Hybrid AC/DC Micro grids: A Bridge to Future Energy Distribution Systems

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ABSTRACT: About one century after its surrender to the AC technology in electric power systems, the DC power has come back as an increasingly strong rival, thanks to the technology advancements in power conversion, generation, transmission, and consumption. However, in spite of significant advantages in many applications, there are still several challenges to overcome and the DC technology should be integrated into the system through a smooth and step-by-step process. Micro grids, as a promising building block of future smart distribution systems, are one of the main areas where the DC technologies are expected to prevail. In particular, hybrid AC/ DC Micro grids may facilitate the integration process of DC power technologies into the existing AC systems.

Any of the historical reasons that led AC to dominate over DC power systems are not valid any longer. In the generation sector, many distributed energy resources, such as photovoltaic systems, have emerged that generate power in DC form. Many of the modern electrical loads, as well as energy storage systems, are either internally DC or work equally well with DC power and connect to the AC systems through converters. Thus, application of DC power would allow the elimination of many AC-DC and DC-AC conversion stages, which would in turn result in considerable decrease in component costs and power losses, and increase in reliability. Also, many power quality issues, such as harmonics and unbalances, are not present in these systems.

In our research we focus on the quantification of energy efficiency improvement that hybrid AC/DC systems may introduce in buildings, as well as on the control of the interlinking converter, with the aim of improving the stability and power quality of Micro grids.

1.Introduction:

The legacy paradigm for electricity service in most of the electrified world today is based on the centralized generation-transmission-distribution infrastructure that evolved under a regulated environment. More recently, a quest for effective economic investments, responsive markets, and sensitivity to the availability of resources, has led to various degrees of deregulation and unbundling of services. In this context, a new paradigm is emerging wherein electricity generation is intimately embedded with the load in micro grids. Development and decay of the familiar macro grid is discussed. The salient features of micro grids are examined to suggest that cohabitation of micro and macro grids is desirable, and that overall energy efficiency can be increased, while power is delivered to loads at appropriate levels of quality. Recent developments in the electric utility industry are encouraging the entry of power generation and energy storage at the distribution level. Together, they are identified as distributed generation units. Several new technologies are being developed and marketed for distributed generation, with capacity ranges from a few kW to 100 MW. The distributed generation includes micro turbines, fuel cells, photovoltaic systems, wind energy systems, diesel engines.

2. Definition of Micro grids

The Micro grid (MG) concept assumes a cluster of loads and micro sources operating as a single controllable system that provides both power and heat to its local area. This concept provides a new paradigm for defining the operation of distributed generation.

2.1 Micro grid Architecture:

The MG study architecture is shown in Figure 1. It consists of a group of radial feeders, which could be part of a distribution system. There is a single point of connection to the utility called point of common coupling (PCC). Feeders 1 and 2 have sensitive loads which should be supplied during the events. The feeders also have the micro sources consisting of a photovoltaic (PV), a wind turbine (WT), and fuel cell (FC), a micro turbine (MT), a diesel generator (DG), and battery storage. The third feeder has only traditional loads.

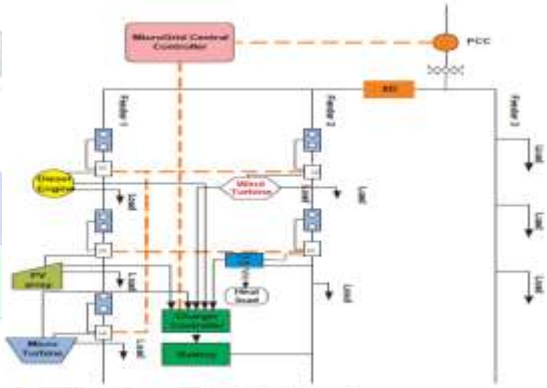

Fig.1 Single Line Grid Layout and design

The static switch (SD) is used to island feeders 1 and 2 from the utility when events happen.

The fuel input is needed only for the DG, FC, and MT as the fuel for the WT and PV comes from nature. To serve the load demand, electrical power can be produced either directly by PV, WT, DG, MT, or FC. The diesel oil is a fuel input to a DG, whereas natural gas is a fuel input to fuel processor to produce hydrogen for the FC. The gas is also the input to the MT. The use of DG, or FC or MT with other fuel types can be modeled by changing the system parameters to reflect the change in the fuel consumption characteristics (e.g. fuel heating values, and efficiency of the engines) Each of the local generation unit has a local controller (LC). This is responsible for local control that corresponds to a conventional controller (ex. automatic voltage regulator (AVR) or Governor) having a network communication function to exchange information between other LCs and the upper central controller to achieve an advanced control. The central controller also plays an important role as a load dispatch control center in bulk power systems, which is in charge of distributed generator operations installed in MG [5].

Furthermore, the central controller is the main interface between the upper grid and the Micro grid. The central controller has the main responsibility for the optimization of the Micro grid operation, or alternatively, it coordinates the actions of the local controllers to produce the optimal outcome.MG technologies are playing an increasingly important role in the world's energy portfolio. They can be used to meet base load power, peaking power, backup power, remote power, power quality, and cooling and heating needs.

2.2 Reasons for Micro grids

The conventional arrangement of a modern large power system offers a number of advantages. Large generating units can be made efficient and operated with only a relatively small number of personnel. The interconnected high voltage transmission network allows the generator reserve requirement to be minimized, the most efficient generating plant to be dispatched at any time, and bulk power to be transported large distances with limited electrical losses. The distribution network can be designed for unidirectional flows of power and sized to accommodate customer loads only. However, over the last few years a number of influences have combined to lead to the increased interest in MG schemes [1] and [7]. The policy drivers encouraging MGs are:

3. Components Required

3.1 Solar Module:

Solar panels (arrays of photovoltaic cells) make use of renewable energy from the sun, and are a clean and environmentally sound means of collecting solar energy. Here at solar panel information, we've amassed a wealth of information relating to solar panels and the field of photovoltaic technology.

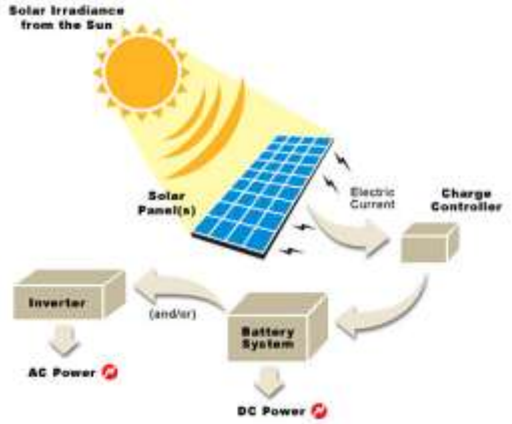

Fig. 2 Block diagram of standalone solar system

Fig. 3 Photograph of solar array installed

A photovoltaic (in short PV) module is a packaged, connected assembly of typically 6×10 solar cells. Solar Photovoltaic panels constitute the solar array of a photovoltaic system that generates and supplies solar electricity in commercial and residential applications. Each module is rated by its DC output power under standard test conditions, and typically ranges from 100 to 365 watts. The efficiency of a module determines the area of a module given the same rated output – an 8% efficient 230 watt module will have twice the area of a 16% efficient 230 watt module. There are a few solar panels available that are exceeding 19% efficiency. A single solar module can produce only a limited amount of power; most installations contain multiple modules. A photovoltaic system typically includes a panel or an array of solar modules, a solar inverter, and sometimes a battery and/or solar tracker and interconnection wiring.

3.2 Rechargeable Battery

A rechargeable battery, storage battery, secondary cell, or accumulator is a type of electrical battery which can be charged, discharged into a load, and recharged many times, while a non-rechargeable or primary battery is supplied fully charged, and discarded once discharged. It is composed of one or more electrochemical cells. The term "accumulator" is used as it accumulates and stores energy through a reversible electrochemical reaction. Rechargeable batteries are produced in many different shapes and sizes, ranging from button cells to megawatt systems connected to stabilize an electrical distribution network. Several different combinations of electrode materials and electrolytes are used, including lead–acid, nickel cadmium (NiCd), nickel metal hydride (NiMH), lithium ion (Li-ion), and lithium ion polymer (Li-ion polymer).

Battery charging and discharging rates are often discussed by referencing a "C" rate of current. The C rate is that which would theoretically fully charge or discharge the battery in one hour. For example, trickle charging might be performed at C/20 (or a "20 hour" rate), while typical charging and discharging may occur at C/2 (two hours for full capacity). The available capacity of electrochemical cells varies depending on the discharge rate.

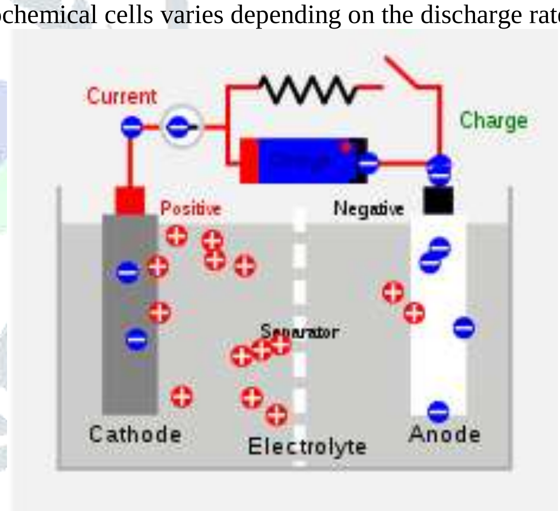

Fig. 4 The charging of battery.

Some energy is lost in the internal resistance of cell components (plates, electrolyte, interconnections), and the rate of discharge is limited by the speed at which chemicals in the cell can move about. For lead-acid cells, the relationship between time and discharge rate is described by Peukert's law; a lead-acid cell that can no longer sustain a usable terminal voltage at a high current may still have usable capacity, if discharged at a much lower rate. Data sheets for rechargeable cells often list the discharge capacity on 8-hour or 20-hour or other stated time; cells for uninterruptible power supply systems may be rated at 15

3.3 Solar Inverter

Solar hybrid inverters convert direct current (DC) from a single solar panel to alternating current (AC). The electric power from several micro-inverters is combined and sent to the consuming devices. The key feature of a micro-inverter is not its small size or power rating, but its one-to-one control over a single panel and its mounting on the panel or near it which allows it to isolate and tune the output of that panel.

Out of this consideration, a usage recommendation has been made in section VI. The designed system has been rigorously tested in extremely harsh environments to ensure reliable, trouble-free operation regardless of any change in climate. Hence, new research directions are explored for the utilization of solar energy, electrical engineering development and power electronics technology.

3.4 Charge controller

A charge controller, charge regulator or battery regulator limits the rate at which electric current is added to or drawn from electric batteries. The terms "charge controller" or "charge regulator" may refer to either a stand-alone device, or to control circuitry integrated within a battery pack, battery-powered device, or battery recharger. It prevents overcharging and may prevent against overvoltage, which can reduce battery performance or lifespan, and may pose a safety risk. It may also prevent completely draining ("deep discharging") a battery, or perform controlled discharges, depending on the battery technology, to protect battery life.

4. Conclusion

The Consortium for Electric Reliability Technology Solutions is pioneering the concept of Micro Grids as an alternative approach to integrating small scale distributed energy resources into electricity distribution networks, and more generally, into the current wider power system. Traditional approaches focus on minimizing the consequences for safety and grid performance of a relatively small number of individually interconnected micro generators, implying, for example, that safety requires they instantaneously disconnect in the event of system outage. By contrast, Micro Grids would be designed to operate independently, usually operating connected to the grid but islanding from it, as cost effective or necessary to maintain performance.

7. Reference:

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