

DETECTION OF TRANSIENT AND HARMONICS DISTURBANCES USING DISCRETE WAVELET TRANSFORM AND ANN.

Ishita Dupare, Pankaj Hedao, Abhay Satmohankar

¹ Student, Electronics Engineering, WCEM, Maharashtra, India

² Asst. Professor, Electronics Engineering, WCEM, Maharashtra, India

³ Asst. Professor, Electronics Engineering, WCEM, Maharashtra, India.

Abstract: In power system power quality problems exists in India. Increase in power quality disturbance i.e. harmonics & transients in the power system affecting the load side severely and decreasing the life of load side equipments. So the detection of this disturbance has become big concern in India. This paper deals with detection of power quality disturbance including both transient and harmonics using wavelet transform. Various features have been extracted by decomposing the signals of harmonics and transients. By which it is easy to classify the category of disturbance. ANN is used as a classifier for classification.

Keywords— Power quality, classification, DWT, feature extraction, ANN

I. INTRODUCTION

Power quality is usually defined as the study of the quality of electrical signal. In the recent years with the growing use of non-linear loads, power electronics based equipment etc., Power quality (PQ) has become a big concern. Poor PQ has consequences such as; malfunctions, instability, shortened life of the equipment etc. Power quality disturbances like; voltage sag, voltage swell, notches, glitches, momentary interruption, harmonic distortions, transients etc. have become common in today's power system. In order to improve the quality of the electric power, the sources and causes of such disturbances must be known. These PQ disturbances are non-stationary in nature and occur for short duration. IEEE 1159-2009 defines these disturbances in terms of their frequency content, magnitude and duration [1].

There are different signal processing methods are employed for the analysis of these PQ signals. Fourier transform gives amplitude frequency representation while the time information gets void is one of the methods for transformation of these signals. Hence Fourier transform has some limitations for analysis of the signal. The windowed version of Fourier transform is Short time Fourier transform (STFT). Short time Fourier transform

(STFT) is the modified version of the Fourier transform which solves some drawbacks of the Fourier transform but it still have a drawback of time-frequency resolution dependent on the fixed window width[2]. Wavelet transform is further modified version of Fourier transform which can fetch frequency and time information simultaneously. It makes this transformation method suitable for the analysis of non-stationary signals. Wavelet transform is again classified into two types continuous wavelet transform and discrete wavelet transform. The discrete version of wavelet transforms; discrete wavelet transform (DWT) is used in this work for the analysis of the PQ signals [3]. So in order to classify the PQ disturbances properly wavelet transform is used. Various features can be extracted using discrete wavelet transform (DWT). There are various literatures proposed which show classification using DWT like; Multi level decomposition of signals is done using DWT, a combined feature vectors are obtained using standard deviation and energy of signals to feed SVM as classifier [3]. Energy distribution pattern of distorted signals are used as feature to classify the PQ disturbances using neural network [4].

Any type of disturbance in voltage or current which causes instabilities on the supply as well as on the load side are known as power quality issues. There are different types of power quality issues, among them transients are high frequency non-stationary disturbances that rides on power system waveform for short time [1]. A transient most commonly occurs due to switching of heavy loads, switching of the capacitor banks, lightning strikes etc. Transients can damage or cause malfunction to the electronic equipment [2]. In order to take preventive action against this transients detection of its characteristics is important. Thus for the analysis of this signal Fourier transform is not enough as it gives transformation only in frequency domain, but not suitable for time domain analysis[5].

II. DISCRETE WAVELET TRANSFORM

The wavelet analysis block transforms the distorted signal into different time-frequency scales. Wavelet analysis employs the expansion and contraction of basis function to detect simultaneously the characteristics of global and local of measured signal. Discrete wavelet transform digital filtering technique is used to decompose the signal at Multilevel signal decomposition is done. The signal can be decomposed to 'N' level to filter out high frequency components. Fig 1 shows the multilevel decomposition of the signal. Here signal F is decomposed to fetch another system.

In DWT multi level decomposition of the signal can be done. The signal can be decomposed into 'N' levels in order to filter out the high frequency component present in the signal. A1 of Fig. 1 is again decomposed to fetch further information present in the signal. This is called multi level decomposition. Since the analysis is repetitive, the decomposition can be done until the details consist of one sample (i.e. single sample). Therefore the appropriate level of decomposition should be selected for suitable criterion [6,7]. The approximations coefficients and detail coefficients are used for detecting the signal disturbance.

The approximation coefficients (A1), the detail coefficients (D1) at the first level and approximation coefficients (A2), the detail coefficients (D2) are considered for disturbance recognition and categorization of the power signal. Fig. 1 shows five level decomposition of the signal. In fig 1 signal of 10 KHz frequency is decomposed further by fetching it to level 1 decomposition. The decomposed lower frequency component of A1 further fetched for decomposition & so on for filtration of the lower frequency signal. Here 7 level decomposition is done. The signals are acquired at 20 kHz sampling frequency.

different level. The composite signal is decomposed into two half sub-bands frequency signal. One band contains high frequency components i.e. detail and another frequency band contains lower frequency components known as approximate signal. The number of samples will be halved at each decomposition level [6].

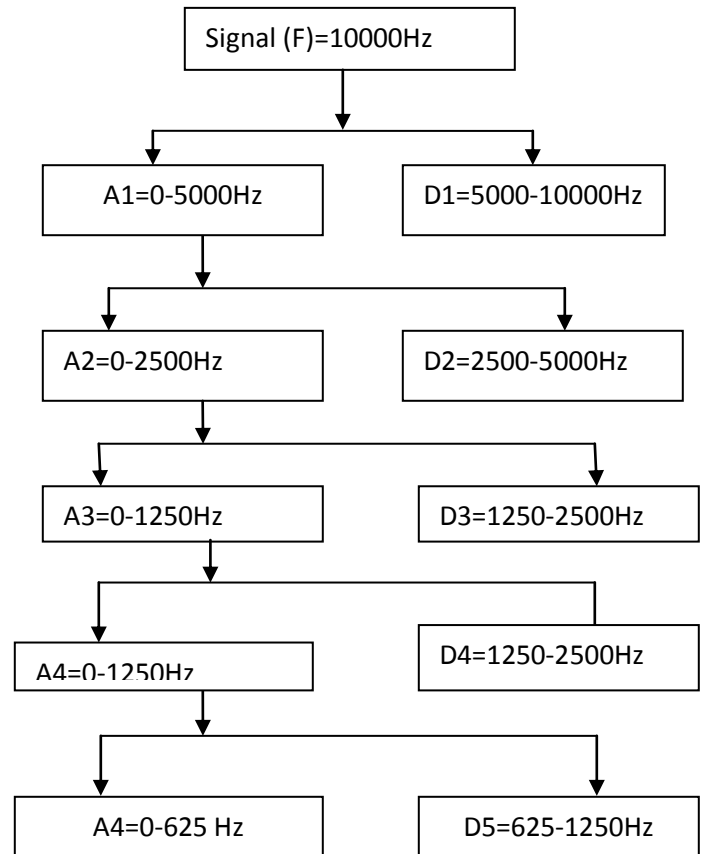


Fig.1 Multi-level decomposition of signal.

III FEATURE EXTRACTION USING DWT

Feature extraction is the operation that transforms a pattern from its original form to a new form suitable for further processing. This feature extraction is done by using DWT from simulated PQ signal for proper classification. The simulations of various signals containing both harmonics and transient disturbances are done using MATLAB. Transient disturbances are created by capacitor switching & harmonics are created by varying non nonlinear load across the rectifier. The analysis is done on various

simulated PQ disturbances which are acquired at a sampling frequency of 20 kHz to get features[7,8].

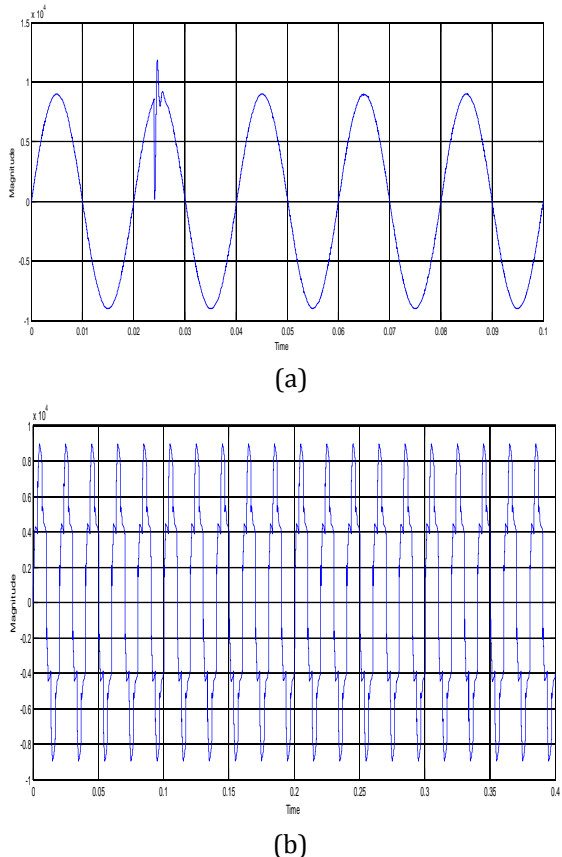


Fig. 2 Simulated power quality signals. (a) Transient signal, (b) Harmonics signal.

The signal acquired using different methods is decomposed into 7 levels using discrete wavelet transform.

Fig. 3(a) 7 level decomposition of the transient signal

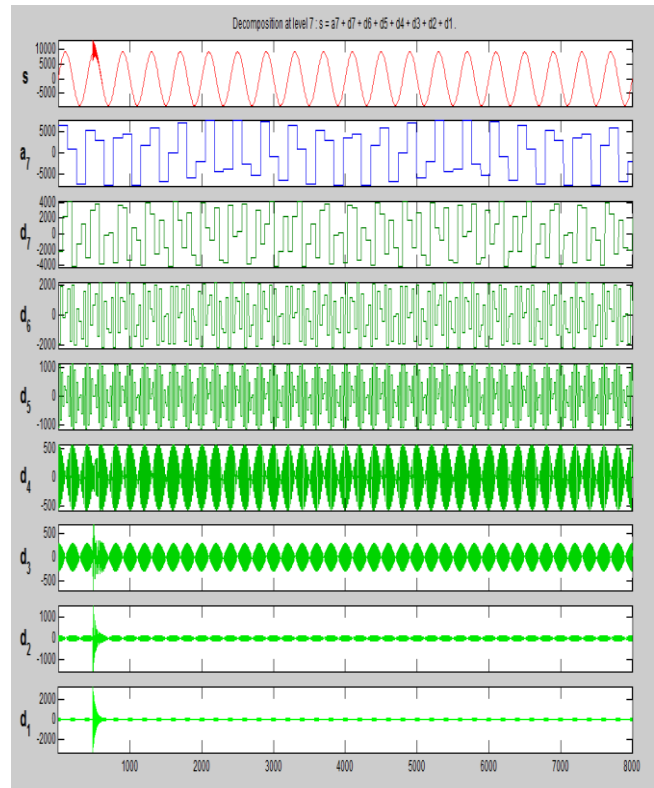


Fig 3(a) & (b) shows the 7 level decomposition of the signal having transient and harmonics disturbance respectively. Here S is the original signal, a7 is the approximation of decomposed signal having fundamental frequency. Plots d1 to d7 are the details. Detail d2 and d3 have maximum magnitude. maximum efficiency. Third stage is testing the neurons which are trained at first stage is tested in order to measure the performance of the network.

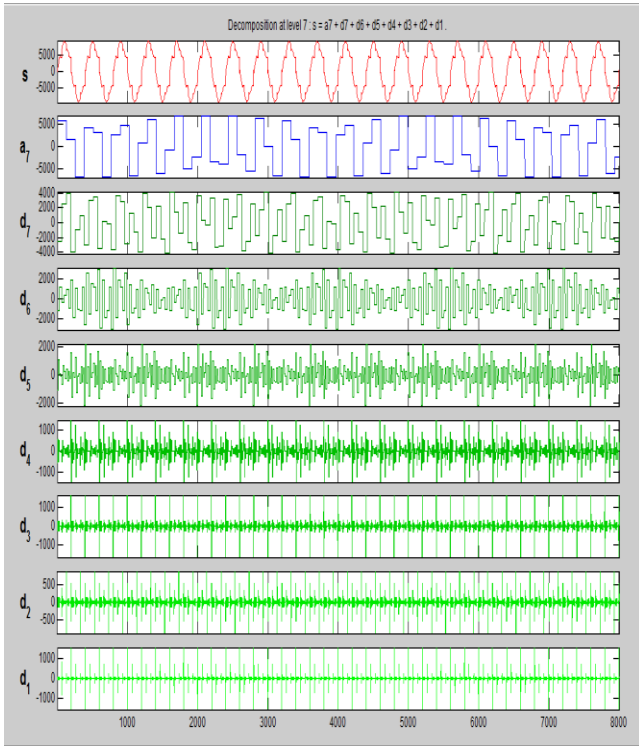
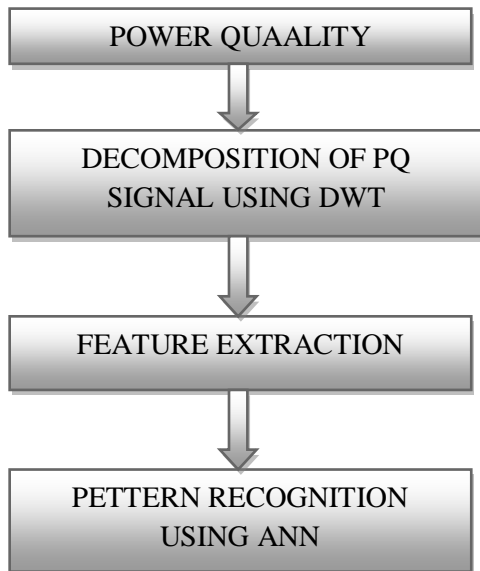


Fig. 3(b) 7 level decomposition of the harmonics signal



V RESULT AND CONCLUSION

110 signals were collected using feature extraction method. Out of the total signals 30% is used for



Fig. 4 Flow chart to detect PQ disturbances.

a) Maximum deviation of d1:

Table 1 shows the maximum deviation analysis of the decomposed signal of level one i.e. d1 as we collected the maximum and minimum values for the two disturbance signals i.e. harmonics & transient.

Table 1: min & max value of max(d1)

Max(d1)	Min	Max
Transient	17.23479384	40.09063352
harmonics	3.42579519	30.01438171

IV PATTERN RECOGNITION USING ANN

In pattern recognition problems, we are using neural network to classify inputs into a set of target categories. The Neural Network Pattern Recognition Tool helps us to select data, create and train a network, and evaluate its performance using mean square error and confusion matrices.

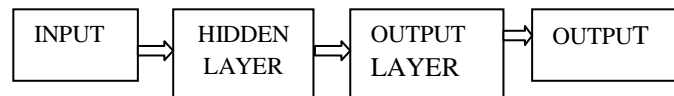


Fig 5. Block diagram of ANN.

Fig 5. Shows a two-layer feed-forward neural network, with hidden and output neurons. Training of ANN consist of three stages, First stage is initial training the inputs are fed to the ANN according to which the neurons get trained by recognizing the pattern of the input. Second stage is validation used to measure network generalization and it determines when to stop the training in order to get

training neuron & 70% used for testing the signals. 32 signals were used for training purpose & 78 signals were used for testing purpose. Fig.6 shows the output of ANN testing result of signal by neurons. First row first column shows that 47 transient signals were detected & 31 harmonics signals were detected.

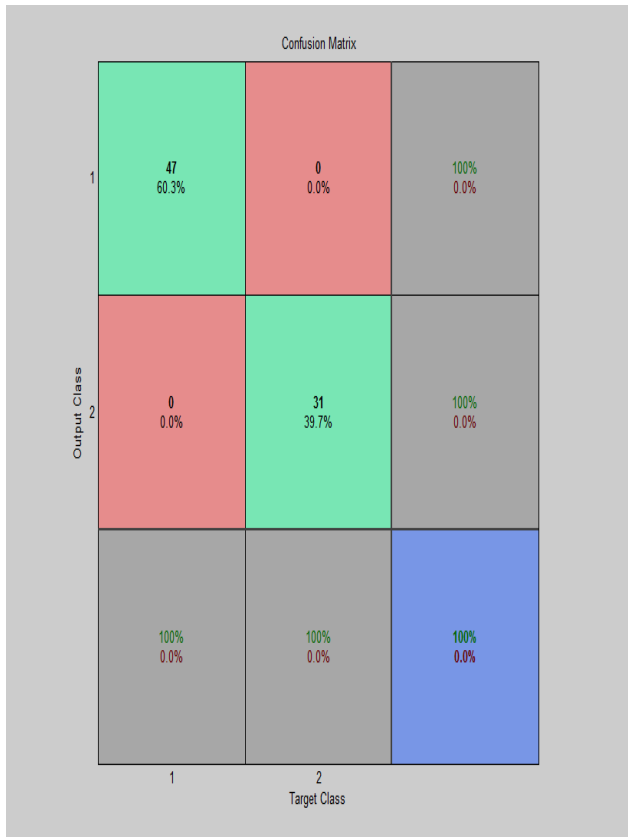


Fig.6 Output of ANN

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