Digital Signal Processing EEET-425

Syllabus 2181 rev1

At the end of this course:

You will have demonstrated that you can **design a digital signal processing filter** that reduces noise and demonstrated that you can **make that filter run in real time** on digital signal processor / microprocessor hardware.

You will have **written a paper for your portfolio** in the IEEE journal format, which you can use in job interviews over the next 10 years to show your knowledge of DSP techniques.

You will **be able to converse with DSP experts** and understand some of the jargon, enabling you to learn more about the subject over your career.

You will **be able to explain to a non-expert some of the tradeoffs in the practical design of digital filters** including how datatypes affect memory usage, execution speed, and round off error and the pro's and con's of two common types of digital filters, namely FIR and IIR filters.

Course Name:	Digital Signal Processing
Number:	EEET-425
Credit Hours:	4
Prerequisites:	1016-304, Differential Equations for Engineering Technology
	0609-333, Concepts in Systems & Signals
	By remaining registered in this course, you are stating that you have met these requirements.

Course Time and Location:	**Lecture:**	TuTh 2:00 – 3:15 pm, Building-Room ENG-1545
	Lab1:	W 12:00 – 1:50 pm, Building-Room ENT-3125
	Lab2:	W 2:00 – 3:50 pm, Building-Room ENT-3125
	Lab3:	M 12:00 – 1:50 pm, Building-Room ENT-3125

Instructor:	Prof. David Orlicki Office: ENT 82-2154
	Phone: (585) 475-4276 or x5-4276 from on campus
	E-mail: dmoiee@rit.edu
Office Hours:	as posted outside office

Course Description:

A practical applied course in the processing of signals using digital techniques. Starts with foundational concepts in sampling, probability, statistics, noise, fixed and floating point number systems and describes how they affect real world performance of Digital Signal Processing (DSP) systems. Fundamental principles of convolution, linearity, duality, impulse responses, and discrete Fourier transforms are developed. FIR and IIR digital filters are designed. DSP techniques such as windowing are introduced. In Co-requisite lab, students get an integrative experience writing DSP code that executes on DSP hardware in real-time. (1016-304, 0609-333)

Rationale and Goals:

Signal processing is an essential component of many systems, including embedded systems. This course extends the concepts of continuous-time and discrete-time systems introduced in 0609-333, specifically convolution, system representations, the Fourier transform and presents the application of these concepts to processing of signals. The goal is to give students the knowledge to digitally process signals using both time and frequency domain representations. Hands-on experience with DSP hardware is provided in the laboratory exercises.

Intended Learning Outcomes:

A student who successfully fulfills the course requirements will have demonstrated the following:

Intended Learning Outcome (ILO's)	Assessment Methods
1. Demonstrate the application of statistics to assess signal to noise improvement and enhanced bit resolution through oversampling. PO#7:	Quizzes, Homework
2. Design FIR, IIR filters using a variety of techniques. PO#5,#7	Quizzes, Homework, Lab Experimentation
3. Analyze filter performance in time and frequency domain. Explain relations between time domain impulse response and frequency domain behavior. PO#7	Quizzes, Homework, Lab Experimentation
4. Understand and appropriately apply windowing techniques. PO#7	Quizzes, Homework, Lab Experimentation
5. Perform digital filtering, and spectrum analysis using tools such as matlab or excel. PO#5,#7	Quizzes, Homework, Lab Experimentation

Text book:

Required: The Scientist and Engineers Guide to Digital Signal Processing, by Steve W. Smith, California Technical Publishing.1997.

Optional: Digital Signal Processing and Applications with the TMS320C6713 DSK 2nd Edition, by Rulph Chassaing and Donald Reay, Wiley Interscience. 2008.

Material Covered / Percentage:

Statistics, Probability, Noise, A/D Conversion, DSP Number Systems	Chapters 1 through 4	20%
Convolution, Convolution properties, linearity	Chapters 5 through 7	10%
Discrete Fourier Transform, Transform Pairs, Spectral Analysis	Chapters 8 through 12	35%
Digital filter design FIR, IIR	Chapters 14 through 21 (omit chapter 18), 31, 33	35%

Foundational – Chapters 1 through 4
Fundamental concepts – Chapters 5 through 12, Chapter 31,33
Digital Filtering – Chapters 14 through 21 (omit chapter 18)
Additional Material – Audio Signal Processing – Chapter 22.

Evaluation Criteria
Several methods of evaluating course objectives will be employed including traditional testing and homework as well as online and/or out of class assessments.

Laboratory:

You must complete and pass the laboratory component of this course in order to receive a passing course grade.

Homework:

- There are eight (8) homework assignments.
  - o Assigned weekly
  - o Due one week after being assigned.
  - o Due at the start of class.
  - o Printed out on paper to facilitate faster grading.
  - o See the schedule spreadsheet at the end of this syllabus for details on the due dates and return dates.
  - o Two homework grades are dropped.

- Your solution must be neat, organized, properly formatted and correct for full credit. Ragged paper is unacceptable:
  - Place the following header information on each page of your assignment:
    - NAME and HOMEWORK #
    - DUE DATE and PAGE NUMBER (current_page OF total_pages)
  - Number each problem including the chapter it comes from.
  - Restate each problem and include any supporting diagrams or schematics that the problem statement refers to.
  - Your solution should be presented in a format that proceeds from left to right and top to bottom. If the organization of the solution is unclear, a grade of zero will be assigned.
  - Box-in the final answer for each problem and make sure you use the appropriate units and engineering notation.
  - Work that is illegible will receive a grade of zero.
  - Use a pencil and an eraser or a pen and whiteout, multiple cross-outs are unacceptable.
  - Make sure that all of the pages of your homework assignment are attached securely by using a staple in the upper-left-hand corner (do not use a paperclip or fold your page corners).
  - *LATE homework assignments* will be returned, un-reviewed, with a grade of zero.

- For **TEAM HOMEWORK PROBLEM(S)**:
  - The team homework problem(s) must also be submitted at the beginning of class one calendar week from when they are assigned. Follow the same format listed above except clearly place your *TEAM NAME and the individual members' names* who worked on the assignment on the top of the first page.
  - Any team member that does not work on this assignment will receive a zero for this portion of the weekly homework grade.

Labs:
- All laboratory exercises must be completed in order to receive credit for this course.
- Regardless of your test and quiz grades an "F" in the laboratory guarantees an "F" in the course. This is a departmental policy; there are no exceptions.
- Lab will use EXCEL, MATLAB and/or a digital signal processing board to perform various tasks related to the course material.

Final Project:

- In the last two weeks, you will design a digital signal processing algorithm for a medical monitoring device and implement that design in hardware, demonstrating that you can build a practical, functioning DSP filter.

- You will document your work in a report written in the IEEE journal paper format.

- Your final report must have sections which address the following aspects (as well as others)

   o 1) signal to noise ratio (SNR), 2) execution speed, 3) memory usage, 4) The type of filter used (FIR or IIR) and how it was designed, 5) frequency response of the filter.

- Additional details project will be provided during class and on mycourses. You will work with your lab team to complete the work and the team will submit one paper for grading.

Quizzes:

- Pre-lecture quizzes will be given on-line using mycourses.

- Quizzes close before lecture starts. Quizzes are time limited so you will have to read the text before beginning the quiz. You can take the quiz as many as three times and only your highest score is recorded. If you read the text, you should get 100% on the pre-class quiz.

- A random set of new questions is generated each time you take the quiz.

- The goal of the pre-lecture quiz is to guide you in recognizing the main points in the reading material before you attend lecture.

- Expect two or three unannounced on-paper quizzes during the quarter on recent course/lab material. These quizzes may take place anytime during class or lab. The goal of the post-lecture quiz is assess your grasp of the material. As such the questions will be more involved.

Midterm Exams

- You may bring one 8.5"x11" sheet with hand written equations, but no worked-out examples or homework problems, for use during the exam. Formula sheets must be submitted with your test. The test will be closed book.

- A make-up test will be considered only if the student informs the instructor of the absence prior to the test date. If prior notification is not possible, notification must take-place immediately following the exam (_leaving a detailed message on my voice-mail is acceptable_). In these cases a make-up test can be scheduled at the instructor's discretion but **will not receive a grade greater than 70%.**

Final Exam:

- Two formula sheets are permitted for the final exam. This exam will be a closed book, closed-note test. There will not be a make-up for the final.

Attendance and Course Participation:

- Students are responsible for all material covered in the readings, lecture, lab, and on the course web pages. This includes unforeseen changes to the quiz/exam schedules.

- Students are fully expected to attend class and participate in the team-based activities by working with their peers and the instructor.

Grading Policy:

Doing: Homework   10%   (8 homeworks, 2 dropped, 6graded)
                Labs   10%   (6 labs, none dropped, 6 graded)
                Final Project   20%   (one submission from each team)

Knowing:

                Pre-lecture Quizzes   15%   (15 quizzes, 2 dropped, 13 graded)
                Midterm exam(s)   25%   (2 midterms)
                Final exam   20%   (1 comprehensive, covers all material)

The final course-grade is based upon the following letter grade breakdown:

93.00-100.00	A
90.00-92.99	A-
87.00-89.99	B+
83.00-86.99	B
80.00-82.99	B-
77.00-79.99	C+
73.00-76.99	C
70.00-72.99	C-
60.00-69.99	D
0.00-59.99	F

Reasonable Accommodations:

RIT is committed to providing reasonable accommodations to students with disabilities. If you would like to request accommodations such as special seating or testing modifications due to a disability, please contact the Disability Services Office. It is located in the Student Alumni Union, Room 1150; the Web site is www.rit.edu/dso. After you receive accommodation approval, it is imperative that you see me during office hours so that we can work out whatever arrangement is necessary.

Special Needs:

Students that have special needs above the usual student, other than the student who is already classified as deaf or hearing impaired and listed on the class roster, must present documentation to the instructor to certify the nature of his or her needs at the beginning of the quarter. This will allow me to plan ahead to best serve you.

Incomplete ("I") and Withdraw ("W") grades:

Incomplete grades "I," will only be given after the "W" week of the semester for appropriate hardship situations (unexpected business trip, illness/death in the family, etc.). An incomplete grade <u>WILL NOT</u> be given to students failing and/or falling behind in their work.

Withdraw grades may be assigned through the designated week of the semester. In unusual circumstances that are *beyond the control of the student*, a "W" may be assigned after the designated week with the approval of the instructor, department chair, & dean. No credit hours are earned & your GPA is not affected by a "W" grade, however a 'W' will show on your transcript.   "Unusual circumstances" does not include poor or lacking performance and the instructor will not sign late 'W' requests unless documented circumstances warrant such action

Academic Honesty:

Rochester Institute of Technology does not condone any form of academic dishonesty. Any act of improperly representing another person's work as one's own is construed as an act of academic dishonesty.

These acts include, but are not limited to:

- Plagiarism in any form (including the use of all or parts of computer programs created by others without clearly indicating that you are not the author)
- The use of information and materials not authorized by the instructor during an examination

If a faculty member judges a student to be guilty of some form of academic dishonesty, the student may be given a failing grade for that piece of work, or for the entire course, depending upon the severity of the misconduct. If the student believes that the action taken by the instructor is incorrect, or that the penalty is too severe, the student may appeal to the Academic Conduct Committee of the college in which the course is offered.

Academic Integrity Statement:

As an institution of higher learning, RIT expects students to behave honestly and ethically at all times, especially when submitting work for evaluation in conjunction with any course or degree requirement. The Department of Electrical, Computer, and Telecommunications Engineering Technology encourages all students to become familiar with the RIT Honor Code and with RIT's Academic Honesty Policy.

- RIT Honor Code URL: http://www.rit.edu/studentaffairs/studentconduct/RITHonorCode1.htm

- RIT Academic Honesty Policy URL: http://www.rit.edu/studentaffairs/studentconduct/rr_academicdishonesty.php

Gender-based discrimination and/or harassment:

RIT is committed to providing a safe learning environment, free of harassment and discrimination as articulated in our university policies located on our governance website. RIT's policies require faculty to share information about incidents of gender based discrimination and harassment with RIT's Title IX coordinator or deputy coordinators, regardless whether the incidents are stated to them in person or shared by students as part of their coursework. If you have a concern related to gender-based discrimination and/or harassment and prefer to have a confidential discussion, assistance is available from one of RIT's confidential resources on campus (listed below).

1. The Center for Women & Gender: Campus Center Room 1760; 585-475-7464; CARES (available 24 hours/7 days a week) Call or text 585-295-3533.
2. RIT Student Health Center – August Health Center/1st floor; 585-475-2255.
3. RIT Counseling Center - August Health Center /2nd floor - 2100; 585-475-2261.
4. The Ombuds Office – Student Auxiliary Union/Room 1114; 585-475-7200 or 585-475-2876.
5. The Center for Religious Life – Schmitt Interfaith Center/Rm1400; 585-475-2137.
6. NTID Counseling & Academic Advising Services – 2nd Floor Lynden B. Johnson; 585-475-6468 (v), 585-286-4070 (vp).

Emergencies:

In the event of a University-wide emergency course requirements, classes, deadlines and grading schemes are subject to changes that may include alternative delivery methods, alternative methods of interaction with the instructor, class materials, and/or classmates, a revised attendance policy, and a revised semester calendar and/or grading scheme.

Student work on the Internet and in publications:

During this course, you will create assignments such as lab reports, final reports, etc. which may be published, in whole or in part, on publicly-accessible websites or in scholarly publications for purposes such as improving education and training. Your work will remain on these sites or in these publications after the end of the course. If you do not wish to make your work public in this way, please contact me in writing during the first week of class to make other arrangements.

Other Course Policies:

- Check the course conference (www pages) for additional course content, announcements or messages DAILY. If I need to contact you personally or the entire class, I will use the myCourses system so make sure that you check the conference daily and that your information is current in the RIT LDAP directory.

- I reserve the right to modify anything on this syllabus including reading assignments, lecture topics, quiz/test dates, homework assignments, etc. I will do so with plenty of notice via in-class announcements and/or using myCourses.

- E-mail will almost always be responded to within 24 hours during the workweek, please do not expect a 20-minute turnaround.

- Graded assignments will generally be returned to you within 7-10 days.

- Requests for the instructor to review a graded assignment must be received within 48 hours of the return of the assignment and will be honored at the instructor's discretion. Reviewing a graded assignment will result in a complete re-grade and may/may not have the desired outcome.

- Although you are EXPECTED and ENCOURAGED to utilize a study-group, individual and original efforts are expected for all exams, quizzes and homework assignments except when otherwise stated; for example team homework assignments are a team activity.

- Any student who is not actively participating in the lecture may be asked to leave.

- Cellular/PCS telephones, pagers, PDAs, etc. must be turned-off or put in vibrate mode during class. If your device disrupts the lecture, you may be asked to leave immediately. Upon a second offense, you will need to explain your actions to the ECTET Department Head before being allowed to return. *If you require an exception to this policy, please see me before creating a disturbance.*

  The devices mentioned above and all other electronic devices except approved calculators and watches must be placed out of your reach and sight during exams.

- You may not use a PDA, PPC, laptop, netbook or other computer, IPOD or similar device in-class or during quizzes or exams. *I know you may enjoy listening to music and instant-messaging while working but have to insist that you leave the distractions out of the classroom.*

- Bring the required textbook to all classes

Wk	Day	Date	Lecture topic	Reading due	Quiz on	HW assign	HW due	HW return
1	Tue	28-Aug	Course, Project Overview	1				
	Thu	30-Aug	Random Variables	2,	2	1 (ch2)		
2	Tue	4-Sep	Signal to Noise Calculations					
	Thu	6-Sep	3 ADC	3 pg 35-58, SUPL-AN804	3			
3	Tue	11-Sep	3-supl. AN-804: ADC dithering	3 multi-rate, SUPL-AN118		2 (ch 3)	1	
	Thu	13-Sep						
4	Tue	18-Sep	4, dsp math	4	4			
	Thu	20-Sep	4, dsp math			3 (ch 4)	2	1
5	Tue	25-Sep	5 linear systems	5, SUPL-diagnosis pneum	5	Lit. review		
	Thu	27-Sep	**MIDTERM** [1-4]					2
6	Tue	2-Oct	6 convolution	6	6	4 (ch 5,6,7)	3	
	Thu	4-Oct	7 convolution	7, SUPL-clinical indicator	7			
7	Tue	9-Oct	**October break: no classes**					
	Thu	11-Oct	FIR, IIR filters	SUPL-FIR,IIR filters			4	3
8	Tue	16-Oct	8 DFT	8	8	5 (ch 8,9)		
	Thu	18-Oct	9 applica. DFT	9	9			4
9	Tue	23-Oct	9 applica. DFT					
	Thu	25-Oct	10 Fourier Transform properties	10	10	6 (ch 10)	5	
10	Tue	30-Oct	IIR filters handout, 3 A/D sampling					
	Thu	1-Nov	11 FT pairs	11	11			5
11	Tue	6-Nov	12 FFT with Matlab tools					
	Thu	8-Nov	14,15 Moving Avg	12	12		6	6
12	Tue	13-Nov	**MIDTERM** [5-10]	14,15, SUPL-dew detector		7 (ch 15)		
	Thu	15-Nov	16 Windowed Sinc	16	16			
13	Tue	20-Nov	19 Recursive filter	19	19	8 (ch 16,19)	7	
	Thu	22-Nov	**Thanksgiving : no classes**					
14	Tue	27-Nov	20 Chebyshev filter	20				
	Thu	29-Nov	17 Custom filter	17	17		8	7
15	Tue	4-Dec	21 Filter Comparison	21				
	Thu	6-Dec	IIR Structures	supl. Notes 67,68,72		practice prob.		
16	Tue	11-Dec	**Reading Day: Final Exam Review**					8
		14-Dec	**FINAL EXAM** (Friday)					

Wk	week start	Lab assignment	Lab due	Lab return
1	27-Aug	1 (Intro to Hardware, IDE)		
2	3-Sep	**Labor Day Week: NO LABS**		
3	10-Sep	2 (ADC, SNR, Dither, std dev)	1	
4	17-Sep	2 (ADC, SNR, Dither, std dev)		1
5	24-Sep	3 (DataTypes, Memory, Speed	2	
6	1-Oct	3 (DataTypes, Memory, Speed		2
7	8-Oct	4 (Convolution FIR Filter)	3	
8	15-Oct	4 (Convolution FIR Filter)		3
9	22-Oct	5 (Freq. Response FIR, IIR)	4	
10	29-Oct	5 (Freq. Response FIR, IIR)		4
11	5-Nov	6 (IIR Filter Design)	5	
12	12-Nov	6 (IIR Filter Design)		5
13	19-Nov	**Thanksgiving Week: NO LABS**		
14	26-Nov	LM61 Equalizer/ Final Project	6	
15	3-Dec	Final Project Consulting		6
16	14-Dec	Final Project Due		