

# ECE 531 – SOFTWARE DEFINED RADIO, SPRING 2024

Instruction Mode: Fully Online

Asynchronous Lecture Format

Lectures posted tentatively on Tuesdays and Thursdays

**Course Page:** <https://d2l.arizona.edu/d2l/home/1418417>

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<b>Instructor:</b>	Dr. Daniel Gallagher	<b>Email:</b>	danielgallagher@arizona.edu
<b>Office:</b>	via Zoom	<b>Office Hours:</b>	<i>TBD / By Appointment</i>

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**Course Description:** This course covers the fundamentals of designing fully functional software defined radio systems using a hardware radio peripheral and GNU Radio software. Students will design and implement core components of physical layer communication systems such as transmitters, receivers, channel estimators, and equalizers.

**Course Format:** Lecture with hands-on labs and final project

**Course Objectives:** After taking this course a student should be able to ...

- Implement fundamental physical-layer components using SDR hardware and software.
- Analyze the performance of physical-layer components using common metrics.
- Design a communication system using SDR subject to system-level requirements.

## Required Materials:

**Textbook:** T. F. Collins, et. al., *Software-Defined Radio for Engineers*, Artech House, 2018. (eBook)

**Hardware:** ADALM-PLUTO, SDR Active Learning Module (Purchase instead of textbook)

**Software:** Mathworks MATLAB with Requisite Toolboxes , GNU Radio, VirtualBox with Extension Pack

## Supplementary Materials:

**Textbook:** Jeffrey H. Reed, *Software radio : a modern approach to radio engineering*, Prentice Hall, 2002.

**Hardware:** RTL2832U Dongle with R820T2 (aka RTL-SDR)

**Software:** [radioconda](#), Ubuntu Linux, [CGRAN](#)

## Prerequisites or Co-requisites:

- MATLAB, Python, C/C++ programming
- ECE 340A, or equivalent
- ECE 429, or equivalent

## Course Grading:

- Lab Assignments (70%), Final Project (30%).
- Grade Scale:  $\geq 90\% = A$ ,  $\geq 80\% = B$ ,  $\geq 70\% = C$ ,  $\geq 60\% = D$ ,  $< 60\% = E$
- All assignment scores will be posted on the class D2L.
- Tentative Lab assignment dates are listed on the final page of this syllabus.

**Dispute of Grade Policy:** If any lab assignment, quiz, discussion, or exam has been graded incorrectly, it is the responsibility of the student to report this to the instructor no later than two weeks from the date the grade is received. The date the grade is received for D2L graded assignments is the date the grade is posted.

**Laboratory Experiments:**

Eight SDR laboratory experiments are planned this semester. Each are to be completed with the students' own SDR hardware and computer with MATLAB or Python and GNU Radio installed. Students may work together to complete each lab assignment. However, plagiarism is prohibited and will result in a zero for that lab assignment. Late assignment submissions will receive a 10% penalty for each day past the due date.

**Final Project:**

A final project using the SDR will be completed during the semester and due on the last day of class. All proposed projects must be submitted for approval by the instructor. Students may work in groups of two or less to complete the project.

**Amateur Radio Licensing:**

Software defined radio hardware is capable on transmitting across a wide range of frequency bands subject to federal regulations. It is the responsibility of the student to ensure they are meeting all requirements for legal emissions when using their SDR. Students are encouraged to maintain a current amateur radio license. The Radio Society of Tucson offers entirely free exams on the second Monday of each month. For further information, see [www.k7rst.org/testing.html](http://www.k7rst.org/testing.html) and [www.k7uaz.com/get-licensed](http://www.k7uaz.com/get-licensed).

**Absence and Attendance Policy:**

The UA's policy concerning Class Attendance, Participation, and Administrative Drops is available at: <http://catalog.arizona.edu/policy/class-attendance-participation-and-administrative-drop>.

The UA policy regarding absences for any sincerely held religious belief, observance or practice will be accommodated where reasonable, <http://policy.arizona.edu/human-resources/religious-accommodation-policy>.

Absences pre-approved by the UA Dean of Students (or Dean Designee) will be honored. See: <http://deanofstudents.arizona.edu/absences>

Participating in the course and attending lectures and other course events are vital to the learning process. As such, attendance is required at all lectures and discussion section meetings. Students who miss class due to illness or emergency are required to bring documentation from their health-care provider or other relevant, professional third parties. Failure to submit third-party documentation will result in unexcused absences.

**Accessibility and Accommodations:**

At the University of Arizona we strive to make learning experiences as accessible as possible. If you anticipate or experience physical or academic barriers based on disability or pregnancy, you are welcome to let me know so that we can discuss options. You are also encouraged to contact Disability Resources (520-621-3268) to explore reasonable accommodation. For additional information on Disability Resources and reasonable accommodations, please visit <http://drc.arizona.edu/>.

Please be aware that the accessible table and chairs in this room should remain available for students who find that standard classroom seating is not usable.

**Classroom Behavior Policy:**

To foster a positive learning environment, students and instructors have a shared responsibility. We want a safe, welcoming and inclusive environment where all of us feel comfortable with each other and where we can challenge ourselves to succeed. To that end, our focus is on the tasks at hand and not on extraneous activities (i.e. texting, chatting, reading a newspaper, making phone calls, web surfing, etc).

Students are asked to refrain from disruptive conversations with people sitting around them during lecture. Students observed engaging in disruptive activity will be asked to cease this behavior. Those who continue to disrupt the class will be asked to leave lecture or discussion and may be reported to the Dean of Students.

**Threatening Behavior Policy:**

The UA Threatening Behavior by Students Policy prohibits threats of physical harm to any member of the University community, including to one's self. See: <http://policy.arizona.edu/education-and-student-affairs/threatening-behavior-students>.

**Code of Academic Integrity:**

Students are encouraged to share intellectual views and discuss freely the principles and applications of course materials. However, graded work/exercises must be the product of independent effort unless otherwise instructed. Students are expected to adhere to the UA Code of Academic Integrity as described in the UA General Catalog. See: <http://deanofstudents.arizona.edu/academic-integrity/students/academic-integrity>.

The University Libraries have some excellent tips for avoiding plagiarism available at: <http://new.library.arizona.edu/research/citing/plagiarism>.

Selling class notes and/or other course materials to other students or to a third party for resale is not permitted without the instructor's express written consent. Violations to this and other course rules are subject to the Code of Academic Integrity and may result in course sanctions. Additionally, students who use D2L or UA email to sell or buy these copyrighted materials are subject to Code of Conduct Violations for misuse of student email addresses. This conduct may also constitute copyright infringement.

**UA Nondiscrimination and Anti-harassment Policy:**

The University is committed to creating and maintaining an environment free of discrimination, <http://policy.arizona.edu/human-resources/nondiscrimination-and-anti-harassment-policy>

Our classroom is a place where everyone is encouraged to express well-formed opinions and their reasons for those opinions. We also want to create a tolerant and open environment where such opinions can be expressed without resorting to bullying or discrimination of others.

**Additional Resources for Students:**

UA Academic policies and procedures are available at: <http://catalog.arizona.edu>

Student Assistance and Advocacy information is available at: <http://deanofstudents.arizona.edu/student-assistance/students/student-assistance>

**Confidentiality of Student Records:** <http://www.registrar.arizona.edu/personal-information/family-educational-rights-and-privacy-act-1974-ferpa?topic=ferpa>

**Subject to Change Statement:**

Information contained in the course syllabus, other than the grade and absence policy, may be subject to change with advance notice, as deemed appropriate by the instructor.

**Tentative Schedule<sup>†</sup>:**

*Note: Course will be offered in an asynchronous format this semester. The tentative dates for lecture topics and lab assignments are shown below. Labs due one week following this date unless otherwise specified.*

TUESDAY		THURSDAY	
Jan 9th		11th	<b>1</b>
		First Class – Course Introduction	
16th	<b>2</b>	18th	<b>3</b>
Review Of Signals and Systems Theory		SDR Software Tools: GNU Radio Introduction	
23rd	<b>4</b>	25th	<b>5</b>
Lab 1: SDR Concepts (Simulation Lab)		Understanding SDR Hardware	
30th	<b>6</b>	Feb 1st	<b>7</b>
		Lab 2: HW & SW Setup (Hardware Required)	
6th	<b>8</b>	8th	<b>9</b>
Probability Theory in Communications		Lab 3: Spectrum Exploration	
13th	<b>10</b>	15th	<b>11</b>
Analog Communications Fundamentals		Lab 4: Analog Modulation – AM/FM	
20th	<b>12</b>	22nd	<b>13</b>
Digital Communications		Digital Communications (cont.)	
27th	<b>14</b>	29th	<b>15</b>
		Timing Synchronization	
Mar 5th		7th	
Spring Recess – No Class		Spring Recess – No Class	
12th	<b>16</b>	14th	<b>17</b>
		Lab 5: Digital Modulation – Symbol Synchronization	
19th	<b>18</b>	21st	<b>19</b>
Carrier Synchronization		Lab 6: Digital Modulation – Carrier Synchronization	
26th	<b>20</b>	28th	<b>21</b>
Frame Synchronization		Lab 7: Digital Modulation – Frame Synchronization	
Apr 2nd	<b>22</b>	4th	<b>23</b>
Digital Filters on SDR		Channel Equalization	
9th	<b>24</b>	11th	<b>25</b>
Basic SDR Radar with GNU Radio		Lab 8: SDR – Software Defined Radar	
16th	<b>26</b>	18th	<b>27</b>
SDR Special Topics and Applications			
23rd	<b>28</b>	25th	<b>29</b>
SDR Special Topics			
30th	<b>30</b>	May 2nd	
Final Class – Project Due			

<sup>†</sup> This schedule is tentative and is subject to change.