Department of Electrical and Computer Engineering
University of Waterloo

ECE 6618 PD – Medium and High Voltage Power Cables
Course Outline – Winter 2019

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Course Content

Introduction: Vast urbanization and increasing pressure to meet high demand in power delivery and the use of renewable energy sources, have resulted in a significant growth in underground cable networks. In addition, underground cables being a critical asset group, any outages due to their failure will result in considerable service delivery and economic impact on the operation of power networks.

Objectives:

- Understand the basic dielectric theory, material properties and design details of underground cables and their accessories.
- Understand typical failure modes and their early detection of underground cables and their accessories.
- Understand the current carrying capacity considering the type of electrical insulation, and temperature distributions.
- Understand the steps involved in cable installations; pulling tension, bending and jamming effects, and bonding.
- Discuss in detail various laboratory and field tests (off-line and on-line) applicable to underground cables.

A detailed course outline is given in the Table below.

Course Evaluation:

- Assignments[1] - 50% — Questions will be assigned at the end of each major topic.
- Final Exam[2] - 50% — A written exam as per the University of Waterloo guidelines.

1. Questions including numerical examples will be assigned at the end of each major topic. In addition, you will be asked to read and evaluate a few selected research papers. The latter will form the reading assignments.
2. It is an "open" book exam; but there is no single book that can be recommended. It is your responsibility to bring the ***Reference Materials*** that may be helpful.

Requisites:

General background in power system components and distribution networks is essential. Knowledge of the course material from ECE 6608PD is an asset. But, lecture 7 will cover the required topics on ***conduction and breakdown mechanisms related to solid dielectrics that*** is essential for understanding the ageing, degradation and failure mechanisms of power cables in service.

Course Content

Lectures	Topics	Description
1-2	**Materials, Design and Manufacturing**	• Design principles and standards • Types of cables • Paper/Oil insulated cables • Extruded polymeric cables • Conductors, • Shielding, sheaths, jackets and armors
3	**Accessories**	• Cables joints, straight joints, transition joints • Cable terminations; polymeric, ceramic • Heat shrink and cold shrink • Electric field distribution and stress grading
4	**Installation**	• Installations process • Direct buried, ducts, troughs and tunnels • Cable pulling issues • Thermo-mechanical forces • Soil thermal resistivity and temperature gradients
5-6	**System Design**	• Ampacity, electric field, eddy currents, conductor resistance. • Cable ratings and calculations • Thermal limits, standards and practical considerations • Sheath bonding • Heat dissipation • Cable system impedance for system studies • Magnetic field considerations
7	**Breakdown Mechanisms**	• Breakdown theories; Townsend and Streamer mechanisms • Corona discharges; • Breakdown in solid dielectrics • Internal and surface discharges • Failure mechanisms
8-9	**Aging**	• Defects, high fields, • Practical aging mechanisms • Partial discharges • Treeing; electrical trees, their growth • Water treeing; vented trees and bow-tie trees
10-11	**Testing and Diagnostic**	• Standards • Classical and modern diagnostic techniques • Dissipation factor, dielectric constant (permittivity), partial discharges • Laboratory and field testing • Acceptance/commissioning and maintenance testing • Low frequency testing
12	**Asset Management**	• Loading schedules, standards and health index • Maintenance plans • Specification on cable procurement • Condition assessment/ranking

Recommended Reference Book

Electrical Power Cable Engineering, Editor: William A. Thue, ISBN**:** 978-0-8247-4303-1 (hardback) 978-0-203-97061-4 (electronic), June 2005. ***Access to this book in electronic version is available from the University of Waterloo Library.*** Link will be posted on UW-LEARN.

Other References:

During the course of presentation, several papers and sections of books/reports will be suggested as ***Reference Materials;*** and these materials will be posted on UW-LEARN.