High-Impedance Fault Detection Using Wavelet Transform

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Abstract— This paper presents a wavelet transform based technique for the detection of High impedance Faults in the distribution feeders. In this study electrical models for a high impedance fault on a power system networks are developed and simulated using Mi-power. The analysis of resulted current signals, using Discrete Wavelet Transform (DWT) is done proving better performance than conventional relays for the detection of high impedance fault.

Keywords— High Impedance Faults, Wavelet Transform, Multi-resolution analysis, detail coefficient, daubachies wavelets, Mi-power software, wavelet toolbox.

INTRODUCTION

Detection of High impedance Faults present still important and unsolved protection problem. HIFs on distribution feeders are abnormal electrical conditions that cannot be detected by conventional relays such as over current relays, impedance relays etc. because of low fault current due to the high impedance fault at the point of fault. These faults often occur when an overhead conductor breaks or touches a high impedance surface such as asphalt road, sand, cement or trees and pose a threat on human lives when neighboring objects come in contact with bare and energized conductors.

HIF can occur in two cases. In case one , a conductor breaks and fall to ground and fallen phase current decreases and protection relays cannot detect fault because because current is not more than setting current of relays. In other case conductor is not break but it touches a high impedance material such as tree branches. In this case feeder current increases but it is not enough to detect by conventional protection relays. Therefore this type of fault is very difficult to detect[1].

The wavelet transform technique recently proposed as a new tool for monitoring and protection of power system[2-6] has received considerable interest in field of power system signal processing[7-8]. The WT 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 currents for the various impedances during fault are used as the medium for fault detection. A three phase to ground fault is considered. A Mi-power software is used to generate the three phase to ground fault current data for the various impedances. A wavelet analysis using daubechies wavelet is than applied to currents. The coefficients of the detailed scales are examined to determine the high impedance fault.

This paper is organized as fallows. Section 2 presents wavelet transform and multi resolution analysis. Section 3 deals with modeling of HIF in Mi-power used for generation of fault currents for various impedances. The implementation of wavelet analysis on the signals generated from the simulations is carried out. Section 4 conclusion is made.

WAVELET TRANSFORM AND MULTI RESOLUTION ANALYSIS

The wavelet transform is a recently developed mathematical tool that provides a non- uniform division of data or signal, into different frequency components, and then studies each component with a resolution matched to its scale [9-10]. It is often used in the analysis of transient signals because of its ability to extract both time and frequency information simultaneously, from such signals. The comparison of the WT with the Fourier transforms (FT) and why it is preferred to the FT has been documented in [11].

Multi-resolution Analysis (MRA) is an alternative approach used to analyze signals to overcome the time and frequency resolution problems, since these problems persist regardless of the transform employed. MRA analyses the signal at different frequencies with different resolutions. It does not resolve every spectral component of the signal equally. It is designed to produce good time resolution and poor frequency resolution at high frequencies and vice versa. The rationale behind this is that the signals that are encountered in practical applications have high frequency components for short durations and low frequency components for long durations.

In DWT, a time scale representation of a digital signal is obtained using digital filtering techniques, developed by [12]. DWT uses filters of different cut-off frequencies to analyze the signal at different scales. The signal is passed through a series of high pass filters to analyze the high frequencies, and it is equally passed through a series of low pass filters to examine the low frequencies. Filtering a signal is synonymous with the mathematical operation of convolution of the signal with the impulse of the filter as presented in equation (1).

$$x[n] * h[n] = \sum_{k=-\infty}^{\infty} x[k] * h[n-k] \qquad (1)$$

where x[n] is a discrete time function, n is an integer and h[n] is the low pass filter impulse. Really the most important part of many signals is the low frequency content. It is what gives the its identity. The high frequency content, on the other hand, only impacts flavor. This is what brings into wavelet analysis, ***approximations*** and ***details***. *Approximations* are the high-scale, low frequency components of the signal, while *details* are the low-scale, high frequency components. Approximations (also known as **the scaling coefficients**) are computed by taking the inner products of the function f(t), the signal, with the scaling basis φj,k, achieved with equation (2).

$$A_{j,k} = < f(t), \emptyset_{j,k}(t) > = \int_{\infty}^{\infty} f(t). \emptyset_{j,k}(t) dt \qquad (2)$$

$$D_{j,k} = < f(t), \psi_{j,k}(t) > = \int_{-\infty}^{\infty} f(t). \psi_{j,k}(t) dt \qquad (3)$$

This is obtained by passing the original signal through a low pass filter while *details* (also known as **the wavelet coefficients**) are obtained by passing the signal through a high pass filter. This operation is computed mathematically by taking the inner products of the function f(t) with the wavelet basis as in equation (3).

Where the scale function φj,k(t) and the wavelet function ψj,k(t) are determined by the particular
mother wavelet ψa,b selected [3]. Unfortunately, performing the above operation on a real digital signal leads to twice the data one started with. Correcting this problem created by the filtering operations, the original signal must be **down sampled**. *Down sampling* a signal is synonymous with reducing the sampling rate, or removing some of the samples of the signal.

As mentioned earlier, the DWT analyses signals at different frequency bands with different resolutions by decomposing the signal into coarse approximation and detail information. DWT uses *scaling functions* and *wavelet functions* in achieving this. These two sets of functions are associated with low pass and high pass filters, respectively. The original signal x[n] is first passed through a half band high pass filter g[n] and a low pass filter h[n]. As said previously, after the filtering exercise, half of the samples would be eliminated. The signal can therefore be sub sampled by two. This constitutes one level of decomposition and can be expressed, mathematically as follows

$$D_j[n] = \sum_k x[n] * g[2n-k] \qquad (4)$$

$$A_j[n] = \sum_k x[n] * h[2n-k] \qquad (5)$$

where Dj is the output from the high-pass filter called Detail and Aj is the output from the low-pass filter called Approximation, at resolution j, j=1, 2, …, J; k=1, 2, …, K, where K is the length of the filter vector, after down sampling by two. The signal decomposition process can be done iteratively with successive approximations being decomposed in turn, so that one signal is broken down into many lower-resolution components. Fig. 1 [11] illustrates a multiple level decomposition procedure for a signal x[n].

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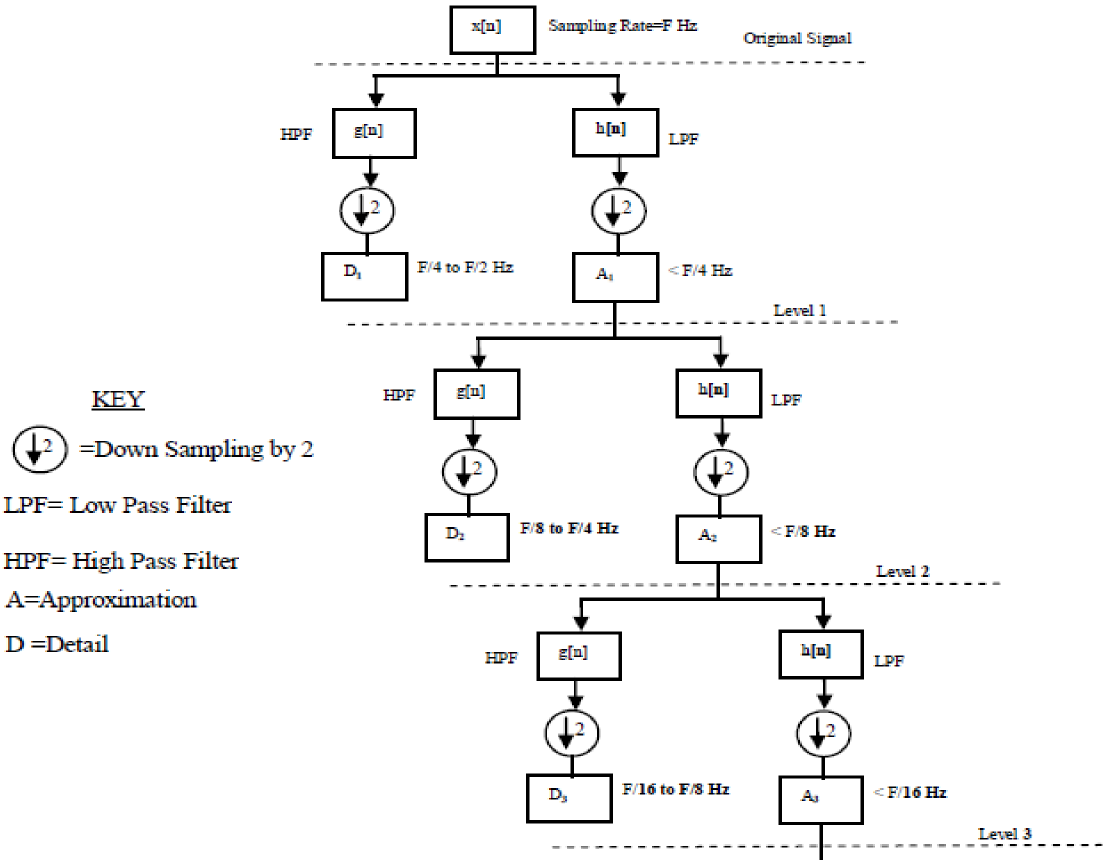

Fig1. Schematic Diagram of Multi-resolution Analysis of DWT Decomposition

SYSTEM MODEL

A sample ten bus system considered for the study. The system consists of three generators, seven lines, three transformers and three loads. System data is on 100MVA base and 60 Hz . this is Simulated for various impedances for the detection of HIFs. A model is developed using Mi-power software for the analysis.

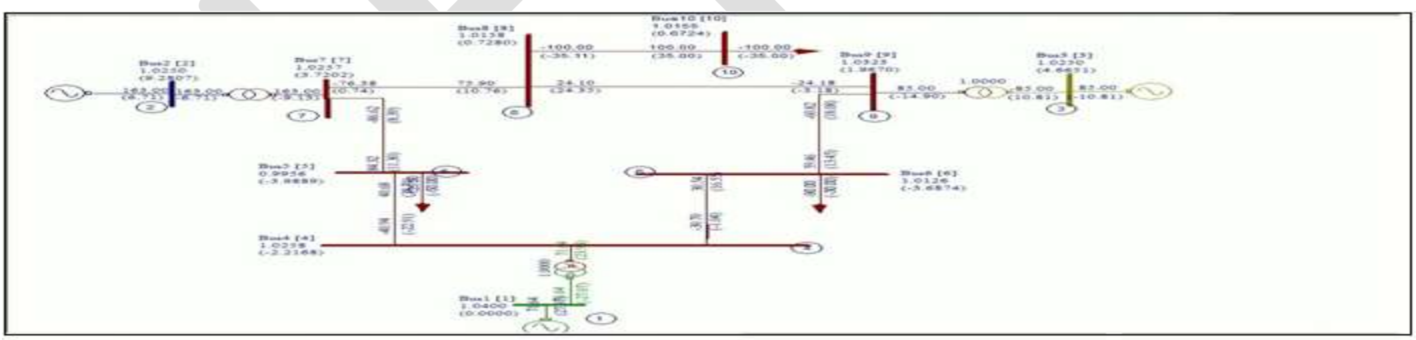

Fig2: HIF model of ten bus system developed using Mi-power software

Case(i): Normal operating condition

Fig 3(a): Current waveform during normal operating condition

Fig 3(b): Current waveform during normal operating condition using Wavelet transform

In case (i) it can be observed that, during normal operating condition there is no change in load current, hence when analyzed with wavelet transform, there no variation of current.

Normal operating current= 3497.35A

Case (ii): Fault with Z=0 Ohm

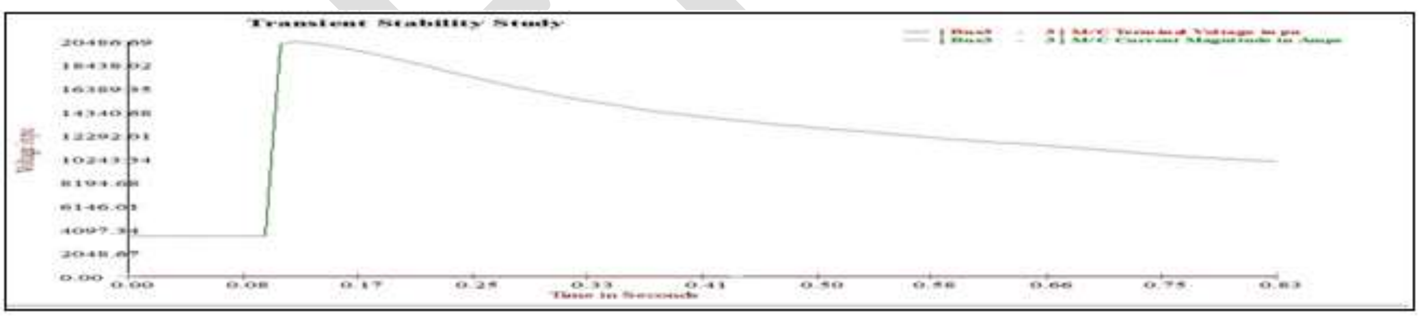

Fig 4: Current and voltage waveforms (Z=0 ohm)

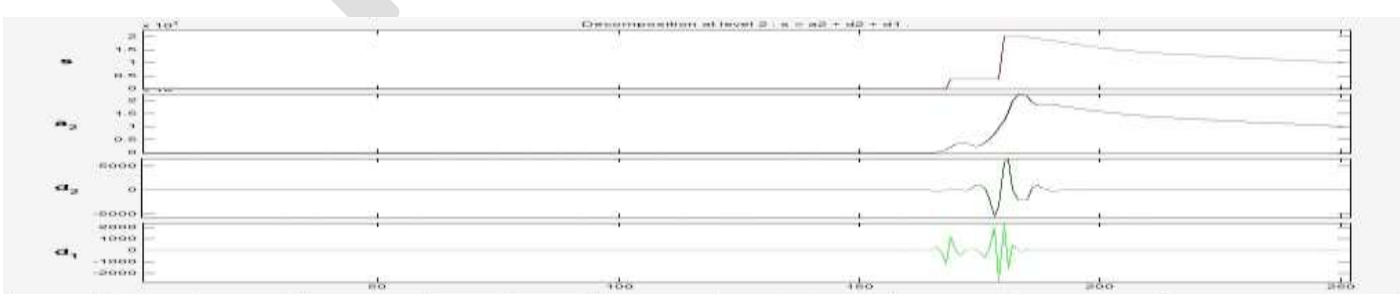

Fig 5: Fault current waveform with Z=0 ohm

Case (iii): Fault with Z=10 Ohm

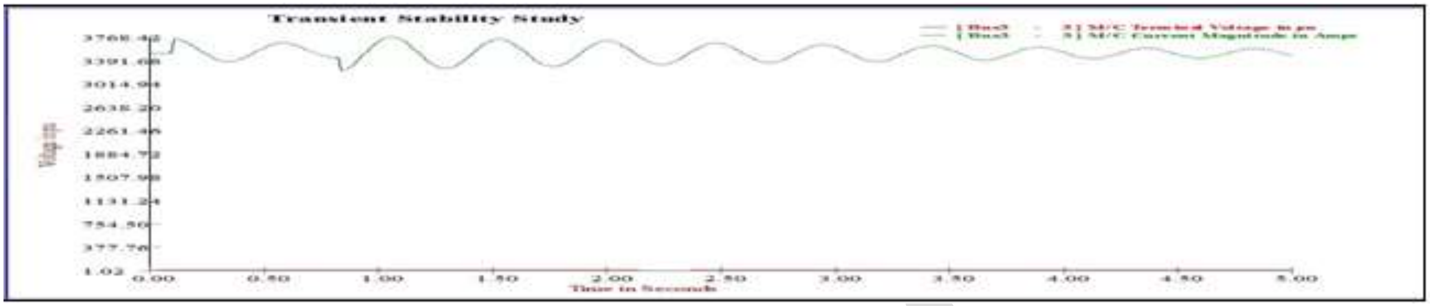

Fig 6: Current waveform with Z=10 ohm

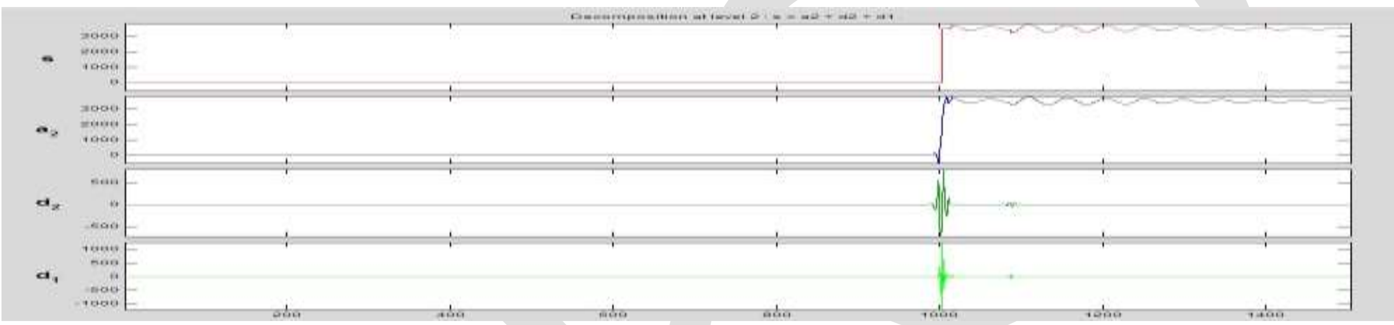

Fig 7 : Current waveform with Z=10 ohm using Wavelet transform

Case(iv). Fault with Z=100 ohm

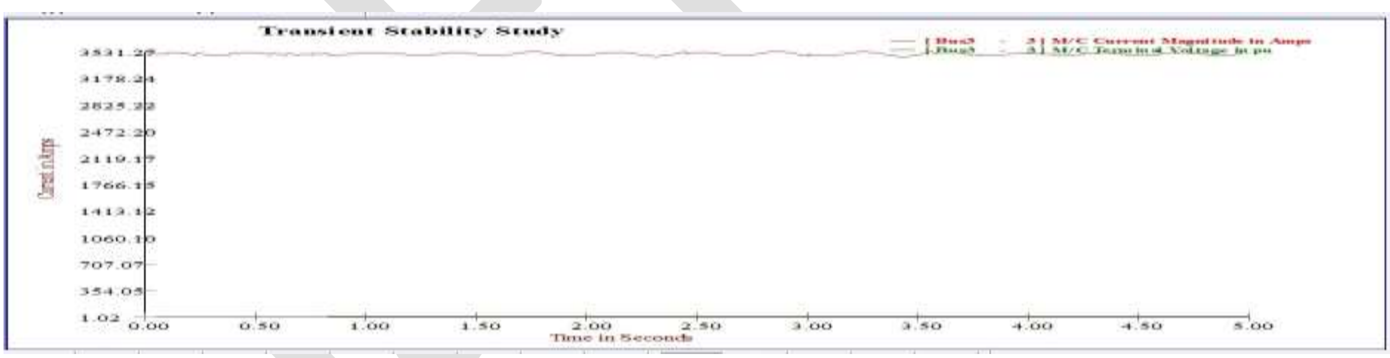

Fig 8: Current waveform with Z=100 ohm

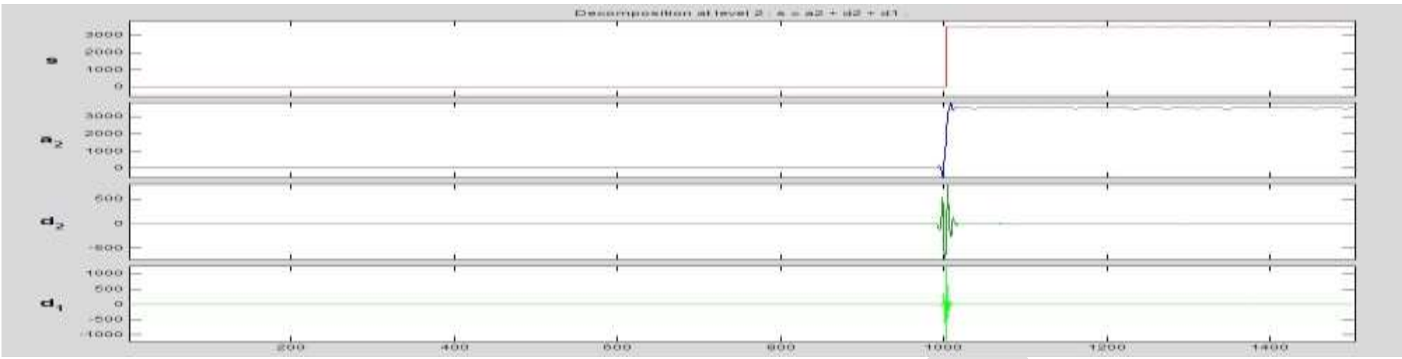

Fig 9: Current waveform with Z=100 ohm with using Wavelet transform

Case(v). Fault with Z=1k Ohm

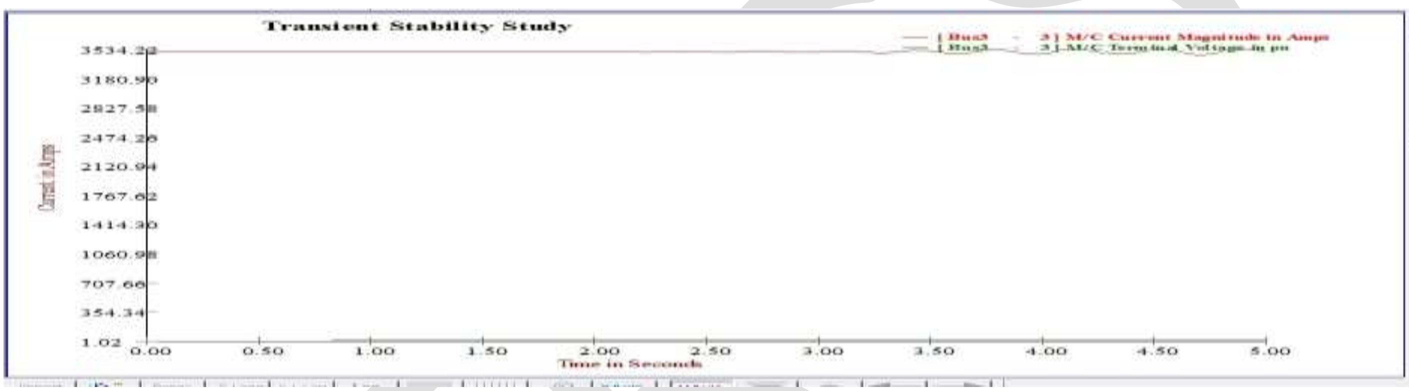

Fig 10: Current waveform with Z=1k ohm

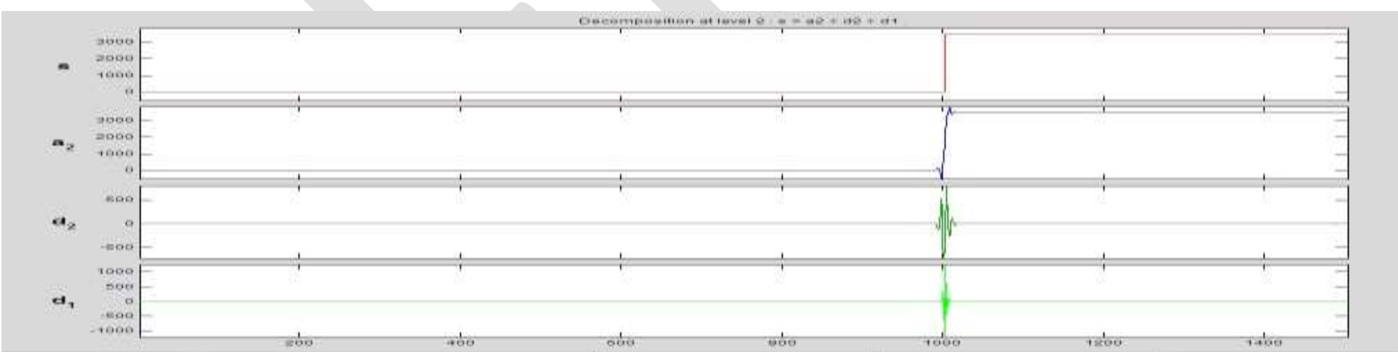

Fig11: Current waveform with Z=1k ohm with using Wavelet transform

When energized conductor breaks or comes in contact with the non-conducting foreign object High impedance fault occurs. Because of this high impedance during fault, fault current is very low which cannot be easily detected by conventional relays. Hence a wavelet transform is used for detection of high impedance fault. Discrete 1D-Wavelet with two-stage decomposition of the signals obtained, using db4 wavelet level 2 detail and approximation coefficients are plotted. From waveforms obtained from wavelet transform, small variations in the current can be easily detected.

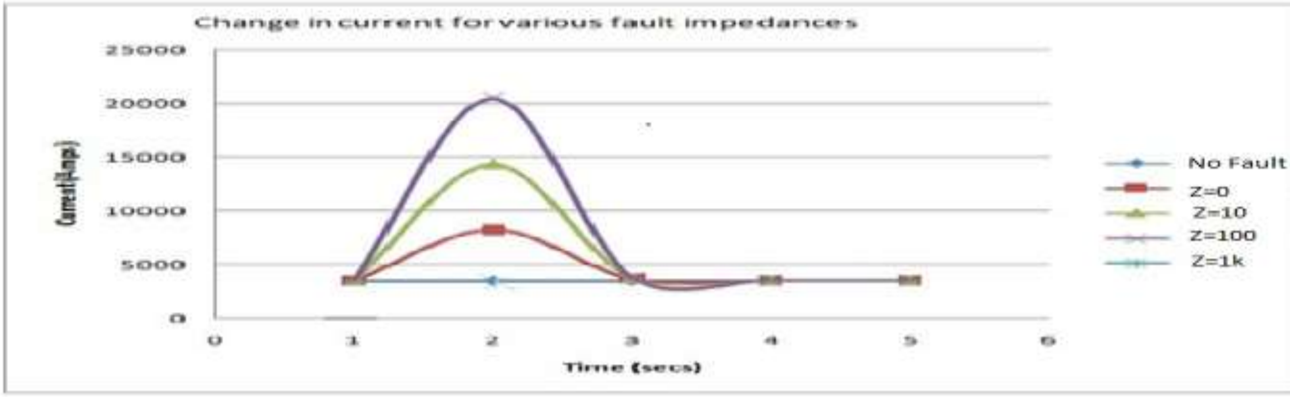

Fig 12: Current waveforms for the faults of various impedances

In case (iv) and (v) fault is created for high impedance values (100 and 1k ohms) this high impedance resist the increase in load current during fault hence it become difficult for the over current relays and other conventional relays to detect the presence of fault. Current signals obtained from these simulations are analyzed using wavelet transform which are very useful n detection of these high impedance faults.

The waveforms of voltage and current generated in the simulations carried out in and are transferred to discrete wavelet transform toolbox of MATLAB to analyze the frequency characteristics of the signals. Performing two-stage decomposition on these signals, using db4 wavelet, yields level 2 detail and approximation coefficients plotted.

Normal operating current= 3497.35 A		
Fault Impedance	Increase in current	
	From	To
Z=0 ohm	3497.35A	20486.69A
Z=10 ohm	3497.35A	3768.42A
Z=100 ohm	3497.35A	3541.12A
Z=1k ohm	3497.35A	3534.20A

Table 1. Increase in load current during fault for various impedances

CONCLUSION

This paper presented a wavelet transform based technique for the detection of high impedance faults in power system network. In this paper a 10 bus system is developed using Mi-power and faults are created for various impedances. Current waveforms are obtained as output of computer simulation. The discrete wavelet transform is used for the analysis of these obtained current waveforms which helps in detection of high impedance faults.

REFERENCES:

[1] "High impedance fault detection of distribution network by phasor measurement units" Vol.4, No.3(2013).

[2] Y. Sheng and S. M. Rovnyak, "Decision Tree-Based Me- thodology for High Impedance Fault Detection," *IEEE Transactions on Power Delivery*, Vol.19, No. 2, 2004, pp. 533-536.

[3] Cui, X. Z. Dong, Z. Q. Bo and S. Richards, "Integrated Scheme for High Impedance Fault Detection in MV Dis- tribution System," *Latin America IEEE/PES Transmis- sion and Distribution Conference and Exposition*, Bogota, 13-15 August 2008, pp. 1-6.

[4] A. R. Sedighi and M. R. Haghifam, "Simulation of High Impedance Ground Fault In Electrical Power Distribution Systems," *International Conference on Power System Technology*, Hangzhou, 24-28 October 2010, pp. 1427- 1435.

[5] C. L. Huang, H. Y. Chu and M. T. Chen, "Algorithm Comparison for High-Impedance Fault Detection Based on Staged Fault Test," *IEEE Transaction on Power De- livery*, Vol. 3, No. 4, 1988, pp. 1427-1435.

[6] H. Calhoun, M. T. Bishop, C. H. Eiceler and R. E. Lee, "Development and Testing of an Electro-Mechanical Re- lay to Detect Fallen Distribution Conductors," *IEEE Tran- saction on Power Apparatus and Systems*, Vol. PAS-101, No. 6, 1982, pp. 1643-1650.

[7] Scheme for High Impedance Faults in Distribution and Utilization Networks," *Proceedings of Canadian Confer- ance on Electrical and Computer Engineering*, Halifax, 7-10 March 2000, pp. 740-744.

[8] A. Lazkano, J. Ruiz, L. A. Leturiondo and E. Aramendi, "High Impedance Arcing Fault Detector for Three-Wire Power Distribution Networks," 10*th Mediterranean Elec-trotechnical Conference*, Lemesos, 29-31 May 2000, pp. 899-902.

[9] "Wavelet Transform Based Algorithm for High- Impedance Faults Detection in Distribution Feeders". European Journal of Scientific Research ISSN 1450-216X Vol.41 No.2 (2010), pp.238-248 © EuroJournals Publishing, Inc. 2010.

[10] Huang, S. and C. Hsieh, 1999. "High-impedance Fault Detection Utilizing A Morlet Wavelet Transform Approach," *IEEE Transactions on Power Delivery*, vol. 14, no. 4, pp. 1401-1410.

[11] Polikar, R. "The Wavelet Tutorial," 1994. Retrieved on April 14, 2008 from http://engineering.rowan.edu/~polikar/WAVELETS/Wttutorial.html

[12] Wavelet. Wikipedia, 2004. Retrieved on April 14, 2009 from http://en.wikipedia.org/wiki/wavelet