

Digital high voltage diagnostics course program

2023-03

A series of lectures and lab demonstration for electrical engineer and PhD students on high voltage engineering, electrical insulation and safety, material aging mechanisms, modern high voltage testing, diagnostic and monitoring techniques, as well as digital substation basics and its monitoring functionalities will be presented during this course. The course includes both fundamental theoretical knowledge and field engineering practices for building up knowledges for future electrification challenges.

Lecturers: Prof. Stanislaw Gubanski (SG), Assoc. Prof. Thomas Hammarström (TH) and Dr. Xiangdong Xu (XX) from Chalmers university of technology.

Invited lectures: Prof. Tord Bengtsson (TB), Dr. Nilanga Abeywickrama (NA) from Hitachi Energy Research.

Time and form:

2023 week 11, Hybrid form, on site: at Chalmers E2 and on-line: Zoom's meeting.

Lectures (between 09:30 – 12:00 and 13:30-16:00)

Language: English

For PhD students: Course higher education credits: 7.5, (open exam, self-selected assignment defense)

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Course content

2023-03-13: Day 1 High voltage engineering basics

09:30-14:00 (1-hour lunch break)

Lecture 1 - Electric fields and stresses (SG): AC and DC electric field distributions and their fundamental differences. Electric field distribution in practical dielectric configurations and different field grading methods in applications.

Lecture 2 - Electric discharges (SG): Breakdown mechanisms in gas, liquid and solid dielectrics, i.e. streamer mechanism, corona, electronegative gases, arc discharge, arc (current) interruption techniques in gases, and particle-initiated breakdown in liquids, intrinsic-, thermal- and partial discharge-initiated breakdown, treeing in solids.

14:10-16:00

Lecture 3 - Generation and measurements of high voltages (XX): generation and measurements of high voltages i.e. transformer-, resonance- and rectifier circuits, impulse generators, voltage and current measurements using different techniques.

Lab tour and demonstration on high voltage generation and measurements.

2023-03-14: Day 2 electrical insulation and its characterization

9:30-12:00

Lecture 4 - Insulation material and system (SG): insulation systems in practice – organic and inorganic materials for insulation, impregnated insulation, composite insulation, ageing and life expectancy. Material solutions for electrical conductivity reduction and field dependence control, as well as its impact on other properties.

Lecture 5 - Dielectric response (SG): conduction and polarization mechanisms in insulation system, dielectric responses, concepts of resistivity (conductivity), permittivity and dielectric losses.

13:00-16:00

Lecture 6 and lab demonstration - Dielectric response measurement techniques (XX), time and frequency domain responses measurements principles and measurement techniques in field applications.

Lab demonstration on dielectric response measurements.

2023-03-15: Day 3 Partial discharges

9:30-10:30

Lecture 7 - Partial discharge (XX, TH): PD basics and its existences in power component insulation systems.

10:30-14:00 (1-hour lunch break)

Lecture 8 - Partial discharge measurements techniques (TH, XX, TB), Classic PD detection circuit Measurements of partial discharge activities under non-sinusoidal voltage transients, Stochastic PD detection as well as review of other PD detection techniques.

14:30-16:00

Lab demonstration on partial discharge and tan delta measurement techniques

2023-03-16: Day 4 Aging, and maintenance strategies

9:30-11:30

Lecture 10 - Aging mechanisms (SG/XX), electric, thermal, etc. aging of power equipment insulation system, including oil impregnated paper insulation, ageing, sources of water and acids in impregnated insulation systems, moisture diagnostics, solid dielectrics in power cables, electric treeing, water treeing,

Lecture 11 - Power components maintenance strategies (SG/XX) Power components condition assessment and maintenance strategies for high voltage insulation systems, basic principles and practical approaches for maintaining high voltage power components insulation systems, i.e. power transformer, cable systems.

13:30-16:00

Lecture 13 - Review on power components' condition assessment techniques for power cables (XX): including cable insulation systems and its degradation mechanisms; review on non-electric and electrical measurement techniques used in power cable diagnostics.

2023-03-17: Day 5 Digital diagnostics technologies

9:30-10:30

Lecture 14 - Digital substation basics (XX, NA): its topology, connection, and communication protocols. technical comparison between digital substation to a conventional high voltage substation.

10:30-12:00

Lecture 15 - Digitalization and power equipment monitoring (NA): Modern and digital substation equipment monitoring and diagnostics in general, and demonstration of a soft-sensing based transformer monitoring technique (Transformer Analyzer).

13:30-14:30

Lecture 16 - On transforming a diagnostic technique into a monitoring product (TB):

Transforming a diagnostic technique into a monitoring product imposes many challenges, both known and unknown. The talk will discuss a number of the known challenges that has been encountered in our history, like considerations on system properties, sensors, platform choice and algorithm design. To detect the unknown challenges as early as possible, field prototypes and pilots are needed and considerations on those are discussed.

14:30-16:00

Open discussions (All) and assignment tasks for PhD students, to be defended 2 weeks after the lecture with assigned opponents.

Bibliography

A. Küchler, High Voltage Engineering, VDI-Buch, Springer Verlag,

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