Classification of Faults in Microgrids System

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Abstract- The smart grid can self-heal and isolate a defect to lessen its harmful effects by using fault detection and location. Numerous methods are put out in the literature for the use of artificial intelligence algorithms in the identification and categorization of defects. Based on data from sensors and smart meters put in the smart grid, this research provides a unique approach for defect detection, classification, characterisation, and localization utilizing fuzzy logic and neural networks. The OpenDSS-Matlab platform is used in tandem with the suggested technique in this paper to enable the simultaneous detection and classification of network faults. The suggested approach is validated using the IEEE 37-bus system. With the suggested approach, a good value of 99.9% precision was reached, as reported in the literature. Network operators may find this strategy helpful in identifying, characterizing, and pinpointing issues.

Keywords— Microgrids, Distributed Generators, Key Busses, Primary, Secondary Controllers.

1. Introduction

In response to a number of global issues, such as growing energy use, environmental concerns, and the depletion of fossil fuels, renewable energy has emerged in recent years. This improvement has led to the emergence of microgrids, which can connect more dispersed energy sources to the grid. Numerous research projects have been started in an attempt to address or mitigate the volatility of renewable energy. An further query along the similar lines Faults of the microgrid kind can arise from either the network or the microgrid side. If faults are not constructed properly, they can result in significant harm to electrical equipment and expensive grid outage. Static switch isolation The microgrid is turned on when a malfunction in the primary network occurs. The smart grid was developed with the objective of integrating intelligence into the power grid through communication devices. Smart grids are complex networks that include many devices to allow control, monitoring and supervision of the network based on energy demand. The smart grid can be defined as an intelligent system us ing information and data collected from sensors, servers, intelligent electronic devices and smart meters in order to make the network more flexible, efficient and reliable. The smart grid offers several advantages for production, transmission, distribution operators and consumers, in particular: demand management because the smart grid allows consumers and operators to manage electricity consumption; ensuring reliability of the network because it makes it possible to anticipate and locate remotely, faults and outages detection in order to allow energy recovery; providing grid stability because the smart grid helps to maintain the balance between production and consumption despite variations of energy demand. In order to migrate to the smart grid across the world, some countries already started to establish roadmaps that would allow them to move towards a smart grid in the next years. In Souhe et al. the authors estimated a deployment of 4 million of smart meters in Cameroon for the next 20 years. Fig. 1 shows the structure of a smart grid. In addition, with the integration of renewable energies and intelligent communication and control devices, the smart grid becomes interactive in order to allow reconfiguration of the system and self-repair of the network when a fault occurs. Several challenges have emerged with these new configurations including: power flow, grid voltage and frequency balance. Under these conditions, a fault can occur in the network, moreover, it is difficult to control or detect these faults. With increasing of the number of faults in different areas of the smart grid, it is a rather complicated problem that requires considering the power generation and distribution infrastructure. In addition, faults can appear through various outages which would lead to a permanent interruption of energy in the network. If maintenance is not carried out as soon as possible, these faults can cause instability in the network and increase technical losses. It is therefore important to identify the faults, their causes and their effects, to develop techniques for detecting and classifying them to allow restoration operations.

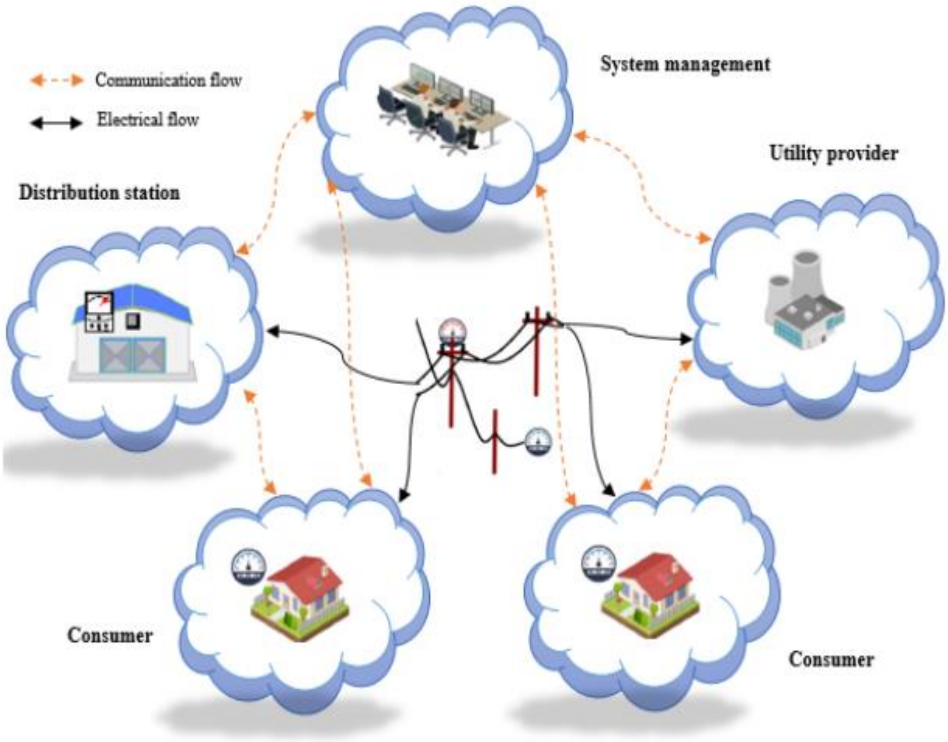


Fig 1: Structure of a smart grid

2. Materials

(i) OpenDSS- The simulation of the electrical distribution network was carried out using OpenDSS (Open Distribution System Simulator) simulator. OpenDSS works through command lines with its own console. It was also designed to be used with tools such as: Matlab, Excel, Python, OMNet ++ and many others software through the COM interface.

(ii) OpenDSS-G- OpenDSS-G is a new step in the evolution of simulation tools for planning and operations based in OpenDSS. This interface has adopted the functionalities of OpenDSS for making easier to the user to use the advance features of the platform. This version includes the parallel processing features included in OpenDSS. In this paper, OpenDSS-G allows us to locate geographically the fault in the power network.

(iii) Matlab- In this paper, the simulations were carried out using the Matlab R2020b 64 bit version. It is used for matrix calcula tions to analyze data and classify it. Matlab helps for the implementation of Neuro-Fuzzy Algorithm.

(iv) Computer- All the simulations of this work were done on a DELL computer with following characteristics: core I5, 3.1 GHz processor, 8 GB RAM, Windows 10/64 bits.

(v) IEEE 37-bus System- electrical system used in this work. This system is a smart IEEE 37-bus system. The IEEE 37-bus system is characterized by 33 KV substation voltage, two transformers, 37 buses under 4.8KV, 32 lines and 65 loads. Smart meters are located on each of the network nodes in order to retrieve data and improve accuracy in fault detection. This network is simulated using OpenDSS time series software in which the various faults were simu lated on the nodes. In addition, it was necessary to perform thousands of simulations of these different types of faults using the OpenDSS-Matlab platform in order to obtain fault location and classification data.

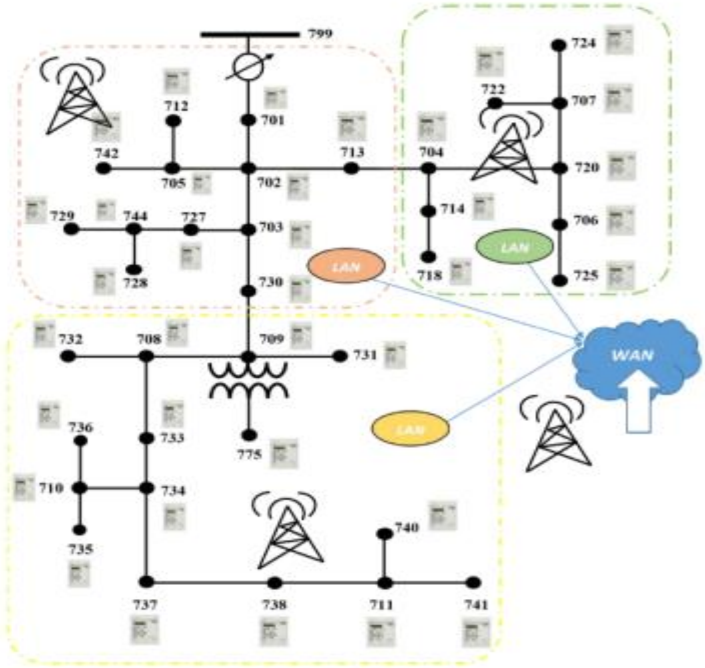


Fig 2: IEEE 37-bus system

3. Methodology

(i) Adaptive Neuro-Fuzzy Inference System (ANFIS)- The Neuro-Fuzzy Inference System is a combination of fuzzy logic and neural networks. In a fuzzy inference system, the member functions used are chosen arbitrarily. With an adaptive Neuro-Fuzzy Inference System (ANFIS), the limb functions are adapted to the database. The modeling of the fuzzy inference system allows the interpretation of the relationships between the inputs and the outputs of the fuzzy algorithm. The ANFIS algorithm also improves the system by adapting the member functions of the inputs and outputs of the sample database. This adaptation is achieved through Neuro-Fuzzy learning. Fig. 3 presents the ANFIS model used in this work.

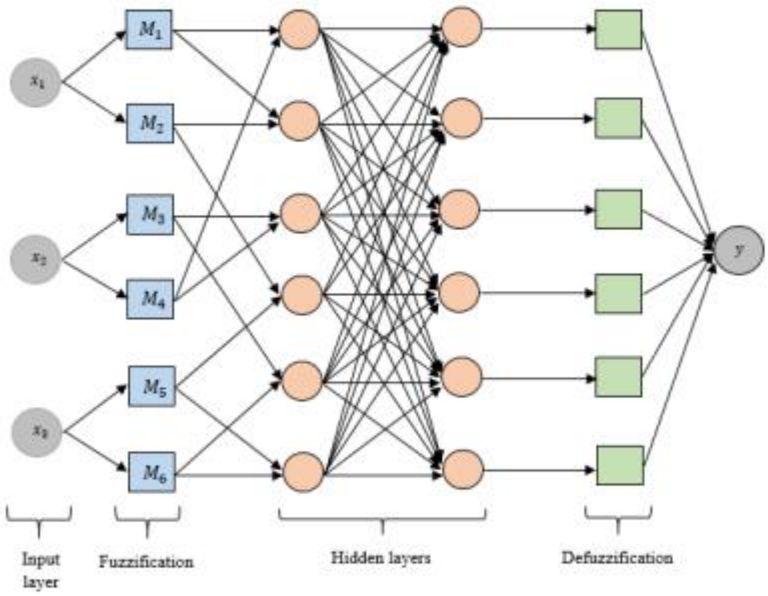


Fig 3: Proposed ANFIS model

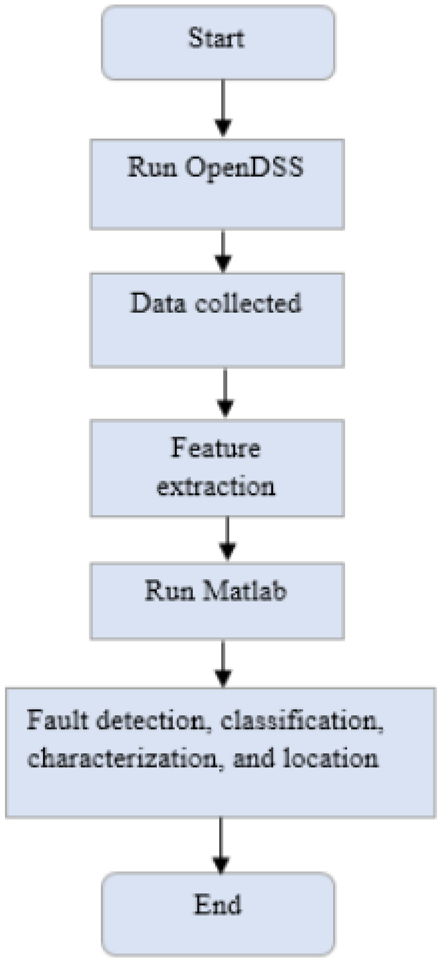
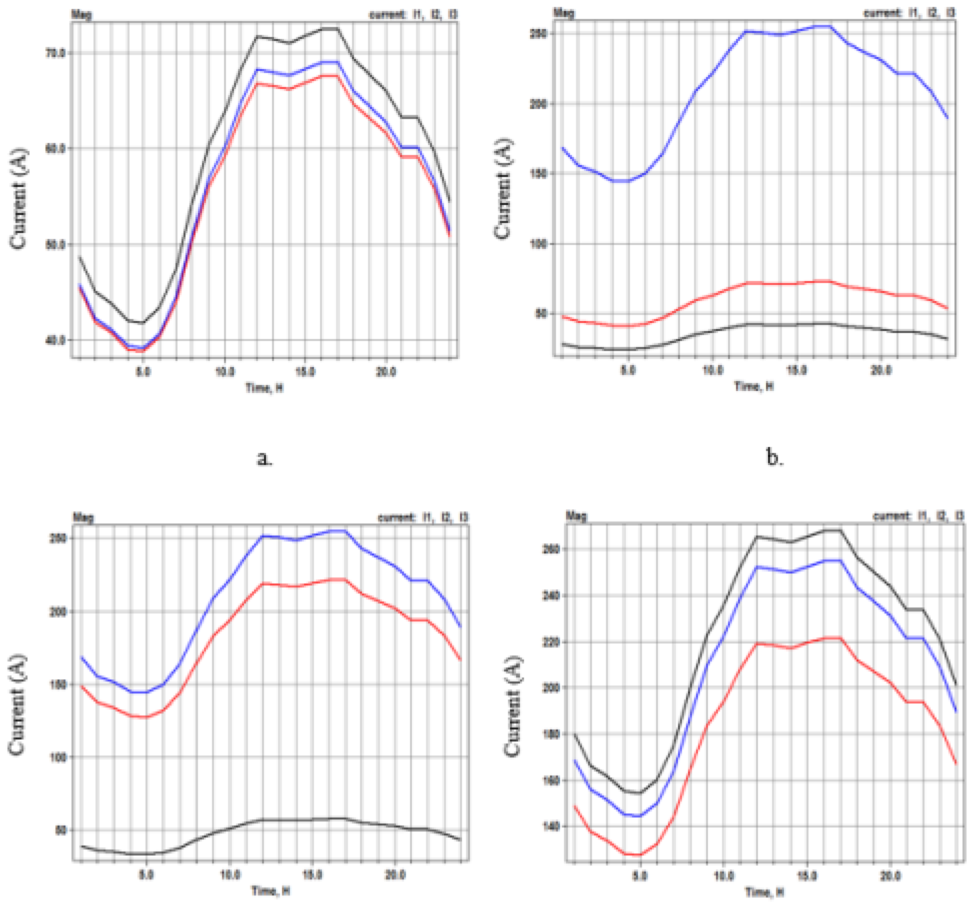


Fig 4: Fault detection, classification and location flowchart

(ii) Proposed Strategy- The method consists of the detection, classification, charac terization and location of faults using data from smart IEEE 37-bus network that we have built. This method is imple mented through the following steps, which the flowchart is given in Fig. 4. First the OpenDSS software is launched in order to sim ulate the operation of the network for the different types of faults that occur in the network. The simulation data obtained from the OpenDSS software is contained in a csv file. These data being collected, a preprocessing makes it possible to extract the important characteristics for the model. Next, Matlab software will be launched for the implementation of the Adaptive Neuro-Fuzzy Inference System algorithm. Using this algorithm, the faults simu lated in the OpenDSS software will be detected, classified, characterized and located at the various points.

4. Result Analysis

A succession of simulations were carried out on the IEEE 37- bus system in the OpenDSS software. Using the OpenDSS software, the operation of the IEEE 37-bus network in nor mal mode and in mode with line-ground, line-line and line-line-line fault is shown in Fig. 5.



a. b.

c. d.

Fig 5: (a) Normal conditions (b) line-ground fault (c) Line-line fault (d) Line-line-line fault

The simulation is carried out using OpenDSS for ana lyzing of distribution network during the faults. The ac curacy of the proposed method is validated by applying it in Matlab using the data of simulations. In addition, the simulation of overvoltage faults, voltage drop and voltage dips allows to obtain Considering the description of IEEE 37-bus system the voltage at buses is 2800 V. In normal condition the voltage is 2800 V, this value is the same with the voltage description. In case of a drop in voltage, the voltage drops to 2600 V. In case of an overvoltage, the voltage increases to 3000 V. A voltage dip is observed for a few milliseconds. The data obtained from the OpenDSS software are trained in the Matlab software in order to detect the posi tion of faults that occur in the network. In addition, using deep learning in Matlab, the precision of fault detection is obtained. So, the identification of fault is successfully achieved for all kinds of faults.

5. Conclusion

A novel approach for the identification, categorization, localization, and description of faults in smart grids was proposed in this work. In order to achieve this, the distribution system diagnostic is based on the Adaptive Neuro-Fuzzy Inference System (ANFIS). To do this, we simulated problems in the electrical distribution network using the OpenDSS program. Moreover, OpenDSS simulated errors were detected and classified using the neuro-fuzzy technique, which was implemented using Matlab software. The neural fuzzy system was trained using the collected data in order to discover and identify errors. Using an IEEE 37-bus system, we were able to validate the suggested technique by detecting single-phase, two-phase, and three-phase short-circuit faults on lines 1, 5, and 31, respectively. Furthermore, this test network's overvoltage and voltage loss were replicated using OpenDSS software. These overvoltage problems and voltage dips were then located using the Matlab technique. The neurofuzzy method's precision values in fault identification demonstrate its dependability in detecting and classifying various types of faults.

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