Partial Discharge Detection and Location for HVDC Cables

Future Power Networks & Smart Grids Centre for Doctoral Training

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Research Motivation

Partial discharge testing is becoming increasingly integral to the condition monitoring of electricity transmission assets.

However the increasing use of high voltage DC links, particularly for national/international interconnectors, and for connections to off-shore wind farms, presents problems for this approach.

There is significantly less experience regarding the behaviour of partial discharge under DC conditions.

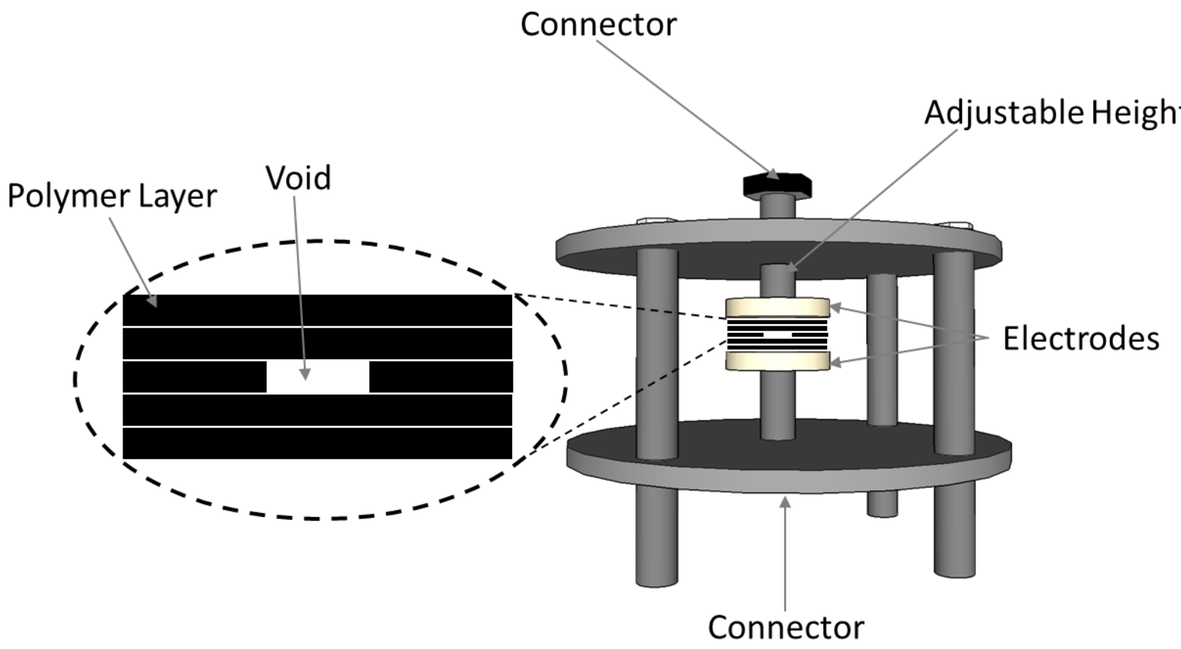
This project aims to address particular knowledge gaps in:

- The interpretation of HVDC PD data.
- The effect of cable insulation material on PD inception.
- Methods of determining the location of PD along a cable.

AC vs DC Partial Discharge

AC	DC
• Well understood phenomenon with industrial experience.	• Poorly understood connection between PD data and specific insulation faults.
• Used as part of condition monitoring schemes.	• Use in condition monitoring schemes yet to be proven.
• Repeated discharge leads to insulation breakdown.	• Repeated discharge symptom of insulation imperfections rather than cause.
• Pulse magnitude significantly greater than background noise. Repletion rate connected to electrical frequency.	• Background noise and disturbance more significant due to smaller pulse magnitude and lower repetition rate.
• Temperature has little effect on PD activity.	• High temperature leads to greater PD repetition rate.
• PD repetition due to cycle in electrical charge direction.	• Repetition due to finite resistivity of insulation. Greater repetition rate at cable energisation/de-energisation, and polarity change.
• Measurands are pulse magnitude and phase.	• Measurands are pulse magnitude and time between pulses.

Test Cell



Experimental Plan

- Voids in polymer cable insulation under investigation
- Artificial voids created from layer polymer films
- Different types of insulation under investigation:
  - Low Density Polyethylene (LDPE)
  - Cross-Linked Polyethylene (XLPE)
  - Polypropylene Laminate (PPL)
- Aim to determine:
  - Validity of test set-up
  - PD inception voltage for each polymer
  - PD activity under AC voltage
  - PD activity under DC voltage
- To understand the effect of polymer type on DC PD activity
- Allow for better interpretation of HVDC PD data
- Analysis will be performed via:
  - Comparison with other experimental data
  - Chemical analysis of degradation
  - Physical analysis of damage
- COMSOL Multiphysics simulations will be completed of:
  - Electric field stresses
  - PD inception voltages

References

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[2] G. Mazzanti and M. Marzinotto, "Fundamentals of HVDC Cable Transmission," in *Extruded Cables for High-Voltage Direct-Current Transmission:Advances in Research and Development*, 1st ed., Wiley-IEEE Press, 2013, p. 384.

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