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RES Based High Efficient High Gain MDIBC for Standalone and Grid Connection Applications

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Abstract:

In this paper a closed loop control of interleaved boost converter is proposed. A suitable DC-DC converter is required for designing high efficiency power systems. Among the various topologies, Multi device Interleaved Boost converter (MDIBC) is considered as a better solution for high power systems due to improved electrical performance, reduced weight and size. Detailed analysis has been done to investigate the benefits of multi device interleaved boost converter compared to the conventional boost converter topologies. a multi device interleaved boost converter (MDIBC) is proposed for high-voltage and high-power applications. One of challenge in designing a boost converter for high power application is how to handle the high current at the input side. A multi device structure with interleaved control is proposed to reduce the input current ripples, the output voltage ripples, size and weight of the passive components with high efficiency compared with the other topologies. By virtue of the converters, the input current can be shared among the cells or phases, so that high reliability and efficiency in power electronic systems can be obtained. In addition, it is possible to improve the system characteristics such as maintenance, repair, fault tolerance, and low heat dissipation. Moreover, the overall performance of the compromised design was shown to be quite good. In addition, low EMI and low stress in the switches are expected, which decreases the conduction losses and lengthens the life time of input source. Even the low voltage stress makes the low-voltage-rated switching devices can be adopted for reductions of conduction losses and cost. The proposed converter is compared to other converter topologies such as conventional boost converter (BC), multi device boost converter (MDBC), and two-phase interleaved boost converter (IBC).Furthermore, a state space average model is derived for these dc/dc converters. The dc/dc converter topologies and their controller are designed and investigated by using MATLAB/ Simulink.

Keywords:

Interleaved Boost converter, PI Controller, DC-DC converter.

I.INTRODUCTION:

A chopper is a static power electronic device that converts fixed dc input voltage to a variable dc output voltage. As chopper involves one stage conversion, these are more efficient [2]-[3]. Choppers are now being used all over the world for rapid transient systems. These are also used in trolley cars, marine hoist, forklift trucks and mine haulers. The future electric automobiles are likely to use choppers for their speed control and braking.

Chopper systems offer smooth control, high efficiency, faster response and regeneration facility [1]. As mentioned above, a chopper is dc equivalent to an ac transformer, have continuously variable turn's ratio. Like a transformer, a chopper can be used to step down or step up the fixed dc input voltage. Boost converter belongs to the family of basic power conversion topologies (the other two being buck and buck-boost derivative).An interleaved boost DC-DC converter seems to be a suitable candidate for current sharing and stepping up the voltage [4]-[5]. The main objective of this paper is to propose a multi device boost converter with interleaved control which reduces the input current and output voltage ripple.

Multi device Interleaved boost converter has been proposed to reduce the size and weight of the passive components such as the inductor, capacitor and input/output electromagnetic interference (EMI) filter. Also, the input current and output voltage ripple can be minimized with high efficiency and reliability. Finally a closed loop control of interleaved boost converter is proposed for high power applications.

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II.PROPOSED CONCEPT :
Conventional Topologies :

DC/DC converter is used to boost the input voltage. The amount of power flow between the input and the output can be controlled by adjusting the duty cycle (ratio of on/off time of the switch). This is done to control the output voltage, the input current, the output current, or to maintain a constant power. Conventional topologies include:

• Boost Converter
• Multi device Boost Converter
• Interleaved Boost Converter

Boost Converter

A boost converter (BC) is a power converter with an output voltage greater than its input voltage. It consists of at least two semiconductor switches (a diode and a switch) and at least one energy storage element (capacitor and/or inductor). Filters made of capacitors are normally added to the output of the converter to reduce output voltage ripple and the inductor connected in series with the input DC source in order to reduce the current ripple.

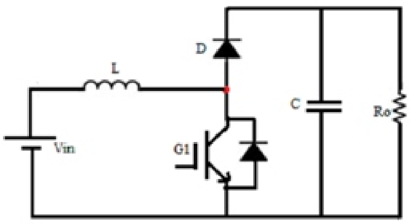

Fig.1 Boost Converter (BC)

When the switch is closed, current flows through the inductor in clockwise direction and the inductor stores the energy. Polarity of the left side of the inductor is positive. When the switch is opened, current will be reduced as the impedance is higher. Therefore, change or reduction in current will be opposed by the inductor. The polarity will be reversed (means left side of inductor will be negative now). Thus two sources will be in series causing a higher voltage to charge the capacitor through the diode [9].

Multi device Boost Converter :

Multi device Boost Converter (MDBC) is a boost converter with more than 2 switches (m is the number of parallel switches).

The working principle is same as that of a boost converter, shown in fig.2. Here the switches are connected in parallel with a single storage element (inductor L)[6]. Thus with m switches, the size of the passive components will be reduced by m times compared with the standard boost converter. In this converter structure, m is selected to be 2.

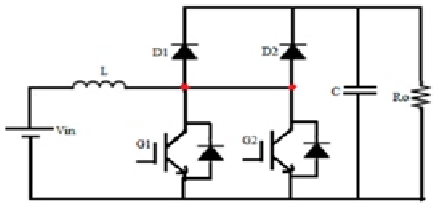

Fig.2 Multi device Boost Converter (MDBC)

Interleaved Boost Converter:

In an interleaved converter several power stages are connected in parallel and driven with gate signals shifted by 360o/n, where n is the number of phases. Effective switching frequency is increased proportionally to the number of phases.

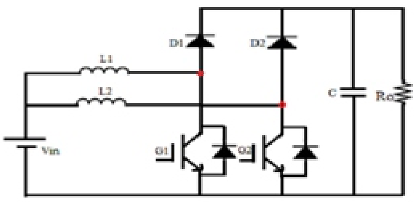

Fig.3 Interleaved Boost Converter (IBC)

Each switching device is switched at the same frequency but at a phase difference of 180o. By splitting the current into two paths, conduction losses can be reduced, increasing overall efficiency compared to a single phase converter. Since the two phases are combined at the output capacitor, effective ripple frequency is doubled, making ripple voltage and ripple current reduction much easier. Switching sequences of each phase may overlap depending upon the duty ratio[6]-[8].

III.PROPOSED CONVERTER STRUCTURE:

The structure of the MDIBC is shown in Fig.4 This converter consists of two-phase interleaved with two switches and two diodes connected in parallel per phase. The easy way to reduce the size of the inductor, capacitor, and input/output EMI filter is by increasing the frequency of the inductor current ripple and the output voltage ripple.

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The phase-shift interleaved control is proposed to achieve the control strategy. This control strategy will provide a doubled ripple frequency in inductor current at the same switching frequency, which can contribute to a higher system bandwidth. This bandwidth achieves a fast dynamic response for the converter and reduces the size of the passive components [6]-[7]. In addition, the sequence of the driving signals is very important to providing a doubled ripple frequency in inductor current at the same switching frequency and to achieve the interleaved control between inductors as illustrated in Fig.5.

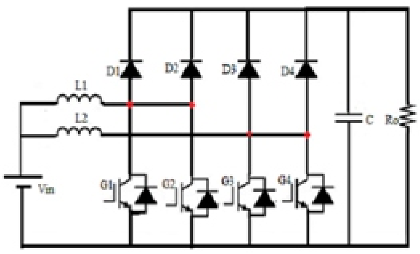

Fig.4 Multi device Interleaved Boost Converter (MDIBC)

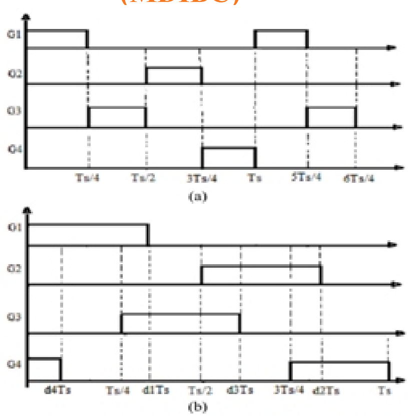

Fig.5 Sequence of the driving gate signals for switches. (a) d = Ts /4. (b) d ≥ Ts /4.

With the proposed control, the switching pattern is shifted by 360◦/ (n ×m), where m is the number of parallel power switches per channel, while n is the number of channels or phases. The input current ripple is (n ×m) times of the switching frequency. Similarly, the output voltage ripple is (n ×m) times of the switching frequency. As a result, the size of the passive components will be reduced by m times compared with the n-phase interleaved dc/dc converters. In this proposed converter structure, m is selected to be 2, while n is chosen to be 2. Fig.5 demonstrates the sequence of the driving signals at different duty cycles. Furthermore, theequivalent circuits of the proposed converter modes for d > 0.25 are presented in Fig.5 (a), where d is the duty cycle.

It is also assumed that the proposed converter operates in the continuous conduction mode (CCM). The load current is assumed to be ripple free. All switches have identical duty cycles which means,

$$d_1 = d_2 = d_3 = d_4 = d$$

The output voltage is,

$$V_o = \frac{Vin}{(1 - mD)} \quad (1)$$

The input current is,

$$I_{in} = \frac{Io}{(1 - mD)} \quad (2)$$

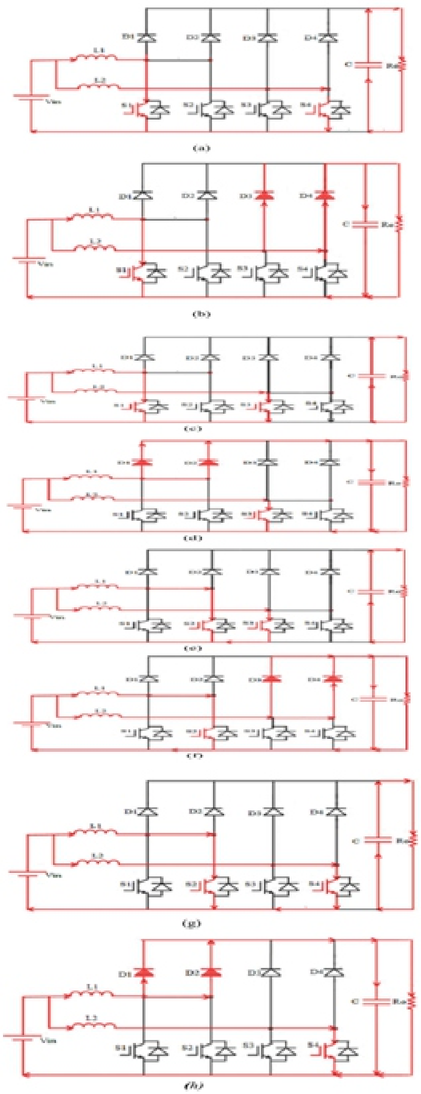

Fig.6.Equivalent circuits of the proposed converter for d >0.25 The intervals are mentioned in Fig.3.5 (b) (a) Mode 1: 0 ≤ t ≤ d4Ts (b) Mode 2: d4 Ts ≤ t ≤ Ts /4 (c) Mode 3: Ts /4 ≤ t ≤ d1 Ts (d) Mode 4: d1 Ts ≤ t ≤ Ts /2 (e) Mode 5: Ts /2 ≤ t ≤ d3 Ts (f) Mode 6: d3 Ts ≤ t ≤ 3 Ts /4 (g) Mode 7: 3 Ts /4 ≤ t ≤ d2Ts (h) Mode 8: d2 Ts ≤ t ≤ Ts .

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The inductor value of MDIBC is given by the following expression:

$$L = \frac{Vin * d}{m * n * f * \Delta I} \quad (3)$$

The capacitor value of *MDIBC* is given by the following expression:

$$C = \frac{Io * d}{m * n * f * \Delta V} \quad (4)$$

m: the number of parallel power switches per channel
n : the number of channels,
f: the switching frequency,
d : duty cycle
ΔI: the input current ripple,
ΔV: the output voltage ripple
Iin : input current
Vo : output voltage

TABLE-3.1:CONVERTER PARAMETERS

TOPOLOGY	[n m]	L (mH)	C (μF)
BC	[1 1]	2.5	100
MDBC	[1 2]	1.25	50
IBC	[2 1]	1.25	50
MDIBC	[2 2]	0.625	25

IV.CLOSED LOOP INTERLEAVED BOOST CONVERTER:

Feedback is used in control systems to change the dynamic behavior of the system, whether mechanical, electrical or biological and to maintain their stability. The control strategy of the proposed converter PI Controller which takes its control signal from the output of the switching converter.

The aim is to regulate the output voltage of the converter across the load resistance to match a precise stable reference voltage. This is achieved by subtracting the desired reference voltage from the sensed output voltage of the converter. The voltage error thus obtained is passed through a PI controller to obtain the desired signal.

The function of the PI controller is to take the input signal, compute its integral, and then compute the output as a combination of input signal, proportional and integral[9]. The output signal controls the converter system.

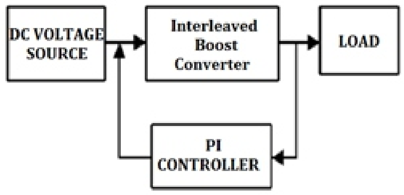

Fig.7 Closed loop control of Interleaved boost converter

SIMULATION RESUTS:

Case 1: Boost converter:

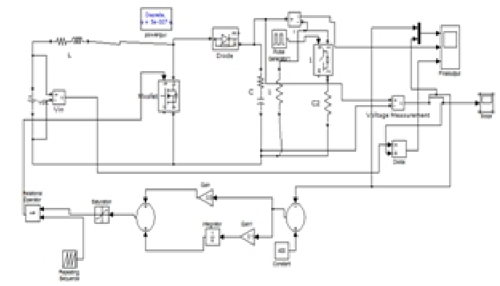

Fig.8 Simulink circuit for boost converter

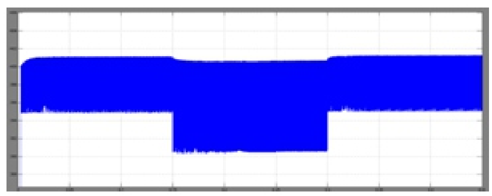

Fig.9.Simulation results for output voltage ripple

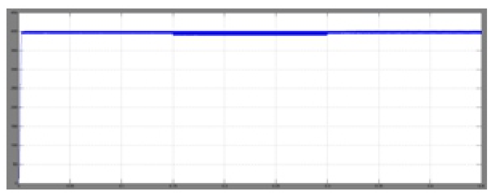

Fig.10.Simulation results for output voltage

Case 2: Interleaved Boost converter

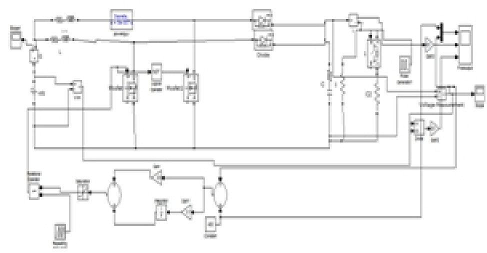

Fig.11.Simulink circuit for interleaved converter

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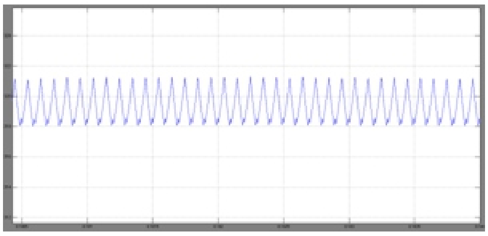

Fig.12. simulation result for input current ripple

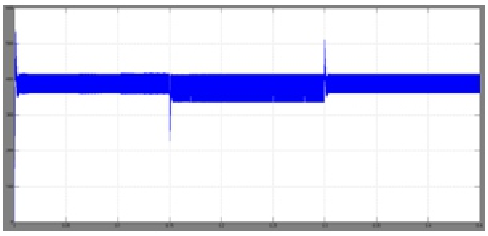

Fig.13. simulation result for output voltage ripple

Case 3: Multi Device Boost converter

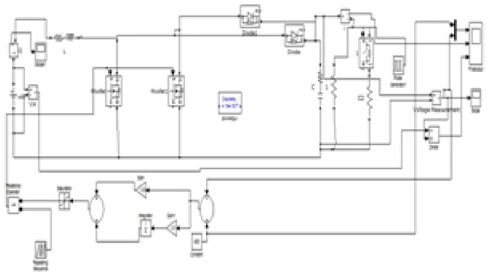

Fig.14. Simulink circuit for multi device boost converter

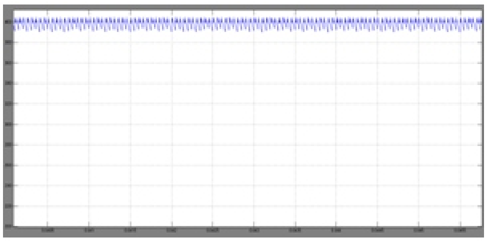

Fig.15.Simulation result for output voltage

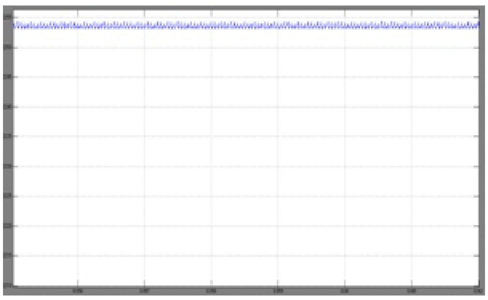

Fig.16.Simulation results for output voltage ripple

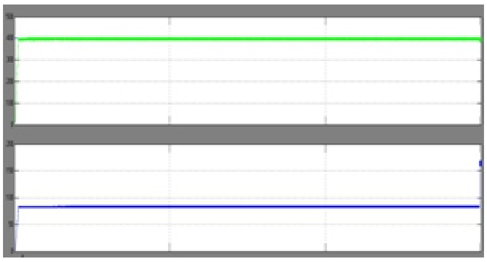

Fig.17. simulation result for output voltage and current

Case 4: Multi Device Interleaved Boost converter

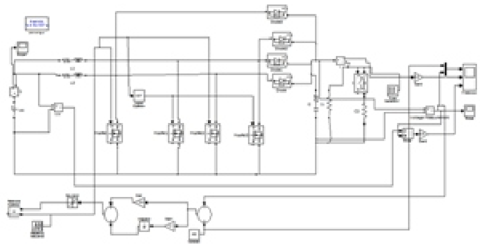

Fig.18.Simulink circuit for multi device interleaved boost converter

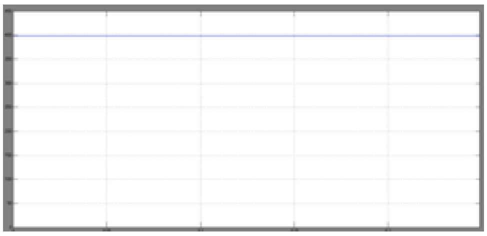

Fig.19.simulation results for output voltage

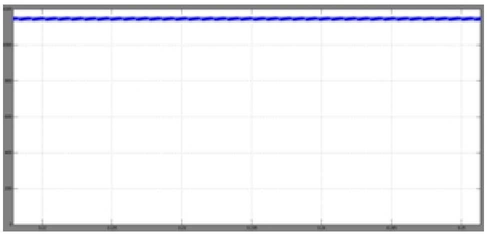

Fig.20.Simulation result for output current

Case 5: Multi Device Interleaved Boost converter with grid

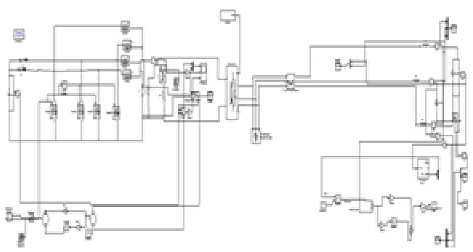

Fig.21..Simulink circuit for grid connected multi device interleaved boost converter

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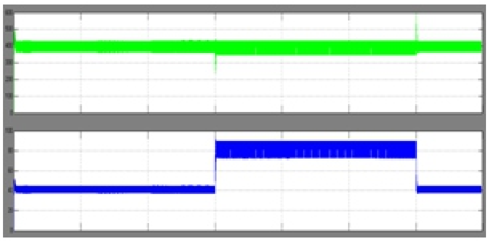

Fig.22.Simulation results for output voltage and current for multidevice interleaved converter

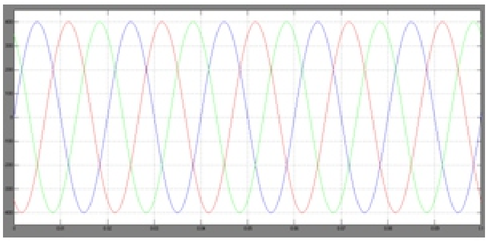

Fig.23.Simulation result for grid voltages

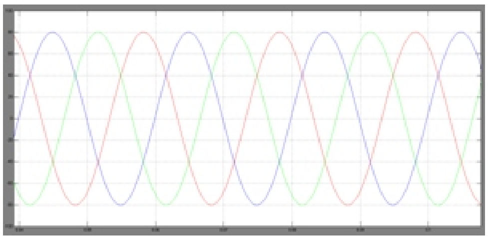

Fig.24.Simulation results for grid currents

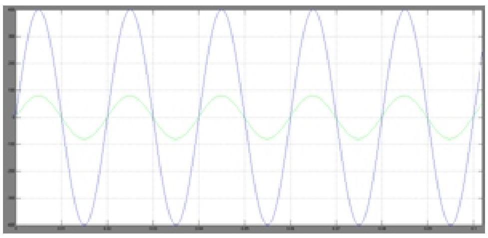

fig.25. Simulation results for grid power factor

CONCLUSION:

An Interleaved multi device boost converter operates efficiently with reduced voltage stress. The main drawback related to this topology output voltage ripple. In order to reduce the ripple, a thorough study on MDIBC was made and modeling of the converter was also done. Simulation was done for both open loop of MDIBC and closed loop modeling of MDIBC with PI controller. This low ripple voltage is connected to grid through an inverter module.

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