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New Reconfiguration Scheme for Distribution Networks Using MLP Neural Networks

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Abstract

Recently, the advantages of using distributed generation have been analyzed in most of scientific discussions. Distributed generation rapidly changes the configuration of the electric industry from monopoly to competitive and will totally change the configuration of power systems in the 21st century. One of the main changes, that can be a disadvantage of distributed generation presence, is changing the radial configuration of distribution networks. Injection of DGs currents to a distribution network results in losing radial configuration and consequently losing the existing coordination among protection devices along with decreasing reliability of the system. In this paper, a new method for distribution system reconfiguration has been presented which by implementing on distribution networks including DG, in addition to maintaining the efficiency of their protection system; optimizes DGs operation through islanding operation and causes the system reliability and total ENS of the system to be decrease. The suggested method has been implemented on a sample distribution network using DIgSILENT Power Factory 13.2 and its results have been presented.

Keywords: Distributed Generation, Distribution System, Reconfiguration, Protection, Neural Network

INTRODUCTION

Radial distribution networks are the most conventional configurations of distribution systems. In such networks, feeders are extended from distribution substations towards lateral feeders, in such a way that all service area is supplied through feeders. In general, the main advantages of radial configuration are its simplicity and its low cost [1]-[3]. In radial configuration, the number of disconnecting devices reduces and design of a protection system is not complicated. Conventional configuration of distribution systems has always been based on the fact that there is no distribution generation in network [4]-[6]. But in recent years, some issues like environmental and geographical restrictions of generation units, increasing trend of load growth in distribution systems and the necessity for constructing new power plants as its consequence, tendency toward applying clean energies and independence from fossil fuels, have caused distributed generation to draw attention to a great extent. Presence of DGs in distribution networks, like many other technologies, has some disadvantages along with so many advantages it can have [7]-[10]. Among advantages of DGs one can mention improvement in power quality and reliability and reduction of loss, meanwhile using DGs leads to complexity in operation, control and protection of distribution systems. Injection of DGs currents to a distribution network results in losing radial configuration and consequently losing the existing coordination among protection devices [11]-[14]. The extent at which protection coordination is affected depends on the size, type and location of DG, in some cases coordination is lost completely and in other cases the coordination range diminishes [15]-[18]. Regarding the influence of DGs on protection of distribution systems, so many researches have been performed so far as well as some researches concerning how to tackle the resultant problems of applying DGs [19]-[24].

A new protection scheme for distribution systems in presence of DGs is proposed in [1]. In the proposed scheme, system's protection is carried out through a computer-based relay which is installed in sub-transmission substation. The relay determines system's status after it receives the required network data, and in the case of fault occurrence it diagnoses its type and location using some trained MLP neural networks, and finally issues the proper commands for protection devices to clear the fault and to restore the network [1].

Following, the proposed protection scheme in [1] is described first, and then, the suggested method for network reconfiguration is explained.

The Protection Algorithm

The general idea of the proposed scheme is based on dividing the distribution system into several zones. Zoning is done through considering locations and generation capacities of DGs along with network loads. After network zoning and determining zones' boundaries, some switches which are capable of operating repeatedly and quickly and are also able to receive remote signals, are placed between each two zones of the system. These switches must also be equipped with check-synchronization relays. To implement the protection scheme, it is required to place a computer-based relay with high processing power and large storage capacity in supplying substation (sub-transmission substation) of the distribution network. The computer-based relay installed in sub-transmission substation holds the main responsibility of system protection and operates through steady monitoring of the currents flowing through some specific points of network. The specific points of network that their currents must be measured and monitored continuously are:

1. All currents flowing through all DGs and main supplying source;
2. Currents flowing through isolating switches of zones;
3. Currents flowing through all network laterals excluding those laterals containing DGs;

In addition to the currents that are measured online and the relay is provided with them continuously, the following data must also be provided and stored in relay's memory as permanent specifications of network:

1. Technical specifications of all network's equipment such as distribution substations, transmission lines, existing protection devices and DGs;
2. Estimated hourly load curve for all loads of network;
3. All data regarding network zoning and the locations of isolating switches;
4. All data regarding operation of relay for different faults;

Network Zoning Approach

For applying the zoning procedure in the distribution system, it is considering one zone for each DG, starting from the beginning of feeder, and each zone extends to the end of feeder as long as the DG within that zone is capable of supplying average load of that zone. When average load of substations located in the zone exceeds generation capacity of zone's DG, zone border finishes, and two circuit breakers are installed in the beginning and in the end of zone points. In the case that there exists a second DG located within the supplying limit of first zone's DG, and as long as zone's average load does not exceed generation capacity of first DG, while moving towards end of feeder, the second DG is regarded within the same zone and zone border extends as far as the zone's average load does not exceed summation of two DG's capacity.

Fault Location Scheme

The most important part of a protection system is accurate determination of the type and location of occurred faults in its protection zone. In [1], through offline calculation, 4 MLP neural networks are trained with the proper input data which is gathered by system modeling and performing short circuit calculations in different locations and with various fault impedances. Then, in case of a fault occurrence, through online calculation, the accurate type and location of the fault are determined by the main relay.

In order to determine the fault type, only the 3 phase current of the main source is used. At this point, there is no need to ANN and it can be determined with normalizing 3 phase output current of the feeding substation.

After recognizing the fault type, its location should be determined. In this paper, MLP neural network is used for specifying exact location of the fault. The outline of the proposed method is shown in Fig. 1.

After recognizing fault type by its corresponded unit, the trained neural network of this kind of fault is activated and receives the input data which has been prepared by the input data preparation program. The output of the neural network will be the fault distance from all DGs and the main source.

Proportional relationship between injected fault current of DGs and feeding substations to each other is taken as the input of neural network in this study. The number of outputs of neural network is n which is equal to the number of fault current suppliers and each output uniquely determines the distance of the fault from its power supply. So, the structure of the neural network used in this paper is shown in Fig. 2.

Only one hidden layer is used for the purpose of constructing the neural network, while the neurons number is related to the modifying conditions and cannot be specified precisely. It has to be mentioned here that in a particular problem, the number of neurons in the hidden layer can be determined with try-and-error method. The number of output layer neurons is equal to the number of outputs. Linear type and hyperbolic tangent type transfer function is considered for output and hidden layer neurons, respectively, and Levenberg-Marquardt algorithm for neural network training method [1].

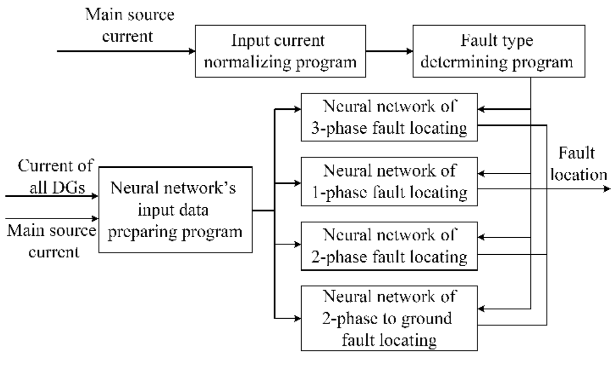

Fig.1. The outline of the proposed fault location scheme

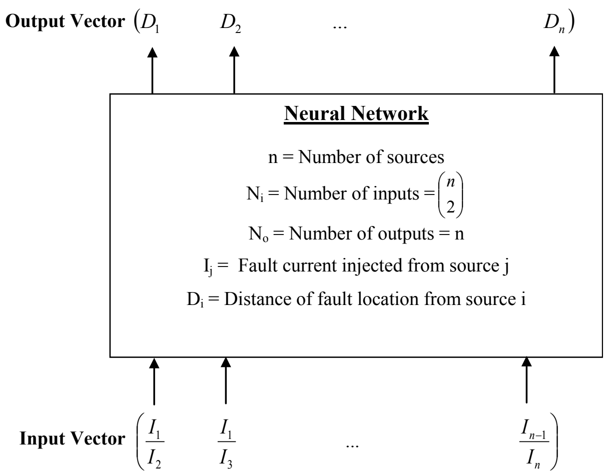

Fig.2. The structure of the neural network

Isolation of Faulty Zone and Network Restoration

The main purpose of protection schemes in electric power systems is isolating faulty zone from the rest of network as far as network loads do not face power cut. Besides, since more than 80 percent of faults are transient and are cleared after a very short time, it is needed to provide a protection scheme with the capability of diagnosing such faults and reacting appropriately when they occur. This feature is gained in power systems through applying re-closers. In conventional electric distribution systems, it is easily possible to recognize transient faults from permanent faults using fuse-re-closer coordination. In the scheme, proposed in this paper, the aim is to separate faulty zone from the rest of network using opening of its isolating circuit breakers along with supplying network zones as far as it can be done. To achieve this purpose, disconnection signal is sent to all circuit breakers placed in faulty zone and downstream zones after diagnosis of location and type of the occurred fault. Also, to cut off supply of faulty zone in the case that there are DGs inside that zone, relay sends disconnection command to all DGs inside that zone. In this condition, faulty zone faces power cut thoroughly, its electrical connection with other parts of network is cut off, and upstream zones continue their synchronous operation with the global network. It is obvious that upstream zones are supplied through main source and their own DGs. Downstream zones, are supplied through island operation of their DGs, if they have any, otherwise their supply is disconnected. To perform re-closing operation, the switch that links zone of fault to upstream network is used and the operation is coordinated with the characteristics of the faulty lateral's fuses through software process done by central relay installed in sub-transmission substation. To carry out this, relay reinvestigates network status after each re-closure attempt and in the case that fault still exists, re-opens the circuit breaker and if fault is cleared, restores the network. To restore the network, relay sends re-closing signal first to zones isolating circuit breakers as well as synchronizing signal from the beginning to the end of feeder, and then brings back DGs located in the faulty zone to network [1].

As it was pointed out before, when network load is higher than average load and a fault occurs in system in this situation of network, as its result some zones go into island operation due to the disconnection signal issued by relay in addition to consequent opening of some of circuit breakers, it is required to perform load shedding operation during zones island operation. In the protection scheme, it has been proposed that to determine the load difference in each zone, summation of the active and reactive powers flowing through zones isolating switches at the time exactly before occurrence of fault.

$$\Delta P_L = \sum P_{CBi} \quad , \quad \Delta Q_L = \sum Q_{CBi} \tag{1}$$

When for each zone ΔPL and ΔQL are known out of (1), it is possible to determine shortage or excess of load regarding generation capacity of each zone. Then, using estimated hourly loads curves of the zone, fault time, ΔPL and ΔQL, and loads degree of importance, load shedding can be done to the extent at which the balance between generation and consumption in each zone is maintained. Of course this operation is needed to be done in the zones that face overload at time of fault occurrence. In the case that at time of fault occurrence loads within the island zone are lower than generation capacities of zone's DGs, relay issues no disconnection signal in order zone's frequency control system decreases generation of DGs to have nominal system frequency. It must be mentioned that when load shedding is needed to be performed as well as determining which loads have to be shed, relay sends disconnection command to load break switch of the relevant distribution substation.

The Proposed Method for Reconfiguration

In case of fault that is i.e. when the sum of output currents of DGs and the main source exceeds the total network load, relay senses the fault in network and designates the type and location of fault via comparing monitored currents with offline calculation results. It also diagnoses the faulty zone. Afterwards, the relay sends proper command for isolation of the faulty zone. In this level, 5 types of zones are produced which can be classified as follows:

1. *First-type zone*: The fault has happened within it and due to relay commands the zone is disconnected from the other parts of the network and the DGs located in it (if it contains DGs) have disconnected.

2. *Second-type zones*: These zones are the zones in which there is one or more DGs and are located upstream the faulty zone. These zones are fed through their own DGs in parallel with the main source. So, the fault occurrence causes no trouble for them.

3. *Third-type zones*: These zones are located upstream the faulty zone and they don't include DG. After isolation of faulty zone they are fed by the main source as well as the DGs located in the second-type zones. So, the fault occurrence causes no trouble for them too.

4. *Forth-type zones*: These zones are located downstream to the faulty zone and have DG. In case of fault, these zones operate as an electric island and their loads are fed by DGs located in them.

5. *Fifth-type zones*: They are referred to zones which are located downstream to the faulty zone and there is no DG within them. Since they don't have DG, occurrence of every fault in their upstream network causes power cut in them. But, these zones can include important loads such as capital health systems or hospitals.

This paper is to designate a solution for feeding fifth-type zones during faults which can decrease the ENS of the network, and to increase the system reliability.

Implementation of the suggested scheme in this paper is subject to some network reconfigurations which are described in the following paragraph.

Required Modifications in Network's Configuration

To restore the fifth-type zones it is required to connect these zones to their upstream or downstream zones. For this purpose following changes are advised in this paper.

1. DGs connected to the LV side of the network should be connected to their upstream and downstream zones' MV feeders via step up transformers.
2. Some CBs should be utilized between each LV side DG and the step up transformer. These CBs should be equipped by shunt trip, shunt close, and under voltage relays. These CBs are used for two reasons. First, they can be opened and closed rapidly for several times. Second, they can receive remote signals from the main relay.
3. Low voltage cable should be established from each LV side DG to step up transformer, in order to transmit power

produced by DG to its adjacent zones. MV transmission network should be established from step up transformers to the zones which lack DG. Through this, it will be possible to transmit the DG produced power to its adjacent zones in which there is no DG.

Fig. 3 represents a typical distribution network along with its zoning and through specifying the quintuple zones created after a fault. In this figure, the suggested changes are specified in the network configuration. In this network, occurrence of faults in the 3rd zone makes the 5 zones existing at the network to be classified as follows:

- First type zone: 3rd zone
- Second type zone: 1st zone
- Third type zone: 2nd zone
- Fourth type zone: 5th
- Fifth type zone: 4th zone

Description of Operation

Whenever any fault occurs, some problems are generated for the sake of the zones of 5th type after the generation of quintuple zones. For overcoming such problems according to the described hypotheses and through changing and advancing the computer relay inside the sub-transmission substation, we may provide the possibility for keeping the 5th-type zones electrified. This process can be done easily through sending due orders to the settled switches and connecting zones with DG to the 5th-type zones.

It should be noted that with the selection of switch types with the mentioned relays and interlocking switches and converting them to changeover, the task is done in automatic fashion but for reaching more reliability and for reaching backup protection, this process is defined for relay as well in order to issue the required orders through relay as well.

In this situation, since the main relay located at the sub-transmission station, is able to distinguish the precise location of fault, we may conclude that if the fault is occurred at MV section, DG zone can both feed its LV network and its upstream or downstream zone (5th type zone) to empower it through connecting to it. So, when the fault is occurred and distinguished by the relay, if it is related to MV side of the faulty zone, besides the low-voltage loads of the fault zone, a 5th-type zone at the vicinity of it can be supplied. Here, it must be noted that if fault is occurred at the LV side, it is enough to open the load switch of the low-voltage section that in this situation, the remainder network operates normally and entire zones operate in synchronized manner. Therefore, only those faults occurred at the MV side is analyzed in this paper.

In situations that relay specifies the location of the fault and issues the required commands, DGs settled at the fault zone, feed their zone in one of the voltage levels and through changing the given configuration, feed the fifth type zone at the vicinity of it. In this occasion, for increasing the reliability of the 5th-type zone and its upstream and downstream zones, these three zones should be synchronized with each other. In other words, DGs of the upstream and downstream zones of the 5th-type zone should be synchronized altogether. Of course, such operations are done simultaneous with the load shedding algorithm of the relay through which amount of loads and their importance are distinguished through load shedding algorithm described previously and loads with higher priority are supplied.

Service Restoration and Normalizing Network

Since more than 80 percent of faults occur in the distribution networks are temporary, the network should be entitled with the opportunity to remove such faults. In the traditional distribution systems, this task is done through re-closers. In the suggestive

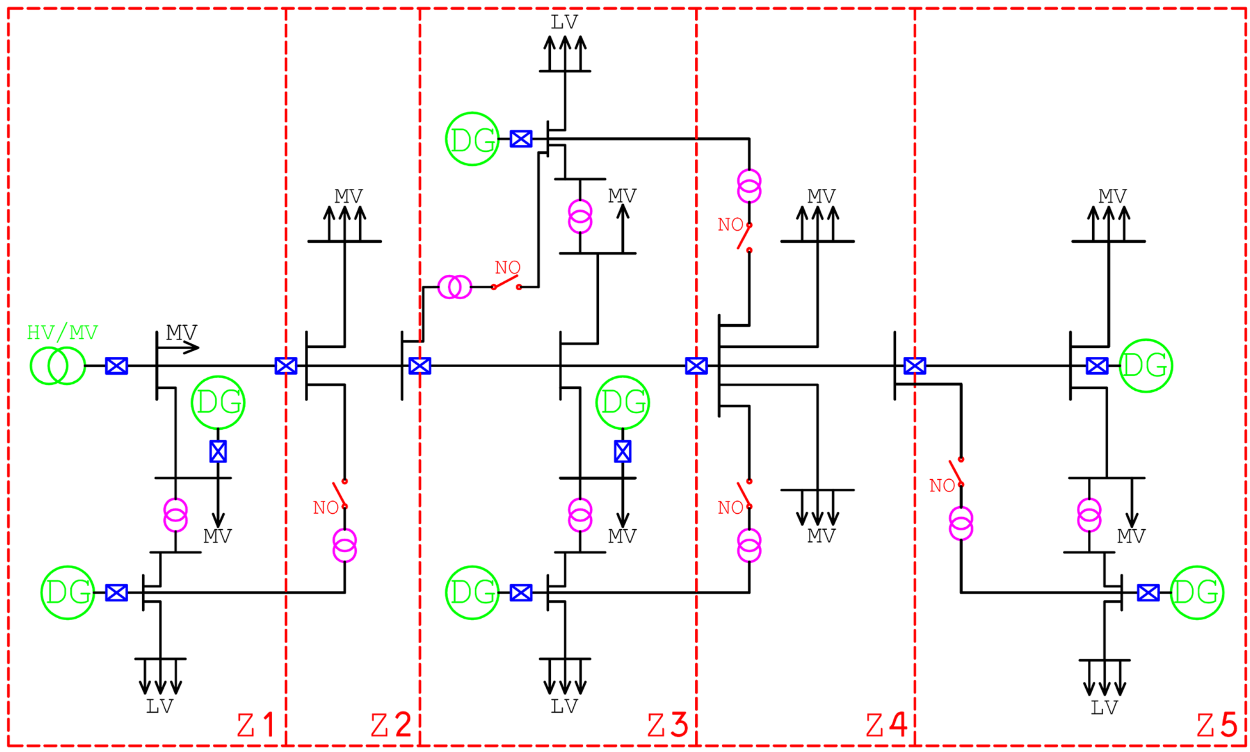

Fig.3. A sample distribution network after performing the suggested reconfiguration

method of this article, the re-closing operation is done by zone's breakers. After the fault occurrence, relay issues the order of opening to the breakers connecting zones. Then after the first re-closure, relay rechecks status of the network. If the fault was temporary, relay, considering the synchronism operations, issues the order of closing to the CBs connecting zones. Of course, this task is done considering the MM and TC curves of fuses in the database of the relay and before blow of the network fuses. Calculation of this time has been planned in the initial offline calculations of the relay. For service restoration and network normalization after fault clearance and closure of the switch connecting the fault zone to rest of the network, re-reconfiguration should be done in that zone. For this task, the CB which is located at the medium voltage side of DG is closed along with the synchronism operations and synchronizes the DG with the global network. Then, CBs connecting zones are closed respectively along with the synchronization operations and the CBs connecting 5th-type zones to the DGs of the adjacent zones are opened. This process can be classified as follows:

1) Service Restoration for the 1st-Type Zone

As mentioned previously, 1st-type zone is the zone in which fault is occurred. This type of zones may either hold or lack DG. For restoration of such zones after fault clearance (temporary or permanent), first the CB connecting this zone to its upstream zone (global network) should be closed. Then, if this zone lacks DG, the downstream zone CB should be closed as well as performing synchronism operation, and if it holds DG, first the CB at the MV side of DG along with synchronism and then the CB at the LV side should be closed. Since for this task it is necessary to open the CB connecting to the 5th type in interlock fashion, 1st type zones are normalized and synchronized with the global network automatically.

2) Service Restoration for the 2nd and 3rd-Type Zones

These zones are attributed to the upstream zones of the fault zone that hold (for 2nd type zones) or lack (for 3rd type zones) DG. Considering the protection algorithm described in Section 2, at the occurrence time of fault these zones are connected to global network and there is no need to restoration.

3) Service Restoration for the 4th-Type Zones

4th-type zones include downstream zones of the fault zone that hold DG. Service restoration of these zones is similar to those for the 1st-type zones such that first their zone CB is closed considering the synchronism operations and then the load CB of DG is opened.

4) Service Restoration for the 5th -Type Zones

These zones are downstream zones of the fault zone that lack DG. After restoration and normalization of other zones of the network, these zones that are located between other zones are automatically restored and connected to the distribution network.

Required Changes in the Protection Algorithm

After network reconfiguration, there should be some necessary adaptations in the protection algorithm of the main relay which are briefly described in the following paragraph.

Load flow and short circuit analysis for the reconfigured distribution system, as explained before, are conducted in the offline calculation of the main relay. Two modifications must be made in the offline calculation. Firstly, all operational data of the main relay for different faults must be stored in the relay's memory according to the method presented previously. In other words, the input data of relay, due to change in the network configuration and the philosophy of protection, must be modified. For this purpose, types of all network zones for different faults should be determined. Thus, as the second modification in the offline calculation, in accordance with fault occurrence in each zone, type of each zone of the network should be determined regarding the fifth-type zones described previously.

In the online calculation of the man relay, first, the location of fault is determined. But, the voltage level of the fault's location should also be identified considering different functions of the relay for LV and MV faults. The next change to be made in the course of doing online calculation is in the algorithm of load shedding operation. As it was referred to previously, considering the synchronization of the fifth-type zones with their 2 adjacent zones, load shedding performs simultaneously in these three synchronized zones. To achieve this goal, the differences in energy production and consumption in these three synchronized zones must be computed together. This is made according to the method explained previously. But this time, the difference between the power production and load in these three zones must be computed by summing up the current flowing through the circuit breakers dividing them from the upstream zone and the downstream one in the immediate second before the occurrence of the fault. Then, using the estimated hourly load curve for all loads within the three zones, the time of fault occurrence, ΔPL and ΔQL values, and the significance degree of the loads, the relay should reduce the number of the loads up to the point that the balance would be made between the production and consumption within them. In other words, these three zones are considered as a new zone and the load shedding operation for the new zone would be made using the input values of its bordering circuit breakers.

When the faults have got cleared, in order to network restoration, the relay will use the data regarding its operation in the case of different faults, which have been stored in its memory.

Simulation of a Sample Distribution Network

The network studied in this paper, is a radial 20kV network in which a 800kVA diesel generator is connected to the 20kV network and a 500 KVA diesel generator is connected to the 400V network. Fig. 4 shows the single line diagram of the network simulated in DIgSILENT Power Factory 13.2.

As could be seen, the network consists of three zones where the first and third zones lack DG and the second zone includes the 800kVA DG. Also, the connection route between the second and the third zones which includes a step-up transformer, low voltage and medium voltage cable network, is the suggested reconfiguration by this paper which is described in section III. To examine the sufficiency and performance of the suggested method, its performance has been studied for different faults. But, due to space limitations, following operation of the designed system for a symmetrical three-phase fault on the connecting line of buses 4 and 5 is presented. In this paper for performing load flow and short circuit analysis of the network DIgSILENT Power Factory 13.2, and for simulating the operation algorithm of the central relay and training the neural networks MATLAB is used.

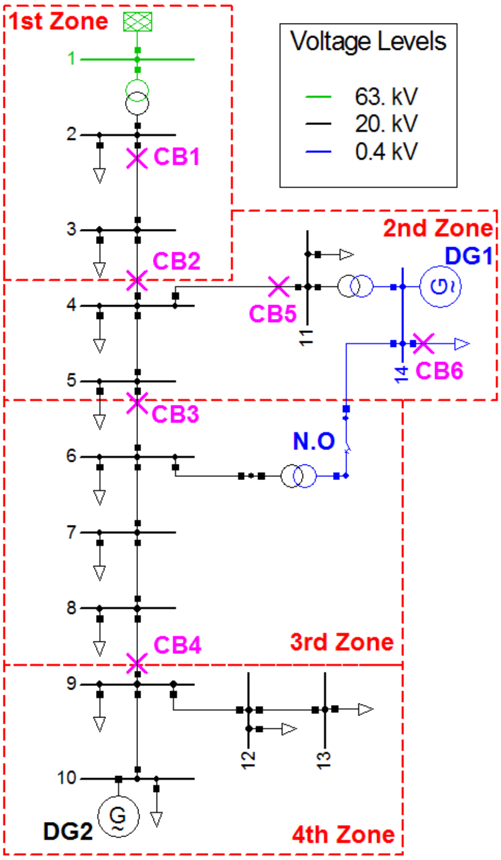

Fig.4. The studied distribution network

In order to prepare the required data for training the neural network, all types of faults in the system in each 50 meter and with 0, 50, 100, 150 ohm fault impedance is simulated and the output current of all power supplies are exploited. Training results of all neural networks are shown in Figs. 5 to 8.

After fault occurrence, the passing currents from the monitored points highly increase and the relay recognizes the fault in the network. Then using its fault location algorithm and trained neural networks, it determines the fault location. In this situation, the main relay, after recognizing the fault, determining its location, and distinguishing the second zone as the faulted zone, immediately sends disconnection commands to CB2, CB3, CB4 and CB5. In this case the first zone is fed by the global network; the low voltage side of the second zone and the forth zone continue their operation in autonomous mode, and the third zone and the medium voltage part of the second zone face power outage. Then the relay sends re-closure command to CB2 in order to recognize the temporary fault and performing the auto re-closing operation. This process can be repeated several times. Of course, due to powerlessness of the low-voltage part of the second zone there is no need for synchronism during the re-closing operation. In the case of temporary fault the relay sends the closing command to CB3, and finally does to CB4 and CB5 as well synchronization operation. But, if the fault is permanent the relay would connect the third zone to the second one through sending connection command to the N.O switch between them. Through closing this switch it would be possible to feed the loads located in the third zone and LV side of the second zone. Regarding the fact that the DG's capacity is less than the total sum of the loads in these two zones, load shedding

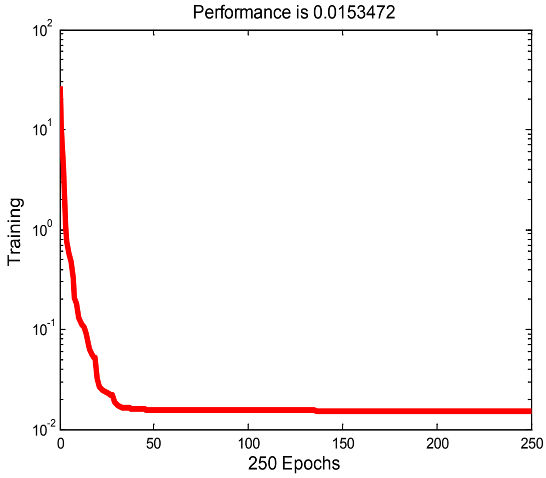

Fig.5. Training result of neural network for 3-phase fault

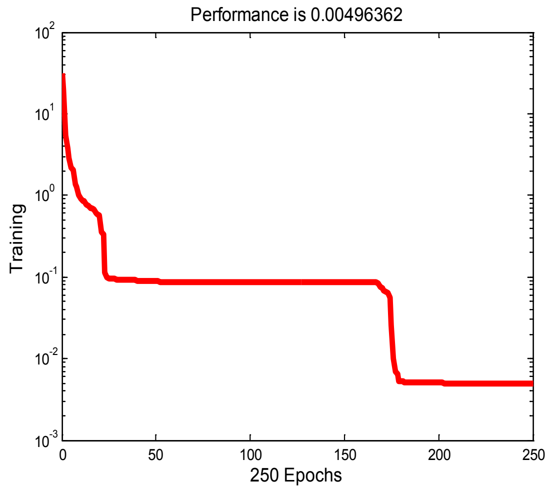

Fig. 6. Training result of neural network for 1-phase fault

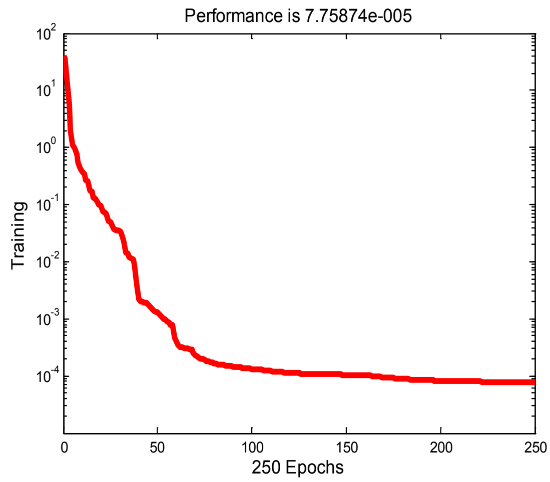

Fig.7. Training result of neural network for 2-phase fault

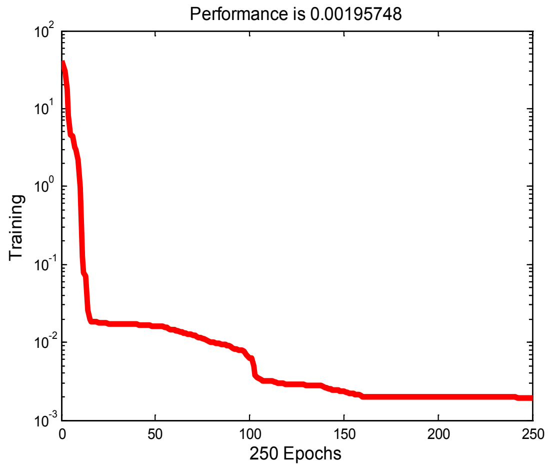

Fig.8. Training result of neural network for 2-phase to ground fault

must be done in them following closing the N.O switch. The loads to be shed is computed according to the total passing current from CB3, CB4 and CB5 before the fault occurrence, and considering the importance of the loads and their estimated value at the moment of fault occurrence. The less important loads are respectively shed to reach a balance in generation and consumption in the formed island. In this way, besides feeding the important loads, we would be able to highly increase the reliability of the network and minimize the network's ENS.

The output of the relay's simulator in case of a 3-phase fault in line connecting buses 4 and 5 is as follows:

>>
The fault is three-phase fault.
The faulty section is the section between buses 4 and 5.
The faulty zone is zone 2.
The fault is in Medium Voltage.
CB2 ==> Opened
CB3 ==> Opened
CB4 ==> Opened
CB5 ==> Opened
CB2 ==> Re-closed
For Transient Fault:
CB3 ==> Closed
CB4 ==> Closed (with synchronizing function)
CB5 ==> Closed (with synchronizing function)
For Permanent Fault:
CB2 ==> Opened
CB (N.O) ==> Closed
Low Voltage section of zone 2 ==> Connected to zone 3
Load 7 ==> Shed
Load 8 ==> Shed
>>

DISCUSSION

The main relay has the ability of distinguishing the accurate location of fault including the zone and branch in which the fault is occurred. However, determining the faulted zone is enough for correct operation of the suggested protection system. Now if a percentage of error is reported in case of measurement equipments, communication network, or other parts of the system, the main relay may make a mistake in distinguishing the exact location of fault, but it rarely happens for it to make a mistake in distinguishing the zone in which the fault is happened.

Most of the communication systems existing in the distribution network have the ability of transferring data required by the suggestive protection system but their specifications, quality, and availability is different. It is obvious that the more is the importance of the protected distribution system, the higher quality communication system may be used for reaching better reliability. In addition, in more important parts of the network, for avoiding the errors resulted from unavailability of the communication system, backup communication system may be installed. So, selection of the proper communication system should be done with the consideration of the technical and economic concerns of the protected network.

Considering IEEE-1547 Standard, all DGs connected to the distribution network should be equipped with various protection relays in order to isolate the distributed generators from the system at the time of fault and to avoid feeding of fault by them. Since the operation speed of the suggestive protection of this paper is higher than the operation speed of these relays, in case of availability of the communication system and the main relay, the protection system operates properly and protects the network considering the described protection philosophy. But, if the main relay or communication system is not available for any reason and is not able to operate properly, the local relays related to the DGs sense the fault and isolate all DGs from the network. Hereafter, structure of the distribution network is transformed to the traditional radial structure and turns to a conventional distribution network without DG and such network is protected by the existing traditional fuses and relays.

CONCLUSION

In this paper a new method for reconfiguration of distribution networks including DG is suggested for optimal operation of DGs. The main goal of the suggested method is feeding the important loads of the network when a fault occurs and optimizing the operation of DGs for the purpose of increasing reliability and reducing ENS in the network. Also, in order to maintain protection coordination among the network's protection equipments, the present protection system in the network was updated to a satisfactory level so that it could protect the reconfigured network as well. Finally, in order to study the sufficiency of the suggested method, it was simulated on a sample distribution network. The simulation results show that in order to optimize operation of distributed energy resources in distribution systems, these systems must be equipped with distribution automation system (DAS). Simulation results also emphasis that through the suggested reconfiguration method, it's possible to suitably use the capacity of DGs to feed the loads in autonomous mode, which leads not only to making the possibility of feeding the most important loads of the network, but also to highly increasing the system reliability.

REFERENCES

[1] Javadian SAM, Haghifam MR, Rezaei N, 2009. A Fault Location and Protection Scheme for Distribution Systems in presence of DG Using MLP Neural Networks. IEEE Power Engineering Society General Meeting, Calgary, Alberta, Canada, pp.1-8.

[2] Ahuja, Das S, Pahwa A, 2007. An AIS-ACO Hybrid Approach for Multi-Objective Distribution System Reconfiguration. IEEE Trans. Power Syst., vol. 22, no. 3.

[3] Siti MW, Nicolae DV, Jimoh AA, Ukil A, 2007. Reconfiguration and Load Balancing in the LV and MV Distribution Networks for Optimal Performance. IEEE Trans. Power Del., vol. 22, no. 4.

[4] Salazar H, Gallego R, Romero R, 2006. Artificial neural networks and clustering techniques applied in the reconfiguration of distribution systems. IEEE Trans. Power Del., vol. 21, no. 3, pp. 1735–1742.

[5] Savier JS, Das D, 2007.Impact of Network Reconfiguration on Loss Allocation of Radial Distribution Systems. IEEE Trans. Power Del., vol. 22, no. 4.

[6] Cecchi V, Yang I, Miu K, Nwankpa CO, 2007. Instrumentation and Measurement of a Power Distribution System Laboratory for Meter Placement and Network Reconfiguration Studies," IEEE Trans. Instrum. Meas., vol. 56, no. 4.

[7] Gomes FV, Carneiro S, 2005. A new heuristic reconfiguration algorithm for large distribution systems. IEEE Trans. Power Syst., vol. 20, no. 3, pp. 1373–1378.

[8] Javadian SAM, Haghifam MR, 2008. Protection of Distribution Networks in Presence of DG Using Distribution Automation System Capabilities. IEEE Power Engineering Society General Meeting, pp. 1-6.

[9] Javadian SAM, Haghifam MR, 2008. Designing a New Protection System for Distribution Networks including DG. The 9th IET International conf. on Developments in Power System Protection, pp. 675-680.

[10] Farzanehrafat A, Javadian SAM, Bathaee SMT, Haghifam MR, 2008. Maintaining the Recloser-Fuse Coordination in Distribution Systems in Presence of DG by Determining DG's Size. The 9th IET International conf. on Developments in Power System Protection, pp. 124-129.

[11] Rezaei N, Haghifam MR, 2008. Protection scheme for a distribution system with distributed generation using neural networks. International Journal of Electrical Power & Energy Systems, Volume 30, Issue 4, pp. 235-241.

[12] IEEE Standard for Interconnecting Distributed Resources with Electric Power Systems, IEEE Std. 1547, July 2003.

[13] IEEE Standard Conformance Test Procedures for Equipment Interconnecting Distributed Resources with Electric Power Systems, IEEE Std. 1547.1, June 2005.

[14] IEEE Guide for Monitoring, Information Exchange, and Control of Distributed Resources Interconnected with Electric Power Systems, IEEE Std. 1547.3, Nov. 2007.

[15] Conti S, Greco AM, Messina N, Vagliasindi U, 2008. Generators Control System in Intentionally Islanded MV Microgrids. International Symposium on Power Electronics, Electrical Drives, Automation and Motion, pp. 399-405.

[16] Oyarzabal J, Jimeno J, Ruela J, Engler A, Hardt C, 2005. Agent based Micro Grid Management System. International Conference on Future Power Systems, pp. – 6.

[17] Dimeas A, Hatziargyriou N, 2004. A Multi Agent System for Microgrids. IEEE Power Engineering Society General Meeting, pp.55 – 58.

[18] Wang L, Cheung H, Hamlyn A, Yang C, Cheung R, 2007. Network-Integrated Protection and Control Strategy for Power Distribution Systems. Large Engineering Systems Conference on Power Engineering, pp. 39 – 43.

[19] Wan H, Wong KP, Chung CY, 2008. Multi-agent Application in Protection Coordination of Power System with Distributed Generations. IEEE Power Engineering Society General Meeting, pp.1-6.

[20] Wu X, Lu Y, Du J, 2008. Wide-Area Current Protection for Distribution Feeders with Distributed Generators. DPRT 2008, pp. 2558-2563.

[21] Figueroa MA, Ordufia E, 2008. Ultra-High-Speed Protection for Medium Voltage Distribution Networks with Distributed IEEE/PES Latin America Generation. Transmission and Distribution Conference and Exposition, pp. 1 – 8.

[22] Tamizkar R, Javadian SAM, Haghifam MR, 2009. Distribution System Reconfiguration for Optimal Operation of Distributed Generation. International Conference on Clean Electrical Power, pp. 217-222.

[23] Javadian SAM, Nasrabadi AM, Haghifam MR, Rezvantalab J, 2009. Determining Fault's Type and Accurate Location in Distribution Systems with DG Using MLP Neural Networks. International Conference on Clean Electrical Power, pp. 284-289.

[24] Javadian SAM, Haghifam MR, Barazandeh P, 2008. An Adaptive Over-current Protection Scheme for MV Distribution Networks Including DG. IEEE International Symposium on Industrial Electronics, pp. 2520-2525.

[25] Javadian SAM, Haghifam MR, 2008. Implementation of a new protection scheme on a real distribution system in presence of DG. POWERCON 2008 and 2008 IEEE Power India Conference, pp. 1-7.