ECE 3510: Introduction to Feedback Systems

Credits and Contact Hours: 4.0 Credit Hours
15 weeks: Three 50-minute lectures + one 3-hour lab per week

Instructor’s Name: Arn Stolp

Text Book(s) and/or Required Material:
- M. Bodson, Introduction to Feedback Systems, course notes available in the University of Utah Bookstore

Catalog Description: Laplace transforms, boundedness and convergence of signals. Transfer functions, stability, steady-state and transient responses, effect of initial conditions, state-space representations. Feedforward and feedback control, steady-state error and integral control, Routh-Hurwitz criterion, root-locus method, application to phase-locked loops. Bode plots, Nyquist criterion, gain and phase margins. The z-transform and the analysis of discrete-time signals and systems. Sampled-data systems, conversions between continuous-time and discrete-time systems. It is recommended that you take ECE 3500 before enrolling in this course.

Prerequisites:
- C- or better in ECE 2240: Introduction to Electric Circuits; and
- Full major status in Computer Engineering

Designation: Selected Elective

Contribution of Course to Meeting the Requirements of ABET Criterion 5: This course teaches electrical engineering science and electrical engineering design.

Specific Outcomes of Instruction: In this course, students will be prepared to:
1. Get an overview of classical linear feedback and control systems.
2. Review and learn how to use Laplace transforms and the frequency-domain to understand and predict time-domain responses.
3. Learn of state-space method and advantages.
4. Find transfer functions that describe electrical and mechanical systems.
5. Determine good vs bad system characteristics.
6. Make and interpret root-locus plots as well as several other techniques.
7. Use these methods to design feedback system compensation.
8. Learn real-world applications and methods including circuitry to implement designs, PID tuning, and even a little PLC ladder-logic.
9. Learn to use Bode and Nyquist plots with feedback systems. Finding transfer functions from frequency response data. Gain, phase and delay margins.
10. Conduct experiments including some design elements. Take, analyze and interpret real data.

Relationship of the Course to the Program Outcomes:
(a) An ability to apply knowledge of mathematics, science, and engineering. Students apply fundamental concepts learned earlier, including Frequency-domain analysis and Laplace transforms, circuit theory to derive models of circuits, and complex analysis. Students apply
this background and material learned in the course especially when solving homework problems.

(b) An ability to design and conduct experiments, to analyze and interpret data, and to debug and analyze software. Several labs require that data be taken on control systems, electric motors and on phase-locked loop circuits. Most labs require that data be collected, interpreted, and presented in an engineering notebook.

(c) An ability to design a system, component, process or software package to meet desired needs. Most labs require that control systems be designed to achieve specified transient response characteristics. Better control of systems and power use will result in beneficial increases in productivity and less waste, helping to create more sustainable systems for all.

(d) An ability to function on multidisciplinary teams. Students work in teams for the labs. Students are required to attend a Mechanical Engineering event to see control systems used by ME's and to consider becoming involved with ME projects.

(e) An ability to identify, formulate, and solve engineering problems. In some of the labs, the students must identify problems encountered and develop solutions for them.

(g) An ability to communicate effectively in written and oral form. The results of the labs are submitted in written form.

(i) A recognition of the need for, and an ability to engage in life-long learning. Some time is spent in class to discuss other classes and subjects in both Electrical and Mechanical Engineering which build upon the concepts learned in this class.

(j) A knowledge of contemporary issues. Class discussion often relates material from this class to contemporary real-world devices and systems.

(k) An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice. In the first three labs, students use PCs and D-Space for real-time data acquisition and control. They must also modify, compile and execute some C code. In the phase-locked loop labs, students use digital oscilloscopes and function generators and build circuits. Students also use the MATLAB software package extensively in the labs and somewhat in homework. They create step response plots, root-locus plots, Bode plots and Nyquist diagrams. They also interpret these plots and take data directly from the plots and displays. The last three labs include the discretization and simulation of continuous-time systems.

Topics Covered in the Course:

- **Continuous-time signals**: Definition and properties of the Laplace transform. Inversion using partial fraction expansions. Boundedness and convergence of signals.