Computer Exercise 3
EL2520 Control Theory and Practice

Kartik Chari
kartikc@kth.se
960807-0174

Devendra Sharma
devendra@kth.se
950815-5497

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Suppression of disturbances

The weight is

$$W_S(s) = \frac{1}{(s + 0.3 + i\sqrt{(100*\pi)^2 - (0.3)^2})(s + 0.3 - i\sqrt{(100*\pi)^2 - (0.3)^2})}$$

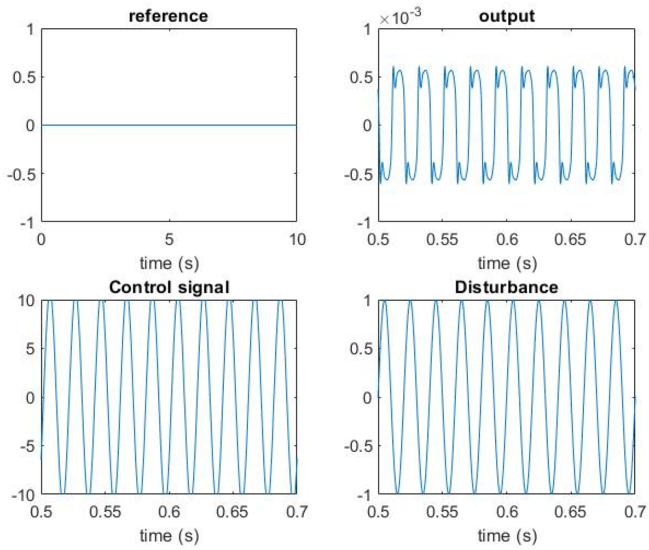

Figure 1: Simulation results with system G, using W_S.

How much is the disturbance damped on the output? What amplification is required for a P-controller to get the same performance, and what are the disadvantages of such a controller?

For calculating the amplification required for a P-Controller for the same performance, we first calculated the $|S(i\omega)|$ at $\omega = 100 * \pi$ and the magnitude $|G(i\omega)|$ at $\omega = 100 * \pi$. Using MATLAB, we got $|S| = 7.899 * 10^{-5}$ and $|G| = 0.0920$. Thus, $|F| = |G|/|S| = 1.164 * 10^3 \ \forall \ |FG| >> 1$. Thus, the approximate amplification for P-Controller should be $1.164 * 10^3$. This is a very high value for a practical controller which may have several hardware limitation problems. Also, another disadvantage to note is that the Proportional Controller will attenuate all the frequencies and not only 50 Hz.

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?

Using the Small Gain Theorem, condition for Robustness is: $|T(i\omega)\Delta_G(i\omega)| < 1$. Here, we calculated the $\Delta_G(s) = \frac{-3}{(s+2)}$. Thus, if we consider $W_T = \frac{3}{(s+2)}$, we have the condition on T as $|T(i\omega)| < \gamma * |W_T|^{-1}$.

Let $\gamma = 10^-4$

The weights are

$$W_S(s) = \frac{1}{(s + 0.3 + i\sqrt{(100*\pi)^2 - (0.3)^2})(s + 0.3 - i\sqrt{(100*\pi)^2 - (0.3)^2})}$$

$$W_T(s) = \frac{0.0003}{(s+2)}$$

Is the small gain theorem fulfilled?

As we can see in the bode plot below, the Magnitude plot of T is always below the plot of $1/\Delta_G$. Thus, the Small Gain Theorem is satisfied.

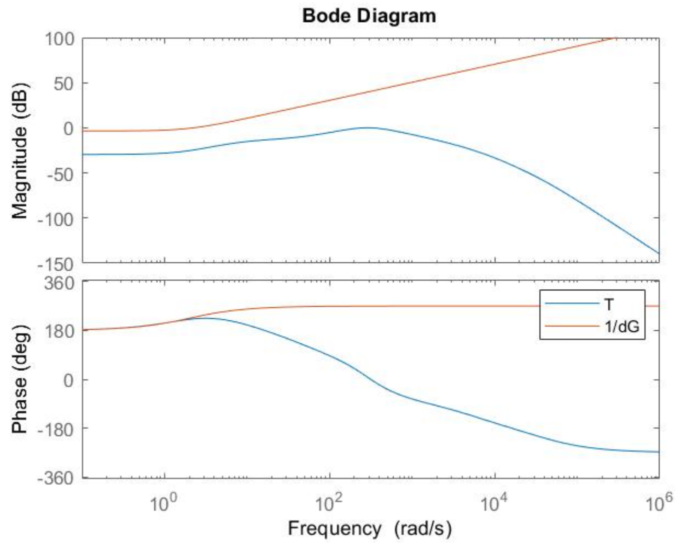

Figure 2: Bode diagram showing that the small gain theorem is satisfied.

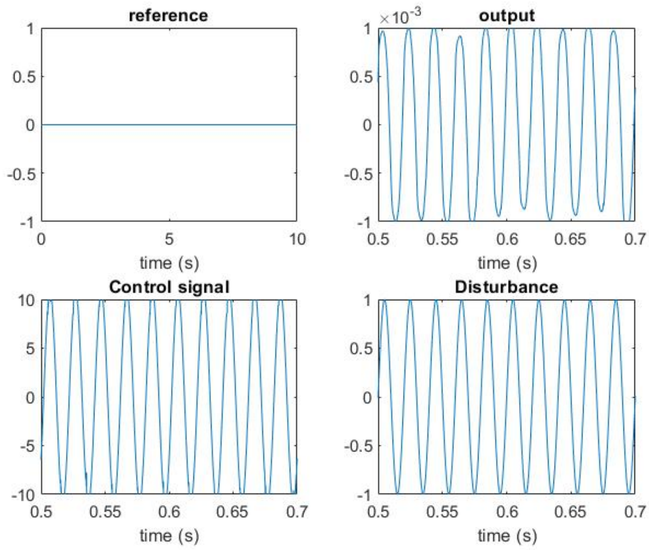

Figure 3: Simulation results with system G_0, using W_S and W_T.

Compare the results to the previous simulation:

When this performance is compared to the Disturbance Rejection Controller, we can see that the amplitude of output has increased by a factor of 2 and also, output is of a sinusoidal form.

Control signal

The weights are

$$W_S(s) = \frac{1}{(s + 0.3 + \sqrt{(100 * \pi)^2 - (0.3)^2})(s + 0.3 - \sqrt{(100 * \pi)^2 - (0.3)^2})}$$
$$W_T(s) = \frac{0.0003}{(s + 2)}$$
$$W_U(s) = \frac{0.55}{(s + 2)}$$

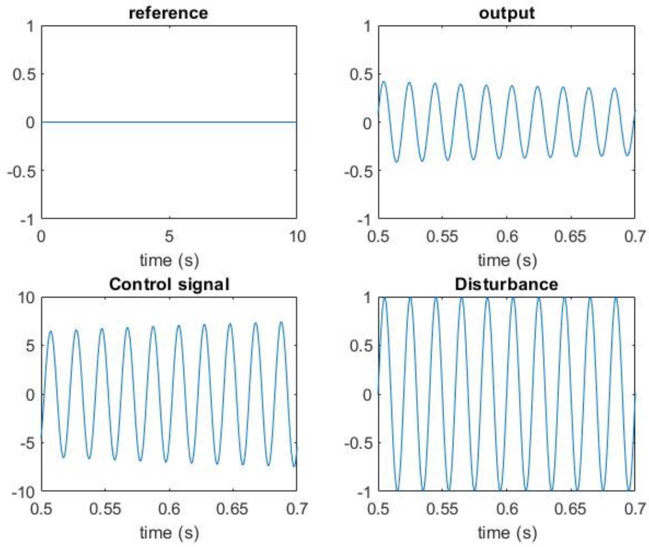

Figure 4: Simulation results with system G_0, using W_S, W_T and W_U.

Compare the results to the previous simulations:

As asked in the problem when we reduced the amplitude to half, we can observe that amplitude of the output has increased almost thousand times i.e. 0.41 as compared to the previous value.