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Development of new passive neuro fuzzy method to increase accuracy and speed of islanding detection in distribution network

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ABSTRACT
Due to advantages of distributed generation systems, their use in distributed systems is more and more every day. In networks that are used in distributed generation resources, the island being a big problem to occur unintentionally. In this paper we will use a new method that combines of neural networks and fuzzy sets. Simulation results performed in the Matlab software environment that island being diagnosed accurately and more quickly done.

Introduction

Currently most energy supplied people in most countries of the world's are from fossil fuels. The used of these fuels have problems, such as environmental contamination of fossil energy and finitely of fossil energy. For this problems countries, have turned to use renewable energy to supply needs energy. Bulk part of power that produce in distribution generation networks, are in renewable energy that can be either DC or AC. Most distribution generation systems through power electronic converters are connected to the network [1].

Although the use of distributed generation systems has many advantages, but is associated with problems such as the possibility of being an island. Island operation occurs if one or more Distribution Generation (DG) continues to energize a part of the grid after the connection to the rest of the system has been lost. In this condition DG supplied the local loads. There are some problems in Island state, such as damage of local consumers that connected to the network in instability of the voltage and frequency conditions, drawback in automatic reclosing. Also this condition can be dangerous to workers that repaired the network. Island state of the IEEE 1547 standard should be the maximum duration of 2 seconds to detect and remove [2].

Many methods have been proposed for the islanding detection that placed in two groups of active and passive. The titles of these methods are below.

Active methods include measuring impedance method, frequency domain analysis, the amplitude changes of voltage and reactive power, the methods are harmonic. Passive methods include relay voltage and frequency relays, relay rate of frequency, change speed, change output power, voltage unbalance and Total Harmonic Distortion (THD) current (voltage). Each of these methods has its own strengths and weaknesses. For instance in rate of frequency change method, almost measuring frequency will be done, then the deciding rapidly and denotation perhaps mistake. Also total harmonic distortion methods, in some condition that connection and disconnection to the network occur but network is not islanded, perhaps mistakenly islanding condition detected [3].

In [4], two new parameters to explore the island is being introduced and used. One of this parameters is unbalanced in voltage and another one is total harmonic distortion current (THD). These two parameter combined with a conventional utilize parameter (voltage amplitude) used for islanding detection.

In [5], a novel approach used for fast detection of power islands in a distribution network using the transient signals generated. In this paper several pattern recognition techniques in the classification of transient signals in an island mode is being used. Discrete wavelet transform of the transient current signals are utilized to extract feature vectors for the classifiers. Samples of the feature vectors corresponding to various islanding and nonislanding events are applied to train (i) a decision tree classifier, (ii) a probabilistic neural network classifier, and (iii) a support vector machine classifier for recognizing the transient patterns originating from the islanding events. The trained classifiers were then tested with unseen test current waveforms. The test results demonstrated that the investigated technique can potentially provide a new way for identification of islanding in distribution systems. One weakness of this approach is mistakes in islanding detection when the measuring signals have noise.

In [6] introduction about categories include active and passive methods to islanding detection has been expressed. Also referred to as passive methods in the case of DG production and power demand loads on the island is the same, not being able to explore the island. Therefore, the passive methods have a Non-Detection Zone (NDZ). Active methods can reduce this weakness, but also can reduce the power quality that is desired. In this paper, a novel Anti-Islanding Method (AIM) is proposed. A single phase DG using the proposed AIM injects the output current with a little harmonic current into the grid and monitors the harmonic components of the voltage at the Point of Common Coupling (PCC) using the Goertzel algorithm. The Goertzel algorithm is a kind of Discrete Fourier Transform (DFT). It extracts the magnitude and phase of the desired frequency from the input signal, with a minimum computation. The proposed islanding detection algorithm resolves the NDZ but also the bad effects on the grid power quality due to injecting harmonic

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components qualified by the interconnection standard. The proposed Islanding Detection Method (IDM) was verified using PSIM simulations and experimental results.

In [7] a passive method is introduced for detecting island state in the DG with inverters connected to the network and without the inverter connected to the network. The method of used this paper was combine of others methods. Then this method has more proficiency. The results obtained using the Matlab simulation shown this proficiency.

Generally, if then the creation of an island state, once part of the island turned out to be more costly than power produced by DG, an island state is easily detectable with monitoring a several parameters such as amplitude voltage, phase shift, changing the frequency and … . But if load in islanding part almost equal to power production by DG, conventional methods have problem to islanding detection. In this case, other methods should be used. For example, in [8], two new parameters for a DG are proposed to explore the island, and an unbalance in voltage and total harmonic distortion currents (THD). This method effectively combined with traditional parameters and new parameters for the islanding detection. This method has been evaluated with radial grid IEEE 34 bus.

In some cases, then the islanding occur, in technical view it is possible to importance local loads energize with DG (Intentional Islanding). This case in economic view has advantage and will also increase the reliability. For this purpose DG control system must have the ability to control the voltage and frequency. In [9] three different governor systems for the control of active power and frequency control in the nature of the gas turbine distributed generation system in the island has been discussed. Simulation results show performance of governors in both cases of islanding operation and operation with distribution network. In operation with distribution network case DG shall be ability regulation of voltage and frequency in allowable range.

In [10], a control strategy during a fault in the system and also for island mode operation is presented. In normal operation, inverter of the DG worked in constant current mode to the injection of nominee power to the network and in islanding mode, the control system switch to the voltage control mode. In this mode the network provides a constant voltage to the loads.

In [11], a control strategy for operation with network and operation in islanding mode were presented. Also an algorithm for reconnecting and synchronous the DG with network was presented.

In [12] a new approach using Rate of Change of Phase Angle Difference (ROCPAD) for islanding detection in distributed generation has been used. The process starts with retrieving the voltage and current signals at the DG end and estimating the phasors (amplitude, phase, and frequency) using synchronous transformation based algorithm. The proposed algorithm is compared with the widely used Rate Of Change of Frequency relays (ROCOF) and found working effectively in the situations where ROCOF fails. The proposed ROCPAD relay is tested on standard IEEE 34 bus and the results indicate that the ROCPAD relay can reliably detect islanding conditions, thus reducing the NDZ compared to existing ROCOF relays.

In this paper the results of passive measurements after processing by the network being used neuro fuzzy have to recognize the island. Application of the passive signals, increase the speed of the islanding detection and in fact neuro fuzzy network has role of processor of the systems.

The system under the studied will be in Section II. In Section III the new method developed in this article (neuro fuzzy method) being used to explore the island, was described. Simulation results will come in Section IV and finally Section V concludes the paper will be presented.

The System Studied

The simple single-line diagram of the distribution network that under the study in this paper, shown in Figure 1[13]. This network is real and worked by the Local Distribution Companies (LDC). As can be seen in the figure, the distributed generation system is a wind farm type and through a breaker and PCC system connected to the distribution network. To evaluate the efficacy of neuro fuzzy network, two faults that are shown in the figure 1 with F1 and F2, has been created. It should be noted that the signals used in neuro fuzzy network to discover an island state are provided in point of connection DG to the distribution network.

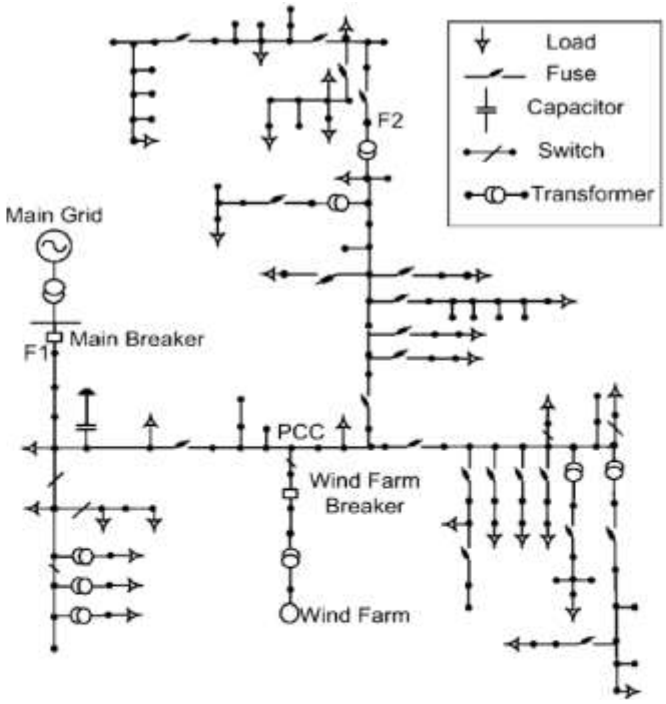

Fig 1. A simple schema of the distribution network [13]

Innovative Neuro Fuzzy Method to Islanding Detection

The general block diagram of the neuro fuzzy method that used was shown in Figure 2. In this method, we first measure voltage, current, frequency, rate of frequency and phase shift. The measured output signals entered in to the fuzzy function blocks. In this block, which consists of a membership function, the amount awarded to any one of entrance into the reference value as a number between zero and one is determined. The outputs of these blocks enter into the neural network. Each of these five entries in this section is allocated a certain weight. Determine weights of neural network were trained using experimental data. For more information on neural networks and teaching see reference [14]. Given that we did not have access to experimental data to adjust the weights, these weights are determined to try and error. The output of the neuron entered into a comparator. If this output increase from the set point that we set it, and stay above of set point for duration time that we set, signal of tripe will be generated. Otherwise recognition of the network was a noise condition and not islanding condition. Then with this method we can detachment of short circuit and other transient condition from islanding condition and don’t generate signal of tripe for transient conditions.

Membership functions for defined of each input are shown in Figures 3 to 7. For sample, we describe the membership function for the frequency input. If the measured frequency is below the 58 Hz, this frequency is completely (100%), belonging to an island condition frequency mode. If the frequency is between 58 to 60 Hz, the frequency belonging to the island state from 1 to zero (0 percent to 100 percent belong to) to linearly decrease. If the frequency is between 60 to 62 Hz, the island belongs to the mode frequency increases linearly from 0 to 1. Finally, if the frequency measured is greater than 62 Hz, this frequency is completely (100%) belongs to the island state. Defined for other membership functions signal also has a similar shape to the function that used for defined of frequency membership function, but their regulation values will vary with the type of signals considered.

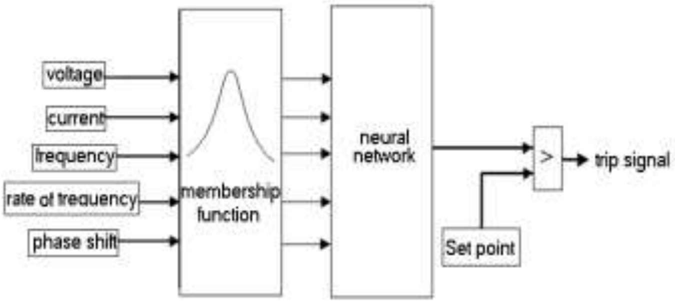

Fig 2. Block diagram of the method used in this paper is to islanding detection

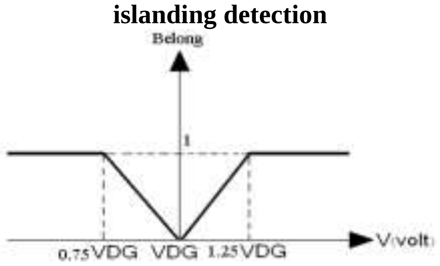

Fig 3. Block Membership function to the voltage

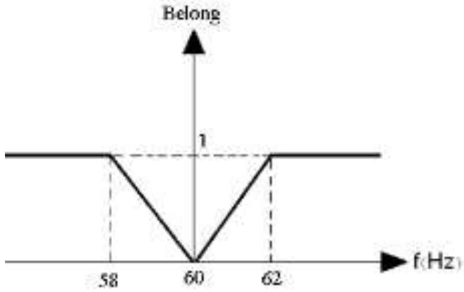

Fig 4. Membership function to the frequency

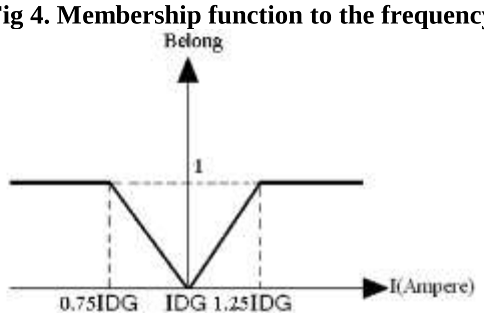

Fig 5. Membership function to the current

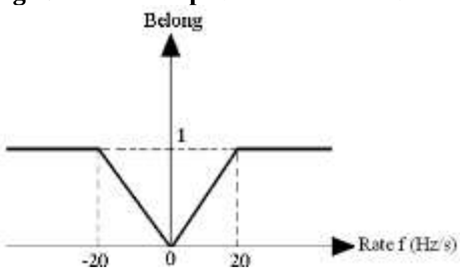

Fig 6. Membership function to the frequency rate

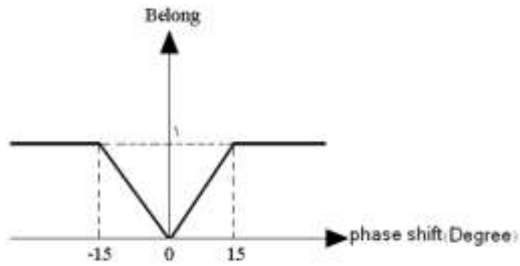

Fig 7. Membership function to the phase shift

An artificial neural neuron consists of inputs with the numbers 1, 2, 3, 4, and 5, weights, summation and excitation function are shown in Figure 8. In fact inputs are amount of belong to the voltage, current, frequency, rate of frequency and phase shift functions respectively that defined in the fuzzy section. Weights of each input are shown with w1, w2, w3, w4 and w5. So we can said briefly that the measured signals of voltage, current, frequency, rate of frequency, and phase shift entered into the fuzzy section. Then the amount awarded to each of these signals belong to the defined functions are determined. Next the signals enter into the neuron. Weights of regulation are multiplied in each of these inputs. Output of this part intern to the summation and then net of summation enter to the activation function of neuron. Output of activation function indicating the Trip signal that it is greater than the regulatory threshold, Trip signal will be issued.

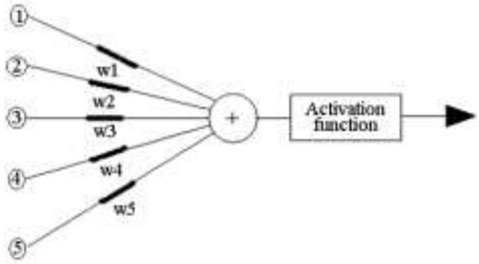

Fig 8. Parts of a neuron

Simulation Results

Results that will come in with the values obtained are the following regulation:

Set point value=0.65

w4 = 0.18, w5 = 0.22 w3 = 0.35, w2 = 0.1, w1 = 0.15.

This article has been studied in six different states. This includes single-phase fault at F1, two-phase fault at F1, three phase fault at F1, single-phase fault at F2, the two-phase fault and three phase fault at place F2. All six case of above, the error in 0.46 sec occurs and at 0.625 seconds Breaker off the main feeder and distribution network come to islanding. It takes time to discover the island is given in Table 1.

Table 1. The time required to Time to islanding detection

Case	Time to islanding detection(ms)
Single-phase fault at F1	34.93
Two-phase fault at F1	35.12
Three phase fault at F1	35.66
Single-phase fault at F2	103.4
Two-phase fault at F2	35.09
Three phase fault at F2	35.11

Conclusion

According to the results presented in Section 4 can be seen that the new innovative way of neuro fuzzy that presented for first time in this paper, has less time to islanding detection that will increase reliability and stability of network. Also, this method has another advantage, and it is that like other existing methods to explore the island, this method not a mistake. Most methods used for islanding detection, transient fault condition are considered as an island state.

Nomenclature

AIM	Anti-Islanding Method
DFT	Discrete Fourier Transform
DG	Distribution Generation
THD	Total Harmonic Distortion
IDM	Islanding Detection Method
LDC	Local Distribution Companies
NDZ	Non-Detection Zone
PCC	Point of Common Coupling
ROCOF	Rate Of Change of Frequency
ROCPAD	Rate Of Change of Phase Angle Difference

Appendix

Overview of network modeling is shown in Figure 9. Numbers attributed to each of the sectors that will be described below. It should be noted that due to the large number of sub blocks, is refrain the bringing them.

No. 1: Thevenin equivalent circuit of main network that includes a source and Thevenin impedance.

No. 2: Transformer to feed distribution network from the main network

No. 3: Producer trip signal to main Breaker

No. 4: Main Breaker

No. 5: Block to create fault in desired location

No. 6: Impedance of line 1

No. 7: Load on number 1

No. 8: Bank of capacitive to produce of required reactive power

No. 9: Impedance of line 2

No. 10: Load of number1 to 9. For simplicity, a number of Loads are shown as a block.

No. 11: Transformer, that connect the generator to the network.

No. 12: Trip signal producer to distributed generation in the island state.

No. 13: Relays and proposed NF system, are within the this block.

No. 14: Distribution generation simulation, breaker relevant busbar.

No. 15: Display time to explore the island

No. 16: Load of number1 to 9. For simplicity, a number of Loads are shown as a block.

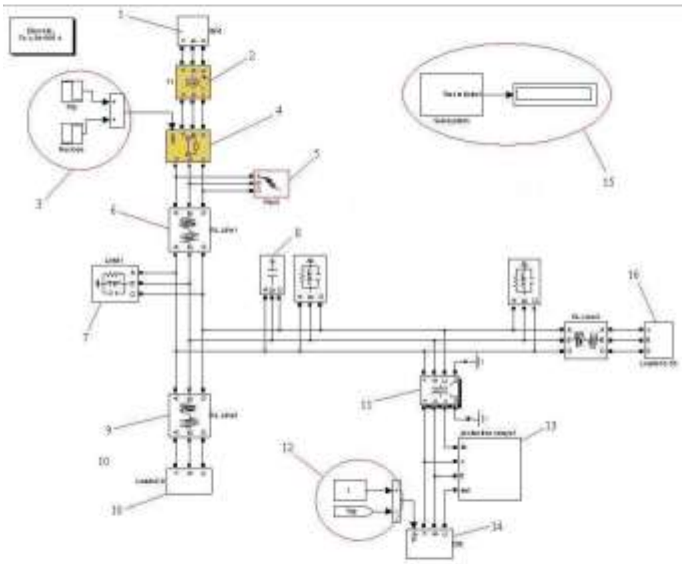

Fig. 8.Network overview of reference [12], simulated in Matlab

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