Impact Factor (SJIF): 4.542

International Journal of Advance Research in Engineering, Science & Technology

e-ISSN: 2393-9877, p-ISSN: 2394-2444
Volume 4, Issue 3, March-2017

APPLICATION OF WAVELET TRANSFORM FOR THE PROTECTION OF TRANSMISSION LINE

Ankit O. Bhojani[1], Dr. Sanjay R. Vyas[2]
[1]PG Scholar, [2]Professor, Electrical Department, LDRP-ITR, Gandhinagar, Gujarat, India

ABSTRACT: The main aim of this paper is to developing protection techniques for transmission line. When a fault occurs the fault voltage and current waveforms contain high frequency transient signals. The proposed method is based on the detection of fault generated transient signals using wavelet transform or analysis. The simulation study is carried out by using wavelet analysis, which indicates the fault detection and classification.

I. INTRODUCTION

An electric power system comprises of generation, transmission and distribution of electric energy. Growth in power systems has lead to very complex networks extended across large areas. A power system, most of the time, operates in a steady state but disturbances, temporary and permanent, occur occasionally by the presence of large number of components which are susceptible to failures caused due to natural calamities, human errors and aging. Faults cause large amounts of currents to flow in the components that would burn out if current flows are not promptly interrupted. The voltages of the faulted phases decrease on the occurrence of a fault. Faults, if not detected and eliminated quickly, may cause severe reduction in system voltage, loss of synchronism, loss of revenue and may damage the equipment permanently. Faults can be minimized by proper power system planning and using sophisticated equipment but the occurrence of faults cannot be eliminated fully. It is, therefore, necessary to protect power systems from faults. 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. This paper has presented a method for obtaining relaying signals based on travelling wave components for designing better protection scheme of transmission line. 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. Travelling waves components are better tool for tripping travelling waves relay at the time of transient faults. The proposed methodology is implemented on a test system and the results are compared with the existing traditional method in the field. Results are almost comparable.

II. WAVELET TRANSFORMS

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. 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 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 parameter s. The mother wavelet is denoted by ψ.

III. FAULT DETECTION

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

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

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.

IV. FAULT LOCATION

Fault Location Tests Results In Simulation.

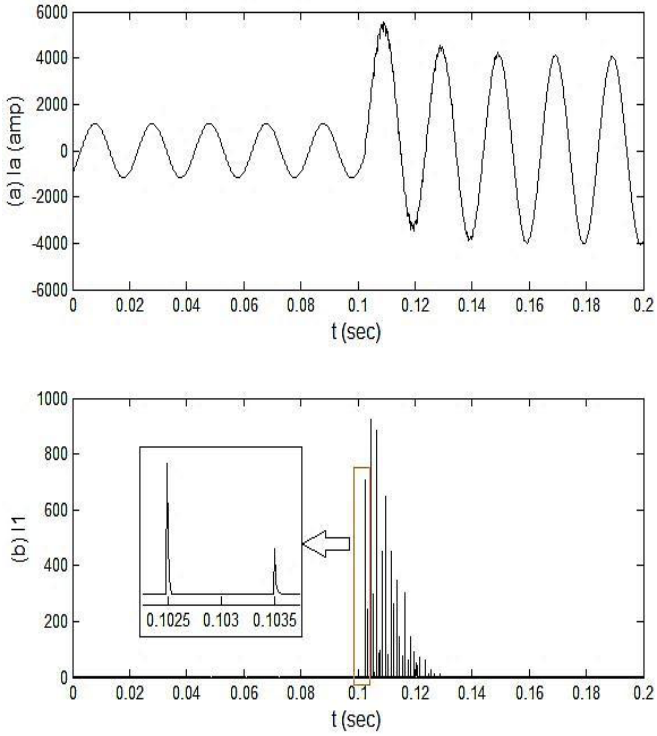

Figure 1. (a) A-Phase current for ABG Fault, (b) Aerial Mode Current Travelling Signal for ABG Fault

Fig. 1. shows the travelling signal for a single-phase to ground fault located at 100km from source side. The first spike is come to source side at 0.1025s. The second spike reflected from fault position at 0.103501sec. Hence the fault location can be calculate as.

$$x = \frac{v \times (0.1035011 - 0.1025)}{2} = 100.1689\ km$$

The performance of the fault location techniques was verified using a set of cases such as different types of fault and fault location, whose result are reported as shown in table 1.

Fault Types	Actual Fault Location (km)	Calculated Fault Location (km)	% Error
AG	10	10.1695	-0.0565
	100	100.1689	0.065
	200	201.2658	0.421
	290	289.83	0.0566
ABG	10	10.1695	-0.0565
	100	100.1689	0.065
	200	197.4669	0.801
	290	291.52	-0.5066
AB	10	10.1695	-0.0565
	100	100.1689	0.065
	200	201.2658	0.421
	290	291.52	-0.5066
ABC	10	10.1695	-0.0565
	100	100.1689	0.065
	200	198.7342	0.423
	290	291.52	-0.5066

Table 1. Results of Fault Location for Different Types of Fault at Different Location

V. SIMULATION

A typical model of a 400-kV and 300-km EHV transmission line with one power source is established in MATLAB, as shown in Fig. The sending end (SE) is modeled as Synchronous machine and the receiving end (RE) are modeled as a three-phase series RLC load. In normal condition, power is transferred from SE to RE through a line having three section, each of 100-km length. Lines are modeled with distributed parameters in the simulation.

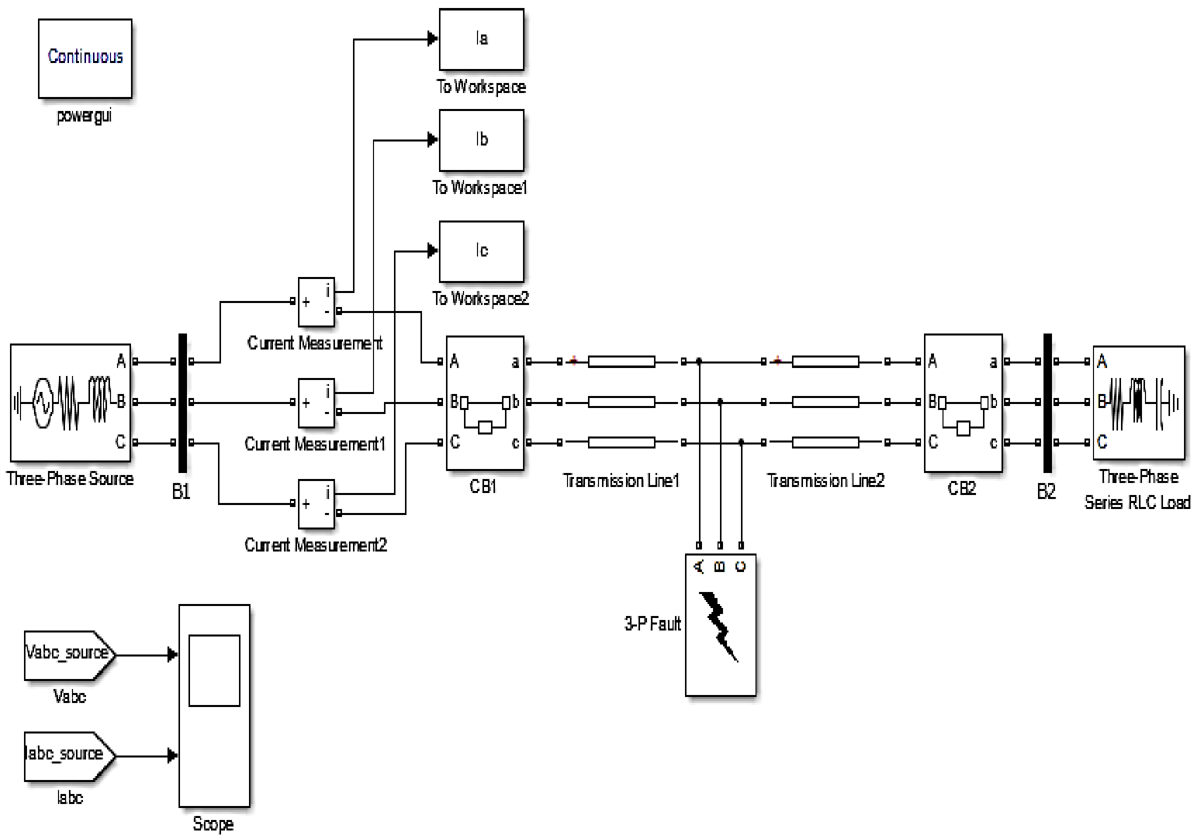

Figure 2. Transmission Line Model in MATLAB

The parameters of the system used for simulation are given in table below.
Three-Phase Source of 400kv
Transmission lines:
Frequency = 50Hz

Z1=0.12+j0.88 ohm/km.
Z0=0.309+j1.297ohm/km.
C1=1.0876*10^-8 F/km.
Line length = 2 line 0f 150km
Three-Phase series RLC load of 10kw

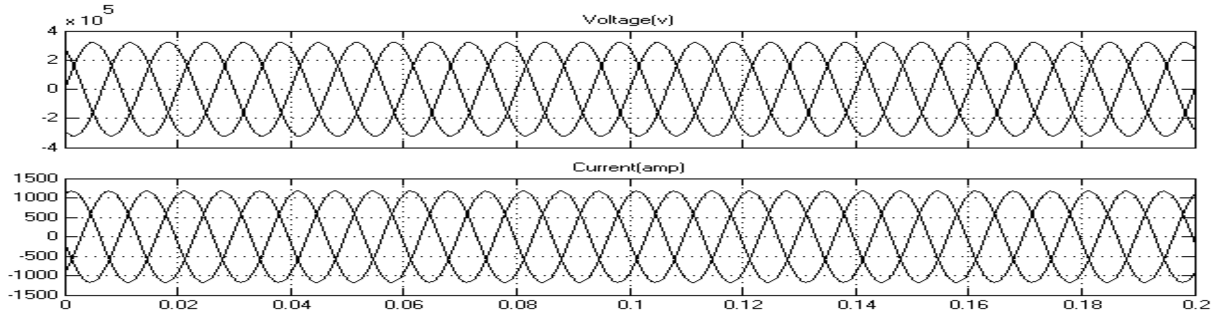

Figure 3. Voltage and Current Waveform during Normal Condition

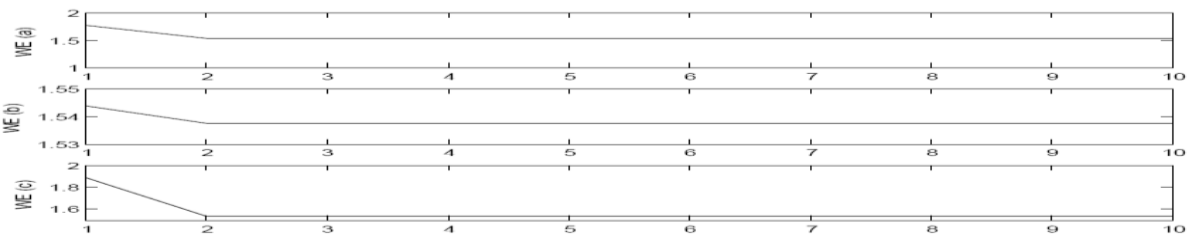

Figure 4. Wavelet Entropy of 3-Phase Current Signal during Normal Condition

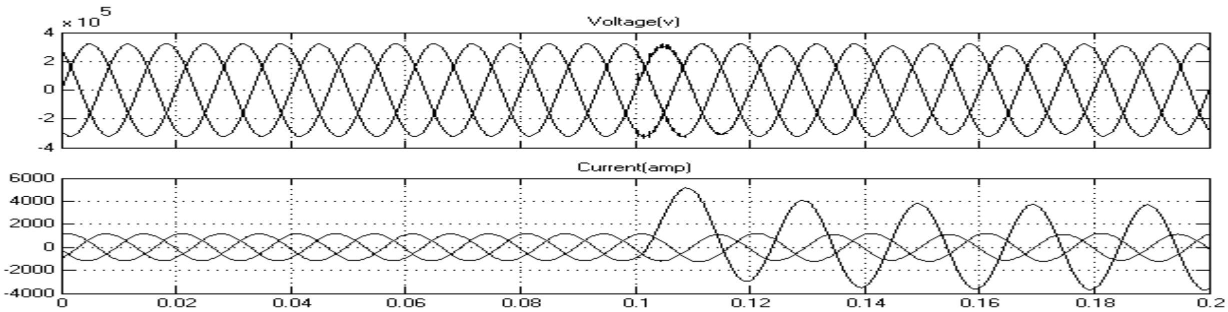

Figure 5. Voltage and Current Waveform during L-G Fault

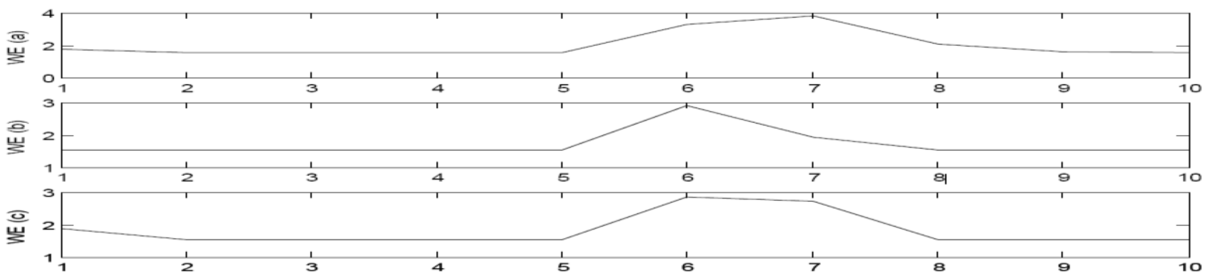

Figure 6. Wavelet Entropy of 3-Phase Current Signal for L-G Fault

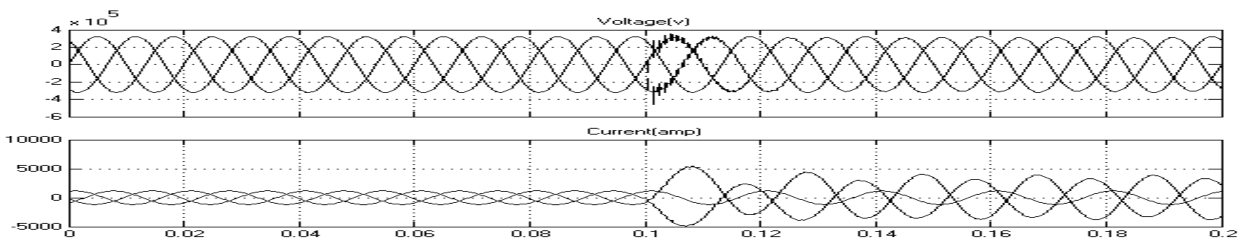

Figure 7. Voltage and Current Waveform during L-L Fault

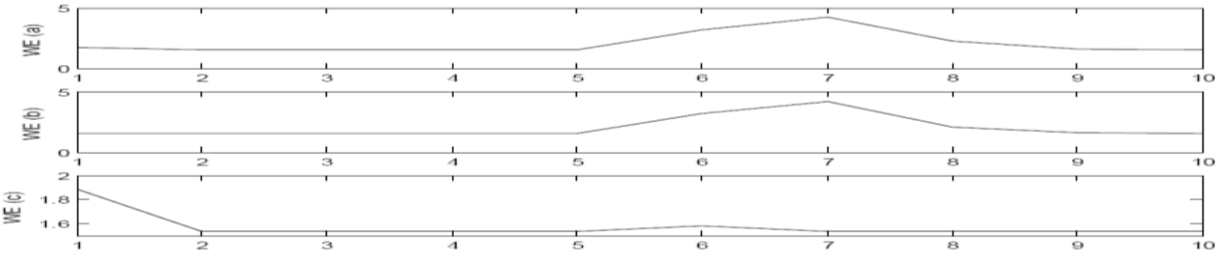

Figure 8. Wavelet Entropy of 3-Phase Current Signal for L-L Fault

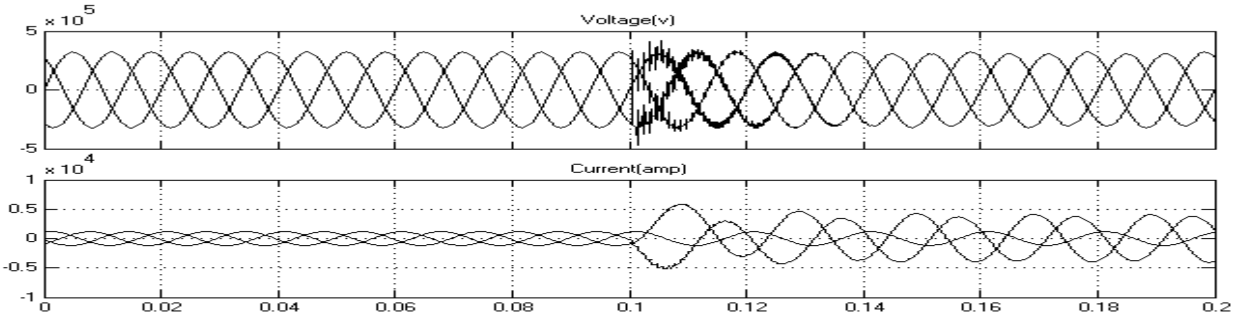

Figure 9. Voltage and Current Waveform during L-L-G Fault

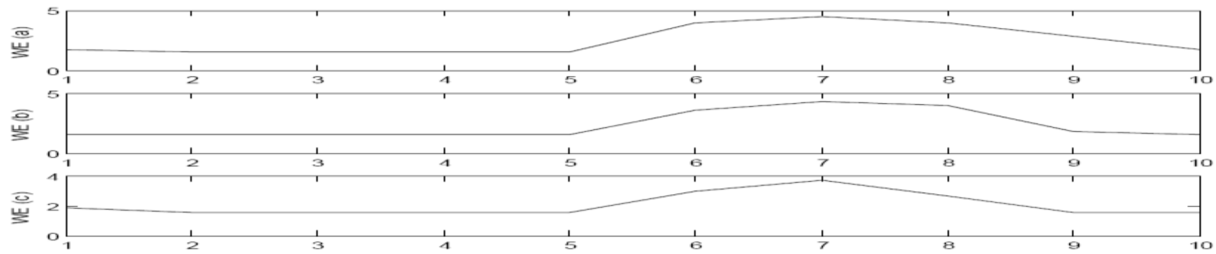

Figure 10. Wavelet Entropy of 3-Phase Current Signal for L-L-G Fault

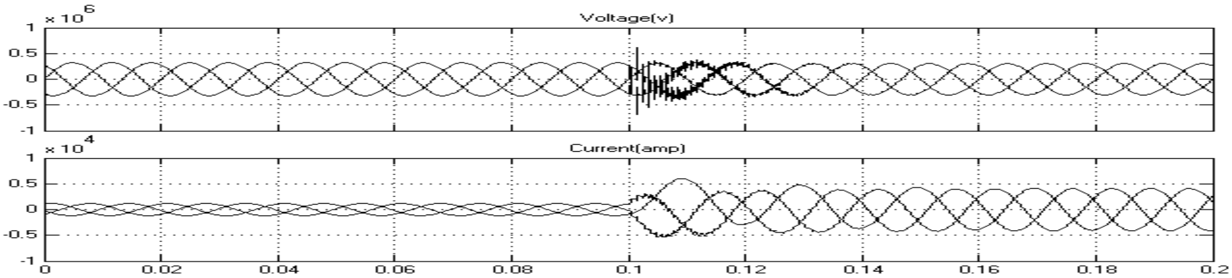

Figure 11. Voltage and Current Waveform during L-L-L Fault

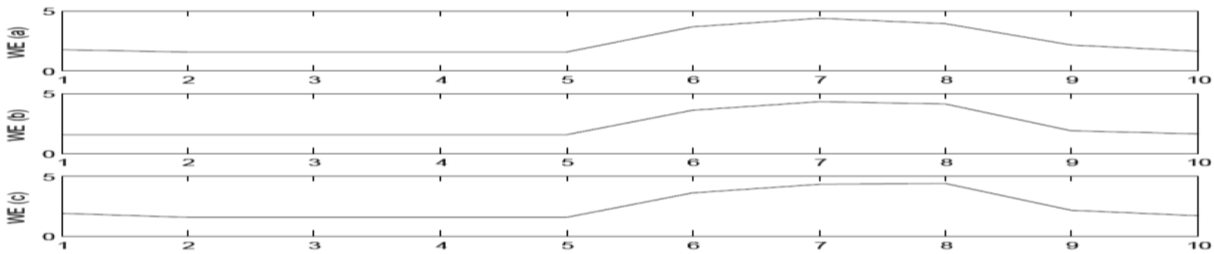

Figure 12. Wavelet Entropy of 3-Phase Current Signal for L-L-L Fault

A typical model of a 400-kV and 300-km EHV transmission line is established in MATLAB, as shown in Fig. Assume that a single-phase-to-ground fault occurs at t=5ms. Set the sampling frequency to be 20 kHz, take 400 sample-log sequence.
The simulation results are shown in Figures from which we can see that the values of the current have a sudden situation at about 0.1 s. A large number of simulation tests have been carried out and the results show that the WSE bears good capability for fault detection in the EHV transmission line.

VI. FAULT CLASSIFICATION

1. Fault Classification for Various Fault Types: The cases of 11 types of faults are simulated and each case is repeated for 5 times, and 55 sets of results are obtained. It can be seen from the results that the WT is feasible in the fault classification, and various types of faults can be classified effectively based on the proposed algorithm. Here as shown in table 4.3, take maximum and minimum values 0f p1, p2 p3, and qo. The condition for LL fault is satisfied in various cases.

2. Fault Classification for Various Fault Inception Angles: In this part, 18 cases with various fault inception angles ranging from 0 to 180 with a step of 10 are investigated and all of the results prove that the faults can be classified correctly by means of the WSE-based algorithm. The corresponding results of fault classification are shown in Table.

3. *Fault Classification for Various Fault Locations:* In this part, 31 cases with various fault locations ranging from 0 km to 300 km with a step of 10 km tested and all of the sets of results are shown in above Table which proves that this fault classification algorithm based on WSE is immune to fault locations.

This proposed fault classification algorithm is provided with high accuracy and is immune to different conditions, such as fault types, fault inception angles, and fault locations, etc.

VII. CONCLUSION

In this paper all types of faults has been detected, classified and located successfully. The modeling and simulation is done in the MATLAB. L-G, LL-G, LL and LLL faults are detected, classified and located for 400-kV and 300-km EHV transmission line with one power source. The methodology based on travelling 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

REFERENCES

[1] M. Solanki, Y. H. Song, S. Potts, A. Perks. “Transient protection of transmission line using wavelet transform.” 7th International Conference on Developments in Power System Protection. (DPSP 2001)

[2] Prashant Gautam, A. K. Jhala. “Fault Detection & Classification of 3-Phase Transmission Line.” International Research Journal of Engineering and Technology. (IRJET)

[3] P.G. McLaren & V. Pathirana, “A Hybrid Algorithm for High Speed Transmission Line Protection.” IEEE TRANSACTIONS ON POWER DELIVERY, VOL. 20, NO. 4, OCTOBER 2005.

[4] E. H. Shehab Eldin and P. G. McLaren, “Travelling wave Distance Protection – Problem Areas and Solutions.” IEEE Transaction on Power Delivery, vol.3, No.3, July 1988, pp.894-902.

[5] Harjinder Singh Sidhu, “HIGH SPEED DIGITAL PROTECTION OF EHV TRANSMISSION LINES USING TRAVELING WAVES.” Thesis, University of Saskatchewan, Canada, April 2004.

[6] David W. P. Thomas, Member, IEEE, Ricardo J. 0. Carvalho and Elisete T. Pereira “Fault Location in Distribution Systems Based on Travelling Waves.”

[7] T.B.Litler and D.J. Morrow, ―Waveletes for the analysis and compression of power system disturbances‖, IEEE Transactions on Power Delivery, Vol.14, No.2, pp. 358-364, April 1999.

[8] A.S.Omar Youssef, ―Fault Classification Based on Wavelet Transforms‖, IEEE Transmission and Distribution Conference and Exposition, Vol. 1, pp. 531-536,
2001.

[9] Das, D.; Singh, N.K.; Sinha, A.K., "A comparison of Fourier transform and wavelet transform methods for detection and classification of faults on transmission lines," *IEEE Power India Conference, 2006*, pp. 1-7.

[10] D.C. Robertson, O.I. Camps, J.S. Mayer and W. Gish, ―Wavelets and electromagnetic power system transients‖, IEEE Transactions on Power Delivery, Vol. 11, No.2, pp.1050-1058, April 1996.