

Analysis of Power System Relaying Operations using Wavelet Transforms

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Abstract: power system is an interconnect system which is very complicate and leads to more problems which are classified as different faults. Each fault leads to total system collapse and it should be rectified automatically. In this paper we have taken an analysis on relay operation which identifies the fault location. It is done by the help of wavelet transforms and by using ANN we have identified the fault location and fault type.
Keywords: Relaying, Power System faults – ANN based Classification – Wavelet Transform.

I. INTRODUCTION

In recent years, researchers have developed powerful wavelet techniques for the multiscale representation and analysis of signals. Wavelets localize the information in the time-frequency plane. One of the areas where these properties have been applied is power engineering. Due to the wide variety of signals and problems encountered in power engineering, there are various applications of wavelet transform. Another important aspect of power disturbance signals is the fact that the information of interest is often a combination of features that the information of interest is often a combination of features that are well localized temporally or spatially such as power system transients. This requires the use of analysis methods sufficiently, which are versatile to handle signals in terms of their time-frequency localization. The main advantage of WT over STFT (Short time- Fourier transform) is that the size of analysis window varies in proportion to the frequency. Most power signals of interest include a combination of impulse –like events such as spikes and transients for which STFT and other conventional time-frequency methods are much less suited for analysis. WT can hence offer a better compromise in terms of localization.

The wavelet transform decomposes transients into a series of wavelet components, each of which corresponds to a time domain signal that covers a specific octave frequency band containing more detailed information. Such wavelet components appear to be useful for detecting, localizing, and classifying the sources of transients. Hence, the wavelet transform is feasible and practical for analyzing power system transients. These transient components are recognized by artificial neural network classifier. Here feed forward network has been used and back propagation algorithm is used in order to classify the faults.

II. TRANSIENTS IN POWER SYSTEMS

Transients are signals, which decay to zero in finite time. Frequency based analysis has been common since Fourier’s time; however frequency analysis is not ideally suited for transient analysis, because Fourier based analysis is based on the sine and cosine functions, which are not transients. This results in a very wide frequency spectrum in the analysis of transients.

Electromagnetic transients in power system result from a variety of disturbances on transmission lines, such as switching, lightning strikes, faults, as well as from other intended or unintended events. Such transients are extremely important, for it is at such times that the power system components are subjected to the greatest stresses from excessive currents or over voltages.

III.
WAVELET TRANSFORM

Wavelet theory is the mathematics, which deals with building a model for non-stationary signals, using a set of components that look like small waves, called wavelets. It has become a well-known useful toll since its introduction, especially in signal and image processing. Various wavelet transforms are there by which a transient signal can be analyzed like Continuous wavelet transform, discrete wavelet transform etc., here in this paper about Discrete wavelet transform has is discussed.

3.1 Discrete wavelet transform (DWT)

To obtain the DWT, the parameters a and b need to discretized. Discretizing $a=2^j$ and $b=2^j$ k will yield orthonormal basis functions for certain choices of Ψ.

$\Psi_{(j,k)}(t) = 2^{-j/2}\, \Psi(2^{-j} t\text{-}K)$ (1)

Mallat showed that Multi Resolution Analysis (MRA) can be used to obtain the DWT of a discrete signal by applying lowpass and high pass filters, iteratively, and subsequently down sampling them by two. Fig.1 illustrates this process, where g[n] and h[n] are the highpass filters, respectively. at each level, this process computes,

$$Y_{high}[k] = \sum_{n} x[n].\, g[2k-n] \qquad (2)$$

$$Y_{low}[k] = \sum_{n} x[n].\, h[2k-n] \qquad (3)$$

where $h[N-1-n] = (-1)^n\, g[n]$ (5)

with N being the total number of samples in x[n] and Y_{high} and Y_{low} are the outputs of highpass and lowpass filters, respectively, at each level. The number of levels this process is repeated depends on the choice of the user. At the last level, the Y_{low} [k] obtained is called as approximation. The Y_{high} [k] computed at each level is called the detail coefficient at that level. Here currents in the three phases are taken as the transients when a fault occurs or for any inrush currents flows through the phases, considered in this paper.

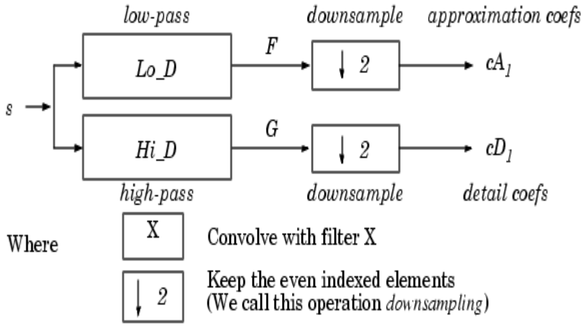
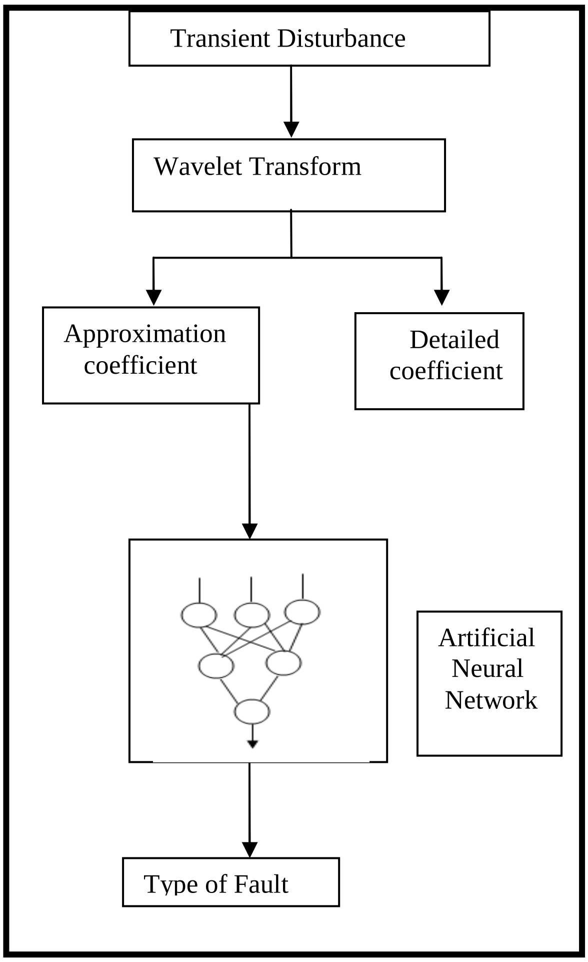


Fig.1. Computation of DWT

As shown in the fig.1, starting from a signal *s*, two sets of coefficients are computed: approximation coefficients CA_1, and detail coefficients CD_1. These vectors are obtained by convolving *s* with the low-pass filter Lo_D for approximation and with the high-pass filter Hi_D for detail, followed by dyadic decimation.

IV. A GENERAL FRAME WORK

The transient disturbance generated due to fault is decomposed by wavelet transform into several detail coefficients and approximations. The decomposition of the signal in to these detail coefficients and approximations are carried out until the fundamental frequency signal (50Hz) is obtained as the approximation at that level. The detail coefficient obtained at the final level is characteristic for each type of simple power system



fault. The artificial Neural Network recognizes this final level approximate coefficient corresponding to the fault.

Fig. 2 depicts illustrated frame work, in which first phase shows wavelet transform and second phase shows fault detecting system.

V. APPLICATION OF ANN TO WAVELET APPROXIMATE COEFFICIENT

In this ANN Backpropagation algorithm is used as a tool in order to classify the faults. ANN has an input layer, a hidden layer and an output layer as shown in Fig.4. The wavelet approximate coefficient of the level 3 is taken from 118 faults and 96 inrush currents and these fed to the input layer of the ANN. In the hidden layer 10 'tansig' neurons is used and one output neuron of 'pure linear' is used for the output. Here Back propagation algorithm is used in order to classify the faults. The stages of Backpropagation algorithm is shown in the Fig.3.

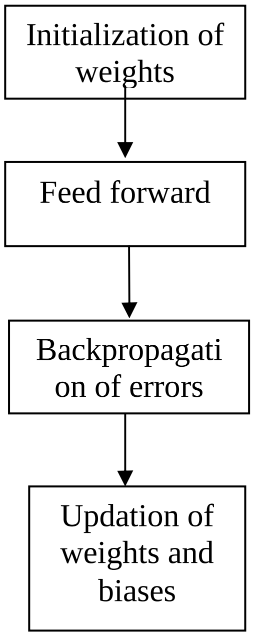


Fig.3. shows the stages of backpropagation algorithm used for training the ANN.
The way how this feedforward network classifies the faults is shown in the Fig.4.

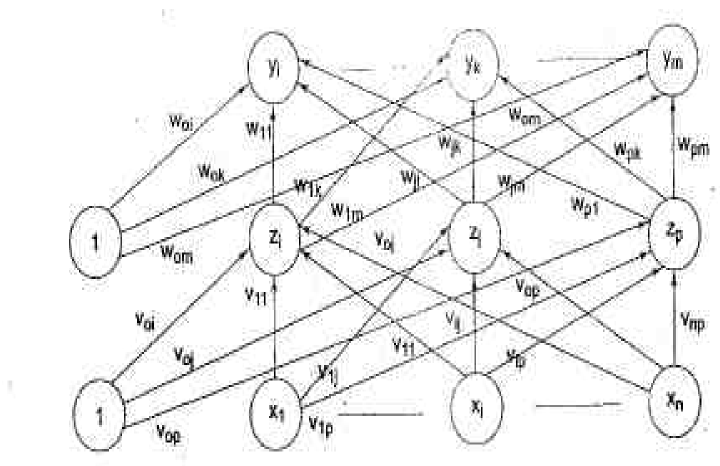


Fig.4. shows the feed forward network

VI. SYSTEM STUDY AND RESULTS

A simple power system network, shown in Fig.5 consisting of a generator, a load, two buses and a transmission line was used for the simulation purpose.

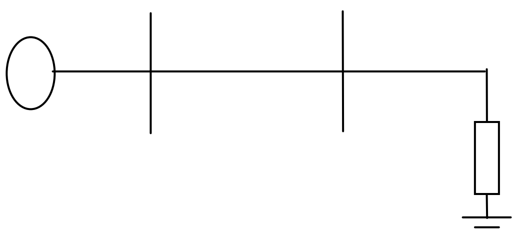
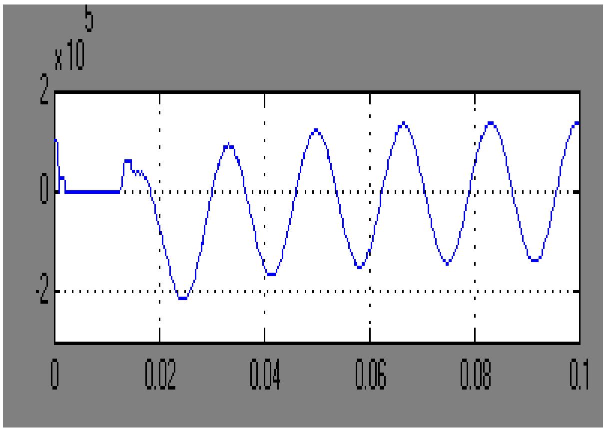


Fig.5. A simple power system network considered for analysis

Faults are created at a distance of 10kms from both the buses. Different types of faults were simulated using MATLAB-Simulink software. Different types of faults were created and the transients were recorded for analysis. Simulation is carried out for Phase A-ground, Phase B-ground, Phase C-ground, Phase AB-ground,



Phase BC-ground, Phase CA-ground, Phase A-Phase B, Phase B-Phase C, Phase C- Phase A faults. Fig.6. shows a sample voltage transient of a fault.

Fig.6. Example of transient Disturbance

6.1 Application of Wavelets

Daubechies wavelet shown in Fig.7. is used as the mother wavelet. The transient wave obtained is decomposed to the 3rd level. Observing the 3rd level of decomposition in Fig.8, the approximation obtained, is $a_{4.}$ This 3rd level approximate coefficient obtained is thus fed to the ANN.
Fig.7. Daubechies wavelet used for the analysis.

6.2 Multiple level decomposition

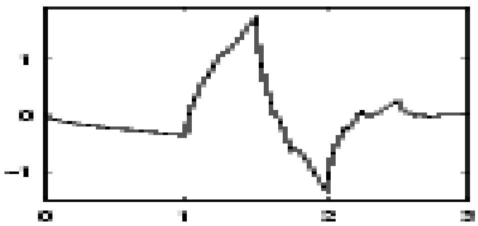


Fig.7 shows the decomposition of the transient wave by wavelet transform. S is the source current transient wave obtained from simulation of faults. $d_{1,}$ d_2, d_3 are the detail coefficients and a_4 is the approximation at level 3.

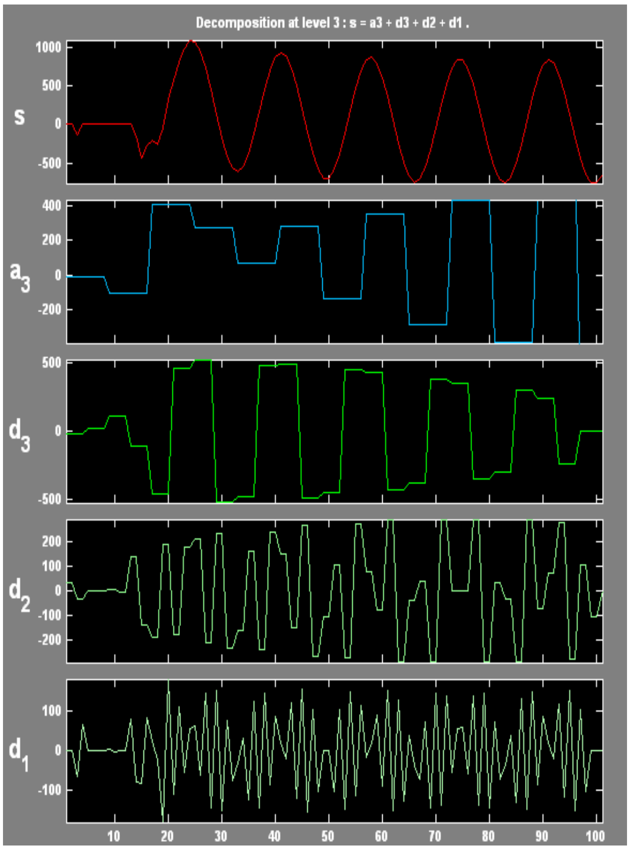


Fig 8. Source Signal decomposed in to approximation and detail coefficients. S is the source signal or the transient disturbance.

6.3 Classification Results of ANN

1. Approximate coefficients of Phase A- ground fault is as shown in fig.9.

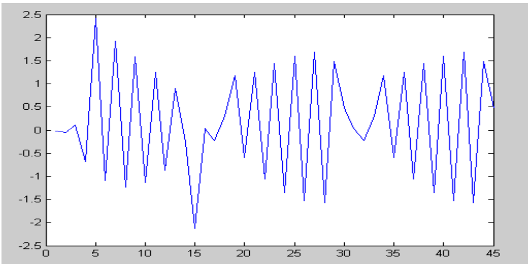


Fig.9

2. Approximate coefficients of PhaseA-Phase B is shown in fig.10

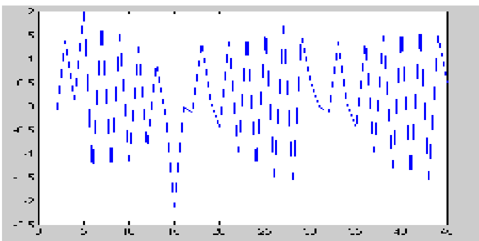


Fig.10

3. Approximate coefficients of Phase A- Phase C fault is as shown in fig.11.

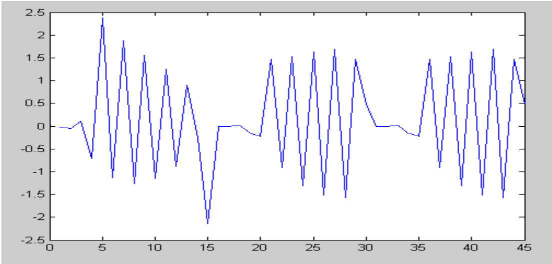


Fig.11

4. Approximate coefficients of inrush currents is as shown in fig.12.

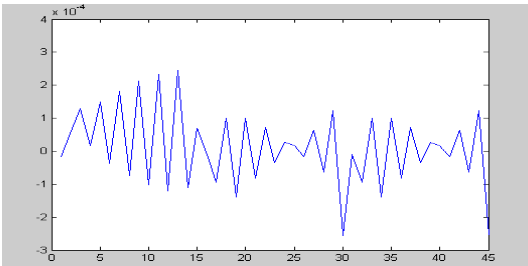


Fig.12

5. Approximate coefficients of phase A, phase B and ground fault is shown in fig.13

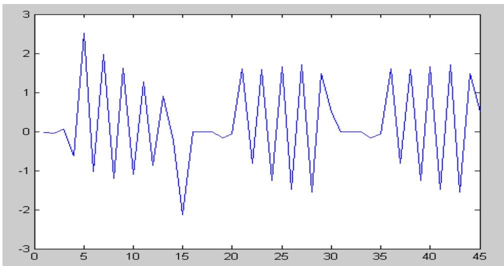


Fig.13

Like this the approximate coefficients of each type of fault and inrush currents are received from wavelet transform. These coefficients are trained by backpropagation network in ANN up to any number of epoches. The trained network is stored and if we test the simulation circuit for various types of faults with this trained ANN network it classifies or identify the type of faults. So this type of technique is mainly useful to identify the inrush and various types of faults. A target matrix has been used here in which it consists of numbers 1,2,3,4..etc for respective type of faults. The decomposed coefficients has been arranged in matrix and it is trained . So if any fault created in simulation the respective number of fault will be displayed.

VII.CONCLUSIONS

The fault or inrush wavelet transforms is used to decompose the transient fault signals to different series of wavelet coefficients, because the fault signature will have very much large number of coefficients. As these obtained samples have larger array size, it becomes complex to train ANN with such large data. So we are going for Discrete wavelet transform technique . These wavelet coefficients are trained by using ANN to identify the different faults. Whenever fault is created in the simulation at that time only DWT dicompose the fault coefficients and send to the ANN. Here we have written a program to interface with the simulation and we have also written a program for discrete wavelet transform and it is interfaced by the the final program which calls all programs. So in this way we have proposed a new classifier technique inorder to identify the faults with 95% efficiency .Here by using better algorithms rather than backpropagation algorithm we can identify the types of faults with more accuracy than the present method.

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