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Implementation of Three Phase Switched Boost Inverter for Induction Motor Drive

R. Ramya*, and V. Krishna Kumar**

ABSTRACT

Three phases Switched Boost Inverter (SBI) for induction Motor drive have been proposed. Switched boost inverter topology is arrived from Z-source inverter alteration. The Z-source inverter (ZSI) uses pair of L and C network impedance connected between the inverter and the Power Source. The merit of using ZSI in motor drive is that, it can be operated in buck or boost mode. When adapting the ZSI to induction motor drives, it minimizes the torque ripple, when operating in boost mode. In ZSI the impedance arrangement increases the cost, size and weight of the inverter. Hence in the proposed topology the ZSI is replaced by SBI. The SBI minimizes the pair of L and C component to single. And also the PV panel is connected to the SBI for enhancing the utilization of Dc supply. The performance of the SBI is continuous and better when the PV is connected. The analysis of three phases SBI, along with induction motor drive control strategy have been enlightened in this paper. From the literature, induction motor has many control strategies for minimizing the torque ripple and harmonic spectrum. Those strategies requirements increase the cost. Hence the proposed work has been validated using Matlab2013a. When adopting three phase SBI to drive three phase induction motor results better improvement in torque ripple minimization, Total Harmonic Distortion (THD).The MPPT on PV panel is used to increases the performance Of the induction motor, when the MPPT is high at which the PV panel produces the maximum power is analyzed in this paper.

Keywords: Z Source inverter, Total harmonic distortion (THD), Switched boost inverter (SBI), Pulse width modulation (PWM) techniques.

1. INTRODUCTION

Recently many converter topologies are becoming more popular because of its efficient performance. The major necessity of converter is to command motor drive according to the switching pulse. Among these converters the Z-source inverter (ZSI) has been operated in both buck mode and boost mode.The Z-source inverter utilizes a unique impedance network to link the converter drive circuit and power source and it overcomes the limitation of traditional voltage source and current source inverter [1]. The new Z-source inverter system provides better performance under voltage sags, reduces line current harmonics, and extends output voltage amplitude range. However the Z-source inverter makes circuit costly, bulky and applicable for high power applications [2, 3]. The power generated from the renewable energy system [4] is connected to utility grid. In remote places where there is less/no feasibility of utility grids, renewable energy Systems provides electricity to the isolated region. These isolated renewable energy systems can be employed to power residential applications. For renewable energy sources, the output voltage and power typically depends on a variety of uncontrollable factors [5], in solar panel radiation intensity determines the obtainable voltage and power output. The Z-source inverter has been implemented with two maximum constant boost control approach operated with maximum voltage gain at variable modulation index [6]. Various modulation strategies has been proposed to preserve the unique harmonic performance of Z-source inverter. The modulation necessity for H-bridge Z-source inverter, three phases inverter, four phase leg inverters have

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been verified [7].The grid connected photovoltaic system approach for Z-source inverter has been proposed, it results better performance than VSI and CSI[8].

The uninterrupted power supply (UPS) by using *Z* source inverter has been proposed, the impedance network couples the main power circuit of an inverter to the battery bank [9]. Therefore the UPS can maintain the desired ac output voltage at the significant voltage of battery bank with high efficiency, low harmonics and fast response. The two cascaded three level Z source inverter with various modulation strategies has been proposed to improve the output voltage level [10]. The harmonic spectrum of the switched boost inverter's output voltage with the PWM techniques has been analyzed and compared with the traditional voltage source inverter [11]. The steady state and small signal analyses of the switched boost inverter is performed and also the comparison of SBI and ZSI with the same input and output parameters [12]. A winding strategy for induction motor drive through control is proposed in [13].

3. SBI TOPOLOGY

A switched boost inverter embracing of one inductor(L), one capacitor(C), two diodes (D_a, D_b), one energetic switch (*S*) is connected between the input voltage source V_s and the inverter network..

Analogous to ZSI, the SBI utilizes the shoot-through state of the inverter bridge network (both switches in one leg of the inverter are turned on simultaneously) to boost the input voltage V_s to capacitor voltage V_c. The steady state operation of the SBI, has been explained by assuming that inverter is in shoot-through zero state for duration $D.\ T_s$ in a switching cycle *T*. The switch *S* is also turned on during this

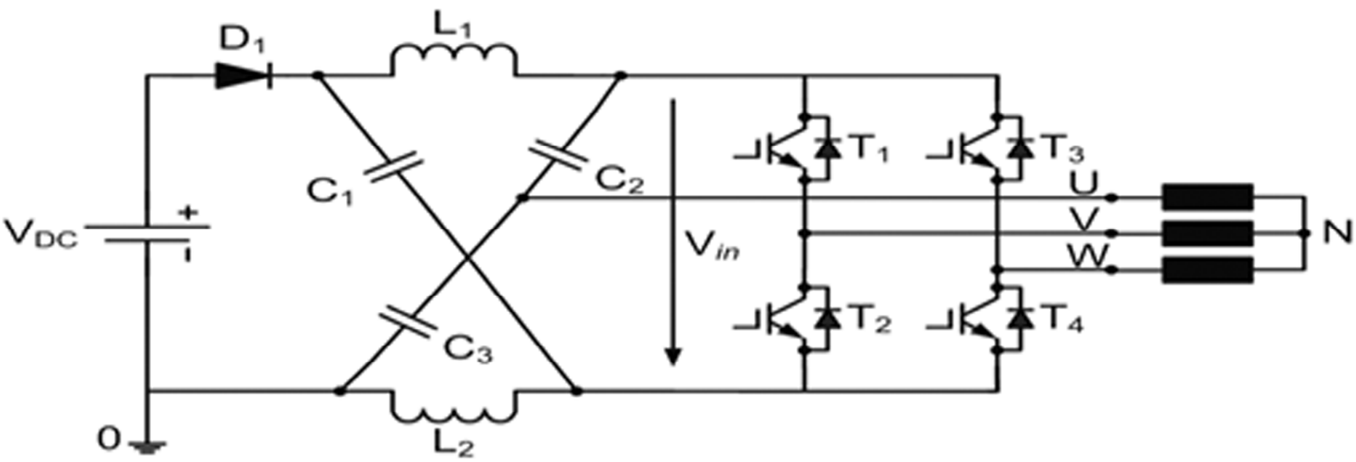

Figure 1: Z-source inverter.

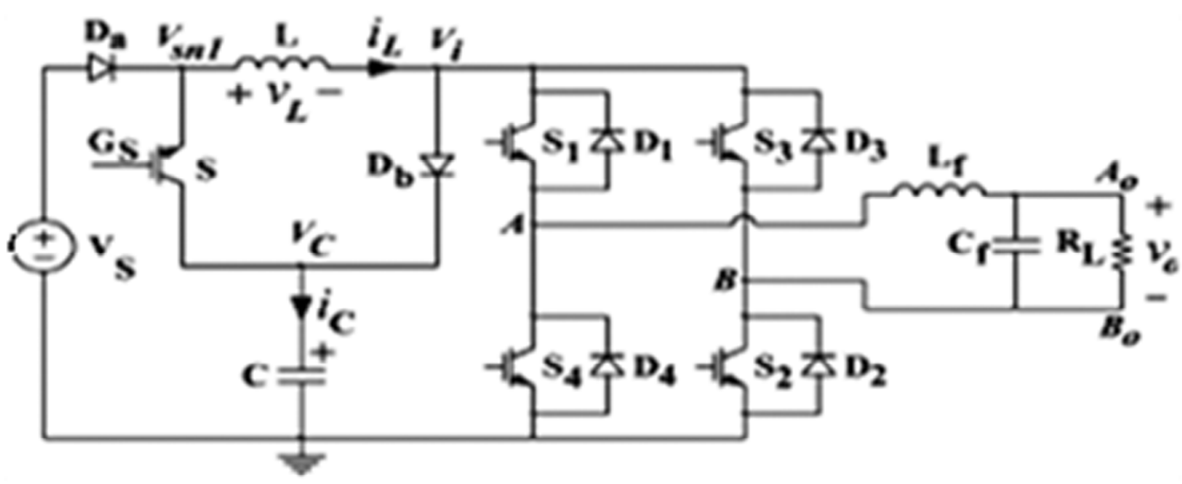

Figure 2: Switched boost inverter

interval. As shown in the equivalent circuit of Fig. 3, the inverter bridge is represented by a short circuit during this interval. The diodes D_a and D_b are reverse biased ($V_c > V_s$), and the capacitor C charges the inductor L through switch S and the inverter bridge. The mathematical equations of the converter in the interval $D.\ T_s$ are given by

$$V_L(t) = V_C(t) \tag{1}$$

$$i_C = -i_L \tag{2}$$

$$V_{in}(t) = 0 \tag{3}$$

The remaining duration in the switching cycle (1-D)T_s, the inverter is in non shoot-through state, and the switch S is turned off.

The inverter bridge is represented by a current source in this interval as shown in the equivalent circuit of Fig. 4. Now, the voltage source and inductor L together supply power to the inverter and the capacitor through diodes and The inductor current in this interval equals the capacitor charging current added to the inverter input current. Note that the inductor current is assumed to be sufficient enough for the continuous conduction of diodes and for the entire interval (1 – D).

The mathematical equations of the converter in the interval (1 – D) are given by

$$V_L(t) = V_S - V_C(t) \tag{4}$$

$$i_C(t) = i_L(t) - i_i(t) \tag{5}$$

$$V_{in}(t) = V_C(t) \tag{6}$$

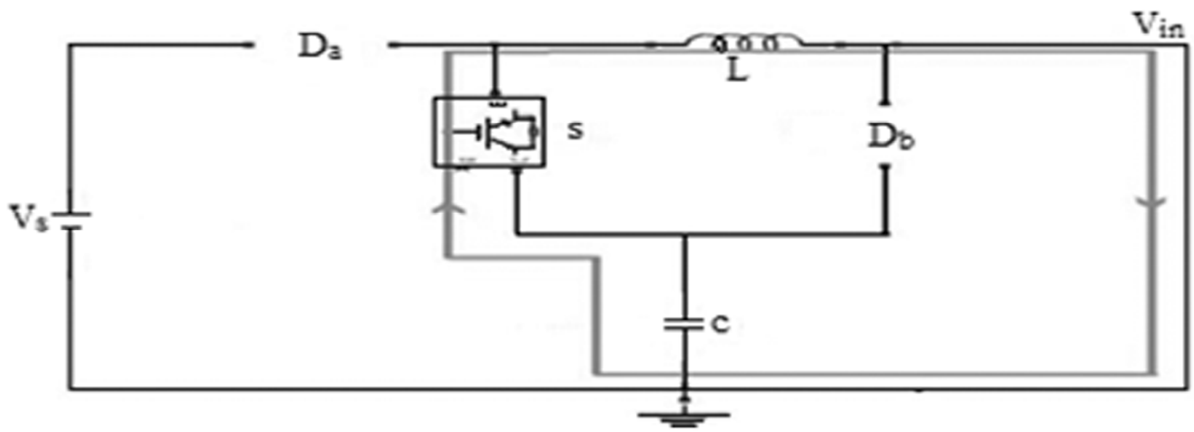

Figure 3: Shoot through state of SBI

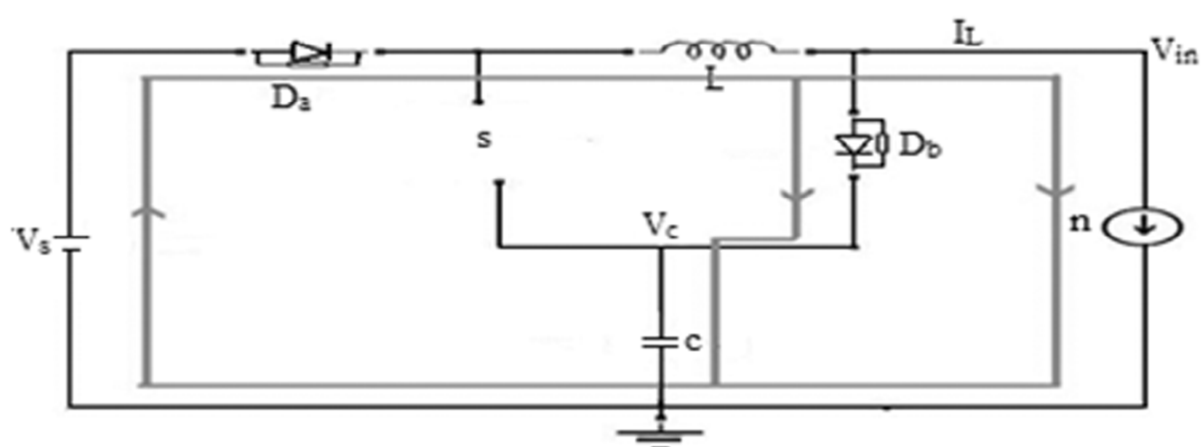

Figure 4: Non shoot through state of SBI

As the average voltage across the inductor L during a switching cycle TS should be equal to zero we get,

$$\frac{V_c}{V_s} = \frac{1-D}{1-2D} \tag{7}$$

4. THREE PHASE SBI TOPOLGY

The three phase SBI operates buck-boost mode just similar to the single phase SBI topology. But the PWM technique for the proposed system is different to operate the SBI. The three phase SBI has six number of switches, and the switch *S* for the boost or buck operation. The PV cell converts the sunlight into the electricity, the dc power is produced .The dc power supply is fed to switched boost inverter in which the buck or boost operation occur and the AC output voltage is obtained to run the induction motor efficiently.

The PV panel fed to the three phase SBI for the operation of induction motor is shown in fig. 5. The PV cell contain the semiconductor material which converts the light energy into the dc power, the output voltage and the current of the PV cell is explained by the following equation.

The PV cell output current is given as,

$$I_{pv} = I_{ph} - I_o\left[\exp\left(\frac{q\left(V_{pv} + I_{pv} IR_s\right)}{2a}\right)\right] - 1 \tag{8}$$

The PV cell output voltage is given as,

$$V_{pv} = \frac{AKT}{q}\ln\left(\frac{\left(I_{ph} - I_{pv} + I_o\right)}{AKT}\right)R_s \tag{9}$$

The light generated current is given as,

$$I_{ph} = \left[I_{scr} + Ki\left(T - 298\right)\right]\lambda/100 \tag{10}$$

The saturation current is given as,

$$I_o = I_{or}\left(\frac{T}{T_r}\right)^3 \exp\left[\frac{q^E go}{BK}\left(\frac{1}{T_r} - \frac{1}{T}\right)\right] \tag{11}$$

The MPPT on the PV panel helps to produce the maximum power when the MPPT is high, the induction motor runs efficiently the normal supply of the DC power. Maximum power point tracking

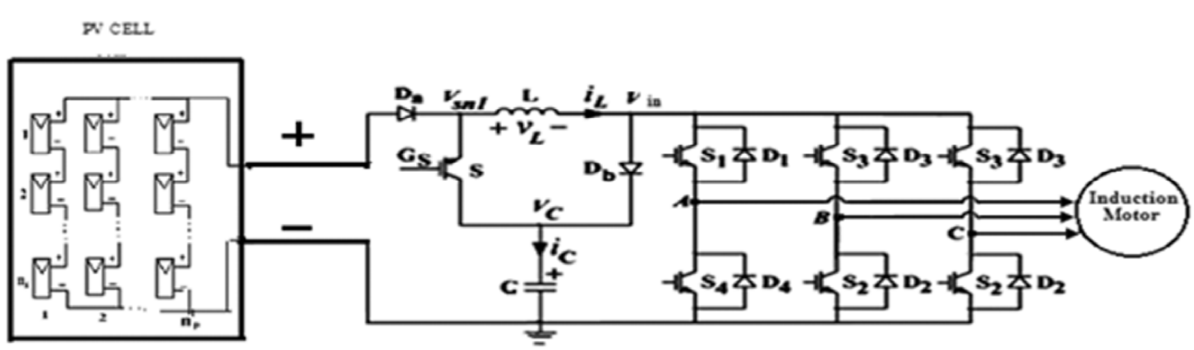

Figure 5: PV cell fed to three phase switched boost inverter

(MPPT) is a technique that charge controllers use for PV solar systems to maximize power output. The individual models of the PV array with inverter are simulated and their characteristics are studied in the literature.

The SBI produces the higher voltage than the ZSI with the same input and the boost factor. The SBI is connected to induction motor as a ac load. The speed and torque produced from this induction motor is shown in fig. 6. The output voltage of the SBI is 1500V when the input voltage is 100Vand the boost factor is 5. The output voltage waveform of the SBI is shown in fig. 7.

5. COMPARISON OF SBI AND ZSI

The fundamental output voltage of THD and the THD (%) are shown in fig. 8 as bar chart.

The THD(%) of the SBI is lower as compared to the ZSI. When the input voltage is 100V, the fundamental output voltage of SBI is 160V and the THD(%) is 150.1, the fundamental output voltage of ZSI is 229V and the THD(%) is 160.32.Therefore the THD is lower for the SBI as compared to the ZSI. The line graph of the fundamental output voltage and the THD of the SBI and the ZSI is shown in fig. 9

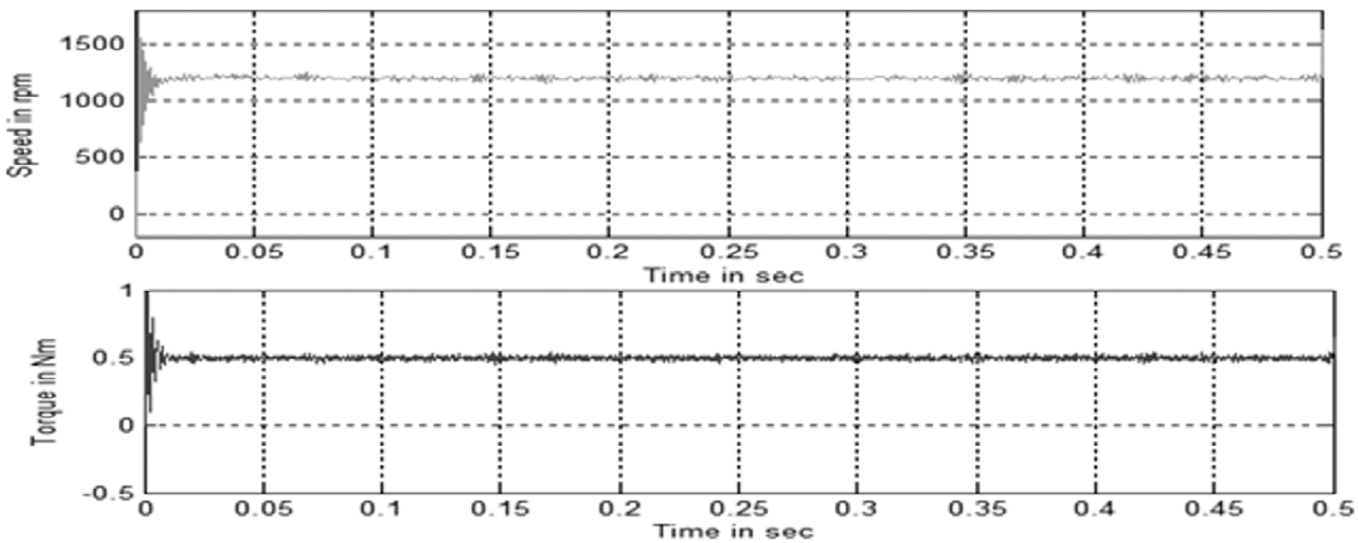

Figure 6: Output Speed and Torque characteristics

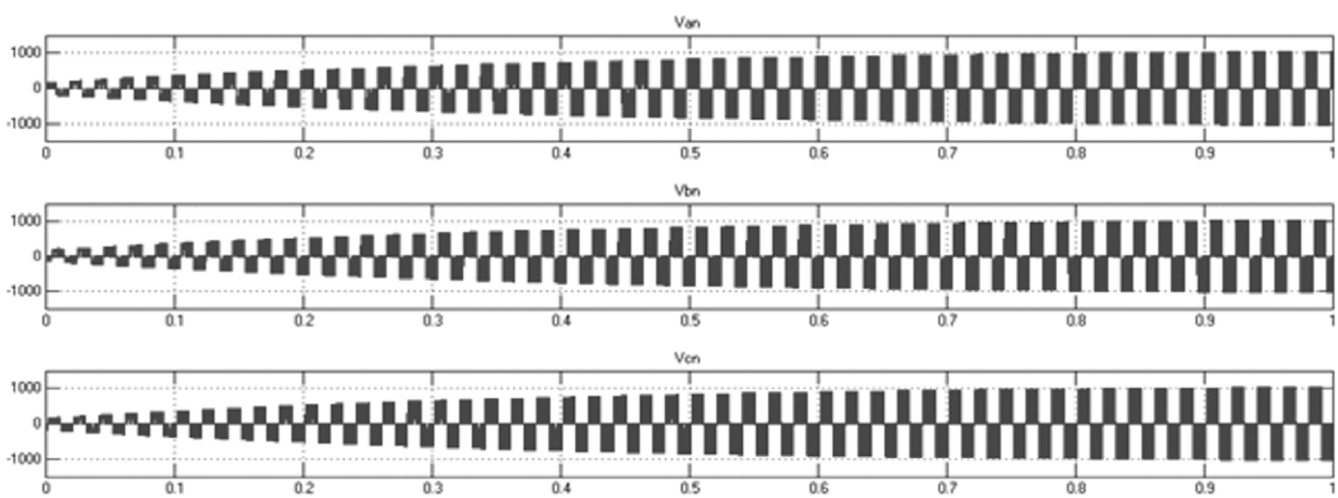

Figure 7: Three phase line voltage of SBI

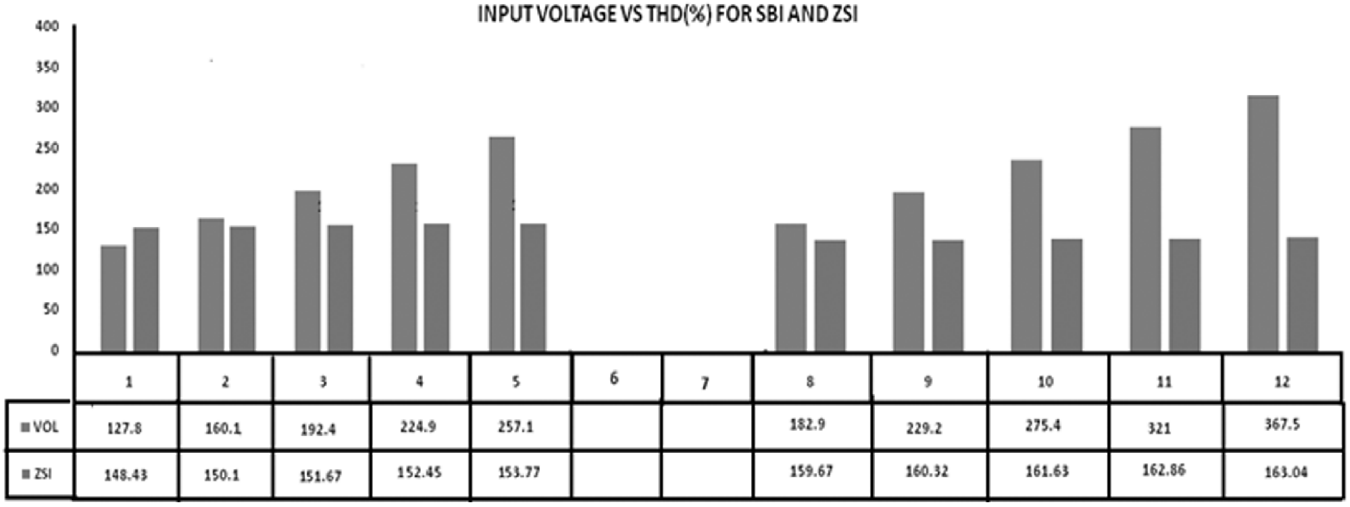

Figure 8: Bar chart for SBI and ZSI

Figure 9: Comparison of THD% for SBI and ZSI

6. CONCLUSION

The SBI is compared with the ZSI and the performance of an SBI is better than the ZSI in terms of THD and torque ripple. The induction motor performance is better for SBI than the ZSI. The maximum power is obtained from the PV panel using the MPPT, so the usage of the rectifier and the regulated power supply (RPS) is avoided. The number of the components and the cost is reduced for SBI as compared to ZSI. The control strategy for the operation of the induction motor is analysed using the SBI and power received from PV panel.

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