ECE 491 − Introduction to Radio Frequency Circuits

Master of Engineering Program (MENG)
University of Illinois at Chicago, College of Engineering

Course Syllabus

Description:

Intended as a first course in radio electronics, it provides a sound theoretical foundation for the design and practical understanding of the operation of basic communications circuits. The design and analysis methods presented rely on lumped-element analysis, which is useful for frequencies up to approximately 100 MHz.

Prerequisites:

Students are expected to have completed the equivalent of ECE 340 (Circuits I) and ECE 311 (Communication Engineering).

Instructor:

Dr. Vladimir Goncharoff	(312) 996-3421 Office
volodia@uic.edu	(312) 996-6465 Fax

Textbook:

None is required, as scanned copies of chapters from these textbooks are provided on the Blackboard course site:

1. Pozar, David M. Microwave and RF design of wireless systems. John Wiley & Sons, Inc., 2000.
2. Ludwig, Reinhold. RF Circuit Design: Theory & Applications, 2/e. Pearson Education India, 2000.
3. Smith, Jack. Modern communication circuits. McGraw-Hill, Inc., 1998
4. Bowick, Christopher. RF circuit design. Newnes, 2011.
5. Hayward, Wes. Introduction to radio frequency design. American radio relay league, 1994.

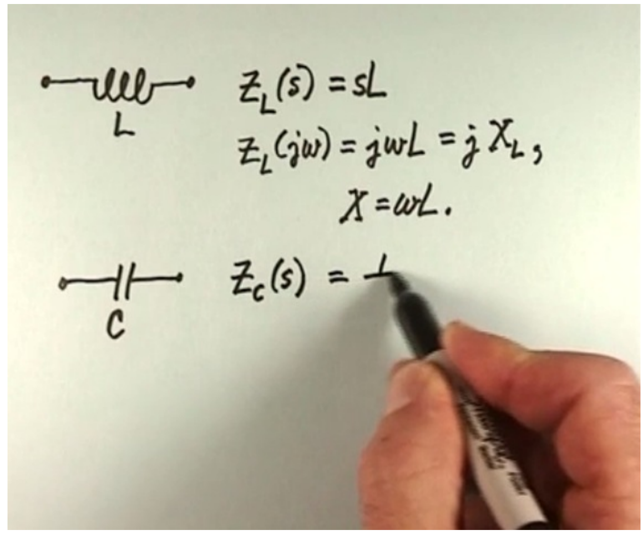
Optional Lecture Notes:

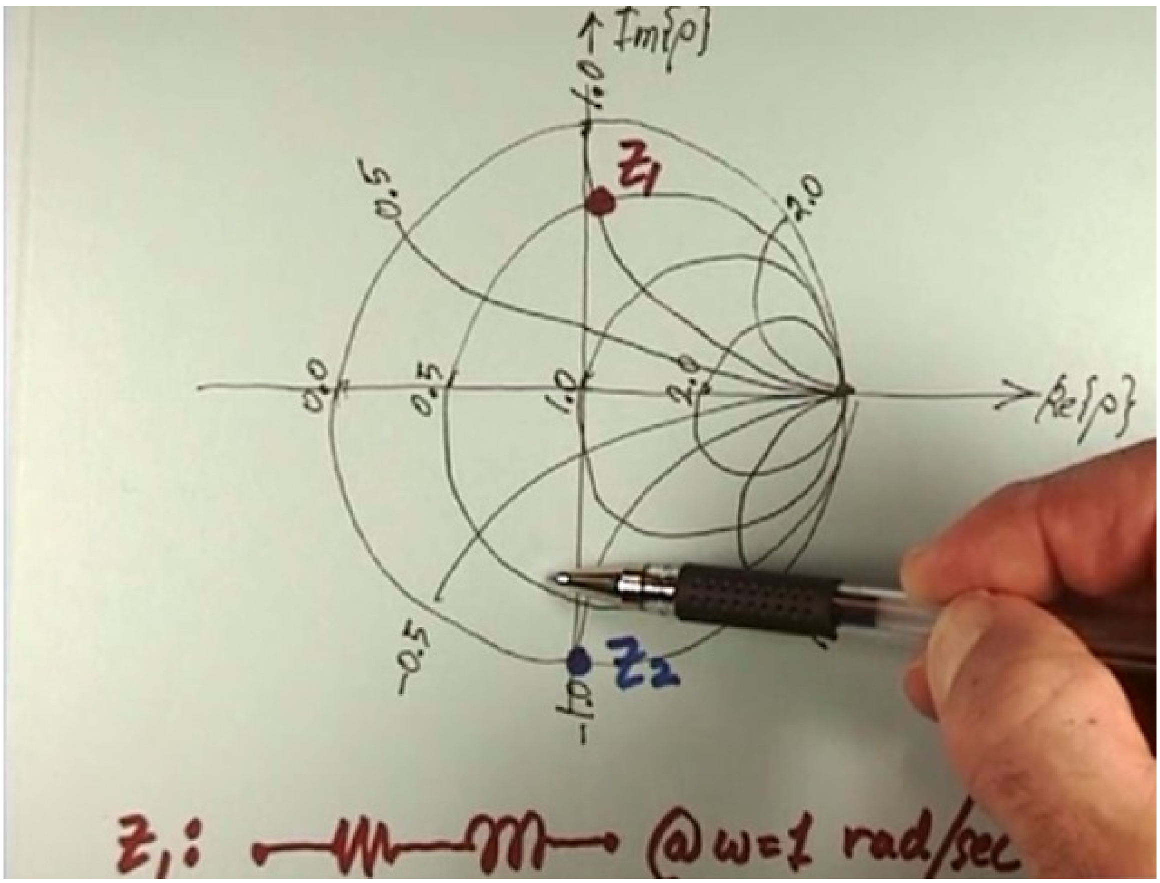
A booklet of handwritten lecture notes used in this video course is available here:

https://www.amazon.com/Introduction-Radio-Frequency-Circuits-supplemental/dp/1535545747

Video Lecture Format:

There are 45 lectures in all (50-60 min. each), which requires one to view three lectures per week in the 15-week semester. Each lecture shows Dr. Vladimir Goncharoff writing and explaining the material in *real time*, thus making it possible to follow along while taking notes. Here are some screen shots from these video lectures:


L
Z_L(s) = sL
Z_L(jω) = jωL = jX_L,
X = ωL.
C
Z_c(s) = 1


Im{ρ}
1.0
z_1
0.5
2.0
0.0
0.5
1.0
2.0
Re{ρ}
-0.5
z_2
-1.0
z_1: @ ω=1 rad/sec

Lecture Topics:

1. Communication circuit building blocks, superheterodyne receiver
2. Image frequency, dual conversion, direct conversion, quadrature-phase mixer
3. Linear amplification, power gain, decibel scale, resistance matching for maximum power gain
4. Nonlinear amplification effects, total harmonic distortion, gain compression
5. Intermodulation products, 3rd order IMD intercept point, dynamic range
6. Bipolar junction transistor, biasing
7. Single and dual power supplies in biasing BJTs, a.c. equivalent circuits for the CE, CB and CC amplifiers
8. CE and CB circuit voltage gain calculation
9. Using CC stage as buffer, voltage gain of cascaded CC-CB amplifier
10. Current mirror used to bias a BJT, FET basics
11. Range of linear BJT operation, tuned circuits
12. Parallel RLC tuned circuit, application to CE stage bandpass filter design
13. Series resonant circuit, RLC bandpass filter attenuation at harmonics of the resonant frequency
14. Ideal transformer, impedance transformation, capacitive autotransformer
15. Capacitive autotransformer used in transistor amplifiers, effects of losses in the tuned circuit
16. Effects of lossy L and lossy C on resonant circuit behavior, inductive transformer
17. Inductive auto-transformer, introduction to L-networks
18. Impedance matching using lowpass and highpass L-networks
19. Cascaded L-networks, virtual resistance, designing L-networks for bandpass filtering
20. Using L-networks to match complex impedances
21. Reflection coefficient, introduction to the Smith Chart
22. Plotting impedances and admittances on a Smith Chart
23. Impedance matching using L-networks as guided by a Smith Chart
24. Smith Chart used to match complex impedances, linear feedback system, operational amplifier as a feedback system building block
25. Single-transistor oscillators
26. Phase-shift oscillator, negative resistance oscillator
27. Voltage-controlled oscillator, crystal resonator
28. Using crystals in series and in parallel mode, crystal oscillator circuits
29. Ideal, switching and nonlinear-type mixers
30. Differential pair, Gilbert Cell mixer
31. Small-signal Gilbert Cell mixer analysis
32. Large-signal Gilbert Cell mixer analysis, nonlinear and diode-ring modulators
33. Effects of coupling and bypass capacitors on the frequency response of transistor circuits
34. Internal capacitances in the BJT, Miller effect
35. Frequency responses of CE and CB circuits as affected by internal BJT capacitances
36. Linear 2-port network analysis: Y, Z and T parameters
37. Evaluating power gain and achieving simultaneous conjugate match based on BJT y-parameters
38. Stability factor based on 2-port parameters, scattering parameters
39. Phase-locked loops
40. PLL phase detectors, s-domain analysis of the PLL
41. Frequency response of the PLL based on a linear model
42. Effect of phase detector on PLL loop filter design, frequency synthesis

43. Introduction to noise theory, noise factor
44. Noise figure of cascaded amplifiers, equivalent noise temperature
45. Concluding remarks

Homework:

Homework is in the form of weekly online quizzes. Students will have the opportunity to print out the homework problems, study them off-line and consult with the instructor if necessary, before submitting the answers for automatic grading on Blackboard. Each submitted answer is immediately marked "correct" or "incorrect", and the student may use this feedback to rework and resubmit problems when necessary.

Examinations:

There are two exams in this course, and students will be given one week to independently solve and neatly write out the solutions for each of them. Exam problems will be similar to the homework problems that precede them, except that detailed work arriving at an exam problem solution must be shown. Unlike for homework grading, partial credit for exam problems will be awarded. Solved exams should be scanned and emailed to the instructor as a PDF file before the stated deadline.

Work Schedule Time Conflicts:

It is understood that students who enroll in this online course are probably employed as full-time workers, and that on occasion demands of the job (such as travel) may interfere with regular lecture viewing and homework submission. In such case please contact the instructor *in advance of a submission deadline* to request a time extension. Keep in mind, however, that no homework or exam submission deadlines will be extended beyond the 16th week of the course.

Grade Determination:

Homework Assignments:	20%	Online quiz, one per week
Exam 1:	40%	Posted during Week 8
Exam 2:	40%	Posted during Week 15

90-100%:	A
80-90%:	B
70-80%	C
60-70%	D