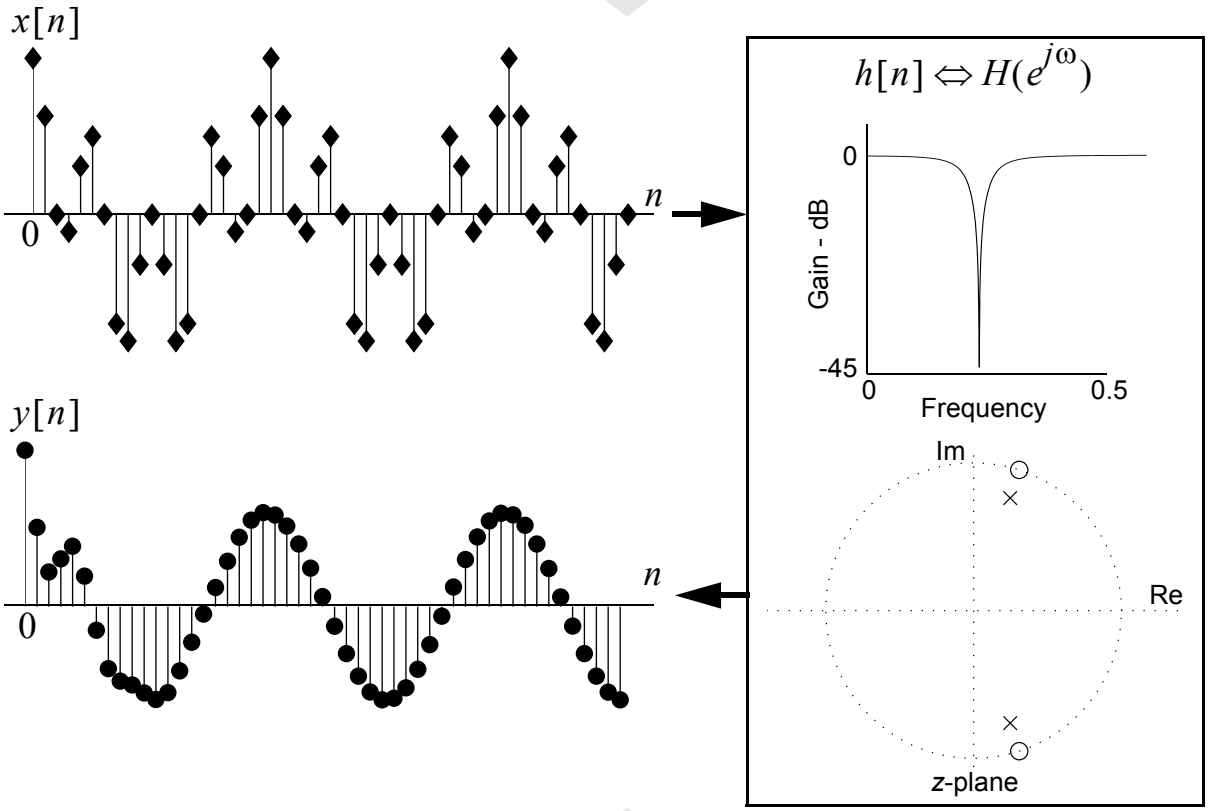
Modern Digital Signal Processing

ECE 5650/4650 Lecture Notes



Chapter 1

Course Introduction/Overview

Contents

.

1.1 Introduction to Modern Digital Signal Processing

- Contemporary DSP
  - Theory
  - Technology
  - Applications
- Course perspective
  - Expected background
  - Where to go from here
- What is this course about?
- The role of computer analysis/simulation tools in and outside this course
- The computer simulation project
- Instructor policies

1.2 Contemporary DSP

- The theoretical foundation for Modern signal processing got it's start back in the late 1960s and early 1970s
- Two key texts which started this era are *Digital Signal Processing* by Oppenheim and Schafer and *Theory and Application of Digital Signal Processing* by Rabiner and Gold, both published in 1975
- The Oppenheim and Schafer *Discrete-Time Signal Processing* text (1989, 1999, 2010) is now in its third edition
- A good source of recent theoretical developments is the *IEEE Journal on Signal Processing* (formerly Acoustics Speech and Signal Processing) and the annual *Proceedings of the International Conference on Acoustics Speech and Signal Processing* (ICASSP)
- Other applied digital signal processing conferences exist and are usually associated with trade shows

1.2.1 The Technology

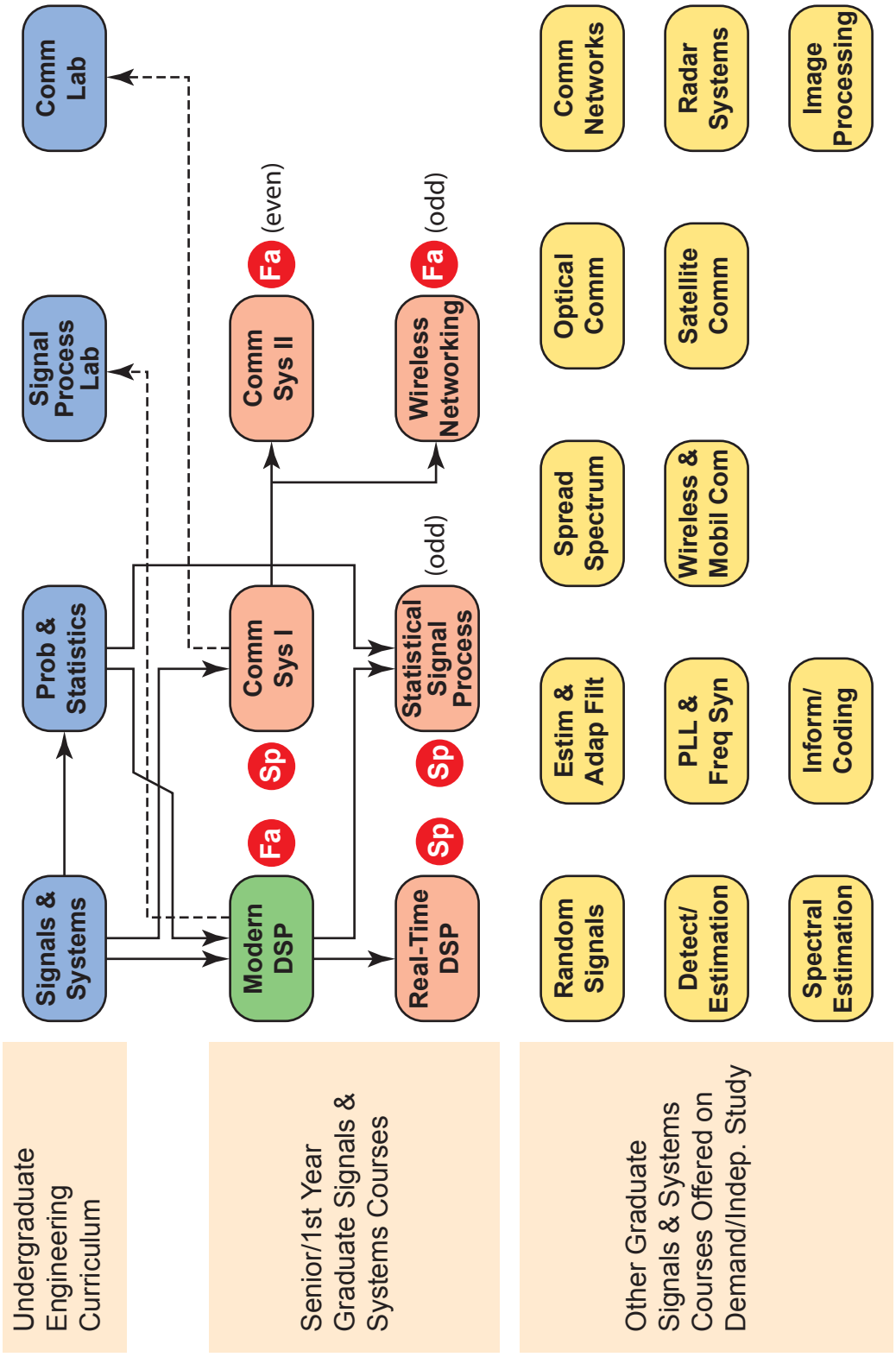
- DSP chips/architectures
  - Integer/Fixed point implementations
  - Floating point implementations
  - FPGA based implementations
- DSP software and tools

1.2.2 Key Applications Areas

- Computers/Internet
  - Broadband access
  - Voice over IP
  - MP3 and related high quality audio formats
  - Multimedia in general: data, voice, music, & video
- Wireless Communications
  - Mobile communications (over 200 million phones/yr over the world)
  - High-speed modems and xDSL
  - Real-time data compression for voice and video
  - Wireless and telecommunication infrastructure
- Industrial
  - Real-time processing of industrial and medical signals
  - PC with DSP for virtual instruments for test and analysis
- Digital Control Systems
  - DSP vs microprocessors and microcontrollers
- Audio
  - MP3 players
  - Home audio and theatre systems
  - Noise cancelling, e.g., quieting a car interior using adaptive noise cancellation

- Video Imaging
  - HDTV
  - Special purpose image processing in instrumentation and medical
- Biomedical
  - Many possibilities
  - Hearing aids
  - Diagnostic imaging
- Military/Aerospace
  - An active DSP area for over 30 years
  - Many consumer DSP applications had their start here
  - Sophisticated surveillance systems and smart weapons
  - Specialty technologies include:
    * Frequency domain processing
    * Parallel processing
    * Radar signal processing
    * Software defined radio

1.3 Course Perspective in Comm/DSP Area ECE



1.4 What is this course about?

- This course has as its focus the *nuts and bolts* of one-dimensional discrete-time signals and systems analysis
  - Developing analytical skills is of primary importance
  - Introducing specialized applications is secondary
- Most all of the theoretical developments will parallel those of a traditional continuous-time signals and systems course
  - Here at UCCS, we now introduce discrete-time signal and systems in ECE 2610 (Intro to Sig & Sys), and more DSP topics are covered in ECE 3205 (Ckts & Sys II)
  - This course pushes the math well beyond the introduction in those courses
- Unique aspects of discrete-time signals and systems include:
  - Analog-to-digital and digital-to-analog interfaces
  - Multi-rate processing systems, i.e., more than one sampling rate in the signal input/output path
  - Software reconfigurability of systems
- Discrete random signals will be introduced
  - This will allow analysis of quantization affects
  - Key to follow-on courses involving statistical signal processing

1.5 Software Analysis/Simulation Tools

- The experimental investigation of discrete-time signals and systems does not require a lab full of test equipment
- What is available from the academic perspective:
  - Basic mathematical analysis tools include
    - MATLAB, Mathematica
  - DSP specific tools include
    - MATLAB/Simulink/SP Block Set, LabView/MathScript
    - Agilent ADS (advanced design system) with Ptolemy
  - Starting from scratch
    - The C/C++ programming language
  - Real-time DSP Development
    - For Texas Instruments DSPs – *Code Composer Studio Platinum Edition*
    - Verilog/VHDL hardware description languages
    - For Analog Devices DSPs – *Visual DSP*
    - Other tools that have code generation capability
- Inexpensive hardware evaluation is also a reality, e.g.,
  - TI C6713 DSK $355 with USB interface
  - Others from Analog Devices and Motorola

1.6 The Computer Projects

- Computer based exercises using MATLAB will be assigned during the semester from the Burrus, et al. text
  - These projects first familiarize you with MATLAB, then work through the many details of DSP in the time and frequency domains
- A larger computer simulation project, will be assigned during the second-half of the semester, in place of additional computer based exercises
  - Past simulation projects have focused on software defined radio concepts, e.g., IF sampling, adaptive filters, a DSP based modem
  - MATLAB is sufficient for this project
- In the Spring Semester ECE 5655, *Real-Time DSP* is offered as a complement to Modern DSP
  - In this course TI Tool set, Code Composer Studio is used to program the high performance C6x processor family (specifically the C6713 DSK)
- Another follow-on path is ECE 5615, *Statistical Signal Processing*, which builds upon the theory side of DSP and introduces random signals
  - Beyond ECE 5650, an undergraduate background in probability and random variables is required

1.7 Course Syllabus

ECE 5650/4650
Modern Digital Signal Processing
Fall Semester 2011

Instructor: Dr. Mark Wickert **Office:** EB-292 **Phone:** 255-3500
mwickert@uccs.edu **Fax:** 255-3589
http://www.eas.uccs.edu/wickert/ece5650/

Office Hrs: Tue. 3:30–4:15 pm and after 7:05 pm as needed, others by appointment.

Required Texts: Alan V. Oppenhiem and Ronald V. Schafer, *Discrete-Time Signal Processing*, third edition, Prentice-Hall, Englewood Cliffs, New Jersey, 2009.

Notes: Course lecture notes will be posted on the course Web Site as password required PDF files. Students are encouraged to download and print them.

Optional Software: MATLAB Student Version with Simulink and signal processing tools. An interactive numerical analysis, data analysis, and graphics package for Windows/Linux/Mac OSX $99.95. Order both from `www.mathworks.com/student`. Note: The ECE PC Lab has the full version of MATLAB and Simulink for windows (release 2011a) with many toolboxes.

Grading:
1.) Graded homework assignments, including MATLAB assignments 25%
2.) Final computer project worth 20%/15%. Grade option with final.
3.) Two "Hour" exams at 15% each, 30% total.
4.) Final exam worth 25%/30%.

Topics	Text Sections
1. Introduction and course overview	1
2. Discrete-time signals and systems	2.0–2.9
3. The z-transform	3.0–3.4
4. Sampling of continuous-time signals and discrete-time random signals	4.0–4.6 2.10, App. A 4.7–4.9
5. Transform analysis of linear time-invariant systems	5.0–5.7
6. Structures for discrete-time systems and finite precision issues	6.0–6.9
7. The discrete Fourier transform	8.0–8.7, 8.9?
8. Computation of the discrete Fourier transform	9.0–9.6
9. Applications of the DFT	Portions of 10.0–10.6

1.8 Instructor Policies

- Homework papers are due at the start of class
- If business travel or similar activities prevent you from attending class and turning in your homework, please inform me beforehand
- Grading is done on a straight 90, 80, 70, ... scale with curving below these thresholds if needed
- Screencasts of the lectures will be made available as soon as possible after each lecture; this may be of help to those of you that travel and to others for review purposes
- Homework solutions will be posted on the course Web site as PDF documents with password protection
- Old exams will be posted on the Web site prior to the hour exams