Computer Exercise 1
EL2520 Control Theory and Practice

Adel Abdelsamed
akmab@kth.se
000321-2412

Simon Spång
sspang@kth.se
000121-2315

April 3, 2024

Disturbance attenuation

How should the extra poles be chosen in exercise 4.2.1? Motivate!

Since we would like the loop gain L to be approximately $L \approx \frac{w_c}{s}$ up to the crossover frequency, high-frequency poles should be added. It is noted that by high-frequency it is meant that $\frac{1}{\tau}$ is sufficiently higher than ω_c. Furthermore, the high frequency poles should not change the gain of the loop L and hence were added using the following form $\frac{1}{(\tau s+1)^n}$. Lastly, since the controller $F_y = G^{-1}\frac{\omega_c}{s}$ has a zero excess of 2, we require at least $n \geq 2$ for the controller to be proper and hence realizable.

The feedback controller in exercise 4.2.2 is

$$F_y(s) = 0.465 \cdot \frac{s+10}{s}$$

The feedback controller and prefilter in exercise 4.2.3 is

$$F_y(s) = \frac{0.04065s^2 + 0.4963s + 1.463}{0.05528s^2 + s}$$

$$F_r(s) = \frac{1}{0.135s + 1}$$

Did you manage to fulfill all the specifications? If not, what do you think makes the specifications difficult to achieve?
The second specification of the disturbance rejection is slightly violated after adding the lead term. Although we use a 2 DOF controller, still we first design F_y to satisfy the disturbance rejection requirements (i.e. shape the controller s.t. $F_y \approx \frac{1}{s}G^{-1}G_d$). This requirement conflicts with the other requirement for reference tracking (i.e. $F_y \approx \frac{w_c}{s}G^{-1}$ which was designed in

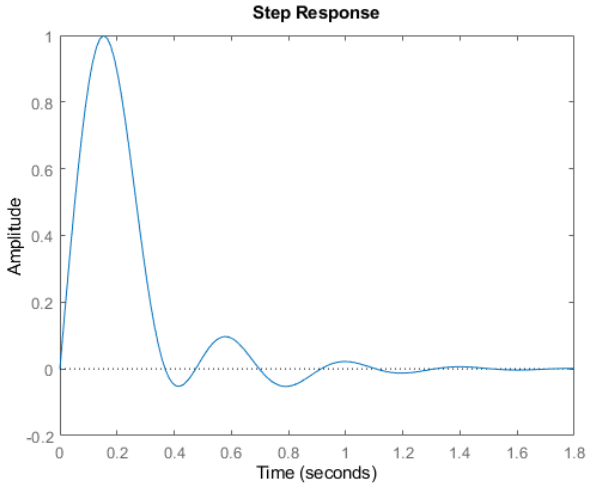

Figure 1: Reference step, exercise 4.2.2.

4.2.1) and hence optimizing disturbance rejection will still influence reference tracking. Only after designing F_y for disturbance rejection, a lead element is added and the pre-filter F_r is tuned to improve the transient response. A more optimal approach would consider both conflicting requirements while designing F_y and F_r.

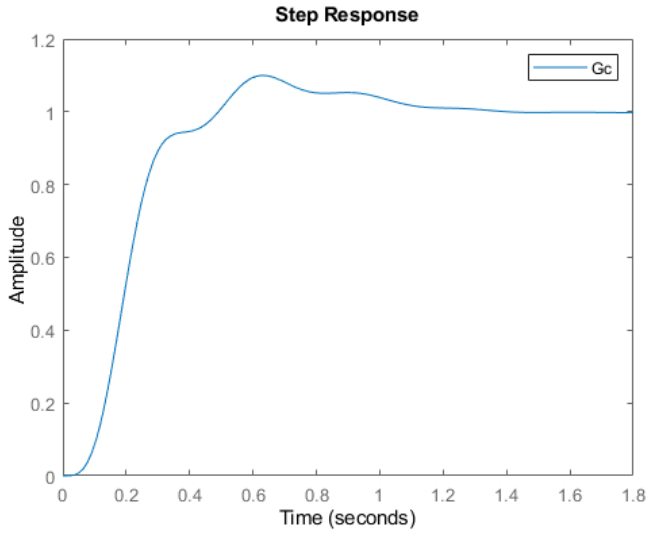

Figure 2: Reference step, exercise 4.2.3.

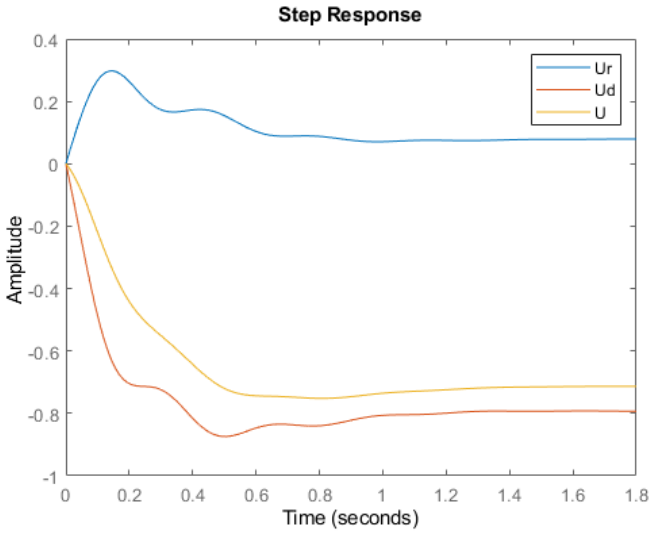

Figure 3: Control signal for a disturbance or a reference step (plus a combination of these)

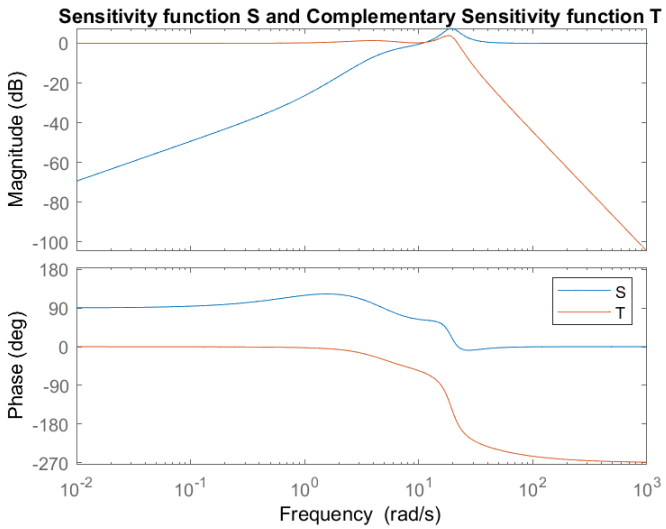

Figure 4: Bode diagram of sensitivity and complementary sensitivity functions, exercise 4.2.4.