



Commercial, construction and agricultural vehicles

Application guide

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Introduction

From autonomous driving to electrification, the biggest mobility megatrends of our time are shaping the field of commercial, construction and agricultural vehicles (CAV).

Semi- and fully autonomous vehicles present a range of new opportunities in terms of efficiency, precision and safety. Imagine machines that run 24/7 with no downtime - Tractors that independently navigate their surroundings and react based on data they collect. At the same time, electrification is increasingly attractive CAVs - Electric drivetrains help manufacturers comply with the latest emissions and energy regulations while operators look forward to greater yield rates.

CAVs are under mounting pressure to provide highest-possible availability and lowest-possible operating costs as operators strive to maximize profits. This is true for agricultural and construction machines as well as trucks and buses. Electronic semiconductor-based systems already play a key role in making commercial vehicles and work machines more efficient. The next step: fully self-driving and self-operating vehicles. Used in agriculture, autonomous tractors can spread fertilizer and plant seeds with outstanding precision. Autonomous technologies also enable small, lightweight swarm robots to replace heavy machinery that is hard on fertile soil. They prevent overcrowding of farmland and can even individually treat plants with herbicides and pesticides. A practice that's kind to the environment – and to farmers' wallets.

Meanwhile, hybrid or fully electric drivetrains can reduce or even eliminate operators' fossil fuel consumption and reduce their CO2 emissions. Compared to combustion ones, electric drivetrains are low maintenance, which results in less hassle and greater productivity. Today, electric drives controlled by modern power electronics can be used as a complement to or substitute for traditional drivetrain technologies. Electric machines can support or fully replace the combustion drivetrain in the engine. In hybrids, the combustion engine delivers part of the propulsive power, while the electric drive provides torque for peak loads. Such a system reduces fuel consumption and allows energy to be recovered during braking. This energy can later be used to accelerate the vehicle and boost fuel efficiency.

An electric motor can also operate as a starter-generator, reducing the drivetrain's complexity by combining the two parts. A diesel electric drivetrain concept is another alternative. Here, the generator provides the electric power needed to operate the vehicle, which is always driven electrically. A battery stores energy recovered during deceleration to ensure an independent energy supply is always available. With no gearbox or clutch, electric machines can provide maximum torque at zero speed – ideal for heavy-duty applications.

Finally, in the case of electric drives, an on-board energy storage solution, such as a battery or fuel cell, can provide enough energy to operate the vehicle for a reasonable length of time. In an electric forklift truck, for example, this could be a shift of several hours while a few minutes may be sufficient for an urban bus that can recharge at each bus stop. Eliminating the combustion engine also represents a major step in improving vehicle availability and reliability.

With proven expertise in CAV applications and a comprehensive portfolio of robust, high-quality control and power semi-conductor solutions, Infineon helps designers and developers engineer CAVs that deliver greater fuel economy, productivity, and reliability.

1 Safety & ADAS Solutions

Self-driving technologies have the potential to revolutionize the CAV sector. Today, operators want commercial vehicles with highest-possible availability and lowest-possible operating costs so they can maximize profitability. Electronic semiconductor-based systems have made trucks, buses, and agricultural and construction machines more efficient already. Fully self-driving vehicles is the logical next step operating 24/7 on construction sites or on highways. Autonomous systems eliminate the need for downtime as well as the most common cause of accidents: people. In agriculture, autonomous tractors can spread fertilizer and plant seeds with utmost precision. Thanks to autonomous technologies, small, lightweight swarm robots can replace heavy machinery that wears on the ground. They prevent overcrowding of farmland and can individually treat plants with herbicides and pesticides. Autonomous vehicles are fitted with camera and radar sensors to identify their surroundings reliably and securely. Navigation and telematics systems provide additional data, which are then combined and consolidated, and the result is finally used to compute commands. Safety and security requirements for semiconductor systems are high. They must be robust enough to withstand harsh environments, such as temperature and vibration, and provide high-level functional safety. Furthermore, as an intricately connected system they must be protected against criminally motivated manipulation.

1.1 24 GHz radar for CAV

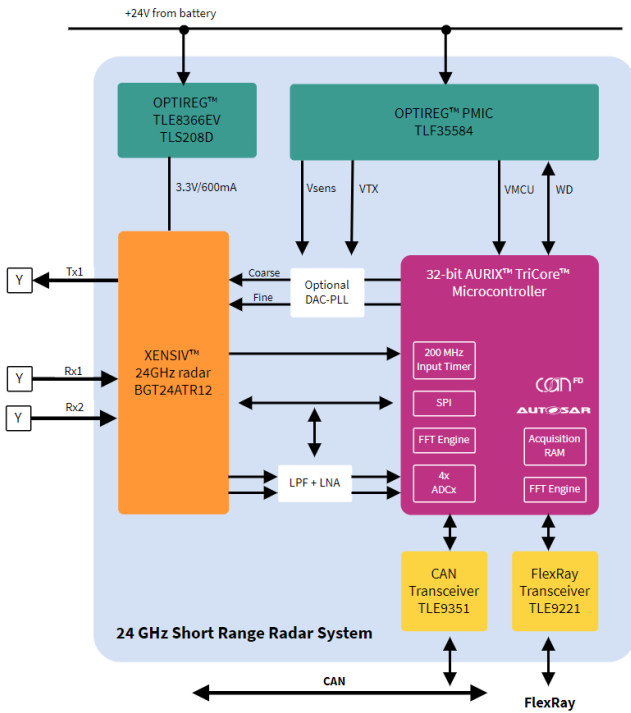


Figure 1 Block diagram of 24 GHz radar for CAV

System benefits

- Complete CAV 24 GHz radar solution from our AURIX™ family
- Lower development costs thanks to an integrated solution with ample storage
- Reference designs save time and costs

Table 1 Suggested Products for 24 GHz radar for CAV

Product	Description
AURIX™	Scalable 32-bit TriCore™ microcontroller family from single to multicore (PRO-SIL™)
TLF35584	System power supply with integrated watchdog (PRO-SIL™)
TLE9221SX	FlexRay transceiver
BGT24ATR12	24GHz radar 1-channel transmitter, 2-channel receiver IC

1.2 Multipurpose camera

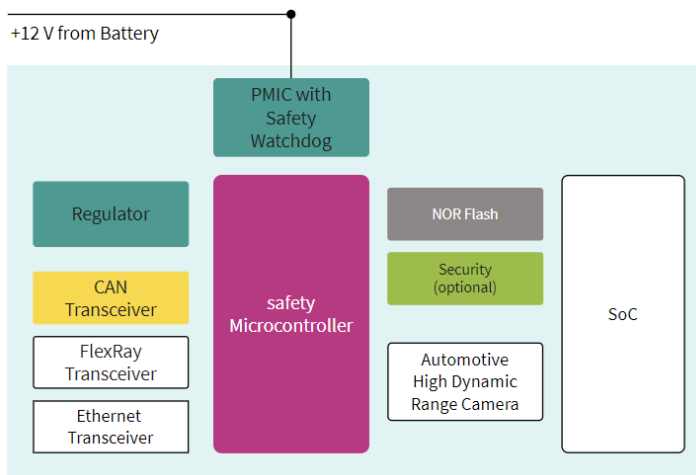


Figure 2 Block diagram of multipurpose camera

System benefits

- The market for automotive ADAS/ AD cameras is evolving rapidly. Enabling advanced driver assistance functions such as automated emergency braking, forward collision warning, along with traffic sign and pedestrian recognition
- Infiniteon offers a highly integrated solution to enable compact and efficient camera systems for the next generation of assistance functions
- Safety host monitoring of camera ECUs – done by AURIX™ – enabling ISO 26262 ASIL-D with analog and high-speed communication peripherals
- Reducing communication load on SoCs w/ HW accelerators to integrate more functions per ECU while offering freedom from interference between multiple applications
- Individual & scalable ADAS/ AD system performance w/ scalable AURIX™ MCU family, including HW & SW concept for camera platform reuses

Table 2 Suggested Products for 24 GHz radar for CAV

Product	Description
AURIX™	Scalable 32-bit TriCore™ microcontroller family from single to multicore (PRO-SIL™)
OPTIREG™ Automotive PMIC	Safety power management ICs (PMIC) consist of integrated, multi-rail supply solutions for demanding automotive systems/ modules in segments such as chassis, safety, ADAS, powertrain, and drive train. Support up to ASIL-D applications.
Network transceiver	Can and FlexRay transceiver
OPTIREG™ linear	Robust automotive linear voltage regulators specially designed for automotive applications with loads, such as transceivers , microcontrollers , active antennas, and sensors

1.3 24V Electric Power Steering for CAV

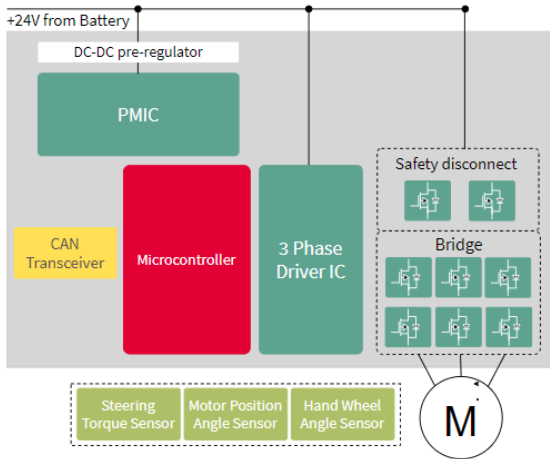


Figure 3 Block diagram of EPS with Active Steering for CAV

System benefits

- Using existing EHPS (Electro-Hydraulic Power Steering) for base steering functionality
- Adding one 3 phase motor to generate torque overlay for Level 2 automation
- Motivation: Enables active lane keep assist for reduction in accidents for improved insurance costs

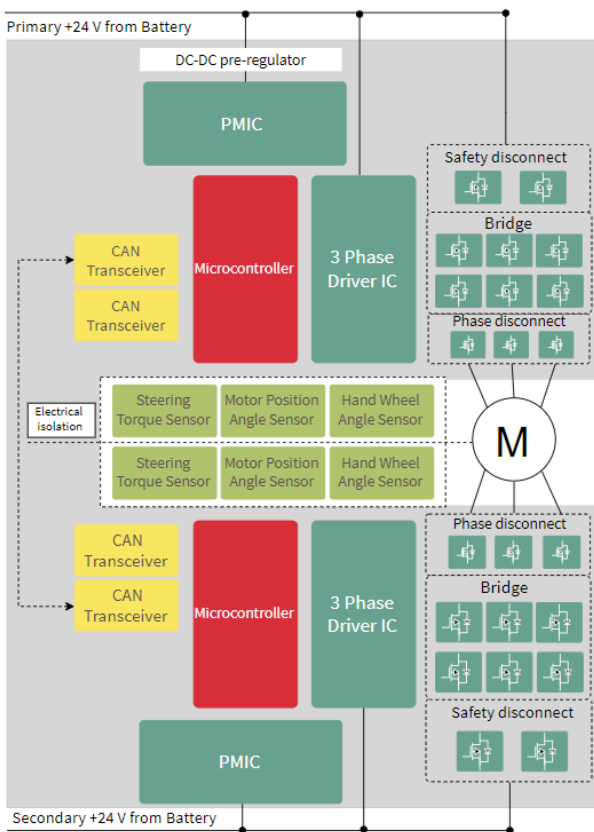


Figure 4 Block diagram of fail Operational EPS for 24V CAV

System benefits

- Enables higher levels of Automation, L3+
- Powerful, scalable, and small footprint
- Proven interoperability between devices and aligned safety concepts
- Adaptable via software to suit a range of models and driving modes
- Synergies with Fail Operational EPS for cars

Table 3 Suggested Products for 24V Electric Power Steering for CAV

Product	Description
AURIX™ TC33x and TC36x Microcontroller	Scalable 32-bit TriCore™ high-performance microcontroller family well suited for safety-critical applications
OPTIREG™ TLF35584 PMIC	Automotive Safety PMIC with integrated features to enable ASIL-D safety. Robust, safe and reliable supply for AURIX™ microcontrollers.
MOTIX™ TLE9180 3-phase motor driver	Advanced gate driver IC dedicated to control 6 external N-channel MOSFETs forming an inverter for high current 3 phase motor drive in Automotive safety-critical applications
OPTIMOS™ N-Channel Automotive MOSFETs	OptiMOS™ enables high power efficiency, reduced switching losses, increased SOA for high current applications in combination with innovative & robust packages at smallest footprint.
XSENSIV™ Magnetic Sensors	Linear hall sensor family for steering wheel torque sensing. iGMR technology family for steering angle sensing and a mix of iGMR, iAMR, and iTMR technologies motor position sensing. Dual die options also available to easily enable redundant sensing for higher levels of Functional Safety.
CAN Transceivers	High-speed CAN Transceivers with up to 8Mb/s transmission speed

1.4 Primary power distribution center

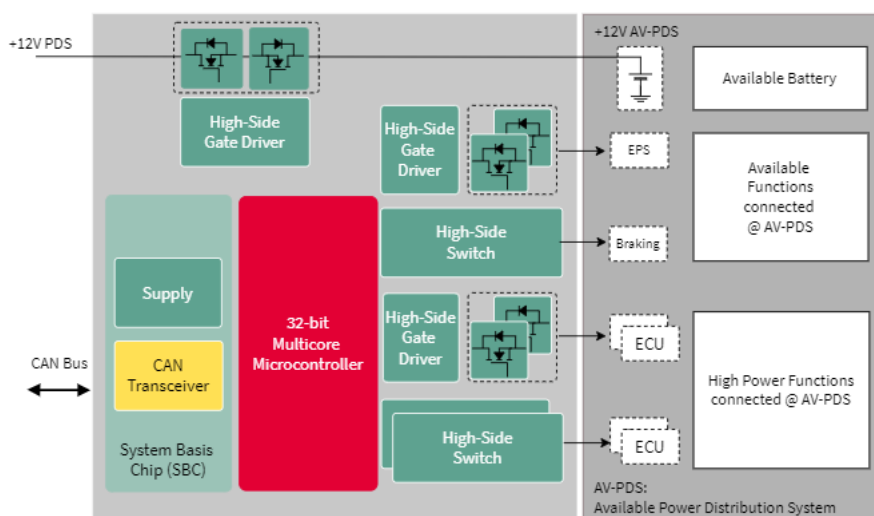


Figure 5 Block diagram of primary power distribution center

System benefits

- Primary power distribution between the energy sources and secondary power distribution and/or smart actuators, domain & zone Controller ECUs.
- Wire harness protection.
- Keep the power supply connected at any time (e.g. off grid parking).
- May be used to:
 - Support the functional safety requirements in power distribution system when the availability of ASIL B or higher is required. In this case the PDP development has to be according to ISO 26262.
 - Ensure the freedom from interference between Power Distribution sub-systems by using the two safety elements Power Connection & Isolation (PCI) and Power Supply Protection (PSP).
- The Infineon chip-set covers the complete functional block with supply, communication, control, sense and actuation devices.

Table 4 Suggested Products for Primary power distribution center

Product	Description
Supply	OPTIREG™ Switcher , OPTIREG™ PMIC
Communication	High Speed CAN-FD Transceiver
Supply & Communication	OPTIREG™ SBC (System Basis Chip)
Microcontroller	TRAVEO™ T2G and / or AURIX™ TC3x
Switches	Power PROFET™ , PROFET™ +2
High-Side Gate Driver	AUIR324x and 2ED2410-EM EiceDRIVER™ APD
MOSFET	OptiMOS™ 40 V N-Channel automotive MOSFET

2 Charging & Energy Solutions

2.1 On Board Charger (OBC)

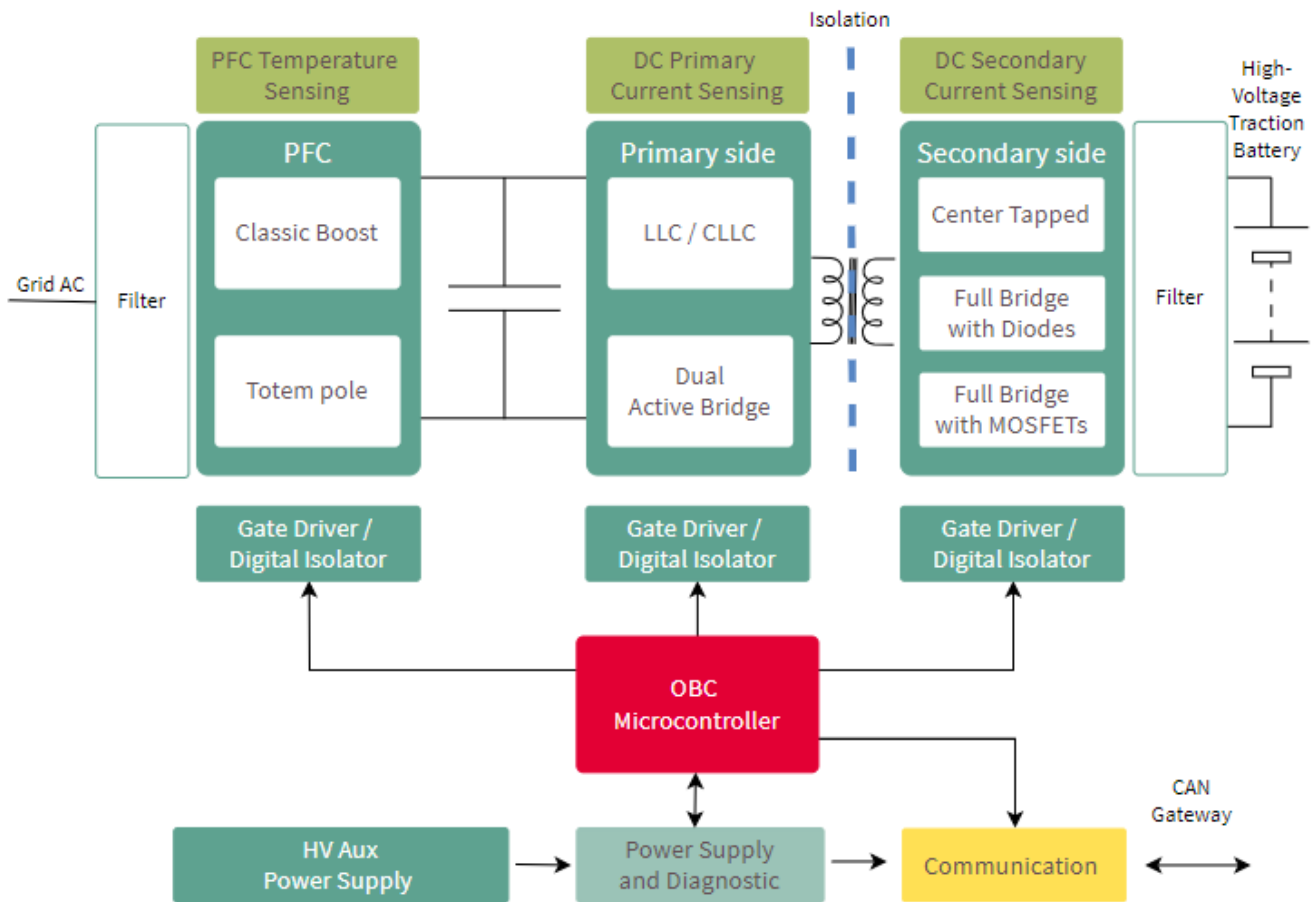


Figure 6 Block diagram of OBC

System benefits

- Suitable for plug-in hybrid and EV
- 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

Table 5 Suggested Products for OBC

Product	Description
AURIX™ TC3xx	Scalable 32-bit TriCore™ high-performance microcontroller family
CoolMOS™	Power MOSFET with high reliability and power density while increasing design flexibility for Hard-switching topologies (with SiC diode), PFC boost-stages, and DC-DC stage of on-board chargers
CoolSiC™ MOSFETs AIMW120R045M1	Silicon Carbide MOSFET family dedicated for current and future On-Board Charger and DC-DC applications in hybrid and electric vehicles, with V_{DS} of 1200V
EiceDRIVER™	Gate driver ICs for MOSFETs, IGBTs, SiC MOSFETs, and GaN HEMTs
XENSIV™ TLI4971	magnetic current sensor for AC and DC measurements in industrial applications

CAN Transceivers	High-speed CAN Transceivers with up to 8Mb/s transmission speed
OPTIREG™	The wide range of product family options for power supply management: OPTIREG™ Switcher, OPTIREG™ Lite SBC Family, and OPTIREG™ PMIC

2.2 Battery Management System (BMS)

The task of battery management systems (BMS) is to ensure the optimal use of the residual energy present in a battery. To avoid loading the batteries, BMS systems protect the batteries from deep discharge and over-voltage, which are results of extremely fast charge and extremely high discharge current. In the case of high voltage batteries, where many sets of parallel cells in series are stacked to produce a battery pack with voltages reaching up to 1000V, the BMS also provides a cell balancing function, to ensure that different battery cells have the same charging and discharging requirements.

Infineon's solutions and design resources for a battery management system, help you to overcome your design challenges and support your success in developing more efficient, longer-lasting and more reliable battery-powered applications.

2.2.1 12V-24V Battery Management System (BMS)

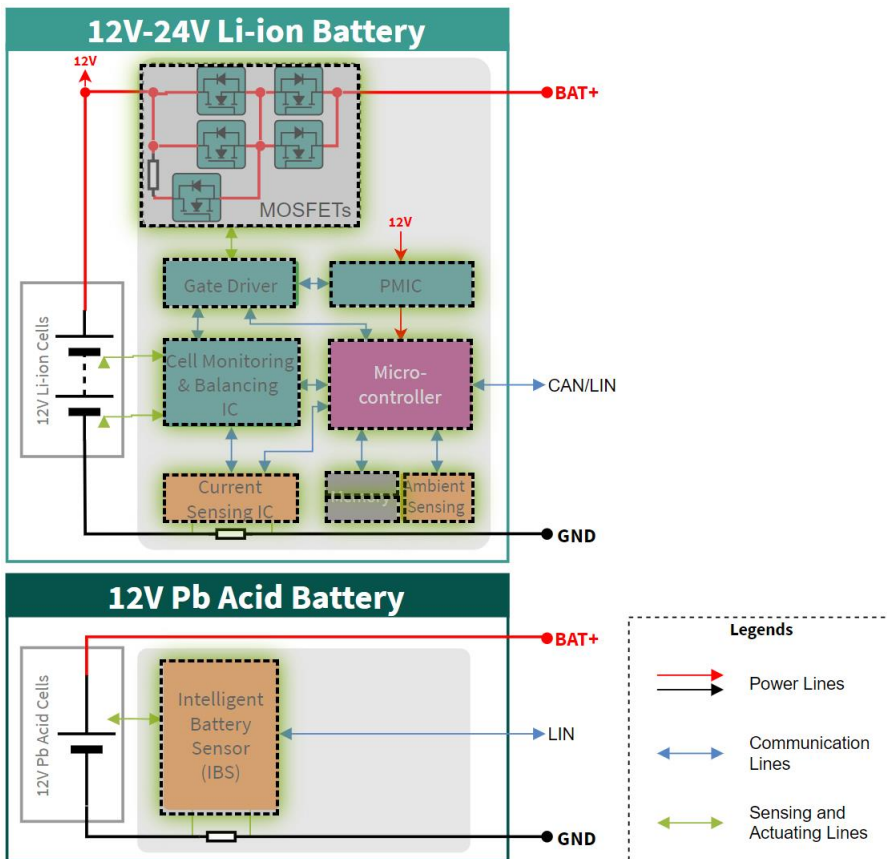


Figure 7 Block diagram of 12V-24V BMS

System benefits

- low-power standby modes for diagnostics, monitoring SOC, SOE, SOH, SOP, SOS, temperature, cell voltages, and currents (including quiescent currents) of cells and the vehicle
- Fast and reliable disconnection of the battery during safety-critical events or off-mode
- Benchmark end-of-life accuracy for cell voltage and current sensing
- Advanced battery cell modeling with machine learning capabilities
- Battery pack monitoring, including thermal runaway, overcurrent, and battery disconnection states
- Battery passport & event logging for SoC and SoH calculations

Table 6 Suggested Products for 12V-24V BMS

Product	Description
TLE9012DQU Cell Monitoring and Balancing ICs	Li-Ion battery monitoring and balancing IC fulfilling main functions: cell voltage and temperature measurement, cell balancing and isolated communication to main battery controller. Support up to ASIL-D applications.
PSoC™ HV PA Pack and current monitoring IC	PSoC™ High Voltage (HV) Precision Analog (PA) is a one-chip solution for smart sensor designs for automotive, providing outstanding battery monitoring and management capabilities. Support up to ASIL-D applications.
XENSIV™ KP236/KP253/KP467 Analog and digital barometric pressure sensors	Pressure sensors for thermal runaway detection. Support up to ASIL-B applications and compliance to GTR20 regulations
AURIX™ TC3x and TC4x families Automotive safety microcontroller	Scalable 32-bit TriCore™ high-performance microcontroller family. Support up to ASIL-D applications.
TRAVEO™ T2G Automotive safety microcontroller	32-bit TRAVEO™ T2G Arm® Cortex® microcontroller family. Support up to ASIL-B applications.
OPTIREG™ PMIC (Automotive)	Safety power management ICs (PMIC) consist of integrated, multi-rail supply solutions for demanding automotive systems/ modules in segments such as chassis, safety, ADAS, powertrain, and drive train. Support up to ASIL-D applications.
OPTIMOS™ Automotive grade MOSFET	Best-in-class low voltage MOSFETs for advanced solid-state battery disconnection. Support up to ASIL-C applications.
EiceDRIVER™ Gate Drivers	Low voltage gate driver ICs for MOSFETs. Support up to ASIL-C applications.
EXCELON™ Automotive grade F-RAM	Lowest-power mission-critical nonvolatile memory combines ultra-low-power operation with high-speed interfaces, instant nonvolatility, and unlimited read/write cycle endurance. Supports up to ASIL-B applications.

2.2.2 HV Battery Management System (BMS)

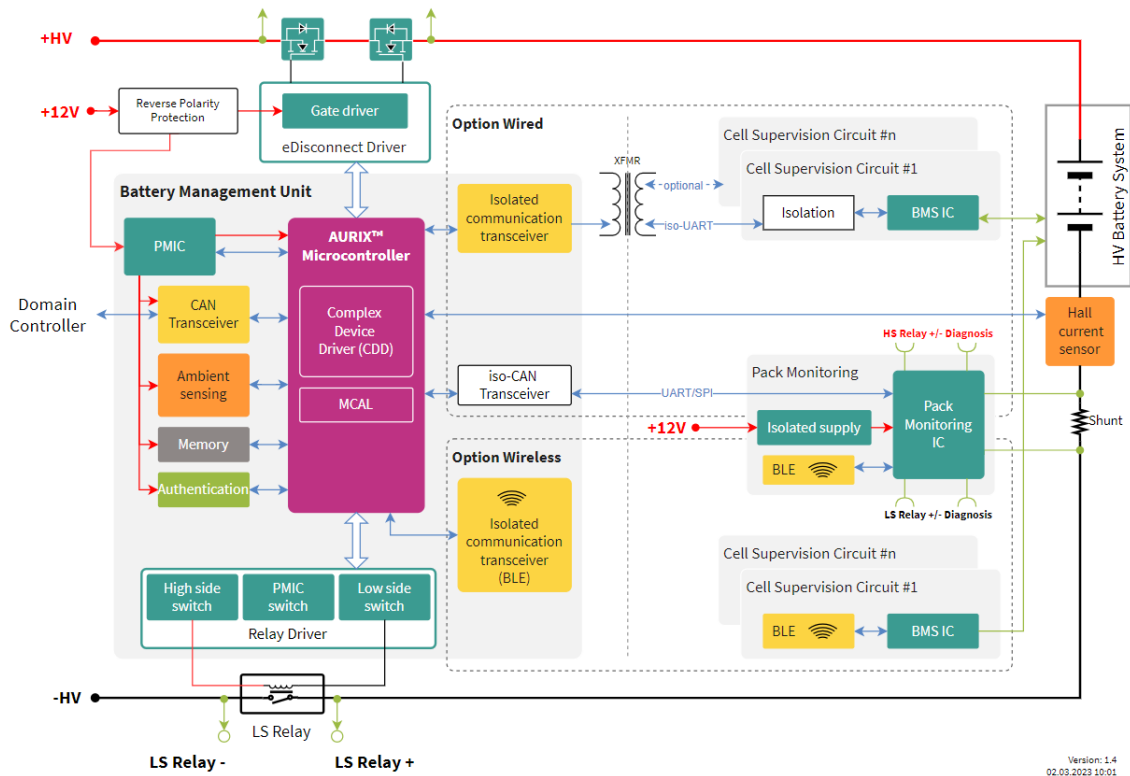


Figure 8 Block diagram of HV BMS

System benefits

- Cell balancing and monitoring solutions for high-voltage batteries with stringent functional safety requirements, including isolated communication transceivers enabling communication with the master controller
- Current sensing solution to accurately predict the State of Charge (SoC)
- Battery disconnecting function to avoid operating outside the safe operating area (SOA) of batteries
- Condition sensing for thermal, electrical, and mechanical strain for improved safety and battery health

Table 7 Suggested Products for HV BMS

Product	Description
TLE9012DQU Cell Monitoring and Balancing ICs	Li-Ion battery monitoring and balancing IC fulfilling main functions: cell voltage and temperature measurement, cell balancing and isolated communication to the main battery controller. Support up to ASIL-D applications.
PSoC™ HV PA Pack and current monitoring IC	PSoC™ High Voltage (HV) Precision Analog (PA) is a one-chip solution for smart sensor designs for automotive, providing outstanding battery monitoring and management capabilities. Support up to ASIL-D applications.
XENSIV™ KP236/KP253/KP464 Analog and digital barometric pressure sensors	Pressure sensors for thermal runaway detection. Support up to ASIL-B applications and compliance with GTR20 regulations
XENSIV™ TLE4972/TLE4973 Pack current hall sensors	Coreless current hall sensor with digital control and diagnostic interface in a leadless VSON-6 (TLE4973)/leaded TDSO-16 (TLE4972) package
TLE9015DQU IsoUART Transceiver	IsoUART transceiver IC designed for connecting several TLE9012DQU devices in a daisy chain inside a Li-Ion battery.
CYW89829	Automotive grade Bluetooth® & Bluetooth® LE SoC with Bluetooth® 5.4 compliant, offering automotive Grade 2 (-40C to + 105C) ambient temperature performance

AIROC™ Bluetooth® LE & Bluetooth®	
AURIX™ TC3x and TC4x Automotive safety microcontroller	Scalable 32-bit TriCore™ high-performance microcontroller family. Support up to ASIL-D applications.
ISOFACE™ 4DIRx4xxHA Automotive-grade Digital Isolator	Automotive grade galvanically isolated output switches
CAN Transceiver TLE9350	High-speed CAN Transceivers with up to 8Mb/s transmission speed
TRAVEO™ T2G Automotive safety microcontroller	32-bit TRAVEO™ T2G Arm® Cortex® microcontroller family. Support up to ASIL-B applications.
OPTIREG™ PMIC (Automotive)	Safety power management ICs (PMIC) consist of integrated, multi-rail supply solutions for demanding automotive systems/ modules in segments such as chassis, safety, ADAS, powertrain, and drive train. Support up to ASIL-D applications.
HITFET™ +12V & HITFET™ +24V Low-side smart switch	Low-side smart switch for driving mechanical relays. Featuring the small package size and the scalability in feature-set and current capability allowing any need to change of loads and devices without major modification of board layout or software
PROFET™+2 12V & PROFET™ +24V High-side smart switch	High-side smart switch for driving mechanical relays. High-side switch providing excellent diagnostic and protection features and a high current sense accuracy
CoolMOS™ and CoolSiC™ Automotive grade high voltage MOSFETs	Best-in-class Silicon and Silicon Carbide MOSFETs for advanced solid-state battery disconnection. Support up to ASIL-C applications.
EiceDRIVER™ Gate Drivers	Gate driver ICs for high voltage MOSFETs. Support up to ASIL-C applications.
EXCELON™ Automotive grade F-RAM	Lowest-power mission-critical nonvolatile memory combines ultra-low-power operation with high-speed interfaces, instant nonvolatility, and unlimited read/write cycle endurance. Supports up to ASIL-B applications.

2.3 Chargers from 50kW to 350kW

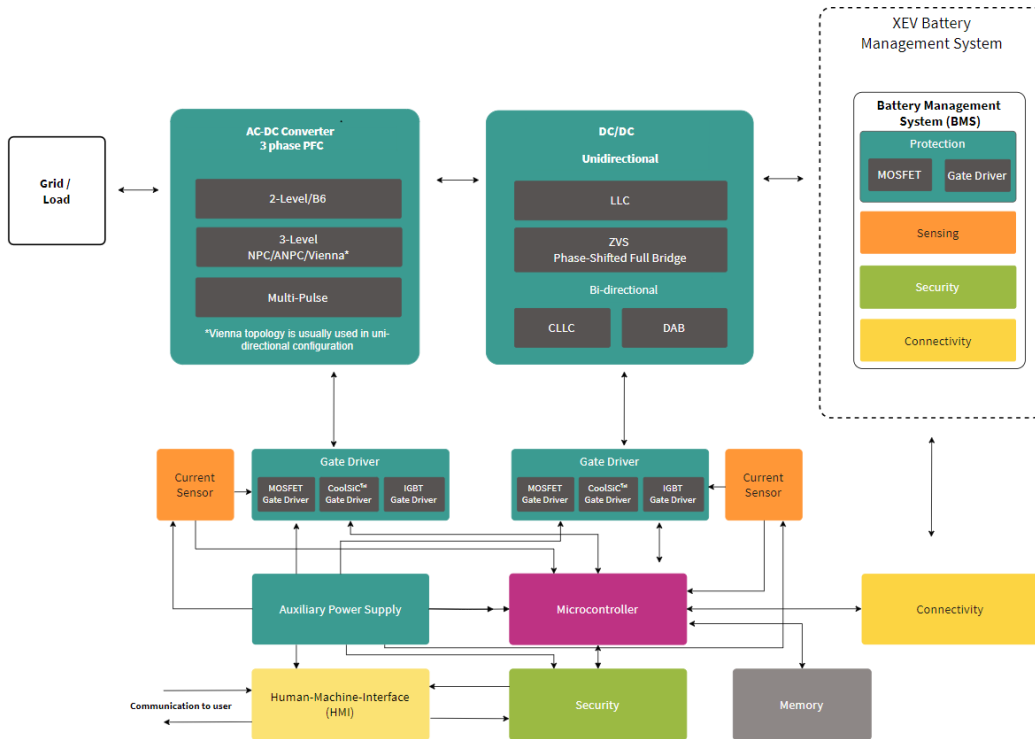


Figure 9 Block diagram of chargers from 50kW to 350kW

System benefits

- A broad range of products for EV charger design, allowing to choose the best-suited solutions for the desired charger’s power level
- Enabling chargers in the power range up to 350 kW, making it suitable for the today's market demand in fast-charging stations
- Tailored gate driver EiceDRIVER™ and microcontroller XMC™ and AURIX™ families for ease of control
- IGBT-based solutions are perfect for both Vienna Rectifier and AFE, for AC-DC conversion
- CoolSiC™ Easy modules enable the AC-DC converter stage to operate at around 40 kHz to 50 kHz
- CoolSiC™ is a good choice for the DC-DC stage to enable high switching possibility to reduce the overall system size and achieve higher efficiency.

Table 8 Suggested Products for chargers from 50kW to 350kW

Product	Description
EiceDRIVER™	Gate driver ICs for MOSFETs, IGBTs, SiC MOSFETs, and GaN HEMTs
XMC™	32-bit industrial microcontrollers based on -up to two- ARM Cortex-M7 processor cores, suitable for EV-charging applications
AURIX™ TC37xTP	Scalable 32-bit TriCore™ high-performance microcontroller family
XENSIV™ TLI4971	Magnetic current sensor for AC and DC measurements in industrial applications
AIROC™ Wi-Fi + Bluetooth® Combos AIROC™ Bluetooth® LE	AIROC™ wireless connectivity products, including Wi-Fi®, Bluetooth®, Bluetooth® Low Energy, and Wi-Fi and Bluetooth® combos
OPTIGA™ Trust	The OPTIGA™ Trust product family offers a full range of security chips to address individual needs in the field of embedded authentication and brand protection and further security applications.

OPTIGA™ TPM SLB9672	Ready-to-use TPM (Trusted Platform Module) security controllers with SPI interface and PQC-protected firmware update mechanism optimized for PCs and servers
CAN Transceivers TLE9250LE	High-speed CAN Transceivers with up to 8Mb/s transmission speed
CoolSiC™ Easy modules 1200V	Superior gate oxide reliability enabled by state-of-the-art trench design, best-in-class switching, and conduction losses, highest transconductance level (gain) and short-circuit robustness.
CoolSiC™ Discrete 1200V	CoolSiC™ MOSFET discretes built on a state-of-the-art trench semiconductor process allowing both the lowest losses in the application and the highest reliability in operation. The 1200 V MOSFET range is available for both industrial and automotive qualified applications, such as on-board charger/PFC .

2.4 Wireless Charging

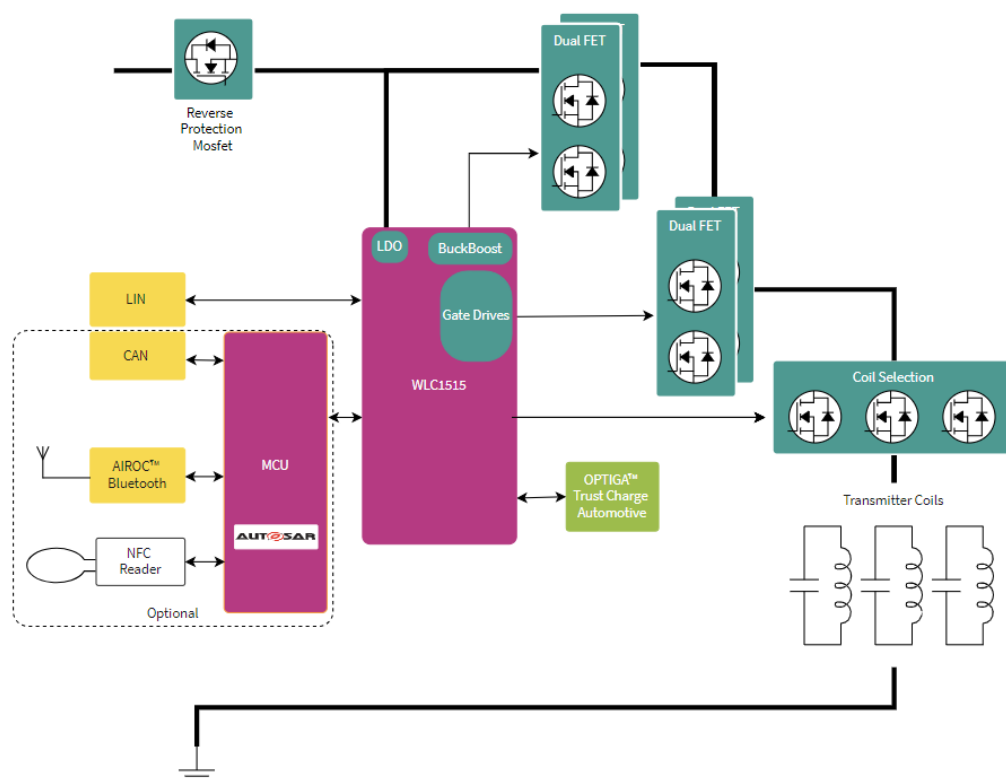


Figure 10 Block diagram of wireless charging

System benefits

- A turnkey wireless charging solution based on a smart chipset for automotive in-cabin power charging applications, which makes the use of charging cables a thing of the past
- With OPTIGA™ Trust Charge automotive, the solution meets the latest Qi 2.0 standard for a safer and more reliable charging experience.
- Simplify the design and power range up to 50W from Infineon solutions
- Ecosystem of trusted partners to offer a comprehensive portfolio of high-power wireless charging solutions exceeding 50W
- WLC1515 wireless controller with integrated DC-DC buck boost controller and gate driver, simplifying the design effort, reducing costs, and maximizing efficiency
- Providing tailored and customized solutions that optimize efficiency and enhance overall performance, with our wide range of diverse applications

Table 9 Suggested Products for wireless charging

Product	Description
Wireless Charging ICs: WLC1515-68LDXS	Automotive wireless charging controller with high levels of integration by including DC-DC buck-boost controllers and inverters with gate drivers, to drive 3-coils (MP-A13). Qi v2.0 BPP + MPP transmitter Qi v1.3 EPP free position transmitter with proprietary extensions
OPTIGA™ Trust Charge Automotive	Optimized solution for in-car wireless charging up to 15 W. This solution also offers AEC Q100 automotive qualification and enables the wireless charger to authenticate to Qi 1.3 certified handhelds.
LIN Transceiver	Single-wire LIN transceiver designed for in-vehicle networks using data transmission rates up to 20 kbps
Automotive MOSFETs	A comprehensive product portfolio of automotive MOSFETs, which are suited for each function such as reverse battery protection, buck boost, bridge inverter, and coil selection

3 24 V body applications

3.1 24 V Body ECU for CAV

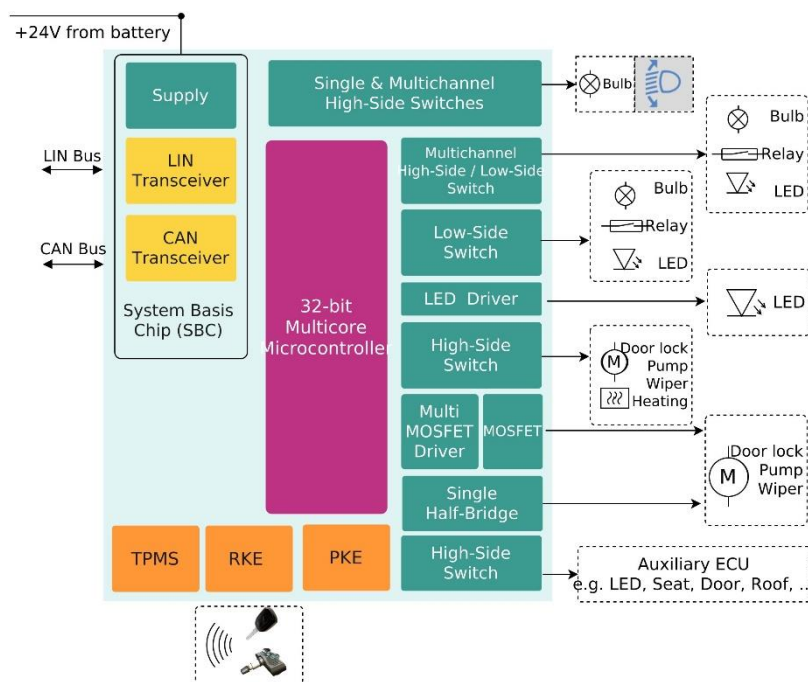


Figure 11 Block diagram of 24 V Body ECU for CAV

System benefits

- Reduced board space due to integrated functionality
- PROFET™+ 24V provides excellent diagnostic and protection features and a high current sense accuracy, even for the smallest loads, such as LEDs
- Supports the “Limp Home” functional safety concept
- Maximum design flexibility and a lower design outlay due to identical footprint & pin-compatibility
- Automotive LED driver products support the transition of lighting solutions to LED exclusively

Table 10 Suggested Products for 24 V Body ECU for CAV

Product	Description
AURIX™	Scalable 32-bit TriCore™ microcontroller family from single to multicore (PRO-SIL™)
Supply ICs	Voltage regulators, DC-DC converters
SPIDER , HITFET™ 24V	Low-side switches 24 V: BTS3028, BT3046, BTS3104
LITIX™ Basic	Scalable linear current sources family for automotive LED applications
SBCs , network transceiver	System basis chips, CAN, LIN and FlexRay transceiver
PROFET™+ 24V	Single- and multi-channel protected high-side switches 24 V

3.2 Low voltage motor control

Depending on a vehicle’s specifications, a CAV is fitted with a brushless DC, brushed DC or unidirectional motor. Regardless of the motor type, every CAV requires robust low voltage motor control with the right selection of diagnostic and protective functions. This application, like many others, comes with its own set of challenges. In particular, the motor control industry faces growing pressure to find new ways to increase energy efficiency. As software takes on a

central role in motor control applications, the systems themselves are becoming more and more complex. Overcoming these challenges requires deep industry know-how coupled with leading-edge products and solutions.

3.2.1 Seat Control Module

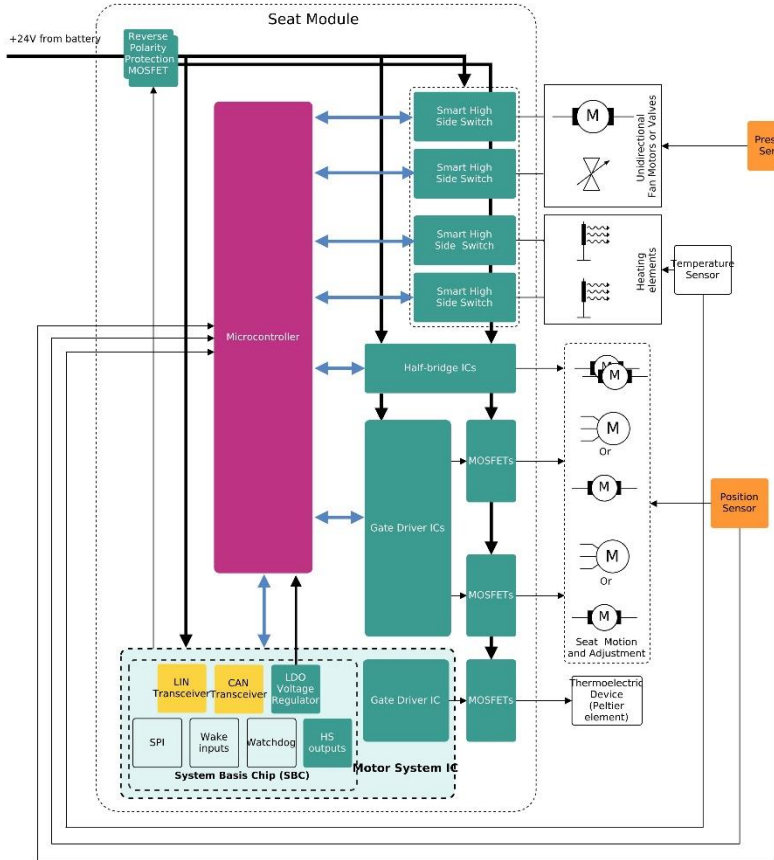


Figure 12 Block diagram of seat control module

System benefits

- System-in-a-package solutions for high-power integrated and protected motor control
- Reduced board space due to integrated functionality
- Protected load control with sophisticated diagnostic features

Table 11 Suggested Products for seat control module

Product	Description
AURIX™ TC22xL	Scalable 32-bit TriCore™ microcontroller family from single to multicore (PRO-SIL™)
NovalithIC™ BTN8982TA	Integrated half-bridge driver
High-current PROFET™	Smart low-ohmic high-side switches for heating applications
PROFET™+ 24V	Smart high-side switches for 24 V applications
TLE6389	DC-DC converter (automotive)
Network transceivers	LIN and CAN transceivers

3.2.2 Brushless DC motor control

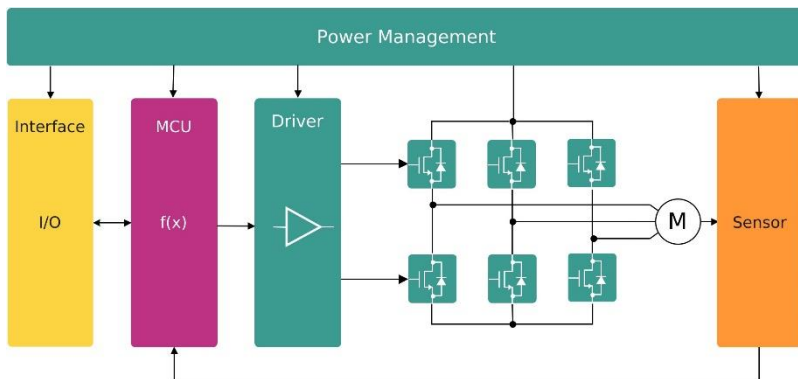


Figure 13 Block diagram of brushless DC motor control

System benefits

- Integrated solution reduces the design outlay
- PWM control
- Discrete solution optimized for all motors thanks to a broad selection of MOSFETs
- Protection functions, including SC, overload, OT and ESD
- Diagnostic functions, including open load, OT detection, integrated OPAMP and current sense

Table 12 Suggested Products for brushless DC motor control

Product	Description
AURIX™	Scalable 32-bit TriCore™ microcontroller family from single to multicore (PRO-SIL™)
TRAVEO™	Scalable 32-bit microcontroller family
MOTIX™	Versatile, automotive-qualified, high-voltage gate driver IC portfolio.
TLE9180	3-phase bridge driver IC for automotive safety applications (PRO-SIL™)
TLE9140	3-Phase universal BLDC Motor Gate Driver IC
Position sensor	Magnetic position sensor and angle sensors
ATV and industrial MOSFETs 60/80/100 V	Single: n-channel 80 V/100 V MOSFET
TLF35584	System power supply with integrated watchdog (PRO-SIL™)
IKW/IKQxxN60/N120/T/H3	Discrete IGBT TO247/Plus 1200 V/600 V/8–120 A

3.2.3 Brushed DC motor control

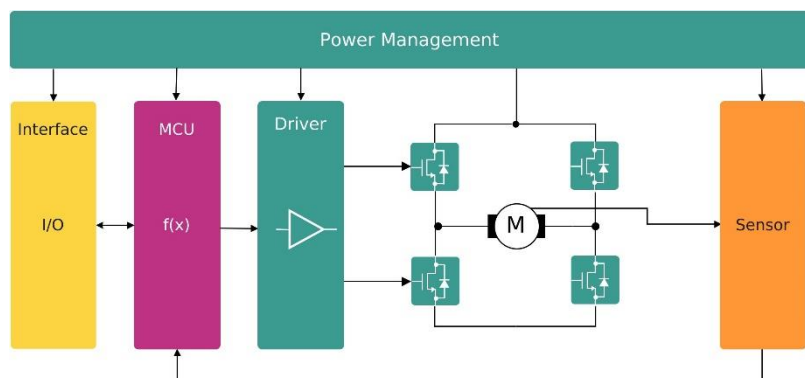


Figure 14 Block diagram of brushed DC motor control

System benefits

- Integrated solution reduces the overall outlay
- Discrete solution optimized for all motors thanks to a broad selection of MOSFETs
- PWM control
- Protection functions, including SC, overload, OT and ESD
- Diagnostic functions, including open load, OT detection, integrated OPAMP and current sense

Table 13 Suggested Products for brushed DC motor control

Product	Description
AURIX™	Scalable 32-bit TriCore™ microcontroller family from single to multicore (PRO-SIL™)
TRAVEO™	Scalable 32-bit microcontroller family
MOTIX™	Versatile, automotive-qualified, high-voltage gate driver IC portfolio.
TLE9180	3-phase bridge driver IC for automotive safety applications (PRO-SIL™)
TLE9140	3-Phase universal BLDC Motor Gate Driver IC
Network transceivers	CAN transceivers
Driver ICs TLE7181/7182	MOSFET driver for H-bridge configuration
ATV and industrial MOSFETs 60/80/100 V	Single: n-channel 80 V/100 V MOSFET
TLE6389	DC-DC converter (automotive) for 24 V applications
IKW/IKQxxN60/N120/T/H3	Discrete IGBT TO247/Plus 1200 V/600 V/8–120 A

3.3 LED Lighting

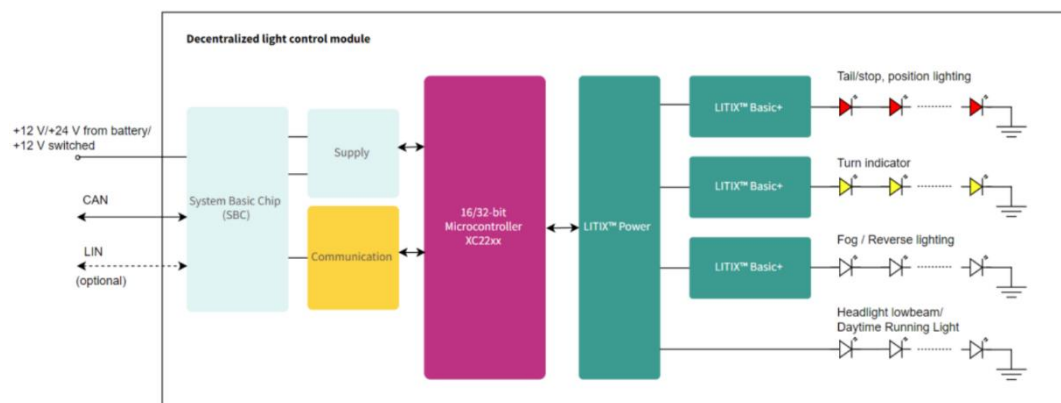


Figure 15 Block diagram of LED lighting

System benefits

- Infineon's LITIX™ Basic+ and LITIX™ Power product family offer suitable LED driver ICs for demanding eCAV lighting applications in both 12V and 24V domains
- Comprehensive product portfolios cover the versatile CAV lighting applications such as front/rear light module, turn indicators, interior lighting and more
- OPTIREG™ system basis chips (SBC) offer high integration and high performance with optimized system cost and space

Table 14 Suggested Products for LED lighting

Product	Description
TRAVEO™ T2G CYT2B9 Series	Designed for automotive body electronics with processing power and network connectivity built into the Arm® Cortex®-M4F
LITIX™ Basic+ TLD1114-1EP, TLD2131-3EP	LED Driver IC family state-of-the-art current accuracy to fulfill worldwide OEM requirements. Qualified for CAV lighting applications
LITIX™ Power TLD6098-1EP, TLD6098-2ES	LED Driver IC family consisting of a buck converter, low-side switch controllers and 4-switch buck-boost controllers. Qualified for CAV lighting applications
OPTIREG™ Lite SBC Family	Basis Chip (SBC) family offering high integration and high performance with optimized system cost for various automotive applications
OPTIREG™ linear	Robust automotive linear voltage regulators specially designed for automotive applications with loads, such as transceivers , microcontrollers , active antennas, and sensors

4 High Voltage Applications

4.1 mPTO

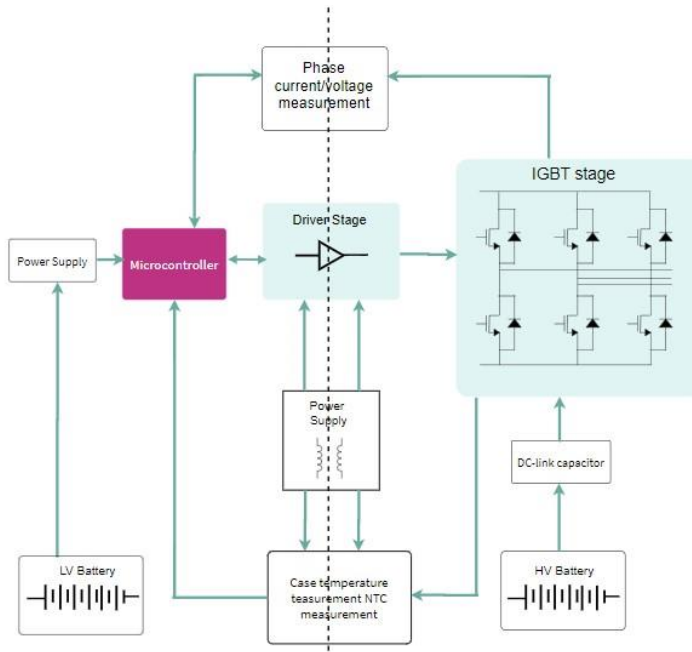


Figure 16 Block diagram of mPTO

System benefits

- Power-product portfolio including both power module and discrete solutions
- Gate drivers featuring galvanic isolation
- Highly efficient 3-phase motor operation thanks to very low conduction losses, even at high switching frequencies
- Broad 32-bit microcontroller solutions dedicated to (H)EV applications

Table 15 Suggested Products for mPTO

Product	Description
FF600R12ME4A	EconoDUAL™ 3 half-bridge power module, 1200 V/600 A
FF900R12IP4V	PrimePACK™ 2 half-bridge power module 1200 V/900 A
FD/DF600R12IP4V	PrimePACK™ 2 high- and low-side chopper modules 1200 V/600 A
IKW/IKQxxN60/N120/T/H3	Discrete IGBT TO247/Plus 1200 V/600 V/8–120 A
2ED300C17-S/ST	Half-bridge high-power IGBT-driver
1ED020I12-FA	Single-channel IGBT-driver IC
2ED010I12-XXX	Dual-channel IGBT-driver IC

4.2 Powertrain inverter

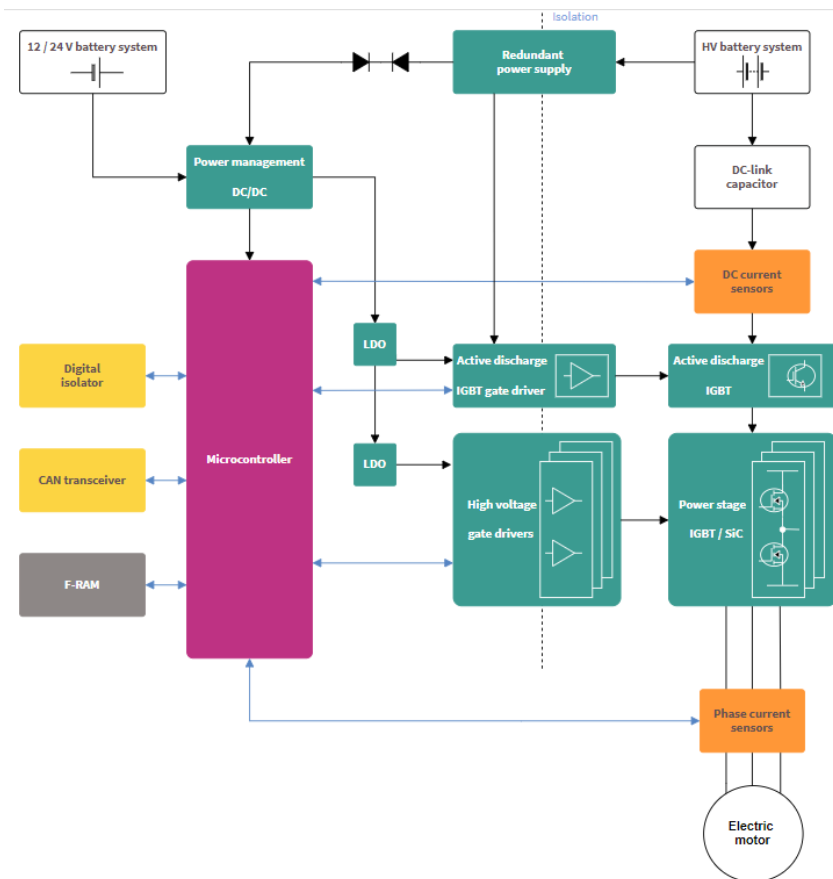


Figure 17 Block diagram of powertrain inverter

System benefits

- Most scalable IGBT & SiC portfolio in the market to address fast platform design and migration
- One Inverter, one Infineon®, complete system solution to enable fast time to market
- Strong synergy and interoperability among semiconductor components e.g. Microcontroller vs. PMIC, Power module vs. Gate-driver, eventually reduced design effort & cost
- Optimized performance thanks to broad and highly scalable 32-bit microcontroller portfolio
- Support functional safety up to ASIL D level
- Inverter evaluation kit featuring HybridPACK™ Drive G2 power module, EiceDRIVER™ and AURIX™ Microcontroller

Table 16 Suggested Products for powertrain inverter

Product	Description
HybridPACK™ Drive G2 FS01MR12A8MA2B	3ph SiC MOS power module, 1.5 mΩ / 1200 V, AQG324
HybridPACK™ Drive G2 FS02MR12A8MA2B	3ph SiC MOS power module, 2.2 mΩ / 1200 V, AQG324
HybridPACK™ Drive G2 FS520R12A8P1LB	3ph Si IGBT power module, 395Amrs / 1200 V, AQG324
EconoDUAL™ 3 FF2MR12MM1H	Half-bridge SiC MOS power module, 2 mΩ / 1200 V
EconoDUAL™ 3 FF900R12ME7	Half-bridge Si IGBT power module, 900 A / 1200 V

EiceDRIVER™ 1EDI305xAS	Single channel isolated high voltage gate driver family for IGBTs and SiC MOS, AEC-Q100
AURIX™ TC3x	32-bit automotive high-performance and scalable microcontroller families
AURIX™ TC4x	32-bit automotive high-performance and scalable microcontroller families
OPTIREG™ TLF3558x	Microcontroller power supply family with integrated functional safety features, AEC-Q100
XENSIV™ TLE4973	Magnetic coreless current sensor family, AEC-Q100
ISOFACE™	Digital isolator family, AEC-Q100
TLE935x	High-speed CAN Transceiver family, AECQ-100

4.3 HV-LV DCDC

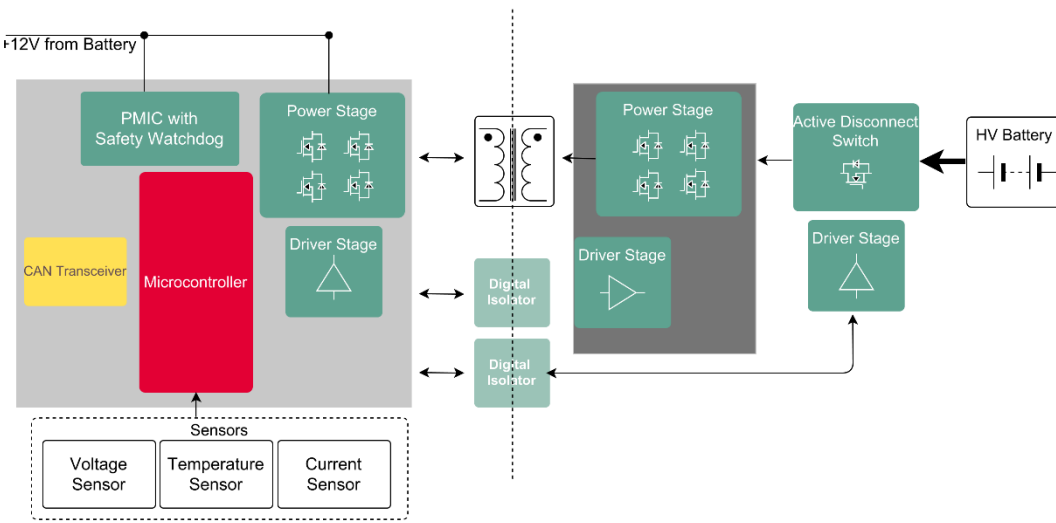


Figure 18 Block diagram of HV-LV DCDC

Design focus

- **Efficiency:** Next-Gen IGBTs and SiC MOSFETs can reduce inverter losses and downstream losses in the motor, minimize overall system costs, and keep the footprint minimized
- **Durability:** XT technology prevents delamination even over long intervals and in harsh conditions
- **Quality:** IFX offers automotive (AQG324) and industrial (IEC60747, ...) qualified components

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 the gate driver
- High-performance 32-bit microcontroller solutions
- Evaluation Kit available to reduce system development time

Table 17 Suggested Products for HV-LV DCDC

Product	Description
AURIX™	Scalable 32-bit TriCore™ high-performance microcontroller family

XENSIV™ TLE4972-AE35D5	Magnetic coreless current sensor in a leaded TDSO-16 package
XENSIV™ TLE5309D	Magnetic angle with analog output, highly immune to air-gap variations
EiceDRIVER™	Gate driver ICs for MOSFETs, IGBTs, SiC MOSFETs, and GaN HEMTs
OPTIREG™ PMIC (Automotive)	Highly integrated solutions for automotive applications - chassis, safety, ADAS, electrical drive train
CAN Transceivers	High-speed CAN Transceivers with up to 8Mb/s transmission speed
EXCELON™ E-RAM	The industry's lowest-power mission-critical nonvolatile memory, combines ultra-low-power operation with high-speed interfaces, instant nonvolatility, and unlimited read/write cycle endurance.
CoolSiC™ MOSFET module	Superior gate oxide reliability enabled by state-of-the-art trench design, best-in-class switching, and conduction losses, highest transconductance level (gain), threshold voltage of $V_{th} = 4\text{ V}$ and short-circuit robustness.

4.4 HV Thermal Management

In contrary to ICE vehicles, the electric motor's low heat production presents a challenge at low temperatures, necessitating additional heating for passenger comfort, which can impact the available range due to increased battery management efforts. Moreover, the rise of fast-charging stations with high power outputs demands precise thermal control to optimize charging efficiency and battery lifespan. Our thermal management system is designed to maintain the electric motor, power electronics, and battery at the ideal temperature while ensuring passenger comfort. A failure in thermal management can lead to various issues, such as demagnetization of magnets, efficiency loss, and even motor burnout. Our comprehensive solution includes various thermal circuits with actuators like electric compressors, coolant pumps, fan motors, valves, flaps, HVAC control modules, and electric heaters. We recognize the importance of integrated liquid-based battery cooling strategies, and our solutions are tailored to ensure optimal performance, longevity, and safety in BEVs, enabling the realization of efficient, quiet, and sustainable vehicles on our roads.

4.4.1 HVAC Control Module

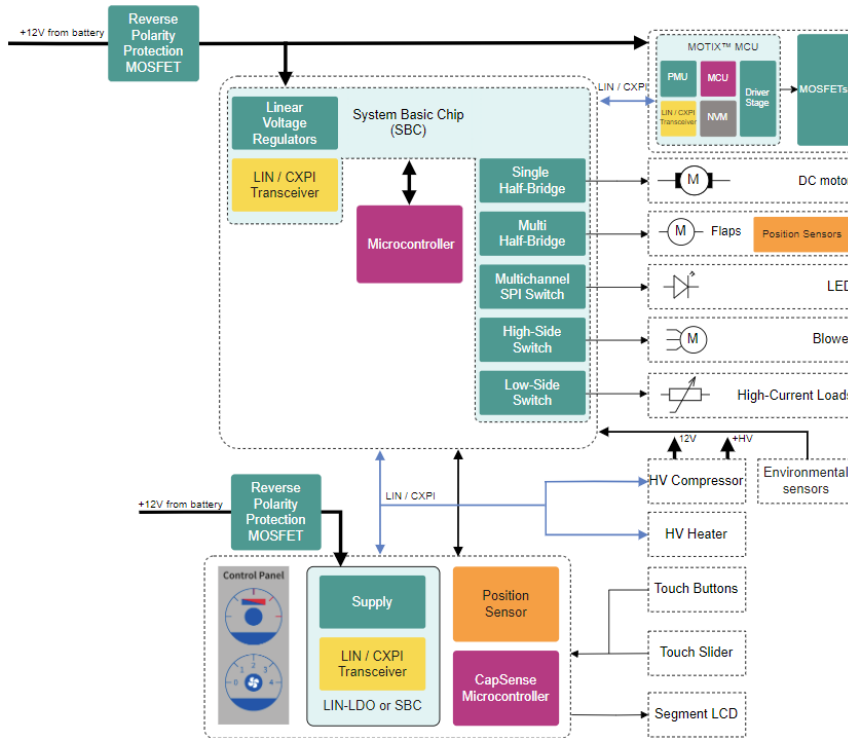


Figure 19 Block diagram of HVAC control module

System benefits

- High-performant, scalable 32-bit microcontrollers (Traveo™ II) for various HVAC control strategies
- Integrated 32-bit Embedded Power ICs or low-ohmic-protected half-bridge ICs (NovalithIC™) for half-or full-bridge DC and BLDC blower motor control
- Industry leading CapSense® technology to create a sleek user interface with 32-bit CapSense Microcontroller (PSoC® 4)
- Plus matching power supply and transceiver solutions incl. System Basis Chips (SBC), Linear Voltage Regulators (LDO), LIN-LDOs, CAN and CXPI transceivers

Table 18 Suggested Products for HVAC control module

Product	Description
TRAVEO™	32-bit TRAVEO™ T2G Arm® Cortex® with great scalability across memory size and pin count
CapSense™	CAPSENSE™ capacitive-sensing supports applications that require touch buttons, sliders, wheels, trackpads, and touchscreens
OPTIREG™ linear	Robust automotive linear voltage regulators specially designed for automotive applications with loads, such as transceivers , microcontrollers , active antennas, and sensors
NovalithIC™	Single half-bridge ICs family providing cost-optimized solutions for high-current PWM motor drives with low board-space consumption
System basis chips (SBC)	Infineon’s System Basis Chips (SBC) offer high integration and high performance at an optimized system cost for HVAC modules

4.4.2 HV PTC Heater Module

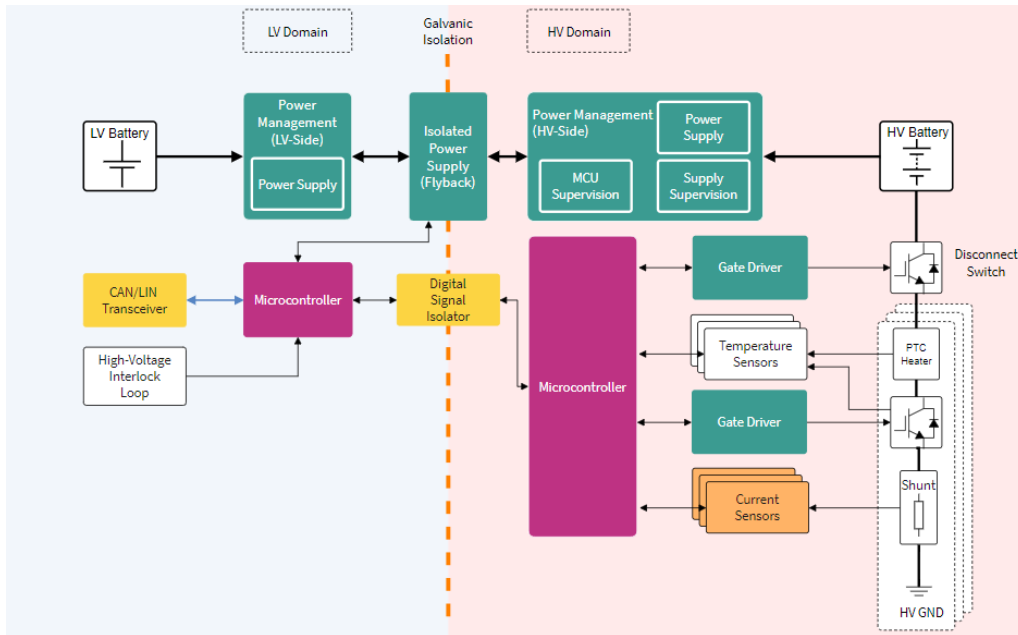


Figure 20 Block diagram of HV PTC heater module

System benefits

- Faster time to market: Flyback converter reference design available to reduce system development time
- Holistic product portfolio for 400V and 800V including supply, communication, control, sense and actuation
- Wide variety of power switches: OptiMOS™ MOSFET, Automotive IGBT and CoolSiC™ MOSFET
- EiceDRIVER™ gate driver ICs for MOSFETs, IGBTs and SiC MOSFETs
- Scalable and reconfigurable microcontroller family PSoC™ 4

Table 19 Suggested Products for HV PTC heater module

Product	Description
TRAVEO™	32-bit TRAVEO™ T2G Arm® Cortex® with great scalability across memory size and pin count
EiceDRIVER™	Gate driver ICs for MOSFETs, IGBTs, SiC MOSFETs, and GaN HEMTs
PSoC™ 4 microcontroller	Scalable and reconfigurable platform architecture for a family of programmable embedded system controllers
XENSIV™	High-precision coreless current sensors family
OPTIREG™ linear	Robust automotive linear voltage regulators specially designed for automotive applications with loads, such as transceivers , microcontrollers , active antennas, and sensors

4.4.3 48 V pumps and fans

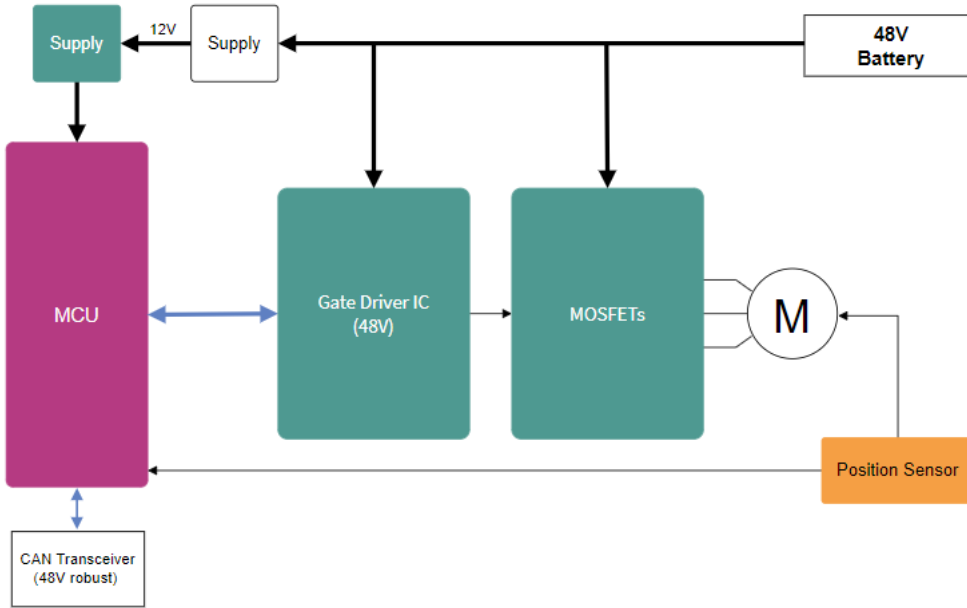


Figure 21 Block diagram of 48 V pumps and fans

System benefits

- A complete system of chipset solutions for 48 V systems - voltage regulators, transceivers, sensors, microcontrollers, smart power drivers and very low-resistance MOSFETs
- MOTIX™ TLE9140EQW BLDC gate driver IC perfectly fitting in 8 V to 72 V systems
- MOTIX™ TLE9180 gate driver IC supporting applications for single and mixed battery systems with battery voltages of up to 48 V
- AURIX™ Family – TC33xLP offers ideal solutions for 48 V applications - 1 core running at 200 MHz / 300 MHz and up to 248 KBytes embedded RAM, and consuming below 1 W

Table 20 Suggested Products for 48 V pumps and fans

Product	Description
AURIX™ Family – TC33xLP	T33xLP offers 1 core running at 200 MHz / 300 MHz and up to 248 KBytes embedded RAM, and consuming below 1 W
MOTIX™ TLE9180	Advanced gate driver ICs with two or three current sense amplifiers (CSA) dedicated to control six external N-channel MOSFETs for high current 3-phase motor drives.
XENSIV™ TLE5501/TLE5014	High-performance magnetic angular position sensor for automotive and industrial applications

4.4.4 HV e-Compressor

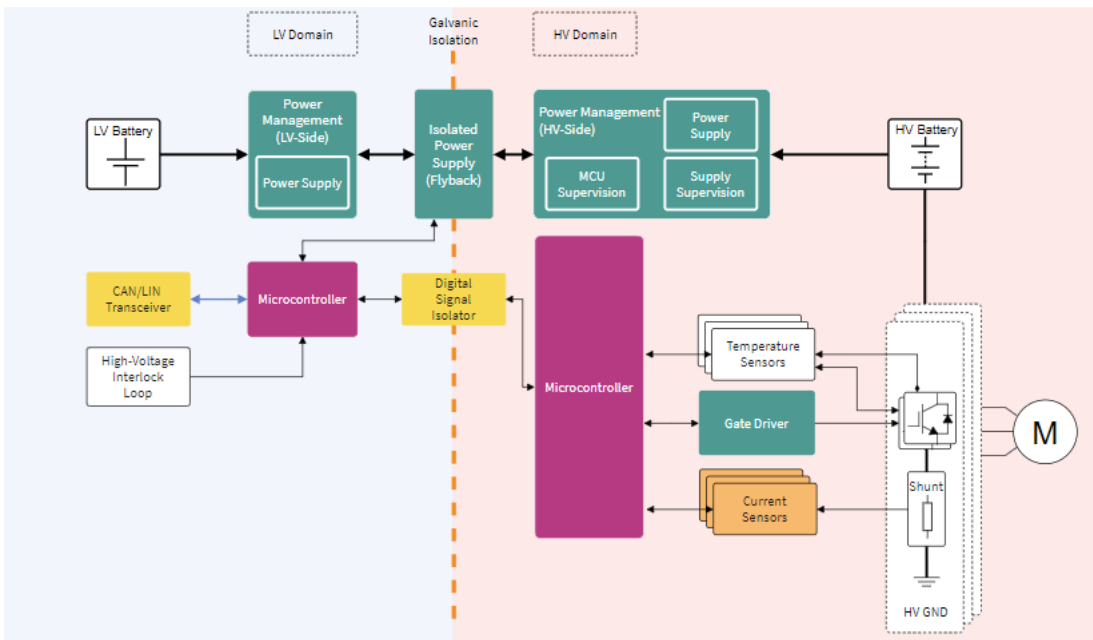


Figure 22 Block diagram of HV e-compressor

System benefits

- By re-using the thermal (waste) energy from the drive train, the heat pump is draining less the battery in the cold seasons compared to e.g., a PTC heater.
- Faster time to market: Flyback converter reference design available to reduce system development time
- Holistic product portfolio for 400V and 800V including supply, communication, control, sense and actuation
- Wide variety of power switches: OptiMOS™ MOSFET, Automotive IGBT and CoolSiC™ MOSFET, Automotive IGBT and CoolSiC™ Module
- EiceDRIVER™ gate driver ICs for MOSFETs, IGBTs and SiC MOSFETs
- Scalable and reconfigurable microcontroller family PSoC™ 4

Table 21 Suggested Products for HV e-compressor

Product	Description
TRAVEO™	32-bit TRAVEO™ T2G Arm® Cortex® with great scalability across memory size and pin count
EiceDRIVER™	Gate driver ICs for MOSFETs, IGBTs, SiC MOSFETs, and GaN HEMTs
PSoC™ 4 microcontroller	Scalable and reconfigurable platform architecture for a family of programmable embedded system controllers
XENSIV™	High-precision coreless current sensors family
OPTIREG™ linear	Robust automotive linear voltage regulators specially designed for automotive applications with loads, such as transceivers , microcontrollers , active antennas, and sensors

5 Fuel Cell

5.1 Fuel Cell control unit

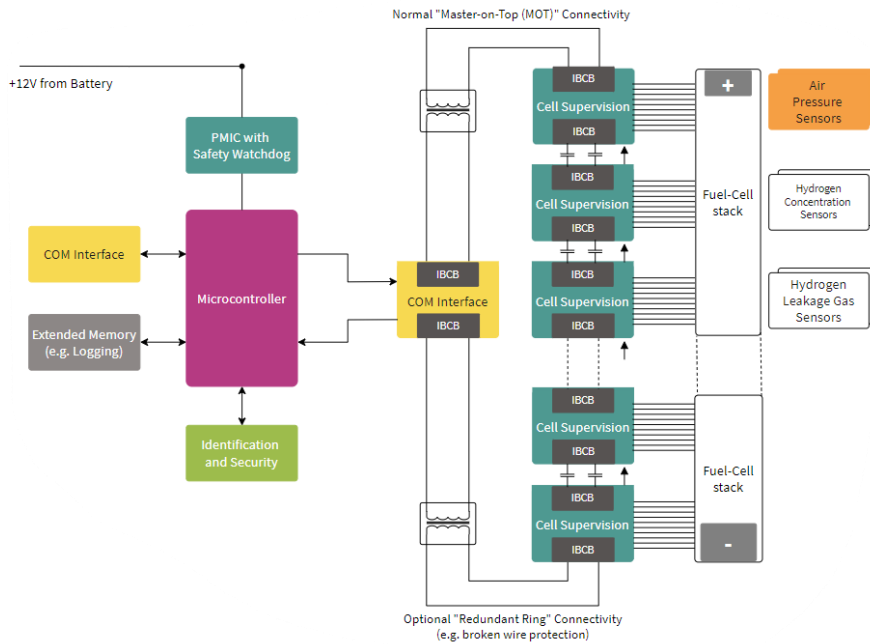


Figure 23 Block diagram of fuel cell control unit

System benefits

- AURIX™ microcontrollers can be paired with OPTIREG™ PMIC solutions to ensure fuel-cell controller safety and security requirements are met
- AURIX™ 32-bit microcontrollers allow for a wide range of memories, peripheral sets, frequencies, temperatures, and packaging options with a high degree of compatibility across generations
- Infineon's global preferred design house partner network can accompany your designs from conception to the verification phase
- Evaluation Kits are available to shorten the system development time

Table 22 Suggested Products for fuel cell control unit

Product	Description
AURIX™	Scalable 32-bit TriCore™ high-performance microcontroller family
XENSIV™ KP276	Media robust Manifold Absolute Pressure (MAP) sensor with digital interface
OPTIGA™ TPM	A turn-key security solution optimized for automotive applications, protecting communication between vehicles and the car manufacturer
OPTIREG™ PMIC (Automotive)	Highly integrated solutions for automotive applications - chassis, safety, ADAS, electrical drive train
Monitoring ICs TLE9012DQU	Multi-channel battery monitoring and balancing system IC with four functions: cell voltage measurement, temperature measurement, cell balancing, and isolated communication to the main battery controller.

5.2 Fuel Cell DCDC boost

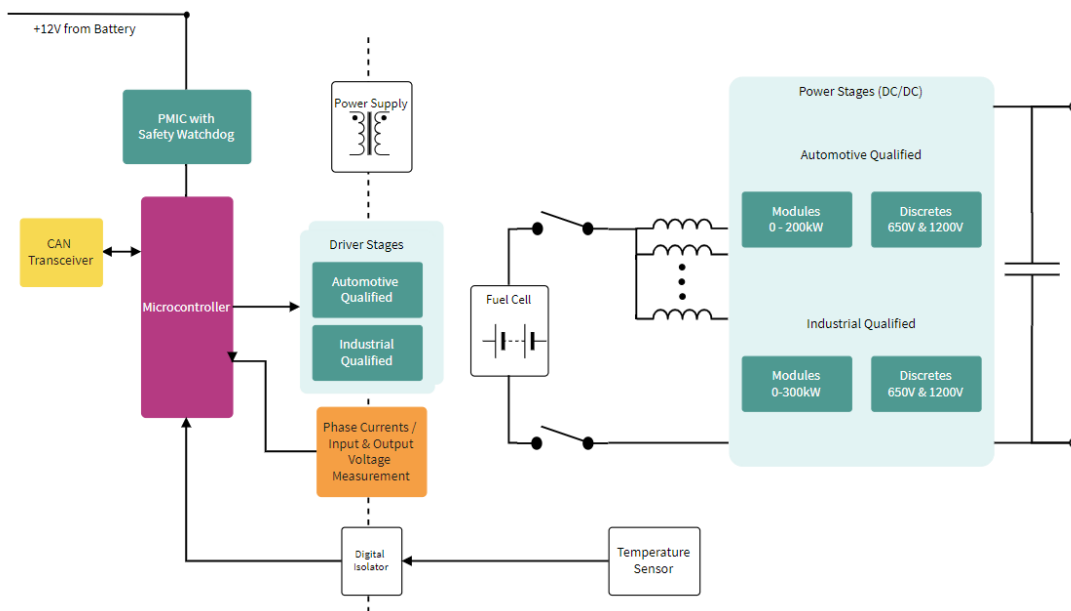


Figure 24 Block diagram of fuel cell DCDC boost

System benefits

- Optimized energy transfer between the fuel-cell stack, traction inverter, and high-voltage battery
- Compact Form by minimized converter dimensions within the vehicle's architecture.
- Wide range of 32-bit microcontroller solutions with a high degree of scalability
- Enhanced efficiency of 1200V CoolSiC™ M1H MOSFET by very low inductances: Easy 1B: 9nH / Easy 2B: 8nH, and low and equal gate inductances
- Easy module portfolio from CoolSiC™ family covers the full performance spectrum
- Evaluation kits are available to reduce system development time

Table 23 Suggested Products for fuel cell DCDC boost

Product	Description
AURIX™	Scalable 32-bit TriCore™ high-performance microcontroller family
XENSIV™ KP276	Media robust Manifold Absolute Pressure (MAP) sensor with digital interface
XENSIV™ TLI4971/TLE4972	High-precision coreless current sensor for automotive and industrial applications
XENSIV™ TLE5009/TLE5109	Fast Giant-Magneto Resistive (GMR) (TLE5009) or Anisotropic Magneto Resistive (AMR) (TLE5109) angle sensor with analog sin/cos output. Available in an 8-pin single, 16-pin single- and dual-sensor SMD package.
OPTIREG™ PMIC (Automotive)	Highly integrated solutions for automotive applications - chassis, safety, ADAS, electrical drive train
EiceDRIVER™	Gate driver ICs for MOSFETs, IGBTs, SiC MOSFETs, and GaN HEMTs
CoolSiC™ MOSFET Modules	Silicon Carbide (SiC) power MOSFET with superior gate oxide reliability enabled by state-of-the-art trench design, best-in-class switching, and conduction losses, highest transconductance level (gain), threshold voltage of $V_{th} = 4\text{ V}$ and short-circuit robustness.

5.3 Fuel Cell electric air compressor

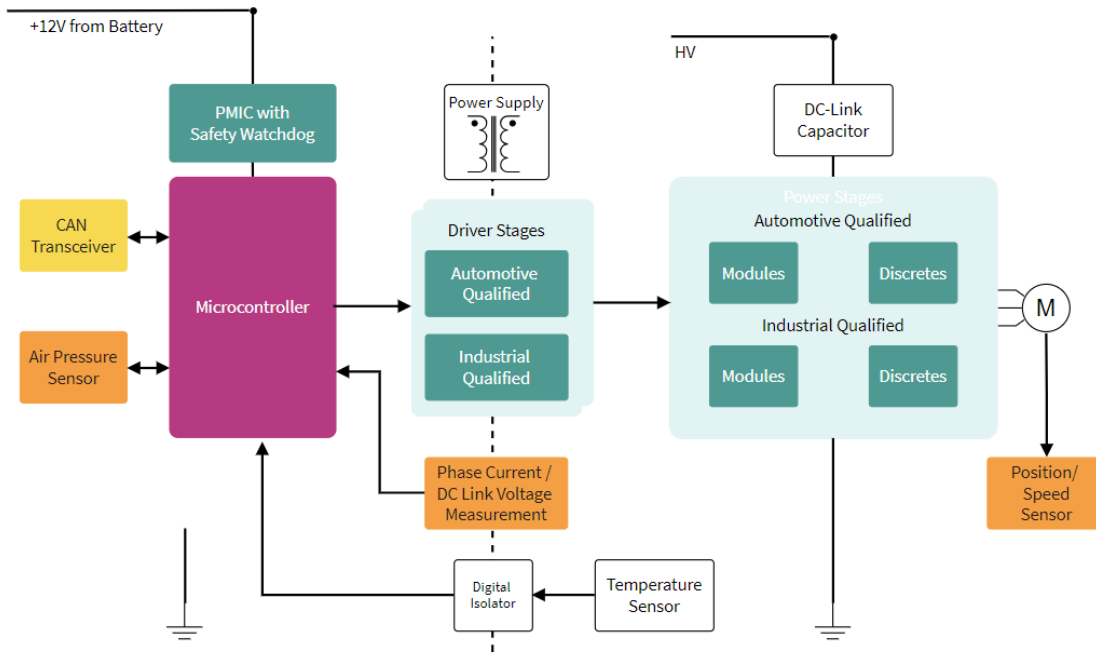


Figure 25 Block diagram of fuel cell electric air compressor

System benefits

- Fully automotive-qualified product portfolio supports a wide range of fuel-cell air compressors and power classes with a compact design and high-power density
- Isolation-integrated gate drivers
- Wide range of 32-bit microcontroller solutions dedicated to xEV applications
- Evaluation kits are available to reduce system development time

Table 24 Suggested Products for fuel cell electric air compressor

Product	Description
AURIX™	Scalable 32-bit TriCore™ high-performance microcontroller family
XENSIV™ TLI4971/TLE4972	High-precision coreless current sensor for automotive and industrial applications
OPTIREG™ PMIC (Automotive)	Highly integrated solutions for automotive applications - chassis, safety, ADAS, electrical drive train
EiceDRIVER™	Gate driver ICs for MOSFETs, IGBTs, SiC MOSFETs, and GaN HEMTs
CoolSiC™ MOSFET Modules	Silicon Carbide (SiC) power MOSFET with superior gate oxide reliability enabled by state-of-the-art trench design, best-in-class switching, and conduction losses, highest transconductance level (gain), threshold voltage of $V_{th} = 4\text{ V}$ and short-circuit robustness.
CoolSiC™ MOSFET Discretes	Suitable for hard- and resonant-switching topologies, including a 650 V option with easy design as a replacement for standard IGBTs, and a 1200 V option offering the highest efficiency and reduced cooling efforts.
Automotive IGBT Discretes	Benchmark 750V EDT2 and 650V TRENCHSTOP™5 AUTO technology for very tight parameter distribution and fast & efficient switching, designed for easy paralleling to enable scalable platform approaches

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