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A High Voltage Gain DC To DC Converter For Distributed Generation Systems with MPPT Controller

KEYWORDS: Distributed Generation, MPPT, coupled inductor

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ABSTRACT *This paper presents, a high voltage gain dc–dc converter for distributed generation (DG) systems with MPPT controller. A high step-up ratio and clamp- mode converter are proposed to achieve high voltage gain and high efficiency. This can be obtained by using two capacitors and one coupled inductor. During the switch-off period, the capacitors are charged in parallel and during the switch-on period they are discharged in series by the energy stored in the coupled inductor. A passive clamp circuit is used to recycle the leakage –inductor energy of the coupled inductor, thus voltage stress on the main switch is reduced. The control method for the circuit is implemented using a MPPT controller which tracks the maximum power of the sources. The converter is suitable for high power applications because of the reduced conduction loss and low input current ripple. The operating principle and MATLAB simulations are discussed in detail.*

I. INTRODUCTION

Distributed generation systems based on renewable energy sources have an important role in recent power generation. It is a technique that employs small-scale technologies like photovoltaic (PV) cells, fuel cells and wind power to produce electricity close to the end users of power. Compared to traditional power generators, distributed generators can provide lower-cost electricity and higher power reliability and security with fewer environmental consequences .But these are low voltage sources, thus high step-up dc-dc converters with good efficiency are necessary for connecting these for high voltage applications.

For high voltage applications pv cells can connect series but it will suffer shadow effect. To step from low voltage to high voltage, high step-up dc-dc converters are usually used as the front-end converters which are required to have a large conversion ratio, high efficiency and small volume. Theoretically the conventional boost converter can provide a high step-up voltage gain with a duty cycle greater than 0.9.

But in practice, it cannot achieve a high voltage gain with parasitic parameter limitations.

Many step- up converters have been proposed to improve the conversion efficiency .The switched capacitor technique can provide a high step-up voltage gain, but the conduction loss and voltage stress on the switch is more.

The coupled inductor technique can be used to obtain a high step-up gain, but the conversion efficiency is limited by the leakage inductor.

II. MAXIMUM POWER POINT TRACKING

Maximum Power Point Tracking is a technique that grid connected inverters, solar battery chargers and similar devices used to get maximum possible power from one or more pv devices. The purpose of the MPPT systems is to sample the output of the cells and apply the proper load to obtain maximum power for any given environmental conditions.

MP PT CONTROLLER

MPPT controller is an electronic system that operates the pv modules in a manner that allows the module to produce all the power they are capable of. It is a fully electronic system that varies the electrical operating point of the modules so that, the modules are able to deliver maximum available power.

MPPT ALGORITHM

MPPT algorithms are necessary because PV arrays have a non linear voltage – current characteristic with a unique point. The main problem solved by the MPPT algorithms is to automatically find the panel operating voltage that allows maximum power output. Different types of algorithms are

Constant voltage MPPT algorithm

Perturb and Observe (P&O) MPPT algorithm

Incremental Conductance (INC) MPPT algorithm

III. PROPOSED SYSTEM

The proposed converter combines the switched capacitor and coupled inductor techniques. A high step-up ratio and clamp-mode converter are purposed, to achieve a high voltage gain and high efficiency. The switching circuit is formed by using two capacitors and two diodes and connected to the secondary side of the coupled inductor to achieve a high voltage gain. The capacitors are charged in parallel and discharged in series by the coupled inductor. A passive clamp circuit is used to clamp the voltage level on the switch. By properly adjusting the coupling of the inductors, the input current ripple can be reduced. .

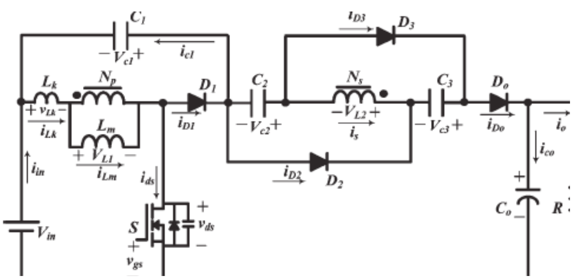

Fig.1. Equivalent circuit of the converter

III. OPERATING PRINCIPLE

There are two modes of operation for the proposed converter, Continuous Conduction Mode (CCM) and Discontinuous Conduction Mode (DCM). The power flow direction of each mode can be explained in the following analysis.

CCM OPERATION

There are five operating modes in one switching period in

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the case of CCM operation. They are described as follows.

Mode I: During this mode, Switch *S* and diodes *D*2 and *D*3 are turned on. Diodes *D*1 and *Do* are turned off. The secondary-side current of the coupled inductor is decreased linearly due to the leakage inductor *Lk*. Energy to load *R* is provided by output capacitor *Co*. This operating mode ends at current *iD*2 equals zero.

Mode II: In this mode, *S* and *Do* turned on. Diode *D*1, *D*2, and *D*3 are turned off. Energy generated by the source *Vin* is stored by magnetizing inductor *Lm*. Through the coupled inductor, some of the energy of source *Vin* transfers to the secondary side. *Vin*, *VC*1, *VC*2, and *VC*3, which are connected in series, discharge to high-voltage output capacitor *Co* and load *R* because of the induced voltage *VL*2 on the secondary side of the coupled inductor. When switch *S* is turned off, this operating mode ends.

Mode III: During this mode, *S* and Diode *D*1, *D*2, and *D*3 are turned off .*Do* is turned on. The parasitic capacitor *Cds* of main switch *S* is charged by the energies of leakage inductor *Lk* and magnetizing inductor *Lm*. *Co* provides its energy to load *R*. This operating mode ends when diode *D*1 conducts.

Mode IV: In this mode *S* and diodes *D*2 and *D*3 are turned off. Diodes *D*1 and *Do* are turned on. The clamp capacitor *C*1 is charged by the energies of leakage inductor *Lk* and magnetizing inductor *Lm*. The leakage inductor energy is recycled and current through *Lk* decreases quickly. High-voltage output capacitor *Co* and load *R* are charged in series by the secondary-side voltage *VL*2 of the coupled equal to zero. Diodes *D*2 and *D*3 start to turn on. This operating mode ends when current through output diode is equal to zero.

5) Mode V: During this mode, *S* and Do are turned off. Diode *D*1, *D*2, and *D*3 are turned on. Output capacitor is discharged to load *R*. Clamp capacitor *C*1 inductor until the secondary current of the coupled inductor is charged by the energies of leakage inductor *Lk* and magnetizing inductor *Lm* Capacitors *C*2 and *C*3 are charged by released energy of the magnetizing inductor *Lm* via the secondary side of the coupled inductor. Thus, capacitors *C*2 and *C*3 are charged in parallel. When *S* is turned on at the beginning of the next switching period, this mode ends.

DCM OPERATION

Leakage inductor *Lk* of the coupled inductor is neglected to simplify the analysis of DCM operation. In DCM operation, there are three modes and are described as follows.

Mode I: During this mode *S* is turned on. The magnetizing inductor *Lm* stores the energy from dc source *Vin*. The input energy is transferred to the secondary side of the coupled inductor, which is connected with capacitors *C*2 and *C*3 in series to provide their energies to output capacitor *Co* and load *R*. This mode ends when *S* is turned off.

Mode II: In this mode, *S* is turned off. Magnetizing inductor energy transfers its energy to capacitors *C*1, *C*2, and *C*3. Output capacitor *Co* provides its energy to load *R*. This mode ends when the energy stored in *Lm* is depleted.

Mode III: During this mode, *S* remains turned off. The energy stored in *Co* is discharged to load *R*, because the energy stored in *Lm* is depleted. This mode ends when *S* is turned on.

IV. BASIC SIMULATION

The converter proposed can be simulated with MATLAB software.

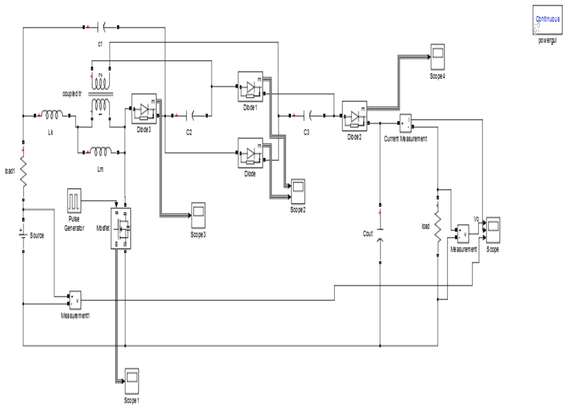

Fig.2. Simulink model

The input and output voltage and current waveforms for the simulation are as shown figure below. An input voltage of 24V is applied. It is rectified and then regulated. The output voltage and current are obtained as 410V and 0.06mA. .

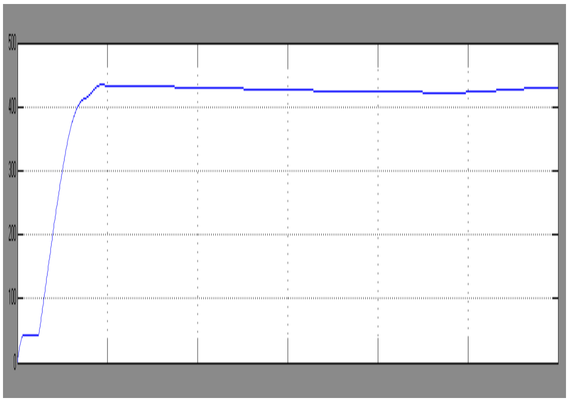

Fig.3. Output voltage waveform

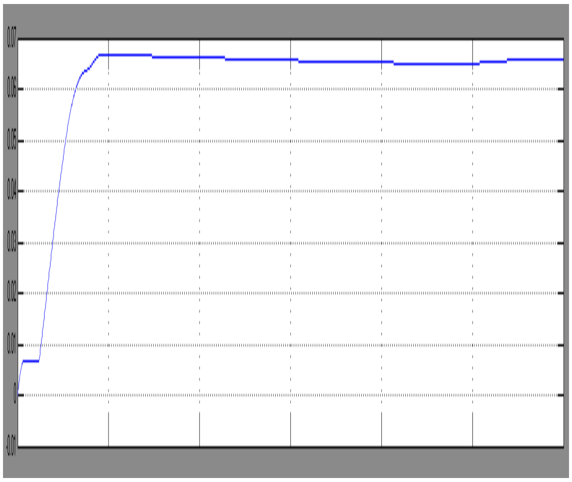

Fig. 4. Output current waveform

V SIMULATION WITH MPPT CONTROLLER

The converter proposed is for distributed generation systems so it can be simulated in MATLAB software with a pv array as input. MPPT controller is used to get the maximum output. The simulink model of the system is shown in figure 5

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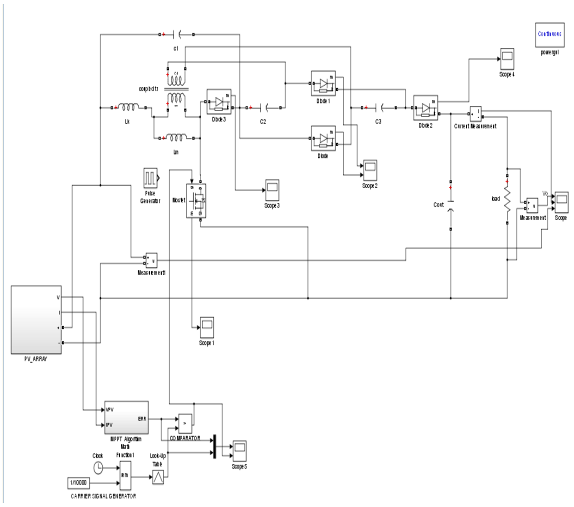

Fig.5. Simulink model

The algorithm used in this circuit is Constant Voltage MPPT algorithm. The simulink model of the MPPT algorithm and PI controller are shown in figure 3 and figure 4.

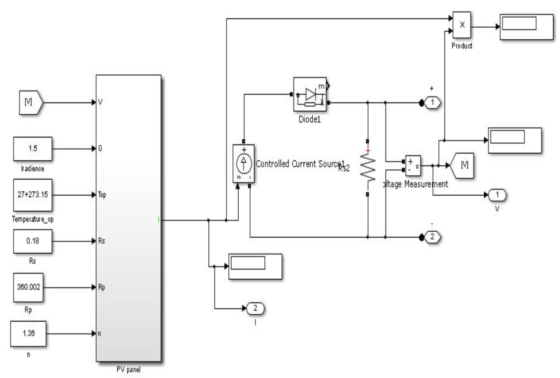

Fig.6. Simulink model for MPPT algorithm

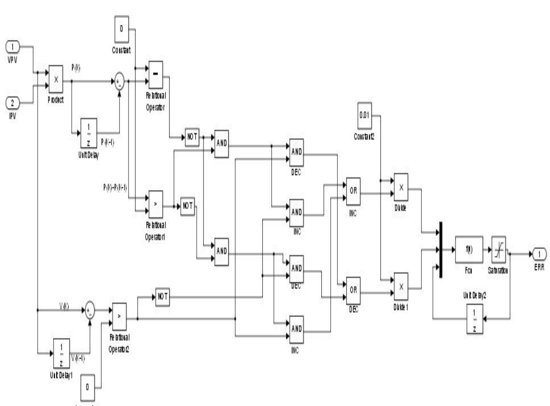

Fig.7. Simulink model for PI controller

The input to the converter is of the PV array, that can be depends on the environmental factors such as temperature and irradiation. The input voltage wave form is shown in figure 8.

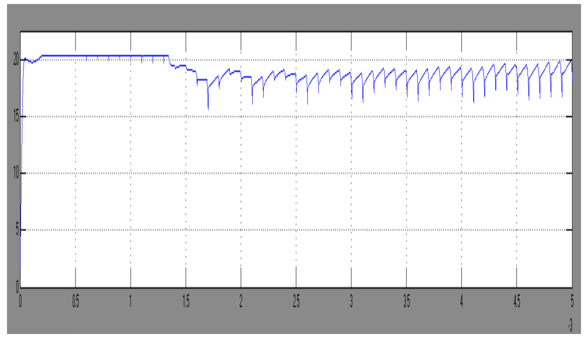

Fig.8. Input voltage wave form

The output voltage and current wave forms are shown in figure 9 and figure 10.

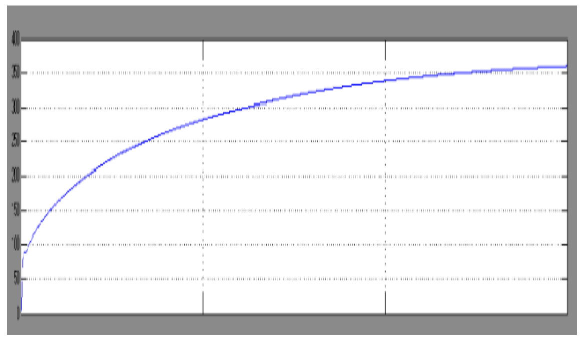

Fig.9. Output voltage wave form

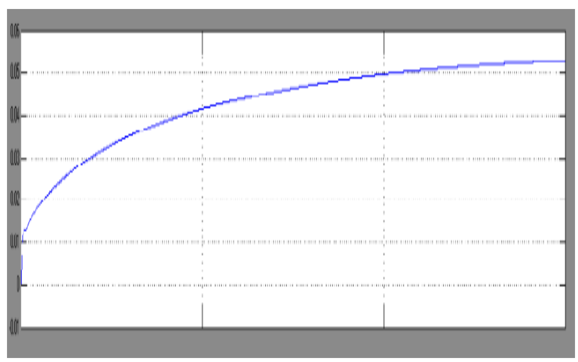

Fig.10. Output current wave form

TABLE 1: COMPARISON OF SIMULATION RESULTS

PARAMETER MEASURED	BASIC SIMULATION	WITH MPPT CONTROLLER
Input voltage	24V	20V
Output voltage	410V	360V
Output current	0.06mA	0.052mA

VI. ADVANTAGES OF PROPOSED SYSTEM

The converter is characterized by a low input current ripple and low conduction losses, making it suitable for high-power applications.

The converter achieves the high step-up voltage gain that distributed generation systems require.

Leakage energy is recycled and sent to the output terminal, and alleviates large voltage spikes on the main switch.

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The main switch voltage stress of the converter is substantially lower than that of the output voltage.

VII. CONCLUSION

In this paper a novel high step-up dc-dc converter for DG systems are discussed. By using the capacitor charged in parallel and discharged in series by the coupled inductor this converter provide high step-up voltage gains and high efficiency. It also has low input current ripple and low conduction losses, making it suitable for high power applications. The turn ratio of the coupled inductor is 1:4, but the output voltage of the converter is 16 times greater than the input voltage. The simulation result with MPPT controller is also has a high voltage gain, reveals the converter is suitable for high power applications.

REFERENCE

[1] A. Timbus, M. Liserre, R. Teodorescu, P. Rodriguez, and | | F. Blaabjerg, “Evaluation of current controllers for distributed power generation systems,” | | IEEETrans.Power Electron., vol. 24, no. 3, pp. 654–664, Mar. 2009. | | [2] Y. A.-R. I. Mohamed and E. F. El Saadany, “Hybrid variable-structure control with evolutionary optimum-tuning algorithm for fast grid-voltage regulation using inverter-based distributed generation,” IEEE Trans. Power Electron., vol. 23, no. 3, pp. 1334–1341, May 2008. | | [3] T. Shimizu, K. Wada, and N. Nakamura, “Flyback-type single-phase utility | | interactive inverter with power pulsation decoupling on the dc input for an ac photovoltaic module system,” IEEE Trans. Power Electron., vol. 21, no. 5, pp. 1264–1272, Sep. 2006. | | [4] A. M. Salamah, S. J. Finney, and B. W. Williams, “Single-phase voltage | | source inverter with a bidirectional buck–boost stage for harmonic injection | | and distributed generation,” IEEE Trans. Power Electron., vol. 24, no. 2, pp. 376–387, Feb. 2009. | | [5] Q. Zhao and F. C. Lee, “High-efficiency, high step-up dc– dc converters,” | | IEEE Trans. Power Electron, vol. 18, no. 1, pp. 65–73, Jan. 2003. | | [6] L. S. Yang, T. J. Liang, and J. F. Chen, “Transformer-less dc–dc converter | | with high voltage gain,” IEEE Trans. Ind. Electron., vol. 56, no. 8, pp. 3144–3152, Aug. 2009. | | [7] B. Axelrod, Y. Berkovich, and A. Ioinovici, “Switched-capacitor/ | | Switched -inductor structures for getting transformer less hybrid dc–dc PWM converters,” IEEE Trans. Circuits Syst. I, Reg. Papers, vol. 55, no. 2, pp. 687–696, Mar. 2008. | | [8] R. J. Wai and R. Y. Duan, “High-efficiency dc/dc converter with highvoltage gain,” Proc. Inst. Elect. Eng.— Elect. Power Appl., vol. 152, no. 4,pp. 793–802, Jul. 2005. |