ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering
Vol. 2, Issue 5, May 2013

Performance Analysis of Fuzzy Flatness Based Speed Control of Three Phase Induction Motor

C.Sasikumar[1], Dr.C.Muniraj[2]

PG Scholar, Department of Electrical and Electronics Engineering, K.S.Rangasamy college of Technology, Tiruchengode,India [1]

Associate Professor, Department of Electrical and Electronics Engineering, K.S.Rangasamy college of Technology, Tiruchengode, India[2]

Abstract: Induction motor plays a vital role in engineering and industry. Induction motor offer a convenient means for controlling the operation of different equipment used in industry. Induction motor input supply will give from the voltage source inverter for its speed control purpose. If we connect induction motor directly to the AC supply its speed control will not applicable, so that we go inverter fed induction motor speed control. Gate pulse has been given by using FPGA processor. Fuzzy flatness program has been flashed in the FPGA processor for generating the gate pulse for VSI inverter. FPGA processor is directly fed to opto-coupler and the driver circuit and then it has given to VSI inverter. Her closed loop control has been achieved by using inductive type proximity sensor. In closed loop control when input voltage has been changed but speed of the induction motor has maintained constant. Fuzzy flatness based control is applied in the speed controller of induction motor. This method gives better efficiency of induction motor speed control. Fuzzy flatness controller method for induction motor gives better performance and reduces tracking error and reduces the torque ripple.

Keywords: VSI Inverter, Fuzzy flatness control and Induction motor.

I. INTRODUCTION

Induction motors are the most frequently used machines in various electrical drives. About 70% of all industrial loads on a utility are represented by induction motors. The control task is further complicated by the fact that induction motors are subject to unknown disturbances and the parameters are of great uncertainty. We are faced then with the challenging problem of controlling a highly nonlinear system, with unknown time-varying parameters, where the regulated output, besides being unmeasurable is perturbed by an unknown additive signal. The issue of controlling electrical drives is nowadays widely solved with the so called field oriented control or vector control. However, tracking control of induction motor [3] the performance will be degraded face to motor parameter variations or unknown external disturbances. To offer control robustness with minimum complexity, have been proposed to improve the control performance. Some nonlinear control methods were applied to the speed and flux control of the induction machine.

The assumptions of different time constants of the loops or a constant rotor flux are not necessary. Fuzzy logic controller has been explained [1], [5] and [6]. The flatness property was used to control continuous nonlinear systems with good performances in term of tracking trajectory. Membership function has been [7], [8] for different function The flatness-based approach described in [2] uses the characterization of system dynamics to generate a suitable output. The flatness control in an induction motor is an important subject because of the need for improvement in operation quality. It, however, is a difficult problem for a conventional approach to achieve since the induction motor driving process is a highly nonlinear system in which many uncertain parameters are involved. Fuzzy control has adaptive capacity to time lag, nonlinearity and uncertain parameters in controlled system.

VSI fed induction motor speed control has explained [10]. A fuzzy controller for the flatness control is designed is to improve the control performance of the induction motor. Designing a fuzzy controller without using the cascade structure is possible due to the flatness of the complete machine model. Especially for small inertias this could be a promising possibility. Further investigations should be done on designing the reference trajectory generation. To exploit the possibilities the control input limitations should be directly taken into account.

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering
Vol. 2, Issue 5, May 2013

II. THREE PHASE INVERTER

The function of an inverter is to change a DC input voltage to an AC output voltage of desired frequency and magnitude. In case of 3-phase inverter, the inverter circuit changes a DC input voltage to a symmetrical AC output voltage of desired magnitude and frequency. Output voltage could be fixed or variable at a fixed or variable frequency. Variable output voltages are obtained by varying the input DC voltage with maintaining the gain of the inverter constant. Meanwhile, if the DC input voltage fixed and not controllable, variable output voltage can be obtained by varying the frequency of the inverter which is usually done by implementing PWM control within the inverter.

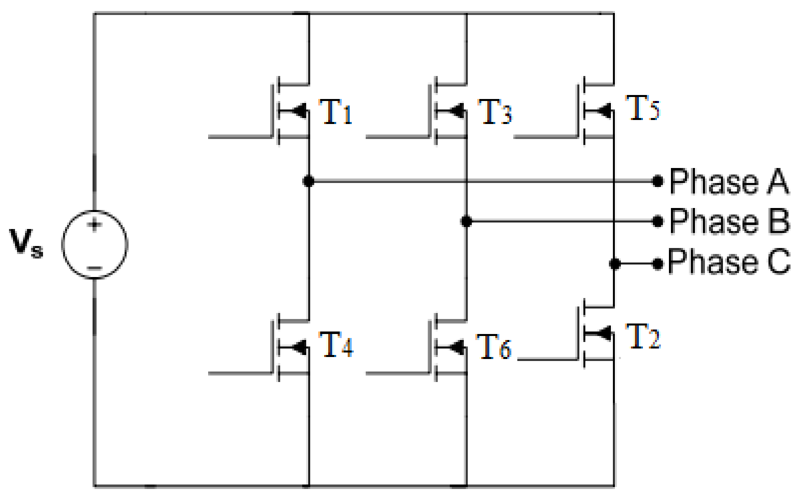

Figure 1 Voltage Source Inverter

The output voltage of an inverter has a periodic waveform which is not purely sinusoidal, but with number of techniques it can be designed to closely approximate to this desired waveform. Inverter can be built with any number of output phases. Practically, single-phase and three-phase inverters are most commonly used. It depends on the user requirement whether in the industrial applications, transportations and home appliances. In most circumstances, three-phase inverter offered better performances as compared to single-phase inverter. Power semiconductors switches are the basic building component of the inverter. Generally there were two types of inverter topology, named as Voltage Source Inverter and Current Source Inverter. Voltage waveform is the independently controlled AC output in the VSI topologies. Meanwhile, in CSI topologies, the independently controlled AC output is a current waveform. VSI can be further divided into three categories which are PWM Inverter, Square Wave Inverter and Single-phase Inverters with Voltage Cancellation. The close-up for 3-phase VSI is shown in Figure 1. The structure of VSI is more widely used in the industrial application due to the voltage source requirement.

A. THREE PHASE 120 DEGREE MODE OF OPERATION

In the three phases IGBT inverter of each conducts for 120 degree of a cycle. IGBT pair in each arm, T_1, T_4; T_3, T_6 and T_5, T_2 is turned on with a time interval of 120 degree. It means that T_1 conducts for 120 degree and T_4 for the next 120 degree of a cycle. IGBTs in the upper group, T_1, T_3, T_5 conduct at an interval of 120 degree. It implies that if T_1 is fired at ωt=0 degree. Then T_3 must be fired at ωt=120degree and T_5 at ωt=240degree. Same is true for lower group of IGBTs. On the basis of this firing scheme. In this T_1 from upper group conducts for 120 degree, T_4 for next 120degree and then again T_1 for 120degree and so on. In the second row, T_3 from the upper group is shown to start conducting 120degree after T_1 start conducting. After T_3 conducting for180degree, T_6 conducts for the next 180degree and again T_3 for the next 180degree and so on. Further, in the third row, T_5 from the upper group starts conducting 120 degree after T_3 or 240 degree after T_1.

After T_5 conduction for 120 degree, T_2 conducts for the next 120 degree, T_5 for the next 120 degree and so on. In this manner, the pattern for firing the six SCRS is identified. This table shows that T_5,T_6,T_1 should be gated for 1; T_6,T_1,T_2 for step 2.T_1,T_2,T_3 for step 3.T_2,T_3,T_4 for step 4 and so on. Thus the sequence of firing the IGBT is T_1, T_2, T_3.T_4.T_5 and T_6.

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering
Vol. 2, Issue 5, May 2013

III.SPEED CONTROLLERS

The goal of the controller is to control the speed of induction motor. Conventional and intelligent controllers are used I voltage control system. It the system having feedback loop, it is fed to the summing point to find out the change in voltage. The conventional PI controller is mostly used in industries compared to other controller, because the PI controller has advantages of both proportional and integral controllers. The output power is maintained constant, whereas the operating voltage is changed.

In automatic control systems the reference input will be an input signal proportional to desired output. The feedback signal proportional to current output of the system. The different types of conventional controllers are P, I PI, PD and PID controller. The Fuzzy Flatness control in an induction motor is an important subject because of the need for improvement in operation quality. Flatness based tracking controller is a very important tool for nonlinear controller design. The flatness property was used to control continuous nonlinear systems with good performances in term of tracking trajectory. The flatness-based approach uses the characterization of system dynamics to generate a suitable output.

A. FUZZY FLATNESS CONTROLLER

The Fuzzy Flatness control in an induction motor is an important subject because of the need for improvement in operation quality. Flatness based tracking controller is a very important tool for nonlinear controller design. The flatness property was used to control continuous nonlinear systems with good performances in term of tracking trajectory. The flatness-based approach uses the characterization of system dynamics to generate a suitable output. Differential flatness has proven to be a very powerful concept for analysis and design of open loop and stabilizing feedback tracking control for nonlinear finite dimensional systems.

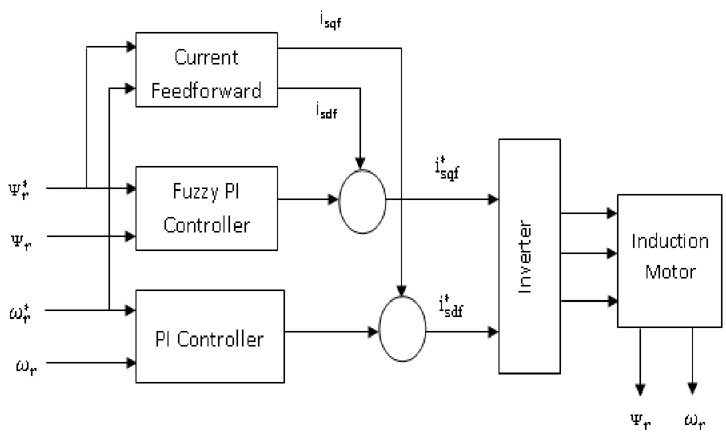

Figure 2 Fuzzy Flatness Controller

The Figure 2 shows Structure chart of an induction motor with fuzzy flatness controller. Fuzzy Flatness-based controller for induction motor vector control system. The flatness-based approach uses the characterization of system dynamics to generate a suitable output and it can control continuous nonlinear systems with good performances in term of tracking trajectory. Fuzzy logic is used to eliminate the effects of the time-varying nonlinear system. Simulation results shown that the fuzzy flatness based control scheme can improve the control performance effectively.

The property of flatness can effectively be used for designing control algorithms. In general the control structure consists of a feedforward and a feedback part. Even if the references are smooth enough deviations from perfect tracking will appear due to disturbances, model uncertainties and other perturbations. Therefore feedback is introduced. Since the system is near to the reference trajectory via feedforward, thus linearizable around it, the feedback can be designed with linear methods also for nonlinear systems. Even though the voltage-fed induction machine is flat and the application of FBC to the complete, nonlinear model would be possible, here a cascade is used due to its simplicity and comparability to the FOC.

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering
Vol. 2, Issue 5, May 2013

IV EXPERIMENTAL SETUP

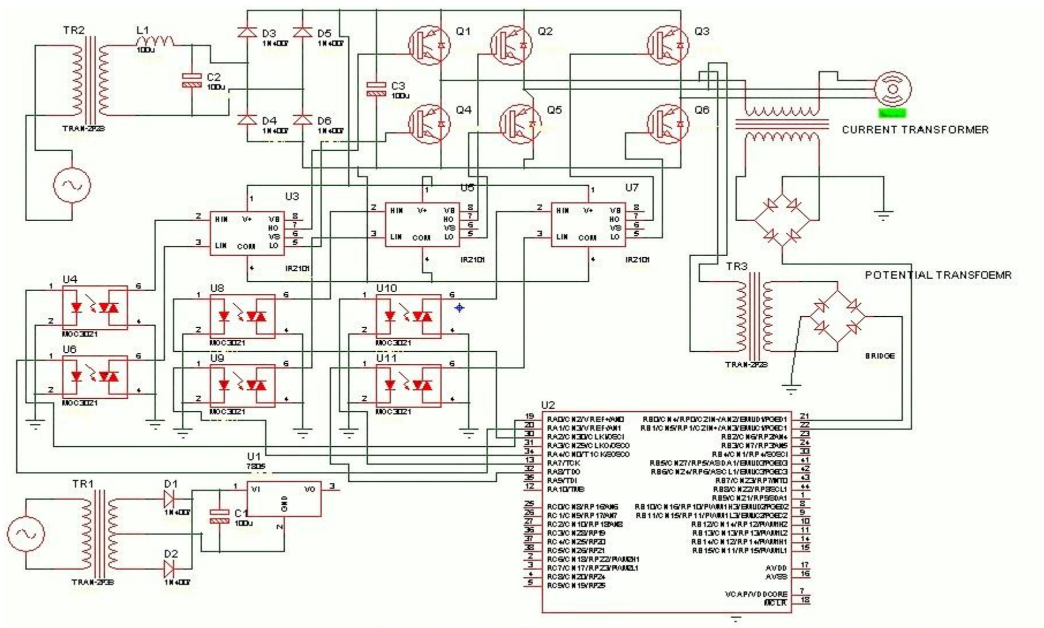

Figure 3 Circuit Diagram of Proposed Method for Induction Motor Speed Control

Figure 4. Experimental Setup

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering
Vol. 2, Issue 5, May 2013

The Figure 3 shows circuit diagram of Proposed Method for Induction Motor Speed Control. Single phase supply is given to full wave diode rectifier. The rectified supply is given to VSI inverter for inverter IGBT switch has used. Inverter output is given to induction motor. For the VSI inverter needs the gate pulse for that FPGA processor and it directly give to gate drive circuit output is fed to the VSI inverter. . Induction motor closed loop control can achieve by using proximity sensor. Through RS232 cable speed of the motor monitoring in the system. The Figure 4 shows experimental setup for induction motor.

V. EXPERIMENTAL RESULT AND ANALYSIS

A. Pulse for IGBT Switches

Pulse generation of the voltage source inverter can give by using FPGA processor. The output waveform has been taken by using DSO (Digital Storage Oscilloscope). Based on the speed variation of the induction motor closed loop control the pulse can be varied. The Figure 5 shows the input pulse for VSI inverter.

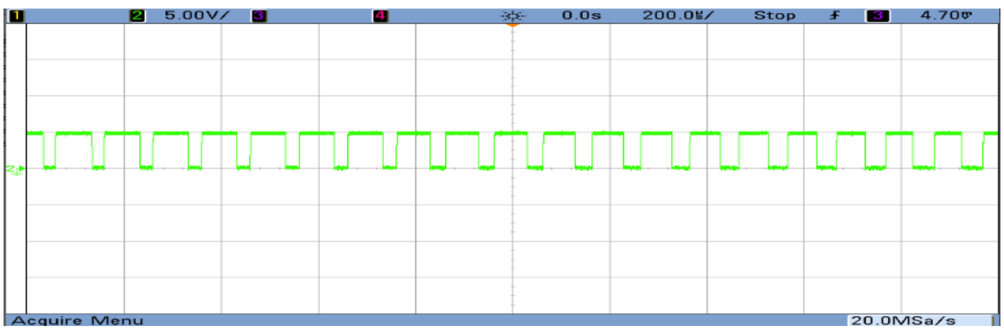

Figure 5 Pulses for IGBT Switches

B. Phase to Phase Voltage waveform

The Figure 6 shows phase to phase voltage at motor running at rated speed condition. At closed loop control the induction motor speed is constant any small voltage variation at input side. But output voltage will be maintained constant in the closed loop control of induction motor. The output waveform has been taken by using DSO (Digital Storage Oscilloscope).

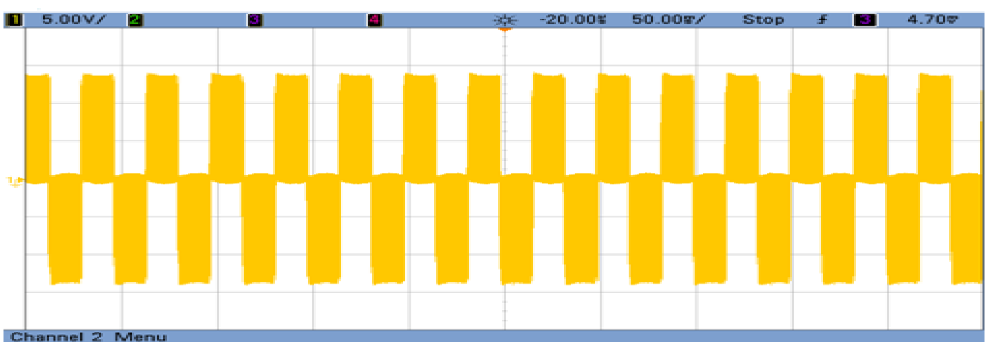

Figure 6 Phase to Phase Voltage Waveform

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering
Vol. 2, Issue 5, May 2013

C. PERFORMANCE OF FUZZY FLATNESS SPEED CONTROLLER

Performance of fuzzy flatness speed controller can be discussed. Steady state performance and transient state performance result has been discussed.

D. Steady State Performance

The Figure 7 shows the steady state performance. Speed control from 0 to 1302RPM. Initially speed has been set as 1302 RPM by using incremental key.

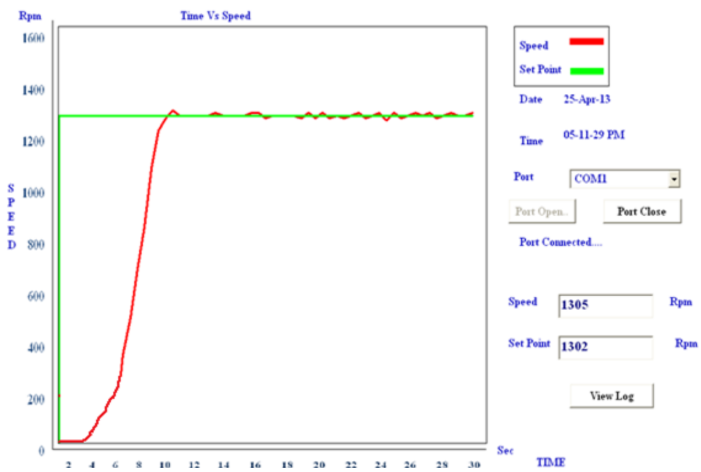

Figure 7 Steady State Performance

After that we can vary the single phase auto-transformer 0Volts to 230Volts at that same time three phase induction motor speed can vary from 0 to set speed 1302 RPM. Initially motor starts from 4seconds and it rise to attain its maximum speed 1302 at 10seconds. Total time taken to attain its set speed will be 6seconds. Maximum overshoot will be 2seconds. Speed curve between set speed and its actual speed of the induction motor has been shown and also set speed and actual speed value will be displayed. The curve shows the set speed (vs) actual speed of three phase induction motor. By using RS232 cable communication hardware to system has been interfaced. The output speed waveform can be monitoring in the system. By using VB software coding speed monitoring system has been developed.

E. Transient State Performance

Figure 8 Transient State Performance Speed Varies 1300 to 1034 RPM

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering
Vol. 2, Issue 5, May 2013

The Figure 8 shows the transient state performance speed varies 1300 to 1034 RPM. Induction motor running at 1300 RPM then by using decrement key set speed as 1034 RPM. Single phase auto-transformer constant 230Volts at that same time three phase induction motor speed can vary from 1300 RPM to set speed 1034 RPM. Set speed has been tracked and its actual speed can be varied. Initially induction motor speed 1300 RPM and it reaches 1034 RPM within 7seconds. Speed curve between set speed and its actual speed of the induction motor has been shown and also set speed and actual speed value will be displayed. The curve shows the set speed vs actual speed of three phase induction motor.

The Figure 9 shows the speed control waveform 1000 to 1310 RPM. Induction motor running at 1000 RPM then by using incremental key set speed as 1310 RPM.

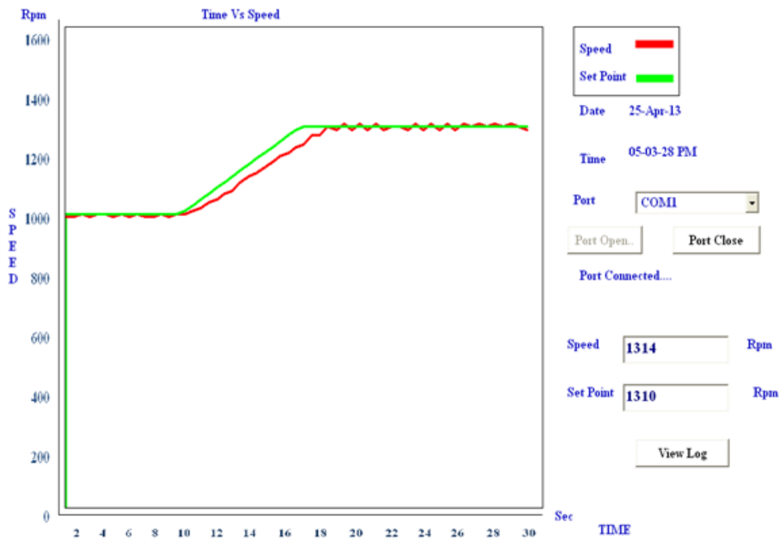

Figure 9 Transient State Performance Speed Varies 1000 to 1310 RPM

Single phase auto-transformer constant 230Volts at that same time three phase induction motor speed can vary from 1000RPM to set speed 1310RPM. . Set speed has been tracked and its actual speed can be varied. Initially induction motor speed 1000 RPM and it speed has been decreased 1310 RPM within 8seconds. Time taken to attain set speed will be very few seconds only. Speed curve between set speed and its actual speed of the induction motor has been shown and also set speed and actual speed value will be displayed. The curve shows the set speed vs actual speed of three phase induction motor.

VI CONCLUSION

Fuzzy Flatness based tracking controller is a very important tool for nonlinear controller design. The Fuzzy Flatness property was used to control continuous nonlinear systems with good performances in term of tracking trajectory. The flatness-based approach uses the characterization of system dynamics to generate a suitable output. The flatness control in an induction motor is an important subject because of the need for improvement in operation quality. It, however, is a difficult problem for a conventional approach to achieve since the induction motor driving process is a highly nonlinear system in which many uncertain parameters are involved. Fuzzy control has adaptive capacity to time lag, nonlinearity and uncertain parameters in controlled system Fuzzy logic based flatness control can improve the operation performance of the induction motor effectively. The performance of fuzzy flatness controller for the speed control voltage source inverter fed induction motor drive has been verified and compared with that of conventional PI controller performance. By applying fuzzy flatness control we can reduce the tracking error and torque ripple of the induction motor. This provides a better method for controlling induction motor.

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering
Vol. 2, Issue 5, May 2013

REFERENCES

[1] Arulmozhiyal, and Dr. Baskaran K "Speed Control of Induction Motor using Fuzzy PI and Optimized using GA" International Journal of Recent Trends in Engineering, Vol.2, No.5, pp.43-47 Feb.2009.

[2] Azeddine Houari, Hugues Renaudineau, Jean-Philippe Martin, Serge Pierfederici, and Farid Meibody-Tabar, "Flatness-Based Control of Three-Phase Inverter with Output LC Filter" IEEE Transactions on Industrial Electronics, Vol.59, No.7, pp.2890-2897 Dec.2012

[3] Chao-Lung Chianga, Ching-Tzong , "Tracking Control of Induction Motor Using Fuzzy Phase Plane Controller with Improved Genetic Algorithm" Department of Electrical Engineering, Elsevier Journal on Power System Engineering Research, Vol.73, No.5, pp. 239-247 April.2005

[4] Durgasukumar, M.K.Pathak , "Torque Ripple Reduction in VSI Fed Induction Motor Drive Using Low Switching Frequency" International Journal of Engineering Science and Technology Vol. 2, No.10, pp.6113-6119 May.2010

[5] Durval de Almeida Souza, Wilson C. P. de Aragão Filho, and Gilberto Costa Drumond Sousa "Adaptive Fuzzy Controller for Efficiency Optimization of Induction Motors" IEEE Transactions on Industrial Electronics, Vol. 54, No. 4, pp.2157-2164 June.2007

[6] Francesco Cupertino, Annamaria Lattanzi, and Luigi Salvatore , "A New Fuzzy Logic-Based Controller Design Method for DC and AC Impressed-Voltage Drives"IEEE Transactions on Power Electronics, Vol. 15, No. 6, pp.974-982 April.2000

[7] Jaime Fonseca, Joao L. Afonso, Julio S. Martins, Carlos Couto , "Fuzzy Logic Speed Control of an Induction Motor" Elsevier, Vol 27, No.2, pp. 523-534 August.1999

[8] P.Tripura and Y.Srinivasa Kishore Babu , "Fuzzy Logic Speed Control of Three Phase Induction Motor Drive" World Academy of Science, Engineering and Technology, Vol.60, No.3, pp.1371-1375 Nov.2011

[9] Praveen Kumar, D.Sunitha , "Speed Control of Induction Motor using PID and Fuzzy Controller" Proceedings of International Conference on Computing and Control Engineering (ICCCE 2012), Coimbatore Institute of Information Technology, Coimbatore, pp.371-375 July.2012

[10] V.Singh, Y.P. Singh , "Voltage Source Inverter Driven Multi-phase Induction Machine" science direct, Vol.29, No.4, pp.813-834 March.2003

BIOGRAPHY

C.Sasikumar was born in India, in the year 1984. he received his bachelor degree in Electrical and Electronics Engineering from Anna University, Chennai in 2009. He worked as Site Engineer at Classic Electricals for Projects (IISC and HAL) Bangalore for two year. At present he is doing his Master's degree in the Anna University, Chennai. He published papers in one international conference and one national conference. His current research area is intelligent techniques and electrical drives. His areas of interests are power electronics and electrical machines.

C. Muniraj was born in India, in 1980. He received B.E.,M.E and Ph.D, degrees in Electrical Engineering at Bharathiyar University and Anna University in 2003, 2006 and 2012 respectively. He has been working as Associate professor in K.S. Rangasamy college of Technology in the Department of Electrical and Electronics Engineering. He has published more than 20 international and national conference papers. He received best paper award from Pentagram Research Center, Hyderabad, in 2007. His researches interests include condition monitoring of power apparatus and systems, power electronics and drives, signal processing and intelligence controller application in electrical drives.