UNIVERSITY of
SOUTH FLORIDA
College of Engineering
Department of
Electrical Engineering

EEL 4936/6592

Wireless Communication Systems Lab

12647 - 20039, Section 001-002, 3 Credits

College of Engineering, Electrical Engineering

COURSE SYLLABUS

Last Updated: 1/12/2021

Semester: Spring 2021
Class Meeting Days: Fridays
Class Meeting Time: 08:00am-10:45am
Class Meeting Location: ENG 201 or MS Teams
Lab Meeting Days: Monday (Sec 001) – Tuesday (Sec 002)
Lab Meeting Time: 09:00am-12:50pm (Monday) – 11:00am-02:50pm (Tuesday)
Lab Meeting Location: ENB 236 or MS Teams
Instructor: Dr. Huseyin ARSLAN
Office Location: ENB 361
Office Hours: Tuesday 07.30-09.00 pm (via MS Teams)
Phone Number: (813) 974-3940
Email: arslan@usf.edu
TAs: Mehmet Mert Sahin, Alihan Okka, Thomas Ranstrom
E-mail: {mehmetmert, alihanokka, jranstrom} @usf.edu

I. University Course Description

It provides the students with an extensive hands-on introduction to digital communications and wireless communication systems; involving testing, modeling, simulation, and measurements of the performance of digital communication systems at both sub-system and complete system levels. It offers technical, practical, and up-to-date treatment of the latest wireless communication technologies and system design implementations. Wireless multipath channel characteristic and its effect on the system will be reviewed. The design of wireless systems to counteract the channel and radio impairments will be discussed and practically shown. Radar, sensing, and REM aspects, wireless sensing, WiFi Sensing, REM and JRC concepts will be introduced.

II. Course Prerequisites

Basic knowledge of Fourier transforms and linear system analysis, digital signal processing, communication systems, programming skill in MATLAB or equivalent will be extremely helpful in understanding the course better. An undergraduate-level “Signals & Systems” and “Probability & Statistics for Engineering” is excellent preparation for this course. Students without any wireless communications background should be prepared well, because certain portions of the course may be challenging to follow.

III. Student Learning Outcomes

Upon successful completion of the course, the students will be in a position to:

a. Use SDR-capable signal analyzers and generators with enhanced capabilities.
b. Understand wireless communication systems front-end hardware such as mixer, filter, power amplifier, LNA, VCO, etc.
c. Understand popularly used modulation types in various wireless standards.
d. Understand the tools used to quantify the quality of wireless signals: Spectrum analysis, Time domain analysis, Code domain analysis, Joint time and frequency analysis, cyclostationarity analysis, angular domain analysis, space domain analysis, EVM, CCDF, Constellation, Eye diagrams, etc.
e. Perform multi-dimensional signal analysis (features of CDMA, Bluetooth, and WLAN signals).
f. Understand filter effect in wireless communication systems and study of various digital baseband filters.
g. Cover synchronization in wireless communications (time, frequency, and phase synchronization) and channel estimation.
h. Observe communication channel impact in wireless systems.
i. Experience RF front-end distortions in wireless systems.
j. Perform interference analysis.
k. Learn main features of OFDM signals
l. Get familiar with the future wireless communication systems and concepts.
m. Learn Signal and waveform design for communication and radar jointly
n. Learn how to design and transmit signals for communication and sensing purposes
o. Measure communication and radar signals
p. Investigate modulation types for communication and sensing purposes
q. Learn hardware impairments and their effects in both communication and radar
r. Analyze radar (sensing) compared to communication
s. Perform blind signal analysis
t. Use of ML for blind signal analysis

IV. Recommended Texts and/or Readings and Course Materials

- Design and Analysis of Wireless Communication Signal, by A Laboratory-Based Approach: Hüseyin Arslan, Wiley, 2021
- Contemporary Communication Systems Using MATLAB, by Gerhard Bauch, Masoud Salehi, John G. Proakis, Cengage Learning, 2013
- Software-Defined Radio for Engineers, by Travis F. Collins, Robin Getz, Di Pu, and Alexander M. Wyglinski, 2018, ISBN-13: 978-1-63081-457-1.

Related reading materials (Manuals, declaration file, and supplement documents) are reachable via course web site.

V. Grading Scale

Grading Scale (%)	
90-100	A
80 - 89	B
70 - 79	C
60 - 69	D
0 - 59	F

VI. Grade Categories and Weights

Assessment		Percentage	Description
Pre-Labs Quizzes		10%	Deadline is beginning of the labs
Lab Reports		30%	Each lab report will be submitted online before the next lab
Project	Preliminary	5%	Report on March 12th
	Final Report + Demo	25%	Last week of classes (during one of the lab sessions)
Final Exam		30%	Last week of classes (during the regular class hour)
Bonus		20%	A publication which is approved by the instructor

*Note: The nature of lecture will be in the following order:
1) Watch offline videos (asynchronous) if available.
2) Attend the synchronous review and Q&A sessions (On the Team Microsoft).
3) Take the quiz before the lab.
4) Attend the lab session (online or face-to-face) and prepare the report.

VII. Course Schedule

Week	Lab Number	Lab Topic	Topics to be discussed in class
1/15	-	There is no lab in first week	Introduction to numerical modeling and experimental implementation environment Introduction to SDR equipment (USRP, Adalm Pluto, and high-end equipment) SDR transceiver and how to use, Laboratory test-bed, Introduction to basic terminology
1/22	1	Introduction to SDR equipment	A basic communication link simulation (AWGN channel), More advanced link simulation (fading channel), Further advanced link simulation (multipath channel), Perfect channel knowledge (no synchronization nor channel estimation)

1/29	2	Link Simulation	Multidimensional (time, frequency, code, etc.) signal analysis through SDR equipment and measurement techniques Performance analysis tools and how to interpret Measurements and visualization tools.
2/5	3	Multi-dimensional signal analysis	Digital modulation techniques and related measurement methods. Constant envelope versus non-constant envelop. Power, spectral efficiency, and data rate trade-offs
2/12	4	Modulation	Pulse-shaping filters and related measurement methods, Nyquist criterion, raised cosine filters, ISI free filtering, roll-off factor, time-bandwidth (BW) relations, Filters and their effect on the communication, Localized versus non-localized pulses, optimal match filtering
2/19	5	Pulse Shaping	RF front-end components and RF front-end impairments Hardware components (LNA, Filters, VCO …), and system analysis along with some measurements Understanding the impact of RF impairments on the system
2/26	6	RF front-end	Wireless channel and channel impact on wireless communications
3/5	7	Wireless Channel	Synchronization, receiver design, including time/frequency/phase synchronization and channel estimation-compensation
3/12	8	Receiver Design	Simulation and evaluation of OFDM Introduction to OFDM and comprehension of various impairments on its performance Understanding and analyzing the OFDM Generating and receiving an OFDM signal, and apply the frequency and time domain analysis Demodulation analysis in the OFDM
3/19	9	OFDM	Multiple accessing and multi-waveform scheduling The general principles of multiple accessing, orthogonal and non-orthogonal multiple accessing Frame structures and multiple accessing mechanisms and receiver techniques corresponding each of these multiple access techniques

			Multi-user communication, multi-user interference, partial overlapping concepts will be discussed
3/26	10	Multiple Accessing	Blindly estimation of signal parameters such as modulation type or pulse-shaping filter type etc. or Radar-sensing of wireless channel using the wireless signal, signal parameter design to have good sensing capabilities
4/2	11	Blind Signal Analysis or Radar and Sensing	Review
4/9	-	Project	Review
4/16	-	SPRING BREAK	-
4/23	-	Project	Review
4/30	-	Project	Test Free Week (the due date for all mandatory graded submission before the final). The policy can be checked in https://www.usf.edu/general-counsel/documents/regulations-policies/new-amended/policy-10-005.pdf

VIII. Laboratory Hours

Students who are able to come to the lab, they can do the experiments using the components and equipment during the lab hours. Those who are not able to come

- Cameras are placed near the benches in the lab. Remote students can partner with another student who are able to come to the lab, or in the worst case, they can partner with a TA. They can have interactive virtual lab experience.
- Video recording of every lab session will be done by the TAs. Some video recordings will be shared with the students on the use of the equipment, how to analyze signals, how to capture signals, how to generate signals, how to do co-simulation with MATLAB and equipment. Use of different SDR equipment will be performed to introduce diversity. Different measurement techniques, how to analyze signals with these measurements will be performed during the lab sessions and will be recorded.

You will receive a schedule that details the operating hours for the Lab in ENB-236. The schedule will also be posted on the door. You are not allowed to use any workbench other than the ones designated for this course.

Graduate students and some undergraduate students who are working on Senior Design Projects also have special access to the lab. You are asked not to attempt entry into the lab outside the

scheduled hours, even if you see that there are some other non-TA students in the room. **It is a strict policy**.

IX. Laboratory Partners

Typically students will work in teams of two (at most three). The team members will be rotated weekly when possible; in the case that multiple laboratory exercises are addressed in a single session, the partners will likely remain the same. Similarly, in the case of a lab exercise that will last multiple sessions, the partners will remain the same. The teaching assistant will make sure that on a given team, there is equal participation from each student and may make specific team assignments to address this point.

X. General Instructions for Writing Your Laboratory Reports

1. Your completed laboratory assignment is to consist of your original laboratory procedure sheets.
2. Each report is to include a ½ to 1-page SUMMARY.
3. For some laboratories, specific questions are asked and specific plots and figures are requested. These figures, graphs, tables, and answers to specific questions specified in the lab write-up are to be included as additional pages under "Discussion of Results." Make sure all figures include a description of what the figure represents (title or caption), and that x- and y-axes of all plots are clearly labeled.
4. Some laboratory procedures ask you to make OBSERVATIONS based on the data that you have recorded, and to perform specific calculations within the procedure. Make sure that you make every effort to respond to all data and observation requests throughout the procedure.
5. You may also want to make a few additional notes while completing the experiments: **observe** the graphs and data, and try to **interpret** them. These notes will help you to write a good summary.
6. Ask questions during the laboratory period to aid in your understanding.
7. Your reports should be generated using a word processor. It is the student's responsibility to make sure that all text in the uploaded file is computer recognizable.
8. While you are encouraged to discuss issues and trade ideas with your lab partner and other students in the lab, your lab SUMMARY and (where applicable) DISCUSSION OF RESULTS must be in your own words.
9. Do your best to reflect your understanding of the concepts related to the lab and discuss the main results you achieved. **The clear communication of your interpretations on the relevant concepts of the experiment is the most important aspect of your report.**

The TAs will provide you a template to help you write your reports. Note that for some of the experiments, there may be additional guidelines.

XI. Projects

By lab 8 (receiver design lab), students are expected to pick a project to carry out from week 11 until the last week of the semester. A project proposal and presentation are required before the announced deadline. The project proposal needs to be approved by the instructor. Unapproved projects and any delay due to the un-approval of the project are students' responsibilities. Therefore, students are required to work with the instructor well ahead of the time for identifying a proper project. Like the regular labs, projects will be carried out with teams of two students, and the partners will remain the same during the project period.

Note: Due to the Covid-19, the lab project can be simulation and theory. The use of the equipment in the course projects is not mandatory but recommended. If needed, TAs can provide data sets for your projects.

Additional Course Features: This course utilizes the University of South Florida's state of the art wireless communication systems laboratory. Students work in up to 3 people laboratory teams that alternate throughout the semester.

XII. Standard University Policies

Policies about disability access, religious observances, academic grievances, academic integrity and misconduct, academic continuity, food insecurity, and sexual harassment are governed by a central set of policies that apply to all classes at USF. These may be accessed at: https://www.usf.edu/provost/faculty/core-syllabus-policy-statements.aspx

XIII. Covid-19 Procedures

All students must comply with university policies and posted signs regarding COVID-19 mitigation measures, including wearing face coverings and maintaining social distancing during in-person classes and labs. Failure to do so may result in dismissal from class, referral to the Office of Student Conduct and Ethical Development, and possible removal from campus. Some of procedures that both students and TAs need to follow during the lab sessions and in-class lectures are listed below:

1- **Complete daily screening as requested.** Anyone experiencing one or more COVID-19 symptoms should not be on campus or, if a resident, should not be outside their

residence hall room and should contact a medical provider immediately and follow their guidance. Please inform your instructor prior to the beginning class if your screening indicates the need for further evaluation and you will not be in class.

2- **Wear face coverings.** All members of the USF community are required to wear face coverings while in classrooms or any other shared space, including specified public or common-use areas where social distancing guidelines cannot be followed. If you have to use a disposable face mask, please discard it in a trash receptacle immediately after use.
3- **Maintain social distancing.** All students, faculty, staff and guests are required to maintain a safe distance from one another. Social distancing is maintained in all indoor and outdoor spaces which are owned or controlled by USF. Stay at least 6 feet (about 2 arms' length) from other people, do not gather in groups, stay out of crowded places and avoid mass gatherings. See the CDC for information on Social Distancing. Please sit in only designated areas in class and do not move chairs or desks in classrooms or common spaces.
4- **Practice good hand hygiene.** Individuals should wash their hands with soap and water for at least 20 seconds as often as possible or use personal hand sanitizers containing at least 60% alcohol. Hand sanitizer stations are available throughout the campus. If you see one, use it! See the CDC recommendations on Hand Hygiene.
5- **Disinfect your classroom or lab space.** Students and faculty are responsible for disinfecting areas within their workspaces by cleaning these at the beginning and end of each class. This includes desktops, seats, and equipment used during class. Disinfectant supplies will be provided. If paper towels are used to disinfect, they must be discarded in a trash receptable immediately after use.

Additional details are available on the University's Core Syllabus Policy Statements page: https://www.usf.edu/provost/faculty/core-syllabus-policy-statements.aspx

XIV. Course Policies: Technology and Media

Canvas: This course will be offered via USF's learning management system (LMS), Canvas. If you need help learning how to perform various tasks related to this course or other courses being offered in Canvas, please view the following videos or consult the Canvas help guides. You may also contact USF's IT department at (813) 974-1222 or help@usf.edu. Notifications, course modules and exams will be uploaded on Canvas.

Microsoft Teams: Synchronous meeting sessions and office hours will be held on MS Teams software.

Online Proctoring: Canvas-based tests and/or quizzes within this course will require online proctoring. Students are therefore required to install the 'Proctorio' program where details can be found on the website https://proctorio.com/.

Kaltura: Course contents such as videos will be recorded via Kaltura software that is compatible with Canvas.

XV. Testing policies/procedures

All the quizzes and exams will be online. The use of 'Proctorio' and a camera are required for all the exams. Your voice and video will be recorded during the exams.

XVI. Course modality and expectations

First lecture on 15 January Friday will start at 8.00 am on MS Teams as well as in-class and it will take the whole 3 scheduled hours. The course will have offline recordings (for asynchronous viewing) and online (synchronous) review and question and answer. Each week will have around 120 minutes of asynchronous viewing and 60 minutes of synchronous review and Q&A. The students are required to watch the offline (pre-recorded) videos before attending the synchronous meeting (online or in-class). After watching the weekly modules and synchronous Q&A sessions, students are required to have a quiz that will be held on every week.

Academic Integrity

The faculty of the Electrical Engineering Department is committed to maintaining a learning environment which promotes academic integrity and the professional obligations recognized in the IEEE Code of Ethics (http://www.ieee.org/about/corporate/governance/p7-8.html). Accordingly, the department adheres to a common Academic Integrity Policy in all of its courses. This policy is to be applied uniformly in a fair and unbiased manner.

University rules regarding academic integrity will be strictly enforced. It is not acceptable to copy, plagiarize or otherwise make use of the work of others in completing homework, project, laboratory report, exam or other course assignments. Likewise, it is not acceptable to knowingly facilitate the copying or plagiarizing of one's own work by others in completing homework, project, laboratory report, exam or other course assignments. It is only acceptable to give or receive assistance from others when expressly permitted by the instructor. Unless specified otherwise, as in the case of all take-home exams, scholarly exchange regarding out-of-class assignments is encouraged. A more complete explanation of behaviors that violate academic integrity is provided at:
http://ugs.usf.edu/pdf/cat1314/08ACADEMICPOL.pdf

The minimum penalty for violation of the academic integrity policy stated in the preceding paragraph is the greater of an automatic zero on the assignment or a letter grade reduction in the overall course grade. Student(s) found in violation of the policy on an exam will receive an F or FF in the course. Violations of the policy will be recorded in a letter from the instructor that is kept in the student files held by the department. A second violation of the policy, irrespective of

whether it was related to an exam or any other course assignment, will result in expulsion from the Electrical Engineering Department.