AUTOMATIC CONTROL, BASIC COURSE (FRT010)

Course Syllabus, Fall 2011

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:** Anton Cervin, anton@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.

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 linearise 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 analyse dynamical systems with respect to stability, robustness, stationary characteristics, controllability, and observabilility.
- 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

Anton Cervin gives the first three lectures, and Erik Johannesson gives the remaining eight lectures. Daria Madjidian leads the first six problem solving sessions, and Anna Lindholm leads the remaining five sessions.

Nr	Date	Time	Room	Topics	Reading
L1	Oct 27	18:30-20:55	7:604	Introduction. PID control. State space models. Linearization	TH 1.1–2.2
E1	Oct 28	13:15-14:50	7:604	Process models. Linearization	
L2	Oct 31	13:15-15:40	7:604	Transfer functions. Block diagrams. Transient response	TH 2.3–3.3
E2	Nov 1	13:15-15:40	7:604	System representations. Block diagrams. Step response	
L3	Nov 3	18:30-20:55	7:604	Frequency response. Bode & Nyquist diagrams. Feedback systems	TH 4.1–5.1
E3	Nov 4	13:15-14:50	7:604	Frequency response. Bode & Nyquist diagrams. Step response	
L4	Nov 14	18:30-20:55	7:602	Stability. The Nyquist criterion. Stability margins	TH 5.2–6.2
E4	Nov 15	13:15-15:40	7:602	Lab 2 preparations. Stability. Root locus	
L5	Nov 17	18:30-20:55	7:602	Sensitivity. Stationary errors	TH 7
E5	Nov 18	13:15-15:40	7:602	The Nyquist criterion. Stability margins	
L6	Nov 21	18:30-20:55	7:602	State feedback. Controllability. Observability	TH 8.1–9.2
E6	Nov 22	13:15-15:40	7:602	Sensitivity. Stationary errors. Controllability	
L7	Nov 24	18:30-20:55	7:602	Kalman filtering. Output feedback. Pole-zero cancellation	TH 9.3–10.2
E7	Nov 25	13:15-15:40	7:602	State feedback. Observability	
L8	Nov 28	18:30-20:55	7:602	Lead-lag compensation. PID analysis and tuning	TH 11.1–12.2
E8	Nov 29	13:15-15:40	7:602	Kalman filtering. Lead-lag filtering	
L9	Dec 1	18:30-20:55	7:602	Set-point handling. Practical modifications. Controller structures. Implementation	TH 12.3–13
E9	Dec 2	13:15-15:40	7:602	PID analysis and tuning	
L10	Dec 5	18:30-20:55	7:602	Synthesis example. Course review	TH 14
E10	Dec 6	13:15-15:40	7:602	Controller structures. Synthesis	
L11	Dec 8	18:30-20:55	7:602	Extra	
E11	Dec 9	13:15-15:40	7:602	Old exam	

The reading references are to the lecture notes by Tore Hägglund, see below.

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 2–Nov 5	Empirical PID control.
Lab 2	Nov 19–Nov 23	Model construction and calculation of PID controller.
Lab 3	Dec 3–Dec 7	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.

Daria Madjidian is responsible for the first two lab exercises, and Anna Lindholm is responsible for the last lab exercise.

Literature

The course is based on the following compendiums:

- Tore Hägglund: *Automatic Control, Basic Course – Lecture Notes.* Department of Automatic Control, Lund University, 2011.
- *Automatic Control, Basic Course – Collection of Exercises.* Department of Automatic Control, Lund University, 2010.
- *Automatic Control, Basic Course – Laboratory Manuals.* Department of Automatic Control, Lund University, 2006.
- *Automatic Control, Basic Course – Collection of Formulae.* Department of Automatic Control, Lund University, 2011.

As reference textbook, we recommend

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

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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