ESE337: Digital Signal Processing: Theory
Fall 2011

2010-2011 Catalog Description:

Discrete-time (DT) signals and their manipulation. Frequency of DT sinusoids, Nyquist frequency range and Nyquist sampling theorem. Fast Fourier transform (FFT) and its employment in computing frequency spectra of DT and CT signals. Discrete convolutions, FIR and IIR digital filters. Z-transform and transfer functions for DT systems. Stability and frequency responses. Filter specifications. Design of FIR filters using window method, least-square and min-max optimal methods. Review of various types of analog filters. Design of IIR filters using impulse-invariance and bilinear transformation. Structure of digital filters.

Course Designation: Required for EE and CE

Text Book: Chi-Tsong Chen, "Digital Signal Processing: Spectral Computation and Filter Design" Oxford University Press, 2001.

Prerequisites: ESE305

Coordinator: Chi-Tsong Chen

Goals: Basic concepts in digital signal processing. Computer computation of frequency spectra of DT and CT signals. Design of FIR and IIR digital filters to process DT and CT signals.

Course Learning Outcomes: Enable students to use FFT to compute frequency spectra of CT signals by selecting adequate sampling periods and data lengths. Design of various analog filters and the use of analog frequency transformations. Design of FIR and IIR digital filters and the discussion of their structures in implementation.

Topics Covered:

Week 1.	Frequency of discrete-time (DT) sinusoids. Nyquist frequency range. Sampling of continuous-time (CT) signals. Sampling and frequency aliasing.
Week 2.	Frequency spectra of CT and DT signals. Nyquist sampling theorem. Fast Fourier transform (FFT) algorithm.
Week 3.	FFT computation of frequency spectra of DT and CT signals. Selection of sampling period and number of data in practice.
Week 4.	Exam I. Review of DT linear time-invariant lumped systems. Discrete convolutions and difference equations.
Week 5.	z-transform, DT transfer functions, poles and zeros. Positive-power

	and negative-power transfer functions. Inverse z-transform.
Week 6.	Stability and frequency responses of DT systems. Specifications of practical filters, group delay. Exam II.
Week 7.	Design of degree 1 digital filters. Notch filters, all pass filters and comb filters. Sinusoidal generators.
Week 8.	Design of FIR filters with linear phase. Windowing method. Design of least square optimal filters.
Week 9.	Design of minimax filters. Remez algorithm. Difficulties in designing IIR filters directly. Exam III.
Week 10.	Design of analog prototype filters: Butterworth, Chebyshev type I and type II, and elliptic filters. Analog frequency transformations.
Week 11.	Design of IIR digital filters: Impulse invariance method, bilinear transformations. Comparison with FIR filters.
Week 12.	Structure of digital filters. Direct form, canonical form, and transposed canonical form. Sensitivity due to finite word length.
Week 13.	Cascade and parallel implementations. Second-order section.
Week 14	Review and Exam IV.

Class Schedule: 3 lecture hour per week.