

RT 122

Fuzzy control: inverted pendulum



Learning objectives/experiments

- design of a fuzzy control for the unstable single-variable system: inverted pendulum (fundamentals from RT 121 are required)
- working with the development software FSH-Shell
- activating of two independent actuators that are coupled via the system
- mastering of non-linearities in the system: inverted pendulum
- mastering of non-linearities in the propeller drive
- optimisation of
 - ▶ fuzzification
 - ▶ rule base
 - ▶ defuzzification with respect to stability
 - ▶ velocity
 - ▶ control quality

Description

- **non-linear, one-dimensional single-variable system with two actuators**
- **inverted pendulum with one input and two outputs**
- **fast, real-time control using microcontroller**
- **implementing fuzzy algorithms**
- **microcontroller-based development process for process control systems**

This experimental unit forms part of a series of teaching systems developed in collaboration with the **Department of Automation and Information Technology at the Harz University of Applied Studies and Research**.

The unstable "inverted pendulum" system acts as a mechanical single-variable system.

The upright position of the pendulum is adjusted by two independent propeller drives and should be achieved quickly and if possible without overshooting. A fuzzy control will be developed and optimised for this purpose.

The inclination of the pendulum is measured by a potentiometer. The sensor supplies a crisp signal to the fuzzy controller, where the signal is transformed into a fuzzy input value and inferred before being transformed back into a crisp output value. This output value controls the actuators, two propeller drives.

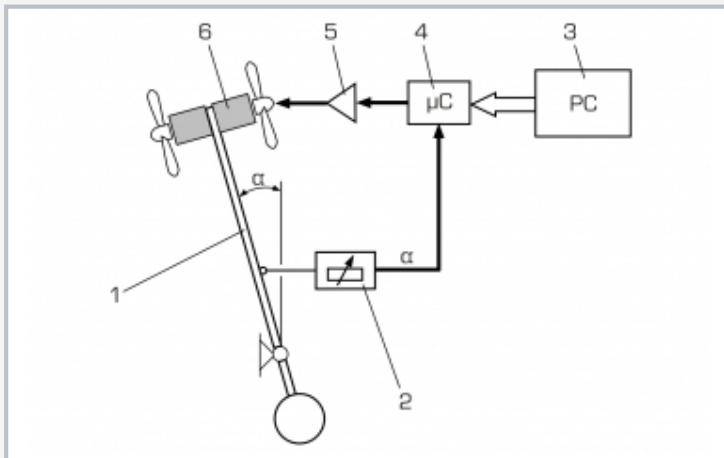
The learning contents of the experimental unit RT 121 are extended by RT 122 that is more complex because of its two independent drives. Conducting the experiment makes high demands on the system optimisation, as the two independent drives have to be tuned.

The control algorithms are initially written and simulated in the user-friendly development software FSH-Shell and then compiled to generate microcontroller code. The control strategy can be optimised at a later date.

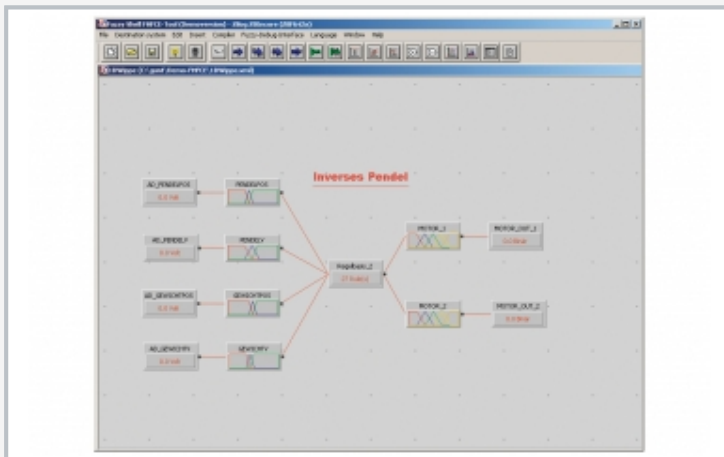
Control algorithms are created, simulated and translated into microcontroller code in the user-friendly developer program.

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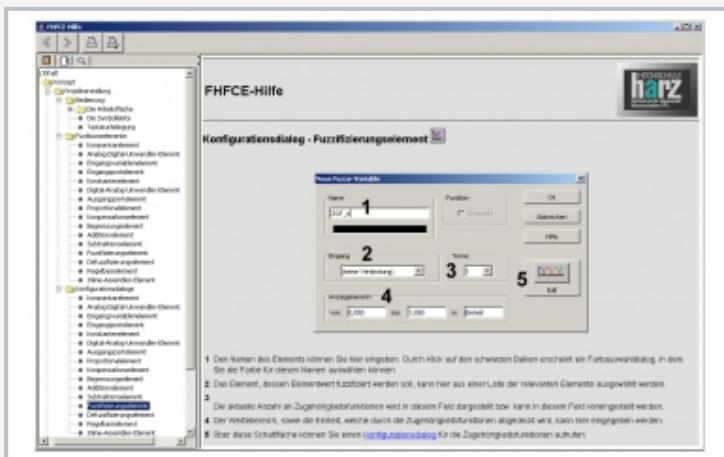
Fuzzy control: inverted pendulum



1 inverted pendulum, 2 pendulum inclination sensor, 3 PC with development software, 4 microcontroller, 5 amplifier, 6 drive motors with propellers



FSH-Shell development software: structure of a fuzzy control



FSH-Shell development software: help function

Specification

- [1] design and optimise fuzzy control systems using microcontroller technology
- [2] inverted pendulum as mechanical single-variable system, SIMO (Single Input – Multiple Outputs)
- [3] 2 independent motors for propeller drive as actuators
- [4] microcontroller with USB port as fuzzy controller
- [5] FSH-Shell development software for designing and optimising the fuzzy controller; software via USB under Windows 7, 8.1, 10
- [6] rotary potentiometer as pendulum inclination sensor
- [7] part of the structured learning concept: level 2a

Technical data

Inverted pendulum

- length: 780mm
- counterweight: 1,89kg

2 drive motors

- 7,2V / 23A

Microcontroller

- 8bit microcontroller Zilog Z8Encore
- 12-fold ADC 8bit

Rotary potentiometer

- resistance value 5kΩ ±20%

230V, 50Hz, 1 phase

230V, 60Hz, 1 phase

120V, 60Hz, 1 phase

UL/CSA optional

LxWxH: 600x520x1200mm (with upright pendulum)

Weight: approx. 36kg

Required for operation

PC with Windows

Scope of delivery

- 1 experimental unit
- 1 FSH-Shell development software + USB cable
- 1 set of instructional material

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Optional accessories

020.30009

WP 300.09

Laboratory trolley