Spring 2019 - Syllabus

EENG 6900- Radio-frequency Integrated Circuit Design

Class meetings B217 Tuesdays and Thursdays 4 – 5:20 pm

Description

Design and analysis of high-speed integrated circuits (Low-noise Amplifier, Voltage-controlled Oscillator, Mixer and Power Amplifier) for communications and other applications requiring a high-frequency operation. Through the course, the students will implement the design and simulation techniques using modern industry-standard tools such as Cadence, ADS, and NI AWR

Credit hours: 3 hrs.

Prerequisite(s): ENG 3520 and EENG 3810 or consent of instructor.

Additional Prerequisites:

- Solid grasp of fundamentals of analog circuit design (e.g. gain, bandwidth, small-signal analysis, feedback)
- Experience using the Cadence tools for schematic design and simulation. *However*, if you have not used cadence before, I will help you find tutorial information to get you up to speed, but you should expect to invest some additional time to learn the tools.

Instructor

Ifana Mahbub, Assistant Professor, Electrical Engineering Department

Office B208, Email Ifana.Mahbub@unt.edu Office hours: Tuesdays and Thursdays 2 – 4 pm or by appointment.

Format

• Lectures, notes would be provided (See suggested reference text books)

• Online: announcements, grades via Canvas https://unt.instructure.com/login/ldap

Grade

Home works: 20%

Design Projects: 40%

Student Lectures 10%

Mid-term exam: 25%

Participation 5%

Grade distribution

A=90-100, B=80-89, C=70-79, D=60-69, F=0-59

Schedules of exams

• Midterm Exam: March 7 (in class)

Textbooks

Required: Behzad Razavi, *RF Microelectronics*, Prentice Hall, 2nd edition, ISBN 978-0137134731.

Additional Reference: Thomas Lee, *The Design of CMOS Radio-frequency Integrated Circuits*, Cambridge University Press, ISBN 978-0521835398.

Homework
Homework will be assigned and graded. Assignments will include analytical problems, simulation task, simple design problems, and other tasks that require more time than an in-class setting allows. The primary purpose of the homework assignments is to help you master the concepts and practice applying them. Discussion of the homework problems is allowed and encouraged, but copying of homework is cheating. The work you turn in must be your own.

Projects
Project reports should be clear, concise, and complete. Reports must be typed or word-pressed and formatted according to the IEEE publication templates available online. Writing is expected to be of a style and quality consistent with professional documentation or publication, including correct spelling and grammar.

Student Lectures
Each student will give at least one lecture on a topic to be agreed upon by the student and the instructor. Typical topics will include a critical review of a relevant journal paper or a tutorial discussion of a topic not otherwise covered in the course, such as advanced CAD techniques.

Late Assignments
Homework assignments and project reports are due at the beginning of class. Late assignments will be penalized 10% per day or fraction thereof for the first 72 hours (including weekends, holidays, etc.). After 72 hours, late assignments will not be accepted.

Class Evaluation by Students
SPOT is a requirement for all organized classes at UNT and is available for your input at the end of the semester.

Course Learning Outcomes (CLO):
Upon successful completion of this course, the students will be able to:

1. Calculate noise (amplitude and phase), linearity, and dynamic range performance metrics for RF devices and circuits
2. Discuss transceiver architectures relevant to current wireless communications standards and their relative advantages and disadvantages
3. Discuss active and passive device technologies relevant to RFICs and their relative performance advantages and disadvantages
4. Design monolithic inductors for integrated amplifiers and oscillators
5. Design IC implementations of RF functional blocks (such as low-noise amplifiers, mixers and oscillators) based on foundry models and design rules to meet specifications for a wireless communications system
6. Discuss monolithic synthesizer architectures and their performance
7. Discuss issues in single-chip radio implementations
8. Utilize RF/microwave CAD software in the design

ABET Student Learning Outcomes (SO)
SO-1 Ability to apply mathematics, science and engineering principles.
SO-2 Ability to design and conduct experiments, analyze and interpret data.

SO-3 Ability to design a system, component, or process to meet desired needs.
SO-4 Ability to function on multidisciplinary teams.
SO-5 Ability to identify, formulate and solve engineering problems.
SO-6 Understanding of professional and ethical responsibility.
SO-7 Ability to communicate effectively.
SO-8 The broad education necessary to understand the impact of engineering solutions in a global and societal context.
SO-9 Recognition of the need for and an ability to engage in life-long learning.
SO-10 Knowledge of contemporary issues.
SO-11 Ability to use the techniques, skills and modern engineering tools necessary for engineering practice.

CLO	**ABET Student Outcomes**										
	SO-1	SO-2	SO-3	SO-4	SO-5	SO-6	SO-7	SO-8	SO-9	SO-10	SO-11
1	X	X	X		X	X		X	X	X	X
2			X		X	X	X	X	X	X	X
3						X	X	X		X	X
4	X	X	X		X	X		X	X	X	X
5	X	X	X		X			X	X	X	X
6			X		X		X	X	X	X	X
7			X		X	X	X	X	X	X	X
8				X						X	X

Policies

A. **Academic Integrity Standards and Consequences.** According to UNT Policy 06.003, Student Academic Integrity, academic dishonesty occurs when students engage in behaviors including, but not limited to cheating, fabrication, facilitating academic dishonesty, forgery, plagiarism, and sabotage. A finding of academic dishonesty may result in a range of academic penalties or sanctions ranging from admonition to expulsion from the University. See full policy at https://policy.unt.edu/sites/default/files/06.003.pdf.

B. **ADA Accommodation Statement.** UNT makes reasonable academic accommodation for students with disabilities. Students seeking accommodation must first register with the Office of Disability Accommodation (ODA) to verify their eligibility. If a disability is verified, the ODA will provide a student with an accommodation letter to be delivered to faculty to begin a private discussion regarding one's specific course needs. Students may request accommodations at any time, however, ODA notices of accommodation should be provided as early as possible in the semester to avoid any delay in implementation. Note that students must obtain a new letter of accommodation for every semester and must meet with each faculty member prior to implementation in each class. For additional information see the ODA website at disability.unt.edu.

C. **Course Safety Procedures (for Laboratory Courses).** Students enrolled in [insert class name] are required to use proper safety procedures and guidelines as outlined in UNT Policy 06.038

Safety in Instructional Activities. While working in laboratory sessions, students are expected and required to identify and use proper safety guidelines in all activities requiring lifting, climbing, walking on slippery surfaces, using equipment and tools, handling chemical solutions and hot and cold products. Students should be aware that the UNT is not liable for injuries incurred while students are participating in class activities. All students are encouraged to secure adequate insurance coverage in the event of accidental injury. Students who do not have insurance coverage should consider Standard Syllabus Statements Related Policy 06.049 Course Syllabi Requirements obtaining Student Health Insurance. Brochures for student insurance are available in the UNT Student Health and Wellness Center. Students who are injured during class activities may seek medical attention at the Student Health and Wellness Center at rates that are reduced compared to other medical facilities. If students have an insurance plan other than Student Health Insurance at UNT, they should be sure that the plan covers treatment at this facility. If students choose not to go to the UNT Student Health and Wellness Center, they may be transported to an emergency room at a local hospital. Students are responsible for expenses incurred there.

D. **Emergency Notification & Procedures.** UNT uses a system called Eagle Alert to quickly notify students with critical information in the event of an emergency (i.e., severe weather, campus closing, and health and public safety emergencies like chemical spills, fires, or violence). In the event of a university closure, please refer to Blackboard for contingency plans for covering course materials.

E. **Student Evaluation Administration Dates**. Student feedback is important and an essential part of participation in this course. The student evaluation of instruction is a requirement for all organized classes at UNT. The survey will be made available during weeks 13, 14 and 15 of the long semesters to provide students with an opportunity to evaluate how this course is taught. Students will receive an email from "UNT SPOT Course Evaluations via IASystem Notification" (no-reply@iasystem.org) with the survey link. Students should look for the email in their UNT email inbox. Simply click on the link and complete the survey. Once students complete the survey they will receive a confirmation email that the survey has been submitted. For additional information, please visit the SPOT website at www.spot.unt.edu or email spot@unt.edu.

Tentative Course Calendar

Week	Date	Topics	Homework/Mini Assignment
1	01/15	RF Overview	
	01/17	Architectures, Smith Charts, impedance matching	
2	01/22	**No class**	
	01/24	Architectures, Smith Charts, impedance matching	HW 1 posted
3	01/29	Noise theory	
	01/31	Noise theory	

4	02/05	Low Noise Amplifier	HW 1 due Project 1 (LNA) posted
	02/07	Low Noise Amplifier	HW 2 posted
5	02/12	Low Noise Amplifier	
	02/14	Low Noise Amplifier	
6	02/19	Mixer Design	HW 2 due Project 2 (Mixer) posted
	02/21	Mixer Design	
7	02/26	Mixer Design	Project 1 (LNA) Due
	02/28	Voltage Controlled Oscillator	Project 3 (VCO) posted
8	03/05	Mid-term Exam Review	
	03/07	Mid-term Exam	
9	03/12	**Spring Break (no classes)**	
	03/14	**Spring Break (no classes)**	
10	03/19	Voltage Controlled Oscillator	Project 2 (Mixer) Due
	03/21	Voltage Controlled Oscillator	
11	03/26	Phase Noise	
	03/28	**No class**	
12	04/02	Phase Noise	Project 3 (VCO) due HW 3 posted
	04/04	Transmitter Architecture, Power Amplifier Theory	
13	04/09	Transmitter Architecture, Power Amplifier Theory	
	04/11	Power Amplifier	
14	04/16	Power Amplifier	HW 3 due
	04/18	Alternative Architectures	

15	04/23	Alternative Architectures	
	04/25	Wrap-up	
16	04/30	Student Lectures	
	05/02	Student Lectures	

Cadence Software Access:
The graduate students will be using the 180nm CMOS process for the projects.

Lab computers where you can access Cadence:

You should be able to remotely log in to the Cadence server from the computers in the B227 lab.