

Rutgers University, Department of Electrical and Computer Engineering
ABET COURSE SYLLABUS
COURSE: 14:332:477

Course Catalog Description:	14:332:447 Digital Signal Processing Design (3) Applications of DSP algorithms in the areas of speech processing, image processing, radar, pattern recognition, and adaptive filtering using software implementations applied to realistic signals.
Pre-Requisite Courses:	14:332:346
Co-Requisite Courses:	None
Pre-Requisite by Topic:	<ol style="list-style-type: none">1. linear system theory2. Signal spectral analysis3. Digital Filtering techniques4. Digital Filtering design methods5. Signal representations (analytic signals)
Textbook & Materials:	C.S. Burrus, J. H. McClellan, C. Sidney, A. V. Oppenheim, T. Parks, R.W. Schafer, H. W. Schuessler, Computer-Based Exercises for Signal Processing Using MATLAB, Prentice Hall, 2003.
References:	S.J. Orfanidis, Introduction to Signal Processing, Prentice Hall, 1996. R.G. Gonzalez, R.E. Woods, S.L Eddins "Digital Image Processing using Matlab, Prentice Hall, 2004.
Overall Educational Objective:	<ol style="list-style-type: none">1.To introduce students to the software and hardware design principles involved in designing a DSP based system.2. To provide students a base for a further study of DSP based systems.
Course Learning Outcomes:	A student who successfully fulfills the course requirements will have demonstrated: <ol style="list-style-type: none">1. An ability to analyze the spectrum of a signal using the DFT, FFT, spectral windows and sliding widows2. An ability to understand in depth multirate processing including interpolation, decimation, and zooming3. An ability to understand Stochastic signals including non-stationary, stationary and ergodic processes, linear systems and stochastic systems4. An ability to use modern spectrum estimation techniques such as Maximum Entropy and methods based on linear prediction.5. A familiarity with adaptive filtering methods in the context of linear prediction models

6. A familiarity with Radar concepts including LFM chirp signals, Range, and velocity processing methods
7. A familiarity with Speech Modeling techniques including speech segmentation, short time Fourier analysis, and vocal tract models
8. A familiarity with signal modeling based on linear prediction with applications in speech processing and spectral analysis of random processes
9. A familiarity with the design specifications of a DSP based product will be obtained by creating a business plan

How Course Outcomes are Assessed:

In Class and Homework assignments (50 %)

Business Plan (30 %)

Prototype Demonstration (20 %)

N = none S = Supportive H = highly related

Outcome	Level	Proficiency assessed by
(a) an ability to apply knowledge of Mathematics, science, and engineering	S	HW Problems and in-class assignments
(b) an ability to design and conduct experiments and interpret data	H	Design problems in Class and HW, Design and Development of Prototype
(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	H	Creation of a business plan and prototype
(d) an ability to function as part of a multi-disciplinary team	H	Groups called companies are formed for each project
(e) an ability to identify, formulate, and solve ECE problems	H	Product design and implementation requires many ECE problems be solved
(f) an understanding of professional and ethical responsibility	H	Business Plan describes social impact
(g) an ability to communicate in written and oral form	H	Business plan is written and presented orally
(h) the broad education necessary to understand the impact of electrical and computer engineering solutions in a global, economic, environmental, and societal context	H	The creation of the business plan requires broad analysis
(i) a recognition of the need for, and an ability to engage in life-long learning	S	Discussion of product life cycle in business plan
(j) a knowledge of contemporary issues	H	Business plan discusses current needs of the market
(k) an ability to use the techniques, skills, and modern engineering tools necessary for electrical and computer engineering practice	H	Rapid prototyping using Matlab and Simulink with the target systems based on Linux, Gate arrays or DSP chips
Basic disciplines in Electrical Engineering	H	DSP algorithm design, Hardware specification, technical specs
Depth in Electrical Engineering	H	Advance algorithms for recognition, tracking etc
Basic disciplines in Computer Engineering	S	Matalb, Simulink
Depth in Computer Engineering	S	Use Case and project management tools are used in design
Laboratory equipment and software tools	S	MATLAB and SIMULINK
Variety of instruction formats	S	Lectures, Problem sessions, Office hour discussions

Topics Covered week by week:

Week 1:	Signal and Systems: Sampling Theory, Difference Equations, Convolution summation, Time-Domain Speech Processing, Quantization effects
Week 2:	The Discrete Fourier Transform: DFT Properties, DFT as a Matrix, Convolution (Circular and Block), Related Transforms, Direct Calculation of the DFT, The Cooley-Tukey FFT, Prime Factor FFTs, General-Length FFTs
Week 3:	Spectrum Analysis: Spectral Windows, Sliding-Window DFT, Narrowband Signals
Week 4:	Discrete-Time Filter Design: Discrete Design of FIR Filters, Least-Squares Design of FIR Filters, Chebychev Design of FIR Filters, Design of IIR Filters
Week 5:	Radar and Sonar Signal Processing: General Description of System Components, Range Determination, Pulse Compression, Velocity Measurement, Doppler Radars, Angle-of-Arrival Determination
Week 6:	Multi-rate Processing: Bandlimited Interpolation, Zoom Transform, Rate Changing
Week 7:	Stochastic Signals: Pseudo-random noise generators, Stochastic Signals, FFT Spectrum Estimation, Modern Spectrum Estimation
Week 8:	Signal Modeling with applications to speech: Linear Prediction, Linear Prediction of Speech, Exponential Modeling, Signal Estimation, Least-Squares Inversion
Week 9:	Adaptive Filters and Signal Modeling: Wiener (Stochastic) Filtering, LMS Algorithm, Adaptive Equalization, Adaptive Arrays, Design of Adaptive Echo Cancellers
Weeks 10 and 11:	Image Processing, Multidimensional Filters and Transforms, Image Models, Image Compression, Image Enhancement and Restoration, Image Segmentation
Weeks 12 - 14:	Pattern Recognition: Statistical classifiers, Clustering, Training and testing, Feature extraction, Neural network classifiers
Week 15:	Review
Week 16:	Final Examination

Computer Usage: Simulations using *Matlab*, *Simulink* and associated *Datablocks*.

Laboratory Experiences: There are in class assignments using Matlab and Simulink DSP toolkits to filter and process signals.

Design Experiences: 50% of the design experience comes from In-class and homework assignments based on predetermined Matlab/Simulink simulations. The remaining 50% is based on a group design. The students create a product oriented design project by the end of the course which can be used as a capstone project. For example, a product was proposed by one group which used DSP image processing methods to aid in parallel parking a car. The product is designed with a detailed technical specification document, a marketing plan and financial projections are estimated for the product. Legal and environmental issues are also incorporated in the resulting business plan which presents the proposed product.

Independent Learning Experiences: 1. Home-Work, 2. Computer-aided Simulation, 3. Testing (Quizzes, Exams)

Contribution to the Professional Component:

(a) College-level mathematics and basic sciences: 0.25 credit hours

(b) Engineering Topics (Science and/or Design): 2.75 credit hours

(c) General Education: 0 credit hours

Total credits: 3

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Date: July 2007