IDENTIFICATION OF ASYMMETRICAL FAULTS IN ELECTRICAL POWER SYSTEMS BASED ON SIGNAL PROCESSING AND NEURAL NETWORK

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ABSTRACT

In the present era, faults are the greatest interruption for the power system utility. Theses, faults on electrical power systems are unavoidable problems and will continue to happen. These faults are effects on the power system reliability and stability, hence, diagnosis and classification of such faults in rapid and accurate way is an important issue. In this paper, combination method of digital signal processing and multi-layer neural network has presented. The methodology has divided in two steps, firstly: wavelet transform has implemented in here for pre-processing the data, which is used to extract the useful information during the fault in both time and frequency domain, and calculate the features of coefficients which is used as input for neural network. Secondly: multi-layer neural network has adopted here to detect and classify the unsymmetrical faults in different conditions such as single line to ground fault, line to line to ground fault and double line fault. Power System Computer-Aided Design /Electromagnetic Transients with DC (PSCAD/EMTDC) used to simulate the three types of asymmetry faults. Simulation results reveal that the proposed method gives satisfactory results, and will be very useful in the development of a power system protection scheme.

Keywords: power system stability, asymmetrical faults, wavelet signal processing, neural network.

1. INTRODUCTION

Electric power systems have quickly growth over the past decays, and have led to a huge incensement of the number of transmission system lines. These lines are subjected to the faults that occur from lightning, short circuits and aging. Majority of the faults are occur on overhead lines in transmission and distribution systems[1], these faults are affecting the power system stability, reliability and quality; in addition, it is also hazardous for human life. Hence, from stability and reliability operations view, detection and classification of transmission line faults in accurate and quick time is very important issue.

Identification and classification of transmission line faults still remain very challenging task. Various methods have been applied for analyzing power system faults. Ernesto. Vazquez *et al.*, [2] has used an online expert system for diagnosis of power system faults. Other some researchers have presented Fuzzy logic [3], and neural network [4, 5]. In recent years, wavelet transform has been implemented for such propose in [6, 7].

In this paper, the presented technique has based on choosing optimal mother wavelet which is used for extracting the coefficients feature from the current signal during the fault conditions of asymmetry faults. Once the data has pre-processed it is directly transferred to train a back-propagation neural network for detection and classification purpose.

2. PROPOSED METHODOLOGY

Methodology has divided here in two main categories as: firstly, extracting the signal by DWT and preprocessing the data to be used for training.

Secondly, normalizing the data and train it using back-propagation neural network to identify the fault and classify the type of fault.

2.1. Discrete wavelet transform

Wavelet transform is a mathematical tool that has been recently used in power system analysis. There are a lot of work presented discrete wavelet transform DWT as a tool to analyze the signal disturbances, because it has more distinctive properties than those extracted by fast Fourier transform (FFT) due to the good time and frequency localization characteristics of discrete wavelet transform [8]. To process the data in a digital sense the DWT is implemented here and it is given by:

$$W(h,i) = \sum_{h}\sum_{i} x(i)\, 2^{-\frac{h}{2}} \psi\left(2^{-h} n - i\right) \tag{1}$$

Where ψ (t) is called mother wavelet.

Moreover, the discrete wavelet transform DWT is implemented here by conducting Multi Resolution Analysis MRA to extract sub-band information from the simulated transient signals. Moreover, the selected wavelet will decompose the signal by using high and low pass filters to analysis the signal at different scales, where, (D) is the Details coefficients which are generated from high pass filters and (A) are approximations coefficients that generated from low-pass filters, and this can be expressed, mathematically in Equation (2, 3):

$$Dj[n] = \sum_{k} x[n].\, g[2n-k] \tag{2}$$

$$Aj[n] = \sum_{k} x[n].\, h[2n-k] \tag{3}$$

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Where *Dj* is called details, and *Aj* is called Approximation, where *j, j=1, 2, J; k=1, 2.K, .K,*

The procedure of analyzing the signal by DWT is shown in Figure-1. The signal S is passed through a series of high pass filters HPF, to analyses the high frequencies, and it is equally passed through a series of low pass filters LPF, to examine the low frequencies, then the output from LPF is approximations and the output of the HPF is details.

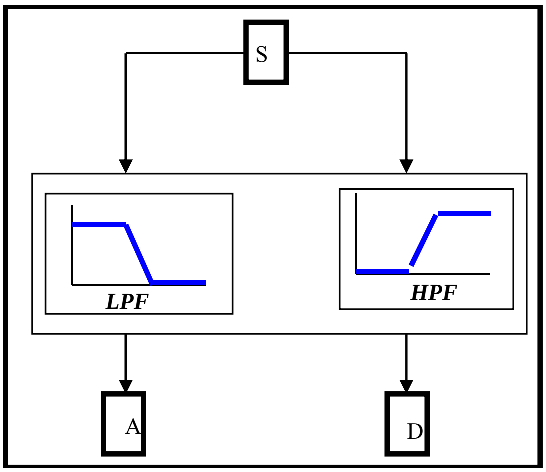

Figure-1. Digital signal process.

2.2. Artificial neural network structure

Artificial Neural Networks ANN model can be classified by its architecture, processing and training. The architecture describes the neural connections. In this work, back propagation artificial neural network BP-ANN has presented which is highly effective for pattern recognition and classification. The task of BP-ANN is to detect and classify the unbalanced faults with different conditions. The proper selection and construction of ANN is playing a key role of The success of the algorithm, The optimum dimension of hidden layer nodes depends on the following conditions: the numbers of input and output nodes, the number of training cases, the amount of noise in the targets, the architecture, the hidden layer node activation function and the complexity of the classification to be learned [9].

The training process is performed using neural network toolboxes in MATLAB. Before the training process, the data sets are normalized and divided 60 % for training 30 % testing and 10 % validation. A structure of the artificial neural networks consists of 3 neurons for the inputs and 1 neuron for the output. The inputs patterns are feature coefficients of DWT for three cycles of three types of unbalanced faults. The output variables of the BP-ANN are designated in Table-1.

Table-1. Output of BP-ANN to identify fault types.

Fault type	A	B	C	G
A-G	1	0	0	1
A-B	1	1	0	0
A-B-G	1	1	0	1

3. SIMULATION SYSTEM OF CASE STUDY

To evaluate the effectiveness and efficiency of the proposed algorithm, the transmission system is adopted here as shown in Figure-2. The system has been simulated using PSCAD/EMTDC software; the study has analyzed different fault condition for a transmission line with use of Bergin line model with 100 km and base voltage of 230 kV and consists of two 3 phase sources, two buses and two circuit breakers. Different types of fault on the transmission line are generated in the PSCAD/EMTDC such as single line to ground, two line to ground and phase to phase fault, generated faults are timed and controlled by logic timed block, also, two circuit breakers have installed for each substation which are independently timed and controlled by timed logic breaker.

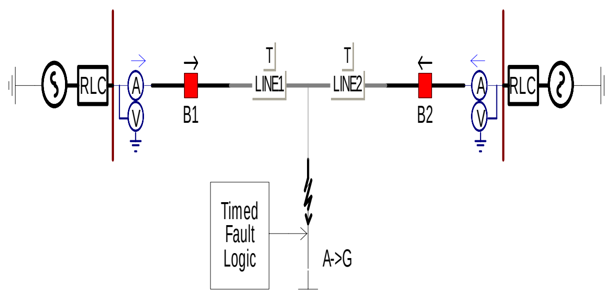

Figure-2. Studied system.

4. RESULTS AND DISCUSSIONS

To approve successes of the presented method in terms of accuracy and computational time huge number of different fault condition has include. In this section the three phase current signals has modeled with different fault conditions has been taken into account, such as single phase to earth fault A-g, double line to ground fault A-B-G and line to line fault A-B. Then, as stated previously by calculating the features of coefficients by applying db4 mother wavelet at level 3 which has been selected after several testing.

As illustrated in Figure-3, single line to ground fault at phase A is created, the fault has initiated at exactly 1 ms; which is clear from Figure-2, at 1 ms point the current for phase A goes up and increased for 3 cycles then go back to normal after fault extinction which is adjusted by fault logic timed block.

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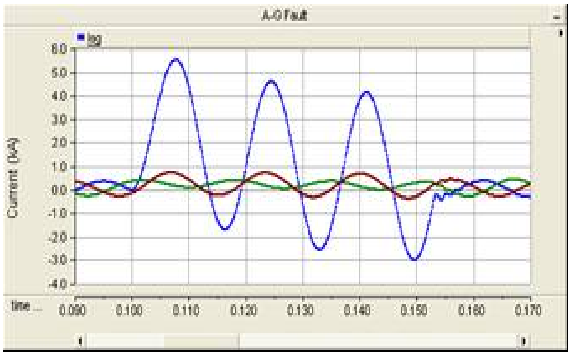

Figure-3. Phase A to ground fault.

In the case of line to line fault, the fault is created at phase A and B as shown in Figure-4. From Figure-4, it is obvious that the fault is in phase A and B it is clear from increasing the value of current signals at fault condition on both phases.

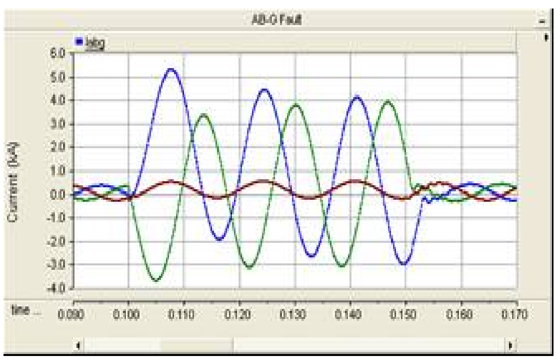

Figure-4. A-B line to line fault.

In this case of double line to ground, the system is simulated for double phase to ground fault, and here A-B phases are considered for fault to ground condition. From Figure-5, it is obvious that the fault is in phase A and B which clear from increasing the value of current signals at fault condition and it is a bit different from line to line fault because of resistance path included of this type.

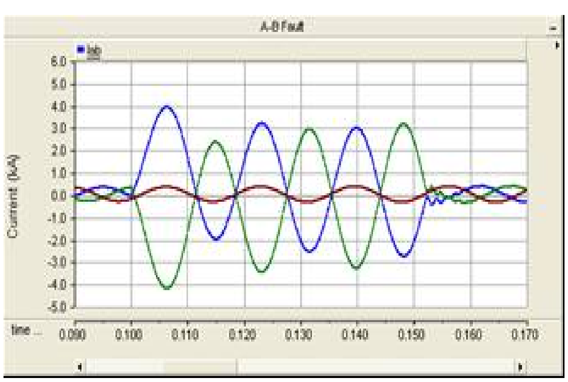

Figure-5. A-B-G double line to ground fault.

4.1. BP-ANN based fault classifier

BP-ANN based Fault detector and Classifier is extensively tested by training normalized inputs using independent data sets consisting of fault samples with different fault types.

The performance of a trained network can be measured to some extent by the errors on the training, validation and test sets. From Figure-6, it is noted that the performance of the training is very well, which almost reached the goal with 12 epochs and very small error of 0.047. This can be approved that the BP-ANN has predicted the inputs with very high accuracy which is about ≈ 98%.

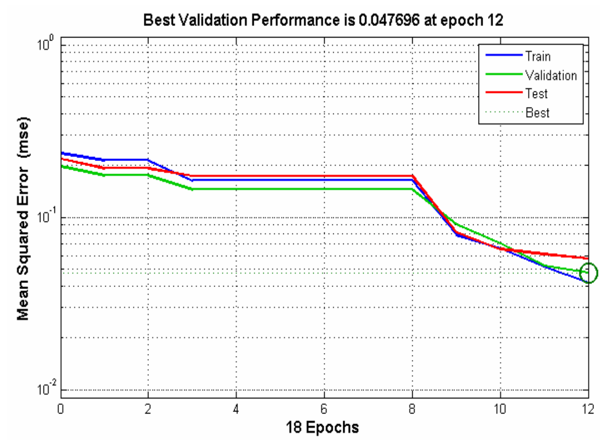

Figure-6. Performance error.

To validate the performance of presented technique the regression analysis between the network response and the corresponding targets has been adopted here. As declare in Figures 7 and 8, that the training and testing performance are precisely one, and that mean, the dataset exactly met the target.

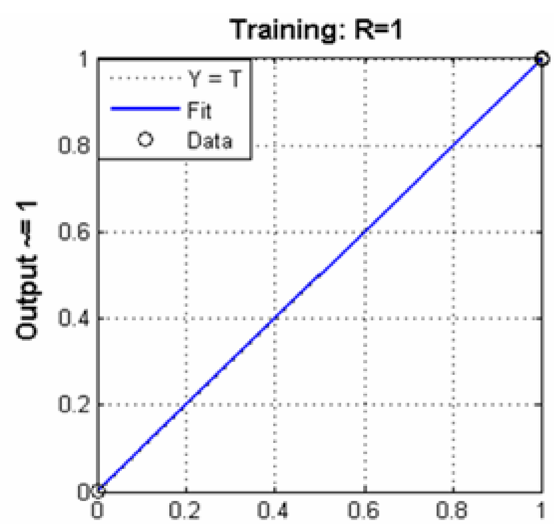

Figure-7. Training regression.

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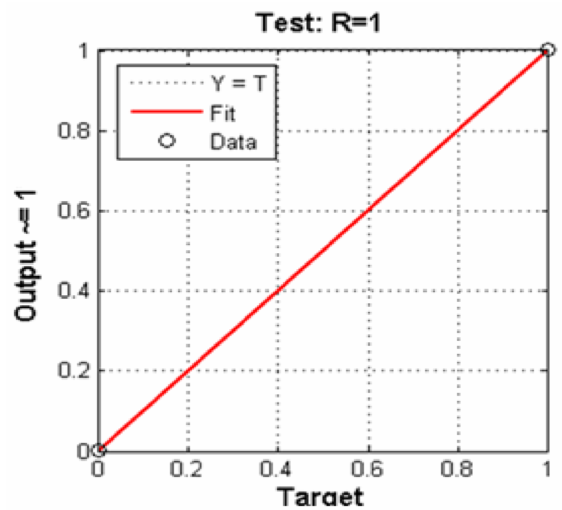

Figure-8. Testing regression.

5. CONCLUSIONS

This paper has presented excellent technique for detecting and classifying asymmetrical faults such as single line to ground fault, line to line fault and double line to ground fault. The presented method is based on the incorporating of wavelet transform and neural network. The proper selection of db4 mother wavelet has played a significant role of extracting the useful information for fault classification. A feed-forward BP-ANN structure using Marquardt Levenberg algorithm is presented for fault detection and classification.

The proposed method has showed brilliant performance in terms of accuracy and computational time. The results have proved that the method has high capability of fault diagnosis and classification. The proposed technique can be used as an effective approach for alternative protection scheme for large electrical power system. Further work will be the investigating the larger system and will included extensive different fault conditions. The outcome of current research will be reported in due to follow.

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