Computer Exercise 4
EL2520 Control Theory and Practice

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Minimum phase case

Dynamic decoupling

The dynamic decoupling in exercise 3.2.1 is

$$W(s) = W_1(s) = \begin{bmatrix} 1 & \frac{-0.000446s-2.306\times10^{-5}}{0.03013s^2+0.002204s+3.328\times10^{-5}} \\ \frac{-0.0004649s-2.624\times10^{-5}}{0.0348s^2+0.002859s+5.052\times10^{-5}} & 1 \end{bmatrix}$$

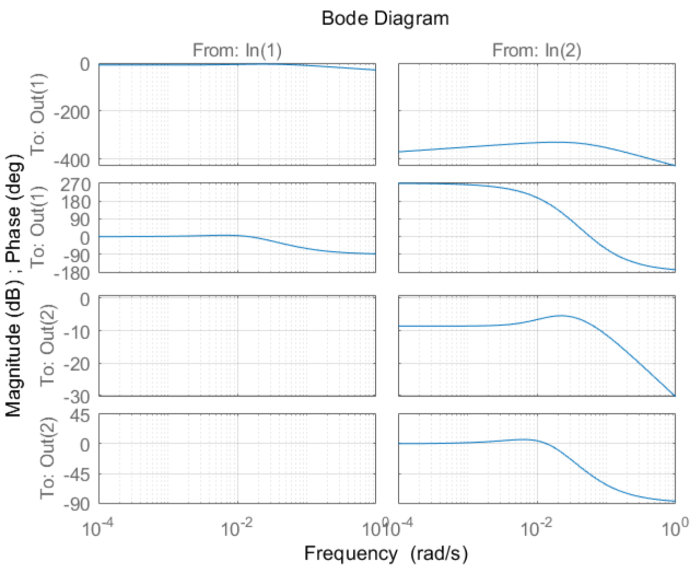
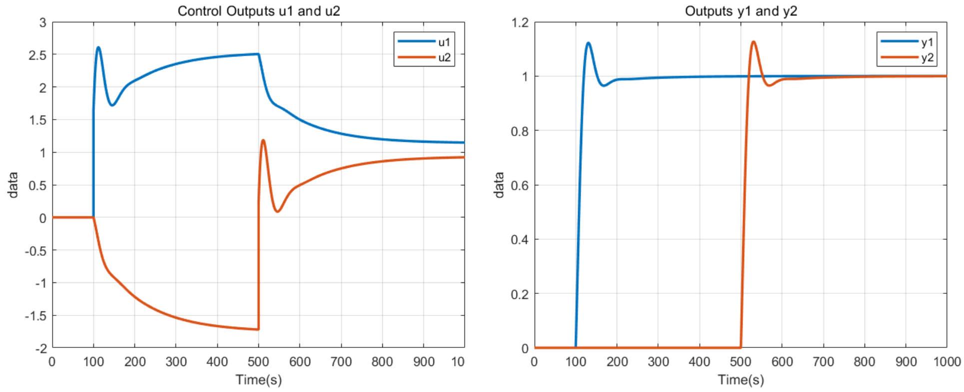


Figure 1: Bode diagram of $\tilde{G}(s)$ derived in exercise 3.2.1

Is the controller good?



(a) Simulation of control outputs (b) Simulation of outputs

Figure 2: Simulink plots from exercise 3.2.4

Due to dynamical decoupling, the controller ensures that output 1 doesn't react to a reference change in reference 2 and vice versa. Also, in minimum phase case, the RGA of $\tilde{G}(s)$ indicates the pairings of (u_1, y_1) and (u_1, y_1). And we can see from fig. 1 that u_1 is attenuated for y_2 and so is u_2.

Are the output signals coupled?
Looking at the plot of the outputs in fig. 2(b) one can see that the outputs are decoupled. When the reference 1 is changed only output 1 reacts. This can be explained by looking at the bode plot in fig. 1. The magnitude of the (1,2)- and (2,1)- element is nearly zero over all frequencies. Also the RGA gives an identity matrix.

Glover-MacFarlane robust loop-shaping

What are the similarities and differences compared to the nominal design? Compared with the nominal design, one can see that the robust design leads to less overshoot and both make the system decoupled. The control input looks similar but it is a bit smaller in the Glover-McFarlane design.

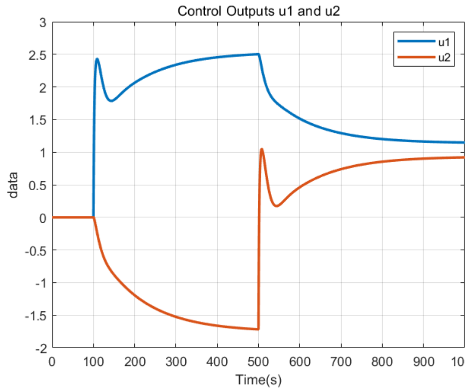
Non-minimum phase case

Dynamic decoupling

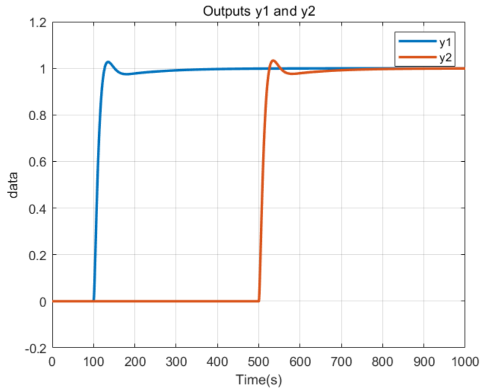
The dynamic decoupling in exercise 3.2.1 is

$$W(s) = W_1(s)\frac{10\omega_c}{s+10\omega_c} = \begin{bmatrix} \frac{-1.143s-0.1039}{s+0.2} & \frac{0.2}{s+0.2} \\ \frac{0.2}{s+0.2} & \frac{-1.615s-0.1386}{s+0.2} \end{bmatrix}$$

Is the controller good?



(a) Simulation of control outputs



(b) Simulation of outputs

Figure 3: Simulink plots from exercise 3.3.4

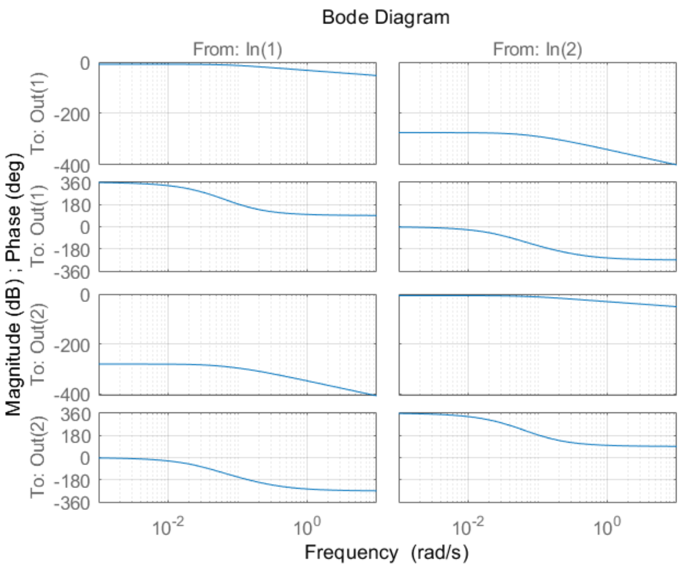
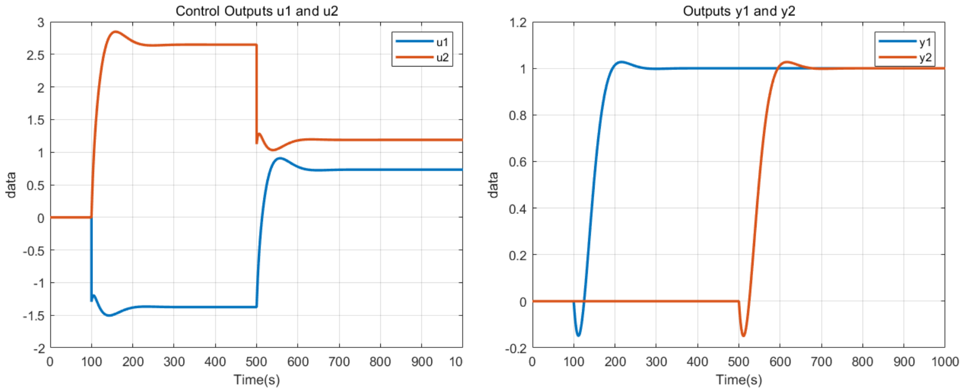


Figure 4: Bode diagram of $\tilde{G}(s)$ derived in exercise 3.2.1

The controller is good in all, it leads to small overshoot, fast rise time. Also it makes the system stable. After a set point change, the outputs show an inverse response. Also, in non-minimum phase case, the RGA of $\tilde{G}(s)$ indicates the pairings of (u_1, y_1) to (u_2, y_2), which can be seen from fig. 4.

Are the output signals coupled?

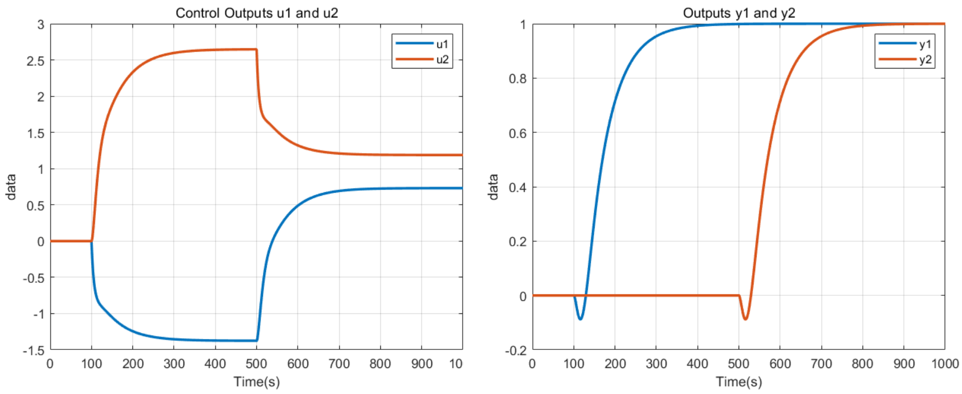
The output signals are not coupled. When the first reference is changing, the second output stays the same.



(a) Simulation of control outputs (b) Simulation of outputs

Figure 5: Simulink plots from exercise 3.2.4

Glover-MacFarlane robust loop-shaping



(a) Simulation of control outputs (b) Simulation of outputs

Figure 6: Simulink plots from exercise 3.3.4

What are the similarities and differences compared to the nominal design? The robustified controller provides output trajectories without overshoot. In terms of decoupling it shows the same result compared with the nominal design. Again we see the inverse response because the system is nonminimum phase.