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Comparison of Various Wavelet Tranforms Families Available in Matlab for Locating Power Quality Disturbances.

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ABSTRACT *Modern electric power system consists of highly non linear load due to introduction of highly sophisticated electronic control at almost all the level power utilization. This modern electrical equipments and machineries along with solid state control are highly efficient, flexible has large number of advantages; however they have created a serious power quality issues like voltage sag, voltage swell and flicker etc. Wavelet transform allows the detection and localisation of disturbances in the voltage waveform. It is possible to use several tools, such as the MATLAB that includes basic commands and a graphic environment. Various wavelet transform methods are available in MATLAB. The most important is to select appropriate wavelet for particular application which is dictated by signal and its characteristics. If we understand the properties of the analysis and synthesis wavelet, we can choose a wavelet that is optimized for our application. This paper presents wavelet transform as tool for location of PQ disturbance. In this paper voltage sag, swell and impulse are simulated using MATLAB code, various wavelet decomposition techniques are applied, compared and reported.*

KEYWORDS : Wavelet Transform, PQ (Power Quality)

I - INTRODUCTION

Electric power quality is an important issue in power systems nowadays. The demand for clean power has been increasing in the past several years. The reason is mainly due to the increased use of microelectronic processors in various types of equipments such as computers programmable logic controllers and diagnostic systems. Most of these systems are quite susceptible to disturbances in the supply voltage. The fast expansion in use of power electronics devices led to a wide diffusion of nonlinear, time-variant loads in the power distribution network, which cause massive serious power quality problems. Electromagnetic disturbances cause big economic losses for industry and residential users. Therefore, monitoring power quality (PQ) disturbances of electric power is fundamental in order to offer solutions especially for utilities and industrial customers. Fourier transform is often used in steady state disturbance monitoring. However, due to the presence of transient disturbance is not adequate. The Wavelet Transform (WT) processing technique has been proposed for power quality monitoring. This transformation is used because of time -frequency multi-resolution analysis property. [4].

The MATLAB is widely used as a tool to study various disturbance under laboratory condition, as various wavelet families are available in MATLAB. The choice of wavelet is dictated by the signal characteristics and the nature of the application. If we understand the properties of the analysis and synthesis wavelet, we can choose a wavelet that is optimized for our application.

The purpose of this paper is to apply different wavelet transforms available in MATLAB on the test signals (generated using MATLAB code with known disturbances) viz. sag, swell and impulse. The results obtained compared and analyzed to select the appropriate wavelet for particular type of PQ disturbance and to locate actual instance of occurrence.

II – Test Signal Generation

The test signal was generated using MATLAB as per definition given in reference [1]**.** Three test signals with different PQ disturbance viz., sag, swell and impulse were considered.

Sag: It is RMS reduction in the AC voltage at power frequency from half of a cycle to a few seconds' duration.

Swell: It is RMS increase in AC voltage at power frequency from half of a cycle to a few seconds' duration.

Impulse or Surge: It is electrical transient characterized by a sharp increase in voltage or current.

The different wavelet decomposition is applied to different power quality disturbances. Table I on shows various wavelet families available in MATLAB. All the data are generated using the MATLAB code at a sampling rate of 1 kHz. To demonstrate the efficacy of the proposed technique some test cases are presented below. A pure sinusoidal voltage signal of 50Hz and 5 Volts amplitude is considered for all simulations. We apply a one-scale wavelet decomposition scheme to three PQ disturbances considered to see the performance of the approach.

Table I. Various Wavelet Families available in MATLAB

Sr No.	Wavelet Family Name	Wavelet Family Short Name
1	Haar wavelet	'haar'
2	Daubechies wavelets	'db'
3	Symlets	'sym'
4	Coiflets	'coif'
5	Biorthogonal wavelets	'bior'
6	Reverse biorthogonal wavelets	'rbio'
7	Meyer wavelet	'meyr'
8	Discrete approximation of Meyer wavelet	'dmey'
9	Gaussian wavelets	'gaus'
10	Mexican hat wavelet	'mexh'
11	Morlet wavelet	'morl'
12	Complex Gaussian wavelets	'cgau'
13	Shannon wavelets	'shan'
14	Frequency B-Spline wavelets	'fbsp'
15	Complex Morlet wavelets	'cmor'

III-Methodology for applying wavelet transforms

Locating the time at which the disturbances occur is one of the capabilities of the wavelet transform. To identify this time we could apply the following steps:

Generate a set of test signals with known disturbance beginning and duration times.

Apply the different wavelet transforms of the MATLAB to this set of signals.

Locate the exact instance of disturbance by means of a visual inspection of the wavelet coefficients,

For example as shown in Fig.1, we have generated a voltage signal with known perturbation. This signal is of 50 Hz, 5Volts amplitude, duration of 400 ms with voltage sag of 40 ms duration starting at hundredth milliseconds. Fig.2 shows detail first level decomposition with daubechies wavelet ('db4'). Table II shows the result of first level wavelet decomposition of three different families. As the sag is from 100 ms to 140 ms, signal is sampled at 1 KHz and first level wavelet decomposition gives location of disturbance between 51 to 71 instance using 'db4' while other wavelets are not as accurate as db4. So, numbers of test signal with different sag level, varying duration, occurring at varying instances have been generated and result of first level wavelet transform of various families are compared. It was evident from the result the daubechies wavelet ('db4') is accurate in locating exact instance of occurrence and duration of sag.

The same procedure is followed for swell and impulse.

IV – Result

A. Voltage sag

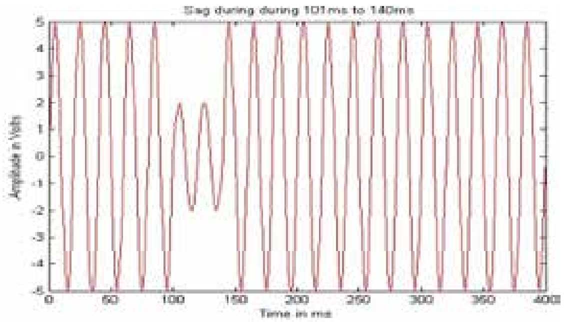

Fig. 1 Voltage Sag

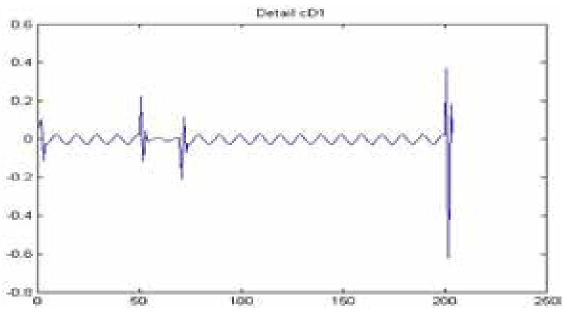

Fig. 2 Detail of first level wavelet decomposition of sag with Daubechies wavelets ('db4')

Table II. Result of Sag

Wavelet used to detect sag	Fault Position detected	Correct Fault Position	Remark
db3	51,71, 72		Accurate but not most sensitive
db4	51,71		Accurate
db10	52,72	51,71	Most sensitive to voltage level with little sacrifice location
sym8	5,200		Not accurate
coif4	5,200		Not accurate

B. Swell

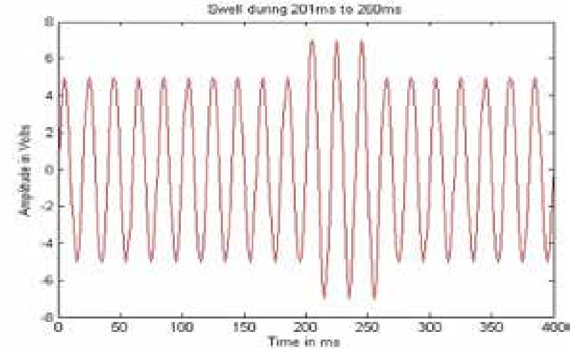

Fig. 3 Voltage Swell

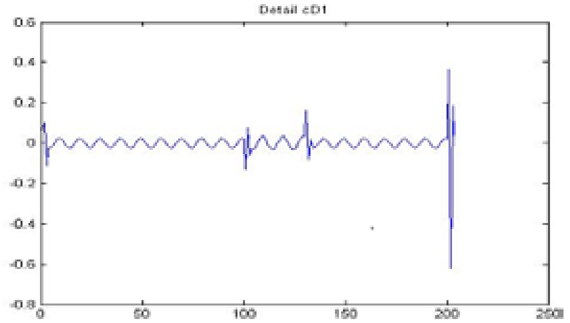

Fig. 4 Detail of first level wavelet decomposition of swell with Daubechies wavelets ('db4')

Table III. Result of Swell

Wavelet used to detect swell	Position detected	Correct Fault Position	Remark
db3	101,102,126, 131		Accurate but not most sensitive
db4	101,131		Accurate
db10	102,132	101,131	Most sensitive to voltage level with little sacrifice location
sym8	4,5,6,204,205		Not accurate
coif4	5,204		Not accurate

C. Impulse

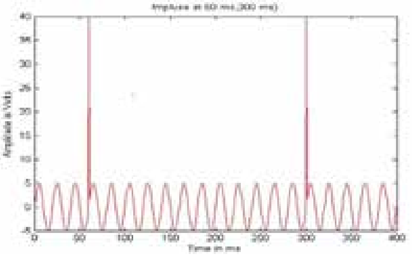

Fig. 5 Voltage Impulse

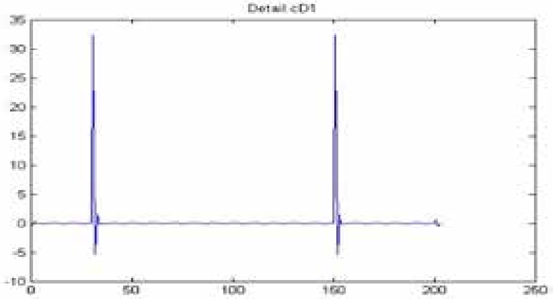

Fig.6 Detail of first level wavelet decomposition Impulse with Daubechies wavelets ('db3')

Table IV. Result of Impulse

Wavelet used to detect impulse	Position detected	Correct Fault Position	Remark
db3	31,151	31,151	Accurate
db4	31,151		Accurate but not most sensitive
db10	21,32, 151,152		Not accurate as db3
sym8	35,155		Not accurate
coif4	35,155		Not accurate

Conclusion and Future work

This paper presents wavelet transform as tool for locating PQ disturbances. The various wavelet families available in MATLAB are applied for identification of PQ disturbances like sag, swell and impulse. After carrying out large number of simulation it was concluded that daubechies wavelet is highly accurate for exact location of PQ disturbances. In case of sag 'db4', for swell 'db4' and for impulse 'db3' gives fairly accurate result as compared to their other counterparts. Here we have considered only three PQ disturbances separately, but practical cases have multiple PQ disturbances occurring simultaneously. However result can be further improved by applying multiple event and PQ disturbances simultaneously along with presence of harmonics in signal.

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