EE 482 - Introduction to Digital Control Systems

Designation: EE elective course for electrical engineering majors.

University Bulletin Description: EE 482: (3) Sampling and hold operations; A/D and D/A conversions; modeling of digital systems; response evaluation; stability; basis of digital control; examples. Course contains a significant laboratory component.
Prerequisites: EE 380, EE 351.

Prerequisites by Topics:
1. The ability to analyze, design, and synthesize continuous-time feedback control systems using Laplace transform, frequency response, and state-space methods.
2. An understanding of the Z-transform and its application to solving difference equations, assessing system stability, and determining the frequency response of a system.
3. 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).
4. Proficiency in the use of basic laboratory equipment (digital oscilloscope, function generator, power supply).

Textbook/Required Materials:
Digital Control System Analysis and Design, Charles L. Phillips, H. Troy Nagle, 1995, Prentice Hall.

Learning Outcomes:
Through problem solving and laboratory practice, this course provides a foundation in discrete-time linear control system theory. After successfully completing the course, students are able to:
1. Represent sampled-data systems using difference equations, transfer functions, all-delay block diagrams and state-space models.
2. Find a small-signal linear model of a nonlinear system at an operating point.
3. Model dynamic systems that contain a time-delay.
4. Obtain a model of a physical system by using least-squares system identification.
5. Analyze, design, and synthesize digital control systems using transform techniques (root locus and frequency response) and state-space methods (pole-assignment and state estimation).
6. Effectively use MATLAB and SIMULINK in the analysis, design, simulation, and real-time implementation of discrete-time control systems.

Topics:
1. Representation of continuous and discrete time systems (6 lectures)
2. Sampling and Reconstruction (3 lectures)
3. Representation of sampled-data systems (6 lectures)
4. Discrete-time approximation of continuous-time controllers (3 lectures)
5. System identification (3 lectures)
6. Time response characteristics (3 lectures)
7. Root locus design techniques (3 lectures)
8. Frequency domain design techniques (5 lectures)
9. State-space design techniques (8 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 emphasizes structured mathematical analysis of systems containing both continuous and discrete time components, and methods for designing discrete time controllers for continuous time systems. In addition to equipping students with tools required by practicing control engineers, the course aims to help students develop an appreciation of research efforts in control system science.

Relationship to Program Outcomes:

O.1.1. Graduates will possess mathematics skills necessary for electrical engineering.
O.1.3. Graduates will have attained computer proficiency.
O.2.5. Graduates will have knowledge of digital systems.
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.4.2. 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.

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