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DIGITAL SIMULATION AND IMPLEMENTATION OF Z-SOURCE INVERTER FED INDUCTION MOTOR

D.Devipriya[1]and N.Gnanasekaren[2]
Misrimal Navajee Munoth Jain Engineering College,
Chennai , India.
devipriya.0809@ gmail.com
neelasekaren@yahoo.com

ABSTRACT:Simulation and implementation of z-source inverter fed induction motor isdiscussed in this paper. The impedancesource inverter employs a uniqueimpedance network coupled withinverter main circuit and rectifier; itovercomes the conceptual and theoreticalbarriers and limitations of the traditional voltage-source converter (abbreviated asV-source converter) and current-sourceconverter (abbreviated as I-sourceconverter). The z-source inverter systemprovide ride-through capability duringvoltage sags, reduces line harmonics,improves power factor and high reliability, and extends output voltagerange.

Keywords:Z-sourceinverter,induction motor,harmonicdistortion, voltage sag.

I.INTRODUCTION

Z-Source Inverter for inductionmotor drives. Z-Source Inverter can beapplied to the entire spectrum of powerconversion. It is used as Boost-Buckconversion where a capacitor and inductorare used. In this thesis, the Z-SourceInverter is considered in place of VoltageSource Inverter and Current SourceInverter. By using this Z-Source Inverterthe problems mentioned are rectified andthen we can get higher efficiency.Traditional source inverters have followingproblems, There can be either a boost or abuck inverter operation and cannot be abuck-boost inverter operation.Their outputvoltage range is limited to either greater or
Smaller than theinput voltage.

In other words;neither the voltagesource inverter canbe used for thecurrent sourceinverter, or vice-versa.They arevulnerable to EMInoise in terms ofreliability.ThisZ-Source Inverter isused to overcome theproblems in thetraditional sourceinverters Bridgerectifier is commonlyused in high power applications.The impedance networkis a two portnetwork. A two port network has inputterminals and outputterminals.Thisnetwork also calledas lattice network.This lattice networkconsists of splitinductors (L1 phaseAC supply is givento the rectifier unit;rectification is aprocess of convertingalternating current orvoltage into a directcurrent or voltage.The three phase andL2) and capacitors(C1 and C2) TheImpedance SourceInverter consists ofvoltage source fromrectifiersupply,impedance network,three phase inverter and with AC motor load.

This network is coupled with inverter maincircuit and source. This impedance network isa second order filter, and also this network isenergy storage or filtering element for theImpedance Source Inverter. DC to ACconverters is known as inverter. The functionof an inverter is to change a DC input voltageto AC output voltage of desired magnitudeand frequency. Three phase inverters arenormally used for high power applications.

Status andopportunities ofphotovoltaicinverters in gried–tied and micro-grid systems arepresented in[1].z-source incerter aregivenin[2].comparisonoftraditionalinverter and z-source inverter arepresented in[3]constant boostcontrol of the z-source inverter to
minimise currentripple and voltagestress are given in [4].PWM of z-sourceInverter are presented in [5].AC output voltagecontrol with minimisation of voltage stressacross devices in the z-source inverter usingmodified SVPWM are given in[6].maximumboost control of the z-source inverter are givenin[7].

Power loss oriented evolution of high voltageIGBTsandmulti-levelconverters intransformerlesstractionapplication arepresented in[8].loss oriented evaluation andcomparison of z-source inverters using differentPWM strategies are given in[9].current modeintegrated control technique for z-source inverterfed IM drives are given in[10].analysis andsimulation of z-source inverter control methedare

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presented in [11].the above literature doesnot deals with simulation and experimentalverification of z-

Source inverter. This works aimto develop an experimental module formicrocontroller based z-source inverter.

II. Z SOURCE INVERTER

The z-Source Network is a combination oftwo inductors and two capacitors. This combinedcircuit, the z-Source Network is the energy storageor filtering element for the z-Source inverter. Thisz-source network provides a second order filter.

This is more effective to suppress voltage and current ripples. The inductor and capacitorrequirement should be smaller compare than thetraditional inverters.When the two inductors (L 1and L2) are small and approach zero, theImpedance source network reduces to twocapacitors (C1 andC2) in parallel and becomestraditional voltage source.

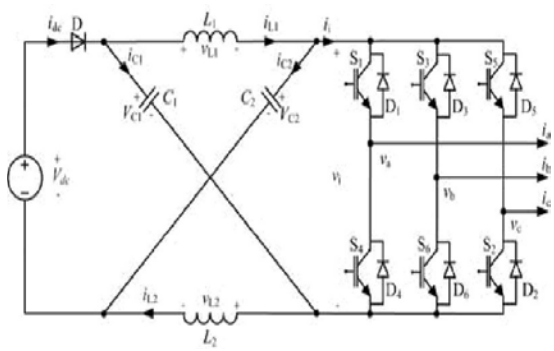

Figure1. Z-source inverter

Therefore, a traditional voltage inverter'scapacitor requirements and physical size is theworst case requirement for the Impedancesource inverter. Considering additional filteringand energy storage provided by the inductors,the Impedance Source Network should requireless capacitance and smaller size compare withthe traditional voltage source inverter.Similarly, when the two capacitors (C1 and C2)are small and approach zero, the ImpedanceSource Network reduces to two inductors (L1and L2) in series and becomes a traditionalcurrent source. Therefore a current sourceinverter's inductor requirements and physicalsize is the worst case requirement for theImpedance Source Inverter. Consideringadditional filtering and energy storage by thecapacitors, the Impedance Source Networkshould require less inductance and smaller sizecompared with the traditional Current SourceInverters.

III . MATHEMATICAL ANALYSIS

Impedance source network ,a two portnetwork which is used to provide mathematicalanalysis.Assume the inductors (L1&L2) andcapacitors (C1 &C2) have the same inductanceand capacitance values respectively
L1 and L2 – series arm inductors;V1 is input voltage;
C1 and C2 – parallel arm capacitors;V2 is output voltage;

The Circuit model is derived in equations 3.1 to3.12.

$$Vc1=Vc2=VC \quad ...3.1$$
$$VL1 = VL2= VL \quad …3.2$$
$$VL = VC$$
$$VD = 2Vc$$
$$VI =0$$

During the switching cycle T

$$VL=VO -VC \quad …3.3$$
$$VD = VO$$
$$VI = VC – V L = 2 VC -Vo)$$
$$VI = 2Vc –V O \quad …3.4$$

Where Vo is the dc source voltageand

$$T=To+T1 \quad …3.5$$

The average voltage of the inductors over one switching period (T)should be zero in steadystate

$$VL = VL = To .Vc +T1 (Vo-Vc) / T =0$$
$$VL = (To .Vc +Vo.T1 - Vc.T1) / T = 0$$
$$VL = (To-T1) VC/ T + (T1.Vo) / T$$
$$Vc/Vo =T1/(T1T0) \quad …3.6$$

Similarly the average dc link voltage across the inverter bridge can be found asfollows fromequation (3.4)

$$VI = VI = (To.0+T1).(2VcVo)/T \quad …3.7$$
$$VI = (2Vc. T1/T) - (T1Vo/T)2Vc=VO$$

From equation (3.6)

$$T1.Vo/ (T1-To) = 2Vc.T1/ (T1-To)$$
$$VC = Vo.T1/ (T1-To)$$

The peak dc-link voltage across the inverterbridge is

$$VI = VC - VL = 2 VC - VO$$

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The buck- boost factor BB is determined by themodulation index M and the Boost factor B. Theboost factor B can be controlled by duty cycle ofthe shootthrough zero state over the non-shootthrough states of the PWM inverter. The shootthrough zero state does not affect PWM controlof the inverter. Because it equivalently producethe same zero voltage to the load terminal. Theavailable shoot through period is limited by thezero state periods that are determined by themodulation index.

IV . SIMULATION RESULT

Simulations have been performed toconfirm the above analysis. Fig.2 shows the circuit configuration of Z – source inverter fedinduction motor. Simulation has become a verypowerful tool on the industry application as wellas in academics, nowadays. Simulation is one ofthe best ways to study the system or circuitbehavior without damaging it.The open loop results and closed loop result for z-sourceinverter are given below. FIG.[4.1].CIRCUIT DIAGRAM = T / (T1To).Vo = B.Vo Where B = T/(T1To)B is a boost factor. The output peak phase voltage from the inverter Vac=M.Vi/2,In this source Vac = M.B.Vo /2In the traditional sourcesVac = M.Vo/2For Z-SourceVac=M.B.Vo2.

The output voltage can be stepped up bychoosingan appropriatebuckBoostfactorBThe capacitor voltage can be expressed Vc2 = VT)FIG[3].

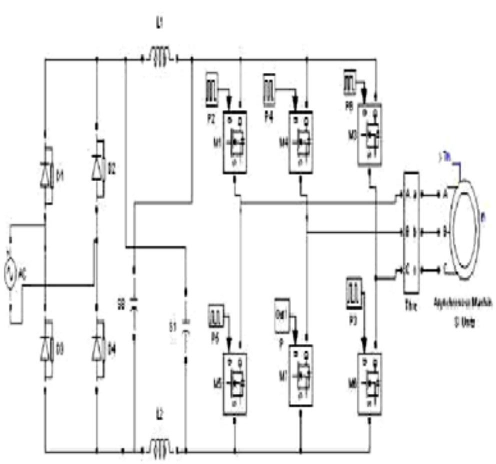

Figure.2 Circuit Diagram

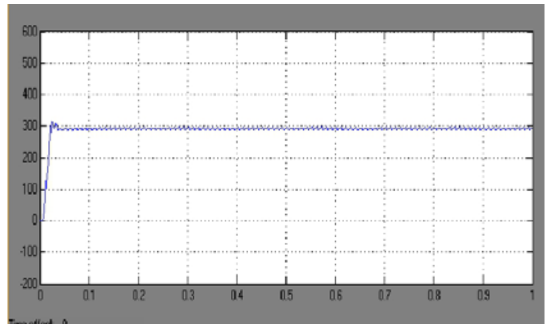

Figure.3. Rectifier output voltage

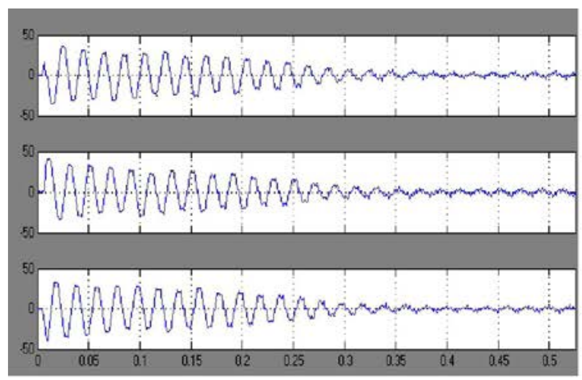

Figure.4 Inverter phase output voltage

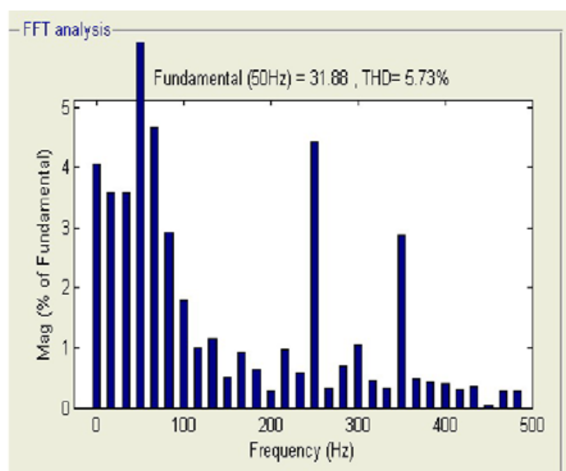

Figure.5 FFT Analysis

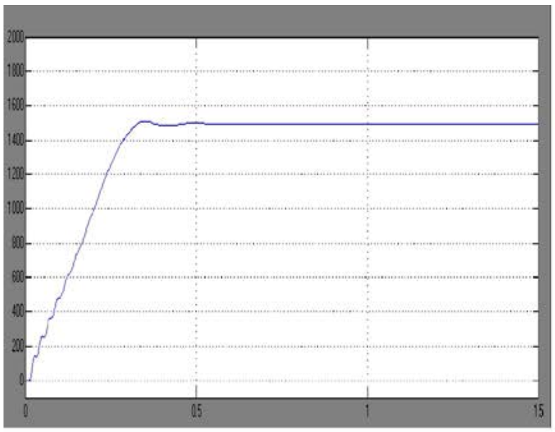

Figure. 6 Inverter Phase Current

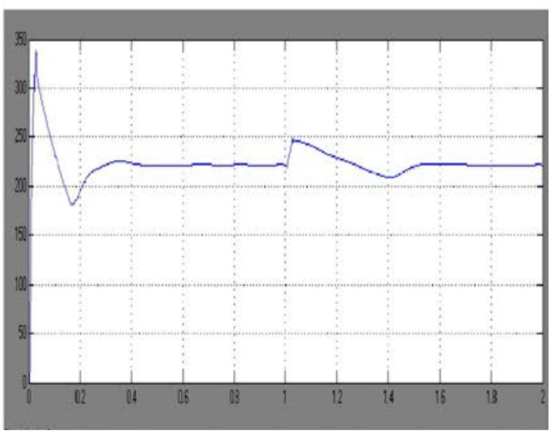

Figure.7 Input voltage

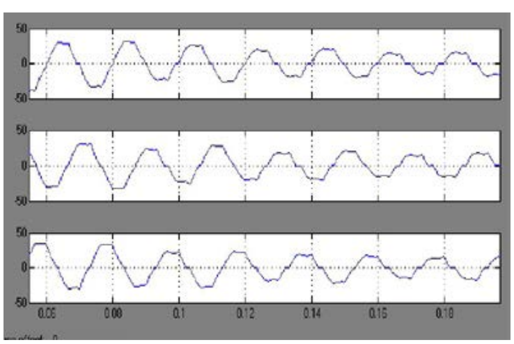

Figure. 8 Rectifier outputvoltage

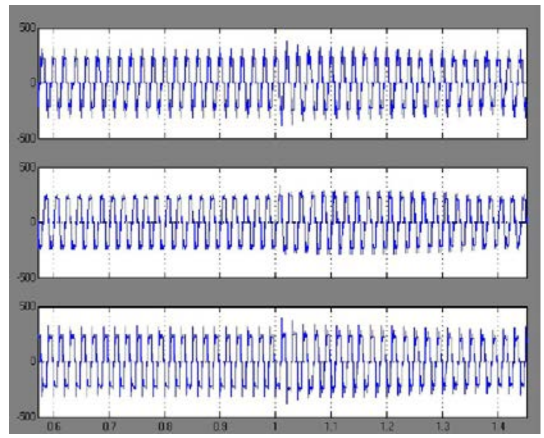

Figure. 9 Output current wave form

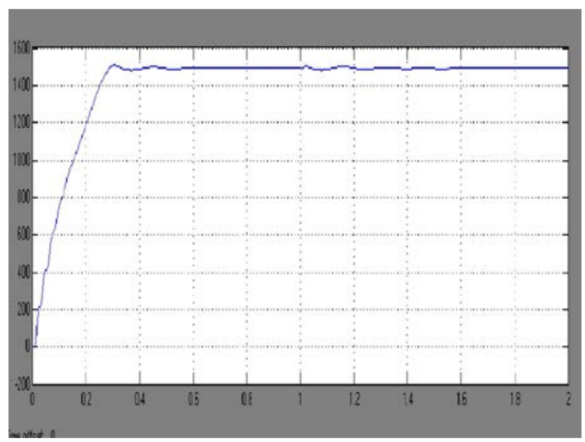

Figure.10 Output voltage

V. EXPERIMENTAL RESULTS

A 0.5 KW, 3 – **Φ** Induction Motordrive is fabricated and tested in the laboratory.The hard ware consists of power circuit andcontrol circuit. The power circuit usesMOSFET'S (IRF 840) and Z – network. Thecontrol circuit uses 8 – bit Atmel **µ**C 89C2051.

This has 15 programmable I/O lines, tow 16 – bit timers, 6 interrupt sources & one UARTchannel. This chip has built in analogcomparator. It can work in lower power idealand power down modes. The pulses aregenerated using the **µ**C 89C2051. They areamplified

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by using the driver IC IR2110.the topview of hardware circuit are shown in fig.Thedriving pulse,Line voltage with r load,Phasevoltage with r load,Line voltage with motor loadare shown below.

Figure.11.Hardware proto type photos

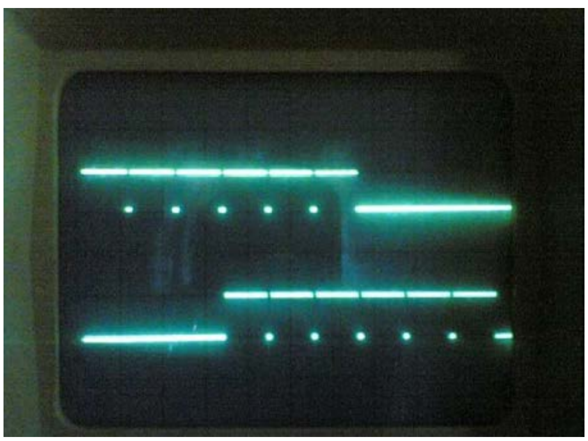

Figure.12. PWM pulses

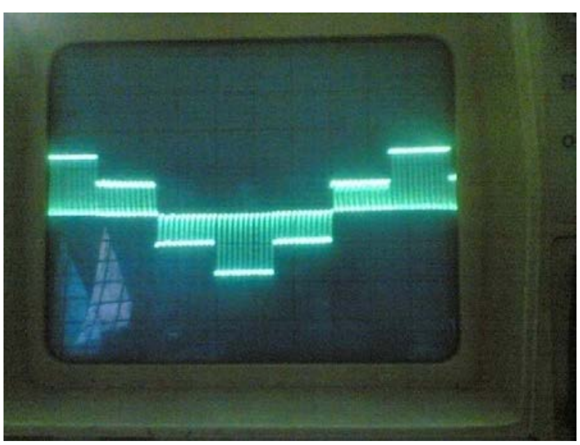

Figure.12.Line voltage with r load

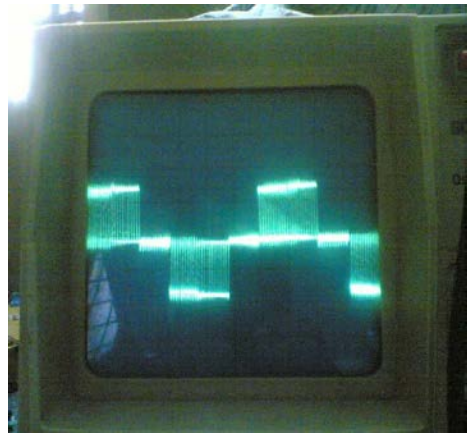

Figure.13 Phase voltage with r load

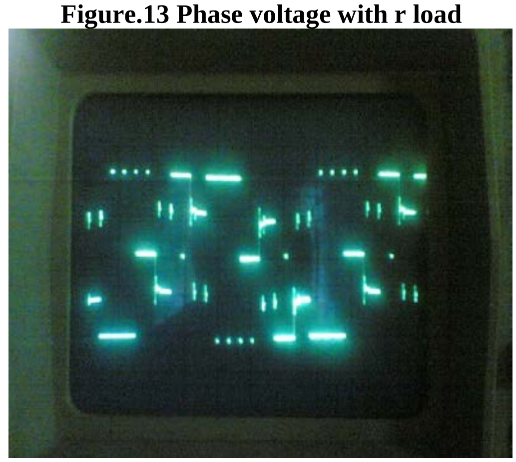

Figure.14 .Line voltage with motor load

experimental results are in line with thesimulation results.compare to other inverter, zsourceinverter reduce harmonics,noise andboost up the voltage. The notches in the waveform are due to e.m.f induced in the winding.

VI. CONCLUSIONS

This paper compares simulation results withexperimental results of Z – source invertersystem. . The Z-source converter overcomes thelimitations of the traditional V-source converterand I-source converter and provides a novelpower conversion concept. The Z-sourceconcept can be applied to all dc-to-ac, ac-to-dc,ac-to-ac, and dc-to-dc power conversion.Itimproves power factor and high reliability, andextends output voltage range. In summary, theZ-source inverter has several unique advantagesthat are very desirable for many applications.Itcan produce any desired output ac

voltage, evengreater than the line voltage.Provides ridethroughduring voltage sags without anyadditional circuits and energy storage.Minimizesthe motor ratings to deliver a requiredpower.Reduces in-rush and harmoniccurrent.Unique drives features include buckboostinversion by single power-conversionstage, improved reliability, strong EMIimmunity and low EMI.

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