Induction Motor Drives Speed Control Using Digital Signal Controllers (DSC)

M. Susila, Dr.B. Karthik and G. Angelo Virgin

Abstract: *Induction motor is widely used in large scale industries as much as employed in small scale industries. In industrial employment, the three phase induction motor faces numerous drawback when they are subjected to heavy loads. These exerted forces are related as disturbances in motor resulting in classification namely internal and external disturbances. Induction motor may exhibit both disturbances under critical conditions; to eliminate these disturbances a microcontroller is employed. This microcontroller can work with all capabilities that a digital signal processor can do. The dsPIC microcontrollerisa16-bit microcontroller unit ((MCU) with computation and throughput capabilities of DSP processor in single core. The digital signal controllers are coded with the vector control r field oriented control scheme to control the speed of the three phase induction motor. A driver circuit of closed loop IGBT is used to limit the fluctuations of current in the induction motor.*

Keywords*: Squirrel cage Induction motor, IGBT gate driver, Dspic microcontroller, Vector control, Isolation and Buffer.*

I. INTRODUCTION

The induction motor is widely used in heavy industries due to its reliability, rugged construction, high efficiency, good power factor and it has a simple starting arrangements. Induction motor drives that exhibit nonlinear characteristics can be subdued by employing numerous vector techniques. Since the paper is related to the speed control, its extreme drawback due to low starting torque associated with proportional increase in load is to be analyzed and studied.

The induction motor is a nonlinear time varying system, whose state transient analysis is much difficult resulting in difficulty toward controlling the speed. Here, the electrical energy is converted into mechanical energy that has high performing driver systems which would produce modified machine performances with dynamic models consisting parametric variations.

An AC induction motor has a fixed outer portion, called the stator and a rotor that spins inside with a carefully engineered air gap between the two. Virtually all electrical motors use magnetic field rotation to spin their rotors. A three-phase AC induction motor is the only type where the rotating magnetic field is created naturally in the stator because of the nature of the supply [2]. DC motors depend either on mechanical or electronic commutation to create rotating magnetic fields. A single-phase AC induction motor depends on extra electrical components to produce this rotating magnetic field. Depending upon the type of control mechanisms likes caller control [2,3], in direct torque

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control[4,5],direct torque control [2,4],field acceleration method, universal field orientation, direct self control [1]the current regulation in the loops are studied.

II. INDUCTION MOTOR DRIVES

Induction motors are categorized on the basis of the windings and their rotating winding which has non-ideal winding distribution for neglecting the effects of slots and space harmonics. The classified elements are, 1) cage or wound rotor (dually fed) and 2) rotating or linear. The single phase and three phase motor are prominently employed throughout the industrial sectors. Among them the three phase winding plays a vital role in controlling the motion of the associated systems.

The performance of the drive is measured by its torque-speed characteristics. The dynamic performance of an AC machine is complex because three phase rotor winding move along with the three phase stator winding. The control methods employed in AC machines are

1) Scalar control (V/F),
2) Vector control or field oriented control (FOC),
3) Direct torque control (DTC).

The proposed scheme is experimented with the vector control mechanism.

A. Vector Control

Vector control deals with the variation of the control variables due to the changes in their magnitude and phase orientation. Unlike the scalar control method, whose variations in the control variables are only due to the changes in the magnitude values of the set point. The proposed method is well known as decoupling, or trans-vector control.

The limiting factor in the scalar control like inherent coupling effect giving sluggish response and the system ability to the higher order effect are sustained in this proposed scheme. There are two general methods of vector control, studied and schematized as1) direct or feedback method (by Blanschke) and2) indirect or feed forward method (by Hasse). Both the scheme generates a unit vector namely, cosine and sine angles for the control stator and rotor flux that provides natural decoupling air gap and coupling effect which has to be compensated by the decoupling compensation current.

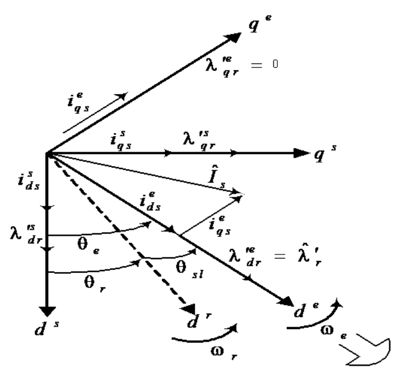

Fig 2.a vector control phase or diagram

At the low frequency response, the voltage signals are very low because of which the ideal integration is difficult since its estimated signal accuracy is reduced. In indirect vector control the torque producing components are controlled only after the transformation is undergone and not by its main reference input. The flux measurement is carried out using flux sensing coilor hall devices.

- Salient features of vector control methods are:
- Frequency is not controlled as such in scalar control.
- The frequency and phase are indirectly controlled with the help of unit vector resulting in the performance of induction motor as self controlled one.
- No instability problem while crossing the breaking point beyond the breakdown or regenerative torque.
- Transient response is fast.
- Speed control can be established in four quadrant system using forward monitoring and reverse monitoring condition.

III. IGBT GATE DRIVER

The electrical drives are classified under two bases

1. Open loop system
2. Closed loop system

The open loop doesn't contain the speed limiter while the closed loop has. There are two types of electrical drives namely1.) Speed loopand2.)Torque loop many applications require the speed of an AC motor to vary.

The easiest way to vary the speed of an AC induction motor is to use an AC drive to vary the applied frequency. Operating a motor at other than the rated frequency and voltage affect both motor current and torque.

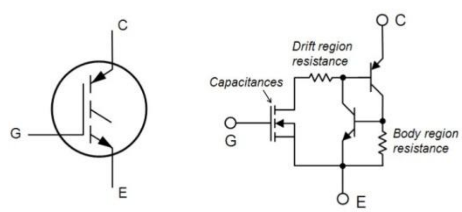

Fig.3.a IGBT symbol

Power diodes provides uncontrolled rectification of power and are used in applications such as electroplating, anodizing, power supplies (AC and DC) and variable frequency drives. They are also used in feedback and freewheeling functions of the converters and snubbers.

IV. VECTOR CONTROL DESIGN

The characteristic features of induction machines are based on the factors like rugged, reliable and their availability in the ranges of fractional horse power (FHP) to multi mega watt capacity. The single phase induction motor produce slow power FHP .In induction machines, the stator and rotor core are made up of laminated ferromagnetic steel sheets.

The torque produced in the induction motor is by the sweeping magnetic field, whose slip frequency and the synchronous speed in RPM is denoted using the equations provided below.

The rotational speed of the induction motor is.

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$$N_e=120f_e/P \quad (1)$$
$$Fe=w_e/2\pi \quad (2)$$

Where
N_e – synchronous speed in Rpm
F_e – stator frequency in Hz

The torque expression is,
$T_e = \pi(p/2) l_r B_p F_p \sin\delta$ (3)

A. General methods of vectors

The two general methods of vector control are

V. Direct or feedback method
VI. Indirect method

The two method generates a unit vectors namely $\sin\theta_e$ and $\cos\theta_e$. Orientation of id_s with rotor flux ψ_r, air gap flu x$\psi_m$or stat or flu xψ_s.

The rotor flux induces natural decoupling while the air gap or stator flux gives coupling effect which has to be compensated by a decoupling compensation current.

The flux produced in the d-qax is is generated from the machine terminal voltage and current with the help of voltage model estimator.

Precision control of flux is generated from the speed control through a bipolar limiter.

VII. Digital Signal Controller

Digital Signal Controller is a hybrid combination of microcontroller and digital signal processor. DSC offers a control oriented peripherals like PWM and watchdog timers with fast interrupt responses.

The microcontroller which would be used in this paper is a 16 bit, 24MCUs that delivers more performance, flexible peripherals for motor control, digital power conversion, low power security and analog integration.

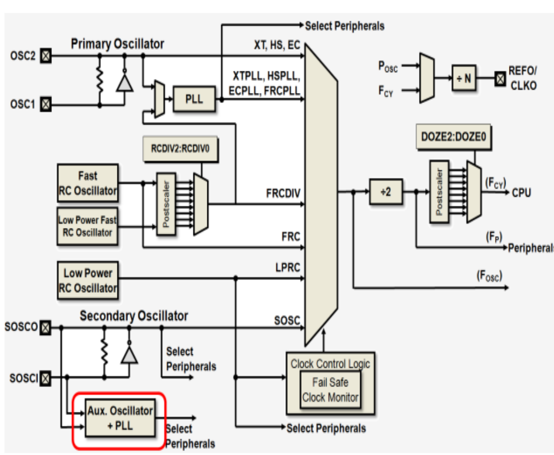

Fig. 5.a dsPIC peripheral interface

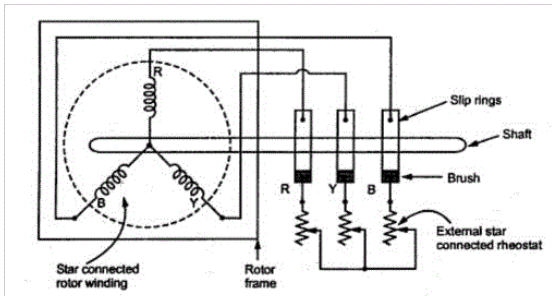

Fig. 5.b squirrel cage induction motor windings

With single cycle execution, deterministic interrupt response, zero overhead looping, and fast DMA, the dsPIC family also adds a single cycle 16x16 MAC and 40-bit accumulators, ideal for math intensive applications like motor control and digital power conversion. Interrupt response, zero overhead looping, and fast DMA, the dsPIC family also adds a single cycle 16x16 MAC and 40-bit accumulators, ideal for math intensive applications like motor control and digital power conversion.

VIII. EXPERIMENTAL RESULTS

Digital signal controllers (DSC) is a single chip, embedded controller that integrates the control attributes of a MCU with computation and throughput capabilities of a DSP in a single core.

During balanced condition there will be no current flowing through the neutral line and hence there is no use of the neutral terminal. But when there will be unbalanced current flowing in the three phase circuit, neutral is having a vital role.

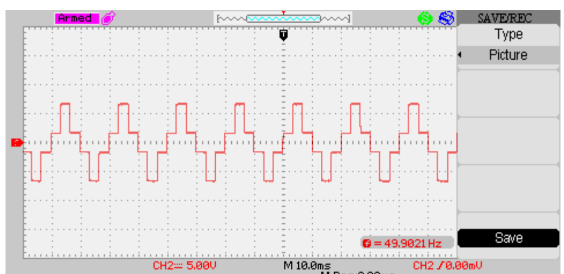

Fig.5.a Output of line voltage

Measure on any phase (S1or S2or S3) with respect to Neutral, it is called "Phase Voltage."It is and mediator between the three wires, producing the combinations of (S1, S2-S2, S3-S3, S1).

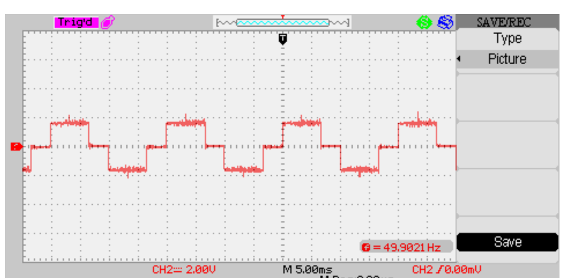

Fig.5.b. Output of phase voltage

A three phase transformer has three sets of primary and secondary windings. Depending upon how these sets of windings are interconnected, determines whether the connection is a starordelt a configuration.

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IX. CONCLUSION

The implementation of the proposed scheme on a digital signal processor (DSP) is formulated, where the runtime of the vector control algorithm is shorter. The industrial applicable drives are said to be called either as constant speed drives (AC) or variable speed drives (DC). The induction motor is called as constant speed drive as the speed of the motor is constant throughout the function.

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