CpE 342: Real Time Digital Signal Processing
Dept. of ECE, Missouri S&T, fall 2010
Tue/Thu, 8:00-9:15 pm. Lecture & Lab: 210 EECH

Instructor: Dr. Y. Rosa Zheng
Dept. of Electrical and Computer Engineering, 225 EECH, 341-6632 (o), zhengyr@mst.edu

LEAD Sessions (tentative): Mondays 6:00 p.m. - 8:00 p.m. or Tuesdays 9:15 a.m. - 10:30 a.m.

Prerequisite:
- El Eng 215 (Discrete-Time Linear Systems) -- Discrete time signals, ADC/DAC, linear time invariant (LTI) systems, impulse response, z-transforms, and Discrete Fourier Transforms.
- Working knowledge of Matlab or C programming.

Important Notice
- In Joe’s SS, you have to register in the lab session first and then in the lecture session.
- Lab sessions are held during the regular class time. A lab session may last longer than a lecture session.

Course Description
Digital signal processing mainly deals with signal enhancement, noise and interference suppression, and signal analysis. DSP algorithms have found wide-spread applications in video, image, audio, speech, and other sensing signals. Real-time DSP aims to perform filtering and signal analysis in a timely manner to reduce excessive delay.

In this course, we will first study basic concepts and algorithms of digital signal processing, followed by the architecture of specialized digital signal processors (DSP chips), then we will focus on how to implement basic filters and DSP algorithms on the programmable DSP chips. We will use Texas Instruments floating point DSP platform (TMS320C6713) to implement real-time data acquisition, FIR/IIR filtering, and FFT algorithms. We will also cover interrupt-driven programming, frame processing, code optimization, quantization effects, and DSP applications. This course will bridge the knowledge gap between computer engineering which emphasizes embedded systems and electrical engineering which emphasizes signal processing algorithms.

Class Home Page: General information regarding the course can be found at the instructor's website at web.mst.edu/~zhengyr/. Course material will be posted on Blackboard at blackboard.mst.edu regularly.

DSP Evaluation Kit: We gratefully acknowledge the University Program of Texas Instruments for its generous donation of TMS320C6713 DSK and Code Composer Studio (CCS) to this course. This donation helped to establish a DSP teaching lab at Missouri S&T since 2006.

Textbook and Other References
The course will be mainly based on the instructor's notes and TI's web documentation. No textbook is required but the following textbooks and websites are very helpful and two of them are highly recommended.
  This book provides some coverage on DSP theory with reduced complexity and it is highly recommended for students with CpE background.


• **Digital Signal Processing and Applications with the C6713 and C6416 DSK** by Rulph Chassaing, Wiley, 2005. This book provides basic coverage on filter theory and DSK programming. There are many great examples and projects with applications to audio processing, video processing, and communications.


**Lectures, Labs, and Exams**

- You are expected to attend every lecture and lab session. You are solely responsible for anything you miss in classes, including announcements, handouts, assignments, and exams, in addition to the course topics discussed in the class. **If you miss a lab session, you'll receive zero for that lab project.**
- Quizzes or group exercises will be given in class randomly throughout the semester. These will help to get feedback about learning and teaching effectiveness. They will not be graded but solutions will be posted, which help you to prepare for the exams. They also serve as a means for attendance record, worth 5 points in the final grade.
- There will be one Matlab project, five hardware experiments, and a final semester project. The lab experiments and semester projects are to be done in groups. Each group consists of two students, preferably one from CpE background and one from EE background. Peer rating will be conducted multiple times throughout the semester and grades for each student are adjusted individually at the end of the semester.
- Lab reports are due by the end of the designated lab sessions. Each group needs to submit only one lab report, but both members of the group have to sign the lab report. By signing the lab report, you consent that you have participated in the experiment and understand all material presented in the report.
- There will be two in-class exams. The exams are closed-book but you can bring a one-page double-sided fact sheet.
- Makeup labs and exams will not be given unless you have a very unusual excuse with the instructor's permission **in advance**, or a documented medical/family emergency.
- If you disagree with the grade of an exam or a lab report, you must contact the instructor within one week from the day the exam/report is handed back to you. After that time, no request for re-grading will be accepted. A re-grade can result in an increase, a decrease, or no change in the grade.
- Topics for the final project will be provided and you may also suggest your own. If you choose your own topic, you are required to write a proposal and discuss it with the instructor within one week from the day the provided topics are posted.
- You will need to demonstrate your final project in the lab besides submitting a final report. Only one report is required for each group. Both members have to participate in the final project demonstration.

**Grading Scheme**

The semester grade will be assigned based upon a weighted average of attendance, lab report, exam, and final project scores. Weights will be assigned as follows:
Quiz/Group Exercise 5%
Six Lab Projects 7% each
Exam I and II 14% each
Final Project 25%

The final letter grades will be given roughly based on these scale: 90-100% =>A; 80-89% =>B; 70-79% =>C; 60-69% =>D, and below 60% =>F.

Important dates
Please inform the instructor any religious or traditional holidays that you may wish to observe. We will try to avoid scheduling examinations on those days. Tentative schedule of the course is attached. Other important dates can be found in the Academic Calendar at http://registrar.mst.edu/calendars/index.html

Class Behavior
- When in class (both lab and lecture sessions), please turn off all cell phones, pagers, and other devices that ring, buzz, or otherwise might disrupt the class.
- You are free to use the lab outside the class time when the lab is open. When sharing with other students in the lab, please use courtesy and follow directions given by the lab manager. Lab safety rules will be given in the first lab session.

Feedback
Feedback and communication with the instructor can be made via in-class questions, office hours, emails, and anonymous letters dropped in instructor’s mailbox or in the department office. Your emails will be read everyday but maybe replied only when needed. Common questions will be answered in class.

Academic Dishonesty:
Academic honesty is fundamental to the activities and principles of a university. All members of the academic community must be confident that each person's work has been responsibly and honorably acquired, developed, and presented. Any effort to gain an advantage not given to all students is dishonest whether or not the effort is successful. The academic community regards academic dishonesty as an extremely serious matter, with serious consequences that range from probation to expulsion. When in doubt about plagiarism, paraphrasing, quoting, or collaboration, consult the course instructor.

Discussion on lab experiments and final projects between groups is permitted, but each group should conduct the experiments and programming independently. If codes from two groups are found to be effectively identical, all members in both groups will receive zero as the grade. Other examples of cheating are
- Submitting a report that the experiment or the write-up is not done by you.
- Sharing results or notes during exams. Stealing other student's results during exams.
- Bring notes, in hard copy or electronic form, to an exam where they are not allowed.
- Continuing work on your exam after we have called for papers.
- Requesting a regrade on an exam or lab report that has been altered after grading.
- Copying paragraphs without putting them in quotation marks or citing the reference.

ADA Statement:
If you have a documented disability and anticipate needing accommodations in this course, you are strongly encouraged to meet with me early in the semester. You will need to request that the Disability Services staff send a letter to me verifying your disability and specifying the accommodation you will need before I can arrange your accommodation. Disability Support Services is located in 204 Norwood Hall. Their phone number is 341-4211 and their email is dss@mst.edu.
CpE 342 - Real-Time Digital Signal Processing

Lecture Outline:
1. Introduction to Digital Signal Processing (Week 1)
   Analog vs. Digital Systems   ADC and DAC
   Nyquist Sampling Theorem   Signal Source Generation
2. Fundamentals of Digital Signals and Systems (Week 2)
   Discrete Time Linear Systems   Impulse Responses
   z-Transforms   Discrete Fourier Transforms (DFT)
3. Digital Filter Design (Week 3)
   Filter Basics   FIR Filter   IIR Filters
4. Review of microprocessor/microcomputer architecture (Week 5)
   Von Neumann and Harvard Architectures   Central Processing Unit (CPU)
   Data and Address Bus Structure   I/O and Interrupts
Exam 1: DSP Basics (Week 5/6)
5. Architecture of DSP chip used in class (Week 7)
   CPU and Bus Structure   Timing and Control
   Addressing Formats   Configuration of Evaluation Board
6. Programming of DSP Chip (Week 9/10)
   Interrupt Driven Programs   Circular Buffer
   Frame Processing   Real-Time Scheduling
Exam 2: Real-Time DSP Implementation (Week 12)
7. DSP Applications (Week 12/13)
   Audio Signal Processing   Image Processing
   Data Compression/Transmission   Wireless Communications

Laboratory Outline:
Lab 0: Matlab implementation of filters (Week 2)
Lab 1: DSK Setup and Software Tool (Week 4)
   TMS320C6713 DSK hook-up, Code Composer Studio (CCS) primer
Lab 2: FIR filter implementation – easy approach (Week 6)
Lab 3: FIR filter implementation – circular buffer method (Week 8)
Lab 4: IIR filter implementation (Week 10)
Lab 5: FFT implementation (Week 12)
Term Project: report due and demo on last day of class (Week 14, 15)

Important Dates:

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<tbody>
<tr>
<td>Exam I (in Class, tentative date)</td>
<td>Tuesday, Sept. 28th</td>
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<tr>
<td>Exam II (in Class, tentative date)</td>
<td>Tuesday, Nov. 9th</td>
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<td>Thanksgiving Break (no class)</td>
<td>Nov. 22-27th</td>
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<td>Final Project report and Demo</td>
<td>Thursday, Dec. 9th/Thursday, Dec. 16th</td>
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