T SOURCE INVERTER BASED PERMANENT MAGNET BRUSHLESS DC MOTOR

Soumya C Sajeevan, George T.V

Abstract— Analysis of T-source Inverter with simple boost control technique for improving voltage gain. T-Source inverter has high frequency low leakage inductance transformer and one capacitance. It has low reactive components in compare with conventional inverter. The T-source network has an ability to perform dc to ac power conversion and it provides buck boost operation in a single stage but the traditional inverter cannot provide such feature. All PWM methods can be used to control T-source inverter. The utilization of shoot-through switching state is enhanced in T-Source inverter which helps in the unique usage of buck-boost feature to the inverter. It is recommended that to maintain the constant voltage in the input side to get the appropriate voltage in the output side.

***Index Terms*—Photovoltaic cell, T source inverter, BLDC motor, Simple boost control.**

I. INTRODUCTION

Power electronic converter system plays an important role in the integration of photovoltaic (PV) sources into the load. Today, a distribution configuration of single-phase grid connected PV inverters with high efficiency, high reliability, and reasonable cost is possible [2]. A PV cell is an electronic device which directly converts sunlight into electricity. Light shining on the solar cell produces both a current and a voltage to generate electric power. The output dc voltage is converted into ac by inverters. The Z-source inverter overcomes the difficulties of conventional voltage and current source inverters. It performs both buck and boost operation. It can be used for both voltage and current source inverter without changing the circuit design also improves the efficiency of the system because of power conversion stage in this circuit is reduced. By modifying the arrangement of passive components we can improve the inverter performance. Among different topologies of Z- source inverter, the topology that is being considered for analysis is T-source inverter. The passive component arrangement is look like the alphabet T. The name of T- source inverter is modified Z-source inverter. As the inverter is derived from the root of Z.-source inverter and the arrangement of passive components looks like the alphabet 'T', the inverter is called modified Z-source inverter or T- source inverter. The boost operation of the inverter is achieved using the concept of shoot-through time period. Normally the inverter converts DC to AC output. By utilizing the T-source inverter, the number of switching components and the total volume of the system can be minimized. Thus, the overall cost of the system is reduced. T- source inverter is utilized to realize inversion and boost function in one single stage. TSI has fewer components. Due to these reason, the efficiency appreciably increase. Unlike the traditional inverter, TSI utilizes a unique impedance network that links the inverter main circuit with the DC source. The LC lattice applied in the ZSI successfully replaces the DC-DC input stage in boost-type voltage source inverters. To minimize the Z-source size, the couple inductors are designed, and the two inductors are built together on one core. The TSI topology requires a very low leakage inductance transformer which should be made with high precision. In such a way, the number of passive elements is reduced because only the transformer and the capacitor are needed. As with a conventional ZSI, the TSI can handle shoot through states when both switches in the same phase leg are turned on. The T-network is used instead of the LC- network for boosting the output voltage by inserting shoot through states in the PWM. T-source Inverter operating principle same as that of conventional ZSI. TSI operate in Shoot through mode and Non shoot through mode. In shoot- through mode of operation, the output voltage is boosted. In conventional method VSI, it is not possible..

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II T-SOURCE INVERTER

A. The New type T – source inverter (TSI) overcome the limitation of traditional voltage source inverter and current source inverter [6] [7]. With the use of TSI, the inversion and also the boost function are accomplished in a single stage. TSI has fewer components. Due to these reasons, the efficiency appreciably increases. Unlike the traditional inverter, TSI utilizes a unique impedance network that links

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the inverter main circuit to the DC source. The passive element of inductor and capacitor is reduced in T-source inverter (TSI). The two inductors are building together and it forms a couple inductors and it has low leakage inductance. Instead of two capacitors used in Z-source inverter (ZSI) the only one capacitor is used in T-source inverter. It should be made with high precision. TSI has the feature of the common dc rail used between source and inverter. The transformer ratio must be 1:1 ratio. The impedance network output is applied to the inverter circuit and the inverter circuit consists of four switches. Boosting capability is achieved by shoot through mode of switches operation. This operation performed by turning on the both switches simultaneously [13].

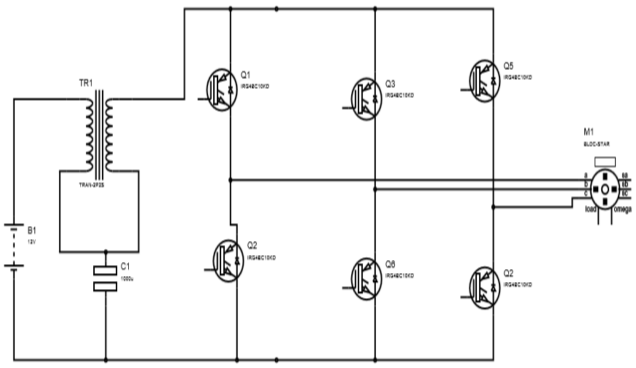

Fig 1 Circuit Diagram of New Type T – Source Inverter

During the shoot through mode state the energy is transferred from capacitor to inductor. At the time, the voltage boosting is capability achieved. The DC voltage is fed as input to the impedance network of TSI which helps to achieve voltage buck and boost properties. Since, the capacitors may be charged to higher voltages than the source voltage, the diode 'D' prevents discharging of capacitors through the source.

2.1 Principle of operation

T – Source Inverter operating principle same as that of conventional ZSI [2]. The T-network is used instead of the LC-network for boosting the output voltage by inserting shoot through states in the PWM. TSI operate in two modes: a) Shoot through mode b) Non shoot through mode

2.1.1 Shoot through mode:

Fig 2. Shows the equivalent circuit of T – Source Inverter in Shoot through mode operation. This shoot through zero state prohibited in traditional voltage source inverter. It can be obtained in three different ways such as shoot through via any one phase leg or combination of two phase leg. During this mode, Diode is reverse biased, separating DC link from AC line.

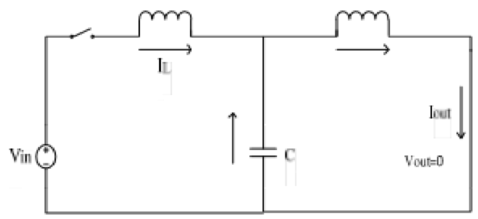

Fig 2 Shoot through mode

2.1.2 Non – shoot through mode:

Fig 3. Shows the equivalent circuit of TSI in Non – shoot through mode operation. In this mode, the inverter bridge operates in one of traditional active states, thus acting as a current source when viewed from T – source circuit.During active state, the voltage impressed across the load. The diodes conduct and carry current difference between the inductor current and input DC current. Note that both the inductors have an identical current because of coupled inductors.

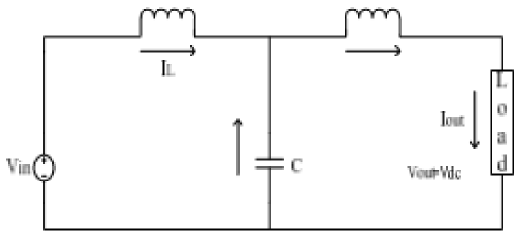

Fig 3 Non shoot through mode

During the design of TSI the most challenging is the estimation of values of the reactive components of the impedance network. The component values should be evaluated for the minimum input voltage of the converter, where the boost factor and the current stresses of the components become maximal. Calculation of the average current of an inductor

$$I_L = \frac{P}{V_{dc}}$$

(1)

The maximum current through the inductor occurs when the maximum shoot-through happens, which causes maximum ripple current. In our design, 60% peak-to-peak current ripple through the Z-source inductor during maximum power operation was chosen. Therefore, the allowed ripple current is ΔI_L, and the maximum current through the inductor is I_{Lmax}:

$$I_{Lmax} = I_L + \Delta I_L$$

$$I_{Lmin} = I_L - \Delta I_L$$

$$\Delta I_L = I_{Lmax} - I_{Lmin}$$

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The boost factor of the input voltage is

$$\beta = \frac{1}{1 - 2_{DZ}}$$

(2)

Calculation of required inductance of T-source inductors

$$L = \frac{T_0 V_C}{\Delta I_L}$$

(3)

where T0 - is the shoot-through period per switching cycle

Calculation of required capacitance of T-source capacitors

$$C = \frac{T_0 I_L}{\Delta V_C} \quad (4)$$

II. BLOCK DIAGRAM OF THE PROPOSED SYSTEM

The proposed system consist of T source inverter topology. It combines the benefits of both buck and boost operation can be performed in a single stage, low switching loss and low reactive loss. Here the input to the inverter is provided with PV panel. MPPT is implemented to track the maximum power from PV. Switching pulses for the inverter is produced using Simple Boost Control technique.

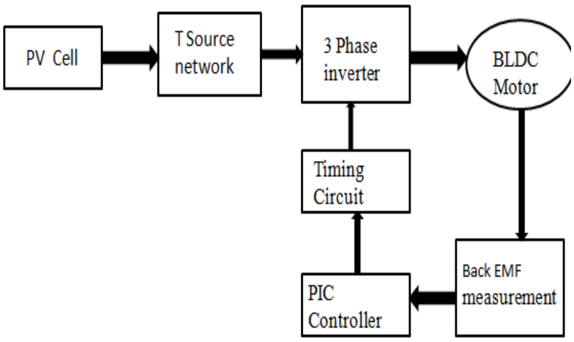

Fig 4 Block diagram of proposed system

IV. SIMPLE BOOST CONTROL

Fig 5.Shows the block diagram of the simple boost control (SBC) technique. In simple boost control, the reference signal is compared with the triangular carrier signal for generating the shoot through pulses (with equal or greater than the peak of triangular signal). To produce switching pulses, two reference waveform having peak value with modulation index (M) are compared with the same triangular frequency triangular signal [5]. These two signals compared by using comparator. By using logic gate, the shoots through pulses are inserted into the switching waveform. These pulses are given to the power IGBT through isolation and gate drive circuit.

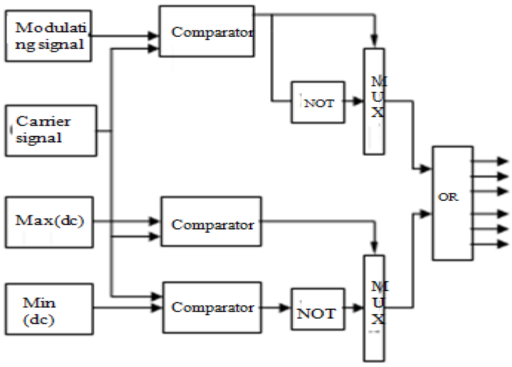

Fig 5 Simple Boost Control

Modulation index:

$$M = \frac{V_{ref}}{V_{Car}} \quad (5)$$

Shoot through duty ratio:

$$D_0 = 1 - M \quad (6)$$

Gain factor:

$$G = \frac{M}{1 - D_0} \quad (7)$$

Boost factor:

$$B = \frac{G}{M} \quad (8)$$

The high voltage gain and a small modulation index have to be used for produce the output voltage. The voltage stress across the switches is high by using this control method. This will restrict the obtainable voltage gain because of the limitation of device voltage rating.

V. BRUSHLESS DC MOTORS

The mechanical brush-commutator mechanism would wear and eventually result in motor failure. The brushless motors gives a solution to this problem and brushless motors provide high speed and fast acceleration, generate less audible noise and electromagnetic interference, and require low maintenance. Brushless dc (BLDC) motors are gaining popularity due to their performance advantages over brushed dc (BDC) motors, including the following Brushless dc motor motors have a relatively flat speed-torque characteristic. This enables the motor to operate at lower speeds without compromising torque when the motor is loaded.

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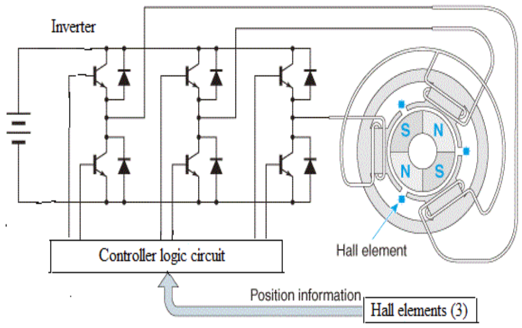

Fig 6 BLDC with sensor control

The brushless dc motor operate at higher-power efficiency compared to induction motors and brushed dc motors because they have permanent magnets on the rotor and there are no brushes for commutation. Brush inspection is eliminated, making them suitable for limited-access areas like compressors and fans. This also increases the life of the motor and reduces the service requirements. They operate much quieter compared to brushed dc motors since brushes make audible noise. Brushless dc motor motors have less electromagnetic interference generation. There are two major concerns with brushless dc motor motors. First, brushless dc motor motors can be more expensive. However, the performance advantages override this concern. Second, brushless dc motor motors need electronic commutation. The stator windings are commutated based on the rotor position. This requirement can be turned into an advantage. The same electronics used to control the commutation can also provide speed control.

VI. SIMULATION RESULTS

Simulations are carried out using MATLAB/Simulink to analyze the operation and overall performance of the T Source Inverter. For simulation PV array is replaced by a 34V dc source. The output voltage is boosted up to 300V by performing shoot-through operation in T- source inverter. Fig 8 shows the output voltage of TSI with filter. The capacitance(C) is modeled 100nF connected to the PV terminal and the ground.

The output waveform of T source inverter ,Pulse for buck, Pulse for boost ,Output of the BLDC motor and Speed waveforms are shown in the figure 7(g) and 7(i) respectively.

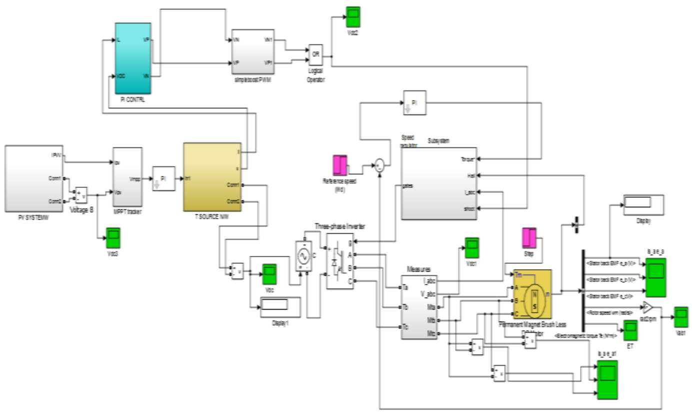

Fig.7(a)Simulation of T Source Inverter

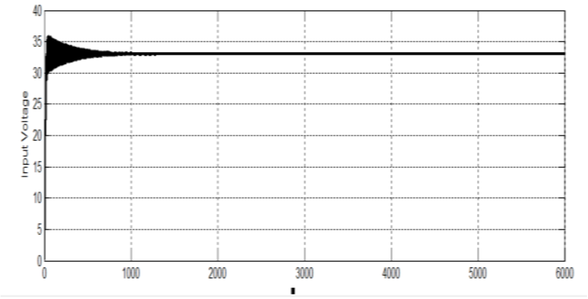

Fig 7(b) Input voltage of PV Panel

The simulation of output waveform is show in the figure below.

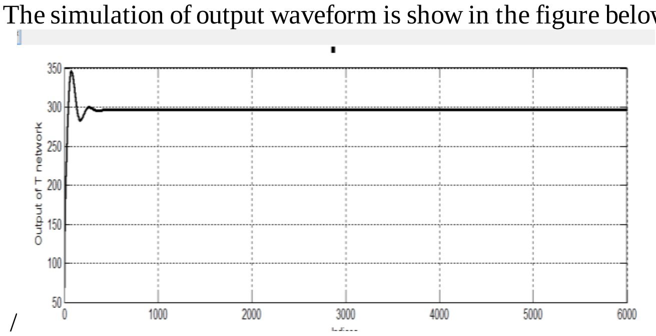

Fig .7(c) Output voltage of T network waveform

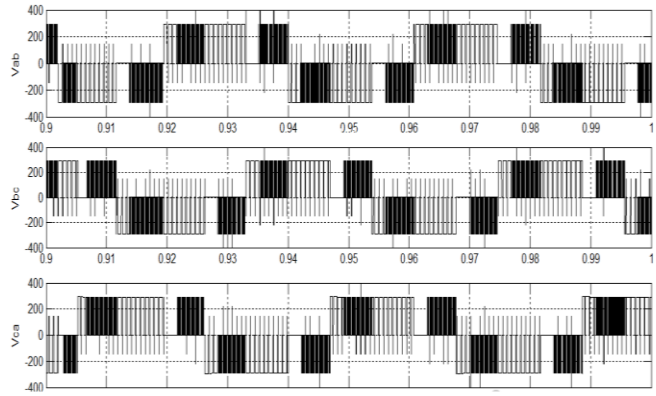

Fig.7(d) Output voltage of the inverter

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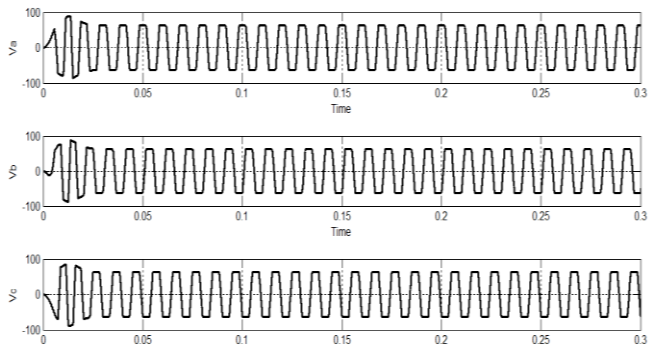

Fig.7(e) Output voltage of BLDC Motor

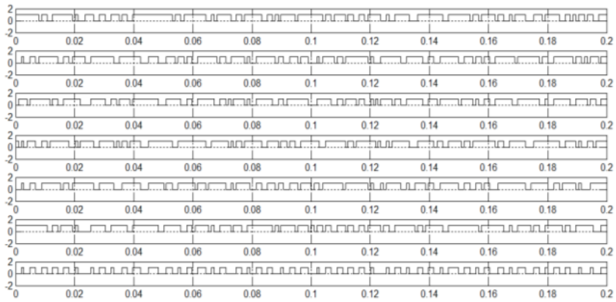

Fig.7(f)Pulse for Boost Operation

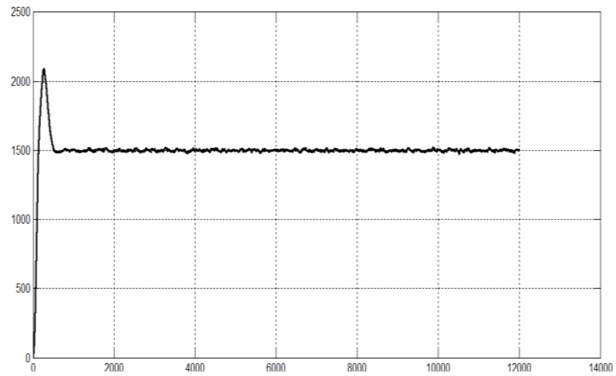

Fig.7(g)BLDC Motor operated at High Speed

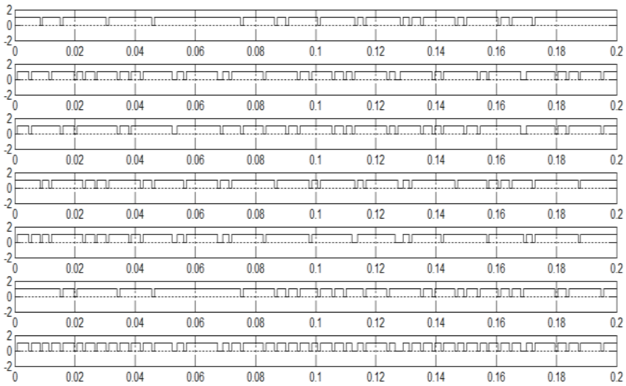

Fig.7(h) Pulse for Buck Operation

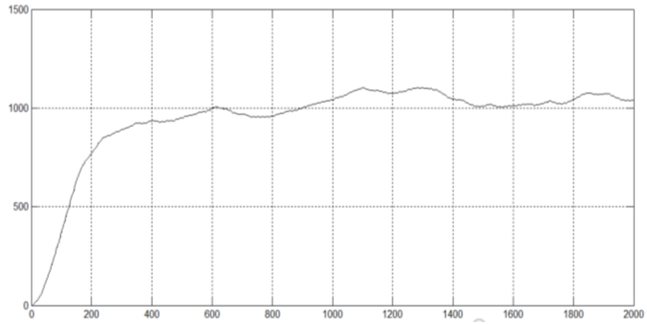

Fig.7(i) BLDC Motor Operated at Low Speed

VI. CONCLUSION

This paper has been investigated the performance of single phase T-source inverter simple boost controller. The voltage boost is inversely related to the shoot through duty ratio-source TSI has fewer reactive components when compared to ZSI and both the buck-boost operation is performed. The single phase TSI with SB control scheme was simulated and the lower order harmonics in the output current was reduced.

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BIOGRAPHY

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