ANFIS AND GENETIC ALGORITHM BASED FAULT CLASSIFICATION OF TRANSMISSION LINE USING DYNAMIC GRID FAULT SIMULATOR

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Abstract— ***This paper presents a technique to detect and classify the different faults in Transmission lines for quick and reliable operation of protection schemes. Discrimination among different types of faults on the transmission lines is achieved by application of evolutionary programming tools. MATLAB software is used to simulate different operating and fault conditions on transmission line, namely single phase to ground fault (L-G), line to line fault(L-L), double line to ground(L-L-G) and three phase short circuit(L-L-L). Discrete Wavelet Transform (DWT) is applied for decomposition of fault transients, because of its ability to extract information from the transient signal both in time and frequency domain simultaneously. The data sets which are obtained from the DWT are used for training and testing the Adaptive Neuro Fuzzy Inference System (ANFIS) architecture and genetic algorithm (GA). After extracting useful features from the measured signals, a decision of fault or no fault on any phase or multiple phases of a transmission line .Sample and hold circuit is used for automation and analysis of transmission line. The designed model can disconnect the transmission line in case of any fault is detected and it also provides a flexible alternative tie line to provide continuous power supply. After the fault is cleared within the specified fault clearance time, the primary line is used to supply the power to the loads.***

Keywords—DWT; ANFIS;SAMPLE AND HOLD;GA

Introduction

The continuous power systems expansion has imposed high requirements in protecting equipment, mainly related with speed and accuracy, which are important factors for fault clearance in order to preserve the stability and reliability [6]. That is, if a fault is not properly detected and removed, widespread damage or a power system blackout may take place. Aiming to prevent fault propagation, protective relays are designed to detect the fault as soon as possible (one cycle or less of the operating nominal frequency). To extract the desired frequency components in the faulted signals on shorter time becomes a challenge. Most of the techniques for detecting faults are focused on the system's operating frequency, that is, the high-frequency components are neglected in the relays' principles. However, fault conditions are able to produce transient information (high-frequency components) that can be embedded into the electrical signals. By this reason, novel protecting schemes are being developed [2]. The discrete wavelet transform (DWT) is a useful technique for analysing the high-frequency components of currents during faults as well as switching operations [3]. Thus, transient analysis plays an important role in the new protecting schemes. For instance, in a new protection scheme for parallel transmission lines is presented, where the high-frequency information (the detail coefficients' norm) produced by the Discrete wavelet transform (DWT) is analysed to evaluate fault conditions. Moreover, the WT has been applied in distance relays in order to detect faults during power swings [5]. On the other hand, the DWT may be used to evaluate the directionality, for example, in a high-speed directional protection scheme is proposed, where the fault detection is carried out using the cumulative sum of a directional signal, previously extracted from its high-frequency information in voltages and currents. Currently, fault detection based on transient analysis has been widely discussed in order to develop real applications.

In a prototype for detecting and identifying faults is presented. However, these strategies must be evaluated under different transient conditions to avoid false triggering, and thus improve its reliability . Due to the effectiveness of WT on transient analysis, it has been combined with other strategies with the purpose of improving the protecting schemes' reliability. For instance, in [2], WT has been combined with artificial neural networks for detecting faults in transmission lines. Likewise, the WT also has been applied with fuzzy logic to classify and to locate faults [14]. Moreover, in [8], a novel technique based on transient analysis is proposed. This strategy combines the Adaptive Neuro Fuzzy Inference System (ANFIS) effective for detecting faults, as well as to identify power swing during faults events . After extracting useful features from the measured signals, a decision of fault or no fault on any phase or multiple phases of a transmission line is carried out using ANFIS classifier. This proposes a wavelet based GA method to classify the power system faults. The proposed algorithm extracts power system faults using DWT. The extracted information from transient signals is simultaneously available in both time and frequency domains. It also takes into account the discontinuities in current samples, which are measured at sending end only. The output signals of DWT are then fed into GA, in which the optimized GA output parameters are used to classify the power system fault transients.

II BLOCK DIAGRAM AND LINE FAULTS

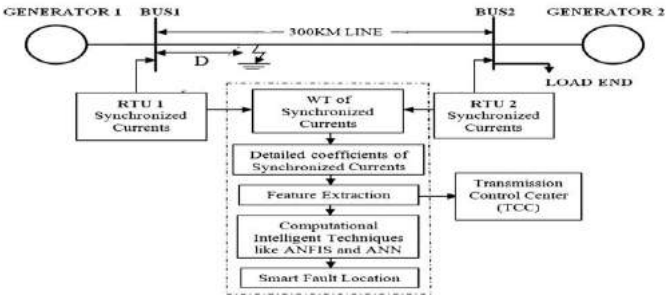

Figure 1. System Block Diagram

The above shows simplified system block diagram . After extract signal from discrete wavelet transform (DWT) sends to Adaptive Neuro Fuzzy Inference System (ANFIS) where fault detect, identified and location determine by computational intelligent technique. The nature of a fault implies any abnormal condition which causes a reduction in the basic insulation strength between phase conductors or between phase conductors and earth. Faults are normally caused by breaking of conductors or due to insulation failure. The other reasons for occurrence of fault include mechanical failures, accidents, excessive internal and external stresses. when a fault occurs on the system, the voltages of the three phases become unequal. As the fault currents are large, the apparatus may get damaged. The flow of power is diverted towards the fault which affects the supply to the neighboring zone. A power system consists of generators, transformers, switchgear, transmission and distribution circuits. these is always a possibility that some fault will occur in some part of the system. The maximum possibility of fault occurrence is on transmission lines due to their greater lengths and exposure to atmospheric conditions

The faults can be classified, according the causes of their incidence .the breakdown may occur at normal voltage due to deterioration of insulation. it may also occur due to damage on account of unpredictable causes which include perching of birds, accident short circuiting by kite strings, surges caused by lightning etc. the ac faults can also be classified as single line to ground fault, double line to ground fault, three phase fault that may occur in the system due to unbalance in current and voltages over voltages, under frequency, temperature rise and instability.

2.1 Types of Faults

A fault occurs when two or more conductors that operate normally with a potential difference comes in contact with each other .these faults may be caused by sudden failure of any equipment by accidental damage or short circuit to overhead lines or by insulation failure resulting from lightning surges.

The faults in a 3-phase system can be classified into two types,

- Symmetrical faults
- Unsymmetrical faults.

symmertical faults

The fault on the power system which gives rise to symmetrical currents i.e equal fault current in the lines with 120^{o} displacement is called a symmetrical fault. If all the three phases may be short circuited with ground or simply got shorted without involving ground .fault currents in each phases will be equal in magnitude with 120^{o} displacement among them, because of this balanced nature of fault, only one phase need to be considered for calculations. The symmetrical fault rarely (2%) occurs but it is the most severe and imposes more heavy duty on the circuit breaker.

- Three phase fault (LLL)
- Three phase to ground fault (LLL-G)

unsymmetrical faults

The faults on the power system which give rise to unsymmetrical currents i.e un equal fault currents in the lines with unequal displacement are known as unsymmetrical faults. if the fault occurs, the currents in the three lines become unequal and so is the phase displacement among them.

The various types of unsymmetrical faults are,

- Single line to ground fault (L-G Fault)
- Double line fault (L-L fault)
- Double line to ground fault (L-L-G fault)

III DISCRITE WAVELET TRANSFORM

Transient voltages and currents during fault carry high frequency component or harmonics which carry important information regarding type and location of fault. Wavelets can be very effectively used in analyzing transient phenomenon of the fault signals. Multi-resolution analysis is one of the tools of Discrete wavelet transform, which decomposes the original signal to low frequency signal called approximations and high frequency signals called details. The important elements in analyzing transient signal using wavelet transform are to select mother wavelet and to decide the number of multiple decomposition steps. The number of decomposition steps is influenced from the sampling frequency of the original signals figure.2.1. In the first decomposition step the signal is decomposed into D1 component of high frequency band and A1 component of low frequency band. The frequency band of D1 component is (fs /2-fs/4) Hz and A1 component is (fs/4-0), fs being the sampling frequency. In the second decomposition step, A1 component extracted from the first decomposition step is again decomposed. Thus, D2 component of high frequency band and A2 component of low frequency band is achieved.

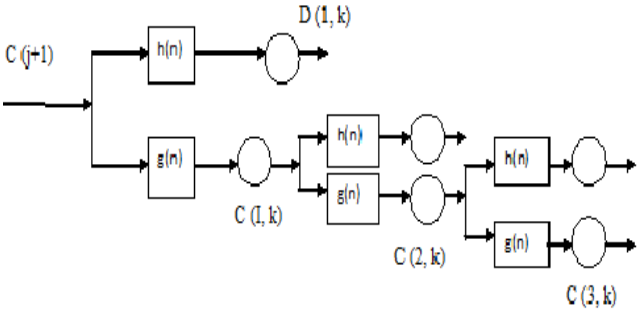

Figure 2. Decomposition of signal

Daubechies Transform

Ingrid Daubechies, one of the brightest stars in the world of wavelet research, invented what are called compactly supported orthonormal wavelets - thus making discrete wavelet analysis practicable. The names of the Daubechies family wavelets are written dbN, where N is the order, and db the ―surname‖ of the wavelet. The db1 wavelet, as mentioned above, is the same as Haar wavelet. Here is the wavelet functions psi of the next nine members of the family. This wavelet type has balanced frequency responses but non-linear phase responses. Daubechies wavelets use overlapping windows, so the high frequency coefficient spectrum reflects all high frequency changes. Therefore Daubechies wavelets are useful in compression and noise removal of audio signal processing.

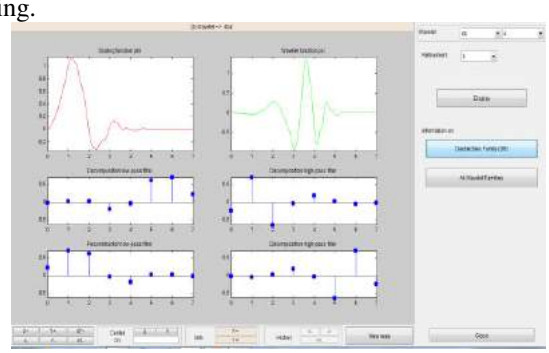

Figure 3. db4 window

IV ADAPTIVE NEURO FUZZY INFERENCE SYSTEM

The Adaptive Neuro Fuzzy Inference System (ANFIS) is a parallel system, capable of resolving paradigms that linear computing cannot They are used for applications where formal analysis is difficult or impossible such as pattern recognition and non linear system identification and control. Neural networks are composed of simple elements which operate in parallel with interconnection between them. The weights of connection determine the network function. A neural network when created, has to be configured which is done using training function. The elements of the network are adjusted automatically to get a particular target output for specific input. A network can have several layers. Each layer has a weight matrix, a bias vector and an output vector. Each neuron in one layer has direct connections to the neurons of the subsequent layer. The second class of feed forward neural network distinguishes itself by the presence of one or more hidden layers, whose computation nodes are called hidden neurons or hidden units. By increasing the number of layers and neurons the network is enabled to extract higher order statistics which is advantageous when number of inputs is large and highly nonlinear. A neural network learns from its environment. In this process parameters of a neural network are adapted through a continuing process of simulation by the environment in which the network is embedded. A popular model for ANFIS is multilayered feed forward back propagation. The multi-layer perception has the ability of handling complex and non-linear input-output relationship with hidden layer. In this back propagation algorithm in the process of supervised learning, the errors are propagated backwards. The idea of back propagation algorithm is to reduce error until the ANFIS learns the training data. The training begins with random weights and the goal is to adjust them so that the error will be minimal. In this work multilayer feed forward network has been chosen to process the prepared input data which were obtained from wavelet transform.

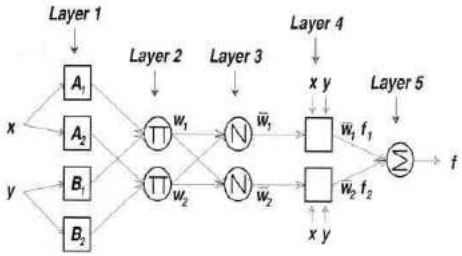

Figure 4 Equivalent ANFIS architecture

If x is A and y is B then z is f(x,y)

where A and B are the fuzzy sets in the antecedents and z = f(x, y) is a crisp function in the consequent. Usually f(x, y) is a polynomial for the input variables x and y. But it can also be any other function that can approximately describe the output of the system within the fuzzy region as specified by the antecedent. When f(x,y) is a constant, a zero order Sugeno fuzzy model is formed which may be considered to be a special case of Mamdani fuzzy inference system where each rule consequent is specified by a fuzzy singleton. the two rules may be stated as:

Rule 1: If x is A1 and y is B1 then f1 = p1x + q1y + r1

Rule 2: If x is A2 and y is B2 then f2 = p2x + q2y + r2

In this inference system the output of each rule is a linear combination of the input variables added by a constant term. The final output is the weighted average of each rule's output.

V.GENETIC ALGORITHM

Genetic algorithm was introduced by John Holland at University of Michigan, United States in 1970s to allow computers to evolve solutions to difficult search and combinatorial problems, such as function optimization and machine learning. Computational studies of Darwinian evolution and natural selection have led to numerous models for solving Optimization. GA's comprise a subset of these evolution-based optimization problems techniques focusing on the application of selection, mutation, and recombination to a population of competing problem solutions.The genetic algorithm then creates a population of solutions and applies genetic operators such as mutation and crossover to evolve the solutions in order to find the best one(s). The basic operation of a GA is conceptually simple; the GA Cycle is illustrated with following concepts:1- Maintain a population of solutions to a problem,2- Select the better solutions for recombination with each other, and , 3- Use their offspring to replace poorer solutions. To use a genetic algorithm, a solution to problem is represented as a function of *genome* (or *chromosome*).

GA operates with a collection of chromosomes called a *population*. The population is normally randomly initialized. As the search evolves, the population includes fitter and fitter solutions, and eventually it converges, meaning that it is dominated by a single solution

Two operators: *crossover* and *mutation* are used to generate new solutions from existing ones.

In crossover, generally two chromosomes, called *parents*, are combined together to form new chromosomes, called *offspring*. The parents are selected among existing chromosomes in the population with preference towards fitness so that offspring is expected to inherit good genes which make the parents fitter. By iteratively applying the crossover operator, genes of good chromosomes are expected to appear more frequently in the population, eventually leading to convergence to an overall good solution. In single or double point crossover, genomes that are near each other tento survive together, whereas genomes that are far apart tend tobe separated. Each gene has an equal chance of coming from either parent. This is called as uniform or random crossover which is used in the proposed method.

The mutation operator introduces random changes into characteristics of chromosomes. Mutation is generally applied at the gene level. In typical GA implementations, the mutation rate (probability of changing the properties of a gene) is very small and depends on the length of the chromosome. Therefore, the new chromosome produced by mutation will not be very different from the original one. Mutation plays a critical role in GA. crossover leads the population to converge by making the chromosomes in the population alike. Mutation reintroduces genetic diversity back into the population and assists the search escape from local optima. Reproduction involves selection of chromosomes for the next generation. In the most general case, the fitness of an individual determines the probability of its survival for the next generation.

Genetic Algorithms (GA) is used as an effective tool in analyzing data and pattern recognition, which are very difficult or even impossible with traditional methods. GA's are parallel, iterative optimizers. GA differ from the most common mathematical programming techniques in several aspects, such as: it uses a population of individuals or solutions instead of a single design point, works on a codification of the possible solutions instead of the solutions themselves, uses probabilistic transition rules instead of deterministic operators and it can handle, with minor modifications, continuous, discrete or mixed optimization problems.

GA differs from conventional optimization techniques thet are

- Gas operate with coded versions of the problem parameters rather than parameters themselves
- Almost all conventional optimization techniques search from a single point, but Gas always operate on a whole population of points(strings)
- GA uses fitness function for evaluation rather then derivatives. As a result, they can be applied to any kind of continuous or discrete optimization problem. The key point to be performed here is to identify and specify a meaningful decoding function.
- Gas use probabilistic transition operates while conventional methods for continuous optimizing apply deterministic transition operates.

GA handles a population of possible solutions. Each solution is represented through a chromosome, which is just an abstract representation. Coding all the possible solutions into a chromosome is the first part, but certainly not the most straightforward one of a GA. A set of reproduction operators has to be determined, too. Reproduction operators are applied directly on the chromosomes, and are used to perform mutations and recombination over solutions of the problem. Appropriate representation and reproduction operators are the determining factors, as the behaviour of the GA is extremely dependent on it. Frequently, it can be extremely difficult to find a representation that respects the structure of the search space and reproduction operators that are coherent and relevant according to the properties of the problems

The procedure of a generic GA is given as follows:

1. Start with randomly generated population
2. Calculate the fitness of each chromosome in the population
3. Repeat the following steps until *n* offspring's have been created
   - Select a pair of parent chromosome from the current population
   - With probability of crossover the pair at a randomly chosen point to form two offspring's
   - Mutate the two offspring's at each locus with probability
4. Replace the current population with the new population
5. Go to step 2.

VI SIMULATION AND RESULTS

The real electrical transmission system under different conditions has been accurately modeled and simulated with the Sim Power system block set of MATLAB. SimPower system block set in MATLAB is a powerful electrical engineering software tool that allows engineers to build electrical models in Simulink environment and change their operating conditions. Here, two electrical systems are studied and analyzed during normal and at different fault conditions.

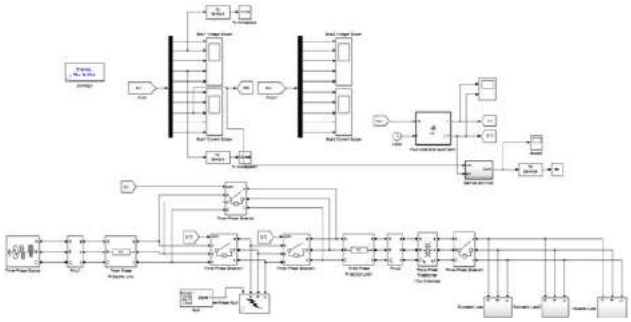

Figure 5. Proposed simulation model

Simulation Results

Simulation was carried out for all different single phase to ground fault, different double Phase with or without ground, and three phase faults with or without ground faults are simulated and analyzed.

L-G Fault

The L-G faults occur in overhead transmission system are R-G, Y-G and B-G faults. For an example R-G fault is considered here. In this figures.6,7 shows the voltage and current waveforms of RG or L-G fault system.

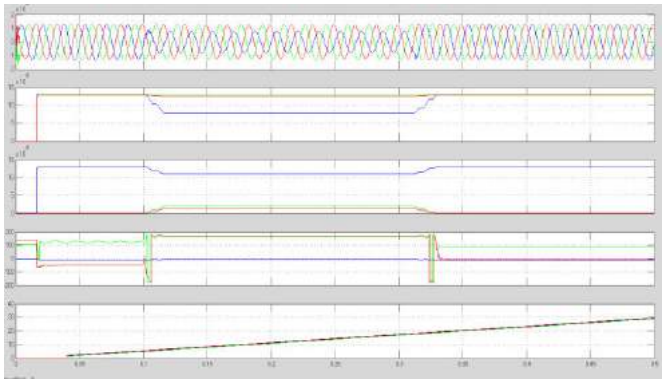

Figure 6. Voltage Waveforms for L-G Fault

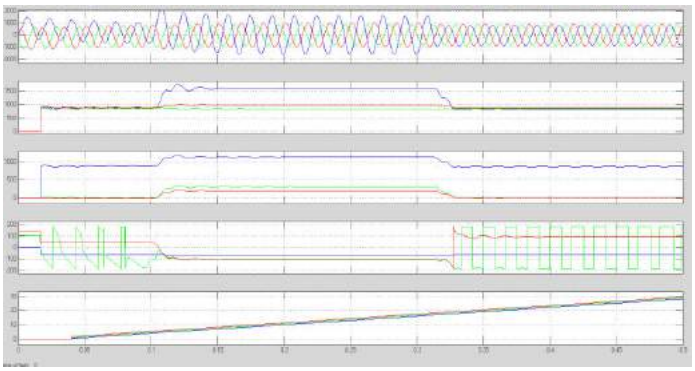

Figure 7. current waveforms for L-G fault

LL-G Fault

In this figures.8,9 shows the voltage and current waveforms of RY-G fault system. The R, Y and zero signals having more transients fault and than other phases. Thet voltage and current waveforms shown below

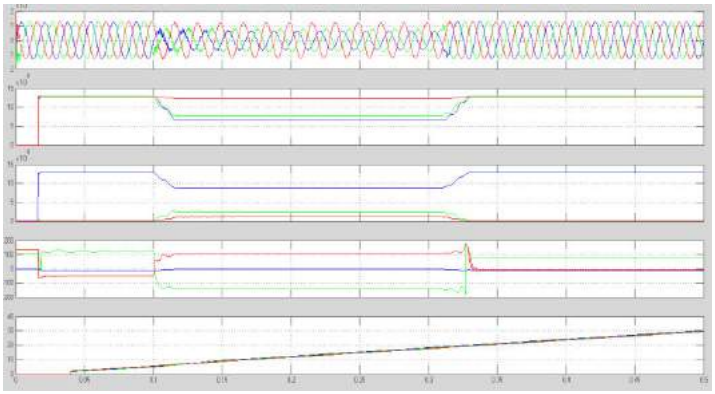

Figure 8. Voltage Waveforms for LL-G Fault.

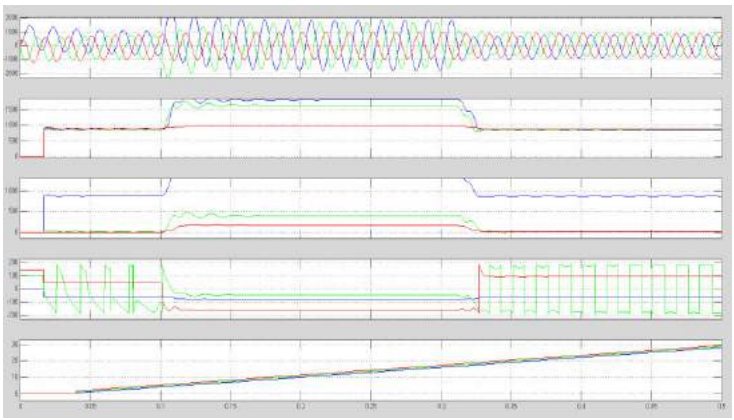

Figure 9. current waveforms for LL-G fault

LLL Fault

In three phase faults occurs in overhead transmission system are RYB faults and R-Y-B-G faults. The below figures.10,11 shows the voltage and current waveforms of R-Y-B fault system. In R, Y and B phase signals having more transient waveform and more faults than other phases

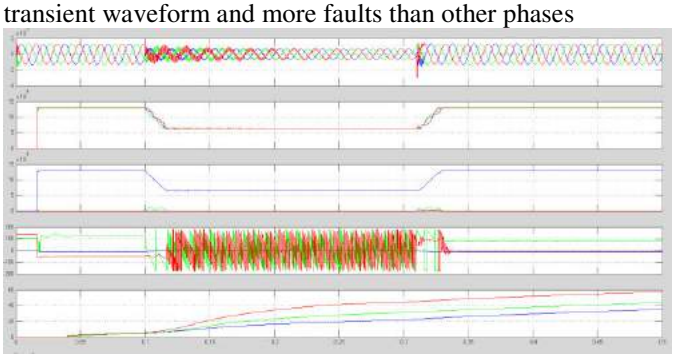

Figure 10. Voltage Waveforms for LLL Fault

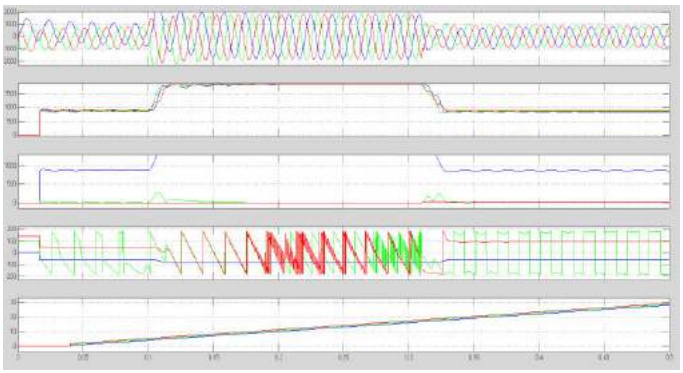

Figure 11. Current Waveform for LLL Fault

VII CONCLUSION

This paper proposed a detection and classification method for the transmission line faults. For the fault detection and classification, a wavelet based analysis technique is used. In this method of discrete wavelet based analysis of transmission line parameters for the fault detection took the advantages of the time and frequency localization of the DWT applied to the high-frequency components of transmission line parameter disturbances. The automation of transmission line using Sample and Hold circuit system has been successfully implemented in MATLAB/Simulink software platform. The simulated results are illustrated that the designed model can disconnect the transmission line in case of line outage is detected and also serves in faster clearance in fault and also it serves as a flexible protection alternative.

REFERENCES

[1] Daniel Guillen, and G. Idárraga-Ospina, august 2014" Fault Detection and Classification in Transmission Line using the Euclidian Norm of the total WSE".IEEE 978-1-4799-6251-8/14.

[2] Manohar singh and Dr. B.K Panigrahi, september 2011 "Transmission Line Fault Detection and Classification. IEEE978-1-4244-7926-9/11.

[3] Eisa Bashier M. Tayeb Orner AI Aziz AlRhirn, january 2012 "Transmission Line Faults Detection,Classification and Location using Artificial Neural Network".IEEE 978-1-4673-6008-1/11

[4] Daniel Guillen, Mario Roberto Arrieta Paternina, Alejandro Zamora, july 2015"Detection and classification of faults in transmission lines using the maximum wavelet singular value and Euclidean norm. IET Gener. Transm. Distrib., 2015, Vol.9, Iss. 15, pp. 2294–2302

[5] Mamta Patel and R. N. Patel, june 2012" Fault Detection and Classification on a Transmission Line using Wavelet Multi Resolution Analysis and Neural Network". IET Gener. Transm. Distrib., 2012, Vol. 7, Iss. 11, pp. 2894–2902.

[6] M.SudheerKumar and P.Sucharith, October 2015"MATLAB/Simulink Based Transmission Line Automation Using Sample and Hold system". IJCSMC, Vol. 4, Issue. 10, pg.413 – 419

[7] Andrade and T. P. de Leão, SEPTEMBER 2014" Fault Location for Transmission Lines Using Wavelet" IEEE Vol. 12,lss. 6, pp.1043-1048.

[8] O A A Elmubark, "Fault Detection, Classification and Location in Power
Transmission Line System Using Artificial Neural Network," MSc.dissertation, Dept. Elec. Eng., Sudan Univ. of Sci. & Tech. Khartoum,March 2011

[9] R.Malkar, V. Magdum and S.Gunda, Transmission line fault analysis using wavelet theory", International journal of Engineering science and Tech, vol.4, No.6, June 2012.

[10] A. Rafinia and J. Moshtagh, "A new approach to fault location in three-phase underground distribution system using combination of wavelet analysis with ANN and FLS," Int. J. Electr. Power Energy Syst., vol. 55, pp. 261–274, Feb. 2014.

[11] Z. He, L. Fu, S. Lin and Z. Bo, "Fault detection and classification in EHV transmission line based on wavelet singular entropy," IEEE Trans. Power Deliv., vol. 25, no. 4, pp. 2156-2163, Oct. 2010.

[12] R. Dubey and S. R. Samantaray, "Wavelet singular entropy-based symmetrical fault-detection and out-of-step protection during power swing," IET Gener. Transm. Distrib., vol. 7, no. 10, pp. 1123-1134, Oct. 2013.

[13] A. Samui and S. R. Samantaray, "Wavelet singular entropy-based islanding detection in distributed generation," IEEE Trans. Power Deliv., vol. 28, no.1, pp.411-418, Jan. 2013.

[14] M.Jaya Bharata Reddy, et al., (2014),"Smart fault location for smart grid operation using RTUs and computional intelligence techniques". IET vol. 55, pp. 261–274, Feb. 2014.