Comparative Analysis of PI and PR Controller for Induction Motor With PLL Technique

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Abstract - *This paper designed a sensor less control scheme PLL technique for controlling of Induction Machine. Then we are comparing the results with two different controllers as 1. PLL with PI controller and 2.PLL with PR controller. After it is comparing between P Iand PR controllers .*Simulations are performedby using the Matlab/Simulink software.

Key Words: **induction motors, sensor less control, phase locked loop.**

1. INTRODUCTION

Although construction of induction motor is simple, its speed control is considered to be far more complex than that of DC motors. The reason is nonlinear and highly interacting multivariable state space model of the motor. The rapid and revolutionary progress in microelectronics and variable frequency static inverters with application of modern control theory has made it possible to build sophisticated controllers for AC motor drives. The design and development of such drive system require proper mathematical modeling of the motor to optimize the controller structure, the inputs needed and the gain parameters. In this chapter the modeling of induction motor is presented.

The dynamic simulation is one of the key steps in the validation of the design process of the motordrive system, which eliminates the designing mistakes and the resulting errors in the prototype construction and testing. The dynamic model of the induction motor in direct, quadrature, and zero-sequence axes can be derived from fundamental equations of transformation.

The dynamic analysis of the symmetrical induction machines in the arbitrary reference frame has been intensively used as a standard simulation approach from which any particular mode of operation may then be developed. Matlab/Simulink has an advantage over other machine simulators in modelling the induction machine using dq0 axis transformation. Generally modelling of these equations is considered difficult so that in this paper they are presented in their simplified form.

The transformations used at various steps are based on simple trigonometric relationship obtained as projections on a set of axes. The dynamic model is used to obtain transient responses, small signal equations, and a transfer function of induction motor. Dynamic models (mathematical models) are employed in to better understand the behaviour of induction motor in both transient and steady state. The dynamic modelling sets all the mechanical equations for the inertia, torque and speed versus time. It also models all the differential voltage, currents and flux linkages between the stationary stator as well as the moving rotor.

The following presents the outline of the work in details. Section 2 represents the review on mathematical modelling of Induction motor , Section 3 represents controller design, Simulation results are presented in Section 4.

2. MATHEMATICAL MODELLING OF IM

The system model defined in the stationary α – β coordinate system attached to the stator is expressed by the following equations. [3].

$$v_{ds} = R_s i_{ds} + \frac{d}{dt}\lambda_{ds} - w_e\lambda_{qs}$$

$$v_{qs} = R_s i_{qs} + \frac{d}{dt}\lambda_{qs} + w_e\lambda_{ds}$$

$$v_{dr} = R_r i_{dr} + \frac{d}{dt}\lambda_{dr} + (w_e - w_r)\lambda_{qr}$$

$$v_{qr} = R_r i_{qr} + \frac{d}{dt}\lambda_{qr} - (w_e - w_r)\lambda_{dr}$$

Torque developed by the induction machine is given by

$$T_e = \frac{3}{2}\frac{PL_m}{L_r}\lambda_{dr} i_{qs}$$

3. ESTIMATOR DESIGN

the electrical angle of the stator flux vector is defined as:

$$\theta_{\psi s} = \tan^{-1}\left(\frac{\psi_{\beta s}}{\psi_{\alpha s}}\right)$$

The derivative of this rotor flux angle (with respect to time) gives the instantaneous angular frequency.

$$w_e = \theta_{\psi s} = \frac{\psi_{\alpha s}\psi_{\beta s} - \psi_{\beta s}\psi_{\alpha s}}{\psi_{\alpha s}^2 + \psi_{\beta s}^2}$$

The estimation of rotor speed is accomplished by an estimation of either synchronous, or slip frequency, with the other being known. In the proposed speed estimation scheme, the synchronous frequency is estimated and slip frequency is assumed as command. So the estimated rotor speed of the sensorless drive is obtained from the above equation as:

$$\widehat{w}_r = \frac{\widehat{w}_e - w_{sl}^*}{P}$$

Where,

$\hat{\omega}_r$ = estimated rotor frequency in rad/sec.

$\hat{\omega}_e$ = estimated synchronous frequency in rad/sec.

ω^*_{sl} = command value of slip frequency rad/sec.

The two-axis orthogonal stationary reference frame quantities are transformed into rotating reference frame quantities using Park transformation as shown . The Park transformation is expressed by the following equations:

$$Id = I\alpha * \cos(\theta) + I\beta * \sin(\theta)$$

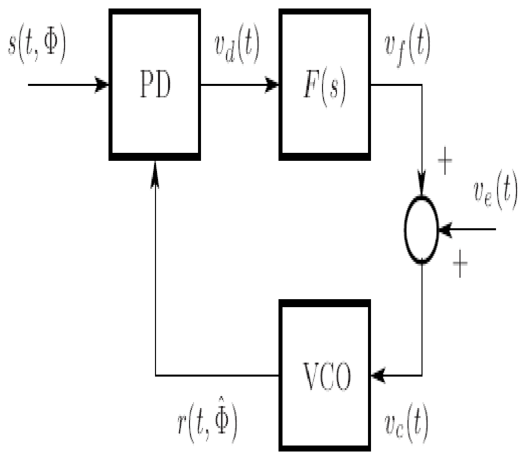
$$Iq = I\beta * \cos(\theta) - I\alpha * \sin(\theta)$$

where, Id, Iq are rotating reference frame quantities Iα, Iβ are orthogonal stationary reference frame quantities θ is the rotation angle

3.1 PLL TECHNIQUE IMPLEMENTATION

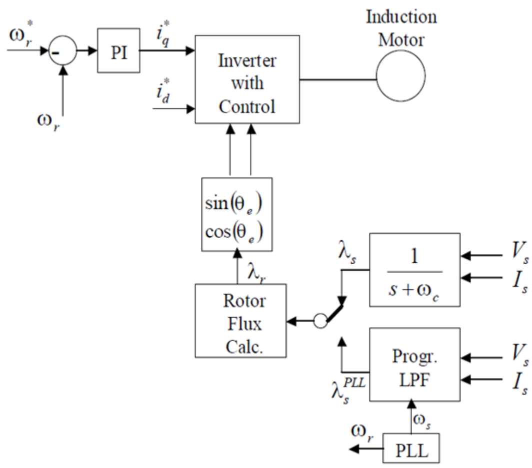
In PLL based controller is designed by using the phased lock loop[2]. Phased lock loop is used for the angle estimation from the currents of the induction motor.

The block diagram of the PLL as shown in the fig. bellow.



Basic block diagram of PLL

A phaselockedloop or phaselockloop abbreviated as PLL is a control system that generates an output signal whose phase is related to the phase of an input signal. There are several different types; the simplest is an electronic circuit consisting of a variable frequency oscillator and a phase detector in a feedback loop. The oscillator generates a periodic signal, and the phase detector compares the phase of that signal with the phase of the input periodic signal, adjusting the oscillator to keep the phases matched.



Proposed PLL control technique

4. SIMULATION & RESULTS

Simulations are performed by using the Matlab/Simulink software. To evaluate the performance of the proposed control structure we are depicting the simulation results for two different cases. One is with PI controller, second one is with PR controller

1. With PI controller.
2. Comparing PI with PR controller.

1.With PI controller.

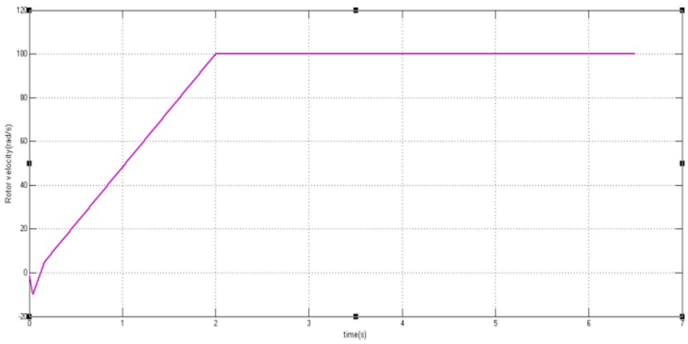


Fig.1(a)

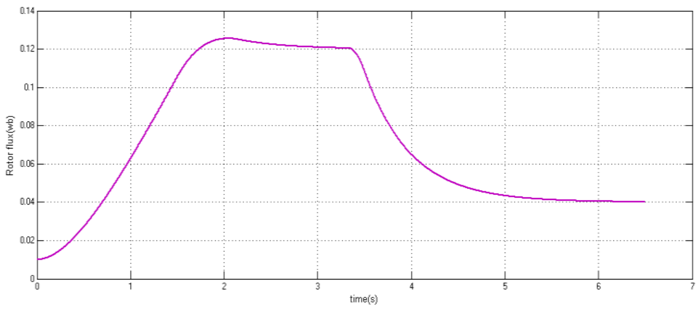


Fig.1(b)

The above fig shows the performance results of induction machine with PI controller.fig.1(a) represents rotor velocity [rad/s] vs time [s] and fig.1(b) represents optimal rotor flux [Wb^2] vs time [s].

2. Comparing PI with PR controller.

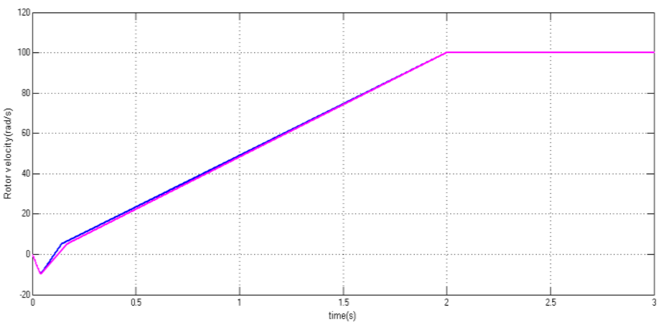


Fig.2(a)

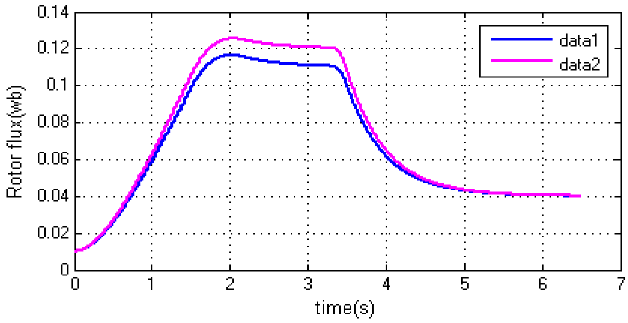


Fig.2(b) [data1-PI, data2-PR]

From above fig.2 (a) and fig.2 (b) shows the comparation results of PI with PR controller. In fig.2(a) shows improved rise time in rotor velocity with PR controller and fig.2 (b) shows decreased peak overshoot and gives optimal rotor flux with PR controller.

In fact, the optimal rotor flux modulus decrease corresponds to a decrease of the stator voltage, so avoiding an excess of current demand which could yield to higher power losses. It is worth noting the smoother response of the rotor flux when PLL technique is used. This can be explained by the fact that the PLL technique is designed for sinusoidal signals, and when the spatial distribution of the IM magnetic flux and current densities fulfil this hypothesis, the PLL observer-based controller shows this smoother behavior [9].

5. CONCLUSION

In this paper sensor less Estimator based PLL technique control scheme for IMs have been designed and simulated with PI controller and PR controller. The comparing results of both PI and PR controllers also have been simulated.By using PR controller system dynamic response improved and peak over shoot decreased.Some interesting issues remain to be investigated, such as the digital implementation of these controllers.

ACKNOWLEDGMENT

The authors thank the anonymous reviewers for their comments, which enabled improvement of the paper.

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