Simulation based Direct Torque Control of Induction Motor with Stator Flux Reimbursement

K.Ramani[1], A.Krishnan[2]
[1] K.S.Rangasamy College of Technology, Tiruchengode. India 637215
Email: kreee82@gmail.com
[2] K.S.Rangasamy College of Technology, Tiruchengode. India 637215
Email: a_krishnan26@hotmail.com

Abstract—**This paper places of interest Direct Torque control (DTC) strategy for induction motor based on fuzzy logic control. Many methods of controlling the performance of induction motors exist. The direct torque control deserves special attention because of high performance vector control based on decoupling the stator flux and electromagnetic torque. In conventional method normal DTC is used to control the torque, but main drawback torque ripple is high. The proposed scheme with use of fuzzy logic the stator flux is compensated, the selection of the most suitable duty cycle value for every switching period is done, so the switching frequency of the inverter is maintain as constant. Hence the torque ripple is reduced.**

Index Terms- **AC Drive, Fuzzy Logic Controller (FLC), Direct Torque Control (DTC).**

I. INTRODUCTION

High dynamic performance of induction motor drive is obligatory in many applications of today's automatic control machine. It is the most commonly used in industrial applications like paper mills, steel Industry etc. How ever the vector control requires computationally intensive algorithms, coupled with closed loop control and precise pulse width modulation requires powerful peripherals to make vector control.

The principle is based on simultaneously decoupling the stator flux and electromagnetic torque. DTC scheme is to control the torque and speed which is directly based on the electromagnetic state of the motor. The direct torque control systems do not require a complex coordinate transform. The decoupling of the nonlinear AC motor structure is obtained by the use of on-off control, which can be related to the on-off operation of the inverter switches [1, 4].

The advantage of this methods are torque response, accurate torque control at low frequencies, torque repeatability, motor static speed accuracy, dynamic speed accuracy [3, 4].

K. Ramani is with department of Electrical and Electronics Engineering, K.S.Ranagasamy College of Technology, Tiruchengode. 637215.(e-mail: kreee82@gmail.com). Mobile Number 9788 518536

Dr.A.Krishnan is Dean, K.S.Rangasamy College of Technology, Tiruchengode, 637215 , Namkkal Dt, Tamilnadu, India (e-mail: a_krishnan26@hotmail.com).

II.MODELING OF INDUCTION MOTOR

Commonly three phase induction motor can be written in the compact form by means of the space vector notation. In the stationary reference frame the space vector equations of the induction motor is

Stator Voltage $$V_s = R_s I_s + \frac{d\lambda s}{dt} \quad (1)$$

Three phase currents and voltages are transformed to two phase stationary d and q axis

d axis stator flux $$\lambda_{ds} = \int (V_{ds} - R_s I_{ds}) dt \quad (2)$$

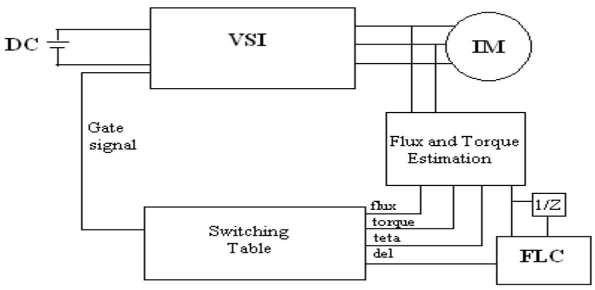
q axis stator flux $$\lambda_{qs} = \int (V_{qs} - R_s I_{qs}) dt \quad (3)$$

Flux angle $$\theta_f = \tan^{-1}\left(\frac{\lambda_{qs}}{\lambda_{ds}}\right) \quad (4)$$

Electromagnetic Torque $$T = \frac{3}{2}\frac{P}{2}(i_{qs}\lambda_{ds} - i_{ds}\lambda_{qs}) \quad (5)$$

IV.PROPOSED METHOD

In the proposed method stator flux is compensated with the use of fuzzy logic controller. The Figure 1. Shows the proposed method. Fuzzy logic control has two inputs and one output, the inputs are flux and change in flux, the output is duty ratio value. The output of fuzzy is given to the switching table. The use of the fuzzy is to calculate the accurate angle for firing the gate signal. The benefits of this proposed method is to reduce the torque ripple and to maintain the inverter switching frequency as



constant

Figure 1. Proposed Method.

VI.INVERTER SWITCHING STATES

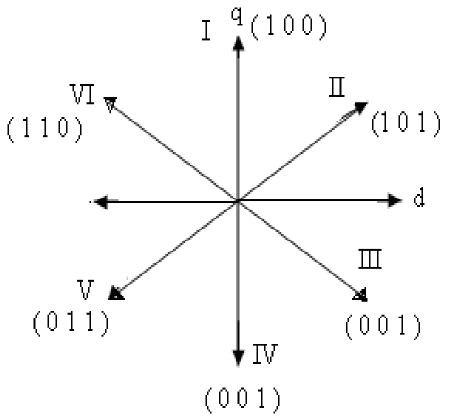


Figure 2. Inverter Switching States.

In inverters, the selected voltage vector is applied for the entire switching period, and thus allows electromagnetic torque and stator flux to vary the whole switching period [5, 6]. This causes high torque and flux ripples.

V.VOLTAGE SOURCE INVERTER

The purpose of a voltage-source inverter (VSI) is to synthesize a nearly sinusoidal output voltage from dc voltage. By proper coordination of switches of a VSI, electrical energy converts DC to AC voltage with desired magnitude and frequency. In VSI, power electronics switches are present and MOSFET switches are used in the simulation. These switches are controlled by varying the firing angle hence it can easily control the turn on and off [8, 9].

TABLE 1
INVERTER SWITCHING TABLE

S_λ	S_T	**1**	**2**	**3**	**4**	**5**	**6**
1	1	V1	I	II	III	IV	V
1	0	VIII	VII	VIII	VII	VIII	VII
1	-1	II	III	IV	V	VI	I
0	1	V	VI	I	II	III	IV
0	0	VII	VIII	VII	VIII	VII	VIII
0	-1	III	IV	V	VI	I	II

VI.FUZZY LOGIC CONTROLLER

The fuzzy logic controller is intended to have two input fuzzy state Variables and one control variable for achieving direct torque control of the induction motor. There are two variable input fuzzy logic controllers, the stator flux and change in flux. The output is duty cycle ratio membership function as shown in figure 3. The Fuzzy logic controller has so many methods that are possible to control the parameter. (6) In this paper the duty cycle output membership functions are singleton. The number of rules used during the Fuzzy Logic design was 54 and the inference method adopted was the Mamdani's minimum operation rule, whereas the defuzzification method used was the centroid criterion [3]. This controller has one output and two inputs, the inputs are stator flux and change in flux that means the previous value of flux, the output is most suitable duty cycle value is given to the switching table and Stator flux position membership function as shown in figure 4.

By fuzzy reasoning, Mamdani's minimum procedure gives,

$$\mu'_{Ni}(n) = \min(\alpha_i, \mu_{NI}(n)) \tag{7}$$

The membership function of the output point given by

$$\mu_N(n) = \max_{i=1}^{i-180} (\alpha_i, \mu'_{NI}(n)) \tag{8}$$

In this case, the outputs are crisp; the maximum criterion is used for defuzzifizcation. By this method, the fuzzy of output which has the maximum possibility distribution, is used as control output.

$$\mu_{Nout}(n) = \max_{i=1}^{7} (\mu_{Nout}(n)) \tag{9}$$

Membership functions of input variables, which are in conventional triangular shapes and with 50% overlapping as shown in figure 5. Each membership function is assigned with seven fuzzy sets, which are negative large (nl), negative medium (nm), negative small (ns), zero (ze), small (ps), medium (m), and large (l). Linguistic rules, which depend on the type of fuzzy logic control, are set up for fuzzy inference.

VII.FUZZY RULES TABLES

Torque error	Motor operating point		
	s	m	l
Stator flux position small			
n–l	vl	vl	vl
n–m	s	s	vl
n–s	z	m	vl
s	s	m	vl
m	s	m	vl
l	vl	vl	vl
Stator flux position medium			
n–l	vl	vl	vl
n–m	s	s	z
n–s	z	m	vl
s	s	m	vl
m	m	l	vl
l	vl	vl	vl
Stator flux position medium			
n–l	m	l	vl
n–m	s	s	z
n–s	z	m	vl
s	s	l	vl
m	m	l	vl
l	vl	vl	vl

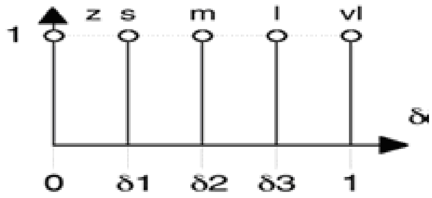


Figure 3. Duty cycle membership function

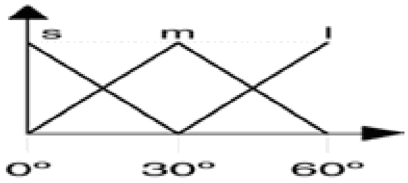


Figure 4. Stator flux position membership function.

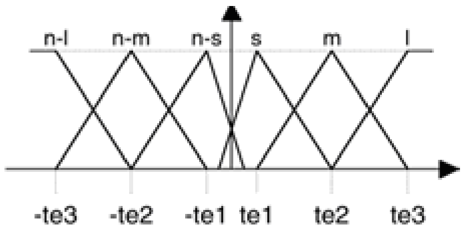


Figure 5. Membership distribution function.

VIII. SIMULATION RESULTS

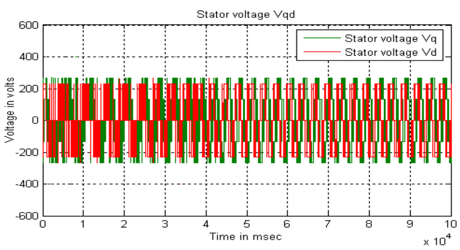


Figure 6. Stator Voltage Vs Time

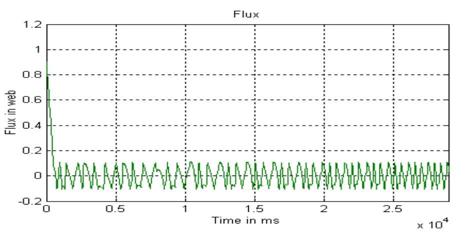


Figure 7. Stator Flux Vs Time

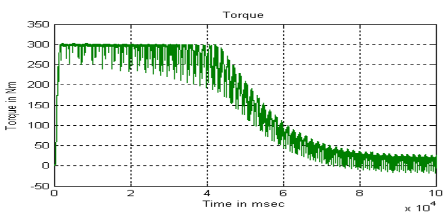


Figure 8. Electromagnetic Vs Time

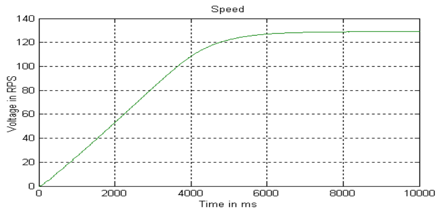


Figure 9. Speed Vs Time

RESULT ANALYSIS AND CONCLUSION

The proposed fuzzy based DTC wave forms are shown in simulation results. In the fuzzy based DTC, the torque ripples are reduced considerably more than 65%. In the conventional DTC the selected voltage vector is applied for the entire switching period and thus allows electro magnetic torque and stator flux to vary for the whole switching period, this cause high torque and flux ripple, the draw backs are overcome by the proposed system. The steady performances of ripples of both torque and flux are considerably superior. The main advancement is Reduction of torque, no flux droppings caused by sector changes circular trajectory, fast torque response Zero steady state torque and flux.

APPENDIX. MOTOR PARAMETERS

Induction Motor Rating	3HP
Pole Pair	2
Stator Resistance	1.55 ohm
Rotor Resistance	1.25 ohm
Stator Leakage Inductance	0.172 H
Rotor Leakage Inductance	0.172 H
Mutual Inductance	0.166 H
Motor Inertia	0.016 Kg-m2

REFERENCES

[1] Modern Power Electronics and AC Drives, by Bimal K. Bose.

[2] Antoni Arias, Luis Romeral, “Stator flux optimized Direct Torque Control system for induction motors,” *Electric Power Systems Research* 73 (2005), pp 257–265.

[3] Takahashi, T. Nogushi, “A new quick-response and high-efficiency control strategy of an induction motor,” *IEEE Trans. Ind. Appl.* 1A-22 (October) (1986), pp 820–827.

[4] Sayeed A. Mir, Malik E. Elbuluk, “Fuzzy Implementation of Direct Self Control of Induction Machines,” *IEEE Trans*. vol. 30, NO. 3, Mayjjune 1994.

[5] Fatiha Zidani and Rachid Nalt Sald, “Direct Torque Control of Induction Motor with Fuzzy Minimization Torque Ripple” *Journal of Electrical Engineering*, NO.56. pp 7–8, 2005.

[6] J. Faiz, M.B.B. Sharifian, “Comparison of different switching patterns in direct torque control technique of induction motors,” *Int. J. Electr. Power Syst. Res.* No.60 (2001) pp 63–75.

[7] R Toufouti, S. Meziane and H. Benalla “Direct Torque Control for Induction Motors Based on Discrete Space Vector Modulation”, *International Journal of Applied Engineering Research* .

[8] Casadei D., G. Serra, and A. Tani, "Improvement of direct torque control performance by using a discrete SVM technique," *in Proc. IEEE 29th Annu. PESC'98*, vol. 2, 1998, pp. 997-1003.

[9] Depenbrock M., "Direct self-control of inverter-fed induction machine", *IEEE Trans. Power Electron.*, vol. PE-3, no. 4, pp. 420-429, Oct. 1988.