FAULT LOCATION IN DISTRIBUTION SYSTEMS BASED ON ARTIFICIAL NEURAL NETWORKS AND APPLICATION OF GIS

Mansooreh ZANGIABADI
University of Tehran
Iran
m.zangiabadi@ece.ut.ac.ir

Mahmood Reza HAGHIFAM
Trabiat Modares University
Iran
Haghifam@modares.ac.ir

Abolhasan KHANBANHA
Kerman Regional Electric Company (KREC), Iran
Khanbanha@krec.co.ir

Mahmood Attari
Kerman Regional Electric Company (KREC), Iran
Attari@krec.co.ir

ABSTRACT

This paper presents a novel approach for fault location in distribution system using neural network. The voltage and current in the instance of fault are used for training. Different faults are simulated in a specific feeder by PSCAD software. The MATLAB and EMTDC are used for simulation in this work. The results of case studies show the capability of neural networks in fault location with negligible error.

Keywords: *Neural networks, Fault location, GIS*

1. INTRODUCTION

Recent restructuring of the power industries such as open access and deregulation lies an impact on the reliability and security of power systems. New technologies for protection and control of power schemes are therefore necessary to be introduced in order to maintain system reliability and security to an acceptable level.

In distribution systems, fault location is estimated by trial and error method. Usually the first guess is based on the information provided by the customer. Then the line is energized section by section until the protective relay trips the feeding circuit breaker and the faulty section is identified. This procedure may be repeated several times which is time consuming and also exposed additional stress on the equipments. It is vital that fault analysis and identification can be carried out quickly for quick restoration of the system.

Two distinct methods named as off-Line and on-line are available in the field of fault location. In the off-line method as mentioned, fault location is implemented after occurrence of the fault and curtailment of service by a separate fault locator.

In on-line methods in contrary to off-line, fault location is solved by design and implementation of the system and some facilities is considered. These methods are faster, easier, and less costly. Some of them apply transiant wideband signals which are generated in faullted conditions in power lines for estimation [1-4]. Pattern recognition methods such as neural networks solve this problem well [5-7].

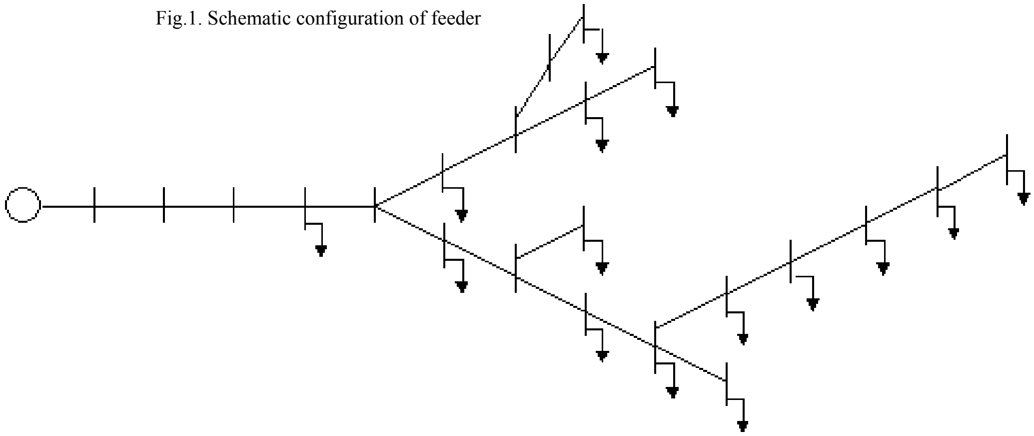
Artificial intelligence techniques naturally become the best choice to improve the performance of the present system used. AI possesses powerful characteristics such as fast learning; fault tolerance and ability to produce correct output when fed with partial input. It can adopt to recognize learned patterns of behavior in electric power systems where exact functional relationships are neither well defined nor easily computable. Various contributions have been reported on the application of Artificial neural network to various power system problems such as fault diagnosis, load forecasting, state estimation and control [8-9].

This paper presents a novel method for fault location in distribution system using neural network. The training of ANN is relatively simple and fast. The predicted results from the ANN are proved to be accurate for a wide range of the system conditions. The software is also combined with the GIS software, so the fault location is displayed in the map on the computer. Simulated results are obtained by applying the proposed method in distribution (20 kV) network of Kerman in south of Iran.

2. PRINCIPALS OF THE PROPOSED FAULT LOCATION METHOD

A typical feeder is chosen to illustrate the proposed method. The schematic configuration of the feeder is shown in Fig.1. The feeder has some laterals to demonstrate the effectiveness of the method. The objective during the development of the proposed fault location method is to bring human classification to a computer system in the form of neural network.

Fig.1. Schematic configuration of feeder



To prepare the input data for neural network, the best way is to collect the real data from the faults or practical tests. In the real world, many factors are effective in the fault current and voltage and affect the accuracy of fault location. But due to lack of information and impossibility of performing practical tests, modeling is the only alternative. Input patterns of neural networks contain of the train and test vectors. The numbers of test vectors are a ratio of train vectors and are completely independent. The training input pattern data in neural networks are the only source of information.

Input patterns contain the rms. values of three-phase voltages and currents in the instance of fault before operation of circuit breakers and this data is enough for detection and location of the fault. After the neural net is trained offline using this data with unsupervised and supervised learning procedures; the network is able to perform the untrained mapping. If these patterns were quite exact and real, the operation of the network would be more accurate. So it is required to obtain the fault currents and voltages corresponding to different faults for different locations along the feeder.

In this case, for having a more exact simulation of the system, the powerful EMTDC software is used in PSCAD environment. The line model is the Bergeron model, which is quite suitable for computer simulation. The simulator output is shown in Figs 2-4 for different types of faults. In these figures, the three phase currents (KA) and voltages (KV) are produced with Fourier transform.

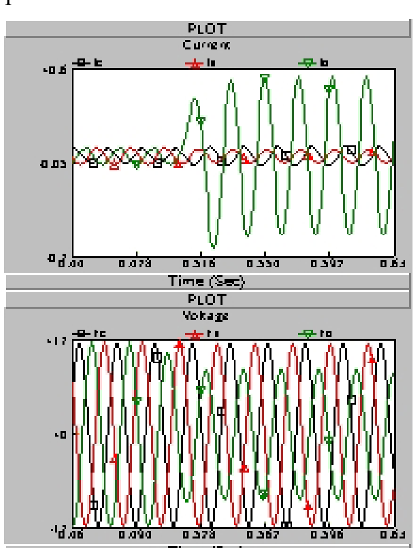


Fig.2. Single-phase to ground fault in the middle of feeder

3. STRUCTURE OF NEURAL NETWORK FOR FAULT LOCATION

Considering the characteristics of multilayer feed forward

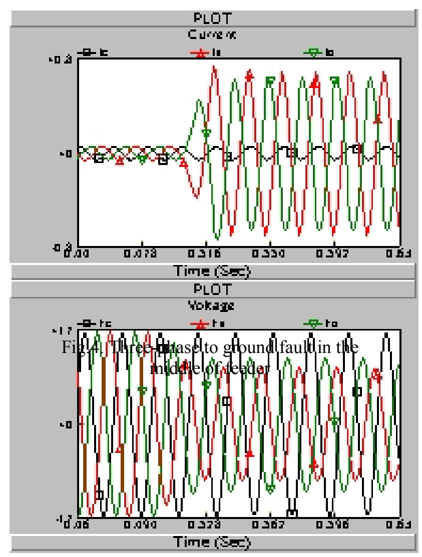
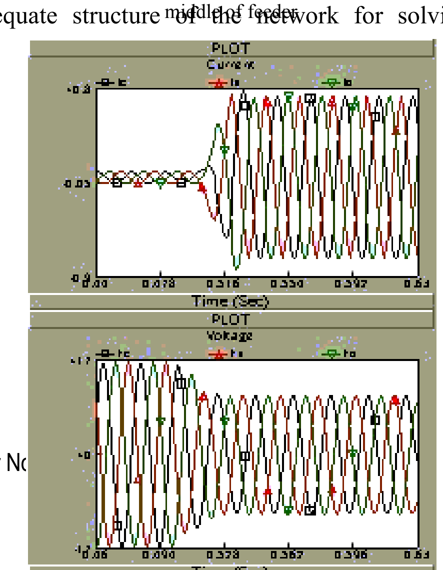


Fig.4. Three-phase to ground fault in the middle of feeder

neural networks and regarding the fault location problem, the adequate structure of the network for solving this

Fig.3. Two-phase to ground fault in the middle of feeder



problem is the multilayer perceptron with error back propagation training algorithm. The neural network is designed with three layers; namely an input layer, a hidden layer and an output layer as shown in Fig.5. The sigmoid transfer function is used between the input and hidden layers and the pure linear transfer function are used between the hidden and output layers.

The numbers of input layer neurons are equal to input and the numbers of output layer neurons are equal to output. There is no exact method for determining the number of hidden layer neurons, but it can be said that the number of hidden layer neurons is a function of the order of non-linearity between the input and output space; so the number of neuron based on the proposed problem is obtained by trial and error [10, 11].

In process of information, the input data which are the three phase voltages and currents are normalized for better and more reliable operation of neural networks. The trained network initiates and determines the final output of the network, which is distance. To specify the number of laterals, a flag is used in the output layer which refers to the lateral that fault is happen. For example, the number of main feeder is chosen zero.

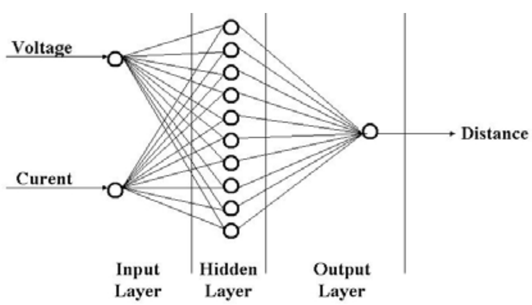


Fig.5. Artificial Neural Network Layout

4. THE RESULTS OF NEURAL NETWORK: TRAIN AND TEST

As about 85 percent of faults happen in power system is line to ground (L-G) faults, so the results of the proposed method applied to this type of fault is explained in details.

Training data is prepared by simulating L-G faults along the feeder in pitches of 50 meters. The resistance of fault is changed in steps of 5Ω from 0 to 25 ohms. For training the network, the fault resistance is chosen zero. The laterals are numbered and the output of network also specifies it. A part of train results is given in Table 1. To illustrate the capability of the method when the fault resistance changes, some test patterns are considered in main lateral and the results are given in Table 2.

After preparing adequate data for training and test of neural networks, now the important key is selecting the number of neurons in the hidden layer of the networks such that the exactness of network is maximum. For this reason, the neural network is trained with deferent neurons. Number of epochs is considered 1000 epochs experimentally. A criterion for selecting best structure is Mean Squared Error (MSE). Percentage of error obtained for L-G fault is shown in Fig.6. Considering the principle of simplicity of network structure, the final structure of neural networks for L-G fault is 6-8-2.

Table.1. ANN predicted fault location results for train patterns

Fault Location (m)	Fault Resistance (Ω)	Error of ANN predicted location (m)	Lateral Number
250	0	0.049	0
700	0	0.0005	0
1000	0	0.068	1
1500	0	4.63	1
1700	0	3.42	3
2000	0	5.53	2
2500	0	2.29	0

Table.2. ANN predicted fault location results for test patterns

Fault Location (m)	Fault Resistance (Ω)	Error of ANN predicted location (m)	Lateral Number
400	5	5.227	0
1000	10	7.439	0
1300	15	9.247	0
1500	5	2.09	0
1800	10	0.9	0
2100	15	3.32	0
2400	10	3.53	0
2800	5	1.607	0

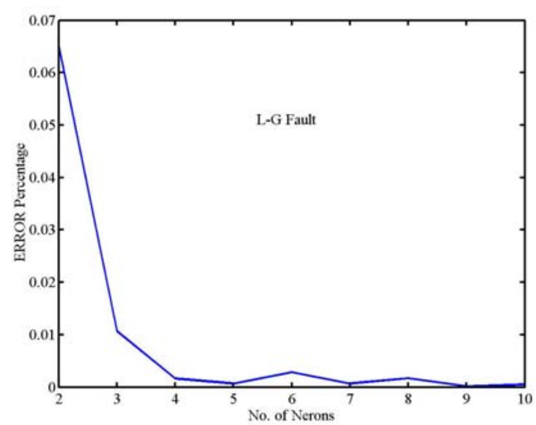


Fig.6. Error Percentage of Neural Network

5. FAULT LOCATION PREDICTION FOR THE OTHER TYPES OF FAULTS

Similar method can be applied to other types of faults such as L-L and L-L-L faults. In general, for three-phase system and for all usual faults, it is possible to use a main neural network consisting of several independent networks that parallel use common input and each is trained for a special fault [12]. The fault detection program defines which of these networks to initiate. So, the structure of fault detector based on neural networks concepts can be considered as Fig.7.

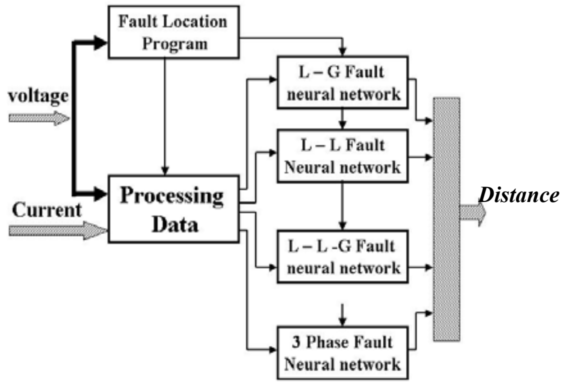


Fig.7. Structure of neural networks as fault locator

The software of proposed method is also combined with the GIS software, so the fault location is displayed in the map on the computer. A schematic map of applying this approach to the typical of feeder in Kerman is shown in Fig.8.

6. CONCLUSION

Design, practical issues, computational aspects and performance of a neural network for fault location in distribution system is described in this paper.

This approach is based on computer simulation and designing. For this reason, MATLAB and EMTDC softwares are used for simulation. To make an efficient evaluation of the proposed algorithms, the performance of the ANN is checked for a typical feeder. The test results indicate the effectiveness of the technique and accuracy of the estimated distance and are demonstrated as well.

The training can be done off-line with the system parameter available. Based on present computer and communication technology, the fault information can be transferred to a remote location for analysis and decision

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8. REFERENCES

[1] A. Girgis, Ch.M. Fallon, D.I. Lubkeman, 1993, " A Fault Location Technique for Rural Distribution Feeders", *IEEE Trans. Industry Applications*, Vol.29, pp.1170-1175.

[2] F.H. Magnago, A. Abur, 1999, "A New Fault Location Technique for Radial Distribution Systems Based on High Frequency Signals", *IEEE Power Engineering Society Summer Meeting 1999*., pp. 426-431.

[3] Z.Q. Bo, R.K. Aggarwal, A.T. Johns, 1996, " A Very Accurate Fault Location and Protection Scheme For Power Cable Using Fault Generated High Frequency Voltage Transients", *Proceeding of the 8th Electro Technical Conference, Industrial Application in Power Systems,* Italy, pp. 777-780.

[4]- F.H. Magnago, A. Abur, 1998, " Fault Location Using Wavelets", *IEEE Trans. Power Delivery*, Vol.13, pp.1475-1480.

[5]- J. Zhu, D. Lubkeman, A. Girgis, 1997, " Automated Fault Location and Diagnosis on Electric Power Distribution Feeders", *IEEE Trans. Power Delivery*, Vol.12, pp. 801-809.

[6]- M. Lehtonen, A. Matsinen, E. Antila, J. Kura, 2000, " An Advanced Model for Automatic Fault Management in Disrtibution Networks", *IEEE Power Engineering Power Society Summer Meeting 2000*, pp.1900-1904.

[7]- K.K. Li, L.L. Lai, A.K. David, 2000, " Application of Artificial Neural Networks in Fault Location Technique", *Proceeding DPRT 2000,* pp. 226-231.

[8]- M. EL-sharkawi, D. Neibur, 1996, "IEEE Tutorial Course on Artificail Neural Networks with Applications to Power Systems", *IEEE Catolog*, No.96 TP 112-0.

[9]- L.L. Lai, 1997, " Application of Neural Networks to Fault Classification and Protection", *IEE International Conference on Advances in Power System Control, Operation and Management (APSCOM-97)*, pp.72-26.

[10]- C.H. Kim, Y.B. Lim, W.G. Chung, T.W. Kwon, J.Y. Hwang and I.D. Kim, 1995, " A study on the Fault Identification of Underground Cable Using Neural Networks", *IEEE Catalog*, No. 95TH8130, pp.571-576, .

[11]- R. P. Lippman, 1997, "An Introduction to Computation with Neural Nets", IEEE ASSP Magazine.

[12]- M.R. Haghifam, S. Hosseini-Naveh, A.A. Yaghoti, 2002, " Fault Location in Underground Power Cables Using Artificial Nueral Networks", *Proceedings of EUROPES2002*, Greece.