



XENSIV™ – sensing the world

Sensor solutions for automotive, industrial
and consumer applications

www.infineon.com/sensors
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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 the world leader in sensing technology, XENSIV™ sensors simplify lives by enabling “things” to “see”, “hear”, “feel” and “understand” their environment. As a result of proven quality and outstanding reliability, customers can rely on XENSIV™ for system stability, durability and integrity. 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.

Furthermore Infineon offers a wide range of automotive qualified pressure sensors for side airbag application, barometric and manifold air pressure measurement as well as tire pressure monitoring systems (TPMS).

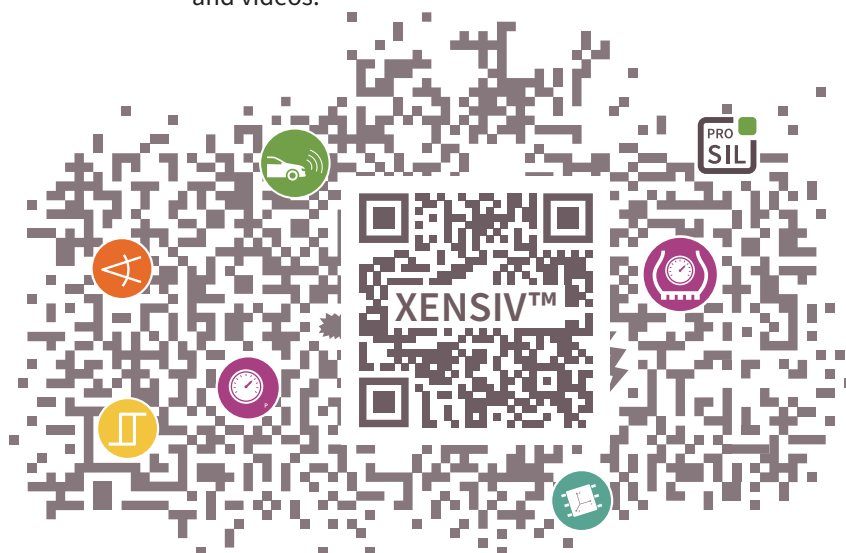
Infineon's RASIC™ 77-GHz chips are used in radar-based driver assistance systems – such as adaptive cruise control and collision warning – which recognize objects at a range of up to 250 meters. With 150 million chips already shipped, we are the market leader in radar chips.

Our increasing range of XENSIV™ sensors families like XENSIV™ MEMS microphones and XENSIV™ barometric pressure supporting support numerous industrial and consumer applications.

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. The sensors are UL certified and offer two independent fast Over-Current Detection (OCD) pins with configurable thresholds enable protection mechanisms for power circuitry (typical 0.7 μs). The Infineon current sensors are the perfect fit for drives or inverter applications.

With a proven track record in IoT innovation, we continue to seamlessly and securely connect people and machines. Many IoT trends such as smart devices and wearables, electromobility and connected cars, smart factories and homes, energy intelligence are being driven by technologies that we develop, with our XENSIV™ sensors families being one of the key elements. Today, we are already inspiring the next generation of smart environments – capable of understanding and responding to human communication. Our 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. Sensors and microphones from Infineon are already delivering this intelligent functionality and inspiring the next step in mobile connectivity.

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



Infineon XENSIV™ solutions from application to sensor



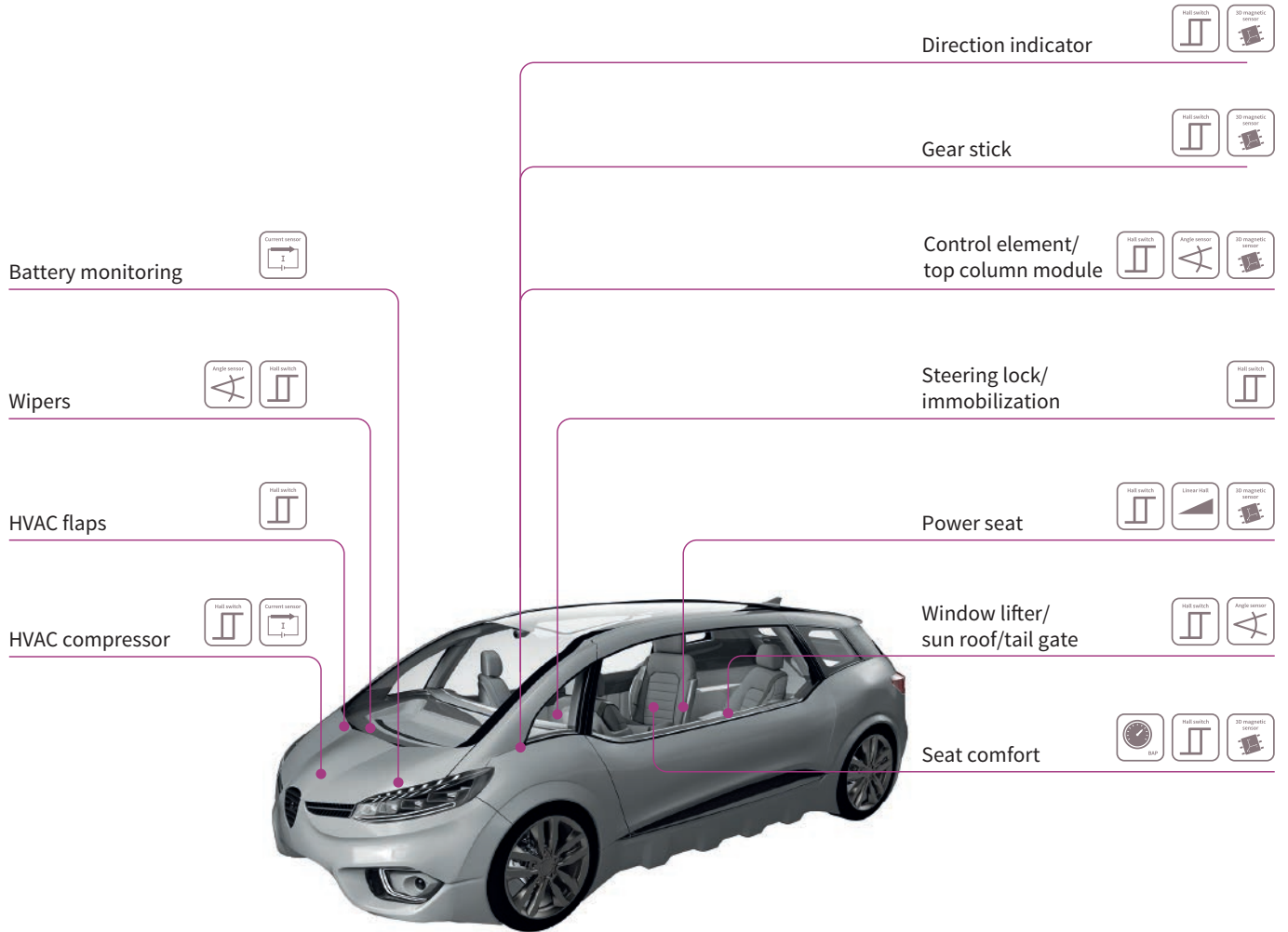
Find your sensor

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



XENSIV™ sensors in body applications





















 Switches	 Linear Hall	 Angle sensors	 Current sensors	 BAP	 3D magnetic sensors
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The body segment presents the most diverse target market for sensors. Hall switches, for example, are deployed in classic applications such as window lift modules, whereas



















new seat comfort systems deploy pressure sensors to control individual pressure levels in seat cushions.

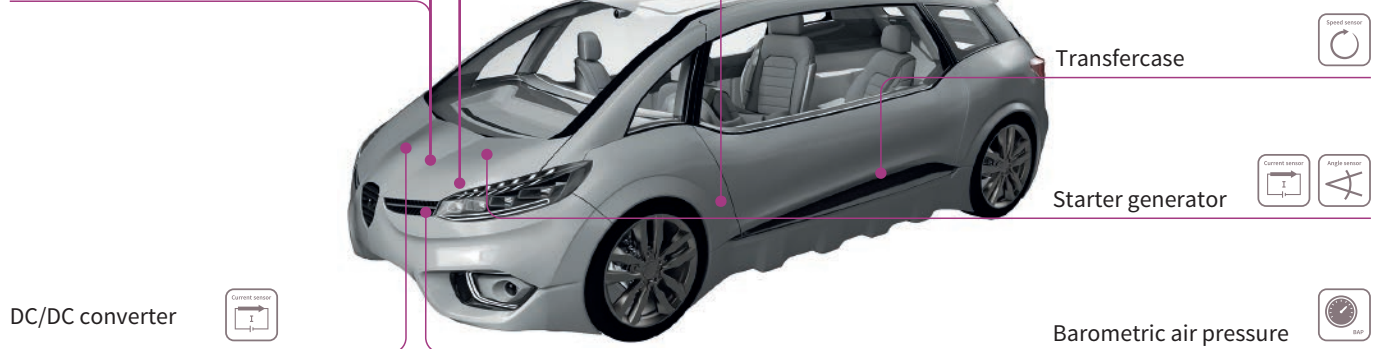
XENSIV™ sensors in powertrain applications

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)   









Transmission

- Clutch position 
- Clutch actuator  
- Transmission speed 
- Transmission actuator  
- Transmission gear position   
- Oil pump   
- Park lock  
- Gear stick   
- Battery monitoring for EV 



- DC/DC converter 

- Transfercase 
- 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

Braking

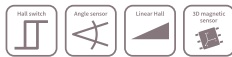
Wheel speed



Brake booster



Brake pedal



Brake light switch



Power steering

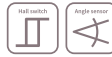
Steering torque



Motor position



Steering angle



Pedestrian protection



Radar



Restraint systems

Seatbelt buckle



Seat position system



Belt pretensioner



Suspension/
Chassis height



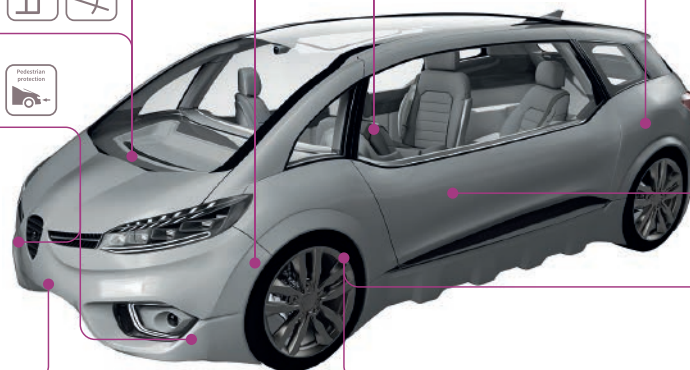
Side crash detection



Tire Pressure
Monitoring System (TPMS)



Indirect TPMS System (iTPMS)



Switches



Linear Hall



Angle sensors



Pedestrian protection



Current sensors



3D magnetic sensors



Radar



BAP



Speed sensors



Side airbag



Tire Pressure Monitoring System (TPMS)

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 in side airbags and pedestrian protection systems and 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.

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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 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

Steering torque sensing



TLE499x – linear Hall sensor series

Torque index sensor



TLE4906 – switches

Steering angle sensing

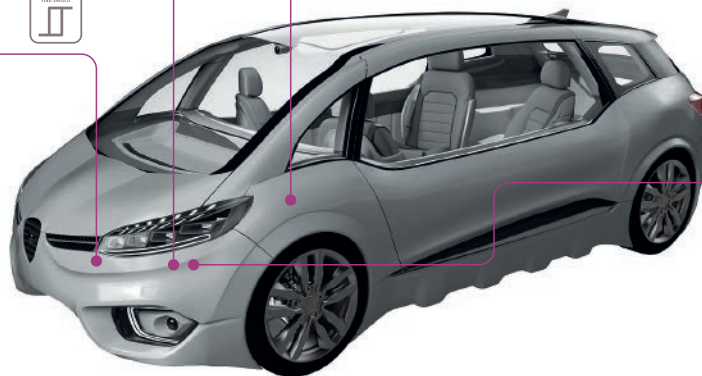


TLE5014/TLE5012B – angle sensor
TLE5009 – angle sensor
TLE5501 – angle sensor

EPS motor position sensing



TLE5x09D – dual-sensor angle
TLE5012BD – dual-sensor angle



Linear Hall



Angle sensors



Steering torque



BLDC motor



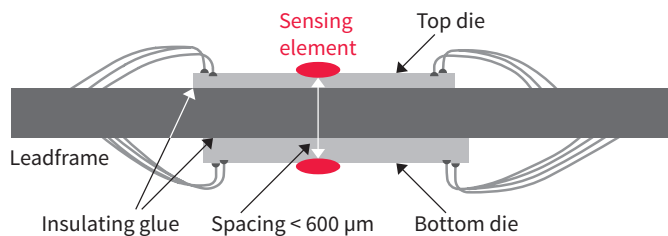
Switches

Position sensor applications in EPS are safety-related and typically rated with the highest ASIL D 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 ASIL D safety level. These demanding specifications can typically be achieved by using redundant sensors as well as comparing their signals on 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

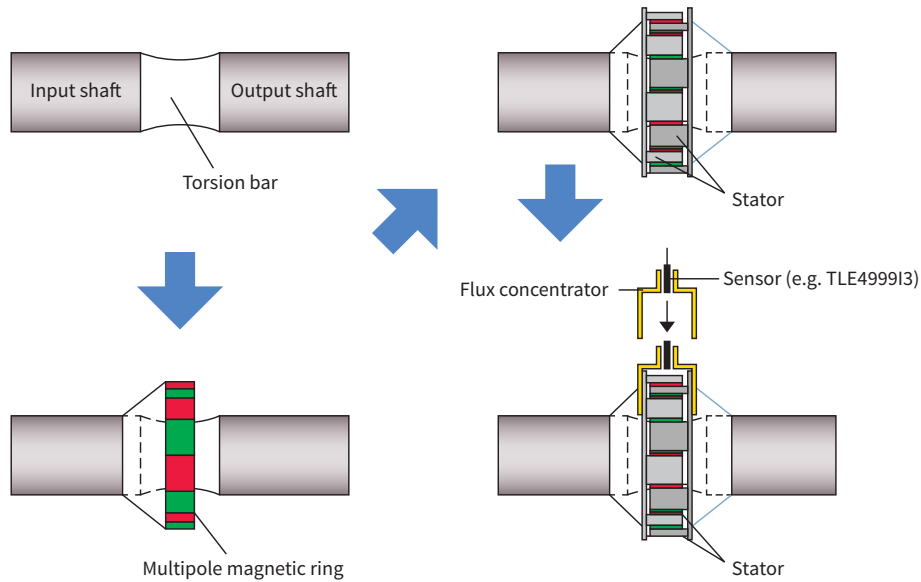
In the field of steering torque sensing, Infineon XENSIV™ TLE499x series offers highly accurate linear Hall sensors for magnetic torque sensing assembly. In order to support a maximum of compatibility with various

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- or 4-pin leaded package (with or 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.

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

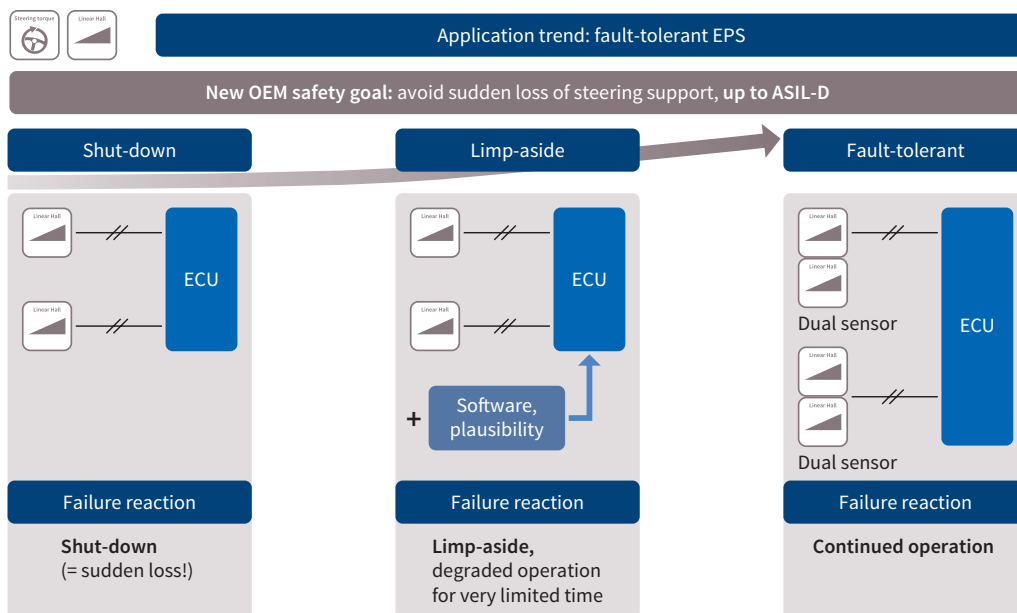
Magnetic torque sensing assembly



Conventional EPS systems 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 TLE4998 dual-sensors or

two TLE4999I3, each of them with two highly accurate redundant Hall measurement channels (main and sub) integrated on one single chip. In case of one TLE4998 or TLE4999I3 signal loss, the remaining dual-sensor (TLE4998) or the single die two channels (TLE4999I3) in the system provides continued operation of the EPS, avoiding an immediate system shut-down.

Application trend: fault tolerant

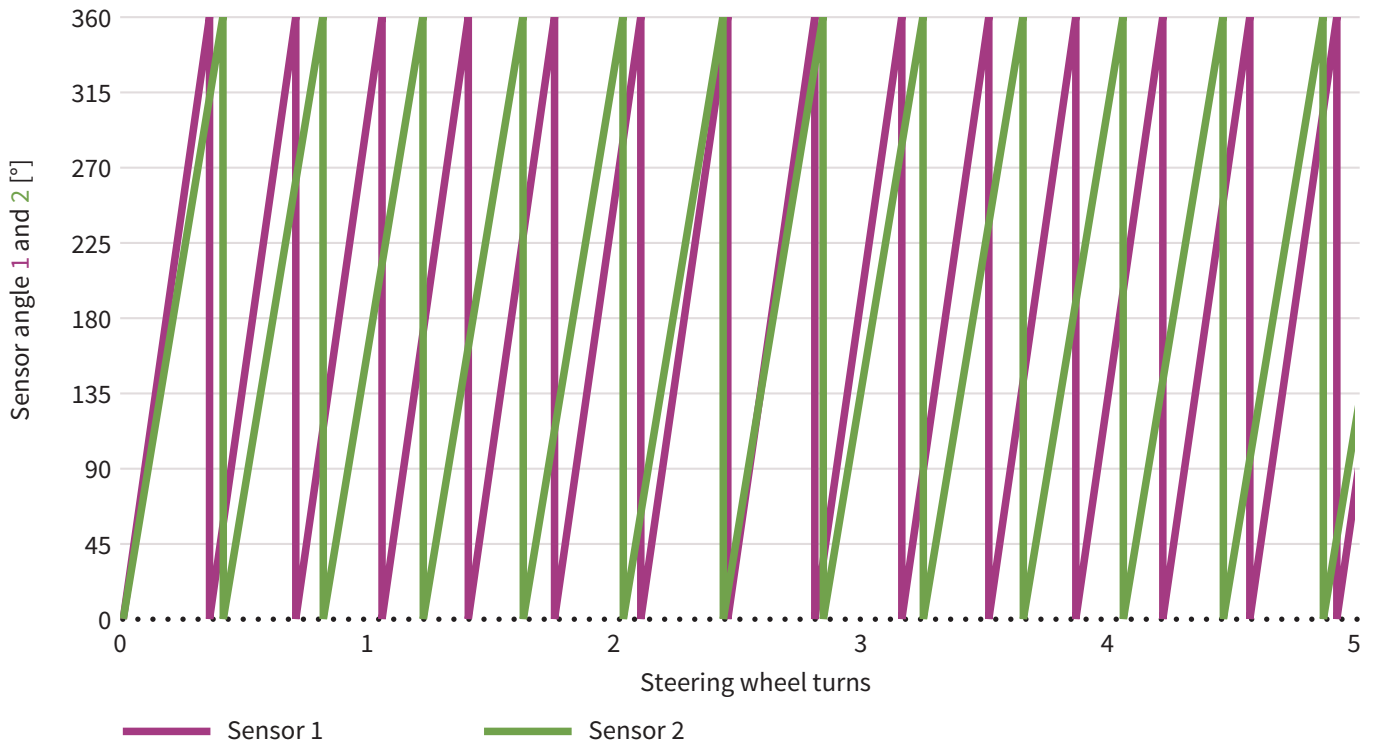


Steering angle sensors

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.

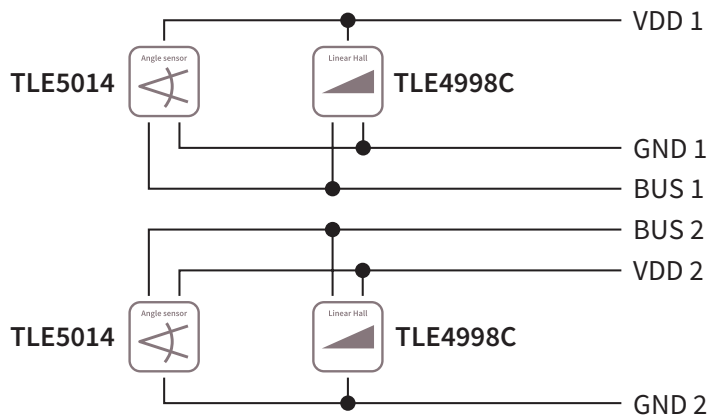
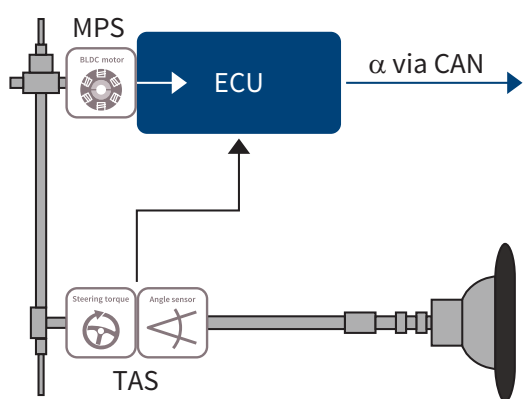
The sensors are also available in dual-sensor packages for module designs, that support an ASIL D-rated steering angle directly at power-on (ASIL D from start).

	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.

Infineon 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

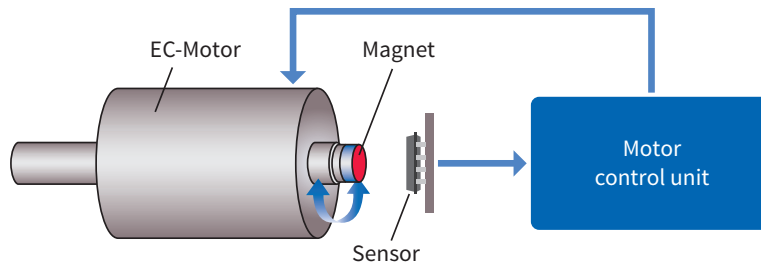


EPS motor position sensors

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 CO₂/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.

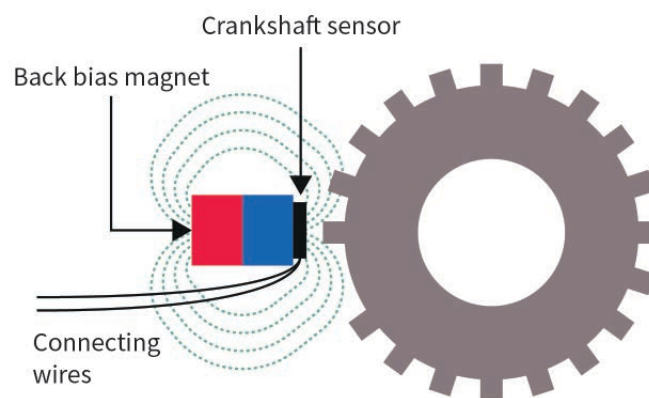


Drive interplay as experienced by the driver

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.

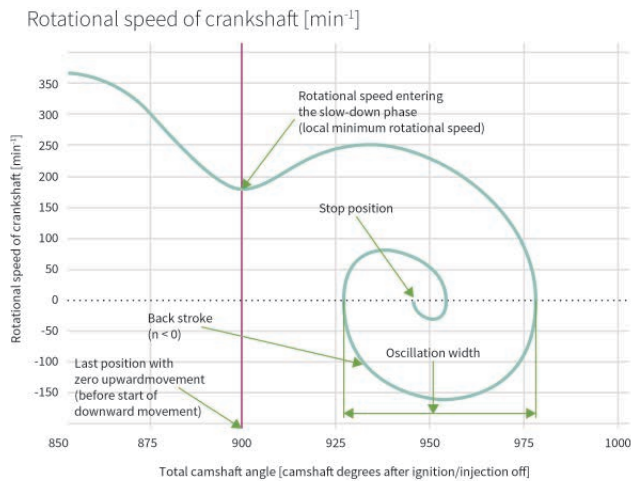


Diagram of the crankshaft coming to rest when ignition is shut off [1]

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).

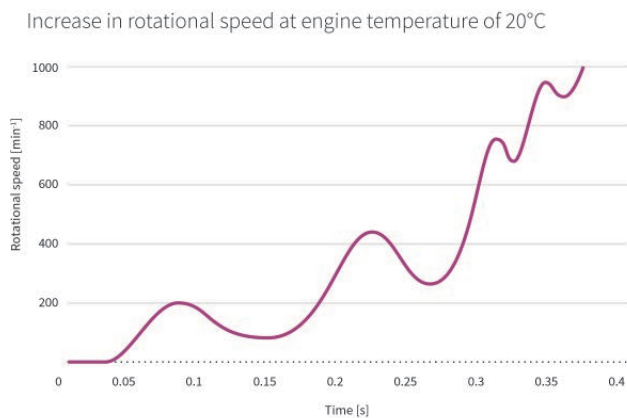


Diagram showing how a crankshaft starts turning again after a direct start [1]

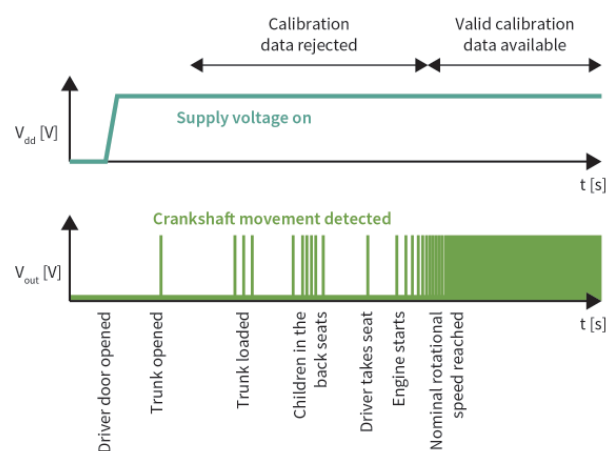
Vibrations while stationary

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.

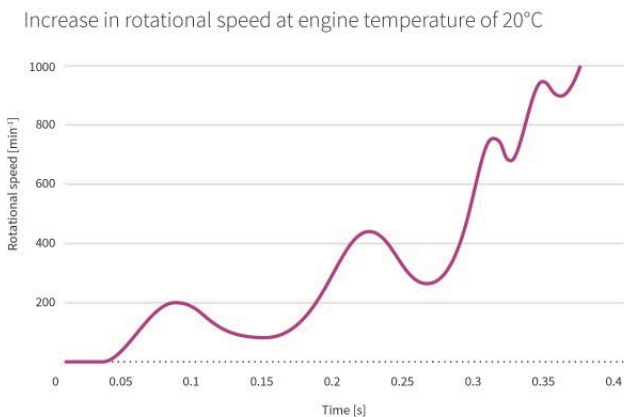


Signal output by the crankshaft sensor when a car is being loaded

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.

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.

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

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.

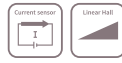
The combustion engines developed today will be around for several decades to come. As such, it is vital that the technology used in these models is reliable, long-lasting, and up to date. Luckily, the challenges that hybrid engines and, in particular, crankshaft and camshaft sensors face in these systems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

Overview of Infineon XENSIV™ crankshaft sensors

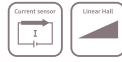
- > TLE4929C-XAx – first-generation low-jitter, Hall-based crankshaft sensor.
- > TLE4929C-XVA – second generation includes several further crankshaft protocols (by number 14) and a time watchdog to overcome start-up vibrations. In addition, this device is available with nickel plating for the first 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

Solar panel tracking



Solar inverter current



Barometric pressure sensing



Wind speed sensing



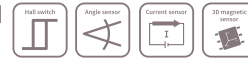
Proximity detection



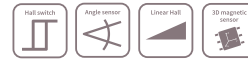
Robot sensing
Tank level measurement



Electric Commutated (EC) motor



Valve position



Control elements



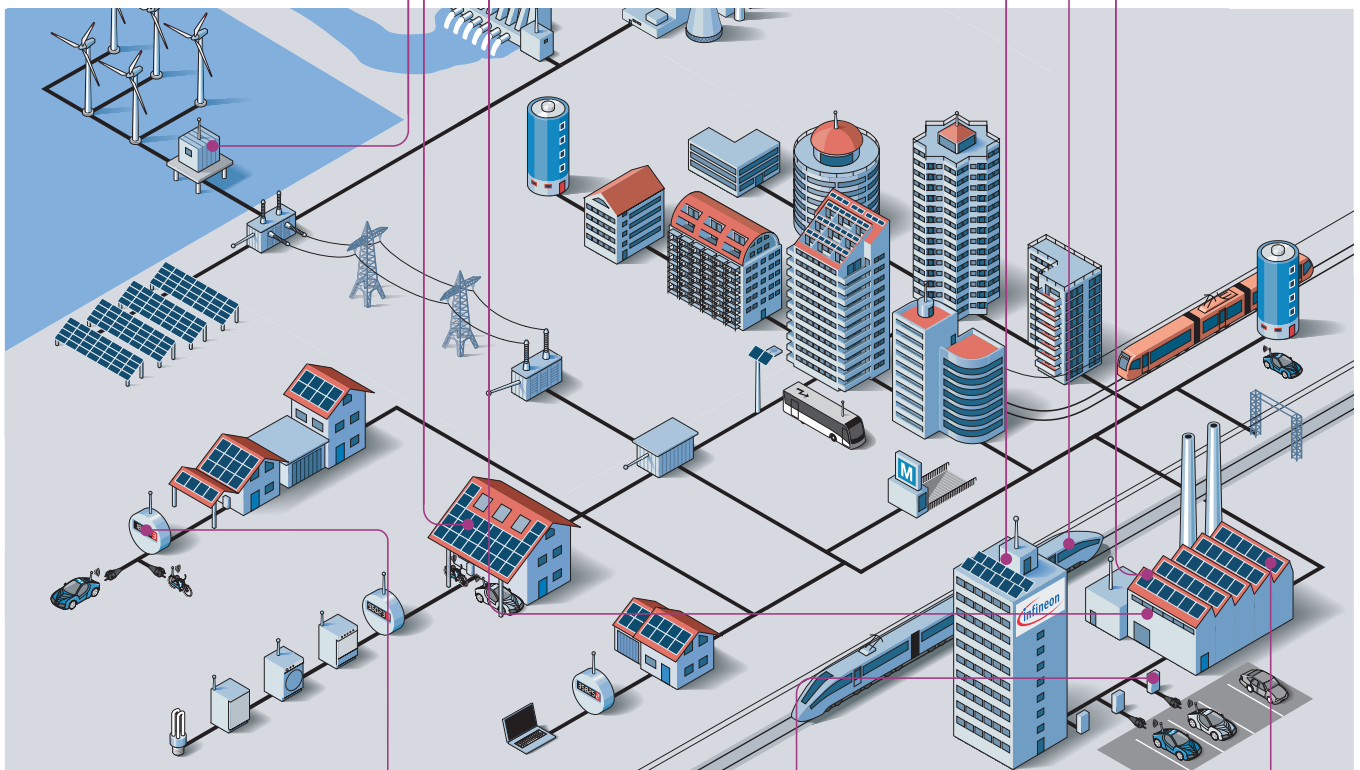
Gear wheel speed sensor



Predictive maintenance



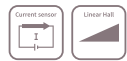
Pneumatics



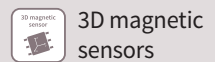
Smart metering



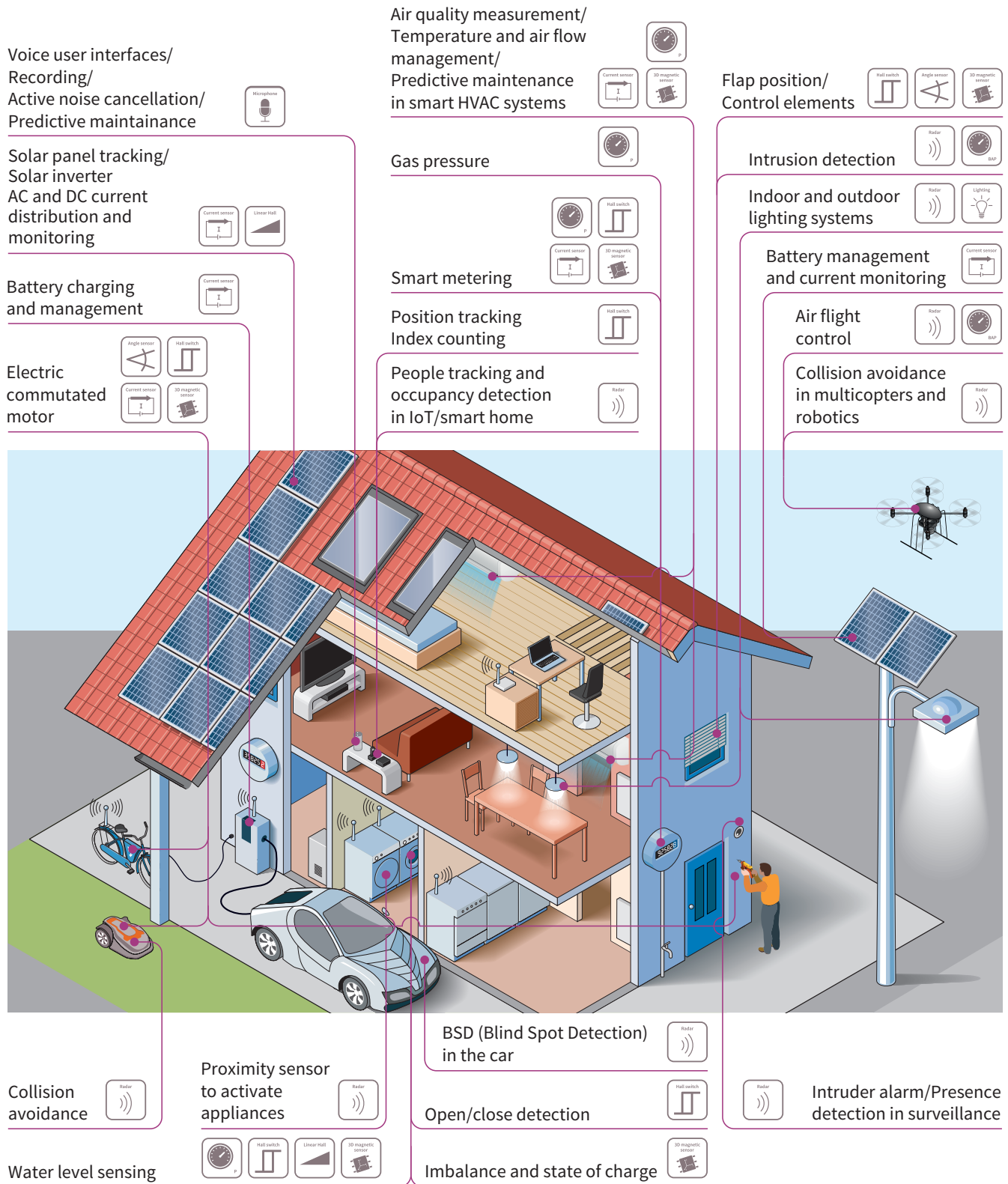
Charger and battery management



Absolute and incremental rotary encoder



XENSIV™ sensors in smart homes



- | | | | | | |
|-------------|-------------|---------------|-----------------|----------|---------------------|
| Hall switch | Linear Hall | Angle sensors | Current sensors | Pressure | 3D magnetic sensors |
| BAP | Radar | Microphone | Lighting | | |

XENSIV™ sensors in smart building

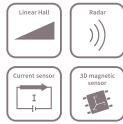
Smart lighting

Presence detection/
People flow monitoring/
Enabled room segmentation



Circuit breaker

State monitoring



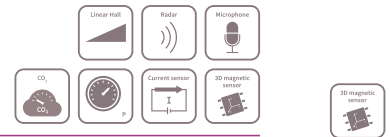
Surveillance cameras

Presence detection for
switching camera on & off/
Perimeter monitoring
outside of the building



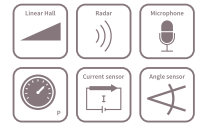
HVAC

Air-flow measurement/
Current sensing at motor and compressor/
Vibration monitoring at compressor/
Noise level monitoring/Indoor air quality monitoring/
Monitoring of motor position/Presence detection



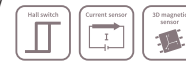
Elevators & escalators

Condition Monitoring & Predictive Maintenance/
Motor position detection/Door position detection/
Device power monitoring/Current sensing at motor and compressors

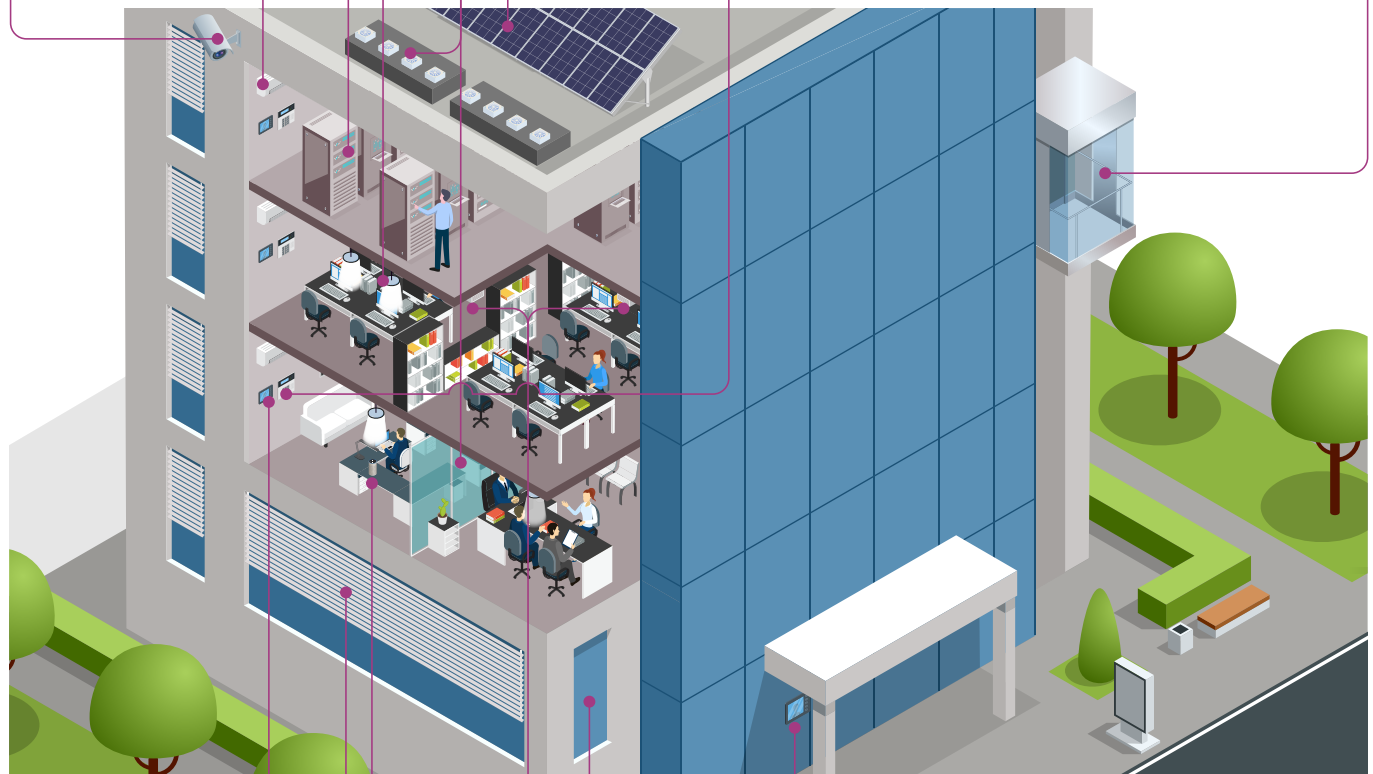


Smart metering

Anti-tampering protection/
Current measurement/
Flow metering



PV Moduls



Shutters

Position detection



Voice control & VUI

Audio/Presence



Access control

Security systems/
Open/close detection



Intrusion detection

Glass break/
Presence detection



Room automation

Presence detection/Indoor air quality monitoring/
Noise level monitoring



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/



Commercial, construction and agricultural vehicles (CAV)

Your source of proven CAV semiconductor solutions
With proven expertise in CAV and a comprehensive portfolio of robust, high-quality control and power semiconductor solutions, Infineon helps you engineer successful designs for all kinds of commercial, construction and agri-

cultural vehicles. Explore our selection of CAV applications to discover more about the best-fit components and solutions for your project. For example, our XENSIV™ Hall and xMR based sensors were developed for switching functions as well as position and speed measurement. www.infineon.com/cav





High-precision coreless current sensors for industrial applications

Infinion'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, power supplies or battery management systems. 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

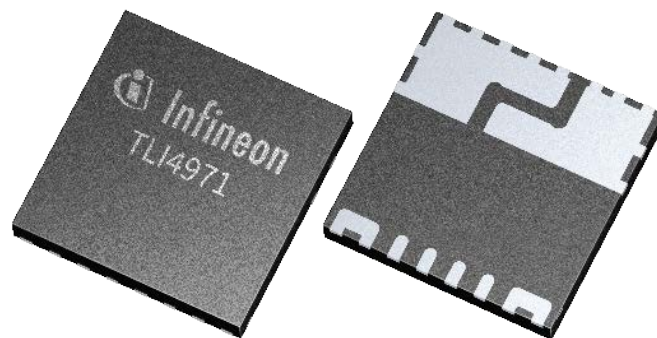
Features

- › Integrated current rail with typical 225 $\mu\Omega$ insertion resistance enables ultralow power loss
- › Smallest form factor, 8x8 mm SMD, for easy integration and board area saving
- › Single supply voltage, 3.1 to 3.5 V
- › Highly accurate, scalable, DC and AC current sensing
- › Bandwidth greater than 120 kHz enables wide range of applications
- › Very low sensitivity error over temperature (max. 2.5%)
- › Excellent stability of offset over temperature and lifetime
- › High robustness to voltage slew rates up to 10 V/ns
- › Galvanic functional isolation up to 1150 V peak V_{IORM} ; 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 (typ. response time 0.7 μ s)
- › Precalibrated sensor

even in a noisy environment with cross-talk from adjacent current lines or magnetic stray fields. Highlights of the 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. The sensor also provides a signal in case of an over or undervoltage condition for the supply voltage.

Applications

- › Electrical drives (up to 690 V)
- › Photovoltaic inverter
- › General purpose inverters, e.g. primary stage of PV inverter
- › Overload and overcurrent detection
- › Current monitoring
- › Chargers Power supplies



Product	Accuracy ¹⁾ [%]	Current range [A]	Bandwidth typ. [kHz]	Sensitivity [mV/A]	Certification	Industrial	Package
TLI4971-A120T5-U-E0001	3.45	120	240	10	UL	●	TISON-8
TLI4971-A120T5-E0001	3.45	120	240	10	-	●	TISON-8
TLI4971-A025T5-U-E0001 ²⁾	3.45	25	240	48	UL	●	TISON-8
TLI4971-A025T5-E0001 ²⁾	3.45	25	240	48	-	●	TISON-8
TLI4971-A050T5-U-E0001 ²⁾	3.45	50	240	24	UL	●	TISON-8
TLI4971-A050T5-E0001 ²⁾	3.45	50	240	24	-	●	TISON-8
TLI4971-A075T5-U-E0001 ²⁾	3.45	75	240	16	UL	●	TISON-8
TLI4971-A075T5-E0001 ²⁾	3.45	75	240	16	-	●	TISON-8

1) Total error over lifetime and temperature

2) Available Q1/2021



Magnetic sensors

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

Infinion XENSIV™ sensors are exceptionally precise thanks to industry-leading technologies. Our benchmark and innovative magnetic sensor portfolio is the perfect fit for various 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 Hall 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

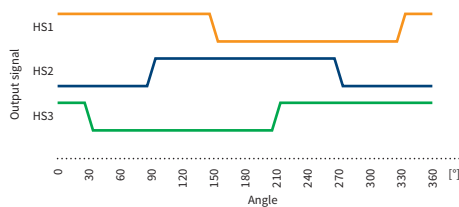
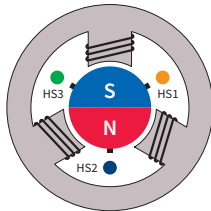


TLE/TLI/TLV4961/64/68

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, 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 ΔB_{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 μ 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 B_{OP} [mT]	Release point B_{RP} [mT]	Hysteresis ΔB_{HY} [mT]	Automotive	Industrial	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

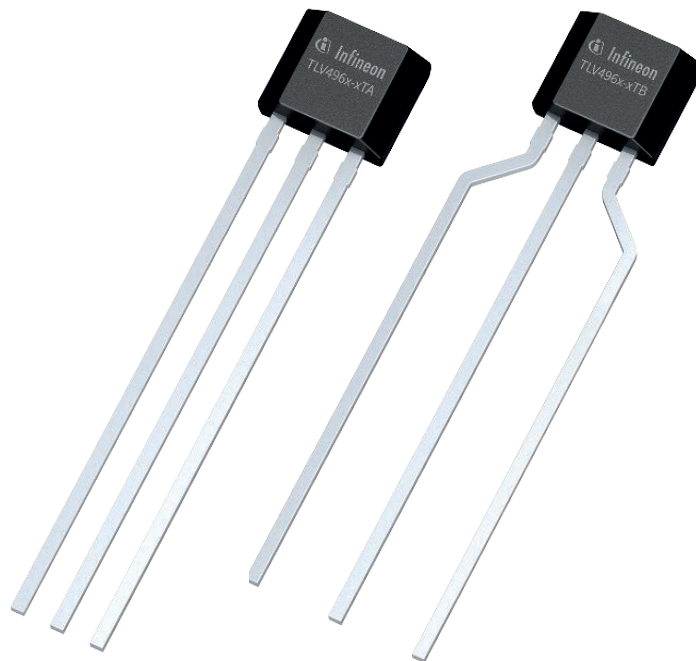
The TLV496x-xTA/B Hall sensor family comprises a line of Hall switches for contactless position sensing. The sensors are specially designed to provide an easy-to-use and cost-effective solution for position sensing applications.

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 TO92S

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 B_{OP} [mT]	Release point B_{RP} [mT]	Hysteresis ΔB_{HY} [mT]	Consumer	Package
TLV4961-1TA	Latch	2.0	-2.0	4.0	●	TO92S-3-1
TLV4961-1TB	Latch	2.0	-2.0	4.0	●	TO92S-3-2
TLV4961-3TA	Latch	7.5	-7.5	15.0	●	TO92S-3-1
TLV4961-3TB	Latch	7.5	-7.5	15.0	●	TO92S-3-2
TLV4964-4TA	Unipolar switch	10.0	8.5	1.5	●	TO92S-3-1
TLV4964-4TB	Unipolar switch	10.0	8.5	1.5	●	TO92S-3-2
TLV4964-5TA	Unipolar switch	7.5	5.0	2.5	●	TO92S-3-1
TLV4964-5TB	Unipolar switch	7.5	5.0	2.5	●	TO92S-3-2
TLV4968-1TA	Bipolar switch	1.0	-1.0	2.0	●	TO92S-3-1
TLV4968-1TB	Bipolar switch	1.0	-1.0	2.0	●	TO92S-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

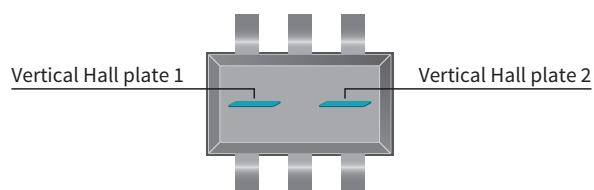
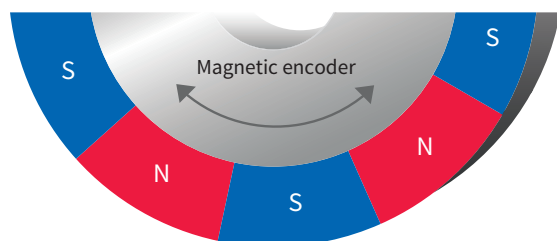
Vertical dual-Hall sensor

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 B_{OP} [mT]	Release point B_{RP} [mT]	Hysteresis ΔB_{HY} [mT]	Automotive	Industrial	Package
TLE4966G/L	Double Hall, speed and direction output	Speed and direction	7.5	-7.5	15	●	-	TSOP6/ 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 (option TLE)

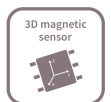
Applications

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

Product	Type	Operating point B_{OP} [mT]	Release point B_{RP} [mT]	Hysteresis ΔB_{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/ Current interface	6.0	4.0	2.0	●	●	–	SSO-3-2
TLE4976-1K	Unipolar switch/ Current interface	9.25	7.25	2.0	●	●	–	SC59
TLE4976-2K	Unipolar switch/ Current interface	4.5	2.7	1.8	●	●	–	SC59
TLV4946-2K	Unipolar switch	18.0	12.5	5.5	–	–	●	SC59
TLV4976-2K	Unipolar switch / Current interface	4.5	2.7	1.8	–	–	●	SC59

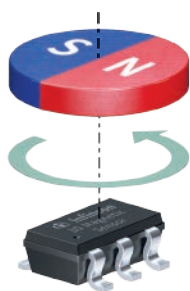


TLV493D-A1B6/TLI493D-A2B6 and new TLI493D-W2BW 3D magnetic sensors for consumer and industrial market

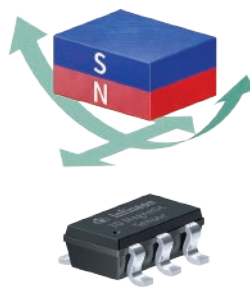


Infineon's new 3D magnetic sensor (TLI493D-W2BW) combines high-accuracy magnetic field measurements with an extremely compact footprint and exceptionally low power consumption (min. 7 nA). This sensor opens up a host of exciting new use cases including innovative human-machine interfaces in the form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

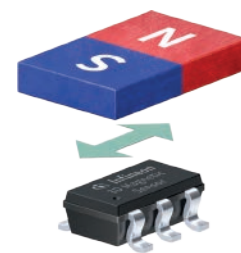
The TLV493D-A1B6 sensor realizes an accurate three-dimensional sensing with extremely low power consumption in a small 6-pin package. Capable of detecting the magnetic field in the x, y, and z-direction, the sensor is ideally suited for the measurement of linear, rotation or 3 dimensional movements. 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.



Rotation movement

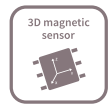


3D movement



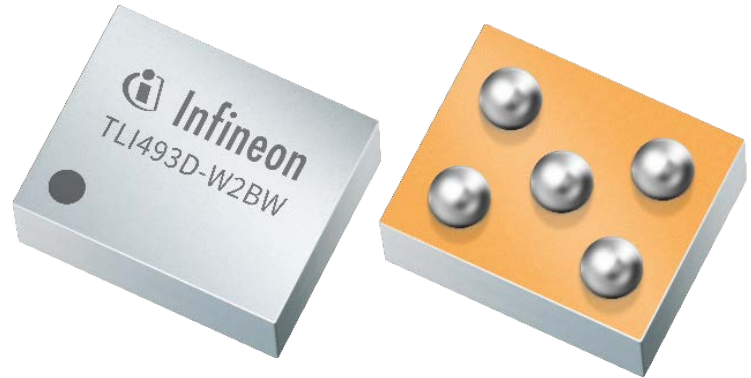
Linear movement

TLV493D-A1B6/TLI493D-A2B6 and new TLI493D-W2BW 3D magnetic sensors for consumer and industrial market



Features

- › 3D magnetic sensing
- › Integrated temperature sensing
- › Low current consumption
 - 7 nA in power-down mode
 - 10 µA in ultra-low power mode
- › 2.8 to 3.5 V operating supply voltage
- › Digital output via a 2-wire standard I²C interface
- › B_x, B_y and B_z linear field measurement up to ±160 mT
- › JESD47 qualified
- › 12-bit data resolution for each measurement direction
- › Various resolution options from 65 µT/LSB to 130 µT
- › Operating temperature range up to -40 to +125°C
- › Extremely accurate, contactless 3D magnetic field measurement
- › Robust to temperature fluctuations
- › High resistance to interference thanks to high magnetic flux density
- › Suited to broad application spectrum in industrial and consumer space
- › Long service life – extremely small package (TLI493D-W2BW)



Product	Temperature range	Qualification	Linear magnetic range	Resolution	I _{DD}	Update rate	Package	Ordering code
TLV493D-A1B6	-40 ... 125°C	JESD47	±130 mT (typ)	98 µT/LSB	7 nA – 3.7 mA	10 Hz – 3.3 kHz	TSOP6	SP001286056
TLI493D-A2B6	-40 ... 105°C	JESD47	±160 mT (min) ±100 mT (min)	130 µT/LSB (65 µT/LSB) ¹⁾	7 nA – 3.3 mA	10 Hz – 8.4 kHz	TSOP6	SP001689844
TLI493D-W2BW A0 TLI493D-W2BW A1 TLI493D-W2BW A2 TLI493D-W2BW A3	-40 ... 105°C -40 ... 125°C	JESD47	±130 mT (typ) ±160 mT (min) ±100 mT (min) ±50 mT (min)	130 µT/LSB (65 µT/LSB)	7 nA – 5 mA	3.3 kHz 7.8 kHz	WFWLB-5-2	SP005409964 SP005409966 SP005409968 SP005409970

1) Half range mode

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

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

New features

- › Sensor address read back
- › Half mode range setting, focusing to 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

TLE493D-A2B6/W2B6

3D magnetic sensors for automotive low-power applications

The TLE493D-x2B6 enables for 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 ± 160 mT.



Features

- > 3D magnetic sensing
- > Integrated temperature sensing
- > 2.8 to 3.5 V operating supply voltage
- > Low current consumption
 - 0.007 μ A in power-down mode
 - 10 μ A in ultra-low power mode
 - Up to 10 power modes
- > Digital output via a 2-wire standard I²C interface
- > Bx, By and Bz linear field measurement ± 160 mT
- > AEC-Q100 qualified
- > 12-bit data resolution for each measurement direction
- > Various resolution options from 67 μ T/LSB to 134 μ T
- > Operating temperature range up to -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	± 160 mT (min) ± 100 mT (min)	130 μ T/LSB (65 μ T/LSB) ¹⁾	7 nA – 3.3 mA	10 Hz – 8.4 kHz	No	TSOP6	SP001689848
TLE493D-W2B6 A0 TLE493D-W2B6 A1 TLE493D-W2B6 A2 TLE493D-W2B6 A3	-40 ... 125°C	AEC-Q100/ ISO 26262 ready	± 160 mT (min) ± 100 mT (min)	130 μ T/LSB (65 μ T/LSB) ¹⁾	7 nA – 3.3 mA	0.05 Hz – 8.4 kHz	Yes	TSOP6	SP001655334 SP001655340 SP001655344 SP001655348

1) Half range mode

The 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 read out only).

With the TLE493D-W2B6 A0-A3, a 3D sensor has been developed, which includes an enhanced dynamic wake up feature. Four pre-programmed address options (A0-A3) will be available, enabling for a fast start up initialization, when used in I²C bus configurations. It also includes enhanced test options and a safety documentation is available to enable the usage of this 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



TLE4999I3/TLE4999C8¹⁾

Fully ISO 26262-compliant linear Hall ICs



Dual channel linear Hall sensor with PSI5 or SPC interface, designed to meet the requirements of safety critical automotive and industrial applications

Our newest members in our broad magnetic position sensor portfolio are the fully ISO 26262-compliant linear Hall sensors for high precision applications.

The TLE4999 sensors are dual channel linear Hall sensors with PSI5 or SPC communication interfaces, compliant to ISO 26262, supporting safety requirements on system level rated up to ASIL D.

Furthermore TLE4999 linear Hall ICs feature two highly accurate Hall measurement channels on a single chip. A plausibility check of two independent and redundant channels on system level enables a high diagnostic coverage. Highest accuracy over a wide temperature range and lifetime is achieved by an integrated digital temperature- and stress-compensation.

Features

- › Two highly accurate redundant Hall measurement channels (main and sub) integrated on one chip
- › Developed compliant to ISO 26262 for safety requirements rated up to ASIL D
- › PSI5 v2.1-compatible interface in synchronous mode with high speed P10P-400/4H protocol (TLE4999I)
- › Fast digital SPC interface with min. 0.5 μ s unit time for transmission of main and sub signals in less than 500 μ s (TLE4999C)
- › Bus capability for up to 4 bus members (TLE4999C)
- › Bi-directional interface for programming via fast SICI interface
- › 13-bit output signals, protected by CRC and rolling counters
- › Digital temperature and stress compensation
- › 3-pin or 4 pin leaded package and 8 pin SMD package options for mounting in PCB-less modules
- › Operating junction temperature range -40°C to 150°C
- › 9 point sensor calibration (TLE4999C)
- › Main and sub channel programmable independently in EEPROM
- › 16-bit user-configurable ID in EEPROM
- › Supply voltage 5.5 to 7 V

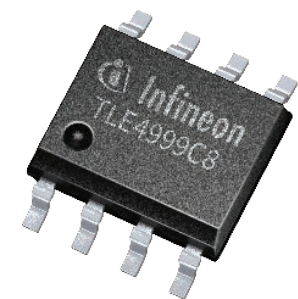
Applications

- › Brake and acceleration pedals
- › Valve or flap position sensing
- › Steering torque sensing
- › High-speed applications
- › Automotive and Industrial safety
- › Any other kind of precise and fast linear measurement application

1) TLE4999C8 planned for 2021, TLE4999C4 planned for 2022



Ranked No. 1 for measurements and sensors



ISO 26262
compliant

TLE499x family

Programmable analog/digital linear Hall sensor family



Infineon'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), TLE4998C with Short PWM Codes (SPC) and the TLE4999I3 with Peripheral Serial Interface (PSI5) and the TLE4999C with SPC. While the TLE4998 devices base on a 12-bit resolution, the TLE4999 delivers a resolution of 13-bits. A newly introduced multipoint linearization feature for the TLE4999C enables to increase the sensing accuracy by adjusting to non linear behavior of magnetic circuit designs. All sensors feature an 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. TLE4999 and TLE4998 sensors also include 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 and TLE4999)
- › 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 is fully ISO 26262 compliant

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

1) More information on PRO-SIL™, see page 73

One sensor channel per package

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 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 SSO-4-1 SSO-3-9 (2 capacitors) TDSO-8
TLE4998S	EEPROM	3/4/ Single die SMD 8	±8.2 to ±245 LSB ₁₂ /mT	< ±400 μT	5 V ±10% (16 V)	●	Ready	SENT	SSO-3-10 SSO-4-1 SSO-3-9 (2 capacitors) TDSO-8
TLE4998C	EEPROM	3/4/ Single die SMD 8	±8.2 to ±245 LSB ₁₂ /mT	< ±400 μT	5 V ±10% (16 V)	●	Ready	SPC	SSO-3-10 SSO-4-1 SSO-3-9 (2 capacitors) TDSO-8
TLE4999I3	EEPROM	3	±73.72 to ±147.44 ²⁾ LSB ₁₃ /mT	< ±300 μT	5.5–7 V ±10% (16 V)	●	Compliant	PSI5	SSO-3-12
TLE4999C ³⁾	EEPROM	SMD 8	±73.72 to ±147.44 ²⁾ LSB ₁₃ /mT	< ±300 μT	5.5–7 V ±10% (16 V)	●	Compliant	SPC	TDSO-8

2) 147.44 LSB₁₃ converts to 294.88 LSB₁₂

3) TLE4999C8 planned for 2021, TLE4999C4 planned for 2022

Two sensors in one SMD package



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

Infineon offers a wide range of Hall sensors in the TDSO package. The two sensors in one package offer sensor redundancy in one package. Sensor redundancy 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 single-sensor solution with only one sensor.

The newest members of the TLE499x family, the TLE4999I3 and TLE4999C8 were developed in full compliance with ISO 26262. Both products include 2 sensor channels on one chip. The products support SPC and PSI5 communication interfaces and come in leaded or SMD package options.

Two sensor channels in one package

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 ¹⁾	Compliant	SSO-3
TLE4999C8 ²⁾	SPC	monolithic ¹⁾	Compliant	TDSO-8

1) 2 sensor channels on one chip

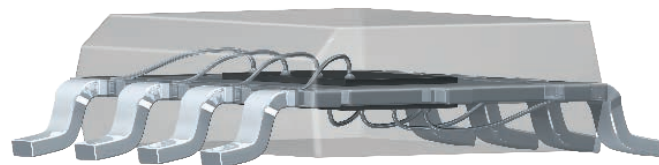
2) TLE4999C8 planned for 2021, TLE4999C4 planned for 2022

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
- > TLE4999x ISO 26262 compliant

Automotive applications

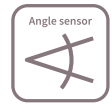
- > Steering torque systems
- > Pedal position
- > Any other safety critical application



1) More information on PRO-SIL™, see page 73

Angle sensors

Compact designs in small outline packages – at highest functional safety



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

Infineon offers a broad variety of high-precision angle sensors in all common technologies such as AMR (Anisotropic Magnetoresistive), GMR (Giant Magnetoresistive) and also TMR (Tunnel Magnetoresistive). The xMR technologies are complementary. Addressing any kind of rotation applications Infineon's sensor portfolio consists of 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. They are also ready to be used in industrial and consumer applications like robotics or gimbal. Angle sensors detect the orientation of an applied magnetic field by measuring sine and cosine angle components with monolithically integrated magneto resistive elements.

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

The new TLE5109A16 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.

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/ 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°, 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



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: $T_A = -40$ to 150°C (ambient temperature)
- › For TLE5501 E0002:
 - Reaching ASIL D with just one single sensor chip
 - ISO 26262-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

TLE5014(D)

Digital iGMR sensor with an easy-to-use plug-and-play concept for highest functional safety applications



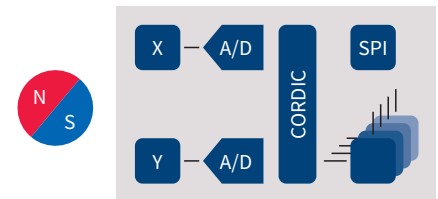
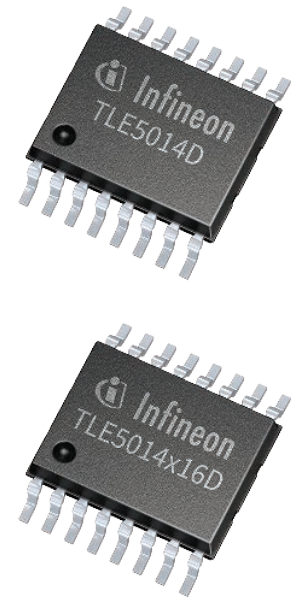
All XENSIV™ TLE5014 angle sensors are available as single and dual die products. The products come pre-configured and pre-calibrated as plug-and-play sensors and are easy to use. Customers can choose between the interfaces SENT, PWM, SPC and SPI. On top of those protocol options, the sensors can be adapted to any kind of application setup via their programmable E²PROM 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
 - 12-bit digital interface with protocol options PWM, SENT, SPC and SPI
 - E²PROM 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 73

TLE5109A16(D) Analog iAMR sensor with temperature compensation



The TLE5109 product family covers Infineon Technologies AG's new ultra-precise, fast analog AMR-based angle sensors which can be used within a very broad magnetic field range, starting at 10 mT reaching up to more than 500 mT. One major benefit of the Infineon iAMR technology is its high angle accuracy, reaching typical values of only 0.1° angle error. Especially at low magnetic fields of 10 ... 20 mT where typically the angle error significantly increases, TLE5109 products are outperforming the market due to their benchmark small typical angle error of only 0.2°. Reaching such low error values at low magnetic fields, TLE5102 products enable very cost-efficient systems as customers can use less powerful and thus more economical magnets.

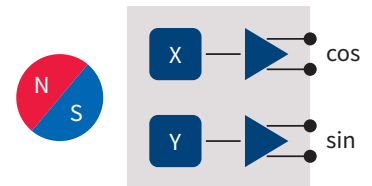
The AMR-based XENSIV™ TLE5109A16 family is complementing the already existing GMR-based TLE5109A16 and diverse TLE5309D products from Infineon. Identical pin-configuration and interfaces of all TLE5x09 sensors inside TDSO-16 package enable customers to switch from one to another product or product version very quickly and at low design-in efforts.

Features

- › Wide magnetic field range: from 10 mT up to > 500 mT
- › High angle accuracy with only 0.1° overall angle error (typ.)
- › Best-in-class typ. angle error of only 0.2° within range 10 ... 20 mT
- › Separate supply pins for top and bottom sensor
- › Low current consumption
- › Quick start-up
- › Optimized 3.3 V or 5 V supply voltage
- › Pre-amplified output signals for differential or single-ended applications for AMR sensor
- › TDSO-16 package
- › Automotive qualified acc. to AEC-Q100
- › Ready for ISO 26262, targeting ASIL D (dual die product)

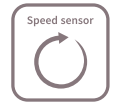
Applications

- › BLDC motor position (e.g. pumps, wipers, brakes and other actuators)
- › EPS rotor position
- › Pedals and rotary switches
- › Valve or flap position sensing
- › Steering Angle Sensing (SAS)
- › Electric motors
- › Magnetic encoders
- › High-speed applications
- › Automotive and industrial safety



1) More information on PRO-SIL™, see page 73

Magnetic speed sensors



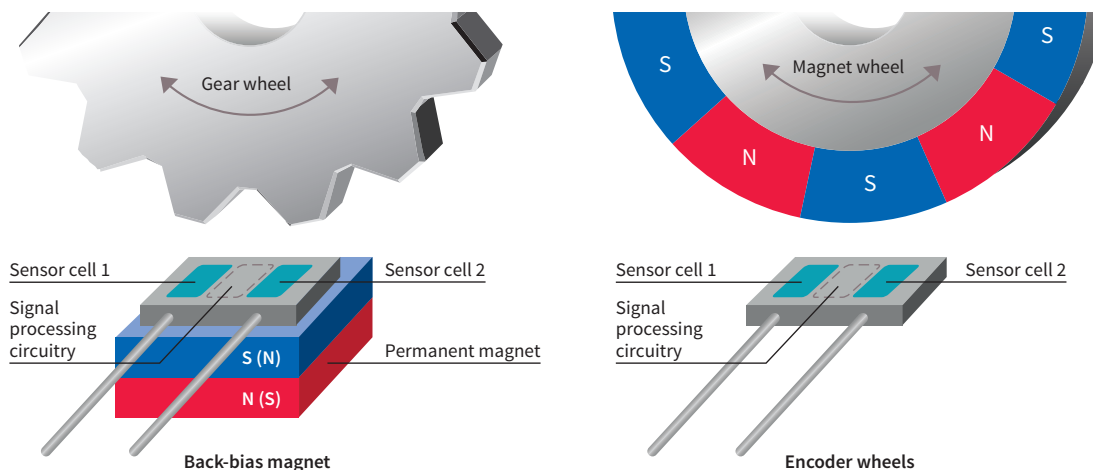
Our Hall- and GMR-based speed sensors are designed to measure speed in safety and powertrain applications such as ESP, ABS, camshafts/crankshafts and automatic transmissions. They may be also used in comparable applications in the industrial sector. The sensors use a ferromagnetic toothed wheel or a magnetic encoder structure to measure rotational speed. We offer a broad range of options to ensure the perfect fit for individual customer applications, including voltage and current interfaces with a variety of different protocols and algorithms, such as e.g. vibration suppression. By integrating the magnetic Hall or

GMR sensing cell and the signal processing unit on a single chip, we deliver optimum performance and cost savings.

The majority of sensors also feature additional benefits such as integrated capacitors (C- types) for high EMC robustness and the highest levels of ESD protection.

We have an outstanding record of excellence in the automotive sector. Infineon's sensors deliver extremely reliable results in safety-relevant applications such as ESP and ABS, and in extremely harsh environments such as engines and transmissions.

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

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Applications

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



TLE4922

2-wheeler speed sensors – cost effective, highly robust, easy-to-use, flexible mounting

This sensor is specially designed for two-wheeler applications, but can also be used in industrial applications. TLE4922 can 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 enables good accuracy over air-gap jumps and immunity to vibration and run-out events. Thanks to its mono-cell design, it is the perfect choice for applications requiring twist-independent mounting. Thus the TLE4922 is well suited for replacing passive sensors, such as Variable Reluctance Sensors (VRS), in two-wheeler applications by providing the user with higher accuracy and a better jitter performance.



Features

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

Applications

- › 2-wheeler
- › Automotive vehicle speed

TLE4924/26/27/28C

High-performance speed sensor family

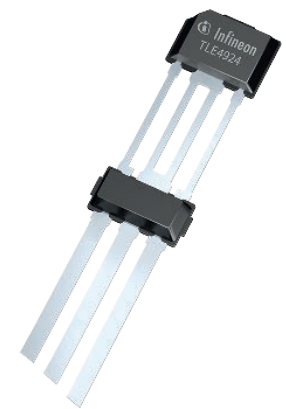
Our proven family of TLE492x differential Hall speed sensors is designed for a broad range of high-performance speed sensing applications in harsh environments, due to the hysteresis and dynamic self-calibration algorithm. All sensors have a three-wire voltage interface, fast start-up time, symmetrical switching thresholds and optional south or north pole pre-induction.

Features

- › High sensitivity and large operating air-gaps
- › Excellent switching performance down to a 1 Hz cut-off frequency
- › Broad operating temperature range
- › High protection against reverse voltage, short circuit and overtemperature
- › Strong EMC robustness and micro-cut performance thanks to module-style package with integrated 47 nF/4.7 nF capacitors
- › Option to use innovative iBB package solution
- › AEC-Q100 qualified

Applications

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



Product	Hysteresis	Comment	Package
TLE4924C-1	Visible fixed	–	SSO-3-9
TLE4924C-2	Visible adaptive	–	SSO-3-9
TLE4926C	Hidden fixed	–	SSO-3-9
TLE4926C-HT	Hidden fixed	High temperature profile	SSO-3-9
TLE4927C	Hidden adaptive	–	SSO-3-9
TLE4928C	Hidden fixed	200 ms watchdog reset	SSO-3-9

TLE4929 Advanced crankshaft sensor family

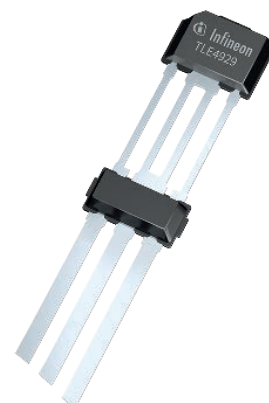
TLE4929 are active Hall sensors ideally suited for future crankshaft applications and similar industrial applications, such as speedometer or any speed-sensor with high accuracy and low jitter capabilities.

Features

- > Differential Hall speed sensor to measure speed and position of tooth/pole wheels
- > Switching point in middle of the tooth enables backward compatibility
- > Robustness over magnetic stray-field due to differential sensing principle
- > Digital output signal with programmable output-protocol including diagnosis interface
- > Direction detection and stop-start-algorithm
- > Vibration algorithm tailored to hybrid powertrains
- > High accuracy and low jitter
- > High sensitivity enable large air-gap
- > End-of-line programmable to adapt engine parameters
- > Can be used as a differential camshaft sensor
- > Automotive operating temperature range

Applications

- > Crankshaft, speed and position sensing



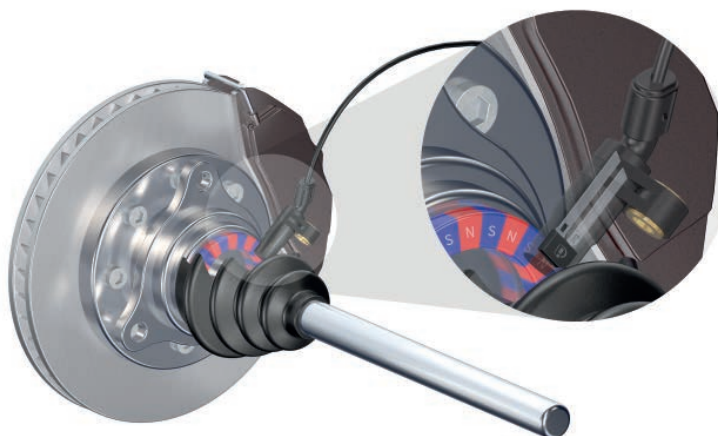
Product	Differentiating features	Package
TLE4929C-X2A	Designed for two-wheeler crank applications	SSO-3-53
TLE4929C-XAF	Programmable EEPROM	SSO-3-52
TLE4929C-XAN	Preprogrammed EEPROM	SSO-3-52
TLE4929C-XVA	<ul style="list-style-type: none"> > Additional protocol options > Additional watchdog for low speed and start-up 	SSO-3-52 SSO-3-53
TLE4929C-XHA	<ul style="list-style-type: none"> > Additional protocol options > Additional watchdog for low speed and start-up > Vibration algorithm tailored to hybrid powertrains > Programmable switching threshold 	SSO-3-53

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



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 to 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
TLE4941plusC	Hall differential	●	●	-	-	Standard	-
TLE4942-1C	Hall differential	●	●	-	●	PWM	-
TLE4943C	Hall differential	●	●	-	●	AK	-
TLE5045iC	iGMR differential	●	-	Compliant	-	Standard	●
TLE5046iC-PWM	iGMR differential	●	-	Compliant	●	PWM	●
TLE5046iC-AK	iGMR differential	●	-	Compliant	●	AK	●

TLE4953C

The two-wire transmission speed sensor

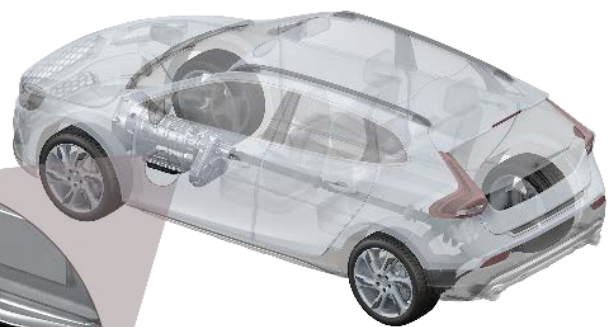
The differential Hall sensor TLE4953C can detect direction and was developed specifically to meet the needs of high-end transmission applications. Its jitter performance and high sensitivity enables designers to create high-accuracy systems with excellent vibration suppression. Adaptive hysteresis and 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.

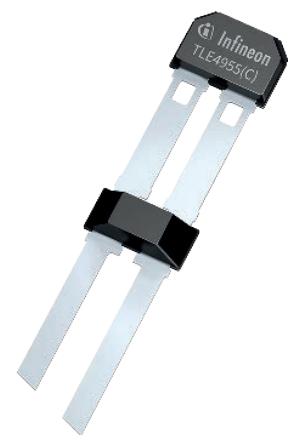
Features

- › 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

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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.

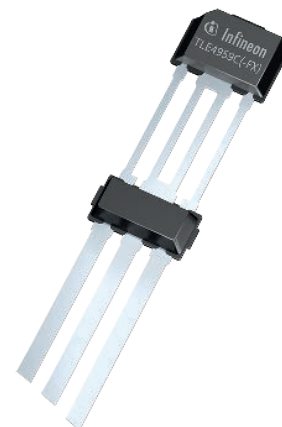
While TLE4959C is provided with the standard protocol, the FX version gives access to different protocols (e.g. speed only) as it is to be programmed at the customer's premises.

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)

Applications

- > Automatic (hybrid) transmission systems



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

Target applications

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



TLE4983/84C

Outstanding camshaft sensing

Our TLE4983/84 chopped mono-Hall sensor family comprises an excellent dedicated feature set. It is highly robust and is equipped with a module-style package with integrated capacitors. Due combining all these features, its the ideal opportunity for automotive camshaft applications. The product family meets all key camshaft sensor requirements including true power-on, Twist-Independent Mounting (TIM) and high phase accuracy for optimum fuel-injection timing. Both sensors deploy a dynamic self-calibration algorithm with programmable power-on and a dynamic switching point. TLE4984, for example, uses an algorithm, that enables fast threshold adjustments with small step sizes during the pre-calibration phase. This, in turn, allows thresholds to be adjusted very accurately. In contrast, the step sizes used by TLE4983 in the pre-calibration phase are approximately 10 times larger. TLE4983 therefore requires only half of the switching events used by TLE4984 to reach calibration mode. These flexible options give designers the freedom to choose the best start-up concept for individual system requirements.

Features

- › True power-on and high phase accuracy for optimal fuel injection timing
- › Self-calibration algorithm for fast start-up and precise calibration
- › Twist-Independent Mounting (TIM)
- › High temperature operating range and EMC robustness
- › Three-wire digital voltage interface (PWM)
- › AEC-Q100 qualified

TLE4986C

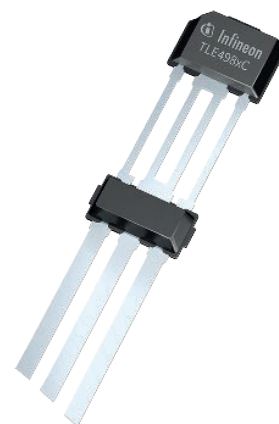
Leading performance

TLE4986C is the latest chopped mono-Hall sensor for automotive camshaft applications. It meets the most stringent requirements for phase accuracy, true power-on, EMC and temperature robustness. TLE4986C can be programmed to achieve the highest system performance with the widest range of target wheels, thus enabling designers to optimize the costs of a mechanical system, while obtaining the highest phase accuracy and greatest robustness against effects such as run-out. The temperature coefficient of the magnet can also be configured to ensure, that the sensor is adapted to the magnetic back-bias design. As with the TLE4983/84 family, TLE4986C also comes with proven features such as a dynamic self-calibration algorithm and module-style package plus integrated capacitors for optimal micro-break and EMC behavior.

Features

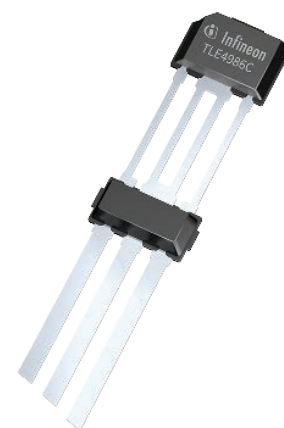
- › True power-on and highest phase accuracy for optimum fuel injection timing
- › Extensive programming options for flexible design of magnetic circuits and optimized performance
- › Self-calibration algorithm for fast start-up and precise calibration
- › Highest temperature operating range and EMC robustness
- › Best-in-class micro-break performance
- › Twist-Independent Mounting (TIM) capability
- › Three-wire digital voltage interface (PWM)
- › AEC-Q100 qualified

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Applications

- › Camshaft speed and position sensing



Applications

- › Camshaft speed and position sensing

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 μ Cut feature
- › Digital magnet temperature compensation
- › Mechanical stress compensation
- › Module package PG-SSO-3-5

TLE5027C/28C

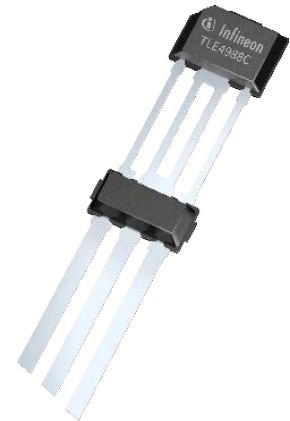
iGMR-based speed sensor

TLE5027C is the world's first 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. TLE5027C can detect the rotation direction of a wheel and transmit 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. The TLE5028C adds an improved immunity towards ESD and EMC to address the problems, caused by harsh high power environments like from hybrid systems. TLE5027C and TLE5028C are 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 from TLE5028C

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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	TLE4924	TLE4926	TLE4927	TLE4928	TLE4929	TLE4941	TLE4941plusC	TLE4942	TLE4943	TLE4953	TLE4955	TLE4959	TLE4983	TLE4984	TLE4986	TLE4988	TLE5025	TLE5027	TLE5028	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	Diff. Hall	Diff. Hall	Diff. Hall	Diff. Hall	Diff. Hall	Mono-Hall	Mono-Hall	Mono-Hall	Mono-Hall	iGMR	iGMR	iGMR	iGMR	iGMR	iGMR
Improved air-gap/jitter performance		-	-	-	-	-	-	•	-	-	-	-	-	-	•	-	-	-	-	•	•	•	•	•	•	
Direction information available		-	-	-	-	-	-	•	-	-	•	•	•	•	-/• ³⁾	-	-	-	-	-	-	•	•	-	-	•
True Power On (TPO)		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	•	•	•	•	-	-	-	-	-	
Twist-Independent Mounting (TIM)		-	•	-	-	-	-	-	-	-	-	-	-	-	-	-	•	•	•	•	-	-	-	-	-	
Vibration suppression algorithm included		-	-	-	-	-	-	•	-	-	-	-	•	•	•	-	-	-	-	-	-	-	-	-	-	
Type of hysteresis ¹⁾		V	H	V	H	H	H	H/V	H	H	H	H	V	V	V	H	H	V/H	V/H	H	H	H	H	H	H	
		F	A	A/F	F	A	F	A/F	F	F	F	A	A	A	A	F	F	P/A	P/A	A	A	A	F	A	A	
Interface ²⁾	# of pins	4	4	3	3	3	3	3	2	2	2	2	2	2	2	3/4	3	3	3	3	3	3	3	2	2	2
	Interface	V	V	V	V	V	V	V	C	C	C	C	C	C	C	V	V	V	V	V	V	V	V	C	C	C
	Protocol	S	S	S	S	S	S	S	S/P	S	S	P	AK	P	P	P	S	S	S	S	S	P	P	S	S	P/AK
Electrostatic Discharge (ESD)	Human Body Model (HBM)	2 kV	3 kV	6 kV	6 kV	6 kV	6 kV	6 kV	12 kV	12 kV	12 kV	12 kV	12 kV	12 kV	12 kV	6 kV	4 kV	4 kV	6 kV	6 kV	8 kV	8 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 diferent 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 CO₂ emissions. Thanks to their accurate measurement capability, Infineon MAP and turbo MAP product with analog or digital interface enable engines to meet these requirements.



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 I²C/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 are ideal for a wide range of applications in automotive and industrial sectors. Typical applications in automotive include side airbag, engine control and seat comfort with high quality, highly accurate products adhering to ISO 26262 standard. Infineon offers the ideal portfolio for these systems.

The analog and digital interfaces of Infineon XENSIV™ pressure sensors provide customers with a high degree of design flexibility and enable manufacturers to meet evolving market demands.

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 function
- › 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 40 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

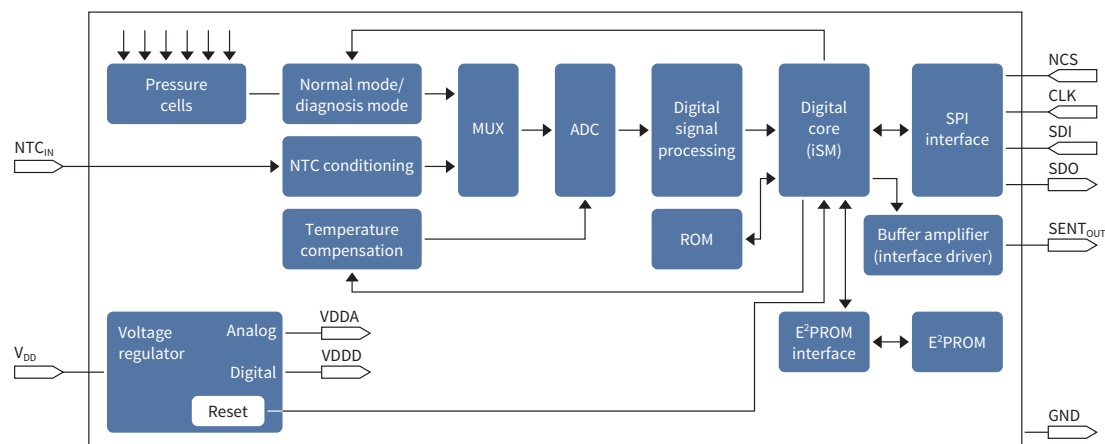


KP25x/KP264 – Digital barometric air pressure (BAP) sensor IC family

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 40 to 165 kPa
- > Temperature range from -40 to +125°C
- > Green SMD package
- > Package option with small 4-hole lid
- > ISO 26262 ready

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 ± 0.77 percent FSS
- > Green SMD package
- > Temperature range -40 to +170°C
- > Integrated NTC temperature sensor functionality with fast start up time (typ. 10ms)

Integrated pressure sensor ICs for manifold and barometric air pressure

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

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

Digital barometric pressure sensors

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 ultrahigh precision ($\pm 2/\pm 5$ cm) and relative accuracy (± 0.6 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 I2C/SPI interface.

DPS310

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

DPS422

Monolithic chip solution that has an ultrasmall critical area and a very thin package (0.73 mm typ.). Beneath high precision pressure metering, DPS422 offers also highly accurate absolute temperature sensing ($\pm 0.4^\circ\text{C}$), which is required in applications like weather stations, thermostats, etc. It can be used in applications such as weather stations/smart thermostats and offers additional features by pressure sensing (e.g. intruder detection, weather forecast).

DPS368

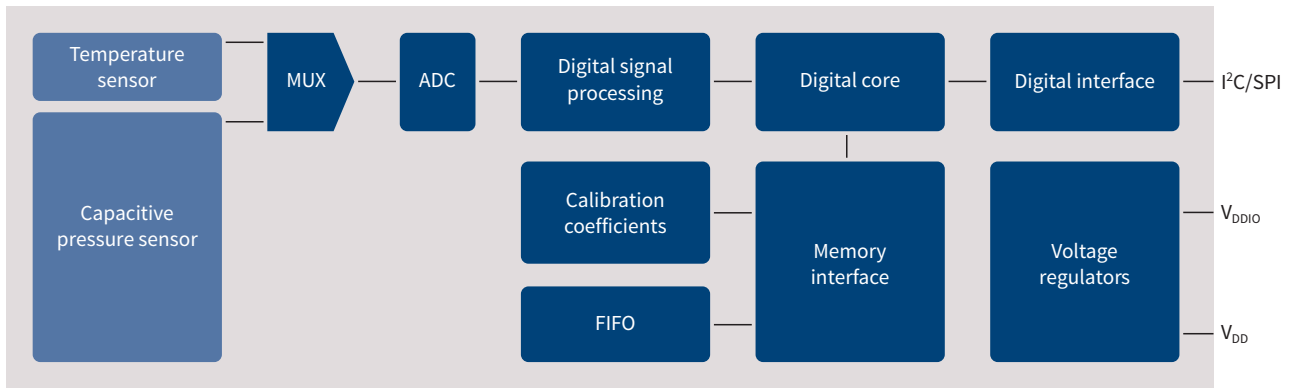
DPS368 offers the best-in-class resolution (± 2 cm), a very fast read-out speed and a low current consumption. The sensor can be used in harsh environment, as it is robust against water (IPx8 - 50 m under water for 1 hour), dust and humidity. The small package size saves up to 80 percent of the space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

Typical applications

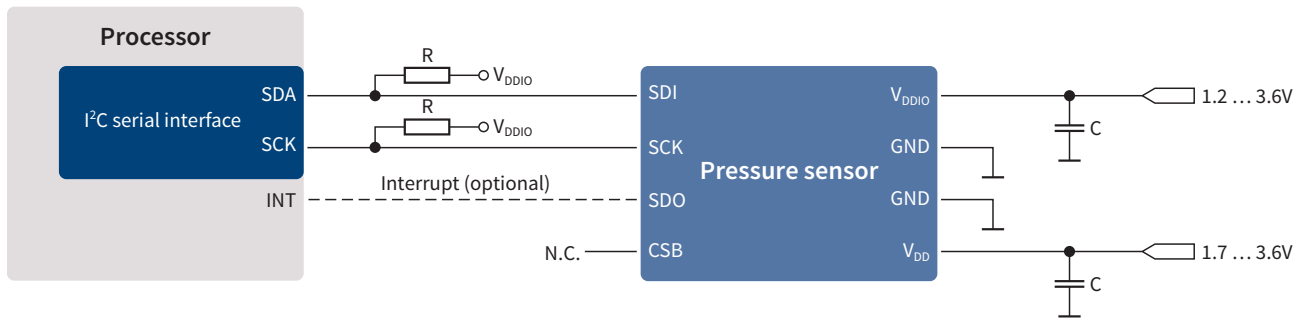
- > Drones: altitude detection and height stability
- > Health and fitness: accurate elevation gain and step counting (e.g. for smart watches)
- > Outdoor navigation: GPS start-up time/accuracy improvement; dead reckoning (e.g. in tunnels)
- > Indoor navigation: floor detection e.g. in shopping malls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

Key product features	DPS310	DPS422	DPS368
Package size	LGA 8-pin: 2.0 x 2.5 x 1.0 mm	LGA 8-pin: 2.0 x 2.5 x 0.73 mm	LGA 8-pin: 2.0 x 2.5 x 1.1 mm
Operating pressure range	300 ... 1200 hPa		
Operating temperature range	-40 ... 85°C		
Pressure level precision	± 0.005 hPa (or ± 0.05 m)		± 0.002 hPa (or ± 0.02 m)
Relative accuracy	± 0.06 hPa (or ± 0.5 m)		
Absolute accuracy	± 1 hPa (or ± 8 m)		
Temperature accuracy	0.5°C	< 0.4°C	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 μA pressure measurement, 1.5 μA temp. measurement, standby 0.5 μA	1.7 μA pressure measurement, 2.0 μA temp. measurement, standby < 1 μA	1.7 μA pressure measurement, 1.5 μA temp. measurement, standby 0.5 μA
Supply voltage	V_{DDIO} : 1.2 – 3.6 V; V_{DD} : 1.7 – 3.6 V		
Operating modes	Command (manual), background (automatic), standby		
Interface	I ² C and SPI, both with optional interrupt		

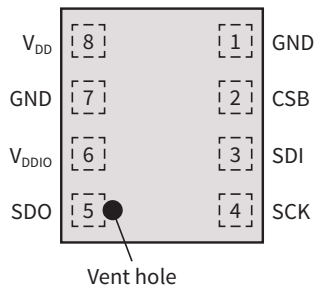
Functional block diagram



Application circuit example (in I²C configuration)



Pin configuration (Top view)

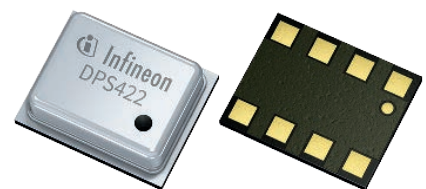
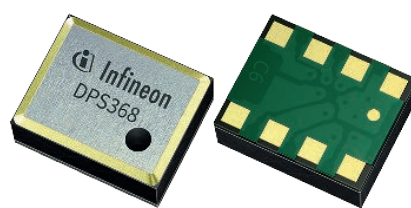


Pin	Name	Function
1	GND	Ground
2	CSB	Chip select
3	SDI	Serial data in/out
4	SCK	Serial clock
5	SDO	Serial data out
6	V _{DDIO}	Digital interface supply
7	GND	Ground
8	V _{DD}	Analog supply

DPS310 package drawing

DPS368 package drawing

DPS422 package drawing



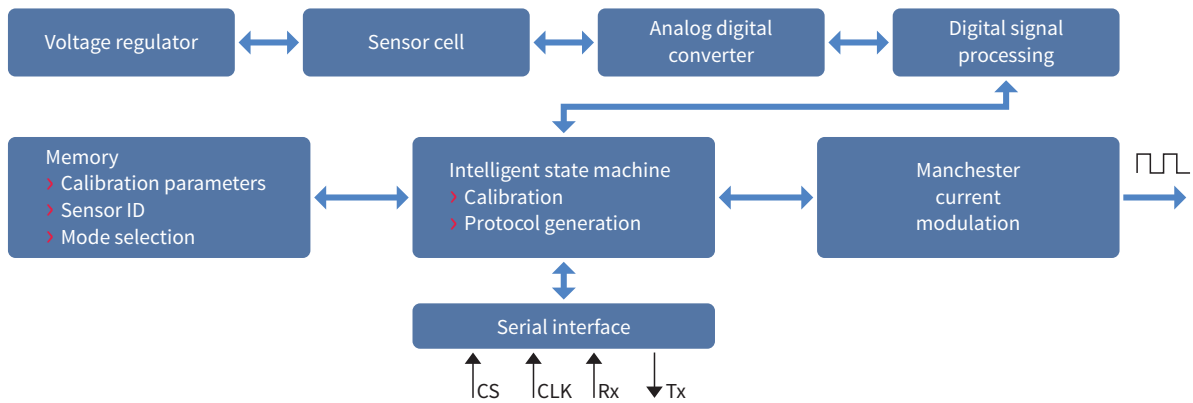
KP200/KP201/KP204

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 73



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.

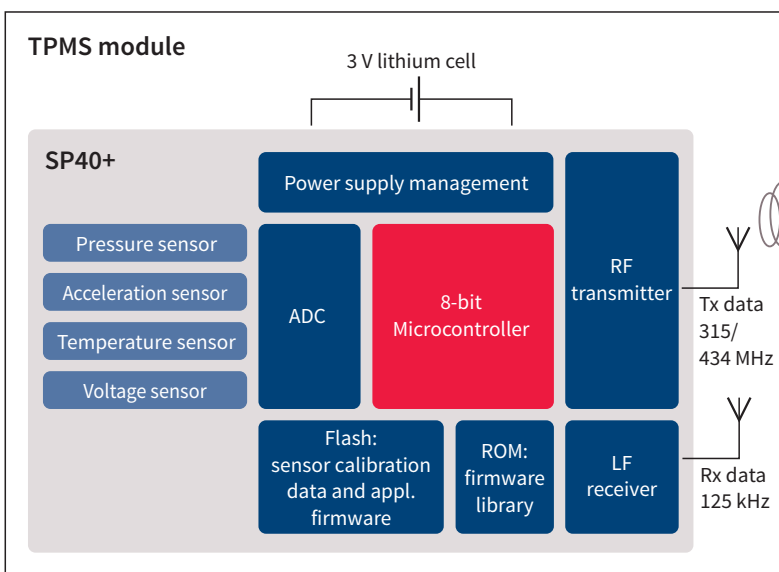
SP40+ measures pressure, radial acceleration, temperature and supply voltage and is certified as a green package compliant with RoHS. SP40+ comes with a pressure-auto-ranging feature, providing best-in-class pressure-accuracy in the range from 100 to 1400 kPa, making it the ideal choice for all car types 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"> > Highest integration > Very low energy consumption > Robust g- and p- sensor > High LF sensitivity
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)

Radar sensors ICs

Giving “eyes” to all sorts of things

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

Infinion 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 high modulation bandwidth up to 2 GHz using 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.

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

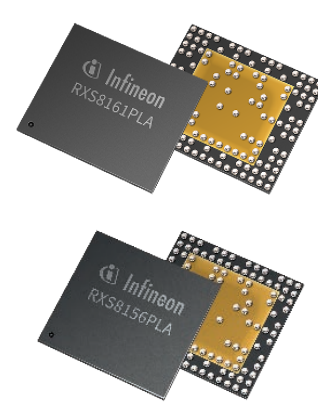
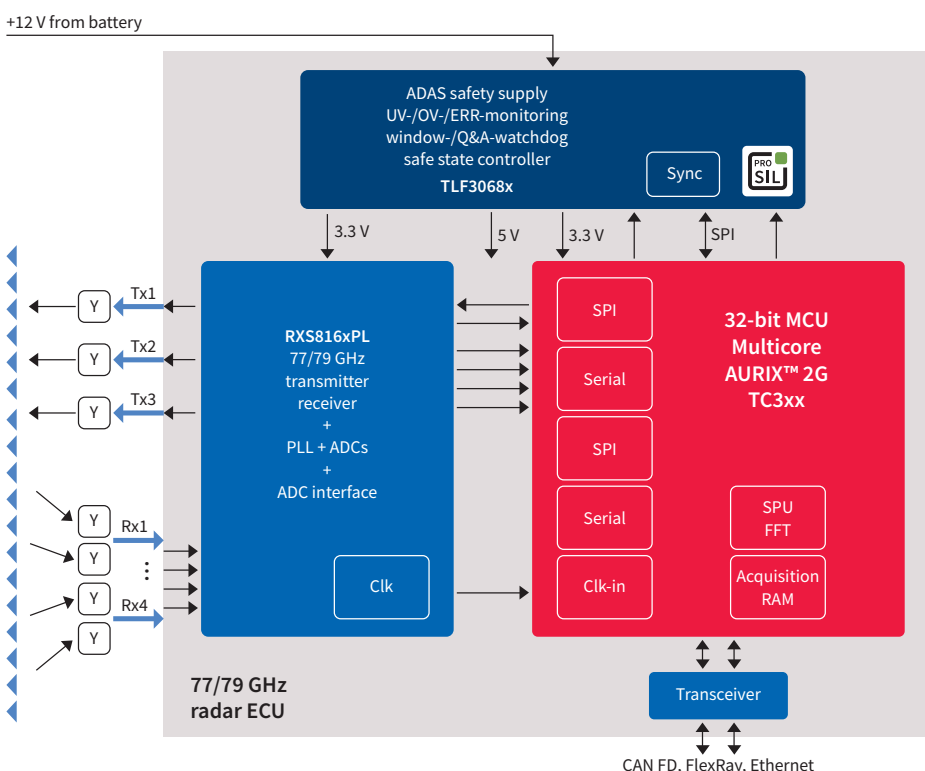
- › Radar 77/79 GHz RF Millimeter Wave IC family (RASIC™ RXS816xPL)
- › Radar MCU family featuring radar signal processing units (2nd generation AURIX™ TC3xx)
- › Radar system power supply with numerous safety functions (TLF3068x)
- › Very compact 3-chip configuration (RXS816xPL+ AURIX™ TC3xx + TLF3068x)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

Product	Configuration	Key benefits	Features
RXS816xPL ¹⁾	3Tx4Rx	Single- and multi-chip versions in 7 x 8.5 mm eWLB package	<ul style="list-style-type: none"> › Flexible FMCW waveform generation › Up to 2 GHz modulation bandwidth
RXS8156PLA ¹⁾	2Tx4Rx	Cost efficient solution for corner radars in 7 x 7.5 mm eWLB package	<ul style="list-style-type: none"> › Four receive channels featuring integrated filters + AD converters › 4 channel LVDS data interface

1) Coming soon



24 GHz radar sensor ICs

Infinion offers a wide portfolio of mmWave radar sensors to address different customer requirements. The BGT24M/L family is the largest and highest integrated 24 GHz radar transceiver family currently on the market, saving ~30 percent board space compared to discrete lineups. Infineon provides a total of five 24 GHz industrial radar chips, providing a range of different transmitter and receiver channel configurations, supporting different application requirements.

Applications

- > Building and smart home (IoT)
- > Indoor/outdoor lighting
- > Security
- > UAV/multicopters
- > Robotics
- > Smart street lighting

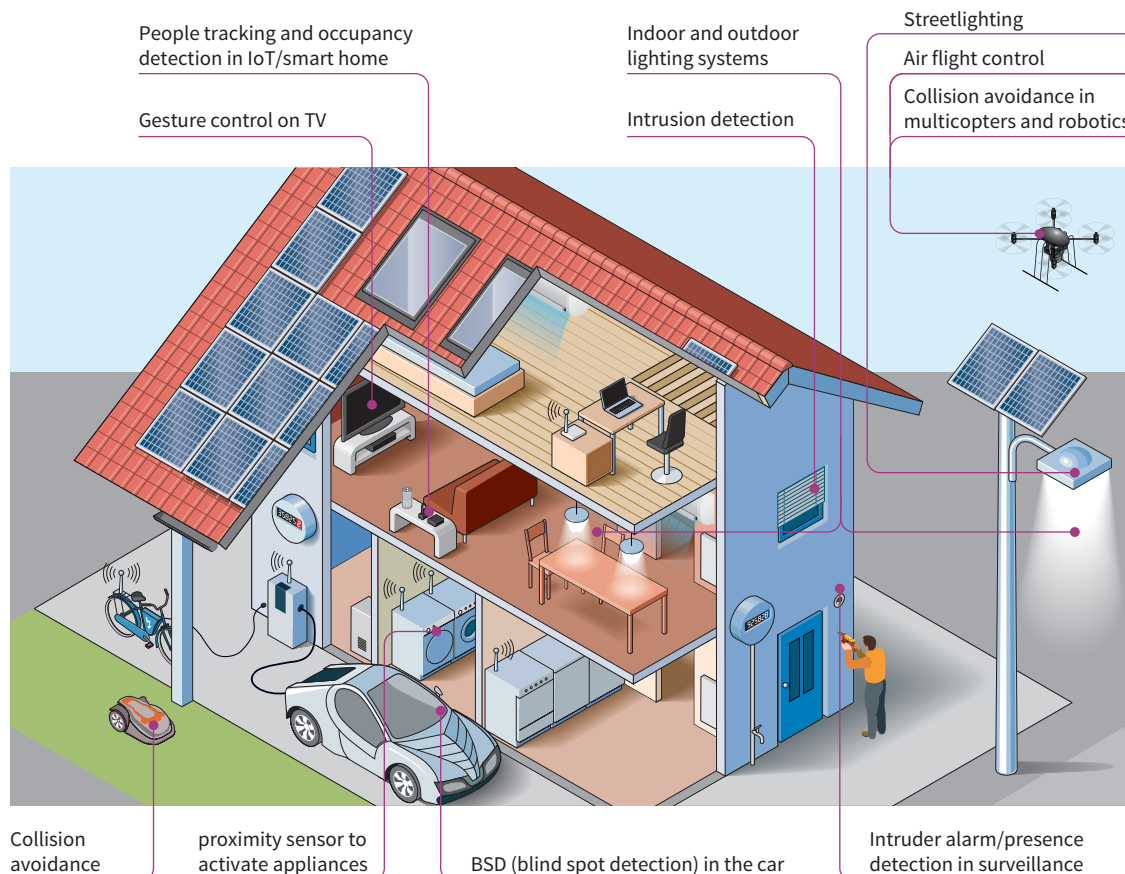


Key benefits

- > Direction, proximity and speed detection
- > Hidden mounting capability
- > Maintains operation through harsh weather conditions
- > Motion tracking
- > Sensitive enough to capture breathing and heartbeat
- > Target positioning
- > Adaptable to different application requirements

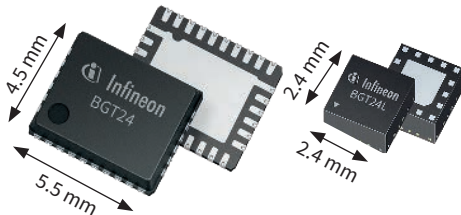
In addition to the BGT24M/L family of MMIC chips, Infineon provides a continuously expanding range of evaluation and demonstration boards to support the testing and development of radar in multiple applications. All boards are provided with base level software to support the ease of use and faster time-to-market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

Utilizing our strong network of partners, the radar portfolio is extended to include a range of easy-to-integrate modules. Each of them contains Infineon's 24 GHz MMIC.



Infinion BGT24M/L family of MMIC chips

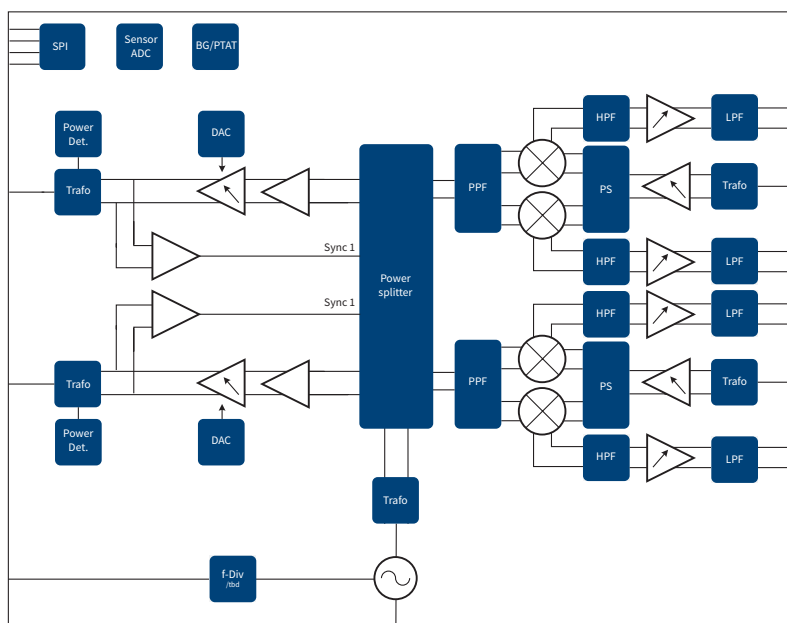
Infinion's range of 24 GHz industrial radar chips provides five configurations of transmit and receiver channels, ensuring that there is a chip to support your specific application. From basic applications such as motion detection in security systems, which only requires one transmit and one receive 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	Infinion MMIC	Benefits
<ul style="list-style-type: none"> > 24 GHz ISM band operation for motion, speed, direction movement and distance measurements > 5 MMIC chips available > Highly integrated 		<ul style="list-style-type: none"> > Long range distance detection of moving objects up to 30 m > Wide range speed detection up to ±100 km/h > Lower BOM costs

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

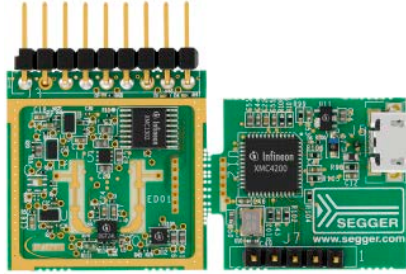
The BGT24LTR22N16 key features

- > 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

Infineon's range of 24 GHz evaluation and demo boards continues to expand to support the needs of our customers and the increasing number of innovative ways radar is being incorporated into new applications.

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

Sense2GoL Pulse (BGT24LTR11 + XMC4700)	Distance2Go (BGT24MTR11 + XMC4200)	Position2Go (BGT24MTR12 + XMC4700)
<ul style="list-style-type: none"> > Capability to detect motion, speed and direction of movement (approaching or retreating) > Detection range of 18 m for human target at a power consumption < 5 mW > High sensitivity of detection in comparison to PIR > Arduino compatible microcontroller board (Arduino standard connectors) > Modulation parameters can be changed to suit the application requirements > Multiple current sensors for current consumption monitoring and optimization > Integrated multiple element patch antennas 	<ul style="list-style-type: none"> > Capability to detect distance of multiple targets > Capability to detect motion, speed and direction of movement (approaching or retreating) > Operates in harsh environments and detects through non-metallic materials > BGT24MTR11 – 24 GHz highly integrated RF MMIC > XMC4200 Arm® Cortex®-M4 –32-bit industrial microcontroller > Debug over Cortex 10 pin debug connector > Integrated multiple element patch antennas 	<ul style="list-style-type: none"> > Capability to detect and track position of multiple targets > Capability to detect distance of multiple targets > Capability to detect motion, speed and direction of movement (approaching or retreating) > Operates in harsh environments and detects through non-metallic materials > BGT24MTR12 – 24 GHz highly integrated RF MMIC > XMC4700 Arm® Cortex®-M4 –32-bit industrial microcontroller > Debug over Cortex 10 pin debug connector > Integrated multiple element patch antennas
<p>Main applications</p> <ul style="list-style-type: none"> > Security > Indoor and outdoor lighting > Smart home > Automatic door opener > Intelligent switches > Speed measurement 	<p>Main applications</p> <ul style="list-style-type: none"> > Drone: soft landing/obstacle avoidance > Smart toilets > Tank level sensing > Intelligent switches 	<p>Main applications</p> <ul style="list-style-type: none"> > Drone/robots: obstacle avoidance > Security > People tracking (IoT, smart home) > Vital sensing
<p>Board dimensions</p> <ul style="list-style-type: none"> > Board 55 mm x 85 mm > Shield: 55 mm x 66 mm 	<p>Board dimensions</p> <ul style="list-style-type: none"> > Board 36 mm x 45 mm 	<p>Board dimensions</p> <ul style="list-style-type: none"> > Board 50 mm x 45 mm
<p>Kit contents</p> <ul style="list-style-type: none"> > RF radar shield: SHIELD_BGT24LTR11 > Programmed controller board: RADAR BB XMC4700 > Micro USB cable > Corner reflector > SW GUI to operate kit > Doppler FW and SW¹⁾ > Schematic and bill-of-materials of module 	<p>Kit contents</p> <ul style="list-style-type: none"> > User's manual > Demonstration board > Corner reflector > SW GUI to operate kit > FMCW FW and SW¹⁾ > Doppler FW and SW¹⁾ > Schematic and bill-of-materials of module 	<p>Kit contents</p> <ul style="list-style-type: none"> > User's manual > Demonstration board > Corner reflector > SW GUI to operate kit > FMCW FW and SW > Doppler FW and SW > Schematic and bill-of-materials of module

Learn radar with Infineon on 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.

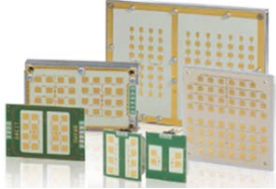
At www.infineon.com/makeradar, you will see how simple it has become to work with ultrasmall radar sensors.

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 own project.

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

24 GHz 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"> Complete module, including radar MMIC, antenna options, MCU signal processing options, and SW options (Doppler, FSK and FMCW versions available) 	 <p>Module (RF module; RF module + MCU including SW)</p>	<ul style="list-style-type: none"> Ease of design Turnkey solution, no need for test and certification

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 home automation, multicopter, robotics and street lighting, are reduced.

Lighting

Security

Touch free switches

Door automation



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 a 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.

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

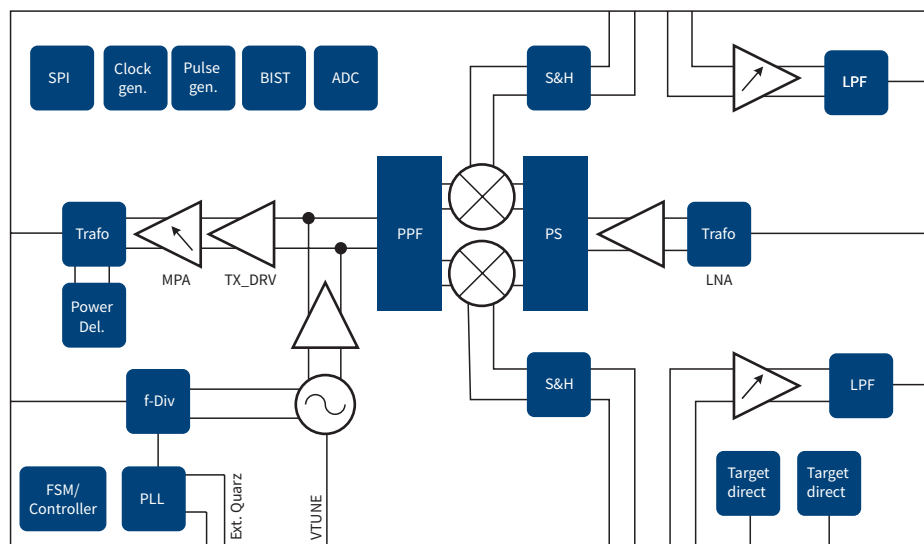
60 GHz radar sensor IC

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

BGT60LTR11AIP¹⁾ for consumer and IoT applications

With their small form factor and low power consumption, 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 localization in surveillance, lighting and smart home appliances. And also for vital sign tracking in consumer electronics, healthcare, driver assistance and industrial applications. The BGT60LTR11AIP¹⁾ is the smallest motion sensor in the market, featuring integrated antennas and integrated detectors. The device supports multiple operating modes including fully autonomous motion sensing that does not require any SW or HW design in effort.

Block diagram



Features and benefits

Key features
1 Transmit, 1 Receive
Integrated detectors
Small footprint: 6.7 mm x 3.3 mm
Radiated power = 8 dBm
Supports doppler and FMCW modes of operation
Antenna in package
Low cost and high integration

Key benefits
Macro motions without microcontroller
No antenna design necessary
Can also measure micromotion, speed and distance when using a microcontroller

Product portfolio

Product	Package
BGT60LTR11AIP ¹⁾	UF2BGA-42-1

1) Available Q3/2020





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>Pressure sensors</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>Radar sensors</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>MEMS microphones</p> <p>Digital 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>PAS CO2 sensor</p> <p>Leveraging photoacoustic spectroscopy (PAS), Infineon has developed an exceptionally small CO2 sensor that overcomes existing size, cost and performance challenges.</p>
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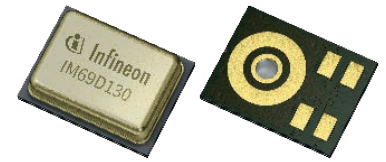
Today, sensors already enable interactions between people and devices

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.

MEMS microphone

Time to debottleneck your audio chain



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's MEMS microphones introduce a new performance class for digital MEMS microphones that overcome 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.



Don't miss a single thing!

With MEMS microphones, you can create a new user experience benchmark in audio recording.



Talk to tomorrow and be heard!

With MEMS microphones, you can define the benchmark in speech recognition for a new user experience.



Hear nothing but your favorite beats!

With MEMS microphones, you can create headsets offering users a benchmark noise cancellation experience.

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 μ s group delay at 1 kHz
- > Tight sensitivity (-36 ± 1 dB) and phase (± 2 deg) tolerances
- > 28 Hz low frequency roll-off
- > 4.0 x 3.0 x 1.2 mm package

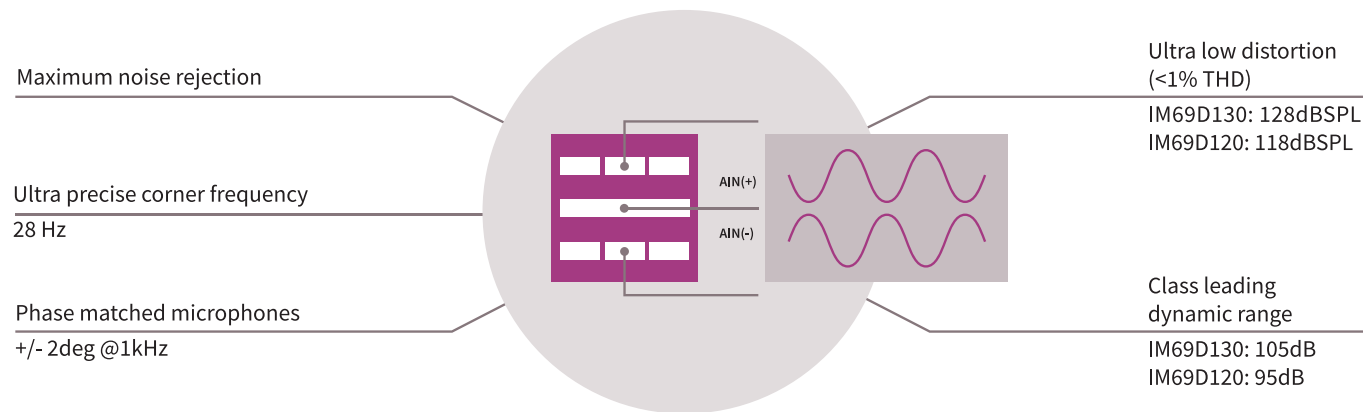
Benefits

- > 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

Infinion's dual backplate MEMS technology is based on a miniaturized symmetrical microphone design, similar as utilized in studio condenser microphones, and results in high linearity of the output signal within a dynamic range of 105 dB. The microphone noise floor is at 25 dB[A] (69 dB[A] SNR) and distortion does not exceed 1 percent even at sound pressure levels of 128 dB SPL (AOP 130 dB SPL). The flat frequency response (28 Hz low-frequency roll-off) and tight manufacturing tolerance result in close phase matching of the microphones, which is important for multi-microphone (array) applications.



Product	OPN	Package	Current consumption [µA]	Sensitivity [dBFS]	Signal to noise [dB]	Supply voltage [V]
IM69D130	IM69D130V01XTSA1	LLGA-5-1	980	-36	69	1.62 – 3.6
IM69D120	IM69D120V01XTSA1	LLGA-5-1	980	-26	69	1.62 – 3.6

Devices with voice user interface

TV, laptop and set top box

Digital voice assistance and robots

Smart home appliances

Conference

Security

Headsets

Audio

Industry 4.0

+ Highest beam-forming precision

+ Best speech recognition

+ Extended voice pick-up distance

+ Best audio quality

+ Ultra clear voice pick-up

+ Sensitive to softest audio signals

+ Best noise attenuation

+ Smallest pattern deviation detection

Environmental sensor ¹⁾

PAS CO2 sensor based on the photoacoustic principle

The PAS CO2 sensor is a real carbon dioxide (CO2) sensor in an unprecedented small form factor. Designed on the basis of a unique photoacoustic spectroscopy (PAS) concept, the sensor saves more than 75 percent space compared to existing commercial real CO2 sensors. Its direct ppm readings, SMD capability and simple design allow for a quicker and easier integration into customers' systems in low and high-volume applications alike.

The photoacoustic principle can be traced back to over 100 years ago and was first discovered by Alexander Graham Bell in 1880. The photoacoustic effect involves the formation of sound waves (pressure changes) following light absorption in a material sample. The sound signal is quantified by detectors, such as microphones. In order to obtain this effect, the light intensity must vary. A PAS gas sensor is based on the principle that gases absorb light in a specific wavelength of the infrared spectrum. CO2 molecules, for example, have strong absorption in the $\lambda = 4.2 \mu\text{m}$ wavelength.

The PAS CO2 sensor module integrates on the same PCB, the photoacoustic (PAS) transducer, a microcontroller for signal processing, algorithms and a MOSFET. As depicted in the block diagram, the PAS transducer includes:

- i) a proprietary infrared emitter with blackbody radiation which is periodically chopped by the MOSFET,
- ii) a narrow-band optical filter passing the CO2 specific wavelength $\lambda = 4.2 \mu\text{m}$, significantly improving the sensor selectivity compared to other gases, including humidity,
- iii) and Infineon's high-SNR (Signal-to-Noise Ratio) MEMS microphone IM69D130, detecting the pressure changes generated by the CO2 molecules.

All the components are developed and designed in-house in accordance with Infineon's high-quality guidelines. The sensor therefore benefits from Infineon's illustrious record of accomplishments in MEMS design and acoustic capabilities, leading to the best-in-class price/performance CO2 sensor.

The PAS CO2 sensor is ideal for smart-home and building automation as well as various indoor air quality IoT devices such as air purifiers, thermostats, weather stations and personal assistants. The sensor enables end users to track, understand and improve the air quality surrounding them in a timely and highly energy-efficient manner.

Key features

- > Unprecedented small form factor in an SMD module (14 x 13.8 x 7.5 mm²)
- > ppm reading of the CO2 level
- > Operating range
 - CO2: 0 ppm to 10,000 ppm
 - Temperature: 0°C to 50°C
- > Supply voltage
 - $V_{\text{DDIO}} = 3.3 \text{ V}$
 - $V_{\text{DD}} = 12 \text{ V}$
- > Interface: UART, I²C, PWM

Benefits

- > Saves space in customers' end products
- > Accurate and robust performance
- > Easy-to-integrate SMD module
- > On-board processing with the integrated microcontroller
- > Manufacturing scalability

Applications

- > Ventilation control/building automation
- > Smart appliances such as air purifiers, air conditioners
- > Consumer devices for air quality monitoring, such as thermostats, weather stations and personal assistants
- > Smart indoor lighting
- > In-cabin air quality monitoring



1) In market 2021

Functional safety – ISO 26262



ISO 26262 defines the development of electric and electronic automotive systems with regard to their functional safety. The aim of this standard is to reduce possible hazards caused by the failure and malfunction of such systems. The safety requirements for the development process depend on the ASIL rating of the target application and can range from ASIL A to ASIL D. Applications such as steering or braking systems are rated with the highest ASIL D level. A failure in such a system can lead to an out-of-control vehicle, possibly resulting in fatal injuries.

All newly developed parts, which are addressing a certain safety goal will be based on an ISO 26262-compliant development flow, thereby allowing direct use in all safety-relevant applications.

Devices which are developed prior to the ISO 26262 as a QM part can nevertheless be used in ISO-compliant systems as outlined in part 8 clause 13 of the standard. In such cases, it is mandatory “to provide evidence of the suitability of hardware components and parts” for use in ISO-compliant systems and also to provide failure modes, their distribution and diagnostic capability.

To support our customers as they strive to achieve the highest ASIL on system level, Infineon provides PRO-SIL™ ISO 26262-ready products the necessary support for qualification of existing pre-ISO 26262 products, , and fully PRO-SIL™ ISO 26262-compliant products the future:

What does ISO 26262-compliant mean?

Infineon PRO-SIL™ ISO 26262-compliant safety sensors fulfil the properties required by the ISO 26262 (Automotive Safety) Standard. PRO-SIL™ ISO 26262-compliant product development follows a product specific safety plan defined by Infineon. The product development follows the Infineon V-model based development lifecycle which encompasses all ISO 26262 required activities and work products related to the product scope. Product relevant safety requirements and required metrics are captured and verified through the development of the product, this includes the product safety concept and ultimately a product safety case which provides the argumentation and evidence showing achievement of the defined safety requirements and process compliance, including all essential supporting processes.

An independent functional safety management organization supports the ISO 26262 conformance safety lifecycle.

For ISO 26262-compliant products a Safety Manual and a Safety Analysis Summary Report can be delivered to our customers in addition to Infineon standard documentation.

Moreover Infineon offers expert support for system integrators to achieve the required ASIL on system level. Infineon’s activities result in a simplified integration in safety-related applications.



What does ISO 26262-ready mean?



ISO 26262 ready

Infineon PRO-SIL™ ISO 26262-ready sensors are developed according to Infineon's sophisticated Automotive Development and Quality Standards. For ISO 26262-ready products additional functional safety analysis will be provided. ISO 26262-ready enables our customers to use Infineon's (QM) products in safety related applications.

For ISO 26262-ready products Safety Manual and a Safety Analysis Summary Report can be delivered to our customers in addition to Infineon standard documentation. These reports are provided to customers to serve as building block for their system level safety concept. Moreover Infineon offers expert support for system integrators to achieve the required ASIL on system level. Infineon's activities result in a simplified integration in safety-related applications.

Infineon PRO-SIL™



The functional complexity and levels of integration of real-time, safety-critical applications continue to increase.

Norms such as IEC 61508 and ISO 26262 mandate more robust products and functional safety concepts in automotive and industrial applications.

Infineon's PRO-SIL™ trademark designates Infineon products, which contain SIL-supporting (Safety Integrity Level) features. The SIL-supporting features are intended to assist the overall system design in attaining the desired SIL (according to IEC 61508) or ASIL (according to ISO 26262) level for safety systems with high efficiency. Products with the PRO-SIL™ label will help you to select Infineon products for safety-relevant (automotive) systems.

More information on PRO-SIL™ can be found at www.infineon.com/prosil

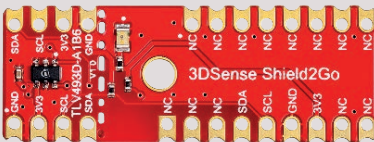

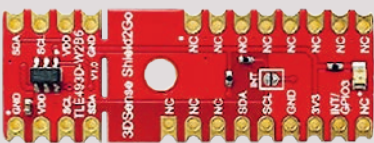

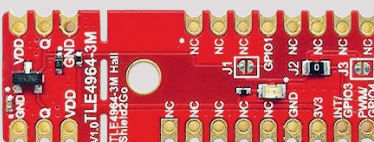


Shield2Go

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

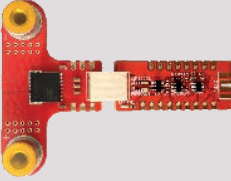

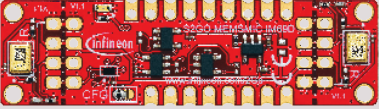

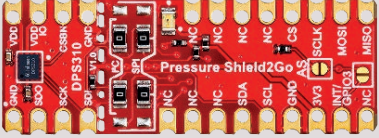



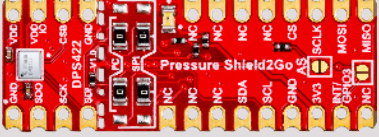

	<p>Product name: OPTIGA™ Trust E Security Shield2Go Sales name: S2GO_Security_OPTIGA_E Ordering code: SP001820138</p>	<p>More information</p> 
	<p>Product name: OPTIGA™ Trust X Security Shield2Go Sales name: S2GO SECURITY OPTIGA X Ordering code: SP002349576</p>	<p>More information</p> 

Sensors

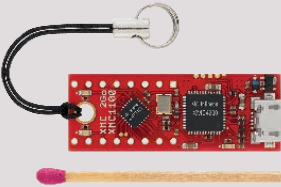

	<p>Product name: TLV493D 3DSense Shield2Go Sales name: S2GO_3D-SENSE_TLV493D Ordering code: SP001823678</p>	<p>More information</p> 
	<p>Product name: TLE493DW2B6 3DSense Shield2Go Sales name: S2GO_3D_TLE493DW2B6-A0 Ordering code: SP004308594</p>	<p>More information</p> 
 <p>Coming soon</p>	<p>Product name: TLI493D W2BW Shield2Go Sales name: S2GO_3D_TLI493DW2BW-A0 Ordering code: SP005410385</p>	<p>Coming soon (Q3/2020)</p>
	<p>Product name: TLE4964-3M Hall Sense Shield2Go Sales name: S2GO_HALL_TLE4964-3M Ordering code: SP004308590</p>	<p>More information</p> 
	<p>Product name: TLE4966K Double Hall Shield2Go Sales name: S2GO_2_HALL_TLE4966K Ordering code: SP004308598</p>	<p>More information</p> 

Shield2Go

Sensors

	<p>Product name: TLI4971 Current Sense Shield2Go Sales name: S2GO_CUR-SENSE_TLI4971 Ordering code: SP005345472</p>	<p>More information</p> 
	<p>Product name: IM69D130 Microphone Shield2Go Sales name: S2GO MEMSMIC IM69D Ordering code: SP002851544</p>	<p>More information</p> 
	<p>Product name: S2GO Pressure Sensor DPS310 Sales name: S2GO_PRESSURE_DPS310 Ordering code: SP001777630</p>	<p>More information</p> 
	<p>Product name: S2GO Pressure Sensor DPS368 Sales name: S2GO PRESSURE DPS368 Ordering code: SP005338022</p>	<p>More information</p> 
	<p>Product name: S2GO Pressure Sensor DPS422 Sales name: S2GO PRESSURE DPS422 Ordering code: SP002983204</p>	<p>More information</p> 

Microcontroller

	<p>Product name: XMC 2Go Kit Sales name: KIT_XMC_2GO_XMC1100_V1 Ordering code: SP001199544</p>	<p>More information</p> 
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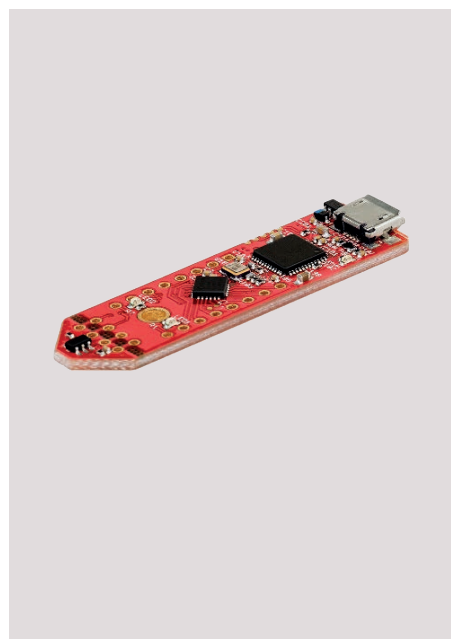
MyIoT – Adapter

	<p>Product name: MyIoT Adapter Sales name: MYIOTADAPTERTOB01 Ordering code: 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>
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Sensor 2GO kits

Infineon'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.



3D Magnetic Sensor 2GO kit

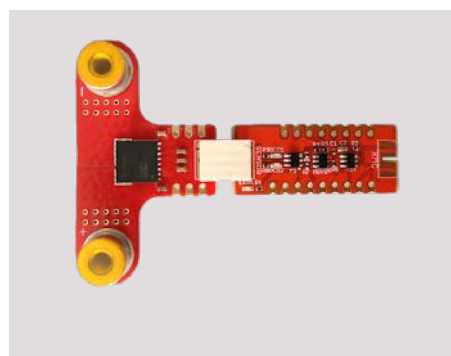
Product name: TLE493D-A2B6 MS2GO /
TLE493D-W2B6 MS2GO /
TLV493D-A1B6 MS2GO

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: SP00534547

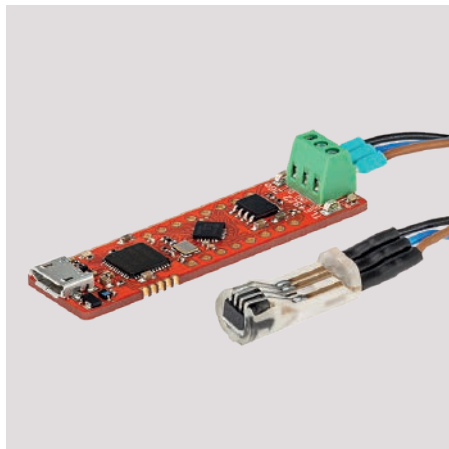
Features

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

More information



Sensor 2GO kits



Speed Sensor 2GO kit

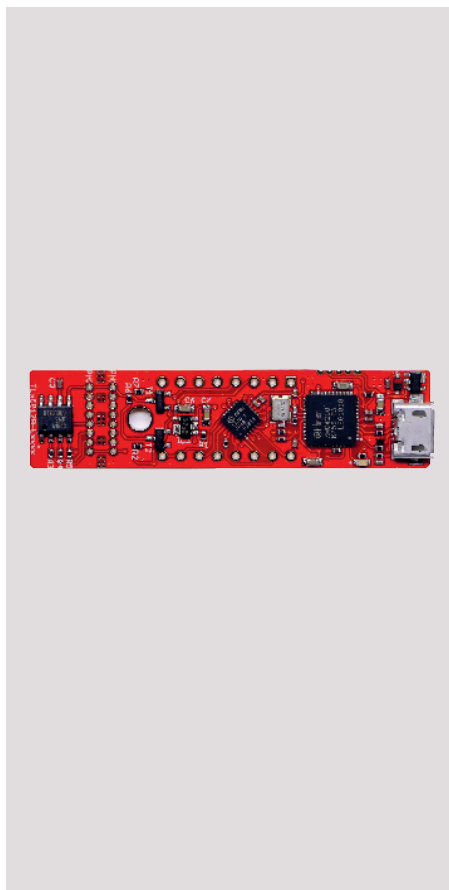
Product name: TLE4922 MS2GO

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

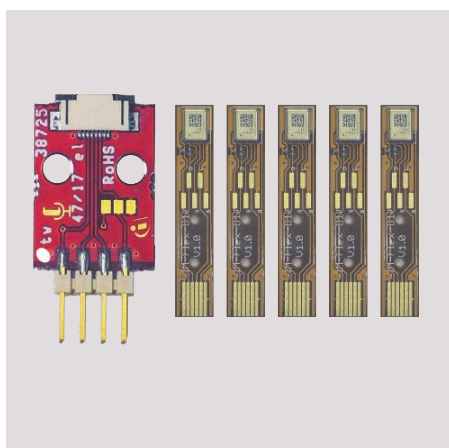
Product name: TLE5012B_E1000_MS2GO/
TLI5012B_E1000_MS2GO/
TLE5012B_E5000_MS2GO/
TLE5012B_E9000_MS2GO

Ordering code: SP002133956/
SP002133960/
SP002133964/
SP002133968

Features

- > Budget-priced evaluation board for angle and position sensing
- > We offer three 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 audio testing setup. The evaluation kit includes five IM69D130 mounted on flex board and one adapter board.





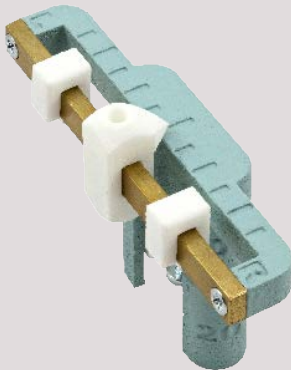



Features

- > 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

	<p>Joystick for all 3D magnetic sensor 2GO kits and Shield2Go Product name: JOYSTICK FOR 3D 2 GO KIT Ordering code: SP001491834 Features</p> <ul style="list-style-type: none"> > Easy mounting on all 3D magnetic sensor 2GO kits and Shield2Go > First magnetic joystick measurements within minutes 	<p>More information</p> 
	<p>Rotate knob for all 3D magnetic sensor 2GO kits, angle sensor 2GO kits and 3D magnetic sensor Shield2Go Product name: ROTATE KNOB 3D 2 GO KIT Ordering code: SP001504602 Features</p> <ul style="list-style-type: none"> > Easy mounting on all 3D magnetic and angle sensor 2GO kits as well as 3D magnetic sensor Shield2Go > Rotate knob with 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 	<p>More information</p> 
	<p>Linear slider for all 3D magnetic sensor 2GO kits and Shield2Go Product name: LINEAR-SLIDER 2GO Ordering code: SP002043034 Features</p> <ul style="list-style-type: none"> > 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 	<p>More information</p> 
	<p>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</p> <ul style="list-style-type: none"> > 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 	<p>More information</p> 

Add ons for Sensor 2GO kits and Shield2Go



Linear control trigger for all 3D magnetic sensor 2GO Kits and Shield2Go

Product name: POWER_DRILL2GO

Ordering code: SP005350194

Features

- > Easy mounting on all 3D magnetic sensor 2GO Kits and Shield2Go
- > Use case: control trigger for e.g. power drill (linear position measurements with 3D Hall sensor)
- > Magnetic slider with magnet included

More information



Human machine interface (HMI) direction indicator for all 3D magnetic sensor 2GO Kits and Shield2Go

Product name: DIR_INDICATOR2GO

Ordering code: SP005350196

Features

- > Easy mountig on all 3D magnetic sensor 2GO Kits and Shield2Go
- > Use case: human-machine interface (3x3 position matrix) for e.g. automotive direction indicator
- > Magnetic direction indicator with magnet included in handle bar

More information



HMI mini control with 4 directions and 360° rotation for all 3D magnetic sensor 2GO Kits and Shield2Go

Product name: MINI_CONTROL2GO

Ordering code: SP005350192

Features

- > Easy mounting on all 3D magnetic sensor 2GO Kits and Shield2Go
- > Use case: left/rigth/forwad and backward including 360° rotation at all positions
- > Control element includes magnet

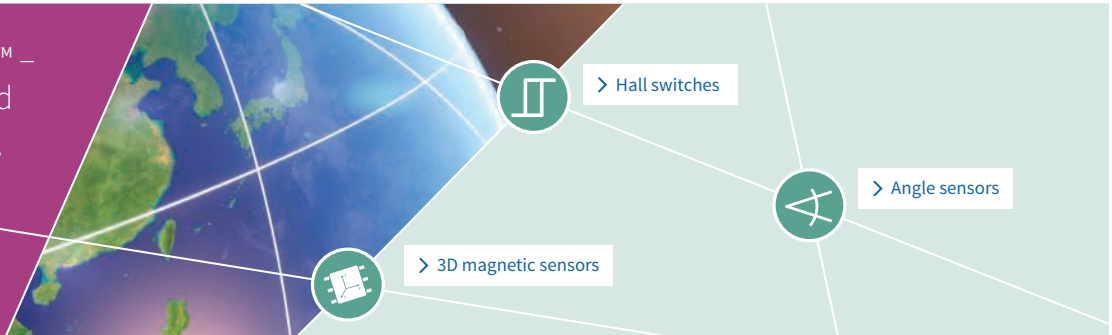
More information

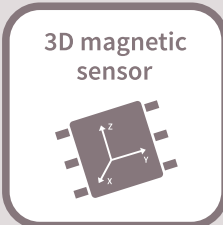
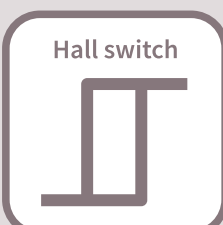
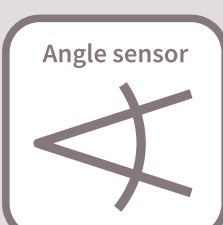


Choose the best fit magnetic sensor solution from broadest portfolio

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.

Infineon XENSIV™ – sensing the world
Online simulation tools

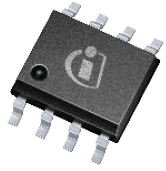


 <p>3D magnetic sensor</p>	<p>XENSIV™ – 3D Magnetic Sensors Simulation Tool</p> <p>3D magnetic field sensor for smaller, more accurate and robust designs. The sensor family, with low current consumption and cost-optimized design, specifically addresses the needs of new magnetic sensor applications in 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.</p> <p>Direct link to the 3D magnetic sensors simulation tool: http://www.infineon.com/3dsim</p>
 <p>Hall switch</p>	<p>XENSIV™ – Magnetic Hall Switches Simulation Tool</p> <p>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.</p> <p>Direct link to the Hall switches simulation tool: http://www.infineon.com/hallsim</p>
 <p>Angle sensor</p>	<p>XENSIV™ – Magnetic Angle Sensors Simulation Tool</p> <p>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.</p> <p>Direct link to the angle sensors simulation tool: http://www.infineon.com/anglesim</p>

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

Packages

DSO-8/TDSO-8



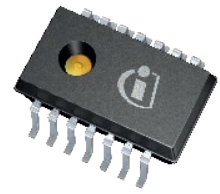
TDSO-16



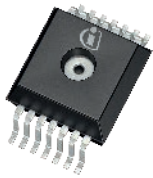
DSOF-8



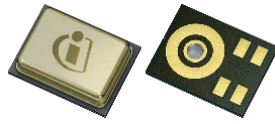
DSOSP-14-6



DSOSP-14-82



LLGA-5



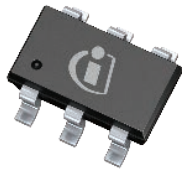
SC59



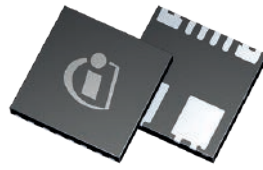
SOT23



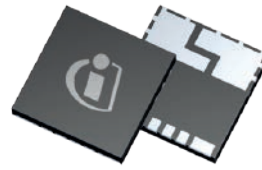
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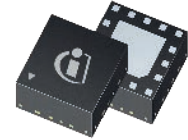
TISON-8-1



TISON-8-5



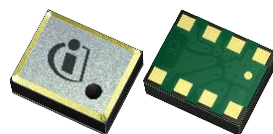
TSNP-16



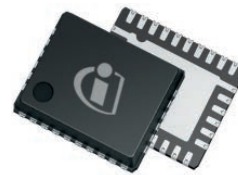
VLGA-8-1



VLGA-8-2



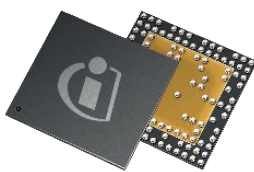
VQFN-32



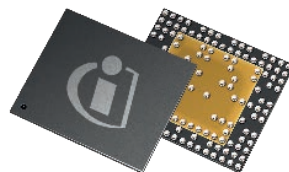
WFWLB-5-2



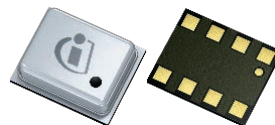
VFWLB-131 (eWLB)



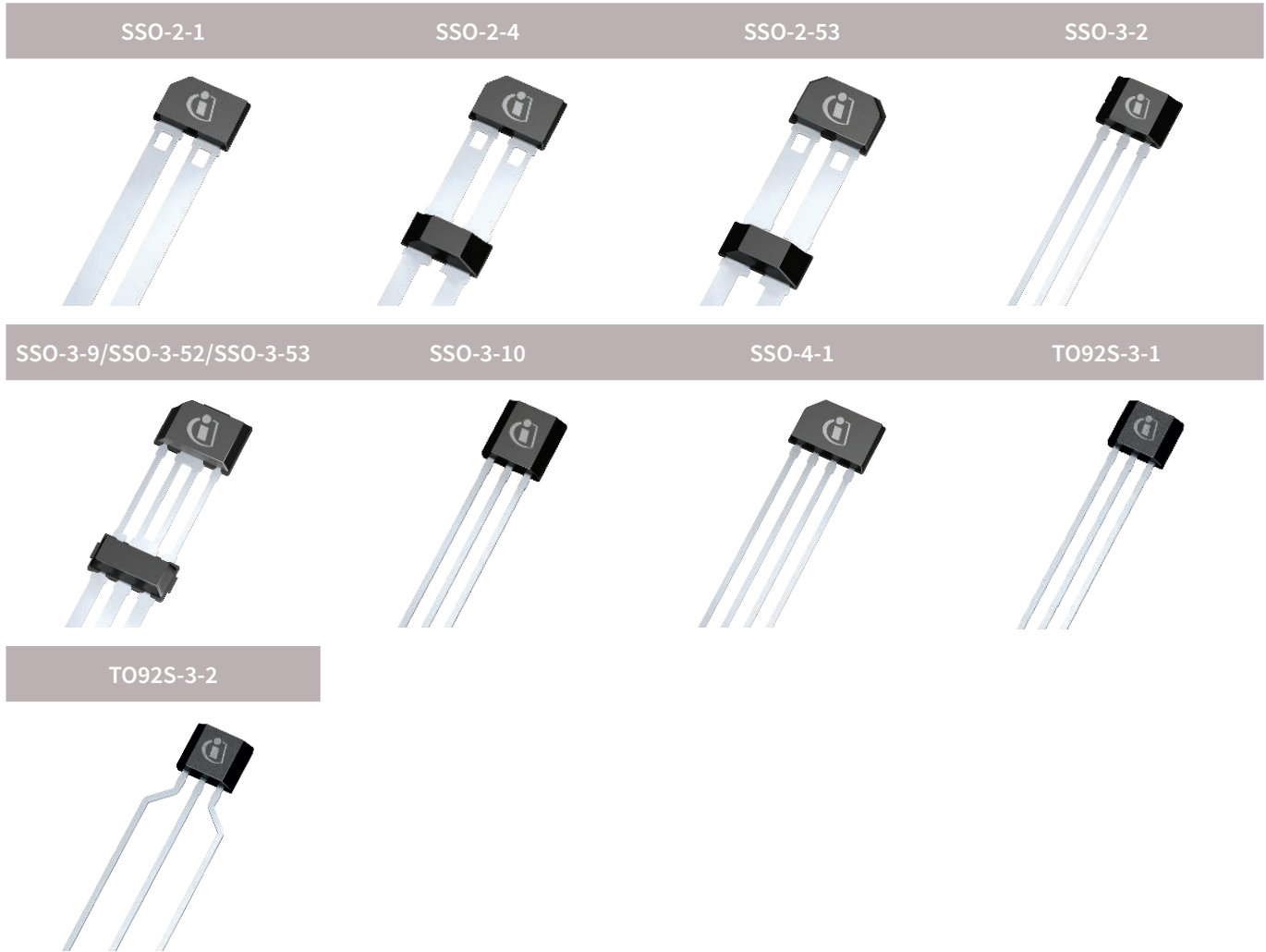
VFWLB-138 (eWLB)



WLGA-8



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