FRTN10 Multivariable Control, fall 2016

Administration

Course responsible is Anton Cervin (anton@control.lth.se, 046-222 44 75, M:5145). Course administrator is Mika Nishimura (mika@control.lth.se, 046-222 87 85, M:5141). Their offices are on the 5th floor of the M building.

Prerequisites

FRT010 Automatic Control, Basic Course or FRTN25 Automatic Process Control is required prior knowledge. It is assumed that you have taken the basic courses in mathematics, including linear algebra and calculus in several variables, and preferably also systems & transforms or linear systems.

Course material

All course material is available in English. Most lectures are covered by the following textbook sold by KFS AB:

Torkel Glad and Lennart Ljung (2003), *Reglerteori — Flervariabla och olinjära metoder* (2 uppl.), Studentlitteratur, ISBN 9789144030036.
English edition: Torkel Glad and Lennart Ljung (2000), *Control Theory — Multivariable and Nonlinear Methods*, CRC Press/Taylor & Francis, ISBN 9780748408788.

Lecture slides, lecture notes, excercise problems, and laboratory assignments are provided on the **course homepage**: `http://www.control.lth.se/course/FRTN10`

Lectures

The lectures (30 hours in total) are given by Anton Cervin on Mondays (w. 35–39, 41), Tuesdays (w. 35–36), and Thursdays (w. 35–41). See the LTH schedule generator for details.

Exercise sessions

The exercise sessions (28 hours in total) are arranged in three groups (free choice):

Group	*Times*	*Room*	*Teaching assistant*
1	Wed 10–12, Fri 8–10	Lab A	Marcus T. Andrén (marcus@control.lth.se)
2	Wed 13–15, Fri 10–12	Lab A	Josefin Berner (josefinb@control.lth.se)
3	Wed 15–17, Fri 13–15	Lab A	Olof Troeng (oloft@control.lth.se)

The sessions are held in the course lab of Automatic Control LTH, located on the ground floor in the south-west part of the Mechanical Engineering building.

Laboratory experiments

The three laboratory sessions (12 hours in total) are mandatory. Booking lists are posted on the course homepage. You must sign up before the first session starts. Before each lab session there are preparatory assignments that must be completed. No reports are required after the labs.

Lab	*Weeks*	*Booking opens*	*Room*	*Responsible*	*Process*
1	37–38	Aug 30	Lab C	Olof Troeng	Flexible servo
2	39–40	Sep 13	Lab C	Josefin Berner	Quadruple tank
3	41–42	Sep 27	Lab B	Marcus T. Andrén	Rotating crane

Exam

The exam is given on October 25 at 08:00–13:00. A second occasion is on January 3, 2017. The textbook, lecture notes, and lecture slides (with markings/notes) are allowed on the exam. You may also bring an *Automatic Control—Collection of Formulae*, standard mathematical tables (TEFYMA), and a pocket calculator.

Weekly plan, fall 2016

Week	*Date*		*Content*	*Relevant book sections*
35	Aug 29	**L1:**	**Introduction**	secs 1.1-1.5
	Aug 30	**L2:**	**Stability and robustness**	secs 1.6, 2.1–2.5, 3.1, 3.4, 3.5
	Aug 31	E1:	Control in Matlab	
	Sep 1	**L3:**	**Disturbance models**	secs 5.1–5.6, 6.1–6.3
	Sep 2	E2:	System representations and stability	
36	Sep 5	**L4:**	**Control synthesis in frequency domain**	secs 6.4–6.6 8.1–8.2
	Sep 6	**L5:**	**Case study**	
	Sep 7	E3:	Disturbance models and robustness	
	Sep 8	**L6:**	**Multivariable zeros, singular values, controllability/observability**	secs 3.2–3.3, 3.5–3.6
	Sep 9	E4:	Loop shaping, preparations for Lab 1	
37	Sep 12	**L7:**	**Fundamental limitations**	secs 7.2–7.9
	Sep 14	E5:	Multivariable zeros, singular values and controllability/observability	
	Sep 15	**L8:**	**Decentralized control**	secs 8.3, 8.5
	Sep 16	E6:	Fundamental limitations	
37–38	*LAB SESSION 1: Loop shaping for flexible servo*			
38	Sep 19	**L9:**	**Linear-quadratic optimal control**	secs 5.7 and 9.1–9.4
	Sep 21	E7:	Controller structures, preparations for Lab 2	
	Sep 22	**L10:**	**Optimal observer-based feedback**	same as L9
	Sep 23	E8:	Linear-quadratic optimal control	
39	Sep 26	**L11:**	**More on LQG**	sec 10.2
	Sep 28	E9:	Kalman filtering, LQG	
	Sep 29	**L12:**	**Youla parametrization, dead-time compensation**	sec 8.4
	Sep 30	E10:	LQG, preparations for Lab 3	
39–40	*LAB SESSION 2: Decentralized control of quadruple tank*			
40	Oct 5	E11:	Youla parametrization, dead-time compensation	
	Oct 6	**L13:**	**Synthesis by convex optimization**	handout
	Oct 7	E12:	Synthesis by convex optimization.	
41	Oct 10	**L14:**	**Controller simplification**	sec 3.6
	Oct 12	E13:	Controller simplification	
	Oct 13	**L15:**	**Overview of the course**	
	Oct 14	E14:	Old exam	
41–42	*LAB SESSION 3: LQG control of rotating crane*			
43	Oct 25		EXAM	