

ELEC4611

Power System Equipment



UNSW

THE UNIVERSITY OF NEW SOUTH WALES

School of Electrical Engineering
and Telecommunications

COURSE OUTLINES - Session 1, 2009

1. Course Staff

Course convener: Dr. Toan Phung, room EE107, toan.phung@unsw.edu.au
Laboratory demonstrators: Mr. Kai Xian Lai, Mr. Ashkan Lorashby

2. Course Details

Credits: This is a 6 UoC course; expected workload is 10-12 hours per week throughout the 12 week session.

Contact hours: The course consists of 2 hours of lectures per week, 1 hour of tutorials per fortnight, and 3 hours of laboratory sessions per fortnight:

Lectures:	Thursdays,	10-12,	room MAT312
Laboratory:	Thursdays,	13-16,	room EE115
	Fridays,	09-12,	room EE115
	Fridays,	13-16,	room EE115
Tutorials:	Thursdays,	17-18,	room MAT125
	Fridays,	15-16,	room RedC3037

Consultations: Students are encouraged to use the open consultation hour (Mon-Fri 2-3pm) rather than contact by email. Students may seek consultation with the course convener at other times by appointment.

3. Course Information

Context: Power Engineering is concerned with the generation, transmission, distribution and utilization of electrical energy. Large power systems are interconnected physical networks of many different types of equipment and apparatus: synchronous generators for generating electricity, power transformers for changing the voltage levels, overhead transmission lines, underground cables, metering and control equipment, switchgear for connection/disconnection, high-voltage insulators, etc. Because of operating conditions (different voltage and power levels) each equipment type in turn comprises many different designs.

Aims: The course aims to provide the student with essential knowledge in high-voltage power system components and equipment such as their functions, physical design, factors affecting their operation, and diagnostic techniques to monitor their condition.

Relation to other courses: The course is a fourth year professional elective offered to students following a BEE course at the University of New South Wales. The course gives the foundations in power system equipment design and technology; as such, the course would normally be taken concurrently with thesis work in the energy systems area.

Pre-requisites: The pre-requisite for the course is ELEC3105, Electrical Energy.

Assumed knowledge: It is further assumed that the students are familiar with MatLab, and have a good computer literacy.

Following courses: Many of the topics covered in this course are expanded in more details in a post-graduate course ELEC9712, High Voltage Systems. This is one of the specialisation courses for a Master degree in Engineering Science (Energy Systems).

Old courses: The course replaces part of a previous course ELEC4205/9213 (Electrical Energy Systems).

4. Learning outcomes

After the successful completion of the course, the student will be able to:

- Understand the functions of various types of equipment and major components used in electrical power systems.
- Understand the different effects (thermal, mechanical, electrical) caused by short-circuit faults and over-voltage transients.
- Calculate the steady-state thermal ratings of power cables and overhead lines.
- Calculate the electric stress and explain the dielectric design of high-voltage components.
- Apply appropriate electrical/physical/chemical measurements for insulation assessment.

The course delivery methods and course content address a number of core UNSW *graduate attributes*; these include:

- Development of in-depth knowledge and understanding in the discipline.
- Development of analytical and critical thinking, which is addressed by the tutorial exercises and class tests.
- Information literacy - the skills to appropriately locate, evaluate and use relevant information.
- The ability to engage in independent and reflective learning.
- Development of effective communication, which is addressed by the laboratory reports.
- Team and collaborative working skills (via laboratory work).

Please refer to <http://www.ltu.unsw.edu.au/content/userDocs/GradAttrEng.pdf> for more information about graduate attributes.

5. Teaching strategies

The course consists of the following elements: lectures, laboratory work, home work, and tutorials:

Lectures:

Students are expected to attend the lectures and prepare themselves for them. The lectures provide the students with a focus on the core material in the course. Generic features and functions of various types of major equipment and apparatus required in a typical power system network are

explained. This is further illustrated with practical examples from Australian power utility installations. Mathematical tools and computer-aided analysis are then used to convey a qualitative understanding of critical issues affecting the operation of power system equipment. This in turn leads students to an appreciation of the equipment ratings, choice of particular insulation materials and designs. The basic principles covering the high-voltage testing and condition monitoring of equipment are presented and then illustrated by examining a wide array of diagnostic devices that are currently being used in the power industry.

Laboratory work:

The laboratory work provides the student with hands-on experience and exposure to practical high-voltage testing, measurement and reporting. Students will work in groups of three. There will be five three-hour experiments in total. The experiments will contain material that may *not* be covered in lectures until after the experiment is done. This requires that the laboratory sheets must be read thoroughly before the laboratory session. Students must come prepared for the laboratory sessions; the laboratory sessions are short, so this is only possible way to complete the given tasks.

Tutorials:

The tutorial sessions provide personal assistance to students in solving problems. A total of 5 problem sets will be presented throughout the semester and some of these will be worked through during the tutorials. The tutorials take the student through all critical course topics and aim to exercise the students' analytical and critical thinking skills. Students are strongly encouraged to complete all the tutorial problems as these help to develop in-depth quantitative understanding of the course materials. During tutorials, students will also be invited to raise any concepts or topics covered in lectures with which they are experiencing difficulty and required another explanation. Tutorials are also opportunities for interactive discussion on any questions, issues or topics relevant to the course.

Home work:

The class lectures can only cover the course material to a certain depth; students must download the lecture notes (from the course web site) and reflect on its content as preparation for the lectures to fully appreciate the course material. Further research and reading from the recommended list of text/reference books are also required. The ability to read the literature, identify relevant parts and extract critical information with the aid of the lectures is regarded as an essential component of this course. Also, a significant component of home work is preparation for laboratory, tutorials, and writing laboratory reports.

6. Assessment details

There are three components of the assessment in this course:

Laboratory work:	10% overall weight (oral examination: 5%, written reports: 5%)
Quizzes:	20% overall weight
Final examination:	70% overall weight

Assessment task due dates are given in the course schedule. Note that there are no marks awarded for tutorial work.

Laboratory work: Students are required to attend all the scheduled laboratory sessions. Assessment of the laboratory component will be on the basis of (i) two detailed written reports to be submitted on selected experiments, and (ii) oral examination conducted by the demonstrators during

each laboratory session. Marks are awarded based on sound explanation of the experiment concept and theoretical analysis, correct measurement results and their interpretation. Students should thus use a laboratory notebook to record detailed documentation of the experimental work performed. A satisfactory performance (50% or greater) in the laboratory component is a necessary requirement to pass this course, irrespective of the marks obtained in the other components. Reports are due on the due date by 5pm. Late submissions carry a 50% penalty for the first week and will not be accepted beyond one week delay. Delays on medical grounds are accepted. The reports should be dropped into the school assignment box next to room EEG12A.

Quizzes: There are two quizzes, each is of one hour duration and closed-book, held during the lecture time through the semester. They are provided in order to get early feedback on student performance. The quizzes test the students general understanding of the course material. Assessment is a graded mark according to the correct fraction of answers to the quiz questions.

Final examination: The exam in this course is a standard closed-book 3 hours written examination, covering all aspects of the course that have been presented in the lectures and tutorials. The exam format will be similar to the previous years' examinations. The examination tests analytical and critical thinking and general understanding of the course material in a controlled fashion. Assessment is a graded mark according to the correct fraction of the answers to the exam questions.

7. Course Schedule

Wk 1:	Course overview Topic 1: Equipment and components used in electrical power systems
Wk 2:	Topic 1 (cont.) Lab 1: Fuses and circuit breakers.
Wk 3:	Topic 2 - Insulation of HV equipment: electric stress calculation, field grading. Lab 1 (odd week group); Tutorial set 1.
Wk 4:	Topic 2 (cont.) Lab 2: Surge propagation in electrical systems; Tutorial set 1.
Wk 5:	Topic 3: Insulation materials, dielectric properties. Lab 2 (odd week group); Tutorial set 2; QUIZ 1
Wk 6:	Topic 4: Overcurrents: electrodynamic forces, thermal effects, protection. Lab 3 (non-destructive HV testing); Tutorial set 2; Lab report no.1 due (24/4/08).
Wk 7:	Topic 4 (cont.) Lab 3 (odd week group); Tutorial set 3
Wk 8:	Topic 5: Equipment rating: thermal equivalent circuit, steady-state temperature rise calculation Lab 4 (impulse voltages in electrical systems); Tutorial set 3.
Wk 9:	Topic 6: Overvoltages: steady-state and transient, transient recovery voltage, current chopping. Lab 4 (odd week group); Tutorial set 4.
Wk 10:	Topic 6 (cont.): surge propagation on transmission lines or cables, overvoltage protection, insulation coordination. Lab 5 (electric stress finite element analysis); Tutorial set 4.
Wk 11:	Topic 7: High-voltage testing techniques and insulation assessment. Lab 5 (odd week group); Tutorial set 5; QUIZ 2.
Wk 12	Topic 7 (cont.); Revision. Lab report no.2 due (5/6/08); Tutorial set 5.

Note that laboratory classes start in week 2 and tutorials start in week 3. The above schedule (this version dated 16/2/09) is provisional at this stage and may be updated during the session. You should attend lectures and regularly check the course website for possible updates.

8. Resources for Students

Textbooks:

There are no prescribed textbooks for the course. A comprehensive set of lecture notes developed by the convener will be made available for download from the course web site.

Reference books:

The following references will each cover parts of the course only. They are listed in no particular order of importance:

- E. Kuffel, W.S. Zaengl, and J. Kuffel, *High Voltage Engineering: Fundamentals*, 2nd ed., Butterworth-Heinemann, 2000.
- P. Gill, *Electrical Power Equipment Maintenance and Testing*, Marcel Dekker, 1997.
- H.M. Ryan (ed.), *High Voltage Engineering and Testing*, 2nd ed., London : Institution of Electrical Engineers, c2001.
- R.E. James and Q. Su, *Condition Assessment of High Voltage Insulation in Power System Equipment*, IET, 2008.
- T.J. Gallagher and A.J. Pearmain, *High voltage: measurement, testing, and design*, Chichester [Sussex] ; New York : Wiley, c1983.
- J.D. Glover, and M. Sarma, *Power System Analysis and Design*, 3rd ed., PWS Publishers, 2001.
- B.M. Weedy, and B. Cory, *Electric Power Systems*, 4th edition, Wiley, 1998.
- N. Mohan, *First Course on Power Systems*, Minneapolis, 2006.
- T.R. Bosela, *Electrical Power System Technology*, Prentice-Hall, 1997.
- J. Eaton, and E. Cohen, *Electric Power Transmission Systems*, 2nd ed., Prentice-Hall.
- M.E. El-Hawary, *Electrical Power System Design and Analysis*, Prentice-Hall, 1983.
- T. Gonen, *Electric Power Distribution System Engineering*, McGraw-Hill, 1986.
- P. Hasse, *Overvoltage Protection in Low Voltage Systems*, Peter Peregrinus, 1992.
- F. Kussy, and J. Warren, *Design Fundamentals for Low Voltage Distribution and Control*, Marcel Dekker, 1987.
- N.H. Malik, et al, *Electrical Insulation in Power Systems*, Marcel Dekker, 1998.
- J.C. Whitaker, *AC Power Systems Handbook*, CRC Press, 1991.

On-line resources:

The web site for this course is: <https://subjects.ee.unsw.edu.au/elec4611/>. It contains lecture notes, tutorials, laboratory materials, past exam papers, as well as other relevant information and announcements about this course.

9. 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 serious offence by the University and severe penalties may apply. For more information about plagiarism, please refer to <http://www.lc.unsw.edu.au/plagiarism>.

All submitted reports and assignments must have an attached cover-sheet that declares that the work detailed in the report/assignment is entirely that of the named student(s) only. The form is available from the EE&T School web site.

Continual Course Improvement

Students are advised that the course is under constant revision in order to improve the learning outcomes of its 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.

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 policies, see <http://scoff.ee.unsw.edu.au/>
