Course Charter for ECE 1456/1234: Digital Signal Processing
Prepared by Prof. Eric L. Miller
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ECE 1456: Digital Signal Processing 4QH

Introduces concepts in modern signal processing. Topics include review of discrete time signals and systems, discrete Fourier transform, realization structures for digital systems, FIR filter design, IIR filter design, fast Fourier transforms, and applications to fast convolution.

Prerequisites: ECE 1333: Linear Systems II

Textbooks: Proakis and Manolakis, *Digital Signal Processing: Principles, Algorithms, and Applications*, 3rd edition

Course Objectives

Upon completion of this course, the student should:

1. Understand the ideas of sampling in both the time and frequency domains specifically as this idea relates to band-limited continuous signals and time-limited aperiodic discrete times signals
2. Understand how the discrete Fourier transform (DFT) is derived from sampling arguments and be able to derive and make use of the properties of the DFT
3. Understand periodic discrete time signals and how they are derived from frequency domain sampling ideas.
4. Understand and be able to make use of circular signal manipulation methods such as circular shifts and circular time reversal
5. Understand and be able to compute circular convolutions both in the time domain as well as in the DFT domain
6. Understand the relationship between linear and circular convolution
7. Be able to implement both FIR and IIR systems using direct form, parallel, and cascade structures
8. Be able to design lowpass, highpass, bandpass, an bandstop FIR filters using windowing and equiripple methods
9. Be able to design IIR filters using analog prototype methods and frequency transformations
10. Understand the divide and conquer strategy underlying most FFT algorithms and be familiar in depth with the radix 2 DIT and DIF algorithms.
11. Be able to implement basic DSP algorithms and methods on state of the art hardware in the native assembly language of the device
12. Be able to design DSP algorithms for the solution of simple “real-world” problems for implementation on this hardware.
13. Be able to write a clear and concise report describing their design and implementation.

Topics Covered

1. Review of aperiodic discrete time signals and systems including the Z and discrete time Fourier transforms
2. Sampling, aliasing and interpolation including a rigorous derivation of the Shannon sampling theorem and the development of periodic discrete time signals based on sampling in the discrete time Fourier transform domain
3. Periodic signals including ho they are defined and manipulated. Circular shifts, circular time reversal, circular symmetries.
4. The discrete Fourier transform, its properties, and its relationship to periodic discrete time signals
5. Circular convolution including its derivation as the IDFT of the product of two DFTs, its mechanics in the time and frequency domains, and its relationship to linear convolution
6. FIR and IIR system structures including direct form, parallel, and cascade implementations
7. Linear phase FIR filter design by windowing and equiripple methods
8. IIR filter design by analog prototype methods including bilinear and impulse invariant transformation methods as well as frequency transformation techniques.

9. Fast Fourier transform algorithms including a detailed derivation of the radix 2 DIT and DFT approaches

Class/Laboratory Schedule

Class: Tuesday and Thursday 6:00 PM – 7:40 PM

Lab: Wednesday evenings

Contribution of course to meeting the professional component

Engineering topics: 4QH

General engineering component: See relation to Program Objectives below

Program Objective	**Assessed**
1.1 Formulate and solve EE problems	HE: 1 midterm for 25%, 1 final for 40%, 7 homeworks for 20%, 1 report for 15%
1.2 Laboratory and computing tools	H: Use of Matlab to solve homework problems (one to three such problems per homework set) which are graded HR: Use of design tools for programming DSP chips in lab complement of class. Assignments are graded.
1.3 Design/conduct experiments/analyze data	NA
1.4 Design systems, components, or processes	H: Two homework sets on the design of digital filters. HR: Algorithm design, implementation, and evaluation on DSP hardware in lab component of class
2.1 Understand/apply mathematics	
2.1.1 Differential calculus	NA
2.1.2 Integral calculus	NA
2.1.3 Complex algebra/analysis	HE: More than half of homeworks involve manipulation of DFTs, DTFTs, and Z transforms all of which are complex-valued creatures
2.1.4 Differential/difference equations	HE: First problem set requires solution of difference equation describing the behavior of LSI DT system
2.1.5 Linear algebra	NA
2.1.6 Multivariate calculus	NA
2.2 Understand/apply physics	
2.2.1 Solid state physics	NA
2.2.2 Electricity and magnetism	NA
2.3 Apply knowledge of programming	
2.3.1 Flow-charting/program design	NA
2.3.2 Language/syntax debugging	H: Homeworks require use of Matlab to do filter design, design system structures, compute FFTs, and solve problems related to circular convolutions, periodic DT signals, and the DFT
2.4 Connect EE subfields	HE: Use ideas from aperiodic DT signals class as well as CT signals and systems
2.5 Information sources/literacy	C: Use of website for class to encourage communication among students and with the professor
2.6 Connect between theory and application	R: Lab component provides for hands on implementation of methods discussed in class
2.7 Connect between classroom and work/co-op	NA
3.1 Effective written communications	RV: 25% of lab report grade based on form and

	expression. 1 revision allowed per assignment to improve grade
3.2 Effective oral communications	NA
3.3 Analyze information/compare alternatives	NA
3.4 Multidisciplinary teams	R: labs done in teams
4.1 Professional/ethical issues	NA
4.2 Lifelong learning	NA
4.3 Career management	NA
5.1 Social/cultural context of EE	R: Required report summarizing the contributio of DSP to some element of modern technology (specch recognition, audio processing, underwater acoustics, medical imaging,…)
5.2 Historical/contemporary issues of EE	R: see above C: Discuss the history of the FFT in class
5.3 Esthetics in engineering	C: The FFT as an example of elegant and useful mathematics
5.4 Esthetics in written/oral expression	R: Revisions of lab reports and essay graded for clarity and conciseness