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Soft-Switching Non-Isolated Current-Fed Inverter

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A B S T R A C T

In this project a non-isolated impulse commutated current-fed voltage doubler based non-isolated inverter for a solar photovoltaic, battery or fuel cell application is proposed. Impulse commutation enables device voltage clamping with zero current commutation of the semiconductor devices. It eliminates the traditional problem of turn-off voltage spike across the devices in current-fed converters. Unlike resonant converters, resonance pulse appears for a very short interval leading to zero current turn-off of devices. It therefore, limits peak and circulating currents through the components. Voltage doubler is selected to achieve 2×gains. Variable frequency modulation ensures output voltage regulation with input and load variations.

Keywords: Current-fed voltage doubler, Frequency modulation and Current-fed converters.

1. INTRODUCTION

Impulse commutation achieves the same merits without compromising on efficiency and without increasing the component count. Traditionally, impulse commutation has been adopted in inverter circuits. Its implementation for the proposed topology offers zero-current commutation of the switches and eliminates the turn-off spike and the associated losses. The commutation strategy also enables natural voltage clamping (NVC) across devices. Just an additional HF small parallel capacitor provides the aforementioned benefits. Although variable frequency modulation controls the load voltage and power, the control circuit is simple because the frequency variations are immune to the load variations.

This has a significant impact on converter efficiency. The frequency range in practice with variation in input voltage Vin is between 50 kHz–170 kHz at full load condition.

The frequency variation is less sensitive to the load variations from full load down to 20% load. The LC filter (Lf and Cf) at the output stage and the line frequency modulation reduces the distortion in the output voltage and current waveforms favoring the use of the proposed two-stage inverter

Energy storage systems offer stability against fluctuations associated with the alternative energy sources and grid. Power converters are mandatory to interface alternative energy sources and storage to the dc bus or the grid, to match the nature of two ports as well as accommodate the variability and intermittency. The inverter should assure lower input current ripple for precise maximum power point tracking (MPPT) in PV and fuel cells.

Low input current ripple also offers effective fuel utilization in fuel cells etc. and enhanced battery performance. Configurations such as the centralized inverter, string inverter, and module integrated converters (MIC) are widely adopted. An existing transformer less inverter topology for solar PV modules eliminates the shoot through problem, reduces the ground currents, and demonstrates high efficiency. Centralized inverters are preferred when several cells are stacked to develop higher voltage. It, therefore, does not require voltage boost and is simpler in design and shows better efficiency. At low source voltage, high voltage gain (up to 10–20×) is required for mentioned applications and two-stage inverter is usually implemented. In two stage inverters, the size of the dc link capacitor responsible for power decoupling depreciates. High-frequency (HF) transformer is usually required in case of voltage-fed topologies.

Dual stage inverter topologies also favor decoupled control where MPPT is realized by the dc/dc converter and the inverter stage is responsible for the current injection.

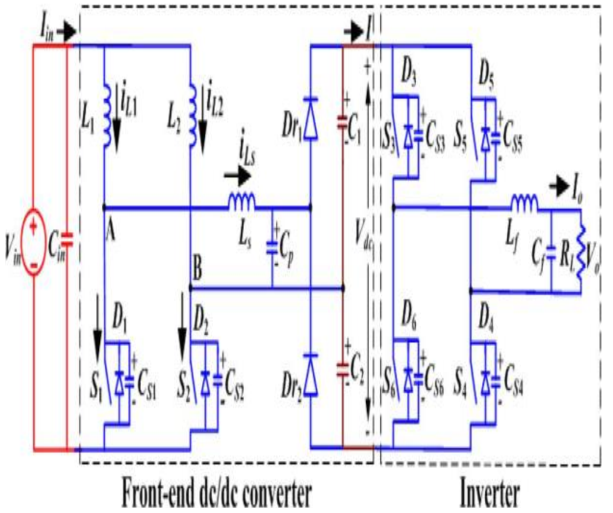
Current-fed voltage doubler can offer 10 × *voltage gain* being transformer less and similarly a non-isolated current-fed voltage quadrupler can offer 20× voltage gain. Current-fed converters get inherently qualified for such applications as they offer low input ripple reducing the input filter requirements and high voltage gain being transformer less. Half bridge topology comprising of dual boost converter offers higher voltage gain compared to full-bridge topology. Traditionally dissipative snubbers or active clamp circuits are required to snub the turn-off voltage spike across the devices in current-fed converters. Dissipative snubbers degrade the converter efficiency while the active-clamp requires floating switches and a large HF capacitor.

A current-fed bidirectional full-bridge converter based inverter achieves ZCS of the primary switches and ZVS of the secondary devices with natural device voltage clamping. Such bidirectional converter is best suited for interfacing batteries with dc micro-grid, fuel cell vehicles, or interfacing two dc buses in dc micro-grid.

2. CIRCUIT DIAGRAM

Current-fed converters get inherently qualified for such applications as they offer low input ripple reducing the input filter requirements and high voltage gain being transformer less. Half bridge topology comprising of dual boost converter offers higher voltage gain compared to full-bridge topology.

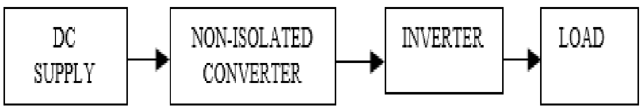
Traditionally dissipative snubbers or active clamp circuits are required to snub the turn-off voltage spike across the devices in current-fed converters. Dissipative snubbers degrade the converter efficiency while the active-clamp requires floating switches and a large HF capacitor. Besides, a current-fed three-phase converter utilizing the transformer leakage inductance and auxiliary capacitor to achieve zero current switching (ZCS).



A zero-voltage switching (ZVS) and ZCS operated current-fed CL-resonant dc/dc converter. A current-fed bidirectional full-bridge converter based inverter. The proposed converter achieves ZCS of the primary switches and ZVS of the secondary devices with natural device voltage clamping.

Such bidirectional converter is best suited for interfacing batteries with dc micro-grid, fuel cell vehicles, or interfacing two dc buses in dc micro-grid.

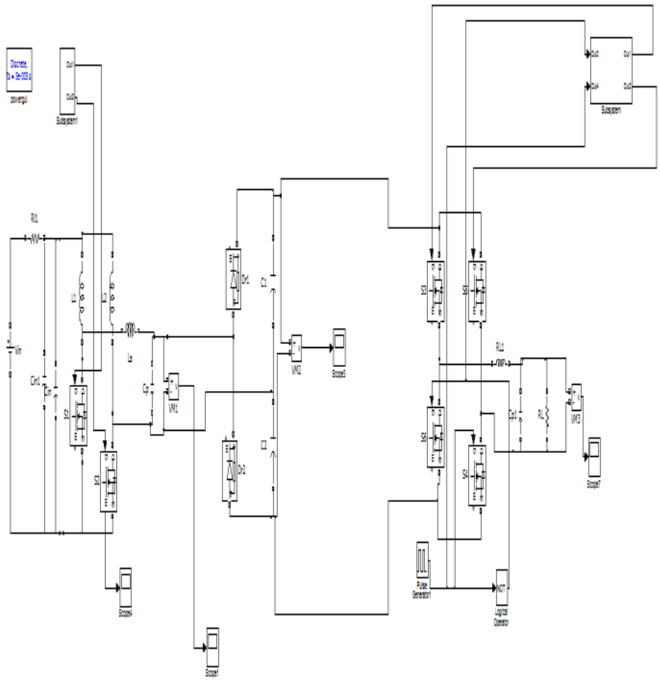
3. BLOCK DIAGRAM



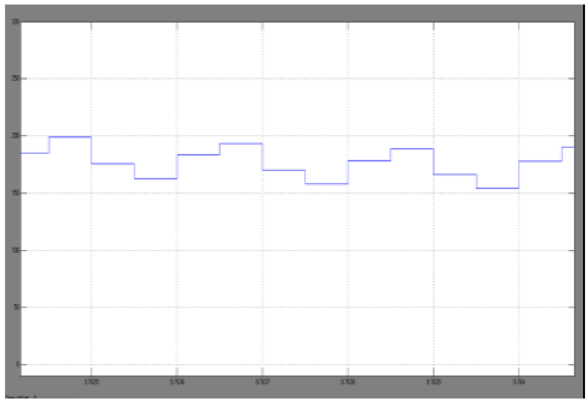
This DC source supplies efficient input voltage and the front end DC to DC converter improves DC voltage. The DC to DC converter switches attain soft switching to reduce switching loss and the conduction loss. This DC voltage gets improved using voltage doublers circuit and converted to AC voltage using inverter. The output AC voltage is fed to the grid.

A non-isolated impulse commutated current-fed voltage doubler based non-isolated inverter for a solar photovoltaic, battery or fuel cell application is proposed. Impulse commutation enables device voltage clamping with zero current commutation of the semiconductor devices. It eliminates the traditional problem of turn-off voltage spike across the devices in current-fed converters. Unlike resonant converters, resonance pulse appears for a very short interval leading to zero current turn-off of devices. It therefore, limits peak and circulating currents through the components. Voltage doubler is selected to achieve 2 × *gains*. Variable frequency modulation ensures output voltage regulation with input and load variations.

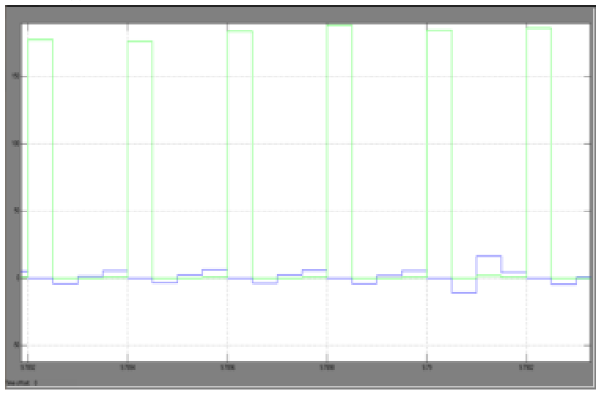
4. SIMULATION AND RESULT



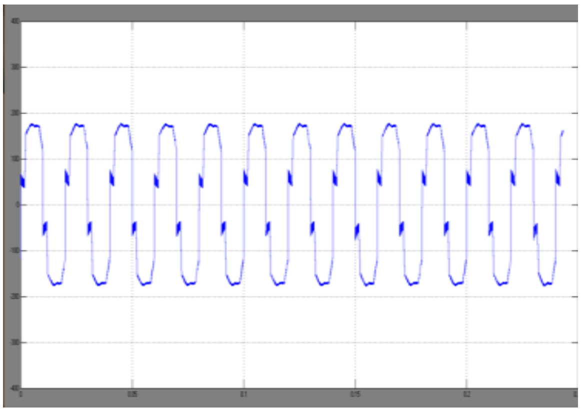
DC OUTPUT VOLTAGE



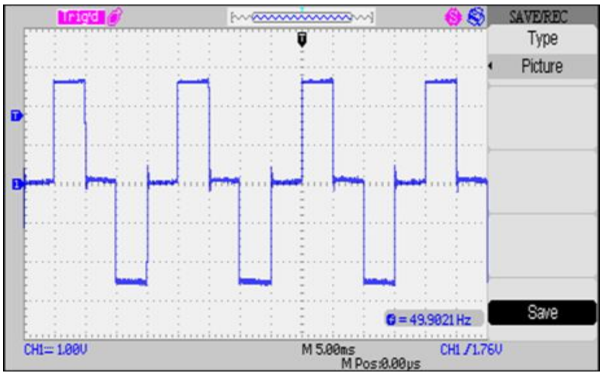
SOFT SWITCHING OUTPUT



AC VOLTAGE



5. HARDWARE SETUP



6. CONCLUSION

Impulse commutation achieves the same merits without compromising on efficiency and without increasing the component count. Traditionally, impulse commutation has been adopted in inverter circuits. Its implementation for the proposed topology offers zero-current commutation of the switches and eliminates the turn-off spike and the associated losses. The commutation strategy also enables natural voltage clamping (NVC) across devices. Just an additional HF small parallel capacitor provides the aforementioned benefits. Although variable frequency modulation controls the load voltage and power, the control circuit is simple because the frequency variations are immune to the load variations.

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