EE 452 Digital Control Systems

Credits: 3

Categorization of credits: engineering topic

Instructor(s): G. Arslan, T. Kuh.

Textbook and Other Required Materials: G. F. Franklin, J. D. Powell, M. Workman, *Digital Control of Dynamic Systems, 3rd Edition*, Longman, 1998.

Designation: Elective

Catalog Description: Sampling/reconstruction, Z-transform, DT transfer function. Reachability/observability. State and output feedback, observer design, input-output models, Diophantine equations. Implementation procedures.

Pre- and Co-requisites: Prerequisites: EE 315 "Signals and Systems Analysis" and EE 351 "Feedback-Control Systems" of Instructor Consent.

Class/Lab Schedule: Three 50-minute lectures per week.

Class Information

This is an undergraduate-level course on computer-controlled dynamic systems. It builds on an introductory undergraduate course in control systems such as EE 351, and emphasizes a discrete-time viewpoint for the analysis of dynamical systems and the synthesis of control laws meeting given design specifications. To follow and appreciate the course, a descent understanding of EE351 material is required.

Topics Covered:

- Computer control (2 hours)
- Sampling of continuous systems (2 hours)
- Computer oriented mathematical models: discrete-time systems (9 hours)
- Analysis of discrete-time systems (9 hours)
- From analog design to digital design (4 hours)
- State-space design methods (6 hours)
- Pole placement design based on input-output models (5 hours)

Course Objectives and Relationship to Program Objectives:

The purpose of the proposed course is to present control theory that is relevant to the analysis and design of computer-controlled systems, with an emphasis on basic concepts and ideas. The control-

system design is carried out up to the stage of implementation in the form of computer programs in a high-level language. [Program Objectives addressed by this course: 1, 2.]

Course Outcomes and Their Relationship to Program Outcomes

The following are course outcomes and the Program Outcomes (numbered 1-7 in square brackets "[ ]") they address:

- The students should be able to (*i*) use ordinary differential equations and Laplace transformation to model physical systems, (*ii*) obtain dynamic responses of linear systems and determine their stability, (*iii*) construct root-locus and Bode plots, and apply Nyquist criterion in the context of controller design, (*iv*) obtain and manipulate state-space representation of dynamical systems using linear algebra, and (*v*) become fluent in digital control systems design. [1]
- The students should be able to translate a set of performance specifications given in words to a formal description of a design problem, and then design a suitable feedback-controller using design tools, followed by simulation and verification using software tools. [1, 2]
- The students should know the techniques for relaxing the constraints or redesigning the controller for achieving closed-loop specifications either in the time-domain or in the frequency domain. They should also know how constraints in the time domain affect the frequency response of the system and vice versa and how to apply these concepts to design. [1, 2]
- Students should know how to debug their controller design, which requires them to iterate on their initial design. [1, 2]
- Students should be able to design digital controllers, assess their design through the constraint specifications, and decide whether their initial design is acceptable or can be improved. [1, 2]

Contribution of Course to Meeting the Professional Component

Engineering topics: 100%

Computer Usage: There is extensive computer usage since the students use the following computer aided design tools: Matlab/Simulink (system design and simulation software tool) and word processing for lab reports. The students are required to use Matlab/Simulink for most of their lab experiments.   In addition, around a third of the homework assignments have a problem, which requires the Matlab/Control Systems design toolbox.

Design Credits and Features: There are 0.5 design credits. There are design problems in the homework assignments, and computer aided design tools are used in assignments.

Person(s) Preparing Syllabus and Date: G. Arslan, September 29, 2014. Y. Dong, June 14, 2021.