NC STATE UNIVERSITY **Spring 2018**

ECE 792: Design of Millimeter-Wave Circuits and Systems

Class Time/Location: Mon. & Wed., 3:00 PM-4:15 PM, EB2 1226

Instructor:
Dr. Brian Floyd bafloyd@ncsu.edu
Associate Professor Office: 441 Monteith Research Center
Office Hours: Mon and Wed (EB2 1014) 1:45 PM-2:45 PM

Course web page https://moodle-courses1617.wolfware.ncsu.edu/course/view.php?id=6210
****Please use the course bulletin board to ask questions about lectures, HW, projects, etc. It is the best way to broadcast questions that may be of interest to everyone.*

Course Objectives:
After taking this course, the student will be able to evaluate and describe requirements for millimeter-wave radio, radar, and radiometer systems; and analyze and design the key integrated circuits found in millimeter-wave receivers, transmitters, and phased arrays.

Course Description:
Topics will include silicon IC technology at mm-wave, radio link budgets, beamformers, amplifiers, phase shifters, oscillators, mixers, transmit/receive front-ends, phased-arrays, receivers, transmitters, radars, and radiometers. Emphasis will be placed on differences encountered in mm-wave IC design as compared to RFIC design due to technology limitations and/or application requirements.

Prerequisites:
ECE 549 RF Design for Wireless and ECE 712 ICs for Wireless Communications

Required Text:
- Sorin Voinigescu, *High-Frequency Integrated Circuits*, 1st ed., Cambridge, 2013

Supplementary Texts:
- Hubregt J. Visser, *Array and Phased Array Antenna Basics*, Wiley, 1st ed., 2005.
- David Pozar, *Microwave Engineering*, Wiley, 4th ed., 2011.
- Merrill Skolnik, *Introduction to Radar Systems*, McGraw-Hill, 3rd ed., 2002.
- John Kraus, *Radio Astronomy*, Cygnus-Quasar Books, 2nd ed., 1986.

Grading:
10% Participation; 30% Homework; 30% Project 1; 30% Project 2

Design Projects and Homework:
Two design projects and approximately five homework assignments are planned. Students will be creating designs using available industry design kits and Cadence, SpectreRF, and Momentum design tools.

→**Late policy**: assignments must be uploaded before 11:55PM on the due date. Late assignments will incur a 20% late penalty except in pre-arranged cases which must be cleared in advance with the instructor.

Planned Course Outline and Readings:

	Topic	Reading Voinegescu	Reading Supplement	Assignment
1	Introduction to mm-wave: Physics, Technology, Markets	1.1-1.4		
2	Active components -- SiGe BiCMOS Technology	4.1, 4.3		
3	Active components -- SOI CMOS Technology	4.2		HW 1
4	Passive components -- Capacitor / Inductor / Transformer	4.5	Dickson	
5	Passive components -- transmission lines			HW 2
6	Passive components -- couplers: Lange, branchline, Wilky			
7	Building Block 1: LNA design, layout, verification	Ch. 3, 7	Floyd	Project 1
8	Building Block 2: PA design, layout, verification	Ch. 6		
9	Millimeter-wave Communication Links and Budgets	2.1-2.3, 2.8		HW 3
10	Phased-Array 1: Beamforming		Parker I	
11	Phased-Array 2: Architecture	2.8	Parker II	HW 4
12	Phased-Array 3: Metrics		Lee (G/T)	
13	mm-wave Phase Shifters -- Active		Multiple	
14	mm-wave Phase Shifters -- Passive		Multiple	Project 2
15	mm-wave Power Combiner/Splitter			
16	Phased-Array Beamformer System-on-Chip		Multiple	HW 5
17	mm-wave Transceivers: Architecture	2.4-2.5	Reynolds	
18	mm-wave Mixers, Active and Passive	Ch. 9	Wilson	
19	mm-wave LO networks and VCOs	Ch. 10	TBD	
20	mm-wave Frequency multipliers, dividers, PLLs	Ch. 11	TBD	
21	mm-wave Transceiver: Extendible Phased-Array Platforms			
22	Radar Fundamentals: FMCW vs Pulse		Zwick	
23	FMCW Radar Building Blocks: Unique aspects			
24	Radar Transceiver System-on-chip		Fujibayashi	
25	Imaging Fundamentals: Passive vs Active		TBD	
26	Radiometer Building Blocks and SOCs			
27	Project Presentations			

Simulation:
Circuit simulation will be performed using Cadence and SpectreRF whereas electromagnetic simulation will be conducted with Momentum.

Students with Disabilities:
Reasonable accommodations will be made for students with verifiable disabilities. To take advantage of available accommodations, students must register with Disability Services for Students at 1900 Student Hearth Center, Campus Box 7509, 515-7653. http://www.ncsu.edu/dso.

Audit Students:
Students auditing the course are expected to maintain a 90% average or better on all homework assignments and must actively attend and participate in lectures. They do not have to complete design projects but are encouraged to explore the designs.

Academic Integrity:
Students should refer to the University policy on academic integrity found in the Code of Student Conduct (found in Appendix L of the Handbook for Advising and Teaching). *It is the instructor's understanding and expectation that the student's name/signature on any test or assignment means that the student neither gave nor received unauthorized aid.* Authorized aid on an individual assignment includes discussing the interpretation of the problem statement, sharing ideas or approaches for solving the problem, and explaining concepts involved in the problem. Any other aid would be unauthorized and a violation of the academic integrity policy. Any computer work submitted must be completed on your own personal computer or from your own NCSU account to avoid confusion about the origin of the file, and no sharing of files in any way is allowed. Students found in violation of the academic integrity policy will be reported to the NCSU Office of Student Conduct.

Supporting Fellow Students in Distress:
As members of the NC State community, we each share a personal responsibility to express concern for one another and to ensure that this classroom and the campus as a whole remains a safe environment for learning. Occasionally, you may come across a fellow classmate whose behavior concerns or worries you. When this is the case, I would encourage you to report this behavior to the NC State Students of Concern website: http://studentsofconcern.ncsu.edu/.