I. INTRODUCTION

Among the techniques for speed sensorless control of IM proposed in literature, the MRAS based estimation is one of the best methods due to its good performance and straightforward stability approach. The method is realized using the concept proposed by Landau, whose basic idea is to compare the outputs of a reference model and of an adjustable model and to find out an adaptation mechanism to minimize the error between two models. Applied MRAS to speed estimation, the reference model is the IM itself, and the adjustable model is a suitable equation where the rotor speed it involved. “Suitable equations” may be a function of flux, or of back e.m.f.s, or outer product of stator current and the back e.m.f.s, as documented in the literature. In this paper, we propose a MRAS-based speed estimation for IM drives using instantaneous reactive power.

II. ESTIMATION ALGORITHM USING INSTANTANEOUS REACTIVE POWER

From the general expression of instantaneous reactive power in d-q frame, we can derive 2 equivalent expressions: in the a-b-c stationary frame (1), and in the d-q stationary frame (2) using state equation of rotor flux.

\[
Q^* = \frac{1}{\sqrt{3}} (v_a i_c - v_c i_a)
\]

\[
Q = \frac{L_m}{\tau_r L_r} (\psi_{dr} q_s - \psi_{qr} i_s) + \omega \frac{L_m}{\tau_r L_r} (\psi_{dr} q_s + \psi_{qr} i_s)
\]  

\[
+ \sigma \left[i_{ds} \left(i_s q_s - i_s q_s^* \right) \right]
\]

The equation (1) is very convenient as the reactive power \(Q^*\) can be measured correctly using the terminal variables. It will be therefore employed as the reference model. Function \(Q\) in (2) will act as an adjustable model, since the rotor speed is involved in its expression.

In practice, a low pass filter (LPF) is used to eliminate the high harmonics (due to the PWM operation of the inverter) from the measured stator voltage and current. Therefore the modified variables are defined as \(Q_{mes}\) and \(Q_{est}\) as illustrated in Fig. 1. Our MRAS based speed estimation algorithm is summarized as follows.

\[
eQ = Q_{mes} - Q_{est}
\]

\[
\hat{\omega}_r = \left(K_p + \frac{K_i}{s}\right)eQ
\]

It is worth to note that (4) represents the PI adaptation law. The physical reason of the integrator (in the PI controller) is that it ensures the error of the reactive power converging asymptotically to zero. That is, the estimated rotor speed converges asymptotically to the correct one.

III. EXPERIMENTAL RESULTS

The control system of Fig. 1. is implemented on the laboratory IM drive using TMS320-C32 DSP. Fig. 2. shows the experimental results of the operation where the motor was started up with a constant speed reference of 0.3pu (90 rad/s), under no-load condition. The flux is maintained to be constant at its rated value. It can be seen that the functions \(Q_{mes}\) and \(Q_{est}\) are almost equal as the motor enters to the constant speed region, resulting in the good form of estimated speed. The technique has following advantages:

- requiring no integrator in the implementation;
- robustness to the stator resistance variation;
- the signal using in the reference model can be measured correctly, without any parameter dependence.