Course Description

This course introduces fundamental technologies for wireless communications. We will address the following topics:

- Analog and digital modulation
- Propagation, shadowing, fading
- Radio trunking
- Multiple access schemes: FDMA, TDMA, CDMA
- Cellular communications
- Diversity
- Equalization
- Channel coding
- Wireless systems and standards (1G/2G/3G systems)
- Speech coding
- OFDM; Multiuser detection; space time coding; smart antenna; software radio, a.k.a., spectrum agile radio or cognitive radio (if time permits)

In the course, students are expected to gain some hand-on experience on W-CDMA systems (3G wireless systems).

Course Prerequisites

- EEL 4514 (Communication Systems and Components) or undergraduate-level communication theory
- EEL 5544 (Noise in Linear Systems) or undergraduate-level probability theory/stochastic processes
- Some exposure to MATLAB
- Graduate status

Textbook

Recommended Readings


Course Information

Instructor:

Dr. Dapeng Oliver Wu
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Email: wu@ece.ufl.edu

TA:

Pratik Prabhanjan Brahma
Email: prprbr@ufl.edu

Course website: http://www.wu.ece.ufl.edu/courses/eel6509s13

Meeting Time

Monday, Wednesday, Friday, period 9 (4:05 pm - 4:55 pm)

Meeting Room

NEB 201

Office Hours

- Dr. Wu: Monday, Wednesday, period 7 (1:55 pm - 2:45 pm), and by appointment via email.

Structure of the Course

The course consists of 28 lectures, 6 homework assignments, and 1 project.

This course is primarily a lecture course. I cover all important material in lectures. Since EEL 5544 is a prerequisite, I assume some previous knowledge about probability theory and stochastic processes, and hence I will cover some material very quickly. Thus, depending on what and how much you recall from earlier study, varying amounts of reading in introductory books on probability theory and stochastic processes (other than the course textbook) may be necessary; these readings are up to the student. I will only give reading assignments from the course textbook.
The class project is described [here](http://www.wu.ece.ufl.edu/courses/eel6509s13/).

**Course Outline**

1. Introduction to current and emerging wireless communication systems (Chaps. 1&2; 3 lecture hours)
2. Frequency reuse, handoff, interference and system capacity, sectorization, cell splitting, spectral efficiency, trunking and grade of service (Chap. 3; 3 lecture hours)
3. Introduction to radio propagation: large- and small-scale effects, multipath, path loss, log-normal shadowing, empirical path loss models (Secs. 4.1, 4.2, 4.6, 4.9, 4.10; 3 lecture hours)
4. Complex baseband model, linear time-varying channels, narrowband signals and Rayleigh fading, Ricean fading, Doppler shift, Doppler spread with uniform scattering (Secs. 5.1, 5.2, 5.6, 5.7; 3 lecture hours)
5. Fade statistics, coherence time, fast vs. slow fading, broadband signals and power delay profile, coherence bandwidth, flat vs. frequency-selective fading, effect on digital transmission (Secs. 5.4, 5.5; 3 lecture hours)
6. Digital and quadrature modulation, error probability with additive Gaussian noise and flat Rayleigh fading, coherent and noncoherent (differential) detection (Secs. 6.4, 6.5, 6.6, 6.7, 6.8, 6.12; 3 lecture hours)
7. Frequency-Shift Keying, coherent and noncoherent demodulation, Minimum-Shift Keying, Gaussian MSK, power and bandwidth efficiencies, Spread spectrum signaling (Secs. 6.9, 6.11; 2 lecture hours)
8. Equalization techniques: linear/nonlinear/adaptive equalization (Secs. 7.2 -- 7.9; 4 lecture hours)
9. Diversity combining techniques: selection, max-ratio, equal-gain; RAKE (Secs. 7.10 -- 7.11; 3 lecture hours)
10. Error control coding techniques: block codes, convolutional codes, Turbo codes (Secs. 7.12 -- 7.18; 3 lecture hours)
11. Speech coding (Chap. 8; 1 lecture hours)
12. Multiple access techniques: FDMA, TDMA, CDMA, ALOHA, Slotted ALOHA, CSMA (Chap. 9; 4 lecture hours)
13. Wireless systems and standards: AMPS, IS-136, GSM, IS-95, WCDMA (11.1 -- 11.4; 3 lecture hours)
14. Advanced topics: OFDM, Multiuser detection, space time coding, smart antenna, software radio (1 lecture hours)

**Course Objectives**

Upon the completion of the course, the student should be able to

- distinguish the major cellular communication standards (1G/2G/3G systems)
- characterize the tradeoffs among frequency reuse, signal-to-interference ratio, capacity, and spectral efficiency
- characterize large-scale path loss and shadowing
- characterize small-scale fading in terms of Doppler spectrum, coherence time, power delay profile, and coherence bandwidth
- analyze the error probabilities for common modulation schemes
- analyze the performance of trunked radio systems
- describe different types of diversity and how they improve performance for mobile radio channels
- describe simple equalization schemes
- characterize TDMA, FDMA and CDMA
Handouts

Please find handouts [here](#).

Requirements

Course Policies

- **Attendance:**
  - It is the student's responsibility to independently obtain any missed material (including handouts) from lecture.
  - There will be *no make-up exams*.
- **During lecture, cell phones should be turned off.**
- **No late submissions of your homework solution, project proposal/report, are allowed.**
- **Announcements:**
  - All students are responsible for announcements made in lecture, on the student access website, or via the class email list.
  - It is expected that you will check your email several times per week for possible course announcements.
- **Students with disabilities:**
  - Student requesting classroom accommodation must first register with the Dean of Students Office. The Dean of Students Office will provide documentation to the student who must then provide this documentation to the Instructor when requesting accommodation. For more information on classroom accommodation, please click [here](#).

- **Intellectual Integrity**

All students admitted to the University of Florida have signed a statement of academic honesty committing them to be honest in all academic work and understanding that failure to comply with this commitment will result in disciplinary action. This statement is a reminder to uphold your obligation as a student at the University of Florida, and to be honest in all work submitted and exams taken in this class and all others. Refer to the academic [honor code](#) for more information.

Students are encouraged to discuss class material in order to better understand concepts. All homework answers must be the author's own work. However, students are encouraged to discuss homework to promote better understanding. What this means in practice is that students are welcome to discuss problems and solution approaches, and in fact can communally work solutions at a board. However, the material handed in must be prepared starting with a clean sheet of paper (and the author's recollection of any solution session), but not refer to any written notes or existing code from other students during the writing of the solution. In other words, writing the homework report shall be an exercise in demonstrating the student understands the materials on his/her own, whether or not help was provided in attaining that understanding.

Useful links:

- For university counseling services and mental health services, please click [here](#).
Grading:

<table>
<thead>
<tr>
<th>Grades</th>
<th>Percentage</th>
<th>Due Dates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Homework</td>
<td>30%</td>
<td>see calendar</td>
</tr>
<tr>
<td>Project proposal</td>
<td>10%</td>
<td>4pm, March 15</td>
</tr>
<tr>
<td>Project report</td>
<td>60%</td>
<td>4pm, May 1</td>
</tr>
</tbody>
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The project report consists of

1. (50%) A written report for your project
2. (25%) Computer programs that you develop for your project
3. (10%) Powerpoint file of your presentation
4. (15%) Your presentation/demo video on YouTube

Grading scale:

Top 25% students will receive A. Average score will be at least B+.

Homework:

- There are six assignments.
- No late submissions are allowed.
- If you wish to dispute a homework grade, you must return the assignment along with a succinct written argument within one week after the graded materials have been returned to the class. Simple arithmetic errors in adding up grade totals are an exception, and can normally be handled verbally on-the-spot during office hours of the TA. For all other disputes, the entire homework may be (non-maliciously) re-graded, which may result in increase or decrease of points.

Class Project:

The class project will be done individually (that is, teaming with other students is not allowed). Each project requires a proposal and a final report. The final report is expected to be in the format of a conference paper plus computer programs and a Powerpoint file. On March 15, the project proposal (up to 2 pages) is due. On May 1, the final report (up to 10 pages) is due. For details about the project, please read here.

Suggested topics for projects are listed here.

Calendar:

Course calendar can be found here.
Related courses in other schools:

- Helsinki University of Technology, S-72.238: Wideband CDMA systems
- Northeastern University, COM3525: Wireless Networks
- Stanford University, EE359: Wireless Communications
- Stanford University, EE360: Advanced Topics in Wireless Communications
- University of California, Berkeley, EE 224B: Fundamentals of Wireless Communication
- University of Texas, Austin, Wireless communications
- University of Texas, Austin, Multiuser wireless communication

MATLAB

- MATLAB Tutorial
- MATLAB Central

Standards:

- IEEE 802.16 (WiMAX) [Introduction]
- 3GPP LTE (Long Term Evolution)

Online Calculator for Erlang-B formula

- http://personal.telefonica.terra.es/web/vr/erlang/eng/mcerlb.htm

Software:

- Advanced Design System (ADS) from Agilent
- Learning by simulations