Partial Discharge Pulse Clustering Method using Wavelet Decomposition Technique and Principal Component Analysis

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ABSTRACT

Clustering techniques using differences in pulse waveforms for partial discharge pulses have been applied to separate noise in on-site partial discharge diagnosis. These methods are effective in distinguishing pulses, but have some difficulties in the classification for small waveforms due to the resolution of the measuring system. To improve this, this study proposed the partial discharge pulse clustering technique using wavelet decomposition method and principal component analysis (PCA). Several kinds of partial discharges such as void, surface, and corona discharges were generated in DC voltage application for power cables and their pulse waveforms were measured. The measured waveforms were divided into several sub-pulse waveforms with high and low-frequency components using the wavelet decomposition method. Various statistical feature parameters were extracted from the derived sub-pulse waveforms. In addition, pulse clustering was performed for each defect type including noise through PCA.

KEYWORDS

Partial Discharges, Wavelet Decomposition, Principal Component Analysis, Clustering methods.

INTRODUCTION

One of the biggest challenges in on-site partial discharge diagnostics is the noise elimination, and pulse waveform analysis is a very effective method for de-noising. The partial discharge pulse waveform depends on the type of defect, the type of measurement sensor, and the distance between the defect and the sensor. Various studies have been performed to analyze pulse waveforms with these characteristics, including statistical feature extraction of PD pulses to compare pulse waveforms [1-2], which are difficult to distinguish when the pulse waveforms have similar shapes. Clustering analysis through time-frequency components [3] such as T-F map shows good performance for clustering when the size of the pulse signal is large, but when the size of the pulse signal is small the clusters may not be clearly distinguished due to the resolution of the measuring system.

The pulse analysis techniques developed in these studies are based on the analysis of the partial discharge waveform and noise generated by specific power equipment to classify measured pulses. However, the classification may not be easy when clustered by limited pulse features only. Therefore, more detailed pulse waveform analysis should be performed for application in various environments and power equipment.

Therefore, this paper studied an effective clustering method of pulse signals using Wavelet Decomposition and Principal Component Analysis. Using selected wavelet decomposition conditions, measured pulse signals were divided into several sub-wavelengths with high-frequency and low-frequency components. Detailed features were extracted from the divided sub-wavelengths. In addition, Principal Component Analysis (PCA) was adopted to classify the signals using the extracted features. For this purpose, DC partial discharge experiments were performed on various types of defects in power cables, and clustering of pulse signals by signal types was performed including noise.

PARTIAL DISCHARGE PULSE MEASUREMENT

Partial discharge pulses are characterized by a frequency component according to the impedance difference in the propagation path between partial discharge source and the sensor. That is, the partial discharge pulse waveforms from the same source can be differently measured depending on the measurement location. In this study, DC partial discharge experiments were performed by applying DC voltage to the AC cable where the model defect was installed. As shown in Fig. 1, 22.9kV AC CNCV cables with 5m and 20m in length were jointed to form a total of 25m. A partial discharge model defect was installed at the 0m location. The DC partial discharge inception voltage (PDIV) was determined when three or more partial discharge pulses occurred in 10 seconds after the DC voltage was applied, and the partial discharge experiment was performed at a voltage of 1.2 times PDIV. Three HFCTs in the frequency band of 1 to 300 MHz were installed at 0 m, 5 m, and 25 m on the outer semi-conducting layer of the cable. Partial discharge pulse waveforms with 200 points for 2 μs were measured using the 100 MS/s partial discharge monitoring system (PDMS) and 1 GHz 5GS/s oscilloscope.

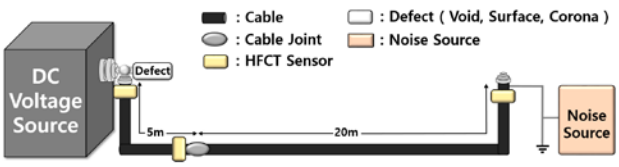

Fig. 1 : Experimental system

To simulate the partial discharge, three different types of defects were modelled and power electronics noise was adopted, as shown in Fig. 2. The void defect was the clyndrical type with 1mm thickness and 2 mm diameter between two insulators. The surface discharge model was composed with the insulation plate having the high-voltage and the ground electrode. The corona defect model was composed with needle and flat electrode.

In addition, to verify the proposed algorithm in this study, fluorescent lamp noise with AC characteristics was considered as an external noise to partial discharges in the cable. The fluorescent lamp noise source was connected to the ground, and then it is verified whether partial