Block-diagram reduction,

Summer, "pickup point"

series, parallel (not like KVL/KCL)

Signal flow graphs & Mason's gain formula. ← X

why just standard negative unity feedback configuration

time domain transfer fn.

$r(t) \to \boxed{G(s)} \to y(t)$

much! X

$$y(t) \overset{?}{=} G(s)\, r(t)$$

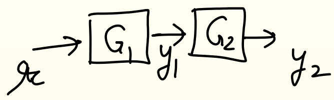
$$Y(s) = G(s)\, R(s) \quad \checkmark$$

$$y(t) = \int_0^t g(t-\tau)\, r(\tau)\, d\tau$$

$$\mathcal{L}^{-1}(G(s)) =: g(t)$$

~~MIMO~~

Series

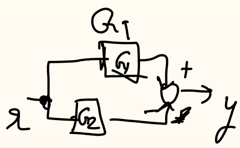


For siso (SISO)

$$y_2 = G_2 G_1 r$$
$$= G_1 G_2 r$$

(series $\equiv$ product)

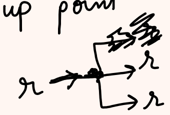
parallel $\equiv$ addition



$$\equiv$$

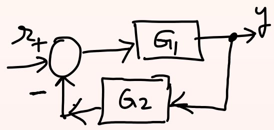
$$r \rightarrow \boxed{G_1 + G_2} \rightarrow y.$$

"pick up point"



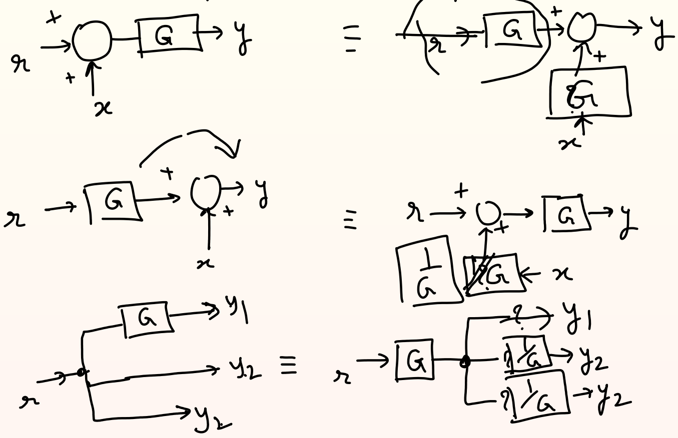
(signal available to many systems)

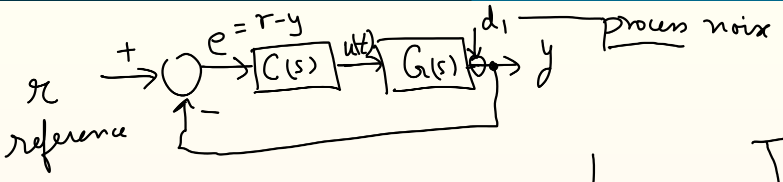
feedback form



$$\equiv \quad r \rightarrow \boxed{\frac{G_1}{1 + G_2 G_1}} \rightarrow y$$

Reduction of multiple (complex) blocks.



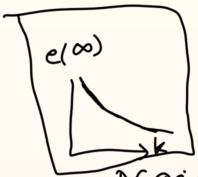


sensitivity function $\frac{1}{1+C(s)G(s)}$

to be low

$r \rightarrow e$.

$d_1 \rightarrow y$

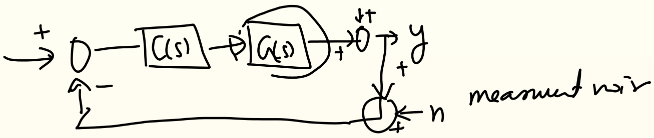


DC gain

When $C(s) = k$ constant gain controller.

$G(s)$ − type 0 $\quad e(\infty)$ (for unit step input) $= \frac{1}{1+k\,G(0)}$

" make k large and achieve low steady state error. "

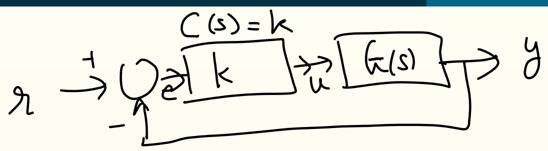


$$n \xrightarrow{C(s)G(s)/(1+CG)} y$$

complementary sensitivity function

tradeoff → Kalman filter

"Bode integral"



PD ✓
PI ✓
PID ✓

$r \longrightarrow y \qquad \dfrac{kG}{1+kG}$

poles
roots (of numerator) $1 + kG$

$G(s) = \dfrac{n(s)}{d(s)} = G_1 G_2$

closed loop poles are roots $\left[d(s) + \overset{P}{\overset{\downarrow}{k}}\, n(s) \right]$

characteristic polynomial.

Suppose roots of $\underline{d}$ & $\underline{n}$ are known.
→ can we deduce roots of $\boxed{d + k n}$

Routh Hurwitz criteria

elementary calculation...