

Implementation of Z-source Inverter using MATLAB Simulation

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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 source 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.

Keywords: - Matlab, z source inverter, sbc method, maximum boost control method

INTRODUCTION

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.

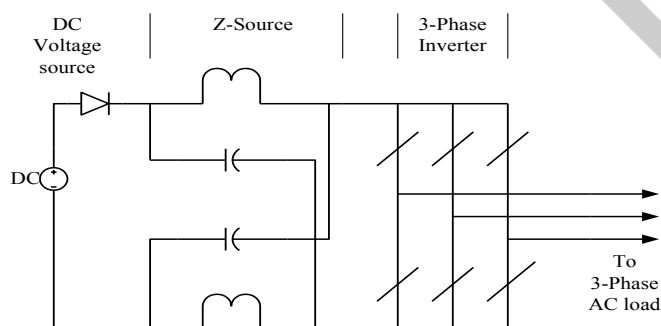


Figure 1 structure of the Z-source converter

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.

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 method 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

I. 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.

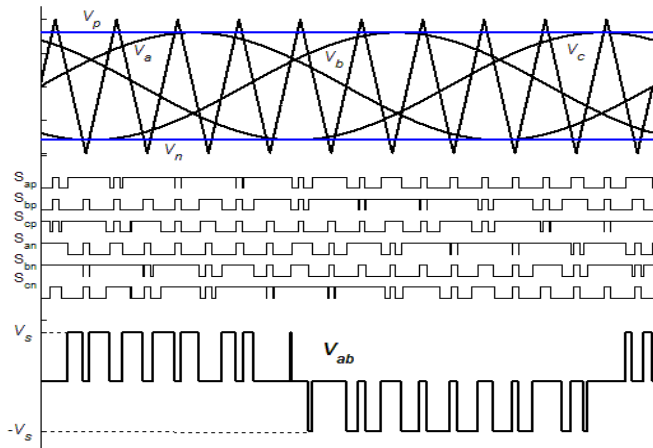


Figure 2 Simple Boost Control method

In 3-phase Z-source inverter, one additional parameter is introduced, 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 obtained by introducing shoot through of minimally one pair of the inverter arm for a short period of time which is called Shoot-through time.

$$B = \frac{T_1}{(T_1 - T_0)} = \frac{1}{(1 - 2T_0/T_1)} = \frac{1}{1 - 2D_0}$$

Where: T0 = Shoot Through Time

T = Switching Period

D0 = Shoot through Duty Ratio

In the simple boost control method, the modulation index (M) and the shoot-through duty ratio (D0) are interdependent each other. The relation between these two parameters is expressed above. We can see from the equation that shoot-through duty ratio (D0) 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

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

BV0 should be the input voltage of the traditional VSI which in the case of Z-source is the voltage applied to inverter bridge.

Say

$$BV_0 = V_{inv}$$

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

II. CONTROL CIRCUIT BLOCK DIAGRAM FOR SIMPLE BOOST CONTROL METHOD

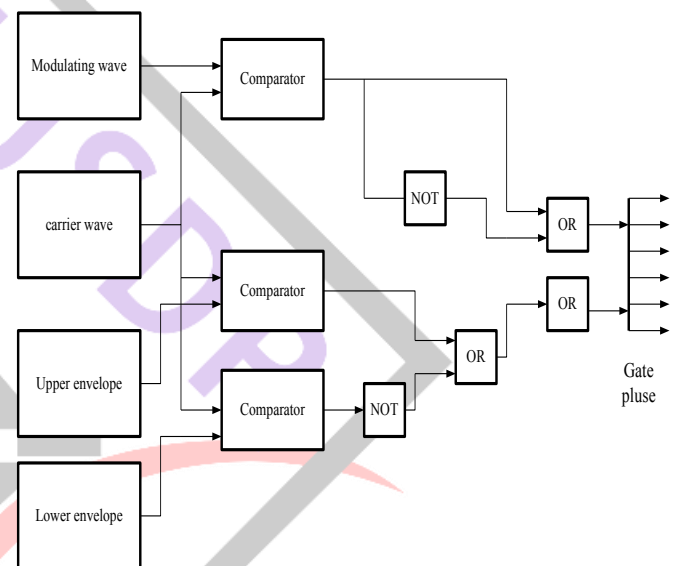


Figure 3 Control circuit of SBC method in Matlab/Simulink

1) Simulation of Z-source inverter with SBC method:

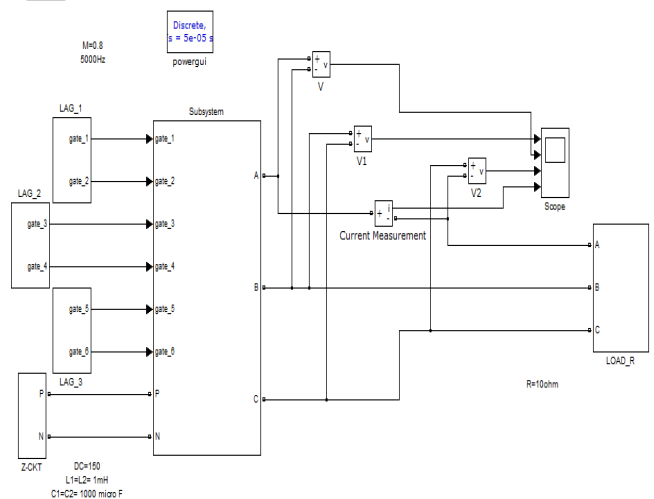


Figure 4 Power Circuit of 3 Phase Inverter

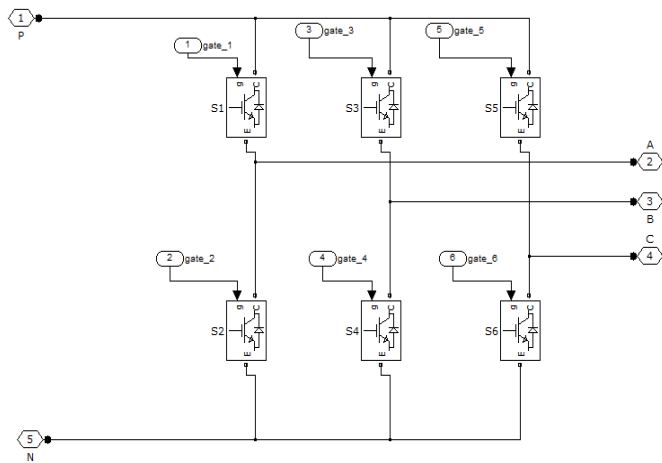


Figure 5 Subsystem of Three phase Inverter

Waveform of Phase Voltage

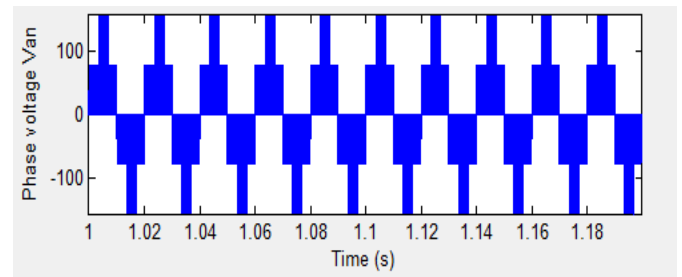


Figure 9 Phase Voltage Waveform

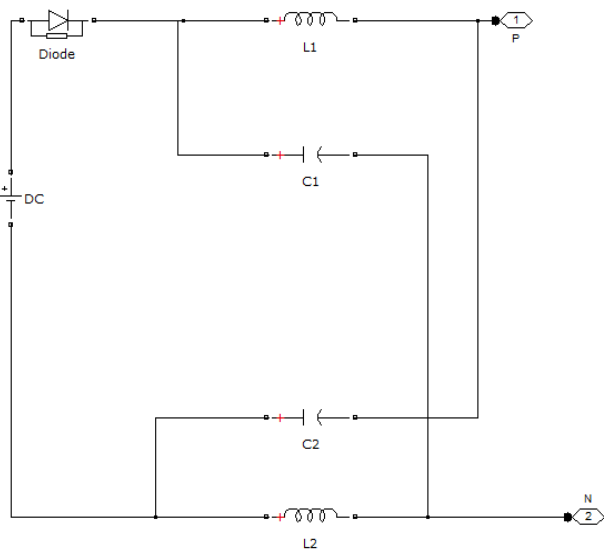
Waveform & THD Analysis for R-Load without filter.
R = 100 Ohm with SBC method

Figure 6 Subsystem of Impedance Source

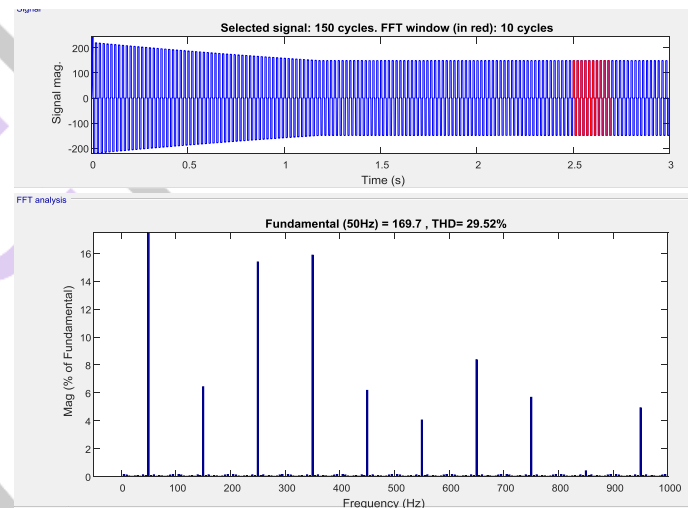


Figure 10 THD of Line to Line Voltage Vab

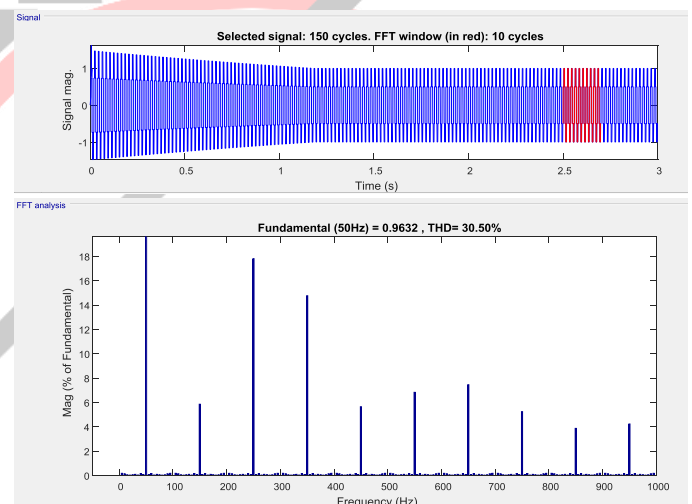


Figure 11 THD of Line Current

Waveform of Line to Line Voltage.

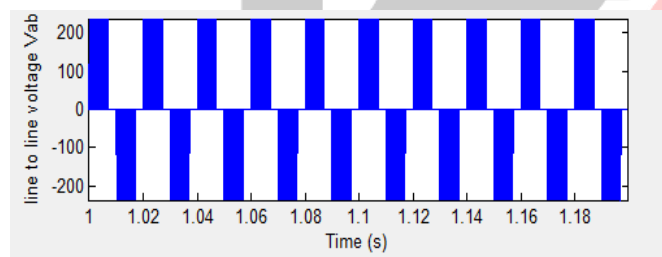


Figure 7 Line to Line Voltage Waveform

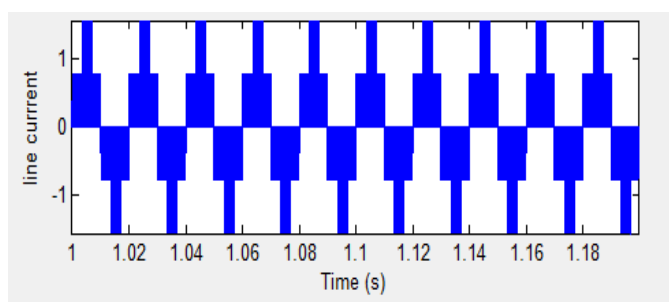


Figure 8 Line to Line Current Waveform

III. MAXIMUM CONSTANT BOOST CONTROL METHOD

Implementation block diagram of MCBC is shown in Fig. with such feature. There are five modulation curves in this control method: three reference signals, V_a , V_b , and V_c , and two shoot through envelope signals, V_p and V_n . When the carrier triangle wave is greater than the upper shoot-through envelope, V_p , or lower than the lower shoot-through envelope, V_n , the inverter is turned to a shoot-through zero state. In

between, the inverter switches in the same way as in traditional carrier-based PWM control.

In order to reduce the volume and cost, it is important always to keep the shoot-through duty ratio constant. At the same time, a greater voltage boost for any given modulation index is desired to reduce the voltage stress across the switches for that MCBC control method.

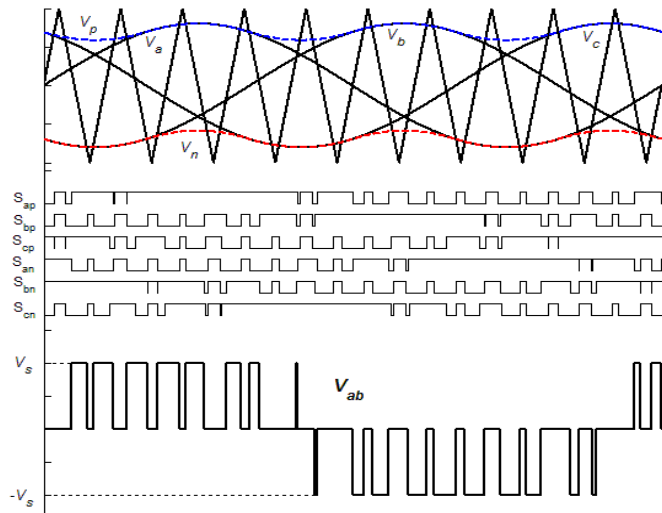


Figure 12 Maximum constant boost control method

1) Maximum Boost Control Method Simulation Circuit

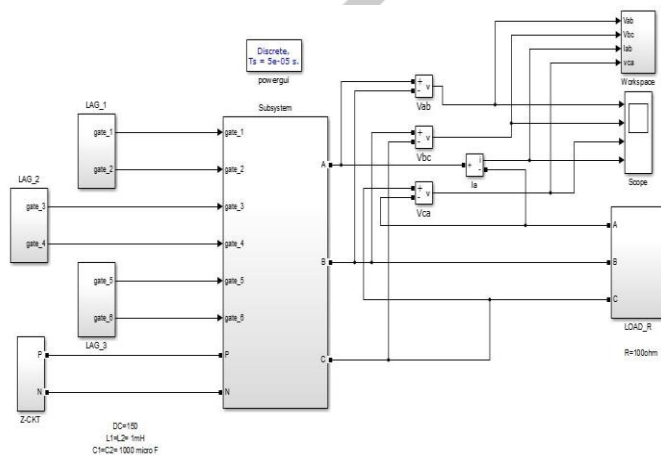


Figure 13 Simulation circuit of Maximum Boost Control Method

Table 1 OUTPUT DATA FOR MBCM

MAXIMUM BOOST CONTROL METHOD			
Name of output	49.5Hz	50Hz	50.5Hz
Vab	35.60%	31.31%	29.39%
Vbc	35.50%	34.48%	34.07%
Vca	32.88%	30.61%	30.97%
Iab	33.87%	29.80%	28.93%

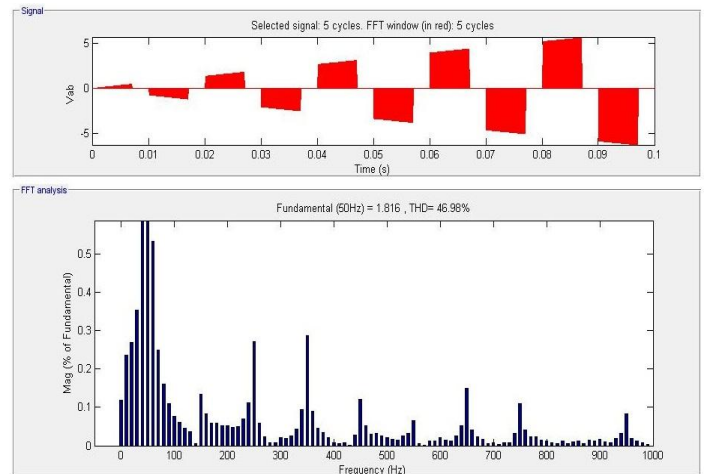


Figure 14 FFT analysis of Line to line voltage (Vab)

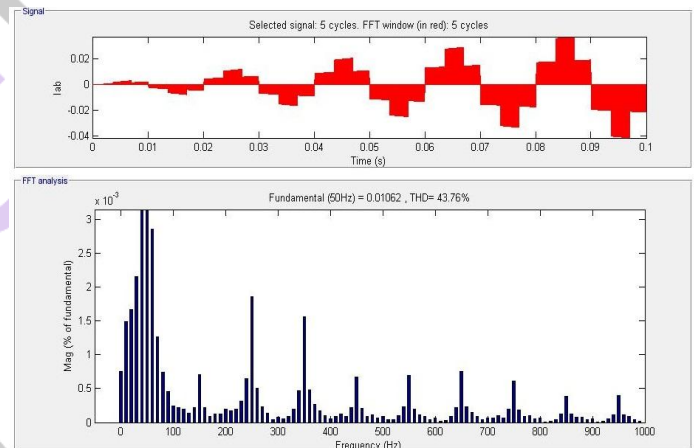


Figure 15 FFT Analysis of Line current (Iab)

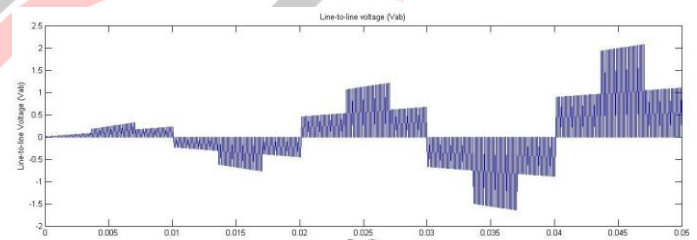


Figure 16 Line To Line Voltage (Vab) Waveforms

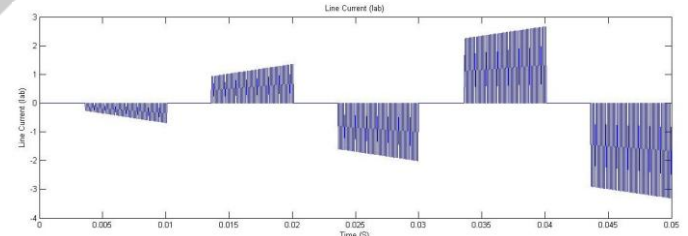


Figure 17 Line Current (Iab) Wave Forms

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