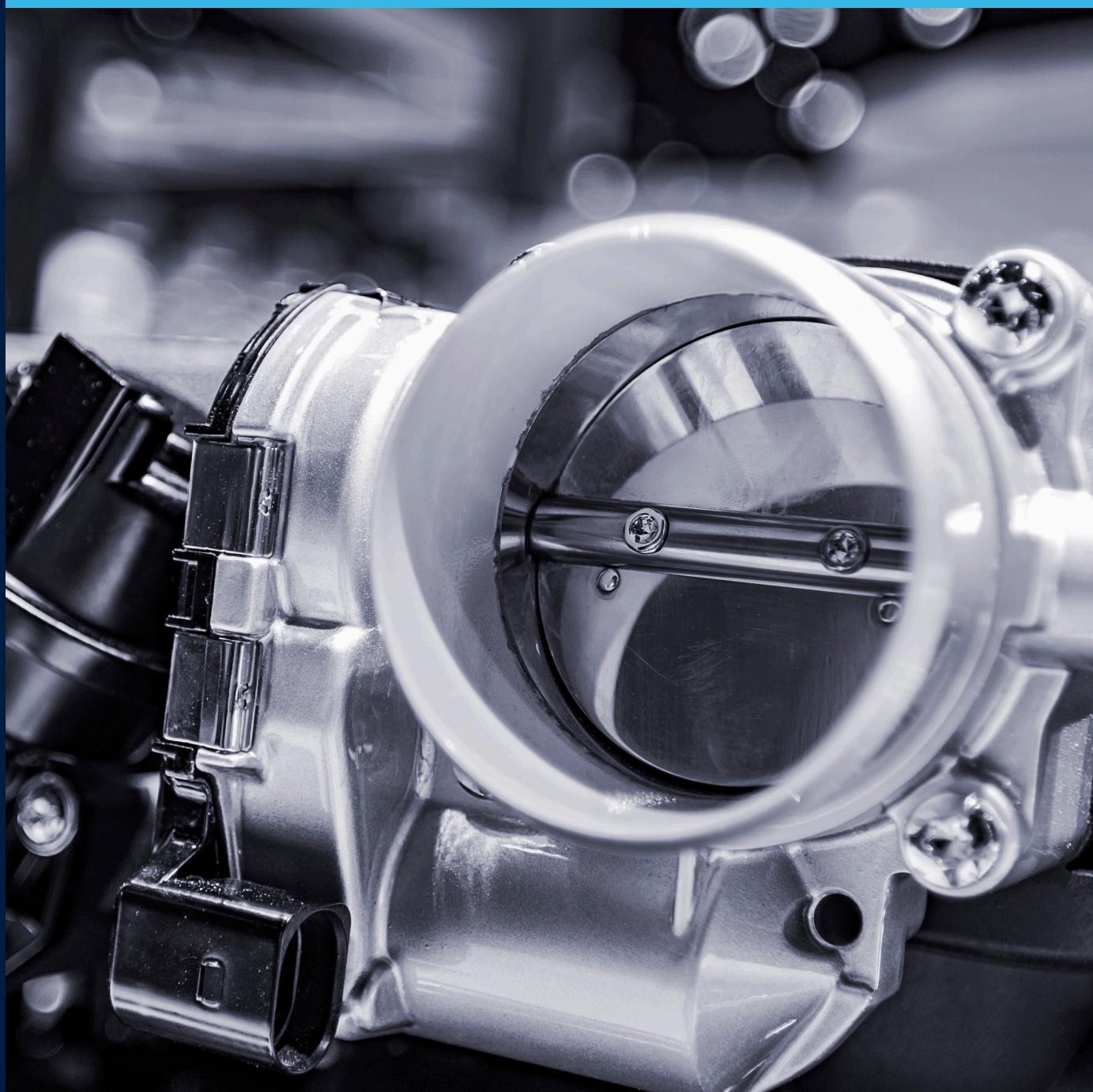




Motor control solutions for automotive applications



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Smart Mobility

It is estimated that 80% of all innovations in the automotive industry today are directly or indirectly enabled by electronics. With vehicle functionality improving with every new model this means a continuous increase in the semiconductor content per car.

With over 30 years' experience in automotive electronics, ST is a solid, innovative, and reliable partner with whom to build the future of transportation.

ST's Smart Mobility products and solutions are making driving safer, greener and more connected through the combination of several of our technologies.

80%
of all innovations
in the automotive
industry today
are enabled by
electronics



SAFER

Driving is safer thanks to our Advanced Driver Assistance Systems (ADAS) – vision processing, radar, imaging and sensors, as well as our adaptive lighting systems, user display and monitoring technologies.

GREENER

Driving is greener with our automotive processors for engine management systems, high-efficiency smart power electronics at the heart of all automotive sub-systems and devices for hybrid and electric vehicle applications.

MORE CONNECTED

Vehicles are more connected using our infotainment and telematics processors and sensors, as well as our radio tuners and amplifiers, positioning technologies, and secure vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2X) connectivity solutions.

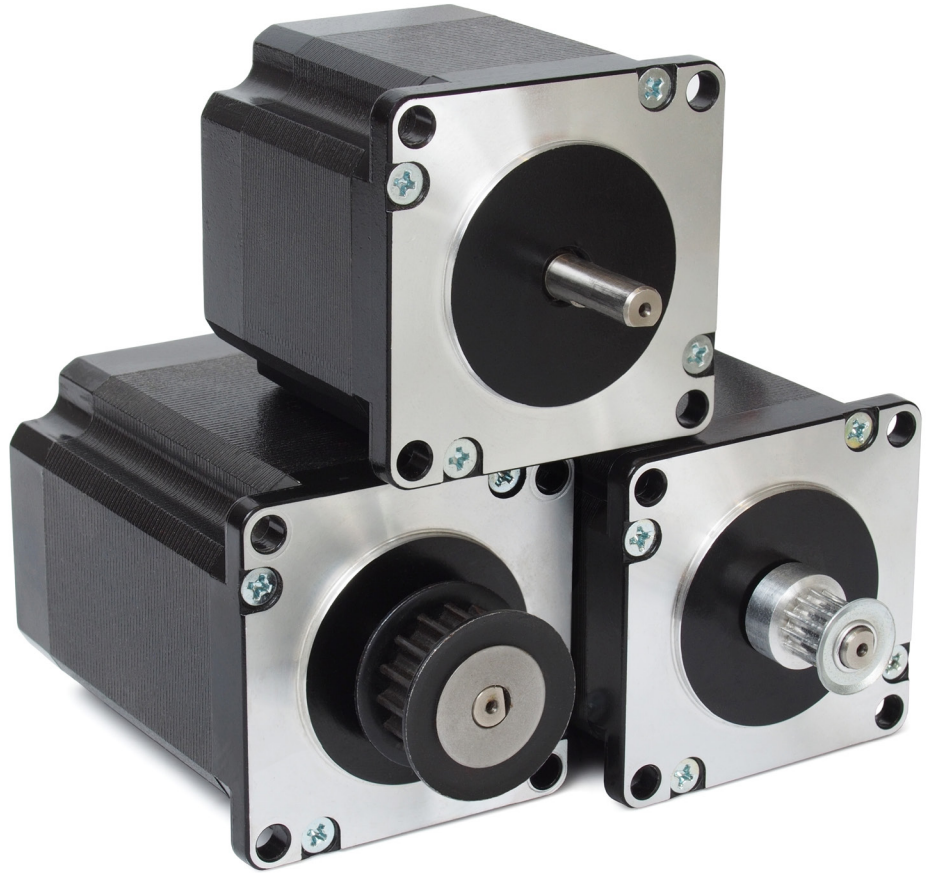
ST supports a wide range of automotive applications, from Powertrain for ICE, Chassis and Safety, Body and Convenience to Telematics and Infotainment, paving the way to the new era of car electrification, advanced driving systems and secure car connectivity.

Motor Control

Today, Motor Control is a key focus segment for automotive applications, from conventional body & convenience and chassis & safety to smart and more innovative domains like electro-mobility and e-powertrains.

Electric motors are today omnipresent inside every vehicle segment. In battery electric vehicles, an electric traction motor even replaces the combustion engine.

And thanks to smarter starter generator and e-turbochargers systems, 48 V small electric motors play a crucial role in reducing CO₂ emissions.



ST is definitely the right partner with whom to develop reliable and cost-effective solutions for automotive motor control applications.

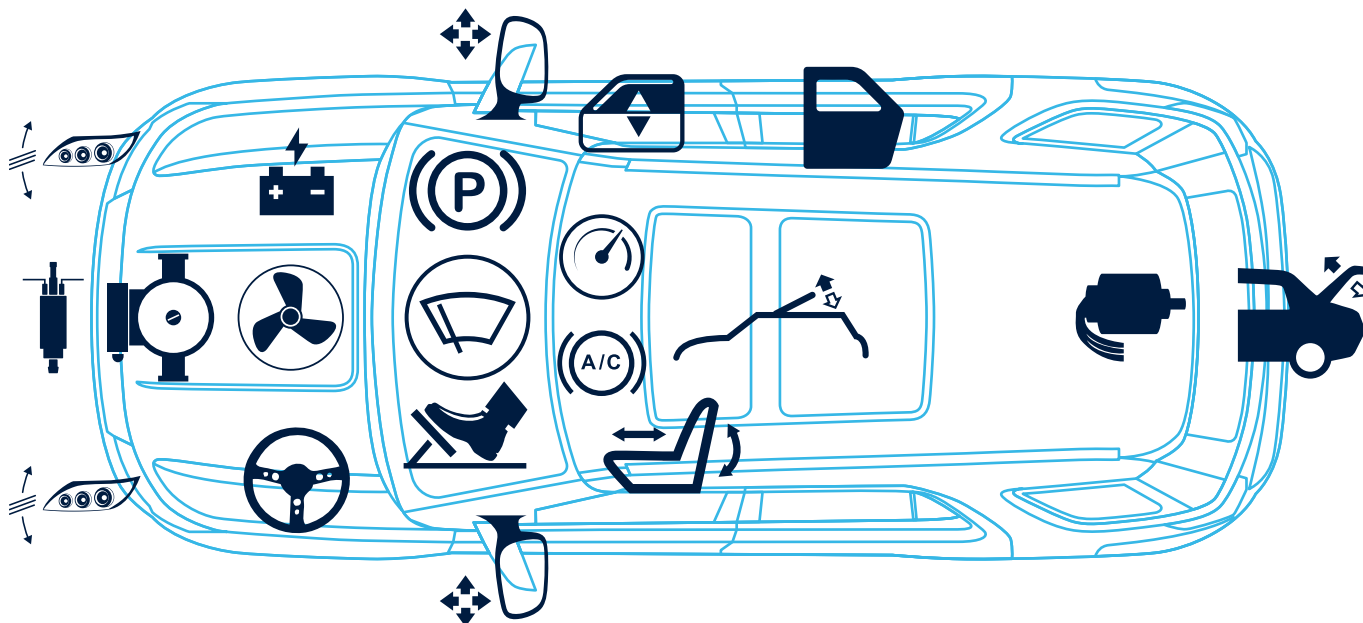
Developers will appreciate the broadest portfolio dedicated to Motor Control solutions for automotive applications.

Discover our leading-edge portfolio of Automotive-grade motor drivers that can control brushed and brushless DC motors as well as stepper motors.

~100

Motors can be present
in a premium vehicle

KEY APPLICATIONS



SOLUTIONS

ST's key functions and solutions for motor control include:

Fans	Transmission	Traction	Starter generator	Turbo charger	Electric pumps (water, oil, fuel)
Wipers	Seat positioning	Window lift	Door lock	Mirror	Head-up display
Car trunk	Electric parking brake	Turbo waste gate	Throttle valve	Sunroof	HVAC blower and flaps
Electric power steering	Brake booster	Active suspension	Analog gauges	Adaptive lighting	Idle actuator

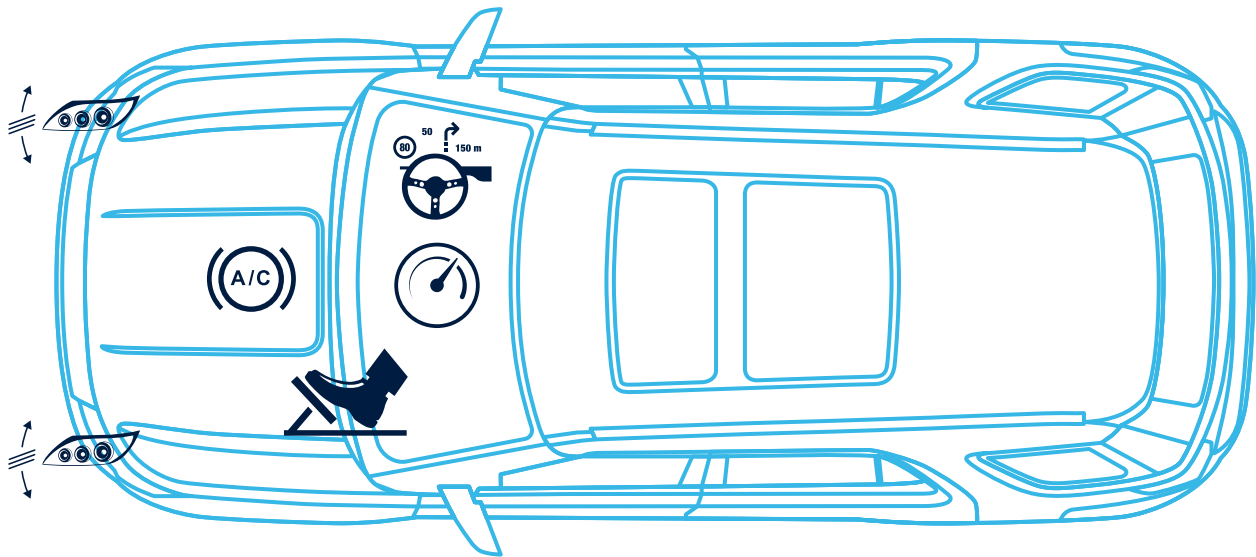


FIND OUT MORE

www.st.com/auto-motorcontrol

Automotive Bipolar Stepper Motor
Automotive BLDC Motor
Automotive Brushed DC Motor

Bipolar stepper motors for automotive



Adaptive
lighting

HVAC flaps

Head-up
display

Idle actuator

Analog gauges



FIND OUT MORE

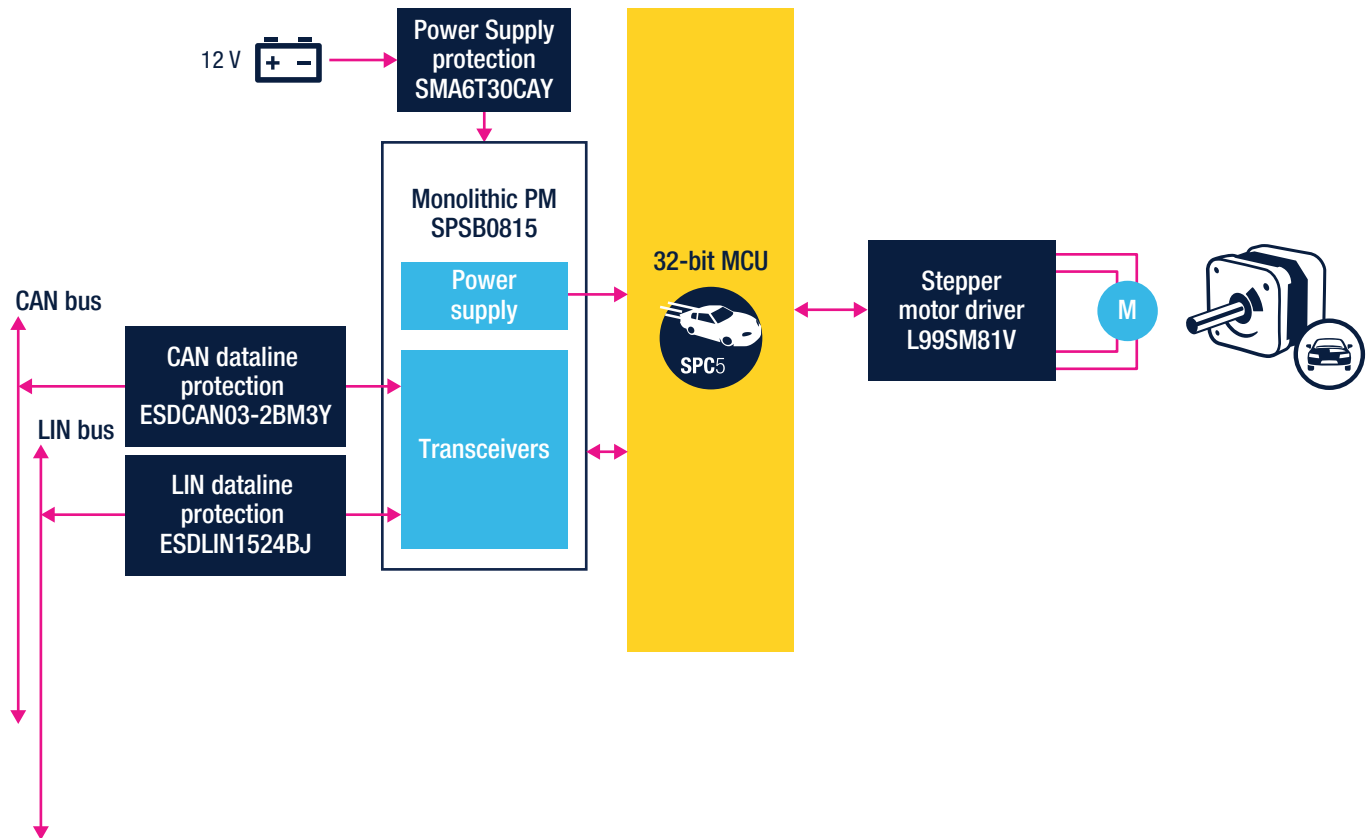
www.st.com/auto-bipolar-stepper

OVERVIEW

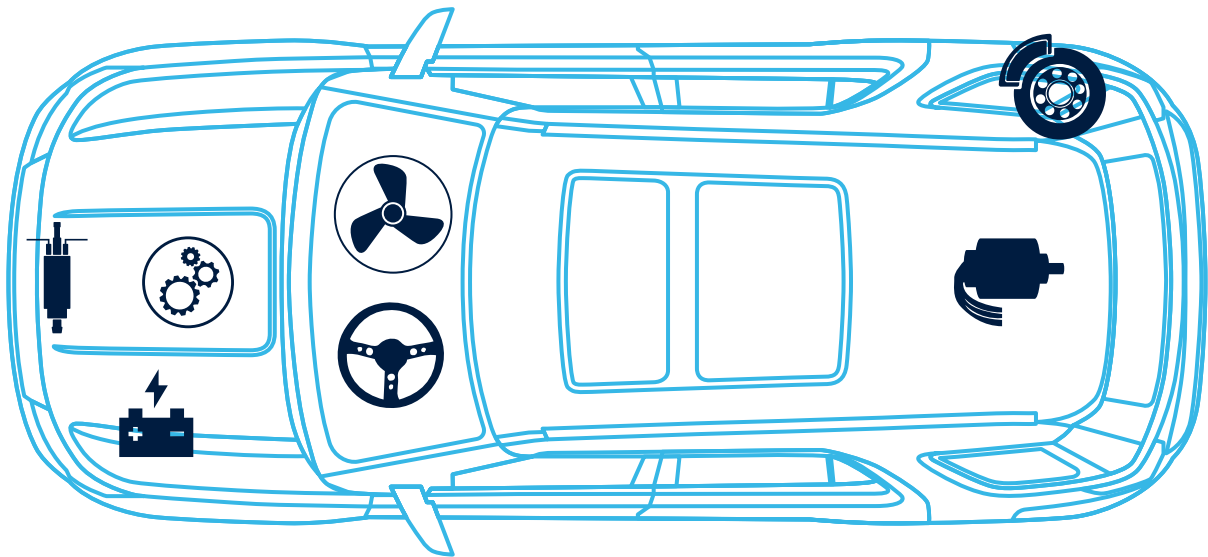
For headlight levelling/swivelling, climate-control flap adjustments or Head-up Display (HUD) positioning, a stepper motor is often the ideal and cost-effective choice for your design. Thanks to its operation mode, a stepper motor runs through a discrete number of positions, so it can then be driven to repeatedly move and hold at one of these steps.

ST offers the best-in-class solutions for stepper motor control, providing integrated drivers for bipolar two-phase stepper motors, capable of current controlled micro-stepping and embedding diagnostic features.

In addition, our SPC5 32-bit automotive microcontrollers are the perfect choice together with voltage regulators and ESD protection ICs to complete your bill of materials and start prototyping.



BLDC motors for automotive



Fans

Transmission

Traction

Starter
generator

Turbo charger

Fuel pump

Active
suspension

Power steering

Brake booster

HVAC blower



FIND OUT MORE

www.st.com/auto-bldc

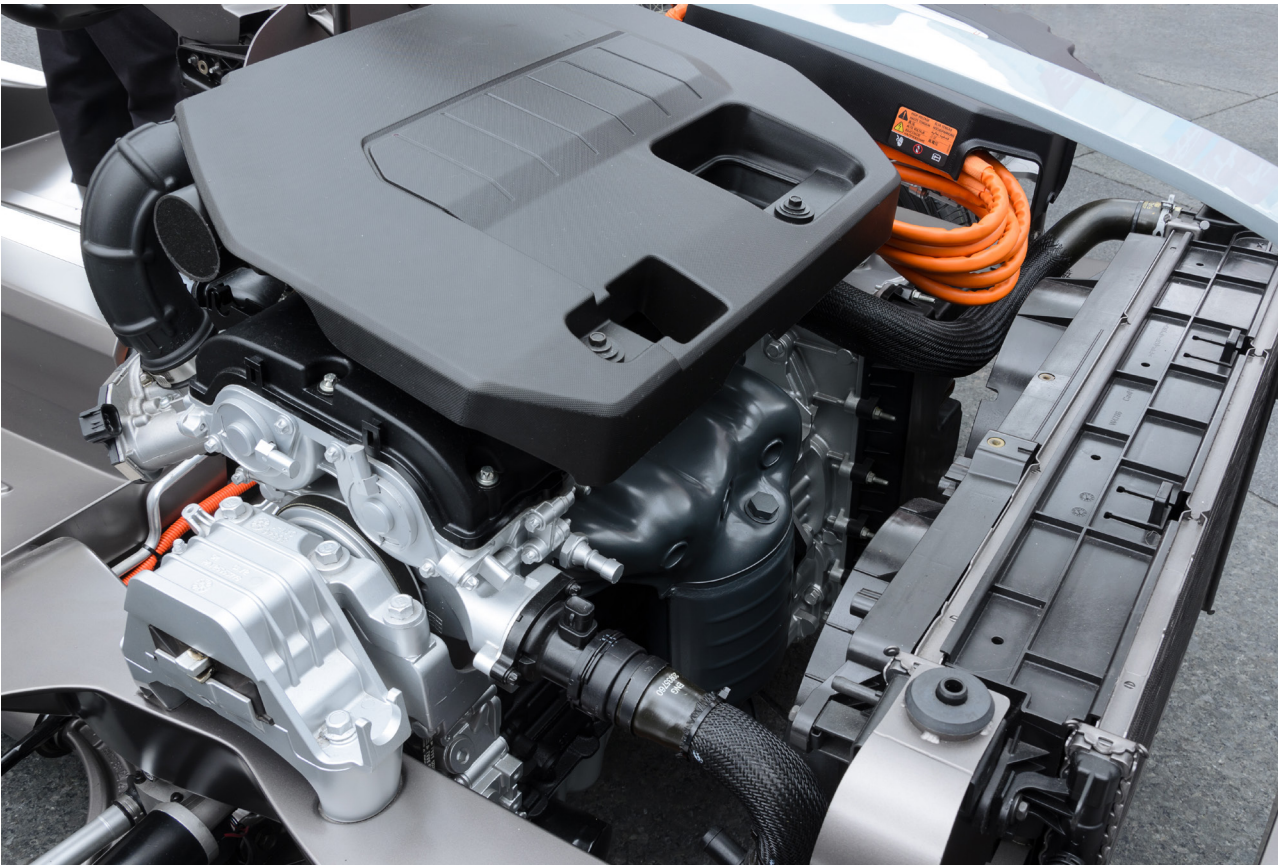


Figure 01: Traction Inverter

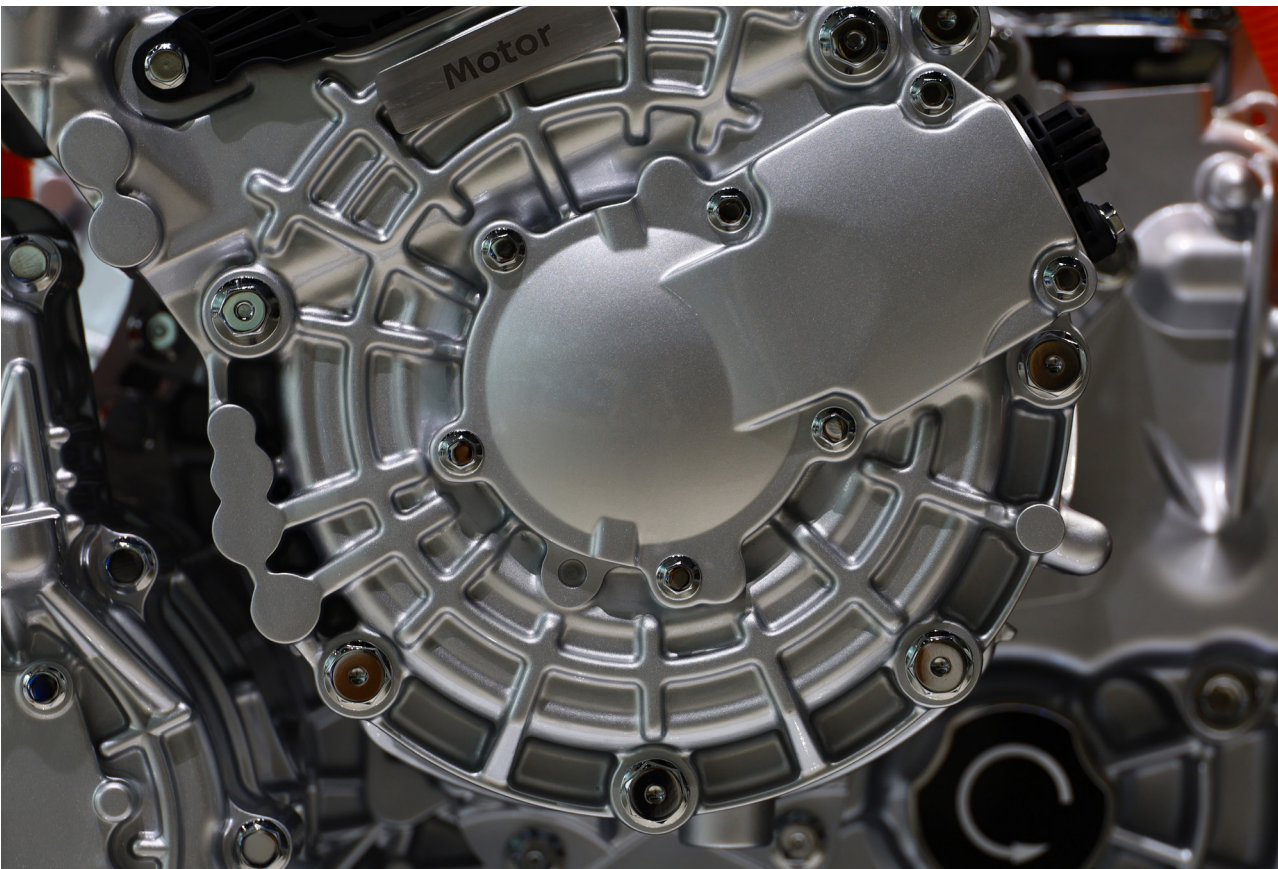
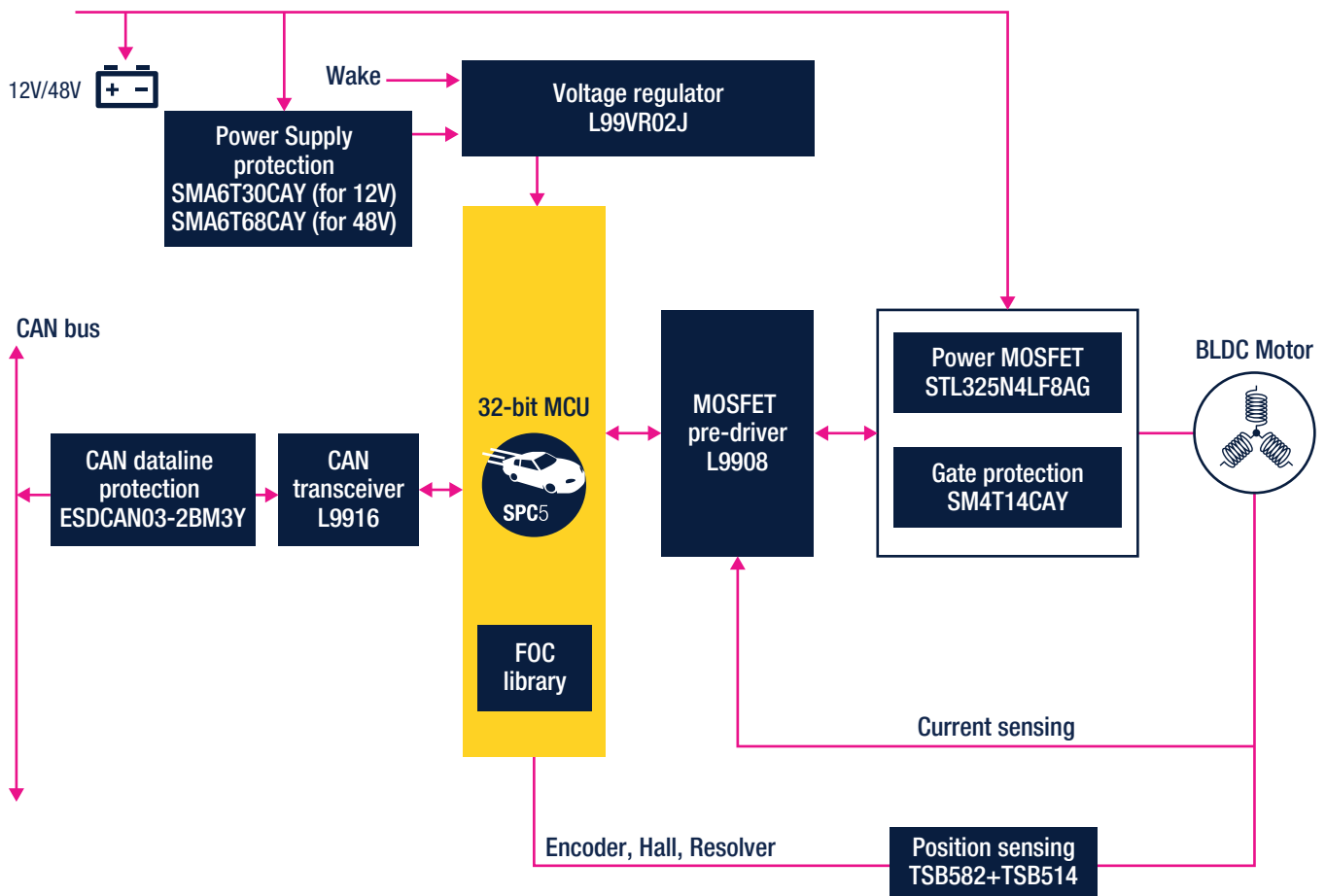


Figure 02: e-compressor

LOW-VOLTAGE BLDC MOTOR OVERVIEW

The use of BLDC motors is growing more and more, even pervading applications where only brushed DC motors were so far adopted. In fact BLDC motors offer certain advantages, such as better efficiency, lower electro-magnetic interference generation, quieter operation, and improved longevity so they seem to be the preferred solution for higher power loads and also for continuous loads. These usually require sophisticated control algorithms and therefore, higher computing power than for driving a brushed DC motor.

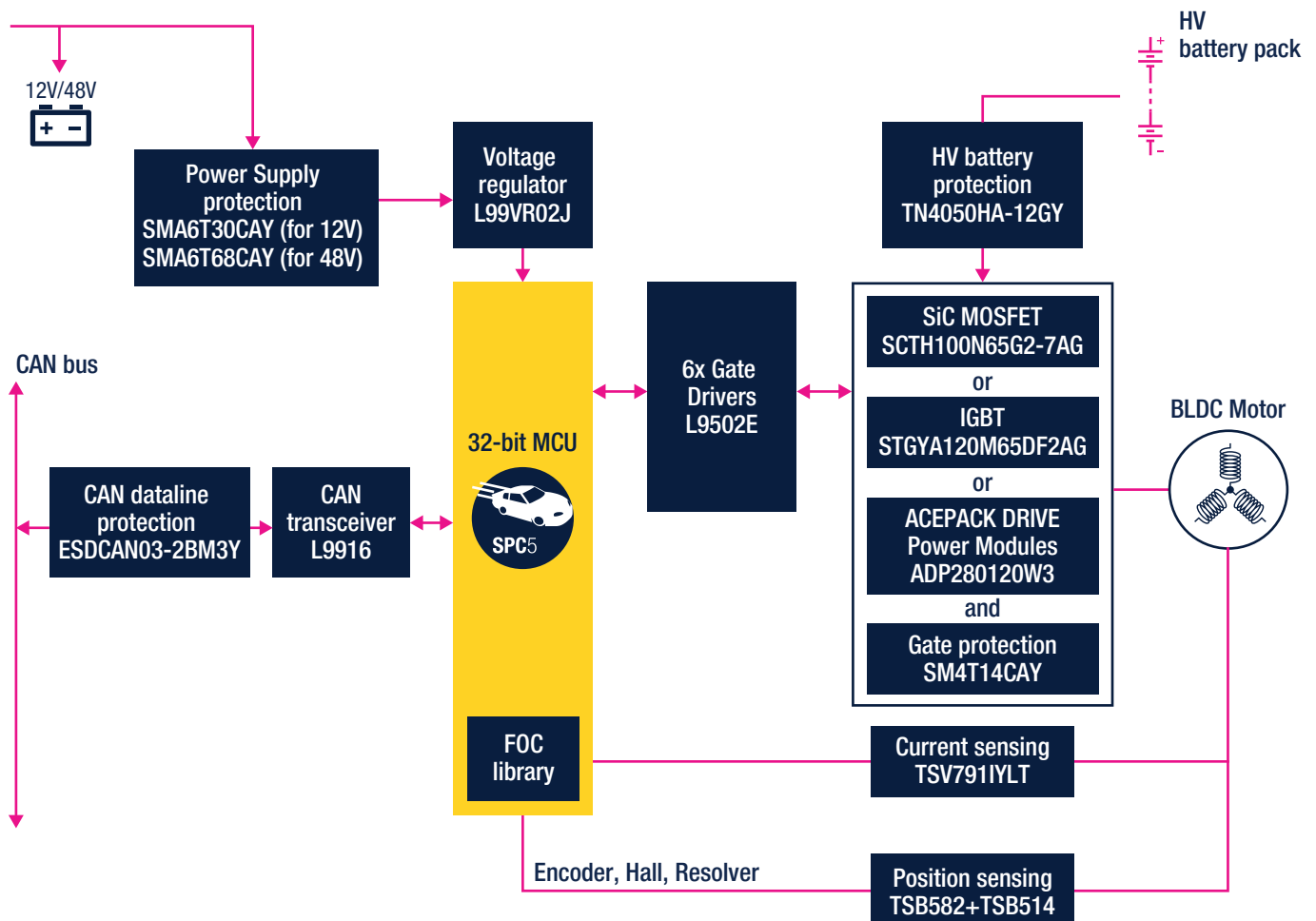
In the chassis domain, we find loads for active suspensions or power steering with a connection to 48V bus. For powertrains, we have many kind of motors that move different pumps (fuel, oil, and coolants) connected to 12V and even 48V supplies when dealing with cooler fans and turbochargers that require more power. For Mild Hybrid Vehicles, usually the 48V bus supplies the starter generator for assisting internal combustion engines. In the Body domain, we can also find BLDC motors driving HVAC blowers.



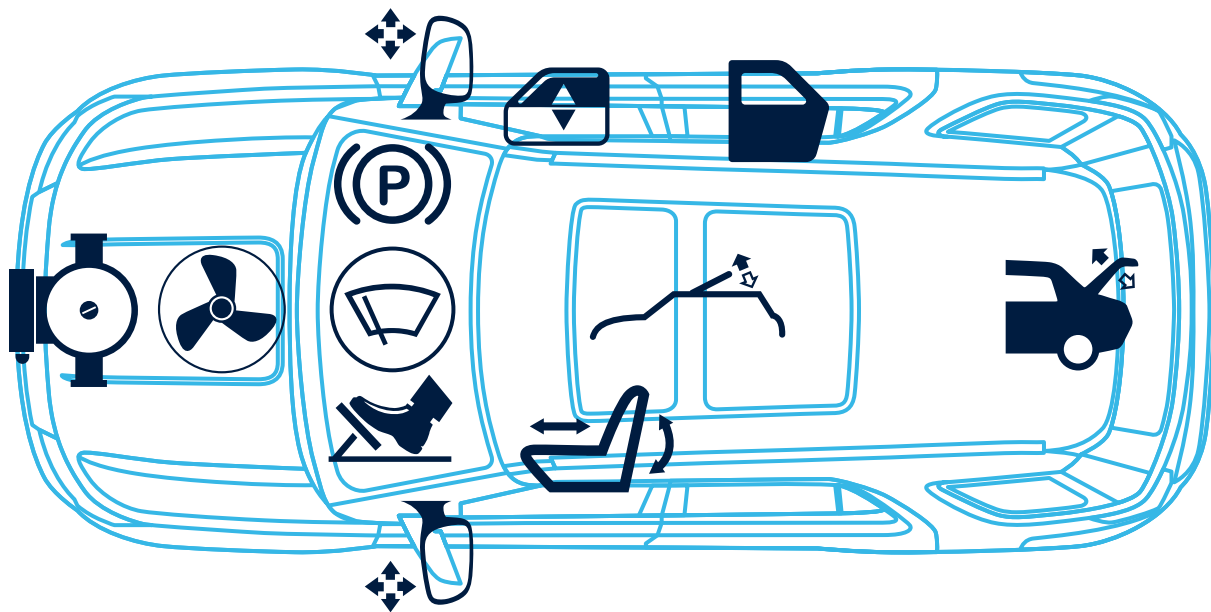
HIGH-VOLTAGE BLDC MOTOR OVERVIEW

The electric vehicle (xEV) segment requires compliance to even more stringent CO₂ emission requirements and safety features, leading to the electrification of systems for mild hybrid vehicles including starter generator (BSG) and e-turbocharger motors, to extremely efficient 3-phase inverters for full battery electric vehicles (BEV). For these applications, ST provides a comprehensive offer to support your BLDC motor control design.

From ISO 26262 ASIL-D compliant automotive "High Performance" SPC5 MCUs specifically designed for real-time applications to IGBT and SiC MOSFETs or integrated modules in innovative packages like ACEPACK DRIVE in addition to 3-phase gate drivers for 6-step/FOC controlled BLDC motors, ESD and TVS protections against transients or spikes. ST is the right partner for all automotive manufacturers and OEMs developing the most advanced and cost-effective motor control solutions.



Brushed DC motors for automotive



Wipers

Seat positioning

Window lift

Door lock

Mirrors

Fans

Washer pump

Car trunk

Electric parking
brake

Turbo waste
gate

Throttle valve

Sunroof

HVAC flaps

Electric power
steering

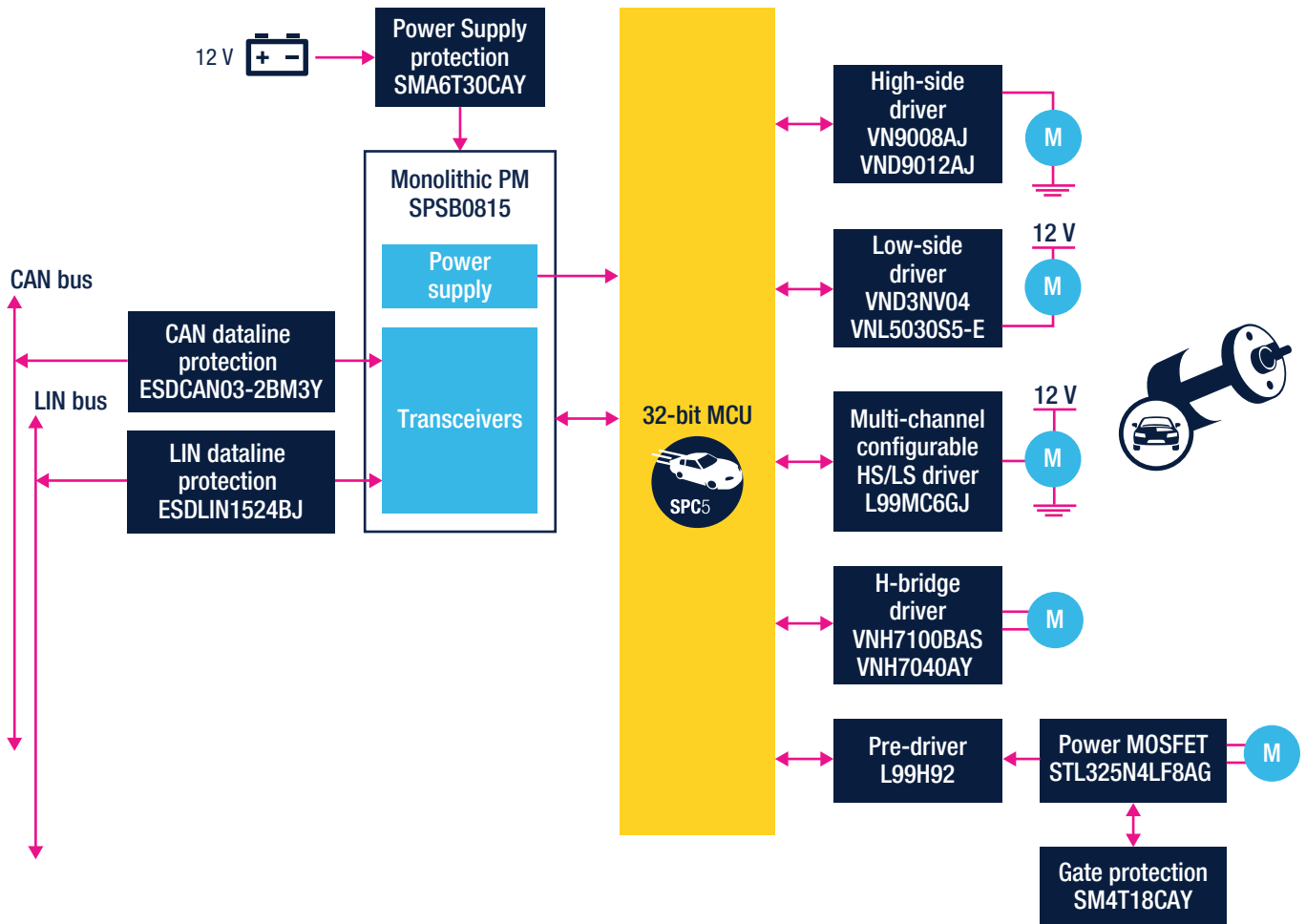


FIND OUT MORE

www.st.com/auto-brushed

BRUSHED DC MOTOR OVERVIEW

Brushed DC motors represent the perfect solution in automotive applications where short operating cycles are required. These internally-commutated motors are easy-to-drive components used in low-voltage applications ranging from trunk control and window lifts to seat positioning, door control, HVAC flaps, EGR, turbo waste gates and throttle valves.



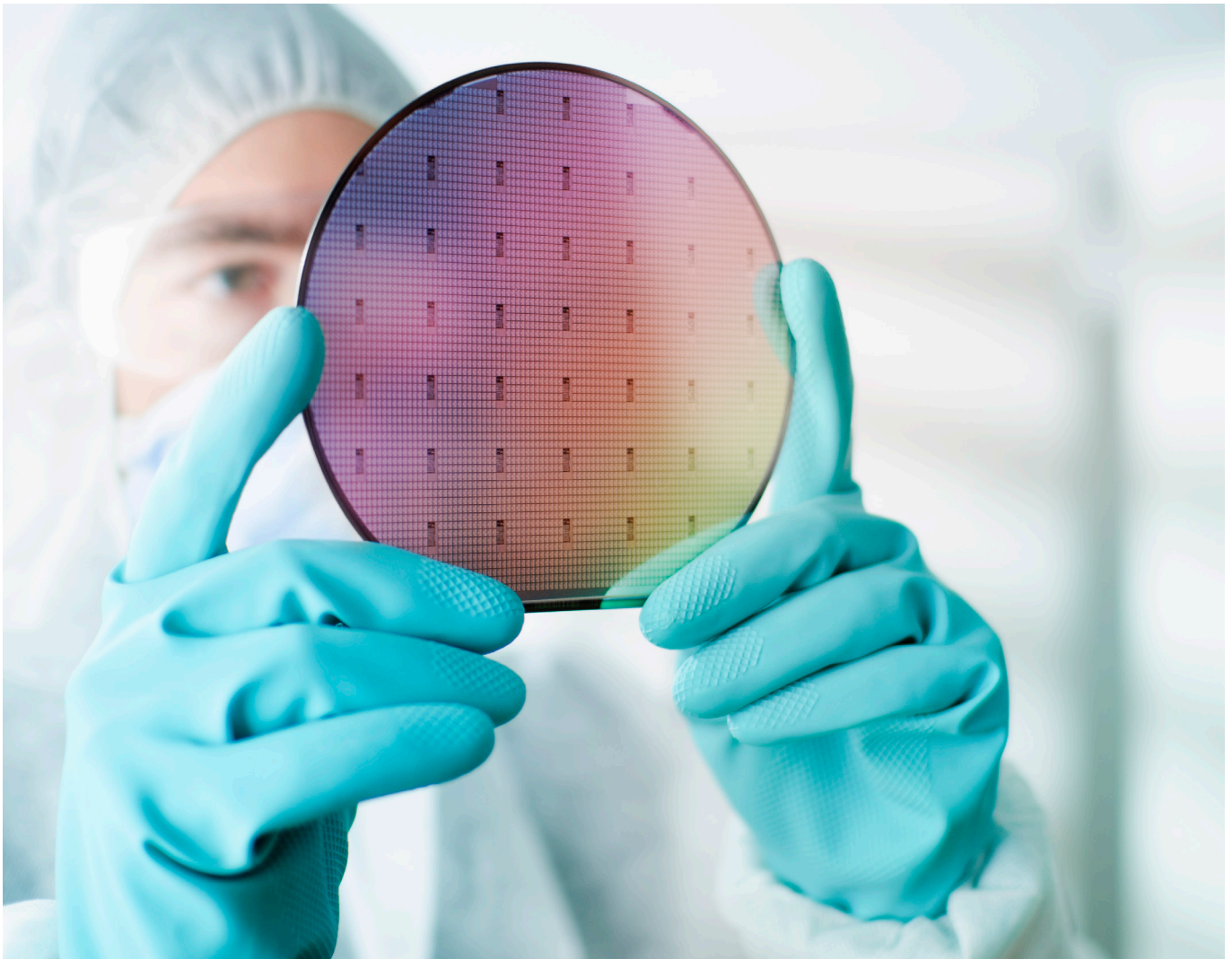
Key Technologies

RESEARCH & DEVELOPMENT AND MANUFACTURING

To keep its technology edge, ST maintains a strong commitment to innovation, with approximately 9,000 people working in R&D and product design and spending about 12% of its revenue in R&D. Among the industry's global technology leaders, ST owns and continuously refreshes a substantial patent library with over 19,500 active and pending patents. The company also uses its over 200 R&D partnerships to further foster its innovation.

ST draws on a rich pool of chip-manufacturing technologies, including advanced FD-SOI (Fully Depleted Silicon-on-Insulator) CMOS (Complementary Metal Oxide Semiconductor), differentiated Imaging technologies, RF-SOI (RF Silicon-On-Insulator), BiCMOS, BCD (Bipolar, CMOS, DMOS), Si MOSFET, SiC MOSFET, Si IGBT, VIPower, Transil, Trench Schottky Diodes, and MEMS technologies.

ST believes in the benefits of owning manufacturing facilities and operating them in close proximity to its R&D operations. ST has a worldwide network of front-end (wafer fabrication) and back-end (assembly and test and packaging) plants. ST's principal wafer fabs are located in Agrate Brianza and Catania (Italy), Crolles, Rousset, and Tours (France), and in Singapore. These are complemented by assembly-and-test facilities located in China, Malaysia, Malta, Morocco, the Philippines, and Singapore.



KEY TECHNOLOGIES FOR AUTOMOTIVE PRODUCTS

CMOS (Complementary Metal Oxide Semiconductor)

CMOS (Complementary Metal Oxide Semiconductor) is a pure digital technology invented in the 60's. It is largely used in digital products for processing purposes. Starting from CMOS, other technologies have been set up including BCD (Bipolar-CMOS-DMOS) used for mixed signal products, FD-SOI that allows to reduce silicon geometries below 28nm, and embedded NVM at the heart of MCUs. The robustness and versatility of this technology, present in billions of devices, makes it very suitable for all automotive applications.

FD-SOI / RF-SOI

Fully Depleted Silicon-on-Insulator, or FD-SOI, is a planar process technology that delivers the benefits of reduced silicon geometries while actually simplifying the manufacturing process. The buried oxide layer, specific to FD-SOI MOS, lowers the parasitic capacitances and efficiently confines the electrons flowing from the source to the drain, dramatically reducing performance degrading for leakage currents. This is a key advantage for pure digital products, especially when required to operate at high temperature, allowing very innovative power management techniques. The advanced ADAS platforms are based on this technology and produced in Crolles 300 facility on a 28nm node. Moreover, thanks to the tight electrostatic control of the transistor, FD-SOI is recognized as a leading technology for low-power, RF and millimeter-wave applications.

Associated with the high-density PCM embedded non-volatile memory, ST offers a unique platform for automotive applications.

Key applications include ADAS, RF switches and tuners, low-noise amplifiers, power amplifiers, monolithic integrated RF and FEMs (switches, LNAs, PAs and passives).

FD-SOI

NON-VOLATILE MEMORIES (eNVM)

ST has a strong background in non-volatile memories (NVM) and has developed embedded NVM technologies to enable real-time MCUs and other products that benefit from real-time access to NVM. Today, automotive volumes are at 90 nm and 40 nm technology nodes, and the new Stellar MCU family uses phase-change memory (PCM) to exploit the features of CMOS FD-SOI technology. This evolution to PCM places ST at the forefront of automotive MCUs.

ST standalone non-volatile memories (NVM) are also highly regarded in the industry, especially our automotive serial EEPROM, which is ideal for high-quality and flexible parameter storage, with a wide portfolio ranging from 1 Kbit to 4 Mbits. The automotive Serial EEPROM is robust, high-performance, and designed for intensive operation at high temperatures, making it suitable for all high-reliability applications. The EEPROM is AEC-Q100 qualified, screened through a specific high-reliability testing flow, and PPAP Level 3 compliant. The EEPROM is manufactured in 150 nm technology nodes and is progressively extending to 110 nm. The I²C, SPI, and Microwire buses are supported for three packages: SO8N, TSSOP8, and DFN8 up to 150°C.



BCD (BIPOLAR-CMOS-DMOS)

BCD (BIPOLAR-CMOS-DMOS) is a key technology for power ICs. BCD combines the strengths of three different process technologies onto a single chip: Bipolar for precise analog functions, CMOS (Complementary Metal Oxide Semiconductor) for digital design and DMOS (Double Diffused Metal Oxide Semiconductor) for power and high-voltage elements.

This combination of technologies brings many advantages: improved reliability, reduced electromagnetic interference and smaller chip area.

BCD has been widely adopted and continuously improved to address a broad range of products and applications in the fields of power management, analog data acquisition and power actuators.

VIPOWER

Vertical Intelligent Power (VIPOWER) is a technology developed by ST and in production since 1991. VIPOWER technology provides control, protection and diagnostics for medium/high power automotive loads. The technology combines Vertical Double Diffused MOS Power devices with their own temperature and current sensors and CMOS and HV components for power, analog, and mixed-signal designs.

VIPOWER technology plays a key role in the move towards electric vehicles. The smart 48 V networks used in mild- and full-hybrid cars require intelligent power switches to drive high- and low-sided loads and electric motors, with very low losses and high current sense accuracy, all monitored via the connections to the ECU microcontroller.

The new VIPOWER M0-9 SPI drivers feature full digital diagnostics with embedded ADC for load current sensing. These new devices implement sophisticated software logic that also simplifies AUTOSAR compliance.



Designed to replace standard melting fuses in automotive power distribution systems, our new STi²Fuse smart switches feature wire harness protection on top of the typical high-side driver functions for additional savings on component and production costs, while extending EV range and reducing the carbon footprint of vehicles.



STPOWER

Leading-edge power technologies for both high- and low-voltage applications combined with a full package range and innovative die bonding technologies exemplify ST's innovation in power transistors of the STPOWER family.

ST offers a wide portfolio of power AEC-Q101 qualified Power MOSFETs ranging from -80 to 1200 V, IGBTs with breakdown voltages ranging from 360 to 1200 V and power bipolar transistors ranging from 15 to 1700 V. The improved thermal design of ST's power electronics systems, and our silicon-carbide (SiC) MOSFETs ensure automotive robustness with the industry's highest temperature rating of 200 °C.

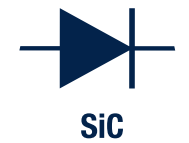
Our extensive STPOWER product portfolio combined with state-of-the-art packaging and protection solutions enable designers to create products with high reliability, efficiency and safety.



Silicon Carbide (SiC)

Silicon Carbide (SiC) is a wide bandgap material, with many advantages compared to silicon in the field of power electronics. Operating temperatures are higher, heat dissipation is improved and switching and conduction losses are lower, making it an ideal technology for vehicle electrification. SiC-based traction inverters can increase electric vehicle range and SiC-based chargers reduce the charge time.

ST produces the automotive grade SiC power devices, in Italy and Singapore front-end wafer fabs and is vertically integrating the entire process with the SiC Substrate fab in Italy to be the key enabler in the automotive industry for vehicle electrification.



Gallium Nitride (GaN)

The major challenge of power electronics today is to deal with the growing need for power and efficiency improvements and, at the same time, the constant pursuit of cost and size reduction. The introduction of wide bandgap (WBG) materials devices moves in this direction, thanks to their electrical features and considering that Si devices have achieved their theoretical limits with the increased switching frequency. Among the WBG semiconductors, Gallium Nitride (GaN) technology is increasing its importance and diffusion in power conversion applications, becoming at the same time also commercially available. GaN power devices have better figure-of-merit (FOM), $R_{DS(on)}$ than silicon counterparts: in fact, this technology shows low specific $R_{DS(on)}$ and leakage, a high breakdown voltage, zero reverse recovery charge and very low intrinsic capacitances. This leads to better efficiency, higher power density and increased maximum frequency in power converters.

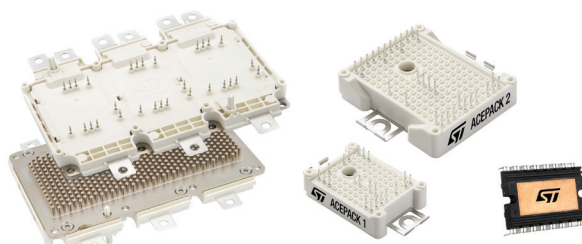


Power modules

Our highly-integrated and high-efficiency ACEPACK power modules, ensures flexible, compact and robust solutions, from few to hundreds of kilowatts, addressing different power converter stages for BEV/HEV, such as main traction inverter, OBC, DC/DC Converters and auxiliaries. Moreover, the very high-power density of the new ACEPACK modules allows to minimize system space occupation responding to the evolving needs of the market.

The ACEPACK power modules family, based on the ST SiC Power MOSFETs, offers wide product portfolio integrating this well-recognized technology. Thanks to their superior features in terms of electrical characteristics and thermal behavior, ACEPACK power modules guarantee a very low $R_{DS(on)}$ and delivers the best compromise between conduction and switching energies to maximize the efficiency of any converter system.

The power modules offer optimal thermal performance thanks to the active metal brazing or direct copper bonding technologies, ensuring higher thermal conductivity and guarantying a very low thermal resistance as well as a high electrical insulation. Moreover, thanks to the operative junction temperature, up to 175°C, a greater power dissipation can be achieved.



TRANSIL

TRANSIL is a key planar technology for our Automotive transient voltage suppressors (TVS) designed to protect automotive sensitive circuits against surges as defined in ISO 7637-2 and ISO 16750 also called load-dump (battery lines), ISO 7637-3 (data lines) and ESD as defined in ISO 10605. Protection is also provided against other perturbations generated by elements like ignition, relay contacts, alternators, injectors, SMPS, etc.

This technology is compatible with high-end circuits where low leakage current and high junction temperatures are required to provide reliability and stability over time.



Data line ESD protection

ST's automotive data line ESD protection devices include transient voltage suppressors (TVS) and application-specific discrete devices that provide system level protection against ESD surges according to standard IEC 61000-4-2. ESD protection devices are manufactured using automotive-grade processes and qualified to AEC-Q101 standards. As such, they can address all automotive applications and domains including advanced driver-assistance systems (ADAS), vehicle-to-everything (V2X), CAN-FD, SerDes (serializer/deserializer), and Ethernet Base-T standards to name just a few, in order to achieve immunity with the very low clamping voltage. Moreover, ST offers innovative, miniature wettable flank DFN packages to ease Automatic Optical Inspection (AOI).

A growing and diversified portfolio of MEMS and sensor solutions

Enabling the transition to a sustainable Onlife era, ST offers an extensive MEMS sensor portfolio based on more than 25 years of experience and innovation. Moreover, our new generation of MEMS sensors features an embedded intelligent sensor processing unit (ISPU) to help meet the challenges of incorporating AI into energy-saving Edge-based applications.



Our sensors offer three key attributes:

- Capable of directly processing the data they capture and delivering meaningful insights in the local device, smart sensors reduce transmitted data and cloud processing requirements, thus lowering power consumption at the system level.
- Able to interface with other sensor applications, our open sensors let third parties benefit from ST's in-sensor processing innovations, while building an ecosystem to jointly create value for customers.
- Providing high-precision data that allows better quality decisions and makes interactions smoother and more natural, our accurate sensors also reduce factory calibration time and resources, which also reduces energy needs.

To reduce design costs and effort for a more rapid time to market, our comprehensive ecosystem includes helpful developer resources with ready-to-use boards as well as software tools and real-life example code.

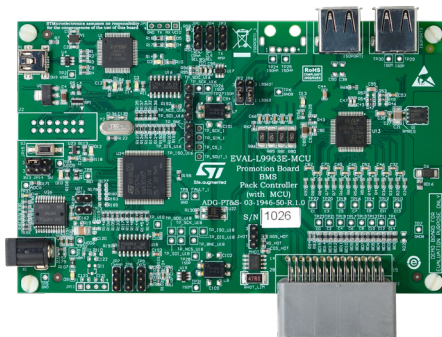
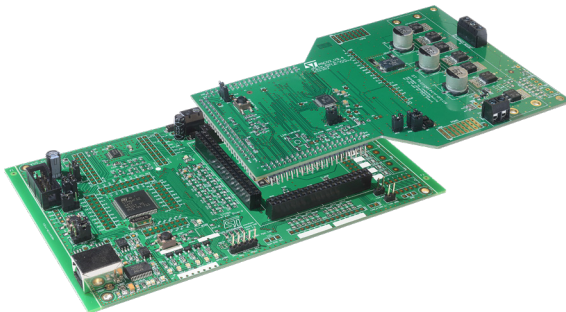
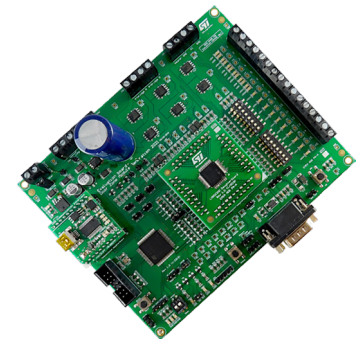
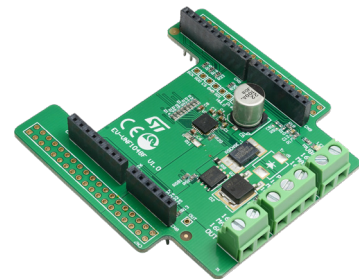
Development Tools

EVALUATION BOARDS, eDESIGN SUITE AND SOFTWARE TOOLS

ST provides a set of eDesign suites tuned to the needs of the Automotive Industry. Once the appropriate products have been selected, a wide range of samples and evaluation boards are available to help you get started and reduce your development times. In addition to boards, ST provide schematics, BOM and Gerber files to facilitate your hardware design and demonstration software packages are also available.

Evaluation kits

Product evaluation kits help you design, test, and calibrate your automotive application. A wide range of boards is available to evaluate the specific features of products and solutions in their applications. A complete set of documents and resources including circuit diagrams and bills of material as well as reference guides is available. Additional software including ready-to-use example code and user-friendly GUIs complete our offer.



FIND OUT MORE
www.st.com/automotive-evalboards

eDesignSuite

eDesignSuite is a comprehensive set of easy-to-use design-aid utilities ready to help you streamline the system development process with a wide range of ST products.



TwisterSIM

TwisterSIM is an off-line Electro-Thermal simulator for our VIPower automotive power devices. It helps shorten design solution cycle by enabling complex evaluations including load-compatibility, wiring harness optimization, fault condition impact and diagnostic behavior analysis and Dynamic Thermal performance.



STPOWER Studio

The STPOWER Studio dynamic electro-thermal simulation software offers comprehensive power and thermal analysis for a growing number of STPOWER devices. It helps users select the best power device for the specific application mission profile and predicts device behavior under given operating conditions.



Rectifier diode simulator

With just a few clicks our on-line FERD & Schottky diode simulator lets you estimate power losses based on application waveforms and select the best components for your solution.



AC switch simulator

Our AC switch simulator provides graphs of estimated temperature and voltage blocking capabilities to so you can quickly determine the best switch for your solution.



TVS simulator

Simply specify the the surge input waveform and system ratings to be protected and this intuitive simulator lets you sort and select the best TVS protection for your design.



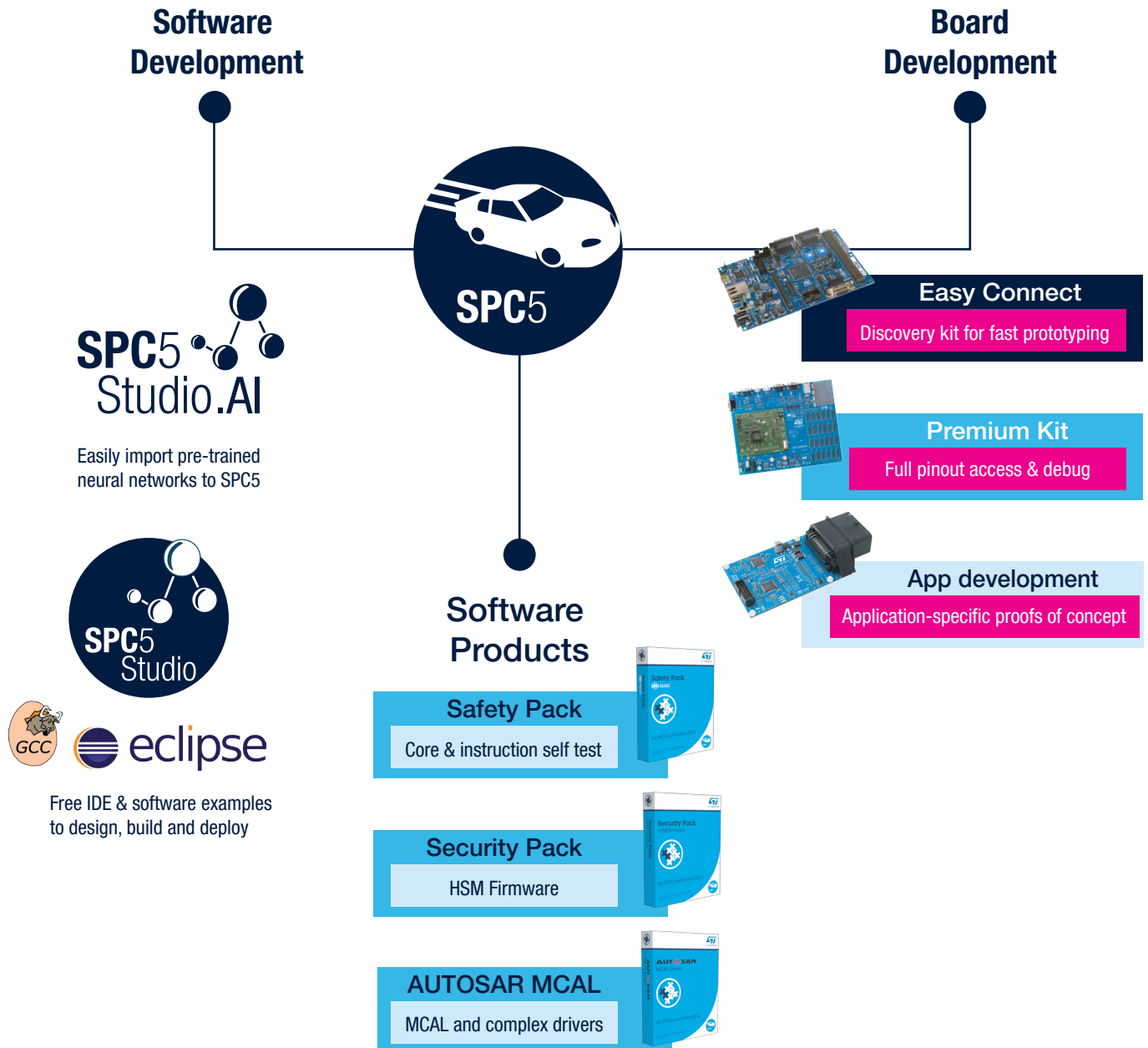
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www.st.com/edesign

COMPREHENSIVE SPC5 AUTOMOTIVE MCU DEVELOPMENT ECOSYSTEM

A rich ecosystem with a full set of hardware and software tools allows developers to save time, simplify implementation, quickly prototype their application and benefit from ready-to-use boards and example code. ST offers a wide set of hardware kits ranging from quick evaluation tools to modular and professional boards for developing final proofs-of-concept.

Together with free downloadable SPC5Studio Integrated Development Enviroments (IDE), engineers can easily set up application projects in a short time. SPC5Studio contains a wide selection of example code for starting projects. Additionally, ST offers a set of licensed software packs addressing Safety, Security and AUTOSAR MCAL components.

ST's network of 3rd parties and partners complement the offer with hardware, such as debugger probes, and software tools including compilers and other services.



FIND OUT MORE
www.st.com/auto-sp5-mcu-evaltools

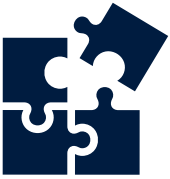
STELLARLINK FAST PROTOTYPING FOR AUTOMOTIVE MCUs

StellarLINK is a USB to JTAG passive debugger dongle for Automotive MCUs. It supports SR5, SR6, and SPC5 automotive microcontrollers and their evaluation boards. StellarLINK is Integrated into StellarStudio and SPC5Studio

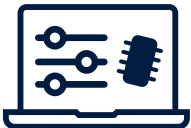
ST programmer & debugger



Supporting Stellar SR5, SR6, and SPC5 MCUs



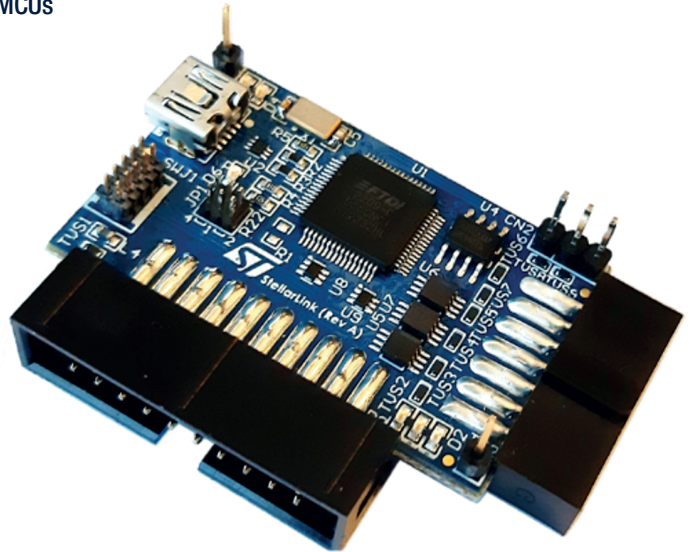
Plug & Play with evaluation boards



Extending Stellar & SPC5 ecosystem



Eco-friendly packaging



FIND OUT MORE

www.st.com/en/development-tools/stellarlink.html

SPC5 SOFTWARE TOOLS



SPC5Studio is a built-on Eclipse plug-in development environment offering a very intuitive and customizable framework to build and deploy embedded applications for SPC5 Power architecture 32-bit microcontrollers.

Integrating software development tools, device configuration tools and examples, SPC5Studio is a complete solution to speed up project development.

Available free for download on the [st.com](https://www.st.com) website.



SPC5Studio includes **SPC5Studio.AI**, a plug-in for Artificial intelligence-based applications, a seamless way to generate, execute and validate pre-trained NN models on automotive MCUs.

Pre-trained neural networks can be automatically generated into an efficient “ANSI C” library that can be compiled, installed and executed.

Pre-trained neural networks can be easily imported by SPC5Studio.AI from the most widely used deep learning frameworks, such as Keras, TensorFlow Lite, Lasagne, Caffe, ConvNetJS, and ONNX.

SOFTWARE PRODUCTS



SPC5 Security Pack provides basic capabilities to support root-of-trust (RoT) where private encryption keys are kept secret during the microcontroller lifetime using a dedicated location inside the OTP space. To further ensure application security, encryption and decryption functionalities are fully executed on the HSM core.



SPC5 Safety Pack is a comprehensive software package rigorously developed according to an ISO 26262-compliant development process, and helps developers achieve the required safety target, up to the most rigorous ASIL-D level. It includes a Safety kit for the Microcontroller Abstraction Layer (MCAL) as well as Core self-test programs that implement safety counter-measures to ensure compliance with MCU ASIL level requirements.



SPC5 AUTOSAR MCAL Driver offers a full set of Microcontroller Abstraction Layer software components in addition to Complex Device Drivers (CDD) to support specific hardware peripherals. MCAL software components are developed in house, through an ISO 26262-certified development process. ST's CDD and MCAL drivers are integrated by 3rd party partners with all the components required for the AUTOSAR architecture including basic software layer and OS, offering a complete off-the-shelf AUTOSAR solution.

ST Security Pack, Safety Pack and AUTOSAR MCAL Pack are licensed products.

AutoDevKit AUTOMOTIVE DEVELOPMENT INITIATIVE

AutoDevKit is a fast growing toolset for Automotive & Transportation Application Development. It allows design engineers to quickly build their prototype combining hardware, firmware and software in an easy way and fully supported by our community.

Our ecosystem offers a wide selection of Automotive MCU and devices covering several automotive applications:

- Battery management systems (BMS)
- Logistics and delivery robots
- AI on standard MCUs
- Internal and external lighting
- Power distribution
- Audio generation and AVAS
- Motor control: door control, side mirror, tailgate and seat adjustment
- HVAC, ventilation, and air quality
- USB type-C power delivery



Once the MCU platform and the functions needed for the application are selected, the developer can start from existing demo codes and customize them using high-level programming, without going into deep technical details.

The automatic pin configuration and the visual procedure enable an easy board assembling with the correct wiring and the embedded debug allows to get a working prototype quickly.

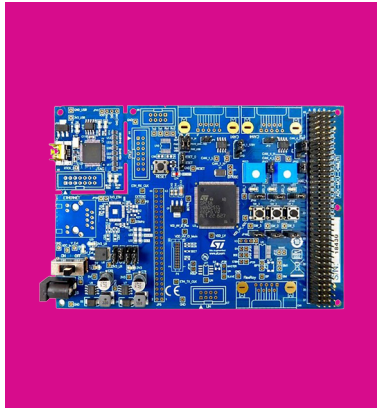


FIND OUT MORE
www.st.com/autodevkit

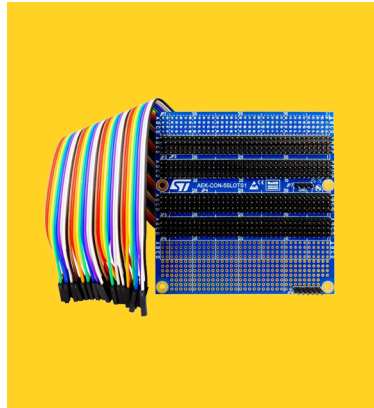
THE AUTODEVKIT ECOSYSTEM INCLUDES:

- MCU Discovery and Functional boards
- System solution and demonstrators
- Embedded software and firmware components and tools

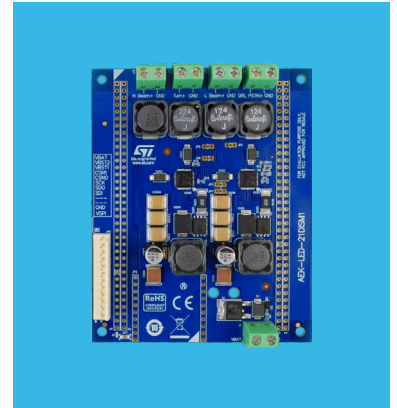
MCU Boards



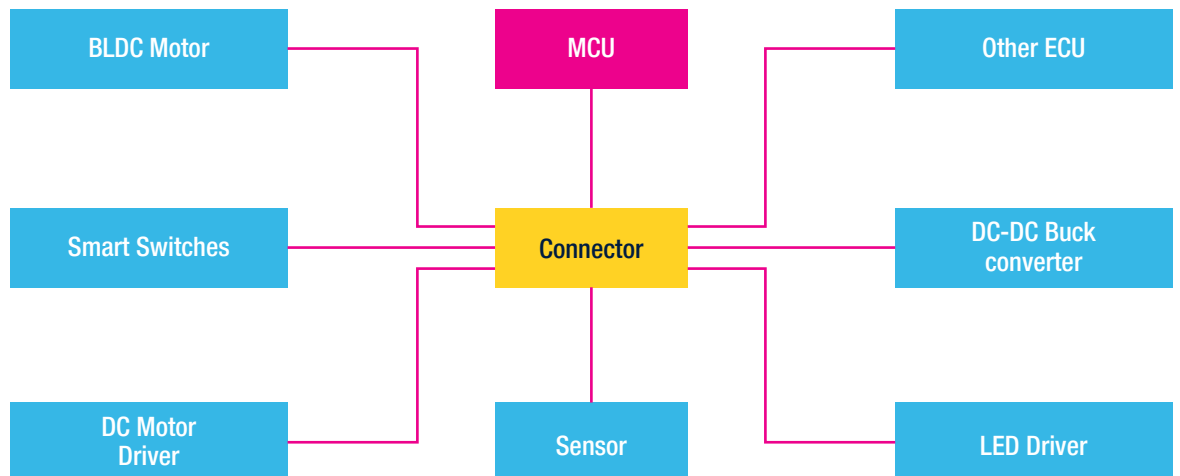
Connector Boards



Functional Boards



Solution /Demonstrator KIT



MCU + Connector + Functional boards