Syllabus for ECE4703
Real-Time Digital Signal Processing
B Term, 2013

Instructor: Prof. D. Richard Brown III

- Office: Atwater Kent 313
- Office hours: Stop by anytime or email me for an appointment.
- email: `drb@ece.wpi.edu`

Class Meets:

AK232, `M--R-` 3:00–4:50pm, Oct 31 – Dec 19 but not Nov 28 (Thanksgiving break).

Official Course Lab Hours:

AK227, `--W--` 3:00pm–4:50pm, Oct 30 – Dec 18, but not Nov 27 (Thanksgiving break).

Examination Schedule:

- Midterm exam: Thursday, November 21.
- Final exam: Thursday, December 19.

Course Description (from the WPI Catalog):

This course provides an introduction to the principles of real-time digital signal processing (DSP). The focus of this course is hands-on development of real-time signal processing algorithms using audio-based DSP kits in a laboratory environment. Basic concepts of DSP systems including sampling and quantization of continuous time signals are discussed. Tradeoffs between fixed-point and floating-point processing are exposed. Real-time considerations are discussed and efficient programming techniques leveraging the pipelined and parallel processing architecture of modern DSPs are developed. Using the audio-based DSP kits, students will implement real-time algorithms for various filtering structures and compare experimental results to theoretical predictions. Recommended background: ECE 2312, ECE 2801, some prior experience in C programming.

Expected Course Outcomes:

Students who successfully complete this course should be able to:

- describe the architecture and basic operation of fixed-point and floating-point DSPs.
- perform worst-case timing analysis and measure execution time on real-time DSP systems.
- develop and realize computationally efficient algorithms on the DSP platform (e.g. FFT, fast convolution).

- optimize DSP code (e.g. software pipelining).

- draw block diagrams of FIR and IIR filters under various realization structures and describe the advantages and disadvantages of each realization structure.

- realize real-time FIR and IIR filter designs on the DSP platform, compare experimental results to theoretical expectations, and identify the source of performance discrepancies.

Expected Background:

Students taking ECE4703 should have a basic understanding of discrete time signals and systems (ECE2312 or equivalent) including a working knowledge of sampling theory, basic filter design techniques, and frequency domain analysis. Students should also have an understanding of computer architecture as well as basic C and assembly language programming skills. Finally, students in ECE4703 are expected to have some experience programming in Matlab and an understanding of basic matrix/vector operations in Matlab.

Potentially Useful Books/Links:

- *Real-Time Digital Signal Processing: Based on the TMS320C6000*, Nasser Kehtarnavaz (Elsevier/Newnes). This has been required for previous offerings of ECE4703, but not all students have found it useful.

- Your ECE2312 textbook. Useful reference material for FIR and IIR filters.

- A C programming reference. Almost all of the coding in this course will be in C. While no particularly advanced C programming skills are required, it is important that you are comfortable writing short programs in C and that you understand how to work with various data types and arrays.

- A Matlab programming reference.

- *Digital Signal Processing and Applications with the C6713 and C6416 DSK*, Rulph Chassaing and Donald Reay.

- *Digital Signal Processing Impl. using the TMS320C6000 DSP Platform*, N. Dahnoun.

- *Digital Signal Processors: Architectures, Implementations, and Applications*, Sen M. Kuo and Woon-Seng Gan.

- *Real-Time Digital Signal Processing from Matlab to C with the TMS320C6x DSK*, Thad Welch, Cameron H.G. Wright, and Michael G. Morrow.

- See the course web page for links to lots of useful reference material for the DSK, the C6713, and Code Composer Studio.

Tentative Course Schedule:

Meeting	Date	Topics
LAB1	10/30	Course introduction, Introduction to the C6713 DSK, Code Composer Studio IDE, Matlab, and basic skills.
1	10/31	Sampling, quantization, and working with the AIC23 codec. Working with audio signals.
2	11/04	DSP basics, memory architecture, I/O, and interrupt data processing. Profiling code to ensure real-time operation.
LAB2	11/06	
3	11/07	Review of FIR filtering. FIR filter design techniques and tools.
4	11/11	FIR filter realization structures and practical considerations.
LAB3	11/13	
5	11/14	Review of IIR filtering. IIR filter design techniques and tools. IIR filter realization structures and practical considerations.
6	11/18	Writing efficient code: optimizing compiler, effect of data types and memory map.
LAB4	11/20	
7	11/21	**Midterm exam**.
8	11/25	C6713 fetch and execute packets, pipelining. C6713 assembly language programming I.
		Thanksgiving break.
9	12/02	C6713 assembly language programming II and code optimization.
LAB5	12/04	
10	12/05	Computation of the Fast Fourier Transform.
11	12/09	Applications of the FFT.
LAB6	12/11	
12	12/12	Adaptive filtering basics. The Least Mean Squares (LMS) algorithm.
13	12/16	Other applications of DSP and review.
LAB7	12/18	
14	12/19	**Final exam**.

Course Web Page and Announcements:

The official web page for this course is:

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`http://spinlab.wpi.edu/courses/ece4703_2013/`

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All course materials including homework assignments, their solutions, any announcements, and useful links will be made available here.

Important course announcements such as schedule changes will be sent via the course email distribution list:

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`ece4703@ece.wpi.edu`

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A test email was sent prior to the first lecture. If you did not receive it, send an email to the Instructor and we will correct the problem.

Grading, Exams, Lab Reports, and Homework Policy:

The grading distribution is as follows: 60% of the final grade will be based on the laboratory grades and 40% of the final grade will be based on the exam grades. Each of the six laboratory assignments is worth 10% of the final grade. The midterm and final exams are each worth 20% of the final grade.

Exams are closed-book and closed-notes. If you wish, you may bring one sheet of letter-sized paper with notes (in your own handwriting – no photocopies) on one or both sides. Calculators are permitted in all examinations.

All laboratory assignments will be completed in **two or three person teams**. Working individually requires approval from the course Instructor. One lab report per team is required. All lab reports must conform to the format specified in the lab assignment.

Laboratory Policies

Each team will be given a packet of cables in order to connect the C6713 DSK to various signal sources, oscilloscopes, and/or the computer. You are responsible for returning the complete kit (cables, connectors, and case) at the end of the course or earlier if you choose to withdraw from the course. If you lose any cables or connectors, you are responsible for buying replacements. Failure to return a complete set of cables will result in a grade of "Incomplete" for the course.

The laboratories in this course are "open" in the sense that it is expected that you will not be able to complete the assignments in the three hours of official laboratory time each week. The AK227 laboratory is shared with several other courses and it is important that you plan your lab work around the time conflicts presented by these other courses. Please be courteous to the instructors and students in these courses. In many cases, instructors of these courses may permit you to work quietly while they lecture if you ask politely and are not disruptive to the class.

Late Policy:

Turning in late work is highly discouraged. If you must turn an assignment in late, the following penalties will be assessed:

- Lab reports: Lab reports are submitted electronically to the Instructor and Teaching Assistant via email by 3:00pm on Thursdays. The late penalty for lab reports is as follows:

  - Report submitted Friday before 3:00pm: -10 points
  - Report submitted Monday before 3:00pm: -25 points

  No reports will be accepted after 3:00pm on Mondays. **The Lab 6 assignment will not be accepted late due to end-of-semester grading constraints**.

- Examinations: Please refer to the ECE4703 academic honesty policy on the course web page regarding makeup examinations.

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