High voltage engineering

Academic Year: (2023 / 2024) **Review date: 24-04-2023**

Department assigned to the subject: Electrical Engineering Department

Coordinating teacher: MARTINEZ TARIFA, JUAN MANUEL

Type: Electives ECTS Credits : 6.0

Year : Semester :

REQUIREMENTS (SUBJECTS THAT ARE ASSUMED TO BE KNOWN)

Fundamentos de Ingeniería Eléctrica
Líneas y subestaciones eléctricas
Circuitos Magnéticos y Transformadores

SKILLS AND LEARNING OUTCOMES

CB1. Students have demonstrated possession and understanding of knowledge in an area of study that builds on the foundation of general secondary education, and is usually at a level that, while relying on advanced textbooks, also includes some aspects that involve knowledge from the cutting edge of their field of study.
CB2. Students are able to apply their knowledge to their work or vocation in a professional manner and possess the competences usually demonstrated through the development and defence of arguments and problem solving within their field of study.
CB4. Students should be able to communicate information, ideas, problems and solutions to both specialist and non-specialist audiences.
COCIN1. Ability to draft, sign and develop projects in the area of industrial engineering for construction, renovation, repair, preservation, demolition, manufacture, installation, assembly or operation of: structures, mechanical equipment, energy installations, electrical and electronic installations, industrial plants and installations and automation and manufacturing processes.
COCIN4. Ability to resolve problems with initiative, decision-making, creativity, and critical reasoning skills and to communicate and transmit knowledge, skills and abilities in the Industrial Engineering field.
COCIN5. Knowledge to perform measurements, calculations, assessments, appraisals, surveys, studies, reports, work plans and other similar jobs.
COCIN6. Ability to deal with mandatory specifications, regulations and norms.
CEP1. Capacity to design a system, component or process in the area of electrical engineering in compliance with required specifications.
CEP2. Knowledge and ability to apply computational and experimental tools for analysis and quantification of electrical engineering problems.
CEP3. Ability to design and carry out experiments to analyze and interpret data obtained.
ECRT4. Capacity for calculation and design of high voltage electrical installations.
CT1. Ability to communicate knowledge orally as well as in writing to a specialized and non-specialized public.

By the end of this content area, students will be able to have:
RA1.3. Coherent knowledge of the branch of electrical engineering including some at the forefront of their branch in electric power facilities.
RA2.1. The ability to apply their knowledge and understanding to analyse engineering products, processes and methods.
RA3.2. An understanding of design methodologies, and an ability to use them.
RA4.3. Workshop and laboratory skills.
RA5.1. The ability to select and use appropriate equipment, tools and methods in electric power facilities.
RA6.3. Demonstrate awareness of the health, safety and legal issues and responsibilities of engineering practice, the impact of engineering solutions in a societal and environmental context, and commit to professional ethics, responsibilities and norms of engineering practice.

OBJECTIVES

-Understanding essential properties of electrical insulating materials.
-Knowledge about degradation mechanisms acting on insulating materials.
-Analysing the interaction between different degradation mechanisms enhancing premature ageing of

electrical equipment.
-Understanding the behaviour of High Voltage (HV) generation and measurement circuits.
-Understanding basic issues about the design of HV equipment insulation systems.
-Calculating electrical stresses applied to one insulating material taking into account the knowledge of its design.
-Getting useful information about acceptance and maintenance tests that certify the insulation status of electrical equipment subjected to High Voltages.

DESCRIPTION OF CONTENTS: PROGRAMME

Theoretical sessions.

1. Introduction.
1.1. High Voltage equipment.
1.2. Electrical, thermal and mechanical stresses applied to electrical equipment.
1.3. Insulation coordination.
1.4 Asset Management.

2. Electrical insulating materials.
2.1. Insulating gases.
2.1.1. Ionization process.
2.1.2. Air.
2.1.3. SF6 and other gases.
2.1.4. Applications
2.1.5. Degradation processes.
2.2. Insulating liquids. Applications and degradation processes.
2.3. Insulating solids.
2.3.1. Breakdown at insulating solids.
2.3.2. Applications.
2.3.3. Degradation mechanisms.
2.3.4. Partial discharges (PD) and tg delta. Equivalent circuit.

3. Devices for insulation tests.
3.1. High voltage generation circuits: AC, DC and impulse tests.
3.2. HV measurement circuits.

4. Insulation systems design.
4.1. Electrical stresses analysis in simple geometries.
4.2. Dielectric strength in common materials.
4.3. Introduction to manufacturing techniques in power cables and electric machines.

5. Degradation mechanisms in electrical equipment.
5.1. General issues.
5.2. Insulated power cables.
5.3. Insulators and bushings
5.4. Aerial conductors.
5.5. Switchgears.
5.6. Power transformers.
5.7. Rotating machines.

6. Maintenance tests for insulation status evaluation.
6.1. Insulation resistance measurement. Polarization index. Applications to different equipment.
6.2. AC and DC withstanding voltages.
6.3. Lightning and switching impulses tests. Surge tests.
6.4. Capacitance and tg delta measurement. Applications to different equipment.
6.5. PD measurements. Applications to different equipment.
6.6. Specific evaluation methods for transformers.
6.7. Specific evaluation methods for generators.
6.8. Fault location in power cables.

Practical sessions:

1.- Introduction to the HV laboratory and safety rules. Impulse tests.
2.- Insulation resistance measurements in power transformer and surge tests measurements in one rotating machine.
3.- Capacitance and tg delta measurements.
4.- PD tests.

LEARNING ACTIVITIES AND METHODOLOGY

- Learning in big groups (theoretical approach), learning in small groups (solving doubts), individual meetings to solve doubts (ask for them by email), individual student work. Theoretical knowledge (3 ECTS).
- Laboratory learning (4 sessions), learning in small groups (solving practical problems), individual meetings to solve problems (ask for them by email), individual student work. Practical knowledge (3 ECTS).

ASSESSMENT SYSTEM

Laboratory qualification:
The qualification will consider the solution to questions in the script after session and behavior and respect for safety rules (15%).

1st examination (May):
40% will be one final examination.
45% will be a continuous evaluation made at small groups. Each small group professor will explain his evaluation criteria, but there will be, at least, 3 exercises along the course.
In addition to this, depending on the number of the students in the subject, professor could qualify one voluntary report to do individually or in groups. This report could, as a maximum, increase the continuous evaluation mark in 30%.
15% will be the practical mark.

It is possible to pass the subject without doing the final examination. In order to achieve this, the student must have a continuous evaluation (85%) and practical (15%) mark above 6/10.

2nd examination (June):
If the student followed the small group evaluation, the final examination will be the same as in 1st examination (May). If not, the examination will have a maximum value of 100%, but the practical mark should be above 5/10.

If the student did not attend to lab sessions, he/she will have to pass an additional lab examination which must be solved without any mistake.

In order to pass the subject (1st or 2nd examination), students must reach one overall qualification of 5 points in a maximum of 10 points.

% end-of-term-examination:	40
% of continuous assessment (assigments, laboratory, practicals…):	60

BASIC BIBLIOGRAPHY

- J.A. Martínez Velasco , Coordinación de aislamiento en redes eléctricas de Alta Tensión,, McGraw Hill.
- J.M. Martínez Tarifa, J. Sanz Feito Aislamiento Eléctrico de Equipos de Alta Tensión, Garceta, 2020
- Khalifa M.; High Voltage Engineering. Theory and Practice,, Marcel Dekker.
- Kreuger F.H.; Partial Discharge Detection in High-Voltage Equipment,, Butterworth & Co..
- P. Gill; Electrical Power Equipment Maintenance and Testing;, Marcel Dekker.
- R.E. James, Q. Su; Condition assessment of High Voltage Insulation in Power System Equipment;, Institution of Engineering and Technology;.

- Stone G., Boutler E.A., Culbert I., and Dhirani H.; Electrical Insulation for Rotating Machines: Design, Evaluation, Aging, Testing and Repair;, IEEE Press Series on Power Engineering, Wiley Interscience.

ADDITIONAL BIBLIOGRAPHY

- D. Kind and H. Kärner; High-voltage insulation technology : textbook for electrical engineers;, Braunschweig : Vieweg;.
- E. Kuffel, W.S. Zaengl, and J. Kuffel; High Voltage Engineering: Fundamentals;, Butterworth-Heinemann;.
- H.M. Ryan ; High Voltage Engineering and Testing;, Institution of Electrical Engineers.
- N.H. Malik; Electrical Insulation in Power Systems;, Marcel Dekker.
- R. Bartnikas and E. J. McMahon; Engineering Dielectrics;, ASTM American Society for Testing and Materials;.
- R.W. Sillars; Electrical Insulating Materials and their Applications;, Ann Arbor, University Microfilms International;.
- T.J. Gallagher and A.J. Pearmain; High voltage: measurement, testing, and design;, Wiley.