Enhanced Single Stage Switched Boost Inverter With Switched Inductor

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Abstract- In a traditional pulse width modulation (PWM) inverter, the obtainable AC output voltage is limited to be less than the dc input voltage, and so, an additional DC-DC boost converter is required to obtain the desired ac output voltage. In order to overcome the limitations of a traditional inverter, a Z-source inverter (ZSI), in which the traditional DC link is replaced with the Z-source network, is introduced. The result in the additional power converter with two-stage DC-DC-AC power conversion is high cost and low efficiency. The new inverter solved boost voltage problem in single stage. The performance study of the inverter is carried out with MATLAB/SIMULINK R2014a. The switching pulses for the control circuit are generated using PIC16F877A microcontroller. A 10 V input voltage, 16V output voltage and 20 W output power prototype circuit is implemented and verified the performance
Keywords – Quasi-Z-source, quasi-switchedboost,shoot through, Swithched inductor

I. INTRODUCTION

A buck DC-AC power conversion is found in the traditional voltage-source inverters (VSI) where the DC source voltage is higher than the peak AC output voltage. An additional DC-DC boost converter is inserted in front of the inverter bridge to obtain a high AC output voltage when a low input voltage is used. The result in the additional power converter with two-stage power conversion is high cost and low efficiency In the traditional VSIs, both power switches in a leg cannot turn on at the same time. In the other hand, a shoot through is forbidden in VSI because it causes a short circuit DC source. To overcome the limitation of the traditional VSIs, Z-source inverters (ZSI) with single-stage power conversion were proposed in. The classical ZSI consists of an L-C network with two capacitors and two inductors connected in an X shape. A shoot-through state, where both of the power switches in a leg are turned on at the same time, is used to boost the input voltage.

. The concept of the switched inductor (SL) techniques is applied to the SBI topologies, and consequently, a class of SL boost inverters (SLBIs) is proposed. Compared with the conventional SBIs, the SLBIs add only three diodes and one inductor to produce a high step-up DC-link voltage.

The rest of the paper is organized as follows. Topology of inverter explained in section II. Experimental results are presented in section III. Concluding remarks are given in section IV.

II. TOPOLOGY INVERTER

2.1– Proposed inverter with Switched inductor

The new families of extended-boost inverter which can be derived by adding diodes and inductor to the single stage boost inverter [1] have higher boost ability and lower voltage stress across the capacitors compared to those of traditional inverter. The single-phase single-stage switched-boost inverter with switched inductor as shown Figure 2. The switch in the quasi switched boost inverter is replaced by the second H-bridge leg with two switches S3 and S4. As a result, the inverter is reduced one active switch compared to the qSBI.

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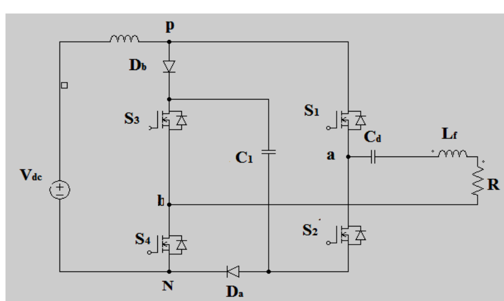

Figure 1 Inverter with four switches

The concept of the SL techniques is applied to the SBI topologies, and consequently, a class of SL boost inverters (SLBIs) is proposed. Compared with the conventional SBIs, the SLBIs add only three diodes and one inductor to produce a high step-up DC-link voltage Single stage switched boost inverter with switched inductor consists of four switches S1, S2, S3 and S4,five diodes D1, D2, D3, Da and Db, two inductors L1,L2 and filter Lf , one capacitor C1, and one output capacitor Cd, and output resistor.

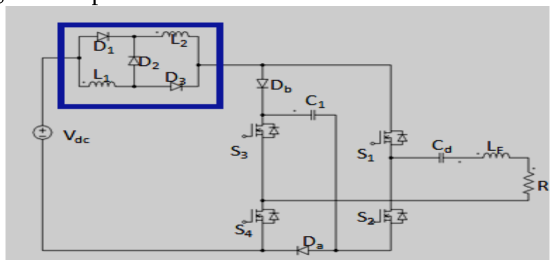

Figure 2. Proposed inverter with Switched inductor

2.2. Operating Principle

The inverter can operate in the shoot-through state, where both switches in the leg are turned on at the same time. The working of the circuit can be explained by 8 modes of operation. During the shoot-through state, D2 is off. while D1 and D3 are on. L1 and . L2 are connected in parallel.

Mode 1: In this mode, switches S1, S2 and S3 are turned on but the switch S4 turned off. At the same time diodes Da, Db, are turned on. The inductor L1 is charged through loop Vdc- L1-L2 –S1- S2 -Da. The capacitor C1 discharged.

Mode 2: In this mode, switches S1, S2 and S4 are turned on. While S1 is turned off. The diode Da, are turned on at the same time. The inductor charged through loop Vdc- L1-L2 –S1- S2 -Da. The capacitor C1 is disconnected. The inverted voltage Vo is zero. Figure 3(b) shows the equivalent circuit diagram of the converter and current paths for this mode is also shown.

Mode 3: In this mode, switches S1, S3 and S4 are turned on switch S2 is turned off. The inductor L1 charged through short circuit path Db- S3 and S4. The inverted voltage Vab is zero. Figure 3(c) shows the equivalent circuit diagram of the inverter and current paths for this mode is also shown

Mode 4:. In this mode, switches S2, S3 and S4 are turned on but the switch S1 is turned off. The inductor L1 and L2 charged through Db-S3-Db .The capacitor C1 discharged. The inverted voltage Vab is equals to a negative voltage C1. Figure 3(d) shows the equivalent circuit diagram of the inverter and current paths for this mode is also shown.

Mode 5: In this mode, switches S1 and S3 are turned on while S2 and S4 turned off. The inverted voltage Vab is zero. Figure 3(e) shows the equivalent circuit diagram of the inverter and current paths for this mode is also shown.

Mode 6: In this mode, switches S2 and S3 are turned on while S1 and S4 turned off. The inverted voltage equals Vab a negative capacitor C1 voltage. Figure 3(f) shows the equivalent circuit diagram of the inverter and current paths for this mode is also shown.

Mode7: In this mode, switches S1 and S4 are turned on while S3 and S2 turned off. The inverted voltage, Vab equals zero. Figure 3(g) shows the equivalent circuit diagram of the converter and current paths for this mode is also shown.

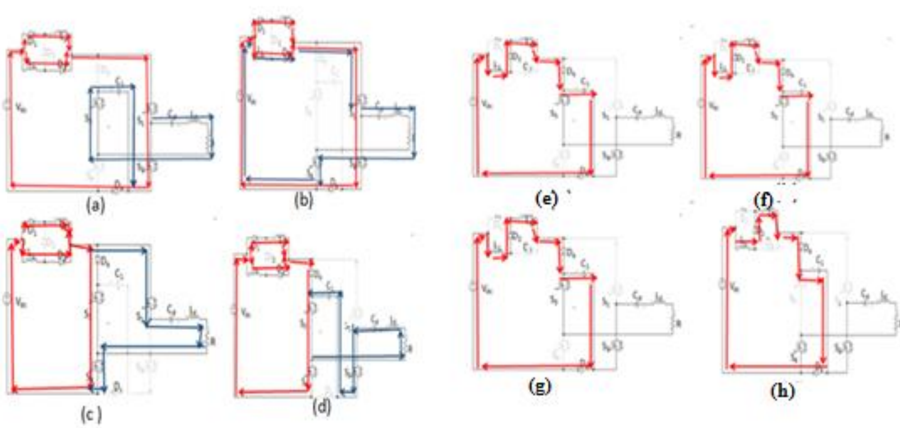

Figure 3. Operating modes in Shoot through state and Non Shoot through state

Mode8: In this mode, switches S2 and S4 are turned on while S1 and S3 turned of. The inverted voltage Vab equals a negative capacitor C1 voltage. Figure 3(h) shows the equivalent circuit diagram of the inverter and current paths for this mode is also shown. In modes 5-8 both and Da are Db forward based. The inductors charged, while charge C1.

III. EXPERIMENT AND RESULTS

3.1. Simulation results

Simulation parameters for the single stage switched boost inverter are given in Table 1. An input voltage of Vdc 96 V gives an output voltage Vo of 169Vrms for an output power Po of 600 W. The switches are MOSFET/Diode with constant switching frequency of 10 kHz. The duty cycle of switches is taken as D=0.32.

Table -1 Simulation Parameters

Parameters	**Specification**
Input voltage V_{in}	96V
Switching frequency f_s	10kHz
Inductor L_1 ,L_f	2mH,10mH
Capacitors C_1, C_d	1360µF,660µF
Resistance	20 Ω

The simulation results of the single stage switched boost inverter are shown in the following figures. It can be seen that the input voltage Vdc is 96 V and the output voltage Vo 130 V.

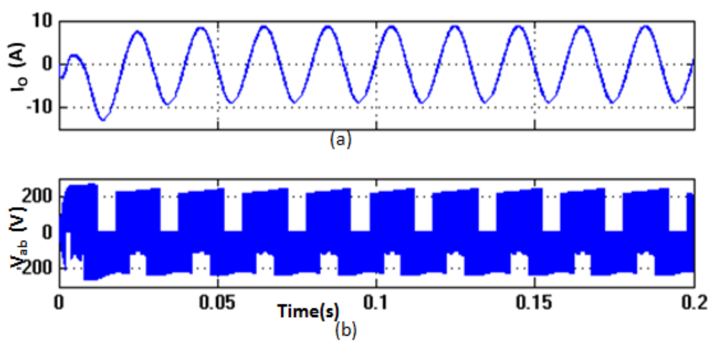

Figure 4. (a) Output current (b) H bridge Voltage

Figure 4 shows output current Io and H bridge output voltage Vab. It can be seen that output voltage is Vo 169 V.

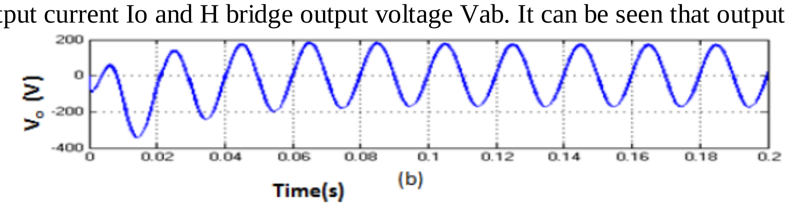

Figure 5. Output voltage

The FFT analysis is shown in Figure 6. According to Figure THD is 4.91%.

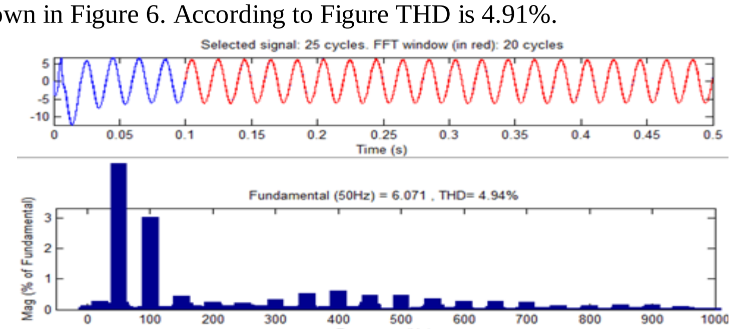

Figure 6. FFT Analysis

3.2 Hardware Implementation

A prototype of single phase single stage switched boost inverter with input voltage of 10V is implemented. The top view of the experimental setup is shown in Figure 7. It consists of control circuit, driver circuit and power circuit. Control circuit is composed of PIC microcontroller and its power supply. The control pulses for MOSFET switches are generated using PIC microcontroller. The pulses from microcontroller are amplified by driver circuit which is composed of TLP250. It also provides isolation between control and power circuit. Power circuit forms the proposed inverter. The experimental setup of single phase switched boost inverter with switched inductor is shown in Figure 7.

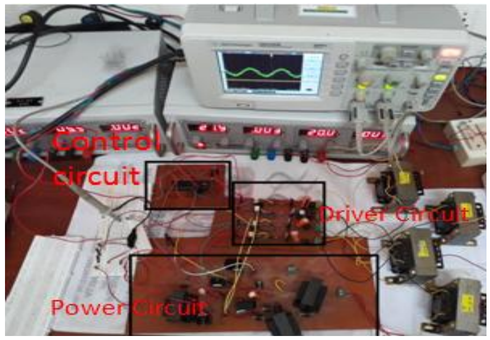

Figure 7 . Experimental setup

IV. CONCLUSION

The single stage switched boost inverter has a high reliability because it immunizes both shoot-through and open-circuit phenomenon. In addition, the AC output voltage of the inverter is higher or lower than the DC input voltage.SL inverter by improving the existing switched boost inverter. The proposed inverter employs a unique SLSBI impedance network to couple the low dc voltage energy source to the main circuit of the inverter. By an in-depth topology analysis, it is known that the proposed inverter can provide a strong boost inversion ability to overcome the limitations of the classical Z-source inverter.

V. REFERENCES

[1] Minh-Khai Nguyen and Tan-Tai Tran, "A Single-Phase Single-Stage Switched-Boost Inverter with Four Switches," IEEE Transactions on power electronics, Vol. 19, No. 5, pp. 1305-1314, May. 2018.

[2] M. K. Nguyen, Y. C. Lim, and G. B. Cho, \ "Switched-inductor quasi-Z-source inverter ," IEEE Transactions on power Electronics, vol. 26, no. 11, pp.3183-3191, Nov. 2011.

[3] M. K. Nguyen, et al. \"A class of quasi-switched Boost inverters," IEEE Transactions on industrial Electronics, vol. 62, no. 3, pp. 1576-1536, mar. 2015.

[4] M. K. Nguyen, et al. \ "A comparison between single-phase quasi-Z-source and quasi-switched boost inverters," IEEE Transactions on Industrial Electronics, vol. 10, no. 1, pp. 6336-6344, Oct. 2015.

[5] T. V. Le, S. J. Park, Y. C. Lim and J. Y. Yoo, "A class of high boost inverters based on switched-inductor structure, Power Electron., 2015, Vol. 8, Issue. 5, pp.750759.

[6] Anu.V and Beena M Varghese, Geethu James et.al \ Performance Analysis and Implementation of Cascaded H-bridge Multilevel Inverter Fed Induction Motor Drive using TMS320F28335DSP Processor ," International Journal of Innovative Science and Research Technology,Volume 4,Issue 6 June. 2019.

[7] F. Z. Peng, \ "Z-source inverter," IEEE Transactions on Industrial Electronics, vol.39, no. 2, pp. 504-510, Mar/Apr. 2003.

[8] Ashish Kumar Gautam, Professor Jisha Kuravila P "Loss Minimization of Vector Controlled Induction Motor during Transient,"International Journal of Innovative science and Research Technology" , SSN no. 2456-2165,Loading Volume4 issue 6 , June-2019.

[9] B. N. Alajmi, K. H. Ahmed, G. P. Adam, and B. W. Williams, \"Single-phase single-stage transformer less grid-connected PV system," IEEE Transactions on Power Electronics, vol. 28, no. 6, pp. 2664-2676, Jun.2013.

[10] Y. Zhou, L. Liu, and H. Li \ "High performance photovoltaic module-integrated converter (MIC) based on cascaded quasi-Z-source inverters (qZSI) using eGaNFETs," IEEE Transactions on Power Electronics, vol. 26, no. 3, Jan.2013.

[11] Thasleena Mariyam, Dr. Babu Paul, Kiran Boby \"Transfomerless Inverter with Interleaved Boost Converter for single phase PV Systems , " SSRG IJEEE, vol.6,Issue5,May. 2019.