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Neural Network Based Fault Location in a Distribution Network With DGs

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Abstract: **The increase in usage of Distributed Generation (DG) in Distribution Networks have much impact on configuration and operation mode of power system. When DG units are connected to distributed networks, the protection devices will be no longer radial and will have severe impacts. In this paper a fault location method by using Neural Networks for distributed networks with DG has presented. This approach is able to determine accurate type and location of fault. Several case studies have been made to verify fault identification method in Distribution system with DG using MATLAB.**

***Index Terms*-Distribution Network, Distributed Generation (DG), Radial Basis Function Neural Network (RBFNN), Distributed Energy Resources (DERs).**

I.INTRODUCTION

Distributed Generation (DG) units can relieve burdened utility systems and increase reliability to consumers who experience frequent outages. Most distribution systems are designed to optimize the delivery of power in one direction. With initiatives on smart grid and sustainable energy, distributed generations (DGs) have major role in the recent trends of modern electric power systems. Future power system networks effectively and efficiently link small and medium scale electric power sources with costumer demands. DG is often used as back-up power to enhance reliability or as a means of deferring investment in transmission and distribution networks, avoiding network charges, reducing line losses, deferring construction of large generation facilities, displacing expensive grid-supplied power, providing alternative sources of supply in markets and providing environmental benefits. Depending on the system configuration and management, the advantages may not be true. In recent years, DG has become an efficient and clean alternative to the traditional electric energy sources, and recent technologies are making DGs economically feasible. DGs are the part of DERs which also include energy storage and responsive loads. Several small generators which produce very small or no greenhouse gas emissions. Transmission and distribution expansion is to reduce along with the avoidance of large power plants. Electricity markets uncertainty favors small generation schemes and DGs are now cost effective to improve the Power quality and reliability. The attractive proposition of DG is that it is distributed round the network close to customers and DGs represent diverse technologies and primary energy sources. Tremendous research work is going on in the areas of DG technologies, sitting and sizing of DG, impact studies of the increased penetration of DG, economic and financial analysis coupled with DG integration, etc. Main capability is to improve efficiency of protection relays in distribution system is location of fault. In this paper a different approach for fault location method for a distribution network with DGs using the radial basis function neural network (RBFNN) is presented. The proposed method determines the fault type, location of the fault and faulty line using three RBFNNs. The first RBFNN determines the fault type, second RBFNN determines the fault distance from each DG units and the main source and the third RBFNN identifies the exact faulty line.

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II.ELECTRICAL POWER DISTRIBUTION SYSTEM

The main function of an electrical power distribution system is to provide power to individual consumer premises. Distribution of electric power to different consumers is done with much low voltage level. Distribution of electric power is done by distribution networks. But radial electrical power distribution system has one major drawback that in case of any feeder failure, the associated consumers would not get any power as there was no alternative path to feed the transformer. In case of transformer failure also, the power supply is interrupted. The drawback of radial electrical power distribution system can be overcome by introducing a ring main electrical power distribution system. Here one ring network of distributors is fed by more than one feeder. In this case if one feeder is under fault or maintenance, the ring distributor is still energized by other feeders connected to it.

III.FAULT LOCATION USING NEURAL NETWORK

To identify the fault type, fault currents from main source are used to know different types of faults by use of RBFNN. Fault location in a test distribution system with DGs are determined by use of two RBFNNs which are developed by which training data sets are generated by performing short circuit simulations.

A.Fault Type Identification

In order to determine the fault type, the 3 phase currents of the main source is used. Fault types considered are Single phase to ground fault (LG), Two phase short circuit grounding fault (LLG), Two phase short circuit fault (LL) and three phase short circuit fault (LLL). By use of RBFNN, we obtain the fault type code (A,B,C,G).

B.Fault Location Method

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The main function is to achieve the distance of fault from each DG units and the main source by use of fault currents. Two RBFNNs are developed, one RBFNN is to obtain the fault distance and the other RBFNN is for determining exact faulty line.

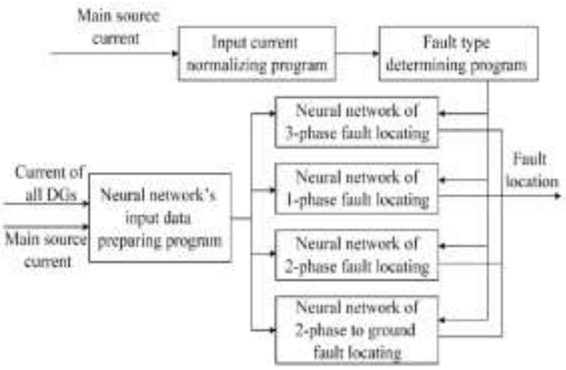

Fig.1 Structure of Proposed method

IV.RADIAL BASIS FUNCTION NEURAL NETWORK

The design of supervised neural network may be pursued in a variety of ways. A completely different approach by viewing the design of a neural network as a curve fitting (approximation) problem in a high dimensional space. Correspondingly, generalization is equivalent to the use of this multidimensional surface to interpolate the test data. In the context of a neural network, the hidden units provide a set of "functions" that constitute an arbitrary "basis" for the input patterns (vectors) when they are expanded into the hidden space; these functions are called radial-basis functions. The construction of a radial-basis function (RBF) network involves the input layers is made up of source nodes (sensory units) that connect the network to its environment. The second layer, the only hidden layer in the network, applies a nonlinear transformation from the input space to the hidden space; in most applications the hidden space is of high dimensionality. The output layer is linear, supplying the response of the network to the activation pattern (signal) applied to the input layer. A pattern-classification problem cast in a high-dimensional space is more likely to be linearly separable than in a low-dimensional space-hence the reason for frequently making the dimension of the hidden space in an RBF network high.

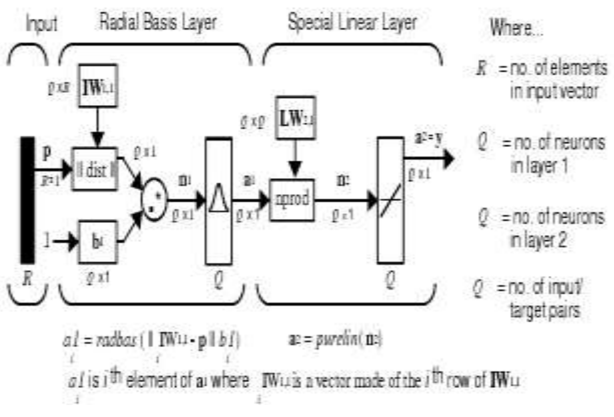

Fig.2 Structure of RBFNN

The implementation procedure in training of RBFNN is shown below.

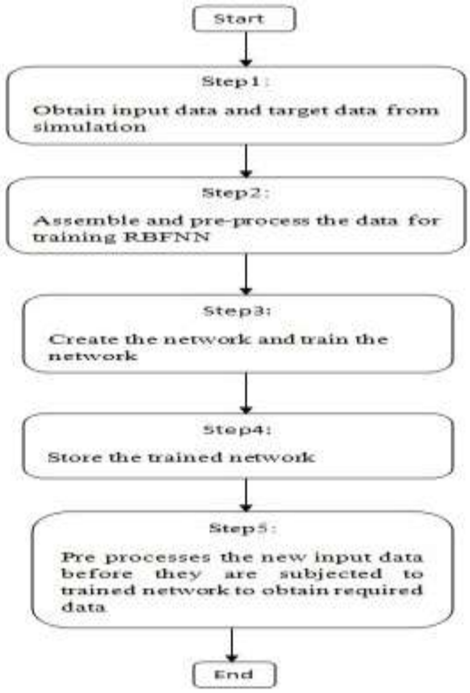

Fig.3 Implementation procedure for training RBFNN

V.SIMULATION RESULTS AND DISCUSSION

In this paper, a distribution network with DGs, the structure is shown below in Fig.4, is established in MATLAB environment. Data is obtained by the simulation. The neural network is developed in MATLAB environment to get algorithm results.

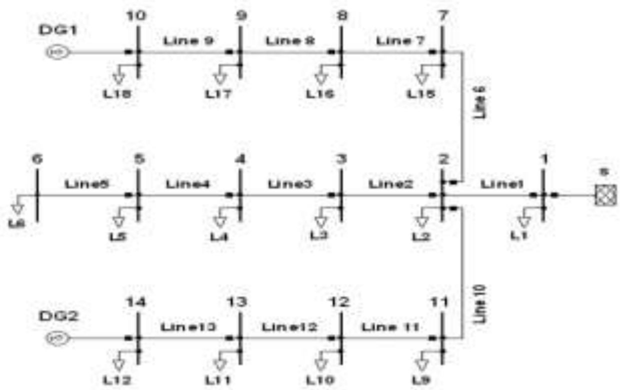

Fig.4 Structure of the test system

In this simulation, the system consists of a 20KV distribution network with two DGs and a Source. The system consists of a 4.5MVA diesel generator as DG1 connected to bus 10, a 3.5MVA diesel generator as DG2 connected to bus 14 and a three phase Source is at bus 1.

The training data for the RBFNNs and fault location method is done by using the MATLAB Software by simulating various faults at every 200m of each line. The description of the inputs and outputs of the training data for the developed RBFNNs are described as follows:

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A.FIRST RBFNN

The number of input neurons are 3, which consists of three phase short circuit currents of main source (Is) and the output neurons are 4 comprising of faulty type code. With the help of voltages from main source (Vs) also we obtain the fault type code. Further more, by consideration of currents and voltages from main source (Is & Vs) together we obtain fault type code.

B.SECOND RBFNN

The number of input neurons are 9, which consists of three phase short circuit currents from 2 DG units and from Source (Is,IDG1,IDG2) and the output neurons are 3 comprising of the fault distances from the main source and two DG units (Ds,DDG1,DDG2). With the help of short circuit voltages from 2 DG units and from source (Vs,VDG1,VDG2) also we obtain the fault distances from the main source and two DG units (Ds,DDG1,DDG2). Further more, by consideration of short circuit currents and short circuit voltages from 2 DG units and from main source (Is,IDG1,IDG2 & Vs,VDG1,VDG2) together we obtain the fault distances from the main source and two DG units (Ds,DDG1,DDG2).

C.THIRD RBFNN

In this case, the number of input neurons are 3, which consists of fault distances from 2 DG units and from main source by short circuit currents, the output neuron is 1 which is the faulty line. With the help of short circuit voltages by considering fault distances from 2 DG units and from main source, we obtain the faulty line. Further more, by consideration of short circuit currents and short circuit voltages together from 2 DG units and from main source we obtain the faulty line.

After determining the fault type, the faulty line is identified. The different fault types selected randomly for the testing the faulty line. The various cases of fault for conditions are presented as follows:

1. Four types of faults at 350m of length of the line 2 from bus 2 to bus 3.

2. Four types of faults at 850m of length of the line 8 from bus 8 to bus 9.

3. Four types of faults at 570m of length of the line 13 from bus 13 to bus 14.

Below Tables shows the results obtained by the RBFNNs testing i.e., RBFNN 2 determines the fault distance (km) from each DG units and source and RBFNN 3 predicts the faulty line.

Table I shows the results of 3 RBFNNs by considering 3 phase short circuit Currents where the fault type is known from RBFNN 1 fault distances from RBFNN 2 and faulty line from RBFNN 3.

Table I

Testing Data	Identify Fault Location				
	RBFNN 1	RBFNN 2			RBFNN 3
	Fault Type	Ds (Km)	DDG 1 (Km)	DDG2 (Km)	Faulty Line no.
1	1-phase to ground	1.2592	4.2592	4 .259	2
	Phase to phase	1.3357	4.3357	4.3357	2
	2-phase to ground	1.234	4.234	4.234	2
	3-phase	1.335	4.335	4.3357	2
2	1-phase to ground	3.419	1.580	6.4192	8
	Phase to phase	3.8	1.2	6.8	8
	2-phase to ground	3.385	1.614	6.3851	8
	3-phase	3.8	1.2	6.8	8
3	1-phase to ground	4.572	7.128	0.4274	13
	Phase to phase	4.579	7.245	0.4206	13
	2-phase to ground	4.2	7.2	0.8	13
	3-phase	4.581	7.289	0.4180	13

Table II shows the results of 3 RBFNNs by considering 3 phase short circuit Voltages where the fault type is known from RBFNN 1 fault distances from RBFNN 2 and faulty line from RBFNN 3.

Table II

Testing Data	RBFNN 1	Identify Fault Location			
		RBFNN 2			RBFNN 3
	Fault Type	Ds (Km)	DDG 1 (Km)	DDG2 (Km)	Faulty Line no.
1	1-phase to ground	1.2	4.2	4.2	2
	Phase to phase	1.291	4.291	4.291	2
	2-phase to ground	1.2	4.2	4.2	2
	3-phase	1.2	4.2	4.2	2
2	1-phase to ground	3.2	1.8	6.2	8
	Phase to phase	3.201	1.799	6.201	8
	2-phase to ground	3.2	1.8	6.2	8
	3-phase	3.2	1.8	6.2	8
3	1-phase to ground	4.2	7.2	0.8	13
	Phase to phase	4.2	7.2	0.8	13
	2-phase to ground	4.2	7.2	0.8	13
	3-phase	4.2	7.2	0.8	13

Table III shows the results of 3 RBFNNs by considering 3 phase short circuit Currents and 3 phase short circuit Voltages where the fault type is known from RBFNN 1 fault distances from RBFNN 2 and faulty line from RBFNN 3.

Table III

Testing Data	RBFNN 1	Identify Fault Location			
		RBFNN 2			RBFNN 3
	Fault Type	Ds (Km)	DDG 1 (Km)	DDG 2 (Km)	Faulty Line no.
1	1-phase to ground	1.2	4.2	4.2	2
	Phase to phase	1.262	4.262	4.262	2
	2-phase to ground	1.2	4.2	4.2	2
	3-phase	1.2	4.2	4.2	2
2	1-phase to ground	3.2	1.8	6.2	8
	Phase to phase	3.200	1.799	6.200	8
	2-phase to ground	3.2	1.8	6.2	8
	3-phase	3.2	1.8	6.2	8
3	1-phase to ground	4.2	7.2	0.8	13
	Phase to phase	4.2	7.2	0.8	13
	2-phase to ground	4.2	7.2	0.8	13
	3-phase	4.2	7.2	0.8	13

VI.CONCLUSION

The presence of Distributed Generation (DG) becomes a multi-source system and results distribution network becomes no longer radial in structure. When a short circuit fault occurs, the protection devices may produce false action and non-action. For such networks predicting the exact fault location is more difficult. Neural network is an effective tool for fault diagnosis. A method using RBF Neural Network to determine the fault type and location of fault in distributed network is presented. The proposed method was implemented on MATLAB and the required data for training the neural networks is extracted.

In this paper, the fault location problem for distribution networks with Distributed Generations (DGs) is studied. With three different Neural Networks are used for the proposed method for fault identification and location in the distribution network with penetration of DG. The results are verified the correctness and effectiveness of the model and out of all the three methods i.e., 3 phase short circuit currents, 3 phase short circuit voltages, 3 phase short circuit currents and voltages; method of 3 phase short circuit currents have a better strong practical value.

VII.APPENDIX

The peak load for all the loads is 1MW and the power factor for all of them is assumed to be 0.92lagging. All the distribution lines are of 1km length and the technical information of the conductors is given below in Table IV. The technical data for DGs is presented in Table V.

Table IV

TECHNICAL DATA OF DISTRIBUTION LINES

R (Ohms)	0.303
X(Ohms)	0.3383
Ro(Ohms)	0.4509
Xo(Ohms)	1.5866

Table V

TECHNICAL DATA OF DGs

Machine	Salient	X'd(pu)	0.256
Voltage	20KV	X"d(pu)	0.168
P(MW)	2.8,3.6	Xo(pu)	0.1
Xd(pu)	1.5	X2(pu)	0.2
Xq(pu)	0.75	Rstr	0.504

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