MODELLING AND SIMULATION OF NEW HYBRID BOOSTING CONVERTER FOR PHOTOVOLTAIC SYSTEM

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ABSTRACT

A hybrid boosting converter (HBC) with collective advantages of regulation capability from its boost structure and gain enhancement from its voltage multiplier structure is proposed in this paper. The new converter incorporates a bipolar voltage multiplier, featuring symmetrical configuration, single inductor and single switch, high gain capability with wide regulation range, low component stress, small output ripple and flexible extension, which make it suitable for front-end PV system and some other renewable energy applications. The operation principal, component stress, and voltage ripple are analyzed in this paper. Performance comparison and evaluation with a number of previous single-switch single-inductor converters are provided.

Index Terms—Bipolar voltage multiplier (BVM), hybrid boosting converter (HBC), nature interleaving, renewable energy, singleswitch single inductor**.**

1. INTRODUCTION

The invention of electricity is one of the greatest of its wonders. Indeed, we cannot even dream of living in absence of electricity in modern world. The economic growth of a country greatly depends on Electric Energy. Increasing demand of electricity and decaying nature of non-renewable energy needs alternate energy resources. Even more importantly, renewable energy produces little or no waste products such as carbon dioxide or other chemical pollutants, so has minimal impact on the environment. Renewable energy also has the advantage of allowing decentralized distribution of energy particularly for meeting rural energy needs. Out of all the renewable energy, solar energy becomes more popular because of its simple structure. Many researchers and scientists contribute towards the development of solar energy in order to increase the conversion efficiency, extracting maximum power. The converter used in solar energy systems plays significant role in energy conversion. These converters are classified in to two types viz multiple converter and multi input converter. A MIC [1] has the following advantages compared to a combination of several individual converters like cost reduction, compactness and more expandability. MICs are being used in aerospace, electric and hybrid vehicles, sustainable energy sources and micro grid applications. In a power system the combination of more power sources make it possible to obtain higher availability. A parallel connection of converters has been used to integrate more than one input energy sources in a power system. The Multi-input DC–DC Converter proposed in [2] has the capability of operating in different Converter topologies (Buck, Boost, and Buck–Boost) in addition to its Bidirectional operation and positive output voltage without any additional transformer.

II.OPERATION PRINCIPLE

A. INDUCTIVE SWITCHING CORE

Here the inductor, switch and input source serve as an inductive switching core as shown in Fig.1.This generates two complementary PMW voltage waveforms at port AO and port OB.Even if the two voltages waveforms have their individual high voltage level and low voltage level, the gap between the two levels is identical, which is an important feature for interleaving operation.

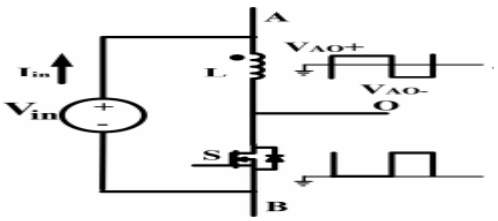

Fig.1.Inductive three-terminal switching core

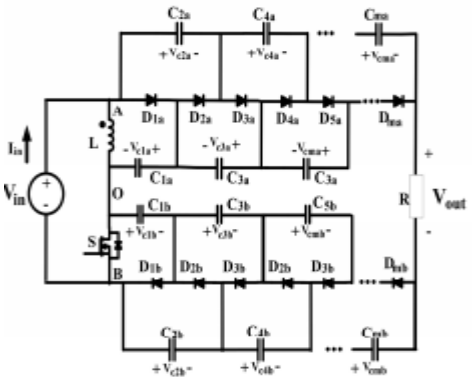

Fig.2. Even order HBC

B. BIPOLAR VOLTAGE MULTIPLIER (BVM)

A BVM comprises of a positive multiplier branch and a negative multiplier branch. Positive multiplier is the same as the traditional voltage multiplier while the negative multiplier has the input at the cathode terminal of cascaded diodes, which can generate negative voltage at anode terminal.

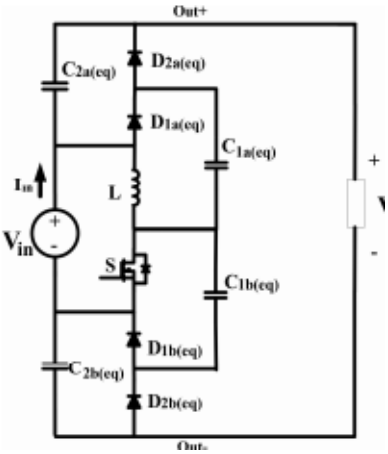

Fig.3.Equivalent even order HBC

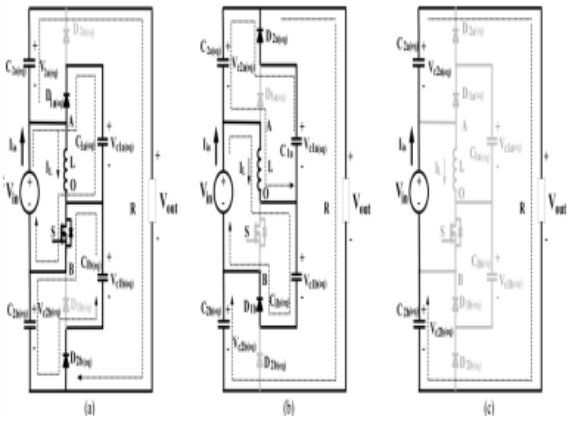

Fig.4.Three operation modes

C. OPERATION PRINCIPLE OF HBC

The general even-order HBC in Fig.2.simplied to an equivalent HBC circuit as shown in Fig.3. Careful examination indicates that two "boost" like sub circuits are intertwined through operating active switch S.The total output voltage of HBC is the sum of the output voltage of two boost sub circuits and the input voltage.Three operation modes are described as shown in Fig.4.

1) Mode 1[0,DTs]: InFig.4a, switch S is turned ON and diodes D1a(eq),D2b(eq) conduct while diodes D2a(eq) and D1b(eq) are reversely biased.The inductor L is charged by the input source. Meanwhile, capacitorC1a(eq).At this interval, following equations can be derived based on the inductive switching core analysis:

$$V_{AO+} = V_{in} V_{OB-} \quad (1)$$

2)Mode 2[DTs,(D+D1)Ts]:As picturized in Fig.4b,when S is turned OFF,the inductor current will free wheel through diodesD2a(eq) and D1b(eq).The inductor is shared by two charging boost loops.In the top loop,capacitor C1a(eq) is releasing energy to capacitor C2a(eq) and load at the same time.In the bottom loop,input source charges capacitor C1b(eq) the inductor L. During this time interval voltage, generated at AO and OB is expressed as follows based on the inductor balance principle

$$V_{AO+} = -V_{in} \frac{D}{D_1} \quad (2)$$

3)Mode 3[(D+D1)Ts,Ts]:At this condition, the circuit will work under DCM operationmode,thus the third state in Fig.4c.appear.At this state,the switch S is kept OFF.The inductor current has dropped to zero and all the diodes are blocked.TheC2a(eq) and C1a(eq) are in series with input source to power the load.During this time interval,voltage generated at port AO is zero while at OB is Vin.

III. PHOTOVOLTAIC MODULE:

Modelling is the basis for computer simulation of a real system. It is usually based on a theoretical analysis of the various physical processes occurring in the system and of all factors influencing these processes.. The most common model used to predict energy production in photovoltaic cell modelling is the single diode circuit model that represents the electrical behaviour of the pn-junction is given in fig 5 Figure shows how photovoltaic system works. The ideal photovoltaic module consists of a single diode.

A solar cell is the building block of a solar panel. A photovoltaic module is formed by connecting many solar cells in series and parallel. Considering only a single solar cell; it can be modelled by utilizing a current source, a diode and two resistors. This model is known as a single diode model of solar cell

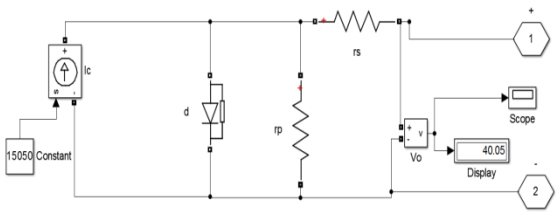

Figure 5: Single diode model of a solar cell

IV SIMULATION RESULTS

In order to verify the feasibility of proposing converter and its performance, simulationresults of a new HBC are provided. The input current is pulsating without terminating to zero and no rush current is observed due to the operation frequency is chosen properly. The output voltage is boosted to 415V and kept stable without high voltage rating filter capacitor. Fig.6. shows Simulink model of proposed converter.

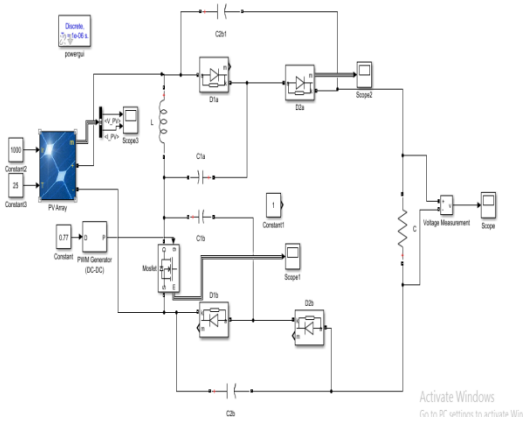

Fig 6 simulink model of proposed system

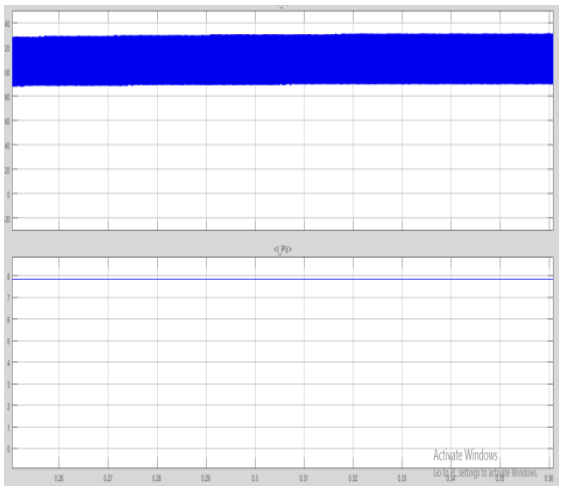

Fig 7 PV panel voltage & current

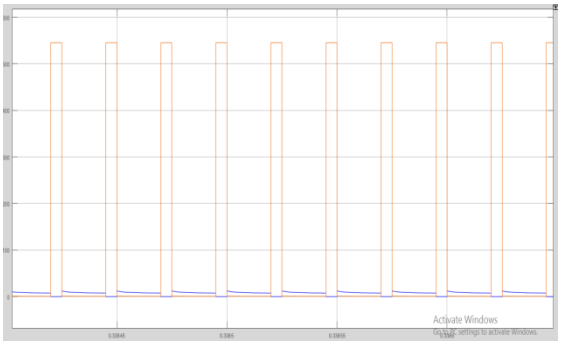

Fig 8 D2a voltage & current

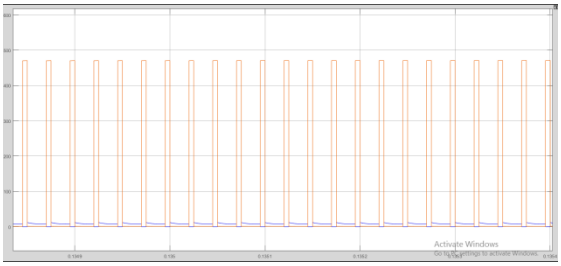

Fig 9 switch voltage&current

V.CONCLUSION

Proposed new HBC composed of an inductive core and BVM is useful for renewable energy applications. Collective advantages of proposed method are gain boosting technique from the voltage multiplier and voltage regulation capability featuring in nature interleaved operation, wide regulation range, low component stresses, small output ripple, flexible gain extension and high efficiency. Compared with other gain boosting technologies like tapped inductor or transformer based method the proposed topology reduces the complexity which is applicable for mass production and it has a better component utilization factor compared with other single switch single inductor DCDC converters. This work provides operation principle and design consideration

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