ELEC-E8116 Model-based control systems
exercises 6

Problem 1. Consider a SISO-system in a one-degree-of-freedom control configuration. The connection between the real and nominal system is

$$G_0(s) = G(s)(1 + \Delta_G(s))$$

By using the Nyquist stability criterion derive a condition to the system to be robustly stable.

Problem 2. Consider the first order process

$$G_P(s) = \frac{k}{\tau s + 1} e^{-\theta s}$$

with parameter uncertainties such that $2 \le k, \theta, \tau \le 3$. The system is modelled with

$$G_0(s) = G(s)(1 + \Delta_G(s))$$

in which the nominal model is chosen to be the first order model without delay

$$G(s) = \frac{\bar{k}}{\bar{\tau} s + 1} = \frac{2.5}{2.5s + 1}$$

Discuss possible candidates for the function $\Delta_G(s)$.

Problem 3. Consider the process described in Exercise 5, Problem 1 with the exception that the process model is uncertain. The true system is

$$G_0(s) = G(s)(1 + \Delta_G(s))$$

in which the relative uncertainty has been modeled as

$$\Delta_G(s) = \frac{10s + 0.33}{(10/5.25)s + 1}$$

Is the controlled (closed loop) system robustly stable?

Problem 4. Let a closed-loop SISO-system be stable. Prove that the maximum delay that can be added to the process without causing closed-loop instability is

$$\theta_{\max} = PM / \omega_c$$

where *PM* is the phase margin of the (original) system and ω_c is the gain crossover frequency.