EE 322/322L
Electronics II – Wireless Communication Electronics
Spring 2006

Instructor: Dr. Keith W. Whites
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Office hours: MWF 9-10 AM

To contact the instructor, please use e-mail rather than the telephone. All e-mail will be answered. The TA(s) and the course instructor will be available in the lab during a number of hours each week to answer your questions and help with your laboratory/homework problems. These hours will be posted later.

Catalog Description: (3-1) 4 credits. Prerequisite: EE 221 and EE 320. A continuation of EE 320 with emphasis on design applications of linear and nonlinear integrated circuits.

Location: The lectures for this course will meet Monday, Wednesday and Friday from 8:00-8:50 AM in room EP 253. Parts and equipment for the course can be found in room EP 127, which is also the location where laboratory work is to be performed. A swipe card is required for access to this room. You may obtain your card from Reeny Wilson in the Residence Life office in Surbeck Center. You will be allowed to work in this lab room during the same times as the departmental open labs (Sunday 5:00-10:00 PM, Monday-Thursday 7:30 AM-10:00 PM, and Friday 7:30 AM-4:30 PM).

Course Reference Materials: Both of the following are required for this course:

1. David B. Rutledge, *The Electronics of Radio*. Cambridge: Cambridge University Press, first ed., 1999. Available at the SDSMT Bookstore.
2. Keith W. Whites, *EE 322 Electronics II–Wireless Communication Electronics Lecture Notes*, 2006. Available from the course web site.

Additional Materials: You will also need the NorCal 40A transceiver kit produced by Wilderness Radio <http://www.fix.net/~jparker/wild.html>. You may purchase your own kit or share one with another student in this course. This kit should be ordered from the SDSMT Bookstore, which requires a $20 deposit. You must place your order no later than **Jan. 24**. Note that this kit is not returnable and the purchase price and deposit are nonrefundable. Additionally, you will need small laboratory tools such as needle nose pliers, side cutters, breadboard, safety glasses, etc.

Grading:
- 40% – Laboratory/homework problems
- 30% – Two semester exams
- 20% – Final examination
- 10% – Final demonstration of transceiver (oral examination)

Laboratory and Homework Policy: One laboratory/homework problem is generally assigned each lecture period. These assignments are listed in the *EE 322 Class Schedule* on the next page. The "Text Problem" column refers to the end-of-chapter problems in the text. Helpful

information and possible changes (additions or deletions) to each assigned text problem can be found on the course web page under the heading "Clarifications and Additional Instructions."

The laboratory assignments must be entirely completed in your laboratory notebook. Working on scratch paper is not allowed. You must make copies of this work (either with carbon paper or photocopies) and turn these in at the beginning of the class period indicated in the "Due Date" column. Late homework will be assessed a 10% per calendar day reduction in points.

If you have purchased your own radio kit, you may work by yourself or with another student. If you are sharing a radio, then you must work with your partner in its construction and measurement. In any event, ***you must be present at all times during the construction of your radio and be present for all measurements made from your radio.***

Lab Book Policy: You are free to use whatever bound notebook you like, including spiral bound. The front of all pages must be numbered consecutively in the upper right-hand corner. (The backs are used as scratch, when needed, and are not numbered.) This numbering must be completed before the lab book is used. A few pages for a table of contents at the beginning of the lab book can be helpful. Date and sign your name at the bottom of every page as you complete it. Mark out empty gaps in your lab book with a large "X". Your lab book must be easily readable by the TA(s) and the instructor.

Exam Policy: The exams will be closed book, closed notes and no formula sheets. Using or referring to equations stored in a calculator is not allowed, even if these equations come pre-programmed into the calculator. If you feel an exam problem was graded incorrectly, it must be resubmitted to the instructor within 24 hours from the time the exam was returned. Failure to write an exam will result in a score of zero. No makeup exams will be given. Allowances will be made for extreme circumstances that were out of the student's control.

Honor System: All work written in the exams, homework and the laboratories must be your own. Failure to abide by this rule will result, at a minimum, in a zero score for the assignment and/or further action following SDSMT regulations. Homework solutions and laboratories can be discussed with your colleagues that are currently enrolled in EE 322, but ***all work you submit must be your own***.

You are not allowed to discuss EE 322 course content with students who have previously taken this course [other than your TA(s), of course], nor are you allowed to use their lab materials concerning the NorCal 40A or examine their radio. Furthermore, all of the data you record in your laboratory notebook must be values ***you*** have measured from the radio ***you*** are constructing. For anyone caught violating these course polices, the minimum penalty will be a ***10% reduction in the final course score*** and the maximum penalty will be ***expulsion from the course***. Multiple infractions of this policy will automatically result in expulsion from the course.

Course Outcomes: Upon completion of this course, students should demonstrate the ability to:

1. Understand the operation of a superheterodyne receiver and its advantages over a direct conversion receiver.
2. Use an automatic waveform generator, and account for the effects of this device – as well as an oscilloscope – on a circuit under test.
3. Properly solder and desolder electrical components to a printed circuit board in an RF circuit.
4. Design an LC ladder filter to meet passband and rejection specifications.
5. Tune a transformer and understand how to use it as an impedance matching device.
6. Design and implement *npn* and *pnp* BJTs as electronic switches.
7. Design and analyze BJT common emitter amplifiers, both with impedance loads and with transformer-coupled loads.
8. Design and analyze BJT emitter follower amplifiers.
9. Recognize BJT differential amplifier circuits and recall their uses.
10. Design and implement JFET source follower amplifiers.
11. Understand the operation and design of class C power amplifiers.
12. Recall the efficiencies of class A and class C amplifiers.
13. Construct and analyze a simple thermal circuit for a transistor and heat sink combination.
14. Recall the basic operation of feedback oscillators.
15. Use a frequency counter to make precise frequency measurements.
16. Understand the operation of Gilbert cell mixers.
17. Understand the sources of spurious responses in receivers and their limiting effects on performance.
18. Design and construct a simple audio amplifier circuit using an LM386 IC.
19. Recall the basic operation of receiver automatic gain control using JFETs as variable resistors.
20. Understand the limiting role of noise in communications circuits.
21. Calculate signal to noise ratio (SNR), minimum detectable signal (MDS), noise power density and noise equivalent power (NEP) from measured data.
22. Understand the effect of cascading noisy electrical components.
23. Understand the source of receiver intermodulation and its effects on receiver performance.
24. Make proper measurements and then calculate the dynamic range of a receiver.
25. Use power splitter/combiner devices and adjustable attenuators.

EE 322 Class Schedule
Spring 2006

#	Date	Ch.	Text Problem	Due Date	Topics
1	1/18	1	1	1/20	Overview. NorCal 40A. Direct conversion vs. superhet rcvrs.
2	1/20	1	2	1/27	Overview. NorCal 40A. Direct conversion vs. superhet rcvrs (cont.).
3	1/23	2	3	1/27	Resistors, capacitors, RC networks. Arbitrary waveform generator.
4	1/25	2	4	1/27	Diodes. Amplitude modulation. Diode detection.
5	1/27	2	5	2/3	RL circuits. Inductive kick. Diode snubbers.
6	1/30	3	6	2/3	RC filters. Series resonance and quality factor. Matching. Soldering.
7	2/1	3	7	2/3	Parallel resonance and quality factor. Transmit filter.
8	2/3	5	8	2/10	Ladder filters. Butterworth and Chebyshev filters. Filter tables. *ADS*.
9	2/6	5	9	2/10	Bandpass ladder filters. Quartz crystals.
10	2/8	5	9 (cont.)	2/10	Impedance inverter. Cohn crystal filter.

11	2/10	6	13*****	2/17	Transformers. Ideal transformers.
12	2/13	6	14*****	2/17	Transformer shunt inductance. Tuned transformers.
13	2/15	8	14***** (cont.)	2/17	Bipolar junction transistors. Large signal models.
14	2/17	–	–	–	Exam review.
–	**2/20**	–	–	–	**No class.**
15	2/22	–	–	–	**Exam #1** (up through and including Text Problem #14).
16	2/24	8	15	3/3	Transistor switches. Voltage regulators.
17	2/27	9	16*****	3/3	CE amp. Max. efficiency of class A amps. Transformer coupled loads.
18	3/1	9	19*****	3/3	Available power. Distortion. Emitter degeneration. Miller effect.
19	3/3	9	20	3/17	Emitter follower and differential amplifiers.
–	**3/6**	–	–	–	**Spring break.**
–	**3/8**	–	–	–	**Spring break.**
–	**3/10**	–	–	–	**Spring break.**
20	3/13	9	21	3/17	Emitter follower and differential amplifiers (cont.).
21	3/15	9	22	3/17	Junction field effect transistors. Source follower amplifier.
22	3/17	10	23	3/24	Class C power amplifiers.
23	3/20	10	23 (cont.)	3/24	Class C power amplifiers (cont.).
24	3/22	10	24	3/24	NorCal 40A power amplifier. Thermal modeling.
25	3/24	10	25	3/31	NorCal 40A power amplifier. Thermal modeling (cont.).
26	3/27	11	25 (cont.)	3/31	Oscillators. Clapp oscillator. VFO startup.
27	3/29	11	26	3/31	Variable frequency oscillator. Gain limiting.
28	3/31	–	–	–	Exam review.
29	4/3	–	–	–	**Exam #2** (up through and including Text Problem #26).
30	4/5	11	27	4/7	Receiver incremental tuning. Crystal oscillators.
31	4/7	12	28	4/12	Mixers. Gilbert cell.
32	4/10	12	29	4/12	Superheterodyne receivers. Spurious responses of mixers.
33	4/12	12	30	4/21	Decreasing channel bandwidth by using CW. Key clicks.
–	**4/14**	–	–	–	**No class.**
–	**4/17**	–	–	–	**No class.**
34	4/19	13	31	4/28	Audio amplifiers.
35	4/21	13	31 (cont.)	4/28	JFETs as variable resistors.
36	4/24	13	32	4/28	Automatic gain control.
37	4/26	14	33	4/28	Noise, SNR, MDS, noise power density and NEP.
38	4/28	14	34	5/5	Nyquist noise formula. Cascading noisy components. Noise figure.
39	5/1	14	35	5/5	Receiver intermodulation and dynamic range.
40	5/3	14	35 (cont.)	5/5	Receiver intermodulation and dynamic range (cont.).
41	5/5	–	–	–	Exam review. Course evaluation.
42	5/9	–	–	–	**Final exam** (all remaining material), 4:00-5:50 PM, Room 253 EP.

***** Use the revised problem located on the EE 322 web site. Do **NOT** follow the text problem.