International Journal for Modern Trends in Science and Technology
Volume: 03, Issue No: 04, April 2017
ISSN: 2455-3778
http://www.ijmtst.com

PV Based ZVZCS Current Control DC/DC Bridge Converter for Battery Charging

Nendragamti Pavan Kumar

Department of Electrical & Electronics Engineering, Sanskrithi School of Engineering, Puttaparthi, Andhra Pradesh, India.

To Cite this Article
Nendragamti Pavan Kumar, "PV Based ZVZCS Current Control DC/DC Bridge Converter for Battery Charging", *International Journal for Modern Trends in Science and Technology*, Vol. 03, Issue 04, 2017, pp. 06-10.

ABSTRACT

An PV based DC/DC Boost converter is increases the DC voltage used to charge the traction battery in an electric conveyance. Photovoltaic cells provide an additional method of acquiring energy, converting sunlight directly into electricity through the use of dc / dc converter. The conventional topological failed to operate the converter with zero current and zero voltage switching during no load condition resulting high voltage spikes in the output voltage. In order to attest reliable operation of the bridge converter under wide load variations, the converter should not only operate with soft-switching from no-load to full-load condition, but additionally from full-load to no-load condition making gamut of operation for achieving such stringent requisites and high reliability, the converter employs a symmetric passive way near lossless auxiliary circuit to provide the reactive current for the full-bridge semiconductor switches, which guarantees zero voltage switching at turn-on times for all load conditions. This is a current driven topology in accumulation with a voltage multiplier in order to clamp the output voltage and additionally slake ZVZCS operation of the converter resulting in high voltage gain.

KEYWORDS: *PV cell, DC/DC Boost converter, Snubber cells, Zero Current Switching (ZCS), Zero Voltage Switching (ZVS), Current Driven Zero Voltage Zero Current Switching (CD ZVZCS), Mc Murray inverter.*

I. Introduction

Power conversion systems in electric conveyances customarily utilize a high energy battery pack to store energy for the electric traction system. Energy conversion during the battery charging is performed by a DC/DC converter using PV cell. Such DC/DC boosts converters, which are habituated to charge the high-energy battery. The switch ratings are optimized for the full-bridge topology, this topology is extensively utilized in industrial applications. This system is high efficiency, high power density and high reliability.

II. POWER CONVERSION SYSTEM

The energy conversion system consists of an ac/dc converter, a three-phase dc/ac inverter, and a dc/dc converter. The ac/dc converter is a plug-in converter, which charges the high-voltage battery.

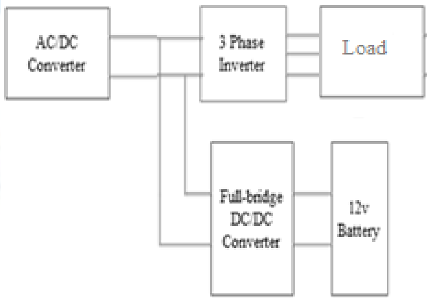

Fig.1 Power Conversion System

The high- voltage battery is supplying power to the three-phase inverter which victuals the three-phase motor. The high- voltage battery is additionally charging the 12V battery through a dc/dc converter.

Different system structures, both bidirectional and unidirectional, are being utilized for the EV power conditioning system. In this system, there are two battery units: a high voltage battery, which aliments the inverter and the electric motor, and a 12V battery. The potency switching contrivances, electric motors plays a consequential role in introducing the hybrid conveyances and fuel cell conveyances in market. The puissance electronic system should be efficient to ameliorate the range of the electric conveyances and fuel economy in hybrid conveyances. The cull of potency semiconductor contrivances, converters/inverters, control and switching strategies, the packaging are very crucial to the development of efficient and high-performance conveyances.

III. FULL BRIDGE SYSTEM

Full-bridge dc/dc converters are extensively applied in medium to high power dc/dc power conversion. For power levels up to 3 kW, the full-bridge converters now employ MOSFET switches and use Phase-Shift Modulation (PSM) to regulate the output voltage. In most of these converters, zero voltage switching (ZVS) is achieved by placing a Snubber capacitor across each of the switches and either by inserting an inductor in series with the transformer or by inserting an inductor in parallel to the potency transformer. In a practical full-bridge configuration, the Snubber capacitor may be the internal drain-to- source capacitor of the MOSFET, the series inductor may be the leakage inductor and the parallel inductor may be the magnetizing inductor of the puissance transformer. This makes the puissance circuit of these converters very simple. However, the full-bridge converter with the series inductor loses its ZVS capability at no-load (or light-load), and the converter with the parallel inductor loses its ZVS under short- circuit. Loss of ZVS implicatively insinuates astronomically high switching losses at high switching frequencies and very high EMI due to the high di/dt of the Snubber discharge current. Loss of ZVS can additionally cause a very strepitous control circuit, which leads to shoot-through and loss of the semiconductor switches. The ZVS range can be elongated by incrementing the series inductance. However, having an astronomically immense series inductance limits the potency transfer capability of the converter and reduces the efficacious obligation ratio of the converter.

When the battery is charged, the load is absolutely zero and the converter should be able to safely operate under the zero load condition. Since ZVS in conventional full-bridge PWM converters is achieved by utilizing the energy stored in the leakage inductance to discharge the output capacitance of the MOSFETs, the range of the ZVS operation is highly dependent on the load and the transformer leakage inductance. Thus, this converter is not able to ascertain ZVS operation for a wide range of load variations.

The leakage inductance of the transformer causes the voltage spikes across the output diodes. Theses spikes are intensified by incrementing the switching frequency of the converter. Thus, the diodes should be designed aggrandized to be able to withstand the voltage spikes, which leads to higher losses due to the higher forward voltage drop of the diodes and poorer reverse recuperation characteristics. In advisement, the spikes significantly increase the EMI noise of the converter. This fact makes the topology not very practical for high frequency, high voltage applications. There are quite a few references that proposed solutions for the voltage spikes across the output diodes. Some references endeavored to decrement the leakage inductance as much as possible though the transformer winding structures, which efficaciously decreases the apex of the voltage spikes across the output diodes. However, reducing the leakage inductance decreases the ZVS operating range of the full-bridge converter, which results in a very narrow range of ZVS operation.

The quandary of voltage spikes is essentially cognate to the voltage-driven output rectifiers. This is due to the fact that the full-bridge inverter engenders high frequency voltage pulses across the output diode rectifier, which is connected to the output inductor as shown in Fig. 2. The voltage-driven rectifier works impeccably if there is no leakage inductance in between the output of the full-bridge inverter and the diode rectifier. However, the else of the leakage inductance makes the rectifier connect two current sources, i.e., leakage inductance and output inductance, together. This connection engenders high voltage spikes across the output diodes. In this paper, an incipient topology is proposed predicated on a current driven rectifier, which efficaciously rectifies the voltage stress quandaries cognate to the full-bridge DC/DC converter. The proposed topology provides zero current switching (ZCS) for the output rectifiers, which eliminates reverse recuperation losses of the output diode rectifiers.

IV. ZVZCS DC/DC CONVERTER

The main quandary regarding the conventional full- bridge converter is the series connection of the leakage inductor and output inductor through the diode rectifier. The current driven ZVZCS DC/DC full-bridge converter system is predicated on a current driven rectifier, which efficaciously rectifies the voltage stress quandaries cognate to the full-bridge DC/DC converter. This topology provides zero current switching (ZCS) for the output rectifiers, which eliminates reverse recuperation losses of the output diode rectifiers.

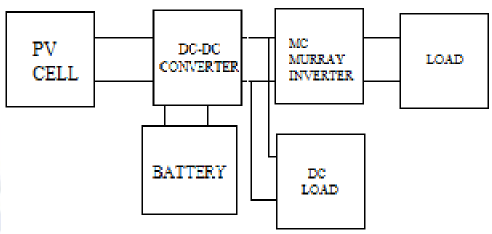

Fig.2 ZVZCS DC/DC converter

In this topology, the full-bridge inverter converts the DC-bus voltage to a high frequency quasi-square wave voltage. Then there is an inductor in series with the transformer, which acts as a current source for a current driven rectifier. The current driven rectifier rectifies the output current of the transformer and transfers power to the output.

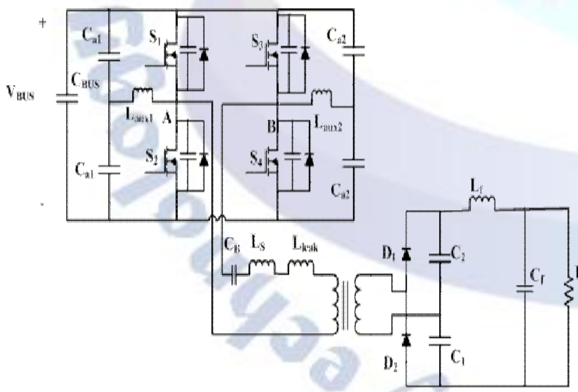

Fig.3 ZVZCS DC/DC Converter Circuit

The converter provides the gamut of operation giving ZVS from no-load to full-load condition. The converter requires same amount of reactive current for both leading and lagging legs. This is due to the fact that the series inductor current commences from zero during the switching of the leading leg MOSFETs, the auxiliary circuit must only provide just enough reactive current to charge and discharge the leading leg MOSFET output capacitors. Consequently, both the auxiliary inductors only carry io as of current, just enough for the ZVS turn–ON of the MOSFETs. Ergo, the two auxiliary circuits are symmetric and, hence, more facile to manufacture.

In this topology, the voltage spikes over the yield diodes are wiped out by utilizing a current-driven setup, which is acknowledged by an arrangement inductance with the fundamental power transformer working in intermittent mode guaranteeing complete vitality exchange and a capacitive channel at the yield of the diode connect. The arrangement inductor goes about as a present source and the capacitive channel clasps the voltage over the diode connect. In one exchanging cycle, the circuit has 14 modes amid unfaltering state operation. Because of the symmetrical structure, the investigation is given for a large portion of an exchanging cycle.

At t_0, S2 is killed. The yield capacitor of S1 is releasing and that of S2 is accusing up of the responsive current gave by the helper circuit. Amid this interim, the optional side diodes are turned around one-sided and are OFF. In this manner, the rising voltage VAB conducts a little current through the DC blocking capacitor C, arrangement inductance Ls, spillage inductance L leak, and polarizing inductance LM. At t1 once the yield diodes get forward one-sided. Here, the yield capacitor of the MOSFET, S1 is as yet releasing to at last achieve zero and that of S2 is energizing to V_{dc}. This mode closes once the voltage over this capacitor ends up plainly zero. This interim finishes once the yield capacitor of the MOSFET S1 has released totally.

The yield diodes cinch the optional voltage to the yield voltage. The capacitor C1 on auxiliary side charges through D1. Along these lines, there is a consistent voltage over the mix of the arrangement inductance and the spillage inductance. Subsequently, the arrangement current increase to its crest esteem. This mode closes once the MOSFET S4, entry way voltage winds up plainly zero. Capacitor of S3 is releasing from and that of S4 is energizing to Vdc. This mode closes when yield capacitor of S3 totally release and S4 yield capacitor got charged to Vdc. Subsequently the current on auxiliary side slopes down. Amid this mode the body diode of S3 is directing.

At t4 begins when VAB is zero. At that point the yield voltage of inverter is zero and the yield diode braces the auxiliary voltage to the yield voltage. The negative voltage will be occurrence crosswise over L series which is the reflected yield voltage at the transformer essential side and connected to S3. This process is same as that of previous step aside from S3 channel is leading as opposed to the body diode of S3. Amid the finish of this mode current through L series is sloping down to zero. S1 kills close to zero current exchanging toward the process. The capacitor C_f bolsters the yield stack with put away vitality while on the transformer essential side there is no present.

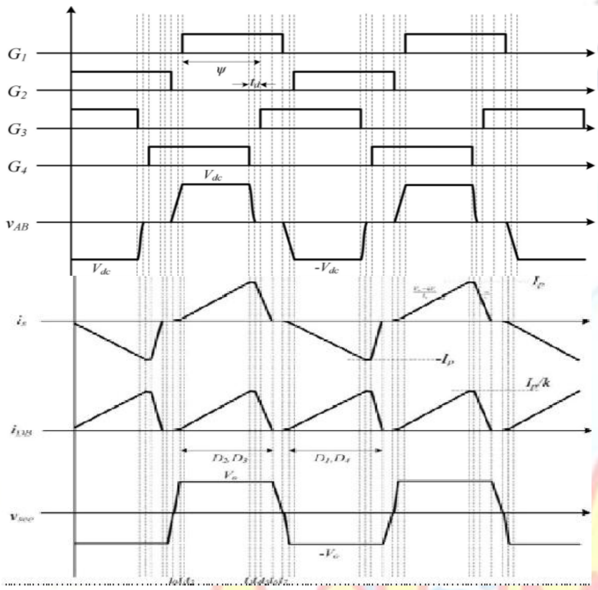

Fig: 4. Waveforms for the different modes of operation

V. SIMULATION/EXPERIMENTAL RESULTS

The conventional ZVZCS DC-DC Converter and CD ZVZCS full-bridge DC-DC converter simulated using MATLAB/SIMULINK and the waveforms are shown below.

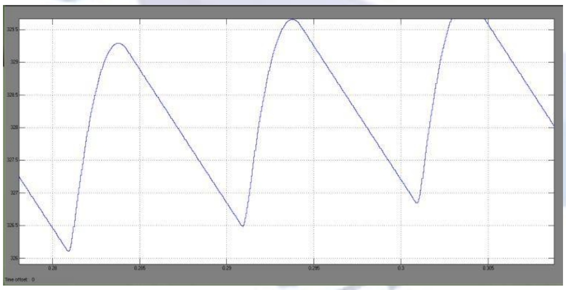

Fig.5. Output voltage waveform of conventional full bridge converter at no-load condition.

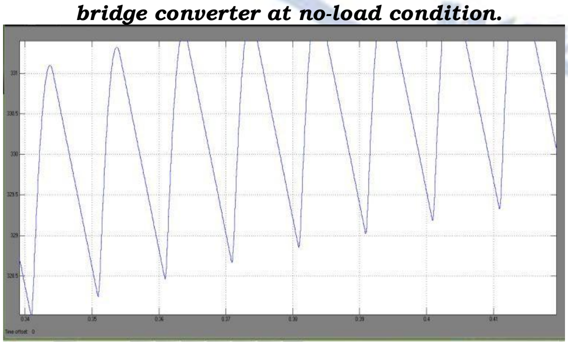

Fig.6. Output voltage waveform of the conventional full-bridge converter at full-load condition.

Fig.5 demonstrates that the yield voltage contained voltage spikes with it for the traditional converter at no-heap condition. Fig.6 demonstrates that while shifting the heap from full-stack condition to no-heap condition the yield voltages is not kept up as consistent and are went with expansive voltage spikes.

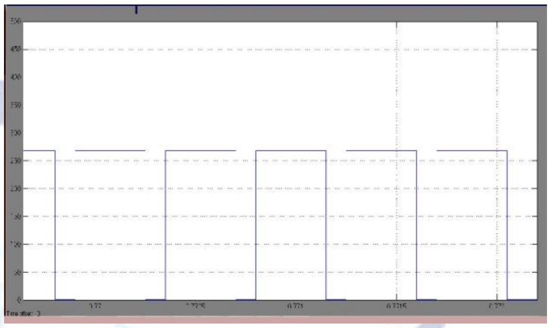

Fig.7. Converter output voltage waveform of CDZVZCS DC-DC converter at full-load condition.

Fig.7 demonstrates the yield waveforms of ZVZCS DC/DC converter Current Driven at no-heap condition. The yield voltage is free from voltage spikes showed up on the auxiliary side of transformer. Dynamic clipping of these voltage spikes are finished by utilizing a current driven rectifier on the auxiliary side of transformer. The yield diode connect clasps voltage spike to the yield voltage. The framework is load autonomous. Thusly by differing the heap from full-load to no-heap the voltage is kept up as practically consistent.

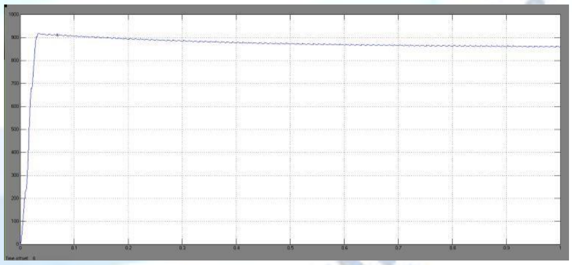

Fig.8. Output voltage waveform of CDZVZCS converter at full-load condition.

Fig.8 demonstrates the converter yield waveforms at full-stack condition. As per this figure, the converter can work with no unfavourable voltage spikes over any of the semiconductors. The voltage multiplier gives the yield voltage as indispensable products of information voltage. The yield got was 794V for a contribution of 230V.Therefore the voltage pick up was right around three times contrasted with the traditional converter. In functional applications we can extend the voltage multiplier cells to any number of stages as indicated by the required voltage.

VI. CONCLUSION

The conventional PV based ZVZCS boost DC-DC converter were simulated utilizing MATLAB/ SIMULINK. The PV based ZVZCS DC/DC converter topology eliminates the deleterious effects of the voltage spikes at the secondary side of the transformer, as well as the freewheeling mode of operation. The output voltage was proximately four times the input voltage incrementing the voltage gain of the converter. It was found that the converter has superior performance over the conventional converter especially in regards to the voltage across the secondary-side diode-bridge providing the load independent output. The topology can be cumulated with a interleaved method for future expansion.

REFERENCES

[1] Bin, G.; Jason, D.; Lai, J.-S.; Zheng, Z.; Chung, L. High boost ratio hybrid transformer DC-DC converter for photovoltaic module applications. IEEE Trans. Power Electron. 2013, 28, 2048–2058. 29.

[2] Tseng, K.-C.; Huang, C.-C.; Shih, W.-Y. A high step-up converter with a voltage multiplier module for a photovoltaic system. IEEE Trans. Power Electron. 2013, 28, 3047–3057.

[3] Majid Pahlevaninezhad, Pritam Das, Josef Drobnik, Praveen K.Jain, and Alireza Bakhshai,"A Novel ZVZCS Full-Bridge DC/DC Converter Used for Electric Vehicles," IEEE Trans.power electron., vol.27, no.6, June 2012.

[4] M. Pahlevaninezhad, J. Drobnik, P. Jain, and A. Bakhshai, "A load adaptive control approach for a zero voltage switching DC/DC converter used for electric vehicles," IEEE Trans. Ind. Electron., vol.59, no.2, pp.920-933, Feb.2011.

[5] Ahmed Yousuf Saber, and Ganesh Kumar Venayagamoorthy, "Plug-in vehicles and renewable energy sources for cost and emission reductions," IEEE Trans. Ind. Electron., vol. 58, no. 4, pp. 1229–1238, Apr. 2011.

[6] W. Xinke, J. Zhang, X. Xie, and Z. Qian, "Analysis and optimal design considerations for an improved full bridge ZVS DC-DC converter with high efficiency," IEEE Trans. Power Electron., vol. 21, no. 5, pp. 1225–1234, Sep. 2006

[7] B. M Hasaneen, and A.Elbaset Mohammed, "Design and simulation of DC/DC boost converter," IEEE Trans. ind. Electron, pp-335-340.

[8] S. M. Lukic, J. Cao, R. C. Bansal, F. Rodriguez, and A. Emadi, "Energy storage systems for automotive applications," IEEE Trans. Ind. Electron., vol. 55, no. 6, pp. 2258–2267, Jun. 2008.

[9] A. Emadi, Y. J. Lee, and K. Rajashekara, "Power electronics and motor drives in electric, hybrid electric, and plug-in hybrid electric vehicles," IEEE Trans. Ind. Electron., vol. 55, no. 6, pp. 2237–2245, Jun. 2008.