EE 380 – Introduction to Linear Control Systems

Designation: EE elective course for electrical engineering majors.

University Bulletin Description: E 380: (3) State variables; time-domain and frequency-domain design and analysis; design of feedback control systems; root locus.
Prerequisites: MATH 220, EE 350.

Prerequisites by Topics:
1. An understanding of the relationship between ordinary differential equations, impulse response functions, frequency response function, and transfer function description of a system.
2. The ability to use Laplace transform techniques to solve ordinary differential equations and to model active and passive circuits.
3. An understanding of the concept of marginal stability, asymptotic stability, and bounded-input bounded-output stability for continuous-time linear systems.
4. Proficiency in the use of MATLAB (graphing, Bode plots, determining the response of linear time invariant systems, finding poles and zeros, generating partial fraction expansions, writing m-files).
5. Proficiency in the use of basic laboratory equipment (digital oscilloscope, function generator, power supply).

Textbook/Required Materials:
Feedback Control of Dynamic Systems, 4th ed., Franklin, G.F., Powell, J.D., and Emami-Naeini, A., Prentice Hall, 2006

Learning Outcomes: Through problem solving and laboratory practice, this course provides a foundation in continuous-time linear control system theory. After successfully completing the course, students are able to:
1. Apply appropriate physical laws to obtain lumped-parameter models of physical systems.
2. Represent a dynamic system using ordinary differential equations, transfer functions, frequency response, and state-space methods.
3. Find a small-signal linear model of a nonlinear system at an operating point.
4. Analyze, design, and synthesize feedback control systems using Laplace transform, frequency response, and state-space methods.
5. Effectively use MATLAB and SIMULINK in the analysis, design, simulation, and real-time implementation of closed-loop systems.

Topics:
1. Dynamic models and response (7 lectures)
2. Basic principles of feedback (6 lectures)
3. Root locus design techniques (8 lectures)
4. Frequency-response design techniques (10 lectures)
5. State-space design methods (9 lectures)

Class/laboratory schedule: Three 50-minute lectures per week and six 2-hour laboratory sessions.

Computer Usage:
1. MATLAB and SIMULINK are used for analysis, design, simulation, and collection of experimental data.
2. A formal technical report for each laboratory project requires the use of word processing.

Laboratory Projects/Assignments:
1. Two to three laboratory projects are completed within six two-hour laboratory sessions.

2. Students work in teams of three; each student maintains a laboratory notebook and the group submits a written report at the end of each project.
3. In addition to the technical content, student assessment is based on their technical writing skills in both their written report and laboratory notebook.
4. Projects involve the use of basic test equipment (digital oscilloscope, function generator, power supply), a variety of control test beds (servomechanisms, magnetic suspension, fluid level control), and a PC-based controller (dSPACE DS1104 R&D Controller Board) that implements controllers specified using the SIMULINK environment.

Contribution to Meeting the Requirements of Criterion 5. Curriculum:
This course contributes to both the engineering topics and design components.
This course enables students to analyze, design, and synthesize continuous-time feedback control systems by providing a foundation in basic concepts and laboratory skills, and is a prerequisite to an elective course on digital control systems (EE 482). Economics and manufacturability issues are considered in the context of designing the simplest control strategy for achieving the desired design specifications.

Relationship to program outcome:
O.1.1. Graduates will possess mathematics skills necessary for electrical engineering.
O.1.3. Graduates will have attained computer proficiency.
O.2.1. Graduates will understand how to analyze and design simple electrical/electronic circuits.
O.2.3. Graduates will understand the basic concepts of linear systems and how they interact with continuous-time signals.
O.3.1. Graduates will have in-depth technical knowledge in one or more areas of specialization.
O.3.2. Graduates will have practical understanding of the major electrical engineering concepts and demonstrate application of their theoretical knowledge of the concepts.
O.4.1. Graduates will interact with industry both within and outside of a classroom setting.
O.4.2. Graduates will develop an appreciation of continuing educational and professional development.
O.5.1. Graduates will have good teamwork skills.
O.5.2. Graduates will possess good oral and written communication skills.
O.6. Graduates will appreciate their role as engineers in society.

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