Program: ECE **Faculty/College**: TGGS
Degree Level: Master

Course 090245235

Testing and Condition Diagnostic of High Voltage Equipment

King Mongkut's University of Technology North Bangkok
The Sirindhorn International Thai-German Graduate School of Engineering
Electrical and Computer Engineering Program

Section 1: General Information

1. **Course code and course title**

   090245235 **Testing and Condition Diagnostic of High Voltage Equipment**

2. **Total credits**

   3 credits ○ (2-2-5) ▯ (3-0-6) ○ (3-0-9) ○ (2-3-7)

3. **Curriculum and course category**:

   Curriculum: *Master of Engineering in Electrical and Computer Engineering*

   Course category: Required Courses

   ○ Core Course ▯ Specific Core Course

   ○ Industrial Internship ○ Master Thesis

   Elective Courses

   ○ General Elective ○ Specific Elective ○ Other Elective

4. **Course coordinator/ Instructors**

   Course Coordinator: Assoc. Prof. Dr.-Ing. Thanapong Suwanasri

   Instructor(s): Assoc. Prof. Dr.-Ing. Thanapong Suwanasri

5. **Semester/ year of study**

   ☑ Semester 1 (Aug. to Dec.) ○ Semester 2 (Jan. to May) Academic Year: 2021

6. **Pre-requisite (if any)**

   ☑ No ○ Yes, please provide: .....

7. **Co-requisites (if any)**

   ☑ No ○ Yes, please provide: .....

8. **Venue of study**

   Lecture Day/Time: Thursdays at 09.00-12.00

   ▯ On-site: Lecture Room No 504 Floor:……5…….

   ○ TGGS, KMUTNB ○ Faculty of Engineering, CU ○ RWTH

   ▯ On-line*: Teaching Media: ▯ Microsoft Teams ○ Google Meet

   ○ Zoom ○ Webex

○ Other (specify) ……..….

Remark: * *During COVID-19, the teaching can be on-site and/or on-line according to TGGS Policy*.

9. Information for quality assurance in education

This course shows evidence of:

- □ Development of implementation from previous practices, e.g. the improvement of class teaching, course content, content classification and methods used for learning assessment
- ○ Involvement from professional bodies/ external agencies in instruction; thus Enhancing student academic and professional experiences
- ○ Integration of research or creative activities with instruction; use of research-based learning management; knowledge management practices for learning improvement
- ○ Integration of academic services and course implementation
- ○ Combination of cultural heritage preservation efforts into instruction or student activities

10. **Date of latest revision**:

Nov 2021

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Section 2: Course Description and Implementation

1. Course Description *(As written in the Official Approved Curriculum)*

Generation of High AC, DC and Impulse voltage, High voltage measurement techniques, Basic of electric field and voltage distribution in insulation, insulation of high voltage equipment, partial discharge, sensor and measurement system, travelling wave theory and condition assessment of underground cable system, power transformer and condition assessment and on-line monitoring of power transformer.

2. Number of hours per semester

Lecture	Practice	Self-study
45 hours/ semester (*3 hours/week**)	*0 hours* (*0 hours/week**)	*105 hours/ semester* (*7 hours/week**)

Remark: * *Based on 15 weeks of lecture*

Course Category: ▯ Lecture ○ Practice ○ Laboratory

Course Evaluation: ▯ A-F ○ S/U ○ P

3. Number of hours per week for academic guidance to individual students

○ 1. Giving academic advice (minimally number hour per week) during the office hour

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ .....

The student can arrange the time other than the office hour via telephone or email for the meeting date/time.

▯ 2. Adopting information technology-based academic advising

▯ Email: thanapong.s@tggs.kmutnb.ac.th

▯ Phone: 0816297055

(Do not distribute this mobile number without permission.)

○ Communication Apps: Line ID:

(Please notify the lecturer when adding the line.)

▯ Meeting Online: Microsoft Team

○ Other (specify) .....

○ 3. .....

4. Course Learning Outcomes (CLOs): Students should be able to:

CLO 1. Explain the theoretical concepts in the followings:

- Generation of High AC, DC and Impulse voltage,
- High voltage measurement techniques,
- Basic of electric field and voltage distribution in insulation,

- Insulation of high voltage equipment,
- Partial discharge measurement, sensor and measurement system,
- Travelling wave theory,
- Condition assessment of underground cable system,
- Power transformer and condition assessment and on-line monitoring of power transformers

CLO 2. Create electric field simulation models using FEMM software (freeware)

CLO 3. Apply the electric field simulation models to analyze and understand electric field stress and voltage distribution of different high voltage equipment.

CLO 4. Apply the electric field simulation models to simulate and implement in the design of high voltage equipment.

CLO 5. Compare the pros and cons of off-line and on-line partial discharge measurement with various high voltage equipment.

Remark: *1. Guidelines according to Bloom's Taxonomy is available at https://courses.dcs.wisc.edu/design-teaching/PlanDesign_Fall2016/2-Online-Course-Design/2_Learning-Objectives-Alignment/6_objectives_blooms-taxonomy.html*

2. For the master level course, CLOs should be "apply" and "analyze" or possibly to consider the doctoral CLOs "evaluate" and "create". "Remember" and "Understand" are for the undergraduate level courses, however, they can be implemented only at the beginning of the course.

3. CLOs can be defined as many as appropriated for the course.

5. The mapping between Expected Learning Outcomes (ELOs) from the curriculum and Course Learning Outcomes (CLOs)

Table 5.1 ELOs-CLOs Consistency *(for a subject-specific course/ a specific curriculum)*

ELOs/CLOs consistency	CLO 1	CLO 2	CLO 3	CLO 4	CLO 5
ELO1					
ELO2	□		□	□	
ELO3					
ELO4		□	□	□	
ELO5					
ELO6		□	□	□	
ELO7					
ELO8	□				□
ELO9					
ELO10					

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Remark: *All ELOs and ELOs for the course (highlighted row) are as written in the Official Approved Curriculum.*

Table 5.2 Mapping desirable characteristics of KMUTNB graduates and CLOs *(for non-specific courses designed for various curriculums)*

Consistency between desirable characteristics of KMUTNB Graduates- CLOs	CLO 1	CLO 2	CLO 3	CLO 4	CLO 5
1. **Professional credentials with critical thinking skills**	▯				▯
2. **Integrity and social responsibility**					▯
3. **Innovative and technopreneur mindset**					▯
4. **Global Competence**		▯	▯	▯	

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Section 3: Student Improvement in relation to Course Learning Outcomes (CLOs)

Organizing learning to develop skills/ knowledge; evaluation of CLOs in accordance with the ones identified in Section 2.4

Course Learning Outcomes (CLOs)	Teaching Methods compliant with CLOs	Evaluation Methods compliant with CLOs
CLO 1	• Lecture* • In-class exercises • Individual and/or group assignment • Additional reading assignments from research and/or literature journals	• Assignment evaluation • Exam****
CLO 2	• Lecture • In-class exercises • Individual and/or group assignment • Group discussions	• Assignment evaluation • Exam
CLO 3	• Lecture • In-class exercises • Individual and/or group assignment • Group discussions	• Assignment evaluation • Exam
CLO 4	• Lecture • In-class exercises • Individual and/or group assignment • Group discussions	• Assignment evaluation • Exam
CLO 5	• Lecture • In-class exercises • Individual and/or group assignment • Group discussions	• Assignment evaluation • Exam

*Remark: * Lecture on the concept of the topic is introduced with basic or fundamental definitions, visualization and correlations. For the complicated equation, the derivation from the basic laws can be shown to students. So, the students do not memorize the equations but understand the basic concept and basic equation. The lecturer will introduce the advanced and new concepts, technologies, and findings to students from publications such as journals and websites and from the research and industrial experiences.*

*** Active learning by asking questions related to the topic in the lecture and encouraging the students to response to the questions. If the students cannot response with answers, then the lecturer will give some guidance until the students can response.*

**** Quiz in the closed-book format on the basic concepts and equations with simple problem solving to evaluate their learning. The solution will be given to students after grading, so they can identify their mistakes and weakness.*

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***** Exam on the basic concepts and equations with simple problem solving in the closed-book format as a review, whereas the complicated/integrated problem solving will be worked in the open-book format.*

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Section 4: Lesson Plan and Evaluation

1. **Lesson Plan**

Week	Topics/Details	CLOs	Hours	Learning and teaching activities; teaching media (if any)	Lecturer
1	Chapter 1 Generation of High voltage 1. Introduction 2. Generation of AC high voltage	1,5	3.0	Lecture presentation slides Examples & In-class exercises Homework assignment	Thanapong
2	Chapter 1 Generation of High voltage 1. Generation of DC high voltage 2. Generation of impulse voltage	1,2,3,4	3.0	Lecture presentation slides Examples & In-class exercises Homework assignment	Thanapong
3	Chapter 2 High voltage Measurement 1. Measurement of AC and DC high voltage	1	3.0	Lecture presentation slides Examples & In-class exercises Homework assignment	Thanapong
4	Chapter 2 High voltage Measurement 1. Measurement of impulse voltage	1,2,3,4, 5	3.0	Lecture presentation slides Examples & In-class exercises Homework assignment	Thanapong
5	Chapter 3 Electric Field Calculation 1. Principle of electric field 2. Electric field in symmetrical shape	1,2,3,4	3.0	Lecture presentation slides Examples & In-class exercises Homework assignment	Thanapong
6	Chapter 3 Electric Field Calculation 1. Finite element method 2. Simulation in FEMM software	1,2,3,4, 5	3.0	Lecture presentation slides Examples & In-class exercises Homework assignment	Thanapong
7	Chapter 4 High voltage Insulation 1. Gas, liquid and solid insulation	1,2,3,4	3.0	Lecture presentation slides Examples & In-class exercises Homework assignment	Thanapong
8	Midterm Exam		3.0	Lecture presentation slides Examples & In-class exercises Homework assignment	Thanapong

9	Chapter 5 Partial discharge and its detection 1. PD classification 2. Severity	1,2,3,4, 5	3.0	Lecture presentation slides Examples & In-class exercises Homework assignment	Thanapong
10	Chapter 5 Partial discharge and its detection 1. Sensors and measurement system	1,2,3,4	3.0	Lecture presentation slides Examples & In-class exercises Homework assignment	Thanapong
11	Chapter 6 Travelling wave and underground cable system 1. Travelling wave theory 2. Underground cable system and its components	1,2,3,4	3.0	Lecture presentation slides Examples & In-class exercises Homework assignment	Thanapong
12	Chapter 6 Travelling wave and underground cable system 1. Condition assessment of underground cable system	1,2,3,4, 5	3.0	Lecture presentation slides Examples & In-class exercises Homework assignment	Thanapong
13	Chapter 7 Condition Assessment of Power Transformer 1. Principle and components 2. Technical specification	1,2,3,4	3.0	Lecture presentation slides Examples & In-class exercises Homework assignment	Thanapong
14	Chapter 7 Condition Assessment of Power Transformer 1. Electrical testing 2. Insulating oil testing 3. Visual inspection	1,2,3,4	3.0	Lecture presentation slides Examples & In-class exercises Homework assignment	Thanapong
15	Chapter 7 Condition Assessment of Power Transformer 1. On-line monitoring system 2. Condition assessment procedure	1,2,3,4, 5	3.0	Lecture presentation slides Examples & In-class exercises Homework assignment	Thanapong
16	Final Exam		3.0	Lecture presentation slides Examples & In-class exercises Homework assignment	Thanapong

2. **Evaluation Plan** (**in accordance with OBE** 2 **mapping framework**)

Course Learning Outcomes (CLOs)	Evaluation Methods	Week of Evaluation	Percentage of Evaluation
CLO 2, 3, 4	Exercises and assignments	Upon assignment (normally weekly)	30
CLO 1, 2, 3, 4, 5	Midterm written exam and workshop	8	30
CLO 1, 2, 3, 4, 5	Final written exam and workshop	16	40

Section 5 Teaching/Learning Resources

Textbooks and materials

1. Thanapong Suwanasri, High Voltage Engineering, 1st Edition, Textbook Publishing Center King Mongkut's University of Technology North Bangkok, Oct 2013, ISBN 978-616-7701-57-8
2. M. Horning, J. Kelly, S. Myers, R. Stebbins, "Transformer Maintenance Guide", Third Edition, S.D. Myers, Inc., ISBN 0-939320-02-9
3. IEEE Guide for Evaluation and Reconditioning of Liquid Immersed Power Transformer, IEEE Std. C57.140, 2017.
4. Partial Discharge Measurement Technique, IEC 60270.
5. William A. Thue, Electrical Power Cable Engineering, Marcel Dekker Inc., 1999, ISBN 0-8247-9976-3.

Section 6 Course Evaluation and Improvement

1. **Course evaluation by students**

The students will have an opportunity to evaluate the effectiveness of the course in a form of paper survey and group interview at the end of each semester. The results of survey and interview including the grading will be reviewed by the curriculum meeting to evaluate the course's effectiveness.

2. **Strategies for assessing learning management**

The students will have an opportunity to evaluate the teaching of the course in a form of paper survey and group interview at the end of each semester. The results of survey and interview including the grading will be reviewed by the curriculum meeting to evaluate the teaching as well as returning to the lecturer for further improvement.

3. **Improvement schemes of course implementation**

The evaluation from the students including the grading will be submitted to the curriculum meeting for reviewing and brainstorming to improve teaching of each course. Comments and suggestions given by the curriculum meeting will be informed to the responsible lecturer of each course.

4. **Verification of students' learning outcomes, referred to OBE 2 and 3**

The grading of this course will be evaluated and reviewed by the curriculum meeting and the TGGS board meeting in order to verify its appropriateness before the final approval.

5. **Course review and improvement plans**

The results of the grading evaluation and student evaluation will be submitted to the curriculum meeting for reviewing and brainstorming to improve the effectiveness of the offered courses. Comments and suggestions will be informed to the responsible lecturer of each course.