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Third Harmonic Injection Control Method for L-Z-Source Inverter Fed Motor Drive

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Abstract:- In this paper it contains the inductor type Z-source inverter, the disadvantage of capacitor charging and discharging can be solved by using diode in the circuit. The inverter can increase the boost factor by changing the value of the different modulation index. By using the third order harmonic injection method the level of the total harmonic distortion (THD) and the losses can be further reduced comparing to the traditional Z-source inverter.

I. INTRODUCTION

In recent years various Z-Source inverters such as Quasi Z-Source inverter, Switched inductor type Z-Source inverter are presented in numerous diversified field of studies which is focused on application and modeling. The Z-Source inverter contains a Power conversion with buck-boost capabilities. The traditional Z-Source inverter contains two inductors and capacitors respectively. The DC voltage input is given to the Z-source inverter.

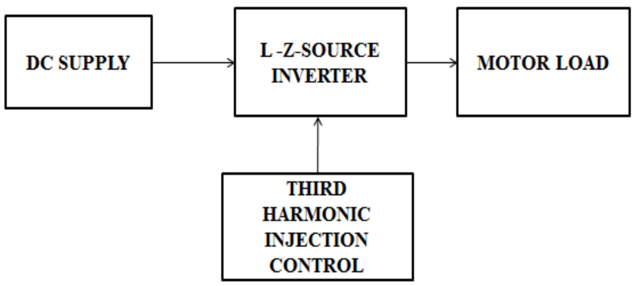


Fig.1 Block diagram

There is some disadvantages present in the traditional Z-source inverter which could be Overcome by inductor type Z-Source inverter. The disadvantages present in the traditional Z-Source inverter such as, during the capacitor charging and discharging the large inrush current flows across the circuit and also the capacitors used in the circuit are of large capacity which is cost effective and reduce the life span of the system. To overcome the disadvantages caused by the traditional Z-source inverter. The proposed inverter eliminates the capacitor in the circuit due to which large inrush current flowing across the circuit is avoided. The efficiency of the proposed inverter can be further more increased. Inductor type Z-source inverter with third order harmonic injection control method can be widely used in engineering applications employing impedance type power inverter.

II. INDUCTOR TYPE Z-SOURCE INVERTER

The proposed L type Z-source inverter contains no capacitor instead it contains two inductors namely (L1 and L2) and three diodes namely (D1, D2 and D3).the diodes D1,D2 and D3 acts as a switch.

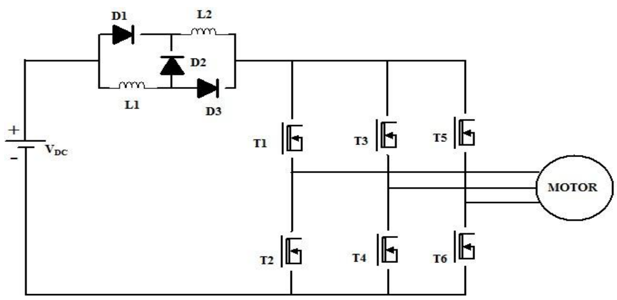


Fig.2 Inductor Type Z-Source Inverter

III. OPERATING PRINCIPLES

The operating principle of the L type Z- Source inverter is similar to the traditional Z- Source inverter, containing six active states and shoot through zero states. Due to the similar operating principle for the simplified analysis only the shoot through and non-shoot through states are considered.

A.NON-SHOOT THROUGH STATE

In the non-shoot through state the D1 and D3 are in open position whereas the diode D2 is in closed position. The dc voltage V_{DC}

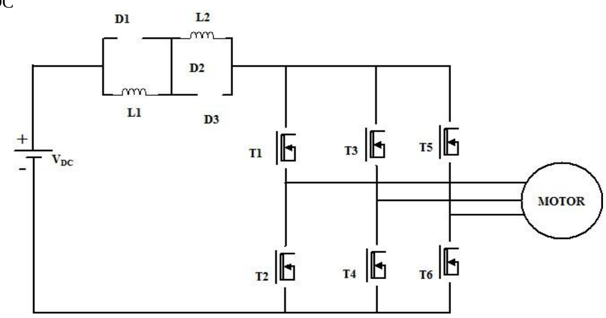


Fig.3 Non-Shoot Through State of Inductor Type Z-Source Inverter

Flow across the inductors L1 and L2 and they are connected in series. The inductor L1 and L2 transfer energy from the dc voltage to the inverter circuit. The circuit for non-shoot through state is given in fig. the voltage across the inductors L1 and L2 during non-shoot through state is given by V_{1N} and V_{2N} respectively.

$$V_{1N} + V_{2N} + V_i = V_{dc} \qquad (1)$$

Therefore the inductors are connected in series the voltage across the inductors L1 and L2 are similar.

$$V_{1N} = V_{2N} \qquad (2)$$

From the equation (1) and (2) the voltage across the inductors L1 and L2 are given by,

$$V_{1N} = \frac{1}{2}V_{dc} - \frac{1}{2}V_i \qquad (3)$$

$$V_{2N} = \frac{1}{2}V_{dc} - \frac{1}{2}V_i \qquad (4)$$

Where V_{dc} is the DC source voltage; V_i is the dc link voltage.

B. SHOOT THROUGH STATE

The Shoot through state occurs when both the switch of the upper or lower leg thyristors of any phase leg gets shorted. During the shoot through state the diodes D1 and D3 are in closed position whereas diode D2 is in open position. The inductors L1 and L2 are connected in parallel which stores the energy.

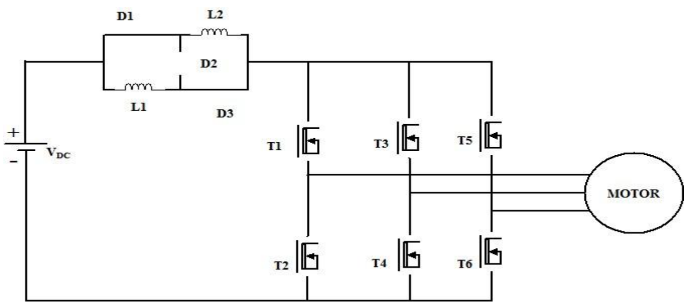


Fig.4 Shoot through State of Inductor Type Z-Source Inverter

The circuit for shoot through state is given in fig. The dc voltage flow across the inductors L1 and L2 are given by V_{1S} and V_{2S} respectively.

$$V_{1S} = V_{2S} = V_{dc} \qquad (5)$$

Applying volt-second balance principle to the inductors L1 and L2 we get,

$$V_i = \frac{1+D}{1-D}V_{dc} \qquad (6)$$

$$B = \frac{1+D}{1-D} \qquad (7)$$

Where B is the boost factor; D is shoot-through duty cycle.

IV. EXTENDED INDUCTOR TYPE Z-SOURCE NETWORK

The extended inductor type Z-source network can improve the voltage gain. By

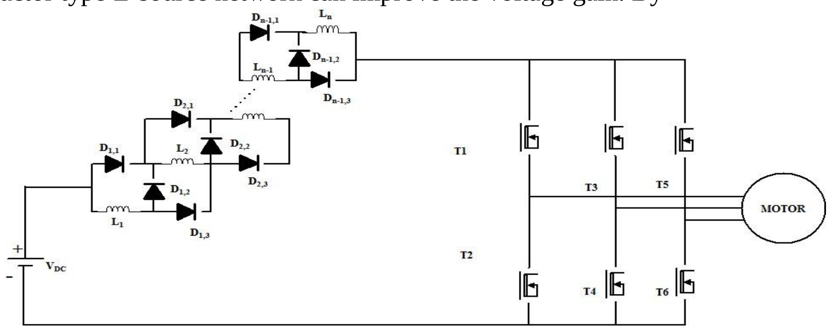


Fig.5 Extended Inductor Type Z-Source Network

Increasing the number of inductors and diodes in the network the boost factor can be improved.

A.NON-SHOOT THROUGH STATE

In the non-shoot through state the diodes such as $D_{1,1}$,$D_{1,3}$,$D_{2,1}$,$D_{2,3}$,…………$D_{n-1,1}$,$D_{n-1,3}$ are kept in open condition. Whereas the diodes such as $D_{1,2}$,$D_{2,2}$,…………$D_{n-1,2}$ are in closed conditions. The

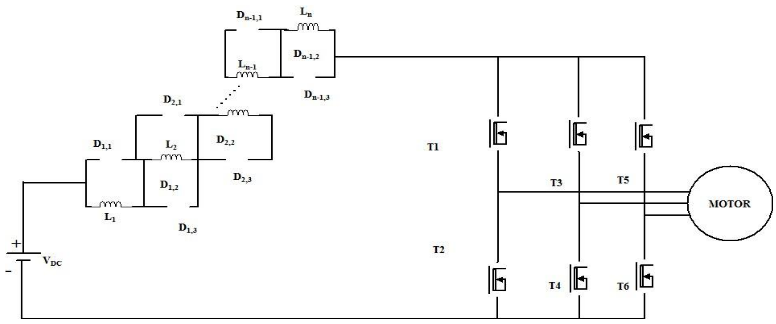


Fig.6 Non-Shoot through State of Extended Inductor Type Z-Source Network

Dc voltage flow across the inductors such as L1,L2,…….Ln-1 and Ln and they are connected in series. The inductor L1,L2,Ln-1 and Ln transfer energy from the dc voltage to the inverter circuit. The circuit for non-shoot through state is given in fig. the voltage across the inductors L1,L2,…….Ln-1 and Ln during non-shoot through state is given by V_{1N},V_{2N},………$V_{(n-1)N}$ and $V_{(n)N}$ respectively.

$$V_{1N} + V_{2N} + \cdots + V_{(n-1)N} + V_{(n)N} + V_i = V_{dc} \qquad (8)$$

Therefore the inductors are connected in series the voltage across the inductors L1,L2,…...,Ln-1 and Ln are similar.

$$V_{1N} = V_{2N} = \cdots = V_{(n-1)N} = V_{(n)N} \qquad (9)$$

Where V_{dc} is the DC source voltage; V_i is the dc link voltage.

B. SHOOT THROUGH STATE

The Shoot through state occurs when both the switch of the upper or lower leg thyristors of any phase leg gets shorted. During the shoot through state the diodes $D_{1,2}$,$D_{2,2}$,………$D_{n-1,2}$ are in open conditions.

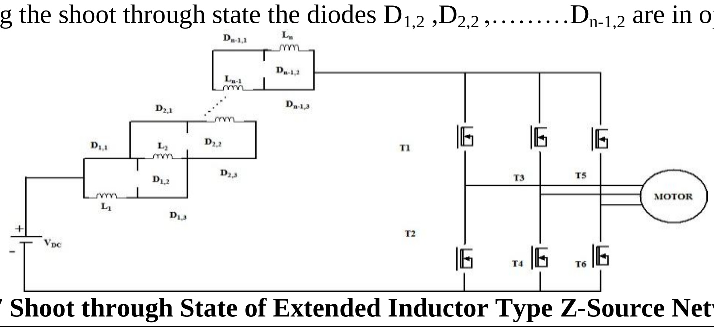


Fig.7 Shoot through State of Extended Inductor Type Z-Source Network

whereas diodes $D_{1,1}$,$D_{1,3}$,$D_{2,1}$,$D_{2,3}$,…………$D_{n-1,1}$,$D_{n-1,3}$ is in closed position. The inductors L1, L2,….., Ln-1 and Ln are connected in parallel which stores the energy. The circuit for shoot through state is given in fig. The dc voltage flow across the inductors L1, L2,….., Ln-1 and Ln are given by V_{1S}, V_{2S},……,$V_{(n-1)S}$ and $V_{(n)S}$ respectively.

$$V_{1S} = V_{2S} = \cdots = V_{(n-1)S} = V_{(n)S} = V_{dc} \quad (10)$$

Applying volt-second balance principle to the inductors L1, L2,….., Ln-1 and Ln we get,

$$B = \frac{1+(n-1)D}{1-D} \quad (11)$$

Where *B* is the boost factor; D is shoot-through duty cycle.
When n=2,

$$B = \frac{1+D}{1-D} \quad (12)$$

When n=1,

$$B = \frac{1}{1-D} \quad (13)$$

The range of D is [0,1).
The boost factor of the inductor type Z-Source inverter can be improved by increasing the number of inductor.

V. THIRD ORDER HARMONIC INJECTION CONTROL METHOD

The third order harmonic injection control method have an advantage that the modulation index can be increased and also the overshoot period can be maintained constant and variable.
If only third order harmonic is injected V_r is given by,

$$V_r = 1.15\sin\omega t + 0.19\sin\omega t \quad (18)$$

In third order harmonic injection constant boost technique the reference sinusoidal signal is merged with third harmonic sinusoidal waveforms with one third amplitude of the fundamental, to generate non-sinusoidal waveforms. Constant shoot-through is provided in zero states by comparing the triangular carrier wave with a positive, negative and constant magnitude and Generate non-sinusoidal reference waveforms. The variable shoot-Through are provided considering the third harmonic injected sinusoidal reference wave and triangular carrier wave.

VI. SIMULATION

A.SIMULATION CIRCUIT

The figure shows the proposed circuit containing inductor type Z-source inverter with third order harmonic

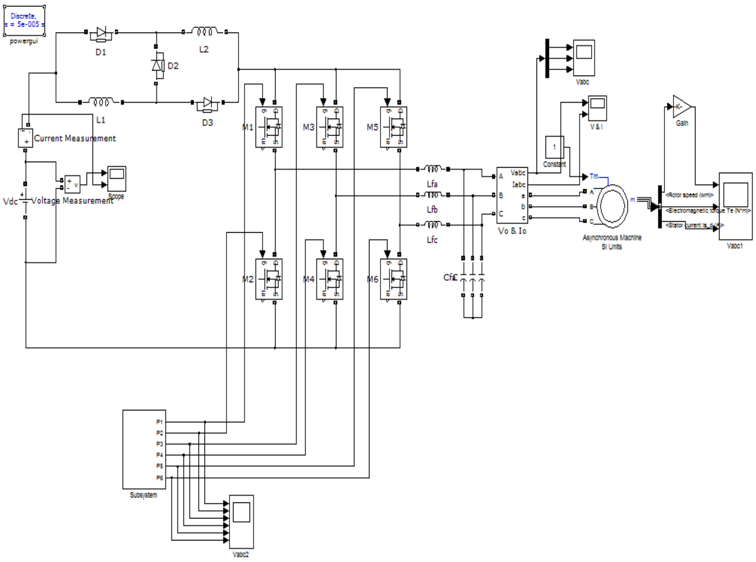


Fig 8.simulation circuit injection control method.

B.INPUT VOLTAGE AND CURRENT

The input DC voltage of about 230V is given as input to the L-Z-source inverter circuit.

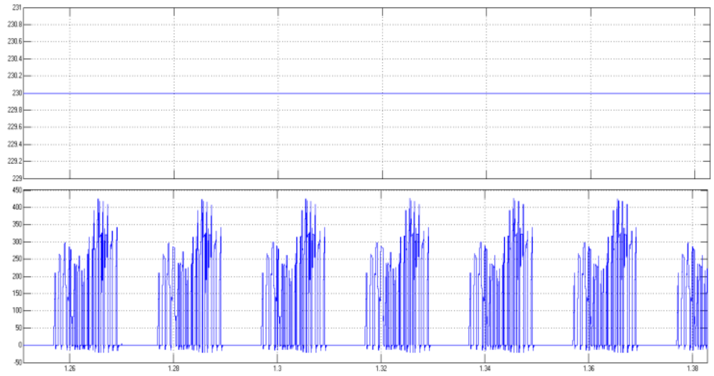


Fig 9. Input voltage and current

C.TRIGGERING PULSES

The switching frequency is about 2.5 KHz.

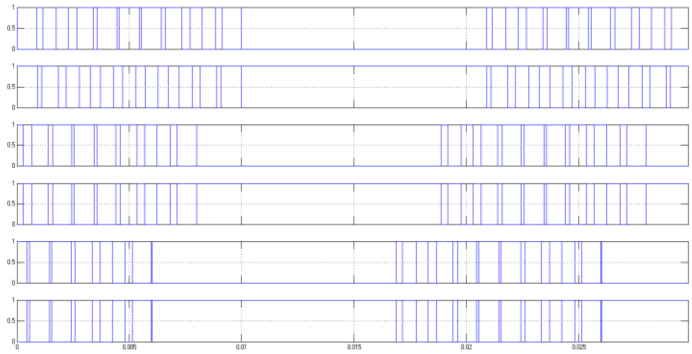


Fig 10. Triggering pulses

D. SIMULATION OUTPUT

The simulation output three phase voltage of magnitude 700V and current of 10A is obtained.

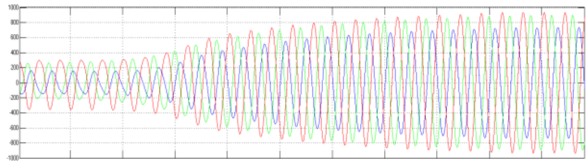


Fig.11 Simulation Output voltage

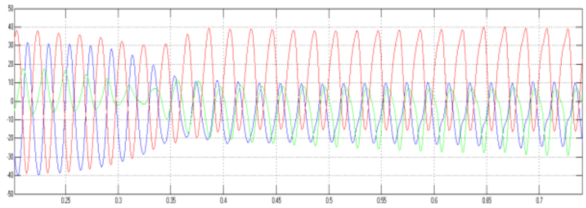
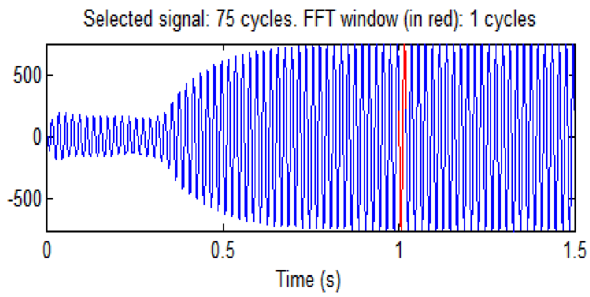


Fig.12 Current

E.THD ANALYSIS

As number of cycles increase the harmonic level will decreased the measured voltage and THD is Minimum**.**



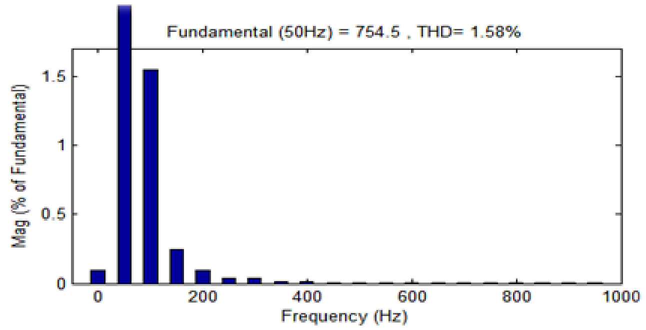


Fig.13 THD Analysis

VII. CONCLUSION

The simulation of the Inductor type Z-source inverter with third order harmonic injection control method is carried. The output voltage and current of the inverter circuit is given. The output across the inverter and the voltage and current given to the induction motor can be controlled by using third order injection control method. From the simulation analysis Inductor type Z-source inverter with third order harmonic injection control method can be widely used in engineering applications employing impedance type power inverter.

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