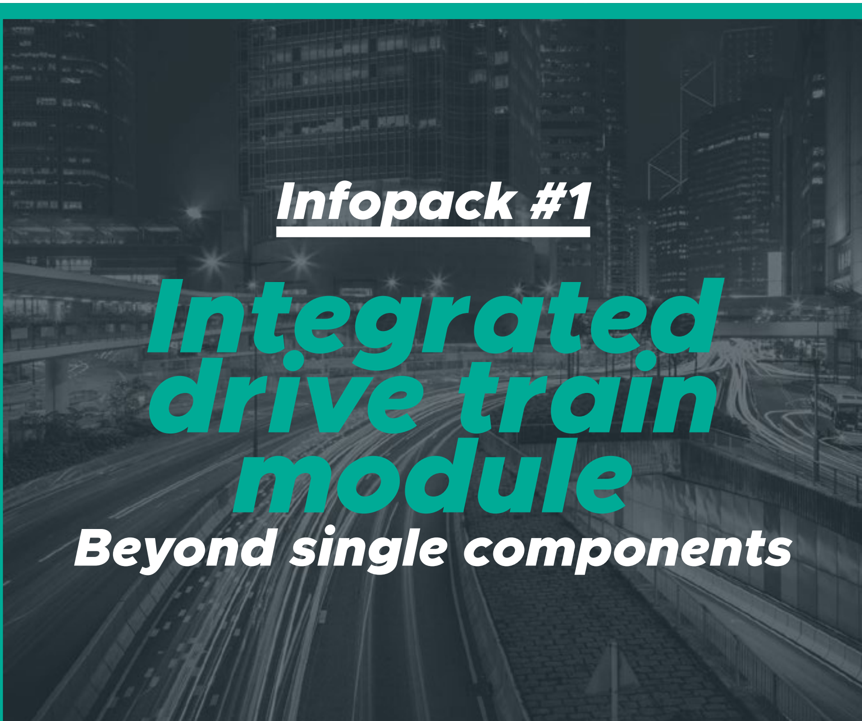
DRIVEMODE

Integrated Modular Distributed Drivetrain for Electric & Hybrid Vehicles



Infopack #1

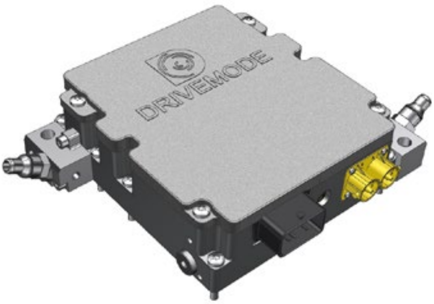
Integrated drive train module

Beyond single components

This project has received funding from the European Union's Horizon 2020 research and Innovation programme under grant agreement No.769989.

Development of SiC converter

Improving thermal performance yielding higher output current

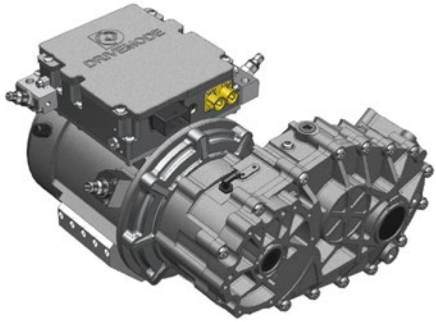


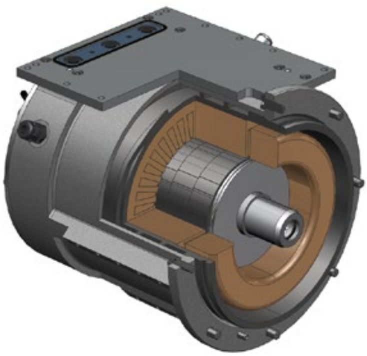
The DRIVEMODE drivetrain concept study requires the converter to deliver up to 140 A of continuous AC current at a challenging power semiconductor switching frequency of 20kHz. To achieve this goal and save expensive SiC MOSFET chip area, a detailed FEM simulation study was performed. The aim of the different optimization steps was to improve the thermal performance of the converter resulting in higher output current. In particular, a slightly increased chip distance has proven to significantly reduce the overall temperature and the temperature difference of chips.
In order to select the optimal chip spacing, various test structures have been analyzed, the thermal influence of the chip spacing was investigated and optimized for the requirements of the inverter. In addition, alternative materials for the use as heat sink and thermal paste were investigated. To support excellent thermal performance a SiN ceramic substrate is used for electrical isolation of heat sink and power electronics. Finally, design variations of the heat sink with an early design of the power hybrids are investigated and optimized in terms of thermal performance and coolant flow dynamics.
The converter concept chosen for the DRIVEMODE demonstrator is based on only 3 parallel SiC MOSFET (1200V) per phase allowing for an output power of 116 kW at a power factor of 0,85 and a battery voltage of 800V. The 35kW/l power density of this full SiC inverter demonstrates an increase by 400% compared to a standard Si power electronics based inverter. A design for manufacturing approach helps to reduce cost further and improve device reliability.

E-motor technology for the IDM

The Permanent Magnet Synchronous Machine: maturity and developments ahead

Within the DRIVEMODE project two electrical motor technologies were evaluated in detail: Permanent magnet synchronous machine (PMSM) and squirrel cage asynchronous induction machine (IM). Both technologies are mature and start of production ready for series production by the year 2020. Permanent magnet motor has been accepted as main traction machine concept because of smaller dimensions and better efficiency. The further expected optimization is mainly in reduction of rare earth magnets volume and overall mass (reduction in used material) while keeping the performance at the same level and on improving the overall efficiency of the proposed design.





Other further development will include focus on, improved over-load, increase of overall efficiency, increase of efficiency in working points, torque ripple reduction by definition of proper skew angle (number of segments), detailed thermal modelling and cooling system improvement. The calculated PMSM torque density (including weight of active parts) is 4.9 Nm/kg, power density is 3.5 kW/kg and power versus used permanent magnet weight is 98 kW/kg with efficiency more than 96%. All data are calculated applying electric current limitation to 140 Aeff at 720 VDC. The overall drive train (gearbox, PMSM and power inverter) will be also analysed in terms of noise and vibrations.

Gearbox and tribology tests

Ensuring lubrication and minimizing viscous power losses at high-speed

To speed up a transmission gearbox to 20,000 revolutions per minute in a controlled manner is an engineering challenge of its own kind, with complexities like noise, vibrations, frictional power losses, and not the least power losses caused by the viscosity of the lubricating oil.

The DRIVEMODE transmission has been designed to operate under elasto-hydrodynamic lubrication, or with thin, semi-solid oil films separating the metal surfaces from each other. By using a lubricating oil of low viscosity and EP additives, combined with a controlled supply of oil, the lubrication conditions in all gear contacts have been assured at the same time as the viscous power losses at the high-speed end have been minimised.

The low viscosity leads to exceptionally thin oil films, which sets high requirements on the surface quality of the gear surfaces. Laboratory experiments are currently being carried out in support of selecting the surface finish and possibly coatings for the gears.

Learn more about our project and its latest development on

drivemode-h2020.eu