ELEC9782
Power System Modelling and Dynamics

Course Outline – Semester 2, 2017

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

Course Staff

The course coordinator and lecturer is:

Dr. Elaine Chen
School of Electrical Engineering and Telecommunications

Consultations: You are encouraged to ask questions on the course material, after the lecture class times in the first instance, rather than via email. You can also post questions in the Moodle discussion forums. ALL email enquiries should be made from your student email address with"ELEC9782" in the subject line, otherwise they will not be answered. Consultation times for the course will be announced in Week 1 via Moodle.

Keeping Informed: The main announcements regarding the course and its assignments will be made through Moodle https://moodle.telt.unsw.edu.au/login/index.php. Announcements may also be made during classes but everything will be formally announced in the "Course Announcements" forum of ELEC9782 in Moodle.

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

This postgraduate course consists of 3 hours of lectures per week in the evenings.

Lectures	Day	Time	Location
	Monday	6-9pm	Civil Engineering 101

Note that there will be some scheduled consultations for the assignments, and group project discussions. Details will be made available in the lectures and on Moodle.

Context and Aims

This course provides advanced knowledge of the main issues involved in the dynamic mechanisms and stability problems in electric power systems, including system modelling, analysis and simulation methods/tools under dynamic conditions.

The aim of ELEC9782 is to make students familiar with the advanced knowledge of power system modelling and dynamics used in modern power system stability analysis, and to enable them to work on relevant projects in power system engineering with some research skills.

Indicative Lecture Schedule

Note that this schedule is provisional at this stage and may be updated during the session. You should attend lectures and regularly check the course *Moodle* website for possible updates. Note that there may be tasks (non-assessable) to undertake on *Moodle* each week as well – be sure to keep up to date with developments.

Period	Topic	Activity
Week 1 (24/7)	- Introduction to power system modelling and dynamics - Review on power system steady state analysis	
Week 2 (31/7)	- Power system stability with classical methods	- Background quiz
Week 3 (7/8)	- Synchronous machine modelling - Application of generator models in stability analysis	- Project topic distributed
Week 4 (14/8)	- Excitation system modelling	
Week 5 (21/8)	- Prime movers and governing system modelling	- Project topic finalized
Week 6 (28/8)	- Load modelling - Power electronic based component modelling	- Assignment 1 due
Week 7 (4/9)	***Mid-Session Quiz***	
Week 8 (11/9)	Transient stability analysis: - A brief review on Equal Area Criteria - Numerical integration methods - Direct methods - Methods of improving transient stability	
Week 9 (18/9)	Small-signal stability analysis: - Local-plant mode oscillations - Inter-area mode oscillations - Sub-synchronous oscillations	
23/9 – 2/10	***Mid-Session Break***	
Week 10 (2/10)	***Public Holiday***	
Week 11 (9/10)	- Voltage stability - Active and reactive power control	
Week 12 (16/10)	- Microgrid dynamics and control	- Assignment 2 due
Week 13 (23/10)	- Course review - Final exam preparation guide	- Project presentation - Project report due

Assessment

Weighting	Task	Submission date
10%	assignments	end of week 6 (assignment 1) end of week 12 (assignment 2)
10%	project report & presentation	during week 13 class (presentation) end of week 13 (report)
10%	background quiz (1 hr)	during week 2 class
20%	mid-session quiz (1.5 hrs)	during week 7 class
50%	final exam (2 hrs)	exam period

Course Details

Credits

This is a 6 UoC course and the expected workload is 10–12 hours per week throughout the 13 week semester. As noted below, most of this time must be self-directed learning.

Relationship to Other Courses

This is a postgraduate course in the School of Electrical Engineering and Telecommunications. It is aimed at students wishing to specialize in power system engineering in their degree, and possibly, their future careers.

Pre-requisites and Assumed Knowledge

The pre-requisite for this course is *ELEC4612 Power System Analysis*. And it is highly desirable that you be familiar with some basic knowledge about control systems and electrical machines before this course is attempted.

Learning Outcomes

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

1. Understand power system stability concepts and analysis methods for power system modelling and dynamics;
2. Model major components of power systems for dynamic stability analysis;
3. Analyze power system behavior under transient conditions based on modern mathematical and computational tools;
4. Understand the principles and methods of active and reactive power control using detailed models of generators, loads and network;
5. Describe the opportunities and challenges of power system modelling and dynamics for future electricity power systems;
6. Gain some project skills by working within a team to solve the power system modelling and stability analysis problem.

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

Syllabus

Introduction to power system modelling and dynamics; power system steady state analysis; per unit value system; power flow equations; nonlinear dynamical systems and respective applications; power system modelling/analysis on electric/magnetic field of generator; modelling generator in three-phase coordinates; park transformation; flux linkage equations and voltage equations of generator after park transformation; generator dynamic equations in dq coordinates; equation of motion; operational parameters of generators; prime movers and governing systems; load modelling and power electronic

based component modelling; transient stability; swing equation analysis; equal area criteria and direct methods; small-signal stability analysis; active and reactive control; microgrid dynamics and control.

Teaching Strategies

Delivery Mode

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

- Formal face-to-face lectures, which provide you with a focus on the core analytical material in the course, together with qualitative, alternative explanations to aid your understanding;
- There are no separate tutorials but done lectures from time to time. Some self-paced exercises will be given out in class during the course.
- Small periodic reference materials/quizzes (non-assessed)

Learning in This Course

You are expected to attend ALL lectures in order to maximise learning. In addition to the lecture notes, you should read relevant sections of any recommended texts and other materials. Reading additional texts and reports 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.

Assessment

The assessment scheme in this course reflects the intention to assess your learning progress through the semester. Satisfactory performance in both the class based assessment and examination is required to pass this course.

Assignments

It is expected that there will be two assignments during the semester. The assignment allows self-directed study leading to the solution of partly structured problems. Marks will be assigned according to how completely and correctly the problems have been addressed and the understanding of the course material demonstrated by the report. These assignments must be undertaken by students individually.

Project Report & Presentation

The project will involve students in an activity suited to their interests and skills in the area of power system modelling and dynamics. Groups of 4 students are very strongly preferred, although smaller groups may also be permitted if and as appropriate – groups and topics must be approved by the course coordinator. In particular, students undertaking a fourth year engineering thesis or post-graduate research thesis should not choose an ELEC9782 project topic that closely relates to their other thesis research. Similarly, students are strongly encouraged not to choose a project that closely relates to any other projects that they have undertaken – for example, in ELEC4612 or other power system analysis related courses.

Projects will focus on two parts:

1) a significant literature review of some aspect of power system modelling and dynamics;
2) building a model of a typical power system and analyzing its stability behavior with dedicated simulation tools.

Each group is required to write a project report, and give an oral presentation (15 minutes, exact time allowed will be notified later) with PowerPoint. A computer and projector for PowerPoint presentations will be available for this and you will also be able to run the presentation from your own laptop if that is preferred.

Assessment of the project will be based on the quality and comprehensiveness of the report and presentation.

Weighting	Task
25%	student self-evaluation (project completion)
25%	student peer-evaluation (project presentation)
50%	lecturer assessment (project report)

All students are required to attend the oral presentation session and provide self-evaluation and peer-evaluation for each group. The evaluation form will be provided in week 12 class.

More information on these projects and suitable topics will be distributed in week 2 and project topics are to be negotiated and finalized by week 6. Details on the formal requirements for the project reports will also be provided at that time.

Background Quiz

The goal of this small in-class quiz is for you to determine whether you have the background needed to take this class, and to do some background work to fill in any areas in which you may be weak. Questions may be drawn from any pre-requisite course material and material covered up to the end of week 1. Marks will be assigned according to the correctness of the responses.

Mid-Session Quiz

The mid-session quiz (closed-book, 1.5-hour) 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 6. It will definitely contain numerical and analytical questions. University approved calculators are allowed. Marks will be assigned according to the correctness of the responses.

Final Exam

The exam in this course is a standard closed-book 2-hour written examination, comprising four compulsory questions. University approved calculators are allowed. The examination tests analytical and critical thinking and general understanding of the course material. Questions may be drawn from any aspect of the course unless specifically indicated otherwise by the lecturer. Marks will be assigned according to the correctness of the responses.

Late Policy

You are expected to submit the assignments and project report on time. The "end of" a week is 5pm on the Sunday that follows that week of class. Late days are counted in 24-hour periods. Submitting between 5:01pm on the due date and 5pm the next day is one day late, and so on. The penalty for lateness is 5% per day. The hard deadline for all the submission is 3 days past the original due date. Late submissions are not accepted after the hard deadline.

Relationship of Assessment Methods to Learning Outcomes

	Learning comes					
Assessment	**1**	**2**	**3**	**4**	**5**	**6**
Assignments	✓	✓	✓	✓	✓	✓
project report & presentation	✓	✓	✓	✓	✓	✓
Background quiz	✓					
Mid-session quiz	✓	✓	✓			
Final exam	✓	✓	✓	✓	✓	✓

Course Resources

Prescribed Textbook

Prabha Kundur, "Power System Stability and Control", McGraw-Hill, ISBN 978-0070359581

Reference Book

P.M Anderson and A.A. Fouad, “Power System Control and Stability”, IEEE Press. ISBN 978-0471238621

On-line Resources

Instead of an assigned text book, regular updates and course materials will be added to the course *Moodle* website. You should check this site frequently. Materials will include summary pdf versions of the lecture PowerPoints. A range of reports, papers and websites will be uploaded throughout the semester to provide more background on power system modelling and dynamic analysis.

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.

Keeping Informed

Announcements may be made during classes, via email (to your student email address) or via online learning and teaching platforms like *Moodle*. From time to time, UNSW will send important

announcements via these media without providing any paper copy. Please note that you will be deemed to have received this information, so you should take careful note of all announcements.

Special Consideration and Supplementary Examinations

You must submit all assignments and attend all examinations scheduled for your course. You should seek assistance early if you suffer illness or misadventure which affects your course progress. All applications for special consideration must be **lodged online through myUNSW within 3 working days of the assessment**, not to course or school staff. For more detail, consult https://my.unsw.edu.au/student/atoz/SpecialConsideration.html.

Continual Course Improvement

This course is under constant revision in order to improve the learning outcomes for all students. Please forward any feedback (positive or negative) on the course to the course convener or via the Course and Teaching Evaluation and Improvement Process. You can also provide feedback to ELSOC who will raise your concerns at student focus group meetings. As a result of previous feedback obtained for this course and in our efforts to provide a rich and meaningful learning experience, we have continued to evaluate and modify our delivery and assessment methods.

Administrative Matters

On issues and procedures regarding such matters as special needs, equity and diversity, occupational health and safety, enrolment, rights, and general expectations of students, please refer to the School and, more generally, 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.

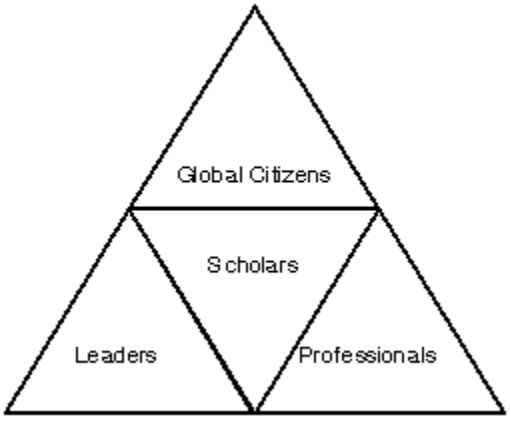
Appendix B: UNSW Graduate Attributes

The course delivery methods and course content addresses a number of core UNSW graduate attributes, as follows:

UNSW graduates will be -

Scholars who are:

- understanding of their discipline in its interdisciplinary context
- capable of independent and collaborative enquiry
- rigorous in their analysis, critique, and reflection
- able to apply their knowledge and skills to solving problems
- ethical practitioners
- capable of effective communication
- information literate
- digitally literate



Leaders who are:

- enterprising, innovative and creative
- capable of initiating as well as embracing change
- collaborative team workers

Professionals who are:

- capable of independent, self-directed practice
- capable of lifelong learning
- capable of operating within an agreed Code of Practice

Global Citizens who are:

- capable of applying their discipline in local, national and international contexts
- culturally aware and capable of respecting diversity, acting in socially just/responsible ways
- capable of environmental responsibility

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