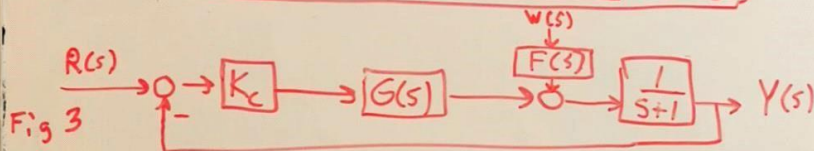
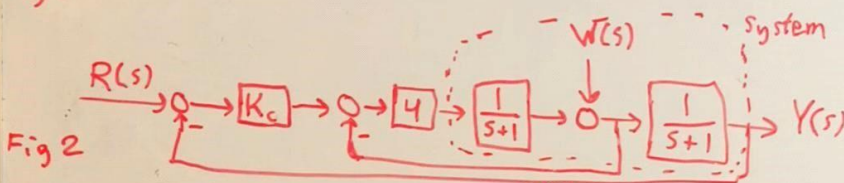
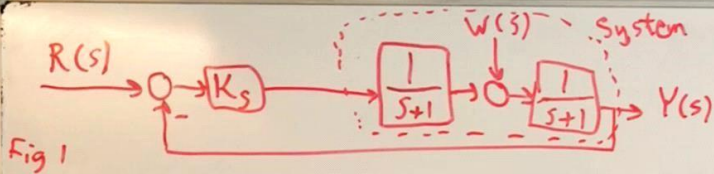


Cascading Control



1) Find $F(s)$ and $G(s)$

$$G(s) = \frac{4 \frac{1}{s+1}}{1 + 4 \frac{1}{s+1}} = \frac{4}{s+5}$$

$$F(s) = \frac{1}{1 + 4 \frac{1}{s+1}} = \frac{s+1}{s+5}$$

2) Compare

Fig 2 is nice!

3) Determine series control K_s for %OS = 16% ($\zeta = 0.5$)

$$\frac{Y(s)}{R(s)} = \frac{K_s \frac{1}{s+1} \frac{1}{s+1}}{1 + K_s \frac{1}{s+1} \frac{1}{s+1}} = \frac{K_s}{s^2 + 2s + 1 + K_s}$$

$$2\zeta \omega_n = 2 \quad \leftarrow$$

$$\omega_n^2 = 1 + K_s \Rightarrow \omega_n = \sqrt{1 + K_s} \quad 2\zeta \sqrt{1 + K_s} = 2 \Rightarrow 2 \cdot 0.5 \cdot \sqrt{1 + K_s} = 2 \Rightarrow \underline{\underline{K_s = 2^2 - 1 = 3}}$$

4) Determine cascade control K_c for %OS = 16% ($\zeta = 0.5$)

$$\frac{Y(s)}{R(s)} = \frac{K_c \frac{4}{s+5} \frac{1}{s+1}}{1 + K_c \frac{4}{s+5} \frac{1}{s+1}} = \frac{4K_c}{s^2 + 6s + 5 + 4K_c}, \quad \omega_n = \sqrt{5 + 4K_c}$$

$$6 = 2\zeta \omega_n = 2\zeta \sqrt{5 + 4K_c} \Rightarrow K_c = \frac{(3/3)^2 - 5}{4} = 7.75 \quad \text{ved } \zeta = 0.5$$

5) Compare rise time

$$T_r = \frac{1.8}{\omega_n}$$

$$\text{Series: } T_{r,s} = \frac{1.8}{\sqrt{1+3}} = \frac{1.8}{2} = 0.9, \quad \text{casc: } T_{r,c} = \frac{1.8}{\sqrt{5+4K_c}} = \frac{1.8}{6} = 0.3 \neq 0.9$$

6) SS-Error

$$\text{series: } K_{p,s} = K_s \Rightarrow sse_s = \frac{1}{1+K_s} = \frac{1}{4}, \quad \text{casc: } K_{p,c} = \frac{4}{5} K_c \Rightarrow \frac{1}{1+4K_c/5} = \frac{1}{7.2}$$

