ELEC ENG 2CF3
Circuits and Waves

COURSE OUTLINE
Please refer to course website for updated information.

COURSE DESCRIPTION
Advanced circuit analysis; sinusoids and complex numbers; Laplace transforms with applications; frequency response; 2-port networks; fundamentals of wave propagation; transmission lines and impedance match; radiation and antennas.
Three lectures, one tutorial; second term

PRE-REQUISITES AND ANTI-REQUISITES
Pre-requisite(s): ELECENG 2CI5 and PHYSICS 1E03
Anti-requisite(s): ELECENG 2FH3 or ELECENG 2FH4

SCHEDULE and MODE OF DELIVERY
The material for this course will be delivered through a mixture of in-person lectures and tutorials (also broadcasted live and recorded via Echo360) along with virtualized experiments in the form of Assignments. As a back-up in the case of campus closures, MS Teams meetings will be scheduled for on-line lectures and tutorials. These are also recorded.
Lectures: Monday and Wednesday from 11:30 am to 12:20 pm in CNH-103, Friday from 1:30 pm to 2:20 pm, in CNH-103.
Tutorial: Thursday 12:30 pm – 1:20 pm, in BSB-B136.
This course does not have a lab component.

INSTRUCTOR
Dr. Natalia K. Nikolova
E-mail: tali@mcmaster.ca
Office: ITB-A308
Phone: 905-525-9140 ext. 27141
Office Hours: In person or through MS Teams call:
    Thursday from 1:30 pm to 2:30 pm
    Friday from 2:30 pm to 3:30 pm
The A2L course webpage will announce any changes that may occur in the Office Hours.

**TEACHING ASSISTANTS**

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

- Nooshin Valizade Shahmirzadi, valizadn@mcmaster.ca
- Mihail Georgiev, georgims@mcmaster.ca
- Sepideh Hassani, hassas52@mcmaster.ca

**COURSE WEBSITE/S**

http://avenue.mcmaster.ca

**COURSE OBJECTIVES**

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

- understand the operation principles of circuits employing operational amplifiers and resistor networks;
- perform variable-frequency circuit analysis in terms of: (i) frequency-dependent responses, (ii) network transfer functions, (iii) Bode diagrams;
- understand the purpose and the design principles of lumped-element filters, including aliasing and anti-aliasing filters as well as the basics of active filters;
- understand the Laplace transform and its applications in transient circuit analysis;
- represent two-port networks in terms of their Z, Y, and H parameters and use this representation in complex network analysis;
- understand the fundamentals of wave motion and the basic parameters of voltage and current waves;
- carry out analysis of transmission lines as distributed-parameter networks and understand their operation in both pulsed and sinusoidal regimes;
- understand the concepts of maximum power transfer and impedance match as well as the parameters describing the performance of connectors, interconnects, and high-speed buses on printed circuit boards (PCBs);
- understand the basic parameters and uses of antennas in the context of wireless communications

**ASSUMED KNOWLEDGE**

Good knowledge of course material from:
• ElecEng 2CI5: nodal and mesh analyses, time response of first-order RC and RL circuits, analysis of RLC circuits using phasors;

• Physics 1E03: electrical charge, current and voltage; resistance, capacitance and inductance, Coulomb’s law, Gauss law, Ampère and Biot-Savart Laws, electric and magnetic forces and field vectors, permittivity and permeability, one-dimensional wave motion.

• Math 1ZA3, 1ZB3, 1ZC3 and 2Z03

### COURSE MATERIALS

**Required Texts:**
- lecture slides and example solutions posted on course webpage
- tutorial notes posted on course webpage
- assignment instructions posted on course webpage

**Optional Texts:**

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

**Other:**
- Software tool for circuit analysis and design: *LTspice XVII*
- Instructions for download and installation are available on the A2L course website.

### COURSE OVERVIEW

<table>
<thead>
<tr>
<th>Week</th>
<th>Topic</th>
<th>Readings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Week 1</td>
<td>Lectures: Operational amplifiers&lt;br&gt;Tutorial: Review of mesh and nodal analyses</td>
<td>lecture and tutorial notes</td>
</tr>
<tr>
<td>Week 2,3</td>
<td>Lectures: (i) Frequency-dependent response, (i) Network transfer function, (iii) Bode diagram&lt;br&gt;Tutorial: Review of Thevenin and Norton equivalents</td>
<td>same</td>
</tr>
<tr>
<td>Week 4</td>
<td>Lectures: Filters, anti-aliasing filters; active filters&lt;br&gt;Tutorial: Operational amplifiers</td>
<td>same</td>
</tr>
<tr>
<td>Week 5</td>
<td>Lectures: Laplace transform with applications in transient circuit analysis</td>
<td>same</td>
</tr>
</tbody>
</table>
Tutorial: Review of phasor analysis, phasor diagrams and complex numbers, steady-state power analysis

Week 6
Lectures: Two-port network parameters: Z, Y, H
Tutorial: Frequency-dependent network analysis

Week 7
Lectures: (i) fundamentals of wave motion, (ii) traveling waves and phasors, (iii) working with complex numbers
Tutorial: Filters

Week 8
Lectures: Transmission lines – lumped-element model, telegrapher’s equations, propagation constant and characteristic impedance, voltage and current traveling waves
Tutorial: Laplace transform and transient circuit analysis

Week 9
Lectures: Transmission lines – per-unit-length parameters, the effect of losses, power flow
Tutorial: Two-port network parameters

Week 10
Lectures: Reflection and transmission in terminated transmission lines; transients on transmission lines
Tutorial: Traveling waves, wave analysis with phasors

Week 11
Lectures: Impedance match and power transfer
Tutorial: Voltage and current traveling waves in transmission lines

Week 12
Lectures: Electric scalar potential and magnetic vector potential in statics and electrodynamics
Tutorial: Transmission-line parameters - propagation constant and characteristic impedance, per-unit-length parameters

Week 13
Lectures: Principle of radiation, Hertzian dipole, electromagnetic waves in free space and their power density; polarization of electromagnetic waves
Tutorial: Reflection and transmission in transmission lines

A more detailed time line is available on the course website.

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

This course does not have labs.

LABORATORY OPERATION

Not applicable.

ASSESSMENT

<table>
<thead>
<tr>
<th>Component</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quizzes</td>
<td>10%</td>
</tr>
</tbody>
</table>
Assignments  20%
Midterm Exam  30%
Final Exam  40%
Total  100%

NOTES: Quizzes will be announced during lectures and A2L announcements, and must be completed by the end of the day. Quiz answers are submitted through Dropboxes on A2L.

Grading and Evaluation Policies
• If the marks of the final exam, the midterm test and the quizzes are all 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. If MSAF is not filed, the assigned mark is 0.

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.

Indicators measured in this course:

- Indicator 1.2: Competence in Natural Sciences
- Indicator 1.3: Competence in Engineering Fundamentals
- Indicator 2.1: Ability to Identify Reasonable Assumptions (Including Identification of Uncertainties and Imprecise Information) That Could or Should be Made Before a Solution Path is Proposed
- Indicator 3.2: Capable of selecting appropriate model and methods and identify assumptions and constraints
- Indicator 8.1: Demonstrates an understanding of the role of the engineer in society, especially in protection of the public and public interest
- Indicator 11.3: Understands the business processes for implementing engineering ideas

<table>
<thead>
<tr>
<th>Outcomes</th>
<th>Indicators</th>
<th>Measurement Methods(s)</th>
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</thead>
<tbody>
<tr>
<td>Understands wave phenomena and their mathematical models</td>
<td>1.2</td>
<td>Assignment on Waves</td>
</tr>
<tr>
<td>Demonstrate ability to analyze circuits employing operational amplifiers</td>
<td>1.3</td>
<td>Assignment on Operational Amplifiers</td>
</tr>
<tr>
<td>Demonstrate ability to perform frequency-dependent network analysis</td>
<td>1.3</td>
<td>Midterm and Final Exam</td>
</tr>
<tr>
<td>Demonstrate ability to perform time-dependent network analysis</td>
<td>1.3</td>
<td>Midterm and Final Exam</td>
</tr>
<tr>
<td>Demonstrate ability to perform frequency- and time-dependent transmission-line analysis</td>
<td>1.3</td>
<td>Assignment on Transmission Lines</td>
</tr>
<tr>
<td>Understanding of approximations in the analysis of op-amp circuits (finite gain, input/output resistances)</td>
<td>2.1</td>
<td>Assignment on Operational Amplifiers</td>
</tr>
<tr>
<td>Understanding of approximations in the analysis of transmission lines (losses and dispersion)</td>
<td>2.1</td>
<td>Assignment on Transmission Lines</td>
</tr>
<tr>
<td>Ability to select between time-domain and frequency-domain models to characterize the performance of transmission lines</td>
<td>3.2</td>
<td>Assignment on Transmission Lines</td>
</tr>
<tr>
<td>Ability to identify the best and the worst conditions in wireless links</td>
<td>3.2</td>
<td>Final Exam</td>
</tr>
<tr>
<td>Knowledge of Canadian regulations safeguarding the public health and safety against excessive electromagnetic emissions</td>
<td>8.1</td>
<td>Assignment on Industry Canada Safety Code 6</td>
</tr>
<tr>
<td>Knowledge of the regulation of the frequency spectrum usage and the associated limitations on the development of new wireless products and services</td>
<td>11.3</td>
<td>Assignment on Frequency Spectrum</td>
</tr>
</tbody>
</table>

www.eng.mcmaster.ca/ece
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.

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
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.

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

Defined Roles
<table>
<thead>
<tr>
<th>Role</th>
<th>Contact Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>TA</td>
<td>The first point of contact for lab supervision</td>
</tr>
<tr>
<td>ECE Lab Supervisor</td>
<td>Steve Spencer- ITB 147</td>
</tr>
<tr>
<td>ECE Chair</td>
<td>Tim Davidson- ITB A111</td>
</tr>
<tr>
<td>ECE Administrator</td>
<td>Kerri Hastings- ITB A111</td>
</tr>
<tr>
<td>ECE Course Instructor</td>
<td>Please contact your specific course instructor directly</td>
</tr>
</tbody>
</table>