ECE 8930: Advanced Power Electronics
FALL 2020

MEETING TIME: TR 12:30 pm – 01:45 pm

INSTRUCTOR(s): Zheyu Zhang
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OFFICE HOURS AND PROCEDURES: TR 9:00 am – 10:00 am, through Zoom Personal Meeting Room
https://zoom.us/j/2947747574?pwd=UTBkeklUL09tbVhEczRHdmp1UG9lZz09
Meeting ID: 294 774 7574
Passcode: dh1G9W

COURSE MODALITY: HYBRID

COURSE DESCRIPTION: Multi-phase (esp. three-phase) AC PWM converters are one of the most popular and important types of power electronics converters. Many emerging applications require the use of three- and multiphase PWM converters: electrified transportation, electronic power distribution systems, and renewable energy systems. They are used in industrial automation, vehicles, wind power generator, appliances in the form of electric motor drives; and used in power systems as electronic transformer, power flow controller, and compensator. There is a real need to have a course focusing on the design of the multi-phase PWM converters, not only their control, but also power stage, system interface, and integration. This course starts from an introduction to AC three-phase PWM converters. Then the detailed power stage design of three-phase PWM converters will be presented, including power semiconductor device selection and loss calculation, passive component selection and design, thermal design, gate drive, protection, auxiliary circuits, sensors, and controller hardware. Afterward, the power converter interface with load and source will be discussed, including dv/dt filter for motor drives, LCL filter for grid-tied applications, and EMI filter for industrial and emerging applications (e.g. aviation). Finally, a high-density converter design methodology will be overviewed with several examples highlighted. The course targets for graduate students with fundamental power electronics knowledge.

COURSE PREREQUISITES: ECE4930/6930 - INTRODUCTION OF POWER ELECTRONICS TECHNOLOGY AND APPLICATIONS

STUDENT LEARNING OUTCOMES: At the completion of the course, students should be able to 1) understand the operation of three-phase PWM converters; 2) be able to design a three-phase converter, including component selection, power stage design, filter design, auxiliary circuit design; 3) be able to consider the important source and load interface issues, including harmonics, EMI noise, dv/dt noise; 4) be able to use simulation in design and validation; 5) understand the basic principle for achieving high power density; and 6) give a technical presentation

REQUIRED MATERIALS: Simulation software — PLECS, MATLAB, and SABER (license will be provided in the class)
Textbook (optional) — 1) Analysis of Electric Machinery and Drive Systems –Krause, Wasynczuk, Sudhoff, 2) Power Electronics : Converters, Applications and Design –Mohan, Undeland, Robbins; 3)

Vector Control and Dynamics of AC Drives –Novotny and Lipo; 4) Power Electronics and Motor Drives: Advances and Trends –Bose; 5) High Power Converters and AC Drives –Wu; 6) Electric Motor Drives: Modeling, Analysis, and Control –Krishnan

Student is required to have a laptop computer, internet connectivity capable of transmitting and receiving video, a video camera, a microphone, and a cell phone

TOPICAL OUTLINE:

Week	Date	Type	Topic	Remarks
W1	08/20/20	Lecture 1	Introduction	Online
W2	08/25/20	Lecture 2	Two-level voltage source converter Overall aspect with design consideration	Online
W2	08/27/20	Lecture 3	Power semiconductors	Online
W3	09/01/20	Lecture 4	Switching loss analysis	Online
W3	09/03/20	Lecture 4 (Cont'd)	Switching analysis with parasitics	Online
W4	09/08/20	Lecture 4 (Cont'd)	Switching analysis with Saber	Online
W4	09/10/20	Lecture 5	Thermal management system	Online
W5	09/15/20	Lecture 6	Capacitor	Online
W5	09/17/20	Lecture 7	Inductor basics	Online
W6	09/22/20	Lecture 7 (Cont'd)	Inductor design consideration	TBD
W6	09/24/20	Lecture 8	Two-level VSC modulation & control	TBD
W7	09/29/20	Lecture 9	Loss calculation	TBD
W7	10/01/20	Lecture 10	Power stage design	TBD
W8	10/06/20	Lecture 11	Gate drive design	TBD
W8	10/08/20	Lecture 12	Protection	TBD
W9	10/13/20	Lecture 13	Dead-time effect	TBD
W10	10/20/20	Lecture 14	Filter design overview	TBD
W10	10/22/20	Lecture 15	EMI filter design	TBD
W11	10/27/20	Lecture 15 (Cont'd)	EMI filter design (Cont'd)	TBD
W11	10/29/20	Lecture 16	Dv/dt issue for motor drives	TBD
W12	11/03/20	Fall break		
W12	11/05/20	Lecture 16 (Cont'd))	Dv/dt filter design for motor drives	TBD
W13	11/10/20	Lecture 17	LCL filter for grid-tied inverter	TBD
W13	11/12/20	Lecture 18	Control and auxiliary hardware	TBD
W14	11/17/20	Lecture 19	Other topology — Three-level neutral-point clamped converter	TBD
W14	11/19/20	Lecture 19 (Cont'd)	Other topology — H-bridge cascaded converter	TBD
W15	11/24/20	Lecture 20	Converter design optimization	TBD
W15	11/26/20	Thanksgiving		
W16	12/01/20	Lecture 20 (Cont'd)	Converter design optimization (Cont'd)	Online
W16	12/03/20	Student presentation 2	Student presentation – Final examination	Online

CLASS CANCELLATION POLICY: Class is cancelled if the instructor is more than 15 minutes late to class.

GRADING POLICY:

A – 90% - 100%; B – 80-89.9%; C – 70-79.9%; D – 60-69.9% & F – < 60%

Grading Type	Weighting
Homework (three)	30 %

Participation and discussion	5 %
Project (one)	20 %
Student presentation (two)	20 %
Final project (one)	25 %
Total	100 %

ATTENDANCE POLICY:

1. The university will assign students a day of the week they are to come this class; on other days, they must attend online.
2. Attendance is optional on days students are to come physically.
3. Online attendance is mandatory.
4. Should you miss a class (including online), it is YOUR RESPONSIBILITY to contact with your instructor within one week to deliver the written excuse by email. Missing class WILL AFFECT your final grade. See grading policy below.
5. A student will be marked absent if not in class/online within 5 minutes of starting time. This can be changed into a tardy. The student is responsible for contacting the instructor after class.
6. The student is responsible for asking the professor to change an absence into a tardy if the student arrived more than 5 minutes late immediately after the class in which the tardy occurs. (No changes will be made on a later day.) The third tardy will result in a loss of 2 participation points, the fourth 2 more points, etc.
7. To maintain physical distancing, individuals arriving first to the classroom should sit farthest from the door. Similarly, at the conclusion of class, students closest to the door should leave first.
8. While on campus, face coverings are required in all buildings and classrooms. Face coverings are also required in outdoor spaces where physical distance cannot be guaranteed. If a student does not have a face covering or refuses to wear an approved face covering without valid documented accommodation, the instructor will ask the student to leave the academic space and may report the student's actions to the Office of Community & Ethical Standards as a violation of the Student Code of Conduct. If the student's actions disrupt the class to the extent that an immediate response is needed, the instructor may call the Clemson University Police Department at 656-2222.
9. Please note that the University may convert to a purely online mode at any time. University classes are initially in a purely online mode and will remain so until Sept. 21.

ACCESSIBILITY STATEMENT: Clemson University values the diversity of our student body as a strength and a critical component of our dynamic community. Students with disabilities or temporary injuries/conditions may require accommodations due to barriers in the structure of facilities, course design, technology used for curricular purposes, or other campus resources. Students who experience a barrier to full access to a class should let the instructor know and make an appointment to meet with a staff member in Student Accessibility Services as soon as possible. You can make an appointment by calling 864-656-6848 or by emailing studentaccess@lists.clemson.edu. Students who receive Academic Access Letters are strongly encouraged to request, obtain, and present these to their instructors as early in the semester as possible so that accommodations can be made in a timely manner. It is the student's responsibility to follow this process each semester. You can access further information here: http://www.clemson.edu/campus-life/campus-services/sds/.

TITLE IX STATEMENT: Clem[son University is committed to a policy of equal opportunity for all persons and does not discriminate on the basis of race, color, religion, sex, sexual orientation, gender, pregnancy, national origin, age, disability, veteran's status, genetic information or protected activity in

employment, educational programs and activities, admissions and financial aid. This includes a prohibition against sexual harassment and sexual violence as mandated by Title IX of the Education Amendments of 1972.

SAFE CAMPUS: Clemson University is committed to providing a safe campus environment for students, faculty, staff, and visitors. As members of the community, we encourage you to take the following actions to be better prepared in case of an emergency:

a. Ensure you are signed up for emergency alerts (https://www.getrave.com/login/clemson)
b. Download the Rave Guardian app to your phone (https://www.clemson.edu/cusafety/cupd/rave-guardian/)
c. Learn what you can do to prepare yourself in the event of an active threat (http://www.clemson.edu/cusafety/EmergencyManagement/)

ACADEMIC INTEGRITY: As members of the Clemson University community, we have inherited Thomas Green Clemson's vision of this institution as a 'high seminary of learning.' Fundamental to this vision is a mutual commitment to truthfulness, honor, and responsibility, without which we cannot earn the trust and respect of others. Furthermore, we recognize that academic dishonesty detracts from the value of a Clemson degree. Therefore, we shall not tolerate lying, cheating, or stealing in any form. In instances where academic standards may have been compromised, Clemson University has a responsibility to respond appropriately to charges of violations of academic integrity. Further information on Academic Integrity can be found in the *Undergraduate Announcements* and in the *Graduate School Policy Handbook*.

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MODIFICATION STATEMENT: The instructor reserves the right to modify any aspect of the syllabus at any time during the semester for reasons including but not limited to COVID-related situations. The date of this version of the syllabus is August 12, 2020

Procedures for turning in homework – online submission is highly recommended.