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Multi Agent System for Fault Location and Isolation in 16- Bus Power Distribution With Distributed Generation Sources using Matlab

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***Abstract*--The Electric power distribution systems are expected to function at all times, even under fault conditions. However, When they operate under fault conditions, the system operator receives information which makes it very difficult to make decisions on whether to restore power distribution system to normal operation. To cope with this uncertainty in decision making, a fault diagnosis method based on Multi Agent System is proposed. The proposed Multi Agent System (MAS) design for fault location and isolation in 16-bus power distribution systems with the presence of Distributed Generation Sources (DGS). In the proposed MAS, agents communicate with their neighbors to locate and isolate the faulty zone. Multi Agent System has a decision making capability. The distributed generation penetration level is considered to be up to 50%. Using Multi Agent System faulted zone have been identified and isolated successfully.**

I. INTRODUCTION

The demand for energy is expected to increase due to a variety of reasons. Power distribution systems are operated by thousands of devices following simple rules with local information. Some of these control devices are already pre-programmed for anticipated situations, but the liberalization of electricity markets or new trends increase interconnectivity between the components and the centralized real-time control becomes more difficult. In the recent years, with the changes in regulatory markets of the generation, transmission and distribution, interest in using new generation technologies like Distributed Generation Sources (DGS) has increased. Distributed generation concept and implementation have been going on for over a decade now with increasing interest due to the numerous advantages it offers such as Voltage support, improved power quality, Loss reduction, Transmission and distribution capacity release, deferments of new or upgraded T&D infrastructure and ability to meet the steep rise in local demand. Using DGS will affect the operation of PDS and new technical issues created.

These issues make the PDS more complicated and more exposed to faults which affect the system's reliability, security, and delivered energy quality. Power interruptions and power quality problems are very costly for utility companies. Reliability of PDS is directly related to the time that utility companies spend on locating and isolating the fault. Fault locating with the minimum time delay can help a fast reconfiguration and restoration for PDS in case of fault occurrence[1]. Therefore fast and accurate fault locating is valuable asset for utility companies to increase their reliability. The fault detection techniques that have dominated the literature for the past decade and have been most effective in practice are based on models constructed almost entirely from process data[3]. This thesis introduces a multi agent approach for fault location and isolation which improves the reliability since it helps to locate and isolate the fault in less time. Recently, several fault-location methods for transmission , and distribution systems have been proposed. They are categorized in three main categories;

1) Impedance based methods; these methods usually calculate the apparent impedance sequences using measurement points data and estimate the possible fault locations based on iterative algorithms[2] . Considering the multiple fault locations estimation in these methods and existence of many laterals in PDS is the drawback of impedance based methods.

2) Wavelet based methods; in which discrete Fourier transform or wavelet transform are used to analyze the fault waveform. It's difficult to guarantee the reliability of these methods because of variety of load characteristics and fault cause in PDS .

3) Intelligent methods consist of artificial neutral networks (ANN) , Expert systems, and multi agent systems (MAS) and etc. ANN based methods need to be trained after any change in system and update the network weights, the other

drawback with ANN based methods is that in case of complicated networks they became slow and may fall in local optimum. Expert system methods have a slow response time since they involve knowledge base maintenance and conventional inference mechanism.

A multi agent system is one of the popular approaches for decentralized management of power systems. Multi-agent technologies can be applied in a variety of applications, such as to perform power system disturbance diagnosis, power system restoration , power system secondary voltage control and power system visualization . Some of the most recent work has implemented a multi-agent system to control the operation of a microgrid. An "agent is an abstraction object (software or hardware) capable of autonomous action in some environment; in other words "is anything that can be viewed as perceiving its environment through sensors and acting upon that environment through effectors" . A multi-agent system is a group of agents, which sense the environment and acts in order to achieve its objectives[1]. Due to the increasing speed and decreasing cost in communication and computation of complex matrices, multi-agent system promise to be a viable solution for today's intrinsic network problems. Each agent is considered to have its special functionalities e.g. acquiring data, analyzing data, managing situations, etc. The proposed multi agent system is different in the way that each agent has a decision making capability. The method uses voltage and current rms values and the calculated impedance to monitor the network and identify the faulty zone. The advantage of this method is that each agent can work independently in case of loss of connection and it needs less communication capacity because agents just talk to their neighbours agent.

II. DG AND MAS

Nowadays, an increasing amount of electrical power is generated by decentralized power generators of relatively small scale (i.e. smaller than 50-100 MW).This way of electrical power generation is referred to as 'Distributed Generation' (DG) because it is spread out over the system. These small power generators are usually located in the vicinity of the electrical loads, and are mostly connected to distribution networks (i.e. at MV- or LV-networks) .

Based on the output power characteristics, DG can be classified as dispatch able or non-dispatch able. The output power of non-dispatch able units, especially the ones driven by renewable energy sources, can show high output-power fluctuations. Energy storage systems, can be applied to smooth this intermittent effect.

Currently, there is wide-spread use of distributed generation across the globe though the level of penetration is still low. By year 2020, the penetration level of DG in some countries such as USA is expected to increase by 25% as more independent power producers; consumers and utility company imbibe the idea of distributed generation.

DG penetration: The ratio of the amount of DG energy injected into the network to the feeder capacity[10].

$$\text{DG penetration} = \frac{\text{capacity factor} \times \text{DG installed capacity}}{\text{feeder capacity}}$$

The use of distributed generation can replace several needs inside the electric sector. With Distributed Generation requirements of heating, quality supply, improving environment and so on can be covered.

1.Multi Agent Systems

"An agent is anything that can be viewed as perceiving its environment through sensors and acting upon that environment through effectors"[6].

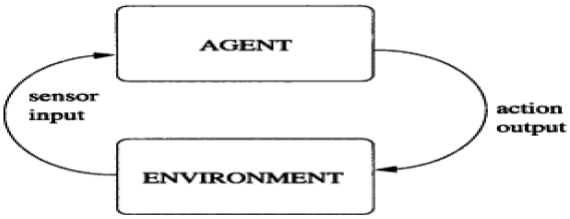


Fig 1 Single Agent System

"A multi-agent system is a combination of several agents working in collaboration pursuing assigned tasks to achieve the overall goal of the system". The multi agent system has become an increasingly powerful tool in developing complex systems that take advantages of agent properties: autonomy, sociality, reactivity and pro-activity.

MAS consists of numerous interacting computing elements, known as agents. Agents are nothing but computer systems with two important capabilities. Firstly , up to some extents ,they are capable of autonomous action – of deciding for themselves what they need to do in order to satisfy their design objectives. Secondly, they are able to interact with other agents – not simply by exchanging data, but by engaging in activities: cooperation, coordination, negotiation, and the like [5].

In a Multi Agent System,

- Each agent has incomplete information
- Control is decentralized
- Data is decentralized
- Computation is asynchronous

Some challenges in developing MAS are task decomposition, defining the agent behavioural rules, agent coordination, setting the environment where agents live[4].

2.Multi Agent System Architecture

Figure 2 shows the architectures and agents connections. Each agents body is composed of the sensors, communication interfaces, and processing

engines.

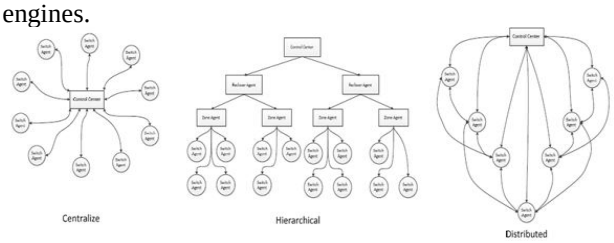


Fig 2.architecture of MAS

In general there are three types of control strategies in controlling agents in MAS, centralized, hierarchical and distributed. Centralized approaches are mostly conventional and tend to be inadequate for future power systems. Hierarchical structures are also similar

to centralize ones and cannot be considered as a distributed control approach. In the distributed architecture which is used in this project all agents just

communicate with their neighbors and have decision making capability. As distributed systems, multi-agent architectures have the capacity to offer several desirable properties over centralized systems.

In general multi agent system and power system model are working in real time. It means that multi agent system and power system model communicate in real time and the data is accessible to agents without any delay in simulation time[1]. In this work both multi agent system and power distribution system are simulated in MATLAB.

III. POWER SYSTEM MODEL

In this paper a standard 16-bus power distribution system will demonstrate improved performance, reliability and security of electric supply through the integration of distributed energy resources and also advanced technologies such as MAS. A standard 16 bus power distribution system which is shown in figure 3 is modelled with controllable switches using SIMULINK SIMPOWER Tool box.

Simulation results are calculated based on PU values. In this work DGS are modelled as a three phase source in series with RL branch. Lines are modelled based on positive, negative and zero sequence impedance value. Different types of faults such as LL,LLG,LG and three phase faults are Modelled with a fault block in SIMPOWER Toolbox and ground resistance is considered to be 0.001 Ω. Loads are modelled with active and reactive power. The power system model could simulate in both continuous or pharos or discreet modes.

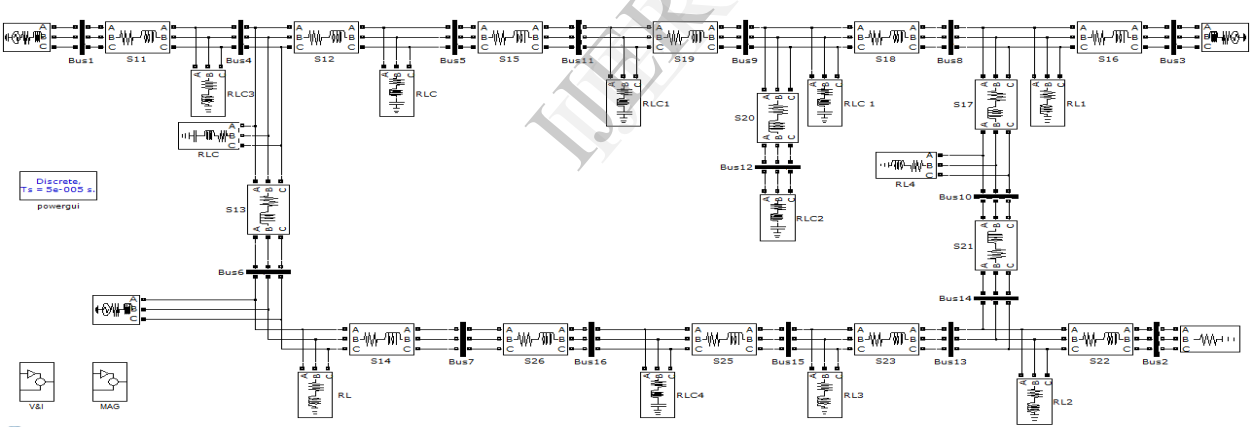


Fig 3. 16 bus PDS

Generators	Ratings
Generating station 1	50 KV,50 MVA
Generating station 2	50 KV,20MVA
Generating station 3	50KV,10MVA

Table 1 generating Station Rating

In this paper, a standard 16-bus power distribution system is divided into three different zones (Zone1, Zone2, Zone3). The Multi Agent System is implemented using MATLAB\SIMULINK. Multi Agent System works in discreet mode. The control characteristics of MAS in each zones is shown in figure 4. The agent have access to voltage and current measurement data themselves and corresponding neighbours data to locate and isolate the faulted zone.

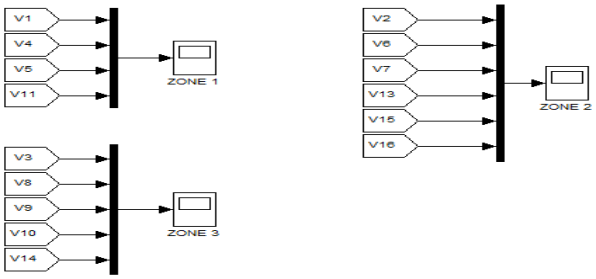


Fig 4.charecteristics of MAS

IV. SIMULATION RESULTS

In order to identify the effect of Distribution Generation Sources on the fault location and isolation application, different penetration level of Distributed generation sources upto 50 percent are simulated. When there is a fault (three phase fault) in the system recloser will trip according to the time periods. Fault location and isolation system will start its fault location and isolation process following a signal sent to Multi Agent System. Once the fault is detected, MAS will locate isolate the faulted zone and restore power to the unaffected zones.

Figure 5 shows results for 0% DG penetration in all three zones and figure 6 shows same scenario for 50% DG penetration.

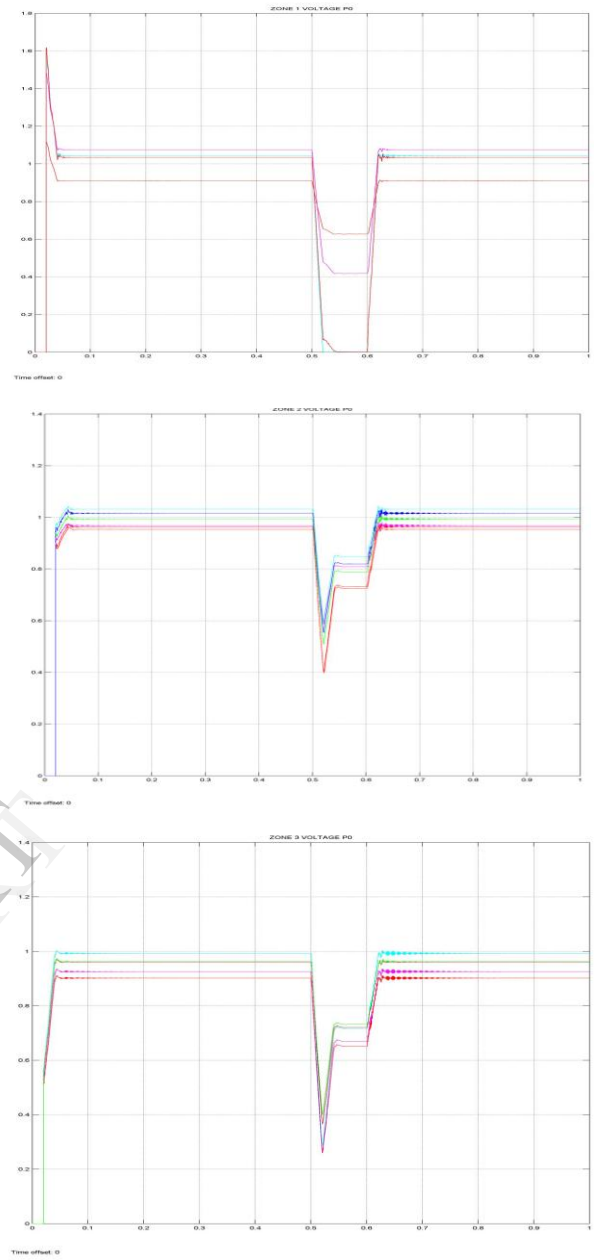
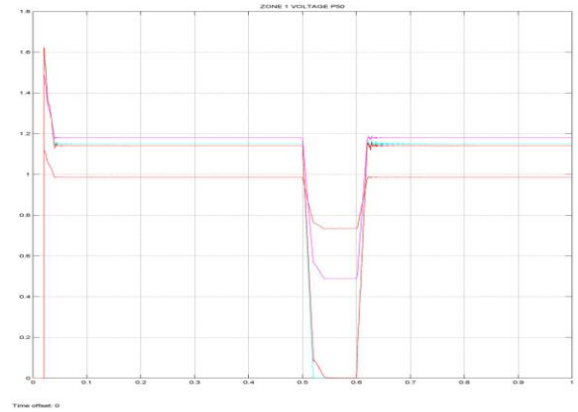


Fig 5 DG penetration of 0%



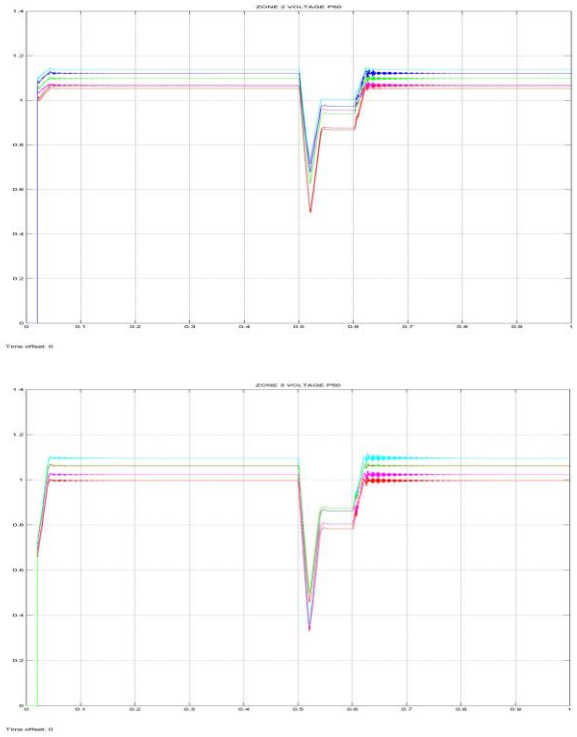


Fig 6 DG penetration of 50%

V. CONCLUSION

This project presents a decentralized Multi Agent System which works in real time with a power system for fault diagnosis applications.
The agents use local voltage and current data information for fault location and isolation process.
In this work both power distribution system and multi agent system are simulated in MATLAB\SIMULINK.
The proposed method is tested with Distributed Generation penetration from 0% to 50% and the results shows the accuracy of the multi agent system.
Faulted zone can be identified and isolated successfully.
This advantages presents a easier and absolute accurate simulation model for identifying application of multi agent system in power distribution system.

VI. FUTURE EXPANSION

a. The proposed approach can be implemented for different IEEE standard bus systems.

b. This simulation model will be used for restoration and reconfiguration process after fault location and isolation.

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