Global Journal of Multidisciplinary Studies Available online at www.gjms.co.in
Volume 3, Issue 3, Feb 2014
ISSN: - 2348-0459

IDENTIFICATION OF FAULT LOCATION ON TRANSMISSION LINES USING WAVELET THRESHOLD

Aparna Soni

Dept. of Electrical Engineering ,Jabalpur Engineering College

Jabalpur, (M.P) India

ABSTRACT

Power system fault location and identification of the different faults on a transmission lines for quick & reliable operation of protection scheme. Fault location estimation is very important issue in power system in order to clear faults quickly & restore power supply but the location of fault can be analyzed only with wavelet transform. Wavelet transform, which is very fast and sensitive to noise, is used to extract transients in the line currents for fault detection. The de-noising process rejects noise by thresholding in the wavelet domain and also improves the quality of the signal. Three wavelet functions ("*db", "coif"* and "*sym"*) and three different thresholding methods are “Rigsure”, “Sqtwolog” and “Minimax” used to de-noise the noise signal. Thresholding rule for three different performance measures were considered to select the appropriate wavelet function to efficient noise removal methods such as, signal-to-noise ratio (SNR), mean square error (MSE), and smoothing ratio, it can be a good way to evaluate the equality of wavelet threshold de-noising. The results show that the wavelet transform can achieve excellent results in signal de-noising; de-noised signal using soft-threshold method is smoother and Soft-threshold method is more suitable.

At the end, I used the classification of wavelet threshold analysis for signal decomposition to monitor some of the faults (e.g. L-G Fault, LL-G Fault, and LLL-G Fault,) in the transmission system. MATLAB simulation results are presented showing the selection of proper threshold value for fault detection also applied the wavelet Toolbox for use with MATLAB for find out the location of the fault.

Keyword: Wavelet transform, discrete wavelet transform, signal de-noising, transmission line faults

Introduction

An electric power system comprise of generation, transmission and distribution of electric energy. Transmission lines are used to transmit electric power to distant large load centers. The rapid growth of electric power system over the past few decades has resulted in a large increase of the numbers of lines in operation and their total length. These lines are exposed to faults as a result of lightning, short circuits, faulty equipments, human errors, overload, and aging. When a fault occurs on a transmission line, the voltage at the point of fault suddenly reduces to a low value and current suddenly increases [1]. A fault occurs when two or more conductors come in contact with each other or ground in three phase systems, faults are classified as Single line-to-ground faults, Line-to-line faults, double line-to-ground faults, and three phase faults. Wavelet thresholding based de-noising technique is used for eliminating the noise present in the signal. The objective of wavelet based de-noising process is to estimate the signal of interest from the composite signal by discarding the corrupted noise. The transient components that vary rapidly are treated as noise. Also proper selection of mother wavelet and the level of decomposition are necessary for effective recognition of disturbance signals in power system [8, 9]. In this paper, I compare the use of various types of wavelet de-noising technique at different scales and level of decomposition on analyzing wavelet transform we explore wavelet de-noising of signal using several thresholding techniques such as “Rigrsure”, “Heursure”, “Sqtwolog” and “Minimax” and determine the best one for signal de-noising. Wavelet de-noising attempts to remove the noise present in the signal while preserving the signal characteristics, regardless of its frequency content wavelet de-noising must not be confused with smoothing; smoothing only removes the high frequencies and retains the lower ones. The Wavelet analysis is one of the methods used for providing discriminative features with small dimensions to classify different disturbance in transmission system [2]. Hence the identification and controlling of these faults is essential and control system plays a prominent role in the overall performance of the transmission system. The classification of wavelet de-noising analysis for signal decomposition to monitor some of the faults (e.g. L-G Fault, LL-G Fault, and LLL-G Fault) in the transmission system. The traditional way of signal de-noising is filtering. Recently, a lot of research about non-linear methods of signal de-noising has been developed. These methods are mainly based on thresholding the Discrete Wavelet Transform (DWT) coefficients, which have been affected by additive white

Gaussian noise. Simple de-noising algorithms that use DWT consist of three steps.

- Discrete wavelet transform is adopted to decompose the noisy signal and get the wavelet coefficients.
- These wavelet coefficients are de-noised with wavelet threshold.
- Inverse transform is applied to the modified coefficients and get de-noised signal.

Thresholding is a simple non-linear technique, which operates on one wavelet coefficient at a time. In its most basic form, each coefficient is threshold by comparing, if the coefficient is smaller than threshold, set to zero; otherwise it kept as it is or it is modified.

MATLAB-SIMULINK is used to generate the line to line voltage data for the various faulted conditions. 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. Numerical findings are presented in the form of graphs and tables. Thresholding generally gives a low pass and “smoother” version of the original noisy signal. In this work, the DWT based de-noising was performed to remove the three different noises from signal. Three different wavelet functions and three thresholding rules were considered to analyze the efficiency on noise removal from faulty signals. The quality of wavelet de-noising is evaluated using the indicators RMSE, SNR and smoothness. The MATLAB simulation results confirm that wavelet threshold method is effective and enjoys some advantages in removing noises.

2. Wavelet Transform

Wavelet transform is an analytical method which units the time domain and frequency domain. In recent years, wavelet transform (WT) has emerged as a powerful signal analysis tool, and is being used successfully in many areas including image compression, biomedical applications, speech processing, acoustics and numerical analysis[12,13,14]. The wavelet transform is change width of the window, which is the most important characteristic of the wavelet transform [7]. When the DWT applied in signal de-noising, implementation involves the following three processing phases:

1) Decomposition-

Select a suitable base wavelet and a decomposition level to generate the approximation and detail coefficients of a noisy signal at the chosen level.

2) Thresholding-

For each level, to generate a threshold and apply it through hard /soft thresholding to the detail coefficients

3) Reconstruction-

Compute for reconstructions using the modified coefficients of various levels.

There are two functions scaling function and mother wavelet (a signal with tiny oscillations) [10].The mother wavelet DWT is expressed by:

(a)

$$\int_{-\infty}^{\infty} \psi(t)\, dt = 0 \qquad ...1$$

The Continuous Wavelet Transform (CWT) given by

(b)

$$CWT(a,b) = \frac{1}{\sqrt{a}} \int_{-\infty}^{\infty} f(t)\overline{\Psi}\left(\frac{t-b}{a}\right) dt \qquad ...2$$

Where a, b are the scale and position parameters.

2.1 Wavelet Filter

The time-frequency representation of DWT is performed by repeated filtering of the input signal with a pair of filters namely, low pass filter (LPF) and high pass filter (HPF), and its cutoff frequency is the middle of input signal frequency. The coefficient corresponding to the low pass filter is called as Approximation Coefficients (CA) and similarly, high pass filtered coefficients are called as Detailed Coefficients (CD). Furthermore, the CA is consequently divided into new approximation and detailed coefficients. This decomposition process is carried out until the required frequency response is achieved from the given input signal. Delivers a smoothed version of the input signal and is derived from a scaling function, associated to the mother wavelet.

2.2 Wavelet based De-noising

The principal work on de-noising is done by Donoho which is based on thresholding the DWT of the signal. The original signal may also have high frequency features. High frequency characteristics of original signal with wavelet transform is preserved. Therefore, the wavelet transform is an effective method for de-noising the noisy signal [3]. Standard wavelet thresholding techniques, consists of hard thresholding and soft thresholding functions. Wavelet de-noising has wide range of application in signal processing as well as other fields. The signals may be one-dimensional, two-dimensional and three-dimensional. I use one dimensional discrete wavelet analysis Tool .De-noising (noise reduction) is the first step in many applications. Other applications include data mining, medical signal/image analysis (ECG, CT, etc.), radio astronomy image analysis etc.

Select the appropriate wavelet and wavelet decomposition level, make wavelet decomposition for the noise signal f (t), get corresponding coefficient of wavelet decomposition. Deal with the threshold for coefficients wj, k which come from the wavelet decomposition, and obtain the estimation value wj, k of the wavelet coefficients of original signal. Make wavelet inverse transform for these estimated values wj, k, and get the signal after de-noising. Signal de-noising using the DWT consists of the three successive procedures, namely, signal decomposition, thresholding of the DWT coefficients, and signal reconstruction.

Thresholding method is categorized into two types such as hard thresholding and soft thresholding. Performance of thresholding is purely depends on the type of thresholding method and thresholding rule used for the given application [4, 5]. The hard threshold function tends to have bigger variance and it is unstable. However, soft thresholding function is much stable than hard thresholding and it tends to have a bigger bias due to the shrinkage of larger wavelet coefficients. Hard and soft thresholding with threshold are defined as follows:

$$W_{ht} = \begin{Bmatrix} w \; |w| \geq t \\ 0 |w| < t \end{Bmatrix}$$

$$W_{st} = \begin{Bmatrix} [sign(w)](|w| - t), |w| \geq t \\ \qquad\qquad\qquad |w| < t| \\ 0, \end{Bmatrix}$$

…3

Where w is a wavelet coefficient; t is a value of threshold which is applied on the wavelet coefficients. From another point of view, thresholding can be either soft or hard. Hard thresholding zeroes out all the signal values smaller than δ. Soft thresholding does the same thing, and apart from that, subtracts δ from the values larger than δ. In contrast to hard thresholding, soft thresholding causes no discontinuities in the resulting signal. In MATLAB, by default, soft thresholding is used for de-noising and hard thresholding for compression.

2.3 Thresholding Algorithms

A variety of threshold choosing methods can be mainly divided into two categories: global thresholding and level dependent thresholding [6]. The former chooses a single value to be applied globally to all empirical wavelet coefficients, while the later chooses different threshold value j for each wavelet level j. To obtain the thresholds properly, each of the parameters (the wavelet basis, the threshold selection algorithm, rescaling function and decomposition level) should be determined thoughtfully. The steps of the algorithm using soft and hard thresholding are as listed below:

Table 1

Thresholding Selection Rules

Name	Description:
Rigsure	Adaptive threshold selection using principle of stein's unbiased Risk Estimation
Sqtwolog	Threshold is equal to the square root of the two decimal logarithms of the signal length(X)

Heursure	Heuristic variant of above option
Minimaxi	Minimax threshold principle

The great importance is the determination of the thresholds selection algorithm .There are four threshold selection rules that are available to use with the Wavelet Toolbox and are listed in Table 1. The received signal levels are separated by wavelet transform. Then, the received signal wavelet coefficients are calculated up to the desired level. For the soft threshold estimator in the first method, a threshold selection rule which is based on Stein's Unbiased Estimate of Risk is used. An estimation of risk for a certain threshold value x0 is obtained, and then by minimizing the risks in x0, a selection of the threshold value is obtained. The second method uses a fixed form threshold which results in minimax performance multiplied by a factor proportional to logarithm of the length of the signal. The third method is a combination of the first and second methods. If the signal-to-noise ratio is very small (for the third method), the SURE estimate is very noisy. If the signal-to-noise ratio is very small and the SURE estimate is very noisy, then the fixed form threshold is used. The fourth method uses a fixed threshold which is chosen to give minimax performance for mean square error. The minimax principle is used in the field of statistics to achieve the "minimum of the maximum mean square error."

The wavelets are function that satisfy certain mathematical requirements and used in representing data or other functions. The fundamental idea behind wavelets is to analyze according to scale. There are many types of wavelets, such as Haar, Daubechies, Coiflet, and Symmlet and so on.

3. Thresholding Rules

Commonly used threshold selection rules are: rigrsure, sqtwolog, heursure and minimaxi rules [15]. Stein unbiased risk threshold (rigrsure) is an adaptive threshold selection principle based on non-partial likelihood estimator.

- **'sqtwolog' universal thresholding method:**

This type of global thresholding method was proposed by Donoho and Johns tone. This is also called "sqtwolog" method in a fixed form .The threshold value is given in equation 4 as

$$\lambda = \hat{\sigma}\sqrt{2}\log n \quad \ldots 4$$

where n is the number of data points, and σ is an estimate of the noise level σ. Donoho and Johns tone proposed an estimate of σ that is based only on the empirical wavelet coefficients at the highest resolution level *J* -1 because they consist most of noise. Most of the function information except the finest details is in lower level coefficients.

- **Rigsure(wtsu) thresholding method*:***

Steins unbiased risk estimator (SURE) or rigrsure is an adaptive thresholding method which is proposed by Donoho and Jon stone and it is based on Stein's unbiased likelihood estimation principle. This method computes is likelihood estimation first using the given threshold t, and then minimize the non-like hood t, so the threshold has been obtained. The Rigrsure method defines the threshold level T by.

$$T = \sigma\sqrt{2\log_e(N\log_2 N}$$

…5

Where N is the number of signal samples; and σ is the standard deviation of the noise.

- **Heursure thresholding method:**

Heursure threshold is a combination of SURE and global thresholding method. If the signal-to noise ratio of the signal is very small, then the SURE method estimation will have more amounts of noises.

- **Minimax thresholding method:**

Minimaxi is a threshold selection scheme using the minimax principle, in which a fixed threshold is selected to obtain the minimum of the maximum mean square error that is obtained for the worst function in a given set, when compared against an ideal procedure.

$$W_{tm=}\begin{Bmatrix} 0.3936 + 0.1829 * \left(\frac{\log(n)}{\log(2)}\right), |n| > 32 \\ 0 \qquad\qquad |n| \leq 0 \end{Bmatrix}$$

…6

In this method, the threshold value will be selected by obtaining a minimum error between wavelet coefficient of noise signal and original signal.

4. Performance Estimation

In this work, to compare the effect of reducing noise in the use of different wavelet bases and different combination of threshold rules, three performance indexes are used to evaluate the noise reduction effect the performance of different wavelet thresholding on de-noising the signals have been measured using four measures such as, which are signal to noise ratio (SNR), mean square error (MSE) and smoothness index [16, 17].

- **Signal to noise ratio**

Signal to noise ratio refers to the signal power to noise power ratio. It is often used as the de-noising effect evaluation index. SNR is measured in decibels. The higher the P*SNR*, the better the quality of the compressed and reconstructed signal

$$SNR = 10\lg\left(\sum_{n=1}^{N} S^2(n) \,/\, \sum_{n=1}^{N}[f_{d(n)-S(n)^2}]\right.$$

…7

Where, *N* is the number of sample points, s (n) is original signal without noise; f d (n) is de-noised signal. The definition of SNR is shown in equation 7. Signal-to-noise ratio is calculated as a relation between the de-noised signal and removed noise.

- **Root mean square error**

Mean square error measures the degree of similarity of the de-noised signal and original signal without noise. Error is smaller, which illustrates the de-noised signal more faithful to the original signal, which is means, error is better noise reduction effect.

$$RMSE = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(G_{(i)} - T_{(i)})^2} \quad \ldots 8$$

Where, G (i) is the original ECG signal, T (i) is the de-noised signal and *n* is the number of the samples. The definition of RMSE is shown in equation 8. The performance of the algorithms is the best when root mean square error between the compressed and the original signal. RMSE and SNR do not fully reflect the de-noising effect.

- **Smoothness index**

Here is another evaluation indicator, smoothness index.

$$r = \sum_{n=1}^{N}[f_{d(n+1)} - f_{d(n)}]^2 / \sum_{n=1}^{N}[f(n+1) - f(n)]^2 \quad ..9$$

Where, f (n) is the original noised signal. The definition is shown in Equation 9. The indicator can reflect the degree of smoothing of the de-noised signal.

5. Simulation results and analysis

Three different signals are used to study the effect of threshold value of discrete wavelet transform coefficients. These signals are considered as original and free of noise signal with different morphology. The objectives of this study were to investigate 1) the suitable wavelet functions and their scale Level 2) the best threshold estimator method and transformation method 3) the suitable threshold rescaling method. There are three wavelet functions and three threshold rules have considered in analyzing the performance of de-noising the signals using soft thresholding method. From the literature, we found that, wavelet transform shows a good performance on de-noising the signal [15]. However, the selection of appropriate mother wavelet functions and number of wavelet decomposition level is still an issue to remove the various kinds of noises from the input signal because there is currently no known method to calculate which wavelet and thresholding parameters best de-noise a signal, tests must be performed to evaluate the de-noising capabilities of wavelets and thresholding parameter combinations. The thresholding criteria, which are used for the evaluation of the proposed de-noising methods are the “rigrsure”, “heursure”, “sqtwolog”, “minimaxi”, as they are mentioned . First, the signal is transformed into the orthogonal domain by taking wavelet transform. Then, the wavelet coefficients are modified according to the thresholding or algorithm. Finally, inverse wavelet transform of the modified wavelet coefficients is taken to reconstruct the de-noised signal [9]. In this paper, different

Volume 3, Issue 3, Feb 2014
ISSN: - 2348-0459

wavelet bases are used, at one scale of decomposition, in all methods. For taking the wavelet and inverse wavelet transform of the signal, available MATLAB commands are used. For evaluating the performance of the proposed algorithm .MATLAB/ software for fault data generation and algorithm implementation the Simulink model of the simulated system in transmission line. Circuit for Creating Power Quality Disturbance Signals Using Simulink MATLAB.

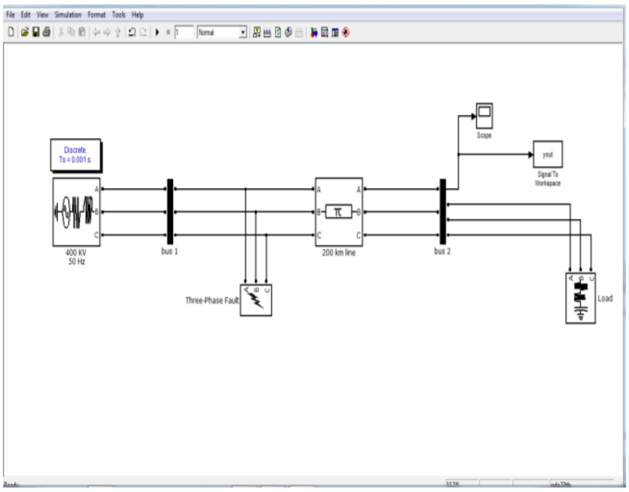

Fig 1 Simulink model of the transmission line system

In this part, I select all the possible cases to illustrate the performance of the proposed fault indicator under internal fault events L-G fault, LL-G fault, and LLLG fault.

6. Study Cases

There are three wavelet functions and three threshold rules have considered in analyzing the performance of de-noising the signals using soft thresholding method. From the literature, we found that, wavelet transform shows a good performance on de-noising the signal. However, the selection of appropriate mother wavelet functions and number of wavelet decomposition level is still an issue to remove the various kinds of noises from the input signal. This technique can be well used to estimate the fault detection and location in a specific transmission system. Hence the identification and controlling of these faults is essential and control system plays a prominent role in the overall performance of the transmission system**.** In this part**,** I select all the possible cases to illustrate the performance of the proposed fault indicator under internal fault events. L-G Fault, LL-G fault, and LLLG fault. Through wavelet analysis the wavelet families are, Daubechies, Coif-Let, and Symmlet. The model of the simulated system, which is a 3 phases, 400KV, 50Hz, line length 200 Km. The output waveform will have a frequency of 50Hz for the various faults simulation test have carried and their results.

Line to ground fault is selected as a simulation case whose fault locations are tabulated along with the %error to compare three different signals are RMSE,SNR and Smoothing ratio(r) used to the effect of threshold value of discrete wavelet transform coefficients. In LG Fault rigsure method is

Global Journal of Multidisciplinary Studies Available online at www.gjms.co.in
Volume 3, Issue 3, Feb 2014
ISSN: - 2348-0459

best result in coif 2 as compare to other de-noising methods. In MSE lower value of db2 as compared to other and signal to noise ratio (SNR) higher the value of db2and sym4 as compare to coif2, smoothing ratio is better in db2 because the smoothness is perfect as compare to other wavelet function. The thresholding criteria, which are used for the evaluation of the proposed de-noising methods, are the “rigrsure”, “sqtwolog”, “minimaxi”, as they are used in wavelet basis function. These signals are considered as original and free of noise signal with different wavelet basis function are db2, sym4, coif2 de-noising performances of the three threshold Rules .The performance measure between de-noised signal and the original signal in LG Fault. Below from fig 1 and the resultant values of estimated given in figure 1.1and1.2 from table 2 and table 2.1.

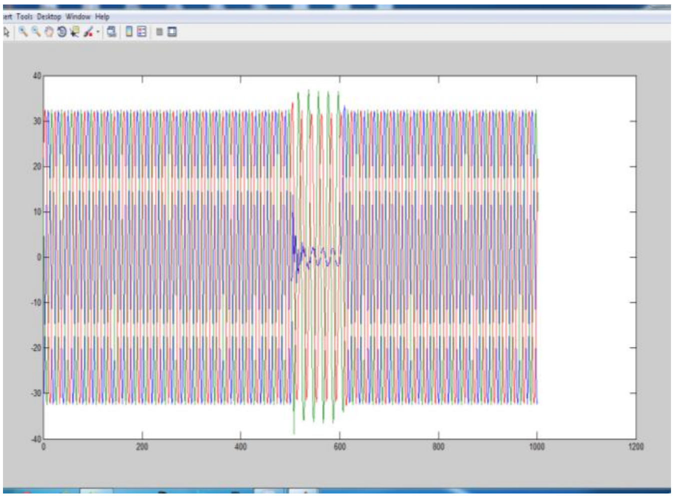

Fig 1.1 Fault current by LG fault

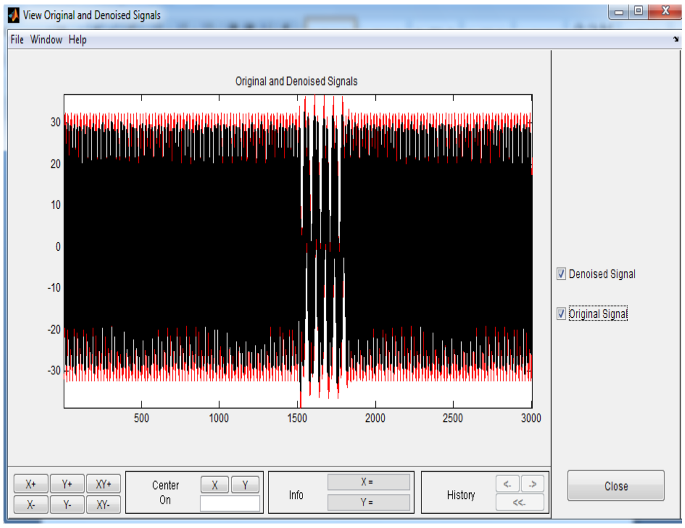

Fig 1.2 Fault current by LG Fault through Wavelet view Original and De-noised signal

Table 2.1

Db2				Sym4			Coif2		
L	Hs	hr	hm	hs	hr	hm	hs	hr	h
1	0.81	3.6	2.45	0.8	0.1	2.43	0.81	0.04	2
2	1.63	0.01	4.9	0.40	0.04	4.9	1.63	0.01	4
3	0.27	0.06	7.35	2.44	0.04	7.3	2.4	0.09	7
4	0.20	0.2	9.8	3.2	0.06	9.8	3.26	0.1	9

5	0.16	0.09	12.2	4.07	0.08	12.3	4.07	0.03	12.2

Table2.2 The results of fault location under db2, sym4, coif2 mother wavelet and 5 decomposition levels in wavelet de-noising algorithm for different wavelet basis function and de- noising performances of the three threshold Rules. In LG Fault rigsure method is best result in coif 2 as compare to other de-noising methods .The performance measure between de-noised signal and the original signal in LG Fault.

Table 2

RMSE SNR

Smoothing ratio

Db2	Sym4	Coif2	Db2	Sym4	Coif2	Db2	Sym4	Coif2
0.05	0.07	0.07	54.07	51.7	50.6	0.99	0.99	0.98
0.10	0.12	0.2	54.59	54.5	53.6	0.99	0.96	0.94
0.16	0.16	0.16	54.93	54.9	54.4	0.98	0.94	0.93
0.21	0.2	0.2	58.74	55.2	53.8	0.99	0.99	0.98
0.18	0.27	0.21	59.05	55.3	55.3	0.98	0.95	0.96

Table2.1The performance measure chosen its represent the Root mean squared error (RMSE), signal to noise ratio (SNR) and Smoothing ratio(r) between de-noised signal and the original signal for different wavelet basis function are db2, sym4, and coif2 de-noising performances as shown in table.

Double line to ground fault is selected as a simulation case whose fault locations are tabulated along with the %error to compare three different signals are RMSE between the compressed & the original signal. The lower the value of RMSE, the lower the error.SNR and Smoothing ratio(r) used to the effect of threshold value of discrete wavelet transform coefficients. In LLG Fault rigsure and sqtwolog method is best result show in db4 as compare to other de-noising methods. In MSE lower value of db4 and coif4 as compare to sym6.The thresholding criteria, which are used for the evaluation of the proposed de-noising methods, are the “rigrsure”, “sqtwolog”, “minimaxi”, as they are used in wavelet basis function. These signals are considered as original and free of noise signal with different wavelet basis function are db4, sym6, coif4 de-noising performances of the three threshold rules .The performance measure between de-noised signal and the original signal in LLG Fault. Below from fig 1 and the resultant values of estimated given in figure 1.3and 1.4 from table 2.2 and table 2.3.

Global Journal of Multidisciplinary Studies Available online at www.gjms.co.in
Volume 3, Issue 3, Feb 2014
ISSN: - 2348-0459

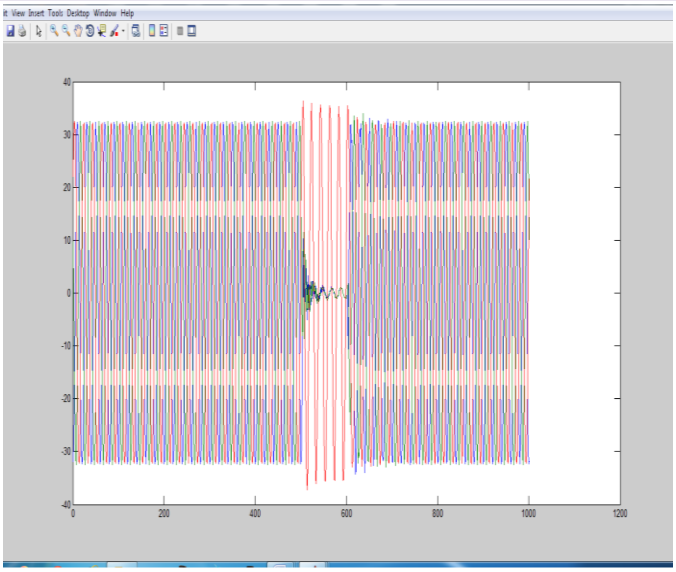

Fig 1.3 Fault current by LLG Fault

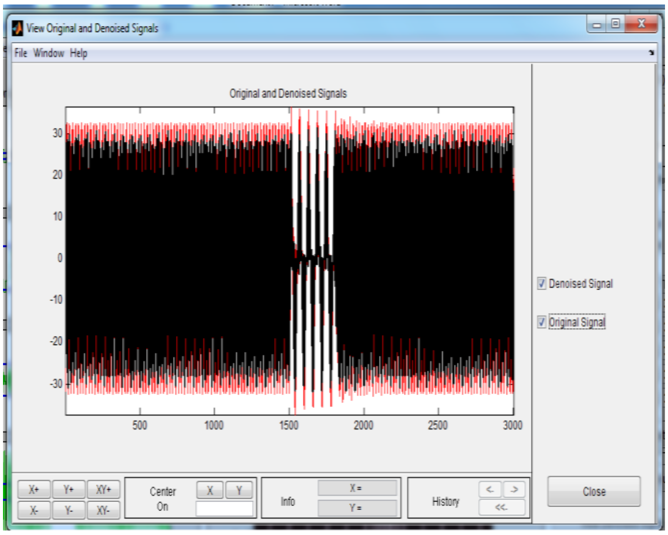

Fig 1.4 Fault current by LLG Fault through Wavelet view Original and De-noised signal

Table 2.2

Db4	Sym6	Coif4

L	Hs	hr	hm	hs	hr	hm	hs	hr	hn
1	0.82	0.02	2.45	0.81	0.02	2.5	0.8	0.01	2.
2	0.40	0.01	4.9	1.6	0.01	4.8	0.4	0.01	4.9
3	0.27	0.1	7.3	2.4	0.52	7.4	0.2	0.2	7.
4	0.21	0.07	9.9	3.2	0.28	9.8	0.3	0.27	9.8
5	0.16	0.2	12.3	4.07	0.19	12.3	0.16	0.12	12

Table2.3 The results of fault location under db4, sym6, coif4 mother wavelet and 5 decomposition levels in wavelet de-noising algorithm for different wavelet basis function and de- noising performances of the three threshold rules .The performance measure between de-noised signal and the original signal in LLG Fault.

Table 2.3

RMSE SNR

Smoothing ratio(r)

Db4	Sym6	Coif4	Db4	Sym6	Coif4	Db4	Sym6	Coif4
0.05	0.12	0.16	46.7	43.5	45.5	1.06	0.9	0.99
0.10	0.07	0.05	51.8	54.3	55.2	0.09	1.0	1.02
0.16	0.05	0.04	54.7	54.7	54.6	0.96	0.99	0.98

0.21	0.1	0.2	55.0	48.9	48.8	0.93	0.98	0.91
0.18	0.05	0.04	55.3	49.2	54.2	0.99	0.93	0.98

Table2.3 The performance measure chosen is the Root mean squared error (MSE), signal to noise ratio (SNR) and Smoothing ratio(r) between de-noised signal and the original signal for different wavelet basis function are db4, sym6, and coif4 de-noising performances as shown in table.

LLLG Fault is selected as a simulation case whose fault locations are tabulated along with the %error to compare three different signals are RMSE,SNR and Smoothing ratio(r) used to the effect of threshold value of discrete wavelet transform coefficients. The thresholding criteria, which are used for the evaluation of the proposed de-noising methods, are the “rigrsure”, “sqtwolog”, “minimaxi”, as they are used in wavelet basis function. In LLLG Fault rigsure de-noising method are better result shown in db5 and sym7. In MSR sym7 and coif 3are lower value in LLLG fault in smoothing ratio (r) smoothness is perfect in sym7 as compare to other. These signals are considered as original and free of noise signal with different wavelet basis function are db4, sym6, and coif4 de-noising performances of the three threshold rules. The performance measure between de-noised signal and the original signal in LLLG fault. Below from fig 1 and the resultant values of estimated given in figure 1.5and 1.6 from table 2.4 and table 2.5.

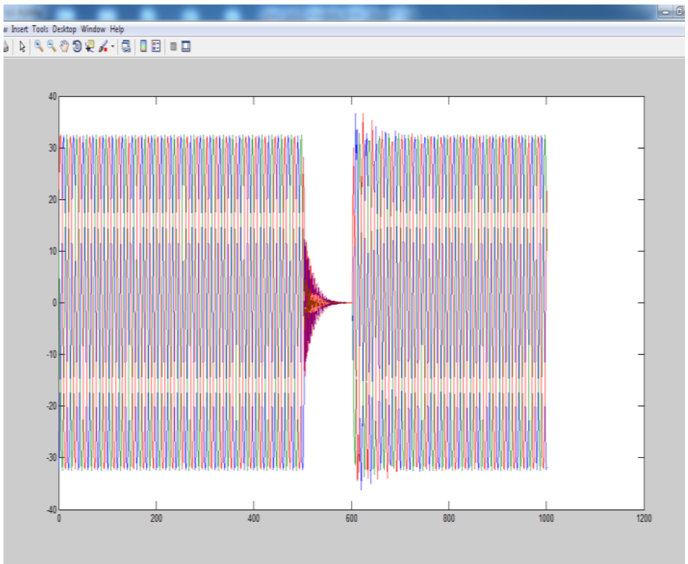

Fig 1.5 Fault current by LLLG Fault

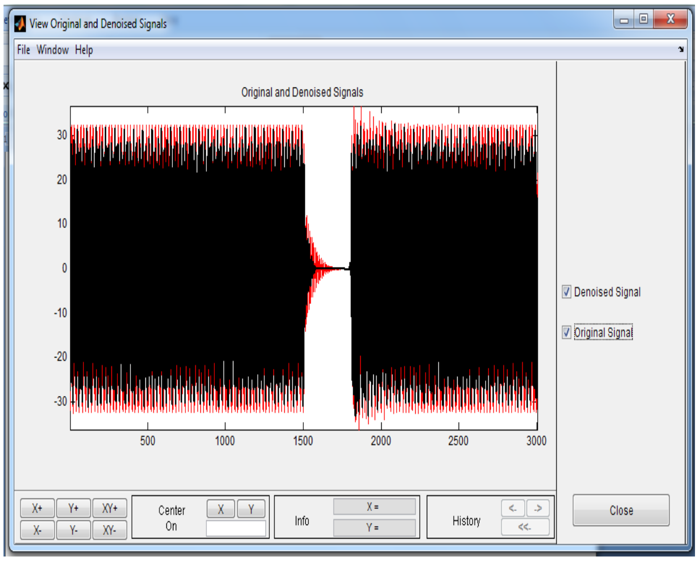

Fig 1.6 Fault current by LLLG Fault through Wavelet view Original and De-noised signal

Table 2.4

Db5				Sym7			Coif3		
L	hs	hr	hm	hs	hr	hm	hs	hr	hm
1	0.8	0.01	2.4	0.81	0.01	2.4	0.82	0.01	[illegible]
2	0.4	0.02	4.9	1.6	0.02	4.7	0.31	0.2	4.8
3	0.2	0.1	7.3	2.4	0.03	7.4	0.2	0.1	7.4
4	0.2	0.2	9.8	3.2	0.5	9.9	0.1	0.5	9.7
5	0.1	0.06	12.2	4.0	0.16	12.3	0.21	0.05	12.2

Table2.4 The results of fault location under db5, sym7, coif3 mother wavelet and 5 decomposition levels in wavelet de-noising algorithm for different wavelet basis function and de-noising performances of the three threshold rules .The performance measure between de-noised signal and the original signal in LLLG Fault.

Table 2.5

RMSE SNR Smoothing ratio(r)

Db4	Sym6	Coif4	Db4	Sym6	Coif4	Db4	Sym6	Coif4
0.05	0.12	0.16	46.7	43.5	45.5	1.06	0.9	0.99
0.10	0.07	0.05	51.8	54.3	55.2	0.09	1.0	1.02
0.16	0.05	0.04	54.7	54.7	54.6	0.96	0.99	0.98
0.21	0.1	0.2	55.0	48.9	48.8	0.93	0.98	0.91
[illegible]8	0.05	0.04	55.3	49.2	54.2	0.99	0.93	0.98

Table2.5 The performance measure chosen is the Root mean squared error (MSE), signal to noise ratio (SNR) and Smoothing ratio(r) between de-noised signal and the original signal for different wavelet basis function are db4, sym6, and coif4 de-noising performances as shown in table.

7. Fault location and Fault types

Percentage error between actual fault time (sec) and observed fault time (sec) is calculated as

$$\%Error*100 = \frac{(\text{Observed time} - \text{Actual time})}{\text{Actual time}}$$

Table 3

% error between actual fault and observed fault

Fault type	Actual fault create time in(sec)	Observed fault clear time in(sec)	% Error
LG	1551	1804	0.16
LLG	1514	1794	0.18
LLLG	1506	1804	0.19

The actual time and observed time where the fault is create and clear with time in current signals are using wavelet transform. It is found that this algorithm are detect fault with the accuracy of 99% enough to be used in identification of transmission line fault location.

8. Conclusion

The SIMULINK model of proposed transmission line system has been developed and fault analysis has been carried out. Different waveforms were observed using SIMULINK. The transient signals have been analyzed using wave menu in wavelet toolbox 1D Discrete wavelet analysis tool is selected for this purpose. The transient signals were synthesized using Discrete Wavelet transform (DWT). The main objective of the work described in this paper was to develop robust de-noising techniques of transmission line fault signal. The best results of wavelet de-noising algorithm were found. Therefore, this technique can be well used to estimate the fault detection and location in a specific transmission system. The results of fault location under db2, db4 mother wavelet and 5 decomposition levels .The overall performance of db2, db4 is better than other mother wavelet is also presented. The "db4" based wavelet transform produces the excellent signal even though the signal contaminates power line noise, and low and high frequency noises. The paper concludes that the "db4" wavelet and rigrsure threshold rule gives the best result for signal de-noising. It is observed that performance of minimax is better than that of sqtwolog .By the comparative analysis of smoothing ratio, signal to noise ratio, and mean square error, an unambiguous evaluation of various algorithms, could be conducted. This method is very simple compared to other de-noising approach like genetic algorithm .Finally it was shown that in detection of transmission line fault location.

9. Reference

[1] Choi, M.S., D.S. Lee and X. Yang, 2005. "A line to ground fault location algorithm for underground cable system", KIEE International Transactions on Power Engineering, 54: 267-273.

[2] IEEE Std. C37.114-2004 "IEEE Guide for Determining Fault Location on AC Transmission and Distribution Lines," In: Proceedings of IEEE transmission and distribution conference, 8 December 2004.

[3] Raghuveer M. Rao & Ajit S. Bopadiker , "Wavelet Transforms –Introduction to Theory and Applications".

[4] Pearson Education Asia, 1998. Bartušek K., Přinosil J., Smékal Z., Wavelet-based de-noising techniques in MRI, Computer Methods and Programs in Biomedicine, (2011), vol. 104, Issue 3, Pages 480-488.

[5] Donoho, D.L. (1995), "De-noising by soft-thresholding," IEEE Trans. on Inf. Theory, 41, 3, pp. 613-627.

[6] Fletcher A.K., De-noising via Recursive Wavelet Thresholding, Master of Science in Electrical Engineering in the Graduate Division of the University of California, Berkele, (2002).

[7] C. Sidney Bums, Ramesh A. Gopinath, Haitao Guo (1998), "Introduction to Wavelets and Wavelet Transforms".

[8] M. Karimi, et al (2000), "Wavelet based on-line disturbance detection for power quality applications," *IEEE Trans. on Power Delivery,* 01.15, no. 4, pp.1212-1220 OCT'

[9] Shyh-Jier Huang, Cheng-Tao Hsieh and Ching-Lien Huang ," Application of Wavelets to Classify Power system Disturbances", Electric Power Systems Research, Volume 47(2), 15 October (1998), 87-93.

[10] C.H. Kim and R. Aggrawal, "Wavelets Transforms in Power Systems", Power Engineering Journal, Volume15, (2001), 193-202.

[11] Mallat, S. G., A theory of multiresolution signal decomposition: the wavelet representation. *IEEE T. Pattern Anal.* 1989, *11*, 674–693.

[12] Chen S., Zhu H.Y., *Wavelet transform for processing power quality disturbances*, EURASIP Journal on Advanced in Signal Processing, Vol. 2007, article ID 47695.

[13] Bruce, Andrew, 1996. Applied Wavelet Analysis with S-plus, New York: Springer-Verlag, XXI, 3385: IL.

[14] John stone, I. M., Silverman, B. W., Wavelet threshold estimators for data with correlated noise. *J. Roy. Stat. Soc. B* 1997, *59*, 319–351.

[15] S.A. Chouakri, F. Bereksi-Reguig, S. Ahmaïdi, and O. Fokapu, "Wavelet Denoising of the Electrocardiogram Signal Based on the Corrupted Noise Estimation," IEEE Computers in Cardiology, vol. 32, pp.1021-1024, 2005.

[16] P.M. Agante and J.P. Marques detect "ECG Noise Filtering Using Wavelets with Soft-thresholding Methods," IEEE Computers in Cardiology, vol. 26, pp.535-538, 1999

.[17] F. Nazan Uçar, M. Korürek, and E. Yazgan"A Noise Reduction Algorithm in ECG Signals Using Wavelet Transform,"Proc. IEEE 2nd Int. Biomed. Eng.Day,1997, pp.36-38.