




# THE ROAD TO THE FUTURE

ELECTRONIC SYSTEMS  
FOR VEHICLES







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**ACCELERATING PROGRESS IN THE AUTOMOTIVE INDUSTRY.** As a partner for car manufacturers all over the world, for many years ZF has been pursuing the same objective: to increase the efficiency and cost effectiveness of individual mobility and transportation. Technical solutions in chassis and driveline technology rely increasingly heavily on electronics, with this field accounting for up to 90% of innovations on board vehicles. ZF's expertise in this area is pooled in the Electronic Systems business unit, where it is used to support the entire ZF product range in order to improve vehicle efficiency.

# SHIFTING TO SUCCESS. MOBILIZING THE FUTURE.

Every year, ZF supplies approximately 5 million gearshift systems to major auto manufacturers around the world. As one of the largest automotive suppliers, however, ZF delivers more than just reliability and quality. With our expertise in shift-by-wire systems, we are helping to actively shape the future of driving.

Imagine cars parking themselves in tight spaces while the driver stands on the sidewalk or in the underground garage and monitors the maneuver on a smart phone from outside the vehicle. What once sounded like pure science fiction will soon be reality thanks to electronic shift-by-wire technology.

This technology is already making shifting easier with rocker switches on the steering wheel or by tapping the gearshift lever. Driving is now more comfortable and more dynamic – and there's no risk of operator errors.

## **Leading the way in shift-by-wire technology**

As a global market leader for shift-by-wire systems, ZF is setting new standards in the development and production of gearshift systems with electronic signal transmission. Electronic shifting is not only an important prerequisite for many future assistant systems, it helps save more than half the weight and a considerable amount of installation space compared to mechanical gearshift mechanisms. This, in turn, is revolutionizing the interior design.

Shift-by-wire is already paving the way to the future of shifting systems in automatic transmissions. When it comes to convenience, the electronic gearshift systems that we produce make shifting gentler, faster, easier, more efficient and, not least, more aesthetic.

## **Progress through experience**

ZF has been developing and producing high quality automotive components and systems for more than 50 years. In all our projects, you also benefit from our comprehensive production knowledge. As the sole supplier of gearshift systems, after all, we also have expertise in developing and producing transmission systems. As a result, we can optimally match gearshift and transmission systems to each other and supply them from a single source.

## **Every project is different**

Our objective is to deliver a fascinating experience of advanced technology. Regardless of the project or customer, our passion for the technology and our expertise in product development enables us to always come up with innovative approaches to individual customer requirements – and our customers benefit from our integrated solution expertise.



Gearshift cover and knob made of burl wood





## OUR RANGE OF GEARSHIFT SYSTEMS AT A GLANCE:

Shift-by-wire gearshifts for automatic transmissions



Shifttronic ®



Rotatronic ®

Shift-by-wire gearshifts for electric vehicles



Slidetronic ®



Automatic gearshift,  
cable-controlled with electronic  
manual mode

# CONTROLLING ELECTRICAL SYSTEMS TO SUIT REQUIREMENTS

As the number of electrical systems rises, so too does the demand for more controls in the car. From seat adjustment and keyless entry systems to electronic damper systems, all electrical systems with a certain basic complexity require controls.

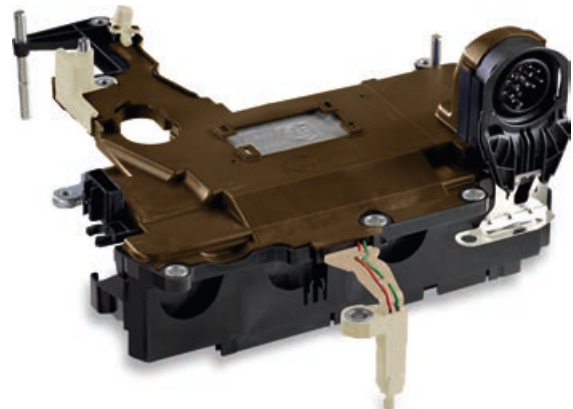
## Enhanced interior comfort

From electrically adjustable steering columns to seats, electronic systems are handling more and more functions for greater comfort and safety. The electrically adjustable steering column makes it easier for the driver to get in and out of the car. Depending on driver recognition or the memory position, the steering column and driver's seat adjust to the desired position. Driver's seat adjustments are possible even in construction machinery, making these vehicles more comfortable to drive.

## Modular control units for automated manual transmissions and hybrid transmissions

The "brain" in the automated drive-train is the transmission control unit. It determines which gear is engaged, thereby also directly controlling the engine speed.

Thanks to a modular system, it is now possible to use virtually the same control units for hybrid versions as those used for "conventional" automatic transmissions: the TCU (Transmission Control Unit) basic module is upgraded to the HCU (Hybrid Control Unit). The module contains both the control hardware and software. The design of the control unit therefore allows for the flexible addition of the power output stages for the relevant drive mode. This also produces the main benefit for the OEM: vehicle platforms with conventional driveline systems can also be designed as hybrid versions without any awkward



Transmission control unit for automatic transmissions

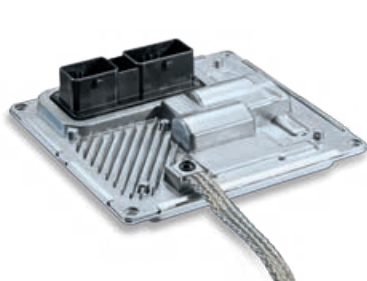
changes to the control architecture. This offers the additional significant advantage of lowering the investment costs associated with supplying hybrid systems.

## Design determined by use

Depending on the area of use, controls for electrical systems can be designed as either a decentralized unit or as part of a larger central control module. When more complex functions or functions relating to safety are involved, software development in accordance with Automotive SPICE is essential in order to guarantee a high level of product quality.



## A SELECTION OF OUR CONTROL SYSTEMS AND ELECTRONIC ASSEMBLIES:



Transmission control unit for  
automated manual transmissions



Control unit for active  
rear-axle kinematics



Steering column  
electronics



Control unit for  
electronic chassis



Electronic control for active  
engine bearing



Control unit for transmissions  
and retarders in trucks and  
buses



# KEY COMPONENTS FOR GREATER EFFICIENCY IN THE DRIVELINE

Developments in automotive technology are increasingly centered around the electrification of the driveline, regardless of whether the focus is on hybrid drive or electric drive technology. ZF is a one-stop supplier of modular, scalable systems in this area. Our extensive product range includes everything from complete hybrid systems and specific subassemblies to individual components such as inverters or DC/DC converters.

Electronic expertise is in particularly high demand for hybrid technology. In the case of a parallel hybrid system, where an electric engine, power electronics and a battery all supplement the combustion engine, the actual fuel economy is determined not by use alone, but also by the perfect interaction of all the components. The ZF hybrid systems are scalable for different performance classes. The inverters can operate all conventional electric motors – both electrical asynchronous motors (ASM) and permanent magnet synchronous motors (PSM).



Passenger car inverter with integrated DC/DC-converter

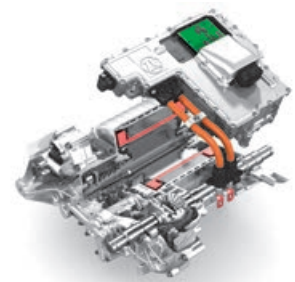
## Energy on board

The successful use of hybrid systems does not just mean that there is sufficient electrical energy available for locomotion. The on-board system also requires a permanent and adequate supply of energy. In order to ensure this supply, either an available generator is used or the function is integrated into the system architecture via a suitable onboard transformer.

Control and integration into the operating strategy and energy management of the vehicle take place via, for example, a CAN bus. As a “one-stop supplier”, we are able to offer our customers the added value that comes with our modular system: your own systems can be optimally integrated into this environment. The standardized system design also speeds up the process of designing and developing different versions.



48 V-hybrid system  
with integrated  
power electronics

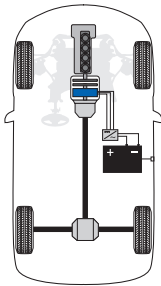


Electric axle drive  
with power electronics

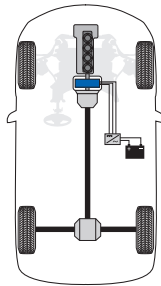




#### Hybrid vehicles with rear-wheel drive

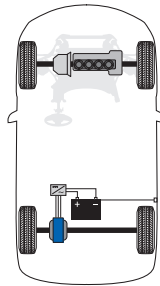


Plug-in hybrid electric vehicle High voltage

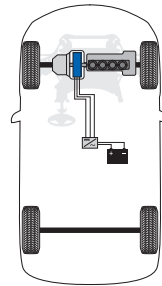


Mild hybrid electric vehicle 48 V

#### Hybrid vehicle with front-transverse drive

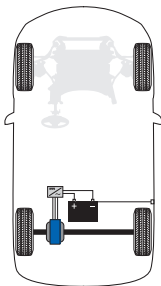


Plug-in hybrid electric vehicle, electric all-wheel drive, High voltage

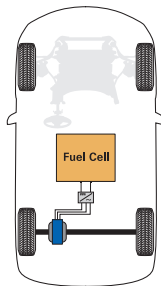


Mild hybrid electric vehicle 48 V

#### Electric vehicles



Battery electric vehicle



Fuel cell (electric) vehicle

ZF relies on parallel hybrids, combined and purely electric drives. In these systems, the combustion engine and electric drives are shifted in parallel. In the combined variant, each type of drive propels one axle. They can be used individually or in combination. The parallel hybrid comes with only one electric machine for the drive and for energy recovery, while common drive components continue to be used.

In the combined drive, the electric motor on the rear axle provides point support for the combustor on the front axle, so that it can operate in an optimum speed range. This saves money but also requires system integration expertise. The parallel hybrid can be designed as a micro, mild or full hybrid. Vehicles with an additional 48 V on-board supply system have the option for a less costly step toward mild hybridization. Based on 48 Volts already a large number of hybrid functions are possible – start/stop, sailing, boost mode, recuperation, electric starting as well as crawling. Thanks to the low-voltage system, the electronic components can, however, be integrated in the vehicle at low cost. Fuel savings of 10 to 15 percent can be achieved.

# SWITCHING TO SAFETY – COMPONENT BY COMPONENT

Quality and safety in production on the one hand, and, on the other hand, quality that offers drivers an enhanced level of safety as they negotiate traffic every day. ZF helps to improve safety by developing reliable components that meet the most exacting of standards. Because we know that it is essential for products to function reliably over the long-term and, sometimes, in the most adverse conditions.

## Functions that guarantee safety

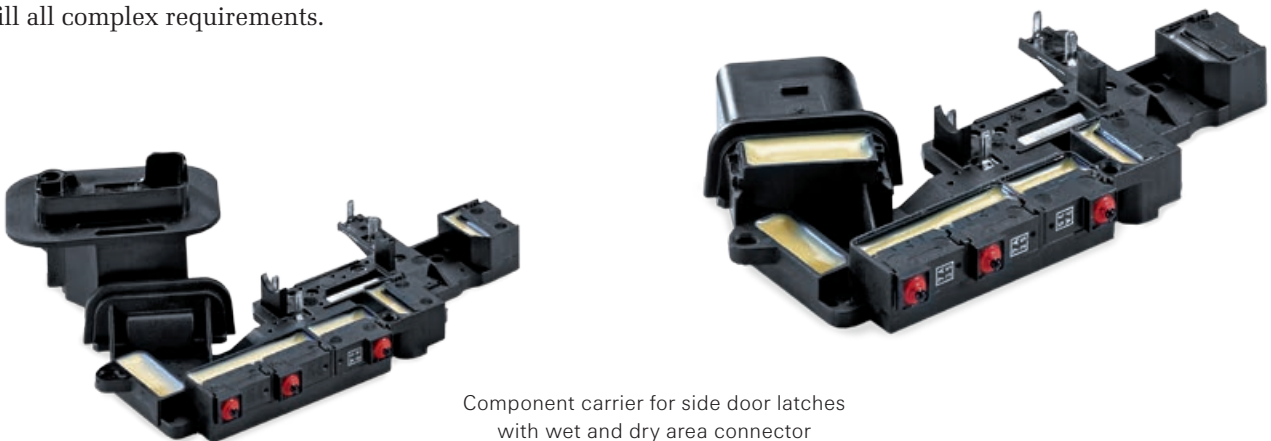
Driver safety begins with intuitive, easy-to-use control units, e.g. for seat adjustment or automatic transmission. It also includes solutions for monitoring seatbelts, tailgates and doors and extends to many other features, such as steering column locks, gear shift gates or immobilizers, brake assistant systems, brake light switches and position indicators. Switches and the more complex product solutions based on them are primarily used for detecting position information. These then switch signal or motor currents.

## Always in the correct position

Reliable position information detection by means of miniature switches are a key area of our expertise. From standardized single switches and pre-assembled solutions with cable harness and connector, right through to customer-specific component carriers – these functional modules fulfill all complex requirements.

## The knowledge that you are in safe hands

We rely on a wide range of areas of expertise to ensure driver safety. Very few of our solutions are “off the rack.” Instead, the vast majority of them are customized to the specific environments of new car designs, developed in close collaboration with the automotive industry and its suppliers. Many of our solutions thus blend in with the overall design of modern vehicles to form a single unit.



Component carrier for side door latches  
with wet and dry area connector



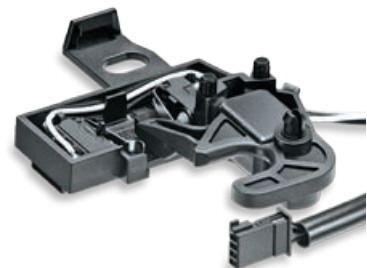
## A SELECTION OF OUR APPLICATIONS FOR SWITCHES AND SWITCH ASSEMBLIES:



Brake assistant



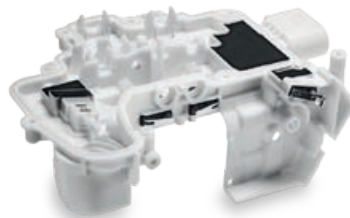
Clutch switches  
for motorcycles



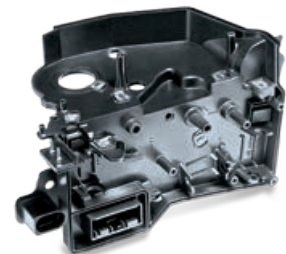
Touch control module,  
shift lock for automatic  
transmissions



Component carrier with insert  
molded stamping grid for the  
three-dimensional configura-  
tion of micro-switches on the  
trunk lock cylinder



Three-dimensional stamping  
grid as component carrier in  
the side door latch



Component carrier for  
side door latch with sensors



# MOVING INTO THE FAST LANE, THANKS TO INNOVATION

Thanks to our innovative developments, we are constantly helping to reduce the environmental impact of cars. Such developments include, for example, components for the driveline. These components make it possible to construct cars that are lighter in weight, thereby reducing both fuel consumption and CO<sub>2</sub> emissions.

The main innovative direction that we are currently taking at ZF Electronic Systems is one that is very important for the future of the car: sensor technology, especially for the driveline.

## **Sensor technology is the key**

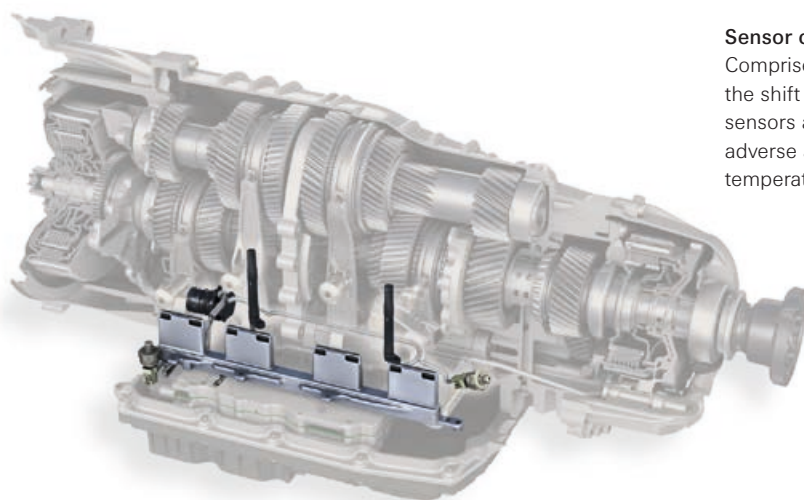
Whether for manual or automatic transmission, steering, the brake or the clutch: in order to reduce weight in the vehicle, mechatronic solutions are in particularly high demand. Such solutions require advanced modules with highly sensitive yet robust sensors that can function reliably for many years. Sensors are used in various different locations where non-contact measurement or a diagnostic switching solution is required.

The components enable the non-contact retrieval of information relating to direction, angle, position, speed and other physical parameters. They play a key role in enhancing the safety and efficiency of the mobility solutions of the future. In addition to enabling the measurement or switching function itself, it is also important that these sensors are integrated into a defined functional area, so that they can fulfill the specific environmental conditions of the application.

It is only through precise knowledge of the state of all of the components in a vehicle system that the driver can be provided with maximum support and that the optimal efficiency of the vehicle can be achieved.

## **Sensor cluster in 7-speed dual clutch transmission.**

Comprises four inductive sensors for directly detecting the shift fork position in the transmission, two speed sensors and a temperature sensor. Operation under adverse ambient conditions in an oil environment at temperatures of up to 150 °C.

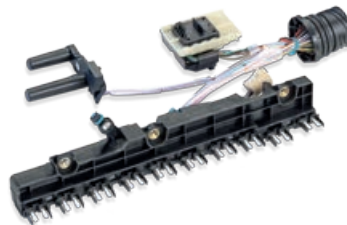




## EXAMPLE OF A SENSOR TECHNOLOGY APPLICATION:



Neutral position sensor  
for start-stop request



Sensor cluster for  
automatic transmissions



Inductive selector lever module  
detecting the selector lever position  
in the gearshift lever housing of  
automatic transmissions



Sensor subassembly as  
brake light switch



Sensor package for  
brake assistant



Non-contact sensor for mea-  
suring wear in commercial  
vehicle braking systems

# RESEARCH AND DEVELOPMENT



Innovations are not a purpose in themselves for ZF; they must pay off, for manufacturers, fleet owners, and drivers, but also for the environment and society. Each new development must prove itself among the conflicting priorities of these criteria.

The ZF Group benefits from an international network of development centers: the main development locations are Friedrichshafen, Dielingen, Passau, Schweinfurt, Schwäbisch Gmünd (Germany), Northville near Detroit (USA), Pilsen (Czech Republic) and Shanghai (China). Worldwide, approximately 5,400 engineers work in Research and Development. Corporate R&D coordinates and supports the activities at the development center in Tokyo (Japan). Every year, ZF invests approximately five percent of its sales in Research and Development. With success, because innovative products from ZF set the standards for state-of-the-art technology – again and again.

Development work at ZF is organized according to decentralized and central functions. The divisions and business units focus on markets and product expertise, ensuring customer-centered, competitive

technological product development. Corporate R&D works with a strong emphasis on basic research and theory and supports the functional development areas in the divisions.



Electronics hardware engineering





Laboratory test-benches  
for power-electronics

### An innovative approach to development

Regardless of whether our objective is to shorten development times, to increase the efficiency of manufacturing processes, to use materials more sparingly or to find and test new materials, one thing is always the same: we do not miss any opportunity to make our development processes environmentally friendly and economical.

Every detail of our electronic components is scrutinized before they enter into manufacture. This greatly reduces the length of time required prior to readiness for the start of mass production and also has the major benefit of keeping development costs low.

The bottom line is that we can honestly say that we have no qualms about allowing any product we have manufactured onto the road.



Software engineering

### Comprehensive testing

Our new developments in particular must pass various tests in order to demonstrate that they offer both reliability and a long serviceable life. At ZF Electronic Systems, we therefore have specialist test centers where we perform a wide range of fundamental tests on components and materials, as well as measurements during the development stage and tests on completed products.

# PRODUCING QUALITY. AND PUTTING QUALITY PRODUCTS ON THE ROAD.



We take pride in the fact that each part we produce is identical to the next, right down to the last detail; that we can make the same part a hundred thousand times without the slightest discrepancy. This may sound dull, but it is a hallmark of our high quality standards.

Walking through our production halls is like walking through an exhibition of the very latest production processes. And that is how it should be: only these modern processes can guarantee absolute top quality – the kind of quality that technology simply has to provide when it is going to be used on roads all over the world.

Only impeccably functioning components will benefit both safety and the environment. For example, the latest generation of SMD high performance placers can place even fine pitch components onto the component carriers with exact precision. We also offer technologies such as chip-on-board.

When it comes to conventional, wired components, we use wave soldering systems; the use of nitrogen allows for an extremely high soldering quality. 100% functional tests, visual inspections, in-circuit tests, unique injection molding and casting expertise – and much, much more.

## **Production characterized by quality**

It is, however, also important that we use flexible manufacturing concepts – from modular assembly to highly automated production lines – so that we can offer top quality at an affordable price. It is also vital for our staff to use their own initiative and demonstrate a high level of commitment in order to optimize processes and take every possible step to ensure genuine quality. ZF customers can rely on up to 100% end of line testing, including complete traceability of all manufactured systems. Our subassemblies and products must meet every aspect of our very exacting standards in a wide range of tests before we let them out onto the roads – all in the interests of the environment, safety and economic driving performance.

## **Hardness test for components**

No matter which component or which system is being tested, conventional tests do not meet our exacting requirements. We perform tests under conditions that are more





extreme than the toughest of external conditions. We also simulate time periods that extend far beyond the expected lifespan of a vehicle. We believe this is essential when safety and reliability are at stake. We accept no compromises. One critical factor in this age of electronics is electromagnetic compatibility. There are two important concerns here: firstly, that there is no adverse effect on equipment and functions and that they are afforded sufficient protection and, secondly, that equipment and systems do not transmit any interference waves that could have an adverse effect on other equipment or systems.

#### **Environmental simulation**

Environmental simulation is another key focus. We conduct functional tests in heat and bitterly cold temperatures, in wet, foggy and salt spray fog conditions, as well as tests that involve jolting, shaking, bumping, strain, warping or pressure. Only components that pass our entire range of tests with flying colors will enter into mass production.

#### **Our test procedures at a glance**

##### **Environmental simulation**

- Functional tests and serviceable life tests under conditions involving heat, cold, damp, corrosive atmospheres such as SO<sub>2</sub>, salt spray fog, oil
- Vibration / shock tests
- Leak tests
- Acoustic measurements
- Haptic tests
- Illumination tests
- Surface tests

##### **Electromagnetic compatibility (EMC)**

- ESD, burst and surge tests
- Simulation of network anomalies, e.g. spikes
- Motor vehicle impulse testing
- System testing in the black box test using control units and intelligent sensors



# THE ZF GROUP

## Shaping the future responsibly


Our enthusiasm for innovative products and processes and our uncompromising pursuit of quality have made us a global leader in driveline and chassis technology. We are contributing towards a sustainable future by producing advanced technology solutions with the goal of improving mobility, increasing the efficiency of our products and systems, and conserving resources.

Our customers in the automotive and industrial sectors welcome our determined focus on products and services, which provide great customer value. Improvements in energy efficiency, cost-effectiveness, dynamics, safety, and comfort are key to our work. Simultaneously, we are aiming for continuous improvement in our business processes and the services we provide. As a globally active company, we react quickly and flexibly to changing regional market demands with the goal of always providing a competitive price/performance ratio.

Our independence and financial security form the basis of our long-term business success. Our profitability allows us to make the necessary investments in new products, technologies, and markets, thus securing the future of our company on behalf of our customers, market affiliates, employees, and the owners of ZF.

Our tradition and values strengthen our managerial decisions. Together, they are both an obligation and an incentive to maintain a reliable and respectful relationship with customers, market affiliates, and employees. Our worldwide compliance organization ensures that locally applicable laws and regulations are adhered to. We accept our responsibility towards society and will protect the environment at all of our locations.

Our employees worldwide recognize us as a fair employer, focusing on the future and offering attractive career prospects. We value the varied cultural backgrounds of our employees, their competencies, and their diligence and motivation. Their goal-oriented dedication to ZF, beyond the borders of their own field of work and location, shapes our company culture and is the key to our success.



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# EFFICIENT MOBILITY: DRIVING US TO DEVELOP INNOVATIVE TECHNOLOGIES

People are in motion, on the way to their destinations. Different means of transportation link the places where we live and study, our workplaces, recreational facilities and travel destinations. The need to conserve resources, reduce noise and emissions and increase safety and comfort are not only key requirements for contemporary mobility but opportunities for sustainable innovation. As one of the world's leading technology companies in drive and suspension technology, we are part of and are also driving this development. We're a reliable partner to our customers, employees and to society in general, with the goal of developing innovative and efficient products that improve quality of life and help shape the future. [www.zf.com](http://www.zf.com)



MOTION AND MOBILITY

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