EE 564: Digital Communication and Coding Systems
Spring 2019

Lecture: Monday, Wednesday 5:00 – 6:50 p.m. in RTH 105

Instructor: Christopher Wayne Walker, Ph.D.
Office: PHE 414
Office Hours: Monday 3:45 – 4:50 p.m.
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Course web page: DEN Blackboard

Required Texts:
No formal textbook. We will utilize power point slides produced by Professor Keith Chugg of USC.

Recommended Texts:
1. S. Benedetto and E. Biglieri, *Principle of Transmission with Wireless Applications*, Kluwer Academic, 1999.
2. B. Sklar, *Digital Communications: Fundamentals and Applications* (2nd Edition), Prentice Hall, 2001.

First Lecture: Monday, January 7
Last Lecture: Wednesday, April 24

No class: Monday, January 21 (MLK Day), Monday, February 18 (President's Day)
Monday March 11 and Wednesday March 13 (Spring Recess)

Course Grading Policy:

Method	Date	Weight
Homework	As assigned in class	20%
Midterm	TBD (take-home)	40%
Final Project Due	Wednesday, May 1, 4:30 p.m.	40%

Contact Information: You are welcome to consult with me or the TA during office hours. If my office hours are not convenient for you or else you have a question that needs addressing before you can see me then you are welcome to call or email me. Email is the preferred method of contact if I can answer your question with an email response, but if we need to have more interaction then you are welcome to call me at my office. If you call and I cannot speak with you immediately then I will set up a time to call you back to discuss any issues or concerns you may have. I want this course to be a positive learning experience for you so please make sure you get all your questions answered.

Homework: Homework will be assigned regularly. You may work with others on the homework assignments but the work you hand in must be your own and not copied from another student. Homework is due at 5:00 p.m. on the due date. Late homework will not be accepted.

Project: A final project will be assigned and will be due at 4:30 p.m. on Wednesday, May 1. The project is to be an individual effort. You may consult with only me or the TA regarding project related questions.

Course Objective: To obtain a systems level understanding of modern digital communication and error correction coding systems. This includes design concepts (digital modulation, coding, synchronization, equalization approaches), analysis techniques (computation of bandwidth, SNR, performance), and fundamental limits (information theory limits). Upon successful completion of this course a student will be well-prepared for a position in industry as a communication systems engineer or, alternatively, to pursue the material in more depth in a doctorate program.

Course outline: (Benedetto Chapter/Section for reference)

1. Overview of digital communication and coding systems (Ch. 1, Ch. 3)

    (a) Basic ideas from information theory
    (b) Block diagram of digital communication system
    (c) Role of error correction (FEC, CRC, ARQ)
    (d) High-level description of modulation and coding techniques

2. Digital communication signals and channels (2.1-2.5)

    (a) Common methods of digital modulation (Amplitude, frequency, phase shift keying)
    (b) Passband signal models. Complex baseband equivalent.
    (c) Pulse shaping and power spectral density
    (d) Signal space representation and dimensionality
    (e) Additive White Gaussian Noise (AWGN) channel
    (f) Intersymbol interference (ISI) channels

3. Optimal demodulation and decoding (2.6 and handouts)

    (a) MAP decision rule and optimality
    (b) Continuous time likelihood for AWGN channel
    (c) Sufficient statistics and reversibility
    (d) Composite hypothesis testing
    (e) Soft-out measures and formats

4. Uncoded, memoryless modulations over the AWGN channel (Ch. 4)

   (a) QASK formats (PAM, QAM, PSK)
   (b) Orthogonal and related modulations
   (c) Performance analysis and bounding techniques
   (d) Phase noncoherent differential methods and
   (e) Spectral efficiency considerations

5. Classical coding (Ch. 10, Ch. 11)

   (a) Linear block codes
        i. Error correction capabilities
        ii. Syndrome based decoding
        iii. Performance bounds
        iv. Example codes
   (b) Convolutional codes
        i. FSMs, state diagrams, trellises, graphical models
        ii. Decoding via Viterbi and Forward-backward algorithm
        iii. Performance bounds
        iv. Tables of best convolutional codes
        v. Parity check trellis for block codes

6. Modern coding (11.3 and handouts)

   (a) Code constructions and variations (LDPC, concatenated convolutional codes, etc.)
   (b) Iterative decoding
        i. Rules of iterative decoding
        ii. Graphical representations and message-passing interpretation
        iii. Analysis and design methods (uniform interleaved analysis and threshold prediction)

7. Uncoded modulations over ISI channels (Ch. 7 and handouts)

   (a) Linear ISI-AWGN channel model
   (b) Viterbi/FBA detection for ISI-AWGN channel
   (c) Linear and decision feedback equalization
   (d) OFDM
   (e) Single carrier FDE

8. Synchronization and peak-to-average power considerations (Ch. 9, Ch. 6, and handouts)

   (a) Maximum Likelihood parameter estimation
   (b) Frame synchroniztion
   (c) Symbol synchronization
   (d) Phase lock loops
   (e) CPM and offset modulations

9. Case study of a modern digital communication system (handouts)

    (a) Examples from WiFi, cellular, and satellite systems

Course schedule:

- Week 1: Overview of digital communication and coding systems
- Week 2: Digital communication signals and channels
- Week 3: Digital communication signals and channels
- Week 4: Optimal demodulation and decoding
- Week 5: Optimal demodulation and decoding
- Week 6: Uncoded, memoryless modulations over the AWGN channel
- Week 7: Uncoded, memoryless modulations over the AWGN channel

- Week 8: Review and Midterm
- Week 9: Classical coding
- Week 10: Classical coding
- Week 11: Modern coding
- Week 12: Modern coding
- Week 13: Uncoded modulations over ISI channels
- Week 14: Synchronization and peak-to-average power considerations

The above outline/schedule is tentative and may change if circumstances warrant.

Statement on Academic Conduct and Support Systems

Academic Conduct:

Plagiarism – presenting someone else's ideas as your own, either verbatim or recast in your own words – is a serious academic offense with serious consequences. Please familiarize yourself with the discussion of plagiarism in SCampus in Part B, Section 11, "Behavior Violating University Standards" policy.usc.edu/scampus-part-b. Other forms of academic dishonesty are equally unacceptable. See additional information in SCampus and university policies on scientific misconduct, policy.usc.edu/scientific- misconduct.

Support Systems:

Student Health Counseling Services - (213) 740-7711 – 24/7 on call
engemannshc.usc.edu/counseling

Free and confidential mental health treatment for students, including short-term psychotherapy, group counseling, stress fitness workshops, and crisis intervention.

National Suicide Prevention Lifeline - 1 (800) 273-8255 – 24/7 on call
suicidepreventionlifeline.org

Free and confidential emotional support to people in suicidal crisis or emotional distress 24 hours a day, 7 days a week.

Relationship and Sexual Violence Prevention Services (RSVP) - (213) 740-4900 – 24/7 on call
engemannshc.usc.edu/rsvp

Free and confidential therapy services, workshops, and training for situations related to gender-based harm.

Office of Equity and Diversity (OED) | Title IX - (213) 740-5086
equity.usc.edu, titleix.usc.edu

Information about how to get help or help a survivor of harassment or discrimination, rights of protected classes, reporting options, and additional resources for students, faculty, staff, visitors, and applicants. The university prohibits discrimination or harassment based on the following protected characteristics: race, color, national origin, ancestry, religion, sex, gender, gender identity, gender expression, sexual orientation, age, physical disability, medical condition, mental disability, marital status, pregnancy, veteran status, genetic information, and any other characteristic which may be specified in applicable laws and governmental regulations.

Bias Assessment Response and Support - (213) 740-2421
studentaffairs.usc.edu/bias-assessment-response-support

Avenue to report incidents of bias, hate crimes, and microaggressions for appropriate investigation and response.

The Office of Disability Services and Programs - (213) 740-0776
[dsp.usc.edu](dsp.usc.edu)

Support and accommodations for students with disabilities. Services include assistance in providing readers/notetakers/interpreters, special accommodations for test taking needs, assistance with architectural barriers, assistive technology, and support for individual needs.

USC Support and Advocacy - (213) 821-4710
studentaffairs.usc.edu/ssa

Assists students and families in resolving complex personal, financial, and academic issues adversely affecting their success as a student.

Diversity at USC - (213) 740-2101
diversity.usc.edu

Information on events, programs and training, the Provost's Diversity and Inclusion Council, Diversity Liaisons for each academic school, chronology, participation, and various resources for students.

USC Emergency - UPC: (213) 740-4321, HSC: (323) 442-1000 – 24/7 on call
dps.usc.edu, emergency.usc.edu

Emergency assistance and avenue to report a crime. Latest updates regarding safety, including ways in which instruction will be continued if an officially declared emergency makes travel to campus infeasible.

USC Department of Public Safety - UPC: (213) 740-6000, HSC: (323) 442-120 – 24/7 on call
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