DIRECT TORQUE CONTROL OF INDUCTION MOTOR DRIVE

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Abstract- This paper presents direct torque control technique ,for induction motor .Direct torque control technique in AC drive systems to obtain high performance torque control .In this paper Discrete space vector modulation technique (DSVM) is applied to 2 level inverter control in proposed direct toque controlled (DTC)induction motor drive having reduced torque ripple even at the low operating speeds and maintaining constant switching frequency has been studied and implemented .The proposed algorithm is very simple and easily implemented to control speed

The proposed scheme is described clearly and simulation results are reported to demonstrate its effectiveness. The entire control scheme is implemented with Matlab/Simulink.

Index Terms—Direct torque control (DTC),Induction Motor ,

I. INTRODUCTION

Now a day's many studies have been developed to find out different solutions for the induction motor control they have features of precise and quick response and reduction of complexity of field oriented algorithm .The direct torque control (DTC) technique has been recognized as variable solution to achieve these requirements. The DTC technique has somewhat similar performance to a field oriented drive but there is difference in DTC scheme is that the DTC achieves the close loop control of the motor stator flux and electromagnetic torque without using current loop.

The DTC consists of adaptive motor model, two hysteresis band comparators a switching table and voltage source inverter (VSI) In order to keep stator flux and torque within the limits of the hysteresis bands. The basic working principle of DTC is that DTC selects one of the six voltage vectors and two zero voltage vectors generated by VSI in order to keep stator flux and torque within the limit of two hysteresis bands.

DTC has considerable ripple in torque, flux and current during steady state which results in harmonics power loss and incorrect speed estimation In order to improve the performance of the DTC in the terms of

Torque, flux and current ripple discrete space vector modulation is proposed.

DSVM discrete space vector modulation can generates a higher number of voltage vector which allows a sensible reduction of the torque and current ripple .The increased number of voltage vectors allows the definition of more accurate switching tables in which the selection of the vectors is made according to rotor speed, flux error and torque error. The switching tables are derived from the analysis of the equations linking the applied voltage vector to the corresponding torque and flux variations. These equations are obtained using a discrete model of machine valid for high sampling frequency

The advantages of the DTC are low complexity and that it only need to use of one motor parameter, the stator resistance ,no pulse width modulation is needed instead one of the six VSI voltage vectors is applied during whole sample periods .All calculation are done in a stationary reference frame which does not involves the explicit knowledge of rotor position still for synchronous motor rotor position must be known at start up. The DTC hence require low computational power when implemented digitally

II. BASIC DTC SCHEME

The block diagram for direct torque control is shown in fig .1 .The control strategy based on flux and torque hysteresis controllers .The command stator flux ϕs^* and torque Te* magnitude are compared with respective estimated values and errors are processed through hysteresis band controllers as shown .DTC uses a simple switching table to determine the desirable output torque by means of current and voltage measurement .It is easy to estimate the values of stator flux and motor torque .The stator voltage component (Vsα, Vsβ) on perpendicular (α,β) reference frame result from measured dc link voltage Udc and switching control logical states Sa,Sb&Sc

$$V_{s\alpha} = \sqrt{\frac{2}{3}} U_{dc} \left(S_a - \frac{1}{2(S_b + S_c)} \right) \quad (1)$$

$$V_{s\beta} = \frac{1}{\sqrt{2}} U_{dc} \left(S_b - S_c \right) \quad (2)$$

And stator current components Iα and Iβ can be determined

$$I_{s\alpha} = \sqrt{\frac{3}{2}} I_a \quad (3)$$

$$I_{s\beta} = \frac{1}{\sqrt{2\left(I_b - I_c\right)}} \quad (4)$$

Stator flux can be calculated from following equation

$$\phi_{s\alpha} = \int \left(V_{s\alpha} - R_s I_{s\alpha} \right) dt \quad (5)$$

$$\phi_{s\beta} = \int \left(V_{s\beta} - R_s I_{s\beta} \right) dt \quad (6)$$

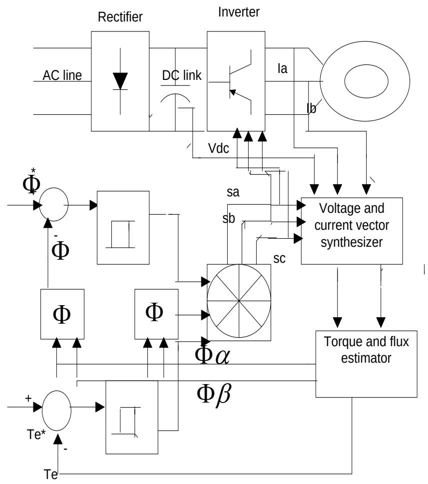

Figure 1.Basic DTC scheme

bΦ	b_T	Sector I	Sect II	SectI II	Sect IV	Sect V	Sect VI
1	1	V_5	V_6	V_1	V_2	V_3	V_4
	0	V_3	V_4	V_5	V_6	V_1	V_2
0	1	V_6	V_1	V_2	V_3	V_4	V_5
	0	V_2	V_3	V_4	V_5	V_6	V_1

Table 1. DTC Switching Table

The magnitude of stator flux can be estimated by

$$\phi_s = \sqrt{\phi^2_{s\alpha} + \phi^2_{s\beta}} \quad (7)$$

By using the flux components, current components and IM number of poles the electromagnetic torque can be calculated by

$$T_{em} = \frac{3}{2} P(\phi_{s\alpha} I_{s\beta} - \phi_{s\beta} I_{s\alpha}) \quad (8)$$

III. DISCRETE SPACE VECTOR MODULATION (DSVM) TECHNIQUE

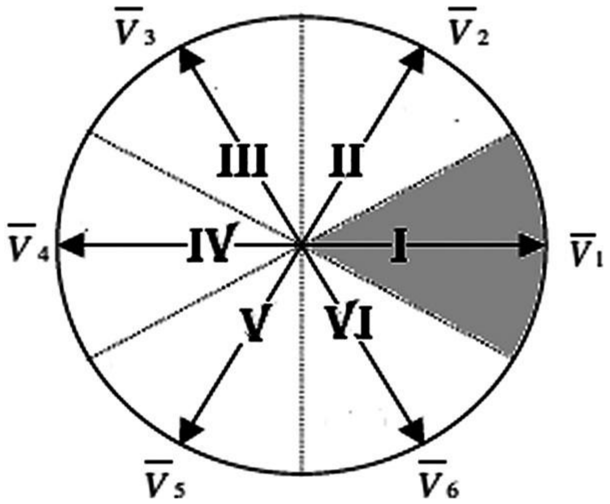

Figure 2:vector diagram for DTC

To modify the basic DTC control scheme in order to improve the performance of induction motor drive in terms of torque and current ripple. For this purpose s SVM technique that uses prefixed time intervals within a cycle period has been proposed. In this way it is possible to synthesize a higher number of voltage vectors with respect to basic DTC scheme without the need of timers or PWM signal generator. It is then possible to define more accurate switching table which allows a sensible reduction of torque and current ripple in the whole speed range

In this method number of voltage vectors is increased using VSI topology and introducing a simplified space vector modulation technique according to the principle of operation new voltage vectors can be synthesized by applying at each sampling period several voltage vector for prefixed time intervals the number of voltage vectors which can be generated is directly related to the number of time intervals by which the sampling period is subdivided .Higher the number of voltage vectors lower the amplitude of current and torque ripple . The advantage of using the DSVM technique is that one can choose among 19 voltage vectors instead of the five of basic DTC as a consequence assuming the same sampling period in the two control scheme the use of DSVM techniques improves the drive performance in terms of torque &current ripple, with an increase of the inverter switching frequency then the use of the DSVM technique is very useful in application where the maximum sampling frequency is limited by large computational time.

IV. COMPARISON OF DTC WITH FOC

Comparison property	DTC	FOC
Dynamic response to torque	Very fast	Fast
Coordinates reference frame	alpha, beta (stator)	d, q (rotor)
Low speed (< 5% of nominal) behavior	Requires speed sensor for continuous braking	Good with position or speed sensor
Controlled variables	Torque & Stator flux	Rotor flux, Torque current iq & Rotor flux current id vector components
Steady-state torque/current/flux ripple & distortion	Low (requires high quality current sensors)	Low
Parameter sensitivity, sensor less	Stator resistance	d, q inductances, rotor resistance
Parameter sensitivity, closed-loop	d, q inductances, flux (near zero speed only)	d, q inductances, rotor resistance
Rotor position measurement	Not required	Required either sensor or estimation)
Current control	Not required	Required
PWM modulator	Not required	Required
Coordinate transformations	Not required	Required
Switching frequency	Varies widely around average frequency	Constant
Switching losses	Lower (requires high quality current sensors)	Low
Audible noise	spread spectrum sizzling noise	constant frequency whistling noise
Control tuning loops	speed (PID control)	speed (PID control), rotor flux control (PI), id and iq current controls (PI)

V. RESULTS

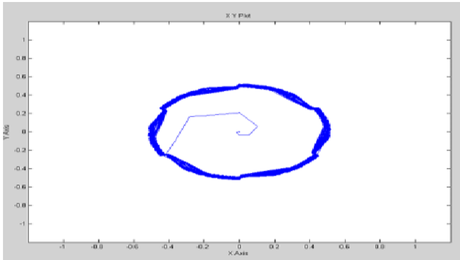

Figure 3.stator flux circular trajectory

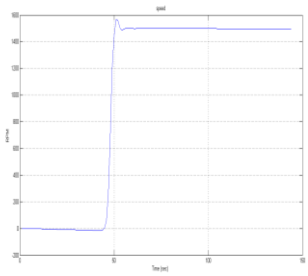

Figure 4. speed

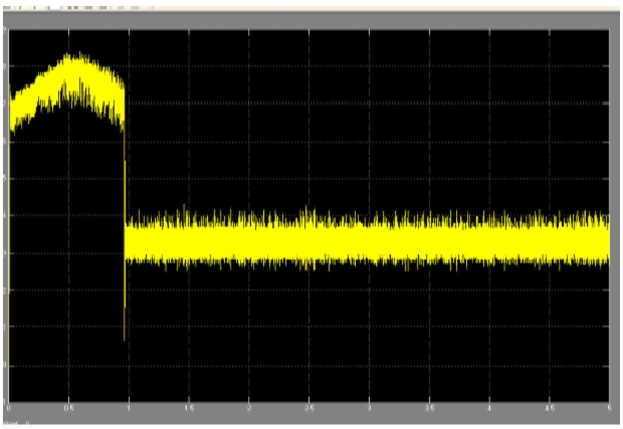

Figure 5. Torque .

VI. CONCLUSION

In this paper a DTC scheme for induction motor drive has been presented to improve the performance of induction motor drive in terms of torque and current ripple .We have used DSVM technique in this method more vectors are generated with specific interval of time to control torque and current ripple using this technique we can improve the motor performance without the need of timers or PWM signals generated

Direct torque control is supposed to be one of the best controllers for driving any induction motor Its principles and basic concept have been introduced and thoroughly explained

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