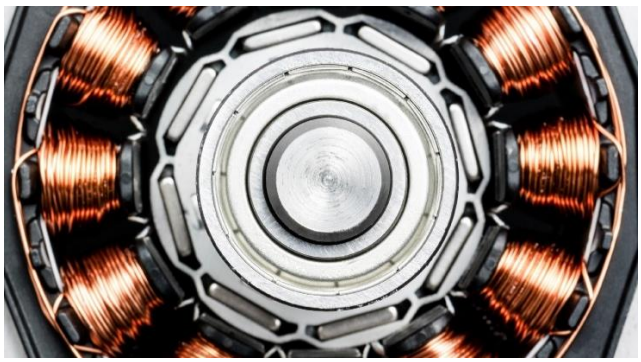
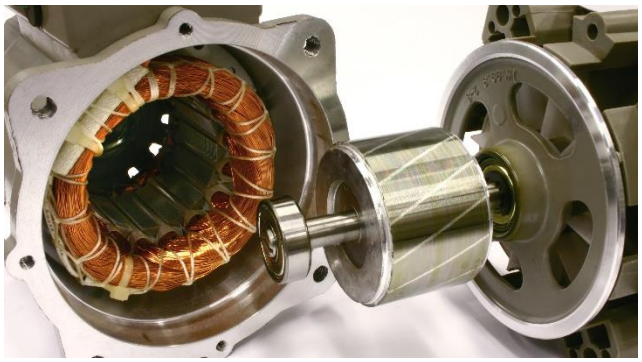
Energy-efficient Control of Electronically Commutated Motors

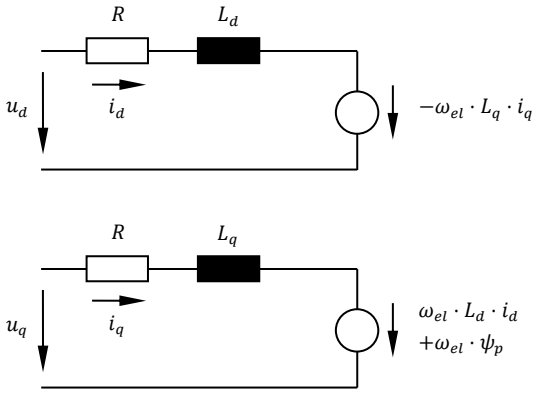
Today‘s market makes increasing demands on the energy efficiency of EC-motors. Besides the motor design itself the used control algorithms have a significant influence on efficiency and performance. In this field a focus of our R&D activities is the development of control algorithms for energy-efficient, robust, and high-dynamic operation of 3-phase electronically commutated synchronous and asynchronous motors.

Motor Types

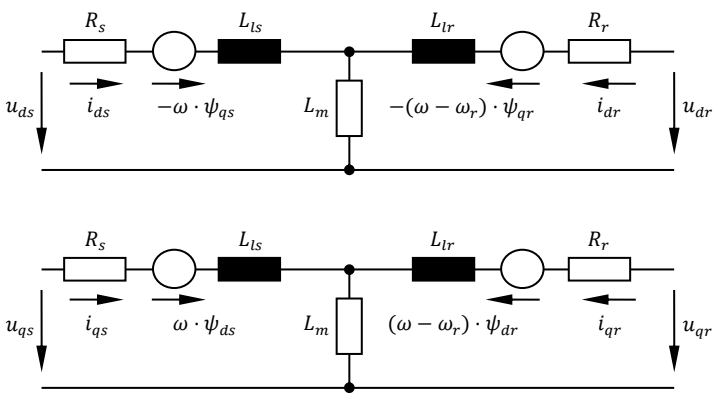
There are many different types and designs of electric motors. The focus of our R&D activities is on permanent-magnet synchronous motors with interior magnets (IPMSM) and surface magnets (SPMSM), as well as on asynchronous (induction) motors with squirrel-cage rotor (ASM). We test our algorithms with different motors in the low voltage range of 12V to 48V as well as with high voltage up to 1000V.







Simplified Model of an IPMSM



Simplified Model of an ASM

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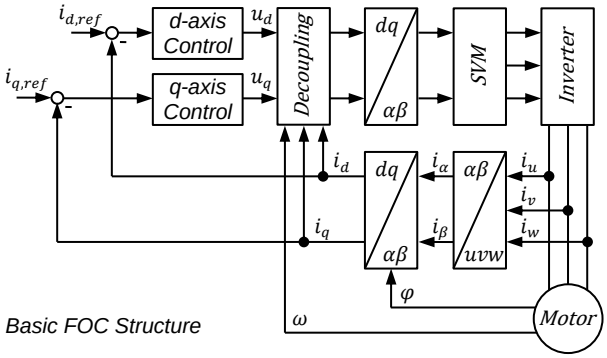
Control Algorithms

When developing our control algorithms, we combine model-based methods of modern control theory with proven classical approaches. The development is strictly model-based with validated simulation models for the motors and inverters in MATLAB/Simulink. The algorithms are tested by simulations before they are integrated into the ECU by automatic code generation and optimized with the real motor.

Currently we use the following control algorithms, among others:

›› Classical commutation methods (Block, Sine)
›› Field Oriented Control (FOC)
›› Direct Torque Control (DTC)
›› Sensorless FOC for the entire speed range (zero speed to high speed)

Our algorithms are characterized by high efficiency and guarantee a robust and highly dynamic control behavior both in the area of constant torque and in field weakening.



Basic FOC Structure

Test and Validation

For testing and continuous further development of our algorithms, we use our own developed rapid control prototyping ECU‘s. These ECU‘s are equipped with a powerful microcontroller and an integrated inverter for controlling motors of different performance and voltage classes. We also carry out system tests on in-house and on customer-specific motor test benches with standardized testing programs.

Production Code Implementation

The production code implementation of our model-based developed algorithms is usually done with dSPACE TargetLink through automatic code generation. This allows us to quickly integrate our software on different platforms such as AUTOSAR (usually as a Complex Device Driver) or proprietary embedded software.

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