ISSN 2250-3153

Artificial Neural Network Based Method for Location and Classification of Faults on a Transmission Lines

Sanjay Kumar K [*], Mr.Shivakumara Swamy.R [**], Dr. V. Venkatesh [***]

[*] PG Student Dept of EEE, Acharya Institute of Technology, Bangalore
[**] Assistant Professor, Department of EEE, Acharya Institute of Technology, Bangalore
[**] Principal, Chennabasaveshwara Institute of Technology, Gubbi, Tumkur dist

Abstract- Transmission lines, among the other electrical power system components, suffer from unexpected failures due to various random causes. These failures interrupt the reliability of the operation of the power system. When unpredicted faults occur protective systems are required to prevent the propagation of these faults and safeguard the system against the abnormal operation resulting from them. The functions of these protective systems are to detect and classify faults as well as to determine the location of the faulty line as in the voltage and/or current line magnitudes Then after the protective relay sends a trip signal to a circuit breaker(s) in order to disconnect (isolate) the faulty line.

This paper presents the use of back-propagation (BP) neural network architecture as an alternative method for fault detection, classification and isolation in a transmission line system. The main goal is the implementation of complete scheme for distance protection of a transmission line system. In order to perform this, the distance protection task is subdivided into different neural networks for fault detection, fault identification (classification) as well as fault location in different zones. Three common faults were discussed; single phase to ground faults, double phase faults and Double phase to ground faults. The result provides a reliable and an attractive alternative approach for the development of a protection relaying system for the power transmission systems.

Index Terms- Transmission lines; fault detection; artificial neural network.

I. INTRODUCTION

An electric power system comprises of generation, transmission and distribution of electric energy. Transmission lines are used to transmit electric power to distant large load centers. The rapid growth of electric power systems over the past few decades has resulted in a large in- crease of the number of lines in operation and their total length. These lines are exposed to faults as a result of lightning, short circuits, faulty equipments, mis operation, human errors, overload, and aging. Many electrical faults manifest in mechanical damages, which must be repaired before returning the line to service. The restoration can be expedited if the fault location is either known or can be estimated with a reasonable accuracy [1].

Faults cause short to long term power outages for customers and may lead to significant losses especially for the manufacturing industry. Fast detecting, isolating, locating and repairing of these faults are critical in maintaining a reliable power system operation [2]. When a fault occurs on a transmission line, the voltage at the point of fault suddenly reduces to a low value. Fault location estimation is very important issue in power system engineering in order to clear faults quickly and restore power supply as soon as possible with minimum interruption. This is necessary for health of power equipment and satisfaction of customer. In the past, several methods have been used for estimating fault location with different techniques such as line impedance based numerical method, travelling wave methods and Fourier analysis [1].

This paper presents a method for detection and identification of the fault type and its zone in the line. Back propagation neural network approach is studied and implemented. Voltages and currents signals of the line are observed to perform these three tasks. The detailed coefficients of all phase current signals that are collected only at the sending end of a transmission line are selected as parameters for fault classification.

Basically, we can design and train the neural networks for solving particular problems which are difficult to solve by the human beings or the conventional computational algorithms [9]. The computational meaning of The training comes down to the adjustments of certain weights which are the key elements of the ANN. This is one of the key differences of the neural network approach to problem solving than conventional computational algorithms. This adjustment of the weights takes place when the neural network is presented with the input data records and the corresponding target values.

II. TRANSMISSION LINES MODEL

The commonly model used for AC overhead transmission lines is called pi model network and is shown in Fig.1. Where shunt admittance has been even divided into two shunt elements connecting to both ends of a pi equivalent network.

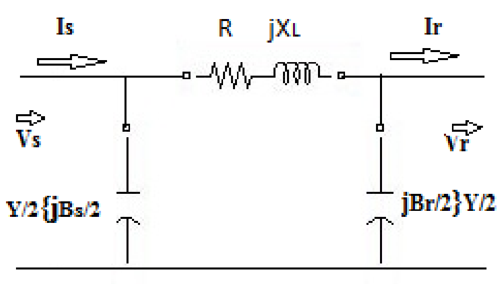

Fig. 1 Π-Network for a Transmission Line Model

A 110 kV transmission line system connects A with B (145 Km) is used to develop and implement the proposed architectures and algorithms for this problem. Fig. 2 shows a single-line diagram of the system used to train and test the neural networks. The system consists of two Substations and (145 Km) transmission line[6].

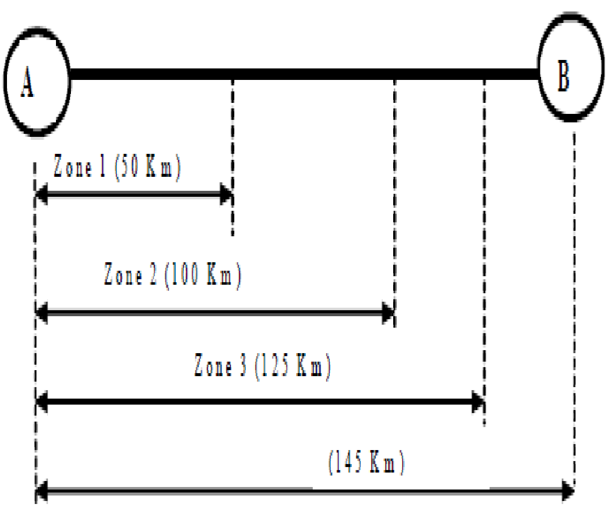

Fig.2. Single-line diagram of the system studied

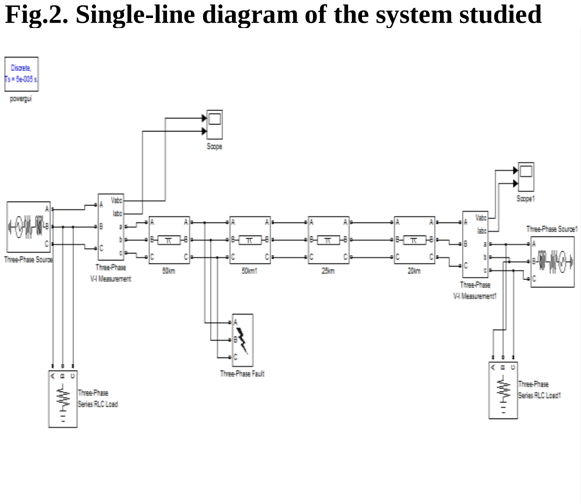

Fig 3. Simulation model of single line diagram

The three-phase voltages and currents, V = [Va Vb Vc] T and I = [Ia Ib Ic] T [8] are measured at substation A in Fig. 2 (4) The simulations results shown in below presents three categories namely (i) phase to ground faults (ii) phase to phase faults and (iii) double-phase to ground faults. observing magnitude of waveforms in the simulations results three phase voltages and currents are tabulated in the Table 1

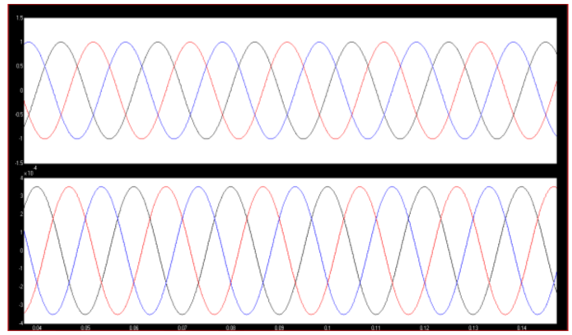

Fig.4. Simulation results for no fault

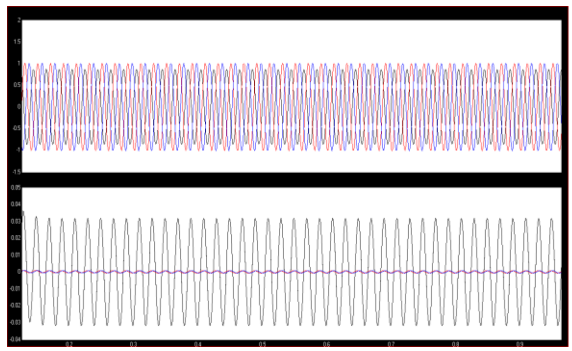

Fig.5.Simulation results for line to ground faults

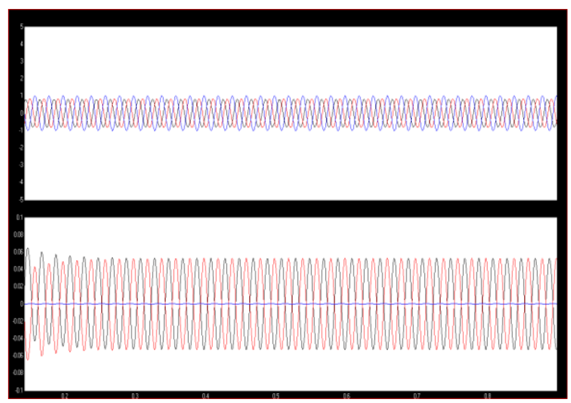

Fig.6. Simulation results for line to line faults

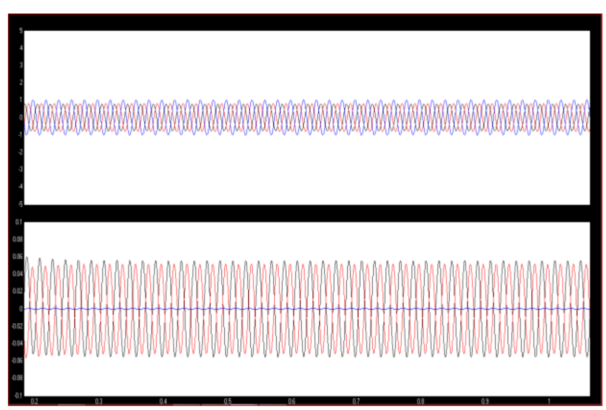

Fig.7.Results for double line to ground faults

Case No.	Input Vector (P.U)						Fault Type
	Va	Vb	Vc	Ia	Ib	Ic	
1	0.997	0.991	0.9985	0.9978	0.9988	0.9984	No Fault
2	0.245	1.056	1.02	3.335	0.853	0.90	A to G
3	1.02	0.245	1.056	0.853	3.335	0.90	B to G
4	1.056	1.02	0.245	0.90	0.853	3.335	C to G
5	0.471	0.650	0.986	-1.23	1.23	0.983	A to B
6	0.986	0.471	0.650	0.984	-1.23	1.23	B to C
7	0.471	0.986	0.650	-1.23	0.984	1.23	A to C
8	0.507	0.507	1.12	7.187	7.855	0.985	A to B to G
9	1.12	0.507	0.507	0.985	7.187	7.855	B to C to G
10	0.507	1.12	0.507	7.187	0.985	7.855	A to C to G

Table.1 Three phase Voltage and Current per Unit Values .

III. BACK PROPAGATION NEURAL NETWORKS

Back Propagation was created by generalizing the Widrow-Hoff learning rule to multiple layer neural networks and nonlinear differentiable transfer functions. Input vectors and the corresponding target vectors are used to train a network until it can approximate a function, associate input vectors with specific output vectors. Neural networks with a sigmoid layer and a linear output layer are capable of approximating any function with a finite number of discontinuities. Standard back propagation is a gradient descent algorithm, as is the Widrow-Hoff learning rule, in which the neural network weights are moved along the negative of the gradient of the performance function. The term back propagation refers to the manner in which the gradient is computed for nonlinear multilayer neural networks [3]

IV. ARTIFICIAL NEURAL NETWORK DESIGN

Artificial neural network (ANN) is made up of many computational processing elements called neurons or nodes These nodes operate in parallel and are connected together in topologies that are loosely modeled after biological neural system[1] The training of ANN is carried out to associate correct output responses to particular input pattern. The artificial neural network is trained so that application of a set of input produces the desired set of outputs. Training is accomplished by sequentially applying input vectors, while adjusting network weights according to pre-detained procedures. During the training process, the network weights gradually converge to values such that each input vector produces the desired output vector.

Transfer function in the ANN is an important key element to invoke the nonlinear relationships that maps the input(s) to the output(s). Without the transfer function the whole operation is linear and could be solved using linear algebra or similar methods. We consider the transfer function for the weighted sum S (lumped input) of the inputs for a successful network design. In the process of learning the neural network presented with pairs of input and output data then teaches how to produce the output when the corresponding input is presented. When learning is complete, the trained neural network, with the updated optimal weights, should be able to produce the output within desired accuracy corresponding to an input pattern.

A. DESIGN OF NEURAL NETWORKS FOR FAULT CLASSIFICATION

Current techniques for fault detection and diagnosis rely on experts and expert systems modeling using Classical techniques in the time or frequency domain. Neural network classifiers can learn and adapt themselves to different statistical distribution and non-linear mappings. The parallel structure of neural net- works permits 'INCIPIENT FAULT DETECTION' which is an indication of an increase in the lead time for detecting faults[4][6]

The design and development of the uses BP network as a fault classifier. The network designed here has six inputs (the three phase voltages and currents) and four outputs associated with the four fault categories. The outputs contain variables whose values are given as either 0 or I corresponding to the three phases and the ground (that is, A, B, C and G) and can be generalized to represent all the practical fault categories permutation involving combinations of phases.

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

TABLE 2.THE BP Classification Network TRUTH TABLE

A large number of networks were extensively studied. After an exhaustive search for the most suitable network size, the one with only one hidden layer and five hidden neurons was chosen to carry out the classification task. The activation function at input layer is linear (-1, 1) function while at hidden layer and output layer is logistic function. The proposed network as stated before has six inputs (the three phase voltages and currents) and four outputs. This network is illustrated in Figure 8

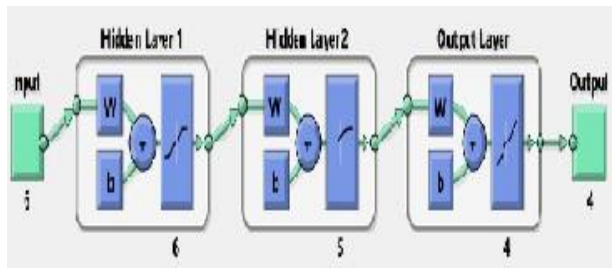

Fig.8.Neural Network architecture for fault classification

B. DESIGN OF NEURAL NETWORK FOR FAULT ISOLATION/LOCATION

The design and development of the detection neural network is followed in this section in order to choose the most suitable BP network as a fault isolator. The network is expected to identify the location of the fault by classifying the identified fault into one of the three fault zones, namely Z1, Z2 and Z3. In fig 3 each Π Transmission lines placed with certain distances and also particular per unit values. when fault occurred within the placed distance and with pu values. Then the proposed neural networks here should isolate the specific zone involved in the fault [7]. The desired truth table for the network training is shown in Table

TABLE 3
THE ISOLATION NETWORK DESIRED RESPONSE

Fault location	Networks output		
	Z1	Z2	Z3
Zone 1	1	0	0
Zone 2	0	1	0
Zone 3	0	0	1

A large number of BP networks with different structures were studied and analyzed in order to obtain the simplest structure. The training includes some of the selected networks, namely structures, 6-5-5-3, 6-6-6-3, 6-7-6-3 and 6-5-4-3. It is found experimentally through trial and error that a BP network with two hidden layers provides the best training performance. The first hidden layer has 5 neurons and the second hidden layer has 4 neurons. The activation function at input layer is linear (-1, 1) function while at hidden layer and output layer is logistic function. This network is shown below figure.9

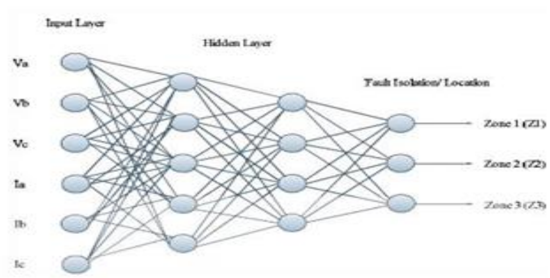

Fig.9. Neural network chosen for fault isolation

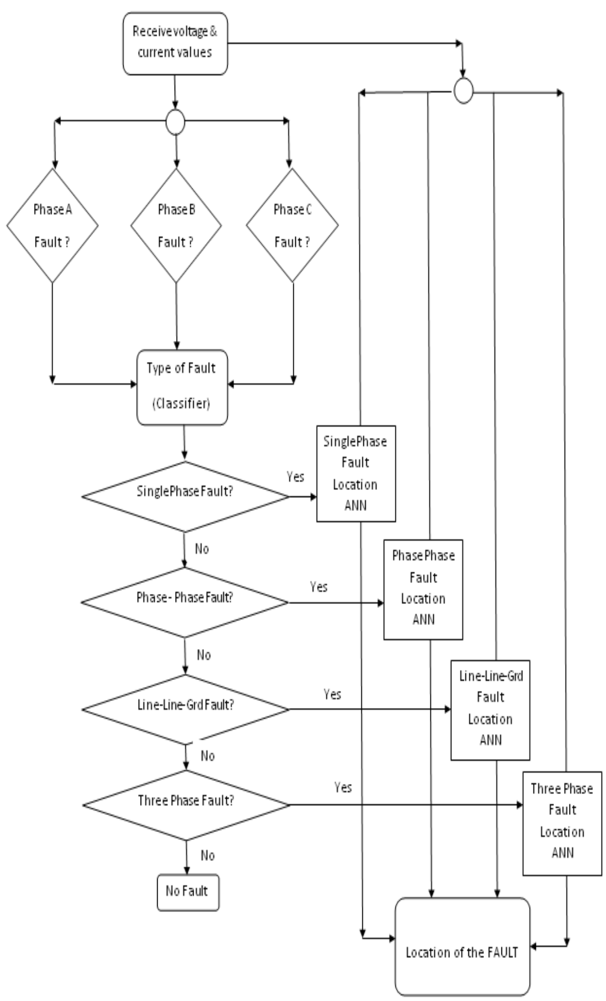

Fig.10. Flowchart depicting the outline of the proposed scheme

V. CONCLUSION

This thesis has investigated the use of back-propagation (BP) neural network architecture as an alternative method for fault detection, classification and isolation in a transmission line system. It uses RMS values of phase voltage and phase current as inputs. Simulation models of the transmission line system are constructed and the generated information is then channeled using MATLAB software (Version 7) and accompanying Power System Block Set.

Three common faults were discussed single phase to ground faults, double phase faults and double phase to ground faults. Due to the flexibility of the neural networks which accept any real values (highly correlated or independent) as an input, resistant to errors in the training data and fast evaluation. The results obtained demonstrate that the performance of the back-propagation (BP) neural network architecture was highly satisfactory. Neural networks, in general, provide a reliable and an attractive alternative approach for the development of a protection relaying system for the power transmission systems.

REFERENCES

[1] Laurene V. Fausett, Fundamentals of Neural Networks: Architectures, Algorithms, and Applications Prentice Hall, 1993.

[2] Nasser D. Tleis, Power Systems Modeling and Fault Analysis Theory and Practice Elsevier Ltd, 2008.

[3] R. Kamyab Moghadas and S. Gholizadeh "A New Wavelet Back Propagation Neural Networks for Structural Dynamic Analysis" IAENG, Engineering Letters, February 2008.

[4] Upendar, J., Gupta, C.P., Singh, G.K., Ramakrishna, G., PSO and ANN-based fault classification for protective relaying. Iet Generation Transmission & Distribution 4, (2010) 1197-1212.

[5] Eisa, A.A.A., Ramar, K. Accurate one-end fault location for overhead transmission lines in interconnected power systems. International Journal of Electrical Power & Energy Systems 32, (2010) 383-389.

[6] O A A Elmubark, "Fault Detection, Classification and Location in Power Transmission Line System Using Artificial Neural Network," M.Sc. dissertation, Dept. Electrical Engineering, Sudan Univ. of Science & Technology- Khartoum, March 2011.

[7] Upendar, J., Gupta, C.P., Singh, G.K. Fault Classification Schemes Based on the Adaptive Resonance Theory Neural Network for protection of Transmission Lines. Electric Power Components and Systems 38, (2010) 424-444.

[8] Salim, R.H., Resener, M., Filomena, A.D., de Oliveira, K.R.C., Bretas, A.S. Extended Fault-Location Formulation for Power Distribution Systems. IEEE Transactions on Power Delivery 24, (2009) 508-516.

[9] Kevin Gurney, An Introduction to Neural Networks UCL Press, 1997

AUTHORS

First Author – Sanjay Kumar K, PG Student Dept of EEE, Acharya Institute of Technology, Bangalore

Second Author – Mr.Shivakumara Swamy.R, Assistant Professor, Department of EEE, Acharya Institute of Technology, Bangalore

Third Author – Dr. V. Venkatesh, Principal, Chennabasaveshwara Institute of Technology, Gubbi, Tumkur dist