-loop poles on the root loci such that the resulting closed-loop poles have a damping ratio equal to 0.7. Determine the corresponding value of gain.

(5)

5. Sketch the Nyquist plot for a feedback system with open-loop transfer function

$$G(s)H(s) = \frac{K(s+1)}{s(s-1)(s^2+4s+16)}; K > 0$$

Find the range of K for which the system is stable.

10

6. Use Bode plot to determine the value of the gain K for which a unity-feedback system with open-loop transfer function

$$G(s) = \frac{10K(s+0.1)}{(s+2)(s+4)(s+5)}$$

gives phase margin of 60° . Also determine the gain margin at this value of K .

10

7. (a) Consider the system described by

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

- Derive a state-space representation of the system.

5

(6)

- (b) For the transfer function models and inputs given below, find the response $y(k)$ as a function of k :

$$G(z) = \frac{Y(z)}{R(z)} = \frac{2z-3}{(z-0.5)(z+0.3)}$$

$$r(k) = \begin{cases} 1; & k=1 \\ 0; & k=0, 2, 3, 4, \dots \end{cases} \quad 5$$

8. Write short notes on any two of the following : 5×2

- (i) Zeigler-Nichols method of tuning PID controller
- (ii) Constant M and N circle method of stability analysis
- (iii) Transfer function of a Zero Order Hold Device
- (iv) Properties of the Z-transform.