Spring, 2020

*** IMPORTANT ***

All lectures have been "zoomed"

Lab 4,5 and the project will require an amateur radio license.

You can get one on your own, or take a licensing exam that we will organize mid semester.

If you wish to earn credit for ham radio licensing, consider taking EE194, Hands on ham radio

Course Description:

- Catalog Description: (4 units) Discrete time signals and systems: Fourier and Z transforms, DFT, 2-dimensional versions. Digital signal processing topics: flow graphs, realizations, FFT, quantization effects, linear prediction. Digital filter design methods: windowing, frequency sampling, S-to-Z methods, frequency-transformation methods, optimization methods, 2-dimensional filter design.

Prerequisites: EECS 120, or instructor permission.

Course objectives: To develop skills for analyzing and synthesizing algorithms and systems that process discrete time signals, with emphasis on realization and implementation.

Why should you care? Digital signal processing is one of the most important and useful tools an electrical engineer could have. It impacts all modern aspects of life and sciences; from communication, entertainment to health and economics.

506 Cory Hall
(510)643-9338
mlustig@eecs.berkeley.edu

Office Hours
506 Cory Hall
W 4:20pm-5:20pm

GSIs:

- Josh Sanz

Office Hours: Thursdays 3:30pm-6:30pm, 400 Cory
jsanz@berkeley.edu

- Alan Dong

Office Hours: Thursdays 3:30pm-6:30pm, 400 Cory
alan_dong@berkeley.edu

- Gautam Gunjala

Office Hours: Thursdays 3:30pm-6:30pm, 400 Cory
gautam.gunjala@berkeley.edu

Lab Assistants

- Rafael Calleja

Lab Office Hours: Monday 11:00am-1:00pm, 105 Cory

- Shivin Devgon

Lab Office Hours: Monday 11:00am-1:00pm, 105 Cory

Class Time and Location:

- MW 2pm-4pm, 141 McCone (webcasted)

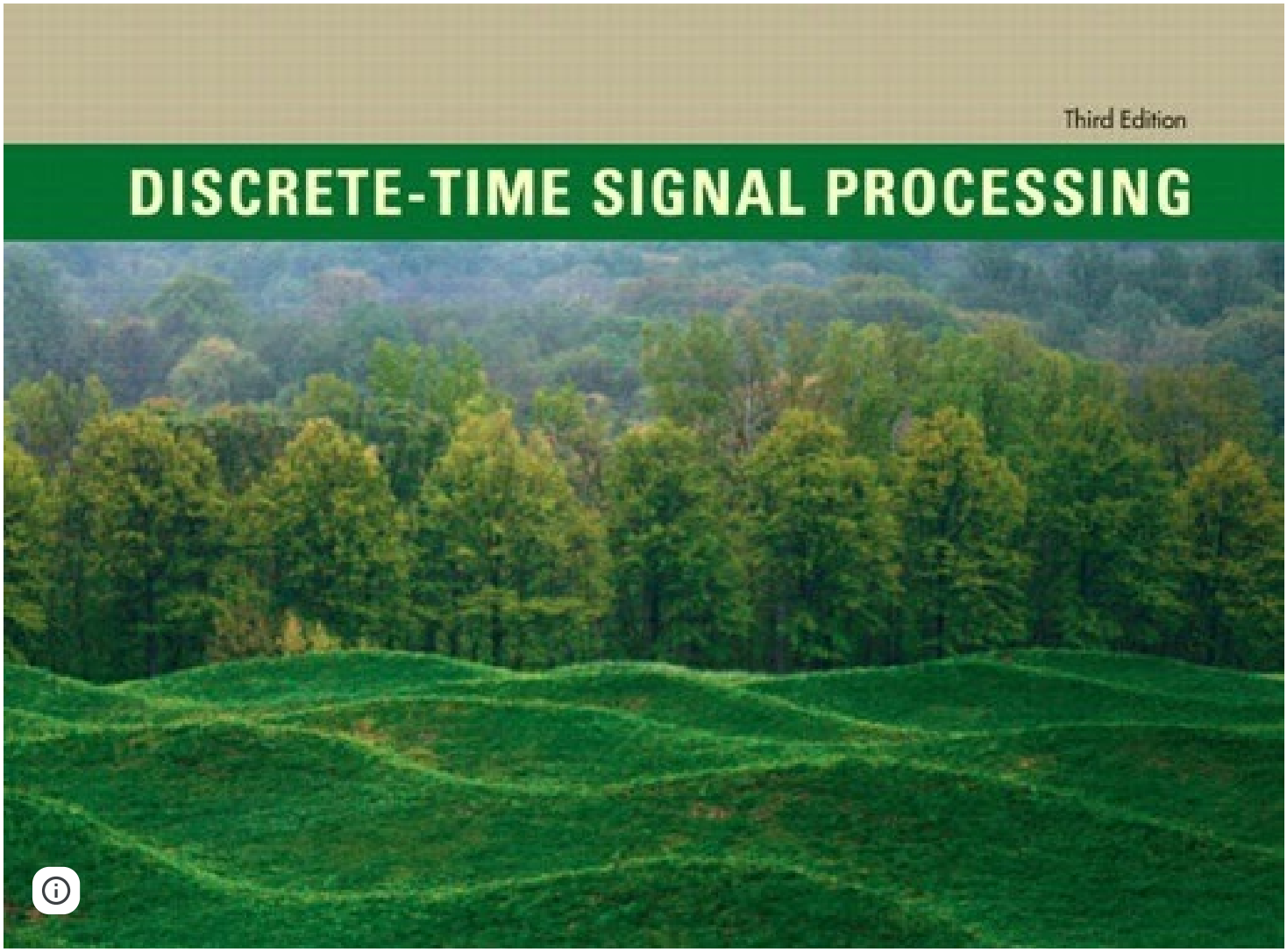
GSI Section:

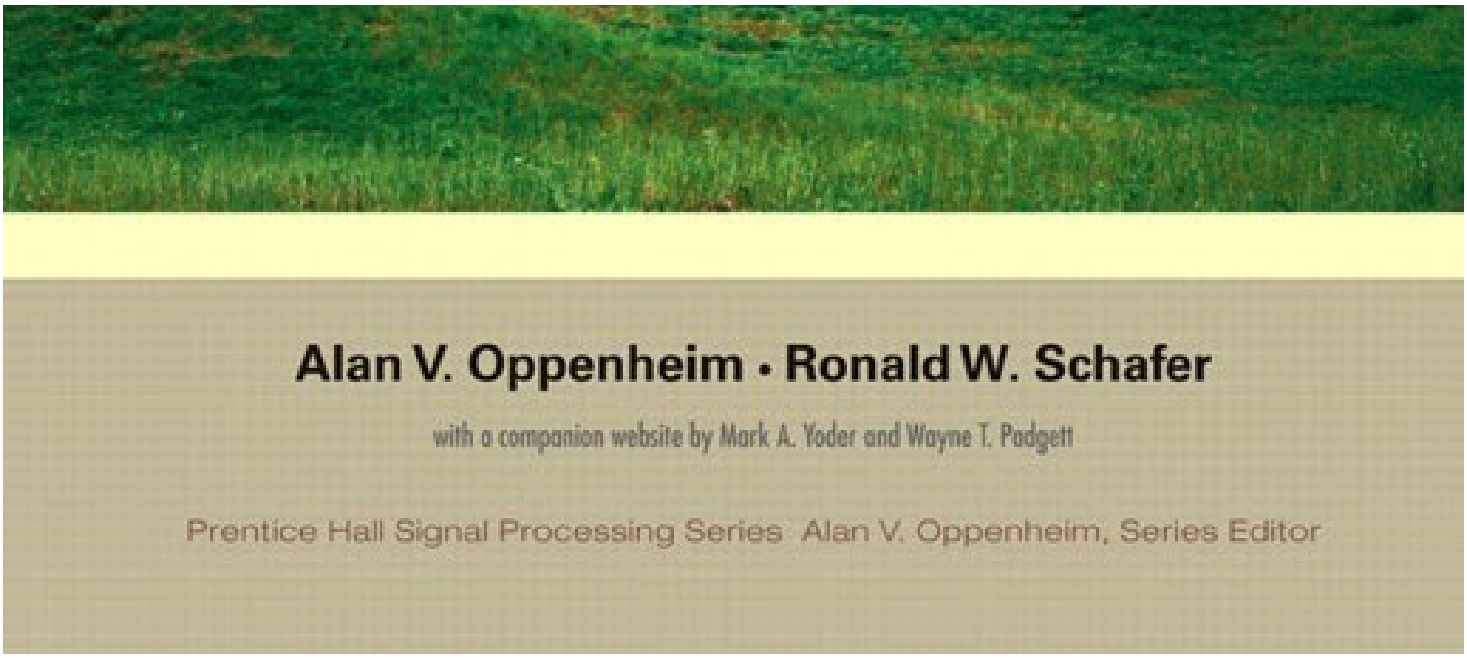
- W 3pm-4pm, 141 McCone, but can vary on some weeks.

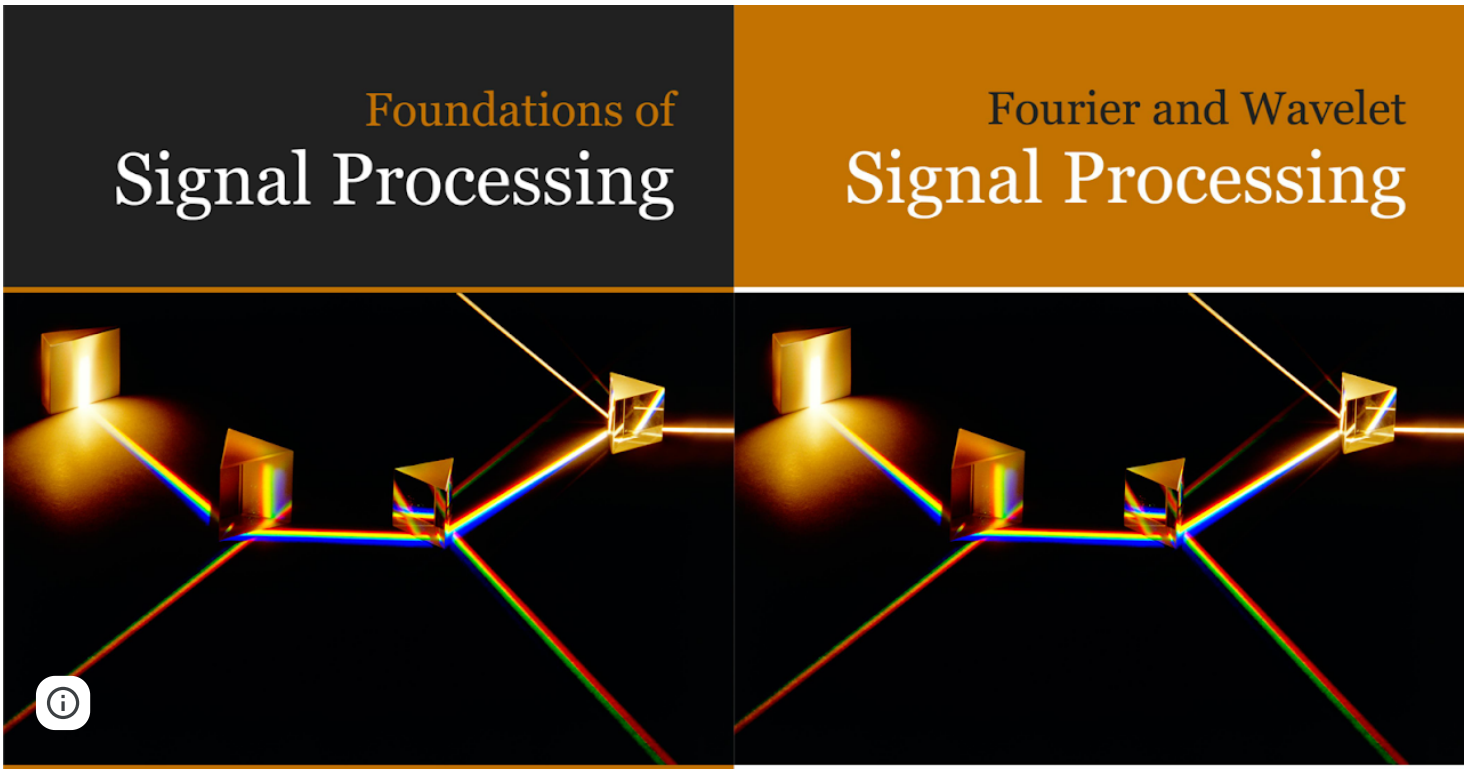
Labs:

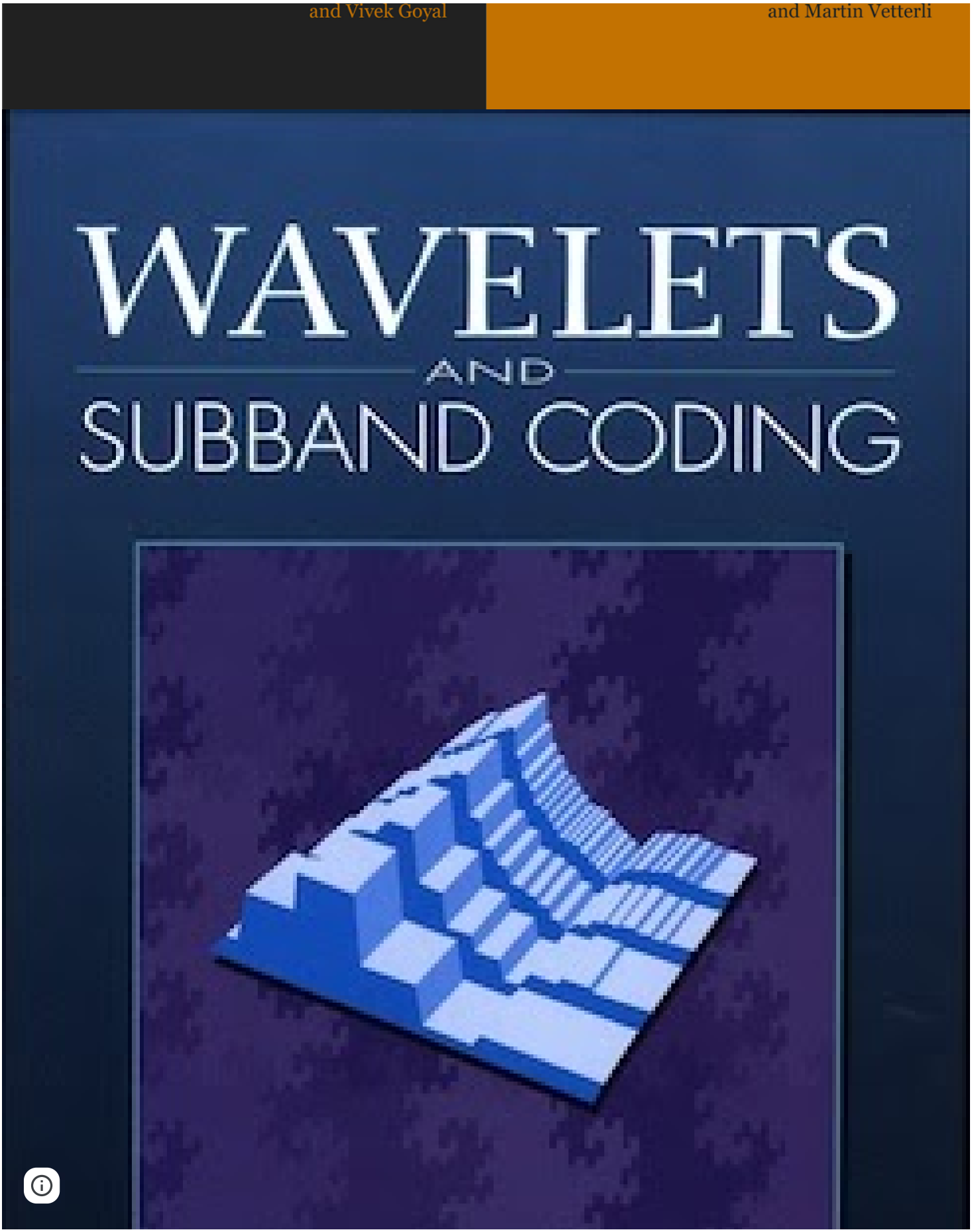
- M 10am-11am, 105 Cory
- W 10am-11am, 105 Cory
- W 11am-12pm, 105 Cory

Week schedule Sp20

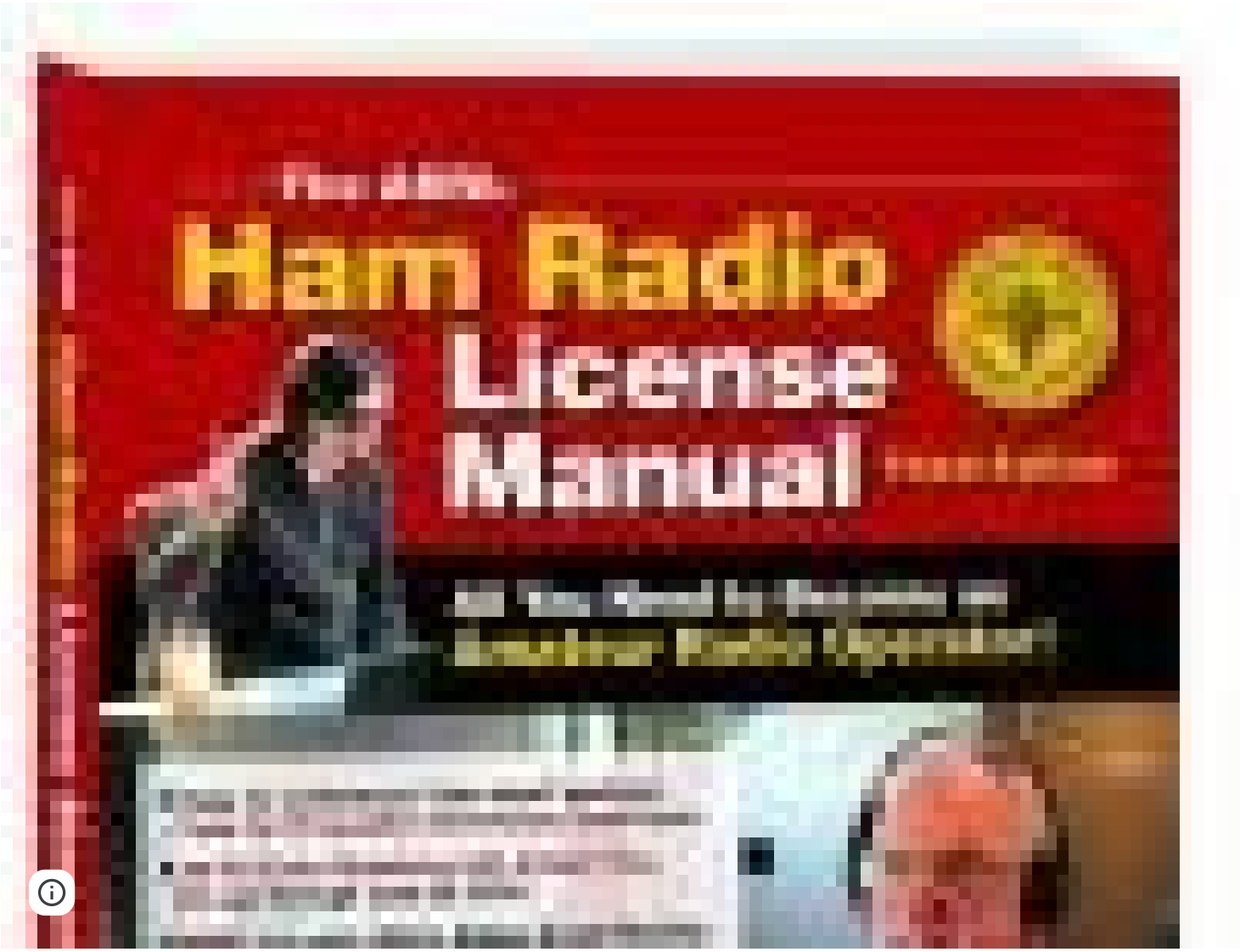



Alan V. Oppenheim • Ronald W. Schafer
with a companion website by Mark A. Yoder and Wayne T. Padgett
Prentice Hall Signal Processing Series Alan V. Oppenheim, Series Editor


Foundations of
Signal Processing
Fourier and Wavelet
Signal Processing


and Vivek Goyal
and Martin Vetterli
WAVELETS
AND
SUBBAND CODING

Martin Vetterli · Jelena Kovačević



Text:

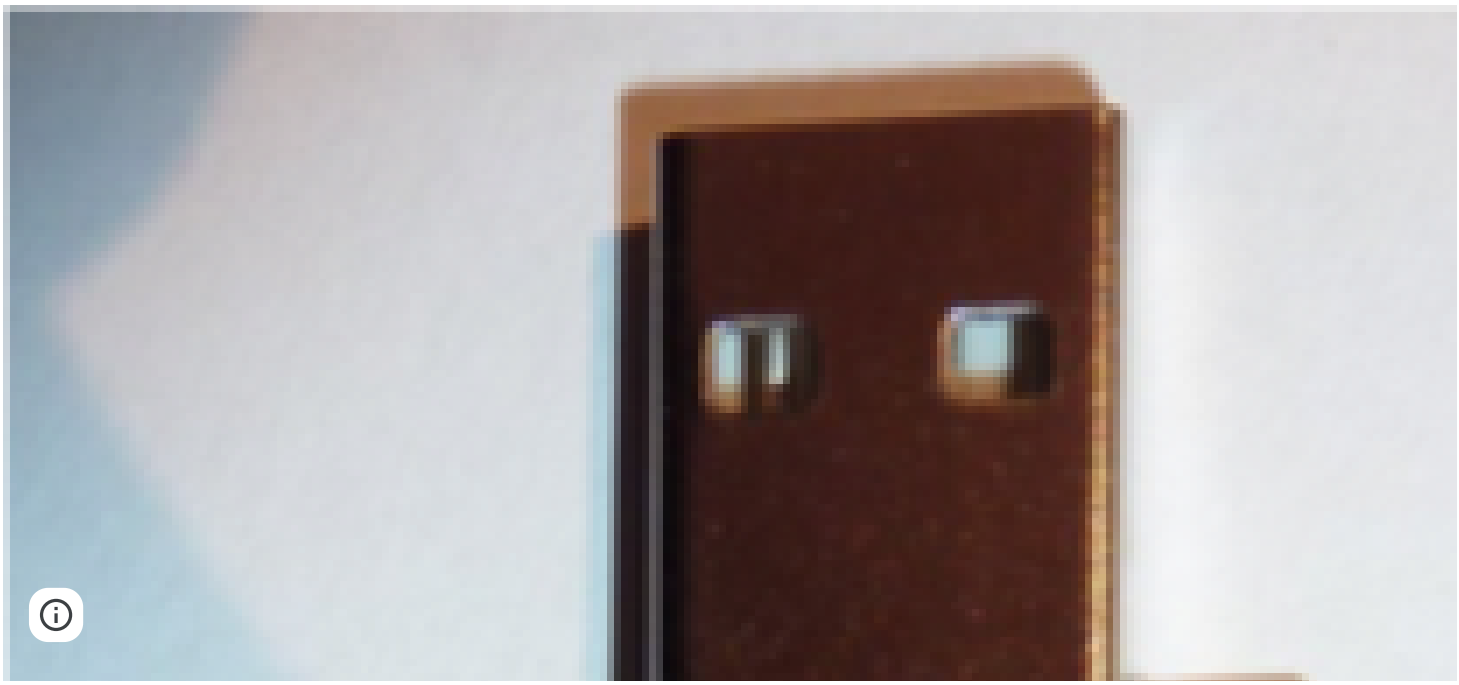
"Discrete Time Signal Processing," by A.V. Oppenheim and R.W. Schafer, Prentice Hall, Third Edition. Book Store Link

Additional Material:

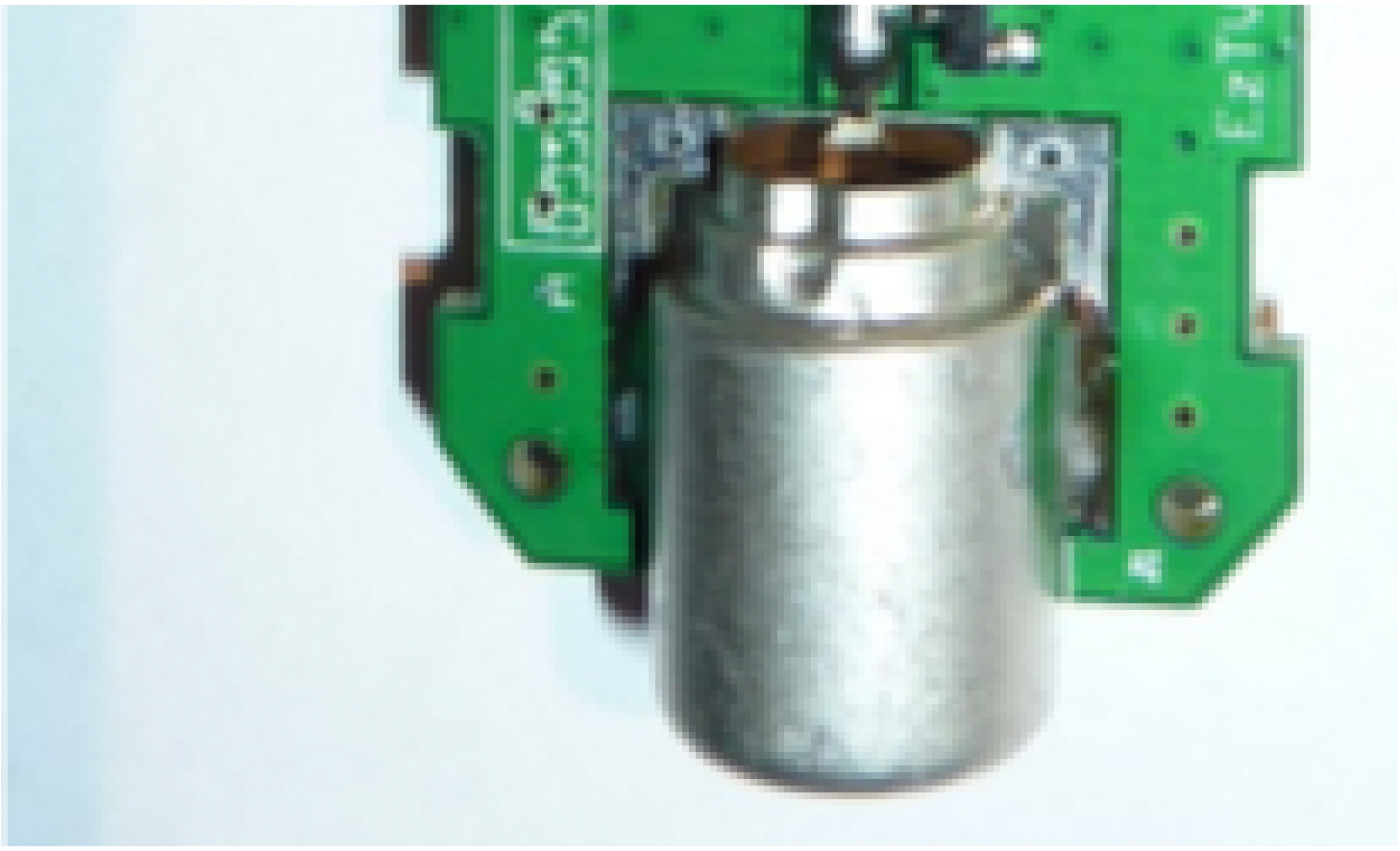
"Wavelets and Subband Coding" By Martin Vetterli and Jelena Kovacevic. Freely available here.

"Foundation of Signal Processing" and "Fourier and Wavelet Signal Processing" By Martin Vetterli, Jelena Kovacevic and Vivek Goyal version freely available Here

Technician Ham Radio License Manual 21$ Amazon (make sure it's 2018-2021 !)




RoHS

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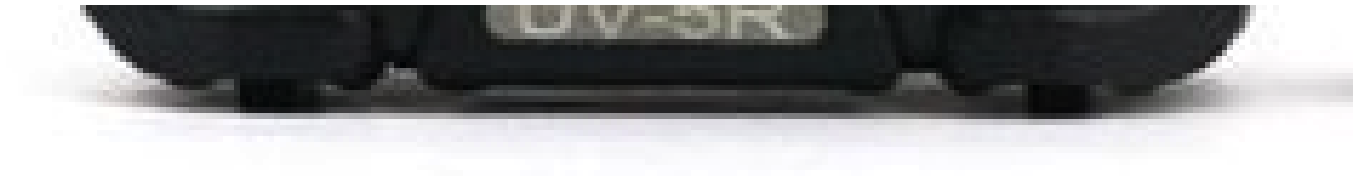

HAM radio and Software Defined Radio Labs and Project

It was discovered by Eric Fry that DVB-T dongles based on the Realtek RTL2832U can be used as cheap Software Defined Radios (SDR). Basically the chip allows the transfer of raw samples to a host computer. The samples can then be used to digitally demodulate and process almost anything that is transmitted between 27-1700Mhz!

Several homeworks/Labs will use the SDR. Each student in the class will receive a dongle and will be able to experiment with its capabilities. The final project will also be based on SDR. Several possibilities are writing an FM receiver, digital radio receiver, Police scanner, GPS receiver, NOAA weather alert receiver or satelite imagery and more.

In addition, each student will get a Baofeng UV-5r hand held radio. This will be used in Labs and the final project in the class. Every student in the class will take a HAM radio licensing exam, and be licensed by the FCC to operate the radios.

If you wish to earn credit for ham radio licensing, consider taking EE194

Resources:

Articles and Links:

- Fast Convolution
- Covers various implementations of linear convolution using the DFT, including Overlap-Add and Overlap-Save.
- The Scientist and Engineer's Guide to Digital Signal Processing
- A great practical introduction to DSP. (Free to download)
- Upsampling vs. Oversampling for Digital Audio
- An article about the benefits of these techniques.
- Quantization Errors
- Information on Gibbs Phenomenon (WikiPedia)

Tentative Course outline:

A list of the topics that will be covered is given Here, in the order that they will be covered This may change based on

and 3); digital filter structures (Chapter 6)

- Discrete Fourier Transform (DFT) and Fast Fourier Transform (FFT) (Chapters 8 and 9)
- Wavelets
- Sampling and quantization, finite word length effects (Chapters 4 and 6)
- Frequency response of LTI systems (Chapter 5) and filter design techniques (Chapter 7)
- 2D signal processing – Tomography
- Compressive Sampling

Approximate Grading distribution:

- Homework (Weekly): 10%
- Labs: 15%
- Midterm 1 (March 4th, in class + section): 30%
- Midterm 2 (April 15th, in class + section): 30%
- Project: 15%

Homework Instruction:

- Weekly assignments consist of problem sets. In addition there will be about 4-6 laboratories consisting of programming using Jupyter (iPython) notebook.
- Homework will be assigned each Monday and due the next Monday 11:59pm.
- Homework submission will be in digital form through Gradescope. Here's a LaTeX template Miki_Lustig_hw01_sol.tex that produces this output after compilation. If you don't want to typeset, scanners are available in the instructional lab, or you can use a document scanning app for your smartphone.
- No late hw without prior consent from the instructor. Submission is time-stamped!
- Homework will be self graded. Self grading is usually part of the following homework which will be due at the same time as the following homework. For example, HW1 self-grading will due at the due date of HW2. If the self-grading due date is different from the following homework, we will announce it.
- Homework slip policy: the homework with the lowest grade will be dropped.

Homework:

- Homework 1 PDF, due Monday, February 3rd
- Homework 2 PDF, due Monday, February 10th
- Homework 3 PDF, due Tuesday, February 18th
- Homework 4 PDF, due Monday, February 24th
- Homework 5 PDF, due Monday, March 2nd

- Homework 7 PDF, due Monday, March 16th
- Homework 8 PDF, due Monday, March 30th
- Homework 9 PDF, due Monday, April 6th
- Homework 10 PDF, due Monday, April 13th
- [Optional] Homework 11: Compressed Sensing ZIP, due Monday, May 4th

Lecture Notes:

All lectures will be "zoomed" at https://berkeley.zoom.us/j/578929564 . Here's a LINK to the calendar file.

- 01/22/2020 Lecture 1B Intro PDF, Lecture 1C Discrete Signals PDF, webcast recording (link)
- 01/27/2020 Lecture 2A Discrete Time Fourier Transform PDF, webcast recording (link)
- 01/29/2020 Lecture 2B The z-Transform PDF, and Lecture 2C DFT PDF, webcast recording (link)
- 02/03/2020 Lectures 3A+3B DFT Properties and Fast Convolutions PDF, webcast recording (link)
- 02/05/2020 Lecture 3C the FFT PDF, webcast recording (link)
- 02/10/2020 Lecture 4A FFT continued and Lab I PDF, Lecture 4B Spectral Analysis using DFT PDF, webcast recording (link)
- 02/12/2020 Lecture 4C Spectral Analysis using the DFT cont. PDF, webcast recording (link)
- 02/19/2020 Lectures 5B Short Time Fourier Transform PDF, and Lecture 5C Introduction to Wavelets PDF, webcast recording (link)
- 02/24/2020 Lectures 6A+6B Orthogonal Wavelets and the Discrete Wavelet Transform PDF, webcast recording (link). Notes on time-frequency tiling by Prof. Gastpar PDF
- 02/26/2020 Lecture 6C Lab 2 PDF, and Wavelet Denoising PDF, webcast recording (link)
- 03/02/2020 Lecture 7A + 7B Sampling and Reconstruction PDF, webcast recording (link)
- 03/04/2020 Midterm -- no lecture
- 03/09/2020 Lectures 8A + 8B, Resampling and Lab 3 PDF, webcast recording (link)
- 03/11/2020 Lecture 8C, Filter Design, part I PDF, webcast recording (link)
- 03/16/2020 Lecture 9A + 9B, Polyphase decomposition and Filter Banks PDF, zoom recording (link)
- 03/18/2020 Lecture 9C. Perfect Reconstruction Filter Banks, PDF, zoom recording (link)
- 03/30/2020 Lecture 11A PDF + 11B PDF Transform Analysis of LTI systems + AllPass, Minimum Phase and General Linear Phase Systems, zoom recording (link)
- 04/01/2020 Lecture 11C Lab 4 PDF, zoom recording (link)
- 04/06/2020 Lecture 12A PDF + 12B PDF, Linear Phase systems, optimal filter design, zoom recording (link)
- 04/08/2020 Lecture 12C, Practical ADC/DAC PDF, zoom recording (link)

- 04/27/2020 Lectures 15A- Lab Project PDF, and 2D signals and Fourier Transforms PDF, zoom recording (link)
- 04/29/2020 Lectures 15C, Tomography PDF, zoom recording (link)

Section Notes:

- 01/27/2020 Section 1 LTI Systems and Linear Regression: Worksheet, Slides, webcast recording (link)
- 02/05/2020 Section 2 z-Transform and DFT: Worksheet, Slides, webcast recording (link)
- 02/12/2020 Section 3 DFT and DCT: Worksheet, Slides, Demo, webcast recording (link)
- 02/26/2020 Section 4 Discrete wavelet transform: Worksheet, Slides, webcast recording (link)
- 03/11/2020 Section 5 Sampling: Worksheet, Slides, Notebook, webcast recording (link)
- 03/18/2020 Section 6 Resampling: Slides, zoom recording (link)
- 04/01/2020 Section 7 Optimal filtering and polyphase decomposition: Slides, zoom recording (link)
- 04/08/2020 Section 8 z-Transform Analysis of LTI Systems, Including (MP, AP, GLP): Slides, zoom recording (link)
- 04/15/2020 Section 9 Midterm 2 Review: Slides, zoom recording (link)