# A Novel Method to Identify the Fault in Transmission Line Using Discrete Wavelet Transform (DWT)

**Dr.M.Pandi Maharajan [1], Dr. J. Barsana Banu [2], Dr.S.Rajalingam [3], Dr.P.Kannan [4], Dr.M.M.Vijay [5], Dr.K.Malarkodi [6]**

[1]Associate Professor, Department of EEE, Nadar Saraswathi College of Engineering & Technology, Vadapudupatti, Theni- 625531, Tamil Nadu, India, pandimaha.net@gmail.com

[2]Assistant Professor, Department of EEE, SBM College of Engineering and Technology, Dindugal 624005, India, Tamil Nadu, India, barsanajamal@gmail.com

[3] Associate Professor, Department of EEE, Saveetha Engineering College, Chennai-602105, Tamil Nadu, India, rajalingams@saveetha.ac.in

[4]Assistant Professor, Department of ECE, Francis Xavier Engineering College, Tirunelveli-627426, Tamil Nadu, India, kannamuthu1987@gmail.com

[5]Assistant Professor, Department of ECE, SCAD College of Engineering and Technology, Cheranmahadevi, Tirunelveli-627414, Tamil Nadu, India, mmvijay.ece@gmail.com

[6] Assistant Professor, Department of ECE, School of Engineering, Saveetha University, Chennai-602105, Tamil Nadu, India, malarkodiharini@gmail.com

**doi: 10.48047/ecb/2023.12.si4.860**

**Abstract:-**

Transmission of energy via overhead transmission lines is a common way for power distribution in this critical service. The location of the fault must be determined in order to recover from the failure. While there is some human error in defect identification, technology-assisted solutions can save time and costs. Some potential fault detection methodologies for effective detection failure in power transmission are proposed in this study. This project is about designing a discrete relay that detects when the input value exceeds the reference value set in the relay and sends a trip signal to the circuit breaker. The tripping action is mostly determined by the voltage and current waveforms obtained during the malfunction at the relay location. Wavelet analysis, a mathematical method for signal analysis, is used to detect and classify the type of transmission line fault. During a fault, the Discrete Wavelet Transform (DWT) is utilized to analyse the current waveform. Fault signals are generated using MATLAB/Simulation. The simulation results show that the suggested fault detection indicator performs well and is simple to implement for computer relaying applications.

**Keyword:**Discrete wavelet, Dual channel 5V Relay module, Temperature module 5V Adopter circuit

## 1. INTRODUCTION

In this study, we solve a big problem with our idea. These days, when three phase transmission line first wire touches second wire, that fault affects the substation and sometimes the substation transformer fused, so we make a system for transmission line all type of fault, for example, in transmission any fault Line to Line fault or Line to ground fault or fire fault then that time automatic transmission line electricity power cut so our substation safe by that faults The wavelet transform typically employs both analysis and synthesis in tandem. For waveform reconstruction, synthesis is utilized; the original signal is decomposed into its constituent wavelet sub-bands or levels.

Each of these levels reflects a portion of the original signal that was present at the time of detection of a fault-generated high frequency transient wave at one end of the line. The idea of Wavelet Entropy is applicable not only to transitory signal feature analysis, but also to fault-specific frequency bands. Individual frequency bands are spaced logarithmically rather than evenly as in Fourier analysis. The decomposed signals have a strong time-frequency localization property, which is one of the wavelet transform's advantages, and so the resulting signal may be analysed in both time and frequency domains. The technique based on the wavelet transform of fault transients is provided in this work. Wavelet transform has some unique features that make it suitable for the specific application in that it maps a given function from time domain to time- scaling domain, unlike the function used in Fourier analysis, the wavelet is localized not only in frequency but also in time, allowing the time of occurrence of the disturbance to be detected.

## 2. NOVELTY OF THE WORK

The method used here for detecting and classifying all forms of faults that occur on transmission lines. When there is a problem on the line, the line currents at the relay point have non-periodic transients and were thus used for the wavelet analysis. Power quality, power system transients, power system protection, condition monitoring, partial discharge, and transformer are all areas where wavelet transform is used in power systems. The wavelet transforms, on the other hand, are primarily concerned with power quality and power system protection. The Fourier Transform approach was compared to the Wavelet transform method for detecting, classifying, and locating transmission line faults.

## 3. PROPOSED METHOD

### 3.1. Block Diagram

Fig.1 shows the proposed block diagram of the Discrete Wavelet Transform-based technique is employed, which includes wavelet decomposition of the signal and normal system operation as a reference analysis. The severity of the disturbance is determined by the type of defect and is expressed by wavelet. It was proposed to use a power system relaying relevant domain and perform wavelet decomposition, taking the maximum value of the approximation coefficient as the base value and comparing with the decomposed current to clearly determine the type of failure. A new technique based on travelling wave for problem location on line with branches is provided, as is transmission line diagnosis. Power quality challenges such as voltage sag, swell, temporary interruption, and oscillatory transient were presented utilizing Morlet wavelet application to resonant grounded power distribution network.

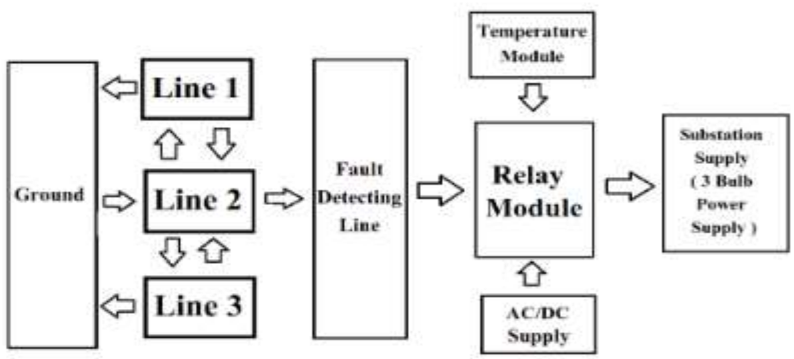


Fig. 1. Proposed Block Diagram

### 3.2. Circuit Diagram

Figure 2 depicts the method employed here for identifying and classifying all types of transmission line failures. When there is a problem on the line, the line currents at the relay point exhibit non-periodic transients, which were utilised in the wavelet analysis. Wavelet transform is used in power systems to improve power quality, power system transients, power system protection, condition monitoring, partial discharge, and transformers. In contrast, wavelet transformations are primarily concerned with power quality and power system protection. For identifying, classifying, and locating transmission line faults, the Fourier Transform method was compared to the Wavelet transform method.

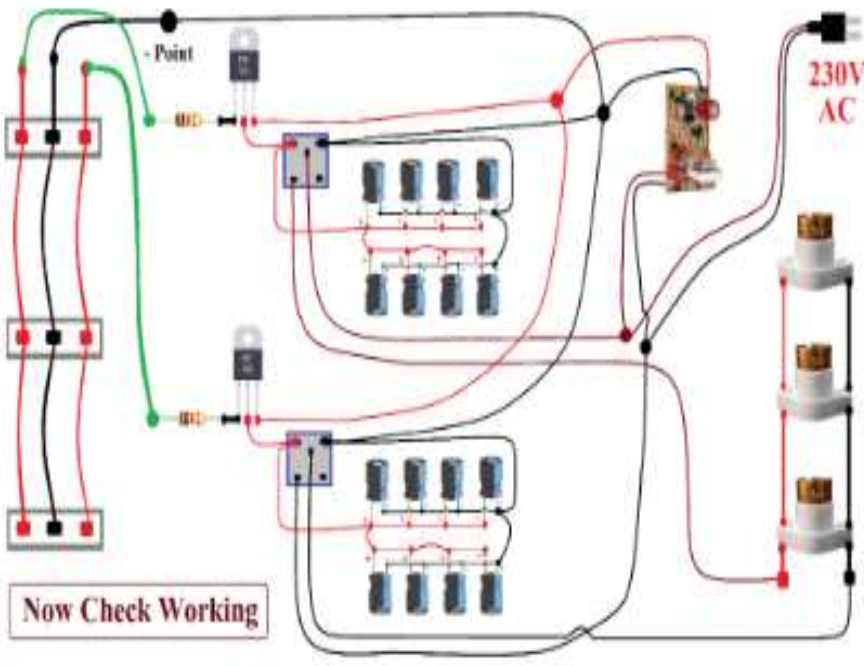


Fig. 2. Connection diagram

## 4. COMPONENTS USED

Table 1. Shows the various components used in the different module is given by

**Table 1. Components used in the system**

| S.NO | NAME OF THE COMPONENTS |
|---|---|
| 1. | Dual channel 5V Relay Modue / Relay |
| 2. | Temperature module |
| 3. | Capacitors25v/1000uf |
| 4. | LED bulb |
| 5. | Resistor |
| 6. | 5V adopter circuit |
| 7. | Steel plate |
| 8. | Jumber wire |
| 9. | PCB |
| 10. | Line filter |
| 11. | AC bulb/holder |
| 12. | Hard cover wire |

### 4.1. Dual Channel 5V Relay Module

Fig.3. shows the 2-Channel 5V Relay Module is a relay interface board that can be controlled directly by a variety of microcontrollers including Arduino, AVR, PIC, and ARM. The relay is controlled by a low level triggered control signal (3.3-5VDC). When the relay is triggered, the typically open or normally closed contacts are activated.

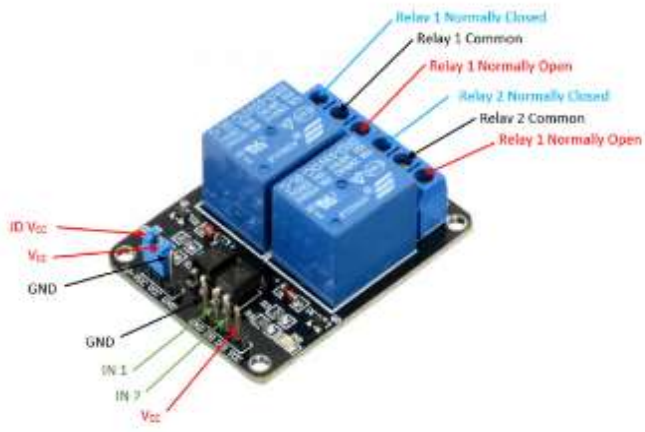


Fig. 3. Dual channel Relay

### 4.2. Temperature Module

Fig. 4. Shows the Temperature Module allows for accurate temperature monitoring over an IP network. It can be used to monitor and adjust the temperature of the environment. It can connect up to four digital temperature sensors and has two internal relays that can be controlled independently.

Fig.. 4. Temperature Module

## 5. DISCRETE WAVELET

### 5.1 Working

This project is entirely based on the relay system, and the relay is an electrical switch, so when the relay module receives a signal, the relay cuts the electricity power, thus the entire project is based on the relay principle. The relay is the device that opens or closes the contacts to cause the other electric control to operate. It identifies an unacceptable or unsatisfactory condition in a designated area and instructs the circuit breaker to disconnect the affected region. As a result, the system is protected from damage. To evaluate the 3 phase fault analysis, the term employs step-down transformers to handle the complete circuit under low voltage conditions of 12v only. The primaries of three transformers are linked in star configuration to a three-phase power supply, while the secondary is also connected in star configuration. The other set of three transformers has its primary linked in star to three phases and its secondary connected in delta.

Transform Wavelet theory is the branch of mathematics concerned with developing a model for non-stationary signals by employing a set of wavelet-like components. Since its introduction, it has been a well-known useful tool, particularly in signal and image processing. Because CWT is computed by changing the scale of the analysis window, shifting the window in time, multiplying the signal, and the information of interest is often a combination of features that are well localised temporally or spatially, the DWT is easier to implement. This necessitates the employment of adequate analysis methodologies, which are adaptable in terms of signal handling in terms of time-frequency localisation. Since Fourier's time, frequency analysis has been widely used; nevertheless, frequency analysis is not well suited for transient analysis since Fourier analysis is based on sine and cosine functions, which are not transients [2].

In the examination of transients, this results in a relatively broad frequency spectrum. Fourier approaches cannot produce adequate localization of a transient signal in both time and frequency at the same time. The key advantage of WT over Fourier Transform is that the size of the analysis window varies with frequency analysis. As a result, WT can provide a better compromise in terms of localisation. The wavelet transform decomposes transients into a sequence of wavelet components [4]. Each of which corresponds to a time domain signal spanning an octave frequency band and carrying more detailed information [11].

These wavelet components appear to be beneficial for identifying, localizing, and classifying transitory sources. As a result, the wavelet transform provides a viable and practical method for analysing power system transients. Figure 2 depicts the high and low frequency splitting of a transient signal. The Mallats algorithm is commonly used to construct the discrete wavelet transform (DWT), and its formulation is related to filter bank theory. This technique is significantly responsible for the wavelet transform, which may be easily performed by employing only two filters, one high pass (HP) and one low pass (LP) at level 1. (k). The results are down sampled by a factor of two, and the same two filters are applied to the output of the previous stage's low pass filter.

The wavelet function (mother wavelet) is used to construct the high pass filter, which measures the details in a given input [3]. In contrast, the low pass filter produces a smoothed version of the input signal and is produced from a scaling function connected with the mother wavelet. The concept is depicted in Figure, which is mathematically stated as

$$Y_{high}[k] = x[n] * H[2k - n] \quad \ldots\ldots\ldots (1)$$

$$Y_{low}[k] = x[n] * L[2k - n] \quad \ldots\ldots\ldots (2)$$

The findings of this analysis are obtained by employing the db4 as the mother wavelet for signal processing. The wavelet energy is calculated as the sum of the squares of the detailed wavelet transform coefficients. The energy of the wavelet coefficient varies across different scales depending on the input signals, with the approximation coefficient at the first level having much more energy than the other coefficients at the same level of the decomposition tree-but because the faulty signals have high frequency dc components and harmonics, it is more distinctive to use energy of the decomposition tree. The DWT's core method is not restricted to dyadic length and is based on a simple technique of down sampling and convolution. The discrete wavelet transform framework is depicted in Figure 3. The signal is down sampled by DWT into detailed and approximate coefficients. Samples are broken down into detailed and estimated coefficients once more.

The extension of DWT used in this work is Daubechies (db). This method assumes that signals can be recovered outside their original support by symmetric boundary value although Symmetrization has the disadvantage of artificially creating discontinuities of the first derivative at the border which has a very small effect in calculation so the detail coefficients figured here show the signal end effects are present, but the discontinuities are very well cleared detected. The fundamental voltage and current phasor's are computed using a Discrete Fourier Transform-based technique that accounts for exponentially fading DC offsets. Using a standard transmission line model, the scheme is evaluated for various sorts of faults with differing fault incidence angles and fault resistances. DFT has various drawbacks that are mitigated by employing DWT [7]. In the MATLAB Sim power system environment, the system is modelled. The results show that the proposed technique is dependable, rapid, and extremely accurate.[17]

**5.2. Discrete wavelet transform for fault analysis**

A.Entropy calculation and wavelet transformation the transient components contain a lot of defect information. As a result, it can be utilised to detect a malfunction or irregularity in equipment or the power supply. It can also be utilised to deal with the problem and determine what caused it. The reliability of the electricity system will be greatly improved as a result. High frequency and instant break are two features of transient signals. Wavelet transform can expose characteristics of data that other signal analysis techniques ignore, and it can be used to analyse electric transient signals. Typically, the wavelet transform of a transitory signal is expressed using a fast multi revolution decomposition technique that uses orthogonal wavelet bases to breakdown the signal into components of different scales. It is equivalent to filtering the signal recursively with a high pass and low pass filter pair. [15]

The approximations are the signal's high scale, low frequency components obtained by filtering the signal with a low pass filter. The details are the signal's low scale, high frequency components obtained by filtering the signal with a high pass filter. These two filters have the same band width. The wavelet decomposition of a signal into high frequency detailed coefficients and low frequency approximation coefficients are shown in Figure 5.

The sample frequency is dropped by half after each stage of breakdown. Then, deconstruct the low-pass filter outputs (approximations) recursively to obtain the components of the following stage.[16] A discrete signal x (n) contains a high-frequency component coefficient Dj (k) and a low-frequency component coefficient Aj after being rapidly converted at instant k and scale j. The frequency spectrum of the information contained in signal components Dj (k) and Aj (k) acquired during reconstruction is shown below.

$$Dj\,(k) : \left[2^{-(j+1)} fs,\ 2^{-j} fs\right] \text{........ (3)}$$

$$Aj\,(k) : \left[0, 2^{-(j+1)} fs\right] \text{........ (4)}$$

The original signal sequence x (n) can be represented by the sum of all components as follows, where j= (1, 2, 3.....m) and fs is the sampling frequency.

$$x\,(n) = D1\,(n) + A1\,(n) = D1\,(n) + D2\,(n) + D3\,(n) + A3\,(n)\ldots\ (5)$$

$$\text{i.e.; } x\,(n) = D1\,(n) + D2\,(n) + \ldots\ldots + DJ\,(n) + AJ\,(n)\ldots\ldots\ (6)$$

Various wavelet entropy measures were defined here; the non-normalized Shannon entropy will be used. The definition of non-normalized Shannon entropy is as follows.

$$Ej = -\sum Ejk\ logEjk \text{ .......... (7)}$$

**Where Ejk is the wavelet energy spectrum at scale j and instant k and it is defined as follows.**

$$Ejk = (Djk)^2 \text{ ........... (8)}$$

Wavelet decomposition and entropy calculations are performed on each phase to identify faults, and the presence of a ground fault can be discovered using the wavelet transform and entropy calculation on zero sequence currents. The modal transformation divides three-phase signals in a linked network into three uncoupled modal components: 1) the ground mode, 2) aerial mode-1, and 3) aerial mode-2. To translate quantities from phase domain to modal domain in non-transposed multiphase systems, an eigenvector-based frequency dependent transformation matrix is required. A frequency independent, real transformation matrix, such as the Clarke transformation, can be used to create balanced and properly transposed lines. Despite the fact that typical distribution systems do not meet the aforementioned characteristics, a frequency-independent real transformation matrix can be utilized to create relatively decoupled signals that can be useful in transient-based fault identification.[12]

**5.3. Detection Methodology for Wavelet**
**5.3.1. Flow Chart**

Fig.5. Shows the flow chart for wavelet transform is useful in analysing transients associated with line faults or switching activities since it allows the use of variable window length. Unlike the Fourier transform, wavelet analysis may analyse a localised portion of a signal and disclose features of data such as break points, discontinuities, and so on. Thus, the wavelet transform is effective in detecting the onset of a defect and realizing non stationary signals with both low and high frequency components. Details of the first decomposition level of the measured current signal can be used to detect faults using haar and db1 wavelets. This category includes high frequencies linked with problems. The norm of the DWT coefficient of these basic frequency components can be used to diagnose a fault. The lines are considered healthy if the norm of the DWT coefficient for line current is less than a specific threshold. The disturbance is chosen when the norm of one or more current DWR coefficients exceeds the threshold value. For fault categorization, a six-level decomposition is used.[13]

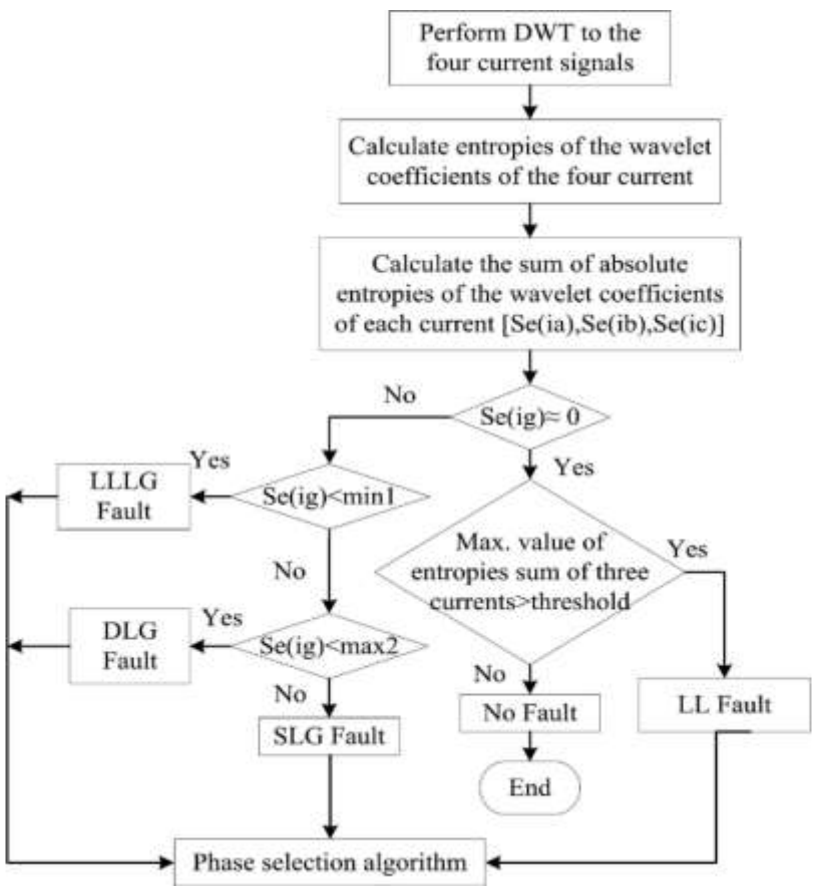


Fig. 5. Flow chart

## 6. USAGE OF WAVELET

### 6.1. wavelet diagram

Figure 6 depicts the Wavelet theory, which is the mathematics that deals with creating a model for non-stationary signals by employing a set of components that resemble little waves called wavelets. Since its introduction, it has been a well-known useful tool, particularly in signal and image processing. Because CWT is computed by changing the scale of the analysis window, shifting the window in time, multiplying the signal, and the information of interest is often a combination of features that are well localised temporally or spatially, the DWT is easier to implement. This necessitates the adoption of analysis methods that are sufficiently diverse to handle signals in terms of time-frequency localisation.

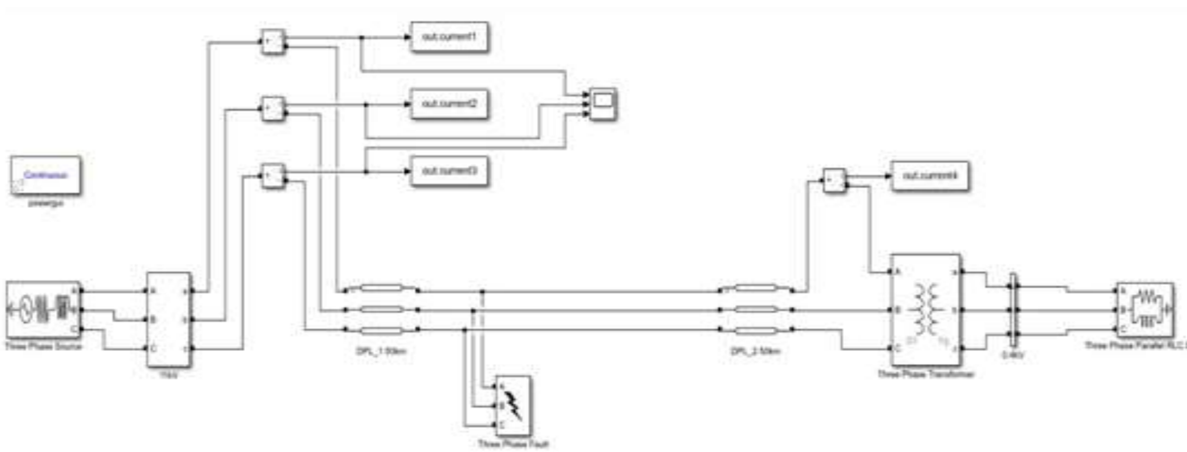


Fig. 6. Wavelet

### 6.2. Components of wavelet

Figure 7 depicts each stage of the wavelet transform, with the signal divided into two components, vi and wi. Wavelet coefficients are high-frequency component elements. The smallest scale, i0, corresponds to the circumstance where a low-frequency component is the sole element.[14]

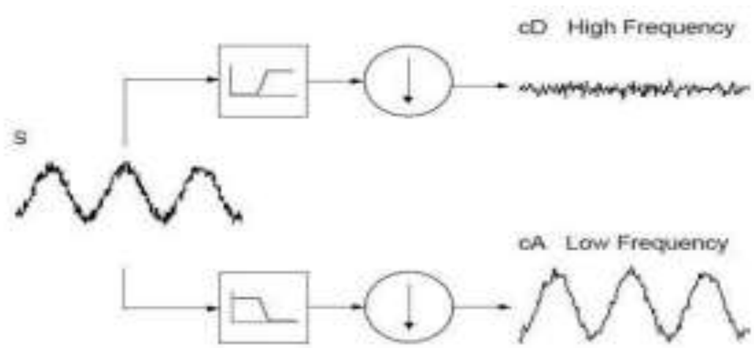


Fig. 7. Components of Wavelet

### 6.3. Results and Discussion (Current & Voltage)

Fig 8. , fig. 9. & fig. 10. Are shows the results of Wavelet Analysis is a strong data compression, processing, and analysis technique. It can be used to extract relevant information from a wide range of data formats, including pictures and audio signals in physics, chemistry, and biology, as well as high-frequency time series in economics and finance.

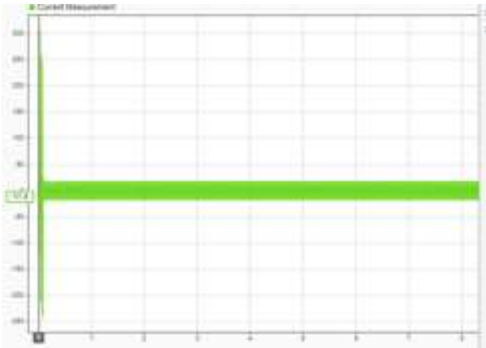

Fig. 8. Current

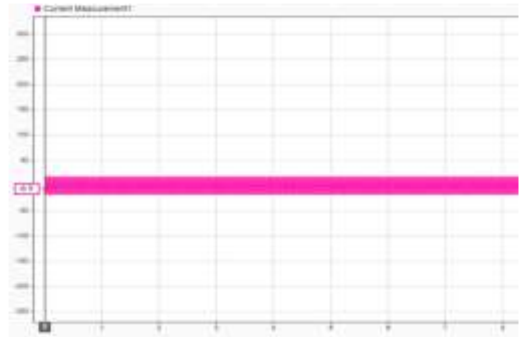

Fig. 9. Volatge

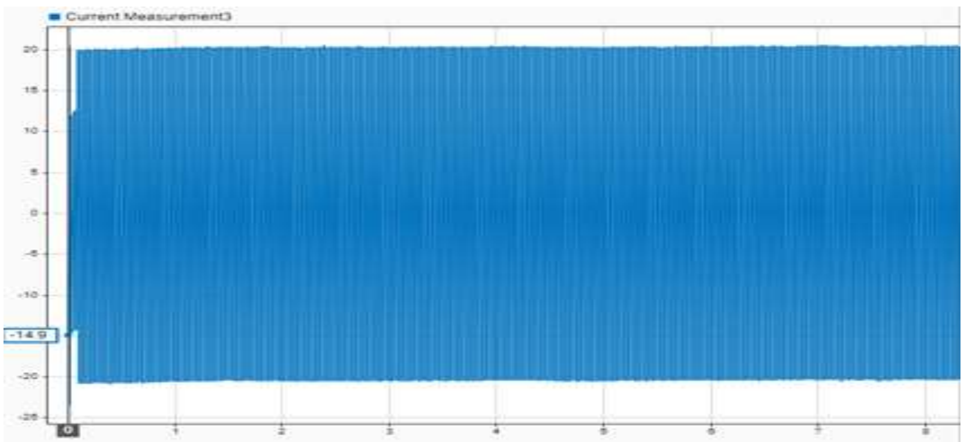


Fig. 10. Voltage and Current

### 6.4. Advantage of wavelet

One of the primary benefits of wavelets is that they allow for simultaneous localisation in the time and frequency domains. The second major advantage of wavelets is that they are computationally very quick when utilising rapid wavelet transform. The ability of wavelets to isolate small details in a signal is a significant advantage.

### 6.5. Disadvantage of wavelet

It gets computationally intensive for fine analysis. The discrete wavelet transform (comp. efficient) is less efficient and natural in its discretization. It takes some effort to invest in wavelets in order to be able to select the appropriate ones for a certain purpose and implement them correctly.

### 6.6. Applications of wavelet

FT, on the other hand, fails for non-stationary signals. In this case, wavelet transforms are most useful for handling no stationary signals. Wavelets are being investigated as a viable instrument to offer concrete results in applications that require both time and frequency information at the same time.

## 7. CONCLUSION

This research provides a wavelet transform-based approach for transmission line fault classification, which is a simple and effective wavelet-based fault detection approach. The Haar and db1 wavelets can identify an abrupt shift in the current component of a fault current in a power system. The fault detection indicator can also perform faulted phase selection. The simulation studies show that the suggested algorithm is viable for transmission line protection to faults such as L-G, L-L, L-L-G, L-L-L, and L-L-L in various locations.

## REFERENCES:

[1] A Yadav, A Swetapadma. Fault Analysis in Three phase Transmission lines Using K-Nearest Neighbor Algorithm, AECC (ICAECC), 2014, 1-5

[2] J Khodaparast, M Khederzadeh. Three phase Fault Detection during Power swing by Transient Motor,IEEE, 30 (5), 2015, 2558-2565

[3] K Saranya, C Muniraj. Separation of Transmission line Insulator Flashover from a 3 phase Fault using Synchronous Measurements for a Smart Grid, IEEE, 2016. DOI: 10.1109/ICEETS.2016.7583806 [4] WP Davis, Analysis Of Faults In Overhead Transmission Lines, Dept. of EEE, California State University, MS Thesis, 2012

[4] A.Ngaopitakkal Pongchaisrikul, A.Kundakorn ,"Analysis of characteristics of simultaneous faults in electrical power system using wavelet transform in Proc" IEEE International Conf. on Sustainable Energy Technologies pp.249-252,2008.

[5] T. B. Littler and d. J. Morrow, A.Kundakorn", Wavelets for the Analysis and Compression of Power System Disturbances", IEEE International Conf. on Sustainable Energy Technologies Transactions on Power Delivery, vol. 14, pp. 358-364, Apr. 1999.

[6] D. Das, N.K. Singh and A.K Singh, A.Kundakorn, "A Comparison of Fourier Transform and Wavelet Transform Methods for Detection and Classification of Faults on Transmission Lines", IEEE Power India Conference, New Delhi Transactions on Power Delivery, Vol. 23, No. 4, October 2008

[7] N. Perera, A. D. Rajapakse and T. E. Buchholzer,"Isolation of Faults in Distribution Networks with Distributed Generators", IEEE Transactions on Power Delivery Vol. 23, No. 4, October 2007.

[8] Zwe-Lee Gaing,"Wavelet-Based Neural Network for Power Disturbance Recognition and Classification", IEEE Transactions on Power Delivery vol. 19, No. 4, pp 1560-1568, October 2004.

[9] Kim C.H., Aggarwal,"Wavelet transforms in power systems", IET Power Engineering Journal vol. 15, pp. 193-200, Aug. 2009.

[10] O.A.S Youssef,"Fault Classification Based on Wavelet Transform", IEEE TD conference. Atlanta, GA Oct. 28-Nov 2001.

[11] A.H. Osman, O.P. Malik, "Protection of Parallel Transmission Lines using Wavelet Transform", IEEE Transactions on power delivery vol.19 no.1, pp 49-55, 2004.

[12] Abdollahi A., Seyedtabaii S.,"Transmission line fault location estimation by fourier and wavelet transforms using ANN", International power engineering and optimization conference pp 23-24, June 2010.

[13] Biswarup, Das and Vittal, Reddy J,"Fuzzy logic based fault classification scheme for digital distance protection", IEEE Transactions on Power Delivery vol. 20, No.20 pp. 609-616, April 2005.

[14] MATLAB/SIMULINK Toolbox, Wavelet Transform, Online. http://www.mathworks.com

[15] Ravindran R, Sathiasamuel CR, Ramasamy P, Balasubramanian K. MSVM-based hybrid energy-fed quasi-Z-source cascaded H-bridge inverter for grid-connected system. Int Trans Electr Energ Syst. 2021;e13139. doi:10.1002/2050-7038.13139

[16] R. Ramkmar and A. A. Vikram, "Wind energy based asymmetrical half bridge flyback converter for BLDC motor," 2017 Third International Conference on Science Technology Engineering & Management (ICONSTEM), Chennai, 2017, pp. 605-610, doi: 10.1109/ICONSTEM.2017.8261394

[17] S. Sathish Kumar, R. Ramkumar, S. Sivarajeswari, D. Ramya, T. Subburaj, Martin Sankoh, "Performance Enhancement of a Three Phase Boost-Cascaded Fifteen Level Inverter Using the PI Controller", Mathematical Problems in Engineering, vol. 2022, Article ID 3888571, 17 pages, 2022. https://doi.org/10.1155/2022/3888571