School of Electrical Engineering & Telecommunications

UNSW Engineering

ELEC4612

Power System Analysis

Term 3, 2022

Course Overview

Staff Contact Details

Convenors

Name	Email	Availability	Location	Phone
Jayashri Ravishankar	jayashri.ravishankar@unsw.edu.au		EE124	

Tutors

Name	Email	Availability	Location	Phone
Anam Malik	anam.malik1@unsw.edu.au			

School Contact Information

Consultations: Lecturer consultation times will be advised during the first lecture. You are welcome to email the tutor or laboratory demonstrator, who can answer your questions on this course and can also provide you with consultation times. ALL email enquiries should be made from your student email address with ELEC/TELExxxx in the subject line; otherwise they will not be answered.

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.

Student Support Enquiries

For enrolment and progression enquiries please contact Student Services

Web

Electrical Engineering Homepage

Engineering Student Support Services

Engineering Industrial Training

UNSW Study Abroad and Exchange (for inbound students)

UNSW Future Students

Phone

(+61 2) 9385 8500 – Nucleus Student Hub

(+61 2) 9385 7661 – Engineering Industrial Training

(+61 2) 9385 3179 – UNSW Study Abroad and UNSW Exchange (for inbound students)

Email

Engineering Student Support Services – current student enquiries

- e.g. enrolment, progression, clash requests, course issues or program-related queries

Engineering Industrial Training – Industrial training questions

UNSW Study Abroad – study abroad student enquiries (for inbound students)

UNSW Exchange – student exchange enquiries (for inbound students)

UNSW Future Students – potential student enquiries

- e.g. admissions, fees, programs, credit transfer

Course Details

Units of Credit 6

Summary of the Course

An overview of 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, single-machine-infinite-bus analysis. Power system control, economic dispatch.

Course Aims

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.

Course Learning Outcomes

After successfully completing this course, you should be able to:

Learning Outcome	EA Stage 1 Competencies
1. Mathematically model major types of components used in electrical power systems	PE1.1, PE1.2, PE1.3, PE1.4, PE1.5, PE1.6, PE2.1, PE2.2, PE2.3, PE2.4, PE3.2, PE3.3, PE3.4, PE3.5, PE3.6
2. Calculate the steady-state power flow in a power system	PE1.1, PE1.2, PE1.3, PE1.4, PE1.6, PE2.1, PE2.2, PE2.3, PE2.4, PE3.1, PE3.2, PE3.4, PE3.5, PE3.6
3. Compute fault parameters for different types of short-circuit faults	PE1.1, PE1.2, PE1.3, PE1.4, PE1.6, PE2.1, PE2.2, PE2.3, PE2.4, PE3.1, PE3.2, PE3.3, PE3.4, PE3.5, PE3.6
4. Calculate the power system dynamics and its stability	PE1.1, PE1.2, PE1.3, PE1.4, PE2.1, PE2.2, PE2.4, PE3.1,

Learning Outcome	EA Stage 1 Competencies
	PE3.2, PE3.4, PE3.5, PE3.6
5. Determine the economic dispatch in a power system	PE1.1, PE1.2, PE1.3, PE1.4, PE2.1, PE2.2, PE2.4, PE3.1, PE3.2, PE3.3, PE3.4, PE3.5, PE3.6
6. Evaluate the system frequency using power system control techniques	PE1.1, PE1.2, PE1.3, PE2.1, PE2.4, PE3.1, PE3.2, PE3.3, PE3.4, PE3.5, PE3.6

Teaching Strategies

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;
- 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.

Laboratory work

The laboratory work provides the student with experience of power system model computation and analysis through application of different software (PowerWorld, PSCAD) and exposure to modeling and analysis of simulated power systems. Students will work individually.

Labs commence in week 2 and a three-hour lab work is scheduled every week, however only four labs will be assessed. The experiments will contain materials that may not be covered in lectures prior to the lab work. 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 tight, so this is the only possible way to complete the given tasks. You are required to attend all the labs, otherwise your lab reports will not be accepted. 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.

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 3, 2022 must take the labs.

Tutorials

The tutorial sessions provide personal assistance to students in solving problems. This will be interative with students working in groups and supported by mentors. A variety of questions will be presented in the tutorials following the lecture content every week. The tutorials take the student through all critical course topics and aim to improve analytical and critical thinking skills. Students are strongly encouraged to complete all the tutorial problems as these will 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.

Additional Course Information

The background knowledge required is a minimum of ELEC3105 for UG students. Although, there are no pre-requisite courses for PG students, the students should have prior knowledge on complex phasor calculations in AC circuits and electrical machine principles.

Indicative Lecture Schedule

	Day	Time	Location
Lectures	Monday	14-16	Online / Rex Vowels
WKS	Wednesday	14-16	Online
	Friday	11-13	CLB6
Laboratory / mentoring	Tue, Thu & Fri	3 hours	Online / EE108

Period	Summary of Lecture Program	Workshop (WKS) schedule
Week 1	Three phase systems	Three phase systems
Week 2	Power system modelling (PU); Ybus matrix building	Ybus
Week 3	Power flow analysis: GS & NR	GS method
Week 4	**LABOUR DAY**	NR method
Week 5	Symmetrical fault analysis	Symmetrical fault analysis
Week 6	**FLEXIBILITY WEEK**	-
Week 7	Unsymmetrical fault analysis;	Unsymmetrical fault analysis;
Week 8	Power system stability	Power system stability
Week 9	Economic dispatch	Economic dispatch
Week 10	Load frequency control	Load frequency control

Indicative Laboratory Schedule

Period	Summary of Laboratory Program
Week 1	-
Week 2	Lab 1 Introduction & Modelling in PW
Week 3	Lab 2 GS Power flow using PW (Assessed)
Week 4	Lab 3 NR Power flow using PW (Assessed)
Week 5	Lab 4 PSCAD Modelling
Week 6	Optional practice
Week 7	Lab 5 Symmetrical fault analysis in PSCAD (Assessed)

Week 8	Lab 6 Unsymmetrical fault analysis in PSCAD (Assessed)
Week 9	Free lab for assignment (Stability PW/PSCAD)
Week 10	Assessment for assignment

Assessment

Assessment task	Weight	Due Date	Course Learning Outcomes Assessed
1. Laboratory	20%	14 Oct, 21 Oct, 4 Nov, 18 Nov	1, 2, 3
2. Online activities	25%	25 Sep, 9 Oct, 30 Oct, 13 Nov, 20 Nov	1, 2, 3, 4, 5, 6
3. Assignment	20%	11 Nov	1, 4
4. Final Exam	35%	Exam period	2, 3, 5, 6

Assessment 1: Laboratory

Due date: 14 Oct, 21 Oct, 4 Nov, 18 Nov

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 three hours. 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

1. A freeware PowerWorld (PW) simulator that can be downloaded to your laptops. Instructions are available in the course website.
2. PSCAD available in the lab and appropriate server access will be provided for offshore students.

Note that these are for Windows only. If you are using Macbooks, you should make your own arrangements to organise a windows laptop. Note that, if you are in Sydney, it is mandatory to attend the labs F2F in room EE108 during the scheduled lab times.

The laboratory in-class assessment is worth 20% of the marks. Only Labs 2, 3, 5 and 6 will be assessed. However, you need to attend all the labs 1-6 to pass the course.

Assessment 2: Online activities

Due date: 25 Sep, 9 Oct, 30 Oct, 13 Nov, 20 Nov

There will be five online quizzes on various topics contributing to 20% 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. 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.

Assessment 3: Assignment

Due date: 11 Nov

This will be a one-week take home assignment on stability. You will be given an analytical question on stability and need to make detailed calculations. Then validate your results via simulations using both PW and PSCAD. A report showing screenshots of the simulation with a detailed description should be submitted via Moodle. The assignment question for each student is different and will be available via the Moodle. The report should be submitted via the same link. The assignment will open **Week 8 on Friday 4 Nov 8 PM and close Fri Week 9 11 Nov 8 PM**. During the Week 10 lab session, you need to run the simulation to the demonstrators for marking. This assessment provides 20% contribution towards your course.

Assessment 4: Final Exam

Due date: Exam period

The final exam in this course will cover all aspects of the course except stability. 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.

You must pass the final exam to pass the course.

Attendance Requirements

Attendance is mandatory for all labs 1-6

Course Schedule

View class timetable

Timetable

Date	Type	Content
O-Week: 5 September - 9 September		
Week 1: 12 September - 16 September	Lecture	Three phase systems
	Tutorial	Three phase systems
Week 2: 19 September - 23 September	Lecture	Power system modelling (PU); Ybus matrix building
	Tutorial	Ybus matrix building
	Laboratory	Lab 1 Introduction & Modelling in Power World (PW)
	Assessment	Quiz 1
Week 3: 26 September - 30 September	Lecture	Power flow analysis: GS & NR methods
	Tutorial	GS method
	Laboratory	Lab 2 GS Power flow using PW
Week 4: 3 October - 7 October	Tutorial	Power flow: NR method
	Laboratory	Lab 3 NR Power flow using PW
	Assessment	Quiz 2
Week 5: 10 October - 14 October	Lecture	Symmetrical fault analysis
	Tutorial	Symmetrical fault analysis
	Laboratory	Lab 4 PSCAD Modelling
	Assessment	Lab 2 report
Week 6: 17 October - 21 October	Assessment	Lab 3 report
Week 7: 24 October - 28 October	Lecture	Unsymmetrical fault analysis
	Tutorial	Unsymmetrical fault analysis

	Laboratory	Lab 5 Symmetrical fault analysis in PSCAD
	Assessment	Quiz 3
Week 8: 31 October - 4 November	Lecture	Power System Stability
	Tutorial	Power System Stability
	Laboratory	Unsymmetrical fault analysis in PSCAD
	Assessment	Lab 5 report
Week 9: 7 November - 11 November	Lecture	Economic dispatch
	Tutorial	Economic dispatch
	Laboratory	Catck-up lab / Assignment work
	Assessment	Quiz 4 Assignement
Week 10: 14 November - 18 November	Lecture	Load frequency control
	Tutorial	Load frequency control
	Laboratory	Assessment for assignment
	Assessment	Quiz 5 Lab 6 report

Resources

Prescribed Resources

J. Duncan Glover, Thomas Overbye, Mulukutla S. Sarma and Adam B. Birchfield, *Power System Analysis and Design*, 7th Edition (SI), Cengage Learning, 2022

Recommended Resources

- 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.

Course Evaluation and Development

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 tutorial hours have been increased to 2 hours weekly and interactive group problem-solving sessions introduced. The lab and Quiz submissions have been adjusted to follow theory. Lab sessions have been introduced every week.

Academic Honesty and Plagiarism

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 https://student.unsw.edu.au/plagiarism. To find out if you understand plagiarism correctly, try this short quiz: https://student.unsw.edu.au/plagiarism-quiz.

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.

Academic Information

COVID19 - 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.

Dates to note

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

Student Responsibilities and Conduct

Students are expected to be familiar with and adhere to all UNSW policies (see https://student.unsw.edu.au/policy), 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 formal classes and *independent, self-directed study*. In periods where you 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.

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.

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:

https://student.unsw.edu.au/guide

https://www.engineering.unsw.edu.au/electrical-engineering/resources

Disclaimer

This Course Outline sets out description of classes at the date the Course Outline is published. The nature of classes may change during the Term after the Course Outline is published. Moodle should be consulted for the up-to-date class descriptions. If there is any inconsistency in the description of activities between the University timetable and the Course Outline (as updated in Moodle), the description in the Course Outline/Moodle applies.

Image Credit

Synergies in Sound 2016

CRICOS

CRICOS Provider Code: 00098G

Acknowledgement of Country

We acknowledge the Bedegal people who are the traditional custodians of the lands on which UNSW Kensington campus is located.

Appendix: Engineers Australia (EA) Professional Engineer Competency Standard

Program Intended Learning Outcomes	
Knowledge and skill base	
PE1.1 Comprehensive, theory based understanding of the underpinning natural and physical sciences and the engineering fundamentals applicable to the engineering discipline	✓
PE1.2 Conceptual understanding of the mathematics, numerical analysis, statistics, and computer and information sciences which underpin the engineering discipline	✓
PE1.3 In-depth understanding of specialist bodies of knowledge within the engineering discipline	✓
PE1.4 Discernment of knowledge development and research directions within the engineering discipline	✓
PE1.5 Knowledge of engineering design practice and contextual factors impacting the engineering discipline	✓
PE1.6 Understanding of the scope, principles, norms, accountabilities and bounds of sustainable engineering practice in the specific discipline	✓
Engineering application ability	
PE2.1 Application of established engineering methods to complex engineering 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	✓
Professional and personal attributes	
PE3.1 Ethical conduct and professional accountability	✓
PE3.2 Effective oral and written communication in 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	✓