ECE 788
Control of Adjustable Speed Drives

COURSE OUTLINE

Please refer to course website for updated information.

CALENDAR DESCRIPTION

AC machine modeling and their control design tools are presented. The focus is on permanent-magnet (PM) and induction machines (IM) supplied by voltage-source inverters. Field-Oriented Control, with and without mechanical sensor, is developed. Common failures in adjustable speed drives are introduced and their effect on the drive performance is analyzed. Fault-tolerant drives are studied and some practical examples from industry are presented. Principal concepts are developed with projects using MATLAB/Simulink.

SCHEDULE And MODE OF DELIVERY

The material for this course will be delivered through a mixture of online videos, textbook readings, live online lectures and tutorials (which are also recorded). Please see the course website for the platform for each component.

INSTRUCTOR

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Office Hours**:** by appointment

McMaster expects to be fully in person in the 2023/24 academic year.
Please check with instructor and/or Avenue to Learn for Schedule and Mode of Delivery.

COURSE WEBSITE/S

Course instructions and lecture material will be posted via Avenue to Learn, the McMaster University electronic learning system, accessible at http://avenue.mcmaster.ca/

COURSE OBJECTIVES

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

- Model a PM drive for control purposes
- Model an IM drive for control purposes
- Design and implement current controller for PM and IM drives
- Design and implement mechanical sensorless control for a PM drive
- Model a PM drive under interturn short-circuit
- Detect interturn short-circuit fault in a PM drive
- Design and implement fault-tolerant control of a PM drive

ASSUMED KNOWLEDGE

Fundamentals of AC machines, Linear control systems, Modern control systems, Observers.

COURSE MATERIALS

Required texts:
Lecture notes and uploaded documents to the course website.

Recommended textbook:
Jean-Paul Louis, Control of Synchronous Motors, Wiley ISTE 2011.
https://onlinelibrary.wiley.com/doi/book/10.1002/9781118601785

COURSE OVERVIEW

Topic	Week
1. Introduction to Adjustable Speed Drives (ASD)	1
2. Modeling of PMSM for Control Purposes (Topic 1)	1-2
3. Average Modeling of Voltage-Source Inverters (Topic 2)	2-3
4. Torque Control of PMSM (Topic 3)	4-5
5. Torque Control of Other Electric Motors (Topic 4)	6-7
6. Speed Control of Electric Motors (Topic 5)	8
7. Common Failures in ASD (Topic 6)	9
8. Modeling of ASD Under Fault Conditions (Topic 7)	10
9. Fault-Tolerant Capability of ASD (Topic 8)	11
10. Fault-Tolerant Control of ASD (Topic 9)	12
11. Conclusion and Wrap-Up	13

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

Five Labs on modeling and control of AC drives. They are all simulation using MATLAB-Simulink (no specific toolbox required), no practical experiments on high-power/high-voltage setups are done.

Lab 1: Modeling of Permanent-Magnet Synchronous Machines (PMSM) (Week 4)
Lab 2: Vector control of PMSM (Week 6)
Lab 3: Direct and indirect torque control of PMSM (Week 8)
Lab 4: Mechanical sensor failure and sensorless control of PMSM (Week 10)
Lab 5: Fault-tolerant control of PMSM (Week 12) (no report)

LABORATORY OPERATION

- Lab Experiments: Every student conducts the lab experiment individually.
- Lab Requirements: Students need to submit their experiment results on Avenue to Learn on the due date described in the lab manual. No late submission will be accepted.

ASSESSMENT

Component	Weight
Lab reports (4 reports x 10%)	40%
Mid-project: report	10%
Mid-project: oral presentation	10%
Final project: report	20%
Final project: oral presentation	20%
Total	**100%**
Writing a paper (bonus)	+10%

Mid-project and final project reports are subject to 20% penalty per day (less than one day is counted as one day). No late submission will be accepted for the paper.

CONDUCT EXPECTATIONS

As a McMaster graduate 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.

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.

ACADEMIC ACCOMMODATIONS OF STUDENTS WITH DISABILITIES

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.

ACADEMIC ACCOMMODATION FOR RELIGIOUS, INDIGENOUS OR SPIRITUAL OBSERVANCES (RISO)

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.

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.

www.eng.mcmaster.ca/ece