341mcd2018

Master Course Description for EE-341 (ABET sheet)

Title: Discrete Time Linear Systems

Credits: 5

UW Course Catalog Description

Coordinator: Tai-Chang Chen, Senior Lecturer, Electrical and Computer Engineering

Goals: To provide students with the fundamental concepts of digital signal processing. To study discrete-time signal and system analysis using time-domain, Fourier and Z-transform techniques. To build proficiency in signal analysis with Python.

Learning Objectives: At the end of this course, students will be able to:

1. *Describe* discrete-time signals in different domains (time, frequency, and Z) and *map* characteristics in one domain to those in another (e.g. distinguish between high and low frequency components of time signals).
2. *Understand* the implications of different system properties and how to test for them.
3. *Perform* convolutions for arbitrary and closed-form discrete-time signals.
4. *Analyze* LTI systems given different system representations (including input-output equations, impulse response, frequency response and transfer function), and *translate* between these different representations.
5. *Solve* linear difference equations associated with linear digital filters by classical techniques and the Z-Transform method.
6. *Use and understand* standard EE terminology associated with digital filtering and LTI systems (e.g. LPF, HPF, impulse response, step response, etc.)
7. *Implement* filters, *analyze* frequency content of signals and responses of systems, *design* filters and *synthesize* signals using Python tools.

Textbook: Sanjit K Mitra, *Signals and Systems 1st Ed.,* Oxford University Press, 2015.

Reference Texts:

1. A. Oppenheim, A. Willsky and S. H. Nawab, *Signals and Systems,* Prentice Hall, 1996.
2. C. Phillips, J. Parr and E. Riskin, *Signals, Systems and Transforms,* Prentice Hall, 2003.

Prerequisites by Topic:

1. Continuous-time linear systems (EE-235)
2. Complex numbers and signals

Topics:

1. Introduction, representation of basic discrete-time signals and operations of discrete-time signals. (1.5 weeks)
2. Example and classification of discrete-time systems (1 weeks)
3. Linear time-invariant systems analysis in the time domain: convolution (1.5 weeks)
4. Linear time-invariant systems analysis in the time domain: difference equation of LTI systems (1 weeks)
5. Fourier frequency domain representations (series and transforms) (1.5 weeks)
6. z transforms, region of convergence, inverse transforms via partial fractions (1 weeks)
7. Linear time-invariant systems analysis in the time domain: transfer functions of IIR and FIR systems, output response, pole-zero location, and frequency response. (1 week)
8. Introduction to DFT, operations of DTF, inverse DFT, circular convolution and FFT (1.5 weeks)

Course Structure: The class meets 4 times a week for a 50 minute lecture and each student participates in one laboratory session that meets for 2 hours a week. There is weekly homework and several laboratory exercises that must be done in Python. There are midterms and final exam and possibly additional quizzes depending upon the instructor.

Computer Resources: The course uses Python for the laboratory exercises and also for checking homework problems. Students are expected to use their personal laptops in the labs, but they may use remote connections to EE Department computers as needed. The students complete an average of 2 hours of computer work per week.

Laboratory Resources: (see Computer Resources)

ABET Student Outcome Coverage: This course addresses the following outcomes:

H = high relevance, M = medium relevance, L = low relevance to course.

(1) *An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.* **(H)** The majority of the lectures and homework deal with the derivations and application of linear mathematics theory to solve difference equations, perform convolutions and transform signals. The homework involves solving signal processing problems identified by the assignments and exemplified by class discussion.

(2) *An ability to apply engineering design to produce solutions that meet speci-*

fied needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors. **(L)** The labs include open-ended assignments in signal synthesis and in digital filter design, with constraints on performance and computation. Social constraints are posed in a music synthesis lab.

(3) *An ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives.* **(M)** The computer labs are conducted in teams. Labs constitute about 20% of their grade, depending on the instructor.

(4) *An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.* **(M)** The labs include assignments where students experiment with different signals and systems to learn fundamental DSP concepts, including: (i) exploring different system configurations in the Z-domain to learn about the associated time-domain and frequency-domain behavior, and (ii) exploring different configurations of FFT parameters.

(5) *An ability to acquire and apply new knowledge as needed, using appropriate learning strategies.* **(H)** Students use Python and associated data acquisition/display tools to solve homework problems on signal analysis and filter design.

Prepared By: Eve Riskin, Laura Vertatschitsch

Last Revised: 16 February 2019 by Tai-Chang Chen