National University of Sciences & Technology (NUST)
School of Electrical Engineering and Computer Science (SEECS)
Department of Electrical Engineering

# Digital Signal Processing

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| **Course Code:** | EE-330 | **Semester:** | 6th |
| **Credit Hours:** | 3+1 | **Prerequisite Codes:** | EE-232 Signals and Systems |
| **Instructor:** | Dr. Ahmad Salman | **Class:** | BEE12-CD |
| **Office:** | B205 IAEC | **Telephone:** | +92-51-90852559 |
| **Lecture Days:** | Tue, Thu, Fri | **E-mail:** | ahmad.salman@seecs.edu.pk |
| **Class Room:** | SEECS CR-05 | **Consulting Hours:** | Prior appointment via email |
| **Lab Engineer:** | Engg. Kalim Ullah, Engg. Munadi Sial | **Lab Engineer Email:** | kalim.ullah@seecs.edu.pk<br>munadi.sial@seecs.edu.pk |
| **Knowledge Group:** | DSSP | **Updates on LMS:** | After every lecture |

## Course Description:

The purpose of this course is to develop physical and mathematical significance of Digital Signal Processing from theoretical, application and implementation perspectives. The topics include a quick review of Discrete-Time signals and systems, z-transform and Discrete-Time Fourier transform (DTFT). This is followed by review of sampling of bandlimited signals and an introduction to multirate systems. A good portion of the course focuses on the frequency domain analysis of systems and the structures for system implementation. Different techniques for filter design against given specifications are then introduced with their practical significance. Discrete Fourier Transform (DFT) is then introduced as a practical spectral analysis tool followed by algorithms for efficient computation of DFT. Lastly, topics related to linear prediction analysis and power spectral estimation will be covered.

## Course Objectives:

- Develop understanding of Digital Signal Processing theory and applications
- A natural extension of signals and systems and digital signal processing
- In depth formalization of fundamental signal processing tools
- Develop a capability to appreciate the physical significance of signal processing techniques and to understand use of these tools
- Develop a mathematical foundation for advanced signal processing techniques

## Course Learning Outcomes:

| CLO | Description<br>After the completion of the course the students will be able to: | BT Level | PLOs |
|---|---|---|---|
| 1. | **Perform** digital sampling and sampling rate conversion operations of decimation and interpolation. | C2 | 1 |
| 2. | **Apply** the concept of frequency responses based on pole-zero positions, minimum phase/all-pass decomposition, linear phase systems in DFT tools for spectral **analysis** | C4 | 2 |
| 3. | **Design** FIR and IIR filters against given specifications | C5 | 3 |
| 4. | **Conduct** experiments on as well as **analyze** and **interpret** experimental digital signals | P4 | 4 |
| 5. | **Demonstrate** DSP concepts through practical labs using DSP Hardware Starter Kits and MATLAB software | P4 | 5 |
| 6. | **Exhibit** good professional and ethical behavior while **adhering** to lab safety rules. | A3 | 8 |
| 7. | **Function** effectively both individually and as a member of a team | A3 | 9 |

**Mapping of CLOs to Program Learning Outcomes**

| PLOs/CLOs | CLO1 | CLO2 | CLO3 | CLO4 | CLO5 | CLO6 | CLO7 |
|---|---|---|---|---|---|---|---|
| PLO 1 (Engineering Knowledge) | √ | | | | | | |
| PLO 2 (Problem Analysis) | | √ | | | | | |
| PLO 3 (Design/Development of Solutions) | | | √ | | | | |
| PLO 4 (Investigation) | | | | √ | | | |
| PLO 5 (Modern tool usage) | | | | | √ | | |
| PLO 6 (The Engineer and Society) | | | | | | | |
| PLO 7 (Environment and Sustainability) | | | | | | | |
| PLO 8 (Ethics) | | | | | | √ | |
| PLO 9 (Individual and Team Work) | | | | | | | √ |
| PLO 10 (Communication) | | | | | | | |
| PLO 11 (Project Management) | | | | | | | |
| PLO 12 (Lifelong Learning) | | | | | | | |

**Assessment Modules, Weightages, and Mapping to CLOs**

| Assessments/CLOs | CLO1 | CLO2 | CLO3 | CLO4 | CLO5 | CLO6 | CLO7 |
|---|---|---|---|---|---|---|---|
| Assignments: 5% | √ | √ | √ | | | | |
| Quizzes: 10% | √ | √ | √ | | | | |
| Midterms: 25% | √ | √ | | | | | |
| Labs:25% | | | | √ | √ | √ | √ |
| End Semester Exam: 35% | √ | √ | √ | | | | |

**Books:**

**Text Book:**
1. Discrete Time Signal Processing, A. V. Oppenheim and R. W. Schaffer, 3rd Edition, 2010.
2. Lecture Notes.

**Reference Books:**
1. Understanding Digital Signal Processing, R. G. Lyons, 3rd Edition, 2011.
2. Digital Signal Processing: Principles, Algorithms and Applications, J. G. Proakis and D. G. Manolakis, 4th Edition, 2007.
3. Signal Processing First, McClellan, Shafer and Yoder, 2nd Edition, 2008.

**Lecture Breakdown:**

| Chapter | Topics | Sections |
|---|---|---|
| 2 | Intro., Discrete Time Signal :Sequences | 2.0 |
| | Discrete Time Systems | 2.1 |
| 2 | LTI Systems, Properties of LTI Systems | 2.3, 2.4 |
| | Linear Constant Coefficient Difference Equation | 2.5 |
| 2 | Frequency Domain Rep of Discrete Time Signals and Systems | 2.6 |
| 3 | Z-Transform | 3.1 |
| | Properties of ROC for Z-Transform | 3.2 |
| 3 | Inverse Z-Transform | 3.3 |
| | Z-Transform Properties | 3.4 |
| 4 | Periodic Sampling | 4.1 |
| | Frequency domain representation of sampling | 4.2 |
| 4 | Reconstruction of a bandlimited signal from its | 4.3 |

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| | samples | |
| 4 | Discrete time processing of continuous time signals | 4.4 |
| 4 | Continuous time processing of discrete time signals | 4.5 |
| 4 | Changing sampling rate using discrete time processing | 4.6 |
| 4 | Digital processing of analog signals | 4.8 |
| 5 | Frequency response of LTI Systems<br>System functions for systems characterized by Linear Constant-Coefficient Difference Equations | 5.1<br>5.2 |
| 5 | Frequency Response of Rational System Functions | 5.3 |
| 5 | Relation b/w Magnitude and Phase<br>All Pass Systems | 5.4<br>5.5 |
| 5 | Minimum Phase System | 5.6 |
| 5 | Linear Systems with Generalized Linear Phase | 5.7 |
| 6 | Block Diagram Representation of Linear Constant Coefficient Difference Equation<br>Signal Flow Graph Representation | 6.1<br>6.2 |
| 6 | Basic Structures for IIR Systems<br>Transposed Forms | 6.3<br>6.4 |
| 6 | Basic Structure for FIR Systems | 6.5 |
| 7 | Analog Filter Design Basics | 7.0 |
| 7 | Design of IIR Filters | 7.1 |
| 7 | Design of FIR Filters | 7.2 |
| 8 | Fourier Transform of Periodic Signals<br>Sampling of Fourier Transform | 8.3<br>8.4 |
| 8 | Discrete Fourier Transform<br>Properties of Discrete Fourier Transform | 8.5<br>8.6 |
| 8 | Linear Convolution using Fourier Transform | 8.7 |
| 9 | Efficient Computation of Discrete Fourier Transform | 9.1 |
| | Course Review | |

| **Tools / Software Requirement:** |
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| Mathworks Matlab |

**Grading Policy:**

**Quiz Policy:**

- In order to give practice and comprehensive understanding of subject, in-class quizzes will be given. Approximately 6-8 quizzes will be taken during the entire semester.
- There will be no retakes opportunities for quizzes.
- Quizzes will be unannounced and normally last for 10-15 minutes.
- The question framed is to test the concepts involved in current or last lecture.
- There will be no best-of grading policy.
- Grading for quizzes will be on a scale of 0 to 10.
- A score of 10 indicates an exceptional attempt towards the answer and a score of 1

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| | indicates your answer is entirely wrong but you made a reasonable effort towards the solution. Scores in between indicate very good (8-9), good (6-7), satisfactory (4-5), and poor (2-3) attempt. Failure to make a reasonable effort to answer a question scores a 0. |
| **Assignment Policy:** | • In order to give practice and comprehensive understanding of subject, home assignments will be given.<br>• Late assignments will be accepted with a 30% penalty of the assignment total.<br>• All assignments will count towards the total (No 'best-of' policy). The students are advised to do the assignment themselves. Copying of assignment is highly discouraged and taken as cheating case and will be forwarded for disciplinary action. The questions in assignment are more challenging to give students the confidence and extensive knowledge about the subject and enable them to prepare for the exams. |
| **Lab Conduct:** | • Each week, there will be three-hour session of lab work<br>• At end of each lab, a lab quiz will be conducted and marked of 10.<br>• The list of lab works and their handouts are kept in a separate folder in the DSSP & Communication Laboratory of SEECS. |
| **Plagiarism:** | • SEECS maintains a strict no tolerance plagiarism policy that applies for quizzes, assignments, exams and any other assessment tools.<br>• While collaboration in this course is highly encouraged, you must ensure that you do not claim other people's work/ idea as your own. Plagiarism occurs when the words, ideas, assertions, theories, figures, images, programming codes of others is presented as your own work.<br>• You must cite and acknowledge all sources of information in your assignments.<br>• Failing to comply with the SEECS plagiarism policy will lead to strict penalties including zero marks in assignments and report to the academic coordination office for disciplinary action. |