Computer Exercise 2
EL2520 Control Theory and Practice

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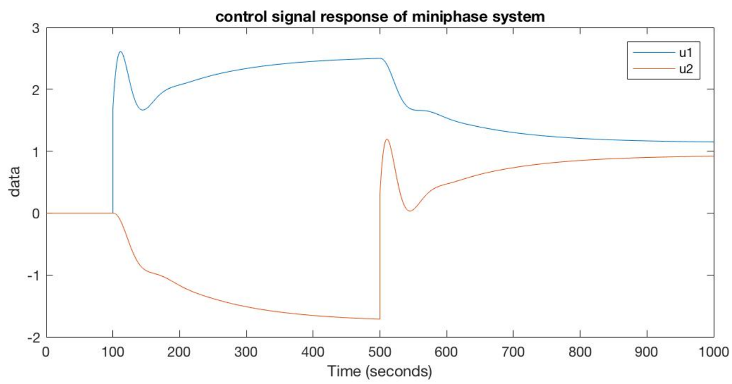
Minimum phase case

The controller is given by

$$F(s) = \begin{bmatrix} 1.6776(1 + \frac{1}{5.9037s}) & 0 \\ 0 & 2.0137(1 + \frac{1}{6.3911s}) \end{bmatrix}$$



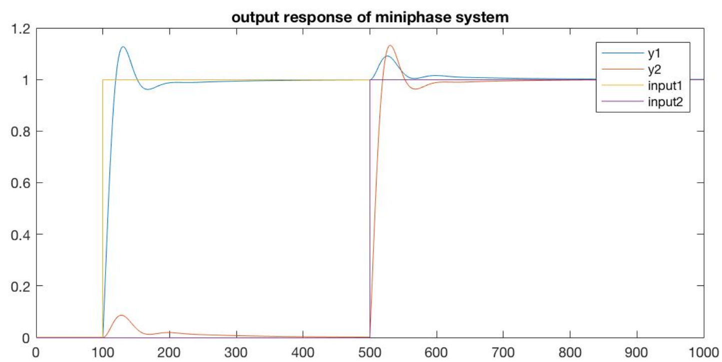
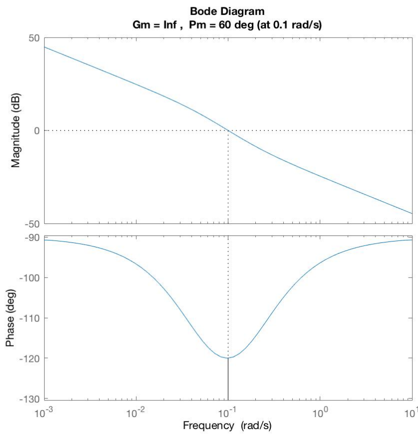


Figure 1: Simulink plots of step responses



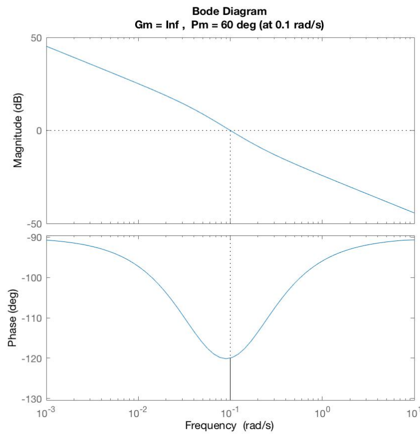


Figure 2: Bode diagram of the loop gain L11(s) and L22(s)

Table 1: Closed loop system (minimum phase) characteristics.

	T_p [s]	T_r [s]	M [%]
input1 to *y1*	30.1	19.08	12.71
input2 to *y2*	30.5	19.10	13.25

In fig.1, the first plot is the control signal *u* and the second is the output as well as the input. Obviously, two outputs are coupled since one input will affect both two outputs. However, when *input1* comes in, *y1* increases much more in a rapid way than *y2*. Also *input2* affects more on *y2* than *y1*. Looking at the control signal, when *u1* increases, it results in an increase of *y1* at the same time. And the same phenomenon happens also for *u2* and *y2*. This perfectly meets our desired pairing.
After deciding the pairs, we list the closed loop characteristics including peak time, rising time and overshoot in Table.1. From the table, overshoot is less than 15% and rising time is shorter than 20s. Moreover, there is almost no static control error. As a result, the controller is fairly satisfied.

Non-minimum phase case

The controller is given by

$$F(s) = \begin{bmatrix} 0 & 0.1469(1+\frac{1}{3.9426s}) \\ 0.1437(1+\frac{1}{4.8107s}) & 0 \end{bmatrix}$$

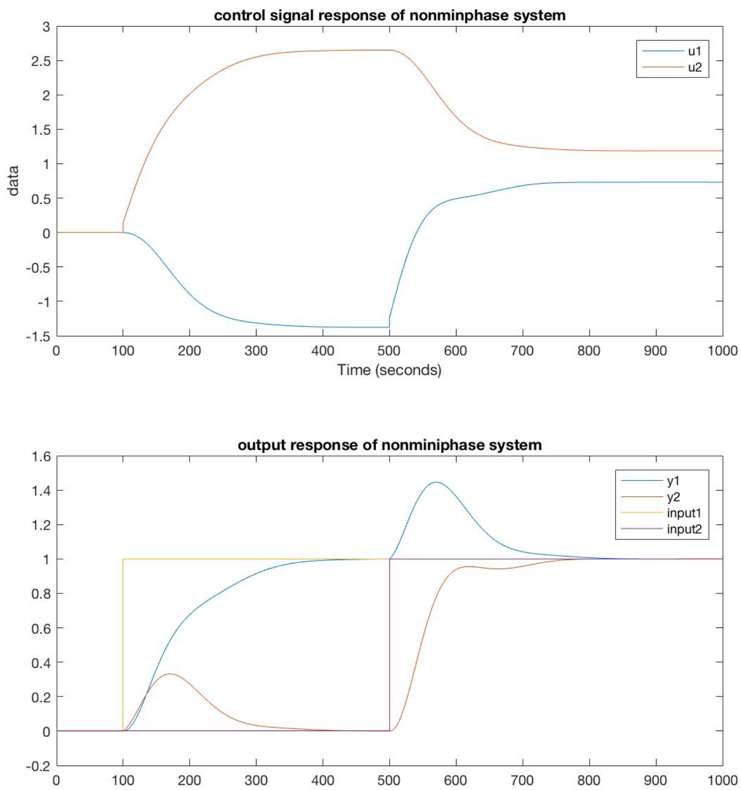


Figure 3: Simulink plots of step responses

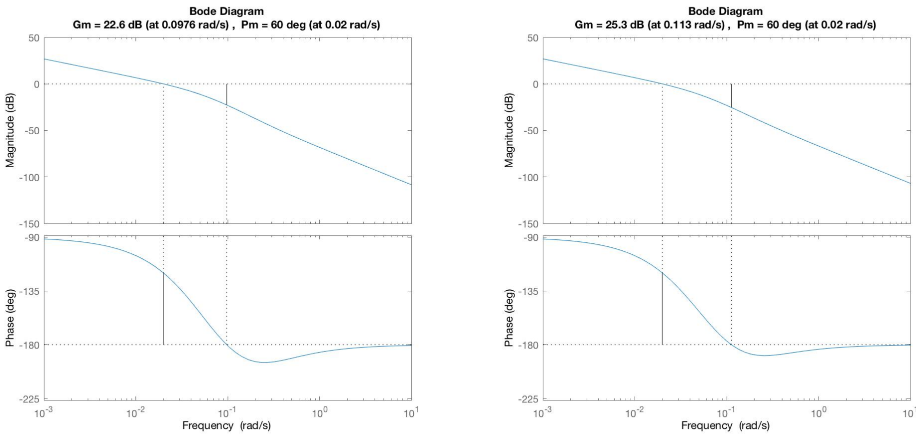


Figure 4: Bode diagram of the loop gain L11(s) and L22(s)

Table 2: Closed loop system (non-minimum phase) characteristics.

	T_p [s]	T_r [s]	M [%]
input1 to *y1*	Not exist	≈ 500	0
input2 to *y2*	Not exist	413	0

In fig.3, we find although *input1* strongly affect both two outputs, but *y2* decrease to 0 afterwards. Then we know *input1* goes with *y1* and *input2* with *y2*. But outputs are still coupled. In fig.3, when *u1* increases, *y2* correspondingly rises. And when *u2* increases, *y1* rises. This follows our desired pairing (*u2* with *y1*, *u1* with *y2*).

The characteristics are shown in Table.2. It is quite apparent that this controller is not good although no overshoot but rising time is too large.

The most difference between minimum phase case and non-minimum phase case is the controller. And from the results above, we know that the controller based on minimum phase has a much better performance than non-minimum phase. Theoretically, the RGA value in this case is 1.4309+0.3544j which is relatively far away from 1 compared to the RGA value in the minimum phase case (0.9835−0.0080j). This means pairing signals in such a way mentioned above is not ideal for the non-minimum phase case.