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An Intelligent control based Self tuned Fuzzy Logic with Indirect Vector controlled of Induction Motor Drive

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Abstract— This paper presents an Intelligent control based fuzzy logic for Sensorless speed control of induction motor drive. The proposed scheme used indirect vector control with fuzzy logic controller which gives optimal condition for maximum torque both in steady state and transient condition and has ability to plan via decomposition of a complex task into manageable subtasks and it has auto tuning property which changes speed according to voltage level. The simulation results of the Intelligent controlled method for an IM drive shows good dynamic response and minimum settling time which is obtained by Fuzzy logic controller.

Index Terms *:— IVC (Indirect Vector control), Fuzzy logic controller (FLC), Induction motor (I/M).*

1. INTRODUCTION

Electric motors are major users of electricity in industrial plants and commercial premises. Previously, DC motors were extensively used in complex speed and position control applications, such as industrial robots and numerically controlled machinery, because their flux and torque can be easily controlled. However, DC motors have the disadvantage of using a commutator, which increases the motor size, the maintenance cost and reduces the motor life. Advances in digital technology and power electronics have made the induction motor control a cost-effective solution. Therefore, DC motors are currently being replaced by induction motors in many industrial plants.

Traditional scalar control techniques for variable speed operation of three phase electric motors offer simple implementation. In some practical situations, however, there are strong reasons to eliminate the speed sensor due to both economical and technical reasons. Recently, it has been shown that speed can be calculated from the current and voltage across the AC motor thereby eliminating the need for speed sensors. There have been many alternative proposals addressing the problem of speed sensorless induction motor control, limit the performance that can be achieved by Field Oriented Control provides the smooth motion at slow speeds as well as efficient operation at high speeds. although the indirect field orientation is simple and preferred, its performance is highly dependent on accurate knowledge of the machine parameters. Research in induction motor control has been focused to remedy the above problems. Much work has been reported in decreasing the sensitivity of the control system to the parameter variation and estimating, rather than measuring the rotor flux and speed from the terminal voltages and currents. This eliminates the flux or speed sensor, there by achieving sensor less control.

Sinusoidal commutation produces smooth motion at slow speeds. There by reducing sensor noise and drift effect as well as cost & size. For dynamic smooth performance of induction motor we use fuzzy logic controller which gives accurate controlled speed via controlling voltage level with the help of PWM controlled inverter, and it simplify complex task into manageable subtasks.

Using fuzzy logic controller voltage source inverter with predictive current controller feeds the induction motor. The technique presented in the literature allows an induction motor to achieve similar torque and speed control performance to a dc machine and has led to induction machine replacing the dc machine in many high- performance applications. Simulation of control scheme is using MATLAB/SIMULINK.

2. INDIRECT VECTOR CONTROL OF INDUCTION MOTOR

The most popular induction motor drive control method has been the field oriented control (FOC) in the past two decades. Furthermore, the recent trend in FOC is towards the use of sensor less techniques that avoid the use of speed sensor and flux sensor. The sensors in the hardware of the drive are replaced with state observers to minimize the cost and increase the reliability. The speed sensor less control of the machine means to estimate the speed signal from machine terminal voltage and currents. A special attention is given to the robustness of the control system to parameter variations.

With the invention of field orientated control, the complex induction motor can be modeled as a dc motor by performing simple transformation. In a similar manner to a dc machine, in induction motor the armature winding is also on the rotor, while the field is generated by currents in the stator winding. However the rotor current is not directly derived from an external source but result from the emf induced in the winding as a result of the relative motion of the rotor conductor with respect to the stator field and armature current. In other words, the stator current is the source of both the magnetic field and armature current. In the most commonly used, squirrel cage motor, only the stator current can directly be controlled, since the rotor winding is not accessible. Optimal torque production condition are not inherent due to the absence of a fixed physical disposition between the stator and rotor field, and the torque equation is non linear. In effect, independent and efficient control of the field and torque is not as simple and straightforward as in the dc motor.

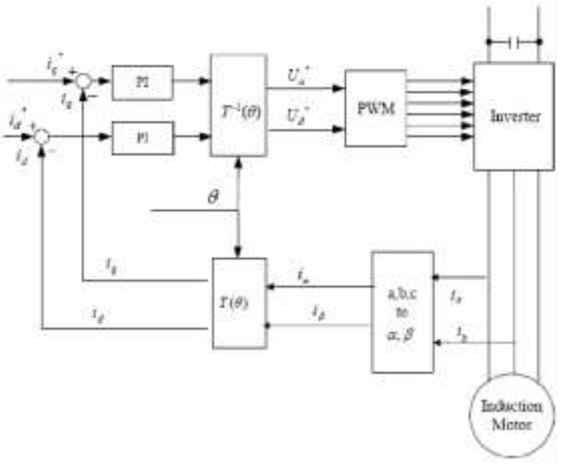


Figure 1. General block diagram for a field orientation control system

3. THREE PHASE INVERTERS

Three phase inverters, supplying voltages and currents of adjustable frequency and magnitude to the stator, are an important element of adjustable speed drive systems employing induction motors. Inverters with semiconductor power switches are d.c. to a.c. static power converters. Depending on the type of d.c. source supplying the inverter, they can be classified as voltage source inverters (VSI) or current source inverters (CSI).VSIs can be either voltage or current controlled. In a voltage- controlled inverter, it is the frequency and magnitude of the fundamental of the output voltage that is adjusted. Feed forward voltage control is employed, since the inverter voltage is dependent only on the supply voltage and the states of the inverter switches, and, therefore, accurately predictable.

With appropriate heat sink, we can rise to 20 KHz however a10KHz, switching losses and conduction losses become equal, moreover, complex mathematical algorithms require much time. Thus 10 KHz is selected as the switching frequency in our algorithms.

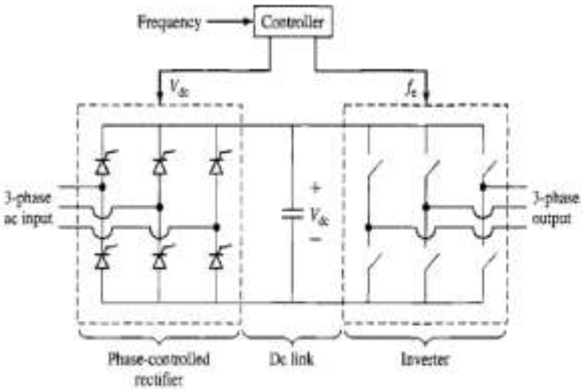


Figure 2. Circuit diagram of Three phase voltage source inverter

4. SELF TUNED FUZZY LOGIC INTELLIGENT CONTROLLER

The fuzzy logic control (FLC) has been an active research topic in automation and control theory since Mamdani proposed in 1974 based on the fuzzy sets theory of Zadeh (1965) to deal with the system control problems that are not to model the fuzzy logic can intelligent control systems. serve as a tool in developing. It has ability to plan via decomposition of a complex task into manageable subtasks and adapt to new situtions. The control system is composed of the following blocs: structure of a complete fuzzy control system is composed of the following blocs: Fuzzification, Knowledge base, Inference engine, Defuzzification. Figure (3) shows the structure of a fuzzy controller.

The Fuzzification module converts the crisp values of the control inputs into fuzzy values. A fuzzy variable has values which are defined by linguistic variables (fuzzy sets or subsets) such as: low, medium, high, big, slow where each is defined by a gradually varying membership function. In fuzzy set terminology, all the possible values that a variable can assume are named the universe of discourse, and the fuzzy sets (characterized by membership function) cover the whole universe of discourse. The membership functions can be triangular, trapezoidal. Its actual operation can be divided into three steps (Figure 3):

i) ***Fuzzification*** – actual inputs are fuzzified and fuzzy inputs are obtained.

ii) ***Fuzzy processing*** – processing fuzzy inputs according to the rules set and producing fuzzy outputs.

iii) ***Defuzzification*** – producing a crisp real value for a fuzzy output.

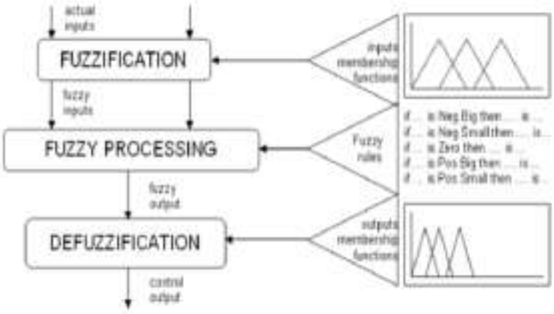
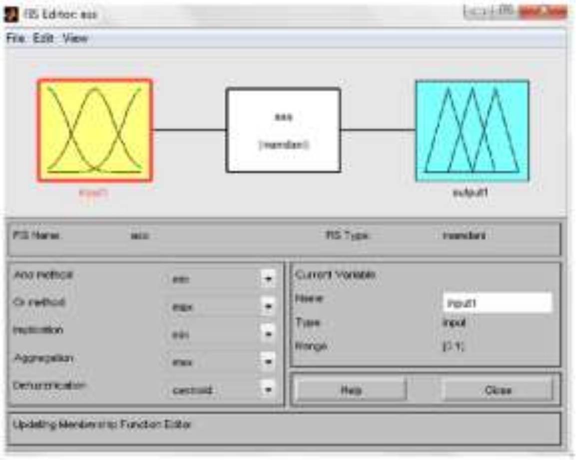


Figure 3. Fuzzy System Scheme



FIS Name: aaa
FIS Type: mamdani
And method: min
Or method: max
Implication: min
Aggregation: max
Defuzzification: centroid
Current Variable
Name: input1
Type: input
Range: [0 1]
Updating Membership Function Editor

Figure. 4. Mamdani architecture approach with input OA1, OA2 and output CA1, CA2

Desigining fuzzy Rule based System using Fuzzy logic toolbox for Matlab provides several built in membership functions like triangular trapezoidal, Gaussian. in figure(4) shows fuzzy inference system its properties are:

And method : min Or
method : max
Implication : min
Aggregation : max
Defuzzification : centroid

if OA1 is ---- and OA2 is --- and then CA1 is ----- and CA2 is if OA1 is ---- and OA2 is --- and then CA1 is ----- and CA2 is

Which maps the observable attributes (OA1,OA2.....,) of the given physical system into its controllable attributes (CA1, CA2....).

Output ----- Observable Attributes

Input------- Controllable Attributes

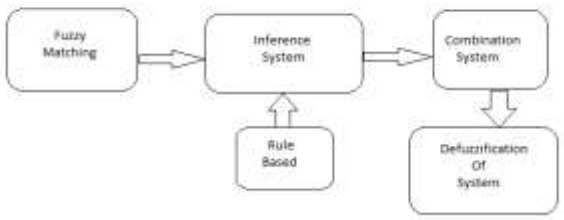
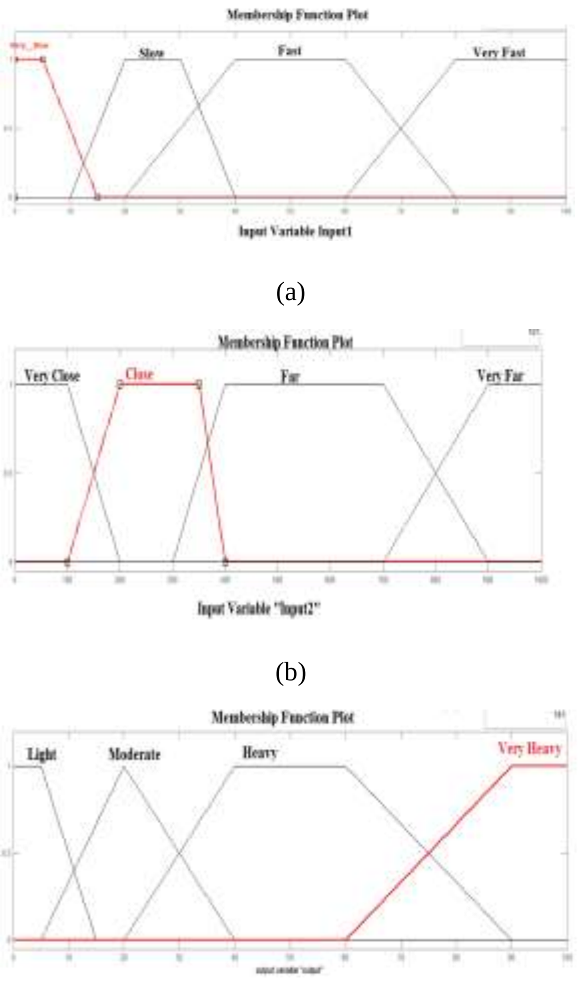


Figure 5. Inference System for Fuzzy Controller Operation

The inference engine is the heart of a fuzzy controller operation which consists of fuzzy matching, inference system, combination and defuzzification. Where as fuzzy matching calculate the degree to which the input data match the condition of the fuzzy rules and its output given to the inference system which calculates the rule's conclusion based on its matching degree and its output given to the combination which combine the conclusion inferred by all fuzzy rules into a final conclusion and lastly for application that need acrisp output an additional step is used to convert a fuzzy conclusion into crisp (non fuzzy) value. There are two major defuzzification techniques (a) the Mean of Maximum method (MOM) and (b) The Center of Area (COA) or centroid method.



(a)

(b)

(c)

Figure 6. (a) Input variable “input1”
(b) Input variable “input 2” (c) Output variable

5. SIMULINK MODEL OF FUZZY LOGIC CONTROLLER WITH INDIRECT VECTOR CONTROL OF INDUCTION MOTOR

This proposed work based on the fuzzy logic intelligent controller which gives accurate result with the help of indirect vector control. The simulink model of fuzzy logic controller with Indirect vector control of Induction Motor is shown in fig (6) which is connected with Pwm IGBT inverter for pulse controlling with the use of fuzzy it gives optimal output speed according to supply voltage. Pwm IGBT inverter used space vector technique which gives 90% more accurate result than simple Pwm technique and the combination of IGBT with space vector Pwm switching can be reduced by 33%

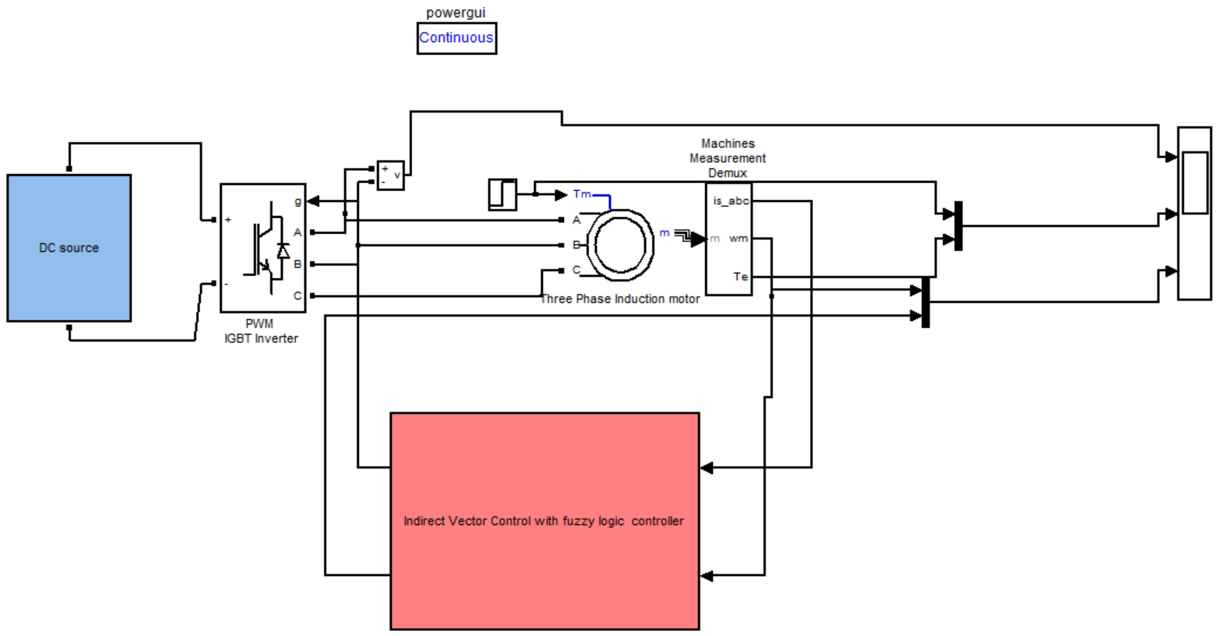


Figure 7. Proposed Simulink model of Induction motor Drive

by choosing to use one of the zero vectors. This simulation optimizes the particular output by using FLC, SVPWM and IVC techniques.

6. MODEL OF INDIRECT VECTOR CONTROL WITH FUZZY LOGIC CONTROLLER OF INDUCTION MOTOR

With the help of Indirect vector control with fuzzy logic controller different simulation results are obtained individually and display on scope block. Where in figure. 7 three phase Iabc takes as a Actual current and Iabc* as a reference speed which is converted 3 phase into two phase by park's transformation and again converted into three phase by inverse Park's.

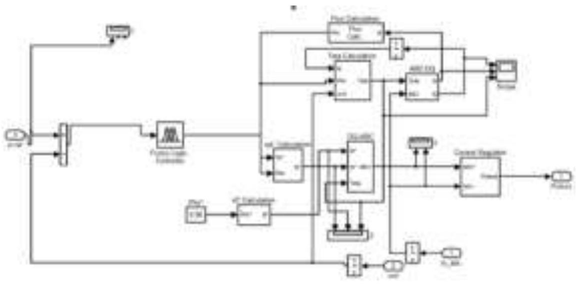


Figure 8. Simulink Model of Indirect vector control with fuzzy logic controller

Simulation Results

Some results demonstrates here for Feedback Indirect Vector control of IM with the help of Simulation using FLC which gives optimal result of IM parameters like Voltage, Current, Speed, Torque, Tata which is shown in Figure below. Input Voltage waveform is shown in Figure (8) which gives 800V uniform Pulse Width Modulation with respect of time. If Compare figure(11) Iq (Actual quadrature current) Figure 12 Id (Actual dired Axis current) and Figure 13 Teta(angle between Iq and Id) to Figure 16 Iq*(Reference quadrature axis current), Figure 17 Id*(Actual direct axis current) and Figure 18. Tera so it is clear that gives accurate current Iq*, Id* and Teta* waveform than Iq, Id, Teta respectively. The output speed is obtained 150 r/sec.

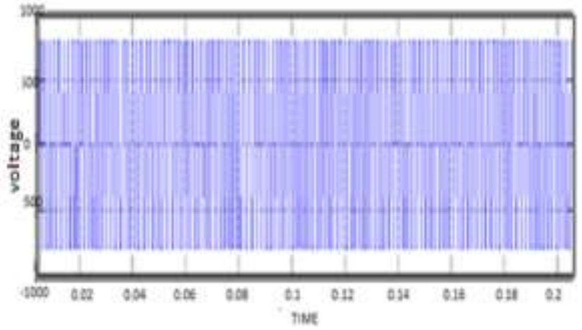


Figure 9. Pwm voltage Vs Time for FuzzyLogic

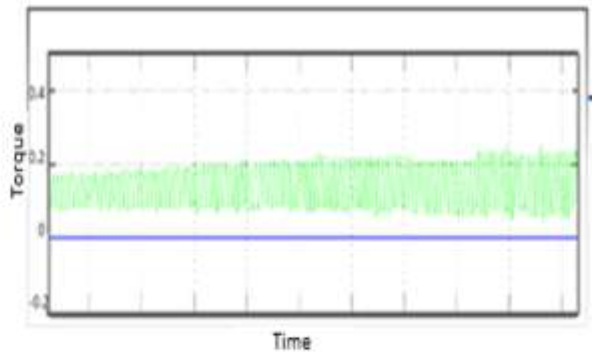


Figure 10. Torque vs Time for FuzzyLogic

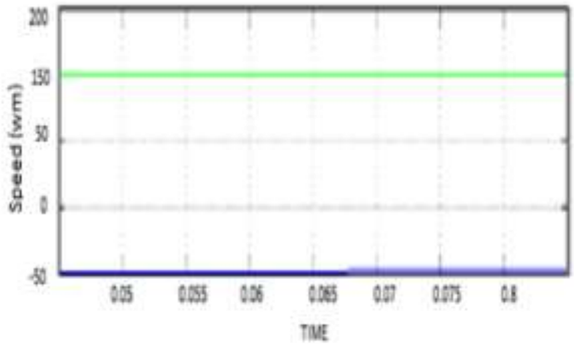


Figure 11. Speed (150 r/sec) Vs Time for FuzzyLogic.

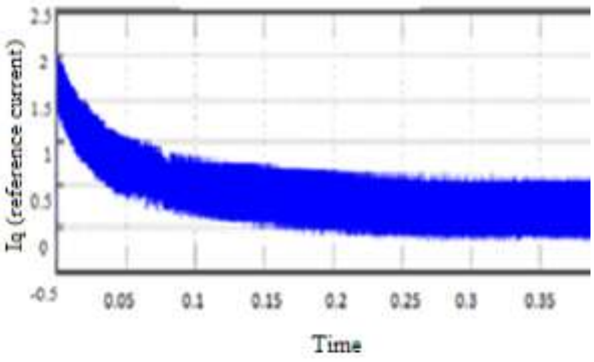


Figure 12. Iq (Reference quadrature current Vs Time) for FuzzyLogic.

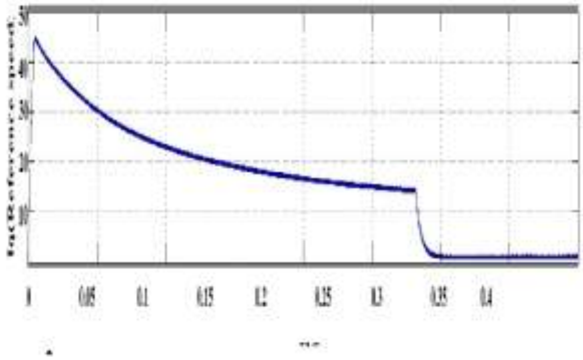


Figure 13. Iq (Reference quadrature current Vs Time) for PI Controller

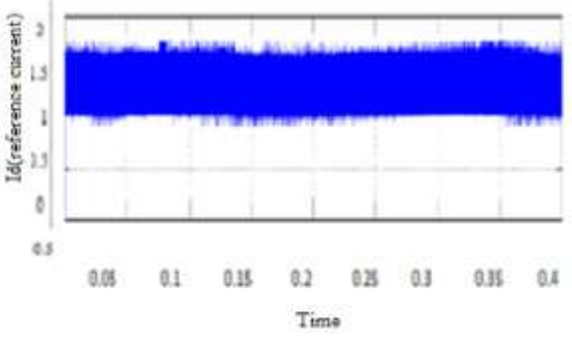


Figure 14. Id (Reference direct Axis current) Vs Time for FuzzyLogic.

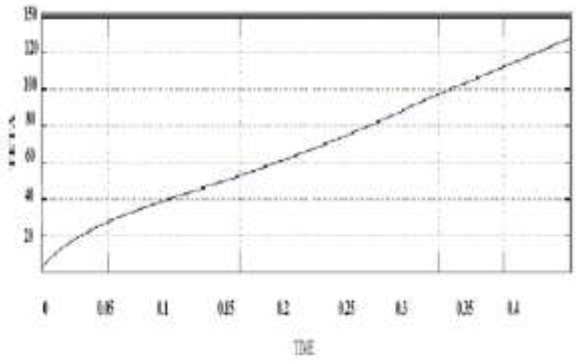


Figure 15. Id (Reference direct Axis current) Vs Time for PI Controller

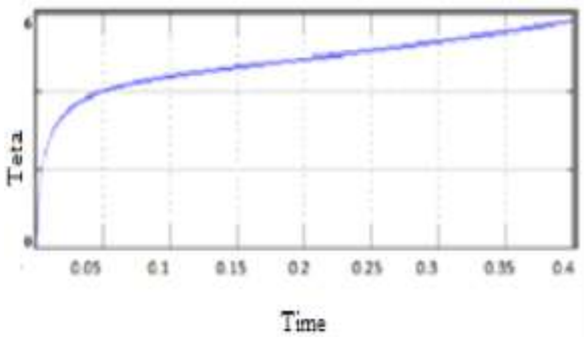


Figure.16 Teta(angle between Iq and Id) Vs Time FuzzyLogic

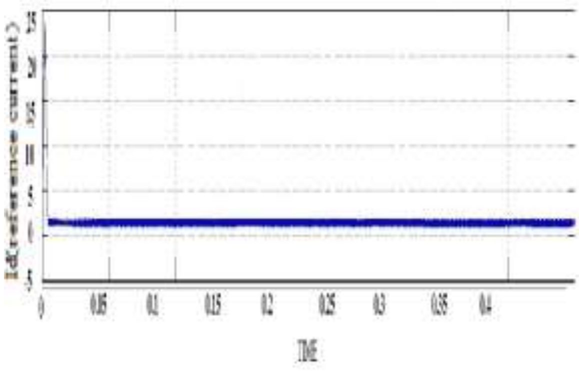


Figure 17. Teta(angle between Iq and Id) Vs Time for PI Controller

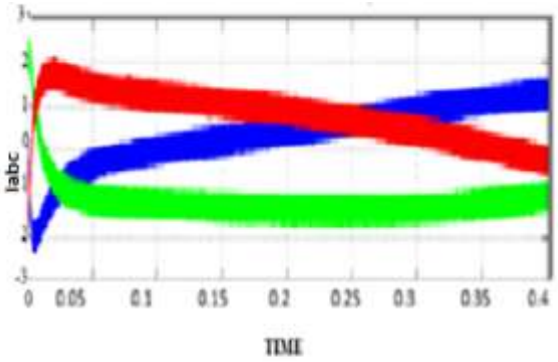


Figure 18. Iabc(Reference current) Vs Time for FuzzyLogic.

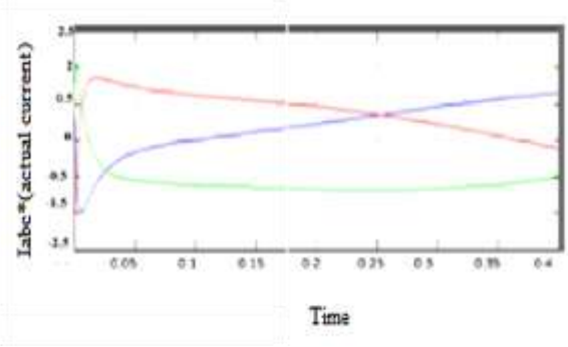


Figure 19. Iabc*(Actual current) Vs Time for FuzzyLogic

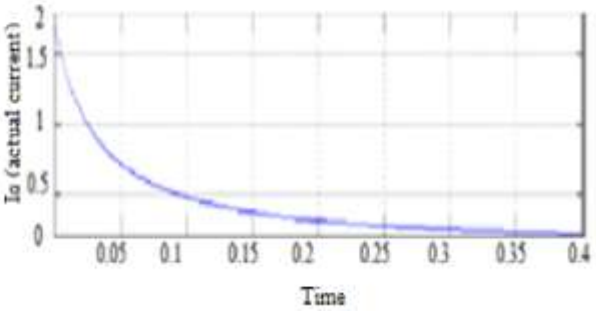


Figure 20. Iq*(actual quadrature axis current) Vs Time for FuzzyLogic.

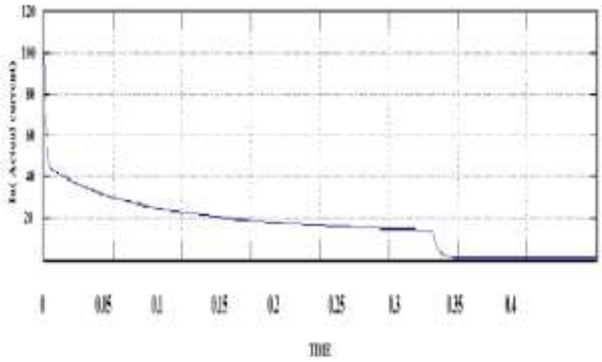


Figure 21. Iq*(actual quadrature axis current) Vs Time for PI controller.

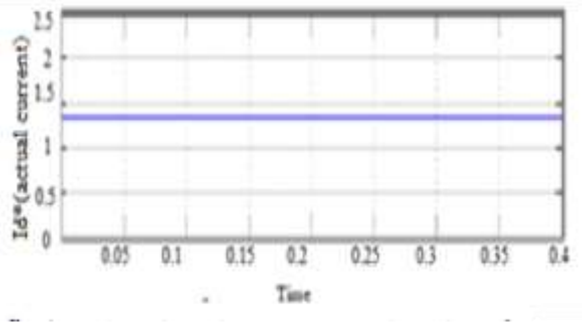


Figure 22. Id*(Actual direct axis current) Vs Time for FuzzyLogic.

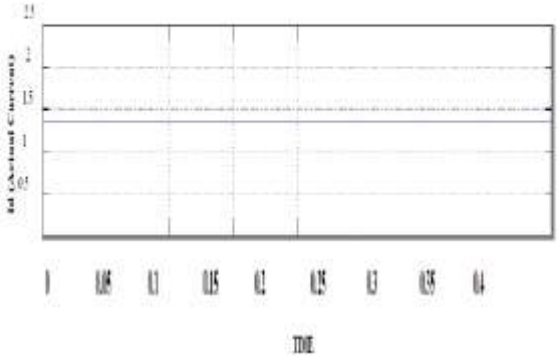


Figure 23. Id*(Actual direct axis current) Vs Time for PI controller.

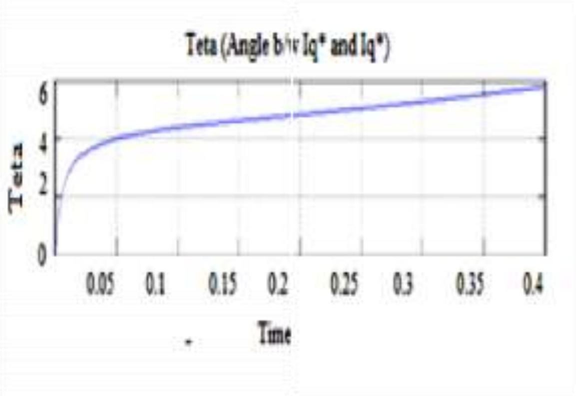


Figure 24. Actual Teta* Vs Time for FuzzyLogic.

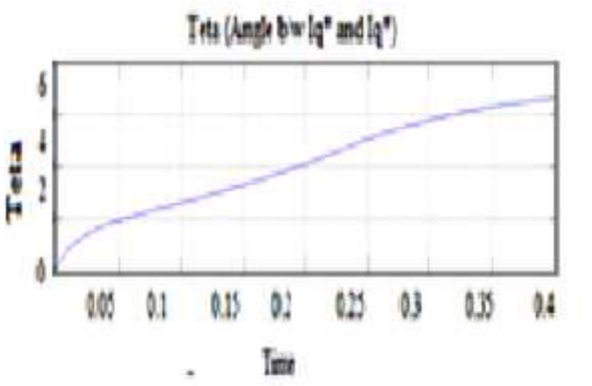


Figure 25. Actual Teta* Vs Time for PI controller.

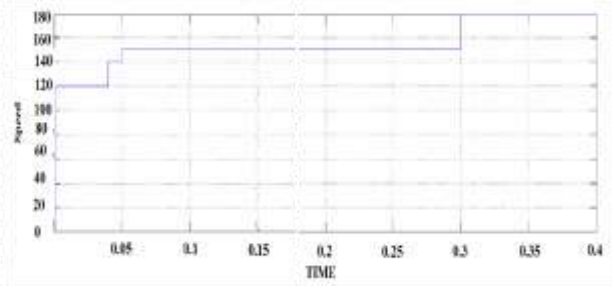


Figure 26. Speed (120,140,150,180) in rps for Fuzzy Logic

7. INPUT PARAMETERS OF INDUCTION MOTOR

PARAMETERS	INPUT VARIABLES
Rated voltage	460V
Rated current	0.3436 A
Ns	150 r/sec
Flux	0.96 wb
Lm	0.71469 H
Ls	0.7329H
L’r	0.7328 H
R’r	2.2605 Ohm
Rs	2.1 Ohm
Tr	0.312417sec
P	4

Table 1: Induction Motor

INPUT SPEED (IN RPS)	FUZZY LOGIC CONTROLLER (TIME IN SEC)	PI CONTROL-LER (TIME IN SEC)
180 rps	0.3	0.35
150 rps	0.05	0.3
140 rps	0.04	0.28
120 rps	0.02	0.25

Table 2 : Induction Motor

8. CONCLUSION

This paper presented a indirect vector control of a induction motor which is used with intelligent fuzzy logic controller for obtaining constant speed 150 r/sec at minimum settling period which is obtained by Fuzzy logic Simulink model at 0.05 sec this is less as compare to PI Controller which takes 0.3 sec. In this way FLC gives better performance as compare to PI controller at same operating condition.

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