Syllabus for ECE4703
Real-Time Digital Signal Processing
B Term, 2006

Instructor:

Prof. D. Richard Brown

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Teaching Assistant:

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- Help session hours: Tuesdays 2-4pm, AK227; Fridays 10am-noon, AK227.
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Class Meets:

AK219, MT-RF 9:00–9:50am, October 24 – December 14 but not Nov 23-24 (Thanksgiving break).

Official Course Lab Hours:

AK227, Wednesdays 11:00am–1:50pm but not Nov 22 (Thanksgiving break).

Examination Schedule:

- Exam 1: Tuesday, November 7.
- Exam 2: Tuesday, November 28.
- Exam 3: Thursday, December 14.

Course Description (from the WPI Catalog):

This course provides a basic introduction to the principles of real-time digital signal processing (DSP). Topics include: design of real-time DSP architectures, sampling and quantization of continuous time signals, design and implementation of FIR and IIR digital filters, and theory and application of the Fast Fourier Transform (FFT). The emphasis of the course is on the design and implementation of DSP algorithms. The algorithms are implemented on personal, portable DSP

boards that the students can either program in the lab or purchase for use on their home computers. This course features an interactive studio format with mini-lectures and labs integrated into three-hour sessions. This format allows the students to try out the algorithms and methods shown in class immediately, with the instructor nearby to lend assistance and advice. Recommended background: ECE 2312, ECE 2801, 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 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 and basic filter design techniques. Students should also have an understanding of computer architecture as well as basic C and assembly language programming skills (ECE2801 or equivalent). Finally, students in ECE4703 are expected to have some experience programming in Matlab and an understanding of basic matrix/vector operations in Matlab.

Required Textbooks:

- *Real-Time Digital Signal Processing: Based on the TMS320C6000*, Nasser Kehtarnavaz (Elsevier/Newnes).

Other Useful Books/Links:

- 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.
- *Digital Signal Processing and Applications with the C6713 and C6416 DSK*, Rulph Chassaing.
- *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.
- 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
1	10/24	Course introduction.
LAB1	10/25	Introduction to the C6713 DSK, Code composer studio, and basic skills.
2	10/26	DSP basics and memory architecture.
3	10/27	DSP I/O and interrupt data processing.
4	10/30	Review of FIR filtering.
5	10/31	Data types and quantization.
LAB2	11/01	Assignment 1 signoffs.
6	11/02	Digital filter design techniques and tools.
7	11/03	FIR filter realization structures and practical considerations.
8	11/06	Review.
9	11/07	EXAM 1
LAB3	11/08	Assignment 2 signoffs.
10	11/09	Review of IIR filtering.
11	11/10	IIR filter realization structures.
12	11/13	Practical considerations for IIR filters.
13	11/14	Writing efficient code: profiling execution time, optimizing compiler, effect of data types.
LAB4	11/15	Assignment 3 signoffs.
14	11/16	C6713 fetch and execute packets, pipelining.
15	11/17	C6713 assembly language programming I.
16	11/20	C6713 assembly language programming II.
17	11/21	Code optimization.
		Thanksgiving break.
18	11/27	Review.
19	11/28	EXAM 2
LAB5	11/29	Assignment 4 signoffs.
20	11/30	Fast Fourier Transform I.
21	12/01	Fast Fourier Transform II.
22	12/04	Fast Fourier Transform III.
23	12/05	Applications of the FFT.
LAB6	12/06	Assignment 5 signoffs.
24	12/07	Adaptive filtering basics.
25	12/08	The Least Mean Squares (LMS) algorithm.
26	12/11	Applications of adaptive filtering.
27	12/12	Review.
LAB7	12/13	Assignment 6 signoffs.
28	12/14	EXAM 3

Course Web Page and Announcements:

The official web page for this course is:

`http://spinlab.wpi.edu/courses/ece4703/`

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:

`ece4703@ece.wpi.edu`

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:

Grading for the course is on a 1000-point scale, with the points distributed as follows:

Laboratory Assignment 1	75
Laboratory Assignment 2	125
Laboratory Assignment 3	125
Laboratory Assignment 4	125
Laboratory Assignment 5	125
Laboratory Assignment 6	125
Exam 1	100
Exam 2	100
Exam 3	100
Total	1000

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 lab assignments (except for the first, as explained below) will be completed in **two person teams**. Working individually or in a three person team requires approval from the course Instructor and will only be permitted in the case of an odd number of students enrolled in the course. One signoff and lab report per team is required. Grade sheets will be distributed with each laboratory assignment that list the specific requirements for each sign-off. The entire team must be present for each sign-off. All lab reports must conform to the format specified in the lab assignment.

The **first lab assignment** is an orientation assignment intended to familiarize you with the course tools. No lab report is required for this assignment. You are permitted to work individually or in a two-person team for this assignment. The signoffs for this assignment will be performed on an *individual basis* to ensure that you have mastered the basic skills of working with CCS and the DSK.

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 lab 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 Signoffs: Lab signoffs are to be completed by 1:50pm on Wednesdays during the official course lab hours. The late penalty for lab signoffs is as follows:
  - Signoff completed Wednesday before 4:00pm: -10 points
  - Signoff completed Thursday before 4:00pm: -25 points
  - Signoff completed Friday before 4:00pm: -40 points

  No signoffs will be accepted after 4:00pm on Fridays.
- Lab Reports: Lab reports (except for the first assignment) are turned in to either the Teaching Assistant or the Instructor by 4:00pm on Thursdays. The late penalty for lab reports is as follows:
  - Report completed Friday before 4:00pm: -10 points
  - Report completed Monday before 4:00pm: -25 points

  No reports will be accepted after 4:00pm on Mondays. **No signoffs or reports will be accepted late for Lab 6 due to grading constraints**. *Late signoffs are available only by appointment with the Teaching Assistant or Instructor.*
- Examinations: Please refer to the ECE4703 academic honesty policy on the course web page regarding makeup examinations.

End of Syllabus