Computer Exercise 3
EL2520 Control Theory and Practice

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Suppression of disturbances

The weight is

$$W_S(s) = \frac{1}{s^2 + 0.2s + \pi^2 \cdot 10^4}$$

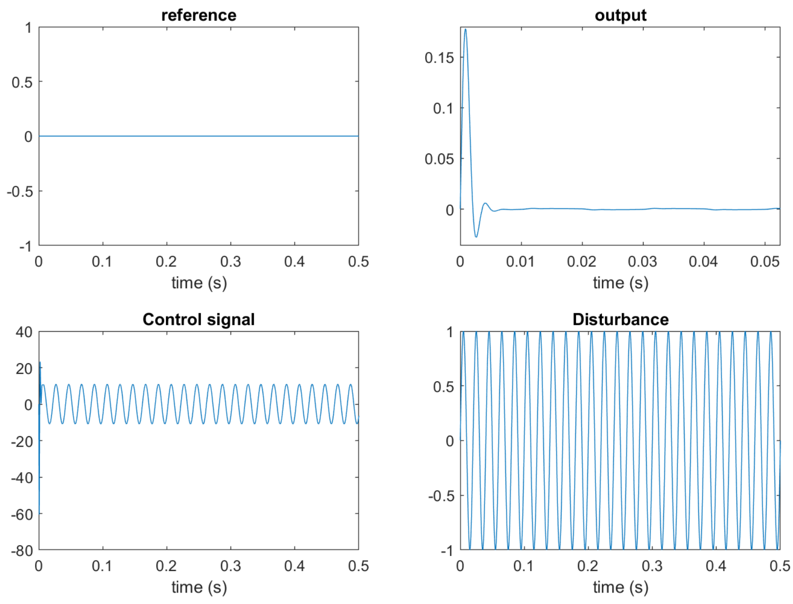

Figure 1: Simulation results with system G, using W_S.

How much is the disturbance damped on the output? The output peaks is $7.21 \cdot 10^{-4}$ except for the inital disturbance with an exceptional higher peak of 0.17791. Hence, the damping is of the size 0.999279 except for the initial damping which is 0.8221.

What amplification is required for a P-controller to get the same performance, and what are the disadvantages of such a controller?
From the hint we get that,

$$\text{if} \quad |FG| >> 1 \quad \text{then} \quad |S| = |FG|^{-1}$$

and we know that

$$F = K$$

for a P-controller. Which gives us that,

$$|y| = |S||d| = |d||KG|^{-1}, \qquad \text{where } G(100\pi) = 0.058,\ |\text{d}|=1 \text{ and } |\text{y}|=7.21 \cdot 10^{-4}$$

$$K = [0.058 \cdot 7.21 \cdot 10^{-4}]^{-1} = 2.39 \cdot 10^{4}$$

The issue with using a P controller, exceptionally with such a high K value, is that we will reduce the disturbance on all frequencies instead of concentrate the reduction on the known disturbance frequency, 50Hz.

Robustness

What is the condition on T to guarantee stability according to the small gain theorem, and how can it be used to choose the weight W_T?

Since $|T\Delta_G| < 1$ and $|\Delta_G| \cdot \gamma \cdot |W_T^{-1}| \leq 1$, then $|W_T| > |\Delta_G| \cdot \gamma$

Where $\gamma = 6.2915 \cdot 10^{-7}$ and $\Delta_G = \frac{s-1}{s+2} - 1 = \frac{-3}{s+2}$

Since W_T should be larger than $|\Delta_G| \cdot \gamma$, we increase the gain a bit more than γ. The weights are

$$W_S(s) = \frac{1}{s^2 + 0.2s + \pi^2 \cdot 10^4}$$
$$W_T(s) = \frac{-1}{s+2} \cdot 10^{-5}$$

Is the small gain theorem fulfilled?
As seen in Figure 2 one could notice that the requirement stated above are fulfilled, i.e. $|T\Delta_G| < 1\ \forall\ \omega$.

Compare the results to the previous simulation
The output peaks have increased to $58.1 \cdot 10^{-4}$ and the initial peak has increased to 0.483, so compared to previous simulation the oscillation has increased and also the maximum peaks.

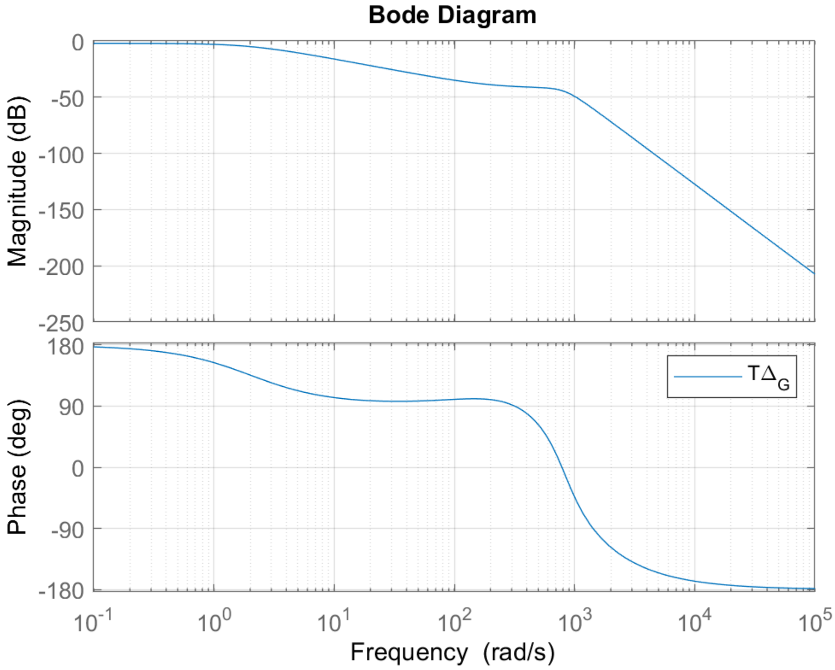

Figure 2: Bode diagram showing that the small gain theorem is satisfied.

Control signal

The weights are

$$
\begin{aligned}
W_S(s) &= \frac{1}{s^2 + 0.2s + \pi^2 \cdot 10^4} \\
W_T(s) &= \frac{-1}{s+2} \cdot 10^{-5} \\
W_U(s) &= \frac{3}{s+1}
\end{aligned}
$$

Compare the results to the previous simulations

The control signal is reduced with more than half but the output gets a lot of oscillation and high peak values close to the disturbance amplitude, which makes a relatively bad controller compared to previously controllers.

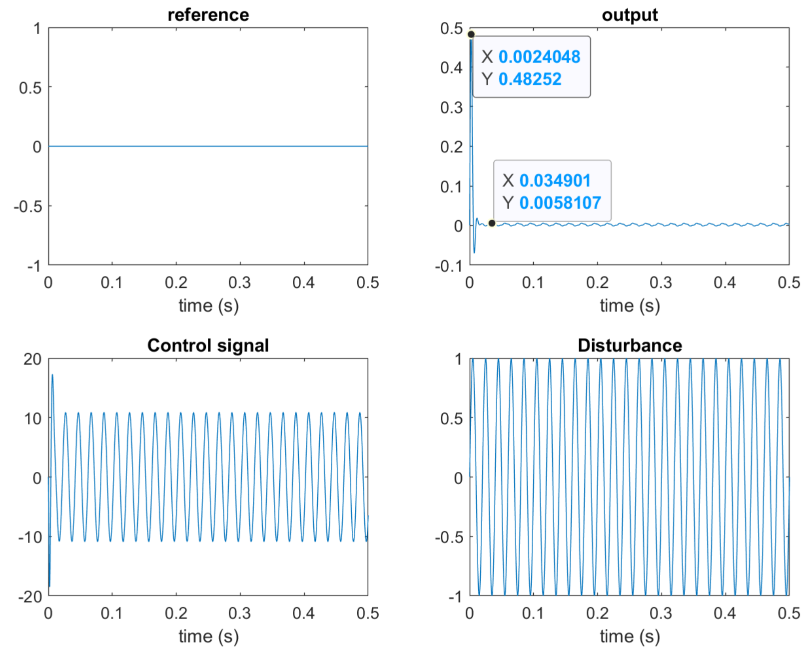

Figure 3: Simulation results with system G_0, using W_S and W_T.

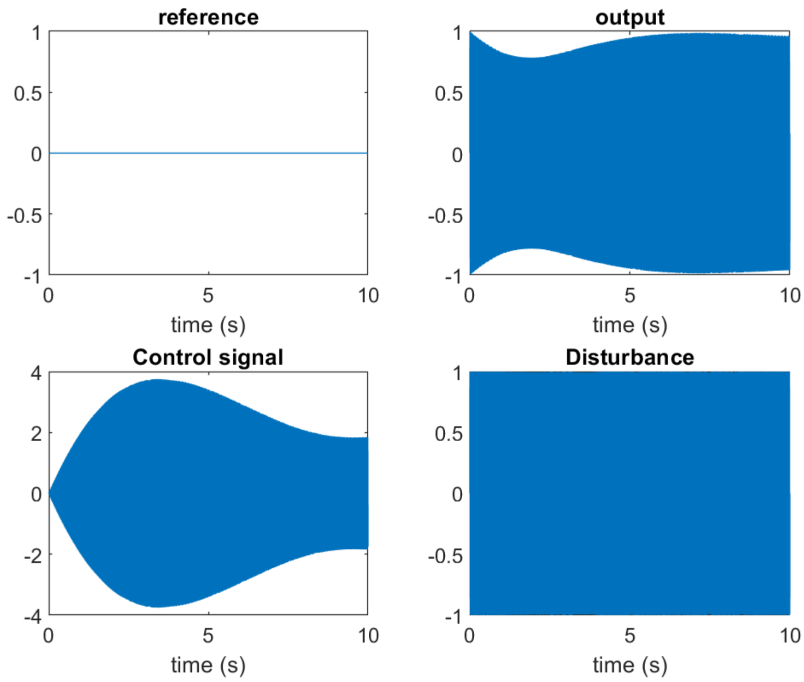

Figure 4: Simulation results with system G_0, using W_S, W_T and W_U.