The Tony Davies High Voltage Laboratory

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UNIVERSITY OF Southampton

The Study of Partial Discharge Signal Limitation for Source Localisation inside a Transformer Winding

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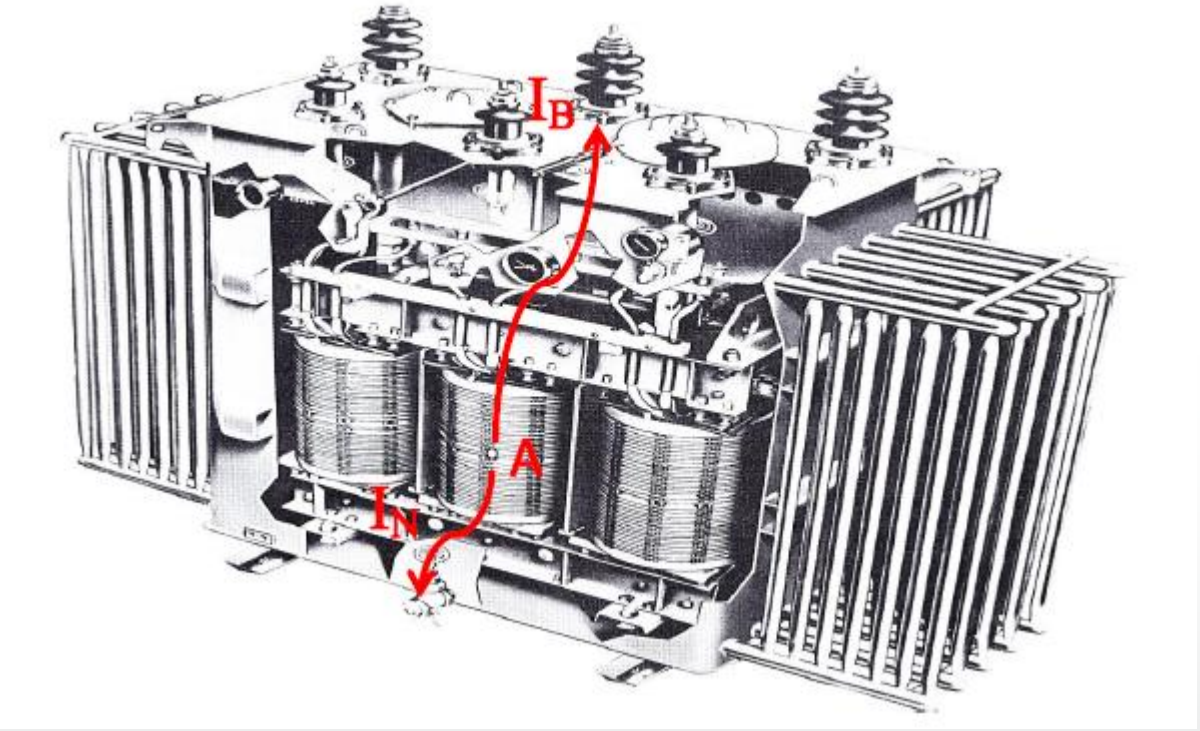
Outline

- Problem statements & Objectives
- Transformer winding equivalent model
- Experiment and PD sources
- PD Localisation
- Signal Limitation
- Summary

Problem Statements

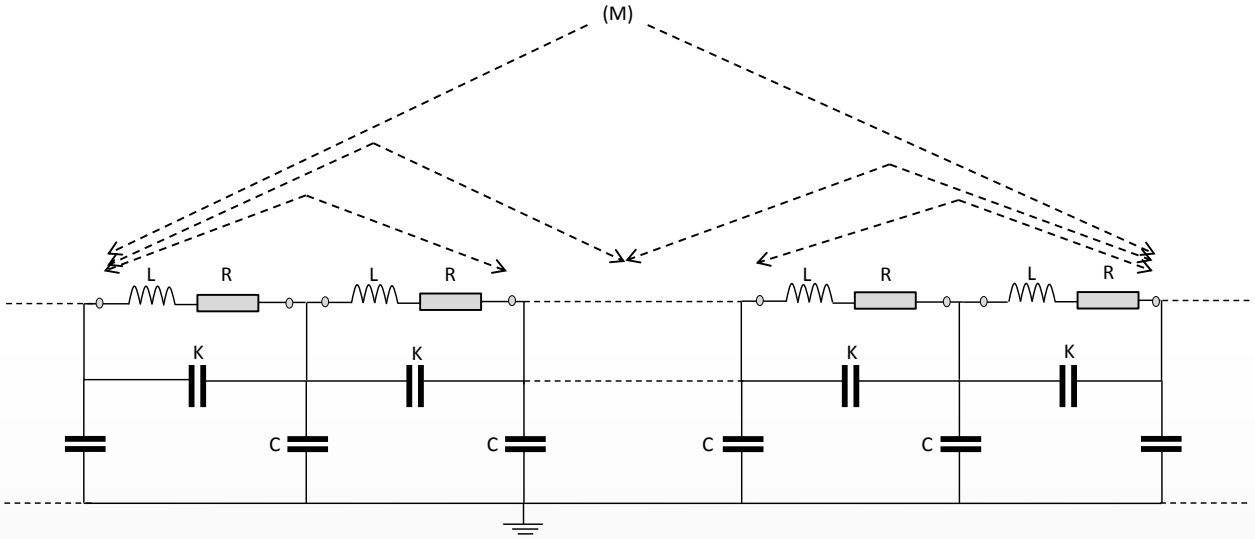
- PD is a common phenomena that may occur in a transformer due to ageing, operational overstressing or defects introduced during manufacture.
- PD activities inside high voltage plant lead to further degradation to insulation material.
- Condition monitoring needs to be reliable and must prevent ultimate failure.
- PD source localisation allows the severity of a fault to be estimated.
- Transformer windings are complex due to their structure and dimensions and also the number of external measurement points are limited.
- An appropriate method of PD measurement and analysis needs to be established.

Objectives



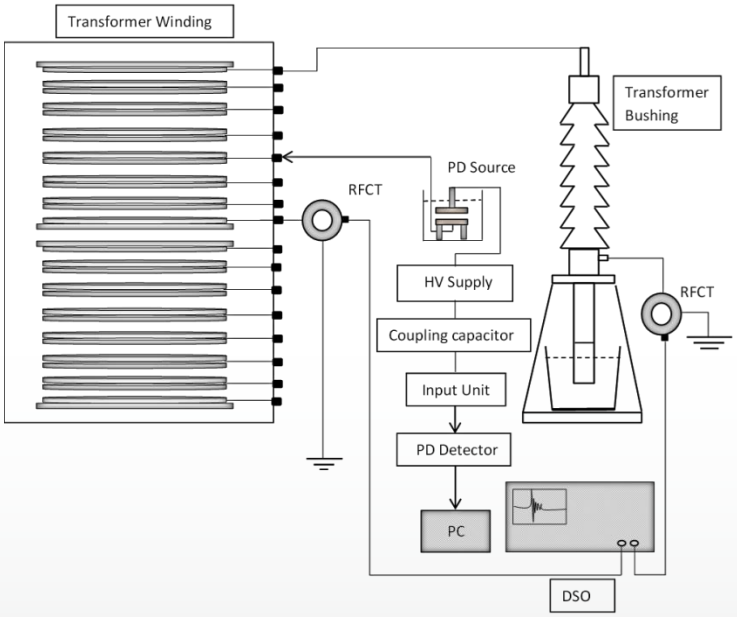
The focus of this study is to develop a new approach into PD localisation while investigating PD activity and propagation inside a high voltage transformer winding.

Equivalent model



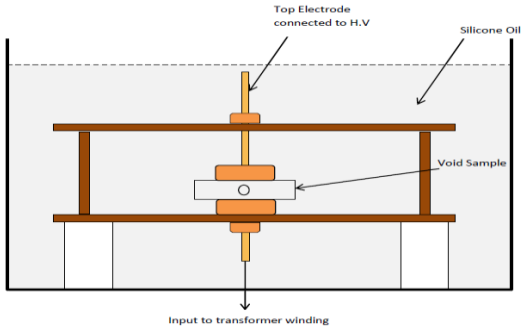
- A large coil covered with oil-paper insulation and immersed in transformer oil.
- RLC transmission line network.
- Coil winding represented as a inductances (L), capacitances (C) represent insulation system while losses are included as resistances (R)

Experiment

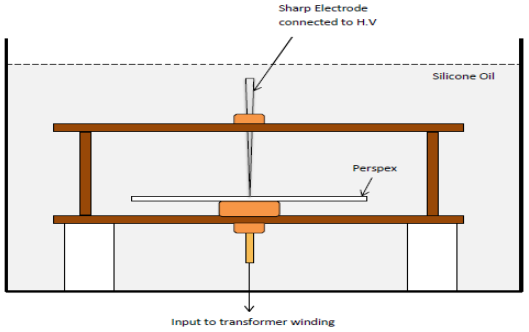


- The winding model is interleaved type model.
- It consists of eight terminals where terminal 1 is connected to the bushing core bar while the last terminal is grounded.
- PD source was injected along the winding.
- Mtronix PD detector is used to detect and quantify PD activity, while Tektronix digital storage oscilloscope stored discharge signals from both measurement points via CT.
- The experiments use Clamp-type RFCTs in the range of 10kHz-200Mhz to measure PD signal propagated to the located measurement points.

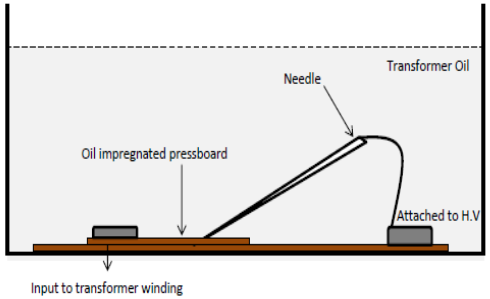
Artificial PD Sources



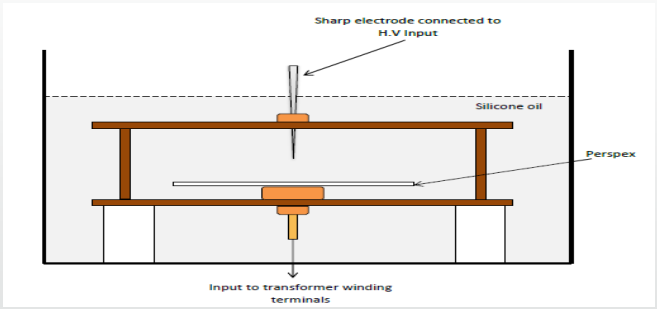
Void discharge



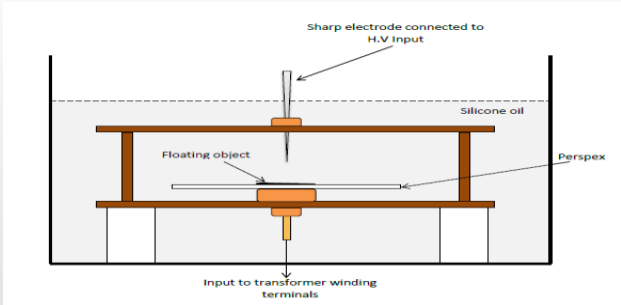
Surface discharge



Surface discharge on pressboard

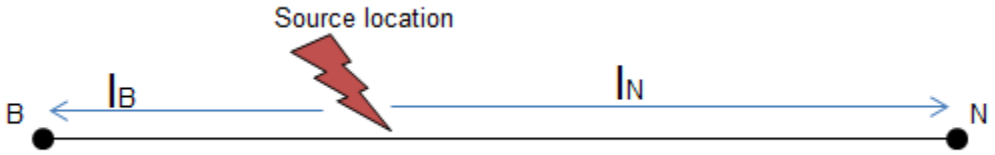


Corona in oil discharge



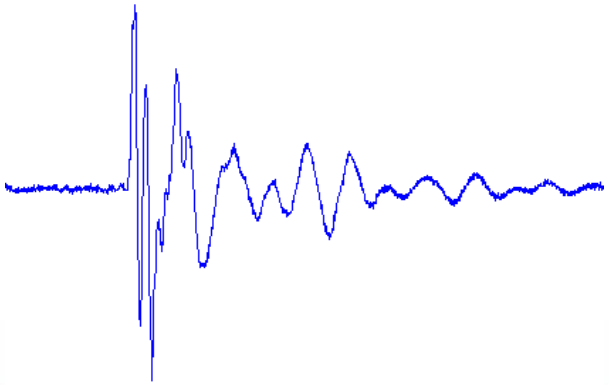
Floating discharge

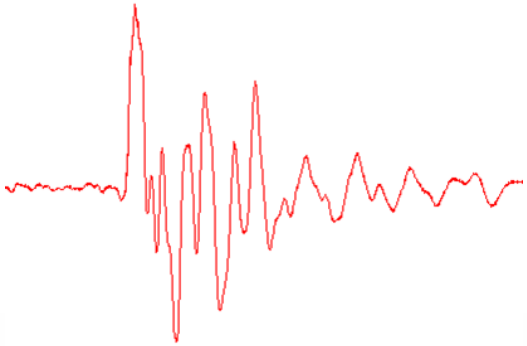
PD localisation



- This approach uses the physical properties of the measured PD signal.
- Produce a ‘feature’ that ultimately allows location of the PD signal source.
- Also can be called an energy based approach.

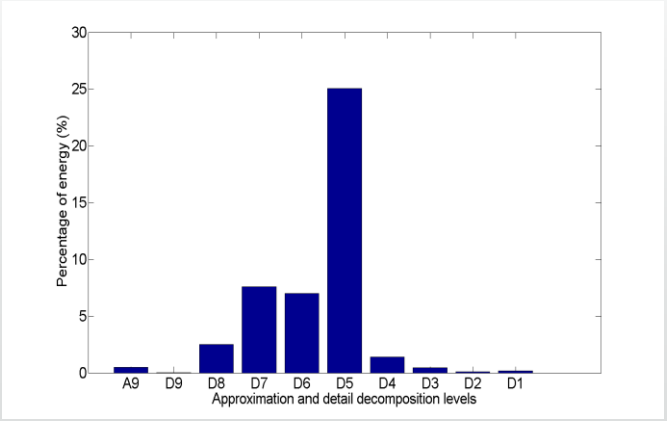
Energy based method

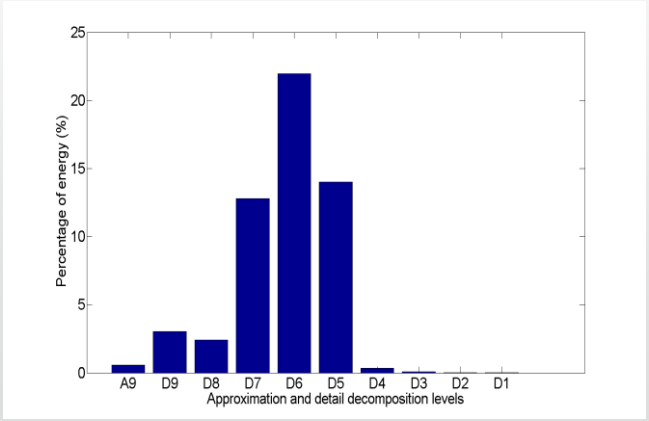




PD signal

Wavelet decomposition



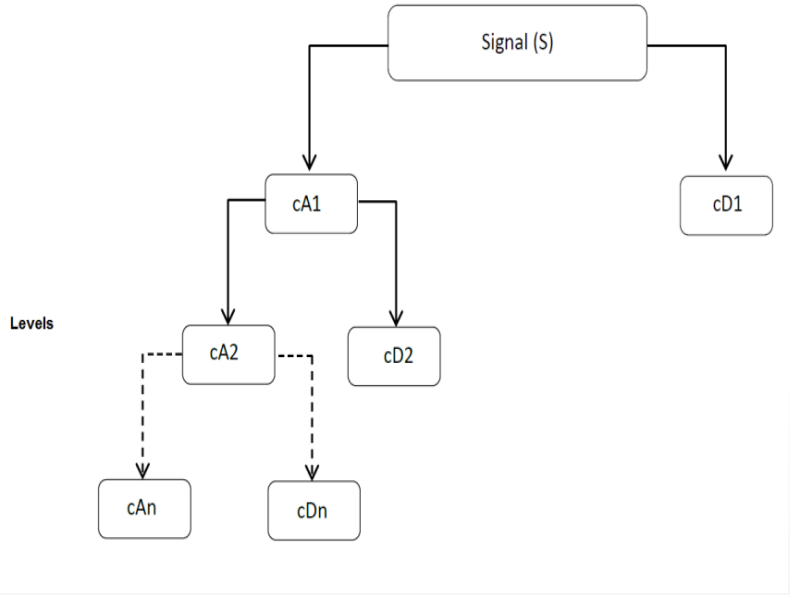


Percentage of Energy

Energy based method (Cont.)

Wavelet Analysis

- Based on wavelet function (ψ) and scaling function (Φ) that provide the time-frequency resolution.
- Multi-resolution analysis – Iterative process.



N- levels decomposition

- A series of filter banks - high pass and low pass filters.
- The decomposition process computes decomposition coefficients, cA and cD.

Energy based method (Cont.)

Terminal	Bushing tap	Neutral to Earth
1	68.53	31.47
2	66.36	33.64
3	57.16	42.84
4	49.30	50.70
5	39.87	60.13
6	36.74	63.26
7	21.86	78.14
8	15.12	84.88

Table 1: Example of the total Percentage of energy for decomposition levels

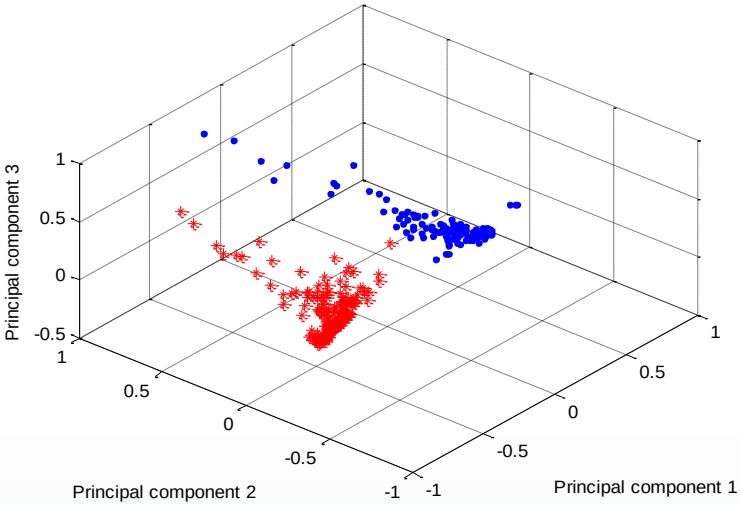
The signal energy is dependent on the location of the source with respect to measurement points

Energy based method (Cont.)

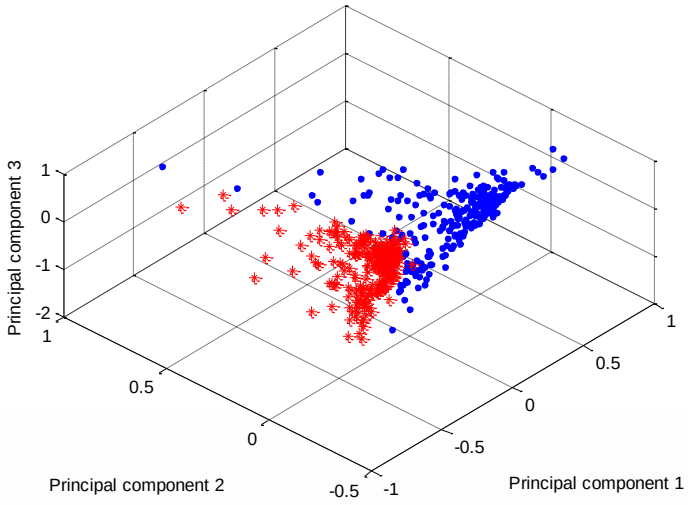
Principal Component Analysis (PCA)

- Statistical procedure that transforms a number of correlated variables into a smaller number of uncorrelated variables called principal components.
- The first principal component accounts for highest variances in the data and each succeeding principal component accounts for the remaining highest variances with respect to the order of principal component.
- Reduces the dimensionality of the dataset and aids visualisation of the features.

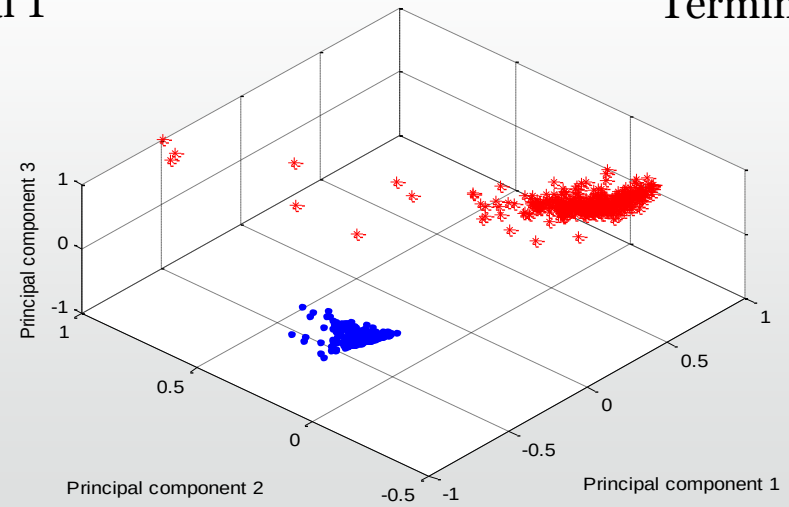
Case I



Terminal 1

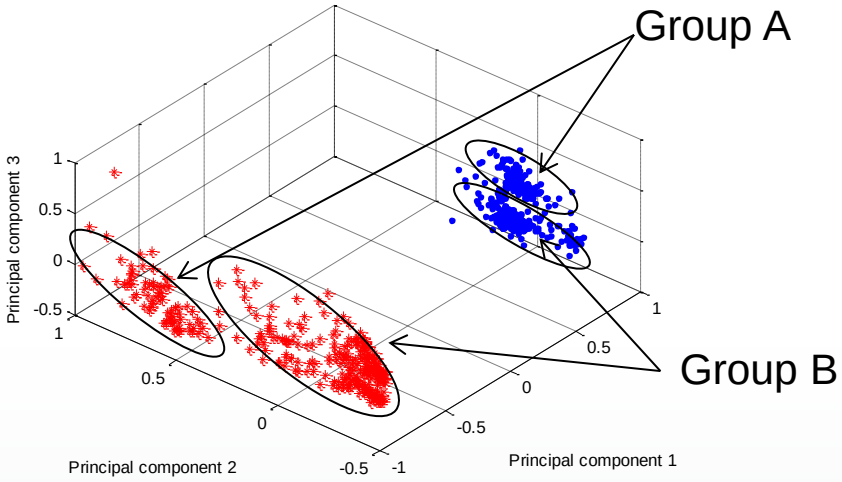


Terminal 4

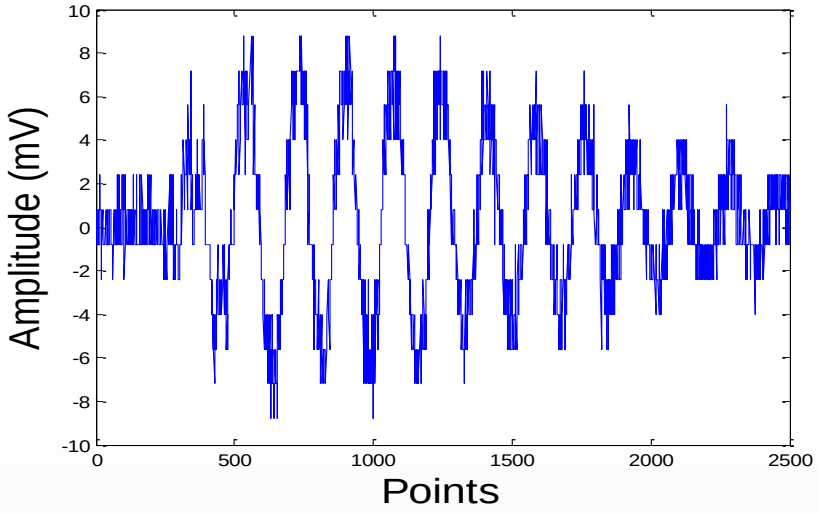


Terminal 8

Case II



Terminal 1



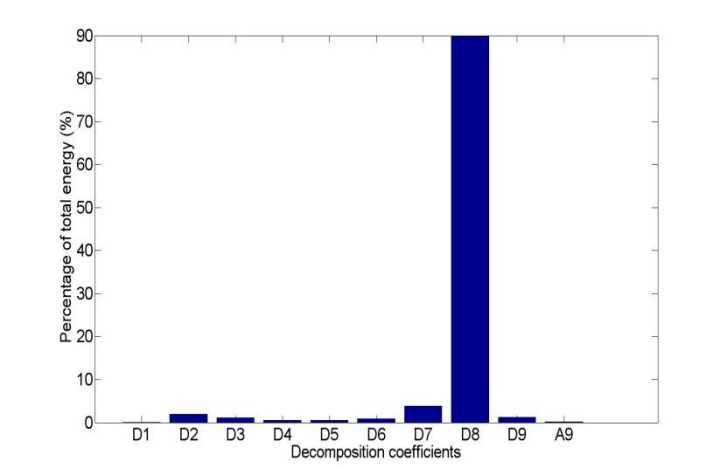
Example of PD pulse signal

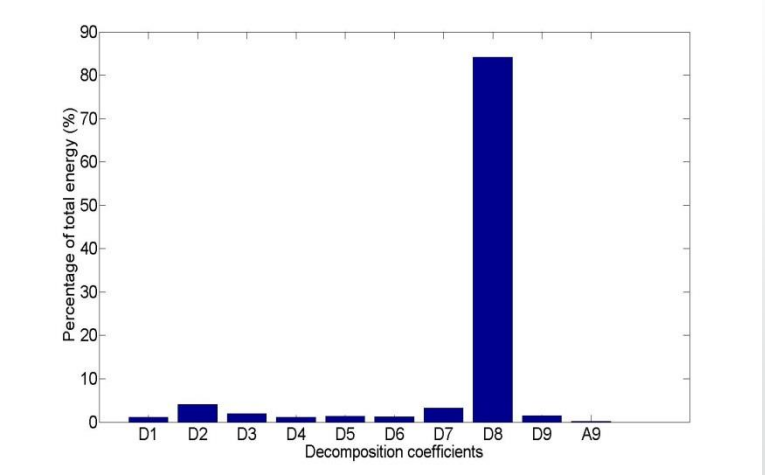
Group A – Noise?? While group B is the main PD signal.

Signal Limitation

- PD may be generated with small magnitudes and will be considerably smaller when detected at the measurement points and information could be buried in the noise.

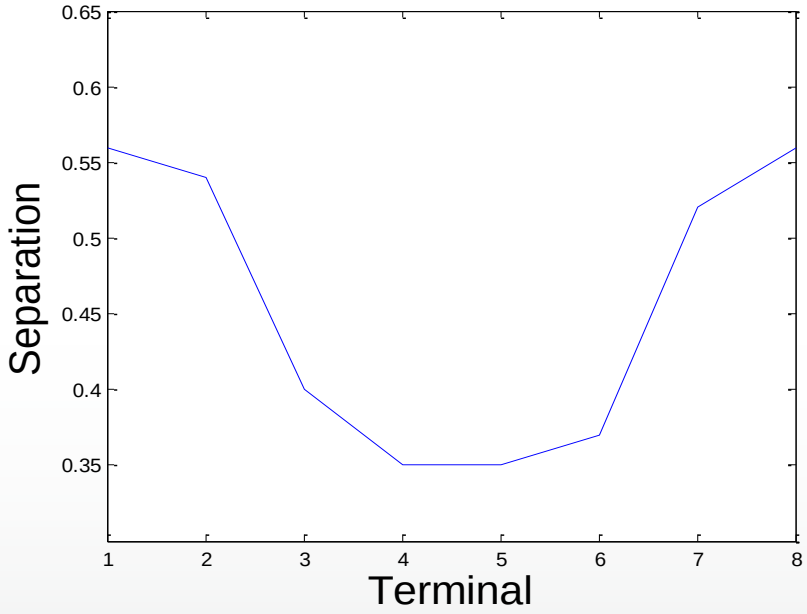
- In the case of small discharge signals, the energies produced by Wavelet analysis are not well distributed.



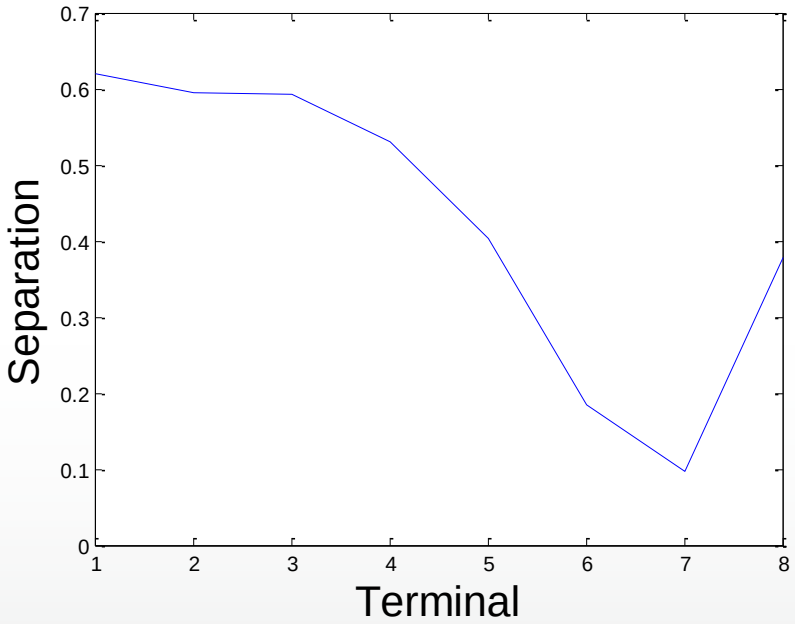


The percentage of energy for a) terminal 1 b) terminal 7

Case I & II



Case I

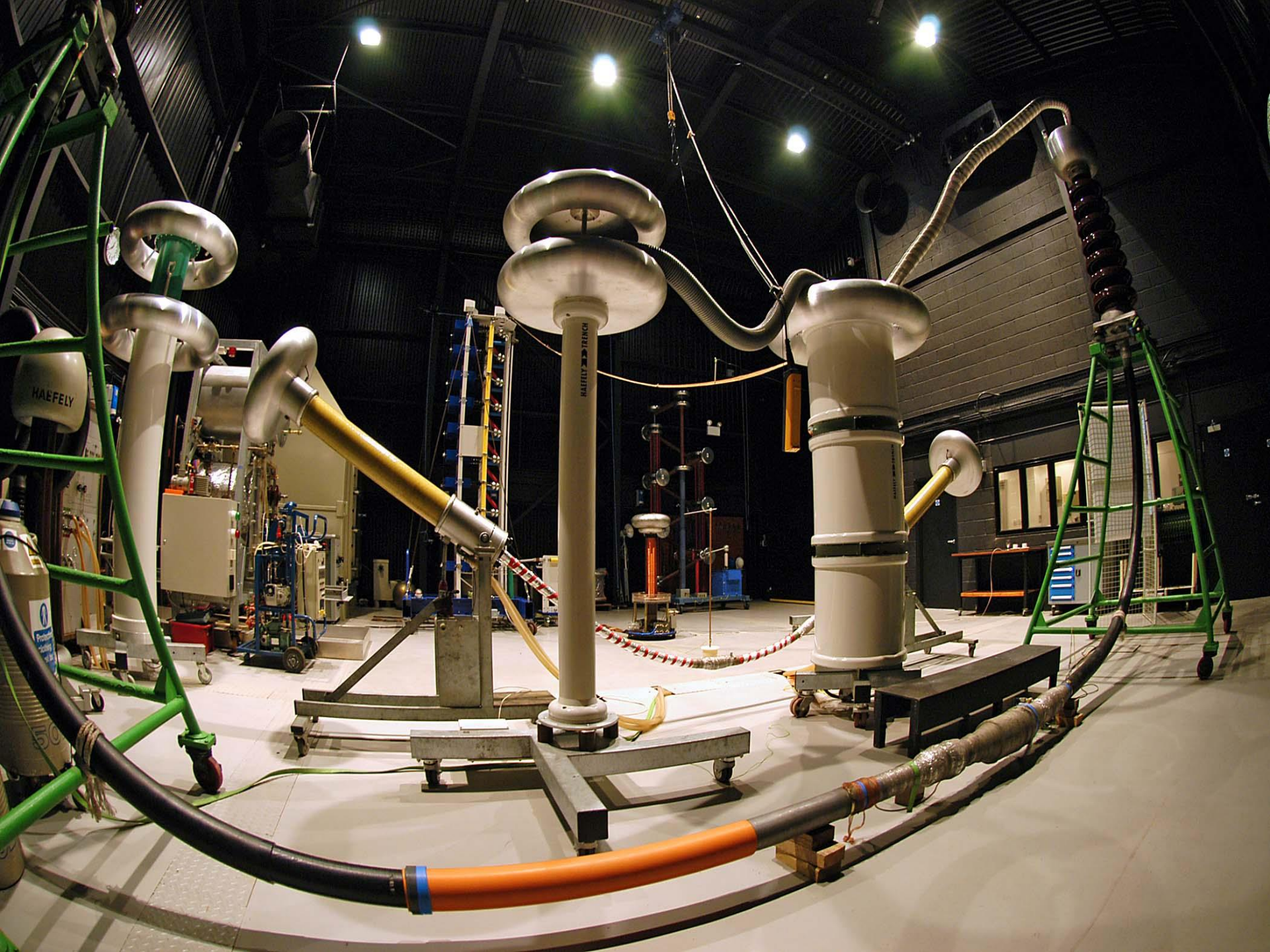


Case II

- Centroid of the clusters have been chosen as a point to measure separation length.
- A plot for all terminals is ‘U’ shaped for case I – indicates the separation length decreasing towards the middle of the winding.
- The localisation result appears slightly different than the previous case.

Summary

- This method using energy of PD signal measured from external points of the winding as a 'feature' shows promising result to locate partial discharge inside a transformer winding, for large discharge signals.
- The Wavelet transform is able to divide the total energy into different levels of energy with respect to frequency and time ranges.
- This is preliminary work towards a new and automatic approach to PD condition monitoring of autotransformer.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