

ECE 699 – Software-Defined Radio
Department of Electrical and Computer Engineering
George Mason University
Spring 2018

Class meetings: Wednesdays 4:30 – 7:10 pm
Planetary Hall 126

Instructor: Brian L. Mark
Nguyen Engineering Building (ENGR), Room 3220
phone: 703-993-4069 email: bmark [at] gmU.edu
web: <http://ece.gmu.edu/~bmark>
office hours: Wednesdays, 2 – 4 pm

Teaching Assistants:

- Hanke Cheng
ENGR 3219 (Networks Lab); phone: 703-993-1602
email: hcheng7 [at] gmU.edu
- Zheng Wang
ENGR 3219 (Networks Lab); phone: 703-993-1602
email: zwang23 [at] gmU.edu

Course Description: The course focuses on the design and implementation of the essential building blocks of a software-defined radio, including sampling, pulse shaping, modulation/demodulation, synchronization, equalization, and coding. The course addresses how the building blocks are put together to construct a fully functional software-defined radio receiver. In parallel with learning the internal elements of a software-defined radio, students will learn about the GNU software radio and the Ettus Universal Software Radio Peripheral (USRP), as well as gain hands-on experience in developing applications on these platforms.

Course website: Log in to your account on <http://blackboard.gmu.edu>

- Log into Blackboard using your GMU email account credentials.
- Assignments, solutions, announcements, and other course materials will be posted on Blackboard.
- Piazza:
 - We will be using Piazza for class discussion. The system is highly catered to getting you help fast and efficiently from classmates, the TA, and myself. Rather than emailing questions to the teaching staff, I encourage you to post your questions on Piazza. If you have any problems or feedback for the developers, email team@piazza.com Find our class page at: <https://piazza.com/gmu/spring2018/ece699/home>

Textbook:

- C.R. Johnson, W.A. Sethares, A.G. Klein, “Software Receiver Design: Build Your Own Digital Communication System in Five Easy Steps,” Cambridge University Press, 2011. ISBN 978-0-521-18944-6. This book is available online through Mason’s subscription to ProQuest Safari Books through the following URL:

<http://proquest.safaribooksonline.com/book/electrical-engineering/communications-engineering/9781107386747>

- Supplementary course materials will also be made available to students via Blackboard.

Prerequisites: Students should have a background in signals and systems concepts at the level of ECE 535 and/or wireless communications at the level of ECE 531. Students should also be comfortable with MATLAB (or Octave) and a general purpose programming language (e.g., C or C++). The particular open software-defined platform that will be used is GNU software radio with the Ettus Universal Software Radio Peripheral (USRP), which is based on Python and C++. Prior knowledge of Python, C/C++, and/or Linux/Unix is helpful, but not necessary.

Grading (tentative):

- Homework = 15%, Labs/Projects = 30%, Midterm Exam = 20%, Final Exam = 35%.

Course Topics (two parallel tracks):

I. Software-Defined Radio Concepts

- Software Radio Overview (2 Weeks)
 - Digital Radio Concepts - “Onion” Model
 - Review of Communication Systems
 - Basic Elements of Software Radio
- Idealized System Layer (4 weeks)
 - Modeling Corruption
 - Modulation and Demodulation
 - Sampling with Automatic Gain Control
 - Digital Filtering
 - Bits to Symbols to Signals
 - Simulating an Idealized System
- Adaptive Component Layer (4 weeks)
 - Carrier Recovery
 - Pulse Shaping and Receive Filtering
 - Timing Recovery
 - Linear Equalization
 - Coding
- Integration Layer (2 weeks)
 - Receiver Design
 - Digital Quadrature Amplitude Modulation Radio

II. GNU Radio and USRP

- GNU Radio Overview (1 week)
- GNU Radio Installation (1 week)
- GNU Radio Companion (1 week)
- Python Programming for GNU Radio (1 week)
- Creating Custom GNU Radio Blocks (1 week)
- USRP Hardware Architecture (1 weeks)
- GNU Radio Example Applications (7 weeks)
Possible examples include:
 - Spectrum Analyzer
 - FM Receiver
 - WiFi Sniffer
 - Spectrum Sensor

Homework Assignments

- Homework problems, some involving MATLAB/Octave, will be assigned weekly.
- Sample solutions to homework assignments will be posted on Blackboard.

Labs/Projects

- Lab-type exercises involving GNU radio and the Ettus USRP will be assigned. These exercises will culminate in one or two projects as examples of GNU radio applications.
- Sample solutions to homework assignments will be posted on Blackboard.

Midterm Exam: Wednesday, March 21, 2018 (in-class, 1.5 - 2 hours).

Final Exam: Wednesday, May 9, 2018 (4:30 – 7:15 pm)

Student disability: If you are a student with a disability and you need academic accommodations, please see me and contact the Office of Disability Services (ODS) at 703.993.2474. All academic accommodations must be arranged through that office. Students must inform the instructor at the beginning of the semester, and the specific accommodation will be arranged through ODS.

Academic Integrity: GMU is an Honor Code university. Please see the University Catalog for a full description of the code and the honor committee process.

Honor Code: To promote a stronger sense of mutual responsibility, respect, trust, and fairness among all members of the George Mason University community and with the desire for greater academic and personal achievement, we, the student members of the university community, have set forth this honor code: Student members of the George Mason University community pledge not to cheat, plagiarize, steal, or lie in matters related to academic work.

Course Schedule:

Week 1:	Jan. 24 Overview of Software-Defined Radio (Chapters 1–3); GNU Radio Overview
Week 2:	Jan. 31 Overview of Software-Defined Radio (Chapters 1–4); Dial Tone in GNU Radio
Week 3:	Feb. 7 Analog Modulation/Demodulation (Chapter 5); GNU Radio Companion; FM/AM in GNU Radio
Week 4:	Feb. 14 Sampling with Automatic Gain Control (Chapter 6); Python Programming for GNU Radio; AGC in GNU Radio
Week 5:	Feb. 21 Digital Filtering and Bits to Symbols to Signals (Chapters 7 and 8); Creating Custom GNU Radio Blocks; Digital Filters in GNU Radio
Week 6:	Feb. 28 Modeling Corruption and Simulating an Idealized System (Chapter 9); Quantization Noise in GNU Radio
Week 7:	Mar. 7 Modeling Corruption and Simulating an Idealized System (Chapter 9); Carrier Recovery in GNU Radio
Week 8:	Mar. 14 Spring Break (No Class)
Week 9:	Mar. 21 Midterm Exam; GNU Radio Lab
Week 10:	Mar. 28 Carrier Recovery (Chapter 10); GNU Radio Lab
Week 11:	Apr. 4 Pulse Shaping and Receive Filtering (Chapter 11); GNU Radio Lab
Week 12:	Apr. 11 Timing Recovery (Chapter 12); GNU Radio Lab
Week 13:	Apr. 18 Linear Equalization (Chapter 13); GNU Radio Lab
Week 14:	Apr. 25 Linear Equalization (Chapter 13); GNU Radio Lab
Week 15:	May 2 Receiver Design (Chapter 15); GNU Radio Lab