

Equal Current Sharing Parallely Connected Interleaved Boost Converter in DC Microgrid using Control Algorithm

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Abstract

In this paper, a micro grid based current sharing between parallely connected second order Boost Converter and Interleaved Boost Converter is proposed. As the output of PV is not predictable, an MPPT based on the Adaptive Neuro Fuzzy Inference System (ANFIS) is used to manage the second order Boost Converter. To offer exact sharing of current between parallel modules in converters, a droop control mechanism is utilized. The PV system's maximum power is tracked using a PI controller, so as to maintain constant DC link voltage at different temperature conditions. Using a PI assisted Bidirectional battery converter, the voltage of the battery is maintained. The nominal voltage for each converter is modified by comparing each converter's output current to the total load current. The entire system is validated through a MATLAB simulation.

Keywords: Interleaved boost converter, second order boost converter

1. Introduction

The development and use of new energy sources have become trends for the present and the future, as the serious pollution caused by traditional energy sources has brought environmental problems to the fore. Distributed-based micro- grids are attracting widespread interest, as they can better exploit the advantages of distributed power sources. Distributed energy storage technology is an efficient measure to meet the needs of new consumption of energy and enhance the stability of the microgrid. Multiple energy storage units (ESUs) can be connected to the AC microgrid via inverters to expand the capacity of the microgrid. Stabilizing the frequency of the AC microgrid is the basic task of various control strategies, and each ESU can be cut off or put in depending on the scale of the load, which

improves the stability of the microgrid. A boost converter is a device that transforms a DC voltage to a greater DC voltage converter. Fig.1 shows schematic diagram of interleaved boost converter. Additional advantages of interleaving include lower ripple currents in input and output circuits. Splitting the output current into two pathways improves efficiency by significantly lowering inductor AC losses and I^2R .

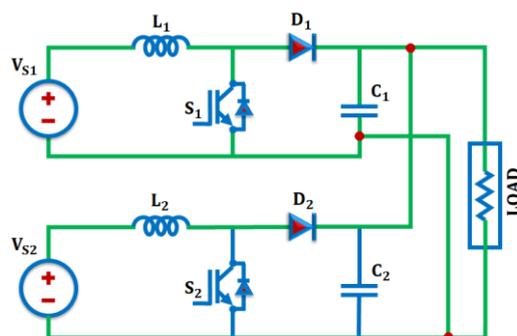


Figure 1. Schematic diagram of Interleaved Boost Converter

It consists of inductor L_1 which is parallel to inductor L_2 , diode D_1 parallel to diode D_2 , switch Q_1 parallel to another switch Q_2 , to form 2 parallel channels between output and input circuit. To achieve interleaving, identical constituents are utilized in the circuit. The gate signal is provided by two switches and is 180 degrees out of phase. The droop control algorithm is used to manage the flow of electricity from sources to loads. Circuit characteristics, particularly line resistances, have an impact on droop control functionality. So the droop controller lacks accuracy due to load sharing. An adaptive droop control technique is used to suppress circulating currents in low voltage DC microgrid. Mathematical computations are used to assess line resistances and droop settings are modified correspondingly. A distributed secondary controller is also suggested to enhance accuracy of load sharing and reduce line resistance effects. The droop controller voltage set point is shifted by the secondary controller. The suggested approaches produce precise load sharing; each converters has power rating and hence current flowing is reduced. Second-order harmonics are common on the dc-bus voltage, resulting in substantial oscillating currents on the converter's resource side. Using resonant regulators and notch filters in the converter's control loops, decrease unwanted currents. The key properties of these approaches are extensively explored in terms of harmonic attenuation and harmonic attenuation stability. To avoid instability, the voltage control loop bandwidth is demonstrated to be limited to less than twice the line frequency. Then, to remove the voltage loop bandwidth constraint, modified resonant regulator and notch filter are presented. The output impedance and stability of the

derived approaches are assessed. A photovoltaic (PV)-based dc microgrid system with Maximum Power Point Tracking (MPPT), energy management and adaptive droop-based load sharing. At the converter's output side, the Proportional Droop Index (PDI) algorithm is introduced, which is a function of voltage fluctuation and normalized current sharing difference. The suggested technique estimates adaptive virtual resistance R_{droop} , which allows the converter of PV to function in either load sharing or MPP modes. The proposed technique overcomes the traditional droop method's poor voltage regulation difficulties by fine-tuning R_{droop} levels. The hybrid energy storage system (HESS) control with a super capacitor (SC) and a battery to manage energy and regulate dc grid voltage in a dc microgrid is also explored.

2. Modified Droop Method Analysis

A new improved droop control scheme for multiple Battery Energy Storage Systems (BESS) in islanded Direct Current (DC) microgrid to reduce (BESSs) is proposed. Depending on the energy capacity, maximum output power and battery type, BESSs have various battery life cycle features and costs for installation. Even though they are sharing the same quantity of energy, these variances result in variable battery degradation costs among BESSs. An incremental cost (IC) of a BESS is utilized for evaluating the BESSs state of charge level and is derived based on the battery life cycle curve. To perform analysis on small signal stability, the suggested method's state-space model is then used. Droop control react to load fluctuations that are unavoidable and RES help it.

As a result, voltage and frequency fluctuate, and the generator's output power deviates from its ideal level. A model predictive control based approach is created, which includes distributed generators and interconnecting converters, to re-establish the voltage and frequency of dc and ac grids while reducing generation cost at short intervals of time, in order to upgrade the set-points of existing assets. The sensitivities are utilised to approximate the problem to a quadratic programming model, which helps to linearly specify the voltage and frequency for resource output power. The second-order frequency sensitivity is also calculated. The concept of current sharing in the classic droop technique is based on the load regulation feature's droop gain of parallel boost converters. The converters' parameters and how they work in continuous current conduction mode. However, due to tolerances in manufacturing, accurate characteristics for converters connected in parallel are impossible

to attain. The 2 boost converters that are connected parallel to a resistive load and cable resistances (R_{c1} , R_{c2}) to the resistive load are depicted in Figures 2(a) and 2(b).

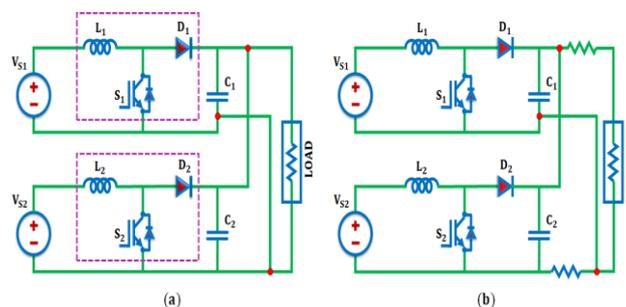


Figure 2. 2 parallel-linked boost converters to a resistive load. Circuit diagram (a) Directly linked to a resistive load. Converters (b) Linked to a resistive load by cable resistances.

Table 1. Parameters of the converter design

Parameter	Converter1	Converter2
Inductance	12.50mH	12.75mH
Capacitance	670F	670F
Switching frequency	25kHz	25kHz
Nominal voltage	6-12v	6-12v

The conventional PV system with BSS is represented in Figure 3. There are two types of converters in this category namely storage side and renewable side converters. Interleaved boost converters are used to strengthen the storage side converter's dependability. When opposed to a single-unit construction, this design has various advantages. Some of these benefits are connected to the system construction, such as the ease of maintenance and capacity to extend output power, as well as performance of system, such as high efficiency, enhanced dynamic response, and low stress on each unit because of load sharing. Ensuring load distributions evenly among converters is the difficulty in using parallel DC-DC converters. The discrepancy in the characteristics of converters connected in parallel results in incorrect current sharing between them. Figure 4 shows the block diagram of the improved droop approach for converters connected in parallel with associated control loops.

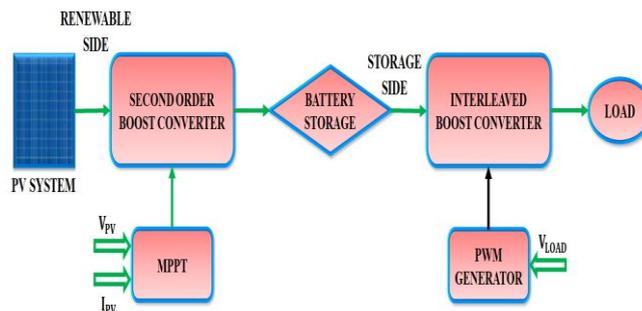


Figure 3. Schematics of MPPT for a standalone PV system with storage in the middle

The inner and outer control loops for each converter are depicted in Figure 4. The SISOTOOL and small state-space averaging approach model in MATLAB are used to develop the outer and inner loops of PI controllers. The improved droop approach with cable resistance application is used to alter the control loop’s outer voltage. V is calculated by subtracting the nominal DC bus voltage from the predicted output voltage of converter i .

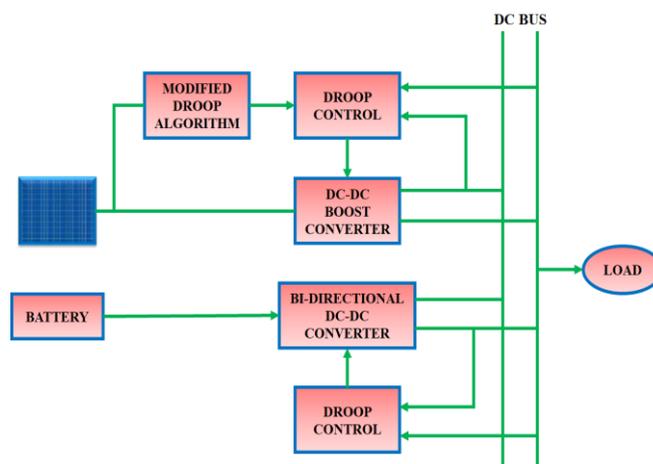


Figure 4. Block diagram of improved droop approach with converters and control loops

2.1 Second Order Boost Converter

For high-power and high-performance applications, linked inductors with a 2 phase interleaved boost DC-DC converter are employed. The benefits of the coupled inductors inter- leaved boost converters are current ripple reduction, low core size and increased system efficiency.

2.2 ANFIS based MPPT

A unique ANFIS based MPPT technique is developed to track the high power of the PV module under various weather conditions. The proposed input variables (T_{pv}) are PV

current (I_{pv}), PV voltage (V_{pv}) and PV cell temperature (T_{pv}). The duty cycle is an output variable that is used to modify the DC-DC switching boost Landsman converter so that high power tracking is maintained. Due to the fact that traditional FLC modelling relies on trial and error, the chances of reaching an optimum routine are limited. Thus, learning ANFIS is utilized to obtain fuzzy rules and membership functions. First and foremost, the training data needs to be gathered. The steps involved in obtaining the training data are as follows:

- The system was simulated under varied temperature and solar radiation circumstances using standard MPPT methodologies.
- A MATLAB application designed specifically for this purpose was used to gather and modify the data.
- After that, the data was encrypted. The data is filtered once more to obtain the data collection's unique rows.

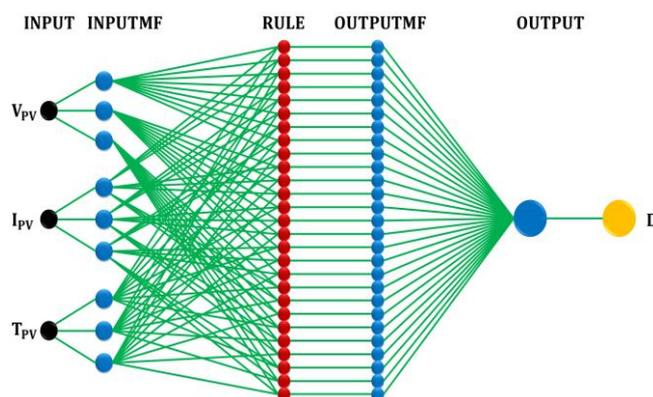


Figure 5. ANFIS model structure

2.3 PI Controller

The PI controller is a feedback controller.. It controls the plant using a weighted sum of errors and the integral of that value. From aerospace to motion control, from sluggish to fast systems, PI-Controllers have been used to control practically any process currently in use. However, despite this achievement, the difficulty of tuning PI-controllers has remained a focus of research. Additionally, PI-Controllers should needs to be returned on a regular basis as operating points and system dynamics varies. This has prompted a lot of research on the capabilities and promise of adaptive PI controllers. Adaptive PI-controllers with a loose definition eliminate time-consuming manual tweaking by automatically giving appropriate PI-controller settings as the operating points or system dynamics varies.

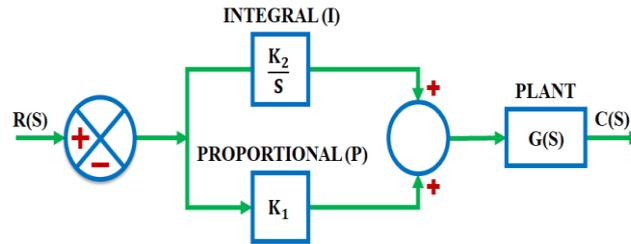


Figure 6. Basic block of PI Controller

3. Proposed Algorithm and Proposed System

3.1 Proposed algorithm

The voltage measurements of the input to the voltage controller of the outer loop are affected by the converter's current sharing percent. Because the converters share half of the total load current, each converter's fraction of current sharing must be equal to 50% of the total load current. If the converter's current sharing percentage is larger than 50%, VCA lowers the converter's nominal voltage reference. Using the total load current and the output current of converter *i* as inputs, the PCS for converter *i* is calculated,

$$PCSi = \frac{I_i}{I_{load}}$$

Between parallel-connected converters, the suggested technique may achieve exact current sharing. Figure 7 depicts the suggested algorithm's flow chart.

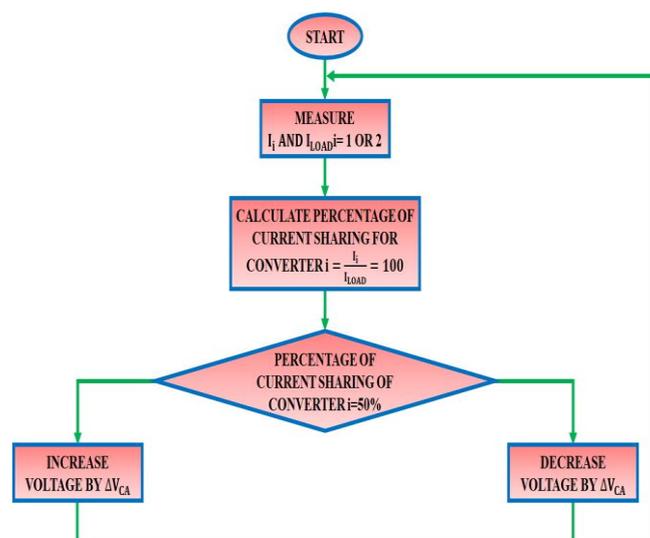


Figure 7. Proposed algorithm's flowchart

The suggested approach accomplish precise sharing of current between parallel connected converters. Small oscillations are detected near the intended operating point for current sharing equally. VCA needs to be set at a low value to minimize harmonics around the ideal point of operating. Furthermore, if the load management features of the converter have a large droop gain, oscillations around the optimum operating point are reduced. For both converters droop gains are chosen in this paper to create minor harmonics in the current waveforms of output around specified operating points. The proposed approach is shown as a block diagram of boost converters that are connected in parallel in Fig. 8.

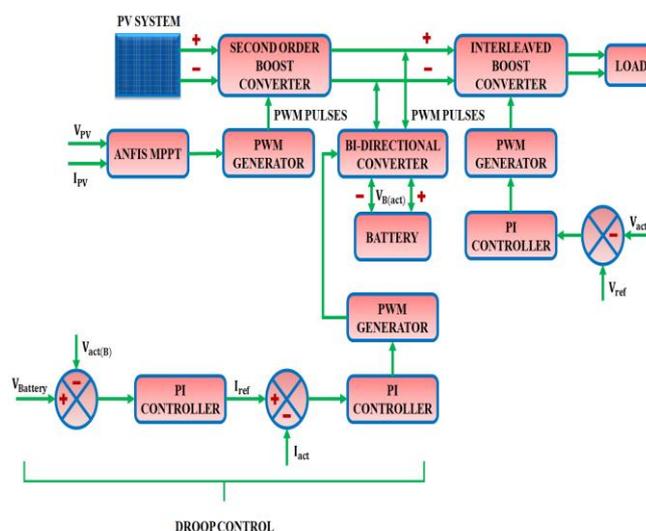


Figure 8. Block Diagram of the Proposed System

3.2 Proposed System

The output voltage from the PV system is enhanced with the aid of a Second Order boost Converter. This converter boost the PV system's output voltage. To track the PV system's maximum power, an ANFIS based MPPT technique is employed. Figure7 shows Block Diagram of Proposed System. The output reference signal is fed to the dc-dc converter, through a PWM generator, which increases the on duty cycle time. The output voltage of the PV system is boosted using an Interleaved Boost Converter. The droop approach is regulated to maintain the state of charge of BESSs in DC-DC converters that are connected in parallel for current sharing equally. The excess energy from the PV system is stored in a battery using a bidirectional battery converter and it assists in equal current sharing. In order to maintain constant dc link voltage, a PI controller technique is employed. The output from the PI is fed to the interleaved boost converter, through a PWM generator, which increases the on time of the duty cycle.

4. Results and Discussion

The simulation results are analyzed using the MATLAB/SIMULINK software. For signal analysis, MATLAB is the finest tool. Open the library browser in Simulink. Before using the Simulink browser, the MATLAB needs to be installed. To open the Simulink library, open MATLAB and type Simulink in the command box. From the Simulink library browser menu, choose file, new model. This section presents the proposed configuration's simulation and experimental results.

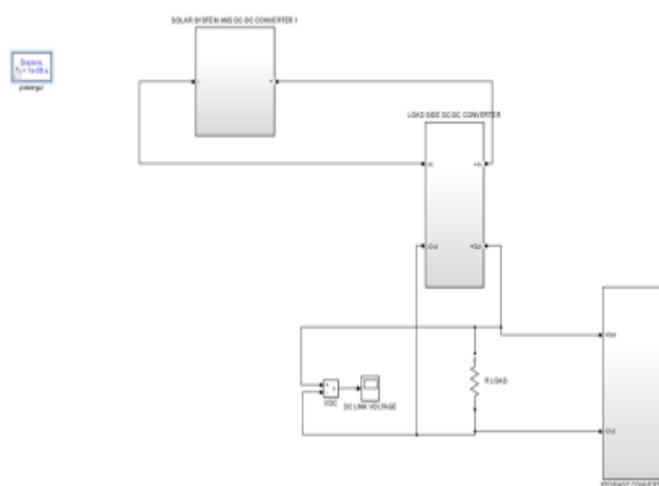


Figure 9. Simulink result of the proposed system

For control purposes, MAT Lab/Simulink was employed, while PLECS was used to represent the modulation stage, power converter, PV strings and grid voltage. The analysis was finished by repeating the experiment set-up situations in order to increase idea verification. It is essential to note that simulation parameters were chosen based on the minimal power experimental prototype. Millions of engineers and scientists around the world use MATLAB's interactive environment and high-level language. It allowed you to visualize concepts in signal and image processing, computational finance, control systems and communications among other areas. SIMULINK makes it simple to construct and simulate a mathematical model representing a physical system

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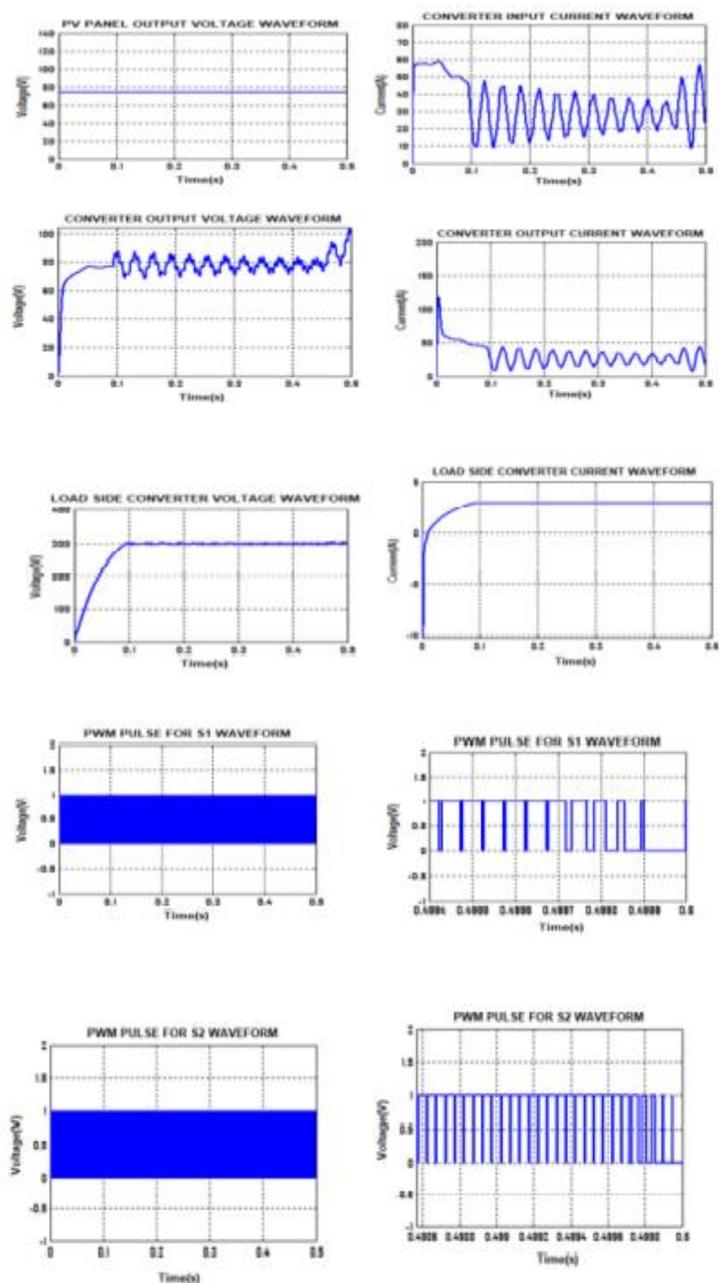


Figure 10. Simulation results

In SIMULINK, models are represented visually as block diagrams. The user selects from a number of blocks in various libraries to represent various phenomena and models in various ways. One of the most important advantages of utilising SIMULINK for dynamic

system analysis is that it allows us to quickly investigate the behaviour of complex systems that is hard to evaluate analytically otherwise. SIMULINK approximate numerically the solutions to mathematical problems that we can't or don't want to solve “by hand”. In general, physical rules are used to create mathematical equations that reflect a specific system and serve as the basis for a SIMULINK model. Figure 10 shows the solar panel voltage representation of input AC, the source of output voltage is 75(V) attained. The converter voltage and current waveform, the converter of output voltage is 100 (V) attained. The DC link voltage waveform, the Dc link of output voltage is 310 (V) attained. The Load side converter current and voltage waveform, the converter of output current is 3.5 (A) attained.

5. Conclusion

This project proposes a micro grid based on parallel connected converters exchanging current equally. It shows how to use ANFIS-based MPPT to optimise the load current sharing of two parallel-connected boost converters to track the maximum power from a PV system. Droop approaches for equal current sharing in parallel-connected second order Boost Converters and interleaved boost converters have been presented. To maintain the state of charge of BESSs, the droop method is regulated by altering the droop coefficient. The converter ignores irradiance level variations and provides enhanced voltage gain with low switching losses. For converting fixed DC voltage to variable frequency AC voltage, a battery is used. Further, the interleaved boost converter’s output is fed to the load and the defined work is implemented in MATLAB/Simulink.

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