EECS 562: Introduction to Communication Systems

Victor S. Frost
Dan F. Servey Distinguished Professor
Chair Electrical Engineering and Computer Science
University of Kansas
Phone: (785) 864-1028
e-mail: vsfrost@ku.edu
http://www.ittc.ku.edu/~frost

1

Course Information

- Semester: Spring 2022
- Lecture: TR 09:30 -10:45 AM LEA 3152
- Discussion: Room 3152 Lea; Monday 5:00 -07:00 PM will be used for test reviews, make up classes, and as needed homework reviews. **Will not meet every week; check class web site to find out if discussion session is meeting.**
- Required Text: Introduction to Communications Systems: An Interactive Approach Using the Wolfram Language, V. S. Frost

  Free from KUScholarWorks
  http://hdl.handle.net/1808/31779

  The required text is an ebook in a .cdf file and requires the Wolfram CDF Player to read. Get the cdf reader at
  http://www.wolfram.com/products/player/

2

Course Information

- Reference Texts:
  - Introduction to Analog & Digital Communications, 2nd Edition, Simon Haykin and Michael Moher
  - Digital & Analog Communication Systems, 8th Edition, Leon W. Couch
  - Introduction to Communication Systems, 3rd Edition, Ferrell G. Stremler.

3

Course Information

Class Web Page:
http://www.ittc.ku.edu/~frost/EECS_562/index_EECS_562_Spring_2022.htm

Lab
Web Site: https://people.eecs.ku.edu/~laurynas/EECS562/
Lab GTA and Grader: Laurynas Lialys- laurynas@ku.edu
Labs start Week of Jan 24, 2022
Lab schedule see: https://people.eecs.ku.edu/~laurynas/EECS562/Lab_Schedule.pdf

Office hours and Contact Information:
- Time: Office hours:
  - In 2054 Eaton Hall-- 8:00 - 9:00 and 2:30 - 4:00 T & R
  - Drop-ins at other times are always welcome
  - Outside of office hours it is best to schedule via call or e-mail to insure that I am available at the time you want to meet.
- Phone:
  - Eaton 864-1028
  - Home 841-3244
- e-mail: vsfrost@ku.edu (best way to contact me)

4

Course deliverables

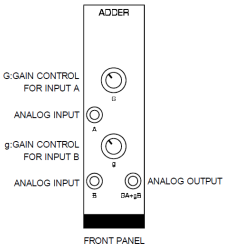
- Exams
- Homework: problems will be assigned & graded.
- Lab
- Grading:
  - 2 - In class tests; = 45% (22.5%/test)
  - Lab = 20%
  - Homework = 7.5%
  - Review Test (Signals & Systems) = 2.5%
  - Final = 25%

  A test will be given near the beginning of the course to review Signals & Systems concepts from EECS 360.
- General guidelines:
  - Only under very extreme conditions will make up tests be given. I MUST be notified BEFORE you miss a test otherwise you WILL get a 0.
  - Late homework will not be accepted. No makeup quizzes will be given.

5

Comment on the Lab

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



6

Initial Grading Scale

- 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

7

Homework

- Electronic submission of homework assignments is required.
- Electronic submission of homework to be sent to Laurynas Lialys-laurynas@ku.edu and cc me at vsfrost@ku.edu.
- Homework will be returned via e-mail.
- All homework assignments will be posted on the class web page
- Solution will not be posted, problems will be worked in class or during office hours upon request.
- Electronic submissions must be in pdf format.
- Important that your submission be readable.
- Electronic submissions must use this file naming format.
  - Homework: your last name_EECS562_HW#
  - For example, for homework # 5 I would submit;
    Frost_ EECS562_HW5.pdf

8

Homework Format

All work containing more than one page must be stapled - no paper clips and no folded corners. In order to facilitate grading of homework problems, homework shall meet the following specifications:

1. Hand written or typed single-sided on 8.5"x11" paper.

2. If not typed then for text and equations, use an HB or No. 2 pencil (or darker), or blue or black ink. (Pencil is preferred.) No other colors please, except in diagrams or graphs.

3. All pages should be numbered i/j in top right hand corner, with your name appearing at the top of each page. It is O.K. to use your initials after the first page.

4. All work must be shown for full grade - be as thorough as possible.

5. Writing should be legible and literate - if the grader cannot read your handwriting, you will receive no credit for the problem.

9

Homework Format

6. Answers are to be boxed and right justified, with the variables, values (if any) and units (if any), included in the box. Right justified means placed on the right side of the page.

7. Leave half an inch between consecutive parts of a question, and draw a line across the page at the end of each complete question.

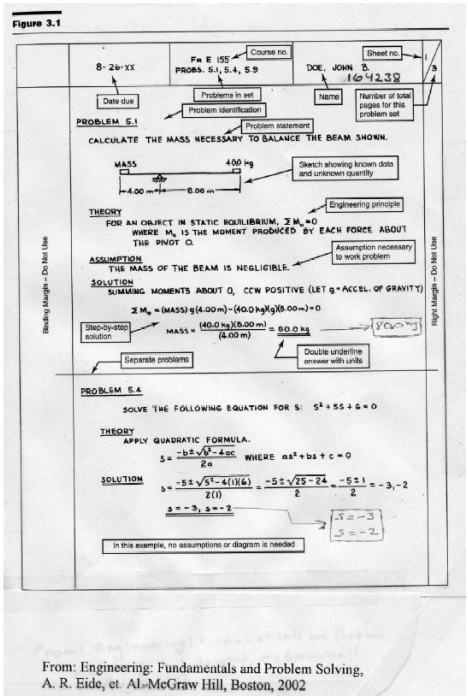
8. No part of a question should appear in any margin of the paper.

9. Diagrams and graphs should be of a good size (say at least 3x5 sq. inch), and may contain colors. Diagrams and graphs must be titled, labeled, and clearly drawn. Tables should also be titled.

10. Graphs should be scaled (put number on axes), labeled (put names /units on axes), and titled at the bottom of the graph. Any graph which occupies an area of less than 3x5 sq. inch and which is not titled will not be graded.

11. Where possible use conventional units such as bits/sec, Hz and km

10



From: Engineering: Fundamentals and Problem Solving, A. R. Eide, et. Al.-McGraw Hill, Boston, 2002

11

Tools Used for Required Text and Class Assignments and Demonstrations

- **REQUIRED:** Wolfram CDF Player
  - Class interactive e-book
  - Interactive documents
  - Installed on all EECS Windows computers
  - http://www.wolfram.com/products/player/
- You will need to use a software tool to create plots, e.g., matlab or excel.
- For homework you can also use WolframAlpha to solve integrals and perform other math calculations, see https://www.wolframalpha.com/

Academic Integrity and Plagiarism

- The department, school and university have very strict guidelines regarding academic misconduct. Obviously, copying is not allowed on exams. Students are expected to submit their own work on individual homework and projects. Lending or borrowing all or part of a simulation model or program from another student is not allowed. Students ARE allowed to borrow and modify any code on this class web site in their projects. Instances of cheating will result in a referral to the department chairman and the dean of engineering.
- All sources in your written work (project reports) must be properly referenced; if you use a source from the literature or the idea of another for your work you must reference it. If you quote or copy a block of text, it must be cited and included in quotation marks (if a sentence or less in length) or in block quote style (if more than a sentence in length). If you paraphrase text (reword a phrase, sentence, or paragraph), you must also quote or blockquote followed by "[paraphrased]" in addition to proper citation. Figures taken from other sources must be referenced.
- I recommend that you take intermediate notes from which you write your own words. I strongly recommend that you not write in one window while displaying the work of others in another window; this is asking for trouble. "Unintentional" paraphrasing is also not an acceptable excuse for academic misconduct.
- Modified with permission from James P.G. Sterbenz http://www.ittc.ku.edu/~jpgs/courses/eecs800/ and John Gauch http://www.ittc.ku.edu/~jgauch/teaching/258.f03/syllabus.html

Use of EdTech Services

- Professors and instructors at the KU School of Engineering are aware that some students are actively posting homework, laboratory, and exam questions and responses to EdTech services (e.g., Chegg) even during exam time frames.
- Keep in mind that when a person signs up to participate by either uploading, and/or downloading, and/or using posted material from these sites, the "terms of service" that are agreed to do not protect the person when KU and/or the School of Engineering decide to conduct investigations related to academic misconduct (e.g., plagiarism and/or cheating).
- In fact, EdTech services, like Chegg, retain contact information of students who use their services and will release that information, which is traceable, upon request. Using these services constitutes academic misconduct, which is not tolerated in the School of Engineering. It violates Article 3r, Section 6 of its Rules & Regulations, and may lead to grades of F in compromised course(s), transcript citations of academic misconduct, and expulsion from the University of Kansas.
- If unsure about assignments, it is important that students use the allowable available resources, such as instructor office hours, graduate teaching assistants, and/or tutoring. The School of Engineering wants students to be successful; cheating is not the way to attain that success.

Use of smartphones, tablets, and laptops in class

- Smartphones, tablets, and laptops may **only** be used in direct support of class activities.
- Texting, general web browsing, checking of e-mail is **NOT** permitted during class.
- Video and audio recording of the EECS 863 class lectures is prohibited.

Course Outline

- Introduction to Communication Systems
- Signals and Systems Review ← ~ Signals and Systems Test
- Baseband Data Transmission; including the concepts of M-ary signals and intersymbol interference (ISI).
- Time-Division Multiplexing
- Double Sideband-Suppressed Carrier Modulation:
- Quadrature Multiplexing and Modulation; including binary phase shift keying (BPSK), quadrature phase shift keying (QPSK) and quadrature amplitude modulation (QAM).
- Frequency Division Multiplexing and Orthogonal Frequency Division Multiplexing ← ~ Test 1

16

Course Outline

- Double sideband-large carrier (DSB-LC)- Commercial AM
- Single sideband (SSB) and vestigial sideband (VSB)
- Frequency and Phase Modulation (FM/PM)
- Superheterodyne Receiver
- Communications Channels, Noise and Link Budgets; including, noise figure, noise temperatures, and antenna gain and associated system tradeoffs using link budgets.
- Performance of Analog Communications Systems in Noise
- Performance of Digital Communications Systems in Noise ← ~ Test 2
- 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 is discussed.
- Introduction to Error Detection and Correction Techniques

17

Course Outcomes

- Calculate and use Fourier Series and Transforms, Energy Spectral Density and Power Spectral Density of signals.
- Explain the basics of line-coding and baseband digital transmission.
- Calculate the required bandwidth for baseband digital signals.
- Explain the basics of analog modulation, DSB-SC, DSB-LC, SSB, VSB, FM and PM.
- Compare analog modulation in terms of bandwidth and power efficiency/requirements.
- Explain the operation of a superheterodyne receiver.

18

Course Outcomes

- Use TDM, FDM, TDMA, FDMA, TDD, FDD to combine signals and calculate required bandwidth.
- Explain the basics of digital modulation, ASK, FSK, PSK, QPSK, MPSK, and M-QAM, OFDM
- Compare digital modulation techniques in terms of bandwidth requirements and energy/bit.
- Calculate signal-to-noise ratios and perform system trade-offs using link budgets.
- Compare the noise performance of DSB-SC, DSB-LC, SSB, and FM. Understand the system trade-offs for analog modulation techniques.
- Calculate bit error rate for BPSK, QPSK, MPSK M-QAM. Explain system trade-offs for digital modulation techniques.
- Explain the operation of OFDM/LTE systems, calculate bit rates, role of CP, and AMC.
- Understand the basics of error control coding.

19