ELEC9711
Power electronics for renewable and distributed generation

Course Outline – Semester 2, 2016

Never Stand Still | Faculty of Engineering | School of Electrical Engineering and Telecommunications

Course Staff

Course Convener: Prof John Fletcher, Room 701, MSEB, 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.

Course Details

Credits

This is a 6 UoC course and the expected workload is 10–12 hours per week throughout the 13 week semester.

Contact Hours

The course consists of 3 hours of lectures/tutorial.

Contact Hours	Day	Time	Location
Lec/tut	Wednesday	6pm - 9pm	To be confirmed

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 HV DC 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, PSIM or SimPower in Matlab-Simulink.

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. be able to select and design important elements of a power converter system.
11. be able to 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 attributes (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, magnetic core and other component selection and design, and case studies of converter system designs.

Course Content	***Hours***
1. DC-DC converters & power supplies	*10*
2. DC-AC Inverters for utility interfacing	*10*
3. Resonant converters	*4*
4. *Power electronics for renewable and utility applications*	*10*
Indicative Total hours	**34**

Teaching Strategies

Delivery Mode

The teaching in this course aims at establishing an understanding of the areas covered using:

- Formal face-to-face lectures, which provide you with a focus on the core analytical material in the course, together with qualitative, alternative explanations to aid your understanding;
- Tutorials, which allow for exercises in problem solving and allow time for you to resolve problems in understanding of lecture material;
- Design and simulation work, which supports the formal lecture material and also provides you with skills necessary to perform a design task.

Learning in this course

You are expected to attend all lectures and tutorials. In addition to the lecture notes, you should read relevant sections of the recommended text. Reading additional texts will further enhance your learning experience. UNSW *assumes* that self-directed study of this kind is undertaken in addition to attending face-to-face classes throughout the course.

Indicative Lecture Schedule

Period	Summary of Lecture Program
Week 1	Introduction to course
Week 2	Review of DC-DC converters
Week 3	Non-ideal switched and components
Week 4	Resonant converters
Week 5	Isolated converters
Week 6	Magnetic components
Week 7	Practical converters
Break	
Week 8	H-bridge converter and current control

Week 9	Wind energy conversion
Week 10	HVDC transmission
Week 11	PV energy conversion and multi-level converters
Week 12	Multi-level converters

Tutorial classes

Lectures will be supplemented with problem solving tutorial sessions. Five to six tutorial sheets may be expected. The problem-solving sessions will be on most recently covered topics. Additionally, PSIM or LTSpice sessions may be arranged in room EE214. 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 any 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. Solutions will be discussed during the tutorial class and the tutor may 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

Assignment	**20%**
Final Exam (3 hours)	**80%**

Assignment

The assignment allows self-directed study leading to the solution of a design task. Marks will be assigned according to how completely and correctly the design problem has been addressed.

The assignment report will be due in Week 13. You are expected to submit the formal report to the school office by **3pm, Friday Week 13**. *Late reports will attract a penalty of 10% per day* (including weekends). You are expected to submit an **individual** formal report for ELEC9711. The mark from your formal report will contribute 20% 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 standard closed-book 3 hour written examination, comprising four questions from which students select to answer only three questions. 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.

Relationship of Assessment Methods to Learning Outcomes

Assessment	Learning outcomes
Assignment	6-8, 10, 11
Final exam	1-11

Course Resources

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 notes written by the lecturer for each section will be available from the course webpage. These will be based on the following text books and other reference material which will be cited within the lecture notes.

All lecture notes, assignments, tutorial and technical report topics for this course can be downloaded on the school webpage, via Current Students → Study Notes → Lecture Notes. You may have to use username: (*your student number*) and password: *ee&tview* in order to access these documents. Students will be expected to bring the printed lecture notes and tutorial sheets into the lecture/tutorial room.

Mailing list

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

Other Matters

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 http://www.lc.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://my.unsw.edu.au/student/atoz/ABC.html), and particular attention is drawn to the following:

Workload

It is expected that you will spend at least **ten to twelve hours per week** studying a 6 UoC course, from Week 1 until the final assessment, including both face-to-face classes and *independent, self-directed study*. In periods where you need to 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.

Keeping Informed

Announcements may be made during classes, via email (to your student email address) or via online learning and teaching platforms like Moodle. From time to time, UNSW will send important announcements via these media without providing any paper copy. Please note that you will be deemed to have received this information, so you should take careful note of all announcements.

Special Consideration and Supplementary Examinations

You must submit all assignments and attend all examinations scheduled for your course. You should seek assistance early if you suffer illness or misadventure which affects your course progress. All applications for special consideration must be **lodged online through**

myUNSW within 3 working days of the assessment, not to course or school staff. For more detail, consult https://my.unsw.edu.au/student/atoz/SpecialConsideration.html.

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.

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:
http://www.engineering.unsw.edu.au/electrical-engineering/policies-and-procedures
https://my.unsw.edu.au/student/atoz/ABC.html

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 Attributes

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	