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Partial Discharge Signal Analysis Using Wavelet Transform Technique: Review

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Abstract— Partial discharge (PD) signals are electrical discharge , which partially can bridge the insulation between two conductors . For such non-stationary signals, the wavelet transform (WT) is more suitable than the traditional Fourier transform (FT) as it provides information in both time and frequency domains. In this paper is described short review of wavelet transform in the suppression of the main types of noise that can affect the observation and analysis of PD signals in high voltage apparatus.

Index Terms— Wavelet transform , Fourier transform, partial discharge, de noise

1 INTRODUCTION

FOURIER analysis on acoustic signals can be carried out and provide useful information if these acoustic signals are not time varying. If the acoustic signals are time varying, it is necessary to perform Fourier analysis at different time instants. Most of the acoustic signals generated by PD contain numerous non- stationary and transitory characteristic: tendencies as well as abrupt changes from the start to the end points of the signals. These characteristics are often the most important part of the signals. Fourier analysis suffers from a serious disadvantage, that is, all temporal information are lost during the transformation process from time domain to the frequency domain. It is impossible to look at a transformed Fourier signal and state when a particular event took place. In an effort to correct this deficiency, the Fast Fourier Transform analyzes only a small section of the signal (window technique). This analysis presents the signal in a two-dimensional function of time and frequency from which temporal and frequency information can be extracted. However the computational precision is limited and is determined by the size of the window employed in the calculation. For this reason this technique is not used to analyze the acoustic signals generated by PD. Wavelet analysis is the best solution. Use of wavelet transform (WT) has many advantages over Fourier transform and has the capability of processing signals with transient features. It allows the use of long time intervals which contain low frequency information, and allows the use of shorter temporal regions which contain high frequency information and bigger area of interest [1].

This paper will provide a brief overview of current research achievements in signal denoising using adaptive wavelet transforms.

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2 FUNDAMENTALS OF WAVELET TRANSFORM

The acoustic signals have some non-linear characteristics due to the dispersive and random like behavior of PD. The problem of non-linearity of the acoustic signal is overcome by using WT which is available from Matlab wavelet toolbox. This tool box is normally used for feature extraction. Pre-processing is carried out with the help of appropriate window functions as illustrated in Figure 1. The values of the wavelet transform are generated from the coefficients from which the features are extracted. Wavelet transform analysis of PD signal is a good tool to analyze non-linearity as it represents the features both in time and frequency domains [2,3]. Generally, discreet wavelet transform (DWT) is used for this purpose [4-6]. One of the capabilities of DWT is that, it produces details of high frequency and low frequency characteristics of the acoustic signals. During the first stage of signal processing, the captured signal is divided into the high frequency and low frequency components. During the second stage of signal processing each of these components is again divided into the high and low frequency parts. With four level wavelet transform, only two stages of signal processing are required [7]. The final output represent different frequency packets of the captured signal in the wavelet transform domain [8,9]. Applications will determine the mother wavelet selected.

Daubechies wavelet transform can also be used to reduce non-linearity and the interfering effect of noise in the acoustic signals generated by PD [10,11]. In this work, the use of

Daubechies wavelets of order 2 has been evaluated, and the results have shown that this technique is able to reduce non-linearity and noise effectively. The decision on the selection of the suitable number of breakup levels will depend on the nature of the signal. Acoustic signals generated by PD in the experiment warrant four levels of decomposition. The low frequency band (approximation) is the most important part of the acoustic signal [12,13].

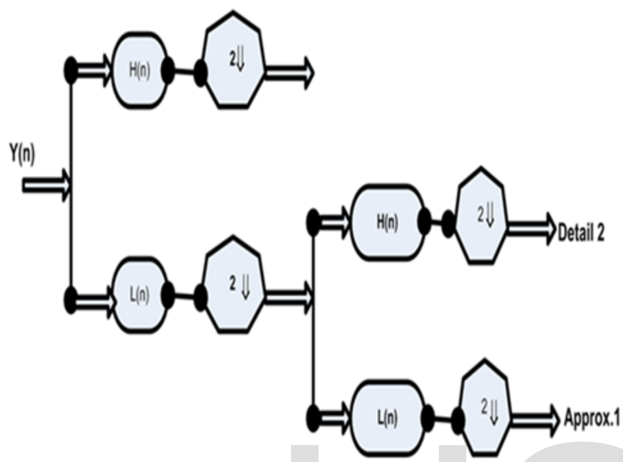

Fig.1 The filtering process in the DWT

3 DWT BASED DENOISING

On-site PD measurements always suffer from presence of excessive external noises including PD shaped pulses such as external corona pulses, continuous periodic signals related to radio transmission signals and interferences from power electronic equipments. Also zero mean white noise signals sometimes could influence PD detection. In DWT based PD denoising procedure, at first measured signal is decomposed using a suitable mother wavelet into an N level of lower resolution signals. Then those coefficients that are related to external noises are eliminated via a thresholding process. In this process, components that represent desired signals are survived to reconstruct PD pulses using Inverse Discrete Wavelet Transform (IDWT). An automated level dependent threshold value is defined in [14]:

$$\lambda j = \frac{mj}{0.647\sqrt{2\,\log nj}} \qquad 1)$$

λj indicate threshold value at jth level. mj and nj represent the median value and the length of coefficients at at jth level.

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References

[[1] Macia-Sanahuja C. and. Lamela-Rivera H, Wavelet analysis of partial discharges acoustic waves obtained using an optical fiber interferometric sensor for transformer applications, 2003 IEEE Int. Symp. Ind. Electron. (Cat. No.03TH8692), vol. 2, pp. 1071–1076, 2003.

[2] Ming Yu B. S., Characterization of Partial Discharge Signals Using Wavelet and Statistical Techniques. Proceedings of International Symposium on Electrical Insulation, 2002, p. . 9–13.

[3] Gulski E, K. F. H Computer-aided recognition of discharge sources, IEEE Trans., vol. 72, pp. 82–92, 1992.

[4] Suresh D, Feature Extraction for Multi Source Partial Discharge Pattern Recognition, in Proceedings of the IEEE Indicon Conference, 2005, pp. 309–312.

[5] Ma, K. I. J. Zhou C, Interpretation of Wavelet Analysis and its Application in Partial Discharge Detection, IEEE Trans. Dielectr. Electr. Insul., vol. 9, pp. 446–457, 1992.

[6] Lalitha EM, S. L.Wavelet Analysis for Classification of Multi-Source PD Patterns, IEEE Trans. Dielectr. Electr. Insul., vol. 7, pp. 40–47, 2000.

[7] Geethanjali B. R, Mary M, Slochanal SR, A Novel Approach for Power Transformer Protection based upon combined Wavelet Transform and Neural Networks (WNN), in Proceedings of International Power Engineering Conference, 2005, pp. 1–1576.

[8] Pihler J D. D., Grcar B, Improved operation of power transformer protection using ANN, IEEE Trans. power Deliv., vol. 12, pp. 1128–1136, 1997.

[9] Mao PL A. R., A wavelet transform based decision making logic method for discrimination between internal faults and inrush currents in power transformers, Int. J. Electr. Power Energy Syst. 22 , vol. 22, pp. 389–395, 2000.

[10] Zhou X S. B., Zhou C, Comparisons of Discrete Wavelet Transform, Wavelet Packet Transform and Stationary Wavelet Transform in De-noising PD Measurement Data, in Proceedings of the International Symposium on Electrical Insulation, 2006, pp. 237–240.

[11] Coifman PR W. M., Entropy-based algorithms for best basis selection, IEEE Trans. Inf. Theory, vol. 38, pp. 719–746., 1992.

[12] D. I, Ten Lectures on Wavelets. Philadelphia: Society for Industrial and Applied Mathematics, 1992, p. pp 1–366.

[13] Al-geelani N. A., Characterization of acoustic signals due to surface discharges on H.V.glass insulators using wavelet radial basis function neural networks, Appl. Soft Comput., vol. 12, pp. 1239–1246, 2012.

[14] X. Zhou, C. Zhou and I. J. Kemp, "An Improved Methodology for Application of Wavelet Transform to Partial Discharge Measurement Denoising," IEEE Transactions on Dielectrics and Electrical Insulation Vol. 12, No. 3; June 2005.