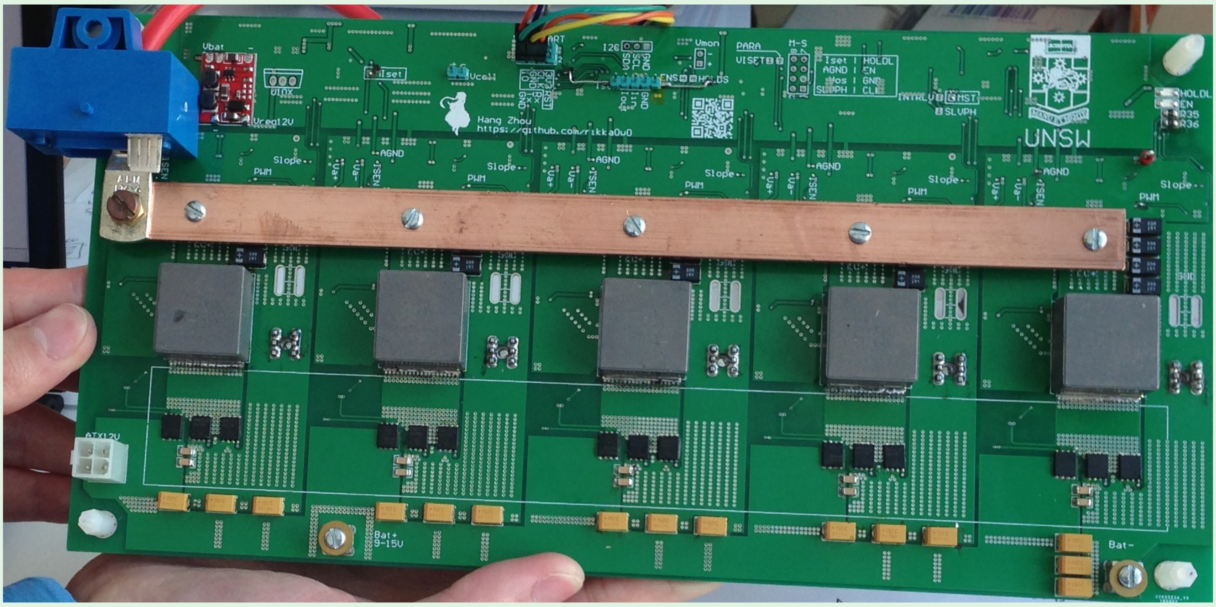
School of Electrical Engineering & Telecommunications

UNSW Engineering

ELEC4614

Power Electronics

Term 1, 2022



Course Overview

Staff Contact Details

Convenors

Name	Email	Availability	Location	Phone
John Fletcher	john.fletcher@unsw.edu.au		Rm 404, G17	029385600 7

Lecturers

Name	Email	Availability	Location	Phone
John Fletcher	john.fletcher@unsw.edu.au		Rm 404, G17	029385600 7

Lab Staff

Name	Email	Availability	Location	Phone
Gamini Liyadipitiya	g.liyadipitiya@unsw.edu.au		Rm 115, G17	

School Contact Information

Consultations: Lecturer consultation times will be advised during the first lecture. You are welcome to email the tutor or laboratory demonstrator, who can answer your questions on this course and can also provide you with consultation times. ALL email enquiries should be made from your student email address with ELEC/TELExxxx 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 Moodle https://moodle.telt.unsw.edu.au/login/index.php. Please note that you will be deemed to have received this information, so you should take careful note of all announcements.

Student Support Enquiries

For enrolment and progression enquiries please contact Student Services

Web

Electrical Engineering Homepage

Engineering Student Support Services

Engineering Industrial Training

UNSW Study Abroad and Exchange (for inbound students)

UNSW Future Students

Phone

(+61 2) 9385 8500 – Nucleus Student Hub

(+61 2) 9385 7661 – Engineering Industrial Training

(+61 2) 9385 3179 – UNSW Study Abroad and UNSW Exchange (for inbound students)

Email

Engineering Student Support Services – current student enquiries

- e.g. enrolment, progression, clash requests, course issues or program-related queries

Engineering Industrial Training – Industrial training questions

UNSW Study Abroad – study abroad student enquiries (for inbound students)

UNSW Exchange – student exchange enquiries (for inbound students)

UNSW Future Students – potential student enquiries

- e.g. admissions, fees, programs, credit transfer

Course Details

Units of Credit 6

Summary of the Course

The subject starts with coverage of the full spectrum of modern power semiconductor devices, their characteristics, both static and switching. Modern power semiconductor devices eg, diodes, thyristors, MOSFETS, and other insulated gate devices such as the IGBT, MCT and the FCT; Static and switching characteristics, gate drive and protection techniques; their drive circuit design and protection techniques including the snubber. Various topologies of power converter circuits are then treated, together with analysis of their operation, control characteristics, efficiency and other operational features. These include major areas of applications in AC-DC, DC-DC, and DC-AC power converter circuits. Analyses of input and output waveforms of these circuits so as to obtain their harmonic performance are also undertaken. A basic understanding of devices, circuit principles and implications in input/output waveform quality is stressed throughout the subject. Application considerations for remote and un-interruptible power supplies, and for computer systems, telecommunications, automobiles, traction and other industrial processes; Utility interaction, harmonic distortion, and power factor will also be included.

Power semiconductor switching devices and their limitations; Switching characteristics, protection and limitations of various types of power semiconductor switches; Elementary concepts in power electronics; Application of power electronic converters in energy conversion, utility applications and power supplies and utilizations; Diode rectifier circuits, multi-pulse rectifiers, input and output waveform characterization, filter design. Non isolated DC-DC converters, circuits topologies, characteristics with continuous and discontinuous conduction, circuit design and control considerations, Quadrant operation; Isolated DC-DC converters, transformer design issues, core resetting; Single-phase and three-phase DC-AC inverters, modulation strategies, output waveform analysis and filter design; Utility interfaces; High power applications; Converter system implementation

Course Aims

This course also aims to equip the student with a basic understanding of modern power semiconductor devices, their strengths, and their switching and protection techniques. These include power diodes, bipolar and MOSFET power transistors, other gate controlled devices such as thyristors, insulated-.â?□gate bipolar transistors (IGBT) and gate turn-.â?□off thyristors (GTO). Various important topologies of power converter circuits for specific types of applications are covered and analyzed. These include controlled and uncontrolled rectifiers, DC-.â?□DC converters and inverters. The course also equips student with ability to understand and analyze the qualities of waveforms at input and output ends of these converters. The quality of these waveforms is of major concern to users of modern power converter circuits and the utility authorities alike.

Course Learning Outcomes

After successfully completing this course, you should be able to:

Learning Outcome	EA Stage 1 Competencies
1. Understand and explain modern power semiconductor devices,	PE1.1, PE1.4, PE1.5, PE2.1,

Learning Outcome	EA Stage 1 Competencies
their strengths, and their switching and protection techniques. These include power diodes, bipolar and MOSFET power trasistors, other gate-controlled devices such as thyristors, insulated-gate bipolar transistors and gate turn-off thyristors	PE2.2, PE3.2, PE3.4
2. Understand and explain the operation of and develop analysis skills for several important topologies of power converter circuits for specific types of applications. These include controlled and uncontrolled rectifiers, DC-DC converters and inverters.	PE1.1, PE1.2, PE1.3, PE1.4, PE1.5, PE2.1, PE2.2, PE3.2, PE3.3, PE3.4, PE3.6
3. Understand and analyse the qualities of waveforms at input and output ends of converters. The quality of these waveforms is of major concern to users of modern power converter circuits and the utility authorities alike.	PE1.1, PE1.3, PE1.5, PE2.1, PE2.2, PE2.3, PE2.4, PE3.2, PE3.4, PE3.6

Teaching Strategies

Please refer to the information in Moodle

Additional Course Information

Other matters

Relationship of Assessment Methods to Learning Outcomes

Student Responsibilities and ConductPlagiarism 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.

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:

Keeping Informed

Announcements may be made during classes, via email (to your student email address) or via OpenLearning and other teaching platforms like Moodle. From time to time, UNSW will send important announcements via these platforms 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.

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.

2015 feedback: As a result of previous feedback obtained for this course we replaced an existing laboratory exercise which students had found difficulty understanding (Unity-power factor converter) with one that demonstrates the detailed characteristics of semiconductor devices to enhance understanding of the switching transients of diodes, MOSFETs and IGBTs.

2016 feedback: Lab exercises 1, 2, and 3 have been modified to reduce the number of test results required to be taken. OpenLearning website developed.

2017 feedback: further modifications to lab exercises and development of the summer online course. Revised OpenLearning site developed based around topics.

2018 feedback: Revised OpenLearning site developed based around topics.

2019 feedback: Further OpenLearning site developments and adjustments for trimesters.

2020 feedback: Feedback on online-only delivery mode due to COVID-19 issues.

Assessment

Assessment task	Weight	Due Date	Course Learning Outcomes Assessed
1. Hand-in Assignment	10%	11/03/2022 03:00 PM	1, 2, 3
2. Mid-semester Test	10%	15/04/2022 03:00 PM	1, 2, 3
3. Laboratory Work and Reports	20%	28/04/2022 03:00 PM	1, 2, 3
4. Final Examination	60%	Not Applicable	1, 2, 3

Assessment 1: Hand-in Assignment

Start date: 25/02/2022 12:00 AM
Due date: 11/03/2022 03:00 PM

Hand-in Assignment #1 worth 10% of the final mark. These exercises will enable you to assess your understanding of particular topics.

Assessment 2: Mid-semester Test

Start date: 28/03/2022 03:00 PM
Due date: 15/04/2022 03:00 PM

This will either be a hand-in assessment or an online quiz.

Assessment 3: Laboratory Work and Reports

Start date: 04/04/2022 12:00 AM
Due date: 28/04/2022 03:00 PM

Laboratory assessment marks (weighted 20%) will be awarded according to your preparation (completing set preparation exercises and correctness of these or readiness for the lab in terms of pre-reading), how much of the lab you were able to complete, your understanding of the experiments conducted during the lab, the quality of the notes you write during your lab work (according to the guidelines given in lectures/demonstrators), and your understanding of the topic covered by the lab. No formal report is required for each lab, except that the Hand-in-Assignment will include a report on one or more of the experiments. The experiment allocation for the Hand-in-Assignment will be announced during the term.

Assessment 4: Final Examination

The final examination will be worth 60%. Copies of examination papers (without solutions) for the past few years will be posted on OpenLearning.

The final exam in this course is a standard open-book 2-hour written examination, comprising **four questions of which three must be answered**. 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 (including laboratory), unless specifically indicated otherwise by the lecturer. Marks will be assigned according to the correctness of the responses. Only University approved calculators are allowed. *Please note that you must pass the final exam in order to pass the course.*

Attendance Requirements

Students are strongly encouraged to attend all classes and review lecture recordings.

Course Schedule

[View class timetable]

Timetable

Date	Type	Content
O-Week: 7 February - 11 February		
Week 1: 14 February - 18 February	Lecture	Introduction; Overview of power semiconductor devices, characteristics, heatsinks and thermal systems.
Week 2: 21 February - 25 February	Lecture	Introduction; Overview of power semiconductor devices, characteristics, heatsinks and thermal systems.
Week 3: 28 February - 4 March	Lecture	Non-isolated dc-dc converters (buck, boost, buck-boost)
Week 4: 7 March - 11 March	Lecture	Non-isolated dc-dc converters (buck, boost, buck-boost)
Week 5: 14 March - 18 March	Lecture	dc-ac converters (inverters) – single- and three-phase
Week 6: 21 March - 25 March	Topic	Flexibility week: worked examples or revision
Week 7: 28 March - 1 April	Lecture	Isolated dc-dc converters (flyback and forward converter)
Week 8: 4 April - 8 April	Lecture	Isolated dc-dc converters (flyback and forward converter)
Week 9: 11 April - 15 April	Lecture	Rectifiers – diode, thyristors, single-phase and three-phase, uncontrolled and controlled
Week 10: 18 April - 22 April	Lecture	Rectifiers – diode, thyristors, single-phase and three-phase, uncontrolled and controlled

Resources

Recommended Resources

Reading List:

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.

Course Evaluation and Development

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Laboratory Workshop Information

Laboratory:

Undergraduate and postgraduate students in ELEC4614 will be required to perform three-five timetabled 3hr laboratory experiments. The timetabled laboratories will be conducted in the room indicated at the beginning of this course outline. Each experiment set will accommodate two or three students. The laboratory schedule will be released in week 1/2 with laboratories commencing week 3. Online labs will be available.

Note that laboratory is a compulsory part of ELEC4614 and students must attend the laboratory during their allotted times and commence their experiments well in time. ***Late arrivals in the laboratory will not be allowed to proceed with the experiments.***

Students must complete all timetabled experiments to qualify for further assessment.

A sample list of laboratory experiments for this course is given below.

Face-face Laboratory Experiments:

E1 - Buck DC-DC Converter

This experiment introduces the step-down DC-DC PWM converter. Its steady-state characteristic in both continuous and discontinuous modes of operation is studied. The effects between the PWM duty cycle, switching frequency and buck inductor and capacitor values on the input/out characteristics are brought out. The dynamic characteristics of the converter are obtained through frequency response tests.

E2 - Boost DC-DC Converter

This experiment introduces the step-up DC-DC PWM converter. Its steady-state characteristic in both continuous and discontinuous modes of operation is studied. The effects between the PWM duty cycle, switching frequency and boost inductor and capacitor values on the input/out characteristics are brought out. The dynamic characteristics of the converter are obtained through frequency response tests.

E3 - Single-phase Inverter

An introduction to the H-bridge inverter, associated modulation schemes and the frequency spectra of voltage and current waveforms.

E4 - Three-phase inverter

This experiment introduces you to the three-phase inverter circuit. Switching schemes for producing three-phase balanced six-step (quasi-square wave) and sine modulated AC output voltages will be studied. Effects of modulation frequency and third-harmonic injection into the modulating waveform will be studied.

E5 – Switching Characteristics

Measure and understand the dynamic characteristics of diodes and semiconductor devices during turn-on and turn-off transients. Be able to determine devices losses using an oscilloscope.

Laboratory sheets are available from the OpenLearning site for this course. Students must bring a completed and signed laboratory form that confirms that the student has read and understood the expectations of the student and their conduct in the laboratory. This includes appropriate clothing, shoes etc.

All experiments are interfaced with high-speed digital storage oscilloscopes and digital signal processors, when appropriate, with multi-channel data acquisition, waveform generation, control and data analysis, so that complex controls and data analyses are performed quickly and easily.

Laboratory Assessment:

At the end of each laboratory session, each student will be required to show their laboratory results to the lab demonstrator for marking. Students are expected to prepare their log books with data, graphs and waveforms generated during their experiments. The lab demonstrator will mark their results and answers to lab sheet questions in their log books and keep a record for forwarding to the lecturer. The log books are expected to include statements about their main observations of performance and characteristics the circuit studied and their conclusions. Answers to questions set in last section of the laboratory sheets for each experiment must also be included.

Note: *All figures/tables must be properly captioned. All graphs/oscilloscope traces must be properly labeled. Axes of all graphs and traces must be properly labeled and scaled. Operating conditions under which data were gathered must also be included.*

Academic Honesty and Plagiarism

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.

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.

Academic Information

COVID19 - 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.

Dates to note

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

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.

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.

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

Image Credit

UNSW

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Acknowledgement of Country

We acknowledge the Bedegal people who are the traditional custodians of the lands on which UNSW Kensington campus is located.

Appendix: Engineers Australia (EA) Professional Engineer Competency Standard

Program Intended Learning Outcomes	
Knowledge and skill base	
PE1.1 Comprehensive, theory based understanding of the underpinning natural and physical sciences and the engineering fundamentals applicable to the engineering discipline	✓
PE1.2 Conceptual understanding of the mathematics, numerical analysis, statistics, and computer and information sciences which underpin the engineering discipline	✓
PE1.3 In-depth understanding of specialist bodies of knowledge within the engineering discipline	✓
PE1.4 Discernment of knowledge development and research directions within the engineering discipline	✓
PE1.5 Knowledge of engineering design practice and contextual factors impacting the engineering discipline	✓
PE1.6 Understanding of the scope, principles, norms, accountabilities and bounds of sustainable engineering practice in the specific discipline	
Engineering application ability	
PE2.1 Application of established engineering methods to complex engineering 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	✓
Professional and personal attributes	
PE3.1 Ethical conduct and professional accountability	
PE3.2 Effective oral and written communication in 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	✓