



# XENSIV™ – sensing the world

Sensor solutions for automotive, industrial  
and consumer applications

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## Infineon XENSIV™ – sensing the world

Infineon XENSIV™ sensors are exceptionally precise thanks to industry-leading technologies. They are the perfect fit for various customer applications in automotive, industrial and consumer markets.

From a world leader in sensing technology, XENSIV™ sensors simplify lives by enabling “things” to “see”, “hear”, “feel” and , “smell” and therefore intuitively “understand” their environment. Providing exceptional accuracy and best-in-class measurement performance, XENSIV™ sensors add extraordinary value to customer applications. More than 40 years’ experience in sensing solutions and a deep-rooted system understanding result in the broadest portfolio of ready-to-use sensor solutions on the market. Ecosystem partners and our customers partner with us for leading technologies, perfect-fit solutions and continuous innovation.

At Infineon, we are committed to making cars safer, smarter and greener with our innovative and leading sensor portfolio. Today, a new car features numerous safety, body and powertrain applications that rely on sensors. Clearly focused on future trends, our outstanding portfolio of sensor ICs for numerous safety-relevant automotive systems makes cars much safer. In Electric Power Steering (EPS), our magnetic angle sensors and linear Hall sensors are used to measure the steering angle and steering torque. Since all our newly developed parts are based on an ISO 26262-compliant development flow, we do our utmost to support our customers’ designs in achieving the ASIL classification. This means that they can be deployed directly in all safety-relevant applications – making us a leader in supporting ISO 26262-compliant systems.

As part of our comprehensive XENSIV™ sensor family, we now also offer high-performance MEMS microphones qualified according to the state-of-the-art automotive quality standard AEC-Q103-003. These microphones close the industry gap, providing the best possible fit for automotive applications. Automotive XENSIV™ MEMS microphones combine our proven expertise in the automotive industry with our technical leadership in high-end silicon microphones. Our high performance MEMS microphones are also the first choice for consumer applications.

On the automotive front – where safety and high precision are essential – many manufacturers rely on our XENSIV™ products for tire pressure monitoring system (TPMS), seat comfort, side crash detection, pedestrian impact detection and weather applications.

Infineon's RASIC™ 77-GHz chips are used in Radar-based driver assistance systems – such for Adaptive Cruise Control or collision avoidance – which recognize objects at a range of up to 250 meters. With more than 200 million chips already delivered to customers, we are the market leader in Radar chips.

Our comprehensive family of XENSIV™ sensors includes a wide choice of pressure sensors tailored specifically to the needs of [automotive](#), [industrial](#) and [consumer](#) sectors. Offering rapid time-to-market, our XENSIV™ portfolio ensures the perfect fit for all performance and integrity needs. Featuring analog and digital interfaces, these sensors give customers a high degree of design flexibility, while also enabling manufacturers to meet evolving market and compliance demands.

The latest XENSIV™ PAS CO2 sensor is an exceptionally small, real CO2 sensor and is ideal for high-volume smart home and building automation applications such as

Use the qr-code or visit us on [www.infineon.com/xensiv](http://www.infineon.com/xensiv) to get the whole portfolio overview, our latest downloads and videos.

demand-controlled ventilation systems, air purifiers and thermostats. This disruptive sensor technology enables users to accurately measure and adjust indoor air quality, contributing to the overall wellbeing, health and productivity of occupants while also optimizing energy efficiency.

Our XENSIV™ – high-precision coreless current sensors are dedicated for high voltage industrial applications which require an accurate and stable current measurement, such as electric drives or photovoltaic inverters up to 120 A.

In the Internet of Things, sensors are omnipresent and mark the starting point of each and every IoT system. They collect all kinds of data on their surroundings, providing the entry point for all subsequent functions and features. Building on its well-founded systems expertise, Infineon's broad portfolio in the XENSIV™ family contains ready-to-use solutions to enable a fast time-to-market and reliable functionality for applications in the area of smart home & smart building, smart things, smart factory or smart cars.

Today, we are already inspiring the next generation of smart environments, capable of understanding and responding to human communication.

Infineon's semiconductors are at the very heart of machine-to-machine (M2M), human-machine interface (HMI), mobile and wireless infrastructure technologies. As the technological boundary between humans and machines gradually disappears, these devices need even more advanced intelligence, enriched with voice assistance capabilities and the latest sensor fusion innovations, not to mention robust security technologies to protect personal data.

Infineon's sensors and microphones are already delivering this intelligent functionality and inspiring the next step in mobile connectivity.



# Infineon XENSIV™ solutions from application to sensor



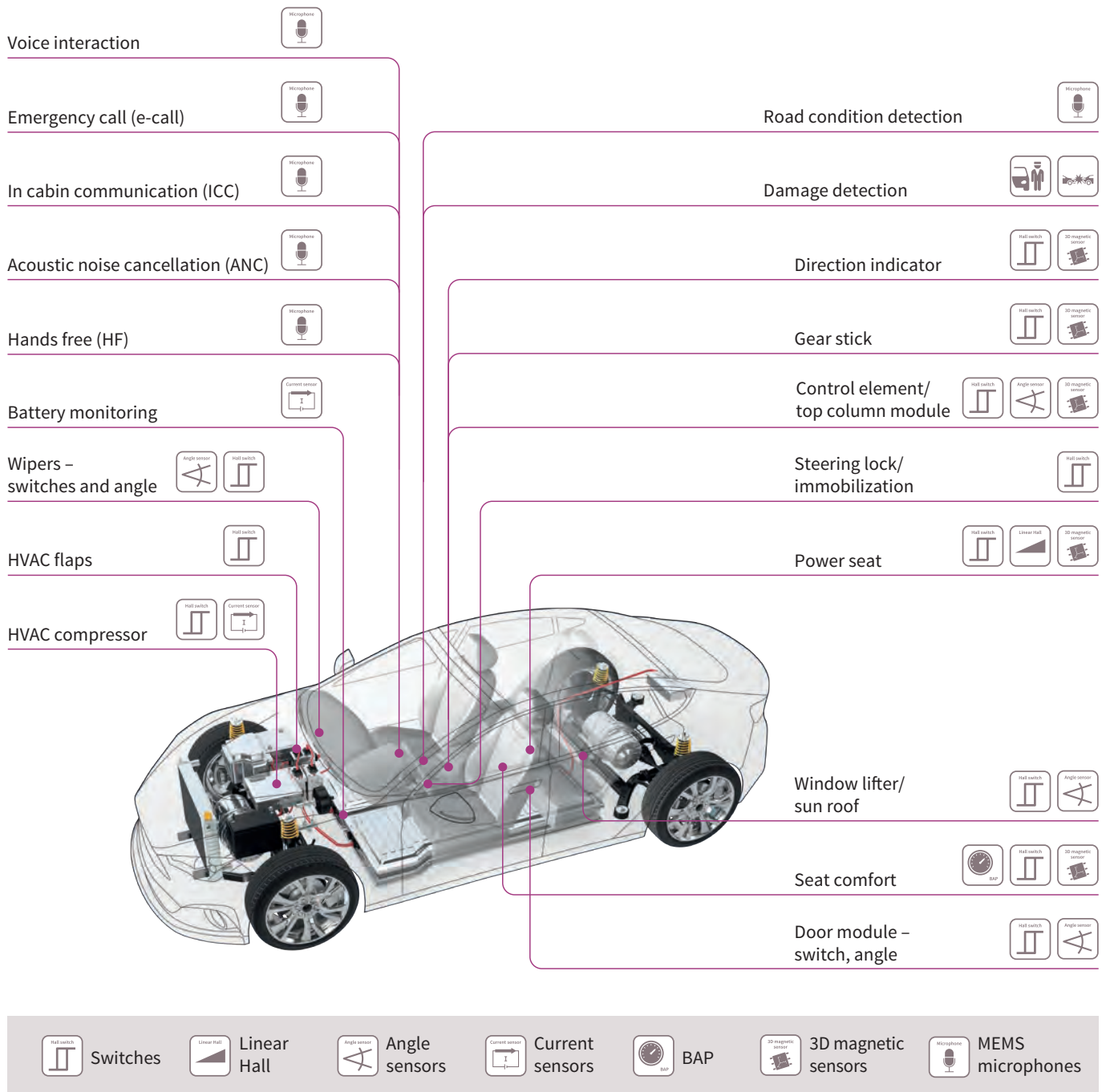
## Find your sensor

Welcome to our new interactive sensor selection tool, designed to connect you with the best fit for your design as quickly and effortlessly as possible. Simply select the overarching industry (automotive or industrial/consumer) and drill down on the applications till you find your target use case. The selection tool will then tell you what Infineon XENSIV™ sensor is the best choice for your design. It couldn't be easier.

Find your sensor on [www.infineon.com/fastfinder](http://www.infineon.com/fastfinder)



# XENSIV™ sensors in body applications



The body segment presents the most diverse target market for sensors. Sensors are used for position sensing, motor control, comfort features and HMI applications. Sensor content is expected to grow further as interior and comfort is

becoming a key differentiation factor for OEM's. At Infineon, we support body applications with one of the broadest portfolios of sensors and sensing principles in the market at outstanding levels of quality and reliability.

# XENSIV™ sensors in powertrain applications

## Engine

Crankshaft



Camshaft position



Manifold air pressure



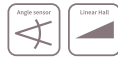
Secondary air valve



Turbo charger



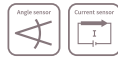
Throttle position



Variable valve position



HEV electric motor



Pedal position



Exhaust Gas Recirculation (EGR)



DC/DC converter



## Transmission

Clutch position



Clutch actuator



Transmission speed



Transmission actuator



Transmission gear position



Oil pump



Park lock



Gear stick



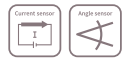
Battery monitoring for EV



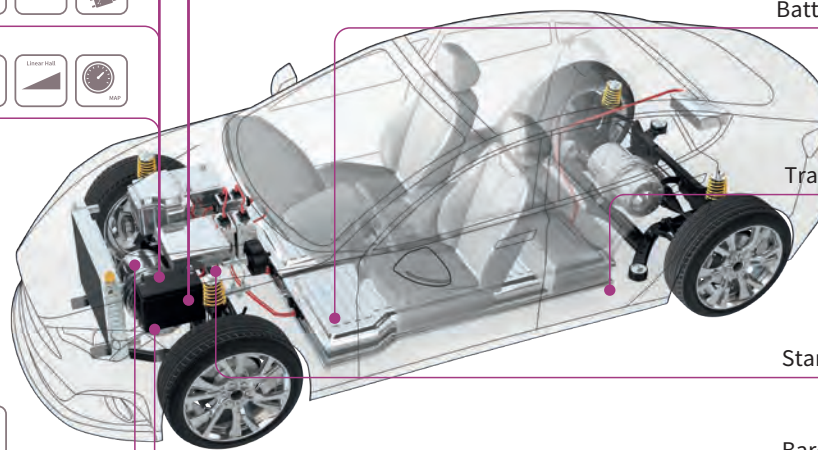
Transercase



Starter generator



Barometric air pressure



Switches



Linear Hall



Angle sensors



Current sensors



BAP



MAP



Speed sensors



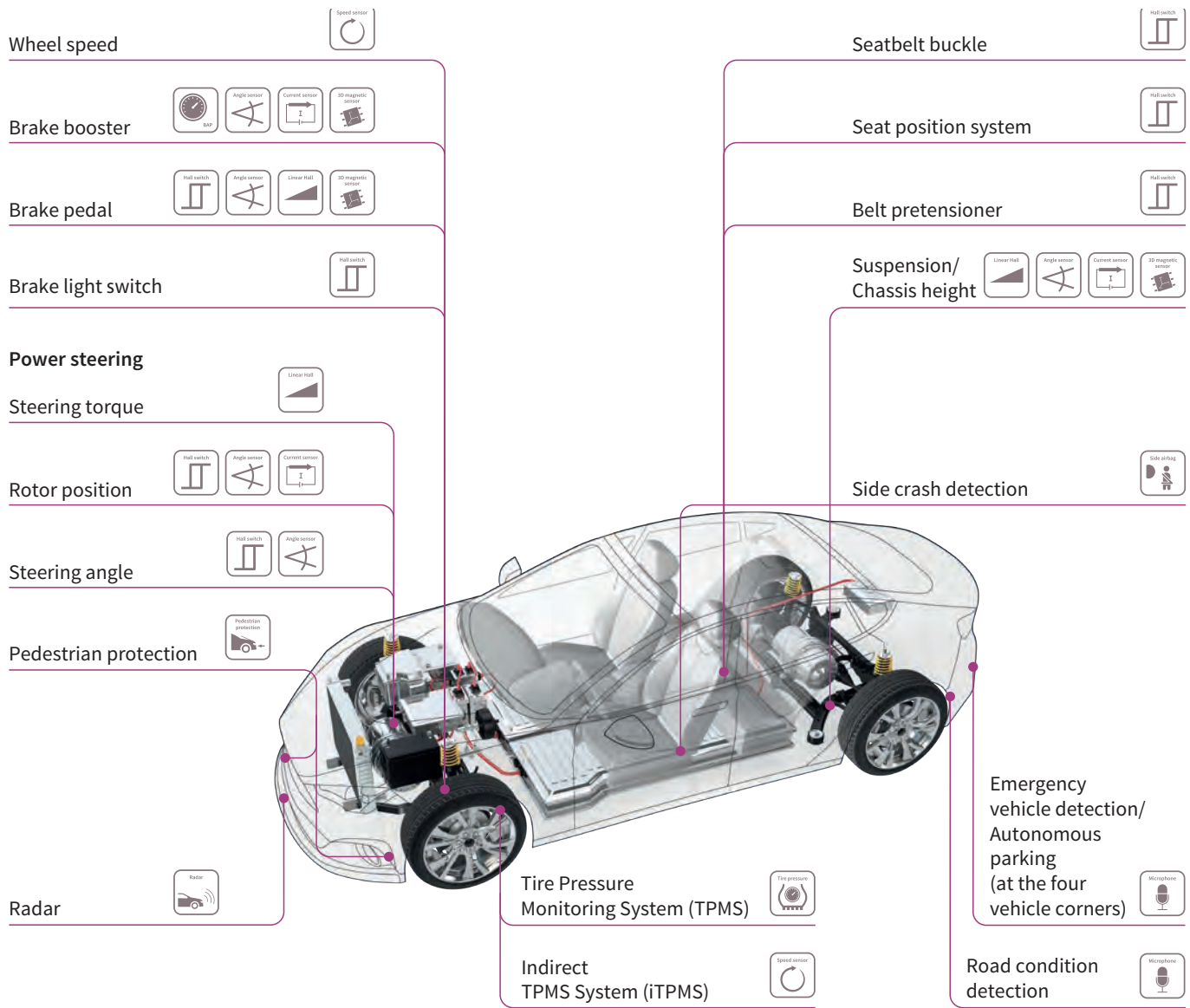
3D magnetic sensors

Crankshaft, camshaft and transmission speed sensors as well as MAP and BAP pressure sensors are only some of the key elements of multiple modern powertrain applications,

such as engine and transmission, which significantly boost drivetrain efficiency. Our broad portfolio of products fits every customer requirement.



# XENSIV™ sensors in safety applications



|          |             |               |                       |  |                     |
|----------|-------------|---------------|-----------------------|--|---------------------|
| Switches | Linear Hall | Angle sensors | Pedestrian protection | Current sensors                        | 3D magnetic sensors |
| Radar    | BAP         | Speed sensors | Side airbag           | Tire Pressure Monitoring System (TPMS) | MEMS microphones    |

At Infineon, we focus in particular on sensors for safety applications. These include radars in automatic cruise control systems, wheel speed sensors in ABS and ESP features, pressure sensors and silicon microphones in emergency vehicle detection systems, side airbags and pedestrian

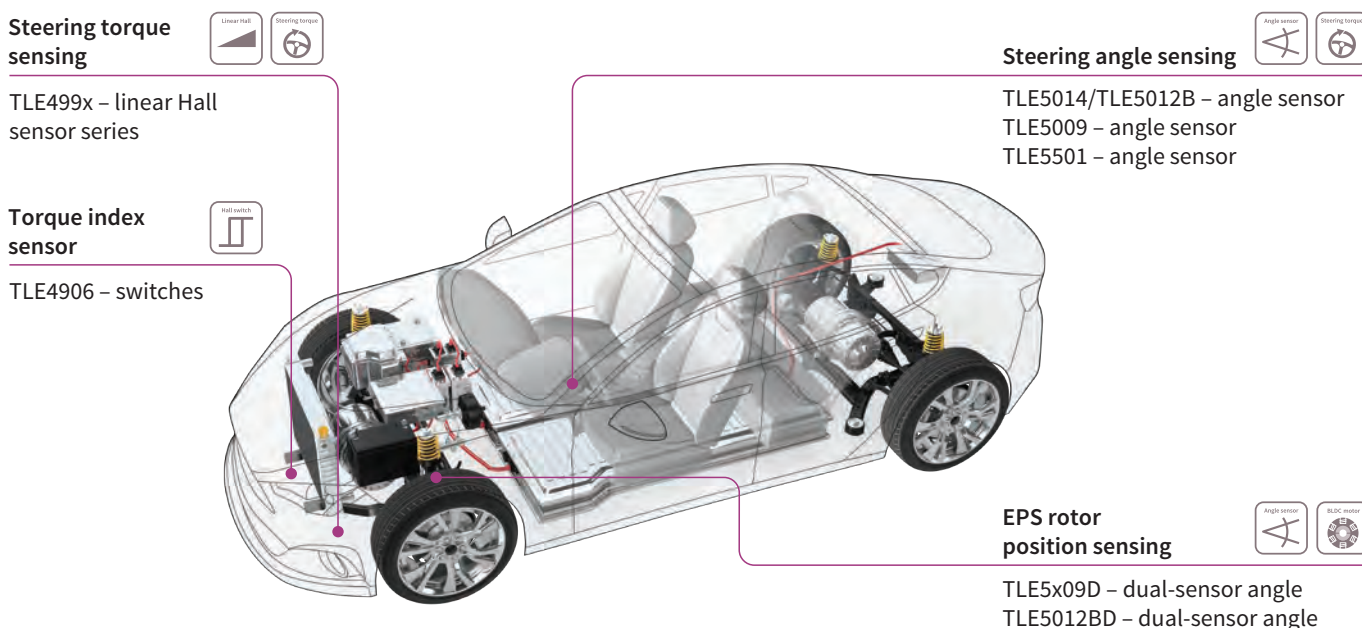
protection systems, as well as TPMS sensors. We are the global market leader in most of these areas and our customers value the outstanding levels of quality and reliability that we deliver.

## Magnetic position sensors for highest energy efficiency and functional safety in Electric Power Steering (EPS)

Compared to conventional hydraulic power steering solutions, Electric Power Steering (EPS) enables higher energy efficiency, increased steering functionality and reduced space requirements in passenger vehicles.

The functionality of EPS is based on several system-side position sensors, that measure the steering torque input from the driver, the rotor position of the EPS motor, that moves the steering rack and the steering wheel's absolute position.

### Typical application for Infineon magnetic position sensors in EPS



|             |               |                 |            |          |
|-------------|---------------|-----------------|------------|----------|
| Linear Hall | Angle sensors | Steering torque | BLDC motor | Switches |
|-------------|---------------|-----------------|------------|----------|

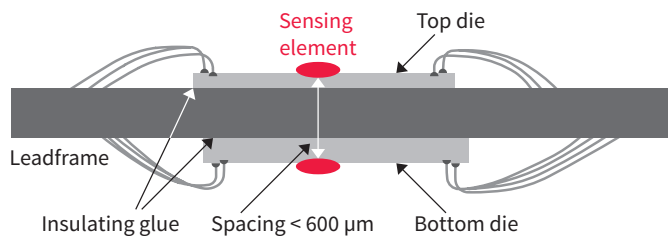
Position sensor applications in EPS are safety-related with the highest safety level. The ISO 26262 standard sets high requirements for the diagnostic coverage of random failures and the avoidance of systematic failures in order to reach the highest safety rating on system level resulting in a safety classification of the category ASIL D.

These demanding specifications can typically be achieved by using redundant sensors as well as comparing their signals in a microcontroller.

Infineon offers dual-sensor solutions with two redundant sensors in the place of one for all position sensor applications in EPS. Our dual-sensor package integrates two magnetic position sensors with separate supply pins and separate signal outputs. They are electrically independent thanks to galvanic isolation. This means that the two sensors work independently, thereby increasing system reliability.

## Magnetic position sensors for the ultimate in energy efficiency and functional safety in Electric Power Steering (EPS)

Side view of Innovative stack-mounted dual-sensor technology with bonding wires



Transparent 3D-graph of dual-sensor TDSO-16-2 package







Thanks to the use of innovative stack-mounting technology, the devices of the angle sensor family combine two independent sensors within standard and space-saving TDSO packages which are only about 1 mm thick. It has the same width and length as a conventional single-sensor package. Compared to the common approach of side-by-side sensor

placement, the advantages of the top-bottom placement include a more homogeneous magnetic field over the sensing elements and a significantly smaller footprint. This saves precious space and cuts down on expense in safety-critical applications.

## Steering torque sensors

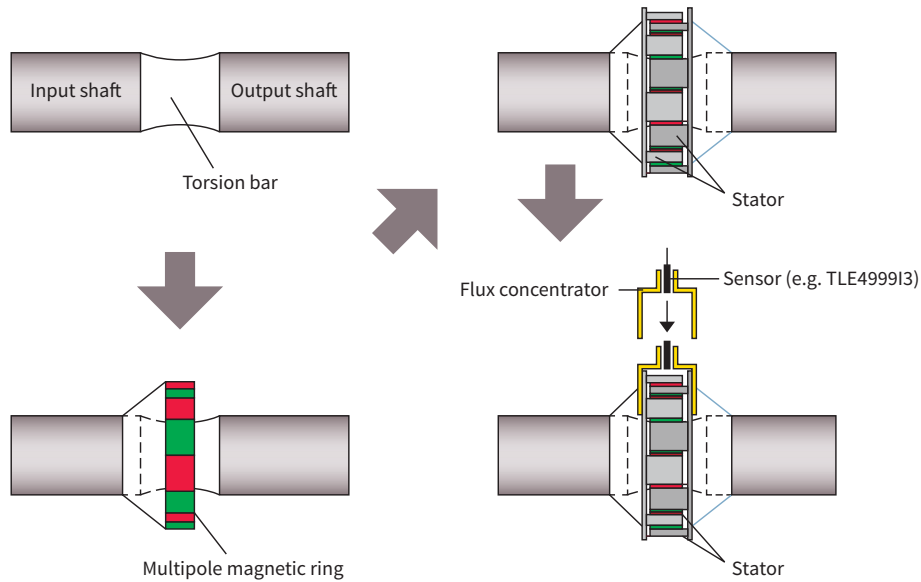
In the field of steering torque sensing, Infineon XENSIV™ TLE499x series offers highly accurate linear Hall sensors for magnetic torque sensing assembly. In order to support a maximum of compatibility with various

Electronic Control Unit (ECU) designs, the TLE499x sensors feature PWM, SENT, SPC, PSI5 or ratiometric analog output. They are available in leaded packages, as well as 1 mm-thick dual- or single-sensor SMD packages.

|   |           |   |
|---|-----------|---|
|  | TLE4997x  | Programmable linear Hall sensor with temperature compensation and ratiometric analog output. Available in a 3-pin leaded package (without integrated capacitors) and an 8-pin dual- or single-sensor SMD package.   |
|  | TLE4998x  | Programmable linear Hall sensor with digital stress and temperature compensation and PWM, SENT or Short-PWM-Code (SPC) output. Available in a 3- or 4-pin leaded package (with or without integrated capacitors) and an 8-pin dual- or single-sensor SMD package. |
|  | TLE4999I3 | Programmable dual channel linear Hall sensor with PSI5 interface. Developed compliant to ISO 26262 for safety requirements rated up to ASIL D. Available in a 3 pin leaded package.   |
|  | TLE4999Cx | Programmable dual channel linear Hall sensor with Short-PWM-Code (SPC) interface. Developed compliant to ISO 26262 for safety requirements rated up to ASIL D. Available in an 8-pin dual- or single-sensor SMD package, 4-pin leaded package planned (e/o 2021)  |

# Magnetic position sensors for the ultimate in energy efficiency and functional safety in Electric Power Steering (EPS)

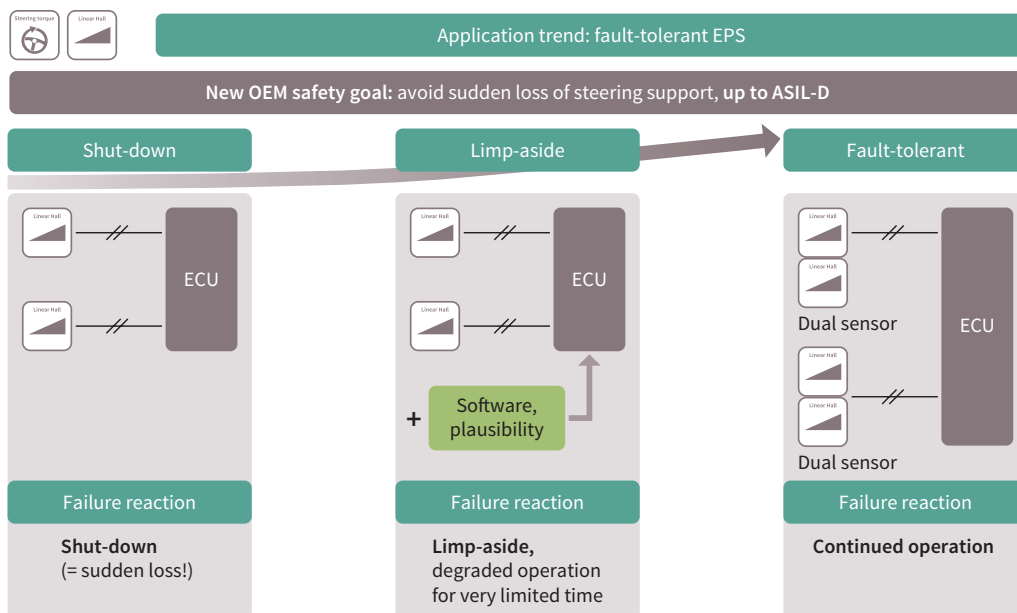
## Magnetic torque sensing assembly



Conventional EPS systems, which use two linear Hall sensors for ASIL D compliance, have to shut-down in the event of a loss of one sensor signal. Therefore, the trend in EPS systems is to increase availability by implementing additional sensor signals or plausibility mechanisms. To support this trend towards high-availability EPS functionality, Infineon recommends the usage of two

TLE4998xD dual-sensors or two TLE4999x, each of them with two highly accurate redundant Hall measurement channels (main and sub) integrated on one single chip. In case of one TLE4998xD or TLE4999x signal loss, the remaining dual-sensor (TLE4998xD) or the single die two channels (TLE4999x) in the system provides continued operation of the EPS, avoiding an immediate system shut-down.

## Application trend: fault tolerant

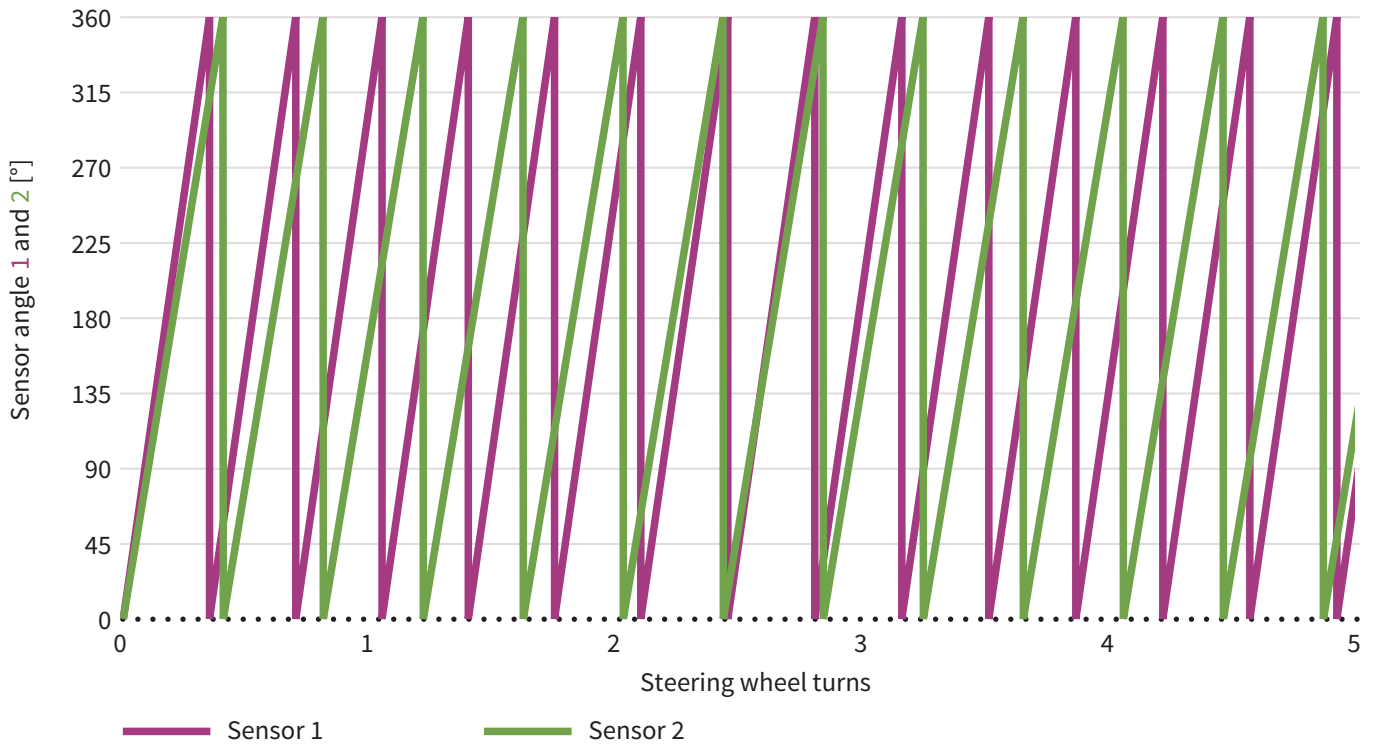


## Steering angle sensors

The absolute steering angle position is an input for the Electric Stability Program (ESP) and other driver assistance systems. A typical module design used for steering angle measurement is a design featuring gear

wheels with a slightly different number of teeth. The angular positions of the gear wheels are measured by two angle sensors, where the absolute steering wheel position is calculated from those positions via the Vernier principle.





### Schematic steering angle sensor module and illustration of the Vernier principle



## Steering angle sensors

The angle sensors for absolute steering angle measurement are available as a single-sensor SMD package for conventional designs, which achieve the ASIL D rating via a plausibility calculation of the two angle sensor signals as a result of a significant movement of the steering wheel.

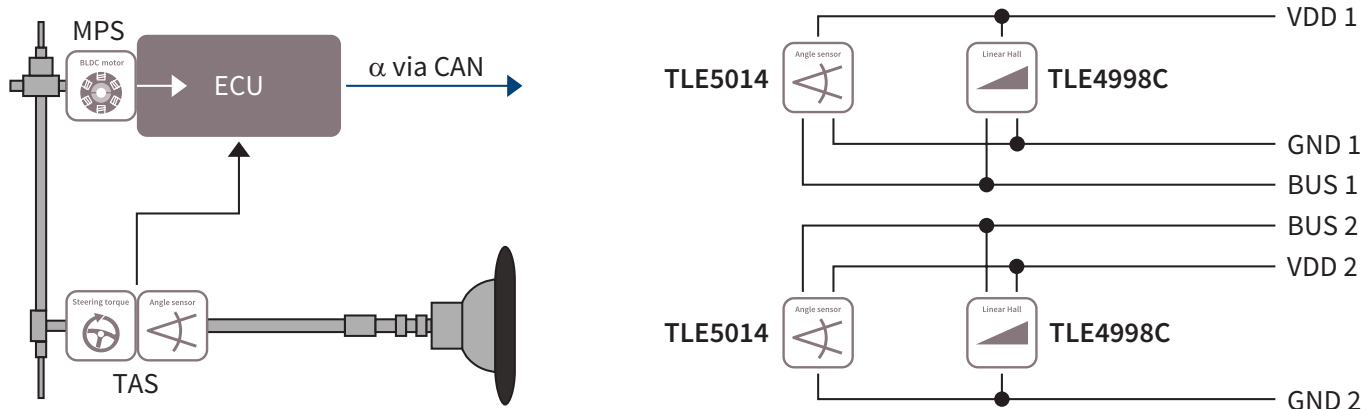
The sensors are also available in dual-sensor packages for module designs, that support an ASIL D-rated steering angle directly at power-on (ASIL D from start).

|   |               |  |
|---|---------------|--|
|  | TLE5009(D)    | Fast Giant-Magneto Resistive (GMR) angle sensor with analog sin/cos output. Available in an 8-pin single, 16-pin single- and dual-sensor SMD package.  |
|  | TLE5109A16(D) | Fast Anisotropic Magneto Resistive (AMR) angle sensor with analog sin/cos output. Available in an 8-pin single, 16-pin single- and dual-sensor SMD package.  |
|  | TLE5014(D)    | ISO 26262-compliant (ASIL C-metric), programmable GMR angle sensor with PWM, SENT or SPC output. Supports Torque-Angle-Sensor (TAS) module bus configuration with TLE4998C. Available in a 16-pin single- and dual-sensor SMD package.               |
|  | TLE5501       | ISO 26262-compliant (ASIL D-metric) Tunneling Magneto Resistive (TMR) angle sensor with analog sin/cos output. Available in an 8-pin single SMD package. Decoupled bridges for redundant external angle calculation and highest diagnostic coverage. |

Infiniteon angle sensors support steering angle sensor configurations with an on-board microcontroller, as well as satellite sensor designs, due to a broad variety of supported communication interfaces. In particular, the SPC interface allows the connection of angle sensor(s) and linear Hall

sensor(s) on a bus line in combined Torque-Angle-Sensor (TAS) modules. Compared to conventional designs with separate torque sensor and angle sensor modules, this configuration reduces the cost of wiring and saves module space.

### Schematic TAS module set-up and SPC bus configuration of the TLE5014 and TLE4998C

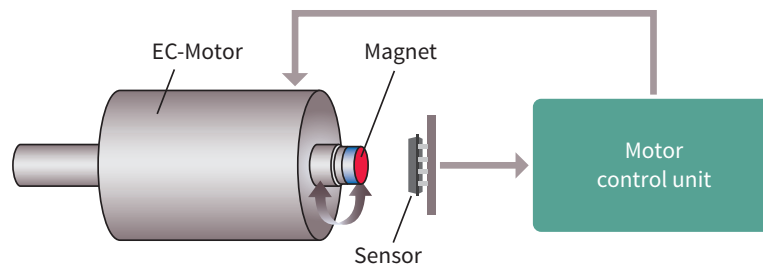


## EPS rotor position sensors

The motor, that drives the steering rack in an EPS system is usually a highly efficient brushless DC (BLDC) motor, which relies on a fast and accurate position sensor for commutation. In this application, short latency and high

accuracy are essential, as these sensor parameters have a significant impact on torque stability and the energy efficiency of the motor.

### Schematic of BLDC motor with a magnetic position sensor for commutation







A correct commutation of the EPS motor has to be ensured, in order to avoid a blocked steering or the erratic steering support. This application is also classified in the category of ASIL D. To achieve this high level of functional safety, Infineon offers angle sensors in the dual-sensor package that allow the integration of two redundant sensors in the place of one.

The TLE5309D, in particular, meets the highest functional safety requirements by using a combination of AMR (Anisotropic-Magneto-Resistance) and GMR (Giant-Magneto-Resistance) technology, which not just offers redundan-

cy, but also integrated diversity in a single product. Depending on the overall EPS system architecture, the motor position sensor can be directly mounted on the steering ECU, or connected via a cable in a satellite configuration.

The very high level of sensor accuracy required for highest energy efficiency, comparable to the performance of costly resolver solutions, is typically achieved by implementing a continuous calibration algorithm on the steering ECU. By monitoring the sensors output signals and calculating the compensation parameters during operation, this algorithm compensates any drift that occur over temperature and lifetime.

|   |               |   |
|---|---------------|---|
|  | TLE5009A16(D) | Fast dual-GMR angle sensor with analog sin/cos output. Available in a 16-pin dual-sensor SMD package.   |
|  | TLE5109A16(D) | Fast dual-AMR angle sensor with analog sin/cos output. Available in a 16-pin dual-sensor SMD package.   |
|  | TLE5309D      | Combined AMR and GMR sensor for integrated diversity, featuring fast analog sin/cos output. Available in a 16-pin dual-sensor SMD package.        |
|  | TLE5012BD     | Digital GMR angle sensor with SPI + incremental encoder interface or Hall switch emulation output. Available in a 16-pin dual-sensor SMD package. |

# New challenges for engine sensors in hybrid powertrains

The prospect of emissions penalties as of 1 January 2021 is prompting many manufacturers to switch to lower-carbon drive systems. Electric cars have become a key talking point on everyone's agenda – especially in California, where a very promising startup recently (February 2020) secured a higher market capitalization than the biggest European car manufacturer.

But there is a wide playing field between conventional combustion engines and all-electric cars, presenting less radical pathways towards achieving the EU fleet-wide average emission target for new cars of 95 g CO<sub>2</sub>/km. Scaling from models with a 12 V belt starter generator through integrated 48 V starter generators to high-power 400 V drives, hybrid cars have the potential to drastically reduce noise in urban areas.

Combustion engines in these hybrid cars face a number of specific challenges when the car is being driven by the electric motor. We will be taking a closer look at them in this article. Time to explore the many additional functions a single crankshaft sensor has to fulfill in a hybrid motor...

Car manufacturers across the globe are expanding their portfolio of drive systems. Even looking beyond the fuel cells and synthetic fuels of tomorrow, there is still a huge number of hybrid options spanning the gap between combustion engines and electric motors.

These options range from stop-start combustion engines, where the motor shuts off for a few seconds at a red light and then cold starts, to plug-in hybrids that can easily drive 50 kilometers in all-electric mode before the combustion engine kicks in as the battery runs low or the vehicle is travelling at high speeds on a highway.

Two different implementations of even the most recent stop-start systems have already been brought to market. In one instance, the combustion engine starts again as if it had not been driven for an hour. The second solution monitors the movement of the engine as it comes to a stop, so when the engine starts up again, the car already knows the position of the crankshaft and the next cylinder to be fired. If we look at the starter generator attachment points on the drive shaft, or the points where the clutch connects different motors to the drive axle, we quickly see that the combustion crankshaft assembly options are virtually limitless.



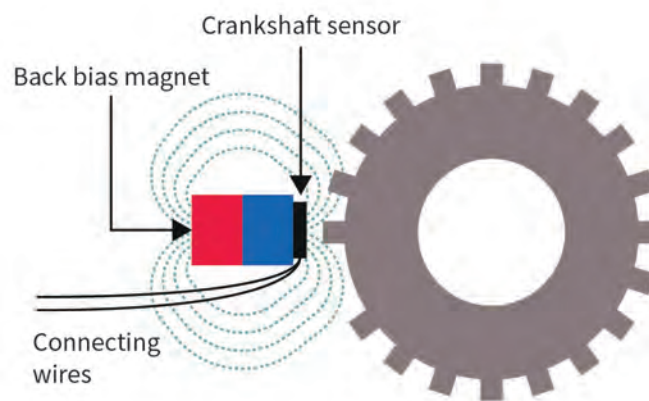


## Drive interplay as experienced by the driver

To maximize acceptance of new electric drive systems, manufacturers must win over former combustion enthusiasts with ease of operation and a predictable, smooth driving experience free of “nasty surprises”.

It’s important that a combustion engine can spring smoothly and almost imperceptibly into action – as already experienced at traffic lights or in traffic jams in start-stop mode. Here, it is essential that the car knows the angle of the crankshaft at all times. If the car stops for three minutes in a traffic jam, the crankshaft sensor is able to ignore a slight temperature drift or, ideally, compensate for it. During a 30-minute drive on rough roads with a crankshaft that is free to move when decoupled from traction wheels, however, the sensor could incorrectly count a slight shake or vibration of a tooth or, in the worst case, interpret these movements as a new, valid signal.

### Diagram of a sensor module



The following is a list of functions that help sensors to accurately count teeth.

### The conventional stop-start algorithm

The “smallest” solution for reducing fuel consumption involves switching off the engine. It is already widely deployed and available as a conventional stop-start algorithm. This function is able to correctly interpret short stops in congested traffic or at red lights and can compensate for small temperature drifts.

Magnets are subject to very strong temperature drifts, which can change the magnetic field by up to 40 percent

To ensure a combustion engine can glide into action, it is important that the sensor does not incorrectly count any of the teeth moving past it. It is imperative that the sensor:

- > Does not miss any teeth
- > Does not count any additional teeth
- > Does not mistake the rotational direction

These criteria are broken down inside the crankshaft sensor as there is basically a magnet inside the sensor housing and the field lines of this magnet are modulated by the teeth as they spin past.

As such, the sensor’s performance is ultimately determined by fluctuations in magnetic field strengths. And these are dependent on a number of factors including the air gap between the sensor and the trigger wheel and the temperature. To ensure we do not get sidetracked by the various mechanical and electrical details, this paper focuses primarily on the mechanical components that are relevant to the sensor’s performance.

over the given temperature range. In the case of crankshafts with well-fitting bearings, the next most significant factor to impact sensor behavior is electrical in source. Number three in the lineup are changes in the air gap between the trigger wheel on the crankshaft and the sensor module on the engine block.

Ideally, the sensor remains fully calibrated and when the combustion engine starts again, it is able to correctly output the position and rotational direction of the crankshaft as soon as the first tooth of the trigger wheel spins past. This functionality can be implemented without any modi-

fications to the architecture of a combustion engine. All it requires is a slightly larger starter battery and starter motor and modifications to the software in the controller.

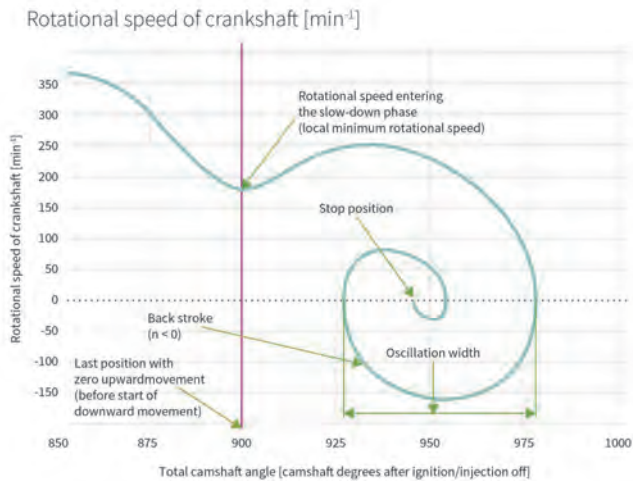


Diagram of the crankshaft coming to rest when ignition is shut off [1]

Figures 2 and 3 show how the disengaged crankshaft comes to a stop when the ignition is turned off as well as the quickest possible start for an Otto engine when compressed air is still in the cylinder (known as a direct start).

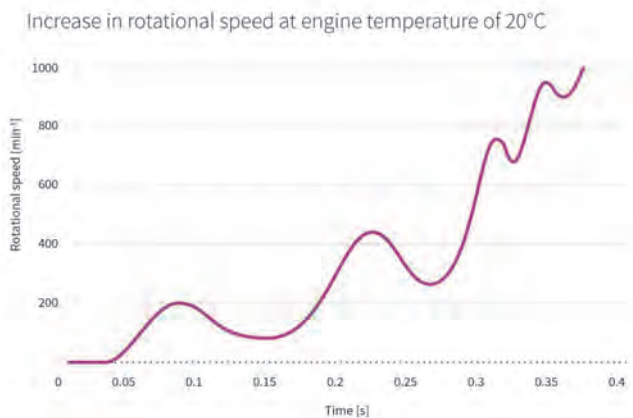


Diagram showing how a crankshaft starts turning again after a direct start [1]

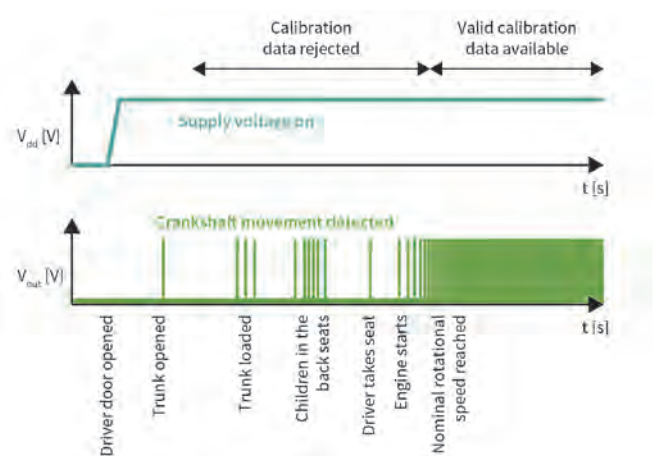
### Vibrations while stationary

Modern cars carry out a range of self-diagnostic checks as soon as the driver’s door is opened. This reduces the amount of time it takes for a warning lamp to light up. A lot of other things can happen, however, from the moment the car door is opened to the time the car pulls away. The car can be loaded, for example, or children have to be buckled into their seats. As such, it is completely normal for the car to rock slightly while stationary. These slight movements

travel through the drive wheels, transmission and clutch and cause the crankshaft trigger wheel to turn. In some unfortunate situations, this can result in the crankshaft sensor picking up a valid magnetic signal.

To overcome this issue, an algorithm has been implemented in the sensor to delete calibration data generated before the engine is switched on.

If we take just a brief look at the wide range of hybrid architectures, it quickly becomes clear that this add-on function will help car manufacturers to identify and ignore any inaccurate calibration data.

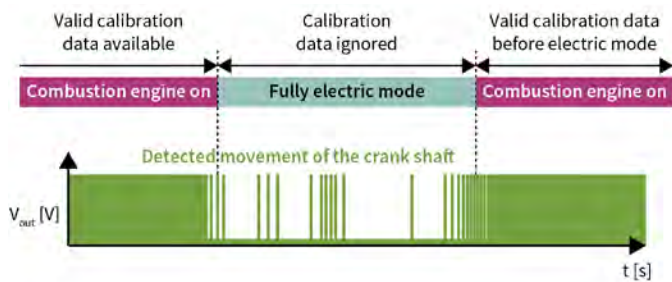


Signal output by the crankshaft sensor when a car is being loaded

As figure 4 shows, we can draw several conclusions from the sensor’s output signals over time. Firstly, we can see that the nominal rotational speed was not reached as soon as the sensor was activated. Consequently, the calibration data gathered up to the time where the nominal rotational speed was achieved can be reset without difficulty. Secondly, we see that this procedure can be repeated multiple times if the sensor does not identify a tooth for a certain period of time.

### Hybrid algorithm

A new function is required for a “big” plug-in hybrid solution. To correctly identify the position of the crankshaft trigger wheel, an algorithm has been implemented in the sensor that detects slower, sub-nominal crankshaft rotation and, in conjunction with other monitoring functions, prevents incorrect calibrations. New calibration data is only accepted when the system is operating normally.



### Signal output by the crankshaft sensor when driving in electric mode

This function enables every crankshaft vibration to be captured with the corresponding signals for forward and

backward movement without the crankshaft sensor incorrectly responding to supposed changes to the mechanical setup such as a shift in the air gap or some other mechanical misalignment.

Collectively, the algorithms named here enable the movements of the crankshaft trigger wheel to be accurately observed and tracked. The engine control unit knows at all times which stroke each piston is on and how much time is left until the next ignition (based on the crankshaft angle). If the algorithms are correctly aligned, the system will operate correctly, ensuring that the engine warning light stays off.

## Improved crankshaft sensor enables other components to last longer

As the crankshaft sensor always provides reliable information, the sizing of components required to restart the combustion engine can be reduced. The starter generator usually turns the crankshaft for several rotations until the home position of the crankshaft has been detected and a minimum rotational speed in excess of several hundred rotations has been reached. With an advanced crankshaft sensor, the fuel can be injected and ignited in just half a rotation. Starting the engine in this way requires only a fraction of the battery energy needed for a cold start. Manufacturers can thus choose between a longer service

life for the starter and battery, or size down and save costs and weight, which – in turn – translates into a slight drop in consumption.

This design also enables a great driving experience as the combustion engine starts easily and smoothly without creating any negative impressions.

## More precise switching points with differential camshaft sensor

As part of its XENSIV™ family of sensors, Infineon Technologies has developed active Hall sensors specifically for camshaft and crankshaft applications. These devices can help to optimize the drive experience while extending service life. Installed on the camshaft, the XENSIV™ TLE4929C, for instance, can compensate for production and assembly tolerances on the supplier and manufacturer sides thanks to its programmable switching threshold. This ability means that this position sensor improves angle accuracy on both on the camshaft and the crankshaft.

First of all, it should be noted here that differential Hall sensors, by their very physical nature, only switch when the centerline of the tooth is in front of the sensor. Starting

from the centerline of the tooth and moving out, the following tolerances must be taken into account:

- > Mechanical tolerances on the tooth itself cause the magnetic center to deviate from the mechanical center
- > Mechanical assembly tolerances for the module on the engine block account for the largest deviation
- > Mechanical installation tolerances for the magnet and sensor in the module also have to be added
- > It goes without saying that the installed magnets are not 100% homogenous; nor are they magnetized at a perfect 90° angle
- > Finally, there are also electrical tolerances within certain limits that are attributable to the sensor manufacturer.

## Error distribution in degrees for camshaft



- Mechanical tolerance: Module (+/-0.5 mm)
- Mechanical tolerance: Magnet (+/-0.2 mm)
- Mechanical tolerance: Sensor (+/-0.1 mm)
- Mechanical tolerance: Chip (+/-0.1 mm)
- Magnetization tolerance for the magnet
- Electrical tolerance of switching threshold
- Temperature drift of sensor
- Non-compensated mechanical stress

### Breakdown of position errors by category

Systematic errors are compensated for by the engine control unit and are not included in the above list. They include signal propagation delays, which are already accounted for in the control unit's timer.

All of the components listed above result in a random error, which at best resolves itself but, at worst, can represent a massive fault. To meet the accuracy requirements of today's systems, modern sensors allow switching thresholds to be individually set. The module manufacturer can do this at relatively low cost by individually calibrating the switching point of the module at the end of the production process. It can also be done on the dry engine itself at a slightly higher cost.

The benefit for the car manufacturer here is that the calibration also compensates for their own production tolerances. In contrast, the tier 1 supplier can only compensate for the module itself; the OEM's installation error is not mitigated at all.

A cost-benefit analysis for the required tolerances and resulting calibration cost is advisable.

The actual calibration process is very simple:

At a mid-point in the switching threshold, suitable systems are used to measure the misalignment between the mechanical center of the tooth and the actual electrical edge. After this, the systematic errors are subtracted and the remaining offset is programmed and permanently stored in the sensor as the programmable switching threshold. As shown in figure 6, this method can be used to eliminate nearly all sources of error and improve the overall accuracy from  $\pm 0.6^\circ$  camshaft to  $\pm 0.1^\circ$  camshaft.

## Summary

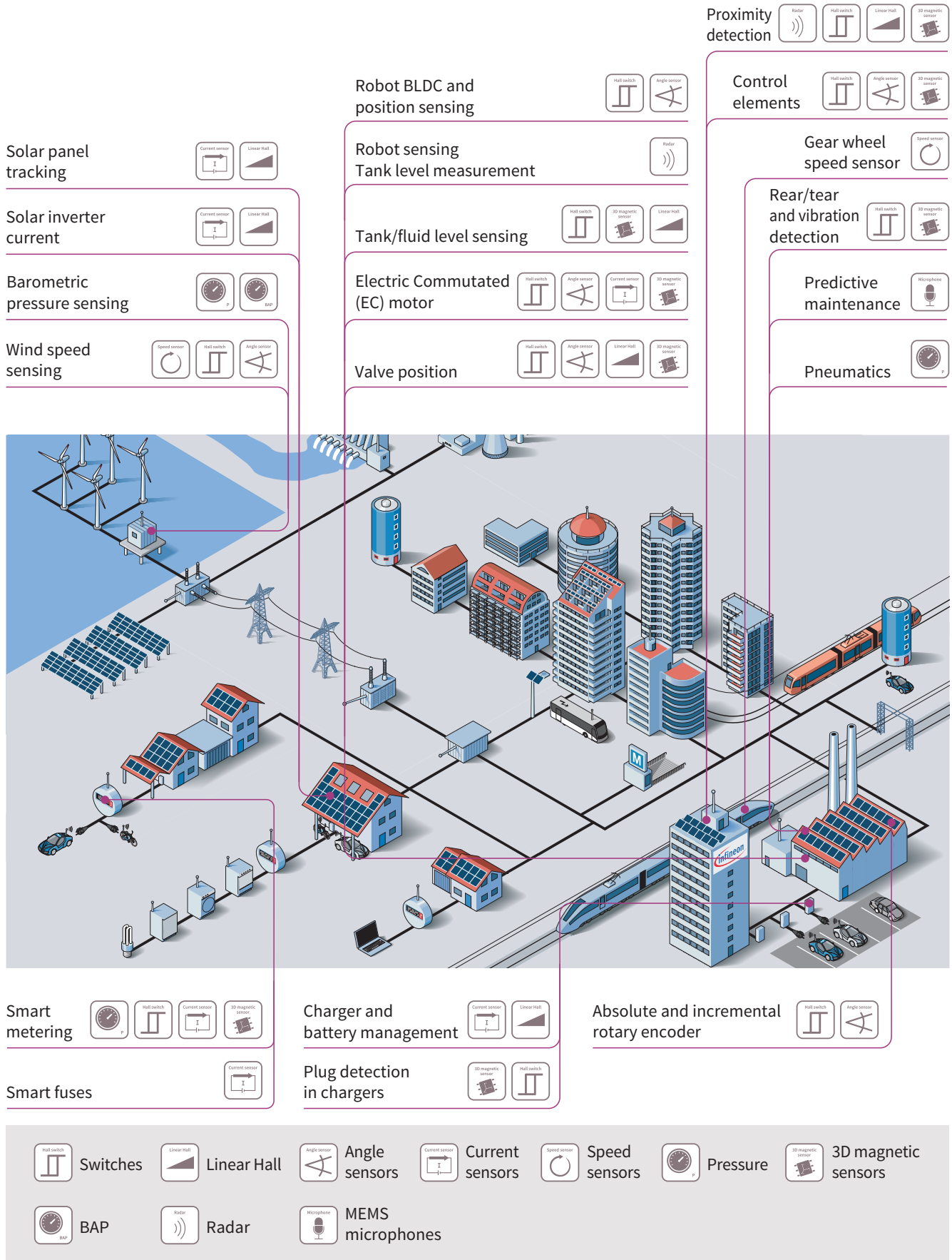
The combustion engine has had its day. From 2020 to 2025, all major car manufacturers worldwide will develop and launch their last hybrid platforms. After this, even the last remaining development engineers working on combustion engines and possibly also transmissions will have to find a new home in the emerging fields of fuel cell, battery and electric drive technologies.

The combustion engines developed today will be around for several decades to come. As such, it is vital that the technology used in these models is reliable, long-lasting, and up to date. Luckily, the challenges that hybrid engines and, in particular, crankshaft and camshaft sensors face in these systems are already known and being successfully addressed by Infineon.

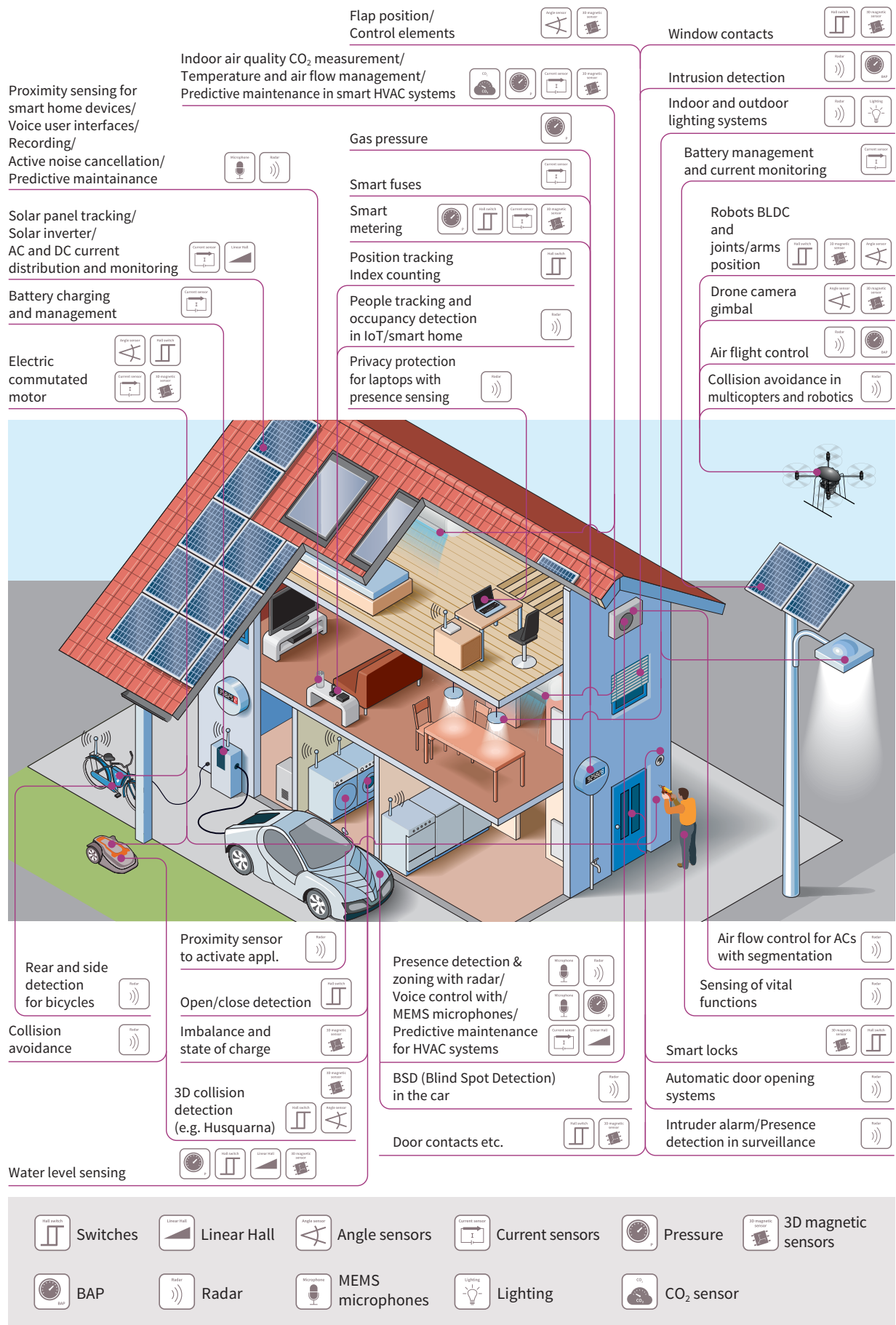
## Overview of Infineon XENSIV™ crankshaft sensors

- > TLE4929C-XAx – first-generation low-jitter, Hall-based crankshaft sensor.
- > TLE4929C-XVA – second generation includes several further crankshaft protocols (by number 14) and a time watchdog to overcome start-up vibrations. In addition, this device is available with nickel plating for the first time.
- > TLE4929C-XHA – third generation includes an additional dedicated hybrid watchdog and a new calibration feature to meet increased absolute phase accuracy requirements.

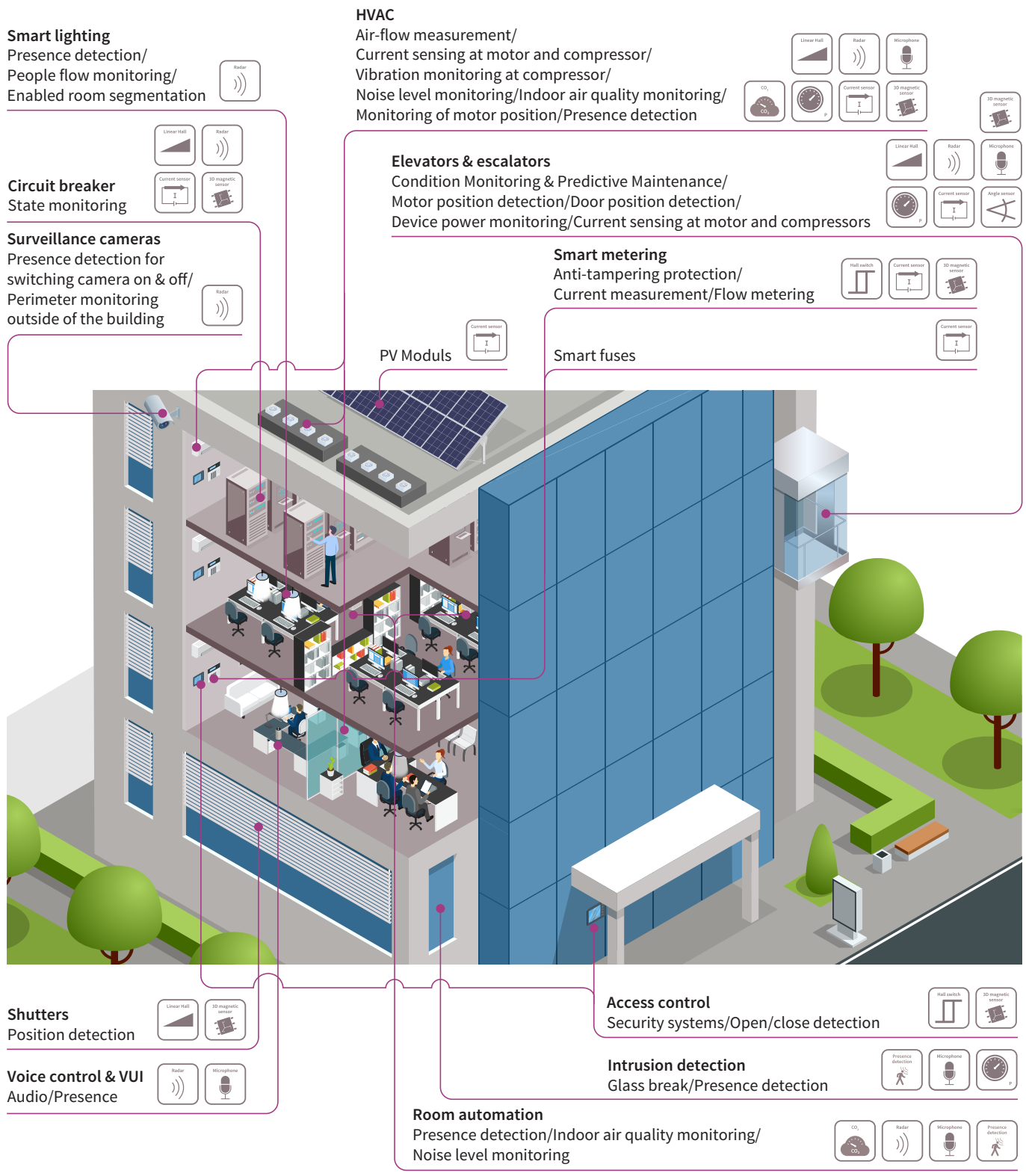
# XENSIV™ sensors in smart industry



# XENSIV™ sensors in smart homes



# XENSIV™ sensors in smart building



|          |             |                    |                 |          |                     |
|----------|-------------|--------------------|-----------------|----------|---------------------|
| Switches | Linear Hall | Angle sensors      | Current sensors | Pressure | 3D magnetic sensors |
| BAP      | Radar       | Presence detection | MEMS Microphone | Lighting | CO <sub>2</sub>     |

## 2-wheeler and all-terrain vehicles

Increasingly strict emissions legislation in many countries is also driving demand for efficiency-enabling semiconductor solutions in the small 1- to 2-cylinder combustion engine segment. Looking beyond standard carburetors, customers are increasingly looking for more electrified solutions, ranging from enhanced carburetors to full EFI (Electronic Fuel Injection).

As the market leader in automotive electronics, Infineon is ideally positioned to meet growing needs for fuel-efficient solutions through a wide range of microcontrollers, XENSIV™ sensors, power supplies, transceivers, driver ICs, MOSFETs, IGBTs as well as fully integrated U-chip solutions. [www.infineon.com/cms/en/applications/consumer/light-vehicles/](http://www.infineon.com/cms/en/applications/consumer/light-vehicles/)



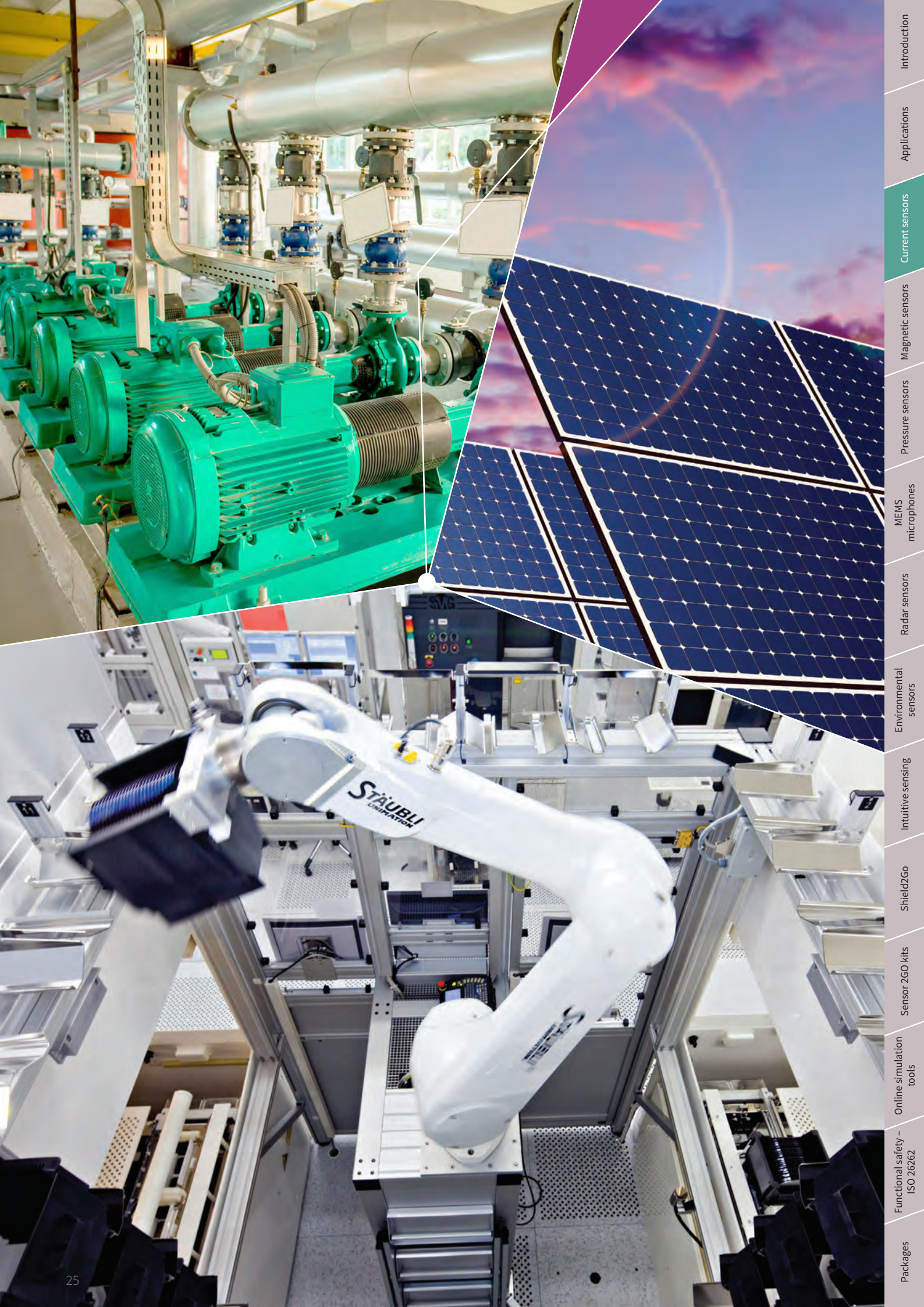
## Commercial, construction and agricultural vehicles (CAV)

As a supplier of semiconductor and system solutions, Infineon constantly develops innovative and efficient solutions. Keeping up with the latest market trends in commercial, construction, and agriculture vehicles (CAV), requires increasingly eco-friendly products and solutions. Especially for CAVs that must operate at the highest possible availability and the lowest possible total cost of ownership (TCO). Semi- and fully-autonomous technologies make CAVs safer for operators while also being more efficient and precise. Machines that run 24/7 with no downtime. Tractors that independently navigate their surroundings and react based on data they collect. Such machines literally leave fully human-operated systems in the dust. At the same time, electrification is becoming an increasingly attractive option for

CAVs. But electrification is not limited to the main drive alone: Hydro-electric or full electric power steering, actuators for lifting, tilting and positioning the fork will reduce the need for energy consuming continuously running hydraulic systems. Joysticks and controls using magnetic sensors will significantly enhance the reliability and longevity of the systems, electrically adjustable and actuated seats, the drivers comfort. All these systems will experience extended lifetime and higher accuracy by using Infineon's range of Hall switches, 3D magnetic, angular and linear Hall sensors. Manufacturers rely on electric drivetrains to comply with the latest emissions and energy regulations. At the same time, operators use electrification to boost higher process efficiency and yields. [www.infineon.com/cav](http://www.infineon.com/cav)







Packages

Functional safety - ISO 26262

Online simulation tools

Sensor 2GO kits

Shield2Go

Intuitive sensing

Environmental sensors

Radar sensors

MEMS microphones

Pressure sensors

Magnetic sensors

Current sensors

Applications

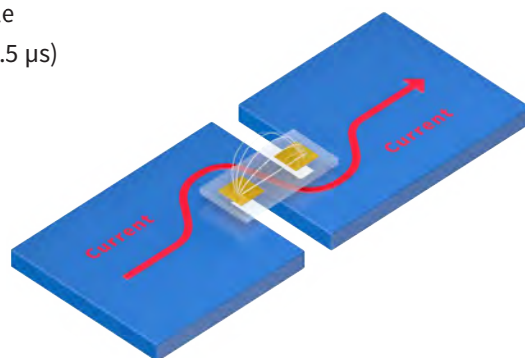
Introduction

# High-precision coreless current sensors for industrial applications

Infineon's current sensors provide accurate and stable current measurement up to 120 A. The products are intended for use in high-voltage industrial applications such as electric drives, photovoltaic inverters, chargers and power supplies. The coreless open-loop sensors are based on Infineon's precise and stable Hall technology. Thus, the output signal is highly linear over temperature and lifetime. Due to a lack of an iron core, the sensor signal doesn't show hysteresis and it doesn't suffer from saturation. Thanks to the integrated current rail there is no need for external calibration. The differential measurement with two Hall cells ensures high accuracy even in a noisy environment with cross-talk from adjacent current lines or magnetic stray fields. Highlights of the XENSIV™ TLI4971 include best-in-class thermal performance for high currents as a result of its innovative TISON-8 package as well as isolation against high voltages. The two output pins for fast overcurrent signals can be used for pre-warning and system shut-down. Designers can program the threshold levels of the overcurrent signals and thus adapt them to individual requirements without any external components.

## Features

- › Integrated current rail with typical 220  $\mu\Omega$  insertion resistance enables ultralow power loss
- › Small form factor, 8x8 mm SMD, for easy integration and board area saving
- › Highly accurate, scalable, DC and AC current sensing
- › Bandwidth of 240 kHz enables wide range of applications
- › Very low sensitivity error over temperature (< 2.5%)
- › Excellent stability of offset over temperature and lifetime
- › Galvanic functional isolation up to 1150 V peak VIORM; partial discharge capability of at least 1200 V; 4 mm clearance and creepage
- › Differential sensor principle ensures superior magnetic stray field suppression
- › Two independent fast over-current detection (OCD) pins with configurable thresholds enable protection mechanisms for power circuitry (typical < 1.5  $\mu\text{s}$ )
- › Pre-calibrated sensor



## Applications

- › Electrical drives (up to 690 V)
- › Photovoltaic inverter
- › General purpose & GAN based inverters
- › Chargers
- › Power supplies

| Product                | Max. Error <sup>1)</sup> [%] | Current range [A] | Bandwidth typ. [kHz] | Sensitivity [mV/A] | Certification | Industrial | Supply [V] | Package |
|------------------------|------------------------------|-------------------|----------------------|--------------------|---------------|------------|------------|---------|
| TLI4971-A025T5-U-E0001 | 3.45                         | 25                | 240                  | 48                 | UL            | ●          | 3.3        | TISON-8 |
| TLI4971-A025T5-E0001   | 3.45                         | 25                | 240                  | 48                 | -             | ●          | 3.3        | TISON-8 |
| TLI4971-A050T5-U-E0001 | 3.45                         | 50                | 240                  | 24                 | UL            | ●          | 3.3        | TISON-8 |
| TLI4971-A050T5-E0001   | 3.45                         | 50                | 240                  | 24                 | -             | ●          | 3.3        | TISON-8 |
| TLI4971-A075T5-UE0001  | 3.45                         | 75                | 240                  | 16                 | UL            | ●          | 3.3        | TISON-8 |
| TLI4971-A075T5-E0001   | 3.45                         | 75                | 240                  | 16                 | -             | ●          | 3.3        | TISON-8 |
| TLI4971-A120T5-U-E0001 | 3.45                         | 120               | 240                  | 10                 | UL            | ●          | 3.3        | TISON-8 |
| TLI4971-A120T5-E0001   | 3.45                         | 120               | 240                  | 10                 | -             | ●          | 3.3        | TISON-8 |

1) Total error over lifetime and temperature



## Magnetic sensors

Exceptionally precise magnetic sensors comprising industry-leading Hall switches, linear, angle, 3D, current sensors as well as speed sensors

Infinion XENSIV™ sensors are exceptionally precise thanks to industry-leading magnetic technologies. Our benchmark and innovative magnetic sensor portfolio is the perfect fit for numerous customer applications in automotive, industrial and consumer markets. We offer all magnetic sensor technologies with in-house production, thus our customers can choose between Hall sensors, AMR (Anisotropic Magneto Resistive), GMR (Giant Magneto Resistive) or TMR (Tunnel Magneto Resistive) sensors in order to find their best-fit solution for their application. Infineon's XENSIV™ magnetic sensors combine highest-accuracy with proven quality and more than 40 years of experience in sensing solutions.

Generally, magnetic sensors are able to detect magnetic fields and process this information. The outcome on the position, angle and strength (Hall-effect) or the direction (Magneto Resistive) of an applied magnetic field can be converted into specific output signals. Our magnetic sensor portfolio comprises Hall switches, linear sensors, angle sensors, 3D Hall sensors, current sensors as well as magnetic speed sensors with their respective field of application.

Our portfolio includes a broad range of ISO 26262 compliant products meeting safety requirements as SEooC (Safety Element out of Context) up to the highest safety level of ASIL D, which are well perceived within the market and used in a wide range of automotive and industrial safety applications.

# Hall switches

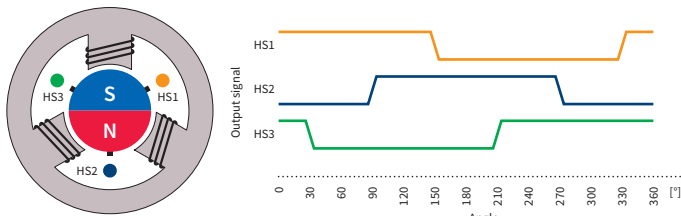
Broadest energy saving portfolio of high precision Hall switches for automotive, industrial and consumer applications

TLE/TLI/TLV4961/64/68

Energy-efficient Hall switch family for up to 32 V

The TLE/TLI/TLV496x-xM/L family of Hall switches saves energy and enables designers to create precise and compact systems. With an operational current consumption of just 1.6 mA, TLE/TLI/TLV496x-xM/L products can cut energy consumption by up to 50 percent, compared with similar competitor products. Thanks to its small magnetic hysteresis, the family paves the way for precise switching points in systems. The integrated temperature profile compensates magnetic drifts and enables stable performance over temperature and lifetime.

TLE/TLI/TLV496x-xM products come in the smallest SOT23 package, thus reducing height by 10 percent compared with predecessor products. The sensors also feature an integrated functionality test for better system control.



## Features

- › Current consumption of just 1.6 mA
- › 3 to 32 V supply voltage range (over voltage up to 42 V)
- › 7 kV ESD protection (HBM)
- › Overtemperature and overcurrent protection
- › Temperature compensation
- › Smallest SOT23 package
- › Dedicated products for industrial applications (TLI496x) and consumer applications (TLV496x)
- › AEC-Q100 qualified

## Applications

- › Window lifter
- › Power closing
- › Gear stick
- › Seat belt
- › BLDC commutation  
(e.g. wiper, seat belt pretensioner, pump, seating)
- › Service robots
- › Power tools
- › White goods

| Product      | Type    | Operating point $B_{OP}$ [mT] | Release point $B_{RP}$ [mT] | Hysteresis $\Delta B_{HY}$ [mT] | Automotive | Industrial | Consumer | Package       |
|--------------|---------|-------------------------------|-----------------------------|---------------------------------|------------|------------|----------|---------------|
| TLE4961-1M/L | Latch   | 2.0                           | -2.0                        | 4.0                             | ●          | ●          | ●        | SOT23/SSO-3-2 |
| TLE4961-2M   | Latch   | 5.0                           | -5.0                        | 10.0                            | ●          | ●          | ●        | SOT23         |
| TLE4961-3M/L | Latch   | 7.5                           | -7.5                        | 15.0                            | ●          | ●          | ●        | SOT23/SSO-3-2 |
| TLE4961-4M   | Latch   | 10.0                          | -10.0                       | 20.0                            | ●          | ●          | ●        | SOT23         |
| TLE4961-5M   | Latch   | 15.0                          | -15.0                       | 30.0                            | ●          | ●          | ●        | SOT23         |
| TLE4964-1M   | Switch  | 18.0                          | 12.5                        | 5.5                             | ●          | ●          | ●        | SOT23         |
| TLE4964-2M   | Switch  | 28.0                          | 22.5                        | 5.5                             | ●          | ●          | ●        | SOT23         |
| TLE4964-3M   | Switch  | 12.5                          | 9.5                         | 3.0                             | ●          | ●          | ●        | SOT23         |
| TLE4964-4M   | Switch  | 10.0                          | 8.5                         | 1.5                             | ●          | ●          | ●        | SOT23         |
| TLE4964-6M   | Switch  | 3.5                           | 2.5                         | 1.0                             | ●          | ●          | ●        | SOT23         |
| TLE4964-5M   | Switch  | 7.5                           | 5.0                         | 2.5                             | ●          | ●          | ●        | SOT23         |
| TLE4968-1M/L | Bipolar | 1.0                           | -1.0                        | 2.0                             | ●          | ●          | ●        | SOT23/SSO-3-2 |
| TLI4961-1M/L | Latch   | 2.0                           | -2.0                        | 4.0                             | -          | ●          | ●        | SOT23/SSO-3-2 |
| TLV4961-1M   | Latch   | 2.0                           | -2.0                        | 4.0                             | -          | -          | ●        | SOT23         |
| TLV4961-3M   | Latch   | 7.5                           | -7.0                        | 15.0                            | -          | -          | ●        | SOT23         |
| TLV4964-1M   | Switch  | 18.0                          | 12.5                        | 5.5                             | -          | -          | ●        | SOT23         |
| TLV4964-2M   | Switch  | 28.0                          | 22.5                        | 5.5                             | -          | -          | ●        | SOT23         |



## TLE/TLI4963/65-xM 5 V high-precision automotive/industrial Hall-effect sensor

TLE/TLI496x-xM are integrated Hall-effect sensors specially designed for highly accurate applications. The sensors provide an easy-to-use and cost-effective solution for position sensing applications, requiring high temperature stability of the magnetic threshold.

Target applications for TLE/TLI496x-xM are all low-power applications requesting a precision Hall latch or Hall switch with a broad operating temperature range.

By offering an excellent magnetic behavior Infineon's switches are ideally suited for:

- › Index counting application with a pole wheel
- › Rotor position detection (BLDC motors)
- › Open/close detection

### Features

- › 3.0 to 5.5 V operating supply voltage
- › Low current consumption 1.4 mA
- › ESD protection 4 kV HBM
- › Active error compensation (chopped)
- › High stability of magnetic thresholds
- › Low jitter (typ. 0.35  $\mu$ s)
- › Operating temperature range:
  - from -40 to +170°C (TLE496x-xM)
  - from -40 to +125°C (TLI496x-xM)
- › Small SMD package SOT23
- › TLE: AEC-Q100 qualified
- › TLI: JEDEC qualified



| Product    | Type            | Operating point<br>$B_{OP}$ [mT] | Release point<br>$B_{RP}$ [mT] | Hysteresis<br>$\Delta B_{HY}$ [mT] | Automotive | Industrial | Consumer | Package |
|------------|-----------------|----------------------------------|--------------------------------|------------------------------------|------------|------------|----------|---------|
| TLE4963-1M | Latch           | 2.0                              | -2.0                           | 4.0                                | ●          | ●          | ●        | SOT23   |
| TLE4963-2M | Latch           | 5.0                              | -5.0                           | 10.0                               | ●          | ●          | ●        | SOT23   |
| TLE4965-5M | Unipolar switch | 7.5                              | 5.0                            | 2.5                                | ●          | ●          | ●        | SOT23   |
| TLI4963-1M | Latch           | 2.0                              | -2.0                           | 4.0                                | -          | ●          | ●        | SOT23   |
| TLI4963-2M | Latch           | 5.0                              | -5.0                           | 10.0                               | -          | ●          | ●        | SOT23   |
| TLI4965-5M | Unipolar switch | 7.5                              | 5.0                            | 2.5                                | -          | ●          | ●        | SOT23   |

## TLV496x-xTA/B

## Precision Hall-effect sensor for consumer applications in leaded package

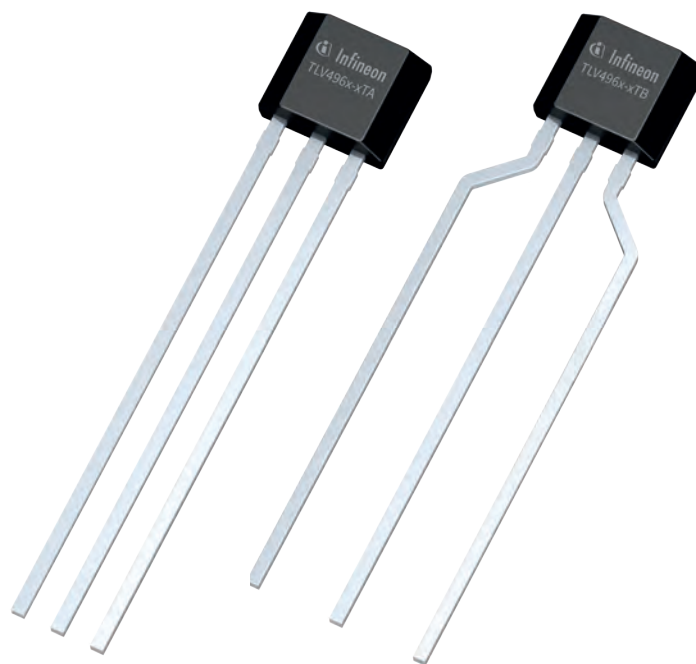
The TLV496x-xTA/B Hall sensor family comprises a line of Hall switches for contactless position sensing. The sensors are specially designed to provide an easy-to-use and cost-effective solution for position sensing applications.

### Features

- > 3.0 to 26 V operating supply voltage
- > Low current consumption 1.6 mA
- > ESD protection 4 kV HBM
- > Operating temperature range from -40 to +125 °C
- > Leaded package T092S

### Applications

- > BLDC motor commutation for consumer devices (e.g. e-bikes, fans, aircons)
- > Position detection e.g. flaps and control buttons



| Product     | Type            | Operating point<br>$B_{OP}$ [mT] | Release point<br>$B_{RP}$ [mT] | Hysteresis<br>$\Delta B_{HY}$ [mT] | Consumer | Package   |
|-------------|-----------------|----------------------------------|--------------------------------|------------------------------------|----------|-----------|
| TLV4961-1TA | Latch           | 2.0                              | -2.0                           | 4.0                                | ●        | T092S-3-1 |
| TLV4961-1TB | Latch           | 2.0                              | -2.0                           | 4.0                                | ●        | T092S-3-2 |
| TLV4961-3TA | Latch           | 7.5                              | -7.5                           | 15.0                               | ●        | T092S-3-1 |
| TLV4961-3TB | Latch           | 7.5                              | -7.5                           | 15.0                               | ●        | T092S-3-2 |
| TLV4964-4TA | Unipolar switch | 10.0                             | 8.5                            | 1.5                                | ●        | T092S-3-1 |
| TLV4964-4TB | Unipolar switch | 10.0                             | 8.5                            | 1.5                                | ●        | T092S-3-2 |
| TLV4964-5TA | Unipolar switch | 7.5                              | 5.0                            | 2.5                                | ●        | T092S-3-1 |
| TLV4964-5TB | Unipolar switch | 7.5                              | 5.0                            | 2.5                                | ●        | T092S-3-2 |
| TLV4968-1TA | Bipolar switch  | 1.0                              | -1.0                           | 2.0                                | ●        | T092S-3-1 |
| TLV4968-1TB | Bipolar switch  | 1.0                              | -1.0                           | 2.0                                | ●        | T092S-3-2 |



## TLx4966 xG family Two-in-one double Hall sensor

Our XENSIV™ TLx4966 xG family features two integrated, calibrated sensor elements for detecting direction and counting indexes in one device. This two-in-one feature eliminates the need for a second sensor, which in turn cuts engineering and production costs. Using just one sensor ensures perfect alignment of the sensor elements raising system quality and reliability.

### Features

- › Two Hall probes
- › Excellent matching between the two Hall probes
- › Hall plate distance of 1.45 mm
- › Outstanding quality
- › Information on direction and speed
- › TSOP6 package
- › AEC-Q100 qualified

### Applications

- › Window lifter
- › Sunroof
- › Automatic tailgate
- › Automated doors
- › Sun blinds

## TLE4966V-1G

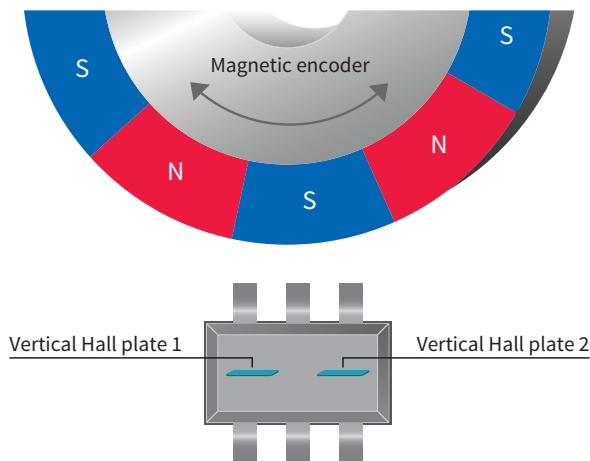
### Vertical dual-Hall switch

The Infineon vertical double Hall switch TLE4966V-1G is a further development of the TLX4966 xG family. Completely new is the vertical orientation of the Hall plates resulting in in-plane field sensitivity which enables entirely new application layouts. Designed in a new technology, this device offers high voltage capabilities with very small current consumption. The product can be operated from unregulated power supplies, which offers our customers unique freedom of design for their system. This product is AEC-Q100 certified and enables our customers to build systems for the highest automotive quality requirements.

#### Features

- > Saves space
- > Easy mounting of sensor and PCB board
- > Allows increased mounting flexibility
- > Enables new, compact system designs

#### Sensing direction parallel to target to wheel



| Product     | Type   | Output              | Operating point<br>$B_{OP}$ [mT] | Release point<br>$B_{RP}$ [mT] | Hysteresis<br>$\Delta B_{HY}$ [mT] | Automotive | Industrial | Consumer | Package           |
|-------------|--|---------------------|----------------------------------|--------------------------------|------------------------------------|------------|------------|----------|-------------------|
| TLE4966G/L  | Double Hall, speed and direction output          | Speed and direction | 7.5                              | -7.5                           | 15                                 | ●          | ●          | ●        | TSOP6/<br>SSO-4-1 |
| TLE4966-2G  | Double Hall, two independent outputs             | Speed and direction | 7.5                              | -7.5                           | 15                                 | ●          | ●          | ●        | TSOP6             |
| TLE4966-3G  | Double Hall, speed and direction output          | Speed and direction | 2.5                              | -2.5                           | 5                                  | ●          | ●          | ●        | TSOP6             |
| TLE4966V-1G | Vertical double Hall, speed and direction output | Speed and direction | 2.5                              | -2.5                           | 5                                  | ●          | ●          | ●        | TSOP6             |
| TLI4966G    | Double Hall, speed and direction output          | Speed and direction | 7.5                              | -7.5                           | 15                                 | -          | ●          | ●        | TSOP6             |



## TLE/TLI/TLV49x6 family

### High-precision Hall switches

The TLE49x6, TLI49x6, and the TLV49x6 family comprises high-precision, unipolar Hall-effect switches and latches for different magnetic sensitivities. TLE/TLI/TLV49x6 products have proven successful in many automotive, industrial and consumer applications. The family includes two-wire sensors with a current interface.

#### Features

- › Broad, successful family concept
- › Best in class quality
- › Chopped Hall system for high sensitivity
- › High jitter performance
- › SMD and leaded packages
- › Open collector or current interface
- › Temperature compensation
- › Up to 18 V supply
- › Dedicated products for industrial (TLI49x6) and consumer applications (TLV49x6)
- › AEC-Q100 qualified (TLE products)

#### Applications

- › Power closing
- › Gear stick
- › Seat belt
- › HVAC flap
- › BLDC commutation
- › 2-wheeler applications

| Product      | Type                                   | Operating point<br>$B_{OP}$ [mT] | Release point<br>$B_{RP}$ [mT] | Hysteresis<br>$\Delta B_{HY}$ [mT] | Automotive | Industrial | Consumer | Package      |
|--------------|--|----------------------------------|--------------------------------|------------------------------------|------------|------------|----------|--------------|
| TLE4906K/L   | Unipolar switch                        | 10.0                             | 8.5                            | 1.5                                | ●          | ●          | ●        | SC59/SSO-3-2 |
| TLE4906-2K   | Unipolar switch                        | 18.0                             | 12.5                           | 5.5                                | ●          | ●          | ●        | SC59         |
| TLE4906-3K   | Unipolar switch                        | 28.0                             | 22.5                           | 5.5                                | ●          | ●          | ●        | SC59         |
| TLE4946K     | Latch                                  | 14.0                             | -14.0                          | 28.0                               | ●          | ●          | ●        | SC59         |
| TLE4946-1L   | Latch                                  | 15.0                             | -15.0                          | 30.0                               | ●          | ●          | ●        | SSO-3-2      |
| TLE4946-2K/L | Latch                                  | 2.0                              | -2.0                           | 4.0                                | ●          | ●          | ●        | SC59/SSO-3-2 |
| TLE4976L     | Unipolar switch/<br>Current interface  | 6.0                              | 4.0                            | 2.0                                | ●          | ●          | ●        | SSO-3-2      |
| TLE4976-1K   | Unipolar switch/<br>Current interface  | 9.25                             | 7.25                           | 2.0                                | ●          | ●          | ●        | SC59         |
| TLE4976-2K   | Unipolar switch/<br>Current interface  | 4.5                              | 2.7                            | 1.8                                | ●          | ●          | ●        | SC59         |
| TLV4946-2K   | Unipolar switch                        | 18.0                             | 12.5                           | 5.5                                | -          | -          | ●        | SC59         |
| TLV4976-2K   | Unipolar switch /<br>Current interface | 4.5                              | 2.7                            | 1.8                                | -          | -          | ●        | SC59         |



## 3D magnetic sensors for consumer and industrial markets

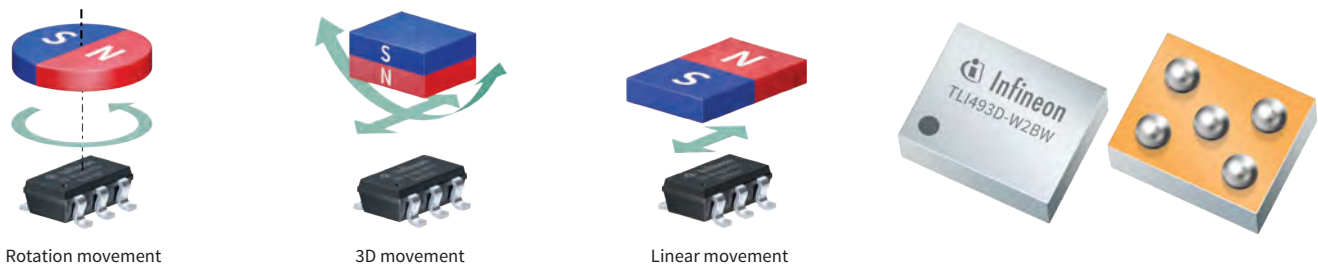
Infineon's 3D magnetic sensor (TLI493D-W2BW) combines high-accuracy magnetic field measurements with an extremely compact footprint and exceptionally low power consumption (min. 7 nA). This sensor opens up a host of exciting new use cases including innovative human-machine interfaces in the form of industrial joysticks, ergonomic pushbuttons on domestic appliances and highly precise position control in robotics.

The TLV493D-A1B6 sensor realizes an accurate three-dimensional sensing with extremely low power consumption in a small 6-pin package. Capable of detecting the magnetic field in the x, y, and z-direction, the sensor is ideally suited for the measurement of linear, rotation or 3 dimensional movements. Thanks to its small package and low power consumption, the TLx493D-AxB6 can be used in new applications, replacing potentiometer and optical solutions. Featuring contactless position sensing and high temperature stability of the magnetic threshold, the sensor allows systems getting smaller, more accurate and more robust.

The TLE493D-P2B6 is Infineon's newest magnetic 3D sensor enabled by new and improved accuracy. It is the best product for high performance applications with respect to pricing and package size. The TLE493D-P2B6 has extremely low quiescent current and wake up function in small package. Also the sensor provides options for configuration to fit best to customer requirements (e.g. data communication, definition of measurements, etc.). The safety manual supports functional safety applications. The configurability of the sensor is used in application platforms to adapt end customer wishes. TLE493D-P2B6 is available in 4 different variants ending with A0, A1, A2 or A3. The underlying feature is the so called Bus mode configuration of this device. It's possible to connect up to 4 sensors to one I<sup>2</sup>C bus. The specific addressing is then done via 4 different variants.

# 3D magnetic sensors for consumer and industrial markets

The TLV493D-A1B6 sensor realizes accurate three-dimensional sensing with extremely low power consumption in a small 6-pin package. Capable of detecting the magnetic field in the x, y, and z-direction, the sensor is ideally suited for the measurement of linear, rotation, or 3-dimensional movements. Thanks to its small package and low power consumption, the TLx493D-AxB6 can be used in new applications, replacing potentiometer and optical solutions. Featuring contactless position sensing and high-temperature stability of the magnetic threshold, the sensor allows systems to get smaller, more accurate, and more robust.



## Features

- › 3D magnetic sensing
- › Integrated temperature sensing
- › Low current consumption
  - 7 nA in power-down mode
  - 10  $\mu$ A in ultralow power mode
- › 2.8 to 3.5 V operating supply voltage
- › Digital output via a 2-wire standard I2C interface
- › Bx, By and Bz linear field measurement up to  $\pm 160$  mT
- › JESD47 qualified
- › 12-bit data resolution for each measurement direction
- › Various resolution options from 65  $\mu$ T/LSB to 130  $\mu$ T
- › Operating temperature range from -40 to +125°C

| Product  | Temperature range | Qualification | Linear magnetic range                    | Resolution                    | $I_{DD}$      | Update rate       | Package | Ordering code  |
|--|-------------------|---------------|--|-------------------------------|---------------|-------------------|---------|--|
| TLI493D-A2B6   | -40 ... 105°C     | JESD47        | $\pm 160$ mT (min)<br>$\pm 100$ mT (min) | 7.7 or 15.4 LSB12/mT          | 7 nA – 3.3 mA | 10 Hz – 8.4 kHz   | TSOP6   | SP001689844  |
| TLI493D-W2BW A0<br>TLI493D-W2BW A1<br>TLI493D-W2BW A2<br>TLI493D-W2BW A3 | -40 ... 125°C     | JESD47        | $\pm 50$ , $\pm 100$ or<br>$\pm 160$ mT  | 7.7, 15.4 or<br>30.8 LSB12/mT | 7 nA – 3.4 mA | 0.05 Hz – 8.4 kHz | WLB     | SP005409964<br>SP005409966<br>SP005409968<br>SP005409970 |
| TLV493D-A1B6   | -40 ... 125°C     | JESD47        | $\pm 130$ mT (typ)                       | 10.2 LSB12/mT                 | 7 nA – 3.7 mA | 10 Hz – 3.3 kHz   |         |  |
| TLV493D-A2BW   | -20 ... 85°C      | JESD47        | $\pm 50$ , $\pm 100$ or<br>$\pm 160$ mT  | 7.7, 15.4 or<br>30.8 LSB12/mT | 7 nA – 3.4 mA | 6 Hz – 11.6 kHz   | WLB     | SP005542151  |

1) Half range mode

While the TLV493D-A1B6 just supports a typical value for the linear magnetic range of  $\pm 130$  mT, the TLI493D-A2B6 specification includes also a minimum value of  $\pm 160$  mT.

With the TLI493D-A2B6, broader microcontroller compatibility, as well as an enhanced feature set, is included.

## New features

- › Sensor address read back
- › Short mode range setting, focusing on the half of the magnetic range, ensuring higher accuracy
- › Higher update frequency allows for an application field that requires faster update speed
- › Angular mode (for x and y read-out only)

## Applications

- › Anti tempering protection in smart meters
- › Joysticks e.g. for medical equipment, cranes,
- › CCTV-control, game consoles
- › Control elements e.g. white goods multifunction knobs
- › Industrial joysticks
- › Ergonomic push- and control buttons on domestic appliances and power tools
- › Position control in robotics

# 3D magnetic sensors for automotive low power applications

Infineon's TLE493D-x2B6 enables all kind of automotive control element applications within the passenger compartment or under the hood with a temperature range of -40 to +125°C, with linear magnetic range requirements up to  $\pm 160$  mT.



## Features

- > 3D magnetic sensing
- > Integrated temperature sensing
- > 2.8 to 3.5 V operating supply voltage
- > Low current consumption
  - 0.007  $\mu$ A in power-down mode
  - 10  $\mu$ A in ultralow power mode
  - Up to 10 power modes
- > Digital output via a 2-wire standard I2C interface
- > Bx, By and Bz linear field measurement  $\pm 160$  mT
- > AEC-Q100 qualified
- > 12-bit data resolution for each measurement direction
- > Various resolution options from 67  $\mu$ T/LSB to 134  $\mu$ T
- > Operating temperature range from -40 to +125°C

| Product  | Temperature range | Qualification                | Linear magnetic range                    | Resolution                                     | $I_{DD}$      | Update rate       | Wake-up | Package | Ordering code  |
|--|-------------------|------------------------------|--|--|---------------|-------------------|---------|---------|--|
| TLE493D-A2B6   | -40 ... 125°C     | AEC-Q100                     | $\pm 160$ mT (min)                       | 130 $\mu$ T/LSB (65 $\mu$ T/LSB) <sup>1)</sup> | 7 nA – 3.3 mA | 10 Hz – 8.4 kHz   | No      | TSOP6   | SP001689848  |
| TLE493D-P2B6 A0<br>TLE493D-P2B6 A1<br>TLE493D-P2B6 A2<br>TLE493D-P2B6 A3 | -40 ... 125°C     | AEC-Q100/<br>ISO 26262 ready | $\pm 160$ mT (min)<br>$\pm 100$ mT (min) | 130 $\mu$ T/LSB (65 $\mu$ T/LSB) <sup>1)</sup> | 7 nA – 3.3 mA | 0.05 Hz – 8.4 kHz | Yes     | TSOP6   | SP005557415<br>SP005557413<br>SP005557411<br>SP005557408 |
| TLE493D-W2B6 A0<br>TLE493D-W2B6 A1<br>TLE493D-W2B6 A2<br>TLE493D-W2B6 A3 | -40 ... 125°C     | AEC-Q100                     | $\pm 160$ mT (min)<br>$\pm 100$ mT (min) | 130 $\mu$ T/LSB (65 $\mu$ T/LSB) <sup>1)</sup> | 7 nA – 3.3 mA | 0.05 Hz – 8.4 kHz | Yes     | TSOP6   | SP001655334<br>SP001655340<br>SP001655344<br>SP001655348 |

1) Half range mode

The XENSIV™ sensor TLE493D-A2B6 features include a sensor address read-back feature for additional communication verification, a half range mode focusing to half of the magnetic range, ensuring higher accuracy, and an angular mode (for x and y readout only).

With the TLE493D-W2B6/ P2B6 A0-A3, a 3D sensor family with an enhanced dynamic wake-up feature was developed. Four pre-programmed address options (A0-A3) are available, enabling for a fast start-up initialization when used in I2C bus configurations. Our sensors include enhanced test options, and safety documentation is available to enable the usage of this sensor in the context of ASIL B systems.

Compared to the previous products of this family the new TLE493D-P2B6 A0-A3 family offers enhance precision in x-, y-, z- sensing direction, while otherwise featuring the same dynamic wake-up features, programmability, and test options like TLE493D-W2B6 A0-A3. We provide safety documentation on request for usage of the sensor in the context of ASIL B systems.

## Applications

- > Control elements for infotainment/navigation systems, air-conditions, multifunctional steering wheels, seat controls
- > Top column modules e.g. direction indicator, wiper control
- > Gear stick position sensing
- > Multi-function knobs
- > Pedal/valve position sensing

[www.infineon.com/3d-magnetics](http://www.infineon.com/3d-magnetics)

[www.infineon.com/magnetic-sensors](http://www.infineon.com/magnetic-sensors)

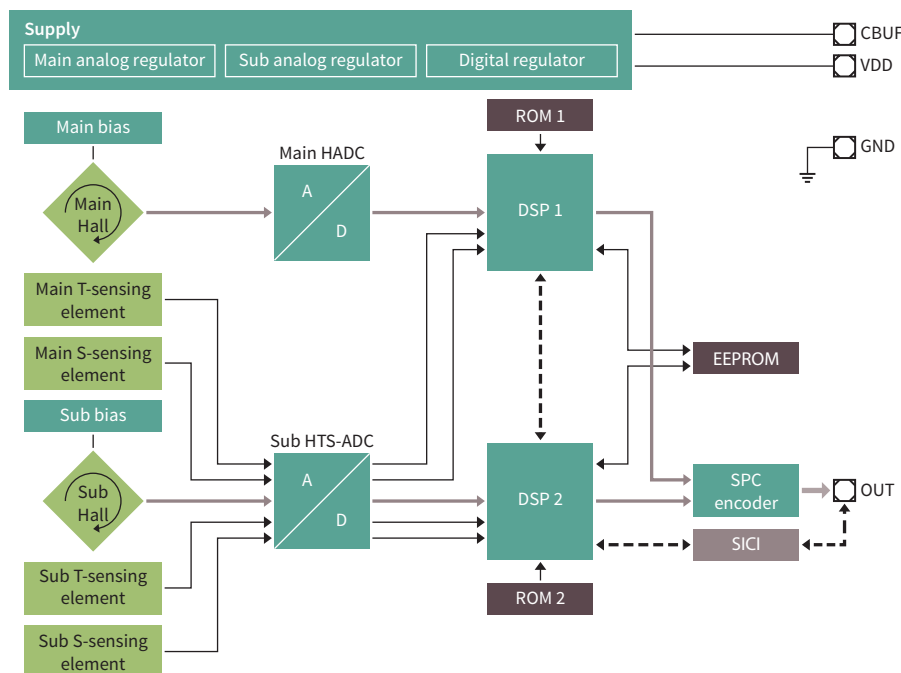


# Linear sensors

Programmable dual channel linear Hall sensor with fast SPC interface for high precision applications

Infineon's TLE4999C8 is a programmable dual channel linear Hall sensor designed to meet the requirements of safety critical automotive and industrial applications. It is developed in full compliance with ISO 26262 by means of two sensor elements included within one monolithic silicon design. In order to fulfill the state-of-the-art safety requirements on system level and enable ASIL D system developments the sensor cells are designed in a complementary way. Their signals follow two independent analog paths. Each signal path has its own digital signal processing unit to ensure maximum independency - redundancy, respectively. The sensor offers a multi-point calibration with up to 9 selectable set points for enhanced linearization of the output signal. For an easy and flexible adaptation to non-linearity of magnetic circuit design, the chip provides 5 different calibration characteristics. TLE4999C features a digital Short-PWM-Code (SPC) interface, with a bus-capability for up to 4 sensor ICs on a single data output. The communication interface with min. 0.5  $\mu$ s unit time guarantees a fast transmission of complete 2 channel data signal in less than 500  $\mu$ s. The additionally implemented frame holder circuit enables the synchronicity of multiple sensors (e.g. in combination of angle sensors) via a SPC bus. The chip offers a 12, 14 and 16 Bit resolution of the output signal, ensuring highest flexibility and superior noise performance.

Highest accuracy over a wide temperature range and lifetime is achieved by an integrated digital temperature- and stress-compensation. The chip is available in a thin 8-pin SMD single sensor package.



**Features**

- > Fully ISO 26262 compliant, supports ASIL D systems
- > < 2 % sensitivity drift, < 100  $\mu$ T offset drift overtemperature and life time specification
- > Integrated digital temperature- and stress-compensation
- > Fast digital SPC interface with a unit time down to 0.5  $\mu$ s
- > Multi-point calibration with up to 9 linearization set points

**Key benefits**

- > High diagnostic coverage, ISO 26262-compliance and dual sensor cell integration enable development of fail operational systems
- > Multi-point calibration for better fit into various magnetic circuit designs
- > Easy system integration due to programmability of several sensor parameters

**Applications**

**Automotive safety critical applications**

- > Electric power steering
- > Linear movement position sensing
- > Pedal position
- > Electric throttle control
- > Seat rail adjustment
- > Headlight adjustment

**Industrial applications**

- > Small home appliances
- > Joystick applications

**Infineon ISO 26262 dual channel linear Hall product portfolio**

| Sales name                | Interface              | Magnetic linear range [mT] | Sensitivity  | Sensitivity drift [%] | Gain    | Magnetic offset drift [ $\mu$ T] <sup>1)</sup> | ISO 26262 | Ordering code | Package  |
|---------------------------|------------------------|----------------------------|--|-----------------------|---------|--|-----------|---------------|----------|
| TLE4997A8D                | Analog ratiometric     | 50, 100, 200               | $\pm$ 60 mV/mT default for 100 mT range, with gain 1.5                       | $\pm$ 3               | $\pm$ 4 | < $\pm$ 400                                    | Ready     | SP000902760   | TDSO-8   |
| TLE4998P8D                | Digital interface PWM  | 50, 100, 200               | $\pm$ 48 LSB <sub>12</sub> /mT default for 100 mT range, with gain 1.5       | $\pm$ 2               | $\pm$ 4 | < $\pm$ 400                                    | Ready     | SP000902776   | TDSO-8   |
| TLE4998S8D                | Digital interface SENT | 50, 100, 200               | $\pm$ 48 LSB <sub>12</sub> /mT default for 100 mT range, with gain 1.5       | $\pm$ 2               | $\pm$ 4 | < $\pm$ 400                                    | Ready     | SP000902784   | TDSO-8   |
| TLE4998C8D                | Digital interface SPC  | 50, 100, 200               | $\pm$ 48 LSB <sub>12</sub> /mT default for 100 mT range, with gain 1.5       | $\pm$ 2               | $\pm$ 4 | < $\pm$ 400                                    | Ready     | SP000902768   | TDSO-8   |
| TLE4999I3                 | Digital interface PSi5 | 12.5, 25                   | $\pm$ 147.5 LSB <sub>13</sub> /mT default for 25 mT range, with gain 1.5     | $\pm$ 2               | $\pm$ 5 | < $\pm$ 100/<br>< $\pm$ 200 <sup>2)</sup>      | Compliant | SP001689862   | SSO-3-12 |
| TLE4999C8/4 <sup>3)</sup> | Digital interface SPC  | 25, 50                     | $\pm$ 36.875 LSB <sub>12</sub> /mT default for in 50 mT range, with gain 1.0 | $\pm$ 2               | $\pm$ 5 | < $\pm$ 100/<br>< $\pm$ 200 <sup>2)</sup>      | Compliant | SP002662500   | TDSO-8-1 |

1) Maximum over drift overtemperature and life time  
 2) Main channel/sub channel  
 3) TLE4999C4 planned for 2022



## TLE499x family: programmable analog/digital linear Hall sensor family

Infiniteon's family of TLE499x linear Hall ICs is tailored to the needs of highly accurate angular and linear position detection and current measurement applications. Each product measures the vertical component of a magnetic field and outputs a signal that is directly proportional to the magnetic field. These programmable linear Hall sensors come with different interface options: TLE4997 features ratiometric analog output, while TLE4998P comes with pulse width modulation (PWM), TLE4998S with single edge nibble transmission (SENT), and TLE4998C with short PWM codes (SPC). These high-precision 12-bit resolution linear Hall sensors feature EEPROM memory for flexible programming across a wide range of parameters.

Thanks to digital signal processing based on a 20-bit DSP architecture plus digital temperature compensation, these sensors deliver outstanding temperature stability compared with similar compensation methods. TLE4998 also includes stress compensation to withstand stress effects from the package, such as moisture, thus ensuring best-in-class accuracy over the device's lifetime.

### Features

- > Best-in-class accuracy with low drift of output signal temperature range lifetime (including stress compensation in TLE4998)
- > Programmable transfer function (gain, offset), clamping, bandwidth, and temperature characteristics
- > AEC-Q100 qualified
- > Available in various packages including SSO-3-9 with two integrated capacitors to improve ESD and ESC behavior
- > Dual-die SMD package
- > TLE4997, TLE4998 ISO 26262 ready
- > TLE4999 fully ISO 26262 compliant for highest ASIL-levels

### Applications

- > Detecting linear and angular position
- > Detecting pedal and throttle position
- > Steering torque measurement
- > Headlight leveling
- > High-current sensing
- > Seat position and occupant detection
- > Suspension control
- > Detecting gear stick/lever positions
- > Detecting liquid levels in fuel tanks
- > Current sensing e.g. for battery management

| Product                   | Programmable | Number of pins       | Sensitivity (programmable range)                       | Magnetic offset | Supply voltage (extended range) | Automotive | ISO 26262 | Interface | Package  |
|---------------------------|--------------|----------------------|--|-----------------|---------------------------------|------------|-----------|-----------|--|
| TLE4997                   | EEPROM       | 3/Single die SMD 8   | ±12.5 to ±300 mV/mT                                    | < ±400 µT       | 5 V ±10% (7 V)                  | ●          | -         | Analog    | SSO-3-10<br>TDSO-8   |
| TLE4998P                  | EEPROM       | 3/4/Single die SMD 8 | ±0.2 to ±6%/mT   | < ±400 µT       | 5 V ±10% (16 V)                 | ●          | Ready     | PWM       | SSO-3-10<br>SSO-4-1<br>SSO-3-9<br>(2 capacitors)<br>TDSO-8 |
| TLE4998S                  | EEPROM       | 3/4/Single die SMD 8 | ±8.2 to ±245 LSB <sub>12</sub> /mT                     | < ±400 µT       | 5 V ±10% (16 V)                 | ●          | Ready     | SENT      | SSO-3-10<br>SSO-4-1<br>SSO-3-9<br>(2 capacitors)<br>TDSO-8 |
| TLE4998C                  | EEPROM       | 3/4/Single die SMD 8 | ±8.2 to ±245 LSB <sub>12</sub> /mT                     | < ±400 µT       | 5 V ±10% (16 V)                 | ●          | Ready     | SPC       | SSO-3-10<br>SSO-4-1<br>SSO-3-9<br>(2 capacitors)<br>TDSO-8 |
| TLE4999I3                 | EEPROM       | 3                    | ±73.72 to ±147.44 <sup>2)</sup> LSB <sub>13</sub> /mT" | < ±300 µT       | 5.5-7 V ±10% (16 V)             | ●          | Compliant | PSI5      | SSO-3-12   |
| TLE4999C8/4 <sup>1)</sup> | EEPROM       | Single die SMD 8     | ±36.85 to ±73.7 LSB <sub>12</sub> /mT                  | < ±300 µT       | 5 V ±10% (16 V)                 | ●          | Compliant | SPC       | TDSO-8   |

1) TLE4999C4 planned for 2022

2) 147.44 LSB<sub>13</sub> converts to 294.88 LSB<sub>12</sub>



# Dual linear sensors

## Two sensors in one SMD package

The SMD package (TDSO) includes two independent sensors with separate power supplies and separate signal outputs. Due to special mounting technology, Infineon can keep dual-sensor package sizes very small to enable compact PCB layouts and small magnet sizes.

Infineon offers a wide range of Hall sensors in the TDSO package. The combination of two sensors in one package offers sensors redundancy, a feature that is especially interesting for new generation EPS steering systems with increased ISO 26262 requirements and other safety-critical applications. All sensors are automotive qualified.

Most products are also available as a single-sensor solution with only one sensor. The newest member of the TLE499x family, the TLE4999I3, is a fully ISO 26262-compliant linear Hall sensor that includes 2 sensor channels on one chip. The SSO-3 package allows PCB-less application flexibility and the PSI5 interface enables low EMI at high-speed communication with minimum wiring.

### Features

- > Two sensors in one package
- > Separate power supply and signal output
- > AEC-Q100 qualified
- > Temperature range from -40 to +125°C
- > Outstanding quality
- > Single-sensor versions available
- > 16-pin and 8-pin versions available
- > ISO 26262-ready
- > TLE4999I3 ISO 26262-compliant

### Automotive applications

- > Steering torque systems
- > Pedal position
- > Any other safety-critical application

| Product                   | Interface | Dual-/single-sensor available | ISO 26262 | Package |
|---------------------------|-----------|-------------------------------|-----------|---------|
| TLE4997A8D                | Analog    | yes/yes                       | Ready     | TDSO-8  |
| TLE4998P8D                | PWM       | yes/yes                       | Ready     | TDSO-8  |
| TLE4998S8D                | SENT      | yes/yes                       | Ready     | TDSO-8  |
| TLE4998C8D                | SPC       | yes/yes                       | Ready     | TDSO-8  |
| TLE4999I3                 | PSI5      | monolithic <sup>1)</sup>      | Compliant | SSO-3   |
| TLE4999C8/4 <sup>2)</sup> | SPC       | monolithic <sup>1)</sup>      | Compliant | TDSO-8  |

1) 2 sensor channels on one chip

2) TLE4999C4 planned for 2022



ISO 26262  
compliant



ISO 26262  
ready



# Angle sensors

Compact designs in small outline packages – at highest functional safety

**Highest variety – low end to high end sensors, standardized and specialized in three xMR magnetic technologies: GMR, AMR and TMR**

Angle sensors detect the orientation of an applied magnetic field by measuring sine and cosine angle components with monolithically integrated magneto resistive elements.

Infineon offers a large variety of high-precision angle sensors in all common technologies such as AMR (Anisotropic Magneto resistive), GMR (Giant Magneto resistive) and also TMR (Tunnel Magneto resistive). The xMR technologies are complementary. Addressing any kind of rotation applications, Infineon's sensor portfolio consists of products with analogue and digital outputs, as single and dual-chip channel variants and as products for safety-relevant applications. The two-channel analogue TMR angle sensors TLE5501, the digital GMR angle sensor family TLE5014 and the high-precision AMR-based TLE5109 products are among the latest additions to the growing sensor portfolio, which includes all common technologies and is designed for both, industrial and automotive applications.

Infineon's new magnetic sensor products TLE5501, are fast analogue TMR-based angle sensors dedicated to automotive applications. Their fields of use range from steering angle applications, with the highest functional safety requirements, to motors for wipers, pumps and actuators and electric motors in general.

The new TLE5109A16 AMR based products address the need for very precise, fast and yet cost-efficient angle measurement at the highest functional safety levels in automotive and industrial applications. These include position measurement in brushless DC motors for pumps, wipers or brakes, position measurements of valves, flaps or pedals and steering angle measurement.

Infineon's broad portfolio of iGMR sensors are ideal for a wide range of angle applications, such as BLDC motors or steering angle sensors. They are pre-calibrated and ready-to-use. Different levels of signal processing integration from the straight forward TLE5012B to the highly complex and programmable TLE5014 enable designers to optimize system partitioning.

The large portfolio of Infineon Angle sensors is equally suited to meet ready to use industrial and consumer applications like robotics or gimbal and highly safety critical Automotive Applications such as braking or steering.

## iGMR, iAMR and iTMR based angle sensors

### Diverse redundant sensor with analog and digital interface

| Product        | Technology | Die configuration | Sin/cos output | Angle output | Second interface | Accuracy              | ISO 26262    | Package           |
|----------------|------------|-------------------|----------------|--------------|------------------|-----------------------|--------------|-------------------|
| TLE5009        | GMR        | Single die        | Analog sin/cos | –            | –                | 0.9°                  | Ready        | DSO-8             |
| TLE5009A16(D)  | GMR        | Dual die          | Analog sin/cos | –            | –                | 1.0°                  | Ready        | TDSO-16           |
| TLE5011        | GMR        | Single die        | SSC (SPI)      | –            | –                | 1.6°                  | Ready        | DSO-8             |
| TLI5012B       | GMR        | Single die        | SSC (SPI)      | SSC (SPI)    | PWM/IIF/SPC/HSM  | 1.9°                  | QM           | DSO-8             |
| TLE5012B(D)    | GMR        | Single & dual die | SSC (SPI)      | SSC (SPI)    | PWM/IIF/SPC/HSM  | 1.0°                  | Ready        | DSO-8/<br>TDSO-16 |
| TLE5014C16(D)  | GMR        | Single & dual die | –              | SPC          | –                | 1.0°                  | Compliant    | TDSO-16           |
| TLE5014P16(D)  | GMR        | Single & dual die | –              | PWM          | –                | 1.0°                  | Compliant    | TDSO-16           |
| TLE5014S16(D)  | GMR        | Single & dual die | –              | SENT         | –                | 1.0°                  | Compliant    | TDSO-16           |
| TLE5014SP16(D) | GMR        | Single & dual die | –              | SPI          | –                | 1.0°                  | QM/Compliant | TDSO-16           |
| TLE5109A16(D)  | AMR        | Single & dual die | Analog sin/cos | –            | –                | 0.5°                  | Ready        | TDSO-16           |
| TLE5309D       | AMR + GMR  | Dual die          | Analog sin/cos | SSC (SPI)    | –                | AMR 0.5°,<br>GMR 1.0° | Ready        | TDSO-16           |
| TLE5501        | TMR        | Single die        | Analog sin/cos | –            | –                | 1.0°                  | Compliant    | DSO-8             |

SPI = Serial peripheral interface

IIF = Incremental interface

PWM = Pulse width modulation

[www.infineon.com/angle-sensors](http://www.infineon.com/angle-sensors)



# iTMR based angle sensors

Tunneling Magneto Resistive (iTMR) technology is offering high sensing sensitivity with a high output voltage, reducing the need for an internal amplifier. Thus, the sensor can be connected directly to the microcontroller without any further amplification. In addition, iTMR technology shows a very low temperature drift, reducing external calibration and compensation efforts. The iTMR technology is also well known for its low current consumption.

## TLE5501

With the TLE5501 products, Infineon is currently launching the first angle sensor products based on iTMR technology. TLE5501 is available in two versions.

### TLE5501 – product versions with different pin out:

- > TLE5501 E0001: pin-compatible to TLE5009 automotive qualified acc. AEC-Q100
- > TLE5001 E0002: decoupled bridges for redundant external angle calculation and highest diagnostic coverage, realizing ISO 26262-compliant development ASIL D



### Features

- > Large output signals of up to 0.37 V/V for direct microcontroller connection
- > Discrete bridge with differential sine and cosine output
- > Very low supply current: ~2 mA
- > Magnetic field range (20-100 mT)
- > Typ. angle error ~ 1.0 ° (overtemperature and lifetime)
- > DSO-8 package
- > AEC-Q100, grade 0:  $T_A = -40^{\circ}\text{C}$  to  $150^{\circ}\text{C}$  (ambient temperature)
- > For TLE5501 E0002:
  - Reaching ASIL D with just one single sensor chip
  - ISO26262-compliant development ASIL D

### Applications

- > Steering angle sensor
- > BLDC motor commutation (e.g. wipers, pumps and actuators)
- > Angular position sensing for e.g. robotics or gimbal
- > Electric motors
- > Industrial automation
- > Safety applications

# iGMR based angle sensors

**iGMR**

TLE5014(D)


**Digital iGMR<sup>2)</sup> sensor with an easy-to-use plug-and-play concept for highest functional safety applications**

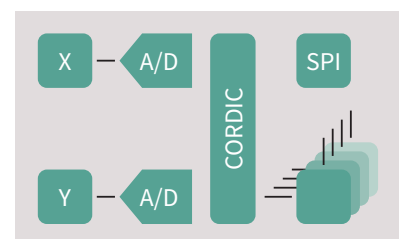
All XENSIV™ TLE5014 angle sensors are available as single and dual die products. The products come pre-configured and pre-calibrated as plug-and-play sensors and are easy to use. Customers can choose between the interfaces SENT, PWM, SPC, and SPI. On top of those protocol options, the sensors can be adapted to any kind of application setup via their programmable E<sup>2</sup>PROM interfaces. TLE5014 magnetic angle sensors meet ISO 26262 ASIL C for the single die and ISO 26262 ASIL D for the dual die versions. All products are ready for applications with the highest functional safety requirements. The sensors show an extremely small angle error of less than 1° across the entire temperature profile and lifetime. This is particularly helpful in applications with the need for very accurate position sensing such as steering angle sensing or motor commutation. Further application areas range from rotor position measurement, electric power steering (EPS), pedal position to any other kind of position measurement.

## Features

- › Easy-to-use, plug-and-play sensors, pre-configured and pre-calibrated
- › Offering high flexibility:
  - Available as single and dual die products
  - 12bit digital interface with protocol options PWM, SENT, SPC and SPI
  - E<sup>2</sup> PROM and look-up table for customer configuration and calibration
- › High angle accuracy: max. 1.0° over temperature and lifetime
- › High voltage capability up to 26 V
- › Development fully compliant with ISO 26262
  - Developed acc. ASIL D level
  - Dual die sensors reaching ASIL D, single die sensors ASIL C metrics
- › Safety manual and safety analysis summary report available on request

## Applications

- › Steering angle sensing (SAS)
- › Motor commutation
- › Rotor position measurement
- › Pedal position
- › Safety applications
- › Any other kind of high-accuracy position measurement



1) More information on PRO-SIL™, see page 88

2) Giant Magneto Resistance

**ISO 26262 compliant**

# iGMR based angle sensors

TLE5012B, TLE5012B(D)

iGMR sensor with integrated angle calculation and multiple interfaces

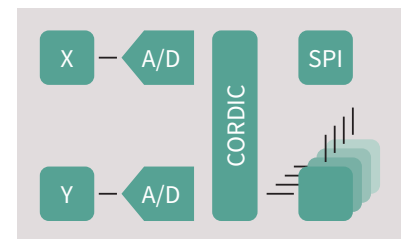
## Features

- › Integrated angle calculation with CORDIC algorithm
- › 15-bit representation of calculated angle value
- › High update rate up to 43  $\mu$ s (23 kHz)
- › Range of selectable interfaces
- › SPI compatible Synchronous Serial Communication (SSC)
- › Bi-directional communication up to 8 Mbit/s
- › Pulse Width Modulation (PWM)
- › Hall Switch Mode (HSM) for motor commutation
- › Incremental Interface (IIF)
- › Temperature compensation and auto-calibration algorithm
- › Diagnostic function for sensor elements and circuitry with PRO-SIL™ support
- › Dual die SMD package (redundancy)
- › ISO 26262 ready
- › Available as single and dual die product

## Applications

- › Steering angle
- › Brushless DC motor commutation (for example Electric Power Steering (EPS))
- › Rotary switches
- › General angular sensing
- › Incremental or absolute magnetic encoders
- › Gimbals, drones, robots

iGMR



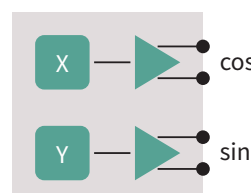
# iAMR based angle sensors

TLE5109A16(D)

Analog iAMR sensor with temperature compensation

## Features

- › Features a differential or single-ended analog interface for sine and cosine values
- › Internal temperature drift compensation for gain and offset
- › Also available as a dual-sensor package
- › ISO 26262 ready
- › Available as single and dual die product



iAMR



ISO 26262 ready

1) More information on PRO-SIL™, see page 88

# Combined iAMR and iGMR based angle sensors

**iAMR**  
**iGMR**

TLE5309D

Dual angle sensor combining iAMR and iGMR technology

The TLE5309D is a diverse redundant angle sensor with analog outputs. It combines a Giant Magneto Resistance (GMR) sensor for full 360° angle range with an Anisotropic Magneto Resistance (AMR) sensor for high precision in a flipped configuration in one package. Sine and cosine angle components of a rotating magnetic field are measured by Magneto Resistive (MR) elements. The sensors provide analog sine and cosine output voltages that describe the magnetic angle in a range of 0 to 180° (AMR sensor), and 0 to 360° (GMR sensor), respectively.



The differential MR bridge signals are independent of the magnetic field strength, and the analog output is designed for differential or single ended applications.

The output voltages are designed to use the dynamic range of an A/D-converter using the same supply as the sensor as voltage reference. Both sensor ICs are supplied independently by separate supply and ground pins.

## Summary of features

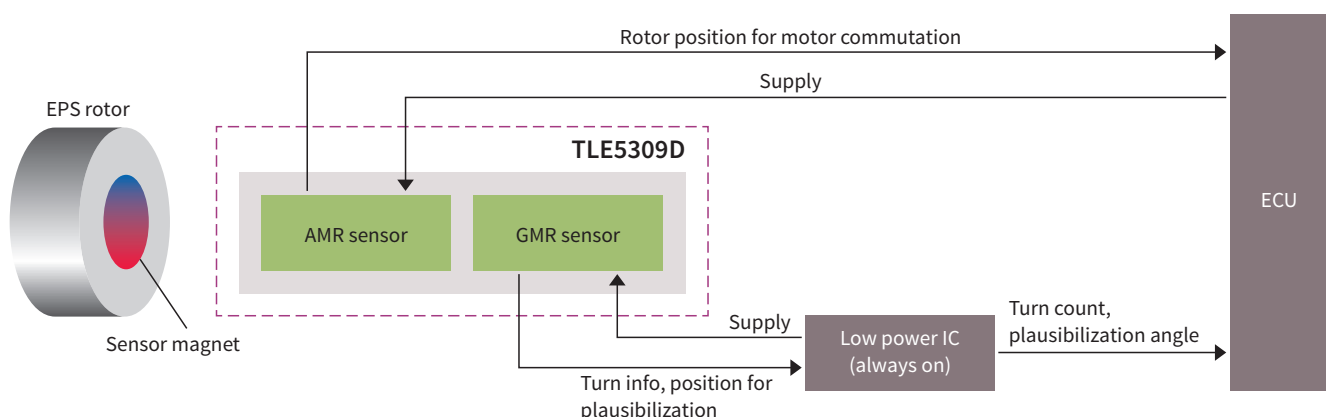
- > Separate supply pins for AMR and GMR sensor
- > Diverse redundant design with one GMR sensor (top die) and one AMR sensor (bottom die) in one package
- > Low current consumption and very fast start up
- > 360° contactless angle measurement
- > Immune to airgap variations due to MR based sensing principle
- > Operating temperature: -40°C to 125°C (ambient temperature)

## Potential applications

The TLE5309D angle sensor is designed for angular position sensing in safety critical automotive applications. Its high accuracy and 360° measurement range combined with short propagation delay makes it suitable for systems with high speeds and high accuracy demands such as brush-less DC (BLDC) motors for actuators and electric power steering systems (EPS). At the same time its fast start-up time and low overall power consumption enables the device to be employed for low-power turn counting. Extremely low power consumption can be achieved with power cycling, where the advantage of fast power on time reduces the average power consumption.

- > BLDC motors for electric power steering (EPS)
- > Low-power turn counter

## Diagnostic functions in combination with iAMR and iGMR diversity supports ASIL D applications



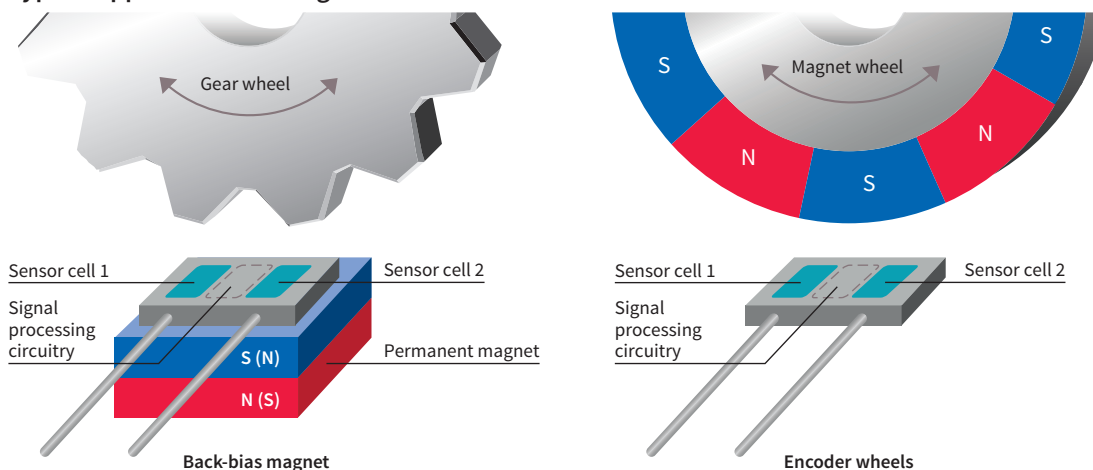


# Magnetic speed sensors

Easy to use, robust and cost-effective sensors for speed measurement

Infineon's Hall- and GMR-based magnetic speed sensors are designed to measure speed in safety and powertrain applications such as speedometers, ABS, camshafts/crankshafts, and automatic transmissions. They are also used in similar applications in the industrial sector. The sensors use a ferromagnetic gear tooth or encoder structure to measure linear or rotational speed and position. Hall sensor measuring rotational speed with a gear tooth and a magnetic encoder wheel. The majority of sensors also feature additional benefits such as integrated capacitors for high EMC robustness and the highest levels of ESD protection.

## Typical application of a magnetic differential sensor



## TLE4921-5U

Highly robust and cost-effective speed sensor

TLE4921-5U is a highly robust and cost-effective solution for measuring speed in a wide range of automotive and industrial applications, delivering outstanding performance while enabling simple, low-cost magnetic circuit designs, making it ideal for all entry-level speed sensing applications.

### Features

- › Good sensing performance and high sensitivity
- › Well suited to harsh environments thanks to dynamic offset cancellation, EMI robustness, reverse polarity and overvoltage protection
- › Suitable for a broad temperature range
- › Flexible sensor module interface that can be configured for two-wire and three-wire interfaces
- › AEC-Q100 qualified

### Applications

- › Engine speed and position (e.g. crankshaft)
- › Transmission speed
- › Speedometer
- › Industrial speed and position sensing



## TLE4922

### Highly robust, easy-to-use mono-Hall speed sensor with twist-independent mounting

This sensor is specially designed to provide an easy-to-use, robust and cost-effective solution for vehicle or industrial speed sensing applications. The TLE4922 can, therefore, be back-biased using a simple, low-cost bulk magnet, while providing a good air gap performance and switching accuracy. Its hidden adaptive hysteresis and calibration algorithm enable good accuracy over air gap jumps and immunity to vibration and run-out events.

#### Features

- › Large operating air gap capability
- › Flexible mounting (also known as Twist-independent mounting)
- › Hidden adaptive hysteresis
- › Low current consumption
- › Reverse magnetic polarity capability
- › Advanced protection technology
  - Reverse voltage protection at  $V_S$ -pin
  - Short-circuit protection
  - Overtemperature protection
- › Wide operating temperature ranges of  $-40^{\circ}\text{C} \leq T_j \leq \pm 150^{\circ}\text{C}$
- › High ESD robustness up to  $\pm 4$  kV HBM
- › 3-wire PWM voltage interface

#### Applications

- › Industrial applications
- › Two-wheeler and automotive vehicle speed



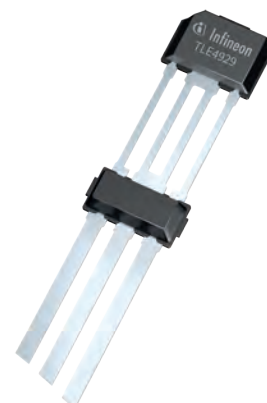
## TLE4929

### Fully programmable crankshaft sensor

The TLE4929 is an active Hall sensor ideally suited for crankshaft applications and similar industrial applications, such as a speedometer or any speed sensor with high accuracy and low jitter capabilities. Also, the compatible 3-pin-package allows a one-to-one-replacement of the former generation of crankshaft sensors without direction detection, TLE4924/25/26/27/28. Through the EEPROM of the TLE4929C various parameters of the former TLE492x-family can be mimicked.

#### Features

- › Differential Hall speed sensor to measure speed and position of tooth/pole wheels
- › Switching point in the middle of the tooth enables backward compatibility
- › Robustness over magnetic stray-field due to the differential sensing principle
- › Precise miss fire detection through excellent jitter performance
- › Dedicated hybrid engine algorithm keeps combustion engine calibrated during an electric drive cycle
- › Digital output signal with programmable output-protocol including diagnosis interface
- › Direction detection and stop-start-algorithm
- › High accuracy and low jitter
- › High sensitivity enables large air gap
- › End-of-line programmable to adapt engine parameters
- › Can be used as a differential camshaft sensor
- › Pre-programmed version, TLE4929C-X2A available for 2-wheeler applications
- › Automotive operating temperature range



| Product | Sensor technology | AEC-Q100 qualified | Automotive | Industrial | RoHS | HAL free |
|---------|-------------------|--------------------|------------|------------|------|----------|
| TLE4922 | Mono-Hall         | ●                  | ●          | ●          | ●    | ●        |
| TLE4929 | Differential Hall | ●                  | ●          | ●          | ●    | ●        |

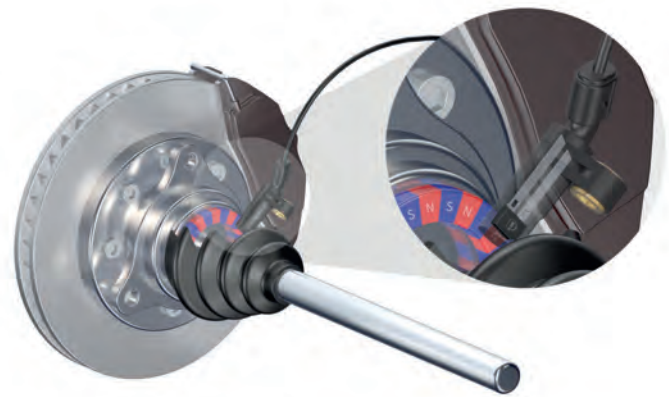


# Safety first by Infineon wheel speed sensors

Nowadays, wheel speed sensors have to support an ever-growing list of applications. Years ago, ABS systems simply needed to know if a wheel was blocked, and then ESC used the accurate speed of all four wheels for its corrections. Since then, an increasing number of modules in the car take the wheel speed into account for their intelligent functions. The electrical parking brake, for example, needs to know about every inch a car moves when it's supposed to be stationary, and iTPMS uses sophisticated algorithms to determine if a wheel lacks air pressure, and even the central locking locks the doors after a couple of meters and the radio turns up the volume in line with increasing speed. All of the above rely on accurate information from the wheel speed sensor.

## Applications

- > Wheel speed sensing in automotive applications
- > Antilock Braking Systems (ABS)
- > Electronic Stability Programs (ESP)
- > Automatic transmissions
- > iTPMS TLE5041plusC, TLE5045iC and TLE5046iC



TLE4941plusC/TLE4942-1C/TLE4943C  
My car, how fast and how far does it drive?

The TLE4941plusC, our best selling sensor, has become an industry standard for wheel speed sensing. TLE4942-1C and TLE4943C are complementing this sensor with additional direction information using PWM or AK protocol, respectively.

As a single chip sensor it magnetically measures the cars wheel speed with its differential Hall technology, making it the ideal all-purpose sensor, equally suitable for pole wheel and steel wheel applications. These sensors are immune towards any kind of undesired magnetic stray fields, ferromagnetic particles or other disturbances, because of their differential principle.

## Features

- > Family of Hall sensors available with and without direction detection
- > Excellent stray field robustness



## Applications

- > Pole wheel applications
- > Steel/tooth wheel applications by using back bias magnet

## Wheel speed sensor selection guide for high selling product portfolio

| Product      | Sensor technology | Pole wheel | Steel wheel | ISO 26262 | Direction detection | Protocol | iTPMS |
|--------------|-------------------|------------|-------------|-----------|---------------------|----------|-------|
| TLE4941plusC | Hall differential | ●          | ●           | -         | -                   | Standard | -     |
| TLE4942-1C   | Hall differential | ●          | ●           | -         | ●                   | PWM      | -     |
| TLE4943C     | Hall differential | ●          | ●           | -         | ●                   | AK       | -     |

## TLE5045iC, TLE5046iC High end GMR wheel speed sensors

The TLE5045/46iC is Infineon's next generation wheel speed sensor family based on GMR technology. The family consists of a designed-to-cost speed-only TLE5045iC, and a high-end TLE5046iC providing not only direction detection but also offering true "zero-speed" capability as well as possibilities of self-diagnostics.

TLE5045iC and TLE5046iC are developed according ISO 26262 to fulfill ASIL B, supporting ASIL D systems. The TLE5046iC with direction detection is available with PWM or AK protocol.

### Features

- › One family of speed sensors for all wheel speed sensing applications in same package
- › Best in class in sensitivity, jitter and duty cycle, independent from magnetic target wheel
- › "Zero speed" capability
- › ISO 26262 compliant ASIL B development, supporting system ASIL D
- › Multiple protocol variants with and without self-diagnosis functionality
- › Integrated circuitry for improved EMC and ESD robustness even without external capacitor

### Applications

- › Pole wheel applications
- › Autonomous driving (e.g. park assist)




### Wheel speed sensor selection guide for high selling product portfolio

| Product       | Sensor technology | Pole wheel | Steel wheel | ISO 26262 | Direction detection | Protocol | iTPMS |
|---------------|-------------------|------------|-------------|-----------|---------------------|----------|-------|
| TLE5045iC     | iGMR differential | ●          | -           | Compliant | -                   | Standard | ●     |
| TLE5046iC-PWM | iGMR differential | ●          | -           | Compliant | ●                   | PWM      | ●     |
| TLE5046iC-AK  | iGMR differential | ●          | -           | Compliant | ●                   | AK       | ●     |

## TLE4953C

### The two-wire transmission speed sensor

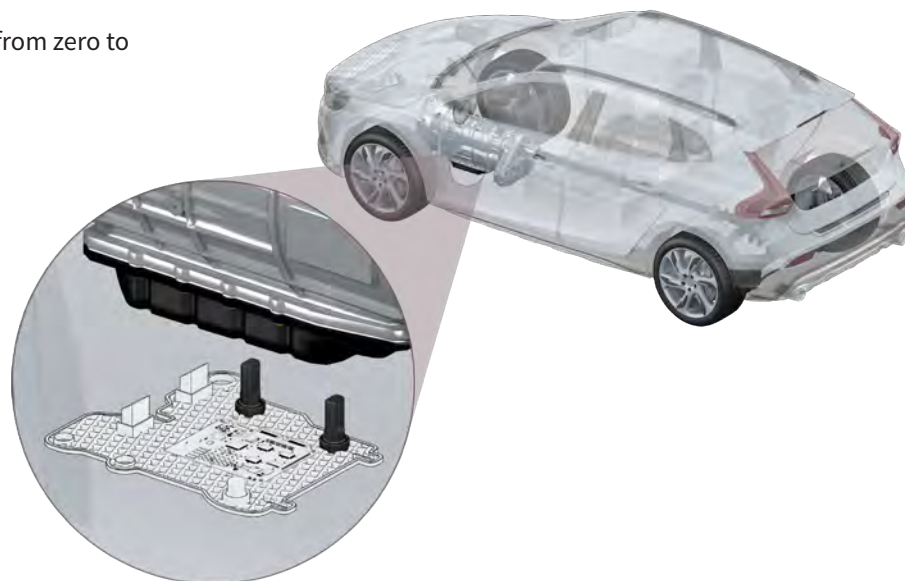
The differential Hall sensor TLE4953C can detect direction and was developed specifically to meet the needs of high-end transmission applications. Its jitter performance and high sensitivity enables designers to create high-accuracy systems with excellent vibration suppression. Adaptive hysteresis and the dynamic self-calibration algorithm ensure outstanding measurement results with both fine and coarse target wheels. As with other Infineon speed sensors, the south and north poles can be pre-inducted. TLE4953 features a current interface and comes in a two-wire package with an integrated 1.8 nF overmolded capacitor for improved EMC.

#### Features

- › Detection of rotation direction
- › Highly accurate speed measurements from zero to 12 kHz over large operating air-gaps
- › Excellent vibration suppression
- › Broad operating temperature range
- › AEC-Q100 qualified

#### Applications

- › Automatic transmission systems
- › Industrial speed sensing using current sensor interfaces



## TLE4955(C)

### Leading the way in vibration robustness

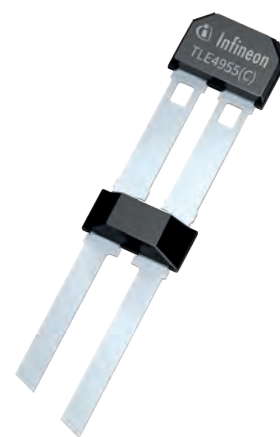
TLE4955 is a new family of differential Hall sensors specifically designed to meet the latest requirements in transmission vibration suppression. It provides best-in-class vibration suppression for applications, that require a two-wire current interface. The TLE4955 family provides a similar algorithm plus dynamic self-calibration, jitter and sensitivity levels as our proven TLE4953, thus ensuring accurate speed measurements in the harshest of environments for both fine and coarse target wheels.

Designers can choose different interface protocol versions.

#### Features

- › Detection of rotation direction
- › Best-in-class vibration suppression
- › Highly accurate speed measurements from zero to 12 kHz over large operating air-gaps
- › Broad operating temperature range
  - Four different interface protocols
- › AEC-Q100 qualified

[www.infineon.com/speed-sensors](http://www.infineon.com/speed-sensors)



#### Applications

- › Automatic transmission systems
- › Industrial speed sensing using current sensor interfaces

## TLE4959C(-FX)

### State-of-the-art three-wire transmission speed sensor with direction detection

With our TLE4959 you now can also address your 3-wire applications with the latest state-of-the-art technology of IFX transmission sensors. Differential Hall sensor TLE4959 is your choice when you need a 3-wire-sensor with direction detection and active vibration suppression. Beside its outstanding airgap and best of class Hall jitter performance, with its high immunity against strayfields it is the ideal match not only for traditional transmissions but also particularly for hybrid applications.

While TLE4959C is provided with the standard protocol, the FX version gives access to different protocols (e.g. speed only) as it is to be programmed at the customer's premises.

#### Features

- › Active vibration suppression
- › Highly accurate speed measurements from 0 Hz to 10 kHz over large operating air-gaps (up to 20k for -FX)
- › Common three-wire voltage interface
- › Broad operating temperature range
- › AEC-Q100 qualified
- › FX version customer programmable (protocol, hysteresis level)

## TLE4959-5U (-FX)

### State-of-the-art 4-wire transmission speed sensor with direction detection

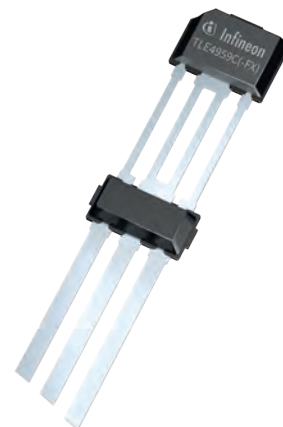
Infineon released its new transmission speed sensors, the XENSIV™ TLE4959-5U and the TLE4959-5U-FX. These are 4-wire voltage interface differential hall speed sensor for transmission speed applications with vibration suppression and direction detection output. The FX version flexible in terms of protocol, it has customer programmable EEPROM.

State-of-the-art 4-wire transmission speed sensor with direction detection. The TLE4959-5U (FX) is an integrated differential Hall speed sensor ideally suited for transmission applications. Its basic function is to provide rotational speed and direction of rotation information to the transmission control unit. Sophisticated vibration suppression with excellent air-gap performance. TLE4959-5U (FX) includes a sophisticated algorithm which actively suppresses vibration while keeping excellent air-gap performance.

#### Features

- › Voltage interface
- › Active vibration suppression
- › Direction detection output
- › Dynamic self-calibration
- › 0 Hz capability
- › FX: flexible protocol through customer programmable EEPROM

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#### Applications

- › Automatic (hybrid) transmission systems



#### Target applications

- › Automatic transmission applications
- › Transmission applications with speed with direction detection

## TLE4988C

Reduced dependence on rare-earth backbias magnets thanks to advanced performance

The Infineon XENSIV™ TLE4988C products feature advanced camshaft sensing performance and improved application adaption. One major benefit of the advanced sensor performance is the reduced dependence from rare-earth backbias magnets for module manufacturers. The TLE4988C has proven right performance with a ferrite backbias magnet for all relevant parameters such as phase jitter, phase accuracy or speed effect across key temperature, air gap and rpm ranges.

### Features

- › Digital output signal (voltage interface)
- › True Power On functionality (TPO)
- › Auto TPO – automatic in car calibration
- › Improved switching level/phase accuracy
- › TC range including ferrite
- › High speed digital interface for diagnosis / test
- › Twisted Independent Mounting (TIM)
- › EEPROM for algorithm options and ID (on request)
- › Increased ESD and EMC immunity, improved  $\mu$ Cut feature
- › Digital magnet temperature compensation
- › Mechanical stress compensation
- › Module package PG-SSO-3-5

## TLE5028C

iGMR-based speed sensor

TLE5028C is our 2<sup>nd</sup> generation Crank speed sensor solution based on Giant Magneto Resistive (iGMR) technology. It provides a higher air-gap and greatly reduced jitter over frequency and temperature performance. All of which puts it ahead of other magnetic sensing technologies and makes it the preferred solution for high-accuracy powertrain speed sensor systems – both today and in the future. TLE5028C can detect the rotation direction of a wheel and transmits this information during the first output pulse, making it the perfect fit for the latest engine systems that use a start-stop feature as well as for automatic transmission applications in the automotive sector. It's improved robustness against ESD and EMC answers to the challenges of harsh high power environments typically present in hybrid systems. TLE5028C is available in our well-established, module-style package with integrated capacitors. It uses a three-wire digital voltage interface (PWM).

### Features

- › Outstanding jitter performance thanks to giant magneto resistive technology
- › High sensitivity ( $B_{\min} < 1$  mT) and large air-gap capability
- › Detection and transmission of rotation direction during the first output pulse
- › Three-wire digital voltage interface (PWM)
- › Large frequency range
- › Broad operating temperature range
- › AEC-Q100 qualified
- › Improved EMC and ESD immunity

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### Applications

- › Camshaft speed and position sensing

**iGMR**

### Applications

- › Automatic transmission systems
- › Engine speed (crankshaft)

# Magnetic speed sensors – overview

|  | Icon/Description        | TLE4921    | TLE4922   | TLE4929    | TLE4941    | TLE4941plusC | TLE4942    | TLE4943    | TLE4953    | TLE4955    | TLE4959             | TLE4988   | TLE5028C | TLE5041plusC | TLE5045 | TLE5046 |
|--|-------------------------|------------|-----------|------------|------------|--------------|------------|------------|------------|------------|---------------------|-----------|----------|--------------|---------|---------|
| Automotive                               | Wheelspeed              | -          | •         | -          | •          | •            | •          | •          | -          | -          | -                   | -         | -        | •            | •       | •       |
|  | Wheelspeed/Transmission | -          | -         | -          | •          | •            | •          | -          | -          | -          | -                   | -         | -        | -            | -       | -       |
|  | Transmission            | •          | •         | -          | •          | •            | •          | -          | •          | •          | •                   | -         | -        | -            | -       | -       |
|  | Transmission/Engine     | •          | -         | -          | -          | -            | -          | -          | -          | -          | -                   | -         | -        | -            | -       | -       |
|  | Engine                  | •          | •         | •          | -          | -            | -          | -          | -          | -          | -                   | •         | •        | -            | -       | -       |
| Industrial                               |                         | •          | •         | •          | -          | •            | -          | -          | -          | -          | -                   | -         | -        | -            | -       | -       |
| Sensor technology                        |                         | Diff. Hall | Mono-Hall | Diff. Hall | Diff. Hall | Diff. Hall   | Diff. Hall | Diff. Hall | Diff. Hall | Diff. Hall | Diff. Hall          | Mono-Hall | iGMR     | iGMR         | iGMR    | iGMR    |
| Improved air-gap/jitter performance      |                         | -          | -         | •          | -          | -            | -          | -          | -          | -          | •                   | •         | •        | •            | •       | •       |
| Direction information available          |                         | -          | -         | •          | -          | -            | •          | •          | •          | •          | - / • <sup>3)</sup> | -         | •        | -            | -       | •       |
| True Power On (TPO)                      |                         | -          | -         | -          | -          | -            | -          | -          | -          | -          | -                   | •         | -        | -            | -       | -       |
| Twist-Independent Mounting (TIM)         |                         | -          | •         | -          | -          | -            | -          | -          | -          | -          | -                   | •         | -        | -            | -       | -       |
| Vibration suppression algorithm included |                         | -          | -         | •          | -          | -            | -          | -          | •          | •          | •                   | -         | -        | -            | -       | -       |
| Type of hysteresis <sup>1)</sup>         |                         | V          | H         | H/V        | H          | H            | H          | H          | V          | V          | V                   | V/H       | H        | H            | H       | H       |
|  |                         | F          | A         | A/F        | F          | F            | F          | A          | A          | A          | A                   | P/A       | A        | F            | A       | A       |
| Interface <sup>2)</sup>                  | # of pins               | 4          | 4         | 3          | 2          | 2            | 2          | 2          | 2          | 2          | 3/4                 | 3         | 3        | 2            | 2       | 2       |
|  | Interface               | V          | V         | V          | C          | C            | C          | C          | C          | C          | V                   | V         | V        | C            | C       | C       |
|  | Protocol                | S          | S         | S/P        | S          | S            | P          | AK         | P          | P          | P                   | S         | P        | S            | S       | P/AK    |
| Electrostatic Discharge (ESD)            | Human Body Model (HBM)  | 2 kV       | 3 kV      | 6 kV       | 12 kV      | 12 kV        | 12 kV      | 12 kV      | 12 kV      | 12 kV      | 6 kV                | 6 kV      | 6 kV     | 12 kV        | 12 kV   | 12 kV   |
| Package without integrated capacitor     |                         | •          | •         | -          | •          | -            | -          | -          | •          | •          | •                   | -         | -        | -            | •       | •       |
| Package with integrated capacitor        |                         | -          | -         | •          | -          | •            | •          | •          | •          | •          | •                   | •         | •        | •            | -       | -       |

1) H = Hidden; V = Visible; F = Fixed; A = Adaptive; P = Programmable  
 2) AK = AK protocol; C = Current; V = Voltage interface; S = Single pulse; P = PWM protocol  
 3) Depending on derivative



# Pressure sensors

For automotive, industrial and consumer applications

Our comprehensive family of sensors includes a wide choice of pressure sensors tailored specifically to the needs of automotive, industrial and consumer sectors. Offering rapid time-to-market, our portfolio ensures the perfect fit

for all performance and integrity needs. Featuring analog and digital interfaces, these sensors give customers a high degree of design flexibility, while also enabling manufacturers to meet evolving market and compliance demands.



Cars have to act and perform in the same way whether driving along a coast or through mountains. As a result of different locations, the composition and the quality of the air around changes. It is important that the engine react immediately to these changes. Infineon offers various pressure sensors for barometric measurements with analog and digital interface and various pressure ranges.



Powertrain systems have to fulfill the constantly increasing stringent media requirements. Environmental legislation aims to deliver cleaner air by ensuring a steady global decrease in CO<sub>2</sub> emissions. Thanks to their accurate measurement capability, Infineon MAP and turbo MAP product with analog or digital interface enable engines to meet these requirements.



Typical safety-related automotive pressure sensing applications such as side impact and pedestrian protection call for the highest quality and accuracy standards with full ISO 26262 compliance. Every year thousands of pedestrians are severely injured in traffic due to slow or failing sensing elements. Our Infineon XENSIV™ safety pressure sensor family includes integrated pressure sensors that tick all these boxes with PS15 peripheral sensor interfaces for safety-critical use cases. Our sensors support new safety systems, increasing the protection of pedestrians and car occupants in the event of a collision.



Our family of digital barometric pressure sensors also gives designers the best choice when it comes to mobile and wearable devices. Highlights include small form factors to facilitate system integration, highest precision and relative accuracy over a wide temperature range, fast read-out speeds via the serial I<sup>2</sup>C/SPI interface, and low power consumption to ensure longer battery lifetimes.

#### Automotive applications

- › Barometric absolute pressure
- › Seat comfort systems
- › Manifold absolute pressure
- › Exhaust gas recirculation
- › Secondary air valve
- › Fuel vapor/ORVR
- › Natural gas vehicle
- › Side crash detection
- › Pedestrian impact detection
- › Battery monitoring for EV
- › Brake booster
- › 2-wheeler ECU and MAP

#### Industrial applications

- › Industrial and process controls
- › Gas flow
- › Level meter
- › Barometric pressure
- › Altitude compensation systems
- › Weather stations
- › Engine management systems
- › Medical equipment

#### Consumer applications

- › Multicopter
- › Health and fitness
- › Outdoor navigation
- › Indoor navigation
- › Smart home
- › Air flow control
- › Health care



# Absolute pressure sensors (MAP and BAP)

Infineon's pressure sensors offer the highest quality and accuracy for safety-relevant automotive, industrial, or consumer lifestyle applications. Typical safety-related automotive pressure sensing applications such as side-impact and pedestrian protection call for the highest quality and accuracy standards with full ISO 26262 compliance. Our XENSIV™ family includes integrated pressure sensors that tick all these boxes with PSI5 peripheral sensor interfaces for a safety-critical use case.

Discover our highlight product dedicated to **2-wheelers: KP212 enables lower CO<sub>2</sub> emissions**, as well as lower fuel consumption, which makes it the right fit product worldwide to fulfill emission regulation requirements such as CN6 and Bharat 6. Of course, these sensors can also be used in industrial control, consumer applications, as well as medical applications.

## KP21x/KP22x – Analog manifold air pressure sensor IC family (MAP + turbo MAP)

### Features

- › Manifold air pressure measurement – MAP and turbo MAP
- › Excellent accuracy of up to 1.0 kPa over a large temperature range
- › Ratiometric analog voltage output proportional to the applied pressure
- › Output signal fully compensated over pressure and temperature
- › Pressure range from 10 to 400 kPa
- › Temperature range from -40 to +140°C
- › Output clamping (optional)
- › Complete product family available with multiple transfer functions
- › Reverse polarity protection
- › Green SMD package

## KP23x – Analog barometric air pressure (BAP) sensor IC family

### Features

- › Absolute air pressure measurement
- › Excellent accuracy of 1.0 kPa over a large temperature range
- › Ratiometric analog voltage output proportional to the applied pressure
- › Output signal fully compensated across pressure and temperature range
- › Pressure range from 15 to 165 kPa
- › Temperature range from -40 to +125°C
- › Serial service interface
- › Open Bond Detection (OBD) for supply and GND
- › Inverse polarity protection
- › Green SMD package

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

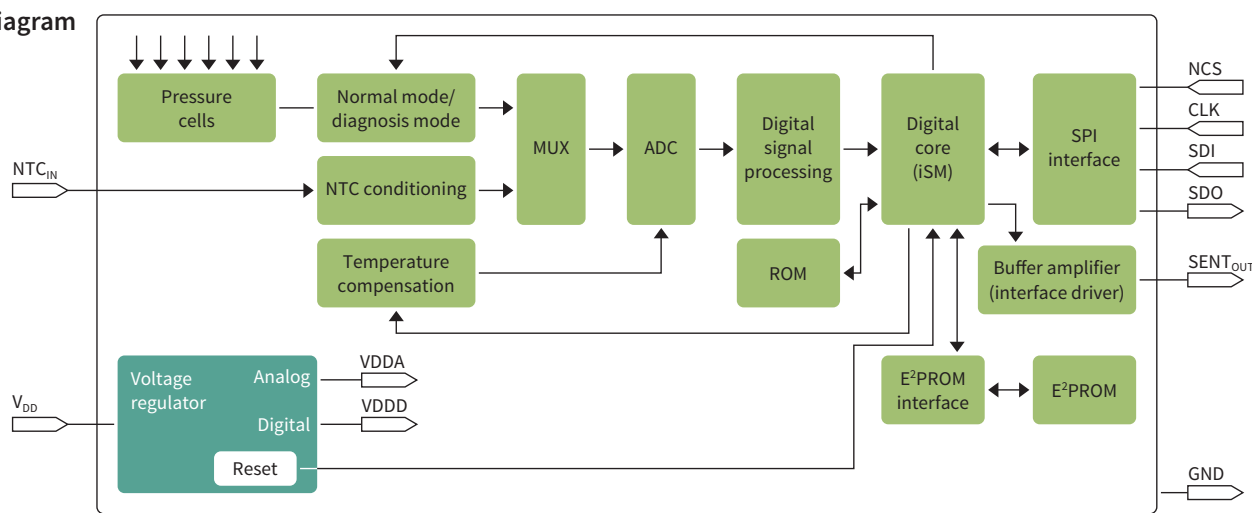


## KP25x/KP264 – Digital barometric air pressure (BAP) sensor IC family

### Features

- › Absolute air pressure measurement
- › Excellent accuracy of 1.0 kPa over a large temperature range
- › Real 10-bit pressure resolution
- › Integrated temperature sensor
- › Real 10-bit temperature resolution
- › Power-down mode for reduced power consumption
- › Self diagnosis features
- › Output signal fully compensated across pressure and temperature range
- › Pressure range from 10 to 165 kPa
- › Temperature range from -40 to +125°C
- › Green SMD package

### Block diagram



## KP276 – Media robust MAP sensor with digital interface

### Features

- › Media robustness for current automotive requirements
- › Digital single edge nibble transmission (SENT) interface (282 clock ticks)
- › Excellent accuracy of  $\pm 0.77$  percent FSS
- › Green SMD package
- › Temperature range -40 to +170°C (170°C for 20 min. max., 150°C operating)
- › Integrated NTC temperature sensor functionality with fast start up time (typ. 10ms)

### Integrated pressure sensor ICs for manifold and barometric air pressure

| Product             | Max. accuracy [kPa] | Max. operating temperature [°C] | Automotive | Industrial | ISO 26262 | Pressure range [kPa] |
|---------------------|---------------------|---------------------------------|------------|------------|-----------|----------------------|
| KP21x <sup>1)</sup> | 1.0                 | 140                             | ●          | ●          | -         | 10 ... 150           |
| KP22x <sup>1)</sup> | 2.5                 | 140                             | ●          | ●          | -         | 10 ... 400           |
| KP23x <sup>1)</sup> | 1.0                 | 125                             | ●          | ●          | -         | 15 ... 115           |
| KP236N6165          | 1.0                 | 125                             | ●          | ●          | -         | 60 ... 165           |
| KP253               | 1.0                 | 125                             | ●          | ●          | Ready     | 60 ... 165           |
| KP254               | 1.5                 | 125                             | ●          | ●          | Ready     | 40 ... 115           |
| KP255 <sup>1)</sup> | 1.4                 | 140                             | ●          | ●          | Ready     | 10 ... 125           |
| KP256               | 1.0                 | 125                             | ●          | ●          | Ready     | 60 ... 165           |
| KP264 <sup>2)</sup> | 1.5                 | 125                             | ●          | ●          | Ready     | 40...115             |
| KP276 <sup>1)</sup> | 3.0                 | 170                             | ●          | ●          | Ready     | 10 ... 400           |

1) For more information on the product, contact our product support  
2) Package with small 4-hole lid



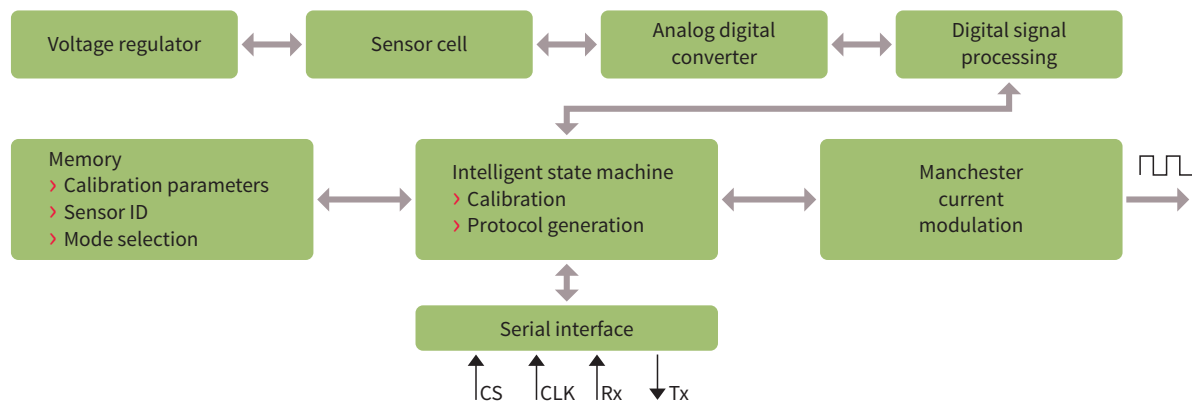
# KP200/KP201/KP204

PSI5 PRO-SIL™ ready pressure sensor ICs for side crash detection and pedestrian protection



## Features

- › Two-wire interface with on-chip current modulator for PSI5 communication
- › Fully PSI5 compliant with support for multiple modes
- › Synchronous or asynchronous data transmission
- › EEPROM for unique ID number, calibration and mode selection
- › Serial service interface for EEPROM programming
- › On-chip voltage regulator
- › Reverse polarity protection
- › Fully AK-LV29 and AK-LV38 compliant
- › Patented online diagnosis for pressure cells and circuitry
- › PRO-SIL™ support in line with IEC 61508 and ISO 26262
- › Green SMD package
- › KP201 qualified for higher operating temperatures up to 125°C
- › KP204 with 4-hole lid supporting insect intrusion protection



1) More information on PRO-SIL™, see page 88



ISO 26262  
ready

# SP40+

## Tire pressure sensor for Tire Pressure Monitoring Systems (TPMS)

SP40+ provides a very high level of integration and is optimized to perform all of the functions necessary to implement a state-of-the-art sensor module for Tire Pressure Monitoring System (TPMS). With its integrated microcontroller, sensors and convenient peripherals, the SP40+ needs the addition of only a few passive components and a battery to complete a full TPMS module.

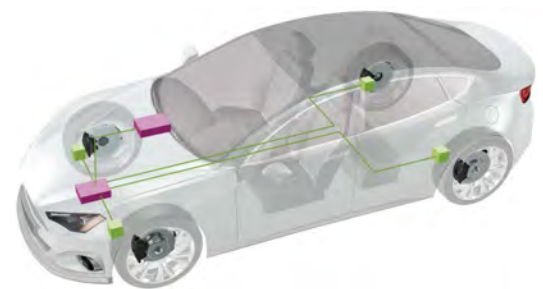
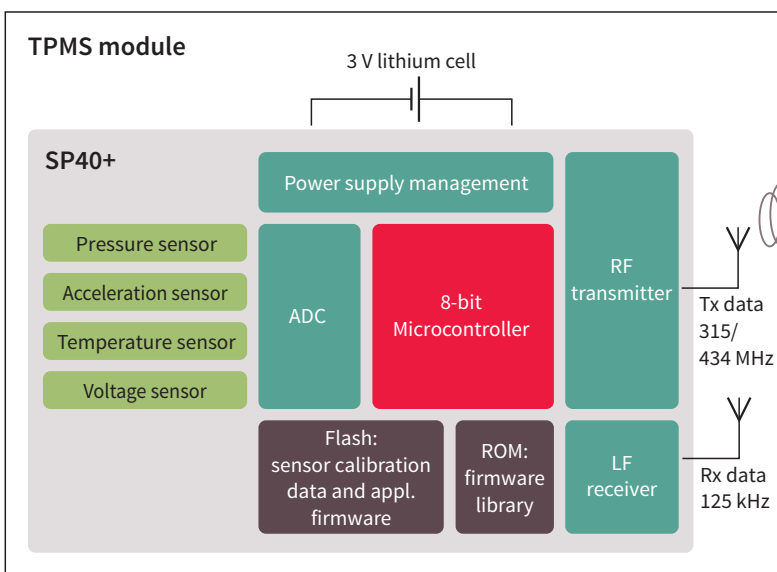
SP40+ measures pressure, radial acceleration, temperature and supply voltage and is certified as a green package compliant with RoHS. SP40+ comes with a pressure-auto-ranging feature, providing best-in-class pressure-accuracy in the range from 100 to 1400 kPa, making it the ideal choice for all car types from passenger vehicle to heavy trucks.

Compared to the previous generation SP37, the SP40+ family offers even lower current consumption and more features like larger flash, better sensor accuracy and higher pressure range.

### Features

- › Pressure sensor
- › Radial acceleration sensor
- › Temperature sensor
- › Supply voltage sensor
- › Embedded 8051 compatible 8-bit microcontroller
- › 12 kB on-chip flash memory, plus optional additional 2 kB (for example for LF bootloader)
- › 160 Byte retention RAM
- › 315 and 434 MHz FSK/GFSK/OOK/ASK RF transmitter
- › RF output power of 5 dBm
- › 125 kHz ASK high-sensitivity LF receiver
- › Advanced power control/wake-up system to minimize battery charge consumption
- › Ultra-low power down current of < 540 nA
- › Supply voltage range from 1.6 to 3.6 V
- › Operating temperature range from -40 to +125°C
- › DSOSP-14-82 package
- › RoHS compliant, green package

| Product     | Pressure range [kPa] | On-chip flash memory [kB] | Key features   |
|-------------|----------------------|---------------------------|--|
| SP400-11-01 | 100–900              | 12                        | <ul style="list-style-type: none"> <li>› Highest integration</li> <li>› Very low energy consumption</li> <li>› Robust g- and p- sensor</li> <li>› High LF sensitivity</li> </ul> |
| SP400-11-11 | 100–900              | 12 + 2                    |  |
| SP400-15-11 | 100–1400             | 12 + 2                    |  |



SP40+ fully supports all necessary requirements for a Tire Pressure Monitoring System (TPMS)

# Digital barometric pressure sensor

For mobile and wearable devices

Infineon's digital barometric pressure sensor family is the best choice for mobile and wearable devices due to its small form factor, high precision, and low power consumption. Pressure sensing is based on capacitive technology, which guarantees ultra-high precision ( $\pm 2$  cm) and excellent relative accuracy ( $\pm 0.06$  hPa) over a wide temperature range. The sensor's internal signal processor converts the output from the pressure and temperature sensor elements to 24-bit results. Each pressure sensor has been calibrated individually and contains calibration coefficients. The coefficients are used in the application to convert the measurement results to true pressure and temperature values. All sensors have a FIFO that can store the latest 32 measurements. Since the host processor can remain in a sleep mode for a longer period between readouts, a FIFO can reduce the system power consumption. Sensor measurements and calibration coefficients are available via the serial I<sup>2</sup>C/SPI interface.

## DPS310


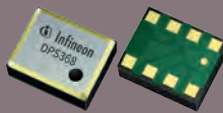
A barometric pressure sensor with very low power consumption is recommended for applications where power consumption is critical and the highest precision in pressure metering is required.

## DPS368

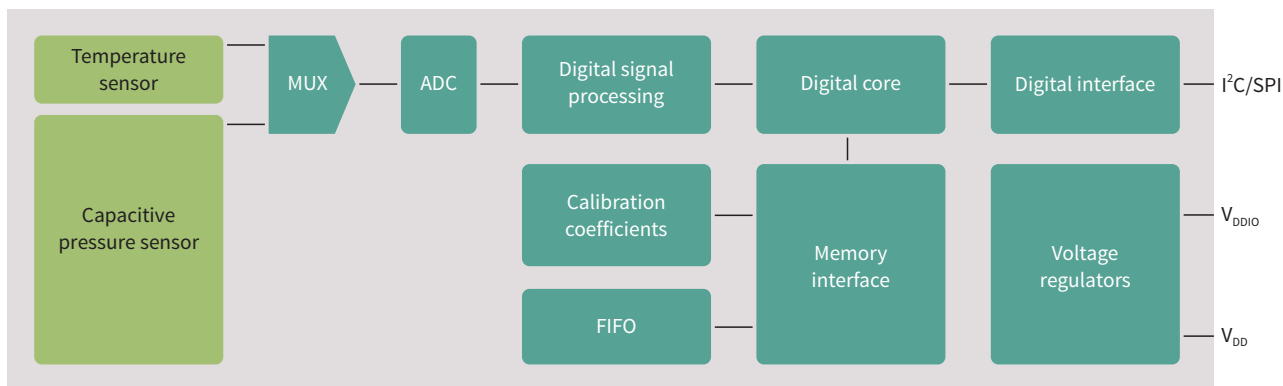
DPS368 offers the best-in-class resolution ( $\pm 2$  cm), a very fast read-out speed, and low current consumption. The sensor can be used in a harsh environment, as it is robust against water (IPx8 - 50 m underwater for 1 hour), dust and humidity. The small package size saves up to 80 percent of the space and makes the DPS368 ideal for mobile applications and wearable devices.

## Typical applications

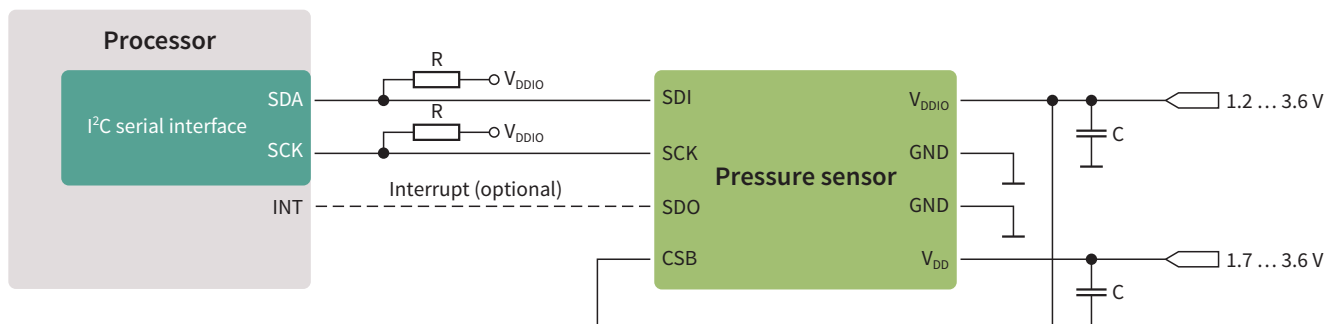
- > Drones: altitude detection and height stability
- > Health and fitness: accurate elevation gain and step counting (e.g. for smartwatches)
- > Outdoor Navigation: GPS start-up time/accuracy improvement; dead reckoning (e.g. in tunnels)
- > Indoor navigation: floor detection e.g. in shopping malls and parking garages
- > Smart home: micro weather forecasting; room temperature control; intruder detection
- > Airflow control: Smart filter replacement alarm (e.g. in home appliances); predictive maintenance
- > Health care: fall detection; respiratory devices; smart inhalers

| Key product features                             | DPS310   | DPS368  |
|--|--|---|
|  |   |  |
| Package size                                     | 2.0 x 2.5 x 1.0 mm   | 2.0 x 2.5 x 1.1 mm  |
| Operating pressure range                         | 300 ... 1200 hPa   |   |
| Operating temperature range                      | -40 ... 85°C   |   |
| Pressure level precision                         | $\pm 0.002$ hPa (or $\pm 0.02$ m)  |   |
| Relative accuracy                                | $\pm 0.06$ hPa (or $\pm 0.5$ m)  |   |
| Absolute accuracy                                | $\pm 1$ hPa (or $\pm 8$ m)   |   |
| Temperature accuracy                             | 0.5°C  |   |
| Pressure temperature sensitivity                 | 0.5 Pa/K   |   |
| Measurement time                                 | 3.6 ms (low precision); 27.6 ms (standard mode)                                      |   |
| Average current consumption @ 1 Hz sampling rate | 1.7 $\mu$ A pressure measurement, 1.5 $\mu$ A temp. measurement, standby 0.5 $\mu$ A |   |
| Supply voltage                                   | V <sub>DDIO</sub> : 1.2 – 3.6 V; V <sub>DD</sub> : 1.7 – 3.6 V                       |   |
| Operating modes                                  | Command (manual), background (automatic), standby                                    |   |
| Interface  | I <sup>2</sup> C and SPI, both with optional interrupt                               |   |

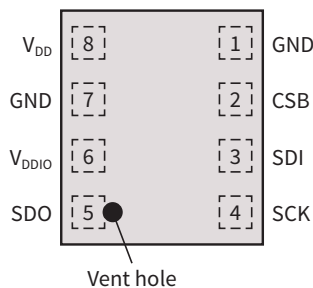
### Functional block diagram



### Application circuit example (in I²C configuration)



### Pin configuration (top view)



| Pin | Name              | Function                 |
|-----|-------------------|--------------------------|
| 1   | GND               | Ground                   |
| 2   | CSB               | Chip select              |
| 3   | SDI               | Serial data in/out       |
| 4   | SCK               | Serial clock             |
| 5   | SDO               | Serial data out          |
| 6   | V <sub>DDIO</sub> | Digital interface supply |
| 7   | GND               | Ground                   |
| 8   | V <sub>DD</sub>   | Analog supply            |

### Infineon inside pressure sensor partners

Building upon its best-in-class technology, Infineon offers a full range of barometric pressure sensors as chipsets. Infineon's network of global partners offers customers a comprehensive portfolio of Infineon inside pressure sensors that will propel performance to the next level even for the most demanding applications.

Visit [www.infineon.com/pressure-sensor-partners](http://www.infineon.com/pressure-sensor-partners) to learn more and purchase our partner solutions.



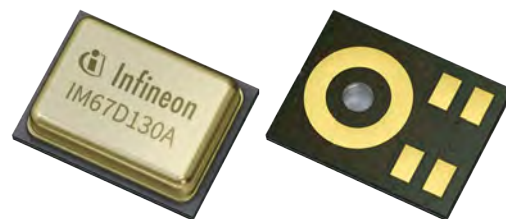


- Introduction
- Applications
- Current sensors
- Magnetic sensors
- Pressure sensors
- MEMS microphones
- Radar sensors
- Environmental sensors
- Intuitive sensing
- Shield2Go
- Sensor 2GO kits
- Online simulation tools
- Functional safety - ISO 26262
- Packages

# IM67D130A

## MEMS microphones for automotive applications

As part of our comprehensive XENSIV™ sensor family, we now also offer high-performance MEMS microphones, qualified according to the state-of-the-art automotive quality standard AEC-Q103-003. Such microphones close the gap in the automotive industry, providing the best possible fit for automotive applications. These automotive XENSIV™ MEMS microphones combine our proven expertise in the automotive industry with our technical leadership in high-end MEMS microphones. They are suited to all applications inside and outside the car, where the best audio performance in harsh automotive environments is required.



Typical applications for automotive MEMS microphones will revolutionize the in-cabin user experience



### Speech: Hands free / e-call / ICC

Enabling distortion free audio capturing for all speech related application thanks to their high SNR and low distortions

Interior



### Speech: Microphone arrays – beamforming voice command

Making possible to operate infotainment systems with voice commands due to their narrow sensitivity matching for enhanced performance of beam-forming arrays

Interior



### Active and road noise cancellation

Enabling a quite environment for a comfortable trip as such microphones are a good fit for ANC applications thanks to their flat frequency and stable phase response

Interior



In addition, they will enhance autonomous driving features ...  
and even allow interaction from outside of the vehicle



- Event sound detection / sirens detection / contact detection
- Road condition detection

Contributing to road safety, as they can be employed to pick up sounds like sirens from emergency vehicles or to detect dangerous road conditions thanks their large dynamic range and acoustic overload point

exterior



#### Voice recognition / external interaction

Allowing external interaction e.g. for controlling certain functions via voice commands due to their good suitability for voice recognition use cases

exterior

#### Customer benefit

- › Automotive qualification according to AEC-Q103, together with long term availability reduces design-in risk and effort
- › Increased operating temperature range allows flexible usage in automotive environment up to +105°C
- › Best in class audio performance (SNR, AOP, THD) for optimum speech quality and capture of distortion-free audio signals in loud environments as they can occur inside a car
- › Narrow sensitivity matching for enhanced performance of beam-forming (noise suppression) arrays
- › Flat frequency and stable phase response for optimal fit in acoustic noise cancellation use cases

| Parametrics             | IM67D130A   |
|-------------------------|-------------|
| Acoustic overload point | 130 dB SPL  |
| Current consumption     | 980 $\mu$ A |
| Interfaces              | PDM         |
| Sensitivity             | -36 dBFS    |
| Signal to noise         | > 67 dB(A)  |
| Supply voltage          | 1.62–3.6 V  |
| Ordering code           | SP005582032 |

# MEMS microphones for consumer

Low self-noise (SNR), wide dynamic range, low distortions, high acoustic overload point

The popularity of voice user interfaces and the usage of audio recording to share information and experiences are increasing dramatically. However, the performance of microphones often limits the potential of today's cutting-edge devices. Not anymore!

Infineon XENSIV™ MEMS microphones introduce a new performance class for MEMS microphones that overcomes existing audio chain limitations. IM69D130 is designed for applications where low self-noise (high SNR), wide dynamic range, low distortions, and a high acoustic overload point are required. Infineon's latest analog XENSIV™ MEMS microphone IM73A135 pushes the level of audio performance even further (Highlights).

## Features

- › 69 dB(A) signal-to-noise ratio (SNR)
- › Below 1 percent distortions at 128 dB SPL (130 dB SPL AOP)
- › Digital (PDM) interface with 6  $\mu$ s group delay at 1 kHz
- › Tight sensitivity (-36  $\pm$ 1 dB) and phase ( $\pm$  2 deg) tolerances
- › 28 Hz low frequency roll-off
- › 4.0 x 3.0 x 1.2 mm<sup>3</sup> package

## Benefits

- › High fidelity and far-field audio recording
- › Matched, noise and distortion-free audio signals for advanced audio processing
- › Ultralow group delay for latency-critical applications
- › No analog components required

## Typical applications

- › High-quality audio capturing: e.g. cameras, camcorders, conference systems
- › Voice user interface: e.g. smart speaker, home automation, and IoT devices
- › Active noise cancellation: headphones and earphones
- › Audio pattern detection: predictive maintenance, security or safety applications

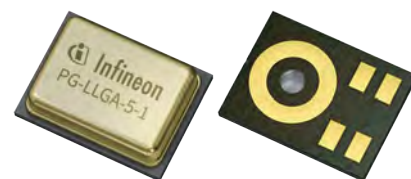
## Product portfolio

| Product  | OPN              | Package     | Current consumption                      | Sensitivity | Signal to noise [dB] | Supply voltage [V] |
|----------|------------------|-------------|--|-------------|----------------------|--------------------|
| IM69D130 | IM69D130V01XTSA1 | LLGA-5-1    | 980 $\mu$ A                              | -36 dBFS    | 69                   | 1.62–3.6           |
| IM69D120 | IM69D120V01XTSA1 | LLGA-5-1    | 980 $\mu$ A                              | -26 dBFS    | 69                   | 1.62–3.6           |
| IM73A135 | IM73A135V01XTSA1 | PG-LLGA-5-2 | 170 $\mu$ A @ 2.75 V, 70 $\mu$ A @ 1.6 V | -38 dBV     | 73                   | 1.52–3.0           |

NEW

Our new IM73A135 sets a new performance benchmark in MEMS microphones

Infineon's latest MEMS microphone IM73A135 sets a new performance benchmark in MEMS microphones. Best-in-class signal to noise ratio (SNR) of 73 dB and a high acoustic overload point of 135 dB SPL enables crystal clear audio pick up. This high dynamic range microphone with a small footprint of 4 x 3 x 1.2 mm<sup>3</sup> is based on Infineon's new Sealed Dual Membrane MEMS technology, which allows for better handling during assembly. The IM73A135 allows designers to reach a level of high audio performance that was previously only achievable by ECMs while at the same time reaping the benefits inherent in MEMS technology.

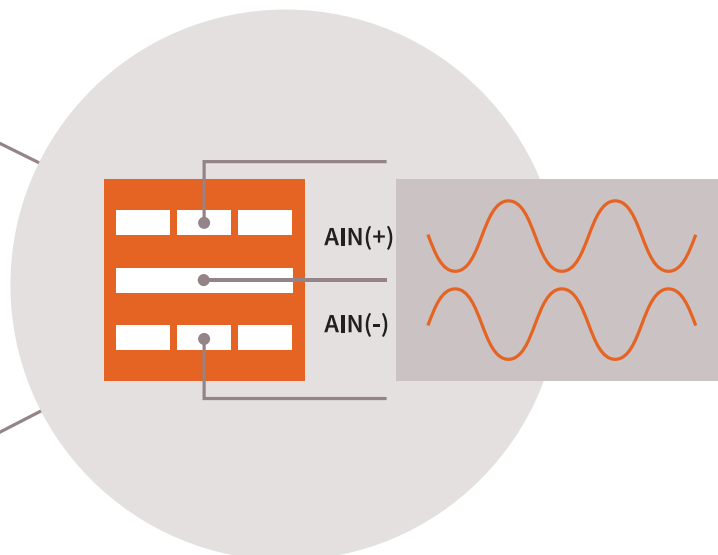


## Infineon's Sealed Dual Membrane (SDM) MEMS technology

Infineon's SDM MEMS technology is based on a miniaturized symmetrical microphone design. High-end studio microphones are based on a similar working principle to achieve a highly linear output signal. The MEMS structure is hermetically sealed and comprises two moving membranes and a capacitive plate. Sealing the capacitance area enables practically noise-free audio signal capturing, allowing for an increase in SNR from 70 dB up to 75 dB.

Maximum SNR  
up to 75 dB

Ultra low distortion  
up to 140 dB SPL AOP



## Infineon inside MEMS microphone partners

Building upon the superior XENSIV™ MEMS microphone performance, Infineon's extensive network of global partners offers customers a comprehensive portfolio of XENSIV™ MEMS microphone-based reference designs, as well as Infineon inside MEMS microphones that will propel audio performance to the next level even for the most demanding applications. Click on the buttons below to learn more and purchase our partner solutions.



# Radar sensors ICs

## Giving technology the ability to “see”

Radar offers a host of advantages over passive infrared (PIR) technology in motion detection applications. These include greater accuracy and more precise measurement of detected objects, paving the way for new capabilities in speed detection and motion sensing. These advanced capabilities enable all sorts of “things” such as **robots**, **cars**, **smart home** devices and even **lights** to “see” their surroundings and respond dynamically.

Market leader in radar chips, we offer a wide portfolio of mmWave radar sensors as part of our XENSIV™ family. Designed to support different **industrial**, **home** and **consumer** applications, this portfolio includes the smallest 24 GHz MMIC in the market as well as the largest and most integrated 24 GHz radar transceiver family currently available. In addition, customers can rely on us for the full range of automotive radar 24/77/79 GHz front-end MMICs (RASIC™) supporting everything from safety-critical applications such as automatic emergency braking to **driver assistance systems**.



# RASIC™ automotive radar 77/79 GHz

## Front-end ICs for automotive radars

### RXS816xPL – family of single-chip front-end MMICs for 77/79 GHz automotive RADAR

Infineon has been delivering automotive 77GHz radar products for over 10 years. Infineon’s family of radar transceiver IC (RASIC™) addresses the needs of 77/79 GHz radar for all safety-critical applications from automatic emergency-braking (AEB) to high-resolution radars in automated driving. It supports fast ramps for precise distance measurement and simultaneous transmitter operation for MIMO.

RXS816xPL is a highly integrated device that performs all functions of a radar front-end in a single device – from FMCW signal conditioning to generation of digital receive data output. On-chip sensors for temperature, output power and multiple monitors/supervisory circuits allow for calibration and monitoring. Programming and Status are communicated via SPI.

### 77/79 GHz – Product overview

| Product    | Configuration | Key benefits   | Features   |
|------------|---------------|--|--|
| RXS816xPL  | 3Tx4Rx        | RXS8161: single-chip versions<br>RXS8162 and future products: multi-chip versions in 7 x 8.5 mm eWLB package | <ul style="list-style-type: none"> <li>Flexible FMCW waveform generation</li> <li>Four receive channels featuring integrated filters + AD converters</li> <li>4 channel LVDS data interface</li> </ul> |
| RXS8156PLA | 2Tx4Rx        | Cost efficient solution for corner radars in 7 x 7.5 mm eWLB package   |  |

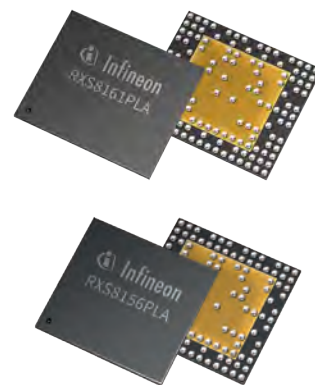
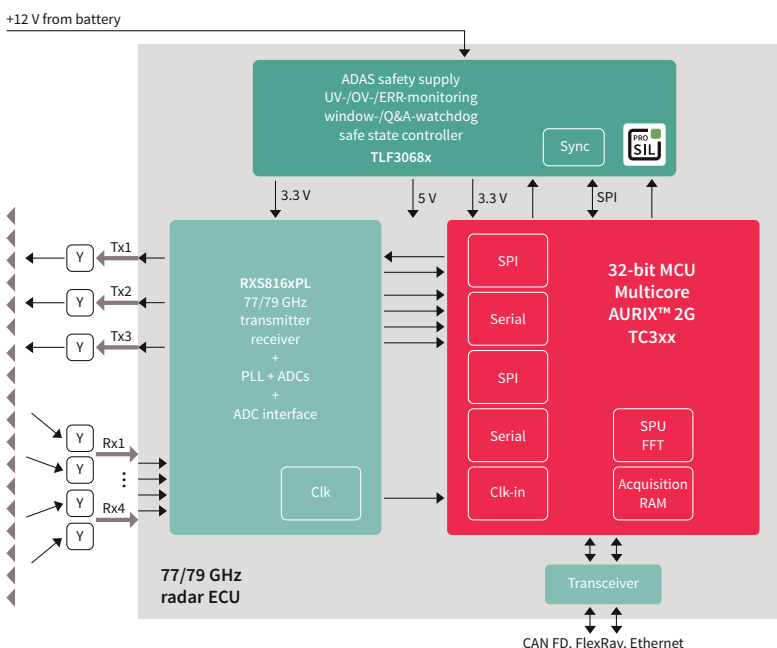
### Infineon offers a complete suite of 77/79 GHz radar chipsets consisting of

- › Radar 77/79 GHz RF Millimeter Wave IC family (RASIC™ RXS816xPL)
- › Radar MCU family featuring radar signal processing units (2<sup>nd</sup> generation AURIX™ TC3xx)
- › Radar system power supply with numerous safety functions (TLF3068x)
- › Very compact 3-chip configuration (RXS816xPL+ AURIX™ TC3xx + TLF3068x) for e.g. AEB sensor

### Customer benefits:

- › One 77/79 GHz radar platform supporting all types of automotive radar applications
- › Scalability by cascading multiple RF MMICs and MCUs enabling most advanced sensors
- › Flexibility through numerous configuration parameters and on-chip monitoring functions
- › ASIL-C support reducing customer R&D efforts

Please be aware that 77/79 GHz Radar products are not available via Infineon’s distribution partners.



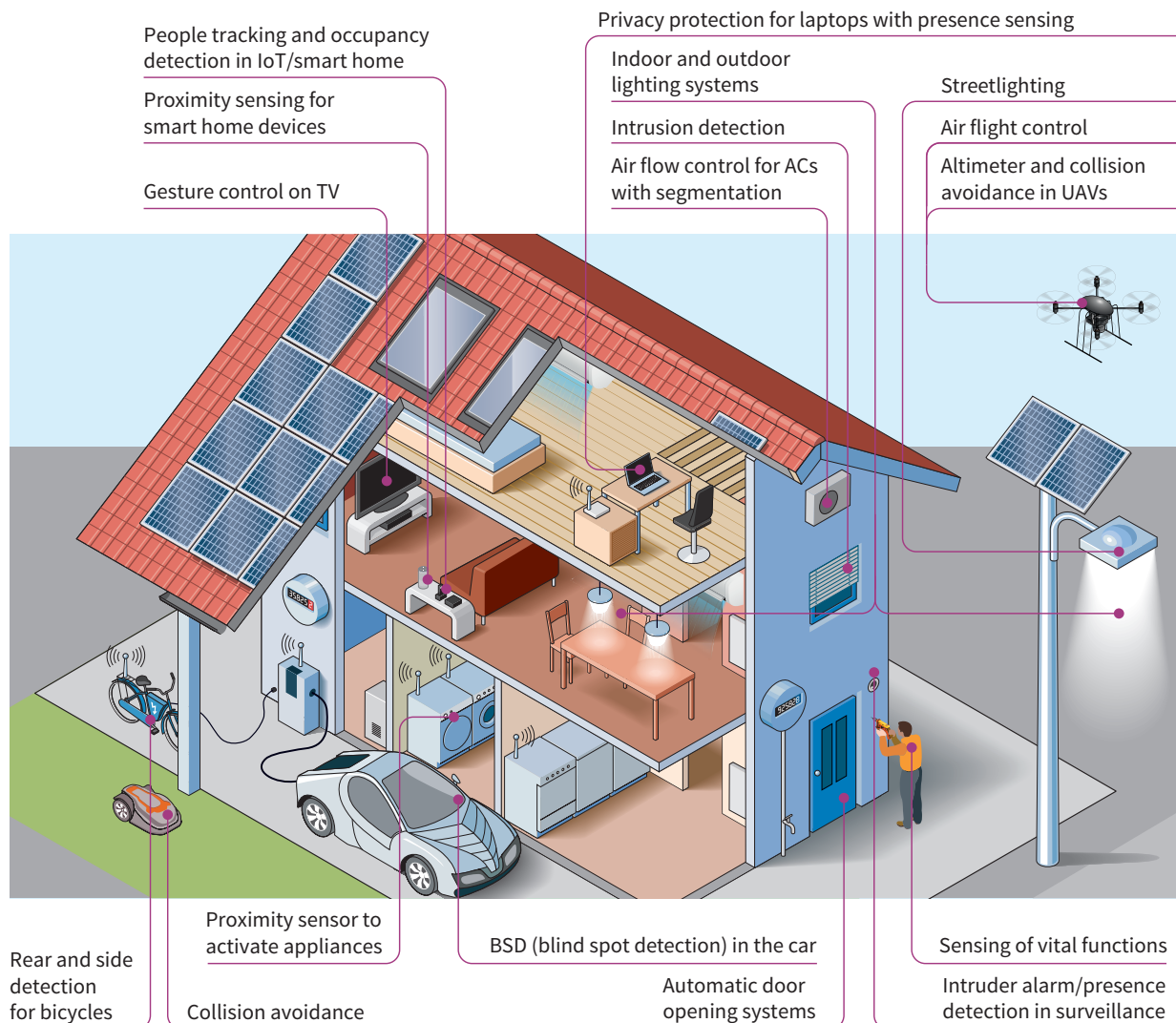
# Radar sensors for IoT & consumer devices

As market leader in radar chips, we offer a wide portfolio of mmWave radar sensors as part of our XENSIV™ sensor family – including Doppler radar as well as FMCW radar systems. This portfolio includes the smallest 24 GHz MMIC in the market as well as the most integrated and largest 24 GHz radar transceiver family currently available. Those radar chips are designed to support different industrial, smart home, and consumer applications. In addition, we also offer radar sensors in the 60 GHz range, which are used in consumer products such as Smart TVs or the Google Pixel 4 Smartphone.

## Motion detection with radar offers significant advantages over PIR and other motion-sensing technologies

With our 24 and 60 GHz radar sensors, we cover a wide range of applications. Many of them are based on motion detection triggering systems like lighting solutions, automatic doors, camera and security systems, or smart home devices. In contrast to other motion detection technologies like PIR, radar technology offers significant advantages. These include smaller system sizes, greater accuracy, and more precise measurements of detected objects. In addition, radar can also determine the direction of a moving object, speed of an object, distance, and depending on the antenna configuration, even the position of a moving object.

## Applications for Infineon’s radar sensors





**Key benefits of radar sensing**

- > Direction, proximity, and speed detection
- > Segmentation and tracking functionalities
- > Target positioning
- > Detection through non-conductive materials
  - Product design flexibility
  - Anonymous sensing
- > Maintains operation through harsh environmental conditions such as rain, snow, fog, dust, etc.
- > Sensitive enough to capture breathing and heartbeat
  - Radar can feel presence & vital functions
- > Radar performance parameters can be adjusted
  - Adaptable to different application requirements

**Applications**

|                    |                    |                     |                    |                     |
|--------------------|--------------------|---------------------|--------------------|---------------------|
| Smart Home         | Alarm system       | IP Camera           | Lighting           | Smart building      |
| Smart factory      | Presence detection | Smart city lighting | LCD TV             | Notebook            |
| Privacy protection | Mobile phone       | Sensing             | Home Appliance     | Household           |
| Service robots     | Toilet             | Health care         | Elderly monitoring | Sleeping monitoring |
| Sports watch       | Energy efficiency  | Energy saving       | Wristbands         | Smartwatch          |

New application or simple PIR replacement? Radar has it covered.

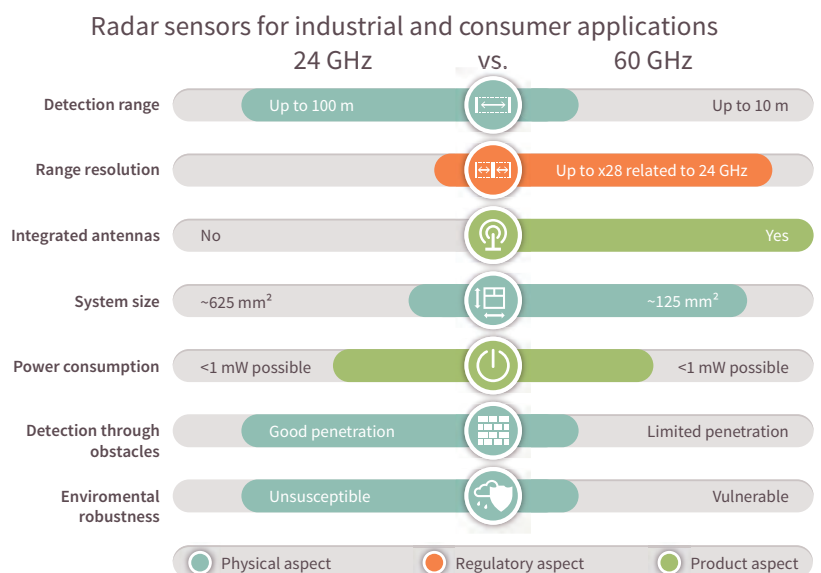
Radar, used in motion detection applications, increases accuracy when compared to passive infrared (PIR) technology, allowing more precise measurement of object detection, and providing new capabilities such as the detection of speed and the direction of moving objects. Radar is also superior to camera-based systems by allowing detection of the objects while keeping identities anonymous.

## Example applications that can benefit from radar technology

|  |  |   |  |  |
|--|--|---|--|--|
| <p><b>Smart Home</b></p>  <p><b>Robust, discreet, small</b></p>                         | <p><b>Door opening</b></p>  <p><b>Direction of travel to remove false opening</b></p>         | <p><b>Security</b></p>  <p><b>Privacy protection, and increased accuracy</b></p> | <p><b>Lighting</b></p>  <p><b>Indoor and outdoor. Resistant to harsh weather</b></p> | <p><b>Monitors and laptops</b></p>  <p><b>Small, hidden, sensitive</b></p>          |
| <p><b>Home appliances</b></p>  <p><b>Activate displays based on presence around</b></p> | <p><b>Air conditioners</b></p>  <p><b>Track people to move the airflow away from them</b></p> | <p><b>Smart speaker</b></p>  <p><b>Eliminate keyword based activation</b></p>    | <p><b>TV</b></p>  <p><b>Safe energy &amp; OLED lifetime by turning off</b></p>       | <p><b>Gaming and VR</b></p>  <p><b>Enhance gaming experience</b></p>                |
| <p><b>Gesture control</b></p>  <p><b>Additional gesture package available</b></p>     | <p><b>Material detection</b></p>  <p><b>Object recognition and classification</b></p>       | <p><b>Service robots</b></p>  <p><b>Robust, small footprint, accurate</b></p>  | <p><b>Robotics</b></p>  <p><b>Safety, accuracy and efficiency</b></p>              | <p><b>Vital sensing</b></p>  <p><b>Breathing &amp; heart rate measurement</b></p> |

## When to use 24 GHz or 60 GHz radar technology

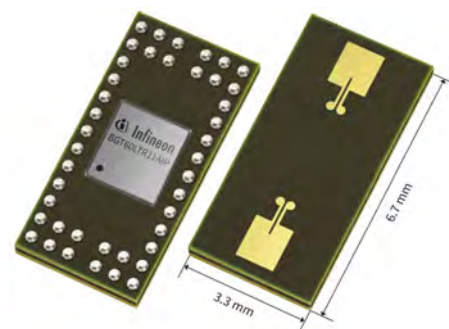
In the 24 GHz range, the bandwidth for FMCW radar operations covers 250 MHz within the regulated ISM band. In the 60 GHz regime, an unlicensed ultra-wideband of up to 7 GHz can be used for short-range applications. Consequently, 60 GHz FMCW radar systems can offer a better resolution and therefore allow additional use cases such as human tracking and segmentation. Even gesture control, material classification, or the monitoring of various vital functions (respiration, heartbeat, or even blood pressure) is possible with radar technology due to micro-motion detection.





# 60 GHz radar sensor IC

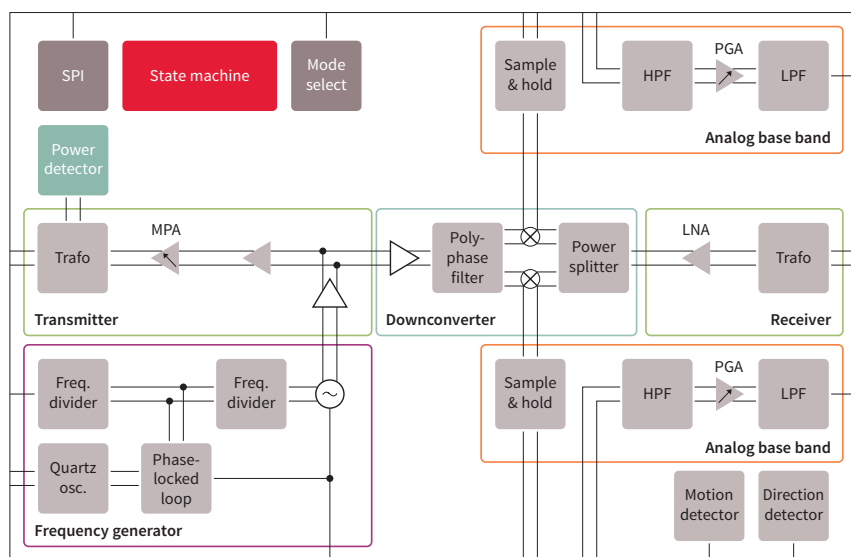
Infineon's innovative 60 GHz radar chip enables things to see and revolutionizes the human-machine interface.



## BGT60LTR11AIP for consumer and IoT applications

The BGT60LTR11AIP is a fully integrated microwave motion sensor including Antennas in Package (AIP) as well as built-in detectors for motion and direction of motion. A state machine enables. In this autonomous mode, it detects a human target up to 5 m with a low power consumption of less than 5 mW. The BGT60LTR11AIP enables radar technology for everyone, since it does not require know-how in RF, antenna design, or radar signal processing. These features make the small-sized radar solution a compelling smart and cost-effective replacement for conventional PIR sensors in low power or battery-powered applications. Also, with its small form factor, Infineon's highly integrated radar sensor solutions bring innovative, intuitive sensing capabilities to many applications. Radar has been demonstrated to be a powerful sensor for short-range motion detection.

### Block diagram of the BGT60LTR11AIP



### Target application

- > Smart building and smart home
- > Home appliances
- > Smart home security
- > Room air conditioners
- > Automated door openers
- > Smart entrance counter solution

### Key features

- > 3.3 x 6.7 x 0.56 mm package size
- > 1Tx 1Rx Antennas in Package (AIP) with 80° field of view
- > Built-in motion detector
- > Built-in direction of motion detector
- > Multiple modes of operation incl. a completely autonomous mode
- > Adjustable performance parameters: detection sensitivity, hold time and frequency of operation
- > FR4 material for PCB design is sufficient

### Key benefits

- > Autonomous mode:
  - Up to 5 m detection range
  - Less than 5 mW power consumption
  - Requires minimal external circuitry incl. crystal, LDO and some resistors capacitors

### Product portfolio

| Product                             | Package     | SP Number                              |
|-------------------------------------|-------------|--|
| BGT60LTR11AIP<br>DEMO BGT60LTR11AIP | UF2BGA-42-1 | SP005537624<br>[Demo Kit: SP005422969] |

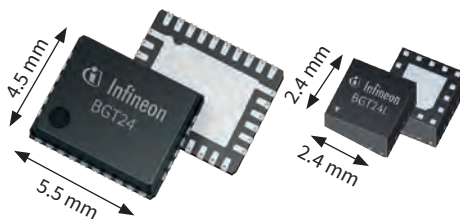
# 24 GHz radar sensor ICs

Infinion BGT24M/L family of MMIC chips

Infinion's range of 24 GHz industrial radar chips provides five configurations of transmit and receiver channels, ensuring that there is a chip to support your specific application. From basic applications such as motion detection in security systems, which only requires one transmit and one receive channel, to more complex applications like 3D positioning, which requires two or more receive channels, our range of radar chips supports all of your requirements.

| Features | Infineon MMIC | Benefits |
|----------|---------------|----------|
|----------|---------------|----------|

- > 24 GHz ISM band operation for motion, speed, direction movement and distance measurements
- > Five 24 GHz chips available
- > Highly integrated MMICs

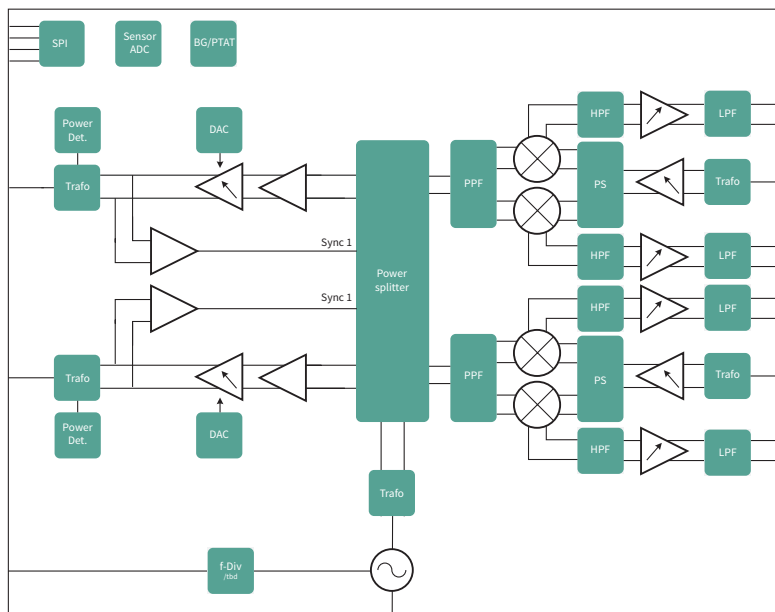


- > Long-range distance detection of moving objects up to 50 m
- > Wide range speed detection up to  $\pm 100$  km/h
- > Low BOM costs

| Product    | Configuration | Features  |
|------------|---------------|---|
| BGT24MTR11 | 1Tx + 1Rx     | <ul style="list-style-type: none"> <li>&gt; Measures, not just motion, but also speed, direction, and distance</li> <li>&gt; Small form factor</li> <li>&gt; Resistance to moisture, dirt, and temperature</li> <li>&gt; Increased area coverage</li> <li>&gt; Discrete design</li> <li>&gt; Low power MMICs for energy saving</li> <li>&gt; Privacy protection</li> <li>&gt; Adaptable to different application requirements</li> <li>&gt; Highly integrated chips eliminating costly external components</li> </ul> |
| BGT24MR2   | 2Rx           |   |
| BGT24MTR12 | 1Tx + 2Rx     |   |
| BGT24LTR11 | 1Tx + 1Rx     |   |
| BGT24LTR22 | 2Tx + 2Rx     |   |

### The BGT24LTR22 key features

- > 24 GHz transceiver MMIC
- > Fully integrated low phase noise VCO
- > Integrated analog base band stage with programmable gain and filter settings
- > Bi-directional pin for synchronization
- > Built in temperature compensation circuit for VCO stabilization, no PLL needed
- > Low power consumption
- > Fully ESD protected device
- > Single ended RF and IF terminals
- > Single supply voltage 1.5 V



## 24 GHz evaluation and demonstration boards

In addition to the BGT24M/L family of MMIC chips, Infineon provides a continuously expanding range of evaluation and demonstration boards to support the testing and development of radar in multiple applications of our customers. All boards are provided with base-level software to support the ease of use and faster time-to-market integration.

| Features   | Infineon development kit  | Benefits   |
|--|---|--|
| <ul style="list-style-type: none"> <li>&gt; Four system boards available</li> <li>&gt; All include 24 GHz radar chip and XMC™ microcontroller</li> <li>&gt; Kit contains user manual, GUI, MATLAB compiler and Gerber files</li> <li>&gt; Software available via Infineon Toolbox</li> </ul> |  | <ul style="list-style-type: none"> <li>&gt; Capability to detect motion, speed and direction of movement (approaching or retreating) distance and angle of arrival based on hardware</li> <li>&gt; Fast prototyping with available software</li> </ul> |

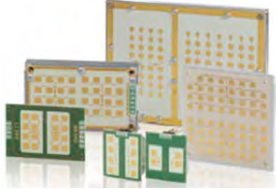
Demonstrator with SW support

| Sense2GoL Pulse<br>(BGT24LTR11 + XMC4700)  | Distance2Go<br>(BGT24MTR11 + XMC4200)   | Distance2GoL<br>(BGT24LTR11 + XMC4700)   | Position2Go<br>(BGT24MTR12 + XMC4700)   |
|--|---|--|---|
| <ul style="list-style-type: none"> <li>&gt; Capability to detect motion, speed, and direction of movement (approaching or retreating)</li> <li>&gt; Detection range of 18 m for a human target at a power consumption &lt; 5 mW</li> <li>&gt; High sensitivity of detection in comparison to PIR</li> <li>&gt; Arduino compatible microcontroller board (Arduino standard connectors)</li> <li>&gt; Modulation parameters can be changed to suit the application requirements</li> <li>&gt; Multiple current sensors for current consumption monitoring and optimization</li> <li>&gt; Integrated multiple-element patch antennas</li> </ul> | <ul style="list-style-type: none"> <li>&gt; Capability to detect the distance of multiple targets</li> <li>&gt; Capability to detect motion, speed, and direction of movement (approaching or retreating)</li> <li>&gt; Operates in harsh environments and detects through non-metallic materials</li> <li>&gt; BGT24MTR11 – 24 GHz highly integrated RF MMIC</li> <li>&gt; XMC4200 Arm® Cortex®-M4 –32-bit industrial microcontroller</li> <li>&gt; Debug over Cortex 10 pin debug connector</li> <li>&gt; Integrated multiple-element patch antennas</li> </ul> | <ul style="list-style-type: none"> <li>&gt; Capability to detect the distance of the closest human target</li> <li>&gt; Capability to detect motion, speed, and direction of movement (approaching or retreating)</li> <li>&gt; Very low power consumption due to duty cycling options</li> <li>&gt; Operates in harsh environments and detects through non-metallic materials</li> <li>&gt; BGT24LTR11 – 24 GHz highly integrated RF MMIC</li> <li>&gt; XMC4700 Arm® Cortex®-M4 –32-bit industrial microcontroller</li> <li>&gt; Debug over Cortex 10 pin debug connector</li> <li>&gt; Microstrip patch antennas with 10 dBi gain and 29°/80° field of view</li> </ul> | <ul style="list-style-type: none"> <li>&gt; Capability to detect and track the position of multiple targets</li> <li>&gt; Capability to detect the distance of multiple targets</li> <li>&gt; Capability to detect motion, speed, and direction of movement (approaching or retreating)</li> <li>&gt; Operates in harsh environments and detects through non-metallic materials</li> <li>&gt; BGT24MTR12 – 24 GHz highly integrated RF MMIC</li> <li>&gt; XMC4700 Arm® Cortex®-M4 –32-bit industrial microcontroller</li> <li>&gt; Debug over Cortex 10 pin debug connector</li> <li>&gt; Integrated multiple-element patch antennas</li> </ul> |
| <p><b>Main applications</b></p> <ul style="list-style-type: none"> <li>&gt; Security</li> <li>&gt; Indoor and outdoor lighting</li> <li>&gt; Smart home</li> <li>&gt; Automatic door opener</li> <li>&gt; Intelligent switches</li> <li>&gt; Speed measurement</li> </ul>  | <p><b>Main applications</b></p> <ul style="list-style-type: none"> <li>&gt; Drone: soft landing/obstacle avoidance</li> <li>&gt; Smart toilets</li> <li>&gt; Tank level sensing</li> <li>&gt; Intelligent switches</li> </ul>   | <p><b>Main applications</b></p> <ul style="list-style-type: none"> <li>&gt; Smart home devices</li> <li>&gt; Indoor and outdoor lighting systems</li> <li>&gt; Unmanned Aerial Vehicles (UAV)</li> <li>&gt; Security systems from commercial surveillance to low-power IP cameras</li> <li>&gt; HVAC products like smart air conditioners</li> <li>&gt; Smart sanitary facilities (eg Smart Toilets)</li> </ul>  | <p><b>Main applications</b></p> <ul style="list-style-type: none"> <li>&gt; Drone/robots: obstacle avoidance</li> <li>&gt; Security systems incl. surveillance cameras</li> <li>&gt; People tracking (IoT, smart home)</li> <li>&gt; Vital sensing</li> </ul>   |
| <p><b>Board dimensions</b></p> <ul style="list-style-type: none"> <li>&gt; Board 55 mm x 85 mm</li> <li>&gt; Shield: 55 mm x 66 mm</li> </ul>  | <p><b>Board dimensions</b></p> <ul style="list-style-type: none"> <li>&gt; Board 36 mm x 45 mm</li> </ul>   | <p><b>Board dimensions</b></p> <ul style="list-style-type: none"> <li>&gt; Board 55 mm x 85 mm</li> <li>&gt; Shield: 55 mm x 66 mm</li> </ul>  | <p><b>Board dimensions</b></p> <ul style="list-style-type: none"> <li>&gt; Board 50 mm x 45 mm</li> </ul>   |
| <p><b>Kit contents</b></p> <ul style="list-style-type: none"> <li>&gt; RF radar shield: SHIELD_BGT24LTR11</li> <li>&gt; Programmed controller board: RADAR BB XMC4700</li> <li>&gt; Micro USB cable</li> <li>&gt; SW GUI to operate kit</li> <li>&gt; Doppler FW and SW<sup>1)</sup></li> <li>&gt; Schematic and bill-of-materials of module</li> </ul>  | <p><b>Kit contents</b></p> <ul style="list-style-type: none"> <li>&gt; User's manual</li> <li>&gt; Demonstration board</li> <li>&gt; SW GUI to operate kit</li> <li>&gt; FMCW FW and SW<sup>1)</sup></li> <li>&gt; Doppler FW and SW<sup>1)</sup></li> <li>&gt; Schematic and bill-of-materials of module</li> </ul>  | <p><b>Kit contents</b></p> <ul style="list-style-type: none"> <li>&gt; RF radar shield: SHIELD_BGT24LTR11</li> <li>&gt; Programmed controller board: RADAR BB XMC4700</li> <li>&gt; Micro USB cable</li> <li>&gt; SW GUI to operate kit</li> <li>&gt; Doppler FW and SW<sup>1)</sup></li> </ul>  | <p><b>Kit contents</b></p> <ul style="list-style-type: none"> <li>&gt; User's manual</li> <li>&gt; Demonstration board</li> <li>&gt; Corner reflector</li> <li>&gt; SW GUI to operate kit</li> <li>&gt; FMCW FW and SW</li> <li>&gt; Doppler FW and SW</li> <li>&gt; Schematic and bill-of-materials of module</li> </ul>   |

1) Usage of the FMCW and/or Doppler FW and SW requires agreeing to Infineon's user's agreement and licensing terms.

## 24 GHz partner modules

Partnering with the leading radar solution providers enables Infineon to connect our customers looking for turnkey solutions and design support for a complete range of applications.

| Features   | Partner modules using Infineon chips  | Benefits   |
|--|---|--|
| <ul style="list-style-type: none"> <li>› Complete module, including radar MMIC, antenna options, MCU signal processing options, and SW options (Doppler, FSK and FMCW versions available)</li> </ul> |  <p>Module (RF module; RF module + MCU including SW)</p> | <ul style="list-style-type: none"> <li>› Ease of design</li> <li>› Turnkey solution, no need for test and certification</li> </ul> |

By integrating Infineon's 24GHz MMIC chip into the partners easy-to-use and simple-to-integrate modules the complexity and time to market for a range of applications such as smart home automation, camera & security systems, air conditioners, UAVs, robotics, and smart lighting, are reduced.

## Partners

Visit the link below to view our network of partners who provide modules and design support for all 24GHz industrial applications: [www.infineon.com/24GHzPartners](http://www.infineon.com/24GHzPartners)



Learn radar with Infineon on [www.infineon.com/MakeRadar](http://www.infineon.com/MakeRadar)

For the first time, we bring radar to makers and developers. Here you can test, develop, and learn radar and its applications. At [www.infineon.com/makeradar](http://www.infineon.com/makeradar), you will see how simple it has become to work with ultrasmall radar sensors. The board and data will flow to your browser for testing, and this is not all, if you want to take the next step just take the available Arduino code examples and start your project.

## PAS CO2

High performance in a small size – Introducing a disruptive CO<sub>2</sub> sensor based on photoacoustic spectroscopy (PAS)

Infineon's PAS CO<sub>2</sub> breaks the boundaries of CO<sub>2</sub> sensing with its exceptionally small form factor and high accuracy.

Measure what matters with our PAS CO<sub>2</sub> sensor<sup>1)</sup>

CO<sub>2</sub> measurement contributes to improvements in health, comfort and productivity as well as energy efficiency. Even at moderate levels, CO<sub>2</sub> can have a negative impact on health and productivity, causing drowsiness and headaches. Fortunately, smart indoor air quality sensors can “smell” rising levels of CO<sub>2</sub> and either alert the user or trigger a system response. Awareness of indoor air quality is further increasing as a result of the COVID-19 pandemic, making accurate, affordable monitoring solutions like XENSIV™ PAS CO<sub>2</sub> more important than ever. Given the correlation between CO<sub>2</sub> and aerosol concentration, CO<sub>2</sub> sensors can contribute to mitigating the transmission. Furthermore, CO<sub>2</sub> sensors can facilitate demandcontrolled ventilation, leading to improvements in energy efficiency and significant savings on energy bills.

Accurate, real-time CO<sub>2</sub> measurement thanks to superior MEMS technology

Widespread adoption of CO<sub>2</sub> sensors has so far been hampered by size, performance and cost constraints. Infineon's PAS CO<sub>2</sub> sensor leverages photoacoustic spectroscopy (PAS) technology to provide an exceptionally small, real CO<sub>2</sub> sensor that is both highly accurate and cost-effective. Infineon's leading position in MEMS technology is the foundation for this unique and accurate CO<sub>2</sub> detection approach. Reliable CO<sub>2</sub> measurement enables smart monitoring of indoor air quality, facilitating improvements in health, productivity and overall well-being. These features make the PAS CO<sub>2</sub> sensor ideal for applications in building automation as well as for integration into consumer IoT devices such as air purifiers, thermostats, baby monitoring devices, wake-up alarms and smart speakers.

Disruptive environmental sensor technology from Infineon

PAS CO<sub>2</sub> integrates on the PCB a photoacoustic transducer, including an acoustic detector, infrared source and optical filter; a microcontroller for signal processing; and a MOSFET chip to drive the infrared source. The exceptional sensitivity of the acoustic detector coupled with the integrated PCB design reduce space requirements by more than 75 percent compared to NDIR CO<sub>2</sub> sensors.

1) In market H2/2021

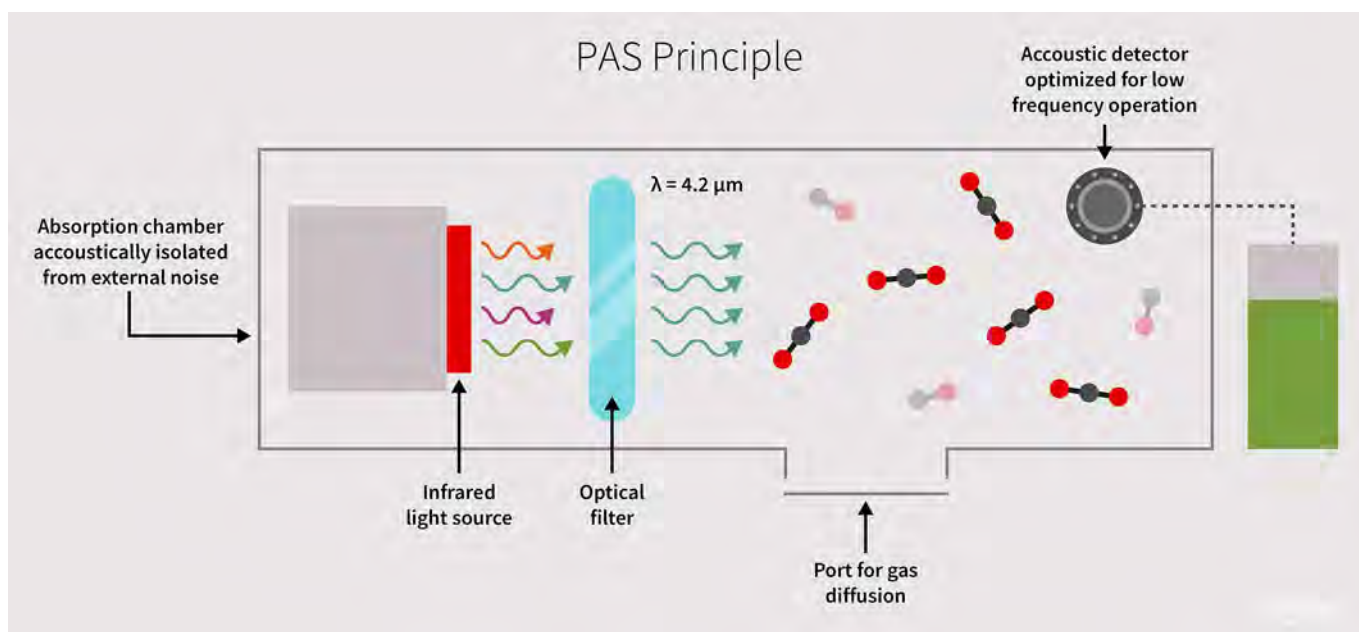


# PAS CO<sub>2</sub>

High performance in a small size – Introducing a disruptive CO<sub>2</sub> sensor based on photoacoustic spectroscopy (PAS)

## The PAS (photoacoustic spectroscopy) principle:

The sensor is characterized by a disruptive measurement principle called PAS (photoacoustic spectroscopy). It works as follows: pulses of infrared light pass through an optical filter tuned to the CO<sub>2</sub> absorption wavelength. The CO<sub>2</sub> molecules absorb the filtered light, causing them to shake and generate a pressure wave with each pulse. This is called the photoacoustic effect. The sound is then detected by an acoustic detector optimized for low frequency operation and converted to a CO<sub>2</sub> concentration reading by the microcontroller.



## Features and benefits

| Features  |
|---|
| > Exceptionally small form factor (14 x 13.8 x 7.5 mm <sup>3</sup> )  |
| > High accuracy ( $\pm 30 \text{ ppm} \pm 3\%$ of reading)  |
| > SMD package delivered in tape and reel  |
| > Advanced compensation and self-calibration algorithms   |
| > Various configuration options (e.g. sampling rate, baseline calibration) and interfaces (UART, I <sup>2</sup> C, PWM) |

| Benefits  |
|---|
| > Space savings in customers' end products                        |
| > High-quality data and compliance with smart building standards  |
| > Cost-effective high-volume assembly and easy system integration |
| > Plug & play for fast design-to-market                           |
| > Customer flexibility thanks to configuration options            |

## Applications

- > HVAC (Heating, Ventilation and Air Conditioning) systems
- > Smart home appliances such as air purifiers, air conditioners and thermostats
- > Consumer devices for air quality monitoring such as personal assistants and CO<sub>2</sub> traffic lights
- > Smart indoor lighting

[www.infineon.com/CO2](http://www.infineon.com/CO2)





# Intuitive sensing

Giving things human-like senses for a better contextual awareness

Imagine a world where technology is unobtrusive and seamlessly integrated into our lives. Where intentional/ deliberate communication between people and devices is no longer necessary. In this world, there is no need to push buttons or issue commands in order to activate devices, because technology is capable of interpreting implicit intentions and context. This enhances the user experience and makes it more natural – it almost seems like the devices around us intuitively understand what we want them to do. At Infineon, this future is already becoming reality. We develop sensor solutions that enable simple and effortless user interactions with all kinds of smart devices. Bridging the gap between the real and digital worlds, our technology is developed to make life easier, safer, greener and more

efficient. Our intuitive sensing solutions are at the very core of this mission. Reflecting our belief that the essential value of sensor technology lies in making our lives more convenient through seamless, natural interactions between people and sensing devices, our aim is to leave you free to focus on what really matters in life.

## Choose your type of sense

Thanks to industry-leading technologies Infineon XENSIV™ sensors are exceptionally precise. They are the perfect fit for various customer applications in automotive, industrial and consumer markets.

|  |   |  |  |
|--|---|--|--|
| <p><b>Pressure sensors</b></p> <p>Our digital barometric pressure sensors give designers the best choice when it comes small form factors, highest precision and accuracy over a wide temperature range, fast read-out speeds and low power consumption.</p> | <p><b>Radar sensors</b></p> <p>Radar supports existing applications while providing features that enable completely new use cases. It measures velocity, range and angle, both horizontal and vertical, for precise position mapping and 3D tracking.</p> | <p><b>MEMS microphones</b></p> <p>MEMS microphones overcome existing audio chain limitations and are designed for applications where low self-noise (high SNR), wide dynamic range, low distortions and a high acoustic overload point are required.</p> | <p><b>PAS CO2 sensor</b></p> <p>Leveraging photoacoustic spectroscopy (PAS), Infineon has developed an exceptionally small CO2 sensor that overcomes existing size, cost and performance challenges.</p> |
|--|---|--|--|

## Today, sensors already enable interactions between people and devices

This interaction often depends on the interpretation and merging of information from different sources. Machines cannot yet read our minds and do not always have the information necessary to correctly evaluate a given situation. So, we sometimes have to explicitly tell devices what we want them to do. This can be inconvenient and time-consuming. Inspired by human nature, Infineon intuitive sensing solutions are designed to take the complexity out of our interaction with devices.

Reflecting a holistic approach, we combine different sensors with state-of-the-art software to create a comprehensive picture of the world around us. By fusing several smart sensors into one coherent intelligent system, our intuitive sensing solutions simplify complex technical processes and enable people to effortlessly interact with devices. These smart devices intuitively sense the world around them, determining what is expected and needed from them.

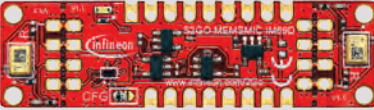









# Shield2Go

Infinion's Shield2Go boards offer a unique customer and evaluation experience – the boards are equipped with one Infineon IC and come with a ready to use Arduino library. Customers can now develop their own system solutions by combining 2GO boards together with Infineon MyIoT adapters. MyIoT adapters are gateways to external hardware solutions like Arduino and Raspberry PI, which are popular IoT hardware platforms. All this enables the fastest evaluation and development of IoT system.

## Security

|   |  |   |
|---|--|---|
|  | <p><b>Product name:</b> OPTIGA™ Trust E Security Shield2Go<br/> <b>Sales name:</b> S2GO_Security_OPTIGA_E<br/> <b>Ordering code:</b> SP001820138</p> | <p>More information</p>  |
|  | <p><b>Product name:</b> OPTIGA™ Trust X Security Shield2Go<br/> <b>Sales name:</b> S2GO SECURITY OPTIGA X<br/> <b>Ordering code:</b> SP002349576</p> | <p>More information</p>  |

## Sensors

|   |   |   |
|---|---|---|
|  | <p><b>Product name:</b> IM69D130 Microphone Shield2Go<br/> <b>Sales name:</b> S2GO MEMSMIC IM69D<br/> <b>Ordering code:</b> SP002851544</p>     | <p>More information</p>  |
|  | <p><b>Product name:</b> S2GO Pressure Sensor DPS310<br/> <b>Sales name:</b> S2GO_PRESSURE_DPS310<br/> <b>Ordering code:</b> SP001777630</p>     | <p>More information</p>  |
|  | <p><b>Product name:</b> S2GO Pressure Sensor DPS368<br/> <b>Sales name:</b> S2GO PRESSURE DPS368<br/> <b>Ordering code:</b> SP005338022</p>     | <p>More information</p>  |
|  | <p><b>Product name:</b> TLE493DW2B6 3DSense Shield2Go<br/> <b>Sales name:</b> S2GO_3D_TLE493DW2B6-A0<br/> <b>Ordering code:</b> SP004308594</p> | <p>More information</p>  |
|  | <p><b>Product name:</b> TLE4964-3M Hall Sense Shield2Go<br/> <b>Sales name:</b> S2GO_HALL_TLE4964-3M<br/> <b>Ordering code:</b> SP004308590</p> | <p>More information</p>  |

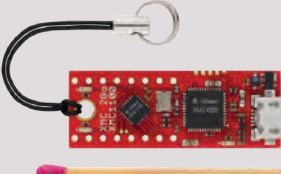



# Shield2Go

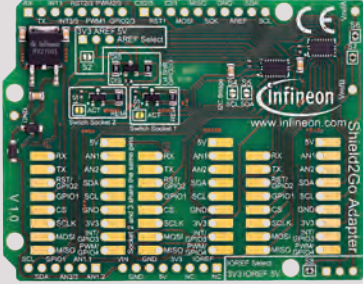

## Sensors

|   |  |   |
|---|--|---|
|    | <p><b>Product name:</b> TLE4966K Double Hall Shield2Go<br/> <b>Sales name:</b> S2GO_2_HALL_TLE4966K<br/> <b>Ordering code:</b> SP004308598</p>   | <p>More information</p>    |
|    | <p><b>Product name:</b> TLI493D W2BW 3D Sense Shield2Go in small WLB-5 package (1.13 mm x 0.93 mm x 0.59 mm)<br/> <b>Sales name:</b> S2GO_3D_TLI493DW2BW-A0<br/> <b>Ordering code:</b> SP005410385</p> | <p>More information</p>    |
|    | <p><b>Product name:</b> TLI4971 Current Sense Shield2Go<br/> <b>Sales name:</b> S2GO_CUR-SENSE_TLI4971<br/> <b>Ordering code:</b> SP005345472</p>  | <p>More information</p>    |
|  | <p><b>Product name:</b> TLV493D 3D Sense Shield2Go<br/> <b>Sales name:</b> S2GO_3D-SENSE_TLV493D<br/> <b>Ordering code:</b> SP001823678</p>  | <p>More information</p>  |

## Microcontroller

|   |   |   |
|---|---|---|
|  | <p><b>Product name:</b> XMC 2Go Kit<br/> <b>Sales name:</b> KIT_XMC_2GO_XMC1100_V1<br/> <b>Ordering code:</b> SP001199544</p> | <p>More information</p>  |
|---|---|---|

## MyIoT – Adapter

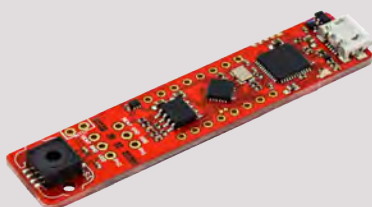
|   |   |   |
|---|---|---|
|  | <p><b>Product name:</b> MyIoT Adapter<br/> <b>Sales name:</b> MYIOTADAPTERTOBO1<br/> <b>Ordering code:</b> SP002434972</p> <p>Infineon's 2Go boards offer a unique customer and evaluation experience – the boards are equipped with one Infineon IC and come with a ready to use Arduino library. Customers can now develop their own system solutions by combining 2Go boards together with Infineon MyIoT adapters. MyIoT adapters are gateways to external hardware solutions like Arduino and Raspberry PI, which are popular IoT hardware platforms. All this enables the fastest evaluation and development of IoT system.</p> | <p>More information</p>  |
|---|---|---|

# Sensor 2GO kits

Infiniteon's XENSIV™ sensor 2GO kits are budget-priced evaluation boards that are already equipped with a sensor combined with an Arm® Cortex®-M0 CPU.

The sensor 2GO kits provide a complete set of on-board

devices, including an on-board debugger. Build your own application and gadget with the sensor 2GO kits. Our 2GO kits are ready-to-use plug-and-play boards.



### Automotive pressure sensor 2GO kit

**Product name:** KP215F1701-PS2GO-KIT/KP229E3518-PS2GO-KIT/  
KP236- PS2GO-KIT/KP254-PS2GO-KIT/KP275-PS2GO-KIT

**Ordering code:** SP002676652/SP002676656/ SP002676664/  
SP002676664/SP002676648

#### Features

- > We offer five different derivatives
  - KP215F1701 MAP: Analog Manifold Air Pressure Sensor
  - KP229E3518 TurboMAP: Analog Turbo Manifold Air Pressure Sensor
  - KP236 BAP: Analog Barometric Air Pressure
  - KP254 dBAP: Digital Barometric Air Pressure (SPI)
  - KP275 dMAP: Digital Manifold Air Pressure Sensor (SENT)
- > Pressure and external temperature measurement - ONLY KP275dMAP
- > CSV file can be generated for each derivative
- > External NTC included KP275-PS2GO-KIT
- > Configuration of different transfer functions possible, KP215F1701-PS2GO-KIT and KP229E3518-PS2GO-KIT
- > A pressure connector consisting of a fast connector for 6mm tubes, pressure couple, and sealing is included
- > GUI software for free download
- > Power over USB (micro USB), ESD and reverse current protection
- > GUI for free download

More information



### 3D magnetic sensor 2GO kit

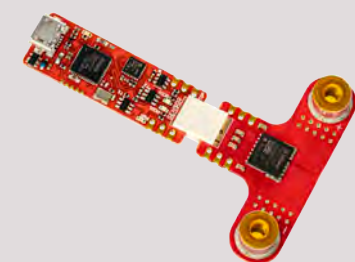
**Product name:** TLE493D-A2B6 MS2GO/  
TLE493D-W2B6 MS2GO/  
TLV493D-A1B6 MS2GO

**Ordering code:** SP001707582/  
SP001707578/  
SP001707574

#### Features

- > We offer three different derivatives
  - TLE493D-A2B6 (three dimensional magnetic sensor)
  - TLE493D-W2B6 (three dimensional magnetic sensor)
  - TLV493D-A1B6 (three dimensional magnetic sensor)
- > XMC1100 (Arm® Cortex™-M0 based)
- > On-board J-Link Lite Debugger (Realized with XMC4200 Microcontroller)
- > Power over USB (Micro USB), ESD and reverse current protection
- > GUI for free download

More information



### TLI4971 current sensor 2GO kit

**Product name:** TLI4971\_MS2GO

**Ordering code:** SP005345474

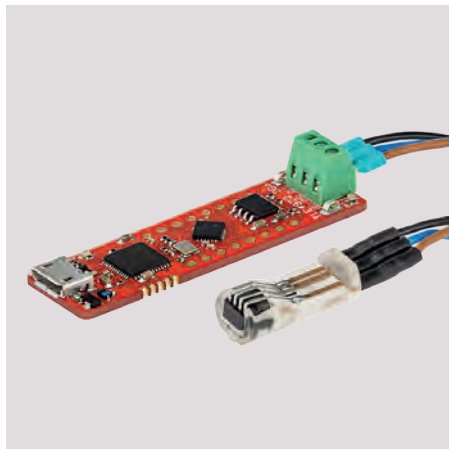
#### Features

- > TLI4971-A120T magnetic current sensor
- > Sensor board for high current capability ( $\leq 20$  A)
- > Complete evaluation set including control and debug
- > First measurements possible within minutes

More information



# Sensor 2GO kits



## Speed sensor 2GO kit

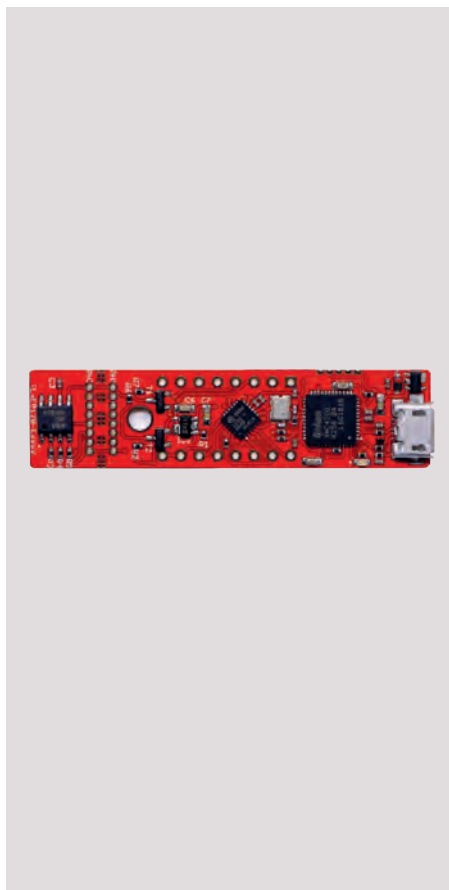
**Product name:** TLE4922 MS2GO

**Ordering code:** SP003029974

### Features

- > Budget-priced evaluation board for speed sensing
- > Complete speed sensor incl. back-bias magnet, fixing and cable
- > TLE4922 (active mono cell Hall sensor)
- > XMC1100 (Arm® Cortex™-M0 based)
- > On-board J-Link Lite Debugger (realized with XMC4200 microcontroller)
- > Power over USB (Micro USB), ESD and reverse current protection
- > GUI based tool for real in-application evaluation for free download

More information



## Angle sensor 2GO kit

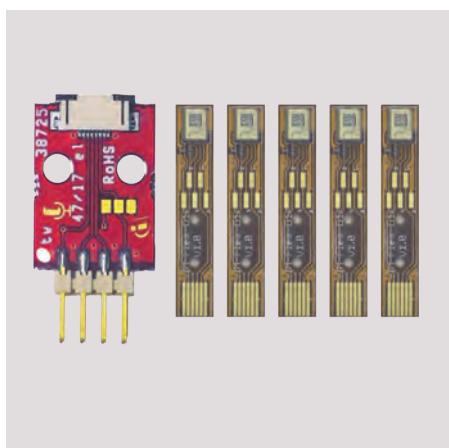
**Product name:** TLE5012B\_E1000\_MS2GO/  
TLI5012B\_E1000\_MS2GO/  
TLE5012B\_E5000\_MS2GO/  
TLE5012B\_E9000\_MS2GO

**Ordering code:** SP002133956/  
SP002133960/  
SP002133964/  
SP002133968

### Features

- > Budget-priced evaluation board for angle and position sensing
- > We offer four derivatives:
  - TLE5012B E1000 version: automotive predefined variant with SSC and IIF communication protocols
  - TLE5012B E5000 version: automotive predefined variant with SSC and PWM communication protocols
  - TLE5012B E9000 version: automotive predefined variant with SSC and SPC communication protocols
  - TLI5012B E1000 version: industrial predefined variant with SSC and IIF communication protocols
- > TLE5012B/TLI5012B GMR digital angle sensor
- > XMC1100 (Arm® Cortex™-M0 based)
- > On-board J-Link Lite Debugger (realized with XMC4200 microcontroller)
- > The kit is compatible with the angle rotate knob for fast evaluation
- > GUI based tool for real in-application evaluation for free download

More information



## MEMS microphone

**Product name:** EVAL\_IM69D130\_FLEXKIT

**Ordering code:** SP002153022

The flex evaluation kit allows simple and easy evaluation of XENSIV™ MEMS microphone IM69D130. The flex board can be easily connected to the audio testing setup. The evaluation kit includes five IM69D130 mounted on a flex board and one adapter board.

### Features

- > Quick and easy evaluation of XENSIV™ MEMS microphones
- > Flex dimensions: 25 x 4.5 mm
- > Adapter dimensions: 20 x 15 mm

More information



# Add ons for Sensor 2GO kits and Shield2Go



## Joystick for all 3D magnetic sensor 2GO kits and Shield2Go

**Product name:** JOYSTICK FOR 3D 2 GO KIT  
**Ordering code:** SP001491834

### Features

- > Easy mounting on all 3D magnetic sensor 2GO kits and Shield2Go
- > First magnetic joystick measurements within minutes

More information



## Rotate knob for all 3D magnetic sensor 2GO kits/Shield2Go, angle sensor 2GO kits

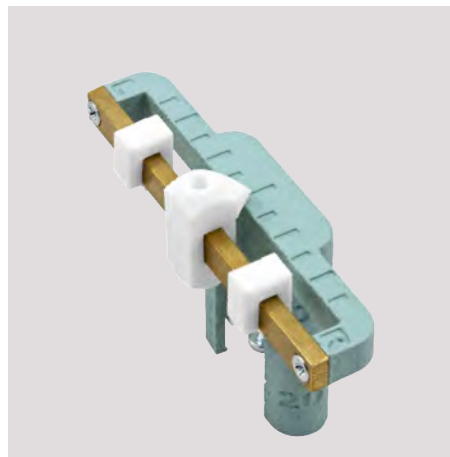
**Product name:** ROTATE KNOB 3D 2 GO KIT/  
 ROTATEKNOBANGLE2GOTOBO1

**Ordering code:** SP001504602/SP002441192

### Features

- > Easy mounting on all 3D magnetic and angle sensor 2GO kits as well as 3D magnetic sensor Shield2Go
- > Rotate knob with a magnet as used in control elements and push buttons
- > Use cases 3D magnetic sensors: rotational and vertical movements of control elements and push buttons
- > Use cases angle sensors: simulates rotational movements for angle measurements

More information



## Linear slider for all 3D magnetic sensor 2GO kits and Shield2Go

**Product name:** LINEAR-SLIDER 2GO

**Ordering code:** SP002043034

### Features

- > Easy mounting on all 3D magnetic sensor 2GO kits and Shield2Go
- > First magnetic linear evaluations within minutes
- > Use case: linear movements
- > Linear slider with magnet – flexible setup: adaptable air-gaps, two different magnetic strengths/materials and distance limiters

More information



## Out of shaft adapter for all 3D magnetic sensor 2GO kits and Shield2Go

**Product name:** OUT OF SHAFT FOR 3D 2 GO

**Ordering code:** SP003475178

### Features

- > Easy mounting on all 3D magnetic sensor 2GO kits and Shield2Go
- > Use case: angle measurement in out of shaft configuration with 3D Hall sensor
- > Three different out of shaft configurations possible (x-z, y-z and x-y axis)
- > Magnetic rotation bar with ring magnet included

More information

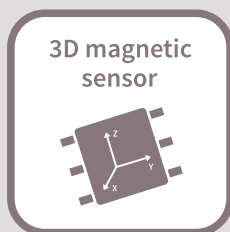
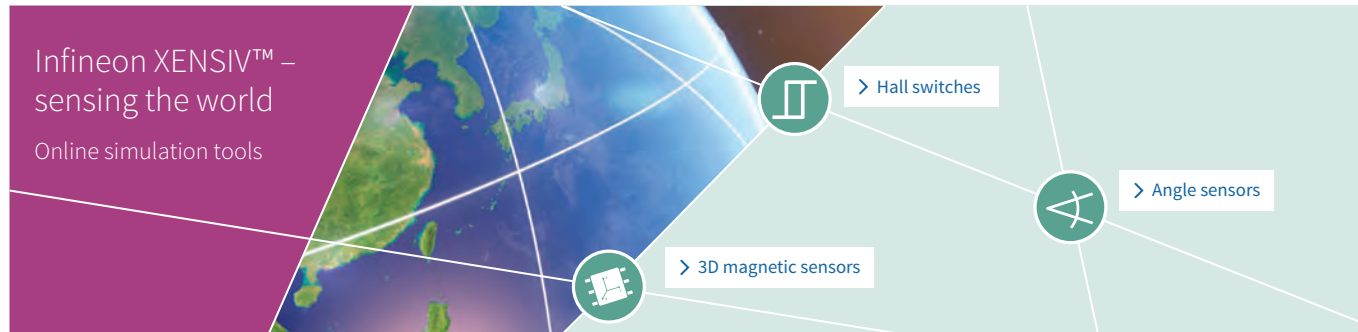


# Add ons for Sensor 2GO kits and Shield2Go

|   |  |   |
|---|--|---|
|    | <p><b>Linear control trigger for all 3D magnetic sensor 2GO Kits and Shield2Go</b></p> <p><b>Product name:</b> POWER_DRILL2GO</p> <p><b>Ordering code:</b> SP005350194</p> <p><b>Features</b></p> <ul style="list-style-type: none"> <li>&gt; Easy mounting on all 3D magnetic sensor 2GO Kits and Shield2Go</li> <li>&gt; Use case: control trigger for e.g. power drill (linear position measurements with 3D Hall sensor)</li> <li>&gt; Magnetic slider with magnet included</li> </ul>   | <p>More information</p>    |
|   | <p><b>Human Machine Interface (HMI) direction indicator for all 3D magnetic sensor 2GO Kits and Shield2Go</b></p> <p><b>Product name:</b> DIR_INDICATOR2GO</p> <p><b>Ordering code:</b> SP005350196</p> <p><b>Features</b></p> <ul style="list-style-type: none"> <li>&gt; Easy mounting on all 3D magnetic sensor 2GO Kits and Shield2Go</li> <li>&gt; Use case: human-machine interface (3x3 position matrix) for e.g. automotive direction indicator</li> <li>&gt; Magnetic direction indicator with magnet included in the handle bar</li> </ul> | <p>More information</p>   |
|  | <p><b>HMI mini control with 4 directions and 360° rotation for all 3D magnetic sensor 2GO Kits and Shield2Go</b></p> <p><b>Product name:</b> MINI_CONTROL2GO</p> <p><b>Ordering code:</b> SP005350192</p> <p><b>Features</b></p> <ul style="list-style-type: none"> <li>&gt; Easy mounting on all 3D magnetic sensor 2GO Kits and Shield2Go</li> <li>&gt; Use case: left/right/forward and backward including 360° rotation at all positions</li> <li>&gt; Control element includes a magnet</li> </ul>  | <p>More information</p>  |
|  | <p><b>OpenClose Adapter for Hall switch Shield2Go</b></p> <p><b>Product name:</b> OPENCLOSE2GOHSTOBO1</p> <p><b>Features</b></p> <ul style="list-style-type: none"> <li>&gt; Open &amp; Close detection with magnet for positions detection</li> <li>&gt; Presence and non-presence detection</li> </ul>   | <p>More information</p>  |

## Choose the best fit magnetic sensor solution from broadest portfolio

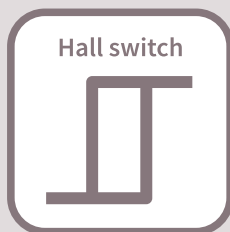
Our sensor simulation tools allow you to compare products in application conditions. The tools are easy-to-use and will guide you in identifying the most suitable Infineon XENSIV™ - sensor combined with the best-fit magnet.



### XENSIV™ – 3D Magnetic Sensors Simulation Tool

3D magnetic field sensor for smaller, more accurate and robust designs. The sensor family, with low current consumption and cost-optimized design, specifically addresses the needs of new magnetic sensor applications in consumer, industrial and automotive. They are ideally suited for the measurement of three dimensional movement within a magnetic field, linear slide movement as well as 360° angle rotation.

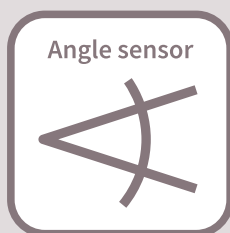
Direct link to the 3D magnetic sensors simulation tool:  
<http://www.infineon.com/3dsim>



### XENSIV™ – Magnetic Hall Switches Simulation Tool

Discover Infineon’s broad energy saving portfolio of Hall switches in smallest package. Simulate your Hall switch applications and see the results in an accurate simulation of the magnetic field and the switching behavior of the Hall switch in the application.

Direct link to the Hall switches simulation tool:  
<http://www.infineon.com/hallsim>



### XENSIV™ – Magnetic Angle Sensors Simulation Tool

Highest variety - low end to high end, standardized and specialized in all four magnetic technologies: Hall, GMR, AMR and TMR. This tool calculates the valid distance from the magnet surface to the sensor and the assembly error, given certain parameters: magnetic properties, sensor specification and assembly tolerances.

Direct link to the angle sensors simulation tool:  
<http://www.infineon.com/anglesim>

All simulation tools can be easily accessed via this link: <https://www.infineon.com/cms/en/tools/landing/sensor.html>

# ISO 26262 - Functional Safety (FuSa)

## Dependable electronics based on Functional Safety

The transformation in the automotive industry is being driven by megatrends such as automated driving and connectivity, all of which increases the need for safe electronic systems. These systems require highly integrated and safe electronic semiconductors. Today's standard for safe automated and safe autonomous systems is the ISO 26262 that is already implemented in the Infineon automotive products and well-established in the company's development processes and all product support activities.

Infineon is actively monitoring the trends in the automotive industry. We provide components and chipsets as well as system knowledge to support all safety-relevant automotive systems. Our broad product portfolio addresses a wide range of functionalities with sensors, computing and actuating chips complemented by power supply chips and communication ICs. For easy integration and minimum effort at the system integrator level, Infineon provides all of the necessary supporting information and documentation, as well as support from our team of experts. The required conformity evidence to ISO 26262 series of standards is available for all Infineon automotive safety products.

Functional safety is an inherent part of the proprietary development processes in Infineon. All products with assigned ASIL-classified safety requirements are subject to appropriate internal audits, assessments, and confirmations. With that, we ensure that these components fulfill the requirements for ISO 26262-compliant and ISO 26262-ready classifications – both are recognizable by our PRO-SIL™ trademark. With regard to ISO 26262-compliance, PRO-SIL™ indicates that assigned product safety requirements are fulfilled and conform to the ISO 26262 series of standards. With regard to ISO 26262-readiness, PRO-SIL™ indicates that the integrator gets the necessary information to integrate a non-ISO 26262 developed part into his safe system according to ISO 26262 clause 8-13.

All ISO 26262-compliant and ISO 26262-ready parts are produced according to Infineon's comprehensive automotive quality processes, resulting in the highest-possible product reliability. With our passion for quality and by taking a holistic functional safety approach, Infineon provides dependable electronics to support today's safety-relevant systems and future fail-operational systems essential for highly automated and autonomous driving.



ISO 26262  
ready



ISO 26262  
compliant

# Dependability is the key driver for the megatrend towards autonomous driving

The future car is fully connected and always online. It is all-electric and autonomous. To make this a reality, it takes both – technology and trust.

All levels of automated driving, but especially higher levels such as Level 3, 4, 5, require the driver’s and passengers’ trust for its adoption. Car occupants and other road users need to trust in cars that enable safe and flawless automated driving in any environment, regardless of the roads’ type and condition, the weather or the age of the car. They also want to trust in the fact that automated cars are secure.

Especially, higher levels of automated driving systems are the basis for trust only if they feature high availability of safety and cybersecurity. Only then will they be perceived as “dependable” – and thus be fully trusted.

## Dependable electronics enable systems that are the foundation for trust

The key to the successful combination of both technology and trust, is dependable electronics.

So what is it that distinguishes Infineon’s dependable electronics? Quite simply:

We offer innovative top-quality semiconductors and semiconductor solutions combined with broad system knowledge. As your trusted partner for premium products and services, we understand the dependability system requirements of robustness, reliability, availability, safety, and security as well as the added value of operational excellence.

## Infineon is automotive dependability










Infineon’s dependable electronics are built on a zero defect automotive quality mindset, which results in the high reliability and robustness of our semiconductors. They also incorporate a holistic Functional Safety approach enabling highly available fail-operational systems that meet the requirements of functional safety in accordance with ISO 26262. Furthermore, our dependable electronics leverage a deeply embedded broad system knowledge. We add extensive cybersecurity expertise that integrates our scalable product portfolio and a vast security system know-how.

All these ingredients of our dependable electronics enable a dependable, robust, safe and secure system that operates in all conditions. Our dependable electronics product portfolio provides [sensors](#), [microcontrollers](#), [memory solutions](#), [power electronics](#), [vehicle communications](#) and [power supply ICs](#).

So if you want to rely on a trusted partner offering all relevant ingredients for your dependable systems – automotive quality, Functional Safety, cybersecurity, innovative products, system understanding, operational excellence – then you need Infineon and Infineon automotive dependability.

As the number one partner in the automotive industry, we shape the future of mobility making cars clean, safe and smart – through dependable electronics that enable systems that are the foundation for trust.

### ProSIL™ products support a safety use case

| Customer use case  | System integration   |  | Safety feature description  | Infineon label  |
|--|--|--|---|---|
|  | Efforts  | Documentation  |   |   |
| Design with safety product to develop its own safety system  | <br>Use case specific | <br>Use case specific | Product with diagnostic or safety features  |                      |
| Hardware integration using products developed with Infineon automotive processes                   | <br>Medium            | <br>Safety app. note  | Safety analyses and customer documentation supporting ISO 26262 system integrations |  ISO 26262 ready     |
| System designed around Infineon components developed specifically for safety relevant applications | <br>Low               | <br>Safety manual     | Product developed according to ISO 26262 process with required documentation        |  ISO 26262 compliant |



# Packages

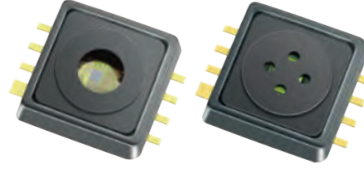
DSO-8/TDSO-8



TDSO-16



DSOF-8



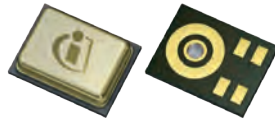
DSOSP-14-82



DSOSP-14-82



LLGA-5



SC59



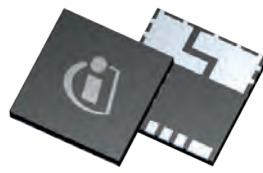
SOT23



TSOP6



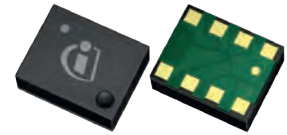
TISON-8-5



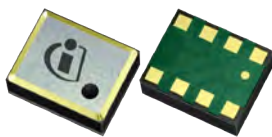
TSNP-16



VLGA-8-1



VLGA-8-2



VQFN-32



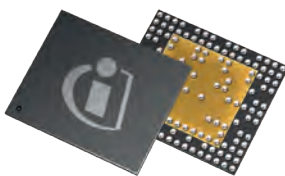
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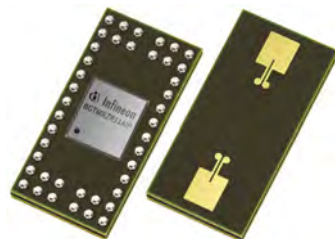
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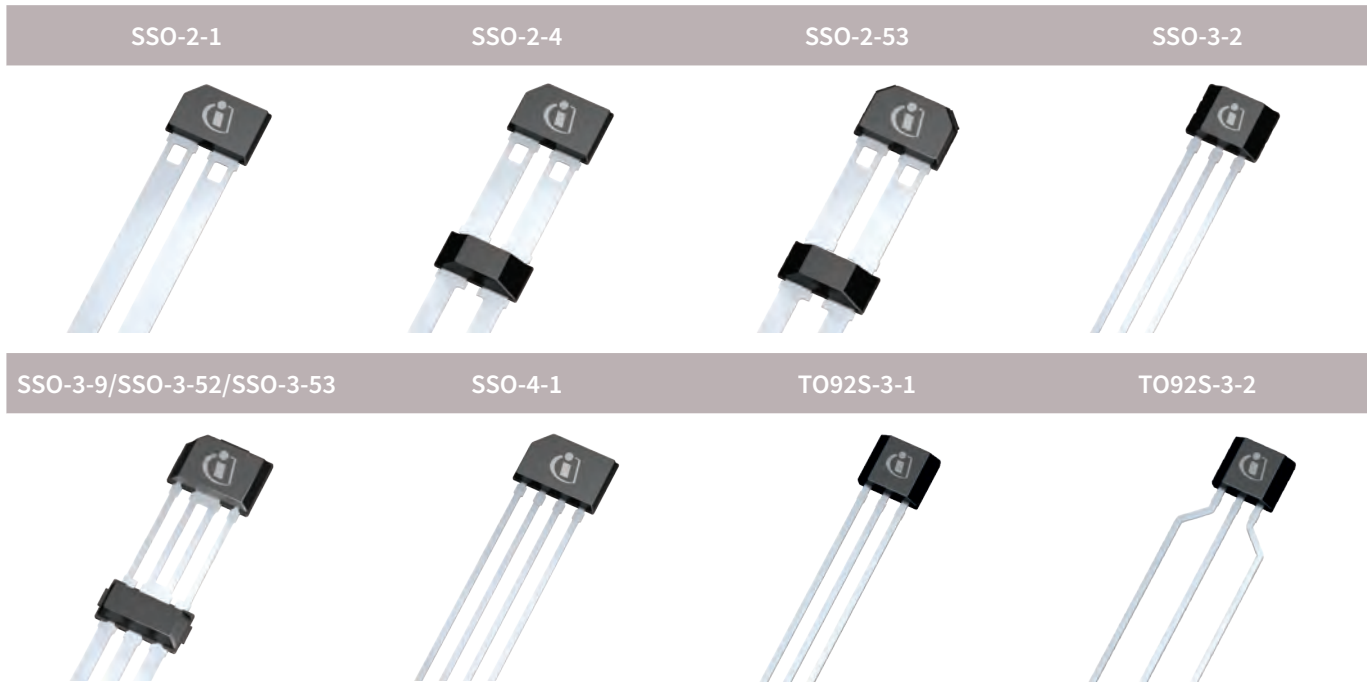
VFWLB-138 (eWLB)



UF2BGA-42-1



For further information on Infineon packages, please visit our website at [www.infineon.com/packages](http://www.infineon.com/packages)



For further information on Infineon packages, please visit our website at [www.infineon.com/packages](http://www.infineon.com/packages)

# Where to buy

Infiniteon distribution partners and sales offices:

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

# Service hotline

Infiniteon offers its toll-free 0800/4001 service hotline as one central number, available 24/7 in English, Mandarin and German.

- > Germany ..... 0800 951 951 951 (German/English)
- > China, mainland ..... 4001 200 951 (Mandarin/English)
- > India ..... 000 800 4402 951 (English)
- > USA ..... 1-866 951 9519 (English/German)
- > Other countries ..... 00\* 800 951 951 951 (English/German)
- > Direct access ..... +49 89 234-0 (interconnection fee, German/English)

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

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

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### Additional information

For further information on technologies, our products, the application of our products, delivery terms and conditions and/or prices, please contact your nearest Infineon Technologies office ([www.infineon.com](http://www.infineon.com)).

### Warnings

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Except as otherwise explicitly approved by us in a written document signed by authorized representatives of Infineon Technologies, our products may not be used in any life-endangering applications, including but not limited to medical, nuclear, military, life-critical or any other applications where a failure of the product or any consequences of the use thereof can result in personal injury.