MECH528/EECE508
Multivariable Feedback Control
Syllabus

Summer semester, 2016/17. Hours: TuTh 2-3:30pm. Location: FSC-1613

Instructor Information

Instructor	Email	Office Location & Hours
Dr. Ryozo Nagamune	nagamune@mech.ubc.ca	Kaiser 3104, by appointment

General Information

Course Description and Goals

This course is an introduction to the analysis and design of linear multivariable feedback control. The main goal of this course is to provide students with modern robust control techniques which are immediately applicable to complex engineering problems. Topics covered in the course are fundamental limitations of feedback control, concepts of uncertain systems and robustness, representations of uncertain systems and feedback loops in terms of linear fractional transformations, various analysis and synthesis techniques for uncertain control systems, and model reduction. For robust control system analysis and synthesis, a unified approach based on linear matrix inequalities is exclusively utilized. Students will learn how to formulate multivariable robust control problems, and how to solve it by using Matlab Robust Control Toolbox plus convex optimization software. Practical control examples in mechanical and electrical engineering will be given to illustrate the usefulness of multivariable robust control.

By the end of the course, we expect that students will be able to:

- Formulate multivariable control analysis and synthesis problems.
- Express uncertain models with parametric and dynamic uncertainties in terms of linear fractional transformations.
- Understand fundamental limitations of feedback systems caused by unstable poles, non-minimum phase zeros, and time-delay.
- Understand the concept and the importance of robustness in feedback systems.
- Analyze robust stability and robust performance of uncertain systems.
- Design optimal robust controllers with various techniques, such as H2, H-infinity, loop-shaping, and μ-synthesis.
- Understand the numerical efficiency of linear matrix inequalities (LMIs).
- Use MATLAB Robust Control Toolbox to analyze, design, and implement uncertain control systems.

Required Textbooks

None. Lecture notes and slides will be provided.

Optional Textbooks

Multivariable Feedback Control – Analysis and Design (2nd Edition): Wiley, 2005, Sigurd Skogestad and Ian Postlethwaite

Control Thoery – Multivariable and Nonlinear Methods: Taylor & Francis, 2000, T. Glad and L. Ljung

Essentials in Robust Control: Prentice Hall, 1998, K. Zhou

Robust Control Design with MATLAB: Springer, 2005, D.-W. Gu, P. Hr. Petkov and M. M. Konstantinov

Course Schedule

Week	Topic	Homework
1-2	Introduction, Well-posedness & Internal stability of feedback systems	HW1
3	Performance limitations of feedback systems, Uncertainty descriptions	HW2
4-5	LFT representations, Robust stability and robust performance	HW3, 4
6	Model reduction, Linear matrix inequalities	HW5
7-8	H-infinity control, multi-objective control	HW6, 7, 8
9-10	μ-analysis and synthesis, H-infinity gain scheduling	HW9, 10
11-12	Applications, Summary, Project presentation	

Additional Information and Resources

Project

Each student is required to formulate a realistic control problem (preferably related to his/her own research, or otherwise we can help), to do analysis and design for the problem using the course material, to analyze the designed controller in simulation (and in implementation if possible), to give a seminar, and to submit a report. The project should show the usefulness and/or the limitation of multivariable (robust) control theory.

Grading Scheme (Tentative. The instructor reserves the right to change the scheme.)

Homework 70%, Project 30%

Academic Integrity

The academic enterprise is founded on honesty, civility, and integrity. As members of this enterprise, all students are expected to know, understand, and follow the codes of conduct regarding academic integrity. At the most basic level, this means submitting only original work done by you and acknowledging all sources of information or ideas and attributing them to others as required. This also means you should not cheat, copy, or mislead others about what is your work. Violations of academic integrity (i.e., misconduct) lead to the breakdown of the academic enterprise, and therefore serious consequences arise and harsh sanctions are imposed. For example, incidences of plagiarism or cheating may result in a mark of zero on the assignment or exam and more serious consequences may apply if the matter is referred to the President's Advisory Committee on Student Discipline. Careful records are kept in order to monitor and prevent recurrences. Link to the relevant Calendar section: http://www.calendar.ubc.ca/vancouver/index.cfm?tree=3,286,0,0