ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 4, April 2015

Performance Analysis and Comparison of Conventional and Interleaved DC/DC Boost Converter Using MULTISIM

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ABSTRACT: Step up conversion is widely used in many applications such as Electric vehicles, Photovoltaic (PV) system, Uninterruptible power supplies (UPS) and fuel cell system. This paper shows simulation of conventionaland interleaveddc-dc boost converter using NI MULTISIM software. Theseconvertersare tested by varying the input voltage with constant duty cycle in Continuous Conduction Mode (CCM). The performance parameters of both the converters are compared. Control of these converters is done by switching signals having fixed switching frequency.Using interleaved converter we can reduced ripple at output voltageand output current.

KEYWORDS: NI MULTISIM, Conventional Boost Converter, Interleaved Boost converter, Ripple voltage, Ripple current.

I. INTRODUCTION

For power electronic interfaces in renewable energy sources such as photovoltaic power systems and fuel cells DC-DC converters are more important components. Main disadvantage of these renewable sources is that they give low voltage output and thus needs booster in order to provide enough output voltage. Thus Interleaved Boost converter is a solution for such a systems, which can give high step up voltage having smaller ripple to the output voltage and output current. Also there is low switching loss for this circuit having faster transient response. Interleaved boost converter is made up of two identical boost conversion units with an auxiliary inductor. Both the active power switches of this converter can turn on at zero voltage due to this there is reduction in their switching losses which increases the conversion efficiency. Operation analysis and design of the converter becomes quite simple as both the parallel operated boost conversion units are identical.

II. BASIC BOOST CONVERTER

Boost converter gives its output voltage higher than the input voltage. Operation of this converter is controlled by periodically opening and closing an electronic switch. Fig.1 shows circuit for basic dc-dc boost-converter. This boost converter consists of source voltage VS, inductor L, controlled semiconductor switch S (such as MOSFET/ IGBT/ BJT), diode D, capacitor C, Load Resistance RL and output voltage of converter VO. The diode D becomes OFF When switch S gets closed and the energy from the source is gets stored into the inductor L. The diode-D becomes ON when switch S gets opened and energy stored in the inductor gets transferred to the filter capacitor C. Longer the switch is closed, more the energy gets stored in to the inductor and as soon as diode becomes ON this energy gets transferred to the capacitor. Fig.2 shows square wave given to the semiconductor switch S and output current across inductor L.

For the analysis of the boost converter basic parameters used are:

I. Output voltage $V_{O,}$
II. V_R – Output ripple voltage,
III. I_{R-} Output ripple current,
IV. F-the switching frequency of the switch S in Hz.

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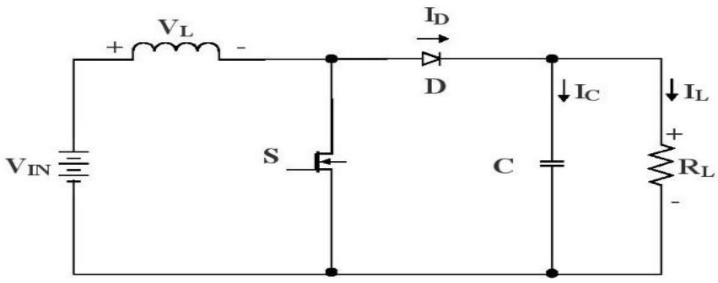

Fig 1: Basic boost converter

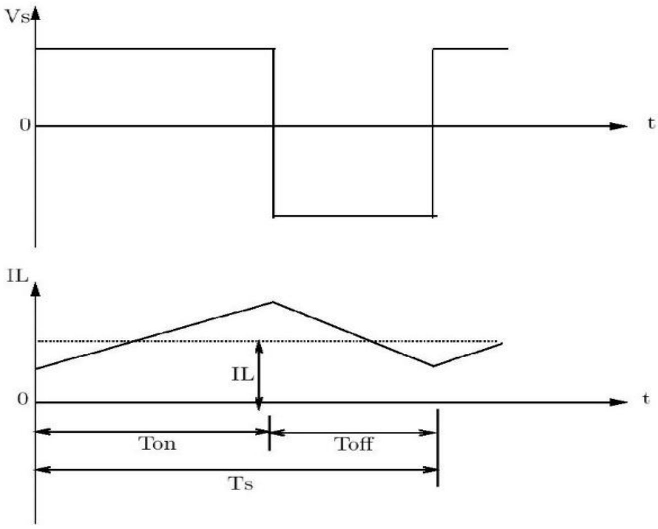

Fig 2: Continuous conduction mode

In CCM over one time period time integral of the inductor voltage must be zero,

$$V_{in}.T_{ON} + (V_{in} - V_{out})T_{OFF} = 0$$

Dividing both sides by T, and rearranging terms,

$$\frac{V_{out}}{V_{in}} = \frac{T_S}{T_{OFF}} = \frac{1}{1-D}$$

Assuming a lossless circuit $P_I = P_O$,

$$\frac{V_I}{V_O} = \frac{I_O}{I_I} = 1 - D$$

Where D is duty cycle, T is the total time period for one cycle.

III. PERFORMANCE ANALYSIS AND OPERATION OF BASIC BOOST CONVERTER USING MULTISIM

Simulation is the important step to examine behaviour and performance of electric circuits before hardware implementation. Boost converter can operate in both discontinuous current mode (DCM) & continuous current mode (CCM), these modes can be determined through the value of inductor current. But in this paper only continuous current

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mode (CCM) is used for performance analysis. The simulation models designed in MULTISIM is shown below in fig.3,

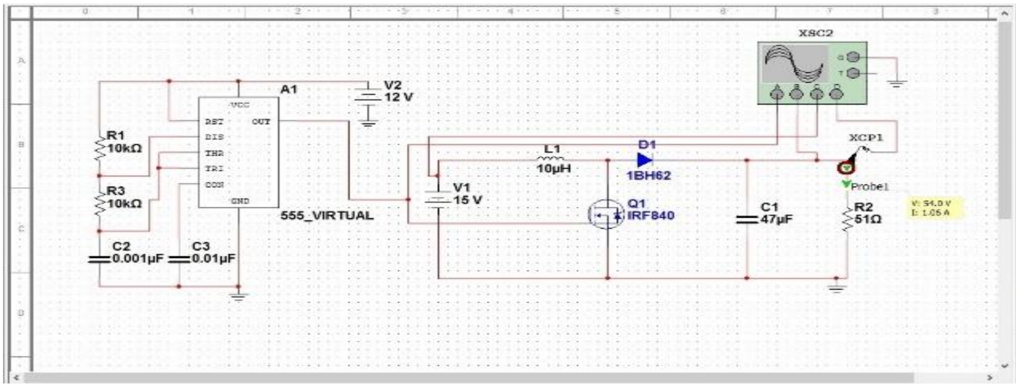

Fig 3:Basic Boost converter using MULTISIM

Fig.4 shows the simulation results for output voltage of basic boost converter along with switching frequency.

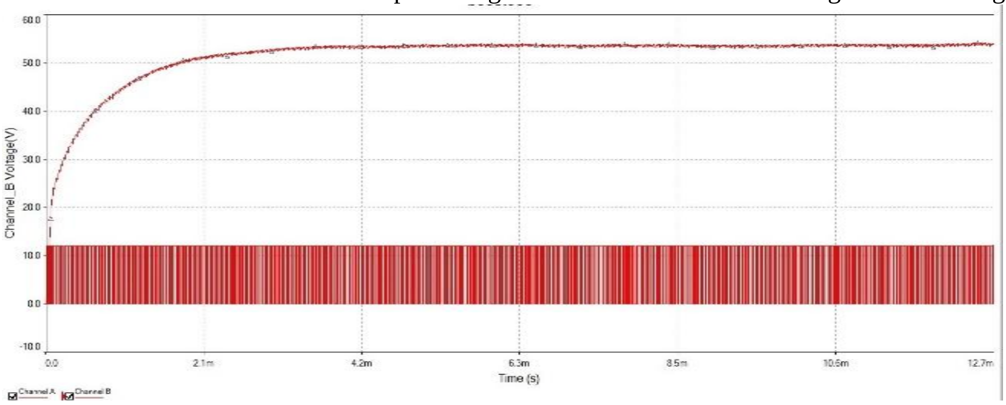

Fig 4:Output voltage of basic Boost converter

Fig.5 shows simulation results for output ripple voltage of basic Boost converter which is about 0.7V for 15V input.

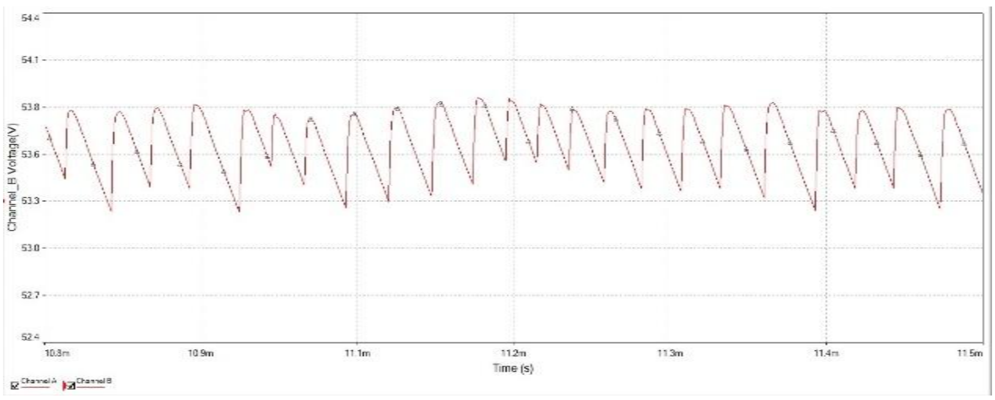

Fig 5:Output ripple voltage of basic Boost converter

Fig.6 shows simulation results for output ripple current of basic Boost converter which is about 1.1mA for 15V input.

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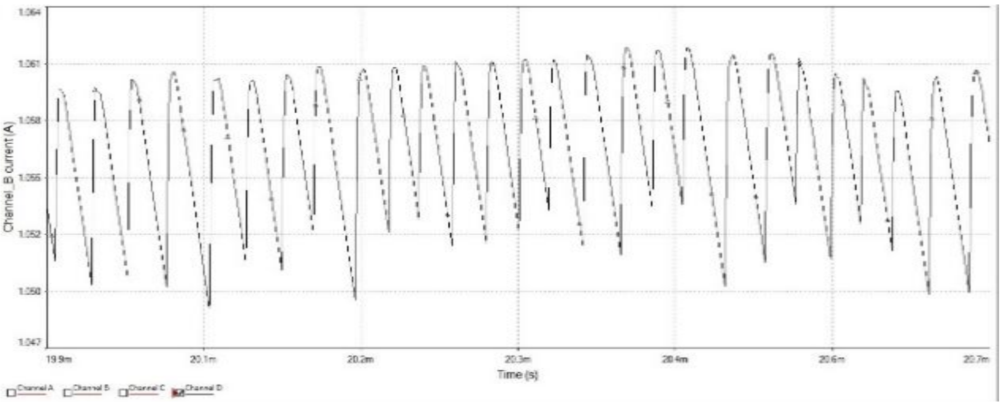

Fig 6:Output ripple current of basic Boost converter

Following Table 1 shows variation in simulation results for output voltage ripple and output ripple current of basic Boost converter by varying input voltage from 9V to 15V.

Input Voltage	Input frequency	Output Voltage	Output Voltage ripple	Current ripple
9V	35KHz	32.3V	0.3V	0.78mA
10V	35KHz	35.0V	0.4V	0.80mA
11V	35KHz	39.1V	0.5V	0.90mA
12V	35KHz	43.3V	0.5V	1.0mA
13V	35KHz	46.6V	0.6V	1.1mA
14V	35KHz	50.7V	0.7V	1.1mA
15V	35KHz	53.9V	0.7V	1.1mA

Table 1: SimulatedOutput of basic Boost converter

IV. INTERLEAVED BOOST CONVERTER

In interleaving technique an interconnection of multiple switching cells is done by synchronizing several frequency sources which helps to increase the effective pulse frequency and operating them with phase shift related to number of switching cells. Interleaving technique saves energy and improves power conversion without affecting conversion efficiency. This converter is consists of two boost conversion units parallely connected, having switches S1 and S2, inductors L1 and L2, diodes D1 and D2, Capacitor C and load resistor RL with common input source (VIN). The Circuit diagram for interleaved dc-dc boost converter is shown in Fig.7.

The IL1-current in the inductor L1 increases linearly when the switch S1 gets turned ON, and energy gets stored in the inductor L1. Diode D1 conducts and the stored energyin the inductor decreases with a slope based on the difference between the input and output voltage when switch S1 is gets turned OFF. The inductor gets discharged transferring current to load RL via diode D1. After half switching cycle of switch S1 switch S2 gets turned ON to complete the cycle of events. Effective ripple frequency at the output capacitor is twice than that of a single-phase boost converter is due to the combination of both the power channels at output capacitor and amplitude of the input current ripple is small. This is the advantage of this topology for the renewable energy sources.

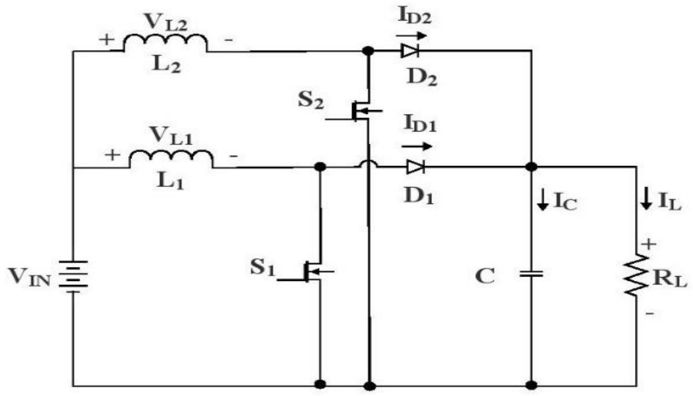

Fig 7: Interleaved Boost converter

The phase difference PD between two switching cells isgiven by,

$$P_D = \frac{360}{\text{N}}$$

Where ‘N’ is the number of partially connected boost converters. Thus for a two phase interleaved boost converter N=2 and phase difference becomes 180 degrees.

According to switching of converter it operates in three modes:

I. Mode I: switch S1 closed, switch S2 opened
II. Mode II: switch S1 opened, switch S2 opened
III. Mode III: switch S1 opened, switch S2 closed

V. PERFORMANCE ANALYSIS AND OPERATION OF INTERLEAVED BOOST CONVERTER USING MULTISIM

The simulation models are created using MULTISIM and performance parameters of the converters are verified. Input DC voltages are varied from 9V to 15V with constant duty cycle and output voltages are measured. The MULTISIM simulation models for interleaved boost converteris shown below in fig.8.

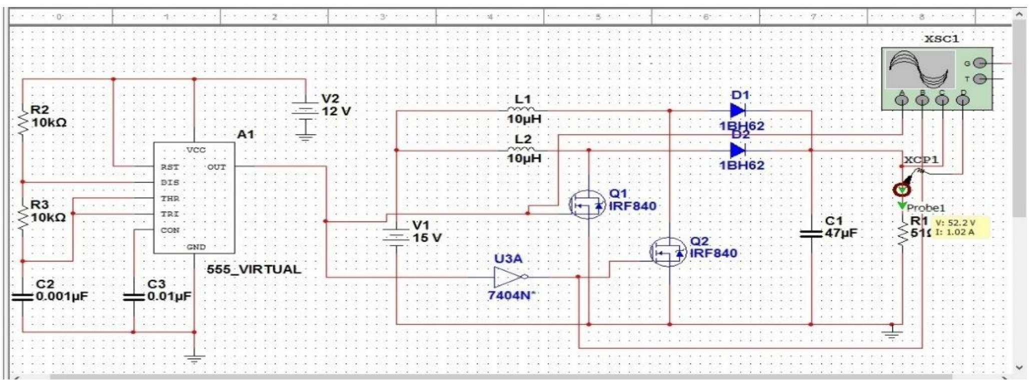

Fig 8: Interleaved Boost converter using MULTISIM

Fig.9 shows the simulation results for output voltage of Interleaved Boost converter along with switching frequency.

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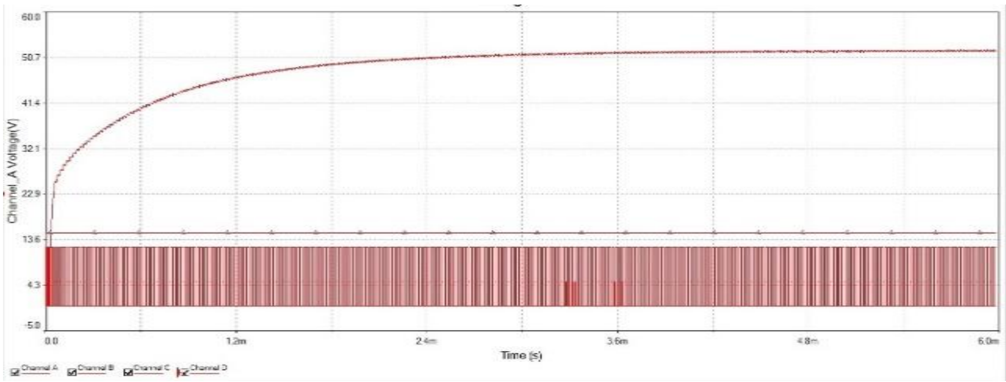

Fig 9: Output voltage of Interleaved Boost converter

Fig.10 shows simulation results for output ripple voltage of Interleaved Boost converter which is about 0.36V for 15V input.

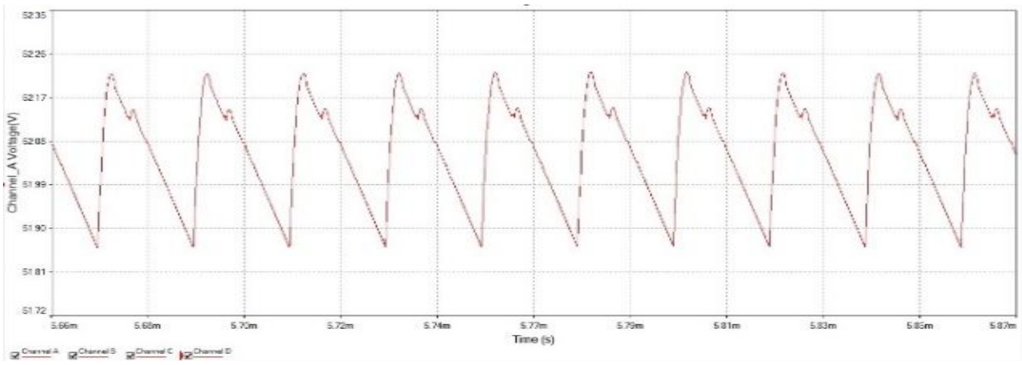

Fig 10: Output ripple voltage of Interleaved Boost converter

Fig.11 shows simulation results for output ripple current of Interleaved Boost converter which is about 0.70mA for 15V input.

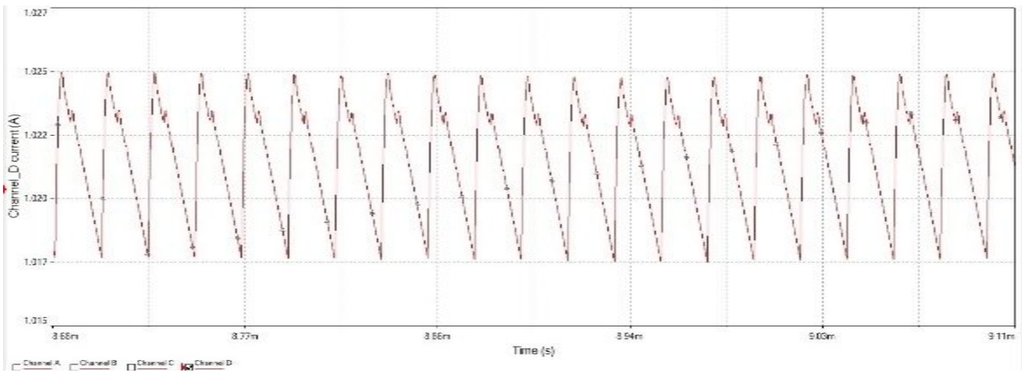

Fig 11: Output ripple current of Interleaved Boost converter

Following Table 2 shows variation in simulation results for output voltage ripple and output ripple current of Interleaved Boost converter by varying input voltage from 9V to 15V.

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Input Voltage	Input frequency	Output Voltage	Output Voltage ripple	Current ripple
9V	35KHz	32.1V	0.20V	0.40mA
10V	35KHz	34.8V	0.23V	0.46mA
11V	35KHz	38.8V	0.24V	0.50mA
12V	35KHz	42.0V	0.27V	0.56mA
13V	35KHz	45.0V	0.31V	0.60mA
14V	35KHz	48.3V	0.33V	0.66mA
15V	35KHz	52.0V	0.36V	0.70mA

Table 2: SimulatedOutput of Interleaved Boost converter

Following Table 3 shows the comparison between conventional boost converter and interleaved boost converter.

Parameter	Boost converter	Interleaved Boost converter
Input voltage	15V	15V
Switching frequency	35K	35K
Output voltage	53.9 V	52.0 V
Voltage ripple	0.6 V	0.36 V
Current ripple	1mA	0.7 mA
Efficiency	88%	90%

Table 3: Comparison between conventional boost converter and interleaved boost converter.

VI. CONCLUSION

This paper discusses the principle and operation of interleaved boost converter. Both the boost converters are simulated using NI MULTISIM at fixed switching frequency and fixed duty ratio. And comparison between conventional boostthese simulation results. These results shows the advantagesof interleaved boost converter having higher efficiency andreduced ripple of output current by 30% and ripple of output voltage by 41%.

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