

## Z Source Inverter Topologies-A Survey

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### Abstract

*Need for alternative energy sources to satisfy the rising demand in energy consumption elicited the research in the area of power converters/inverters. An increasing interest of using Z source inverter/converter in power generation involving renewable energy sources like wind and solar energy for both off grid and grid tied schemes were originated from 2003. This paper surveys the literature of Z source inverters/converter topologies that were developed over the years.*

**Keywords:** Z source converter/inverter, topology modifications, voltage boosting

### 1. Introduction

Ever since the evolution of Z source inverter, it has been an area of wide research especially due to its application in power generation based on various renewable energy sources [1-7]. Typical Z source inverter (ZSI) uses a LC impedance network between the source and voltage source inverter (VSI). Z source inverter (ZSI) has the property of stepping down or stepping up the input voltage, as a result, the output can be either higher or lower than the input voltage as per requirement. Moreover the conversion can be done in a single stage unlike the already existing systems with two stages of conversion.

Exhaustive researchs are carried out to compare the numerous characteristics of ZSI with the voltage source and current source inverters and explaining the generalized cascading concepts. This concept highly enhances the reliability of the inverter and is mostly achieved using the shoot through process [8-15]. Developments are also made in increasing the applicability in various other fields like electric vehicles, motor drives, power quality improvements and various high power applications. Studies are also conducted to determine the value of Z source network based on the various requirements [16-23].

### 2. Z source Inverter/Converter Topologies

Various new topologies have been developed in the Z source inverter/converter primarily to improve the efficiency by reducing the number of switches, switching cycles and passive component, improving current and voltage gain and reducing component stresses [24-45]. Various control strategies and topologies are developed to improve reliability [49-56] and reduce harmonics and other electromagnetic noise interference are found in [46-50].

Many improvements are made in the basic topology of ZSI to arrive at numerous topologies like switched inductor/capacitor, tapped inductor, magnetically coupled ZSI and transformer isolated type which are developed mainly to enhance the output voltage boosting and inversion ability along with reducing component stresses [31], [41], [65-81]. Other than three phase ZSI, single phase ZSI have been developed over these years with dual grounding, reduced switch and various control techniques [57-64]. Albeit the concept of Z source power conversion introduced originally for dc-ac conversions, researchers are able to use the concept in developing a variety of converters which does dc-dc [82-87], ac-dc [88-90] and ac-ac conversions as well [90-130]. The ac-ac conversion also includes the integration of Z source network in matrix converters including sparse matrix converters. These matrix converters are highly efficient with extended output voltage and the provision to control input power factor. They can also be used in application requiring bidirectional power flow [104-128]. In embedded

ZSI topologies, the DC source is embedded within the Z network unlike the traditional one. Smoother and smaller current and voltage are maintained across the DC input source thus reducing the capacitor voltage stress and ripples in the input current with high boost ratio [131-136].

Quasi Z source inverters/converters topologies are developed as discussed in [42], [53-54], [63], [137-160]. Different types of these models are developed by just adding inductors, capacitors and diodes to the traditional topology to form switched inductor type, two stage network type etc. These new topologies have increased voltage gain, continuous and constant input current with reduced switching count, voltage and current stress. On top of it all, it requires lesser shoot through current for same voltage gains [161-180]. The quasi Z source network is also used in implementing DC-DC converters as well [181-182].

Z source multi level inverters (MLI) are mainly a mixture of cascaded basic units and H bridge circuit, diode clamped. These units produce positive and zero voltage levels and at the same time, it obtains positive, zero and negative voltage levels from H bridge circuit, so the number of semi conductor switches is reduced with respect to traditional multilevel inverters [182-190]. It is most reliable against short circuit faults and THD of injected voltage is decreased compared to traditional MLI. Single Z source based MLI with reduced number of switches is developed mainly for lower and medium power level application. Other ZSMLI topology like, single Z source based cascaded transformer MLI uses the same technique as that of the traditional transformer based cascaded inverter, found to be more reliable against short circuit faults and also seemed to maintain the THD almost constant for different boost ratio.

With further developments to the concept of multi level ZSI Neutral Point Clamped (NPC) inverters with Z-source network became an attractive solution. Multi-level output is obtained with reduced passive components by connecting low cost front end diode rectifier to NPC ZSI. Concepts of quasi Z source and trans Z source inverters are introduced in NPC to obtain very high quality output voltage with lesser voltage distortions, reduced inverter noise and enhanced buck-boost features. Various modulation techniques like Pulse Width Modulation (PWM), space vector and digital controls like FPGA could be used effectively in NPC ZSI as well [192-206].

Trans Z source neutral clamped inverter is developed by using a transformer and a capacitor to constitute the Z network. It is able to produce multi level output along with reduced passive components and improved the efficiency compared to traditional one. Increased voltage gain, reduced voltage stress, continuous input current and boost inversion capability are some of the features developed in Trans ZSI during these years [207-213]. As part of reducing the losses and improving the efficiency, a new topology called nine switch inverter is developed [214-217]. Even dual output could be obtained from these types of inverters. They are also able to provide bidirectional flow of power and find applications in hybrid electric vehicles [218-219]. In the concept of semi-ZSI only two active switches are used to achieve the same output with the special feature of no shoot through zero state as that of traditional ZSI [220-221].

Inverse Watkins-Johnson Topology is a robust one and has high immunity towards electromagnetic interference noise by allowing shoot-through of the inverter leg switches. As a modification of the transZSI LCCT ZSI is developed by integration of q-ZSI with a built in high frequency transformer and features continuous input current and improved relation between boost ratio to modulation index. It has more voltage gain compared to q-ZSI and prevents transformer core saturation compared to trans ZSI due to presence of two built-in DC-current-blocking capacitors connected in series with transformer windings [222-224].

Other topologies are developed mainly by altering the shape of the Z-network [225-228].  $\Gamma$ -source inverters have impedance network in  $\Gamma$  shape with lesser passive components and boosted output voltage [229-230].

### 3. Conclusion

It is well understood from the recent researches that Z source inverter/converter is gaining popularity and with advanced modulation techniques coming into play, it can be used in a wide range of applications. It can improve the efficiency of the drive systems, reduce harmonics and help in maintaining the power quality. Even years after its introduction, the scope of improvement and applicability in various applications are still high and still a hot topic for most of the researchers. With the need for change over from conventional sources of energy to new

renewable sources of energy in most of the applications, the importance of Z source inverter/converter keeps rising day by day.

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