International Journal of Electrical and
Electronics Engineering (IJEEE)
ISSN(P): 2278–9944; ISSN(E): 2278–9952
Vol. 9, Issue 5, Jul–Dec 2020, 83–90

International Academy of Science, Engineering and Technology
Connecting Researchers; Nurturing Innovations

FAULT DETECTION SCHEME FOR LONG TRANSMISSION LINES USING WAVELET ENTROPY

V R. Sai Kumar Sripadanna[1] & B. Venkata Krishna[2]

[1]PG Student, Department of EEE, SRKR Engineering College, Bhimavaram, India

[2]Assistant Professor, Department of EEE, SRKR Engineering College, Bhimavaram, India

ABSTRACT

For fast detection of faults, wavelet entropy based fault detection scheme is proposed in this paper and tested its performance on long transmission line power network. For extraction of frequency components, discrete wavelet transform (DWT) is used. Since the fault transient phenomena are clearly identified by daubechies family, db4 coefficients are used for calculation of entropies. This scheme later tested on the transmission line network with various types of faults at different fault locations, inception angles, and fault resistances. All these cases are investigated in MATLAB-SIMULINK software environment.

KEYWORDS: *Faults, Wavelet Entropy, Db4*

Article History

Received: ***15 Oct 2020*** **|** ***Revised:*** ***22 Oct 2020*** **|** ***Accepted:*** ***29 Oct 2020***

INTRODUCTION

In Power system components, various sources are interconnected through transmission lines. When these lines are long in structure, the chances of fault occurrence are high. These faults need be detected quickly and accurately to protect healthy system by isolate the faulty component. Several schemes were proposed in this fault detection area [1]-[2].

Among all approaches, wavelets are extensively used in fault detection, classification and location tasks [3]-[10]. Wavelet Transform (WT) used for protection of various transmission line networks like two end transmission links, parallel transmission lines and teed-networks. The performance of these WT based approaches purely depends on the mother wavelet function and decomposition level coefficients. The performance of the schemes alters based on these selections. For most of the fault detection schemes, first and second level decomposition coefficients of Daubechies 4 (db4) wavelet family are used for fault detection and later these information are extended to classification and location of the faults [2]. Further wavelet transform is applied for protection of parallel transmission lines. Boundary protection of series compensated transmission lines using DWT with db4 as a mother wavelet is presented in [5]. Instead of taking individual instantaneous phase currents, a model signal is taken with three phase currents and it is processed further through wavelet filters to extract frequency components. The paper has also used level-1 decomposition coefficients and finally the abnormal condition is detected by using a threshold value (0.3). In the paper, threshold values are selected from extensive case studies. In [6], a combined wavelet and artificial neural network (ANN) approach is introduced where the energy spectra of the level-5 approximation and the level-3 detail coefficients of three-phase currents are used for fault detection. Several other works were reported in [7]-[14] for transmission line fault detection using features of the wavelet transform. In this paper, wavelet entropy concept with ‘haar’ wavelets is implemented for detection of faults. The same method is useful for faulty phase classification also whose results are provided in next sections.

WAVELET ENTROPY CONCEPT FOR FAULT DETECTION

Wavelet transform (WT) is a powerful tool in the analysis of transient phenomena in power systems. It has the ability to extract information from the transient signals simultaneously in both time and frequency domains and has replaced the Fourier analysis in many applications. This ability to tailor the frequency resolution can greatly facilitate the detection of signal features that may be useful in characterizing the transient cause or the state of the post disturbance electrical system. The recorded transient waveforms in power system may contain unique signatures revealing the causes of the corresponding transient events. To automatically analyse those recorded waveforms, an important step is to find out those signatures. Due to the non-stationary property of the transient signals, traditional analysis methods such as Fourier Transform are not very suitable for this task. Unlike Fourier Transform, Wavelet Transforms use fast decaying kernel functions, which may better represent and analyse the transient signals. The main characteristic of the WT is that it uses a variable window to scan the frequency spectrum, increasing the temporal resolution of the analysis. The suitability of application of DWT for fault detection and classification process is already available in [4] and it is expressed as,

$$w_f(a,b) = \int_{-\infty}^{\infty} x(t).\varphi_{a,b}(t).dt \quad (1)$$

Where $x(t)$is the signal to be transformedand $\varphi_{a,b}(t)$is the transformation function (mother wavelet function). In this paper, single level one dimensional decomposition using ‘Haar’ wavelet family is used. In this paper, Shannon entropy is calculated using the detailed coefficients given by

$$E_j = -\sum_{k=1}^{N} E_{jk} log E_{jk} \quad (2)$$

The energy calculated from the equation (2) is given by

$$E_{jk} = |D_j(k)|^2 \quad (3)$$

When this energy exceeds predefined threshold, a fault can be registered.

SYSTEM STUDIED

A power system model shown in Fig 1 is considered for implementation proposed method. This test system specifications are 400 KV, 50 Hz with positive and zero-sequence impedance (per km base) of the transmission line are (0.03 + j 0.34) Ω and (0.28 + j 1.04) Ω respectively. The FD utilized instantaneous current signal with1 kHz sampling rate for verification of case studies.

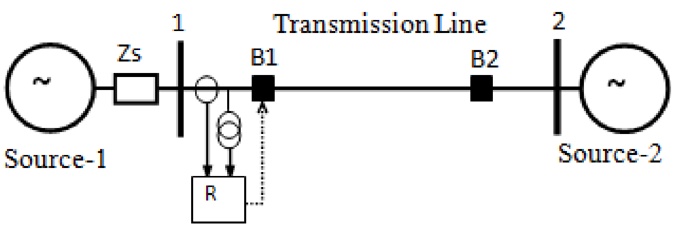

Figure 1: Test System for Studying the Proposed Scheme.

SIMULATION RESULTS

Various faults are investigated on test system to show the dependability of the proposed scheme.

Performance of detection scheme during LG faults: Three LG faults are simulated to test the dependability of the proposed method. Initially AG fault is tested with fault location of 135 km, 0.05 sec inception time of fault with fault resistance of 30Ω. Fig 2 shows the corresponding simulation result of the method. Later, BG fault is tested with fault location of 180 km, 0.07 sec inception time of fault with fault resistance of 50Ω. Fig 3 shows the corresponding simulation result of the method. Next, CG fault is tested with fault location of 150 km, 0.04 sec inception time of fault with fault resistance of 20Ω. Fig 4 shows the corresponding simulation result of the method. From all these Figures from 2 to 4, faulty phase identification is also achieved with the proposed scheme along with fault detection.

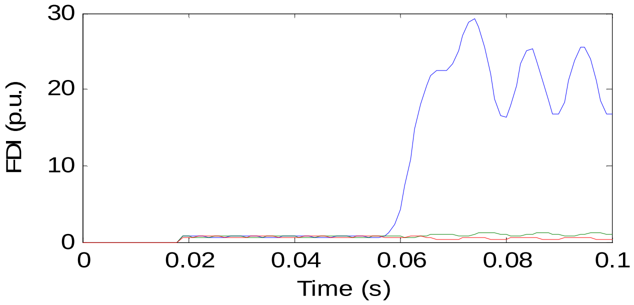

Figure 2: Detection Results of Wavelet Entropy Method for AG Fault.

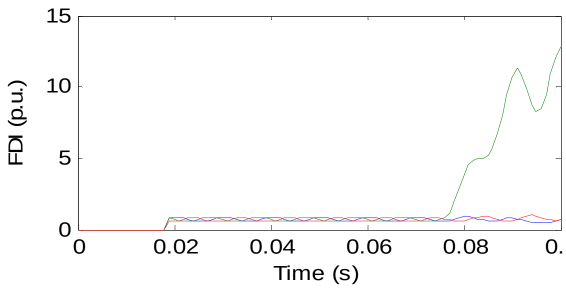

Figure 3: Detection Results of Wavelet Entropy Method for BG Fault.

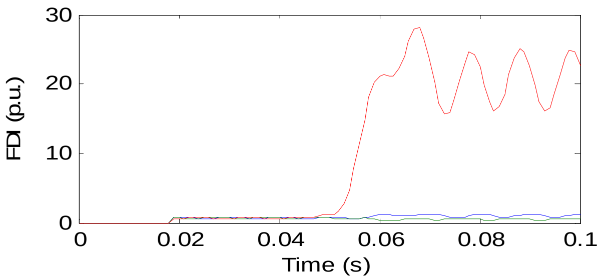

Figure 4: Detection Results of Wavelet Entropy Method for CG Fault.

Performance of detection scheme during LL faults: Three LL faults are simulated to test the dependability of the proposed method. Fig 5 shows the response of the fault detection scheme when the AB type fault is tested with fault location of 80 km, 0.06 sec inception time of fault with fault resistance of 10Ω.From Fig 5 it is clearly evident that the phase selection is quite easy during faults. When the faults are replaced by BC and AC faults, the responses of the method are presented in Fig 6 and 7. For these two cases, location of the transmission line is 220 km, inception time 0.055 sec and fault resistance of 1 Ω.

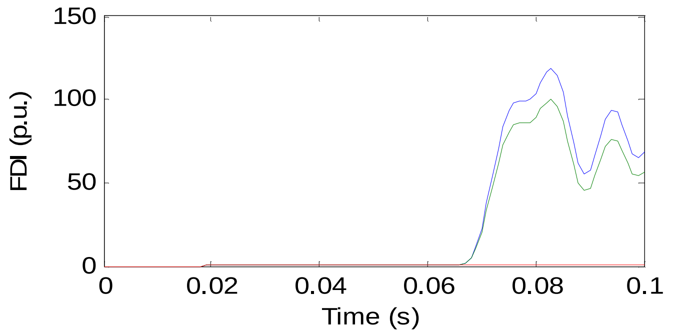

Figure 5: Detection Results of Wavelet Entropy Method for AB Fault.

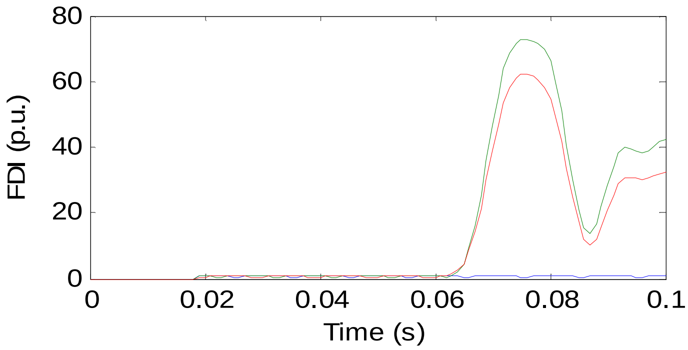

Figure 6: Detection Results of Wavelet Entropy Method for BC Fault.

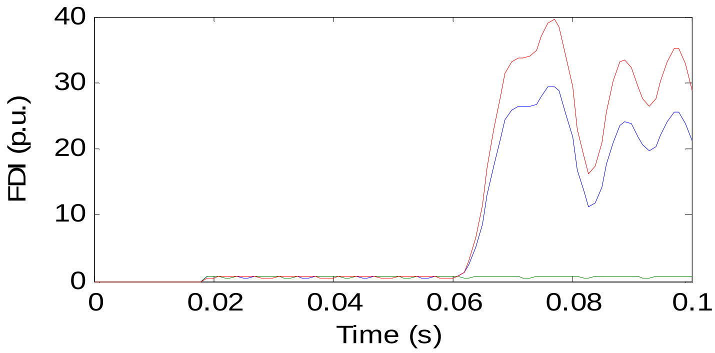

Figure 7: Detection Results of Wavelet Entropy Method for AC Fault.

Performance of detection scheme during LLG faults: Three LLG faults are possible in transmission lines which are simulated to test the dependability of the proposed method. Initially ABG fault is tested with fault location of 235 km, 0.05 sec inception time of fault with fault resistance of 10Ω. Fig 8 shows the corresponding simulation result of the method. Later, BCG fault is tested with fault location of 80 km, 0.07 sec inception time of fault with fault resistance of 10Ω. Fig 9 shows the corresponding simulation result of the method. Next, ACG fault is tested with fault location of 280 km, 0.08 sec inception time of fault with fault resistance of 20Ω. Fig 10 shows the corresponding simulation result of the method. From all these Figures from 8 to 10, faulty phase identification is also achieved with the proposed scheme along with fault detection.

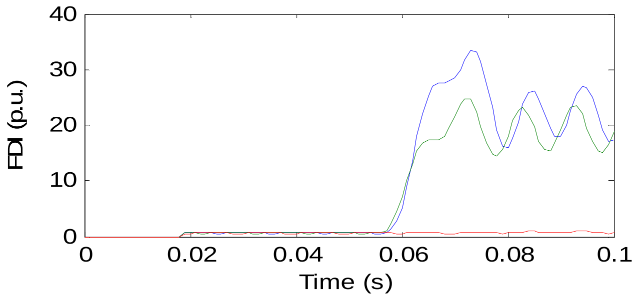

Figure 8: Detection Results of Wavelet Entropy Method for ABG Fault.

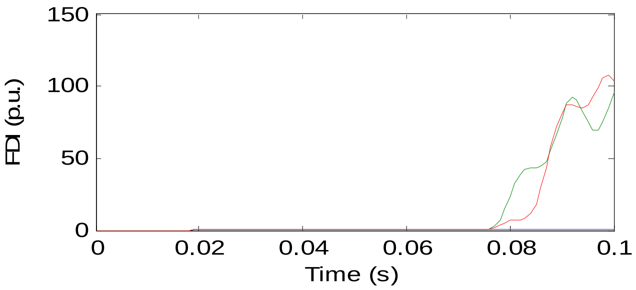

Figure 9: Detection Results of Wavelet Entropy Method for BCG Fault.

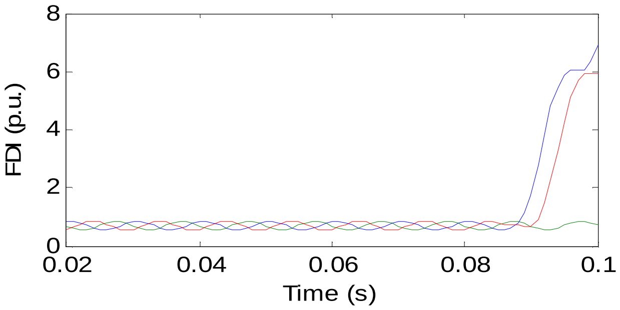

Figure 10: Detection Results of Wavelet Entropy Method for ACG Fault.

Performance of detection scheme during 3-phase fault: Along with aforementioned unsymmetrical faults, the performance of 3-phase fault is investigated in this case. For this case, 3-phase fault is created at 200 km initiated at 0.03 sec with a fault resistance of 5Ω is simulated and corresponding results are presented in Fig 11.

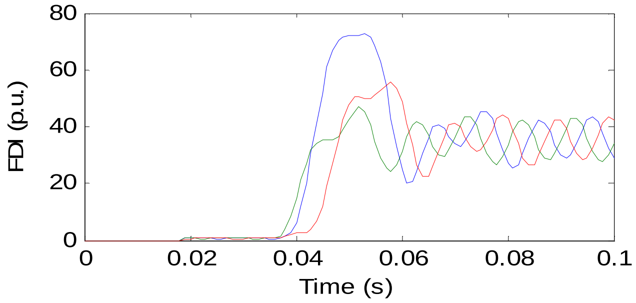

Figure 11: Detection Results of Wavelet Entropy Method for ABCG Fault.

Performance of detection scheme during far end fault: The scheme is reliable when it provides accurate decisions during typical faults. For this, AG fault is located at 290 km with fault resistance of 5Ω initiated at 0.04 sec is simulated and detected by the proposed method shown in Fig 12.

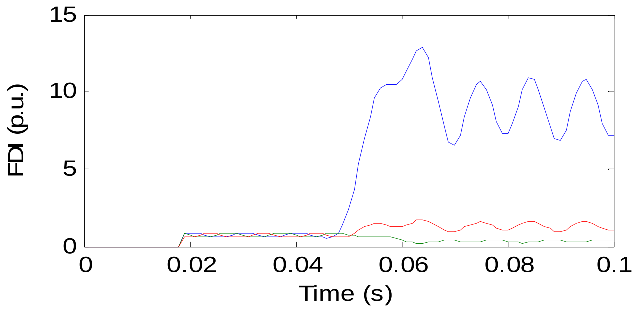

Figure 12: Detection Results of Wavelet Entropy Method for Far-end LG Fault.

Performance of detection scheme during high resistive ground fault: The proposed method is tested for BG fault with fault resistance of 150Ω located at 100 km. The scheme provided correct decision during high resistive faults along with normal faults. Fig 13 shows the corresponding results.

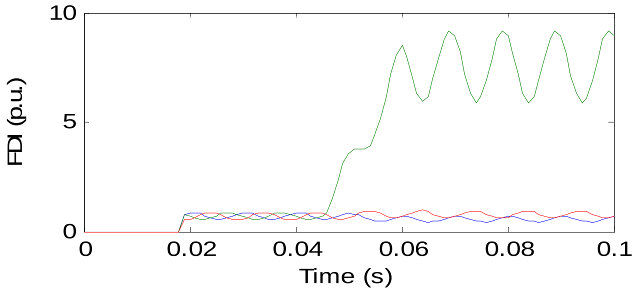

Figure 13: Detection Results of Wavelet Entropy Method for High Resistive BG Fault.

CONCLUSIONS

In this paper, wavelet entropy based fault detection scheme introduced for transmission line fault detection and faulty phase classification. The method is simple and produced reliable detection decisions during all types of normal faults. This method also yields accurate decisions during typical far end and high resistive faults. In all cases, the detection decisions generated within one cycle from the fault inception shows the speed of the protection scheme.

REFERENCES

1. *P. M. Anderson, Power system protection. IEEE Press & McGraw-Hill; (1999)*
2. *Osman AH, Malik OP. Transmission line distance protection based on wavelet transforms. IEEE Transactions on Power Delivery 2004, 19(2):515–23*
3. *Osman AH, Malik OP. Protection of parallel transmission lines using wavelet transform. IEEE Transactions on Power Delivery 2004; 19(1): 49-55*
4. *Liang F, Jeyasurya B. Transmission line distance protection using wavelet transform algorithm. IEEE Transactions on Power Delivery 2004; 19(2):545–53*
5. *Megahed AI, Moussa AM, Bayoumy AE. Usage of wavelet transform in the protection of series-compensated transmission lines. IEEE Transactions on Power Delivery2006; 21(3): 1213-1221*
6. *Zhang N, Kezunovic M. Transmission line boundary protection using wavelet transform and neural network.IEEE Transactions on Power Delivery2007; 22(2): 859–869*

7. *Huang SJ, Hsieh CT. High-impedance fault detection utilizing a Morlet wavelet transform approach. IEEE Transactions on Power Delivery1999; 14(4): 1401-1410*

8. *Michalik M, Lukowicz M, Rebizant W, Lee SJ, Kang SH. Verification of the Wavelet-Based HIF Detecting Algorithm Performance in Solidly Grounded MV Networks. IEEE Transactions on Power Delivery 2007; 22(4): 2057 – 2064.*

9. *Zhang DJ,WuQH,BoZQ, Caunce B. Transient positional protection of transmission lines using complex wavelets analysis.IEEE Transactions on Power Delivery2003; 18(3): 705–710.*

10. *Youssef OAS. New algorithm to phase selection based on wavelet transforms. IEEE Transactions on Power Delivery2002; 17: 908- 914.*

11. *Silva KM, Souza BA, Brito NSD. Fault detection and classification in transmission lines based on wavelet transform and ANN. IEEE Transactions on Power Delivery 2006; 21: 2058-2063.*

12. *LiangF,Jeyasurya B. Transmission line distance protection using wavelet transform algorithm. IEEE Transactions on power delivery 2004; 19(2): 545-553.*

13. *Valsan SP, Swarup KS. Wavelet transform based digital protection for transmission lines. International Journal of Electrical Power & Energy Systems 2009; 31(7): 379-388.*

14. *ElSafty S, El-Zonkoly A. Applying wavelet entropy principle in fault classification. International Journal of Electrical Power & Energy Systems2009; 31(10): 604-607.*