Comparative Study of Sensorless Vector Control PMSM Drive for Electric Vehicle Application

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ABSTRACT

The expensive and sensitive component in the motor drive is the sensors which have defects such as manufacture or external environmental effects, as a solution the soft sensor (observer) can be used to realize the sensorless vector control of Permanent Magnet Synchronous Motor (PMSM) which has been widely used in industries and traction of electric vehicle applications and increase reliability due to its high efficiency. This paper focuses on a comparative study between first order Sliding Mode Observer (SMO) and Second Order Sliding Mode Observer (SOSMO) -based sensorless control of a PMSM drive. The results were obtained using 60 kW PMSM drive that the use of SOSMO can improve significantly the performances of the PMSM drive in steady and transient states.

Keywords: Sensorless control, SMO, SOSMO, Observers, PMSM

1 Introduction

The permanent magnet synchronous motor speed control systems [1-2] are widely used in several applications as electric vehicles, avionics etc. For this reason, it is necessary to have good torque control performance, and a relatively wide range of speed control, where the magnetic field-oriented vector control is widely used [3]. Generally, the PMSM motor is necessary to use at least one rotor position/speed sensor, this can create obstacles to control, including the complexity, size, and cost of the whole system. Otherwise, we need solutions to dispense and replace it to achieve higher reliability and less maintenance requirements, there are various sensorless techniques (observer-based methods) [4] that can provide strong robustness as well as high accuracy over a wide speed range with relatively simple implementation. This paper treats two types of speed observers which are first order Sliding Mode Observer (SMO) [5] and Second Order Sliding Mode Observer (SOSMO) [6] and tries to give a comprehensive comparison between them.

2 Methodology

The simulation of the FOC with a 60 kW PMSM drive is carried out using Matlab-Simulink. The objective is a comparison in terms of tracking capability and disturbance sensitivity. A speed and load torque profiles are used to simulate a real vehicle rolling scenarios. The performances of two-speed observers will be compared through simulation studies (Table 1), to evaluate some dynamic and static performances.

3 Results and Discussion

The simulation results show that FOC control can work ordinarily in several conditions of high speed and medium speed for both observers. According to analysis from the simulation, we can figure out that the SMO is not optimum because of chattering sensitivity, it can be seen that SOSMO sensitivity to noises appears clearly but in the start instant of estimation (Figure 1a). The SOSMO responds smoothly and recovers to the desired value quickly. As for the SMO first order, it takes time to recover and bears the fluctuations all the time no matter how value we change the load as shown in Figure 1b.

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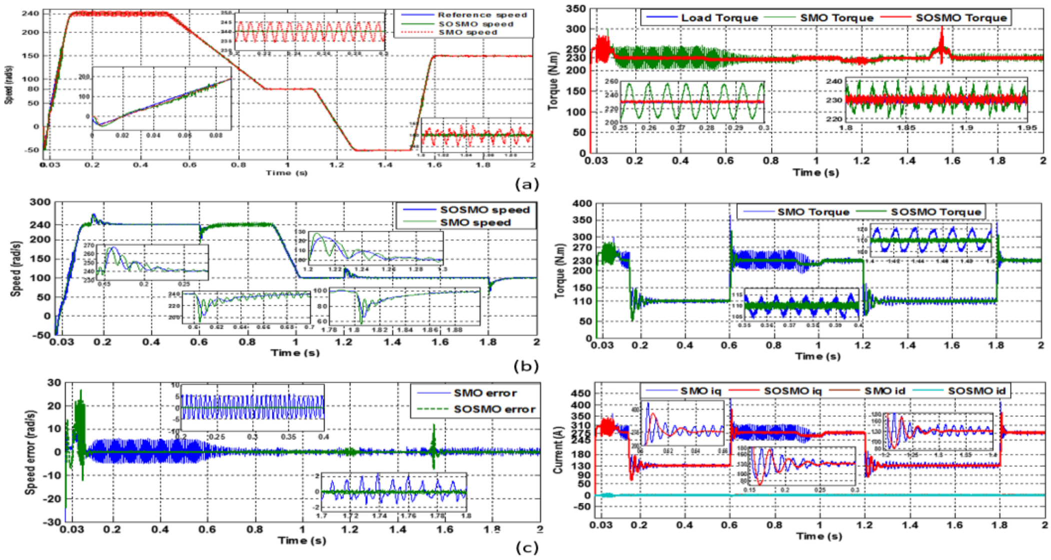

Figure 1: *Comparison between SMO and SOSMO speed estimated and Torque response,* **(a).** *with nominal load,* **(b).** *with load variation.* **(c).** *error between measured speed and estimated speed with control current responses under load variation*

Table 1: *Performances Comparison*

Performances	**Observers**		**Amelioration rate**
	SMO	**SOSMO**	
Speed error Tracking Steady state	±2.5%	±0.2%	12.5 times
Speed error Tracking Transient state	±2.5% at maximum power become 5%	±2.5%	−50%
Torque Fluctuation	±4.3%	±1.74%	+2.5 times
Current Fluctuation	±5.5%	±1.8%	+3 times
Sensitivity against Load variation	±17%	±15.5%	+9%

4 Conclusion

This paper presents a comprehensive comparison of two techniques based on sliding mode observation. Firstly, field-oriented control and observer design are combined to taking into account the nonlinear model for an PMSM. Secondly, the simulation results have demonstrated the effectiveness amelioration of design scheme and have shown that the saturation function can achieve good performance in comparison to the other like sigmoid function. Moreover, the robustness against speed variations, confirms the good dynamic performances of the developed drive systems.

How to Cite

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References

[1] Sheela, A., Atshaya, M., Revathi, S., & Singh, N. J. (2021, February). Investigation on PMSM for electric vehicle applications using co-simulation of MATLAB and magnet software. In IOP Conference Series: Materials Science and Engineering (Vol. 1055, No. 1, p. 012138). IOP Publishing.

[2] Huang, Q., Huang, Q., Guo, H., & Cao, J. (2023). Design and research of permanent magnet synchronous motor controller for electric vehicle. Energy Science & Engineering, 11(1), 112-126.

[3] Tang, X., Zhang, Z., Liu, X., Liu, C., Jiang, M., & Song, Y. (2023, February). A Novel Field-Oriented Control Algorithm for Permanent Magnet Synchronous Motors in 60 Coordinate Systems. In Actuators (Vol. 12, No. 2, p. 92). MDPI.

[4] Bendjedia, B., & Chouireb, S. (2023, March). Comparative Study Between Sensorless Vector Control of PMSM Drives based on MRAS, SMO and EKF Observers. In 2023 International Conference on Advances in Electronics, Control and Communication Systems (ICAECCS) (pp. 1-6). IEEE.

[5] Temesi, B. M., & Gautadottir, U. G. (2020). Sensorless Control of PMSM Drive Using Sliding-Mode-Observers.

[6] Kyslan, K., Petro, V., Bober, P., Šlapák, V., Ďurovský, F., Dybkowski, M., & Hric, M. (2022). A Comparative Study and Optimization of Switching Functions for Sliding-Mode Observer in Sensorless Control of PMSM. Energies, 15(7), 2689.

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