Comparison of DC-DC boosted Voltage Source inverter and Impedance Source Inverter

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***Abstract*— This paper deals with a comparison of impedance source inverter using simple boost control and the dc-dc boosted Voltage Source Inverter (VSI) with sinusoidal pulse width modulation using simulation studies. The Z-Source Inverter(ZSI) has the capability to buck-boost the available input voltage without any intermediate boost conversion stage. It utilizes the shoot-through states effectively to boost the input voltage.To increase and convert the available dc voltage into ac voltage, a dc-dc boost converter must be connected in cascade with the VSI. This two stage of conversion has some disadvantages like increased cost, reduced efficiency with complex control system. The simulation of ZSI with Simple Boost Control (SBC) and dc dc boosted VSI is done using MATLAB and their comparative simulation results are presented. The operating principle, design details along with the simulation results prove the validity of the design in terms of its ability to provide high voltage gain at higher power level and low device stress. Simulation results produce a boost factor of 3.5 and deliver the output power of 100W.**

Keywords*— *Boost factor, Shoot-through, modulation index, Simple boost control ,Simulation, gain.

I. INTRODUCTION

In a Voltage Source Inverter (VSI), the upper and lower devices of each phase leg cannot be gated simultaneously otherwise a shoot-through would occur and destroy the devices. The VSI has six active states and two zero states .It can only operated as a buck converter(step-down).Therefore, the ac output voltage is limited and cannot exceed the dc-rail voltage.

The impedance-source network is invented to overcome the limitations of the VSI and Current-Source Inverter (CSI). ZSI has nine permissible states[1]. It has eight switching states same as that of VSI but it has one extra zero state named as shoot through zero state. It occurs at both devices of any one phase leg are gated on simultaneously. The Z-source network makes the shoot-through zero state possible. This shoot-through zero state provides the unique buck-boost feature to the the inverter. To control the shoot through PWM technique, various methods are exhibited. Here Simple Boost Control(SBC) method is adopted. It controls the shoot through duty ratio and produce s higher voltage. ZSI and modified ZSI topologies[4] find applications in adjustable speed drives, uninterruptible power supply (UPS) and hybrid electric vehicles.

DC-DC boost converters serve many purposes. The conventional boost converter can be advantageous for step-up applications that do not demand very high voltage gain, mainly due to low conduction loss and design simplicity. Typical applications are renewable energy systems, fuel cells.

This paper deals with a comparison between impedance source inverter using simple boost control and the dc-dc boosted VSI with sinusoidal pulse width modulation technique for gating the switches. Two different MATLAB/SIMULINK based models of dc-dc boosted inverter and ZSI are implemented for 100W star connected resistive load with the same source voltage.

II. CONVERTER TOPOLOGY

A.Circuit Description

Fig.1.shows the impedance source inverter, which consists of inductors L1 and L2 and capacitors C1 and C2 connected at both ends (Z-shape) which acts as a buffer between load and source. Fig.2. shows the dc-dc boosted VSI which comprises of inductor L, capacitor C, MOSFET switch S and the diode D performs boost operation.

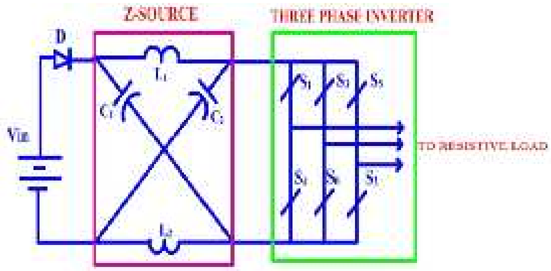

Fig.1. Impedance source inverter

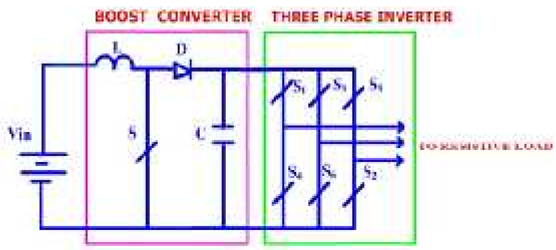

Fig. 2. DC-DC boosted VSI

III. MODES OF OPERATION

1. *Shoot through state*

The equivalent circuit of the inverter bridge is shown in the Fig.3. The inverter bridge is operating in one of the seven shoot-through states. During this mode, the input S is disconnected and load is shorted through Z-source network. The energy stored in the inductor is transferred to the capacitor and hence the capacitor voltage is boosted up. Depending on the voltage boost requirement, the shoot-through interval T_0 or its duty cycle $\frac{T_0}{T}$ is determined.

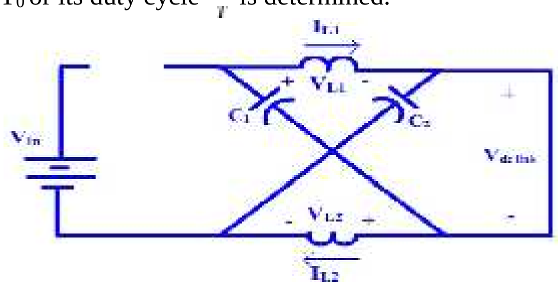

Fig.3. Shoot through state.

2. *Non-shoot-through state*

During non-shoot through switching state, the input diode turns on, and the dc input voltage source as well as the inductors transfer energy to the load and charge the capacitors. As a result the dc-link voltage of bridge is boosted. Fig.4 shows the equivalent circuit of the ZSI with non-shoot through state. During non-shoot through state, the inverter bridge is in one of the eight non shoot-through switching states.

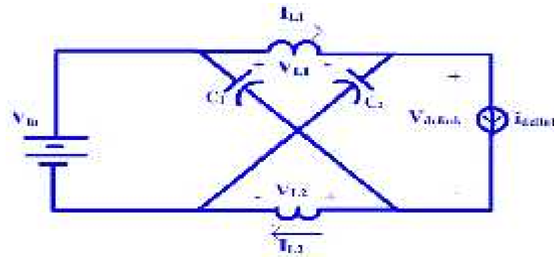

Fig.4. Non-Shoot through state.

3. *Simple boost control method*

Various modified PWM control techniques includes Simple Boost Control (SBC) method, Maximum Boost Control (MBC)[2], Constant Boost Control(CBC)[3] methods are used for producing the pulses. In SBC method, by comparing three sinusoidal reference signals and two constant voltage envelopes with the triangular carrier wave, firing pulses are generated. When the magnitude of the triangular carrier wave becomes higher than or equal to the upper envelope (or) lower than or equal to the lower envelope, shoot through pulses are produced. SBC method is used to control the shoot through duty ratio. The maximum shoot-through duty ratio of the simple boost control is limited to (1-*M*), thus reaching zero at a modulation index of one. So to obtain high boosted voltage, a small modulation index needs to be used. Fig.5. shows the illustration of simple boost control method.

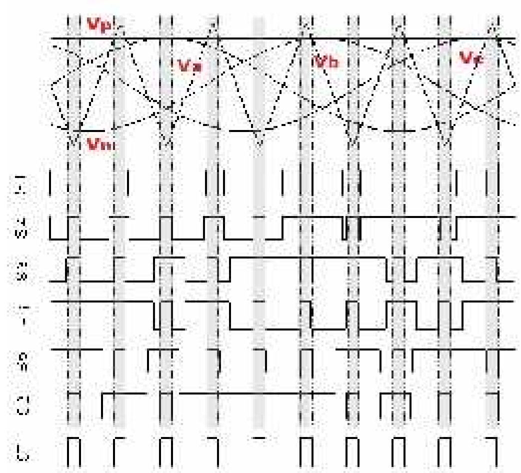

Fig.5. Illustration of Simple boost control method

Matlab simulations are done with the parameters as shown in Table.I[6],[7]

TABLE.1. DESIGN SPECIFICATIONS

Parameters	Values
Input DC voltage	30V
Line to line voltage	100V(peak)
Output AC Power	100W
Switching frequency	10kHz
Modulation index	0.64

Shoot through duty ratio	0.36
Boost factor	3.5

V. SIMULATION RESULTS

A. Simulation results of ZSI with SBC

The ZSI circuit with resistive load of 80Ω is simulated using the SBC control technique. The output voltage and current waveforms are shown in fig.6. It is capable of generating 100V with the dc input voltage of 30V.It is seen from the figure.7,that the load current obtained is 0.9A.

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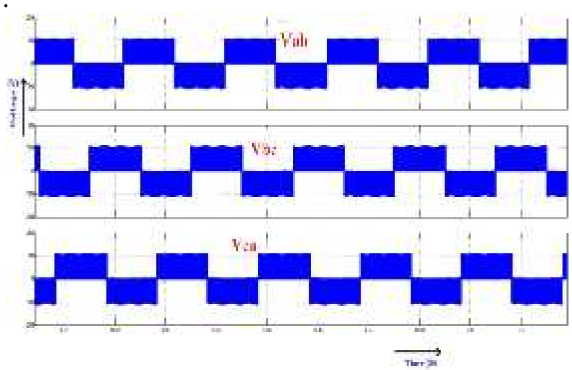

Fig.6. Output load voltage waveform of ZSI.

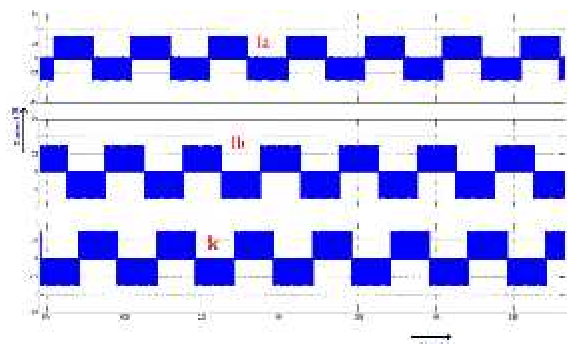

Fig.7. Output current waveform of ZSI.

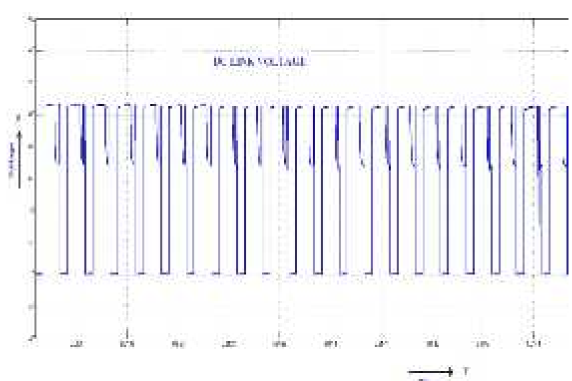

Fig..8. Dc link voltage waveform of ZSI

From the Fig.8, it is found that the ZSI has attained the dc link voltage of 116V due to the shoot through state and LC impedance network.

B .Simulation results of DC-DC Boosted VSI with SPWM

The dc-dc boosted VSI is simulated with the traditional SPWM technique. From the Fig.5.6, it is observed that the dc-dc boosted VSI has output voltage of 100V with the input voltage of 30V and from the fig.5.7,the load current is found as 0.7A.

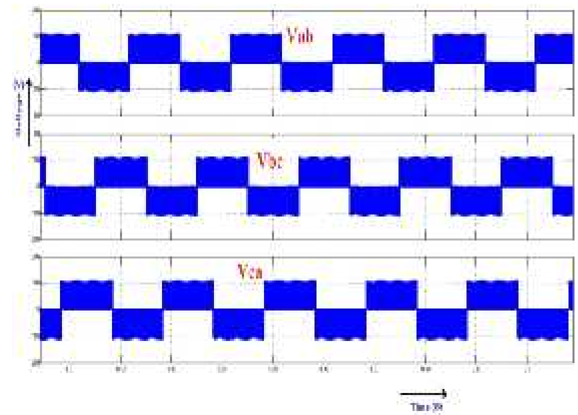

Fig..9. Output load voltage of DC-DC boosted VSI

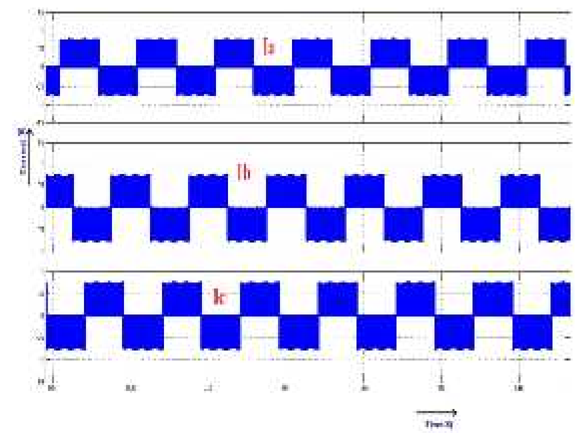

Fig.10. Output phase current of DC-DC boosted VSI

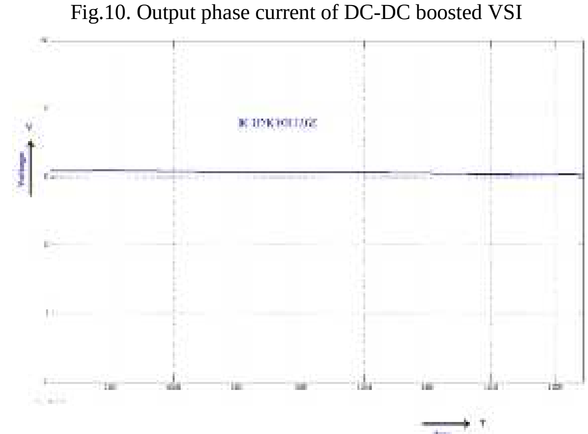

Fig.11. DC-link voltage of DC-DC boosted VSI

The dc link voltage of dc-dc boosted VSI is shown in Fig.5.8,it is seen that the dc-dc boosted voltage has attained the value of 113V and it is a constant dc voltage.

VI. COMPARATIVE ANALYSIS OF ZSI AND DC-DC BOOSTED VSI

From the harmonic spectrum shown in Fig.12,it is clear that the THD value is found as 1.26% for ZSI and 2.41% for DC DC boosted VSI as shown in Fig.13.

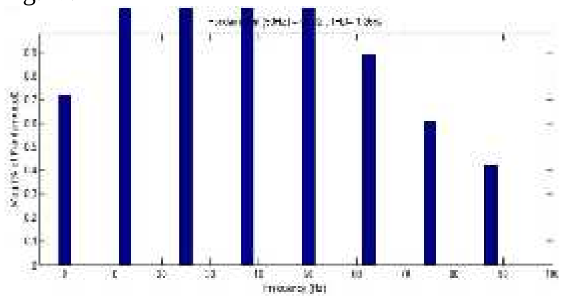

Fig.12. Spectrum of Total harmonic distortion of ZSI

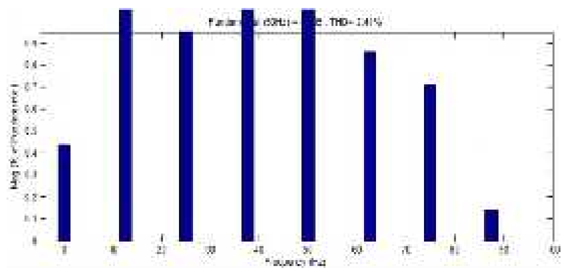

Fig.13. Spectrum of THD value of DC-DC boosted VSI

VII . CONCLUSION

The performance of dc-dc boosted VSI using SPWM and ZSI using SBC technique with three resistive load are studied by MATLAB/SIMULINK environment. The Z-source inverter intentionally utilizes the shoot-through zero states to boost dc voltage and produce an output voltage greater than the original dc voltage. The THD value of ZSI is lesser than the dc-dc boosted VSI. Boosted output voltage from the inverter and lower THD value of ZSI show that the ZSI has more advantages over dc-dc boosted VSI. Compared with traditional inverter, the ZSI has maximum boost capability due to impedance network. As number of switches used in the ZSI is less, switching losses is less and efficiency is more comparatively. Due to aforesaid advantages ZSI finds more applications. Future scope of this work is to implement closed loop control system for ZSI for electric vehicle applications.

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