AUTOMATIC CONTROL, BASIC COURSE (FRT010)

Course Syllabus, Fall 2013

Higher education credits: 7.5 ECTS (one eighth of a year of full-time studies). **Grading scale:** Fail, 3, 4, 5. **Level:** G2 (Secondary basic level). **Language of instruction:** English. **Course coordinator:** Associate Professor Charlotta Johnsson, lotta@control.lth.se, and Dr. Anna Lindholm, anna@control.lth.se, Department of Automatic Control, Lund University, Sweden. **Recommended prerequisites:** Calculus in One Variable, Calculus in Several Variables, Linear Algebra, Linear Systems or Systems and Transforms. **Assessment:** Written exam, three laboratory exercises. **Further information:** The course is given at Zhejiang University in Hangzhou, China. **Home page:**

`http://www.control.lth.se/Education/EngineeringProgram/FRT010_China.html`

Aim

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 mainly covers linear continuous-time systems.

Knowledge and understanding

For a passing grade the student must

- be able to define the fundamental concepts of control.
- be able to linearize nonlinear dynamical models.
- be able to compute the relations between dynamical models in the form of transient responses, transfer functions, differential equations on state-space form, and frequency responses described with Bode or Nyquist diagrams.
- be able to analyze dynamical systems with respect to stability, robustness, stationary characteristics, controllability, and observability.
- be able to implement controllers using discretization of analog controllers.

Skills and abilities

For a passing grade the student must

- be able to design controllers from given specifications on robustness and performance based on models on state-space form, transfer function form, Bode diagrams or Nyquist diagrams.
- be able to design controllers based on cascade connections, feedforward, and delay compensation.
- be able to evaluate controllers by analysing transient and frequency responses, and via laboratory experiments on real processes.

Judgement and approach

For a passing grade the student must

- understand relationships and limitations when simplified models are used to describe complex dynamical systems.
- show ability for teamwork and collaboration at laboratory exercises.

Lectures and Problem Solving Sessions

Charlotta Johnsson gives the first two lectures, Karl-Erik Årzén gives the following two lectures, and Anna Lindholm gives the remaining seven lectures. Yang Xu leads the first four problem solving sessions, and Olof Sörnmo leads the remaining seven sessions. The lectures and the problem solving sessions are given in Building 7, room 102, 204 or 304.

Nr	Date	Time	Room	Topics
L1	Oct 28	18:30-20:55	7:102	Introduction. The PID controller. State-space models
L2	Oct 29	18:30-20:55	7:204	Linearization. Transfer functions. Transient response.
E1	Oct 30	19:20-20:55	7:204	Process models. Linearization.
E2	Oct 31	19:20-20:55	7:204	System representations. Block diagrams. Step response.
L3	Nov 6	15:55-18:20	7:204	Second-order systems. Frequency response. Review of process models
E3	Nov 6	19:20-20:55	7:204	Frequency response. Bode & Nyquist diagrams. Step response.
L4	Nov 7	15:55-18:20	7:204	Feedback. Stability. Stationary errors.
E4	Nov 7	19:20-20:55	7:204	Lab 2 preparations. Stability. Root locus.
L5	Nov 14	15:55-18:20	7:304	The Nyquist criterion. Stability margins. Sensitivity.
E5	Nov 14	19:20-20:55	7:304	The Nyquist criterion. Stability margins.
L6	Nov 20	15:55-18:20	7:304	State feedback. Controllability. Integral action.
E6	Nov 20	19:20-20:55	7:304	Sensitivity. Stationary errors. Controllability.
L7	Nov 21	15:55-18:20	7:304	Observability. Kalman filtering. Output feedback.
E7	Nov 21	19:20-20:55	7:304	State feedback. Observability.
L8	Nov 27	15:55-18:20	7:304	Lead-lag compensation. Frequency analysis of PID.
E8	Nov 27	19:20-20:55	7:304	Kalman filtering. Lead-lag filtering.
L9	Nov 28	15:55-18:20	7:304	More on PID. Controller structures.
E9	Nov 28	19:20-20:55	7:304	PID analysis and tuning.
L10	Dec 4	15:55-18:20	7:304	Sampling and discretization. Course review.
E10	Dec 4	19:20-20:55	7:304	Controller structures. Synthesis.
L11	Dec 5	15:55-18:20	7:304	Extra.
E11	Dec 5	19:20-20:55	7:304	Old exam.

Each lecture has a separate chapter in the lecture notes by Tore Hägglund, see 'Literature'.

Laboratory exercises

The course contains three mandatory laboratory exercises (4 hours each). The sessions are held in Educational Building no. 10, room 3101.

Lab 1	Nov 4–Nov 8	Empirical PID control.
Lab 2	Nov 18–Nov 22	Model construction and calculation of PID controller.
Lab 3	Nov 25–Nov 29	State feedback and Kalman filtering.

You will work in groups of two or three students. You should ideally work in mixed Swedish/Chinese groups.

The manuals for Labs 2 and 3 contain preparatory exercises that must be solved before the laboratory exercise. At the start of Lab 2, a quiz with two review questions are given. You must give correct answers to both questions in order to proceed with the laboratory exercise. Signup-sheets for the laboratory exercises will be circulated at the lectures.

Yang Xu is responsible for the first lab exercise, and Olof Sörnmo is responsible for the last two lab exercises.

Literature

The course is based on the following compendiums:

- Tore Hägglund: *Automatic Control, Basic Course – Lecture Notes.* Department of Automatic Control, Lund University, 2012.
- *Automatic Control, Basic Course – Collection of Exercises.* Department of Automatic Control, Lund University, 2012.
- *Automatic Control, Basic Course – Laboratory Manuals.* Department of Automatic Control, Lund University, 2012.
- *Automatic Control, Basic Course – Collection of Formulae.* Department of Automatic Control, Lund University, 2012.

As reference textbook, we recommend

- Karl Johan Åström & Richard Murray: *Feedback Systems: An Introduction to Scientists and Engineers.* Princeton University Press, 2008. The newest version of the book can be downloaded for free at

  `http://www.cds.caltech.edu/~murray/amwiki`

Examination

The below information applies to students from LTH, taking the course. Examination of students from Zhejiang University is directed by Zhejiang University.

The mandatory parts of the course are

- the three laboratory exercises,
- the written exam.

The final grade is based only on the result from the written exam.

The exam is given Saturday, December 7. The time and location of the exam will be announced later. You may bring the collection of formulae and a pocket calculator (without any control software) to the exam.

In case of absence or failure it is possible to write any of the FRT010 re-exams at LTH.

Recommended Exercise Problems

S = Solved at exercise session. H = Recommended to be solved at home.

E1	S:	1.1a, 1.3abc, 1.5
	H:	1.7, 1.8
E2	S:	2.1ab, 2.4ab, 2.11ab, 2.12, 2.9
	H:	2.5ab, 2.6, 2.11cd
E3	S:	3.3bd, 3.4b, 3.5, 4.1
	H:	3.1, 3.2, 3.3ac, 3.6
E4	S:	Lab 2 preparatory exercises 3.1 and 3.5; 5.1, 5.2, 5.5, 5.8
	H:	7.3, 7.4, 5.3a, 5.4
E5	S:	5.13, 5.10, 5.11, 5.14
	H:	5.7
E6	S:	4.2, 4.4, 4.6, 4.7, 6.4, 6.5
	H:	4.3, 4.5, 6.1a
E7	S:	9.2, 9.5, 6.3
	H:	9.4, 6.1b
E8	S:	9.6, 9.3, 8.1, 8.2, 8.3, 8.4
	H:	9.10, 8.5, 8.6
E9	S:	7.5, 7.2, 7.6, 7.7
	H:	7.8, 7.10
E10	S:	10.1, 10.6, 10.9, 10.10, 11.1
	H:	10.2, 10.5, 10.7, 11.2
E11	S:	Old exam (to be distributed later)

Contact Information

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