1-1-2019

Three-Phase Motor Drive using Hall Sensors and Field Oriented Control

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Opportunity and Significance

Permanent magnet synchronous motors (PMSM) are a promising candidate for the push to electrify transportation. They have many benefits over DC motors, however they require advanced control techniques that use accurate rotor position, to achieve optimal operation.

Using Field Oriented Control (FOC) and hall sensors allows for a low-cost, reliable solution for PMSM drives.

Technical Objectives

- High power density motor drive with accurate speed control.
- Retrieve accurate position information from low-resolution Hall sensors.
- Implement field oriented control and Space-Vector PWM using a TI TMS320 MCU.
- Design a compact PCB with a small footprint.

Related Work and State of Practice

- High power density motor drives are a much researched area of power electronics.
- This work utilizes the well established method of FOC and implements a recently developed hall sensor interpolation algorithm.

Technical Approach

- The motor drive takes input from a high voltage DC source and uses an integrated power module to output an AC current to the motor.
- A position interpolation algorithm that uses a speed estimation is employed to get accurate rotor position information from low resolution hall sensors.
- FOC and Space-Vector PWM are used to apply the appropriate voltage vectors to the motor.

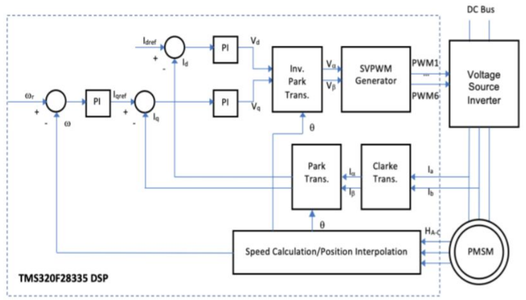

Fig. 1 Block diagram of the FOC control strategy.

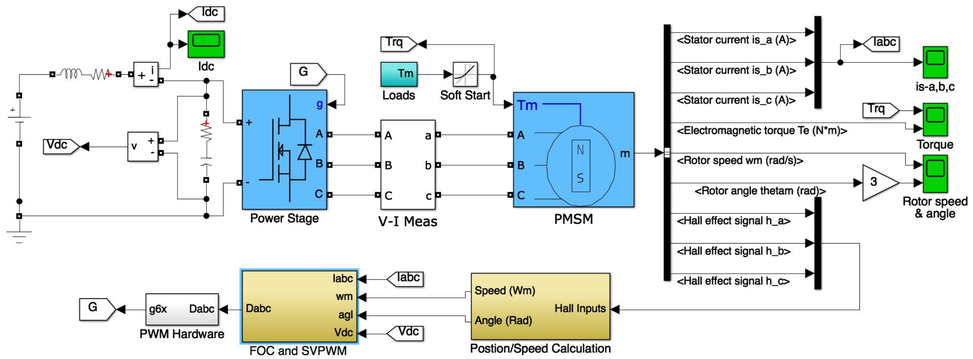

Fig. 2 MATLAB/Simulink motor drive simulation with hall sensor interpolation algorithm.

Results and Next Steps for Development

Simulation results proved the validity of using low resolution sensors for advanced control. An approximate system efficiency of 92% was achieved in simulation.

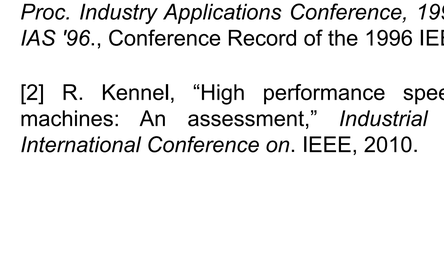

Fig. 3 Simulation result

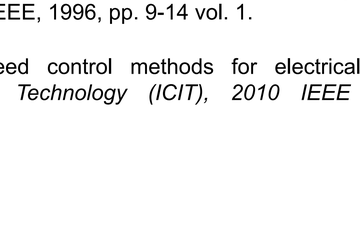

Fig. 4. Motor drive test bed

Further work is required to finish the PCB design and perform real-world testing.

Commercialization Plan & Partners

The project's use of permanent magnet brushless motors and advanced control techniques with reduced torque ripple, make the device attractive for use in electric powertrain applications. Therefore, companies interested in E-mobility are viable future partners.

References

[1] S. Morimoto, M. Sanada, and Y. Takeda, "Sinusoidal current drive system of permanent magnet synchronous motor with low resolution position sensor," in *Proc. Industry Applications Conference, 1996. Thirty-First IAS Annual Meeting, IAS '96.*, Conference Record of the 1996 IEEE, 1996, pp. 9-14 vol. 1.

[2] R. Kennel, "High performance speed control methods for electrical machines: An assessment," *Industrial Technology (ICIT), 2010 IEEE International Conference on*. IEEE, 2010.