A SENSORLESS SPEED CONTROLLER FOR INDUCTION MOTORS

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***Abstract*— This paper presents a novel sensorless strategy for controlling speed in AC drives containing induction motors. The controller uses field oriented control strategy calculated with estimated rotor flux and speed. These estimates are obtained via a robust estimator.**

***Keywords*— sensorless, speed control, induction motors, electric machines**

I INTRODUCTION

AC drives including induction motors (IM) are often used in modern industry. In order to improve the performance, field oriented control (FOC) is used in many applications (Bose, 2002). When this strategy is to be implemented, mechanical and flux sensors are avoided to diminish cost and improve ruggedness. In such case, the FOC is calculated using speed and flux estimates. In order to obtain these estimates many algorithms have been developed. These algorithms use electrical variables (currents and voltages) measurements. Open-loop estimators and closed-loop estimators based on the IM model can be found in the literature. An excellent survey of sensorless control of the IM has been presented in (Holtz, 2002).

A widely used technique to obtain an estimate of rotor flux consists on estimating stator flux via an open-loop integrator and then, calculating the estimated rotor flux from the IM dynamic model (Holtz, 2002). In this case, rotor flux can be estimated ignoring the rotor time constant. This fact is the main advantage of this technique, since the rotor time constant is a parameter that varies with the temperature and the flux value (for instance, large variations occur in the field weakening zone).

Nevertheless, when open-loop integrators are included in the control law, bias appears, deteriorating the performance of the estimate. Generally, in such case the control law tries to diminish this bias. Consequently, a flux distortion is provoked and the generated torque contains ripple.

In order to overcome the open-loop estimator drawbacks, closed-loop estimators have been proposed (Hurst *et al.*, 1998). Moreover, to avoid integration drift problems, a low pass filter is used to replace the ideal integrator. This technique fails at low frequency, where field orientation is lost, degrading the drive performance.

In this work a sensorless FOC strategy for controlling speed in AC drives containing IMs is proposed. A new method for estimating rotor flux is introduced. The proposed method has two very interesting features. It is a closed-loop technique (open-loop techniques drawbacks are avoided) and the rotor flux estimation is independent of the rotor time constant. In addition, the estimator also provides estimated speed and estimated rotor resistance.

The proposed technique avoids the errors introduced by low pass filters used in other proposals (see Derdiyok *et al.*, 2002; Li *et al.*, 2005). In this way, whole-system performance is improved.

The paper is organized as follows. In section II, the IM model is presented. The proposed estimator is introduced in section III. In section IV and V, convergence analysis of the flux estimator is developed. In section VI, rotor resistance and speed estimates are computed. Estimator performance under uncertainty is analyzed in section VII. In section VIII, a sensorless control strategy is introduced. In order to validate our proposal, simulation results are presented in section IX. Finally, in section X conclusions are drawn.

II INDUCTION MOTOR MODEL

The equations describing the induction motor in a stationary two-axes reference frame are given in the symmetrical form by (Vas, 1992),

$$\begin{aligned} pi_s^s &= k_1\left[v_s^s - i_s^s R_s - k_2 p\phi_r^s\right] && (1)\\ p\phi_r^s &= k_3 i_s^s - \frac{1}{\tau_r}\phi_r^s - n_p\omega_r \mathbf{J}\phi_r^s && (2)\\ T &= \frac{M}{L_r} n_p \phi_r^s \cdot \mathbf{J} i_s^s && (3)\\ Jp\omega_r &= T - T_l - B\omega_r && (4) \end{aligned}$$