Assignment 1

TTK4210 - Advanced Control of Industrial Processes

Sondre Myrberg
sondrmyr@stud.ntnu.no

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1. Installation of K-Spice

Done, nothing more to report from here.

2.

a. Startup

Startup completed and model loaded.

b. Simulation

The model simulates nicely with a maximum speed at about 400.

c. Graphs and parameters

The inital values of the controller `LIC0001` is shown in Figure 1.

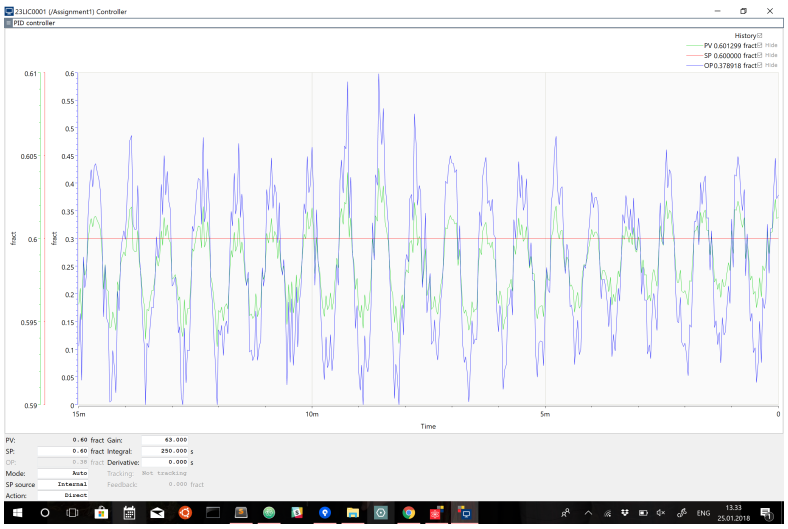

Figure 1: Initial values of the controller `LIC0001`

3. Model survey

The three main control loops for the 3-phase vessel `23VA0001` are the control loops for the two levels of fluid and the final loop for the amount of gas inside the vessel.

4. Model simulation and controller tuning

a.

In the first controller `LIC0001` we observe fast dynamics and aggressive controlling, which could be the result of high gain and integral time, which is quite the opposite from the other controller `LIC0002` which has small gain and short integral time, and corresponding slower dynamics.

b.

When tuning these controllers a general rule of thumb is tuning the controller with the corresponding fastest dynamics first. This will affect the other controller the least. In this case this is the `LIC0001` controller.

c.

Using Skogestad IMC tuning of PID controllers we need to obtain Δu, Δt, Δy, θ and τ_C to get our control parameters K_C and τ_I where K_C is the gain and τ_I is the integral time. This is given as

$$K_C = \frac{1}{k'} \cdot \frac{1}{\theta + \tau_C}$$
$$\tau_I = \min\{\tau_1, 4(\tau_C + \theta)\}$$
$$k' = \frac{\Delta y}{\Delta t \Delta u}$$

Using the model for a step response integrating model we get no τ_1 and therefore $\tau_I = 4(\tau_C + \theta)$. Further we must chose the tuning parameter τ_C. A rule of thumb for this is for 'fast', but more towards oscillating, control we chose $\tau_C = \theta$ and for 'slower', but less robust for disturbance, we chose $\tau_C = 3\theta$. Doing an open loop step response on `LIC0001` we obtain the values

$$\Delta u = 0.1 \qquad \theta = 20$$
$$\Delta y = 0.114 \qquad \Delta t = 1048$$

This yields the following parameters for different τ_C

τ_C	3θ	θ
K_C	11.49	22.98
τ_I	320	160

For the controller `LIC0002` we get the values

τ_C	3θ	θ
K_C	5.99	11.97
τ_I	80	40

The 'fast' controller gets a small oscillation here, but the response with $\tau_C = 3\theta$ gives a fairly good response. All in alle we can conclude that the first controller was too aggressively tuned while the second was too slow.

5. Model Control Language (MCL) and data logging

a.

When not tuning the controllers we get the responses shown in Figure 2, Figure 3, Figure 4 and Figure 5 in Appendix A.

b.

When the controllers are tuned with the paramters from above we get the responses shown in Figure 6, Figure 7, Figure 8 and Figure 9 in Appendix A.

6. Model survey

a.

The component `ASC0001` is an Anti Surge Controller that protects the compressor from surge. This is critical for the compressor to function properly.

b.

The `23HX0001` is a cooler. This component cools the gas that is fed back to the tank in one of the main control loops and the gas that is released. As we need to cool both the air released and the air fed back we place this before the feed back loop, so that we don't need two coolers.

c.

The component `PSV0001` is a safety valve to ensure that the pressure in the vessel isn't getting too high and blows up.

A. Plots

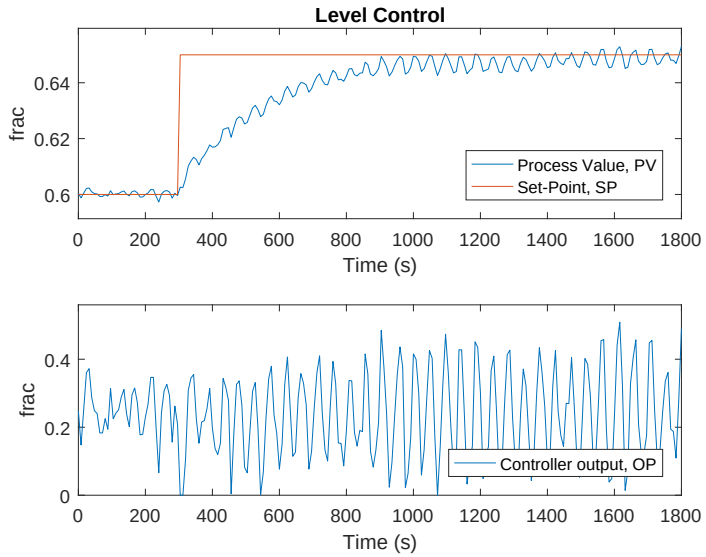

Figure 2: Response in `LIC0001` with step in the controller `LIC0001`

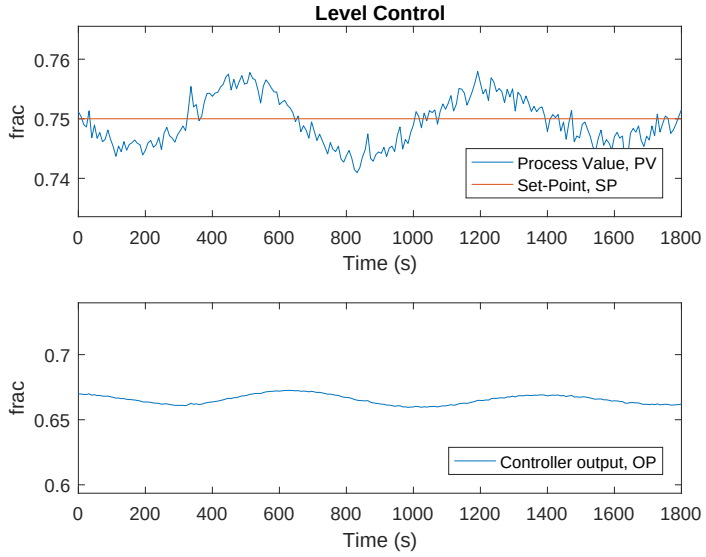

Figure 3: Response in `LIC0002` with step in the controller `LIC0001`

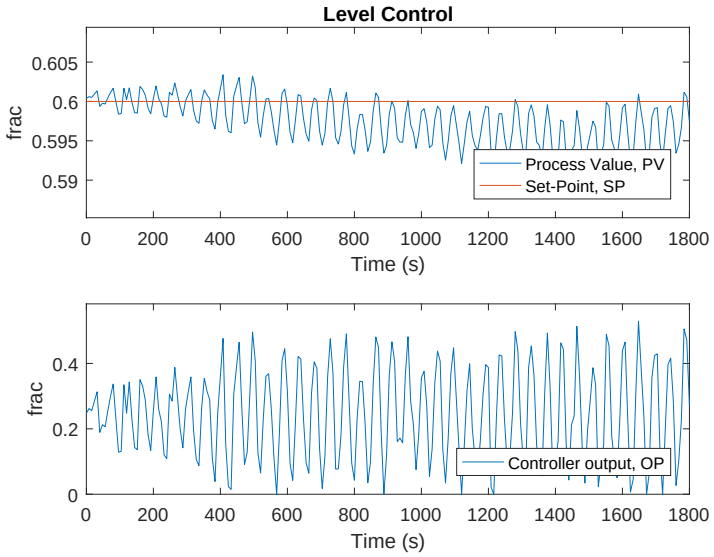

Figure 4: Response in `LIC0001` with step in the controller `LIC0002`

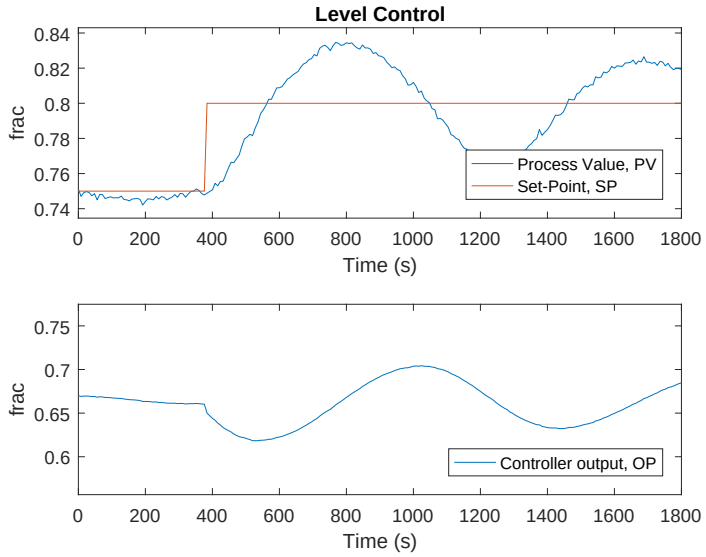

Figure 5: Response in `LIC0002` with step in the controller `LIC0002`

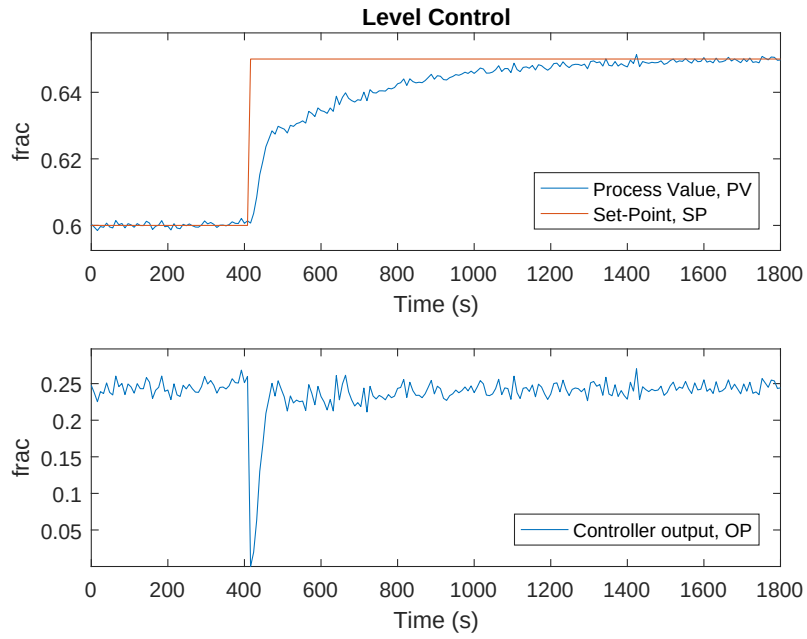

Figure 6: Tuned response in `LIC0001` with step in `LIC0001`

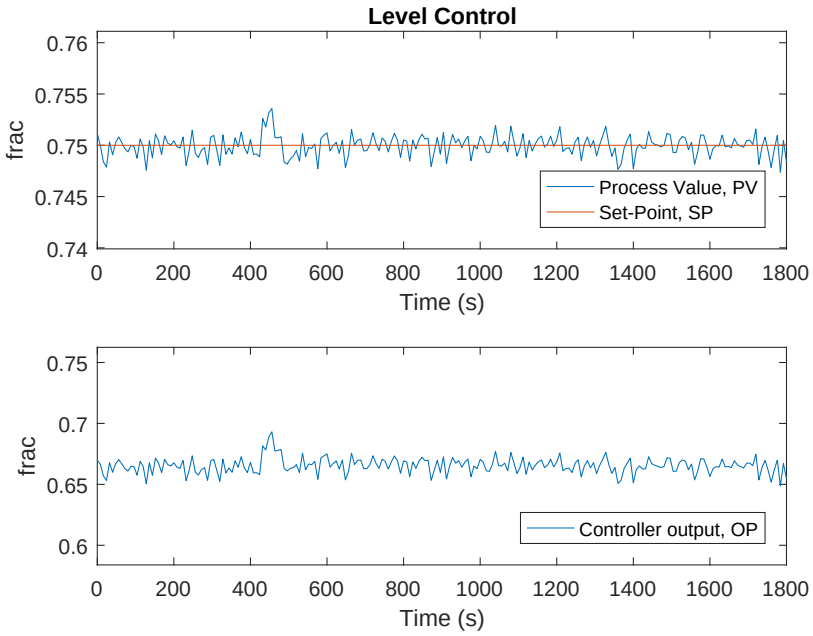

Figure 7: Tuned response in `LIC0002` with step in `LIC0001`

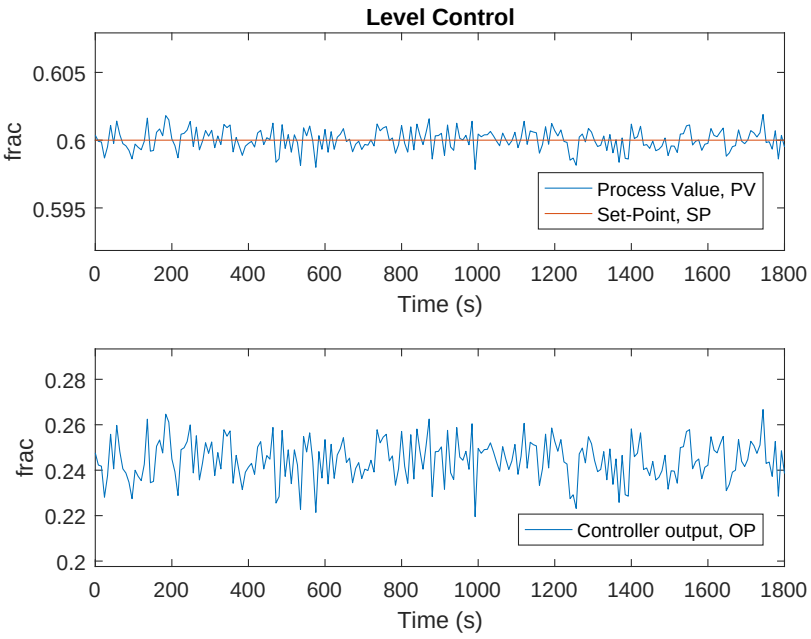

Figure 8: Tuned response in `LIC0001` with step in `LIC0002`

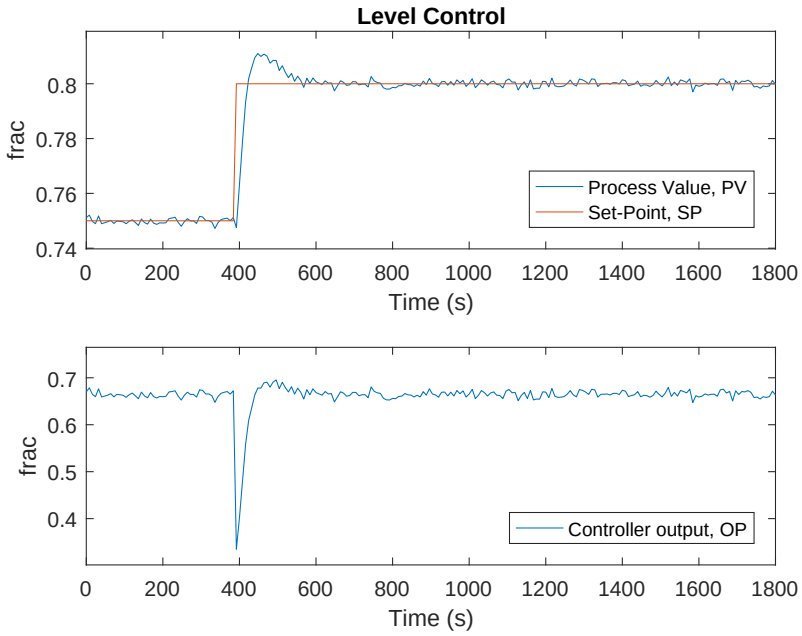

Figure 9: Tuned response in `LIC0002` with step in `LIC0002`