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Abstract- An appropriate method of fault detection and classification of power system transmission line using discrete wavelet transform is proposed in this paper. The detection is carried out by the analysis of the detail coefficients energy of phase currents. Discrete Wavelet Transform (DWT) analysis of the transient disturbance caused as a result of occurrence faults is performed. The work represented in this paper is focused on classification of simple power system faults using the maximum detail coefficient, energy of the signal and the ratio of energy change of each type of simple simulated fault are characteristic in nature and used for distinguishing fault types.

***Index Terms** – Transmission line faults, wavelets transform.*

I. INTRODUCTION

Electromagnetic transients in power systems are characterized by high frequency components during a short period of time, such as faults, are extremely important [1] .A fault occurs when two or more conductors come in contact with each other or ground in three Phase systems in transmission line faults are classified as Single line-to-ground faults, Line-to-line faults, Double line-to-ground faults, and Three phase faults. For it is at such times that the power system components are subjected to the greatest stresses from excessive currents.These faults give rise to hazardous damage on power system equipment and Fault which occurs on transmission lines not only effects the equipment but also the power quality. Hence, it is necessary to detect the fault and its type and location on the line and clear the fault as soon as possible in order not to cause such damages. Flashover, lightning strikes and birds. Natural phenomena of wind, snow and ice-load lead to short circuits. Deformation of insulator materials also leads to shunt faults. It is essential to detect the fault quickly and separate the faulty section of the transmission line as early as possible . Locating ground faults quickly is very important to economy and safety of power quality index. Wavelet theory is the mathematics which deals with building a model for processing of non-stationary signals, using a set of components that look like small waves, called wavelets of signal. It has become a well-known useful tool since its helpful, especially in signal processing [2].[3].

The DWT is easier to implement than Continuous Wavelet Transform CWT because CWT is computed by changing the scale of the analysis window and shifting the window in time or multiplying the signal and the information of interest is often a combination of features that are well localized temporally or spatially.This requires the use of analysis methods sufficiently in which it is versatile to handle signals in terms of their localization of time-frequency. . Frequency based analysis has been common since Fourier's time. However frequency analysis is not ideally suited for transient analysis. Fourier based analysis is based on the sine and cosine functions not to used for transients. These results in a very wide frequency spectrum in the analysis of transients Fourier techniques cannot simultaneously achieve good localization in both time and frequency resolution for a transient waves. [3].The main advantage of WT over Fourier Transform is that the size of analysis window varies in proportion to the frequency analysis at which WT can offer a better compromise in terms of localization. [6]

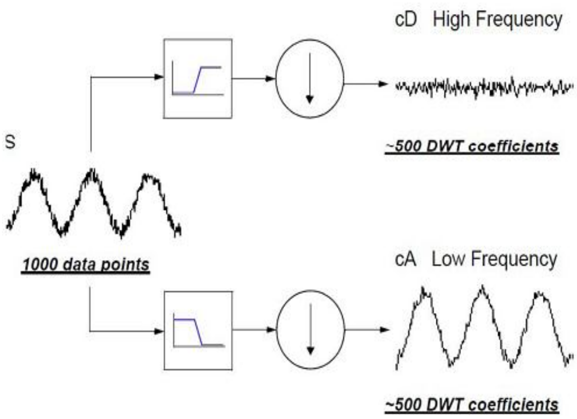

Fig. 1. Analyses of signal using wavelet transform

The wavelet transform decomposes transients into a series of wavelet components having 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 and classifying the sources of surges. Hence, the WT is feasible and practical for analyzing power system transients and disturbances[1-6].

The discrete wavelet transform (DWT) is normally implemented by Mallat's algorithm its formulation is related to Multiresolution analysis theory. Wavelet transform is largely due to this technique, which can be efficiently implemented by using only two filters, one high pass (HP) and one low pass (LP) at level (k) at which fundamental components generate. The results are down-sampled by a factor two and the same two filters are applied to the output ofthe low pass filter from the previous stage of the signal. The high pass filter is derived from the wavelet function (mother wavelet) and measures the details in a certain input having low pass filter on the other hand delivers a smoothed version of the input signal and is derived from a scaling function associated to the mother wavelet. The idea is illustrated in Figure.2. Which mathematically is expressed

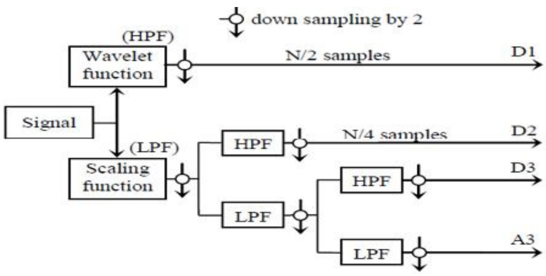

Fig.2.DWT multilevel decomposition

In this analysis, results are carried out by using the db4 as mother wavelet for signal analysis .The wavelet energy is the sum of square of detailed wavelet transform coefficients. The energy of wavelet coefficient is varying over different scales depending on the input signals which contain energy of signal is contained mostly in the approximation part and little in the detail part-as the approximation coefficient at the first level having much more energy than the other coefficients at the same level of the decomposition tree-but because the faulty signals have high frequency dc components and harmonics, it is more distinctive to use energy of detail coefficients. The basic algorithm for the DWT is not limited to dyadic length and is based on a simple scheme: down sampling and convolution . As usual, when a convolution is performed on finite-length signals of border distortions arise. In this work the extension of DWT is Daubechies ('db') this method assumes that signals can be recovered outside their original support by symmetric boundary value although Symmetrization has the disadvantage of artificially creating discontinuities of the first derivative at the border which is very small effect in calculation so the detail coefficients figured here show the signal end effects are present, but the discontinuities are very well cleared detected. The fundamental voltage and current phasors are estimated using Discrete Fourier Transform based algorithm which mitigates the effects of exponentially decaying DC offsets. The scheme is tested for different types of fault with varying fault incidence angles and fault resistances using typical transmission line model in Fig.1. The DFT have some disadvantages that overcome by using DWT.The system is modeled in MATLAB SimPowersystems environment.Results indicate that the proposed scheme is reliable,fast and highly accurate

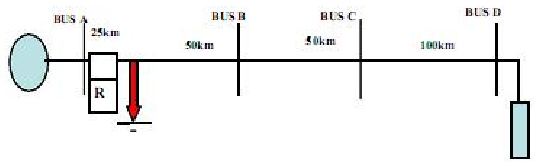

Figure 3: Single line diagram of simulated power network.

II. FAULT DETECTION BY USING ENERGY OF THE DETAIL COEFFICIENTS

When fault occurs within the power network, the transient voltage and current signal in the fault section contain predominant high frequency omponents.This is due to superimposed reflection of the fault signals the fault point The energy of these high frequency signals is used as indicator of the fault occurrence in circuit. The fault detection rules are established by means of the analysis of the current waveforms in time domain and in the first decomposition level of the DWT. This level contains highest frequency components.In order to compute the wavelet coefficients energy, a moving data window goes through the current wavelet coefficients shifts one coefficient at a time shown in given equation.

$$Ew = \sum_{k=1}^{Nw} [dw(k)]^2$$

Where dw(k) is the Kth wavelet coefficient within the wth window and Nw is the window length which computed as

$$Nw = Ns/2$$

Where Ns is the number of samples within one cycle of the fundamental frequency of 50 Hz

III. POWER SYSTEM SIMULATION MODEL

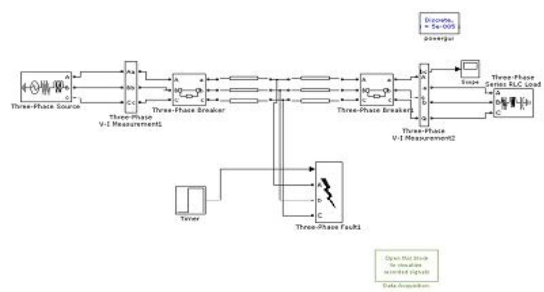

Figure 4: Typical transmission line model in MATLAB

The data of AC system is given below

Components	Parameters
Frequency	50 Hz
Source 1	6.6 kV
Transmission line parameter	R1=0.01273 Ohm/Km R0= 0.3864 Ohm/Km X0= 0.009337H/Km X1=0.0041264H/Km
Load	6.6 Kv PL=0.07 and QL=0.004
Line length	200 Km

Table.1.Transmission line parameters

The simulation time was at 50µs and resistance fault equal 1ohm in which three phase current signals at normal condition were recorded and decomposed using DWT (db4 level 1) to get there maximum details coefficient, energy of these signals and then making compression of these signals and take the ratio of energy change from the first level with keeping approximation with no change because fault inception have great effect on detail coefficient as it generate a high frequency component to signals. First Faults were created at a line for one cycle , analysis these signals before the realizing and switching off the circuit breaker. Different types of faults were simulated using MATLAB simulation [6] and after recorded transient signals they were decomposed using wavelet toolbox to get there maximum details coefficient, energy of these signals and then making compression to these signals to get the ratio of energy change from the first level and how faults make changes to the energy of these signals. Simulation was carried out for all different single phase to ground fault but only shown here is Phase-A to ground all different double Phase with or without ground are simulated and analyzed but only shown here are Phase-AB (double phase fault) and AB-G (double phase to ground fault) and three phase faults.[4]. Making compression of current signals using threshold energy ratio with the first energy level for all current signals with keeping approximation with no change to compute the threshold of energy ratio change, if any energy ratio exceed this ratio level this means that there is a faulty condition to that phase of line. In our work if the energy ratio was exceed 0.001 this phase is a faulty phase of transmission line. Secondly to decide if this double phase or double phase to ground fault it was very cleared that if the fault is double phase the energy ratio will be the same for these two faulty phases with comparison with the energy ratio of double faulty phases when there is double phase to ground fault these ratio were not same, were some different. These results will be very cleared in next figures and tables of paper.

IV. SIMULATION RESULTS OF FAULTS CASES

A. Normal condition

Three phase current signals (A blue, B green and C red colures) at no fault condition and there detail coefficient are shown in figure .5. which indicate that when there are no fault the detail coefficient of these signals are near to reach zero(straight line) and only appear the ending effect of daubechies wavelet which also very small and near zero (1*10-3) and the energy of each signals are present and the rate of energy change after signals compression are very small near 0.001 shown in Table.2.

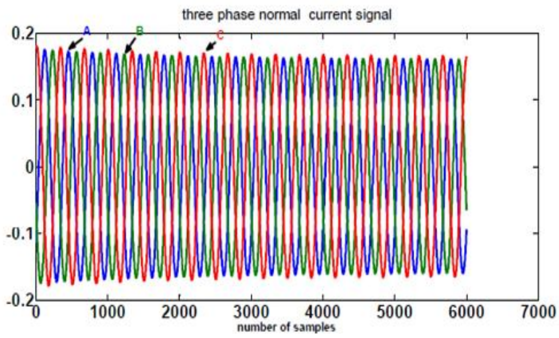

Fig.5.Three phase current signals at normal condition

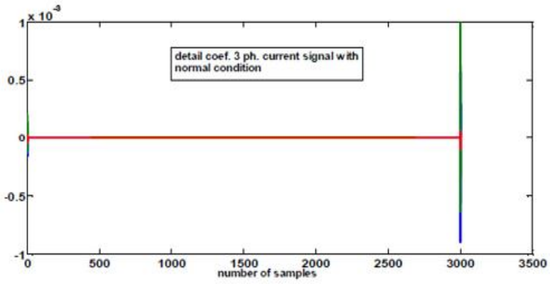

Fig.6.Detail coefficient at normal condition

	Condition	Normal
A	Max.D	0.180
	Energy	82.40
	E.ratio	0.001
B	Max.D	0.174
	Energy	81.45
	E.ratio	0.001
C	Max.D	0.178
	Energy	86.80
	E.ratio	0.001

Table.2.Maximum detail coefficient ,energy and energy ratio chang of three phases at normal condition.

B. Single phase to ground fault

Three phase current signals with phase A to ground fault are shown in figure .7. The arrow pointed very clear when the fault inception began (around sample 1800 which is half number of samples from its original signal fault inception time) although two other phases had no change or less change with comparison with this great amount of change at that A phase. This also described by the data included in Table 3 as the faulty phase was the highest in detail coefficient (greater than 0.001) energy and the change of energy ratio (higher than normal condition) so it was much cleared to detect the faulty phase of transmission line.

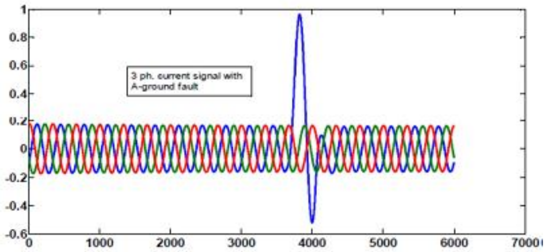

Fig.7.Three phase current signals at Single phase to ground Fault

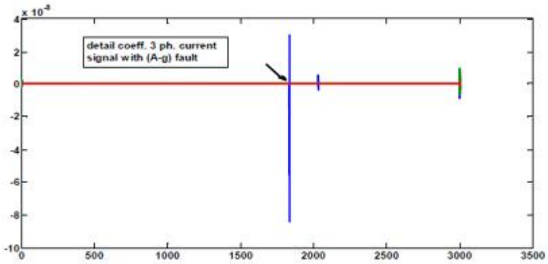

Fig.8. Detail coefficient at Single phase to ground fault

Fault Type		A	B	C
A-g	Max.D	**0.996**	0.174	0.178
	Energy	**195.5**	81.52	84.16
	E.ratio	**0.008**	0.001	0.00
B-g	Max.D	0.175	**0.56**	0.178
	Energy	81.51	**176.8**	84.16
	E.ratio	0.001	**0.002**	0.00
C-g	Max.D	0.001	0.001	**0.029**
	Energy	81.51	81.52	**173.6**
	E.ratio	0.001	0.001	**0.029**

Table.3.Maximum detail coefficient, energy and energy ratio change of three phases at Single phase to ground fault .

C. Double phase to ground fault

Three phase current signals with phases A-B to ground fault were shown in figure 9 only two faulty phases at the fault inception time catch a great amount of change and high level of detail coefficient although the healthy phase had nearly zero change . This also described by the data included in Table 4 as the healthy phase was nearly no change and nearby normal condition in detail coefficient, energy and the change of energy ratio although faulty phases were so different and the maximum detail coefficient of these faulty phases were greater than 0.001 this means that these phases were in fault condition and when making compression the amount of energy change for two faulty phase were different not in same amount this will indicate that these faulty phases were connected to the ground of transmission line.

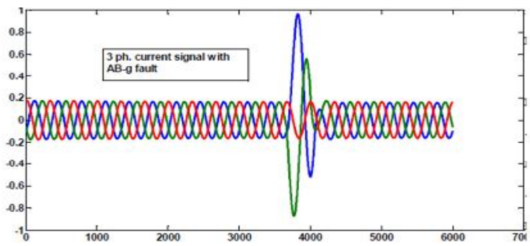

Fig.8.Three phase current signals at Single phase to ground Fault

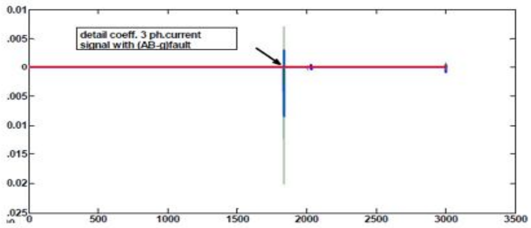

Fig.9. Detail coefficient at Double phase to ground fault

Faut Type	Condition	A	B	C
AB-g	Max.D	0.966	0.56	0.178
	Energy	195.5	176.8	84.16
	E.ratio	**0.008**	**0.02**	0.00
BC-g	Max.D	0.175	0.561	0.599
	Energy	81.51	176.9	173.6
	E.ratio	0.001	**0.02**	**0.029**
CA-g	Max.D	0.966	0.174	0.599
	Energy	195.5	81.52	173.7
	E.ratio	**0.008**	0.001	**0.029**

Table.4.Maximum detail coefficient, energy and energy ratio change of three phases at Single phase to ground fault

D. Double phase fault

Three phase current signals with phases A-B fault were shown in figure 10 only two faulty phases at fault time catch a great amount of change although the healthy phase had nearly no change. This also described by the data included in table 4 as the healthy phase was nearly no change and nearby normal condition in detail coefficient, energy and the change of energy ratio although faulty phases were so different than normal condition and the maximum detail coefficient of these faulty phases were greater than 0.001 this means that these phases were in fault condition and when making compression the amount of energy change ratio of two faulty phases were typically same or in neglected difference amount this will indicate that these faulty phases were not connected to the ground of transmission line.

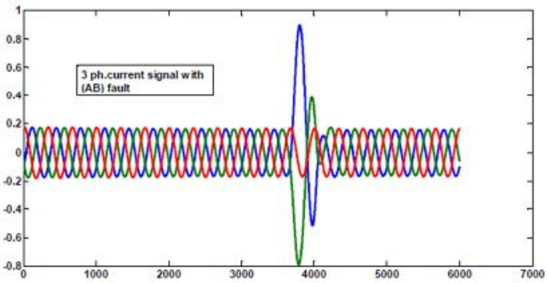

Fig.10.Three phase current signals at Double phase fault

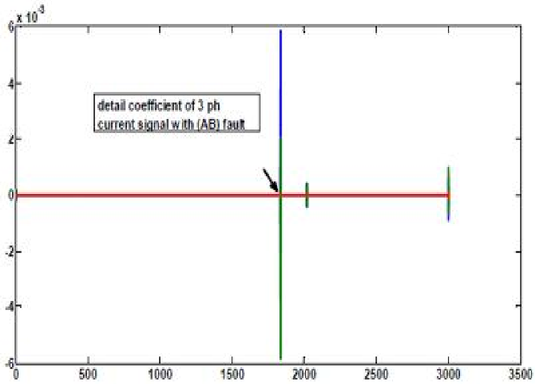

Fig.11. Detail coefficient at Double phase to ground fault

Fault Type	Condition	A	B	C
AB	Max.D	0.006	0.006	0.00
	Energy	180.2	155.4	87.06
	E.ratio	**0.006**	**0.006**	0.00
BC	Max.D	0.001	0.009	0.25
	Energy	81.65	176.1	146.4
	E.ratio	0.001	**0.0024**	**0.025**
CA	Max.D	0.712	0.174	0.549
	Energy	142	81.44	174.7
	E.ratio	**0.018**	0.001	**0.019**

Table.4.Maximum detail coefficient, energy and energy ratio change of three phases at Double phase to ground fault

E. Three phase fault

Three phase current signals with three phase fault were shown in figure 12 shown that at fault inception time there were great change to all phases energy , energy ratio and all maximum detail coefficient of these faulty phases were higher than 0.001 and the energy of each signals were presented in table 5 which were higher than normal condition.

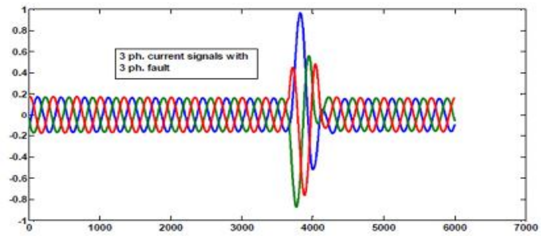

Fig.12.Three phase current signals at Three phase fault

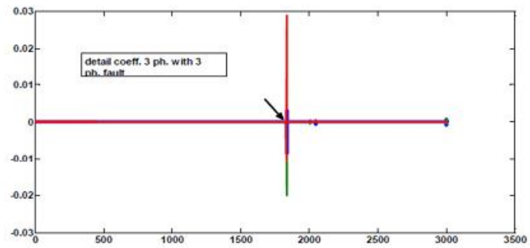

Fig.13. Detail coefficient at Three phase fault

Fault Type	Condition	A	B	C
ABC	Max.D	0.008	0.56	0.484
	Energy	200	176.8	163.9
	E.ratio	0.008	0.02	0.029

Table.5.Maximum detail coefficient ,energy and energy ratio change of three phases at three phase fault

V. CONCLUSION

The application of wavelet transform to detect and identify the type of fault was achieved a very good and accurate classification for the change in the signal shape due to fault phenomena. The ability of wavelets to decompose the signal into frequency bands in both time and frequency resolution allows accurate fault identification. This paper presents a data reduction technique for estimation of fault classification on transmission lines rapidly and accurately as the data collected from the first level so no needed for more filters to used and fast detecting time of fault occurrence in the power system. In this work, the proposed method used wavelet decomposition which provides more features about the signals. After wavelet decomposition with first level maximum detail of wavelet coefficients were calculated for each current signals waveform with or without fault condition and with making looking to data after fault inception and take like a threshold condition of that maximum detail coefficient as if it is increased than 0.001 this means faulty condition and to know whether there was a phase to phase fault or double phase to ground fault using compression of these signals with the ratio of the amount of energy change at first level and keeping the approximation with no change as two faulty phases energy ratio will be similar and equal if there was phase to phase fault and this energy ratio will be with different value if the fault was double phase with ground in the circuit. In further work, the technique which has the best performance will be used for a more complicated power system and using the logic method to take these results as a preprocessing in operation for fault fast detection and accuracy of classification.

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