Fall 2021 - Syllabus

EENG 4010 and 5410 - RF and Microwave Engineering Design and Applications

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

Every other Tuesday there will be hands-on lab which will be taking place in B288. Your seat for the lab and the class will be assigned and you need to sit in the same place throughout the semester. Students are also requested to wear face mask during the class and the lab to ensure the safety and well-being of everybody

Instructor Contact

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Pronouns: She/her/hers
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Teaching Assistant: Sujan Aryal

Office D144, Email sujanaryal2@my.unt.edu, Office hours: Tuesday and Thursday 3 – 4 pm or by appointment.

Communication Expectations: The primary tool that will be used to communicate directly with students would be via Canvas. You can send your personal concerns or questions via Email. You can expect to receive a response to emails by 48 hours. To schedule an appointment outside of the office hours, send an email first and we will arrange a meeting.

Course Description

This course is made possible through the multi-year support received from the Office of Naval Research (ONR) for the North Texas Navy STEM Coalition (NT-NSC) awarded to the College of Engineering at UNT (PI Kaul; Co-PI Mahbub). The course is designed to provide an overview of the RF and microwave engineering design and applications with laboratory modules designed to provide hands-on experiences. The course starts with an introduction to the various uses of RF and microwave systems in our everyday lives starting from cell phones to various wireless systems and networks. Basic introduction to the mechanics of fields and wave propagation through air, water and other media with practical demonstrations are integrated in the laboratory modules. Motivation for RF electronics and RF MEMS is discussed in the context of Navy relevant areas. Design and modeling of RF passive components such as inductors, capacitors, varactors, resonators and antennas will be covered. The course evolves into the practical applications of these passive components for sensors and actuators, specifically in the context of wearable and implantable biomedical applications and flexible electronics. Through this course, students will have the opportunity to design and simulate structures using modern industry-standard tools such as ADS and HFSS and make measurements using high-frequency measurement instrumentation such as Vector Network Analyzer and Spectrum Analyzer. The lab modules will help in cultivating interdisciplinary perspectives with hands-on exercises for undergraduate and graduate students enrolled in the course. Students enrolled in this course AND the accompanying sister course during Spring 2021 (offered by Prof. Kaul) will have the opportunity to apply and be considered

for selected internships at Naval facilities in the US (US Citizenship is required) in Summer 2021 and following years which will be coordinated by Prof. Kaul. As both courses are administered in the 2020-2021 Academic Year and subsequent years, opportunities will exist for UNT students to increase their awareness of STEM related career opportunities with the US Navy through in-person guest visits, webinars, and informational videos.
Prerequisite(s): ENG 3410 or consent of instructor.

Course Topics

1. Overview of the RF and microwave engineering design and applications. Laboratory modules designed to provide hands-on experiences
2. Basic introduction to passive and active RF and microwave components and circuits for wireless communications
3. Introduction to the mechanics of fields and wave propagation through different media with laboratory experiments including practical demonstrations
4. Introduction to transmission-line theory; planar transmission-lines and S-parameters
5. RF electronics and RF MEMS discussion in the context of US Navy relevant research areas
6. Design and modeling of RF passive components such as inductors, capacitors, varactors, resonators and antennas for the applications of wearable and implantable sensors
7. Learning the simulation techniques using the industry-standard tools such as ADS and HFSS
8. Learning the measurement techniques using the high-frequency measurement instrumentation such as Vector Network Analyzer (VNA), RF signal generator and Spectrum Analyzer (SA)

Grade

Home works: 10%
Quizzes: 30%
Mid-term Exam: 20%
Lab Participation and Lab Reports: 30%
Group Project Presentation: 10%

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

Schedules of exams
• Midterm Exam: October 28th, 2021

Textbooks
Microwave Engineering, 4th Edition, by David M. Pozar, John Wiley and Sons Inc., 2012.

Notes and laboratory manual would be provided during the lab and posted on Canvas. Broad audience literature articles will also be posted on Canvas.

Homework

Homework will be assigned and graded. Assignments will include analytical problems, simulation task, simple mathematical 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 turned in every other Tuesday before the start of the new lab session.

Late Assignments
Homework assignments and project reports are due at the beginning of class/lab. 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. Analyze passive and active components at RF and microwave frequencies
2. Analyze RF and microwave networks containing passive distributed components
3. Perform lab experiments including using bench-top instruments such as a Vector Network Analyzer, Spectrum Analyzer and RF Signal Generator
4. Perform a variety of microwave and RF measurements
5. Perform analysis of transmission-line networks, impedance matching and S-parameters
6. Learn advanced design software to perform electromagnetic simulation and characterization of microwave circuits and antenna
7. Use ADS, HFSS and CST Studio software as a tool to solve for the electric and magnetic fields from charges and currents of the designed passive components and RF MEMS
8. Organize and write technical lab reports, analyze and summarize results
9. Organize and make technical presentations
10. Opportunities to interact weekly with the instructor and the teaching assistant during regular office hours and discussion sections in order to further the students' learning experiences and the students' interest in the material

ABET Student Learning Outcomes (SO)
1. an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics
2. an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors
3. an ability to communicate effectively with a range of audiences

4. an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts
5. an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives
6. an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions
7. an ability to acquire and apply new knowledge as needed, using appropriate learning strategies

CLO	**Student/ABET Criterion 3 Outcomes**						
	SO-1/ 3[1]	**SO-2/ 3 [2]**	**SO-3/ 3 [3]**	**SO-4/ 3 [4]**	**SO-5/ 3 [5]**	**SO-6/ 3 [6]**	**SO-7/ 3 [7]**
1	**x**						
2	**x**						
3	**x**					**x**	
4	**x**					**x**	
5	**x**						**x**
6	**x**					**x**	
7	**x**					**x**	
8	**x**		**x**				
9	**x**		**x**				
10			**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 this class 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		
1	08/24	Introduction, review of TL	
	08/26	Field Analysis of TL	

2	08/31	Lab 1: Introduction to ADS and HFSS	
	09/02	Reflections, standing waves, quarter wave transformer	HW 1 posted
3	09/07	Guest lecture Transients on TL	
	09/09	Smith Charts, single stub matching, single stub matching with equal or unequal impedances	
4	09/14	Lab 2: Bow-tie Antenna simulation in ADS	HW 1 due
	09/16	Double stub matching	
5	09/21	Lossy TL, Lossy line example with Smith chart, coaxial lines and connectors	Quiz 1
	09/23	Impedance and multi-port network	
6	09/28	Lab 3: Spiral based coil simulation in HFSS	HW 2 posted
	09/30	Z and S matrices	
7	10/05	S Parameters, ABCD Parameters and TRL Calibration	
	10/07	Broad band tuning	HW 2 due
8	10/12	Lab 4: Various transmission line simulation in ADS	
	10/14	Lumped Element Networks	
9	10/19	**3-** Element Lumped Element Networks	Quiz 2
	10/21	**Mid-term exam review**	HW 3 posted
10	10/26	Lab 5: Band-pass filter and Directional Coupler design	
	10/28	**Mid-term Exam**	
11	11/02	Power Dividers and couplers, Wilkinson Power Divider	HW 3 due
	11/04	Quadrature coupler, coupling and cross talk, coupled line analysis	
12	11/09	Lab 6: Measurement with Vector Network Analyzer	
	11/11	Navy officer talk/Lumped element filter design, coupled line filter	Quiz 3

13	11/16	Stub filter design, transparencies, Stepped impedance filter design	HW 4 posted
	11/18	TEM/ TE/ TM waves, rectangular waveguides	
14	11/23	Lab 7: Measurement with Spectrum Analyzer	
	11/25	Thanksgiving break	
15	11/30	Circular waveguides, field patterns, Bessel functions, Waveguide Feeds/Aperture Coupling	HW 4 due Quiz 4
	12/03	**Group Project Presentation**	

ADS and HFSS Software Access:
The software will be available in B288 lab. We will work on remote access as well.