Assignment 2

TTK4210 - Advanced Control of Industrial Processes

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1. Model implementation

The model given by

$$G = \left[\begin{array}{c|c} A & B \\ \hline C & \mathbf{0} \end{array}\right]$$

$$G_d = \left[\begin{array}{c|c} A & B_d \\ \hline C & \mathbf{0} \end{array}\right]$$

with A, B, C and B_d given in the exercise text is implemented as a Simulink subsystem as shown in Figure 1.

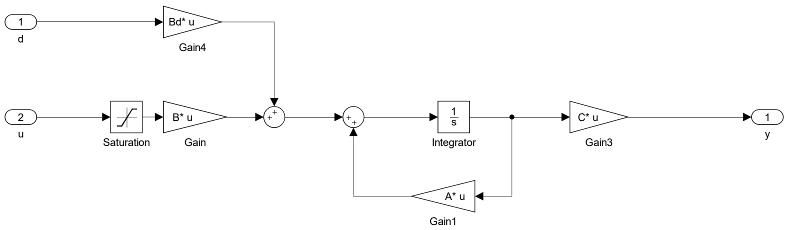

Figure 1: Simulink model of LV-model

2. Controller design

a. PI controller

Firstly we design a PI controller as shown in Figure 2. With K_p and K_i as diagonal matrices this represents two individual control loops. With sqaure pulses as reference and som fast trial and error tuning we get the really bad response shown in Figure 3. This is with saturation in the input signal.

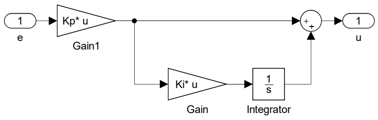

Figure 2: PI controller

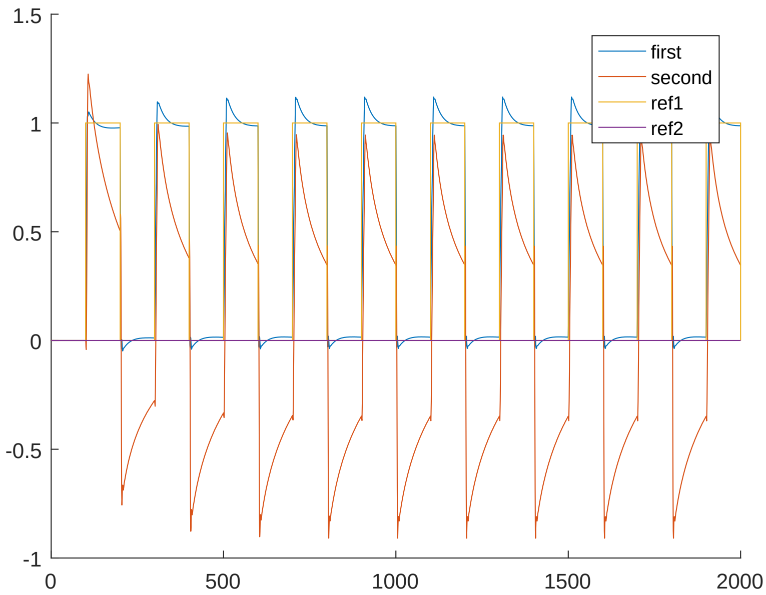

Figure 3: Bad response from a barely tuneid PI controller

b. Dynamic decoupling

For a decoupled controller we use

$$G(s)_{\text{des}} = W(s)G(s)$$
$$\implies W(s) = G^{-1}(s)G(s)_{\text{des}}$$

where $G(s)_{\text{des}}$ is diagonal with the elements from the diagonal of $G(s)$. With the MATLAB code

```
sys = ss(A,B,C,0);
G = tf(sys);
Gdes = blkdiag(G(1,1) , G(2,2));
W = G\Gdes;
decoup = ss(W);
```

we get a state space model with our new decoupled model added as shown in Figure 4.

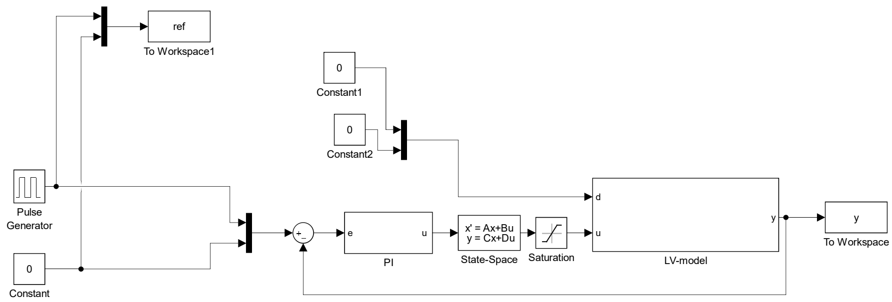

Figure 4: System with decoupled state space model added

Without saturation on the input the system, especially the second output, follows the reference good. This is shown in Figure 5. However when saturation is added we see that are model is wrong as the results are crazy. This is shown in Figure 6.

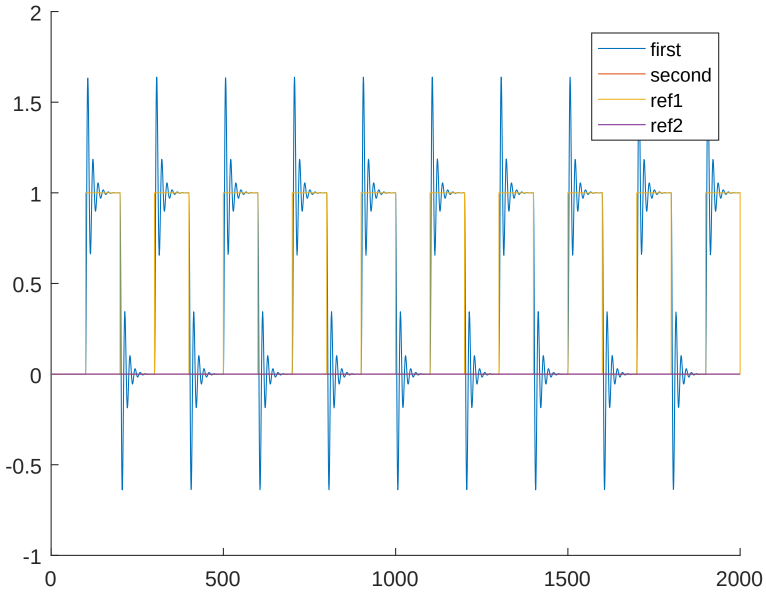

Figure 5: Output of the system with decoupling and without saturation on input

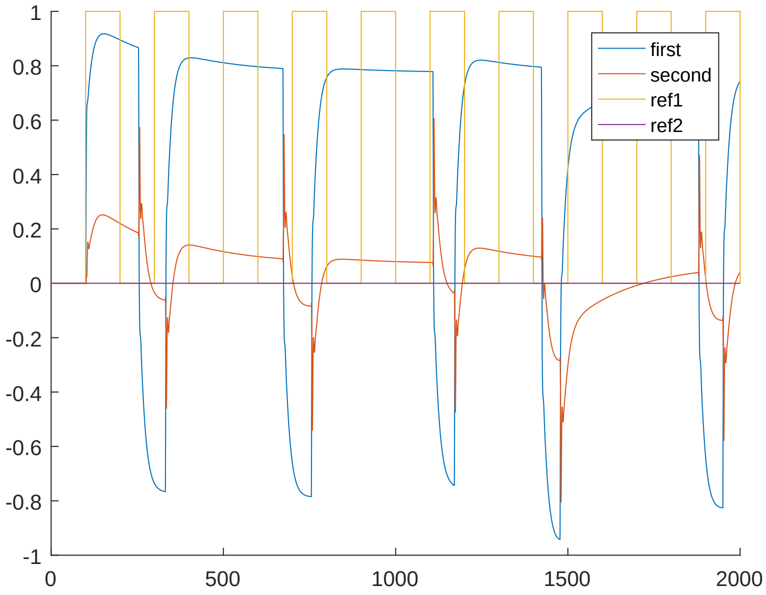

Figure 6: Output of the system with decoupling and saturation on input

c. Kalman filter

With a Kalman filter added as shown in Figure 7 and the MATLAB code

```
[K,S,e] = lqr(A,B,eye(5), eye(2));
```

we get a LQR-controller. Combining this with the PI-controller we could get better results when noise is added to the system, because of the use of state estimatoors instead of noisy measurements.

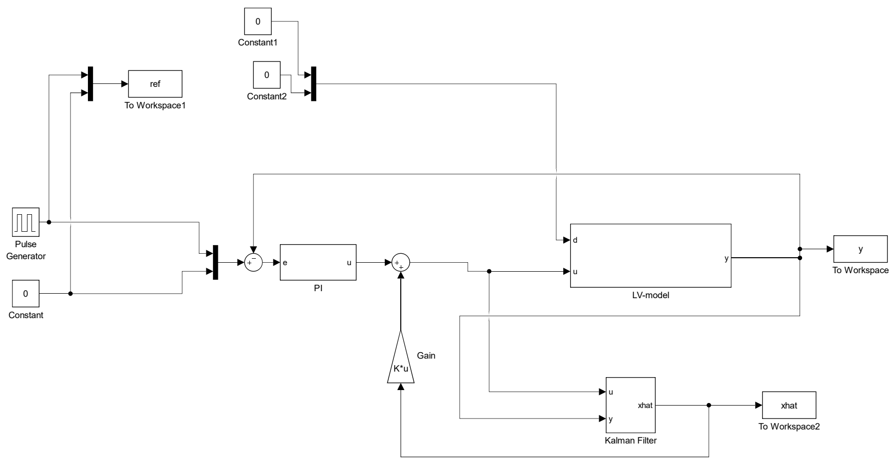

Figure 7: Kalman filter added to PI controller model