

CONNECTIVE eDRIVE

COOPERATION SPEEDS UP INNOVATION

We are convinced that the greatest innovative potential of an electric traction motor lies in its interfaces and in the skillful assembly of different component and material innovations.

For decades now, electric motors have been continually refined. The semiconductor industry rolls out new IGBTs, MOSFETs and diodes at ever shorter intervals and with ever smaller losses, whilst the development departments of the materials and component suppliers expand their portfolios with increasing frequency.

With CONNECTIVE, the new platform for next generation e-drive systems, Alvier Mechatronics is setting pioneering new standards of cooperation.

CONNECTIVE uses the advantages of an increasingly interconnected world to create new e-drive systems that combine the **best innovations** and thus deliver **sustainable commercial profits**.



The magic word is CO-CREATION, and here at Alvier it's not simply a modern buzzword, but the heart of the concept itself. Because right from the start, creative minds and experienced specialists collaborate closely and exchange ideas so that together they can develop new and pre-eminently **future-proof approaches** to the electrification of vehicles. In this world, motor and component manufacturers work hand in hand with mechatronics engineers, instrumentation and control engineers, materials producers and software specialists.

Even in the very first development project this interdisciplinary cooperation has already worked exceptionally well and produced **remarkable results**. In only four months, specialists from eight organizations from all over the world have succeeded in developing a 48V unit with an output of 50 kW which is now ready for bench testing.

Alvier Mechatronics provided the technical impetus here, bringing the partners together and continually challenging them with innovative ideas.

- // **MOTEG GmbH** contributed their know-how in the areas of motor design and mechanical integration
- // **CirQua** optimized the almost completely automated control of the motor
- // **Vishay®** were responsible for the development of the electronic components
- // **Höganäs** pointed out the strengths of soft magnetic composites for electric motors and of metal powders for transmissions
- // **Dontyne** designed a very compact transmission
- // **Sentec** contributed a new circuit carrier which permits high-level integration of the electronics, something that's only possible thanks to a combination of AIN-DCB and PCB
- // The entire development project was supported by corresponding simulation software by **CADFEM**



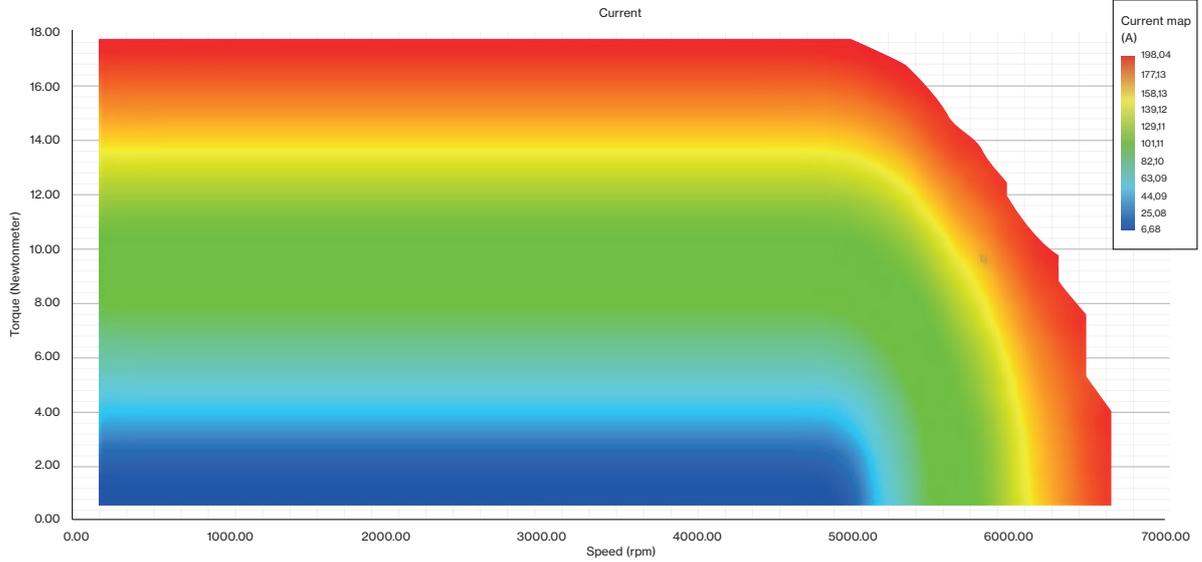
Thanks to close, collaborative cooperation, extensive knowledge-sharing and an open atmosphere of dialogue and debate, an e-drive system has been created: the **CONNECTIVE eDrive**.

This system consists of two mutually integrated motors of different types:

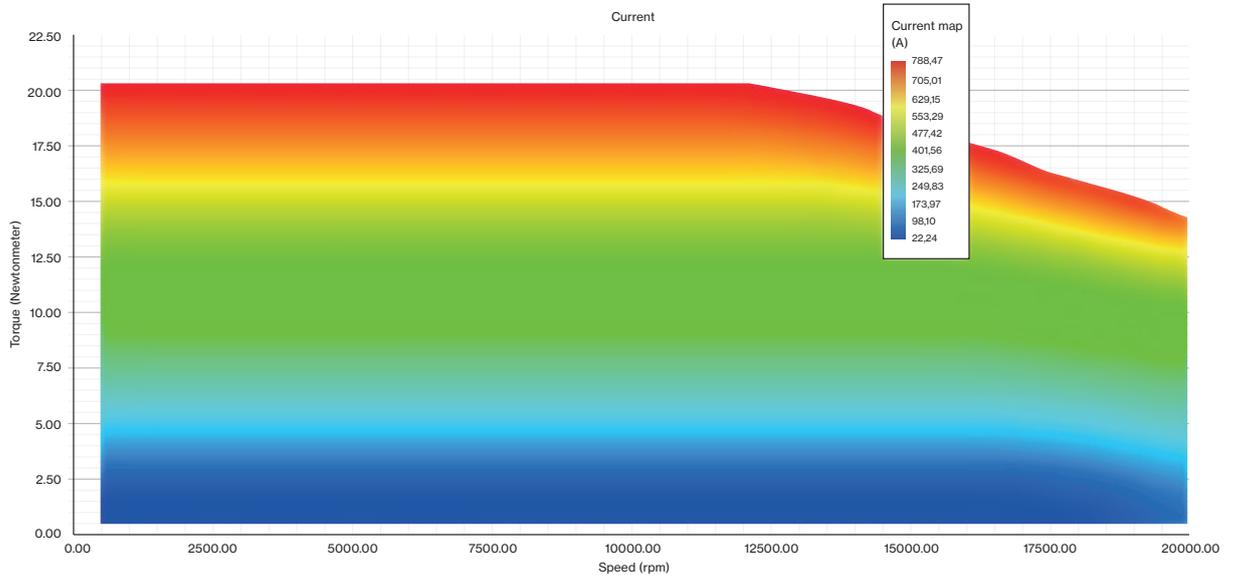
- // a high-torque 15 kW axial flux motor
- // a high-speed 35 kW radial flux motor

In this constellation the advantages of each of the motors can be **perfectly exploited**, so that the system operates particularly efficiently.

/ AXIAL FLUX MOTOR – TORQUE AT SPEED

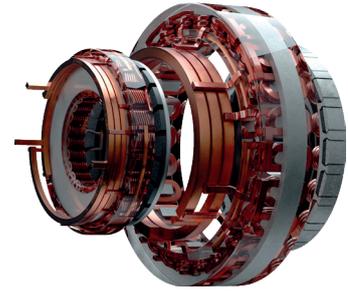


/ RADIAL FLUX MOTOR – TORQUE AT SPEED



Thanks to its compact design the eDrive can be installed at the different positions of a 48 V hybrid vehicle and its high performance also makes it ideally suited for use in purely battery-driven automobiles.

This drive also offers outstanding driving enjoyment when used as a sole motor in the increasingly popular LSEV (Low Speed EV) or Double 100 (100 km range and 100 km/h speed) small urban vehicles.

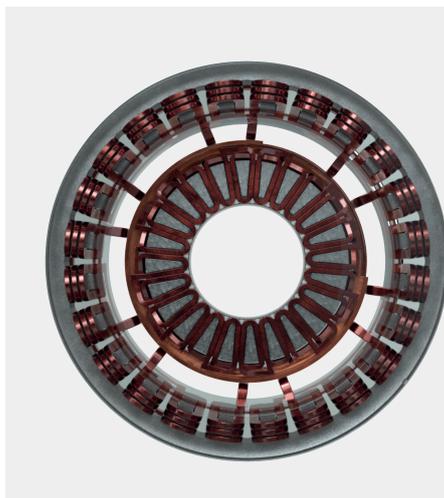


/ EXPERIENCE INNOVATION

Inside the system is a 15 kW high-torque axial flux motor in 24/20 design with an outer diameter of 144 mm and an axial length of 28 mm. This provides high torques at up to 9000 rpm. The result is **optimal acceleration and the best possible elasticity** of the system in all driving situations across the entire speed range.

It's no coincidence that we decided to use an axial flux motor. They offer many advantages, particularly when manufactured from soft magnetic composite (SMC). The stator is pressed all in one go in its entire geometry. After a short bake-out period it's ready for use and the very simple pre-wound coils can be slid on. The otherwise complicated winding processes are completely dispensed with. The yoke in the rotor also consists of SMC and carries magnets. In this new concept, the design of the complete motor, which is sometimes rather complex, is implemented via the shaft system and the heat sink that regulates the stator temperatures, and is thus simple and reliable.

Around the axial flux motor, Moteg has positioned a very compact radial flux motor with a high pole count (24/20) as a high-speed motor with an outer diameter of 250 mm and 20 mm active stator length. This has an output of 35 kW and 17 Nm up to 18000 rpm and is responsible for the eDrive's continuous performance. Here, too, both the design and the choice of material are of crucial importance:



The stator is produced from extremely fine SMC, in order to achieve extremely low eddy current losses at high speeds and an additional high electrical switching frequency of around 40 kHz. Here, the outer diameter of 250 mm presented the developers with a particular challenge: compressing the powder requires extreme force which only very few special presses can deliver.

Their solution: the stator was segmented, which means only very minimal design sacrifices, even with maximum tolerances. Here, too, pre-wound coils are simply slid onto the teeth after production in order to simplify processes.

The entire wiring is completed via busbars which, thanks to the integrative approach, do not require any additional installation space.

The rotor consists of a magnet embedded in an innovative SMC material. This achieves a complete separation of permanent magnet and reluctance torque. This rotor structure saves weight, simplifies the design considerably and at the same time increases mechanical robustness.

As the stator has very low eddy current losses, cooling focuses on the coils, as they account for most of the heat in the motor. Here a simple physical principle is used: pulsating heat pipes. These transfer the heat reliably from the coils to the heat sink and require only minimal installation space.

The electronics are also integrated extremely close to the motors and share the heat sinks. Not only does this create very low inductance power electronics, but it also provides an ultra-low inductance connection between the motor and the electronics. This is thanks, not least, to the innovative circuit carrier developed by Sentec which makes it possible to mount power semiconductors on an AlN-DCB with very good thermal conductivity – even using silver sintering – and at the same time place the actuator directly alongside on a PCB.

For the intermediate circuit capacitor we've used the new improved MKT1820 series film capacitors from our partners Vishay. The defining characteristic of this extremely reliable technology is its self-healing capability.

/ TUNED TO EFFICIENCY

The CONNECTIVE eDrive is systematically designed for efficiency at all operating points. The motor control was developed by CirQua within an extremely short timespan on the basis of the flux linkage diagrams, and then fully optimized in record time.

A smart software system determines how the motors perform in each of the eDrive's operational states and, taking into account the efficiency aspect, controls how they share in the vehicle's performance. And the individual units can also assume other functions: for example, should the axial flux motor not be required in the current operational situation, it can be used, say, as a drive for the A/C compressor. The switching operation requires no further electronics, but is effected via freewheels and clockwise-anticlockwise rotation.



The transmission with its tothing ratio of 12:1 was configured by Dontyne and their software and uses gears which are also manufactured from powdered material. This offers **immense advantages** with regard to weight, gear geometry, and also NVH-optimization.

Together with Moteg, we have created an eDrive which embodies the fully optimized mechanical integration of all components. The compact size (axial length 340 mm for motor and transmission and outer diameter of motor 275 mm), the low system weight and the low production costs of the eDrive show what is possible when specialists cooperate closely within a network in a non-competitive spirit.

/ THE FUTURE HAS ALREADY BEGUN

It's already clear that, despite the short development period, the new CONNECTIVE eDrive is a real innovation. Modern materials and production processes enable a completely new design delivering more sustainability, more efficiency and more performance. Because the CONNECTIVE eDrive offers **maximum performance with minimal installation space**, whilst its production is resource-saving, fast and scalable.

/ HIGHLIGHTS

- // New technology for high-speed rotors
- // A circuit carrier that affordably combines the advantages of AIN-DCB and PCB
- // Ultra-compact e-motors (15 kW axial flux motor and 35 kW radial flux motor with a stator length of 20 mm)
- // New-generation enhanced film capacitors
- // An easy-to-produce stator for high-speed radial flux motors
- // Greatly simplified coils that significantly reduce investment costs and production costs
- // Transmission design that reduces weight, costs and NVH and simultaneously allows more design freedom
- // A new combination of high-torque and high-speed e-motors
- // A design that achieves 35 kW in combination with 15 kW within a diameter of 260 mm and an axial length of 146 mm

/ MANY THANKS TO ALL OUR PARTNERS:

