Wavelet Entropy Energy Based Distance Protection of Transmission Line

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Abstract

In order to avoid economic losses, power utility companies have been attempting to discover and locate three-phase transmission line problems as quickly as possible. Over the last few decades, power system protection technology has progressed from electromechanical to solid-state and processor-based intelligent devices.

Using multiresolution analysis, the Wavelet transform (WT) can divide signals into multiple frequency bands (MRA). It may be used to identify faults and calculate the phasors of voltage and current signals, both of which are necessary for transmission line distance protection. This study presents a Digital Transmission Line Remote Protection Scheme based on the analysis of the measured voltage and current signals at the relay position using WT and MRA. The system was tested experimentally and by both computer simulation. Tests included solid ground defects, phase defects, high impedance and non-linear ground defects and lines.

Keywords: Traveling waves · Discrete wavelet transform (DWT) · Fault classifications · Fault distance · MRA · EHV/UHV

Introduction

In the present era, the facility system is being deregulated, across the world , to satisfy increasing electricity demand also to extend economic efficiency. In deregulated envi- ronment, to satisfy the increasing electricity demand, the transmission lines are carrying power at their maximum rat- ing. an outsized amount of current during unavoidable events like faults on transmission lines damages the electrical equip- ment. Thus, to attenuate equipment damage and restore the availability at the earliest, the abnormalities should be sensed, located, classified, and isolated from the system as quickly as possible. at the present, agile and accurate cable protection is feasible due to the industrial revolution. in protection philosophy [1]. a couple of such protection philosophies designed for enhancing protection system reliability are discussed below.

Liao [2] has analyzed the performance of various fault location algorithms, like the impedance-based algo- rithm (IBA), compensation-based algorithm (CBA), lumped, and distributed parameter line model-based algorithms. it's been concluded that IBA is more computationally effi- cient but less accurate than CBA, lumped, and distributed parameter line model-based algorithms. to enhance the fault location estimation further, Liao [3] has proposed two algorithms: iterative and non-iterative algorithm. the foremost important contribution of the algorithms is that the calcula- tion of the fault distance isn't influenced by the variance of the cable parameters. However, [2, 3] needs spe- cific algorithms under specific fault conditions for accurate fault location. In [4], a two-terminal data-based novel numer- ical algorithm has been proposed for fault location. during this work, the character and site of a fault are determined using the smallest amount error squares technique. The advantage of this algo- rithm is that for single-line to ground fault detection it doesn't need zero-sequence resistance. However, the proposed algorithm was designed specifically for detecting only the foremost common line to ground faults. Further, to reinforce the fault analysis accuracy, Wavelet-Multi Resolution Analysis (WT-MRA) is being employed as WTs can extract the foremost utilitarian features of the signal at different frequency bands with different resolutions [5]. In [6, 7], a frequency domain methodology supported WT–MRA has been proposed for cable fault analysis. These methodologies have used higher level detail coefficients for fault detection and classification in doubly fed transmission lines of 300 km long. Further, in [8] a maximum overlap discrete wavelet trans- forms (MO-DWT) has been employed for fault analysis. The proposed methods have employed wavelet coefficient ener- gies of MO-DWT for detection and classification of faults. However, the algorithm has been confined to fault detection and classification only. The algorithm [9] has used one end current signals for fault classification and therefore the methodology may fail to classify double line to ground faults (RYG, YBG and BRG).

Most of the research works proposed are supported the impedance value [2] also as on the features extracted from filtered complex post-fault signals [3–9]. In contradic- tion, the traveling wave-based techniques are agile, accurate

[10] and wish only short window data [11]. Liu et al. [12] have proposed a wave protection to reinforce relia- bility of the protection system. during this work, the direction of the fault is decided using the directional traveling waves energy ratios. However, the performance could also be suffering from initial fault angle. Wang et al. [13] designed ultra-high wave protection technique. during this work, empirical mode decomposition-based polarity comparison principle is used for cable protection. However, the empirical mode decomposition of a sign requires a group of pre-fixed filters supported the selection of the mother wavelet. Liang et al. [14] have proposed a fault location algorithm using the correlation function-based wave . during this algorithm, a comparison between spline WT and Harr WT has shown and justifies that the spline WT is acceptable and generates the edge-enhanced WT for the wave signal because it's better frequency response. In [15], a fault location algorithm supported traveling waves for teed circuits has been proposed. The effect of the presence of series capacitors and fault resistance on the proposed algorithm is negligible. However, the accuracy of those methods is influenced by the choice of the frequency. Validation of the research works [2–15] is confined to simulation environment only.

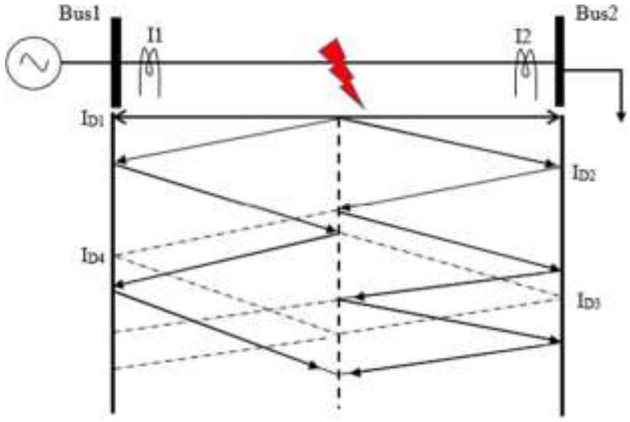
The following are the decent attempts made by different researchers to validate the real-time applicability of their research works using laboratory model. Ananthan et al. [16] have designed a numerical protection algorithm using DWT multi-resolution analysis (MRA) of current signals. The pro- posed algorithm detects and classifies a fault using dominant harmonic components of current signals. The performance of the algorithm has been validated on a scale down labo- ratory model of EHV transmission lines for fault detection and discrimination only. However, estimation of fault loca- tion not discussed which may be a vital task of a cable protection algorithm to revive the faulted line at the earliest. In [17], a distance relay having quadrilateral characteristics is realized using Intel 8097 microcontroller and validated on a laboratory model of cable . However, the road capacitance has been ignored. In [18], differential pro- tection function has been realized using Wi-Fi technology, data acquisition cards (DAQ cards), virtual instrumentation (LabVIEW). The proposed function has been validated on a 300-km-long cascaded M-transmission line model. However, fault detection is completed using steady-state parameters of fault current rather than transient parameters. a way is pro- posed to spot and classify faults using the time-tagged, prevalent harmonic phasors of existing signals [19]. it had been verified on the size down laboratory model to point out its real- time applicability. Nevertheless, the suggested approach is restricted only to detecting and classifying faults. In [20] a artificial neural network (ANN)-based real-time fault detec- tor was created. The fault location is estimated using before and after fault current and voltage measurements. In [21], support vector regression (SVR)-based fault detection and classification methodology has been validated in real-time on a laboratory cable of 400 km long. during this work, harmonic signatures of current signals are extracted using DFT and fed to SVR as inputs for fault location.

1 Traveling waves and DWT-MRA technique

The literature shows that traveling waves are the best choice for agile and accurate failure analysis of transmission lines. In addition, DWTMRA is a preferred choice for error analysis because the more useful properties of the signal in different frequency bands with different resolutions are briefly discussed in the following subsections, the traveling wave phenomenon and the DWTMRA method for extracting traveling waves.

2 Brief description of the traveling wave phenomenon

In This subsection briefly describes the phenomenon of traveling waves. As shown in Figure 1, the voltage at the point of failure drops dramatically to a very low value. Therefore, the voltage at the point of failure briefly generates a high-frequency electromagnetic pulse (surges and surges), known as traveling waves. Ideally, these high-frequency surges of current and voltage propagate at the speed of light to both ends of the wave. However, the speed of propagation of the traveling waves is determined in real time by the inductance (L) and the capacitance values. (C) the transmission line.Traveling waves that hit both ends of the line are refracted and reflected as shown in the figure. The first wave fronts are recorded when the initial traveling wave first reaches both ends of the line and are referred to as ID1 and ID2. The reflected signal from each respective bus (Bus 1 and Bus 2) propagates along the transmission line and reaches the point of failure as shown in Fig.



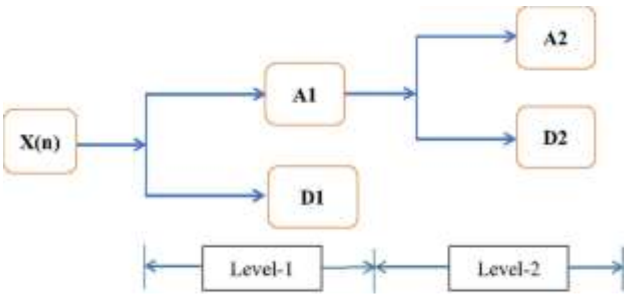


Fig. 1 Traveling wave phenomenon

Fig. 2 Discrete wavelet transform-multi-resolution analysis

from the fault point the refracted wavefront will reach both ends of the line and they are denoted as I_{D3} and I_{D4}. This process continues until these high frequency surges dies out [23].

Extraction of traveling waves with the DWTMRA technique

This section briefly describes the technique of discrete traveling wave analysis - Multiple Resolution Analysis (DWTMRA) and the extraction of traveling waves. and approaches based on the Short Time Fourier Transform (STFT) Figure 2 shows the signal processing, X (n), decomposition on different frequency levels (approximation (A1, A2 ...) and detail (D1, D2 ...)) by sequential High pass and low pass filtering using DWTMRA. The process of high-pass and low-pass filtering is called subband coding. The details (D1, D2 ...) of the signal consist of the error signatures [5]. In general, the frequency band of traveling waves is around 20 kHz to 2 MHz [10]. Therefore, the detail coefficients of the first level (D1) shown in FIG. 1 contain the signatures of the traveling waves. Among all mother waves, wave db4 shows a good performance in fault analysis in the network .

Proposed Methodology

As shown in Figure, L represents the total length of the transmission line i - j in km, M represents the fault distance from Busi in km, t1 and t2 represent the time of arrival of the first waves that are in Busi and Busj. spread out in sec and CTi and CTj represent current transformers in Busi and Busj, respectively. Ri and CBi represent relays and circuit breakers in Busi. While Rj and CBj represent relays and circuit breakers in Busj. Assume that various errors occur at distance 'M' from Busi. The temporal incidence of the first traveling waves in Busi and Busj is t1 and t2, respectively. Assuming that the 3F current signals from CTi and CTj are transmitted to the System Protection and Control Center (SPCC) using the best communication technology without loss of data transmission, the operating time of the proposed scheme running in SPCC is that for fault detection and localization a quarter cycle while for data transfer between SPCC and the respective relays and finally give when a trip signal is sent to the circuit breaker, it takes a total of one cycle of its fundamental frequency, so the proposed scheme is agile compared to conventional protection relays. The data acquired and sampled with the corresponding sampling frequency, in this study 2 MHz are taken into account for the simulation validation and 45 kHz for the real-time validation. With SPCC, the 3F current signals (IA, IB and IC) recorded by CTi and CTj are sampled at the appropriate sampling rate under all conditions. These signals are broken down into detail coefficients (IAdc, IBdc and ICdc) and approximation coefficients (IAac, IBac, ICac and INac) using the DWTMRA technique, as described in subsection 2.2. These coefficients are called traveling waves. These waves go through the dq transform to determine the d-axis components of the detail coefficients (Idn). At the same time, the pointers of the 3F current signals are estimated from the approximation coefficients (IAac, IBac, ICac and INac).). on.As soon as the fault has been recognized, the arrival time (t1 and t2) of the first incident traveling waves is recorded for the estimation of the fault location (M) and the energy values of the approximation coefficients are also estimated. for fault classification at the same time.

Result:

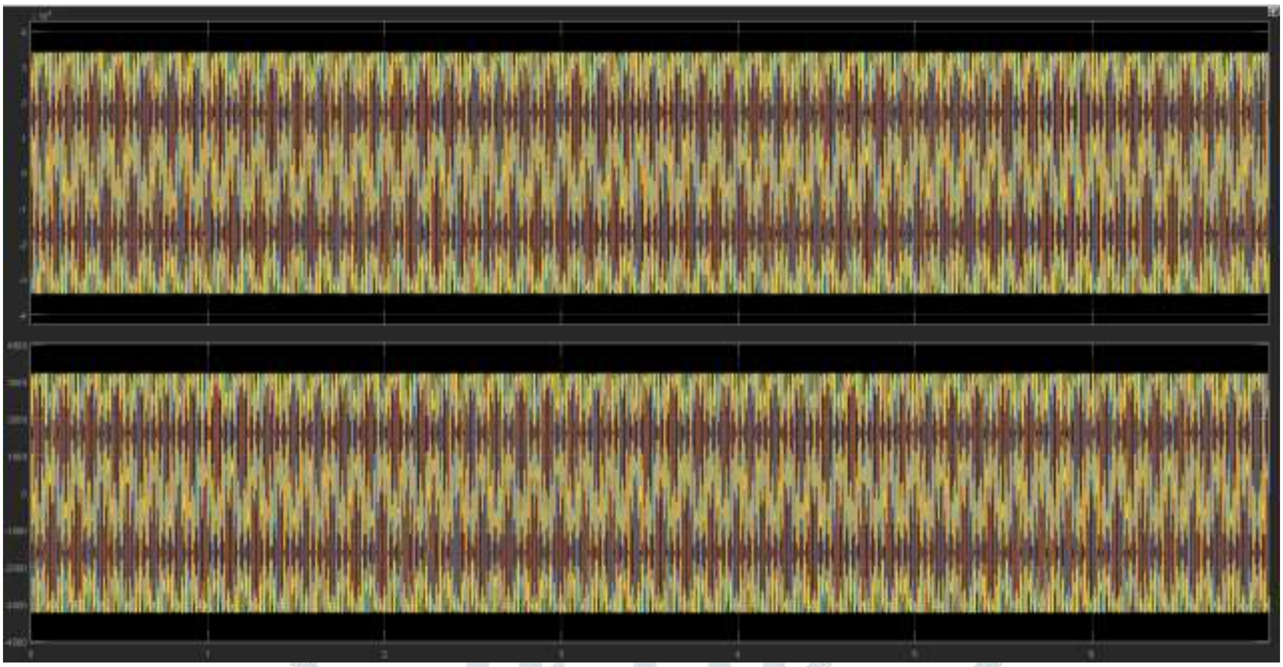


Figure 3:- Voltage and Current Waveform Under Normal Condition

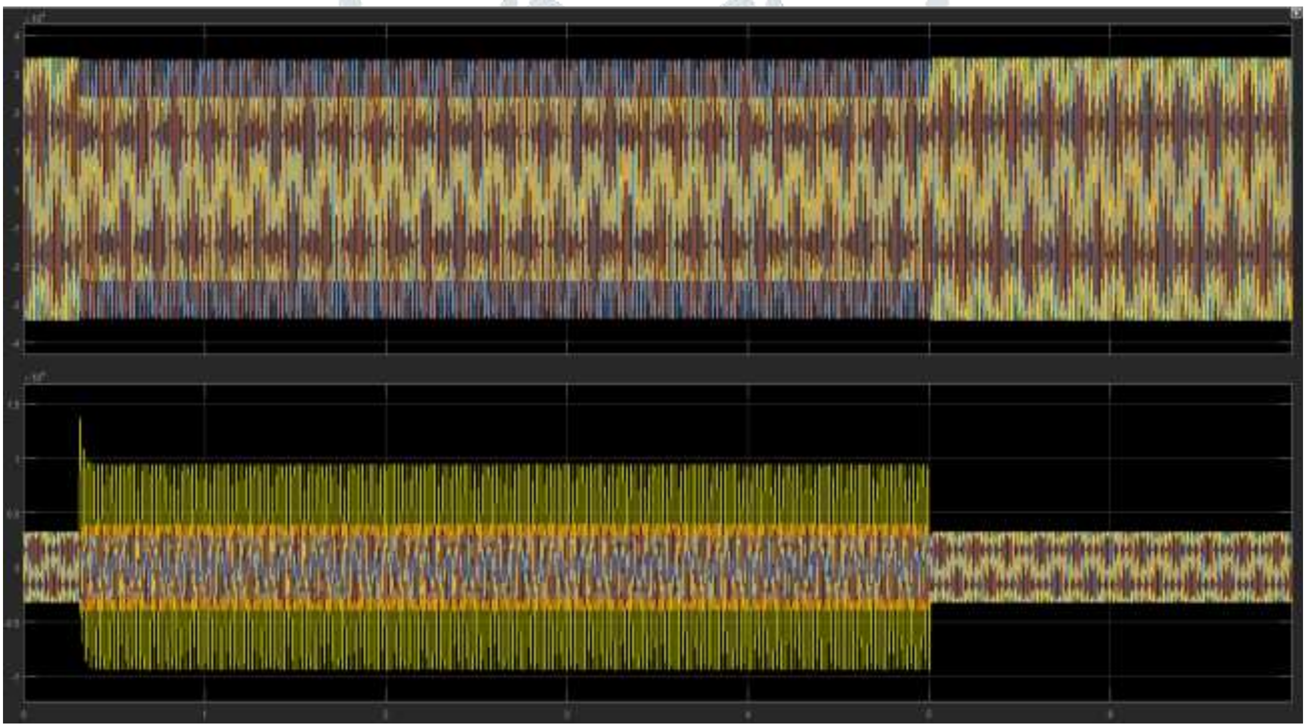


Figure 4:- Voltage and Current Waveform Under L-G Fault Condition

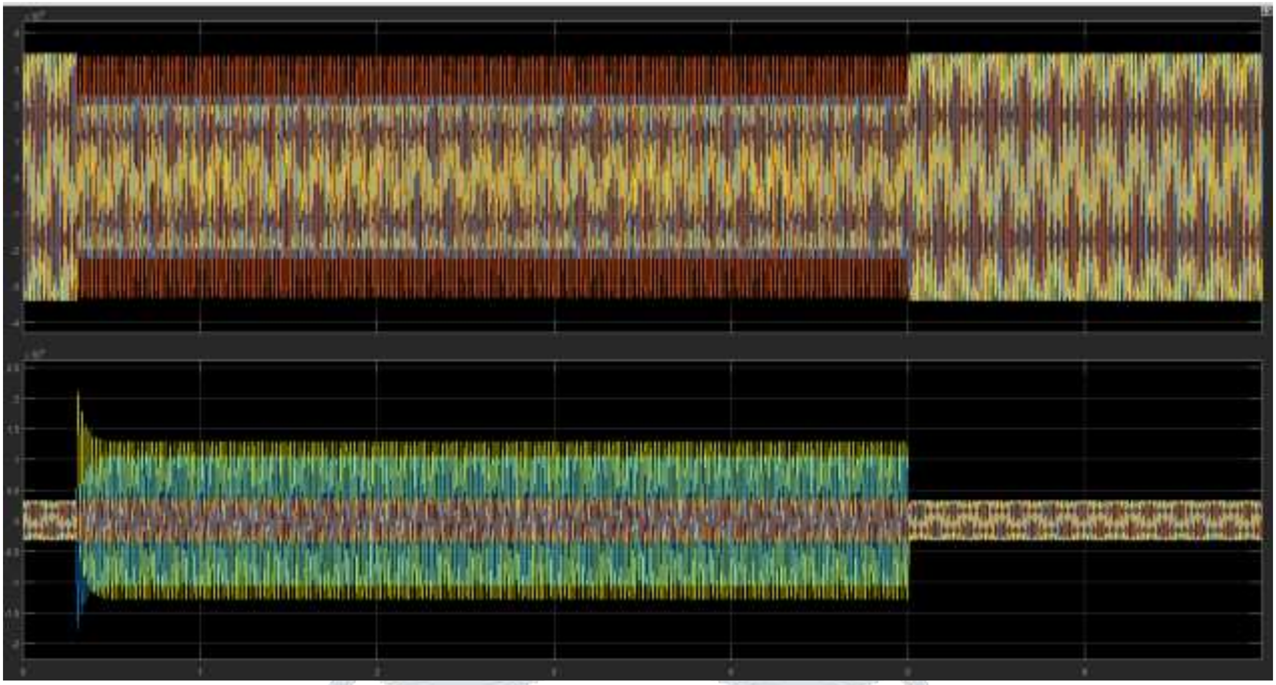


Figure 5:- Voltage and Current Waveform Under LL-G Fault Condition

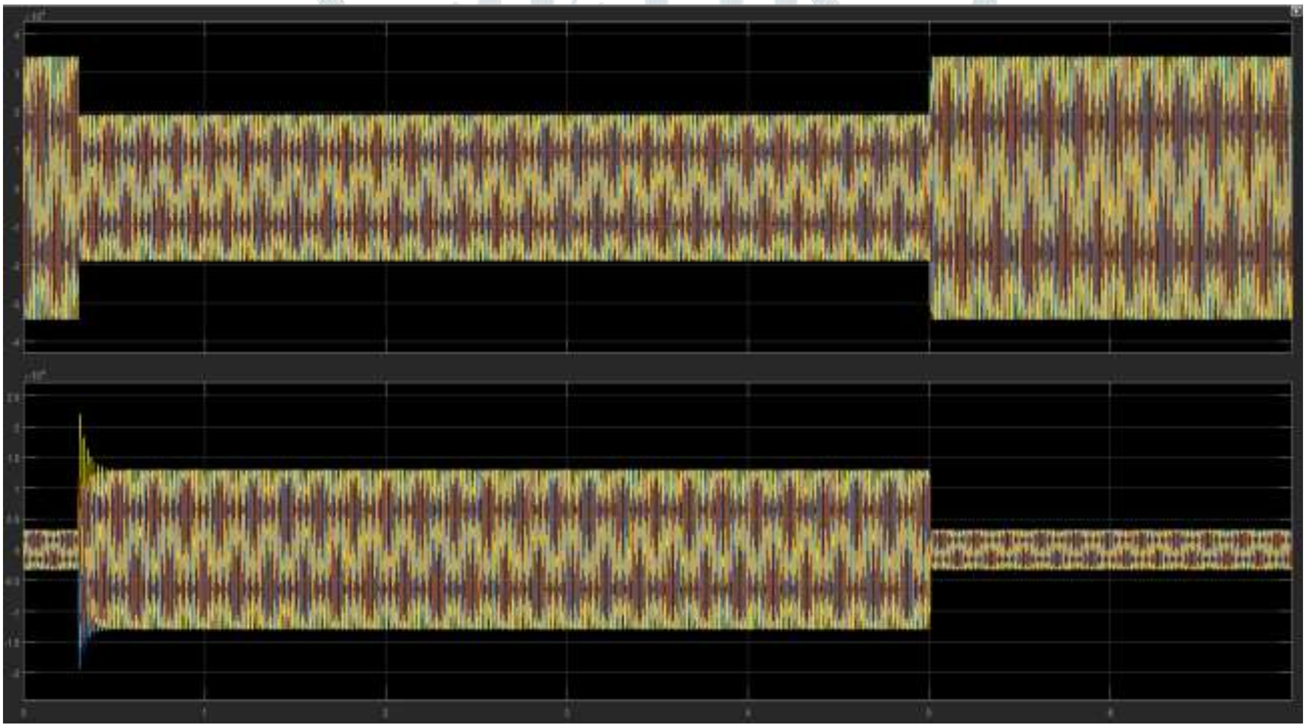


Figure 6:- Voltage and Current Waveform Under LLL-G Fault Condition

The errors are recognized and classified into different types and this is done with the help of the Haar-Mutter wavelet. The energy of the respective current signal is obtained by the wavelet multi-resolution MRA block and classifies the error. Signal when a fault is detected and keeps the trigger signal low even if the fault detection signal is low the comparator system compares the voltage and the threshold value of the current signal set by the developer. This threshold value is determined based on the system analysis for different. fixed state error This is the downside of this system.

References:

1. Phadke AG, Thorp JS (2009) Computer Relaying for Power Sys- tems, 2nd Edition, Wiley Online Library
2. Liao Y (2006) Fault location utilizing unsynchronized volt- age measurements during fault. Electr Power Component Syst 34(12):1283–1293

3. Liao Y (2008) Transmission line fault location algorithms with- out requiring line parameters. Electr Power Component Syst 36(11):1218–1225
4. Radojevic´ Z, Terzija V (2007) Effective two-terminal numerical algorithm for overhead lines protection. Electr Eng 89(5):425–432
5. Liang J, Elangovan S, Devotta JBX (1998) A wavelet multires- olution analysis approach to fault detection and classification in transmission lines. Int J Electr Power Energy Syst 20(5):327–332
6. Jaya Bharata Reddy M, Venkata RD, Mohanta DK (2013) Robust transmission line fault classification using wavelet multiresolution analysis. Comput Electr Eng 39(4):1219–1247
7. Jaya Bharata Reddy M, Mohanta DK (2008) Adaptive-neuro-fuzzy inference system approach for transmission line fault classification and location incorporating effects of power swings. IET Gener Trans Distrib 2(2):235–244
8. Costa FB, Souza BA, Brito NSD (2012) Real-time classification of transmission line faults based on maximal overlap discrete wavelet transform. PES T&D 2012, Orlando, FL, 1–8
9. Chanda D, Kishore NK, Sinha AK (2003) Application of wavelet multiresolution analysis for classification of faults on transmission lines. IEEE conference on convergent technologies for Asia-Pacific Region. TENCON 4:1464–1469
10. Edmund OS, Armando G (2014) Locating faults by the traveling waves they launch. Texas A&M Conference for Protective Relay Engineers
11. Mallikarjuna B, Chatterjee D, Reddy JBM, Mohanata DK (2018) Real-time wide-area disturbance monitoring and protection methodology for EHV transmission lines. INAE Lett 3:87–106
12. Venkatesan R, Balamurugan B (2001) A real-time hardware fault detector using an artificial neural network for distance protection. IEEE Trans Power Deliv 16(1):75–82
13. Mallikarjuna B, Gopakumar P, Sinha Roy D, Jaya Bharata Reddy M (2019) A real-time synchronized harmonic phasor measurements- based fault location method for transmission lines. J Control Autom Electr Syst 30:1082–1093
14. Bewley LV (1931) Traveling waves on transmission systems. Transactions of the American Institute of Electrical Engineers 50(2):532–550
15. https://web.iitd.ac.in/~sumeet/WaveletTutorial.pdf
16. Wong C-K, Leong I-T, Lei C-S, Jing-tao Wu, Ham Y-D (2001) A novel algorithm for phasor calculation based on wavelet analysis [power system analysis]. 2001 power engineering society summer meeting. conference proceedings (Cat. No.01CH37262). Vancou- ver, BC, Canada 3:1500–1503
17. Marti JR (1982) Accurate modelling of frequency-dependent trans- mission lines in electromagnetic transient simulations. IEEE Trans Power Apparatus Syst PAS-101(1):147–157
18. https://hvdc.ca/webhelp/ol-help.htm#EMTDC/Transmission_ Lines/Frequency_Dependent_Models.htm
19. Pal D, Mallikarjuna B, Reddy RJ, Reddy MJB, Mohanta DK (2017) Synchrophasor assisted adaptive relaying methodology to prevent zone-3 mal-operation during load encroachment. IEEE Sens J 17(23):7713–7722