
Consensus and control of Micro Grid using Graph Theoretical Approach

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Abstract.

The paper introduces the micro grid survey and the renewable energy sources connected to micro grid, which forms a graph structure. With the help of graph theoretical approach how synchronization and consensus can be achieved which is very useful for any system operation. With the consensus, one can easily achieved the synchronization, which leads to less time delay. Various control strategies studied and compared for microgrid as a system. The four renewable energy sources are connected in microgrid which forms a multi agent system in which micro grid is works a master whereas four renewable energy sources acts as a slave and this is case of multi agents system. The objective of this survey is to attract the researcher in field of control and stability of microgrid and increase the chances of implementation of intelligent control methods. In the paper different renewable energy sources connected to microgrid as individual agents and works as a whole to meet the power requirements efficiently. The goal is to assess and classify the layout control techniques and assessment algorithms for the microgrid structures to maintain stability, reliability, load variations in standalone operation mode.

Keywords. Microgrid, Renewable Energy Sources, Multi-Agent System, Consensus Algorithm.

1. INTRODUCTION

For a variety of reasons, electricity generation is shifting away from traditional energy sources and toward renewable energy sources. This is owing to weather alter and the rapid exhaustion of traditional power resource such as gas, coal and oil, all of which are seeing exponential increases in their energy use [1]. The MicroGrids (MGs) which is integration of distributed energy resources are not only cost-effective, flexible and consistent however, gives ecological advantages as weigh against to the accessible main grid network. Annual load growth creates a gap between demand and traditional power output, as we can observe. [2].The MGs' rapid installation and on-demand requirements make them a viable alternative to today's energy-related issues, filling the gap between demand and generation. In most MGs, renewable energy sources (RES), like as solar photovoltaic cells, wind energy, fuel cells, and micro turbines, as well as diesel generators, are employed. [3].So as we see that many of the present MGs are linked to stand-alone or grid-connected systems. These two forms of microgrid connections are often used, with standalone MGs taking precedence above economic benefits in order to provide a steady power supply to consumers. [4].Grid-connected MGs are mostly acceptable to bear the incorporation of distributed generation units and, specially, of RES in distribution networks [5].Infiltration of these renewable energy resources is growing at constant speed. Initially, the Low Voltage networks are going to transform from passive to active. After that, amplify the complexity by using power electronics converters. That's why there is two solutions for function i.e. islanded and grid-connected modes [6]. Later, such MGs' control architecture may be used to build smart grid (SG) features. A brief conversation on critical controllers for MGs are presented in [7-11], offers a short overview on decentralized control techniques. Only some distributed control schemes have been mentioned in [12]. While in [13, 14], a few applications on hierarchical control schemes are mentioned. a few overview

mechanism also are to be had on MGs as a selected control feature viz. electricity allocation [15], voltage and frequency control [16]. Many of those overview literatures discusses the concepts in the back of those control strategies, however, the use of MAS in intelligent controlling of micro grid is not further extended. Also unbiased control of power equipment's operations the use of multi- agent systems (MAS) has been furnished to address several limits [17]. MAS are combination of numerous intelligent agents that linked together to resolve bigger troubles that not be covered or complete by the individual agents [18].

2. MICROGRID SYSTEM AND ITS ARCHITECTURE

Microgrid consists of different energy resources working in small scales where economic management becomes complicated. The MGs System is shown in fig 1. which shows are as connected with four renewable energy resources and these sources acts like individual agents of Multi Agent System. The main function of MAS is for MGs to interact with main grid to provide better operation. MGs are made up of a variety of DERs and users that may be represented as autonomous agents. Each agent has a specific amount of intelligence based on its kind and structure, which it uses to achieve pre-determined goals. MAS is a good choice for establishing a intelligent energy management system in MGs since it is strongly connected to distributed intelligence. It presents a framework for determining the optimum agent action by combining artificial intelligence and mathematics techniques. There are three common features shared by all agents: initiative, reactivity, and social capacity [19].

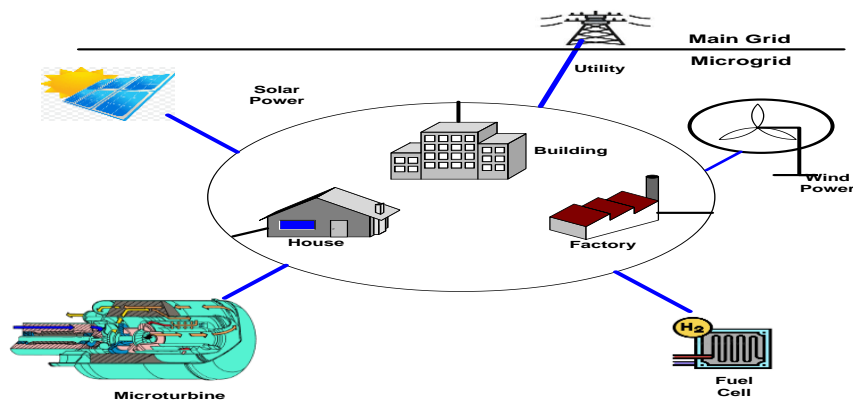


Figure 1:Microgrid System

Fig. 2 shows DC MGs containing nonconventional energy sources along with battery storage. Then, using power electronic converters, common energy resources are combined to form a dc bus. One of MG's top priorities is capable for function by a variety of RES and satisfy power requirement in the situation of a power outage. To accomplish the intended result, subsystems might communicate with one another. [20-21].

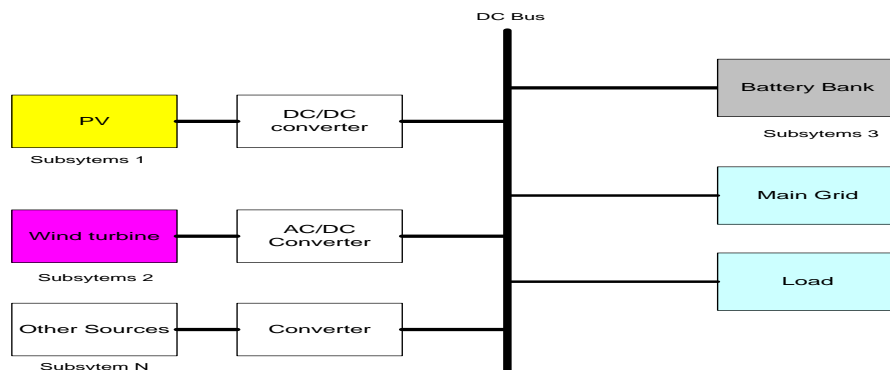


Figure 2: DC Microgrid

2.1. Microgrid architecture and control requirements

The main idea behind MGs is to connect a small number of DG devices in order to manage them efficiently without creating a complex community. A hierarchical manage method, a factor of not point of common coupling (PCC), distributed controls the usage of nearby data, and a selected location are the major additives that allow DG devices to be incorporated in a scientific manner to make sure consistent system performance. The MGs idea and distribution community are depicted in Fig. 3.

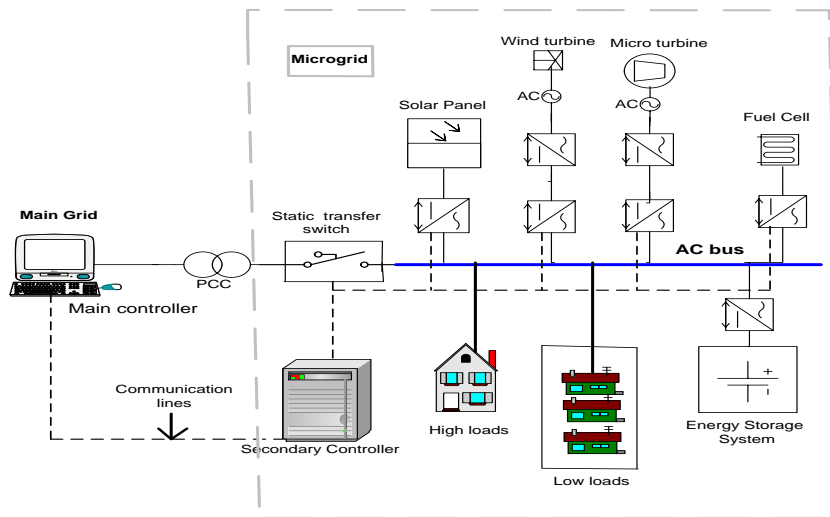


Figure 3: Modern distribution network.

2.2 Control Strategies: scenarios

Control strategies for MGs system with renewable energy resources can be divided into two main (a) Centralized control (b) Decentralized control which is shown in fig 4. Which can be further separated into sub- types. The centralized control is generally used in small MGs whereas decentralized control is used in high rated MGs having large numbers of component's due to centralized control is sluggish.

Centralized Control-Using a centralized control mechanism, MGs systems may be monitored and regulated separately. Secondary control approaches, such as power quality regulation, are based on renewable generation and load, with transitory control goals. On these classifications centralized control the load sharing ratio of the energy storage system can be adjusted on the MGs system level efficiency and / or the power capacity estimate.

Decentralized Control- Local measurements are used in the decentralized control technique, which decides operation at the component level using a built-in algorithm. Given the MG design, the multi-agent system (MAS) is the most effective approach to implement the decentralized control mechanism. The decentralized control approach of the distributed energy storage system relies on the adjustment of the primary MGs descent control, depending on the level of the MGs system. Both centralized and decentralized control techniques offer advantages and disadvantages that vary based on the MG's operational situation. So another control technique, distributed multi-agent control, is presented here, and it is a study topic in control system development. It analyses a system with autonomous agents that are linked via a decentralized communication network. The following is a summary of the MGs control functional requirements for efficient and reliable operation.

- The load sharing between each component of MGs mainly renewable sources is efficient.
- The transition between island and grid connected modes is smooth i.e. proper synchronization.
- Optimization of DERs units to reduce MGs running cost for economic dispatch.

The typology of control strategies for MGs is shown in figure below and comparison of control methods is presented in tabular form.

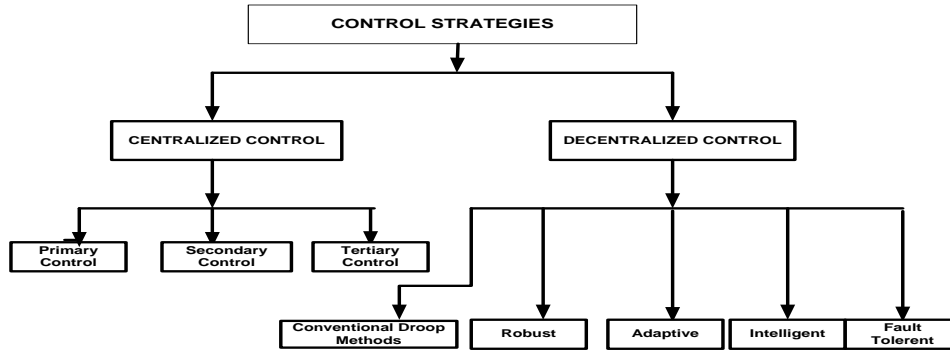


Figure 4: Main Control Strategies

Table 1: Comparison of control methods

| Factors | Centralized | Decentralized |
|----------------------------------|------------------|-----------------|
| DG possession | Self-possessor | Many possessor |
| Goals | Determined tasks | undecided tasks |
| In service employees | accessible | In accessible |
| Flexibility | fewer | large |
| Extension | difficult | simple |
| Communication requirements | Much larger | small |
| Establishment expenditure | Large | small |
| Additional significant operation | doable | unfeasible |

3. MULTI-AGENT SYSTEM

Multi Agent System (MAS) is a group of several agents in the system which is having a common objective and make intelligent decision with respect to energy management system with the rapid development of computing and allied areas like advanced sensor, actuators and devices in past decade, use of MAS is growing exponentially. In recent time, MAS have been widely investigated because of their application in spacecraft formation, social network, energy network, smart grid, micro grid power system, computer games, flight formation, robotics, transportation etc. MAS have many features like multi-tasking, cost effectiveness, distribution, fault tolerance, flexibility etc [22-24]. Multi agent system will be incorporated with the physical and chemical properties [25-30].

The use of Multi agent system (MAS) is mainly brings the intelligence in the operation of micro grid. With the lack of flexibility of SCADA cannot be applicable for high penetration of distributed energy system so this problem can be overcome by MAS. In MAS complex control problem divided in too many subparts and individual agent can solve these individual issues. In general the consensus algorithm is given by the following equation

$$\dot{x}_i(t) = \sum_{j \in N(i)} a_{ij} (x_j(t) - x_i(t)) \quad i = 1, 2, \dots, n, \quad (1)$$

Where a_{ij} is the (i, j) entry of the adjacency matrix of the associated graph at time t , and $x_i(t)$ is the information state of the i th agent. Graph theory is most suitable for MAS as main agent is treated as master whereas remaining agent as Slave. All slaves are connected to each other, which share information among them and follow the master command. Here considering four different renewable energy sources are attached with Micro grid whose aim is to maintain the synchronization so that there will be least amount of energy loss. The effect of consensus is shown in figure.

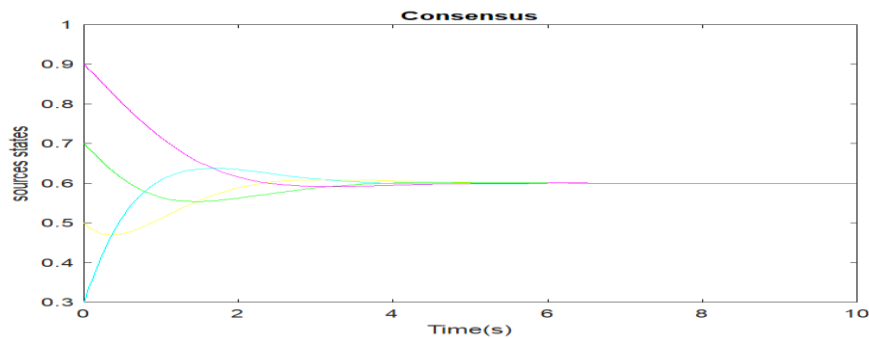


Figure 5: Consensus of Multi Agent System

Figure 5 shows multi agent technology interaction with MGs agents. The multi-agent method introduces various applications of the MGs, such as market operation, distributed management system and so on. Several agents were proposed, and simulated multiple micro-grid market scenarios and introduced the implementation of MAS in micro-grid operation. MAS has the following applications. The advantage of consensus is that if consensus is achieved then there will be minimum loss of energy and time. Here considering four renewable energy sources connected to MGs consensus is achieved.

- MGs control considering renewable energy, voltage control and thermal limit.
- Interaction between entities to achieve effective market operations.
- Decisions can be made with ready-made data or information.
- Expansion of existing systems / functions

4. CONCLUSION AND FUTURE SCOPE

This paper review the works related to MGs based on Graph Theory approach using MAS. Comparison of centralized and decentralized control of MGs discussed. Implementation of MAS on MGs of consensus control using graph theory approach is being suggested. Various applications of MAS on MGs have been discussed considering the electricity at islands modes of MGs and controlling through MAS. In addition, this document provides a method and enlightenment for using a multi-agent system to operate and control the MGs. The challenges faced by the MAS are also discussed, which will help researchers in this field to update and focus on exploring MAS in MGs applications. In future with more number of renewable energy sources connected to MGs problem can be considered.

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