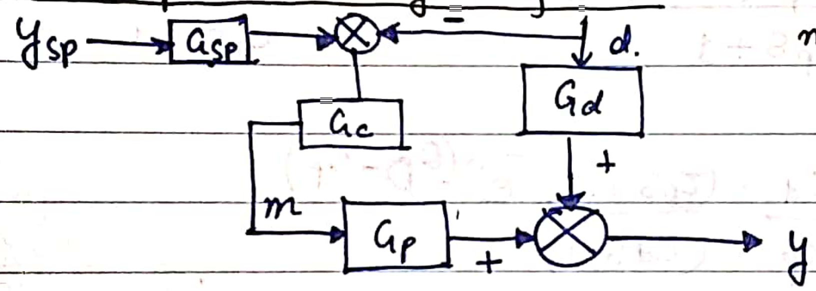
$$\boxed{G_c = \frac{G_d}{G_p}} \qquad \boxed{G_{sp} = \frac{1}{G_d}}$$

Ex 1 : $G_p = \dfrac{K_p}{\tau_p s+1}$ $\quad G_d = \dfrac{K_d}{\tau_d s+1}$

Remarks : 1) FFC = FPC_p

FBC : $Q = Q_s + K_c e$

* Closed loop block diagram for FFC



from.

$$m = \frac{G_d}{G_{sp}}\left[\frac{1}{G_d} y_{sp} - d\right]$$

21.10.19 FFC

$$\boxed{G_c = \frac{G_d}{G_p}}$$

Ex $G_p = \dfrac{K_p}{\tau_p s+1}$ $\quad G_d = \dfrac{K_d}{\tau_d s+1}$

Substituting, $G_c = \dfrac{G_d}{G_p} : \dfrac{K_d(\tau_p s+1)}{(\tau_d s+1)K_p}$

$\therefore G_c = \dfrac{K_d}{K_p} \cdot \dfrac{(\tau_p s+1)}{(\tau_d s+1)} \doteq$ Lead-Lag system

$\tau_p > \tau_d$: Lead system

$\tau_p < \tau_d$: Lag system.

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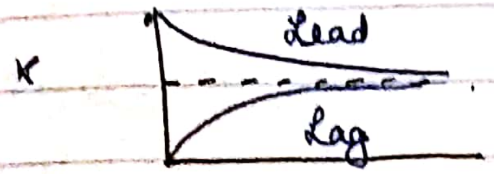

1st order Lead-Lag system.

* If $\tau_p = \tau_d$, $\quad G_c = \frac{K_d}{K_p} = K$: Proportional controller (FBC)

or $G_c = K =$ Static FFC {no S term}

or Zero Pole Cancellation {No Zero, No Pole}

Ex.
$$G_p = \frac{K_p e^{-\theta_p s}}{\tau_p S + 1} \qquad G_d = \frac{K_d e^{-\theta_d s}}{\tau_d S + 1}$$

$$G_c = \frac{K_d}{K_p} \cdot \frac{(\tau_p S + 1)}{(\tau_d S + 1)} \cdot e^{-S(\theta_D - \theta_p)}$$

Is it physically realisable? Condition : $\theta_d \geq \theta_p$

Ex.
$$G_p = \frac{K_p}{(\tau_1 S + 1)(\tau_2 S + 1)} \qquad G_d = \frac{K_d}{(\tau_d S + 1)}$$

Modify controller eqn to make it implementable

$$G_c = \frac{K_d}{K_p} \cdot \frac{(\tau_1 S + 1)(\tau_2 S + 1)}{(\tau_d S + 1)}$$

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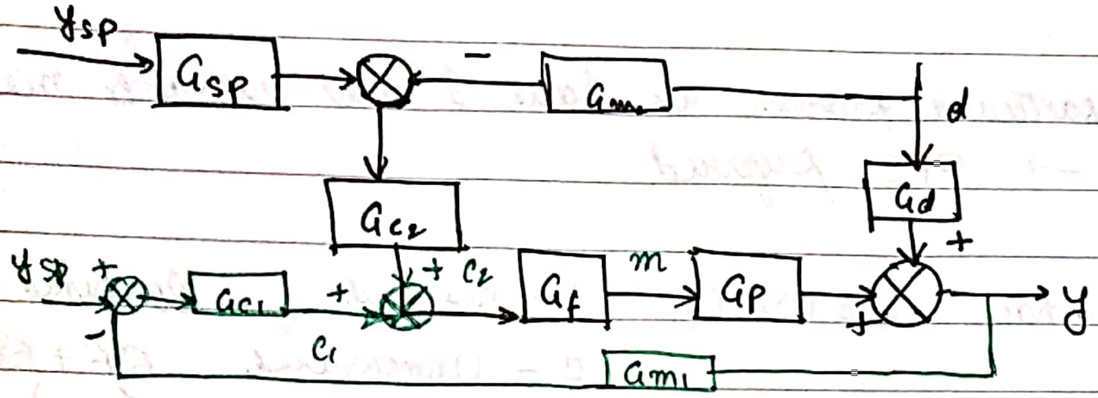


FFC controller Block Diag.

Combining with FBC closed loop Block Diag.
Adding the two control outputs of FBC to FFC.

* $y = G_p m + G_d d$

$$m = G_f(c_1 + c_2) = G_f\left[\underbrace{G_{c_1}(y_{sp} - G_{m_1} y)}_{c_1} + \underbrace{G_{c_2}(G_{sp} y_{sp} - G_{m_2} d)}_{c_2}\right]$$

$$\therefore y = G_p G_f \left[G_{c_1}(y_{sp} - G_{m_1} y) + G_{c_2}(G_{sp} y_{sp} - G_{m_2} d)\right] + G_d d.$$

$$\Rightarrow y = G_p G_f\left[G_{c_1} y_{sp} - G_{c_1} G_{m_1} y + G_{c_2} G_{sp} y_{sp} - G_{c_2} G_{m_2} d\right] + G_d d$$

$$\therefore \boxed{y = \frac{G_p G_f (G_{c_1} + G_{c_2} G_{sp})}{1 + G_p G_f G_{c_1} G_{m_1}} y_{sp} + \frac{G_d - G_p G_f G_{c_2} G_{m_2}}{1 + G_p G_f G_{c_1} G_{m_1}} d}$$

Closed loop transfer function for combined FF+FB controllers.

CE : $1 + G_p G_f G_{c_1} G_{m_1} = 0$ ... FF+FB

... FB

∴ Feedforward controller has no instability problem

→ For a particular process, we have 1 load variable measured cont. → FFC preferred.

→ We have 2 LV @ 1 - measured. → Combined scheme
2 - Unmeasured. FF + FB

Measured Unmeasured

or FFC depends on process model which is inaccurate. leads to control variable being affected which is taken care of by FBC

Advantages : 1) No Instability problem

2) Takes action before effect of disturbance has been felled by process

3) Good for slow process. (FBC Disadv.)

Disadvantages- 1) Involves process model which is not accurately known ∴ performance degraded

2) Need to determine the parameters [parameter identification technique involved]

3) Not applicable for unmajor / minor disturbances (FBC Adv)

* Ratio Control

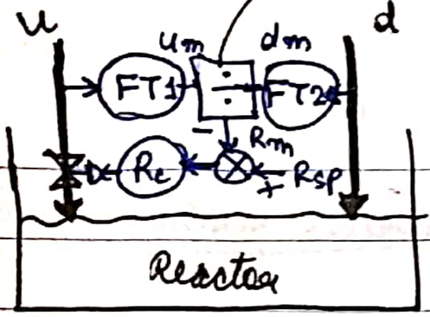
→ 1 measured, 1 manipulated variable.

→ Special type of FFC.

→ Obj: To maintain R $\left\{ R = \frac{MV}{LV} = \frac{u}{d} \right\}$

d = Wild stream

$$R_m = \frac{u_m}{d_m}$$



Eg. → Combustion Chamber
Fuel / Air ratio
→ PH reactor : Acid / Base
→ Distillation col: Reflux Ratio

For FFC, LV measured. Same thing in RC ∴ Inference FFC
But actually FBC.