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COMPARISION BETWEEN TWO LEVEL AND THREE LEVEL INVERTER FOR DIRECT TORQUE CONTROL INDUCTION MOTOR DRIVE

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ABSTRACT-*Direct torque control method is a powerful control technique for specially Induction motor drive. Now a days Direct Torque Control using Digital signal processors more popular in the ac motor control, in particular the induction motor drives. The quick response and smooth control of DSP's are being utilized to perform real time simulation on the ac motor variables, such as electromagnetic torque, fluxes, mechanical speed, etc. This paper presents the implementation of a high performance induction motor control technique known as direct torque control (DTC) utilizing three level inverter and compare between basic DTC scheme and modified DTC scheme(Three level inverter) to minimize the sampling period of the implemented drive system, DTC drives. Experimental results of this high performance drive system on a5hp standard induction motor are as expected and agree with the theoretical work Index term: Induction motor3phase, 5HP, Voltage source Inverter*

I. INTRODUCTION

IM control technique using direct torque control (DTC), was introduced about a few year ago, has a relatively simple and wide range of control structure at least as good as the FOC technique . It is also known that DTC drive is less sensitive to parameter changing. DTC method is based mainly on space vector theory by selecting proper space vector voltage across the sampling period the required control on stator flux and torque is obtain. The DTC drive consists of DTC controller, torque and flux calculator, and a voltage source inverter (VSI) as depicted in Figure 1. The configuration is much simpler than the FOC system. The technique can be easily implemented with using hysteresis controllers that is one for torque and for flux. The implementation of DTC of IM, although simple but requires a fast processor to perform real time simulation of electromagnetic torque and stator flux based on sampled terminal variables. Still micro-controllers have been used extensively in scalar or vector control of AC machines. However, to obtain a high performance and smooth control AC Induction motor drives, use of a fast processor is required. The solution to this problem is to use a processor that can perform fast calculations of the estimated values that in the case of DTC is the torque and stator flux. With the current research trend in motion control, undoubtedly, the DSP-based system will dominate the above problem. This is particularly true, example, with the newly introduced DSP TMS320F2407 family and DSP controllers which are specifically designed for digital motor control.

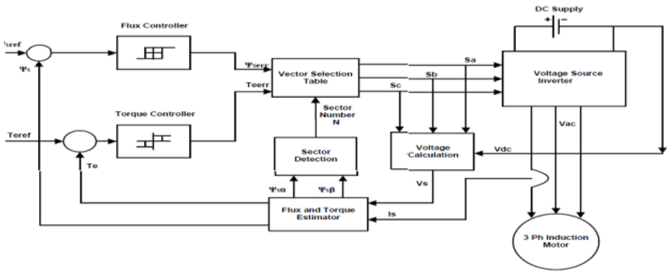

Figure1. Basic Direct Torque Induction Scheme

II. CONCEPT OF DIRECT TORQUE CONTROL

IM having VSI connected has eight possible configurations of six switching devices within the inverter. As a result, there are eight possible input voltage vectors to the IM. For controlling the stator flux and torque DTC utilizes eight possible stator voltage vectors

Switching States of Phase Leg a of VSI:

$$V_{ab} = V_a - V_b \quad \text{-------} \quad (1)$$

$$V_{bc} = V_b - V_c \quad \text{-------} \quad (2)$$

$$V_{ca} = V_c - V_a \quad \text{-------} \quad (3)$$

Sa consisting of switching devices T1 and T4

III. SWITCHING STATES FOR VOLTAGE SOURCE INVERTER

STATE	STATE No.	SWITCH STATES		
		Sa	Sb	Sc
T1, T2, T6 are on	1	1	0	0
T2, T3, T1 are on	2	1	1	0
T3, T4, T2 are on	3	0	1	0
T4, T5, T3 are on	4	0	1	1
T5, T6, T4 are on	5	0	0	1
T6, T1, T5 are on	6	1	0	1
T1, T3, T5 are on	7	1	1	1
T4, T6, T2 are on	0	0	0	0

Table: 1 Selections for Inverter switching states

In general, in a symmetrical three-phase induction machine, an instantaneous electromagnetic torque is a cross product of the stator and rotor flux linkage space vector or stator current space vector and stator flux linkage space vector

Te = 3/2PΨs x Is   ------- (4)

Ψs= stator flux linkage space vector

Te = 3/2P/2 Lm/Ls' ΨsΨrSinγ ----- (5)

In the above equation the electromagnetic torque given is a sinusoidal function of the angle γ between the stator and rotor flux linkage space vector. The magnitude of the stator flux is normally kept constant and the motor torque is controlled by means of the angleγ .The variation stator flux will produce a variation in the developed torque because of change in angle γ

$$\text{Ie } \Delta Te = 3/2P/2Lm/Ls' \, (\Psi s+\Delta\Psi s) \, \Psi r \, Sin\gamma \text{ -------- } (6)$$

It is therefore required to controlled torque very effectively by rotating the stator flux vector directly in a given direction torque switching frequency,

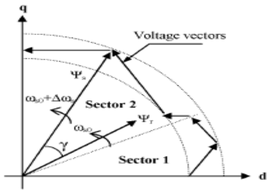

Figure: 2 Optimized Voltage Vector In The Torque Control

Stator flux behavior compared to rotor flux is shown in fig after step variation stator pulsation, the initial pulsation and allows the step variation. Controlling the stator flux and electromagnetic torque control achieved by using the appropriate stator voltages can quickly change the electromagnetic torque. Choosing suitable voltage vectors which increases or decreases y the causes the electromagnetic torque to increase or decrease.

$\Delta\Psi_s$	ΔC_e	S_1	S_2	S_3	S_4	S_5	S_6
1	1	V_2	V_3	V_4	V_5	V_6	V_1
	0	V_7	V_0	V_7	V_0	V_7	V_0
	-1	V_6	V_1	V_2	V_3	V_4	V_5
0	1	V_3	V_4	V_5	V_6	V_1	V_2
	0	V_0	V_7	V_0	V_7	V_0	V_7
	-1	V_5	V_6	V_1	V_2	V_3	V_4

Table: 2 Sector Selections for Direct Torque Control

Fig shows the partition of the complex plan in six angular sectors S I= 1…6

System core consists of a flux and torque calculated and from that width of the hysteresis can be determine, a flux and speed controller and a torque are determine by two measure motor stator flux current, the dc voltage and the state of the switches, references of flux and torque are compared with actual value of flux and torque and two level for flux and three level for torque hysteresis control method produces control signal

$$vs(t)=2/3(vsA(t)+avsB(t)+a2vsC(t)),\text{where } a=e2/3Л \text{ --------}(7)$$

vsA, vsB,vsC are the instantaneous phase that voltage

For the switching VSI it can be shown for a DC link voltage of Vd, the voltage space vector is given by Sa(t), Sb(t), and Sc(t) are the switching functions of each leg of VSI, such that

The stator flux linkage of an IM can be expressed in the stationary reference frame (w=0) with the help of the following two equations**.**

$$Vqs = r_s i_{qs} + \frac{d\lambda qs}{dt} + \omega \lambda_{ds} \quad \text{--------- (8)}$$

$$Vds = r_s i_{ds} + \frac{d\lambda_{ds}}{dt} + \omega\lambda qs \quad \text{--------- (9)}$$

The IM stator voltage equation which is in the stator reference frame (ω=0) is given by:

$$\bar{V}_S = R_S \bar{I}_S + \frac{d\bar{\Psi}_S}{dt} \quad \text{----- (10)}$$

Where Vs, Is, Ψs are the stator voltage, current and stator flux space vectors respectively. According to equation above if the stator resistance is small and can be neglected, the change in stator fluxThis simply means that the tip of the stator flux will follow that of the stator voltage space vector multiplied by the small change in time.

$$\bar{\Psi}_s \approx \bar{\Psi}_{s0} + \int_0^t \bar{V}_s dt \quad \text{-------- (11)\\}$$

For one period of the voltage applied remain constant

$$\bar{\Psi}_s(k+1) \approx \bar{\Psi}_s(k) + \bar{V}_s T_e \quad \text{----------- (12)}$$

hence if the voltage drop due to stator resistance is ignored then above equation can be written as

$$\Delta\bar{\Psi}_s \approx \bar{V}_s T_e \quad \text{-------- (13)}$$

Hence if the stator flux space vector (magnitude and angle) is known, its locus can be controlled by selecting appropriate stator voltage vectors. In DTC the stator flux space vector is obtained by calculation utilizing the motor terminal variables (stator voltages and currents). The stator flux is forced to follow the reference value within a hysteresis band by selecting. The electromagnetic torque is proportional to the vector product between stator vector and rotor flux and the expression is

$$C_e = k(\bar{\Psi}_s \times \bar{\Psi}_r) = k|\bar{\Psi}_s||\bar{\Psi}_r| \sin(\delta) \quad \text{-------- (14)}$$

Where

Ψs = stator vector flux

Ψr = rotor vector flux and

δ = angle between stator and rotor flux vector

The appropriate stator voltage vector is obtained using the hysteresis comparator and selection table.

IV. THREE LEVEL INVERTER

In three (multi level) level inverter harmonic analysis is in terms of Total Harmonic Distortion (THD) for different power circuit topologies for induction motor drives. The most common multilevel inverter are the neutral-point-clamped inverter (NPC), flying capacitor inverter (FC), and cascaded H-bridge inverter (CHB). After the performance analysis of these topologies of multilevel inverter and various multi carrier PWM control techniques, results of the simulation are superiorior over two-level pulse width modulation based inverter fed drives.

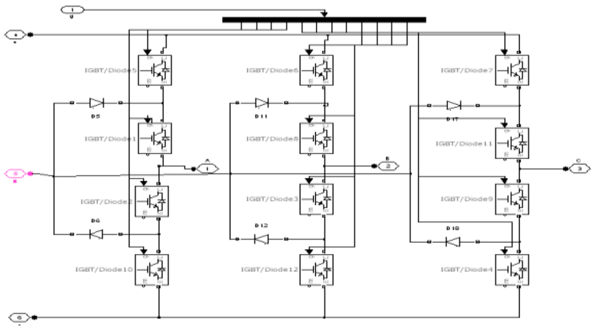

Figure 3 Three level direct torque control scheme

Voltage vector and voltage hexagon in three level inverter

V. SIMULATION RESULT OF THREE LEVEL INVERTER

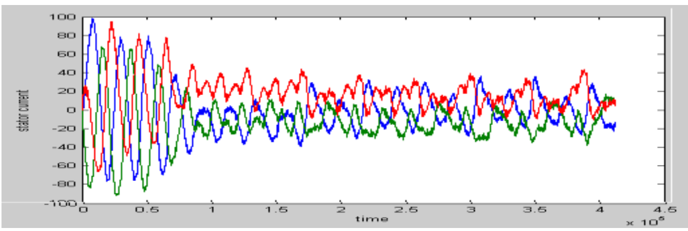

Figure 4 Plot of Stator current

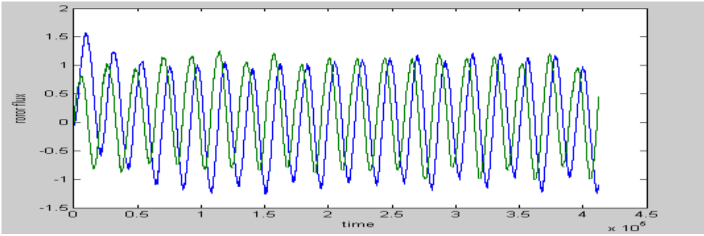

Figure 5 Plot of Stator flux

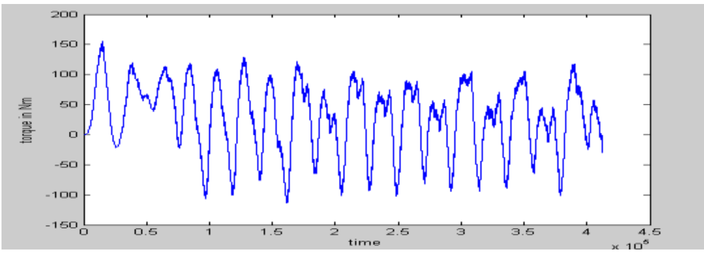

Figure 6 Plot of Torque

VI. CONCLUSION

This paper offers a modification in direct torque control method (DTC) to obtain fast and superior dynamic torque response. Considering effects of load and velocity of motor, an optimized switching table (OST) which is substantial factors in selecting appropriate vector, on changes of torque is proposed. Moreover, vector selection among appropriate vectors is on the basis of producing the least torque ripple. Following are the determination of OST, a closed-loop control strategy is presented for regulating voltage deviation of capacitors which restricting them to specified limit Simulation results demonstrate that using the proposed technique fulfills this objective even in the presence of pulsating torque. By comparing to the basic DTC method, it is substantiated that exerting the offered method benefits a simple implementation and provides the possibility of reducing dc link capacitor.

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