Journal of Engineering Technology and Sciences
Volume 02, Issue 03, March 2025 *ISSN: 3048-913X*
www.jets.org.in *DOI: https://doi.org/10.5281/zenodo.14998091*

Sliding Mode Without Sensors Induction Motor Drive Vector Control

Varma[1] and Pandian[2]
Department of Electrical Engineering, VIT, Vellore, Tamil Nadu
[1]Corresponding Author: varmaviteee@gmail.com

To Cite this Article
Varma and Pandian, "Sliding Mode Without Sensors Induction Motor Drive Vector Control", Journal of Engineering Technology and Sciences, Vol. 02, Issue 03, March 2025, pp: 16-

***Abstract**: This research discusses the design process of sliding mode controllers used for sensorless field-oriented induction motor control. A sliding mode regulator uses a sliding surface integration for speed regulation to improve controller performance. The adaptive observer implements the MRAS technique which determines rotor speed estimation used in the speed feedback loop. The experimental research verifies the effectiveness of this proposed method.*
***Keywords**: Sliding-mode control, induction motor, focused on the field, Sensorless speed control and adaptive observation*

I. Introduction

Modern versions of DSPs together with power electronic technologies enable straightforward implementation of various innovative control strategies in electrical machine drives. Researchers focus intensely on sliding mode variable structure control as it represents a major breakthrough for electrical machinery control through its robust nature against external disturbances and parameters changes alongside fast dynamic response and good performance against unmolded dynamic. The "two-loop control" represents the standard method which speed drive systems adopt for their induction motor drive system applications that employ SMC.

The system implements a vector controller which uses SMC regulation inside an inner loop and contains an outer-loop speed controller with SMC integrated sliding surfaces. The primary objective of vector control is to establish independent control of torque and flux excitation in DC motors. Induction motor vector control necessitates an understanding of stator current monitoring and rotor speed. Speed sensors fail to implement in numerous applications because of their high price together with maintenance difficulties and disturbances.

Several field-based control approaches that lack speed sensors have been proposed in the field. The definitions of stability remain inadequate because the field-based methods are linked to different types of control techniques. The techniques exhibit unreliable performance when utilized in environments with low speeds. During this research a sensorless decoupling control technique is presented. The paper explains both the motor model and field-oriented control system. The third section describes a procedure for speed estimation which removes the necessity for a speed detecting device. The system requires compensation for its uncertainties by implementing a sliding mode control system. This paper concludes through observations using experimental results displayed in section V to prove the feasibility of the proposed approach.

II. Speed with Rotor Flux Observer

Scientists have presented many different approaches for deriving motor speed measurements based on terminal measurements. Most estimating methods use adaptive systems for their operation. For improved motor speed estimation one must use a dynamic representation using the stationary (α β) reference frame. A stationary (α β) reference frame serves as an advantageous platform to state the equations because motor voltages and currents are monitored within this frame.

III. Adaptive Speed Estimator

The plan contains an adaptive system alongside two adjustable models which serve as reference and adjustable components. The Real platform appears in the "reference model" section. The adjustable model serves as the observer while its parameters remain adjustable. A PI-type controller functions through the adaptation mechanism to compute unknown parameters by comparing reference and adjustable models. The adjustable model receives updates from the estimated parameter which leads to satisfactory performance results. Figure 1 shows the configuration.

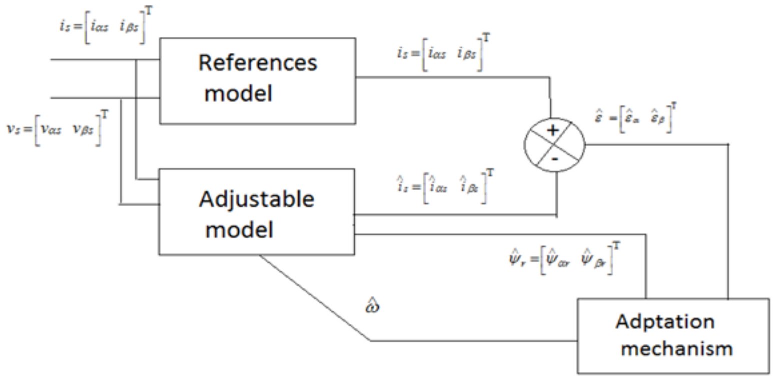

Fig 1: Speed estimation for adaptive scheme

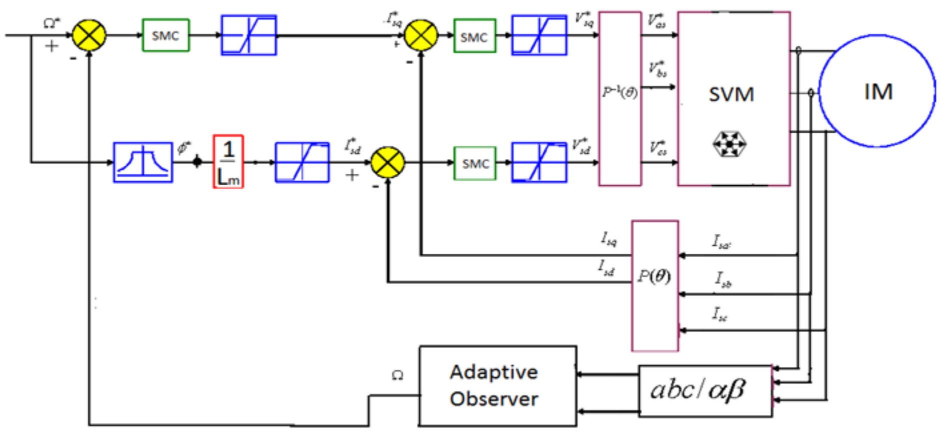

Fig 2: Induction motor control scheme

IV. Experimental Results

In this part, an appropriate test setup was used to empirically test the suggested overall closed-loop control system, which includes the speed observer (Fig. 3). The following makes up the test setup: The behavior of the induction motor with load torque TL=0 at various speeds is depicted in Figure 4. It is evident that the suggested SMC control scheme performs well in tracking and has a quick response time. We observe that the behavior of the estimated and real speeds is identical. This indicates that the adaptive observer can precisely monitor the speed command even during speed transients.

It's also crucial to note that, in the low-speed zone, the estimated and actual speeds match identically (Figure 5). The speed error between the calculated and reference values is shown in Figure 6. The calculated rotor speed is close to the actual values, as seen in Fig. 6. This indicates that the observer system fully satisfies our needs and has good estimation accuracy even in low-speed regions. The trajectories of the direct current (Ids) and quadratic current (Iqs) are shown in Figures 7.

Fig 3: Laboratory experimental set-up

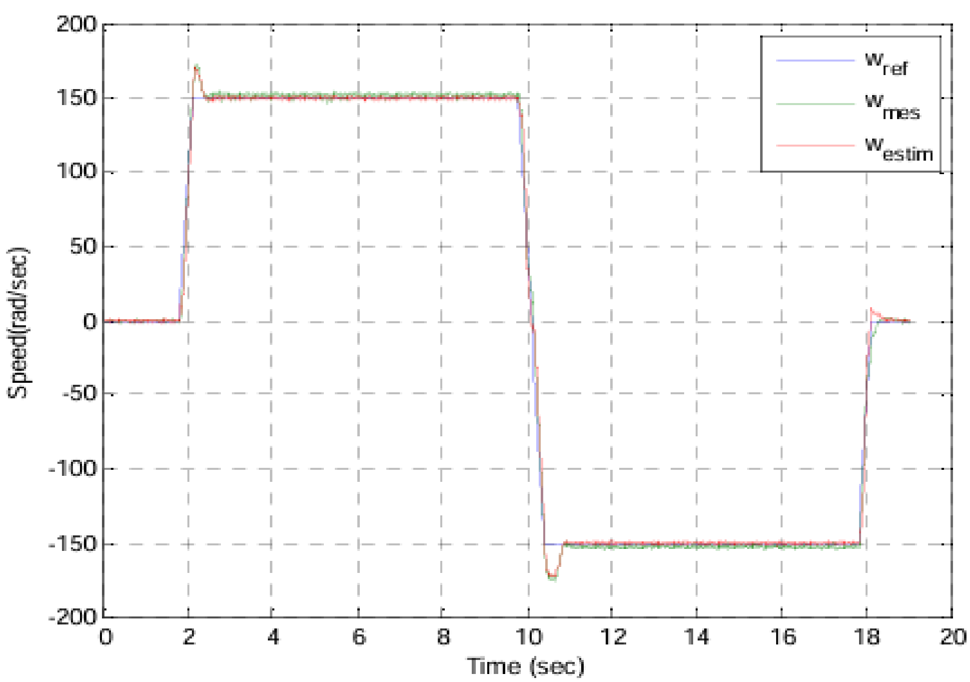

Fig 4: Estimate Vs Real speed

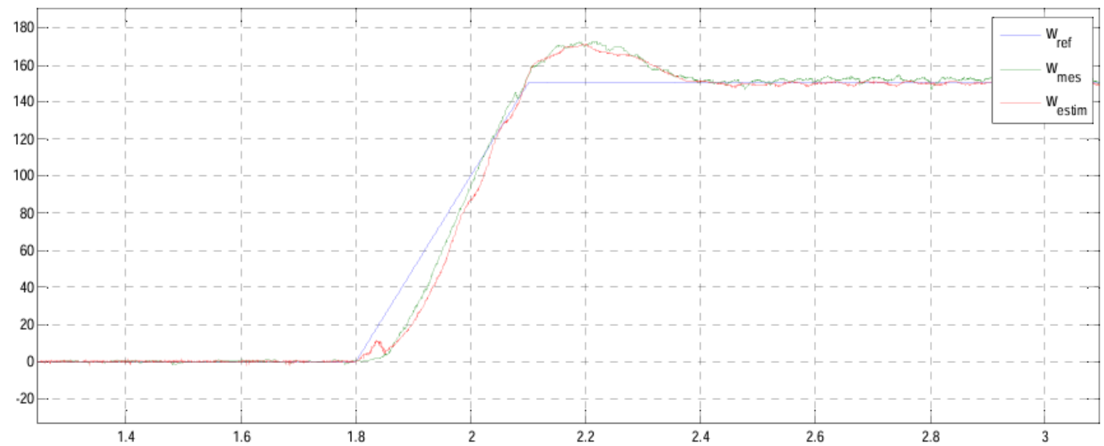

Fig 5: Zoom speed

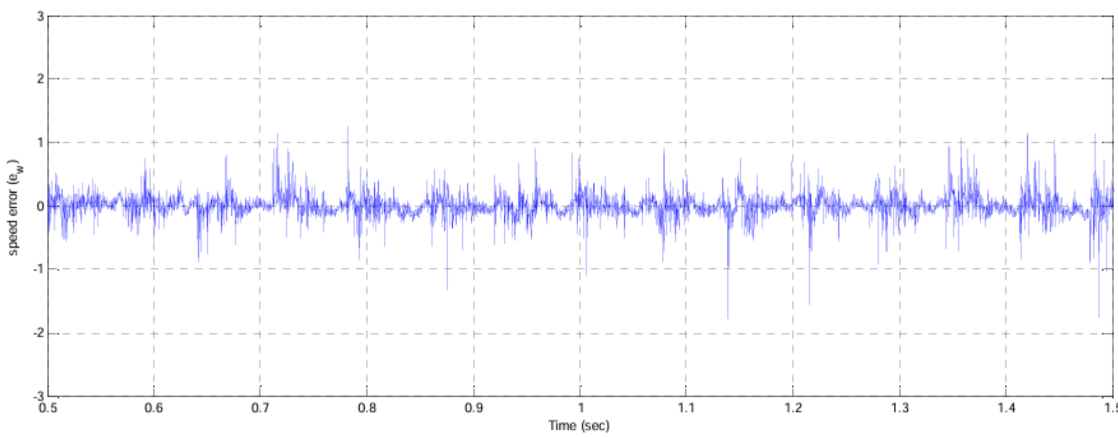

Fig 6: Speed estimate error

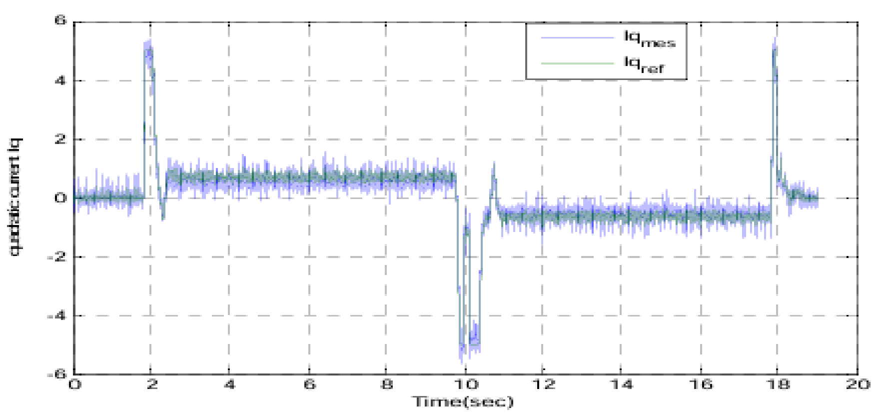

Fig 7: Quadratic current response

V. Conclusion

The research develops a field-oriented IM drive control system which operates without mechanical sensors by implementing the sliding mode approach. The authors presented an evaluation of the adaptive interconnected observer based on the MRAS technique regarding its performance for speed and flux estimation. The proposed design implements a FOC controller with a sturdy sliding mode controller to achieve effective speed tracking in instant messaging applications under low-speed conditions.

References

[1] Swetananda Jena and Kanungo Barada Mohanty, "Robust Field Oriented Induction Machine Control Using SMC," The 5th PSU-UNS International Conference on Engineering and Technology, May 2-3 2011.
[2] Shady M. Gadoue and Damian Giaouris, "MRAS Sensorless Vector Control of a n I nduction Motor Using New Sliding-Mode and Fuzzy-Logic Adaptation Mechanisms," IEEE Transactions On Energy Conversion, vol. 2, no. 25, June 2010.
[3] D. Traore and J. de Leon, "Sensorle ss induction motor adaptive observer-backstepping controller:experimental robustness tests on low frequencies benchmark," IET Control Theory and Applications, 6 May 2010.
[4] Teresa Orlowska-Kowalska and Mateusz Dybkowski, "Stator- Current-Based MRAS Estimator f or a Wide Range Speed-Sensorless I nduction-Motor Drive," IEEE Transactions On Industrial Electronics, vol. 57, no. 4, APRIL 2010.
[5] Hung-Chih Chen and Chun-I Wu, "Integral Sliding-Mode Flux Observer for Sensorless Vector-Controlled Induction Motors," International Coriference on System Science and Engineering, 2010.
[6] Jianan Wang and ChunmingLi, "The Application of Integral Sliding Mode Variable Structure in Induction Motor Vector Control System," 2nd International Conference on Mechanical and Electronics Engineering, 2010
[7] Kanungo Barada Mohanty, "Sensorless Sliding Mode Control of Induction Motor Drives," TENCON 2008 - 2008 IEEE Region 10 Conference, 19-21 Nov. 2008.