High Voltage Gain Interleaved DC Boost ConverterApplication for Photo voltaic Generation System

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Abstract

This paper introduces a new high-voltage boost-embedded DC-DC boost converter. This transformer is a non-isolated step-up transformer that can step up the DC voltage from an input voltage of 2 VDC to an output voltage of 130VDC. It is suitable for use with any DC renewable energy source such as solar power generation system etc. The power of this paper converter is 350 W. The proposed converter has a total of four DC boost converter modules connected in parallel. For the same purpose, these switching devices are controlled with a 90 degree offset between them thanks to the interlacing technology. This results in a smoother DC output. However, the high-gain DC-to-DC boost converter of this project was made by implementing a MATLAB/SIMULINK-based digital signal processing board (here TMS320F2812). The laboratory test shows that the transformer works very well and its performance is good.

Keywords: non-isolated boost converter; 4 phase Interleave technique**;** DSP implementation

1. Introduction

In general, Photo Voltaic cell (or Solar cell) can transform the energy form any light

junction in the PV cells, energy will be transformed by causing a movement of electrons in PV's
sources into an electrical dc power source. When the electromagnetic wave in light source impacts the semiconductor
semiconductor junction. By connecting the external of the load side, the current will flows into an
electrical circuit. However, there are some limitations on the PV's power rating. Due to the output voltage of such PV cell and PV panel is not high enough to provide to a customer in general, thus, the PV's
output voltage has to be boosted up higher enough for providing any electrical appliances, it is dependingon its applications.[3]

- 42 V (Power Net) a new standard voltage for automobile systems,
- 48 V; 120 V; or 400 V to 480 V for stand-alone or parallel grid
- connections,270 V or 350 V for the standard on the all-electric aircraft,
- 350 V (transit bus systems) to 750V (tramway and locomotive systems).

Or converted into AC by using DC-AC converter (Inverter) for AC loads. Therefore, DC boost converter is needed to boost up a dc voltage. Normally, a traditional non-isolated DC boost converter has a significant disadvantage due to its low voltage. Thus, a high gain DC converter has to be proposed. However, such DC converter must have a good reliability in long time operation. In which, it also should be a small size in order to ease of installation, maintenance, power lossless and toughness [1-7]. The proposed

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system are shown in Figure 1.

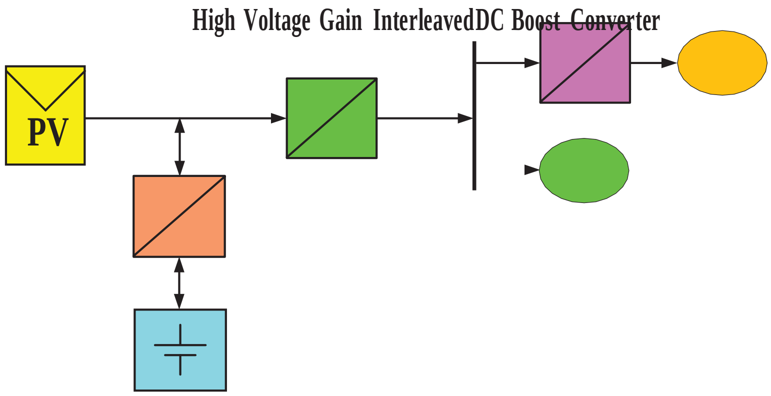


Fig. 1. The proposed system

2. DC Boost Converter Topologies

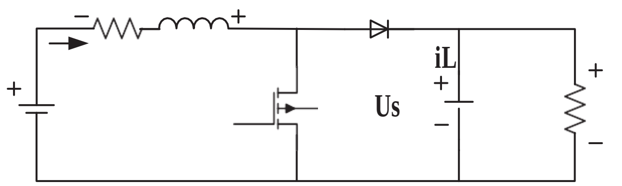
Typical boost converter

High voltage gain DC converter that proposed in this paper is considered from a traditional non- isolated DC boost converter as shown in Figure 2. However, the difference between DC Converter in Figure 2 and 3 is the location of diode, but its operations of both circuits are the same. Thus, voltage gain of the circuit is given in (1). [8]

$$G_B = \frac{U_O}{U_S} = \frac{1}{(1-D)}$$

(1)

URL UL

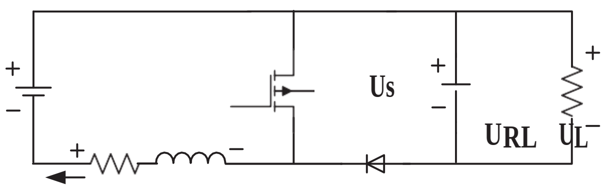


D

S C Uo

−

Fig. 2. Boost converter with inductor and diode in positive side



iL

S C UoD

Fig. 3. Boost converter with inductor and diode in negative side

Double Dual Boost Converter

The topology of this converter is shown in Figure 4. The configuration is composed of two conven- tional boosts with input coupled inversely. Switches commands of each boost are delayed of a half switching period each. [2]

iL1

Us+

URL1 UL1

D1

S1 Ca io

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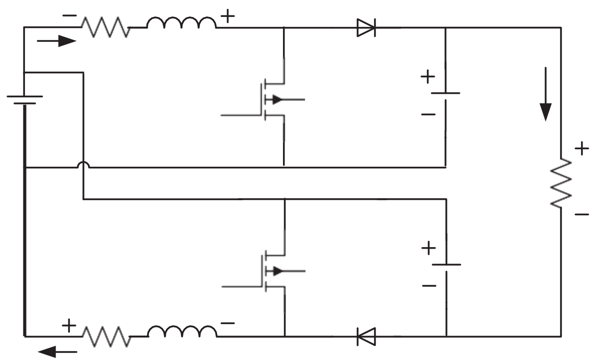


Fig. 4. Double dual boost converter

The relation of voltage gain and duty-cycle of this topology is given in (2).

DDB

$$\frac{U_O}{U_S} = \frac{(1 + D)}{(1 - D)}$$

(2)

From (1) and (2), it is clear that G_{DDB} is greater than G_B $(D + 1)$ times. Moreover, structures like boost, the higher the duty-cycle, the lower the efficiency. This is an advantage of double dual boost compared with a classical boost in the case of the same power, same input and output voltage.

Interleaved boost converter

In this section, the connection of converters based on the basic boost topology. For example, connec- ting two boost converters in parallel at the input derives the well-known interleaved boost sourced by a single DC voltage source as shown in Figure 5 and the interleaved boost version is shown in Figure 6. However, if one wishes to use a single source to power two boost converters but not of the same type.[1]

iL2 iL1

+

Us_

URL2 URL1

UL2 UL1

S1 S2

D2D1

C Uo

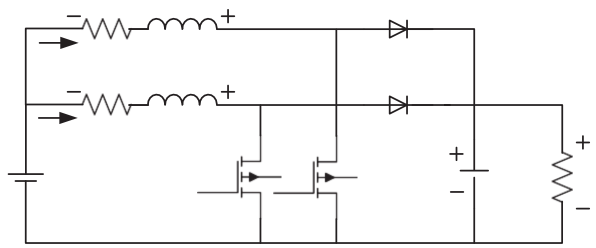
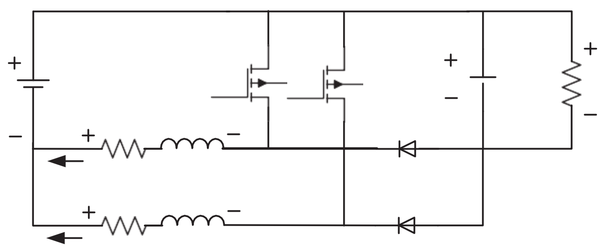


Fig. 5. Two phases interleaved Boost converter (inductor and diode in positive side)



Us

iL1 iL2

URL1 URL2

S1 S2

UL1 UL2

C Uo

D1D2

Fig. 6. Two phases interleaved Boost converter (inductor and diode in negative side)

There are two configurations of interleaving DC boost converter circuit in this

(especially inductor), reduce a ripple current and also increasing the converter's efficiency.

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project as shown in Figure 5 and 6, respectively. An advantage of the interleaved technique is to reduce the converter size

3. High Voltage Gain Interleaved DC Boost Converter

High voltage gain DC boost converter that proposed in this paper is a combination of two 2 phase interleaved boost converter from Figure 5 and 6 together as shown in Figure 7. Such circuit is called as 4 phase interleaved DC boost converter. The four switching devices (here is Power MOSFET IRF3415) are controlled in 90 phase delay to each others simultaneously (interleave technique method), in order to smooth output ripple current, raising power rating and efficiency as described above. [1-3]

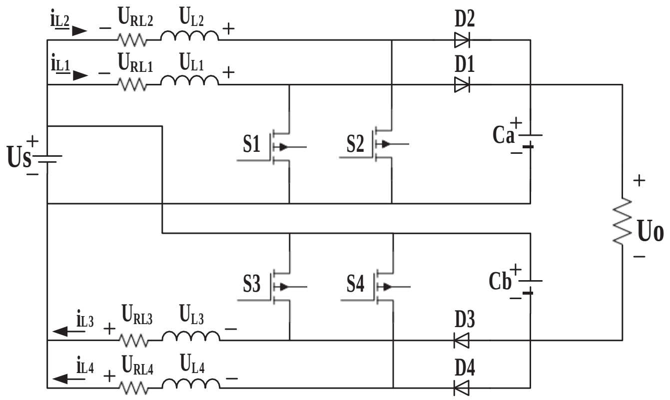

Fig. 7. High voltage gain Interleaved DC boost converter

Voltage gain of the circuit can be determined by applying KVL in two separated circuits as follows is
(3) and (4).

$-U_O + U_{Ca}$

$U_O = U_{Ca}$

U_{Cb} U_S 0 + − =

U_{Cb} U_S −

(3)

(4)

when

U_s is DC input voltage

U_o is DC output voltage

U_{Ca} is Capacitor voltage across C_a

U_{Cb} is Capacitor voltage across C_b

Thus, voltage gain of the circuit is given in (5).

$$\frac{U_O}{U_S} = \frac{(1+D)}{(1-D)} \tag{5}$$

This means that the voltage can be raised over than a traditional non-isolated boost converter depend on the value of the duty cycle.

Inductance Design

Since the interleaving concept can reduces input current ripple also with inductance sizing, but the converters must be operated in continuous conduction mode (CCM). With a maximum current ripple (ΔI_L), it allowed to use for determining an appropriate value of And the current through the inducto inductance as follows is (6).

$$L = \frac{D.U_S}{4.\Delta I_L . f_S} \tag{6}$$

Capacitance Design

The output voltage ripple of the circuit depends the size of capacitor. However, there are two capacitors that connected in series, which effect to output voltage ripple (ΔU_{bus}). The value of each capacitor depends on output current (I_{out}), duty cycle (D) and depends inversely with U_{bus} , switching frequency (f_S) as follows is (7).

$$C = \frac{I_{out}.D}{} \tag{7}$$

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bus

2. *U* Δ
bus· *f S*

Table 1. Component specification

Devices	Value
Inductances (L_1,L_2 ,L_3,L_4)	840—H , EE42core
Capacitances (C_a,C_b)	470—F,450V
Power switches (S_1,S_2,S_3,S_4) Diodes (D_1,D_2 ,D_3,D_4)	
Input voltage Output voltage	
Maximum power output Switching frequency; f_S	

IRF3415 RURG3020
24 Vdc
130 Vdc
350 W
25 kHz

4. Experimental Results

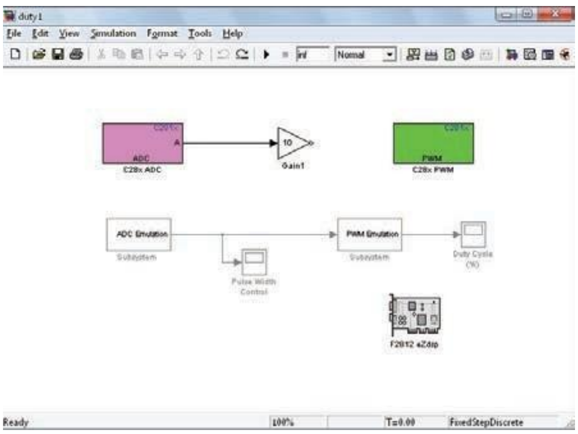


Fig. 8. TMS320F2812 control model

The proposed DC boost converter is built in a laboratory scale using TMS320F2812

DSP board. The DSP board is set for generating a suitable control signals for all four switching devices in the circuit. However, in order to controlling the essential data and some important control parameters, MATLAB/Simulink is used as a basis platform for managing the control model and such control data through TMS320F2812 DSP board are shown in Figure 8 and 9

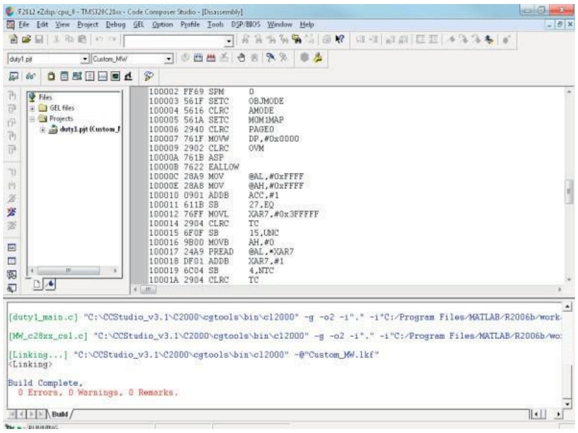
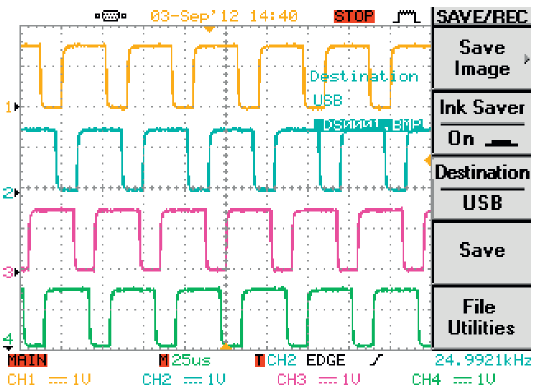


Fig. 9 TMS320F2812 command windows

The gate driving signals of switching devices generated from TMS320F2812 are shown in Figure 10.

A phase angle of each gate driving signals is 0, 90, 180 and 270 degree.

The experimential results shown that the steady state interleaved averaged inductor currents i_{L1}, i_{L2} i_{L} and i_{L4} were 3.4A, 3.8A, 3.4A and 3.2A respectively. The inductor current waveforms are shown inFigure 11.



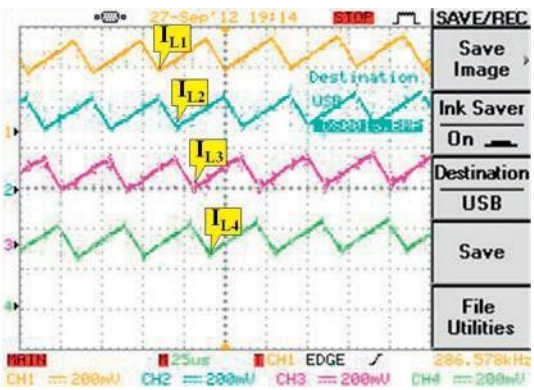
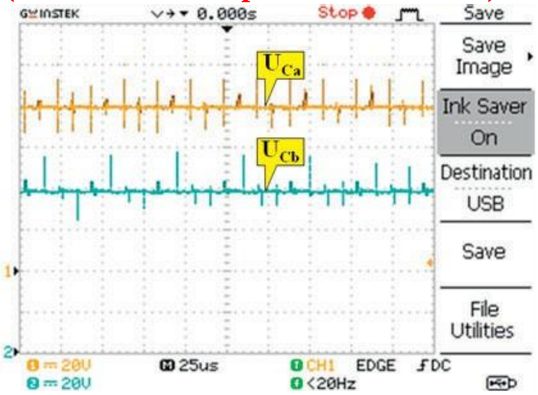


Fig. 10 Gate driving signals generated from TMS320F2812 Fig. 11 The steady state inductor currents of proposed converter

The voltage of output capacitors U_C and U_{Cb} are the same as 78V. The capacitor voltage waveformsar shown in Figure 12.



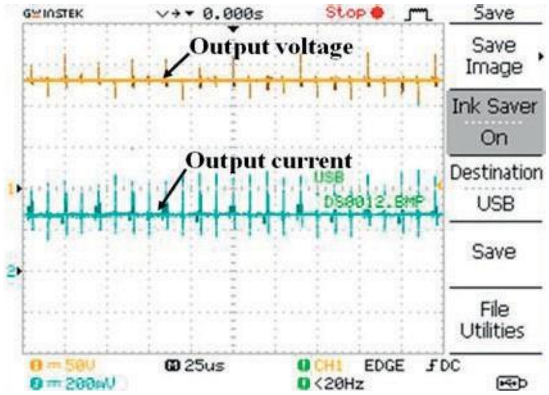


Fig. 12 The voltage waveforms of output capacitors Fig. 13 The steady state inductor
currents of proposed converter

The aximum output power of proposed converter is 350W This output power is calculated by multiply output voltage 130Vdc and output current 2.8A. The output voltage waveform and output current waveform are shown in Figure 13

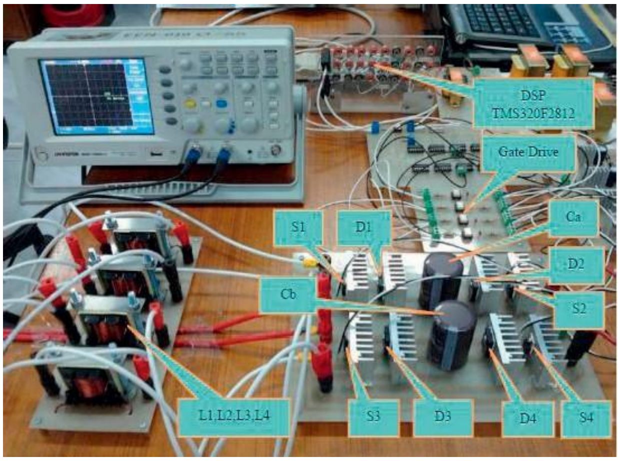


Fig. 14 The proposed prototype converter system

5. Conclusion

This article presents a DC Boost Converter designed for use in a solar power generation system using tab technology. This converter is a non-isolated boost converter that can step up the DC voltage from 2 V DC input voltage to 130V DC output voltage with a power of 350W. Each switch control signal has a four-phase difference of 90 degrees. But in the experimental results, the inductor currents in each stage are not exactly the same, because the High Voltage Gain interleaved DC boost converter presented in this article can be applied to any renewable energy system and some related applications.

Further research is to analyze in balancing the inductor currents and feedback control scheme in orderto stabilize the converter output voltage.

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