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APPLICATION OF TRAVELLING WAVES FOR THE PROTECTION OF TRANSMISSION LINE

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ABSTRACT: The main aim of this paper is to represents the protection of transmission line and a method for obtaining relaying signals based on travelling wave. As this scheme utilizes high frequency components for detection of fault, it is the quickest possible scheme for the protection of power system as a whole and gives more accurate information about the fault location compared to the traditional available scheme.

I. INTRODUCTION

For protecting a transmission line, relay is first and most basic component. For the stability of the electrical network, it is important to clear faults on high voltage transmission line quickly. The conventional method of fault detection is mainly based on impedance measurement techniques. To calculate the impedance, the fundamental frequency components of the voltage and current signals have to be extracted. The filtering involved in this process has an inherent delay Fault generated transients or travelling wave signals provides the very first information about a possible disturbance on the line and hence can be used to detect faults very quickly and can also measure the distance to the fault using the time taken for a wave to travel from the relaying point to the fault and back. Different methods of protection base on travelling wave are available like Fourier Transform, Discrete Fourier Transform, Correlation technique, Wavelet Transform etc. With the impedance measurement technique, operating time of a relay is comparatively low for close-up faults and it is quite high at the locations near to the reach point of the relay. For the last several years, Fourier transform has been extensively used by many researchers in the field of power system protection. However, when a signal is transformed to the frequency domain, the time domain information is lost, which is a serious drawback with Fourier transform. In the Fourier transform of the signal, it is impossible to predict when a particular event has taken place. Fault

signal contain numerous non-stationary or transitory characteristics. These characteristics are often very significant in the signal, and Fourier analysis is not suited for their detection. Wavelet transform are capable of revealing those aspects of data are usually missed by other signal analysis techniques. Furthermore, as wavelet analysis provides information in both frequency and time, it can compress or de-noise a signal without appreciable degradation.

II. TRAVELLING WAVE

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 travelling wave (TW). These travelling waves propagate away from the fault in both directions at speeds close to that of light. Here single-end method of travelling wave method is used for estimate fault location. Although the single-ended fault location method is less expensive than the double-ended method, since only one unit is required per line and a communication link is not required.

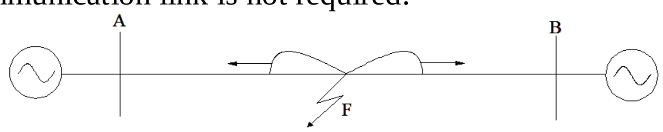

Fig.1. Propagation of electromagnetic waves in HV line after a fault

The transmission line conductors have resistances and inductances distributed uniformly along the length of the line. Travelling wave fault location methods are usually more suitable for application to long lines. Power transmission lines have the properties of voltage and current waves that travel on the line with finite speed of propagation. Travelling wave methods for transmission lines fault location have been reported since a long time. Subsequent developments employ high speed digital recording technology by using the travelling wave transients created by the fault. It is well known that when a fault occurs in overhead transmission lines systems, the abrupt changes in voltage and current at the point of the fault generate high frequency electromagnetic impulses called travelling waves which propagate along the transmission line in both directions away from the fault point as shown in fig. 2. These transients travel along the lines and are reflected at the line terminals following the rules of Bewley's Lattice Diagrams. If the times of arrival of the travelling waves in the one ends of the transmission line can be measured precisely, the fault location then can be determined by comparing the difference between these two arrival times of the two consecutive peaks of the travelling wave signal.

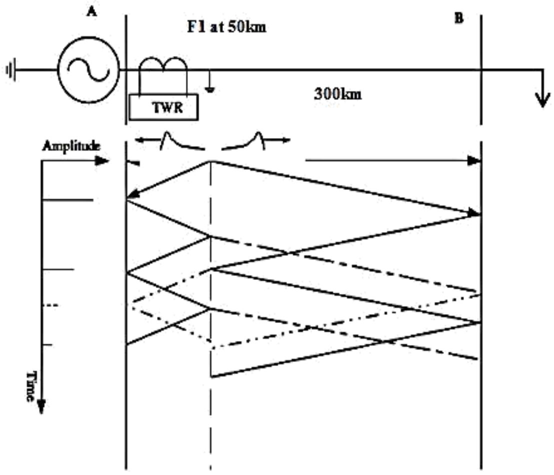

Fig.2.Bewley's Lattice Diagram

III. WAVELET TRANSFORMS

Most signals are represented in the time domain. More information about the time signals can be obtained by applying signal analysis, i.e. the time signals are transformed using an analysis function. The Fourier transform is the most commonly known method to analyze a time signal for its frequency content. A relatively new analysis method is the wavelet analysis. The wavelet analysis differs from the Fourier analysis by using short wavelets instead of long waves for the analysis function. The wavelet analysis has some major advantages over Fourier transform which makes it an interesting alternative for many applications. The use and fields of application of wavelet analysis have grown rapidly in the last years. The Fourier transform only retrieves the global frequency content of a signal. Therefore, the Fourier transform is only useful for stationary and pseudo-stationary signals. The Fourier transform does not give satisfactory results for signals that are highly non-stationary, noisy, a-periodic, etc. These types of signals can be analyzed using local analysis methods. These methods include the short time Fourier transform and the wavelet analysis. All analysis methods are based on the principle of computing the correlation between the signal and an analysis function. The analysis of a non-stationary signal using the FT or the STFT does not give satisfactory results. Better results can be obtained using wavelet analysis. One advantage of wavelet analysis is the ability to perform local analysis. Wavelet analysis is able to reveal signal aspects that other analysis techniques miss, such as trends, breakdown points, discontinuities, etc. The wavelet analysis calculates the correlation between the signal under consideration and a wavelet function ψ (t). The similarity between the signal and the analyzing wavelet function is computed separately for different time intervals, resulting in a two dimensional representation. The analyzing wavelet function ψ (t) is also referred to as the mother wavelet. The continuous wavelet transform.

The continuous wavelet transform is defined as

$$W_{T,m}(t) = \frac{1}{\sqrt{s}} \int_{-\infty}^{\infty} s(t)\psi| \left(\frac{t-\tau}{s}\right) dt$$

The transformed signal XWT (T, s) is a function of the translation parameter T and the scale parameters. The mother wavelet is denoted by ψ.

IV. FAULT DETECTION

Transient signals have some characteristics such as high frequency and instant break, so wavelet transform is strong tool for them in feature picking-up, and it satisfies the analysis need of electric power transient signals. DWT is determining by filtering the signal with a high-pass and low-pass filter pair. Filtering by high-pass filter produces details and filtering by low-pass produces approximations.

Let current signal S (t), which is a discrete sequence with n samples, be the signal sequence to be analyzed as follows.

1) First, analyze the S (t) by DWT, where the db4 mother wavelet and find 1st level decomposition coefficient, as Dj is detail coefficient and Aj is approximation coefficient.

2) Second, find wavelet energy spectrum Ej as

$$Ej = |Dj|^2$$

3) Third, in order to obtain the entropy of the signal, the probability pi is defined as follows

$$p_i = Ei / \sum_{j=1}^{r} E_j$$

where r is number of detail coefficient Dj.

4) Finally, Wavelet Energy Entropy (WEE) of S (t) is obtained by

$$WEE = -\sum_{i=1}^{r} p_i ln\, p_i$$

WEE is sensitive to the transients produced by the faults. Therefore, the proposed WEE will be suitable and useful for measuring the uncertainty and complexity of the analyzed signals, and will provide an intuitive and quantitative outcome for the fault diagnosis.

V. FAULT CLASSIFICATION

Discrete Wavelet Transform (DWT) has been used for detecting and classifying faults on transmission lines. For detection and classification of faults on transmission lines different types of faults at different locations on the line were simulated and their current signals were sampled at regular intervals of time.

For classification using DWT a few parameters are defined as given below.

Sa= Summation of 3rd level coefficients for phase A.

Sb= Summation of 3rd level coefficients for phase B.

Sc= Summation of 3rd level coefficients for phase C.

The parameters Qa, Qb and Qc are defined as:

Qa= Summation of absolute values of 3rd level coefficients for phase A.

Qb= Summation of absolute values of 3rd level coefficients for phase B.

Qc= Summation of absolute values of 3rd level coefficients for phase C.

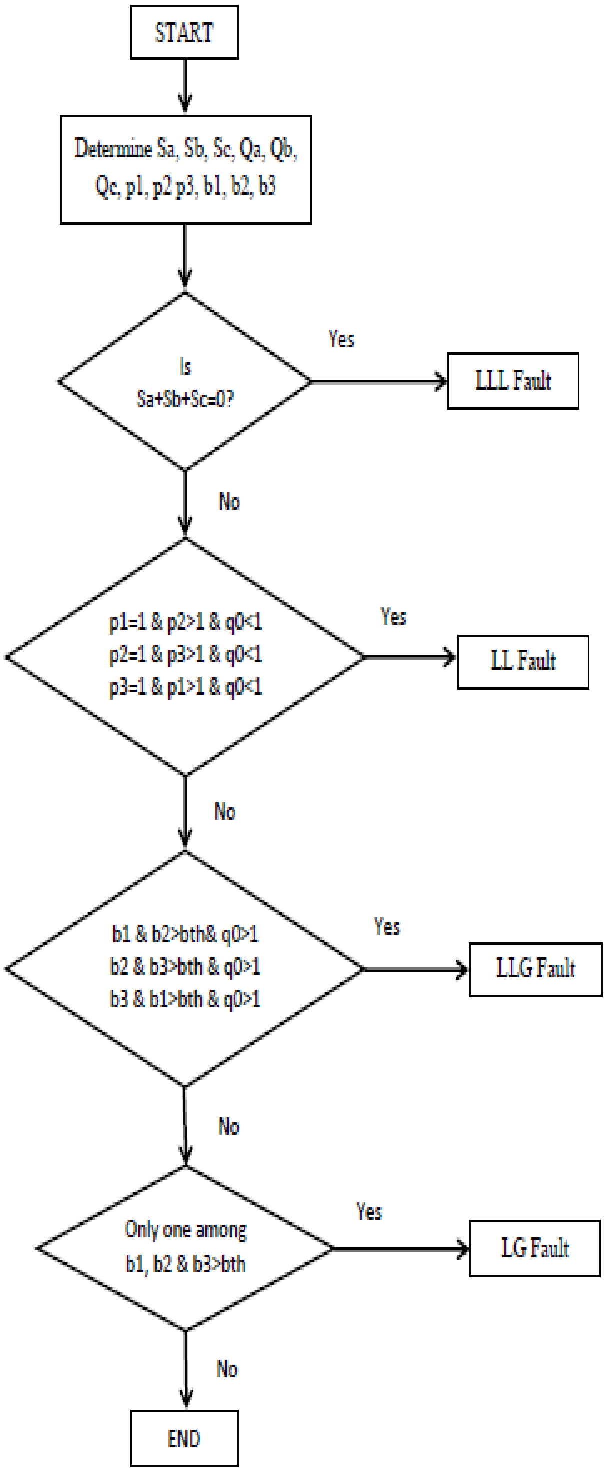

Fig.3. Fault classification algorithm using DWT

VI. FAULT LOCATION

Fault location for close-in and remote-end fault.

Close-in Faults:-

The WTCs of the ground mode are found to be insignificant; hence this type of fault is classified as an ungrounded. The fault location can be calculated using the time difference between the first two peak values of WTCs, as follows

$$x = \frac{v\ dt}{2}$$

In the case of ungrounded faults, the fault location can be found directly since there are no reflections from the remote-end bus.

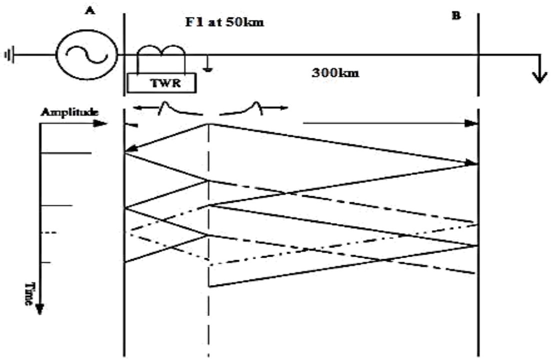

Fig.4. Close-in Fault Applied to the Power System Model

Remote-end Faults:-

For ungrounded fault, the fault location can be calculated using the time difference between the first two peak values of WTCs,

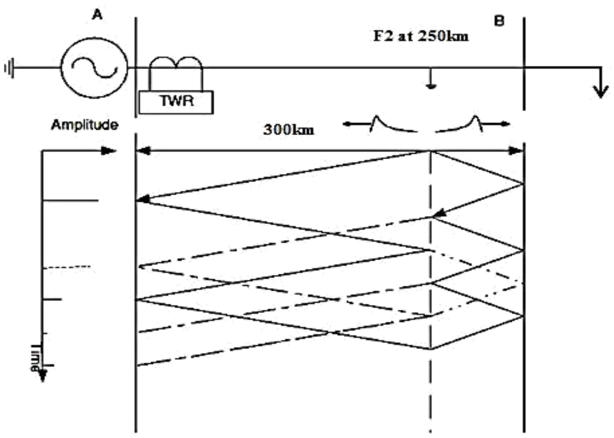

Fig.5.Remote-end Fault Applied to the Power System Model

VII. CONCLUSION

This paper presents a methodology based on traveling wave for EHV transmission line protection was developed. A Wavelet Transform based fault detection and classification approach for large scale power transmission networks is proposed. The high frequency components derived by wavelet transform from fault signals are used as discriminative features for detection and classification. The proposed method utilizes wavelet entropy values obtained from discrete wavelet transform for fault detection. The test results prove that the WE is sensitive to sudden changes in transient signals, and used to detect the faults under various situations. The proposed algorithm for fault classification based on the wavelet transform ratios between the faulty phase and sound phase is accurate and feasible. And it is an effective and robust algorithm which is suitable in the case of various fault conditions such as different types of fault, fault location, fault inception angle and fault resistance.

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