ELEC ENG 4FJ4

Devices and Antennas for Wireless Systems

COURSE OUTLINE

Please refer to course website for updated information.

CALENDAR/COURSE DESCRIPTION

Fundamentals of the technology of wireless communications. transmission lines and waveguides, scattering parameters, impedance matching, power dividers, directional couplers, microwave resonators and filters, low-noise amplifiers, antenna fundamentals, microwave and antenna measurements.

PRE-REQUISITES AND ANTI-REQUISITES

Prerequisite(s): Registration in level III or greater in any Computer or Electrical Engineering Program; electrical stream – ELEC ENG 3FK4; biomedical and computer engineering streams – ELEC ENG 2FL3
Antirequisite(s): None

SCHEDULE AND MODE OF DELIVERY

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

Lectures: Tuesday, Thursday and Friday from 11:30 am to 12:20 pm, on WebEx. Lecture time slots are likely to change during the 1st week of the term to avoid conflicts with other courses for all students enrolled in ElecEng 4FJ4.. After the 1st week, the lecture times will be set to a weekly schedule, which will not change until the end of the term, unless special announcement is made.
Tutorial: Thursday 1:30 pm – 2:20 pm, on WebEx. Tutorial time slots are likely to change during the 1st week of the term to avoid conflicts with other courses for all students enrolled in ElecEng 4FJ4.. After the 1st week, the tutorial times will be set to a weekly schedule, which will not change until the end of the term, unless special announcement is made.
Labs: Five labs in total (rm. ITB-155)

- Room is assigned but will not be used in accordance with current University Policies.
- Labs will be carried out at home from November 16 to December 9, 2020. Earlier and later dates are also allowed upon request.
- Equipment and lab kits will be handed out by TAs to students in accordance with a schedule. Students will have 5 days to complete the labs and return the kits and the equipment to the TAs. Extensions are possible upon request.
- TAs will be available online (WebEx) to supervise and help with the lab exercises.

- Failure to perform the labs in the Fall term of 2020 will lead to a mark of 0 for this course component. However, the labs can be completed after the end of the term (for example, during the Winter term) and the course grade will be properly corrected on Mosaic.

INSTRUCTOR

Dr. Natalia K. Nikolova
Email: talia@mcmaster.ca
Office: ITB-A308
Phone: 905-525-9140 Ext. 27141

Office Hours (delivered online):
Tuesday 2:30 pm to 4:00 pm
Thursday 2:30 pm to 4:00 pm
or by appointment

Please note that during the university closures due to Covid-19 in the Fall Term, instructors will not be in their offices. Please see the course website for clarification on their availability.

TEACHING ASSISTANTS

Contact information and Office Hours are provided on the A2L course website.

- Daniel Tajik
- Vartika Tyagi

COURSE WEBSITE

http://avenue.mcmaster.ca/

COURSE OBJECTIVES

By the end of this course, students should be able to:

- understand the operation principles and the system architecture of the radio receiving and radio transmitting equipment (Indicator 1.4);
- perform analysis and design of simple passive radio-frequency (RF) and microwave circuits using the Smith Chart (Indicator 1.4);
- perform microwave circuit analysis in terms of scattering parameters using signal flow graphs (Indicator 1.4);
- use basic microwave test instrumentation (signal generators, oscilloscopes, spectrum analyzers and vector network analyzers) to measure single-port and multi-port microwave devices and antennas (Indicators 1.4, 4.2);
- use professional design software for microwave circuit analysis and design (Indicators 1.4, 4.2);
- use professional design software for antenna design (Indicators 1.4, 4.2);
- fabricate and test simple circuit and antenna prototypes using microstrip technology (Indicators 1.4, 4.2, 13.3);

- understand fabrication tolerances and their impact on the circuit performance (Indicators 1.4, 4.2, 13.3);
- generate technical documentation and propose further improvements on existing wireless technology solutions (Indicators 1.4, 4.2, 13.3).

ASSUMED KNOWLEDGE

- Maxwell's Equations, Wave Equation
- Fundamentals of Transmission Line Theory

COURSE MATERIALS

Required Texts:

- lecture notes posted on course webpage
- laboratory workbooks posted on course webpage
- Michael Steer, "Fundamentals of Microwave and RF Design," 3rd ed., 2019, University of North Carolina Press; freely available at https://repository.lib.ncsu.edu/handle/1840.20/36776

Calculator:

Only the McMaster Standard Calculator (Casio fx-991 MS or MS Plus) will be permitted in tests and examinations. This is available at the Campus Store.

Other Materials:

OPTIONAL TEXTS (copies available in THODE):
D.M. Pozar, "Microwave Engineering," 3rd or 4th ed., Wiley, 2012.
M. Steer, "Microwave and RF Design," SciTech, 2010.

COURSE OVERVIEW

Date/Week	Topic	Readings
Week 1	Radio Systems: An Overview Tech. Brief: WiFi and Bluetooth RF Systems	lecture notes and courseware
Week 2	Maxwell's Equations in Phasor Form; Complex Constitutive Parameters; Microwave Power and Energy Tech. Brief: Complex Permittivity of Human Tissue	same
Week 3	Principle of Radiation; Polarization Tech Brief: Microwave Filed Interaction with the Human Body	
Week 4	TEM and Quasi-TEM Transmission Lines, *PUL* Parameters, Voltage & Current Waves Tech. Brief: Microstrip Technology	same

Week 5	Terminated Transmission Lines; The Smith Chart and Basic Impedance-Matching Methods Tech. Brief: Baluns	same
Week 6	Scattering Parameters and Signal Flow Graphs Tech. Brief: The Vector Network Analyzer	same
Week 7	1-port and 2-port Passive High-frequency Components: Capacitors, Inductors, Terminations, Attenuators Tech. Brief: Microwave Filters	same
Week 8	3-port and 4-port Passives: Power Dividers, Directional Couplers and Hybrids Tech. Brief: Circulators	same
Week 9	Microwave Waveguides Tech. Brief: Waveguide Couplers	same
Week 10	Active High-frequency Components: Schottky, PIN and Gunn Diodes; High-frequency Transistors Tech. Brief: Low-noise Amplifiers	same
Week 11	The Dipole Antenna; Antenna Characteristics Tech. Brief: Anechoic Chambers	same
Week 12	Propagation Models: Friis Equation; System Noise; Receiver Sensitivity Tech. Brief: Link Budget and Link Margin	same
Week 13	Printed Antennas; Cell-phone, Bluetooth and WiFi Antennas Tech. Brief: Antenna Arrays	same

A more detailed time line is available on the course web site.

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).

LABORATORY OVERVIEW

Modules	Topic	Readings
1	Introduction to Scattering Parameters and Vector Network Analyzers (VNAs): 1-Port Calibration, Instrument Noise Floor, and Measurements of 1-Port Devices	Lab Workbook
2	VNA 2-Port Calibration, Instrument Noise Floor, and Measurements of 2-port Devices	Lab Workbook
3	VNA Measurements of Multi-port Passive Devices	Lab Workbook
4	Antenna Measurements with a VNA	Lab Workbook
5	Wireless Link: Effects of distance, antenna gain, polarization mismatch and presence of obstacle on signal strength and signal-to-noise ratio	Lab Workbook

LABORATORY OPERATION

Each student in the course is required to pass the lab safety quiz prior to attempting any of the laboratories. The video and quiz will be on Avenue to Learn.

ASSESSMENT

Component	Weight
Practice Work (Design Project)	10%
Assignments	20%
Laboratory	15%
Quizzes	10%
Midterm Exam	15%
Final Exam	30%
Total	100%

BONUS Components:

- PRACTICE WORK (3% toward final course grade)
- ASSIGNMENT 3 BONUS (Mixer Design) (3% toward final course grade)
- HI-SCI BONUS (3 theoretical problem sets) (5% toward final course grade)

NOTE: Quizzes, midterm test and final exam will be carried out online.

Grading Policies

- If all three marks for the final exam, the midterm test and the quizzes are below 50%, the overall course grade is fail (F).
- Deferred exams may be oral.
- All grades are final unless error in marking is proven.
- Marking scheme is flexible only if the final-exam mark ≥ 89 %.
- Late submissions of assignments are subject to 50% penalty per day (less than one day is counted as one day)
- No make-up midterm tests will be granted.
- Weight of missed midterm test will be transferred to final exam provided MSAF is filed.

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.

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.

REQUESTS FOR RELIEF FOR MISSED ACADEMIC WORK

McMaster Student Absence Form (MSAF): In the event of an absence for medical or other reasons, students should review and follow the Academic Regulation in the Undergraduate Calendar "Requests for Relief for Missed Academic Term Work".

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.

ACCREDITATION LEARNING OUTCOMES

Note: The *Learning Outcomes* defined in this section are measured throughout the course and form part of the Department's continuous improvement process. They are a key component of the accreditation process for the program and will not be taken into consideration in determining a student's actual grade in the course. For more information on accreditation, please ask your instructor or visit: http://www.engineerscanada.ca .

Outcomes	Indicators	Measurement Method(s)
Ability to perform analysis and design of simple radio-frequency (RF) and microwave circuits using the Smith Chart.	1.4	Midterm (Q on Smith Chart) Final Exam (Q on Smith Chart)
Ability to perform microwave circuit analysis in terms of scattering parameters using signal flow graphs.	1.4	Final Exam (Q on SFG)
Ability to use basic microwave test instrumentation (signal generators, oscilloscopes, spectrum analyzers and vector network analyzers) to measure single-port and multi-port microwave devices.	1.4 4.2	Laboratory Exercises
Basic skills in using professional design software for microwave circuit analysis and design.	1.4 4.2	Assignments AND Practice Work (Design Project)
Ability to fabricate simple circuit prototypes using microstrip technology and to test them.	1.4 4.2	Practice Work (Design Project)
Basic understanding of fabrication tolerances and their impact on the circuit performance.	1.4 4.2	Practice Work (Design Project) AND All Laboratories
Ability to generate technical documentation and to propose further improvements on existing solutions.	1.4 4.2	Practice Work (Design Project) AND All Laboratories AND All Assignments

Electrical and Computer Engineering Lab Safety

Information for Laboratory Safety and Important Contacts

This document provides important information for the healthy and safe operation of ECE instructional laboratories. This document is required reading for all laboratory supervisors, instructors, researchers, staff, and students working in or managing instructional laboratories in ECE. It is expected that revisions and updates to this document will be done continually. A McMaster University lab manual is also available to read in every laboratory and online https://hr.mcmaster.ca/app/uploads/2019/07/2019-McMaster-Lab-Manual.pdf

General Health and Safety Principles

Good laboratory practice requires that every laboratory worker and supervisor observe the following whether conducting lab work at school or at home:

1. Food and beverages are not permitted in the instructional laboratories.
2. A Laboratory Information Sheet on each lab door identifying potential hazards and emergency contact names should be known.
3. Laboratory equipment should only be used for its designed purpose.
4. Proper and safe use of lab equipment should be known before using it.
5. The course TA leading the lab should be informed of any unsafe condition.
6. The location and correct use of all available safety equipment should be known.
7. Potential hazards and appropriate safety precautions should be determined, and sufficiency of existing safety equipment should be confirmed before beginning new operations.
8. Proper waste disposal procedures should be followed.
9. Personal ergonomics should be practiced when conducting lab work. https://bit.ly/3fOE71E
10. Current University health and safety issues, and protocol should be known. https://hr.mcmaster.ca/resources/covid19/workplace-health-and-safety-guidance-during-covid-19/

Location of Safety Equipment

Fire Extinguisher
On walls in halls outside of labs

Telephone
On the wall of every lab near the door

First Aid Kit
ITB A111, or dial “88” after 4:30 p.m.

Fire Alarm Pulls
Near all building exit doors on all floors

Who to Contact

Emergency Medical / Security: On McMaster University campus, call Security at extension **88** or **905-522-4135** from a cell phone.
Non-Emergency Accident or Incident: Immediately inform the TA on duty or Course Instructor.
University Security (Enquiries / Non-Emergency): Dial 24281 on a McMaster phone or dial 905-525-9140 ext. 24281 from a cell phone.
See TA or Instructor: For problems with heat, ventilation, fire extinguishers, or immediate repairs
Environmental & Occupational Health Support Services (EOHSS): For health and safety questions dial 24352 on a McMaster phone or dial 905-525-9140 ext. 24352 from a cell phone.
ECE Specific Instructional Laboratory Concerns: For non-emergency questions specific to the ECE laboratories, please contact 24103.

In Case of a Fire (On Campus Dial 88)

When calling to report a fire, give name, exact location, and building.

1. Immediately vacate the building via the nearest Exit Route. Do not use elevators!
2. Everyone is responsible for knowing the location of the nearest fire extinguisher, the fire alarm, and the nearest fire escape.
3. The safety of all people in the vicinity of a fire is of foremost importance. But do not endanger yourself!
4. In the event of a fire in your work area shout "*Fire!*" and pull the nearest fire alarm.
5. Do not attempt to extinguish a fire unless you are confident it can be done in a prompt and safe manner utilizing a hand-held fire extinguisher. Use the appropriate fire extinguisher for the specific type of fire. Most labs are equipped with Class A, B, and C extinguishers. Do not attempt to extinguish Class D fires which involve combustible metals such as magnesium, titanium, sodium, potassium, zirconium, lithium, and any other finely divided metals which are oxidizable. Use a fire sand bucket for Class D fires.
6. Do not attempt to fight a major fire on your own.
7. If possible, make sure the room is evacuated; close but do not lock the door and safely exit the building.

Clothing on Fire

Do not use a fire extinguisher on people

1. Douse with water from safety shower immediately or
2. Roll on floor and scream for help or
3. Wrap with fire blanket to smother flame (a coat or other nonflammable fiber may be used if blanket is unavailable). Do not wrap a standing person; rather, lay the victim down to extinguish the fire. The blanket should be removed once the fire is out to disperse the heat.

Equipment Failure or Hazard

Failure of equipment may be indicative of a safety hazard - You must report all incidents.

Should you observe excessive heat, excessive noise, damage, and/or abnormal behaviour of the lab equipment:

1. Immediately discontinue use of the equipment.
2. In power labs, press wall-mounted emergency shut-off button.
3. Inform your TA of the problem.
4. Wait for further instructions from your TA.
5. TA must file an incident report.

Protocol For Safe Laboratory Practice

Leave equipment in a safe state for the next person - if you're not sure, ask!

In general, leave equipment in a safe state when you finish with it. When in doubt, consult the course TA.

Defined Roles

TA	The first point of contact for lab supervision	
ECE Lab Supervisor	Steve Spencer- ITB 147	steve@mail.ece.mcmaster.ca
ECE Chair	Tim Davidson- ITB A111	davidson@mcmaster.ca
ECE Administrator	Kerri Hastings- ITB A111	hastings@mcmaster.ca
ECE Course Instructor	Please contact your specific course instructor directly	