School of Electrical Engineering and Telecommunications

Term 3, 2020
Course Outline

ELEC9711
Power Electronics for Renewable and Distributed Generation

COURSE STAFF

Course Convener: Prof John Fletcher, Room 404, G17, john.fletcher@unsw.edu.au

Consultations: You are encouraged to ask questions on the course material, during or after the lecture class times in the first instance, rather than via email. Consultation times can be organized by email. ALL email enquiries should be made from your student email address with ELEC9711 in the subject line; otherwise they will not be answered.

Keeping Informed: Announcements may be made during classes, via email (to your student email address) and/or via online learning and teaching platforms – in this course, we will use Open Learning https://www.openlearning.com/unswcourses/courses/elec9711-2020. Please note that you will be deemed to have received this information, so you should take careful note of all announcements.

COURSE SUMMARY

Contact Hours

The course consists of up to 4 hours of lectures/tutorial per week.

Contact Hours	Day	Time	Location
Lecture/Tutorial	Tuesday	6pm - 8pm	Online
Lecture/Tutorial	Thursday	6pm - 8pm	Online

Context and Aims

Power electronic circuits are an essential component of renewable and distributed energy sources including wind turbines, photovoltaics, marine energy systems and energy storage systems. They are also finding increasing use in other utility applications including active power filters, VAr compensator, dynamic voltage restorers and HVDC transmission systems. Electronic processing of electrical power for these applications also provides the means to control these elements of the electrical grid and its generation sources.

The course is aimed at students who have already been introduced to a first course in Power Electronics which covers steady-state characteristics of various AC-DC, DC-DC, and DC-AC converter circuits. The fourth-year elective course ELEC4614 – Power Electronics offered by EE&T, UNSW, is such a course. The objective of ELEC9711 is to show how these converter topologies are utilised in renewable energy systems (wind and PV), in utility applications (for example HVDC) and to further investigate the converters in terms of their efficiency, control characteristics, description of dynamics and their closed-loop control. Some advanced converter topologies, especially in the context of large and complex applications, which are beyond the scope of a first course in power electronics, are also treated.

The course also introduces students to computer modelling of power electronic converters and their control circuits using modern simulation platforms like LTSpice, PLECS, PSIM or SimPower in Matlab-Simulink.

Indicative Lecture Schedule

Period	Summary of Lecture Program
Week 1	Introduction to Course
Week 2	Hard-Switched DC-DC Converters; **Assignment 1 Released**
Week 3	Resonant-Switched DC-DC Converters
Week 4	Isolated DC-DC Converters; **Assignment 1 Due**
Week 5	Grid-Connected H-Bridge Converters; **Assignment 2 Released**
Week 6	Three-Phase Inverter Control
Week 7	Wind Energy Electrical Systems; **Assignment 2 Due**
Week 8	Photovoltaic Electrical Systems; **Assignment 3 Released**
Week 9	HVDC Transmission Systems
Week 10	Multi-Level Converters; **Assignment 3 Due**

Assessment

Assignment 1	10%
Assignment 2	10%
Assignment 3	20%
Final Exam (2 hours, answer 3 out of 4 questions)	60%

Important Health Related Notice

Your health and the health of those in your class is critically important. You must stay at home if you are sick or have been advised to self-isolate by NSW health or government authorities. Current alerts and a list of hotspots can be found here. **You will not be penalised for missing a face-to-face activity due to illness or a requirement to self-isolate**. We will work with you to ensure continuity of learning during your isolation and have plans in place for you to catch up on any content or learning activities you may miss. Where this might not be possible, an application for fee remission may be discussed.

If you are required to self-isolate and/or need emotional or financial support, please contact the Nucleus: Student Hub. If you are unable to complete an assessment, or attend a class with an attendance or participation requirement, please let your teacher know and apply for special consideration through the Special Consideration portal. To advise the University of a positive COVID-19 test result or if you suspect you have COVID-19 and are being tested, please fill in this form.

UNSW requires all staff and students to follow NSW Health advice. Any failure to act in accordance with that advice may amount to a breach of the Student Code of Conduct. Please refer to the Safe Return to Campus guide for students for more information on safe practices.

COURSE DETAILS

Credits

This is a 6 UoC course and the expected workload is 15 hours per week throughout the 10-week term.

Relationship to Other Courses

This is a postgraduate course in the School of Electrical Engineering and Telecommunications.

Pre-requisites and Assumed Knowledge

It is essential that you are familiar with the content of ELEC4614 Power Electronics including basic DC/DC isolated and non-isolated converters, the H-bridge converter and thyristor rectifier/inverter circuits. A good grasp of DC, AC and transient circuit analysis will assist with the course.

Learning outcomes

After successful completion of this course, you should be able to:

1. Understand the use of power converters in wind turbines.
2. Understand the use of power converters in PV applications.
3. Understand the concept of maximum power point tracking.
4. Understand how real and reactive power flow can be controlled from a renewable or distributed energy resource to the utility network.
5. Understand the basic components of an HVDC system and the control of real power flow.
6. Understand power converters with non-ideal devices and elements.
7. Develop analytical techniques for analysing the steady-state and dynamic characteristics of converters.
8. Understand the quadrant operation of various types of converters and their control requirements, selection of converters, components, etc.
9. Understand how to design the hierarchical control structures for power converters and systems.
10. Select and design important elements of a power converter system.
11. Apply the theories of power electronic converters and control system design to implement power converter systems which are appropriate for specific applications.

This course is designed to provide the above learning outcomes which arise from targeted graduate capabilities listed in ***Appendix A***. The targeted graduate capabilities broadly support the UNSW and Faculty of Engineering graduate capabilities (listed in ***Appendix B***). This course also addresses the Engineers Australia (National Accreditation Body) Stage I competency standard as outlined in ***Appendix C***.

Syllabus

The topics to be covered in this course will include: Grid integration of electrical power from renewable sources; Current and voltage control; Advanced topics in DC-DC converters, inverters, AC-DC converters and AC-AC converters for use in utility interfacing; resonant converters for DC-DC conversion; converter circuit and system modelling using LTSpice or other simulation platforms, device selection and their modeling, component selection and design, and case studies of converter system designs.

TEACHING STRATEGIES

Delivery Mode

The teaching in this course aims at establishing a good fundamental understanding of the areas covered using:

- Online lecture videos and screencasts which explain the important concepts for each topic of the course;
- Formal lectures/tutorials, which provide you with alternative explanations to aid your understanding. They also allow for exercises in problem solving and allow for time for you to resolve problems in understanding of lecture material;

- Design and simulation work, which supports the lecture video material and also provides you with skills necessary to perform a design task.

Learning in this course

You are expected to attend all lecture/tutorial classes in order to maximise learning. You **should** watch the relevant online lecture videos before attending the lecture/tutorial classes. Reading additional texts will further enhance your learning experience. Group learning is also encouraged. UNSW *assumes* that self-directed study of this kind is undertaken in addition to attending formal classes throughout the course.

Tutorial classes

Five to six tutorial sheets may be expected. The problem-solving sessions will be on most recently covered topics. Additionally, online PSIM or LTSpice sessions may be arranged. Students will be expected to participate vigorously during these sessions, in the form of questions, suggested solutions and methods. Participation by students and the tutor should be viewed as desirable aspects of these sessions.

You should attempt all of your problem sheet questions in advance of attending the tutorial classes. The importance of adequate preparation prior to each tutorial cannot be overemphasized, as the effectiveness and usefulness of the tutorial depends to a large extent on this preparation. Group learning is encouraged. Answers for these questions will be discussed during the tutorial class and the tutor will cover the more complex questions in the tutorial class. In addition, during the tutorial class, 1-2 new questions that are not in your notes may be provided by the tutor, for you to try in class. These questions and solutions may not be made available on the web, so it is worthwhile for you to attend your tutorial classes to gain maximum benefit from this course.

ASSESSMENT

The assessment scheme in this course reflects the intention to assess your learning progress through the term. Ongoing assessment occurs through the three assignments.

Assignments

The assignments allow self-directed study leading to the solution of a design task or theoretical questions. Marks will be assigned according to how completely and correctly the design problem or theoretical question has been addressed.

The assignments will be released in week 2 (10%, submit week 4), week 5 (10%, submit week 7) and week 8 (20%, submit week 10). You are expected to submit any requested formal materials to the school office (or, if specified by Moodle) by 3pm, Friday of the indicated week. Late submissions will attract a penalty of 10% per day (including weekends).

You are expected to submit an individual solution/report/design for each assignment for ELEC9711 not a group report. The marks from your assignments will contribute 40% of your final class mark. Late submissions will not be accepted. You must include a signed cover sheet http://scoff.ee.unsw.edu.au/forms/assignmentcover.pdf declaring that the work submitted is your own work and this must be the first page of the report.

Final Exam

The exam in this course is a two-hour written examination, comprising four questions from which students select to answer only three questions. Only University approved calculators are allowed. The examination tests analytical and critical thinking and general understanding of the course material in a controlled fashion. Questions may be drawn from any aspect of the course unless specifically indicated otherwise by the lecturer. Marks will be assigned according to the correctness of the responses. *Please note that you must pass the final exam in order to pass the course.*

Relationship of Assessment Methods to Learning Outcomes

	Learning outcomes										
Assessment	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
Assignment 1	✓	✓	✓	-	-	-	-	-	-	-	-
Assignment 2	-	-	✓	✓	✓	✓	✓	-	-	-	-
Assignment 3	✓	✓	✓	✓	✓	✓	✓	✓	-	-	-
Final exam	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

COURSE RESOURCES

Textbooks

Reference textbooks

1. N. Mohan, T. M. Undeland & W. P. Robins, "Power Electronics; Converters, Applications and Design", John Wiley, Second Edition, 1995, New York.
2. J. G. Kassakian, M.F. Schlecht & G.C. Verghese, "Principles of Power Electronics", Addison Wesley, 1991.
3. R. W. Erickson, "Fundamentals of Power Electronics", Kluwer Academic Publications, 1997.
4. D. W. Hart, "Introduction to Power Electronics", Prentice Hall International, 1997.

On-line resources

Lecture Content

Lecture videos and lecture notes written by the lecturer for each section will be available from the course webpage on Open Learning. These are based on the textbooks listed above and other reference material which will be cited within the lecture videos/notes.

All lecture videos, notes, assignments, tutorial and technical report topics for this course can be downloaded from the Open Learning website. Students will be expected to have watched the relevant lecture videos before class and have access to, or to bring printed, tutorial sheets to the tutorials.

Open Learning

As a part of the teaching component, Open Learning will be used to disseminate teaching materials, host forums and occasionally, quizzes. Assessment marks will also be made available via Open Learning: https://www.openlearning.com/unswcourses/courses/elec9711-2020.

Mailing list

Announcements concerning course information will be given in the lectures and/or on Open Learning and/or via email (which will be sent to your student email address).

OTHER MATTERS

Dates to note

Important Dates available at: https://student.unsw.edu.au/dates

Academic Honesty and Plagiarism

Plagiarism is the unacknowledged use of other people's work, including the copying of assignment works and laboratory results from other students. Plagiarism is considered a form of academic misconduct, and the University has very strict rules that include some severe penalties. For UNSW policies, penalties and information to help you avoid plagiarism, see https://student.unsw.edu.au/plagiarism. To find out if you understand plagiarism correctly, try this short quiz: https://student.unsw.edu.au/plagiarism-quiz.

Student Responsibilities and Conduct

Students are expected to be familiar with and adhere to all UNSW policies (see https://student.unsw.edu.au/policy), and particular attention is drawn to the following:

Workload

It is expected that you will spend at least **15 hours per week** studying a 6 UoC course, from Week 1 until the final assessment, including both formal classes and *independent, self-directed study*. In periods where you need to complete assignments or prepare for examinations, the workload may be greater. Over-commitment has been a common source of failure for many students. You should take the required workload into account when planning how to balance study with employment and other activities.

Attendance

Regular and punctual attendance at all classes is expected. UNSW regulations state that if students attend less than 80% of scheduled classes they may be refused final assessment.

General Conduct and Behaviour

Consideration and respect for the needs of your fellow students and teaching staff is an expectation. Conduct which unduly disrupts or interferes with a class is not acceptable and students may be asked to leave the class.

Work Health and Safety

UNSW policy requires each person to work safely and responsibly, in order to avoid personal injury and to protect the safety of others.

Special Consideration and Supplementary Examinations

You must submit all assignments and attend all examinations scheduled for your course. You can apply for special consideration when illness or other circumstances beyond your control interfere with an assessment performance. If you need to submit an application for special consideration for an exam or assessment, you must submit the application **prior to the start** of the exam or before the assessment is submitted, except where illness or misadventure prevent you from doing so. Be aware of the "fit to sit/submit" rule which means that if you sit an exam or submit an assignment, you are declaring yourself well enough to do so and cannot later apply for Special Consideration. For more information and how to apply, see https://student.unsw.edu.au/special-consideration.

Continual Course Improvement

This course is under constant revision in order to improve the learning outcomes for all students. Please forward any feedback (positive or negative) on the course to the course convener or via the Course and Teaching Evaluation and Improvement Process. You can also provide feedback to ELSOC who will raise your concerns at student focus group meetings. As a result of previous feedback obtained for this course and in our efforts to provide a rich and meaningful learning experience, we have continued to evaluate and modify our delivery and assessment methods. This includes changing the content of the class to include more renewables and distributed generation and revising the assessment scheme. For the course delivered in 2017, the assessment schedule and weighting were adjusted such that the final exam represents 60% of the final mark, with assignments and coursework representing 40% in total. In 2019, the course underwent digital uplift and received a huge investment in the production of online materials, key concept videos and podcasts. These were used in 2020 for the first time.

Administrative Matters

On issues and procedures regarding such matters as special needs, equity and diversity, occupational health and safety, enrolment, rights, and general expectations of students, please refer to the School and UNSW policies:
https://student.unsw.edu.au/guide
https://www.engineering.unsw.edu.au/electrical-engineering/resources

APPENDICES

Appendix A: Targeted Graduate Capabilities

Electrical Engineering and Telecommunications programs are designed to address the following targeted capabilities which were developed by the school in conjunction with the requirements of professional and industry bodies:

- The ability to apply knowledge of basic science and fundamental technologies;
- The skills to communicate effectively, not only with engineers but also with the wider community;
- The capability to undertake challenging analysis and design problems and find optimal solutions;
- Expertise in decomposing a problem into its constituent parts, and in defining the scope of each part;
- A working knowledge of how to locate required information and use information resources to their maximum advantage;
- Proficiency in developing and implementing project plans, investigating alternative solutions, and critically evaluating differing strategies;
- An understanding of the social, cultural and global responsibilities of the professional engineer;
- The ability to work effectively as an individual or in a team;
- An understanding of professional and ethical responsibilities;
- The ability to engage in lifelong independent and reflective learning.

Appendix B: UNSW Graduate Capabilities

The course delivery methods and course content addresses a number of core UNSW graduate attributes, as follows:

- Developing scholars who have a deep understanding of their discipline, through lectures and solution of analytical problems in tutorials and assessed by assignments and written examinations.
- Developing rigorous analysis, critique, and reflection, and ability to apply knowledge and skills to solving problems. These will be achieved by the laboratory experiments and interactive checkpoint assessments and lab exams during the labs.
- Developing capable independent and collaborative enquiry, through a series of tutorials spanning the duration of the course.
- Developing digital and information literacy and lifelong learning skills through assignment work.

Appendix C: Engineers Australia (EA) Professional Engineer Competency Standard

	Program Intended Learning Outcomes	
PE1: Knowledge and Skill Base	PE1.1 Comprehensive, theory-based understanding of underpinning fundamentals	✓
	PE1.2 Conceptual understanding of underpinning maths, analysis, statistics, computing	✓
	PE1.3 In-depth understanding of specialist bodies of knowledge	✓
	PE1.4 Discernment of knowledge development and research directions	
	PE1.5 Knowledge of engineering design practice	✓
	PE1.6 Understanding of scope, principles, norms, accountabilities of sustainable engineering practice	
PE2: Engineering Application Ability	PE2.1 Application of established engineering methods to complex problem solving	✓
	PE2.2 Fluent application of engineering techniques, tools and resources	✓
	PE2.3 Application of systematic engineering synthesis and design processes	✓
	PE2.4 Application of systematic approaches to the conduct and management of engineering projects	
PE3: Professional and Personal Attributes	PE3.1 Ethical conduct and professional accountability	
	PE3.2 Effective oral and written communication (professional and lay domains)	✓
	PE3.3 Creative, innovative and pro-active demeanour	✓
	PE3.4 Professional use and management of information	✓
	PE3.5 Orderly management of self, and professional conduct	
	PE3.6 Effective team membership and team leadership	