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Most Suitable Algorithm for Transmission Line Protection

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ABSTRACT: Continuous expansion of power network and integration of variable nature load to the network have resulted in high requirement of protection equipments which has high speed as well as accuracy. These have been considered as the key factors for clearing the faulty events. In the conditions when fault is not properly identified and cleared, then it may cause widespread damage to the network of power. The research activity related to two separate algorithms for identification and classification of transmission line faults. In the first algorithm, current supported approach using discrete wavelet transform (DWT) and Wigner Distribution function is proposed for detection and classification of transmission line faults. In the second algorithm, voltage based approach using discrete wavelet transform is proposed for detection and classification of transmission line faults. Algorithms are tested for different case studies such as variations in fault location on transmission line, variations in fault impedance and event of reverse power flow in MATLAB simulink environment.

KEYWORDS: Discrete Wavelet Transform, Symmetrical Fault, Unsymmetrical Fault, Wigner Distribution Function.

I.INTRODUCTION

Performance of network of power might be affected by faults which takes place on the transmission and distribution lines. This may lead to interruption in the flow of power in network. Sometimes this may also result in blackout. Fast identification of faults and estimation of fault location accurately will help to maintain and restore the supply at fast rate. This will result improved reliability of power supply which ultimately will lead to improved economy. Therefore, for providing protection system of high accuracy to protect network of power against faults including phase to ground (LG), two phase (LL), two phase to ground (LLG) and three-phases to ground (LLLG), the efficient identification and discrimination of faults is required essentially. The investigation of faults on the network of power includes the identification of origin of time of failures in addition to the identification and location of faulty event which occurs on the system. Different techniques of signal processing including wavelet transform (WT), neural network (NN), and Fuzzy logic (FL) are extensively used to detect and classify faults on the network of power system [1]. An in-depth review literature reported in the field of intelligent systems application for diagnosis of faults on the power transmission lines is reported in reference [2]. A fault location method which is simple in nature and effective to locate fault on the multi-terminal transmission lines with the help of unsynchronized measurements is introduced by authors in reference [3]. In reference [4] authors introduced a technique for implementation of wavelet transforms (WT) for identifying, classifying and locating the faults on transmission line.

In this paper, current supported approach using discrete wavelet transform (DWT) and Wigner Distribution function is proposed for detection and classification of transmission line faults. In the second algorithm, voltage based approach using discrete wavelet transform is proposed for detection and classification of transmission line faults. Algorithms are tested for different case studies such as variations in fault location on transmission line, variations in fault impedance and event of reverse power flow. The algorithms are also tested for switching transients. Performance of the algorithms is compared with the performance of an algorithm reported in literature. The study is performedin MATLAB software and Simulink environment.

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II.LITERATURE SURVEY

Generally incident faults on the lines of power system include line to ground (LG), double line (LL), double line to ground (LLG) and three phase fault without involvement of the ground (LLL), three-phase fault with involvement of the ground (LLLG) and inter-circuit faults [5]. In [6] authors proposed a new model to functionally represent the phases of a transmission line. The detection and classification strategy are developed from the analysis of the model's parameters and were evaluated using a set of simulated faults and a real database. The results show that the proposed model detects faults very quickly, using a vastly simplified mathematical process, and is able to classify faults accurately. In [7] authors proposed a novelhybrid framework that is able to rapidly detect and locate a fault on power transmission lines. The proposed algorithm presents a fault discrimination method based on the three-phase current and voltage waveforms measured when fault events occur in the power transmission- line network. . Silva *et al.* [8], proposed a novel method for transmission line fault detection and classification using oscillographic data. The fault detection and its clearing time are determined based on a set of rules obtained from the current waveform analysis in time and wavelet domains. The method is able to single out faults from other power-quality disturbances, such as voltage sags and oscillatory transients, which are common in power systems operation. The literature has been reported on the different aspects of the faults in the power system. Krishnanand *et al.* [9], presented a pattern recognition approach for current differential relaying of power transmission line. The proposed scheme is evaluated for current differential protection of a transmission line fed from both ends for a variety of faults, fault resistance, inception angles, and significant noise in the signal using computer simulation studies lines. In [10], authors proposed an algorithm for detection of faults on power transmission line using the pilot impedances with synchronized data.

This improved the sensitivity and reliability of protection scheme. In [11], author presented an algorithm for detection, classification and localization of faults on a transmission line consisting of overhead line and underground cable. It is based on the entropy concepts hybridized with the fast discrete orthogonal S- transform (FDOST) for feature extraction for detection of faults and classification using the support vector machine (SVM) and support vector regression (SVR). Rathore et al. [12], proposed an algorithm using wavelet and alienation coefficients for protection of multi- terminal transmission line (MTTL). It is based on the application of wavelet transform based approximate coefficients of voltages and currents calculated over quarter cycle period for detection, classification and location of faults on the MTTL. In [13], authors proposed technique to estimate the location of faulty point on the on transmission lines. In [14], a fault detection approach which is fast and computationally efficient has been proposed to provide protection to the power transmission network. This is based on the calculation of mean error. To avoid false detection, a particle swarm optimization supported method with selection of optimal threshold is introduced by the authors. In [15], a method based on estimated Euclidean distance between successive samples of signal to design a fast and effective algorithm for detection and classification of faults on the electric power transmission networks. Magnitudes of fundamental components of currents were evaluated using the discrete Fourier transform considering as actuating signals for the proposed algorithm. In [16], a fault detection and classification algorithm which effectively protects thetransmission line against the faults is proposed. Algorithm is based on the combination of Wavelet transform (WT) and linear discriminant analysis (LDA). Proposed algorithm used the current signals for identification of phases which are faulty in nature. In [17] Discrete WT (DWT) based differential relaying protection scheme is developed for detection and classification of fault pattern on power transmission line. The scheme is based on use of current signals measured on two ends of power transmission line. These current signals are synchronized and processed using DWT based spectral energy (SE).

It is pointed out that the algorithms used for the detection and classification of transmission line faults must detect the faults in minimum time and should be capable to detect faults during different conditions such as different values of fault impedance, various fault locations, reverse power flow. It is observed that reported algorithms are not effective for all conditions. Hence, there is a need to design algorithms which are effective in identification as well as classification of faults on transmission lines in all conditions with wide range of parameters.

III.METHODOLOGY AND DISCUSSION

Methodology proposed for identification as well as classification of faults on transmission line to design an effective transmission line protection scheme is designed separately for the current based protection scheme and voltage based protection scheme. In current based scheme algorithm proposed for the detection and classification of transmission line faults to design an effective protection scheme for transmission line based on current signal is formulated. In voltage based scheme The voltage based transmission line protection scheme is based on the discrete wavelet transform. Voltage signal with the help of DWT with db5 as mother wavelet is processed for fourth decomposition

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level. Absolute values of detailed coefficient obtained at second level of decomposition are designated as discrete wavelet transform based fault index using voltage signal. This fault index is designated as DWTV index. This is used for identification of different faults types as well as discrimination of faulty phase from healthy phase. MATLAB codes used for the proposed fault index based on voltage signal.

The wavelet transform (WT) is a mathematical technique which decomposes a signal into various levels by dilating a single prototype function with high resolution. This gives representation of signal in time as well as frequency. A wavelet transform (WT) is represented by wavelets. These wavelets are scaled and translated copies of a finite-length or fast-decaying oscillating waveform.

Wigner distribution function (WDF) is a method which can be applied for processing of signals for analysis in time-frequency domain. WDF function had been implemented first time in physics for quantum corrections in the year 1932 by the scientist Eugene Wigner. Wigner distribution function gives high clarity in some cases in comparison to the short-time Fourier transform (STFT) and Gabor transform (GT).

The Gabor Wigner Distribution is given by the below detailed relation.

$$D_x(t,f) = G_x(t,f) \times W_x(t,f) \quad (1)$$

IV.EXPERIMENTAL RESULTS

Detection of LG fault using voltage based fault index (a) voltage waveform (b) proposed DWTV-index for phase-A (c) proposed DWTV-index for phase-B (d) proposed DWTV-index for phase-C. Current based scheme shows result as shown in Fig.1. A line to ground (LG) fault is simulated at middle of the transmission line by grounding the phase-A of the transmission line illustrated in Fig.1. Voltage signal is recorded on bus B1 at sending end of the transmission line. Voltage signal is processed using discrete Wavelet transform with 3.8 kHz sampling frequency of up to fourth decomposition level using db5 as mother wavelet. The detailed coefficient obtained at second level of decomposition is obtained. The absolute values of this detailed coefficient are designated as DWTV index which is also considered as fault index for the recognition of faulty events.

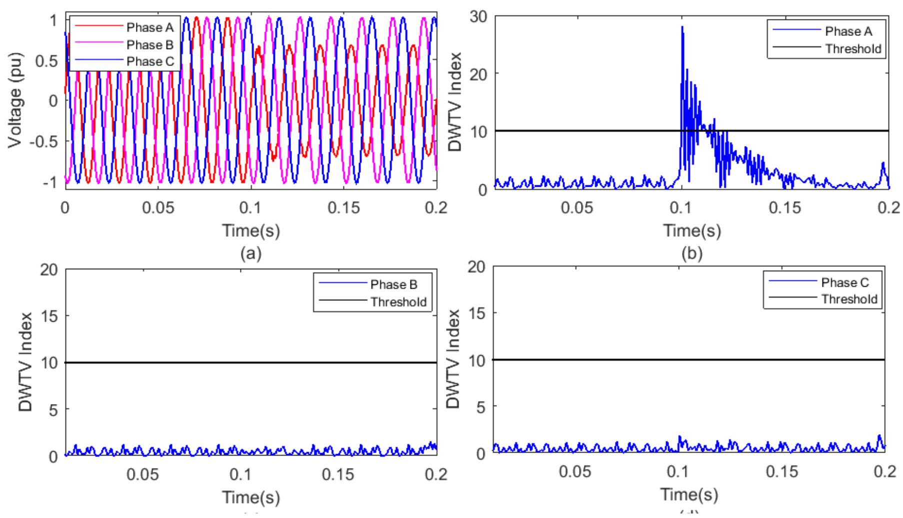

Fig. 1 Waveforms in LG fault condition

A LLLG fault is realized at centre of test line illustrated in Fig.2. Voltage signal is recorded on bus B1 at sending end of the transmission line by short circuiting all the three phases at the same time. Voltage signal is processed using discrete Wavelet transform with 3.8 kHz sampling frequency up to fourth level of decomposition using db5 mother wavelet. The detailed coefficient obtained at second level of decomposition is obtained. The absolute values of this detailed coefficient are designated as DWTV index which is also considered as fault index for the recognition of faulty events. The voltage signal of all the phases is shown in Fig.2 (a). The DWTV index corresponding to phase-A is illustrated in Fig.2 (b). Similarly, the DWTV index corresponding to phase-B is illustrated in Fig.2 (c). The DWTV index for phase-C is illustrated in Fig.2 (d). Threshold magnitude of fault index is taken as 10 for discriminating faulty phases from healthy ones.

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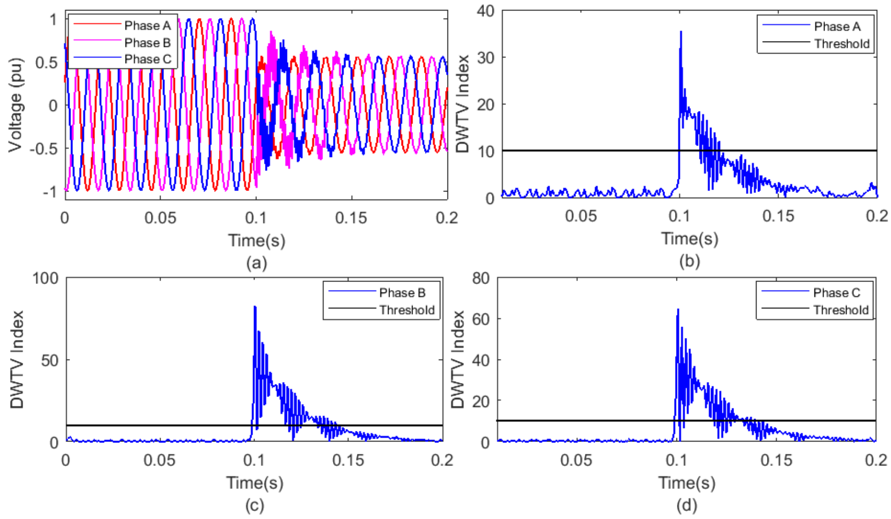
V. RESULT AND DISCUSSION

Faults on the power system network may be classified based on number of faulty phases. The peak magnitude of current supported fault index calculated on node B1 of test system are provided in Table 1. This is inferred that for LG fault, the values of fault index are high corresponding to one phase only whereas for event of LLLG fault the magnitudes of fault index for all phases are high. However, for the LL and LLG faults the fault index has high values for two phases only. Further, based on values of fault index corresponding to the faulty phase, various types of faults can be classified. For event of LLLG fault, magnitudes offault index is maximum for phase-A having value greater than $9x10^6$ whereas the value are less than $5x10^6$ for event of LG fault. For the LL fault the values of fault index lies between $5x10^6$ and $8x10^6$ whereas for the LLG fault magnitude of fault index lies between



$8x10^6$ and $9x10^6$. Table 1 presents peak values of proposed voltage supported fault index

Faults on the network of power system may be classified based on number of faulty phases. The peak magnitude of voltage supported fault index calculated on node B1 of test system are provided in Table 2. This is observed that for LG fault, magnitude of fault index are high corresponding to one phase only whereas for the during the LLLG fault, magnitude of fault index corresponding to all phases are high. However, for the LL and LLG faults the fault index has high values for two phases only. Further, based on values of fault index corresponding to the faulty phase, various types of faults can be classified.

Table 1: Peak values of proposed Current supported fault index

Fault Type	Proposed Fault Index		
	Phase-A	Phase-B	Phase-C
LG	$4.5x10^6$	0	0
LL	$7x10^6$	$4.25x10^6$	0
LLG	$8.5x10^6$	$4.5x10^6$	0
LLLG	$10x10^6$	$4.5x10^6$	$3x10^6$

Performance of algorithm is compared with algorithm available. It is observed that performance of the algorithm reported has not been tested in different scenarios such as impact of variation of fault location, variation of fault impedance and reverse power flow. However, performance of algorithm is tested in all type of operating scenarios. Hence, the proposed algorithm can invariable be used in the numerical relays for transmission line protection. However, further testing of algorithm reported is required before practical implementation.

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For event of LL fault, magnitude of fault index is maximum for phase-A having value greater than 90 whereasthe value are less than 30 for event of LG fault. For the LLG fault the values of fault index lies between 50 and 90 whereas for the LLLG fault, magnitude of fault index lies between 30 and 50. Table 2 presents peak values of proposed voltage supported fault index

Table 2 : Peak values of proposed voltage supported fault index

Fault Type	Proposed Fault Index		
	Phase-A	Phase-B	Phase-C
LG	28	1	1
LL	100	50	1
LLG	65	65	5
LLLG	35	80	65

Performance of algorithm is compared with algorithm available. However, performance of algorithm is tested in all type of operating scenarios. Hence, the proposed algorithm can invariable be used in the numerical relays for transmission line protection. However, further testing of algorithm reported is required before practical implementation.

VI.CONCLUSION

Main conclusions of research activity related to identification and classification of transmission line faults using Wigner distribution function and discrete wavelet transform algorithm based on current features are detailed in this paper. Further, the main conclusions of research work related to identification and classification of faults on transmission line using discrete wavelet transform algorithm based on voltage features are also presented in thechapter. Recommendations based on proposed research work for future work have also been discussed in brief and provided in the paper. Research work included in this paper proposed an algorithm for identification and classification of power system faults which is based on Wigner distribution function and Discrete Wavelet transform is detailed. The algorithm is successfully tested on a transmission line of line length 230 km inMATLAB/Simulink environment.

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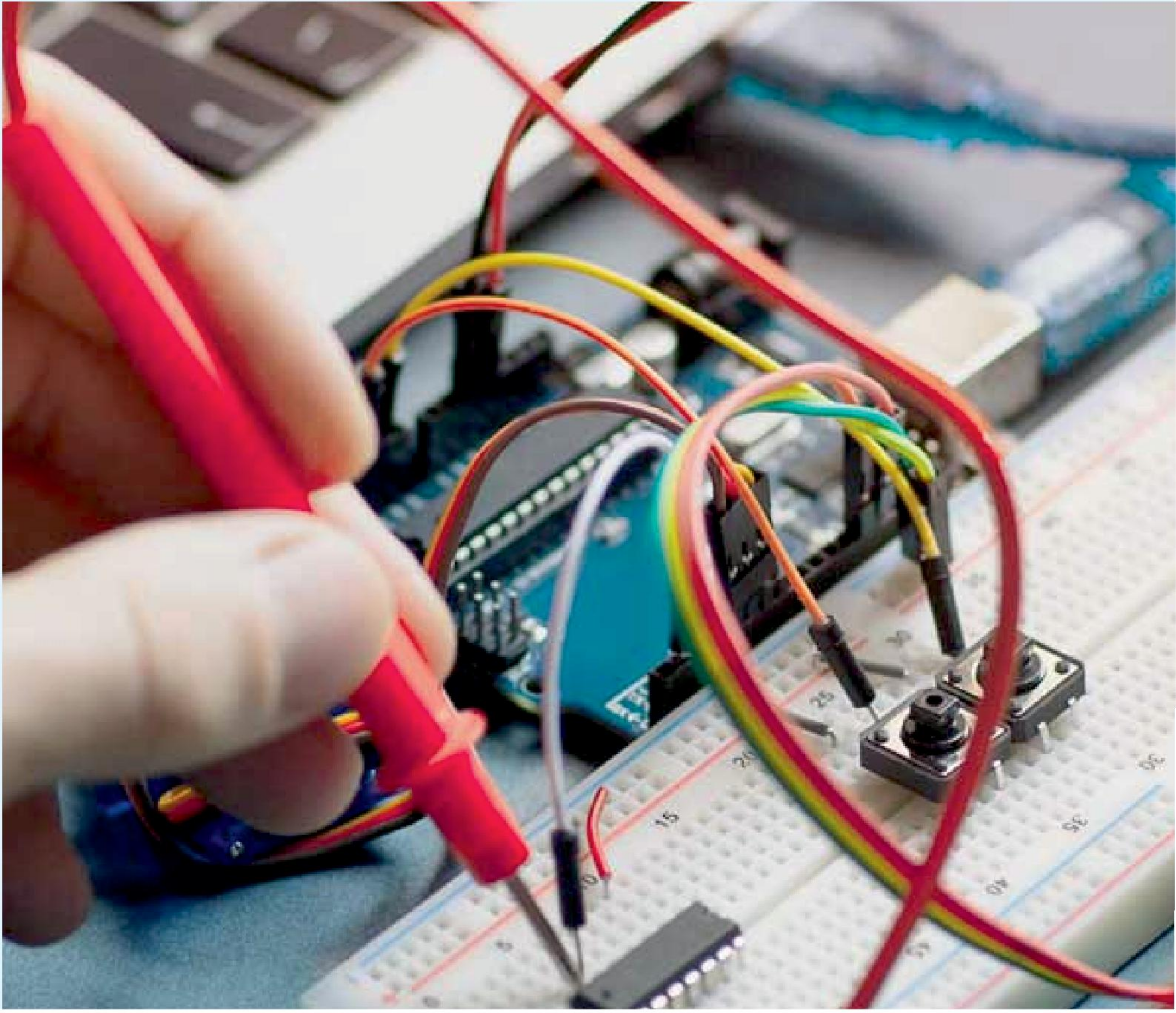

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