Control Method of Energy Storage Interface for DC Micro Grid: A Review

Kinjal thakor[1], Hetal desai[2]

[1]Student in Dept. of EEE, Navrachana University, Vadodara, India
[2]Assistant Professor in Dept. of EEE, Navrachana University, Vadodara, India

Abstract - *In this paper explained about battery energy storage system and control methods like improved droop method, frequency control method, double closed loop control. The battery energy storage system (BESS) is a crucial part of a DC micro-grid as a result of renewable energy generation sources are fluctuating. The BESS will provide energy whereas the renewable energy is absent within the DC micro-grid. The circuit topology of the projected BESS are introduced. The non-isolated two-way DC/DC convertor is used because the converter of the battery energy storage system to connect the DC micro-grid. The output power of every energy storage interface convertor is balanced whereas maintaining the bus voltage constantly. DC-DC power converters are wide utilized in numerous applications use in DC switch power supplies, hybrid electric vehicles, renewable energy sources, and Energy Storage Systems (ESS). The turbine is interfaced to the microgrid with a rectifier and a buck convertor that are controlled to take care of a relentless DC bus voltage. whereas the PV array is connected via boost convertor that extracts most power from the circuit. The microgrid system conjointly consists of a centralized Battery Energy Storage System (BESS).*

Key Words: Battery energy storage system(BESS), DC/DC Converter, double loop control, improved droop control, frequency control

1. INTRODUCTION

DC micro-grid is a small strength technology and distribution device which mixes dispensed strength, load, strength garage gadgets, converters and tracking and safety gadgets within the side the shape of direct current. Compared with AC micro-grid, DC micro-grid has no troubles of segment synchronization, harmonic and reactive strength loss, so it has obtained terrific interest in current years. As an vital a part of DC micro-grid, strength garage unit performs a function of stabilizing DC bus voltage fluctuation and supplying strength and strength aid thru the connection of bidirectional DC/DC converter and DC bus.

In the modern-day DC micro-grid system, electricity gadgets can now no longer gain breakthroughs in voltage and electricity in a short time, and unmarried strength garage interface converter can now no longer meet the desires of high-electricity strength garage interface converters within side the modern-day DC micro-grid. For this reason, parallel connection of more than one converters is an powerful way to enhance the output electricity of strength garage interface converters. Among the associated studies contents of parallel connection of strength garage interface converters, the electricity allocation of every strength garage unit is of outstanding importance. If the burden electricity distribution is unreasonable, the strength garage interface converter may go in overload or light load for an extended time, ensuing within side the discount of reliability and performance of the strength garage interface converter.

studies on parallel energy allocation of power garage interface converters has carried out positive results. It especially specializes in cutting-edge sharing manipulate of parallel power garage interface converters. Current sharing manipulate schemes at this level are essentially divided into categories: bus cutting-edge sharing manipulate approach and bus-much less cutting-edge sharing manipulate approach. The bus cutting-edge sharing manipulate approach connects all converters thru a cutting-edge sharing bus to gain the cause of acquiring cutting-edge sharing indicators for every unit, however this reduces the reliability of the system. The cutting-edge-sharing bus manipulate approach does now no longer want to increase the cutting-edge-sharing bus among the manipulate of every converter, as a consequence enhancing the reliability of parallel system. At present, the primary manipulate techniques of non-cutting-edge-sharing bus are slump manipulate approach and frequency manipulate approach. Drop manipulate approach is straightforward to implement, however on the fee of the output traits of the converter, the output voltage cannot attain the education value. Frequency manipulate approach obtains cutting-edge sharing records via way of means of injecting disturbance frequency, which has excessive reliability and avoids the discount of output voltage. realizes cutting-edge sharing manipulate via way of means of the use of the AC sign transmitted from the output cease of the converter, and achieves good cutting-edge sharing effect. proposes an improved slump manipulate approach primarily based totally on nation of charge (SOC) for DC dispensed power garage system. This approach can realize the dynamic allocation of load energy amongst distinct power garage units. The sag coefficient in conventional sag manipulate is inversely proportional to the n energy of SOC. By changing the energy exponent n of SOC, the price of SOC and output energy stability may be adjusted inversely proportional to the n energy of SOC. By changing the energy exponent n of SOC, the price of SOC and output energy stability may be adjusted.

In this paper, the converter used within side the interface of battery strength garage machine is studied. The converter adopts the non-remoted bi-directional DC / DC structure. The manipulate approach adopts the modern-day sharing manipulate approach without bus, together with the advanced slump manipulate approach and frequency manipulate approach. Under the circumstance of retaining the bus voltage constant, the parallel connection of the strength garage interface converter is managed and the output electricity of every strength garage interface converter is balanced.

2. BATTERY ENERGY STORAGE SYSTEM

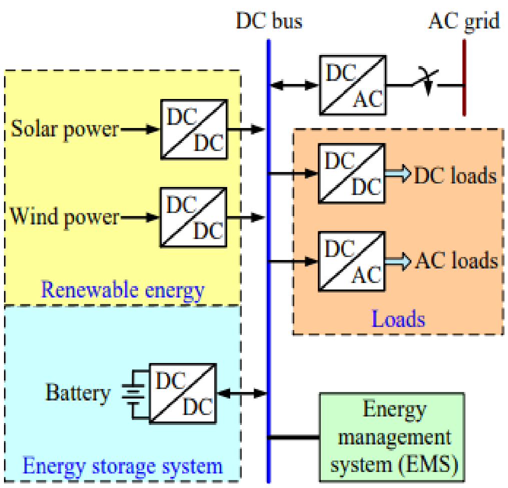


FIG-1: BATTERY ENERGY STORAGE SYSTEM OF DC MICRO GRID(BESS) (chang, 2018)

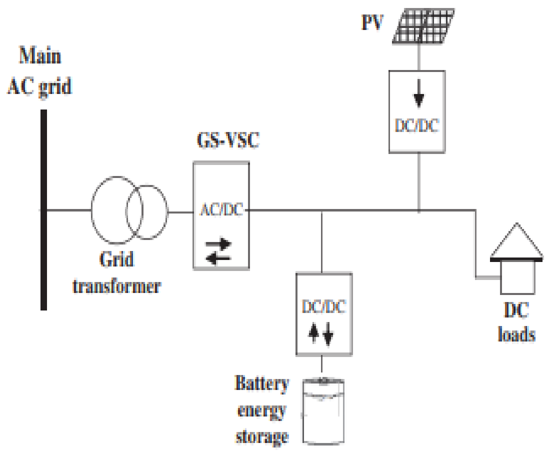
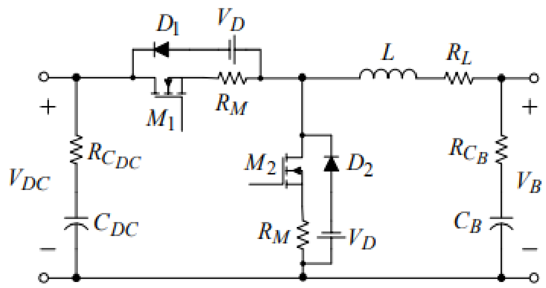


FIG-2: THE LAYOUT OF THE STUDIED DC MICRO GRID FOR THE INTERATION OF PV AND BESS (EGHTEDARPOUR, 2012)



(chang, 2018)

FIG-3: CIRCUIT CONFIGURATION OF THE BATTERY CHARGER/DISCHARGER

The typical structure of DC micro-grid with distributed generation and battery energy storage system is shown in Fig. 1. within the battery energy storage system, every energy storage unit is connected to the DC bus in parallel by bifacial DC/DC interface converter, and also the load power needs to be allotted fairly among the interface converters. The investigated DC micro-grid format is proven in Fig. 2.

The system consists of a PV supply connected through a DC/DC boost converter and electric battery energy storage, that is connected through a bi-directional buck-boost DC/DC converter. The BESS is employed to balance the ability distinction between the PV power provide and load demand in islanding mode. A bi-directional DC/AC convertor called AC/DC is additionally wont to connect the DC bus and AC main grid, which allows bi-directional power flow. The system configuration of the DC micro-grid is proven in Figure 3.

The developed battery energy storage system consists of the battery and also the bifacial DC/DC converter. Figure two shows the circuit configuration of the battery charger/discharger. The buck convertor and boost converter is combined to form the bifacial convertor. In charging mode, the buck converter is operated with (M1, D2), whereas in discharging mode, the boost convertor is operated with (M2, D1).

The non-ideal circuit parts are included within the circuit configuration. The non-ideal parts embody the equivalent series resistance (ESR) of the ability switch (RM), the ESR of the inductance (RL), the ESR of the condenser (RCB, RCDC), and the forward conductivity voltage of the diode (VD). Inductance current IL, DC-link voltage VDC and battery voltage VB are wont to confirm the duty magnitude relation of the ability switches. The remarks alerts are sampled with the aid of using the analog to digital converter.

3. ANALYSIS OF CONTROL METHODS

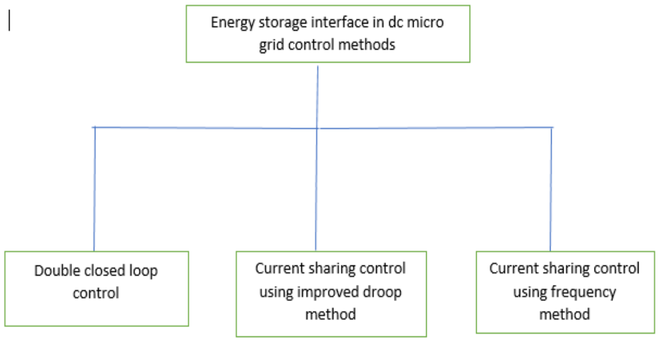
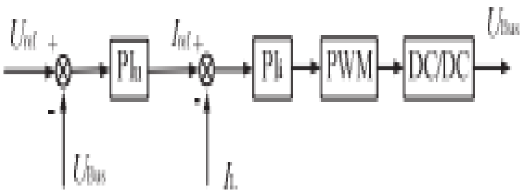


FIG.-4: Classification Of Energy Storage System

3.1. Double Closed Loop Control



(HOU, 2019)

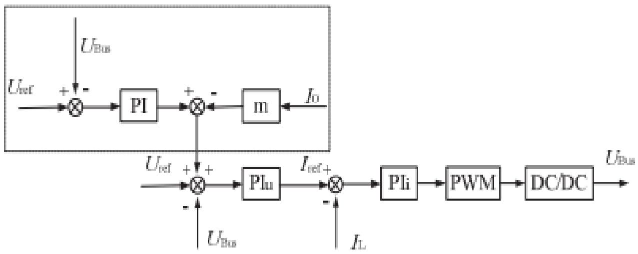
FIG.-5: BLOCK DIAGRAM OF DOUBLE CLOSED LOOP CONTROL

For parallel manipulate of power garage interface converters, with out contemporary sharing manipulate, every power garage unit adopts double closed-loop manipulate method with voltage outer loop and contemporary internal loop. The block diagram shown in fig. 5 By evaluating the reference price Uref of DC bus voltage with Ubus of DC bus voltage, the voltage error is obtained.

After PI controller, the reference price Iref of inductance error is obtained. The reference value Iref of inductance current is as compared with IL of inductance current value. The error value of inductance contemporary is obtained. Finally, the PWM manipulate sign is generated with the aid of using PI controller and modulator to force the on-off of transfer tube in bidirectional DC/DC converter. The segment shift manipulate common sense is carried out in closed loop operation.

The proportional-integral (PI) controller based scheme is evolved on this paper. he manage block diagram to facilitate bidirectional modern float is proven in Fig. 5. Here, the PI controller is regulating the segment shift in step with the reference modern. Here, PWM alerts for “Conv2” are managed through the manage logic, whilst the PWM alerts for “Conv1” are fixed. Thus, segment shift is produced withinside the output voltage of “Conv2” with recognize to the output voltage of “Conv1”.

3.2. Current Sharing Control Using Improved droop method



(HOU, 2019)

FIG.-6: BLOCK DIAGRAM OF current sharing control using improved droop method

Droop method is the primary control technique for load present day sharing in dc microgrid applications. The traditional dc droop control technique is found out with the aid of using linearly lowering the dc output voltage because the output present day will increase. This technique has limitations. First, with the attention of line resistance in a droop-managed dc microgrid, for the reason that output voltage of each converter can not be precisely the same, the output present day sharing accuracy is degraded. Second, the DC bus voltage deviation will increase with the burden because of the droop action.

In this subject matter is often specializing in ac microgrids, on account that the software electric grid is predicated on ac systems. However, diverse sustainable power resets and hundreds, such as photovoltaic (PV) modules, batteries, and LEDs, have natural dc couplings, so it's miles a extra green technique for connecting those resets and hundreds immediately to shape a dc microgrid through using dc-dc converters with out ac-dc or dc-ac transformations. In a dc microgrid, there may be no reactive electricity and there are no harmonics, so better electricity best and gadget performance are acquired in comparison to ac systems. Therefore, there may be an growing attention on dc microgrids nowadays. The typical configuration of a dc microgrid is proven in Fig. 6

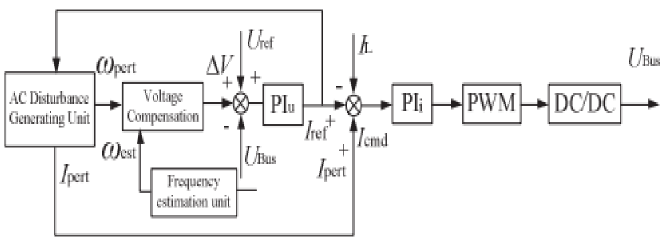
In a droop method of dc microgrid, the electricity sharing approach is found out via way of means of linearly decreasing the voltage reference as the output modern increases. Although droop control is extensively hired as a decentralized approach for load electricity sharing, its boundaries ought to be noted. The output modern sharing accuracy is reduced down due to the impact of the voltage drop throughout the road impedance. This impact is comparable to the reactive electricity sharing of ac microgrids with inductive line impedances. To decorate the reactive electricity sharing accuracy in the ac microgrid with inductive line impedances.

LIMITATIONS OF THE CONVENTIONAL DROOP CONTROL METHOD IN DC MICROGRIDS

(a) The traditional droop method approach is the degradation of the contemporary sharing accuracy Since the output voltage can't be precisely the equal because of the extra voltage drop throughout the line resistances, the burden contemporary sharing accuracy is decreased down.

(b) Voltage deviation exists because of the droop action.

3.3. Current Sharing Control Using Frequency method



(HOU, 2019)

FIG.-7: BLOCK DIAGRAM OF CURRENT SHARING CONTROL USING FREQUENCY METHOD

The block diagram of present day sharing control for parallel connection of energy storage interface converter with the aid of using frequency technique is proven in Fig. 7. Current sharing control the usage of Frequency technique is to attain excessive frequency AC disturbance signal Ipert and excessive frequency AC disturbance signal wpert thru the AC disturbance producing unit of the inductance current reference value Iref of voltage PI controller.

The frequency of excessive frequency AC disturbance signal wpert is proportional to the inductance current reference cost Iref, and the inductance current reference value Iref may be judged with the aid of using frequency. The excessive frequency AC disturbance signal Ipert is superimposed with the reference value Iref of inductance current and the real inductance current IL to attain the real current value of Icmd. Because the current value Icmd of every energy storage unit contains the excessive frequency AC disturbance signal Ipert, the AC alerts of every energy storage system unit can be superimposed to the DC bus thru the energy storage interface converter, after which the DC bus voltage Ubus is collected. The measured DC bus voltage signal Ubus is surpassed thru the frequency estimation unit to attain the frequency west of the incorporated excessive frequency AC disturbance signal.

Comparing the frequency est of the synthesized excessive frequency AC disturbance signal with the frequency wpert of the excessive frequency AC disturbance sign of the energy storage unit, the voltage compensation amount deltaV is received thru the voltage repayment unit. DC bus voltage reference cost Uref and DC bus voltage Ubus are superimposed with voltage compensation amount deltaV. The inductance current reference cost Iref is received with the aid of using voltage PI controller, after which the present day guidance cost Icmd is received. The PWM manipulate signal is in the end generated with the aid of using current of PI controller, which drives the switching on and off of every transfer withinside the energy storage interface converter. west and deltaV may be decided with the aid of using the subsequent formula.

$$\omega_{est} = \frac{\sqrt{\sum_{i=1}^{n} C_i^2 \cdot \omega_{ipest}^2}}{\sqrt{\sum_{i=1}^{n} C_i^2}}$$

$$\Delta V = \frac{\omega_{est} - \omega_{pest}}{\omega_{est}} U_{Bus}$$

(HOU, 2019)

FIG.-8: FORMULA FOR CURRENT SHARING CONTROL USING FREQUENCY METHOD

In the formula, Ci is the weighted coefficient of different disturbance frequencies of every energy storage unit and wipert is the disturbance frequencies of every energy storage system unit.

Table-1: Comparison Table

NO.	TECHNIQUES	LOAD SHARING	IMPLEMENTATION COMPLEXITY	VOLTAGE REGULATION	OTHER FEATURES	APPLICATION
1.	Double closed loop control	good	Medium/complex	Good	Reliable distribution with low noise and uncertainty Good power sharing Greater effective then linear control strategy	High voltage dc
2.	Improved droop control	good	medium	Good	Greater economic Greater reliability	Low voltage dc
3.	Frequency control method	good	medium	good	technique for paralleled power converters the signals from the individual cells are summed at a node, and the sum is accessible to all the cells.	Electrical power system

Table-2: Summary Table

No.	Author/publication year	Topic name
1.	N. Eghtedarpour, E. Farjah*[2012]	Control strategy for distributed integration of photovoltaic and energy storage systems in DC micro-grids
2.	David J. Perreault, t L. Selders, Jr, John G. Kassakian[2013]	Frequency-Based Current-Sharing Techniques for Paralleled Power Converters
3.	Lu, Xiaonan; Guerrero, Josep M.; Sun, Kai; Vasquez, Juan Carlos[2014]	An Improved Droop Control Method for DC Microgrids Based on Low Bandwidth Communication with DC Bus Voltage Restoration and Enhanced Current Sharing Accuracy
4.	C. Phurailatpam, R. Sangral, S.N. Singh, F. G. Longatt [2015]	Design and Analysis of a DC Microgrid with Centralized Battery Energy Storage System
5.	Yuan-Chih Chang *, Hao-Chin Chang and Chien-Yu Huang[2018]	Design and Implementation of the Battery Energy Storage System in DC Micro-Grid Systems
6.	Mohamed A. A. Mohamed1, 2 , Quanxue Guan1 , Mohamed Rashed1[2018]	Control of DC-DC Converter for Interfacing Supercapcitors Energy storage to DC Micro Grids
7.	Ligang Hou, Xianghua Tang, Xiongjie Shi, Hui Jiang, Hui Liu, Yan Song, [2019]	Research on Control Method of Energy Storage Interface for DC Micro-grid
8	O. Abdel-Rahim, H. Funato and H. Junnosuke	Droop method based on model predictive control for DC microgrid
9	X. Li, D. Hui, and X. Lai	Battery Energy Storage Station (BESS)- Based Smoothing Control of Photovoltaic (PV) and Wind Power Generation Fluctuations
10	J. Jiang, Y. Bao, and L. Y. Wang,	Topology of a Bidirectional Converter for Energy Interaction between Electric Vehicles and the Grid
11	C. Menictas, M. Skyllas-Kazacos, and T.M. Lim	Advances in Batteries for Medium and Large-Scale Energy Storage
12	Lu Minghui, Duan Shanxu, Cai Jiuqing, Chen Changsong	Research on parallel current sharing control of power regulation system based on energy storage
13	Carrizosa, M.J.; Arzandé, A.; Navas, F.D.; Damm, G.; Vannier	. A control strategy for multiterminal DC grids with renewable production and storage devices
14	Sahoo, S.K.; Sinha, A.K.	Control techniques in AC, DC, and hybrid AC-DC microgrid: A review.
15	Kumar, M.; Srivastava, S.C.; Singh, S.N.	Control strategies of a DC microgrid for grid connected and islanded operations

4. CONCLUSION

The goal of this document is the parallel connection of two-way DC/DC converters in a microgrid DC battery system, which uses an improved droop control method, double-loop control and frequency control methods for control. It has been confirmed that while the intermediate circuit voltage remains constant, the output current and output power of the parallel storage interface converter can be balanced, and according to explanation we conclude that the current sharing control using frequency method is more inefficient because it have less limitation and operation is easy to control. The possibility of using control methods is discussed.

REFERENCES

1. C. Phurailatpam, R. Sangral, B. S. Rajpurohit, S. N. Singh and F. G. Longatt, "Design and analysis of a DC microgrid with centralized Battery Energy Storage System," 2015 Annual IEEE India Conference (INDICON), New Delhi, India, 2015, pp. 1-6, doi: 10.1109/INDICON.2015.7443215.

2. L. Hou, X. Tang, X. Shi, H. Jiang, H. Liu and Y. Song, "Research on Control Method of Energy Storage Interface for DC Micro-grid," 2019 IEEE 3rd Conference on Energy Internet and Energy System Integration (EI2), Changsha, China, 2019, pp. 1579-1583, doi: 10.1109/EI247390.2019.9061799.

3. M. A. A. Mohamed, Q. Guan and M. Rashed, "Control of DC-DC Converter for Interfacing Supercapcitors Energy storage to DC Micro Grids," 2018 IEEE International Conference on Electrical Systems for Aircraft, Railway, Ship Propulsion and Road Vehicles & International Transportation Electrification Conference (ESARS-ITEC), Nottingham, UK, 2018, pp. 1-8, doi: 10.1109/ESARS-ITEC.2018.8607327.

4. Lu, X., Guerrero, J. M., Sun, K., & Vasquez, J. C. (2014). An Improved Droop Control Method for DC Microgrids Based on Low Bandwidth Communication with DC Bus Voltage Restoration and Enhanced Current Sharing Accuracy. I E E E Transactions on Power Electronics, 29(4), 1800-1812.

5. Perreault, D.J., R.L. Selders, and J.G. Kassakian. “Frequency-Based Current-Sharing Techniques for Paralleled Power Converters.” IEEE Trans. Power Electron. 13, no. 4 (July 1998): 626–634.

6. Yuan-Chih Chang *, Hao-Chin Chang and Chien-Yu Huang, “Design and Implementation of the Battery Energy Storage System in DC Micro-Grid Systems,” Energies 2018, 11, 1566; doi:10.3390/en11061566.

7. N. Eghtedarpour, E. Farjah,”Control strategy for distributed integration of photovoltaic and energy storage systems in DC micro-grids.” doi:10.1016/j.renene.2012.02.017

8. O. Abdel-Rahim, H. Funato and H. Junnosuke, "Droop method based on model predictive control for DC microgrid," 2016 19th International Conference on Electrical Machines and Systems (ICEMS), Chiba, Japan, 2016, pp. 1-6.

9. X. Li, D. Hui, and X. Lai, "Battery Energy Storage Station (BESS)- Based Smoothing Control of Photovoltaic (PV) and Wind Power Generation Fluctuations," IEEE Trans. Sustainable Energy, vol. 4, no.2, pp.464-473, 2013

10. J. Jiang, Y. Bao, and L. Y. Wang, “Topology of a Bidirectional Converter for Energy Interaction between Electric Vehicles and the Grid,” Energies, vol. 7, pp. 4859-4894, 2014

11. C. Menictas, M. Skyllas-Kazacos, and T.M. Lim, Advances in Batteries for Medium and Large-Scale Energy Storage, 1st ed., Woodhead Publishing, 2014.
12. Lu Minghui, Duan Shanxu, Cai Jiuqing, Chen Changsong. Research on parallel current sharing control of power regulation system based on energy storage [A]. Organizing Committee of the Academic Annual Conference of Power Electronics and Electric Drive in Chinese Universities. Papers of the Seventh Annual Conference of Power Electronics and Electric Drive in Chinese Universities [C]. Organizing Committee of the Academic Annual Conference of Power Electronics and Electric Drive in Chinese Universities, 2013:4.

13. Carrizosa, M.J.; Arzandé, A.; Navas, F.D.; Damm, G.; Vannier, J.-C. A control strategy for multiterminal DC grids with renewable production and storage devices. IEEE Trans. Sustain. Energy 2018, 9, 930–939.

14. Sahoo, S.K.; Sinha, A.K.; Kishore, N.K. Control techniques in AC, DC, and hybrid AC-DC microgrid: A review. IEEE J. Emerg. Sel. Top. Power Electron. 2018, 6, 738–759.

15. Kumar, M.; Srivastava, S.C.; Singh, S.N. Control strategies of a DC microgrid for grid connected and islanded operations. IEEE Trans. Smart Grid 2015, 6, 1558–1601.