PV Fed Interleaved Superboost Converter with MPPT Controller for Renewable Energy Applications

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Abstract

Generally high voltage boost gain cannot be achieved in conventional step-up converters since the parasitic parameters will set an upper limit on the duty ratio at which the converter can efficiently operate. In recent years many high step-up DC-DC converters have been proposed. Among the developed converters, the high step-up single switch converters exhibit large input current ripple which make them unsuitable to operate at heavy load due to high conduction losses. So a new super boost converter is designed. This converter consists of switched capacitors and two coupled inductors. This combination of coupled inductors and switched capacitors can provide high voltage boost gain while operating with small duty cycle. By using one individual DC voltage source in an interleaved manner the converter can be powered. The configuration of the proposed converter advantages such as low power losses, longer lifetime of input sources due to non-pulsating input current, low voltage stress across the main switches and slow output fluctuation. The concept is to constant voltage By implementing this converter a 22.5 times gain can be reached 0.5 duty ratio and turns ratio equal to 2.Simulation results will be presented to demonstrate the authenticity of the proposed converter.
Keyword- Super boost DC/DC Converter, Photovoltaic systems, Interleaved boost converter, Coupled inductor, MPPT Controller, Incremental conductance algorithm

I. INTRODUCTION

In recent years due to limited resources of fossil fuels and also their environmental impacts such as pollution to the nature renewable energy systems such as PV systems, wind and fuel cells have received much attention[1].Among the renewable energy systems PV systems are expected to play an important role in the future. As two influential factors in regards to the performance and efficiency of a PV system, the impact of characteristic mismatches amongst PV cells and the phenomenon of maximum-power drop due to partial shading have been the subject of intense research. Recently non-isolated high step-up dc–dc converters are used in many applications, such as high-intensity discharge lamp for auto motives, dc back-up energy systems for UPS, renewable energy systems, fuel cell systems, and hybrid electric vehicles. In order to provide high output voltage, the classical boost converter should operate at extreme duty cycle, and hence the rectifier diode must sustain a short pulse current. High step-up converters with coupled inductors can provide high output voltage without using extreme duty cycle and yet reduce the switch voltage stress. With high amplitude [2]. This results in severe reverse recovery as well as high electromagnetic interference problems.

PV cells generate low output voltage so a high step-up DC/DC converter is necessary to boost the PV voltage to a DC load or micro grid voltage or required level of inverter DC link voltage supplying an AC load/utility [3]. By using conventional step-up converter high voltage gain cannot be achieved. Among the developed converters, the high step-up single switch converters exhibit large input current ripple.

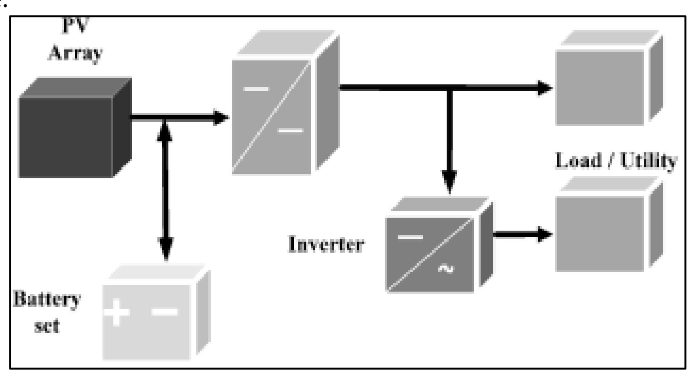

Fig. 1: Typical photo voltaic system

This paper a new high step-up interleaved boost converter is proposed. Proposed interleaved converter can be powered by using either one individual DC source in an interleaved manner or two independent voltage sources as a multiport converter [6]. Interleaved structure includes the combination of coupled inductors and diode-capacitor multiplier stages so super boost gain can be easily achieved with minimum number of multipliers and low turns ratio of coupled inductors while the converter operates at low turns ratio. The proposed converter exhibits high efficiency in a wide range of operation [4]-[5]. It also presents low current ripples and low conduction losses which make it suitable for high power applications. In addition, the voltage stress across the switches and diodes is much lower than the output voltage.

II. CONVERTER STRUCTURE

The proposed interleaved high step-up converter is shown in Fig.2.The coupled inductor can be modeled as the combination of a magnetizing inductor, an ideal transformer and series leakage inductors in each winding.

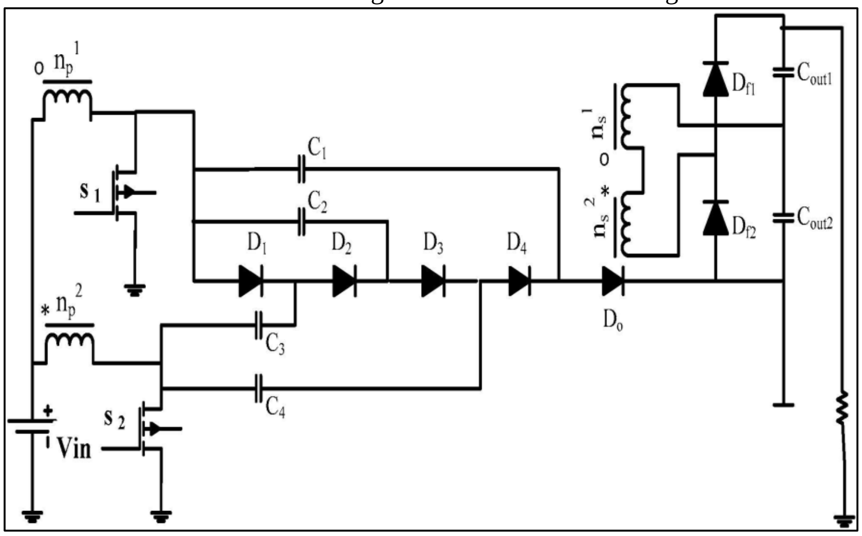

Fig. 2: Proposed converter circuit diagram

The converter is composed of two coupled-inductors and four diode-capacitor voltage multiplier (DCVM) stages. Each DCVM stage consists of one diode and one capacitor. The DVCM stages are inserted between the input and output stages of the converter to enhance the voltage conversion ratio. Here four DCVM stages are used. By increasing the number of DCVM stages, it is possible to reach a higher voltage gain at constant duty ratio. In the circuit analysis, it is assumed that the converter operates in continuous conduction mode (CCM) and the duty ratio of the switches are greater than 0.5. The coupled inductors are resided in the proposed converter so that a modified flyback-forward interleaved structure is formed. The primary windings of the coupled inductors with np^1 and np^2 turns are employed in the input stage to decrease the input current ripple, whereas the secondary windings with ns^1 and ns^2 turns are connected in series with the output stage to enlarge the voltage gain.

III. BLOCK DIAGRAM OF THE SYSTEM

The proposed converter can be powered either by one individual DC voltage source in an interleaved manner or two independent DC voltage sources as a multiport converter. It also presents low current ripples and low conduction losses which make it suitable for high power applications. In addition, the voltage stress across the switches and diodes is much lower than the output voltage.

Solar cell is given as the input supply as DC voltage source. Solar cells are connected in series and parallel to set up the solar array. Solar cell can be regarded as a non-linear current source. Its generated current depends on the characteristic of material, age of solar cell, irradiation and cell temperature. The output voltage from the solar cell is given to the interleaved boost converter with voltage multiplier. By using CRO the output voltage is measured. The PIC Microcontroller will controls the signals from input and output. Driver circuit also need to control the circuit components of the converter. The 12V DC power supply is given to the driver circuit and 5V DC supply is given to the PIC microcontroller.

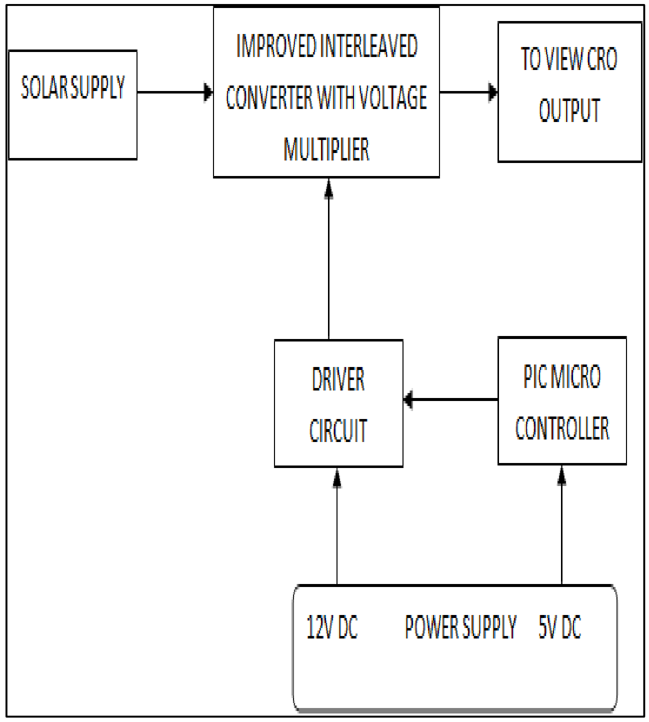

Fig. 3: Block diagram of proposed converter

IV. DESIGN OF PROPOSED SYSTEM

In order to simplify the circuit analysis of the proposed converter, some assumptions are made as follows

1) All of the circuit components are considered ideal and there is no power loss in the system.
2) The proposed converter is operating in CCM and in the steady-state condition
3) The leakage inductance of the coupled inductors are neglected.
4) The capacitors are sufficiently large, such that the voltages across them are considered as constant

A. Voltage Gain of the Converter

We are having capacitor voltages in the DCVM stages and the relation between capacitor voltages can be written as

$$V_{C3} = V_{C4} - V_{C2} = V_{Cout3} - V_{Cl} = 1/(1-D)V_{in} \quad (1)$$

$$V_{Cl} - V_{C4} = V_{C2} - V_{C3} = -1/(1-D)V_{in} \quad (2)$$

From (1) and (2) capacitor voltages C_1-C_4 and C_{out3} Can derived as

$$V_{C3} = 1/(1-D)V_{in} \quad (3)$$

$$V_{C2} = V_{C3} + 1/(1-D)V_{in} = 2/(l-D)V_{in} \quad (4)$$

$$V_{C4} = V_{C2} + 1/(1-D)V_{in} = 3/(l-D)V_{in} \quad (5)$$

$$V_{Cl} = V_{C4} + 1/(1-D)V_{in} = 4/(l-D)V_{in} \quad (6)$$

$$V_{Cout3} = V_{Cl} + 1/(1-D)V_{in} = 5/(1-D)V_{in} \quad (7)$$

When S_1 is ON and S_2 is OFF, V_{Cout1} is equal to the sum of the secondary voltage of the coupled inductors. When S2 is ON and S_1 is OFF, V_{cout2} is also equal to the sum of the secondary voltage of the coupled inductors. Therefore, the voltage V_{Coutl} and V_{Cout2} can be obtained by (8)

$$V_{Coutl} = V_{Cout2} = n.V_{in}(1+D/1-D) \quad (8)$$

The output voltage is derived from (9):

$$V_o = V_{Coutl} + V_{Cout2} + V_{Cout3} = 2n+5/1-D \quad (9)$$

Thus, the voltage gain of the proposed converter can be
Expressed as:

$$M = V_o/V_{in} = 2n+5/1-D \quad (10)$$

From the above equation (10) it is clear that the proposed converter is able to provide a high voltage gain without requiring an extreme duty ratio.

B. Incremental Conductance Algorithm

The disadvantage of the perturb and observe method to track the peak power under fast varying atmospheric condition is overcome by IC method. The IC can determine that the MPPT has reached the MPP and stop perturbing the operating point. If this condition is not met, the direction in which the MPPT operating point must be perturbed can be calculated using the relationship between dl/dV and –I/V This relationship is derived from the fact that dP/dV is negative when the MPPT is to the right of the MPP and positive when it is to the left of the MPP.

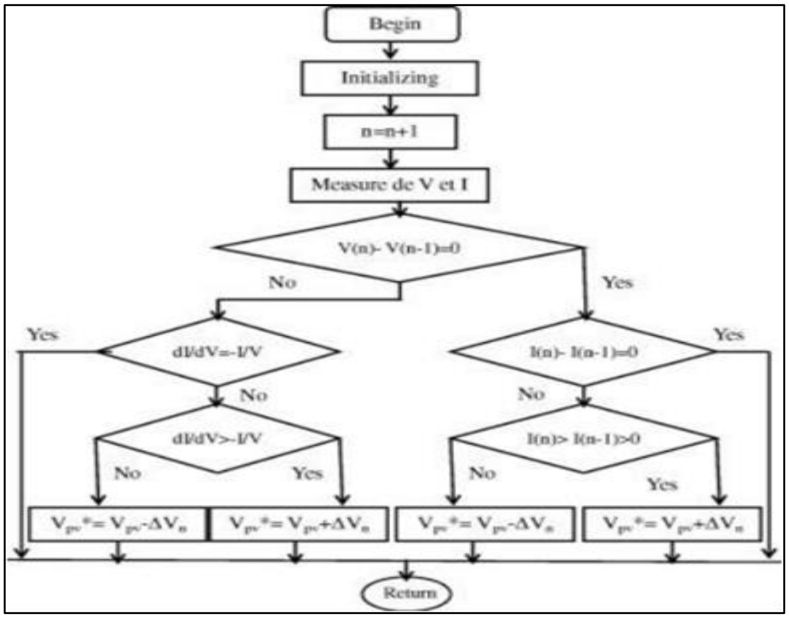

Fig. 4: Flowchart of IC algorithm

The basic relations of this IC method are as follows.
$dI\ dV = -\ I\ V$ At MPP
$dI\ dV > -\ I\ V$ Left of MPP
$dI\ dV < -\ I\ V$ Right of MPP

Where I and V are P-V array output current and voltage respectively. Fig.4 shows the flowchart of incremental conductance algorithm. The left hand side of equations represents incremental conductance of P-V module and the right hand side represents the instantaneous conductance. When the ratio of change in output conductance is equal to the negative output conductance, the solar array will operate at the maximum power point.

V. SIMULATION RESULTS

In this section simulation results of a DC/DC system are presented to verity the effectiveness of the proposed converter. The simulation model of proposed PV fed interleaved super boost converter with MPPT controller for renewable application is developed in MATLAB/simulink software. Following Fig. 5. Represents the simulation model of the proposed system.

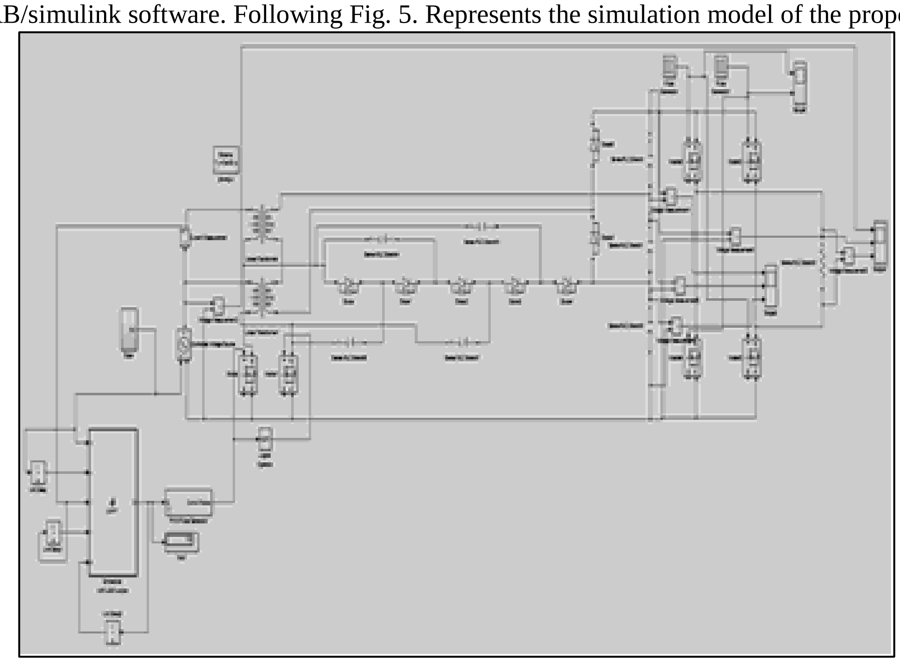

Fig. 5: Simulation Diagram

The Fig.7 represents the solar input voltage and Fig.8 and Fig.9 Represents the converter and inverter output voltage waveforms.

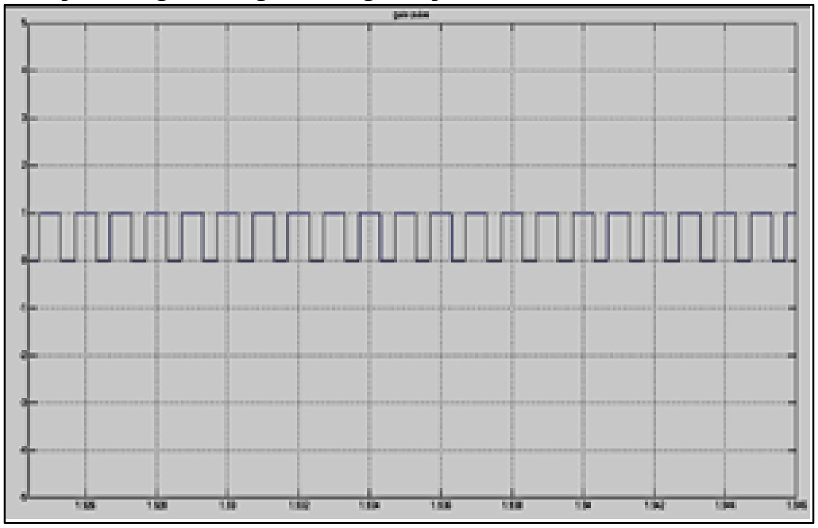

Fig. 6: Gate Pulse

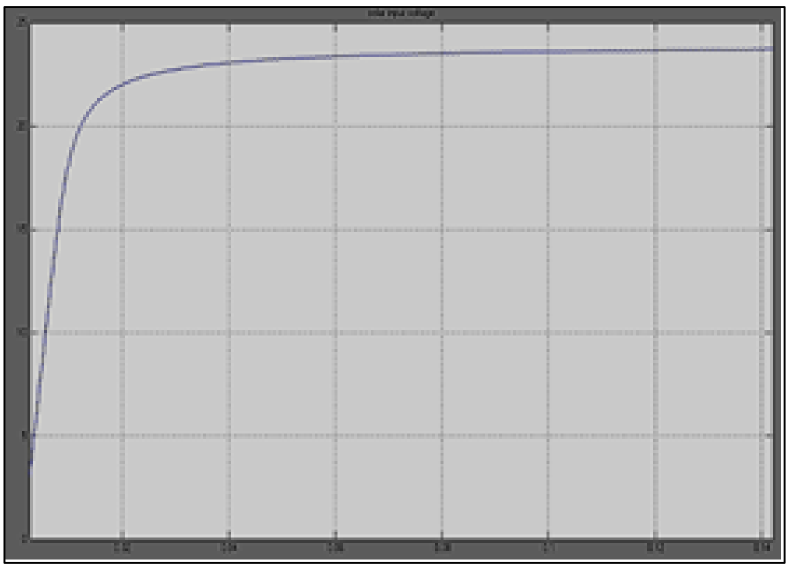

Fig. 7: Solar Input Voltage

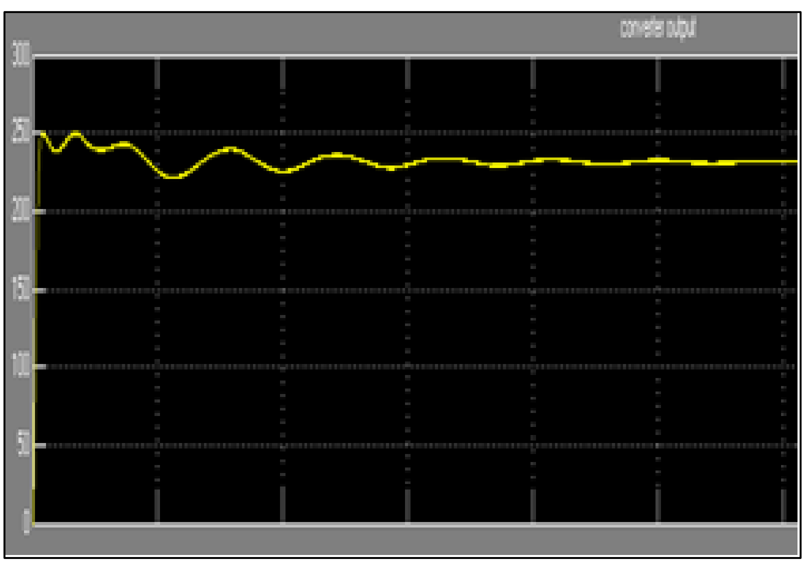

Fig. 8: Converter Output Voltage

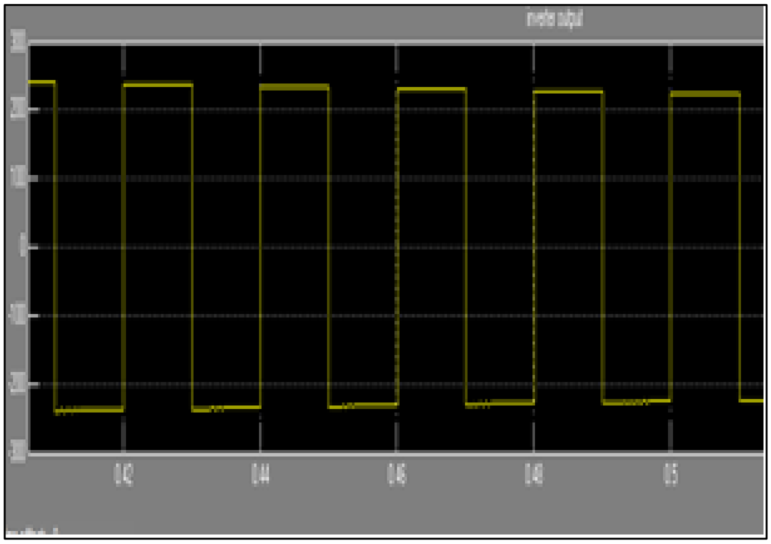

Fig. 9: Inverter Output Voltage

VI. CONCLUSION

In this paper a super boost high step-up interleaved converter with MPPT controller is reviewed and investigated. This converter includes coupled inductors and diode capacitor mulpilers stages. By using minimum number of multipliers and with turns ratio of 0.5 high step-up gain is achieved. The proposed converter exhibits high efficiency in a wide range of operation which makes it suitable for high power application. The proposed converter needs the lowest duty ratio which leads to the minimum conduction losses and hence the maximum efficiency .The simulations results verify the authenticity of the theoretical analysis and the effectiveness of the proposed system as a super high step-up converter.

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