Department of Electrical and Computer Engineering

EEL4583 Introduction to RF Systems

Fall 2021

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Office Hours: M 09:00 AM-12 PM
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Day and Time: Wednesdays, 5:00pm-7:40pm

Location: EC1113

Course Description and Purpose

The course introduces the basic concepts of wireless transceiver design for digital communications.

Textbook: Kevin McClaning, "Wireless Receiver Design for Digital Communications, 2nd Edition" SciTech Publishing, 2012, ISBN13-978-1891121807.

Other Reference: Tony J. Rouphael, "Wireless Receiver Architectures and Design: Antennas, RF, Synthesizers, Mixed Signal, and Digital Signal Processing," Elsevier Science, ISBN: 97-801-2378640.

SOFTWARE

Microwave Office, ADS

Prerequisite Courses

EEL 3514 – Communication Systems

Course Objectives

Upon completing this course, students will be able to:

- Apply RF terminology such as dB, dBm, S-parameters, VSWR, return loss, mismatch loss
- Introduce the main RF system blocks in transceivers and their functions: low noise amplifiers, mixer, voltage-controlled oscillators, filters, digitizers, …
- Study impairment in RF front-ends

- Understand main concepts and measurement parameters such as phase noise, sensitivity, temperature, non-linearity, EVM, BER, dynamic range, and their impact on RF systems.
- Analyze the trade-offs between different RF architectures and their requirements
- Introduce examples of radio architectures from commercial systems.

Important Information

Before starting this course, please review the following pages:

- Accessibility and Accommodation
- Academic Misconduct Statement

*Instructors retain the right to modify the course syllabus for any reason throughout the semester provided that:

- fair and adequate notice is given to enrolled students either by e mail, in writing, or through online publishing.
- modifications to the syllabus are not arbitrary or capricious; and,
- students are not unfairly disadvantaged by mid semester changes to grading standards, attendance standards, or performance measures.

Department Regulations Concerning Incomplete Grades

To qualify for an Incomplete, a student:
1. Must contact (e.g., phone, email, etc.) the instructor or secretary before or during missed portion of class.
2. Must be passing the course prior to that part of the course that is not completed
3. Must make up the incomplete work through the instructor of the course
4. Must see the instructor. All missed work must be finished before last two weeks of the following term.

ABET Relationship of course to program outcomes:

(Select corresponding boxes below to applicable program outcomes for the course.)

☒ 1. an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.

☐ 2. an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors.

☐ 3. an ability to communicate effectively with a range of audiences.

☐ 4. an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.

☐ 5. an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet

objectives.

☐ an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.

☒ 7. an ability to acquire and apply new knowledge as needed, using appropriate learning strategies.

Sample Grading Scheme

Letter	Range%	Letter	Range%	Letter	Range%
A	95 or above	B	83 - 86	C	70 - 76
A-	90 - 94	B-	80 - 82	D	60 - 69
B+	87 - 89	C+	77 - 79	F	59 or less

GRADING POLICY

Grading Policy	
Topic	Percentage
Homework/Pop Quizzes	10%
Project	15%
Exam I	25%
Exam II	25%
Final	25%

HOMEWORK

- Will be assigned weekly
- Homework submitted through Canvas
- Some homework will include a small MATLAB/RF CAD exercise. Tutorials will be provided by the instructor.

PROJECT

- Students are encouraged to form a team of up to 4 students
- Each group has the choice to pick either a research project or simulation-based project
- Research topics will be provided by the instructor

MIDTERMS

- In-class exam
- One (1) cheat sheet
- No smartphones & no Google

- **Based on Class and Homework**
- **There is a possibility for a web-based exam**

FINAL EXAM

- Taken during Final Examination Week
- Comprehensive
- Web-based or in-class multiple-choice exam
- Open book. Closed notes, no Google

TOPICS

1. Radio frequency basics: Decibels, impedance matching, S-parameters
2. Signals, noise, and modulation: white noise, analog and digital modulation, quadrature modulations, spectrum analysis
3. Filters: reviews of different types of filters in RF systems
4. Noise Fundamentals: equivalent models for RF devices, signal to noise ratio, cascade performance, sensitivity, dynamic range
5. Linearity: distortion, Intermodulation, amplifier nonlinearity, gain compression and output saturation.
6. Mixers: study mixer operation, frequency inversion, image frequency, spurious calculations.
7. Oscillators: Ideal and real-world oscillator, phase noise, spurious components.
8. Cascade designs: minimum detectable signal, dynamic range, gain distribution, system non-linearity
9. Digitizers: analog to digital converters, digital to analog converters
10. Transceiver architecture: design system architectures using knowledge from previous chapters.

Course Schedule

Session	Topic	Book Chapter
1	Syllabus / RF Basics	1
2	Signals, Noise Modulation	2
	Propagation	3
3	Antennas	4
	Filters	5

4	Noise	6
	Noise	6
5	Noise	6
6	**Exam I**	**Chapters 1, 2, 3, 4, 5, & 6**
	Linearity	7
7	Linearity	7
	Linearity	7
8	Mixers	8
	Mixers	8
9	Oscillators	9
	Oscillators	9
10	Cascade Design	10
	Cascade Design	10
11	**Exam II**	**Chapters 7, 8, 9, & 10**
	Digitizing	11
12	Digitizing	11
	Modulation/Demodulation	12
13	Transceiver Architectures	Other references
	Transceiver Architectures	Other references
14	Transceiver Architectures	Other references
	Transceiver Architectures	Other references
15	Project Presentation	
	Project Presentation	
16	Final Exam	