

**ELEC ENG 4PK4**  
**Power Electronics**

**COURSE OUTLINE**

Please refer to course website for updated information.

**COURSE DESCRIPTION**

To analyze, model, and predict the performance of basic power converter configurations. To explain topologies of power electronics, AC/DC, DC/DC, DC/AC and AC/AC. To design proper switching circuits.

**PRE-REQUISITES AND ANTI-REQUISITES**

Prerequisite(s): Registration in any Computer Engineering or Electrical Engineering Program, ELECENG 2CJ4, ELECENG 3EJ4

**SCHEDULE AND MODE OF DELIVERY**

The material for this course will be delivered through a mixture of online videos, textbook readings, live Q&A sessions during lecture time slots, and simulation-based laboratories. All of the usual in-class material will be made available online as pre-recorded videos. Students must watch the videos before attending the lecture sessions. In the online lecture sessions, we will have a live question & answer period related to the current material or any previous class material. The platform for each component is noted at the end of each line.

**Lectures:** Monday 1:30pm-2:20pm, Wednesday 12:30pm-2:20pm (on Microsoft Teams)

**Tutorial:** Monday 11:30am-12:20pm (on Microsoft Teams)

**Labs:** There are 5 simulation-based labs in this class, which run for two weeks each. All students will submit their completed lab report by 5:30pm on the Friday of the second week of the lab. Students can work on labs at their own pace. A TA will be available online on Microsoft Teams Mon-Fri from 2:30pm to 5:30pm to answer questions regarding the lab. Students may choose to attend any online lab help session, but should be advised that starting the lab and joining a help session sooner in the 2-week lab period will ensure TA help is available, whereas asking for help near the end of the 2-week lab period may restrict the time the TA can help you if the student volume is high at this time.

**INSTRUCTOR**

**Dr. Jennifer Bauman**  
Office: ITB-A217  
Email: [jennifer.bauman@mcmaster.ca](mailto:jennifer.bauman@mcmaster.ca)

**Office Hours:**  
Email for an 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

<b>Ahsanul Rafi</b> <a href="mailto:rafim1@mcmaster.ca">rafim1@mcmaster.ca</a> Office hours: email for appointment	<b>Henry Zheng</b> <a href="mailto:zhengp4@mcmaster.ca">zhengp4@mcmaster.ca</a> Office hours: email for appointment	<b>Nishant Kashyap</b> <a href="mailto:kashyan@mcmaster.ca">kashyan@mcmaster.ca</a> Office hours: email for appointment
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#### COURSE WEBSITE

<http://avenue.mcmaster.ca>

#### COURSE OBJECTIVES

Power electronic converters are used in different applications that range from low-power phone/laptop battery chargers, home appliances, and automotive systems; to medium-power renewable energy systems, switching power supplies, and industrial motor drives, to high-power active filters and high voltage AC transmission systems for power systems. By the end of this course, the student will be able to:

1. Define power electronics and recognize power electronic devices, circuits, and applications.
2. Classify converter types and conversion functions.
3. Recognize converter topologies, derive their governing equations, and design, analyse and simulate converter circuits.
4. Draw I-V characteristics of power devices and analyse their switching behaviour.
5. Interpret power device datasheets and use the appropriate parameters in design, analysis and simulation.

#### ASSUMED KNOWLEDGE

Students should have knowledge of following topics:

1. Circuits Analysis and Systems
2. Electronic Devices

#### COURSE MATERIALS

**Required Text:** N. Mohan, T. M. Undeland, and W. P. Robbins, *Power Electronics: Converters, Applications, and Design*, Media Enhanced Third Edition, John Wiley & Sons, 2003, ISBN 978-0-471-22693-2.

**Calculator:** Any calculator is permitted for use in exams.

**COURSE OVERVIEW**

Date/Week	Topic
<b>Week 1</b>	Introduction to Power Electronics, Review of Electric Circuits
<b>Week 2</b>	Power Semiconductor Devices
<b>Week 3</b>	Non-Ideal Devices
<b>Week 4</b>	AC -> Uncontrolled DC: Diode Rectifiers
<b>Week 5</b>	AC -> Controlled DC: Phase-Controlled Rectifiers and Inverters
<b>Week 6</b>	DC -> DC: Non-Isolated DC/DC Converters (Buck)
<b>Week 7</b>	DC -> DC: Non-Isolated DC/DC Converters (Boost)
<b>Week 8</b>	DC -> DC: Non-Isolated DC/DC Converters (Buck-Boost)
<b>Week 9</b>	DC -> DC: Isolated DC/DC Converters
<b>Week 10</b>	DC -> AC: Single Phase Inverters
<b>Week 11</b>	DC-> AC: Three Phase Inverters
<b>Week 12</b>	Review

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 (on the course website).

**LABORATORY OVERVIEW**

Date/Week	Topic
<b>Lab 1</b>	Simulation of Diode Rectifier
<b>Lab 2</b>	Simulation of Thyristor Converter
<b>Lab 3</b>	Simulation of Buck Converter
<b>Lab 4</b>	Simulation of Boost Converter
<b>Lab 5</b>	Simulation of Flyback Converter

**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.

The labs will be performed in groups of up to two students. Ensure the names and student ID of each student are clearly marked on the first page of the lab report.

**ASSESSMENT**

Component	If Final Exam Mark > Midterm Exam Mark	If Final Exam Mark <= Midterm Exam Mark
Labs (5 x 5%)	25%	25%
Midterm	0%	20%
Final Exam	65%	45%
Research Report	10%	10%
Total	100%	100%

Late submissions of labs or the research report are subject to 20% penalty per day (less than one day is counted as one day).

No make-up midterm tests will be granted. Weight of a missed midterm test will be transferred to final exam.

Prior to the “Last day for withdrawing from courses without failure by default” date you will receive marks for Labs 1 and 2, which constitute at least 10% of the final grade.

**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](http://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](mailto: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.

#### **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>.

**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> .

<b>Outcomes</b>	<b>Indicators</b>	<b>Measurement Methods(s)</b>
<b>Problem Analysis</b>	2.3	Exams
<b>Investigation</b>	3.3	Labs
<b>Design</b>	4.1	Exams

**Note: Although all labs will be virtual in Fall 2020, the Lab Safety Information is included below so that students can become familiar with general lab safety rules, for any future lab work they may do.**

## 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	<a href="mailto:steve@mail.ece.mcmaster.ca">steve@mail.ece.mcmaster.ca</a>
ECE Chair	Tim Davidson- ITB A111	<a href="mailto:davidson@mcmaster.ca">davidson@mcmaster.ca</a>
ECE Administrator	Kerri Hastings- ITB A111	<a href="mailto:hastings@mcmaster.ca">hastings@mcmaster.ca</a>
ECE Course Instructor	Please contact your specific course instructor directly	