UNSW SYDNEY | Australia's Global University

School of Electrical Engineering and Telecommunications

Term 3, 2019
Course Outline

# ELEC9781
# Power System Stability

## COURSE STAFF

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**Consultations:** You are encouraged to ask questions on the course material, via Moodle discussion forums and group mentors. Active participation in the online discussion forum is expected to provide peer-to-peer support. For any questions that remain unresolved via the above means, you are encouraged to contact the lecturer after the lecture class times in the first instance, rather than via email. If an email enquiry becomes necessary, it should be made from your student email address with ELEC9781 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.

## COURSE SUMMARY

### Contact Hours

The course consists of 3 hours of lectures each week. There are four laboratory sessions which will be run during the lecture times. Please note these dates for assessment purposes.

| Lectures | Day | Time | Location |
|---|---|---|---|
| | Friday | 4-7 pm | EE108 (Map ref: G17) |

### Context and Aims

For reliable service, a bulk electricity system must remain intact and be capable of withstanding a wide variety of disturbances. Hence it becomes essential to design a power system that is operable in a secured and controlled manner such that probable contingencies can be sustained without loss of load as well as without cascading power interruptions.

This course helps a student to analyse the stability issues in a power system and focuses on small signal stability, transient stability and voltage stability. It highlights the significance of dynamic modelling of generators, loads, excitation systems and prime movers in analysing the stability issues.

**Indicative Lecture Schedule**

| Period | Summary of Lecture Program |
|---|---|
| Week 1 | Review of synchronous machine theory – Stability classification – Modelling aspects: Synchronous machine classical model, Eq' model, Park's model – Prime mover, Exciter models |
| Week 2 | Transient stability – step by step solution of swing equation – multi-machine systems |
| Week 3 | Transient stability – Numerical Integration Methods: Euler and Fourth Order Runge-Kutta methods |
| Week 4 | Lab1: Modelling |
| Week 5 | Small signal stability – Linearized model of synchronous machine – Eigen values – Eigen vector analysis |
| Week 6 | Power system stabilizers |
| Week 7 | Lab2: Transient Stability analysis |
| Week 8 | Lab3: Small-signal stability analysis |
| Week 9 | Voltage stability – phenomena and components – steady state stability (PV and VQ curves) |
| Week 10 | Lab exam; Assignment due - 25 Nov (Week 11) |

**Assessment**

| | |
|---|---|
| Lab (Lab 1-3: 5 marks each, Lab exam- 15 marks) | 30% |
| Assignment (Problem solving) | 20% |
| Final Exam (2 hours) | 50% |

**Must pass the final exam to pass the course.**

## COURSE DETAILS

### Credits

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

### Relationship to Other Courses

This is a postgraduate course in the School of Electrical Engineering and Telecommunications. It is an advanced disciplinary elective course in the Energy Systems stream of the postgraduate study.

### Pre-requisites and Assumed Knowledge

The course is heavily analytical and involves software simulations using DigSILENT Power Factory. A prior knowledge of power system analysis at the undergraduate level is necessary to complete this course successfully.

### Learning outcomes

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

1. Model the power system components for stability considerations.
2. Investigate transient stability issues of single and multiple synchronous machines in power systems.
3. Analyse the small signal stability of the power systems with and without excitation systems.
4. Evaluate the various aspects of voltage stability in traditional power systems.
5. Interpret and devise schemes for adapting the stability techniques in the current distributed power systems.

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

Topics covered comprise, numerical integration techniques for transient stability, small-signal stability modeling via state-space representation of the system, Eigen value analysis, Multi-machine stability analysis, Stability controllers, Voltage stability concepts, Loadability limits, PV and VQ curves.

## TEACHING STRATEGIES

### Delivery Mode

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

- In-class lectures and discussions, 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 support the formal lecture material and also provide you with practical construction, measurement and debugging skills.

### Learning in this course

You are expected to attend all lectures, tutorials, and lab sessions in order to maximise learning. 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 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

Problem solving is in-built in the lectures. There will be opportunities for students to work on numerical questions on their own to enable deeper understanding and practice towards final exam preparation.

### Laboratory classes

There will be three software laboratory sessions during the lecture times in Weeks 4, 5 and 8, with an individual lab exam in Week 10. The software simulation is via DigSILENT PowerFactory. 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.

## ASSESSMENT

The assessment scheme in this course reflects the intention to assess your learning progress through the term. Ongoing assessment occurs through the laboratory sessions and assignment.

### Laboratory Assessment

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. 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.

The laboratory in-class assessment is worth 15% of the marks. There are three lab exercises and each will be contributing to 5% marks towards the course. This means if you are unable to complete any particular lab session, you will miss 5 marks straightaway. The final lab exam is worth 15% of the marks and is scheduled in Week 10.

### Assignment

The assignment is entirely problem solving covering all topics in the course. This will be useful to have an in-depth understanding of the concepts and for your final exam preparations. The assignment is worth 20% towards the course and will be made available in Week 3. The submission deadline is on or before 25 Nov (Week 11).

**Final Exam**

The exam in this course is a standard closed-book 2 hour written examination and contributes 50% towards the course. 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. ***Please note that you must pass the final exam in order to pass the course.***

**Relationship of Assessment Methods to Learning Outcomes**

| | **Learning outcomes** | | | | |
|---|---|---|---|---|---|
| **Assessment** | **1** | **2** | **3** | **4** | **5** |
| Laboratory | ✓ | ✓ | ✓ | ✓ | ✓ |
| Assignment | ✓ | ✓ | ✓ | ✓ | - |
| Final exam | ✓ | ✓ | ✓ | ✓ | ✓ |

## COURSE RESOURCES

**Textbooks**

**Textbooks**

Course material compiled by the course coordinator is available online in Moodle. The lecture slides and lecture videos will be made available in Moodle as well, with links to numerous online videos.

Reference books

- Kundur P. *Power System Stability and Control*. McGraw-Hill, 1994.
- Anderson P.M. and Fouad A.A. *Power System Control and Stability*. Wiley-Interscience, 2003.
- Van Cutsem T. and Vournas C. *Voltage Stability of Electric Power Systems*. Springer, 1998.
- Sallam A.A. and Malik, O.P. *Power system stability: modelling, analysis and control*. The Institution of Engineering and Technology, 2015.
- Kimbark E.W. *Power system stability – Vol I, II and III*. IEEE Press, 1995.

**On-line resources**

Moodle

As a part of the teaching component, Moodle will be used to disseminate teaching materials, host forums and occasionally quizzes. 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

**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 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.

**Student Responsibilities and Conduct**

Students are expected to be familiar with and adhere to all UNSW policies (see https://student.unsw.edu.au/guide), 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 the online student survey myExperience. You can also provide feedback to STEEP who will raise your concerns at student focus group meetings.

**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

## APPENDICES

### 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 | ✓ |
| **a n d P e** | 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 | |