Department of Electrical and Computer Engineering
University of Waterloo

E & CE 665 - High Voltage Engineering Applications

Course Outline – Spring 2021

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Calendar Description:

Clasical methods of generation and measurements of all three types of voltages are considered first. In addition, the course deals with the emerging technologies in high voltage engineering focusing on both the generation and measurement aspects of special types of high voltages and their applications.

Part I: Concentrates on generation of high voltage ac, dc and impulse voltages of both switching and lightning surges. Measurements techniques based on different types of potential dividers and spark-gaps for ac, dc, and impulse measurements will be covered. Both destructive and non-destructive tests used in insulation performance evaluations are discussed.

Part II: The second part deals with generation and measurements of special types of high voltages needed for industrail applications.

Part III: The course also covers some applications of HV engineering in biotechnology and nanotechnology field.

Objectives:

- Study the theory of high voltage generation and measurements.
- Learn the operation of high voltage power supplies for ac, dc, and impulse voltages.
- Learn high voltage measurement techniques and testing.
- Get familiar with various applications where high voltage/high field is used.

References:

1. Lecture Notes
2. High Voltage Engineering – Fundamentals, 2nd Edition, E. Kuffel, W. S. Zaengl, and Kuffel, J. Oxford ; Boston : Newnes, 2000.
3. Advances in High Voltage Engineering: A. Haddad, D.F. Warne, Published by the Institution of Engineering & Tchnology, London, UK, 2004.
4. High Voltage Engineering; Practice and Theory by J.P. Holtzhausen and W.L. Vosloo, ISBN: 978 - 0 - 620 - 3767 - 7
5. Selected archival papers.

Prerequisites:

Basic knowledge of circuit analysis, and low voltage measurement techniques.

Basic knowledge of using MATLAB.

Familiarity with electrical power system components is useful.

Contents:

Numbers	Topics	Sub-Topics
1	**Introduction**	• Introduction to High Voltage Engineering and its Applications
2	**Generation of AC and DC Voltages**	• Production of high ac, and dc voltages for research and testing purposes • Special features of high voltage generating equipment • Rectifier circuits, half-wave, full-wave and multiplier circuits • Electrostatic generators • Test transformers • Single unit and casecade transformers • Resonant circuits
3	**Overvoltages and Insulation Coordination**	• Origin of high voltages • lightning phenomena • Switching transients • Temporary overvoltages • Practices in Insulation Coordination
4	**Generation of impulse Voltages and fast pulses**	• Standard lightning and switching impulses • Full wave and chopped wave impulses • Marx's principle and multi stage generators • Study of wave shaping circuits for generating lightning and switching impulses • Generation of special types of high voltage pulses of very fast rise time and short durations • Impulse currents
5	**Measurements of High Voltages**	• Clearance requirements • Voltage measurements by sphere gaps • Use of standard test data and correction factors • Potential dividers for ac and dc voltage measurements • Potential dividers for impulse voltage measurements • Resistive dividers, mixed dividers and capacitive dividers • Low voltage arm measuring instruments • Measurements of fast pulses (sub-microsecond rise time) • Electrostatic voltmeters • Sources of errors in HV measurements
6	**Destructive Tests**	• Breakdown and flashover studies • Wet and dry flashover at power frequency • Concept of Withstand • Flashover under polluted conditions • Up-and-down method for impulse and switching surges
7	**Non-destructive Tests**	• General remarks on Corona Discharges • Visible corona • Corona inception and extinction • Partial discharge (PD) measurements • Capacitance and tan delta measurements
8	**Applications in Biotechnology and Nanotechnology**	• Air Purification by Electrostatic Precipitators • Particle charging and collection • Flue gas emission control and acid rain issues • Electrospinning for nanofabrication • Pulsed electric field applications in biotechnology – food treatment • Waste water treatment technologies