Dynamics and motion control

Course specification, spring 2012, period 3

Course number: MF2007

Credits: 9 hp

Course coordinator: Bengt Eriksson, 08-7906390, benke@md.kth.se

Introduction

The course gives insight in mechatronic control system design. The focus is on modelling, design and prototyping of control systems for mechatronic applications. The course integrates previous knowledge primarily from courses in mechanics, mathematics, automatic control, electrical and software engineering. After the course you will be able to specify, model, design, partly implement and analyse control systems typical for mechatronic products, using professional computer based tools.

Course aim

At the end of the course, you should be able to:

1. Specify overall performance requirements for a motion control system.
2. Derive dynamic models of typical mechatronic applications.
3. Find good parameters of dynamic models using experimental methods.
4. Analyse the dynamic behaviour of derived models in both frequency and time domain.
5. Design model based feedback and model following control, i.e., servo control, both in continuous and discrete time.
6. Simulate application and control system models in continuous and discrete time for the purpose of verification, performance analysis and further devlopment
7. Design and structure the controller software for microprocessor implementation.
8. Understand implementation restrictions due to sensor and actuator limitations and microprocessor resources such as computing speed and fixed vs. floating point arithmetic.

Course overview

The course includes lectures to provide overview and inspiration, exercise band laboratory work in which the participants work on a set of exercises (modelling, simulation, design and experiments) to be carried in small groups but to a large extent without direct supervision. The experiments are modularized, and results from each module should be shown to an assistant in the lab for control on a regular basis. Two separate workshops will be carried out, they should result in written reports to be handed in. An important part of the exercises is to learn and use modern computer-based control engineering tools for modelling, simulation and rapid prototyping of control applications.

Prerequisites

The course builds upon knowledge and experiences as provided by the Intermediate thesis project in Mechatronics, MF106X, MF107X or MF109X(4F1822).
The course also requires knowledge and experience corresponding to basic courses in control theory (e.g. Automatic Control, Basic Course, EL1000 (2E1200), programming Applied Programming and Computer Science, Part 1, 4 credits, DD1322 (2D1322) and DD1324 Applied Programming and Computer Science, Part 2, 2 credits) and electronics.

Follow-up

Recommended follow-up courses are MF2044, Embedded Control System II, 6hp. Mechatronics advanced course, 18 hp.

Examination requirements

- (1) Completed exercises.
- (2) Two written workshop reports, A and B.
- (3) Written exam.
- Grading: A-F according to ECTS based on a weighted combination of the bullets 2 and 3 above.

Notes on the Workshops:

i) the workshops must be handed in latest, on the last day of the sheduled period, i.e., last day of the written exams week.

ii) if the worksops are not handed in in time, they will not be corrected and graded until the next sheduled written exam.

iii) if handed in workshops are graded with an E or higher, is it not possible to hand in the workshops at a later sheduled time to get a higher grading.

Literature and course material

The litterature will be handed out on the lectures. Most of the course material, essentially everything except for the literature extracts, is made available from the course web page.

- *This document* which defines and gives an overall description of the course.
- Janscheck Klaus ***Mechatronic system design***, Springer. (Selected chapters).
  (Available on-line via KTH library.
- Wittenmark, B., Åström, K-J., Årzén, K-E. ***Computer Control: An overview***, IFAC Professional Brief.
  (Available on-line via http://www.ifac-control.org/).
- Glad, T., Ljung, L. ***Reglerteknik – Grundläggande teori***, Studentlitteratur (not included).
  (Or similar basic engineering text on automatic control).
- *Lecture notes*.
- *The exercise specification* which includes a set of exercise modules.

- *The workshop specification*, and information about how the project should be carried out and reported.
- *Tool descriptions and tutorials* for the control design, simulation and prototyping part of the project.

Course implementation

The course consists of the following important pieces.

- A set of two-hour lectures that cover the most central part of the course and serve as an essential foundation for the exercises and experiments to be carried out.
- Modelling, control and implementration exercises according to the *Exercise specification.* Each week there are two three-hour scheduled slots for hands-on exercise work in the course laboratory. There are a number exercise modules where results from each module should be checked with one of the assistants in th lab. **Note**: An important idea behind the course is that exercises and experiments should be solved as far as possible within the student groups, i.e training in real problem solving without involvement of teachers or assistants. This may involve substantial struggling in which the teamwork is essential. *Don't give up*, you learn a lot more from finding the solution on your own than from asking the lecturer for it. *Also don't forget to consult the course material when you get stuck!*
- Control design and implementation workshops. In the workshops you will carry out development of a control system involving the steps of modelling of the process to be controlled; verification of the model against the real process; and analysis and control design. The workshop descriptions will be handed out seperatly.
- One very important aspect of the course is that of structured system development. You will be developing a number of system models and designs, and you will be using a number of tools. You will save time if you think about saving and storing the different models appropriately. Storing earlier versions makes it easier to go back to a version where it "worked"!

Exercise and laboratory facilities used

- **Course laboratory** includes a number of dedicated PC's equipped with Matlab/Simulink, and dSPACE rapid control prototyping software/hardware, together with drive units and mechanical processes. These PC's are used for modelling, identification, simulation, design and rapid prototyping.
  NOTE! Since the number of stations is limited, booking lists will be used.
- All analysis, control design and simulation work can be performed on any computer having Matlab, Simulink and Control System Toolbox installed. KTH has a site license for this software.

Course evaluation and feedback

Feedback from course participants is very important (as is feedback in most control systems) for us to be able to improve the course. Feedback is encouraged and welcome both during and at the end of the course when a questionnaire for course evaluation will be distributed.