New Product Update

Automotive, high-precision, linear 3D Hall-effect sensor with I²C interface

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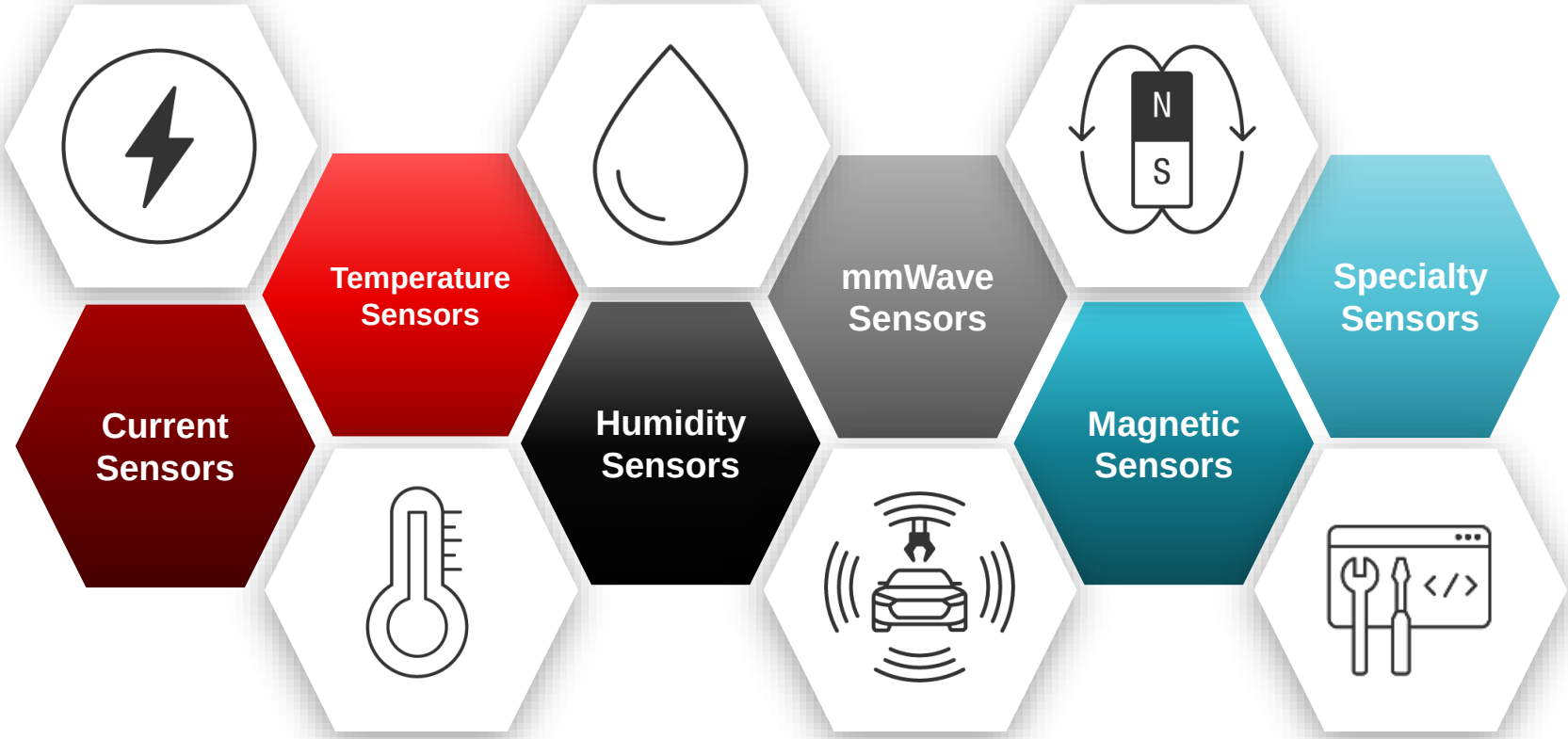
Agenda

- Hall-effect portfolio
- TMAG5173-Q1 product overview
- Functional Safety overview and benefits
- System-level benefits

Please feel free to “chat” Sagir, systems Engineer, who is available to answer any questions you have throughout this presentation.

Sensors to accurately measure the real world

Design intelligent systems with highly accurate, small-size sensors

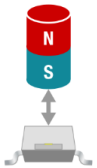


Position Sensing Portfolio Overview

Hall

Switch

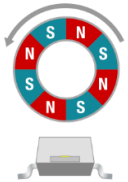
Indicates the presence or absence of a magnetic flux density that exceeds a defined threshold.



Hero Parts: DRV5032, TMAG5231, TMAG5123-Q1, TMAG5124-Q1

Latch

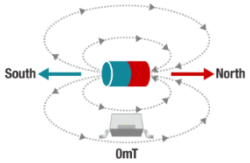
Indicates the most recently measured magnetic flux density. Alternating south and north poles are required to toggle the output.



Hero Parts: DRV5013-Q1, TMAG5110-Q1, TMAG5111-Q1

Linear & Angle

The device outputs a signal (either analog or digital) proportional to the magnetic flux density.



Hero Parts: TMAG5170-Q1, DRV5055-Q1, DRV5053-Q1, DRV5056-Q1

Ultrasonic

Analog Front End

Solutions for presence, proximity, position and level sensing. AFE solutions drive ultrasonic transducers and include amplification and filter circuity before further processing by the MCU for a flexible solution.

Hero Parts: TDC1000-Q1, TUSS44x0

Analog Front End + Digital Processing

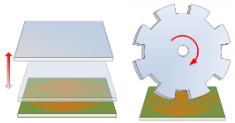
Solutions for presence, proximity, position and level sensing. These solutions include further processing (like computing time-of-flight measurements) to off-load work done by the MCU for a more integrated solution.

Hero Parts: PGA460-Q1

Inductive

Resonant (LDC-FDC)

Solutions for touch buttons, incremental encoders/event counting, metal proximity detection and liquid level sensing. Resonant LDC solutions enable the next generation of reliable, contactless sensing for harsh environments.



Hero Parts: LDC3114-Q1, LDC161x-Q1, LDC131x-Q1, FDC1004-Q1

Contactless Inductive

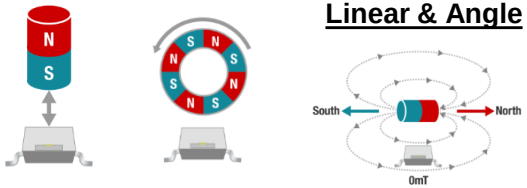
Inductive position sensor front-end with differential sine-cosine output, designed for functional safety applications.

Hero Parts: LDC5072-Q1

Position Sensing | Vectors of Innovation

Hall

Switch **Latch** **Multi-Axis Linear & Angle**

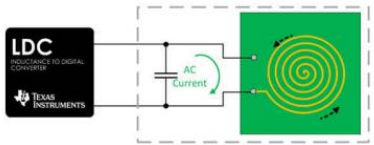


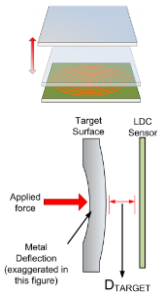
Utilize Magnetic Flux to detect proximity, rotation, and position without mechanical contact.

Inductive

Resonant (LDC-FDC) **Contactless Inductive**

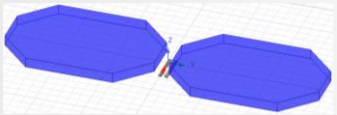
Utilize change in Sensor inductance created by button deflection to detect position without a magnet or mechanical contact.

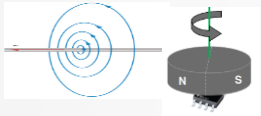




Hall

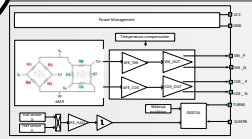
- Integrated Magnetic Concentrator for high SNR and industry highest sensitivity in-plane silicon hall sensor
- Stray Field Immunity for improved robustness to environmental fields
- Optimized Hall sensor to improve SNR, lower response time, and lower power

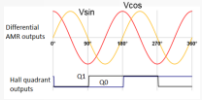




AMR

- In-house ARM sensing element that is optimized to application
- 0-latency signal chain with support for 100k RPM
- Integrated Hall +AMR elements for sensor redundancy and smart quadrant





Inductive

- High speed digital interface with calculated angle output in addition to sin/cos
- Improved angle accuracy < 0.5° with less than 1 µs latency
- Sensing element design tool to automate sensing element development and generate PCB design

TMAG5173-Q1 High-Precision 3D Hall-Effect Sensor With I2C Interface

Features

Standard Specs:

- Supply voltage: **2.3 to 3.6V**
- Linear magnetic range (X,Y,Z):
  - TMAG5173x1-Q1: ±40 mT & ±80 mT
  - TMAG5173x2-Q1: ±133 mT & ±266 mT
- Sleep current: 8nA (typical)
- AEC-Q100 qualified for grade 1 (-40C to 125°C ambient)
- Angle CORDIC for X-Y, Y-Z, or Z-X plane with a resolution of 1/16 degree
- I2C interface with cyclic redundancy check
  - Maximum 1 MHz I2C clock speed
- Configurable unipolar and omni polar switch function
- Integrated temperature compensation for multiple magnet types
- Built-in temperature sensor

Critical Specs:

- Accuracy:
  - Sensitivity mismatch temperature drift X-Y axes: **±2%** (maximum)
  - X-Y angle measurement temperature drift: **±1.2°** (maximum)
- Functional safety-compliant: **ASIL B and SIL 2**

Applications

- Steering column control
- Steering wheel control
- Shifter systems
- E-bikes
- Actuators
- Door module
- Power seats
- Magnetic proximity switch

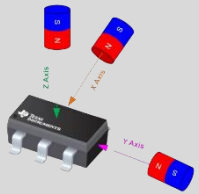
Benefits

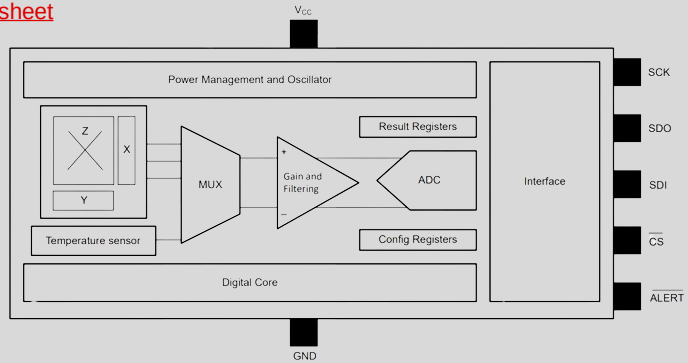
- Voltage range compatible with many battery types and traditional MCUs
- Comprehensive range of magnetic sensitivity options
- Enables precise system measurement
- The I2C interface, while supporting multiple operating VCC ranges, ensures seamless data communication with microcontrollers
- Eliminates error due to magnet shifting over temperature
- Suitable for the harshest automotive grade 1 environments

Resources and Block Diagram

- Apps Doc: Measuring 3D Motion Absolute Position Sensors
- User Guide: Joystick and Lever Design With Hall-effect Sensors
- Safety Manual
- TMAG5173 Evaluation Module(EVM)
- TI Magnetic Sense Simulator(TIMSS)
- TMAG5173-Q1 Datasheet
- EVM Users Guide
- Product folder

SOT-23
2.9 mm × 2.8 mm





EE Steering Column Control Module for Automotive System

Position Sensors

Hero Devices: TMAG5173-Q1, TMAG5170-Q1

Customers: Europe, China, and Japan Tier1

Challenges in this EE

- **Accuracy**
  - Able to model performance along with mechanical tolerances
  - Meet industry's benchmark performance specifications
- **Low cost**
  - Minimal components for the overall system
- **Functional safety**
  - Comply to industry standards
- **Platform adaptability**
  - Supports different interfaces
  - Able to meet multiple OEMs needs

Where TI Position Sensing excels to overcome these challenges

- Offering the best accuracy with <1.5° sensing angle error
- Up to ASIL-D Systematic Capability (ISO26262)
- Magnetic sensors (3D) allow measurement of complete field for complex angle measurements
- Built-in diagnostics to enhance the robustness and reliability of the system
- Supports different voltage (3.3V or 5V) nodes with the same device
- Offers I2C, SPI, PWM, SENT, SIN/COS

Hero Devices	EE	More resources
TMAG5173-Q1	Steering Column Control	- Apps: Measuring 3D Motion Absolute Position Sensors - Apps: Joystick and Lever Design With Hall-effect Sensors - EE Block diagram - TMAG5173-Q1 Datasheet - TMAG5173 Evaluation Module - TMAG5170-Q1 Datasheet - TMAG5170U Evaluation Module - Safety Manual
TMAG5170-Q1		

What is Functional Safety?

“Absence of unreasonable risk due to hazards caused by malfunctioning behavior of E/E Systems”

[ISO 26262 - Part 1: 3.67]

Any electronic system will have some inherent, quantifiable random failure rate. It is not possible to develop a system with zero random failures.

- Electronic system failure possibilities include not only IC, but also sensors, connectors, cables, solder joints, capacitors, solenoids, antennas, lamps, relays, etc.
- For each system function, there is some tolerable failure rate which does not lead to unacceptable risk of hazardous events.
- Example: If a steering sensor element malfunctions, will the driver have an acceptable probability to remain in control and halt the vehicle without physical injury?

What is the Goal of Functional Safety?

A functional safety approach shall prevent or limit
- Loss of life
- Excessive environmental damage
- Significant loss of, or damage to property
- Major injury or illness
- Loss of control/mitigation against catastrophic risk.

Due to failures in the technical design i.e, malfunction of the electrical system

The goal is not to provide the perfect car. E.g.
- A car that does not skid on icy road
- A car that is 100% safe –never has a accident

We can, however , have a safety goal for the vehicle/car to keep a safe distance from other cars/objects.

ISO 26262 ASIL Ranking Table

ASIL Rankng Table					
Severity (How Bad)	Probability of Exposure		Controlability by driver		
			C1 Simply Controllable >99% of drivers able to control	**C2** Normally Controllable >90% of drivers able to control	**C3** Difficult to Control <90% of drivers able to control
S1 (Light or Moderate Injury)	**E1**	Very Low	QM	QM	QM
	E2	Low < 1%	QM	QM	QM
	E3	Medium 1~10%	QM	QM	ASIL - A
	E4	High > 10%	QM	ASIL - A	ASIL - B
S2 (Severe Injury / Survival Probable)	**E1**	Very Low	QM	QM	QM
	E2	Low < 1%	QM	QM	ASIL - A
	E3	Medium 1~10%	QM	ASIL - A	ASIL - B
	E4	High > 10%	ASIL - A	ASIL - B	ASIL - C
S3 (Life Treatening Injury)	**E1**	Very Low	QM	QM	ASIL - A
	E2	Low < 1%	QM	ASIL - A	ASIL - B
	E3	Medium 1~10%	ASIL - A	ASIL - B	ASIL - C
	E4	High > 10%	ASIL - B	ASIL - C	ASIL - D

EPS Wrong Torque:
S3
E4
C3

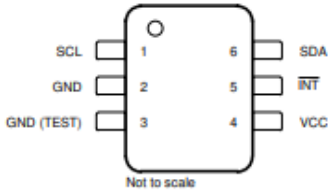
ASIL D

Headlight Burnt out:
S0 – S1
E4
C2 – C3

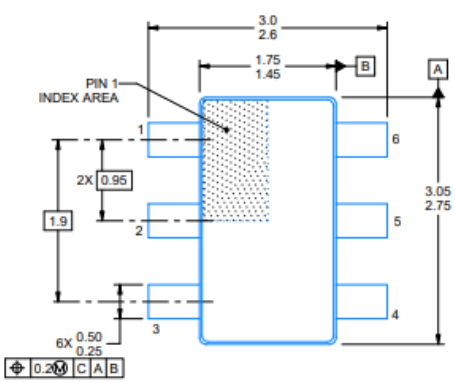
ASIL A or ASIL B

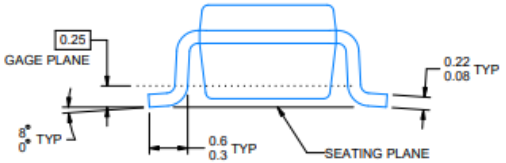
TMAG5173-Q1 Device Options

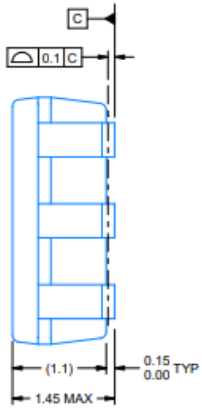
	Temp Grade	Linear Magnetic Range (X,Y,Z)
TMAG5173X1-Q1	Grade1 (Ta=125, Tj<150)	±40 & ±80 mT
TMAG5173X2-Q1	Grade1 (Ta=125, Tj<150)	±133 & ±266 mT

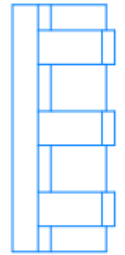


PIN		TYPE	DESCRIPTION
NO.	NAME		
1	SCL	IO	Serial clock.
2	GND	GND	Ground
3	GND (TEST)	I	TI Test Pin. Connect to ground in application.
4	VCC	P	Supply voltage
5	INT	IO	Interrupt input/ output. If not used and connected to ground, set MASK_INTB = 1b.
6	SDA	IO	Serial data.









Texas Instruments

Getting started

You can start evaluating this device leveraging the following:

Content type	Content title	Link to content or more details
Product folder	TMAG5173-Q1	TMAG5173-Q1 data sheet, product information and support | TI.com
Customer training series or webinar session	FAE update	First week of august
Application brief	Absolute angle measurement for rotational motion using Hall-Effect sensor	Absolute Angle Measurements for Rotational Motion Using Hall-Effect Sensors (Rev. B)
Application brief	Measuring 3D motion with Absolute position sensors	Measuring 3D Motion With Absolute Position Sensors (Rev. B)
Technical Video	Designing with hall-effect sensor (EPS)	Designing with Hall-effect sensors: Steering column stalk | Video | TI.com
Selection and design tools and models	TIMSS (Texas Instruments Magnetic Sensing Simulator)	https://webench.ti.com/timss/
Development tool or evaluation kit	TMAG5173-Q1EVM	TMAG5173EVM Evaluation board | TI.com

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