EE 351 – Discrete-Time Linear Systems

Designation: EE elective course for electrical engineering majors.

University Bulletin Description: EE 351: (3) Introduction to discrete-time signal processing; sampling, linear time-invariant systems, discrete-time Fourier transform and discrete Fourier transform, Z transform. Prerequisite: EE 350.

Prerequisites by Topics:
1. Understanding elementary continuous-time signals (delta and unit step) and concepts such as periodicity, even-odd signals, and time transformations.
2. Understanding linear constant coefficient differential equations and their solutions.
3. Understanding continuous-time systems, system properties, impulse response, the convolution integral, and properties of convolution.
4. Understanding the Fourier series decomposition of continuous-time periodic signals.
5. Understanding the system eigenresponse and its use for computing the system output when a periodic input signal is applied.
6. Understanding the continuous-time Fourier transform and its properties, for measuring the spectral content of an aperiodic continuous-time signal.
7. Understanding the Laplace transform and its uses in solving differential equations and in characterizing properties of systems.
8. Understanding Matlab and its use in simulating signals, in filtering, and in analyzing signals and systems in the frequency domain.

Textbook/Required Materials:
Digital Signal Processing: Principles, Algorithms, and Applications, 3rd ed., J. G. Proakis and D. G. Manolakis, Prentice Hall, 1996

Learning Outcomes:
This course provides foundational education for students in sampling of continuous-time signals and in time, frequency, and Z-domain descriptions of discrete-time signals and systems. Through lecture and out-of-class assignments, students learn:
1. How to design a sampling and reconstruction system to meet specific requirements.
2. How to solve (discrete-time) difference equations.
3. How to determine the system frequency response and eigenresponse.
4. Z-domain descriptions of signals and systems, for use in solving difference equations, in determining whether or not a system is causal and stable, in performing convolution sums, and in qualitative assessment of system frequency response.
5. How to design simple frequency-selective filters via pole and zero placement.
6. The discrete Fourier transform for practical evaluation of a signal's spectral content and a system's frequency response.

Topics:
1. Introduction: signal types, signal processing objective and applications (3 classes)
2. Fundamental discrete-time signals, periodicity, and time transformations (4 classes)
3. Ideal and practical sampling and reconstruction systems (8 classes)
4. Discrete-time linear systems: difference equations, impulse response, convolution sum and properties (9 classes)
5. Discrete-time Fourier transform and Frequency Response (8 classes)
6. Z-transform (8 classes)
7. Discrete Fourier Transform (3 classes)

Class/laboratory schedule: Three 50-minute lectures per week.

Computer usage:
The Matlab signal processing software is used in most homework assignments. Matlab assignments include: i) building a 512-level uniform quantizer; ii) iterating difference equations; iii) exploring frequency selectivity by filtering sinusoids; iv) frequency response evaluation and approximation using the DFT; v) linear and nonlinear phase characteristics and their effects; vi) notch filter design and filtering to cancel 60 Hz interference.

Contribution to Meeting the Requirements of Criterion 5. Curriculum:
This course contributes to both the engineering topics and design components.
This course provides EE grounding in sampling, discrete-time signals, and discrete systems. The course culminates with simple frequency-selective filter design based on pole-zero placement, and with signal (spectrum) analysis via the Discrete Fourier Transform. This course is a prerequisite for the senior elective courses EE453 (Digital Signal Processing) and EE429 (Digital Control Systems). Topics pertaining to sustainability are considered in a minor way through discussion of the differences between analog and digital signal processing, and through the development of various digital filter structures for implementing the filtering operation.

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.2.3. Graduates will understand the basic concepts of linear systems and how they interact with continuous-time signals.
- 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.

Prepared by: David J. Miller **Date**: 3/31/08