

School of Electrical Engineering & Telecommunications  
University of New South Wales

## ELEC4614 - POWER ELECTRONICS

# Course Outline

**Lecturer:** F. Rahman

**Location:** Room EE133, Tel.: 9385 4893, email: f.rahman@unsw.edu.au

**Laboratory:** B. Karanayil (In-charge)

**Tutor:** G. Foo

### Course Objective:

Power electronic circuits are now-a-days essential for a whole array of consumer and industrial electronics products. At the low power end, these may include switched-mode regulated power supplies for hand-held devices, TVs, light fittings, computers and other entertainment systems. At the high power end, there are diverse industrial applications in high voltage DC transmission, grid connections for wind generators and PV systems; Power supplies for telecommunication equipment, welding, furnaces, and smelting; Power electronic converters for variable-speed drives in automotive and railway traction and accessories, in steel rolling, textile, paper rolling mills, machine tools, robotic, disk and other automation drives, ship propulsion and positioning, aircraft actuators and navigation, to name a few. Electronic processing of electrical power for these applications also provides the means to control these processes to obtain certain desirable goals such as energy efficiency, better product quality and accurate control of the processes

The subject is primarily concerned with the wide range of power electronic converter circuits for AC-DC, DC-DC and DC-AC power conversion. The operating principles, design, characteristics, protection and application of these electronic power converter circuits are treated in detail, with the goal of equipping the students with capability to design, select and maintain such power supplies. The reliable, efficient, cost effective and appropriate converter for a particular application is usually foremost in the mind of a power electronics engineer.

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-gate bipolar transistors (IGBT) and gate turn-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-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 concerns to users of modern power converter circuits and the utility authorities alike.

**Opportunities:**

The course is intended for students who may want to work in environments where all aspects of the design, application and maintenance of power electronic circuits which employ many diverse power semiconductor devices and their ancillary control circuits at both low and high power levels are carried out.

**Brief syllabus:**

The subject starts with coverage of the full spectrum of modern power semiconductor devices, their characteristics, both static and switching, 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.

**Handbook Entry:****ELEC4614 POWER ELECTRONICS**

Staff Contact: Prof. M. F. Rahman

UOC6 HPW4 S1

Prerequisites: ELEC2031 & ELEC2032

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; Various DC-DC, AC-DC and DC-AC converter circuit topologies, their characteristics and control techniques; 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; EMI and EMC considerations.

**Textbook:**

1. N. Mohan, T. M. Undeland & W. P. Robins, "Power Electronics; Converters, Applications and Design", John Wiley, Second Edition, 1995, New York.

**References:**

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.

**Topics Covered:**

<b>Section</b>	<b>Topic</b>	<b>Hours</b>
1	Overview of power semiconductor devices, characteristics, drive circuits, review of some electric and magnetic circuit concepts.	4
2	Diode (Uncontrolled) rectifiers	3
3	Non-Isolated DC - DC converters	4
4	Isolated DC - DC Converters	3
5	DC - AC Converters (Inverters)	5
6	Resonant (Soft - switched) converters	2
7	Device characteristics revisited, converter design issues	3
Total hours		24

**Note:**

All lecture notes, assignments, tutorial and laboratory sheets for this subject can be found on the school webpage, via Current Students → Study Notes → Lecture Notes. You may have to use username: (*your student number*) and password: *ee&tviv*. Students will be expected to bring the printed lecture notes and tutorial sheets into the lecture/tutorial room.

**Assessment:**

Students will be assessed according to the following scheme:

Final Examination	60% of total
Hand-in questions and assignments	20% of total
Laboratory work and reports	20% of total

The final examination will be for 60 marks. Any four, each of equal mark, out of the six questions set in the final examination may be answered. Copies of examination papers (without solution) for the past few years are posted on the webpage.

**Assignments:**

Students, both under- and postgraduate, may be given hand-in questions and assignments worth 20 marks. Marks scored in these assignments should be indicative of the level of understanding of and proficiency in the topics covered. Assignments will appear on the school webpage about ten days before their due dates.

**Laboratory:**

Undergraduate and postgraduate students in ELEC4614 will be required to perform four laboratory experiments. These will be conducted in room 119. Please consult the School Office about your laboratory group. Each experiment set will accommodate up to two students. The laboratory schedule will be available on the school webpage on or before the end of week. Laboratory will start from **week 2**.

Each student in ELEC4614 will be required to submit detailed reports on TWO of the four experiments performed. Each report is worth five marks. The attendance and satisfactory completion of all four experiments is worth ten marks. Students will be advised as they progress through the laboratory as to which experiments they will write reports on and their submission dates.

*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.***

The list of laboratory experiments for this course is given below.

**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. The control loop design for voltage and current control is also studied.

**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. The control loop design for voltage and current control is also studied.

**E3. Inverter**

Single and three phase pulse-width modulated inverter circuits, Transistor and diode turn-on and -off transients, Modulation schemes, effect of dead times and modulation frequency on output waveform quality.

#### **E4. PWM Rectifiers with Unity Power Factor**

Input harmonics and power factor of simple diode rectifiers. Input distortion.  
Power factor correction technique using a single power semiconductor switch.

Laboratory sheets may be downloaded from the school webpage.

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 Reports:**

Each laboratory report must include:

1. a cover page stating the title of the experiment, the student name and number, the course number and title and the lecturer's name.
2. a signed declaration on the cover page stating that all written materials submitted is the student's own work
3. an introduction which reflects the student's understanding of the operation and characteristics of the circuits studied followed by objective/goals(s) that the student expects to reach through performing the experiment
4. experimental data in the form of tables, printouts of oscilloscope (CRO) traces which are authenticated by the laboratory staff. These pages must be numbered and the laboratory staff's signature must be obtained on the last page.
5. calculation steps and graphs produced after analysis of experimental data
6. results/graphs from computer simulation, if applicable
7. students' observation/discussion of results obtained
8. answers to questions set in last section of laboratory sheets
9. students' own conclusion (about half a page) on what was achieved and learned through the experiment. This will be viewed as one of the most important parts of the report

*Note: All figures/tables must be properly captioned. All graphs/CRO 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.*

#### **Tutorials:**

Lectures will be supplemented with problem solving sessions. Five to six tutorial sheets may be expected, each including about ten problems. These problem-solving sessions will be on most recently covered topics. 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.

Tutorial sheets are available on the webpage. Solutions of problems set in tutorial sheets will be posted on the school webpage progressively, soon after problems set in each tutorial sheet are covered in class.