ECE 631 – Software-Defined Radio
Department of Electrical and Computer Engineering
George Mason University
Fall 2019

Class meetings: Wednesdays 7:20 – 10:00 pm
Nguyen Engineering Building 1108

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, 2:00 – 4:00 pm

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/fall2019/ece631/home

Textbook:
- 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.
**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**

- 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 week)

- GNU Radio Example Applications (7 weeks)  
  Possible examples include:
  - Spectrum Analyzer
  - FM Receiver
  - WiFi Sniffer
  - Spectrum Sensor
Grading (tentative):

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

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 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, Oct. 16, 2019 (in-class, 1.5 – 2 hours).

Final Exam: Wednesday, Dec. 11, 2019 (7:30 – 10:15 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: *subject to updates*

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<thead>
<tr>
<th>Week 1:</th>
<th>Aug. 28</th>
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<tbody>
<tr>
<td></td>
<td>Overview of Software-Defined Radio (Chapters 1–3); GNU Radio Overview</td>
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<td><em>Lab 1, Part 1: GNU Radio Installation</em></td>
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<td>Week 2:</td>
<td>Sep. 4</td>
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<td>Overview of Software-Defined Radio (Chapters 1–4); <em>Lab 1, Part 2: Dial Tone</em></td>
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<td>Week 3:</td>
<td>Sep. 11</td>
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<td>Analog Modulation/Demodulation (Chapter 5); <em>Lab 2: Visualization, FM Demod, AM Demod</em></td>
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<td>Week 4:</td>
<td>Sep. 18</td>
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<td>Sampling with Automatic Gain Control (Chapter 6); <em>Lab 3: Python Programming, AGC</em></td>
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<td>Week 5:</td>
<td>Sep. 25</td>
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<td>Digital Filtering and Bits to Symbols to Signals (Chapters 7 and 8); <em>Lab 4, Part 1: Creating Custom GNU Radio Blocks</em></td>
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<td>Week 6:</td>
<td>Oct. 2</td>
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<td>Modeling Corruption and Simulating an Idealized System (Chapter 9); <em>Lab 4, Part 2: Digital Filters</em></td>
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<td>Week 7:</td>
<td>Oct. 9</td>
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<td>Modeling Corruption and Simulating an Idealized System (Chapter 9); <em>Lab 5: Quantization Noise</em></td>
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<td>Week 8:</td>
<td>Oct. 16</td>
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<td>Midterm Exam;</td>
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<td>Week 9:</td>
<td>Oct. 23</td>
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<td>Carrier Recovery (Chapter 10); <em>Lab 6: Carrier Recovery</em></td>
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<td>Week 10:</td>
<td>Oct. 30</td>
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<td>Pulse Shaping and Receive Filtering (Chapter 11); <em>Lab 7: Timing Recovery</em></td>
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<td>Week 11:</td>
<td>Nov. 6</td>
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<td>Timing Recovery (Chapter 12); <em>Lab 7: Timing Recovery</em></td>
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<td>Week 12:</td>
<td>Nov. 13</td>
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<td>Linear Equalization (Chapter 13); <em>Lab 9: Equalization</em></td>
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<td>Week 13:</td>
<td>Nov. 20</td>
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<td>Coding (Chapter 14); <em>Lab 10: Adaptive Equalization</em></td>
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<td>Week 14:</td>
<td>Nov. 27</td>
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<td>No Class [Thanksgiving Break]</td>
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<td>Week 15:</td>
<td>Dec. 4</td>
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<td>Digital Quadrature Amplitude Modulation (Chapter 16) <em>Scholarly Paper Presentations</em></td>
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WAVES: Wellness, Alcohol and Violence Education and Services
WAVES promotes wellness within the Mason community through health education, alcohol/drug assessment and education, and violence awareness, prevention and sexual assault response. We help students make healthy, safe choices and encourage lifelong, thoughtful healthy decision-making through individualized support, creative programming, and evidence-based education and outreach.

WAVES office 703-993-9999
SUB I, Suite 3200
24-Hour Sexual and Intimate Partner Violence Crisis Line 703-380-1434
waves.gmu.edu

- 703-360-7273 (Fairfax County Office for Women and Domestic and Sexual Violence Services 25 hotline)
- 703- 228-4848 (Arlington County Domestic Violence Services Hotline)
- 703-368-4141 (Prince William County Sexual Assault Victims Advocacy Services (SAVAS) hotline)
- 1-800-838-8238 (Virginia Family Violence and Sexual Assault Hotline)
- 1-800-656-HOPE (Rape, Abuse and Incest National Network)
https://ohl.rainn.org/online/

CAPS: Counseling and Psychological Services
Counseling and Psychological Services (CAPS) provides a wide range of free confidential services to students, faculty, and staff. Services are provided by a staff of professional clinical psychologists, social workers, counselors, learning specialists, and psychiatric providers. CAPS individual and group counseling, workshops, and outreach programs are designed to enhance students' personal experience and academic performance. Visit us at caps.gmu.edu for additional resources.

- For consultation or emergency assistance during office hours call 703-993-2380.
- For assistance during non-office hours, call University Police at 703-993-4357.
- 703-527-4077 (CrisisLink)
- 1-800-273-8255 (National Suicide Prevention Lifeline)
- 1-877-838-2838 (Veterans' Crisis Hotline)

Student Health Services (SHS) — Provides confidential health care to enrolled students in emergency and non-emergency circumstances on the Fairfax, Arlington and Prince William campuses. If there is a medical emergency and Student Health Services (SHS) is closed, please contact the free after-hours nurse ((703) 993-2831), a hospital emergency room, an urgent care facility, or call 911.

SUB 1, Suite 2300
703-993-2831

University Police:
Emergency: 911 Non-Emergency: (703) 993-2810
Reporting a Crime (Crime Solvers Anonymous Tip Hot-Line): (703) 993-4111
Mason Police Website: http://police.gmu.edu/
Eric Heath, Chief of Police Phone: (703) 993-3840 E-mail: eheath2@gmu.edu