MF2007 - Workshop B

Adam Lang
861110-3956

Gabriel Andersson Santiago
910706-4538

Andreas Fröderberg
880730-7577

April 6, 2016

Task 1

Level 1

The model following part were derived by inverting each block of the DC motor model step by step and was verified by using outputs from the DC motor model as input for the inverse model. This should yield the same input for the DC motor model as output for the inverse model and it did.

In order to design the trajectory planner values for a_{max} and v_{max} needed to be decided. v_{max} was read from a velocity plot when the motor model was fed with 24 V. a_{max} was calculated to a value around 600-700 but that value saturated the voltage from the model follower. a_{max} was therefore tweaked into a value which never saturates the voltage. The values derived can be seen in the following table.

a_{max}	255
v_{max}	270

The signal from the trajectory planner with Rs = 10 and Rs=100 can be seen in Figure 3.

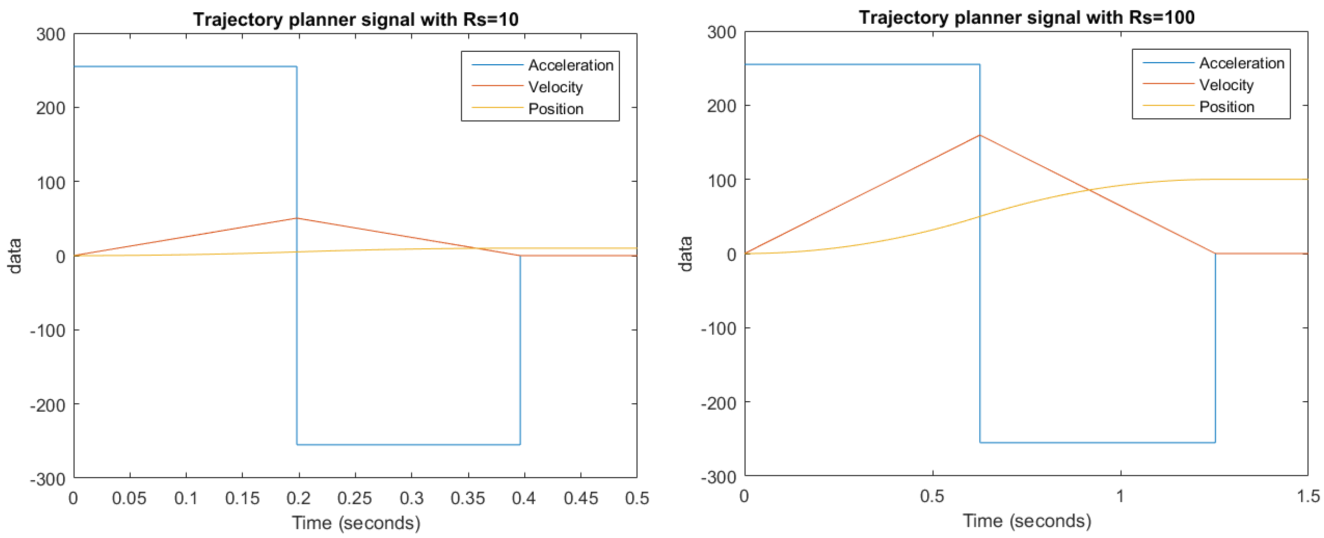

Figure 1: The trajectory planner with different Rs values

Task 2: Writing Controller Code

Level 1

The code equivalent to the Simulink blocks gave similar results which can be seen in Figure 2 and Figure 3. A sampling time of 10 ms was used for the code. Different sampling times were tested and it was noticed that when using a higher sampling time the impact on the trajectory planner increased. When a higher sampling time is used the change of acceleration is missed by a few milliseconds and therefore impact the velocity and position. This gives the difference in the position of the motor which is seen in Figure 3.

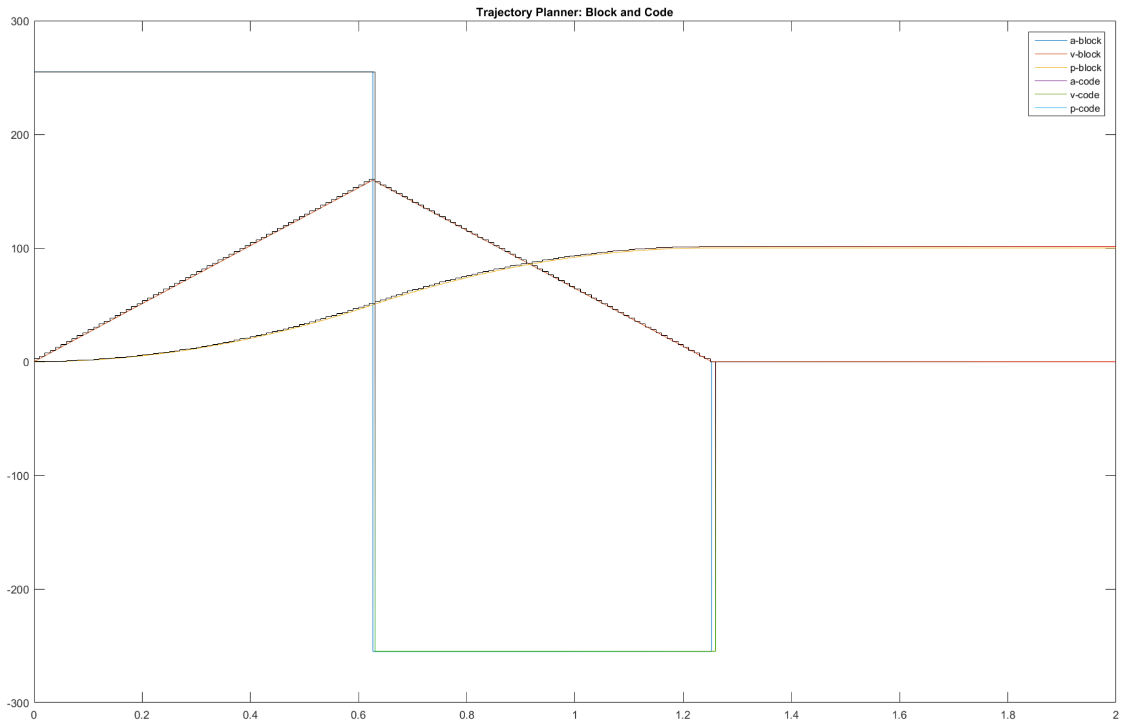

Figure 2: Trajectory planner signal comparison

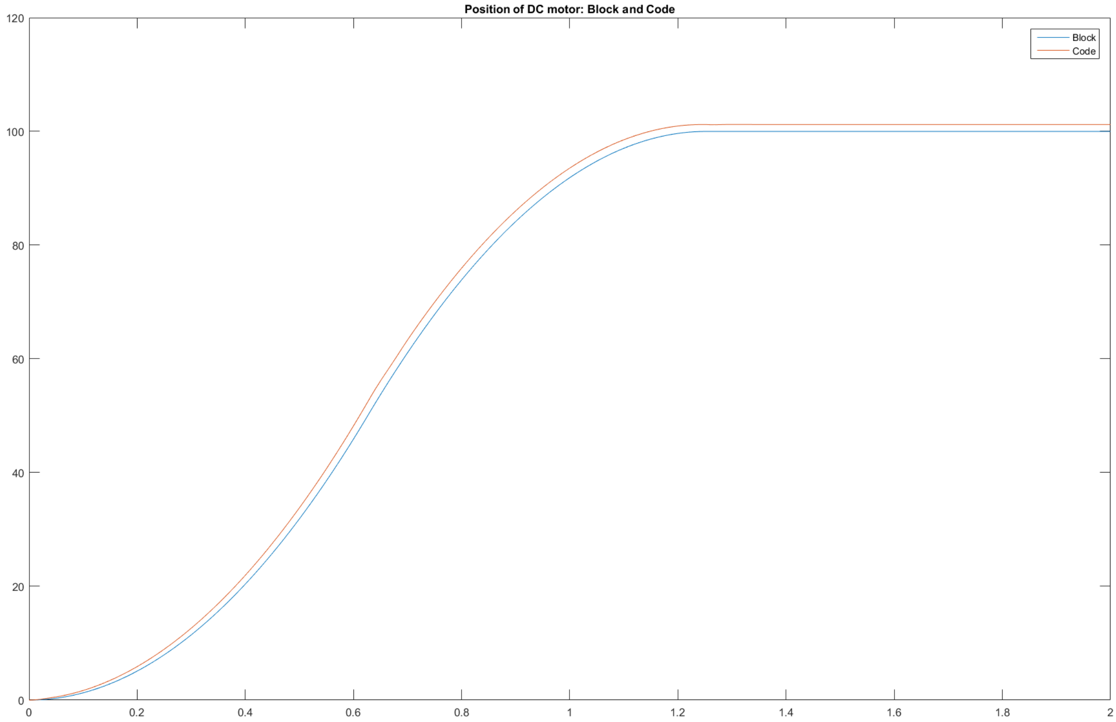

Figure 3: Motor position comparison

A close-up of the sampling time problem is shown in Figure 4. When the velocity increases it the code signal follows the curve perfectly but when the change in acceleration happens the velocity code signal gets "out-of-sync".

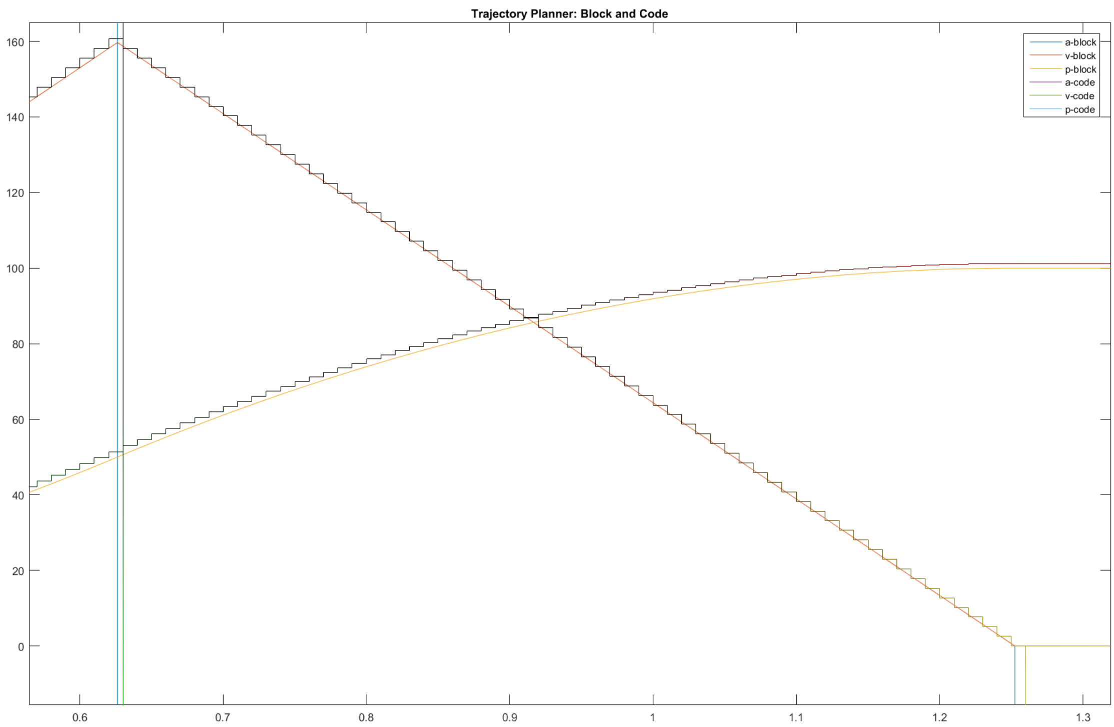

Figure 4: Close-up of trajectory planner signal

Level 2

Some modifications to the code had to be made to make it work in dSPACE but the same code is used for the plot in Figure 5. The performance of the trajectory planner in dSPACE worked excellent. It behaved almost exactly like in Simulink on the Dc motor model.

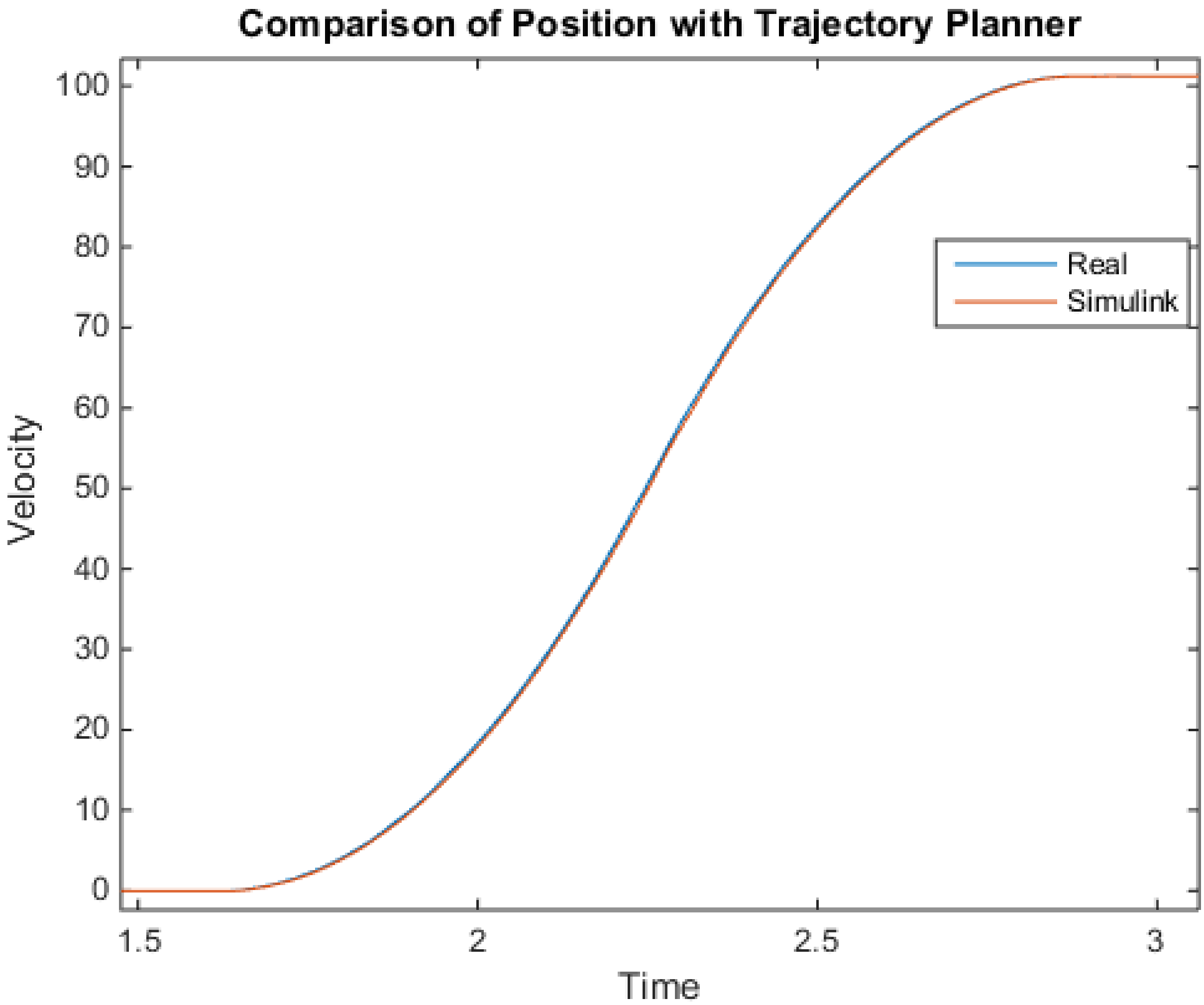

Figure 5: Comparison on the performance of the trajectory planner

Task 3: Robustness to parameter uncertainty and sensor noise

Since the plant have a transfer function as,

$$G_o(s) = \frac{25.15}{s + 2.157} \tag{1}$$

and an $A_m(s)$ of same order should be chosen, the following functions is used,

$$A_m(s) = s + \omega_1$$
$$A_o(s) = s + \omega_2$$

with

$$\omega_1 = 10$$
$$\omega_2 = 5$$

These values gives the plot seen in figure 6

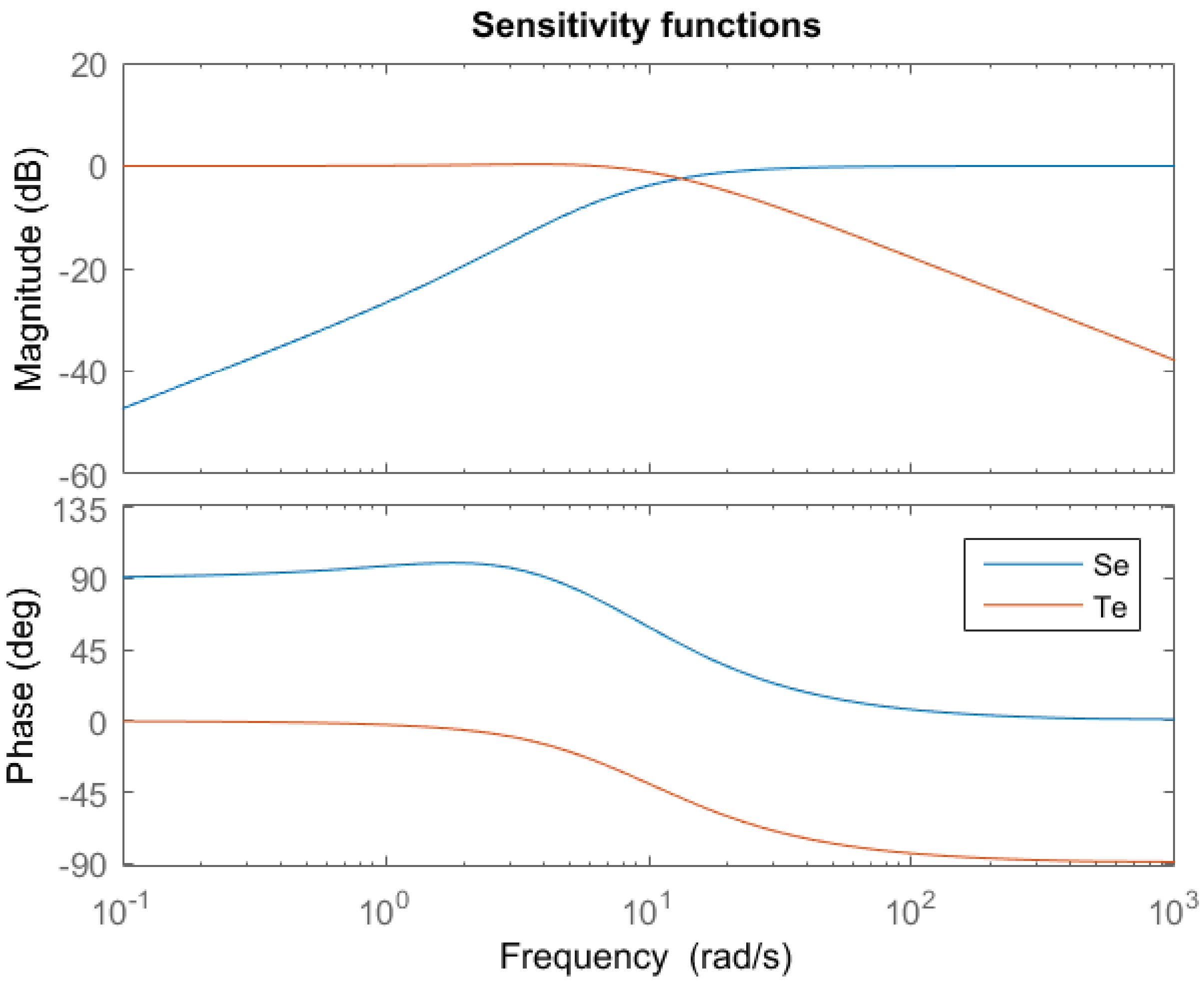

Figure 6: The sensitivity and conmplementary sensitivity function

when the poles for $A_0(s)$ is increased to five times $A_m(s)$ the results in figure 7 is obtained.

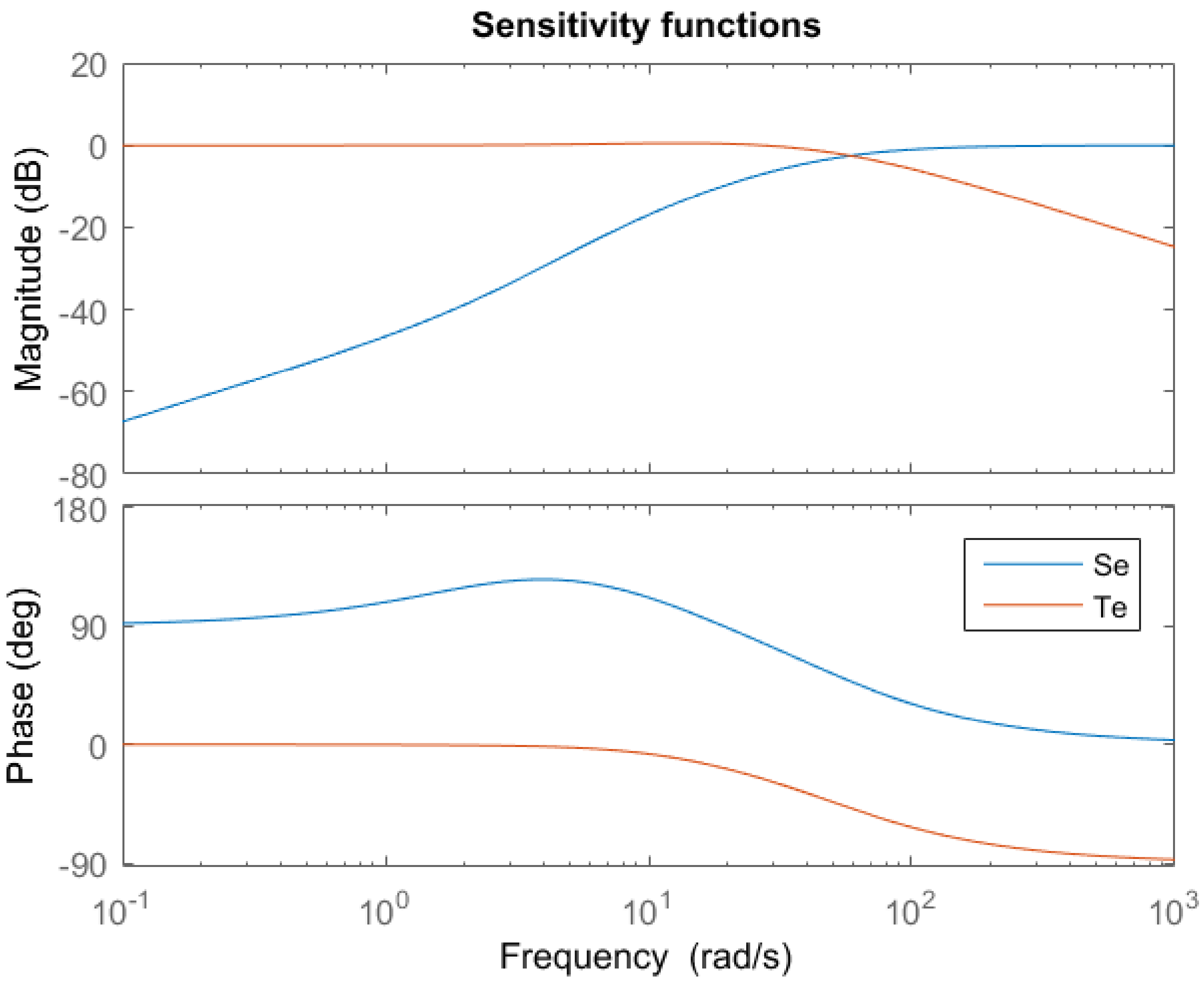

Figure 7: S_e and T_e with five times faster $A_o(s)$ poles

From the plots we can see that there is a possibility to adjust the system to be less sensitive to noise and disturbances from either the sensor or the plant. This means that if there is a good plant model, there is more room for sensor noise.

Level 2

The velocity controller from Exercise 3 was used as controller. Following the first part of the task the chosen values can be seen in the following table.

Am	500
Ao_1	1000
Ao_2	2000

1

Figure 8 shows the step responses for two different values of Ao. A force of 5000 N is applied at the time 0.03 seconds.

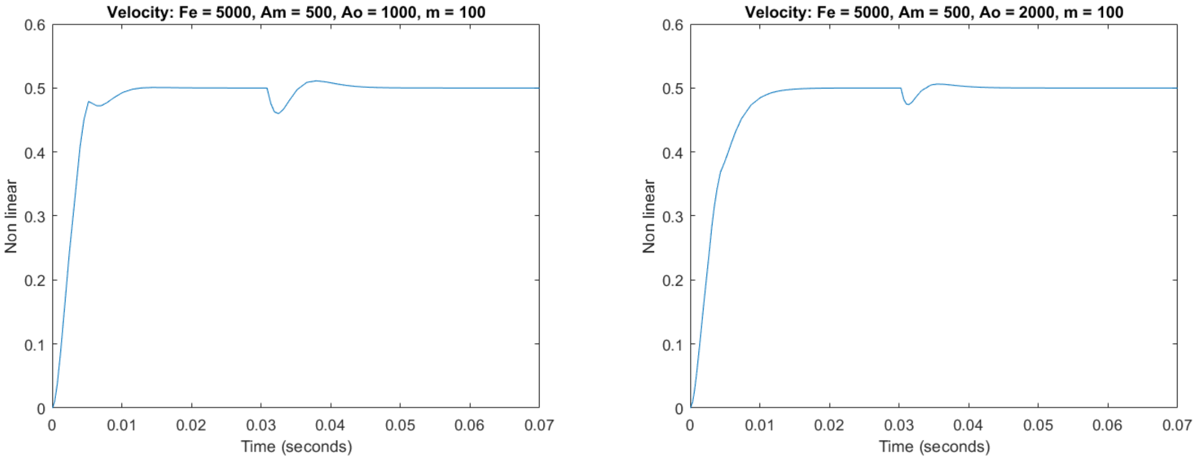

Figure 8: Comparison between the two different Ao values

2

Figure 9 shows the step responses for two different values of Ao and now with a mass of 200 kg instead of 100 kg. The system behaves more or less the same as with a mass of 100 kg.

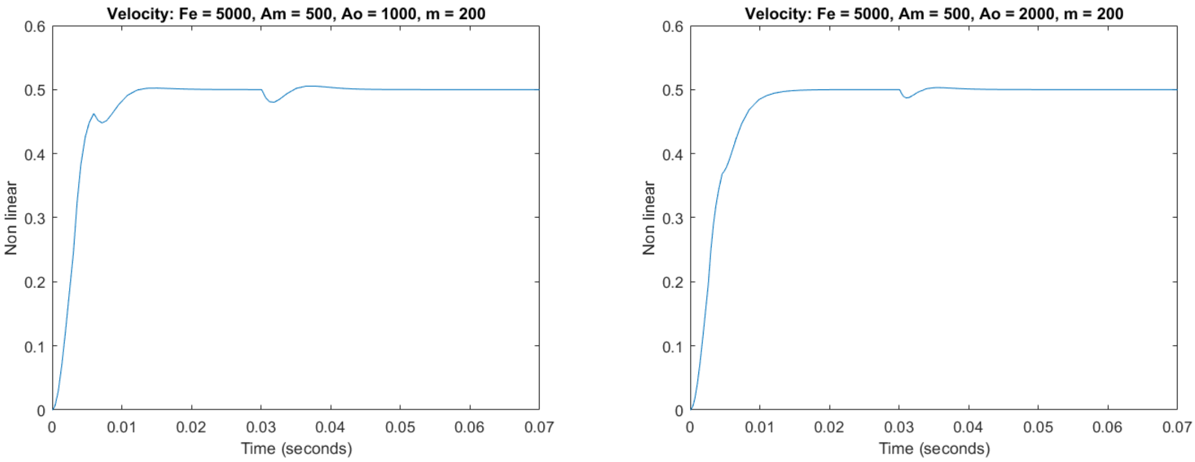

Figure 9: Comparison between the two different Ao values

3

Figure 10 shows the step responses for two different values of Ao with a sine wave as noise. The sine wave has a frequency of 1700 rad/s.

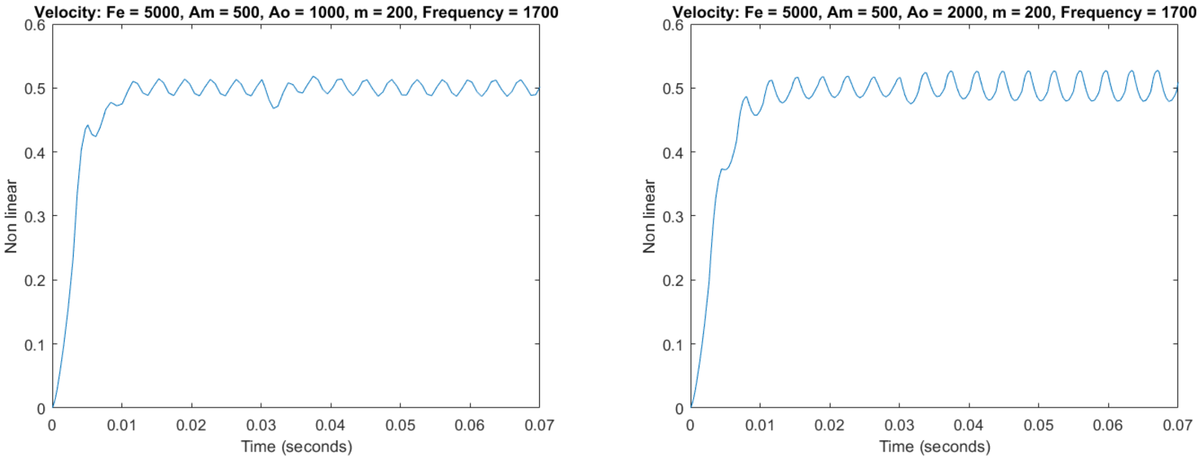

Figure 10: Comparison between the two different Ao values

Figure 11 shows the complementary sensitivity function for the two different Ao values. The magnitude when the frequency is 1700 rad/s is shown which shows that a lower Ao value dampens the noise more. It was hard to find a frequency were the noise dampening were very noticeable but the dampening can be seen in Figure 10 were the noise affects the system less when Ao=1000 compared to Ao=2000.

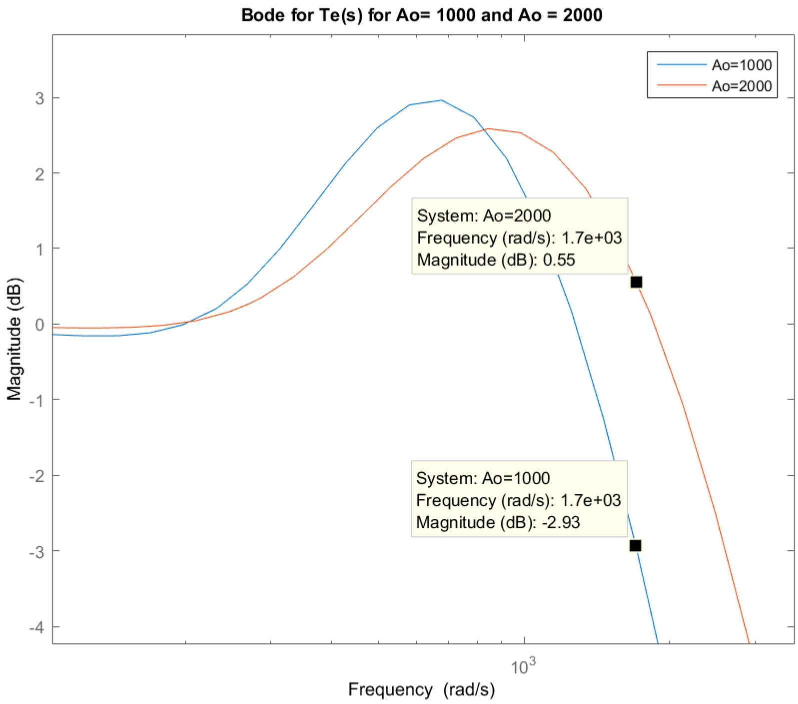

Figure 11: Comparison between the complementary sensitivity functions