University of Southern California

Ming Hsieh Department of Electrical Engineering

Course Number & Title: EE 448L, Communication Electronics

Units: 4

Semester: Spring 2019

Schedule: Mondays & Wednesdays & Fridays 10:00 am – 11:50 am

Location: OHE 230

Instructor: Hossein Hashemi

Office: PHE 616

Office Hours: Mondays & Wednesdays 8:45 am – 9:45 am

Contact Information: hosseinh@usc.edu, 213-740-3596

Teaching Assistant: Samer Idres (idres@usc.edu)
TA Office Hours: Tuesdays 4:00pm – 6:00pm
TA Office Location: PHE 530

Course Website: http://blackboard.usc.edu

Catalogue Description

Analysis, design, and experimental evaluation of transistor-level communication circuits and micro-systems. Transmission lines, impedance matching, noise, distortion, tuned amplifiers, mixers, oscillators, phase-locked loops.

Course Description

EE 448L covers theory, analysis, design, assembly, and measurement of circuits that are used in wireless communication systems. The course includes weekly homework assignments, six experimental designs and laboratory measurements, and an integrated circuit final design project. Each student will complete design and characterization of a complete wireless receiver throughout the semester.

Learning Objectives

EE 448L is a senior-level undergraduate and first-year graduate course covering communication circuits at theoretical, simulation, and experimental levels. At the completion of the subject students will be able to (1) analyze, design, and simulations of circuits for various wireless applications, (2) design printed circuit boards (PCB) and solder surface mount components, and (3) conduct measurements using oscilloscopes, signal generators, spectrum analyzers, etc.

Prerequisite: Analog circuits (EE 348L or equivalent)

Main Text Book: B. Razavi, *Design of Analog CMOS Integrated Circuits*, McGraw Hill, 1st Edition, 2000.

Supplementary Texts:

- Thomas H. Lee, *The Design of CMOS Radio-Frequency Integrated Circuits*, Cambridge University Press, 2nd Edition, 2004.
- Kenneth K. Clarke and Donald R. Hess, *Communication Circuits: Analysis and Design*
- David B. Rutledge, *The Electronics of Radio*

Readings: Lecture notes & selected chapters of the main text book

Grading:

Homework	10%
Laboratory Projects	30%
Midterm Exam	20%
Final Exam	40%

Tentative Weekly Schedule

Week	Date	Subject	Readings	HW
1	Mon 01/07/2019	BJT: device physics, large-signal expressions	Lecture Notes	HW 1 assign
	Wed 01/09/2019	BJT: small-signal model + basic amplifiers		
	Fri 01/11/2019	BJT: biasing + amplifiers		
2	Mon 01/14/2019	BJT: differential pairs	Lecture Notes	HW 2 assign
	Wed 01/16/2019	BJT: differential amplifiers, examples		HW 1 due
	Fri 01/18/2019	Frequency response + Bode plot		
3	Mon 01/21/2019	Martin Luther King's Birthday	Lecture Notes	HW 3 assign
	Wed 01/23/2019	Frequency response		HW 2 due
	Fri 01/25/2019	Miller theorem + Associating poles to nodes		
4	Mon 01/28/2019	Open circuit time constant (OCT)	Lecture Notes	HW 4 assign
	Wed 01/30/2019	Short circuit time constant (SCT) method		HW 3 due
	Fri 02/01/2019	LAB 0: introduction to measurements		
5	Mon 02/04/2019	Review of RLCT circuits, passive resonators	Lecture Notes	HW 5 assign
	Wed 02/06/2019	Series-parallel conversion		HW 4 due
	Fri 02/08/2019	Maximum power transfer, impedance matching		
6	Mon 02/11/2019	Tuned amplifiers	Lecture Notes	HW 6 assign Lab 1 assign
	Wed 02/13/2019	Common-base tuned amplifier		HW 5 due
	Fri 02/15/2019	Inductively-degenerated common-emitter amplifier		
7	Mon 02/18/2019	President's Day	Lecture Notes	HW 7 assign
	Wed 02/20/2019	Mid-Term Exam (10:00am – 11:50am)		HW 6 due
	Fri 02/22/2019	Feedback: basics		
8	Mon 02/25/2019	Feedback: root locus, Routh-Hurwitz	Lecture Notes	HW 8 assign Lab 2 assign
	Wed 02/27/2019	Feedback: root locus, Routh-Hurwitz		HW 7 due
	Fri 03/01/2019	LAB 1: wideband amplifier		
9	Mon 03/04/2019	Oscillator: introduction, start-up, steady-state analysis	Lecture Notes	HW 8 assign
	Wed 03/06/2019	Oscillator: examples, voltage controlled oscillators		HW 7 due Lab 1 due
	Fri 03/08/2019	Oscillator: examples, voltage controlled oscillators		
10	Mon 03/11/2019	Spring Recess		
	Wed 03/13/2019			
	Fri 03/15/2019			
11	Mon 03/18/2019	Nonlinearity and distortion (1/2)	Lecture Notes	HW 9 assign
	Wed 03/20/2019	Nonlinearity and Distortion (2/2)		HW 8 due
	Fri 03/22/2019	LAB 2: tuned amplifier		
12	Mon 03/25/2019	Communication systems: amp./phase/freq. modulation	Lecture Notes	HW 10 assign Lab 3 assign Lab 4 assign
	Wed 03/27/2019	Multipliers and mixers		HW 9 due Lab 2 due
	Fri 03/29/2019	LAB 3: amplifier nonlinearity characterization		
13	Mon 04/01/2019	Communication systems: modulators & demodulators TX/RX architectures	Lecture Notes	HW 11 assign Lab 5 assign
	Wed 04/03/2019	Communication systems: link budget analysis		HW 10 due Lab 3 due

	Fri 04/05/2019	LAB 4: voltage-controlled oscillator		
14	Mon 04/08/2019	Noise: basics mathematics, physics, noise models	Lecture Notes	HW 12 assign
	Wed 04/10/2019	Noise: circuit models, noise calculation in circuits		HW 11 due Lab 4 due
	Fri 04/12/2019	Noise: input-referred equivalent noise generators		
15	Mon 04/15/2019	Noise: noise figure, low-noise amplifiers	Chapters 1, 2	Lab 6 assign
	Wed 04/17/2019	MOSFET: device physics, large-signal expressions		HW 12 due
	Fri 04/19/2019	LAB 5: frequency down-conversion mixer		
16	Mon 04/22/2019	MOSFET: small-signal models + basic amplifier stages	Chapter 3, 4	
	Wed 04/24/2019	MOSFET: differential amplifiers + biasing		HW 12 due Lab 5 due
	Fri 04/26/2019	LAB 6: wireless receiver		
17	Mon 05/06/2019	Final Exam (8:00am – 10:00am)		

Tentative Lab Schedule

Lab 1	**Wideband Voltage Amplifier**	Hand-in: Monday, February 11
	Due dates	
	Submit design schematic & layout (first iteration)	Wednesday, February 20
	Receive commented design schematic & layout	Friday, February 22
	Upload final PCB layout (.gbr file)	Wednesday, February 27
	Experiment (soldering + measurements)	Friday, March 1
	Submit lab report	Wednesday, March 6
Lab 2	**Narrowband Low-Noise Amplifier**	Hand-in: Monday, February 25
	Due dates	
	Submit design schematic & layout (first iteration)	Wednesday, March 6
	Receive commented design schematic & layout	Friday, March 8
	Upload final PCB layout (.gbr file)	Wednesday, March 20
	Experiment (soldering + measurements)	Friday, March 22
	Submit lab report	Wednesday, March 27
Lab 3	**Amplifier Nonlinearity Characterization**	Hand-in: Monday, March 25
	Due dates	
	Experiment (measurements)	Friday, March 29
	Submit lab report	Wednesday, April 3
Lab 4	**Voltage-Controlled Oscillator**	Hand-in: Monday, March 25
	Due dates	
	Submit design schematic & layout (first iteration)	Wednesday, April 10
	Receive commented design schematic & layout	Friday, April 12
	Upload final PCB layout (.gbr file)	Wednesday, April 17
	Experiment (soldering + measurements)	Friday, April 19
	Submit lab report	Wednesday, April 24
Lab 5	**Frequency Down-Conversion Mixer**	Hand-in: Monday, April 1
	Due dates	
	Submit design schematic & layout (first iteration)	Wednesday, April 10
	Receive commented design schematic & layout	Friday, April 12
	Upload final PCB layout (.gbr file)	Wednesday, April 17
	Experiment (soldering + measurements)	Friday, April 19
	Submit lab report	Wednesday, April 26
Lab 6	**Wireless Receiver**	Hand-in: Monday, April 15
	Due dates	
	Experiment (measurements)	Friday, April 26
	Submit lab report	Wednesday, May 1

Homework

Unless otherwise stated, homework assignments are due on Wednesdays at the beginning of the class. Solutions will be posted on the class website on the same day.

Late homework will not be accepted. No exceptions except institution-established emergency reasons; credit for such late homework is with the discretion of the professor.

Limited collaboration in solving homework problems is allowed. This includes reviewing and discussing the problems with current EE 536a students and TA prior to writing down your solution. Everybody has to write his/her own solution independently and make sure to fully understand it. Exchanging solutions, consulting with people other than class members, finding solutions on the web or elsewhere, etc. are not allowed. Violations result in losing the credit for the entire homework set in addition to a significant percentage of the overall course grade, all with the discretion of the professor.

All answers should be clearly and fully justified. If we can't figure out your steps from is turned in, points will be deducted, even if your final answer is correct.

One or more of the homework assignments include design problems as well as the typical analysis problems. Simulation and performance verification of the design problems will be in the Cadence environment.

Statement on Academic Conduct and Support Systems

Academic Conduct

Plagiarism – presenting someone else's ideas as your own, either verbatim or recast in your own words – is a serious academic offense with serious consequences. Please familiarize yourself with the discussion of plagiarism in *SCampus* in Section 11, *Behavior Violating University Standards*https://scampus.usc.edu/1100-behavior-violating-university-standards-and-appropriate-sanctions/. Other forms of academic dishonesty are equally unacceptable. See additional information in *SCampus* and university policies on scientific misconduct, http://policy.usc.edu/scientific-misconduct/.

Discrimination, sexual assault, and harassment are not tolerated by the university. You are encouraged to report any incidents to the *Office of Equity and Diversity* http://equity.usc.edu/ or to the *Department of Public Safety* http://capsnet.usc.edu/department/department-public-safety/online-forms/contact-us. This is important for the safety whole USC community. Another member of the university community – such as a friend, classmate, advisor, or faculty member – can help initiate the report, or can initiate the report on behalf of another person. *The Center for Women and Men* http://www.usc.edu/student-affairs/cwm/ provides 24/7 confidential support, and the sexual assault resource center webpage sarc@usc.edu describes reporting options and other resources.

Support Systems

A number of USC's schools provide support for students who need help with scholarly writing. Check with your advisor or program staff to find out more. Students whose primary language is not English should check with the *American Language Institute* http://dornsife.usc.edu/ali, which sponsors courses and workshops specifically for international graduate students. *The Office of Disability Services and Programs* http://sait.usc.edu/academicsupport/centerprograms/dsp/home_index.htmlprovides certification for students with disabilities and helps arrange the relevant accommodations. If an officially declared emergency makes travel to campus infeasible, *USC Emergency Information* *http://emergency.usc.edu/*will provide safety and other updates, including ways in which instruction will be continued by means of blackboard, teleconferencing, and other technology.