

DIGITAL SIGNAL PROCESSING

- COURSE NO.:** ME 383Q (Unique No. 77685)
- INSTRUCTOR:** Ronald E. Barr, Ph.D., P.E.
Professor of Mechanical Engineering
- TIME and PLACE:** TTH 4-6:30 PM, (room TBA)
- OFFICE HOURS:** MTWTH 3:00-4 PM, ETC 3.104A, or by appointment
- ABSTRACT:** Review of Fourier analysis methods; sampling and quantizing theory; analog/digital conversion; discrete Fourier transform, including FFT; spectral estimation; the z transform; design of finite impulse response (FIR) and infinite impulse response (IIR) digital filters; properties of stochastic signals; applications to engineering problems.
- OUTLINE:** (see attached)
- TEXT:** Baher, H.: Analog and Digital Signal Processing, John Wiley and Sons, New York, 1990.
- (Optional) Ingle, V. and Proakis, J.: Digital Signal Processing Using MATLAB V.4., PWS Publishing Co., Boston, 1997.
- PREREQUISITES:** Graduate standing and consent of the instructor. A substantial amount of numerical analysis using computer software and hardware of the student's choice is required in the course. The normal mode of presentation of homework results is through computer plots, graphs, and charts.
- GRADING:**
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|-------------------------------|------------|
| Homework Assignments (4 Sets) | 40% |
| In-Class Exam #1 | 25% |
| In-Class Exam #2 | 25% |
| Project | <u>10%</u> |
| Total | 100% |
- PROJECT:** A Final Project will be assigned in this class. The student will pick an application in their field of some data that needs some signal processing (FFT, digital filter, etc.) The student will apply techniques learned in class and write a brief final report.
- POLICIES:** Please refer to the Graduate Catalog and Course Schedule for policies related to dropping the course, academic dishonesty, special services, and other student matters.

DIGITAL SIGNAL PROCESSING

OUTLINE

- I. Introduction to Analog and Digital Signals
 - a. Analog signals
 - b. Discrete-time and digital signals
 - c. Deterministic and random signals

- II. Review of Fourier and Laplace Analysis
 - a. Fourier Series
 - 1. Periodicity
 - 2. Complex form derivation
 - 3. Real coefficients derivation
 - 4. Even and odd functions
 - 5. Line spectra
 - 6. Gibb's phenomenon
 - 7. Some conditions for convergence
 - b. Fourier Transform
 - 1. The Fourier integral
 - 2. Basic Properties of the Fourier transform
 - i. Symmetry
 - ii. Conjugate relationships
 - iii. Linearity
 - iv. Scaling
 - v. Shifting theorem
 - vi. Modulation
 - vii. Differentiation
 - viii. Convolution
 - 3. Parseval's Theorem and energy spectra
 - 4. Wiener-Kintchine Theorem
 - 5. Fourier transform of periodic signals
 - c. Laplace Transform
 - 1. The Laplace integral
 - 2. The Laplace transform of some elementary functions
 - 3. Significance of poles and zeros
 - d. The Impulse Function

- III. Sampling and Quantizing of Analog Signals
 - a. Sampling
 - 1. Pulse-Amplitude Modulated (PAM) Sampling
 - 2. Ideal Sampling
 - 3. Aliasing and the Nyquist Sampling Rate
 - 4. Sampling Theorem
 - b. Quantizing
 - 1. An Ideal Quantizing Scheme
 - 2. Binary Representation

- 3. Analog-to Digital and Digital-to Analog Conversion
- c. Reconstruction of Sampled Signals

IV. Digital Fourier Analysis

- a. Discrete Fourier Transform (DFT)
 - 1. Properties of the DFT
 - i. Linearity
 - ii. Cyclic Convolution
 - iii. Symmetry and Conjugate Pairs
- b. Fast Fourier Transform
 - 1. Decimation in Time
 - 2. Decimation in Frequency
 - 3. Butterfly Diagrams
 - 4. Bit Reversal Process
- c. Leakage and Windows
- d. Spectral Estimates via FFT

V. Digital Filtering Methods

- a. The Z-Transform
 - 1. Properties of the Z-Transform
 - 2. The Inverse Z-Transform
 - 3. Mapping from s to Z Planes
- b. Design Characteristics of Analog Filters
 - 1. The Ideal Filter
 - 2. Amplitude Response Characteristics
 - 3. Butterworth, Chebyshev, and Elliptic Filters
- c. Finite Impulse Response (FIR) Digital Filter
 - 1. Design of FIR Filters Using Ideal Models
 - 2. Effects of Truncation and Windowing
- d. Infinite Impulse Response (IIR) Digital Filters
 - 1. Analog Design Models
 - 2. The Bilinear Transformation
 - 3. Frequency Warping
- e. Design of Digital Filters Using Pole-Zero Plots
 - 1. Design of a 60-Hertz Notch Filter
- f. Adaptive Filtering

VI. Introduction to Stochastic Signals

- a. Statistical Properties of Stochastic Signals
 - 1. Mean Square
 - 2. Probability Density Functions
 - 3. Autocorrelation Functions
 - 4. Cross-Correlation Functions
 - 5. Power Spectral Density**
 - 6. Cross-Spectral Density and Coherence