University of Trento

Prof. Alberto Bemporad September 10, 2010

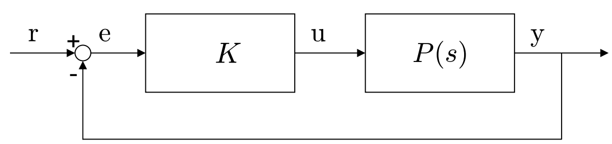
Automatic Control 2

Exercise 1 (10 points)

Consider the system described by the transfer function

$$P(s) = \frac{20s + 20}{(s^2 + 13s + 30)(s^2 + 20s + 25)}$$

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.
   Note: $\angle P(j\omega^*) = -\pi$ for $\omega^* \simeq 17$ rad/s, and $\mathrm{Re}[P(j\omega^*)] \simeq -0.0023$.

Exercise 2 (10 points)

Consider the transfer function from u to y

$$P(s) = \frac{s + 1}{(s + 2)(2s^2 + 2s + 9)}$$

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 $t_r \leq 0.2$ s
3. Overshoot $\hat{s} \leq 10\%$

<u>**Exercise**</u> <u>3</u> (3 points)

1. For the continuous-time system $\dot{x} = -x^5$, determine if the functions $V_a(x) = x^3/3$ and $V_b(x) = x^2/2$ are Lyapunov functions.

2. Find, if possible, a Lyapunov function for the discrete-time system $x(k+1) = -2x(k)$, and motivate your choice.

<u>**Exercise**</u> <u>4</u> (7 points)

1. Define what is the "*receding horizon*" concept used in model predictive control.

2. Describe the windup effect, and briefly describe a possible strategy to counteract it.