

Engineering and Information Technologies

Unit of Study Description

ELEC5204 Power Systems Analysis and Protection

Unit Coordinator	Professor Vassilios G. Agelidis v.agelidis@ee.usyd.edu.au
School	School of Electrical and Information Engineering
Credit Value	6
Session	Semester 1
Prohibitions	<u>ELEC4201</u>
Assumed Knowledge Description	The unit assumes basic knowledge of circuits, familiarity with basic mathematics, competence with basic circuit theory and an understanding of three phase systems, transformers, transmission lines and associated modeling and operation of such equipment.
Brief Description	This unit provides the basis for the analysis of electricity grids using symmetrical components theory. Such analysis theory is the basis for the understanding of electrical faults and the design of protection strategies to safeguard the electrical equipment, and maintain safety of the plant at the highest possible level. The following specific topics are covered: The types and causes of power system faults; balanced faults and short circuit levels; an introduction to fault current transients in machines; symmetric components, sequence impedances and networks; the analysis of unsymmetrical faults. Review of the impact of faults on power system behaviour; issues affecting protection scheme characteristics and clearance times; the security and reliability of protection schemes; the need for protection redundancy and its implementation as local or remote backup; zones of protection and the need for zones to overlap; the analysis and application of over-current and distance relay protection schemes with particular reference to the protection of transmission lines.
Lecturer(s)	Dr Don Geddey, don.geddey@transgrid.com.au Mr Keith Mitchell, komitch@bigpond.com
Text or Reference Book(s)	<u>REFERENCE</u> : Hadi Saadat , <i>Power System Analysis</i> , McGraw-Hill Higher Education, Edn:,, <u>REFERENCE</u> : Arthur R. Bergen and Vijay Vittal, <i>Power Systems Analysis</i> , Prentice Hall, Edn:2nd Edition,, <u>REFERENCE</u> : Edited by the Electricity Training Association, <i>Power System Protection, Volume 1: Principles and Component</i> , , Edn:,, <u>REFERENCE</u> : Pieter Schavemaker and Lo van der Sluis , <i>Electrical Power</i>

	<p><i>System Essentials</i>, Wiley, Edn:.,,</p> <p><u>REFERENCE</u>: B.M. Weedy and B.J. Cory,<i>Electric Power Systems</i>, Wiley, Edn:4th Edition,,</p> <p><u>REFERENCE</u>: Nasser Tleis,<i>Power Systems Modelling and Faulty Analysis (Theory & Practice)</i>, Newnes, Edn:.,,</p> <p><u>REFERENCE</u>: J. Lewis Blackburn, Thomas J. Domin ,<i>Protective Relaying Principles and Applications</i>, CRC Press, Edn:3rd Edition,,</p>
Other Resources	No text required. Notes will be on the web
Teaching & Learning Sessions	<p><u>Lecture</u>, Workload : 2 hours per week, presented in 1 session(s) per week for 13 week(s) of semester. Devoted to explaining concepts plus review quiz each day.</p> <p><u>Tutorial</u>, Workload : 1 hours per week, presented in 1 session(s) per week for 12 week(s) of semester. More detailed questions to develop better understanding and analysis techniques.</p> <p><u>Laboratory</u>, Workload : 2 hours per week, presented in 1 session(s) per week for 12 week(s) of semester. Hands on experience with power system behaviour and protection design.</p>
Graduate Attributes	<p><u>Discipline Specific Expertise</u>, Level : Intermediate-Advanced Gain an understanding of the basic concepts in electricity networks. It builds on the previous knowledge gained in circuits and power electronics and power systems.</p> <p><u>Communication</u>, Level : Intermediate-Advanced Students need to work in groups in the labs. They need to write lab reports, as well as do some detailed analysis, short-circuit analysis and protection and present it in the form of assignment reports.</p> <p><u>Information Skills</u>, Level : Advanced Need to understand and follow lab procedures and conduct experiments under controlled conditions. Need to read IEEE and IET Research Papers and Articles on Industrial Standards and assimilate this knowledge in evaluating various solutions to protection problems.</p> <p><u>Science and Engineering Fundamentals</u>, Level : Intermediate-Advanced Gain an ability to apply their knowledge of circuit fundamentals to electricity networks analysis and protection fundamentals.</p> <p><u>Teamwork and Project Management</u>, Level : Intermediate Group work in labs and tutorials.</p> <p><u>Design and Problem Solving Skills</u>, Level : Intermediate-Advanced Extensive design and analysis work is done in tutorials, labs, and assignment.</p>

<p>Learning Outcomes</p>	<ol style="list-style-type: none"> 1. Ability to demonstrate an understanding of symmetrical components theory and its application. (Graduate Attribute Type : Discipline Specific Expertise) 2. Proficiency in determining maximum and minimum short circuit levels in power networks using knowledge of principles and concepts developed throughout the course. (Graduate Attribute Type : Discipline Specific Expertise) 3. Capacity to apply knowledge of concepts and principles studied to demonstrate why protection systems are required and their respective functions to the extent of the material presented. (Graduate Attribute Type : Discipline Specific Expertise) 4. Ability to design basic protection schemes, drawing on principles and knowledge at hand, as well as other available resources to solve the problem to specifications. (Graduate Attribute Type : Design and Problem Solving Skills) 5. Ability to demonstrate an understanding the functions of switch gear and other devices. (Graduate Attribute Type : Science and Engineering Fundamentals) 6. Ability to demonstrate a basic understanding electrical safety issues and systems earthing to the extent of the material presented. (Graduate Attribute Type : Science and Engineering Fundamentals) 7. Ability to incorporate professional standards for economical, environmental, social and safety issues into the design, implementation and operation of power systems by drawing on Australian codes and standards. (Graduate Attribute Type : Professional Practice) 8. Ability to write reports and present information to communicate engineering information clearly, concisely and accurately at a level commensurate with the expected technical knowledge level of the stakeholders involved. (Graduate Attribute Type : Communication) 9. Ability to use a power system simulator to design, test and confirm protection requirements for a given system within the limits of the material presented. (Graduate Attribute Type : Discipline Specific Expertise)
<p>Assessment Components</p>	<p><u>Assignment</u>: Assignments throughout the semester. Weighting = 25 : Week Due = Week 3 Teamwork Component Target Outcomes = 1 2 3 7 8</p> <p><u>Lab Report</u>: Laboratory Work with the power system simulator that offers a breadth of experimental work with the latest digital relays and some of the experiments are as follows: symmetrical faults, unsymmetrical faults,</p>

	<p>transient overvoltage, grading of overcurrent protection for three-phase faults, directional control of relay tripping, distance and zone protection, grid transformer differential protection, busbar protection, generator protection, auto-reclosing</p> <p>Weighting = 15 : Week Due = Continuous Teamwork Component Target Outcomes = 1 2 3 4 5 6 7 9</p> <p><u>Final Exam</u>: End of Semester Examination Weighting = 60 : Week Due = Exam Period Target Outcomes = 1 2 4 5 6</p>
<p>Grading Description</p>	<p>Grades in this unit are awarded at levels of HD (High Distinction), D (Distinction), CR (Credit), P (Pass) and F (Fail) as defined by Academic Board Resolutions: Assessment and Examination of Coursework. Details of Academic Board Resolutions are available on the University's Policy website at http://www.usyd.edu.au/ab/policies/Assess_Exam_Coursework.pdf. Standards for grades in individual assessment tasks and the summative method for obtaining a final mark in the unit will be set out in a marking guide supplied by the unit coordinator.</p>
<p>Syllabus/Schedule</p>	<p><u>Week 1</u>: Three-phase power systems, historical developments, characteristics influencing generation and transmission, environmental aspects of electrical energy generation, transmission and distribution systems, energy utilization, balanced three-phase and unbalanced three-phase systems, introduction to short circuit analysis and symmetrical component theory.</p> <p><u>Week 2</u>: Short circuit analysis techniques, synchronous machines, synchronous generator in parallel operation, the operation of a generator on infinite busbars, salient pole generators, per unit system, overhead line, underground cables, positive, negative and zero sequence networks</p> <p><u>Week 3</u>: Equivalent circuits and parameters of electricity networks, synchronous machines, armature reaction, steady-state salient pole rotor, transient analysis, asymmetry, machine reactances, negative sequence reactance, zero sequence reactance, direct and quadrature axis values, effect of saturation on machine reactances, transformer positive sequence equivalent circuits, transformer zero sequence equivalent circuits, auto-transformers, transformer impedances</p> <p><u>Week 4</u>: Overhead lines and cables, calculation of series impedance, calculation of shunt impedance, overhead line circuits with or without earth wires, OHL equivalent circuits, cable circuits, overhead line and cable data</p> <p><u>Week 5</u>: Current and voltage transformers, capacitor voltage transformers, errors, composite errors, transformer classes, optical instrument transformers, Electromechanical relays, static relays, digital relays, numerical relays</p> <p><u>Week 6</u>: Principles of time/current grading, standard I.D.M.T. overcurrent relays, combined I.D.M.T. and high set instantaneous overcurrent relays, very inverse overcurrent relays, Extremely Inverse overcurrent relays, Independent (definite) time overcurrent relays, Relay current setting, Relay</p>

time grading margin, calculation of phase fault overcurrent relay settings, directional phase fault overcurrent relays, Earth fault protection, Directional earth fault overcurrent protection, Earth fault protection

Week 7: Unit protection of feeders, balanced voltage system, digital/Numerical current differential protection systems, Phase comparison protection scheme considerations

Week 8: Busbar protection requirements, types of protection system, system protection schemes, Differential protection principles, high impedance differential protection

Week 9: Transformer protection, winding faults, magnetising inrush, transformer overheating, transformer overcurrent protection, restricted earth fault protection, differential protection, combined differential and restricted earth fault schemes, earthing transformer protection, auto-transformer protection, tank-earth protection, oil and gas devices, transformer-feeder protection, condition monitoring of transformers

Week 10: Principles of distance relays, relationship between relay voltage and ZS/ZL ratio, zones of protection, distance relay characteristics, effect of source impedance and earthing methods

Week 11: Generator earthing, stator winding faults, stator winding protection, differential protection of direct-connected generators, differential protection of generatorâ transformer units, overcurrent protection, stator earth fault protection, overvoltage protection, undervoltage protection, low forward power/reverse power protection, unbalanced loading, under/overfrequency/overfluxing protection, rotor faults, loss of excitation protection, overheating, mechanical faults

Week 12: AC motor protection, thermal (Overload) protection, start/stall protection, short circuit protection, earth fault protection, negative phase sequence protection, wound rotor induction motor protection, RTD temperature detection, undervoltage protection, loss-of-load protection, protection for synchronous motors

Week 13: Revision text/enhanced

Study Week : This week is left free for independent study.

Exam Period : Any Exam or Quiz worth more than 30% of the final assessment will be scheduled in this two week period.

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