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SIMULATION COMPARISONS OF INDUCTION MOTOR DRIVE WITH ESTIMATOR AND PLL

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ABSTRACT

This paper proposes a new control scheme for controlling of Induction Machine. In this control mechanism we are comparing the results with different schemes as 1. Rotor angle based speed estimation and 2. Phased lock loop based speed estimation. Then it is preceded with comparison through these two estimation methods. The simulation has been done and results is verified and validated in MATLAB /SIMULINK with different test conditions.

KEYWORDS: Induction Motor, PLL, V/f Control.

INTRODUCTION

The adjustable speed drives (ASD) are used more and more in industrial processes. The widespread industrial use of Induction Motor (IM) has been stimulated over the years by their relative cheapness, low maintenance and high reliability. The control of IM variable speed drives [1] often requires control of machine currents, which is normally achieved by using a voltage source inverter. A large number of control strategies have been registered so far. The volts per hertz (v/f) control of IM drives with inverters are widely used in a number of industrial applications promising not only energy saving, but also improvement in productivity and quality. The low cost applications usually adopt v/f scalar control when no particular performance is required. Variable-speed pumps, fans are the examples.

For those applications which require higher dynamic performance than v/f control, the dc motor like control of IM that is called, the Field Oriented Control (FOC) is preferred. During the last few years, a particular interest has been noted on applying speed FOC to high performance applications that is based on estimation of rotor speed by using the machine parameters, instantaneous stator currents and voltages.The benefits of speed sensorless control are the increased reliability of overall system with the removal of mechanical sensors, thereby reducing sensor noise and drift effects as well as cost and size. However to exploit the benefits of sensorless control, the speed estimation methods must achieve robustness against model and parameter uncertainties over a wide speed range. To address this issue, a variety of approaches have been proposed.

While all the speed techniques eliminate the use of mechanical speed sensor, they require the stator current and stator voltage signals as input. This requires at-least two current sensors and two voltage sensors on the stator side. It is difficult to get current sensors with equal gains over the wide range of frequencies, voltages and currents used in a practical inverter. The problem is exacerbated if the motor windings are not perfectly balanced or if the current sensors have some dc offset. Over last few years, techniques of stator current reconstruction from the dc link current have been suggested in literature.

The remaining of sections of the paper are organized as follows. In Section II, Induction motor modeling. In Section III, controller design, Simulation results are presented in Section IV.

INDUCTION MOTOR MODELLING

In this paper a squirrel cage Induction motor is modeled based on the Rotor reference frame. Torque developed by the induction machine is given by

$$T_e = \left(K_P + \frac{K_i}{s}\right)(\omega_{ref} - \omega)$$

$$\omega = \int \theta dt$$

Here based on the speed error we control the induction machine speed

CONTROLLER DESIGN

1 Rotor angle based controller

The controller is designed by using the flux estimation. The flux calculation was done from the currents through the machine. Here we are considering only the mutual inductance of machine for the flux linkages

The mathematical formulae for estimation of machine as follows

$$P_{hir} = L_m * \frac{I_d}{(1 + T_r s)}$$

Here L_m represents mutual inductance and I_d represents Direct axes currents. In this section rotor angle is estimated by using the speed and integrator.

Here the discrete integrator is preferred for the estimation of angle of the machine

$$\theta = \int (\varpi_r + \omega_m)$$

$$\omega_r = L_m * \frac{I_q}{(T_r * P_{hir})}$$

and W_m is the rotor speed.

The angle theta is used for the estimation of the Id and Iq currents from the park transformation.

Where I_q estimated as follows,

$$I_q = \left(\frac{2}{3}\right) * \left(\frac{2}{P}\right) * \left(\frac{L_r}{L_m}\right) * \left(\frac{T_e}{P_{hir}}\right)$$

2 PLL Based Controller

In PLL based controller is designed by using the phased lock loop. Phased lock loop is used for the angle estimation from the currents of the induction motor.

The block diagram of the PLL based controller is shown in the Fig.1

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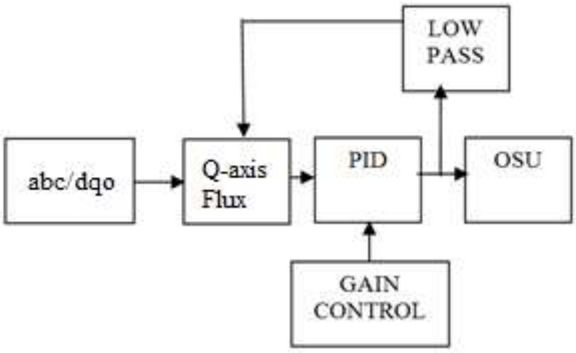

Fig 1. Block diagram of the PLL used for the estimation of angles

The three-phase input signal is converted to a dqo rotating frame (Park's transformation) using the angular speed of an internal oscillator. The quadrature axis of the signal, proportional to the phase difference between the abc signal and the internal oscillator rotating frame, is filtered with a mean (Variable Frequency). A Proportional-Integral-Derivative (PID) controller, with an optional automatic gain control (AGC) , keeps the phase difference to 0 by acting on a controlled oscillator. The PID output, corresponding to the angular velocity, is filtered and converted to the frequency, in hertz, which is used by the mean value.

3 Hysteresis Controller

The hysteresis controller is used for the generation of pulses instead of pulse width modulation. Here an advantage is generation of pulses in the band of hysteresis. Hysteresis band will protect the pulse generation efficiency and effectiveness compared with the pulse width modulation.

This pulses generated with different bands with the band range of 0 .05 to 10. It gives much response with the band value of 0.5 to 5 of effective value.

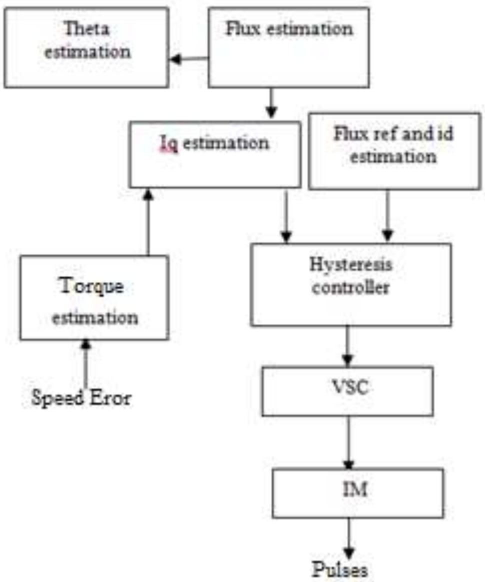

Fig 2. Proposed controller for the IM drive system

SIMULATION RESULTS

The simulation model had been generated based on the controller as shown in the Fig.3and the simulation studies have been discussed based on two conditions.

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a) Constant reference speed signal
b) Time variant reference speed signal

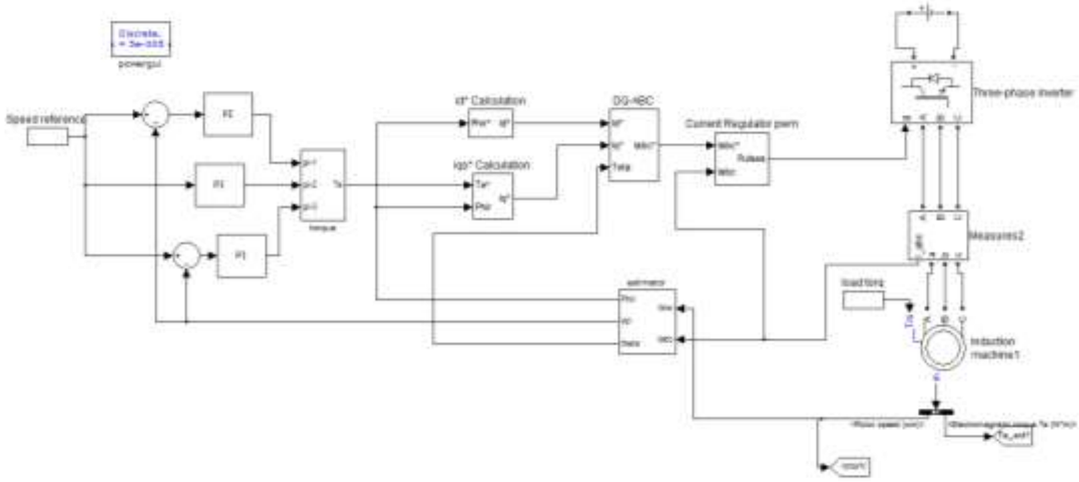

Fig.3 Simulink Implementation of Induction Motor Drive

a) Constant reference speed signal

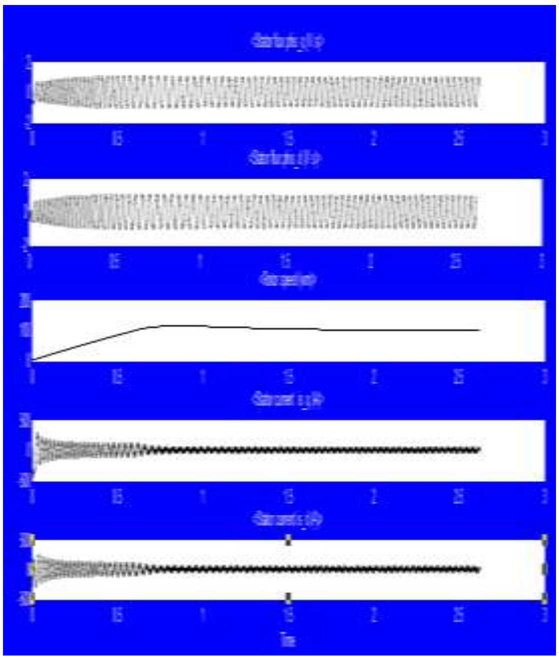

Fig4. Performance results of Induction Machine with constant reference control as d-axis flux, q-axis flux, speed, d-axis current and q-axis current with rotor angle estimation.

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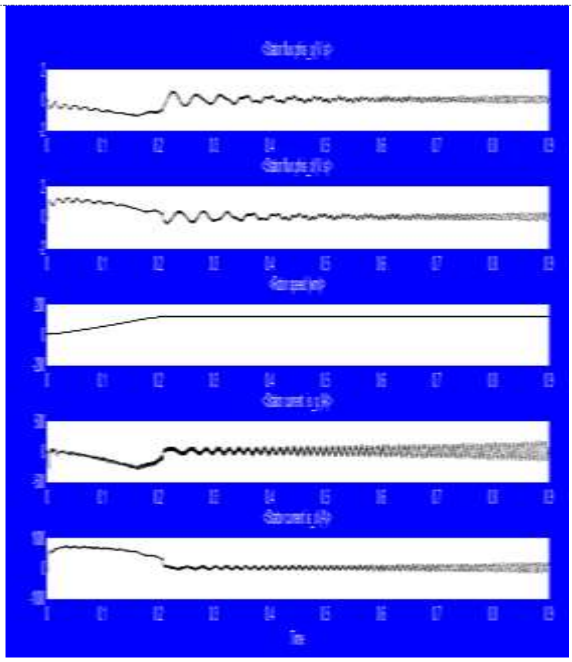

Fig5. Performance results of Induction Machine with constant reference control as d-axis flux, q-axis flux, speed, d-axis current and q-axis current with PLL.

In this case the constant reference speed signal taken as the reference and while situation we observe the characteristics of the induction machine response in case of rotor reference angle based speed tracking system the speed tracking error is very low and controller will gives much efficient manner. The optimal flux automatically reaches an adequate value consistent with the load torque value, highlighted by the behavior of the transient due to the load torque decrement. Results can be obtained in the case of the PLL observer based controller. the rotor velocity and the optimal square rotor flux modulus, and their references the power loss in copper and core, and the stator current and voltage components

b) Time variant reference signals

In this section, consider time variant reference signal. This reference aims at verifying the precision and the chattering effect of the proposed controllers. In particular, it is worth noting the good performance of the two controllers even when crossing the zero, both controllers perform well when the reference rapidly changes. The control performance with the two observers is here evaluated considering the precision error

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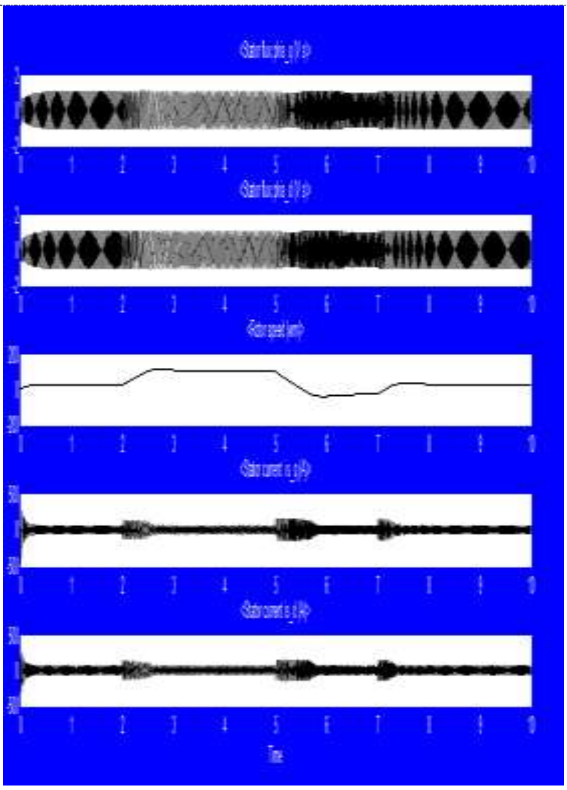

Fig 6. Performance results of Induction Machine with variable reference control as d-axis flux, q-axes flux, speed, d-axis current and q-axis current with rotor angle estimation.

CONCLUSION

In this paper, two control schemes for IMs have been designed and simulated. Both schemes use a controller designed to track a desired rotor velocity signal and an optimal rotor flux modulus. The unmeasured variables are reconstructed by means of a controller, which allows the determination of the rotor flux, and by two types of observes for the flux estimation: the first consists of a further torque estimation, and the second is based on a generalization of the PLL technique. In general, both control schemes yields satisfactory results, as verified by numeric simulations making difficult to decide which control scheme performs better. Some interesting issues remain to be investigated, such as the digital implementation of these controllers.

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