**Course Profile**

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| **Course Title:** Digital Signal Processing | | **Course Code:** ETE 321 |
| **Credit:** 3.0 | **Total Mark:** 100 | **Contact Hour:** 1.5 hr |

**Rationale:** Digital Signal Processing (DSP) is one of the hottest areas in circuit branches. DSP is a regular course for ETE, CSE, IT and EEE students, both in Undergraduate and in Post Graduate Level. DSP has also found applications in all engineering disciplines. However, critical understanding of the concepts from both theoretical and practical dimension is still lacking. This training program will help the faculty and students to bridge this gap and enable them to better concepts for real life applications. Here we learn about MATLAB.

**Objective:** Upon completion of this course student will be able to:

* Apply digital signal processing fundamentals.
* Understand the processes of analog-to-digital and digital-to-analog conversion.
* Master the representation of discrete-time signals in the frequency domain, using z-transform, discrete Fourier transform (DFT), and cosine transform.
* Understand the implementation of the DFT in terms of the FFT, as well as some of its applications (computation of convolution sums, spectral analysis).
* Learn the basic forms of FIR and IIR filters, and how to design filters with desired frequency responses.
* Appreciate relationships between first order low pass, and high pass filters, and between second-order Peaking and Notching filters. Design digital filters using MATLAB.
* Use appropriate windows to diminish the effect of leakage.
* Demonstrate the effect of the time window length on the achievable spectral resolution.
* Learn the design procedures for filter bank.
* Do a time-frequency analysis of a signal.
* Become aware of some applications of digital signal processing.

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| **Learning Outcomes** | **Course Content** | **Teaching Learning Strategy** | **Assessment Strategy** |
| 1. About the signals, systems and signal processing. 2. Basic Elements of a Digital Signal Processing System. 3. Advantages of Digital over Analog Signal Processing 4. Classifications of Signals. 5. Analog-to-Digital and Digital –to-Analog Conversion.   . | **Chapter 1.Signals, Systems, and Signal Processing**  1.1 Definition of Signals and Signal processing systems  1.2 Block Diagram of a Digital Signal Processing  1.3 Classifications of Signals  The Concept of Frequency in Continuous-Time and Discrete-Time Signals. | Lecture, Discussion, Problem based learning, Exercise. | Assignment, Q/A, MCQ |
| 1. Understand the Multichannel and Multidimensional Signals. 2. Continuous-Time Versus Discrete- Time signals 3. Identify Continuous-valued Versus Discrete-Valued Signals | **Chapter 2Classifications of Signals**  2.1 Classifications of Signals.  Multichannel and Multidimensional Signals.  2.2 Continuous-Time Versus Discrete- Time signals.  Identify Continuous-valued Versus Discrete-Valued Signals.  2.3 Deterministic Versus random Signals | Lecture, Discussion, Problem based learning, Exercise | Do |
| 1. A brief review of some basic and related terms. 2. Basic parts of an analog-to-digital Converter. 3. Sampling process 4. Quantization of sinusoidal Signals 5. Digital and Analog converter | **Chapter 3**. **Analog-to Digital and Digital-to-Analog Conversion**  3.1 A brief review of some basic and related terms.   * Sampling, Quantization, Coding   3.2 Sampling of Analog Signals  The Sampling Theorem  3.3 Quantization of Continuous-Amplitude Signals.  Quantization of sinusoidal Signals. | Lecture, Discussion, Problem based learning, Exercise | Do |
| 1. Describe the basics of linear time-invariant systems and systems. 2. Determine whether a system is linear, time-invariant, and causal. 3. Represent continuous-time linear systems by differential equations, and discrete-time linear systems by difference equations. 4. Find the output of a simple linear system by solving its differential or difference equation. 5. Find the output of a simple linear system through convolution techniques. | **Chapter 4. Analysis of Discrete-Time Linear Time-Invariant Systems.**  4.1 The basics of linear time-invariant systems and systems.  Techniques for the Analysis of Linear systems.  4.2 Resolution of a Discrete-Time Signal into Impulses  Response of LTI system to arbitrary Inputs: The convolution Sum.  4.3 Properties of Convolution and the Interconnection of LTI System. | Lecture, Discussion, Problem based learning, Exercise | Do |

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| 1. Determine the responses of linear systems to simple inputs using Fourier transform techniques. 2. Use the discrete Fourier transforms (DFT) to approximate the discrete-time Fourier transform (DTFT) of discrete-time signals. 3. Determine the responses of continuous time linear systems to simple inputs using Laplace transform techniques. 4. Determine the responses of discrete time linear systems to simple inputs using *z*-transform techniques. 5. Use MATLAB to plot signals. 6. Use MATLAB to generate computer implementations of the techniques for analysis and design of linear systems discussed in this course. | **Chapter 5**:**Analysis of Discrete-Time Linear Time-Invariant Systems. (Cont.)**  5.1 Causal Linear Time-Invariant System  Stability of Linear Linear-Time-Invariant Systems.  5.2 Systems with Finite-Duration and Infinite-duration Impulse Response.  5.3 MATLAB to generate computer implementations of the techniques for analysis and design of linear systems discussed in this course**.** | Lecture, Discussion, Problem based learning, Exercise | Do |
| 1. Understand the Definition and basic functions of correlation of Discreet Time signal. 2. Response of LTI Systems to Arbitrary Inputs: The correlation Sum. 3. Draw the Graphical computation of correlation system. 4. Understand the Properties of Correlation | **Chapter 6: Correlation of Discrete Time Signal**  6.1 Definition of correlation of discrete time signal.  Equation of correlation function and explanation.  6.2 Properties of Correlation of discrete time signal.  Cross correlation and Autocorrelation Sequences  6.3 Mathematical proved of the Properties of Correlation  Graphically representation by using MATLAB.  6.4 Computation of Correlation Sequences. | Lecture, Discussion, Problem based learning, Exercise | Do |
| 1. Understand the Definition and basic functions of convolution of Discreet Time signal. 2. Response of LTI Systems to Arbitrary Inputs: The Convolution Sum. 3. Draw the Graphical computation of convolution. 4. Understand the Properties of Convolution Systems. 5. Uses of convolution system.   . | **Chapter 7:Convolutions of Discrete Time Signal**  7.1 Definition of convolution of discrete time signal.  Equation of convolution function and explanation.  7.2 Properties of convolution of discrete time signal.  7.3 Mathematical proved of the Properties of convolution  Graphically representation by using MATLAB.  7.4 Computation of Correlation Sequences. | Lecture, Discussion, Problem based learning, Exercise | Do |
| 1. Become familiar with the computation of the z-transform of various signals and with the determination of the ROC. 2. Learn and understand the properties of the z-transform and how these can be used to simplify the computations. 3. Learn the process of inverting the z-transform by using the method of partial-fraction explanation. 4. Understand how LTI systems are represented in the z-domain and the relationships to the frequency response. | **Chapter 8. The z- transform and It’s Application to the of LTI**  **System.**  8.1 Definition of the Direct z-transform and The inverse z-transform. Determination the z-transform of the signal.  8.2 Region of convergence for x(z) and its corresponding causal and ant causal.  8.3 Properties of the Z-transform.  8.4 The inverse z-transform.  Representation of an LTI system in the z-transform.  Solution of difference equations. | Lecture, Discussion, Problem based learning, Exercise | Do |
| 1. Understanding the about rational z-transform of discrete-time signals. 2. Understand the poles and Zeros function and can draw the poles and zeros of the signal. 3. Understand the properties of the z-transform. 4. Response of Systems with Rational System Functions. | **Chapter** 9:**Rational z-transform**  9.1 Briefly Discussion of Rational z-Transform.  Definition of Poles and Zeros.  9.2 Pole Location and Time-Domain Behavior for Causal Signals.  Pole-Zero Plot and the ROC.  Poles and Zeros of the Rational z-Transform  9.3 The System Function of a Linear Time-Invariant System.   * The System Function of LCCDEs. | Lecture, Discussion, Problem based learning, Exercise | Do |
| 1. Understanding the inverse transform for discrete-time signals. 2. Understand the properties of the inversion of the z-Transform. 3. Ability to compute transform and inverse transform 4. Ability to apply transform for analyzing linear time invariant (LTI) systems. | **Chapter 10:Inversion of the z-Transform.**  10.1 Briefly Discussion of Inversion of the z-transform.  The Inverse z-Transform by Contour Integration.  10.2 The Inverse z-Transform by Power Series Expansion.  The Inverse z-Transform by Partial-Fraction Expansion.  10.3 Decomposition of rational Z-transform. | Lecture, Discussion, Problem based learning, Exercise | Do |
| 1. Understand the Fourier series for Discrete-Time Periodic and Aperiodic Signals. 2. Understand the Power Density Spectrum of Periodic Signals. 3. Learn the process of Convergence of the Fourier Transform. 4. Understand About the process Energy Density Spectrum. 5. Relationship of the Fourier Transform of the   Fourier Transform to the z-Transform. | **Chapter 11.Frequency analysis of Discrete-Time Signals)**  11.1 Definition and Discussion about the Fourier Series for Discrete-Time Periodic Signals.  Power Density Spectrum of Periodic Signals.  11.2 The Fourier Transform of Discrete-Time Aperiodic Signals.  Convergence of the Fourier Transform.  11.3 Energy Density spectrum of periodic and Aperiodic Signals.  11.4 Relationship of the Fourier Transform to the z-Transform.  Frequency Domain Classification of Signals: The concept of Bandwidth. | Lecture, Discussion, Problem based learning, Exercise | Do |
| 1. Understand the basic theory of the Discrete Fourier Transform and the mathematical representations. 2. Learn the process of Frequency Domain Sampling and Reconstruction of Discrete-Time Signals. 3. Understand the relationship of the DFT to other Transform. 4. Can understand the properties of the Discrete Fourier Transform. | **Chapter 12.Discrete Fourier Transform**  12.1 Definition and Discussion about the Discrete Fourier Transform.  12.2 Frequency- Domain Sampling and Reconstruction of Discrete-Time signals.  The DFT as a Linear Transformation.  12.3 Relationships of the DFT to other Transforms.  12.4 Properties of the DFT.  Periodically, Linearity, and Symmetry properties. | Lecture, Discussion, Problem based learning, Exercise | Do |
| 1. Learn the process of Frequency Domain Sampling and Reconstruction of Discrete-Time Signals. 2. Understand the relationship of the DFT to other Transform. 3. Understand the properties of the Discrete Fourier Transform. | **Chapter 13.Properties of the DFT**13.1Definition and Discussion about the Discrete Fourier Transform.  13.2 Frequency- Domain Sampling and Reconstruction of Discrete-Time signals.  The DFT as a Linear Transformation.  13.3 Relationships of the DFT to other Transforms.  13.4 Properties of the DFT.  Periodically, Linearity, and Symmetry properties. | Lecture, Discussion, Problem based learning, Exercise | Do |
| 1. Describe the response of systems with rational systems function. 2. Determine the pole-zero systems with non -zero Initial Conditions. 3. Determine the frequency components of signals using the Fourier transform. 4. Use the discrete Fourier transforms (DFT) to approximate the discrete-time Fourier transform (DTFT) of discrete-time signals | **Chapter 14**. **Analysis of Linear Time-Invariant Systems in the z-domain.**  14.1 Response of systems with rational system in the z-domain.  Response of Pole-zero systems with Nonzero initial conditions.  14.2 Transient and steady-State Response.  Causality and stability.  Pole-Zero Cancellations.  14.3 Multiple-Order Poles and Stability.  Stability of second-Order Systems. | Lecture, Discussion, Problem based learning, Exercise | Do |
| 1. Understand the operation of the filters and describe them in the frequency domain from their magnitude characteristics. 2. Design low pass, high pass, band pass and notch filters, comb filters, all pass filters. 3. Collaborate with fellow students in a team, in order to solve complex filter design and implementation problems. | **Chapter 15**. **Linear Time-Invariant systems as 15.1 Frequency Selective Filters.**  The basic principles of the filters and its division.  15.2 General theory of the signal filtration, filter parameters and its derivation. I  Ideal Filter characteristics:  Low pass, High pass, Band pass and All pass filter.  15.3 Design Low pass, High pass, Band pass and All pass filter.  15.4 Notch Filter, Comb Filter, Digital Sinusoidal Oscillators. | Lecture, Discussion, Problem based learning, Exercise | Do |
| 1. Determine the Direct form Structure. 2. Determine the Cascade-Form Structure. 3. Describe the frequency-sampling Structures. 4. Find out the lattice Structure. | **Chapter 16**. **Structures for FIR Systems**  16.1 Introduction the Structure for FIR Systems.  Direct form Structure.  16.2 The frequency-sampling Structures.  Lattice Structure  16.3 Practice of Example | Lecture, Discussion, Problem based learning, Exercise | Do |
| * 1. Determine the Direct form Structure.   2. Determine the Cascade-Form Structure.   3. Determine Parallel-Form Structures   4. Determine the Lattice and Lattice-Ladder Structures for IIR Systems. | **Chapter 17. Structures for IIR Systems**  17.1 Introduction the Structure for IIR Systems.  Direct form Structure.  17.2 Signal Flow Graphs and Transposed Structure.  Cascade-Form structure.  17.3 Parallel-Form structure.  Lattice and Lattice-Ladder Structure for IIR systems. | Lecture, Discussion, Problem based learning, Exercise | Do |
| 1. Understand the basic concepts about Design Filter and mathematical representation and its properties. 2. Design of Linear-Phase FIR Filters Using Windows. 3. Design of Linear-Phase FIR Filters by the Frequency-Sampling Method. 4. Comparison of Design Methods for Linear –Phase FIR Filters. | **Chapter 18:FIR filter design**  18.1 Basic theory of Digital Theory and mathematical function.  18.2 Symmetric and Ant symmetric FIR Filters.  Design of Linear-Phase FIR Filters using Windows.  Design of Linear-Phase FIR Filters by the Frequency- Sampling Method.  18.3 Design of FIR Differentiators.  Comparison of Design Methods for Linear-Phase FIR filters. | Lecture, Discussion, Problem based learning, Exercise | Do |
| 1. Understand the basic concepts about Design Filter and mathematical representation and its properties. 2. Design IIR Filter by Approximation of Derivatives. 3. Design IIR Filter by Impulse Invariance. 4. Determine the characteristics of commonly used Analog Filters. | **Chapter 19**.**IIR filter design.**  19.1 Basic theory of Digital Theory and mathematical function.  Design IIR Filter by Approximation of Derivatives.  19.2 Design IIR Filter by Impulse Invariance.  IIR Filter Design by the Bilinear Transformation.  19.3 Characteristics of commonly used Analog Filters.  Some Examples of Digital Filter Designs Based on Bilinear Transformation. | Lecture, Discussion, Problem based learning, Exercise | Do |
| 1. Determine the Frequency Domain Sampling and Reconstruction of Discrete-Time Signals. 2. Interpret and apply Discrete Fourier Transform and FFT algorithm. 3. Analyze the Relationship of the DFT to other Transform. | **Chapter 20. The Discrete-Fourier Transform– Frequency Domain Sampling: The Direct Fourier Transform.**  20.1 Introduction to The Direct Fourier Transform.  Frequency-Domain Sampling and Reconstruction of Discrete-Time Signals.  20.2 The Discrete Fourier Transform (DFT).  The DFT as a linear Transformation.  20.3 Relationship of the DFT to other Transforms. | Lecture, Discussion, Problem based learning, Exercise | Do |

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| 1. Determine the Periodically, Linearity, and Symmetry Properties. 2. Analyze the additional DFT properties. | **Chapter 21The Discrete-Fourier Transform- Properties of the DFT.**  21.1 Periodically, Linearity, and Symmetry Properties.  Multiplication of Two DFTs and Circular Convolution.  21.2 Additional DFT properties.  21.3 Relationship of the DFT to other Transforms. | Lecture, Discussion, Problem based learning, Exercise | Do |
| 1. Describe the factors that led Determine efficient computation of the DFT. 2. Design Radix-2 FFT Algorithms. 3. Design Radix-4 FFT Algorithms. 4. Split-Radix FFT Algorithms. | **Chapter 22**. **Efficient Computation of the DFT: Fast Fourier Transform Algorithms. 22.1**  Direct Computation of the DFT.  Divide-and-Conquer Approach to Computation of the DFT.  22.2 Radix-2 FFT Algorithms.  Radix-4 FFT Algorithms.  1.3 Split-Radix FFT Algorithms.  Implementation of FFT Algorithms. | Lecture, Discussion, Problem based learning, Exercise | Do |
| 1. Determine efficient computation of the DFT. 2. Design Radix-2 FFT Algorithms. 3. Design Radix-4 FFT Algorithms. 4. Split-Radix FFT Algorithms. | **Chapter 23**. **Applications of FFT Algorithms**.  23.1 Applications of FFT Algorithms.  Efficient Computation of the DFT of Two Real sequences.  23.2 Efficient Computation of the DFT of a 2N-Point Real sequence.  23.3 Use of the FFT Algorithm in Linear Faltering and Correlation. | Lecture, Discussion, Problem based learning, Exercise | Do |
| 1. Interpret Sampling of Band pass Signals. 2. Represent of Band pass filter. 3. Determine Sampling and Band pass Signals | **Chapter 23**. **Sampling and Reconstruction of Signals.**  24.1 Direct Computation of the DFT.  Divide-and-Conquer Approach to Computation of the DFT.  24.2 Radix-2 FFT Algorithms.  Radix-4 FFT Algorithms.  24.3.Split-Radix FFT Algorithms.  Implementation of FFT Algorithms. | Lecture, Discussion, Problem based learning, Exercise | Do |

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| **Recommended Books and Materials** | |
| ***Text Books:***   1. Digital Signal Processing , principles , Algorithms and Applications, Third Edition , John. G. Proakis, Dimitris G. Manolakis | ***References:***   1. Digital Signal Processing, Sanjit K. Mitra . |