Rutronik TechTalk

Education Inspiration Exchange

TDK-Micronas GmbH

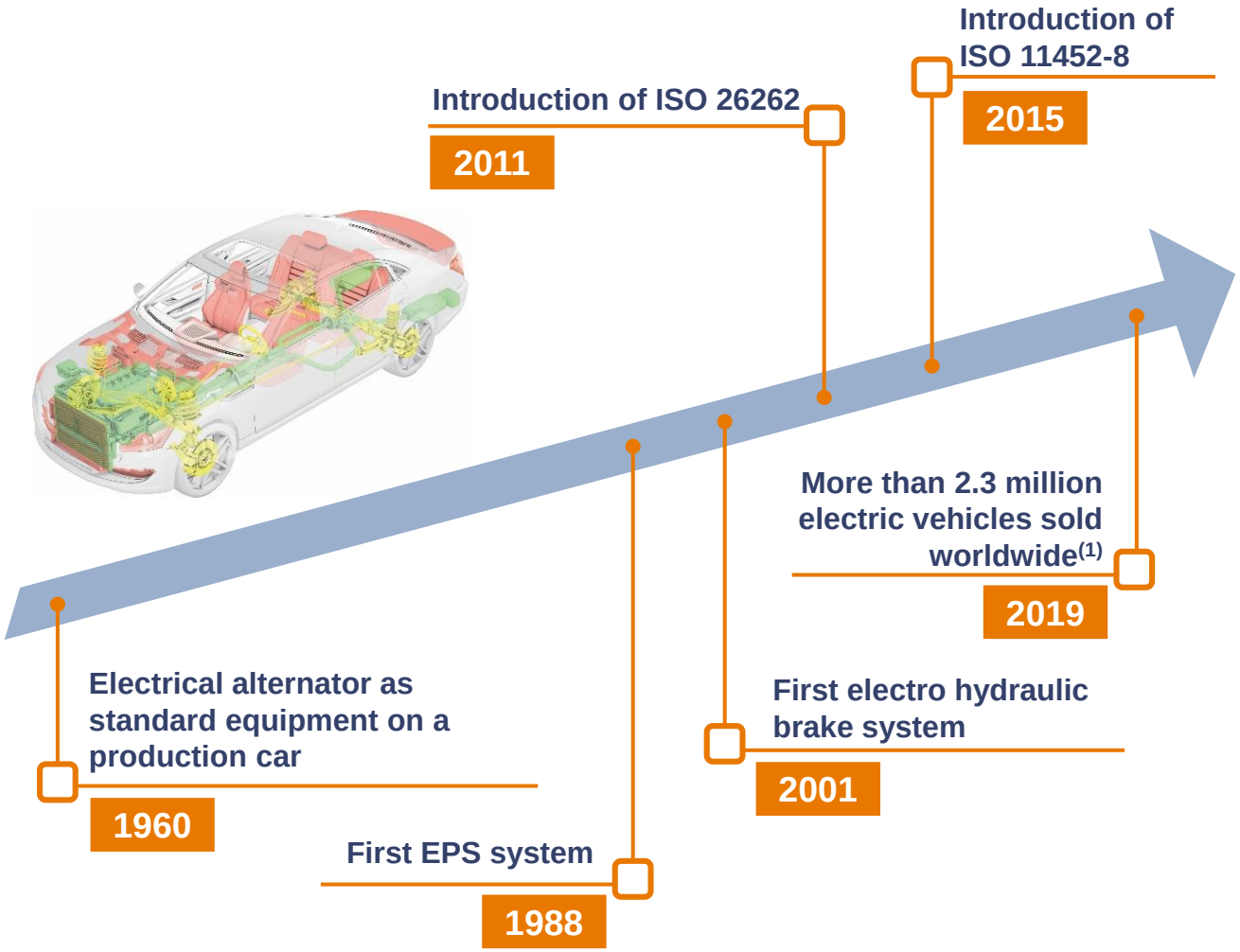
Stray-field robust 3D HAL® position sensor family

Frederik Berstecher – Marketing 3D Position Sensors

3D HAL® Technology based Stray-field Robust Position Sensor Family – HAL 39xy

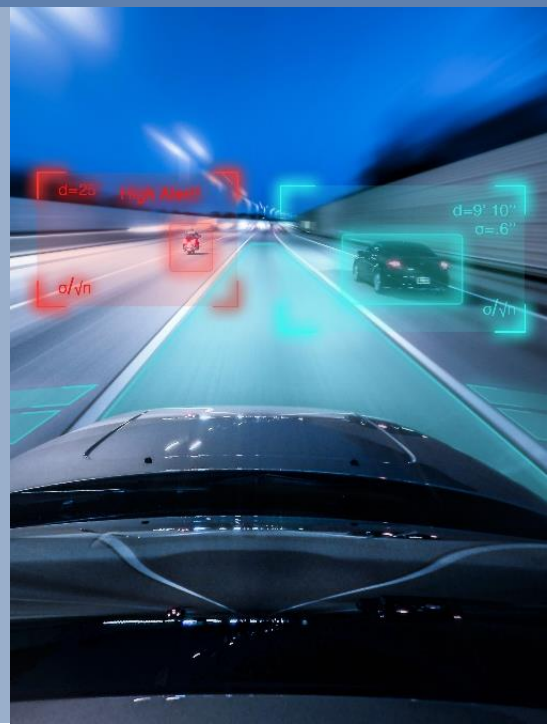
Attracting Tomorrow

Position Measurement more Important than Ever



Modern vehicles require optimized sensor and actuator solutions

- Increased safety in braking, suspension and steering modules
- Enhanced comfort and reliability by replacing mechanical and hydraulic systems with electric systems and contactless sensors
- Increased energy efficiency and reduced CO_2 emissions
- Improved cost efficiency

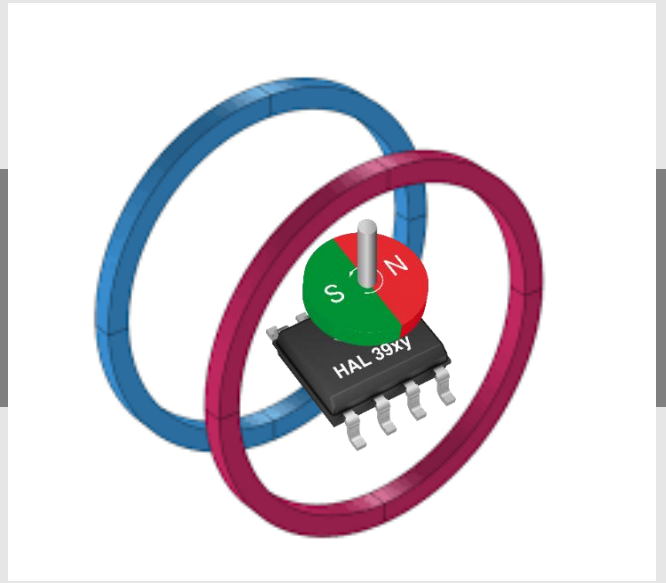


Source: (1) Zentrum für Sonnenenergie- und Wasserstoff-Forschung Baden-Württemberg (2020)

The Challenge of Stray Field Immunity

Two kinds of stray fields can be present

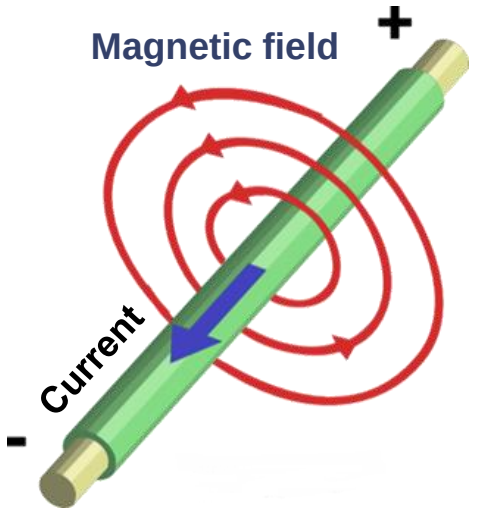
Homogenous stray field



(ISO 11452-8 up to 4000 A/m, Error < 0.12°)

or

Gradient field



Increased angular error up to 5°

Active compensation is required in the presence of stray fields

3D HAL® Technology based Stray-field Robust Position Sensor Family – HAL 39xy

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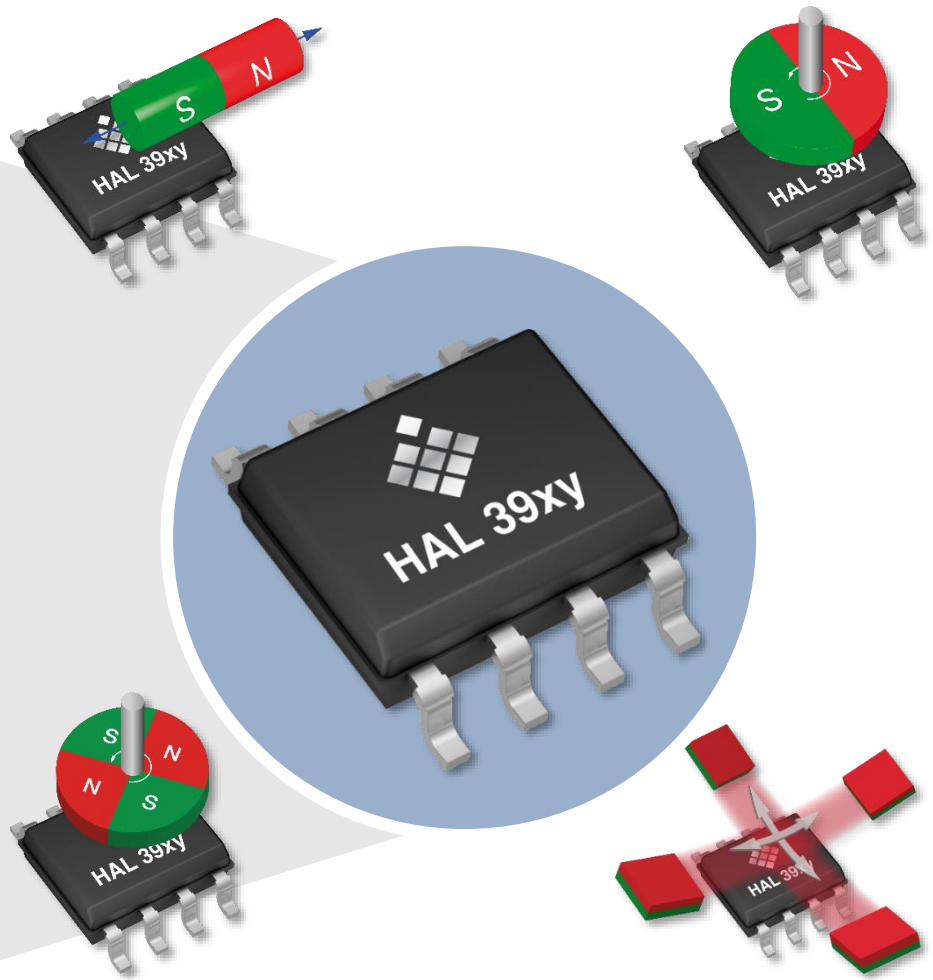
Targeting Main Market Requirements

- Stray field robustness
- Functional safety
- 3D capability
- Digital interfaces
- Low power mode

- Innovative sensor array
- Efficient on-chip diagnostics
- 3D HAL® Technology
- Flexible architecture
- Direct battery supply

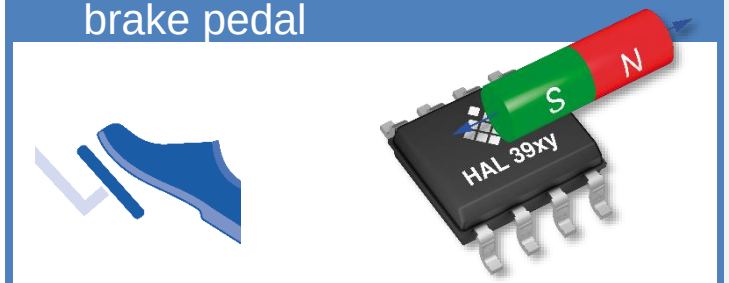


Unique sensor array concept of HAL 39xy with stray field compensation

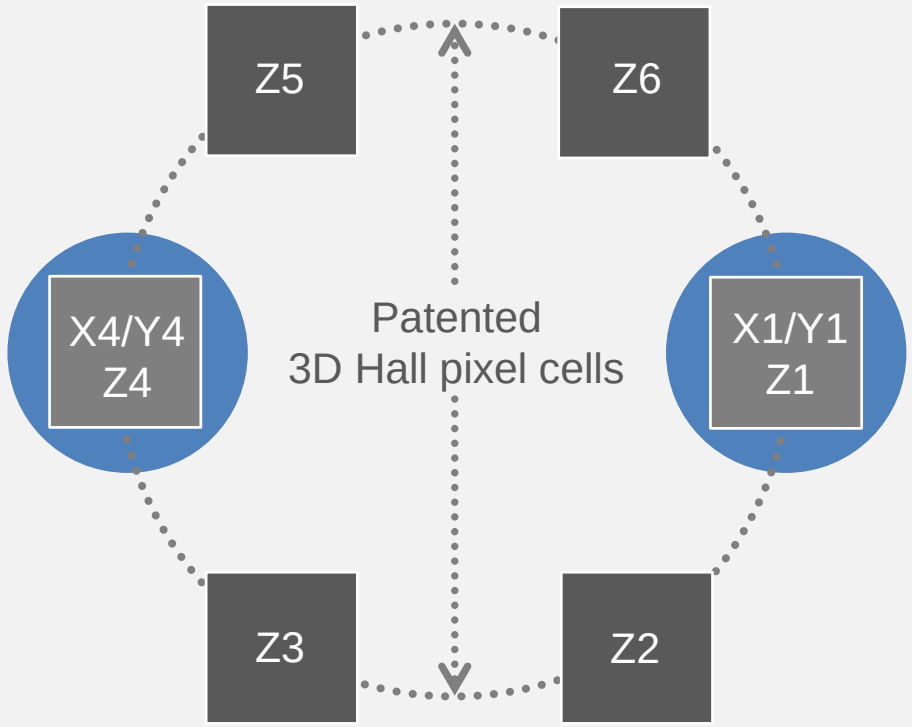
Attracting Tomorrow

Linear position

- Extended range up to 30 mm
- E.g. EGR valve, Turbo charger, brake pedal



Hall-effect sensor array



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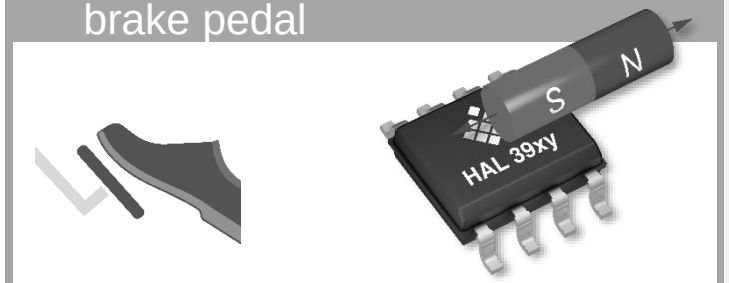

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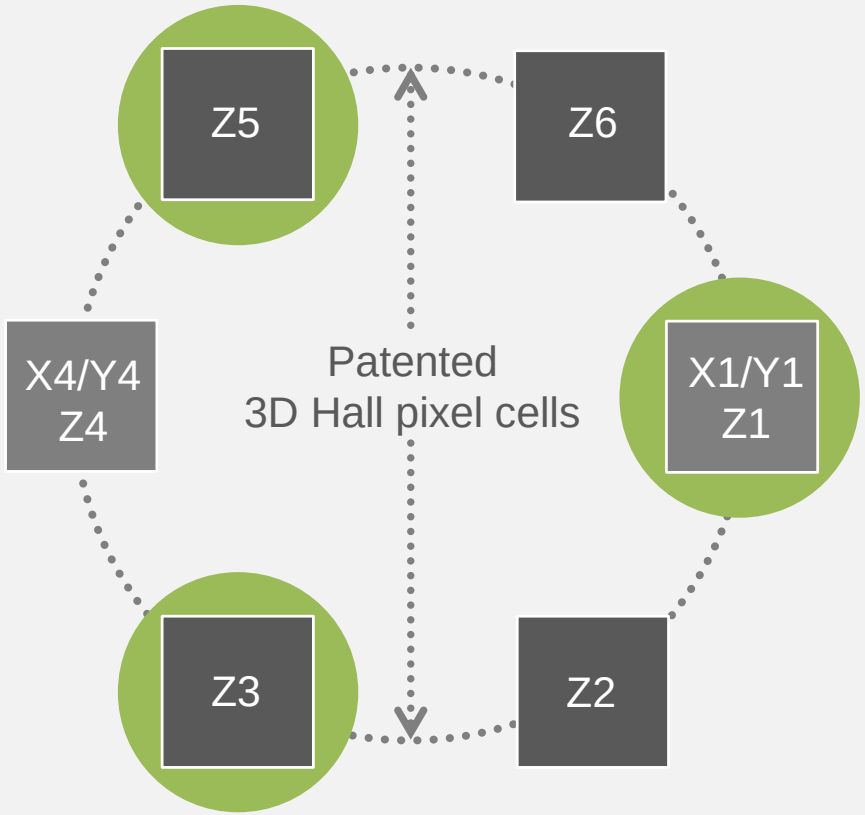
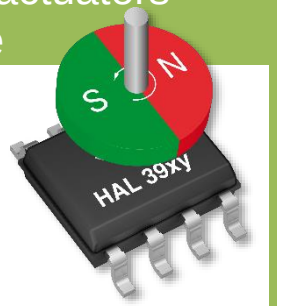


Rotary position up to 360°
- E.g. Air management valves
- E.g. Transmission actuators
- E.g. Steering angle



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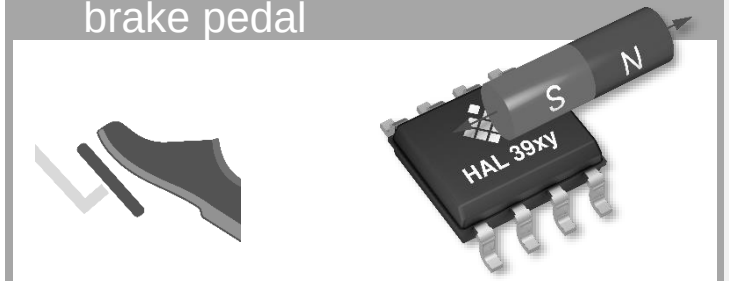
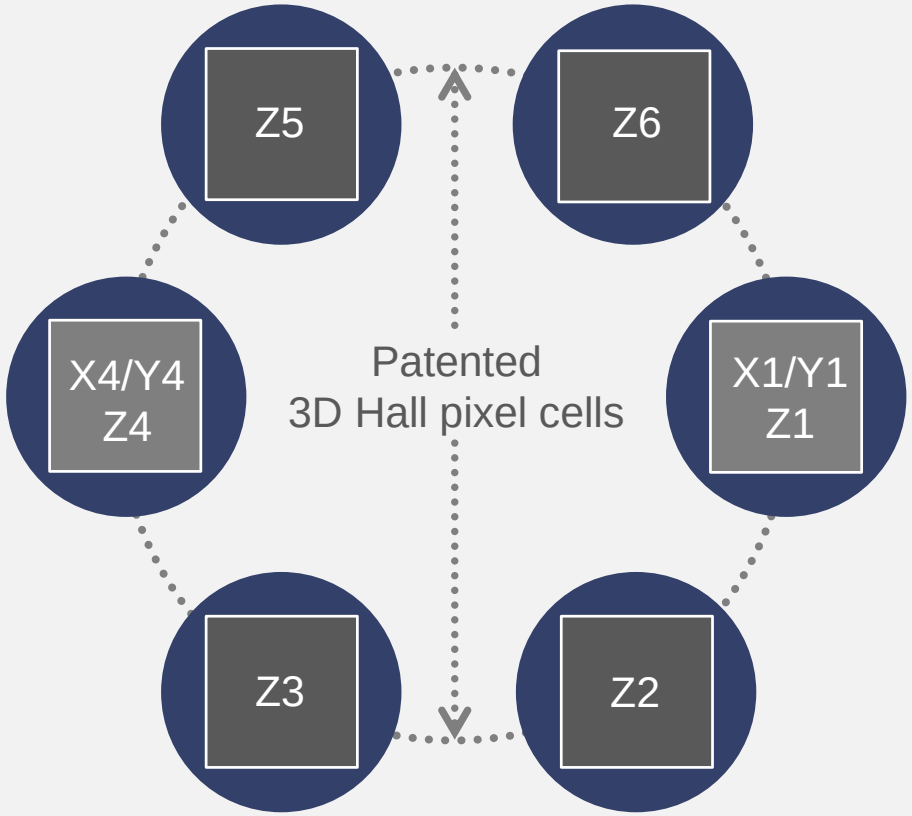


Rotary position up to 180°
- Compensation of gradient fields generated by power lines
- E.g. accelerator pedal

Hall-effect sensor array



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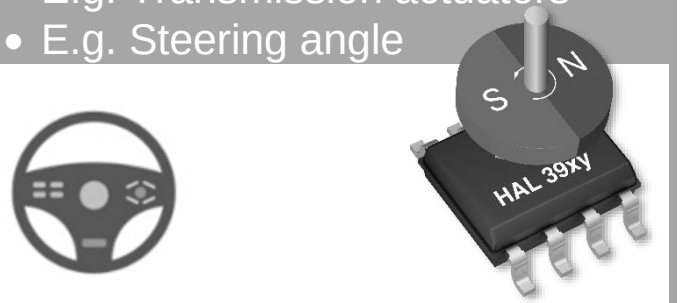

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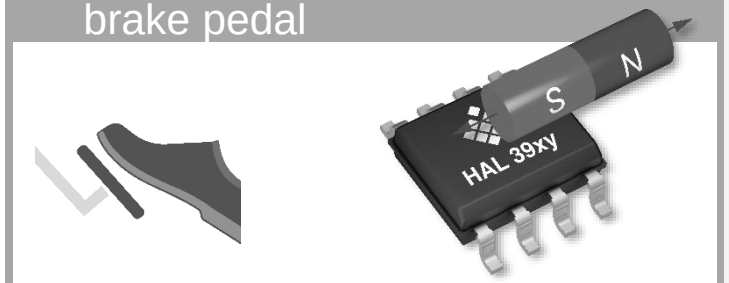

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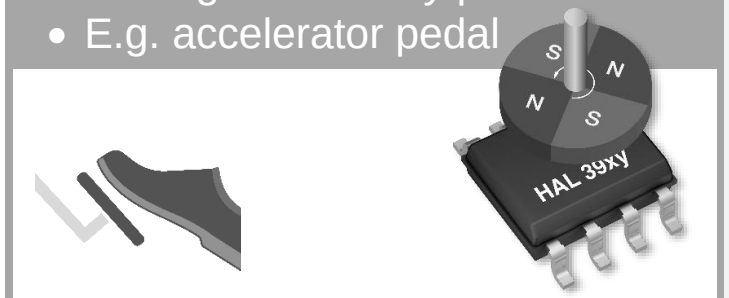

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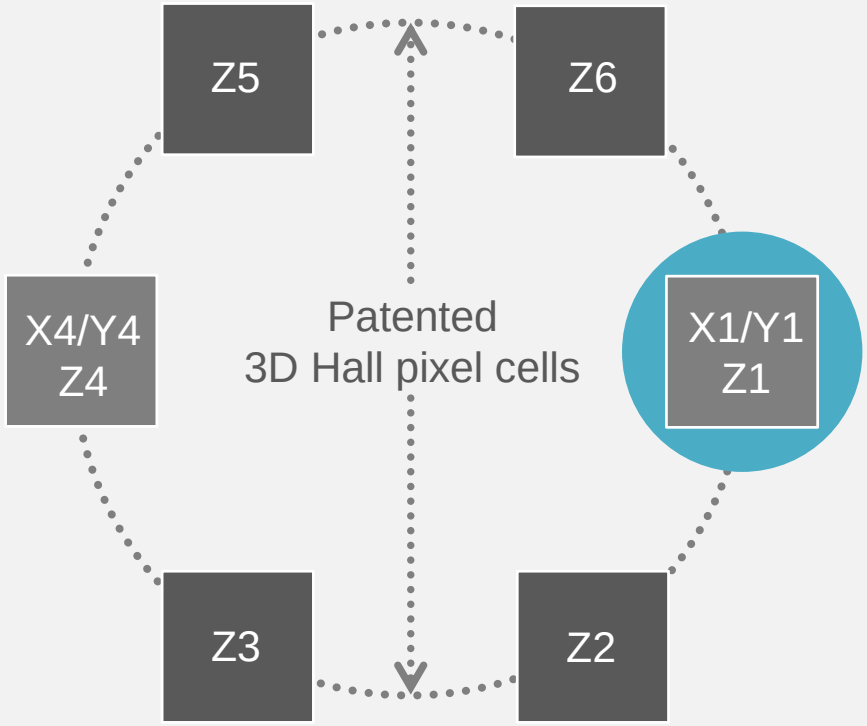

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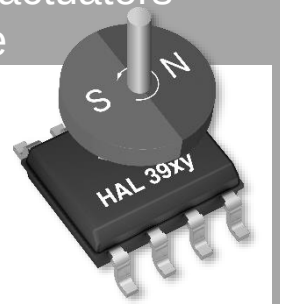
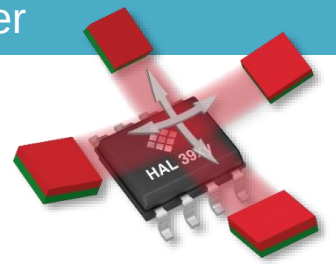


Real 3D magnetic field measurement (B_X, B_Y, B_Z)
- No stray field compensation
- E.g. gear shifter



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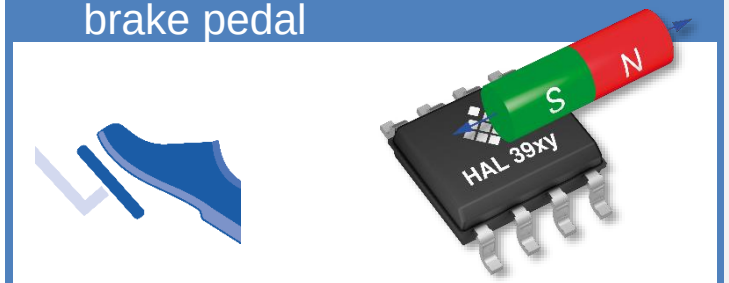

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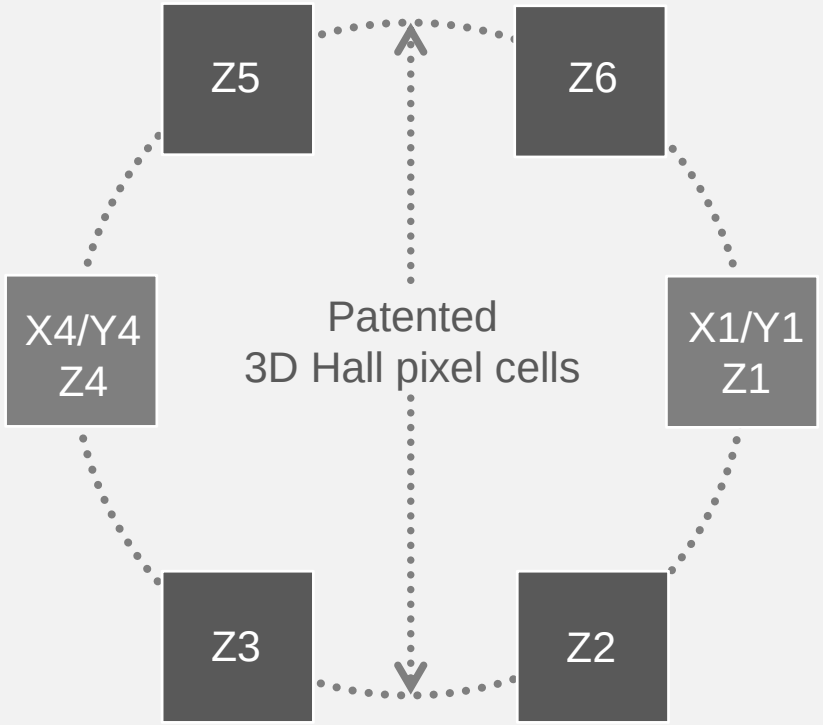

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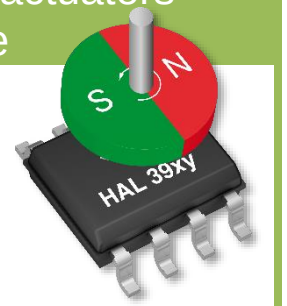

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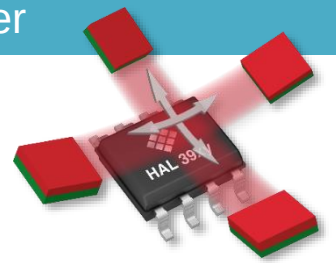
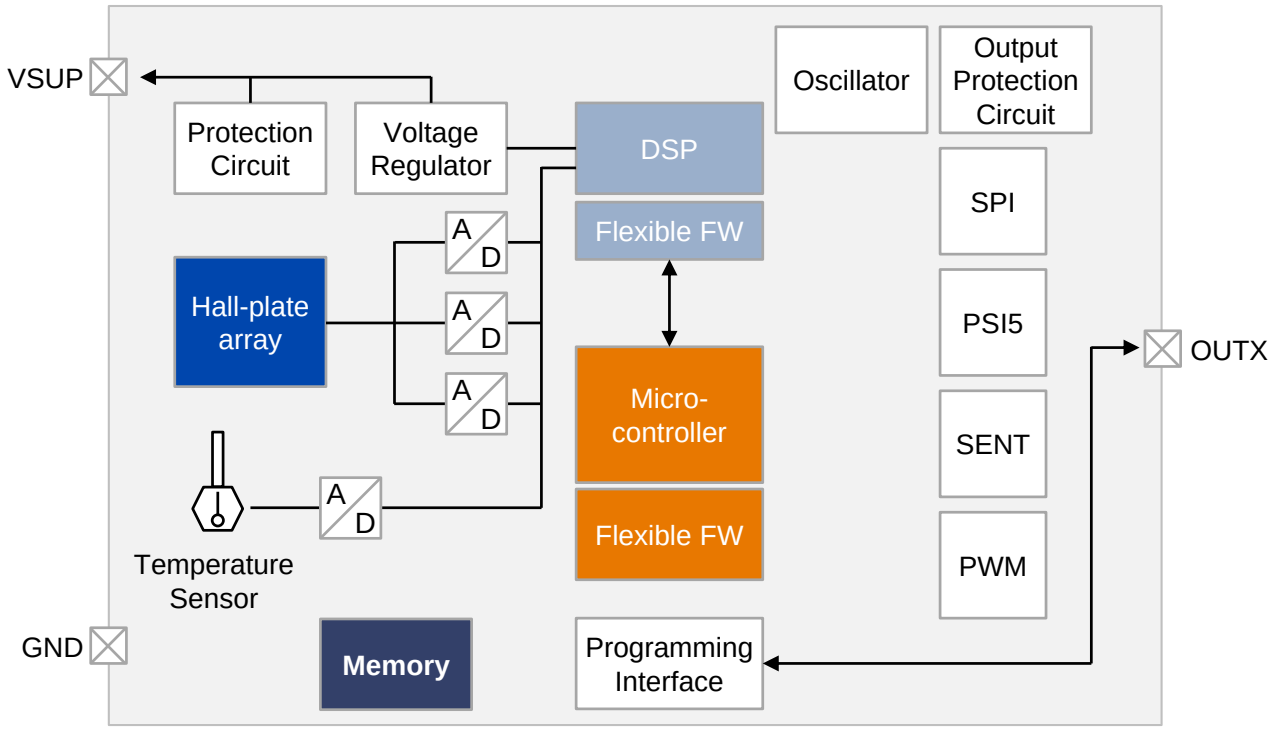


Customer configurable for different measurement tasks

Flexible Architecture of HAL 39xy Family

DSP
- Fast and customizable signal processing
- Fast prototyping

Hall-plate array
- Efficient stray field compensation
- Flexibility for custom measurement tasks
- Enables 2D and 3D measurements



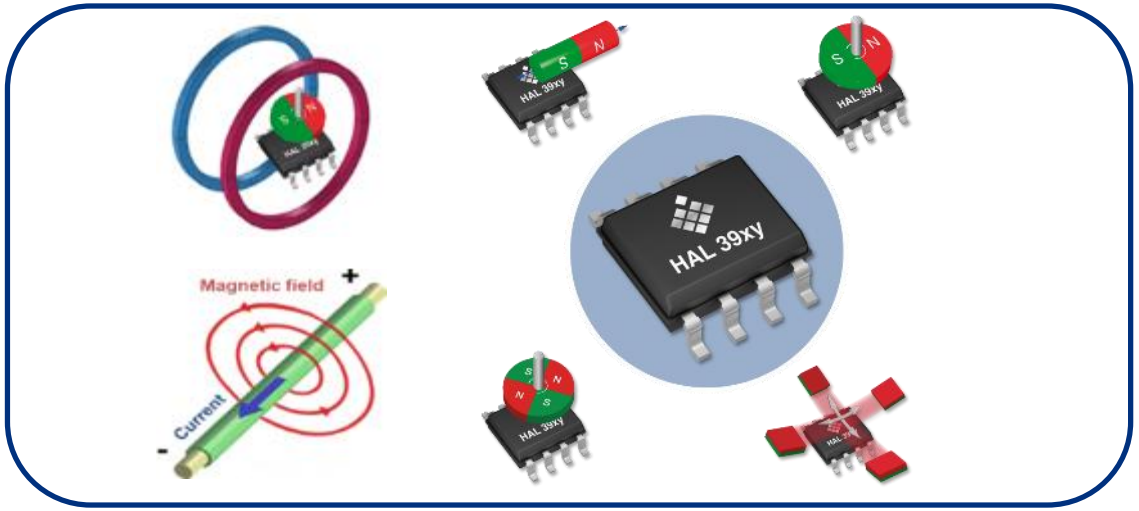
Microcontroller with programmable firmware
- Flexible output formats
- Overall scheduling
- Interface configuration
- Quick reaction to changes in interface standards (e.g. SENT/PSI5)
- Fast prototyping
- Supervision tasks for enhanced functional safety

Memory calibration and configuration data

HAL 39xy – One Pager

Applications

- **Stray-Field Robust Position Detection up to 360°**
- **Stray-Field Robust Linear Position Detection**
- **Real 3D Position Detection**



Features

- Stray-Field robust position detection
  - Homogenous: ISO 11452-8:2015 with 4 kA/m DC
  - Gradient fields generated by high currents
  - Error due to Stray-Field <= 0.12°
- Bandwidth up to 8 kHz
- Various output formats
  - SPI (HAL 3900), SENT/PWM (HAL 3930)
  - SPC (HAL3970), PSI5 rev. 2.x (HAL 3980)
- Angular error: +/- 0.5° (plus life time drift: +/- 0.45°)
- Setpoint linearization (17 variable & 33 fixed)
- Wide supply voltage range: 3.0 V … 16 V
- ISO 26262 development: ASIL-B ready
- Customized sleep mode possible
- SOIC-8 package

USPs

- One device for various stray-field robust measurements
- High temperature grade (TA ≥ 150 °C)
- Battery capable device (Load dump robust)
- Customized sleep mode (wake-up by angle/field strength)
- Programmable via output pin with min. VSUP
- Highly flexible architecture to enable customized variants

HAL 39xy Stray-field Robustness vs. Competition (Datasheet Comparison)

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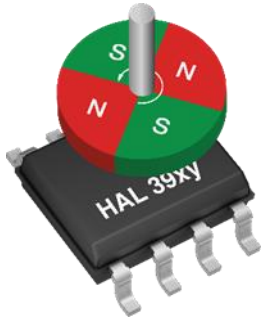
- **Error according to ISO 11452-8:2015, at 25°C, with stray-field of 4 kA/m from X,Y and Z direction**

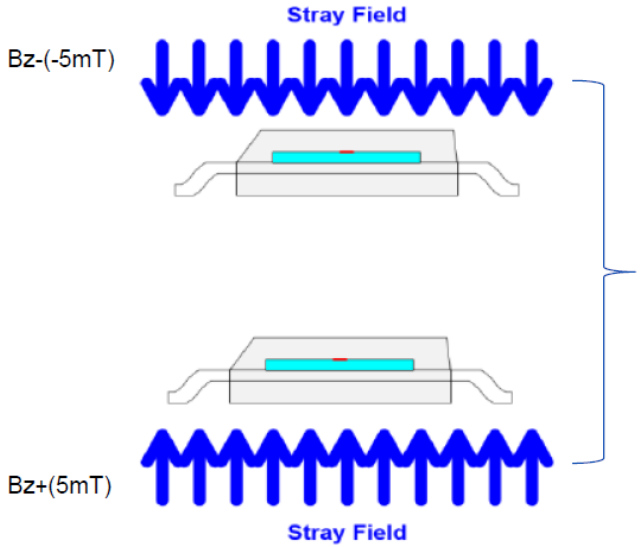
Condition	HAL 39x0	Competitor A
Configuration 1:	Max. **0.12° with 10 mT** wanted signal	Not supported
Configuration 2:	Max. **0.1° @ 10 mT** wanted signal	Max. **0.6° @ 20 mT** wanted signal Max. **0.3° @ 42 mT** wanted signal

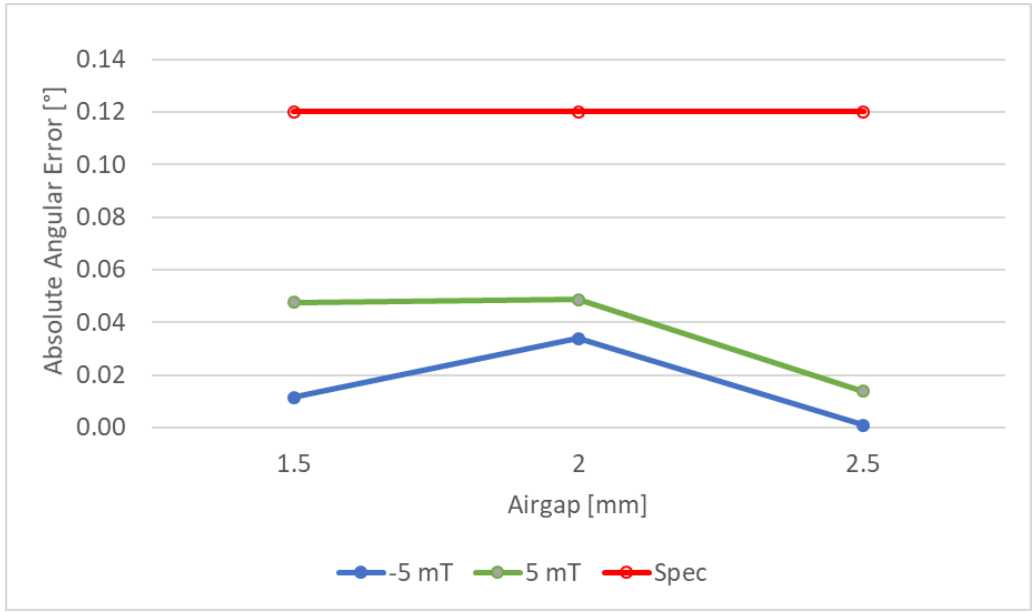
Configuration 1:

Configuration 2:



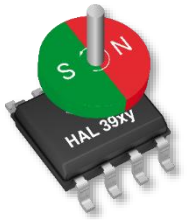
Worst case condition Z-direction:





3Z-Plate setup: 90° range, 2-pole magnet (ferrite)

How does the stray-field compensation work?



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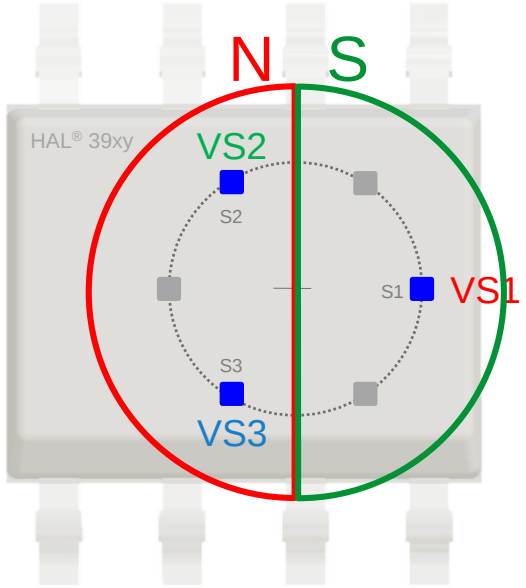
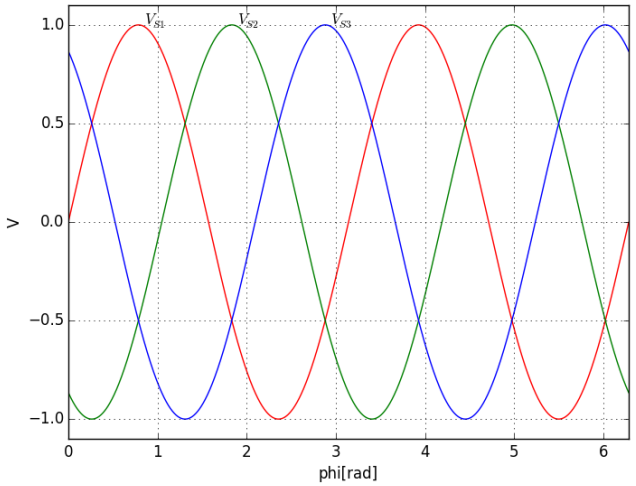
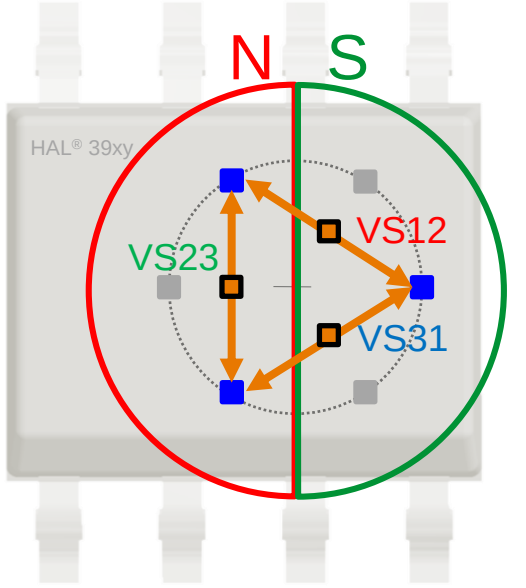
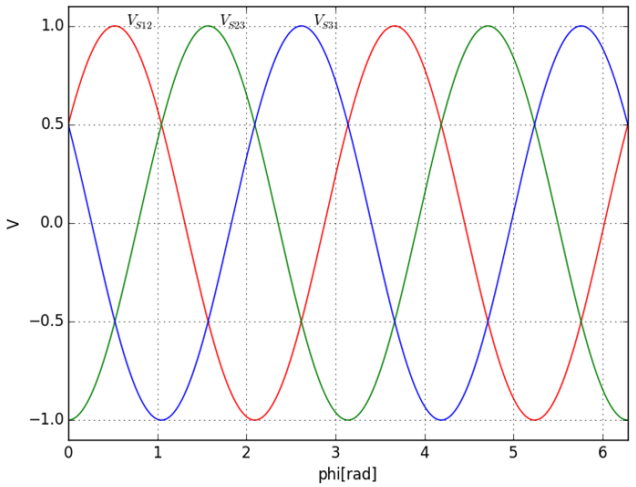








Differential Measurement – 3 x Z plates

- For 3 Z-plates the angle can be calculated with the following formula at any plate permutation
- For stray field compensation one possibility would be calculating the disturbing field by **averaging the raw sensor signals and subtracting it from each raw signal** before angle calculation

- Calculation of
  - VS12 = VS1 – VS2
  - VS23 = VS2 – VS3
  - VS31 = VS3 – VS1
- to get three new offset free signals

- Angle calculation by using:
- $\theta = ATAN\left(\frac{\sqrt{3}*VS12}{VS23 - VS31}\right)$

Patent pending

Automotive Application Examples

Accelerator

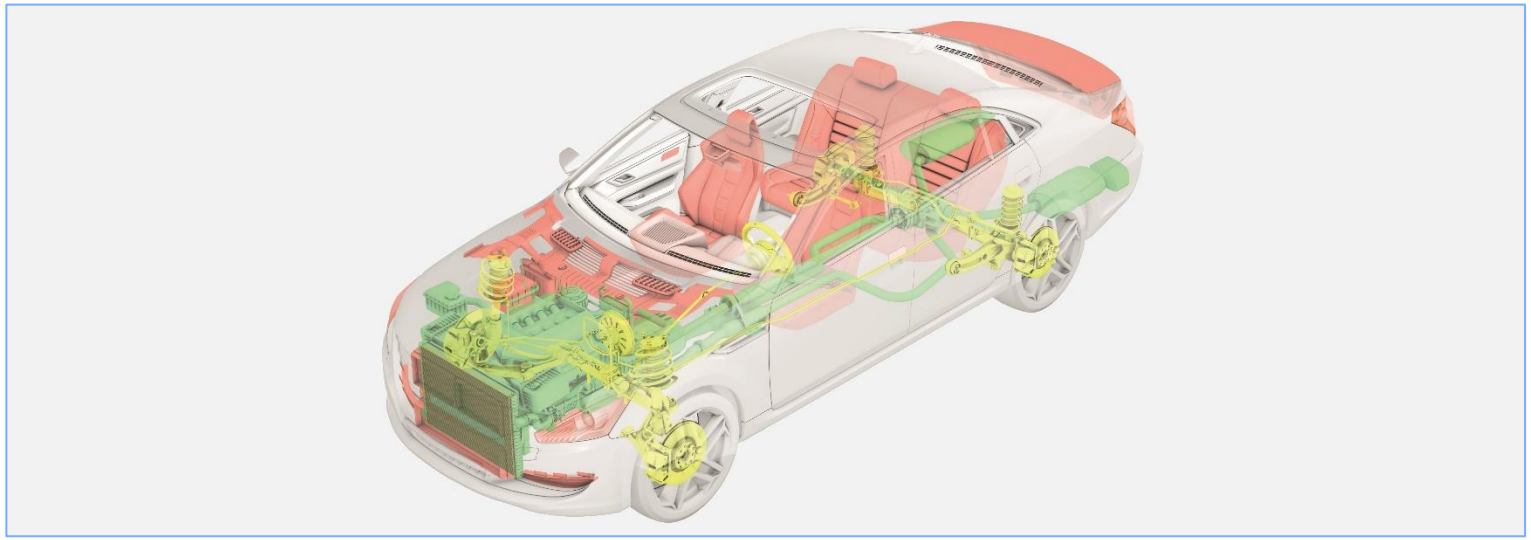
Brake position detection

Gear shift position detection

Dual-clutch transmission

Transmission

Steering angle detection



Clutch position detection

Adaptive front lighting

Exhaust gas recirculation

Throttle valve

Turbo-charger

Water valve

Liquid level measurement

Chassis position detection

Adaptive suspension

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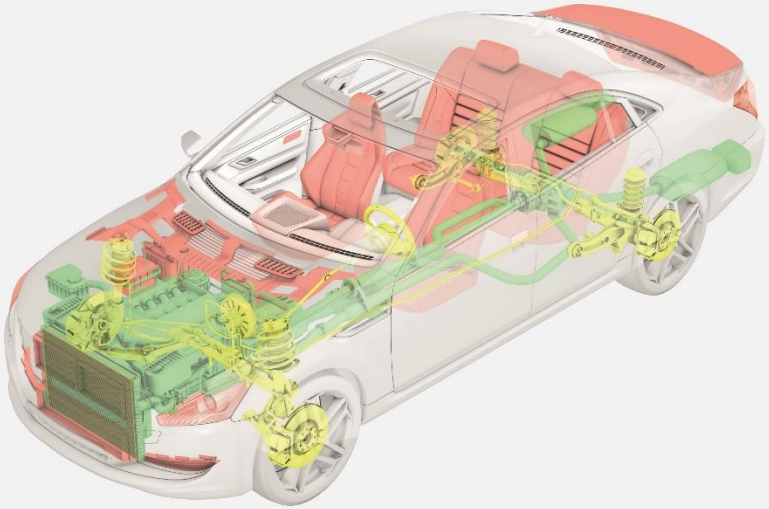

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Automotive Application Examples: Brake Stroke Position Detection

Automotive Application Examples

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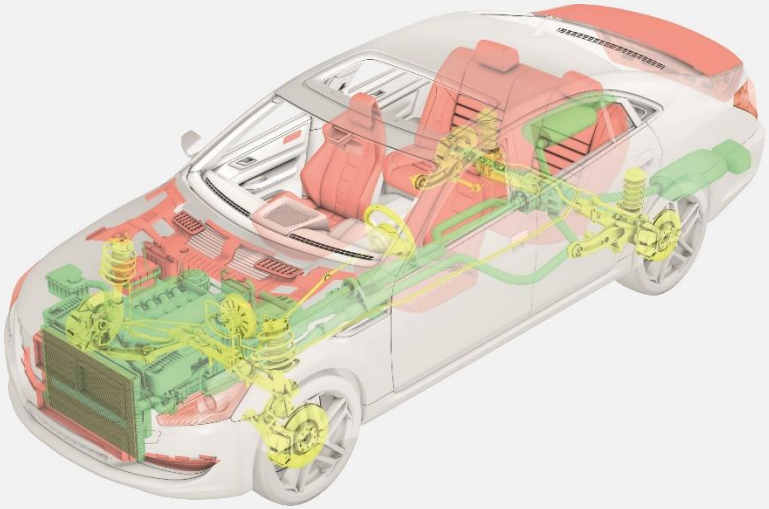
Gear shift position detection

Dual-clutch transmission

Transmission



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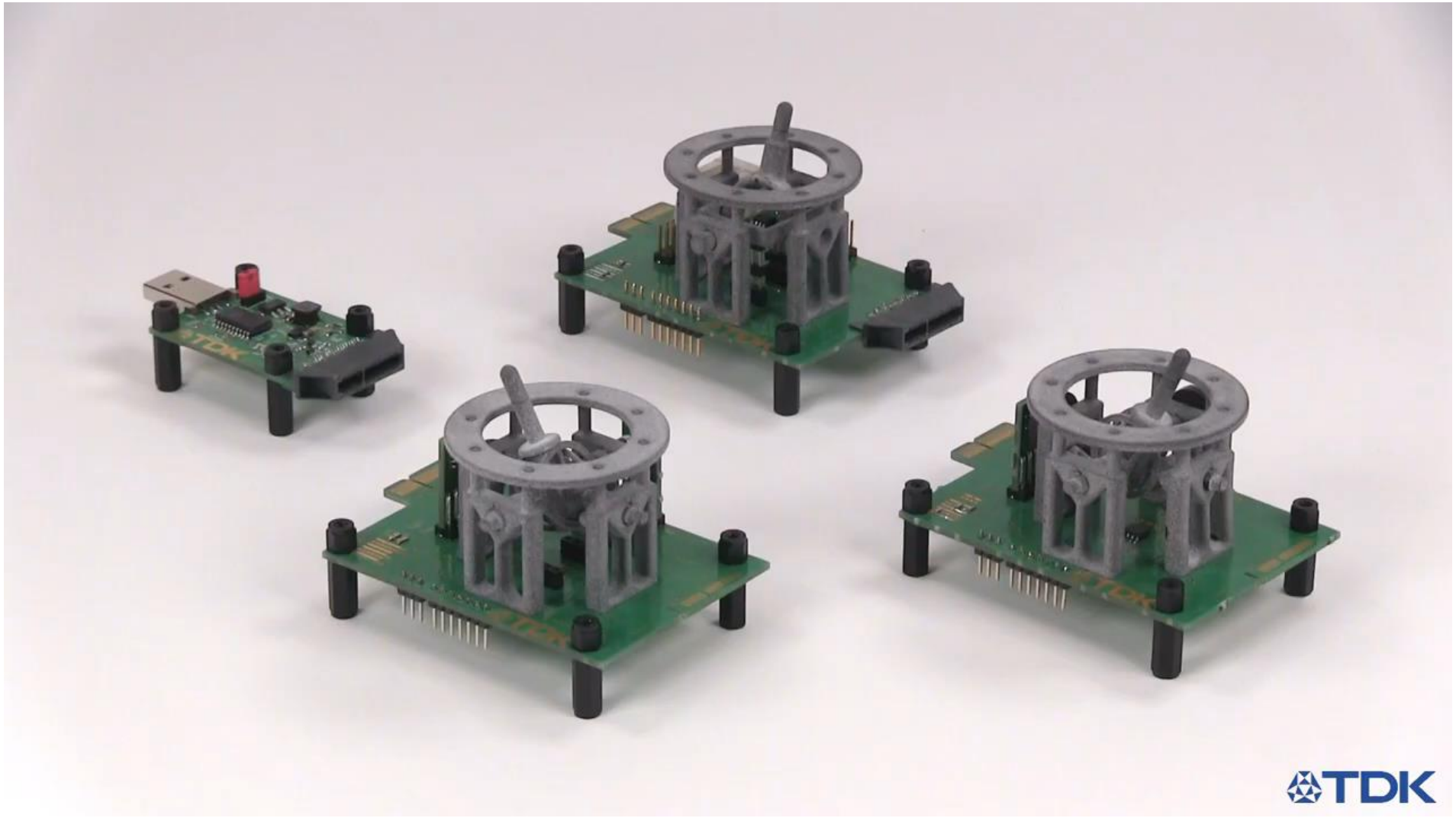
Automotive Application Example: Joystick & Gear Shift Position



Customization of HAL 39xy

- **HAL 39xy offers higher flexibility for today‘s automotive and industrial market needs**
- **Please get in touch with RUTRONIK ELECTRONICS WORLDWIDE Sales Team if you are looking for new enhanced solutions, like:**

Flexible interfaces
e.g. switch output

Customized signal processing
e.g. sum of Z Hall-plates for current measurement; processing of external signals (like temperature sensor information)

Special safety mechanisms for Functional Safety requirements

Outlook for HAL/R/C® 39xy 3D Hall-effect sensors

In Mass production

December 2020

Further package types
Engineering samples
(dual-die, integrated caps)

Summer 2021

Mass production

Q1 2022

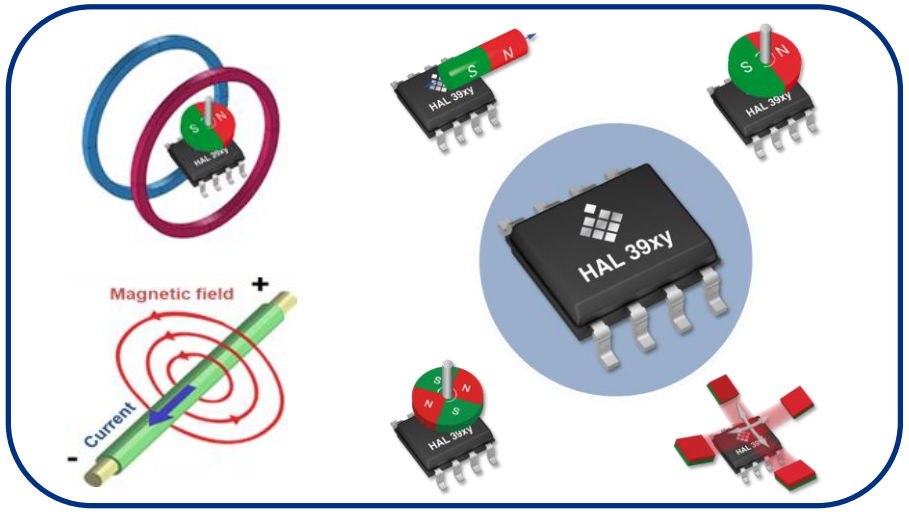
HAL 39xy at a glance ASIL ready

- **Best in class regarding**

- Unique stray-field concept
  - ¬ for linear & rotary setup‘s up to 360°

- Stray-field robustness @ 4 kA/M
  - ¬ HAL 39xy <= 0.12° (full-filling VW norm)
  - ¬ Competition <= 0.6°

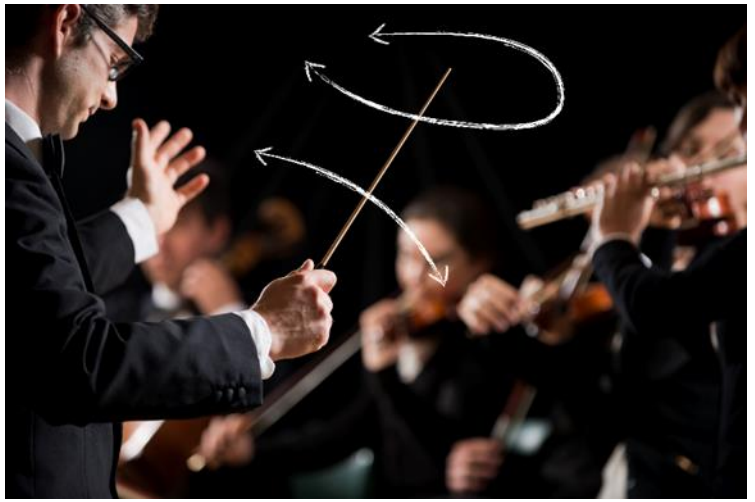
Elektronik Produkte des Jahres 2019



- Flexible measurement setup/front-end
  - ¬ One hardware for four different measurement setup‘s
  - ¬ Competition needs three different setup‘s
  - ¬ Real 3D capability (direct measurement)

- Customized sleep modes (wake-up by angle/field change)

- Highly flexible architecture to enable customized variants



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Thank you for your attention!

Questions?