Quasi-Z-Source Inverter using Sliding Mode Controller with Impedance Network

B. Kalaiselvi, S. Prakash

Abstract*: Quasi inverter is designed in this paper to enhanced gain operation using sliding mode controller (SMC) with Z-source inverter (ZSI). It has boost voltage conversion at low ratio in duty cycle and output voltage quality is improved by high modulation index. Direct current (DC) is converted to alternating current (AC) with higher frequency pulse width modulation (PWM) signals. To reduce the inrush current in starting period it draws a low voltage at capacitors. This proposed inverter consists of common ground to source as well as bridge rectifier. Moreover, the ripple current is almost negligible in this ZSI. This paper proposes the ZSI with impedance of two switches network and the theoretical analysis done also it is confirmed in MATLAB/Simulink.

Keywords*: Inrush current, quasi ZSI, two switched network, , ripple current, sliding mode controller.

I. INTRODUCTION

Traditional voltage and current source converters are used to buck or boost inversion with the conversion of dc to ac voltage. They are used in wide range of industries and applications but still they have some limitations [1-2]. The ZSI has efficient feature to overcome the above problems and it is done DC-AC conversion and perform efficient single stage operation. It has both of buck and boost operation capabilities, higher efficiency and reduced cost due to fewer components in converter while compared with existing DC-AC converters [3].

To get high voltage gain, the additional boost converter to be added but it will leads to short circuit in the semiconductor devices. The network impedance has the bridge converter inductors and capacitors in between source [4-5]. Here the inductors are energized by capacitors at shoot through state and energy in inductors are discharged to dc-link that increases the voltage gain [6]. inverter cost and size are increased when the high voltage stress on its capacitors of impedance network and the PV applications required normally boost voltage ratio through a day so converter is connected between them and it needed to do high gain conversion and steady state AC –DC conversion but it can be done with single stage using ZSI [7-8].

To attain the voltage, the stress switches needed to be reduced on its impedance network without changing their components. The boost factor for switch inverter is same as the conventional inverters [9-10]. The capacitor stresses are reduced using switched inductor and however the traditional ZSIs have some demerits like high stress on capacitors and semiconductor devices, low voltage capability and inrush current [11-12]. The Z-source converter is also suitable for renewable energy sources like solar, wind and fuel cell etc. In this paper, the two switched impedance network is proposed and the boost factor is heightened.

The voltage gain is achieved through the ZSI at low duty cycle and the modulation index is increasing the gain of voltage. The stress voltage on the components such as switches and capacitors can be reduced and that can be used to lower rating devices and the starting inrush current problem is minimized. The ripple current is eliminated by the inductors. The single stage operation is performed that will reduce the cost and size as well as providing efficient features. The small duty ratio is reducing the losses of conduction and the overall system efficiency will be higher.

II. PROPOSED SYSTEM OPERATION AND PRINCIPLE

The proposed novel inverter comprises of five diodes, four inductors and four capacitors. This inverter is operating in metal oxide semiconductor field effect transistors (MOSFET) which has the higher commutation speed as well as high efficiency at low voltage and achieving efficient boost factor using sliding mode controller. The PWM is providing signals to switching devices and it improves the system efficiency and reducing the capacitor stress using two switched inductors. The inductors and capacitors are used to boost the system voltage and hence switches counts are reduced. AC to DC conversion is performed by using inverter at single stage operation. However, the boost factor is increased in low duty ratio compared with conventional inverters. A boost factor of this arrangement further increased using passive components such as capacitors, inductors addition to diodes. It provides continuous current to load from the source to reduce the losses in conduction and improving the efficiency of the system. This system is operating in two states that shoot through and non through states and hence both devices of same phase in inverter are turned ON at same instant. This ZSI provides continuous current flow to the load and to increase the voltage gain an additional elements are used such as capacitors, inductors etc. The AC-DC conversion with two switched network impedance is increase the voltage gain.

Through the inductors the current ripples are eliminated. The modulation index is given in following equation,

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$$V_G = \frac{M}{2M^2 - 1} \quad (1)$$

A quazi ZSI which performed during shoot through and non-shoot through states are analyzed and proposed boost system is shown in following fig.1.

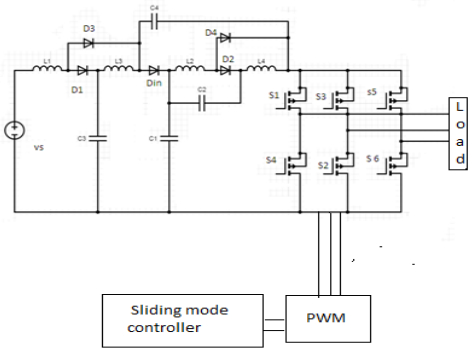

Fig. 1. Proposed Hybrid System

A. Shoot Through State

In this state, devices in same leg of inverter are turned ON that can be any phase of leg at the same time for obtaining high voltage. During this state, the inverter diodes Din, D1, and D2 are in OFF state, whereas the diodes D3 and D4 are ON state and capacitors are providing energy to inductors that stores the electromagnetic energy. The inductor voltages are in steady state by applying the KVL on impedance network.

B. State of Non Shoot Through

In this state, there are six ON states and two OFF stages during dc voltage is overwhelmed across the 3 phase load then the active states of the six switches are come to play their role and the two off states are come to play while the terminals of load are shorted through low or high devices. At this state, diodes in inverter Din, D1, and D2 are ON state where the diodes D3 and D4 are turned OFF. The inductors that stored electromagnetic energy is supplied to system to achieve high voltage gain and also capacitors are charged through inductor from source input voltage.

III. SIMULATION AND RESULTS

The proposed system consists of inverter which performing single stage process with two switched impedance network to draw continuous input current and obtain more voltage. It is implemented in MATLAB/Simulink. It consists of four inductors (L1, L2, L3 and L4), five power diodes (D1, D2, Din, D3 and D4), four capacitors (C1, C2, C3 and C4), three phase inverter and filter. The Simulink model of proposed system is designed to supply continuous current to load and high output voltage as shown in fig.2.

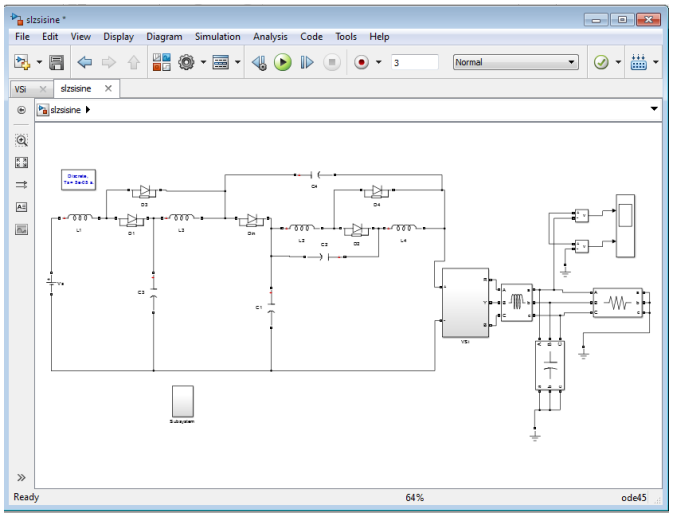

Fig. 2.Simulink Model of Proposed System

Input voltage of the proposed system is 37V which is shown in following fig. 3.

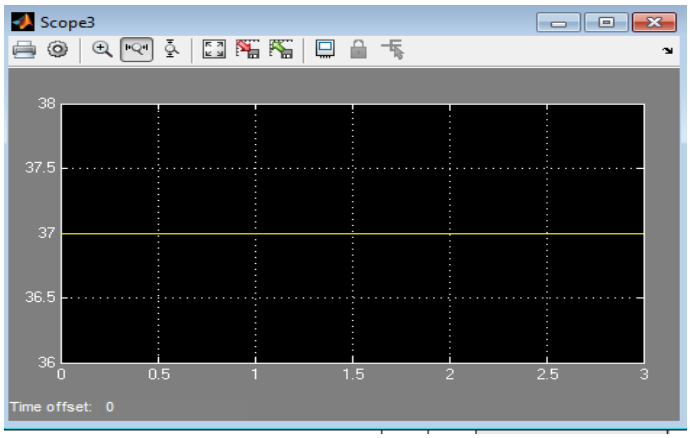

Fig. 3.Input Voltage

The proposed inverter is performed single stage operation. The system output voltage is shown in fig. 4. The input voltage is 37V and obtained result is 250v.The purpose of this work to boost the voltage from input source and convert AC-DC.

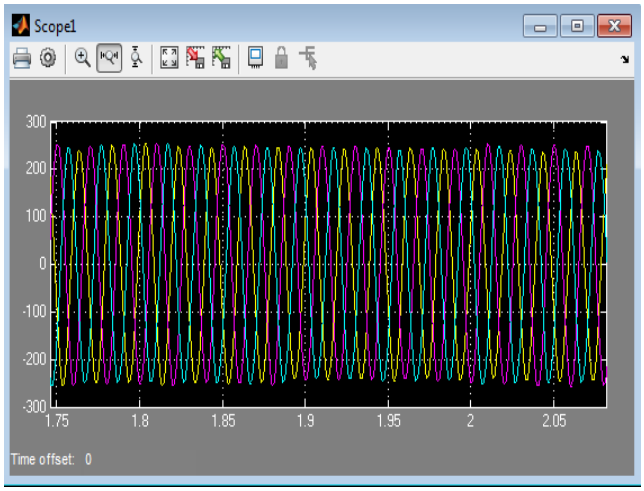

Fig. 4.Output System Voltage

The system output current is 15A obtained and fig.5

represents the output current of the system.

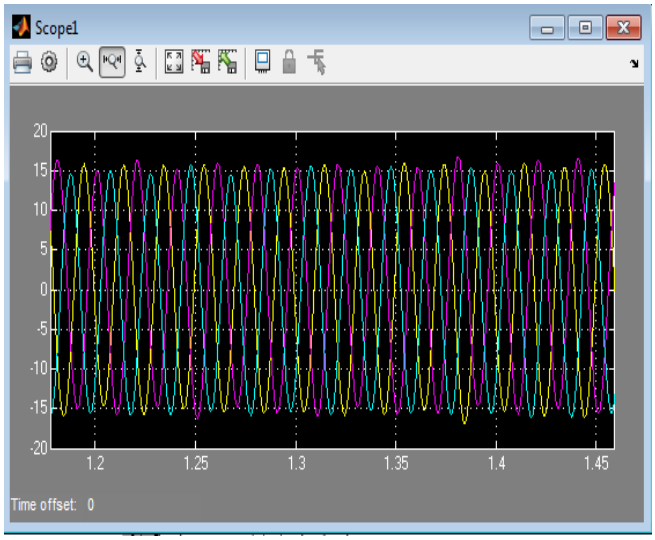

Fig. 5.Output System Current

IV. CONCLUSION

In this paper, a two switched impedance network and ZSI are combined to provide continuous current to load and achieve high voltage gain. The aim of this paper achieved through quazi ZSI with two switched impedance network using sliding mode controller (SMC). The startup inrush current is decreased and high modulation index is obtained. It posses high output voltage gain and the current ripple in proposed inverter is zero. Proposed system provides low capacitors stress voltage and system efficiency is improved. The proposed inverter is designed and verified through the implementation of the system in MATLAB/Simulink.

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