Sensorless Control of PMSM

Subject: Energy and Environment
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Sensorless control has been identified as a unique selling proposition for inverters controlling synchronous motors. In this thesis a sensorless algorithm for a surface mounted Permanent Magnet Synchronous Machine was analysed and implemented on a digital signal processor. The algorithm estimates position and speed with measured phase currents and measured or reference voltages. Additionally, different plausibility checks were analysed for evaluating the calculated angle.

Currently Permanent Magnet Synchronous Machines (PMSMs) are used in a large spectrum of applications. The most common way to control the speed and torque of these motors is a vector control structure. This structure requires a precise knowledge of the motor's electrical coordinates and speed. Usually a position sensor is placed on the rotor shaft of the machine to collect the required information. Such shaft sensors increase the drive system's cost and the motor size. Furthermore in rough environments, e.g. at high/low temperatures, pressure variations or vibrations, a position sensor may fail. For these reasons more effort has recently been put into sensorless research to replace the shaft sensor.

Sensorless methods are based on the examination of measured or reference voltages and measured currents of the motor to gain a signal which is proportional to rotor angle. The most important characteristics of an electric motor are the rotor's induced voltage and the magnetic saliency.

The sensorless algorithm used in this project estimates the machine's induced voltage. With this information it is possible to calculate its position and speed. Since the induced voltage rises linearly with speed, the algorithm can only deliver reliable results at a speed above 5 to 10% of the base speed. To overcome this restriction, a start-up algorithm was additionally implemented. It drives the motor to a certain speed at which point the sensorless control can take over. For a controlled shut-down, the same principle is applied. Smooth switching between the start-up mode and sensorless operation is complete. Further switching during operation between sensor and sensorless control is also supported.

The sensorless algorithm was tested at medium and high speed and delivered acceptable results. Motor start-up was successful and a smooth switching to sensorless control was achieved.

In addition to sensorless control, a plausibility analysis was done for validating the estimated angle. In a drive system, the angle verification can be used to inform the higher level controller if the angle drifts away. The higher level controller may decide whether measures like switching to another position source must be taken. Different analytical possibilities were simulated, implemented and tested to verify speed, generator constant, estimated angle and the motor and observer parameters.

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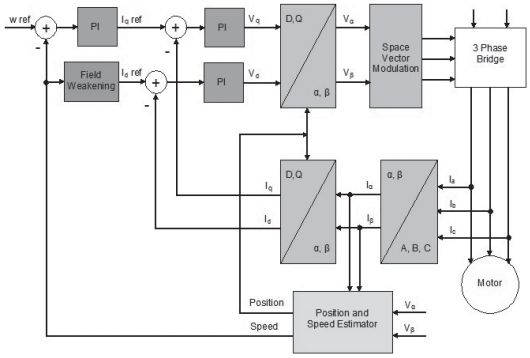

PMSM sensorless vector control with position and speed estimator