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Reactive Power Sharing in Islanded Microgrid by Droop Control Method

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ABSTRACT

The proposed method mainly includes two important operations: error reduction operation and voltage recovery operation. The sharing accuracy is improved by the sharing error reduction operation, which is activated by the low-bandwidth synchronization signals. However, the error reduction operation will result in a decrease in output voltage amplitude. Therefore, the voltage recovery operation is proposed to compensate the decrease., due to increasing the demand of electricity as well as rapid depletion of fossil fuels, and the government policies on reduction of greenhouse gas emissions , renewable energy technologies are more attractive and various types of distributed generation sources, such as wind turbine generators and solar photo voltaic panels are being connected to low-voltage distribution networks. Micro grid is an integrated system that contain in s distributed generation sources, control systems, load management, energy storage and communication infrastructure capability to work in both grid connected and island mode to optimize energy usage. The paper presents a advanced control technique for a micro grid system which works efficiently under a decentralized control system.

KEYWORDS: *Microgrid, Renewable Energy resources, Distributed Generation, Droop Control.*

I. INTRODUCTION

The increasing high energy demand along with low cost and higher reliability requirements, are driving the modern power systems towards clean and renewable power. Microgrid technologies are going to be a huge supports for small distributed generation (DG) units on power system. Distributed generation (DG) units in microgrid dispatch clean and renewable power compared to the conventional centralized power generation. Microgrids are systems which operate with different types of loads and micro sources. Due to high penetration of distributed generation (DG) units with different types of loads can cause power quality and power control issues. The total load demand sharing by distributed generation units should share equal load to maintain power control stability [1]. A voltage and frequency droop control methods are used for sharing active and reactive power from multiple distributed generation units. These distributed generation units are operated by inverters and DC storage units, where a number of parallel inverters are operated [2], [5], [10]. All the distributed generation units are highly responsible for stabilize the system voltage and frequency while sharing active and reactive power in an autonomous microgrid [4]. There are many techniques presented without control interconnection in [5], [9]. Conventionally, they are based on the frequency and voltage droop concept to achieve load sharing. These conventional droop controller methods, however, only work well for linear and mostly resistive load. For nonlinear load, the power transients and load harmonic components cannot be shared properly. For an islanded microgrid, the total loads must be properly shared by multiple distributed generation units in decentralized manner [3], [5], [11]. The real power sharing at steady state is always accurate while the reactive power sharing is sensitive to the impacts of mismatched feeder impedance [3]- [6], [12]. The reactive power sharing accuracy in a simplified microgrid with two distributed generation (DG) units has been introduced in many literatures [7]-[9]. For a networked microgrid configuration with linear and non linear loads, the reactive power sharing is more challenging. To reduce the reactive power sharing errors in microgrid system, some of improved methods have been introduced [2]-[8], [13]. The control issues regarding reactive power sharing in networked microgrid is more challenging. To improve reactive power sharing and control in networked microgrid, this paper proposed a simple reactive power sharing compensation scheme. For improvement of reactive power sharing and control in networked microgrid, a control method is introduced to reduce reactive power sharing errors by injecting a small real power disturbance, which is activated by the low-bandwidth synchronization signals from central controller. Reactive power sharing errors are significantly reduced with this proposed method. After the compensation, the proposed droop controller will be automatically switched back to conventional droop controller. The proposed compensation method achieves accurate reactive power sharing at steady-state and is effective for micrograds with all types of configurations and load locations. Figure 1 shows the world capacity of micro grid.

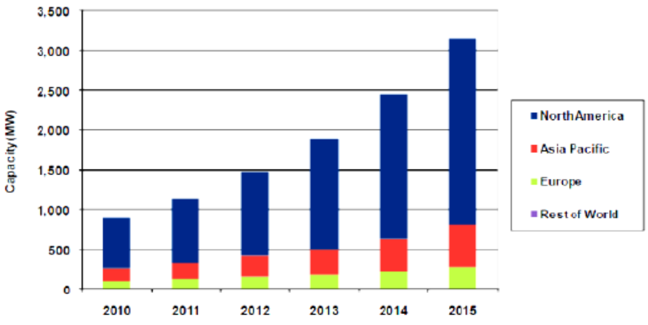


Fig-1 World capacity of micro grid

II. LITERATURE SURVEY

The net micro grid could even provide ancillary services such as local voltage control. In case of disturbances on the main network, micro grids could potentially disconnect and continue to operate separately. This operation improves power quality to the customer. From the grid's perception, the benefit of a micro grid is that it can be considered as a controlled entity within the power system that can be functioned as a single aggregated load. Customers can get benefits from a micro grid because it is designed and operated to meet their local needs for heat and power as well as provide uninterruptible power, enhance local reliability, reduce feeder losses, and support local voltages. In addition to generating technologies, micro grid also includes storage, load control and heat recovery equipment. The ability of the micro grid to operate when connected to the grid as well as smooth transition to and from the island mode is another important function

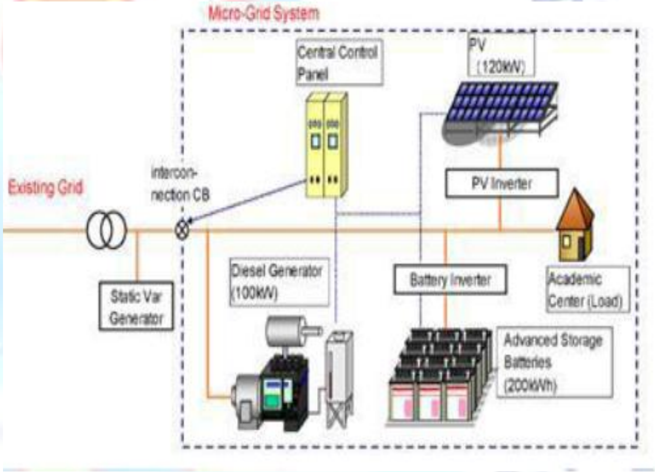


Fig-2: Microgrid system

A. Supply to Grid

The Power Stream Microgrid is connected to the distribution system and is supplying energy to the grid using renewable solar or wind power. Stored electricity from the Sodium Nickel Chloride, Lithium Ion Battery and Lead Acid Battery Systems can also be used to supply energy to the grid. During the Supply to Grid operating mode, the natural gas generator will not be operated

B. Supply from Grid

The Power Stream Microgrid is connected to the distribution system and is taking energy from the grid to power its load. Electricity can also be stored in the Sodium Nickel Chloride, Lithium Ion Battery and Lead Acid Battery Systems for future consumption. During the Supply from Grid operating mode, the solar photovoltaic system and wind turbine system may also be powering the load and charging the batteries, but the natural gas generator will not be operated.

C. Island (Generator)

The Power Stream Microgrid is designed to operate in isolation from the distribution grid with the Island (Generator) operating mode. During this mode, the natural gas generator will be the primary source of electricity with the renewable solar and wind generators providing supplementary power. Electricity stored in the Lead Acid, Sodium Nickel Chloride and Lithium Ion Battery Systems can also be used at this time.

D. Island (No Generator)

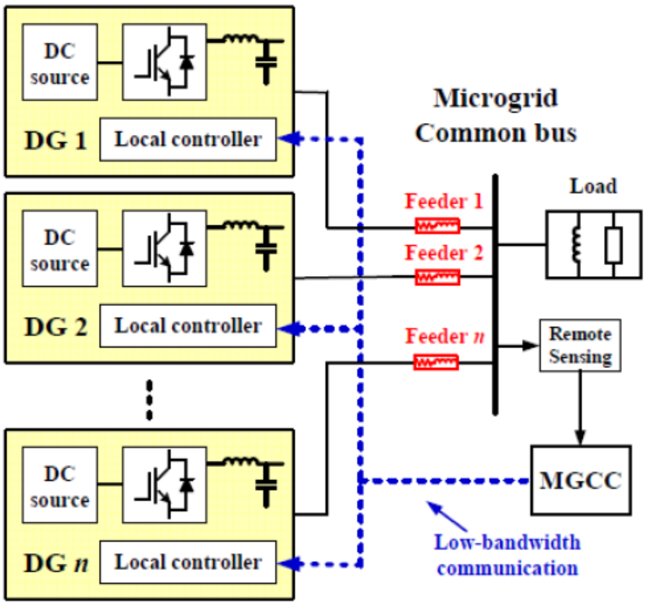
The Power Stream Microgrid is designed to operate in isolation from the distribution grid with the Island (No Generator) operating mode. During this mode renewable solar and wind generators will be primary source of power. Electricity stored in the Lead Acid, Sodium Nickel Chloride and Lithium Ion Battery Systems can also be used at this time. Since all generation sources are intermittent with this operating mode, low priority Microgrid loads may be disconnected depending on the amount of generation available.

E. Black Start

The Power Stream Microgrid is designed to have black start capability that involves using backup systems to help launch the Microgrid's generation sources. During this mode, the Microgrid is not connected to the distribution system and does not have electricity serving its load. The Microgrid will use the backup systems to initiate the renewable generation sources and connect the battery systems to help restore power to system loads.

F. Intentional Grid Outage (Generator)

The Power Stream Microgrid is designed to operate in the event of an outage of the distribution system and provide seamless service to its loads. Utilities from time-to-time have planned outages to allow for maintenance and servicing. In this scenario, the Microgrid will automatically disconnect from the grid and start drawing electricity from the natural gas generator, renewable energy sources and battery systems. Since this operating mode involves a planned outage, the battery systems can be fully charged ahead of time to maximize the amount of power for loads during the outage.



III. REVIEW OF CONVENTIONAL DROOP CONTROL METHOD

Most of the wireless-control of paralleled - inverters uses the conventional droop method, which introduces the following droops in the amplitude E and the frequency ω of the inverter output voltage [2],[5].

$$\omega = \omega o - D_P.P \qquad (1)$$
$$E = Eo - D_Q.Q \qquad (2)$$

Where ωo and Eo are the output voltage angular frequency and amplitude at no load, and DP and DQ are the droop coefficients for the frequency and amplitude, respectively. Figure 3: Conventional droop control scheme.

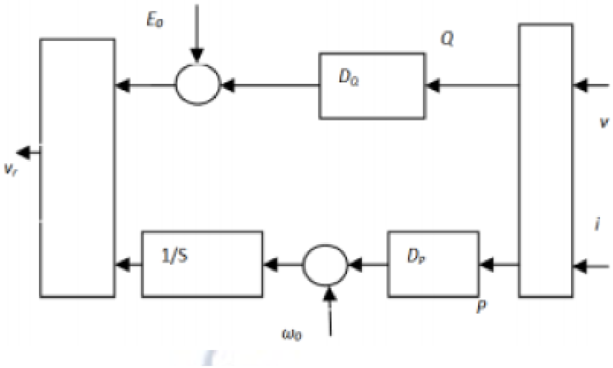


Figure 3: Conventional droop Control Scheme

It is well known that if droop coefficients are increased, then good power sharing is achieved at the expanse of degrading the voltage regulation. From Eq. 3 and Eq. 4, we can find the droop coefficients as

$$DP = (W_o - w)P_{max} = \Delta\omega / P_{max} \quad (3)$$

$$DQ = (E_o - E) / Q_{max} = \Delta E / Q_{max} \quad (4)$$

In conclusion, the conventional droop method has several intrinsic problems related to its limited transient response, since the system dynamics depends on the power-calculation filter characteristics, the droop coefficients, and the output impedance. These parameters are determined by the line-frequency, the maximum allowed frequency and amplitude deviations, and the nominal output power. Thus, by using the conventional droop method, the inverter dynamics cannot be independently controlled

IV. PROPOSED CONTROL TECHNIQUE

In complex configurations of microgrids, the reactive power sharing errors are caused by a number of factors and its compensation strategy is difficult. Therefore, for improvement of reactive power sharing and control in networked microgrid, a control method is introduced to reduce reactive power sharing errors by injecting a small real power disturbance, which is activated by the low-bandwidth synchronization signals from central controller without knowing the detailed microgrid configuration [1]. This feature is very important to achieve the “plug-and-play” operation of DG units and loads in the microgrid.

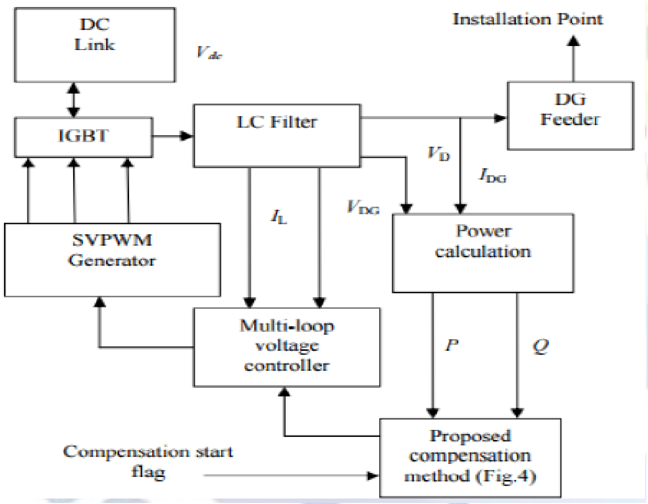


Figure 4: Illustration of microgrid configuration.

Initial power sharing using conventional droop method and power sharing improvement through synchronized compensation method are the two stages of proposed compensation method. In 1st stage of compensation, the conventional droop controller method in Eq. 1 and Eq. 2 are adopted for initial power sharing before receiving the compensation flag signal from central controllers. During this stage, the steady-state averaged real power (PAVE) shall also be measured for use in second stage. The real and reactive powers are measured by first order LPFs for the conventional droop controller in Eq. 1 and Eq. 2. The measured average real power (PAVE) is also saved in this stage for reactive power sharing accuracy improvement control in second stage.

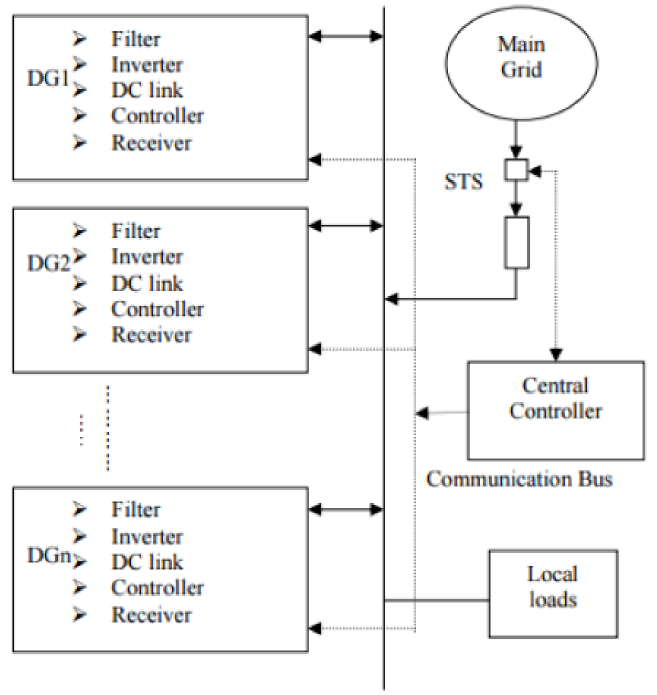


Figure 5: Configuration of the DG units.

In 2nd stage of reactive power compensation, the reactive power sharing error is compensated by introducing a real-reactive power coupling transient and using an integral voltage magnitude control in synchronized manner. Once a compensation starting signal (sent from the central controller) is received by the DG unit local controller, the averaged real power calculation stops updating, and the last calculated PAVE is saved and the used as input of the compensation scheme.

V. RESULTS AND DISCUSSION

The below figures show the performance of the whole system in islanded and grid connected mode.

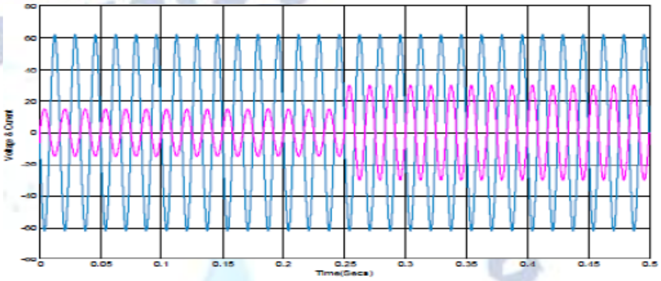


Figure 6:Grid voltage and grid current in without Grid connected operation of microgrid

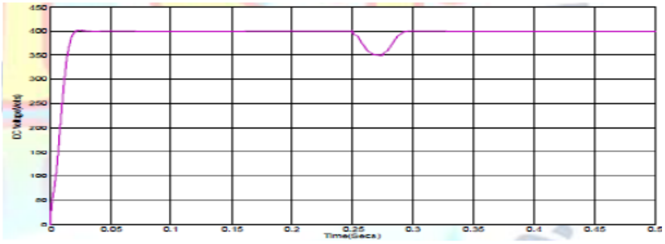


Figure 7: Dclink Voltage without Grid connected operation of microgrid

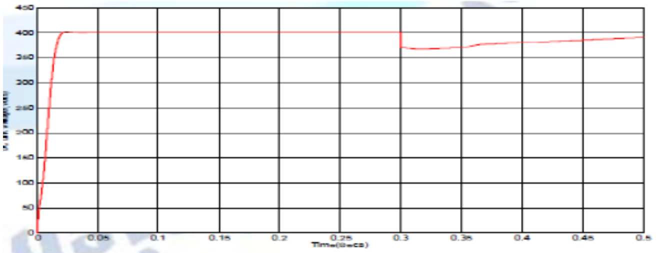


Figure 8: Dclink Voltage with Grid connected operation of microgrid

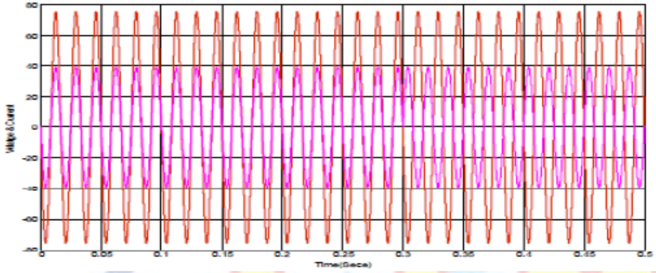


Figure 9: Load voltage and load current in Grid connected operation of microgrid

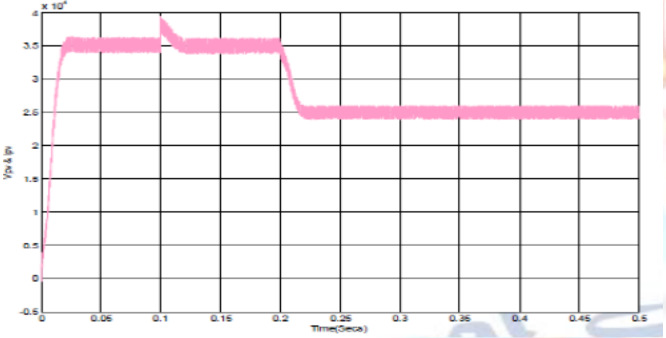


Figure 10: Power Generated by PV system

VI. CONCLUSION

In this paper, a control strategy for parallel connected DG System forming a microgrid was presented. This control strategy combines frequency and voltage droop method and inverter voltage regulation control scheme The first operation changes the voltage bias of the conventional droop characteristic curve periodically, which is activated by the low-bandwidth synchronization signals.. The load changes can be taken up by the parallel connected DGs. Moreover, seamless transfer between islanded and grid connected mode is achieved without causing negative influences on both utility and critical loads.

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