George Mason University
School of Information Technology and Engineering
Department of Electrical and Computer Engineering

ECE 429 **Control Systems Laboratory** **FALL 2003**

http://ece.gmu.edu/~gbeale/ece_429/syl_429_f03.html

PREREQUISITES: ECE 421 or POI.

HONOR CODE POLICY:

All students are expected to abide by the George Mason University Honor Code. Although students will work in teams to carry out the experiments, each student is required to submit his/her own lab report. Lab reports MUST be done individually. It is an honor code violation to submit another person's work as your own OR to allow your work to be submitted as another person's work. Any reasonable suspicion of an honor violation will be reported.

INTRODUCTION:

The faculty supervisor for this course is Dr. Beale, Room 257, Science and Technology II, 993-1596. The Graduate Teaching Assistant for the course will be responsible for providing assistance to the students during the lab and during his/her office hours. The GTA will also be responsible for all grading in the lab, and will set standards for the grading. The weighting of the various experiments will be based on the number of weeks assigned to the experiments.

In addition to the list of reference texts in the Bibliography at the end of the syllabus, students are referred to the various examples and design procedures available on Dr. Beale's website at:

http://ece.gmu.edu/~gbeale/ece_421/examples_421.html.

OBJECTIVES:

The objective of this laboratory is to enable the students to strengthen their understanding of the design and analysis of control systems through practical exercises. This will be accomplished by using modern software resources to analyze and simulate the performance of realistic system models and to design control systems to satisfy various performance specifications.

OVERVIEW:

The control systems laboratory consists of three separate units. Each unit consists of several experiments. Unit A involves compensator design for a system involving time-domain specifications, uncertainty, and nonlinearities. Unit B involves the design and implementation of control systems using actual hardware. Unit C involves compensator design for a system using frequency-domain specifications for a non-minimum-phase system.

Students in the lab will be divided into groups of 2-3 students each. Students will document each experiment with a description of their procedures, results of their analysis or design, and plots as appropriate. The reports for the various experiments within a particular set will be turned in to the GTA at one time when the set is completed.

Unit A – 4 weeks:

The transfer function which is to be used in this set of experiments represents the relationship between the heading angle of a ship and the angle of the rudder used for controlling heading. A compensator will be designed for the nominal linear system model, and the performance of the closed-loop system will be evaluated. Following that, nonlinearities and changes to the ship model will be introduced, and their effects on performance and stability will be investigated. Simulation of the system will be done in SIMULINK.

Unit B – 6 weeks:

This set of experiments is intended to introduce students to the design of control systems for more realistic applications, and to interface their control designs with actual hardware. Control design will be done in MATLAB on a PC, and the designs will then downloaded to the dedicated control processor. The hardware to be controlled consists of a multi-inertia mechanical rotational system. Students are able to see the effects of different control designs on the responses of an actual system, the effects of hardware limits, and the effects of implementing control designs on a computer.

Unit C – 3 weeks:

The plant transfer function has a right-half-plane (non-minimum-phase) zero. Design specifications are given in the frequency domain. A compensator must be designed so that all specifications are satisfied. The closed-loop system will be evaluated from several perspectives. Characteristics in the closed-loop system's step response related to the non-minimum-phase zero will be identified and discussed.

Last Day to Drop without Dean's Permission: Friday, September 26
No class on Tuesday, October 14, due to **COLUMBUS DAY BREAK!!!**

Bibliography

[1] J.J. D'Azzo and C.H. Houpis, *Linear Control System Analysis and Design*, McGraw-Hill, New York, 4th edition, 1995.

[2] Richard C. Dorf and Robert H. Bishop, *Modern Control Systems*, Addison-Wesley, Reading, MA, 7th edition, 1995.

[3] G.F. Franklin, J.D. Powell, and A. Emami-Naeini, *Feedback Control of Dynamic Systems*, Addison-Wesley, Reading, MA, 3rd edition, 1994.

[4] Graham C. Goodwin, Stefan F. Graebe, and Mario E. Salgado, *Control System Design*, Prentice Hall, Upper Saddle River, NJ, 2001.

[5] Benjamin C. Kuo, *Automatic Controls Systems*, Prentice Hall, Englewood Cliffs, NJ, 7th edition, 1995.

[6] Norman S. Nise, *Control Systems Engineering*, John Wiley & Sons, New York, 3rd edition, 2000.

[7] Katsuhiko Ogata, *Modern Control Engineering*, Prentice Hall, Upper Saddle River, NJ, 4th edition, 2002.

[8] C.L. Phillips and R.D. Harbor, *Feedback Control Systems*, Prentice Hall, Upper Saddle River, NJ, 4th edition, 2000.

[9] G.J. Thaler, *Automatic Control Systems*, West, St. Paul, MN, 1989.

[10] John Van de Vegte, *Feedback Control Systems*, Prentice Hall, Englewood Cliffs, NJ, 3rd edition, 1994.

[11] William A. Wolovich, *Automatic Control Systems*, Holt, Rinehart, and Winston, Fort Worth, TX, 3rd edition, 1994.