Computer Exercise 2
EL2520 Control Theory and Practice

Kartik Chari
kartikc@kth.se
960807-0174

Devendra Sharma
devendra@kth.se
950815-5497

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Minimum phase case

The controller is given by

$$F(s) = \begin{bmatrix} \dfrac{9.904s + 1.678}{5.904s} & 0 \\ 0 & \dfrac{12.87s + 2.014}{6.391s} \end{bmatrix}$$

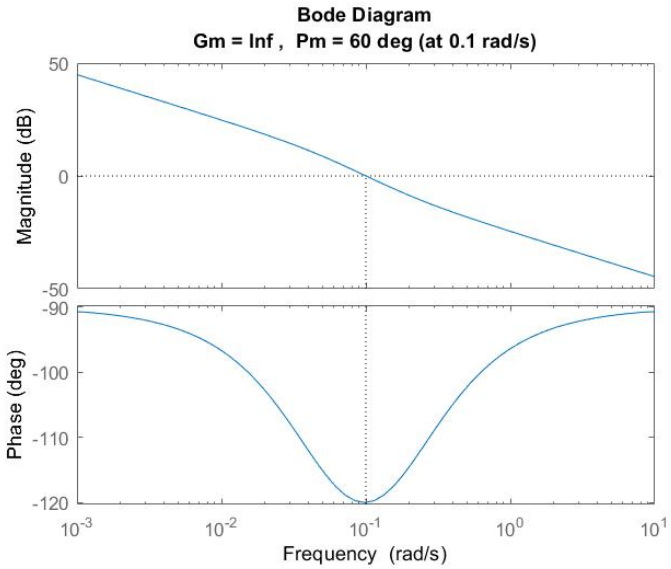

Figure 1: Bode diagram of the loop gain $L_{11}(s)$ (Minimum Phase) from exercise 3.2.1

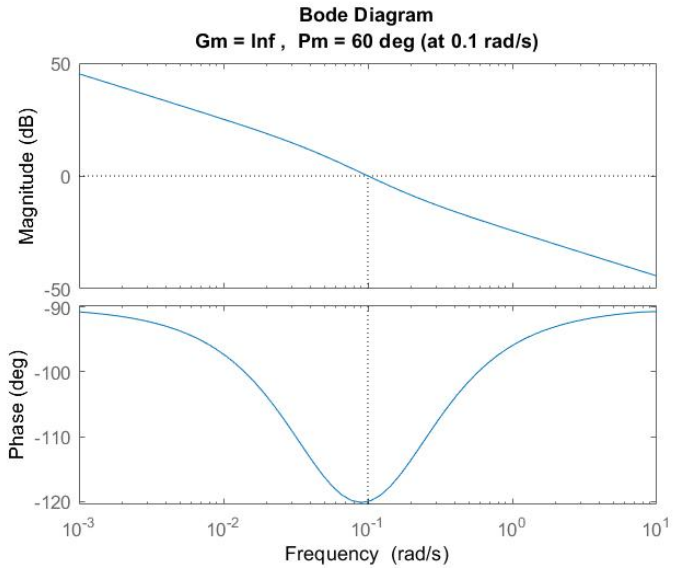

Figure 2: Bode diagram of the loop gain $L_{22}(s)$ (Minimum Phase) from exercise 3.2.1

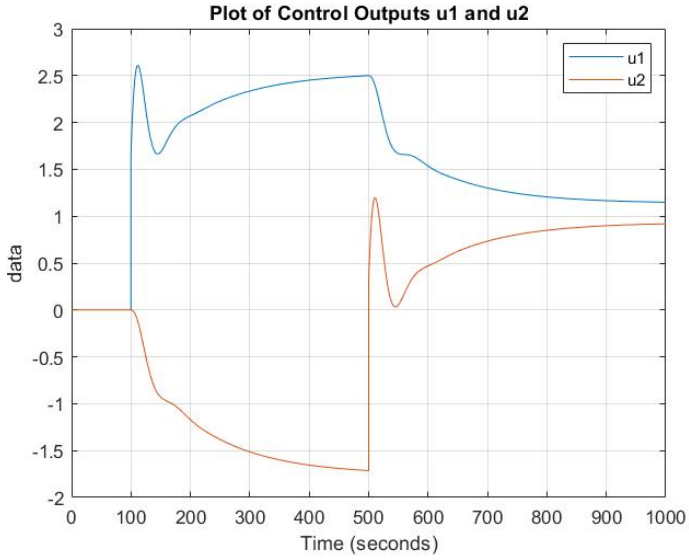

Figure 3: Control Signal plot (Minimum Phase) from exercise 3.2.3

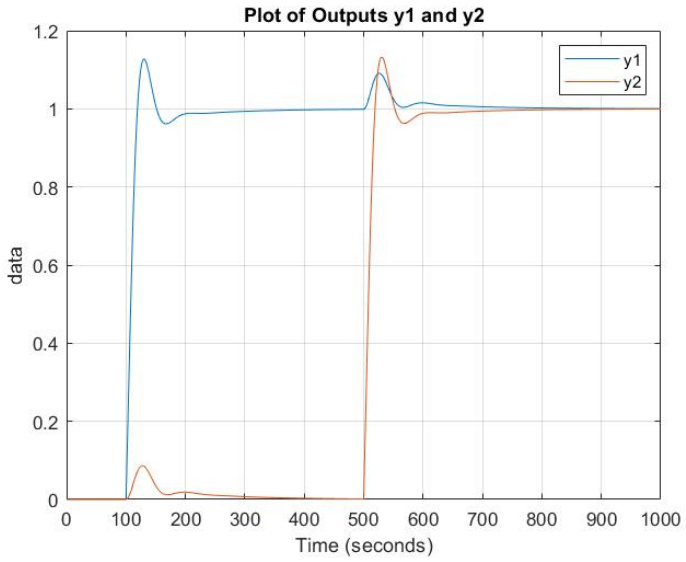

Figure 4: Output plot (Minimum Phase) from exercise 3.2.3

Is the controller good?
From the above fig.4 we can see that the peak overshoot for both the outputs is less than 15% and the rise time is less than 20s. Also, the steady state error is zero for both outputs which clearly shows that the controller is good.

Are the output signals coupled?
RGA Analysis for the Minimum Phase Case showed that the control signal U_1 is to be paired with output Y_1 and U_2 is to be paired with output Y_2. The step input 1 is applied at $t = 100s$ and step input 2 is applied at $t = 500s$. From fig 4 we can see that each input effects both the outputs but for input 1, the output y_1 is affected to a greater extent and the output y_2 is very less affected. Similarly, the input 2 affects y_2 way more than it affects y_1. On a similar note, from fig. 3 we can see that as u_1 primarily affects y_1 and u_2 primarily affects y_2 even though both control signals have a little affect on the other outputs. This behavior is exactly what we desired.

Non-minimum phase case

The controller is given by

$$F(s) = \begin{bmatrix} 0 & \dfrac{0.5792s + 0.1469}{3.943s} \\ \dfrac{0.6915s + 0.14374}{4.811s} & 0 \end{bmatrix}$$

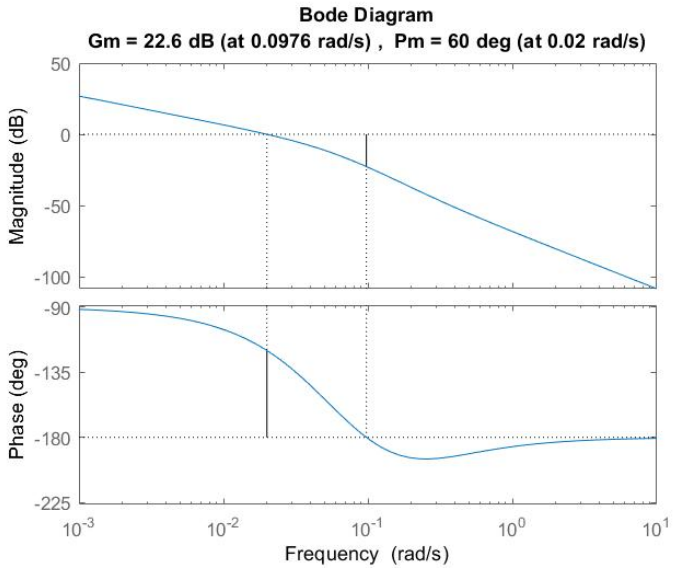

Figure 5: Bode diagram of the loop gain $L_{11}(s)$ (Non-Minimum Phase) from exercise 3.2.1

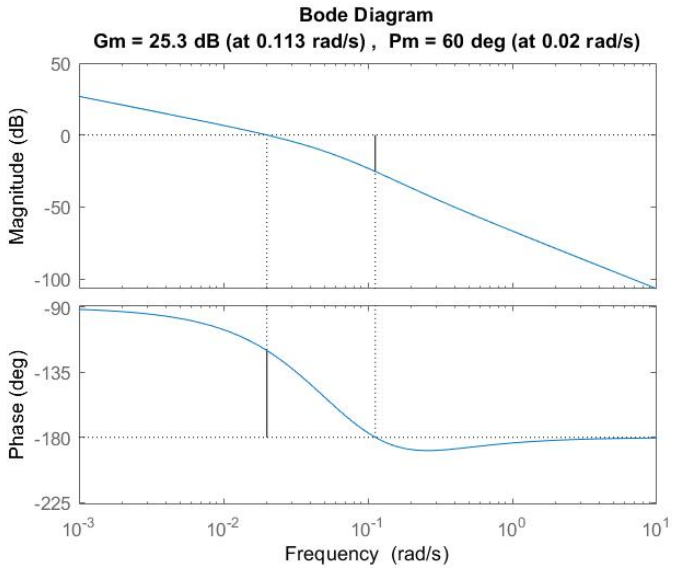

Figure 6: Bode diagram of the loop gain $L_{22}(s)$ (Non-Minimum Phase) from exercise 3.2.1

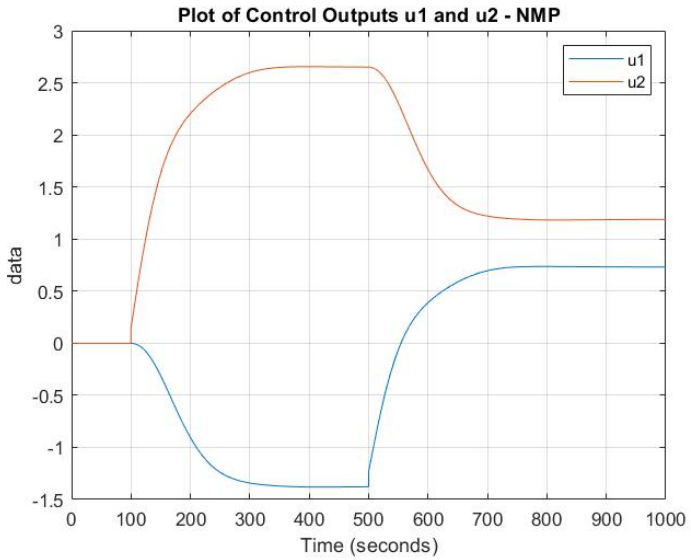

Figure 7: Control Signal plot (Non-Minimum Phase) from exercise 3.2.3

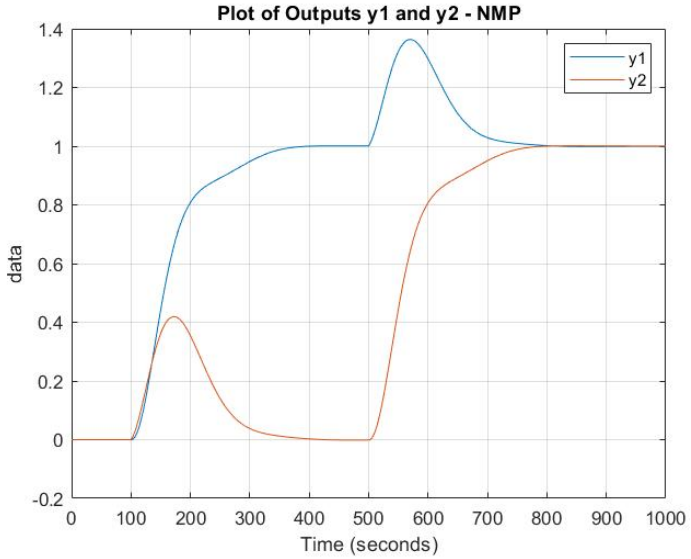

Figure 8: Output plot (Non-Minimum Phase) from exercise 3.2.3

Is the controller good?

By observing the plot of outputs y1 and y2 for Non Minimum Phase i.e. figure 8, we can observe that controller is not good since rising time is too high for it. Thus, we can conclude that the controller for the Minimum Phase case has way better performance than the Non-minimum Phase case.

Are the output signals coupled?

For the Non minimum Phase case, the RGA analysis showed that the control signal U_1 is to be paired with output Y_2 and U_2 is to be paired with output Y_1. The step input 1 is applied at $t = 100s$ and input 2 is applied at $t = 500s$. By observing figure 8, we can see that as the reference input 1 is applied, both the outputs are affected but the effect is observed to be prominent in output Y_1 as output Y_2 gradually tends to zero. Similar response is observed at $t = 500s$, when input 2 acts and Y_1 initially is affected but the controller succeeds to attenuate the load. Coming to the Control Signal, initially U_1 acts for tracking of output Y_2 and U_2 acts for tracking of output Y_1 but due to coupling the other outputs are also affected but to a lesser extent and the controller succeeds to attenuate the cross pairing between U_1 –> Y_1 and U_2 –> Y_2