RECOGNITION OF POWER SYSTEM TRANSIENTS AND FAULT ANALYSIS BASED DISCRETE WAVELET TRANSFORM AND NEURAL NETWORK

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ABSTRACT
Now days, because of the great extent of capital investment to generate electrical power supply, power supply has become as an article of trade. It is extremely significant to serve the power in reliable and stable need to ensure customers requirement. To attain stability and to ensure power quality performance it is very important to identify power system faults. High impedance fault (HIF) is one of the various fault causes; distinctive characteristics of this type of faults are asymmetry and nonlinearly behavior. Arc which is usually associated with these kinds of faults is considered as a source of human life risks and fire hazardous. Hence, detection and protection of such faults still remain a topic of study. In this paper PSCAD/EMTDC simulation, software is used to simulate the high-voltage transmission system and modeling of HIF. MATLAB software is used for; advanced signal processing tools such as discrete wavelet transform (DWT) which is used as feature extraction to get an useful information from faulted signal, back propagation neural network (BP-NN) for detection of high impedance fault.

KEY WORDS
Power System Stability, Fault Analysis, High Impedance Fault, Neural Network, Discrete Wavelet Transform,

1. Introduction
The quick development of power systems over the earlier years has resulted in an increase of operation and total length of lines. Overhead Transmission lines are used to transmit electricity to distant large load centers, These lines are exposed to be broken and fallen down on the ground or make nearly touch with other subjects like trees or building, crating high impedance fault [HIF], which inhibits the flow through the fault current to less than the sensitivity level of conventional protection systems [1]. Besides that, arc which is commonly associated with HIF is considered as a source of human live risks and fire hazardous. Therefore, from the view of public safety, reliability and stability, detection and recognition of such faults are very important [2]. There is some literature talking about high impedance fault detection algorithms and techniques. In [3], the technique was based on the modification of over current protection devices, but this technique has given unpredicted results because of the similarity of current that result from HIF to other normal operation. Other schemes were based on fractal techniques [4], the concept of this technique is to analyze chaotic properties of high impedance fault, however, make direct calculation of fractal dimensions not effective for HIFs detection.

Some other algorithms, based on the changes in harmonics; such as the third harmonic method [5] and nearest neighbor rule algorithm [6]. Moreover, some others are based on signal processing techniques for fault feature extraction is carried out of using different filters such as Fourier Transform and Kalman Filter [7, 8]. Nevertheless, detection of high impedance faults would be very difficult due to its distinctive characteristics. Hence, researchers have introduced new intelligent techniques such as neural network and fuzzy logic, [9]. In recent times, wavelet transform has been introduced for detection of high impedance fault, [10-11-12], these algorithms can extend the operation to certain level, but it has difficulties to discriminate these types of faults for other events that behave like HIF, such as capacitor switching, load switching, etc.

Even though, much literature has been discussed for high impedance fault detection using wavelet or / and neural network, but there is a few researchers have introduced

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The new algorithm which is a combination of wavelet transforms and neural network. In, [13-14], the authors have been introduced a new algorithm by linking of wavelet transform and neural network. The techniques have been used for high impedance fault detection and classification in distribution system level.

This paper purposes new method for detection of high impedance fault in transmission system level; it is presented by linking of optimal mother wavelet that has been chosen and back-propagation neural network for detection and classification of high impedance fault.

2. Modeling of High Impedance Fault

As we declared in the overview, for the subject of the circumstances of arc irregularity, which is changes from one-half cycle to others, which mean the arc parameters that extracting by positive half cycle is inappropriate for the others. The model of HIF is proposed to be modeled using a PSCAD/EMTDC developed custom model. The proposed model is described in [15], and its designed in PSCAD/EMTDC is shown is figure (1).

![Figure (1) New HIF Developed Model](image)

Furthermore, in figure (3), we can see a different patent of high impedance fault, which is the nonlinear variations of the arc which causes the arc voltage waveform distortion, distorting it into a near square wave.

![Figure (2) HIF Arc Current Waveform](image)

![Figure (3) Arc Voltage](image)

3. Discrete Wavelet Transform

Wavelet is a powerful signal processing tool, in theory is a mathematics, which deals with building a model for non-stationary signals. In the conventional Fourier transforms it does not has the essential time information associated with transient signals; the advantages of wavelet transform over Fourier transform it possess time and frequency information, which is considered as the useful tool for analyzing non stationary transient phenomena such as these associated with transmission-line faults. The essentially unlike between wavelet transform and Fourier transforms, in that the wavelet implements the variable window for signal analysis. Since, there are different sorts of wavelets, such as
Daubichis, Symmlet and Coiflet wavelet, however, the proper choice of the mother wavelet acting appropriate role for detection and localizing different types of transient signals. In this situation since we are studying the detection and analyzing of low amplitude and short duration of high frequency current signal, and after a numerous simulation test of selection of mother wavelet, we found the most suitable mother wavelet is Daubichies’s wavelet four db4, [16].

Discrete Wavelet Transform (DWT) is used for feature extraction, which provides high-frequency resolution and with low time resolution for low frequencies and vice versa. The discrete wavelet transform is well-defined as follow:

\[ WDT(m,n) = \frac{1}{\sqrt{a^m}} \sum_k x(k) g(a^m n - b k) \]  

Where \( g(k) \) is the mother wavelet, \( x(k) \) is the signal input and \( a, b \) are the scaling and translation parameters.

One step of the preprocessing data is the feature extraction process, which, is not useful to use the wavelet extracted signal as straight input to train neural network, because that will increase the number of inputs, then large size of neural network. In this work, to overcome these problems we have calculate the coefficients' features of wavelet such as Mean, Standard Deviation, skewness and Kurtosis, and this approach reduces the size of neural network and remains important features of original signal.

4. Neural Network Structure

In this work study, we have selected the back propagation artificial neural network (BP-ANN), which is considered a most powerful for pattern recognition [14]. The goal of BP-ANN is to detect and classify HIF from normal system operation. One of the main serious problems in construction the neural network is the proper choice of hidden layer numbers. Using very less neurons in the hidden layer might inhibit training procedure to diverge, whereas using so numerous of neurons would yield extensive training time. As well as many hidden layer neurons may result in divergence. Meanwhile, the data window is divided into two time periods to calculate the features of wavelet signal, hence it is four samples are considered for each phase a,b,c; therefore, 12 inputs are fed to ANN. In this paper to verify the performance of ANN architecture the number of testes has been performed and concluded of choosing five neurons for first hidden layer and four neurons for second hidden layer and one neuron for output layer. The output of ANN is binary output 0 for normal conditions (N) and 1 for HIF (H),

5. Simulation of Case Study

The test has been done using PSCAD/EMTDC program, the schematic diagram of the tested system 230 kV are shown in figure (4).

The transmission line is selected to be a Frequency dependent model which is the most accurate model, which represents all frequency dependent effects of a transmission line, and it is very useful for transients and fault analysis studies. The length of the line is considered to be 100 Kms with power system frequency of 50 Hz, and ground resistance is considered to be 100 Ω.

6. Result and Discussion

A number of different cases of high impedance faults were simulated and analyzed using PSCAD/EMTDC
software; faults were created at different distance of source side and were carried out for phase c to ground fault with inception time of 0.205 s and Extinguished after three cycles. The process has been started by generating the HIF on phase c, then, by using db4 wavelet, we have extracted the useful information from faulted current signal, after that some features of current signal have been calculated as mention before and used as inputs to train ANN. D4 has been selected after some training of other mother wavelet to represent the character of studied signal, because it can generate coefficients as many as possible within the time scale domain.

Discrete wavelet transform is carrying out up to level 2 on the measured faulted current signal as shown in Figure (6), the HIF which is clear on faulted phase c, it has generated the high spikes with a certain amplitude, and the values of detailed coefficients of first-level d1 and second levels d2 are close to zero before the fault occurs, but when the fault happens, the values go up for a short period.

In figure (7), shows the behavior of discrete wavelet transform db4 in two levels d1 and d2, under the condition of load switching situation, and we can observe that the effect of HIF and normal condition operation is quietly different, and that is due to the fact of appearing the high-frequency part of signal during the very short time.

Finally, as we discussed in introduction section regarding to the methods that used for recognition of high impedance fault and other power system disturbances, however, each of discussed techniques has improved the detection to certain level, but also has its drawback as well. Hence, the advantages of proposed method over other techniques are, firstly: appropriate selection of mother wavelet has given higher accuracy, secondly:
preprocessing operation has reduced the number of inputs and size of ANN structure, thirdly: combination of wavelet and neural network can detect the fault and discriminate it from other similar behavior events.

7. Conclusion

In the present time, it is very significant to run the power in high efficiency and reliable and stable fashion, therefore, accurate identification and classification of the fault events has become a priority of concern. In this work, power system network and modeling of HIF has simulated using PSCA/EMTDC Software, the technique of linking wavelet transform with neural network, has simulated in Matlab Software, and the advantages of combination is to reduces the size of neural network and remains essential features of original signal. The incorporation of wavelet and ANN could achieve good accuracy of (≈98%).

References