SPEED CONTROL OF INDUCTION MOTOR BY USING DIRECT TORQUE CONTROL

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ABSTRACT: ***Direct Torque Control is a control technique used in AC drive systems to obtain high performance torque control. The conventional DTC drive contains a pair of hysteresis comparators, a flux and torque estimator and a voltage vector selection table. The torque and flux are controlled simultaneously by applying suitable voltage vectors, and by limiting these quantities within their hysteresis bands, de-coupled control of torque and flux can be achieved. However, as with other hysteresis-bases systems, DTC drives utilizing hysteresis comparators suffer from high torque ripple and variable switching frequency. The most common solution to this problem is to use the space vector depends on the reference torque and flux. The reference voltage vector is then realized using a voltage vector modulator. Several variations of DTC-SVM have been proposed and discussed in the literature. The work of this project is to study, evaluate and compare the various techniques of the DTC-SVM applied to the induction machines through simulations. The simulations were carried out using MATLAB/SIMULINK simulation package. Evaluation was made based on the drive performance, which includes dynamic torque and flux responses, feasibility and the complexity of the systems.***

KEYWORDS: Induction motor, state feedback and estimator direct torque control, pulse-width modulation

I. INTRODUCTION

Because of their robustness, cheapness, high speed operation and less maintenance requirements, the induction motors (IM) are the most common type of electromechanical drive in industrial, commercial and residential applications. To reach the best efficiency of induction motor drive (IMD), many new techniques o f control have been developed in the last few years. In general, induction motor can be controlled by both open and closed loop control techniques. Then by estimating the speed and voltage simpler alternative to the vector control is the direct torque control (DTC). While DTC and VC have different concept of operation, they both provide an effective control of the flux and torque .The direct torque control (DTC) is the main interest of this project and it will be described in the following Sections. However, a brief introduction about IM design and characteristics, IM model and its observailbilty and Controllability need to be labeled first for better understanding of the project. Industrial loads require operation at wide range of speeds. Such loads are generally termed as variable speed drives. These drives demand precise adjustment of speed in a steeples manner over the complete speed range required. The loads may be constant torque oral function of speed. These loads are driven by hydraulic, pneumaticor electric motors. An industrial drive has some special features when driven by electric motors. Induction machines have provided the most common form of electromechanical drive for industrial, commercial and domestic applications that can operate at essentially constant speed. Induction machines have simpler and more rugged structure, higher maintainability and economy than dc motors. The possible forms of drive motors are dc drives, ac drives. DC motors are versatile for the purpose of speed control but they suffer from the disadvantage imposed by the commentator. The Field Oriented Control (FOC) and the Direct Torque Control (DTC) are two types of drives employed for high performance applications. Direct Torque Control was introduced in Japan by Takahashi (1984) and Depenbrock (1985). Vector controlled induction motors are employed in high performance drives

II .DESIGN AND OPERATION OF IM

The induction motor (IM) is an alternating current machine having the armature winding on the stator and the field winding on the rotor

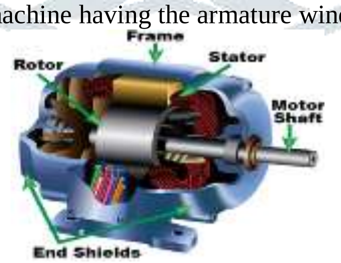

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Fig1 : Diagram for induction motor

When a three phase voltage is applied to the stator winding terminals, three phase balanced currents flow in the armature windings and consequently a rotating magnetic motive force (MMF) field is yielded .This field rotates at synchronous speed □□□□ in revolution per minute. where□ Supply frequency and Number of poles. By faraday's law, this rotating stator magnetic field induces voltages in the rotor windings causing balanced currents to flow in the short circuited rotor. As a result, a rotor MMF is formed. An electromagnetic torque (Te) is produced due to the interaction between the stator and rotor rotating magnetic fields. The difference between the rotor speed and the stator speed (synchronous speed) defines the per unit slip (s) where

S=120f/p

f : Supply frequency and

p: Number of poles.

By faraday's law, this rotating stator magnetic field induces voltages in the rotor windings causing balanced currents to flow in the short circuited rotor. As a result, a rotor MMF is formed. An electromagnetic torque (Te) is produced due to the interaction between the stator and rotor rotating magnetic fields. The difference between the rotor speed and the stator speed (synchronous speed) defines the per unit slip (s) where

At zero rotor speed (relaxed condition), a unity slip is produced. At synchronous rotor speed, a nil slip is obtained and hence no torque is produced. The motoring operation of IM is typically in the region of $0 < s < 1$.
A typical torque-speed characteristic of an induction motor is shown in Fig.2.

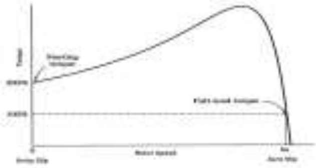


Fig2:Torque-speed characteristics of induction motor

The rotor of the induction machine can be either a wound rotor containing three windings similar to the stator once or a squirrel-cage rotor consisting of conducting bars shaped like a squirrel cage.

III SPEED CONTROL OF INDUCTION MOTOR

1 .INTRODUCTION OF INDUCTION MOTOR:

Induction motor control methods are divided into scalar and vector control. In scalar control, which is based on relationships valid in steady state, only the magnitude and frequency of voltage, current, and flux linkage space vectors are controlled. Consequently,the scalar control does not act on space vector position during transients.Contrarily, in vector control, not only the magnitude and frequency (angular speed) but also the instantaneous positions of voltage, current, and flux space vectors are controlled.

1.1SPEED CONTROL OF INDUCTION MOTOR

DC motors are versatile for the purpose of speed control but they suffer from the disadvantage imposed by the commentator. On the other hand ac drives are viable competitors with the advent of thrusters power converter technology. The evolution of ac variable speed drive technology has been partly driven by the desire to emulate the performance of dc drive such as fast torque response and speed accuracy, while utilising the advantages offered by standard ac motor.

1.2 TYPES OF SPEED CONTROL:

There are two types of speed control techniques available according to the forming of loop.
(a). open loop speed control**:**
In this, the stator voltage was varied, and the supply frequency was at the same time differed such that the V/f ratio stayed steady. this kept the flux consistant and thus the maximum torque at the time of varying speed.
b) closed loop speed control**:**
In this, speed of the rotor is measured and compared with reference speed.the difference is given to a PI controller which tries to minimize the error to zero and according to PI output frequency and voltage is define for SVPWM based inverter.
In this closed loop speed controlling technique, there are 2 types.
Those are
1. field oriented control.
2. direct torque control.
In this project, the direct torque control is used for speed controlling of induction motor.

1.3 FIELD ORIENTED CONTROL:

Vector control, also called field-oriented control (FOC), is a variable-frequency drive (VFD) control method in which the stator currents of a three-phase AC electric motor are identified as two orthogonal components that can be visualized with a vector.

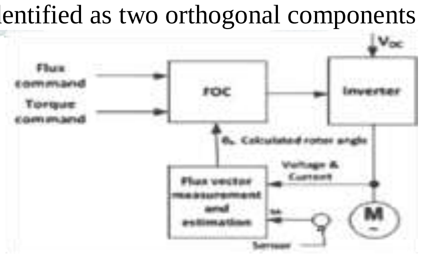


Fig 3.Block Diagram of Field Oriented Control

1.4 DIRECT TORQUE CONTROL:

Direct torque control (DTC) is one method used in variable frequency drives to control the torque (and thus finally the speed) of three-phase AC electric motors. This involves calculating an estimate of the motor's magnetic flux and torque based on the measured voltage and current of the motor. The direct torque control (DTC) is the main interest of this project and it will be described in the following sections.
However, a brief introduction about IM design and characteristics, IM model and its observailbilty and controllability need to be labelled first for better understanding of the project.

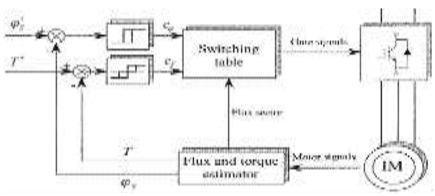


Figure 4: Direct torque control of induction machine

1.5 DTC BLOCK DIAGRAM

DTC was introduced by Takahashi (1984) in Japan and then in Germany by Depenbrock (1985) Unlike the traditional vector control, DTC doesn't require coordinate transformation, PI regulators, PWM and positionencoders. Hence, DTC is much simpler. Moreover, Both DTC and VC provide good dynamic response but DTCis less sensitive to the motor parameter variations.DTC Block diagram is shown in .Basically, both torque and stator flux need to be estimated so that theycan be directly controlled in a way that keeps them within a hysteresis band close to the desired values. This isachieved by choosing the appropriate sector in space vector modulation which will be described in section X.According to the torque produced by a pole machine can be calculated by equation One can notice that the torque is dependent on the stator flux rotor flux and the angle between their vectors However, they will be independently controlled as will be shown

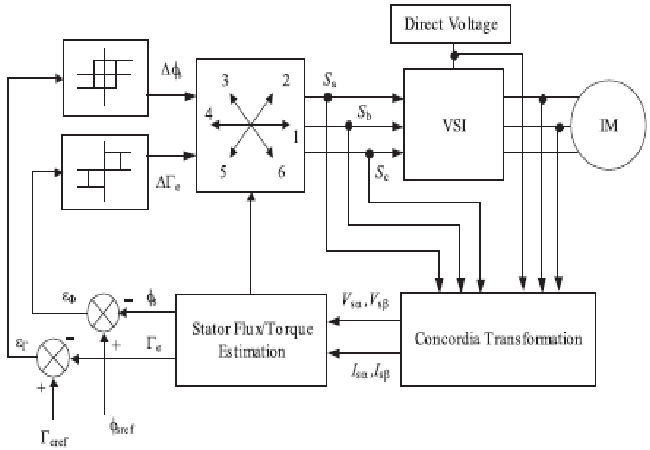
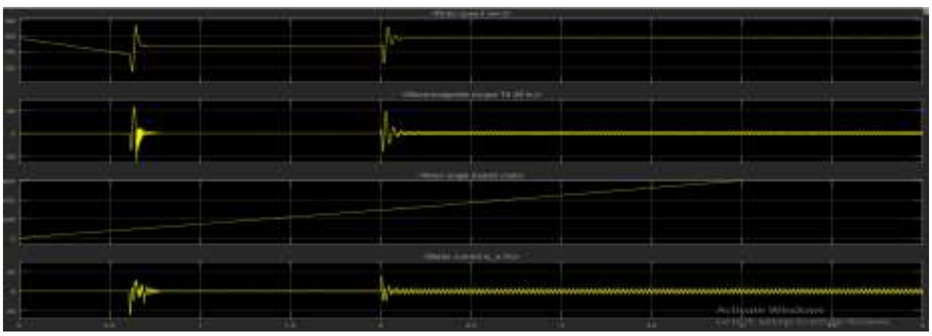


FIG 5: DIRECT TORQUE CONTROL OF INDUCTION MOTOR

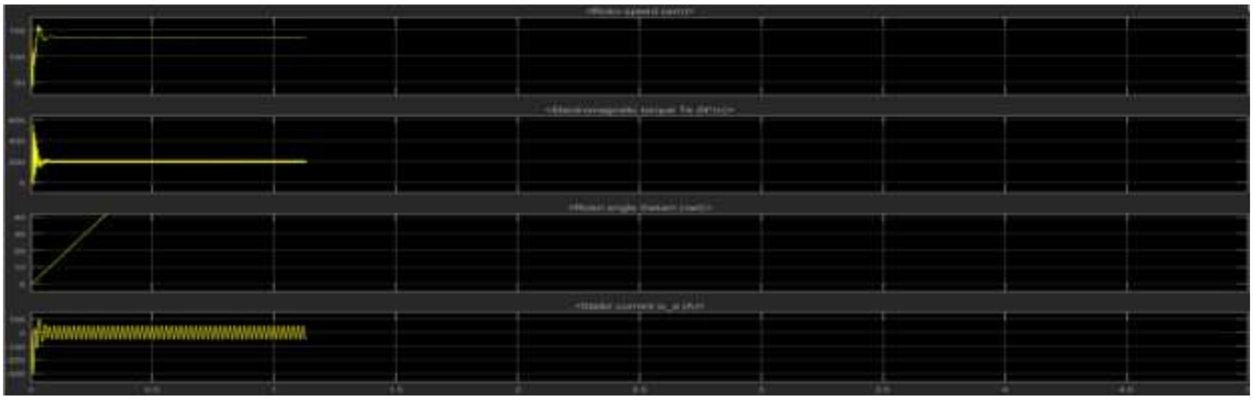
The main objective of DTC is to control the inductionmotor. The per-phase equivalent circuit of an induction motor is valid only in steady-state condition. In an adjustable speed drive likethe DTC drive, the machine normally constitutes an element withina feedback loop and hence its transient behavior has to be taken intoconsideration. The induction motor can be considered to be atransformer with short circuited and moving secondary. Thecoupling coefficients between the stator and rotor phases change continuously in the course of rotation of rotor Direct torque control has its roots in field-oriented controland direct self control. Field-oriented control uses spatial vectortheory to optimally control magnetic field orientation. It has beensuccessfully applied to the design of flux vector controls and is welldocumented. Direct self-control theory is less well known. Thefundamental premise of direct self control is as follows. Given aspecific dc-link voltage (Edc) and a specific stator flux level ,a unique frequency of inverter operation is established

IV SIMULATION RESULTS

WAVE FORM AT 2 SEC



WAVE FORM AT 5 SEC



V CONCLUSION

Direct torque control combines the benefit of direct flux and torque control into sensor less variable frequency drive that does not require a PWM modulator. Recent advances in digital signal processor and application specific integrated circuit and the theoretical concepts developed so far for direct self control makes this possible. The objective of the present work was to make a model of direct torque control of three phase induction motor. Various speed control schemes were studied and extensive literature survey was carried out for understanding the direct torque control technique. MATLAB/SIMULINK was chosen as modeling and simulation tool because of its versatility. Model for direct torque controlled induction motor was developed using MATLAB/SIMULINK and performance of the system for different t of changing the values of K p and Ki on the performance characteristics, was studied. The model was validated by comparing the plots of various performance parameters with those available ewith literature. It was also observed that for motoring operation, the performance was best in terms of starting time, overshoot and undershoot

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