ECE 4880: RF Systems

Fall 2015

MWF: 11:15pm – 12:05pm Classroom: Hollister 306

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Weekly Events	Monday	Wednesday	Friday
Fall semester starts on 8/25	**8/24** No class	**8/26** Class introduction	**8/28** The history of radios
Homework 1 due (Friday 5pm at dropbox)	**8/31** Review: LC resonators	**9/2** Review: LC resonators	**9/4** Review: Maxwell equations and plane waves
Homework 2	**9/7** Labor Day: no class	**9/9** Review: Distributive and lumped-element transmission lines	**9/11** Review: Reflection and impedance in Smith Chart
Homework 3	**9/14** Functional modules in RF transceivers: filters and circulators	**9/16** Functional modules in RF transceivers: amplifiers, LNA and PA	**9/18** Functional modules in RF transceivers: Mixer and others
Homework 4	**9/21** Free space and channel modeling	**9/23** Idealized RF designs: Unilateral link budget	**9/25** Matrix representation in signal chain
In-class Prelim 1	**9/28** Matrix representation in signal chain	**9/30** Noise figure	**10/2** **In-class Prelim 1**
Homework 5	**10/5** Noise: mismatch, mixing and image	**10/7** Introduction to Simulink signal models	**10/9** No Class
	10/12 Fall break: No class	**10/14** Nonlinearity in radio frequency modules	**10/16** Nonlinearity and intermodulation (IM)
Homework 6	**10/19** Interplay between noise and nonlinearity	**10/21** Noise and nonlinearity: desensitization and jamming	**10/23** Noise and nonlinearity: dynamic range
Homework 7	**10/26** Architecture to improve linearity: parallel	**10/28** Architecture to improve linearity: feedthrough and feedback	**10/30** Frequency strategy: Superheterodyne
In-class Prelim 2	**11/2** Frequency strategy: Superheterodyne	**11/4** Frequency strategy: homodyne	**11/6** **In-class Prelim 2**
Homework 8	**11/9** Phase noise in oscillators: sources and adverse effects	**11/11** Phase noise in oscillators: modeling	**11/13** Data converter: type and main effects

Homework 9	**11/16** Data converter: bandwidth and range	**11/18** Data converter: implications on filtering	**11/20** Local area radios: Wifi, Zigbee, Bluetooth
	11/23 Cellular network: 3G, 4G and 5G	**11/25** Thanksgiving: No class	**11/27** Thanksgiving: No class
Homework 10	**11/30** Broadcasting network: radios and TVs	**12/2** An outlook of RFID	**12/4** An outlook of UWB radio

Course description: This course addresses the design of radio-frequency links in the component view to enable eventual full-duplex, multi-access wireless network. The analysis will reside mostly in the signal (SIMULINK) level instead of the circuit implementation, although the nonideal circuit characteristics will be reflected in the signal representation. Federal Communications Commission (FCC) and Occupational Safety & Health Administration (OSHA) standards will be introduced. Existing standard protocols will be selectively introduced including FM, TV broadcast, Bluetooth, Z-wave, Zigbee and Wi-fi.

Pre-requisites: ECE 3030 or consent of the instructor

Related courses: ECE 4870 (Radar Remote Sensing); ECE 4670 (Digital Communication); ECE 5680 (Wireless Communication); ECE 5790 (RFIC Design).

Logistics: 3 units. Lectures only. There are two prelim exams and one final exam.

Office hour: Thursday 4:30pm – 6:00pm

Textbooks:

1. Required: W. F. Egan, *Practical RF System Design*, Wiley 2004.
2. Recommended: T. H. Lee, *The Design of CMOS Radio Frequency Integrated Circuits*, *2nd Ed*, Cambridge, 2004. (Selected chapters that treat system aspects only. No transistor circuits will be included).
3. Recommended: T. J. Rouphael, *Wireless Receiver Architecture and Design: Antennas, RF, Synthesizers, Mixed Signal and Digital Signal Processing*, Academic Press 2014.
4. Recommended: M. Steer, *Microwave and RF Design: A System Approach, 2nd Ed.*, 2013, SciTech.

TA hour for SIMULINK help: Thursday 5 – 6 pm in Phillips 303 when necessary.

Grades: Homework (20%), prelim exam (20% each), class presentation (5%), and final exam (35%)

Course outcomes:

1. The student can analyze the signal flow in a given block diagram of radio transceivers in both analytical and SIMULINK representations.
2. The student can analyze the fundamental tradeoffs in noise, nonlinearity and spectral/component costs in a given FCC-approved wireless system.
3. The student will acquire sufficient design skills for active participation in amateur radio clubs and remote-control robotics.

Presentation signup: FM radio, TV broadcast, Wi-fi, Bluetooth, Z-Wave, Zigbee, and UWB. (1) Introduction (from FCC and current implementation); (2) Critical choices in the signal chain and components; (3) Hardware or software choices.

Final exam: 12/12 (Sat.) 2pm. Place: TBA.