Research Article

Interleaved DC-DC Boost Converter with Novel Isolation Technique

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Abstract: – In this paper, a novel isolation technique for Interleaved DC-DC boost converter is proposed and results are compared with Interleaved Boost Converter using isolation transformer. In the proposed converter isolation is obtained by power semiconductor switch. The disadvantages of isolationtransformer are leakage reactance, circulating currents which results in more losses. This drawback has overcome by proposed converter, which provides isolation and alsoleads to the reduction of switching losses. To achieve isolation a power MOSFET is connected between the source and converter as a physical isolating device. The isolating MOSFET switch is controlled by micro-controller.The proposed converter is developed in MATLAB/SIMULINK environment, to analyze its behavior and response. The schematic is analyzed and tested at 60V/220V, 3.96kW and this operation is validated by implementing in the hardware model at 12V/40V, 12W.
Keywords: Interleaved Boost Converter; Isolation; Microcontroller; circulating current;
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INTRODUCTION

In power electronics, applications of interleaving technique are used in numerous ways, mainly in high power applications. In such applications, the voltage and current values can easily go beyond the limit that one power device can handle without getting damaged. Several power components connected in series and/or parallel can be a solution for the above problem. But, current and voltage sharing among the components are still the concerns. Therefore, instead of paralleling power device components, paralleling power converters is alternative solution which has extra advantages. Besides, with the power converter paralleling theory, interleaving concept occurs naturally. Advantages like harmonic cancellation, better efficiency, high power density, and better thermal performance can be achieved. Interleaving technique will also efficiently reduce the active filters size and weight.

Boost power supplies are primarily used for creating higher voltages from low-voltage input sources. As the requirement of power increases, a single power stage will be not sufficient. Hence, by using interleaving which is also called "multiphasing" technique can be adapted for high power application. It is equivalent to a parallel connection of two or more sets of diodes, switches and inductors connected to a filter capacitor and output load [1] [2].

In most of the applications, it is preferred to obtain dc isolation between the control circuit and the power circuit or between the converter input and output usually for safe guard of components.

The interleaved boost converter using isolation transformer has more losses because of leakage reactance of the transformer windings. It costs more than 10% of converters used in small application. In small application, because of its windings and insulation the weight of the transformer is more than twice the weight of converter and it occupies more space in such circuits [3][4].

In the proposed circuit, isolation is provided by connecting the isolating MOSFET switch between source and the converter. It provides physical isolation for the converter from the source. It iscontrolled by micro-controller by monitoring

the output and input at time intervals.The proposed converter reduces the losses and increases the lifespan of inductors since there are no circulating currents. It costs less than the interleaved boost converter using isolation transformer and it occupies less space because the isolating MOSFET switch is small in size.

II. PROPOSED CIRCUIT

The proposed Interleaved Boost Converter circuit consists of MOSFET switch between source and converter for isolationpurpose, it is as shown in Fig 1.

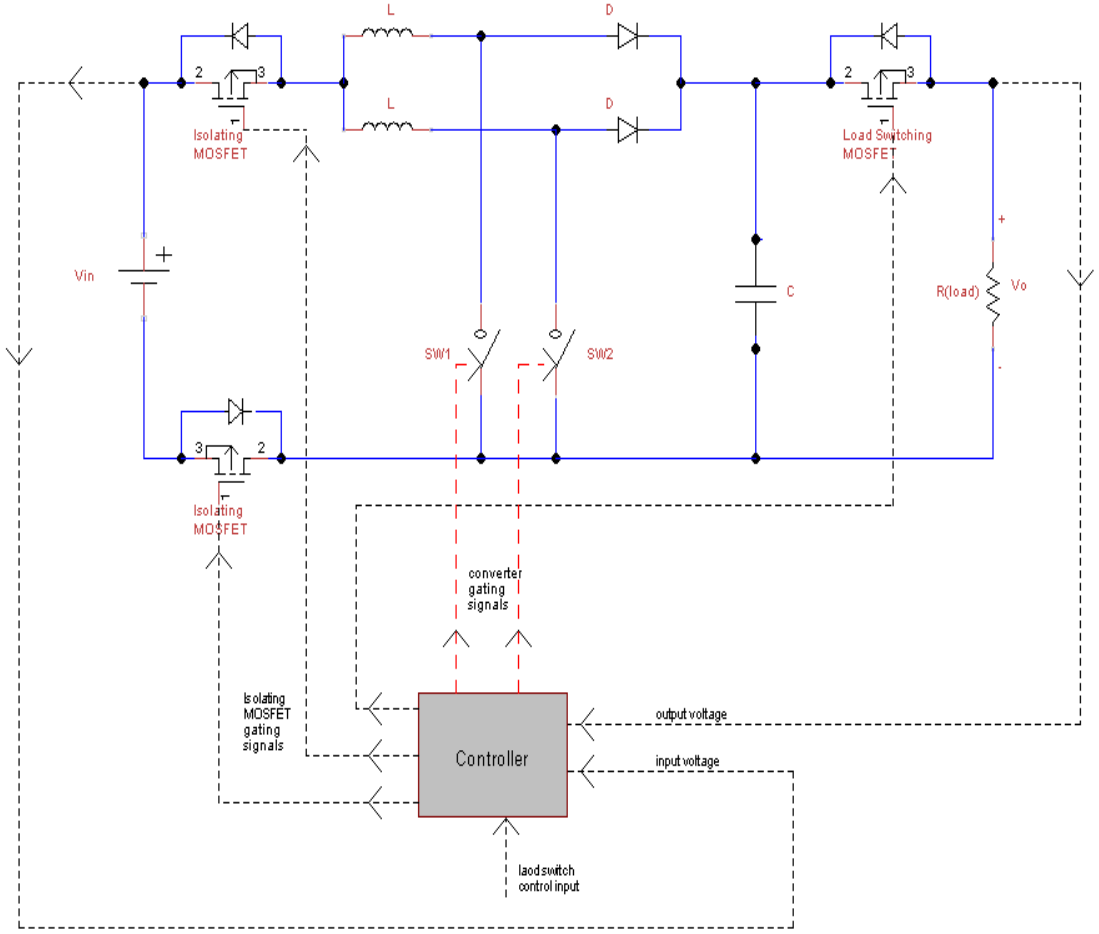

Fig. 1. Proposed Interleaved Boost Converter using MOSFET switch

III. PRINCIPLE OF OPERATION

When a load is connected, the isolating MOSFET switch is kept ON which connects the converter to the source. Hence, when the converter is connected to the load the principle of operation of the proposed circuit is same as the conventional interleaved boost converter. When the load is removed by disconnecting the load switch or when a mistaken load is connected the isolating MOSFET switch is turned off, this isolates the converter from the source.The isolating MOSFET switches are controlled by micro-controller which monitors the output voltage across the load, input voltage provided by the source and load switch status [6][7].

IV. SIMULATION AND COMPARISON OF RESULTS

The simulation of the proposed circuit is performed using MATLAB/SMULINK. Below Table 1 shows the simulated values.

TABLE 1. SIMULATED VALUES OF PROPOSED IBC

Sl.no.	Parameters	Specification
1.	DC Input Voltage	60V
2.	DC Output Voltage	220V
3.	Switching frequency	50kHz
4.	Power rating	3.96kW
5.	Input current	66A
6.	Output current	18A
7.	Inductor value(L)	132.24µH
8.	Capacitor value(C)	135µH

The simulation circuit of Interleaved Boost Converter without isolation and its waveforms are as shown in Fig. 2 and Fig. 3.

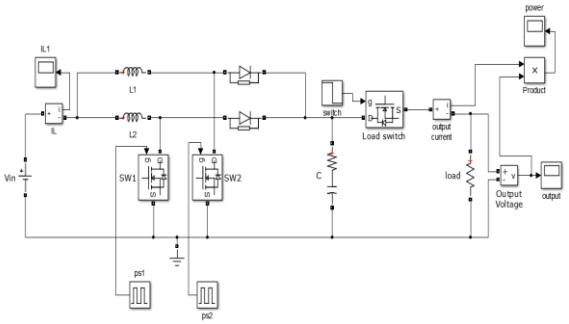

Fig. 2. Interleaved boost converter

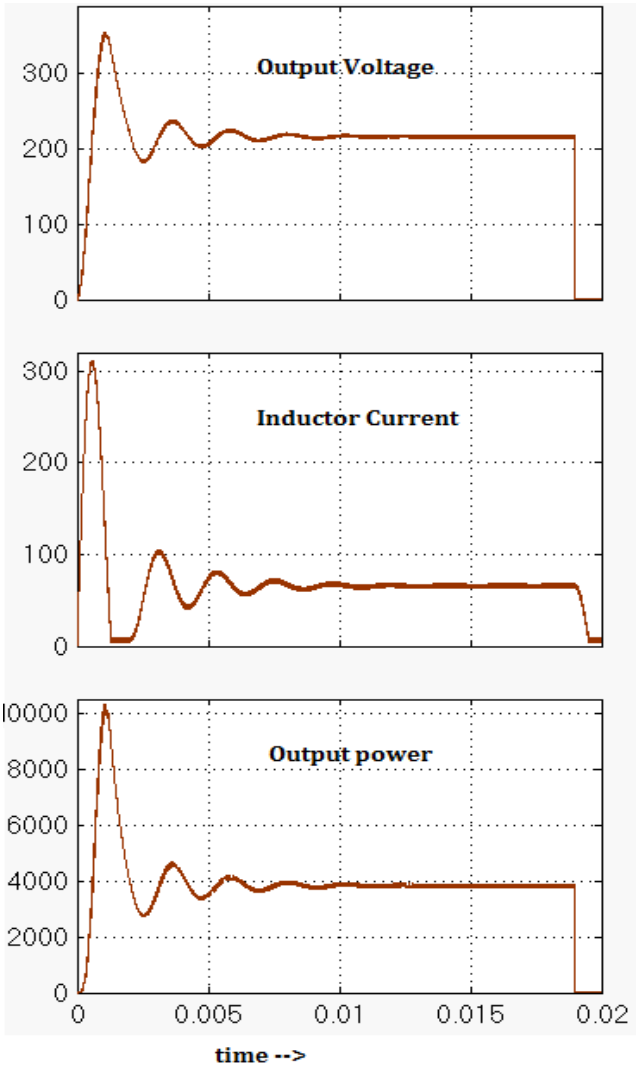

Fig. 3. waveforms of IBC converter without isolation

The simulation circuit of Interleaved Boost Converter with isolation transformer and its waveforms are as shown in Fig. 4 and Fig. 5.

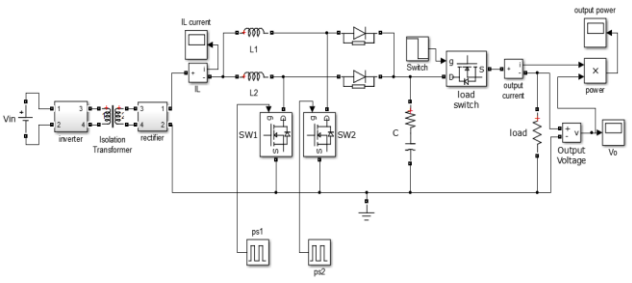

Fig. 4. IBC with isolation transformer

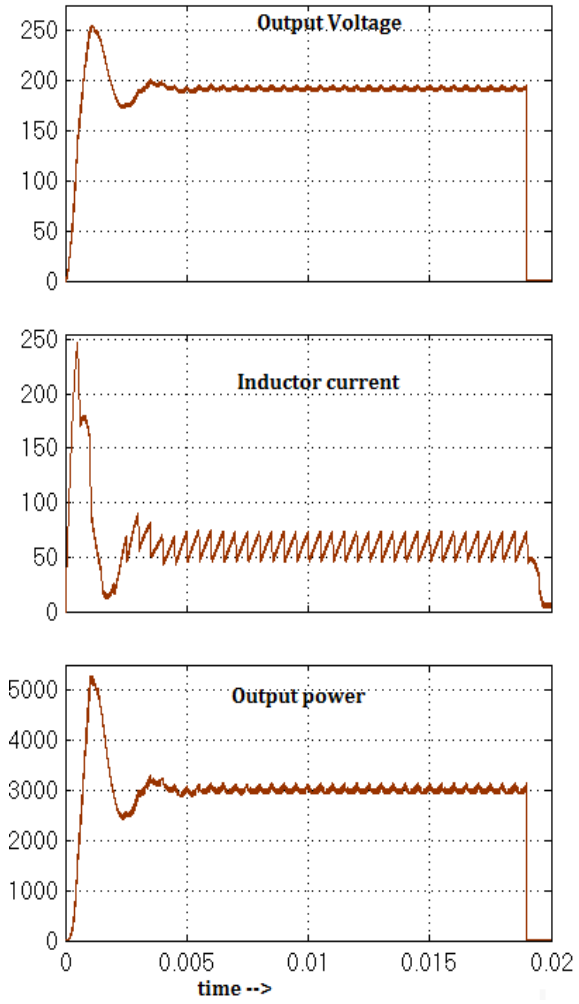

Fig. 5. waveforms of IBC converter with isolation transformer

The simulation circuit of Interleaved Boost Converter using MOSFET isolation and its waveforms are as shown in Fig. 6 and Fig. 7.

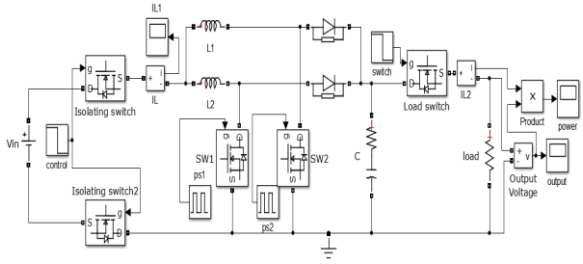

Fig. 6. IBC using MOSFET isolation

From the table, it is clear that the isolation which is very much essential in high power applications is almost done with transformer when it is done with proposed circuit has more advantages compared to isolation by transformer.

V. EXPERIMENTAL RESULTS

The proposed system simulated is constructed in hardware to further validate via experimental studies. Fig. 8 shows the prototype of the interleaved converter using MOSFET isolation. It consists of 12V battery as input source, different loads are connected to verify the isolation status at under-load and overload conditions. Output of 40V is produced by interleaved boost converter. The isolating MOSFET and the converter duty cycle are controlled by micro-controller. The output voltage of prototype viewed using an oscilloscope is as shown in Fig. 9

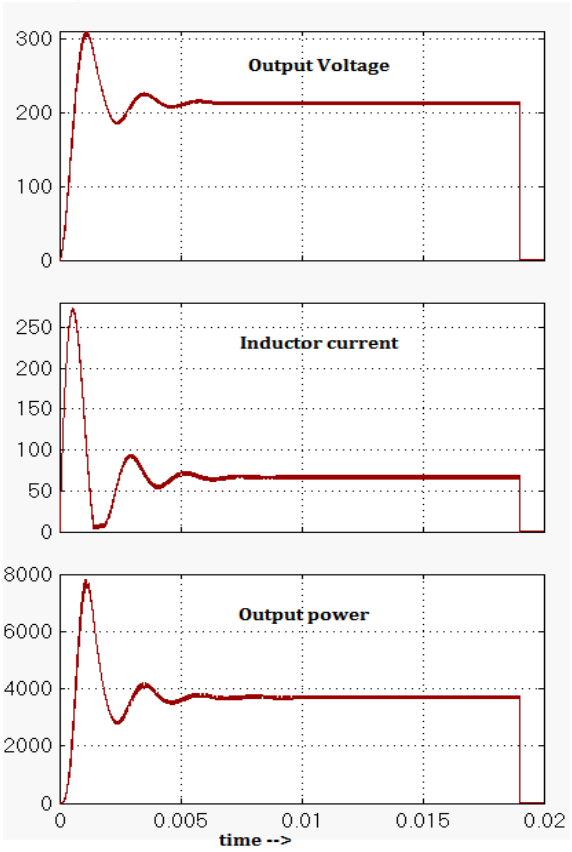

Fig. 7. waveforms of IBC converter using MOSFET isolation

TABLE 2. COMPARISON OF SIMULATION RESULTS

Parameters	IBC without isolation	IBC with isolation transformer	IBC with isolating MOSFET device
Output Voltage (theoretical value =220V)	216V	192V	212V
Voltage ripple	3.2V	6V	3.2V
Output power	3.83kW	3.02kW	3.7kW
Efficiency	96.71%	76.26%	93.43%
Current drawn by the inductor during no load condition	about 8A	about 8A	Less than 0.05A
Leakage Reactance	High	High	Very low

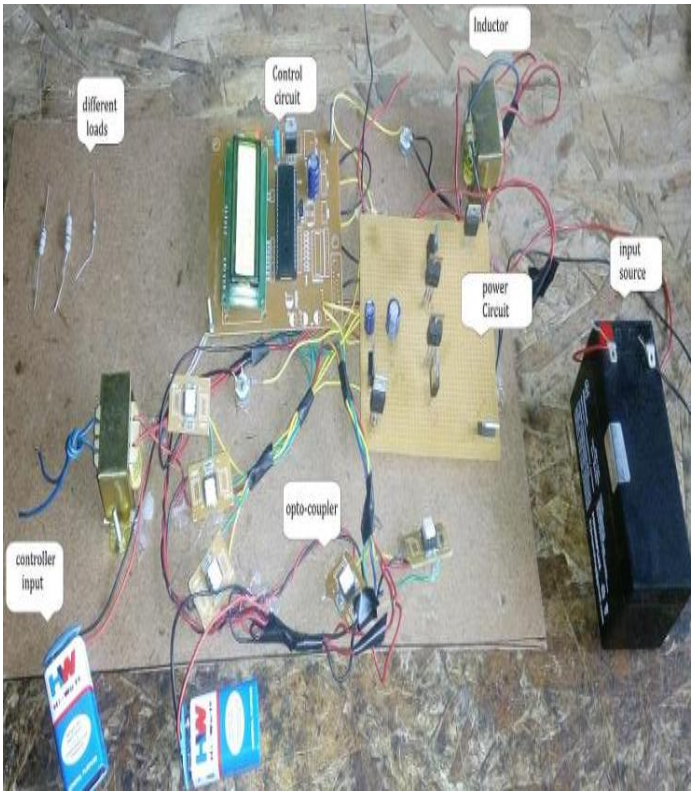

Fig 8: Hardware Prototype

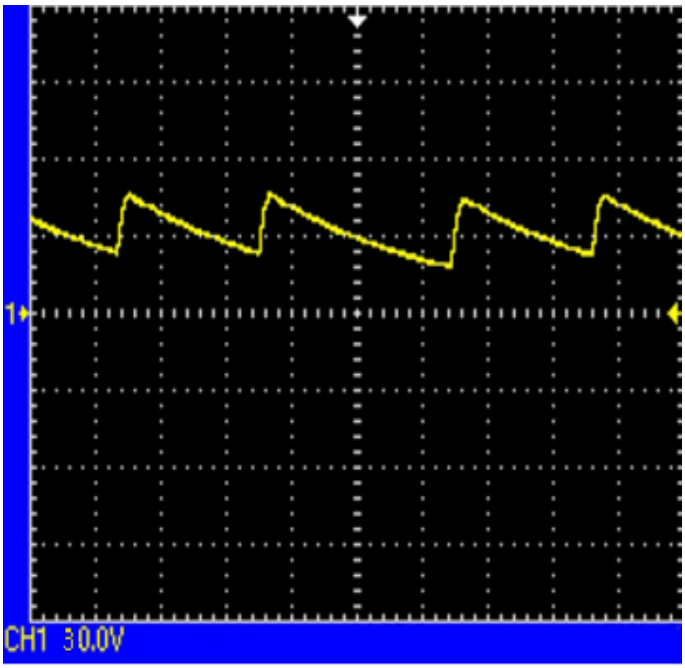

Fig 9: Hardware output voltage waveform

VI. CONCLUSION

The MOSFET isolated Interleaved Boost converter is used for better isolation in the converter used for low power application. It provides better efficiency compared to converter using isolation transformer. In the proposed circuit there is no leakage reactance during no-load condition. Hence, it optimizes power consumption. Complete analysis of the operations and the performances of the proposed converter are presented in this paper. A prototype of the converter was built and tested for validation of operation and performance of the proposed converter.

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