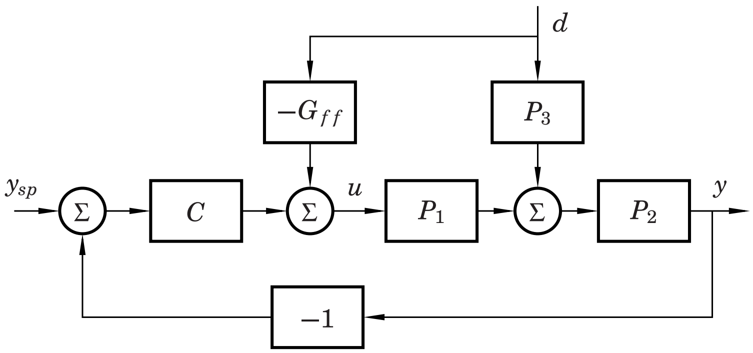
Exercises for Chapter 5

1. Consider the block diagram in Figure 1.



Figur 1 Feedforward from load disturbance d

The three process transfer functions are

$$P_1 = \frac{1}{1+2s}e^{-2s} \qquad P_2 = \frac{1}{1+s} \qquad P_3 = \frac{1}{1+s}e^{-s}$$

and C is a PI controller. The feedforward transfer function is

$$G_{ff} = K_{ff}\frac{1+sT_z}{1+sT_p}e^{-sL_{ff}}$$

a. Assume that $G_{ff} = 0$, i.e. we have no feedforward, and that the PI controller has parameters $K = 0.32$ and $T_i = 2.85$ (AMIGO). What is the value of IAE at step changes in d?

b. Now assume that controller C is in manual mode. Design the feedforward filter G_{ff} according to the rule of thumb in the book. What is the value of IAE?

c. Can you decrease the IAE value by adjusting T_p and T_z? What is the new value of IAE?

d. Now connect controller C. What value of IAE do you get? Can you reach the same IAE value as in **c** by adjusting T_p and T_z?

2. Consider the block diagram in Figure 1. The three process transfer functions are

$$P_1 = \frac{1}{1+10s} \qquad P_2 = 1 \qquad P_3 = \frac{1}{1+s}e^{-10s}$$

Determine the feedforward transfer function G_{ff} according to the rule of thumb in the book. What is the IAE value obtained at step changes in load d? Is this a good design?

3. Assume that we have an oscillatory process with transfer function

$$P(s) = \frac{1}{s^2 + 0.4s + 1}.$$

The relative damping is $\zeta = 0.2$. We would like to have good responses to step changes in both setpoint and load.

a. Design a PI and a PID controller. You may assume that the setpoint weightings are $b = c = 0$.

b. Feed the setpoint through the notch filiter

$$M_y = \frac{s^2 + 0.4s + 1}{(s + 1)^2}$$

according to Figure 5.1 in the book. Let $M_u = 0$. How does this filter influence the responses?

4. Consider the process

$$P(s) = \frac{1}{(s + 1)(0.1s + 1)(0.01s + 1)(0.001s + 1)}$$

controlled by a robust PID controller with $K = 3.75$, $T_i = 0.38$, and $T_d = 0.13$, and that a second-order measurement filter

$$G_f(s) = \frac{1}{0.005s^2 + 0.1s + 1}$$

is used to suppress measurement noise. Find suitable reference filters such that the Integrated Absolute Error, during a unit step change in the reference value, is as small as possible at the same time as the process value does not exceed the set point by more than 0.001. Use

a) Set-point weighting as in chapter 3.4 in the course book

b) An arbitrary set-point filter, $F(s)$, with the set-up as in Figure 3.10, page 75 in the course book

c) Two reference filters $M_u(s)$ and $M_y(s)$ as in Figure 5.1, page 140 in the course book

Discuss your results.

Note! You do not have to find optimal solutions.