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AN ASYMMETRICAL INTERLEAVED DC-DC BOOST CONVERTER FOR HIGH STEP UP APPLICATIONS

K.Suganya[1], M.Purushothaman[2]

PG Scholar, Karpaga Vinayaga College of Engineering & Technology, Chennai, India[1]
Assistant Professor, Karpaga Vinayaga College of Engineering & Technology, Chennai, India[2]
Sugan7v@gmail.com[1], purushoth143@gmail.com[2]

ABSTRACT

A new high step-up converter is projected for a photovoltaic system. An asymmetrical interleaved high step-up converter achieves high step up gain through a voltage multiplier module. The voltage multiplier module is organised by a conventional boost converter and coupled inductors. A conventional boost converter is incorporated to achieve a considerably higher voltage conversion ratio. This configuration reduces the current stress through each power switch. And also constrains the input current ripple, which decreases the conduction losses of MOSFETs. Since the energy stored in leakage inductances is recycled to the output terminal, the efficiency of the system is improved.

Keywords: Asymmetrical Interleaved Converter, Coupled Inductor, PV system

I. INTRODUCTION

Mounting energy shortage has valued the use of renewable energy systems like PV system. But the energy obtained from renewable systems is considerably low. Thus, high step-up dc-dc converters are widely engaged in many renewable energy applications [7]. Photovoltaic systems are predicted to play an important role in future energy creation [12]. These systems convert light energy into electrical energy, and by using step-up converter they transfer low voltage into high voltage.

II. CONVENTIONAL ASYMMETRICAL INTERLEAVED CONVERTER

An asymmetrical interleaved converter is extensively used for achieving high step-up conversion and for high-power application [14]. A conventional boost converter and two coupled inductors are located in the voltage multiplier module, which is mounted on a boost converter to form an asymmetrical interleaved structure. Primary windings of the coupled inductors are engaged to reduce the input current ripple, and secondary windings of the coupled inductors are connected in series to lengthen the voltage gain.

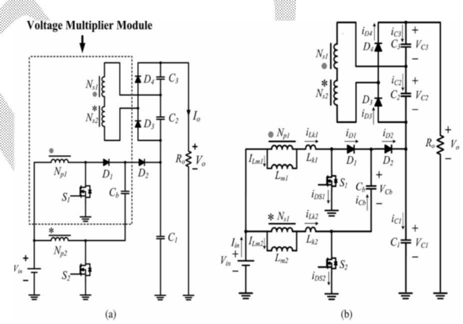

Fig.1. Circuit diagram of proposed system

The proposed converter operates in continuous conduction mode (CCM). The duty cycles during steady operation are interleaved with a 180◦ phase shift and it is greater than 0.5

III. MODES OF OPERATION

Mode 1 *[t0, t1]*: At t=t0, The power switches *S*1 and *S*2 are turned ON. Now all the diodes are reversed-biased and the Magnetizing inductors *Lm*1 and *Lm*2 as well as leakage inductors *Lk*1 and *Lk*2 are linearly charged by the input voltage source *V*in.

Mode 2 *[t1, t2]*: At *t*=*t*1, the power switch *S*2 is turned OFF, therefore the diodes *D*2 and *D*4 are turned ON. The energy stored in the magnetizing inductor *Lm*2 is transferred to the secondary side and it charges the output filter capacitor *C*3. The input voltage source, and the energy stored in magnetizing inductor *Lm*2, leakage inductor *Lk*2,

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voltage-lift capacitor *Cb is* discharged to the output filter capacitor *C*1 through the diode *D*2, thereby extending the voltage on *C*1 .

Mode 3 *[t*2*, t*3*]:* At *t*=*t*2, the diode *D*2 automatically turns OFF because the overall energy stored in the leakage inductor *Lk*2 is entirely released to the output filter capacitor *C*1. The Magnetizing inductor *Lm*2 transfers energy to the secondary side and it charges the output filter capacitor *C*3 through the diode *D*4 until *t*3.

Mode 4 *[t*3*, t*4*]:* At *t*=*t*3, the power switch *S*2 is turned ON and all the diodes are turned OFF. Now all the diodes are reversed-biased and the Magnetizing inductors *Lm*1 and *Lm*2 as well as leakage inductors *Lk*1 and *Lk*2 are linearly charged by the input voltage source *V*in.

Mode 5 *[t*4*, t*5*]:* At *t*=*t*4, the power switch *S*1 is turned OFF, therefore diodes *D*1 and *D*3 are turned ON. Now the energy stored in the magnetizing inductor *Lm*1 is transferred to the secondary side and it charges the output filter capacitor *C*2. The input voltage source and the energy stored in the magnetizing inductor *Lm*1 is completely released to the voltage-lift capacitor *Cb* through the diode *D*1, which supplies extra energy to *Cb*.

Mode 6 *[t*5*, t*0*]:* At *t*=*t*5, the diode *D*1 is automatically turns OFF because the entire energy stored in the leakage inductor *Lk*1 is totally released to voltage-lift capacitor *Cb*. Now the magnetizing inductor *Lm*1 transfers energy to the secondary side and it charges the output filter capacitor *C*2 through the diode *D*3 until *t*0.

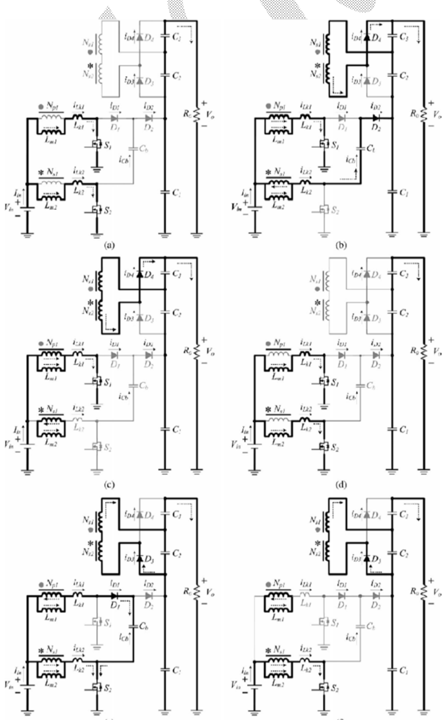

Fig.2. Modes of operation of the proposed system

IV. Voltage Gain

From the equivalent circuit of the proposed converter, the first phase converter is considered as a conventional boost converter. Thus the voltage derived from *VCb* can be expressed as,

= ── (1)

When the power switch *S*1 is switched ON and the power switch *S*2 is turned OFF, the voltage *VC*1 can be derived from,

= ── + = ── (2)

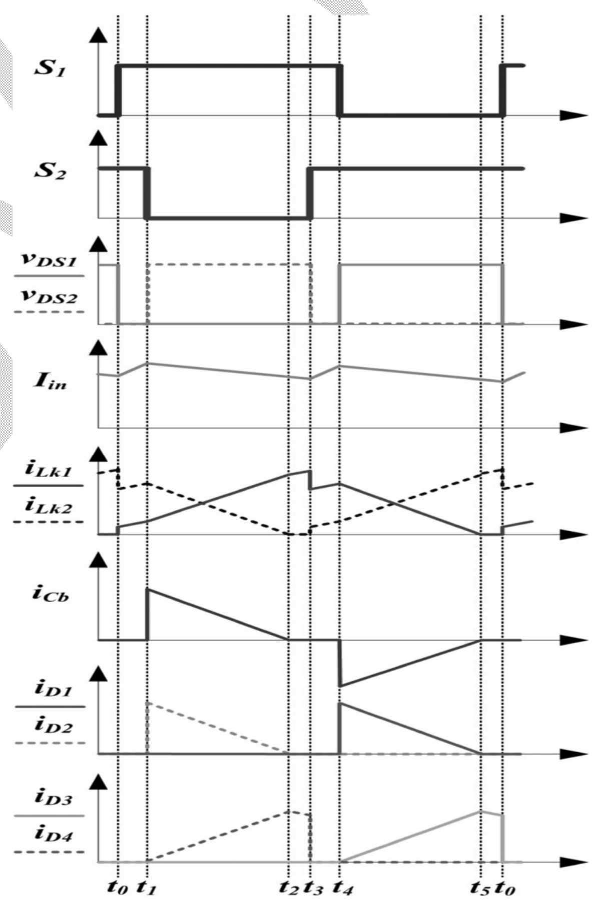

Fig.3. Steady Waveform of the Proposed Converter at CCM

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The energy transformation from the primary side charges the output filter capacitors *C*2 and *C*3. When the power switch *S*2 is in turn-on state and the power switch *S*1 is in turn-off state, *VC*2 is equal to the induced voltage of *Ns*1 and the induced voltage of *Ns*. And when the power switch *S*1 is in turn-on state and the power switch *S*2 is in turn-off state, *VC*3 is also equal to induced voltage of *Ns*1 and the induced voltage of *Ns*2. As a result, voltages *Vc*2 and *Vc*3 can be derived from

= = . (1 + ——) = —— (3)

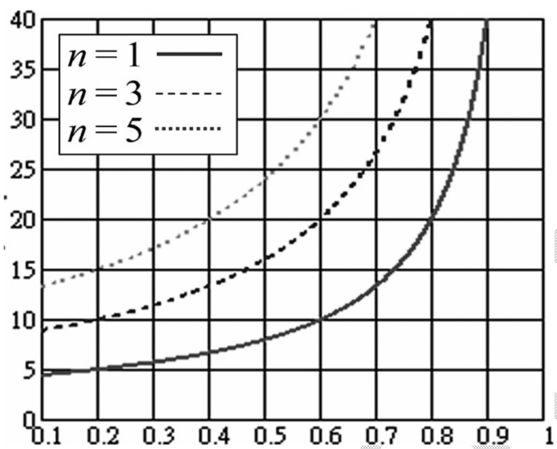


Fig.4. Voltage Gain versus Turns Ratio n and Duty Cycle

The output voltage V_0 can be derived from,

= + + = —— (4)

The voltage gain of the proposed asymmetrical interleaved converter is expressed as,

/ = —— (5)

When the duty cycle is merely 0.6, the voltage gain reaches 10 at a turns ratio *n* of 1. The voltage gain reaches 30 at a turn's ratio *n* of 5.

V. SIMULATION CIRCUIT DIAGRAM

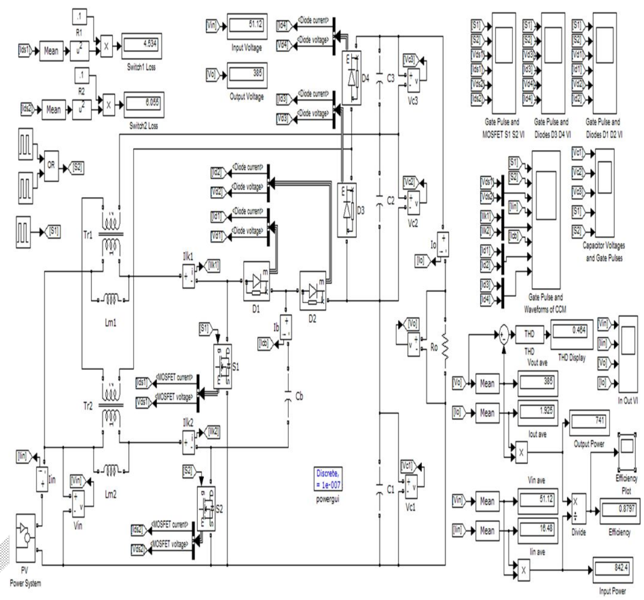
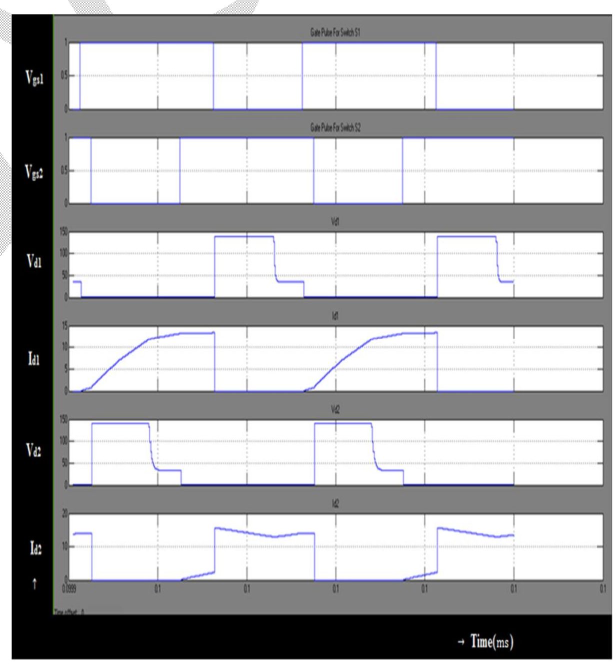


Fig.5. Simulation Circuit of the Proposed System

VI. SIMULATION RESULTS

Voltage and current waveform of MOSFET S1 and S2



Voltage and current waveform of diode D1 and D2

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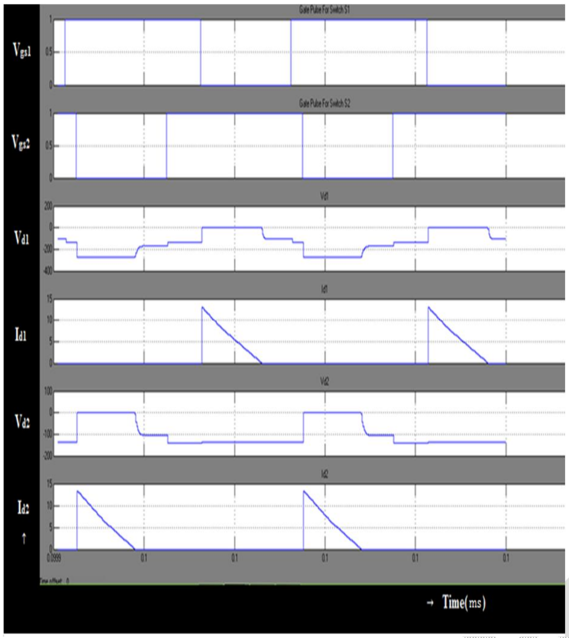
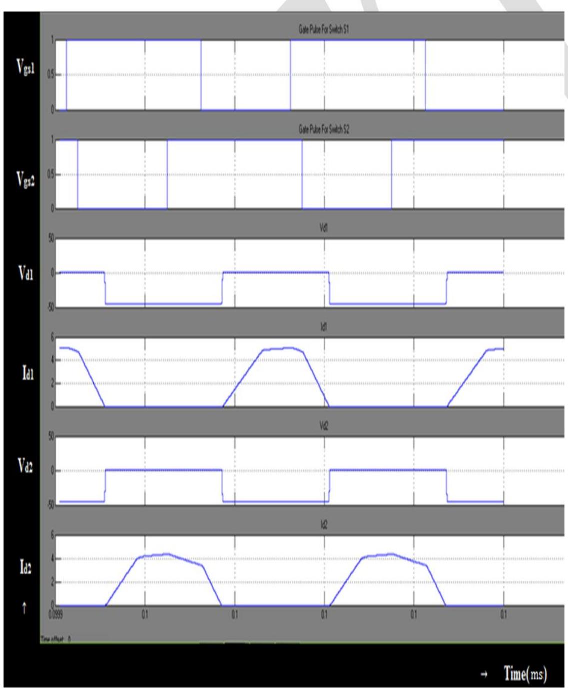
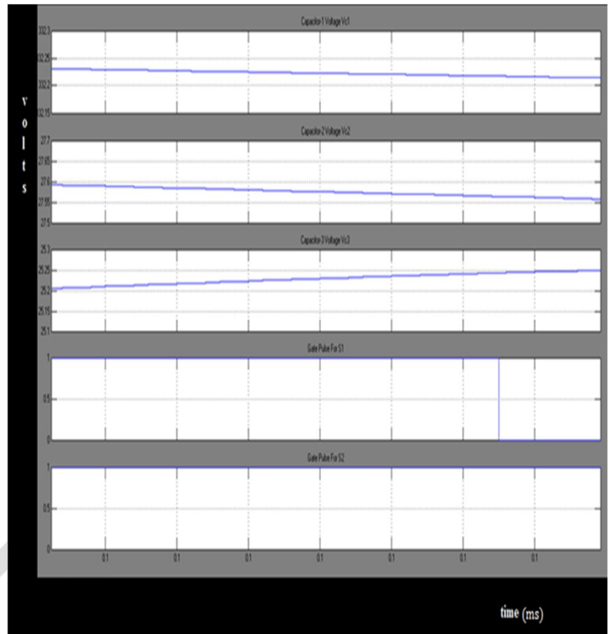


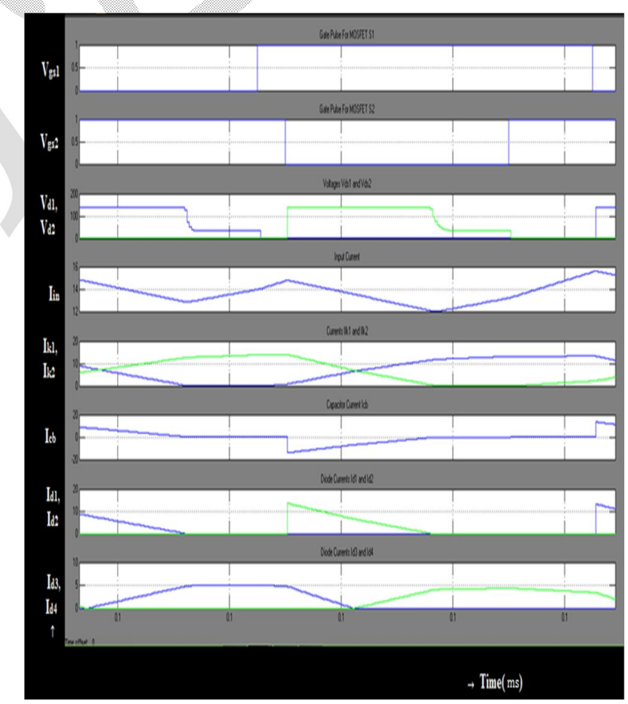
Voltage and current waveform of diode D3 and D4



Capacitor voltage and gate pulse



Voltage and current waveform of CCM



Voltage and current waveform of proposed converter

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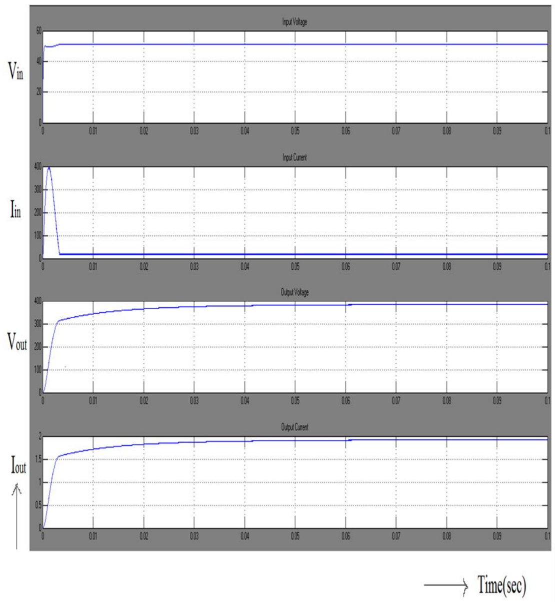
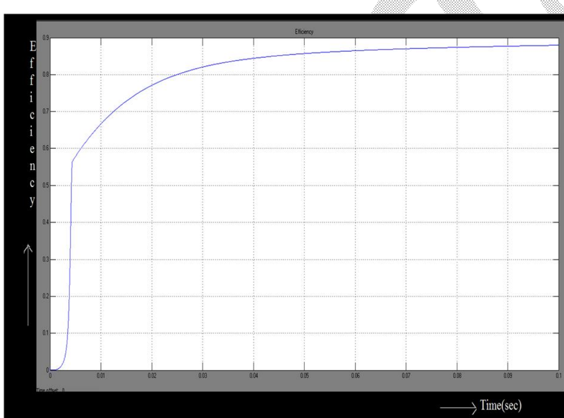


Efficiency waveform of the proposed system



VII. CONCLUSION

This paper has offered the principles, steady state analysis, and experimental results for a proposed asymmetrical interleaved converter. The proposed converter has been successfully employed in an efficiently high step-up conversion without an excessive duty ratio. The interleaved PWM scheme decreases the currents that pass through each power switch and constrained the input current ripple. The experimental results indicate that leakage energy is recycled through capacitor *Cb* to the output terminal. The voltage stresses over the power switches are also restricted. Higher efficiency is obtained. Thus, the proposed asymmetrical interleaved converter is suitable for PV systems and other renewable energy applications which need high step-up and high-power energy conversion.

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