Interleaved Boost Converter for High Power Application

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***Abstract*- This study presents an interleaved boost converter. Unlike the usually boost converter, this converter is used for high power. This converter is use to handle high current at input and high voltage at output. This converter is suitable for stepping-up the voltage on high power application. Design of this converter is similar to boost converter, but the differences are this converter will use two inductances, two diodes and two IGBT switch. Interleaved boost dc-dc converter is suitable for fuel cell application.**

***Keywords:*- interleaved boost converter, high power application, high voltage at output.**

I. INTRODUCTION

In high power application, it becomes a challenge to maintain high efficiency using conventional boost converter. The low input voltage causes large input current to flow. Also with low duty cycle operation the rms ripple current through the boost diode and output capacitor becomes very high. These increase the losses enormously and make the conventional boost converter quite inefficient. Moreover, parasitic ringing present in practical circuits induces additional voltage stresses and necessitates the use of switches with higher blocking voltage rating, leading to more losses.

The major challenge of designing a boost converter for high power application is how to handle the high current at the input and high voltage at the output [3]. An effective way is to parallel the inputs of the boost converter for input current sharing [3,4]. Based on this concept, an interleaved boost dc-dc converter is a suitable candidate for stepping-up the voltage on high power application [1,2,3-8].

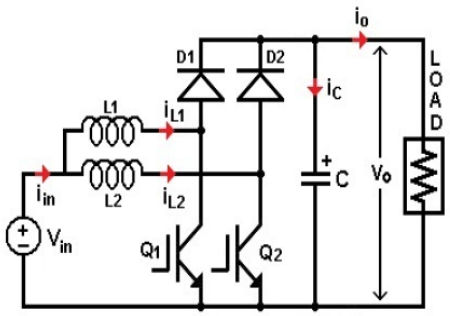

Figure 1: Interleaved Boost DC-DC Converter schematic diagram

The objectives of the interleaved boost converter are to:

- Handle high current at input at input and high voltage at output.
- Stepping-up the voltage on high power application.

The work plan in this project covered the main areas of development:

- Estimation for inductance and capacitance value.
- Build and simulate the circuit designed using PSIM software.
- Developed and executing a program to run the switching by using PIC MPLAB IDE from Microchip Technology Inc.
- Download program to target chip PIC 16F873.
- Make observation on the result.

- Analyze the result and make comparison between simulation and experimental.

The interleaved boost converter is developed and tested by using PSIM simulation, PIC software, and hardware prototype. The research methodology flow chart is shown in Figure 2.

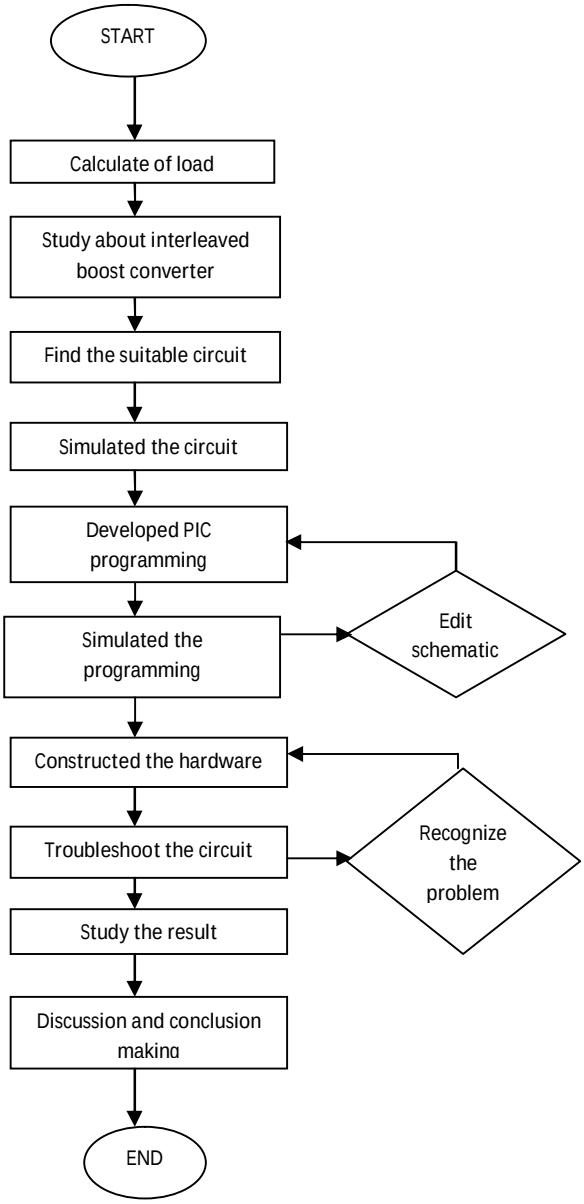

Figure 2: Research methodology flow chart

II. CONVERTER OPERATION

A. *Switching Strategy*

This project used IGBT as the main switching devices. IGBT has simpler driving circuits than other power transistors and could lead to high-switching applications [9]. The parallel inductance, two diode, capacitor and resistive load, R is also used in this project.

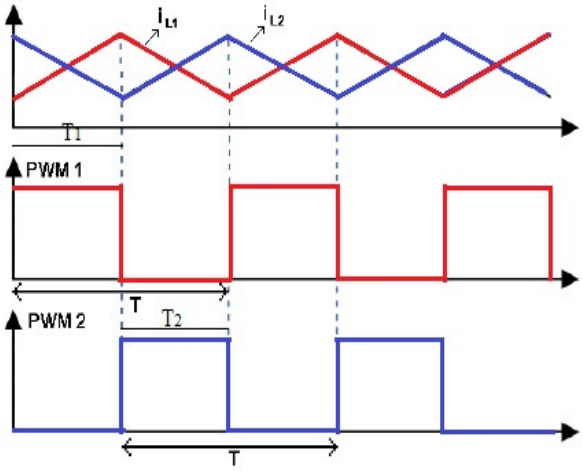

Figure 3: Inductor Current and PWM Signals of Interleaved Boost DC-DC Converter.

At T_1, Q_1 is closed and Q_2 is opened. The current of the inductor L_1 start to rise, while L_2 continues to discharge.

At T_2, Q_2 is closed and Q_1 is opened. The current of the inductor L_2 start to rise, while L_1 continues to discharge.

Figure 4(a) and (b) show the direction of current flow. For state 1, IGBT1 is ON while IGBT2 is OFF. For state 2, IGBT2 is ON while IGBT1 is OFF.

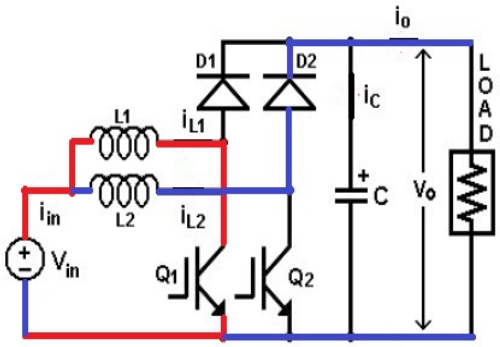

Figure 4(a)

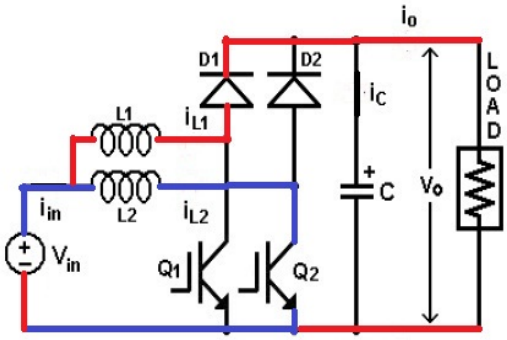

Figure 4(b)

B. *Design consideration*

1. *Inductance value*

The selection of inductance is done using the formula [10,11].

$$L = \frac{V_S D}{\Delta I_L F} \quad (1)$$

Where:

Vs = source voltage

ΔI_L = inductor current ripple

D = duty ratio

F = frequency (Hz)

2. *Simulation parameters for interleaved boost converter*

Interleaved boost converter is simulated in PSIM with the parameters as shown in Table I.

TABLE I: Simulation Parameters interleaved boost converter

Parameters	Values
Input voltage	12 V
Switching Frequency	1000Hz
Duty Ratio	0.5
Inductance, L	50mH
Capacitance, C	2000uF

C. *Simulation on interleaved boost converter*

The simulation of the circuit for interleaved boost converter is simulated using PSIM software. The DC input voltage is 12V. The complete circuit is shown in Figure 5. Figure 6 shows the inductor current. Figure 7 shows PWM and figure 8 shows output current and voltage.

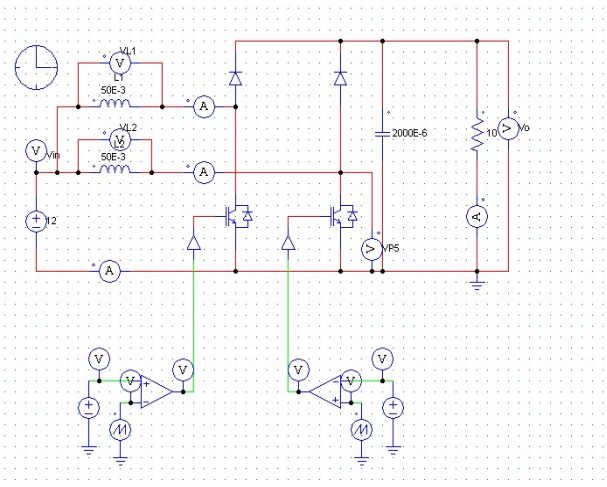

Figure 5: interleaved boost converter

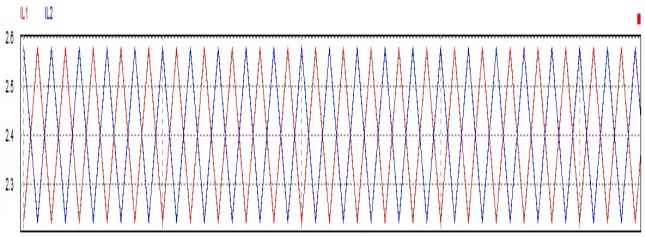

Figure 6: inductor current 1 and 2

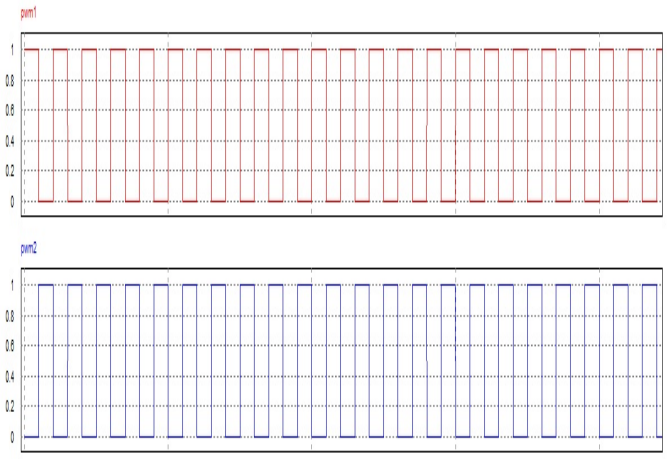

Figure 7: PWM 1 and PWM 2

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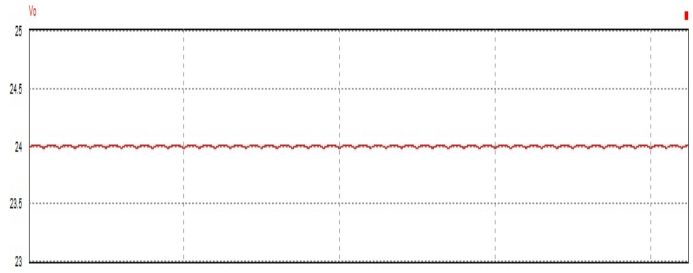

Figure 8: voltage output

D. Hardware Construction

1. PIC Programming

PIC16F873 is used in the interleaved boost converter. The flowchart of the program that has been implemented for PIC16F873 is shown in Figure 9. The layout of the PIC16F873 is shown in Figure 10.

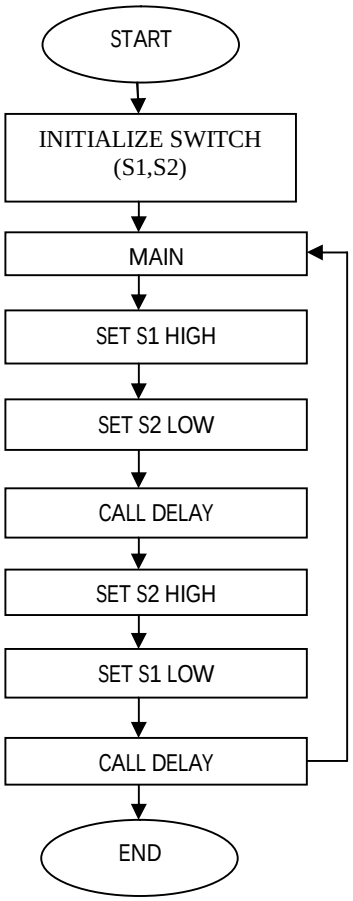

Figure 9: The flowchart of the program that has been implemented for PIC16F873

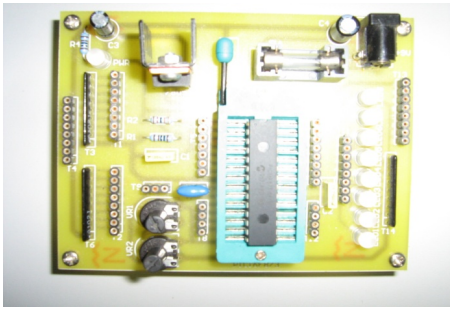

Figure 10: The layout of the PIC16F873

2. *Circuit Components*

i. IGBT IRF 640

Applications

- High current switching
- Uninterruptible power supply (ups)
- DC/DC converters for telecom
- Industrial and lighting equipment

ii. Driver IR2110

The IR2110 are high voltage, high speed power MOSFET and IGBT drivers with independent high and low side referenced output channels. Proprietary HVIC and latch immune CMOS technologies enable ruggedized monolithic construction. Logic inputs are compatible with standard CMOS or LSTTL output, down to 3.3V logic. The output drivers feature a high pulse current buffer stage designed for minimum driver cross-conduction. Propagation delays are matched to simplify use in high frequency applications. The floating channel can be used to drive an N-channel power MOSFET or IGBT in the high side configuration which operates up to 500 or 600 volts.

iii. 6N136

A separate connection for the bias of the photodiode improves the speed by several orders of magnitude over conventional phototransistor optocouplers by reducing the base-collector capacitance of the input transistor.

iv. NMA0505SC AND NMA0515SC

The NMA series of industrial temperature range DC-DC converters are the standard building blocks for on-board distributed power systems. They are ideally suited for providing dual rail supplies on primarily digital boards with the added benefit of galvanic isolation to reduce switching noise. All of the rated power may be drawn from a single pin provided the total load does not exceed 1watt.

v. TC4420

TC4420 is a non-inverting driver. These drivers are fabricated in CMOS for lower power, more efficient operation versus bipolar drivers. The devices have TTL-compatible inputs, which can be driven as high as VDD + 0.3V or as low as – 5V without upset or damage to the device.

III. RESULT AND DISCUSSION

The purposes of this experiment are to determine and ascertain the performance of the system and to ascertain validity of the results within those results obtained in simulation. Figure 11 show the prototype of interleaved boost converter. Figure 12(a) and (b) show the inductor current 1 and 2 waveforms from the experiment. Figure 13 show PWM 1 and 2 and figure 14 show output voltage waveform.

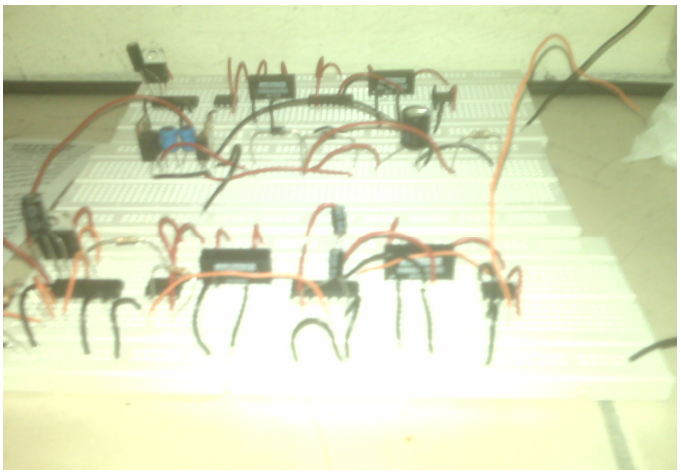

Figure 11: interleaved boost converter prototype

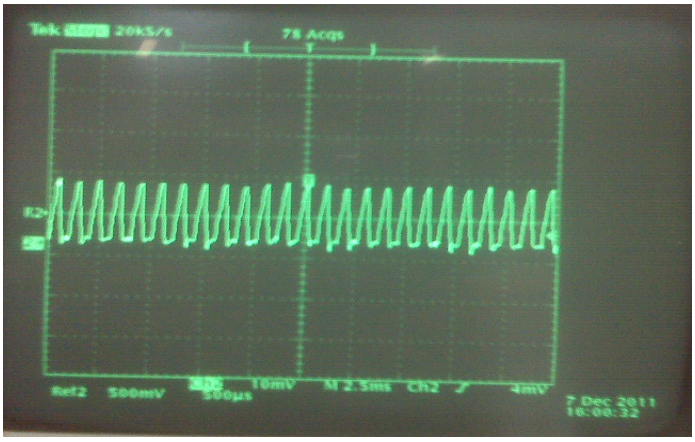

Figure 12(a): inductor current 1

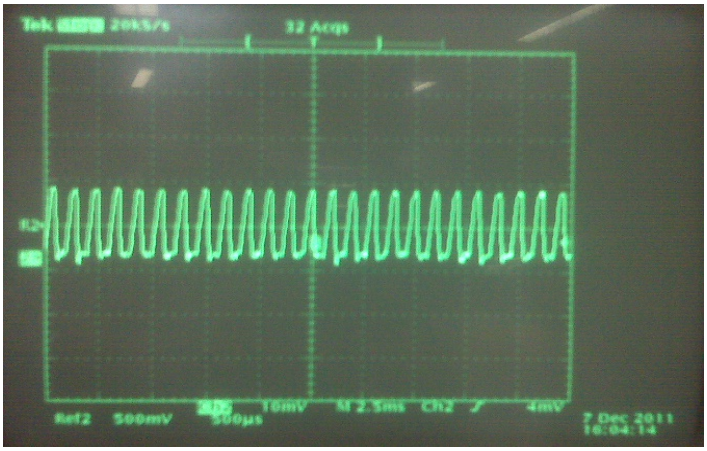

Figure 12(b): inductor current 2

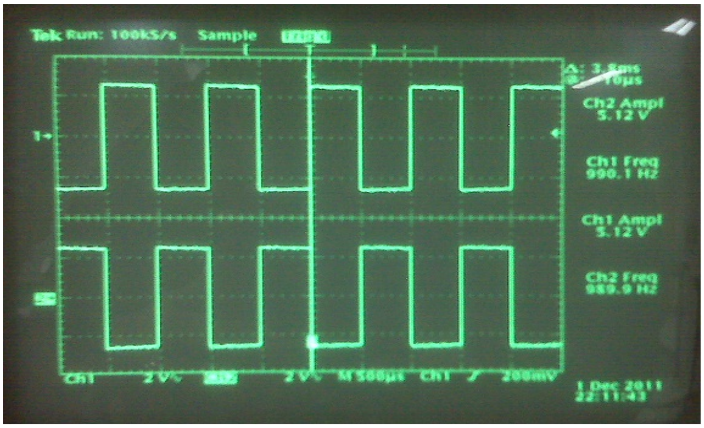

Figure 13: PWM 1 and 2

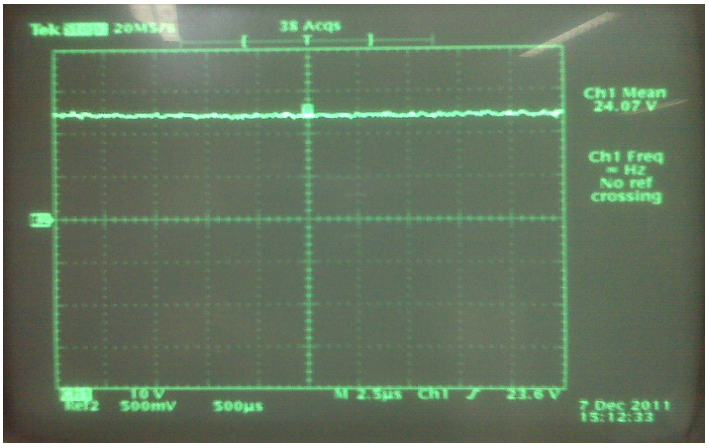

Figure 14: voltage output

TABLE II: Simulation and hardware result

Parameters	Simulation	Experimental
Input voltage (V)	12	12
Output voltage (V)	24	24

From the experiment, output voltage is same with simulation, 24V. The interleaved boost converter have problem to handle high input current. To solve this problem the input need to be parallel so that input current can be shared. Suitable inductance also is a problem for this converter but the problem can be settled down by using equation 1.

IV. CONCLUSION

Interleaved boost converter is used for high power application. This converter is suitable for stepping-up the voltage on high power application. Design of this converter is similar to boost converter, but the differences are this converter will use two inductances, two diodes and two IGBT switch. This converter is suitable for fuel cell application. After done the experiment, output voltage is same with simulation 24V.

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