School of Electrical Engineering and Telecommunications

Term 1, 2021
Course Outline

ELEC4612
Power System Analysis

Course Staff

Course convener: Dr. Jayashri Ravishankar, Room # 122, Building G17
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Course websites: OpenLearning https://www.openlearning.com/
Moodle https://moodle.telt.unsw.edu.au/login/index.php

Consultations: You are encouraged to ask questions on the course material, during lecture and tutorial times, rather than via email. You are strongly encouraged to use the online discussions in the course websites and MS Teams. 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 course facilitator, 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 6 contact hours every week that includes laboratory and tutorial sessions from Weeks 1-10. 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	Monday	15-17	Online (MS Teams)
Tutorial	Tuesday	13-14	TETB G16 / Online
	Tuesday	14-15	TETB G16 / Online
Laboratory / mentoring	Wed, Thu & Fri	3 hours	Online / EE206
Midterm	W7 Tuesday	15-17	Online

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: 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	Assessments
Week 1	Three phase systems	
Week 2	Power system modelling; Ybus matrix building	Quiz 1 (Sun)
Week 3	Power flow analysis: Gauss-Seidel technique	
Week 4	Power flow analysis: Newton-Raphson technique;	Quiz 2 (Sun)
Week 5	Symmetrical & Unsymmetrical fault analysis;	
Week 6	FLEXIBILITY WEEK (Tutorial sessions are available)	
Week 7	Power system stability	Quiz 3 (Mon); Mid-term exam (Tue)
Week 8	Economic dispatch without loss	Quiz 4 (Sun)
Week 9	Economic dispatch with loss	
Week 10	Load frequency control	Quiz 5 (Sun)

Indicative Laboratory Schedule

Period	Summary of Laboratory Program	Assessments
Week 1	Lab 1 Introduction / STACK tutorial / Microgrid project	
Week 2	Lab 2 Power flow / STACK tutorial / Microgrid project	
Week 3	Lab 2 Power flow / STACK tutorial / Microgrid project	Lab 2 (Fri)
Week 4	Lab 3 Faults / STACK tutorial / Microgrid project	
Week 5	Lab 3 Faults / STACK tutorial / Microgrid project	Lab 3 (Fri)
Week 6	Optional Lab / STACK tutorial / Microgrid project	
Week 7	Lab 4 Stability / STACK tutorial / Microgrid project	
Week 8	Lab 4 Stability / STACK tutorial / Microgrid project	Lab 4 (Fri)
Week 9	Lab 5 Economic dispatch / STACK tutorial / Microgrid project	
Week 10	Lab 5 Economic dispatch / STACK tutorial / Microgrid project	Lab 5 (Fri)

Assessment

Laboratory Assessments (5% x 4)	20%
Online activities	30%
(Quiz – 10%; Course progress – 5%, microgrid project –10%, engagement – 5%)	
Mid-term Exam	15%
Final Exam	35%

You must pass (Mid-term + Final exam) to pass the course!

Important Health Related Notice

Your health and the health of those in your class is critically important. You must stay at home if you are sick or have been advised to self-isolate by NSW health or government authorities. Current alerts and a list of hotspots can be found here. **You will not be penalised for missing a face-to-face activity due to illness or a requirement to self-isolate**. We will work with you to ensure continuity of learning during your isolation and have plans in place for you to catch up on any content or learning activities you may miss. Where this might not be possible, an application for fee remission may be discussed.

If you are required to self-isolate and/or need emotional or financial support, please contact the Nucleus: Student Hub. If you are unable to complete an assessment, or attend a class with an attendance or participation requirement, please let your teacher know and apply for special consideration through the Special Consideration portal. To advise the University of a positive COVID-19 test result or if you suspect you have COVID-19 and are being tested, please fill in this form.

UNSW requires all staff and students to follow NSW Health advice. Any failure to act in accordance with that advice may amount to a breach of the Student Code of Conduct. Please refer to the Safe Return to Campus guide for students for more information on safe practices.

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 Master of Engineering Science and Master of Engineering programs in Electrical Engineering.

Learning outcomes

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

1. Model major types of components used in electrical power systems including microgrids.
2. Calculate the steady-state power flow in a power system and microgrids.
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. Analyse power system control aspects.

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; Overview of techniques related to distributed generation.

Teaching Strategies

Delivery Mode

The course consists of the following elements: online activities, in-class discussions, laboratory work, exercise questions, tutorials and interactive quizzes.

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

- In-class discussions / lectures, which provide you with a focus on the core analytical material in the course, together with qualitative, alternative explanations to aid your understanding;
- Mentoring sessions that will promote group work and enhance deeper learning of the concepts;
- Interactive quizzes focus on active, student-directed learning and give 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;
- 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 lectures, labs, and mid-term exams in order to maximise learning. You must prepare well for your laboratory classes and your lab work will be assessed. There will be problem solving exercises in the lab sessions which must be completed. 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.

Laboratory / mentoring 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 will also receive mentoring from a dedicated mentor in small groups, where you will learn the applications of concepts to microgrids. You are required to attend laboratory all weeks, except Week 6 (flexibility week).

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, 2021 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), problem solving exercises and the mid-term 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 task. You are required to maintain a record of your lab observations.

Lab work is scheduled every week for one hour. It is essential that you complete the laboratory preparation before coming to the lab. You will then complete the experiments and show the results on the PC screen before leaving the lab (if you attend F2F) or share your screen (if online).

After completing each experiment, your work will be assessed by the laboratory demonstrator. Both the screen and your understanding of the lab work (via viva) will be assessed.

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 in the lab.

The lab reports for each lab should be submitted online on Fridays (8 pm) of the allocated weeks (see indicative laboratory schedule for the deadline). The report requires a set of questions to be answered, along with any graphical plots that may be asked for the report. Details are available in the lab manual.

The lab work is software based and uses a freeware PowerWorld simulator that can be downloaded to your laptops. Instructions are available in the course website. Note that this is for Windows only. If you are using Macbooks, you should make your own arrangements to organise a windows laptop. Alternatively, if you are in Sydney, you can attend the labs F2F in room EE206 during the scheduled lab times. You **must take prior approval** from the coordinator to attend the F2F lab sessions.

The laboratory in-class assessment is worth 20% of the marks. Although there are five lab exercises only Labs 2-5 will be assessed, each worth 5%.

Online activities

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 quizzes should be submitted online on Sundays (8 pm) of the allocated weeks, except for Quiz 3 (see indicative lecture schedule for the deadlines). Detailed course material and all lecture videos are available in OpenLearning (OL). To ensure that you use the materials effectively, a mark of 5% is allocated to the progress bar monitor in OL. Additionally, to apply the concepts learnt in the course to distributed energy resources, you will be required to complete a microgrid project with the help of mentors during the lab session, which is worth 10%. Your attendance and engagement during these interactive lab sessions will be assessed every week out of 5. You will have to attend 8 out of the 9 sessions to get a total of 8 x 5 = 40 marks, which will be scaled to 5% contribution towards the course.

Mid-term Exam

The mid-term 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 will be online via Moodle STACK questionnaire, held during **Week 7 Tuesday 3-5 pm**. This assessment provides 15% contribution towards your course.

Final Exam

The final exam in this course will cover 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-term exam. A thorough knowledge of these topics is essential to answer the exam questions. The exam format will be announced closer to the time. 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-term 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	✓	✓	✓	✓	✓	-
Online activities	✓	✓	✓	✓	✓	✓
Mid-term 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.

Moodle https://moodle.telt.unsw.edu.au/login/index.php
Moodle will be used to host quizzes. Assessment marks will also be made available via this platform.

Mailing list

All announcements concerning course information will be available in OpenLearning. They may also be reiterated during the lectures and/or via Moodle announcements.

Other Matters

Dates to note

Important Dates available at: https://student.unsw.edu.au/dates

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 **15 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 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. Be aware of the "fit to sit/submit" rule which means that if you sit an exam or submit an assignment, you are declaring yourself well enough to do so and cannot later apply for Special Consideration. For more information and how to apply, see https://student.unsw.edu.au/special-consideration.

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 been increased to 4 hours which includes two hours of interactive problem-solving sessions. The lab and Quiz submissions have been adjusted to follow theory. More online support is provided via small group mentoring during the lab sessions to help with further problem solving. Lab sessions have been introduced every week. Application of the concepts have been extended to modern power systems (microgrids).

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

Competency Standards		Learning Outcomes
PE1: Knowledge and Skill Base	PE1.1 Comprehensive, theory-based understanding of underpinning fundamentals	1, 2, 3, 4, 5, 6
	PE1.2 Conceptual understanding of underpinning maths, analysis, statistics, computing	1, 2, 3, 4, 5, 6
	PE1.3 In-depth understanding of specialist bodies of knowledge	1, 2, 3, 4, 5, 6
	PE1.4 Discernment of knowledge development and research directions	1, 2, 3, 4, 5, 6
	PE1.5 Knowledge of engineering design practice	1
	PE1.6 Understanding of scope, principles, norms, accountabilities of sustainable engineering practice	1, 2, 3
PE2: Engineering Application Ability	PE2.1 Application of established engineering methods to complex problem solving	1, 2, 3, 4, 5, 6
	PE2.2 Fluent application of engineering techniques, tools and resources	1, 2, 3, 4, 5
	PE2.3 Application of systematic engineering synthesis and design processes	1, 2, 3
	PE2.4 Application of systematic approaches to the conduct and management of engineering projects	1, 2, 3, 4, 5, 6
PE3: Professional and Personal Attributes	PE3.1 Ethical conduct and professional accountability	2, 3, 4, 5, 6
	PE3.2 Effective oral and written communication (professional and lay domains)	1, 2, 3, 4, 5, 6
	PE3.3 Creative, innovative and pro-active demeanour	1, 3, 5, 6
	PE3.4 Professional use and management of information	1, 2, 3, 4, 5, 6
	PE3.5 Orderly management of self, and professional conduct	1, 2, 3, 4, 5, 6
	PE3.6 Effective team membership and team leadership	1, 2, 3, 4, 5, 6