

Overview Of Sensorless Control Methods Of PMSMs Using High Frequency Injection

Alex Franko¹, Branislav Takáč¹, Eliáš Baltazár Špilák¹, Pavol Makyš¹

1 University of Žilina, Žilina, Slovakia

INTRODUCTION

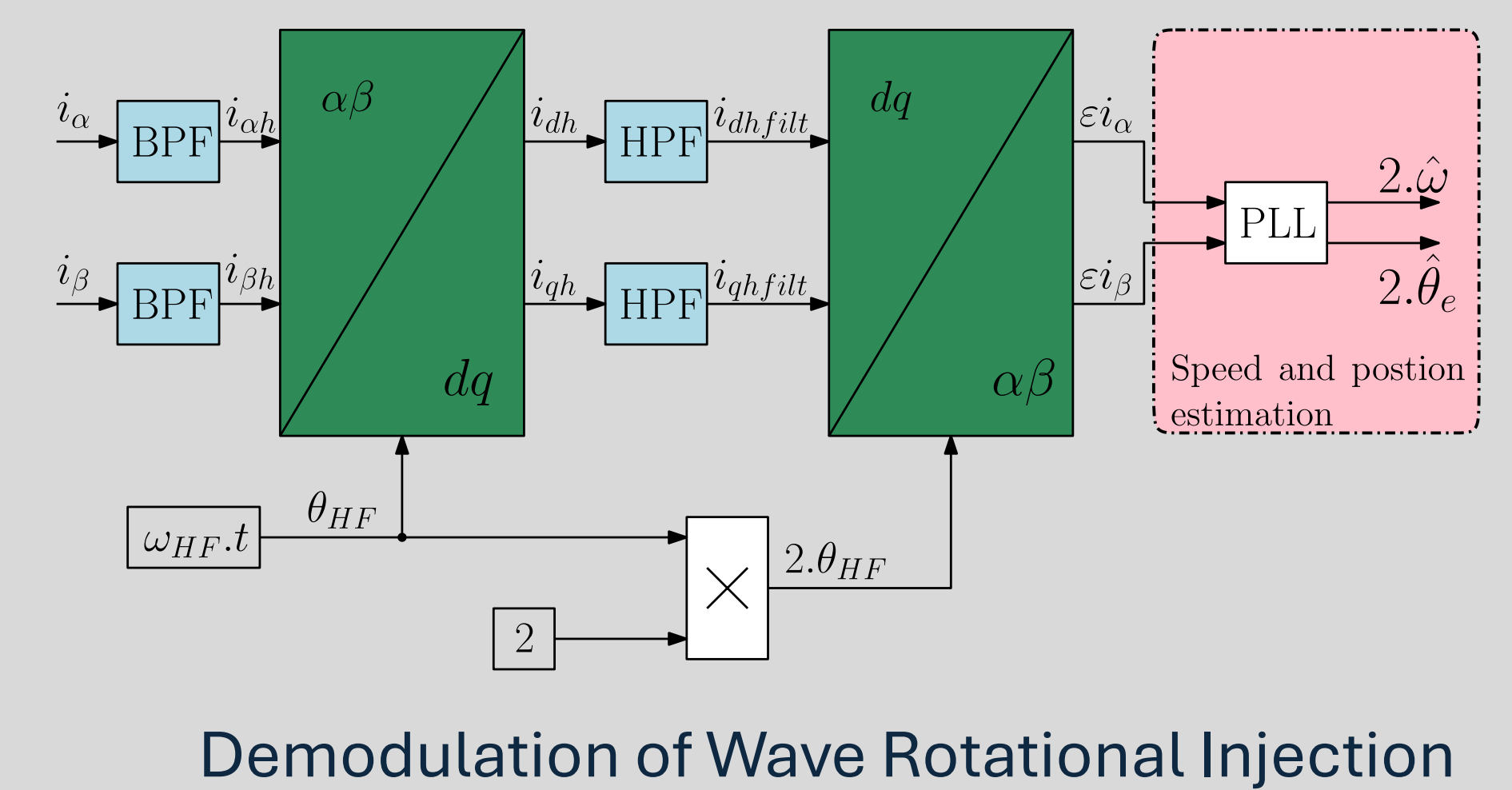
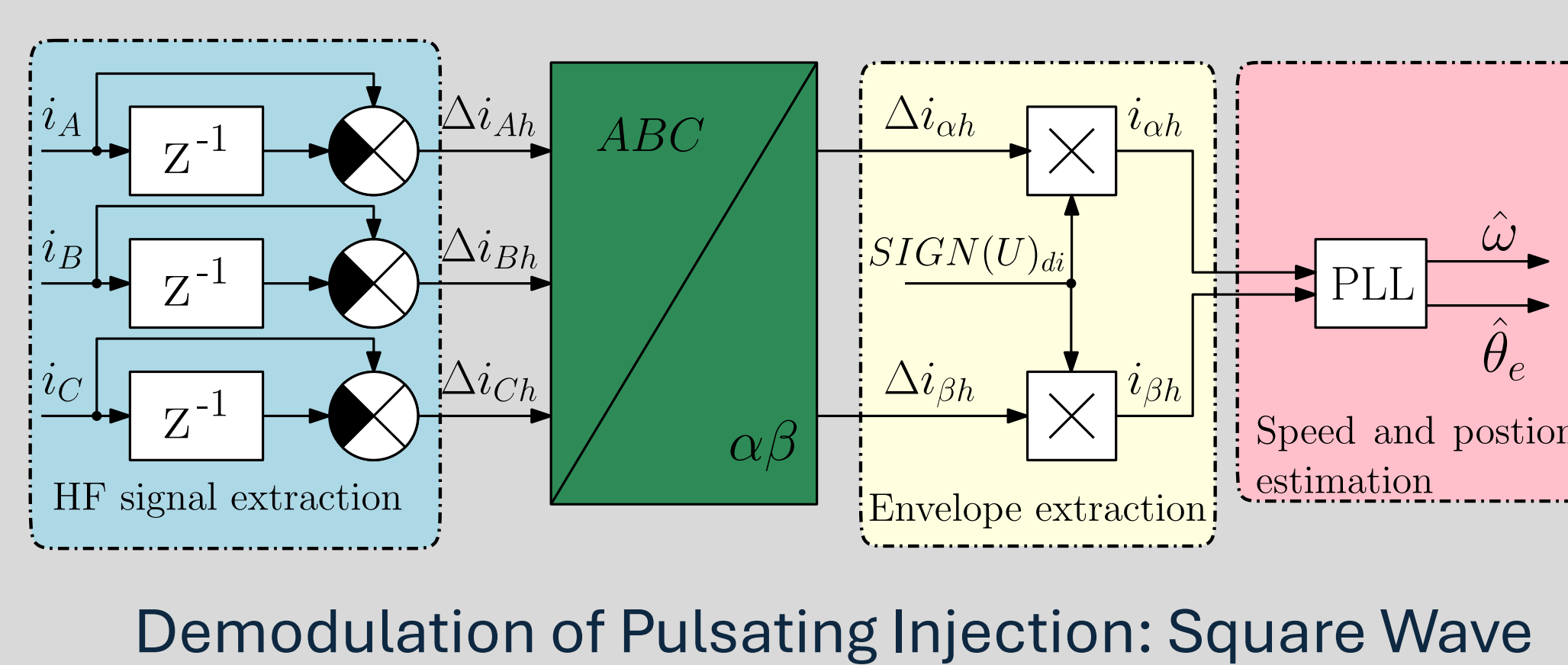
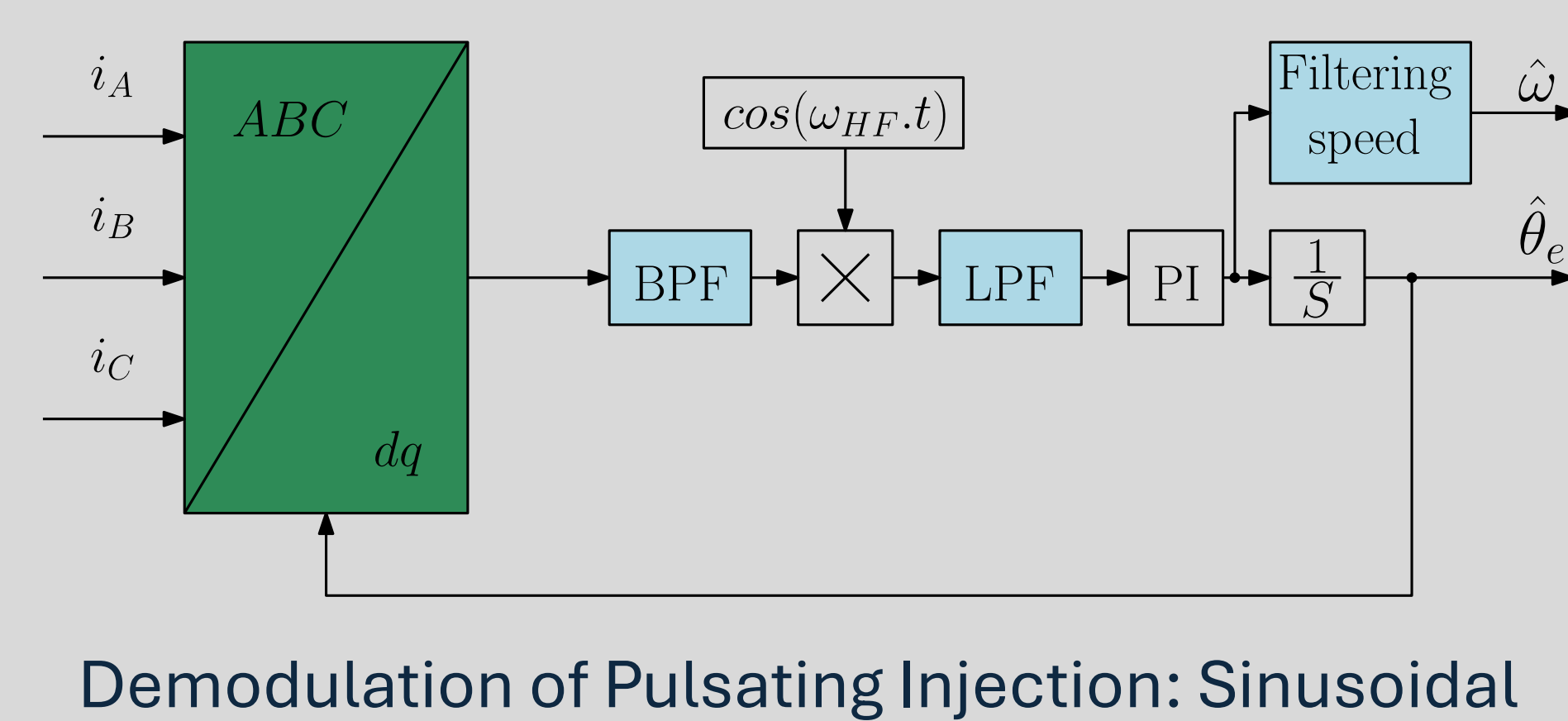
Permanent Magnet Synchronous Motors (PMSMs) are widely used in electric vehicles, robotics, and renewable energy due to their efficiency, compact design, and torque-speed characteristics, but traditional position sensors like encoders and resolvers increase cost and complexity, driving demand for sensorless control in cost-sensitive and reliability-critical applications.

Effective control of PMSMs relies on precise rotor position and speed information, essential for regulating stator currents and optimizing torque production. Sensorless control eliminates physical sensors by estimating rotor position and speed based on the motor voltage and current measurements, offering reduced system costs, improved reliability, and simplified integration.

This work contributes to advancing sensorless PMSM drive technology, emphasizing the critical role of high frequency injection (HFI) in achieving high-performance operation across diverse applications. The proposed methodologies and findings aim to enhance the reliability and precision of PMSM drives, particularly in scenarios requiring robust low-speed performance.

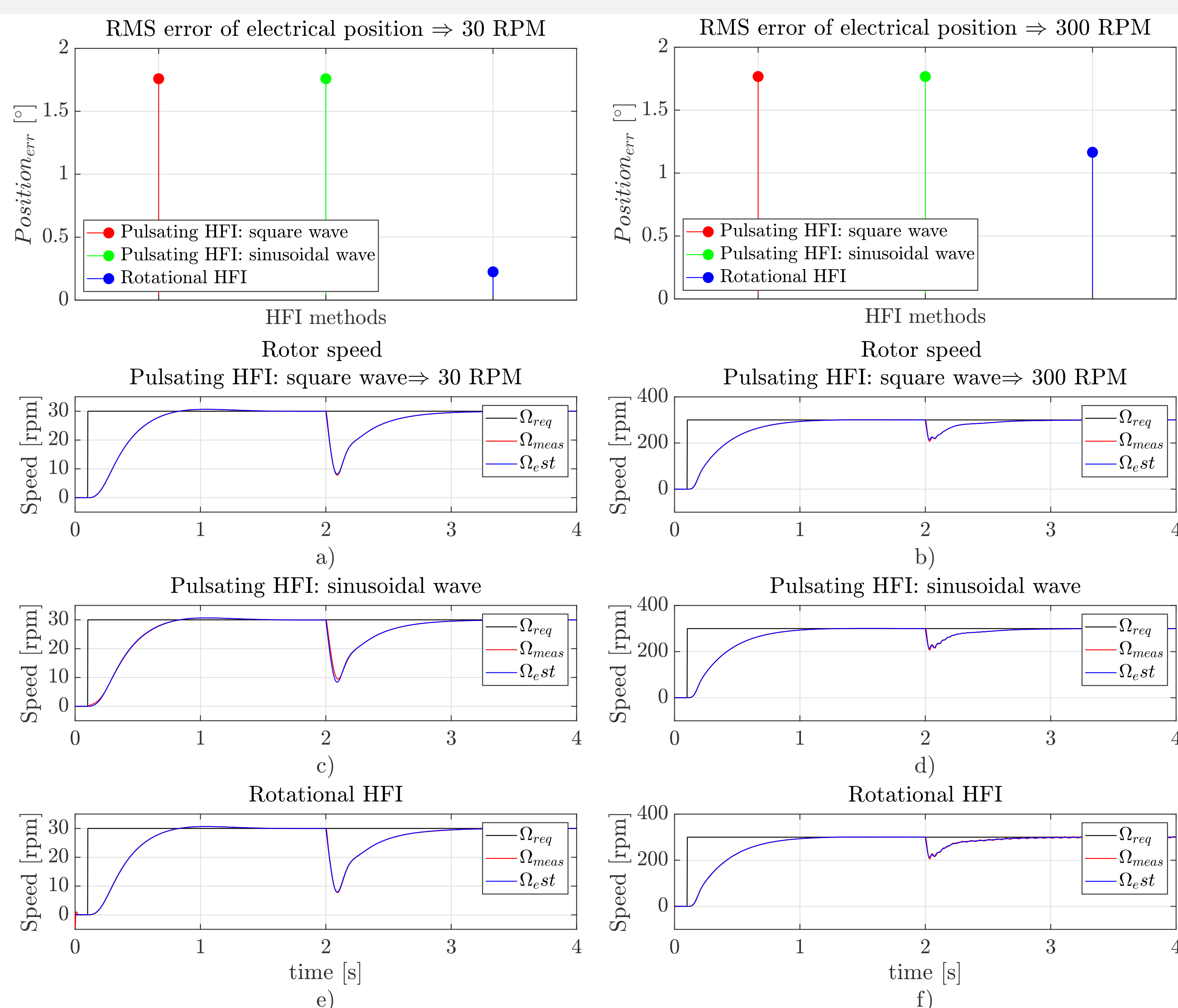
MATERIALS, METHODS & IMPLEMENTATION

This study employs three distinct demodulation strategies for each high-frequency injection (HFI) method, allowing for a comprehensive evaluation of their performance. The experimental and simulation work was conducted using a 6-phase Permanent Magnet Synchronous Motor (PMSM) with high inductance saliency, rated for 48V. Simulations were carried out in Matlab/Simulink, while experimental evaluations were performed on the same motor platform, controlled by an NXP microcontroller. Rotor position and speed were estimated and compared to reference values obtained from an encoder to validate the accuracy of the sensorless control methods.

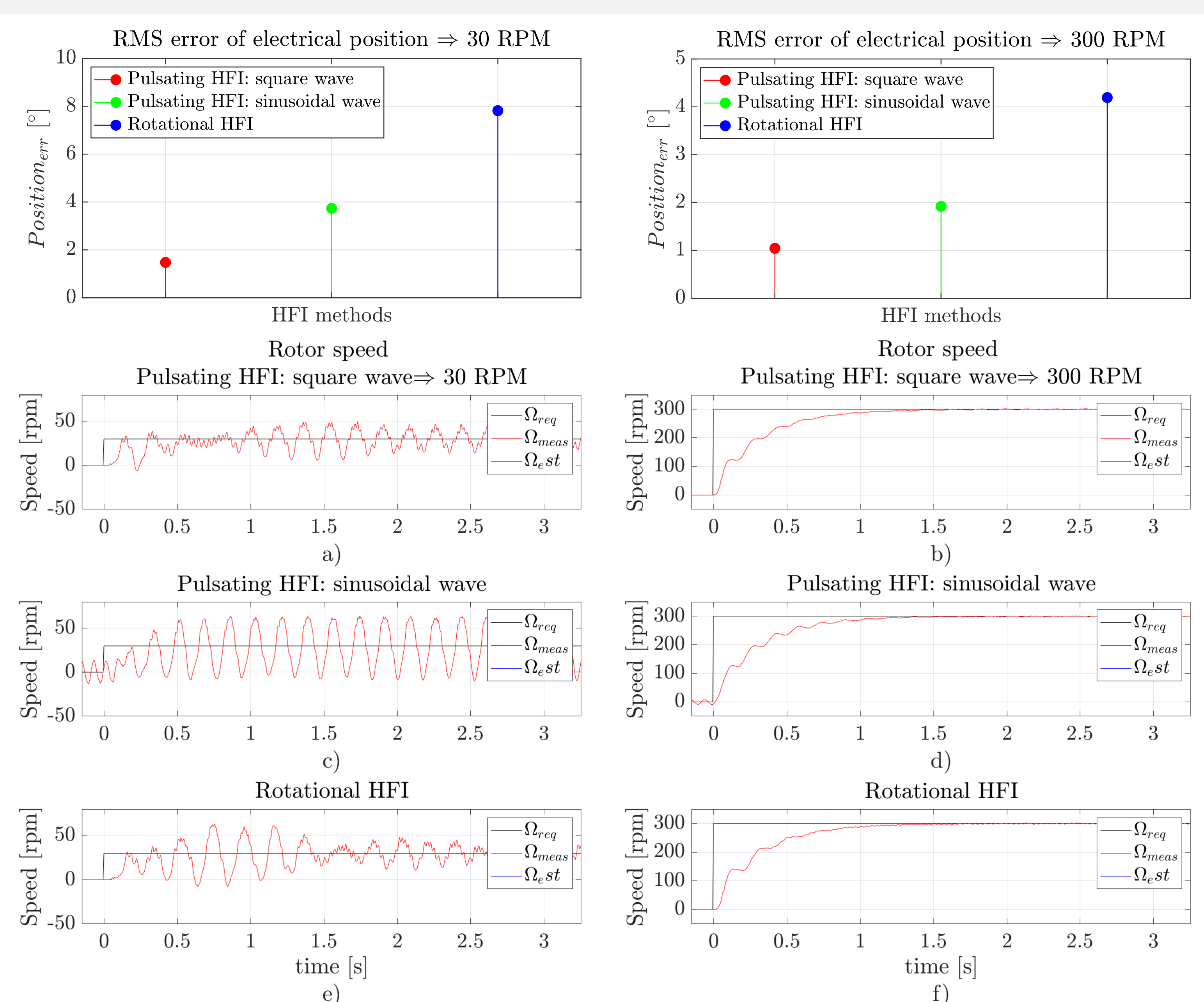


RESULTS

Simulation evaluation



Experimental evaluation



CONCLUSION & IMPLEMENTATION PATH

The study demonstrates that pulsating HFI outperforms rotational HFI in position estimation accuracy and speed stability, making it well-suited for high-precision sensorless PMSM control. Its ability to achieve lower RMS error and ensure smooth speed tracking highlights its advantages for applications requiring reliability and accuracy. Future research could explore its robustness under varying operating conditions, the impact of parameter variations, or the potential benefits of hybrid approaches.