Angle Sensor

GMR-Based Dual Die Angle Sensor

TLE5012BD

Data Sheet

Rev. 1.2, 2017-01-13

Sense & Control

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Revision History	
Page or Item	**Subjects**
Rev. 1.2, 2017-01-13	
6	Changed in Rev. 1.1: Table 1-1: package version number removed
10	Changed in Rev. 1.1: Table 4-2 ESD protection modified
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15	Changed in Rev. 1.2: Figure 6-3 added
15	Changed in Rev. 1.2: Table 6-2 modified
16	Changed in Rev. 1.2: Chapter 6.5: marking table corrected

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Preface

This document is an addendum to the TLE5012B datasheet and describes the TLE5012BD dual die angle sensor. For all parameters which are not specified here, the TLE5012B datasheet is valid.

1 Product Description

Figure 1-1 PG-TDSO-16 package

1.1 Overview

The TLE5012BD is a fully redundant 360° angle sensor that detects the orientation of a magnetic field. This is achieved by measuring sine and cosine angle components with monolithic **i**ntegrated Giant Magneto Resistance (iGMR) elements.

Highly precise angle values are determined over a wide temperature range and a long lifetime using an internal autocalibration algorithm.

Data communications are accomplished with a bi-directional Synchronous Serial Communication (SSC) that is SPI-compatible.

The absolute angle value and other values are transmitted via SSC or via a Pulse-Width-Modulation (PWM) Protocol. The sine and cosine raw values can also be read out. These raw signals are digitally processed internally to calculate the angle orientation of the magnetic field (magnet).

The TLE5012BD is a pre-calibrated sensor. The calibration parameters are stored in laser fuses. At start-up the values of the fuses are written into flip-flops, where these values can be changed by the application-specific parameters.

Online diagnostic functions are provided to ensure reliable operation.

Table 1-1 Derivate Ordering codes (see Chapter 5 for description of derivates)

Product Type	Marking	Ordering Code	Package
TLE5012BD E1200	121200	SP001205296	PG-TDSO-16
TLE5012BD E9200	129200	SP001205300	PG-TDSO-16

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1.2 Features

- **G**iant **M**agneto **R**esistance (GMR)-based principle
- Fully redundant design with two sensor ICs in one package
- Integrated magnetic field sensing for angle measurement
- 360° angle measurement with revolution counter and angle speed measurement
- Two separate highly accurate single bit SD-ADC
- 15 bit representation of absolute angle value on the output (resolution of 0.01°)
- 16 bit representation of sine / cosine values on the interface
- Max. 1.0° angle error over lifetime and temperature-range with activated auto-calibration
- Bi-directional SSC Interface up to 8Mbit/s
- Supports Safety Integrity Level (SIL) with diagnostic functions and status information
- Interfaces: SSC, PWM, Incremental Interface (IIF), Hall Switch Mode (HSM), Short PWM Code (SPC, based on SENT protocol defined in SAE J2716)
- Output pins can be configured (programmed or pre-configured) as push-pull or open-drain
- Bus mode operation of multiple sensors on one line is possible with SSC or SPC interface in open-drain configuration
- 0.25 µm CMOS technology
- AEC-Q100 automotive qualified
- ESD > 4kV (HBM)
- Green package with lead-free (Pb-free) plating, halogen free

1.3 Application Example

The TLE5012BD GMR-based dual die angle sensor is designed for angular position sensing in automotive applications such as:

- Electrical commutated motor (e.g. used in Electric Power Steering (EPS) and actuators)
- Steering angle measurements
- General angular sensing

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2 Pin Configuration

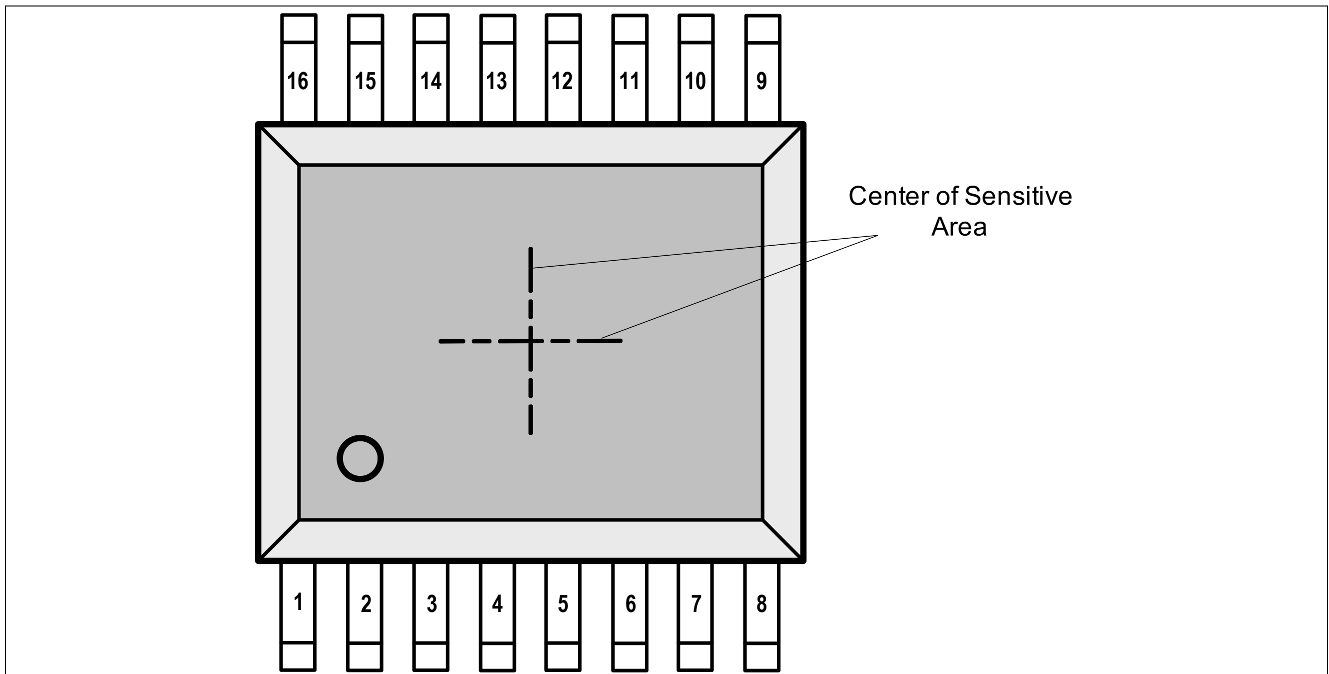

Figure 2-1 Pin configuration (top view)

2.1 Pin Description

Table 2-1 Pin Description

Pin No.	Symbol	In/Out	Function
1	IFC1 (CLK / IIF_IDX / HS3)	I/O	Die 1 Interface C: External Clock[1)] / IIF Index / Hall Switch Signal 3
2	SCK1	I	Die 1 SSC Clock
3	CSQ1	I	Die 1 SSC Chip Select
4	DATA1	I/O	Die 1 SSC Data
5	DATA2	I/O	Die 2 SSC Data
6	CSQ2	I	Die 2 SSC Chip Select
7	SCK2	I	Die 2 SSC Clock
8	IFC2 (CLK / IIF_IDX / HS3)	I/O	Die 2 Interface C: External Clock[1)] / IIF Index / Hall Switch Signal 3
9	IFB2 (IIF_B / HS2)	O	Die 2 Interface B: IIF Phase B / Hall Switch Signal 2
10	GND2	-	Die 2 Ground
11	VDD2	-	Die 2 Supply Voltage

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Table 2-1 Pin Description (cont'd)

Pin No.	Symbol	In/Out	Function
12	IFA2 (IIF_A / HS1 / PWM / SPC)	O	Die 2 Interface A: IIF Phase A / Hall Switch Signal 1 / PWM / SPC output
13	IFA1 (IIF_A / HS1 / PWM / SPC)	O	Die 1 Interface A: IIF Phase A / Hall Switch Signal 1 / PWM / SPC output
14	VDD1	-	Die 1 Supply Voltage
15	GND1	-	Die 1 Ground
16	IFB1 (IIF_B / HS2)	O	Die 1 Interface B: IIF Phase B / Hall Switch Signal 2

1) External clock feature is not available in IIF or HSM interface mode

3 Dual Die Angle Output

The bottom sensor element of the TLE5012BD is flipped relative to the orientation of the top sensor element Therefore the rotation direction sensed by the bottom element is opposite to the top element. This is advantageous for safety critical applications, as the two sensor elements do generally not output the same angle. **Figure 3-1** shows the output of the two sensor ICs for a given external magnetic field orientation.

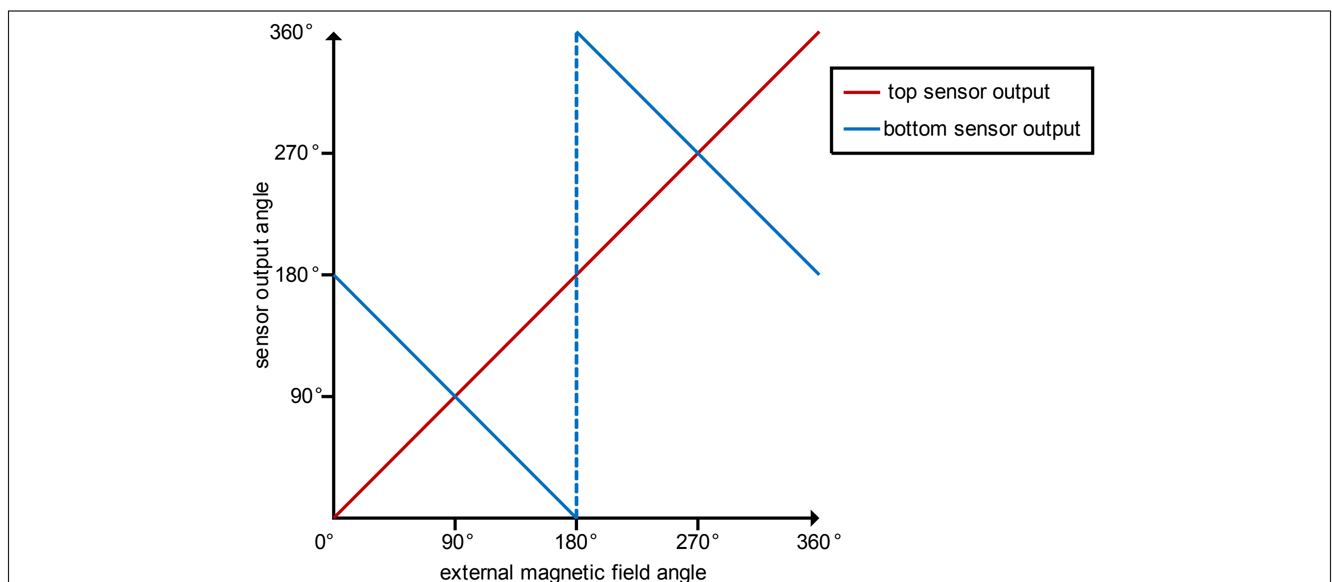

Figure 3-1 Dual die angle output

For applications where an identical angle output of both ICs is desired, the rotation direction and angle offset of one sensor IC can be reconfigured by changing the settings in the ANG_BASE and ANG_DIR registers via SSC interface.

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4 Specification

4.1 Absolute Maximum Ratings

Table 4-1 Absolute maximum ratings

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Ambient temperature	T_A	-40		125	°C	qualification acc. to AEC Q100 grade 1
Junction temperature	T_J	-40		150	°C	
				150	°C	For 1000 h, not additive

Attention: Stresses above the max. 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 device.

Table 4-2 ESD protection

Parameter	Symbol	Values		Unit	Notes
		Min.	Max.		
ESD voltage	V_{HBM}		±4.0	kV	[1] ground pins connected
	V_{HBM}		±2.0	kV	[1]
	V_{CDM}		±0.5	kV	[2]
	V_{CDM}		±0.75	kV	[2] for corner pins

1) Human Body Model (HBM) according to ANSI/ESDA/JEDEC JS-001

2) Charged Device Model (CDM) according to JESD22-C101

4.2 Calculation of the Junction Temperature

The total power dissipation P_{TOT} of the chips leads to self-heating, which increases the junction temperature T_J above the ambient temperature.

The power multiplied by the total thermal resistance R_{thJA} (junction to ambient) yields the junction temperature. R_{thJA} is the sum of the two components Junction to Case and Case to Ambient.

$$R_{thJA} = R_{thJC} + R_{thCA} \tag{4.1}$$

$$T_J = T_A + \Delta T$$

$$\Delta T = R_{thJA} \times P_{TOT} = R_{thJA} \times \left(V_{DD} \times 2 I_{DD} + \sum_Q V_Q \times 2 I_Q\right) \quad (I_{DD}, I_Q > 0 \text{, if direction is into IC})$$

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Factors of 2 in the calculation account for the two sensor ICs in the TLE5012BD. Example (assuming no load on V_{out}).

$$V_{DD} = 5V$$
$$2I_{DD} = 28\,mA$$
$$\Delta T = 120\left[\frac{K}{W}\right] \times \left(5[V] \times 0.028\,[A] + 0[VA]\right) = 16.8K \tag{4.2}$$

For molded sensors, the calculation with R_{thJC} is more appropriate.

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5 Pre-Configured Derivates

Derivates of the TLE5012BD are available with different pre-configured register settings for specific applications. The configuration of all derivates can be changed via SSC interface. A detailed table of settings of the derivates can be found in the latest **TLE5012B Register Setting User Manual**

5.1 IIF-type: E1200

The TLE5012BD-E1200 is preconfigured for Incremental Interface and fast angle update rate (42.7 µs). It is most suitable for BLDC motor commutation.

- Autocalibration mode 1 enabled.
- Prediction disabled.
- Hysteresis is set to 0.625°.
- 12bit mode, one count per 0.088° angle step.
- Incremental Interface A/B mode.

5.2 SPC-type: E9200

The TLE5012BD-E9200 is preconfigured for Short-PWM-Code interface. It is most suitable for steering angle and actuator position sensing.

- Angle update time is 85.4 µs.
- Autocalibration, Prediction, and Hysteresis are disabled.
- SPC unit time is 3 µs.
- SPC interface is set to open-drain output.

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6 Package Information

6.1 Package Parameters

Table 6-1 Package Parameters

Parameter	Symbol	Limit Values			Unit	Notes
		Min.	Typ.	Max.		
Thermal resistance[1]	R_{thJA}		120	140	K/W	Junction to air[2]
	R_{thJC}			35	K/W	Junction to case
	R_{thJL}			70	K/W	Junction to lead
Moisture Sensitivity Level	MSL 3					260°C
Lead Frame	Cu					
Plating	Sn 100%					> 7 µm

1) R_{th} values only valid for both dies supplied with V_{DD}

2) according to Jedec JESD51-7

6.2 Package Outline

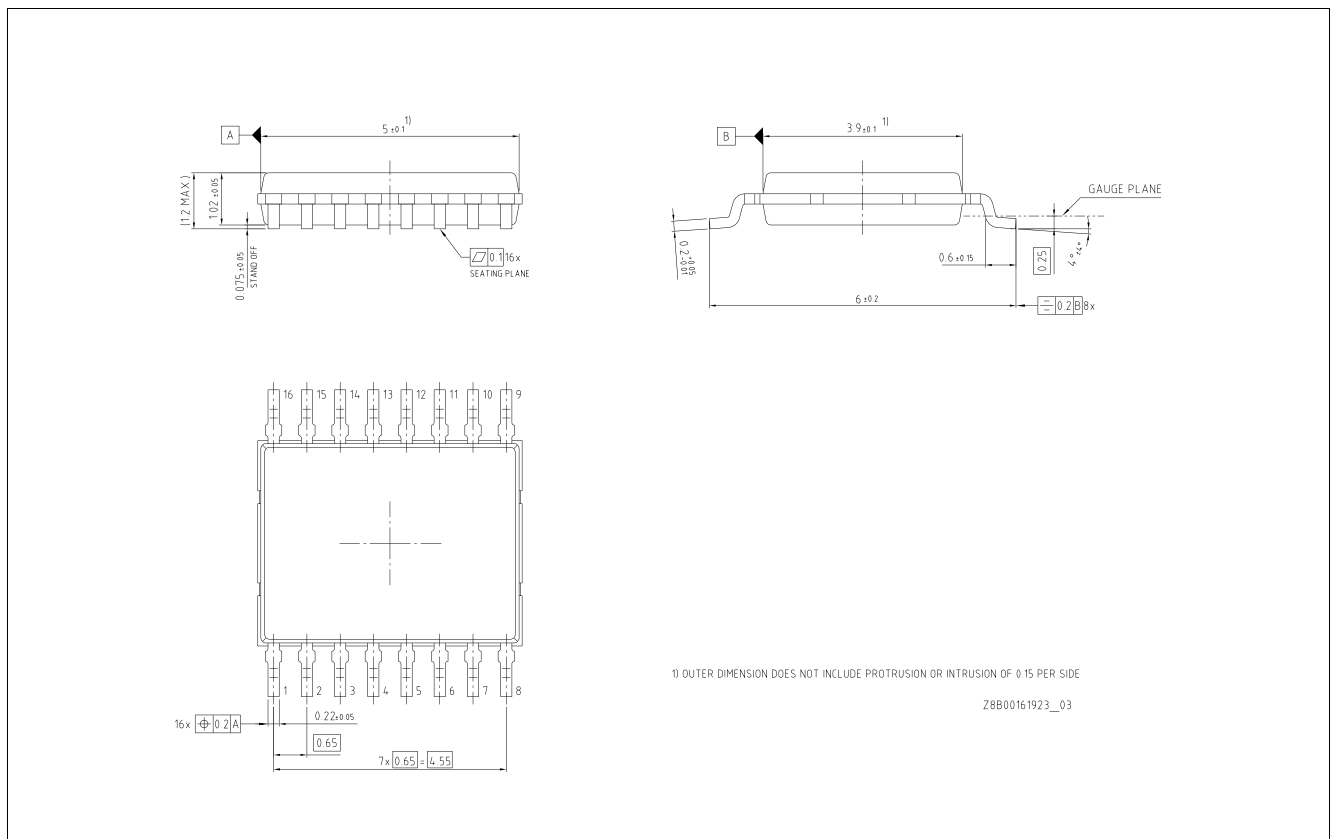

Figure 6-1 PG-TDSO-16 package dimension

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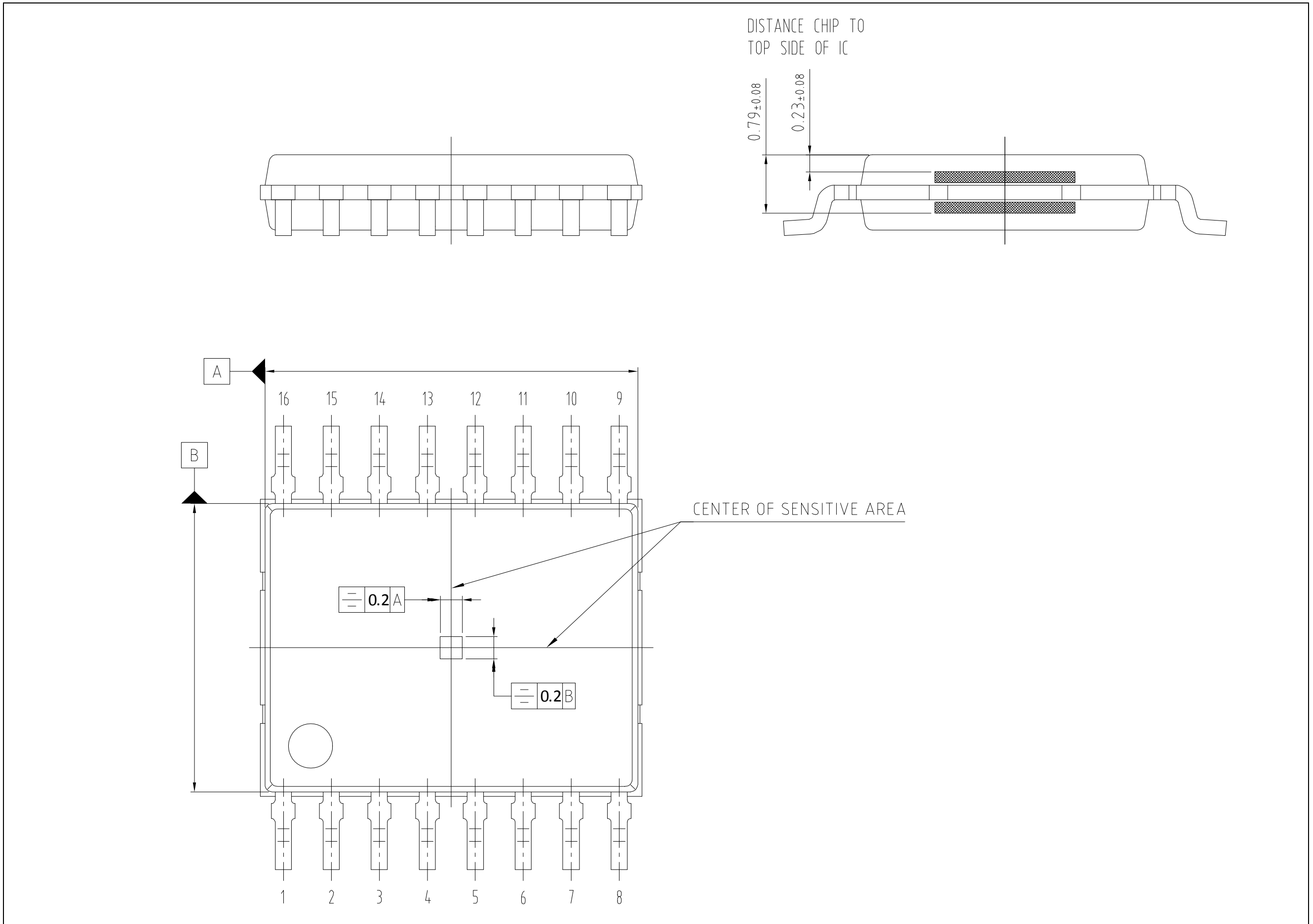

Figure 6-2 Position of sensing element, reference to package

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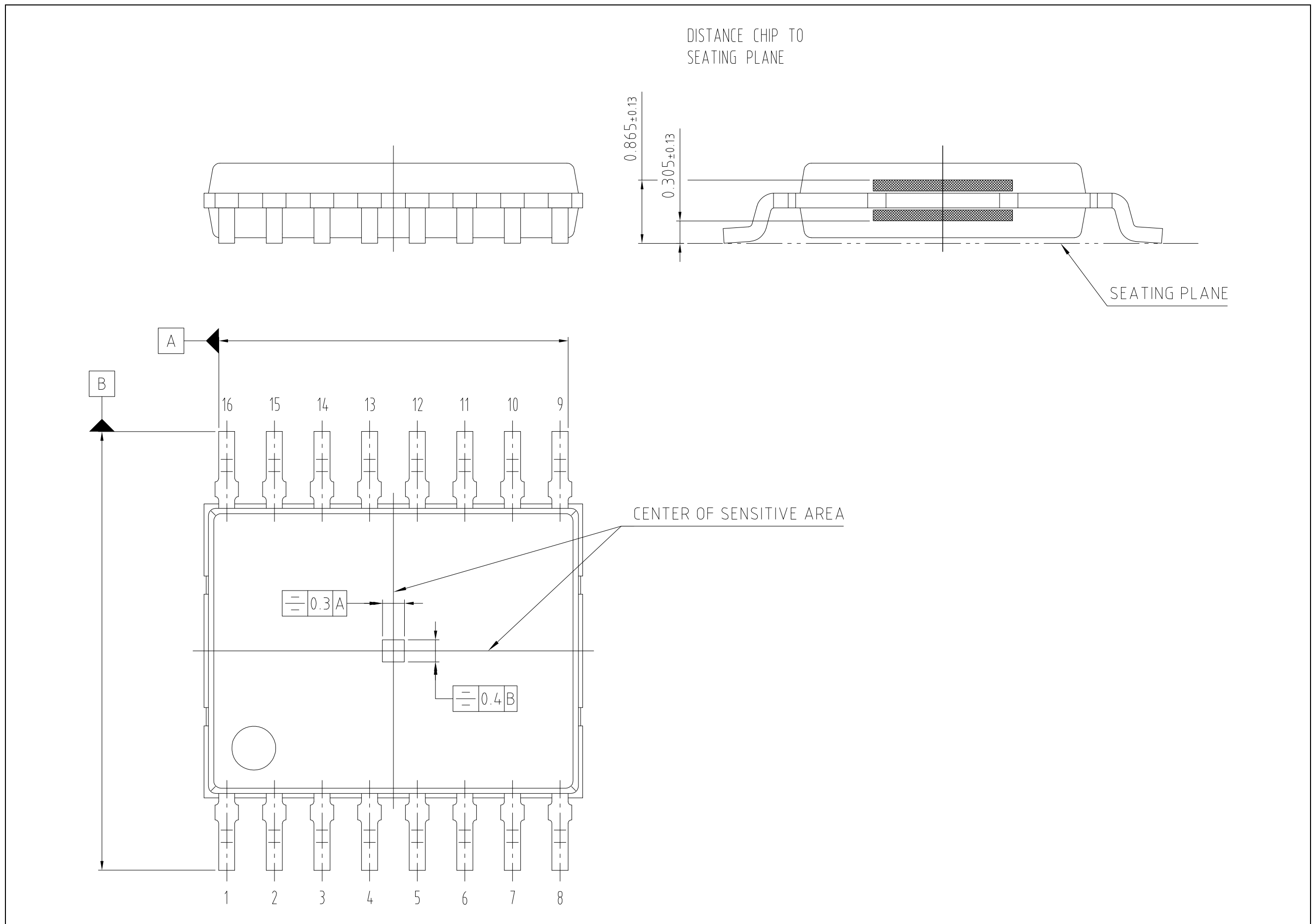

Figure 6-3 Position of sensing element, reference to lead frame

Table 6-2 Sensor IC placement tolerances in package

Parameter	Values		Unit	Notes
	Min.	Max.		
position eccentricity	-100	100	µm	in X- and Y-direction, reference to package
position eccentricity	-150	150	µm	in X-direction, reference to lead frame
position eccentricity	-200	200	µm	in Y-direction, reference to lead frame
rotation	-3	3	°	affects zero position offset of sensor
tilt	-3	3	°	

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6.3 Footprint

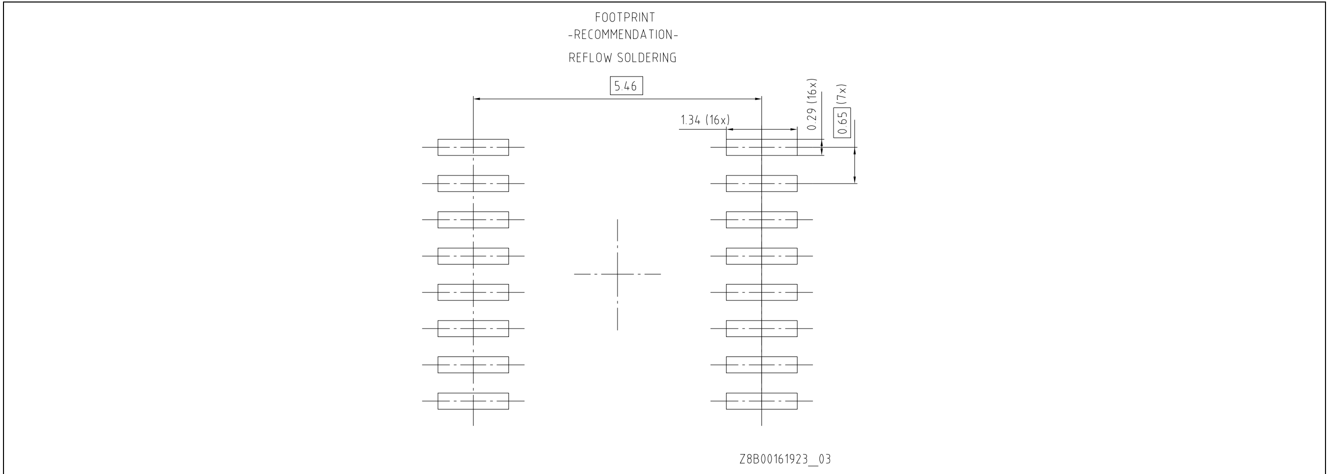

Figure 6-4 Footprint of PG-TDSO-16

6.4 Packing

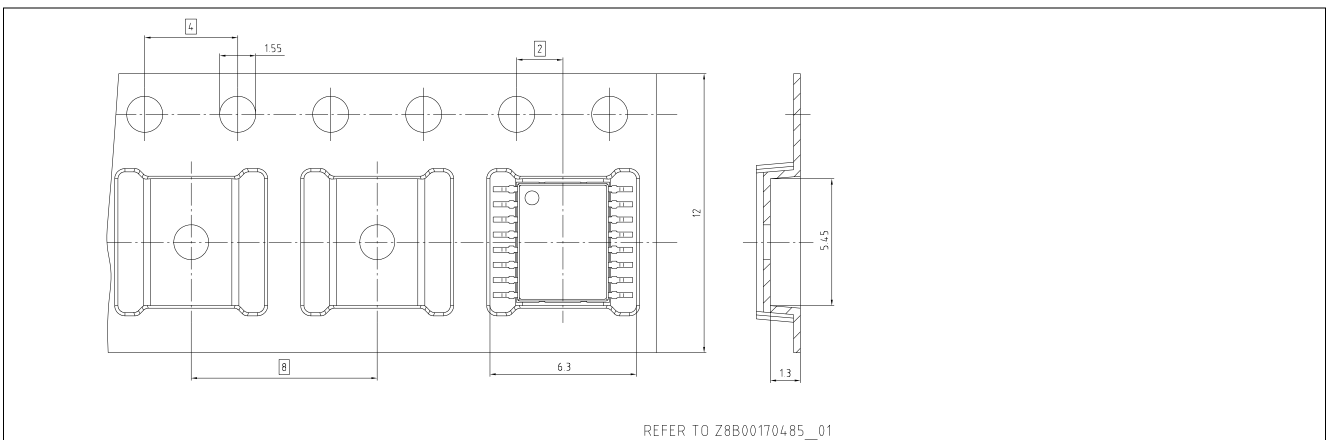

Figure 6-5 Tape and Reel

6.5 Marking

The device is marked on the frontside with a date code, the device type and a lot code. On the backside is a 8 x 18 data matrix code.

Position	Marking	Description
1st Line	Gxxxx	G = green, 4-digit = date code
2nd Line	12x200	Type (6 digits), See ordering **Table 1-1**
3rd Line	xxx	Lot code (3 digits)

Note: For processing recommendations, please refer to Infineon's Notes on processing

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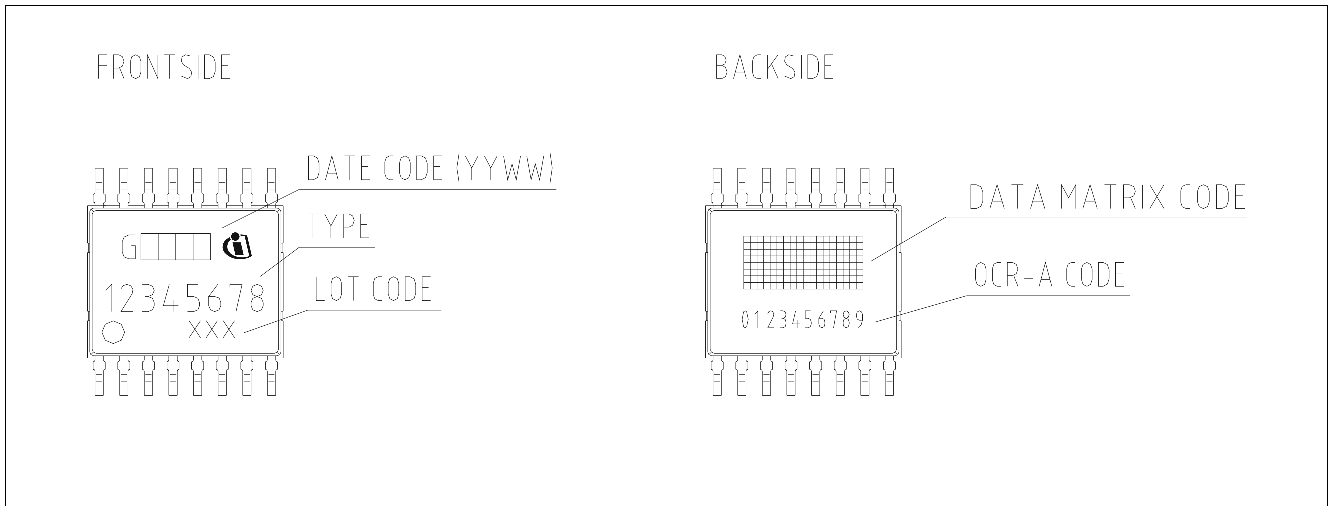

Figure 6-6 Marking

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