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DESIGN OF Z-SOURCE INVERTER FOR INDUCTION MOTOR DRIVE

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Abstract: ***This Paper presents a power converter which is Impedance fed and abbreviated as Impedance Source Inverter & its control method for implementing dc to ac, ac to dc, dc to dc, ac to ac power conversion. this converter has a unique impedance network (or circuit) and this unique network is coupled with converter main circuit to power source, thus providing unique features that cannot be obtained in VSI, CSI power converters. The ZSI converter overcomes the limitations and barriers that are occurred in VSI, CSI theoretically and conceptually. this ZSI concept can be applied to all dc to ac, ac to dc, ac to ac & dc to dc power conversions. This paper mainly focuses on conversion of dc to ac power by using source of dc voltage & experimental results will be shown below.***

Keywords—component; converter, inverter, impedance source inverter.

Introduction

There Exist two traditional converters: Voltage Source Converter and Current Source Converter. In the voltage source converter, the ac output voltage is limited below and cannot exceed the dc rail voltage or the dc rail voltage has to be greater than the ac input voltage .therefore, the V-Source inverter is a buck(step down) inverter for dc to ac power conversion and voltage source converter is a boost rectifier for ac to dc power conversion. For applications where as over drive is desirable and the available dc voltage is limited, an additional dc-dc boost converter is needed to obtain a desired ac output. The additional power converter stage increases system cost and lowers efficiency.

- An output LC filter is needed for providing a sinusoidal voltage compared with current source inverter, which causes additional power loss and control complexity.

In CSI converter the ac output voltage has to be greater than the original dc voltage that feeds the dc inductor or the dc voltage produced is always smaller than ac input voltage.therefore,the current source inverter is a boost inverter for dc to ac power conversion and I-source converter is a buck rectifier for ac to dc power conversion.

- For applications where a wide range of voltage is desirable an additional dc to dc buck(or boost) converter is needed. The additional power conversion stage increases system costs & lowers efficiency.

In addition, both the V-source converter and I-source converter have the following common problems.

- They are either a boost ort buck converter and cannot be a buck-boost converter. i.e., their obtainable output voltage range is limited to either greater or smaller than the input voltage.
- They are vulnerable to EMI noise in terms of reliability.
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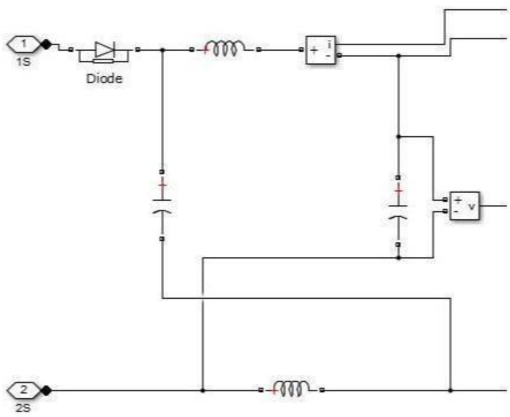
I. Z-Source Converter

To overcome the above problems of the traditio0nal V-source and I-source converters, this paper presents an impedance-source (or impedance-fed) power converter (abbreviated as Z-source converter) and its control method for implementing dc to ac, ac to dc, ac to ac, dc to dc power conversion.Fig. 1 shows the general Z-source converter structure. It employs an unique impedance network (or circuit) 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 inductor and capacitor are used as impedance source act respectively. The Z-source converter overcomes the above mentioned limitations and conceptual barriers of V- and I-source converters.

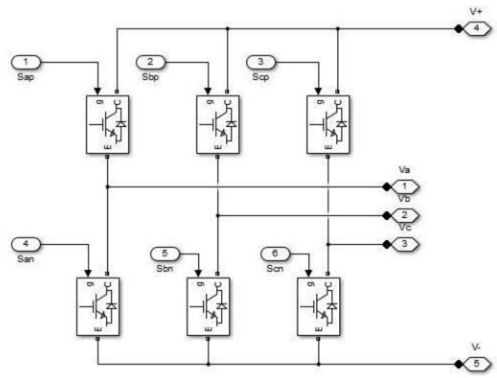


In Above Fig. it consists of split inductor L1 and L2 and capacitors C1 and C2 connected in X shape. These two L and C is employed to provide impedance source(Z-source) coupling with the converter (or inverter) to the load. Therefore, dc source can be a battery, fuel cell, diode rectifier or any dc fed supply, we have proposed the dc source can be a battery. The inductance L1 and L2 can be provided through a split inductor or two separate inductors.

To describe the operating principle and control, this paper focuses on an application for 3-phase induction motor drive. The diode in series with the dc source is usually needed for preventing reverse current flow.

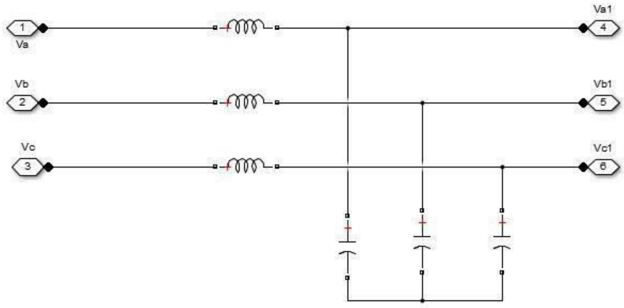
II. OPERATING PRINCIPLE AND CONTROL

The unique features of Z-source inverter are that the output ac voltage can be any value between zero and infinity regardless of the dc source voltage. That is, the Z-source inverter is a buck-boost inverter has a wide range of obtainable voltage. The traditional V- and I-source inverters cannot provide such feature.

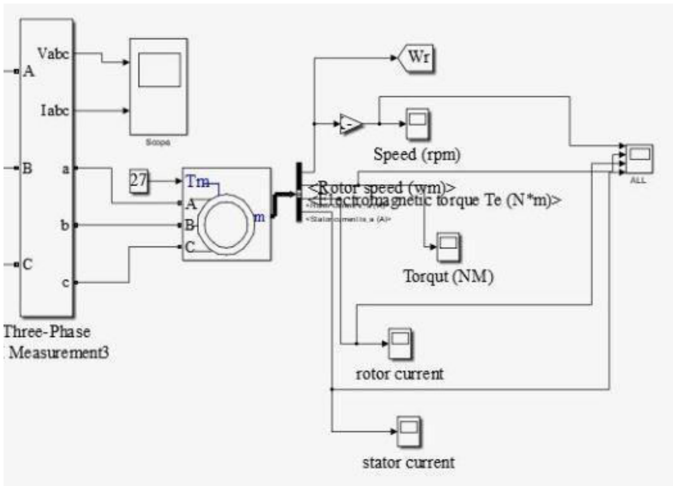


To describe the operating principle and control of the Z-source inverter in above Fig. let us briefly examine the Z-source inverter structure. The three phase Z-source inverter bridge has nine permissible switching states(vectors). However, the 3-phase inverter bridge has one extra zero state (or vector) when the load terminals are shorted through both upper and lower devices of any one phase leg (i.e., both devices are gated on), any two-phase legs, or all three phase legs. We call this third zero state (or vector) the shoot-through zero state, which can be generated by seven different ways: shoot-through via only one phase leg, combination of any two-phase legs, and all three phase legs. The Z-source network makes the shoot-through zero state possible. This shoot-through zero state provides unique buck-boost feature to the inverter.

When the dc supply fed to the converter the capacitor will be in the charging condition and current flows through the inductor. The energy has been stored in the capacitors, when the first leg phase has been short circuited automatically, dc source draws more current from the supply. So, that the inductor comes into the action and inductor will never allow sudden change of currents and inductor becomes open circuited and two capacitors C1 and C2 will come in the series connection, the voltage of c1 and c2 are doubled in series connection and the capacitor starts discharging while the one phase leg has been short circuited. The inductor will remain in open circuit until the capacitor fully discharges. Those discharged voltage will flow through bridge inverter and at the time of leg phase short circuited the voltage has been step-up in the peak condition occurs.



The Above Fig. shows that second order filter used in the Z-source inverter. This filter circuit has been used to filter the harmonics in the dc equivalent voltage before applied to the bridge inverter.



Assuming that the inductors L1 and L2 and capacitors C1 and C2 have the same inductance (L) and capacitance (C), respectively, the Z-source network becomes symmetrical. From the symmetry and the equivalent circuits, we have

$$V_{c1}=V_{c2}=V_c,\ V_{l1}=V_{l2}=V_l$$

When in a shoot-through state during time interval Tsh, in switching cycle Ts, the inverter side of the Z-source network is shorted as in Fig. Therefore, $V_l=V_c$, $V_i=0$ Alternatively, when in a non-shoot-through active or null state during time interval Tn, current flows from the Z-source network through the inverter to the connected ac load. The inverter side of the Z-source network can now be represented by an equivalent current source, as shown in Fig. This current source sinks a finite current when in an active state and sinks zero current when in a null state. the following equations can be written

$$V_l=V_{dc}-V_c,\ V_i=V_c-V_l$$

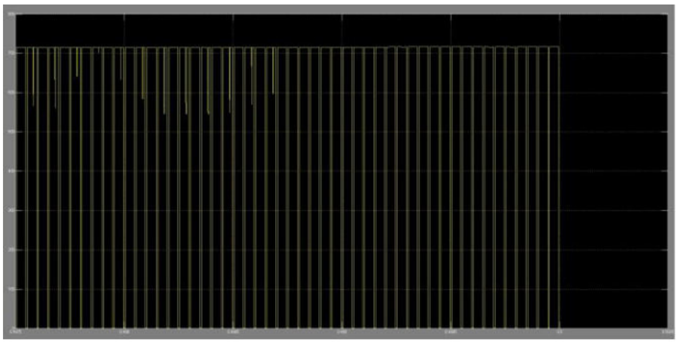
Where Vdc is the dc source voltage, Vi is the dc-link voltage across the inverter bridge and Ts=Tn+Tsh. The average voltage of the inductors over one switching period Ts should be zero in steady state; thus, we have

$$V_c=1-(T_{sh}/T_s)/1-(2T_{sh}/T_s) * V_{dc}$$

Where Tsh/Ts is shoot-through duty ratio. The peak dc link voltage across the inverter bridge can be written as described in the capacitor voltage of the Z-source network is dependent on the shoot-through time and can be stepped up by increasing it. The average of the dc-link voltage across the inverter bridge is identical to the capacitor voltage because the average of an inductor voltage becomes zero. The peak dc-link voltage that is equivalent to the dc input voltage of the inverter at the non-shoot-through state, can be expressed as the shoot-through duty ratio and dc input voltage.

Vi=Vc-Vl= 1/1-(2Tsh/Ts) *Vdc

III. CALCULATION OF INDUCTOR AND CAPACITOR



The Above Fig. presents the dc link voltage waveforms, the output of above dc voltage waveform before entering to the bridge inverter i.e., peak voltage when capacitors c1 and c2 will become series connected.

L1=L2=L; C1=C2=C.

Vin=input DC source voltage

CAPACITORS ACROSS VOLTAGE

=>>2vc=B*Vin

GAIN=>> G=((Vac(ig))/(Vin/2)

Boost factor=>> B=(2G-1)

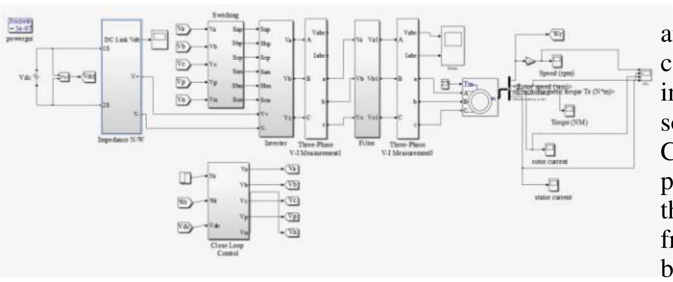
Modulation index=>> M=(G%2G-1)

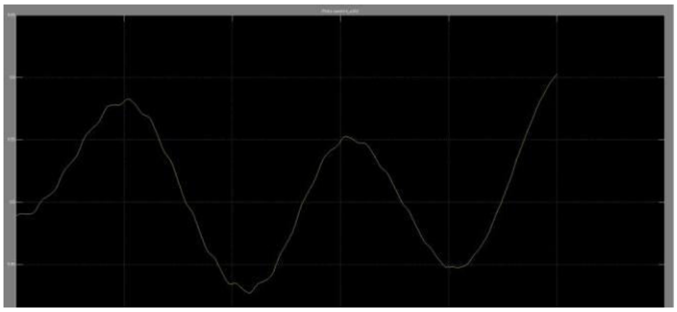
Modulation index should be always less than 1.

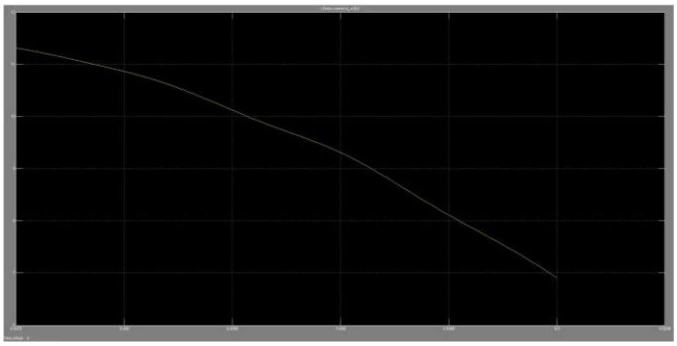
Duty ratio=To/Ts

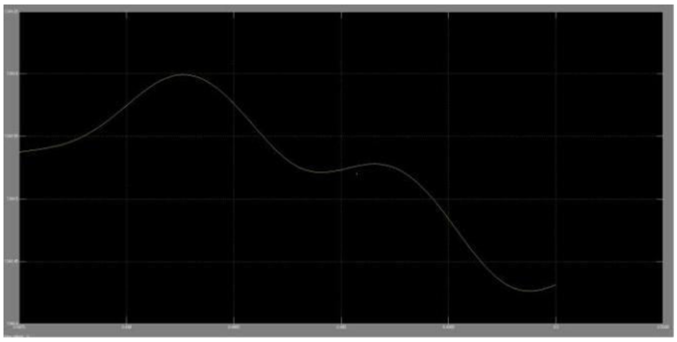
IV. SIMULATION RESULTS

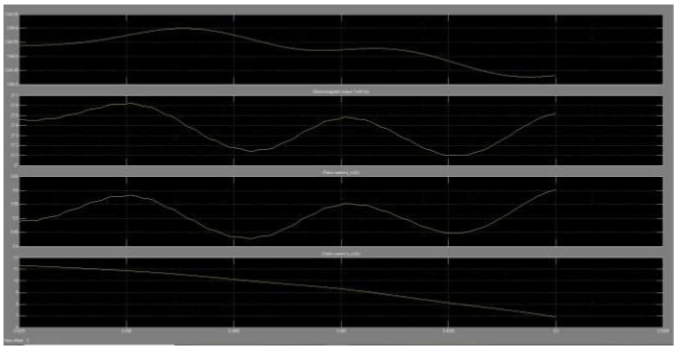
As we discussed earlier this paper focuses on application needed for three-phase induction motor drive. The simulation results are shown below which are obtained the output from Z-source inverter and coupled to load (electric induction motor).











Simulation have been performed to confirm the above analysis. The above output waveforms show the circuit configuration and shows simulation waveforms when the dc input voltage given to impedance circuit Vo=12v and the Z-source network parameters are L1 = L2 = L and C1=C2=C=1200micro farads. the purpose of system is to produce a three-phase voltage that are required to drive three-phase induction motor by taking source voltage 12v. from the above Fig. it is clear that the capacitor voltage was boosted to Vcc=1200v. the shoot-through zero state was populated evenly among the three-phase legs.

V. CONCLUSIONS

This paper has presented an impedance-source power converter for implementing dc-to-ac, ac-to-dc, ac-to-ac, and dc-to-dc power conversion. The Z-source converter employs a unique impedance network (or circuit) to couple the converter main circuit to the power source, thus providing unique features that cannot be observed in the traditional voltage-source and current-source converters where a capacitor and inductor are used, respectively. The Z-source converter overcomes the conceptual and theoretical barriers and limitations of the traditional voltage-source converter and current-source converter and provides a novel power conversion concept. The Z-source concept can be applied to almost all dc-to-ac, ac-to-dc, ac-to-ac, and dc-to-dc power conversion.

Through the example, the paper described the operating principle, analyzed the circuit characteristics, and demonstrated its concept and superiority. Analytical, simulation, and experimental results have been presented. The Z-source inverter can boost–buck voltage, minimize component count, increase efficiency, and reduce cost.

It should be noted again that the Z-source concept can be applied to the entire spectrum of power conversion. Based on the concept, it is apparent that many Z-source conversion circuits can be derived. As another example, the Z-source concept can be easily applied to adjustable-speed drive (ASD) systems as shown in Fig. The Z-source rectifier/inverter system can produce an output voltage greater than the ac input voltage by controlling the boost factor, which is impossible for the traditional ASD systems.

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