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NEW TOPOLOGY OF QUASI Z- SOURCE INVERTER AND ITS COMPARATIVE ANALYSIS WITH CONVENTIONAL Z- SOURCE INVERTER

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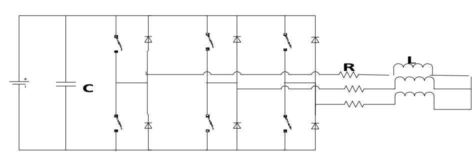
Abstract- This paper presents the designing of Quasi Z-source inverter (known as Q Z-source inverter). The Z-source employs a unique impedance network to couple the circuit to the power source. The draw backs observed in Z-Source Inverter can be overcome by using this Q Z Source Inverter. Such as input current is discontinuous and capacitor has high voltage stress that overcomes by the quasi Z-source inverter. The quasi Z-source is very much similar to the Z-source inverter in some aspects. The quasi Z-source inverter have several advantages such as: reduce source stress, lower component ratings and simplified control strategies. Like Z-source inverter, quasi Z-source inverter also suitable for applications which require large range of gain such as in motor controllers or renewable energy sources.

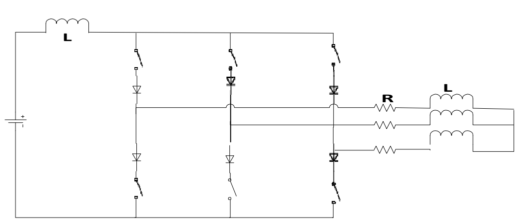
Keywords—Inverter, current source inverter, voltage source inverter, z-source inverter, quasi z- source inverter.

I. Introduction

In Power electronics, inverter assumes an indispensable part. Inverters are known as the circuits which change over a dc power into an ac power at desired output voltage and frequency. The ac output voltage can be fixed or variable frequency. The change can be accomplished either by controlling turn – on and turn – off devices (e.g. Bipolar junction transistor BJT, Insulated gate bipolar transistor IGBT) or by thyristors, contingent upon applications. Inverters are extensively classified as voltage source inverter (VSI) and current source inverter (CSI). The voltage source inverter (VSI) has a few restrictions and hypothetical hindrances – The dc source has little or immaterial impedance. At the end of the day, it has stiff dc voltage source at its input side.



(a)



(b)

Fig.1. Traditional inverter (a) VSI (b) CSI

The ac output voltage is constrained underneath the dc voltage. Because of the low internal impedance, the terminal voltage remains generously steady with the adjustments in load. In this way, it is appropriate for single motor drives and multi motor drives. Because of low time consistent of its internal impedance a short circuit occurs across terminal, makes current ascent quick. For applications, for example, over drive, an extra dc-dc support converter is expected to acquire a desired ac output.

The shoot – through issue by electromagnetic impedance (EMI) noise's misstating-on is a noteworthy executioner to the converter reliability. An additional LC filter is expected to control complexity [1].

on the other hand, the current source inverter (CSI) is one in which the dc source has high impedance. On the off chance that the current source inverter is fed by the phase controlled rectifier through a large series inductor then the load current is controlled as opposed to the load voltage and inverter output voltage is dependent on the load impedance. Due to the large internal impedance, the terminal voltage of the current source inverter (CSI) does not considerably stays steady with an adjustment in load. At the end of the day, it changes with an adjustment in load. In this manner, an adjustment in load on any motor influences different motors, if connected in a multi-motor drive. Subsequently, current source inverter (CSI) isn't appropriate for multi-motor drives.

For applications where an extensive variety of voltage is required, an additional dc-dc buck (or boost) converter is connected. Electromagnetic interference (EMI) noise's misstating – off happens which causes open circuit issue which is a noteworthy executioner to the converter's unwavering quality.

An series diode with a combination of fast and high – execution transistors, for example, insulated gate bipolar transistor (IGBT) is required to obstruct the reverse voltage. In this manner, it forestalls coordinate utilization of low – cost and superior insulated gate bipolar transistor (IGBT) modules [1].

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Likewise, both the voltage source inverter (VSI) and current source inverter (CSI) have same following problems-

They can't be a buck – boost converter. Rather than it, they are either buck or boost converter at a time. The output voltage might be either more greater than or less than input voltage, but not both.

If there should arise an occurrence of unwavering quality, electromagnetic impedance (EMI) noise's is a noteworthy executioner. The fundamental circuit of one type of inverter can't be utilized for the other type of inverter.

II. Z -Source Inverter

Another cross section organize known as impedance – bolstered control converter (truncated as Z - source converter)[2]-[5] is connected to beat the previously mentioned hypothetical obstructions and constraints of the voltage source converter and the current source converter and gives a decent power transformation

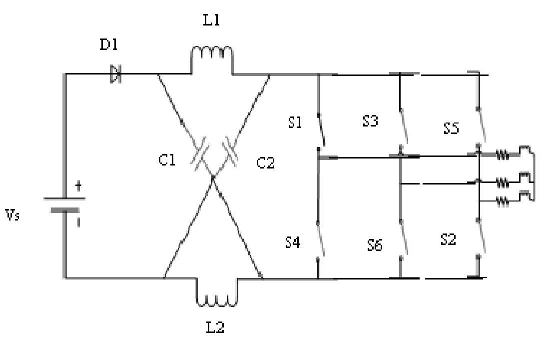


Fig.2 Z-source Inverter

Fig. 2 demonstrates the impedance sustained power converter structure proposed. The z source converter comprises of a one of a kind impedance arrange that couples the primary circuit to the power source, or another converter. This gives a remarkable element of both buck and lift change ability, that can't be gotten in the voltage source converter and current source converter.

Fig. 2 demonstrates a two port system that comprises of two inductors and two capacitors associated in X-configuration which gives an impedance source associated with the load. The dc source or load can be either a voltage or a current source or load. The dc source can be a battery, energy unit and load can be inductor, capacitor, resistor, or blend of these.

There are six switches which is a blend of exchanging gadgets like protected insulated gate bipolar transistor (IGBTs) and an anti parallel diode. This impedance sustained system can be connected to all dc-to-ac, ac - to-dc, ac - to-ac, dc-to-dc power transformation. The control technique for the Z-source inverter is depicted in [6]-[7].

The Z - source inverter operation modes –

Active mode, shoot through mode, and three discontinuous modes. In active mode, just a single device conducts in each phase leg. In active mode, the inverter is controlled as the voltage source inverter.

The shoot through mode is that mode in which both switches in at least one phase conduct. In this mode, the voltage across inverter is zero.

$VC_1+VC_2>V_0$ (1)

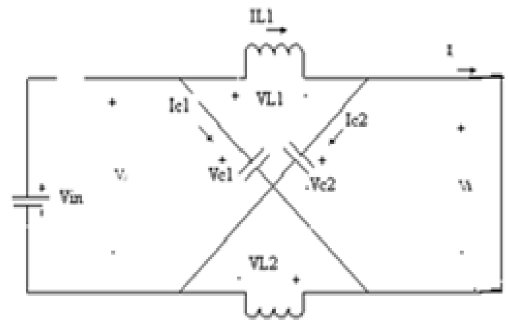


Fig.3. Shoot through state of Z- source inverter

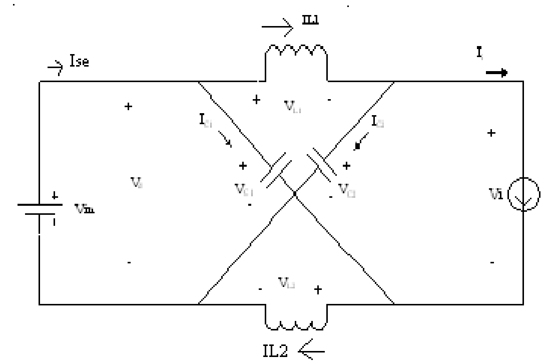


Fig.4. Non-shoot through state of Z- source inverter

Let assume that inductors L_1 and L_2 have same inductance (L) and capacitors C_1 and C_2 have same capacitance (C). The network becomes symmetrical. From symmetry we have the following equations as described in [1], [11].

$L_1=L_2=L \quad C_1=C_2=C$ (2)

$V_{C1}= V_{C2}= V_C$ (3)

During switching cycle T, the capacitor charges the inductor. Thus, the inductor voltage becomes

$V_L=V_C$, $V_D=2V_C, Vi=0$ (4)

During the switching cycle T, in the non- shoot through states for an interval T_1, the equation becomes

$V_L=V_0-V_C$ (5)

$V_D=V_0$ (6)

$V_i=V_C-V_L=2V_c-V_0$ (7)

Here V_0 is the dc source voltage, V_I is the average dc link voltage

$T=T_0+T_1$ (8)

In steady state during one switching period (T) the average voltage of the inductor must be zero, from eq. (4), (5), (6) and (7) we get,

$$V_L=\overline{V_L} = \frac{T_0V_c+T_1(V_0-V_c)}{T}=0 \quad (9)$$

$$\frac{V_C}{V_0} = \frac{T_1}{T_1-T_0} \quad (10)$$

The average dc-link voltage,

$$\overline{V_i} = \hat{V_i} = \frac{T_0.0+T_1(2V_c-V_0)}{T} = \frac{T_1}{T_1-T_0} = V_c \quad (11)$$

The peak DC link Voltage as in (7) can be expressed as

$$\hat{V_i} = V_c - V_L = 2V_c - V_0 = \frac{T}{T_1-T_0}V_0 = BV_0 \quad (12)$$

Here,

$$B= \frac{T}{T_1-T_0} = \frac{1}{1-2\frac{T_0}{T}} \geq 1 \quad (13)$$

B is the boost factor.

The peak dc-link voltage $\hat{V_i}$ is equal to the dc –link voltage of inverter. The output peak phase voltage can be expressed as,

The output peak phase voltage can be expressed as,

$$\hat{V}_{ac} = M.\frac{\hat{V_i}}{2} \quad (14)$$

M is modulation index

From equation (12) and (14),

$$\hat{V}_{ac} = M.B.\frac{V_0}{2} \quad (15)$$

In voltage source inverter,

$$\hat{V}_{ac} = M.\frac{V_0}{2} \quad (16)$$

From eq. (15) output voltage can be stepped up and stepped down by choosing buck boost factor B_B

$B_B=M.B=(0\sim\infty)$ (17)

From eq. (3), (10) and (13), the capacitor voltage becomes,

$$V_{c1} = V_{c2} = V_c = \tan\theta = \frac{1-\frac{T_0}{T}}{1-2\frac{T_0}{T}}V_0 \quad (18)$$

The Z-source inverter consists of nine permissible switching states as the voltage source inverter has eight switching states. The Z- source inverter has one more zero state. This shoot through zero state occurs when the load terminal are shorted both the upper and lower device of any one or two or all the three phase legs. This shoot through zero state is not available in the voltage source inverter.

In addition, Z-source inverter has the following drawbacks. The capacitor in the impedance fed X- shape network must sustain high voltage.

It provides discontinuous input current in the boost mode. The discontinuous current is not permissible for many sources and requires large input filters.

III. Quasi Z- Source Inverter

To overcome the above problems of the impedance – fed converter (abbreviated as Z- source inverter), this paper compares a new topology known as quasi Z -source inverter (abbreviated as QZSI) [8]-[9] and its control method can be used for ac-to-dc , dc-to-ac , ac-to-ac , dc-to-dc Conversion .

C1

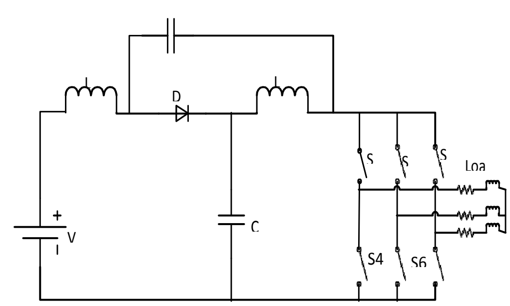


Fig.5. Quasi Z-Source Inverter

Fig.5 demonstrates the general semi Z-source inverter structure. Its internal impedance organize interfaces the converter fundamental circuit to the power source or load. The quasi Z-source inverter comprises of two inductors L1 and L2 and two capacitors C1 and C2. The inductor exhibit in the quasi Z-source inverter decreases the source current. The capacitor voltage is lower than if there should arise an occurrence of Z-source inverter. The quasi Z-source network connected the converter to the dc source and load. The dc source can be a battery, fuel cell, photovoltaic cell and load can be inductor, capacitor, resistor, or a combination of these. The six switches are a mix of exchanging gadgets like insulated gate bipolar transistor (IGBTs) and an anti parallel diode. The continuous quasi Z-source inverter gives an earthing between the dc – link and input source, by which there is a diminishment in common mode, noise can occur. The low voltage stress is obtained on the capacitors.

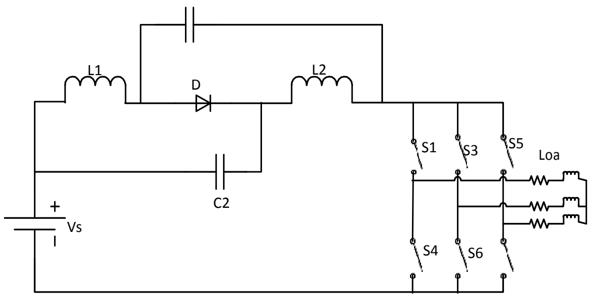


Fig.6.Discontinous quasi Z-source inverter

In the discontinuous mode of quasi z-source inverter, the aim is to obtain the low voltage stress on the capacitors C1 and C2 again. This low voltage stress on capacitors results in more space savings designs.

There are nine switches six effective states, two additional zero states and one direct zero state. The direct zero state and traditional zero state will not affect output voltage. In the active state, only one device conducts in each phase leg [10], [12].

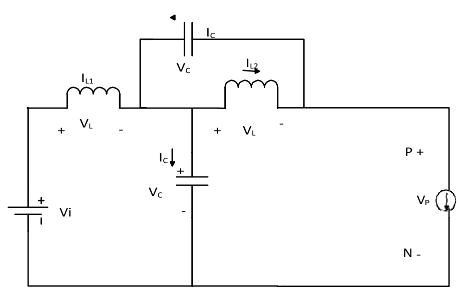


Fig.7. Active state quasi z- source inverter

During switching cycle T, in the active state for an interval T_1 the equation becomes

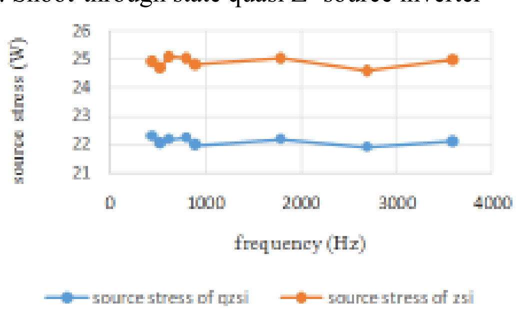
$V_{L2}=V_{C2}-V_{out}=-V_{C1}$ (19)

$V_{C2}=V_{out}-V_{C1}$ (20)

$Vin=V_{L1}+V_{C2}$ (21)

$Vout=V_{C2}+V_{C1}$ (22)

Fig.8. Shoot-through state quasi Z- source inverter



The shoot-through state is that mode in which both switches in at least one phase conduct. In this mode, the voltage across inductor is zero.

During switching cycle T, in the shoot-through state for an To, the equation becomes,

$V_{out}=0$ (23)

$V_{C2}=V_{L2}$ (24)

$V_{L2}=-V_{C1}$ (25)

$V_{C2}=-V_{C1}$ (26)

$V_{in}=V_{L1}+V_{C2}$ (27)

$V_{in}=V_{L1}-V_{C1}$ (28)

The average voltage of inductor is zero.

$$V_{L2}=\frac{To.Vc2+T1(-Vc1)}{T}=0 \quad (29)$$

$$V_{L2}=\frac{To.Vc2+T1(Vc2-Vout)}{T}=0 \quad (30)$$

$$V_{C2}=\frac{T1}{T}V_{out} \quad (31)$$

From eq. (27) and (28), we have,

$$V_{L1}=\frac{To(Vin+Vc1)+T1(Vin-Vc2)}{T}=0 \quad (32)$$

$$V_{out}=\frac{To.0+T1(Vc1+Vc2)}{T}=V_{c2} \quad (33)$$

$$V_{out}=V_{c2}=\frac{T1}{T1-To}Vin \quad (34)$$

IV. Experimental Result

The simulation can performed to verify the above advantages of interest of the quasi Z-source inverter. The simulation can be performed for both Z-source inverter and quasi Z-source inverter. The parameters can be set for both Z-source inverter and quasi Z-source inverter and results are as per the following.

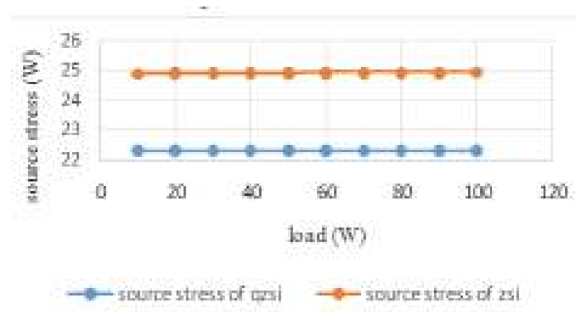


Fig.09. Source stress as a function of load

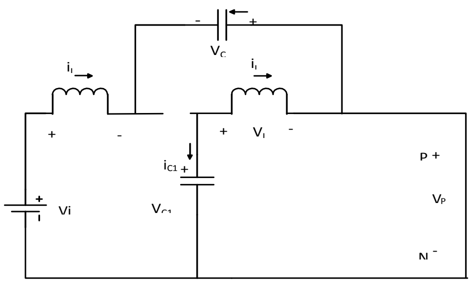


Fig.10. Source stress as a function of frequency

Here the fig. 9. indicates chart of source stress with variation of load for both quasi Z-source inverter and Z-source inverter. The source stress in quasi Z-source inverter begins from 22.27 W and in the Z-source inverter it begins from 24.90W. The fig. 10 indicates chart of source stress with the variation of frequency for both quasi Z-source inverter and Z-source inverter. From the above the two charts, it is demonstrated that the source stretch is reduced in the quasi Z-source inverter when compared with the Z-source inverter.

V. Conclusion

There are hindrances of the Z-source inverter which are overwhelmed by quasi Z-source inverter as is clear from the finding reported in this paper. The quasi Z-source inverter has a few favorable circumstances which incorporate diminished source stress, lower component ratings and simplified control strategies. It is additionally suitable for renewable energy applications.

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