TTK4210 Advanced Control of Industrial Processes
Department of Engineering Cybernetics
Norwegian University of Science and Technology
Spring 2018 - Assignment 2
Due date: Wednesday 7 February at 16:00.

Consider a modified version of the detailed LV model for a distillation process of equation (13.19) in Skogestad & Postlethwaite (2^{nd} edition):

```
A   = [ -0.005131  0         0        0        0       ;
        0         -0.07366   0        0        0       ;
        0          0        -0.1829   0        0       ;
        0          0         0       -0.4620   0.9895  ;
        0          0         0       -0.9895  -0.4620  ];
B   = [ -0.629   0.624 ;
         0.055  -0.172 ;
         0.030  -0.108 ;
        -0.186  -0.139 ;
        -1.230  -0.056 ];
C   = [ -0.7223  -0.5170   0.3386  -0.1633   0.1121 ;
        -0.8913  -0.4728   0.9876   0.8425   0.2186 ];
Bd  = [ -0.062  -0.067 ;
         0.131   0.040 ;
         0.022  -0.106 ;
        -0.188   0.027 ;
        -0.045   0.014 ];
```

1. **Model implementation**
   Implement the LV model in Simulink.
   Use `saturation` blocks (found in the `discontinuities` library) of ± 0.5 for the inputs to the LV model. You may use `manual switch` blocks (found in the `signal routing` library) to make it possible to choose if the saturation should be turned on or off for the simulations.

2. **Controller design**
   Design three different controllers for the model:

   (a) A controller based on two PI/PID loops.

   (b) A controller based on dynamic decoupling.

   (c) A controller based on multi-variable controller synthesis (LQG/H_2/H_∞).

   All the controllers should be designed to give zero stationary deviation. The dominating time constant for the closed loop should be around one minute.

   Decoupling is described very briefly in Skogestad & Postlethwaite. See [1] for a more thorough description for 2×2 systems. Decoupling is also described on page **55** of the course notes.

3. **Simulation (with disturbances)**
   Simulate each of the three controllers in Simulink.
   Use the following reference signals:
   $y_{1,ref}$: square pulse, amplitude 1, frequency 0.005 Hz
   $y_{2,ref}$: 0
   Try both small disturbances, and disturbances so large that the inputs are saturated (or alternatively adjust the saturation limits for the inputs) - over a considerable time period. As an example, you may use the following disturbances when the saturation blocks are set to ± 0.5:
   State noise: White noise with variance 0.01
   Measurement noise: White noise with variance 0.02
   Discuss on the results of the simulation. Can you think of a method for improving the performance when inputs are saturated? (You do not have to implement it yet, but you might have some ideas)

References

[1] Harold L. Wade, Inverted decoupling - a neglected technique, ISA Transactions, 36:3-10,1997.