



# Shaping future electromobility with semiconductor innovations

Semiconductor solutions for hybrid electric and electric cars



## Stepping up to the energy challenge

The need to conserve natural resources, reduce emissions and raise energy efficiency has become a major public concern. Amidst worries about dependence on oil and climate change, demand for electricity continues to soar. According to the International Energy Association, worldwide demand for electrical energy is set to rise by more than 60% over the next 20 years.

The way forward does not necessarily lie in producing more electricity, but in wasting less of it. To sustain our current economic model into the future, we need to optimize energy efficiency across the entire power chain, stretching from generation through distribution to actual consumption. In other words, industry faces the challenge of developing smart solutions that enable climate-neutral sourcing, intelligent distribution through smart grids and efficiency-aware applications and appliances.

### Semiconductors – key enablers in “going smart”

Semiconductors play a key role in building more intelligence into the energy cycle. Underpinned by our sense of environmental responsibility and strategic focus on energy efficiency, mobility and security, we are already delivering the semiconductor innovations required to resolve these challenges and design intelligent power networks, accelerating the paradigm shift toward electromobility on the road. When it comes to building tomorrow’s electric infrastructure, our semiconductor solutions will form the backbone of the enabling smart grid, allowing drivers to recharge intelligently, pay securely and feed power back into the electricity grid.



## Spotlight on personal mobility

Personal mobility is a big contributor to CO<sub>2</sub> emissions. Consequently, the current focus on energy efficiency means that the spotlight falls on cars. The growing number of cars on our roads each year is forcing industry players and policy-makers to explore alternative forms of mobility with a smaller CO<sub>2</sub> footprint.

One extremely effective way of reducing carbon emissions involves electrifying the drivetrain of cars. The advantages of Electric Vehicles (EV) include higher energy efficiency of the drivetrain, lower noise levels and zero tailpipe emissions when powered solely by the battery.

However, for EVs to be truly viable, various challenges must be overcome. These include the high initial cost of the battery and the lower driving range. Widespread acceptance also hinges on a standardized infrastructure for recharging with uniform connectors and charging voltages, for instance. And – most importantly – intelligent energy concepts are key to achieving environmental goals. EVs must be part of a smart electricity grid which relies on Information Technology (IT) to increase efficiency, reliability and interoperability.

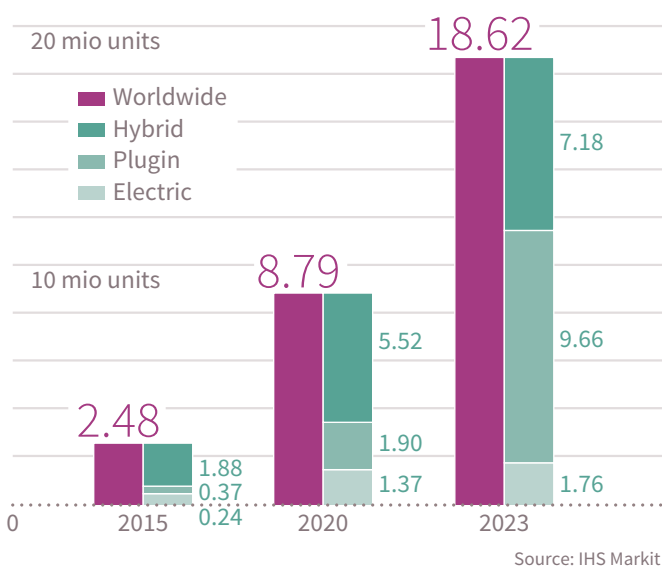


# Moving forward

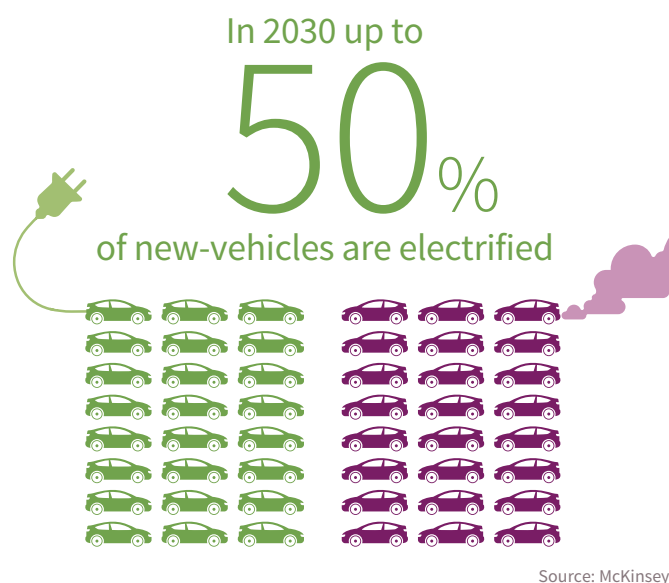
The transition to a new age of mobility will be a gradual one. As we move beyond the Carbon Age and our dependence on fossil fuels, Hybrid Electric Vehicles (HEV) will play an important role alongside lower-carbon combustion engines during the transitional period. Although electric drivetrains are already more energy efficient than combustion models, further improvements are still required.

Vehicles that combine an electric drive with a compact battery and complementary internal combustion engine will basically pave the way for all-Electric Vehicles (EV). Drivetrain electrification calls for high-power semiconductors designed to automotive quality standards. Expertise in both power semiconductors and automotive electronics is thus essential to successfully serve the emerging HEV and EV markets.

## Hybrid and electric vehicles



## A driving force of innovation



Although the combustion engine still dominates today's drivetrain technologies, electrification is emerging as an increasingly strong force in shaping the green mobility landscape of tomorrow.



## Experience pays

As the global leader in advanced power and automotive electronics, we are the only player worldwide who combines both areas of expertise – bundling more than 40 years of experience in automotive electronics and high-power electronics with more than 15 years of experience in electromobility. We have been a leading supplier of high-power IGBT modules for drive and traction applications for many decades.

We now have the broadest (H)EV range of power modules and chips dedicated to optimizing overall system cost, minimizing power losses, increasing power density, maximizing power savings, extending mileage and improving battery efficiency. Carmakers and system suppliers all over the world already rely on products from Infineon Technologies to drive new innovations.

This bundled experience makes us the ideal partner to drive the trend toward electric cars and benefit from this growing market. Here we envisage strong revenue growth as the powertrain semiconductor bill-of-materials for an EV/HEV is a multiple higher than the corresponding bill for a combustion engine.

While a car with a conventional internal combustion engine contains an average semiconductor value of US\$ 352, the value contained in an average hybrid or electric vehicle is approximately US\$ 700. Approximately three quarters of this incremental semiconductor content is accounted for by power semiconductors. They are the decisive factor in high-power electric drives and are also the key to cutting costs. Innovative system solutions, and in particular the use of silicon carbide-based components, have an enormous potential when it comes to making electric driving more affordable.

Our strong commitment to driving efficiency and cost-effectiveness in the industry is reflected by our active involvement in a variety of research projects. For instance, we initiated the E3Car (Energy Efficient Electrical Car) European research project which involves 30 European companies and academic institutes working together to develop electronic innovations aimed at raising the efficiency bar by 35%.

# Leading innovative semiconductor solutions for HEVs/EVs

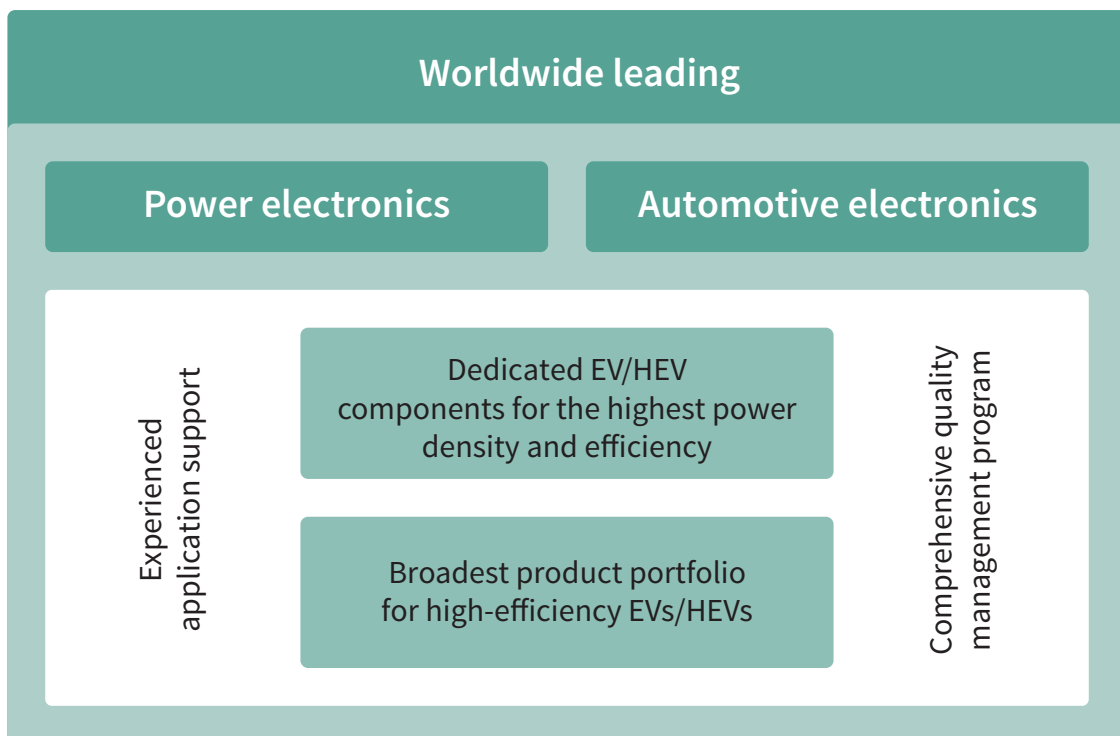
A new era is dawning stringent CO<sub>2</sub> emission standards call for cleaner cars. In a Battery Electrical Vehicle (BEV), the combustion engine is replaced by at least one electric motor, while in a plug-in or Hybrid Electrical Vehicle (PHEV/HEV), the combustion engine is supplemented in addition to an electric motor. Regardless of the model, bundled high-power and automotive system expertise is essential to serving this market successfully.

As the world leader in advanced power electronics and in automotive electronics, our know-how and system expertise put us in a perfect position to provide innovative, high-performance semiconductor solutions with best-in-class technologies for hybrid and electric vehicles.

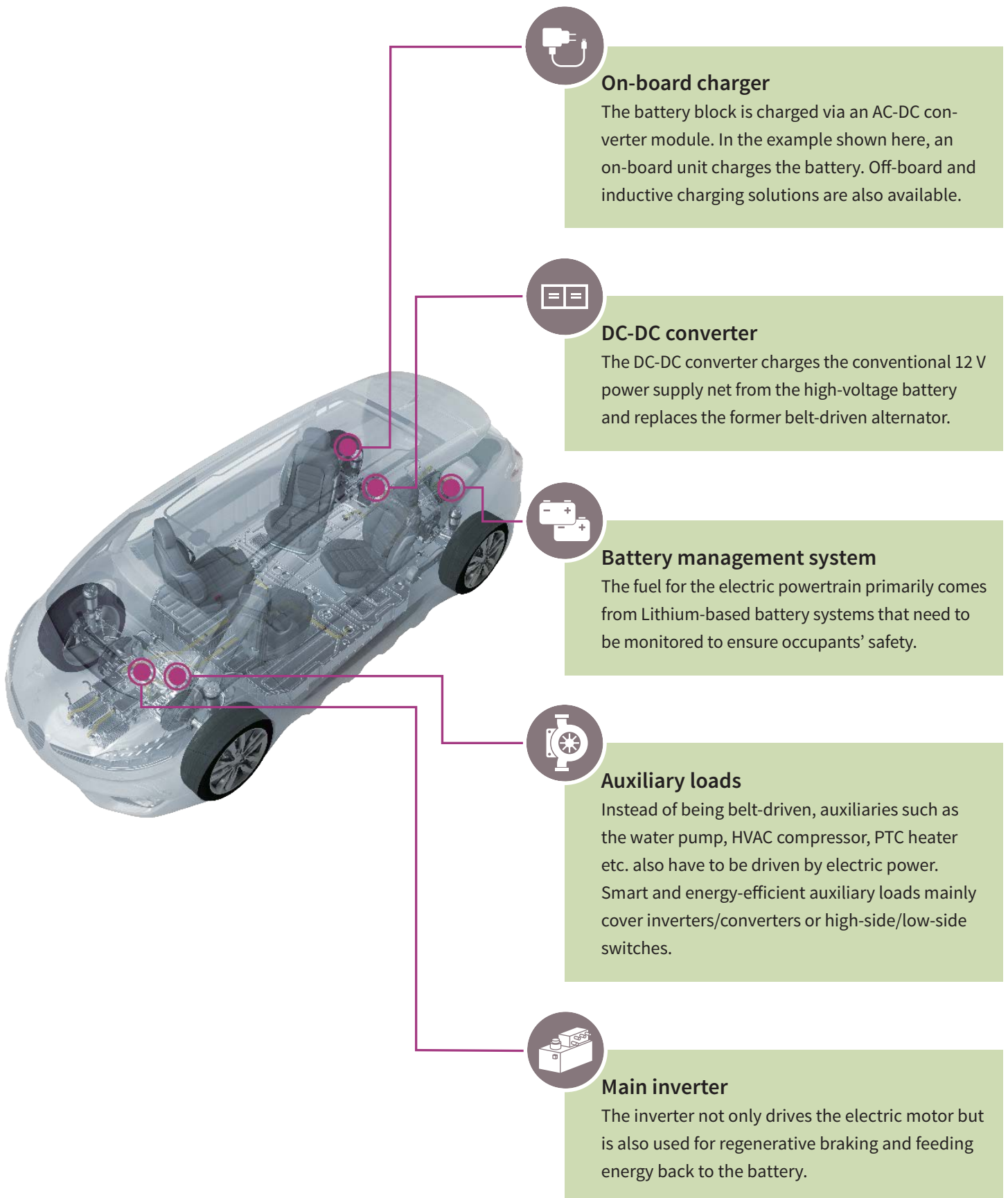
Drawing on our long-standing experience in the development of leading IGBT power modules and high-efficiency technologies for the industrial market, we have developed dedicated, automotive-qualified high-power modules for the highest power densities and efficiency. Our broad and

scalable product portfolio enables a smooth transition across all power classes from mild HEV to high-power EV. Suitable for all electric drivetrain architectures, we are the only player in the market to offer a complete portfolio of products consisting of discrete components and high-power modules making us a one-stop shop for ensuring fast time-to-market for our customers.

Thanks to our system expertise, we are able to provide complete chipsets offering optimized performance and reduced overall system costs. Our semiconductor solutions for (H)EV are proof of the exceptional quality and reliability that the world's leading automotive manufacturers have come to know and expect from Infineon. And we are proud to be able to deliver market-leading (H)EV solutions already today. By offering innovative and highly efficient products of outstanding quality, we are driving innovative electrified powertrain solutions geared toward more sustainable mobility choices.

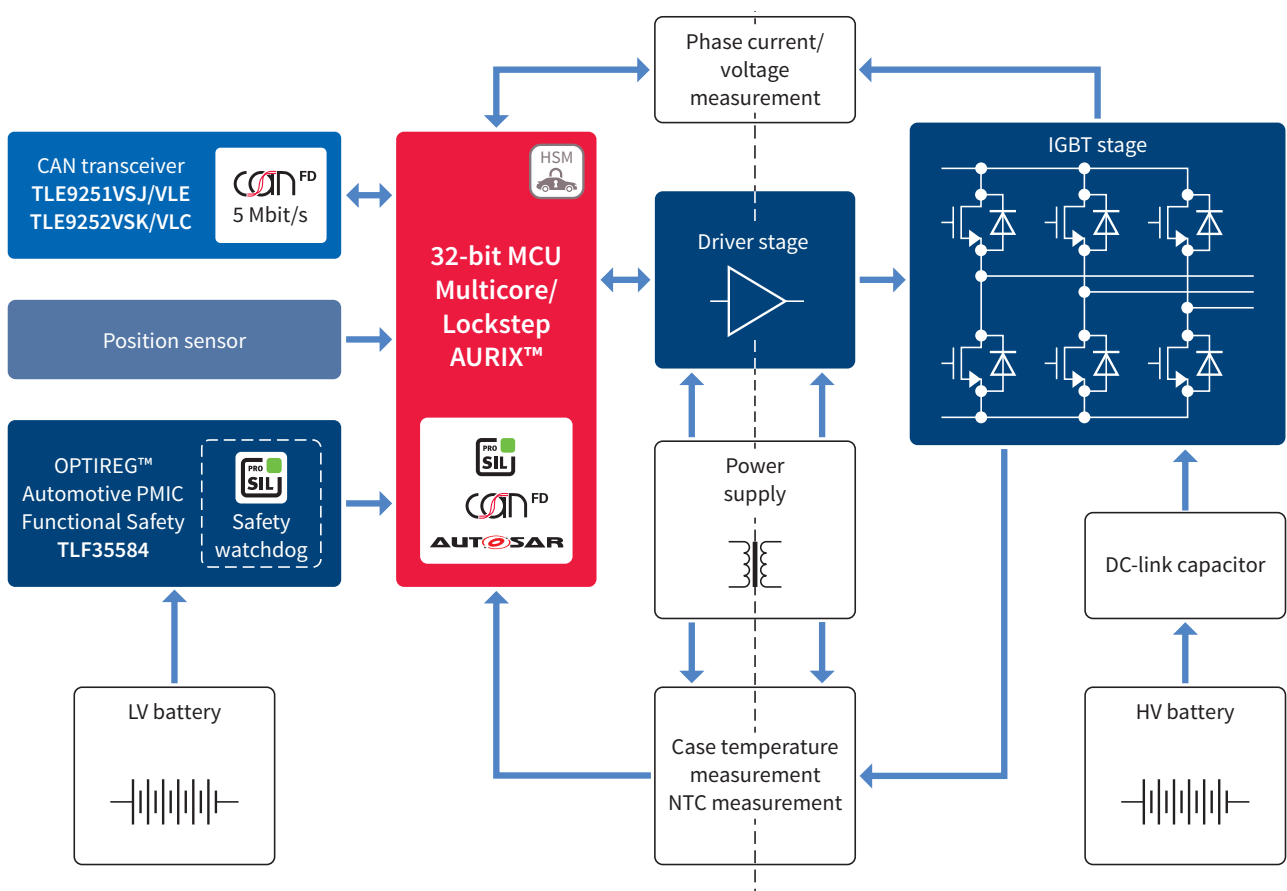


# Application overview



# Main inverter

In vehicles with an electric drivetrain, the inverter controls the electric motor. This is a key component in the car as, similar to the Engine Management System (EMS) of combustion vehicles, it determines driving behavior. Regardless of whether the motor is synchronous, asynchronous or brushless DC, the inverter always functions in a similar way and is controlled by an integrated PCB, which should be designed to minimize switching losses and maximize thermal efficiency. Not only does the inverter drive the electric motor, but it also captures the energy released via regenerative braking and feeds it back to the battery. As a result, the range of the vehicle is directly related to the efficiency of the main inverter.



## System benefits

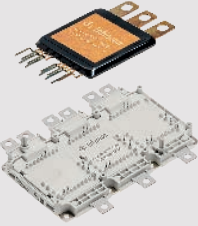
- > Fully automotive-qualified product portfolio supporting a wide range of motors, generators and power classes
- > Automotive-qualified power semiconductor portfolio including both power module and discrete solutions for flexible coverage of all power classes
- > Highly efficient 3-phase driver thanks to very low conduction losses even at high switching frequencies
- > Isolation integrated in gate driver
- > Wide range of 32-bit microcontroller solutions dedicated to (H)EV applications with a highly cost-effective resolver interface
- > OPTIREG™ Automotive PMIC multi-rail, safety power supply combined with AURIX™ microcontroller to enable functional safety
- > Evaluation kit available to reduce system development time






## Our semiconductor solutions for the main inverter


Our highly reliable semiconductor solutions support a wide range of motors, generators and power classes, enabling compact and cost-efficient system designs that offer high energy efficiency thanks to the reduction of power losses. Highlights include:




Our HybridPACK™ family enables a smooth transition across all power classes from HEV to EV (from 10 kW to 180 kW). These integrated power modules contain all power semiconductors required to drive electric motors of up to 180 kW, with the added bonus of compact inverter designs and optimum support for water cooling.



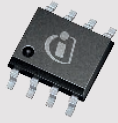
High-efficiency, low-loss IGBT discretes bundle our outstanding trench- and fieldstop technologies to reduce saturation voltages well below the levels offered by competing standard NPT IGBTs – without increasing the switching losses. These IGBT discretes offer maximum flexibility and scalability when it comes to the application design, for all power classes.




The Infineon® EiceDRIVER™ family includes single and dual-channel automotive IGBT driver ICs that provide galvanic isolation and bidirectional signal transmission. These products are ideal for the main inverter systems in automotive applications where efficiency, space savings and monitoring functions are priorities.




Our highly scalable 32-bit microcontrollers AURIX™ family, with its superior performance, ASIL-D supportive functions and integrated resolver-to-digital interface, is the perfect brain for energy-efficient electric drivetrains.



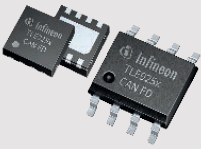
Our position sensors enable close-loop feedback of the motor position for Field-Oriented Control (FOC) that supports the highest safety levels.



OPTIREG™ Automotive PMIC: ISO26262-compliant, multi-rail power supply with microcontroller-, communication-, and sensor- supply rails and monitoring/supervisory functions (PRO-SIL™).



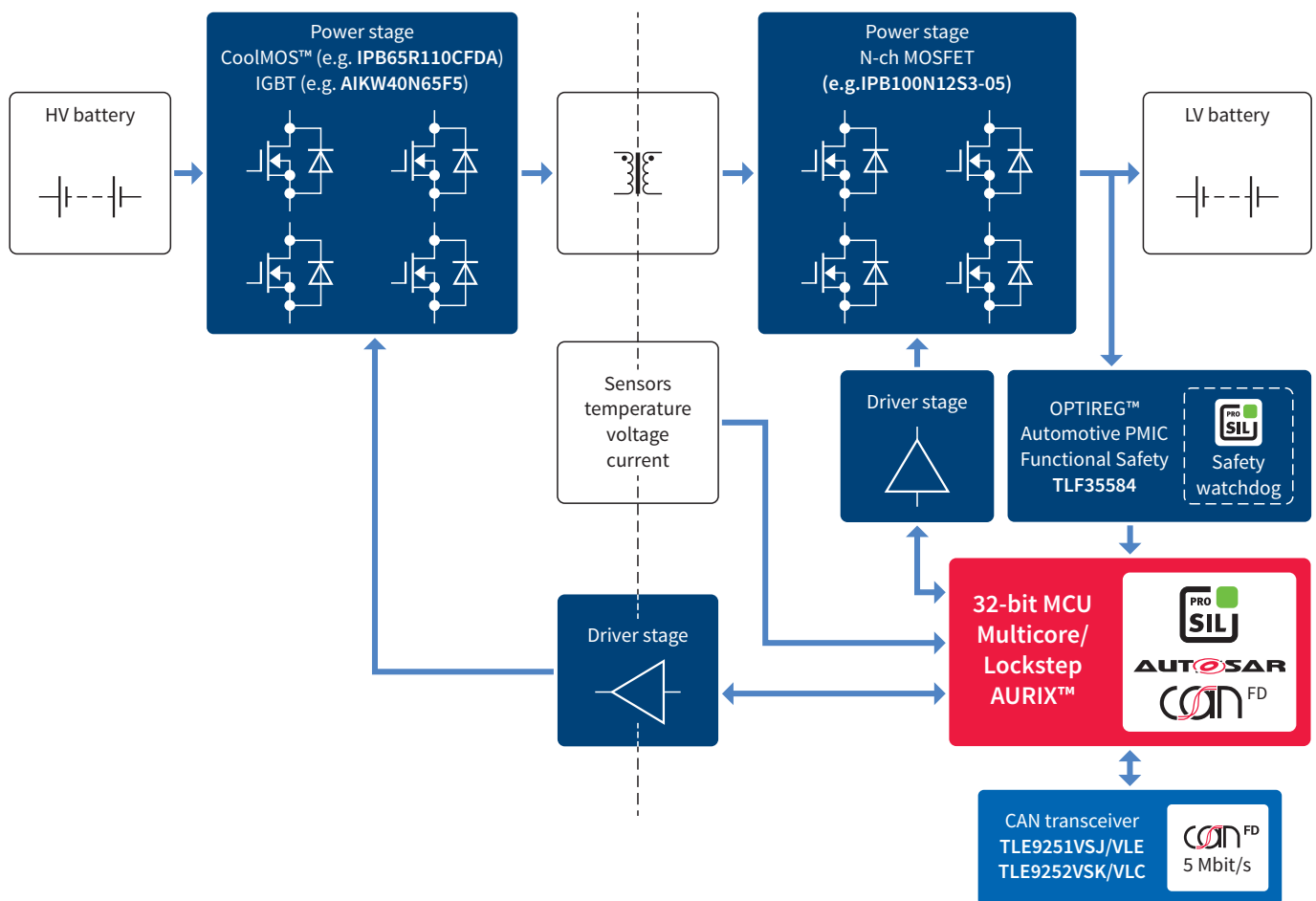
TLE9252V, a 14-pin automotive transceiver designed for HS CAN networks with Flexible Data-rate up to 5 Mbit/s in automotive and industrial applications. The dual power supply concept (state machine supplied by  $V_{BAT}$  or  $V_{CC}$ ) avoids disruption of communication during  $V_{BAT}$  cranking.



TLE9251V, a 8-pin automotive transceiver designed for HS CAN networks with Flexible Data-rate up to 5 Mbit/s in automotive and industrial applications. The TLE9251V which  $V_{CC}$  can even be switched off, while still being able to wake-up by signals on the CAN bus. Additionally TLE9251V with VIO input pin can interface either with 3.3 V or 5 V micro-controllers.

# Auxiliary HV/LV DC-DC converter

Different voltage levels are required by the various electronic components in an EV. High-voltage batteries with different voltage levels are currently available on the market. In addition, the power classes scale from 1 kW to 5 kW depending on the number of low-voltage applications. In the past, the alternator was used to supply the 12 V power supply system. In EVs and HEVs, the DC-DC converter supplies the 12 V power system from the high-voltage battery. Designers are called on to increase the conversion efficiency as a way of extending the range of the vehicle. Furthermore, different components may be required depending on whether the design is geared toward a uni- or bidirectional energy transfer.



## System benefits

- › Fully automotive-qualified product portfolio including both power module and discrete solutions
- › Supports a wide range of highly efficient conversion topologies (including bidirectional)
- › Compact design with the highest power density
- › Very low switching losses at high switching frequencies
- › Isolation integrated in gate driver
- › 32-bit multicore microcontrollers enabling sub-system integration (PFC + DC-DC control)
- › OPTIREG™ Automotive PMIC includes functions for functional safety and enables power supply of complete system
- › Automotive standard communication (CAN)
- › Evaluation kit available to reduce system development time



## Our semiconductor solutions for the DC-DC converter

Our chip solutions enable designers to build small DC-DC converters with a high power density, thereby supporting all voltage and power classes. Highlights include:




CoolMOS™ transistors for the high-voltage side – this MOSFET is based on our super-junction technology, ensuring a low  $R_{DS(on)}$  at high switching frequencies.

Our Easy automotive power modules with a high-speed IGBT3 and rapid diode enable a compact design and the highest energy efficiency ratings for converters from about 2–10 kW.

The EiceDRIVER™ family includes single and dual-channel automotive IGBT driver ICs that provide galvanic isolation and bidirectional signal transmission. These products significantly reduce the space requirements on the control board. Our automotive-qualified gate driver ICs help simplify design and optimize performance in all FETs and IGBTs driving stages.

Thanks to its multicore architecture, our highly scalable 32-bit microcontroller AURIX™ family enables sub-system integration e.g. PFC + DC-DC control, thereby reducing the design-in effort.

The linear Hall IC family is optimized for measuring high currents with a different digital output.



High-efficiency, low-loss IGBT discretes bundle our outstanding trench- and fieldstop technologies to reduce saturation voltages well below the levels offered by competing standard NPT IGBTs – without increasing the switching losses. These IGBT discretes offer maximum flexibility when it comes to application design.

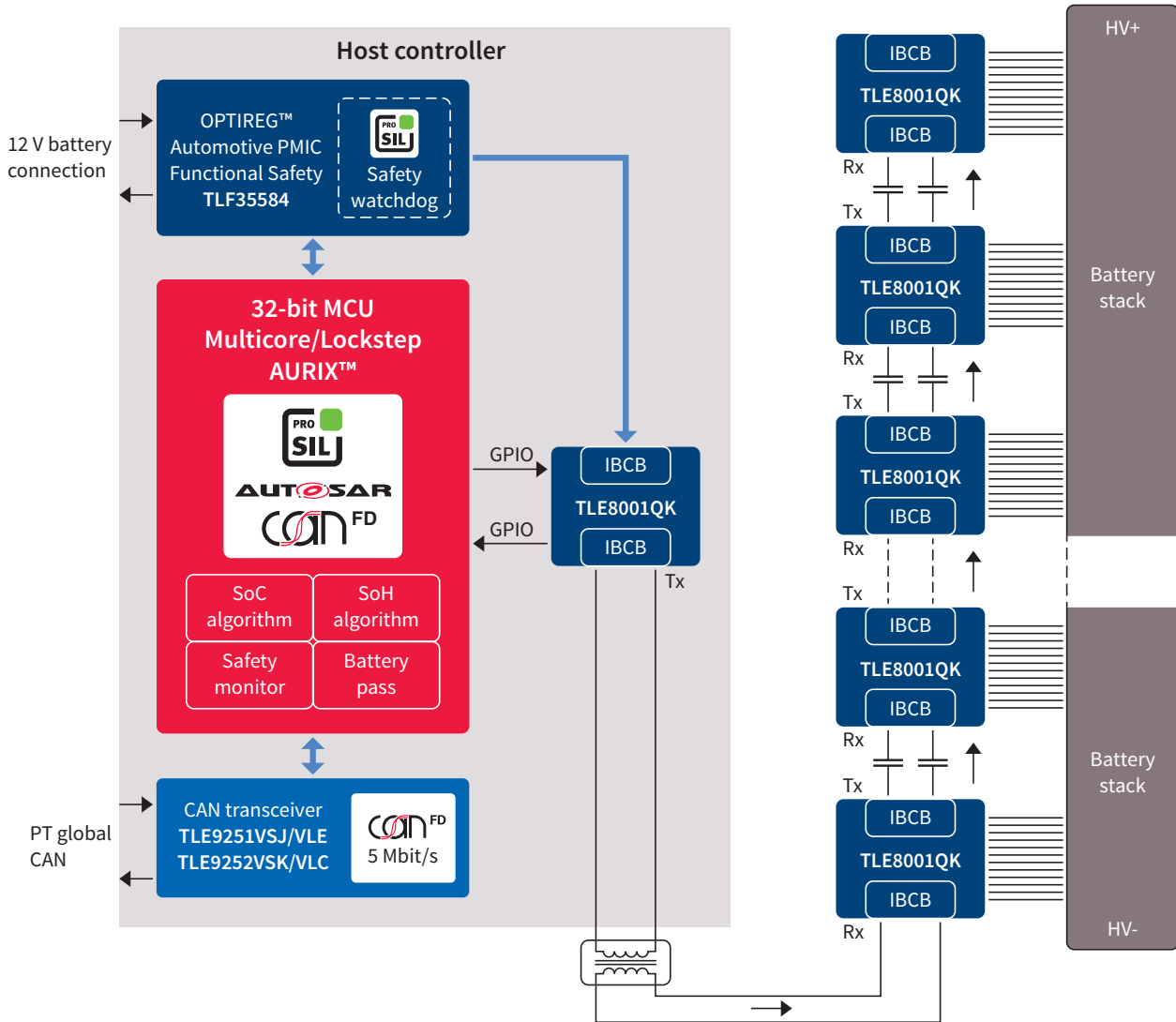
Multi-rail power supply optimized for system supply and functional safety.

TLE9252V, a 14-pin automotive transceiver designed for HS CAN networks with Flexible Data-rate up to 5 Mbit/s in automotive and industrial applications. The dual power supply concept (state machine supplied by  $V_{BAT}$ , or  $V_{CC}$ ) avoids disruption of communication during  $V_{BAT}$  cranking.

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# Battery management system

The battery monitoring system is in charge of monitoring each of the cells included in a battery pack and ensuring that they are operated within the safe operating range. It monitors and reacts to the State of Health (SoH), State of Charge (SoC) and Depth of Discharge (DoD) with the assistance of balancing ASICs. It is also able to operate under low-current consumption mode to ensure holiday parking. Furthermore, it prevents illegal manipulation of both the system and battery packs via integrated security on the AURIX™ microcontroller.



## System benefits

- > Fully automotive-qualified product portfolio offering the full pallet of products from a single source
- > Embedded authentication possible thanks to the AURIX™ HSM controller
- > Compatible communication protocol from microcontroller due to sensing ICs
- > Common safety concept for microcontroller and power supply
- > Integrated standby controller in AURIX™
- > OPTIREG™ Automotive PMIC multi-rail, safety power supply combined with AURIX™ to enable functional safety
- > Fully synchronized voltage measurement of all cells in the battery thanks to a low-latency IBCB communication bus and the ADC architecture of the sensing ICs
- > Capacitive-isolated communication contributes to reducing the system cost by avoiding transformers as well as common mode chokes
- > Integrated filtering facilitates the size reduction of external filter components



## Our semiconductor solutions for battery management



32-bit multicore TriCore™ microcontroller family, optimized for highly demanding powertrain applications (PRO-SIL™)



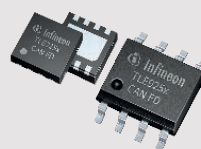
OPTIREG™ Automotive PMIC: ISO26262-compliant, multi-rail power supply with microcontroller-, communication-, and sensor-supply rails and monitoring/supervisory functions (PRO-SIL™)



Battery management sensing IC offering 12-channel voltage measurement, 5 temperature sensor connections and a best-in-class communication protocol



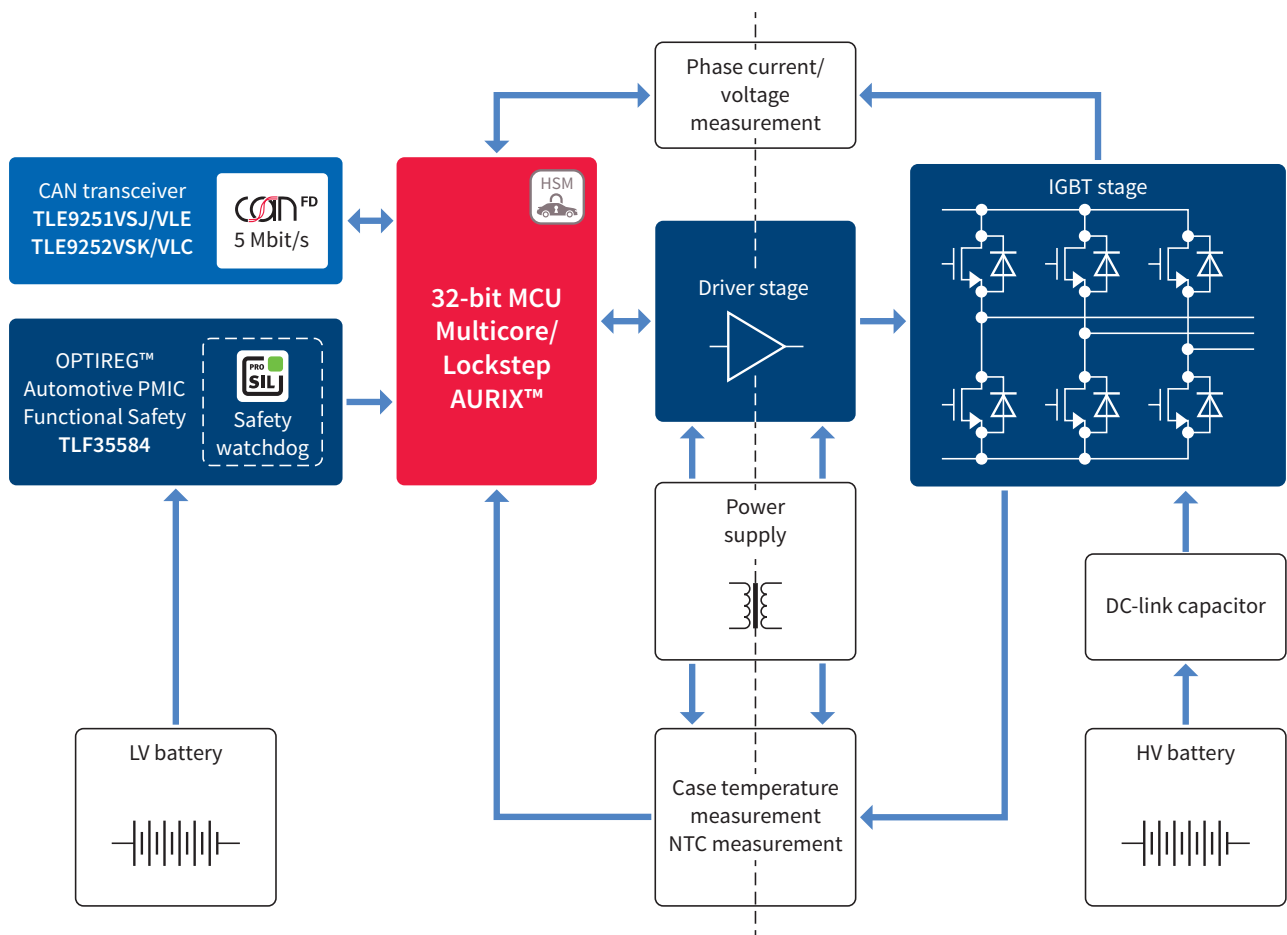
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# Auxiliary loads

In HEVs and EVs, typical auxiliary systems (PTC heaters, auxiliary drives etc) are supplied via the high-voltage battery. Notably, the devices that were formerly belt-driven (such as the air conditioning, oil pumps and cooling pumps) have now been electrified and integrated into the power system. These auxiliary drives now deliver power on demand, thereby increasing the vehicle's energy efficiency. As power from the battery is expensive, the challenge is to use the electric power as efficiently as possible. Designers therefore strive to optimize the power efficiency of not just these drives, but of all other auxiliary systems.







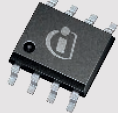


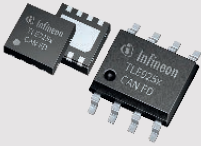
## System benefits

- > Automotive-qualified power semiconductor portfolio including both power module and discrete solutions for flexible coverage of all power classes
- > Highly efficient 3-phase driver thanks to very low conduction losses even at high switching frequencies
- > Isolation integrated in gate driver
- > Scalable 32-bit microcontroller solutions dedicated to drive (H)EV auxiliary motors
- > Multi-rail power supply for AURIX™ microcontroller
- > Evaluation kit available to reduce system development time



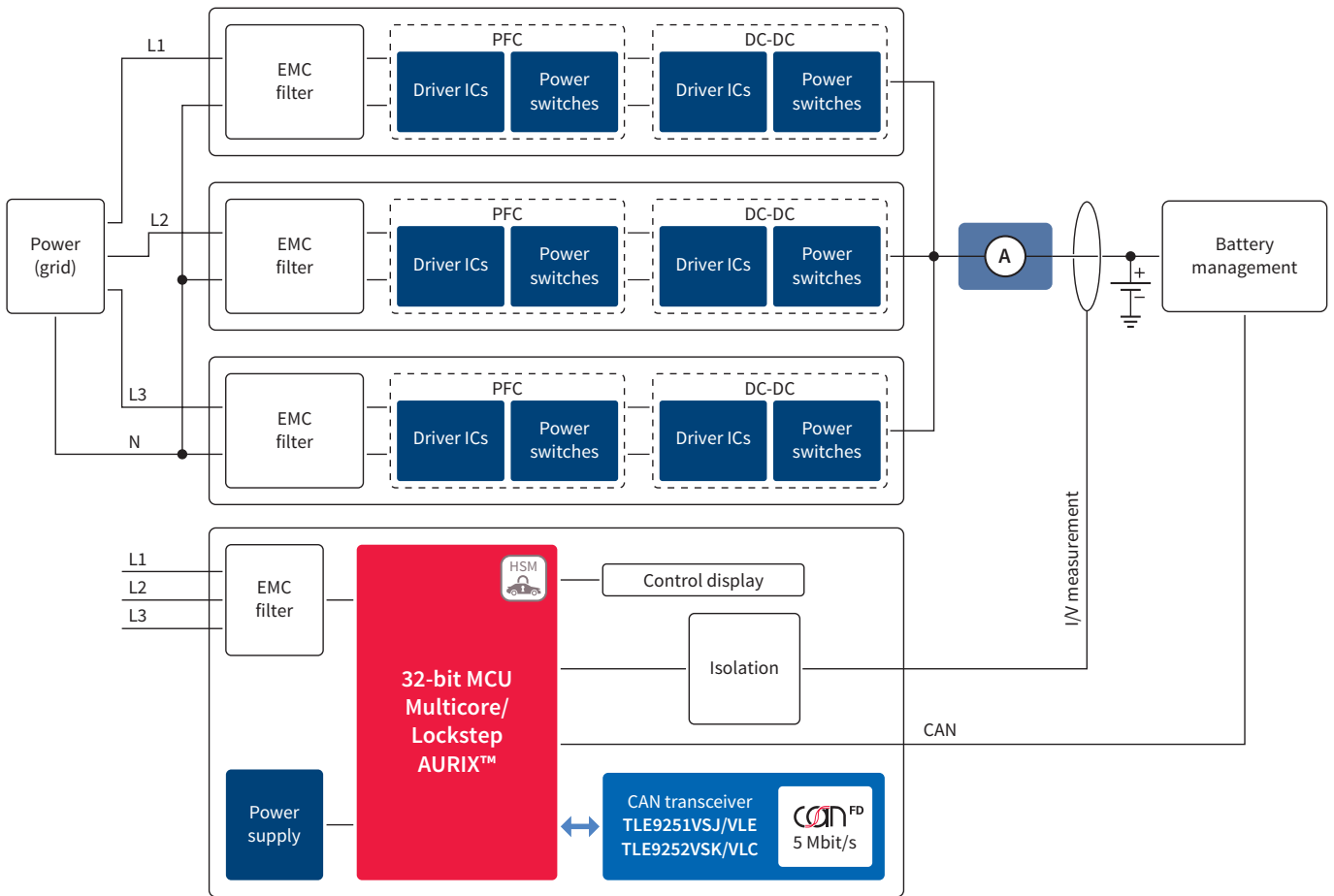
## Our semiconductor solutions for the auxiliary loads

Our fully automotive-qualified product portfolio supports a wide range of motors, generators and power classes, enabling compact designs that offer a high power density. Highlights include:

 <p>Our Easy automotive power modules enable compact designs and the highest energy efficiency ratings for auxiliary drives and converters.</p>  <p>High-efficiency, low-loss IGBT discret es bundle our outstanding trench- and fieldstop technologies to reduce saturation voltages well below the levels offered by competing standard NPT IGBTs – without increasing the switching losses.</p>  <p>The EiceDRIVER™ family includes single and dual-channel automotive IGBT driver ICs that provide galvanic isolation and bidirectional signal transmission. These products significantly reduce the space requirements on the control board. Our automotive-qualified gate driver ICs help simplify design and optimize performance in all FET and IGBT driving stages.</p>  <p>Our highly scalable, ASIL-D-supporting 32-bit microcontrollers dedicated to (H)EV solutions are the perfect complement to our product portfolio for energy-efficient electric drivetrains.</p>	 <p>Our position sensors enable close-loop feedback of the motor position for Field-Oriented Control (FOC) that supports the highest safety levels.</p>  <p>Wide portfolio of power supplies complete our semiconductor offering for auxiliary drives</p>  <p>TLE9252V, a 14-pin automotive transceiver designed for HS CAN networks with Flexible Data-rate up to 5 Mbit/s in automotive and industrial applications. The dual power supply concept (state machine supplied by <math>V_{BAT}</math> „or“ <math>V_{CC}</math>) avoids disruption of communication during <math>V_{BAT}</math> cranking.</p>  <p>TLE9251V, a 8-pin automotive transceiver designed for HS CAN networks with Flexible Data-rate up to 5 Mbit/s in automotive and industrial applications. The TLE9251V which <math>V_{CC}</math> can even be switched off, while still being able to wake-up by signals on the CAN bus. Additionally TLE9251V with VIO input pin can interface either with 3.3 V or 5 V microcontrollers.</p>
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# On-board charger

The battery in an electric vehicle is useless without a battery charger. And all electronic systems depend on the battery for power. In vehicles fitted with an on-board charger unit, the battery can be charged from a standard power outlet. Charging via the main grid calls for design flexibility due to the different voltage and current levels in different countries. And needless to say, the charging time is also an important factor for car drivers. System designers face the challenge of supporting the varied voltage and current levels while increasing the power density. When it comes to on-board charging, the key success factors involve efficiency and a high power density for a small form factor. The long-term trend is moving toward bidirectionality, where the charger also feeds power from the car to the smart grid.



## System benefits

- > Suitable for plug-in hybrids and EVs
- > Integrated Power Factor Correction (PFC)
- > Galvanic isolation
- > Wide range of input and output voltages
- > Adjustable current limits
- > Automotive standard communication (CAN)
- > Modular concept enables 1 to 3-phase AC power supply


Looking for Off-board charging semiconductor solutions, please visit our web-site: [www.infineon.com/ev-charging](http://www.infineon.com/ev-charging)



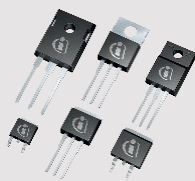


## Our semiconductor solutions for on-board chargers

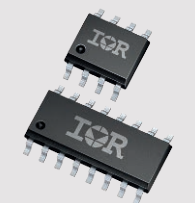
Our comprehensive product portfolio provides the perfect fit for compact charger units (> 10 kW/dm<sup>3</sup>) designed for high switching frequencies, lower weight and adjustable displacement power factors. Our isolated gate drivers ensure safe operation. Highlights include:




Thanks to its multicore architecture, our highly scalable 32-bit microcontroller AURIX™ family enables sub-system integration e.g. PFC + DC-DC control, thereby reducing the design-in effort.



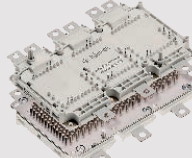
CoolMOS™ transistors – high-voltage automotive MOSFETs for low-power charging solutions (overnight).



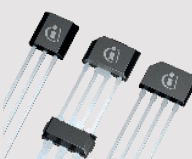
Our comprehensive portfolio of automotive-qualified gate driver ICs helps simplify design and optimize performance in all FETs and IGBTs driving stages for automotive on-board chargers.




Easy 1B/2B – flexible power module solutions for low-power charging solutions.




HybridPACK™ – power module solutions for high-power charging solutions.



The linear Hall IC family is optimized for measuring high currents with a differential digital output.



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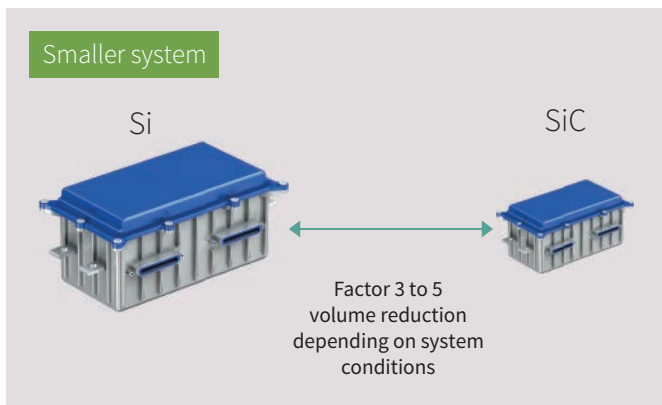
# SiC for automotive applications

## Gearing up for a new generation of power electronics

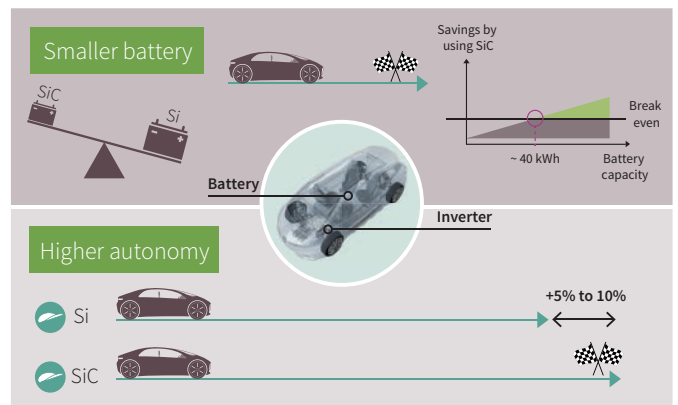
Demand for plug-in hybrid and all-electric vehicles (xEV) continues to rise. These vehicles are packed full of power electronics – most of which are currently based on silicon. However, the latest xEV designs call for advances in efficiency and power density. Silicon carbide (SiC) is emerging as the material of choice for overcoming the performance

plateau of silicon. Highlights such as low switching losses, a high temperature capability and high switching frequency make it ideal for meeting the highest xEV requirements. SiC-based solutions promise to be more efficient, compact and lighter than conventional applications.

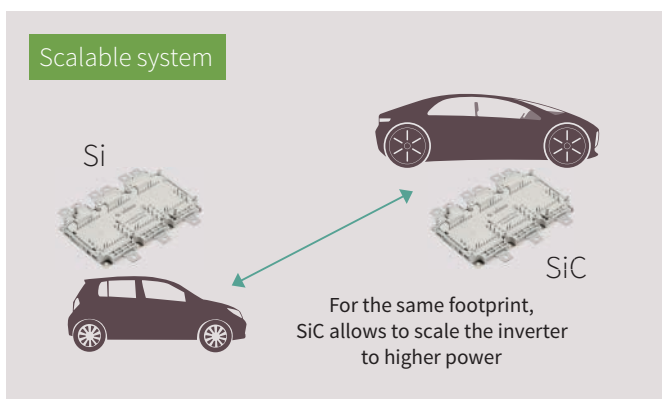
### Higher power density



### Lighter, smaller battery and longer range



### Scalability



### Benefits of SiC

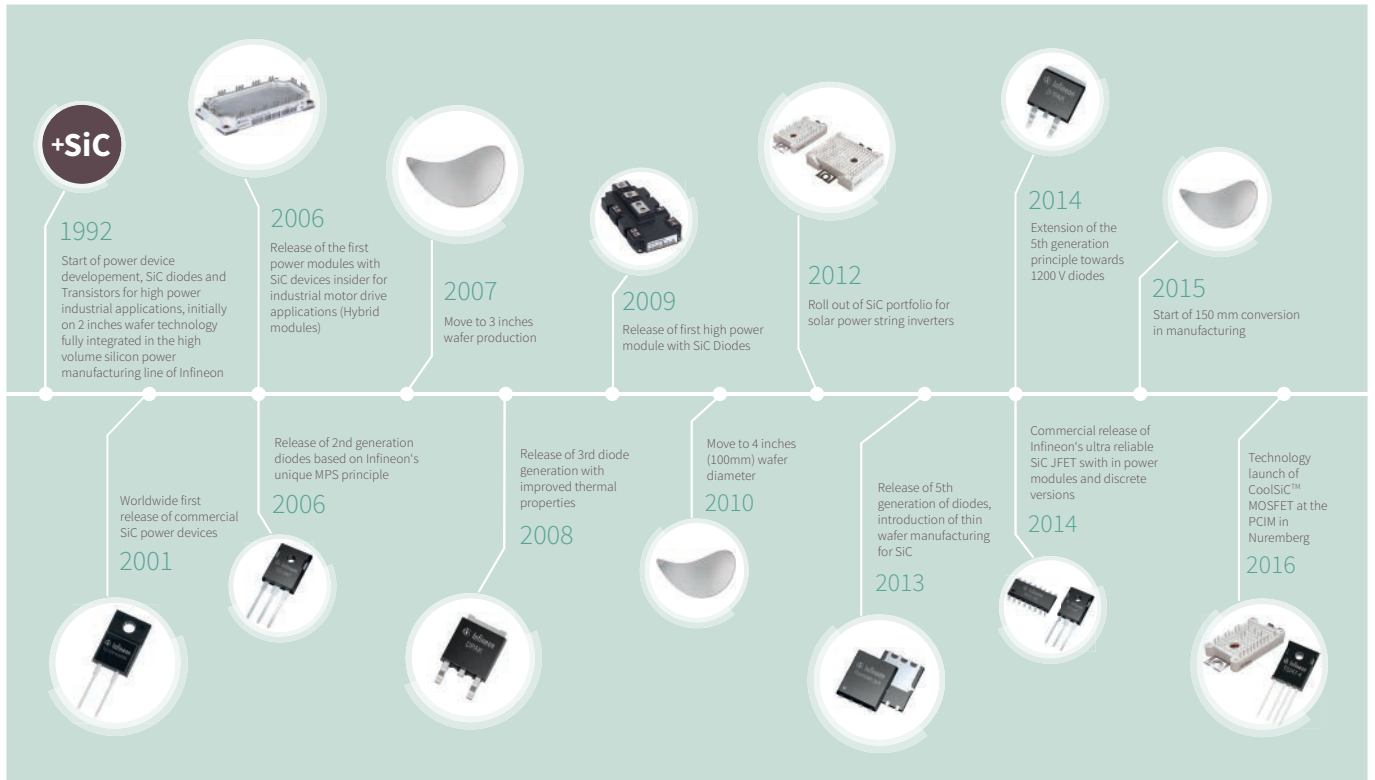


## Synergized expertise

As the No. 1 player in automotive power semiconductors worldwide, Infineon has developed one of the broadest technology portfolios available on the market. The company has developed expertise in silicon, SiC and gallium nitride (GaN), complemented by innovative packaging and

gate driver solutions. Infineon is now leveraging over five decades of experience in both high-voltage components and automotive semiconductors to bring the benefits of SiC technology to the automotive world.

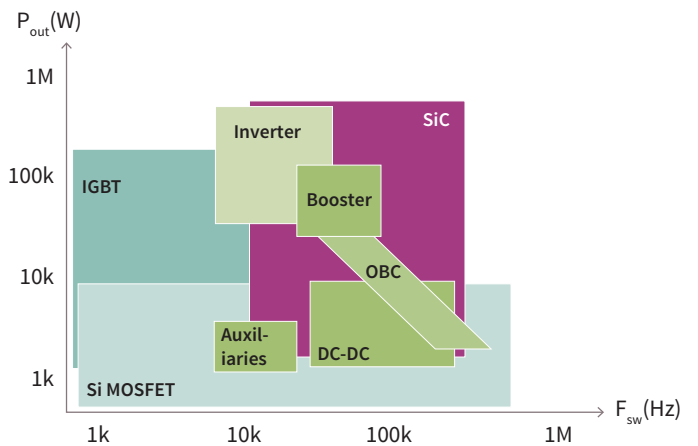
### SiC – where do we come from?



## Technology portfolio

As a technology leader for SiC power semiconductors, Infineon aims to actively drive down the cost/performance ratio of SiC and accelerate its market introduction. Building on recognized expertise in automotive systems, Infineon will support its partners in designing the next generation xEV that take full advantage of the performance potential of SiC. All this in order to create additional value for its customers.

Once Infineon is ready for an open-market approach, customers can look forward to compact and highly efficient SiC devices that offer performance and efficiency gains of up to 10 percent for a variety of driving scenarios.



# Product portfolio overview for (H)EV applications

## Automotive power modules

**HybridPACK™ 1, HybridPACK™ Light, HybridPACK™ DC6 – power module for hybrid and fully electric vehicle applications for a power range up to 100 kW**

Sales name	$I_c$ [A]	$V_{CES}$ [V]	Application	Product status	Packages
FS400R07A1E3_S7	400	705	Inverter	Released	HybridPACK™ 1
FS215R04A1E3D	215	400	Inverter	Released	HybridPACK™ 1
FS200R07A5E3_S6	200	705	Inverter	Released	HybridPACK™ Light
FS400R07A3E3	400	705	Inverter	Released	HybridPACK™ 1 DC6
<b>NEW!</b> FS400R07A3E3_H6	400	705	Inverter	Released	HybridPACK™ 1 DC6 Wave
<b>NEW!</b> FS650R08A4P2	650	750	Inverter	Coming Q4/2019	HybridPACK™ 1 DC6i

**HybridPACK™ 1 Pin-Fin – power module for hybrid electric vehicle applications for a power range up to 100 kW**

Sales name	$I_c$ [A]	$V_{CES}$ [V]	Application	Product status	Packages
FS400R07A1E3_H5	400	650	Inverter	Released	HybridPACK™ 1 Pin-Fin
FS200R12A1E3_H5	200	1200	Inverter	Released	HybridPACK™ 1 Pin-Fin

**HybridPACK™ 2 – power module for hybrid and fully electric vehicle applications for a power range up to 180 kW**

Sales name	$I_c$ [A]	$V_{CES}$ [V]	Application	Product status	Packages
FS400R12A2T4	400	1200	Inverter	Not for new design	HybridPACK™ 2
FS600R07A2E3_B31	600	680	Inverter	Not for new design	HybridPACK™ 2 Enhanced
FS600R07A2E3_B32	600	680	Inverter	Not for new design	HybridPACK™ 2 Enhanced
FS800R07A2E3_B31	800	680	Inverter	Not for new design	HybridPACK™ 2 Enhanced
FS800R07A2E3_B32	800	680	Inverter	Not for new design	HybridPACK™ 2 Enhanced
FS900R08A2P2_B31	900	750	Inverter	Released	HybridPACK™ 2 Enhanced
FS900R08A2P2_B32	900	750	Inverter	Released	HybridPACK™ 2 Enhanced

### HybridPACK™ Drive – power module for hybrid and fully electric vehicle applications for a power range up to 180 kW

Sales name	$I_c$ [A]	$V_{CES}$ [V]	Application	Product status	Packages
FS820R08A6P2	820	750	Inverter	Released	HybridPACK™ Drive
FS820R08A6P2B	820	750	Inverter	Released	HybridPACK™ Drive
FS820R08A6P2LB	820	750	Inverter	Released	HybridPACK™ Drive
<b>NEW!</b> FS660R08A6P2FB	660	750	Inverter	Coming Q3/2018	HybridPACK™ Drive Flat
<b>NEW!</b> FS660R08A6P2FLB	660	750	Inverter	Coming Q3/2018	HybridPACK™ Drive Flat
<b>NEW!</b> FS770R08A6P2B	770	750	Inverter	Coming Q4/2018	HybridPACK™ Drive Wave
<b>NEW!</b> FS950R08A6P2B	950	750	Inverter	Coming Q3/2019	HybridPACK™ Drive Performance
<b>NEW!</b> FS380R12A6T4B	380	1200	Inverter	Coming Q1/2019	HybridPACK™ Drive Performance 1200 V

### HybridPACK™ DSC – molded power module for hybrid and fully electric vehicle applications for a power range up to 100 kW

Sales name	$I_c$ [A]	$V_{CES}$ [V]	Application	Product status	Packages
FS200R07A02E3_S6	200	700	Inverter	Released	HybridPACK™ DSC L
FF400R07A01E3_S6	400	700	Inverter	Released	HybridPACK™ DSC S
<b>NEW!</b> FF450R08A03P2	450	750	Inverter	Coming Q3/2019	HybridPACK™ DSC S

[www.infineon.com/hybridpack](http://www.infineon.com/hybridpack)

### Automotive Easy modules – power modules for auxiliaries and charger applications up to 10 kW

Sales name	$I_c$ [A]	$V_{CES}$ [V]	Application	Product status	Packages
FS75R07W2E3_B11A	75	650	Inverter	Released	Automotive Easy 2B
FS50R07W1E3_B11A	50	650	Inverter	Released	Automotive Easy 1B
F4-50R07W1H3_B11A	50	650	DC-DC converter	Released	Automotive Easy 1B
F4-75R07W1H3_B11A	75	650	DC-DC converter	Released	Automotive Easy 1B

[www.infineon.com/autoeasy](http://www.infineon.com/autoeasy)

### Evaluation kits

Board name	SP nummer	Description
Hybrid kit 1+	SP000806996	Evaluation kit for applications with HybridPACK™ 1 FS400R07A1E3
Easy kit aux drives	SP001020068	Evaluation kit for applications with Easy 1B FS50R07W1E3_B11A
Easy kit DC-DC	SP001007734	Evaluation kit for applications with Easy 1B F4-50R07W1H3_B11A
Hybrid KIT Drive	SP001464622	Inverter evaluation kit with HybridPACK™ Drive FS820R08A6P2B
Hybrid KIT Drive sense	SP001464626	Inverter evaluation kit with HybridPACK™ Drive FS820R08A6P2LB (long AC tabs) and LEM current sensor
Hybrid KIT DSC	Coming Q3/2018	Inverter evaluation kit with HybridPACK™ DSC S FF400R07A01E3_S6

[www.infineon.com/evaluation-boards](http://www.infineon.com/evaluation-boards)

# Discrete IGBTs

Sales name	$I_C$ [A] <sup>1)</sup>	$V_{CES}$ [V] <sup>2)</sup>	Incl. diode	Application	Product status	Packages
AIKB20N60CT	20	600	Yes	Motor drives, AirCon/HVAC, PTC heater	Released	TO-263-3-2
AIKP20N60CT	20	600	Yes	Motor drives, AirCon/HVAC, PTC heater	Released	TO-220-3-1
AIKQ100N60CT	100	600	Yes	Main Inverter, Motor drives, AirCon/HVAC, PTC heater	Released	TO-247-3-46
AIKQ120N60CT	120	600	Yes	Main Inverter, Motor drives, AirCon/HVAC, PTC heater	Released	TO-247-3-46
AIKW20N60CT	20	600	Yes	Motor drives, AirCon/HVAC, PTC heater	Released	TO-247-3-41
AIKW30N60CT	30	600	Yes	Motor drives, AirCon/HVAC, PTC heater	Released	TO-247-3-41
AIKW50N60CT	50	600	Yes	Motor drives, AirCon/HVAC, PTC heater	Released	TO-247-3-41
AIKW75N60CT	75	600	Yes	Main inverter, Motor drives, AirCon/HVAC, PTC heater	Released	TO-247-3-41
AIGW40N65F5	40	650	No	DC-DC converter, On-board charger	Released	TO-247-3-41
AIGW40N65H5	40	650	No	DC-DC converter, On-board charger	Released	TO-247-3-41
AIGW50N65F5	50	650	No	DC-DC converter, On-board charger	Released	TO-247-3-41
AIGW50N65H5	50	650	No	DC-DC converter, On-board charger	Released	TO-247-3-41
AIKW40N65DF5	40	650	Yes	DC-DC converter, On-board charger	Released	TO-247-3-41
AIKW40N65DH5	40	650	Yes	DC-DC converter, On-board charger	Released	TO-247-3-41
AIKW50N65DF5	50	650	Yes	DC-DC converter, On-board charger	Released	TO-247-3-41
AIKW50N65DH5	50	650	Yes	DC-DC converter, On-board charger	Released	TO-247-3-41
AUIRG4BC30U-S	12	600	No	PTC heater	Released	TO-263-3-2
AUIRG4PC40S-E	31	600	No	PTC heater	Released	TO-247AD
AUIRG4PH50S	33	1200	No	PTC heater	Released	TO-247AC
AUIRGB4062D1	39	600	Yes	Motor drives, AirCon/HVAC, PTC heater	Released	TO-220AB
AUIRGDC0250	81	1200	No	PTC heater	Released	Super-TO-220
AUIRGP35B60PD	34	600	Yes	DC-DC converter, On-board charger	Released	TO-247AC
AUIRGP35B60PD-E	34	600	Yes	DC-DC converter, On-board charger	Released	TO-247AD
AUIRGP4062D	24	600	Yes	Motor drives, AirCon/HVAC, PTC heater	Released	TO-247AC
AUIRGP4062D-E	24	600	Yes	Motor drives, AirCon/HVAC, PTC heater	Released	TO-247AD
AUIRGP4063D	48	600	Yes	Motor drives, AirCon/HVAC, PTC heater	Released	TO-247AC
AUIRGP4066D1	90	600	Yes	Motor drives, AirCon/HVAC, PTC heater	Released	TO-247AC
AUIRGP50B60PD1	45	600	Yes	DC-DC converter, On-board charger	Released	TO-247AC
AUIRGP65G40D0	41	600	Yes	DC-DC converter, On-board charger	Released	TO-247AC
AUIRGF65G40D0	41	600	Yes	DC-DC converter, On-board charger	Released	TO-247AD
AUIRGP66524D0	40	600	Yes	DC-DC converter, On-board charger	Released	TO-247AC
AUIRGF66524D0	40	600	Yes	DC-DC converter, On-board charger	Released	TO-247AD
AUIRGPS4070D0	120	600	Yes	Main inverter, Motor drives, AirCon/HVAC, PTC heater	Released	Super-274
AUIGR4045D	6	600	Yes	Motor drives, AirCon/HVAC, PTC heater	Released	DPAK (TO-252)
AUIRGS30B60K	50	600	No	Motor drives, AirCon/HVAC, PTC heater	Released	D2PAK (TO-263)
AUIRGS4062D1	39	600	Yes	Motor drives, AirCon/HVAC, PTC heater	Released	D2PAK (TO-263)
AUIRGL30B60K	50	600	No	Motor drives, AirCon/HVAC, PTC heater	Released	TO262-3-901
AUIRGL4062D1	39	600	Yes	Motor drives, AirCon/HVAC, PTC heater	Released	TO262-3-901
AUIRGU4045D	6	600	Yes	Motor drives, AirCon/HVAC, PTC heater	Released	IPAK (TO-251)

1)  $I_C$  = Nominal current

2)  $V_{CES}$  = Collector to emitter saturation voltage

[www.infineon.com/automotive-igbt-discretes](http://www.infineon.com/automotive-igbt-discretes)

# CoolMOS™ superjunction power MOSFET

## CoolMOS™ CFDA

$R_{DS(ON)}$ [mΩ]	TO-252 DPAK	TO-263 D <sup>2</sup> PAK	TO-220	TO-247
660	IPD65R660CFDA	IPB65R660CFDA	IPP65R660CFDA	
420	IPD65R420CFDA			
310		IPB65R310CFDA	IPP65R310CFDA	
190		IPB65R190CFDA	IPP65R190CFDA	IPW65R190CFDA
150		IPB65R150CFDA	IPP65R150CFDA	IPW65R150CFDA
110		IPB65R110CFDA	IPP65R110CFDA	IPW65R110CFDA
80				IPW65R080CFDA
48				IPW65R048CFDA

## CoolMOS™ CPA

$R_{DS(ON)}$ [mΩ]	TO-262 I <sup>2</sup> PAK	TO-263 D <sup>2</sup> PAK	TO-220	TO-247
299		IPB60R299CPA		
199		IPB60R199CPA		
99	IPI60R099CPA	IPB60R099CPA	IPP60R099CPA	IPW60R099CPA
75				IPW60R075CPA
45				IPW60R045CPA

## CoolMOS™ C3A

$R_{DS(ON)}$ [mΩ]	TO-252 DPAK	TO-263 D <sup>2</sup> PAK	TO-247
2700	IPD80R2k7C3A		
290		IPB80R290C3A	IPW80R290C3A

[www.infineon.com/coolmos](http://www.infineon.com/coolmos)

# Automotive gate driver ICs

Suitable for our power products: EiceDRIVER™ – Gate drivers providing galvanic isolation and bidirectional signal transmission with a high ambient temperature capability (supporting IGBT and SiC technologies)

Sales name	I <sub>Output</sub> [A]	Voltage class [V] (supported IGBT technologies)	Packages	Product status
1ED020I12FTA	2	400–1200	DSO-20	Released
2ED020I12FA	2	400–1200	DSO-36	Released
1ED020I12FA2	2	400–1200	DSO-20	Released
1EDI2001AS	1	400–1200	DSO-36	Released
1EDI2002AS	1	400–1200	DSO-36	Released
1EBN1001AS	15	400–1200	DSO-14	Released
<b>NEW!</b> 1EDI2010AS	1	400–1200	DSO-36	Released
<b>NEW!</b> 1EDI2004AS	2	400–1200	DSO-36	In development (samples available)
<b>NEW!</b> 1EDI30xxAS	10	400–1200 (and SiC technologies)	DSO-20	In development (samples Q1 2019)

[www.infineon.com/automotive-eicedriver](http://www.infineon.com/automotive-eicedriver)

Infineon's comprehensive portfolio of automotive-qualified gate driver ICs helps simplify design and optimize performance in all Fets and IGBTs driving stages.

Sales name	I <sub>Output</sub> [mA]	Voltage class [V]	Packages	Product status
<b>NEW!</b> AUIRS2336S	200	600	SOIC-28W	Released
<b>NEW!</b> AUIRS1170S	3000	600	PSOP-8L	Released
AUIRS2113S	2500	600	SOIC-16	Released
AUIRS2181S	1900	600	SOIC-8	Released
AUIRS21811S	1900	600	SOIC-8	Released
AUIRS21814S	1900	600	SOIC-8	Released
AUIRS2191S	3500	600	SOIC-8	Released
AUIRS2301S	200	600	SOIC-8	Released
AUIRB24427S	6000	600	SOIC-8	Released
AUIRS2117S	290	600	SOIC-8	Released
AUIRS2118S	290	600	SOIC-8	Released
AUIRS2123	500	600	SOIC-8	Released
AUIRS2124	500	600	SOIC-8	Released
AUIRS2127S	290	600	SOIC-8	Released
AUIRS20302S	105	200	SOIC-28	Released
AUIRS21271S	290	600	SOIC-8	Released
AUIR2085STR	1000	600	SOIC-8N	Released
<b>NEW!</b> AUIR2114SS/2214SS	3000	1200	SSOP-24	In development (samples available)

[www.infineon.com/gate-driver-ics](http://www.infineon.com/gate-driver-ics)



# CoolSiC™ automotive Schottky diode







	Sales name	I <sub>F</sub> [A]	V <sub>DC</sub> [V]	Application	Product status	Packages
NEW!	AIDW10S65C5	10	650	On-board charger, Auxiliaries	Coming soon	TO247-3-41
NEW!	AIDW12S65C5	12	650	On-board charger, Auxiliaries	Coming soon	TO247-3-41
NEW!	AIDW16S65C5	16	650	On-board charger, Auxiliaries	Coming soon	TO247-3-41
NEW!	AIDW20S65C5	20	650	On-board charger, Auxiliaries	Coming soon	TO247-3-41
NEW!	AIDW30S65C5	30	650	On-board charger, Auxiliaries	Coming soon	TO247-3-41
NEW!	AIDW40S65C5	40	650	On-board charger, Auxiliaries	Coming soon	TO247-3-41

[www.infineon.com/coolpic-schottky-diode](http://www.infineon.com/coolpic-schottky-diode)

# Battery management sensing IC

Sales name	# channels	Balancing current [mA]	Temperature sensors	Active balancing	Packages
TLE8001QK	12	200	5	Yes	LQFP-64

# High-speed CAN transceiver with Flexible Data-rate up to 5 Mbit/s

Sales name		Transmission rate (max)	Low-power mode I <sub>q</sub> [μA] (max)	Bus wake-up capability	Wake-up inputs	Number of channels	CAN FD	Package
High-speed CAN ISO 11898-5								
TLE9251VSJ		5 Mbit/s	< 15 μA @ 5 V stand-by	•		1	•	DSO-8
TLE9251VLE		5 Mbit/s	< 15 μA @ 5 V stand-by	•		1	•	TSON-8
TLE9251SJ		5 Mbit/s	< 15 μA @ 5 V stand-by	•		1	•	DSO-8
TLE9251LE		5 Mbit/s	< 15 μA @ 5 V stand-by	•		1	•	TSON-8
TLE9252VSK		5 Mbit/s	< 26 sleep mode	•	•	1	•	DSO-14
TLE9252VLC		5 Mbit/s	< 26 sleep mode	•	•	1	•	TSON-14

# Automotive power supplies

OPTIREG™ Automotive PMIC: ISO26262-compliant, multi-rail power supply with microcontroller-, communication-, and sensor- supply rails and monitoring/supervisory functions.

Sales name	Microcontroller main voltage [V]	Product status	Packages
TLF35584QWS1	5.0	Released	VQFP-48
TLF35584QVVS2	3.3	Released	VQFP-48
TLF35584QKVS1	5.0	Released	LQFP-64
TLF35584QKVS2	3.3	Released	LQFP-64

[www.infineon.com/optireg](http://www.infineon.com/optireg)

# Automotive microcontrollers

Product type	Max. clock frequency [MHz]	Program memory [KByte]	SRAM (incl. cache) [KByte]	Co-processor <sup>1)</sup>	Cores/lockstep	Timed I/O GPIO	Number of ADC channels	External bus interface	CAN/CAN FD nodes	Communication interfaces <sup>2)</sup>	Temperature ranges <sup>3)</sup>	Packages	Additional features/remarks <sup>4)</sup>
<b>AURIX™ TC2xx family</b>													
TC299TP	300	8000	728	FPU	3/1	263	84/10 DS	Yes	6	4x ASCLIN, 6x QSPI, 3x MSC, 2x I <sup>2</sup> C, 15x SENT, HSSL, 5x PSI5, 2x FlexRay, Ethernet, CAN FD	K	LFBGA-516	EVR, STBU, HSM
TC298TP	300	8000	728	FPU	3/1	232	60/10 DS	Yes	6	4x ASCLIN, 6x QSPI, 3x MSC, 2x I <sup>2</sup> C, 15x SENT, HSSL, 5x PSI5, 2x FlexRay, Ethernet	K	LBGA-416	EVR, STBU, HSM
TC297TP	300	8000	728	FPU	3/1	169	60/10 DS	No	6	4x ASCLIN, 6x QSPI, 3x MSC, 2x I <sup>2</sup> C, 15x SENT, HSSL, 5x PSI5, 2x FlexRay, Ethernet, CAN FD	K	LFBGA-292	EVR, STBU, HSM
TC277TP	200	4000	472	FPU	3/2	169	60/6 DS	No	4	4x ASCLIN, 4x QSPI, 2x MSC, HSSL, I <sup>2</sup> C, 10x SENT, 3x PSI5, FlexRay, Ethernet, CAN FD	K	LFBGA-292	EVR, WUT, HSM
TC275TP	200	4000	472	FPU	3/2	112	48/6 DS	No	4	4x ASCLIN, 4x QSPI, 2x MSC, HSSL, I <sup>2</sup> C, 10x SENT, 3x PSI5, FlexRay, Ethernet, CAN FD	K	LQFP-176	EVR, WUT, HSM
TC265D	200	2500	240	FPU	2/1	112	50/3 DS	No	5	4x ASCLIN, 4x QSPI, 2x MSC, I <sup>2</sup> C, 10x SENT, HSSL, 3x PSI5, FlexRay, Ethernet, CAN FD	K	LQFP-176	EVR, STBU
TC264D	200	2500	240	FPU	2/1	88	40/3 DS	No	5	4x ASCLIN, 4x QSPI, 2x MSC, I <sup>2</sup> C, 10x SENT, HSSL, 3x PSI5, FlexRay, Ethernet, CAN FD	K	LQFP-144	EVR, STBU
TC234LP	200	2000	192	FPU	1/1	120	24	No	6	2x ASCLIN, 4x QSPI, 4x SENT, FlexRay, CAN FD	K	TQFP-144	EVR, WUT, HSM
TC233LP	200	2000	192	FPU	1/1	78	24	No	6	2x ASCLIN, 4x QSPI, 4x SENT, FlexRay, CAN FD	K	TQFP-100	EVR, WUT, HSM
TC224L	133	1000	96	FPU	1/1	120	24	No	3	2x ASCLIN, 4x QSPI, 4x SENT	K	TQFP-144	EVR, WUT
TC223L	133	1000	96	FPU	1/1	78	24	No	3	2x ASCLIN, 4x QSPI, 4x SENT	K	TQFP-100	EVR, WUT
TC222L	133	1000	96	FPU	1/1	59	14	No	3	2x ASCLIN, 4x QSPI, 4x SENT	K	TQFP-80	EVR, WUT

1) CIF = Camera and external ADC interface, FFT = Fast Fourier Transform accelerator, FPU = Floating Point Unit, PCP = Peripheral Control Processor

2) ASC = Asynchronous Serial Channel, ASCLIN = Asyn/Synchronous Local Interconnect Network, HSSL = High-Speed Serial Link, I<sup>2</sup>C = Inter-Integrated Circuit, LIN = Local Interconnect Network, MLI = Micro Link Interface, MSC = Micro Second Channel, PSI5 = Peripheral Sensor Interface 5, QSPI = Queued Serial Peripheral Interface, SENT = Single Edge Nibble Transmission, SSC = Synchronous Serial Channel

3) Ambient temperature range: A = -40 ... 140°C, B = 0 ... 70°C, F = -40 ... 85°C, H = -40 ... 110°C, K = -40 ... 125°C, L = -40 ... 150°C, X = -40 ... 105°C

4) EVR = Embedded Voltage Regulator, HSM = Hardware Security Module, STBU = Stand-by Control Unit, WUT = Wake-Up Timer

Product type	Cores/lockstep	Max. clock frequency [MHz]	Program memory [KByte]	SRAM (incl. cache) [KByte]	Radar accelerator/radar interface <sup>3)</sup>	CAN/CAN FD nodes	Ethernet 100/1000 Mbit	External bus interface <sup>2)</sup>	Communication interfaces	HSM	Temperature ranges	Packages	Additional features/remarks <sup>3)</sup>	
<b>AURIX™ TC3xx family</b>														
<b>NEW!</b>	TC399XP	6/4	300	16000	2816	No	12	1	EBU, eMMC, 2x HSSL	6x SPI, 2x FlexRay, 12x LIN, 25x SENT, 4x PSI5, 2x I <sup>2</sup> C, 4x MSC	EVITA full	K, L	LFBGA-516	5 V/3.3 V EVR, 8-bit SCR
<b>NEW!</b>	TC397XX	6/4	300	16000	6912	No	12	1	eMMC, 2x HSSL	6x SPI, 2x FlexRay, 12x LIN, 25x SENT, 4x PSI5, 2x I <sup>2</sup> C, 4x MSC	EVITA full	K, L	LFBGA-292	5 V/3.3 V EVR, 8-bit SCR
<b>NEW!</b>	TC397XP	6/4	300	16000	2816	No	12	1	eMMC, 2x HSSL	6x SPI, 2x FlexRay, 12x LIN, 25x SENT, 4x PSI5, 2x I <sup>2</sup> C, 4x MSC	EVITA full	K, L	LFBGA-292	5 V/3.3 V EVR, 8-bit SCR
<b>NEW!</b>	TC389QP	4/2	300	10000	1568	No	12	1	HSSL	5x SPI, 2x FlexRay, 24x LIN, 25x SENT, 4x PSI5, 2x I <sup>2</sup> C, 3x MSC	EVITA full	K, L	LFBGA-516	5 V/3.3 V EVR, 8-bit SCR
<b>NEW!</b>	TC387QP	4/2	300	10000	1568	No	12	1	HSSL	5x SPI, 2x FlexRay, 24x LIN, 25x SENT, 4x PSI5, 2x I <sup>2</sup> C, 3x MSC	EVITA full	K, L	LFBGA-292	5 V/3.3 V EVR, 8-bit SCR

1) SPU = Signal Processing Unit

2) HSSL = High-Speed Serial Link

3) 8-bit SCR = Standby Controller for low-power modes, EVR = Embedded Voltage Regulator

# Automotive position sensors

## Angle sensors suitable for motor position applications within the main drive and auxiliary loads

Product	Technology	Accuracy	Angle output	Application	Product status	Package
TLE5012B(D)	GMR (single and dual)	1.0°	SSC (SPI)	Auxiliary loads	Released	TDSO-16
TLE5014(D)	GMR (single and dual)	1.0°	PWM/SENT/SPC	Main drive, Auxiliary loads	Released	TDSO-16
TLE5109A16(D)	AMR (single and dual)	0.5°	Analog sin/cos	Main drive	Released	TDSO-16
TLE5309D	AMR + GMR (dual die)	AMR 0.5°, GMR 1.0°	Analog sin/cos	Main drive	Released	TDSO-16

## Hall switches suitable for motor position applications within the main drive and auxiliary loads

Product	Type	Operating point B <sub>OP</sub>	Release point B <sub>RP</sub>	Application	Product status	Package
TLE4961-1M/-2M/-3M/-4M/-5M/-6M	Latch	2.0/5.0/7.5/10.0/15.0	-2.0/-5.0/-7.5/-10.0/-15.0	Auxiliary drives	Released	SOT23/SSO-3-2
TLE4964-1M/-2M/-3M/-4M/-5M/-6M	Switch	18.0/28.0/12.5/10.0/7.5/3.5	12.5/22.5/9.5/8.5/5.0/2.5	Auxiliary drives	Released	SOT23/SSO-3-2
TLE4968-1M/L	Bipolar	1.0	-1.0	Auxiliary drives	Released	SOT23/SSO-3-2

## 3D sensors suitable for motor position applications within the main drive and auxiliary loads

Product	Technology	Accuracy	Angle output	Application	Product status	Package
TLE493D-A2B6	Hall	1° (x/y) 4.5° (xy/z)	I <sup>2</sup> C (x/y vectors) (xy/z vectors)	Main drive, Auxiliary loads	Released	TSOP-6
TLE493D-W2B6	Hall	1° (x/y) 4.5° (xy/z)	I <sup>2</sup> C (x/y vectors) (xy/z vectors)	Main drive, Auxiliary loads	Released	TSOP-6

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- > China, mainland ..... 4001 200 951 (Mandarin/English)
- > India ..... 000 800 4402 951 (English)
- > USA ..... 1-866 951 9519 (English/German)
- > Other countries ..... 00\* 800 951 951 951 (English/German)
- > Direct access ..... +49 89 234-0 (interconnection fee, German/English)

\* Please note: Some countries may require you to dial a code other than "00" to access this international number.  
Please visit [www.infineon.com/service](http://www.infineon.com/service) for your country!



Mobile product catalog

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Published by  
Infineon Technologies AG  
81726 Munich, Germany

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Order number: B136-H9536-V4-7600-EU-EC-P  
Date: 10 / 2018

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