Bing Tian, Qun-tao An, Li Sun, Dong-yang Sun, Jian-dong Duan, 2016. Initial position estimation strategy for a surface permanent magnet synchronous motor used in hybrid electric vehicles. *Frontiers of Information Technology & Electronic Engineering*, **17**(8):803-813. http://dx.doi.org/10.1631/FITEE.1500298

Initial position estimation strategy for a surface permanent magnet synchronous motor used in hybrid electric vehicles

Key words: Surface permanent magnet synchronous motor, Initial position estimation, Nonlinear model, Hybrid Injection, Position observer

Corresponding author: Li Sun
E-mail: motor611@sina.com

Introduction

- Precise initial position is required to help start HEVs under a heavy load condition. However, rotor shaft coupling Hall-Effect Sensor provides the rotor position with a resolution of ±30 electrical degree.
- Surface-PMSM (SPMSM) machine is one of candidates for HEVs due to its simple structure. But the spatial saliency level of an SPMSM is so small that it is difficult to perform position estimation based on high frequency injection.
- To tackle the above problem, we proposed a hybrid injection position estimation for SPMSMs. It is based on the concept of saturating motors before estimating rotor position, along with that a special signal demodulator is introduced for position information extraction.
- The proposed method is validated by both the simulation and experimental results

Investigation of the spatial saliency for an SPMSM machine

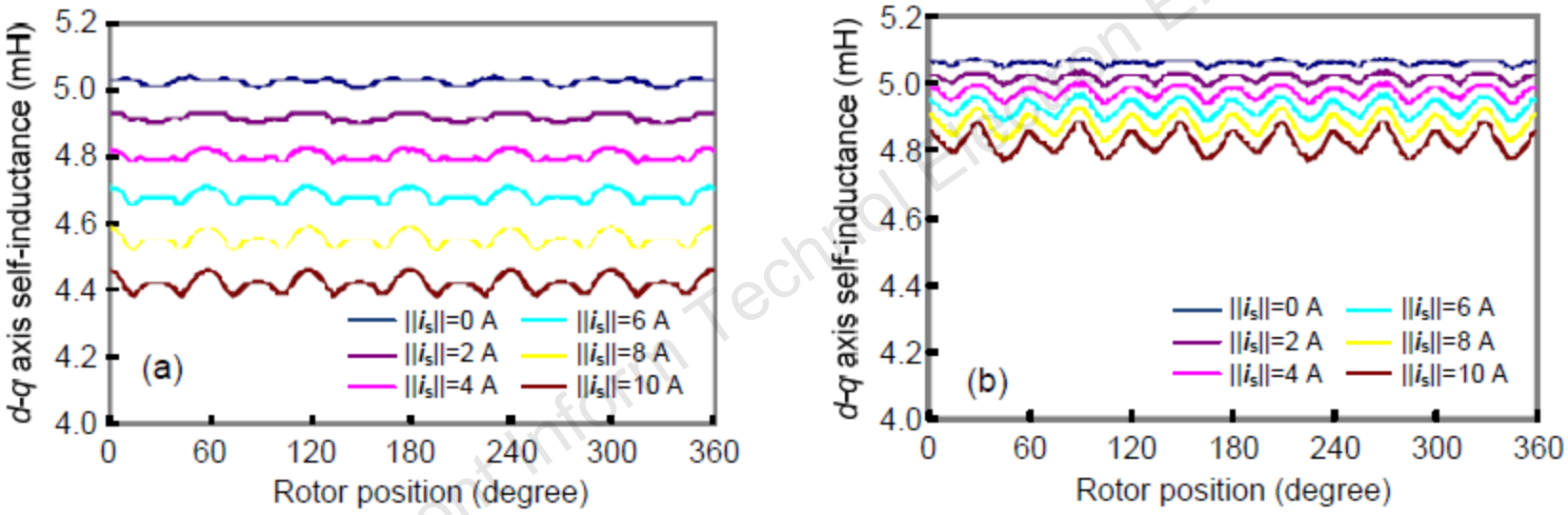

Fig. 3 Inductance-position characteristics: (a) L_{qq}-position; (b) L_{dd}-position

An example of detecting magnetic polarity

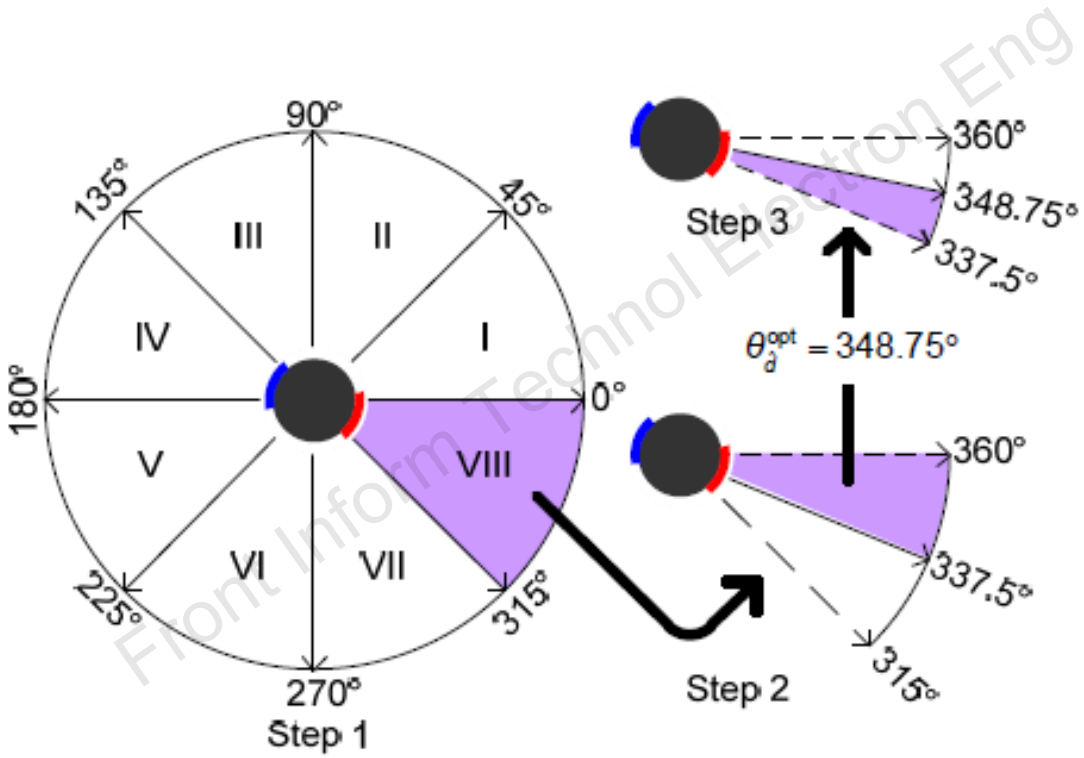

Fig. 6 Saturation-based magnetic polarity identification

Position observer is applied after magnetic polarity identification

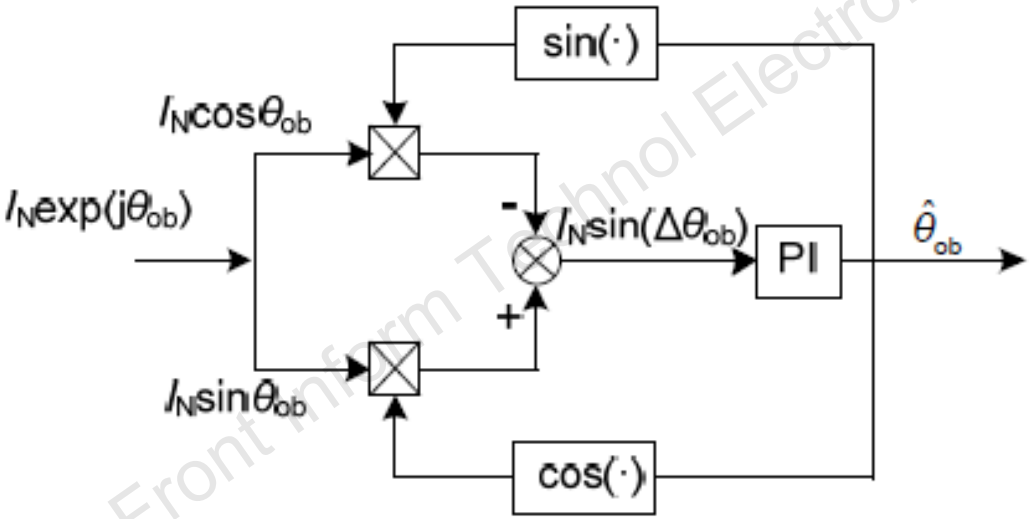

Fig. 7 Block diagram for a position observer

Injection of a DC excitation current vector to detect the magnetic polarity

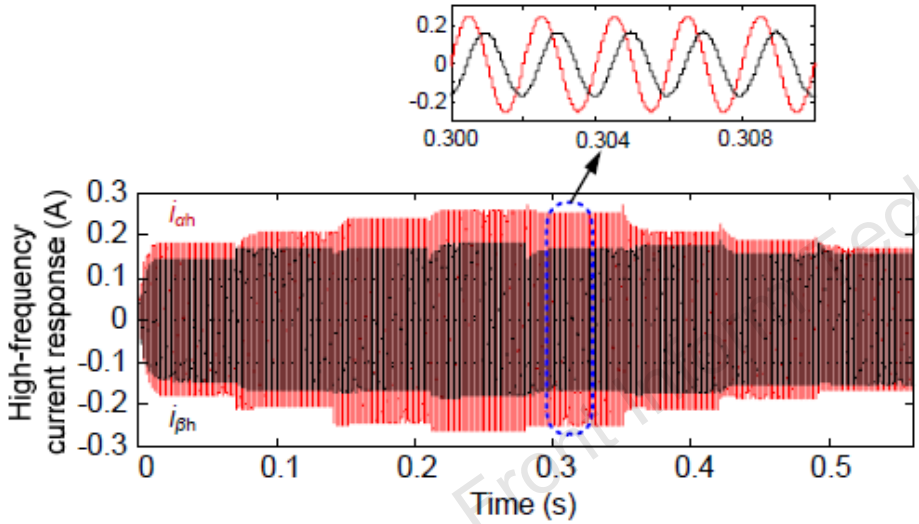

Fig. 10 Simulation results for extracting 500 Hz currents

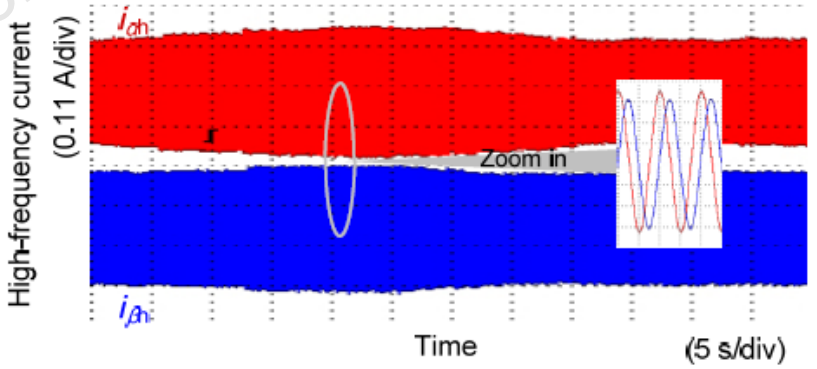

Fig. 15 Extracted 500 Hz current responses in the α-β frame

Magnetic polarity confirmation by the comparison of saturation evaluation function

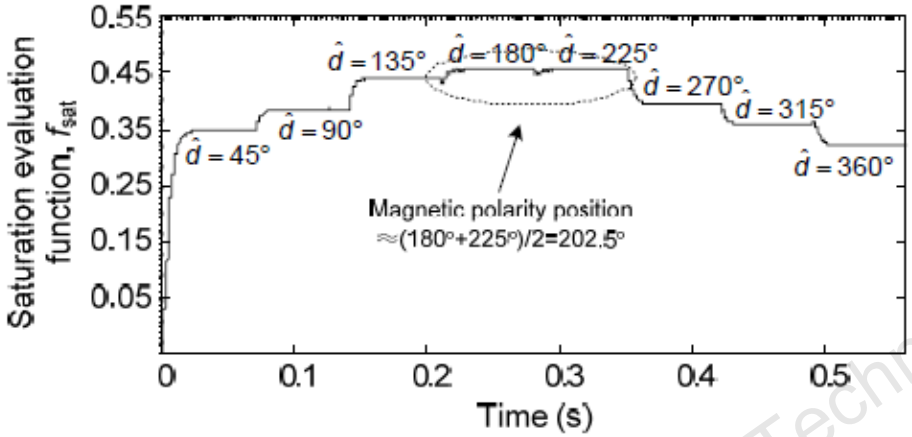

Fig. 11 Simulation process for identification of magnetic polarity

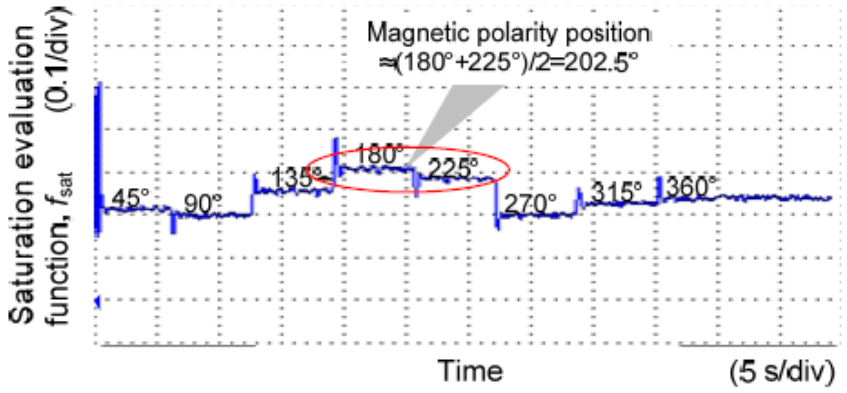

Fig. 16 Experimental process for identification of magnetic polarity

Position observer

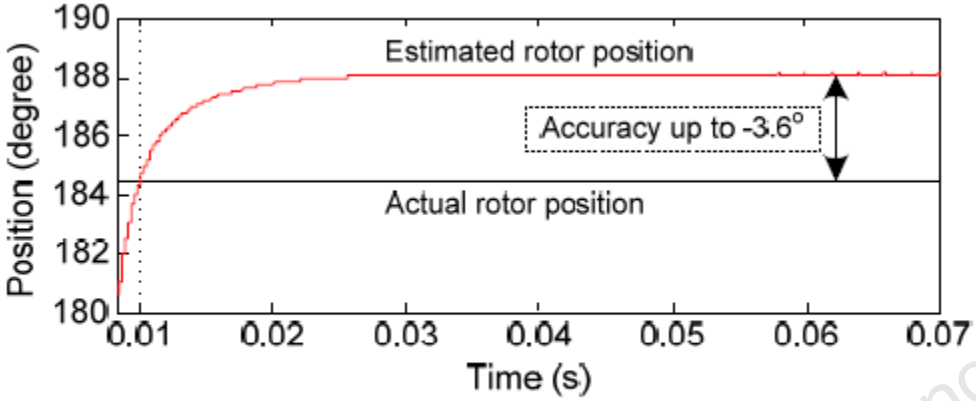

Fig. 13 Simulation performance of the position observer

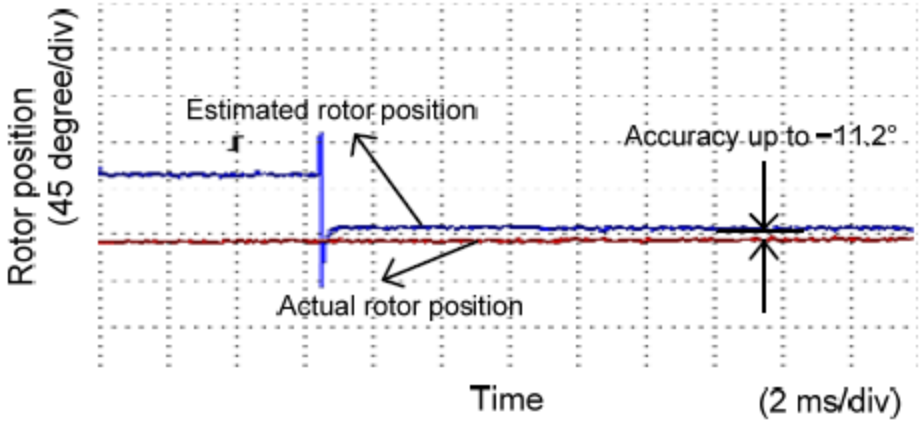

Fig. 18 Experimental results for the position observer

Distribution of estimation error (absolute value) versus rotor position

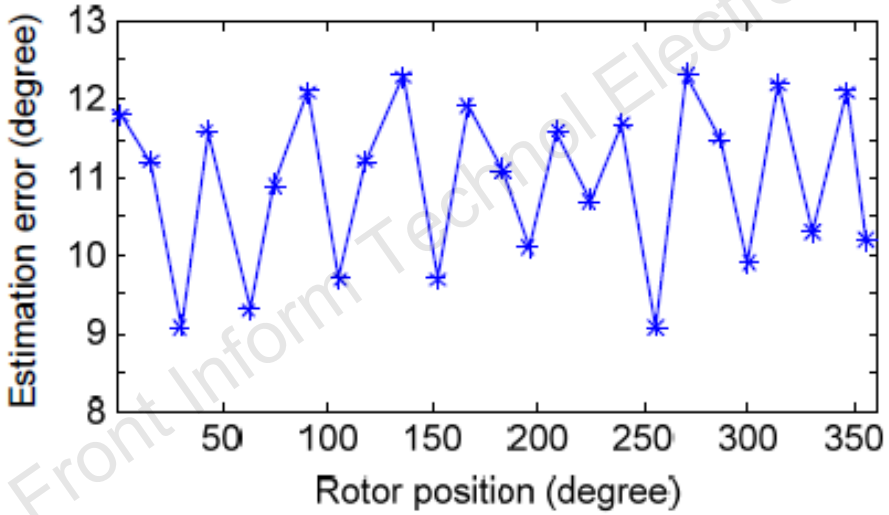

Fig. 19 Distribution of the estimation error versus rotor position

Conclusions

- The proposed position estimation is feasible for SPMSM which is based on the concept of saturating motors before estimating rotor position.
- The proposed position demodulator is easy to implement with only two second-order BPFs and three inertia filters.
- The position estimation error of the proposed method is less than 13° (electrical) according to experimental results.