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Study of Distributed Controlling Techniques in Micro Grids

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Abstract: *Microgrids are moving from laboratory benches and pilot demonstration sites to commercial markets thanks to technological improvements, lower costs, proven track record and growing recognition of their benefits. They are used to improve the reliability and resilience of power grids, manage the addition of distributed clean energy resources such as wind and solar photovoltaic (PV), reduce fossil fuel emissions, and provide power in areas not supported by a centralized electrical system. The infrastructure is provided. This article presents the control techniques for DC micro-network, distributed control, and description of micro-grid systems.*

Keywords: *DC, microgrid, PV, AC.*

I. Introduction

The term micro-grid (µG) refers to the concept of individual subsystems for electricity connected to a limited number of distributed energy resources (DER), both renewable and conventional, including photovoltaic, wind, hydroelectric, internal combustion engine , gas turbine and micro turbine combined with a group of loads [1, 2]. The use of individually distributed energy resources such as micro-generation can lead to problems such as increased local voltage, the possibility of overcoming the thermal limits of some lines and transformers, insulation and high capital costs [3]. Micro-networking could be a better solution to these problems. In a µG system, DERs must be equipped with electronic power interfaces (PEI) and appropriate controls to ensure the flexibility to operate as a single aggregate system and to maintain energy quality and energy production. [4]. from a grid standpoint, the main advantage of a µG is that it is treated as a controlled unit within the electrical system that can function as a single load. From the customer's point of view, µG is beneficial because it can meet their electricity and heat needs locally, provide uninterrupted electricity, improve power quality (PQ), reduce power loss, and provide voltage support. Furthermore, µG can reduce pollution and global warming through the use of low-carbon technologies [4].

One of the main objectives of µG is to combine the benefits of low carbon unconventional / renewable generation technologies and highly efficient combined heat and power (CHP) systems. The choice of a decentralized generator depends mainly on the climate and topology of the region. The sustainability of a µG system depends on the energy scenario, strategy and policy of that country and differs from region to region. These issues are beyond the scope of this review.

II. Literature Review

SharafSumaiya et al. [5] this text proposes the modeling of a standalone DCPV microarray system. The implemented system is meant and modeled with the specified input PV modules, controls, electronic power converters and storage devices. it's wont to power DC or AC loads with their requirements. The system is tested and analyzed in various temperature and irradiation scenarios to demonstrate its validity. The system is implemented and modeled with Simulink / MatLab. The losses of the system are reduced and thus its efficiency is increased.

Umesh C. Pati et al. [6] this document designs the modeling of photovoltaic modules (PV modules) and therefore the design of a MPPT (Maximum point Tracking) control algorithm for a stand-alone PV system for distributed generation (DG). A detailed mathematical model of the PV module is provided. One among the foremost classic MPPT (Perturb and Observe MPPT) is employed to trace the utmost point of the system. Sun Power PV arrays are taken under consideration and therefore the simulation results show the properties of the module and array. an in depth design technique is provided for the MPPT technique and therefore the simulation is performed with different solar irradiations.

Dmitry Tugayet al. [7] Work with the utilization of simulations within the software environment of Matlab / Simulink/ Sym Power Systems takes under consideration the development of an area smart grid energy supply system with distributed solar energy plants. The model obtained allows to review the functioning of the intelligent grid altogether quasi-stationary and transition modes, including emergencies. A feature of the proposed model is that the location of places for the installation of compensation devices of the active power filter, the utilization of which allows you to supply the specified quality of electricity and to realize the minimum energy losses within the elements of the facility system.

S. Linnet jaya et al. [8] this text attempts a detailed review of microgrids for hybrid renewable energy sources. The most important challenge during a microgrid is predicting the supply of renewable energy and cargo management. The hybridization of renewable energies and traditional energy sources reduces the above problem to a greater extent. Although the value of capital is considerably high due to nature and long-term sustainability, it creates a path to the main challenges of the microarray.

III. Description of the Micro-Grid Systems

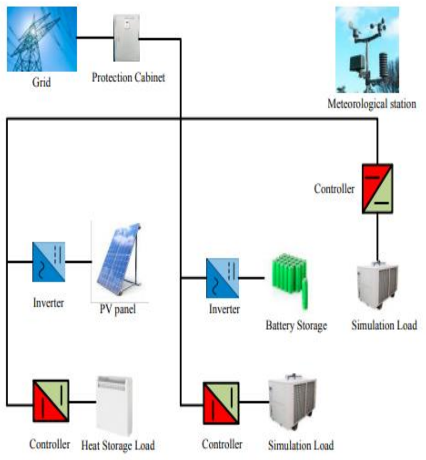

Fig. 1. System schematic layout of the micro-grid system

Figure 1 shows a schematic view of the grid connected microgrid systems studied in Ningbo and Sichuan, China. The system consists of photovoltaic modules, electrical macro-grid, battery packs, weather station, simulation load, thermal storage load, inverter and other control components. The simulation load and the heat storage load are used to simulate a typical residential building, including the consumption of electricity and heat. The photovoltaic modules and battery packs are each connected to the AC bus via converters. The simulation load and the heat accumulator load are connected to the AC bus via controls. In this micro-grid system, photovoltaic modules are used to generate electricity both for self-consumption, for battery storage, and for connecting it to the electricity grid. Energy consumption is replaced in experimental tests by the simulation load for energy planning. There are two battery management systems (BMS) that work independently of each other to perform different functions. One is gateway monitoring, the other is battery monitoring. In addition, the micro-network has an intelligent system for managing the loads that can be shipped.

For this micro-network system it is necessary to coordinate the meeting between supply and demand. Since the power supply can be derived from the grid, PV modules and battery packs, optimized operation is offered to improve the performance of the PV micro-grid system in terms of both renewable energy penetration and economic gains over time of use. (TO YOU). Price. When the power consumption is at its maximum, the PV power and the battery supply the electricity. If the PV power is greater than the required consumption, the remaining power grid can be connected or the battery stored.

IV. Control Technique for DC MicroGrid

The DC microarray control topologies shown in Figure 2 play a key role in the better, more stable, and more efficient operation of DC MG. Electronic power converters serve as an interface for proper grid control with better voltage regulation and better current distribution. Not only do they act as interfaces, but also facilitate the correct connection between the different units in the DC MG. It is necessary to develop a better control strategy to reduce the effect of the non-linearity created by the converters due to their constant performance. The rapid increase in non-linear loads and the generation of distributions made the control structure more complex, which is also inevitable,

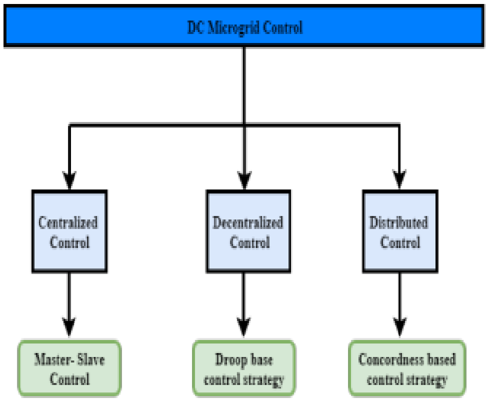

Fig. 2. DC MG Control strategies

The various control targets are [9]:

- Gradual transition from island operating mode to grid connected operating mode; Ø voltage regulation and current distribution;
- Stable operation with non-linear and constant power load;
- Optimization of the production of micro-sources (SM) for participation in the energy market;
- Control of the flow of electricity between MG and the rest of the network using an efficient and adequate energy management system (EMS);
- Efficient load distribution and adequate means of communication between DERs;
- appropriate control mechanisms to avoid a power failure and the possibility of a black start;
- Optimization of production costs and economic distribution of costs;
- Maximize the potential of DERs and reduce transmission losses;
- Ability to provide uninterrupted power to critical loads such as hospitals, industries and other major utilities.

A. Centralized Control

Networked units [10] in a given location reach information controlled by a microcontroller, switch or even a server. Communication is the central element of such a system, which helps to facilitate the operation of the centrally controlled system. Data from different units of a DC-MG is first recorded by the system operator. The collected data is then processed and the necessary control commands are sent to them via an appropriate means of communication. Some of the advantages of centralized control are: strong controllability of the whole system, desire for a single control, ability to define global strategies to control the system and observability. A master-slave control, as shown in Figure 3, is an exceptional technique widely used to achieve parallel operation of multiple sources. In this mechanism, a converter acts as a voltage source converter (VSC) which acts as the master and commands the slave units to regulate the intermediate circuit voltage. The remaining converters act as slaves, providing the necessary electrical support as directed by the master controller. The main converter works to keep the line voltage within the tolerance band and the remaining converters, which act as slaves, help the master achieve the same result.

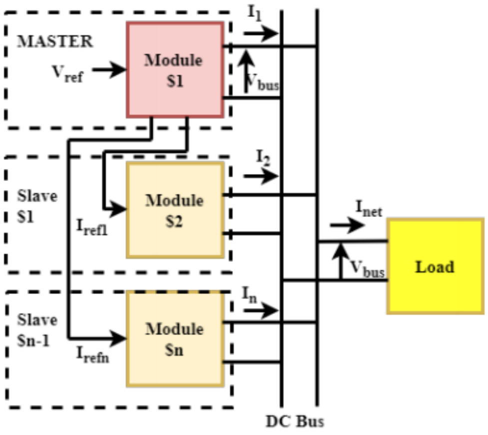

Fig. 3. A schematic for Master-Slave controller

The control mechanism depends entirely on a high-speed communication platform. Any corrected communication error affects the overall system performance and can even lead to complete system failure. The main disadvantages of this control strategy include short battery life, low scalability, the need for supervisory control, expensive and poor fault tolerance capability.

A master-slave control algorithm for full-bridge cross-input serial converters and parallel output converters is discussed in [11], which is controlled by a phase shift controller. The limited range of output voltage regulation is reduced by the main regulator. Its advantages include flexibility and ease of implementation, making it suitable for high power and high voltage utilities. Federico and. Al. [12] suggested a master-slave control for the electrical bus application and hypothesized that it would achieve an efficiency greater than 3% compared to existing conventional strategies.

B. Decentralized Control

In a decentralized controller [13], the distributed units are controlled by the local autonomous controllers via independent local variables and there is no communication support in the controller. This control strategy is considered the most reliable despite its limitations due to the absence of a communication link. In [14], decentralized control based on a switching current mode is proposed in which the voltage controlled source is replaced by a current controlled source. The results state that the proposed control leads to improved transient response, better connect and disconnect capability, better voltage regulation, and adequate current distribution. Researchers proposed a multi-agent control system (MAS) [15] that combines the advantages of centralized and decentralized control systems. Its advantages include better fault tolerance capability, more flexible and scalable, easy to implement, inefficient and good power management capability. Some of the widely accepted decentralized control systems are described below.

1. Conventional Droop Control

Static characteristics are based on the performance model. When a current is introduced into the network, it generates a direct voltage of the network proportional to each other. This is one of the common decentralized control strategies [15] to minimize or eliminate the current flowing between drives without a means of communication. They also provide good tension regulation in the microarrays. The same equation is given as,

$$V_{ref} = V_o+(I_{ref} \times R_{droop})$$

Vref is the reference DC line voltage, Vo is the PEC output voltage, Io is the output current, and Rdroop is the virtual resistance. 4 shows the conventional droop control diagram. Incorrect static resistance selection will lead to poor load distribution and poor voltage regulation, as well as poor performance in RES units.

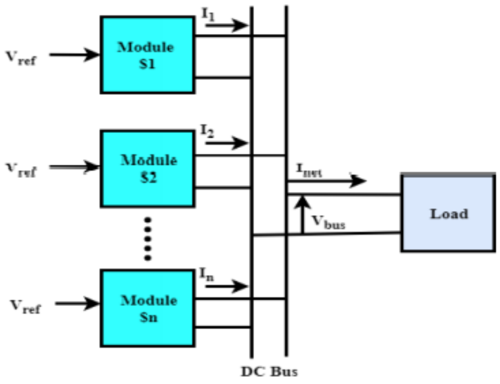

Fig. 4. A conventional voltage-droop control scheme

Figure 5 shows the voltage control scheme of a DCDC converter. [16] Decentralized static method proposed for a low voltage direct current microgrid. All network parameters such as BESS SoC, power supply resistance effect etc. have been taken into account. To obtain a better power distribution between the DERs, three operating modes and error states were taken into account.

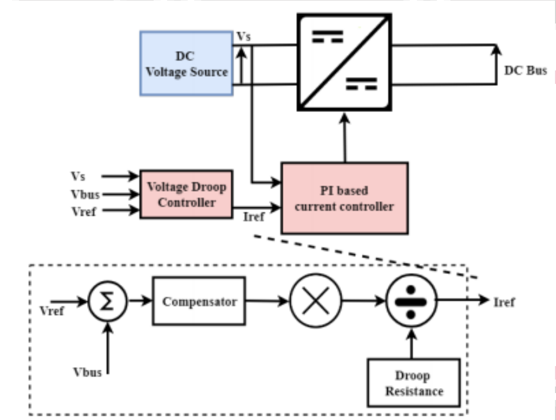

Fig. 5. Voltage control scheme of the DC-DC converter

2. Virtual Resistance based Droop Control

The disadvantages of the static control mechanism are solved by the proposal of a virtual static resistance [17]. The proposed method introduces a virtual resistance called static resistance (R_{droop}) which is a function of the terminal voltage.

$I_{ref} = (V_{ref} - V_o) / R_{droop}$ (2)

$R_{droop} = func(V_o)$ (3)

This is done to make the static characteristics non-linear and thus the voltage regulation is improved.

3. Adaptive Droop Control

An adaptive lowering strategy for DC MG is discussed in [18], in which solar PV, fuel cells and BESS are considered. For good power distribution, the charging and discharging of BESS units is managed using an adaptive two-way static strategy. In [19], an adaptive static closed control loop (CRM) strategy was used to implement the static function of MG DC. In order to simultaneously achieve voltage stability and current distribution, a time-varying pattern is recorded, a projection algorithm and normalization technique with the above-mentioned adaptive static strategy are used. In article [20], an adaptive droop strategy for low voltage direct current MG was proposed, which is based on a frequency superimposed on a virtual resistor. Alternating current is introduced on both the primary and secondary sides using local measurement data to account for static gains and achieve better voltage regulation and load distribution. Voltage regulation and load sharing are achieved by injecting alternating current into the primary and secondary levels using locally available measurements to adjust droop gains. This made the system free of communication links and cheaper. Another parameter that affects the affectivity of the proposed regulator is the injection of AC into a DC MG, which poses stability problems and reduces the quality of the current.

V. Distributed Control

A network of several regulators installed in each PE source forms a distributed control system which helps to maintain a constant line voltage with proper load sharing. This control mechanism has the advantages of both centralized and decentralized control. The control of each PE device communicates via a communication medium like that of a decentralized control, but with limited bandwidth. This helps to perform important operations like SoC balancing, power restoration, load sharing, etc. Any significant increase in distributed production units (DGs) makes it difficult to implement a centralized control scheme. In such a crisis, the distributed controller turns out to be a better competitor. An added benefit of such a controller is that the system will work even if the communication link is lost because it is immune to point failure. The main disadvantages are deviations in bus voltage, complex analysis behavior and errors in tracking performance.

In reference [21], an extended droop architecture for DC MG is proposed. Improved voltage regulation and optimal performance is achieved by using an optimal non-linear regulator. All the information on how the MG works is needed for the controller to convert it into a linear, near-optimal control problem. The proposed control is better than conventional static methods even for intermittent media and is more stable and robust. The system is more stable by operating as a traditional method of controlling static losses in some special cases. A new approach is proposed for the control of distributed droop and energy storage (ES) in a DC-MG, which forms an array network. Static features are activated for each Member State using local BESS. A feed-forward approach is used to match the MS voltages to the line voltage by periodically changing the duty cycle of the PECs. The proposed controller claims faster update rates and a reduction in the number of ES drives [22].

A distributed control strategy is proposed which helps improve voltage regulation and local power distribution in a DC-MG. A distributed computer network is used for data exchange, with the average voltage across the network estimated using a voltage observer. It uses PI control and adaptive attenuation, with the virtual impedance of the DERs adjusted by the current regulators.

VI. Conclusion

Microgrid systems can use an energy management system to provide an energy generation profile that matches the load profile of residential or regional buildings. This document was presented in Control Technologies for DC Microgrid, Distributed Control. The description of the microarray systems is provided in this document. Ningbo's photovoltaic system offers higher efficiency than Sichuan. The microsystem can make a high profit in the operational strategy, the power consumption during peak hours is mainly derived from battery discharge or PV power. The low price of electricity is stored in the battery overnight. The monthly balance of electricity flows is further examined and the same trends are found over time.

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