Disturbance and Detection in Power quality with Classification

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Abstract - *Power quality (PQ) monitoring is an important service that many utilities perform for their industrial and larger commercial customers. Detecting and classifying the different electrical disturbances which can cause PQ problems is a difficult task which requires a high level of engineering knowledge. The vast majority of the disturbances are non-stationary and transitory in nature subsequently it requires advanced instruments and procedures for the examination of PQ disturbances. In this work a hybrid procedure is utilized for describing PQ disturbances utilizing wavelet transform and fuzzy logic. A number of PQ occasions are produced and decomposed utilizing wavelet decomposition algorithm of wavelet transform for exact recognition of disturbances. The PQ disturbances are contaminated with noise the identification gets to be difficult and the feature vectors to be separated will contain a high amount of noise which may corrupt the characterization precision. Consequently a Wavelet based denoising system is proposed in this paper before feature extraction process. Two extremely distinct features basic to all PQ disturbances like Energy and Total Harmonic Distortion (THD) are separated and is nourished as inputs to the fuzzy expert system for precise recognition and order of different PQ disturbances.*

Key Words*: *Power Quality, DWT, Fuzzy Expert, Wavelet.

1. INTRODUCTION

The power quality examination is a critical component in the cutting edge power frameworks. The electrical engineer must comprehend a specific statistical information and framework when they break down the electric power quality issues. POWER QUALITY (PQ) is typically characterized as the investigation of the nature of electric power signals. Lately, grid users have distinguished an expanding number of downsides created by electric PQ variation. The PQ of electrical power is normally ascribed to electrical cable aggravations, for example, wave shape issues, overvoltage, capacitor switching transients, harmonic distortion, and impulse transients. In this way, electromagnetic transients, which are fleeting voltage surges sufficiently capable to smash a generator shaft, can bring about sudden disastrous harm. Harmonics, infrequently alluded to as electrical contamination, are bends of the typical voltage waveforms found in AC transmission, which can emerge at for point in a power system. the discrete wavelet transformation (DWT) is a powerful figuring and scientific apparatus which has been utilized freely as a part of connected science, signal preparing and all the more critically in the zone of power quality analysis. The main cause behind the degradation of power quality is the power line disturbances. With an end goal to discover a solution for the above issue, one needs to recognize and order the power quality disturbances precisely for further examining and research.

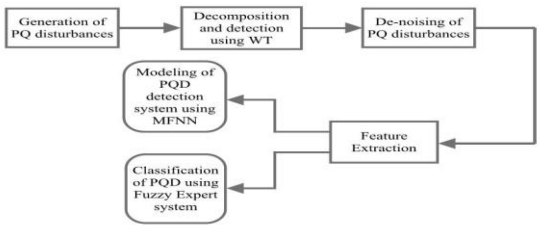

Figure 1 Block Diagram of the method adopted

2. DECOMPOSITION USING WAVELET TRANSFORM

The detection of PQ disturbances has undergone significant advancements after the use of wavelet transform(WT) recently. Whereas FT and STFT use exponential basis functions, the WT uses a wavelet basis function which gives much better results. The wavelet basis function scales itself in accordance with the frequency under examination. The signal is decomposed into several different frequency levels using wavelet transform and these are called as wavelet coefficients. There are two types of WT based on the type of signal: continuous wavelet transform (CWT) and discrete wavelet transform (DWT).

2.1 DISCRETE WAVELET TRANSFORM (DWT)

In wavelet investigation, the Discrete Wavelet Transform (DWT) decays a sign into an arrangement of commonly orthogonal wavelet basis functions. These functions contrast from sinusoidal basic functions in that they are spatially limited – that is, nonzero over just part of the aggregate signal length. Moreover, wavelet capacities are expanded, deciphered and scaled forms of a typical function φ, known as the mother wavelet. The DWT is invertible, so that the original signal can be totally recouped from its DWT representation.

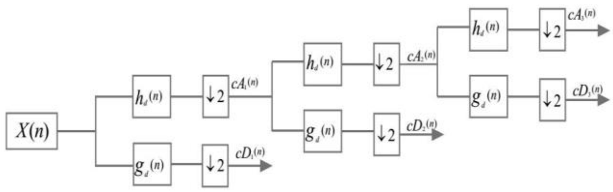

Figure 2 Decomposition Algorithm

3 GENERATION OF PQ DISTURBANCES

The various power quality disturbances such as Sag, Swell, Interruption, and Sag with harmonics and Swell with harmonics are generated with different magnitudes using MATLAB.

3.1 SIGNAL SPECIFICATION

Ts (time period) =0.5 sec

fs (sampling frequency) =6.2 KHz

f=50Hz

No of cycles=25

No of samples/cycle=120

Total Sampling points=3200

Duration of disturbance=0.2 second. The interval of disturbance from 0.2 to 0.4 second of time which is between 1250 to 2500 sampling points.

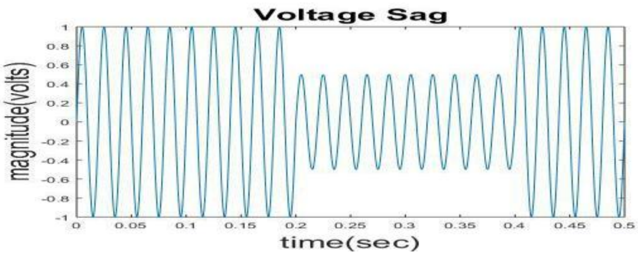

Fig 3 Voltage Sag

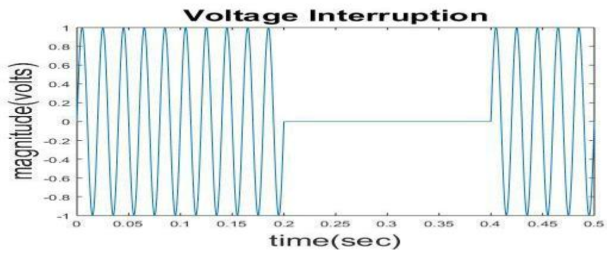

Fig 4 Voltage Swell

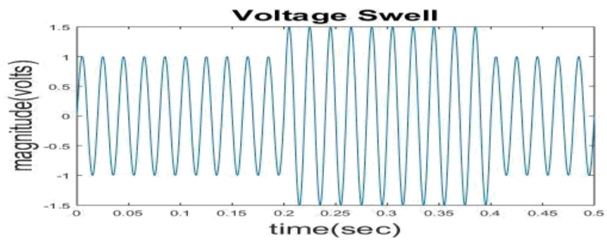

Fig 5 Voltage Interruption

3.2 Decomposition Using Wavelet Transform

The above disturbances are decomposed into different levels through wavelet decomposition algorithm. The unique deviation of every power quality disturbance from the original sinusoidal waveform is distinguished both in the approximate and detail coefficients. The different disturbances are examined with different levels. Generally, single or dual scale signal decomposition is satisfactory to differentiate disturbances from their background because the decomposed signals at lower scales have high time localization.

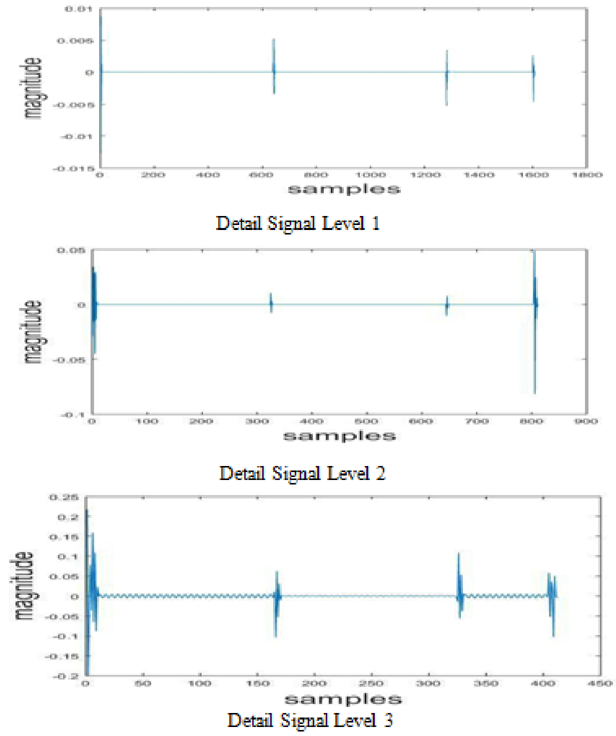

FIG 6 Decomposition of voltage sag

Reduction in nominal value of the waveform can be marked from the approximate and detail coefficient of level4 decomposition as shown in Figure 6.

4.0 DETECTION IN THE PRESENCE OF NOISE

The presence of noise in power quality disturbances creates a new obstruction for detection as it is tough to detect the exact location of disturbance in a high noisy environment with a low SNR(signal to noise ratio).The presence of noise likewise affects the classification accuracy as the feature vectors to be extracted for classification will also contain the noise contribution and the exact quantity of noise present are entirely dubious and hence de-noising of the disturbance is necessary for feature extraction and classification

4.1 DENOISING OF POWER QUALITY DISTURBANCES

Steps involved in De-noising

Basically de-noising of signal consists of three steps:

- Decomposition: It consists of selecting a proper mother wavelet and deciding a level n up to which the signal S is to be decomposed using the selected mother wavelet. The level of decomposition n is selected as required and in this case it is selected as five.
- Thresholding: For each level from 1 to n, a threshold is selected and soft thresholding is applied to the detailed coefficients.
- Reconstruction: Wavelet reconstruction is computed based on the original approximation coefficients of level n and the modified detail coefficients of levels from 1 to n.

4.2 THRESHOLDING BASED DE-NOISING

In the first stage, the noise containing sinusoidal signal is decomposed by selected wavelet basic function "db8" up to 5 levels. Coefficients at every level are compared within this level and absolute maximum coefficient is stored to be the threshold value. The maximum coefficient is found as it shows the maximum noise characteristic. After processing, five detailed threshold values and one approximate threshold value will be stored for future signal denoising. In the next stage, the power quality disturbance signals polluted by noises are recorded as before. The disturbance signal is decomposed by the same wavelet basic function to the same level to generate wavelet transform coefficients. All coefficients at every level will be thresholded by the corresponding threshold value that is determined at the first stage. Any coefficients after the thresholding are the disturbance coefficients. Therefore after decomposition, the coefficients of the signal are greater than the coefficients of the noise, so we can find a suitable T as a threshold value. When the wavelet coefficient is smaller than the threshold, it is assumed that the wavelet coefficient is primarily created by the noise, so that coefficient is set to 0 and then discarded. When the wavelet coefficient is greater than the threshold, it is assumed that wavelet coefficient is mainly given by the signal, so that the coefficient is kept or shrinks to a fixed value, and then the signal denoised can be reconstructed through the new wavelet coefficients using wavelet transform

Table 1 Feature Vector for Voltage Sag

Magnitude Of Disturbance (%)	THD	Energy
10	1.1391762	2889.9301
18	1.1929565	2585.0633
32	1.1391365	2419.1693
42	1.1030099	2507.5566
48	1.1808535	2126.5567
62	1.1159453	2256.5965
71	1.2141041	2018.8106
78	1.0593922	2156.1619
88	1.0518685	2145.7391

4.3 RESULTS

The selection of threshold value is crucial in wavelet based PQ signal de-noising. In this case, Minimaxi thresholding rule is used.

4.4 DE-NOISING OF SAG DISTURBANCE

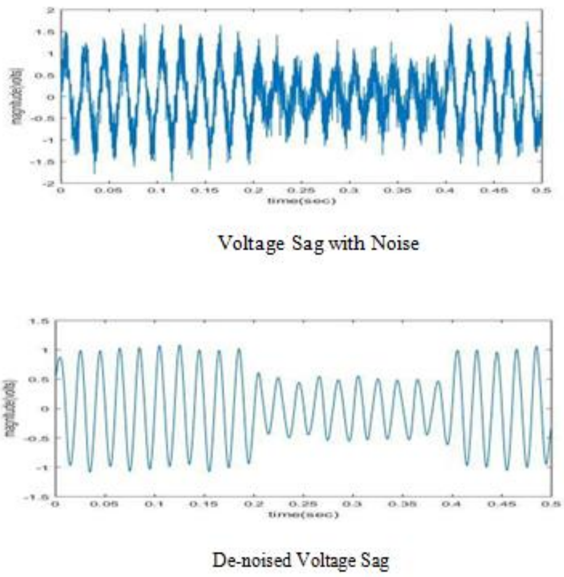

Fig 7 Voltage sag with noise & denoised.

Figures 7 show the disturbance in the presence of noise. and the de-noised signal after using wavelet based de-noising methods. It can be seen that the de-noised signal is very similar to the originally simulated signal making this method a very effective one.

5 DESIGN OF DATABASE OF DIFFERENT PQ DISTURBANCES

A database of Energy and THD of different PQ disturbances is obtained. Diverse PQ disturbances with diverse magnitude of fault are generated and considered for feature extraction which shown in table 1.

5.1 MODELING OF PQD USING MFNN

This section points out the endeavor at displaying a detection framework for power quality disturbances utilizing MFNN. This model predicts the rate of disturbances in different power quality occasions as an element of Energy and THD of various power quality occasions. The system is given both input information and desired reaction and is prepared in a supervised way utilizing the back propagation algorithm. The back propagation algorithm performs the input to output mapping by making weight association alteration taking after the error between the calculated output esteem and the desired output reaction. The preparation stage is over after a progression of cycles. In every cycle, output is compared with desired reaction and a match is acquired.

6 CLASSIFICATIONS USING FUZZY EXPERT SYSTEM

A FL framework depicts the control activity of a procedure in terms of basic If-Then principles. It portrays the calculation for procedure control as a fuzzy connection between data on the procedure conditions to be controlled and the control activity. Subsequently it gives a linguistic or fuzzy model that is produced in view of human experience and aptitude as opposed to a scientific model. In a FL framework, the control activity is resolved from the assessment of an arrangement of basic linguistic principles. The advancement of guidelines requires a careful comprehension of the procedure to be controlled, however it doesn't require scientific model of the framework. The model can be multi-input multi-output or single input single output.

The primary segments of the FL framework are:

1. Fuzzification: The FL utilizes the linguistic variables rather than numerical variables. In this present reality, measured amounts are genuine numbers (crisp).The procedure of changing over a numerical variable into a linguistic variable is called fuzzification. It is classification of input information into reasonable linguistic values or sets.
2. Principle Base or Decision Making: This is construing fuzzy control activity from the learning of the control rules and the linguistic variable definition. It has 3 different subcomponents.
   - IF(predecessor or antecedent) part of the principle – utilization of fuzzy administrators in it.
   - THEN part of the principle – suggestion from predecessor part to the resulting part.

Aggregation (gathering) of the resulting of all principles. The output of every guideline is accumulated to get the last output. Some generally utilized collection strategies are Mamdani type implication (Min-Max implication), implication, Sugeno type implication and Lusing Larson type. The Mamdani type implication is utilized with the end goal of classification.

Defuzzification: This is the change of the derived fuzzy control activity to a fresh or non-fuzzy control activity. The decision of defuzzification methodology is a trade-off amongst exactness and computational power. A portion of the normally utilized techniques are Center of Area strategy, Height strategy, Center of gravity of biggest territory strategy and Mean of Maxima technique.

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