University of Macau

Faculty of Science and Technology

Department of Electrical and Electronics Engineering

Part A: Course Outline

Course Title:	Protection of Power System and Electrical Machines		
Course Code:	ELEC335	Year of Study:	4
Compulsory/Elective:	Elective		
Course Prerequisites:	ELEC331-Advanced Topics on Electric Machines		
Prerequisite Knowledge	Circuit Analysis, electrical machine		
Class/Laboratory Schedule:	2-hour lecturer, 2-hour simulation/tutorial per week		
Duration	One semester	Credit Units	3.5
Text Books and References:	[1] Electrical Power System Protection: 2nd Edition, Christopoulos and A. Wright, Springer [2] Power System Protection, P.M. Anderson, McGraw-Hill, IEEE Press Series on Power Engineering		
Course Description:	The course provides students with essential knowledge in power system and machine protection. It discusses protection of electrical equipment from over voltages, over current and short circuit faults using protection devices/systems such as fuses, protective relays; circuit breakers etc		
Topics Covered	1. Introduction 2. Instrument Transformers 3. Fuses 4. Power system protection (including distribution, transmission and bus protection) 5. Electrical machine protection (including transformer, motor and generator protection)		
Course Objectives:	1. To introduce the students the principles of different protection schemes. [a,e,k] 2. To develop students with an understanding of the characteristics, advantages and defects of different protection methods [a,b,e,k] 3. To prepare the students to design/coordinate protection scheme(s) for given requirements.[a,c,e,k] 4. To develop students with an understanding short circuit calculation [a,e]		
Course Assessment:	Assignments : 5% Quiz :10% Simulation Projects : 25% Test: 30% Final Exam. : 30%		

<table>
<tr><td>Relationship to Program Objectives and Outcomes</td><td>This course primarily contributes to EEE program outcomes that develop students abilities to:
a. Ability to apply knowledge of mathematics, science and engineering.
e. Ability to identify, formulate and solve engineering problems.
k. Ability to use the techniques, skills and modern engineering tools necessary for engineering practice.

This course secondarily contributes to EEE program outcomes that develop students abilities to:
b. Ability to design and conduct experiments.
c. Ability to design a system, component or process to meet desired needs..</td></tr>
<tr><td>Course Contents and Relationship to Program Criteria:</td><td>
<table>
<tr><th>Week no.</th><th>Topics</th><th>Program Criteria</th></tr>
<tr><td>2</td><td>Introduction
Protective apparatus, basic requirements of protection , basic components of protection, symmetrical components, symmetrical networks and fault analysis</td><td>BS,ES,</td></tr>
<tr><td>1</td><td>Fuses
History, rewireable type, cartridge type, Operating characteristics, application of selection of fuses</td><td>BS,ES,</td></tr>
<tr><td>1</td><td>Instrument Transformers
Purpose, basic theory of operation of voltage transformers and current transformers</td><td>BS, ES, LA, DE</td></tr>
<tr><td>5</td><td>Power System Protection
a. Distribution Protection: instantaneous overcurrent protection, time overcurrent protection, directional protection, coordination
b. Bus protection: differential protection, bus configurations, common bus protection schemes, impacts of CT saturation
c. Transmission Protection: distance Relays, directional impedance relay characteristics, characteristic, multi-stage distance relay, quadrilateral characteristics, under reach, over reach, ground faults and compensation factor, pilot relay protection</td><td>DIC,ES, DE, CV</td></tr>
<tr><td>4</td><td>Electrical Machine Protection
a. Transformer protection: review on transformer, differential protection, restricted earth fault, HV overcurrent, Buchholz protection, overloading
b. Motor protection: review of motor, early motor protection relays, steady-state temperature rise, thermal time constant, motor current during start and stall conditions, stalling of motors, unbalanced supply voltages, determination of sequence currents , derating due to unbalanced currents, electrical faults in stator windings earth faults phase–phase faults, typical protective settings for motors
c. Generator protection: review on generator, stator earthing and earth faults, overload protection, overcurrent protection, overvoltage protection, unbalanced loading, rotor faults, reverse power , loss of excitation, loss of synchronization, field suppression, industrial generator protection, numerical relays</td><td>DIC,ES, DE, CV</td></tr>
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Contribution of Course to meet the professional component:	This course prepares students to work professionally in the area of power protection engineering. Students should be able to apply knowledge of mathematics and engineering, and identify formulas to solve power engineering problems.
Course Instructor(s):	
Prepared by:	Dr. Chi Kong Wong

Part B: General Course Information and Policies

Instructor: Office:

Office Hour: Phone:

e-mail:

Program Criteria Policy:

Course VS Program Criteria

Scale: 1 (Highest) to 4 (Lowest)

Course	PS	DIC	BS	CS	ES	DE	LA	CV	DM
Protection of Power System and Electrical Machines		4	3		1	3	4	3	

Terms:

Probability and Statistics (PS), Differential and Integral Calculus (DIC), Basic Science (BS), Computer Science (CS), Engineering Science (ES), Differential Equation (DE), Linear Algebra (LA), Complex Variables (CV), Discrete Mathematics (DM)

Program Outcome Policy:

Course VS Course Outcomes

(H= Highly Related, S = Supportive, N = None)

Course	a	b	c	d	e	f	g	h	i	j	k
Protection of Power System and Electrical Machines	H	S	S	N	H	N	N	N	N	N	H

The electrical and electronics engineering program outcomes are:

a. Ability to apply knowledge of mathematics, science and engineering.

b. Ability to design and conduct experiments.

c. Ability to design a system, component or process to meet desired needs.

d. Ability to function on multidisciplinary teams.

e. Ability to identify, formulate and solve engineering problems.

f. Understanding of professional and ethical responsibility.

g. Ability to communicate effectively.

h. Broad education necessary to understand the impact of engineering solutions in global and societal context.

i. Recognition of the need for and an ability to engage in life-long learning.

j. Knowledge of contemporary issues.

k. Ability to use the techniques, skills and modern engineering tools necessary for engineering practice.

Course Assessment Policy:

- Homework assignments will be given to students according to the course progress , no late homework is accepted. Zero mark will be given when homework is copied.
- 6 Quizzes will be held during the semester.
- 2 simulation projects will be performed during the semester.
- 1 test and 1 final exam will be performed.