Again, from equation (3) and (5)

$$\frac{V_0(s)}{V_i(s)} = \left[\frac{Z_2Z_4}{Z_1Z_2+Z_1Z_3+Z_1Z_4+Z_2Z_3+Z_2Z_4}\right]$$

Now putting the values of Z_1, Z_2, Z_3 and Z_4, we get

$$\frac{V_0(s)}{V_i(s)} = \left(\frac{\frac{1}{s^2 C_1C_2}}{\frac{R_1}{sC_1}+R_1R_2+\frac{R_1}{sC_2}+\frac{R_2}{sC_1}+\frac{1}{s^2C_1C_2}}\right)$$

$$\frac{V_0(s)}{V_i(s)} = \frac{1}{1+s(R_1C_1+R_2C_2+R_1C_2)+s^2 R_1R_2C_1C_2}$$

Problem 1.4. Evaluate $\frac{C}{R_1}$ and $\frac{C}{R_2}$ for a system whose block diagram representation is shown in figure below: R_1 is the input to summing point No. 1.

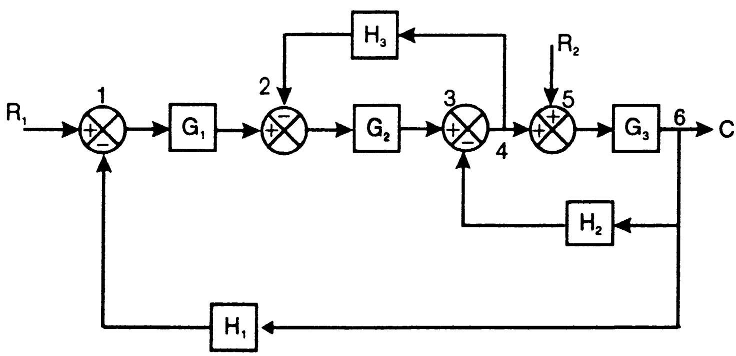

Fig. P. 1.4

Solution:

For finding C/R_1;

From eqns. (6) to (8), the transfer function of the system is obtained as

$$G(s) = \frac{\theta(s)}{E_a(s)} = \frac{K_T}{s[(R_a + sL_a)(Js + f_o) + K_T K_b]}$$

Problem 1.7. Derive the transfer function of field controlled d.c. motor.

Solution:

Field-control

A field-controlled d.c. motor is shown in Fig. P.1.7.

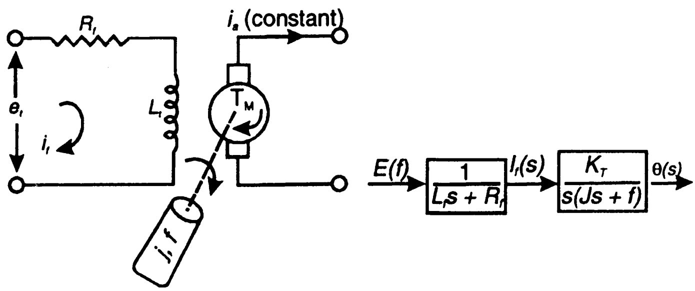

Fig. P.1.7 (a) Field-controlled d.c. motor
(b) Block diagram of field-controlled motor

In this system,

R_f = field winding resistance (Ω).

L_f = field winding inductance (H).

e = field control voltage (V).

i_f = field current (A).

T_M = torque development by motor (Nm).

J = equivalent moment of inertia of motor and load referred to motor shaft (kg-m^2).

Step III: The overall system by eliminating the feedback path.

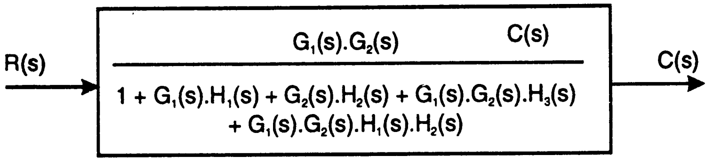

Fig. P. 1.12 (c)

Problem 1.13. Find the overall output *C(S)* of the system block diagram given

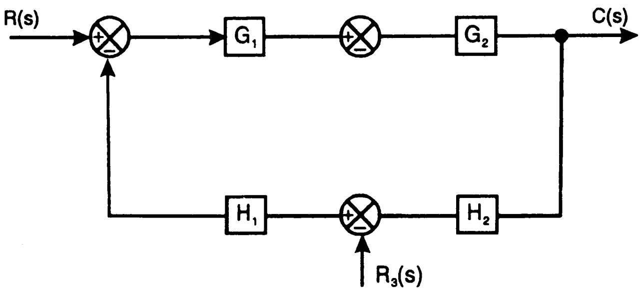

Fig. P. 1.13

Solution:

For the multiple inputs we have to consider one input at a time making others zero.

$$C_1(s) = \frac{G_1G_2}{1+G_1G_2H_1H_2}R_1(s)$$

$$C_2(s) = \frac{G_2}{1+G_1G_2H_1H_2}R_2(s)$$

$$C_3(s) = \frac{G_1G_2H_1}{1+G_1G_2H_1H_2}R_3(s)$$

Now the overall output,

$$C(s) = C_1(s)+C_2(s)+C_3(s)$$

$$= \left(\frac{G_1G_2R_1(s)+G_2R_2(s)+G_1G_2H_1R_3(s)}{1+G_1G_2H_1H_2}\right)$$

Solution:

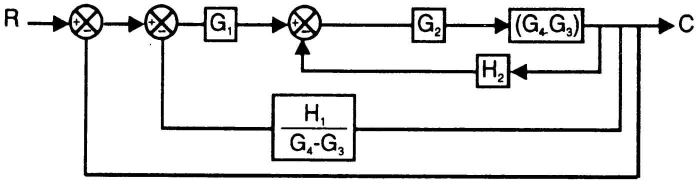

Fig. P. 1.15 (a)

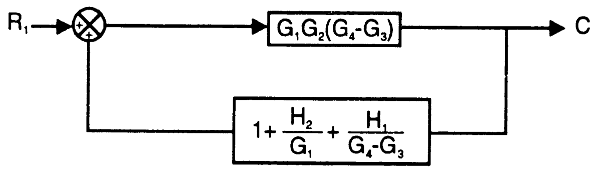

Fig. P. 1.15 (b)

$$\therefore \quad \frac{C}{R} = \frac{G_1G_2\,(G_4 - G_3)}{1 + G_1G_2\,(G_4 - G_3)\left(1 + \dfrac{H_2}{G_1} + \dfrac{H_1}{G_4 - G_3}\right)}$$

$$= \frac{G_1G_2\,(G_4 - G_3)}{1 + H_2G_2\,(G_4 - G_3) + G_1G_2H_1 + G_1G_2\,(G_4 - G_3)} \quad \textbf{Ans.}$$

Problem 1.16. Determine the closed loop transfer function of system given below:

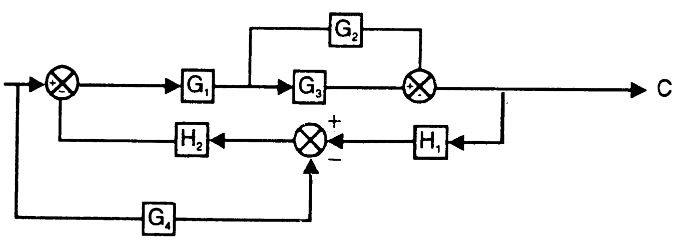

Fig. P. 1.16