A REVIEW ON VARIOUS Z-SOURCE FED MULTILEVEL INVERTER

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ABSTRACT

Multilevel inverter created a new evolution of newer topologies. Some of the recently proposed multilevel inverter topologies with reduce power switch count are reviewed and analysed. This paper will expose the idea of qualitative and quantitative parameter of multilevel inverter. Then this paper will share creation and an updating of various Topologies. Based on a detailed comparison of these topologies as presented in this paper, with multilevel solution can be arrived at for a given application.

***Keywords*: Quasi Z Source Inverter, Switched Inductor Z Source Inverter, Transformer Z Source Inverter, Z Source Inverter.**

I. INTRODUCTION

Uninterruptible power generation only can able to satisfy the need of powers. It's only possible to do to by multilevel inverters with various input sources (battery, fuel, photovoltaic array…).DC to AC Current/Voltage conversion is a key technology in the modern set up generation, transmission, distribution and utilization of electric energy .Based on the types of output waveform only decided the inverters type. That is square wave inverters, quasi square wave inverters, conventional PWM inverters and multilevel inverters.

The unique structure of multilevel voltage sources inverters allow them to reach high voltages with low harmonic distortion without the use of transformer (or) series connected synchronized switching devices. As the number of voltage levels increases, the harmonic content of output voltage waveform decreases significantly. Using multilevel inverters application in fuel cell, solar cell and wind turbine is increasing now a day's rapidly. Therefore, Harmonic reduction techniques in multilevel inverters are considered very important task.

II. MULTILEVEL INVERTERS

One of the most promising power electronics converter is multilevel inverters. Some industrial application of inverters are for adjustable speed AC Drives, induction heating, stand by air-craft power supplies, UPS for computers, HVDC transmission line etc., suppose the DC power input to the inverter is obtained from an existing power supply Network (or) from a rotating alternator through a rectifier (or) a battery, fuel cells , photovoltaic array (or) magneto Hydro Dynamic generator(MHD).In this regard the conversion takes place that is AC to DC conversion and DC to AC inversion is called a DC-link converter. This DC link Converters with interesting properties such as buck-boost characteristics and single stage conversion, which improves the inverter reliability and enlarges its application fields.

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Some Basic Requirements of a good multilevel inverters are enumerated.

[1] Its output voltage waveform should be sinusoidal.

[2] Its gain should be high.

[3] Its output voltage and frequency should be controllable in the desired usage.

[4] The power required by its controlling circuit should be minimum.

[5] The semiconductor devices used in the inverter should have minimum switching and conduction losses.

[6] Its working life must be long.

[7] The size of the filter required should be small.

The Disadvantage of multilevel configurations over the two level inverter configuration are the increase in the number of power devices required and the circuit complexity, which necessitates complex control schemes that add to the cost and reduces the reliability of the converter. This may lead the overall system to be more complex. Therefore in practical implementation reducing the number of switches and gate driver circuits is very important. But the reduced component inverters can perform only buck, boost (or) buck boost capability with the additionally introduced DC-DC conversion. Then there came a emerging topology in power electronics which perform buck – boost and DC –AC conversion in a single stage. The main feature of multilevel inverter is ability to reduce the voltage stress on each power device. Due to the utilization of multiple purpose applications. This paper will investigates and analyses sources with Z source, QZSI, SL Z source and T source.

III. Z-SOURCE INVERTER

More generation resources are required to handle the rapid increase in the energy demand in present year. The renewable energy resources such as fuel cells, photovoltaic and wind are gaining great importance because of environmental concern and limited fossil fuel resources. Recent days inverters are designed with reduced active semiconductor devices with the point of view for industrial application found increased reliability and lower cost due to reduced complex control circuitries and gating's. This requirement should be satisfied by emerging topology in power electronics. Therefore Z source topology has drawn a lot of attention.

The Z source inverter (ZSI) is a single stage buck boost conversion system uses a unique LC network. Z source is a composition of two capacitors and two inductors in arrangement of X model is employed to provide impedance that is called Z source inverter. The ZSI have drawn tremendous interest in the shoot through state to boost the input voltage, which improves the inverter reliability and expands its application fields. Z source inverter performance was analysed with induction motor.

The traditional inverter based induction motor drive system consists of a front end three phase diode rectifier, DC link LC filter and three phase inverter bridge.it has some common limitations and problems. This problem was overcome by Z source inverter. Presence of Z network highly enhances the reliability of the inverter since the shoot through can no longer destroy the inverter.

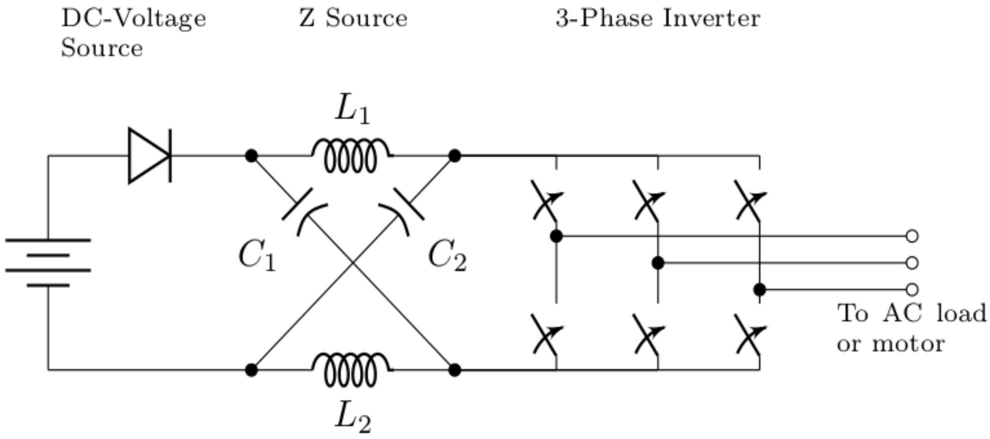

Fig 1: Z- Source Inverter

The Z source inverter fed induction motor power circuit consists of four major parts a front end diode rectifier, Z network an inverter bridge and a three phase induction motor . The differences are that a DC link circuit is implemented by the Z source network (C_1, C_2, L_1 and L_2). Small range of input capacitors also serves as a DC source feeding the Z source network and are used to the suppress voltage surge that may occur due to the line inductance during diode commutation and shoot through mode of inverter , thus requiring a small value of capacitance. These changes can easily be realized and implemented from the traditional inverter fed induction motor.

Since the Z source inverter bridge could boost the DC link capacitor voltage to any desired value that is above the average DC value of the rectifier, a desired output voltage is always obtainable regardless of the line voltage (Olszewski 2005). A conventional PWM inverter is always operating at modulation index of 1, the DC-DC boost PWM converter boosts the DC voltage to a desired level since the inverter always operates with modulation index of 1; the Z-source inverter outputs a maximum obtainable voltage while keeping the device voltage under a given value. With these assumptions, an obtainable motor phase voltage and current for various loads are shown in Table1. A conventional PWM inverter is always operating at modulation index of 1, the DC-DC boost PWM converter boosts the DC voltage to a desired level since the inverter always operates with modulation index of 1; the Z-source inverter outputs a maximum obtainable voltage while keeping the device voltage under a given value. With these assumptions, an obtainable motor phase voltage and current for various loads are shown in Table1.

It can be seen that, for low and medium power applications, Z-source inverter based operation provides better motor phase voltages and it ensures the wide range of operation of the drive for the same input DC voltage. Depending upon the time period of the shoot-through in one switching cycle, the DC link voltage of the inverter could be increased or reduced as required by the application (Chen et al 2007).

Table 1. Illustrate The Advantages of The Z-Source Inverter Based System Over Traditional Power Conversion Topologies For Induction Motor Drives

Power rating of the motor		**10 KW**	**20 KW**	**30 KW**	**40 KW**	**50 KW**
DC supply voltage (V)		340	325	305	280	250
Motor phase voltage (V)	Conventional PWM inverter	120.2	117.9	107.8	99	88.4
	DC-DC boost+ PWM inverter	148.5	148.5	148.5	148.5	148.5
	Z-source inverter	155.2	152.1	148	142.9	136.8
Motor current (A)	Conventional PWM inverter	39.7	77.3	115.9	158.5	209.4
	DC-DC boost+ PWM inverter	32.1	59.9	84.2	105.6	124.7
	Z-source inverter	29.6	56.2	81.1	105.3	129.5

IV. QUASI Z-SOURCE INVERTER

The Quasi Z source inverter as an alternative to power conversion method as it can both buck and boost the input voltages. ZSI have some drawbacks it's avoided by a new topology known as quasi ZSI. The traditional QZSI has two types of operational states at the DC side.

(1)Non shoot through state: The inverter bridge viewed from the DC side is equivalent to current source.

(2)Shoot through state: Forbidden in the traditional VSI.

Due to this two state may cause a short circuit of the voltage source and damage the devices. This QZSI protects from the shoot through state by boost the DC link voltage. The main difference between ZSI and QZSI are QZSI draws a continuous DC current from the sources.

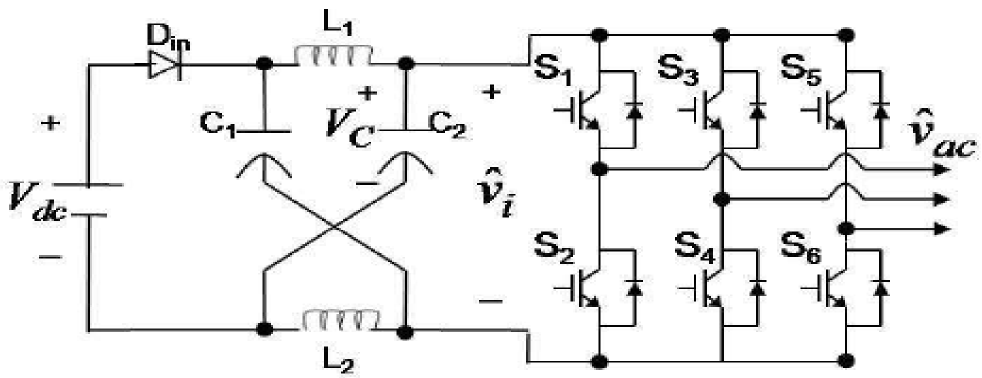

Fig 2: Quasi Z- Source Inverter.

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V. SWITCHED INDUCTOR Z - SOURCE INVERTER

The SL-Z source inverter has the features of minimizing the voltage Stress across the capacitors and switches. SL –ZSI consisting of two tremendous operational states.

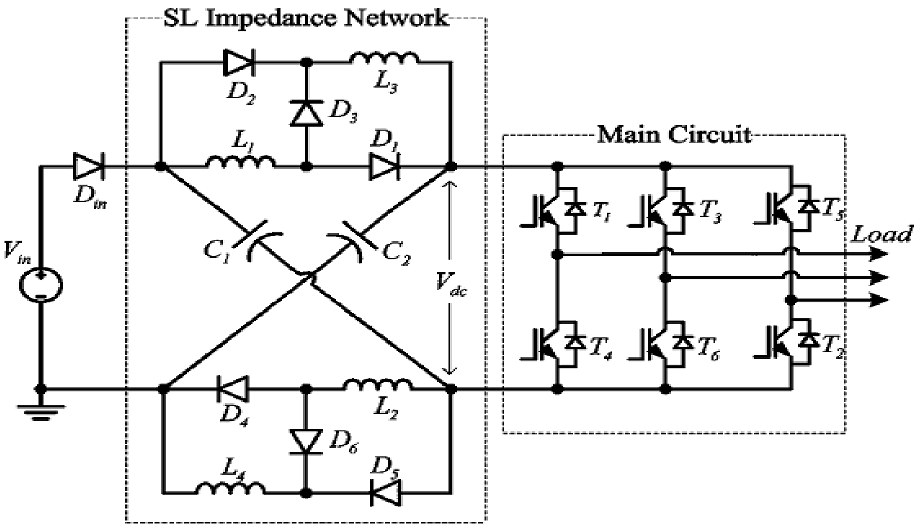

Fig 3: Switched Inductor Z- Source Inverter.

(1) Shoot through state: If switch S is ON condition, the various diodes are D_{in}, D_1, D_2, D_3 , D_4, D_5 and D_6 are represents in Table NO:2 Then frequently D_1 and D_2 are turned ON the L_1 and L_3 are charged and D_3 is turned OFF. On the next arm when the diodes D_4 and D_5 are turned ON the L_2 and L_4 are charged and D_6 is turned OFF. In this mode the relative voltage should be represented by equation

$$\mathbf{V_{in} + V_c - V_L = 0}$$

(2) Non Shoot through state: If switch S is OFF condition,the various diodes are D_{in},D_1,D_2,D_3,D_4,D_5 and D_6 are represents in Table No:2 Then frequently D_1 and D_2 are turned OFF and D_3 is turned ON, this makes L_1 and L_3 to be joined in series. On the other arm when the diodes D_4 and D_5 are turned ON and D_6 is turned OFF the L_2 and L_4 are connected in series. In this mode D_{in} remains Turned ON. At present the relative voltage should be determine by the principle of volt second balance equation

$$\mathbf{-V_c-2V_L = 0, \qquad V_{in} - V_{dc} - V_L + V_c - V_L = 0}$$

TABLE 2: SWITCH(S) POSITION TABLE.

S	D_{in}	D_1	D_2	D_3	D_4	D_5	D_6
ON	OFF	ON	ON	OFF	ON	ON	OFF
OFF	ON	OFF	OFF	ON	OFF	OFF	ON

Assumptions

1) Improved SL Z-Source operates in CCM (continuous conduction mode)

2) All components are assumed ideal & $L_1 = L_2 = L_3 = L$; $C_1 = C_2 = C$.

3) Because of the symmetry of the inductors & capacitors $V_{C1} = V_{C2} = V_C$, $V_{L1} = V_{L2} = V_{L3} = V_{L4} = V_L$.

VI. TRANSFORMER Z- SOURCE INVERTER

TZSI is the resemblance of Z source inverter except the use of high frequency, low leakage inductance transformer and one capacitance. Comparatively, it has low reactive components with conventional ZSI. This is the reason to efficiency is appreciably increases. The TZSI topology requires a very low leakage inductance transformer with high precision. So number of passive elements reduced, that's only the transformer and capacitor are needed. As compare with quasi ZSI, the TZSI topology features a common DC rail between the source and inverter, which is unlike traditional ZSI circuits. 1:1 transformer ratio allows for a change of output voltage, Z source converter as contrasted with the voltage resulting from the shoot through index.

The Trans Z- source inverters has features such as DC input source & reduced capacitor counts. The Trans Z-source inverters can be obtained from either voltage /current fed Z- source inverters. It's having unique advantages i.e., increased voltage gain &reduced voltage stress. In the voltage fed quasi Z-source inverter with continuous input current two dc inductors can be separated or coupled.

When the two inductors are coupled the voltage across the inductor L_1 is reflected to the inductor L_2 through magnetic coupling. Then one of the two capacitors for instance C_2, can be removed from the circuit. The rearrangement of the circuit yields the structures fig.4 furthermore the voltage across L_2 can be made proportional to the voltage across L_1 by changing the turns ratio n_2 / n_1. As the voltage constraint associated with one of the capacitor is released the two windings, to some extent, behave more like fly back transformer rather than the original coupled inductors except that the current flows simultaneously through both windings in some operations states. Therefore it is named as the voltage fed trans quasi Z source inverter and the expanded motoring operation range in the current trans quasi Z source inverters when the turns ration of the transformer winding is over1.

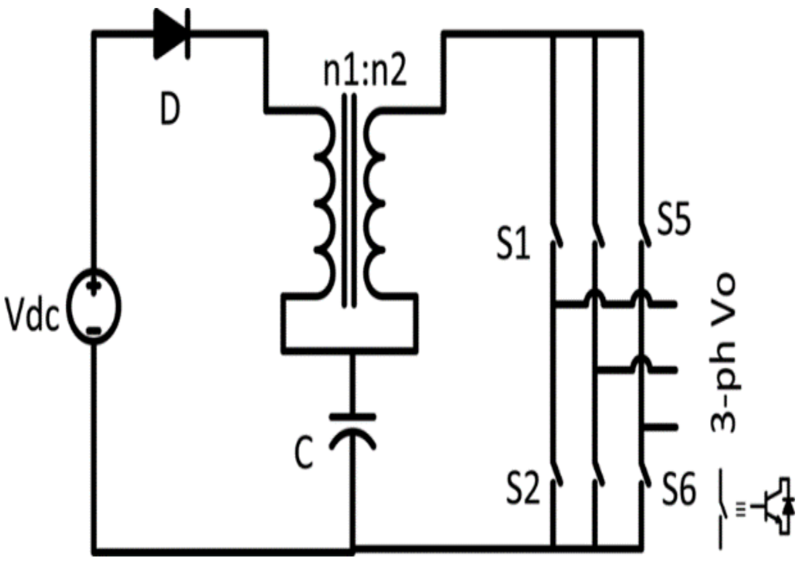

Fig 4: Transformer based Z- Source Inverter.

It is similar to Z source except the use of high frequency low leakage inductance transformer and one capacitance .It has low reactive components in compare with conventional ZSI. Due to this the efficiency is appreciably increases. The T-ZSI topology requires a very low leakage inductance transformer which should be made with high precision. In such a way number of passive elements is reduced because only the transformer and the capacitor are needed.as compare with quasi ZSI, the TZSI topology features a common dc rail between the source & inverter with traditional ZSI circuits moreover use of a transformer with other than a 1:1 transformer ratio allows for a change of D/P voltage Z source converters as contrasted with the voltage resulting from the shoot through index or the modulation index.

Table.3 The Characteristics Of Different ZSI Topologies.

	ZSI	QZSI	SL-ZSI	TSI/TRANS-ZSI
Number of elements	Two inductors Two capacitors One diode	Two inductors Two capacitors One diode	Four inductors Two capacitors Seven diodes	One transformer One capacitor One diode
Continuous input current	No	Yes	No	No
Start up inrush current	Yes	No	Yes	Yes
Common earthing	No	Yes	No	Yes
Boost factor	(1/1- 2Do) 0 ≤ D0 ≤ 0.5	(1/1- 2Do) 0 ≤ D0 ≤ 0.5	(1+Do/1-3Do) 0 ≤ D0 ≤ 1/3	(1/1-(n+1)Do) 0 ≤ D0 ≤ (n+1) n is transformer ratio

VII. CONCLUSION

This article presented an intensive overview of the ZSI's different topology improvements and different arrangements. However, this study is limited to voltage-type dc/ac ZSI configuration to present more comparative details. This overview with help power electronics researchers and engineers to understand and identify the pros and cons of each topology and choose the most suitable one for their applications.

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