KNE241: Power Electronics

Semester II, 2012
Unit Outline

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CRICOS Provider Code: 00586B
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Unit Description*

The aim of this unit is to provide students with sufficient knowledge for analysing/designing power electronic circuits for practical applications. The unit is mainly concerned with a wide range of power electronic devices/circuits, which are used in many industrial applications such as dc motor control, renewable energy generation, electric vehicle, computer power supplies, utility power system and many industrial processes. In power electronic circuits, various power semiconductor devices are used. In this unit, the operating principles, design, characteristics, protection and application of power conversion devices/circuits will be treated in detail to provide the students with the ability to design/select/maintain a reliable, efficient, cost effective and appropriate power converter for a particular application. The topics covered include: Steady state power analysis, Three phase circuits & power computation, Power semiconductor devices, Rectifiers, Pulse width modulated dc to dc converters and their control, Inverters, Applications such as wind/solar power generation, battery charger, dc/ac motor control.

Unit Content

- Introduction to Power Electronics
- Review of three phase circuits, ac power analysis, power computation & Fourier series
- Power semiconductor devices and their switching characteristics
- Gate drive circuits, Isolation, Protection of power devices and circuits
- AC to DC converter circuits:
  - Uncontrolled diode rectifier circuits: Single phase and three phase
  - Thyristor controlled rectifier circuits: Single phase and three phase
- PWM DC to DC converter circuits
  - DC-DC Converter Circuits: operation and analysis
  - Control of dc to dc converter
- DC to AC converter circuits (Inverters):
  - Single phase inverter
  - Three phase inverter

Intended Learning Outcomes*

On completion of this unit, students should be able to:

1. analyse steady state ac power and three phase circuits
2. investigate the characteristics of power electronic devices such as diode, thyristor, power BJT, IGBT and MOSFET
3. select and use power electronic devices for the control, conversion and protection of electrical energy in various applications.
4. design reliable and efficient power electronic converter circuits such as rectifiers, PWM dc-dc converter, inverters for various applications.
5. specify design criteria (power, efficiency, ripple factor, harmonic distortions, and power factor) for the designed power electronic converters.
6. apply power electronic technologies in various applications such as renewable energy generation, electric vehicle, energy conservation and in utility applications, which are becoming enormously important.
7. use application software for simulating power converter circuits for various applications.
Generic graduate attributes

The University has defined a set of generic graduate attributes (GGAs) that can be expected of all graduates (see http://www.utas.edu.au/policy/attributes_grads.pdf). By undertaking this unit you should make progress in attaining the following attributes:

**Knowledge:** Students will develop ability in applying basic engineering knowledge to complex engineering problems and technical competence in power electronics design.

**Communication skills:** Students will develop communication skills through active engagement during lecture, tutorial, laboratory sessions and cooperative learning (peer learning) in a multi-cultural environment.

**Problem-solving skills:** Students will develop problem solving skills by problem identification, formulation and solution through problem based learning (PBL) in this unit. They will learn to take responsibility for their own learning.

**Alterations to the unit as a result of student feedback**

Student Evaluation of Teaching and Learning teaching (SETL) for both the teaching and unit were carried out to improve teaching and learning for this unit. SETL is a system designed to gather feedback from students to assist academic teaching staff development and formulate their unit organisation and teaching. Based on the student SETL responses, feedback and suggestions, the following alterations are made;

- The laboratory equipment and facilities have been improved.
- Lab sheets have been improved considerably

**Prior knowledge &/or skills**

**Prior knowledge & skills:**

- Students should have prior knowledge in basic semiconductor physics, PN junction, fundamentals of ac/dc circuits, mathematics (differential equation solutions, Fourier series)

**Prerequisite Units:**

The following are the prerequisite for this unit. Students should have passed the following units.

**Prerequisite:** KNE223 Electrical Engineering 1 or KNE222 Electronic Engineering, KME271 Engineering Mathematics

M. Excl KNE331 (Advanced Circuits and Power Electronics)

**Learning expectations and teaching strategies/approaches**

**Expectations**

The University is committed to high standards of professional conduct in all activities, and holds its commitment and responsibilities to its students as being of paramount importance. Likewise, it holds expectations about the responsibilities students have as they pursue their studies within the special environment the University offers.

The University’s Code of Conduct for Teaching and Learning states:

> Students are expected to participate actively and positively in the teaching/learning environment. They must attend classes when and as required, strive to maintain steady progress within the subject or unit framework, comply with workload expectations, and submit required work on time.
Teaching and learning strategies

Learning strategies

- Lectures will be employed to deliver core concepts, theory and examples supported by notes, textbook, references and on-line materials.
- Tutorials will be used to develop, reinforce and test understanding of the subject & students are expected to participate actively.
- Laboratory sessions (in a group) will be employed to aid student’s understanding of the subject matter through hands on practical sessions.
- Problem based learning will be exercised through problem based assignments/tutorials.

Learning resources required

Required text books


Recommended reading


E- (electronic) resources

- Institute of Electrical and Electronic Engineering: http://www.ieee.org
- The Institution of Engineering and Technology: http://www.theiet.org

Power electronic components and control IC manufacturers

- Power electronic technology: http://powerelectronics.com/mag/power_top_companies/
- Semikron international: www.semikron.com
- International Rectifier: http://www.irf.com
- Infineon Technology: http://www.infineon.com
- Vishay (Siliconix): http://www.vishay.com
- Fairchild Semiconductor: http://www.fairchilddemi.com
- STMicroelectronics: http://www.st.com
- Philips Semiconductors: http://www.semiconductors.philips.com
- Toshiba http://www.toshiba.com
- Freescale Semiconductor http://www.freescale.com
- National Semiconductor: http://www.national.com
- IXYS: http://www.ixys.com
- Texas Instruments: http://www.ti.com
- Microchip: http://www.microchip.com

Library

Books are available in the Science Library.
MyLO

Course information and materials will be available in MyLo.


Other learning resources

Lecture notes on MyLo

Equipment & materials

- Equipment and materials for lab experiments are available in the power lab.

Computer hardware & software

Unit-specific software: Matlab/Simpower

For MyLO

To access MyLO from your own computer you will need the appropriate software, and hardware to run that software. Please see UConnect at http://uconnect.utas.edu.au/ for information about computer software you will need.

Note: Older computers may not have the hardware to run some of the required software applications. Contact your local IT support person or the Service Desk on 1818 if you experience difficulties.

See MyLO: Information for Students for further information about accessing MyLO.
Details of teaching arrangements*

*Lectures:* Three hours lectures per week.

*Tutorials:* One hour tutorial session per week.

*Practical/laboratory sessions:* Six “three hour” laboratory sessions.

### Teaching time table

<table>
<thead>
<tr>
<th>Components</th>
<th>Day</th>
<th>Time</th>
<th>Place</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lectures</td>
<td>Tuesday</td>
<td>09:00-11:00 AM</td>
<td>Engg. 209</td>
</tr>
<tr>
<td></td>
<td>Monday</td>
<td>5:00-6:00 PM</td>
<td>Engg.LT 201</td>
</tr>
<tr>
<td>Tutorials</td>
<td>Monday</td>
<td>06:00-07:00 PM</td>
<td>Engg.LT 201</td>
</tr>
<tr>
<td></td>
<td>(some tutorials may be on other lecture days)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Lab Time Table

<table>
<thead>
<tr>
<th>Lab #</th>
<th>Title</th>
<th>Week &amp; place</th>
<th>Group 2A</th>
<th>Group 2B</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Modeling using Matlab/Simpower</td>
<td>Week 2</td>
<td>23-07-12 Group 2A &amp; Group 2B</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>PC Lab 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>• Safety Instructions &amp; Measurements in Power Electronics</td>
<td>Week 6</td>
<td>20-08-12</td>
<td>24-08-12</td>
</tr>
<tr>
<td></td>
<td>• Switching characteristics of power semiconductor devices</td>
<td>Power Lab</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>• Single Phase Diode Rectifier Circuits</td>
<td>Week 7</td>
<td>27-08-12</td>
<td>31-08-12</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Power Lab</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>• Three Phase Diode Rectifier Circuits</td>
<td>Week 8</td>
<td>10-09-12</td>
<td>14-09-12</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Power Lab</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>• Thyristor controlled rectifier Circuits</td>
<td>Week 9</td>
<td>17-09-12</td>
<td>21-09-12</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Power Lab</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>• DC to DC converter circuits</td>
<td>Week 10</td>
<td>24-09-12</td>
<td>28-09-12</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Power Lab</td>
<td></td>
<td></td>
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</tbody>
</table>
Specific attendance/performance requirements*

- UTAS requires all students must attend at least 2/3 of total number of Lectures and tutorials. It is strongly recommended that students attend all the lectures, tutorial classes, and class tests.
- Students must attend all the laboratory sessions.
- Students are required to submit all the laboratory reports on time.
- Students who are repeating the unit should attend all the lectures, tutorials and lab classes.
- Students are required to have a minimum of 40% in the internal component (which include class tests and Lab works) and 40% in the final exam.
- To pass this unit, students have to obtain 50% mark (together in internal component and final exam).

Workshops/seminars

Online activities

Field trips

Practicum/work experience placements

Occupational health and safety (OH&S)

As standard practice, you must wear clothes appropriate for laboratory work. You will be asked to leave the laboratory if you turn up wearing thongs, shorts, or a T-shirt !! As per your workshop practices sessions, you must wear proper shoes, jeans or trousers, and long-sleeve shirts to protect against spillage or abrasion, and avoid wearing ties or scarves that can get caught in machinery. Any loose clothing or long hair should be suitably restrained.

The School of Engineering issues a document to all students outlining its OH&S policy for the School's Laboratories and Workshops. It is a requirement that all students must have read this document prior to entering any of the School’s workshops or laboratories.

“Students and staff working in the Civil & Mechanical Engineering laboratories are required to conform to the following dress requirements:

Protective footwear conforming with AS2210 having protective toe caps, full length trousers, tight fitting protective long sleeve jacket or coat, no loose clothing or hair. “

The University is committed to providing a safe and secure teaching and learning environment. In addition to specific requirements of this unit you should refer to the University’s policy at:
## Assessment*

### Assessment Summary:

<table>
<thead>
<tr>
<th>Component</th>
<th>Weight/Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class Tests</td>
<td>20%</td>
</tr>
<tr>
<td>Laboratory works</td>
<td>20% Laboratory Report (10) &amp; Lab Performance (10%)</td>
</tr>
<tr>
<td>Final exam</td>
<td>60%</td>
</tr>
</tbody>
</table>

## Assessment Schedule & Details*

<table>
<thead>
<tr>
<th>Components</th>
<th>Details</th>
<th>Schedule</th>
<th>Learning outcomes</th>
</tr>
</thead>
</table>
| Class Tests     | **Class Test 1**  
- Introduction  
- Review of three phase circuits, ac power analysis & power computation, Fourier series  
- Power semiconductor devices and their switching characteristics  
- Gate drive circuits & isolation, Protection of power devices and circuits  
- Rectifier circuits  

**Class Test 2**  
- DC to DC converters  
- Inverters  

- Date: August 21,2012  
- Time: 9 to 10 AM  
- (Week 6, Tuesday)  

- Date: Oct. 02, 2012  
- Time: 9 to 10 AM  
- (Week 11, Tuesday)  

- 1,2,3,4,5  |

| Lab sessions    | As shown in lab Time Table  | 2,6,7  |

| Final Exam      | Three hour written exam which will cover all materials covered in the unit (Lectures, tutorials, Assignments/Home works & Labs) | Examination period | 1,2,3,4,5,6  |
How your final result is determined*
- The final mark is the aggregate of internal component (40%) [class tests (20%), Laboratory works (20%),] and final examination (60%).

Submission of Assignments*
- Assignments will not contribute to the internal mark. They are meant as a self-evaluation tool for students.

Submission of Lab reports
- Students need to submit the lab report at the end of the lab session except for Lab 1.

Requests for extensions
- Only extensions for assessment tasks will be considered on the basis of medical reasons.
- Students should produce an appropriate medical certificate before the due date of the assessment task.
- If students are not able to come to the university they should inform the unit coordinator by email or telephone.

Penalties*
- Unauthorized late submissions of assessment tasks will not be accepted.
- Authorized late submissions of assessment tasks may incur a deduction of 20% off the assigned marks for each working day (maximum delay can be up to 1 day) that the submission is overdue.
- Students are required to attend all the class tests. If a student does not have valid reasons (e.g., a medical certificate) not to sit for a class test his/her mark will be zero in that particular class test.

Review of results and appeals
The review of results and appeals will be according to the university procedure.

It is expected that students will adhere to the following policy for review of any piece of continuous assessment.

1. Within 5 days of the release of the assessment result, the student should request an appointment with the Lecturer. The student should be prepared to discuss specifically which section of the marking criteria they are disputing and why they consider the mark is inappropriate.
2. Following this discussion, students may request a formal remark of the original submission (in accordance with Rule of Academic Assessment 111, clause 22.1). This remark will be undertaken, where practicable, by an alternative assessor.
3. Students may also request a review of the final result in a unit. The request and payment must be made within 10 days from the date of the result notification. Students are referred to Rule of Academic Assessment 111, clause 23 at http://www.utas.edu.au/university-council/university-governance/rules and http://www.studentcentre.utas.edu.au/examinations_and_results/results/result_review_results.htm
**Academic referencing***

In your written work, you will need to support your ideas by referring to scholarly literature, works of art and/or inventions. It is important that you understand how to correctly refer to the work of others and maintain academic integrity. Failure to appropriately acknowledge the ideas of others constitutes academic dishonesty (plagiarism), a matter considered by the University of Tasmania as a serious offence. The appropriate referencing style for this unit is according to IEEE format. See page 4 in http://www.ieee.org/portal/cms_docs/pubs/transactions/auinfo03.pdf

For information on presentation of assignments, including referencing styles:

http://utas.libguides.com/referencing

Please read the following statement on plagiarism. Should you require clarification please see your unit coordinator or lecturer.

**Academic misconduct***

*Academic misconduct* includes cheating, plagiarism, allowing another student to copy work for an assignment or an examination and any other conduct by which a student:

(a) seeks to gain, for themselves or for any other person, any academic advantage or advancement to which they or that other person are not entitled; or

(b) improperly disadvantages any other student.

Students engaging in any form of academic misconduct may be dealt with under the Ordinance of Student Discipline, and this can include imposition of penalties that range from a deduction/cancellation of marks to exclusion from a unit or the University. Details of penalties that can be imposed are available in the Ordinance of Student Discipline – Part 3 Academic Misconduct, see http://www.utas.edu.au/universitycouncil/legislation/

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**Plagiarism**

Plagiarism is a form of cheating. It is taking and using someone else’s thoughts, writings or inventions and representing them as your own; for example, using an author’s words without putting them in quotation marks and citing the source, using an author’s ideas without proper acknowledgment and citation, copying another student’s work. If you have any doubts about how to refer to the work of others in your assignments, please consult your lecturer or tutor for relevant referencing guidelines, and the academic integrity resources on the web at:

http://www.academicintegrity.utas.edu.au/

The intentional copying of someone else’s work as one’s own is a serious offence punishable by penalties that may range from a fine or deduction/cancellation of marks and, in the most serious of cases, to exclusion from a unit, a course or the University.

The University and any persons authorised by the University may submit your assessable works to a plagiarism checking service, to obtain a report on possible instances of plagiarism. Assessable works may also be included in a reference database. It is a condition of this arrangement that the original author’s permission is required before a work within the database can be viewed.

For further information on this statement and general referencing guidelines, see http://www.utas.edu.au/plagiarism/ or follow the link under ‘Policy, Procedures and Feedback’ on the Current Students homepage.

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**Further information and assistance**

If you are experiencing difficulties with your studies or assignments, have personal or life-planning issues, disability or illness which may affect your course of study, you are advised to raise these with your lecturer in the first instance.

There is a range of University-wide support services available to you including Teaching & Learning, Student Services, and International Services. Please refer to the Current Students homepage at: http://www.utas.edu.au/students/

Should you require assistance in accessing the Library visit their website for more information at http://www.utas.edu.au/library/
# Unit schedule

<table>
<thead>
<tr>
<th>Week</th>
<th>Date beginning</th>
<th>Topic</th>
<th>Readings / Resources</th>
<th>Further Information</th>
</tr>
</thead>
</table>
| 1    | 16-07-12       | • Unit outline & Introduction to Power Electronics  
• Review of three phase circuits  
• Power analysis & Computation | Lecture notes & text book | |
| 2    | 23-07-12       | • Power analysis & Computation  
• Fourier series | Lecture notes & text book | |
| 3    | 30-07-12       | • Power semiconductor devices and their switching characteristics  
• Gate drive circuits & isolation, Protection of power devices and circuits | Lecture notes & text book | |
| 4    | 04-08-12       | • Uncontrolled diode rectifier circuits: Single phase | Lecture note & texts book | |
| 5    | 13-08-12       | • Uncontrolled diode rectifier circuits: Three phase  
• Effect of Source Inductance  
• Rectifier circuit design | Lecture note & texts book | |
| 6    | 20-08-12       | • Thyristor controlled rectifier circuits: Single Phase | Lecture note & texts book | |
| 7    | 27-08-12       | • Thyristor controlled rectifier circuits: Three Phase | Lecture note & texts book | |
|      |                | **Mid-semester break** *(Break (September 03 to September 09, 2012))* | | |
| 8    | 10-09-12       | • DC to DC converter | Lecture note & texts book | |
| 9    | 17-09-12       | • DC to DC converter | Lecture note & texts book | |
| 10   | 24-09-12       | • DC to DC converter | Lecture note & texts book | |
| 11   | 01-10-12       | • Inverters: single phase & 3 Phase square wave | Lecture note & texts book | |
| 12   | 08-10-12       | • PWM Inverters | Lecture note & texts book | |
| 13   | 15-10-12       | • Review | Lecture note & texts book | |