TMR transmission speed sensor for toothed wheel applications in top-read

Features

- High magnetic field sensitivity enables ultra-low jitter over high operating air-gap range
- Two wire PWM current interface
- Direction detection
- Vibration suppression (active via protocol suppression; passive via adaptive hysteresis)
- Differential sensing principle enables magnetic stray field robustness
- Equipped with sintered ferrite back-bias magnets and algorithm optimized for toothed wheel applications
- EMC robust without the need of capacitors on sensor leads
- Comprehensive digital diagnostic interface, enabling readout of internal signals and electronic chip ID

ISO 26262 compliant

RoHS

Potential applications

- Ideal for the use in harsh environments, particularly automotive transmissions
- Suitable for all kinds of transmission systems including DHT (dedicated hybrid transmission) and EV (electric vehicle) concepts.

Product validation

Qualified for automotive applications. Product validation according AEC-Q100.

ISO 26262 safety element out of context for safety requirements up to ASIL B(D).

Description

The TLE5555iC is a differential magnetic speed sensor based on tunnel magnetoresistance (TMR) sensing technology. This technology enables best-in-class jitter and air gap performance and allows sensing flexibility in top and side read configuration. It basic function is provide information about the rotational speed and the direction of the rotation to the transmission control unit. Therefore the sensor family includes a sophisticated algorithm which actively suppress vibration. The output has been designed as a two wire current interface based on a PWM (pulse width modulation) principle. The TLE5555iC operates without external components and is fully EMC-compliant thanks to its capacitor integrated on silicon level.

The "iCB-top" family members are designed for toothed wheel applications and have a ferrite back-bias magnet attached. It comes in a RoHS compliant two-pin-package, qualified for automotive usage. It is recommended to use the iCB-top within an overmolded module. For magnetic encoder (ME) applications, other sensors - called ME family - are available.

Note

This document is an internet datasheet, it does not completely specify our products. Please contact Infineon if you need the full version of the datasheet.

Ordering information

Product name	Ordering code	Marking	Package
TLE5555iCB E0-top	SP003883500	55BET0	PG-SSOA22-2-51
TLE5555iCB E1-top	SP005401486	55BET1	PG-SSOA22-2-51
TLE5555iCB E4B-top	SP005832705	55BET4	PG-SSOA22-2-51

Table of contents

1 Pin description and application diagram

The device shall operate in the following application circuits:

1. with sensing resistor connected to the GND pin of the sensor

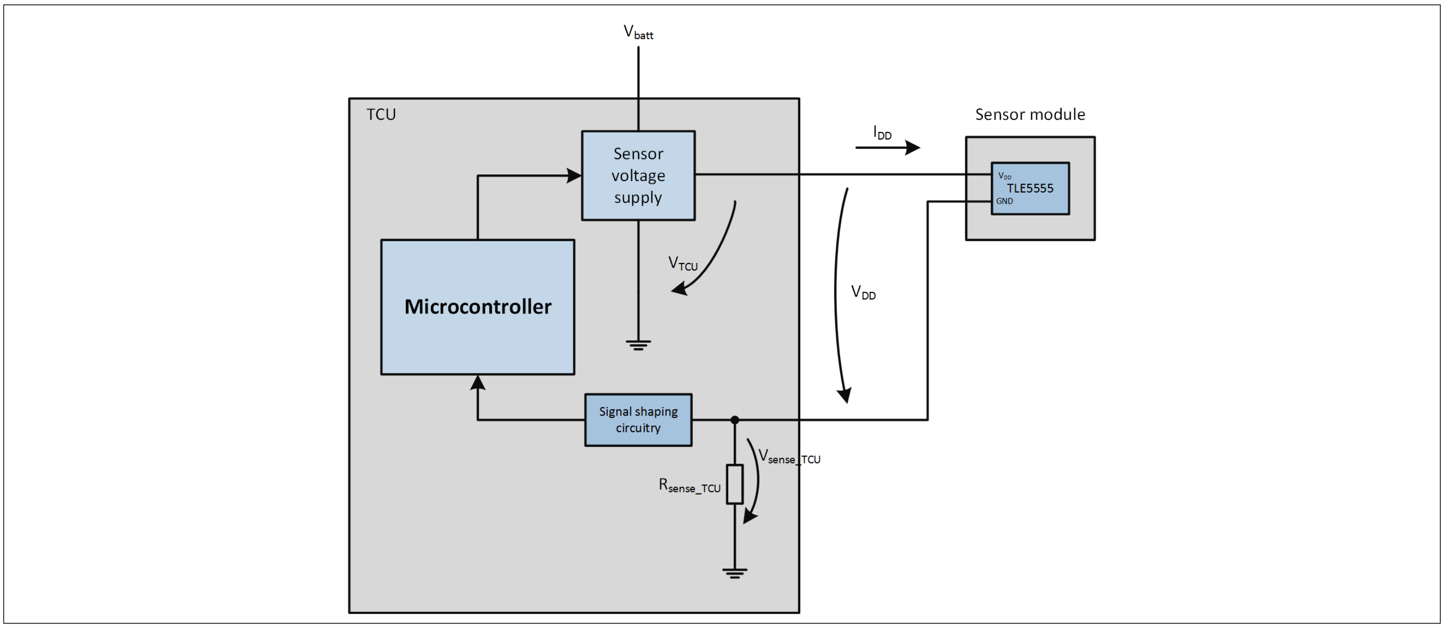

Figure 1 **TCU application circuit**

2. in a current mirror configuration with the sensing element connected to the current mirror

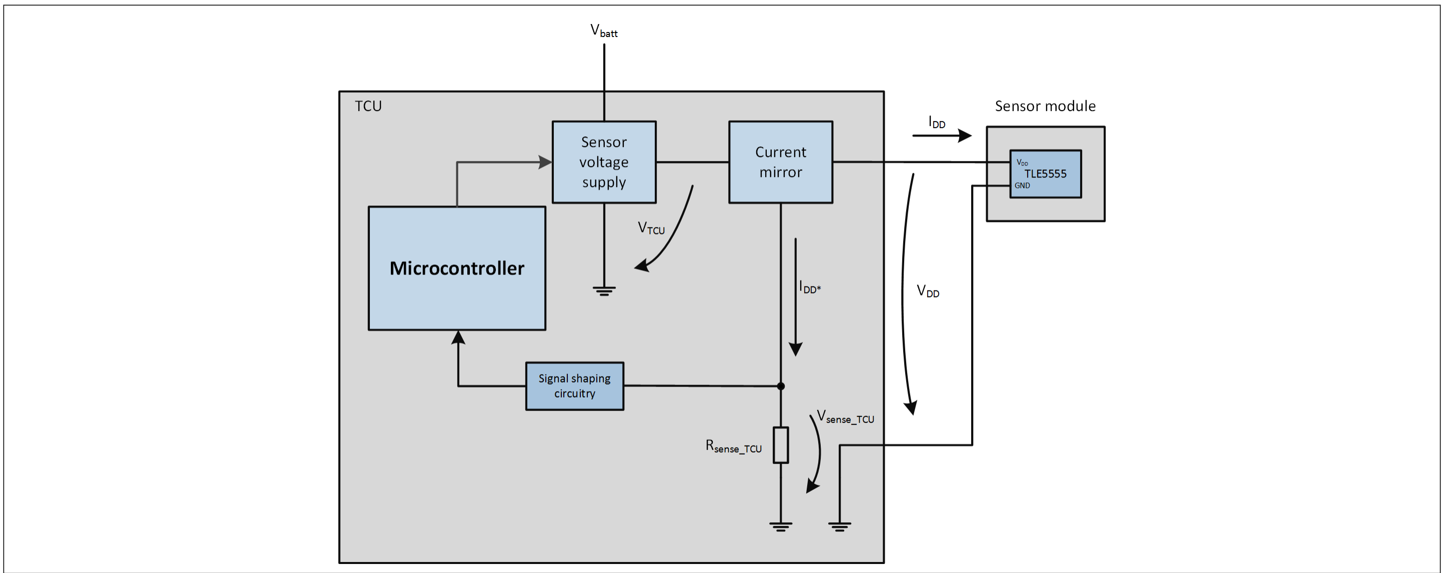

Figure 2 **Current mirror application circuit**

I_{DD*} is the mirrored current of I_{DD}

Figure 3 Pin configuration

Pin No.	Symbol	Function
1	V_{DD}	positive supply
2	GND	negative supply

2 Operating range

All parameters specified in the following sections refer to these operating conditions unless noted otherwise. For further details please refer also to any relevant application note.

Table 1 Operating range

Parameter	Symbol	Values			Unit	Note or condition
		Min.	Typ.	Max.		
Supply voltage	V_{DD}	4.0	9.0	24.5	V	Measured on IC leads.
Operating junction temperature	T_J	-40		175	°C	2500h; T_J variations described in safety manual
Magnetic input frequency range	f_{MAG}	0		16	kHz	
Limit threshold speed	dB_{SPD_LIMIT}		69	118	µT	amplitude value; differential signal: R-L; at 25°C; $TC_{\Delta B}$ of typ. -1900ppm/K; 99.99% criterion

3 Characteristics

The product characteristics are valid over the operating range.

Table 2 Characteristics

Parameter	Symbol	Values			Unit	Note or condition
		Min.	Typ.	Max.		
Supply current low	I_{LOW}	6.0	7.0	8.0	mA	
supply current high	I_{HIGH}	12.0	14.0	16.0	mA	
Supply current failure indication	I_{FI}	2.0	3.0	3.5	mA	signal path deactivated; might increase to max. 3.9mA if the IC leads are connected to the magnet
Supply current ratio	I_{HIGH}/I_{LOW}	1.9	2.0	2.2		
Supply current ratio	I_{LOW}/I_{FI}	2.0	2.2	2.95		
Output rise and fall slew rate	*SR*	8	17	26	mA/µs	between 10% to 90% of the nominal supply current levels I_{LOW} and I_{HIGH}; R_M=75Ω
Power on time	t_{ON}			1	ms	after V_{DD} comparator release
Period jitter	S_{JIT}			0.2	%	1σ period jitter $dB_{SPD} \geq 2 \times dB_{SPD\_LIMIT}$ f_{MAG}<12kHz
Overtemperature warning	T_{J_WRNNG}	165		185	°C	WRNNG pulses are delivered if T_J exceeds T_{J_WRNNG}
Valid for protocols with WRNNG pulses						
Low signal warning	dB_{WRNNG}/dB_{LIMIT}		2			WRNNG pulses are delivered if dB_{SPD} is below 2 x $dB_{SPD\ LIMIT}$; or if dB_{DIR} is below 1 x $dB_{DIR\ LIMIT}$
VDD warning level	$V_{DD\ WRNNG}$	3.57	3.77	3.99	V	WRNNG pulses delivered in case of undervoltage; valid for protocols with WRNNG pulses
VDD reset level	$V_{DD\ RESET}$	2.85	3.00	3.26	V	I_{FI} in case of undervoltage; valid for protocols with WRNNG pulses
Valid for protocols without WRNNG pulses						
VDD reset level	$V_{DD\ RESET}$	3.42	3.60	3.78	V	I_{FI} in case of undervoltage; valid for protocols without WRNNG pulses
Following characteristic depends on protocol definition						
Pulse without direction information	n_{NODIR}	1	1	1	pulse	valid for protocols with STRT pulse; on wheel rotation startup, the 1st pulse is a STRT pulse, the 2nd pulse provides correct direction information

(table continues...)

Table 2 (continued) Characteristics

Parameter	Symbol	Values			Unit	Note or condition
		Min.	Typ.	Max.		
Pulse without direction information	n_{NODIR}	0	0	0	pulse	Valid for protocols without STRT pulse; on wheel rotation startup, pulses are suppressed until direction information is available

4 Protocol timing

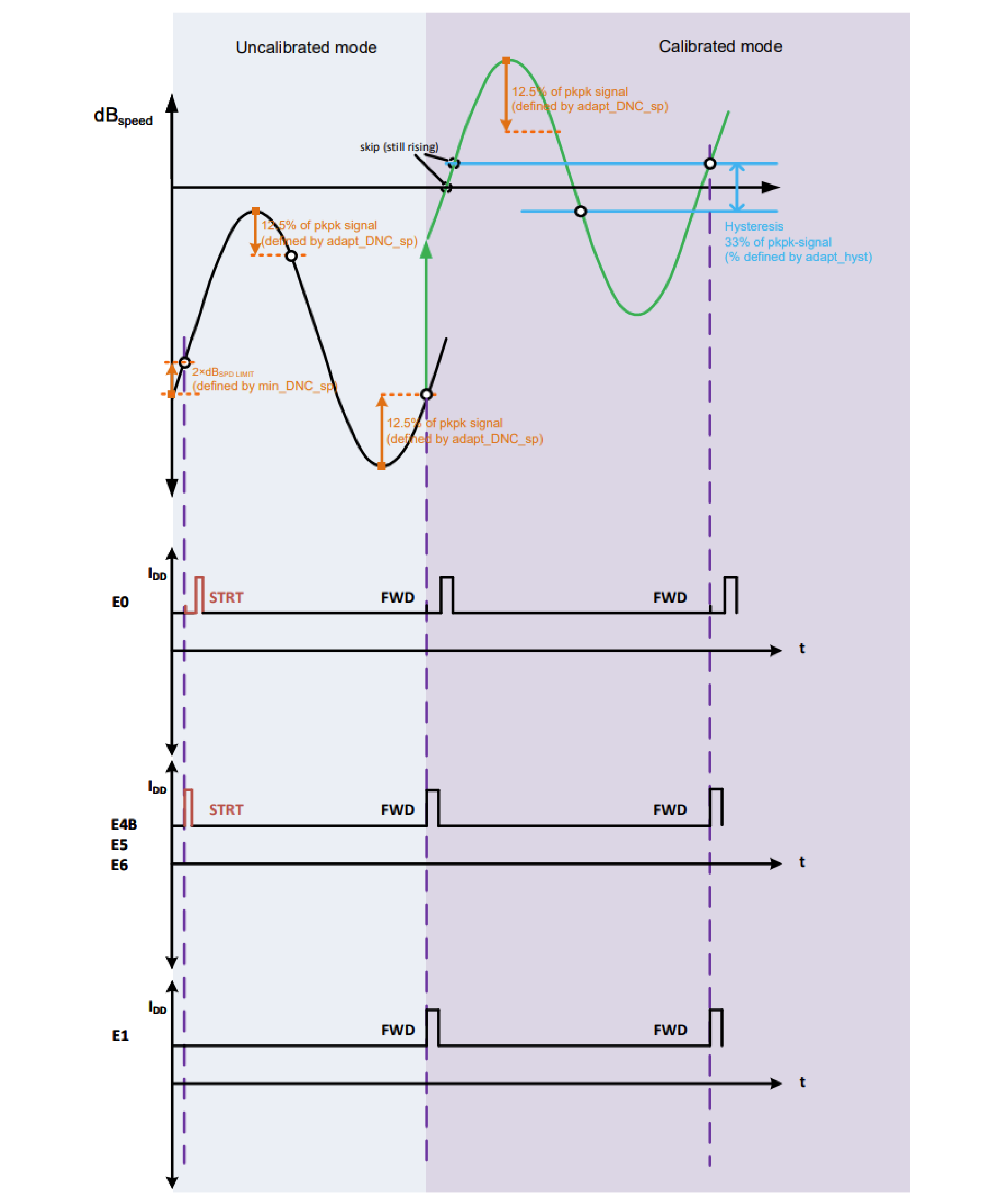

Figure 4 **Protocol timing description**

The sensor provides a PWM-protocol. The frequency of the PWM-pulses rising edges is proportional to the rotational speed of the rotating axis. The pulse width instead provides additional information such as the wheel rotation direction. The table below lists the pulse naming and description.

Pulse	Symbol	Description
STRT pulse	t_{STRT}	first pulse after power on, undervoltage, microbreak or temperature watchdog reset
FWD pulse	t_{FWD}	forward pulses are delivered during wheel rotation in forward direction
BWD pulse	t_{BWD}	backward pulses are delivered during wheel rotation in backward direction
WRNNG FWD pulse	t_{WRNNG_FWD}	warning forward pulses are delivered on low rotational speed if the sensor detects a warning condition and forward rotation direction
WRNNG BWD pulse	t_{WRNNG_BWD}	warning backward pulses are delivered on low rotational speed if the sensor detects a warning condition and backward rotation direction
SPD pulse	t_{SPD}	speed pulses are delivered at high rotational speed to prevent pulse overlapping
ALV pulse	t_{ALV}	alive pulse t_{ALV} is delivered every T_{ALV} at low frequency to ensure correct connection between sensor and TCU. If a speed and/or direction pulse is triggered during alive pulse, then this pulse will be delayed and delivered after the alive pulse.
ALV period	T_{ALV}	alive pulse t_{ALV} is delivered every T_{ALV} at low frequency to ensure correct connection between sensor and TCU

60/120/30 protocol (E0 sales type)

The 60/120/30 protocol is well established since decades in the transmission market. It provides rotational direction information only at low speed. This protocol is available as "E0" sales type.

Table 3 60/120/30 protocol timing

Parameter	Symbol	Values			Unit	Note or condition
		Min.	Typ.	Max.		
STRT pulse	t_{STRT}	26.5	30	34	µs	
FWD pulse	t_{FWD}	52.5	60	67.5	µs	during wheel rotation from V_{DD} to GND; above a typical frequency of 1 kHz, SPD pulses are delivered
BWD pulse	t_{BWD}	105	120	135	µs	during wheel rotation from GND to V_{DD}; above a typical frequency of 1 kHz, SPD pulses are delivered
SPD pulse	t_{SPD}	26.5	30	34	µs	above a typical frequency of 1 kHz, SPD pulses are delivered without direction information

45/90/20 protocol (E4B sales type)

The 45/90/20 protocol is available as "E4B" sales type.

Table 4 45/90/20 protocol timing

Parameter	Symbol	Values			Unit	Note or condition
		Min.	Typ.	Max.		
STRT pulse	t_{STRT}	17	20	23	µs	
FWD pulse	t_{FWD}	39.5	45.0	50.5	µs	during wheel rotation from V_{DD} to GND; above a typical frequency of 14.3 kHz, SPD pulses are delivered
BWD pulse	t_{BWD}	79	90	100	µs	during wheel rotation from GND to V_{DD}; above a typical frequency of 8.7 kHz, SPD pulses are delivered
WRNNG FWD pulse	t_{WRNNG_FWD}	158	180	202	µs	above a typical frequency of 4.8 kHz, FWD pulses are delivered
WRNNG BWD pulse	t_{WRNNG_BWD}	210	240	270	µs	above a typical frequency of 3.7 kHz, BWD pulses are delivered
SPD pulse	t_{SPD}	17.5	20	22.5	µs	
ALV pulse	t_{ALV}	444	500	556	µs	
ALV period	T_{ALV}	21.5	25.0	29.1	ms	time between following rising edges

45/180 protocol (E1 sales type)

The 45/180 protocol is available as "E1" sales type.

Table 5 45/180 protocol timing

Parameter	Symbol	Values			Unit	Note or condition
		Min.	Typ.	Max.		
FWD pulse	t_{FWD}	39.5	45	50.5	µs	during wheel rotation from GND to V_{DD}; above a typical frequency of 14.3 kHz, pulses overlap
BWD pulse	t_{BWD}	158	180	202	µs	during wheel rotation from V_{DD} to GND; above a typical frequency of 4.9 kHz, pulses overlap

5 Application information

In the so called back bias applications, a permanent magnet is attached to the sensor and generates a static magnetic field. This static field is influenced by the rotating wheel in front of the sensor. The magnetic signal at the position of the sensor strongly depends on the mechanic and magnetic boundary conditions such as tooth wheel design, permanent magnet strength or air gap.

The TMR sensor detects the differential magnetic field (called dB_{SPD}) and provides an electrical output according to the movement of the wheel. The number of sensor pulses increases with increasing rotational speed of the shaft. The rotational speed of the shaft can be measured by counting the number of pulses delivered by the sensor within a certain time window. Additionally, the rotation direction of the shaft is determined by the sensor. Depending on the detected rotation direction a different pulse length is delivered via PWM (pulse width modulation) protocol.

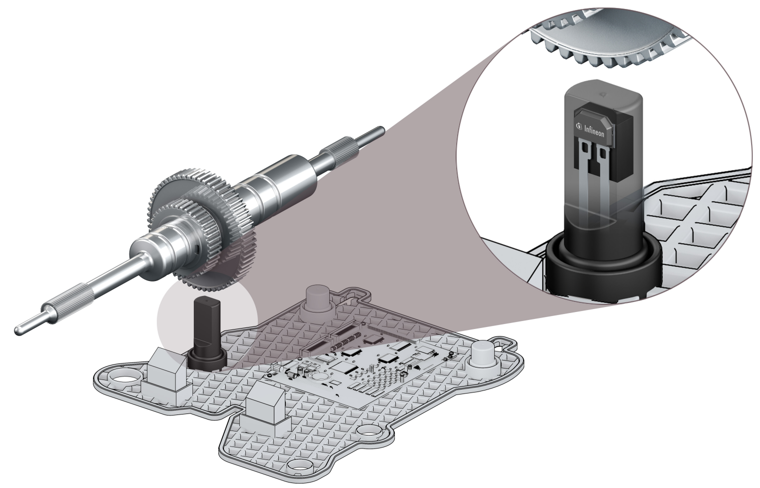

Figure 5 Application example

6 Package drawing

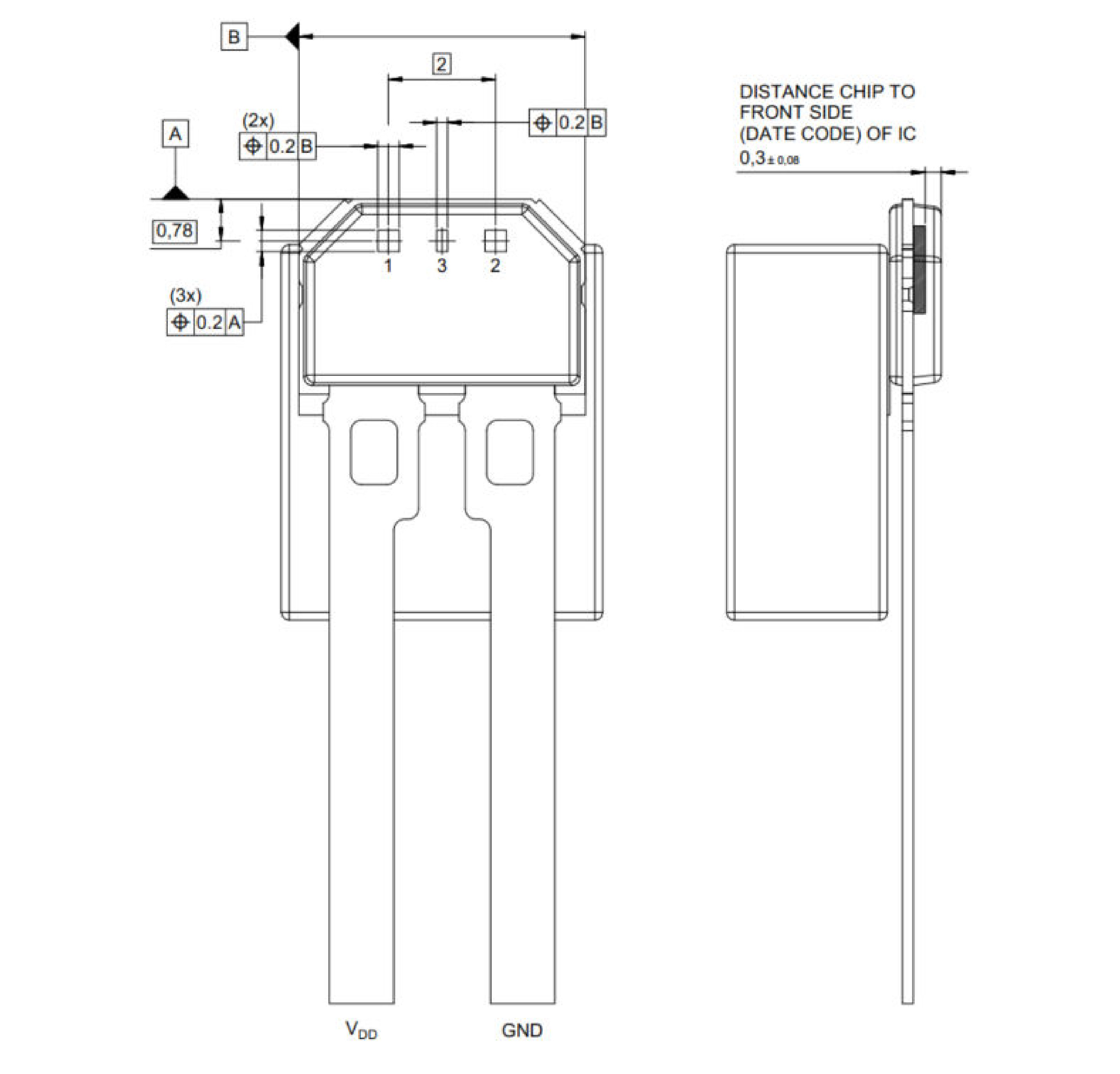

Figure 6 **Sensing element location**

7 Revision history

Document version	Date of release	Description of changes
1.00	2023-12-12	First released internet version of datasheet

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Edition 2023-12-12

Published by

Infineon Technologies AG

81726 Munich, Germany

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Document reference
IFX-jobid__2023121291452153_LastLeaf2