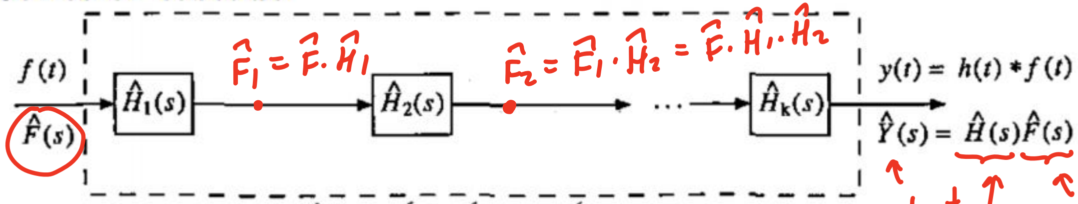
• LTIC system combinations

- **Series or cascade:**



$\hat{F}_1 = \hat{F}\cdot\hat{H}_1$

$\hat{F}_2 = \hat{F}_1\cdot\hat{H}_2 = \hat{F}\cdot\hat{H}_1\cdot\hat{H}_2$

$$\underbrace{\hat{Y}(s)}_{\text{output}} = \underbrace{\hat{H}(s)}_{\text{overall transf. function}}\underbrace{\hat{F}(s)}_{\text{original input}}$$

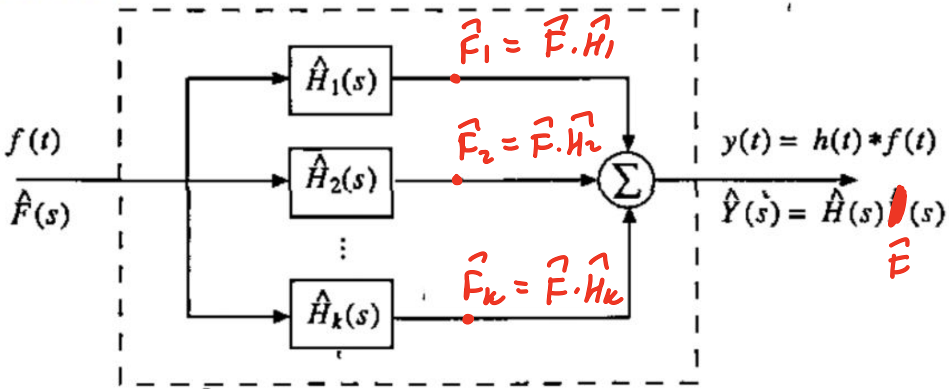
$$\Rightarrow \hat{H} = \hat{H}_1\cdot\hat{H}_2\cdot\ldots\hat{H}_K \Rightarrow h(t) = h_1(t) * h_2(t) * \ldots * h_K(t)$$

$$\frac{1}{(\cancel{s+1})(s+2)}\cdot\frac{\cancel{s+1}}{s+3}$$

We can't create new poles, but can cancel some

- LTIC system combinations-cont

- **Parallel:**



$$\hat{Y} = \hat{F}.\hat{H}_1 + \hat{F}.\hat{H}_2 + \ldots + \hat{F}.\hat{H}_k = \hat{F}\,(\underbrace{\hat{H}_1 + \hat{H}_2 + \ldots \hat{H}_k}_{\hat{H}})$$

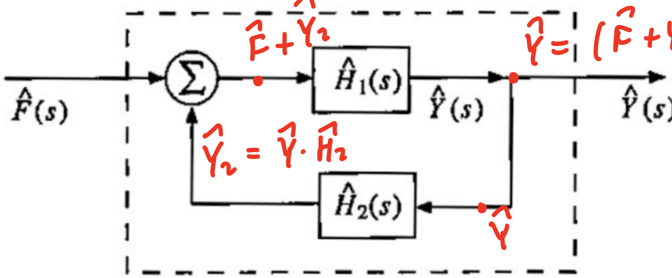
We can't create new poles, but can cancel some

$$\downarrow \mathcal{L}^{-1}$$

$$h(t) = h_1(t) + h_2(t) + \ldots + h_k(t)$$

- LTIC system combinations-cont

- Basic feedback:



?

$\hat{Y} = (\hat{F}+\hat{Y}_2)\hat{H}_1$

$\hat{Y}(s) = \hat{F}\cdot\hat{H}$

$$\hat{Y} = (\hat{F}+\hat{Y}_2)\hat{H}_1 = (\hat{F}+\hat{Y}\cdot\hat{H}_2)\cdot\hat{H}_1 = \hat{F}\hat{H}_1 + \hat{Y}\hat{H}_1\hat{H}_2$$

$$\hat{Y}(1-\hat{H}_2\hat{H}_1) = \hat{F}\hat{H}_1$$

$$\hat{Y} = \frac{\hat{F}\hat{H}_1}{1-\hat{H}_2\hat{H}_1} = \hat{F}\underbrace{\left(\frac{\hat{H}_1}{1-\hat{H}_2\hat{H}_1}\right)}_{\hat{H}}$$

forward path

forward path

feedback path

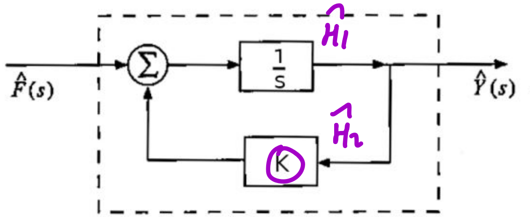
$$y(t) = \cancel{\frac{f(t)*h_1(t)}{1-h_2(t)*h_1(t)}}$$

not valid!

Can create new poles

• LTIC system combinations - Example # 21

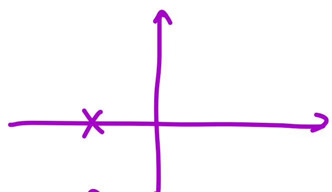
- Consider the system below



- For which value(s) of K is the system BIBO stable?

$$\hat{H} = \frac{\hat{H}_1}{1-\hat{H}_2\cdot\hat{H}_1} = \frac{1/s}{1-K\cdot\frac{1}{s}} = \frac{1}{s-K}$$

single pole @ $s=K$



LHP for BIBO stability $\Rightarrow$ we need $K<0$.