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Analytical investigation of faults in Power Transmission line : A review

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Abstract-*This paper describes a Wavelet transform technique to analyze power system disturbance such as transmission line faults with Biorthogonal and Haar wavelets. In this work, wavelet transform based approach, which is used to detect transmission line faults, is proposed. The coefficient of discrete approximation of the dyadic wavelet transform with different wavelets are used to be an index for transmission line fault detection and faulted – phase selection and select which wavelet is suitable for this application. MATLAB/Simulation is used to generate fault signals. Simulation results reveal that the performance of the proposed fault detection indicator is promising and easy to implement for computer relaying application.*

Key Words*: Transmission line fault detection, faulted - phase selection, Wavelet transform technique, Fault location.*

I. INTRODUCTION

In power transmission line protection, faulty phase identification is very important items which need to be addressed in a reliable and accurate manner**.** Distance relaying techniques based on the measurement of the impedance at the fundamental frequency between the fault location and the relaying point have attracted wide spread attention. Transmission line fault identification requires fast and accurate analysis. The tripping action depends mainly on the voltage and current waveforms during the fault.

Nowadays, the fault detection technique has used high frequency components instead of the fundamental signal component. This leads to a new scheme named transient based protection. In such a protection system, it is essential that the fault signal has to be analysed accurately. Fourier Transform was used in the early stage as a mathematical tool to analyse the transient fault signal. However, it has been shown that the analysis based on Fourier transform, sometimes, is not precise enough. In recent years, Wavelet Transform has been used extensively for signal and image processing. It has been found that the Wavelet Transform is capable of investigating the transient signals generated in a power system

Wavelet analysis which is a mathematical tool for Signal analysis is used to detect the type of fault occurring on the transmission line. The wavelet transform is introduced as a method for analyzing electromagnetic transients associated with power system faults and switching. This method, like the Fourier transform, provides information related to the frequency composition of a waveform, but it is more appropriate than the familiar Fourier methods for the non-periodic, wide-band signals associated with electromagnetic transients. It appears that the frequency domain data produced by the wavelet transform may be useful for analyzing the sources of transients through manual or automated feature detection schemes.

Transmission lines are used to transmit electric power to distant large load centers. The rapid growth of electric power systems over the past few decades has resulted in a large increase of the number of lines in operation and their total length. These lines are exposed to faults as a result of lightning, short circuits, faulty equipments, miss-operation, human errors, overload, and aging. Many electrical faults manifest in mechanical damages, which must be repaired before returning the line to service. The restoration can be expedited if the fault location is either known or can be estimated with a reasonable accuracy. Faults cause short to long term power outages for customers and may lead to significant losses especially for the manufacturing industry. Fast detecting, isolating, locating and repairing of these faults are critical in maintaining a reliable power system operation. When a fault occurs on a transmission line, the voltage at the point of fault suddenly reduces to a low value. This sudden change produces a high frequency electromagnetic impulse called the traveling wave (TW).

The distribution of the results should be done through any of the following data:

1) Faulted phase (s). 2) Fault type
3) Total fault location 4) Fault location
5) Fault resistance 6) DC offset.
7) Breaker operating time 8) Auto re-close time

The simulation of the voltage and current transient is important for the design of the fault location algorithm, analysis of various possible fault conditions and the proper functioning of the fault locator. The analysis of faults and disturbances in power systems is a fundamental foundation for a secure and reliable electrical power supply with a flow chart as shown in below fig.1.

$$DWT[m,k] = \frac{1}{\sqrt{a_0^m}} \sum_n x[n] g\left[\frac{k - na_0^m}{a_0^m}\right] \qquad (2)$$

Where g[n] is the mother wavelet, and the scaling and translation parameters a and b are functions of an integer parameter m, $a=a_o^m$ and $b=na_o^m$.

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Wavelet transform possesses some unique features that make it very suitable for this particular application. It maps a given function from the time domain into *time-scaling* domain. The basis function used in the wavelet transform is band pass characteristics which makes this mapping similar to a mapping to the time-frequency plane. Unlike the basis functions used in Fourier analysis, the wavelets are not only localized in frequency but also in time. This localization allows the detection of the time of occurrence of abrupt disturbances, such as fault transients.

III. DIFFERENT TYPES OF WAVELET SIGNALS

Many published woks introduce the wavelet transform as a tool to analyze the power system disturbances. In this work, a dyadic wavelet transform based approach, which is used to detect transmission line faults, is proposed. The typical wavelets used to detect power disturbance are mainly Haar, Daubechies, Coiflets, Bi orthogonal, Morlet and Symlets. In wavelet analysis, a MOTHER WAVELET is chosen as the prototype for generating other basis window functions. i.e., all the window functions are obtained by translating and scaling the mother wavelet.

A. *Translation*

Translation is related to the location of the window, as the window is shifted along the signal. This term corresponds to time information in the transform domain.

B. *Scale*

Scaling implies the increasing or reducing the width of the mother wavelet. The scales in the wavelet analysis similar to that used in maps, high scales correspond to a non – detailed global view (of the signal), and low scales correspond to a detailed view. Similarly, in terms of frequency, low frequencies (high scales) correspond to global information of a signal (that usually spans the entire signal), whereas high frequencies (low scales) correspond to detailed information of a hidden pattern in the signal (that usually lasts a relatively short time).Scaling, as a mathematical operation, either dilates or compresses a signal. Larger scales correspond to dilated (or stretched out) signals and small scales correspond to compressed signals. The frequency parameter in wavelets is given as

SCALE = (1/FREQENCY) (3)

Higher scales correspond to non – detailed global view if the signal and low scales correspond to detailed view. Similarly, in terms of frequency, low frequencies (high scales) correspond to global information of the signal (that usually spans the entire signal), whereas high frequencies (low scales) correspond to detailed information of a hidden pattern in the signal (that usually lasts a relatively short time).

IV. DETECTION SCHEME

At the incidence of fault, variation of both voltage and current at the location of protective relay is expected. The severity of the distortion from normal waveform depends mainly on the type of fault. In this application the usage of current waveform for each phase as base of respective comparison will be suggested. The normal operation of the system was taken as reference for our analysis. Wavelet decomposition of this normal state is performed using third level decomposition. Faults are simulated for the power system including phase to ground faults, double phase faults and double phase to ground faults. Taking the maximum value of approximation coefficient as the base value of each decomposed waveform and comparing it with the three phase decomposed currents during the fault, respective faults was clearly detected. If the application to be accurate,the decomposition of the signals using different levels should be required. After different trials it was possible to differentiate between such faults by the sum of both approximation and detailed coefficients for fifth level decomposition.

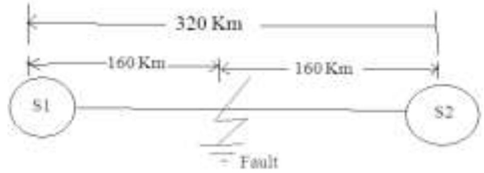


Fig.4: Schematic diagram for simulated Power system

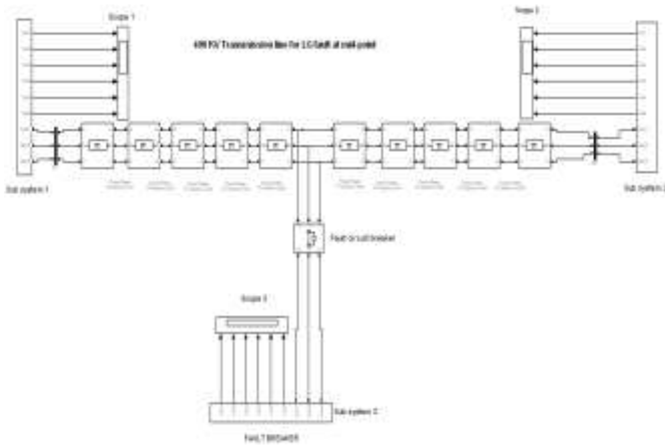


Fig.5: Simulink diagram of 400KV transmission line with fault breaker

The Simulink diagram of 400 KV transmission line with fault breaker is shown in above fig.5 which is having two equal lines each of 160Km length. For evaluating the performance of the proposed algorithm, this paper adopts MATLAB/Simulink for fault data generation and algorithm implementation is shown in below fig.6.Distributed line model is utilized in this simulation. In this work, the phase difference between S1 and S2 is set as 20 degrees.

When the LG fault i.e., Phase–A to ground occurs on the 400 KV transmission system, the respective parameters goes into abnormal conditions, as shown in below fig.6.The voltage of phase-A will be dropped from 0.02 sec to 0.1 sec i.e., circuit breaker transition time 0.005 sec. The fault breaker will be closed after clearing of fault i.e., the voltages and currents are goes to normal conditions.

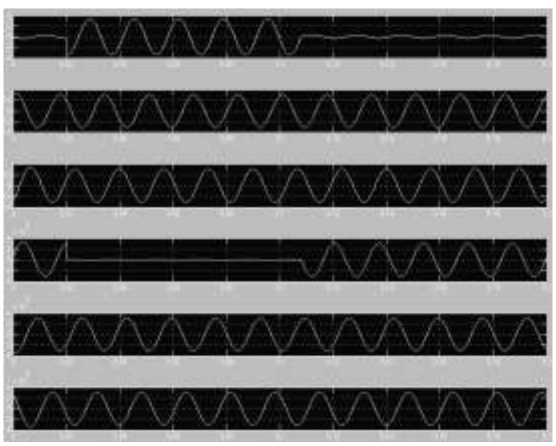


Fig.6: Phase currents and voltages for LG fault at midpoint of the transmission line

A. *Application of wavelet transform (Biorthogonal and Haar Wavelets) to detect faulted phase*

When a fault occurs on the transmission line it should cause to sudden raise in the fault signals like current signals. So that the Biorthogonal and Haar wavelet signals are used to detect which fault is occurred and at what location should be identified. The Biorthogonal and Haar wavelets are used to detect fault location are explained below. The detection of LG fault using Biorthogonal and Haar wavelets are shown in fig.7 &fig.8. respectively

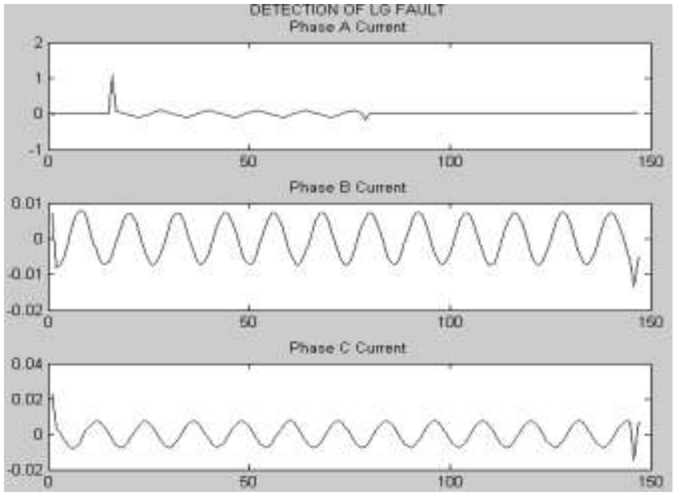


Fig.7.Detection of LG fault using Biorthogonal wavelet

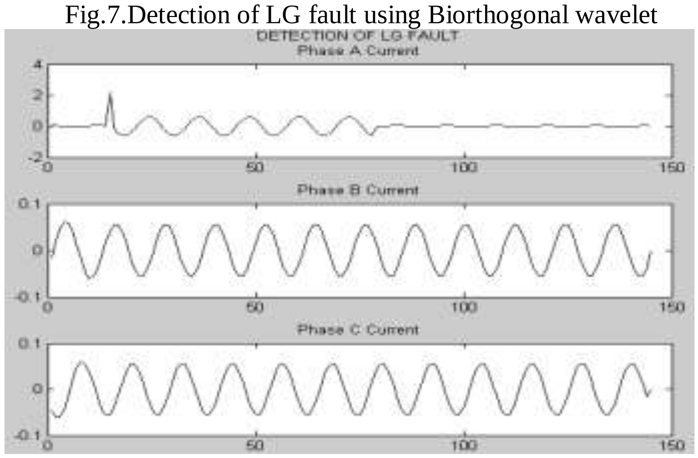


Fig.8.Detection of LG fault using Haar wavelet

Similarly the detection of LL,LLG and LLL faults must be done by these two wavelets.the detection of LLL fault phase detection using Biorthogonal and Haar wavelets are shown in below fig.9 and fig.10 respectively.

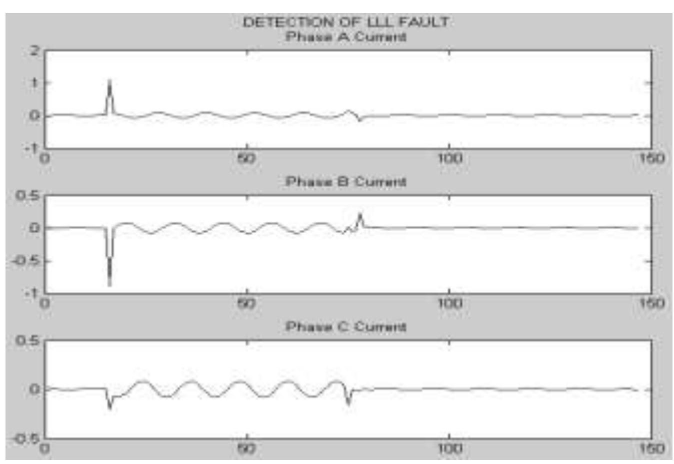


Fig.9.Detection of LLL fault using Biorthogonal wavelet

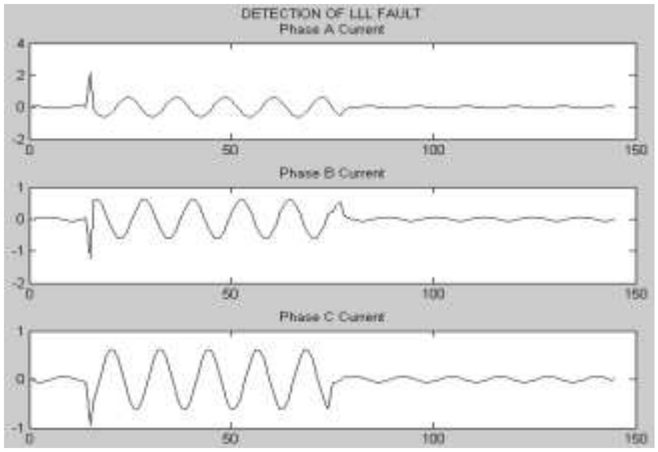
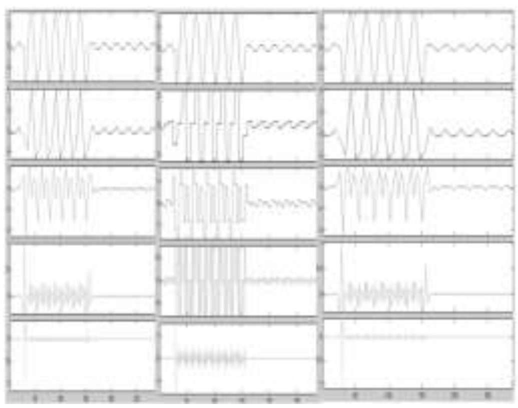


Fig.10.Detection of LLL fault using Haar wavelet

The comparison of Biorthogonal and Haar wavelets transformation should be leads to more accurate detection of faulted phase ,so that which wavelet is more suitable for this application can be easily recognized.

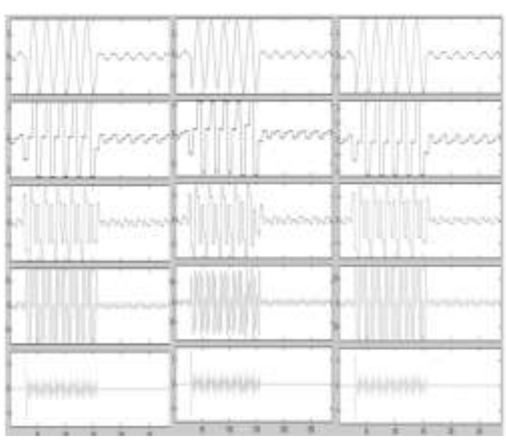
B. *Detection of faulted location using wavelet transformation for LG fault*

The detection of fault location along the transmission line by Biorthogonal wavelet is explained in below. The approximate and detail signals of phase-A current for LG Fault at middle, S1 and S2 ends of the transmission line using Biorthogonal wavelet for this application is shown in fig.11.Similarly the Haar wavelet is applied for this application to detect faulted location along the transmission system is shown in below fig.12.



Middle 'S1' end 'S2' end

Fig.11: Approximate and detail signals of phase-A current for phase-A LG fault at middle, S1 and S2 ends of the transmission line using Biorthogonal wavelet transformation**.**



Middle 'S1' end 'S2' end

Fig.12: Approximate and detail signals of phase-A current for phase-A LG fault at middle, S1 and S2 ends of the transmission line using Haar wavelet transformatio

VI. CONCLUSION

A wavelet transform based approach for transmission line protection is presented in this work i.e., a simple and effective fault detecting approach based on wavelet transform is applied. The abrupt change of current component of the fault current for a power system can be detected by the Biorthogonal and Haar wavelet transforms. The fault detection indicator also can achieve the task of faulted-phase selection. The simulation studies demonstrate that the proposed algorithm is feasible for transmission line protection to other faults such as L-L, L-L-G, L-L-L and L-L-L-G faults in different locations. By comparing Biorthogonal and Haar wavelet transforms, the Biorthogonal is more suitable than Haar wavelet transform is conformed. The detection of faulted phase and faulted location by other wavelets should be applied to get suitability of application along the transmission line. So that different wavelet signals like Coiflets and Daubechies-etc should be apply for this consideration.

The simulation studies have demonstrated that the proposed method is able to detect different types of faults in the power system.

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