Department of Electrical Engineering and Computer Science
The University of Kansas

EECS 562- Intro to Communication Systems

Spring 2025

Catalog Data: EECS 562 (4) Intro to Communication Systems: A first course in communications, including lectures and integrated laboratory experiments. After a review of spectral analysis and signal transmission, analog and digital communications are studied. Topics include: sampling, pulse amplitude modulation, and pulse code modulation; analog and digital, frequency, and phase modulation; frequency and time division multiplexing; and system noise performance and BER calculations. Prerequisite: EECS 212 and EECS 361.

Prerequisites by Topics:

1. Signals and Systems
2. Fourier Series and Fourier Transforms; properties of the Fourier Transform
3. Filters
4. Discrete Fourier Transform
5. Sufficient computer familiarity to be able to use MatLab.

Instructional Mode: In person class. Location: LEA Rm 1136. Time: TR 1:00-2:15 PM.

Discussion Sessions:

Monday 5:00-6:50 PM in 2112 Lea. These sessions will be used for test reviews, make up classes, and as needed homework reviews. These sessions will not meet every week; check class web site to find out if discussion session is meeting. Use of the discussion session will be announced in class and on the class web site.

Required Textbook: Introduction to Communication Systems: An Interactive Approach Using the Wolfram Language, by Frost, V.S., 2021, University of Kansas Libraries, ISBN 978-1-936153-25-1, URI http://hdl.handle.net/1808/31779

Software: MATLAB, Wolfram CDF Player - available at http://www.wolfram.com/products/player/,

Class web page: http://www.ittc.ku.edu/~frost/EECS_562/index_EECS_562_Spring_2025.html

Course Objectives: Students will be able to:

1. Calculate and use Fourier Series and Transforms, Energy Spectral Density and Power Spectral Density of signals.
2. Explain the basics of line-coding and baseband digital transmission.
3. Calculate the required bandwidth for baseband digital signals.
4. Explain the operation of a superheterodyne receiver.
5. Understand the mathematical basis of DSB-SC, AM, SSB, PM and FM; comparing these in terms of bandwidth and power requirements; and using FDM, FDMA, and FDD to combine such signals.
6. Understand the mathematical basis of PAM, PCM (including quantization noise), digital pulse transmission (including ISI and bandwidth requirements), and TDM, TDMA, and TDD.
7. Understand the mathematical basis of ASK, FSK, PSK, QPSK, M-QAM, OFDM.
8. Working with noise and signal-to-noise ratios, and comparing the noise performance of DSB-SC, AM, SSB, PM, and FM.
9. Calculate bit error rate for BPSK, QPSK, MPSK, and M-QAM. Explain system trade-offs for digital modulation techniques.
10. Explain the operation of OFDM/LTE systems, calculate bit rates, role of CP, and AMC.
11. Apply with signal-to-noise ratios and link budgets for link design.
12. Operating a spectrum analyzer and performing laboratory investigations of communication systems.
13. Understand the basics of error control coding.

Student Outcomes: Students should be capable of:

1. Calculating and using Fourier Series and Transforms, Energy Spectral Density and Power Spectral Density of signals.
2. Explaining the basics of line-coding and baseband digital transmission, including pulse shaping and inter-symbol interference.
3. Calculating the required bandwidth for baseband digital signals.
4. Explaining the basics of analog modulation, DSB-SC, DSB-LC, SSB, VSB, FM and PM.
5. Comparing analog modulation in terms of bandwidth and power efficiency/requirements.
6. Explaining the operation of a superheterodyne receiver.
7. Use TDM, FDM, TDMA, FDMA, TDD, FDD to combine signals and calculate required bandwidth.
8. Explaining the basics of digital modulation, ASK, FSK, PSK, QPSK, MPSK, and M-QAM, OFDM, including bandwidth

requirements.

9. Comparing digital modulation techniques in terms of bandwidth requirements and energy/bit.
10. Calculating signal-to-noise ratios and perform system trade-offs using link budgets.
11. Comparing the noise performance of DSB-SC, DSB-LC, SSB, and FM. Understand the system trade-offs for analog modulation techniques.
12. Calculating bit error rate for BPSK, QPSK, MPSK M-QAM. Explain system trade-offs for digital modulation techniques.
13. Explaining the operation of OFDM/LTE systems, calculate bit rates, role of CP, and AMC.
14. Understanding the basics of error control coding, including linear block codes and the concept of Hamming distance.

Instructor: Victor S. Frost

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785-864-1028
vsfrost@ku.edu (e-mail is the best ways to contact me)
More information about me can be found at http://www.ittc.ku.edu/~frost/

Office Hours: 8:00 - 9:00 AM TR and 3:00 - 4:00 PM TR
I am available outside of office hours: e-mail to confirm my availability and day/time.

Computer Usage:
Plotting with MATLAB. For plotting in MATLAB see Plotting Functions using fplot see: https://www.youtube.com/watch?v=Xaos1ALprCQ and for creating stem plots in MATLAB see:https://www.youtube.com/watch?v=bWIzuYwwAbk
Interacting with Wolfram Computable Document Format (CDF) files for interactive content. Wolfram CDF Player is installed on all EECS Windows computers and a free download is available at http://www.wolfram.com/products/player/

Grading: The following percentages will be used to arrive at the final grade:

Test 1	21% (Some formulas and tables will be provided)
Test 2	21% (Some formulas and tables will be provided)
Signals & Systems Test	3%
Final Exam	25% (Some formulas and tables will be provided)
Lab	20%
Homework	10%

Tests and the final exam will be closed book/closed notes.
Final letter grades are determined from the final grade scores using

90 – 100%	A
80 – 89%	B
70 – 79%	C
60 - 69 %	D
0 – 59%	F

Lower limit on these ranges maybe reduced as a function of the distribution of the final scores.
This class will **not** use +/- grading.

Homework:

1. Homework is intended to illustrate and reinforce concepts covered in class.
2. There is a strong correlation between the course grade and understanding concepts demonstrated in homework problems.
3. Assigned homework problems are posted on the class web site.
4. There will be approximately one homework assignment per week.
5. Collaboration with classmates is permitted. Copying is not permitted.
6. Each homework problem is counted as 10 points, e.g., an assignment with 6 homework problems will be 60 points
7. Plots and graphs on homework must be generated by a computer tool, e.,g, MATLAB.
8. Solution will not be posted; any problem will be worked in class, in review sessions or during office hours upon request.
9. Homework must be submitted in the specified format given at Homework Format.
10. Your solution to assigned problems must be submitted via e-mail in PDF using this file name format:
    LastName_562_Homework#.pdf, e.g., Frost_562_Homework5.pdf .
    The subject line in the e-mail must be LastName_562_Homework#, e.g., Frost_562_Homework5

11. Homework must be submitted by email to the grader Fatima Al-Shaikhli at fatima.al-shaikhli@ku.edu
12. Homework is due at 5:00 pm on the due date.

Quizzes: Quizzes maybe given at random and unannounced. Quiz scores will be counted as homework.

Make-ups: Make-up exams are given rarely, and only if:

1. I am informed IN ADVANCE, and
2. I deem the reason to be sufficiently meritorious (job interviews and pleasure trips are not). If the reason is illness, I REQUIRE documentation of the illness from a health-care professional.

Class decorum: The School of Engineering is a professional school, and the decorum in this class will reflect that. You are expected to arrive on time, leave on time, and act professionally in class. This includes being intellectually and physically involved in the class. Cell phones are **not** to be used in class. Use of tablets, and laptops during class is discouraged; tablets, and laptops may **only** be used in direct support of class activities, e.g., following along in the ebook. Texting, general web browsing, checking of e-mail is **NOT** permitted during class. Video and audio recording of the EECS 361 class lectures is **strictly prohibited**.

Attendance Policy: Attendance at all class meetings is expected. Although there is no direct grading component based on attendance, anything presented in class is considered required material. There is a strong correlation between attendance and the course grade.

Academic Misconduct: Instances of cheating will be referral to the Dean. Cheating includes, but is not limited to: copying another exam, copying of hardcopy or online solutions or previously worked homework or exam solutions, having another person do your work, use of "tutoring" websites like chegg.com.

Course Evaluation: A course evaluation will be available to students at the end of the semester.

Special Needs: Any student who has a disability that demands special accommodations should contact the Student Access Center at https://access.ku.edu/ in order to make arrangements. Also, members of KU sanctioned organizations (band, athletic teams, etc.) that have special needs should also contact the instructor as the need arises.

Course Schedule (subject to change)

Topic

1. Introduction to Communication Systems (~1 lecture)
2. Signals and Systems Review (~2 lecture)

---- ~ Signals and Systems Review Test (~1 lecture)

3. Baseband Data Transmission; including the concepts of M-ary signals and ISI. (~2 lecture)
4. Time-Division Multiplexing (~1 lecture)
5. Double Sideband-Suppressed Carrier Modulation (~1 lecture)
6. Quadrature Multiplexing and Modulation; including binary phase shift keying (BPSK), quadrature phase shift keying (QPSK) and quadrature amplitude modulation (QAM). (~2 lecture)
7. Frequency Division Multiplexing and Orthogonal Frequency Division Multiplexing (~2 lecture)

---- ~Test 1 (~1 lecture review & 1 lecture for test)

8. Double sideband-large carrier (DSB-LC)- Commercial AM (~1 lecture)
9. Single sideband (SSB) and vestigial sideband (VSB) (~1 lecture)
10. Frequency and Phase Modulation (FM/PM) (~2 lecture)
11. Superheterodyne Receiver (~1 lecture)
12. Communications Channels, Noise and Link Budgets; including, noise figure, noise temperatures, and antenna gain and associated system tradeoffs using link budgets. (~3 lecture)
13. Performance of Analog Communications Systems in Noise (~2 lecture)

---- ~Test 2 (~1 lecture review & 1 lecture for test)

14. Performance of Digital Communications Systems in Noise (~2 lecture)
15. Multimegabit/sec Terrestrial Wireless Communication Systems: Applying OFDM to achieve high speed data transfer over terrestrial channels using the real-life examples of LTE/5G and Wi-Fi. (~1 lecture)
16. Introduction to Error Detection and Correction Techniques (~1 lecture)

Laboratory

Instructor: Syed Sahdman abidsahdman@ku.edu
Office: Eaton 2060 (in the lab)
Office Hours: Wednesday 11:00-1:00 or by appointment
Laboratory Location: Eaton 2060
Schedule:

M 09:00 -10:50 AM
W 09:00 -10:50 AM
W 01:00 -02:50 PM

Goals

Develop physical intuition of different analog modulation (demodulation) techniques by performing amplitude modulation, frequency modulation, frequency and time division multiplexing, and digital bandpass modulation in the laboratory setup. Also, through the laboratory experiments, sampling, quantizing, encoding, and noise analysis will be performed and analyzed.

Expectations & Important information

• Students are expected to read the lab write-up before each lab and get familiar with it.
• Attendance is mandatory. No make-up for the missed lab will be given without a valid absence verification. A valid absence might be considered only for illnesses (a cold is not an excuse) and university sponsored events. Proper documentation must be presented to the lab instructor.
• No food or drinks are allowed in the lab.
• Be punctual. No additional time will be given.
• For every lab session, you will have assigned lab partners. This information will be announced in the lab.
• A lab report is due one week from the completion of the lab and must be turned in within a due date. The report must be submitted online in PDF format via e-mail.
• Late work will be accepted with a penalty of 5 points (from the lab report portion) for every day it is late. However, if the work is late more than 7 days it will receive zero.
• Lab equipment is very expensive. Use it accordingly.

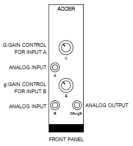
Grading Breakdown

Lab Report: 90%
Participation and Preparation 10%
Lab reports are weighed proportionally to the assignment's perceived difficulty. The breakdown is as follows:

Lab 1 – 5 %	Lab 4 – 19 %
Lab 2 – 19 %	Lab 5 – 19 %
Lab 3 – 19 %	Lab 6 – 19 %

Comment on the Lab

- Sometimes the modules have hardware problems.
- Part of being an EE/CoE is learning how to troubleshoot.
- So once you identify a faulty module give it to the lab GTA
- He will provide a replacement.



Comprehensive Final Exam: May 12, 2025 1:30-4:00 PM

Late work: Assignments should be submitted on the indicated due date/time. I acknowledge that life happens, and sometimes a deadline cannot be met because of illness, caregiving responsibilities, work demands, mental health struggles, and emergencies. In these cases, I request that you contact me via email as soon as possible to arrange an alternative due date. I believe the material in this course is valuable, and I want to work with you so you can successfully complete the assignments. If I do not receive any communication from you before the assignment is due you will receive a 0 for late assignments.

Changes: Changes announced in class and/or on the class web page will supersede these written instructions.

IEEE Code of Ethics

We, the members of the IEEE, in recognition of the importance of our technologies in affecting the quality of life throughout the world, and in accepting a personal obligation to our profession, its members and the communities we serve, do hereby commit ourselves to the highest ethical and professional conduct and agree:

I. To uphold the highest standards of integrity, responsible behavior, and ethical conduct in professional activities.

1. to hold paramount the safety, health, and welfare of the public, to strive to comply with ethical design and sustainable development practices, to protect the privacy of others, and to disclose promptly factors that might endanger the public or the environment;

2. to improve the understanding by individuals and society of the capabilities and societal implications of conventional and emerging technologies, including intelligent systems;

3. to avoid real or perceived conflicts of interest whenever possible, and to disclose them to affected parties when they do exist;

4. to avoid unlawful conduct in professional activities, and to reject bribery in all its forms;

5. to seek, accept, and offer honest criticism of technical work, to acknowledge and correct errors, to be honest and realistic in stating claims or estimates based on available data, and to credit properly the contributions of others;

6. to maintain and improve our technical competence and to undertake technological tasks for others only if qualified by training or experience, or after full disclosure of pertinent limitations;

II. To treat all persons fairly and with respect, to not engage in harassment or discrimination, and to avoid injuring others.

7. to treat all persons fairly and with respect, and to not engage in discrimination based on characteristics such as race, religion, gender, disability, age, national origin, sexual orientation, gender identity, or gender expression;

8. to not engage in harassment of any kind, including sexual harassment or bullying behavior;

9. to avoid injuring others, their property, reputation, or employment by false or malicious actions, rumors or any other verbal or physical abuses;

III. To strive to ensure this code is upheld by colleagues and co-workers.

10. to support colleagues and co-workers in following this code of ethics, to strive to ensure the code is upheld, and to not retaliate against individuals reporting a violation.

Important Resource and Policy Information

- Explanation of instructional time expected for out-of-class student work per credit:

  see https://policy.ku.edu/registrar/credit-hour .

- Accommodations and/or information for students with disabilities:

  see https://access.ku.edu/syllabus-statement .

- Sexual Harrassment Policy:

  see https://policy.ku.edu/civil-rights/sexual-harassment .

- Nondiscrimination, Equal Opportunity, and Affirmative Action Policy:

  see https://policy.ku.edu/IOA/nondiscrimination .

- KU Statement on Diversity and Inclusion: see https://policy.ku.edu/provost/diversity-inclusion .

- Academic Misconduct (USRR 2.7.1):

  see https://policy.ku.edu/governance/USRR#art2sect6 .

- Change of Grade:

  see https://policy.ku.edu/registrar/grade-change and

  https://policy.ku.edu/governance/USRR#art2sect3 .

- Code of Student Rights and Responsibilities:

  see https://policy.ku.edu/student-affairs/student-code .

- Commercial Note-Taking:

  see https://policy.ku.edu/provost/commercial-note-taking .

- Mandatory Reporting:

  see https://policy.ku.edu/civil-rights/mandatory-reporting .

- Racial and Ethnic Harassment Policy:

  see https://policy.ku.edu/civil-rights/racial-ethnic-harassment-policy .