GRD Journals | GRD Journal for Engineering | National Conference on Emerging Research Trend in Electrical and Electronics Engineering (ERTE'19) | May 2019
e-ISSN: 2455-5703

Power Quality Enhancement with Microgrid

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Abstract

Grid connection capability of distributed generation attracts researchers due to the cumulative demand for electricity and environment pollution concern as a new emerging technology for providing reliable and clean power supply. A microgrid comprises distributed generation, energy storage, loads, and a control system that is capable of operating in grid-tied mode and/or islanded mode. As operation modes are shifted, the microgrid should successfully manage the voltage and frequency adjustment in order to protect the grid and any loads connected to the system. Facilitation of the generation-side and load-side management and the resynchronization process is required. This paper presents an overall description and typical distributed generation technology of a microgrid. It also adds a comprehensive study on energy storage devices, microgrid loads, interfaced distributed energy resources (DER), power electronic interface modules and the interconnection of multiple microgrids. Details of stability, control and communication strategies are also provided in this study. This article describes the existing control techniques of microgrids that are installed all over the world and has tabulated the comparison of various control methods with pros and cons. Moreover, it aids the researcher in envisioning an actual situation using a microgrid today, and provides insight into the possible evolvement of future grids. In conclusion, the study emphasizes the remarkable findings and potential research areas that could enrich future microgrid facilities.
Keyword- Microgrid, Power Quality, Distributed Energy Resources

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I. INTRODUCTION

Today, several mission critical loads are present on the power system, which require quality power for their proper functioning. Popular technologies, which provide quality power, during the failure of grid, include use of Microturbines, fuel cells, as well as renewable energy sources like solar Photo Voltaic (PV) and wind power. These small generators, dispersed throughout the power system, have been used primarily for backup and were not synchronized to the grid power supply. Furthermore, they were not interconnected. There has been a trend to change the role of this Distributed Generations (DG) from backup to primary energy supply and to have flexible interconnection strategies. The concept of Microgrid (MG) has thus grown out of this desire for a flexible interconnected system. A MG on the low voltage (LV) distribution is an appropriate solution for:
1) The customer with mission critical loads receiving quality power
2) The Distribution Network Operators (DNOs) as relief for their already overloaded system

DGs are emerging as new paradigm to produce onsite, highly reliable and good quality power. The power system is going through a rapid growth with the connection of DGs in the distribution system. Transmission through pipes is slowly and surely replacing the age-old concept of transmission through wires. One of the most promising applications of this new concept corresponds to the Combined Heat and Power (CHP) application leading to an increase of the overall energy utilization in the total system. This is due to the fact that compared to the electricity transmission, transporting low grade recovered heat is prohibitively expensive relative to its net economic value. Thus generating close to potential user of waste heat has a compelling attraction. The installation of DG has enabled the DNOs to postpone incurring expenditure on expansion of the transmission and distribution network. To install a new DG unit at a particular point in the distribution network, the DNO needs to quantify the capacity of the DG. If the customer has a DG of definite capacity, the DNO should be able to identify the optimal location for it. A variety of approaches have been suggested for achieving the flexibility of operation of the MG. Depending on the type of load requirements, Microgrids can operate with ac or dc power, resulting in ac or dc Microgrids. The coexistence of ac and dc subgrids in a hybrid Microgrid is proposed by Loh et al. Control strategies for MG islanded operation have been discussed by Lopes Et al.

Controller design and optimization method of a Microgrid is presented by Chung et al. An ac-ac matrix converter has been utilized to interface high speed Microturbine generator to utility grid as distributed generation unit. Lately, the concept of virtual flux has been introduced by Hu et al for droop control of Microgrid voltage and frequency. In this paper, an attempt has been made by the author to model the MG in a manner which is simple, with control schemes that has matured in the industry and involves less expenditure. Any addition or removal of a DG from the MG is a plug and play matter.

II. ARCHITECTURE

A micro grid may comprise part of MV/LV distribution systems and clustered loads that are served by single or multiple DERs. From the operation perspective, a micro grid may operate with a point of common connection (PCC) to the rest of the area's electric power system and/or seamlessly transfer between two states of the grid-connected and an isolated grid (IG) mode. While physically connected to the main grid, the operating and control mode of the micro grid may shift between a grid dependent (GD) mode or a grid-independent (GI) mode (autonomous mode) depending on power exchange and interaction of the micro grid with the backbone system. The micro sources of special interest for Micro grids are small (<100-kW) units with power electronic interfaces. These sources, (typically micro turbines, PV panels, and fuel cells) are placed at customer's sites. They are low cost, low voltage and have high reliable with few emissions. Power electronics provide the control and flexibility required by the Micro grid concept. Correctly designed power electronics and controls insure that the Micro grid can meet its customers as well as the utility's needs. Micro grids consist of several basic technologies for operation, Such as DG, DS, and control system. Increasing reliability, efficiency and safety of the power grid. Enabling decentralized power generation so homes can be both an energy client and supplier (provide consumers with interactive tool to manage energy usage).Flexibility of power consumption at the client side to allow supplier selection (Enables distributed generation).Increase GDP by creating more jobs related to energy industry in industry manufacturing, plug-in electric vehicles, solar panel and wind turbine generation and also in information technology industry.

- Enabling informed participation by customers
- Accommodating all generation and storage options
- Enabling new products, services, and markets
- Providing the power quality for the range of needs in the digital economy
- Optimizing asset utilization and operating efficiently
- Operating resiliently against all hazards

These objectives can be met by adopting the latest technologies to ensure success, while retaining the flexibility to adapt to further developments. Advances in simulation tools will greatly assist the transfer of innovative technologies to practical application for the benefit of both customers and utilities. Developments in communications, metering and business systems will open up new opportunities at every level on the system to enable market signals to drive technical and commercial efficiency.

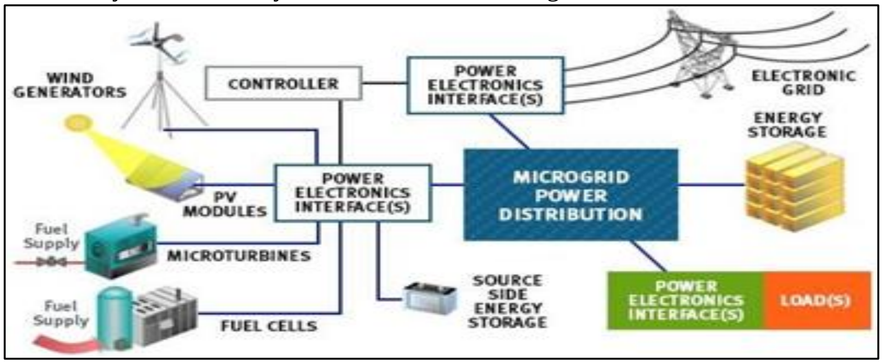

Fig. 1: Microgrid Model

III. OPERATION

Basic Micro grid architecture is shown in figure 2. This consists of a group of radial feeders, which could be part of a distribution system or a building's electrical system. There is a single point of connection to the utility called point of common coupling.

Some feeders, (Feeders A-C) have sensitive loads, which require local generation. The noncritical load feeders do not have any local generation. In our example this is Feeder D. Feeders A-C can island from the grid using the static switch which can separate in less than a cycle. In this example there are four micro sources at nodes 8, 11, 16 and 22, which control the operation using only local voltages and currents measurements. When there is a problem with the utility supply the static switch will open, isolating the sensitive loads from the power grid. Feeder D loads ride through the event. It is assumed that there is sufficient generation to meet the loads' demand. When the Micro grid is gridconnected power from the local generation can be directed to feeder D.

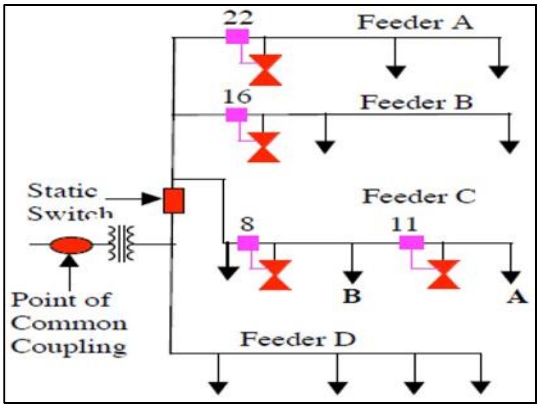

Fig. 2: Basic microgrid architecture

IV. MICROGRID CONTROL

MG control architecture can be broadly classified into following types:

A. Centrally Controlled

A MG Central Controller (MGCC) installed on grid substation at the PCC, centrally controls the MG operation. It sends control signals to the second level of controllers, such as those at group of loads (Load Controller or LC) or controllers located at MS (Microsource Controller or MC). Depending on the economic managing function, stability control and other functionalities that are built into the MGCC, it communicates with the LC and MC and provides set points to both LC and MC. Schematic diagram of such a MG is shown in Fig. 3.

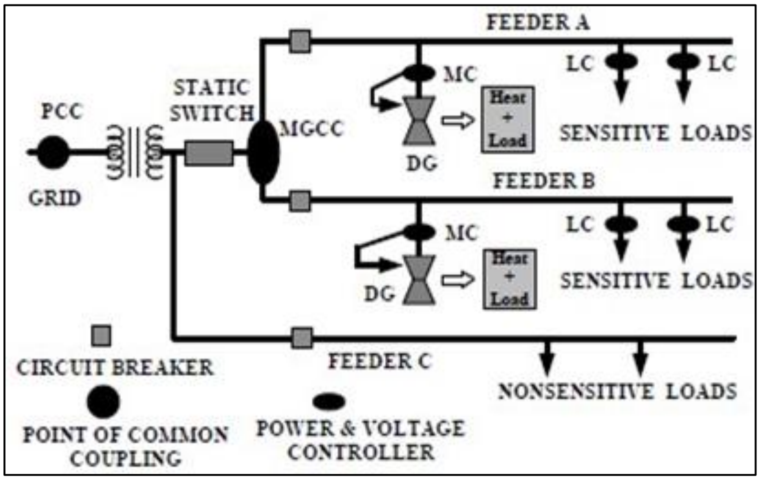

Fig. 3: Schematic of centrally controlled microgrid

B. Autonomous Control

Each MS on the MG has its own autonomous control. There is no component, such as master controller or central storage unit which may be critical for the operation of the MG. This model has an advantage that the MS can be connected at any point on the MG, which will allow a plug and play operation model for each component of the MG. Further, with one MS more than the quantity required for meeting the total load on the MG, greater security and reliability of the MG can be ensured in the event of loss of a MS. This control architecture is discussed later for the control of the MG. A single line layout of the proposed MG is shown in Fig. 4.

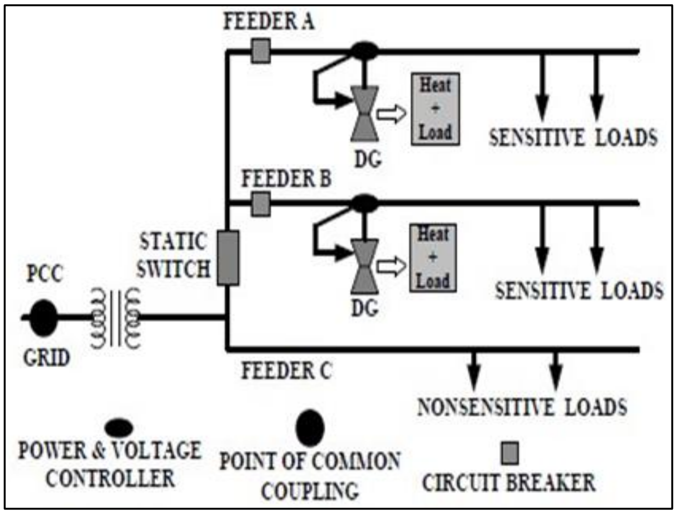

Fig. 4: Autonomous control

C. Unit Power Control

In this mode of operation, each MS regulates the voltage at its output terminal, which is also the point where it is connected to the grid. The MS sources a constant power into its connection point in grid connected mode. If the load increases anywhere in the MG, the extra power is drawn from the utility grid. This mode supports the CHP mode of operation because production of power depends on the heat demand. Electricity is then generated at higher efficiencies. When the MG islands itself, the MS"s frequency droop ensures that the power requirement of all loads is met within the MG.

V. CONFIGURING MICROGRID

A. Control of MG Interfaced with Rotating Machines

The microgrid can be configured in any of the following ways of the various alternatives available, the diesel engine and synchronous generator have received acceptance with small and medium sized consumers and are the most widely used back up source of power. If such machines are connected to the MG, three modes of control are possible:

1) Fixed power control
2) Fixed speed control
3) Droop Control

The fixed power control logic is adopted for plants connected to utility grid with no obligation regarding load regulation. However, when such a plant has to work under isolated condition and if there is more than one unit on the MG, then droop control method has to be adopted.

B. Control of MG with Inverter Interface

There are several energy sources like fuel cells, solar PV units, Micro turbines etc. (popularly called Micro Sources or MS) which produce dc output or produce electrical output at frequencies not compatible with the grid frequency. In such cases, the system block shown in Fig. 5 is adopted. The MS is made to charge a battery, which in turn feeds power to the MG through an inverter. Moreover, it will be assumed that, if the power demand is within the capability of the device, the dc voltage is kept constant by the primary generator controls.

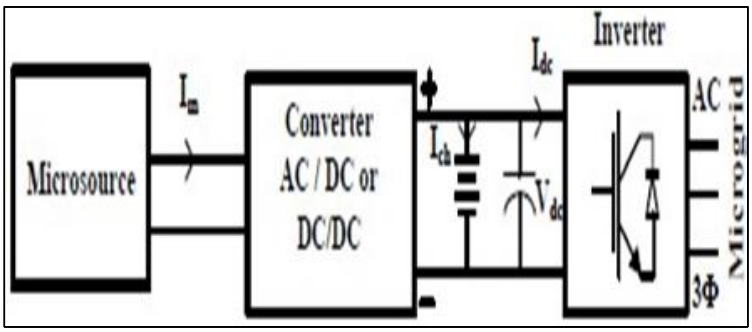

Fig. 5: Block diagram of a Microsource connected to the grid

VI. CONCLUSION

Micro grids will provide improved electric service reliability and better power quality to end customers and can also benefit local utilities by providing dispatch able load for use during peak power conditions and alleviating or postponing distribution system upgrades. There are a number of active micro grid projects around the world involved with testing and evaluation of these advanced operating concepts for electrical distribution systems.

A simple and low cost control method using parallel inverters on a MG is studied. The control method has also allowed plug and play operation when the MS is added or removed from the MG. The use of the frequency droop method has provided for the control of the MG without the use of expensive and complex communication system between the MSs. The MG works in appropriate manner for mission critical loads, where it is essential to provide quality power and accommodate load changes.

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