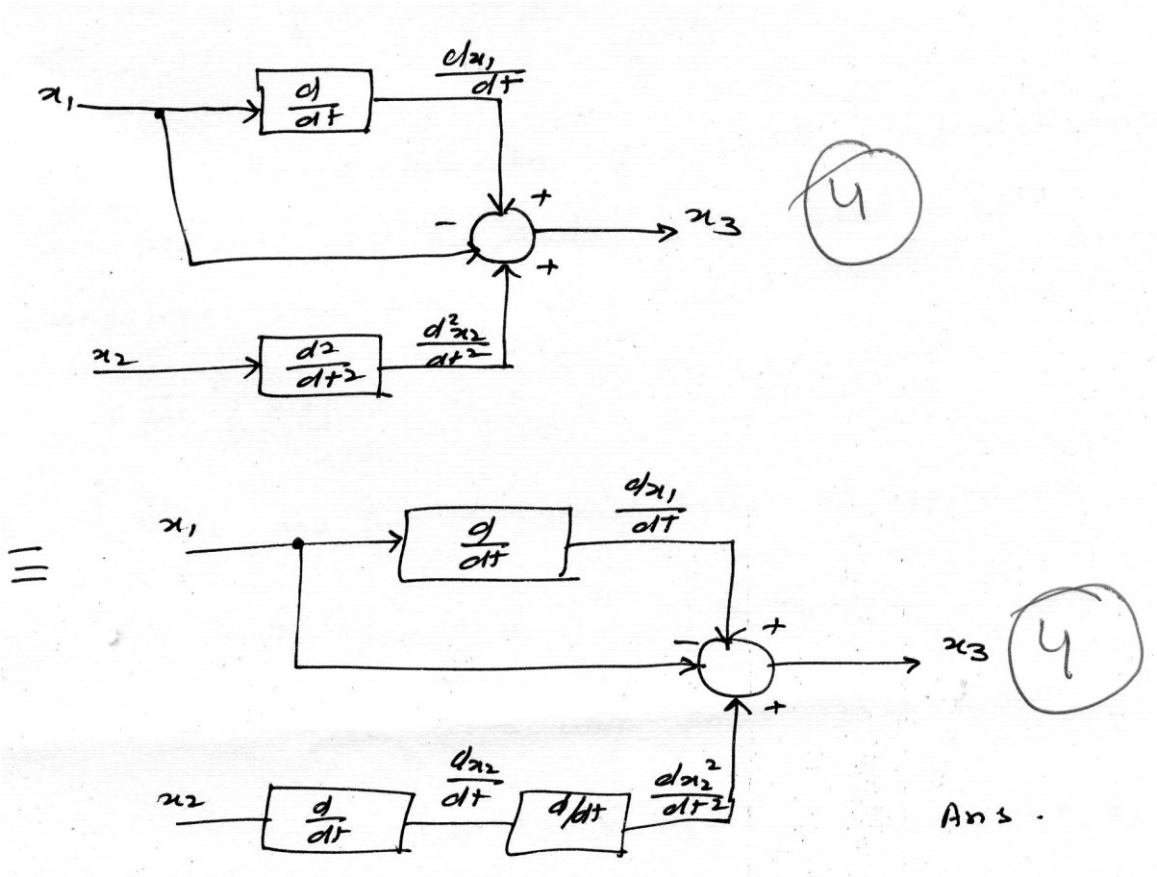
Q.2 a. Discuss the important characteristics of feedback in reference to control systems. **(8)**

Answer: **Refer article 1.5 of Text Book-I**

b. Draw the block diagram for the system represented by the following equation.

$$x_3 = \frac{d^2x_2}{dt^2} + \frac{dx_1}{dt} - x_1$$ **(8)**

Answer:



Q.3 a. Name the various test functions used in control system analysis. Explain each one clearly bringing out their relative merits and limitations. **(8)**

Answer: **Refer Article 3.13 of Text Book-I**

b. Determine the Inverse Laplace transform of the following function

$f(s) = \dfrac{2s+6}{s^2+3s+2}$ **(8)**

Answer:

$$F(s) = \frac{2s+6}{s^2+3s+2}$$

$$= \frac{2s+6}{(s+1)(s+2)}$$

Partial fractions are

$$\frac{2s+6}{(s+1)(s+2)} = \frac{A}{s+1} + \frac{B}{s+2} \quad \text{— (2)}$$

$$2s+6 = A(s+2) + B(s+1)$$

Compare coefficients of

$s \longrightarrow A+B=2$ — (1) — (2)

Constant $\longrightarrow 2A+B=6$ — (2)

By solving eqn 1 & 2 we get

$A=4$

& $B=-2$] — (2)

So $F(s) = \dfrac{4}{s+1} - \dfrac{2}{s+2}$

taking Inverse Laplace transform

$f(t) = 4e^{-t} - 2e^{-2t}$ — (2)

Q.4 a. With the help of example explain Routh stability criterion used to determine the stability of a control system. **(8)**

Answer: **Refer Article 5.3 of Text Book-I**

b. Determine the location of roots of following equation using continued fraction stability criterion. **(8)**

$Q(s) = s^3 + 6s^2 + 12s + 8 = 0$

Answer:

$$\frac{Q_1(s)}{Q_2(s)} = \frac{s^3+12s}{6s^2+8} = \frac{1}{6}s + \frac{\frac{32}{3}s}{6s^2+8} \quad \text{— 3}$$

$$= \frac{1}{6}s + \frac{1}{\frac{9}{16}s + \frac{1}{\frac{4}{3}s}} \quad \text{— 3}$$

Since all the coefficients of s in the continued fraction are positive, all the roots of the $Q(s)=0$ have negative real parts — 2

Q.5 a. Give the important characteristics of signal flow graphs in reference to control system representation. **(8)**

Answer: **Refer article 8.3 of Text Book-I**

b. Obtain C/R ratio for a system whose signal flow graph is represented by the following figure: **(8)**

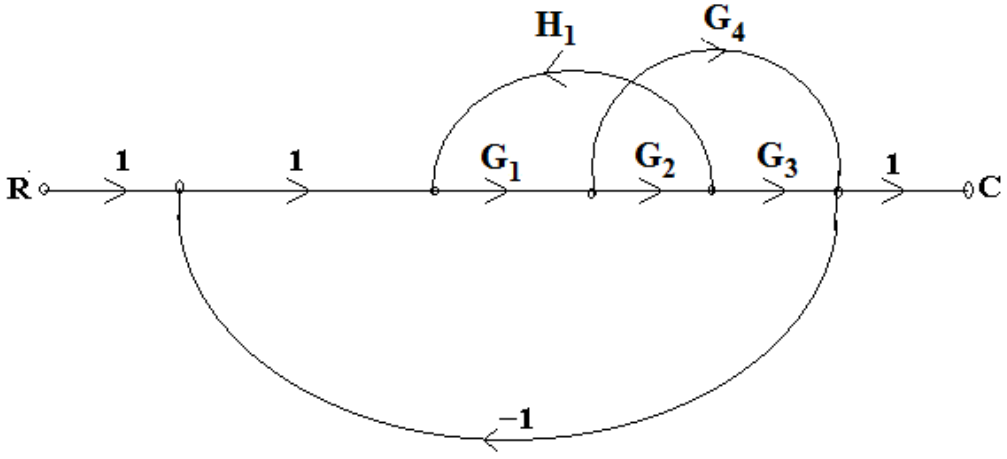


Fig.1

Answer:

There are two forward paths with gains as

$P_1 = G_1 G_2 G_3$ and $P_2 = G_1 G_4$ — (2)

There are five loops with gains as

$L_1 = G_1 G_2 H_1$ $L_2 = G_2 G_3 H_2$ $L_3 = -G_1 G_2 G_3$

$L_4 = G_4 H_2$ $L_5 = -G_1 G_4$ — (2)

There is no set of non touching loops, so we can write

$\Delta = 1 - (L_1 + L_2 + L_3 + L_4 + L_5)$ — (1)

$= 1 - G_1 G_2 H_1 - G_2 G_3 H_2 + G_1 G_2 G_3 - G_4 H_2 + G_1 G_4$

Since all the loops touch the first forward path

$\Delta_1 = 1$ & $\Delta_2 = 1$. — (1)

Using Mason's formula the gain for the first forward path

$$T_1 = \frac{P_1 \Delta_1 + P_2 \Delta_2}{\Delta} = \frac{G_1 G_2 G_3 + G_1 G_4}{\Delta} = \frac{G_1 G_2 G_3 + G_1 G_4}{\Delta}$$ — (1) (2)

where $\Delta = 1 - G_1 G_2 H_1 - G_2 G_3 H_2 + G_1 G_2 G_3 - G_4 H_2 + G_1 G_4$

Q.6 a. Define parabolic-error constant for a general control system. Derive the values of parabolic error constants and steady-state error due to parabolic-input for type 0, 1 and 2 systems. **(8)**

Answer: **Refer article 9.7 of Text Book-I**

b. Define and illustrate with the help of examples the following terms in reference to the control system design.
(i) Gain margin (ii) Phase margin **(8)**

Answer:

Q.7 Write notes on any **TWO** of the following: **(2x8)**

(i) System compensation
(ii) Polar plots
(iii) Nyquist stability criterion

Answer: **(i) Refer article 10.5 of Text Book-I**
(ii) Refer article 11.5 of Text Book-I
(iii) Refer article 11.10 of Text Book-I

Q.8 Give a step wise procedure for drawing the root- locus in reference to control systems. Illustrates the procedure with the help of an example. **(16)**

Answer: **Refer article 13.9 of Text Book-I**

Q.9 Explain how the Bode plots for a continues time system can be constructed. Illustrate with the help of an example. **(16)**

Answer: **Refer article 15.5 of Text Book-I**

TEXT BOOK

I. Feedback and Control Systems (Schaum's Outlines), Joseph J DiStefano III, Allen R. Stubberud and Ivan J. Williams, 2nd Edition, 2007, Tata McGraw-Hill Publishing Company Ltd