



## IMPLEMENTATION OF BOOST CONVERTER WITH VOLTAGE MULTIPLIER MODULE FOR A PHOTOVOLTAIC SYSTEM

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### ABSTRACT

DC-DC Boost converter is developed with high voltage step-up conversion ratios. A boost converter is used as frontend photovoltaic system. The voltage multiplier module attains high step up gain without operating with high duty ratio. It contains conventional boost converter and coupled inductors. Additional boost converter is integrated in first phase to obtain higher voltage conversion ratio. The two-phase configuration reduces the current stress through power switch and constrains input current ripple, which decreases the conduction losses of MOSFETs. In boost converters, an LC-circuit with high quality factor (Q-factor) is employed to amplify the dc input voltage to required high voltage level. For this, MOSFET power switch is employed to make and break a high current pulse through the inductance. When current is made to flow through inductance, energy is stored in inductance and when this current is cut the stored energy in inductance is transferred to Capacitance, which results in a high voltage across capacitor and this high voltage is filtered and fed to dc-bus. The proposed circuit with a 12v input voltage and 118v output voltage. The efficiency is 99%.Efficiency is high because energy stored in leakage inductances is recycled to the output terminal.

### 1. INTRODUCTION

The increasing number of renewable energy sources and distributed generators requires new strategies for the operation and management of the electricity grid in order to maintain or even to improve the power-supply reliability and the quality of source present. In addition, liberalization of the grids leads to new management structures, in which trading energy and power is becoming increasingly important. The power-electronic technology plays an important role in distributed generation and in integration of renewable energy sources into the electrical grid and it is widely used and rapidly expanding as these applications become more integrated with the grid-based systems. During the last few years, power electronics has undergone a fast evolution, which is mainly due to two factors. The first one is the development of fast semiconductor switches that are capable of switching quickly and handling high powers. In renewable energy systems, photovoltaic systems are expected to play an important role in future energy production. Such systems transform light energy into electrical energy, and convert low voltage

into high voltage via a step-up converter, which can convert energy into electricity using a grid-by-grid inverter or store energy into a battery set. The Boost converter performs importantly among the system because the system requires a sufficiently high step-up conversion.

The performance of the converter is similar to an active-clamped fly back converter; thus, the leakage energy is recovered to the output terminal. Despite these advances, conventional step-up converters with a single switch are unsuitable for high-power applications given input large current ripple, which increases conduction losses. Thus, numerous interleaved structures and some asymmetrical interleaved structures are extensively used. The current study also presents an asymmetrical interleaved converter for a high step-up and high-power application. It obtains extra voltage gain through the voltage-lift capacitor, and reduces the input current ripple, which is suitable for power factor correction (PFC) and high-power applications. In this paper, an asymmetrical interleaved high step-up converter that

combines the advantages of the aforementioned converters is proposed, which combined the advantages of both. In the voltage multiplier module of the proposed converter, the turn's ratio of coupled inductors can be designed to extend voltage gain, and a voltage-lift capacitor offers an extra voltage conversion ratio. The conventional sources of energy are rapidly depleting and the cost of energy is rising, photovoltaic energy becomes a promising alternative source. Its advantages are abundant, pollution and recyclable.

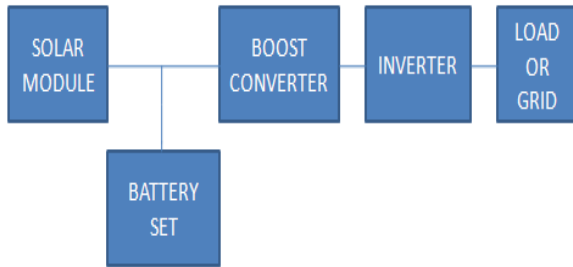


Fig1 shows Typical Photovoltaic system Operating Principle Description

The proposed boost converter with voltage multiplier module is shown in diagram. A conventional boost converter and two coupled inductors are located in the voltage multiplier module, which is located on a boost converter to form an asymmetrical interleaved structure. Primary windings of the coupled inductors with  $N_p$  turns are employed to decrease input current ripple, High step up converter with voltage multiplier and secondary windings of the coupled inductors with  $N_s$  turns are connected in series to extend voltage gain.

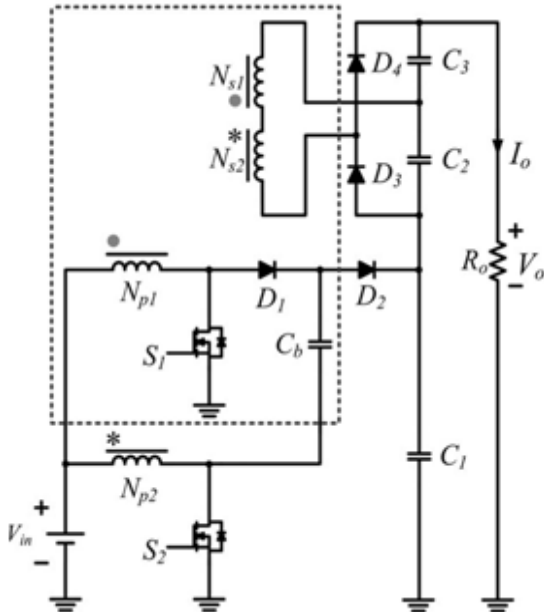


Fig2 shows proposed high step up converter with a voltage multiplier module.

The turn's ratios of the coupled inductors are the same. The coupling references of the inductors are denoted. The equivalent circuit of the proposed converter is shown where  $L_{m1}$  and  $L_{m2}$  are the magnetizing inductors. Where  $L_{k1}$  and  $L_{k2}$  represent the leakage inductors,  $S_1$  and  $S_2$  denote the power switches,  $C_b$  is the voltage-lift capacitor, and  $n$  is defined as a turn's ratio  $N_s / N_p$ . The proposed converter operates in continuous conduction mode (CCM), and the duty cycles of the power switches during steady operation are interleaved with a 180° phase shift; the duty cycles are greater than 0.5.

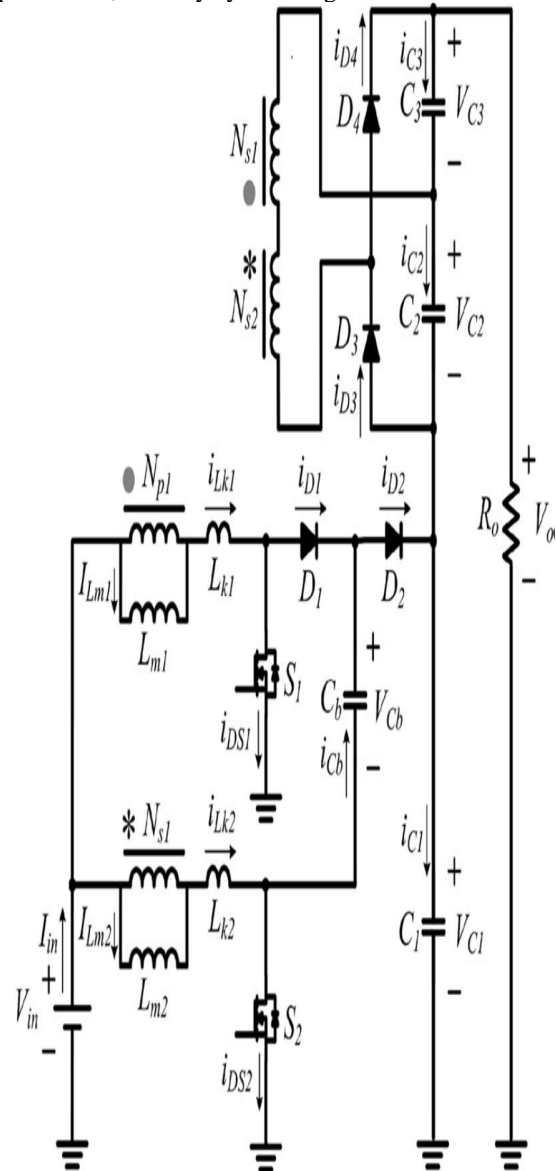


Fig.3 shows Equivalent circuit of proposed converter.

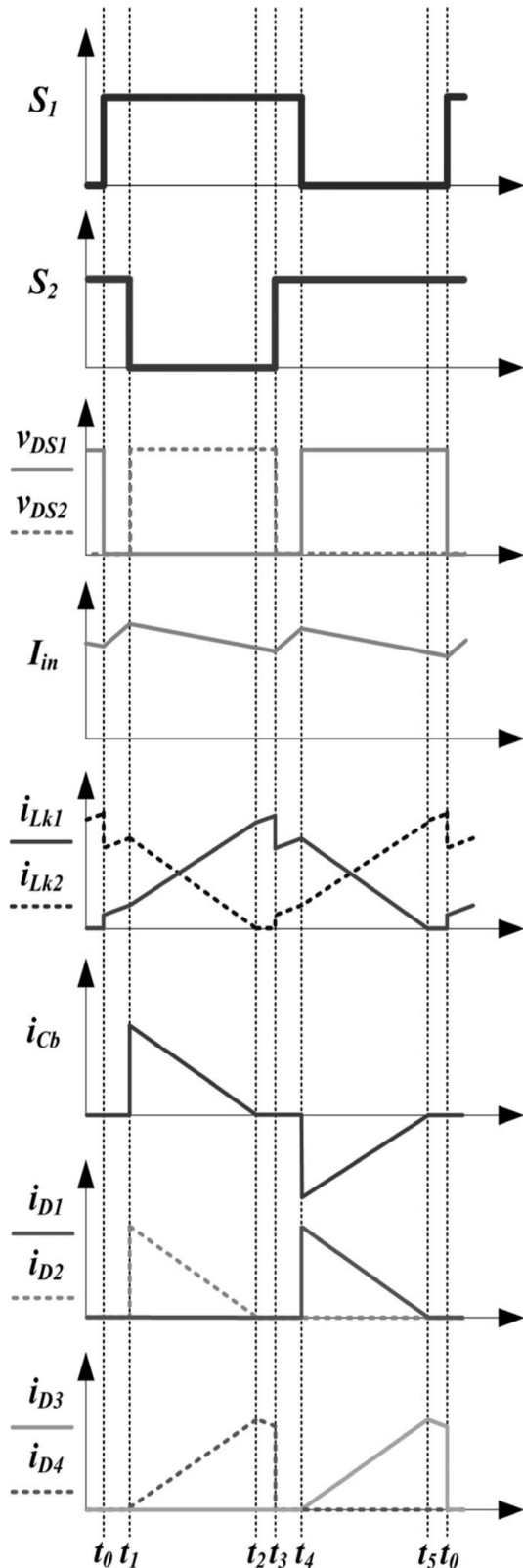


Fig.4 shows steady state waveforms of the proposed converter

Mode 1 [t0, t1]: At t=t0, switches S1 and S2 are both turned ON. The diodes are reversed-biased. Magnetizing inductors Lm1 and Lm2 as well as leakage inductors Lk1 and Lk2 are linearly charged by the input voltage source Vin.

Mode 2 [t1, t2]: At t=t1, switch S2 is switched OFF, thereby turning ON diodes D2 and D4. The energy that magnetizing inductor Lm2 has stored is transferred to the secondary side charging the output filter capacitor C3. The input voltage source, magnetizing inductor Lm2, leakage inductor Lk2, and voltage-lift capacitor Cb release energy to the output filter capacitor C1 via diode D2, thereby extending the voltage on C1.

Mode 3 [t2, t3]: At t=t2, diode D2 automatically switches OFF because the total energy of leakage inductor Lk2 has been completely released to the output filter capacitor C1. Magnetizing inductor Lm2 transfers energy to the secondary side charging the output filter capacitor C3 via diode D4 until t3.

Mode 4 [t3, t4]: At t=t3, switch S2 is switched ON and all the diodes are turned OFF. The operating states of modes 1 and 4 are similar.

Mode 5 [t4, t5]: At t=t4, switch S1 is switched OFF, which turns ON diodes D1 and D3. The energy stored in magnetizing inductor Lm1 is transferred to the secondary side charging the output filter capacitor C2. The input voltage source and magnetizing inductor Lm1 release energy to voltage-lift capacitor Cb via diode D1, which stores extra energy in Cb.

Mode 6 [t5, t0]: At t=t5, diode D1 is automatically turned OFF because the total energy of leakage inductor Lk1 has been completely released to voltage-lift capacitor Cb. Magnetizing inductor Lm1 transfers energy to the secondary side charging output filter capacitor C2 via diode D3 until t0.

#### Steady State Analysis

The transient characteristics of circuitry are disregarded to simplify the circuit performance analysis of the proposed converter in CCM, and some formulated assumptions are as follows:

- 1) The components in the proposed converter are same;
- 2) leakage inductors Lk1 and Lk2 are neglected;
- 3) Voltage Vcb, VC1, VC2 and VC3 are considered to be constant because infinitely large size capacitance.
- 4) Voltage gain
- 5) Voltage stress on semiconductor elements
- 6) Conduction loss
- 7) Voltage stress on semiconductor on turns ratio of n.

Analysis of conduction losses, which indicates the relationship among duty cycle, turns ratio and components. The proposed converter for each

application can be designed on the basis of selected turns Ratios, components, and considerations.

## 2. SOLAR CELL

A solar cell is also called as photovoltaic cell. it is an electronic device that converts the energy of light directly into electricity by the photovoltaic effect. it is a form of photoelectric cell which, when exposed to light, can generate and support an electric current without being attached to any external voltage source.

Photovoltaic is the field of technology and research related to the practical application of photovoltaic cells in producing electricity from light, through it is often used specifically to refer to the generation of electricity from sunlight. Cells can be described as photovoltaic even when light source is not necessarily sunlight. In such cases the cell is sometimes used as photo detector, detecting light or other electromagnetic radiation near the visible range, or measuring light intensity.

The operation of photovoltaic cell requires three basic attributes:

- 1) The absorption of light, generating either electron-hole pairs or exactions.
- 2) The separation of charge carriers of opposite types.
- 3) The separate extraction of those carriers to an external circuit.

In contrast, a solar thermal collector collects heat by absorbing sunlight, for the purpose of either direct heating or indirect electrical power generation. Photo electrolytic cell on the other hand, refers either a type of photovoltaic cell or a device that splits water directly into hydrogen and oxygen using only solar illumination.

## 3. PERFORMANCE COMPARISON

For demonstrating the performance of the proposed converter, the proposed converter is compared with other high step-up interleaved converters introduced. The high step-up interleaved converters introduced are also suitable for high step-up, high-power conversion of the PV system, and the other high step-up interleaved. Converter asymmetrical interleaved structure as proposed converter is favorable for dc-micro grid applications. Both of converters use coupled inductor and voltage doubler to achieve high step-up conversion. For the proposed converter, the step-up gain is highest and the voltage stress on switch is the lowest, as converter introduced. Under the turns ratio  $n$  designed as less than 2, the highest voltage stress on diodes of the proposed converter is the lowest among the compared converters. In addition, the quantities of diodes are the least as converter.

Because the components of the proposed converter are the least among the compared converters,

the reliability is higher and the cost is lower. Thus, the proposed converter is suitable for high step-up, high-power applications such as PV system.

## 4. DESIGN AND EXPERIMENT OF PROPOSED CONVERTER

The design consideration of the proposed converter includes components selection and coupled inductors design, which are based on the analysis presented in the steady state section. In the proposed converter, the values of the primary leakage inductors of the coupled inductors are set as close as possible for current sharing performance. Due to the performances of high step-up the turn's ratio  $n$  can be set 1 for the prototype circuit with input and output voltage to reduce cost, volume, and conduction loss of winding. Thus, the copper resistances which affect efficiency much can be decreased to certain value. The value of magnetizing inductors  $L_{m1}$  and  $L_{m2}$  can be design based on the equation of boundary operating condition, which is derived from

$$L_m (\text{critical}) = D (1 - D)^2 R_o / 2(n + 1)(2n + 2)f_s$$

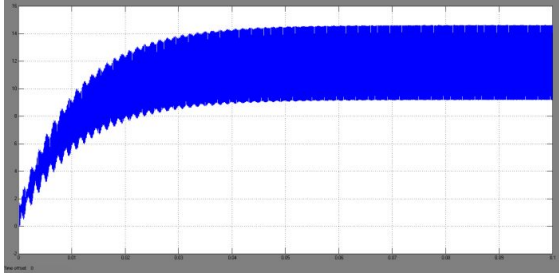
Where  $L_m$  (critical) is the value of magnetizing inductors at the boundary operating condition,  $f_s$  is the switching frequency, and  $R_o$  is the load. To suppress the voltage ripple on the voltage-lift capacitor  $C_b$  to an acceptable value is the main consideration. The equation versus the voltage ripple and the output power or output current can be derived by the equation as follows

$C_b = P_o / V_o f_s \Delta V_{C_b} = I_o / f_s \Delta V_{C_b}$  where  $P_o$  is the output power,  $V_o$  is the output voltage,  $f_s$  is the switching frequency, and  $\Delta V_{C_b}$  is the voltage ripple on the voltage-lift capacitor  $C_b$ . The efficiency of the proposed converter under constant input voltage/constant output voltage can be measured. The output voltage is changed as load shift and the detected feedback signal is processed via proportional-integral controller, and the internal comparator generates interleaved PWM with angle 180° phase shift. Due to the insufficient voltage of PWM, the PWM is supported to control power switches.

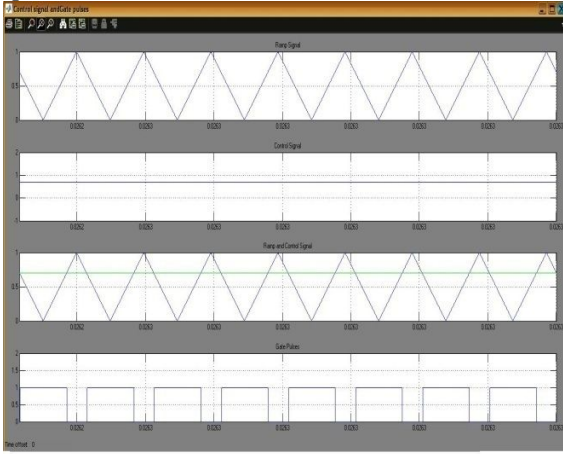
Hall sensor is used to detect the input current for over current protection (OCP). The input voltage  $V_i$  supplied by the PV module and battery set. Applications of the proposed converter are Dc micro grid and High power applications.

5. SCREEN SHOTS

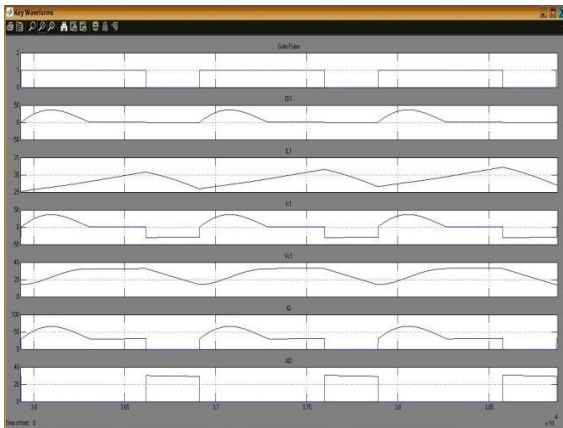
Input Voltage



Pv Module and Battery set are the input sources, time offset set in X-axis and voltage values in Y-axis. The input  $v_i$  supplied it starts from 0v to 14v. The average input is 12v.

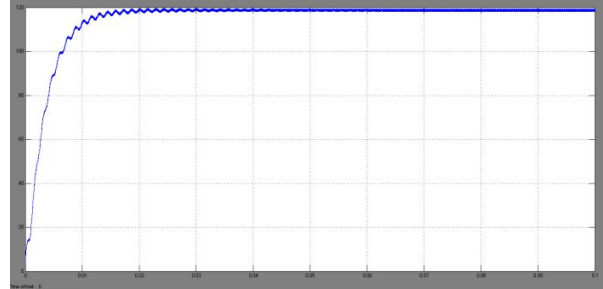


The measured waveforms of  $V_{gs1}$ ,  $V_{gs2}$ ,  $i_{Lk1}$ ,  $i_{Lk2}$ ,  $V_{ds1}$  and  $V_{ds2}$ . The switch voltage is clamped, which is much smaller than the output voltage 118V. The measured waveforms of  $V_{gs1}$ ,  $V_{gs2}$ ,  $i_{D1}$ ,  $i_{D2}$ ,  $i_{D3}$  and  $i_{D4}$  at  $P_o$ . The measured waveforms are consistent with the steady-state analysis.



The simulation result of voltage on all capacitor  $i_{d1}$  is equal to  $i_{d2}$  plus output voltage of boost converter, and  $V_{cb}$  is equal to the output voltage of the boost converter.  $V_{c1}$  is twice of  $L1$   $k1$  equal to  $I2$ .

Output Voltage



Voltage in x-axis and time offset in y-axis, output gradually increases from 0v to 118v and average output value is 118v. The maximum efficiency is 99%.

6. CONCLUSION

The proposed boost converter has been successfully implemented in an efficiently boost conversion without high duty ratio and a number of turn's ratios through the voltage multiplier module and voltage clamp feature. In the voltage multiplier module of the proposed converter, the turn's ratio of coupled inductors can be designed to extend voltage gain, and a voltage-lift capacitor offers an extra voltage conversion ratio. The advantages of the systems are low conduction losses, current ripples and cost increased the system efficiency with the help of voltage multiplier module. Thus the proposed converter is suitable for PV systems or other renewable energy applications that need high boost up power energy conversion. The maximum efficiency is 99% and the simulation is done with the help of MATLAB Software.

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