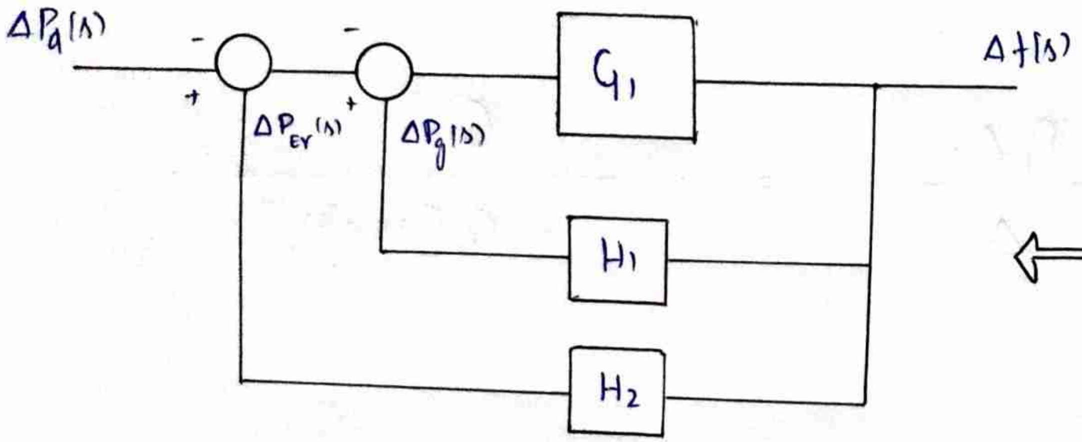
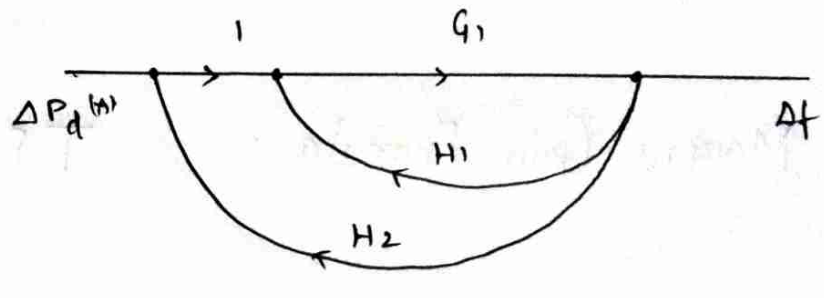
Block Diagram Reduction





Signal flow graph.

$$G_1 = 1/D+sM$$

$$H_1 = \frac{-\left[s\left[K_p\beta\alpha_0 R+1\right] + K_I\beta\alpha_0 R\right]\left[1+sF_pT_r\right]}{R s(1+sT_g)(1+sT_c)(1+sT_r)}.$$

$$H_2 = \frac{-\left[K_p\beta\alpha_1 K_{EV}s + K_I\beta\alpha_1 K_{EV}\right]e^{-st}}{s+s^2T_{EV}}.$$

$P_1 = G_1$; $L_1 = G_1 H_1$; $\Delta = 1 - [H_1 + H_2] G_1$

$\Delta_1 = 1 - 0 = 1$; $L_2 = G_1 H_2$

Maison's Gain Formula :- $$T.F = \frac{P_1 \Delta_1}{\Delta} = \frac{G_1}{1 - G_1 [H_1 + H_2]}$$

$$T.F = \frac{1/D+SM}{1 + \frac{1}{D+SM}\left[\frac{[s(K_p \beta \alpha_0 R + 1) + K_I \beta \alpha_0 R][1 + sF_p T_r]}{Rs(1+sT_c)(1+sT_g)(1+sT_r)} + \frac{[K_p \beta \alpha_1 K_{EV} s + K_I \beta \alpha_1 K_{EV}] \times e^{-sT}}{s + s^2 T_{EV}}\right]}$$

$$
T.F = \cfrac{\cancel{1/(D+SM)}}{\cfrac{\underbrace{\left[RS(1+ST_g)(1+ST_r)(1+ST_c)(D+SM)(s+s^2T_{EV})\right] + \left[\left[s(K_p\beta\alpha_0R+1) + K_I\beta\alpha_0R\right]\left[1+sF_pT_r\right]\left[s+s^2T_{EV}\right]\right]}_{①} + \underbrace{\left[Rs(1+ST_g)(1+ST_H)(1+ST_c)\left[K_p\beta\alpha_1\cancel{e^{-st}}K_{EV}s + K_I\beta\alpha_1\cancel{e^{-st}}K_{EV}\right]\right.}_{②} e^{-st}}{\underbrace{\cancel{(D+sM)}(1+ST_g)(1+ST_c)(1+ST_r)(s+s^2T_{EV})Rs}_{③}}}
$$

$$
= \cfrac{1/\cancel{(D+SM)}}{\cfrac{① + ② \times e^{-st}}{③}} \Longrightarrow \frac{N(s)}{P(s) + Q(s)e^{-st}}
$$

$$N(s) = n_5 s^5 + n_4 s^4 + n_3 s^3 + n_2 s^2 + n_1 s^1 + n_0 .$$

$$N(s) = s^5 \left[R T_{EV} T_r T_c T_g \right] + s^4 \left[R \left[T_g T_r T_{EV} + T_r T_c T_{EV} + T_c T_g T_{EV} + T_r T_c T_g \right] \right]$$

$$+ s^3 \left[R \left[T_g T_{EV} + T_r T_{EV} + T_c T_{EV} + T_g T_r + T_r T_c + T_c T_g \right] \right] +$$

$$s^2 \left[R \left[T_r + T_g + T_c + T_{EV} \right] \right] + s \left[R \right] .$$

$$P(s) = P_6 s^6 + P_5 s^5 + P_4 s^4 + P_3 s^3 + P_2 s^2 + P_1 s^1 + P_0$$

$$P(s) = s^6 \left[RMT_r T_c T_g T_{EV} \right] + s^5 \left[RT_{EV} \left[DT_r T_g T_c + MT_g T_r + MT_r T_c + MT_c T_g \right] + RMT_r T_c T_g \right]$$

$$+ s^4 \left[RT_{EV} M \left[T_r + T_c + T_g \right] + RM \left[T_g T_r + T_r T_c + T_c T_g \right] + T_{EV} RD \left[T_g T_r + T_r T_c + T_c T_g \right] + \right.$$

$$\left. RDT_r T_c T_g \right] + s^3 \left[RM \left[T_r + T_c + T_g + T_{EV} \right] + T_{EV} RD \left[T_r + T_c + T_g \right] + RD \left[T_r T_c + T_c T_g \right. \right.$$

$$\left. \left. + T_g T_r + T_c T_{EV} + T_r T_{EV} + T_g T_{EV} \right] + F_p T_r T_{EV} + T_{EV} F_p T_r K_p \beta \alpha_0 R \right] + s^2 \left[RM + RD \left[T_c + \right. \right.$$

$$\left. \left. T_g + T_r + T_{EV} \right] + T_{EV} \left[K_p \beta \alpha_0 R + K_I \beta \alpha_0 R + 1 \right] + F_p T_r \left[K_p \beta \alpha_0 R + 1 \right] \right] + s \left[RD + T_{EV} K_I \beta \alpha_0 R \right.$$

$$\left. + K_p \beta \alpha_0 R + K_I \beta \alpha_0 R + 1 \right] + K_I \beta \alpha_0 R .$$

$$Q(s) = \left[q_4 s^4 + q_3 s^3 + q_2 s^2 + q_1 s + q_0\right] \times e^{-s\tau}$$

$$Q(s) = s^4\left[K_p \beta \alpha_1 K_{EV} R T_r T_c T_g\right] + s^3\left[K_p \beta \alpha_1 K_{EV} R \left[T_r T_g + T_r T_c + T_c T_g\right] + K_I K_{EV} \beta \alpha_1 R T_r T_c T_g\right]$$

$$+ s^2\left[K_p \beta \alpha_1 K_{EV} R \left[T_c + T_g + T_r\right] + K_I \beta \alpha_1 K_{EV} R \left[T_g T_r + T_r T_c + T_c T_g\right]\right] + s\left[K_p K_{EV}\right.$$

$$\left.\beta \alpha_1 R + K_I K_{EV} \beta \alpha_1 R \left[T_c + T_g + T_r\right]\right] + K_I \beta \alpha_1 K_{EV} R \quad \times e^{-s\tau}.$$