

## SKU-Digital Signal Processing

DSP stands for Digital Signal Processing which is the basis of many areas of technology, from mobile phones to modems and multimedia PCs. DSP is traditionally a highly mathematical subject, and the standard DSP textbooks contain a lot of mathematical exposition. SKU-Digital Signal Processing is a necessary for a profound understanding of the subject. However, many people just want a simple introduction to the basic concepts and techniques of DSP. This courseware introduces the basic concepts of Digital Signal Processing by use of analogies, animations and examples.

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## Digital Signal Processing

Any kind of signal processing which is carried out in digital domain is called digital signal processing.

### Topics covered in SKU-Digital Signal Processing:

#### Introduction

**Topics Covered:** What is DSP, Basic elements of DSP, Advantages over Analog Signal Processing, Limitations, Applications, Signal, Continuous time signals, Discrete time signals, Digital (Discrete Value Signal) signals, Classification of signals, Operation on Discrete Signals, Discrete Time Systems, Response, Convolution, Properties of Convolution, Operations and Application of Convolution, Correlation, Cross Correlation and Auto Correlation, Properties of Auto and Cross Correlation, Application of Correlation.

## Sampling and Reconstruction

**Topics Covered:** Sampling in time domain and frequency domain, Sampling theorem, Effect of undersampling aliasing, over sampling, under sampling, Discrete time decimation and interpolation, Quantization, Quantization error, Encoding, Analog to Digital conversion Sample and hold, Quantization and coding, Over sampling A/D converters, Digital to Analog Conversion, Sample and hold, first order hold, linear interpolation with delay, Over sampling D/A converters.

## Discrete Time Signal Analysis

**Topics Covered:** Fourier series, Properties of Discrete Fourier series, Periodicity, Linearity, Duality, Complex conjugation of the periodic sequence, Time Reversal, Symmetry, Time scaling, Difference, Periodic convolution, Fourier Transform, Properties of Fourier transform, Discrete Time Fourier Transform (DTFT), Sampling in Time Domain, Properties of DTFT, Discrete Fourier Transform, Sampling in Frequency Domain, Relationship between DTFT and DFT, Computation of DFT and IDFT, Properties of DFT, Circular convolution (Multiplication of DFTs), linear convolution, Fast Fourier Transforms (FFTs), Split and conquer Approach, Radix-2, Decimation in Time (DIT) FFT, The Butterfly, Radix-2, Decimation in Frequency (DIF) FFT, The Butterfly, Algorithmic development, Computational advantage and features, Comparison of DIT and DIF, Modifications to improve speed: Properties of FFTs.

## DT-LTI System Analysis Z-Transform

**Topics Covered:** DT-LTI System Analysis in Time domain, FIR and IIR systems and their representation using Difference Equation, Z-Transform, Definition and its need, Single sided and Double sided Z-Transform, Region of convergence and its Role, Relation between Laplace Transform and Z-Transform, Computation of Z-Transform, Relation between Z-Transform and F-Transform, Inverse Z-Transform, Power Series method, Partial fraction expansion method, Residue method, Application of Z-Transform, System Analysis in Z-Domain.

## Frameworks for Digital Filter Design

**Topics Covered:** Introduction to filter, Ideal Filter, Characteristics, Basic Analog filter approximations and Low Pass Filter design, Butterworth filter, Chebyshev filter, Type I Chebyshev filter, Type II Chebyshev filter, Elliptic filter, Design of Normalized Low Pass Filter, Frequency Transformation for filter design, Types of digital filter: FIR and IIR filter, Choosing between FIR and IIR filter.

## Infinite Impulse Response (IIR)

**Topics Covered:** Introduction, IIR filter specification and steps involved in design, IIR Coefficient calculation method, Impulse Invariant method, Bilinear transform, Comparison between impulse invariant and bilinear transform method, IIR Filter Realization Direct form I, Direct form II, Cascade form, Parallel form, Other forms, Finite word length effect, Applications of IIR filter.

## Finite Impulse Response (FIR)

**Topics Covered:** Introduction, Linear phase response and its implications, Types of linear phase FIR filter, Filter Design, FIR filter design specifications and Methods, Window method of FIR filter design, Steps Involved, Different Window functions and comparison, Frequency Sampling Method of FIR filter design, Type-I Filter Design, Type-II Filter Design, FIR Filter Realization structures, Finite word length effect, Applications of FIR filter.

**Finite Impulse Response (FIR)**

**Topics Covered:** Introduction of DSP Processor, Computer Architecture, Von Neumann architecture, Harvard Architecture, Modified Harvard Architecture, Pipelining, SIMD, VLIW and Superscalar, General purpose digital signal processors, Fixed point digital signal processor, Floating point digital signal processing, Study of DSP processors such as TMS320C5X, TMS320C6X, Programming Methodologies of DSPs, Assembly level, High Level language (using C/C++ and Cross compilers), System Based (using MATLAB /Simulink and cross compilers).

**Print Shots of SKU-Digital Signal Processing:**

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### Non Sinusoidal Signal

Any non-sinusoidal signal can be decomposed into the sum of sine waves.

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### Multidimensional Signal:

Mathematical function of three or more variables.  
For example – video signal (moving picture).

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### Fourier Series

Fourier Series is a mathematical tool to REPRESENT continuous time periodic signal with frequency components.

Time Domain → Fourier Series → Output Amplitude Spectrum

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### Frequency Resolution of DFT

$X(\omega)$  is divided into 'N' discrete points, called as N - point DFT.  
Frequency Resolution of DFT is decided by Number of DFT point 'N'.

Better frequency resolution

**Multichannel Signals :**  
 Signals are generated by multiple sources.

$$x(n) = \begin{bmatrix} x_1(n) \\ x_2(n) \\ x_3(n) \end{bmatrix}$$

Multichannel Signal

**Multidimensional Signal :**  
 A signal is a function of multi independent variables.

$I(x,y,t) \rightarrow \begin{cases} R & I_r(x,y,t) \\ G & I_g(x,y,t) \\ B & I_b(x,y,t) \end{cases}$

**Correlation**

**RADAR System**

Transmitted Signal

Reflected Signal

Delayed Signal + Noise

Transmitter

Receiver

**One-Dimensional Signal:**  
 Mathematical function of **one** variable.  
 For example – speech signal.

Time