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HIGH VOLTAGE BOOST-HALF- BRIDGE (BHB) CELLS USING THREE PHASE DC-DC POWER CONVERTER FOR HIGH POWER APPLICATIONS WITH REDUCED SWITCH

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Abstract:

In this paper, the areas of power electronic converter system there is a general trend to high power densities that is driven by cost reduction and an increased functionality. The demand for DC-DC converters and related semiconductor components is nowadays an emerging expectation to meet the pursuit of energy efficiency and to reduce the power demand. This paper deals with the multiphase DC–DC converters based topology applied for high-voltage applications. The proposed converter is configured such that the Boost-Half- Bridge (BHB) cells and voltage doublers are connected in parallel and in series to increase the output voltage.

Index Terms: Active Clamping, Boost-Half-Bridge (BHB), High Step-Up, Multiphase & Soft-Switched

1. Introduction:

The Step-Up dc–dc converter has been increasingly needed in high-power applications, such as fuel-cell systems, photovoltaic systems, hybrid electric vehicles, and uninterruptible power system (UPS), where high-step-up ratio and the use of high-frequency transformers for galvanic isolation and safety purpose are required. The multiphase dc–dc converter could be a choice of topology for high-power applications. In order to reduce the volume of a system, the most appropriate topology for the intended application must be chosen. Applying DC–DC converters can help to reduce the switching losses and/or to raise the switching frequency of the power switches. DC-DC power converters are employed in a variety of applications, including power supplies for personal computers, office equipment, spacecraft power systems, laptop computers, and telecommunications equipment, as well as dc motor drives.

The input to a DC-DC converter is unregulated dc voltage Vg. The converter produces a regulated output voltage V, having a magnitude (and possibly polarity) that differs from Vg. For example, in a computer off-line power supply, the 120 V or 240 V ac utility voltages is rectified, producing a dc voltage of approximately 170 V or 340 V, respectively.

A DC-DC converter then reduces the voltage to the regulated 5 V or 3.3 V required by the processor ICs. High efficiency is invariably required, since cooling of inefficient power converters is difficult and expensive. The ideal dc-dc converter exhibits 100% efficiency; in Practice, efficiencies of 70% to 95% are typically obtained. This is achieved using switched-mode, or chopper, circuits whose elements dissipate negligible power. The multiphase converter has reduced volume of input and output filters resulting from the interleaved switching. Another advantage provided by the multiphase converter is output ripple cancellation, which results in increasing the effective output frequency without sacrificing the switching losses. The increasing effective frequency reduces component size. A full-bridge-based current-fed converter with active clamp also achieve ZVS of main switches, but the single-active clamp branch suffers from high-current rating and high- switching frequency, which is three times the switching frequency of the main switch. The passive and active clamping versions of the L- type half-bridge-based current-fed converter were proposed with similar advantages and disadvantages discussed in the aforementioned schemes. In the meanwhile, the boost-half-bridge (BHB) converter has been presented. It demonstrates the following features: small input filter due to continuous input current, low electromagnetic interference (EMI) due to ZVS turn ON of all power switches, wide-input voltage range application due to wide-duty cycle range. The BHB converter with a voltage doublers rectifier at the secondary has further advantages, which are no dc magnetizing current of the transformer, reduced voltage surge associated with diode reverse recovery, and no circulating current due to absence of output filter inductor.

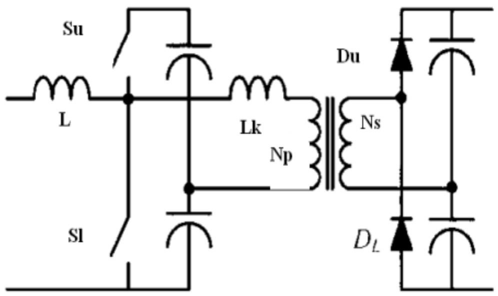


Figure 1: BHB cell as a building block for the proposed multiphase converter

In this paper, multiphase dc–dc converters using a BHB converter as a basic building block are proposed for high-voltage & high-power applications. A generalized multiphase dc–dc converter is configured in such a way that the BHB cell and the voltage-doublers rectifier are connected in series, in parallel, or by combination of them at the primary and secondary, respectively, to increase the output voltage and/or the output power. Therefore, the device current rating of the proposed multiphase converter is reduced by increasing the number of parallel connection, and the device voltage rating is reduced by increasing the number of series connection. In summary, in addition to the advantages of the conventional multiphase converter, which include reduced current rating and reduced volume of input and output filters resulting from the interleaved switching, the proposed multiphase converter has the following features.

- Significantly reduced turn ratio of the transformer and voltage rating of the diodes and capacitors, and therefore, especially suitable to high-step-up applications.
- Natural ZVS turn-ON of main switches using energy stored in transformer leakage inductor, and zero-current switching (ZCS) turn-OFF of rectifier diodes, which results in greatly reduced voltage surge associated with the diode reverse recovery.
- No additional clamping and start-up circuits required due to the proposed interleaved asymmetrical PWM switching.
- High component availability, easy thermal distribution, and low profile due to the use of multiple small components instead of single-large component.
- Flexibility in device selection by proper choice of topology resulting in optimized design under harsh design specification.

2. Multiphase DC–DC Converter:

A) Generalized Multiphase DC-DC converter:

Fig. 1 shows the BHB cell that is used as a building block of the proposed multiphase converter. Fig. 2 shows the block diagram arrangement of an system of the DC- DC converter circuit.

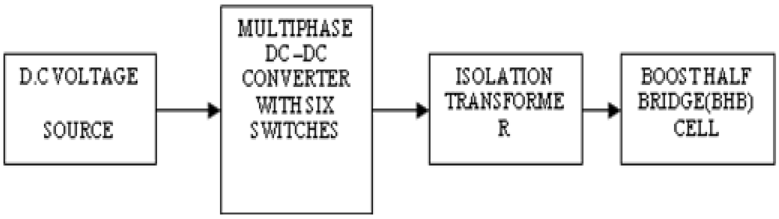


Figure 2: Block Diagram of DC/DC Converter

B) Working Operation:

Fig. 3 shows the schematic arrangement of proposed converter, which is made up of Isolation transformer, Boost Half bridge cell, and voltage doublers and rectifier circuit.

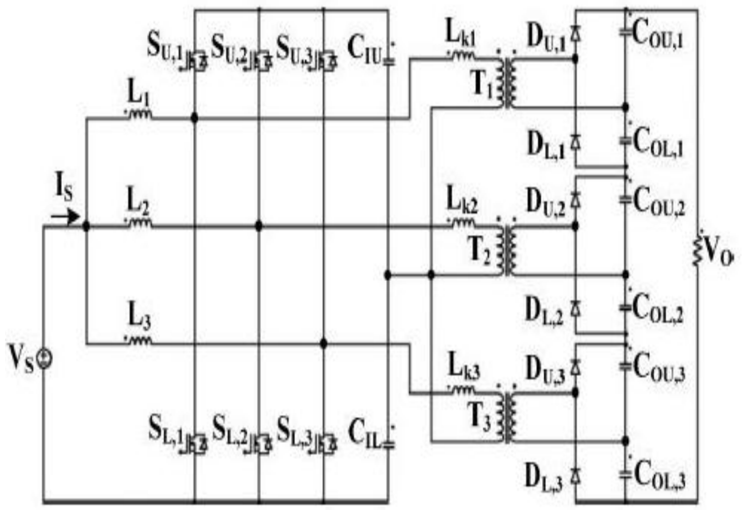


Figure 3: Schematic arrangement of Proposed Converter

The D.C voltage source is given to a Multiphase DC– DC Converter, In a Multiphase DC – DC Converter which is made up of six power electronics switches. Which converts DC into a pulsating DC that pulsating DC output is given to a isolation transformer through BHB which increases the voltage that is more than input. The isolation transformer is protecting the secondary side and primary side that means in case the voltage variation is occurred in secondary side due to change in load, which does not affect the primary side because of that isolation transformer. In a multiphase DC-DC converter is use of an the BHB cell and the voltage doubler rectifier are connected in series, in parallel, or by combination of them at the primary and secondary, respectively, to increase the output voltage and the output power. Therefore, the device current rating of the multiphase converter is reduced by increasing the number of parallel connection, and the device voltage rating is reduced by increasing the number of series connection.

Advantages:

The multiphase DC–DC converter has several advantages over the conventional dc–dc converter based on full-bridge, half-bridge, and push–pull topologies,

1) Reduction of MOSFET.
2) Conduction losses.
3) Easy device selection due to reduced current rating.
4) Reduction of the input and output filters.

5) Effective-switching frequency by a factor of phase number and reduction in transformer size due to better transformer utilization.
6) Several isolated three-phase dc–dc converters have been proposed for high-power applications
7) High-step-up ratio and the use of high-frequency transformers for galvanic isolation and safety purpose are required.

Applications:

This multiphase DC-DC converter can be used for an following applications

1) This DC–DC converter has been increasingly needed in high-power applications, such as fuel-cell systems
2) Photovoltaic systems
3) Hybrid electric vehicles, and
4) Uninterruptible power system (UPS).

C) ZVS Characteristics of Main Switch:

The soft switching PWM DC-DC converter is defined here as the combination of converter topologies and switching strategies that result in Zero Voltage and Zero Current Switching. Soft switching techniques are used in PWM DC-DC converters to reduce switching losses and electromagnetic interference (EMI).The technique of zero voltage switching in modern power conversion is explored. Zero voltage switching can best be defined as conventional square wave power conversion during the switch's on-time with "resonant" switching transitions. For the most part, it can be considered as square wave power utilizing a constant off-time control which varies the conversion frequency, or on-time to maintain regulation of the output voltage.

ZVS benefits are as follows:

Zero power “Lossless “switching transitions, Reduced EMI/RFI at transitions, No power loss due to discharging Current, No higher peak currents, Square wave systems, High efficiency with high voltage inputs at any frequency, Reduced gate drive requirements.

D) Interleaving Effect:

The interleaved power conversion refers to the strategic interconnection of multiple switching cells for which the conversion frequency is identical, but for which the internal switching instants are sequentially phased over equal fractions of a switching period. This arrangement lowers the net ripple amplitude and raises the effective ripple frequency of the overall converter without increasing switching losses or device stresses. An interleaved system can therefore realize a savings in filtration and energy storage requirements, resulting in greatly improved power conversion densities without sacrificing efficiency. The leg of the multiphase converter is switched with a phase difference of $2\pi/(N \cdot P)$. The ripple frequency of the input and input capacitor currents becomes $N \cdot P$ times the switching frequency of the main switch. The rms current of the input and input capacitor also decrease as N and P increases. The ripple frequency of the output capacitor current becomes P times the switching frequency of the main switch. The rms current of the output capacitor decreases as P increases. Due to the interleaved operation, the weight and volume of input capacitors, output capacitor, and input inductors are significantly reduced. Thus the interleaving effect on the input capacitors CIU and CIL differs from that of the input inductor and output capacitor. The interleaving effect on the input inductor and output capacitor of the proposed converter is obvious and has been mentioned in many literatures. The interleaving effect on the input capacitors CIU and CIL differs from that of the input inductor and output capacitor.

3. Simulation Result and Output Waveform of a DC-DC Converter:

Simulation Circuit of DC-DC Converter:

The Simulation circuit of DC-DC converter is shown in following figure, this circuit can be implemented in MATLAB/SIMULINK. In this simulation circuit consists of six power electronics switches, isolation transformer and boost half bridge cell. In a Matlab, simpower system power elctronics, can be used for to an make a simulation circuit. To make the connection for the simulation circuit of the converter circuit, that circuit arrangement is shown in second chapter of Multiphase Converter section.

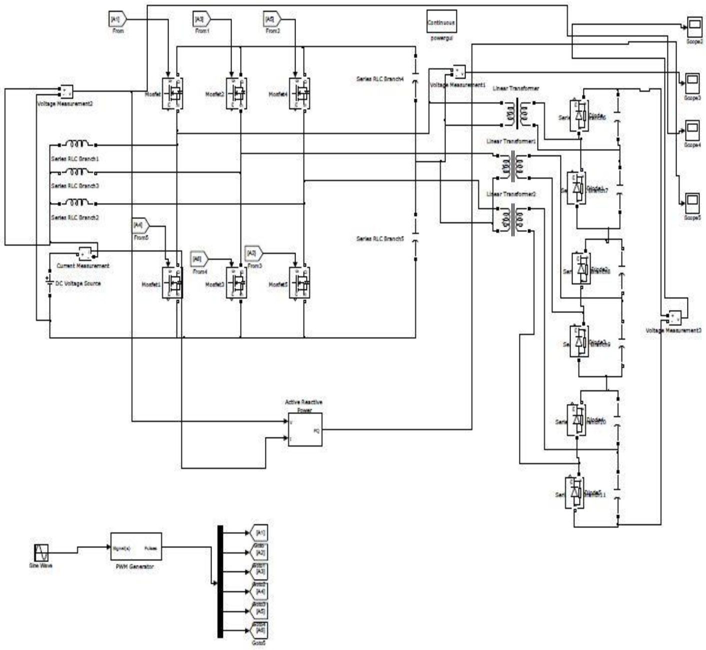
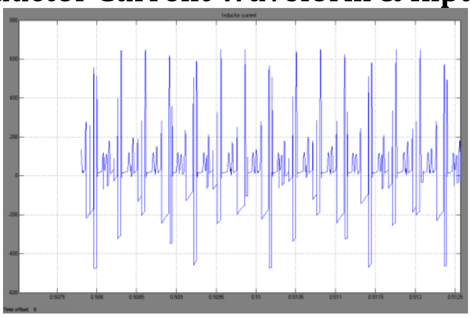


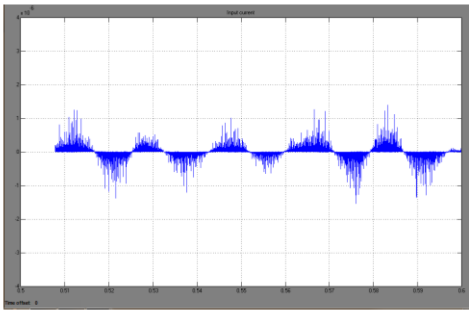
Figure 4: Simulation Circuit of DC-DC Converter

Simulation Results:

Inductor Current Waveform & Input Current Waveform



a)

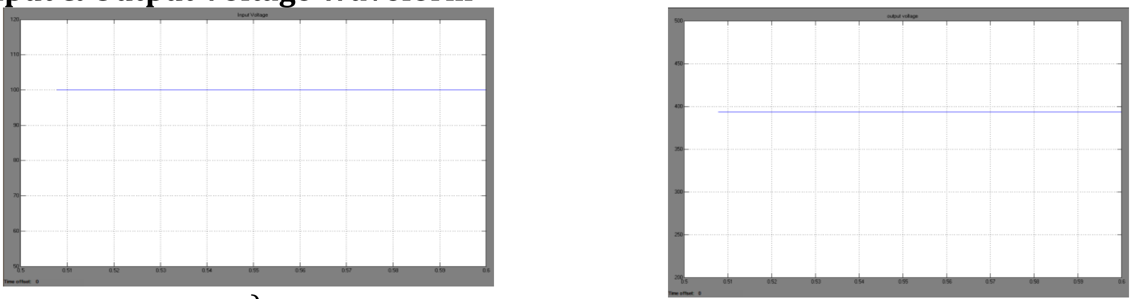


b)

Figure 5: a) Output of Inductor current & b) Input Current

The simulation results shows for an the interleaved inductor currents and input current waveforms. Actually, the input capacitors were separated for each phase and this helps to alleviate the unbalance caused by difference in circuit parameters or mismatch in duty cycle. Fig. shows the drain-source voltages of switches S_L and S_U , and primary transformer current I_{LK}. The extended waveforms of Fig. are shown in Fig. and. It can be seen from Fig and that both lower switch S_L and upper switch S_U are being turned on with ZVS, respectively. Fig. and show ZCS turn ON and OFF of upper diode D_U and lower diode D_L, respectively. A proper transformer turn ratio is chosen within the usable range, considering the actual duty cycle range, which also affects the voltage and current rating of the switch and diode. It should be noted that the peak voltage rating of the main switch is calculated to be V_S,min/(1 − Dmax), where Dmax depends on the output voltage, and therefore, the MOSFETs with lower R_{ds}(ON) can be chosen for the proposed converter, resulting in reduced conduction losses. The peak diode voltage rating is 133 V, a third of output voltage, due to the series connection of the three voltage doublers. A Schottky diode of voltage rating of 170 V with lower reverse recovery loss and forward voltage drop can be used, and the losses associated with rectifier diodes can be significantly reduced. With N = 3 and several cases of P, the current rating of the main switch and rectifier diode can also be calculated using the current waveform.

Input & Output Voltage Waveform



a) b)

Figure 6: a) Input & b) Output Voltage Waveform

5. Conclusion:

This paper proposes the a generalized multiphase DC-DC converter designed using the BHB cell and voltage doublers are connected in series to increase the output voltage and also the multiphase DC- DC converter with multiphase structures allow the current sharing among phases to reduce device current stresses and interleaving control schemes reduce the ripple currents in passive components. The soft switching mechanism allows the reduction of switching losses and is significant to achieve high efficiency power conversions. Simulation and experiments were performed to show the proposed method. The proposed converter will be implemented in the future which will show the better performance.

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