PhD Public Defence

Title: Position Estimation Error Analysis, Self-Commissioning and Compensation for Low-Speed Sensorless Synchronous Machine Drives

Location: Pontoppidanstræde 101, room 1.001

Time: Monday 23 September at 13.00

PhD defendant: Hechao Wang

Supervisor: Associate Professor Kaiyuan Lu

Moderator: Associate Professor Pooya Davari

Opponents: Associate Professor Pooya Davari, Dept. of Energy Technology, Aalborg University (Chairman)
Dr.-Ing. Ralph Kennel, Technische Universität München, Germany
Professor Radu Bojoi, Politecnico di Torino, Italy

All are welcome. The defence will be in English.

Abstract:

Synchronous machine is widely used in modern industries due to its well-known advantages of high efficiency, compact size and high torque density. Field Oriented Control (FOC) is often adopted for effective control of the synchronous machine which requires the rotor position information. Position sensors, such as encoder, resolver or Hall component, will increase the cost and reduce the reliability of the drive. Instead of using a shaft position sensor, various position estimation methods (known as sensorless drives) have been extensively studied in the last few decades for the purposes of reducing the cost and increasing the reliability. In medium-high speed operation range, back electromotive force (EMF), which contains the information of rotor position, is utilized to estimate the position. However, for low-speed operation, the signal of back EMF is too low to be observed. Thus, high frequency (HF) signals are injected into the motor to track the rotor saliency for position estimation.

It is known that a lot of factors may affect the accuracy of the estimated position in pulse-injection based sensorless drive, such as inverter nonlinearity, resistive voltage drop, speed dependent back EMF, injection voltage magnitude and the self- & cross-saturation effects. The influence of the aforementioned factors and their compensation methods have been researched separately in existing studies. However their influences on position estimation interact with each. Therefore detailed quantitative comparison and analysis of their influences on position estimation error are investigated, which will be helpful in developing effective position error compensation methods for improving the performance of sensorless drives.

The position estimation error caused by load-dependent cross-saturation effect is an important issue in the saliency tracking based sensorless methods. It is found out through the entire study that this load-dependent position estimation error caused by the machine cross-coupling effect is an intrinsic error that cannot be detected and compensated by the position estimation algorithms themselves. Furthermore, the load-dependent position estimation error can be significant for the HF signal injection based position estimation algorithms, where the machine HF model is utilized. Thus, it is important to find an efficient and simple-to-implement method to identify this error. The self-commissioning and on-line identification methods proposed in this report are verified to be effective and can be a beneficial supplement in achieving high performance synchronous machine sensorless drive systems.