Automatic Control, Basic Course

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- Presentation: Control Department and Myself
- Course Overview
- Introduction to Automatic Control
- The PID controller (=Chapter 1)
- Laboration 1

Dept. of Automatic Control at Lund University

- Founded in 1965 by Karl Johan Åström
- Approx. 60 persons and 60 MSEK

Dept. of Automatic Control at Lund University

Basic and advanced control education for almost all engineering disciplines at the Faculty of Engineering ($\approx$ 1000 students/year)

Our research if concentrated on

- Modeling and Control of Complex Systems
- Control and Real-Time Computing
- Process Control
- Robotics
- Automotive Systems
- Biomedical Projects
- Tools.

Bo Bernhardsson

Academia

- LTH - E81, MSc 1986
- PhD in Automatic Control, Lund University, 1992.
- Post-doc at Univ. of Minnesota 1992-93
- Associate Professor etc, Lund University, 1993-1999
- Professor 1999-now, on leave 2001-2010

Industry

- Expert, Ericsson 2001-2010
- Expert area: "Mobile System Design and Optimization"
- 30 granted patents in the area of mobile communications
- 10^9 control loops

The aim of the course is to give knowledge about the **basic principles of feedback control**.

The course will give insight into what can be achieved with control—the possibilities and limitations.

The course focuses on **linear continuous-time systems**.

Course Program

15 Lectures

15 Exercises

3 Mandatory Laborations, sign up for lab1 asap

Literature

Exam

Like More Control Theory?

Follow the parallel course

<p style="text-align:center; color:blue">Control Theory 3hp</p>

First Lecture: Thursday 28/1 at 15.15-17, M:2112 (seminar room)
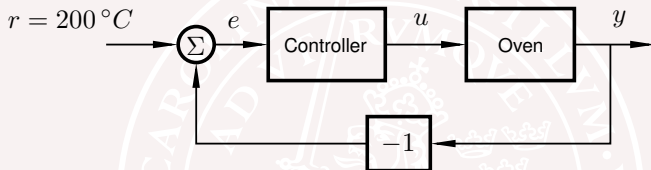
Switch to other presentation

The PID Controller

- The oldest controller type
- The most widely used
  - Pulp & paper industry 86%
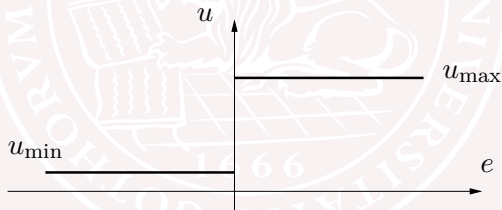 - Steel industry 93%
  - Oil refineries 93%
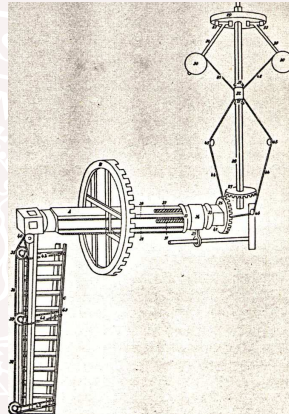
- y – actual temperature
- r – desired temperature
- e – control error
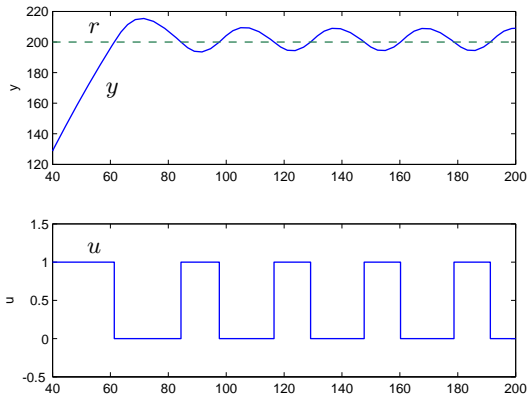- u – heating element power $(0 \leq u \leq 1)$

Control error: $e = r - y$

$$u = \begin{cases} u_{\min}, & e < 0 \\ u_{\max}, & e > 0 \end{cases}$$
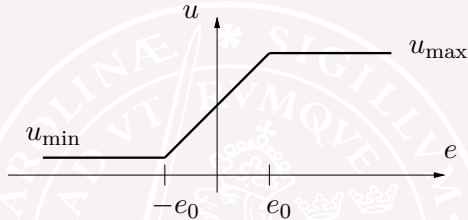
On/Off Control – Oven Example

- Oscillations
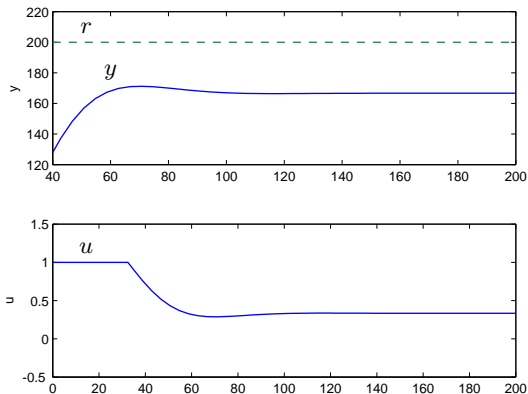
$$u = \begin{cases} u_{\max}, & e > e_0 \\ u_0 + Ke \\ u_{\min}, & e < -e_0 \end{cases}$$

K – proportional gain

u_0 – bias term (often 0)

P Control – Oven Example

- Stationary error

(What is the value of K in the simulation above, $u_0 = 0$?)

Assume the controller works within the proportional band
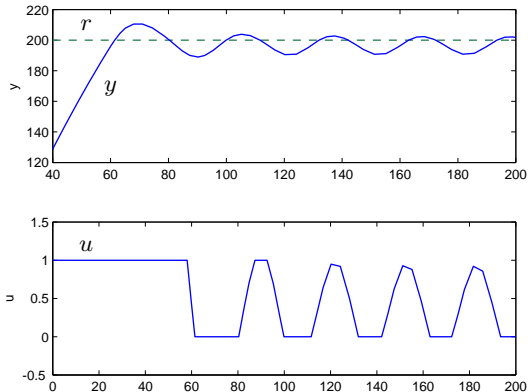$(-e_0 < e < e_0)$. Then

$$e = \frac{u - u_0}{K}$$

Two ways to reduce the stationary control error e:

- Make K larger
- Adjust u_0

P Control – Oven Example

Increased gain K:

- Smaller stationary error
- Larger oscillations

Proportional–Integral Control

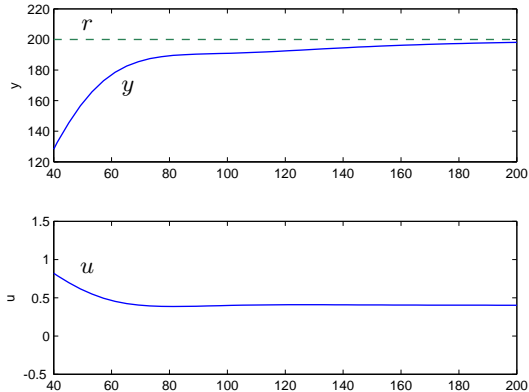Add automatic adjustment of the bias term ("automatic reset")

Keep adjusting the control signal as long as there is an error

PI-controller:

$$u(t) = K\left(e(t) + \frac{1}{T_i}\int_0^t e(s)ds\right)$$

T_i is called "integral time"

- No stationary error
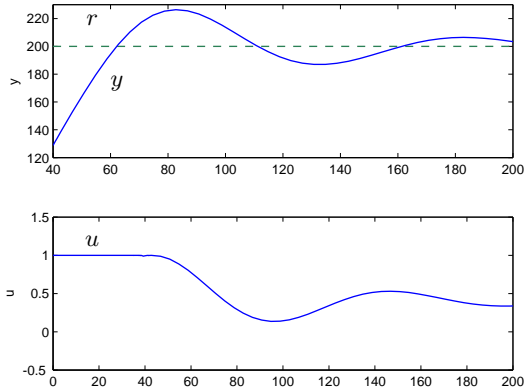
Consider a PI-controller:

$$u(t) \;=\; Ke(t) + K_i \int_0^t e(s)ds$$

Assume that there is an equilibrium with constant $e(t) = e_0$ and $u(t) = u_0$. Then we must have $e_0 = 0$!
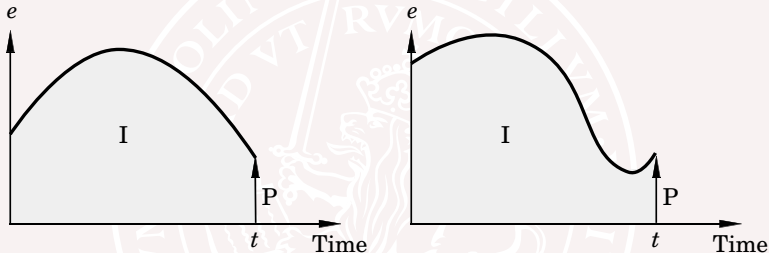
Can you explain this?

PI Control

Smaller integral time T_i (i.e. larger integral action):

- Larger oscillations

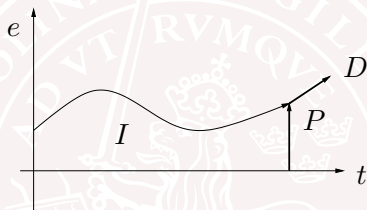A PI controller gives the same control signal in these two cases:

Problematic for processes with inertia, e.g.

- temperature
- position

Add prediction of the control error

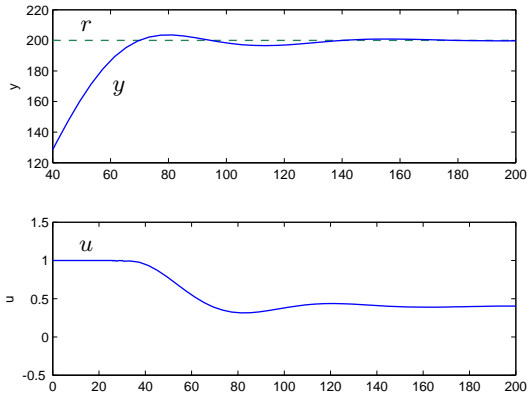PID-controller:

$$u(t) = K\left(e(t) + \frac{1}{T_i}\int_0^t e(s)ds + T_d\frac{de(t)}{dt}\right)$$

T_d – derivative time

- Reduced oscillations

Control of the water level in the upper or lower tank

- Open-loop and closed-loop control
- Manual and automatic control
- Empirical tuning of P, PI and PID controllers

The manuals for Labs 2 and 3 contain **preparatory assignments** that must be solved before the laboratory exercise.

At the start of Lab 2, a **quiz** with two review questions will also be given. You must give correct answers to both questions in order to proceed with the laboratory exercise.

Signup for laboration 1 at home page now.

No written lab report.

- Sign up for Lab1 asap !
- Read course program and get all material
- Read math repetition material if needed
- Read first lecture in [TH]