COURSE DESCRIPTION

Nonlinear Microwave/RF Devices and Circuits

ECE 770-T16

DESCRIPTION:

The main focus of this course is on the application of Electromagnetic and Electronic concepts to the design and analysis of microwave nonlinear active devices (transistors, diodes) and circuits typically used in radio communications infrastructure. Topics covered include:

- Review of linear active microwave circuits design
- Fundamentals of Nonlinear Circuits
- Nonlinear Active Devices Modeling
- Nonlinear Circuit Analysis
- RF Power Amplifiers
- Linearization Techniques
- Advanced RF Transmitters Topologies

Although, this course focuses on the technology of discrete RF and microwave circuit design, examples of integrated circuits will also be presented to show the two worlds.

OBJECTIVES:

Students are expected to be able to design and analyze various nonlinear active microwave circuits after successful completion of the course work. For that, this course aims to provide fundamentals of modeling/analysis/simulation techniques for RF/Microwave devices and circuits. It introduces various design principles and methods of practical nonlinear circuits.

PREREQUISITES:

- Basic knowledge in Electromagnetic and analog Electronic
- Electrical and Computer Engineering course “Microwave and RF Engineering” (ECE 473 or ECE 671) or equivalent, or permission of the instructor

DESIGN PROJECT:

Each student will have a design project dealing with the design of a particular nonlinear RF active circuit with realistic specifications. The design project requires that the student use RF CAD software Agilent's Advanced Design System.

COURSE CONTENT:

Detailed Description	Lecture hours
Review of linear microwave circuits: - matching networks - gain circles - stability circles	3 hours

noise circles	
Nonlinear circuit analysis: - spectral domain analysis - time domain analysis - Newton-Raphson Method - harmonic balance analysis	4.5 hours
Nonlinear active device modeling: - small signal equivalent circuits - nonlinear I-V and C-V models for MOSFETS - nonlinear models for GaAs MESFETs and HEMTs - nonlinear bipolar device modeling. - load-pull techniques	4.5 hours
RF power amplifiers (PA) for wireless communications: - practical design of linear RF PAs, - overdriven PAs and Class F mode - switching mode PA - power amplifier bias circuit design	9 hours
Nonlinear effects in RF PAs and linearization techniques	4.5 hours
Power efficiency enhancement techniques	4.5 hours
Advanced Transmitters Architectures	3 hours
Other RF transmitters components	3 hours

COURSE MATERIALS: Course notes, problem sets and solutions will be available on LEARN at the start of the term.

TEXTBOOKs

- Recommended:
  - "Nonlinear Microwave Circuit Design", 2/E, By Franco Giannini, Giorgio Leuzzi", 4/E. by John Wiley and Sons, 2004, ISBN 0470847018,
- Additional References
  - Steve C. Cripps, RF Power Amplifiers for Wireless Communications, Second Edition, Artech House, ISBN: 1-59693-018-7
  - Stephen A. Maas, Nonlinear Microwave and RF Circuits, Second Edition, Artech House, ISBN: 1-58053-484-8
  - Andrei Grebennikov, Nonlinear Microwave and RF Circuits, First Edition, McGraw-Hill, ISBN: 0-07-144493-9

- Peter Aaen, Jaime A. Plá, John Wood, (2007) Modeling and Characterization of RF and Microwave Power FETs, Cambridge University Press, ISBN: 0521336171

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Plagiarism: For all assignments, students are welcome to consult with others. Nevertheless, each student is expected to add value beyond that of the work developed in conjunction with others and the submitted material must be in the student's own words.

Grievance: A student who believes that a decision affecting some aspect of his/her university life has been unfair or unreasonable may have grounds for initiating a grievance. Read Policy 70, Student Petitions and Grievances, Section 4, www.adm.uwaterloo.ca/infosec/Policies/policy70.htm. When in doubt please be certain to contact the department's administrative assistant who will provide further assistance.

Discipline: A student is expected to know what constitutes academic integrity [check www.uwaterloo.ca/academicintegrity/] to avoid committing an academic offence, and to take responsibility for his/her actions. A student who is unsure whether an action constitutes an offence, or who needs help in learning how to avoid offences (e.g., plagiarism, cheating) or about "rules" for group work/collaboration should seek guidance from the course instructor, academic advisor, or the undergraduate Associate Dean. For information on categories of offences and types of penalties, students should refer to Policy 71, Student Discipline, www.adm.uwaterloo.ca/infosec/Policies/policy71.htm. For typical penalties check Guidelines for the Assessment of Penalties, www.adm.uwaterloo.ca/infosec/guidelines/penaltyguidelines.htm.

Appeals: A decision made or penalty imposed under Policy 70 (Student Petitions and Grievances) (other than a petition) or Policy 71 (Student Discipline) may be appealed if there is a ground. A student who believes he/she has a ground for an appeal should refer to Policy 72 (Student Appeals) www.adm.uwaterloo.ca/infosec/Policies/policy72.htm.

Note for Students with Disabilities: The Office for Persons with Disabilities (OPD), located in Needles Hall, Room 1132, collaborates with all academic departments to arrange appropriate accommodations for students with disabilities without compromising the academic integrity of the curriculum. If you require academic accommodations to lessen the impact of your disability, please register with the OPD at the beginning of each academic term.