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Performance Analysis of Direct Torque Controlled Induction Motor using Artificial Neural Networks

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Abstract:
This paper presents the controlling of induction motor with DTC method by using ANFIS controller Fuzzy rules were implemented and better results were shown. This paper developed based on DTC method and SVPWM method. Description about DTC and SVPWM was also discussed below. Advantages of ANFIS over ANN also shown. This paper was implemented in MATLAB/SIMULNK software.

Keywords: *DTC-Direct Torque Control, ANN-Artificial neural Network, ANFIS-Adaptive Neuro-Fuzzy Inference System, SPWM-Sinusoidal Pulse Width Modulation, SVPWM-Space Vector Pulse Width Modulation, THD-Total Harmonic Distortion*

I. INTRODUCTION

Induction motor rules the World because of its variable speed nature. This motor is used in industries very well. The controlling is also getting another priority for Induction Motor (IM).This motor is becoming available from Half kilowatt to thousands of kilowatt in workshops. It is having advantages like simple design, reliable operation, low initial cost and high efficiency. These can be used for various voltage applications.IM is of two types like Squirrel cage and Wound rotor method. Based on the mode of application of torque, they chosen.

Controlling of IM is also an essential part in this paper. For Variable frequency drives (VFD) are controlled in Both Scalar and Vector method. V/f method is known as Scalar one. On The other hand FOC and DTC are called as Vector control. In this paper Direct Torque Controlling was used Over FOC method. FOC based controlling was used in [2], Whereas DTC mode was in [3]. Comparison between FOC and DTC was shown in [7] for PMSM drives.

Controlling of IM was by using PI and Fuzzy were discussed in [4]. PI controller is having some disadvantages like more time, less speed, less accuracy. In order to overcome these, Fuzzy controller was evolved, which was shown in [5].

On the other end, Fuzzy is also having losses of human error at the time of ruling and membership functioning. So there is need for an intelligent controller evolution. To overcome above Disadvantages, Neural Networking concept was developed, which was shown in [6].This paper explains about DTC, SVPWM and ANFIS concepts in below sections.

II. DIRECT TORQUE CONTROLLING

DTC is one of the effective controlling methods over FOC method. In mid 80's DTC was proposed by I.Takahashi, T.Nougouchi and Depenbrock. According to this, errors of Flux and Torque parameters are enough to calculate voltage component of IM. These errors were minimized by using controllers. The reduced error is converted into gating pulses by using required PWM technique

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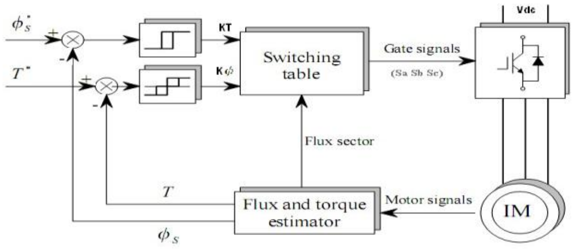

Fig.1 shows the Block diagram for controlling of IM.

DTC is having more dynamic performance, no need of current control, PWM modulator, Rotor positioning. It is having less control cycle time (10 to 30 mille Sec.). It can be operated in wide range of switching frequency. It does not require Coordinate transformation too.

It is also having some disadvantages like Ripples can be generated in flux and torque, Because of using variable switching frequency there s a need to employ hysteresis controller, Because of flux and current distortion there is a chance to change sector position.

III. Pulse Width Modulation

PWM is of two type; Sinusoidal and Space vector techniques. In this paper SVPWM technique was used to generate gating pulses.

WORKING OF SVPWM:

SVPWM method makes voltage component into discrete signal. It represents this signal into three-dimensional view as show in below

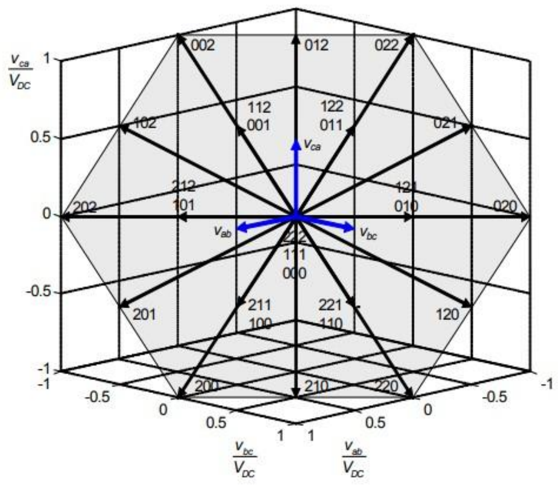

Fig.2 Three-dimensional view of Space vector diagram.

The discrete signal splits into six-sectors for each 60 degree angle. We consider them as six-areas. Every vector is having its individual geometry representation. When one error signal approaches in one direction, it selects one area in same direction. It compares the signal with less distanced reference signal. This reference signal is considered as origin point to create another hexagon. The next three pulses in same direction can be used to select the triggering angles.

SVPWM is more efficient than SPWM; because of splitting into discrete signals it can choose triggering pulse accurately.

IV. Adaptive Neuro Fuzzy Inference System

This paper was evolved, by overcoming the disadvantages of neural Networks concept, these disadvantages discussed below.

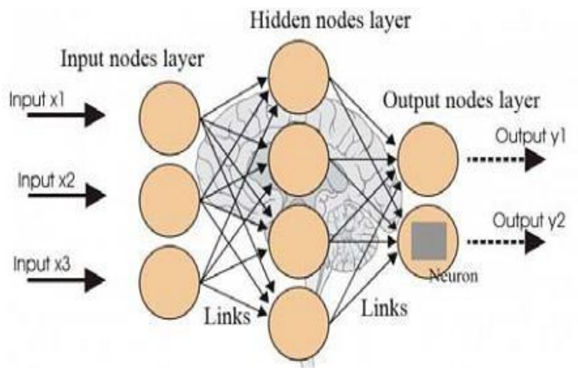

Fig.3 shows the layers of ANN.

As per our concept, ANN works on propagation basis.

- ANN is not having specific rules to construct the exact architecture so, it can be generated by experience and trial and error basis only.
- It does not give any clue, why and how it gives the solution to the problem. So, there is no trust on the structure.
- At the time of input, the evolved error has to convert into numerical manner, it makes disturbances in circuit.
- Because of the presence of processors, it depends o equipment which may create error.

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To overcome above limitations ANFIS was evolved. It is also called as combination of neural networks with fuzzy logic.

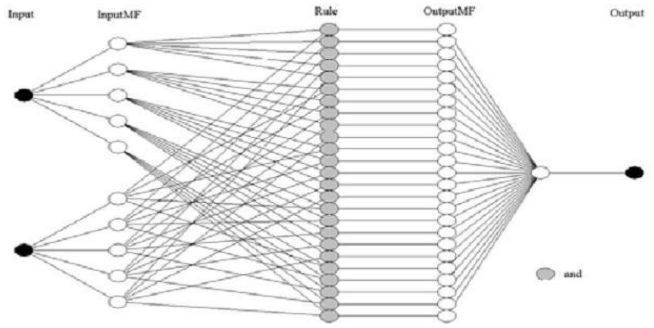


Fig.4 shows the general structure of the ANFIS

For this paper, the obtained flux is give n to fuzzy controller, as four inputs to generate one output. Each input will generate three membership functions. By using these membership functions 81 rules drawn. Each membership function has it's own constant value (carry value) to add at the time of problem solving. This addition of carry values wills takes place in Neural networks process.

The obtained sets of values were again given to another fuzzy logic system to generate pulses to select sectors for PWM technique. 27 rules were written to complete PWM technique. The selected sectors were used to trigger the gating pulses.

ANFIS can be used to reduce losses in transmission lines, Machine learning, artificial intelligence concepts.

V. Simulation

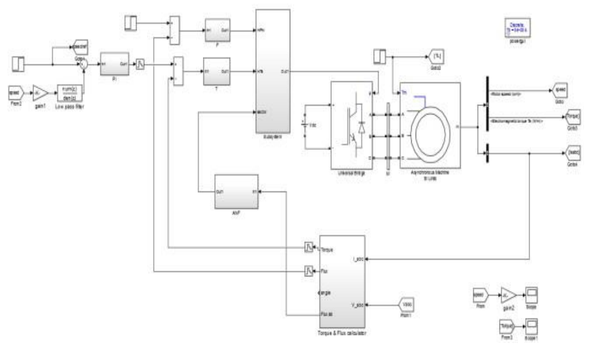
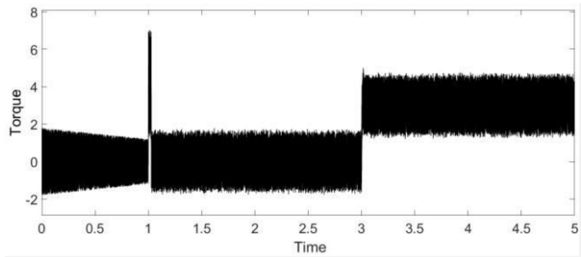


Fig.5 shows the Simulation view of the proposed topology

TABLE I
Shows the parameters considered for this paper.

PARAMETER	VALUE
Motor Power(Kw)	4
Bus voltage(V)	400
Phase Resistance(ohm)	1.54
Flux Reference(web)	0.5
Flux Hysteresis Band	±0.005
Torque Hysteresis band	±0.5



This paper was tested under three considerations of speed of 250RPM, 1500RPM, and 2800RPM. 400 Volts of DC supply is given to drive, calculated flux and torque are used to estimate the errors evolved. These errors were hysteresis band to reduce them and the output is fed to artificial controller (ANFIS). This generates the pulses through SVPWM technique and triggers the drive efficiently.

VI. Results

To analyze the results both Conventional and Proposed models were simulated in MATLAB/SIMULINK software.

For lower range (250 RPM) details of behavior was given in below. Below figure 6&7 shows the speed of the conventional and proposed circuit.

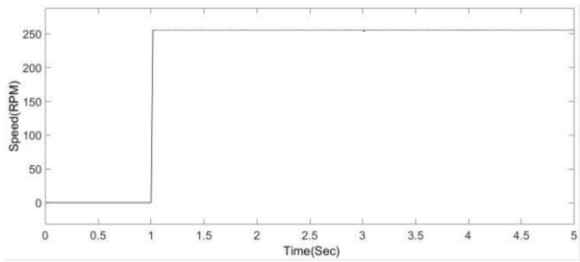


Fig.6. Shows the Speed for Conventional Circuit.

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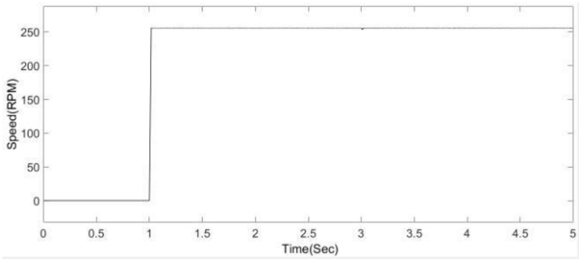


Fig.7 shows the speed of the proposed circuit.

Fig.6 is having maximum speed at 1.027sec and 1.023 for Fig.7.Below figures 8&9 shows the Torque of the conventional and proposed topology.

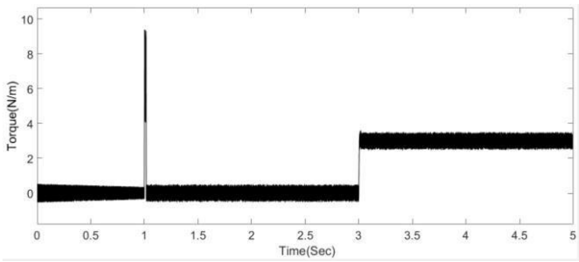
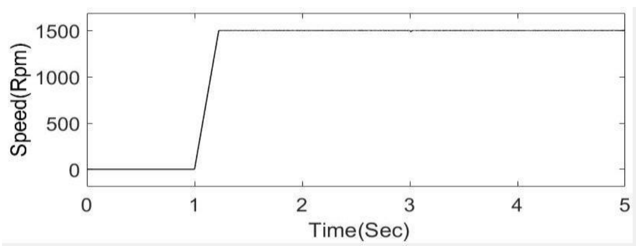


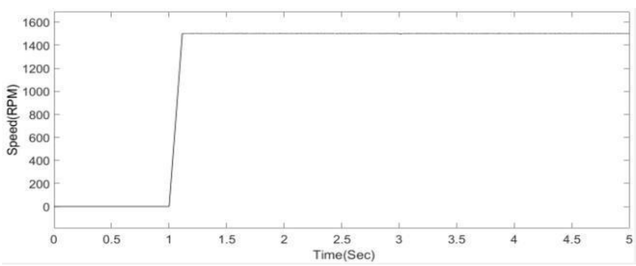
Fig.8 shows the torque behavior of conventional topology.

Fig.9 shows the torque behavior of the proposed concept. THD for values for before and after changing torque,
Conventional is having more percentage than proposed circuit.

For Medium Speed Range (1500), results were discussed below.



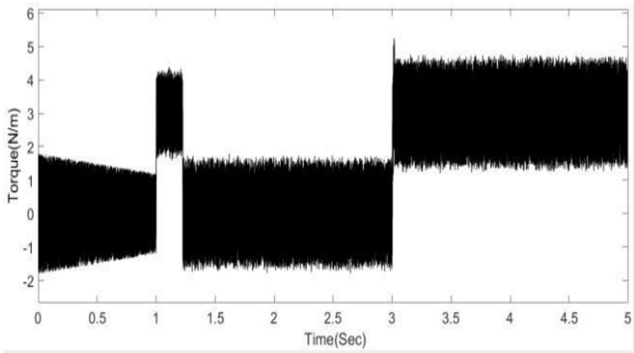
(10)



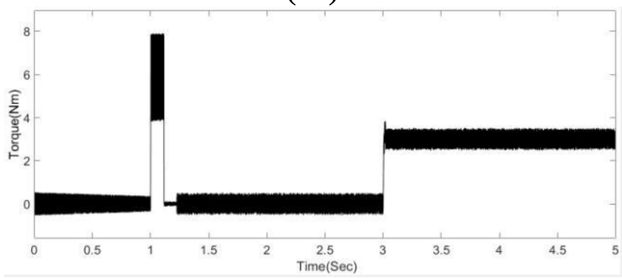
(11)

Fig.10 and 11 shows the Speed behavior of the conventional and proposed topology.

Maximum speed for ANN and ANFIS models is of 1.225 Sec and 1.120Sec respectively.



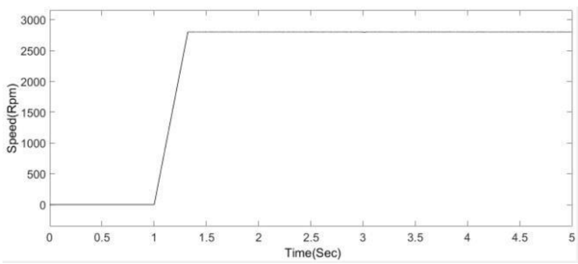
(12)



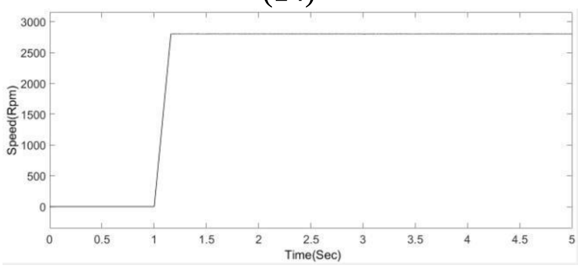
(13)

Fig.12 and Fig. 13 shows the Torque for the Conventional and proposed topology.

FOR MAXIMUM SPEED (2800) results were given below.



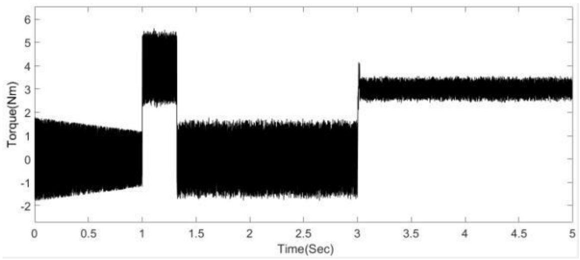
(14)



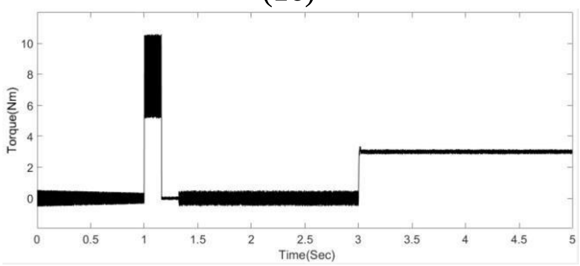
(15)

Fig. 14 and Fig.15 Shows the speed for Conventional and Proposed topology.

Time of Maximum speed is of 1.322 Sec and 1.173 sec for ANN and ANFIS respectively.



(16)



(17)

Fig.16 and Fig.17 Shows the Torque characteristics for Conventional and Proposed.

VII. CONCLUSION

Controlling of induction motor by using ANFIS was observed. The results of both conventional and proposed method were observed. Maximum speed attaining capability in less time was seen for ANFIS controller as compared with ANN and less Ripple content was shown for ANFIS controller. THD values for ANFIS is less than ANN Controller.

By observing above details, ANFIS controls more efficiently than ANFIS. This paper was implemented in MATLAB/SIMULINK software.

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