University of Trento

Prof. Alberto Bemporad July 19, 2010

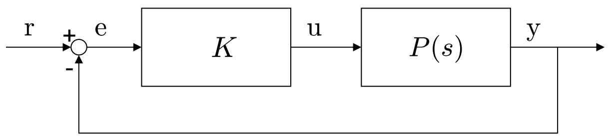
Automatic Control 2

Exercise 1 (10 points)

Consider the system described by the transfer function

$$P(s) = \frac{s^3 + 6s^2 + 12s + 8}{(s^3 + 3s^2 + 3s + 1)(4s^2 + 2s + 1)}$$

- Sketch the asymptotic and real Bode diagrams (magnitude and phase) of $P(s)$.
- 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 internally stable.
Note: The equation $\angle P(j\omega) = -\pi$ has solutions for $\omega^* = 0.78$ rad/s with $\text{Re}[P(jw^*)] = -2.46$.

Exercise 2 (10 points)

For $P(s)$ and the same feedback system depicted above design a dynamic feedback controller $K(s)$ satisfying the following specifications

- Track a step reference $r(t) = c, \forall t > 0$, c is a constant, with finite steady-state error $e_d \leq 0.2$
- Rise time $t_r \leq 2.5$ s
- Resonant peak $M_r \simeq 1.65$ dB

<u>**Exercise** 3</u> (6 points)

Given the discrete-time linear system

$$\begin{aligned} x_1(k+1) &= 0.5x_1(k) \\ x_2(k+1) &= x_1(k) + 0.5x_2(k) \end{aligned}$$

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

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

- For a discrete-time linear system, describe what deadbeat control is, and what is the procedure to design a deadbeat controller.
- Define the concept of 'system identification', and motivate why it is often used in practice. Also define the meaning of the terms 'black box', 'grey box' and 'white box' referred to identification.