TLE5046SiC-PWM2

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 ISO26262

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.

https://www.infineon.com/cms/en/applications/automotive/chassis-safety-and-adas/?redirId=64493

Description

The TLE5046SiC-PWM2 is a wheel speed sensor with direction indication designed for sophisticated vehicle control systems. TLE5046SiC-PWM2 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

TLE5046SiC is ASIL B(D) compliant and can be integrated in an ASIL D system. It has a very low FIT rate, due to the design and technical concept.

The safety concept is described in detail in the Safety Analysis Summary Report [10] and the Safety Manual [11] and will be delivered on request.

Product Variants and Ordering Codes

Table 1 Product Variants

Product Type	Load Resistor[1]	Marking	Ordering Code	Package	ASIL
TLE5046SiC-PWM2-R100 [1] [2]	$50\ \Omega \leq R_M \leq 100\ \Omega$	462X0I	SP005965719	PG-SSO-2-1	ASIL B(D)
TLE5046SiC-PWM2-R050 [1] [2]	$15\ \Omega \leq R_M \leq 50\ \Omega$	462X0E	SP005965728	PG-SSO-2-1	ASIL B(D)

1) see Chapter 1
2) enhanced Safety Concept, for details see Safety Manual

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1 Application Circuit

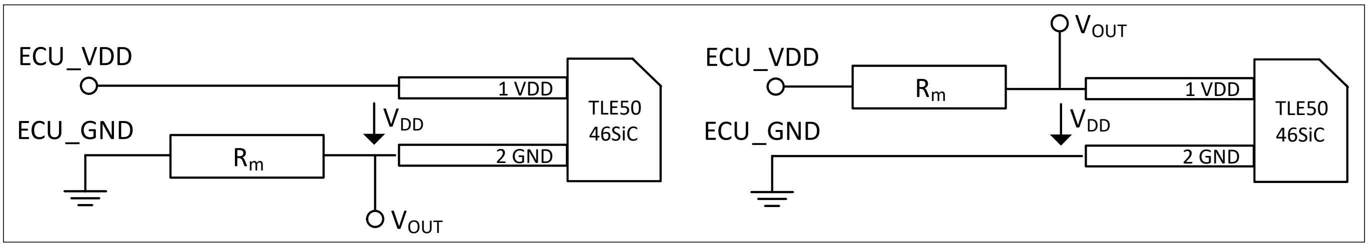


Figure 1 **Pin Configuration PG-SSO-2-1**

Table 2 **Pin Description**

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

2 Absolute Maximum Ratings

Table 3 Maximum Ratings[1)]

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

1) Stresses above 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 Conditions[1)]

Parameter	Symbol	Values			Unit	Note or Test Condition
		Min.	Typ.	Max.		
Passive overall lifetime	$L_{Tpassive}$	15	-	-	years	$T_J \leq$ 50°C, V_{DD} = 0 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 V → 0 V → 12 V; T_A = 25°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

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-R100
		4.25	-	20	V	TLE5046SiC-R050
Load resistor	R_m	50		100	Ω	-R100 Chapter 5.2.2
		15		50	Ω	-R050 Chapter 5.2.2
Junction temperature mission profile [1)]	T_J	-40		125	°C	either 10000 h
		-40		150	°C	or, 5000 h
		-40		160	°C	or, 2500 h
		-40		170	°C	or, 500 h
		-40		110	°C	or, 12500 h
		-40		190	°C	additional 4 h, V_{DD} < 16.5 V
		-10		60	°C	additional 30000 h (battery charging time)
Supply voltage modulation [2)]	V_{AC}			6	Vpp	V_{DD} = 13.5 V, 10 < f_{mod} < 150 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°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°C	80	100	120	µT	99% criterion
Minimum differential magnetic input signal amplitude, magnetic encoder application [2) 3)]	dB_{limit_x} T_a = 175°C	30	50	70	µT	99% criterion
Magnetic induction amplitude at each GMR sensing element [2)]	B_x	-25	-	25	mT	T_J = 25°C; the -0.2%/°K TC of pole wheel must be taken into account
Dynamic and static homogeneous external disturbance fields [2)]	B_{ext_XYZ}	-2		2	mT	In calibrated mode. Same field at both probes, no unwanted pulses
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

(table continues...)

Table 5 (continued) Operating Range

Parameter	Symbol	Values			Unit	Note or Test Condition
		Min.	Typ.	Max.		
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 $f_{mag} \leq 10$ Hz; 10 missing pulses out of 1000, valid for $f_{mag} > 10$ 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 $T_A \rightarrow$ junction temperature T_J: $T_J = T_A + \Delta T_{JA}$
ΔT_{JA_typ} (typical value) = 13.5 V * 10.5 mA * 120 K/W (typical sensor module R_{TH}) = 17 K.

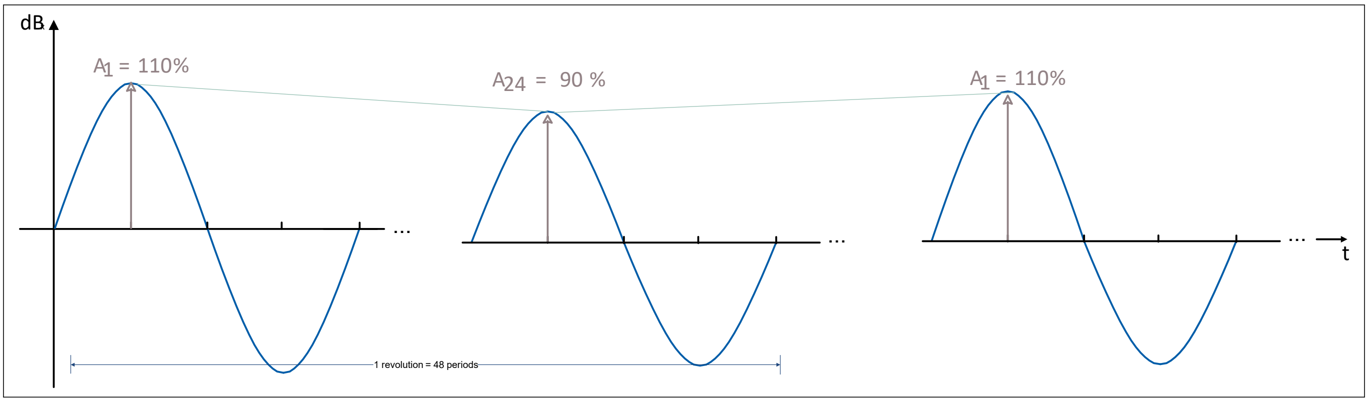


Figure 2 Recurring air-gap variation

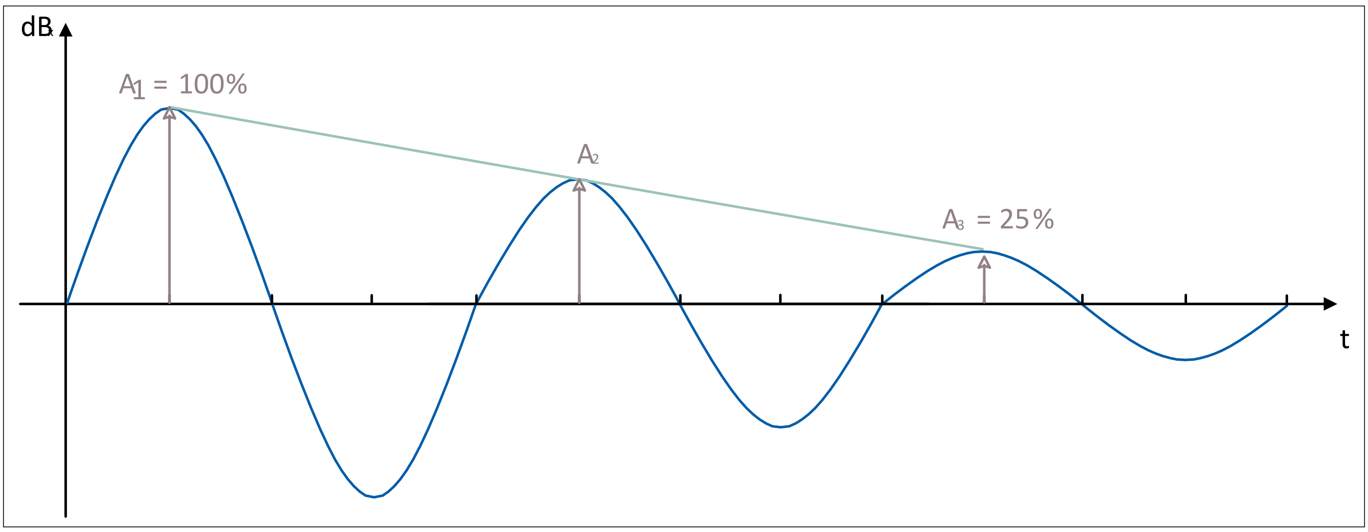


Figure 3 Non-recurring air-gap change

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 V and T_A = 25°C.

Table 6 Functional Parameters

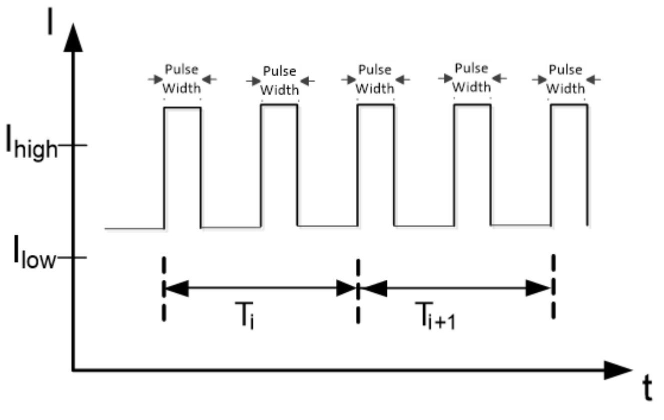
Parameter	Symbol	Values			Unit	Note or Test Condition
		Min.	Typ.	Max.		
Periodic jitter[1)]	S_{jit}	-	-	±0.07	%	± 1 σ value; differential magnetic input signal and calibrated mode, frequency 1 Hz < f_{mag} < 3 kHz, amplitude 376 µT ≤ ΔB_X ≤ 500 µT; Figure 11, Figure 12, Figure 13
Periodic jitter[1)]	S_{jit}	-	-	±0.05	%	± 1 σ value; differential magnetic input signal and calibrated mode, frequency 1 Hz < f_{mag} < 3 kHz, amplitude 501 µT ≤ ΔB_X ≤ 6.3 mT; Figure 11, Figure 12, Figure 13
Periodic jitter[1)]	S_{jit}	-	±0.02		%	± 1 σ value; differential magnetic input signal and calibrated mode, frequency 1 Hz < f_{mag} < 3 kHz, amplitude 6.3 mT ≤ ΔB_X ≤ 50 mT; Figure 11, Figure 12, Figure 13
Duty cycle	DC	40	-	60	%	In calibrated mode; sinusoidal input signal and calibrated mode; f_{mag} > 1 Hz; s; DC = 100% * t_1/T, B_{ext_XYZ} = 0 mT, differential magnetic input signal amplitude 2x dB_{limit_x} ≤ ΔB_X ≤ 50 mT; Figure 14
Power-on time[1)]	t_{on}	-	-	200	µs	
Magnetic edges required for first offset correction[1)]	n_{start}	-	-	4	-	f_{mag} ≥ 1 Hz
Magnetic edges required for first output pulse[1)]	n_{first_pulse}	1	-	2	-	After t_{on}
Supply current during static output low state PWM2/Protocol	I_{low}	5.95	7	8.05	mA	
Supply current during static output high state PWM2/Protocol	I_{high}	11.9	14	16.1	mA	
I_{Error} failure indicating current	I_{Error}	1	3.5	3.8	mA	Low current indicates detected error
Output current slew rate	SR_r, SR_f	11	-	28	mA/µs	See ; $SR_r = (I_{90\%} - I_{10\%}) / t_r$; $SR_f = (I_{90\%} - I_{10\%}) / t_f$

(table continues...)

Table 6 (continued) Functional Parameters

Parameter	Symbol	Values			Unit	Note or Test Condition
		Min.	Typ.	Max.		
Supply current ratio	I_{high} / I_{low}	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-PWM2/R100	V_{Hys}	1.5		1.7	V	Chapter 5.2.2
Supply voltage hysteresis TLE5046SiC-PWM2/R050	V_{Hys}	0.65		0.75	V	Chapter 5.2.2

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



$$\sigma = \sqrt{\frac{\sum_{i=1}^{n} \Delta T_i^2}{n-1}}$$

$$\Delta T_i = T_i - T \qquad T = \frac{\sum_{i=1}^{n} T_i}{n}$$

$$S_{jit} = \frac{1}{T} \cdot (1 \cdot \sigma) \cdot 100 \quad \%$$

Figure 4 Period jitter definition for coil measurements

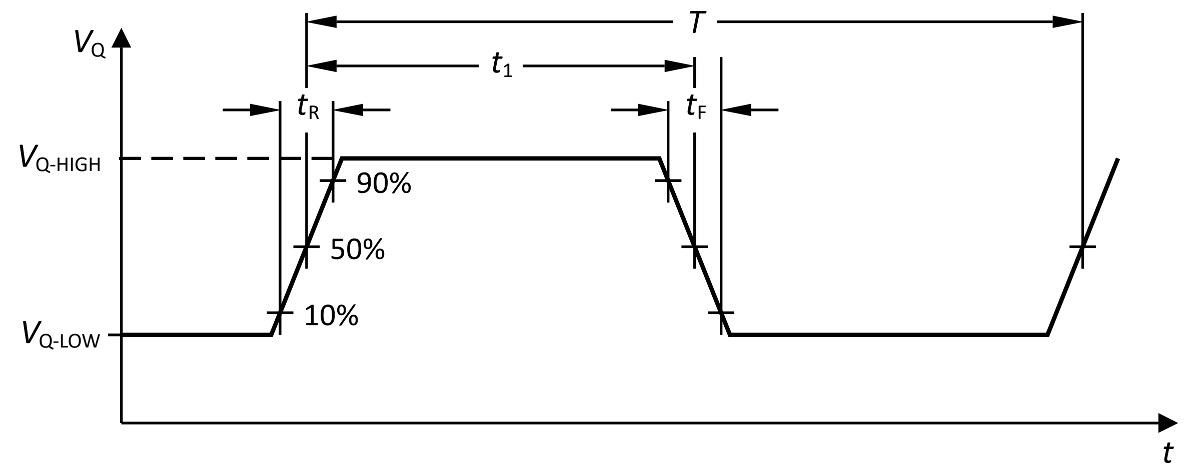


Figure 5 Definition of Slew Rate and Duty Cycle = t1/T * 100%

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-PWM2 facing a magnetic encoder wheel is shown.

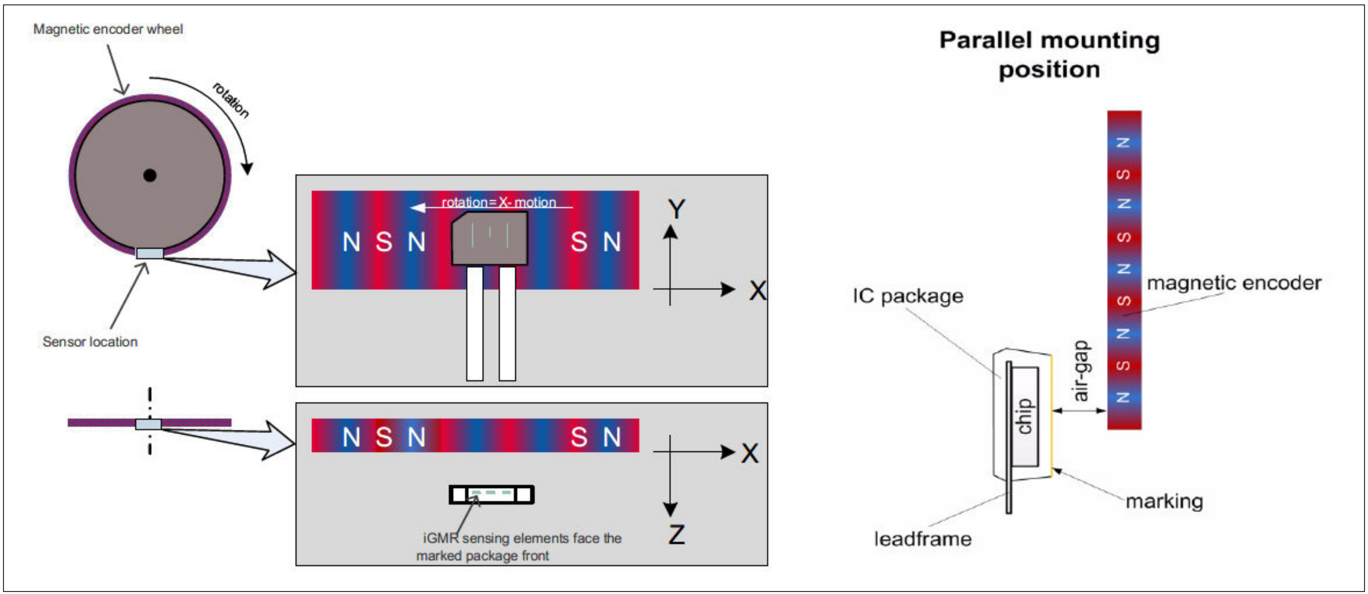


Figure 6 **TLE5046SiC in Magnetic Encoder Mounting Position**

***Note**: Y = 0 mm refers to the B_y = 0 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.

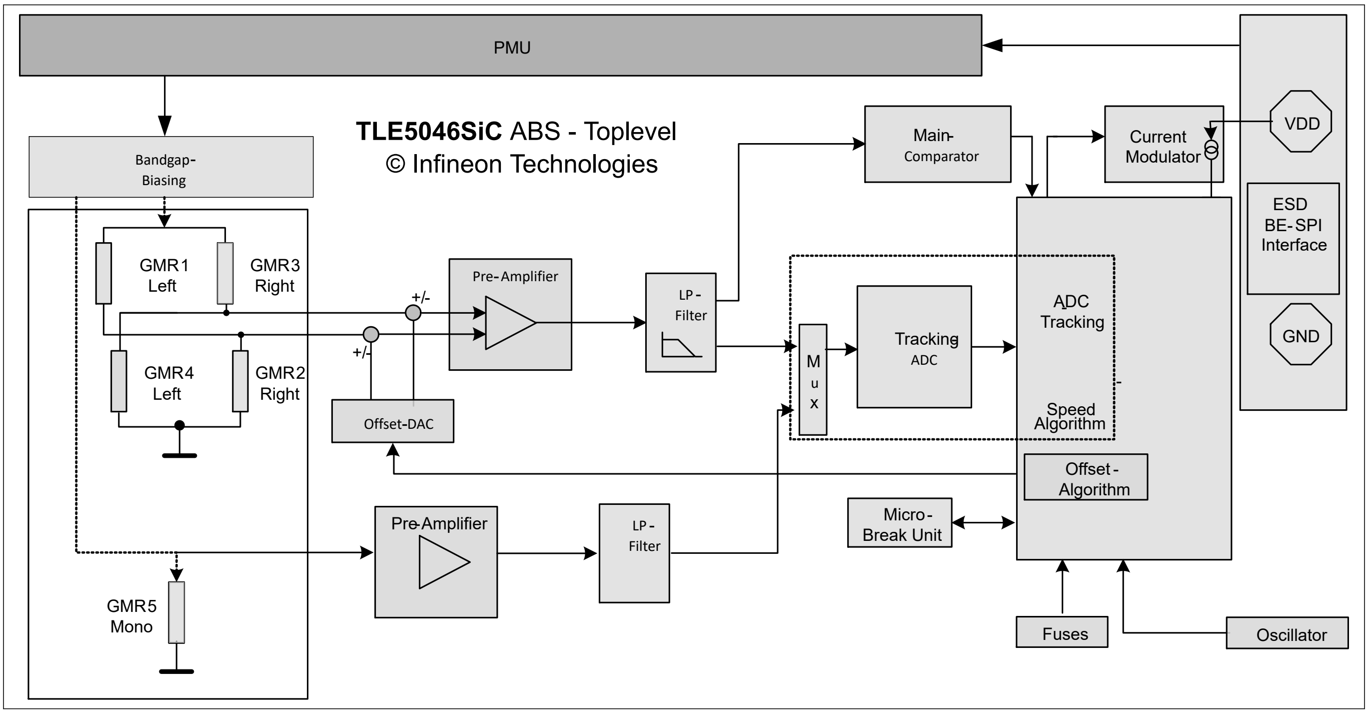


Figure 7 **Block diagram**

5.2 Switching Behavior

The first output pulse is generated when the input field exceeds the minimal magnetic threshold “2 x dB_{limit}”. This leads to phase shift in the Duty Cycle during uncalibrated mode (see Figure 9), 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 with the warning pulse but ensures that after startup, while direction is still invalid, a valid speed signal is issued.

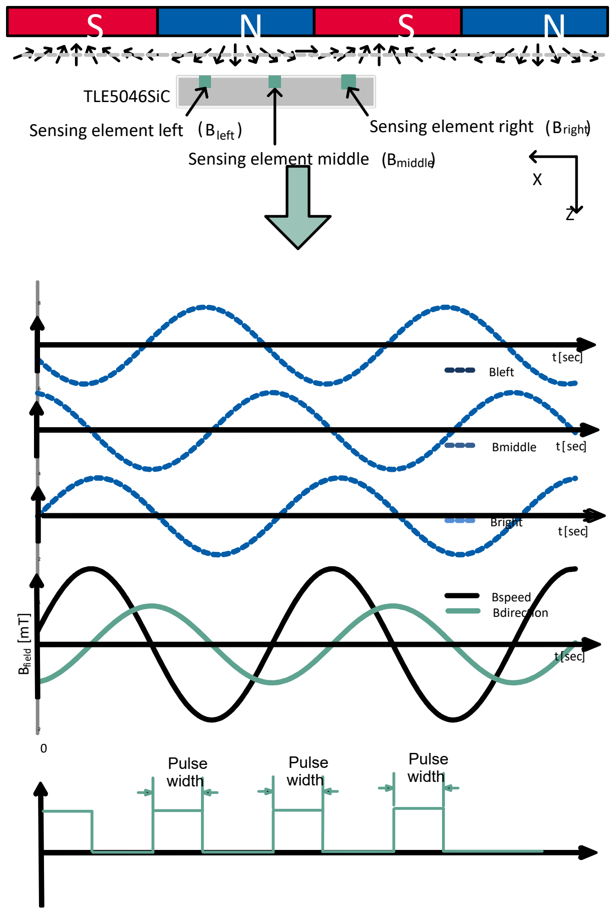


Figure 8 **Magnetic input signal and corresponding output switching**

5.2.1 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 * dB_{limit_x}.
The devices 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.

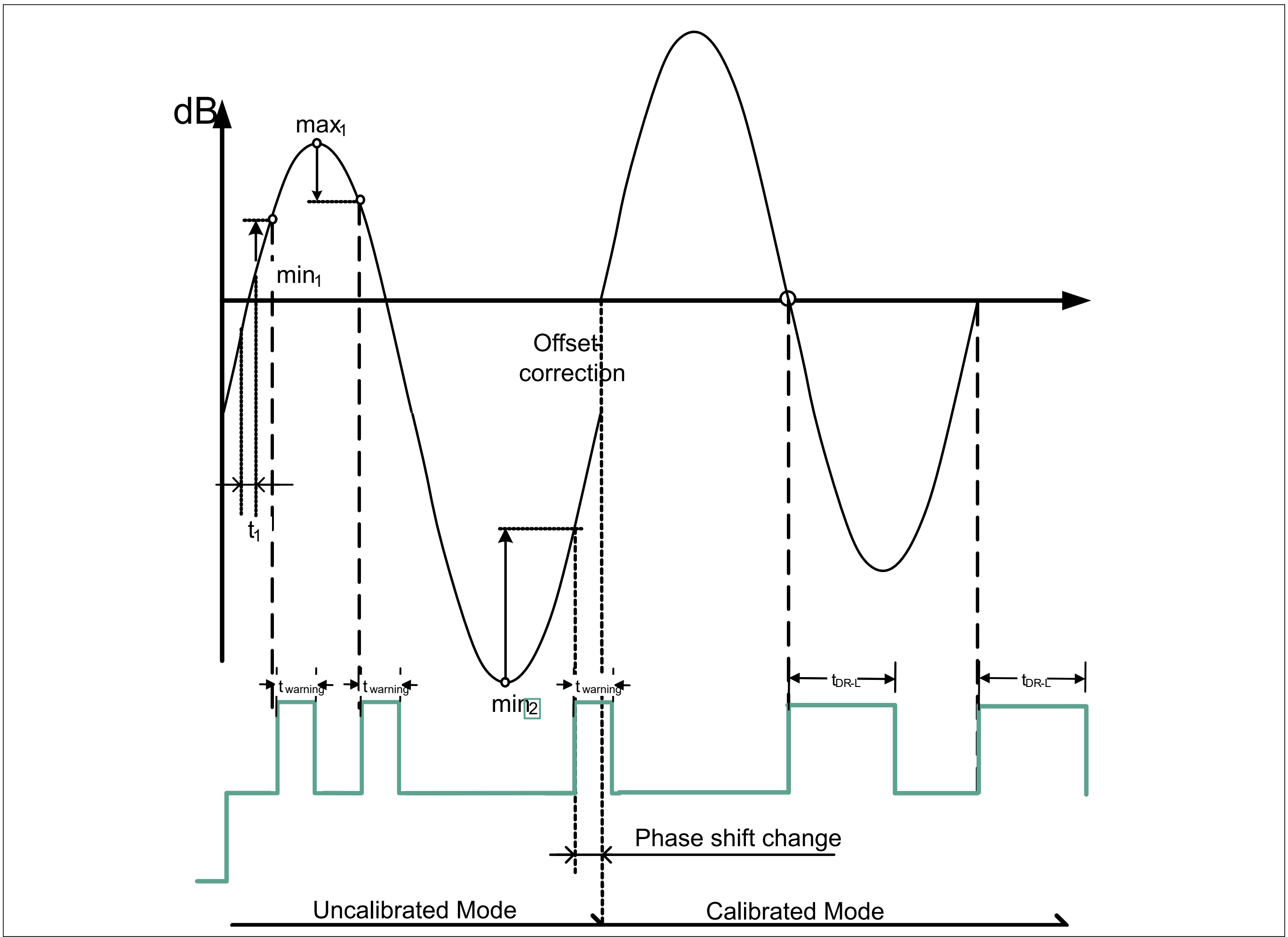


Figure 9 **First positive offset correction**

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 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}.

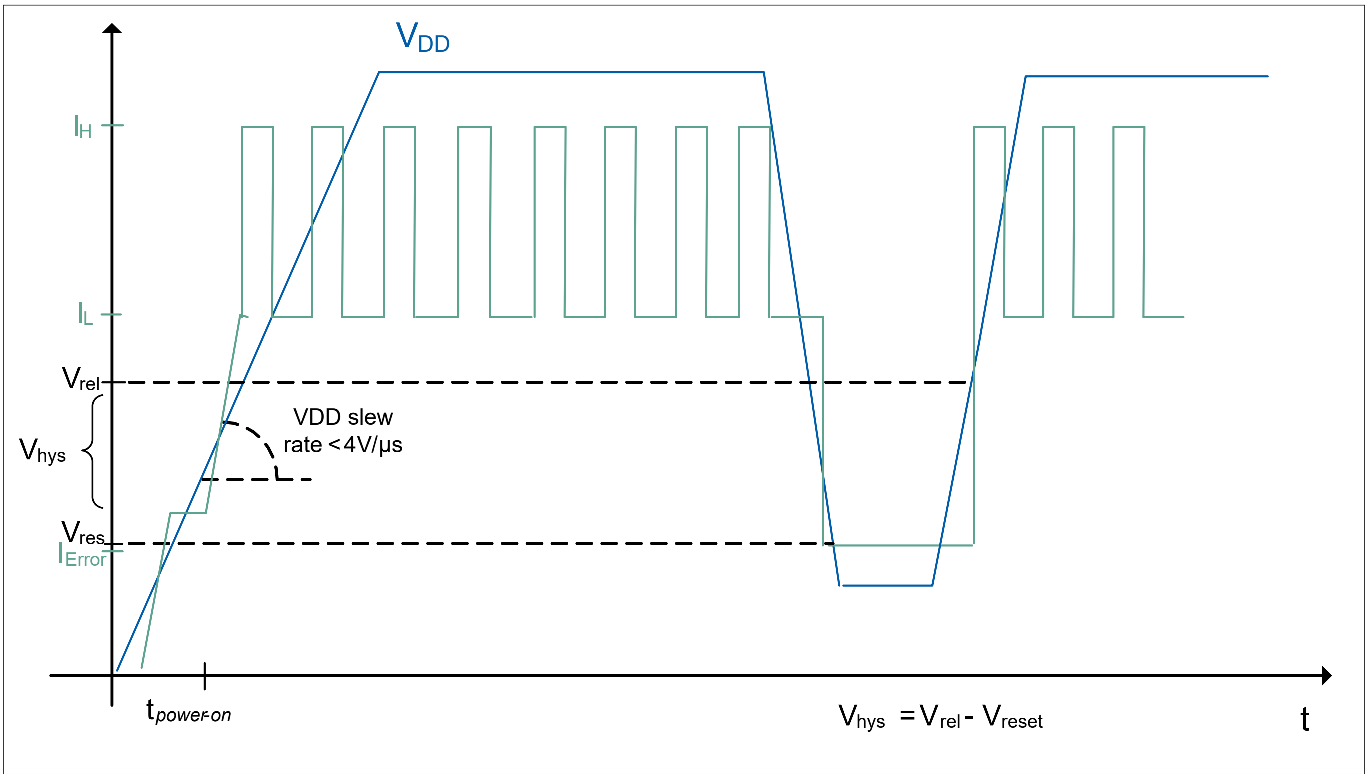


Figure 10 Undervoltage behavior

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.

PWM2 version is designed to have a longer standstill period compared to the standard PWM version and in case a SM is active and standstill condition is present, the warning will not be broadcasted. This means the warning information is NOT dominant towards the standstill pulse. As long as the standstill condition is given; standstill pulses will be transmitted. With the next zero crossing speed event the warning pulse will indicate that a SM is active; this condition will last as long as the failure is persistent. For details please see the respective Safety Manual.

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
- 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.

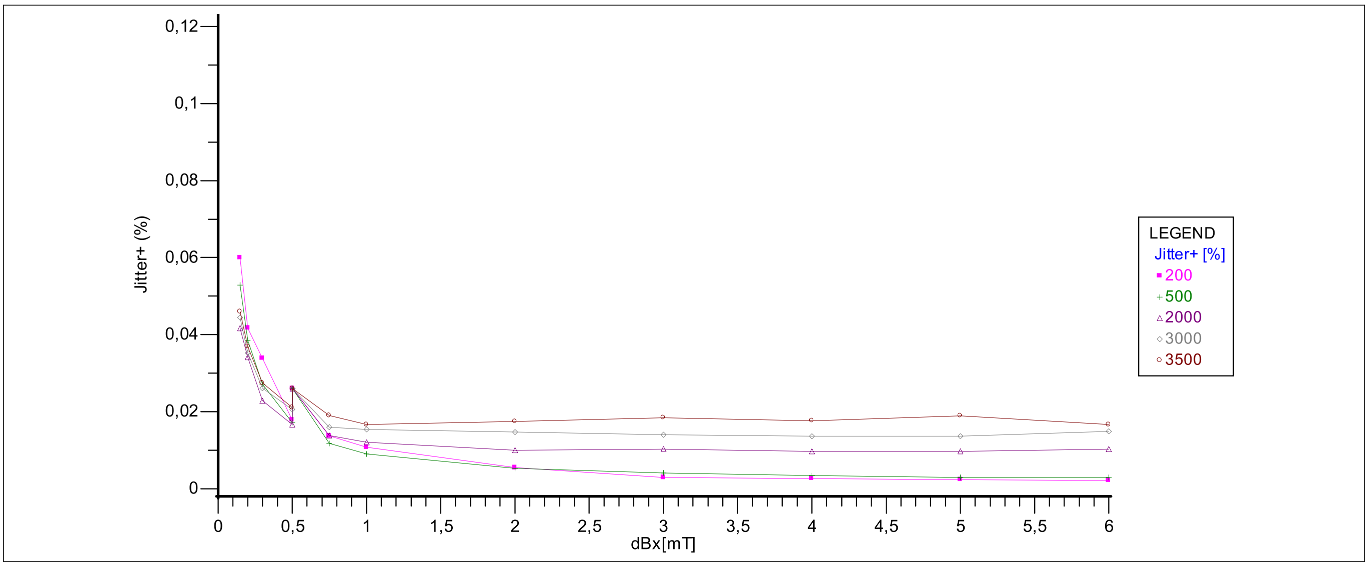


Figure 11 **Jitter performance over different frequencies Ta = -40°C**

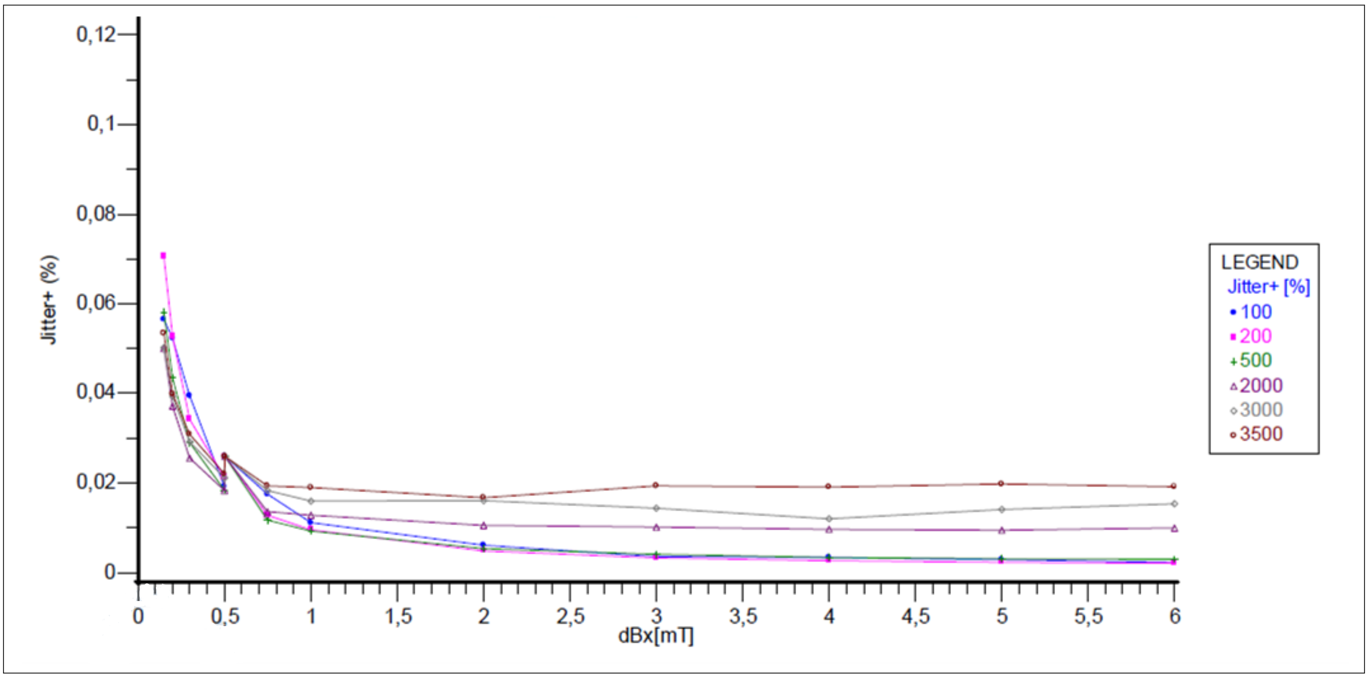


Figure 12 Jitter performance over different frequencies Ta = 25°C

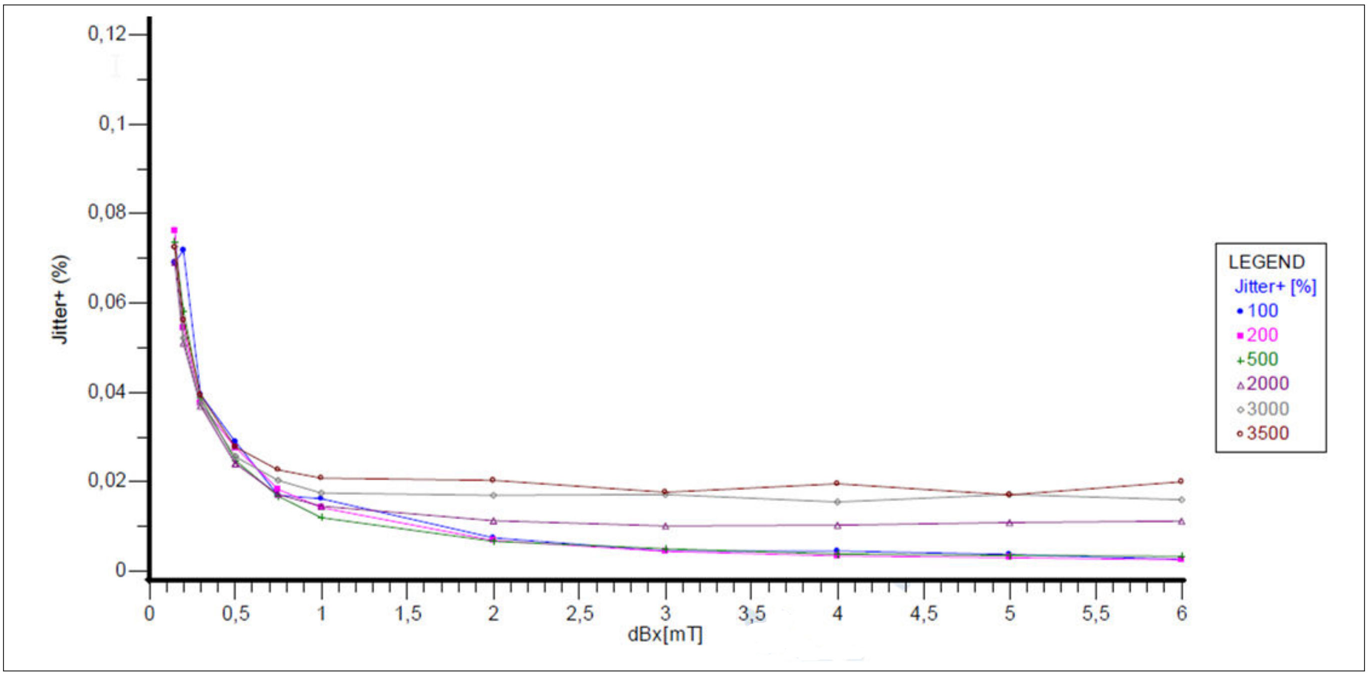


Figure 13 Jitter performance over frequency Ta = 175°C

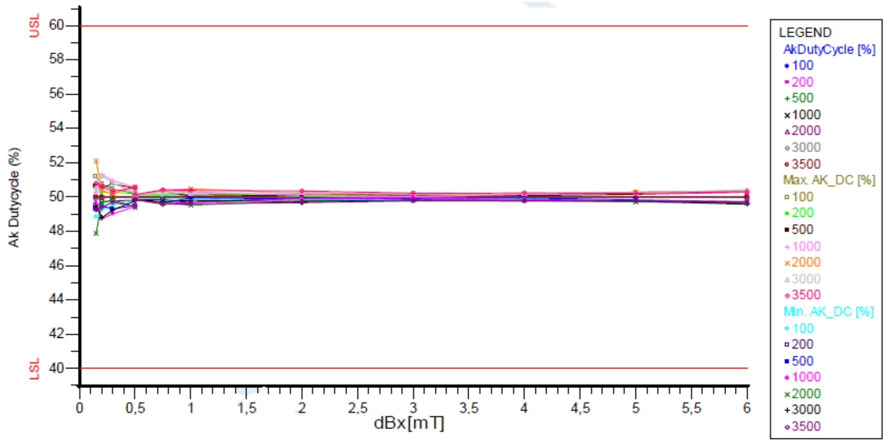


Figure 14 **Duty Cycle performance**

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 air gap stays constant.

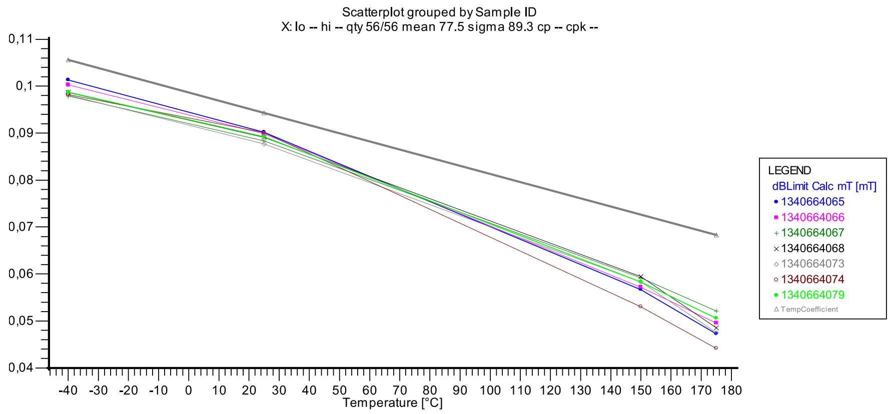


Figure 15 **dBlimit over temperature with implemented Temperature coefficient of -2000 ppm/K**

6 PWM2/Protocol Description

The output has been designed as a two wire current interface based on a Pulse Width Modulation principle. Each zero crossing of the magnetic input signal triggers an output pulse indicated by IHigh and ILow current consumption.

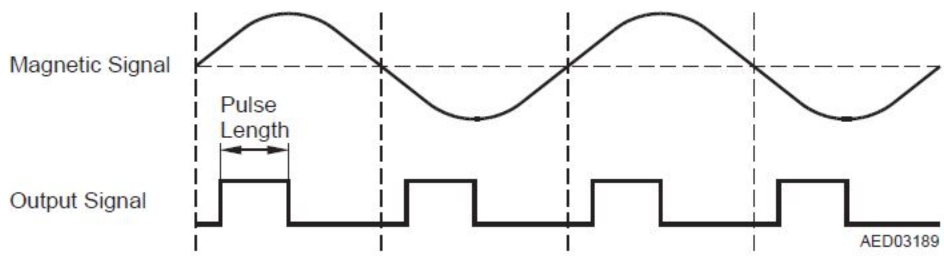


Figure 16 Zero-Crossing Principle and Corresponding Output Pulses

6.1 Timing Characteristics

Table 7 Timing Characteristics TLE5046SiC-PWM2

Parameter	Symbol	Values			Unit	Note or Test Condition
		Min.	Typ.	Max.		
Pre-low length	tpre-low	38	45	52	µs	
Length of Warning pulse	tWarning	38	45	52	µs	
Length of DR-L pulse	tDR-L	76	90	104	µs	
Length of DR-R pulse	tDR-R	153	180	207	µs	
Length of DR-L & EL pulse	tDR-L&EL	306	360	414	µs	
Length of DR-R & EL pulse	tDR-R&EL	616	720	828	µs	
Output of EL pulse, maximum frequency	f_{ELmax}	–	117	–	Hz	
Length of stand still pulse	t_{Stop}	1.232	1.4	1.656	ms	
Stand still period	T_{Stop}	590	737	848	ms	
ΔB_{EL}	ΔB_{EL}		345		µT	4*ΔB_{limit}
$\Delta B_{Warning}$	$\Delta B_{Warning}$		160		µT	2*ΔB_{limit}

Due to decreasing cycle times at higher frequencies, the longer pulses (EL) are only output up to frequencies of approximately 117 Hz. For higher frequencies and differential magnetic fields below ΔB_{EL}, the output pulse lengths are 90 µs or 180 µs respectively. If the magnitude of the magnetic differential field is below $\Delta B_{Warning}$, the output pulse length is 45 µs. The warning pulse length is also used for indicating an incorrect direction. The warning output is dominant, this means that close to the limit Airgap the direction and the assembly position information are disabled. For magnitudes of the magnetic differential field below ΔB_{limit}, signal is lost. In case no magnetic differential signal is detected for a time longer than the stand still period T_{Stop}, the stop pulse is output. Between each magnetic transition and the rising edge of the corresponding output pulse the output current is low for $t_{pre\text{-}low}$.

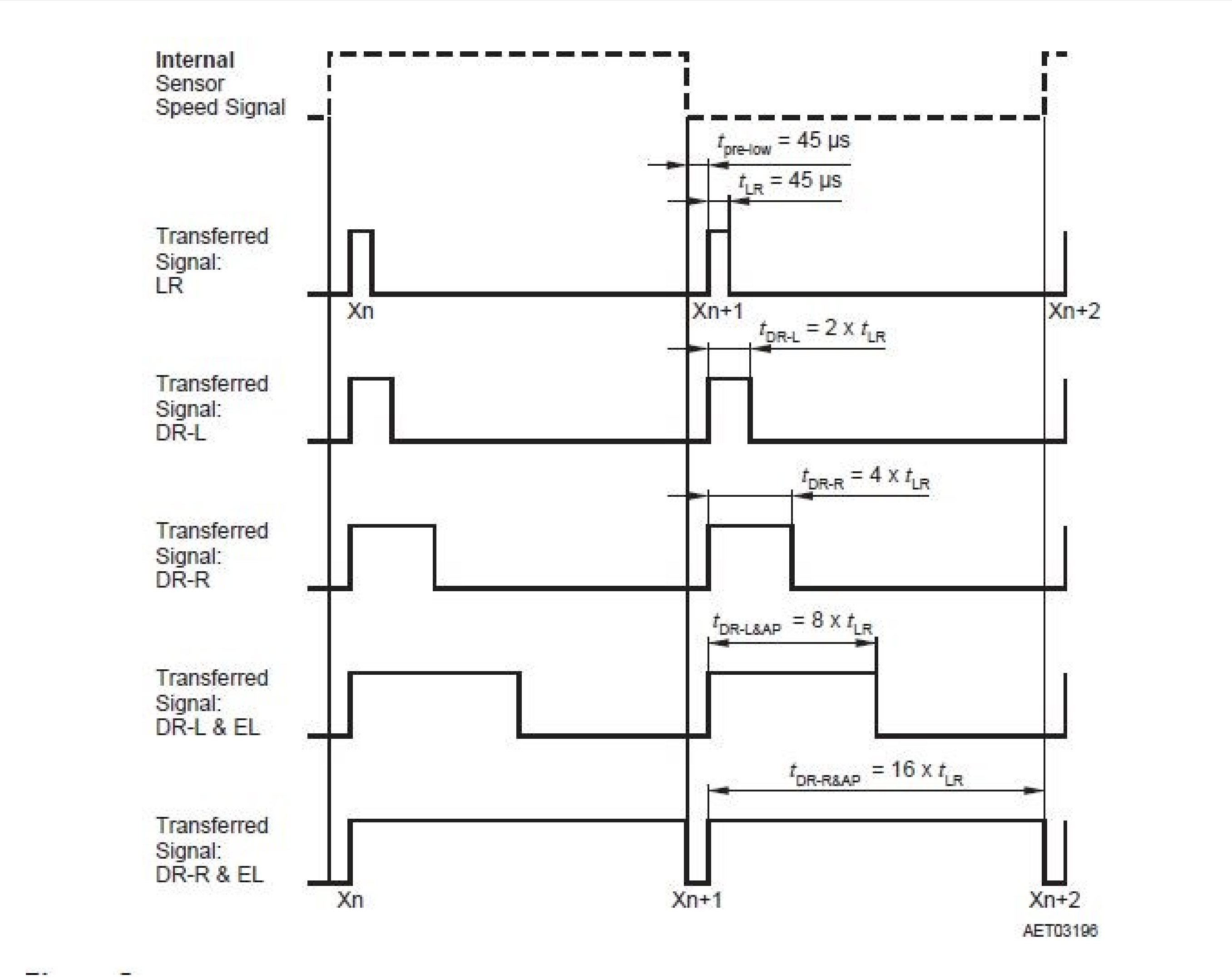


Figure 17 **Definition of PWM2/Interface**

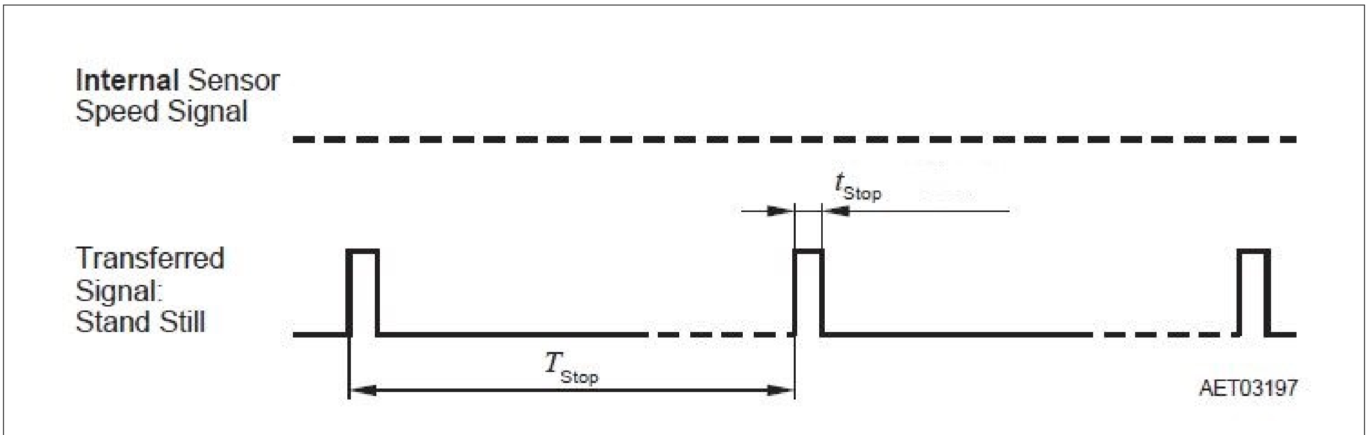


Figure 18 **Definition of PWM Interface Standstill**

Direction of rotation right and left pulse

DR-R information is issued in the output pulse length when the target wheel in front of the IC moves from the pin GND to the pin VCC see Figure 1. DR-L information is issued in the output pulse length when the target wheel in front of the IC moves from the pin VCC to the pin GND.

EL pulse range

If the magnetic differential field exceeds ΔB_{EL} (Einbaulage), the output pulse lengths are 90 µs or 180 µs respectively, depending on the direction of rotation. When the magnitude of the magnetic differential field is below ΔB_{EL}, the output pulse lengths are 360 µs and 720 µs respectively, depending on left or right rotation. The device works with full functionality.

Warning pulse range

Warning pulse information is issued in the output pulse length when the magnetic field is below a critical value (for example. the air-gap between the IC and the target wheel exceeds a critical value).

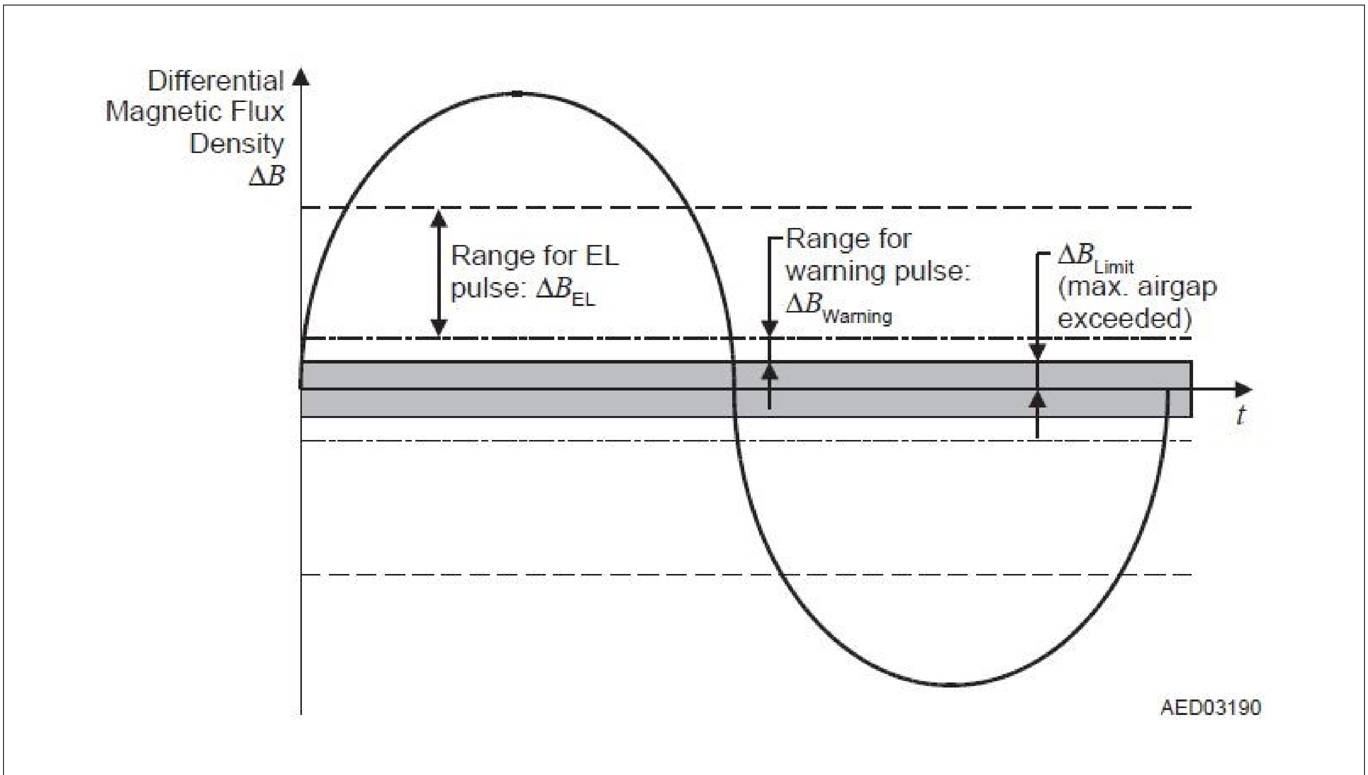


Figure 19 **Definition of Differential Magnetic Flux Density Ranges**

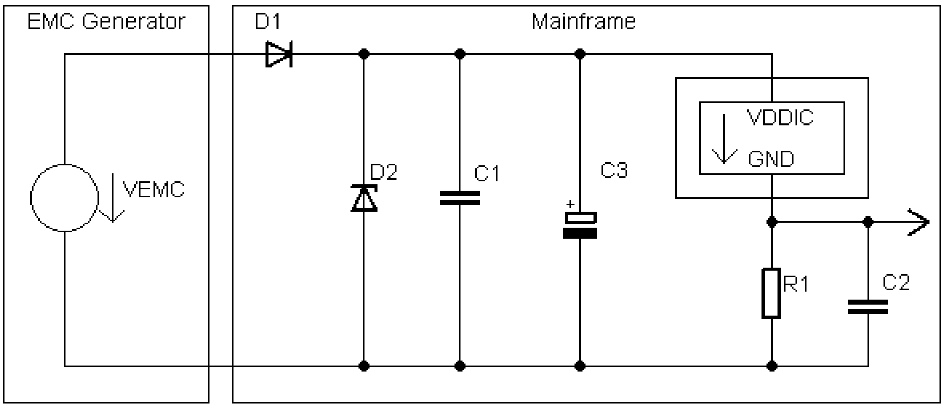
7 EMC and ESD Characteristics

The TLE5046SiC is characterized according to the IC level EMC requirements described in the "Generic IC EMC Test Specification" Version 2.0 from 2014. 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



Components:
D1: reverse polarity protection diode
D2: Zener diode with specific clamping voltage (e.g.27V)
C1: 10µF, 35V
C2: 1nF,100V
C3: 10nF
R1: 75Ω

Figure 20 EMC Test circuit

7.1.1 Electrical Transient Conduction along Supply Lines

General requirements:

- The supply voltage has a value of 13.5 V ± 0.2 V (for test pulse 4 supply voltage is 12 V ± 0.2 V)
- The ambient temperature for these tests is 23°C ± 5°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 mm ± 50 mm
- Pulses are applied to the input terminal of the Loadbox

Table 8 Applicable Pulses, Parameters and Functional Class Requirements

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

1) Output signal overlaid by burst pulses.
2) Additional Pulse parameters: t_f = 5 ms, t_6 = 15 ms, t_7 = 50 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 V ± 0.2 V
- The ambient temperature for these tests is 23°C ± 5°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 9 Test Level and Criteria for Fast Pulses Measurement

Test Pulse	Test Level U_S	Internal resistance	Pulse parameters[1)] t_1 | t_d	Minimum number of pulses or test time	Functional class
3a	-220 V	R_i = 50 Ω	100 µs | 100 ns	10 min	A
3b	+150 V	R_i = 50 Ω	100 µs | 100 ns	10 min	A

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

7.1.3 ESD HBM & CDM

Table 10 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

9.1 Bending and assembly

By following our package handling and assembly recommendation[1)] 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 11 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.

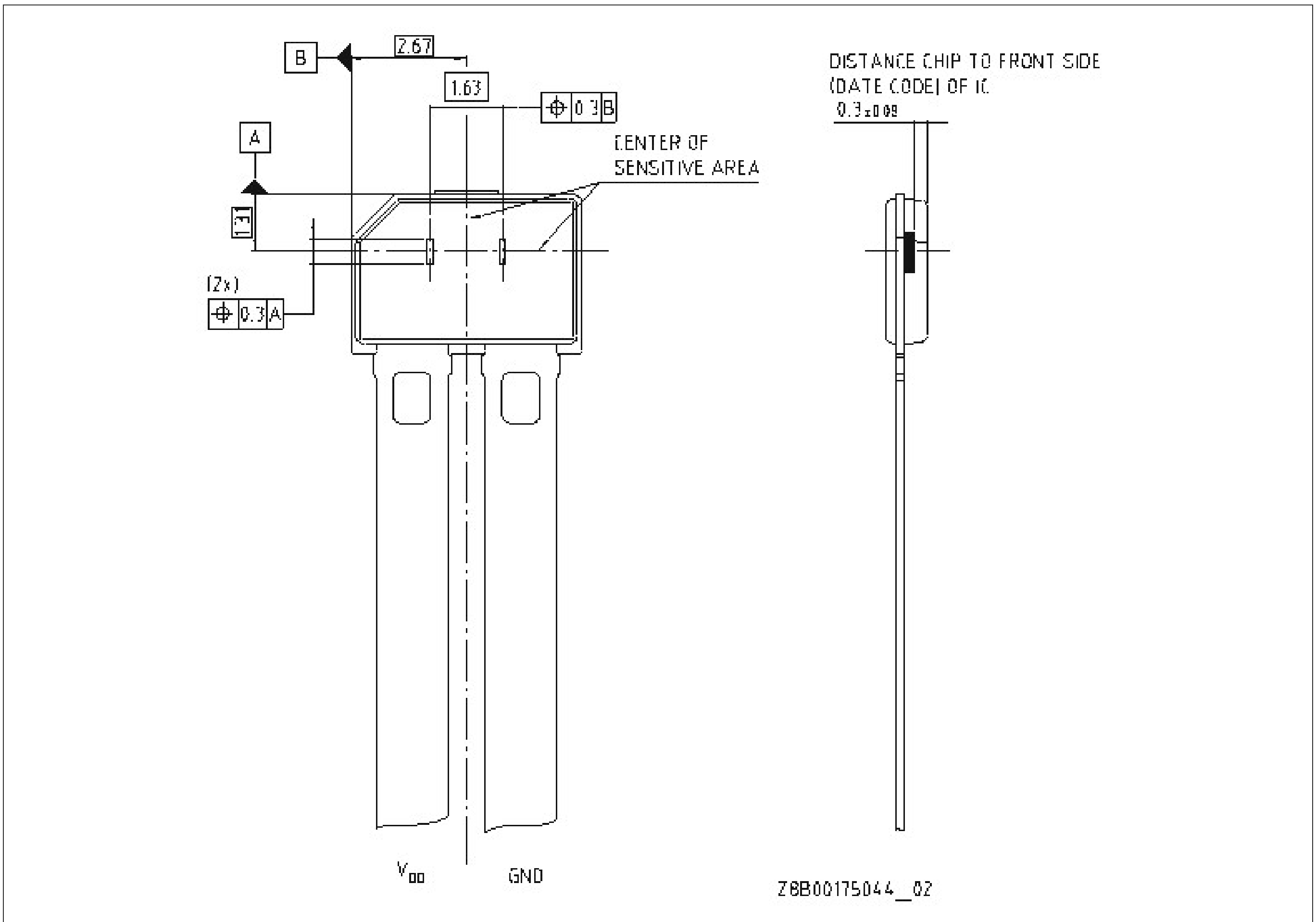


Figure 21 Distance from package surface to silicon (= sensing element)

1 The document is available at https://www.infineon.com/dgdl/Infineon-Recommendation.

9.3 Package

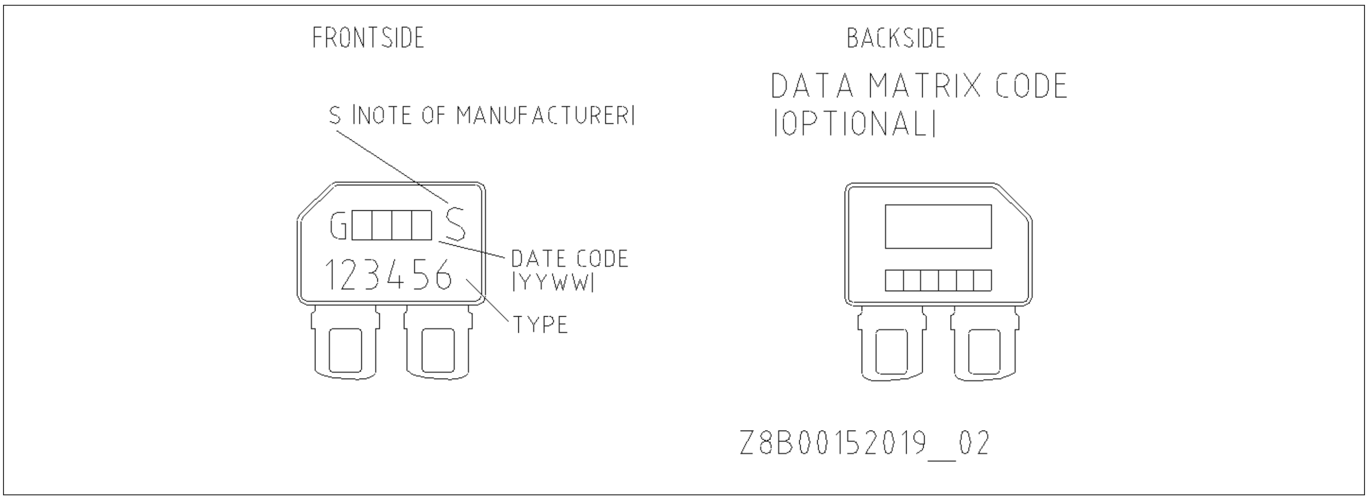


Figure 22 PG-SSO-2-1 marking

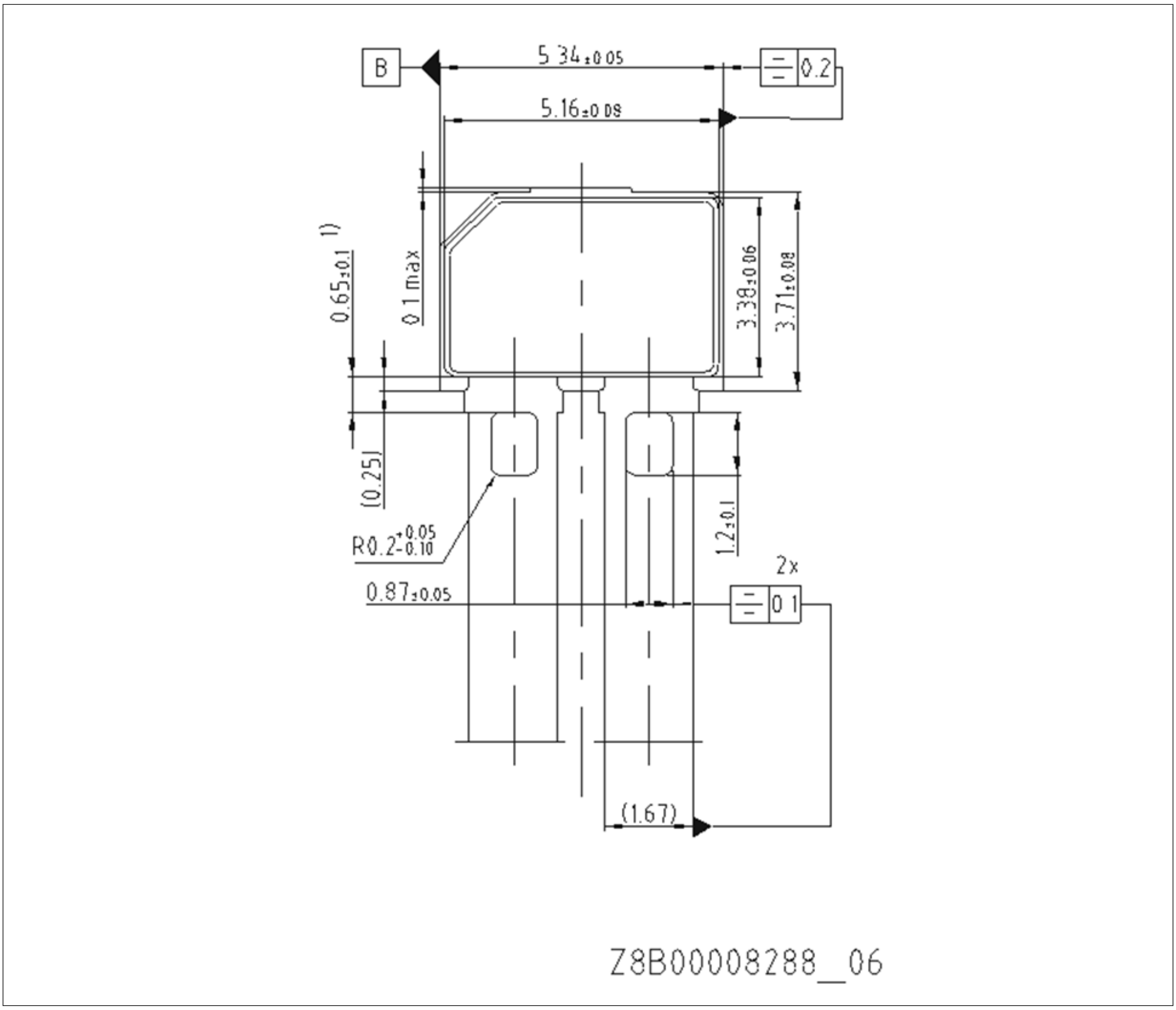


Figure 23 PG-SSO-2-1 package outline

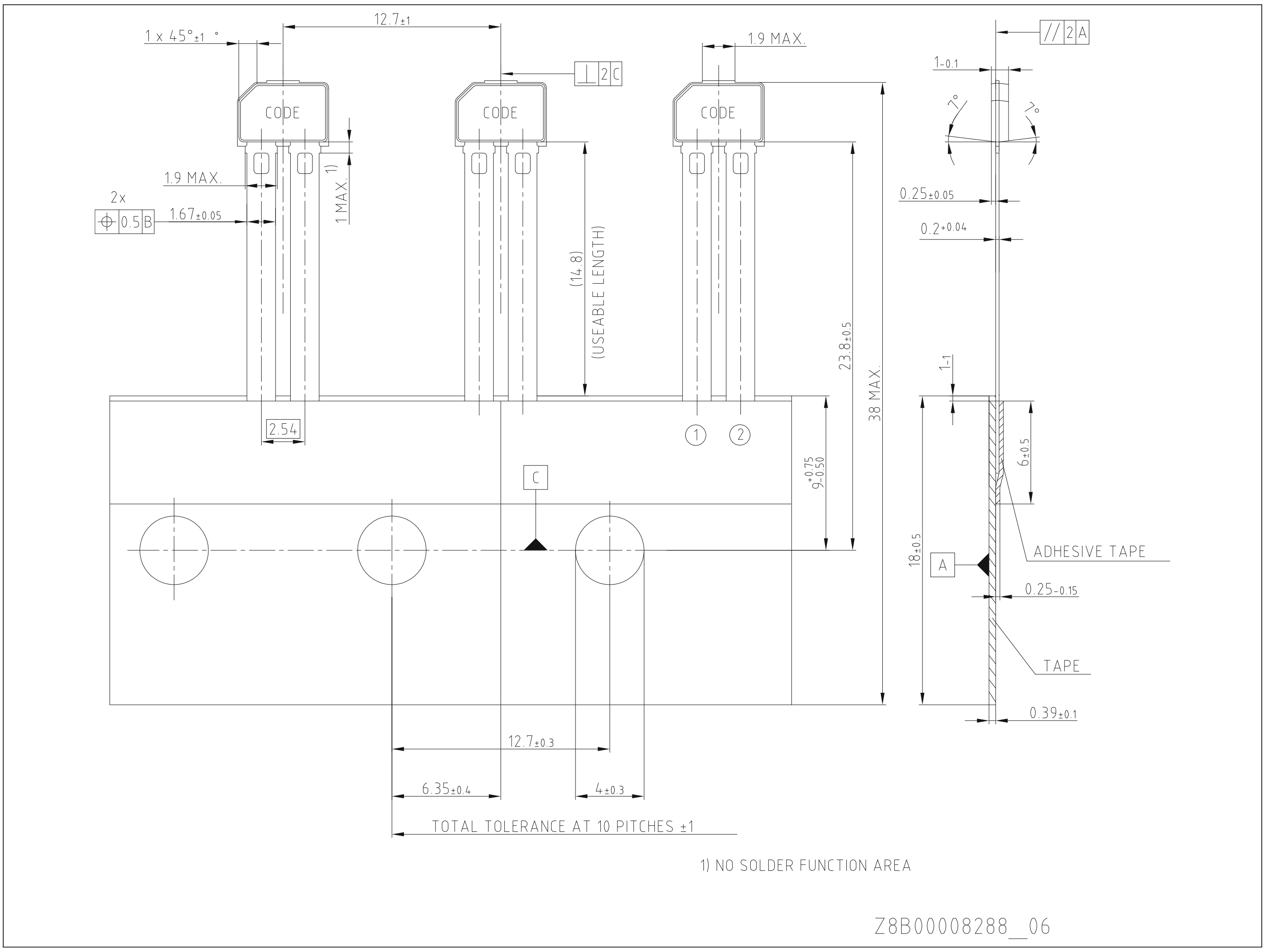


Figure 24 **PG-SSO-2-1 packing**

Dimensions in mm

***Note**: For further information on alternative packages, please visit our website: https://www.infineon.com/cms/en/product/packages/?redirId=54632website.*

10 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

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] *Safety Manual TLE5046SiC*
[11] *Safety Analysis Summary Report TLE5046SiC*

Revision history

Document version	Date of release	Description of changes
1.0	2024-02-06	First release

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Edition 2024-02-06

Published by

Infineon Technologies AG

81726 Munich, Germany

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Document reference
IFX-pdb1695287339667