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Inverter Design using PV System Boost Converter

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Abstract:

Many types of renewable energy, such as photovoltaic (PV), wind, tidal, and geothermal energy, have attracted a lot of attention over the past decade. Among these natural resources, the PV energy is a main and appropriate renewable energy for low-voltage dc-distribution systems, owing to the merits of clean, quiet, pollution free, and abundant. In the dc-distribution applications, a power system, including renewable distributed generators (DGS), dc loads (lighting, air conditioner, and electric vehicle), and a bidirectional inverter, is shown in fig. 1,in which two PV arrays with two maximum power point trackers (MPPTS) are implemented. However, the I–V characteristics of the PV arrays are nonlinear, and they require MPPTS to draw the maximum power from each PV array. Moreover, the bidirectional inverter has to fulfill grid connection (sell power) and rectification (buy power)with power-factor correction (PFC) to control the power flow between dc bus and ac grid,and to regulate the dc bus to a certain range of voltages, such as 380± 10 v.

Keywords: *Bidirectionalinverter, Buck/boost,Maximum power point trackers(MPPTs), DCdistribution applications*

I. INTRODUCTION

The objective of this research is to quantify the increase in efficiency of a multiple-panel PVsystemby allocating individual MPPTs with DC converters to each panel. Applications best suited for multiple MPPTs are also considered and recommendations for usage based on present and near-future technologies are provided. Finally, the possibility of integrating MPPTs with converters for each individual solar cell in a system will be analyzed, and recommendations to achieve optimal efficiency in a cost efficient and realistic manner will be provided.

The goals of this research are:

- To simulate and analyze the typical power in PV array.
- Basic overview of MPPTs to include tracking algorithms.
- Perturbation and observation tracking method.
- To simulate and analyze the methodology chosen for MPPTs.
- Building the case for the usage of multiple MPPTs.
- To determine the best control mode for proposed buck/boost.
- To implement a single-phase bidirectional inverter using AC and DC power supply unit.

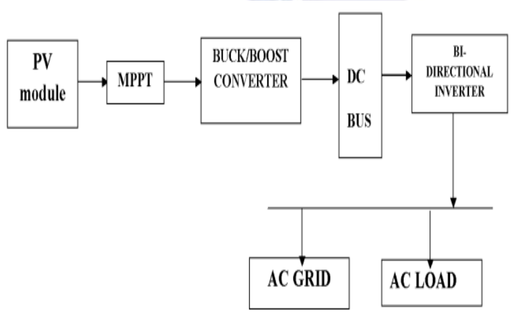

Fig.1 Block Diagram

II. PV INVERTER SYSTEM WITH BUCK/BOOST MPPT SYSTEMS

A conventional two-stage configuration is usually adopted in the PV inverter systems. Each MPPT is realized with a boost converter to step up the PV-array voltage close to the specified dc-link voltage. The boost converter is operated in by-pass mode when the PV-array voltage is higher than the dc-link voltage, and the inverter will function as an MPPT. The characteristics of PV arrays are different from each other, the inverter operated in by-passmode cannot track each individual maximum power point accurately, and the inverter suffers from as high-voltage stress as the open voltage of the arrays.

To release the abovementioned limitation, an MPPT topology, which combines buck and boost converters is proposed in this project, in which the points is based on a perturbation and observation method. The MPPT will switch operation modes between bucks and boost when the output voltage of a PV array is close to the dc- bus voltage. The designed controller can switch control laws to achieve smooth mode transition and fulfill online configuration check for the MPPTs, which can be either separate or in parallel connection, to draw the maximum power from the PV arrays more effectively. Additionally, a uniform current control scheme is introduced to the controller to equally distribute the PV-array output current to the two MPPTs in parallel operation.

To eliminate leakage ground current circulating through PV arrays and ground, several transformers less inverter topologies were proposed. Even though they can achieve high efficiency, they require more components than the conventional fullbridge topology.

The bidirectional full bridge inverter is operated with bipolar modulation to avoid leakage ground current and to save power components while still sustaining high efficiency. Note that a full-bridge inverter operated with bipolar modulation can achieve only low frequency common-mode voltage, resulting in low leakage ground current. To regulate the dc-bus voltage for the gridconnected inverter, the controls, such as robust, adaptive, and fuzzy, were adopted. When adopting these controls for the studied dc- distribution system,a heavy step-load change at the dc-bus side will cause high dc-bus voltage variation and fluctuation, and the system might run abnormally or drop into under or over voltage protection. Bulky dc-bus capacitors can be adopted to increase the hold-up time and suppress the fluctuation of the DC-bus voltage, but it will increase the size and cost of the system significantly.

The MPPT topology is formed from a buck converter and a boost converter but with a shared inductor to accommodate wide PV-array voltages from 0 to 600 V. For various PV-array applications, the two MPPTs will be connected separately or in parallel. The MPPT senses PV voltage, dc-bus voltage, and inductor current into the singlechip PIC microcontroller to determine operational mode and duty ratio for tracking the maximum power point accurately.

When voltage is higher than, the MPPT is operated in buck mode, and switch is turned ON to magnetize inductor and thus increase inductor current. While switch is turned OFF, inductor releases its stored energy through diodes.

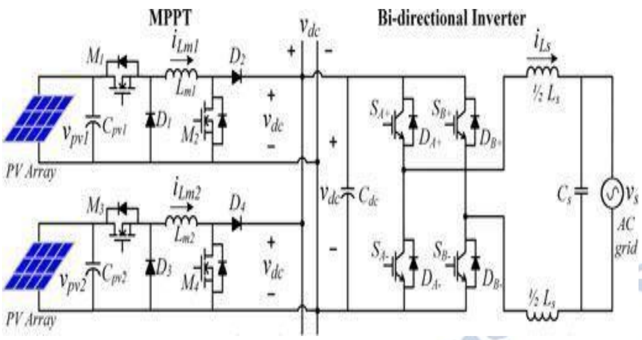

Fig 2 . Circuit diagram for PV Inverter System with the Buck/Boost MPPT Systems

$$d_{boost} = \frac{v_{dc} - v_{PV}}{v_{dc}}$$

(for boost mode) Maximum power from PV arrays, a perturbation and observation control algorithm for tracking maximum power points is adopted. If the maximum power level of a PV array is higher than the power rating of an MPPT, the two MPPTs will be in parallel operation to function as a single MPPT. Thus, it requires an online configuration check to determine the connection types of the two MPPTs, separately or in parallel. Moreover, if the two MPPTs are in parallel operation, a uniform current control scheme is introduced to equally distribute the PVarray output current to the two MPPTs. The operational-mode transition control between buck and boost is also used. Combines buck and boost converters is proposed in this project, in which the control algorithm or tracking maximum power points is based on a perturbation and observation method. The MPPT will switch operation modes between buck and boost when the output voltage of a PV array is close to the dc-bus voltage. The designed controller can switch control laws to achieve smooth mode transition and fulfill online configuration check for the MPPTs, which can be either separate or in parallel connection, to draw the maximum power from the PV arrays more effectively. Additionally, a uniform current control scheme is introduced to the controller to equally distribute the PV-array output current to the two MPPTs in parallel operation. To eliminate leakage ground current circulating through PV arrays andground, several transformer less inverter topologies are proposed.

III. Simulation Model and Results

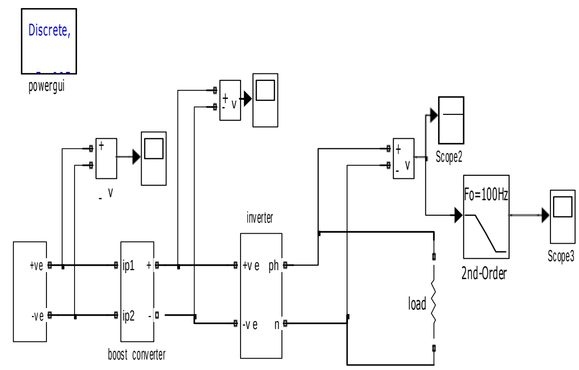

Fig.3. Simulation model for proposed circuit

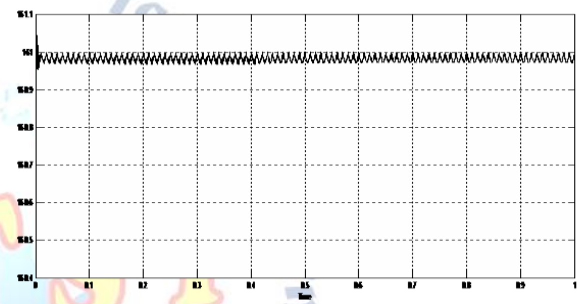

Fig.4. Simulation results for proposed circuit

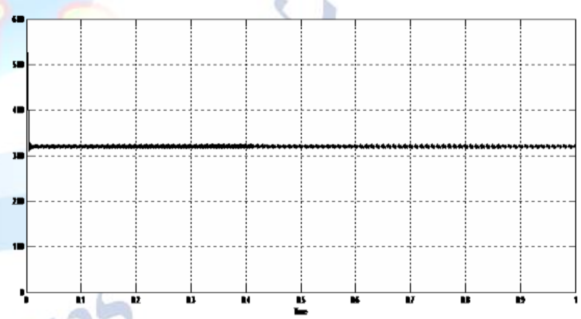

Fig.5. Simulation results for proposed circuit

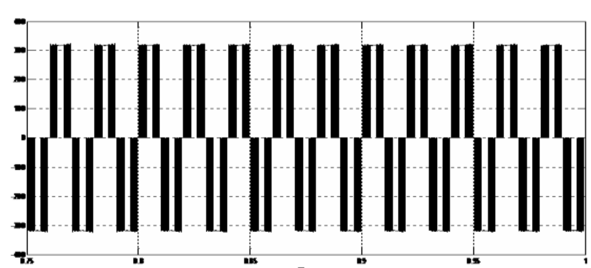

Fig.6. Simulation results for proposed circuit

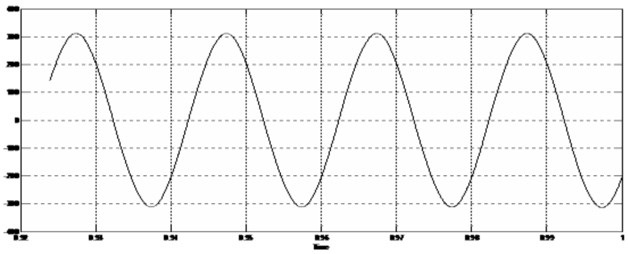

Fig.7. Simulation results for proposed circuit

IV. Conclusion

A single-phase bidirectional inverter with two buck/boost MPPTs has been designed and implemented. The inverter controls the power flow between dc bus and ac grid, and regulates the dc bus to a certain range of voltages. A droop regulation mechanism according to the inductor current levels has been proposed to balance the power flow and accommodate load variation. Since the PV-array voltage can vary from 0 to 600 V, the MPPT topology is formed with buck and boost converters to operate at the dc-bus voltage around 230 V, reducing the voltage stress of its followed inverter. The controller can online check the input configuration of the MPPTs, equally distribute the PV-array output current to the two MPPTs in parallel operation, and switch control laws to smooth out mode transition. Integration and operation of the overall inverter system have been discussed in detail, which contributes to dc- distribution applications significantly. The output voltage is 230 V amplitude in volts and output current is 55A current in amps. The output of PV voltage is 55 V in constant value DC and the output of PV current is 10 amps. A single-phase bidirectional inverter with two buck/boost maximum power point trackers (MPPTs) by using the closed loop circuit. This paper is workout by simulink using matlab .

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