University of Trento

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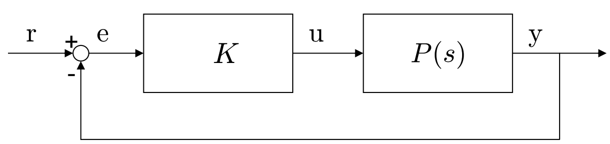
Automatic Control 2

Exercise 1 (10 points)

Consider the system described by the transfer function

$$P(s) = \frac{s^2 + 16s + 15}{(s^2 + \frac{13}{5}s + \frac{1}{4})(s^2 + 360s + 28800)}$$

1. Sketch the asymptotic and real Bode diagrams (magnitude and phase) of $P(s)$.
2. After sketching the Nyquist diagram of $P(s)$, consider the feedback system below



where K is a static feedback controller and $K > 0$. By using the Nyquist criterion, compute the number of unstable poles of the closed loop system as a function of K, and determine for which values of $K > 0$ the closed loop system is stable.

Exercise 2 (10 points)

Consider the transfer function from u to y

$$P(s) = 0.5\frac{s+1}{(s+8)(s+2)^2}$$

Design a dynamic feedback controller $u = -K(s)(y - r)$ satisfying the following specifications:

1. Track a step reference with zero steady-state error
2. Rise time $t_r \leq 0.018$ s
3. Overshoot $\hat{s} \leq 10\%$

Exercise 3 (8 points)

For each of the continuous-time linear systems

$$(a) \quad \begin{cases} \dot{x}_1(t) &= x_1(t) \\ \dot{x}_2(t) &= x_1(t) + x_2(t) \end{cases}$$

$$(b) \quad \begin{cases} \dot{x}_1(t) &= -x_1(t) + x_2(t) \\ \dot{x}_2(t) &= -x_2(t) \end{cases}$$

determine (if possible) a Lyapunov function to prove the origin is a globally asymptotically stable equilibrium point. Hint: exploit the linearity of the systems.

Exercise 4 (3 points)

Describe (in a qualitative way) the four steps of the general procedure for black-box system identification, from experiment design to validation.