ECE 746
Analysis and Design of RF ICs for Communications

COURSE OUTLINE

Please refer to course website for updated information.

COURSE DESCRIPTION

This course provides fundamental and in-depth knowledge of the analysis and design of radiofrequency (RF) integrated circuits (IC) in CMOS technology for wireless communications. The topics include the modeling of active and passive components for AC and noise analysis and design examples of amplifiers, filters, oscillators, PLL and frequency synthesizers. Circuit performance will be evaluated by both hand calculations and computer simulations. A good understanding of circuit analysis and CAD tools (e.g., HSPICE or SpectreRF) is required.

SCHEDULE and MODE OF DELIVERY

The material for this course will be delivered through a mixture of online videos, textbook readings, live online lectures and tutorials (which are also recorded), and virtualized laboratories and projects. The platform for each component is noted at the end of each line.

Lecture: Tuesday, 11:30 – 14:20, starting from Jan. 7, 2025

INSTRUCTOR

Dr. Chih-Hung (James) Chen
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Office: ITB-A321
Phone: 905-525-9140 ext. 27084
Office Hours**:** By appointment on Microsoft Teams

COURSE WEBSITE/S

http://avenue.mcmaster.ca

COURSE OBJECTIVES

By the end of this course, students should be able to demonstrate their competency and be knowledgeable on the operating principles, design methodologies, and analysis techniques of radio frequency (RF) integrated circuits (IC) and their applications. They will be measured using three metrics:

- Knowledge Base for Engineering - Competence in Specialized Engineering Knowledge Related to Electronic Devices and Circuits.
- Problem Analysis - Obtain substantiated conclusions as a result of a problem solution, including recognizing the limitations of the solutions.
- Investigation - Capable of selecting appropriate models and methods and identifying assumptions and constraints.

ASSUMED KNOWLEDGE

Good knowledge of circuit theory, microelectronics, and microwave engineering. Special emphasis is on the semiconductor devices, small-signal models, scattering parameters, linear two-port network theory, circuit design (e.g., single-stage and differential amplifiers, passive and active filters, and negative feedback circuits), and circuit analysis (in both time and frequency domains).

COURSE MATERIALS

Textbooks:
Bosco Leung, *VLSI for Wireless Communications*, Prentice-Hall, TK7874.75.L48, 2002

Reference Texts:
1. B. Razavi, RF Microelectronics, Prentice-Hall Inc., 1998.
2. T.H. Lee, The Design of CMOS Radio-Frequency Integrated Circuits, Cambridge University Press, 1998.
3. G. Gonzalez, Microwave Transistor Amplifiers: Analysis and Design, 2nd ed., Prentice-Hall Inc., 1997.
4. Lawrence P. Huelsman, Active and Passive Analog Filter Design: An Introduction, McGraw-Hill, 1993.
5. D.A. Johns and K. Martin, Analog Integrated Circuit Design, John Wiley & Sons, Inc., New York, 1997.
6. P.E. Allan and D.R. Holberg, CMOS Analog Circuit Design, 2nd ed.,Oxford Press, 2002.
7. B. Razavi, Design of Analog CMOS Integrated Circuits, McGraw-Hill, 2001.
8. Clarke and Hess, Communication Circuits: Analysis and Design, Krieger, Reprint, 1994.
9. H.L. Krauss, C.W. Bostian, F.H. Raab, Solid State Radio Engineering, Wiley, 1980.

COURSE OVERVIEW

Week	Topic
1	Passive and Active Components at RF
2 - 3	Noise Theory
4 - 5	Design of Low-noise Amplifiers
6 - 7	Nonideality

8	Design of Active Mixers
9 - 10	Volterra Series
11	Voltage-controlled Oscillators (VCO) and Phase Noise
12 - 13	Design of Phase-locked Loop (PLL)

At certain points in the course, it may make good sense to modify the schedule. The instructor may modify elements of the course and will notify students accordingly (in class, on the course website).

ASSESSMENT
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Component	Weight	Note
Assignments	60%	Three assignments (LNA, Mixer, and VCO)
Term Project	40%	
Total	100%	

Late submissions of assignments or project reports are subject to a 20% penalty per day (less than one day is counted as one day).

ACADEMIC INTEGRITY

You are expected to exhibit honesty and use ethical behaviour in all aspects of the learning process. Academic credentials you earn are rooted in principles of honesty and academic integrity. It is your responsibility to understand what constitutes academic dishonesty. Academic dishonesty is to knowingly act or fail to act in a way that results or could result in unearned academic credit or advantage. This behaviour can result in serious consequences, e.g. the grade of zero on an assignment, loss of credit with a notation on the transcript (notation reads: "Grade of F assigned for academic dishonesty"), and/or suspension or expulsion from the university. For information on the various types of academic dishonesty please refer to the Academic Integrity Policy, located at https://secretariat.mcmaster.ca/university-policies-proceduresguidelines/
The following illustrates only three forms of academic dishonesty:
• plagiarism, e.g. the submission of work that is not one's own or for which other credit has been obtained.
• improper collaboration in group work.
• copying or using unauthorized aids in tests and examinations.

AUTHENTICITY / PLAGIARISM DETECTION

Some courses may use a web-based service (Turnitin.com) to reveal authenticity and ownership of student submitted work. For courses using such software, students will be

expected to submit their work electronically either directly to Turnitin.com or via an online learning platform (e.g. A2L, etc.) using plagiarism detection (a service supported by Turnitin.com) so it can be checked for academic dishonesty.

Students who do not wish their work to be submitted through the plagiarism detection software must inform the Instructor before the assignment is due. No penalty will be assigned to a student who does not submit work to the plagiarism detection software. All submitted work is subject to normal verification that standards of academic integrity have been upheld (e.g., on-line search, other software, etc.). For more details about McMaster's use of Turnitin.com please go to www.mcmaster.ca/academicintegrity.

COURSES WITH AN ON-LINE ELEMENT

Some courses may use on-line elements (e.g. e-mail, Avenue to Learn (A2L), LearnLink, web pages, capa, Moodle, ThinkingCap, etc.). Students should be aware that, when they access the electronic components of a course using these elements, private information such as first and last names, user names for the McMaster e-mail accounts, and program affiliation may become apparent to all other students in the same course. The available information is dependent on the technology used. Continuation in a course that uses on-line elements will be deemed consent to this disclosure. If you have any questions or concerns about such disclosure please discuss this with the course instructor.

Some courses may use online proctoring software for tests and exams. This software may require students to turn on their video camera, present identification, monitor and record their computer activities, and/or lock/restrict their browser or other applications/software during tests or exams. This software may be required to be installed before the test/exam begins.

COPYRIGHT AND RECORDING

Students are advised that lectures, demonstrations, performances, and any other course material provided by an instructor include copyright protected works. The Copyright Act and copyright law protect every original literary, dramatic, musical and artistic work, including lectures by University instructors.

The recording of lectures, tutorials, or other methods of instruction may occur during a course. Recording may be done by either the instructor for the purpose of authorized distribution, or by a student for the purpose of personal study. Students should be aware that their voice and/or image may be recorded by others during the class. Please speak with the instructor if this is a concern for you.

CONDUCT EXPECTATIONS

As a McMaster student, you have the right to experience, and the responsibility to demonstrate, respectful and dignified interactions within all of our living, learning and working communities. These expectations are described in the Code of Student Rights & Responsibilities (the "Code").

All students share the responsibility of maintaining a positive environment for the academic and personal growth of all McMaster community members, whether in person or online. It is essential that students be mindful of their interactions online, as the Code remains in effect in virtual learning environments. The Code applies to any interactions that adversely affect, disrupt, or interfere with reasonable participation in University activities. Student disruptions or behaviours that interfere with university functions on online platforms (e.g. use of Avenue 2 Learn, WebEx or Zoom for delivery), will be taken very seriously and will be investigated. Outcomes may include restriction or removal of the involved students' access to these platforms.

ACADEMIC ACCOMMODATIONS

Students with disabilities who require academic accommodation must contact Student Accessibility Services (SAS) at 905-525-9140 ext. 28652 or sas@mcmaster.ca to make arrangements with a Program Coordinator. For further information, consult McMaster University's Academic Accommodation of Students with Disabilities policy.

ACADEMIC ACCOMMODATION FOR RELIGIOUS, INDIGENOUS OR SPIRITUAL OBSERVANCES (RISO)

Students requiring academic accommodation based on religious, indigenous or spiritual observances should follow the procedures set out in the RISO policy. Students should submit their request to their Faculty Office **normally within 10 working days** of the beginning of term in which they anticipate a need for accommodation or to the Registrar's Office prior to their examinations. Students should also contact their instructors as soon as possible to make alternative arrangements for classes, assignments, and tests.

EXTREME CIRCUMSTANCES

The University reserves the right to change the dates and deadlines for any or all courses in extreme circumstances (e.g., severe weather, labour disruptions, etc.). Changes will be communicated through regular McMaster communication channels, such as McMaster Daily News, A2L and/or McMaster email.

RESEARCH ETHICS

The two principles underlying integrity in research in a university setting are these: a researcher must be honest in proposing, seeking support for, conducting, and reporting research; a researcher must respect the rights of others in these activities. Any departure from these principles will diminish the integrity of the research enterprise. This policy applies to all those conducting research at or under the aegis of McMaster University. It is incumbent upon all members of the university community to practice and to promote ethical behaviour. To see the

Policy on Research Ethics at McMaster University, please go to
http://www.mcmaster.ca/policy/faculty/Conduct/ResearchEthicsPolicy.pdf.

www.eng.mcmaster.ca/ece