ELEC/TELE4617
Power System Protection

Course Outline – Semester 2, 2016

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

Course Staff

Course Convener: Dr. ZHANG Daming, Room 650, E10, daming.zhang@unsw.edu.au

Consultations: You are encouraged to ask questions on the course material, after the lecture class times in the first instance, rather than via email. Lecturer consultation times will be advised during lectures. ALL email enquiries should be made from your student email address with ELEC/TELE4617 in the subject line.

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.

Course Summary

Contact Hours

The course consists of 3 hours of lectures each week, four laboratory sessions, each of which is 3 hours, and seven tutorials.

	Day	Time	Location
Lectures	Wednesday	9am-12nn	CLB 8
Tutorials	Thursday	Class 1: 1pm-2pm Class 2: 2pm-3pm	ChemSc M11
Laboratory sessions	To be informed separately when the final attendance list is available.		ElecEng130

Context and Aims

Power system protection is an integral part of every power system. All power equipment including power generators, step-up transformers, step-down transformers, transmission lines, power capacitors and electric motors and other loads etc need protection. The necessity for protection is incurred by all kinds of contingencies such as equipment failure due to insulation deterioration, lightning strike, short-circuit by nature force or creature-made happenings, inappropriate operation of power system and other inadvertent incidences. Some power equipment is very expensive such as MW generators which could cost millions of dollars. Furthermore outage due to failure of power system causes severe damage to economy and inconvenience to people's daily life. A properly designed protection can ensure power supply cut to minimum users yet continue supply power to other end users in case that a fault occurs in the system. It is a sophisticated art which needs a systematic study in order to master. All these call for a new module for undergraduate students to learn in the field of power system protection.

The course is aimed at students who have been introduced with fundamental knowledge of power system. The objectives of this course are

After taking this course the students will have a deep understanding on the concepts of power system protections, instrument transformers, fundamentals of relaying, overcurrent protection and coordination, directional overcurrent protection, differential protection, distance protection, distributed generation protection, IEC61850 based substation automation etc.

Indicative Lecture Schedule

Period	Summary of Lecture Program
Week 1	**Introduction to power system protection**
Week 2	**Review on fault analysis**
Week 3	**Fundamentals of electromechanical relays and digital protective relaying**
Week 4	**Fundamentals of electromechanical relays and digital protective relaying**
Week 5	**Instrument transformers, circuit breakers and fuse**
Week 6	**Instrument transformers, circuit breakers and fuse**
Week 7	**Overcurrent protection and coordination**
Week 8	**Directional overcurrent protection**
Week 9	**Mid-Semester Exam**
Mid-term break	
Week 10	**Directional overcurrent protection**
Week 11	**Differential protection**
Week 12	**Distance protection**
Week 13	**Distance protection; Summarization on course**

Assessment

For undergraduate students:

Mid-Semester Exam	15%
Laboratory sessions	10%
Final Exam (3 hours)	75%
Final results	Addition of three components

For postgraduate students:

Mid-Semester Exam	15%
Laboratory sessions	10%
Final Exam (3 hours)	75%
Assignment	15%
Final results	(Addition of four components)*100/115

Course Details

Credits

This is a 6 UoC course.

Relationship to Other Courses

This is a course in the School of Electrical Engineering and Telecommunications open to both undergraduates and postgraduates.

Pre-requisites and Assumed Knowledge

It is essential that you are familiar with basic electrical power engineering knowledge before this course is attempted. If you are undergraduates of UNSW, you need to have taken ELEC3105 Electrical Energy and ELEC4612 Power System Analysis. Under special cases, you could be allowed to take this course even if you have not taken ELEC4612.

Learning outcomes

After successful completion of this course, you should be able to grasp:

1. Calculation of both symmetrical and un-symmetrical fault currents
2. Understanding the fundamentals of electromechanical relays and digital protective relaying
3. The basic methods of calculating the magnitude and angle of voltage and current for the digital relaying
4. The methods to choose suitable current transformer, voltage transformer and circuit breakers etc for fulfilling power system protection
5. Design of overcurrent protection and its coordination
6. Design of directional overcurrent protection
7. Design of differential protection
8. Design of distance protection
9. Understanding the basic concepts of islanding in the operation of microgrid; understanding of application of IEC61850 communication protocol in the power system protection

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 capabilities (listed in ***Appendix B***). This course also addresses the Engineers Australia (National Accreditation Body) Stage I competency standard as outlined in ***Appendix C***.

Syllabus

Course Content	**Hours**
1. Introduction to power system protection	1.5
2.Review on fault analysis	1.5
3. Relaying: operating principles	4.0
4. Current and voltage transformers and circuit breakers and fuses	6.0
5.Overcurrent protection and its coordination	4.5
6.Directional overcurrent protection	4.5
7.Differential overcurrent protection	5.5
8.Distance protection	5.5
9.Islanding detection, distributed and renewable power generation protection and load shedding	0.5
10.IEC61850 based substation automation including protection	0.5
Total	34.0

Teaching Strategies

Delivery Mode

The teaching in this course aims at establishing a good fundamental 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;
- Laboratory sessions, which allows you to access latest digital relays and their application to power system protection.

Learning in this course

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

Tutorial classes

You should attempt all of your problem sheet questions in advance of attending the tutorial classes. The importance of adequate preparation prior to each tutorial cannot be overlooked, as the effectiveness and usefulness of the tutorial depends to a large extent on this preparation. Group learning is encouraged. Answers for these questions will be discussed during the tutorial session.

Laboratory sessions

Totally there are four laboratory sessions, each of which has an individual user manual. You need to do sufficient preparation by reading the manual before going for each session. Otherwise you could be faced with being short of time to complete the three-hour laboratory sessions.

Assessment

The assessment scheme in this course reflects the intention to assess your learning progress through the semester. Ongoing assessment occurs through the mid-semester exam.

Mid-Semester Exam

The mid-session examination tests your general understanding of the course material, and is designed to give you feedback on your progress through the analytical and descriptive components of the course. Questions may be drawn from any course material up to the end of week 6. It will definitely contain numerical and analytical questions. Marks will be assigned according to the correctness of the responses.

Final Exam

The exam in this course is a standard closed-book 3-hour written examination, comprising four compulsory 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 (including laboratory), unless specifically indicated otherwise by the lecturer. Marks will be assigned according to the correctness of the responses.

Laboratory sessions

You will be assessed by the laboratory demonstrators during each session.

Assignment

This assignment is on application of IEC61850 to power system protection. It is only for postgraduate students. Details can be found in a separate file.

Course Resources

References

1. Protective Relaying: Principles and Applications, Third Edition, J. Lewis Blackburn, Thomas J. Domin, CRC Press, 2007.
2. Power System Analysis, John J. Grainger and William D. Stevenson, JR., McGraw-Hill, 1994.
3. Power system relaying, Horowitz, Stanley H. Phadke, Arun G, 3rd edition, Chichester, West Sussex, New York: Wiley 2008.
4. Digital protection for power system, AT Johns and SK Salman, IEE Power series 15, Peter Peregrinus Ltd., 1995.
5. Power system protection, P.M. Anderson, Wiley-Interscience, 1999.
6. Power system protection and communications, Akhtar Kalam, DP Kothari, New Age Science, 2010.
7. INSTRUMENT TRANSFORMERS AND PROTECTION SETTINGS, RASTKO ZIVANOVIC, School of Engineering Systems, The Adelaide University, Adelaide, SA, API sponsored notes.
8. TELECOMMUNICATIONS AND COMMUNICATIONS PROTOCOLS, AKHTAR KALAM, School of Engineering and Science Victoria University Adelaide, SA, API sponsored notes.
9. PROTECTION OF TRANSMISSION AND DISTRIBUTION NETWORKS, ARINDAM GHOSH, School of Engineering Systems Queensland University of Technology Brisbane, Qld, API sponsored notes.
10. Power system protection, P. Wang.
11. Protection of Electricity Distribution Networks, 2nd Edition, Juan M. Gers and Edward J. Holmes, The Institution of Electrical Engineers, 2004.
12. Grid converters for photovoltaic and wind power systems, Remus Teodorescu, Marco Liserre and Pedro Rodriguez, Wiley, 2011.

On-line resources

Moodle

As a part of the teaching component, Moodle will be used to disseminate teaching materials, and host forums. Assessment marks will also be made available via Moodle: https://moodle.telt.unsw.edu.au/login/index.php.

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.

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.

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 Capabilities

The course delivery methods and course content directly or indirectly addresses a number of core UNSW graduate capabilities, 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.
- Developing ethical practitioners who are collaborative and effective team workers, through group activities, seminars and tutorials.
- Developing independent, self-directed professionals who are enterprising, innovative, creative and responsive to change, through challenging design and project tasks.
- Developing citizens who can apply their discipline in other contexts, are culturally aware and environmentally responsible, through interdisciplinary tasks, seminars and group activities.

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	✓