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ADBS Control Method for Coordinating Multiple Energy Storage Devices in DC Micro grid

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ABSTRACT

Management of multiple energy storage devices in a DC microgrid is a challenge. Conventional method, such as droop control, cannot ensure accurate current sharing in coordinating multiple battery banks, which limits the DC microgrid system performance. This paper proposed an active DC bus signaling (ADBS) method to coordinate multiple battery banks in a DC microgrid. It has the advantages of accurate current sharing. Using the proposed ADBS method, the master controller can collect State of charge (SoC) of each slave battery bank by actively varying the DC bus voltage levels and monitoring the current change. The master module then sets a working voltage level after decision-making. The proposed method was experimentally evaluated, and the experimental results show that all the possible working voltage levels can be reached and the accuracy of current sharing is guaranteed.

Keywords

Wind- Solar MG, PMSG, Solar Panel, NSLMF, Power Quality.

1. INTRODUCTION

The micro grid concept acts as a solution to the conundrum of integrating large amounts of Micro generate 'on without disrupting the operation of the utility network. With intelligent coordination of loads and micro-generation, the distribution network subsystem (or 'micro grid') would be less troublesome to the utility network, than conventional micro generation. 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/correct voltage sag. 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.

1.2 Objectives

The main aim of this dissertation is an active DC bus signaling (ADBS) method to coordinate multiple battery banks in a DC micro grid. It has the advantages of accurate current sharing. Using the proposed ADBS method, the master controller can collect State of charge (SoC) of each slave battery bank by actively varying the DC bus voltage levels and monitoring the current change. The master module then sets a working voltage level after decision-making. The proposed method was experimentally evaluated, and the experimental results show that all the possible working voltage levels can be reached and the accuracy of current sharing is guaranteed.

2. LITERATURE SURVEY

Fulong Li, Zhengyu Lin, Zhongnan Qian, Jiande Wu-
This paper proposed an active DC bus signaling method to coordinate multiple battery banks in a DC micro grid. The proposed method has been experimentally evaluated, and the experimental results show that accurate current sharing can be achieved. The experimental results also show the expandability of the proposed ADBS method. However, this method has some limitations. Firstly, the number of the battery banks is finite. Adding more battery banks needs more voltage levels to switch ON/OFF slave battery bank modules. The levels of DC bus voltage cannot be too large, which might cause the unstable operation. Secondly, the information exchange is achieved through voltage level, so it is only suitable for the low speed application.

Kai Strunz, Ehsan Abbasi, and Duc Nguyen Huu-
A dc micro grid for renewable power integration has been proposed. The operational optimization and power-electronics based voltage–power droop control was developed, and the functioning was demonstrated through simulation. Interaction with the main grid was controlled as a result of an operational optimization that seeks to minimize cost and emissions. A method to quantify the uncertainty affiliated with the forecast of aggregated wind and PV-based power generation was created and used to quantify the energy reserve of the battery energy storage system. The battery is parallel-connected with a super capacitor to form multilevel energy storage. The latter plays a critical role in compensating renewable power fluctuations and providing the power needed when EVs stop by for fast charging. In accordance with the micro grid paradigm, operation is also supported in autonomous mode to support UPS when the connection to the main grid is unavailable. During such periods, fast charging is not supported, as the priority shifts to supplying critical local loads.

X. Lu, J. M. Guerrero, K. Sun and J. C. Vasquez, -
In this paper, an LBC -based distribution control method for dc micro grids is proposed. Concretely average voltage and average current PI controller are employed to enhance the

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load current sharing accuracy and restore the local dc output voltage. The control loops are implemented locally, and the required voltage and current data are sent to the control system of the other converters through the LBC network. Hence, the distributed control system that meets the decentralized configuration of micro grid is realized. The model of the proposed control system is obtained and the stability is analyzed. It is demonstrated that even though a high communication delay is employed (approximately 20ms), the stability of control system can also be guaranteed.

Ganesh R, G. Panda and R. Peesapati –

The load sharing in a dc micro grid has been studied and analyzed in details. the improved droop control scheme has been implemented in MATLAB/SIMULINK to check the effectiveness. The performance and effectiveness of the overall control strategy has been tested in real –time using vertex -6 FPGA ML 605 Evaluation kit. The outcome in the HIL simulation environment clearly shows the flexibility of the controller in achieving effective load sharing and maintaining constant load voltage under different dynamic conditions.

3. DC MICROGRIDS

3.1 General Information about Micro grid

The DC micro grid has become a new trend for micro grid study with the advantages of high reliability, simple control and low losses. With regard to drawbacks of the traditional droop Control strategies.

As electric distribution technology steps into the next century, many trends are becoming noticeable that will change the requirements of energy delivery. These modifications are being driven from both the demand side where higher energy availability and efficiency are desired and from the supply side where the integration of distributed generation and peak shaving technologies must be accommodated [1].

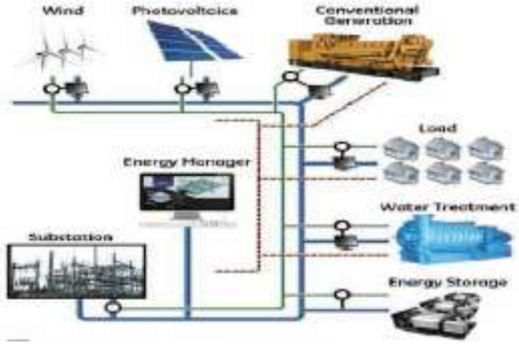

Fig.No 1 Microgrid power system

Power systems currently undergo considerable change in operating requirements mainly as a result of deregulation and due to an increasing amount of distributed energy resources (DER). In many cases DERs include different technologies that allow generation in small scale (micro sources) and some of them take advantage of renewable energy resources (RES) such as solar, wind or hydro energy. Having micro sources close to the load has the advantage of reducing transmission losses as well as preventing network congestions.

Moreover, the possibility of having a power supply interruption of end-customers connected to a low voltage (LV) distribution grid (in Europe 230 V and in the USA 110 V) is diminished since adjacent micro sources, controllable loads and energy storage systems can operate in the islanded mode in case of severe system disturbances. This is identified nowadays as a micro grid. Figure 3.1 depicts a typical micro grid. The distinctive micro grid has the similar size as a low voltage distribution feeder and will rare exceed a capacity of 1 MVA and a geographic span of 1 km. Generally more than 90% of low voltage domestic customers are supplied by underground cable when the rest is supplied by overhead lines. The microgrid often supplies both electricity and heat to the customers by means of combined heat and power plants (CHP), gas turbines, fuel cells, photovoltaic (PV) systems, wind turbines, etc. The energy storage systems usually include batteries and flywheels [2].The storing device in the microgrid is equivalent to the rotating reserve of large generators in the conventional grid which ensures the balance between energy generation and consumption especially during rapid changes in load or generation [3].The microgrid often supplies both electricity and heat to the customers by means of combined heat and power plants (CHP), gas turbines, fuel cells, photovoltaic (PV) systems, wind turbines, etc. The energy storage systems usually include batteries and flywheels [2].The storing device in the microgrid is equivalent to the rotating reserve of large generators in the conventional grid which ensures the balance between energy generation and consumption especially during rapid changes in load or generation. From the customer point of view, micro grids deliver both thermal and electricity requirements and in addition improve local reliability, reduce emissions, improve power excellence by supportive voltage and reducing voltage dips and potentially lower costs of energy supply. From the utility viewpoint, application of distributed energy sources can potentially reduce the demand for distribution and transmission facilities. Clearly, distributed generation located close to loads will reduce flows in transmission and distribution circuits with two important effects: loss reduction and ability to potentially substitute for network assets. In addition, the presence of generation close to demand could increase service quality seen by end customers.

Micro grids can offer network support during the time of stress by relieving congestions and aiding restoration after faults. The development of micro grids can contribute to the reduction of emissions and the mitigation of climate changes. This is due to the availability and developing technologies for distributed generation units are based on renewable sources and micro sources that are characterized by very low emissions.

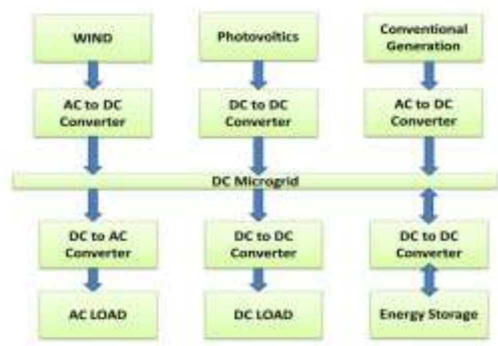

Fig No .2 Block diagram of Microgrid power system

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3.2 Benefits of DC Micro grids

It is hard to argue against the fact that local distribution systems would greatly benefit from using dc rather than ac as an interconnection bus. Some of the facts validating this statement follow.

- Most renewable sources produce dc power, and most modern loads—commercialized as ac loads such as LED lights, consumer electronics, and motor drives—are provided with a front-end rectifier while the load itself is served from an internal dc bus and can therefore be connected more efficiently to a dc bus by eliminating the front end and its losses. For example, large rectifier/inverter motor drives commonly used in intensive manufacturing plants use topologies. These drives could save up to 50% of their losses if powered directly from dc bus.

- Many classic ac generation resources using rotating electromechanical machines can operate more efficiently if they are connected though variable-frequency power converters instead of being forced to operate connected to a fixed- frequency ac bus.

- Electric energy-storage devices, fundamental components for the operation of micro grids, are also dc in nature. Among the different battery storage technologies, flow batteries have characteristics that are very attractive to micro grids, such as deep discharge capability without affecting cycle life, fast response, decoupled power and energy ratings, and no cell-to-cell equalization needs. However, these batteries have limitations to supplying high voltages without increasing the cost of the system, and therefore would need a dc–dc in front of the dc–ac converter in ac applications. These battery technologies that are already provided with an internal dc–dc converter would be easily integrated to a fixed dc bus with reduced cost and increased efficiency.

- The expected proliferation of electric vehicles during the next few years may represent one of the most demanding challenges in electric power distribution. Fast battery chargers can be simplified and made more efficient if powered from a high-voltage dc bus.

- A dc micro grid is much less susceptible to failure due to main grid disturbances because the ac–dc converter interface between the ac grid and the dc micro grid provides an energy-storage buffer and can replace the functionality of fast active switches used in the ac micro grids.
- Power quality problems, such as sags, swells, imbalances, and flickering, among others, associated with the high penetration of renewable resources that show varying power output, are an important issue in ac micro grids but are easily mitigated in dc systems with robust control of the dc bus voltage.

- Stability depends on maintaining the dc bus voltage within the normal operating range for all the devices connected to the bus under every transient and steady state condition. Although stability is more challenging as larger and more complex dc micro grids are implemented and different dc micro grid clusters are connected together, the solutions are simpler than for ac micro grid systems.

- Advances in dc–dc converter technology have resulted in highly efficient and reliable converters providing the "dc transformer" effect that counterbalances the decisive factor that favored ac systems in the 1900s. In fact, high-voltage dc transmission lines are now being used to link separated ac grids with different ratings where the ac power is rectified into dc power that is then converted to a higher dc voltage level for transmission. This provides space savings and removes the need for synchronization.

Consequently, strong arguments indicate that implementing micro grids by using a common dc voltage is simpler, more reliable, and more efficient than using ac to implement micro grids.

A micro grid is capable of operating in grid-connected and stand-alone modes, and handling the transitions between these two modes .In the grid-connected mode, the power deficit can be supplied by the main grid and excess power generated in the micro grid can be traded with the main grid and can provide ancillary services. In the islanded mode of operation, the real and reactive power generated within the micro grid, including the temporary power transfer from/to storage units, should be in balance with the demand of local loads. IEEE Standard 1547 includes guidelines for interconnection of DER units. Islanding, i.e., disconnection of the micro grid from the host grid, can be either intentional (scheduled) or unintentional. Intentional islanding can occur in situations such as scheduled maintenance, or when degraded power quality of the host grid can endanger microgrid operation. Unintentional islanding can occur due to faults and other unscheduled events that are unknown to the microgrid; proper detection of such a disconnection is imperative for safety of personnel, proper operation of the microgrid, and implementation of changes required in the control strategy. The technical literature offers a wealth of islanding
detection algorithms, which operate based on frequency/voltage measurements (pasive) or disturbance injection (active) (e.g.
Micro grids that do not have a PCC are called isolated microgrids. This is the case of remote sites (e.g., remote communities or remote industrial sites) where an interconnection with the main grid is not feasible due to either technical and/or economic constraints; therefore, isolated microgrids operate permanently in stand-alone mode.

4. SYSTEM DEVELOPMENT

4.1 Configuration of System

The DBS control strategy improves the stability of the DC micro grid changing operating points of the DERs and the grid-tied converter (GTC) depending on locally measured DC bus voltages. Most of the DBS control strategies have been investigated and verified under a specific operation mode of the DC micro grid and therefore may not be applicable to both grid –connected and islanded modes. Some of the DBS Control strategies perform DC voltage regulation using either the GTC or the Battery energy storage systems (BESSs).
A typical configuration of DC micro grid with multiple energy storage devices can be seen in Fig.3. It contains three main parts, namely, energy storage devices, power generations and power consumptions.

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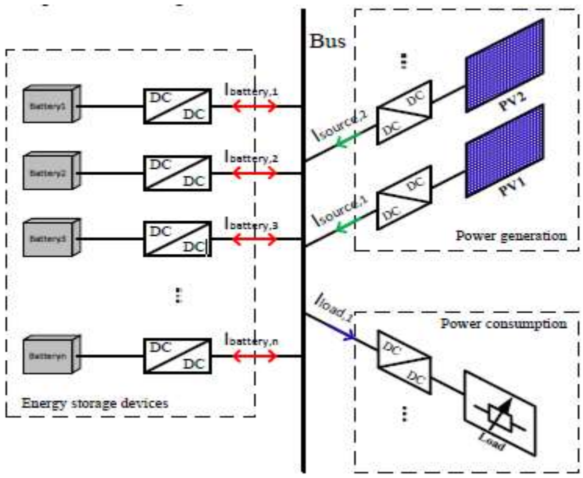

Fig. No 3. Configuration of a typical DC Micro grid

The power generations include PV, wind turbine and fuel cell, which only provide power. The green arrow in Fig.3 shows the power flow. In contrast, the load only consumes power from the micro grid and the blue arrow shows the power flow. Battery banks can absorb or release power, which is labeled with red arrow.

5. SIMULATIONS & RESULT ANALYSIS

5.1 Simulink model of Proposed System

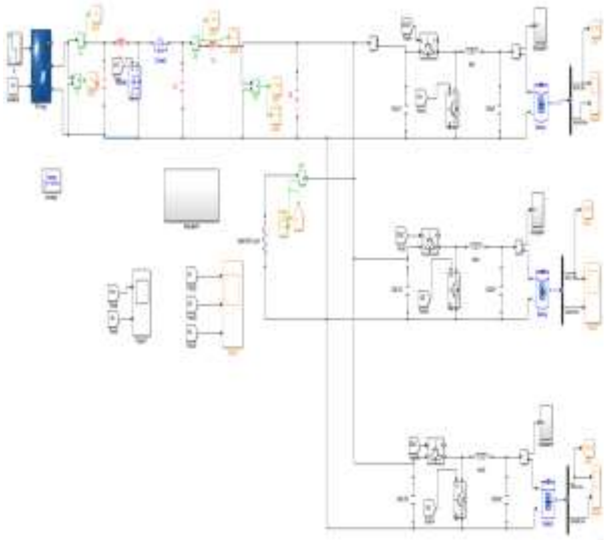

Fig.No 4 Simulink model of Proposed System

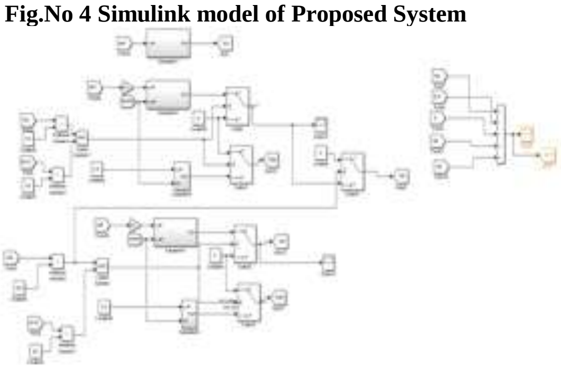

Fig. No 5 Simulink model of Control Mechanisms

5.2 Simulink Results of Proposed System

5.2.1 Case Study-1

When solar irradiation at 1000, dc grid vtg is 180v, so the current injected by PV system satisfies load demand. Slave1 and Slave2 are in discharging mode. When solar irradiation falls to 700, dc grid vtg falls, dc grid vtg falls, so the current injected into by PV system reduces, which is fed by battery system. Master and Slave1 satisfy the requirement. Slave2 is in charging mode.

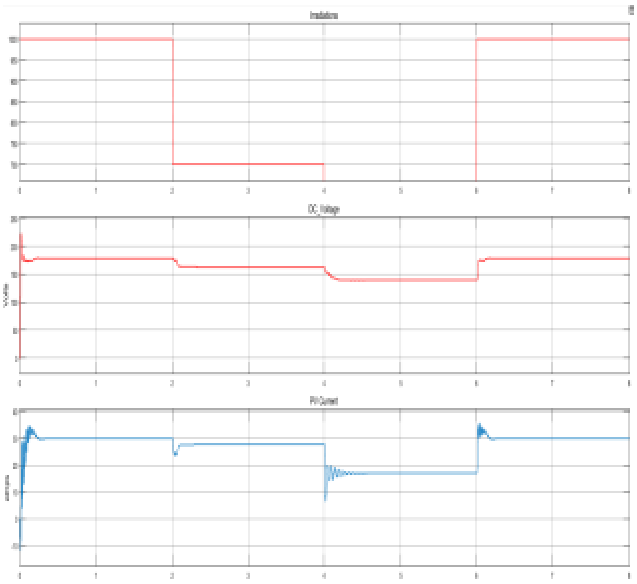

Fig.No 6 (a) Simulink Result of Case Studdy-1

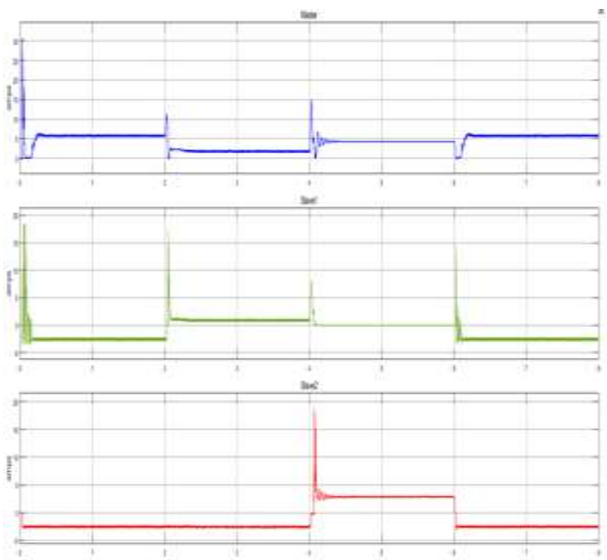

Fig.No 6 (b) Simulink Result of Case Studdy-1

5.1.2 Case Study-2

When solar irradiation falls to 400, dc grid vtg falls, dc grid vtg falls, so the current injected into by PV system reduces, which is fed by battery system. Master and Slave2 satisfy the requirement. In this Fig. SOC of slave1 is less than 80% , it will not get activated. Only Slave 2 will inject current.

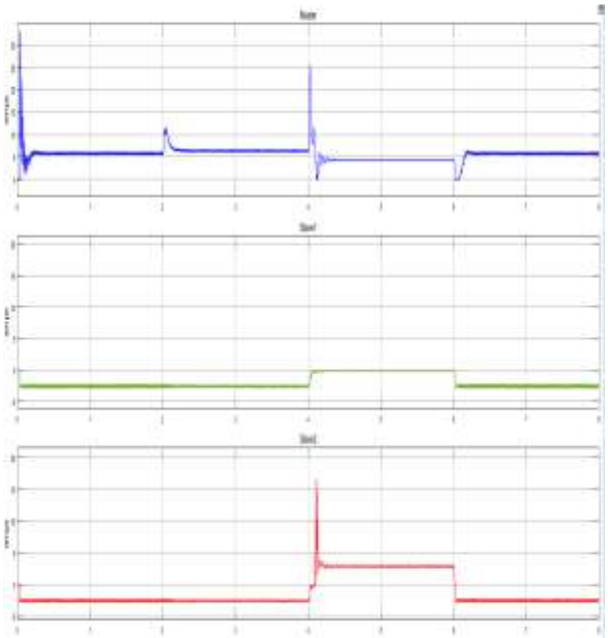

Fig.No 7 Simulink Result of Case Studdy-2

CONCLUSION

This thesis proposed an active DC bus signaling method to coordinate multiple battery banks in a DC micro grid. The proposed method has been experimentally evaluated, and the experimental results show that accurate current sharing can be achieved. The experimental results also show the expandability of the proposed ADBS method. However, this method has some limitations. Firstly, the number of the battery banks is finite. Adding more battery banks needs more voltage levels to switch ON/OFF slave battery bank modules. The levels of DC bus voltage cannot be too large, which might cause the unstable operation. Secondly, the information exchange is achieved through voltage level, so it is only suitable for the low speed application.

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