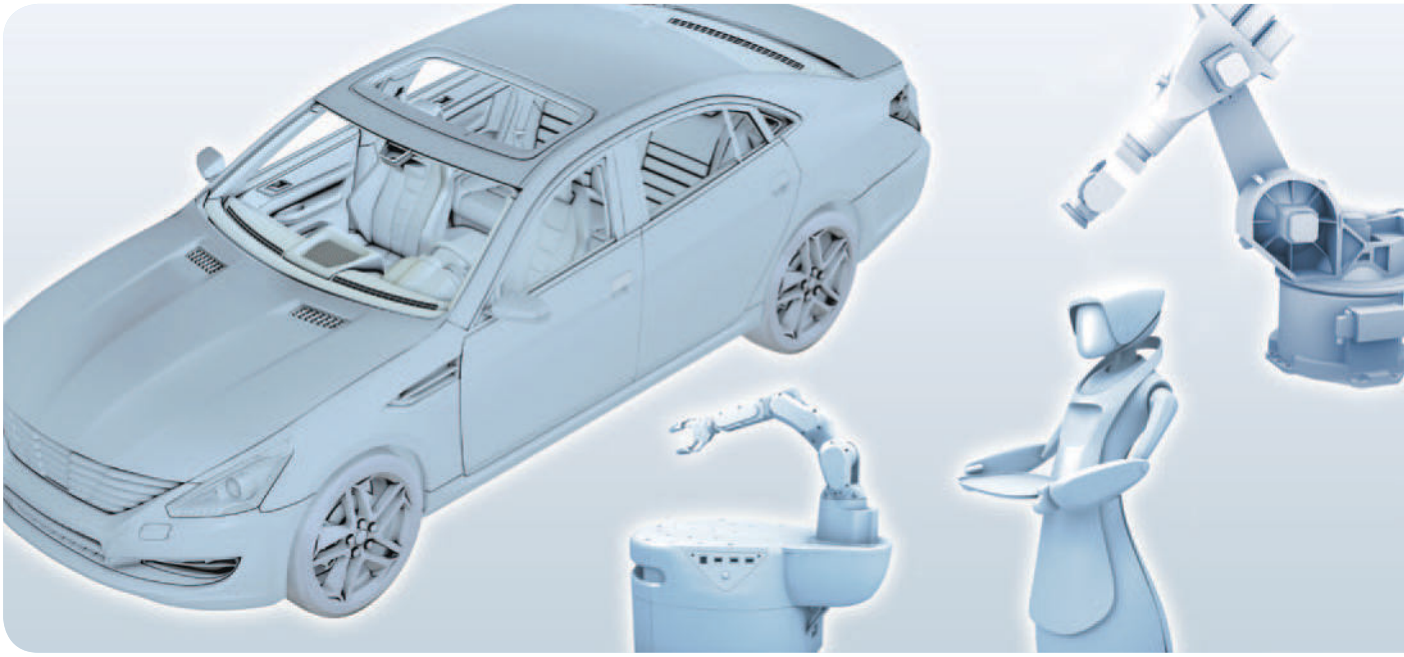
TDK

MICRONAS



Micronas Sensors and Motor Controllers

Hall sensors, current sensors, and embedded motor controllers

TDK's Sensor Portfolio

TDK's complete range of sensors, marketed under the product brands TDK, EPCOS, InvenSense, Micronas, and Tronics includes temperature sensors, pressure sensors, angle sensors, and current sensors.

All information about sensors and sensor systems can be found in the TDK Product Center on **product.tdk.com**.

Precise current sensors are indispensable for intelligent power in electric vehicles and smart grids. Temperature sensors and sensor systems are used to regulate the temperature of refrigerators and air-conditioning systems or to measure the temperature of operating fluids in motor vehicles, for example. Pressure sensors are used in a wide range of applications in automotive and industrial electronics, medical engineering, and environmental technology.

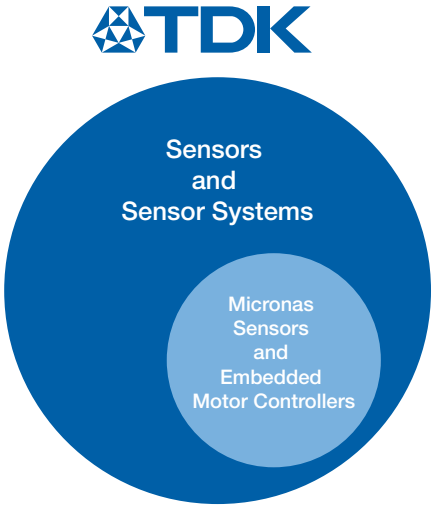
Motion-based devices detect and track an object's motion in three-dimensional space enabling key functions in many consumer electronic devices including mobile, wearable, Smart Home, and automotive and industrial devices. For high-performance requirements in motion sensing, TDK offers MEMS products, such as accelerometers and gyroscopes used in navigation, motion tracking and motion control, as well as optical stabilization.

Micronas Sensors and Embedded Motor Controllers
(shown in this catalog)

Magnetic-field sensors based on Hall-sensors can be found in almost any machine that needs to measure position, linear or rotational movement or even current.

Hall-effect sensors, current sensors, and embedded motor controllers are marketed under the product brand Micronas.

Analog and mixed-signal ASICs, also employed in TDK's magnetic sensors, are marketed under the product brand ICsense.



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Overview of Product Lines

Linear Hall Sensors

HAL 8 Product Family

- T_J = –40 to 170 °C
- TO92UT or TO92UP package
- Programmable (EEPROM)
- Proven-in-use quality
- Temperature stability

HAL 830
- Analog output

HAC 830
- Integrated Caps
- Analog output

HAL 835
- Analog and PWM output
- High accuracy

HAL 18 Product Family

- T_J = –40 to 170 °C
- TO92 package
- Ratiometric analog output
- Value optimized version (10 bit)

HAL 1870
- Programmable (EEPROM)
- PWM output

HAL 1880
- Programmable (EEPROM)

HAL 1881/82/83
- Pre-configured sensitivity (EEPROM)

HAL 1890
- Programmable (EEPROM)
- SENT output

HAL 24 Product Family

- T_J = –40 to 170 °C
- TO92 , SOIC8, or TSSOP14 package
- Programmable (EEPROM)
- On-board diagnostic features
- Versatility and high precision

HAL 2420/2421
- 2-point calibration
- Analog output

HAL 2425
- 2-point calibration
- 16 setpoints linearization
- Analog output

HAR 2425
- Dual-die version
- Analog output

HAL 2455
- 16 setpoints linearization
- PWM output

HAR 2455
- Dual-Die version
- PWM output

Direct-Angle Sensors

HAL 37 Product Family

- T_J = –40 to 170 °C
- SOIC8, TO92UP, or TO92UF package
- Superior accuracy
- Programmable characteristics in a non-volatile memory
- Diagnostic functions
- Measurement of angular and linear position

HAL 371x
- 12-bit analog or PWM modulo output

HAL 372x
- 12-bit analog output

HAL 373x
- PWM and SENT output

HAR 371x
- 12-bit analog or PWM modulo output
- Dual-die variant

HAR 372x
- 12-bit analog output
- Dual-die variant

HAR 373x
- PWM and SENT output
- Dual-die variant

HAR 379x
- PWM and SENT output
- Dual-die variant
- ISO 26262 ready

HAC 371x
- 12-bit analog or PWM/ SENT modulo output
- Integrated capacitors
- ISO 26262 ready

HAC 372x
- 12-bit analog output
- Integrated capacitors
- ISO 26262 ready

HAC 373x
- PWM and SENT output
- Integrated capacitors
- ISO 26262 ready

HAL 39 Product Family

- T_A = –40 to 160 °C
- SOIC8 package
- ASIL-B ready SEooC acc. to ISO 26262
- Stray field compensation for homogenous and gradient magnetic fields
- 3D position detection (linear movement, angle and position)
- Direct 12 V battery supply
- Programmable characteristics in a non-volatile memory

HAL 3900
- SPI interface
- Position and B_X, B_Y, B_Z

HAL 3930
- PWM/SENT/Switch interface
- Up to two angles

HAL 3970
- SPC interface

HAL 3980
- PSI5 Rev. 2.x interface
- Angle and angle velocity

Hall Switches

HAL 1002 Switch

- Open-drain output (3-wire)
- Chopper stabilized
- Highly precise customer-programmable switching points
- T_J = –40 °C to 170 °C
- TO92UT package

HAL 15 Switch Family

- Open-drain output (3-wire) or current output (2-wire)
- Chopper stabilized
- Wide range of highly precise switching points
- T_J = –40 to 170 °C
- SOT23 and TO92UA package

Embedded Motor Controllers

HVC 42/44 Product Family

- T_J = –40 up to 160 °C
- QFN40 package, 6x6 mm
- All-in-one flexible integration of entire embedded Motor Control IPs
- Communication via e.g. UART, SPI, LIN2.x
- Dual Mode Supply Voltage: 5.4 V to 18 V, 40 V load dump fulfillment of Automotive OEM requirement specifications
- Internal Half-Bridges with charge pump up to 3 × 600 mA steady current,1000 mA amplify current

HVC 4222F
- 2 KB SRAM, 32 KB Flash
- T_A up to 150 °C

HVC 4223F
- 2 KB SRAM, 32 KB Flash
- T_A up to 125 °C

HVC 4420F
- 4 KB SRAM, 64 KB Flash
- T_A up to 125 °C

HVC 4422F
- 4 KB SRAM, 64 KB Flash
- T_A up to 150 °C

Magnetic Current Sensors

CUR 40 Product Family

- High-precision contactless and linear current sensor
- Programmable
- Output: Ratiometric analog, SPI
- T_A = –40 °C to 150 °C
- SOIC8 package

CUR 4000
- Magnetic Flux Range: ±100 mT

Introduction to Hall-Effect Sensors

The Hall effect was named after its discoverer, the American physicist Edwin Herbert Hall. A Hall sensor detects magnetic fields perpendicular to a current-carrying conductor, creating an electrical voltage across the current flow direction. There are many possible applications of this physical principle allowing the strength of an external magnetic field to be determined and measured. Current measurements are possible as each conductor through which current flows creates its own a magnetic field which can be used to indirectly measure the current. Since the Hall effect is most pronounced in semiconductors, typically a small plate of semiconductor material is used as the Hall element.

In a semiconductor die, the Hall voltage is generated by an external magnetic field acting perpendicular to the current direction. Hall sensors measure the component of the magnetic flux perpendicular to the chip surface.

In today's Hall sensors, the required evaluation electronics is normally integrated on the chip together with the Hall plate. Field lines that penetrate the Hall element vertically generate a proportional electrical voltage, which is processed by a digital signal processor and converted into a usable output format.

The first CMOS-based Hall sensors were pioneered and developed by what is now TDK-Micronas in the early 1990s. As the manufacturing process became cheaper, the ICs could be better integrated, allowing the design of more complex circuits. Now, digital and analog functions are combined on the same chip as mixed-signal integrated circuits.

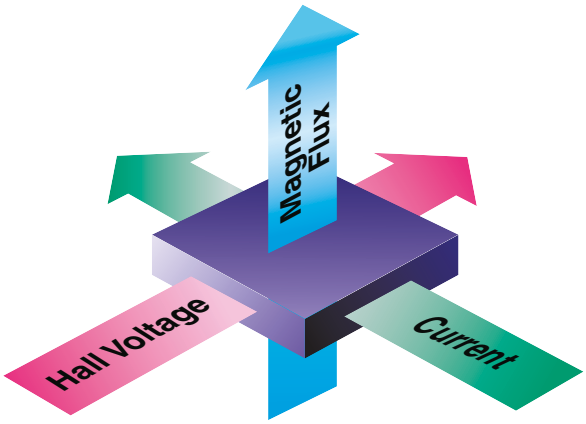
Hall sensors process very low signal voltages and are therefore prone to offset drifts that can occur as a result of temperature and voltage fluctuations, as well as mechanical stress. To combat this, the active offset compensation limits the offset to only a few µV over the entire operating temperature. EMC robustness and voltage stability of the circuit was also improved. The result is a complete CMOS Hall sensor system that includes on-chip signal processing and nonvolatile memory integration.

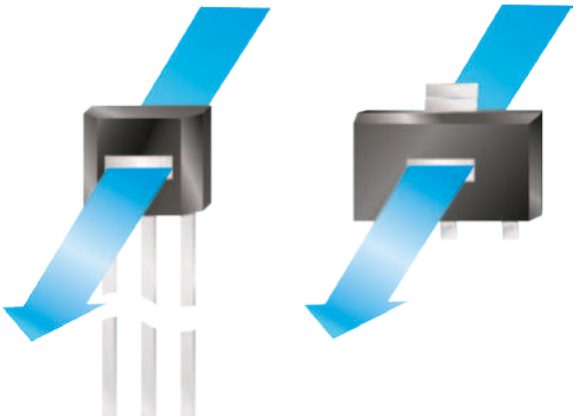
In addition, by using both vertical and horizontal Hall elements, high-precision angle sensors and multidimensional magnetic field measurements are now possible: Vertical Hall elements detect magnetic field lines parallel to the sensor surface, while the horizontal Hall elements detect the vertical component impinging on the chip surface. This is crucial for use in the automotive industry which requires tighter integration and EMC optimization of components in automotive designs. Such sensors with integrated blocking capacitors must meet the functional safety requirements of ISO 26262. In safety-critical applications, high reliability can be achieved with the help of the redundancy principle by means of two independent semiconductor chips in a single package.

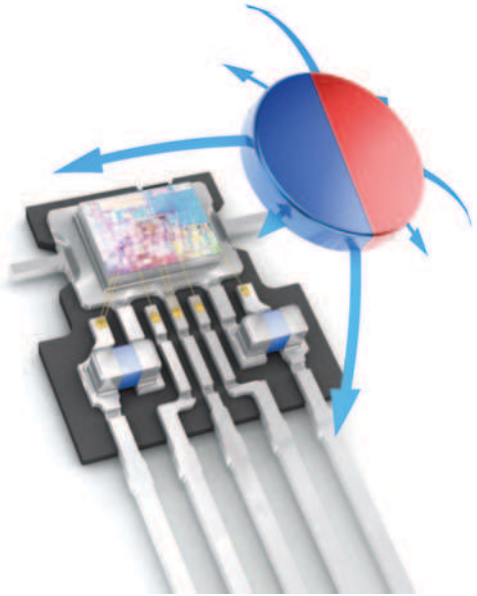
Introduction to Hall-Effect Sensors

CMOS Hall sensors feature cost-effective monolithic integration of Hall element and evaluation circuit on a single chip.

This makes them suitable for cost-sensitive applications or for detecting stronger magnetic fields.







Suggested Automotive Applications (Combustion Engine

Pedal Position

Gear Shift Position

BLDC Motor Commutation

Throttle Valve

Adaptive Suspension System



Seat Position Detection

Seat-Belt Presence Detection

Motor Control / Rotor Position

Steering Motor Position

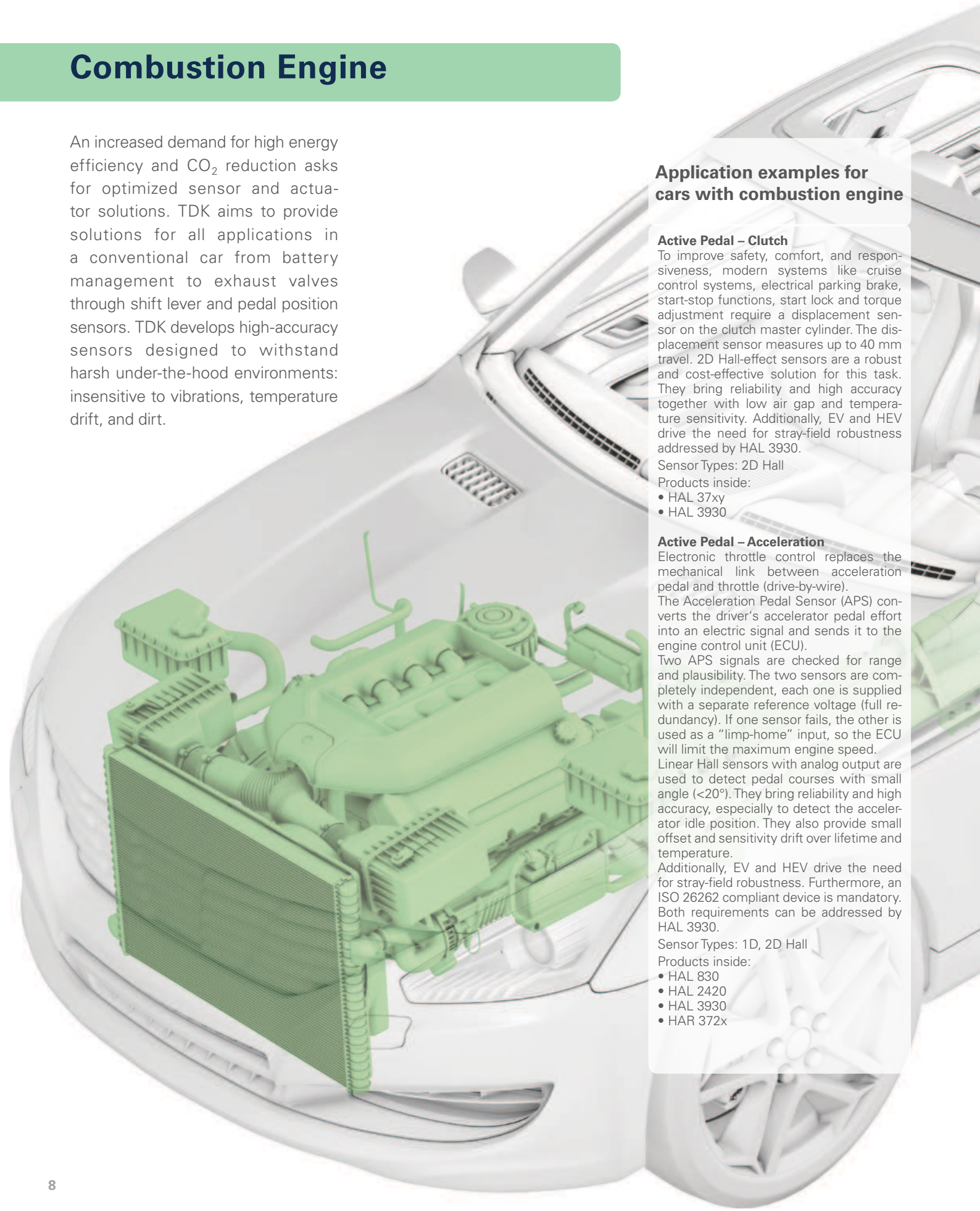
and/or Electric Drive) with Micronas Products



Automotive Applications

Combustion Engine

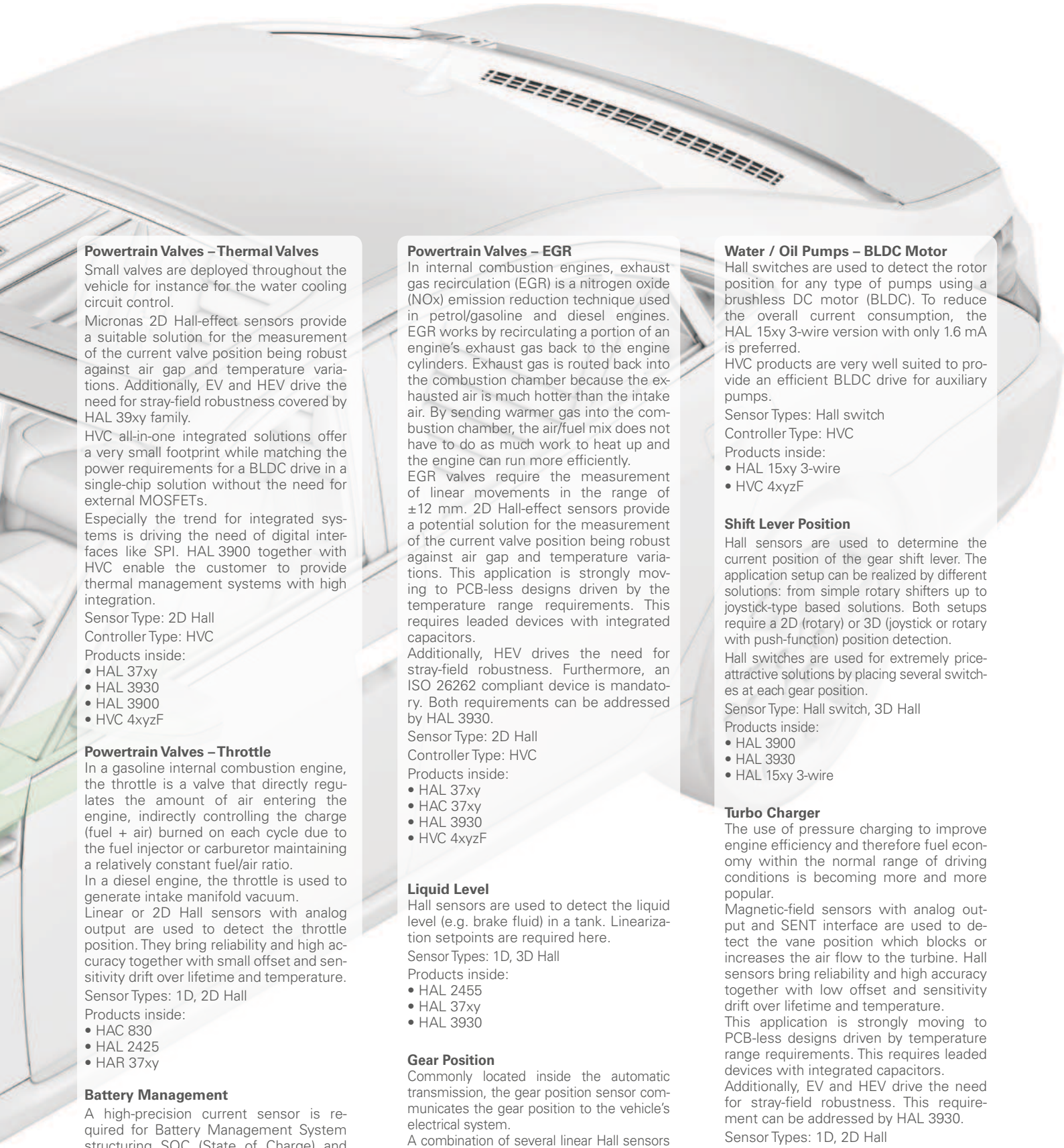
An increased demand for high energy efficiency and CO_2 reduction asks for optimized sensor and actuator solutions. TDK aims to provide solutions for all applications in a conventional car from battery management to exhaust valves through shift lever and pedal position sensors. TDK develops high-accuracy sensors designed to withstand harsh under-the-hood environments: insensitive to vibrations, temperature drift, and dirt.



Application examples for cars with combustion engine

Active Pedal – Clutch
To improve safety, comfort, and responsiveness, modern systems like cruise control systems, electrical parking brake, start-stop functions, start lock and torque adjustment require a displacement sensor on the clutch master cylinder. The displacement sensor measures up to 40 mm travel. 2D Hall-effect sensors are a robust and cost-effective solution for this task. They bring reliability and high accuracy together with low air gap and temperature sensitivity. Additionally, EV and HEV drive the need for stray-field robustness addressed by HAL 3930.
Sensor Types: 2D Hall
Products inside:
- HAL 37xy
- HAL 3930

Active Pedal – Acceleration
Electronic throttle control replaces the mechanical link between acceleration pedal and throttle (drive-by-wire).
The Acceleration Pedal Sensor (APS) converts the driver's accelerator pedal effort into an electric signal and sends it to the engine control unit (ECU).
Two APS signals are checked for range and plausibility. The two sensors are completely independent, each one is supplied with a separate reference voltage (full redundancy). If one sensor fails, the other is used as a "limp-home" input, so the ECU will limit the maximum engine speed.
Linear Hall sensors with analog output are used to detect pedal courses with small angle (<20°). They bring reliability and high accuracy, especially to detect the accelerator idle position. They also provide small offset and sensitivity drift over lifetime and temperature.
Additionally, EV and HEV drive the need for stray-field robustness. Furthermore, an ISO 26262 compliant device is mandatory. Both requirements can be addressed by HAL 3930.
Sensor Types: 1D, 2D Hall
Products inside:
- HAL 830
- HAL 2420
- HAL 3930
- HAR 372x



Powertrain Valves – Thermal Valves

Small valves are deployed throughout the vehicle for instance for the water cooling circuit control.

Micronas 2D Hall-effect sensors provide a suitable solution for the measurement of the current valve position being robust against air gap and temperature variations. Additionally, EV and HEV drive the need for stray-field robustness covered by HAL 39xy family.

HVC all-in-one integrated solutions offer a very small footprint while matching the power requirements for a BLDC drive in a single-chip solution without the need for external MOSFETs.

Especially the trend for integrated systems is driving the need of digital interfaces like SPI. HAL 3900 together with HVC enable the customer to provide thermal management systems with high integration.

Sensor Type: 2D Hall

Controller Type: HVC

Products inside:
- HAL 37xy
- HAL 3930
- HAL 3900
- HVC 4xyzF

Powertrain Valves – Throttle

In a gasoline internal combustion engine, the throttle is a valve that directly regulates the amount of air entering the engine, indirectly controlling the charge (fuel + air) burned on each cycle due to the fuel injector or carburetor maintaining a relatively constant fuel/air ratio.
In a diesel engine, the throttle is used to generate intake manifold vacuum.
Linear or 2D Hall sensors with analog output are used to detect the throttle position. They bring reliability and high accuracy together with small offset and sensitivity drift over lifetime and temperature.

Sensor Types: 1D, 2D Hall

Products inside:
- HAC 830
- HAL 2425
- HAR 37xy

Battery Management

A high-precision current sensor is required for Battery Management System structuring SOC (State of Charge) and SOH (State of Health) estimation. Hall-based magnetic-field sensors enable current measurements with high sensitivity and high accuracy in high-power applications with low output voltage drifts over temperature and a multiple magnetic-field range. The galvanically isolated power and sensing circuits are of particular benefit in 12/48 V battery monitoring and start-stop systems.

Sensor Types: Current, 1D Hall

Products inside:
- CUR 4000
- HAL 2425

Powertrain Valves – EGR

In internal combustion engines, exhaust gas recirculation (EGR) is a nitrogen oxide (NOx) emission reduction technique used in petrol/gasoline and diesel engines. EGR works by recirculating a portion of an engine's exhaust gas back to the engine cylinders. Exhaust gas is routed back into the combustion chamber because the exhausted air is much hotter than the intake air. By sending warmer gas into the combustion chamber, the air/fuel mix does not have to do as much work to heat up and the engine can run more efficiently.
EGR valves require the measurement of linear movements in the range of ±12 mm. 2D Hall-effect sensors provide a potential solution for the measurement of the current valve position being robust against air gap and temperature variations. This application is strongly moving to PCB-less designs driven by the temperature range requirements. This requires leaded devices with integrated capacitors.
Additionally, HEV drives the need for stray-field robustness. Furthermore, an ISO 26262 compliant device is mandatory. Both requirements can be addressed by HAL 3930.

Sensor Type: 2D Hall

Controller Type: HVC

Products inside:
- HAL 37xy
- HAC 37xy
- HAL 3930
- HVC 4xyzF

Liquid Level

Hall sensors are used to detect the liquid level (e.g. brake fluid) in a tank. Linearization setpoints are required here.

Sensor Types: 1D, 3D Hall

Products inside:
- HAL 2455
- HAL 37xy
- HAL 3930

Gear Position

Commonly located inside the automatic transmission, the gear position sensor communicates the gear position to the vehicle's electrical system.
A combination of several linear Hall sensors (up to six) is deployed in each transmission. Recent developments use 2D position sensors as well. Analog or PWM output is required. Linearization setpoints are needed depending on the travel distance to measure. Functional safety requirements drive the need for digital output formats like SENT.

Sensor Types: 1D, 2D Hall

Products inside:
- HAL 188x
- HAL 85x
- HAL 3930

Water / Oil Pumps – BLDC Motor

Hall switches are used to detect the rotor position for any type of pumps using a brushless DC motor (BLDC). To reduce the overall current consumption, the HAL 15xy 3-wire version with only 1.6 mA is preferred.
HVC products are very well suited to provide an efficient BLDC drive for auxiliary pumps.

Sensor Types: Hall switch

Controller Type: HVC

Products inside:
- HAL 15xy 3-wire
- HVC 4xyzF

Shift Lever Position

Hall sensors are used to determine the current position of the gear shift lever. The application setup can be realized by different solutions: from simple rotary shifters up to joystick-type based solutions. Both setups require a 2D (rotary) or 3D (joystick or rotary with push-function) position detection.

Hall switches are used for extremely price-attractive solutions by placing several switches at each gear position.

Sensor Type: Hall switch, 3D Hall

Products inside:
- HAL 3900
- HAL 3930
- HAL 15xy 3-wire

Turbo Charger

The use of pressure charging to improve engine efficiency and therefore fuel economy within the normal range of driving conditions is becoming more and more popular.
Magnetic-field sensors with analog output and SENT interface are used to detect the vane position which blocks or increases the air flow to the turbine. Hall sensors bring reliability and high accuracy together with low offset and sensitivity drift over lifetime and temperature.
This application is strongly moving to PCB-less designs driven by temperature range requirements. This requires leaded devices with integrated capacitors.
Additionally, EV and HEV drive the need for stray-field robustness. This requirement can be addressed by HAL 3930.

Sensor Types: 1D, 2D Hall

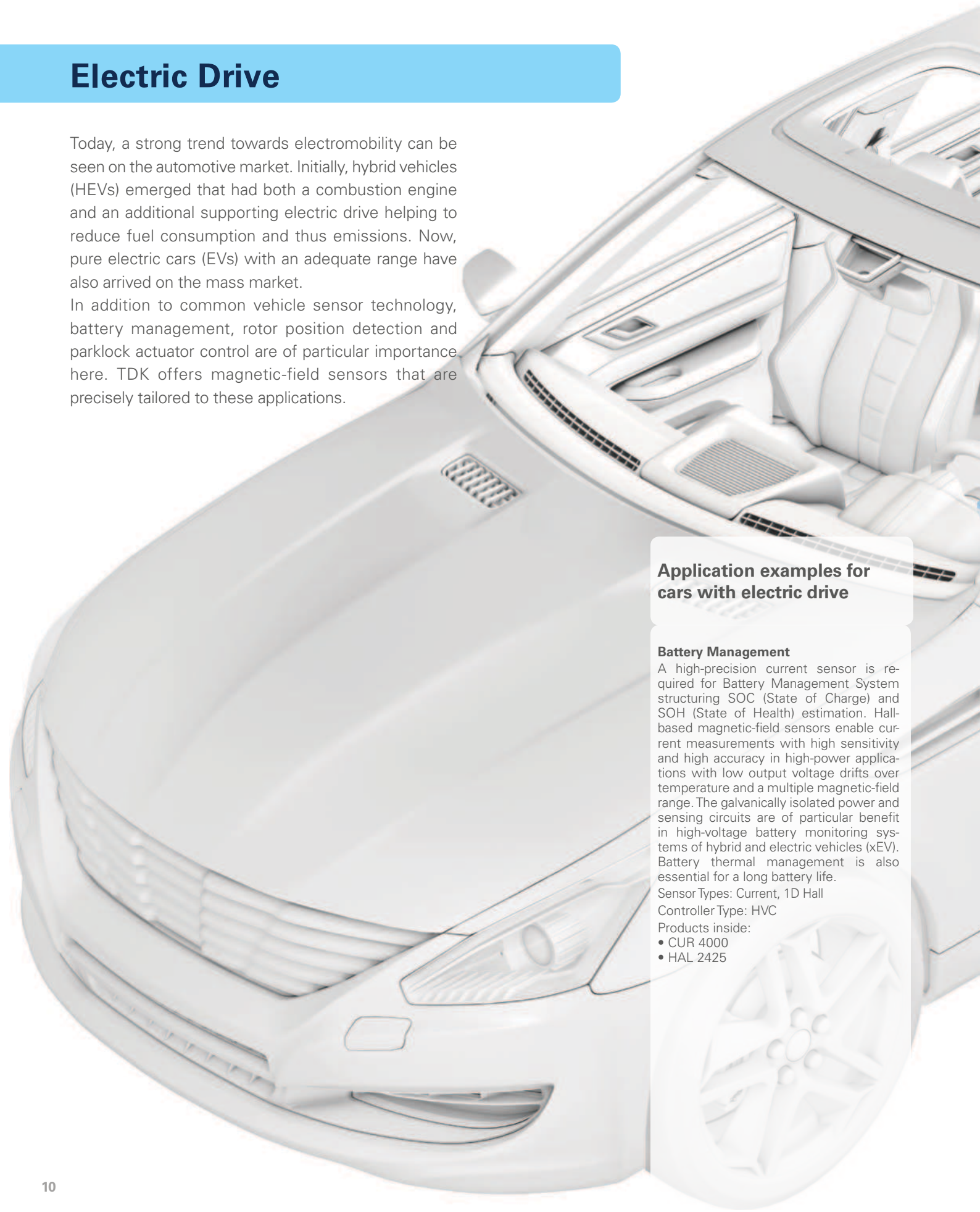
Products inside:
- HAC 37xy
- HAL 3930
- HAC 830
- HAL 2425

Automotive Applications

Electric Drive

Today, a strong trend towards electromobility can be seen on the automotive market. Initially, hybrid vehicles (HEVs) emerged that had both a combustion engine and an additional supporting electric drive helping to reduce fuel consumption and thus emissions. Now, pure electric cars (EVs) with an adequate range have also arrived on the mass market.

In addition to common vehicle sensor technology, battery management, rotor position detection and parklock actuator control are of particular importance here. TDK offers magnetic-field sensors that are precisely tailored to these applications.



Application examples for cars with electric drive

Battery Management

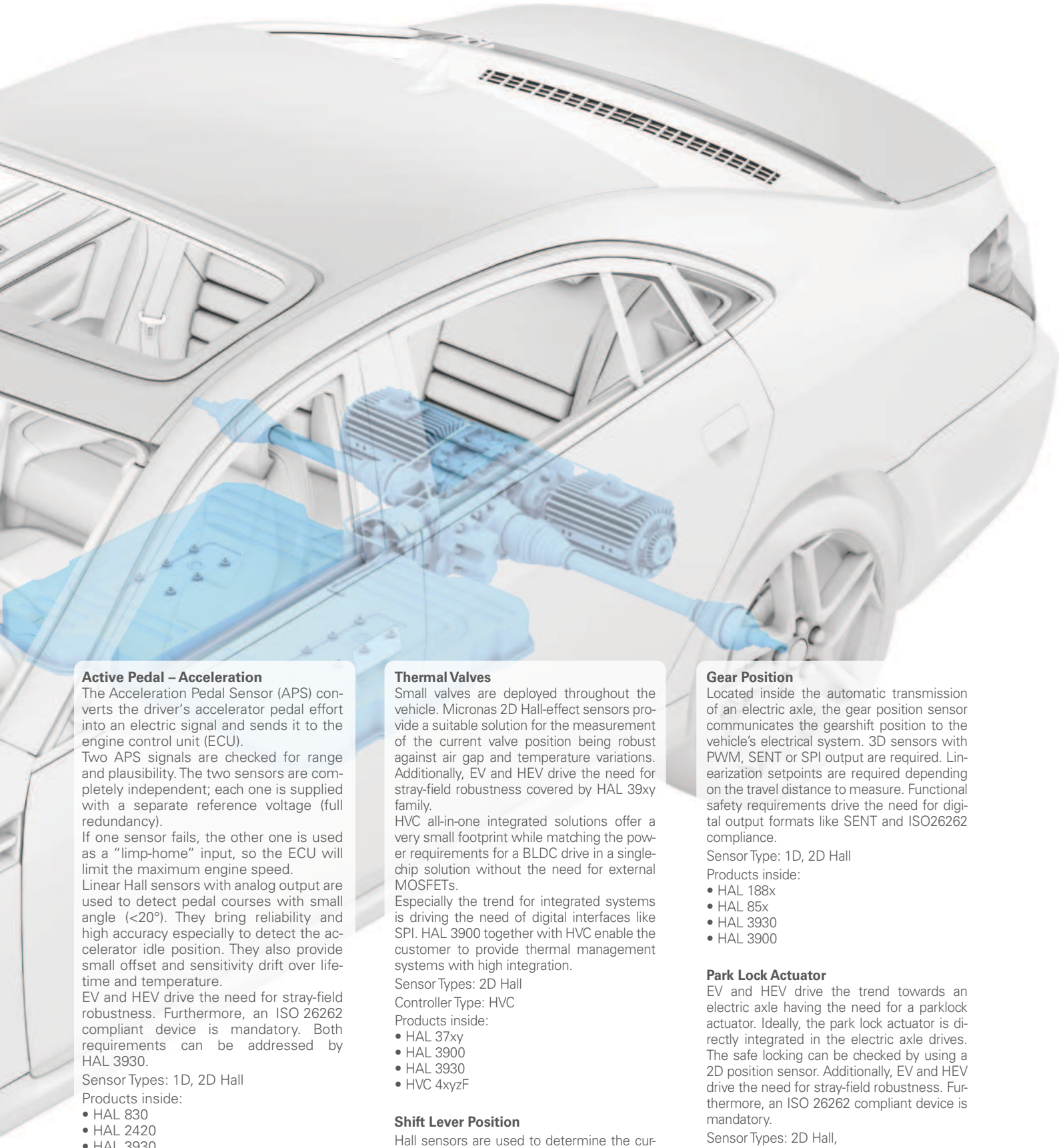
A high-precision current sensor is required for Battery Management System structuring SOC (State of Charge) and SOH (State of Health) estimation. Hall-based magnetic-field sensors enable current measurements with high sensitivity and high accuracy in high-power applications with low output voltage drifts over temperature and a multiple magnetic-field range. The galvanically isolated power and sensing circuits are of particular benefit in high-voltage battery monitoring systems of hybrid and electric vehicles (xEV). Battery thermal management is also essential for a long battery life.

Sensor Types: Current, 1D Hall

Controller Type: HVC

Products inside:

- CUR 4000
- HAL 2425



Active Pedal – Acceleration
The Acceleration Pedal Sensor (APS) converts the driver's accelerator pedal effort into an electric signal and sends it to the engine control unit (ECU).
Two APS signals are checked for range and plausibility. The two sensors are completely independent; each one is supplied with a separate reference voltage (full redundancy).
If one sensor fails, the other one is used as a "limp-home" input, so the ECU will limit the maximum engine speed.
Linear Hall sensors with analog output are used to detect pedal courses with small angle (<20°). They bring reliability and high accuracy especially to detect the accelerator idle position. They also provide small offset and sensitivity drift over lifetime and temperature.
EV and HEV drive the need for stray-field robustness. Furthermore, an ISO 26262 compliant device is mandatory. Both requirements can be addressed by HAL 3930.
Sensor Types: 1D, 2D Hall
Products inside:
- HAL 830
- HAL 2420
- HAL 3930

Liquid Level
Hall sensors are used to detect the liquid level (e.g. brake fluid) in a tank. Linearization setpoints are required here.
Sensor Types: 1D, 3D Hall
Products inside:
- HAL 2455
- HAL 37xy
- HAL 3930

Thermal Valves
Small valves are deployed throughout the vehicle. Micronas 2D Hall-effect sensors provide a suitable solution for the measurement of the current valve position being robust against air gap and temperature variations. Additionally, EV and HEV drive the need for stray-field robustness covered by HAL 39xy family.
HVC all-in-one integrated solutions offer a very small footprint while matching the power requirements for a BLDC drive in a single-chip solution without the need for external MOSFETs.
Especially the trend for integrated systems is driving the need of digital interfaces like SPI. HAL 3900 together with HVC enable the customer to provide thermal management systems with high integration.
Sensor Types: 2D Hall
Controller Type: HVC
Products inside:
- HAL 37xy
- HAL 3900
- HAL 3930
- HVC 4xyzF

Shift Lever Position
Hall sensors are used to determine the current position of the gear shift lever. The application setup can be realized by different solutions: from simple rotary shifters up to joystick-type based solutions. Both setups require a 2D (rotary) or 3D (joystick or rotary with push-function) position detection.
Hall switches are used for extremely price-sensitive solutions by placing several switches at each gear position.
Sensor Types: Hall Switch, 3D Hall
Products inside:
- HAL 3900
- HAL 3930
- HAL 15xy 3-wire

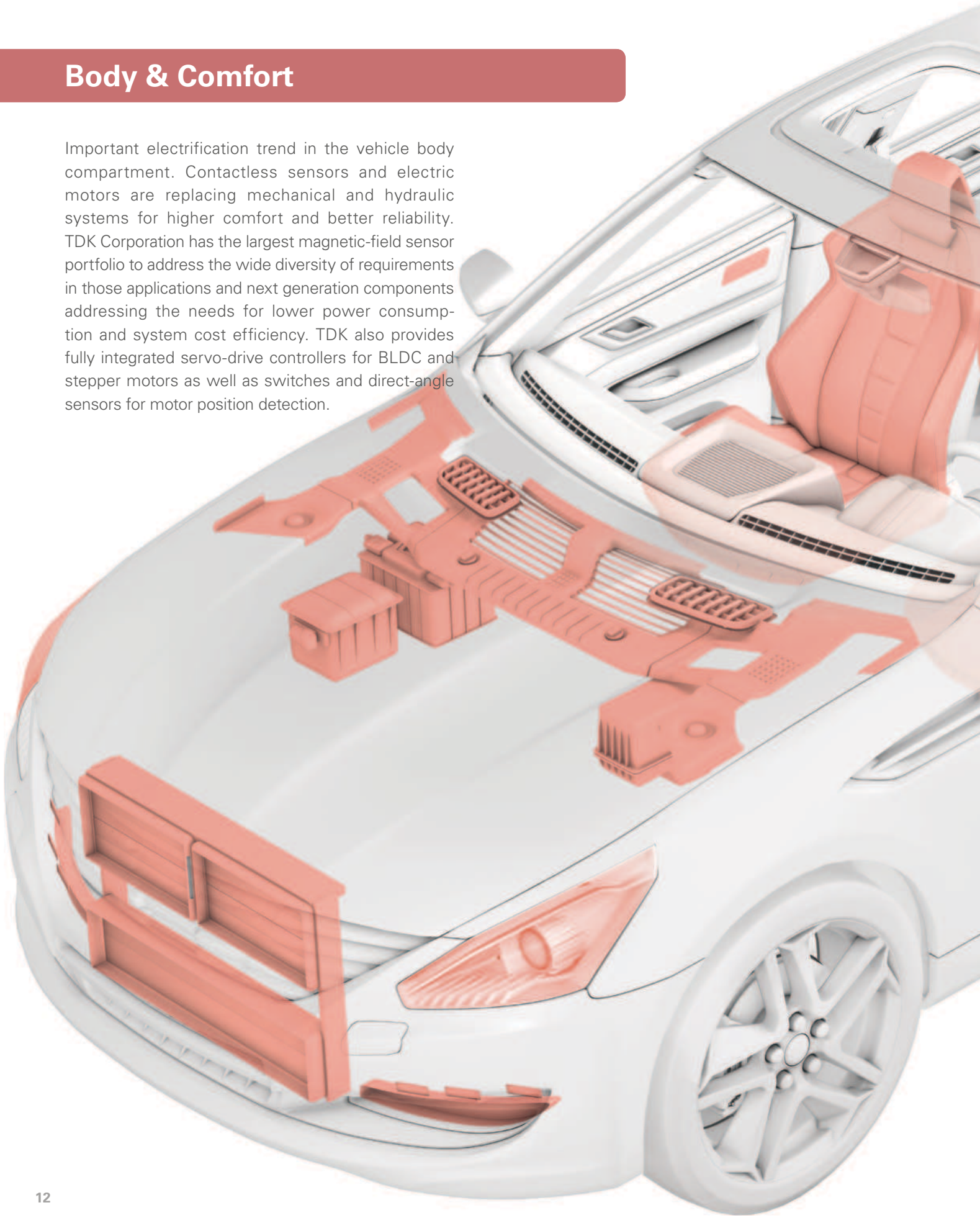
Gear Position
Located inside the automatic transmission of an electric axle, the gear position sensor communicates the gearshift position to the vehicle's electrical system. 3D sensors with PWM, SENT or SPI output are required. Linearization setpoints are required depending on the travel distance to measure. Functional safety requirements drive the need for digital output formats like SENT and ISO26262 compliance.
Sensor Type: 1D, 2D Hall
Products inside:
- HAL 188x
- HAL 85x
- HAL 3930
- HAL 3900

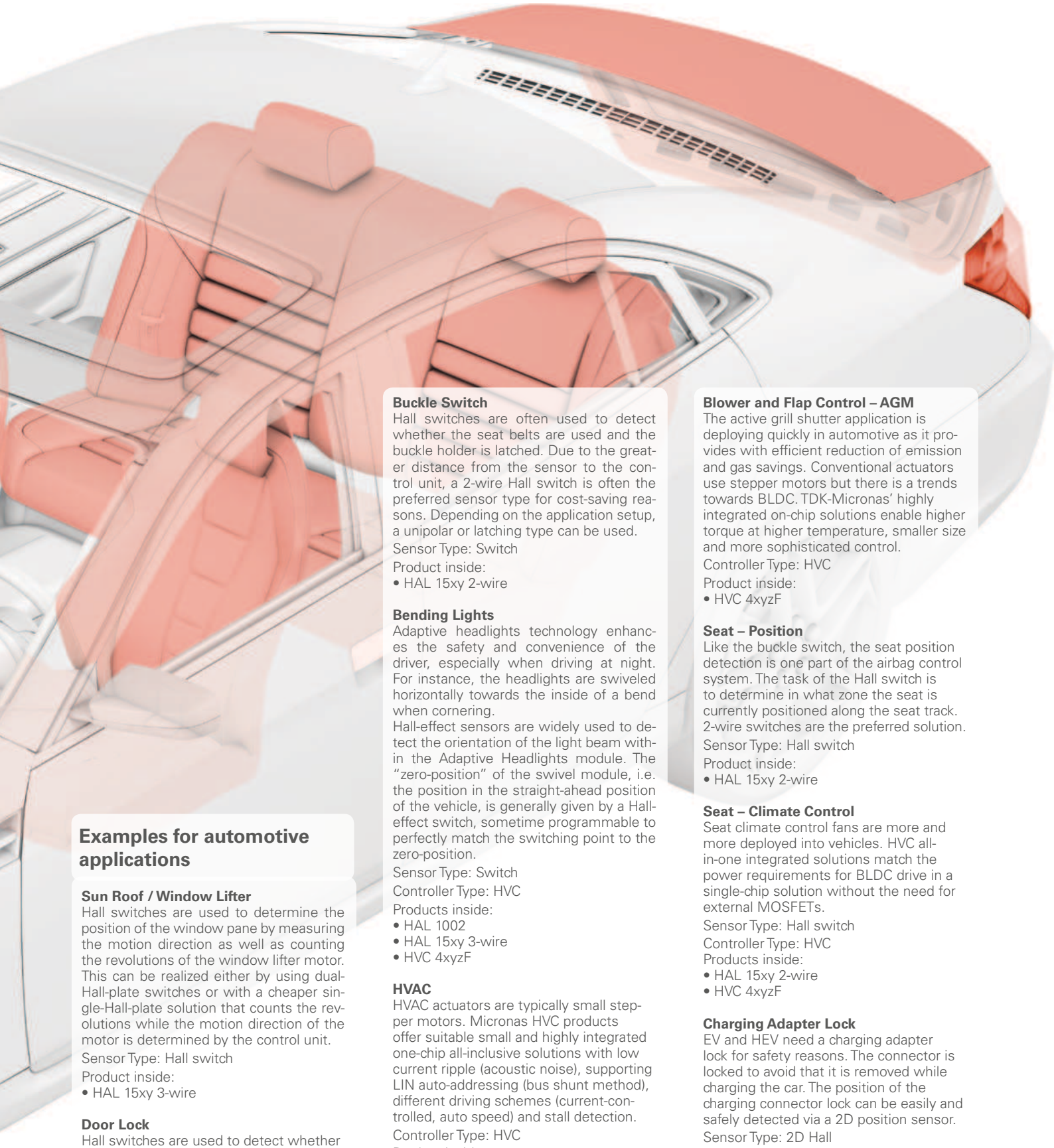
Park Lock Actuator
EV and HEV drive the trend towards an electric axle having the need for a parklock actuator. Ideally, the park lock actuator is directly integrated in the electric axle drives. The safe locking can be checked by using a 2D position sensor. Additionally, EV and HEV drive the need for stray-field robustness. Furthermore, an ISO 26262 compliant device is mandatory.
Sensor Types: 2D Hall,
Controller Type: HVC
Products inside:
- HAR 37xy
- HAL 3900
- HAL 3930
- HVC 4xyzF

Automotive Applications

Body & Comfort

Important electrification trend in the vehicle body compartment. Contactless sensors and electric motors are replacing mechanical and hydraulic systems for higher comfort and better reliability. TDK Corporation has the largest magnetic-field sensor portfolio to address the wide diversity of requirements in those applications and next generation components addressing the needs for lower power consumption and system cost efficiency. TDK also provides fully integrated servo-drive controllers for BLDC and stepper motors as well as switches and direct-angle sensors for motor position detection.





Examples for automotive applications

Sun Roof / Window Lifter
Hall switches are used to determine the position of the window pane by measuring the motion direction as well as counting the revolutions of the window lifter motor. This can be realized either by using dual-Hall-plate switches or with a cheaper single-Hall-plate solution that counts the revolutions while the motion direction of the motor is determined by the control unit.
Sensor Type: Hall switch
Product inside:
- HAL 15xy 3-wire

Door Lock
Hall switches are used to detect whether the car doors are locked or not. By skipping the third wire, the 2-wire sensor type is preferred for this kind of application in order to save costs.
Brushless actuators allow tamper-proof lock design.
Sensor Type: Hall switch
Controller Type: HVC
Products inside:
- HAL 15xy 2-wire
- HVC 4xyzF

Buckle Switch
Hall switches are often used to detect whether the seat belts are used and the buckle holder is latched. Due to the greater distance from the sensor to the control unit, a 2-wire Hall switch is often the preferred sensor type for cost-saving reasons. Depending on the application setup, a unipolar or latching type can be used.
Sensor Type: Switch
Product inside:
- HAL 15xy 2-wire

Bending Lights
Adaptive headlights technology enhances the safety and convenience of the driver, especially when driving at night. For instance, the headlights are swiveled horizontally towards the inside of a bend when cornering.
Hall-effect sensors are widely used to detect the orientation of the light beam within the Adaptive Headlights module. The "zero-position" of the swivel module, i.e. the position in the straight-ahead position of the vehicle, is generally given by a Hall-effect switch, sometime programmable to perfectly match the switching point to the zero-position.
Sensor Type: Switch
Controller Type: HVC
Products inside:
- HAL 1002
- HAL 15xy 3-wire
- HVC 4xyzF

HVAC
HVAC actuators are typically small stepper motors. Micronas HVC products offer suitable small and highly integrated one-chip all-inclusive solutions with low current ripple (acoustic noise), supporting LIN auto-addressing (bus shunt method), different driving schemes (current-controlled, auto speed) and stall detection.
Controller Type: HVC
Product inside:
- HVC 4xyzF

Blower and Flap Control - LED Fans
Typically used for LED light cooling and mist removal, LED fans require efficient actuators with very small footprint.
HVC all-in-one integrated solutions match the power requirements for BLDC drive in a single-chip solution without the need for external MOSFETs.
Controller Type: HVC
Product inside:
- HVC 4xyzF

Blower and Flap Control – AGM
The active grill shutter application is deploying quickly in automotive as it provides with efficient reduction of emission and gas savings. Conventional actuators use stepper motors but there is a trends towards BLDC. TDK-Micronas' highly integrated on-chip solutions enable higher torque at higher temperature, smaller size and more sophisticated control.
Controller Type: HVC
Product inside:
- HVC 4xyzF

Seat – Position
Like the buckle switch, the seat position detection is one part of the airbag control system. The task of the Hall switch is to determine in what zone the seat is currently positioned along the seat track. 2-wire switches are the preferred solution.
Sensor Type: Hall switch
Product inside:
- HAL 15xy 2-wire

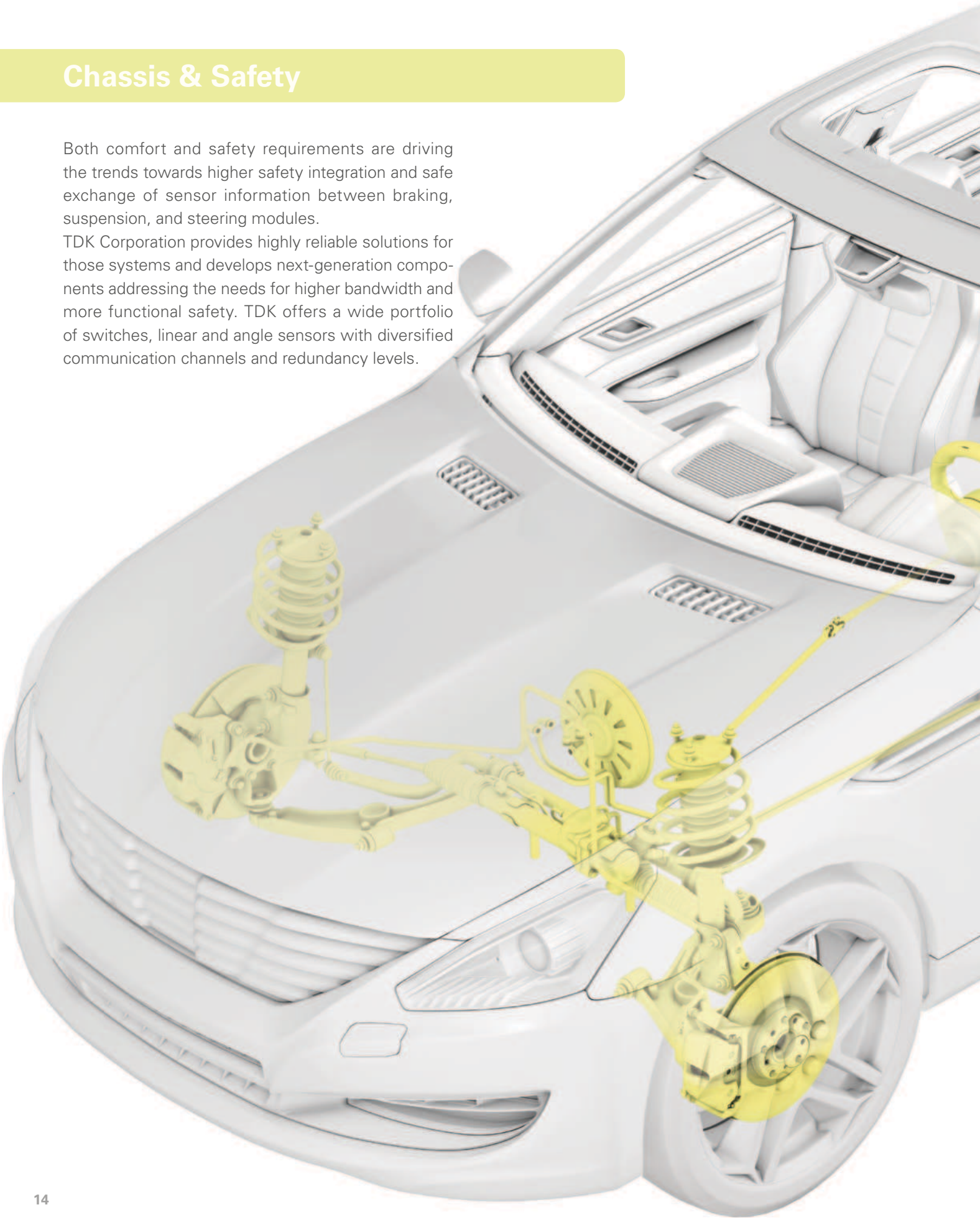
Seat – Climate Control
Seat climate control fans are more and more deployed into vehicles. HVC all-in-one integrated solutions match the power requirements for BLDC drive in a single-chip solution without the need for external MOSFETs.
Sensor Type: Hall switch
Controller Type: HVC
Products inside:
- HAL 15xy 2-wire
- HVC 4xyzF

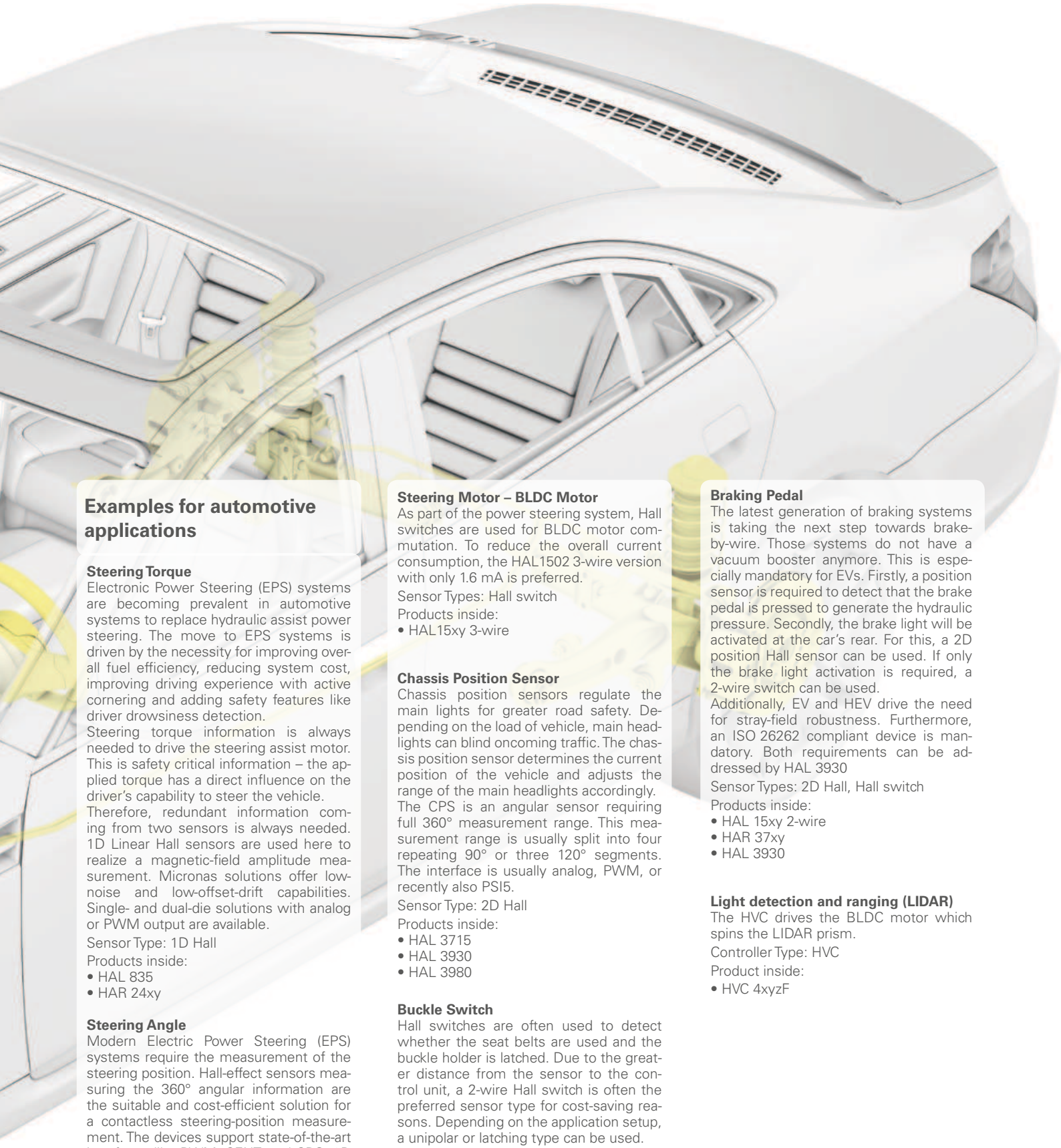
Charging Adapter Lock
EV and HEV need a charging adapter lock for safety reasons. The connector is locked to avoid that it is removed while charging the car. The position of the charging connector lock can be easily and safely detected via a 2D position sensor.
Sensor Type: 2D Hall
Product inside:
- HAL 3930

Automotive Applications

Chassis & Safety

Both comfort and safety requirements are driving the trends towards higher safety integration and safe exchange of sensor information between braking, suspension, and steering modules.
TDK Corporation provides highly reliable solutions for those systems and develops next-generation components addressing the needs for higher bandwidth and more functional safety. TDK offers a wide portfolio of switches, linear and angle sensors with diversified communication channels and redundancy levels.





Examples for automotive applications

Steering Torque
Electronic Power Steering (EPS) systems are becoming prevalent in automotive systems to replace hydraulic assist power steering. The move to EPS systems is driven by the necessity for improving overall fuel efficiency, reducing system cost, improving driving experience with active cornering and adding safety features like driver drowsiness detection.
Steering torque information is always needed to drive the steering assist motor. This is safety critical information – the applied torque has a direct influence on the driver's capability to steer the vehicle.
Therefore, redundant information coming from two sensors is always needed. 1D Linear Hall sensors are used here to realize a magnetic-field amplitude measurement. Micronas solutions offer low-noise and low-offset-drift capabilities. Single- and dual-die solutions with analog or PWM output are available.
Sensor Type: 1D Hall
Products inside:
- HAL 835
- HAR 24xy

Steering Angle
Modern Electric Power Steering (EPS) systems require the measurement of the steering position. Hall-effect sensors measuring the 360° angular information are the suitable and cost-efficient solution for a contactless steering-position measurement. The devices support state-of-the-art interfaces like PWM, SENT, and SPC. 2D Hall-effect sensors are used, because 360° angular measurement is required. Stray-field robustness is now becoming more importance due to the car electrification.
Sensor Types: 2D Hall
Products inside:
- HAL 3930
- HAL 3970

Steering Motor – BLDC Motor
As part of the power steering system, Hall switches are used for BLDC motor commutation. To reduce the overall current consumption, the HAL1502 3-wire version with only 1.6 mA is preferred.
Sensor Types: Hall switch
Products inside:
- HAL15xy 3-wire

Chassis Position Sensor
Chassis position sensors regulate the main lights for greater road safety. Depending on the load of vehicle, main headlights can blind oncoming traffic. The chassis position sensor determines the current position of the vehicle and adjusts the range of the main headlights accordingly.
The CPS is an angular sensor requiring full 360° measurement range. This measurement range is usually split into four repeating 90° or three 120° segments. The interface is usually analog, PWM, or recently also PSI5.
Sensor Type: 2D Hall
Products inside:
- HAL 3715
- HAL 3930
- HAL 3980

Buckle Switch
Hall switches are often used to detect whether the seat belts are used and the buckle holder is latched. Due to the greater distance from the sensor to the control unit, a 2-wire Hall switch is often the preferred sensor type for cost-saving reasons. Depending on the application setup, a unipolar or latching type can be used.
Sensor Type: Switch
Product inside:
- HAL 15xy 2-wire

Liquid Level
Hall sensors are used to detect the liquid level (e.g. brake fluid) in a tank. Linearization setpoints are required here.
Sensor Types: 1D, 3D Hall
Products inside:
- HAL 2455
- HAL 37xy
- HAC 37xy
- HAL 3930

Braking Pedal
The latest generation of braking systems is taking the next step towards brake-by-wire. Those systems do not have a vacuum booster anymore. This is especially mandatory for EVs. Firstly, a position sensor is required to detect that the brake pedal is pressed to generate the hydraulic pressure. Secondly, the brake light will be activated at the car's rear. For this, a 2D position Hall sensor can be used. If only the brake light activation is required, a 2-wire switch can be used.
Additionally, EV and HEV drive the need for stray-field robustness. Furthermore, an ISO 26262 compliant device is mandatory. Both requirements can be addressed by HAL 3930
Sensor Types: 2D Hall, Hall switch
Products inside:
- HAL 15xy 2-wire
- HAR 37xy
- HAL 3930

Light detection and ranging (LIDAR)
The HVC drives the BLDC motor which spins the LIDAR prism.
Controller Type: HVC
Product inside:
- HVC 4xyzF

Industrial Applications

Attractive Robotics

Robotic is set to be the next wave of growth for the electronic industry. Micronas sensors and motor controllers offer solutions for many kinds of different robots.



Industrial Robotic Arm

Initiatives such as Industry 4.0 and Made in China 2025 as well as the emergence of 5G communication accelerate the adoption of collaborative robotic arms with associated sensors and actuators in factories. Precise displacement, angle and motor control are key to the deployment of such robots – This is also the focus of our sensors and actuators.

- Motor control: HVC
- Joint Angle measurement: HAL 3900
- Stroke measurement: HAL 3900



Personal & Toys

From a small toy or pet robot to an humanoid service robot, a large diversity of robot are expecting to join our homes, retails, and companies. TDK focuses here to provide with adequate motor control solutions.

- Motor control: HVC



Home Care

Already deployed in mass production, those robots are helping us into our daily activities at home. Efficient motor control and precise position detection is required. Motor position: HVC

- Motor control: HVC
- Lift or bump detection: Switches



AGV (Automated Guided Vehicle), AMR (Automated Mobility Robot)

Already deployed in factories of large e-commerce companies, those robots are set to become the solution for warehousing, order processing but also to solve the "last-mile delivery" issue for the e-commerce industry. MSBG is making sure that its e-mobility solutions are adapted to this growing segment

- Motor control: HVC
- Door lock, lift and bump detection: Switches

Attractive Mobility





Presently, we see an increase in the share service of electric vehicles smaller than cars such as electric scooters, electric bikes, and senior cars (electric carts). These micromobilities integrate all transportation means into one mobility service (MaaS: Mobility as a Service). TDK aims to contribute to the development of the next-generation mobility society including MaaS by applying technologies, trends, and know-how related to the micromobility industry. In addition, TDK strives to offer semiconductor solutions for special utility and recreational vehicles.

Light E-mobility

- Motor commutation: HVC, Switches
- Acceleration grip: 2D Hall

Utility Vehicles / Recreational Vehicles / Boats / Agriculture & Heavy Machinery

- Pedal: 1D Hall
- Throttle: 2D Hall
- Torque & angle sensor: 2D Hall
- Joystick: 3D Hall
- Knob, thumbwheel, slider, paddle: 1D Hall

Attractive Energy



Due to the increasing environmental awareness and the demand for renewable energy, the development of high-efficiency power electronics is required to improve the production, conversion, and storage of this "green" energy. With various types of current sensors, TDK is able to offer solutions for specific needs such as for battery management or surge-protection systems.

Attractive Energy

- Energy conversion and storage
  (PV solar, Battery Energy storage System (BESS)
- BMS sensor: CUR, 1D Hall
- Surge protection: switches
- UPS (Uninterrupted Power Supply): CUR

Hall Switches

Variant		Magnetic Characteristics Typical @ 25 °C		Type				Typical temperature coefficient				Configuration		Package		Current Consumption					Supply Voltage			Application Range		
		B_{ON} – [mT]	B_{OFF} – [mT]	Unipolar	Unipolar Inverted	Bipolar	Latching	0 ppm/K	–300 ppm/K	–1000 ppm/K	–1200 ppm/K	2-Wire	3-Wire	SOT23	TO92UT [3)4)]	I_{SUP} = 1.6 mA	I_{SUP} = 7 mA	$I_{SUPlow1}$ = 2...5 mA	$I_{SUPlow2}$ = 5...7 mA	$I_{SUPhigh}$ = 12...17 mA	V_{SUP} = 2.7..24 V	V_{SUP} = 3...24 V	V_{SUP} = 4.5V... 8.5 V	Position Detection	RPM Measurement	Brushless DC Motors
HAL 10xy	HAL 1002	Programmable		●	●		●	Programmable[2)]					●		●		●				●					
HAL 15xy[1)]	HAL 1501	0.4	–0.4			●		●					●	●	●	●					●			●	●	●
	HAL 1502	2.5	–2.5				●			●			●	●	●	●					●			●	●	●
	HAL 1503	5.5	3.7	●						●			●	●	●	●					●			●	●	
	HAL 1504	7.6	–7.6				●				●		●	●	●	●					●			●	●	●
	HAL 1505	13.5	–13.5				●				●		●	●	●	●					●			●	●	●
	HAL 1506	18.9	17.3	●							●		●	●	●	●					●			●	●	
	HAL 1507	28.2	23.9	●					●				●	●	●	●					●			●	●	
	HAL 1508[2)]	–5.5	–3.7	●						●			●	●	●	●					●			●	●	
	HAL 1509	3.7	5.5		●					●			●	●	●	●					●			●	●	
	HAL 1510	12	7	●							●		●	●	●	●					●			●	●	
	HAL 1561	4	–4				●	●				●		●	●				●	●		●		●	●	●
	HAL 1562	12	–12				●	●				●		●	●				●	●		●		●	●	●
	HAL 1563	7.6	9.4		●			●				●		●	●				●	●		●		●	●	
	HAL 1564	4.1	6		●					●		●		●	●			●		●		●		●	●	
	HAL 1565	6	4.1	●						●		●		●	●			●		●		●		●	●	
	HAL 1566	9.4	7.6	●				●				●		●	●				●	●		●		●	●	

[1)]ISO 26262 compliant [2)]north pole sensitive [3)]straight or spread leads [4)]standard 15.7 ± 0.2 mm or long lead length 21 ± 0.2 mm

For consumer/industrial applications, please contact TDK-Micronas for 3-wire versions with a junction temperature range from –40 °C to 140 °C.

Magnetic Current Sensors

Variant			Magnetic Range		Output			Configuration				Electrical Characteristics		Package	Application	
		Programmable	B_{min} [mT]	B_{max} [mT]	Analog	SPI	SENT	Overvoltage Detection	Undervoltage Detection	Open VSUP Detection	Open GND Detection	V_{SUP} [V]	Iout (max) - [mA]	SOIC8	Generic Application	Battery Monitoring
CUR 40xy	CUR 4000	●	–100	+100		●		●	●			3.0 to 5.5		●		●

Linear Hall Sensors

Variant			Magnetic Range		Type										Configuration					Electrical Characteristics		Config.		Package							Application Range					
																															Function		Generic Application			
		Programmable	B_{min} [mT]	B_{max} [mT]	Setpoints	Analog	PWM	PSI5	SPI	SENT	SPC	Integrated Capacitors	Redundancy Function	Stray-Field Compensation	Overvoltage Detection	Undervoltage Detection	Open VSUP Detection	Open GND Detection	Overcurrent Detection	V_{SUP} [V]	Iout (max) - [mA]	2-Wire	3-Wire	TO92UA	TO92UT	TO92UP	TO92UG	TO92UF	SOIC8	TSSOP14	Linear Movement	Current Measurement	Rotary Position	Leveling	Force/Pressure	Torque Measurement
HAL 8xy	HAL 830	●	±30	±100	2	●									●	●	●	●		4.5 to 5.5	1.2		●		●					●	●	●	●	●	
	HAC 830	●	±30	±100	2	●						●			●	●	●	●		4.5 to 5.5	1.2		●			●				●	●	●	●	●	
	HAL 835	●	±15	±150	2	●	■								●	●	●	●		4.5 to 5.5	1.2		●		●					●	●	●	●	●	●
	HAL 855	●	±30	±150	32		■									●	●	●		4.5 to 14	20		●		●					●	●	●	●	●	
	HAL 856	●	±30	±150	32		■									●	●	●		4.5 to 14	◆	●			●					●	●	●	●	●	
HAL 18xy	HAL 1870	●	±20	±160	0		■								●	●			●	4.5 to 5.5	5		●	●						●	●	●	●		
	HAL 1880	●	±20	±160	0	●									●	●			●	4.5 to 5.5	1		●	●						●	●	●	●		
	HAL 1881		–50	+50	0	●									●	●			●	4.5 to 5.5	1		●	●						●	●	●	●		
	HAL 1882		–80	+80	0	●									●	●			●	4.5 to 5.5	1		●	●						●	●	●	●		
	HAL 1883		–100	+100	0	●									●	●			●	4.5 to 5.5	1		●	●						●	●	●	●		
	HAL 1890	●	–100	+100	0					●					●	●			●	4.5 to 5.5	1		●	●						●	●	●	●		
HAL 24xy	HAL 2420	●	±25	±200	2	●									●	●	●	●	●	4.5 to 5.5	1.2		●		●			●		●	●	●	●	●	●
	HAL 2421[1)]	●	±25	±200	2	●									●	●	●	●	●	4.5 to 5.5	1.2		●		●					●	●	●	●	●	●
	HAL 2425	●	±25	±200	16	●									●	●	●	●	●	4.5 to 5.5	1.2		●		●			●		●	●	●	●	●	●
	HAR 2425	●	±25	±200	16	●							●		●	●	●	●	●	4.5 to 5.5	1.2		●						●	●	●	●	●	●	●
	HAL 2455	●	±25	±200	16		■								●	●	●	●	●	4.5 to 5.5	1.2		●		●			●		●	●	●	●	●	●
	HAR 2455	●	±25	±200	16		■						●		●	●	●	●	●	4.5 to 5.5	1.2		●						●	●	●	●	●	●	●

[1)] T_J = –40 °C to 140 °C ■ Programmable PWM frequency ◆ Programmable: see data sheet

Direct Angle Sensors

HAL 37xy	HAL 3715	●	±20	±100	33	●									●	●	●	●	●	4.5 to 5.5	1.2		●					●		●				●	●	
	HAL 3725	●	±20	±100	33	●									●	●	●	●	●	4.5 to 5.5	1.2		●					●		●				●	●	
	HAL 3726	●	±20	±100	33	●									●	●	●	●	●	4.5 to 5.5	1.2		●					●		●	●			●	●	
	HAL 3727	●	±20	±100	33	●									●	●	●	●	●	4.5 to 5.5	1.2		●					●		●	●			●	●	
	HAL 3735	●	±20	±100	33		■			●					●	●	●	●	●	4.5 to 5.5	1.2		●					●		●				●	●	
	HAL 3736	●	±20	±100	33		■			●					●	●	●	●	●	4.5 to 5.5	1.2		●					●		●	●			●	●	
	HAL 3737	●	±20	±100	33		■			●					●	●	●	●	●	4.5 to 5.5	1.2		●					●		●	●			●	●	
HAR 37xy	HAR 3715	●	±20	±100	33	●							●		●	●	●	●	●	4.5 to 5.5	1.2		●							●				●	●	
	HAR 3725	●	±20	±100	33	●							●		●	●	●	●	●	4.5 to 5.5	1.2		●							●				●	●	
	HAR 3726	●	±20	±100	33	●							●		●	●	●	●	●	4.5 to 5.5	1.2		●							●	●			●	●	
	HAR 3727	●	±20	±100	33	●							●		●	●	●	●	●	4.5 to 5.5	1.2		●							●	●			●	●	
	HAR 3735	●	±20	±100	33		■			●			●		●	●	●	●	●	4.5 to 5.5	1.2		●							●				●	●	
	HAR 3736	●	±20	±100	33		■			●			●		●	●	●	●	●	4.5 to 5.5	1.2		●							●	●			●	●	
	HAR 3737	●	±20	±100	33		■			●			●		●	●	●	●	●	4.5 to 5.5	1.2		●							●	●			●	●	
	HAR 3795	●	±20	±100	33		■			●			●		●	●	●	●	●	4.5 to 5.5	1.2		●							●				●	●	
	HAR 3796	●	±20	±100	33		■			●			●		●	●	●	●	●	4.5 to 5.5	1.2		●							●	●			●	●	
	HAR 3797	●	±20	±100	33		■			●			●		●	●	●	●	●	4.5 to 5.5	1.2		●							●	●			●	●	
HAC 37xy	HAC 3715	●	±20	±100	33	●						●			●	●	●	●	●	4.5 to 5.5	1.2		●					●						●	●	
	HAC 3725	●	±20	±100	33	●						●			●	●	●	●	●	4.5 to 5.5	1.2		●					●						●	●	
	HAC 3726	●	±20	±100	33	●						●			●	●	●	●	●	4.5 to 5.5	1.2		●					●		●	●			●	●	
	HAC 3727	●	±20	±100	33	●						●			●	●	●	●	●	4.5 to 5.5	1.2		●					●		●	●			●	●	
	HAC 3735	●	±20	±100	33		■			●		●			●	●	●	●	●	4.5 to 5.5	1.2		●					●						●	●	
	HAC 3736	●	±20	±100	33		■			●		●			●	●	●	●	●	4.5 to 5.5	1.2		●					●		●	●			●	●	
	HAC 3737	●	±20	±100	33		■			●		●			●	●	●	●	●	4.5 to 5.5	1.2		●					●		●	●			●	●	
HAL 39xy	HAL 3900	●	±10	±130	33				●					●	●	●	●	●	●	3.0 to 5.5	–		●						●		●				●	●	
	HAL 3930	●	±10	±130	33		■			●				●	●	●	●	●	●	3.0 to 18	20		●						●		●				●	●	
	HAL 3970	●	±10	±130	33						●			●	●	●	●	●	●	3.0 to 16	20		●						●		●				●	●	
	HAL 3980	●	±10	±130	33			●						●	●	●	●	●	●	3.0 to 16.5	–	●							●		●				●	●	

■ Programmable PWM frequency

Generic Applications

RPM Measurement

Rotary Position

Linear Movement

Levelling

Force/Pressure Measurement

Torque Measurement

Current Sensing

Stray-Field Compensation

HAL® 1002

In-System Programmable Hall Switch



Functions

The HAL 1002 is the optimal system solution for applications, such as:

- Position detection
- Current measurement

Application Examples

- Endposition detection
- Liquid-level detection
- Electronic fuse
- Bending lights

Features

- Operates from –40 °C up to 170 °C junction temperature
- High-precision Hall switch with programmable switching points and switching behavior
- Switching points programmable from –30 mT up to 150 mT in steps of 0.5% of the magnetic field range
- Multiple programmable magnetic characteristics in a non-volatile memory (EEPROM) with redundancy and lock function
- Temperature characteristics are programmable for matching all common magnetic materials
- Programming through modulation of the supply voltage
- Operates from 4.5 V up to 5.5 V supply voltage in specification and functions up to 8.5 V
- Operates with static magnetic fields and dynamic magnetic fields up to 2 kHz
- Magnetic characteristics are extremely robust against mechanical stress effects
- Overvoltage and reverse-voltage protection at all pins
- Short-circuit protected push-pull output
- High ESD performance: 8 kV
- EMC optimized design
- Package: TO92UT-2

HAL® 15xy

First ISO 26262 Compliant Low-Power Hall Switch Family



Application Examples

The HAL 15xy sensor family is a potential system solution for applications, such as:

- Endposition detection
- Brushless DC motor commutation
- Revolutions per minute (RPM) or other rotary measurements

Features

- 3-wire version with a short-circuit protected open-drain output
- 2-wire version with current output
- Very low current consumption of typ. 1.6 mA (3-wire)
- Wide supply voltage operation from 2.7 V to 24 V (3-wire)
- Overvoltage protection capability up to 40 V
- Available in the smallest SOT23 and TO92UA package
- Highest ESD performance up to ±8 kV (HBM)
- Reverse-voltage protection at supply pin (–18 V)
- Operating with static and dynamic magnetic fields up to 12 kHz at lowest output jitter of typ. 0.72 µs (RMS). Customized versions are possible up to 93 kHz.
- AEC-Q100 qualification
- ISO 26262 compliant with additional functional safety features like power-on self-test
- Wide junction temperature range from –40 °C to 170 °C, especially designed for operation in harsh environments
- Magnetic characteristics are robust against mechanical stress
- Broad variety of temperature-compensated constant switching points
- Package: SOT23 or TO92UA

For consumer/industrial applications, please contact TDK-Micronas for 3-wire versions with a junction temperature range from –40 °C to 140 °C.

HAL 18xy

Linear Hall-Effect Sensor Family – Programmable or with Fixed Sensitivity



Application Examples

HAL 18xy is a potential system solution for applications such as:

- Linear movement
- Distance measurements
- Current measurements
- Gear position sensor

Features

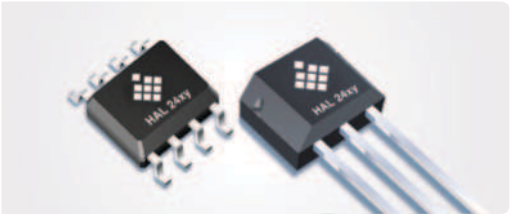
- Operates from –40 °C up to 170 °C junction temperature
- Linear Hall-effect sensors with ratiometric analog, PWM, or SENT output
- Various programmable magnetic characteristics with non-volatile memory
- Digital signal processing
- Continuous measurement ranges from ±20 mT to ±160 mT
- Temperature characteristics programmable for matching all common magnetic materials
- Programming via supply voltage
- Lock function and built-in redundancy for EEPROM memory
- Operates from 4.5 V up to 5.5 V supply voltage
- Operates with static magnetic fields and dynamic magnetic fields up to 5 kHz
- Overvoltage and reverse-voltage protection on VSUP pin
- Magnetic characteristics extremely robust against mechanical stress
- Short-circuit protected output
- Package: TO92UA

Type	Sensitivity [mV/mT]	Output
HAL 1880	programmable	analog
HAL 1881	50	analog
HAL 1882	31.25	analog
HAL 1883	25	analog
HAL 1870	programmable	PWM
HAL 1890	programmable	SENT

Note: HAL 1880 can replace HAL 1820.
HAL 188y can replace HAL 182y.

HAL® 24xy

Precise and Robust Programmable Linear Hall-Effect Sensor Family



Applications

The HAL 24xy is a potential system solution for applications such as:

– Angular measurement: throttle position, pedal position, steering torque, and EGR applications

Family Overview

HAL 2420	Analog output, 2-point calibration
HAL 2421	Low-Noise, T_J=140 °C
HAL 2425	Analog output, 2-point calibration, 16 setpoints linearization
HAL 2455	PWM output (up to 2 kHz), 16 setpoints linearization

Features

– High-precision linear Hall-effect sensor with ratiometric 12-bit analog output
– 16 setpoints for various output signal characteristics (HAL 2425), HAL 2455)
– High immunity against ESD (8 kV)
– Multiple customer-programmable magnetic characteristics in EEPROM with redundancy and lock function
– Programmable temperature compensation for sensitivity and offset
– Magnetic field measurements in the range up to 200 mT
– Low output voltage drifts over temp.
– Open-circuit (ground and supply line break detection), overvoltage and under-voltage detection
– Programmable output clamping function
– Digital readout of temperature and magnetic field information in calibration mode
– Operates from 4.5 V up to 5.5 V supply voltage in specification
– Operates with static magnetic fields and dynamic magnetic fields up to 2 kHz
– Overvoltage and reverse-voltage protection at all pins
– Short-circuit protected push-pull output
– Package: SOIC8 or TO92UT

HAR® 24xy

Precise and Robust Programmable Linear Hall-Effect Sensor Family – with Redundancy Functionality



Applications

The HAR 24xy is a potential system solution for applications such as:

– Angular measurement: throttle position, pedal position, steering torque, and EGR applications
– Distance and linear movement measurements in safety critical applications

Family Overview

HAR 2425	Analog output, 2-point calibration, 16 setpoints linearization
HAR 2455	PWM output (up to 2 kHz), 16 setpoints linearization

Features

– High-precision linear Hall-effect sensor with ratiometric 12-bit analog output (HAR 2425) or PWM output (HAR 2455)
– Dual-die Hall-effect sensors for true redundancy
– 16 setpoints for various output signal characteristics
– High immunity against HBM ESD (8 kV)
– Multiple customer-programmable magnetic characteristics in EEPROM with redundancy and lock function
– Programmable temperature compensation for sensitivity and offset
– Magnetic field measurements in the range up to 200 mT
– Low output voltage drifts over temp.
– Open-circuit (ground and supply line break detection), overvoltage and under-voltage detection
– Programmable output clamping function
– Digital readout of temperature and magnetic field information in calibration mode
– Operates from 4.5 V up to 5.5 V supply voltage in specification
– Operates with static magnetic fields and dynamic magnetic fields up to 2 kHz
– Overvoltage and reverse-voltage protection at all pins
– Short-circuit protected push-pull output
– Package: TSSOP14

HAL® 83x

Programmable Linear Hall-Effect Sensor Family



Applications

The HAL 83x is a potential system solution for applications such as:

- Linear movement
- Angle detection
- Accelerator pedal
- Throttle position
- Steering torque
- Exhaust gas recirculation
- Turbo charger

Note: HAL 830 can replace HAL 805, HAL 815 or HAL 817

HAL 835 can replace HAL 810 or HAL 825

Features

- High-precision linear Hall-effect sensor with 12-bit analog output
- Programmable temperature compensation for sensitivity
- Open-circuit (ground and supply line break) detection with 5 kΩ pull-up and pull-down resistor, overvoltage and undervoltage detection
- Programmable clamping function
- Programming and operation of multiple sensors at the same supply line
- High immunity against ESD
- Operates from 4.5 V up to 5.5 V supply voltage in specification and functions up to 8.5 V
- Overvoltage and reverse-voltage protection at all pins, short-circuit protected push-pull output
- Magnetic field measurement range from ±15 mT up to ±150 mT (HAL 835)
- Flexible analog / PWM output (HAL 835)
- Programmable low-pass filter at 80 Hz (less noise) or 2 kHz (faster response) (HAL 835)
- Offset drift over temperature less than ±0.2% of V_{SUP} (±0.1% for HAL 835)
- Package: TO92UT

HAL 830	Analog output, 30 mT to 100 mT range
HAL 835	Analog and PWM output, 15 mT to 150 mT range additional features

HAC® 830

Robust Multi-Purpose Linear Hall-Effect Sensor with Integrated Capacitors



Applications

The HAC 830 is a potential system solution for applications such as:

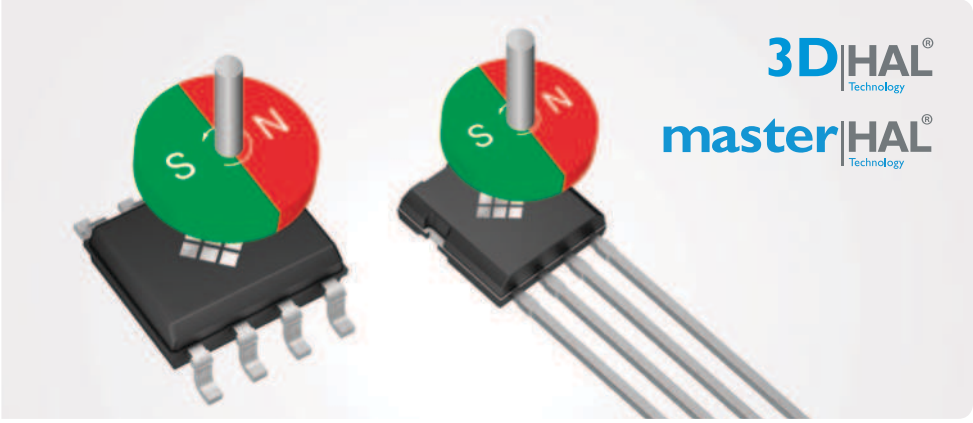
- Linear movement
- Angle detection
- Accelerator pedal
- Throttle position
- Steering torque
- Exhaust gas recirculation
- Turbo charger

Features

- High-precision linear Hall-effect sensor with 12-bit analog output
- Integrated capacitors for improved electromagnetic compatibility (EMC) and PCB-less applications
- Programmable temperature compensation for sensitivity
- Open-circuit (ground and supply line break) detection with 5 kΩ pull-up and pull-down resistor, overvoltage and undervoltage detection
- Programmable clamping function
- Programming and operation of multiple sensors at the same supply line
- High immunity against HBM ESD
- Operates from 4.5 V up to 5.5 V supply voltage in specification and functions up to 8.5 V
- Overvoltage and reverse-voltage protection at all pins, short-circuit protected push-pull output
- Magnetic field measurement range from ±30 mT up to ±100 mT
- Package: TO92UP

3D HAL® Technology from TDK-Micronas

Stray-Field Robust Position Detection



In the area of position detection in Automotive or Industrial applications, the requirements to sensors are steadily increasing. Their accuracy and reliability in harsh environments has to grow steadily. For applications measuring small distances (up to 6 mm) or small angle ranges (up to 60°), established linear (1D) Hall-effect sensors could show excellent and reliable performance.

For larger ranges, a new technology is needed. To this end, TDK-Micronas has developed the Hall sensor family HAL 37. With this family, angle measurements, formerly only to be done with on-chip flux concentrators or complex dual-package AMR (Anisotropic Magneto Resistance) sensors, can now be implemented in a CMOS process. Contrary to the AMR technology, measurements of angles up to 360°, as well as linear distances can both be realized.

As a next step, stray-fields are a big challenge for magnetic-field sensors. The motors and power lines in hybrid electric vehicles (HEVs) and battery electric vehicles (BEVs) carry high currents and can generate magnetic fields that interfere with magnetic-field sensors. Today, a modern Hall-effect sensor must offer robust stray-field immunity conforming to the latest ISO 11452-8 standard and related OEM requirements.

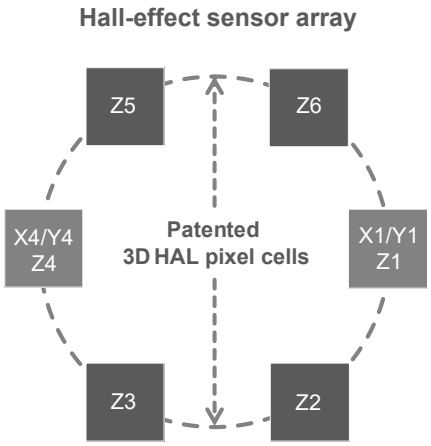
Overall, the various family members support different output formats like ratiometric analog, PWM, SENT, SPI, PSI5, and SPC. The devices can be easily adapted to the different applications by providing easy programmability. Key parameters like offset, gain, zero angle, output offset and gain, setpoints for linearization and clamping levels can be stored in the built-in memory.

Today, the product family consists of the second-generation HAL 37xy and the third-generation HAL 39xy.

License Note:
HAL/HAC/HAR 37xy and HAL 39xy use licenses of Fraunhofer Institute for Integrated Circuits IIS.

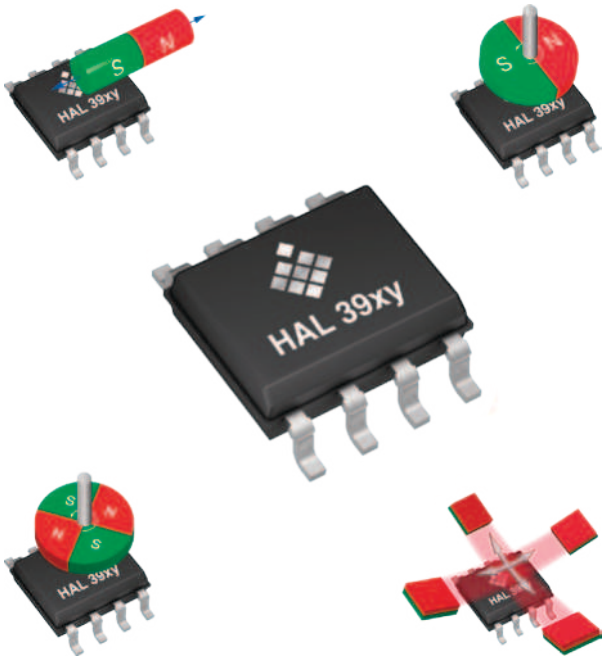
Stray-Field Compensation with HAL 39

The requirement for stray-field immunity is addressed by the HAL 39 family. Its unique stray-field concept is based on an array of vertical and horizontal Hall plates using the patented 3D HAL pixel cell. The highly flexible sensor array enables design engineers to select the best stray-field compensation for any given measurement task.



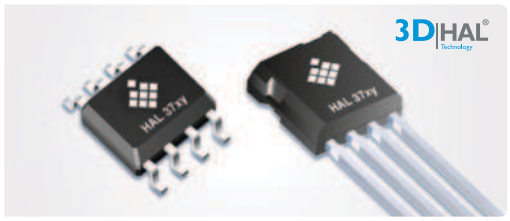
The HAL 39xy family offers four different measurement modes:

– Linear position detection with stray-field compensation
– Rotary 360° angle detection with stray-field compensation
– Rotary 180° angle detection with stray-field compensation, including gradient fields
– Real 3D magnetic field measurement (B_X, B_Y, B_Z)



HAL® 37xy

Programmable Hall-Effect Sensor Family for Rotational or Linear Position Detection based on 3D HAL® Technology



Functions

HAL 37xy provides a potential system solution for functions such as:

- Rotary movement detection
- Linear movement detection

Applications Examples

- EGR valve position
- Clutch pedal position
- Gear selector
- Cylinder and valve position sensing
- Non-contact potentiometer

Features

- Measurement extremely robust against temperature and stress influence
- Operating with magnetic field amplitudes down to ±20 mT with an angular accuracy of ±0.5% FS (digital output, X-Y Hall plates)
- 12 bit ratiometric linear analog output for HAL 372x
- HAL 371x with modulo 90°/120° for chassis systems
- 0.2 kHz to 2 kHz PWM (up to 12 bit) or 12 bit SENT output for HAL 373x
- Programmable arbitrary output characteristic with up to 33 setpoints
- Operates from V_{SUP} = 4.5 V up to 5.5 V
- Operates from T_J = –40 °C up to 170 °C
- Programming via the sensor's output pin
- Programmable characteristics in EEPROM with redundancy and lock function
- 2nd-order temperature-dependent offset of programmable for X/Y- or Z-channel
- On-board diagnostics
- Short-circuit protected push-pull output
- Over-/reverse-voltage protection at VSUP
- Under- and overvoltage detection at VSUP
- Wire-break detection with pull-up and pull-down resistor
- Package: SOIC8 or TO92UP

HAC® 37xy

Programmable Hall-Effect Sensor Family based on 3D HAL® Technology – with Integrated Capacitors



Functions

HAC 37 provides a potential system solution for functions such as:

- Rotary movement detection
- Linear movement detection

Applications Examples

- EGR valve position
- Turbocharger Actuator Position
- Position detection in Transmission Systems
- Cylinder and valve position sensing
- Non-contact potentiometer

Features

- Measurement extremely robust against temperature and stress influence
- Integrated capacitors for improved electromagnetic compatibility (EMC) and PCB-less applications
- Operating with magnetic field amplitudes down to ±20 mT with an angular accuracy of ±0.5% FS (digital output, X-Y Hall plates)
- 12 bit ratiometric linear analog output for HAC 372x
- HAC 371x with modulo 90°/120° for chassis systems
- 0.2 kHz to 2 kHz PWM (up to 12 bit) or 12 bit SENT output for HAC 373x
- SENT SAE J2716 rev. 2016 protocol:
  - H.1 Format: Transmission of position and temperature or magnetic field amplitude on fast and slow channel
  - H.2 Format: Three data nibbles
  - H.4 Format: Secure channel format
- Programmable arbitrary output characteristic with up to 33 setpoints
- Operates from V_{SUP} = 4.5 V up to 5.5 V
- Operates from T_J = –40 °C up to 170 °C
- Programming via the sensor's output pin
- Programmable characteristics in EEPROM with redundancy and lock function
- 2nd-order temperature-dependent offset of programmable for X/Y- or Z-channel
- On-board diagnostics
- Wire-break detection with pull-up and pull-down resistor
- Package: TO92UF

HAR® 37xy

Programmable Hall-Effect Sensor Family based on 3D HAL® Technology – with Redundancy Functionality



Functions

HAR 37xy provides a potential system solution for functions such as:

- Rotary movement detection
- Linear movement detection

Applications Examples

- EGR valve position
- Clutch pedal position
- Gear selector
- Cylinder and valve position sensing
- Non-contact potentiometer

Features

- Measurement extremely robust against temperature and stress influence
- Operating with magnetic field amplitudes down to ±20 mT with an angular accuracy of ±0.5% FS (digital output, X-Y Hall plates)
- 12 bit ratiometric linear analog output for HAR 372x
- HAR 371x with modulo 90°/120° for chassis systems
- 0.2 kHz to 2 kHz PWM (up to 12 bit) or 12 bit SENT output for HAR 373x
- HAR 379x: SENT SAE J2716 rev. 2016 protocol:
  - H.1: Two 12 bit fast channels (position & temperature or magnetic amplitude)
  - H.2: 12 bit fast channel
  - H.4: 12 bit secure single sensor
- Programmable arbitrary output characteristic with up to 33 setpoints
- Operates from V_{SUP} = 4.5 V up to 5.5 V
- Operates from T_J = –40 °C up to 170 °C
- Programming via the sensor's output pin
- Programmable characteristics in EEPROM with redundancy and lock function
- 2nd-order temperature-dependent offset of programmable for X/Y- or Z-channel
- On-board diagnostics
- Package: SOIC8

HAL® 39xy

Programmable Hall-Effect Sensor Family for 3D Position Detection – with Stray-Field Compensation



Functions

HAL 39xy provides a potential system solution for functions such as:

- Rotary movement detection
- Linear movement detection
- 3D position detection (two angles or B_X, B_Y, B_Z raw values)

Applications Examples

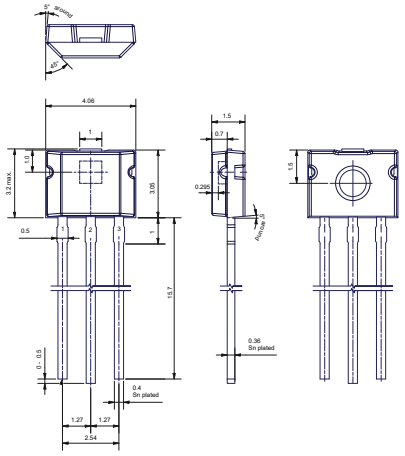
- Chassis position
- Turbo-charger actuators
- Valve position detection (e.g. EGR)
- Shift position
- Steering angle
- Fuel-level measurements
- Clutch position
- Transmission position detection

Features

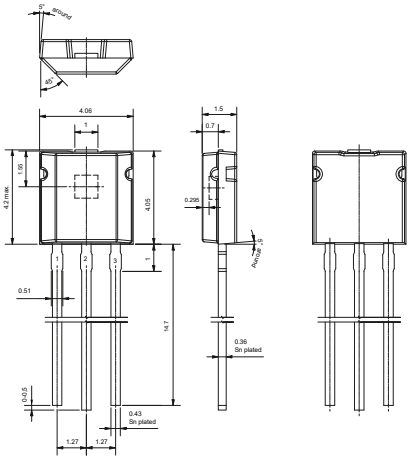
- Accurate angular measurement up to 360° and linear position detection
- 3D position detection
- Robust against magnetic stray fields
- ASIL B ready (SEooC according to ISO 26262)
- Wide supply voltage range: 3.0 V to 18 V
- Configurable output slew rates: 0.1 kHz to 2 kHz PWM frequency (up to 13 bit)
- SENT according to SAE J 2716 rev. 4Support of three different SENT frames (HAL 3930)
  - H.1: Two 12 bit fast channels (position & temperature or magnetic amplitude)
  - H.2: 12 bit fast channel
  - H.4: 12 bit secure single sensor
- SPC interface with ID selection mode, rolling counter, temperature information
- SPI interface (slave) with low-power modes
- PSI5 interface according to rev. 2.2
- T_A = –40 °C up to 160 °C
- Programming via the sensor's output pin or VSUP for HAL 3980

Package Information for Hall Switches, Linear Hall Sensors, and Direct-Angle Sensors

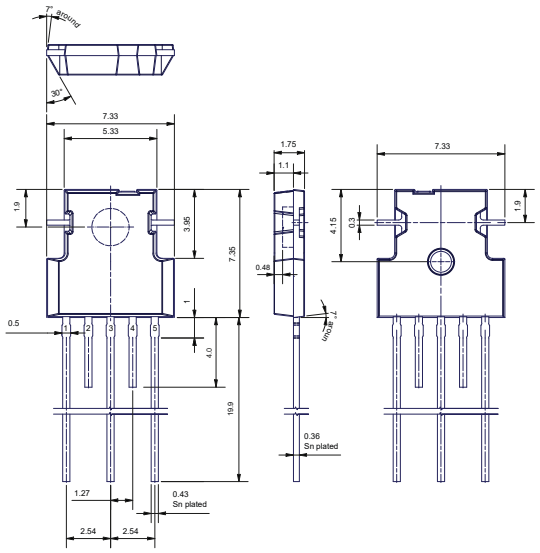
TO92UA



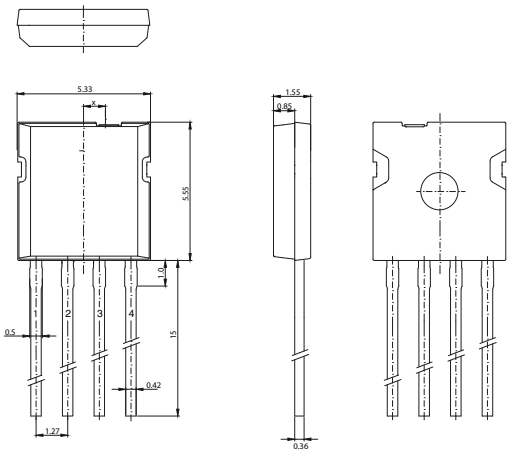
TO92UT



TO92UF

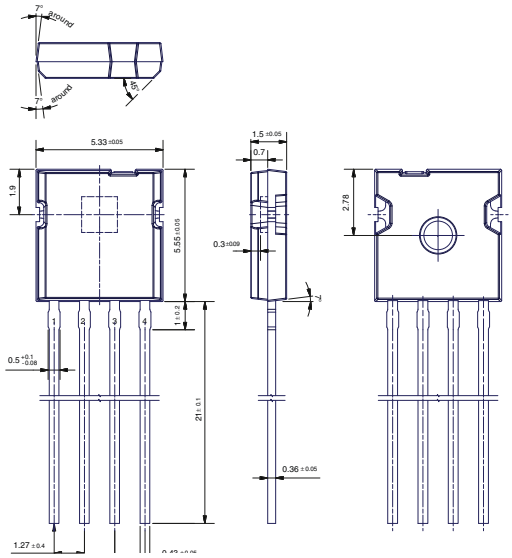


TO92UP

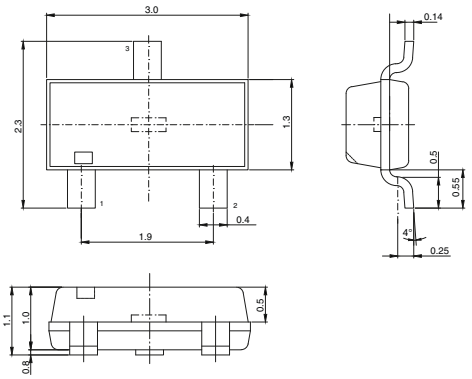


Package Information for Hall Switches, Linear Hall Sensors, and Direct-Angle Sensors

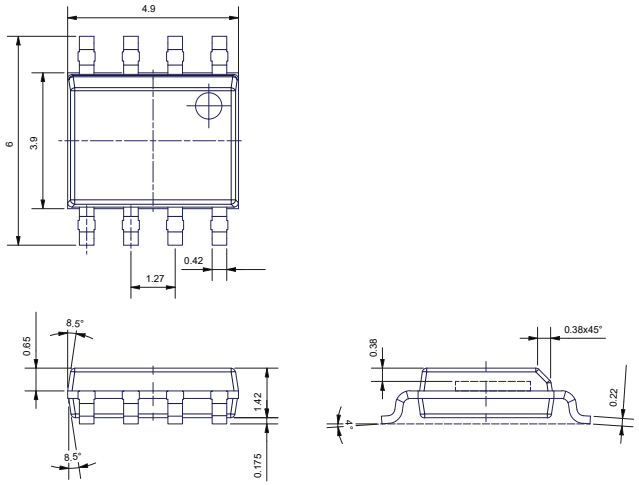
TO92UG



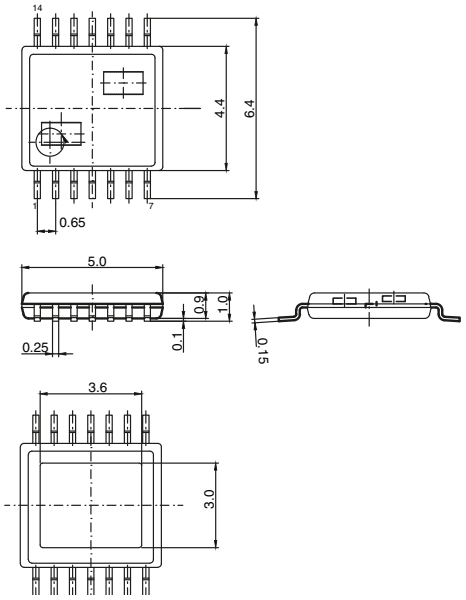
SOT23



SOIC8

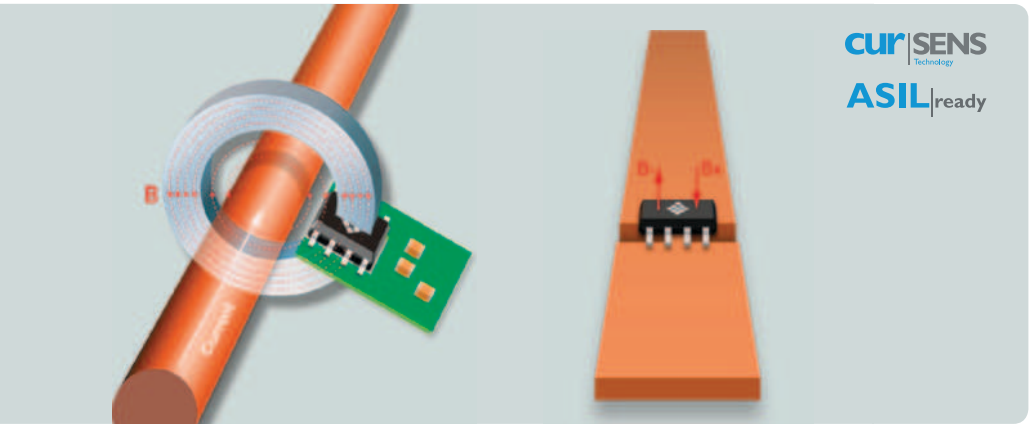


TSSOP14



Current Sensing

High-Precision Current Sensors



The CUR 4000 is a single-axis contactless magnetic-field sensor for galvanically isolated DC and AC current measurements and can be used in high-voltage battery monitoring systems of hybrid and electric vehicles (xEV).

A flexible Multi-Hall-Array allows linear or differential magnetic-field sensing for contactless and precise current sensing up to ≥2000 A.

CUR 4000 can be used for different module concepts like core-based or coreless. In the linear modes of CUR 4000, a configurable array of Hall elements enables highly accurate measurements for core-based stray-field robust sensor-module designs. The differential mode enables small coreless and stray-field robust system designs without shields.

Read-out of the complete Hall array provides an output-offset temperature-drift below ±0.05 percent full scale. Furthermore,the sensor delivers a hysteresis-free output signal. A non-linearity error of ±0.2 percent and a noise performance of ±0.005 percent full scale allows precise current measurements with a signal bandwidth of up to 8 kHz.

Current sensing modules equipped with the CUR 4000 can be programmed directly in-circuit by a microcontroller via SPI interface.

CUR 4000 is defined as ASIL-B ready SEooC (Safety Element out of Context)according to ISO 26262.

Major characteristics like gain and offset, etc. can be adjusted to the magnetic circuitry by programming the non-volatile memory. The device is qualified according to AEC-Q100-Rev-H and is designed for automotive applications with operation in an ambient temperature range (T_A) of –40 °C up to +150 °C.

CUR 4000 is available in a small eight-pin SOIC8 SMD package.

CUR 4000

High-Precision Programmable Closed-Loop Current Sensor



Functions

CUR 4000 provides a potential system solution for current measurement.

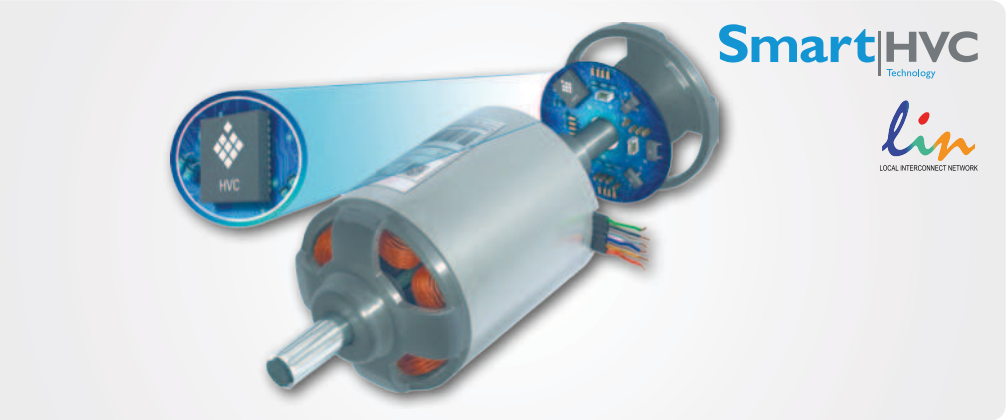
Applications Example

- xEV battery monitoring
- Stationary battery management

Features

- Non-intrusive, galvanically isolated contactless current measurement
- High-precision, linear magnetic-field sensing with flexible Hall plates array for core-based current sensing
- Differential magnetic-field (stray-field compensated) coreless current sensing without shields
- ASIL-B ready (SEooC according to ISO 26262)
- Signal bandwidth up to 8 kHz
- Total system error <1 %
- Programmable linearization with 33 equidistant or 17 variable setpoints
- Programmable adjustment and temperature compensation for gain and offset
- Low-power mode with wake-up functionality
- SPI interface for calibration, test, and debugging via microcontroller
- Digital 16-bit readout of magnetic-field information via SPI (up to 5 MHz)
- ±100 mT magnetic-field range
- Operates from –40 °C up to 150 °C (T_A)
- Operates from 3.0 V up to 5.5 V
- Programmable clamping threshold
- Over-/undervoltage detection on VSUP
- Overtemperature supervision
- Reverse-/overvoltage protection at VSUP
- Magnetic-field-out-of-range detection
- SOIC8 SMD package
- Qualified according to AEC-Q100-Rev-H

Introduction to Embedded Motor Controllers



The Micronas embedded motor controller family combines an industry standard Arm® Cortex®-M3 microcontroller core and a wide range of additional functions which, up to now, could only be realized via a combination of several external semiconductor parts.

The family is designed as an embedded controller for smart actuators. It features advanced integration for compact and cost-effective system designs for use in automotive applications and beyond (industrial, consumer, instrumentation, etc.).

Replacement of conventional mechanical drive by "on-demand" electric drive and a general adoption of a more efficient solution to control electrical motors are the main reasons for a growing demand for cost-effective system solutions for electrical motor control and drive. Long lifetime reliability, reduction of weight as well as overall dimension, and flexibility to easily adapt to several types of motors and applications are additional key issues which have to be addressed especially for automotive applications. Thanks to their better efficiency, lower acoustic- and electrical noise, brushless DC (BLDC) are gaining a significant share of the electrical motors by replacing conventional motors.

Micronas embedded motor controllers integrate almost all surrounding circuits needed for driving electrical motors. In addition to the UART interface, the built-in networking capabilities enable the deployment of LIN bus control compliant to LIN-2.x for a wider range of applications like e.g. cross-linked smart actuator. Reducing the number of external components to a minimum, the product's flexible peripherals allow direct controlling of brushless, brush-type DC- and stepper electrical motors, either by means of six fully integrated half-bridges or by controlling three external MOSFET half-bridges. Thanks to this flexibility in driving the electrical motor, the HVC controllers provide an effective system solution for both small and medium sized electrical motors, enabling a common product platform by a family concept. This gives our customers a decisive competitive edge because they are much faster at the implementation stage and need fewer resources in the development process of their various applications.

HVC 42/44

Embedded Motor Controllers for Smart Actuators









The Micronas HVC embedded motor controller family enables cost-effective realization of powerful and compact DC motor (BLDC or stepper) control. The new HVC 4422F offers extended memory size to address the OEM diagnostic requirements and allows operation in high-temperature environments. An integrated Memory Protection Unit (MPU) supports RTOS requirements. Powered by a high-performance 32-bit Arm® µC core (Arm® Cortex®-M3) and integrating high-performance analog functions, the HVC economically addresses growing challenges in the automotive market and beyond (industrial, consumer, instrumentation, etc.). The flexible peripherals of the product provide all means to directly control brush-type, stepper (bipolar or three phase), or brushless direct current (BLDC) motors via integrated high-performance half-bridges without the need for external components.

Beside timers/counters, interrupt controller, multichannel A/D converter, SPI, and enhanced PWMs with diagnosis functions, this device contains an advanced LIN UART interface with a LIN 2.x transceiver with provisions for voltage regulators for direct connection to a 5.4 V to 18 V automotive power supply. The support of various power management modes makes it possible to adjust current consumption according to system needs. The HVC further features a flash program memory with a size of up to 64 kbytes, providing high flexibility in code development, production ramp-up, and in-system code update.

Various integrated digital and analog circuit units such as comparators with virtual star point reference, current scaling or an embedded programmable gain amplifier allow users to further minimize the number of external components. The computation capacity supports complex motor control algorithms such as Space Vector Modulation (SVM) for Permanent Magnet Synchronous Motors (PMSM) in addition to six-step commutation with sensor feedback or sensorless control as well as various stepping configurations. The setup makes the adaption to new motor types fast and easy.

Features

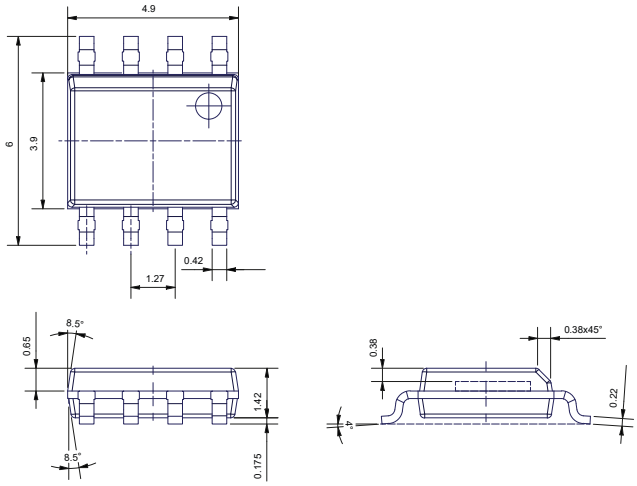
- Six integrated half-bridges up to 6 x 500 mA or 1000 mA (depending on configuration)
- Temperature range up to T_A =150 °C (Automotive Grade 0)
- Supply voltage: 5.4 V ... 18 V, Load dump up to 40 V
- High-performance 32-bit Arm® Cortex®-M3, running at up to 20 MHz
- Memory:
  - up to 4 kbyte RAM
  - up to 64 kbyte Flash
  - On-chip NVRAM with wear leveling
- Logic modules dedicated for controlling BLDC or BDC motors
- Comparators with integrated virtual star point and reference currents
- Digital and window watchdog timers with different, independent clocks
- 12-bit multi-channel ADC
- Programmable gain amplifier
- 16-bit free-running counter with three capture/compare-modules
- Two 16-bit timers
- Enhanced PWMs (EPWMs), providing edge/center-aligned signals with non-overlapping capability
- SPI and enhanced LIN 2.x UART
- LIN 2.x transceiver
- Integrated temperature sensor
- Active EMI suppression hardware
- Several diagnosis and protection functions such as:
  - Integrated H-bridge diagnostic features
  - Internal protection for non-overlapping bridge activation
  - Clock/temperature/supply supervision
  - Overvoltage/Overcurrent protection
- Power saving modes
- Package: QFN40 - 6x6

Functions

HVC is the enhanced system solution to drive stepper, BLDC or up to two BDC motors for various applications in the automotive environment, like grille shutter, HVAC flaps, LED headlight & fan and much more, as well as in the industrial environment, enabling smart mechatronical actuators.

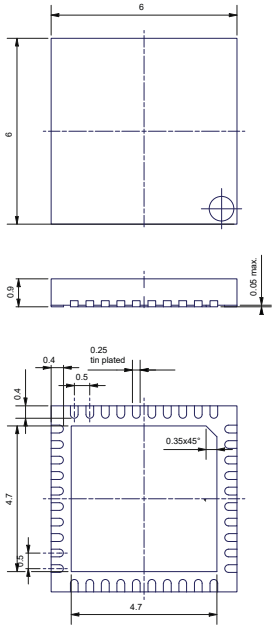
Package Information for Magnetic Current Sensors

SOIC8



Package Information for Embedded Motor Controllers

QFN40 - 6x6



Contact

Hall Switches, Direct-Angel Sensors, Magnetic Current Sensors, and Embedded Motor Controllers

Contact for Micronas products worldwide
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Phone +49 761 517 0
www.micronas.tdk.com

All information about sensors and sensor systems can be found in the TDK Product Center on **product.tdk.com**.



Trademarks
– 1D HAL
– 2D HAL
– 3D HAL
– curSENS
– easyLIN
– HAL
– HAC
– HAR
– masterHAL
– SmartHVC
– zero ppm

Please be sure to request delivery specifications that provide further details on the features and specifications of the products for proper and safe use. Please note that the contents may change without any prior notice due to reasons such as upgrading.

About TDK Corporation

TDK Corporation is a world leader in electronic solutions for the smart society based in Tokyo, Japan. Built on a foundation of material sciences mastery, TDK welcomes societal transformation by resolutely remaining at the forefront of technological evolution and deliberately "Attracting Tomorrow." It was established in 1935 to commercialize ferrite, a key material in electronic and magnetic products. TDK's comprehensive, innovation-driven portfolio features passive components such as ceramic, aluminum electrolytic and film capacitors, as well as magnetics, high-frequency, and piezo and protection devices. The product spectrum also includes sensors and sensor systems such as temperature and pressure, magnetic, and MEMS sensors. In addition, TDK provides power supplies and energy devices, magnetic heads and more. These products are marketed under the product brands TDK, EPCOS, InvenSense, Micronas, Tronics and TDK-Lambda. TDK focuses on demanding markets in automotive, industrial and consumer electronics, and information and communication technology. The company has a network of design and manufacturing locations and sales offices in Asia, Europe, and in North and South America. In fiscal 2021, TDK posted total sales of USD 13.3 billion and employed about 129,000 people worldwide.

About TDK-Micronas

TDK-Micronas is the center of competence for magnetic-field sensors and CMOS integration within the TDK group. TDK-Micronas has gained operational excellence for sensors and actuators production in over 25 years of in-house manufacturing. It has been the first company to integrate a Hall-effect based sensor into CMOS technology in 1993. Since then, TDK-Micronas has shipped over five billion Hall sensors to the automotive and industrial market. The operational headquarters are located in Freiburg im Breisgau (Germany). Currently, TDK-Micronas employs around 1,000 people.

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