INTENDED AUDIENCE: Third Year Undergraduates/ First Year Graduate (Masters Students)

INDUSTRIES APPLICABLE TO: Texas Instruments, Analog Devices, Samsung, almost any industry which works in communication and signal processing would value this training, as a core discipline.

COURSE OUTLINE:
The course begins with a discussion on Discrete Time signals and systems. This is followed by an introduction of the Z transform, its properties and system theoretic implications. The foundations of digital filter design and realization are built up. Practice Problems with solutions, summaries of each lecture and illustrative explanations of concepts are all additionally provided, to enhance learning.

COURSE PLAN:

Week 1: Analog to digital conversion: moving from the continuous independent variable to the discrete independent variable:
  i. The sampling theorem and its consequences: uniform and non-uniform sampling • ii. Aliasing and its manifestation • iii. Correlating the analog and discrete time domains • iv. Discretization of the dependent variable (quantization): distinction from sampling • v. Formalizing the notion of a discrete sequence and a discrete system. Examples of prototype discrete systems. • vi. Difference equations and their solutions

Week 2: Discrete time systems and their characterizing properties:
  i. Linearity, shift-invariance, memory, causality, stability, realizability and other related system properties. • ii. Linear shift-invariant (LSI) systems and their importance. • iii. The impulse response and its role in characterizing LSI systems. • iv. Linear difference equations, linear constant coefficient difference equations and their solution (LCCDEs). • v. The relation between LCCDEs and LSI systems • vi. Eigenvectors and eigenvalues of systems. The role of the sinusoid and the complex exponential. • vii. Frequency response and its meaning.

Week 3: Frequency Domain Analysis for Discrete Time Systems:
  i. The notion of discrete system frequency response in more detail • ii. The Discrete Time Fourier Transform (DTFT) and its properties • iii. The existence of a frequency response for LSI systems • iv. Relation between the impulse response and frequency response • v. Discretization of the frequency response: the Discrete Fourier Transform (DFT) • vi. Going back and forth between discrete time (independent variable) and discrete frequency: time domain and frequency domain aliasing • vii. Frequency selective systems and filters • viii. Energy/ Power Spectral density • ix. The Parseval’s Theorem: specific statement for the frequency domain

Week 4: The generalized eigenfunction domain (z-domain) and its use:
  i. The z-transform and the inverse z-transform • ii. The z-transform as a generalization of the DTFT • iii. Methods for forward and inverse z-transformation • iv. Region of convergence (ROC) and its implications. • v. Rational and irrational systems. • vi. LCCDEs revisited: rational transfer functions • vii. Poles and Zeros: their significance and relation to system properties: stability, causality. • viii. Z-transforms and DTFTs: interrelationship, role of pole-zero configuration. • ix. Minimum and non-minimum phase systems. x. Contour integration for inverse z-transformation and the generalized form of Parseval’s Theorem. • xi. The relation between system realization and the transfer function: DSP components

Week 5: Efficient computation of the Discrete Fourier Transform: Fast Fourier Transforms (FFTs):
  i. The notion of decimation and partitioning in time and frequency. • ii. FFT algorithms for a power-of-two number of points N. • iii. FFT algorithms for composite N, in general • iv. Spectral analysis of real life signals and the FFT • v. Linear convolution and circular convolution: their relationship to the FFT.

Week 6: Digital Filters and their general characteristics:
  i. Magnitude and phase responses, specifications for discrete systems: ideal frequency responses • ii. Unrealizability of the ideal and the need to approximate • iii. Finite and infinite impulse response systems: advantages and disadvantages • iv. Phase response: phase and group delay

Week 7: Finite Impulse Response (FIR) Filters and their design:
  i. Why FIR filters? Advantages and Disadvantages. • ii. Windowing and the design of FIR filters using windows. • iii. Odd-length and even-length FIR filters. • iv. Optimum FIR filter design: equiripple filters and Parks-McClellan’s algorithm. • v. The frequency sampling method of FIR filter design

Week 8: Infinite Impulse Response (IIR) Filters and their design:

Week 9: Realization of Discrete Time systems:
  i. Realizability (finite average computation per output sample) and rationality • ii. Components in realization: multipliers, adders, delays • iii. Hardware for DSP systems: special features/dedicated systems • iv. Direct Form I and II realizations • v. Cascade and Parallel Realizations

Week 10: Yet to update

Week 11: Yet to update

Week 12: Yet to update