Karlsruhe Institute of Technology

KIT - Mobility Systems Center

Elektrotechnisches Institut (ETI)

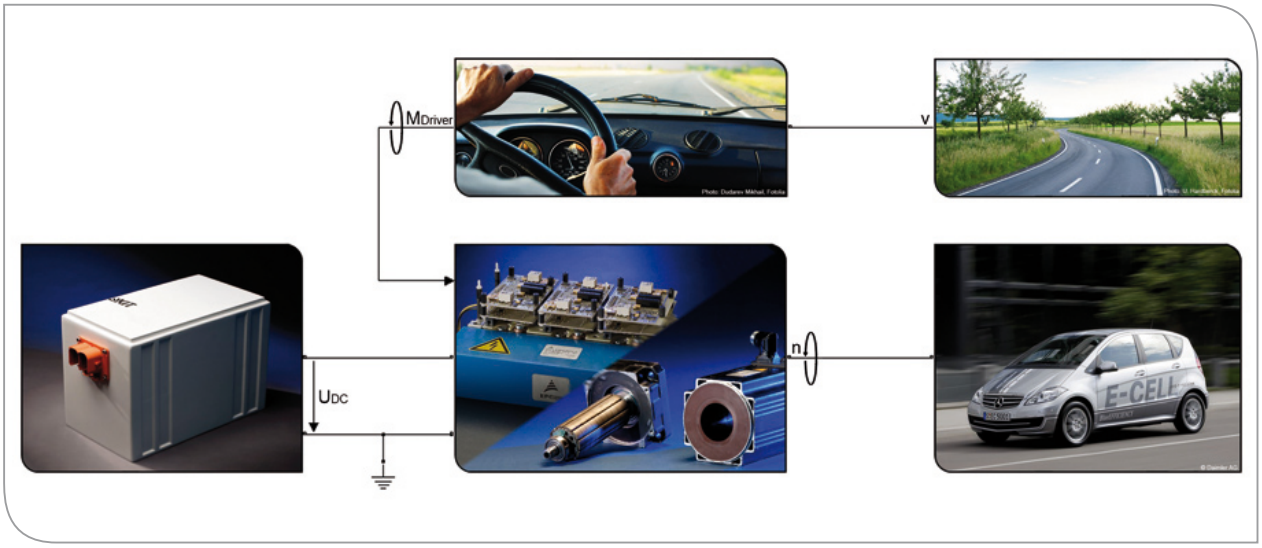
Modeling, Simulation and Optimization of Electro-Mechanic Drive Trains

Because of the rapid innovation of electric and hybrid vehicles, designing optimal drive trains for any specific application remains challenging. Computer-based simulations and optimization offer an effective approach to address this need. This demands modeling of the whole drive train, from energy storage to the wheels.

Mercedes-Benz E-Cell SLS: Electric vehicle with four electric motors

Modeling of the Total System

The electro-mechanic drive train of electric and hybrid vehicles can be completely different depending on the application. Chemical energy storage, power electronics, electric motor, gears, differentials, wheels, and in the case of hybrid cars, a combustion engine, can each be designed and combined in numerous ways. The resulting multiplicity of drive train variants can be handled by modeling the system in a modular way using several complexity levels for each component. Single subsystems can thereby be easily exchanged, and arbitrary drive train topologies can be implemented. At the Karlsruhe Institute of Technology (KIT), all component models can be validated using test benches.



Modular structure of the total system

Simulation and System Optimization

The resulting complexity of the systems and their numerous parameters render analytical optimization impractical. However, today's computer technology offers new strategies. Noncausal simulations of the total system offer calculations of energy flows dependent on different driving cycles and the possibility of detailed analyses of individual components and their dynamic interactions. Using this approach, the effect of varying parameters for single components as well as on the overall performance of the system can be identified. Optimization algorithms can subsequently be used to find the best solution for specific applications.

As an example, this strategy has been applied to design a DC/DC-converter to change the intermediate circuit voltage of the inverter. Based on this hardware design, the optimization algorithms can be used to define an operation strategy for optimal efficiency, too.

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