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Fuzzy Logic Controlled Current Source- Quasi ZSI Fed IM

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Abstract-Quasi ZSI are used for induction motors operating at low input voltage. This work deals with comparison of FLC & PI controlled current fed quasi ZSI fed IMdrive systems. Open loop and closed loop systems are simulated by considering step change in load. The results of open loop and closed loop systems are compared. The objective of this work is to improve the dynamic response of CFQZSI using FLC. The time responses of PI and FLC controlled closed loop systems are also compared. Fuzzy logic controlled system is proposed to improve the dynamic response of CFQZSI fed induction drive system. Design and simulation results are presented to demonstrate the new features. FLC is observed to provide better control the another controllers and it also has improved damping characteristics.

The hardware is fabricated and the experimental results are compared with the simulation results.

I. INTRODUCTION

The combination of boost converter and voltage source inverter result in Z source inverter. The inverter is capable of stepping down and stepping up the input voltage. According to Panthee the power conditioning of renewable source system can be improved by controlling the Z source inverter. According to Peng. Current fed quasi z source inverter in HEV drive system Harmonics could beminimizedin vector modification. As per Tang Advanced z source inverter is responsible to produce reduced z source capacitor voltage stress and soft start capability. Analysis and design of bi-directional Z-source inverter for Electrical vehicle Xu. Comparative evaluation of modified PWM Z-source inverter with respect to various load applications and demand is analyzed A. Krishnan .Pulse width modulation of Z- source inverter is given by Li . Harmonic control of Z – source inverter for UPS applications is given by Kulka . Photovoltaic grid connected system based on cascaded quasi –Z source is better simulated Aravind[8]. Analysis of sinusoidal pulse width modulation control strategies for quasi Z –Source Inverter is given by Das .Four quasi ZSIis given by Peng . Current fed quasi Z source inverter with voltage buck boost and regeneration capability is given by Lei . Carrier based PWM VSI over modulation strategies analyses, comparison and design is given by Lipo . PWM switching strategies for current fed inverter drivers given by Bowes.Natural current balancing of multicell current source converters is given by McGrath Ang Zsourcecurrenttype inverters: digital modulation and logic implementations are calculated. Three phase dual buck inverter with unified pulse width modulation is discussed by Sun . A High efficiency A.C / D.C converter with quasi activeisanalyzedbyAthab.Powerfactor correction and its methodologies are discussed Athab . Design of asingle phase rectifier with improved power factor and low THD using boost converter techniques discussed Taib. A novel common power factor correction scheme for homes and offices Basu. Single phase power factor correction is analyzed Cobos .Novelhigh-efficiencystepupconverter Tseng. A.C – A.C resonant converter. For induction heatingtheclosedloopcontrolledis modified to improvise Reddy . pulse controller fed induction heater is controlled with Embedded system Reddy .According to Reddy Embedded controlled isolated bridge DC-DC converter with Fly back Snubber. PIC based implementationofZV.ZCSinterleavedboost converter is given by Kirubakaran.To the authors knowledge, the literature does not deal with current fed QZSI based IMdrive and the comparison of PI and FLC based QZSI system .This work compares the dynamic response of PI based system with FLC based system. This work proposes FLC based QZSI for the control of inductionmotor.

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I. Z SOURCEINVERTER

The problems of traditional source inverters can be overcome by Z Source Inverter. This Z source inverter employs a unique Z network coupled with the inverter main circuit to the power source. The comparison of this inverter with the traditiona ltype ha sit shown specificfeatures.3ph A.C.supplyissuppliedtotherectifier,whichwould convertthreephaseA.C. to D.C. The DC rectified is now fed to an inverter through an Z network. The output of Z inverter is now fed to the IMas input. The blocks are explained using the diagram shown in Fig.1.

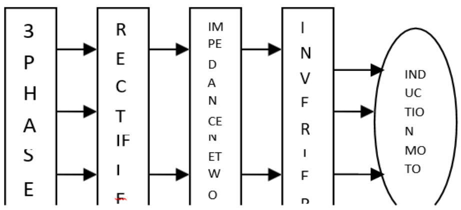

Fig1: Block Diagram of IMDrive System

II. MATHEMATICAL ANALYSIS

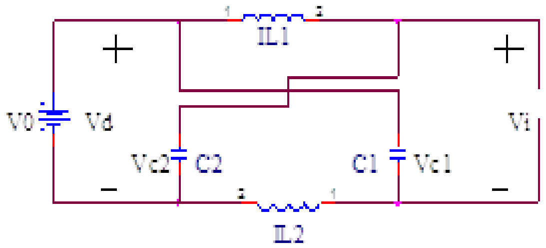

Fig2: Z N/W

Assume inductors L_1& L_2Capacitors (C_1& C_2) bothhas the same valuesrespectively.L_1& L_2 –arm series inductors; V_1 is input supply ;C_1 and C_2 –arm parallel Capacitors; V_2 is output voltage;

V_{DC}= [1/[1-2D]]*Vin [1]

L= [D_0 [1-D_0] T*V_0] / [[1-2D]*[ΔI_L]] [2]

C = I_0D T_S /ΔV_C [3]

The torque equation for IMis as follows:

$T_d - T_L = J\, d\omega/dt + B\omega$ [4]

$T = V^2 S r_2\, r_2 / (\sqrt{(S^2 X^2 + r^2)})$ [5]

TABLE 1 : SIMULATION PARAMETRES

PARAMETER	VALUE
Vin	230v
L1,L2,L3	4.8MH
C01,C02	100PF
C1,C2	4000UF
Motor	1500rpm,0.5hp
MOSFET(IRF840)	500V/8A
DIODE	230V/1A
V0	415V

The parameters used for simulation are obtained using the above formulae.Block diagram of the proposed QZSI system is shown in Fig.3.The speed of the IMis observed and it is made compared withthereferencespeed.Thedifferenceerror isgiven to the FLC. The microcontroller generates the pulses with requiredwidth.

IV. SIMULATION RESULTS

Open loop controlled drive system with step change in load is shown in Fig.4.The parameters used for simulations are given in Table-I

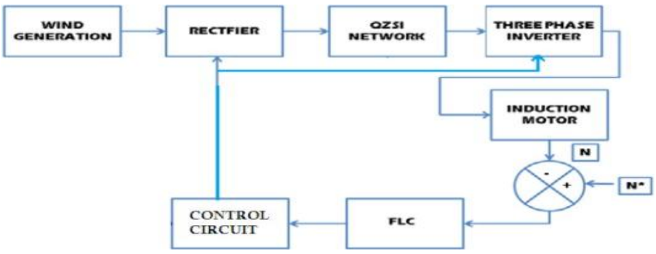

Fig3: Block Diagram of Proposed QZSI system

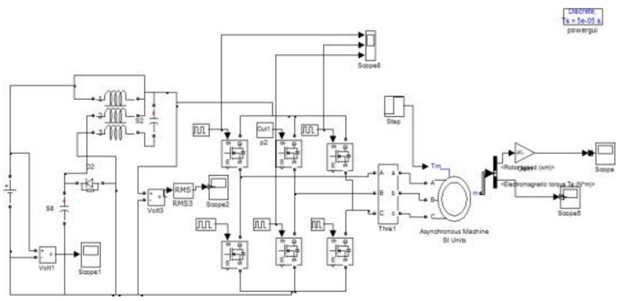

Fig. 4 Open loop system with step changein Torque.

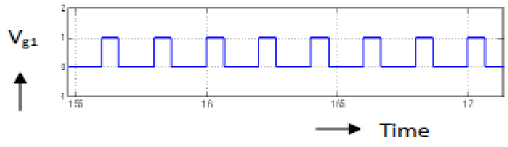

Fig. 5 Switching pulse for M1

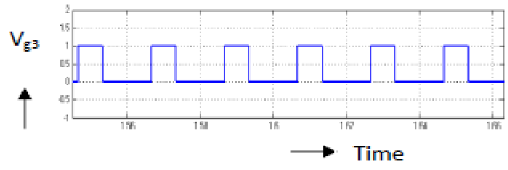

Fig. 6 Switching pattern for M3

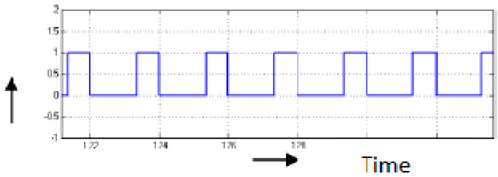

Fig. 7 Switching pattern for M5

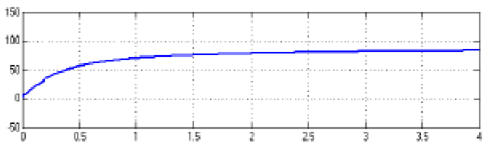

Fig. 8 Output voltage - Quasi Z-source

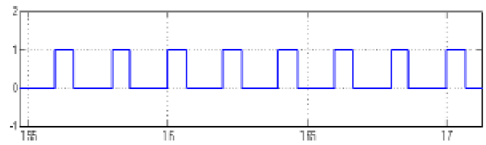

Fig.9 Switching Pulse for M6

The output of DC supply is applied to the QZ network and its output is fed to the inverter. The output of the inverter is givento the three phase induction motor. The speed response isshown in Fig.10. The speed decreases due to the increase in the load torque. The speed decreases from 1490 RPM to 1250 RPM. The torque response is shown in Fig. 11. The torque increases from 2 to 7 Nm.

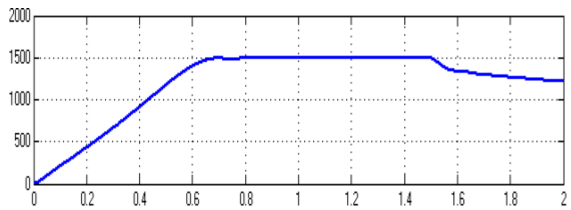

Fig. 10 Speed Response

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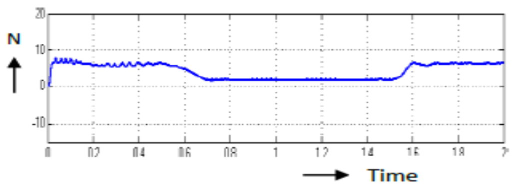

Fig.11 Torque Response

Closed loop PI controlled system is projected in Fig.12. Real-time speed is compared with the set speed and the error is applied to a PI controller.TheoutputofPIcontrollerupdates the pulse width. The speed response is shown in Fig.13. The speed reduces and reaches set value. The torque developed is shown inFig.

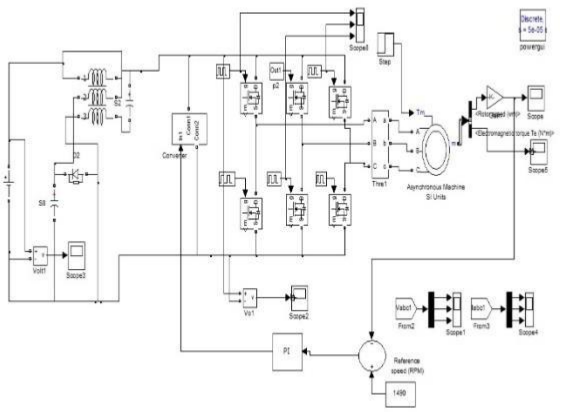

Fig. 12 Closed loop system with PI controller

A control logic is selected using if then else rules after defining the sets. Rules are developed based on knowledge aboutsystem. The output variables are connected into disp values to control the pulse width of gate pulses applied to the switching of QZSI.The PI controller is replaced by FLC. The speed and torque responses are analyzed in Fig.15 and 16 respectively. It can be noted that the speed response is smoother with FLC. The speed reaches set value and the torque oscillations are minimized. The summary of dynamic responses with PI and FLC is given in Table1. Settling time is reduced from 1.35 to 0.23 seconds. Steady state error is reduced from 25 RPM to 0.08 RPM by replacing PI withFLC.

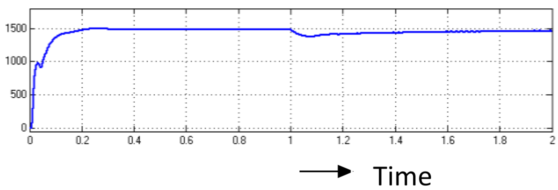

Fig. 13 Speed Response

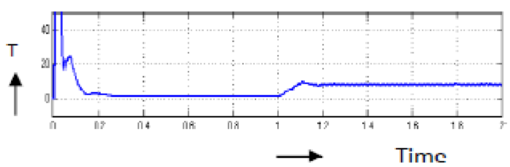

Fig. 14 Torque Response

TABLE 2: Summary of DynamicResponses with PI and FLC

Controller	Rise time (s)	Settling time (s)	Steady state error (RPM)
PI	0.17	1.35	25
FUZZY	0.15	0.23	0.08

The PI controller is replaced by fuzzy logic controller. The inputs to FLC are error andits derivative. The input variables 1 and 2 are delineatedinFig.17andFig.18.TheOutput- variable is shown in Fig 19. The Fuzzy rule Base is given inTable-3.

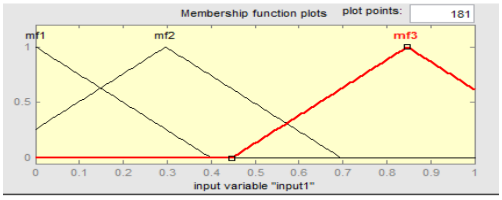

Fig. 17Input-variable-1

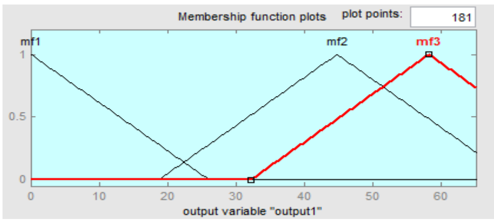

Fig. 18 Input-variable2

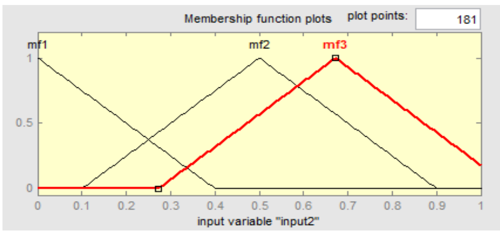

Fig. 19 Output-variable 1

Table 3: Fuzzy Rule Base

e/Δe	PL	PM	PH
PL	PH	PM	PL
PM	PL	Z	PH
PH	Z	PM	PH

V. EXPERIMENTALRESULTS

The hardware is prepared and testified in the laboratory. The experimental prototype is shown in Fig.20. The hardware consists of control board and inverter board. Switching pulse for M1 and output of driver are shown in Figs.21 and 22 respectively. Switching pulse and driver output for M3 are shown in Figs.23 and 24 respectively. Switching pulse and driver output for M5 are shown in Figs. 25 and 26 respectively. The output voltage of QZ network is shown in Fig.27. The voltage output of inverter is shown in Fig.28. The details of hardware components are given in Table 4.

Table 4: Hardware Parameters

PARAMETER	VALUE
Vin	48v
L_1,L_2,L_3	5MH
C01,C02	100PF
C1	2200UF

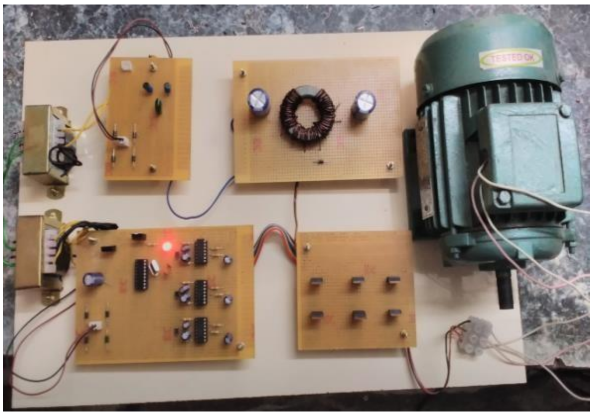

Fig.20 Experimental setup

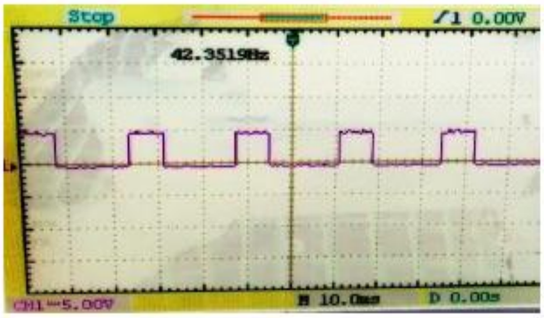

Fig.21 Switching - pulse for M1

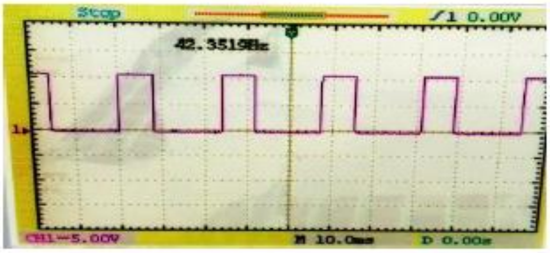

Fig.22 Output pulse for driver of M1

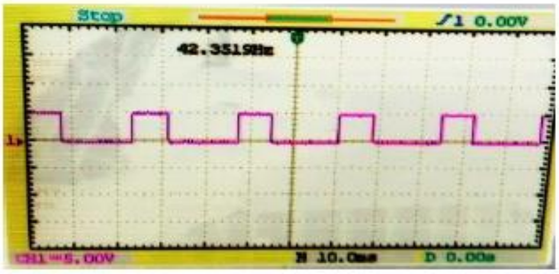

Fig.23 Switching- pulse for M3

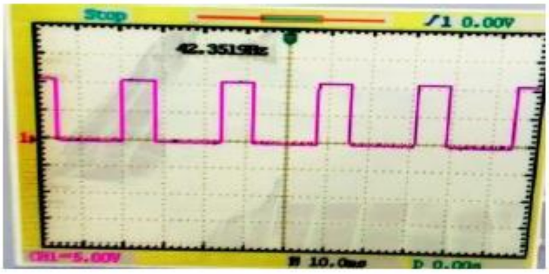

Fig.24 Output pulse from driver of M3

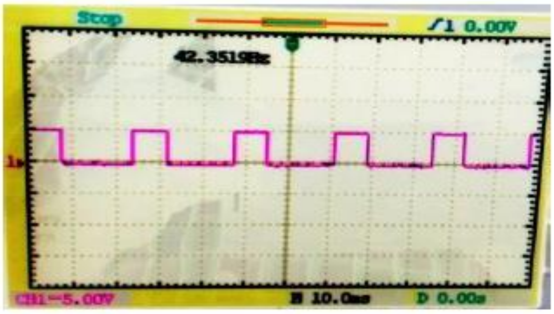

Fig.25 Switching - pulse for M5

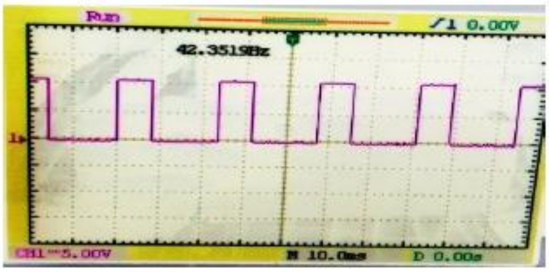

Fig.26 Output pulse for driver M5

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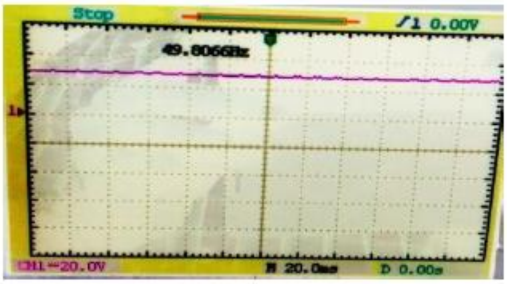

Fig.27 Output voltage

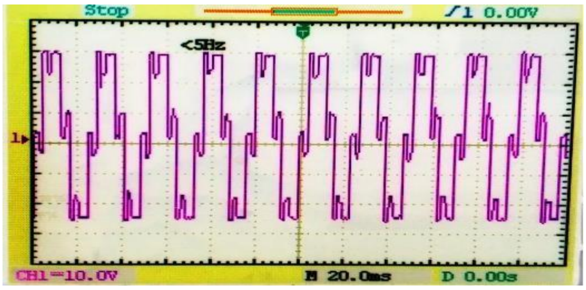

Fig.28 Output voltage of inverter

Complete hardware is shown in Fig.28. Two voltageregulationsareusedtosupply5Vand 12 V for PIC and driver respectively. Port B of PIC is used for generating driving pulses. Threedriversareusedtoamplifythepulsesto the level of 10V.

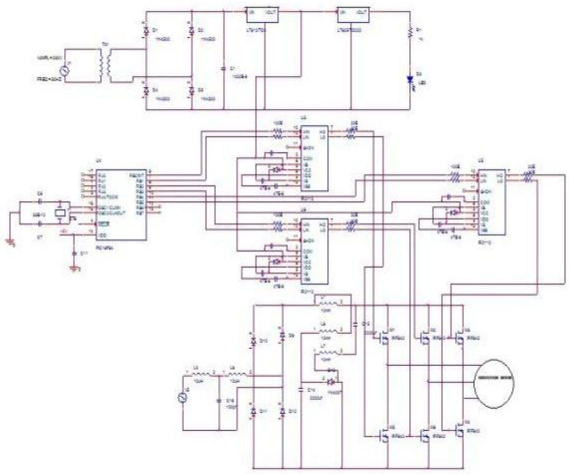

Fig. 12 Closed loop system with PI controller

VI. CONCLUSION

This work has reviewed various controllers for QZSI fed IMin closed loop. The PI and FLC controlled current fed QZSI based IMdrivesaresuccessfullydesigned,modeledand simulated successfully. Fuzzy rules are implemented to control pulse width of QZSI inverter to improve stability. The results of simulation are compared. The studyindicates that FLC based system gives superior response since settling time and steady state error are reduced. The experimental results are similar to the simulation results. The disadvantage of QZSI is that it requires two capacitors and a coupledinductor.

ThisworkdealswithcomparisonofPI and FLC controlled drive systems. The comparison between FLC & ANN based drives will be done in nearfuture.

Appendix I -List ofcomponents

S.No	Name	Rating	Type
1	Capacitor	1.00E-03	Electrolytic
2	Capacitor	4.70E-05	Electrolytic
3	Capacitor	3.30E-11	disc
4	Capacitor	2.20E-03	Electrolytic
5	Diode	1000V ,3A	PN Junction
6	Inductance	10uH	ferrite coil
7	MOSFET (IR840)	600V,8A	N-channel
8	Resistor	1k	Quarter watts
9	Resistor	100E	
10	Resistor	22E	
11	Regulator	12V	L7812/TO3
12	Regulator	5V	L7805/TO2 20
13	IC	IR2110	Opto-coupler
14	Pic controller	PIC16F8 4A	RISC
15	PCB	V105	General

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AUTHORS PROFILE

Mrs.Shunmugakani.P has finished her B.E in EEE from ManonmaniumSundaranar University, Tamil Nadu in the year of 2004 and her masters M.E in Power Electronics and Industrial Drives from Sathyabama University, Tamil Nadu in the year of 2008. She is currently doing her research at Sathyabama University Chennai,India. Her research specialization includes Z source inverter fed induction motor drives. She has published many papers in the indexed Journals. She has 15 years of experience in the Teaching field which has encouraged her more in her research areas.

Dr.D.Kirubakaran has awardedhis Ph.D from Anna University in 2010 and M.E. degree from Bharathidasan University in 2000. His area of specialization Includes AC-AC converters for induction heating, Non conventional energy sources. He is presently guiding ten research scholars and has published more than 30 papers. He has published many papers in scopus indexed Journals. He has more than 15 years of Teaching experiences. His major achievements enrolled many betterment in the students profile. He has been invited as Special Guest and speaker for many conferences and workshops. Has played vital role in the anna university examinations. His contributions are not ended only on those, guided effectively many scholars and produced many research experts.