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Identification and Classification of Faults in High Voltage Radial Ug Cables by Wavelet Transform

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ABSTRACT *:This paper deals with the identification and classification of faults in high voltage radial UG cables by wavelet transform. It presents the use of wavelet as a pattern classifier to perform the tasks of different fault identification and classification .In this work the cable model is taken and the different faults in the cable were identified and classified by wavelet and are compared. The under ground system is very important for distribution systems especially in metropolitan cities, air port and defense service The UG system provides a large capacity in transmission and no harm from visual harassment. How ever, it is difficult than those of over head transmission systems. In ordered to minimize such defectives of the faulted UG systems, the design and construction should be optimized In that fault detection, classification and also location to become easy and reliable. This wavelet analysis reduces the effect of system variables such as fault resistance, fault type and fault inception angle. The result show that the proposed technique is able to offer high accuracy in fault classification tasks*

Keywords: *UG cables,Wavelet, faults ,DWT,Matlab*

I. INTRODUCTION

The Wavelet Transform (WT) is a digital signal processing (DSP) technique based on translation and dilation of a window, named the mother wavelet [8]. The technique allows high frequency event‟s location with a greater time resolution. The DFT yields frequency coefficients of a signal, which represents the projection of orthogonal Sine and Cosine basic functions. Such transforms have been successfully applied to stationary signals where the frequencies of the signals do not vary with time. However, for non-stationary signals, any abrupt change may spread all over the frequency axis. Under this situation, the Fourier techniques are less efficient in tracking the signal dynamics, therefore, an analysis adaptable to non- stationary signals [8] is required instead of Fourier based methods. Consequently, the Short Time Fourier Transform uses a (time-frequency) window to localize – in time - sharp transitions for non- stationary signals. The STFT uses a fixed time frequency window, which is inadequate for the practical power system faults encountering change in frequencies. The Wavelet Transform (WT) technique, recently proposed in literature as a new tool for monitoring power quality problems [3-7], has received considerable interests in field of power system signal processing [8-9]. The WT is well suited to wide band signals that may not be periodic and may contain both sinusoidal and non sinusoidal components. This is due to the ability of wavelets to focus on short time intervals for high frequency components and long time intervals for low frequency components. In this paper the output line voltages at load terminals are used as the medium for fault detection. A line to ground fault is defined as a single connection between a phase and the ship‟s hull. MATLAB-SIMULINK is used to generate the line to line voltage data for the various faulted conditions. A Wavelet analysis using Daubechies Wavelets is then applied to line voltages. The coefficients of the detailed scales are examined to determine the line on which ground fault has occurred in balanced load or unbalanced load conditions. This paper is organized as follows. Section-2 presents Wavelet transform and Multi-resolution analysis. Section-3 concerns with the proposed Wavelet based fault detection method for balanced and unbalanced ungrounded power system. Section-4 deals with MATLAB-SIMULINK model used for generation of line to line voltage data for fault conditions in Naval typical integrated power system and implementation of the developed algorithm to demonstrate the efficiency and effectiveness of the proposed method. Numerical findings are presented in the form of graphs and tables.Wavelets are functions that satisfy certain requirements. The very name wa6elet comes from the requirement that they should integrate to zero, „waving‟ above and below the x-axis. The diminutive connotation of wa6elet suggests the function has to be well localized. Other requirements are technical and needed mostly to insure quick and easy calculation of the direct and inverse wavelet transform. Compared with traditional Fourier method, there are some important differences between them. First Fourier basis functions are localized in frequency but not in time while wavelets are localized in both frequency (via dilation) and time (via translation). Moreover, wavelets can provide multiple resolution in time and frequency. Second, many classes of functions can be represented by wavelets in more compact way. For example, functions with discontinuities and functions with sharp spikes usually take substantially fewer wavelet basis functions than sine-cosine basis functions to achieve a comparable approximation.

II. THEORY OF WAVELET ANALYSIS

Wavelets are functions that satisfy certain requirements. The very name wa6elet comes from the requirement that they should integrate to zero, „waving‟ above and below the x-axis. The diminutive connotation of wa6elet suggests the function has to be well localized. Other requirements are technical and needed mostly to insure quick and easy calculation of the direct and inverse wavelet transform. Compared with traditional Fourier method, there are some important differences between them. First Fourier basis functions are localized in frequency but not in time while wavelets are localized in both frequency (viadilation) and time (via translation). Moreover, wavelets can provide multiple resolution in time and frequency. Second, many classes of functions can be represented by wavelets in more compact way. For example, functions with discontinuities and functions with sharp spikes usually take substantially fewer wavelet basis functions than sine-cosine basis functions to achieve a comparable approximation.

There are many types of wavelets [9,10], such as Harr, Daubechies 4, Daubechies 8, Coiflet 3, Symmlet 8 and so on. One can choose between them depending on a particular application. As with the discrete Fourier transform, the wavelet transform has a digitally implementable counterpart, the discrete wavelet transform (DWT). If the „discrete‟ analysis is pursuing on the discrete time, the DWT is defined as

$$C(j,k) = \sum_{n \in Z} s(n) g_{j,k}(n) \quad (j \in N, k \in Z)$$

where, s(n) is the signal to be analyzed and $g_{j,k}(n)$ is discrete wavelet function, which is defined by

$$g_{j,k}(n) = a_0^{-j/2} g(a_0^{-j} n - k b_0)$$

By using wavelets analysis, sub-band information can be extracted from the simulated transients, which contain useful fault features. By analyzing these features of the detail signals, different types of fault can be detected and classified. As mentioned earlier, the choice of analyzing wavelets plays a significant role in fault detection and identification.

III. SIMULATION EXPERIMENT

There are many types of wavelets [9,10], such as Harr, Daubechies 4, Daubechies 8, Coiflet 3, Symmlet 8 and so on. One can choose between them depending on a particular application. As with the discrete Fourier transform, the wavelet transform has a digitally implementable counterpart, the discrete wavelet transform (DWT). If the „discrete‟ analysis is pursuing on the discrete time, the DWT is defined as

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$$g_{j,k}(n) = a_0^{-j/2} g(a_0^{-j} n - k b_0)$$

Select a_0 and b_0 carefully, the family of scaled and shifted mother wavelets constitute an orthonormal basis of $l^2(Z)$ (set of signals of finite energy). When simply choose a_0 = 2and b0=1, a dyadic-orthonormal wavelet transform is obtained. With this choice, there exists an elegant algorithm, the multi resolution signal decomposition (MSD) technique [11], which can decompose a signal into levels with different time and frequency resolution. At each level j, approximation and detail signals Aj, Dj can be built. The words„approximation‟ and „detail‟ are justified by the fact that Aj is an approximation of A_{j_1} taking into account the „low frequency‟ of A_{j_1}, whereas the detail Dj corresponds to the „high frequency‟ correction. The original signal can be considered as the approximation at level 0.

The coefficients C (j,k) generated by the DWT are something like the „resemblance indexes‟ between the signal and the wavelet. If the index is large, the resemblance is strong, otherwise it is slight. The signal then can be represented by its DWT coefficients as

$$s(n) = \sum_{j \in N} \sum_{k \in Z} C(j,k) g_{j,k}(n)$$

When fix j and sum on k, a detail Dj is defined as

$$D_j(n) = \sum_{k \in Z} C(j,k) g_{j,k}(n)$$

Then sum on j,the signal is the sum of all the details

$$s(n) = \sum_{j \in N} D_j(n)$$

Take a reference level called J, there are two sorts of details. Those associated with indices j5J correspond to the scales 2j52J, which are the fine details. The others, which correspond to j\J, are the coarser details. If these latter details are grouped into

$$A_J = \sum_{j > J} D_j$$

which defines an approximation of the signals. Connect the details and an approximation, the equality

$$s = A_J + \sum_{j \le J} D_j$$

which signifies that s is the sum of its approximation A_J and of its fine details. The coefficients produced by DWT, therefore, can be divided into two categories: one is detail coefficient, the other is approximation coefficient. To obtain them, MSD provides an efficient algorithm known as a two channel sub-band coder using quadrature mirror filters [12]. Then the detail part is still represented by wavelets, which can be regarded as series of band-pass filters, whereas the approximation is represented by the dilation and translation of a scaling function, which can be regarded as a low-pass filter

A.METHOD OF SIMULATION OF THE PROPOSED SYSTEM

Since the impedance of the total line length is a known quantity, the distance to the fault will be obtained proportional to the imaginary component of the measured impedance. The overall flowchart of the proposed algorithm is shown in Fig.

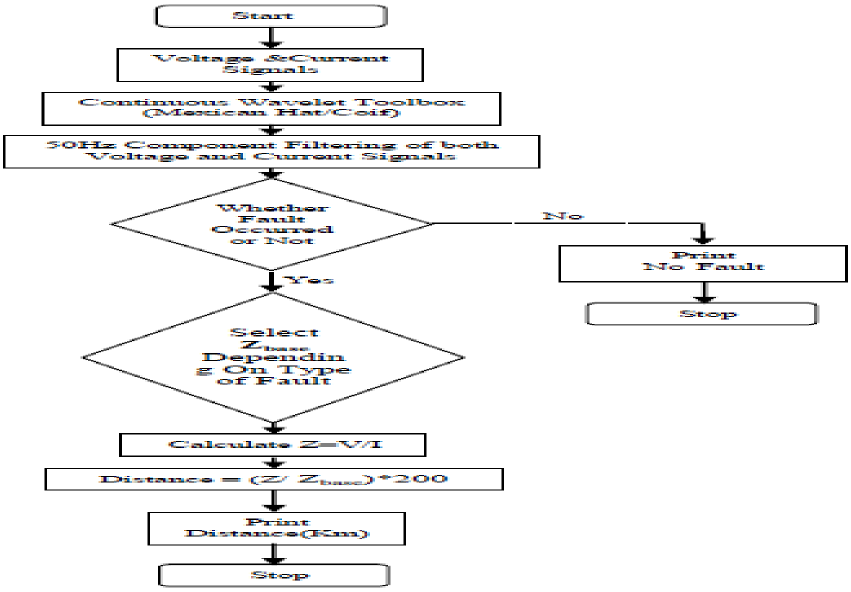

Fig .1 Overall flow chart of proposed system.

IV .SIMULATION OF THE PRAPOSED SYSTEM

For evaluating the performance of the proposed algorithm, the authors adopt MATLAB/ Simulink for fault data generation and algorithm implementation. Fig 1 depicts the Overall flow chart of proposed system, Fig. 2. Depicts the single-line diagram of the simulated system, which is a **400KV**, **50Hz, Transmission Line**

cable of Length of 200Km, PI section.

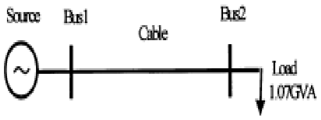

Fig.2 Single line diagram of the simulated system

B.STUDY CASES;

In this part**,** the authors select all the possible cases to illustrate the performance of the proposed fault indicator under internal fault events. L-G Fault, LL fault , LLG fault and LLG fault First, a phase-‚a‟ to ground fault is selected as a simulation case whose fault locations are tabulated along with the %error to compare the deviation from the calculated value using both mother wavelets Db Sampling Period = 0.000125,For scale a = 110.345 the output waveform will have a frequency of 50Hz.for the various faults simulation test have carried and their results are shown in figures below from fig 3.1 to 4.6and the resultant values of estimated given in figures from table 1 to table 4.

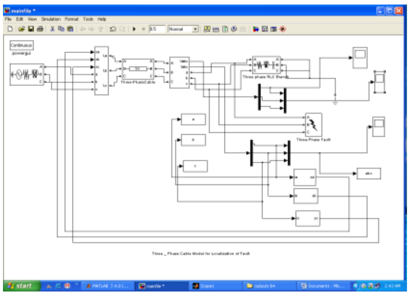

Fig.3 Matlab simulink model of the 200km Pi section UG cable

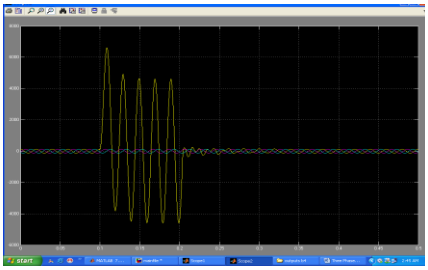

Fig 3.1 Fault current by LG fault

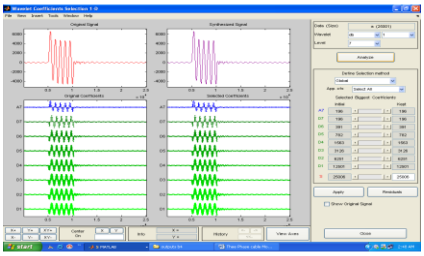

Fig 3.2Fault current by LG fault By Wavelet

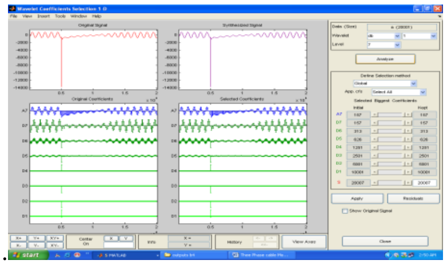

Fig 3.3 Fault current through Phase A(LG-Fault)

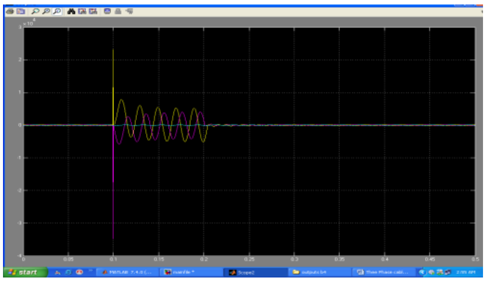

Fig 3.4Fault current by LLG Fault

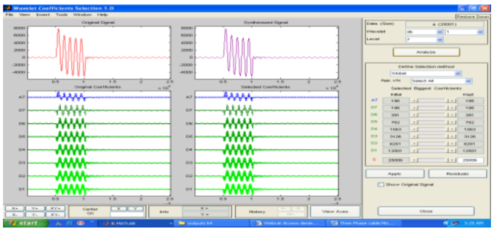

Fig 3.5 Fault current by LLG Fault By wavelet

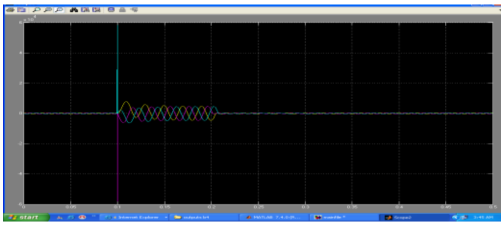

Fig 3.6 Fault current by LLLG

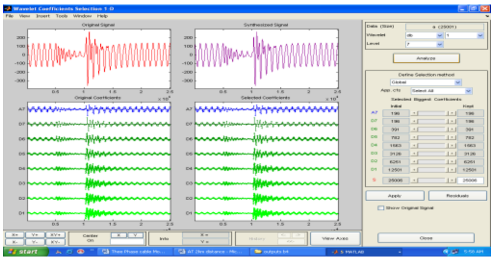

Fig 3.7 Fault current by LLLG by wavelet

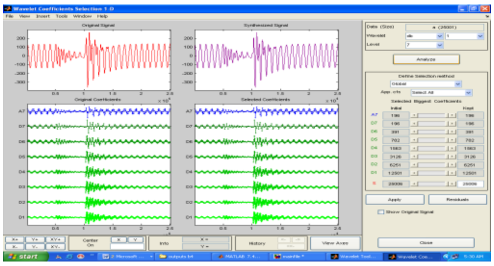

Fig 4.2 LG fault current by wavelet

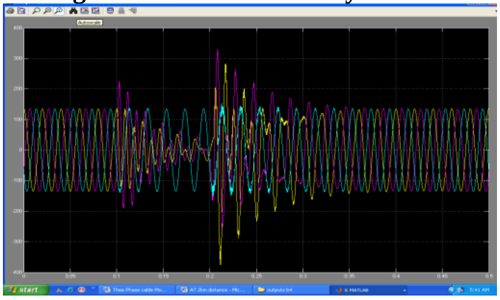

Fig 4.3Fault current for LLG fault

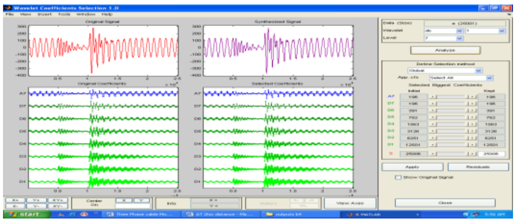

Fig 4.4 Fault current for LLG fault By wavelet

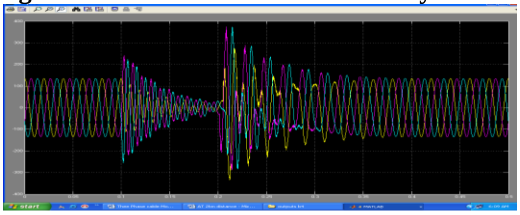

Fig 4.5 Fault current for three phase fault-(LLLG)

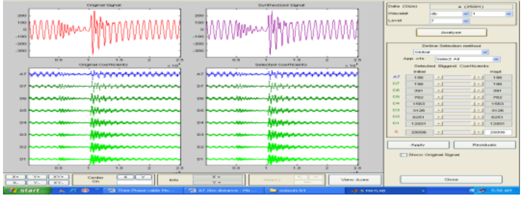

Fig 4.6Fault current for LLLG fault By wavelet

The fault analysis on a high voltage UG cable is carried by both simulink and wavelet technique at a distance of 2 km from the supply system and the results are shown in fig from 4.1 to 4.6.The simulation results are plotted with time Vs magnitude of fault current.

Lg Fault (Coif Let)		
Actual Distance (KM)	**Calculated Distance(KM)**	**%Error**
50	**51.38**	**2.76**
100	**104.11**	**4.11**
150	**158.83**	**5.88**
200	**214.30**	**7.15**

Table-1 LG fault

Actual Distance (KM)	**Calculated Distance(KM)**	**%Error**
50	**50.12**	**0.24**
100	**99.92**	**-0.08**
150	**149.24**	**-0.506**
200	**199.74**	**-0.13**

Table-2 LLG fault

Table-3

LL Fault (Coif Let)		
Actual Distance (KM)	**Calculated Distance(KM)**	**%Error**
50	**69.61**	**39.22**
100	**119.64**	**19.64**
150	**154.31**	**2.873**
200	**192.49**	**-3.755**

Table-3 LL fault

Actual Distance (KM)	**Calculated Distance(KM)**	**%Error**
50	**49.89**	**-4.22**
100	**96.04**	**-3.96**
150	**145.82**	**-2.786**
200	**196.21**	**-1.895**

Table-4 LLLG Fault

IV. CONCLUSION

In the present work , fault location is calculated and are shown in fig from 3.1 to 4.6 by using Continuous Wavelet Transform (CWT) using MATLAB simulation model. For all the faults under consideration with moving window algorithm, the error in the fault location is varied from - 10% to 13%. As the fault resistance in the fault increases the %error increases and the increase in %error is rapid at high fault resistances. As we are taking the impedance of the circuit during fault condition and healthy condition to calculate the distance where the fault has occurred, the %error in the distance measurement increases with the increase in fault resistance. If the fault resistance increases then resistance of the circuit under fault condition will be increased which may dominate the effect of reactance in that case and thus there may be some increase in %error. Tests including phase to ground faults and phase to phase faults and simulation results show that this CWT algorithm is identifying the fault from the instant at which faulted sample data enters the window and calculating the fault distance within half cycle after the fault inception. Identification of the frequency components in power system waveforms by using Mexican hat and Coif let as mother wavelet is also presented. The results of the present work will be useful in including innovative features in microprocessor based distance relays.

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