

ELEC ENG 4FJ4
Devices and Antennas for Wireless Systems

COURSE OUTLINE

Please refer to course website for updated information.

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

Lectures: Monday 9:30 am to 10:20 am, Tuesday 10:30 am to 11:20 am, Thursday 9:30 am – 10:20 am (ETB-230)

Tutorial: Thursday 11:30 am – 12:20 pm (TSH-B126)

Labs: One lab every two weeks (ITB-155)

Sections: L01 Mon 2:30 pm – 5:30 pm (Sep. 9, Sep. 23, Oct. 7, Oct. 28, Nov. 11, Nov. 25)
L02 Mon 2:30 pm – 5:30 pm (Sep. 16, Sep. 30, Oct. 21, Nov. 4, Nov. 18, Dec. 2)
L03 Tue 2:30 pm – 5:30 pm (Sep. 10, Sep. 24, Oct. 8, Oct. 29, Nov. 12, Nov. 26)
L04 Tue 2:30 pm – 5:30 pm (Sep. 17, Oct. 1, Oct. 22, Nov. 5, Nov. 19, Dec. 3)
L05 Wed 2:30 pm – 5:30 pm (Sep. 11, Sep. 25, Oct. 9, Oct. 30, Nov. 13, Nov. 27)
L06 Wed 2:30 pm – 5:30 pm (Sep. 18, Oct. 2, Oct. 23, Nov. 6, Nov. 20, Dec. 4)
L07 Thu 2:30 pm – 5:30 pm (Sep. 12, Sep. 26, Oct. 10, Oct. 31, Nov. 14, Nov. 28)
L08 Thu 2:30 pm – 5:30 pm (Sep. 19, Oct. 3, Oct. 24, Nov. 7, Nov. 21, Nov. 29)
Make-up labs: every Friday 2:30 pm – 5:30 pm, Dec. 5, Dec. 6

INSTRUCTOR

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

Office Hours:
Tuesday 2:30 pm to 4:00 pm
Wednesday 2:30 pm to 4:00 pm
or by appointment

TEACHING ASSISTANTS

Contact information and Office Hours are provided on the Avenue To Learn course website.

- Alex Beaverstone
- Vartika Tyagi
- Imaan Ali-Mohammad

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 and in ITB-155):
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 Field Interaction with the Human Body	
Week 4	TEM and Quasi-TEM Transmission Lines, <i>PUL</i> 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	The Gunn Oscillator	Lab Workbook
2	PIN Diodes	Lab Workbook
3	Microwave Detection with a Crystal Detector	Lab Workbook
4	Introduction to Scattering Parameters and Vector Network Analyzers: Measurements of 1-Port Devices and Antennas	Lab Workbook
5	Measurement of the Scattering Parameters of Multi-port Devices	Lab Workbook
6	Antenna pattern and impedance match	Lab Workbook

LABORATORY OPERATION

- At the beginning of every term, every undergraduate student using an ECE Lab is required to complete the ECE Lab Safety Quiz (one completed quiz covers every course that term). The quiz and other information is provided on the webpage: <https://www.eng.mcmaster.ca/ece/resources#health-safety>
- Access to all labs is restricted in the interest of security and safety. Information on accessing and using the lab can be found on the webpage: <https://www.eng.mcmaster.ca/ece/labs-and-health-safety#Labs-Access-and-Use>
- Please obtain your own Access Card for use during regular building hours / The TA will open the lab at regularly scheduled lab times
- The labs for this course will be held in ITB-155.
- The student is expected to download the lab workbook for the respective lab session from the A2L course webpage and to bring along a printout to the lab.
- The Lab Report consists of simply filling in the required information in the printout of the lab workbook.
- There are REVIEW QUESTIONS at the end of each of the exercises. The student must provide answers to these questions, which are closely related to the DISCUSSION and the PROCEDURE parts of the exercises.
- The student is expected to hand in the lab report to the teaching assistant (TA) at the end of the lab session. Take home work should not be necessary.
- Laboratories are mandatory. Overall lab mark below 50% means failure of the course.

Grading the Lab Report:

- Total points: 100
- Penalty for a missing item in the PROCEDURE part: -5 points
- Penalty for a missing plot or table in the PROCEDURE part: -10 points
- Penalty for a missing or wrong answer in the REVIEW QUESTIONS part: -10 points

ASSESSMENT

Component	Weight
Practice Work (Design Project)	5%
Assignments	15%
Laboratory	15%
Midterm Exam	20%
Final Exam	45%
Total	100%

BONUS PRACTICE WORK (3% toward final course grade)

BONUS ASSIGNMENT (Mixer Design) (3% toward final course grade)

HI-SCI BONUS (3 theoretical problem sets) (5% toward final course grade)

Grading Policies

- failure on both the final and the midterm exams means failure of the course
- deferred exams may be oral
- all grades final unless error in marking proven
- marking scheme flexible only if final-exam grade $\geq 89\%$
- 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

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

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.

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.

It is your responsibility to understand what constitutes academic dishonesty. For information on the various types of academic dishonesty please refer to the Academic Integrity Policy, located at <http://www.mcmaster.ca/academicintegrity>

The following are only three samples of the various forms of academic dishonesty:

1. Plagiarism, e.g. the submission of work that is not one's own or for which other credit has been obtained.
2. Improper collaboration in group work.
3. Copying or using unauthorized aids in tests and examinations.

ACADEMIC ACCOMMODATIONS

Students with disabilities who require academic accommodation must contact Student Accessibility Services (SAS) to make arrangements with a Program Coordinator. Student Accessibility Services can be contacted by phone 905-525-9140 ext. 28652 or e-mail sas@mcmaster.ca. 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 requiring a RISO accommodation should submit their request to the Engineering Student Services office normally within 10 working days of the beginning of term in which they anticipate a need for accommodation or to the Registrars Office prior to their examinations.

Students should also contact their instructors as soon as possible to make alternative arrangements for classes, assignments, and tests.

STUDENT ABSENCE AND SUBMISSION OF REQUEST FOR RELIEF FOR MISSED ACADEMIC WORK

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":
<http://www.mcmaster.ca/msaf/>

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.

ONLINE ACCESS OR WORK

In this course, we will be using **Avenue to Learn**. Students should be aware that, when they access the electronic components of this course, private information such as first and/or 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. **The Instructor will take every precaution to prevent disclosure of such private information through posted material on the Avenue to Learn course webpage. The Instructor, however, cannot guarantee that such disclosure will not occur as he/she has no control over the overall website administration.** Continuation in this course will be deemed consent to this disclosure. If you have any questions or concerns about such disclosure, please discuss this with the course instructor.

www.eng.mcmaster.ca/ece

Electrical and Computer Engineering Lab Safety

Information for Laboratory Safety and Important Contacts

This document is for users of ECE instructional laboratories in the Information Technology Building.

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.

General Health and Safety Principles

Good laboratory practice requires that every laboratory worker and supervisor observe the following:

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.

Location of Safety Equipment

Fire Extinguisher

On walls in halls outside of labs

First Aid Kit

ITB A111, or dial "88" after 4:30 p.m.

Telephone

On the wall of every lab near the door

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

In Case of a Fire (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 Lab, 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	