AUTOMATIC CONTROL, BASIC COURSE (FRT010)

Course Syllabus, Fall 2015

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:** Martina Maggio and Kristian Soltesz, 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

Martina Maggio gives lectures L1-L6, Kristian Soltesz gives lectures L7-L11. Yang Xu leads the problem solving sessions E1-E11. The room codes are to be read “building:room”.

Nr	Date	Time	Room	Topics
L1	Nov 2 (Mon)	18:30-20:55	7:304	Introduction. The PID Controller. State-space Models.
L2	Nov 3 (Tue)	15:55-17:30	7:304	Linearization. Transfer Function. Block diagram representation. Transient Response.
E1	Nov 3 (Tue)	18:30-20:55	7:304	Process models. Linearization.
L3	Nov 4 (Wed)	15:55-17:30	7:304	Step response analysis. Frequency Response. Relation between Model Descriptions..
E2	Nov 9 (Mon)	18:30-20:55	7:304	System representations. Block diagrams. Step response. Linearization.
E3	Nov 10 (Tue)	15:55-17:30	7:304	Frequency response. Bode & Nyquist diagrams. Step response.
L4	Nov 10 (Tue)	18:30-20:55	7:304	Feedback–An Example. Stability. Stationary errors.
E4	Nov 11 (Wed)	15:55-17:30	7:304	Lab 2 preparations. Stability. Root locus.
		Course pause Nov 12 - Nov 16.		
L5	Nov 17 (Tue)	15:55-17:30	7:202	The Nyquist Criterion. Stability Margins. Sensitivity.
E5	Nov 17 (Tue)	18:30-20:55	7:304	The Nyquist criterion. Stability margins.
L6	Nov 18 (Wed)	15:55-17;30	7:202	State Feedback. Controllability. Integral Action.
E6	Nov 18 (Wed)	18:30-20:55	7:304	Sensitivity. Stationary errors. Controllability.
L7	Nov 24 (Tue)	15:55-17:30	7:202	Observability. Kalman Filtering. Output Feedback. Pole/Zero cancellation.
E7	Nov 25 (Wed)	15:55-17:30	7:202	State feedback. Observability.
L8	Dec 1 (Tue)	15:55-17:30	7:202	Lead-lag Compensation. Frequency Analysis of PID.
	Dec 1 (Tue)	18:30-20:55	7:304	Extra “catch-up” exercise session.
E8	Dec 2 (Wed)	15:55-17:30	7:202	Kalman filtering. Lead-lag filtering.
L9	Dec 8 (Tue)	15:55-17:30	7:202	More on PID. Controller structures.
E9	Dec 8 (Tue)	18:30-20:55	7:304	PID analysis and tuning.
L10	Dec 9 (Wed)	15:55-17:30	7:202	Sampling and Discretization. A Control Example.
E10	Dec 9 (Wed)	18:30-20:55	7:304	Controller structures. Synthesis.
L11	Dec 15 (Tue)	15:55-17:30	7:202	Course Review.
	Dec 15 (Tue)	18:30-20:55	7:304	Extra “catch-up” exercise session.
E11	Dec 16 (Wed)	15:55-17:30	7:202	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). Each exercise will be given at two occasions. It is mandatory to sign up for one occasion per exercise through the course homepage. The room codes are to be read “building:room”.

Nr	Date	Time	Room	Topics
Lab 1	Nov 9 (Mon)	08:30-12:30	10:3101	Empirical PID control.
	Nov 10 (Tue)	08:30-12:30	10:3101	
Lab 2	Nov 18 (Wed)	08:30-12:30	10:3101	Model construction and calculation of PID controller.
	Nov 19 (Thu)	08:30-12:30	10:3101	
Lab 3	Dec 10 (Thu)	08:30-12:30	10:3101	State feedback and Kalman filtering.
	Nov 11 (Fri)	08:30-12:30	10:3101	

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. Sign-up lists for the laboratory exercises will be available on the course web page.

Yang Xu is responsible for the 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, 2014.
- *Automatic Control, Basic Course – Collection of Exercises.* Department of Automatic Control, Lund University, 2014.
- *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 on December 17. 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:	1.1, 1.2, 1.7
	H:	1.5a-c, 1.6, 1.9
E2	S:	2.1, 2.14ab, 2.15,
	H:	2.2ab, 2.16ab
E3	S:	2.5, 2.9, 2.11, 2.13, 3.1, 3.2, 3.4bd, 3.5b, 3.7
	H:	2.6, 3.4ac, 3.5a, 3.6
E4	S:	4.1, Preparatory exercises 3.1 and 3.5 in Lab 2, 4.9, 4.11, 4.2, 4.6, 4.4
	H:	6.3, 6.4, 4.3, 4.5
E5	S:	4.13, 4.15, 4.17, 4.18, 4.7
	H:	4.12, 4.14, 4.19
E6	S:	5.5, 5.8, 5.10, 5.11
	H:	5.2, 5.6
E7	S:	5.3, 5.12, 5.9
	H:	5.13
E8	S:	6.11, 6.12, 6.13, 6.14, 6.5, 6.2
	H:	6.15
E9	S:	6.7, 6.8, 7.1, 7.6, 7.8, 7.9
	H:	6.6, 6.9, 7.2, 7.5
E10	S:	8.1
	H:	8.2
E11	S:	Old exams

Contact Information

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