

Electrical Engineering 133

Analog Communications Design Laboratory

Course description: This course provides a practical and dominantly experimental, design-oriented, exposure to RF modulation, demodulation and system integration that includes a capstone project which builds and field tests a 24MHz FM two-way radio.

Prerequisites: EE 113 and EE 122

Text books:

Matthew M. Radmanesh, “Radio Frequency and Microwave Electronics (Illustrated),” Prentice Hall PTR, New Jersey, 2001.

Course objectives:

- (1) Introduction to analog modulation/demodulation of signals
- (2) Introduction to nonlinear circuit behavior
- (3) Design of tuned circuits
- (4) Transistor-level circuit design at radio frequencies
- (5) Application-oriented design using RF ICs
- (6) Practical experience in analog RF system integration and design—individual blocks and interfacing between blocks
- (7) Experimental project to design, build and test a two-way radio system
- (8) Introduction to selected state-of-the-art system concepts for RF communications

Topics covered:

1. AM/FM signals in both frequency and time domains
2. RLC passive filters and impedance transformations
3. Tuned circuits and related bandwidth
4. AM demodulation using diode peak detection
5. Single stage, low noise amplifier using bipolar transistor
6. AM modulation using two- and four-quadrant multipliers with bipolar, transistor-level as well as IC-level implementations
7. Oscillators and voltage-controlled oscillators for FM modulation
8. Frequency translation, heterodyning and synchronous demodulation
9. Intermediate frequency (IF) amplification and filtering
10. Power amplifier, inter-stage and antenna matching
11. Specification of 24 MHz radio system
12. Design project
13. Selected topics in state-of-the-art ICs (ISSCC) and related communications examples
14. Demonstration of project results

Class and laboratory schedule:

2 lecture periods and 1 three-hour+ laboratory

Contribution of course to program objectives:

Engineering topics: 100% or 3 units

Relation of course to program objectives (these are addressing ABET—accreditation):

The outcomes of this course contributes to include:

Outcome #1—Demonstrated ability to apply both mathematics and engineering design to analog RF communications

Outcome #2—Ability to design and experimentally test RF circuits and systems

Outcome #3—Ability to design a FM radio system, to given specifications, and understand integrated components (both inside ICs and at system integration level)

Outcome #4—Ability to work as teams both in sub-block level design and overall system testing

Outcome #5—Ability to address a broad range of RF problems—transistor-level, using ICs and other system components as well as packaging, antenna and power supply issues

Outcome #6—Limited exposure to ethical issues (FCC, bandwidth, security...)

Outcome #7 –Ability to give both oral presentation and written report on radio system (and field testing)

Outcome #8—Understanding of both radio communications evolution and related technical/social issues

Outcome #9—Exposure to state-of-the-art (ISSCC papers) gives clear message about rapid evolution in the field

Outcome #10—Various examples emphasize contemporary issues

Outcome #11—Building experimental RF system inherently emphasizes use of tools and engineering practice

Outcome #12—Provides self-confidence and detailed experience in RF—useful for hands-on job experience as well as preparation for graduate training and advanced courses such as EE 214 and 414

Author/date: R. Dutton 1/2/02

Mechanics and Logistics:

There will be pre-lab assignments for each lab. You are expected to have all work completed **before** lab period. The pre-labs will be collected at the end of lab and will be returned at the next class.

You are required to keep a hard-bound lab notebook. It is expected that you use this notebook as the permanent and detailed record of all work during the quarter. You should develop good work habits of collecting data and documenting your work **directly** in the notebook (versus scraps of paper that get copied into it later---NOT a good idea; we strongly discourage the practice)

Lab write-ups are due a few days after the respective lab periods (either one- or two-week labs). Your TA will tell you more specific details about time and place for turning in the write-ups. There will be examples given of good write-ups. Basically, they should **concisely summarize all the important details of the lab**, including: abstract of key results, brief introduction (including block diagrams, circuit schematics and measurement equipment used), orderly presentation of results (including critical discussion of interpretation of the data, critical assessment of problems encountered, concise summary by way of figures, tables etc.), conclusion. The total length of each write-up is on the order of 5-7 pages. These write-ups will be integrated in the final project report.

Final Project, Demo-Day and Final Write-up—After completing the required labs, the last few weeks of the quarter are devoted to integrating the final projects. The objective is to completely integrate your walkie-talkie radio system and to field test it using both the portable antennae as well as the super-antenna on top of the Packard Building. There will be a Demo-Day (Sat. Mar. 16, 2002) when we use the super-antenna and have all groups do a campus “walk-about”—who can go the farthest afield and still receive signals from Packard. The final write-up, like the previous lab write-ups in form, summarizes the final project with emphasis on the collection of data on the system and detailed discussion of the system integration issues.

Quizzes—There will be about four to five short (~15 min.) in class quizzes. These quizzes will be proficiency tests of your ability to use the results of lab and lecture material. Basically, the lectures are targeted fairly specifically at solving problems associated with the labs. Through both the pre-lab and lab work, you will practice and hopefully become proficient at using the course materials (i.e. things from the textbook and other notes). The quizzes are basically to encourage you to keep up with materials and have them more deeply ingrained in long-term memory.

Grading:

Notebook/Pre-Labs	10%
Lab Write-ups	20%
Quizzes	20%
Final Project	20%
Final Write-up	30%
<hr/>	
Total	100%

Readings from textbook:

Part I—The Highest Fundamentals

Chapter 3 (sections 3.11-3.13)—topics: Miller’s Theorem, other general Theorems, power calculations and units (dB, dBm...)—pages 92-104 (~12 pages)

Chapter 4 (sections 4.3-4.4)—topics: Bipolar transistor (review of device, models and biasing)—pages 122-142 (~20 pages)

Part II—Wave Propagation in Networks

Chapter 5 (sections 5.3-5.4)—topics: frequency ranges of signals and applications—pages 170-176 (~6 pages)

Chapter 6 (all sections)—topics: RF components, Resonant Circuits (and “Q”), Impedance Transformations and Matching—pages 193-240 (~47 pages)

Chapter 7 (sections 7.6.4-7.6.7)—topics: Reflections and Standing-Wave-Ratio (SWR as in SWR Meter)—pages: 258-265 (~7 pages)

Chapter 8 (sections 8.1-8.5)—topics: Two-port Networks with emphasis on S-parameters—pages: 287-302 (~19 pages)

Part III—Passive Circuit Design

Chapter 9 (all sections)—topics: The Smith Chart—pages: 323-337 (~14 pages)

Chapter 10 (section 10.3)—topics: Using Smith Chart—pages: 365-376 (~11 pages)

Chapter 11 (sections 11.1-11.5)—topics: Design of Matching Circuits (using Smith Chart)—pages: 387-402 (~15 pages)

Part IV---Basic Considerations in Active Networks

Chapters 12-13 (TBD)

Chapter 14 (all sections)—topics: Noise—pages: 465-485 (~20 pages)

Part V—Active Networks: Linear and Nonlinear Design

Chapters 15-21 (TBD)

Estimated Readings (without TBD parts): 170 pages (total book=800+ pages)