APPLICATION OF WAVELET TRANSFORM FOR MONITORING SHORT DURATION DISTURBANCES IN DISTRIBUTION SYSTEMS

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ABSTRACT

This paper presents features that characterize power quality disturbances from recorded voltage waveforms using wavelet transform. The concept of Discrete Wavelet Transform for feature extraction of power quality disturbance signals has been incorporated as a powerful tool for detecting and classifying power quality disturbances like Sag, Swell and Interruption and decomposed up to 4 levels using Db4 wavelet. The Multiresolution analysis is used to classify and quantify the power quality disturbances which obtained by plotting the standard deviations of the decomposed signal at different resolution level. The clear information for detection of power quality disturbances are obtained by plotting the entropy of the decomposed signal at different levels.

Keywords
power quality, detection of disturbances, Daubenchies, discrete wavelet transform, Multiresolution analysis, entropy.

I. INTRODUCTION

Electric Power Quality is a very important issue as far the power supply utilization is concerned. The increased requirements on supervision, control and performance in modern power systems make power quality monitoring a common practice for utilities. Studies of power quality phenomena have emerged as an important subject in recent years due to renewed interest in improving the quality of the electric supply. Poor power quality may cause many problems for affected loads such as malfunctions, instabilities
and short lifetime. In order to improve electric power quality, the sources and causes of disturbances must be known before appropriate mitigating action can be taken and continuous recording of disturbance waveforms is necessary. To determine the causes and disturbances one must detect and localize those disturbances and classify the types of the disturbances. New tools are required to extract all relevant information from the recordings in an automatic way.

Wavelet Transform is a mathematical tool like Fourier transform, which provides an automatic detection of power quality disturbance waveforms, especially using Daubechies family. Wavelet Transform provides the time-scale analysis of the non-stationary signal. It decomposes the signal to time scale representation rather than time frequency representation. A voltage event is an abnormal and temporary variation of the magnitude of voltage supply. Voltage dips, short interruption and voltage swells are the most important events in voltage signals for detecting and supply that produce huge losses in industrial and commercial due to sensitivity of equipment to the voltage variations.

Santoso et al [1] proposed wavelet transform technique for the detection and localization of the actual power quality disturbances. Gaoda et al. [2] introduced the use of wavelet transform and multi-resolution signal decomposition as a powerful analysis tool that can be used to monitor and measure the system response to distorted signal. Heydt and Galli [3] proposed wavelet techniques for the identification of the power system transient signals. Fuzzy logic control technique has been discussed by Hiyama et al [4] to enhance power system stability using static VAR compensator. A hybrid scheme using a Fourier linear combiner and a fuzzy expert system for the classification of transient disturbance waveforms in a power system has been presented by Dash et al [5]. Styvaktakis et al [6] developed an expert system to classify different types of power system events and offer useful information in terms of power quality. Huang et al [7] presented a neural-fuzzy technology based classifier for the recognition of power quality disturbances. Olivier et al [8] investigated the use of a continuous wavelet transform to detect and analyze voltage sags and transients. They developed an efficient and simple algorithm for detecting and measuring power quality analysis. He and Starzyk [9] proposed a novel approach for power quality disturbances classification based on wavelet transform and self organizing learning array system. Wavelet transform has been utilized here to extract feature vectors for various power quality disturbances based on multi resolution analysis. Lin and Wang [10] proposed another model for power quality detection for power system disturbances using adaptive wavelet networks. Elkalashy et al [11] used discrete wavelet transforms to detect high impedance faults due to leaning trees. The need to analyze power quality signals to extract their distinctive features made Gargoom et al [12] to use Hilbert transform and Clarke transform for the classification of power quality signals and they compared the performance of these techniques with wavelet transform. A new method has been proposed by Peres and Barros [13] for the online real-time detection and classification of voltage events in power systems. They used wavelet analysis for the detection and estimation of time related parameters of an event and used extended Kalman filtering for the confirmation of the event.

This paper deals with the use of discrete wavelet transform and multi-resolution analysis to detect and analyze voltage sag, swell, and interruption. Daubechies wavelet transform is very accurate for analyzing Power Quality Disturbances among all the
wavelet families, for transient faults. The names of the Daubechies family wavelets are written as DbN, where N is the order, and db the “surname” of the wavelet. The localization and duration of the disturbance has been detected using the first decomposition level i.e. the detail DI of the first decomposition level clearly indicates the time interval of the event and hence can classify the phenomena as momentary or temporary. The shape of the standard deviation curve provides information about the harmonic content in the signal and also the entropy curve of the signal at different decomposition levels can classify the disturbances present in the signal.

II. DETECTION AND LOCALIZATION OF DISTURBANCES

This paper presents multiresolution signal decomposition technique as a powerful tool for detecting and classifying disturbances in the electrical distribution system. The proposed technique will deal with the problem not only in time domain or frequency domain, but in a wavelet domain which covers both the time and frequency domains. Multiresolution signal decomposition technique can detect and diagnose defects and provide early warning of impending power quality problems. Using the properties of the wavelet and the features in the decomposed waveform one will have the ability to extract important information from the distorted signal at different resolution levels and classify the types of disturbance.

Power quality disturbances that are analyzed using discrete wavelet transform and multiresolution analysis are

- Normal/Pure sinusoidal signal
- Sinusoidal signal with intermediate sag
- Sinusoidal signal with intermediate swell
- Sinusoidal signal with intermediate interruption

All these signals were analyzed using Wavelet Transform. Here we have chosen Daubechies 4 at level 4 for the analysis. Fig. 2(a) shows the coefficients of detail level DI of a pure sinusoidal signal and reveals the coefficients of detail level 1 of a sinusoidal signal having intermediate sag. It is observed that sufficiently large detail coefficient
occurs around at 400th sample and at 800th sample. Similarly Fig. 2(b) shows the coefficients of detail level 1 of the signals with intermediate swell and interruption.

![Figure 2 a](image1)

![Figure 2 b](image2)

Fig.2 Magnitude of detail coefficients of DWT (a) Pure sinusoidal signal and Sinusoidal signal with intermediate sag (b) Sinusoidal signal with intermediate swell and Sinusoidal signal with intermediate interruption.

The wavelet transform coefficients with high values indicate the power quality disturbance events and the exact location of the disturbance. The other part of the decomposed signal of detail d1 is smooth indicating that the signal follows some regular patterns in those periods without having any electrical noise. Detail d1 shows the exact location of the disturbance.
The standard deviations are plotted against the decomposition level to obtain the standard deviation curve. The standard deviation curves for the low frequency (50 Hz) signal and high frequency (154.7 kHz) signal are shown in Fig.3 and Fig.4. The basic difference in the two curves is that for low frequency signal there is one peak and for high frequency signal there are two peaks.

III. DETECTION ALGORITHM

In this proposed algorithm the various level multi-resolution analysis features to find the detail coefficients threshold value. Initially the fundamental frequency and the phase angle shift for each window are also compute.
The detection algorithm is shown in Figure 5

IV. RESULTS AND DISCUSSIONS

Fig. 6 shows the standard deviation curves for 50 Hz. signals with power quality disturbances i.e. sag, swell and interruption respectively. It is seen that the peak value of the curve detects the type of disturbance.

For example the peak value of standard deviation curve in Fig. 6(a) is less that that at Fig. 3 indicating that there is sag in the disturbed signal. For interruption the peak is still less than that in sag. Similarly for swell the peak of the curve is higher than that of the ideal signal. Hence the standard deviation curves clearly detect the type of the disturbance.
Fig. 6 Standard deviation curves for low frequency signal with quality disturbances (a) sag (b) swell (c) interruption

Fig 7 shows the curve of entropy of different short duration disturbed signals at different decomposition levels. Initially the magnitude of the curve for swell is high and that for interruption is low. By observing the nature of the entropy curves of different disturbed signals with respect to the normal signal the type of disturbance can be easily detected.
The standard deviation curves for high frequency signal are shown in Fig. 8. It is found that the second peak of the curve remains same irrespective of the presence of disturbance in the signal. By observing and monitoring the changes occurring at the first peak with respect to the peak for normal sinusoid we can categorically define the type of disturbance. The first peak of standard deviation curve is less in case of sag and still less in the case of interruption as compared with the normal signal.
Fig. 8 Standard deviation curves for high frequency signal with power quality disturbances (a) sag (b) swell (c) interruption

Fig. 9 shows the entropy curve for different power quality disturbances at high frequency.
V. CONCLUSIONS

This paper presents a new method for the detection and classification of voltage events in the method proposed uses the results obtained in the simultaneous application of the discrete wavelet transform and an extended Kalman filtering to the samples of voltage supply for more accurate detection and estimation of the magnitude and duration of a voltage event. The standard deviation curves both for low and high frequency signals have been analyzed. Using different Properties of discrete wavelet transform one can detect, localize and classify different short duration disturbances in a signal.

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REFERENCE


