Science and Technology Publishing (SCI & TECH)
ISSN: 2632-1017
Vol. 3 Issue 3, March - 2019

Power Transmission Line Fault Location Estimation Using The Traveling Wave Method

Eyakeno Luke[1]
Department of Electrical/Electronic and Computer Engineering, University of Uyo, AkwaIbom, Nigeria

Kalu Constance[2]
Department of Electrical/Electronic and Computer Engineering, University of Uyo, AkwaIbom, Nigeria
constance.kalu@yahoo.com

Udofia, Kufre[3]
Department of Electrical/Electronic and Computer Engineering,
University of Uyo, AkwaIbom, Nigeria

***Abstract*— In this paper, power transmission line fault location estimation using the traveling wave method is presented. Specifically, the double terminals traveling wave fault location method is used. The method determines the fault location by using precisely measured arrival time of the traveling wave at each end of the line. Importantly, the method uses the propagation time of the high frequency traveling wave created whenever a fault occurs on a transmission line to detect and also to locate the fault. The relevant mathematical expressions pertaining to the model are presented. The model was simulated using Simulink and the input data from a case study three phase transmission line with the following parameters : wave propagation speed is 299,792 km/s, the sampling time is 10 µs and the total length of the transmission line is 46 Km. During the simulation, different three phase faults are simulated at different locations along the transmission line. The results on the fault location distance and the percentage error in fault location calculation for the different fault locations show that the maximum percentage error is 1.13 % and it occurred for a fault at a distance of 12.2 km. The r-squared value between the actual and the estimated fault location is 0.9993. In all, the results show that the traveling wave method is effective in estimating the location of faults on the case study transmission line.**

Keywords*— *Transmission Line, Fault Location, Fault Detection, Traveling Wave, Power Transmission, Propagation Speed, Three Phase Transmission Line

I. INTRODUCTION

According to experts in the power industry, faults are inevitable on power transmission lines [1,2,3,4]. As such, experts and operators are developing measures to address the faults when they occur. Notably, the location of transmission line fault is needed so that the fault can be corrected and the power system restored to normal operating condition [5,6,7]. In practice, manual determination of the fault location is difficult especially for large power networks covering several kilometers of distance. As such, operators use different methods to assist in the determination of fault location.

Normally, whenever a fault occurs on a transmission line, transient voltage and current will be generated and these waves will traveling both directions from the fault location towards the terminals where the transmission line is connected [11,12]. One method used to determine the fault location is the traveling wave method [13,14,15]. Basically, the traveling wave method works by obtaining the arrival time of the traveling waves and then use the traveling times along with other pertinent information about the transmission line to determine the location of the fault [16,17,18]. Specifically information on the length of the line and wave propagation velocity are used along with the traveling wave arrival times to the line terminals are used to analytically determine the fault location. In this paper, the traveling wave method is used and sample transmission line is modeled in MATHLAB for different fault types and fault locations. The traveling wave method is then employed in the MATHLAB simulations to determine the fault locations.

II. METHODOLOGY

When a fault occurs on a power transmission line, there will be a sudden change in voltage or in the current. This sudden change at the fault point generates high frequency electromagnetic signal which is referred to as traveling wave. From the fault location, the traveling wave will propagate in both directions towards the two ends (terminals) of the line. The time it takes the two traveling waves to reach the end of the terminals are used to determine the fault location. In that case, assuming a lossless transmission line length is d (in km), the travelling wave velocity is denoted as υ (in km/s), the fault occurred at a distance of 'x' km from terminal A of the line, capacitance and inductance per unit length of the line are denoted as "L' and C' and the characteristic impedance of the line is Z_c, then, the voltage and current values are given as [20];

$$\frac{\partial e}{\partial x} = L' \frac{\partial i}{\partial t} \quad (1)$$

$$\frac{\partial i}{\partial x} = L' \frac{\partial e}{\partial t} \quad (2)$$

The solutions to the two differential equations are given as;

$$e(x,t) = e_f(x - vt) + e_r(x + vt) \qquad (3)$$
$$i(x,t) = \frac{e_f}{Z_c}(x - vt) + \frac{e_r}{Z_c}(x + vt) \qquad (4)$$

The time the travelling waves will travel from the fault location to terminal A and terminal B are denoted as τ_A and τ_B respectively. Then, the location of the fault, denoted as x *in* km is determined as follows;

$$x = \frac{d-(\tau_A - \tau_B)v}{2} \qquad (5)$$

Where v is the wave propagation speed which is 299,799 km/sec.)

The prediction percentage error ,$P_e(\%)$ is given as

$$P_e(\%) = \frac{(Actual\ distance\ of\ fault\ location - Predicted\ distance\ of\ fault\ location)100}{Total\ Lenght\ of\ the\ transmission\ line} \qquad (6)$$

III. SIMULATION, RESULTS AND DISCUSSION

A program written in MATLAB syntax was used for the simulation. The dominant frequency was extracted from the transient wave through the use of wavelet transform. Also, the Daubechies wavelet is used both to detect and also to locate the disturbance event. Among the different Daubechies wavelet filter coefficients, the modal signals are decomposed using the Daubechies 4 wavelet filter coefficients [20].

Figure 1 shows that when theDaubechies 4 method was used the disturbance occurred at level one. In Figure 7, S is the input signal (current phase A signal) a1 and d1 are the decomposed residual plots which was passed through the spectral signal to generated the energy with other statistical parameters as shown in Figure 2; the energy values (under the plot of energy against frequency) was then used to determine the fault location via traveling wave method. The same process was done for phase B (in Figure 3 and Figure 4) and for phases (in Figure 5 and Figure 6).

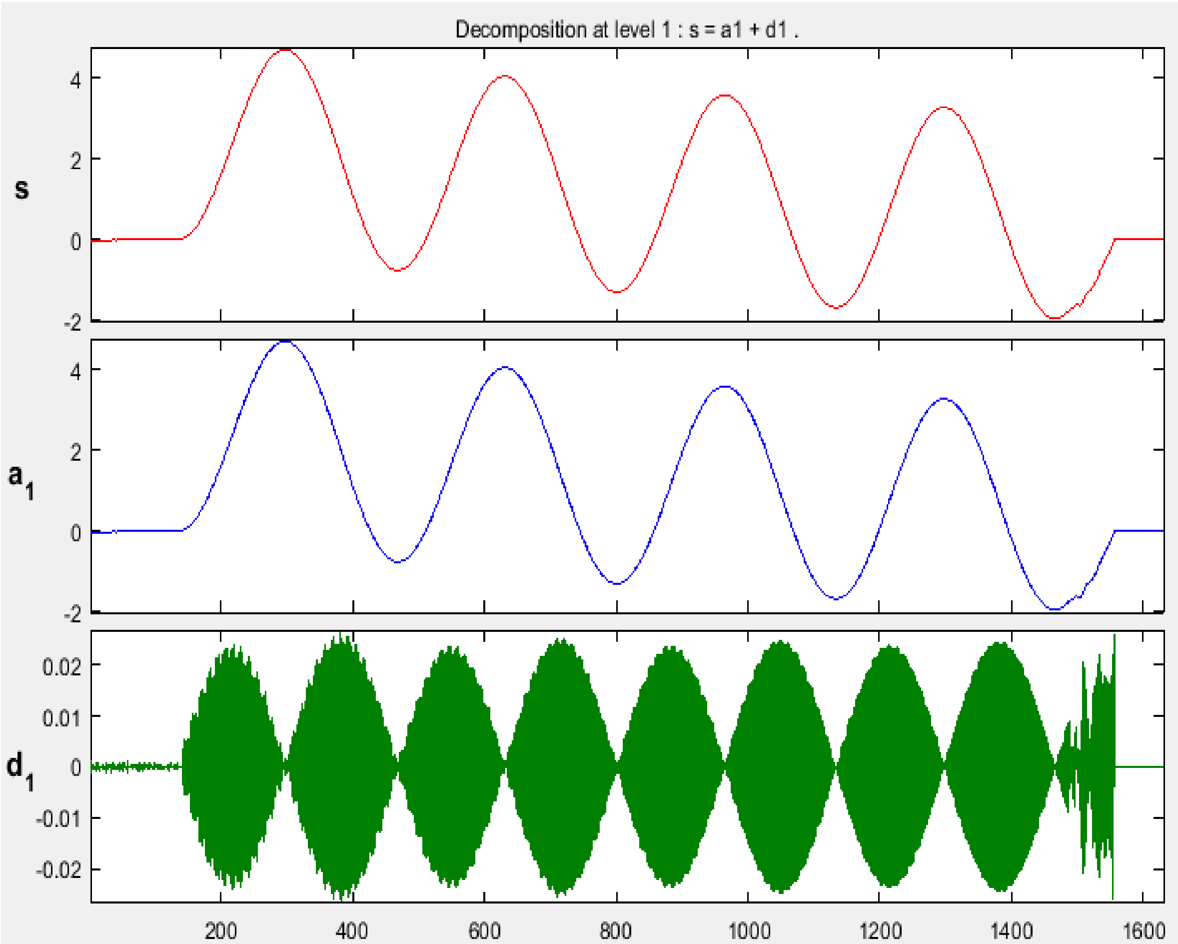

Figure 1; Phase A current Signal

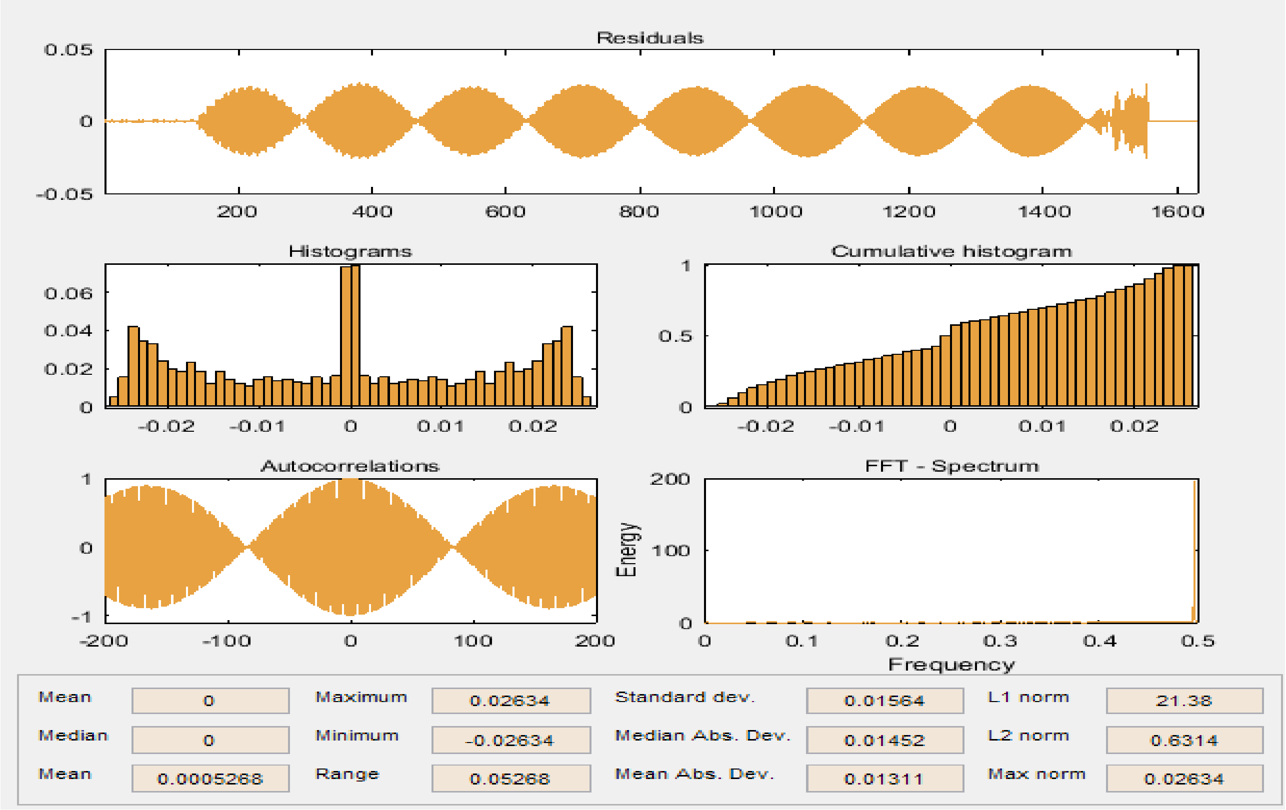

Figure 2; The spectral analysis of the decomposed signal of current of phase A.

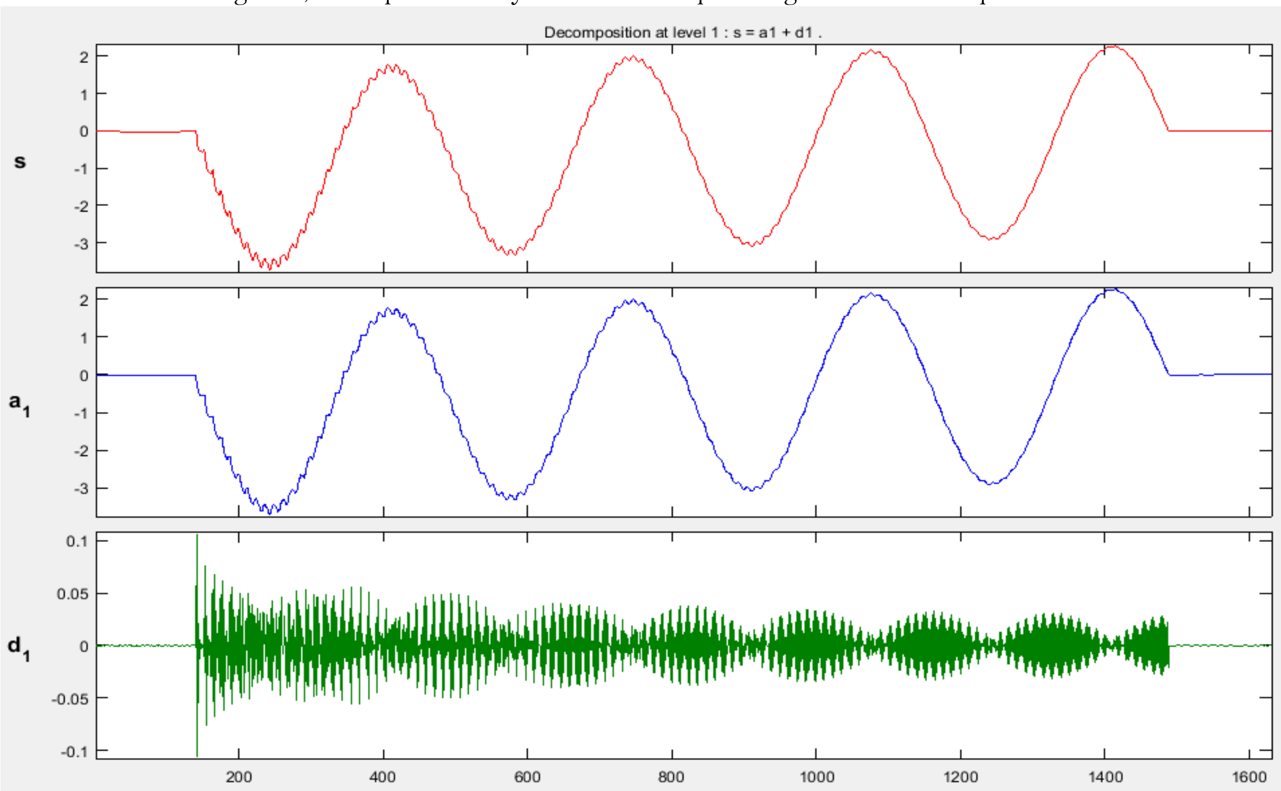

Figure 3: Phase B current Signal

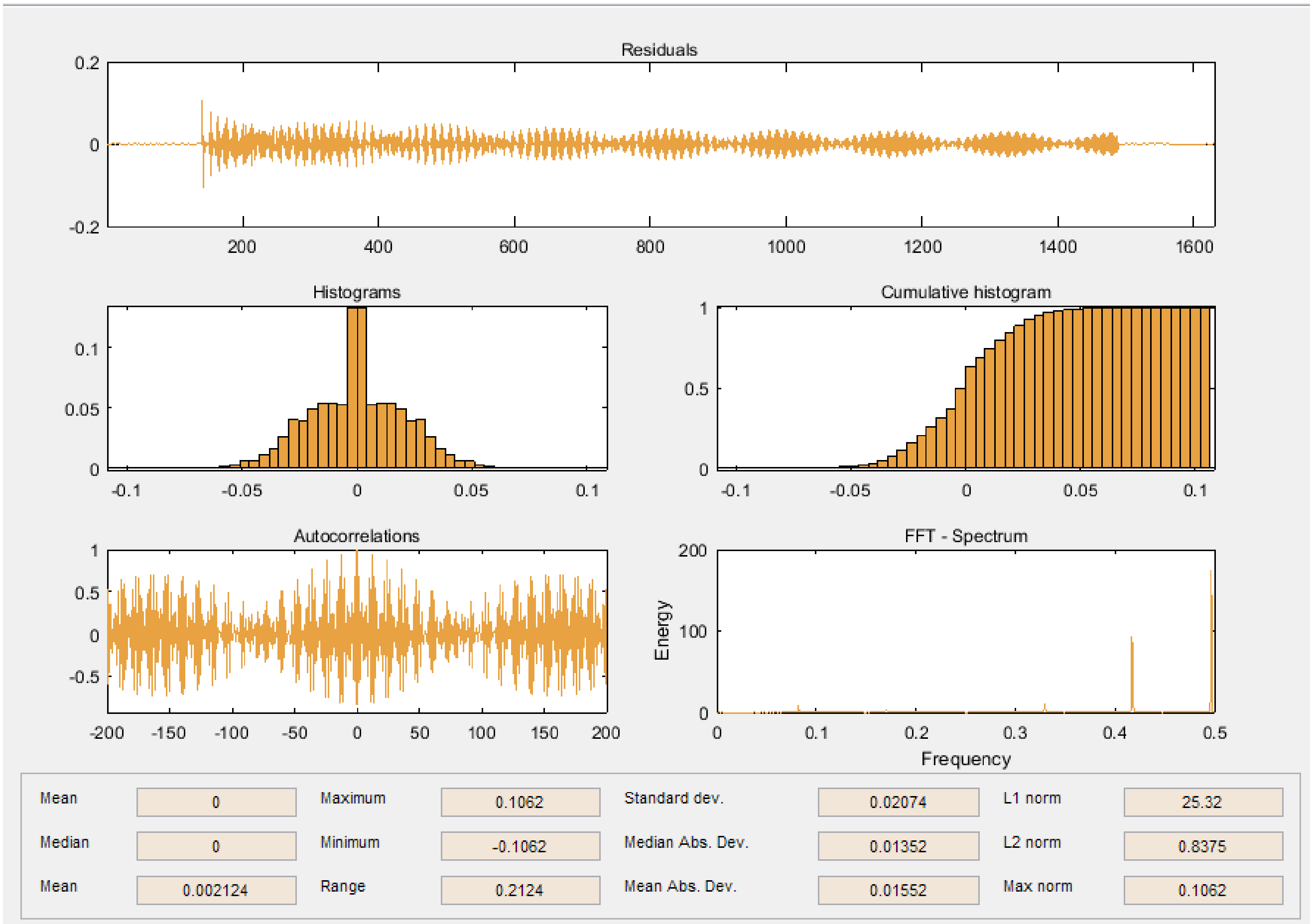

Figure 4; Spectral Analysis of the decomposed signal of Current of Phase B.

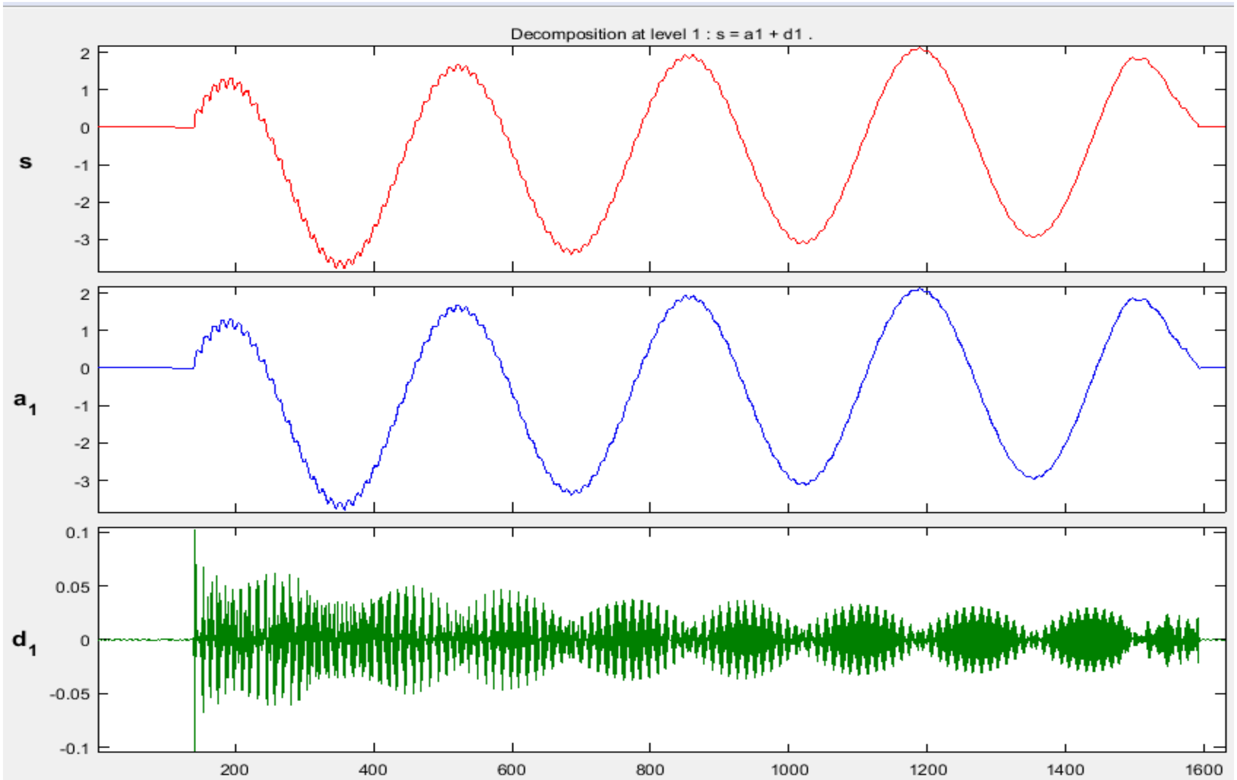

Figure 5: Phase C current Signal

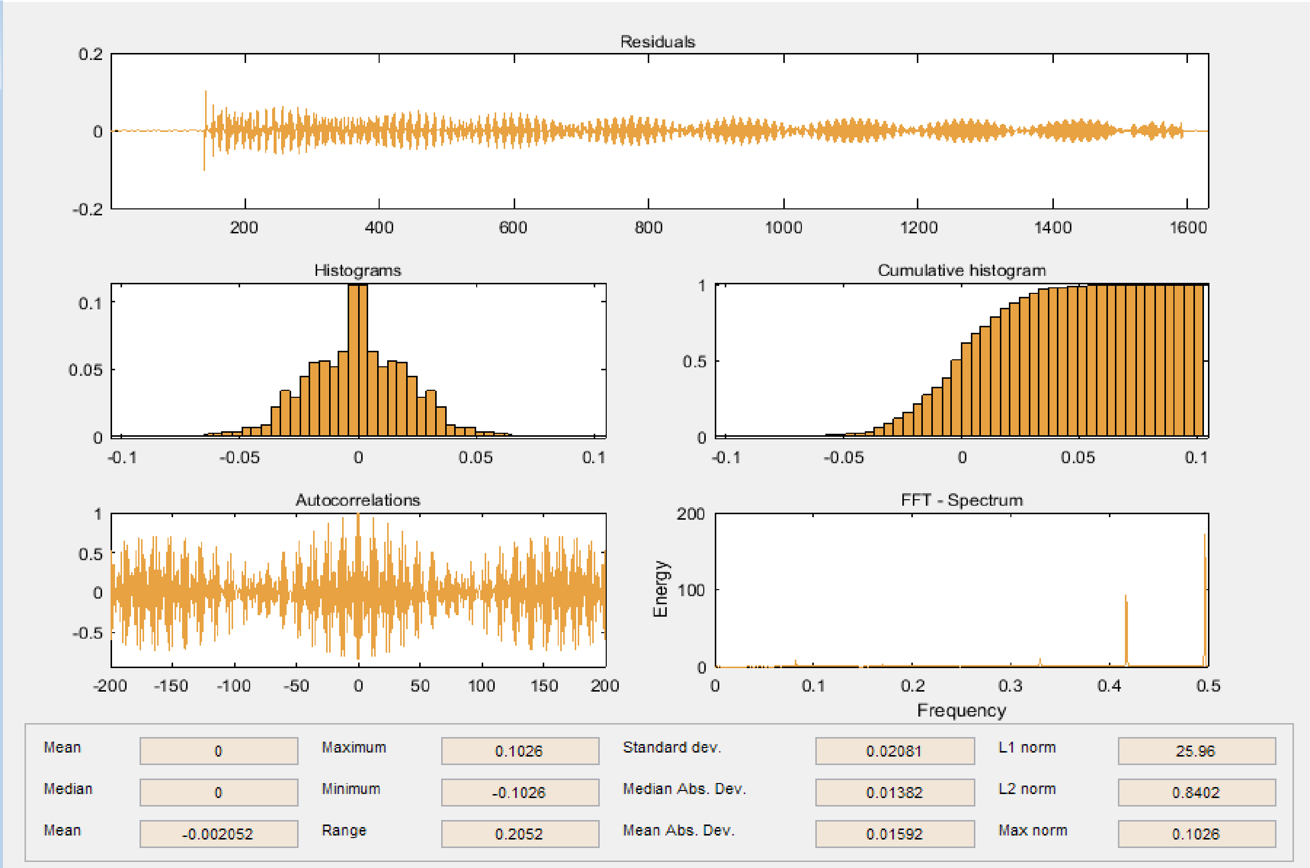

Figure 6: Spectral Analysis of the decomposed signal of Current of Phase C.

During the simulation, different three phase faults are simulated at different locations along the transmission line. The line parameters are:v = 299,792 km/s, the sampling time is 10 μs and the total length (d) of the transmission line is 46 Km. The results of the measured propagation times, τ_A and τ_B for the different fault types and fault location are given in Table 1. In Table 1, the fault location based on traveling wave is calculated using Equitation (5); for the first row, $\tau_A = 1.75\text{ ms} = 0.00175\text{s}$, $\tau_A = 1.85\text{ ms} = 0.00185$, d =46 km and v =299,792 km/s, then ;

$$x = \frac{46 - (0.00175 - 0.00185)299792}{2} = 7.78\text{ km}$$

The prediction percentage error , $P_e(\%)$ is computed from Equation (6) as follows;

$$\boldsymbol{P_e}(\%) = \frac{(8.20-7.78)100}{46} = 0.913\%$$

The results on the fault location distance by the travelling wave method and the percentage error in fault calculation for all the other fault locations are given in Table 1. In all, the maximum percentage error1.13 % and it occurred for a fault at a distance of 12.2 km. The r-squared value between the actual and the estimated fault location is 0.9993.

Table 1: The measured propagation times, τ_A and τ_B for the different fault types and fault location

Actual fault location distance km	τ_A (ms)	τ_B (ms)	**Fault location distance by the travelling wave method (km)**	**Percentage error in fault calculation (%)**
8.20	1.75	1.85	7.78	0.91
12.20	1.30	1.38	11.68	1.13
22.00	0.07	0.07	22.43	-0.93
25.00	0.18	0.17	24.58	0.91
35.50	1.38	1.30	35.00	1.09
r-squared =0.9993				

IV. CONCLUSION

Travelling method of fault location on a transmission line is presented. The method used the propagation time of the high frequency traveling wave created whenever a fault occurs on a transmission line to detect and also locate the fault. The key mathematical expressions pertaining to the model are presented. The model was simulated using Simulink and input data from a case study three phase transmission line. The results show that the traveling wave method is effective in estimating the location of faults on a transmission line.

REFERENCES

[1] Zhou, Y., Xu, G., & Chen, Y. (2012). Fault location in power electrical traction line system. *Energies*, *5*(12), 5002-5018.

[2] Liang, R., Yang, Z., Peng, N., Liu, C., &Zare, F. (2017). Asynchronous fault location in transmission lines considering accurate variation of the ground-mode traveling wave velocity. *Energies*, *10*(12), 1957.

[3] Wang, L. (2016). The fault causes of overhead lines in distribution network. In *MATEC Web of Conferences* (Vol. 61, p. 02017). EDP Sciences.

[4] Esen, V., Oral, B., &Akinci, T. C. (2015). The determination of short circuits and grounding faults in electric power systems using time-frequency analysis. *Journal of Energy in Southern Africa*, *26*(2), 123-132.

[5] Pinto Moreira de Souza, D., da Silva Christo, E., & Rocha Almeida, A. (2017). Location of faults in power transmission lines using the ARIMA method. *Energies*, *10*(10), 1596.

[6] Bouthiba, T. (2004). Fault location in EHV transmission lines using artificial neural networks. *International Journal of Applied mathematics and computer science*, *14*, 69-78.

[7] Sahu, S., & Sharma, A. K. (2013). Detection of fault location in transmission lines using wavelet transform. *Int. J. Eng. Res. Appl*, *3*(2), 149-151.

[8] Liu, K., Liu, T., Shu, H., & Yu, J. (2013). A Study on the Transmission Line Transient Protection Containing Static Synchronous Compensator. *Energy and Power Engineering*, *5*(04), 1192.

[9] Rao, P. S., &Naik, B. B. (2013). Pattern recognition approach for fault identification in power transmission lines. *Signal*, *1*, H1.

[10] Baseer, M. A. (2013). Travelling waves for finding the fault location in transmission lines. *Journal Electrical and Electronic Engineering*, *1*(1), 1-19.

[11] Baseer, M. A. (2013). Travelling waves for finding the fault location in transmission lines. *Journal Electrical and Electronic Engineering*, *1*(1), 1-19.

[12] Ashok, V., Bangarraju, K. G. V. S., & Murthy, V. V. N. (2013). Identification and classification of transmission line faults using wavelet analysis. *ITSI Transactions on Electrical and Electronics Engineering*, *1*(1), 117-122.

[13] Roshni, U., Niranjan, V., Prakash, C. D., &Srinivas, R. (2012). Location of Faults In Transmission Line Using Fast Fourier Transform And Discrete Wavelet Transform In Power Systems. *Undergraduate Academic Research Journal (UARJ)*, *1*(1), 84-86.

[14] De Andrade, L., & De Leão, T. P. (2012). Travelling wave based fault location analysis for transmission lines. In *EPJ Web of Conferences* (Vol. 33, p. 04005). EDP Sciences.

[15] Glik, K., Rasolomampionona, D. D., &Kowalik, R. (2012). Detection, classification and fault location in HV lines using travelling waves. *PrzeglądElektrotechniczny (Electrical Review)*, *88*(1A), 269-275.

[16] Liang, R., Yang, Z., Peng, N., Liu, C., &Zare, F. (2017). Asynchronous fault location in transmission lines considering accurate variation of the ground-mode traveling wave velocity. *Energies*, *10*(12), 1957.

[17] Zhou, C. C., Shu, Q., & Han, X. Y. (2017). A single-phase earth fault location scheme for distribution feeder on the basis of the difference of zero mode traveling waves. *International Transactions on Electrical Energy Systems*, *27*(5), e2298.

[18] Berestycki, J., Harris, S. C., &Kyprianou, A. E. (2011). Traveling waves and homogeneous fragmentation. *The Annals of Applied Probability*, *21*(5), 1749-1794.

[19] Desai, M. A. A. R. S. (2014). Using Wavelet for Finding Fault Place and Neural Network for Types of Facult in Transmission Lines. *International Journal of Engineering Research and General Science*, *2*(4).

[20] Ayyagari, SuhaasBhargava, "ARTIFICIAL NEURAL NETWORK BASED FAULT LOCATION FOR TRANSMISSION LINES"(2011).University of Kentucky Master's Theses. 657. Available at : https://uknowledge.uky.edu/cgi/viewcontent.cgi?article=1656&context=gradschool_theses Accessed on 19th November 2018