

Course Outline

Winter 2024

ECE474 Radio and Wireless Systems

ECE 770-Topic 22: Special Topics in Antenna and Microwave Theory: Radio and Wireless Systems

Instructor

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Teaching Assistant: TBD,

COURSE DESCRIPTION: Designers of building blocks often ignore the motivation behind the various specifications they are given and their connections with the overall system performance once integrated in a radio communication systems. This translates often in a lack of global optimization, which sacrifices the best performance that could have been achieved. As radio and wireless systems are posing increasingly stringent specifications, integration of component-level building blocks to system-level design process is essential and circuit design and radio system engineering will merge. Therefore, it is crucial to train future designers with system-level knowledge.

This course covers a wide range of radio and wireless systems aspects including communication signals and the underlying modulation and multiple access techniques, tradeoffs among different transceiver (transmitter/receiver) architectures (conventional and modern), antennas and radio waves propagation, and design considerations of RF/microwave building blocks, radio and wireless systems. In particular, it links circuits design specifications and system requirements defined in wireless standards.

The course will include:

- Introduction to Modulation and Multiple Access Techniques (2 Weeks)
- System level Key Characteristics and Parameters in Radio and Wireless Systems (3 Weeks)
 - o Receiver: Noise, Sensitivity, Dynamic Range, Blocking, Spurious products.
 - o Transmitter: Linearity (IMD, ACPR, EVM), Efficiency.
 - o Noise/Linearity Budget for Radio & Wireless Systems
- Key Building Blocks (3 Weeks)
 - o Low Noise Amplifiers,
 - o Mixers & Modulators (IQ)
 - o Oscillators
 - o Power Amplifiers
- RF Radio Transceivers Architectures (2 Weeks)
 - o Transmitter Architectures
 - o Receivers Architectures
- Antenna Fundamentals (1 Week)
 - o Basic Antenna Operation
 - o Antenna Types and Specifications
- Antenna Systems (1 Week)
 - o Antenna Arrays
 - o Phased Arrays & Beam forming.
- Special Topics on Radio & Wireless Systems (1 Week)

Objectives: After successful completion of the course work, students are expected to be able to analyze and design radio and wireless systems. This course will equip students with the basics in modern radio and wireless systems design by

- learning the overall picture of conventional and modern radio and wireless systems
- understanding the tradeoffs between different transceiver architectures in relation to a given communication standard
- evaluating the impact of different impairments in radio and wireless systems on performance, including interference, different noise sources and nonlinearity
- learning how to use computer aided design tools to assess the system level performances of radio transceivers and links.
- distinguishing and analyzing the propagation issues on several radio and wireless systems.

PREREQUISITES:

- ECE 375, MATH 212 or equivalent, or permission of the instructor;
- Level at least 4A Computer Engineering or Electrical Engineering.

DESIGN PROJECT/LAB: To let students have a chance to practice and understand the subjects learned in the course, several design and simulation cases of wireless link aspects using SystemVue CAD tool from Keysight Technologies are assigned as the course project. The students will have also chance to experience the theory covered in the course and to validate the project simulations in a laboratory where they will have access to state of art equipment.

USE OF CALCULATORS IN EXAMINATIONS

Programmable and/or scientific calculators without formulae storage and /or text display features may be used during examinations. Personnel computers may not be used in examinations.

GRADING BASIS

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|-------------------|-----|
| Lab/Project | 20% |
| Mid-term | 30% |
| Final Examination | 50% |

TEXTBOOK

Required Textbook:

- Instructor's Course Notes

Recommended books:

- B. Razavi, RF Microelectronics, Prentice Hall, 1998.
- Kai Chang, RF and Microwave Wireless Systems, Wiley, 2000.
- John S. Seybold, Introduction to RF Propagation, Wiley, 2005.
- Louis E. Frenzel Jr., Principles of Electronic Communication Systems, 3rd Edition, McGraw Hill, 2008.
- Michael Steer, Microwave and RF Design – A System Approach, SciTech, 2010.
- D. M. Pozar, Microwave and RF Wireless Systems, Wiley, 2001.

Academic Integrity: To maintain a culture of academic integrity, members of the University of Waterloo community are expected to promote honesty, trust, fairness, respect and responsibility. [Check www.uwaterloo.ca/academicintegrity/ for more information.]

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, and 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.