IOSR Journal of Engineering (IOSRJEN) **www.iosrjen.org**
ISSN (e): 2250-3021, ISSN (p): 2278-8719
PP 82-88

A Case Study of Fault Detection in Cascaded H-Bridge Multilevel Inverter Using Artificial Neural Network Based On Wavelet Decomposition

Prarwesh R Meshram, Prof. Prachi Chintawar
Department of Electrical Engineering Vidarbha Institute of Technology, Uti, Umred Road, Nagpur Maharashtra, India
Department of Electrical Engineering Vidarbha Institute of Technology, Uti, Umred Road, Nagpur Maharashtra, India

Abstract: *Fault detection plays very important role in high cost and safety-critical responsive processes. In Early times detection of process faults can help avoid abnormal event progression. Fault detection can be accomplished through various means of technologies. This paper presents the literature survey of major methods and current state of research in the field of research with a selection of important practical applications. Transmission lines faults are the inevitable part of any power system. They cause a disruption in the power supply, which is undesirable in nature. With an ever-increasing demand for better performance and minimal interruptions, accurate fault analysis is necessary to restore a system to its normal operation by detecting and clearing the transmission line fault. This paper presents a comprehensive review of the techniques employed in fault analysis which have evolved over the last decade. This review paper mainly focuses on the implementation of discrete wavelet transform (WT), and Artificial Neural Network for Fault detection of any system.*

Keywords: *Fault analysis, Wavelet transforms, Artificial Neural Networks*

I. Introduction

Increasing demands on reliability and safety of technical plants require early detection of process faults . Methods are required to develop that enable earlier detection of process faults than conventional limit and trend checking based on single process variable. These types of methods can encompass information from not just one process variable but also include nonmeasurable variables as process state, parameters and characteristics quantities, [1, 2, and 3]. Some methods are require accurate process models while others rely primarily on available historical process data. In this brief of review paper is outlined introduction to the field with the major methods and its literature references. Transmission line protection has always been a topic of major concern with field of Electrical engineering, as it is a vital power system and its constantly exposed to the environmental conditions. Indeed, the faults due to overhead transmission lines are about 50% as compared to the different types of faults that can be occur in a power system [1].. It is a direct measure of a system's capability to detect, classify and locate the fault and take preventive measures to protect the remaining equipment of the power system. One of the most important equipment in the protection of transmission line is the protective relay. It is found that Relay continuously monitors the transmission line by receiving voltages and/or currents as inputs from voltage and current transformers Thus the detection, classification and location of faults using different protective relays have become more effective in a major area of research historically. Over the past century, the protective relays have evolved from electromechanical relays to static relays to computer based digital relays. The digital relays operate based on fast accurate algorithms for fault detection, classification and location. Due to the dynamic nature of fault transients in the system, recent studies show that frequency domain analysis needs to be employed to capture the transient frequency components to accurately detect the occurrence of the fault [2-5].

Robertson et Al [6] have presented a comparative study of fault analysis using Fourier transform (continuous and STFT) analysis and continuous wavelet transform (CWT) analysis. The authors have shown the superiority of wavelet transform for better fault analysis in the subject. The process of extracting the particular wavelet features of the system during fault occurrence has been explained.

Mallat et al[7]. Proposed discrete wavelet transforms (DWT) using multi resolution analysis (MRA) for signal decomposition. The authors have proposed MRA technique which divides the given signal into bands of frequency using high pass and the low pass filtering operation. This type of analysis is used to solve the resolution issues with FT and STFT for better fault analysis

Wavelet MRA has been developed for fault analysis. MRA coefficients (extracted from low/high pass filtering operation form the original) are derived to extract the transient fault frequency components occurring during the fault. These extracted wavelet features are used for fault analysis.

Artificial Neural Networks (ANN) is recently developed tool in engineering technology, capable of the machine learning and pattern recognition using suitable interconnected layers. The learning process in these networks involves updating the weights of interconnections between adjacent layers. These networks can be trained using sample of the data and are capable of recognizing unique patterns or occurrence of events. It is this feature of neural networks that make them highly suitable for implementation in transmission line fault analysis techniques. Several researchers have been developed methodologies for the process of fault analysis using wavelet transform along with different types of neural networks such as Feed-forward neural networks (FFNN), Back propagation neural networks (BPNN), Probabilistic neural networks (PNN) and Perceptron neural networks. Fuzzy logic technique is used in different engineering applications for solving the uncertainty problem. The key benefit of fuzzy logic is that to have knowledge representation is explicit using simple "if-then" relations [8]. The basic structure of fuzzy inference system (FIS) is a model that maps the input characteristics to the input membership function, input membership function to rules, rules to a set of output characteristics, output characteristics to output membership functions and output membership function to a single valued output or a decision associating with a output. Several researchers have developed methodologies for fault analysis using wavelet transform and FIS.

The next section deals with a comprehensive review of wavelet transform, ANN, fuzzy logic for the application of fault detection, classification and location of transmission line faults. A flowchart explaining the paper scheme is given in figure 1. As there is a large number of research publications in the area of wavelet transform of application for fault analysis and page limitation,

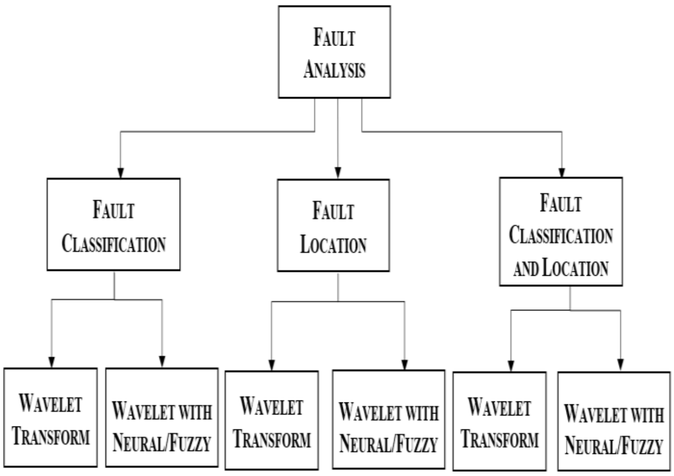

Fig 1: Block diagram representation of literature survey on wavelet based fault analysis

II. Basic Terminology

It is of importance to define terminology of a field: fault, failure and malfunction, types of faults and fault detection.are as follows,

A. Fault

A fault is an unpermitted deviation of at least one characteristics property (feature) of the system from the acceptable, usual, standard condition [1,2].

B. Failure

A failure is a permanent interruption of a system's ability to perform a require function under specified operating conditions [1].

C. Malfunction

A malfunction is an intermittent irregularity in the fulfillment of a system's desired function, [1]. Development of events "failure" or "malfunction" from a fault is illustrated in Fig. 1

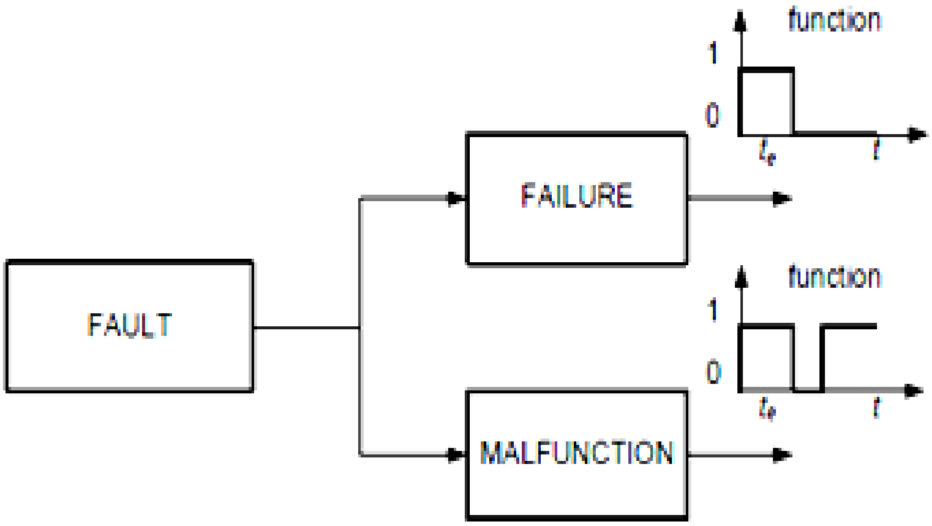

Fig. 2 Progression of fault toward failure or malfunction

D. Fault Detection

Fault detection determines the occurrence of fault in the monitored system of the transmission line. It consists of detection of faults in the processes, actuators and sensors by using dependencies between different measurable signals. Related tasks are fault isolation and fault identification. Fault isolation method determines the location and the type of fault whereas fault identification determines the magnitude (size) of the fault. Fault isolation and fault identification are together referred as fault diagnosis, [4]. The task of fault diagnosis consists of the determination of the type of the fault, where as many details as possible such as the fault size, location and time of detection, [1].

III. Fault Classification Methods

E. Using Wavelet Transform

The following section delivers a brief review about selected papers published on wavelet transform for transmission line fault classification.

Hong et al. [9] have given an algorithm using B-Spline wavelet for fault classification at a sampling rate of 600 Hz. It is totally based on observing the rapid change in the current signal which occurs during faults. The advantages of using a B-Spline wavelet were discussed. Wavelet coefficients of the fault currents at scale two are used to evaluate the moving average of wavelet transform which is used for analysis purpose. If the moving average exceeds a pre-set value, presence of a fault is detected. Fault classification is also based on comparison of data with specific threshold value. The proposed algorithm is very suitable for any voltage level. The author uses this algorithm for classification of faults in a three generator 220kV power network.

Mahanty et.al [10] have developed a fault classification algorithm by generating fault data with the help of electromagnetic transient program (EMTP) and fault classification and detection was done by wavelet tool box in MATLAB. Variations in fault inception angle, fault resistance have been drastically considered. In the proposed algorithm, bi-orthogonal spline wavelet has been used as the mother wavelet and The sampling frequency incorporated was 1.8 kHz. MRA level 1 detail of phase currents along with the delta currents are used to discriminate the type of fault. The authors give a fault classification algorithm based on the above idea from which one has to calculate peak absolute value of the sum of the level 1 detail of three phase currents. From these ratios and peak absolute values, the fault is classified. The author uses this algorithm for classification of faults in both singly and doubly fed lines.

Jamali et al. [11] have presented an algorithm for fault classification for single phase faults and It includes the calculation of a mode current that is sampled at a frequency of 10 kHz. Db 8 wavelet is used to find fault analysis up to level 7 coefficients for fault classification. This has been tested on a 500 kV line simulation. The results show the ability of the procedure to discern the type of fault. An advantage of this algorithm is that of its performance is independent of line parameters. It is useful for fault classification in transmission lines performance having reactor compensation, which is of great significance in modern power systems.

Kim et al. [12] have presented a novel technique for detecting High impedance faults (HIFs) for HV transmission lines using WT. The Db-4 level one detail wavelet coefficients were chosen for the study with sampling frequency of 3840 Hz. The absolute sum of detail coefficients were calculated and compared with a threshold frequency level. Based on the threshold value, the fault was classified. The authors have tested this technique on a 154 kV transmission line system and it was versatile and can adapt to variation in system parameters.

Youssef [13] has presented another algorithm for fault classification based on wavelet transform. In this method, single-level Daubechies (Db) wavelet signal decomposition is used as the mother wavelet for fault analysis and a 10 kHz sampling frequency was used. The algorithm calculates the difference between every two successive wavelet samples of the three phase line currents and compares them together to identify and classify the fault. The author has used a 400 kV doubly-fed transmission line for the simulation used to evaluate the performance.

Chanda et al. [14] used 3rd level wavelet MRA detail coefficients with Db 8 as mother wavelet for three phase currents. A sampling frequency of 12.5 kHz is taken and the ten wavelet levels are considered. The author has considered a 230 kV transmission line fed from both the ends. Fault data is generated using EMTP software. Summation of third level detail coefficients of each phase currents are used for fault classification. The algorithm is immune to variations in fault inception angle, fault resistance and fault location.

Reddy et al. [15] have used wavelet MRA technique in collaboration with Global Positioning System (GPS) for fault classification in multi generator systems. They have used DB 4 as the mother wavelet for extracting up to level seven detail coefficients of the synchronized current signal. The sampling frequency employed was 12.5 kHz. The level six detail coefficients in the MRA output were found to be suitable forThe equations are as an exception to the prescribed specifications of this template. You will need to determine whether or not your equation should be typed using either the Times New Roman or the Symbol font (please no other font) To create multileveled equations, it may be necessary to treat the equation as a graphic and insert it into the text after your paper is styled.

F. Using Wavelet Transform and Neural Network

The following section gives a brief review about selected papers published on WT and soft computing techniques (ANN, fuzzy logic) for transmission line fault classification. Fault features are extracted using WT and soft computing techniques are used to classify the type of fault using extracted features.

Mahmood et al. [16] have proposed a technique of fault detection whereby automatic transient fault classification in doubly-fed transmission lines can be performed using Wavelet MRA and PNN. Db 8 wavelet is used as mother wavelet with a sampling frequency of 20 kHz, the 5th level detailed coefficients are obtained and these features are extracted suitably to be fed as input to the PNN. Each of the 3 outputs of the PNN correspond to the three types of transients- lightning, switching and fault- and only one of them will be high in the process of classification. A 500 kV transmission line was used for MATLAB simulation for fault analysis.

Kashyap et al. [17], proposed a method for fault classification using wavelet transform and Probabilistic Neural Network (PNN). The 4th level Meyer wavelet detail coefficients of transient disturbances are obtained using MRA technique. As the detail coefficients of each type of simple fault are distinct in nature, this is used as input to Probabilistic Neural Network (PNN) which classifies the detail coefficients and thus the fault can be identified for the fault analysis. A singly fed transmission system was considered for fault simulation studies.

Silva et al. [18] presented an algorithm based on wavelet transform and ANN that can be used for fault classification. Db 4 has been used as mother wavelet. Level 1 detail coefficients were extracted at a sampling frequency of 1200Hz. The authors used 230kV, five generators power network. An algorithm is proposed to identify the first and last samples of fault clearing time using up sampling technique which are resampled to a smaller frequency to compress the frequency spectrum of faulted current. Five consecutive voltages and current samples are windowed within the fault clearing time and are fed as input to ANN. The output of ANN gives the type of fault.

IV. Fault Location Methods

The following section gives a brief review about selected papers published on wavelet transform for transmission line fault location

G. Using Wavelet Transform

Chanda et al. [19] presented a Wavelet MRA technique for fault location. The algorithm is basically based on the fact that the second and third harmonics are the most dominant components of a fault. For this type of methodology, the third level coefficients of the transient signal (frequency range of this level is 97-195 Hz) are extracted using MRA. This paper provides for an accurate location mechanism. In addition of , a cubical interpolation technique has been proposed to aid the process. This interpolation of technique starts with an assumption of a cubic polynomial and is an iterative process which pinpoints the location of the fault with a high degree of accuracy. It have been shown with results that this scheme is quite fast, accurate and suitable at any voltage level of the line. However, a drawback in this technique is that it assumes that the fault is identified and is classified before the procedure starts. This may not be the case in practical systems.

Osman et al. [20] have used wavelet transform MRA technique to estimate the voltage and current phasors from the measured three phase signals. The author calculates the norm of the detail coefficient (D1) obtained by using Db 1 wavelet for each of input current. A disturbance is detected when norm value of a phase exceeds a threshold value. The author has used sampling frequency of 960 Hz. Using WT based phasor estimation technique, the impedance seen by the relay is estimated. The impedance of the system calculated is used for distance protection. The authors have used double fed 240 kV line for analysis. The authors have been used PSCAD for simulation and experimental verification for different types of faults to demonstrate the reliability of the proposed techniques. Osman et al. [24] have proposed for another scheme to detect faults in a parallel transmission and send appropriate trip signal to the circuit breaker. By subtracting the current phasor of magnitudes of the respective phases which have been diagnosed with disturbance, the fault is been identified and trip signal is sent.

Magnago et al. [21] have presented an approach for fault location using wavelet MRA technique for calculating Db 4 level 1 and 2 detail wavelet coefficients at a sampling frequency of 100 kHz for the fault signal of syetm. The location can be determined by forming the modal component of the fault signal. This component is been compared with the reflected travelling waveform in the line for fault location. This type of differential analysis serves as for all types of faults, irrespective of line impedance and line parameters. It is also shown as to be suitable for mutually coupled lines and series capacitor for compensated lines. The authors have used single fed 345 kV line for simulation using EMTP.

H. Using Wavelet Transform and Neural Network

Ngaopitakkul et al. [22] have proposed a good method to combining both wavelet transform and probabilistic neural networks. Db4 is used as the mother wavelet to decompose for high frequency components of scales 1 to 5 from the positive sequence phase current waveforms. There are basically two input neurons and one output neuron and The input wavelet transform coefficient’s are fed to all neurons in the first layer in ANN. The distance from the input to the weight vector is deduced from the radial basis layer, based on a relation. These are fed as inputs to every neuron in the second layer which generates a probability vector as its output, and the maximum value is then selected. Due to based on maximum probability, the fault location is estimated. The output values of the PNN system are having a range of 1 to 9, and each correspond to a particular location of the fault. A doubly fed 500 kV transmission line was simulated in EMTP. There are various types of fault signals are generated and variations in fault inception angles and location have been considered.

Abdollahi et al.[23] have presented a fault location estimation algorithm for the system whereby a fault classifier network and wavelet decomposition were employed. The mother wavelet used was db9 and level three detail coefficients were derived for each phase at a low frequency lavel. The procedure requires the pre-fault and post- fault voltages and current waveforms for the efficient performance of the algorithm. To have two independent inputs -one from the MRA network and the other from the fault classifer network were required. They have also presented a distance estimation formula based on voltage, current and the difference between prefault and postfault voltages and currents at the fault point. A doubly fed 230 kV transmission line is simulated using PSCAD/EMTDC and tested with various types of faults

V. Fault Detection using artificial intellegence techniques

The fault diagnoses are usually follows after the fault detection wherein the kind, size and location of the fault will be determined. In the past two decades, the techniques of neural networks are growing, as a data-driven method, which provides a totally new perspective to fault diagnosis. Neural networks can be applied for fault diagnosis using different approaches of the systems. Pattern recognition approach and residual generation are followed by decision making are the most common ones. The second approach is been generally more suitable for dynamic systems. Different neural network architectures have been tried for fault diagnosis. Arvind et al [24] have used the Hopfield network for identification of system parameters. The obtained parameters are further passed to Adaptive Resonance Theory (ART) network for fault diagnosis. The problem with this method is the choice of the optimal window size to detect the system parameters. Ashraf Megahed [25] have proposed a model based fault diagnosis method to detect the fault and isolate faults in the robot arm control system. The fault in the system is detected when the error (i.e. difference between the system output and the estimated output) exceeds a predetermined threshold. Once the fault is detected the estimated parameters are transferred to the fault classifier so that output is easy to find. Yang et al [26] have proposed a new neural network for fault diagnosis of rotating machinery which synthesizes the ART and the learning strategy of Kohonen network. Yanghong et al [27] have proposed a novel method for fault diagnosis of analog circuits with tolerance using wavelet packet decomposition and probabilistic neural networks. Where the fault feature vectors are extracted and fed to the probabilistic neural network. The BPN is probably the most widely used neural network structure for classification of faults. BPN can be viewed as the gradient descent technique, used to minimise the total squared error of the fault output and therefore possesses a high degree of credibility of the faults.

VI. Conclusion

Early fault detection can be minimize plat downtime, also extended equipment life, increase the safety of the system and reduce manufacturing costs. This paper presents a comprehensive review of various techniques involving wavelet transform utilizes for fault analysis of the transmission lines and similarly the fault detection in transmission line using ANN with its different method. The use of wavelet MRA techniques along with the ANN have proven to be reprehensive and actual in the field of fault analysis also all the author have made a responsive attempt to compile as lot of development as possible in this filed Number of issues must be considered when choosing particular fault detection method a desired method should be used after studying all this method the MRA Analysis and wavelet decomposition could be the better methods for fault detection in future.

References

[1]. Badri Ram and D.N.Vishwakarma,"Power System Protection and Switchgear", Tata Mc-Graw Hill Publication Company Limited, New Delhi, 2005, pp.6-9,119-123.

[2]. Kim and Aggarwal, "Wavelet transform in power systems," Power Engineering Journal, Vol. 15, No. 4, pp. 193–202, August 2001.

[3]. C. Chui, "An Introduction to Wavelets", Academic Press, New York, Vol.1, pp. 553 - 559, 1992.

[4]. Shyh-Jier Huang, Cheng-Tao Hsieh and Ching-Lien Huang, "Äpplication of wavelets to classify power system disturbances", Electric Power Systems Research, Vol. 47, No.2, pp. 87-93, October 1999.

[5]. T.B. Litler and D.J. Morrow, "Waveletes for the analysis and compression of power system disturbances", IEEE Transactions on Power Delivery, Vol.14, No.2, pp. 358-364, April 1999.

[6]. D.C. Robertson, O.I. Camps, J.S. Mayer and W. Gish, "Wavelets and electromagnetic power system transients", IEEE Transactions on Power Delivery, Vol. 11, No.2, pp.1050-1058, April 1996

[7]. Stephane Mallat, "A theory of multiresolution asignal decomposition: The wavelet representation", IEEE Transactions on Pattern Analysis and Machine Intelligence, Vol. 11,No. 7,pp. 674-693, July 1989.

[8]. L.A. Zadeh, "Fuzzy Sets", Information and Control, Vol.8, No.3, pp. 338-353, June 1965.

[9]. Cheng Hong and S. Elangovan, "A B-Spline Wavelet Based Fault Classification Scheme for High Speed Protection Relaying", Electric Machines and Power Systems, Vol.28, No.4, pp. 313-324, 2000.

[10]. R. N. Mahanty and P. B. Dutta Gupta, "An Improved Method for Digital Relaying of Transmission Lines", Electric Power Components and Systems, Vol. 32, No.10, pp. 1013-1042, 2004.

[11]. Sagedh Jamali and Navid Ghaffarzadeh, "Adaptive Single-pole Auto-reclosure for Transmission Lines Using Sound Phases Currents and Wavelet Packet Transform", Electric Power Components and Systems, Vol. 38, No. 14, pp. 1558-1576, 2010.

[12]. Chul-Hwan Kim, Hyun Kim, Young-Hun Ko, Sung-Hyun Byun, Raj K. Aggarwal, and Allan T. Johns, "A Novel Fault-Detection Technique of High-Impedance Arcing Faults in Transmission Lines Using the Wavelet Transform", IEEE Transactions on Power Delivery, Vol. 17, No. 4, pp. 921-929, October 2002.

[13]. A.S.Omar Youssef, "Fault Classification Based on Wavelet Transforms", IEEE Transmission and Distribution Conference and Exposition, Vol. 1, pp. 531-536, 2001.

[14]. D. Chanda, N. K. Kishore and A. K. Sinha, "Application of Wavelet Multiresolution Analysis for Classification of Faults on Transmission Lines", Proc. of The IEEE Conference On Convergent Technologies for Asia-Pacific Region(TENCON),Vol.4, pp. 1464-1469,2003.

[15]. M.Jaya Bharata Reddy, D.Venkata Rajesh and D.K.Mohanta,"Robust Transmission Line Fault Classification Using Wavelet Multiresolution Analysis", Computers and Electrical Engineering (Elsevier publication), Vol.39, No. 4, pp. 1219-1247,May 2013.

[16]. Farhan Mahmood, Suhail Aftab Qureshi and M. Kamran, "Application of Wavelet Multi-resolution Analysis and Perceptron Neural Networks for Classification",Australasian Universities Power Engineering Conference (AUPEC '08), pp. 1-5, 14-17 December 2008.

[17]. Harish Kashyap and Jayachandra Shenoy, "Classification of Power Systems Faults using Wavelet Transform and Probabilistic Neural Networks", International Symposium on Circuits And Systems (ISCAS), 25-28 May 2003.

[18]. K.M.Silva, B.A.Souza and N.S.D.Brito, "Fault Detection and Classification in Transmission Lines Based on Wavelet Transform and ANN", IEEE Transactions on Power Delivery, Vol. 21, No. 4, pp. 2058-2063, October 2006.

[19]. D. Chanda, N.K. Kishore and A.K. Sinha, "A Wavelet Multiresolution Analysis for Location of Faults on Transmission Lines", Electrical Power & Energy Systems, Vol.25, pp.59-69, 2003.

[20]. A.H. Osman and O.P. Malik, "Transmission Line Distance Protection Based on Wavelet Transform", IEEE Transactions on Power Delivery, Vol. 19, No. 2, pp. 513-523, April 2004.

[21]. F.H. Magnago and A. Abur, "Fault Location using Wavelets", IEEE Transactions on Power Delivery, Vol.13, No.4, pp.1475-1480, 1998.

[22]. Atthapol Ngaopitakkul and Chaiyan Jettanasen,"Combination of Discrete Wavelet Transform and Probabilistic Neural Network algorithm for detecting Fault Location on Transmission Systems", 14th International Journal of Innovative Computing, Information and Control (ICIC International), Vol. 7, No. 4, pp. 1861-1873, April 2011.

[23]. A. Abdollahi and S. Seyedtabaii, "Transmission Line Fault Location Estimation by Fourier & Wavelet Transforms Using ANN", The 4th International Power Engineering and Optimization Conference (PEOCO), Shah Alam, Selangor, Malaysia, 23-24 June 2010.

[24]. Arvind et al , Fahmida N. Chowdhury and Jorge L. Aravena, "A Modular Methodology for Fast Fault Detection and Classification in Power Systems", IEEE Transactions on Control Systems Technology, Vol. 6, No. 5, pp. 623-634, September 1998.

[25]. Ashraf Megahed, A. Monem Mouss and A.E. Bayoumy, Lee et al "Usage of Wavelet Transform in the Protection of Series-Compensated Transmission Lines", IEEE Transactions on Power Delivery, Vol. 21, No. 3, pp. 1213-1221, July 2006.

[26]. Yang et al , P.S. Bhowmik, P.Purkait and K.Bhattacharya, "A Novel Wavelet Transform and Neural Network Based Transmission Line Fault Analysis Method", International Journal of Electrical Power and Energy Systems, Vol. 31, No.5, pp. 213-219, January 2009.

[27]. Aritra Dasgupta, Sudipta Nath and Arabinda Das, Yanghong et al, "Transmission Line Fault Classification and Location Using Wavelet Entropy and Neural Network", Electrical Power Compoents and Systems, Vol.40, No.15, pp. 1676-1689, 2012.

[28]. J.B.Reddy and D.K. Mohanta, "Adaptive neuro-fuzzy inference system approach for transmission line fault classification and location incorporating effects of power swings", IET General Transmission and Distribution, Vol. 2, No.2, pp. 235-244, 2008.