Partial Discharge Detection and Location for HVDC Cables

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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 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 no 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.

Locating Partial Discharge

There are a variety of methods for determining the location of a partial discharge under AC conditions, however the practical use of these methods under DC conditions is yet to be demonstrated. Common methods for AC PD are:

- Acoustic detection.
  - Requires moving detector, likely impractical for length of HVDC cable, or for subsea applications.
- Traveling wave location from pulse.
  - Small pulse size and repetition rate, may make this impractical.
- Time-domain waveform measurement.
  - For example from leakage current instability.
  - Only for particular causes of PD, such as water-treeing.
  - Further research required to determine usability.

High Voltage DC Cables

There are four main insulation types used for cables in use for HVDC links today:

- Mass impregnated non-draining (MIND).
- Oil-Filled.
  - Self contained oil-filed (SCOF).
  - High pressure oil filed (HPOF).
- Extruded Insulation.
  - Low density polyethylene (LDPE).
  - Cross linked polyethylene (XLPE).
- Polypropylene Paper Laminate (PPL).

In modern HVDC links, extruded insulation is the most common, with the newer PPL type beginning to see some use. This project will look at how the choice of LDPE, XLPE or PPL affects the partial discharge activity observed.

Research Plan

The plan for this project is to first investigate the effect of different insulation types on the PD activity. SP Energy Networks is providing cable samples for testing, and data from other research projects into PD in HVDC cables may be drawn upon. From this knowledge the feasibility of different PD location methods will be assessed.

Activity	Year 1	Year 2	Year 3
Literature Review			
Investigation of effect of Insulation on PD			
Considartion of detection technologies			
Write-up			

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