Comfort, Performance, Environmental Protection: Powertrain Components and Systems for Passenger Cars and Commercial Vehicles

The demands placed on suppliers in the automotive sector are changing dramatically. Increasingly, suppliers are being called upon to integrate components into complex systems—a development task that can only succeed on the basis of close partnerships with vehicle manufacturers. The future will bring continued demands for reduced fuel consumption, emissions, weight and installation space, along with enhanced comfort, safety, and driving dynamics. To meet these goals, innovative solutions and new products are essential.

ZF has taken responsibility here, demonstrating expertise in generating comprehensive solutions with its integrated powertrain systems. In doing so, it consistently pursues a systems approach in developing and manufacturing new products and technologies that represent real advances. ZF provides overall solutions that meet the demands of overall systems.

One example: As a powertrain specialist and manufacturer of electric drives, ZF can also provide superior integration for the full spectrum of hybrid powertrain designs and thus offer production-ready solutions that are already reducing fuel consumption and emissions for the vehicles of tomorrow.

Hybrid Module

The hybrid module combines ZF’s core areas of expertise in the driveline—the electric motor, torsional damping, and wet clutch—superbly integrated and mutually adjusted.

A special highlight is the possibility of integrating the module into existing driveline architectures without taking up additional installation space.

DynaStart®

DynaStart®, the electric motor from ZF, forms the basis for electrifying the driveline. Used in passenger cars, commercial vehicles and construction machines, the electric motor ensures outstanding efficiency, cost-effectiveness, and functionality in conjunction with the other hybrid system components. The electric motor is available with internal or external rotor, depending on the needs of individual applications.

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<p>| Electric drives: The DynaStart® product range |</p>
<table>
<thead>
<tr>
<th>Internal rotor type</th>
<th>External diameter [mm]</th>
<th>Electric active length [mm]</th>
<th>Max. current [A]</th>
<th>Max. torque [Nm]</th>
<th>Max. n [rpm]</th>
</tr>
</thead>
<tbody>
<tr>
<td>SG269</td>
<td>270</td>
<td>80</td>
<td>440</td>
<td>230</td>
<td>6,500</td>
</tr>
<tr>
<td>SG345</td>
<td>345</td>
<td>110</td>
<td>350</td>
<td>500</td>
<td>4,500</td>
</tr>
<tr>
<td>SG430</td>
<td>430</td>
<td>160</td>
<td>350</td>
<td>1,100</td>
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<tr>
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<td>230</td>
<td>165</td>
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<tr>
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<td>75</td>
<td>240</td>
<td>265</td>
<td>6,500</td>
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<tr>
<td>SG325</td>
<td>325</td>
<td>56</td>
<td>325</td>
<td>210</td>
<td>6,500</td>
</tr>
</tbody>
</table>
Hybrid Technology – Future-oriented and Environmentally Friendly

More than ever before, our society is focusing on preserving the environment, the climate, and fossil fuels. ZF has been working together with car makers for years now on hybrid strategies that significantly lower fuel consumption and CO₂ emissions. A number of systems are already ready for series production, and they also set new standards for cost-efficiency.

Comprehensive experience in powertrain technology at ZF ensures that these new systems can also be integrated into existing power-trains in order to meet all energy conversion and vibrational damping requirements. This integration expertise, which allows to combine the entire range of powertrain functions into complex systems, is the key to introducing hybrid technology on a broad scale.

### Electric drives: Overview

<table>
<thead>
<tr>
<th>Power [kW]</th>
<th>Mild hybrid</th>
<th>Full hybrid</th>
<th>Plug-in hybrid</th>
<th>Delivery truck</th>
<th>City bus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Torque [Nm]</td>
<td>4–20</td>
<td>20–70</td>
<td>50–100</td>
<td>25–130</td>
<td>100–200</td>
</tr>
<tr>
<td>Electric active length [mm]</td>
<td>50–80</td>
<td>55–105</td>
<td>55–105</td>
<td>55–105</td>
<td>100–200</td>
</tr>
<tr>
<td>Fuel reduction</td>
<td>up to 15%</td>
<td>up to 30%</td>
<td>up to 50%</td>
<td>up to 50%</td>
<td>up to 35%</td>
</tr>
<tr>
<td>Electrical range [km]</td>
<td>1.5</td>
<td>15–45</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
</tr>
</tbody>
</table>

### Hybrid module operations

**Ready for start-stop operation:**

The electric motor is running, and can start up the combustion engine in fractions of a second by engaging the start-up clutch.

**Dynamic starter:**

The start-up clutch is engaged, and the torque brings the engine to the right torque level in less than 0.2 second.

**Recuperation:**

Brake energy is not wasted as heat, but rather stored as electric energy.

**Boost:**

When starting up or accelerating, the combustion engine’s torque is boosted by torque from the electric motor. Especially at low rpm levels, this can fill gaps in the combustion engine’s torque curve.

**Coasting mode:**

For full use of roll energy, e.g. on downhill gradients. Touching the gas pedal retrieves full engine function.

**Purely electric drive:**

For example, driving in noise protected or non-emission zones, or when maneuvering in tight spaces.
The Hybrid Module – Integrating all Operations

The task:
Hybrid drives combine the high torque of electric drives at low rpm levels with the dominant torque of combustion engines at high rpm ranges. Putting the efficiency and emission advantages into practice requires mastering the complex interplay of components across the entire range of operating conditions. In particular, the relatively high degree of technical complexity – due to two drivelines in a single vehicle – requires a network approach that links different system structures.

ZF is developing hybrid drives that meet this systems approach.

The technology:
The permanent excited synchronous motor that was developed by ZF features extremely short axial dimensions and superior power. The module’s operations include vibration damping, torque transmission, dynamic starter, clutch actuation, and electric power generation. Its starter clutch separates the powertrain from the combustion engine, which allows the vehicle both to operate fully electrically and to convert braking energy into electric energy without loss of friction in the combustion engine. The hybrid module enables the combustion engine to be started with minimal electromotor torque. During start-up, the electric motor accelerates the rotor and the clutch disc in fractions of a second. The clutch then engages and the inertia of the rotating masses boosts the combustion engine up to or even above idling rpm. This process takes place so quickly that drivers don’t even notice it. The clutch has torque transfer capability of levels over 1,000 Nm.

Benefits
- Dramatic reduction in fuel consumption and emissions
- Very fast and quiet engine start and therefore comfortable start-stop operation
- Recuperation of electric energy from braking
- Improved driving dynamics thanks to power boost for combustion engine during acceleration
- Purely electric operation (no emissions) by separating the combustion engine from the driveline

The Hybrid Module – Integrating all Operations

Power boost: More torque

The system: Hybrid module characteristic degree of efficiency (Udc 202 V, electric)

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The hybrid module from ZF: Integrated into the existing transmission architecture
Integration Expertise

As a result of joint research and development work with vehicle manufacturers and other partners ZF has developed mild and full hybrids with both internal and external rotors. These electric drives can be integrated into new or already existing powertrains without sacrificing any known driveline functions.

Thanks to its expertise in powertrain components, ZF Friedrichshafen AG can integrate start-up, shift, vibrational damping, and actuation elements. For example, the extremely flat starter clutch with sintered facings make powerful hybrid solutions possible for front-transverse applications as well. This ensures not only environmental but also economic advantages for vehicle manufacturers.

Power Electronics – Key Components for More Efficiency in the Driveline
ZF offers modularly scalable systems from a single source for the electrification of the driveline. Products ranging from the complete hybrid system and defined assemblies to single components such as the inverter or DC/DC converter can be provided. The added value of a modular construction system from a single source for ZF customers: They can optimally integrate their own systems into the provided environment and the consistent system design accelerates the design and development of new variants.

Benefits
- Greater efficiency and cost effectiveness
- Simple adaptation and integration
- Considerable installation space saved compared to conventional solution

Installation space saved

- 30 %
The task:
As a specialist for start-up elements, ZF has been developing electric motors for parallel hybrids that meet extremely high demands for performance density and cost effectiveness. Ambitious fuel consumption targets and reductions in CO2 emissions can be reached – combined at the same time with improvements in driving performance and comfort.

The technology:
The first mild hybrid entered series production in Europe in 2009 with a starter generator from ZF. With an installation length of 65 mm and 15 kW of power, the DynaStart® electric motor is helping to reduce fuel consumption and CO2 emissions by up to 15%. Thanks to no additional installation space requirements, ZF also ensures a high degree of cost-effectiveness for vehicle manufacturers, because they can continue to work with existing vehicle concepts. The DynaStart® starter generator from ZF has been specially developed for parallel hybrid solutions – short installation length, high energy efficiency, and sufficiently robust to achieve superior results in the complex environment between the engine and the transmission.

The DynaStart® starter generator is available with an internal or external rotor. Permanently excited neodymium iron boron magnets are used so no electric current is needed to excite the field. This means that the power electronics can be smaller. In contrast to conventional electric motors, completely automatically wound coils are used on specially formed laminated cores. This robust design allows for cost-effective series production.

Electric motors have been produced in Schweinfurt for standard-series applications since May of 2008 – and with every use they make a substantial contribution to reducing emissions and conserving resources.

DynaStart® – The Basis for Hybridization in Passenger Cars

DynaStart® – Electric motor for passenger cars

Mild hybrid SG325
Technical data
- Permanently excited synchronous machine
- External operating principle, air-cooled
- Fixed installation on crankshaft
- External diameter 325 mm
- Motor power 12 kW (for 105 V and 6,000 rpm)
- Maximum cold-start torque 220 Nm (for 325 A)
The task:
Use of urban delivery vehicles, city buses, and construction machines are all dominated by fuel-intensive, frequent start-up and operating procedures and short driving distances. This yields an enormous potential for saving fuel costs and the possibility of significantly reducing exhaust and noise emissions. In short, the ideal area of application for hybrid vehicles.

The technology:
Designed as a full hybrid and embedded in transmission systems from ZF Friedrichshafen AG, the DynaStart® electric motor provides torque levels of up to 1,200 Nm with a maximum power of 200 kW. Extensive tests ensure operational safety and suitability for daily use. This means no limits in driving performance or comfort even for purely electric operations. Despite its high level of power, DynaStart® is integrated into existing transmission architecture with no additional installation space requirements.

For construction machines, driving operations represent the secondary area of application. For them, the primary benefit of driveline electrification is to support auxiliary drives or to run them entirely.

DynaStart® – Economical Solution for Commercial Vehicles

Hybrid transmission systems: HyTronic for trucks (1), EcoLife for buses (2), S-Matic for agricultural machines (3), and ERGOPower for construction machines (4)

Benefits
- Optimum economic returns from hybridization
- Reduced fuel consumption, exhaust emissions, noise emissions
- Outstanding overall performance for delivery vehicle, city bus, and construction machine applications
- Greater cost effectiveness
- Use of proven technologies
- Production of sophisticated hybrid transmission systems

DynaStart® – Electric motor for commercial vehicles
Passenger Car
Product Portfolio

**Powertrain Technology**
- Transmissions
  - Manual and automatic transmissions
  - Dual clutch transmissions
  - Hybrid systems

**Driveline Components**
- Gearshift systems  
- Electronic components
- Clutch systems
- Torque converters
- Dual-mass flywheels
- Axle drives
- Bevel gear sets
- Differentials
- Powertrain suspension systems

**Transmissions**
- Manual and automatic transmissions
- Hybrid systems

**Chassis Technology**
- Axles
  - Front and rear axle systems
  - Corner modules

**Damper modules and damping systems**
- Tie rods
- Stabilizers
- Stabilizer links
- Control arms
- Suspension joints
- Wheel carriers
- Leveling systems
- Crash-absorption elements
- Chassis mounts
- Precision plastics parts
- Electronic components

**Steering Systems**
- Mechanical, hydraulic, and electric power steering systems
- Steering pumps
- Steering columns
- Steering accessories

Commercial Vehicle
Product Portfolio

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