LUND UNIVERSITY

LTH
FACULTY OF ENGINEERING

Course syllabus

Olinjär reglering och servosystem Non-Linear Control and Servo Systems

FRTN05, 7,5 credits, A (Second Cycle)

Valid for: 2023/24
Faculty: Faculty of Engineering, LTH
Decided by: PLED F/Pi
Date of Decision: 2023-04-18

General Information

Elective for: D4, E4-ra, F4, F4-r, M4-me, Pi4-ssr, MMSR2
Language of instruction: The course will be given in English

Aim

The aim of the course is to the learn to recognize nonlinear control problems, to master the most important analysis techniques for nonlinear systems, and the learn how to use practical tools for nonlinear control design.

Learning outcomes

Knowledge and understanding
For a passing grade the student must

- be able to define fundamental control-theoretical stability concepts
- have insight in the basic differences between nonlinear and linear dynamical systems
- be able to linearise nonlinear models around stationarity points and around trajectories
- be able to analyse the influence of common nonlinearities (saturation, backlash, deadzone etc) in control loops and how these should handled from a control point of view
- understand stability analysis including Lyapunov theory, the small-gain theorem, and the circle criterion, and be able to apply it in control design
- be able to give an overview of modern directions in nonlinear control.

Competences and skills
For a passing grade the student must

- be able to derive mathematical models for and simulate simple nonlinear systems
- be able to analyse limit circles both quantitatively and qualitatively
- be able to design controllers for simple nonlinear systems using model-based nonlinear control and relay feedback
- be able to solve simple optimization problems and interpret the solutions in terms of feedforward and feedback structures
- be able to practically apply control design to real nonlinear processes during laboratories
- be able to use computer tools for simulation and analysis of nonlinear systems.

Judgement and approach
For a passing grade the student must

- be able to understand relations and limitations when simple models are used to describe complex dynamical systems
- be able to evaluate dominating nonlinearities and dynamics
- sbow ability for teamwork and collaboration in groups during laboratory exercises

Contents

The course describes how non-linear systems can be treated through analysis, simulation and controller design.

Laboratory exercises: Analysis using the describing function and control design with dead-zone compensation for an air throttle used in car motors;
Energy-based design of a swing-up algorithm for an inverted pendulum;
Trajectory generation using optimal control for the pendulum-on-a-cart process.

Lectures: Non-linear phenomena. Mathematical modelling of nonlinear systems, Stationary points, Linearisation around stationary points and trajectories, Phase plane analysis. Stability analysis using Lyapunov methods, circle criterion, small-gain and passivity. Computer tools for simulation and analysis, Effects of saturation, backlash and dead-zones in control loops, Descring functions for analysis of limit cycles, High-gain methods and relay feedback, Optimal control, Nonlinear synthesis and design.

Examination details

Grading scale: TH - (U,3,4,5) - (Fail, Three, Four, Five)
Assessment: Written exam (5 hours), three laboratory exercises. In the case of less than 5 registered students, the retake exams may be given in oral form.

The examiner, in consultation with Disability Support Services, may deviate from the regular form of examination in order to provide a permanently disabled student with a form of examination equivalent to that of a student without a disability.

Parts
Code: 0114. **Name:** Examination.
Credits: 6. **Grading scale:** TH. **Assessment:** Passed exam
Code: 0214. **Name:** Laboratory Work 1.
Credits: 0,5. **Grading scale:** UG. **Assessment:** Preparation exercises and approved participation in the laboratory
Code: 0314. **Name:** Laboratory Work 2.
Credits: 0,5. **Grading scale:** UG. **Assessment:** Preparation exercises and approved participation in the laboratory
Code: 0414. **Name:** Laboratory Work 3.

Credits: 0,5. **Grading scale:** UG. **Assessment:** Preparation exercises and approved participation in the laboratory

Admission

Assumed prior knowledge: FRTF05 Automatic Control, Basic Course.
The number of participants is limited to: No
The course overlaps following course/s: FRT075

Reading list

- Will be decided at the latest one month before the course start. Will be announced on the course home page: http://www.control.lth.se/course/FRTN05/.

Contact and other information

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Course homepage: http://www.control.lth.se/course/FRTN05