

TLE5046SiC Data Sheet

TLE5046SiC

High End GMR Wheel Speed Sensor ASIL B (D)

Features and Benefits

- Developed according to ISO 26262, compliant to the requirements of ASILB(D)
- Low jitter 0.02% due to high switching accuracy enables iTPMS
- Wide operating junction temperature range -40°C to 190°C
- Two-wire current interface providing speed and direction information
- High sensitivity enables outstanding air gap performance along with immunity against y-displacement effect
- Robustness against external magnetic disturbances up to 2 mT through differential sensing principle
- Advanced stop-start capabilities enabled by
 - Innovative watchdog concept to guarantee maximum signal availability
 - No loss of direction information during start stop condition
- Small sensor package 5 x 3 mm without need of external capacitor saves module size, increases robustness against mechanical stress and enables design freedom
- Advanced EMC concept maximizes the availability of the sensor signal
- New established Micro Break feature designed to be immune against disturbances on supply line



PRO-SIL™ for ISO 26262

TLE5046SiC is accompanied by accurate safety analysis and complete documentation to enable the system integrator to quickly evaluate the compatibility with the system/item and start the integration process. The provided Safety Manual explains how to use the sensor in safety critical applications and the Safety Analysis Summary Report provides the key results of the safety analysis.

<http://www.infineon.com/cms/en/applications/automotive/safety/>

Description

The TLE5046SiC-AK-LR is a wheel speed sensor with direction indication designed for sophisticated vehicle control systems. TLE5046SiC-AK-LR shows best in class jitter performance making it the best choice for wheel speed applications. The rotational speed is sensed with high accuracy, enabling the sensor to be used as a component of indirect tire pressure monitoring systems (iTPMS). It is based on integrated giant magneto resistance (iGMR). Excellent sensitivity to magnetic field is specified over a wide temperature range. To meet harsh automotive requirements, robustness to electrostatic discharge (ESD) and electromagnetic compatibility (EMC) has been maximized without the need of additional external components.

Product Variants and Ordering Codes

Product Variants and Ordering Codes

TLE5046SiC is available in 2 different variants, both are ASIL B (D) compliant and can be integrated in an ASIL D system. Both variants comes up with very low FIT rate, due to the design and technical concept. In addition the TLE5046SiC-AK-ERR Version offers an elaborate safety concept.

Table 1 **Product Variants**

Product Type	Load Resistor ¹⁾	Marking	Ordering Code	Package	ASIL
TLE5046SiC-AK-LR ^{1) 2)}	$15\ \Omega \leq R_M \leq 50\ \Omega$	462X0A	SP005947803	PG-SSO-2-1	ASIL B (D)
TLE5046SiC-AK-ERR ^{1) 3)}	$15\ \Omega \leq R_M \leq 50\ \Omega$	462X0K	SP005965436	PG-SSO-2-1	ASIL B (D)

1) see Application Circuit [Chapter 1](#)

2) basic Safety Concept, for details see Safety Manual

3) enhanced Safety Concept, for details see Safety Manual. This sensor offers lower FIT rates

Due to the “Standard VDA AK4.0” document in Chapter 5.2.4 [10] the bit position #0 can be used as indication for “air gap - Luftspaltreserve” or it can be interpreted as “Error bit” which can be interpreted by the ECU and treated in a special way, to initiate corresponding measures on system level. The air gap warning bit is set when the measured magnetic input signal of the sensor drops below the value of the double magnetic input signal based on the limit air gap.

Table of contents
Table of contents

	Features and Benefits	1
	PRO-SIL™ for ISO 26262	1
	Description	1
	Product Variants and Ordering Codes	2
	Table of contents	3
1	Application Circuit	5
2	Absolute Maximum Ratings	6
3	Operating Range	7
4	Functional Parameters	10
5	Functional Description	12
5.1	Block Diagram	12
5.2	Switching Behavior	13
5.2.1	Operating Modes	14
5.2.1.1	Uncalibrated Mode	14
5.2.1.1.1	Calibrated Mode	14
5.2.2	Undervoltage Behavior	14
5.2.3	Watchdog	15
5.2.4	Safety Mechanisms	15
5.3	Typical Performance	16
6	VDA AK 4.0	19
6.1	Bit Definition	19
6.2	AK 4.0 in TLE5046SiC-AK-LR and TLE5046SiC-AK-ERR	20
6.2.1	Bit stump suppression - Constant time shift of output of speed pulse and data protocol	20
6.2.2	Air Gap Dimension	20
6.2.3	Failure indication state	21
7	EMC and ESD Characteristics	22
7.1	Transient Immunity	22
7.1.1	Electrical Transient Conduction along Supply Lines	22
7.1.2	Electrical Transient Transmission by Capacitive Coupling Clamp (CCC)	23
7.1.3	ESD HBM & CDM	24
8	Product Qualification	24
9	Package Outlines	25
9.1	Bending and assembly	25
9.2	Package surface to silicon	25
9.3	Package	26



Table of contents

10	Revision History	28
11	Terminology	29
12	References	30
	Disclaimer	31

1 Application Circuit

1 Application Circuit

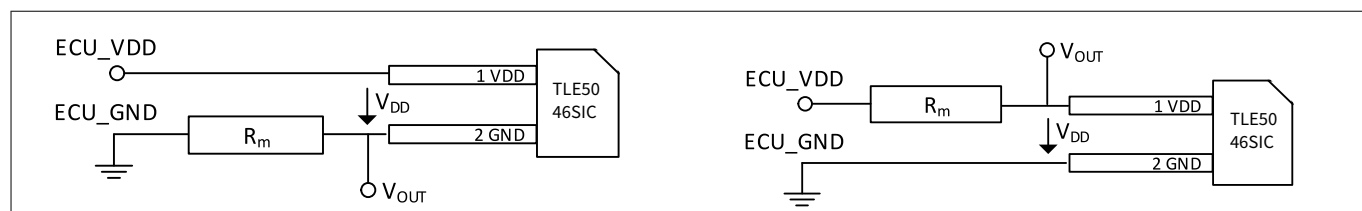


Figure 1 Pin Configuration PG-SSO-2-1

Table 2 Pin Description

Pin No.	Symbol	Function
1	V_{DD}	Supply voltage
2	GND	Ground

2 Absolute Maximum Ratings

2 Absolute Maximum Ratings

Table 3 Maximum Ratings¹⁾

Parameter	Symbol	Values			Unit	Note or Test Condition
		Min.	Typ.	Max.		
Supply voltage	V_{DD}	-	-	24	V	max. 30 min @ $T_J = 25 \pm 5^\circ\text{C}$
		-0.6	-	-	V	$T_J < 80^\circ\text{C}$, I_{DD} reverse current limit applies
Reverse current	I_{DD}	-200	-	-	mA	t = max. 4 h
Junction temperature ²⁾	T_J	-40	-	190	$^\circ\text{C}$	max. 4 h, $V_{DD} < 16.5\text{ V}$
Magnetic flux density	B_{max_x}	-	-	250	mT	max. 1 min @ $T_A \leq 85^\circ\text{C}$
	B_{max_y}	-	-	-	-	-
	B_{max_z}	-	-	500	mT	max. 1 min @ $T_A \leq 85^\circ\text{C}$

- 1) Stresses above the maximum values listed here may cause permanent damage to the device. Exposure to absolute maximum rating conditions for extended periods may affect device reliability. Maximum ratings are absolute ratings; exceeding only one of these values may cause irreversible damage to the integrated circuit.
- 2) This life time statement is an anticipation based on extrapolation of Infineon qualification test results. The actual life time of a component depends on its form of application and type of use etc. and may deviate from such a statement. The life time statement shall in no event extend the agreed warranty period.

Table 4 Lifetime Conditions¹⁾

Parameter	Symbol	Values			Unit	Note or Test Condition
		Min.	Typ.	Max.		
Passive overall lifetime	L_{Tpassive}	15	-	-	years	$T_J \leq 50^\circ\text{C}$, $V_{DD} = 0\text{ V}$ non active operating condition
Active lifetime	t_L	42500	-	-	hours	incl. 30000 h battery charging time
Power-on cycles	n_{PO}	10^6	-	-	-	$V_{DD} = 12\text{ V} \rightarrow 0\text{ V} \rightarrow 12\text{ V}$; $T_A = 25^\circ\text{C}$

- 1) This life time statement is an anticipation based on extrapolation of Infineon qualification test results. The actual life time of a component depends on its form of application and type of use etc. and may deviate from such a statement. The life time statement shall in no event extend the agreed warranty period.

3 Operating Range

3 Operating Range

The following operating conditions must not be exceeded in order to ensure correct operation.

Table 5 Operating Range

Parameter	Symbol	Values			Unit	Note or Test Condition
		Min.	Typ.	Max.		
Supply voltage	V_{DD}	5.2	-	20	V	TLE5046SiC-R050
Load resistor	R_m	15		50	Ω	Chapter 5.2.2
Junction temperature Mission profile ¹⁾	T_J	-40		125	$^{\circ}\text{C}$	either 10000 h
		-40		150	$^{\circ}\text{C}$	or, 5000 h
		-40		160	$^{\circ}\text{C}$	or, 2500 h
		-40		170	$^{\circ}\text{C}$	or, 500 h
		-40		110	$^{\circ}\text{C}$	or, 12500 h
		-40		190	$^{\circ}\text{C}$	additional 4 h, $V_{DD} < 16.5\text{ V}$
		-10		60	$^{\circ}\text{C}$	additional 30000 h (battery charging time)
Supply voltage modulation ²⁾	V_{AC}			6	Vpp	$V_{DD} = 13.5\text{ V}$, $10 < f_{\text{mod}} < 150\text{ kHz}$, sinusoidal shape of supply voltage modulation
Magnetic signal frequency ²⁾	f_{mag}	0	-	3000	Hz	
Minimum differential magnetic input signal amplitude, magnetic encoder application ³⁾	dB_{limit_x} $T_a = 25^{\circ}\text{C}$	70	90	110	μT	99% criterion, Figure 15
Minimum differential magnetic input signal amplitude, magnetic encoder application ^{2) 3)}	dB_{limit_x} $T_a = -40^{\circ}\text{C}$	80	100	120	μT	99% criterion
Minimum differential magnetic input signal amplitude, magnetic encoder application ^{2) 3)}	dB_{limit_x} $T_a = 175^{\circ}\text{C}$	30	50	70	μT	99% criterion
Magnetic induction amplitude at each GMR sensing element ²⁾	B_x	-25	-	25	mT	$T_J = 25^{\circ}\text{C}$
Dynamic and static homogeneous external disturbance fields ²⁾	$B_{\text{ext_XYZ}}$	-2		2	mT	In calibrated mode. Same field at both probes, no unwanted pulses

(table continues...)

3 Operating Range

Table 5 (continued) Operating Range

Parameter	Symbol	Values			Unit	Note or Test Condition
		Min.	Typ.	Max.		
Differential input signal amplitude after nonrecurring air gap change	k_{jump}	60	-	200	%	Within ≥ 3 signal periods. No pulse failure, period jitter and duty cycle exceeding specification; see Figure 3
Differential input signal amplitude change because of a recurring air-gap variation	k_{runout}	90	-	110	%	Once per revolution with 48 periods; see Figure 2
Typical thermal resistance of sensor module ⁴⁾	R_{thJA}		120		K/W	Including customer overmolding

- 1) This life time statement is an anticipation based on extrapolation of Infineon qualification test results. The actual life time of a component depends on its form of application and type of use etc. and may deviate from such a statement. The life time statement shall in no event extend the agreed warranty period.
- 2) Not subject to production test, verified by design/characterization
- 3) 99% criterion is defined as 1% of the magnetic edges are not represented as signal edges at the electric interface. Test condition: 1 missing pulse out of 100 valid for $f_{\text{mag}} \leq 10$ Hz; 10 missing pulses out of 1000 valid for $f_{\text{mag}} > 10$ Hz. An implemented temperature coefficient compensates the magnetic material temperature dependency (-0,2% per Kelvin) and keeps the air gap over temperature constant.
- 4) Calculation ambient temperature T_A --> junction temperature T_J : $T_J = T_A + \Delta T_{\text{JA}} \Delta T_{\text{JA_typ}}$ (typical value) = 13.5 V * 10.5 mA * 120 K/W (typical sensor module RTH) = 17 K

3 Operating Range

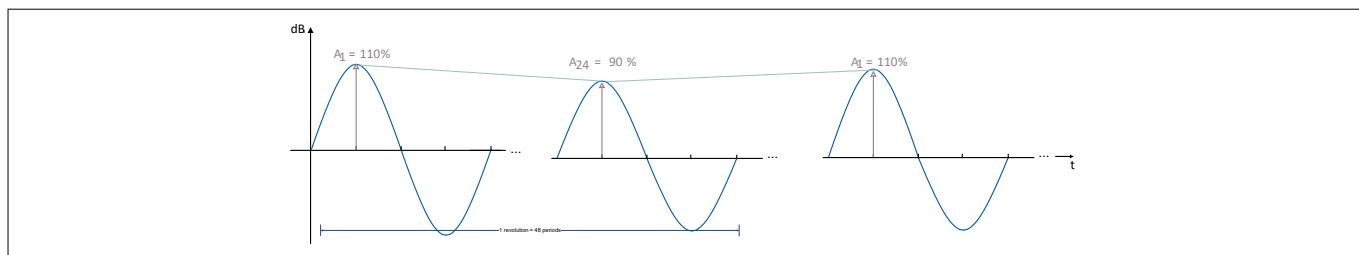


Figure 2 Recurring air-gap variation

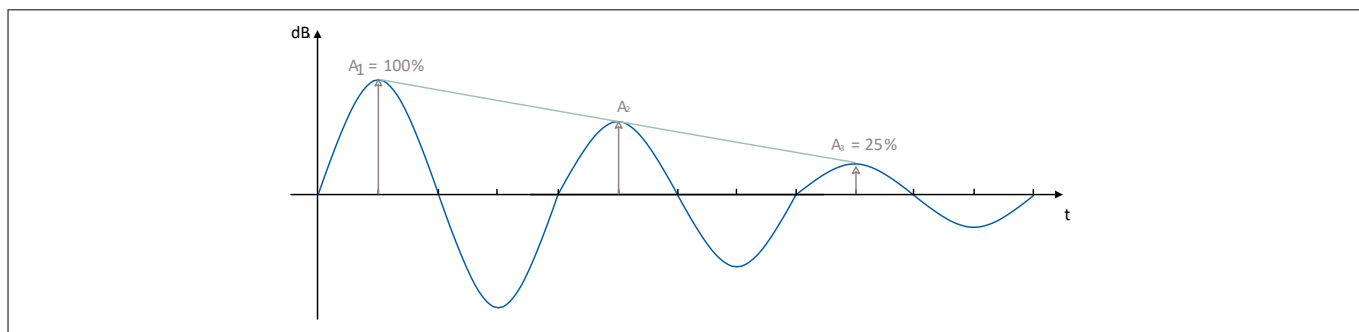


Figure 3 Non-Recurring air-gap change due to e.g. road bumps

4 Functional Parameters

4 Functional Parameters

The magnetic input is assumed sinusoidal with constant amplitude and offset. The typical values shown below are valid for $V_{DD} = 12\text{ V}$ and $T_A = 25^\circ\text{C}$.

Table 6 Functional Parameters

Parameter	Symbol	Values			Unit	Note or Test Condition
		Min.	Typ.	Max.		
Periodic jitter ¹⁾	S_{jit}	-	-	± 0.07	%	$\pm 1\sigma$ value; differential magnetic input signal and calibrated mode, frequency $1\text{ Hz} < f_{mag} < 3\text{ kHz}$, amplitude $376\text{ }\mu\text{T} \leq \Delta B_X \leq 500\text{ }\mu\text{T}$; Figure 11 , Figure 12 , Figure 13
Periodic jitter ¹⁾	S_{jit}	-	-	± 0.05	%	$\pm 1\sigma$ value; differential magnetic input signal and calibrated mode, frequency $1\text{ Hz} < f_{mag} < 3\text{ kHz}$, amplitude $501\text{ }\mu\text{T} \leq \Delta B_X \leq 6.3\text{ mT}$; Figure 11 , Figure 12 , Figure 13
Periodic jitter ¹⁾	S_{jit}	-	± 0.02		%	$\pm 1\sigma$ value; differential magnetic input signal and calibrated mode, frequency $1\text{ Hz} < f_{mag} < 3\text{ kHz}$, Amplitude $6.3\text{ mT} \leq \Delta B_X \leq 25\text{ mT}$; Figure 11 , Figure 12 , Figure 13
Duty cycle ¹⁾	DC	40	-	60	%	In calibrated mode; sinusoidal input signal and calibrated mode; $f_{mag} > 1\text{ Hz}$; s; $DC = 100\% \cdot t_1/T$, $B_{ext_XYZ} = 0\text{ mT}$, differential magnetic input signal amplitude $2 \times dB_{limit_x} \leq \Delta B_X \leq 50\text{ mT}$; Figure 14
Power-on time ¹⁾	t_{on}	-	-	200	μs	
Magnetic edges required for first offset correction ¹⁾	n_{start}	-	-	4	-	$f_{mag} \geq 1\text{ Hz}$
Magnetic edges required for first output pulse ¹⁾	n_{first_pulse}	1	-	2	-	After t_{on}
Supply current during static output low AK 4.0 Protocol	I_{low}	5.95	7	8.05	mA	
Supply current during static output mid state AK 4.0 Protocol	I_{mid}	11.9	14	16.1	mA	
Supply current during static output high AK 4.0 Protocol	I_{high}	23.8	28	32.2	mA	

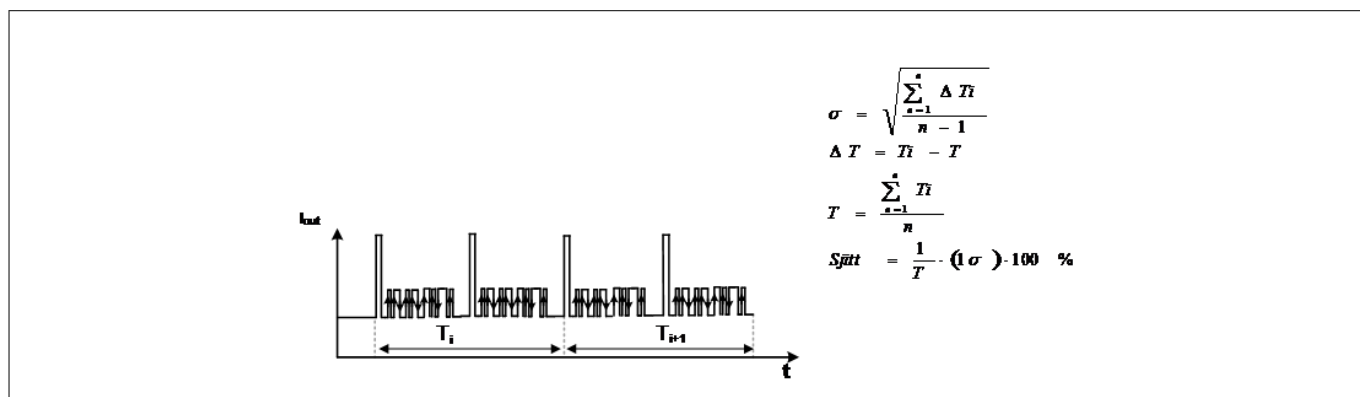
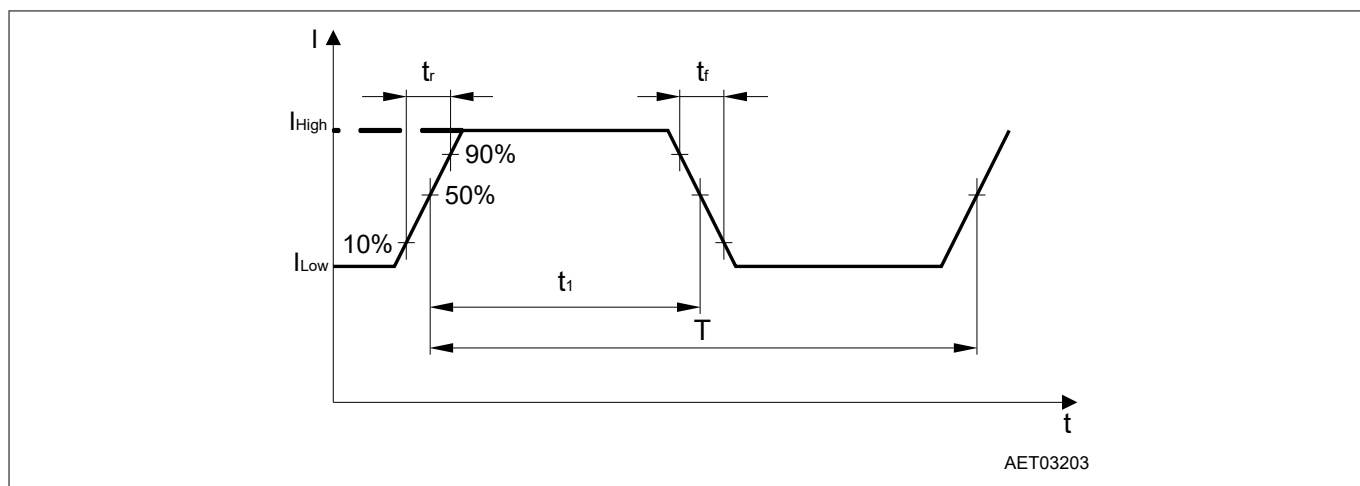
(table continues...)

4 Functional Parameters

Table 6 (continued) Functional Parameters

Parameter	Symbol	Values			Unit	Note or Test Condition
		Min.	Typ.	Max.		
I_{Error} failure indicating current	I_{Error}	1	3.5	3.8	mA	Low current indicates detected error
Output current slew rate	S_{Rr}, S_{Rf}	11	-	28	mA/ μ s	See Figure 5 ; $SR_r = (I_{90\%} - I_{10\%})/t_r$; $SR_f = (I_{90\%} - I_{10\%})/t_f$
Supply current ratio	$I_{\text{mid}}/I_{\text{low}}$	1.9		2.2	-	Same temperature and same R_m for both current levels
Supply current ratio	$I_{\text{high}}/I_{\text{low}}$	3.8		4.5	-	Same temperature and same R_m for both current levels
Supply current ratio ¹⁾	$I_{\text{high}}/I_{\text{mid}}$	1,9		2.2	-	Same temperature and same R_m for both current levels
Switch-off voltage	V_{reset}			3.5	V	Direct on sensor pins Chapter 5.2.2
Supply voltage hysteresis TLE5046SiC-AK	V_{Hys}	1.5		1.7	V	Chapter 5.2.2

1) Not subject to production test, verified by design/characterization.


Figure 4 Period jitter definition for coil measurements for AK 4.0 protocol

Figure 5 Definition of Duty Cycle = $t_1/T \times 100\%$; Rise and Fall Time

5 Functional Description

5 Functional Description

The sensor element has a magnetic interface to detect the increments of a magnetized encoder and its direction: the sensing principle is based on the giant magneto resistance (GMR) principle sensitive to magnetic filed in x-direction. It is designed for maximum sensitivity and suppression of homogeneous fields.

In [Figure 6](#) the typical placement of the TLE5046SiC-AK facing a magnetic encoder wheel is shown.

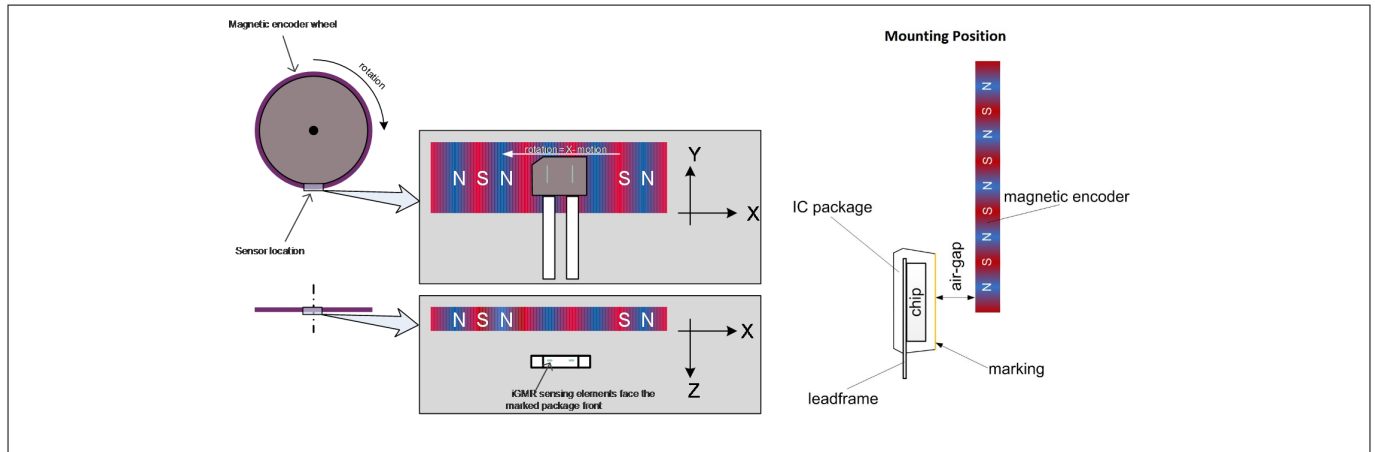


Figure 6 TLE5046SiC in Magnetic Encoder Mounting Position

Note: $Y = 0 \text{ mm}$ refers to the $B_y = 0 \text{ mT}$ line of the magnetized stripe.

5.1 Block Diagram

The sensing elements are integrated on the chip in a Wheatstone Bridge. The bridge is sensing a differential speed signal and suppressing external homogeneous fields. Each half bridge consists of two GMR elements 1.63 mm apart. The direction element is placed almost in the middle of the two speed elements. The signal path comprises a differential amplifier and a noise limiting low pass filter and a comparator. An offset cancellation loop is in place to compensate magnetic and electric offsets. The regulation loop consists of a tracking A/D converter, the digital core to evaluate the offset and the offset DAC to feed in the corrective voltage.

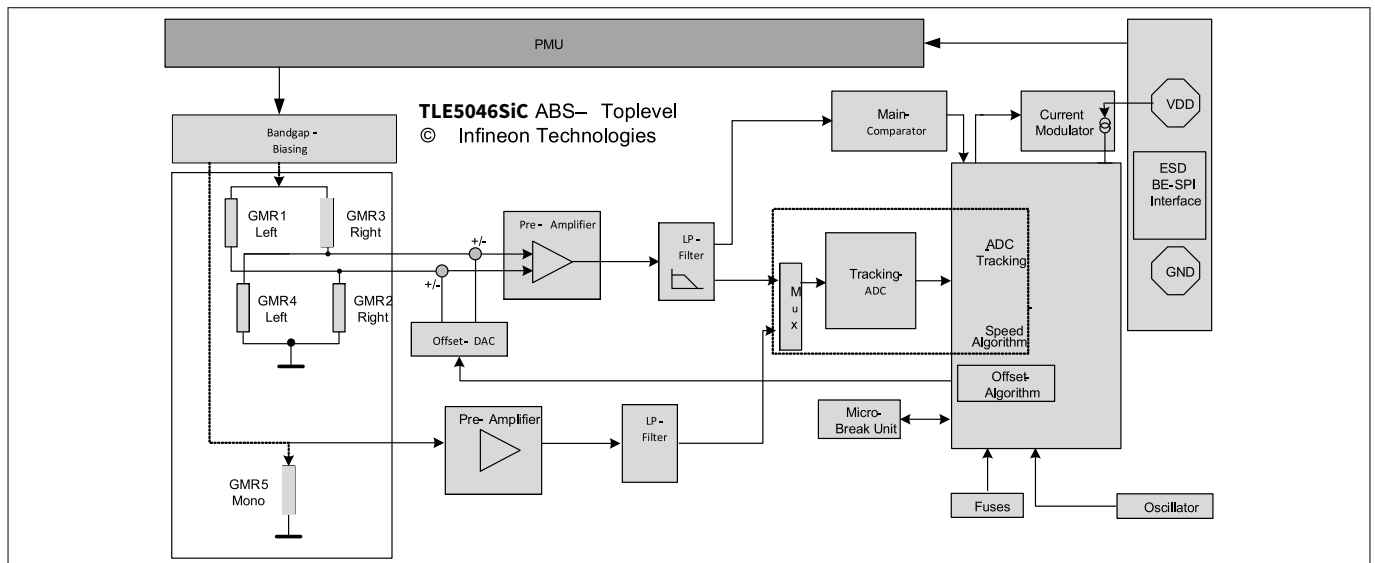


Figure 7 Block diagram

5 Functional Description

5.2 Switching Behavior

The first output pulse is generated when the input field exceeds the minimal magnetic threshold “2 x dBlimit”. This leads to phase shift in the Duty Cycle during uncalibrated mode (see [Figure 11](#)), but ensures the first pulse occurs on first pole pair, so the speed information is immediately available.

After minimum and maximum are detected and offset is compensated, output switching occurs at zero-crossing of the differential magnetic signal.

Direction information on the first output pulse in uncalibrated mode is unknown, this is indicated via the GDR bit in the protocol, but ensures that after startup, while direction is still invalid, a valid speed signal is issued.

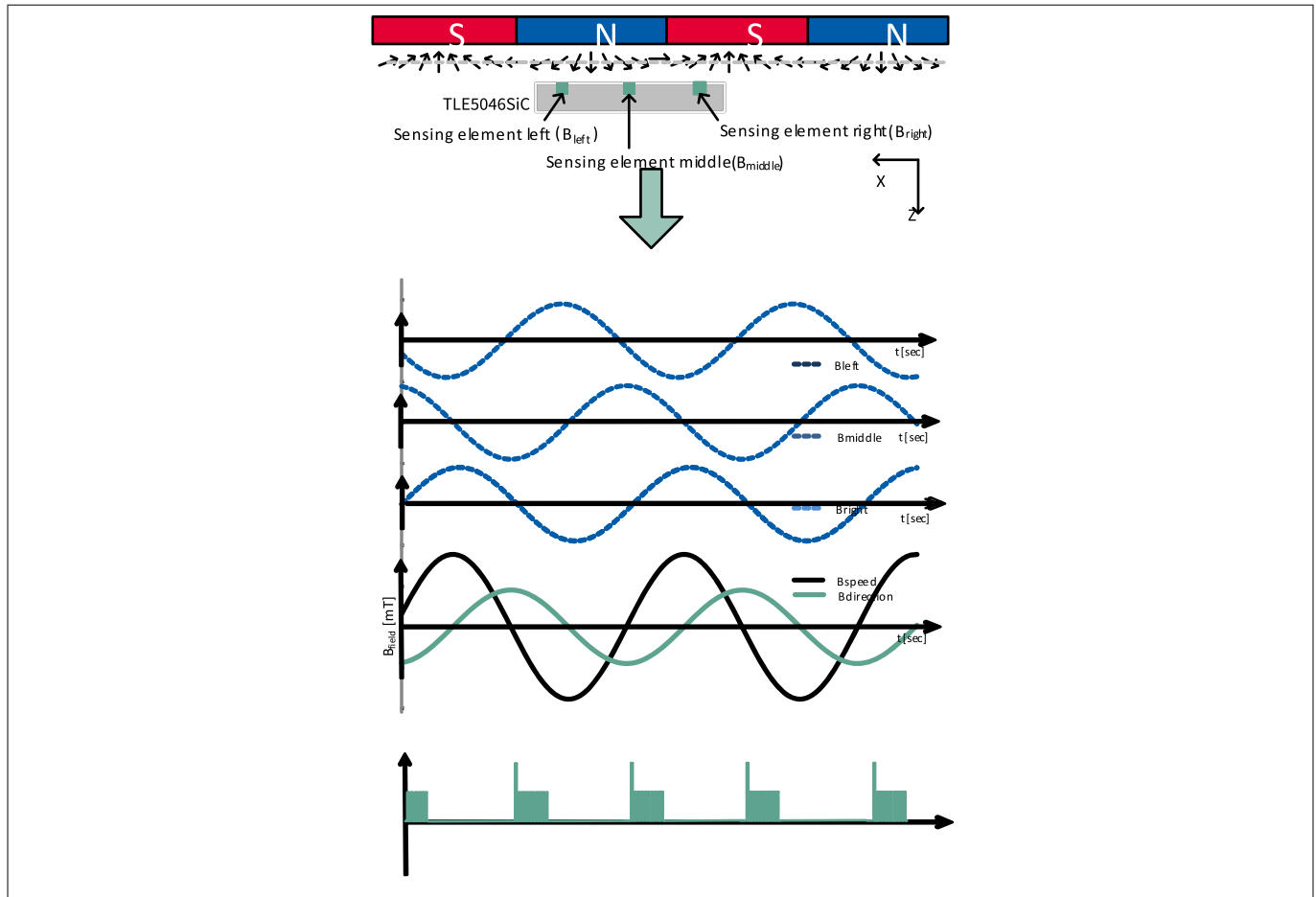


Figure 8 Magnetic input signal and corresponding output switching

5 Functional Description

5.2.1 Operating Modes

The device can be in one of two operating modes, namely uncalibrated mode or calibrated mode.

5.2.1.1 Uncalibrated Mode

After supplying the device it starts tracking the input signal after power on time t_{on} . The device is now in uncalibrated mode with an initial fast offset compensation. In order to trigger the first edge, the magnetic input signal has to exceed $2 \cdot dB_{limit_x}$.

The device switches over to calibrated mode when proper offset compensation is achieved. After the calibration is finished the device operates with its full performance.

5.2.1.1.1 Calibrated Mode

In calibrated mode the output will switch at zero-crossing of the input signal. Signals below a defined threshold dB_{limit_x} do not trigger the current interface to avoid noise induced unwanted output switching. The calibrated mode provides a slower offset compensation to achieve the best jitter performance.

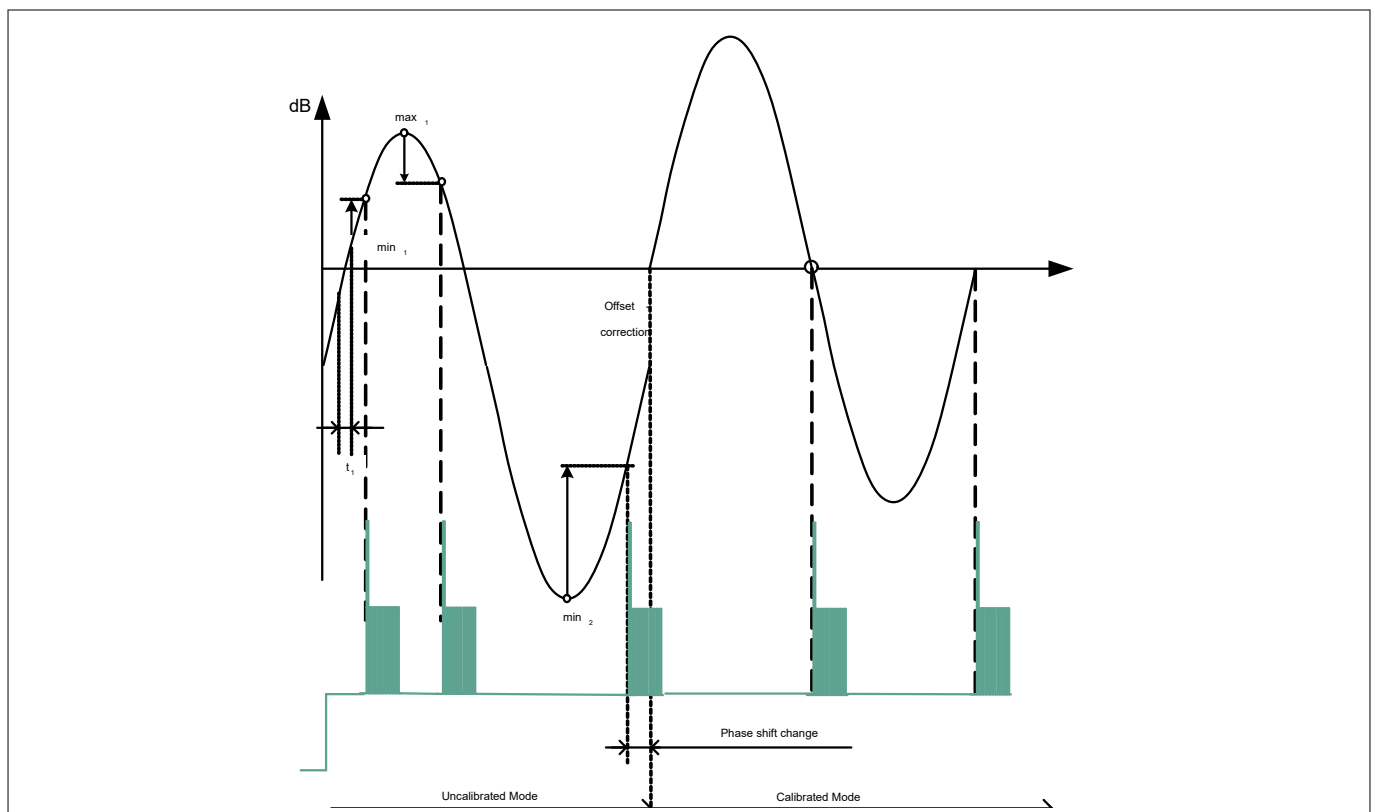


Figure 9 First positive offset correction

5.2.2 Undervoltage Behavior

A hysteresis V_{hys} is implemented depending on the resistor in use avoiding a toggling of the output when the supply voltage V_{DD} is modulated due to the additional voltage drop at R_M when switching from low to high current level.

If the supply voltage V_{DD} drops below the switch-off level V_{reset} the sensor reduces its current consumption to I_{Error} regardless of the magnetic encoder input signal. After V_{DD} exceeding again the voltage release level $V_{release}$ the sensor restarts and resumes in normal operation. The minimum required supply voltage V_{DD} for the chip to

5 Functional Description

power on is defined by the voltage release level V_{rel} . During $t_{power-on}$, the current I will not exceed the level for I_{low} .

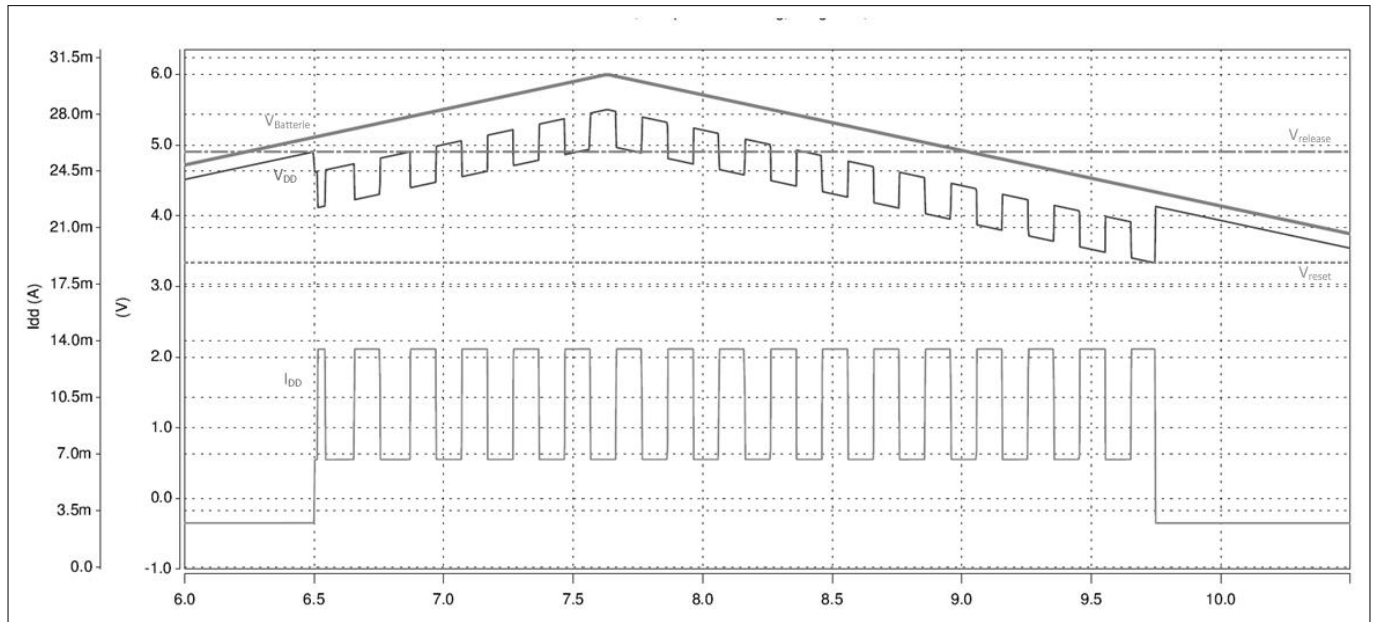


Figure 10 Undervoltage behavior

5.2.3 Watchdog

An innovative temperature watchdog has been designed to maximize the sensor availability and avoid wrong sensor output in extreme conditions created by temperature drift in absence of motion.

5.2.4 Safety Mechanisms

The TLE5046SiC offers safety features to support the Automotive Safety Integrity Level ASIL B and is designed to be used in ASIL D systems.

An embedded safety concept was developed to minimize the effect of hard and soft random errors by the introduction of specific safety mechanisms. In case of an internal error a notification to the ECU is transmitted by either setting the output current level to a constant failure indication level I_{Error} or transmitting an error flag via the protocol.

Following safety mechanisms have been implemented including:

- Undervoltage detection
 - This safety mechanism detects voltage drops to values where the correct functionality of the circuitry is no more ensured. The sensor remains in this state until the error condition is solved and V_{DD} is back into normal operating range
- Detection of discrepancy between number of active fuses and internally stored number of fuses
 - This safety mechanism compares the active fuse bits against the internal stored quantity. The sensor remains in this failure indication state I_{Error} until the device is powered off and on again and the error condition is not present any longer
- Detection of clock malfunction
 - This safety mechanism forces the failure indication state if the clock is either stuck or below 25% of the nominal value

5 Functional Description

- Detection of different numbers between speed and direction path
 - This safety mechanism verifies if more than two consecutive electric events are generated without any detected event in the direction path or vice versa
- Detection of critical airgap, ADC clipping and temperature monitoring
 - This safety mechanisms verifies critical states inside the ASIC itself

The full overview including detailed descriptions of the functionality of each safety mechanism and the detailed failure reaction can be found in the safety manual.

All Infineon experience has been used to identify and prevent common cause of failure in the application including EMC disturbances and mechanical tolerances. An advanced EMC concept, inclusive of microbreak feature without the need of external components, maximizes the availability of the sensor signal at the electrical interface. And the speed algorithm is designed for fast start-up and optimization of duty cycle. The extreme low jitter of the sensor contributes to high time accuracy of the speed signal.

TLE5046SiC is accompanied by accurate safety analysis and complete documentation to enable the system integrator to quickly evaluate the compatibility with the system/item and start the integration process. A detailed description of how the sensor is to be used in an ISO26262 compliant system can be found in the Safety Manual and Safety Analysis Summary Report, which are available on request.

5.3 Typical Performance

Based on characterization results the following typical data was evaluated. The extreme low jitter of the sensor contributes to high time accuracy of the speed signal. In general a very low jitter floor can be seen over the full frequency and temperature range at small fields as well as larger fields.

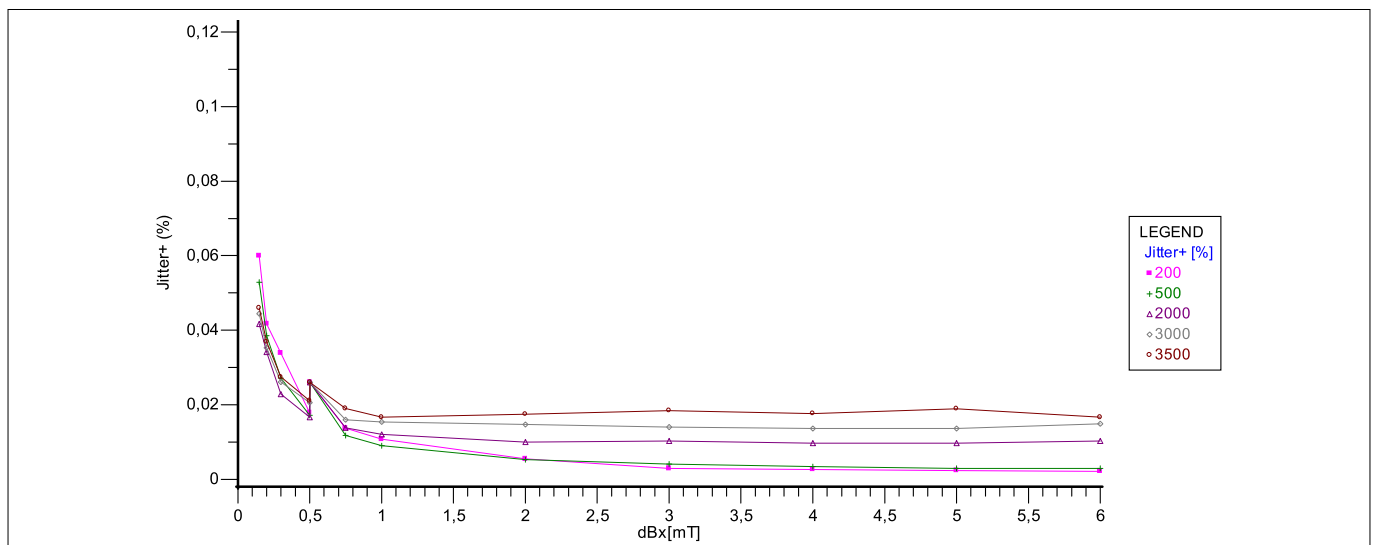


Figure 11 Jitter performance over different frequencies $T_a = -40^\circ\text{C}$

5 Functional Description

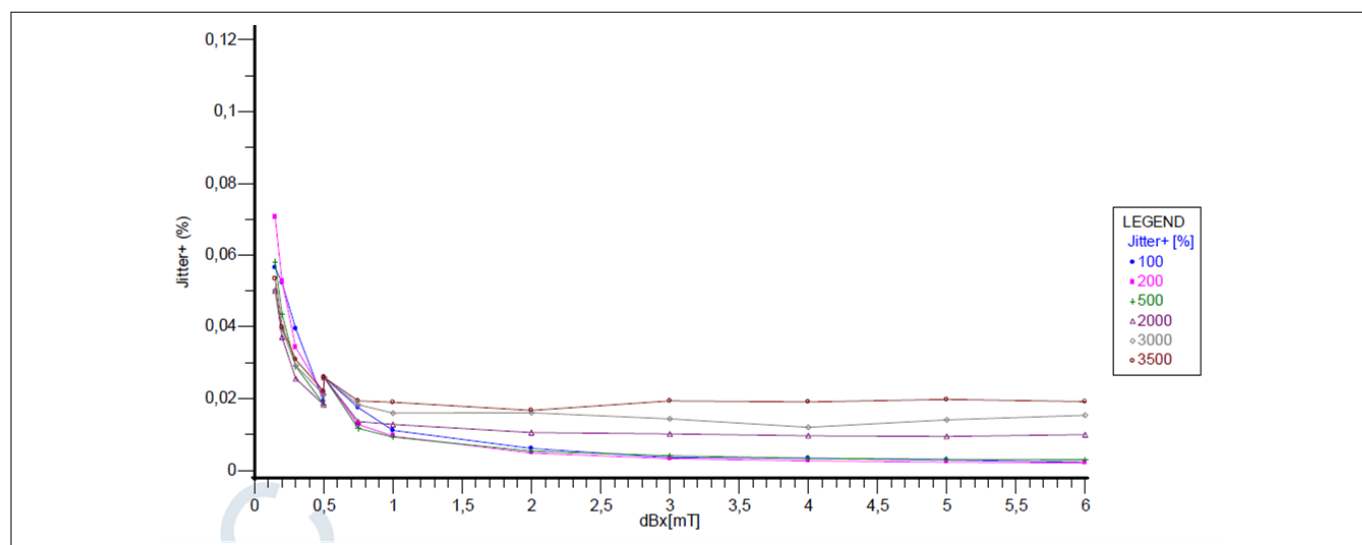


Figure 12 Jitter performance over different frequencies Ta = 25°C

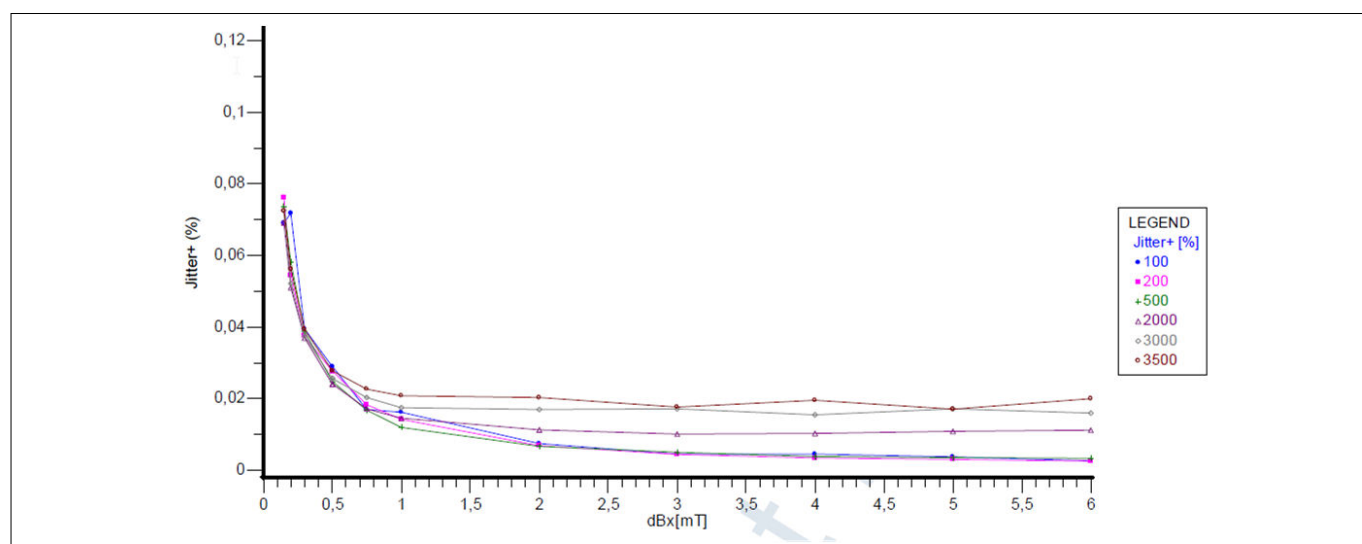


Figure 13 Jitter performance over frequency Ta = 175°C

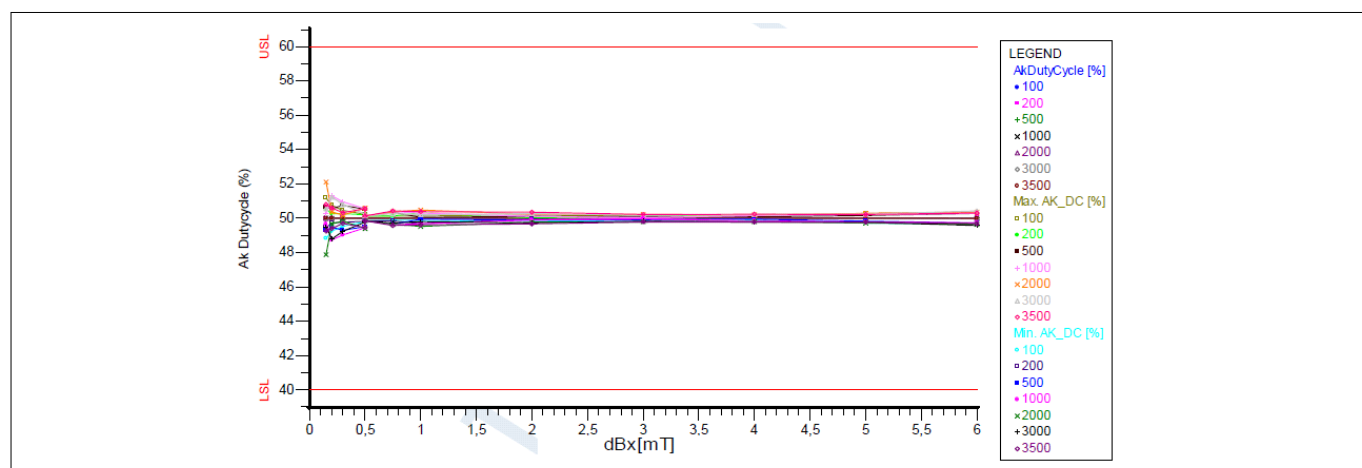


Figure 14 Duty Cycle performance

5 Functional Description

The sensor is designed with a temperature coefficient of -2000 ppm/K to compensate the temperature dependency of magnetic materials. This ensures, that with varying temperature the airgap stays constant.

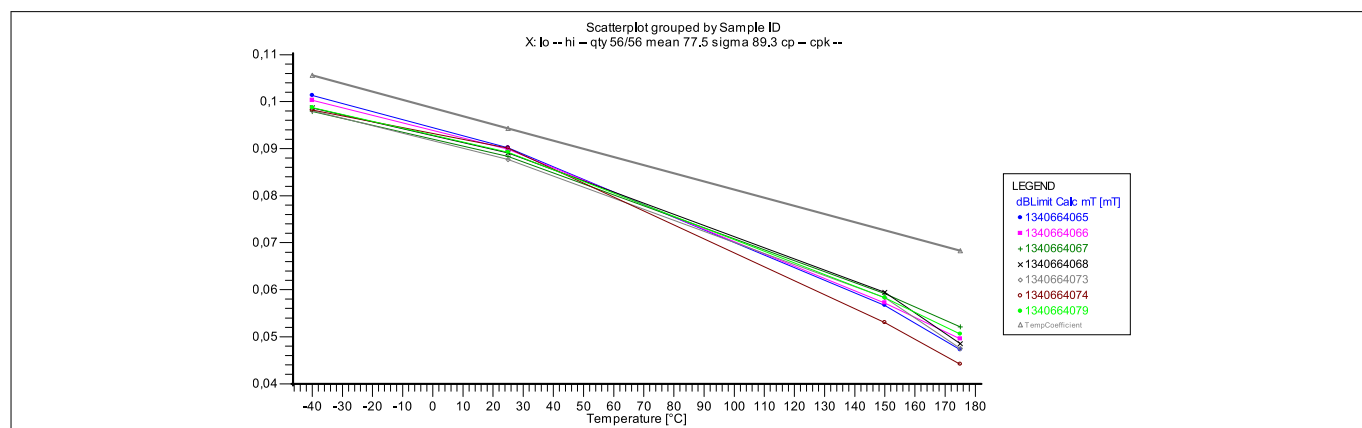


Figure 15 **dBlimit over temperature with implemented Temperature coefficient of -2000 ppm/K**

6 VDA AK 4.0

6 VDA AK 4.0

The devices are compliant to Version: "Requirement Specifications for Standardized Interface for Wheel Speed Sensors with Additional Information "AK-Protocol" Version: 4.0 13.02.2008 of Daimler AG" unless otherwise stated in this document.

6.1 Bit Definition

This following illustration defines the meaning of the data protocol. The bits 0 - 8 in the illustration are designated as the data protocol and their purpose is to transfer the additional information to the speed pulse. The usage of the bits can be seen in [Table 7](#).

Bit position #0, can be used as an indication for air gap reserve (LR), or can be interpreted by the ECU as an "error bit" and treated in a special way. The two different variants TLE5046SiC-AK-LR and TLE5046SiC-AK-ERR perform this behavior, see [Table 1](#).

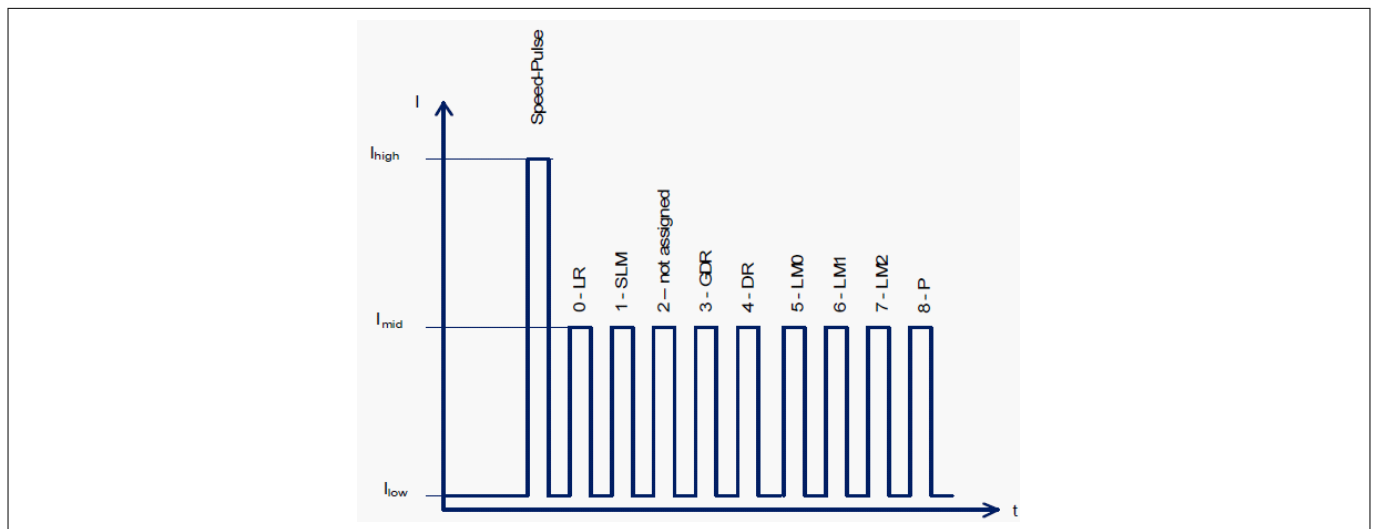


Figure 16 Coding of data bits AK 4.0

Table 7 Coding of Additional Information

Bit	Meaning	Name	Value after power up/under voltage	Condition
0	Error bit or	ERR or	0	1 = error
0	Airgap reserve	LR	0	"1" if $dB < 2 \cdot dB_{limit}$
1	Validity of signal amplitude measurement	SLM	1	0 = measurement of LM0, LM1, LM2 is valid; 1 = invalid
2	Not assigned		0	Default 0
3	Direction validity	GDR	0	"1" = valid, "0" = invalid
4	Direction of rotating information	DR	0	"0" = direction positive
5	Air gap gauge	LM0	0	LSB of airgap gauge
6		LM1	0	
7		LM2	0	MSB of airgap gauge

(table continues...)

6 VDA AK 4.0

Table 7 (continued) Coding of Additional Information

Bit	Meaning	Name	Value after power up/under voltage	Condition
8	Parity	P	To be currently calculated	Always set to get even parity (inclusive Parity bit itself)

Bit 0 used as LR

The LR bit is set to “1” when the measured magnetic input signal of the sensor drops below $2 \cdot dB_{\text{limit}}$ based on the limit air gap see [Table 1](#)

Bit 0 used as ERR

With a change from logic “0” to logic “1”, a status is displayed that is interpreted by the ECU as an “error” in the sensor for example internal errors. Then corresponding measures can be initiated in the safety concept see [Table 1](#)

6.2 AK 4.0 in TLE5046SiC-AK-LR and TLE5046SiC-AK-ERR

For behavior of AK 4.0 we refer to the official “Requirement Specifications for Standardized Interface for Wheel Speed Sensors with Additional Information “AK-Protocol” Version: 4.0 13.02.2008 of Daimler AG” additional properties or properties which are marked as optional in the official document mentioned above, are described in the following sections.

6.2.1 Bit stump suppression - Constant time shift of output of speed pulse and data protocol

The suppression of bit stumps in the Wheel Speed Sensor is required, so that the combination of sensors and ECUs from different manufacturers is as robust as possible. In this case, the sensor output is always completely shifted by a constant bit time when a new protocol start occurs. This is equivalent to a time output offset.

The suppression of bit stumps does function reliably in all speed ranges and in all regular operating states of the sensor, that is also in the standstill protocol. This ensures that no compatibility problems occur in any regular operating cases caused by for example EMC.

6.2.2 Air Gap Dimension

The measured value can be transmitted in the AK protocol using the LM bits, with 8 available gradation according to [Table 8](#).

There is no hysteresis implemented for setting/resetting the LM bits and the air gap is measured in calibrated mode only. In uncalibrated mode, no evaluation takes place, and all bits retain their last value. After power up all bits are set to 0 as a default value. The typical relation between switching field strength and bits put out is given in the subsequent table:

6 VDA AK 4.0

Table 8 Air Gap Table

LM decimal	LM binary	Level in relation to $\text{dB}_{\text{limit}_x}$	Tolerance for TA = -40°C to +150°C
0	000	$0 < \dots \leq 2$	+/- 20%
1	001	> 2	+/- 20%
2	010	> 4	+/- 20%
3	011	> 8	+/- 20%
4	100	> 16	+/- 20%
5	101	> 32	+/- 20%
6	110	> 64	+/- 20%
7	111	> 96	+/- 20%

6.2.3 Failure indication state

TLE5046SiC offers an enhanced safety concept with very low FIT rates. A failure indication state is introduced in this new ABS sensor family. For indicating failures a constant low current I_{Error} is implemented to signalize to the ECU a potentially severe effect on functionality. Furthermore the protocol offers the possibility to transmit information regarding the safety concept to the ECU. The whole safety concept including the functional behavior in case of an error is described in the Safety Manual [\[11\]](#) and the SASR [\[12\]](#).

7 EMC and ESD Characteristics

7 EMC and ESD Characteristics

The TLE5046SiC is characterized according to the IC level EMC requirements described in the “Generic IC EMC Test Specification” Version 2.0 from 2014¹⁾. EMC test report is available on request.

Additionally component level EMC characterizations are performed according to ISO 7637-2:2011, ISO 7637-3:2007 and ISO 16750-2:2010 regarding pulse immunity and CISPR 25 (2009-01) Ed. 3.0 regarding conducted emissions are performed.

Characterization of Electro Magnetic Compatibility are carried out on a sample base of one qualification lot. Not all specification parameters have been monitored during EMC exposure. Only current levels and duty cycle have been monitored.

7.1 Transient Immunity

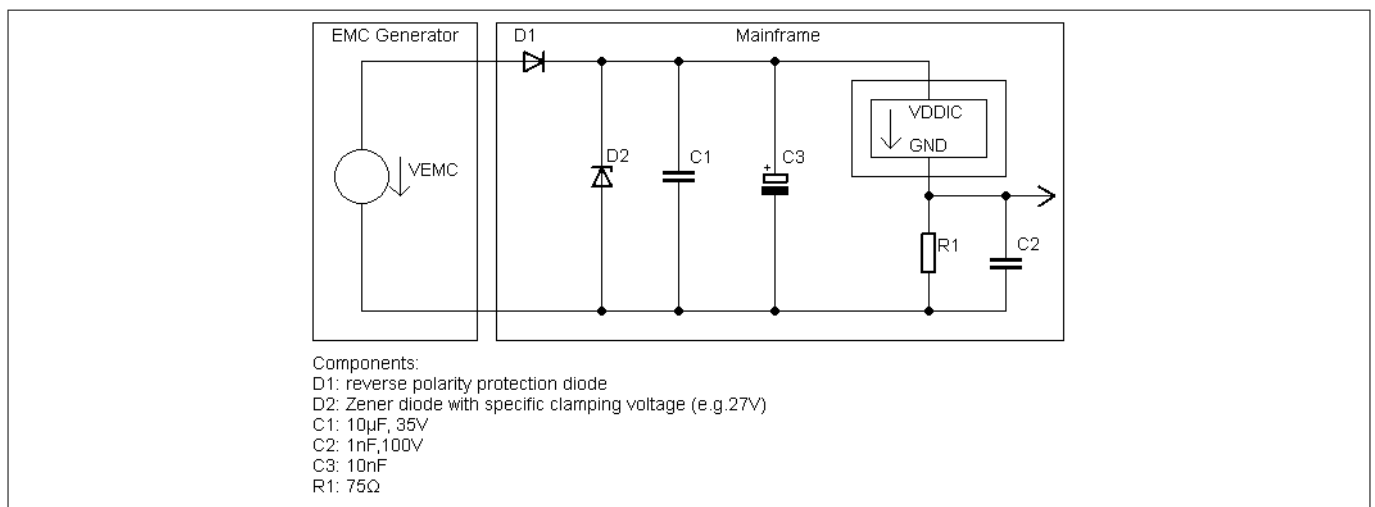


Figure 17 EMC Test circuit

7.1.1 Electrical Transient Conduction along Supply Lines

General requirements:

- The supply voltage has a value of $13.5\text{ V} \pm 0.2\text{ V}$ (for test pulse 4 supply voltage is $12\text{ V} \pm 0.2\text{ V}$)
- The ambient temperature for these tests is $23^\circ\text{C} \pm 5^\circ\text{C}$

Test setup:

- According to ISO 7637-2, 2011 chapter 4.4 for pulses 1, 2a, 2b, 3a and 3b
- According to ISO 16750-2, 2010 chapter 4.6.3 and 4.6.4 for pulses 4 and 5b
- The Loadbox is placed directly on the ground plane
- The wiring harness and the monitoring equipment are insulated 50 mm from the ground plane
- Total wire harness length from the test pulse generator to the DUT does not exceed 500 mm and does not fall below 400 mm including a harness length from the load simulator to the DUT of $200\text{ mm} \pm 50\text{ mm}$
- Pulses are applied to the input terminal of the Loadbox

¹ The document is available at <http://www.zvei.org/generic-ic-emc-test-specification>

7 EMC and ESD Characteristics

Table 9 Applicable Pulses, Parameters and Functional Class Requirements

Test Pulses	Test Level	Number/Duration	Pulse parameters	Functional class
1	-150 V	500	$t_d = 2 \text{ ms}$, $t_1 = 0.5 \text{ s}$	C
2a	+112 V	5000	$t_d = 50 \mu\text{s}$, $t_1 = 0.5 \text{ s}$, $R_i = 2 \Omega$	A
2b	+10 V	10	$t_d = 1$, $R_i = 0.01 \Omega$	C
3a	-220 V	10 min	$t_d = 150 \text{ ns}$, $R_i = 50 \Omega$	A ¹⁾
3b	+150 V	10 min	$t_d = 150 \text{ ns}$, $R_i = 50 \Omega$	A ¹⁾
4- I	$U_{S6} = 8 \text{ V} \mid U_S = 9.5 \text{ V}$	10	$t_8 = 1 \text{ s}$, $t_r = 40 \text{ ms}$, pulse cycle time: 2 s ²⁾	A
4- II	$U_{S6} = 4.5 \text{ V} \mid U_S = 6.5 \text{ V}$	10	$t_8 = 10 \text{ s}$, $t_r = 100 \text{ ms}$, pulse cycle time: 2 s ³⁾	C
4 - III	$U_{S6} = 3 \text{ V} \mid U_S = 5 \text{ V}$	10	$t_8 = 1 \text{ s}$, $t_r = 100 \text{ ms}$, pulse cycle time: 2 s ³⁾	C
4 - IV	$U_{S6} = 6 \text{ V} \mid U_S = 6.5 \text{ V}$	10	$t_8 = 10 \text{ s}$, $t_r = 100 \text{ ms}$, pulse cycle time: 2 s ³⁾	C
5b	+35 V ⁴⁾	1	$t_d = 400 \text{ ms}$, $R_i = 1 \Omega$, pulse cycle time: 60 s ^{3) 5)}	C

1) Output signal overlaid by burst pulses

2) Additional Pulse parameters: $t_f = 5 \text{ ms}$, $t_6 = 15 \text{ ms}$, $t_7 = 50 \text{ ms}$

3) Non-specified pulse parameters according ISO16750-2, 2010

4) Clamping voltage

5) The 18 V Zener-Diode D2 in the load replacement circuit will be replaced by a special suppressor diode for this pulse to limit the pulse voltage to approximately 20 V and to prevent a damage of D2 during the test

7.1.2 Electrical Transient Transmission by Capacitive Coupling Clamp (CCC)

Conditions:

- The supply voltage has a value of $13.5 \text{ V} \pm 0.2 \text{ V}$
- The ambient temperature for these tests is $23^\circ\text{C} \pm 5^\circ\text{C}$

Test setup:

- According to ISO 7637-3, 2007 Chapter 3.4.2
- The monitoring equipment is insulated 50 mm from the ground plane
- Wire harness length is 1700 mm, wiring harness outside the Capacitive Coupling Clamp is 100 mm insulated
- All lines are tested simultaneously under the CCC

Table 10 Test Level and Criteria for Fast Pulses Measurement

Test Pulse	Test Level U_S	Internal resistance	Pulse parameters ¹⁾ $t_1 \mid t_d$	Minimum number of pulses or test time	Functional class
3a	-220 V	$R_i = 50 \Omega$	$100 \mu\text{s} \mid 100 \text{ ns}$	10 min	A
3b	+150 V	$R_i = 50 \Omega$	$100 \mu\text{s} \mid 100 \text{ ns}$	10 min	A

8 Product Qualification

1) Non-specified pulse parameters according to ISO 7637-3, 2007

7.1.3 ESD HBM & CDM

Table 11 ESD Voltage

Parameter	Symbol	Values			Unit	Note or Test Condition
		Min.	Typ.	Max.		
ESD voltage	V_{HBM}	-	-	+/-12	kV	Method AEC-Q100-002 (1.5 kΩ, 100 pF)
ESD voltage	V_{CDM}	-	-	+/-1	kV	Method AEC-Q100-011 (0 kΩ, 200 pF)

8 Product Qualification

Product qualification according to AEC-Q100, Grade 0 is performed.

9 Package Outlines

9 Package Outlines

9.1 Bending and assembly

By following our package handling and assembly recommendation²⁾ remarks for Sensor-packages the sensor terminals can be bent without causing incipient cracks influencing the sensor element function, please contact your key account team for further information. The product is RoHS (restriction of hazardous substances) compliant when marked with letter G in front or after the data code marking and contains a data matrix code. Please refer to your key account team or regional sales if you need further information.

Table 12 Package Parameters PG-SSO-2-1

Parameter		Material
Lead Frame	CuSn1CrNiTi	K62 (UNS:C18090)
Lead Plating	Sn	Tinn

9.2 Package surface to silicon

The distance from the package surface to the surface of the silicon chip.

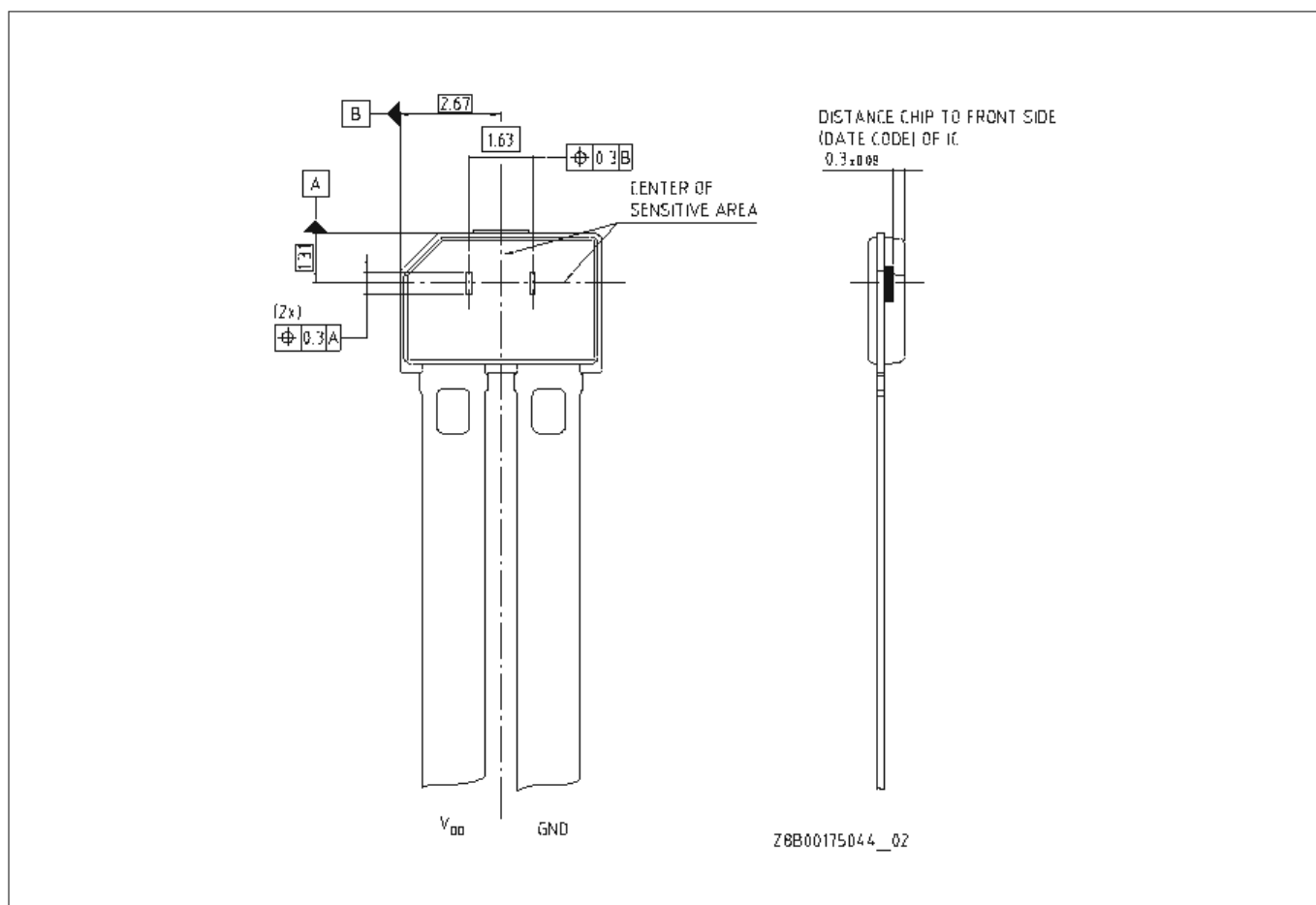
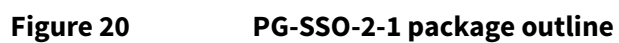


Figure 18 Distance from package surface to silicon (= sensing element)

²⁾ The document is available at <https://www.infineon.com/dgdl/Infineon-Recommendation>

9.3 Package



[illegible]

Note: For further information on alternative packages, please visit our [website](#).

10 Revision History**10 Revision History**

Revision	Date	Changes
1.0	2023-08-23	First release

11 Terminology**11 Terminology**

Reference	Description
ADC	Analog to Digital Converter
ASIC	Application Specific Integrated Circuit
CCC	Capacitive Coupling Clamp
CDM	Charged Device Model
DAC	Digital Analog Converter
DUT	Device Under Test
ECU	Electronic Control Unit
EMC	Electro Magnetic Compatibility
ESD	Electro Static Discharge
GMR	Giant Magneto Resistance
HBM	Human Body Model
IC	Integrated Circuit
PMU	Power Management Unit
RF	Radio Frequency

12 References

12 References

- [1] AEC-Q100
- [2] CISPR 25, 2009
- [3] IEC 61967-4, 2002
- [4] ISO 10605, 2008
- [5] ISO 11452-8, 2007
- [6] ISO 16750-2, 2010
- [7] ISO 26262, 2011
- [8] ISO 7637-2, 2011
- [9] ISO 7637-3, 2007
- [10] Requirement Specifications for Standardized Interface for Wheel Speed Sensors with Additional Information “AK-Protokoll” Version 4.0 2008
- [11] Safety Manual TLE5046SiC
- [12] Safety Analysis Summary Report TLE5046SiC

Trademarks

All referenced product or service names and trademarks are the property of their respective owners.

Edition 2023-08-23

Published by

Infineon Technologies AG
81726 Munich, Germany

© 2023 Infineon Technologies AG
All Rights Reserved.

Do you have a question about any aspect of this document?

Email: erratum@infineon.com

Document reference
IFX-lnb1578403735882

Important notice

The information given in this document shall in no event be regarded as a guarantee of conditions or characteristics ("Beschaffenhheitsgarantie").

With respect to any examples, hints or any typical values stated herein and/or any information regarding the application of the product, Infineon Technologies hereby disclaims any and all warranties and liabilities of any kind, including without limitation warranties of non-infringement of intellectual property rights of any third party.

In addition, any information given in this document is subject to customer's compliance with its obligations stated in this document and any applicable legal requirements, norms and standards concerning customer's products and any use of the product of Infineon Technologies in customer's applications.

The data contained in this document is exclusively intended for technically trained staff. It is the responsibility of customer's technical departments to evaluate the suitability of the product for the intended application and the completeness of the product information given in this document with respect to such application.

Warnings

Due to technical requirements products may contain dangerous substances. For information on the types in question please contact your nearest Infineon Technologies office.

Except as otherwise explicitly approved by Infineon Technologies in a written document signed by authorized representatives of Infineon Technologies, Infineon Technologies' products may not be used in any applications where a failure of the product or any consequences of the use thereof can reasonably be expected to result in personal injury.