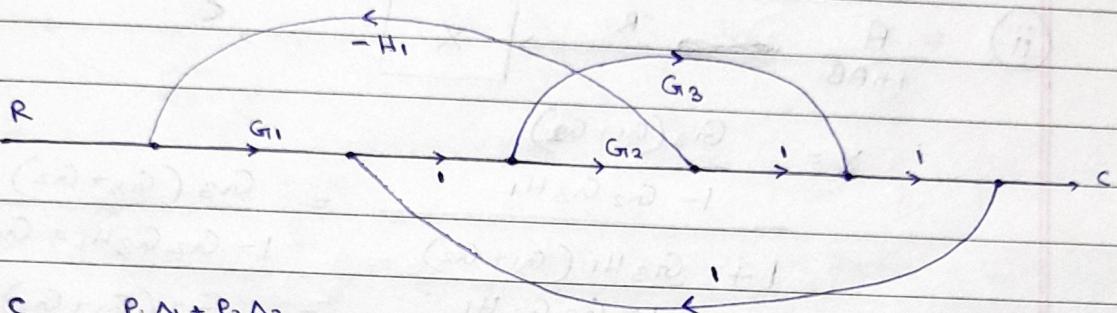
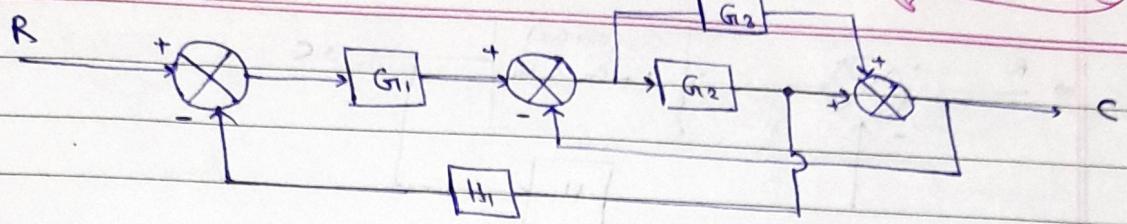


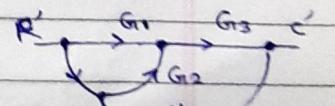
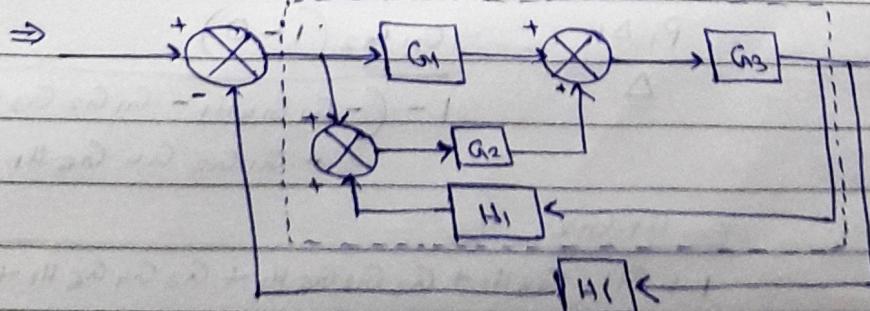
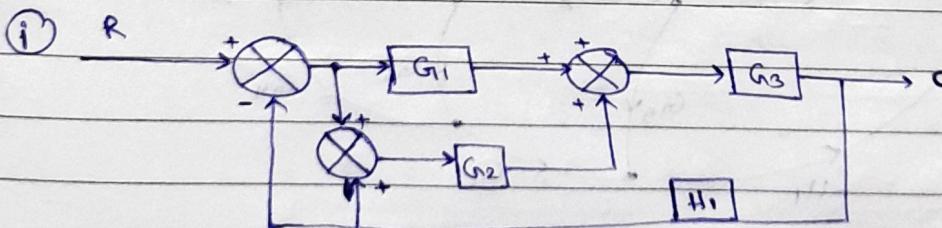
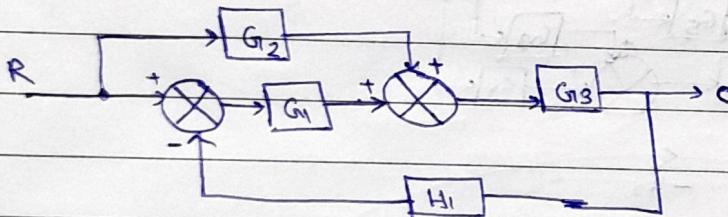
3.



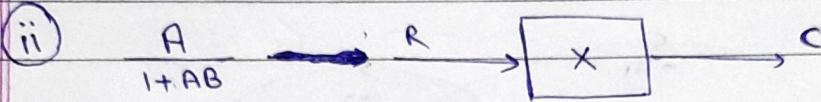
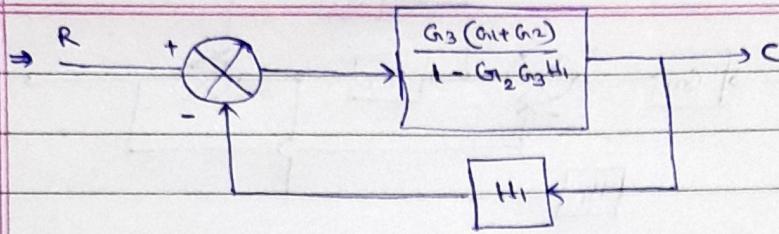
$$\frac{C}{R} = \frac{P_1 \Delta_1 + P_2 \Delta_2}{\Delta}$$

$$= \frac{G_{11} G_{12} (1 - \alpha) + G_{11} G_{13} (1 - \alpha)}{1 - (-G_{11} G_{12} H_1 + G_{12} + G_{13})} = \frac{G_{11} (G_{12} + G_{13})}{1 + G_{11} G_{12} H_1 - G_{12} - G_{13}}$$

4.

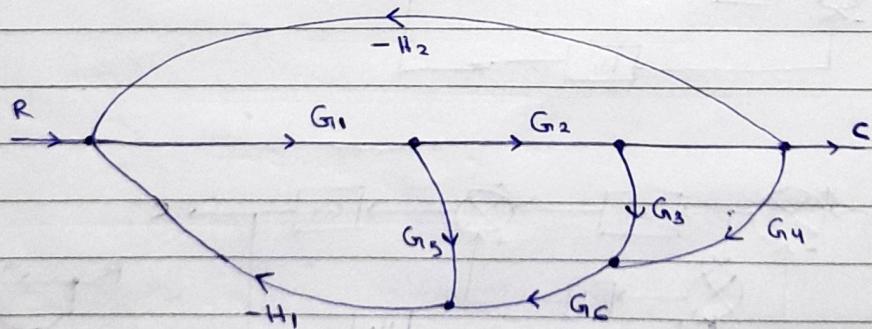
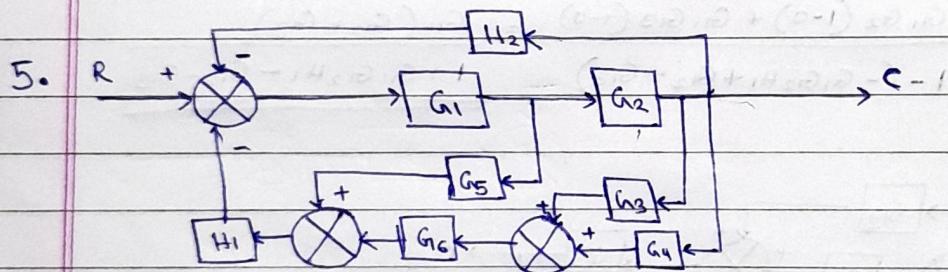


$$\frac{C'}{R'} = \frac{P_1 \Delta_1 + P_2 \Delta_2}{\Delta} = \frac{G_{11} G_{13} + G_{12} G_{13}}{1 - G_{12} G_{13} H_1}$$



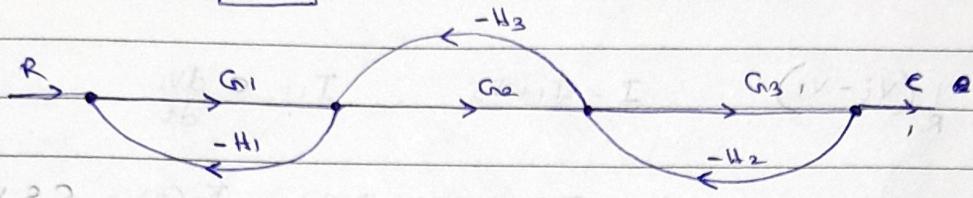
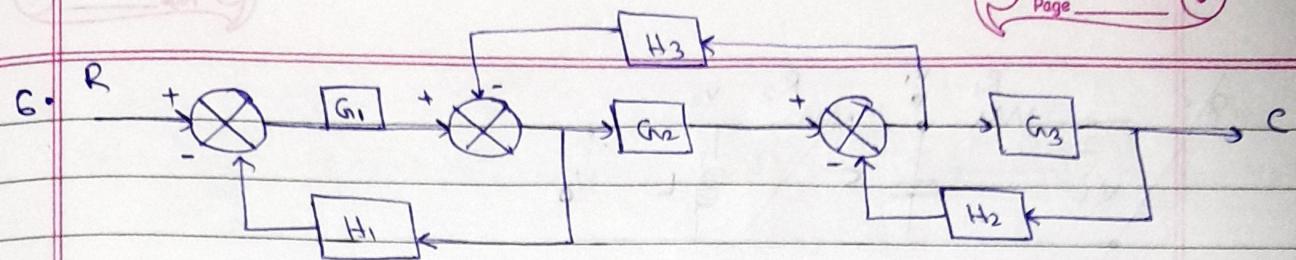
$$X = \frac{G_3(G_1+G_2)}{1-G_2G_3H_1} = \frac{G_3(G_1+G_2)}{1+G_3H_1(G_1+G_2)} = \frac{G_3(G_1+G_2)}{1-G_2G_3H_1+G_1G_3H_1+G_2G_3H_1}$$

$$= \frac{G_3(G_1+G_2)}{1+G_1G_3H_1}$$

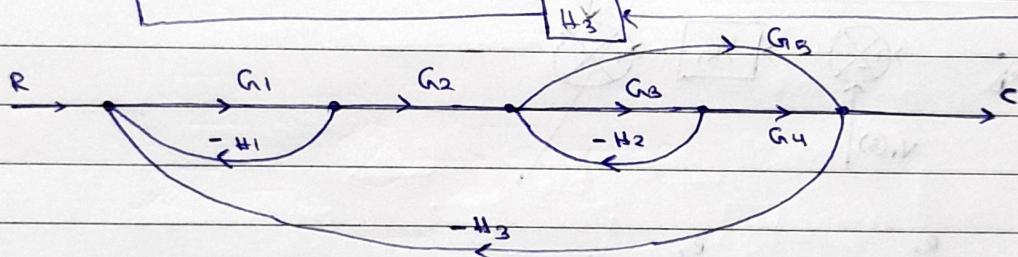
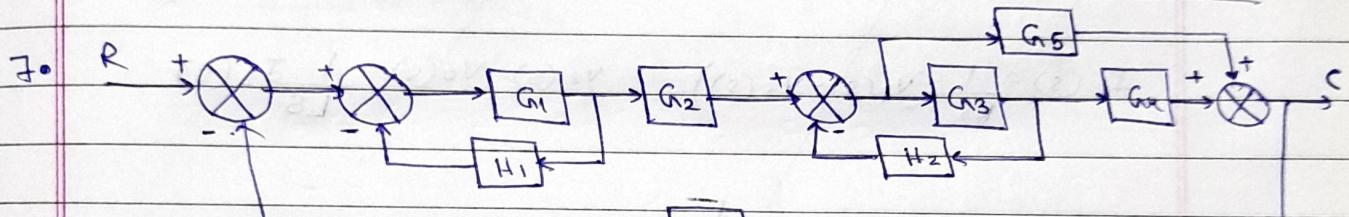


$$\frac{C}{R} = \frac{P_1 \Delta_1}{\Delta} = \frac{G_1 G_2 (1-0)}{1 - (-G_1 G_5 H_1 - G_1 G_2 G_3 G_6 H_1 - G_1 G_2 G_4 G_6 H_1 - G_1 G_2 H_2)}$$

$$= \frac{G_1 G_2}{1 + G_1 (G_5 H_1 + G_2 G_3 G_6 H_1 + G_2 G_4 G_6 H_1 + G_2 H_2)}$$

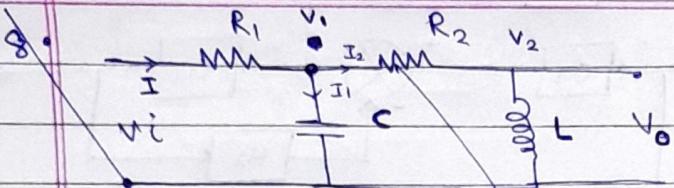


$$\frac{C}{R} = \frac{P_1 \Delta_1}{\Delta} = \frac{G_1 G_2 G_3}{1 + G_1 H_1 + G_2 H_3 + G_3 H_2 + G_1 G_2 G_3 H_2}$$



$$\frac{C}{R} = \frac{P_1 \Delta_1 + P_2 \Delta_2}{\Delta} = \frac{G_1 G_2 G_3 G_4 + G_1 G_2 G_5}{1 - (G_1 H_1 - G_3 H_2 - G_1 G_2 G_5 H_3 - G_1 G_2 G_3 G_4 H_3) + (G_1 H_1 G_3 H_2)}$$

$$= \frac{G_1 G_2 (G_3 G_4 + G_5)}{1 + G_1 H_1 + G_3 H_2 + G_1 G_2 G_5 H_3 + G_1 G_2 G_3 G_4 H_3 + G_1 H_1 G_3 H_2}$$



$$I = \frac{1}{R_1} (V_i - V_1)$$

$$I = I_1 + I_2$$

$$I_1 = C \frac{dV_1}{dt}$$

$$I(s) = \frac{1}{R_1} (V_i(s) - V_1(s))$$

$$I(s) = I_1(s) + I_2(s)$$

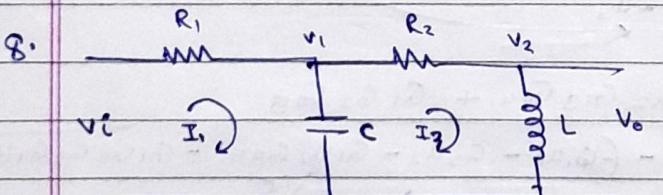
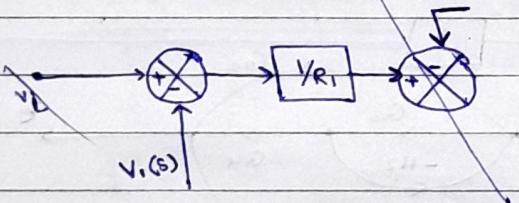
$$I_1(s) = CS V_1(s)$$

$$I_2 = \frac{1}{R_2} (V_1 - V_2)$$

$$V_2 = V_o = \frac{1}{L} \int I_2(t) dt$$

$$I_2(s) = \frac{1}{R_2} (V_1(s) - V_2(s))$$

$$V_2(s) = V_o(s) = \frac{1}{LS} I_2(s)$$

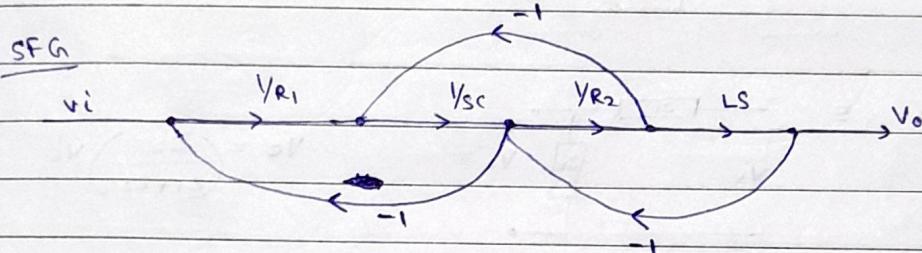
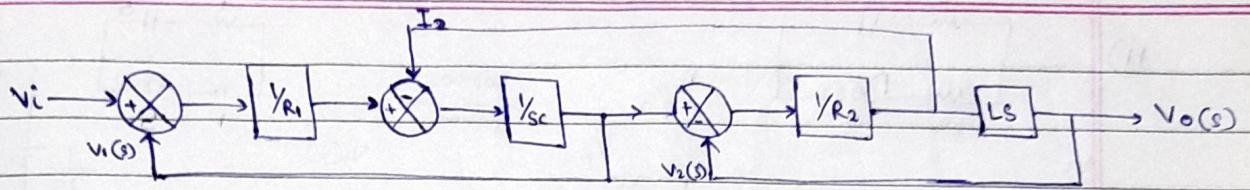


$$I_1 = \frac{1}{R_1} (V_i - V_1)$$

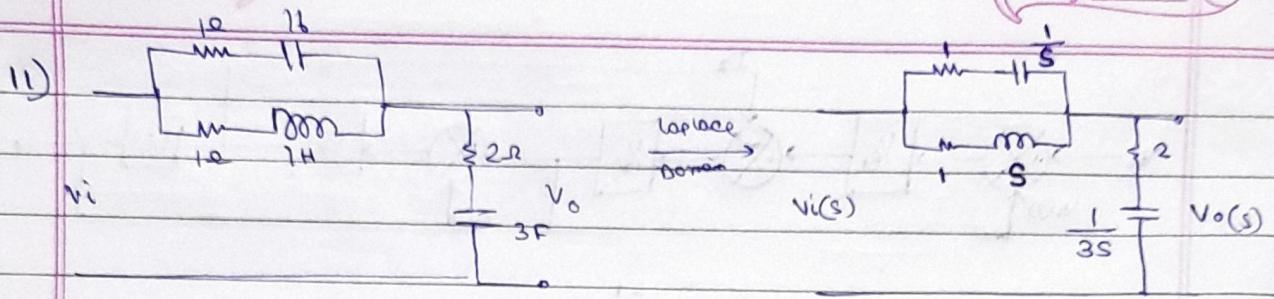
$$V_1 = \frac{1}{SC} (I_1 - I_2)$$

$$I_2 = \frac{(V_1 - V_2)}{R_2}$$

$$V_2 = V_o = LS I_2$$

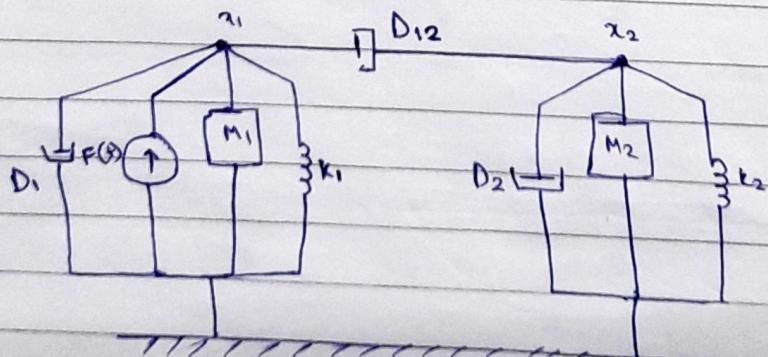
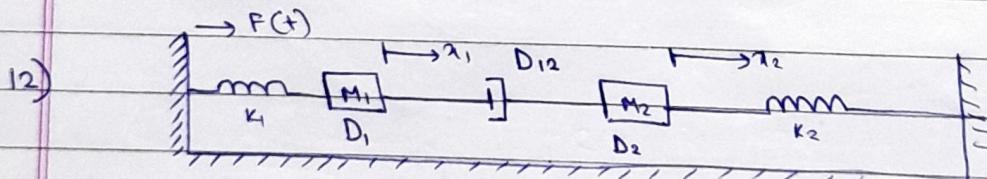


$$TF = \frac{P_1 \Delta I}{\Delta} = \frac{\frac{L}{CR_1 R_2}}{1 + \frac{1}{SCR_1} + \frac{LS}{R_2} + \frac{1}{SCR_2}} = \frac{SL}{SCR_1 R_2 + R_2 + S^2 C R_1 L + R_1}$$



$$V_o = \left(\frac{Z_2}{Z_1 + Z_2} \right) V_i$$

$$\frac{V_o(s)}{V_i(s)} = \frac{2 + \frac{1}{3s}}{2 + \frac{1}{3s} + \left(1 + \frac{1}{s} \right) 11 + s} = \frac{2 + \frac{1}{3s}}{2 + \frac{1}{3s} + \cancel{\frac{(s+1)^2}{s}}} = \frac{6s+1}{9s+1}$$



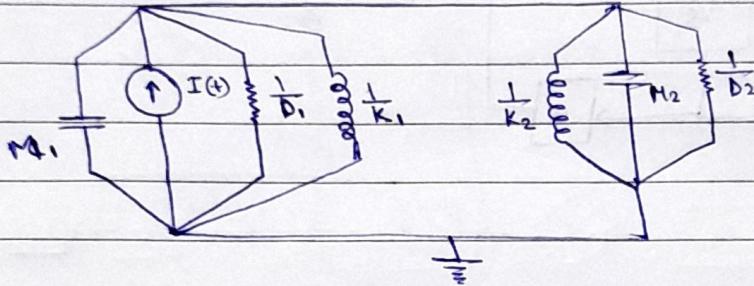
$$F(t) = M_1 \frac{d^2x_1}{dt^2} + K_1 x_1 + D_1 \frac{dx_1}{dt} + D_{12} \frac{d(x_1 - x_2)}{dt}$$

$$0 = M_2 \frac{d^2x_2}{dt^2} + K_2 x_2 + D_2 \frac{dx_2}{dt} + D_{12} \frac{d(x_2 - x_1)}{dt}$$

F-I Analogy

$$F(t) \rightarrow I(t) \quad M \rightarrow C \quad D \rightarrow \frac{1}{R}$$

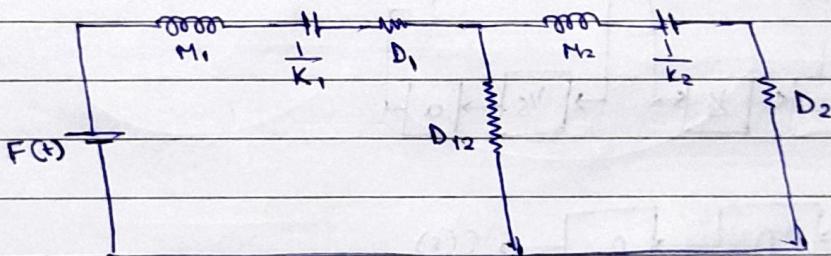
$$v \rightarrow V_L$$

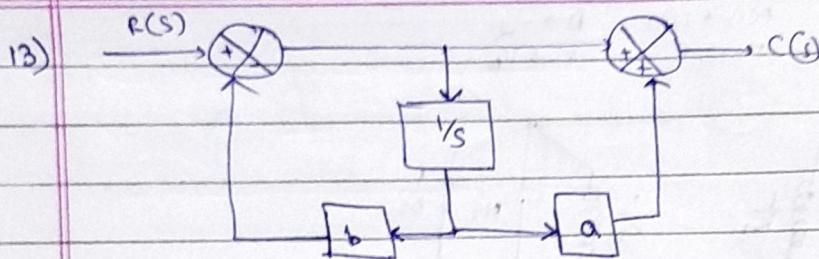


F-V Analogy

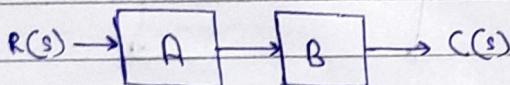
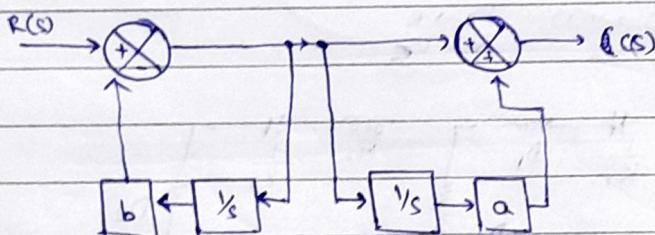
$$F(t) \rightarrow V(t) \quad M \rightarrow L \quad D \rightarrow R$$

$$K = V_C$$

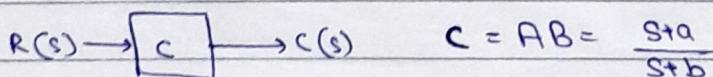




① Using BODR



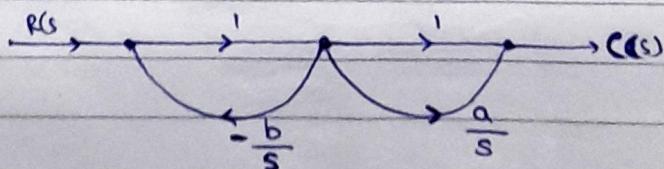
$$A = \frac{1}{1 + b/s} = \frac{s}{s+b} \quad B = \cancel{\frac{1+a}{s}} \quad 1 + \frac{a}{s} = \frac{s+a}{s}$$



$$C = AB = \frac{s+a}{s+b}$$

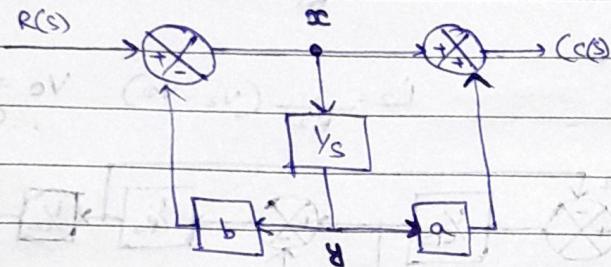
$$\Rightarrow \frac{C(s)}{R(s)} = \underline{\underline{\frac{s+a}{s+b}}}$$

11) Using SFG



$$\frac{C(s)}{R(s)} = \frac{P_1 \Delta_1 + P_2 \Delta_2}{\Delta} = \frac{1 + a/s}{1 + b/s} = \underline{\underline{\frac{s+a}{s+b}}}$$

(11) Using conventional



$$x = R - b y$$

$$y = \frac{x}{s}$$

$$C = x + a y$$

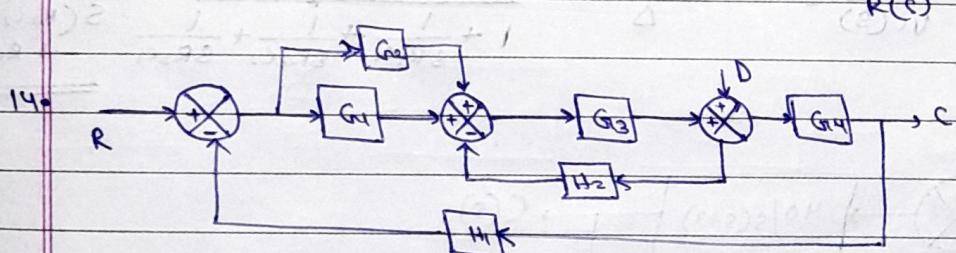
$$x = R - b \frac{x}{s} = x \left(\frac{s+b}{s} \right) = R$$

$$\Rightarrow x = \frac{SR}{s+b} \quad \Rightarrow C = \frac{SR}{s+b} + \frac{aR}{s+b}$$

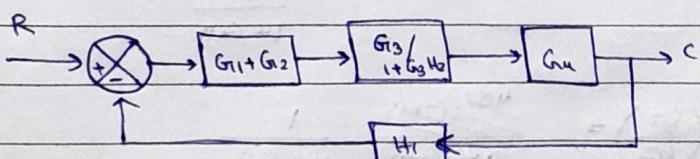
$$y = \frac{x}{s} = \frac{R}{s+b}$$

$$\Rightarrow C = \frac{(s+a)R}{s+b}$$

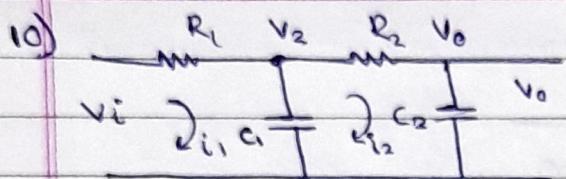
$$\Rightarrow \frac{C(s)}{R(s)} = \frac{s+a}{s+b}$$



$$C_1 = \left. \frac{C}{R} \right|_{s=0} = \frac{G_1 G_2 (G_3 + G_4) / 1 + G_3 G_4 H_1}{H_1 + G_3 G_4 (G_1 + G_2) / 1 + G_3 H_2} = \frac{(G_1 + G_2) G_3 G_4}{H_1 + G_3 H_2 H_1 + G_3 G_4 (G_1 + G_2)}$$

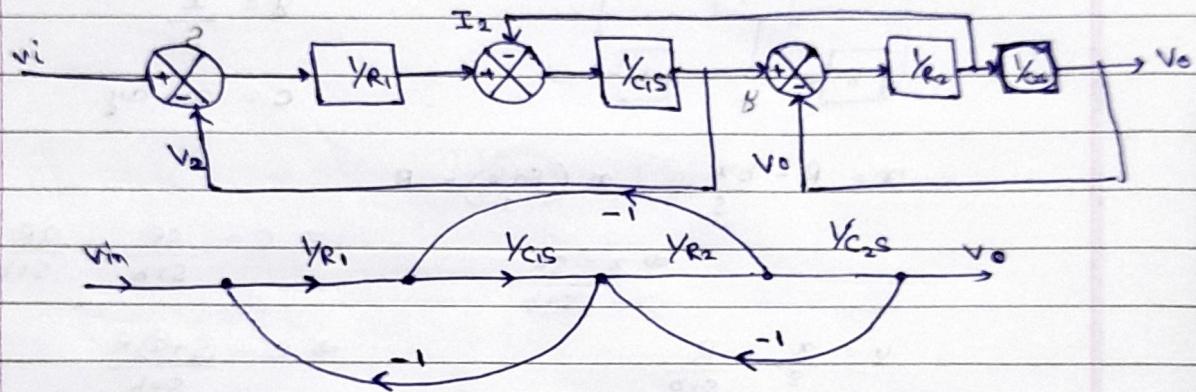


$$C_2 = \left. \frac{C}{D} \right|_{s=0} = \frac{G_4}{1 - G_4 (-H_1) \left(\frac{G_3}{1 + G_3 H_2} \right) (G_2 + G_1)} = \frac{G_4 (1 + H_2)}{1 + H_2 + G_4 H_1 G_3 (G_1 + G_2)}$$

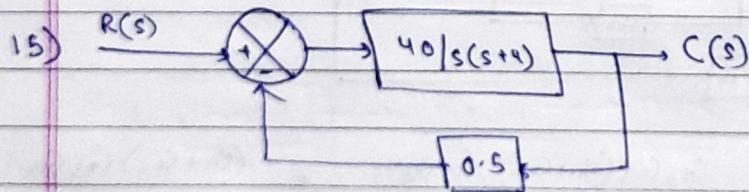


$$i_1 = \frac{1}{R_1} (V_i - V_2) \quad V_2 = \frac{1}{C_1 s} (V_i - V_2)$$

$$i_2 = \frac{1}{R_2} (V_2 - V_o) \quad V_o = \frac{1}{C_2 s} (V_2 - V_o)$$



$$\frac{V_o(s)}{V_i(s)} = \frac{P_1 \Delta_1}{\Delta} = \frac{\frac{1}{C_1 C_2 R_1 R_2 s^2}}{1 + \frac{1}{s R_1 C_1} + \frac{1}{s R_2 C_2} + \frac{1}{s R_2 C_1}} = \frac{1}{s(R_2 C_2 + R_1 C_1 + R_1 C_2)}$$



$$G = \frac{40}{s(s+4)} \quad H = 0.5$$

$$T = \frac{G}{1 + GH}$$

$$S_{G_1} = \frac{G_1}{T} \left(\frac{b_T}{b G_1} \right) = \frac{\cancel{40/s(s+4)}}{\cancel{40/s(s+4)} + \cancel{20/s(s+4)}} \frac{1}{1 + GH}$$

$$= \frac{s^2 + 4s}{s^2 + 4s + 20} \Big|_{s=jw} \quad w=1.3$$

$$= \frac{-\omega^2 + 4j\omega}{-\omega^2 + 4j\omega + 20} = \frac{-1.69 + 5.2j}{18.31 + 5.2j}$$

$$\Rightarrow |S_{G_1}| = 0.287$$

$$S_H = \frac{H}{T} \left(\frac{G_T}{G_H} \right) = \frac{-G_H H}{1 + G_H H} = \frac{-20}{S^2 + 4S + 20}$$

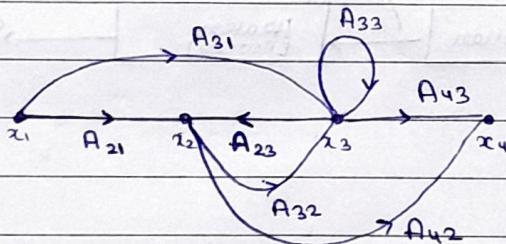
$$= \frac{-20 (18.31 - 5.2j)}{362.29} = -1.01 + 0.28j$$

$$|S_H| = \underline{1.048}$$

Q. $x_2 = A_{21}x_1 + A_{23}x_3$

$$x_3 = A_{31}x_1 + A_{32}x_2 + A_{33}x_3$$

$$x_4 = A_{42}x_2 + A_{43}x_3$$



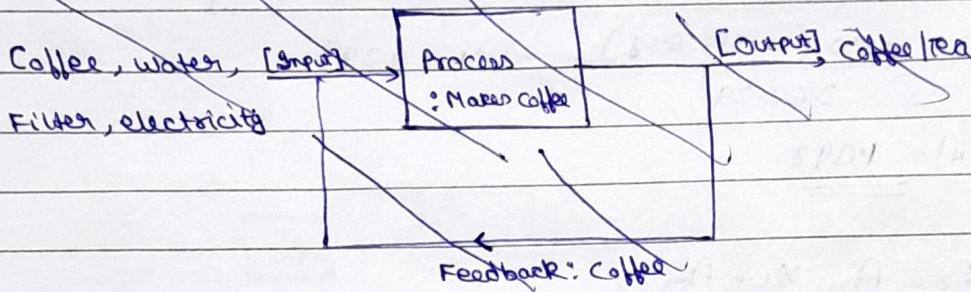
$$\frac{x_4}{x_1} = \frac{P_1\Delta_1 + P_2\Delta_2 + P_3\Delta_3}{\Delta}$$

$$= A_{21}A_{32}A_{43} + A_{21}A_{42}(1-A_{33}) + A_{31}A_{43}$$

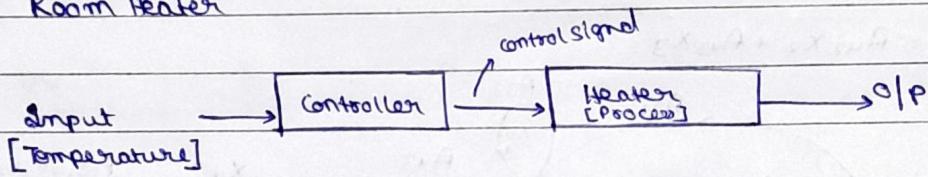
$$\Rightarrow \frac{x_4}{x_1} = \frac{A_{21}A_{32}A_{43} + A_{21}A_{42} - A_{21}A_{42}A_{33} + A_{31}A_{43}}{1 - A_{23}A_{32} - A_{33}}$$

$$\frac{x_3}{x_2} = \frac{P_1\Delta_1}{\Delta} = \frac{\cancel{P_1\Delta_1} A_{32}}{1 - A_{23}A_{32} - A_{33}}$$

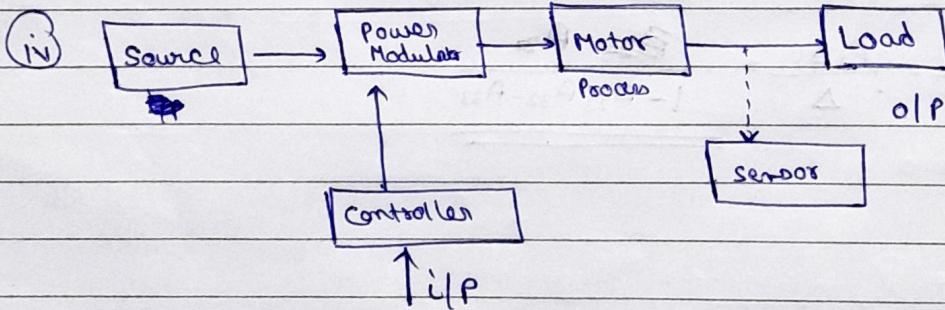
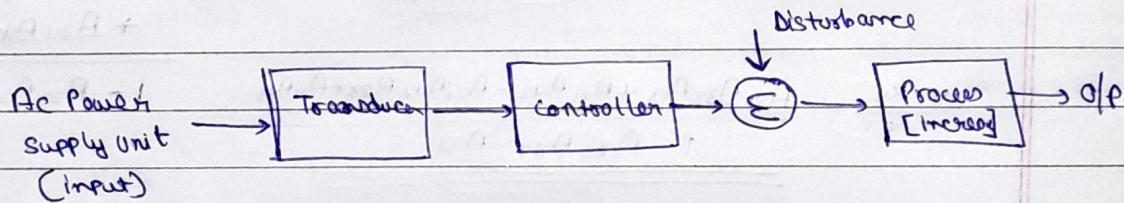
1. (i) Automatic Tea / Coffee Maker



(ii) Room Heater

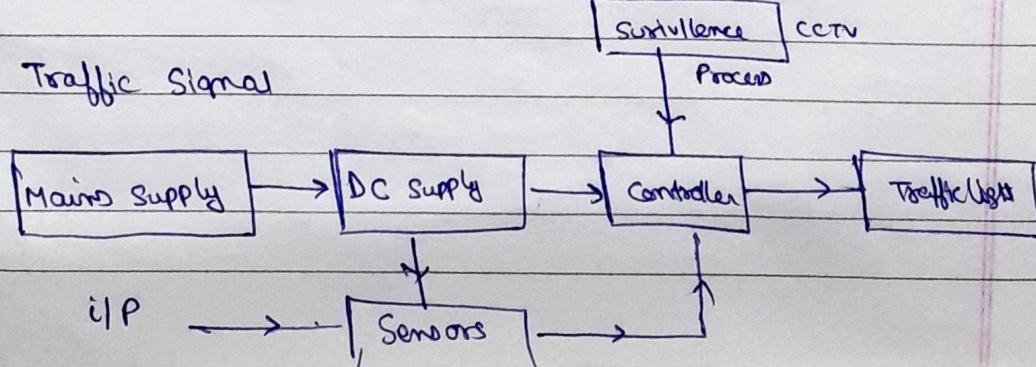


(iii) Fan Regulator

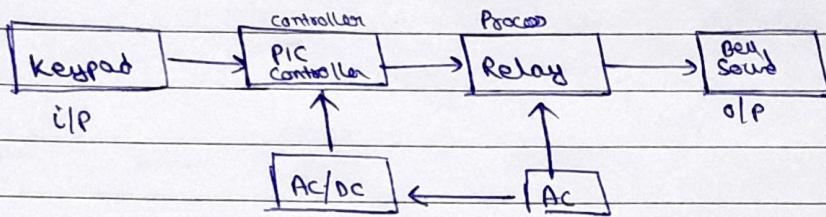


Electrical Driver

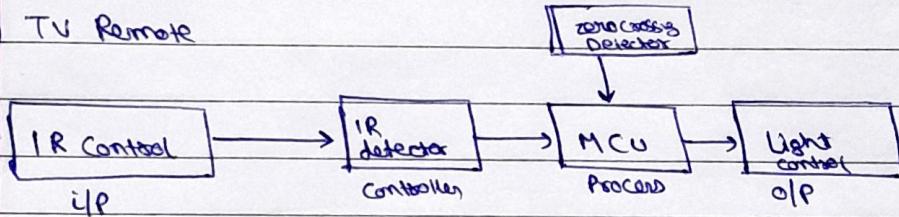
(v) Traffic Signal



(VI) Calling Bell



(VII) TV Remote



2. (i)