Simulation of Z-Source Inverter using SBC Method

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Abstract— There are many application in industry and special machines which require different voltage level and frequency. The power electronics device which converts DC power to AC power at required output voltage and frequency level is known as inverter. Three are mainly Voltage source inverter and current source Inverter is used for DC to AC power conversion. There are some conceptual and theoretical barriers and limitations of this topology. Nowadays Impedance source inverter is used which eliminates that problem. Impedance source inverter is emerging as a new breed of power inverter for convert desire level without using boost circuit, so it reduce loss & cost and improve efficiency. Impedance sources Inverter are used especially in Fuel cell application, PV system and Wind Energy Conversion system etc. This have unique feature which provide desire output voltage. It also Work as buck-boost converter. This work proposes a simulation of three phase Impedance source inverter. The Simulation has been carried out with MATLAB/SIMULINK.

Key words: Z-Source Inverter, SBC Method

I. INTRODUCTION

A. Z Source Inverter

The configuration of 3-phase Z-source inverter is shown in fig. 3. It consists of 2 identical inductors and 2 identical capacitors in X shape is employed to provide an impedance source (Z-source) coupling the converter (or inverter) to the dc source, load, or another converter.

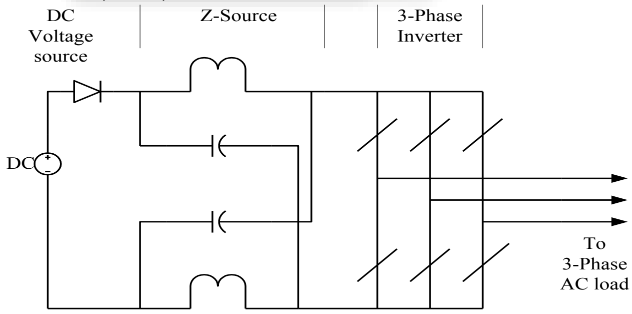

Fig. 1: Structure of the Z-source converter

To overcome the problems of traditional VSI and CSI, a Z-source power converter topology is used. The dc source or load can be either a voltage or a current source or load. Therefore, the dc source can be a battery, diode rectifier, Thyristor converter, fuel cell, an inductor, a capacitor, or a combination of those. Switches used in the converter can be a combination of switching devices and diodes such as the antiparallel combination as shown in Fig. It employs a unique impedance network to couple the converter main circuit to the power source, load, or another converter, for providing unique features that cannot be observed in the traditional V- and I source converters where a capacitor and inductor are used, respectively. Z-source inverter can boost dc input voltage with no requirement of dc-dc boost converter or step up transformer, hence overcoming output voltage limitation of traditional voltage source inverter as well as lower its cost.

A comparison among conventional PWM inverter, dc-dc boosted PWM inverter, and Z-source inverter shows that Z-source inverter needs lowest semiconductors and control circuit cost, which are the main costs of a power electronics system. The Z-source concept can be applied to all dc-to-ac, ac-to-dc, ac-to-ac, and dc-to-dc power conversion.

The traditional VSI has six active vectors and two zero vectors. However, Z-source Inverter Bridge has one extra zero state vector. The unique feature of Z-source inverter is that it can be used as buck-boost inverter that as wide range of obtainable voltage. The traditional V- and I-source inverters cannot provide such feature.

For the traditional V-source inverter, the dc capacitor is the sole energy storage and filtering element to suppress voltage ripple and serve temporary storage. For the traditional I-source inverter, the dc inductor is the sole energy storage/filtering element to suppress current ripple and serve temporary storage. The Z-source network is a combination of two inductors and two capacitors. This combined circuit, the Z-source network is the energy storage/filtering element for the Z-source inverter. The Z-source network provides a second-order filter and is more effective to suppress voltage and current ripples than capacitor or inductor used alone in the traditional inverters. Therefore, the inductor and capacitor requirement should be smaller than the traditional inverters.

B. Control Methods

There are a number of control methods which have been presented so far to control Z-source inverter, mainly there are three control methods for Z-source inverter.

1) Simple boost control method
2) Maximum boost control method
3) Maximum constant boost control method

Now, new mordant control method also used

1) Space vector pulse with modulation
2) Modified space vector pulse with modulation

II. SIMPLE BOOST CONTROL METHOD

Simple boost control uses two straight lines to control the shoot-through states, as shown in Figure. When the triangular carrier waveform is greater than the upper envelope, or lower than the bottom envelope, the circuit turns into shoot-through state. Otherwise it operates just as traditional carrier-based PWM. Figure shows the pulse generation of the three phase leg switches this method is much uncomplicated; however, the resulting voltage stress across the device is relatively high because some traditional zero states are.

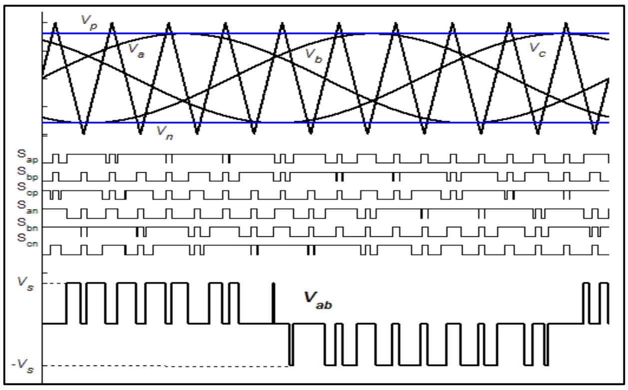

Fig. 2: Simple Boost Control method

In 3-phase Z-source inverter, one additional parameter is introduce, namely the Boost Factor (B), which modifies the AC output voltage equation of traditional 3-phase PWM inverter as following.

$$\hat{V}_{out} = BM\frac{V_0}{2}$$

$\hat{V}_{out}$ = Maximum sinusoidal inverter output voltage
B = Boost factor
M = Modulation Index
V0 = DC Input voltage
If we replace BM with G, then we may rewrite equation as,

$$\hat{V}_{out} = G\frac{V_0}{2}$$

Where G is the inverter gain,
G=BM

It can be seen that has same form with that of the traditional VSI, i.e.

$$\hat{V}_{out} = M\frac{V_0}{2}$$

Where boost factor is obtain by introducing shoot through of minimally one pare of the inverter arm for a short period of time which called Shoot-through time.

$$B = \frac{T1}{(T1-T0)} = \frac{1}{(1-2T0/T1)} = \frac{1}{1-2D_0}$$

Where: T0 = Shoot Through Time
T = Switching Period
D_0 = Shoot through Duty Ratio

In the simple boost control method, the modulation index (M) and the shoot-through duty ratio (Do) are interdependence each other. The relation between these two parameters is expressed above. We can see from the equation that shoot-through duty ratio (Do) decreases with increasing modulation index (M).

$$D_0 = 1-M$$

$$G = BM = \frac{M}{1-2D_0}$$

Since D_0 = 1-M, thus

$$G = \frac{M}{1-2D_0} = \frac{M}{1-2(1-M)} = \frac{M}{2M-1}$$

Infers that the inverter gain (G) can be controlled by adjusting modulation index (M). If we rearrange (1) in the original PWM output voltage equation form, we get

$$\hat{V}_{out} = BM\frac{V_0}{2}$$

BV_0 should be the input voltage of the traditional VSI which in the case of Z-source is the voltage applied to inverter bridge.

Say

$$BV_o = V_{in}v$$

It can be from Fig. That $V_{in}v$ is the voltage stress of the inverter's devices.

III. Control Circuit Block Diagram for Simple Boost Control Method

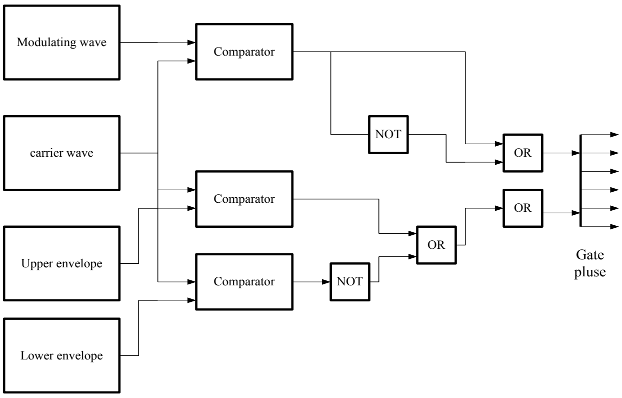

Fig. 3: Control circuit of SBC method in Matlab/Simulink

IV. Simulation of Z-Source Inverter with SBC Method

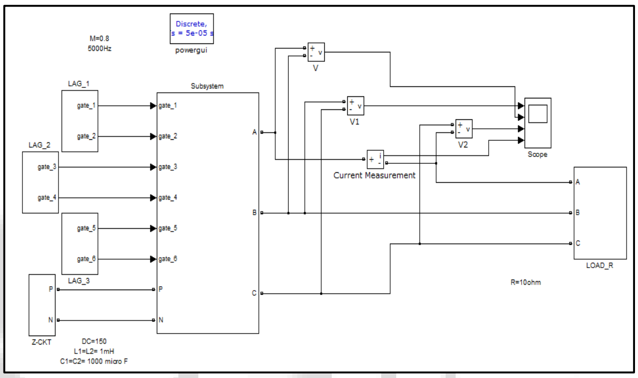
Fig. 4: Power Circuit of 3 Phase Inverter

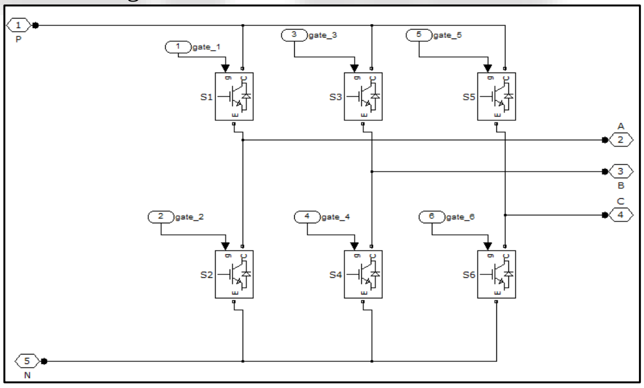
Fig. 5: Subsystem of Three phase Inverter

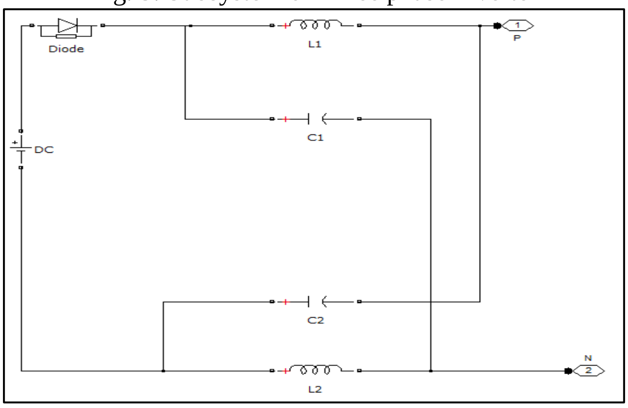

Fig. 6: Subsystem of Impedance Source

V. SIMULATION RESULT

A. *Waveform of Line to Line Voltage*

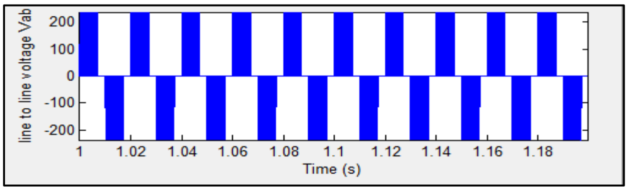

Fig. 7: Line to Line Voltage Waveform

B. *Waveform of Line to Line current*

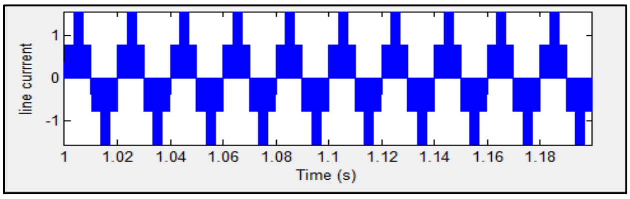

Fig. 8: Line to Line Current Waveform

C. *Waveform of Phase Voltage*

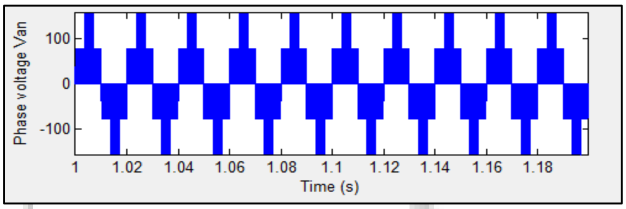

Fig. 9: Phase Voltage Waveform

Waveform & THD Analysis for R-Load without filter.
R = 100 Ohm with SBC method

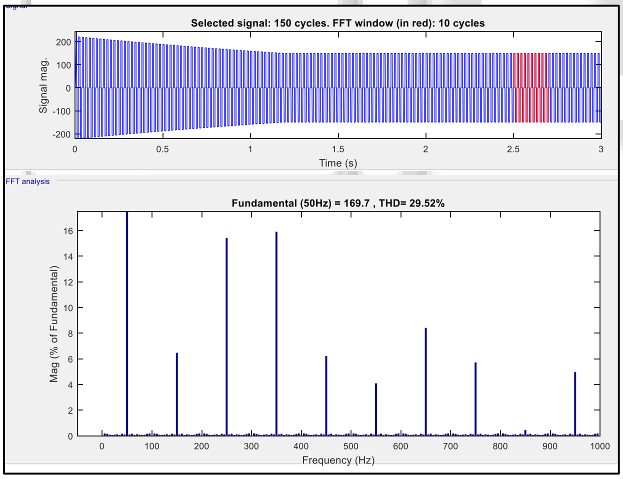

Fig. 10: THD of Line to Line Voltage Vab

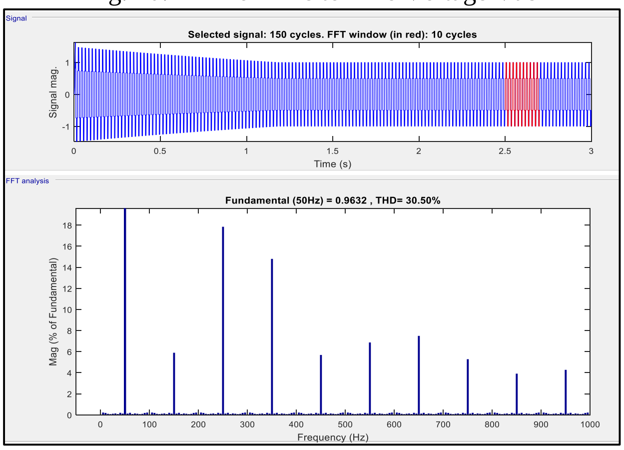

Fig. 11: THD of Line Current

VI. CONCLUSION

The simulation is done in MATLAB and waveforms are verified according to it. The simple boost control method is used to overcome the THD losses. Traditional losses are reduce in ZSI because there is no need of any filter circuit. The ZSI contain two identical inductors and capacitors which acts as impedance source as well as filter circuit.

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