ROBUST CONTROL

Exercise 1 – Classical control / SISO loop-shaping

1. Show that for an open-loop system with:
   - a RHP pole, the closed-loop sensitivity function must have a RHP zero,
   - a RHP zero, the closed-loop complimentary sensitivity function must have a RHP zero.

2. Given a plant model $y = G(s)u + G_d(s)d$ with $|d| < 2$ and:

$$G(s) = \frac{6}{(8s+1)(0.04s+1)^2}, G_d(s) = \frac{4.5}{8s+1}$$

   A. Design a feedback controller, using ideas of loop-shaping of *L* (inverse, P, PI, PID), that satisfies the following objectives:
      a. *Tracking:* rise time < 0.3*s*, overshoot < 2%.
      b. *Rejection of unit step disturbance:* $|y| < 0.1$ at all times, $|y| < 0.01$ after 1.5*s*.
      c. *Input constraints:* $|u| < 3$ at all times.

   B. Design a feedback controller, using H_∞-mixed sensitivity design.

   C. Plot the resulting sensitivity, complementary sensitivity, disturbance sensitivity and loop-gain as functions of frequency, and verify the performance through simulations in the time domain. Also, compute the H_∞-norm of the closed-loop transfer-function from disturbance to output. *Hint: scale the problem and determine the approximate requirements on the closed-loop.*

3. Design an S/KS H_∞ PI – controller for the process:

$$G(s) = \frac{4}{(s-1)(0.02s+1)^2}$$

   with the two performance weights that were given in the course lectures. Plot the response of the closed loop system. Find $\omega_c, M_S, M_T, GM, PM$. (Hint use the minimax solver of MATLAB). Repeat the task by employing the mixsyn solver of MATLAB. What is the structure of the controller? Compare it with the S/KS H_∞ PI – controller.