School of Electrical Engineering and Telecommunications

Term 1, 2019
Course Outline

ELEC4612
Power System Analysis

Course Staff

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Course websites: OpenLearning https://www.openlearning.com/
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Consultations: You are encouraged to ask questions on the course material, after the face-to-face class times, rather than via email. You are strongly encouraged to use the online discussions in the course website. Lecturer consultation times will only be provided for those students actively involving in online discussions. This applies to email enquiries as well. If you have technical problems in using the new platform, you are welcome to email the online facilitators, who can answer your questions. ALL email enquiries should be made from your student email address with ELEC4612 in the subject line; otherwise they will not be answered.

Keeping Informed: Most announcements will be made via OpenLearning. 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 face-to-face session every week, a 1-hour tutorial every fortnight and a 3-hour laboratory session each fortnight. The tutorial and laboratory sessions commence from week 1. The course is available in the online mode via OpenLearning platform. All topics will be available online with enough video content and on an interactive mode. You are strongly encouraged to participate in all online modules.

	Day	Time	Location
Lectures	Wednesday	11am - 1pm	Mathews ThB
	Thursday	1pm – 2pm	Mathews ThB
Laboratory	Mon - Fri	3 hours	EE206 (G17)
Tutorials	Monday	2pm – 3pm	TETB G17
	Monday	3pm – 4pm	TETB G17

Context and Aims

Context: Power systems are complex networks of generators and loads interconnected via transmission lines and various types of equipment and apparatus (transformers, switchgear, etc). An overview of modern power systems meeting present and future challenges involves understanding the fast changing structure of this system, the behaviour of its components under steady state, and dynamic and transient conditions. The course helps with an understanding to evaluate the response of this complex system to variation of loads, and to determine how this system can be controlled to supply the loads reliably, while it is economical and safe to the environment.

Aims: The course will provide students with essential knowledge in the mathematical techniques to analyse power systems, both under steady state and dynamic conditions.

Topics covered comprise: review of the basic concepts used in power system analysis: phasors, complex power, three phase systems and per-unit; application of network matrices techniques and power flow analysis to study the steady-state and dynamic behaviour of power systems; power system fault calculations including: symmetrical components, symmetrical faults, and unsymmetrical faults; power system stability by introduction of swing equation, single-machine-infinite-bus analysis; power system control and economic dispatch.

Indicative Lecture Schedule

Period	Summary of Lecture Program
Week 1	Three phase systems
Week 2	Power system modelling
Week 3	Ybus matrix building
Week 4	Power flow analysis: Gauss-Seidel technique
Week 5	Power flow analysis: Newton-Raphson technique; Mid-term exam
Week 6	Symmetrical fault analysis
Week 7	Unsymmetrical fault analysis
Week 8	Power system stability
Week 9	Economic dispatch; Group report due
Week 10	Load frequency control

Indicative Laboratory Schedule

Period	Summary of Laboratory Program
Week 1	Introduction to Power World Simulator
Week 2	
Week 3	Power flow analysis
Week 4	
Week 5	Fault analysis
Week 6	
Week 7	Transient stability analysis
Week 8	
Week 9	Economic dispatch
Week 10	

Assessment

Laboratory In-class Experiments	15%
Project based learning (PBL)	25%
Mid-Semester Exam	20%
Final Exam (2 hours)	40%

Course Details

Credits

This is a 6 UoC course and the expected workload is 15 hours per week throughout the 10-week semester.

Relationship to Other Courses

The course is a fourth year professional elective offered to students following a BE (ELEC) course at UNSW. The course gives the foundations for power system network analysis and design; as such, the course would normally be taken concurrently with thesis work in the energy systems area.

Pre-requisites and Assumed Knowledge

The pre-requisite for the course is ELEC3105, Electrical Energy. It is further assumed that the students have good computer literacy and mathematical skills.

Following Courses

Some of the topics covered in this course are expanded in more details in a post-graduate course ELEC9715, Electricity Industry Operation and Control. This is one of the specialization courses for a Master degree in Engineering Science (Energy Systems).

Learning outcomes

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

1. Model major types of components used in electrical power systems.
2. Calculate the steady-state power flow in a power system.
3. Analyse different types of short-circuit faults.
4. Calculate the power system dynamics and its stability.
5. Determine the economic dispatch in a power system.
6. Understand power system control.

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

An overview of modern power systems; Review of the basic concepts used in power system analysis: phasors, complex power, three phase systems and per-unit methodology; Modelling circuit of power system components including transformers, generators, transmission lines and loads; Steady state and dynamic behaviour of power systems; Network matrices and power flow analysis; Power system fault calculations: symmetrical components, symmetrical faults, unsymmetrical faults; Power system stability: swing equation; Power system control, economic dispatch.

Teaching Strategies

Delivery Mode

The course consists of the following elements: online activities, in-class discussions, laboratory work, exercise questions, tutorials and project based learning (PBL).

The teaching in this course aims at establishing a good fundamental understanding of the areas covered using:

- In-class discussions, which provide you with a focus on the core analytical material in the course, together with qualitative, alternative explanations to aid your understanding;
- Face-to-face mentoring sessions that will promote group work and enhance deeper learning of the concepts.
- PBL focuses on active, student-directed learning and gives you an authentic, real-world context for learning.
- Tutorials, which allow for exercises in problem solving and allow time for you to resolve problems in understanding of lecture material and PBL activities;
- Laboratory sessions, which support the formal lecture material and also provide you with practical construction, measurement and debugging skills;
- Blended learning activities via online modules that enable active discussions.

Learning in this course

You are expected to attend all face-to-face sessions, tutorials, labs, and mid-semester exams in order to maximise learning. You must prepare well for your laboratory classes and your lab work will be assessed. In addition to the lecture notes/video, you should read relevant sections of the recommended text. Reading additional texts will further enhance your learning experience. Group learning is encouraged and organised during the flipped mode teaching sessions. UNSW *assumes* that self-directed study of this kind is undertaken in addition to attending face-to-face sessions throughout the course.

Tutorial classes

There are five tutorial sheets. The workout solution as well as the video solutions are made available online. Using these resources, 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 overemphasised, as the effectiveness and usefulness of the tutorial depends to a large extent on this preparation. During the face-to-face tutorial session, group learning will be organised in the presence of mentors. Complex exercise question available in OpenLearning will be discussed during these sessions. These solutions will not be made available on the web, so it is worthwhile for you to attend your tutorial classes to gain maximum benefit from this course.

Laboratory program

The laboratory schedule is deliberately designed to provide practical, simulation-based exposure to the concepts conveyed in lectures soon after they are covered in class. You are required to attend laboratory from Week 1 to Week 10. Laboratory attendance WILL be kept, and you MUST attend at least 80% of labs. Due to the 10-week term, the laboratory exercises do not follow the theory. This means you need to go through the theory before attempting the laboratory sessions ahead of the lecture. The online modules greatly assist you with these. Additionally, video instructions for each laboratory exercise is available in the course website.

Laboratory Exemption

There is no laboratory exemption for this course. Regardless of whether equivalent labs have been completed in previous courses, all students enrolled in this course for Term 1, 2019 must take the labs. If, for medical reasons, (note that a valid medical certificate must be provided) you are unable to attend a lab, you will need to apply for a catch-up lab during another lab time, as agreed by the laboratory demonstrator.

Assessment

The assessment scheme in this course reflects the intention to assess your learning progress through the semester. Ongoing assessment occurs through the lab checkpoints (see lab manual), PBL and the mid-semester exam.

Laboratory In-class Experiments

Laboratories are primarily about learning, and the laboratory assessment is designed mainly to check your knowledge as you progress through each stage of the laboratory tasks. You are required to maintain a lab book for recording your observations. A lab book is an A4 size notebook containing a mix of plain pages and graph sheets. You can purchase your own lab book from any stores.

It is essential that you complete the laboratory preparation before coming to the lab. You are required to write the aim of the experiment and complete all theoretical calculations. The pre-lab questions of the labs must be answered in the lab book, before attending the lab session. This will be verified and signed by your demonstrators in the lab. You will be recording your observations/readings in your lab book first and then completing and showing the results on the PC screen before leaving the lab.

After completing each experiment, your work will be assessed by the laboratory demonstrator. Both the screen and your lab book will be assessed by the laboratory demonstrator.

Assessment marks 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, and your understanding of the topic covered by the lab. All lab notebooks have to be submitted at the end of the course.

The laboratory in-class assessment is worth 15% of the marks. There are five lab exercises and each will be contributing to 3% marks towards the course. This means if you are unable to complete any particular lab session, you will miss 3 marks straightaway.

Project Based Learning (PBL)

PBL is introduced in this course for you to gain knowledge and skills by investigating and responding to an engaging challenge in various topics of the course. The students will work in groups. There will be various challenging problems presented to the students. Note that the allocations for each group would be performed at random. The aim of PBL is to work on the solution to a problem both analytically and via software implementation. There will be five online quizzes on various topics contributing to 10% towards the course. These quizzes will be via Moodle. The quizzes will aid understanding of the material. The assessment towards the actual problem challenge will be 10% towards the course. This will include a brief report submission which is due in Week 9. Detailed course material and all lecture videos are available in OpenLearning. To ensure that you use the materials effectively, a mark of 5% is allocated to the progress bar monitor.

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 components of the course. Questions may be drawn from any course material up to the end of week 4 (topics include up to power flow analysis). It may contain questions requiring some (not extensive) knowledge of laboratory material, and will definitely contain numerical and analytical questions. Marks will be assigned according to the correctness of the responses. The test is of 75-minute duration, closed-book, held during **Week 5 Wednesday 18-20 hrs, AinswthG03**. This assessment provides 20% contribution towards your course.

Final Exam

The exam in this course is a standard closed-book 2 hours written examination, covering the aspects of the course from week 5. Note that the material previous to week 5 cannot be completely ignored, although there may not be specific questions from those topics that are already covered in the mid-session exam. A thorough knowledge of these topics is essential to answer the exam questions. The exam format will be similar to the previous years' examinations (fully numerical based). The examination tests analytical and critical thinking and general understanding of the course material in a controlled fashion.

Please note that you must pass the written exam (final exam + mid-session exam put together) in order to pass the course.

Relationship of Assessment Methods to Learning Outcomes

	Learning outcomes					
Assessment	**1**	**2**	**3**	**4**	**5**	**6**
Laboratory practical assessments	✓	✓	✓	✓	✓	-
PBL	✓	✓	✓	✓	✓	✓
Mid-semester exam	✓	✓	-	-	-	-
Final exam	-	-	✓	✓	✓	✓

Course Resources

Textbooks

Prescribed textbook

- J.D. Glover, and M.S Sarma, T.J. Overbye, *Power System Analysis and Design*, 5th Edition (SI), Cengage Learning, 2012.

Reference books

- Stevenson, W D: *Elements of Power System Analysis***,** 4th edition, McGraw-Hill, 1982
- P.Kundur, "Power System Stability and Control", McGraw, 1994.
- Olle. I. Elgerd, 'Electric Energy Systems Theory – An Introduction', McGraw Hill, 2003.
- 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.
- J.C. Whitaker, *AC Power Systems Handbook*, CRC Press, 1991.
- Greenwood, A: *Electrical Transients in Power Systems*. John Wiley.
- Wood, A & Wollenberg, B: *Power Generation Operation & Control*, Wiley,1984

On-line resources

OpenLearning www.openlearning.com

As a part of the teaching component, openLearning platform will be used to disseminate teaching materials and host forums. Assessment marks will also be made available via this platform.

Moodle https://moodle.telt.unsw.edu.au/login/index.php

Occasionally Moodle may be used to host quizzes. Information on this will be made available later.

Mailing list

All announcements concerning course information will be available in OpenLearning. They may also be reiterated during the lectures 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. As of Term 1 2019, assessment of applications for Special Consideration will be managed centrally and the University has introduced a "fit to sit/submit" rule. You will no longer be required to take your original documentation to The Nucleus for verification. Instead, UNSW will conduct source checks on documentation for verification purposes. 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. If you sit an exam or submit an assignment, you are declaring yourself well enough to do so.

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 myExperience. 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. The lecture hours have retained at three hours per week similar to last year. PBL has been introduced. Based on the feedback from previous year on blended delivey, this year the face-to-face mentoring sessions are being introduced, to enable active learning and closer interaction within the group via students as partners.

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 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 ethical practitioners who are collaborative and effective team workers, through group activities, lab work and tutorials.

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	✓