14:332:346 Digital Signal Processing

Course Catalog Description: 14:332:346 Digital Signal Processing (3) Introduction to digital signal processing, sampling and quantization, A/D and D/A converters, discrete time systems, convolution, z-transforms, transfer functions, digital filter realizations, fast Fourier transforms, analog & digital filter design, digital audio applications.

Pre-Requisite Courses: 14:332:345 (and 347) - Linear Systems and Signals (and Lab). C or MATLAB programming experience is required.

Co-Requisite Courses: 14:332:348 (mandatory associated DSP lab)

Pre-Requisite by Topic:  
1. Complex numbers and trigonometry  
2. Differential and integral calculus  
3. Linear time-invariant systems  
4. Convolution and transfer functions  
5. Laplace transforms and z-transforms  
6. Difference equations

Textbook & Materials:  

References:  

Overall Educational Objective:  
To introduce the basic principles, methods, and applications of digital signal processing, emphasizing its algorithmic, computational, and programming aspects.

Course Learning Outcomes:  
A student who successfully fulfills the course requirements will have demonstrated:  
1. Understanding of the two key DSP concepts of sampling and quantization, and the practical issues involved in sampling, aliasing, and analog reconstruction of signals, and in choosing and defining specifications for anti-aliasing pre-filters and anti-image post-filters.  
2. Understanding of the quantization process and some practical implementations of A/D and D/A converters such as the conversion algorithm for bipolar two's complement successive approximation converters.  
3. Understanding of basic discrete-time systems concepts, such as linearity, time-invariance, impulse response, convolution, FIR and IIR filters, causality, stability, z-transforms, transfer functions, frequency response, time constants, transient and steady-state response.  
4. Understanding of how to implement digital filters in software and hardware, using block processing methods based on convolution, or real-time sample-by-sample processing methods based on block diagram realizations that are implemented with linear or circular delay-line
buffers.
5. Ability to translate a filter’s transfer function into block-diagram realizations, such as direct,
canonical, transposed, and cascade forms. And conversely, the ability to start with a given block
diagram, determine its transfer function, and translate it into a real-time processing algorithm
implementable in software or hardware.
6. Understanding of various digital filter design methods meeting prescribed specifications, such
as pole/zero placement or bilinear transformation methods, and appreciating design tradeoffs
between the specifications and filter order, time constant, and pole locations.
7. Understanding of the discrete Fourier transform and the fast Fourier transform and their use in
spectral analysis, data compression, and fast convolution. Understanding of the tradeoffs
between frequency resolution and signal duration and the use of windows for reducing frequency
leakage. Ability to perform short FFTs by hand.

How Course Outcomes are Assessed:

- Pre-requisite Quiz (ABET): 3%
- Homeworks (3% each): 12%
- Random attendance: 10%
- Midterm 1: 20%
- Midterm 2: 20%
- Final Exam (cumulative): 35%

N = none  S = Supportive  H = highly related

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<thead>
<tr>
<th>Outcome</th>
<th>Level</th>
<th>Proficiency assessed by</th>
</tr>
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<tbody>
<tr>
<td>(a) an ability to apply knowledge of Mathematics, science, and engineering</td>
<td>H</td>
<td>HW Problems, Exams</td>
</tr>
<tr>
<td>(b) an ability to design and conduct experiments and interpret data</td>
<td>N</td>
<td></td>
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<tr>
<td>(c) an ability to design a system, component or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability</td>
<td>S</td>
<td>Digital filter design examples meeting prescribed specifications</td>
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<td>(d) an ability to function as part of a multi-disciplinary team</td>
<td>N</td>
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<td>(e) an ability to identify, formulate, and solve ECE problems</td>
<td>H</td>
<td>HW Problems, Exams</td>
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<td>(f) an understanding of professional and ethical responsibility</td>
<td>N</td>
<td></td>
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<td>(g) an ability to communicate in written and oral form</td>
<td>S</td>
<td>HW Problems, exams</td>
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<td>(h) the broad education necessary to understand the impact of electrical and computer engineering</td>
<td>N</td>
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solutions in a global, economic, environmental, and societal context

(i) a recognition of the need for, and an ability to engage in life-long learning S Home-work, emphasized during lectures

(j) a knowledge of contemporary issues N

(k) an ability to use the techniques, skills, and modern engineering tools necessary for electrical and computer engineering practice H HW Problems, Exams

Basic disciplines in Electrical Engineering H HW Problems, Exams

Depth in Electrical Engineering S HW Problems, Exams

Basic disciplines in Computer Engineering H Programming DSP algorithms in C, MATLAB, and assembly language for DSP chips

Depth in Computer Engineering S Software and hardware programming

Laboratory equipment and software tools H Analog Devices DSP-2181 digital signal processor. Programming in C, MATLAB, and DSP software development environment

Variety of instruction formats S Lecture, office hour discussions

### Topics Covered week by week:

<table>
<thead>
<tr>
<th>Lecture</th>
<th>Topic</th>
<th>Exams</th>
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</thead>
<tbody>
<tr>
<td>1-3</td>
<td>Signal and Signal Processing</td>
<td></td>
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<tr>
<td>4</td>
<td><strong>Closed book</strong></td>
<td>PRE-REQUISITE QUIZ (3%)</td>
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<tr>
<td>5-7</td>
<td>Discrete-Time Signals and Systems</td>
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<tr>
<td>8</td>
<td><em>First Recitation</em></td>
<td></td>
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<tr>
<td>9-11</td>
<td>Discrete-Time Fourier Transform</td>
<td></td>
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<tr>
<td>12</td>
<td><em>Second Recitation</em></td>
<td>HW1 due</td>
</tr>
<tr>
<td>13</td>
<td><strong>Closed book</strong></td>
<td>MIDTERM 1 (20%)</td>
</tr>
<tr>
<td>14,15</td>
<td>Digital Processing of Continuous-Time Signals</td>
<td></td>
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<tr>
<td>16,17</td>
<td>Finite-Length Discrete Transform</td>
<td></td>
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<tr>
<td>18</td>
<td><em>Third Recitation</em></td>
<td>HW2 due</td>
</tr>
<tr>
<td>19-21</td>
<td>z-Transform</td>
<td></td>
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<tr>
<td>22</td>
<td><em>Fourth Recitation</em></td>
<td>HW3 due</td>
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<tr>
<td>23</td>
<td><strong>Closed book</strong></td>
<td>MIDTERM 2 (20%)</td>
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<tr>
<td>24, 25</td>
<td>LTI Discrete-Time Systems in the Transform Domain</td>
<td></td>
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<td>26, 27</td>
<td>Digital Filter Structure</td>
<td></td>
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<tr>
<td>28</td>
<td><em>Fifth Recitation</em></td>
<td>HW4 due</td>
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<td></td>
<td><strong>Closed book</strong></td>
<td>FINAL EXAM (35%)</td>
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Computer Usage:
DSP algorithm programming in C, MATLAB, and Assembly Language.

Laboratory Experiences:
14:332:348 Digital Signal Processing Laboratory (mandatory)

Design Experiences:
HW problems in designing digital filters using various techniques. In conjunction with 332:348, designing and programming real-time audio signal processing algorithms on DSP hardware.

Independent Learning Experiences:
1. Homework, 2.MATLAB programming, 3.Testing (Quizzes, Exams)

Contribution to the Professional Component:
(a) College-level Mathematics and Basic Sciences: 0.5 credit hours
(b) Engineering Topics (Science and/or Design): 2.5 credit hours
(c) General Education: 0.0 credit hours
Total credits: 3

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