Implementation of sensorless vector control in permanent magnet synchronous machine drives

Degree programme: Master of Science in Engineering | Specialisation: Energy and Environment
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The modern environement of electric propulsion systems yields an extensive use of high efficient designs such as the permanent magnet synchronous machine. Applications range from fractional horse power systems up to traction drives rated at a few hundred kilowatts. The challange of cost and energy efficiency could partially be anwsered with advanced and rationalizing control methods. One approach towards this goal is sensorless control which is the main subject of this work.

Motivation

An expanding percentage of worldwide consumed energy is delivered by electricity. According to the Swiss Federal Office of Energy, in 2016 a quarter of total consumed energy has supplied electric installations of Swiss households and industry from which a major part makes use of electric machine drives. Consequently efficient electric drive systems have become a focus for numerous applications ranging from simple pumps and fans to automotive traction systems. The competitiveness of electric drives could be increased even further when advanced cost and energy efficient control methods are applied.

Objectives

Reducing the amount of sensors in a drive system offers the potential of decreased factory costs while cutting back the probability of default. In case the most unfavorable sensor, namely the rotor encoder, is omitted, one speaks of sensorless control. This work aims at the target of implementing such control methods in a permanent magnet synchronous machine which is used as a pump drive. Therefor an entire control loop, including estimation and optimization techniques, is designed and employed. In conclusion, the performance is verified on a test bench and moreover on the real system.

Approach

A real-time target computer, programmable with MATLAB/Simulink, is used for implementation steps. Thus, model-based control designs can be tested directly on the physical system. The sensorless strategy is based upon state space observer techniques which make use of a mathematical model and remaining sensor data, such as currents and voltages. The output of the observer is an estimate of the machines rotational angle that replaces the costly mechanical sensor. Once the estimate is fed to the control system, high efficient vector control can be applied again. In a second phase the design is improved by compensating non-idealities via model-based feed-forward and optimization techniques.

Conclusion

A synchronous machine drive rated at 0.5 kW has been employed successfully with sensorless speed control. The estimation design shows promising performance over a wide range of speed and under various load conditions. Furthermore, the system is able to adapt to thermal effects due to a supplemental optimization algorithm. Based on this work, additional methods can be tested straightforwardly and implementations may be done in various systems.

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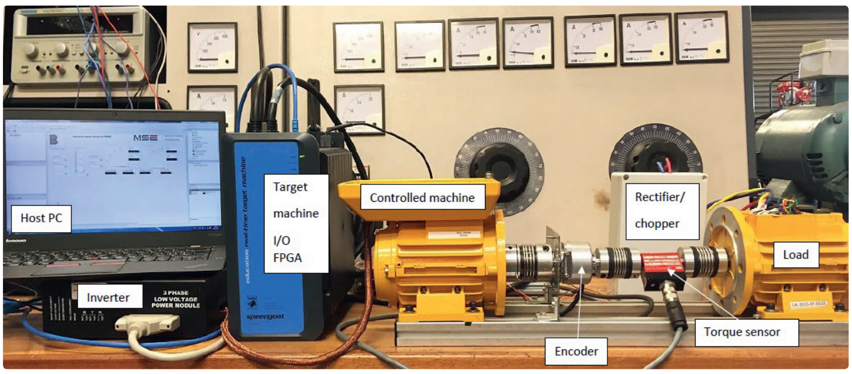

Test set up with two identical permanent magnet synchronous machines