CLASSIFICATION OF FAULT IDENTIFICATION TECHNIQUES IN POWER SYSTEM TRANSMISSION LINES

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***Abstract:** This paper gives an overview of various fault classification methods in lines. Efforts have been made to almost all the techniques and philosophies of transmission lines, which have been reported in the literature. The classification is necessary for reliable and high speed protection followed by digital distance protection. It is therefore an appropriate review of these methods is required. In this paper we have discussed here, short introduction to faults in the transmission lines and the scope of the various old approaches in this area. The innumerable amount of power systems and applications requires the improvement in appropriate techniques for fault classification in the drive systems, to increase the efficiency of the systems and to avoid major damage, so shall it be also concentrate and a newly developed approach in this area.*

***Keywords:** Fault; Fault classification; Protection; Soft computing techniques; Transmission line protection; Transmission lines*

1. Introduction

In this modern age of technological development demand of the electricity is increasing where generation and transmission capacity is not increasing at same rate. This gives constraints on the power system. The erection of a new transmission line is not an easy task especially in the developing countries like India. So a power system engineer must try to use existing transmission lines up to their stability limits.

There is no fault-free system and it is neither practical nor economically viable to build a fault-free system. The various cases observed abnormal circumstances such as natural events, physical accidents, breakdowns, and incorrect operation creating disturbances in the power supply. The consequences of the traumatic disorders are reinforcing the current flow, increasing heat in the conductors, which are among the most important causes of damage produced. The actual level of interference will depend on the resistance to flow and varied impedance between the fault and the source of the power supply. Impedance consists of the fault resistance, resistance and reactance of the Conductor, the impedance of the transformer reactance of the circuit, and an impedance of power plant. Faults in overhead transmission system can be classified into two types, i.e. series (open conductor) faults, and shunt (short circuit) faults. Serial faults can easily be identified by observing the single-phase voltage. If the voltage values are increased, this means that open conductor fault has occurred. These faults are available in two types, i.e., an open conductor of classification of incidents, and two open circuit. These faults are very rare error which has occurred. Short-circuit faults can easily be identified by observing the individual phases current. If the current values increases, it indicates short circuit has occurred. Short circuit faults are divided into two types, i.e. asymmetrical faults, and symmetrical faults. Asymmetrical faults line to ground (LG), line to line (LL), and double line to ground (LLG), and symmetrical faults are triple line (LLL) and triple line to ground (LLLG) faults. The Fig. 1 shows the classification of faults in overhead transmission system.

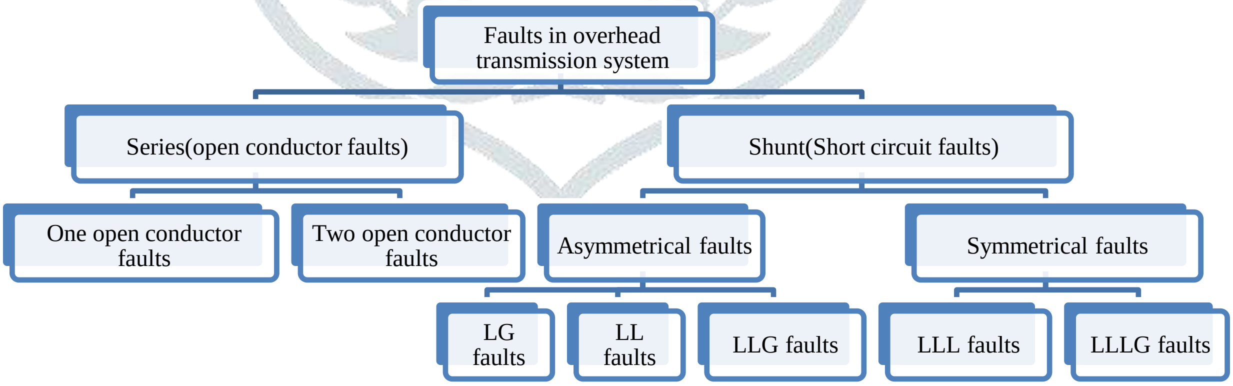

Fig. 1. Classification of faults.

The frequency of occurrence and severity of the faults are going to be compared with human diseases. The most commonly occurring fault is LG fault and the most commonly occurring diseases are headache, cold. As we know, headache and cold are less severe compared to other diseases, in the same way, LG fault also less severe compared to other faults. The next fault in severity wise and occurrence wise is LL fault. It can be compared with diseases like fever and LLG fault with viral fever and 3-phase (LLL and LLLG) faults can be compared with big disease like heart attack, It means that if 3-phase fault has occurred, the entire system collapsed, so that it is in comparison to the major diseases such as heart attack. So protection needs, in order to determine the fault and the fault type and location of the fault within less time classify the larger to avoid damage. For this until now, so many methods have to be invented, each method has its own advantages and disadvantages. To select a fault classification method is a big task for the user.

Therefore, it is necessary to check that all to ensure the efficient and effective fault classification proposed methods. Several fault classification methods together with their implementation are described in the literature.

2. Survey on fault classification methods

The classification is a common procedure with categorization, the procedure in which thoughts and objects are perceived and separated. Classification enables us to see, connections between things that may not be clear, if a view on taking in general. The classification of things makes it less challenging for us to make subjective judgments about the value of the different things. The accuracy of the fault detection and classification are the most important elements for the protection of overhead line. This has a different enthusiasm for temporary protection technology. By so many techniques developed for a classification that the user may get confused to choose the appropriate technology. Easy to understand, this review of the widespread fault classification procedures in 3 types divided up as follows:

(A) Prominent Faults
(B) Hybrid Faults
(C) Modern techniques

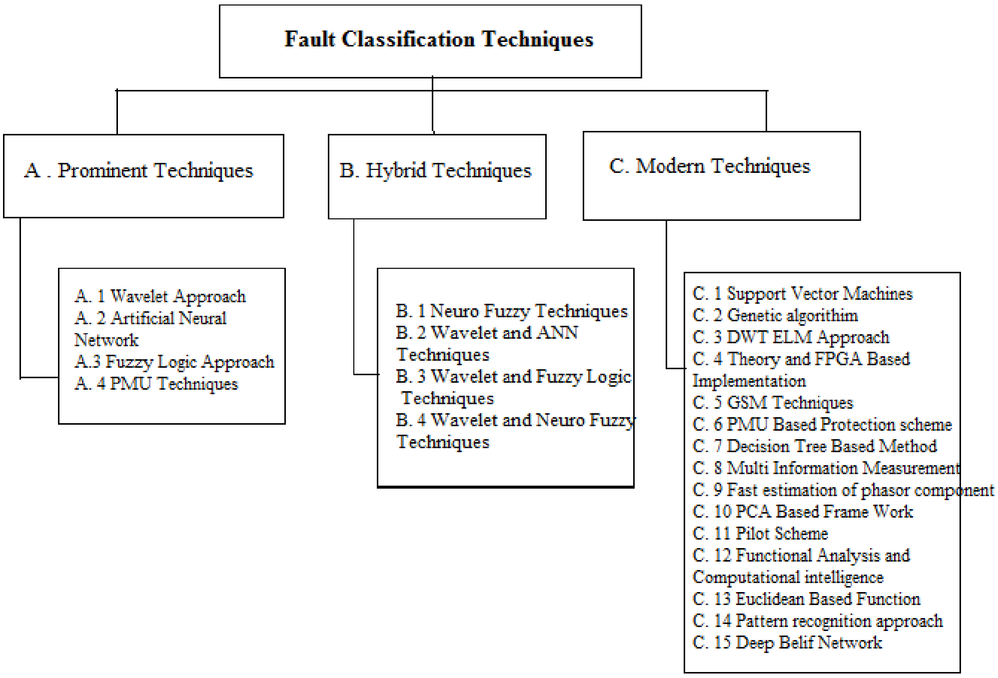

Fig. 2. Tree diagram of fault classification techniques

2.1. Prominent techniques

Prominent techniques are well-known techniques, commonly used for fault classification in transmission lines. These techniques are classified into 3 types. They are

A.1 Wavelet approach
A.2 Artificial neural network approach
A.3 Fuzzy logic approach
A.4 PMU Techniques

The explanation of each technique is given below. The Fig. 3 shows the single line diagram of typical power system considered for the simulation.

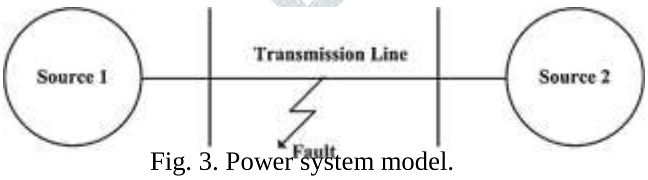

Fig. 3. Power system model.

2.1.1. Wavelet approach

Wavelets are a numerical tool for signal preparing. The basic idea of the wavelet transform (WT) is to choose a reasonable wavelet function as “mother wavelet” and afterward execute examination utilizing moved and enlarged adaptations of this wavelet. Wavelet can be exceptionally attractive repetition and time attributes, when contrasted with Fourier method to be picked up. The Fourier expansion has just no time, frequency identification and determination. This means, it shall be decided by each of the frequencies in the signal does not, at which time to implement them. To get around this problem, conquer WT is proposed. WT are time and frequency data all the time. WT signals can be divided into different frequency bands with the help of multi-resolution analysis (MRA). It can be used in the detection of faults, and of the phasors of current and voltage signals, which are important for the protection of overhead lines to appreciate.

WT signals can be divided into different frequency bands with the help of multi-resolution analysis (MRA). MRA is used for fault analysis in the protection of overhead lines. In the technology, the system was simulated with the electromagnetic transients program (EMTP), and in which the distributed parameter model was used to simulate the transmission line impedances, then scissors model was used to simulate the local and remote end sources.[48][49] In this work the simulation data as input to classify the type of fault. An approach with wavelet technology for the analysis with the help of wavelet entropy principle has been implemented. In the PSCAD/EMTDC used for simulation of the power system are presented.[10] The energies of the wavelet coefficient transient fault caused for error analysis has been used in power transmission systems. The decisive advantage of this technology was recommended to find the faults in real time. [6] The Fig. 4 shows the decomposition of a signal 'S'. In this figure, A and D indicates approximation coefficients and detail coefficients respectively.

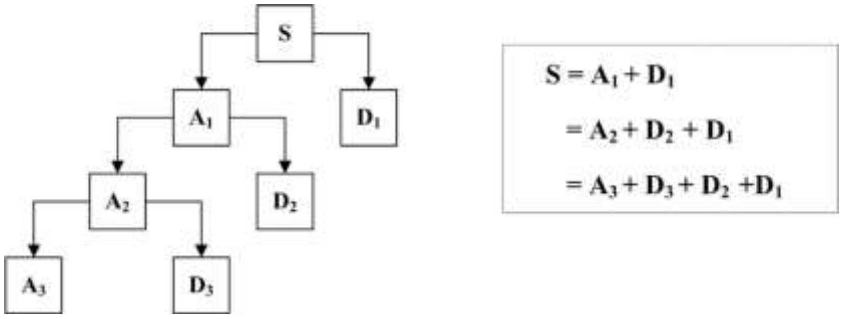

Fig. 4. Three-level decomposition of a signal 'S'.

2.1.2. Artificial neural network approach

Artificial neural network (ANN) has been equipped with distinctiveness of parallel processing, nonlinear mapping, associative memory, and offline and online learning abilities. The wide uses of ANN with its conquering outcomes make it an effective diagnostic mean in electric power systems. They can in this manner be prepared with known case of an issue to obtain information about it. Once suitably prepared, the system can be put to powerful use in understanding "untrained" or "unknown" case of the problem. The essential structure of simulated neuron model appears in Fig. 5.

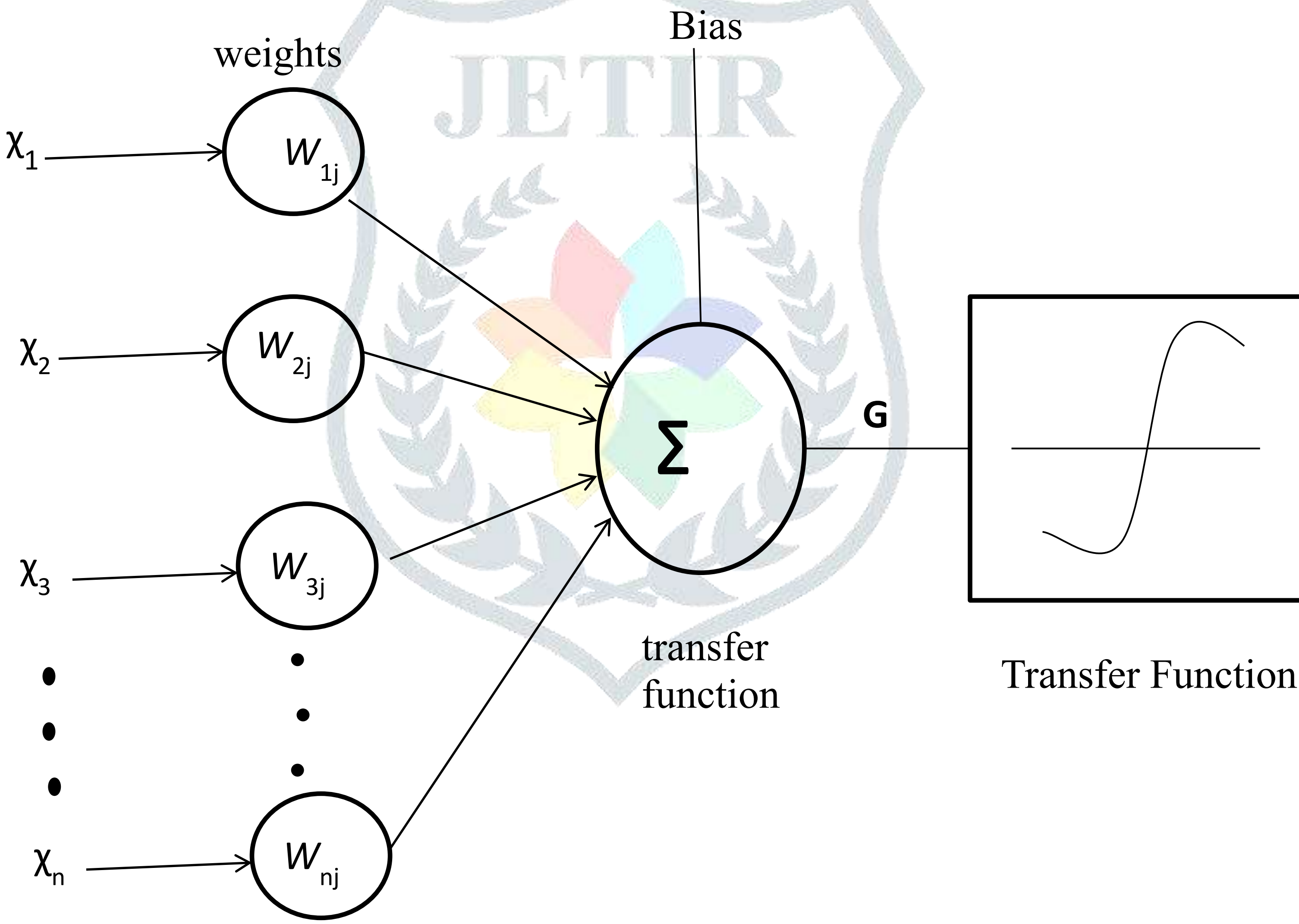

Fig. 5. Artificial neuron model.

It is necessary to identify the fault and classify its type with the aim of establishing safety and stability of the power system [7]. Author developed ANN based monitoring system for health assessment of electric transmission lines. Their system showed satisfactory performance in fault classification by using both MLP (multilayer perceptron) and ART (adaptive resonance theory) classifiers. This approach shows that it is able to achieve results accurately for various combinations of fault conditions [28]. A technique for extra high voltage (EHV) lines for the identification and location via terminal of the high-speed data protection with the use of ANN. Classification of incidents in the overhead lines with the help of artificial neural networks with pre- and post-data of the power system model is presented. [42]

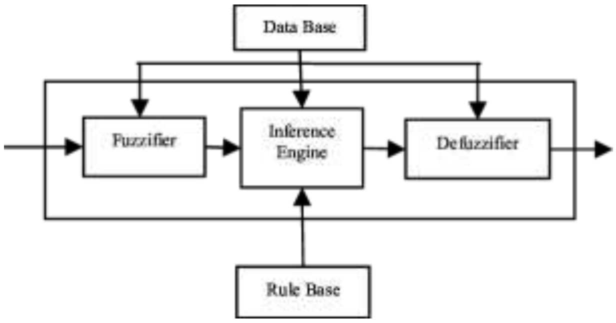

Fig. 6. Fuzzy system.

A distributed and hierarchical neural network (DHNN) system on the basis of the architecture of the hierarchy and integrated module is presented [23]. The DHNN system effectively uses the influential function of artificial neural networks to the characteristics of the sample identification, non-linear approach, associative memory, etc. Its information handling mechanism agrees with the processing of law of classification sketch accuracy in the human biological neural network system.

Fault direction estimation on transmission line is very crucial for enhancing the performance of power system. Advancement of huge generating stations and highly interconnected power systems entails less fault clearing times. The approach of ANN has been positively utilized for the improvement of many of the standard functions that are operated in transmission lines. The accuracy of an electromechanical, static, or a microprocessor based distance relay is affected by different fault conditions and network configuration changes. Hence the direction of the fault should be discriminated to maintain the normal operation of the power system. The Strategy Approaches information of current and voltage tests on a terminal as contribution in the context of each phase ANN for the classification of the type of fault [12]. Another technique for the classification and isolation of errors in the overhead lines with back propagation (BP) neural network architecture. This work highlights phase RMS values of voltage and current as inputs for the classification is used. [21]

2.1.3. Fuzzy logic approach

The use of Fuzzy Logic has become much consideration as of late because of the adequacy in the prerequisite for complex scientific models in critical thinking. Fuzzy Logic uses linguistic terms, which the casual relationship between input and output variables to manage. Thus, the fuzzy-logic technology makes it easier to control and care of the many problems, especially where the numerical model is not clearly known, or is difficult to reconcile. Fuzzy Logic offers not only a competent representation for the estimation of instabilities in addition an imperative representation for vague ideas expressed in natural language. It is a scientific hypothesis, which includes the provision of information to the ambiguity during portrays a meaning or an idea. Blur is basically a method of representing uncertainty. The general procedure performed in a fuzzy logic methodology appears in Fig. 7 where S1, S2, and S3 are three inputs to the fuzzy classifier, used to characterize fault type.

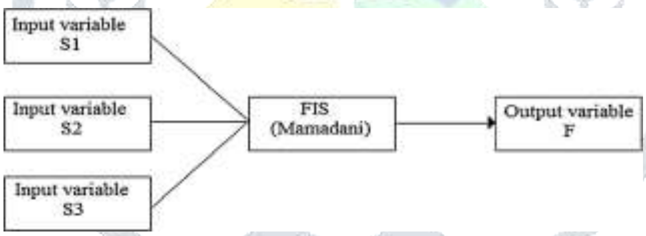

Fig. 7. Fuzzy inference system.

This study presents fuzzy logic based online fault detection and classification of transmission line using Programmable Automation and Control technology based National Instrument Compact Reconfigurable i/o (CRIO) devices[11]. The LabVIEW software combined with CRIO can perform real time data acquisition of transmission line. When fault occurs in the system current waveforms are distorted due to transients and their pattern changes according to the type of fault in the system. The three phase alternating current, zero sequence and positive sequence current data generated by LabVIEW through CRIO-9067 are processed directly for relaying[32]. The result shows that proposed technique is capable of right tripping action and classification of type of fault at high speed therefore can be employed in practical application. This method was able to exactly the phase (s) in all 10 types of shunt errors that may be contained in a transmission line fault happen under different founding angle, and load resistors to classify levels involved [8]. It only requires three line current measurements of the method. The general structure of fuzzy inference system (FIS) utilized as a part of this strategy appears in Fig. 7.

A scheme is designed to recognize the line to ground fault through the use of Fuzzy Logic. The developed method needs post-fault current samples, on the one side of the transmission line only. Simulation studies are in PSCAD/EMTDC, 300 km to 400 kV transmission line model for various types of single-phase, faults and ground. A new strategy of faults in overhead lines on fuzzy systems, the Fuzzy-based technology was superior to each heuristic basis to investigate [29]. In this work, a comparison was made between s-transform and wavelet transform. Finally, you come to the conclusion that s-convert fuzzy decision tree (DT) - provides accurate fault classification.

2.1.4 PMU Technique

Phasor Measurement Unit (PMU) is a technique that synchronized in real-time measurement of the voltages and currents in the form of an integral part of the sequence phasors for the monitoring and control of a power system, especially during stressed conditions. This technique refers to a world-wide Phase Angle Reference Time, which helps to capture a snapshot of the wide-area power system. The uses of this technique are very effective in mitigating blackouts and learn about the behaviour of the power system. Due to the advances in this technology, the micro-based instrumentation such as protective relays and fault recorders (DFRs) PMU together with other existing functions as an advanced function. Thus, this system can be used for the protection of single and double transmission line can be used.[20]

This technique uses sequence voltages and currents at both ends of the transmission line various parameters of the transmission line and the location of the fault on the transmission line to determine and are designed for communication between two modules using GPS. In each module, with PMU, there are other components such as line parameter estimator and distance protection unit, which is also associated with it. The synchronization is determined by the Global Positioning System (GPS).

Line parameter estimator measures the impedance parameters of a transmission line using synchronized voltage and current phasors at both ends of a transmission line based on PMU measurement. And, distance protection unit consists of following components:-

1. Fault detector and classifier
2. Fault locator
3. Making decision unit
4. Conventional distance protection scheme

This technique detects, classify and locate the fault under different conditions with different fault types, fault resistances, power angles, etc.

2.2. Hybrid techniques

Hybrid techniques discuss the integration of the three techniques, namely wavelet approach, ANN approach, and fuzzy logic approach. Hybridization has been to overcome the drawbacks in one approach during its application, with the strengths of the other by appropriately integrating them. These are the combination of one or two prominent techniques. These techniques are classified into 4 types. They are

B.1 Neuro-fuzzy technique
B.2 Wavelet and ANN technique
B.3 Wavelet and fuzzy-logic technique
B.4 Wavelet and neuro-fuzzy technique

2.2.1. Neuro-fuzzy technique

In this part, a brief description of the adaptive Neuro-fuzzy inference system (ANFIS) principles. The basic structure of the kind of Fuzzy Inference System (FIS) could be used as a model that maps input data to input membership functions can be seen. Then maps all membership function as input for rules and regulations in a number of characteristics of the FIS-output. On the last step, FIS cards characteristics of output to membership functions as an output, and the membership as a starting to a decision on the issue. As you can see that the FIS have been put forward, only non-arbitrary membership functions, the arbitrarily chosen. Fuzzy Inference System (FIS) is only for systems that are in the modelling of the structure of fuzzy rule essentially used by the operator-defined [46].

An application of the ANFIS for automated fault analysis in transmission lines with only data on one end of this application of ANFIS to high goals - fast processing, real-time recording of faults can offer [10]. The ANFIS was not only to recognize all shunt faults, but also the type of faults for distance protection system proposed. This method can correctly identify the faulty phases in a transmission line [19]. A fault location technology for a series-compensated transmission system on the basis of the WT and ANFIS. This scheme uses both the line currents wavelet multi-resolution analysis of the fault to obtain recognition [40]. Directions and orders of magnitude of spikes in the wavelet coefficients were used for the detection and classification of faults. After finding the broken sections, the summation of the sixth level MRA coefficients of the currents to ANFIS was fed the correct location of the fault.

2.2.2. Wavelet and ANN technique

Wavelet and ANN technology try the best features of a wavelet approach and artificial neural network approach to combine to give better results in the classification. A new approach of digital relays for transmission line protection is presented. The proposed technique consists of a preprocessing module based on Discrete Wavelet Transforms (DWTs) in combination with an artificial neural network (ANN) for detecting and classifying fault events. The DWT acts as an extractor of distinctive features in the input signals at the relay location. This information is then fed into an ANN for classifying fault conditions. A DWT with quasi optimal performance for the preprocessing stage is also presented. The ability of wavelets to decompose the signal into frequency bands (multi resolution) in both time and frequency allows accurate fault detection. The proposed wavelet has proved optimal performance within the tested faults. The ANNs correctly classify the fault with advantages in accuracy and speed upon classical algorithms. A faster response is obtained since only a quarter of cycle from the occurrence of The fault is required. [4]. This modular approach employs a fault - Classification of network in a simple standard back propagation learning algorithm (SBP) and secondly, a network for demanding the fault location on using Self-Organizing Maps (SOM) is based. The combination of the two ANN and WT fault classification problem has been developed. In this work the input pattern for a simple multi-layer perceptron (MLP) network are wavelet coefficients of the currents. C-language used to develop this technology.

The location, the estimate of the faults in the high-voltage transmission systems and the relative study of the behaviour of Fourier and WT methods with neural network (NN) have been proposed [1]. According to this approach DWT is best for the detection of phase to ground faults and DFT performs better for other disorders. A fault classification technique in transmission system depends on wavelet entropy and neural network is developed [14]. It was found that only three degrees to the decomposition of the voltage signal sufficient for the classification of incidents. The proposed system has been associated with different types of disorders, such as symmetrical and asymmetrical faults for different locations and resistors [14]. Fast and accurate fault classification technique of transfer to new Feature Selection of the wavelet transform, and probabilistic neural network (PNN) will be presented [10]. The Fig. 8 explains the working procedure of wavelet and ANN method.

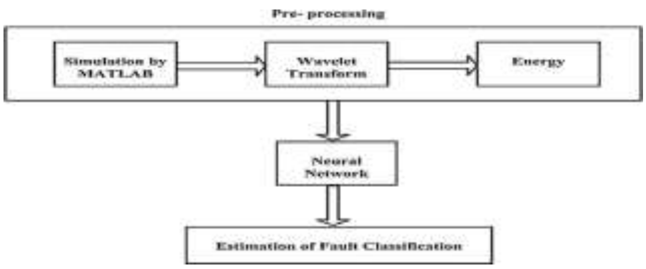

Fig. 8. Fault classification technique using WT and ANN technique.

2.2.3. Wavelet and fuzzy-logic technique

In this technique, provides a real-time wavelet-fuzzy combined approach for digital transmission. The algorithm for the classification employs wavelet multi-resolution analysis (MRA) the difficulties associated with conventional voltage and current measurements due to the effects of factors such as fault inception angle, fault impedance and the distance to be overcome. The proposed algorithm for fault location, unlike conventional algorithms that use deterministic calculations on a clearly defined model to be protected, employs wavelet transform together with fuzzy logic. The wavelet transformation captures the dynamic properties of the non-stationary signals short failure using wavelet-MRA coefficients[14]. The fuzzy logic is employed to integrate expert evaluation by Fuzzy Inference System (FIS), important features of wavelet-MRA coefficients extract for the coherent conclusions about the situation.

2.2.4. Wavelet and neuro-fuzzy technique

The combination of the two Wavelet and neuro-fuzzy-based location technology developed for transmission systems [17]. Location of faults for a series-compensated transmission system with WT and ANFIS has been developed. Wavelet transform together with fuzzy inference system (FIS) and the adaptive neuro-fuzzy inference system (ANFIS) to incorporate expert evaluation so as to extract important features from wavelet multi-resolution analysis (MRA) coefficients for obtaining coherent conclusions regarding fault location. Simulation results indicate that both the classification and localization algorithms are immune to the effects of fault inception angle, impedance and distance. The most significant contribution of this article is that the proposed ANFIS approach has superiority over FIS for location of transmission line faults and thus can be used as an effective tool for real-time digital relaying purposes [41]. In this, wavelet transformations are the three phase currents on both locks of the transmission link. Directions and orders of magnitude of spikes in the wavelet coefficients are used for error analysis. A wide range of disorders with different initially, distinctive and unmistakable fault resistance in both sections of the series compensated Transmission Line are simulated, the execution of the proposed topic area calculation and the legitimacy of the calculation is to identify faults and try to evaluate.

C. Modern techniques

Nowadays, these modern techniques are being implemented for fault analysis in power transmission systems. The various recently developed techniques are explained below.

C.1 Support vector machine

A novel technique for learning the separation of functions in the classification (pattern recognition) tasks or for the implementation of the functional estimation in regression problems is the Support Vector Machine (SVM). It is a computational learning technology is based on the statistical learning theory. In this the input vectors are nonlinearly mapped in a high dimensional stability have more space. It has been effectively applied to many classification problems. The Explanations of the papers on the basis of the SVM are given below.

A new approach to classify fault types and predict the fault location in the high-voltage power transmission lines, by using Support Vector Machines (SVM) and Wavelet Transform (WT) of the measured one-terminal voltage and current transient signals. Wavelet entropy criterion is applied to wavelet detail coefficients to reduce the size of feature vector before classification and prediction stages. The experiments performed for different kinds of faults occurred on the transmission line have proved very good accuracy of the proposed fault location algorithm [27].

A different approach to the location of faults on Support Vector Machines (SVM) during power transmission systems is presented [47]. This technique is also fuzzy set theory for the solution of linear division uncertainty relations. The error rates of the SVMS models low compared to multi-layer perception (MLP) for the steady-state information.

A technique for the exact fault classification scheme in thyristor-controlled series compensator (TCSC) compensates for transmission line with the help of the SVM has been implemented [43]. In this approach an SVM for the classification of faults and its input is independent of the firing angle. So it doesn't have to be wavelet transformation, communication setup and calculation of zero - sequence - current components etc.

C.2 Genetic algorithm

Genetic Algorithms (GA) work with a coding of the variables. The main difference between the genetic algorithms and traditional methods of optimization is that GA uses a population of points at the same time, in contrast to the single-point approach through traditional methods of optimization. Genetic Algorithms (GAs) have recently received much attention as robust stochastic search algorithms for various optimization problems. This class of methods is based on the mechanism of natural selection and natural genetics which combines the notion of survival of fittest. Random and yet structured search and parallel evaluation of the points in search space. The explanation of the following documents shows the classification of the faults in the transmission lines on GA.

A novel technique with genetic algorithm based on neural networks (GANN) for the classification of faults in the transmission lines proposed [37]. This paper also has the comparison between a genetic algorithm based on neural networks and a BP (back propagation) network-based scheme.

A novel method for the classification of the different types of transmission line disturbances caused by the merger of the wavelet transform (WT) and genetic algorithm (GA) was presented [44]. The proposed method contains a pre-processing depends both on the DWT and GA, was used in the DWT characteristic features from the input current signal at the source to extract collected. The data as input for the GA for the classification is given.

C.3 DWT-ELM approach

This approach ensures an accurate hybrid technology for the classification of incidents in a series-compensated. The combination of discrete wavelet transform (DWT) and extreme learning machine (ELM) are used for the classification. A comparison of the proposed fault classifier is equipped with DWT-ANN fault classifier and it is important to note that the presented classifier enables a high degree of accuracy and little learning time in comparison to the other[32].

C.4 Theory and FPGA-based implementation

The recent developments in the FPGA technology on both hardware and software, as well as the rapidly reduces costs, increases the use of FPGA on the territory of the power system.

A better hardware - efficient logic with a field-programmable gate array (FPGA) for the error analysis for overhead lines. The application of an FPGA is a recently new method in the field of Power Systems for the classification[45].

C.5 GSM technique

A global system for mobile communication (GSM), it can be an effective method to the previous special protection systems is applied in order to increase its reliability in the event of network interruptions. In this approach is considered to be a powerful GSM network to send data from one network to another, any variation in the parameters of the transmission is detected to protect the entire transmission and distribution[39].

C.6 PMU-based protection scheme

A PMU-based protection system was proposed[15]. It presents an adaptive protection technology for transmission systems with synchronized phasor measurements. The phasor measurement unit (PMU) protection concept of error detection, classification and direction discrimination. This is the scheme of phasor quantities used a multi-function of the protective relays of the entire line protection in order to achieve enterprise synchronized.

A model for the location of faults for a two-terminal multi-section composite transmission lines, it was the combination of overhead lines and underground power cable, with synchronized phasor measurements[31].

C.7 Decision tree based method

The decision tree mechanism is transparent, and we have a tree structure is easy to follow, in order to explain how a decision will be made. It is perhaps the most highly developed technology for the partitioning example data in a collection of decision rules. Decision Trees for classification problems are often called classification trees. The following documents show how the decision tree mechanism helps in the classification of incidents.

A decision tree technique is used for the classification in the power transmission system has been implemented[36]. It determines the exact fault creation time travelling waves, by the fault and the fault detector is triggered. For this method, data from one side of the protected line is required and the decision-making process, in only 2 ms, this is the best time to previous approaches[13].

A new method for the defective region detection and classification for thyristor-controlled series compensator (TCSC) and Unified Power Flow Controller (UPFC) with the help of the decision tree (DT) is developed. The decision tree-based method uses a cycle data from the founding of the three phase currents together with zero sequence voltage and constructs the optimal decision tree for error analysis in lines.

C.8 Multi-information measurements

A novel method based on multi-Information measurements of fault transient with the help of the information entropy and complexity of the measurement of the fault classification. This method can be used under different transient components work.[23]

C.9 Fast estimation of phasor components

A new method for the transmission of the faulty phases to identify was presented [33]. The proposed algorithm is based on measurements of the phase currents and rapid assessment of the phasor components in relatively short data. The key selection technique uses the relationship between the sizes for different possible fault loops. This method can be grounded and ungrounded differentiate errors with the help of the neutral and phase currents.

C.10 PCA based framework

A novel fault classification method has been proposed[2]. This work is based on phase currents during the first (¼)th of a cycle in a combined procedure, gives better results on symmetrical components method and Principal Component Analysis (PCA). The advantage of this algorithm is used at each end of a transmission line, so that data communication devices are not required.

C.11 Pilot scheme

A novel fault classification technique using reactive power in normal and error conditions[25]. A pilot method needs, there is the sign of the reactive power by a relay to other relay. The decisive advantage of this technique is that no adjustment need. The relay is not required, a threshold value for the parameter. Therefore, this technique is also called as free setting. This technique is independent from the beginning of time and location of the fault.

C.12 Functional analysis and computational intelligence

A new model of functional, the phase of a transmission line is presented. The detection and classification strategy will be developed from the analysis of the model parameters and with the help of simulated faults and a real database is evaluated. The presented mathematical model with stochastic components, the voltage for the current invoice and stochastic deviations, or noise, under normal operating conditions. So, it offers a novel stochastic representation of the lines, the faster detection of unusual behaviour or faults.[9]

C.13 Euclidean distance based function

A new error detection technique is for transmission line protection with euclidean distance between successive current pattern is proposed. This technique is then expanded, incorrect phase to identify them. The relative performance of the procedure, with signals, load change, noise, frequency deviation, Spike and faults in different situations of the power system.[30]

C.14 Pattern recognition approach

A better procedure for the classification of faults in the transmission lines with the help of MATLAB/SIMULINK. Their work shows a discrimination against interference with current and voltage waveforms measured when error occurs in the power transmission system.[38]

C.15 Deep belif network

Artificial Intelligence (AI) Techniques that effectively large amounts of the failure, analyze the data and automatic, accurate diagnostic results, have been widely applied to fault diagnosis of rotating machinery. Conventional AI methods are the use of functions from a human operator, the manually on the basis of diagnostic methods and experiences will be selected. However, the development of robust features for all diagnostic purpose is often labor-intensive and time-consuming, and the functions that might not be suitable for a certain task extracts for others. In this paper, a novel AI method is based on a deep faith Network (DBN) is for the unattended diagnosing a transmission chain proposed and the genetic algorithm is used to optimize the structural parameters of the network [18].

3. Comparison and conclusion

Table 1

Comparison of fault classification techniques

S. No	Name of The Approach	Techniques Used	Simulation Tools Used	Complexity Level
Prominent techniques				
1.	Wavelet Approach	Wavelet Transform, DWT	MATLAB/Simulink, ATP, MATLAB Wavelet Toolbox	Medium
2.	Artificial Neural Network Approach	ANN, Distributed & Hierarchical NN (DHNN), Back-Propagation (BP)	MATLAB NN Tool Box, EMTP, ATP	Complex
3.	Fuzzy Logic Approach	Fuzzy-Set Approach	MATLAB Fuzzy- Logic Tool Box	Simple
4.	Phasor Measurement Unit	Phasor Measurement Unit	MATLAB	Simple
Hybrid Techniques				
5.	Neuro-Fuzzy Technique	Neural Networks, Fuzzy Logic, Fuzzy Neural Network (FNN), ANFIS	MATLAB NN & Fuzzy-Logic Tool Boxes, MATLAB ANFIS Tool Box	Complex
6.	Wavelet And ANN Technique	DWT, CWT	MATLAB Wavelet Toolbox, MATLAB NN Tool Box	Medium
7.	Wavelet And Fuzzy-Logic Technique	Fuzzy-Set Approach, NN	MATLAB Fuzzy- Logic Tool Box, MATLAB Wavelet Toolbox	Simple
8.	Wavelet And Neuro-Fuzzy Technique	Neural Networks, Fuzzy Logic, Wavelet Transform	MATLAB Wavelet, NN & Fuzzy-Logic Tool Boxes. MATLAB ANFIS Tool Box	Complex
Modern techniques				
9.	Support Vector Machines	SVM Classifier, Wavelet	MATLAB SVM Toolbox, EMTP, MATLAB/SIMULINK, ATP	Complex
10.	Genetic Algorithm	GA, NN	EMTP, MATLAB	Complex
11.	DWT-ELM Approach	DWT, ELM	MATLAB/SIMULINK	Medium
12.	Theory And FPGA-Based Implementation	Field-Programmable Gate Array (FPGA)	Real Time Windows Target Toolbox Of MATLAB	Medium
13.	GSM Technique	Global System For Mobile Communication (GSM)	Embedded Based Hardware Design	Simple
14.	PMU-Based Protection Scheme	Phasor Measurement Unit	EMTP/ATP	Simple
15.	Decision Tree Based Method	Discrete Fourier Transform	EMTDC/PSCAD	Complex
16	Multi-Information Measurements	Multi-Information Measurements	MATLAB	Medium
17.	Fast Estimation Of Phasor Components	Zero-Component Current Phasors	ATP-EMTP	Medium
18.	PCA Based Framework	Principal Component Analysis	PSCAD	Medium
19.	Pilot Scheme	Pilot Scheme	MATLAB	Complex
20.	Functional Analysis And Computational Intelligence	Wavelet Transform	MATLAB	Complex

21.	Euclidean Distance Based Function	DWT	MATLAB/SIMULINK	Medium
22.	Pattern Recognition Approach	Multi Resolution Analysis	MATLAB/SIMULINK	Complex
23.	Deep Belif Network	AI, ANN	MATLAB/SIMULINK	Complex

3.2. Conclusion

A classification of the available fault classification procedures in a prominent and hybrid techniques, which are useful, the methods to be used and the combination of different methods for the protection of the drive systems used to know.

Modern techniques contain many new error classification techniques, together with the most important functions. All these techniques have their own features and researches are less operating time of the relay with high speed. So there is a need for the development of new algorithms with advanced optimization techniques and Flexible AC Transmission Systems (FACTS) devices, the higher computing power effectiveness and suitability for real-time applications. Finally the entire article is expected error analysis, for users and developers of Power System Protection to be useful.

References

[1] Abdollahi, A., Seyedtabaii, S., 'Transmission line fault location estimation by fourier & wavelet transforms using ANN," IEEE Conf. Publ. (June), 2010, pp. 573–578.

[2] Alsafasfeh, Qais, Abdel-Qader, Ikhlas, Harb, Ahmad, "Symmetrical pattern and PCA based framework for fault detection and classification in power systems". IEEE Conference Publications,2010, pp. 1–6.

[3] Bouthiba, Tahar, "Fault location in EHV lines using artificial neural networks" Int. J. Appl. Math. Comput. Sci. 14 (1),2004, pp. 69–78.

[4] Cheong, W.J., Agganval, R.K., "A novel fault locations technique based on current signals only for thyristor contolled series compensated transmission lines using wavelet analysis, and self- organizing map neural networks," IET Conf. Publ. 1, 2004, pp. 224–227.

[5] Costa, F.B., Silva, K.M., Souza, B.A., Dantas, K.M.C., Brito, N.S.D, "A method for fault classification in transmission lines based on ANN and wavelet coefficients energy" IEEE Conf. Publ. (July),2006,pp. 3700–3705.

[6] Costa, F.B., Souza, B.A., Brito, N.S.D., "Real-time classification of transmission line faults based on maximal overlap discrete wavelet transform" Transmission and Distribution Conference and Exposition IEEE/PES 1,2012, pp. 1–8.

[7] Dalstein, Thomas, Kulicke, Bemd, "Neural network approach to fault classification for high speed protective relaying." IEEE Trans. Power Deliv. 10 (April (2)),1995, pp. 1002–1011.

[8] Das, Biswarup, Vittal Reddy, J., "Fuzzy-logic-based fault classification scheme for digital distance protection. IEEE Trans." Power Deliv. 20 (April (2)),2005,pp. 609–616.

[9] De Souza Gomes, André, Azevedo Costa, Marcelo, de Faria, Thomaz Giovani Akar, Matos Caminhas, Walmir, "Detection and classification of faults in power transmission lines using functional analysis and computational intelligence". IEEE Trans. Power Deliv. 28 (July (3)),2013, pp. 1402–1413.

[10] El Safty, S., El-Zonkoly, A., "Applying wavelet entropy principle in fault classification" Electr. Power Energy Syst.,2009, pp.604–607.

[11] Ferrero, Alessandro, Sangiovanni, Silvia, Zappitelli, Ennio, "A fuzzy-set approach to fault-type identification in digital relaying". IEEE Trans. Power Deliv. 10 (January (1)), 1995.

[12] Hessine, Moez Ben, Jouini, Houda, "Fault detection and classification approaches in transmission lines using artificial neural networks" IEEE Conf. Publ., 2014, pp. 515–519.

[13] Jamehbozorg, A., Shahrtash, S.M., "A decision tree-based method for fault classification in double-circuit transmission lines. IEEE Trans". Power Deliv. 25 (October (4)),2010, pp. 2184–2189.

[14] Jayabharata Reddy, M., Mohanta, D.K., "A wavelet-fuzzy combined approach for classification and location of transmission line faults. Electr. Power Energy Syst. 29 (November (9)), 669–678, Elsevier.

[15] Jiang, Joe-Air, Chen, Ching-Shan, Fan, Ping-Lin, Liu, Chih-Wen, Chang, Rong-Seng, "A composite index to adaptively perform fault detection, classification, and direction discrimination for transmission lines". IEEE Conference Publications vol. 2,2002, pp. 912–917.

[16] Jiang, Joe-Air, Chen, Ching-Shan, Liu, Chih-Wen, "A new protection scheme for fault detection, direction discrimination, classification, and location in transmission lines". IEEE Trans. Power Deliv. 18 (January (1)), 2003, pp. 34–42.

[17] Jung, C.K., Kim, K.H., Lee, J.B., Klockl,¨ Bernd, "Wavelet and neuro-fuzzy based fault location for combined transmission systems" Electr. Power Energy Syst. 29 (6), 2007, pp. 445–454.

[18] J. He, S. Yang, and C. Gan, "Unsupervised Fault Diagnosis of a Gear Transmission Chain Using a Deep Belief Network," Sensors, vol. 17, no. 7, p. 1564, Jul. 2017.

[19] Kamel, T.S., Moustafa Hassan, M.A., El-Morshedy, A., "Advanced distance protection scheme for long transmission lines in electric power systems using multiple classified ANFIS networks". IEEE Conf. Publ.,2009, pp.1–5.

[20] Kenneth E. Martin, "Phasor Measurements at the Bonneville Power Administration." Power systems and communications infrastructures for the future, Beijing, September 2002.

[21] Kumar K, Sanjay, Swamy R, Shivakumara, Venkatesh, V., "Artificial neural network based method for location and classification of faults on a transmission lines. Int. J. Sci. Res. Publ. 4 (June (6)), 2014,pp. 1–6.

[22] Kumar, Parmod, Jarni, Majid, Thomas, Mini S., Moinuddin, "Fuzzy approach to fault classification for transmission line protection". IEEE Conf. Publ. 2, 2014, pp.1046–1050.

[23] Lin, Xiangning, Mao, Peng, Weng, Hanli, Wang, Bin, Bo, Z.Q., Klimek, A., "Study on fault location for high voltage overhead transmission lines based on neural network system". IEEE Conf. Publ. (November), 2007, pp.1–5.

[24] Ling, Fu, Zhengyou, He, Zhiqian, Bo, "Novel approach to fault classification in EHV transmission line based on multi-information

measurements of fault transient”. IEEE Conference Publications,2010, pp. 1–4.
[25] Mahamedi, Behnam, “A novel setting-free method for fault classification and faulty phase selection by using a pilot scheme”. IEEE Conference Publications, 2011, pp. 1–6.
[26] Mahanty, R.N., Dutta Gupta, P.B., “Application of RBF neural network to fault classification and location in transmission lines”. IEE Proc. Gener. Transm. Distrib. 151 (March (2)), 2004, pp. 201–212.
[27] Malathi, V., Marimuthu, N.S., “Multi-class support vector machine approach for fault classification in power transmission”. IEEE Conference Publications, 2013, pp. 67–71.
[28] Oleskovicz, M., Coury, D.V., Aggarwal, R.K., "A complete scheme for fault detection, classification and location in transmission lines using neural networks. IET Conf. Publ.,2011, pp. 335–338.
[29] Prasad, Avagaddi, Belwin Edward, J., Shashank Roy, C., Divyansh, G., Kumar, Abhay, “Classification of faults in power transmission lines using fuzzy-logic technique. Indian J. Sci. Technol. 8 (30),2015, pp.1–6.
[30] Prasad, Ch. Durga, Prasad, D.J.V., “Fault detection and phase selection using euclidean distance based function for transmission line protection”. IEEE Conference Publications,2014, pp. 1–4.
[31] Rahideh, Abdolhamid, Gitizadeh, Mohsen, Mohammadi, Sirus, “A fault location technique for transmission lines using phasor measurements”. Int. J. Eng. Adv. Technol. 3 (October (1)), 2013, pp. 241–248.
[32] Ray, Papia, Panigrahi, B.K., Senroy, N., “Extreme learning machine based fault classification in a series compensated transmission line”. In: IEEE Conference Publications, December, 2012, pp. 1–6.
[33] Saha, M.M., Rosolowski, E., Izykowski, J., Pierz, P., Balcerek, P., Fulczyk, M., “An efficient method for faulty phase selection in transmission lines”. IEEE Conference Publications,2010a, pp. 1–5.
[34] Saha, M.M., Rosolowski, E., Izykowski, J., Pierz, P., Balcerek, P., Fulczyk, M., “A novel fault classification technique for high speed protective relaying of transmission lines. Modern Electric Power Systems, IEEE Conference Publications, 2010b, pp. 1–6.
[35] Samantaray, S.R., “Decision tree-based fault zone identification and fault classification in fl exible AC transmissions-based transmission line”. IET Conference Publications 3 (5), 2009, pp. 425–436.
[36] Shahrtash, S.M., Jamehbozorg, A., “A decision tree based method for fault classification in transmission lines”. IEEE Conference Publications, 2008, pp. 1–5.
[37] Song, Y.H., “Genetic algorithm based neural networks applied to fault classification for EHV transmission lines with a UPFC”. In: IET Conference Publications, March,1997, pp. 278–281.
[38] Srinivasa Rao, P., Baddu Naik, B., “Pattern recognition approach for fault identification in power transmission lines”. Int. J. Eng. Res. Appl. 3 (September–October (5)), 2013, pp. 1051–1056.
[39] Sujatha, M.S., Vijay Kumar, M., "On-line monitoring and analysis of faults in transmission and distribution lines using GSM. J”. Theor. Appl. Inf. Technol. 33 (November (2)),2011, pp. 258–265.
[40] Tag Eldin, El Sayed Mohamed, “Fault location for a series compensated transmission line based on wavelet transform and an adaptive neuro-fuzzy inference system”. IEEE Conf. Publ.,2010a, pp. 229–236.
[41] Tag Eldin, El Sayed Mohamed, “Fault location for a series compensated transmission line based on wavelet transform and an adaptive neuro-fuzzy inference system”. IEEE Conf. Publ.,2010b, pp. 229–236.
[42] Tarafadr Hagh, M., Razi, K., Taghizadeh, H., “Fault classification and location of power transmission lines using artificial neural network. IEEE Conf. Publ.,2007, pp. 1109–1114.
[43] Tripathi, Pushkar, Sharma, Abhishek, Pillai, G.N., Gupta, Indira, “Accurate fault classification and section identification scheme in TCSC compensated transmission line using SVM”. Int. Sci. Index Int. J. 5 (12), 2011, pp.1023–1029.
[44] Upendar, J., Gupta, C.P., Singh, G.K., “Discrete wavelet transform and genetic algorithm based fault classification of transmission systems”. In: Fifteenth National Power Systems Conference (NPSC), IIT Bombay, December, 2008, pp. 323–328.
[45] Valsan, Simi P., Shanti Swarup, K., “High-speed fault classification in power lines: theory and FPGA-based implementation. IEEE Trans. Ind. Electron. 56 (May (5)), 2009, pp. 1793–1800.
[46] Wang, Huisheng, Keerthipala, W.W.L., “Fuzzy-neuro approach to fault classification for transmission line protection”. IEEE Trans. Power Deliv. 13 (October (4)), 1998, pp. 1093–1104.
[47] Wang, Zufeng, Zhao, Pu, “Fault location recognition in transmission lines based on support vector machines. IEEE Conference Publications, 2009, pp. 401–404.
[48] Youssef, Omar A.S., “Fault classification based on wavelet transforms. Transmission and Distribution Conference and Exposition IEEE/PES 1,2001, pp. 531–536.
[49] Youssef, Omar A.S., “New algorithm to phase selection based on wavelet transforms”. IEEE Trans. Power Deliv. 17 (October (4)), 2002, pp. 908–914.
[50] Youssef, Omar A.S., “Combined fuzzy-logic wavelet-based fault classification technique for power system relaying”. IEEE Trans. Power Deliv.19 (April (2)),2004, pp. 582–589.