ELEC-E8116 Model-based control systems
/exercises 10

Problem 1. Consider the multivariable plant

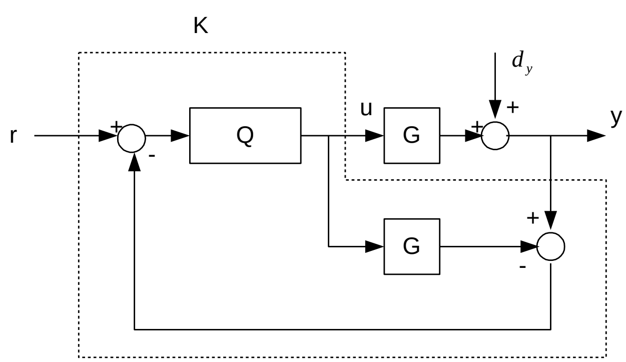
$$G(s) = \frac{1}{(0.2s+1)(s+1)} \begin{bmatrix} 1 & 1 \\ 1+2s & 2 \end{bmatrix}$$

a. Use RGA analysis to evaluate how bad the interconnections between the channels are. Calculate RGA both at zero frequency and the gain crossover frequency. Choose the preferred *pairing* and design *decentralized* PID controllers to control the system. Implement the controller in Matlab/Simulink and plot the responses of the outputs when **a.** a unit step enters the reference of channel 1, **b.** a unit step enters the reference of channel 2 and **c.** unit steps enter at both channels simultaneously. You may use Matlab in implementing the controller and simulating the closed loop, or you can use Simulink if you wish.

b. Design a decoupling controller using the singular value decomposition at zero frequency and choosing the weight matrices W_1 and W_2 accordingly (see Chapter 6 in the lecture slides). Use PID-controllers in the decoupled system. Simulate as in part a.

Hints: Gain crossover of a MIMO system is calculated based on the largest singular value. In tuning the PID controllers you may use the tuning functions in Matlab, see e.g. *pidtune*.

Problem 2: Consider the following IMC-control configuration, in which the process G is assumed stable.



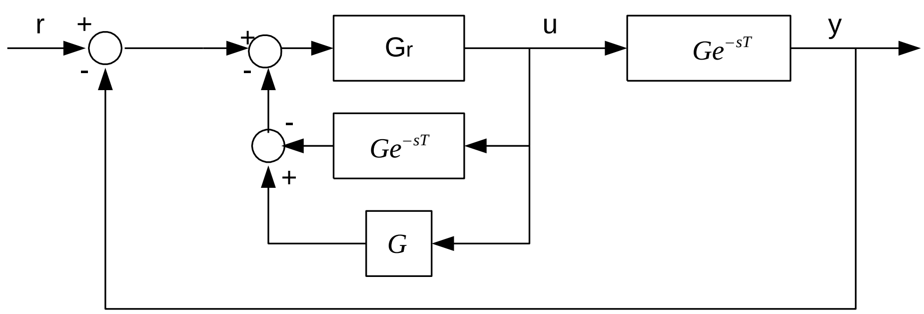
a. Prove that to study the internal stability, the stability of the transfer functions

$$K(I+GK)^{-1} = Q,\ (I+GK)^{-1} = I - GQ,$$
$$(I+KG)^{-1} = I - QG,\ G(I+KG)^{-1} = G(I-QG)$$

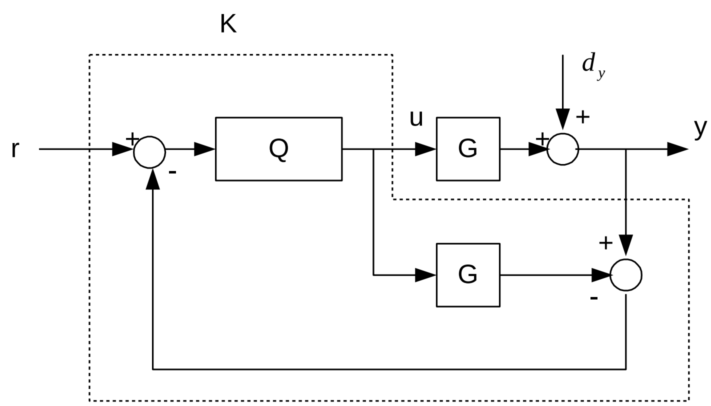
b. must be investigated. Prove that the system is internally unstable, if either Q or G is unstable.

c. Let a stable controller K be given. How can you characterize those processes, which can be stabilized with this controller? (Hint: Change the roles of the controller and process.)

Problem 3. Consider the control configuration shown in the figure (known as the *Smith-predictor*). Calculate the closed loop transfer function and verify the idea behind this controller. Compare to the *IMC*-controller and prove that the Smith predictor always leads to an internally unstable system, if the process is unstable.



Problem 4. Consider the IMC control structure, which is used to control a stable and minimum phase SISO process G.



Note that in addition to the reference r a disturbance signal d_y is modelled to enter at the output of the process. By using the IMC design discussed in the lectures analyse the response to step inputs at r and d_y.