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L-Z Source Based 11 Level Diode-Clamped Multi Level Inverter

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ABSTRACT

Multilevel inverters (MLI) have the capability of producing less distorted ac voltages across its output terminals. The output available across any MLI is a stepped sine wave. Among the available configurations diode clamped topology has the ability of providing reverse recovery ability for the switches. So in this project a new converter topology based on Z-Source configuration combined with a diode clamped multilevel is proposed. Usually classical Z-Source inverters contain a diode, capacitors and inductors for boosting the voltage. The Z-Source inverters suffer with inrush currents and resonance. The disadvantages of these capacitors are eliminated with the help of a new circuit comprising of inductors and diodes. The Z-Source of the network contains only inductors. The Z-Source acts like a current source and is cascaded with a diode clamped multilevel inverter. The main advantage of this configuration is that size of the filter is minimized and has the ability of producing least distortion in output current when the system is operated with lagging power factor loads. The proposed circuit is modeled and simulated using MATLAB/ SIMULINK.

KEYWORDS: *L-Z-Source,Inrush Currents, resonance, Capacitors and inductors, multilevel inverter.*

1. INTRODUCTION

There exist two traditional converters: voltage source (VSI) and current source (CSI). Fig.1 shows the traditional single-phase voltage-source converter (abbreviated as V-Source converter) structure. A dc voltage source supported by a relatively large capacitor feeds the main converter circuit, to a single-phase circuit. The dc voltage source can be a battery, fuel-cell stack, diode rectifier, and/or capacitor. Four switches are used in the main circuit; each is traditionally composed of a power transistor and an antiparallel diode to provide bidirectional current flow and unidirectional Voltage, blocking capability. The V-source converter is widely used.

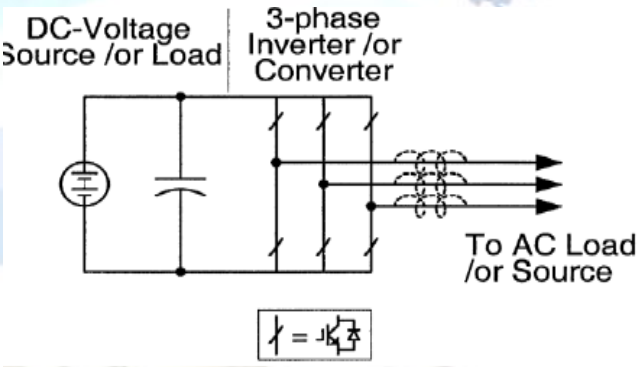

Figure-1 Traditional Voltage Source Inverter

It has the following conceptual and theoretical drawbacks.

- The AC output voltage is limited below and cannot exceed the DC input voltage.
- External equipment is needed to boost up the voltage, which increases the cost and lowers the overall system efficiency.
- There is a possibility for the occurrence of short through which destroys the device.

The ZSIs accomplish a single-stage power conversion with buck-boost capabilities. In ZSIs, both of the power switches in a leg can be turned on at the same time and thereby eliminate the dead time. This significantly improves the reliability and reduces the output waveform distortion. Fig 2 shows shows the classical ZSI in which the two-port impedance network couples the main inverter circuit to the dc source. In order to overcome the shortcomings of the classical ZSI, the quasi-ZSI (qZSI) shown in Fig. 2(b) and SL-ZSI shown in Fig. 2(c) were developed.

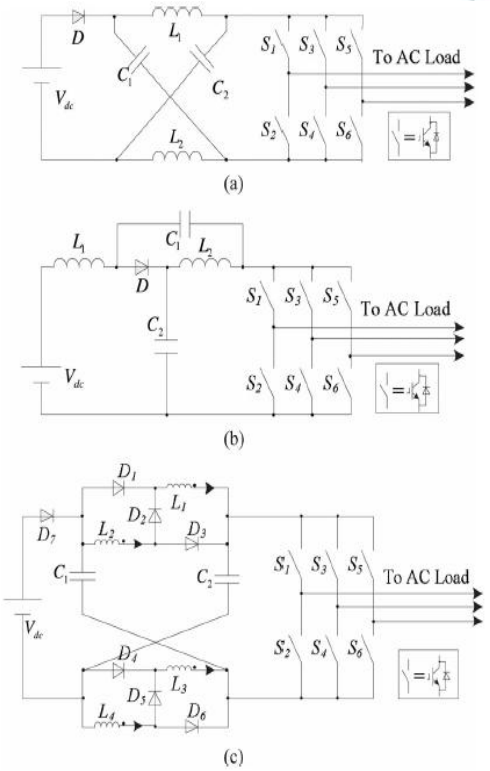

Fig 2- Z source topologies(a)classical ZSI(b)quasi-ZSI(c)SL-ZSI

The Z-Source inverters suffer with inrush currents and resonance. The disadvantages of these capacitors are eliminated with the help of a new circuit comprising of inductors and diodes. The Z-Source of the network contains only inductors. The Z-Source acts like a current source and is cascaded with a diode clamped multilevel inverter.

2. L-Z Source Inverter

Different to the original ZSI, the proposed inverter has nocapacitor, and is composed of two inductors (*L*1, *L*2 , and *L*1 = *L*2), and three diodes (*D*1,*D*2 , and*D*3), as shown in Fig. 3. The combination of *L*2 – *L*3 – *D*1 – *D*2 – *D*3 acts as a switched inductor cell. The proposed topology provides inrush current suppression, unlike the traditional topologies, because no current flows to the main circuit at startup. The proposed topology also provides a common ground for the source and inverter.

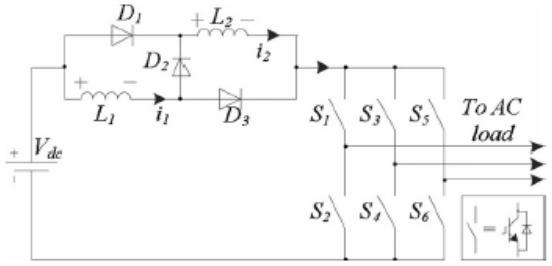

Fig 3-L-ZSI with two inductors

2.1 Operating States:

Operation of L-ZSI takes place in n two states

- shoot through states
- Non shoot through states

Fig 4 shows L-ZSI with n inductors

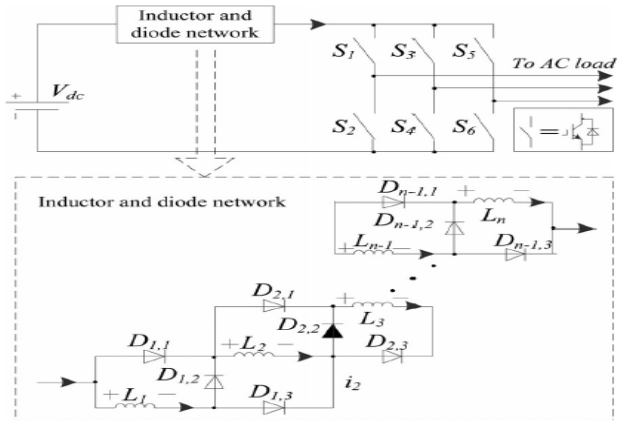

Fig 4 –L-ZSI with n inductors

2.1.1 Shoot –through state:

In the shoot-through state, inverter side is shorted by both the upper and lower switching devices of any phase leg. During the shoot through state, D1,2,D2,2, . . . , Dn−1,2 and Dn,2areoff,whileD1,1,D1,3,D2,1,D2,3,.Dn−1,Dn−1 ,3,Dn,1 andDn,3 are on. L1, L2 , . . ., Ln−1 and Ln are connected in parallel, inductors L1, L2, . . . , Ln−1 and Ln store energy. Equivalent circuit is shown in figure 5(a).

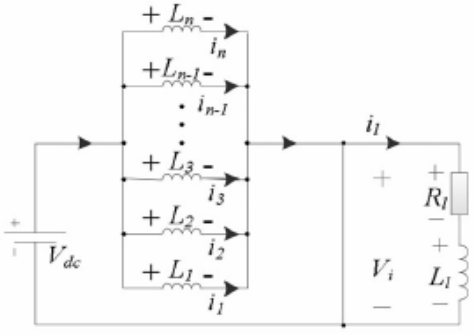

Fig-5(a)operation of L-ZSI with n inductors in shoot through state

2.1.2 Non-Shoot through state:

In the non-shoot-through state, D1,2 ,D2,2, ..Dn−1,2 , and Dn,2 are on, while D1,1,D1,3,D2,1 ,D2,3, . .Dn−1,1,Dn−1,3,Dn,1 , and Dn,3 are off. L1, L2 , . . ., Ln−1 , and Ln are connected in series. L1, L2 , . . ., Ln−1 , and Ln transfer energy from the dc voltage source to the main circuit. Equivalent circuit is shown in fig -5(b)

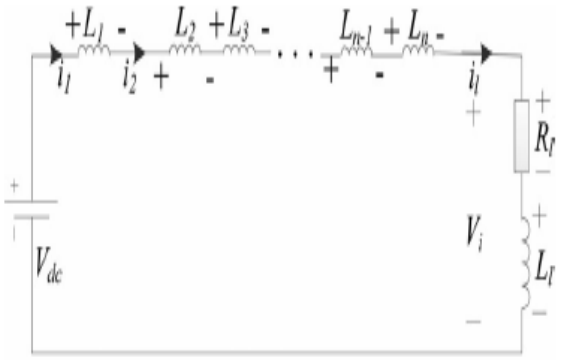

Fig-5(b)operation of L-ZSI with n inductors in non shoot through state

3. Diode Clamped Inverter

There are several drawbacks of two level inverter in which the switching devices have limited ratings .So that these cannot used effectively in high power and high voltage applications. And also at high switching frequencies these two level inverter has high switching losses that leads to decrease in the efficiency. If we consider the Multilevel Inverters, These are suitable for high voltage and high power applications. Because the switching device voltage stresses are controlled. And increasing the number of voltage levels in the inverter without requiring higher ratings on individual devices can increase the power rating. As the number of voltage levels increases the harmonic content of the output voltage waveform decreases significantly.

3.1 Structure and basic operating principle

Consists of series connected capacitors that divide DC bus voltage into a set of capacitor voltages A DCMI with n number of levels typically comprises (n-1) capacitors on the DC bus Voltage across each capacitor is $V_{DC}/(n-1)$ and no of switches per leg is 2(n-1) From the figure we can see the main purpose of the capacitor is to split the dc source into equal voltages and they act as energy sources for the inverter .The number of capacitors require for 11- level (m-level) inverter is 11-1=10 i.e. (m-1) . The number of switching devices per leg is 2 (m-1) i.e. 20 for eleven levels.

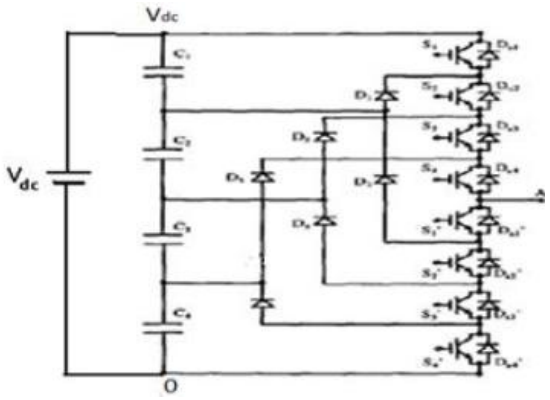

Fig-6 Diode-Clamped inverter of five level

4. Circuit Configuration

Fig.7 shows a proposed system consisting of a L-Z source with n=4 and 11 level diode clamped inverter and LC filter connected to load and filter used here is LC filter

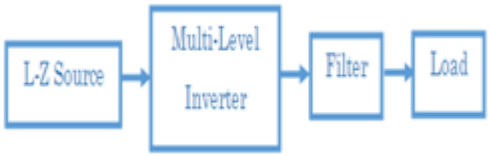

Figure 7: Circuit configuration of L-Z source based 11 level diode-clamped inverter

5. Helpful Hints

Model schematic of LZ Source based diode clamped multilevel inverter is shown in figure 6. The multilevel inverter is controlled with sinusoidal pulse width modulation. The proposed circuit is simulated for different kinds of load. The voltage available at the output terminals of LZ Source is given in fig. Voltage available across the load terminals and current through the load are presented in figure and total harmonic distortion in the output voltage and current for a load resistance of 100 Ohm and inductance of 1 mh are shown in fig respectively.

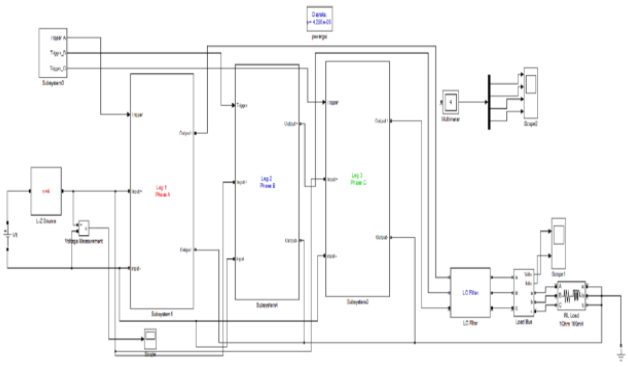

Figure 8: Simulation model of L-Z source 11 level diode-clamped inverter

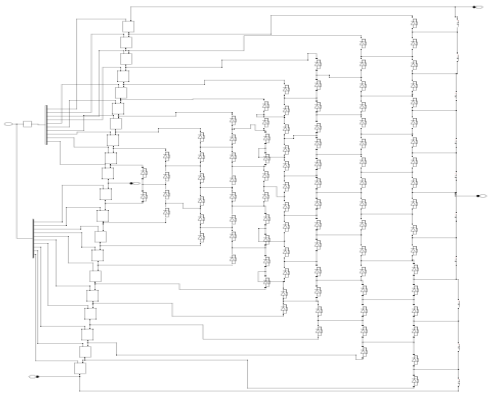

Figure 9: Simulation model of 11 level diode-clamped inverter

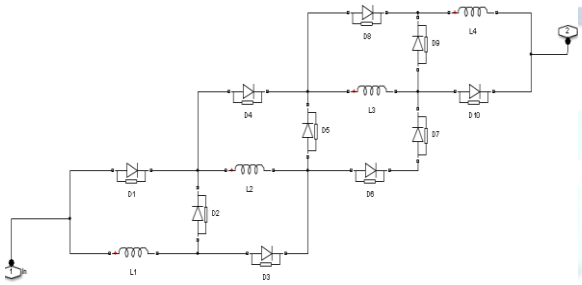

Figure 10: Simulation model of L-Z source with n=4

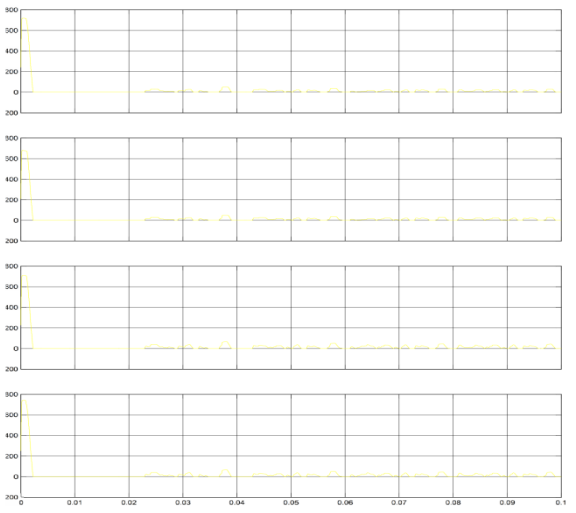

Figure 11: Current through inductors of L-Z source inverter

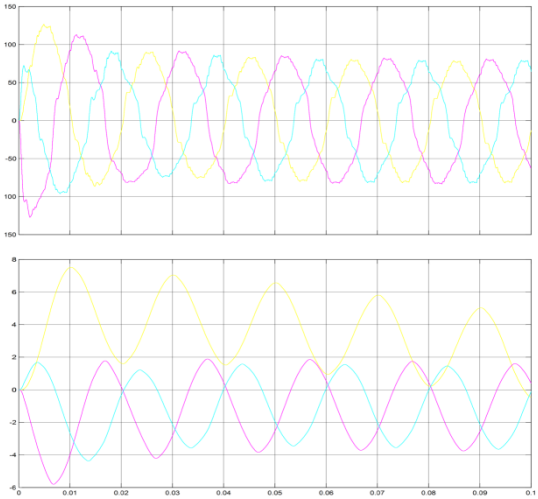

Figure 12: Voltage across load and Current through load for Load with 0.9 pf lagging.

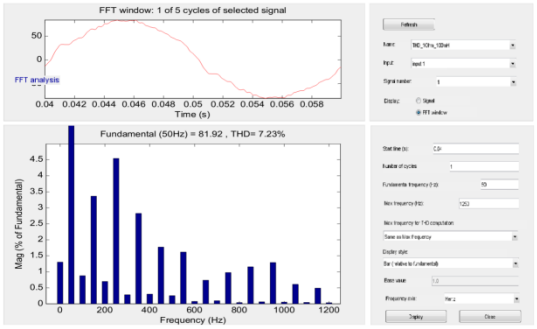

Figure 13 : THD of output load voltage using FFT Analysis tool

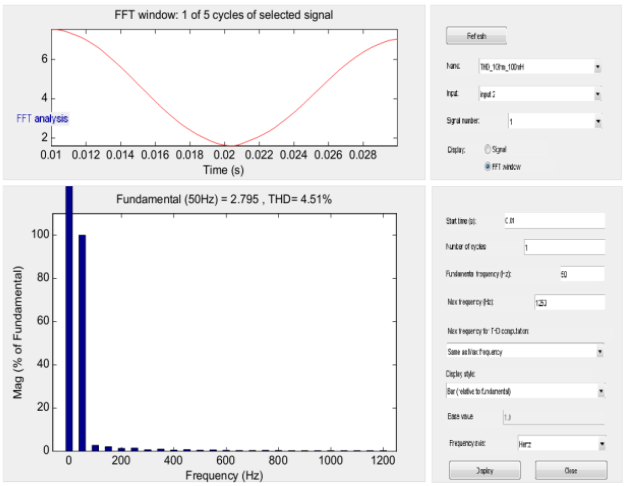

Figure 14: THD of load current using FFT Analysis tool

6. Conclusion

Z Source inverters operate as current source inverters. To enhance the current carrying ability of inverters the z source is replaced with LZ source. This LZ Source is coupled to a 11 level diode clamped inverter. It has been observed that the multilevel level inverters will give better quality output in terms of total harmonic distortion, less distorted The switches that are used in LZ Source are subjected to less voltage stress and a uniform dc voltage is available across the output terminals of LZ source..By connecting a filter across the output terminals the distortion in output voltage and current further reduced and give more sinusoidal voltages and currents.

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