International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 09 Issue: 03 | Mar 2022 www.irjet.net p-ISSN: 2395-0072

CONTROL OF ASYNCHRONOUS MOTOR WITH Z- SOURCE INVERTER

Aboli M. Dobale[1], Dr. Rashmi A. Keswani[2]

[1]PG Student, M. Tech IDC, Priyadarshini College of Engineering, Nagpur, Maharashtra, India.
[2]Associate Professor, Department of Electrical Engineering, Priyadarshini College of Engineering, Nagpur, Maharashtra, India.

Abstract - *The use of induction motors [or Asynchronous motors] in industrial, commercial, and residential sectors has been increased greatly from the day of its evolution. The reason behind is induction motor's having many advantages is their robust construction, self-starting capability, highly reliable, less expensive, and more efficiency. Generally, 3 Phase Induction Motor is widely used in the industry sector. So, an extremely efficient drive circuit arrangement is required for the 3-phase induction motor. Presently, conventional voltage source inverters (VSI) and current source inverters (CSI) are used in the induction motor drive circuit. But, these traditional inverters have numerous limitations and fail to perform at our desired level. In this research, the drawbacks of traditional inverters are eliminated by replacing them with Z-source inverters (ZSI). This paper mainly focuses on effective control of the drive system with a Z-Source inverter (ZSI).*

Key Words: 3-phase IM, voltage source inverter, Z source inverter, Controller, SPWM.

1.INTRODUCTION

In power electronics circuits, traditional inverter topologies [voltage source inverters (VSI) and current source inverters (CSI)] are commonly used for power conversion. However, these inverters have drawbacks, such as the fact that they can only perform a buck or a boost operation, not both. The current-source inverter main power circuit cannot be used for the voltage-source inverter or vice versa; i.e., these traditional inverter power circuits cannot be exchangeable. The electromagnetic interference (EMI) noise is created due to shoot-through and open circuit problems in voltage source inverters and current source inverters, which reduce the inverter's reliability. These are all limitations overcome by using the Z-Source Inverter. In this project, the performance of two Z-Source inverter-fed induction motor drive systems with and without a controller is compared to that of a Voltage Source inverter-fed induction motor drive system. Outcomes from all the systems are to be analyzed and study.

2. RESEARCH METHODOLOGY

2.1. Voltage -Source Inverter fed 3 phase Induction Motor:-

The Block Diagram of Voltage -Source Inverter fed 3 phase Induction Motor consists of three main parts. The DC voltage source, 3 phase Voltage Source inverter, and 3 phase induction motor. In a traditional voltage source system, constant dc voltage is applied to 3 phase inverter. The inverter consists of 6 IGBT switches, for gate pulse triggering here SPWM technique is used. SPWM technique compares the sine wave and carrier signal wave using relational operator, and output is given to the inverter pulses. The output of the inverter is fed to a three-phase induction motor, and the output performance characteristics of the three-phase induction motor [Stator current, Torque, and Speed] are studied and analyzed.

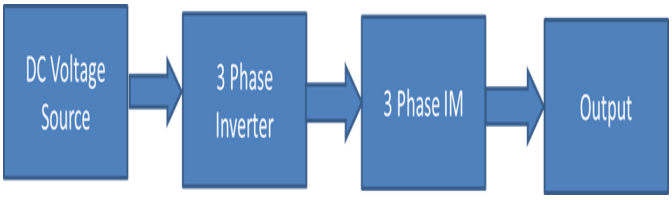

Fig.-1: Block Diagram of Voltage -Source Inverter fed 3 phase Induction Motor

2.2. Z-source Inverter fed 3 phase Induction Motor without Controller:-

Block Diagram of the Z-source Inverter fed 3-phase induction motor without Controller consists of Four main parts as shown in Fig.2. The DC voltage source, Z-source network, 3 phase Voltage Source inverter, and 3 phase induction motor. The Z-Source Inverter consists of a special impedance network that consists of 2 inductors and 2 capacitor topologies. This z-source network is connected between the dc voltage source and 3 phase inverter. The limitations of the traditional inverter are overcome by using the Z-Source Inverter. In this system constant dc supply is fed to z-source network and 3 phase inverter, this inverter converts the constant dc supply to variable ac supply. The inverter consists of 6 IGBT switches, for gate pulse triggering here SPWM technique is used. A variable ac supply is fed to 3 a phase induction motor. Output characteristics of [Stator current, Torque, speed] 3 phase Induction Motor is to studied and analyzed.

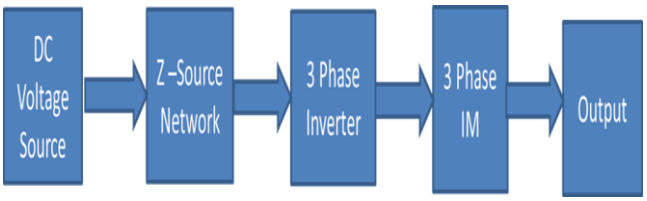

Fig-2 : Block Diagram of Z-source Inverter fed 3 phase Induction Motor without Controller

2.3. Z-source Inverter fed 3 phase Induction Motor with Controller:-

Block Diagram of a Z-source Inverter fed 3 phase induction motor with a Controller consists of Five main parts as shown in Fig.3. The DC voltage source, Z-source network, 3 phase Voltage Source inverter,3 phase induction motor, and PI Controller. This system construction and working are mostly similar to Z-source Inverter fed 3-phase induction motor without Controller but here additional PI controller is connected in the system. In this system, 3 phase induction motor speed is continuously measured and compared with the reference speed. A discrepancy in actual speed and reference speed error signal is shown by PI Controller. The output of the PI controller is fed to 3 phase induction motor at an appropriate speed. Output characteristics [Stator current, Torque, speed] of 3 phase Induction Motor can be controlled as compared to Voltage -Source Inverter fed 3 phase Induction Motor system and Z-source Inverter fed IM without Controller system.

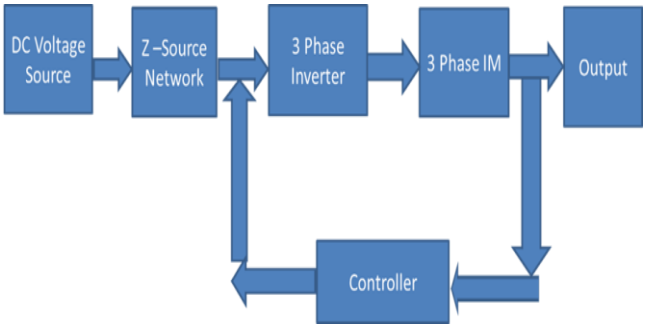

Fig-3 : Block Diagram of Z-source Inverter fed 3 phase Induction Motor with Controller

3. MATLAB SIMULATION AND ANALYSIS

3.1. MATLAB/ Simulink Model implementation of Voltage -Source Inverter fed 3 phase Induction Motor:-

In this section, MATLAB/Simulink is used for the simulation of Voltage -Source Inverter fed 3 phase Induction Motor. The related methodology which is used to implement this model has been discussed in Sections 2.1. Fig. 4 shows the Simulink model of the Voltage -Source Inverter fed 3 phase Induction Motor.

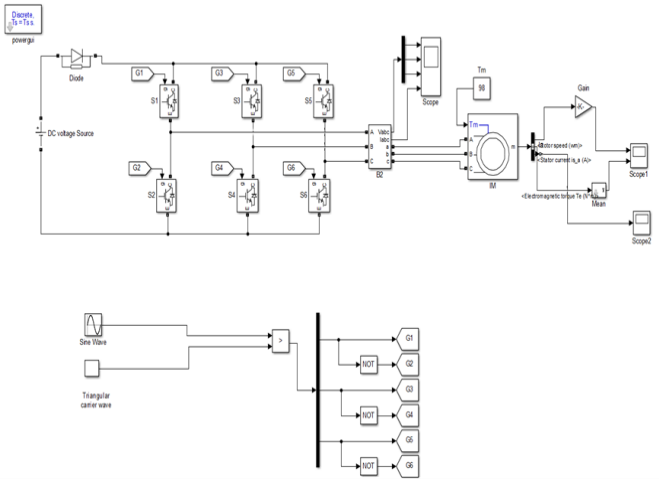

Fig-4: Simulation model of Voltage source Inverter fed 3 phase Induction Motor

3.2. MATLAB/ Simulink Model implementation of Z-source Inverter fed 3 phase Induction Motor without Controller:-

In this section, MATLAB/Simulink is used for Z-source Inverter fed 3 phase Induction Motor without Controller. This model consists of a unique z – source network which is connected between constant dc voltage and 3 phase inverter. The related techniques which are used to implement this model have been discussed in Sections 2.1 and 2.2. Fig. 5 shows the Simulink model of the Z-source Inverter fed 3 phase Induction Motor without Controller.

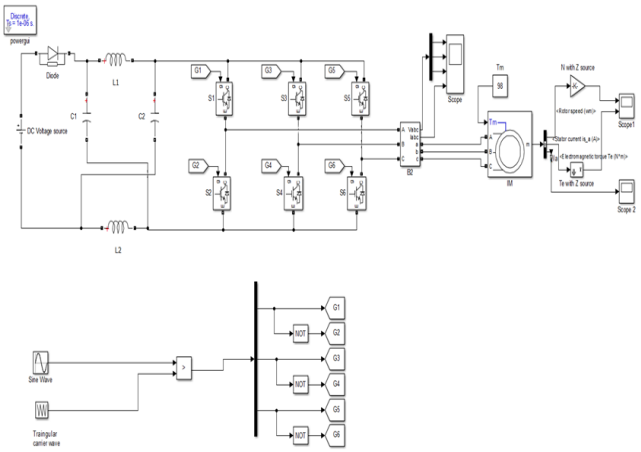

Fig- 5 : Simulink model of the Z-source Inverter fed 3 phase Induction Motor without Controller.

3.3. MATLAB/ Simulink Model implementation of Z-source Inverter fed 3 phase Induction Motor with Controller:-

In this section, MATLAB/Simulink is used for Z-source Inverter fed 3 phase Induction Motor with Controller. The corresponding method which is used to implement this model has been discussed in Sections 2.3 and 2.1. Figure 6 shows the Simulink model of the Z-source Inverter fed 3 phase Induction Motor with Controller.

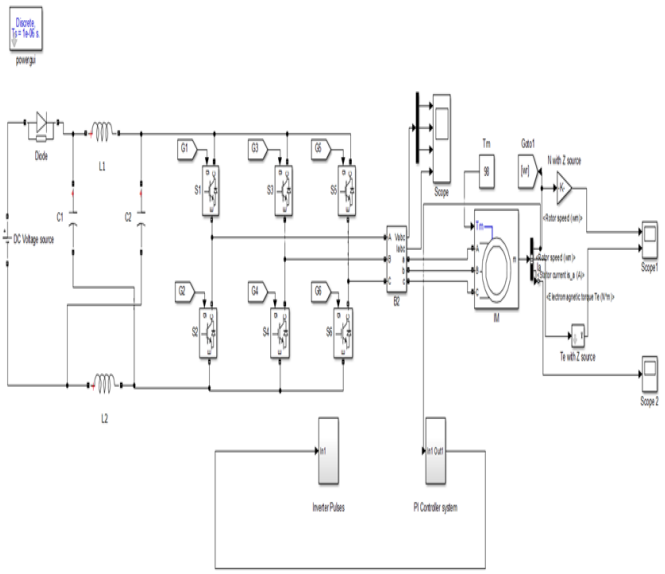

Fig- 6 : Simulink model of the Z-source Inverter fed 3 phase Induction Motor with Controller.

3.4 Induction motor rating :-

The motor used is 3- phase Star Connected Induction motor, Rotor type- Squirrel cage, with the rating as – [4 Pole, 20 HP, 15 KW, 400V, 50HZ, 1460 RPM,98 Nm, 36 A]

Table 1: Induction motor rating

SN.	Parameters	Rating
1	Stator Resistance [Rs]	0.2147 Ω
2	Rotor Resistance [Rr]	0.2205 Ω
3	Stator Leakage Inductance[Lls]	0.991 mH
4	Rotor Leakage Inductance[Llr]	0.991 mH
5	Magnetizing Inductance [Lm]	64.19 mH
6	Stator Reactance [Xs]	0.31133 Ω
7	Rotor Reactance [Xr]	0.31133 Ω

4. RESULTS AND DISCUSSION

The output waveform of VSI fed IM system, ZSI fed without Controller, and ZSI fed with Controller system in the MATLAB simulation is. The waveform of Speed Vs Time, Electromagnetic Torque Vs Time, Stator Current Vs Time are discussed here.

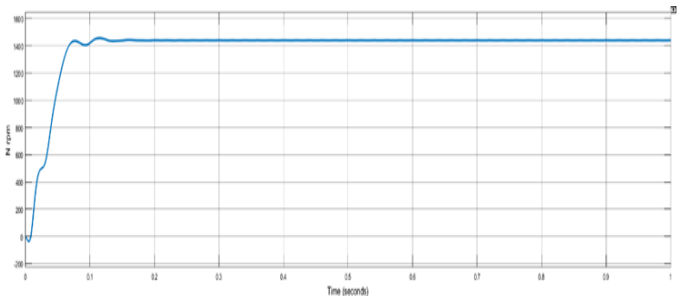

Fig-7: Rotor speed Vs Time curve of Voltage source inverter fed Induction motor

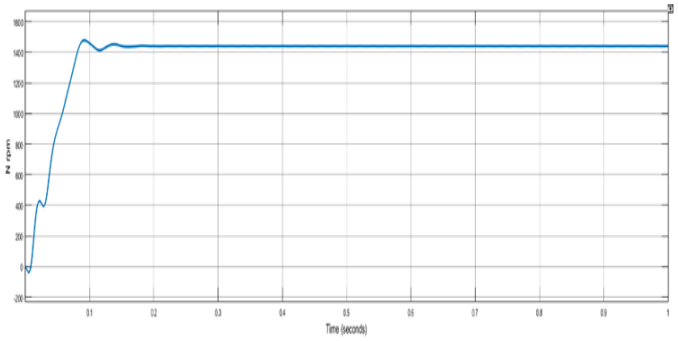

Fig-8: Rotor speed Vs Time curve of Z-source Inverter fed Induction Motor without Controller.

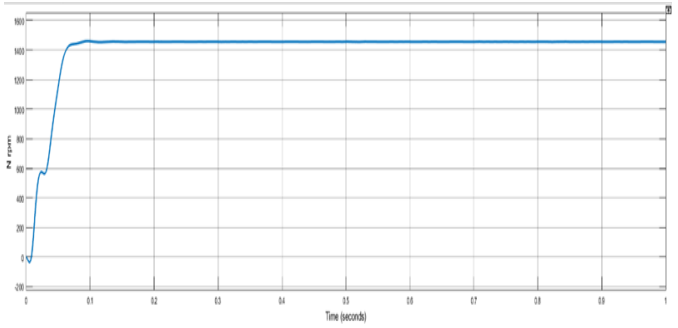

Fig-9: Rotor speed Vs Time curve of Z-source Inverter fed Induction Motor with Controller.

The Rotor speed Vs Time curve of VSI fed IM system, ZSI fed without Controller, and ZSI fed with Controller system are shown in fig.7, fig.8 & fig.9 respectively. In VSI fed IM system Oscillation of rotor speed is more than, ZSI fed without Controller and ZSI fed with Controller system.

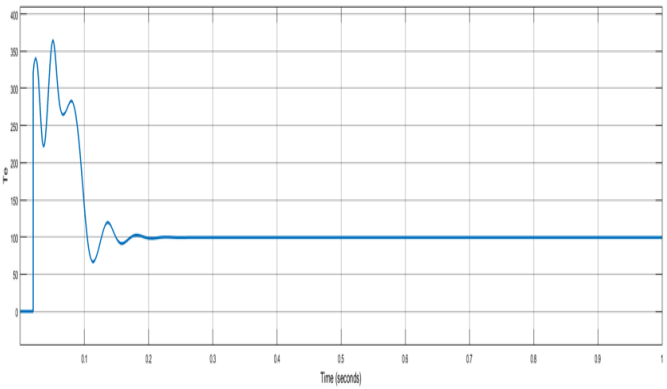

Fig-10: Electromagnetic Torque Vs Time curve of Voltage source inverter fed Induction motor

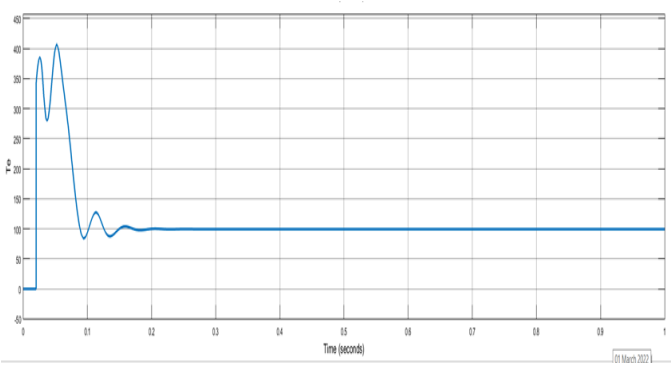

Fig-11: Electromagnetic Torque Vs Time of Z-source Inverter fed Induction Motor without Controller.

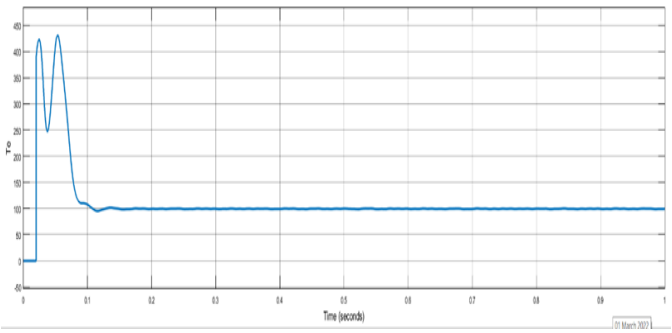

Fig-12: Electromagnetic Torque Vs Time of Z-source Inverter fed Induction Motor with Controller.

The Electromagnetic Torque Vs time curve of VSI fed IM system, ZSI fed without Controller and ZSI fed with Controller system is shown in fig.10, fig,11 & fig.12 respectively. In ZSI fed without Controller and ZSI fed with Controller system time rate and oscillation of generating torque is less. As a result, not only does the motor run at the best speed quality but also power regenerative capacity is increases as compared to VSI fed IM system.

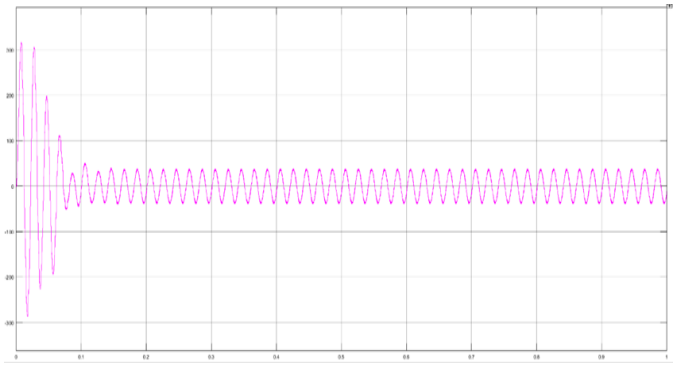

Fig-13: Stator Current Vs Time curve of Voltage source inverter fed Induction motor

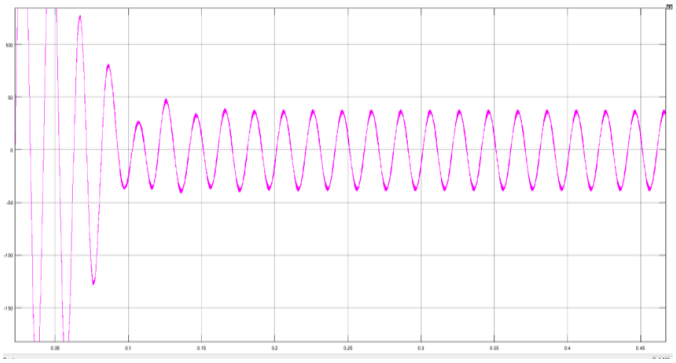

Fig-14: Stator current Vs Time of Z-source Inverter fed Induction Motor without Controller

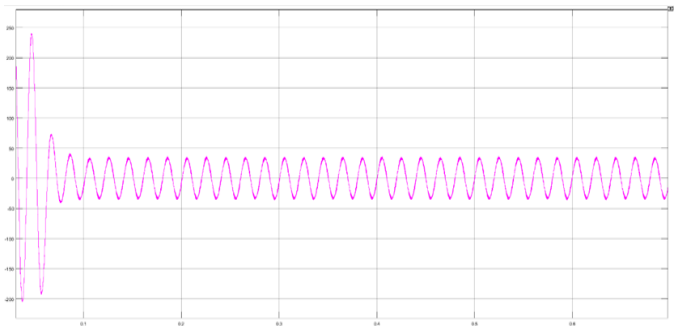

Fig-15: Stator current Vs Time of Z-source Inverter fed Induction Motor with Controller

The Stator current Vs Time curve of VSI fed IM system, ZSI fed without Controller and ZSI fed with Controller system is shown fig, 13, fig.14 & fig.15 respectively. In ZSI fed without Controller and ZSI fed with Controller system obtained smooth output waveform as well as for settling and rising time is less as compared to VSI fed IM system.

Observation Table2: Based on Rise time [second]:-

Inverter	3-phase Induction motor parameters		
	In Speed	In Torque	In Stator current

VSI	0.095 sec	0.054 sec	0.008 sec
ZSI Without Controller	0.085 sec	0.053 sec	0.007 sec
ZSI With Controller	0.075 sec	0.052 sec	0.005 sec

ObservationTable3: Based on Settling time [second]:-

Inverter	**3-phase Induction motor parameters**		
	In Speed	**In Torque**	**In Stator current**
VSI	0.18 sec	0.18 sec	0.17 sec
ZSI Without Controller	0.16 sec	0.16 sec	0.15 sec
ZSI With Controller	0.13 sec	0.13 sec	0.11 sec

5. CONCLUSION

The performance of two Z-Source inverter-fed induction motor drive systems with and without controller and Voltage Source inverter-fed induction motor drive system modelling using MATLAB/ Simulink and Outcomes from all the systems are compared and discussed. From the observations and output performance characteristics, it can be concluded that all limitations of the voltage source inverters are overcomed by using the Z-Source Inverter. The Z-Source inverter-fed induction motor drive systems with and without a controller has less torque ripples, improved stator current quality, better settling time, and obtained smooth output waveforms for the same value of speed [1460 RPM] Electromagnetic torque [98 NM], Stator current [36 A] as compared to Voltage Source inverter-fed induction motor drive system

REFERENCES

[1] Basanti Bhagat, Gurpreet Singh, "Performance and Evaluation of Voltage Source Inverter Fed Induction Motor Drive", International Research Journal of Engineering and Technology (IRJET) ISSN : 2395-0056, Vol. 6, Issue 2 , Feb 2019.

[2] Anant Thakur, "Z-Source Inverter Fed Asynchronous Motor Drive", International Journal of Trend in Scientific Research and Development (IJTSRD) ISSN: 2456-6470, Vol. 4, Issue 1 , December 2019.

[3] R. Malathi , M. Rathina Kumar,R. The Gobi, "Closed-loop Control Of ZSI Fed Induction Motor Drive Using PI And Fuzzy Logic Controllers", International Journal for Research in Engineering Application and Management (IJREAM) ISSN: 2454-9150, Vol. 4, Issue 6, September 2018.

[4] R.Kapil, Dr.Vijayaragavan, "Z-Source Inverter Fed Three Phase Induction Motor Drive with PI and PID Controlled close closed-looptems", International Journal of Advanced Research in Electrical, Electronics, and Instrumentation Engineering (IJAREEIE) ISSN: 2320-3765, Vol. 6, Issue 10, October 2017.

[5] R.A.Keswani, U.E.Hiwase, "MRA analysis for fault identification in multilevel inverter" International Research Journal of Engineering and Technology (IRJET), Vol.4, No.6, 2017, pp.2168-2171

[6] Omar Ellabban; Joeri Van Mierlo and Philippe Lataire, "Comparison between Different PWM Control Methods for Different Z-source Inverter Topologies", The 13th European Conference on Power Electronics and Applications. 8-1, EPE '090. (2009).

[7] Mahima Sharma, Mahendra Lalwani, "Performance Evaluation of Three-Phase Induction Motor Drive Fed from Z-source Inverter", International Journal of Applied Engineering Research ISSN 0973-4562 Volume 13, Number 8 (2018).

[8] Fang Zheng Peng; Alan Joseph; JinWan; Miaosen Shen; Lihua Chen, Zhiguo Pan; Eduardo Ortiz-Rivera and Yi Huang "Z-source Inverter for Motor Drives", IEEE Transactions On Power Electronics, Vol. 20, No. 4. (2005).

[9] Baba, M.; Lascu, C. and Boldea I. "Z converter control of a V/F induction motor drive" IEEE conf. On Industry Applications Conference (2012).

[10] Poh Chiang Loh; Mahinda Vilathgamuwa, D.; YueSen Lai; Geok Tin Chua and Yunwei Li "Pulse-Width Modulation of Z-source Inverters", IEEE Transactions on Power Electronics, Vol. 20, No. 6. (2005).