Online parameter estimation in electric motors

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The permanent magnet synchronous machine (PMSM) can be used for a wide range of applications. In this case, the motor that is examined is inspired of Husqvarna's hand-held electrical tools where the motor is part of its electrical chainsaw. The idea is to investigate and simulate different algorithms for online parameter estimation for the PMSM. Consequently, one of the algorithms is selected as the best one for this application. The motor parameters that are examined by the online parameter estimators are mainly the stator resistance and the inductance.

The stator resistance is linked to the motor's temperature state, which is why it is helpful to gain information about the parameter online. The inductance is not directly connected to any physical quantity, however great deviations of the inductance usually indicate faults in the motor. By estimating these parameters, faulty operating points of the motor and critical damage can be prevented. The motor in this work also uses a sensorless control strategy, meaning that the rotor speed and position are estimated.

The online parameter estimation algorithms presented and simulated in this work are, Extended Kalman Filter (EKF), Recursive Least Square (RLS) and Model Reference Adaptive System (MRAS). The motivations for choosing these three algorithms are that they vary in computational complexity and have different implementation strategies. The EKF is very computationally heavy, thus demanding a powerful processing unit. The RLS algorithm does not require as much computational power as the EKF and is simpler in its implementation. The MRAS algorithm is the simplest one both in terms of computational power and implementation.

The algorithms are implemented and simulated in Matlab/Simulink. A motor model, along with the control system and the estimation algorithms are created as blocks in Simulink. The simulation tests the different algorithms with eight different test cases to emulate the different operating points of the motor. Performance indicators of the simulations are convergence error and settling time. This is presented in tables for each algorithm.

The results show promising results for the EKF where it is able to handle all of the test cases and shows a good convergence behaviour in each case, although the settling time and convergence error varies for each test case. The MRAS is also very good at estimating the parameters, although it fails to properly estimate time varying parameters with the sensorless control strategy, which is a big disadvantage. However, in the test cases that the MRAS works, the convergence error is very small, relative to the EKF. The RLS algorithm does not work well in this application and fails to properly converge to correct parameter values in many of the test cases.

The EKF shows the overall best performance, both in terms of the performance indicators and also, that it is able to handle all of the test cases for the sensorless control system. Consequently, it should be the selected algorithm for this application. However, the MRAS algorithm is able to handle the test cases very well with a control strategy that uses position feedback. This should be taken into consideration when selecting an algorithm. Moreover, future work on the algorithms should include a deeper analysis on the computational complexity of the algorithms and to test all the algorithms on a real application.