MULTIVARIABLE SYSTEMS continued

Interaction Metrics

NI — $NI < 0$ ✗

RGA — $\lambda_{ij} < 0$ ✗

$\lambda_{ij} \sim 1$ ✓

Dynamics

u_1

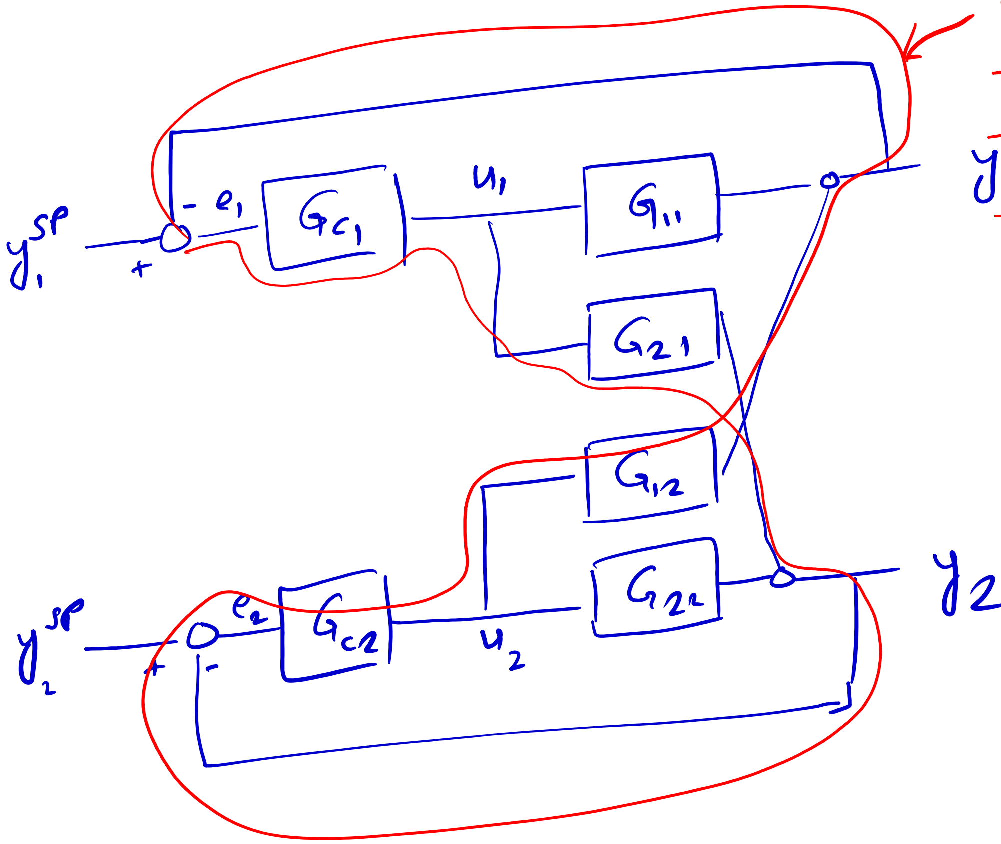
u_2

y_1 ✓✓

y_2 ✓

Large gains & Fast dynamics | Applying Common Sense

DECENTRALIZED CONTROL



due to G_{21} & G_{12} non-zero

- Additional feedback loop
- Destabilize the system
- Require detuning (from usual SISO settings)

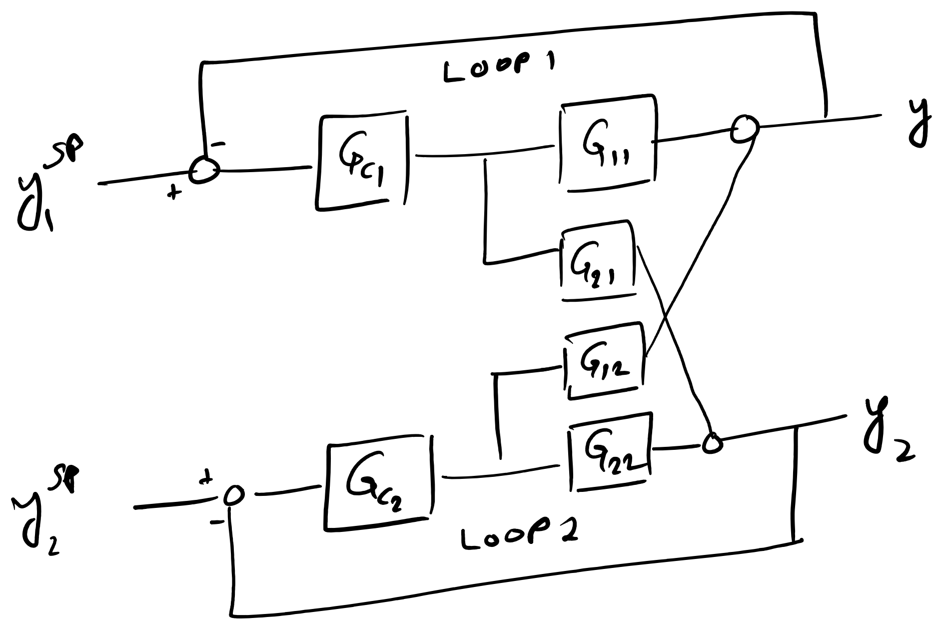
$$u_1 = G_{c_1} e_1$$

$$u_2 = G_{c_2} e_2$$

$$\begin{bmatrix} u_1 \\ u_2 \end{bmatrix} = \begin{bmatrix} G_{c_1} & 0 \\ 0 & G_{c_2} \end{bmatrix} \begin{bmatrix} e_1 \\ e_2 \end{bmatrix}$$

$$\underline{u} = \underline{\underline{G_c}}\, \underline{e}$$

decentralized $\Leftarrow$ diagonal



— Tune more imp loop to its SISO settings (other loop on manual)

— Tune next imp loop with previously tuned loop on auto

— Keep repeating till all loops are tuned.

y_1 ← tightly controlled

y_2 ← loose control

[All detuning necessary due to MV interaction gets taken in Loop 2. (less important)

BALANCED DETUNING

BLT Luyben

Analogy with SISO system

	SISO	MV
CLCE	$1+G_pG_c=0$	$\lvert \underline{\underline{I}} + \underline{\underline{G_p}}\,\underline{\underline{G_c}} \rvert = 0$

$$G_{cl} = \frac{G_pG_c}{1+G_pG_c} \equiv \frac{-1+CLCE}{CLCE} \qquad G = \frac{W}{1+W} \equiv \frac{-1+CLCE^{MV}}{CLCE^{MV}}$$

$$L = 20\log_{10}\left|\frac{W}{1+W}\right|$$

— Obtain individual loop tuning for all loops $\tau_{I_i}^{ZN}$, $K_{c_i}^{ZN}$

— Want $f>1$ (detuning factor)

$$K_c^i = \frac{K_c^{ZN}}{f} \qquad \tau_I^i = f\,\tau_I^{ZN}$$

$i = 1$ to N

$f = ?$

Define $W = -1 + \lvert \underline{I} + G_pG_c \rvert$

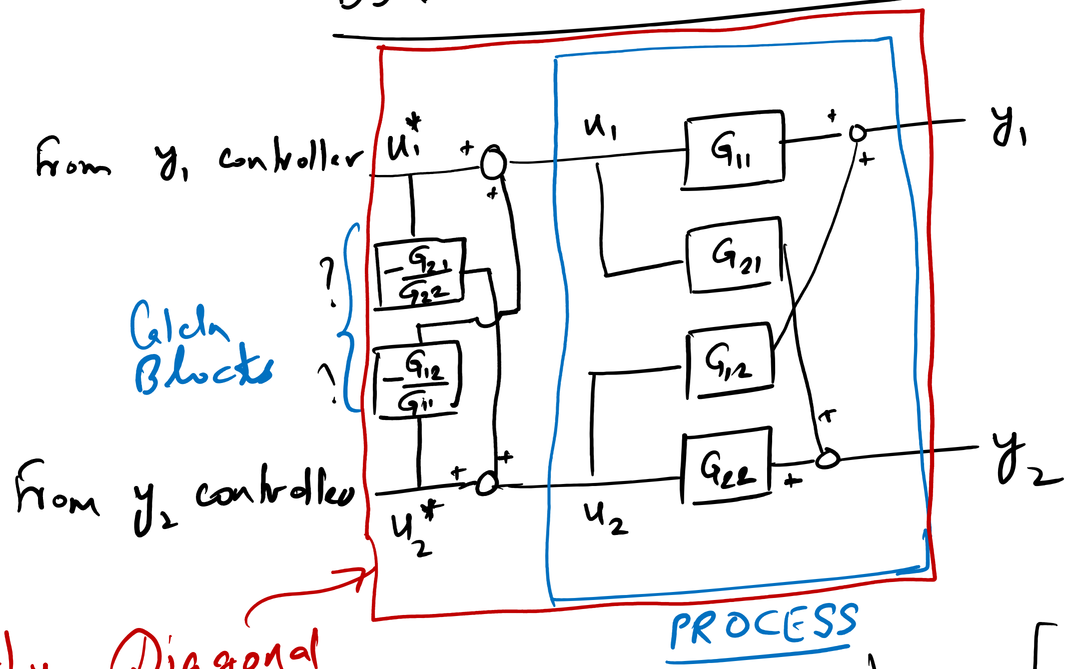
→ Assume $f>1$

Obtain L_{cl} over relevant frequency range

$L_{cl}^{MAX} \overset{?}{=} 2N$ dB $\xrightarrow{\text{Yes}}$ Exit

No (return to Assume $f>1$)

DYNAMIC DECOUPLERS



Nearly Diagonal

$$y_2 \leftrightarrow u_1^*$$

$$y_2 = G_{21}u_1^* - \frac{G_{21}}{G_{22}} G_{22} u_1^*$$

$$= \underbrace{\left[G_{21} - \frac{\hat{G}_{21}}{\hat{G}_{22}} G_{22}\right]}_{\approx 0} u_1^*$$

$$\begin{bmatrix} y_1 \\ y_2 \end{bmatrix} = \begin{bmatrix} G_{11}^* & 0 \\ 0 & G_{22}^* \end{bmatrix} \begin{bmatrix} u_1^* \\ u_2^* \end{bmatrix}$$

$$y_1 = G_{11}u_1^* - \frac{G_{21}}{G_{22}} G_{12} u_1^*$$

$$y_1 = \underbrace{\left[G_{11} - \frac{\hat{G}_{21}}{\hat{G}_{22}} G_{12}\right]}_{G_{11}^*} u_1^* + \underbrace{\left[G_{12} - \frac{\hat{G}_{12}}{\hat{G}_{11}} G_{11}\right]}_{\approx 0} u_2^*$$

$$y_2 = \underbrace{\left[G_{21} - \frac{\hat{G}_{21}}{\hat{G}_{22}} G_{22}\right]}_{\approx 0} u_1^* + \underbrace{\left[G_{22} - \frac{\hat{G}_{12}}{\hat{G}_{11}} G_{21}\right]}_{G_{22}^*} u_2^*$$

- Decentralized Control System Tuning
  - Sequential
  - Balanced Detuning

- Dynamic Decoupling