



Course ID and Title: EE 467 Introduction to Communication Systems

Units: 4 (Converted from 3 units)

****IMPORTANT****

This course will be taught as 4 units in Spring 2024.

To facilitate this, all students should first register for 3 units of EE 467. Then:

- **undergraduates** should register for (1) unit of EE 490
- **graduate students** should register for (1) unit of EE 690

Undergraduates will receive the same grade in EE 490 as they receive in EE 467, and graduate students will receive a grade of CR in EE 690 if they pass the course (C or better for graduate students).

Students should sign up for (1) extra unit by submitting a request for EE 490 or EE 690 in myviterbi.usc.edu, with "Alan Willner" as supervising faculty, and type "4th unit for EE 467" in the text window.

Students are not required to register for the additional unit, but they are encouraged to do so if they want their units to reflect the effort of the course.**

Term—Day—Time: Spring 2024

Class time: 2 X 1:50/week

Location: TBD, but will be at UPC

Instructor: Alan Willner

Office: EEB 538

Office Hours: Mondays 1 pm – 2 pm

Contact Info:

willner@usc.edu, 213-740-4664

Teaching Assistant: TBD

Office:

Office Hours:

Contact Info:

Course Description

Objective: To obtain a familiarity with many basic concepts pertaining to analog and digital transmission of information. The material is beneficial to many areas of electrical engineering.

Description: This course will introduce students to the exciting and rapidly evolving scientific field of data communications. The basic concepts of analog and digital communication systems will be covered. We will discuss signal the physical understanding of Fourier series, transforms, and analysis; modulation and demodulation (e.g., the amplitude, frequency, and phase of a carrier wave); information encoding and decoding; multiplexing and demultiplexing of many channels; and channel capacity, signal power, system noise, link budgets, error rates, and spectral efficiency. Relevant information-transfer systems (e.g., radio, satellite, cellular, networks, and fiber optic) will be reviewed for their present and future applications.

The course includes traditional lecture time by the instructor as well as student presentations near the end of the semester.

Each student is expected to give a 15-minute oral presentation to the entire class on a selected and mutually-agreed-upon topic in modern-day communications. Moreover, each student is expected to submit a 10-20 page written presentation at the end of the semester on the same topic. The paper should include relevant references and figures. The presentation is based on material gleaned from the open literature.

Some specifics of the presentation process include the following points:

- The purpose of the presentation is for the student to study a modern-day topic in detail and clearly convey results to the class audience.
- Topics are chosen from a list after the first month of classes.
- The project will entail 2 consultations with the instructor: (1) the first to discuss direction of topic, and (2) second for preview of presentation slides. These will be scheduled individually.
- Oral presentations near the end of the semester. Duration of each presentation is 15 minutes, plus discussion time and questions.

The term topics will be on state-of-the-art communications issues. Please see a list of detailed topics in a subsequent section of the syllabus.

Learning Objectives

Course Objectives: To introduce students to many basic concepts pertaining to analog and digital transmission of information.

This course should enable a student to obtain a familiarity with most major areas of communication systems as well as delve deeply into a few state-of-the-art topics in the field. Specifically, this course should enable a student to:

- Understand basic concepts of a communication system.
- Identify different types of modulation and multiplexing formats.
- Compute a simple system power budget.
- Explain key differences between direct and coherent detection systems.
- Understand the basic concepts and motivations of communication systems.
- Apply transform theory to time-domain waveforms and frequency-domain spectra.
- Understand the role of probability theory in communication systems, and apply such theory to concepts such as white-Gaussian noise in a transmission link.
- Understand the concept of analog signal modulation, and analyze the benefits (and limitations) of amplitude, frequency, phase, and pulse modulation of analog signals.
- Apply de-modulation techniques to analog signals.
- Understand the concepts of information (de)coding in analog and digital systems.
- Analyze digital transmission systems and understand digital signal generation, transmission, and detection.
- Understand the role of signal quality monitoring techniques (such as the signal-to-noise ratio and bit-error-rates) to digital communication systems.

- Explain the concepts of multi-input-multiple-output systems, orthogonal frequency division multiplexing, and Nyquist pulses.
- Understand the effects of a signal's spectrum and signal power on a link budget and a communication system.
- Understand the role of the above concepts to modern communication systems.
- Research, understand, and orally present information on a specific topic related to modern communication systems (via the course project presentation).
- Write a concise paper summarizing their specific project topic.
- Attend more advanced courses in the future.

Prerequisite: EE 301 - Introduction to Linear Systems

Suggested Co-requisite: EE 364 or 464 - Probability Theory

Concurrent Enrollment: None.

Recommended Preparation: None.

Course Notes

The course is designed for students to attend classes in person. Students take notes during class.

Classes may be recorded, but only when deemed necessary by the instructor.

Grading will be a letter grade.

Technological Proficiency and Hardware/Software Required

None

Required Readings and Supplementary Materials

a. Required Text: Analog and Digital Communication Systems, 5th Ed., M.S. Roden, Prentice Hall

- This text will be available for purchase in the USC Bookstore

b. Other Suggested Texts: (To be put on reserve in Seaver Science and Engineering Library)

1. Communication Systems (3rd Ed.), A. Bruce Carlson
2. Information, Transmission, Modulation, and Noise, M. Schwartz
3. Communication Systems (2nd Ed.), S. Haykin
4. Digital and Analog Communication Systems, K.S. Shanmugam

Optional Readings and Supplementary Materials

Various handouts will be provided by the instructor during the semester.

Description and Assessment of Assignments

The 7 homework assignment sets are composed of engineering problems that deal with aspects of communications covered in class.

The homework problems are meant to provide students with a more rigorous treatment of the technical issues covered in the course.

Each homework set is graded out of a total of 40 points, for a grand total of 280 possible points. Homework accounts for 10% of the course grade.

Participation

Participation is highly encouraged but is not part of the grading for the course.

Grading Breakdown

Table 1 Grading Breakdown

Assessment Tool (assignments)	Points	% of Grade
Homework	280	10
Midterm	100	25
Oral presentation	100	12.5
Written presentation	100	12.5
Final	100	40
TOTAL	680	100

Assignment Submission Policy

Homework: Students will have 1 week to complete a homework assignment from the time the homework problems are distributed to the class.

Grading Timeline

Students can expect to receive the graded homeworks, midterms, presentations, and final exams approximately 1 week after submission.

Course Specific Policies

Students are encouraged to participate in class discussions.
Students are discouraged from using cellphones and texting during class.

Attendance

This class is designed as an in-person course. Class attendance is expected, although the grading system does not take attendance into account.

Classroom norms

Students are encouraged to participate in class discussions.
Students are discouraged from using cellphones and texting during class.

Zoom etiquette

Students are encouraged – but not required -- to keep their video on if class is held by zoom due to unusual circumstances.

Academic Integrity

The University of Southern California is foremost a learning community committed to fostering successful scholars and researchers dedicated to the pursuit of knowledge and the transmission of ideas. Academic misconduct is in contrast to the university's mission to educate students through a broad array of first-rank academic, professional, and extracurricular programs and includes any act of dishonesty in the submission of academic work (either in draft or final form).

This course will follow the expectations for academic integrity as stated in the [USC Student Handbook](#). All students are expected to submit assignments that are original work and prepared specifically for the course/section in this academic term. You may not submit work written by others or “recycle” work prepared for other courses without obtaining written permission from the instructor(s). Students suspected of engaging in academic misconduct will be reported to the Office of Academic Integrity.

Other violations of academic misconduct include, but are not limited to, cheating, plagiarism, fabrication (e.g., falsifying data), knowingly assisting others in acts of academic dishonesty, and any act that gains or is intended to gain an unfair academic advantage.

The impact of academic dishonesty is far-reaching and is considered a serious offense against the university and could result in outcomes such as failure on the assignment, failure in the course, suspension, or even expulsion from the university.

For more information about academic integrity see the [student handbook](#) or the [Office of Academic Integrity's website](#), and university policies on [Research and Scholarship Misconduct](#).

Creating a policy for the use of AI Generators in your course

AI use is not permitted for solving homework assignments and for generating content for the oral and written presentations.

Since creating, analytical, and critical thinking skills are part of the learning outcomes of this course, all assignments should be prepared by the student working individually. Students may not have another person or entity complete any substantive portion of the assignment. Developing strong competencies in

these areas will prepare you for a competitive workplace. Therefore, using AI-generated tools is prohibited in this course and will be identified as plagiarism.

In this class, students are expected to submit work that demonstrates individual mastery of the course concepts. Although students are encouraged to discuss technical issues together, all assignments are expected to be completed individually.

If found responsible for an academic violation, students may be assigned grade penalties and may be reported to the Office of Academic Integrity.

Course Content Distribution and Synchronous Session Recordings Policies

USC has policies that prohibit recording and distribution of any synchronous and asynchronous course content outside of the learning environment.

Recording a university class without the express permission of the instructor and announcement to the class, or unless conducted pursuant to an Office of Student Accessibility Services (OSAS) accommodation. Recording can inhibit free discussion in the future, and thus infringe on the academic freedom of other students as well as the instructor. ([Living our Unifying Values: The USC Student Handbook](#), page 13).

Distribution or use of notes, recordings, exams, or other intellectual property, based on university classes or lectures without the express permission of the instructor for purposes other than individual or group study. This includes but is not limited to providing materials for distribution by services publishing course materials. This restriction on unauthorized use also applies to all information, which had been distributed to students or in any way had been displayed for use in relationship to the class, whether obtained in class, via email, on the internet, or via any other media. ([Living our Unifying Values: The USC Student Handbook](#), page 13).

Course Evaluations

In addition to the end-of-semester student evaluations of the class, the instructor will ask for anonymous mid-semester feedback from the students.

Course Schedule

Table 3 Course schedule

	Topics/Daily Activities	Readings/Preparation	Deliverables
Week 1	Historical background of communication systems; Definition of different types of data signals, Review of various mathematical functions relevant to data channels	Roden, parts of Ch. 1 Roden, Appendices II, III, and IV	
Week 2	Physical understanding of Fourier series and Fourier transforms	Roden, Ch. 2	Homework 1
Week 3	Frequency Analysis; Channel Filtering; Physical understanding of sampling theorems	Roden, Ch. 3 and parts of Ch. 5	
Week 4	Basics of probability in understanding channel noise and Shannon's theorem; Signal-to-noise ratios	Roden, Ch. 4	Homework 2
Week 5	Analog systems using amplitude modulation and demodulation techniques; Coherent and non-coherent detection; Double and single-sideband techniques	Roden, parts of Ch. 5 and Ch. 6	Homework 3
Week 6	Analog systems using frequency modulation and demodulation techniques; Wideband and narrowband FM systems	Roden, parts of Ch. 7	
Week 7	Analog systems using phase modulation and demodulation techniques; Channel multiplexing and demultiplexing techniques in time and frequency	Roden, parts of Ch. 5 and 7	Homework 4
Week 8	System link budgets; Midterm review; Midterm	Handouts	Midterm
Week 9	Pulse modulation in amplitude, width, and position; Digital modulation concepts (symbol encoding, contrast ratio, interference)	Rode, parts of Ch. 5 and 8	

Week 10	Vector analysis of digital data constellation diagrams; digital systems using amplitude-shift-keying	Roden, Ch. 10 and parts of Ch. 11	Homework 5
Week 11	Digital systems using phase-shift-keying	Roden, parts of Ch. 11	
Week 12	Higher-order data modulation formats and techniques; Heterodyne, homodyne, and intradyne approaches	Roden, parts of Ch. 11; Handouts	Homework 6
Week 13	Eye diagrams; Orthogonal frequency division multiplexing; Nyquist pulse modulation	Roden, Ch. 12; Handouts	Homework 7
Week 14	Bit error ratio analysis; Final review; Preparation for oral and written presentations	Roden, Ch. 12; Handouts	
Week 15	Student project oral presentations	Student provided material	Written report
FINAL			Refer to the final exam schedule in the USC <i>Schedule of Classes</i> at classes.usc.edu .

Sample Topics

1. Cable TV and Cable Modems
2. Data Compression
3. Error Correction Codes
4. Fiber Optic Communications
5. Communication Standards (e.g., Gbit/s Ethernet)
6. Real-Time Video Conferencing
7. Satellite Communications
8. Cellular Communications
9. Radar
10. Lidar
11. Short-Range Communications (Bluetooth)
12. MIMO Systems
13. Software-Defined Radio
14. Broadband Networks
15. Immersive Audio and Video
16. Orthogonal Frequency Division Multiplexing
17. World-Wide-Web Connectivity and Routing
18. Millimeter-Wave Free-Space Systems
19. Access Networks
20. Positioning, Navigation, & Tracking (PNT)
21. Security in Communication Systems
22. Quantum Communications
23. Global Positioning System
24. 5G/6G Wireless
25. Digital Signal Processing
26. Augmented/Virtual Reality
27. Security in Communication Systems

Statement on Academic Conduct and Support Systems

Academic Integrity:

The University of Southern California is a learning community committed to developing successful scholars and researchers dedicated to the pursuit of knowledge and the dissemination of ideas. Academic misconduct, which includes any act of dishonesty in the production or submission of academic work, compromises the integrity of the person who commits the act and can impugn the perceived integrity of the entire university community. It stands in opposition to the university's mission to research, educate, and contribute productively to our community and the world.

All students are expected to submit assignments that represent their own original work, and that have been prepared specifically for the course or section for which they have been submitted. You may not submit work written by others or "recycle" work prepared for other courses without obtaining written permission from the instructor(s).

Other violations of academic integrity include, but are not limited to, cheating, plagiarism, fabrication (e.g., falsifying data), collusion, knowingly assisting others in acts of academic dishonesty, and any act that gains or is intended to gain an unfair academic advantage.

The impact of academic dishonesty is far-reaching and is considered a serious offense against the university. All incidences of academic misconduct will be reported to the Office of Academic Integrity and could result in outcomes such as failure on the assignment, failure in the course, suspension, or even expulsion from the university.

For more information about academic integrity see [the student handbook](#) or the [Office of Academic Integrity's website](#), and university policies on [Research and Scholarship Misconduct](#).

Please ask your instructor if you are unsure what constitutes unauthorized assistance on an exam or assignment, or what information requires citation and/or attribution.

Students and Disability Accommodations:

USC welcomes students with disabilities into all of the University's educational programs. [The Office of Student Accessibility Services](#) (OSAS) is responsible for the determination of appropriate accommodations for students who encounter disability-related barriers. Once a student has completed the OSAS process (registration, initial appointment, and submitted documentation) and accommodations are determined to be reasonable and appropriate, a Letter of Accommodation (LOA) will be available to generate for each course. The LOA must be given to each course instructor by the student and followed up with a discussion. This should be done as early in the semester as possible as accommodations are not retroactive. More information can be found at osas.usc.edu. You may contact OSAS at (213) 740-0776 or via email at osasfrontdesk@usc.edu.

Support Systems:

[Counseling and Mental Health](#) - (213) 740-9355 – 24/7 on call

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

[988 Suicide and Crisis Lifeline](#) - 988 for both calls and text messages – 24/7 on call

The 988 Suicide and Crisis Lifeline (formerly known as the National Suicide Prevention Lifeline) provides free and confidential emotional support to people in suicidal crisis or emotional distress 24 hours a day, 7 days a week, across the United States. The Lifeline is comprised of a national network of over 200 local crisis centers, combining custom local care and resources with national standards and best practices. The new, shorter phone number makes it easier for people to remember and access mental health crisis services (though the previous 1 (800) 273-8255 number will continue to function indefinitely) and represents a continued commitment to those in crisis.

[Relationship and Sexual Violence Prevention Services \(RSVP\)](#) - (213) 740-9355(WELL) – 24/7 on call

Free and confidential therapy services, workshops, and training for situations related to gender- and power-based harm (including sexual assault, intimate partner violence, and stalking).

[Office for Equity, Equal Opportunity, and Title IX \(EEO-TIX\)](#) - (213) 740-5086

Information about how to get help or help someone affected by harassment or discrimination, rights of protected classes, reporting options, and additional resources for students, faculty, staff, visitors, and applicants.

[Reporting Incidents of Bias or Harassment](#) - (213) 740-5086 or (213) 821-8298

Avenue to report incidents of bias, hate crimes, and microaggressions to the Office for Equity, Equal Opportunity, and Title for appropriate investigation, supportive measures, and response.

[The Office of Student Accessibility Services \(OSAS\)](#) - (213) 740-0776

OSAS ensures equal access for students with disabilities through providing academic accommodations and auxiliary aids in accordance with federal laws and university policy.

[USC Campus Support and Intervention](#) - (213) 740-0411

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

[Diversity, Equity and Inclusion](#) - (213) 740-2101

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

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) 442-1200 – 24/7 on call

Non-emergency assistance or information.

[Office of the Ombuds](#) - (213) 821-9556 (UPC) / (323-442-0382 (HSC)

A safe and confidential place to share your USC-related issues with a University Ombuds who will work with you to explore options or paths to manage your concern.

[Occupational Therapy Faculty Practice](#) - (323) 442-2850 or otfp@med.usc.edu

Confidential Lifestyle Redesign services for USC students to support health promoting habits and routines that enhance quality of life and academic performance.