AUTOMATIC CONTROL, BASIC COURSE (FRTF05)

Course Syllabus, Fall 2018

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: Anders Robertsson, Dep. 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 Beihang University (BUAA) in Beijing, China.
Home page:

`www.control.lth.se/education/engineering-program/automatic-control-basic-course-china/`

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

Lectures are given by Anders Robertsson (L1-6), Martina Maggio (L7-10) and Charlotta Johnsson (course review). Exercise sessions and labs are given by Johan Ruuskanen (E1-6), Albin Heimerson (E7-10) and Marcus Greiff (E11/Exam). All lectures and exercises are given in Main Building, Room 203.

Nr	Week	Date	Time	Topics
L1	45	Nov 6 (Tue)	14:00-15:35	Introduction. The PID Controller. State-space Models.
L2		Nov 7 (Wed)	14:00-15:35	Linearization. Transfer Function. Block diagram representation. Transient Response.
E1		Nov 7 (Wed)	15:50-17:25	Process models. Linearization.
L3		Nov 8 (Thu)	14:00-15:35	Step response analysis. Frequency Response. Relation between Model Descriptions.
E2	46	13 Nov (Tue)	14:00-15:35	System representations. Block diagrams. Step response. Linearization.
F3/E3		Nov 14 (Wed)	14:00-15:35	Frequency response. Bode & Nyquist diagrams. Step response.
L4		Nov 14 (Wed)	15:50-17:25	Feedback–An Example. Stability. Stationary errors.
E4		Nov 15 (Thu)	14:00-15:35	Lab 2 preparations. Stability. Root locus.
L5	47	Nov 20 (Tue)	14:00-15:35	The Nyquist Criterion. Stability Margins. Sensitivity.
E5		Nov 21 (Wed)	14:00-15:35	The Nyquist criterion. Stability margins.
L6		Nov 21 (Wed)	15:50-17:25	State Feedback. Controllability. Integral Action.
E6		Nov 22 (Thu)	14:00-15:35	Sensitivity. Stationary errors. Controllability.
L7	48	Nov 27 (Tue)	14:00-15:35	Observability. Kalman Filtering. Output Feedback. Pole/Zero cancellation.
E7		Nov 28 (Wed)	14:00-15:35	State feedback. Observability.
L8		Nov 28 (Wed)	15:50-17:25	Lead-lag Compensation. Frequency Analysis of PID.
L9		Dec 29 (Thu)	14:00-15:35	More on PID. Controller structures.
E8	49	Dec 4 (Tue)	14:00-15:35	Lead-lag filtering.
L10		Dec 5 (Wed)	14:00-15:35	Sampling and Discretization. A Control Example.
E9		Dec 5 (Wed)	15:50-17:25	PID analysis and tuning.
E10		Dec 6 (Thu)	14:00-15:35	Controller structures. Synthesis.
L11	50	Dec 11 (Tue)	14:00-15:35	Course review.
E11		Dec 12 (Wed)	14:00-15:35	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 (3h15min each). Each laboratory exercise will be given at two occasions. It is mandatory to sign up for one occasion per exercise through the course homepage. Labs 1-3 are given in F-532, New Main Building.

Nr	**Date**	**Time**	**Topics**	**Responsible**
Lab 1	Nov 13 (Tue)	19:00-22:15	Empirical PID control.	Johan Ruuskanen
	Nov 15 (Thu)	19:00-22:15		
Lab 2	Nov 27 (Tue)	19:00-22:15	Modeling and calculation	Albin Heimerson
	Nov 29 (Thu)	19:00-22:15	of PID controller.	
Lab 3	Dec 4 (Tue)	19:00-22:15	State feedback	Albin Heimerson
	Dec 6 (Thu)	19:00-22:15	and Kalman filtering.	

You will work in groups of two or three students. For the labs 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.

Literature

The course is based on the following compendiums:

- Tore Hägglund: *Automatic Control, Basic Course – Lecture Notes.* Department of Automatic Control, Lund University, 2018.
- *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. Second edition (2016) is available for free download at:

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

Examination

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 on Tuesday December 18 (week 51), 13:00-18:00, in room F102 (New Main Building).

You may bring the collection of formulae[1] and a pocket calculator (without any control software) to the exam.

In case of absence or failure it is possible for LTH students to write any of the FRTF05 re-exams at LTH. For non-LTH students, there will be no re-take exam. LTH students are primarily referred to the ordinary exam occasion in Lund: Wednesday January 9, 2019, 08:00-13:00, Vic:1 and Vic:2. Remember to sign up for the exam according to the standard procedure at LTH.

The corrected exams will be available for inspection at the Department of Automatic Control in Lund. Inspection date will be announced online.

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

[1] clean, no own notes

Contact Information

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