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Shunt Faults Detection on Transmission Line: A Review

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***Abstract*: Transmission line is the most vulnerable element of any electrical power system and its protection very essential because major portion of power system fault occurring in transmission side. The most common and dangerous fault in power system is the short circuit or shunt fault which causes as a result of breakdowns in the insulation of current caring phase conductor. For power system protection it is necessary to detect these faults and cleared as fast as possible. This paper represents a review on different approaches to detection of faults as Fourier Transform and Wavelet Transform.**

***Keywords:* Transmission line faults, Fault detection, Wavelet Transform, Fourier Transform.**

ACRONYMS:

LG Fault	Line to Ground Fault	CWT	Continuous Wavelet Transform
LL Fault	Line to Line Fault	DWT	Discrete Wavelet Transform
LLG Fault	Double Line to Ground Fault	ANN	Artificial Neural Network
LLL Fault	Triple Line or Symmetrical Fault	MRA	Multi Resolution Analysis
FFT	Fast Fourier Transform	FIR	Finite Impulse Response
DFT	Discrete Fourier Transform		

I. INTRODUCTION

Fault detection on transmission lines is an important task to protect electrical power system and maintain system stability. In our power system different types of faults are categorized as shunt and series faults. Shunt faults involves increase in current and fall in voltage and frequency whereas series type of faults involves increase in voltage and frequency and fall in current in the faulted phases. Shunt type of fault can classified as unsymmetrical faults and symmetrical faults. Unsymmetrical faults are : i) LL fault due a short circuit between lines, ii) LG fault caused by a short circuit between one line and ground, and iii) LLG fault which causes by short circuit between two lines and ground. Symmetrical fault is called three phase fault or triple line fault L-L-L [1]. Because of presence of these faults, there is a disturbance in regular waveform of electrical quantities as voltage, current or in frequency.

Present study involves different researches related to transmission line fault detection methods as follows.

II. FOURIER TRANSFORM

In [11], [12] present a system has the ability to detect and classify power system faults by combining conventional signal analysis method which is FFT. The waveforms associated with fast electromagnetic transients are usually non-periodic signals having both high frequency oscillations and localized impulses superimposed on the power frequency and its harmonics. Fourier analysis usage assumes a periodic signal and hence wide-band signal needs denser sampling and longer time periods to maintain good resolution in the low frequencies [13].

The Fourier Transform X (f) of a continuous- time signal x (t) is given below:

$$X(f) = \int_{-\infty}^{\infty} x(t)e^{-j2\pi f} \quad \ldots\ldots 1$$

Where X (*f*) is the frequency domain representation of time domain signal x(t) means time domain signal converted into frequency domain signal. To find X (*f*) on a digital computer with discrete (sampled) and finite length (time-limited) signals, the Discrete Fourier Transform (DFT) is used.

The DFT is defined as:

$$X[k] = \sum_{n=0}^{N-1} x[n]\, e^{-j\frac{2\pi k n}{N}} \quad \ldots\ldots.2$$

Where X[k] act as a spectral function which shows the relative amounts of various exponential components of x(n).

and ***x*** *[n]* = sequence obtained by sampling the continuous time signal x(t) every *Ts* seconds for *N* samples

$$x[n] = X(nTs) \quad n = 0,1,2, \ldots, N-1$$

In [14] author used DFT with ANN for fault detection and classification

III. WAVELATE TRANSFORM

Wavelets can provide multiple resolutions in both frequency and time. The wavelet transform is well suited to wide-band signals that may not be periodic and may contain both sinusoidal and impulse components as is typical of fast power system transients. Advantage of wavelets to focus on short time intervals for high-frequency components and long intervals for low-frequency components improves the analysis of signals with localized impulses and oscillations, in the presence of a fundamental and low-order harmonics [3].

1. Continuous Wavelet Transform(CWT):

CWT uses inner product to measure similarity between signal and analyzing function. The wavelets are generated from a single basic wavelet $\Psi(t)$, namely, mother wavelet, by scaling and translation:

$$\psi_{s,\tau(t)} = \frac{1}{\sqrt{s}}\psi\left(\frac{t-\tau}{s}\right) \quad \ldots\ldots\ldots 3$$

Where *s* is the scale factor, τ is the translation factor and the factor $s^{-1/2}$ is the energy normalization across the different scales. By integrating this equation with time series Xn we can find the CWT coefficients.

2. Discrete Wavelet Transform (DWT):

To obtain the DWT the parameters s and τ need to discretized. Discretizing $s = 2^j$ and $\tau = 2^j k$ will yield orthogonal basis functions for certain choices of ψ:

$$\psi_{(j,k)}(t) = 2^{-j/2}\psi\left(2^{-j}t - k\right) \quad \ldots\ldots\ldots..4$$

There are several papers in which different types of wavelets used for fault detection presented.

IV. DECOMPOSITION OF SIGNAL

Mallat present that Multi Resolution Analysis which is called MRA can be used to find the DWT of a discrete signal by using two FIR filter as lowpass and highpass filters ,by down sampling. In given Figure we can see highpass and lowpass filters. At each level, this procedure computes [3], [4], [5].

With N being the total number of samples in x[n] and detailed component D1 shows output of highpass filter and approximation A1 shows output of lowpass filter. A1 future can divided in D2 which is second level detailed component and in A2 which is second level approximation component.The number of levels in this process is repeated depends on the choice of the user.

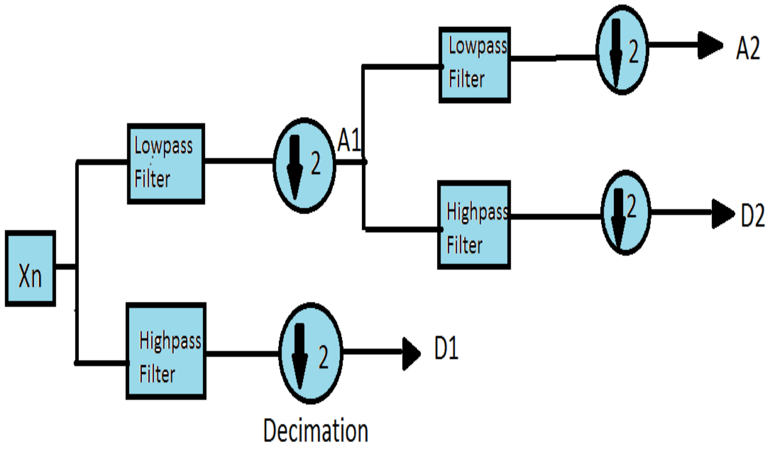

Figure 1: Two level decomposition of wavelet component

The analyzing wavelets are called the “mother wavelets” and it’s dilated and translated versions are called the “daughter wavelets”. It has a digitally implementable counterpart called the discrete Wavelet transform (DWT).

Reference [3] shows Mayer Wavelet used as mother wavelet. In this paper decomposition of signal done at the level 4 means D4 given to the Neural Net for fault classification. In this method wavelet transform detail component apply to the Principal Component Analysis and by neural net fault can be classify.

In paper [1], [2], [4] and [10] fault detection done by Daubechies Wavelet. Daubechies wavelets are the most popular wavelets. They represent the foundations of wavelet signal processing and are used in numerous applications [9]. These are also called Maxflat wavelets as their frequency responses have maximum flatness at frequencies 0 and R. This is a very desirable property in some applications. Daubechies are compactly supported orthonormal wavelets and found application in DWT. Its family has got nine members in it db2,db3,db4,db5,db6,db7,db8,db9and db10.

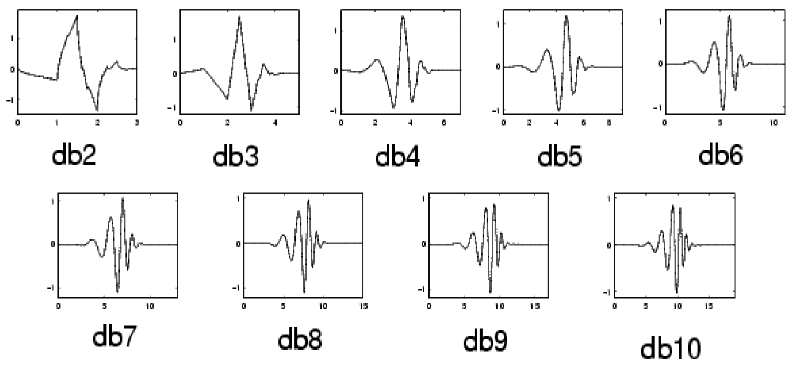

Figure 2: Daubechies Wavelet

In [1] and [2] Daubochie-4 has used for fault detection. Daubechie-4 (db-4) used in analysis as it closely matches the signal to be processed which is most importance in wavelet applications. Wavelet co-efficient of the signal are obtained by the decomposition of a discrete fault current and voltage using Mallat’s algorithm.

In reference [4] given technique consists of a pre-processing module based on time-frequency transforms used with an Artificial Neural Network (ANN) for detecting and classifying fault in power system. The pre-processing module extracts distinctive features in the input signals at the relay location, and simplifies the information contained in the input vector of the ANN, improving it in speed and accuracy. The Wavelet transform Daubechie-6 (db-6) have been used as pre-processor. Artificial neural network based analysis is fast acting and is not affected by problems as inter-circuit faults, homopolar sequence coupling, out of steps or power oscillation. The use of a pre-processor based on wavelet transform simplifies the input data and improves the algorithm in reliability, rapidity and efficiency.

In reference [10] author has chosen Daubechie-8 wavelet as the mother wavelet by comparing its performance with that of few other mother wavelet functions. MRA used for wavelet analysis and a feed-forward neural network based on the supervised back-propagation learning algorithm were used to implement the proposed faulted phase selector system. Neural network was trained with a large number of simulation cases by considering different fault types, fault locations, fault resistances and fault inception angle. In fault classification, the objective is to assign the input patterns to one of all categories. ANNs possess good features such as noise immunity, generalization capability robustness and fault tolerance capability. In this paper, an algorithm for identification of faulted phase during faults on double circuit transmission line has been presented. Given method depends on the current signals extracted from the relay location. Wavelet Transform was applied to extract distinctive features in the input signals.

Wavelet transform approach using Morlet basis function is proposed to supervise power system disturbances in [8]. With the time-frequency localization characteristics embedded in wavelets, the time and frequency information of a waveform can be presented.

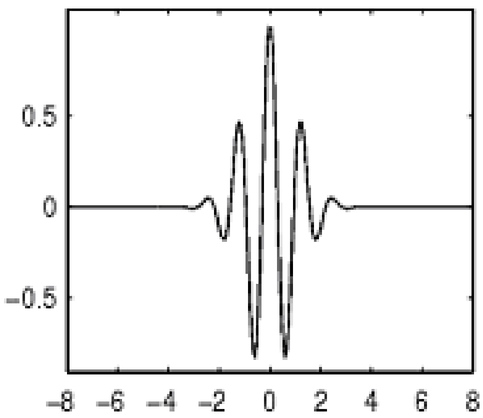

Figure 3: Morlet Wavelet

In [8], author has applied Morlet wavelets to investigate four kinds of electric events that degrade the power quality, including voltage sag and swell, transients, momentary interruption. Given approach was very successful in detecting and localizing different kinds of power system disturbances.

Paper [7] represents an approach to detect fault by Hilbert transform which find the instantaneous values of amplitude and frequency of the low or high-frequency sub-band. Thus the algorithm adaptively takes a way of stationary wavelet packet decomposition, making a MRA on the signal and extracting the components for fault detection. Stationary wavelet packet transform inherits the traditional wavelet packet transform. Without the under sampling process, stationary wavelet packet transform avoids the inherent defects of the traditional wavelet packet transform in low time-resolution. It not only improves the frequency resolution, but also carries a temporal resolution. For any continuous time signal $x(t)$, the discrete stationary wavelet packet coefficient at level i and sub-band k is

$$w_{i,k}(t) = \sum_{\tau=0}^{L_i-1} f_{i,k}(\tau)x[(t-\tau)\ mod\ N]$$

......5

Based on stationary wavelet packet decomposition and Hilbert transform, this paper proposed a new adaptive method to make a MRA on the signals. According to the characteristics of signal, this method can adaptively choose the decomposition paths and levels, thus extract the characteristic components of the signal. Proposed method is also good at less computational workloads

Wavelet Packets is more complex and flexible analysis because in this details as well as approximations are split.

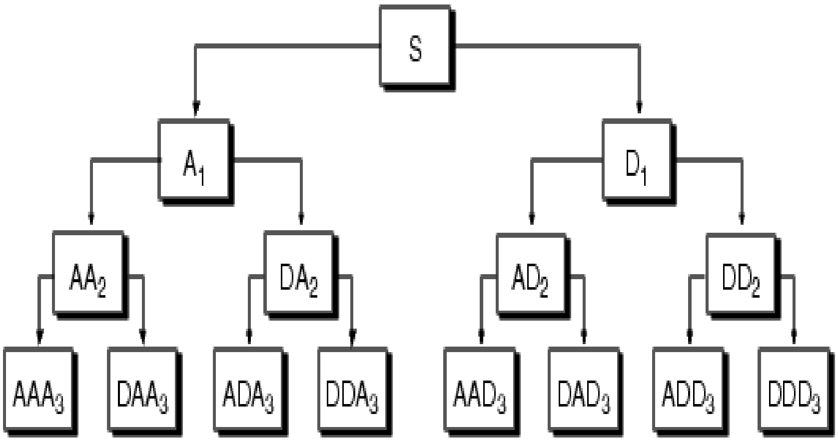

Figure 4: Wavelet Packet Tree

V. CONCLUSION

As we discussed different methods of fault detection in Fourier Transform is used for analysis of sinusoidal signal and having good resolution for low frequency signals, where Wavelets suited for sinusoidal and impulse signals both and have good resolution in time as well as in frequency. Daubechie-4 and Daubechie-6 wavelet are well suited for high frequency fast transients and Daubechie-8 good for slow transients.

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