

# TLE5046iC

## Technical product description

High End GMR Wheel Speed Sensor with direction detection, ASIL B(D)

## About this document

### Scope and purpose

High-level description of the product features and technical characteristics as primary information about the functionality of the TLE5046iC High End GMR Wheel Speed Sensor with direction detection, ASIL B(D)

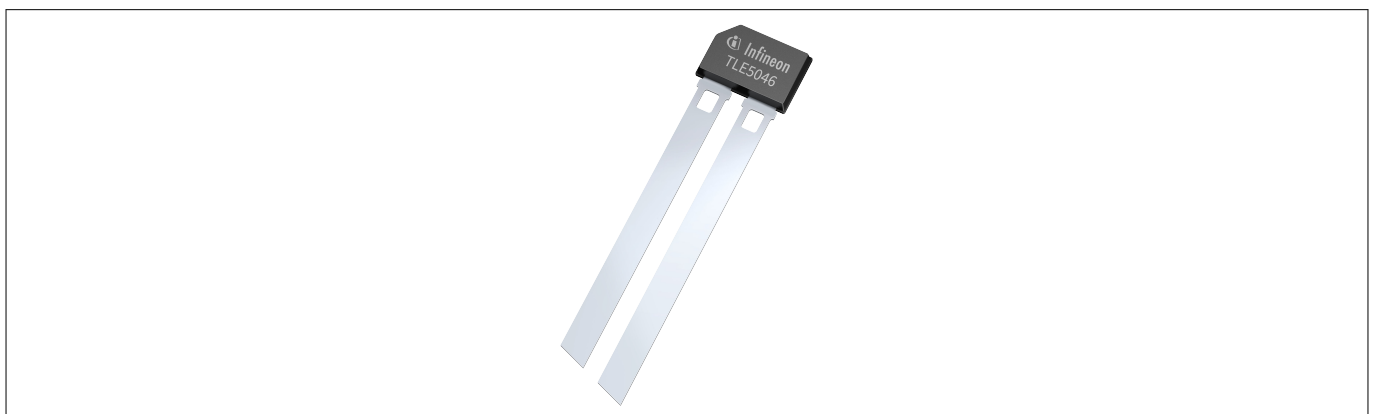
### Intended audience

Automotive suppliers interested in wheel speed sensor applications

## About this product

### Description

Infineon's TLE5046iC is a wheel speed sensor with direction detection designed for sophisticated vehicle control systems. TLE5046iC shows best-in-class jitter performance, thus being 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) was maximized without the need of additional external components.



**Figure 1**      **Product photo**

**About this product**

**Features & Benefits**

- Developed according to ISO 26262, compliant with the requirements of ASIL B(D)
- Low jitter 0.02% due to high switching accuracy enables iTPMS
- Two-wire current interface providing speed and direction information
- Advanced stop-start capabilities enabled by
  - Innovative watchdog concept to guarantee maximum signal availability
  - No loss of direction information during start-stop condition
- Wide operating junction temperature range -40°C to 190°C
- Robustness against external magnetic disturbances up to 2mT through differential sensing principle
- High sensitivity enables outstanding air gap performance along with immunity against y-displacement effects
- Small sensor package 5x3mm 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

**Order Information**

**Table 1**

| <b>Type</b>          | <b>Description</b>  | <b>Ordering Number</b> |
|----------------------|---|------------------------|
| TLE5046iC-PWM2-R050  | Speed sensor with direction detection and PWM protocol, optimized for use with load resistor $R_m \leq 50 \Omega$   | SP002627824            |
| TLE5046iC-PWM2-R100  | Speed sensor with direction detection and PWM protocol, optimized for use with load resistor $50 \Omega \leq R_m \leq 100 \Omega$                               | SP002627830            |
| TLE5046iC-PWM2E-R050 | Speed sensor with direction detection, additional self-diagnostics, and PWM protocol, optimized for use with load resistor $R_m \leq 50 \Omega$                 | SP002627816            |
| TLE5046iC-PWM2E-R100 | Speed sensor with direction detection, additional self-diagnostics, and PWM protocol, optimized for use with load resistor $50 \Omega \leq R_m \leq 100 \Omega$ | SP002627820            |
| TLE5046iC-AK-LR      | Speed sensor with direction detection and AK protocol   | SP001418756            |
| TLE5046iC-AK-ERR     | Speed sensor with direction detection, additional self-diagnostics, and AK protocol   | SP001615796            |

## Table of contents

|           |  |    |
|-----------|--|----|
|           | <b>About this document</b> .....         | 1  |
|           | <b>About this product</b> .....          | 1  |
|           | <b>Table of contents</b> .....           | 3  |
| <b>1</b>  | <b>Product Characteristics</b> .....     | 4  |
| <b>2</b>  | <b>Functional Description</b> .....      | 6  |
| <b>3</b>  | <b>PWM Protocol</b> .....                | 7  |
| <b>4</b>  | <b>AK Protocol</b> .....                 | 8  |
| <b>5</b>  | <b>Safety Mechanisms</b> .....           | 8  |
| <b>6</b>  | <b>ESD and EMC Characteristics</b> ..... | 9  |
| <b>7</b>  | <b>ESD HBM Model</b> .....               | 9  |
| <b>8</b>  | <b>Product Qualification</b> .....       | 9  |
| <b>9</b>  | <b>Pin Configuration</b> .....           | 10 |
| <b>10</b> | <b>Package Outline</b> .....             | 11 |
| <b>11</b> | <b>Terminology</b> .....                 | 12 |
|           | <b>Revision history</b> .....            | 13 |
|           | <b>Disclaimer</b> .....                  | 14 |

**1 Product Characteristics**

**1 Product Characteristics**

**Absolute Maximum Ratings**

Stresses above the maximum values listed here may cause permanent damage to the device.

**Table 2**

| Parameter             | Symbol             | Min. | Typ. | Max. | Unit             | Note / Test Condition   |
|-----------------------|--------------------|------|------|------|------------------|---|
| 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  | $T_J$              | -40  | -    | 190  | $^\circ\text{C}$ | max 4 h, < 16.5 V   |
| Magnetic flux density | $B_{\text{max}_x}$ | -    | -    | 250  | mT               | max. 1min @ $T_A \leq 85^\circ\text{C}$                           |
|                       | $B_{\text{max}_y}$ | -    | -    |      |                  |   |
|                       | $B_{\text{max}_z}$ | -    | -    | 500  | mT               | max. 1min @ $T_A \leq 85^\circ\text{C}$                           |

**Operating Range**

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

**Table 3**

| Parameter  | Symbol   | Min. | Typ. | Max. | Unit             | Note / Test Condition              |
|--|--|------|------|------|------------------|------------------------------------|
| Supply voltage   | $V_{DD}$   | 5.2  | -    | 20   | V                | TLE5046iC-AK*, TLE5046iC-PWM*-R100 |
|  | $V_{DD}$   | 4.25 | -    | 20   | V                | TLE5046iC-PWM*-R050                |
| Operating Temperature  | $T_J$  | -40  |      | 190  | $^\circ\text{C}$ |                                    |
| Magnetic signal frequency  | $f_{\text{mag}}$   | 0    | -    | 3000 | Hz               |                                    |
| Minimum differential magnetic input signal amplitude, magnetic encoder application | $\text{dB}_{\text{limit}_x}$<br>$T_A = 25^\circ\text{C}$ | 70   | 90   | 110  | $\mu\text{T}$    | 99% criterium                      |
| Magnetic induction amplitude at each GMR sensing element                           | $B_x$  | -25  | -    | 25   | mT               |                                    |
| Dynamic and static homogeneous external disturbance fields                         | $B_{\text{ext}_{XYZ}}$                                   | -2   |      | 2    | mT               | no unwanted pulses                 |

## 1 Product Characteristics

### 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  $T_A = 25^\circ\text{C}$ . For a more detailed specification please refer to our product datasheets which are available on request.

**Table 4**

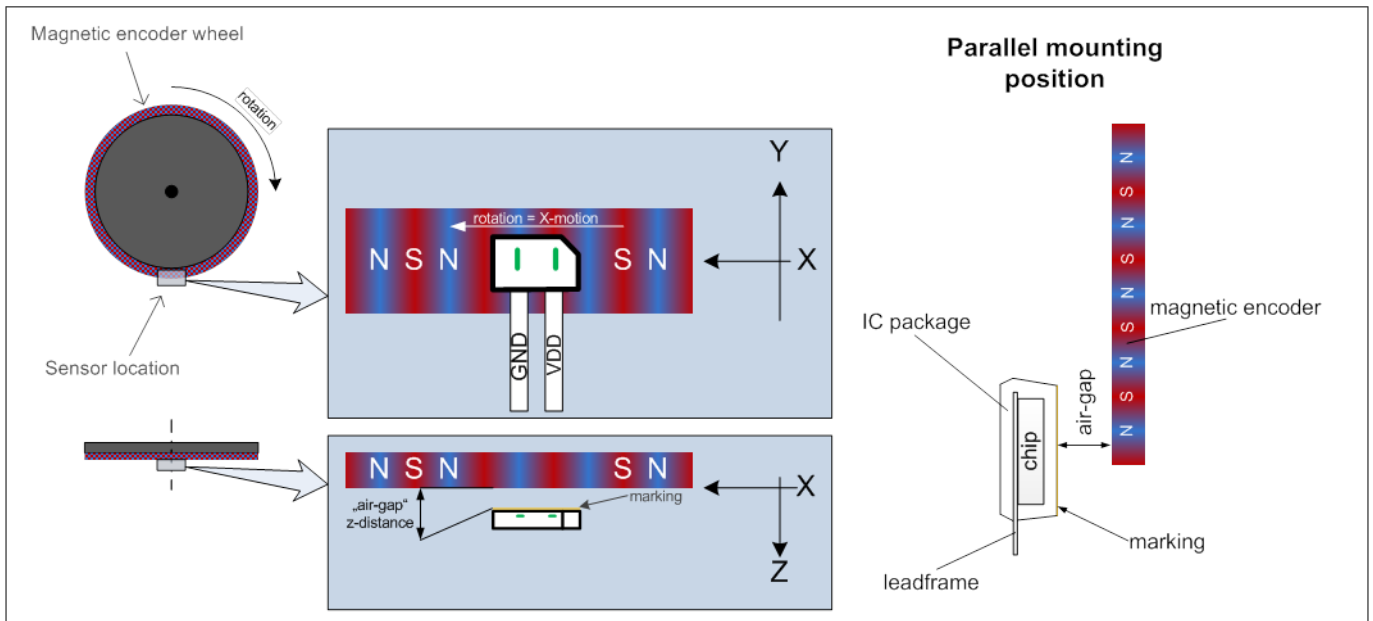
| Parameter   | Symbol                  | Min. | Typ.       | Max. | Unit                 | Note / Test Condition  |
|---|-------------------------|------|------------|------|----------------------|--|
| Period jitter   | $S_{jit}$               | -    | $\pm 0.02$ |      | %                    | $\pm 1\sigma$ value  |
| Duty cycle  | DC                      | 40   | -          | 60   | %                    | in calibrated mode   |
| Supply current during static output low state                           | $I_{low}$               | 5.95 | 7          | 8.05 | mA                   |  |
| Supply current during static output mid state (AK), or high state (PWM) | $I_{mid}$<br>$I_{high}$ | 11.9 | 14         | 16.1 | mA                   |  |
| Supply current during static output high state (AK)                     | $I_{high}$              | 23.8 | 28         | 32.2 | mA                   |  |
| Current level for indicating errors                                     | $I_{Error}$             | 1    | 3.5        | 3.8  | mA                   |  |
| Output current slew rate  | $SR_r, SR_f$            | 11   | -          | 28   | mA/<br>$\mu\text{s}$ | $SR_r = (I_{90\%} - I_{10\%}) / t_r$<br>$SR_f = (I_{90\%} - I_{10\%}) / t_f$ |
| Switch-off voltage  | $V_{reset}$             |      |            | 3.5  | V                    | direct on sensor pins  |
| Supply voltage hysteresis   | $V_{Hys}$               | 1.5  |            | 1.7  | V                    | TLE5046iC-AK*, TLE5046iC-PWM*-R100   |
| Supply voltage hysteresis   | $V_{Hys}$               | 0.65 |            | 0.75 | V                    | TLE5046iC-PWM*-R050  |

**2 Functional Description**

**2 Functional Description**

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

In the figure below the typical placement of the TLE5046iC facing a magnetic encoder wheel is shown. The figure also indicates the coordinate system, which is valid throughout this document.



**Figure 2** Typical placement of the TLE5046iC

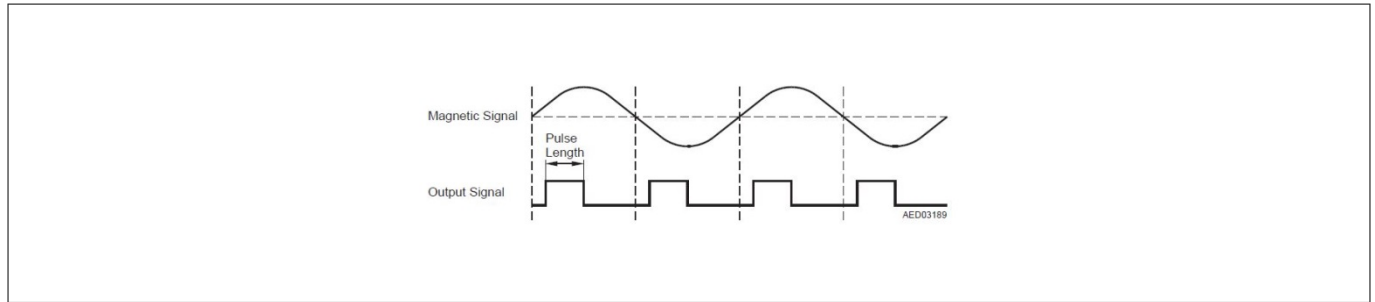
**3 PWM Protocol**

**3 PWM Protocol**

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  $I_{High}$  and  $I_{Low}$  current consumption.

The PWM Protocol is available in two different protocol options: standard TLE5046iC-PWM2 and TLE5046iC-PWM2E with indication of internal errors by using the warning pulse.

The timing characteristic for TLE5046iC-PWM2 and TLE5046iC-PWM2E is given in the table below:



**Figure 3 Signal output pulse**

The timing characteristic for TLE5046iC-PWM2 and TLE5046iC-PWM2E is given in the table below:

**Table 5**

| Parameter                             | Symbol               | Min.  | Typ. | Max.  | Unit    | Note / Test Condition  |
|---------------------------------------|----------------------|-------|------|-------|---------|------------------------|
| Pre-low length                        | $t_{pre-low}$        | 38    | 45   | 52    | $\mu s$ |                        |
| Length of Warning pulse               | $t_{Warning}$        | 38    | 45   | 52    | $\mu s$ |                        |
| Length of DR-L pulse                  | $t_{DR-L}$           | 76    | 90   | 104   | $\mu s$ |                        |
| Length of DR-R pulse                  | $t_{DR-R}$           | 153   | 180  | 207   | $\mu s$ |                        |
| Length of DR-L & EL pulse             | $t_{DR-L\&EL}$       | 306   | 360  | 414   | $\mu s$ |                        |
| Length of DR-R & EL pulse             | $t_{DR-R\&EL}$       | 616   | 720  | 828   | $\mu s$ |                        |
| 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      |                        |
| $\Delta B_{EL}$                       | $\Delta B_{EL}$      |       | 345  |       | mT      | $4 * \Delta B_{limit}$ |
| $\Delta B_{Warning}$                  | $\Delta B_{Warning}$ |       | 160  |       | mT      | $2 * \Delta B_{limit}$ |

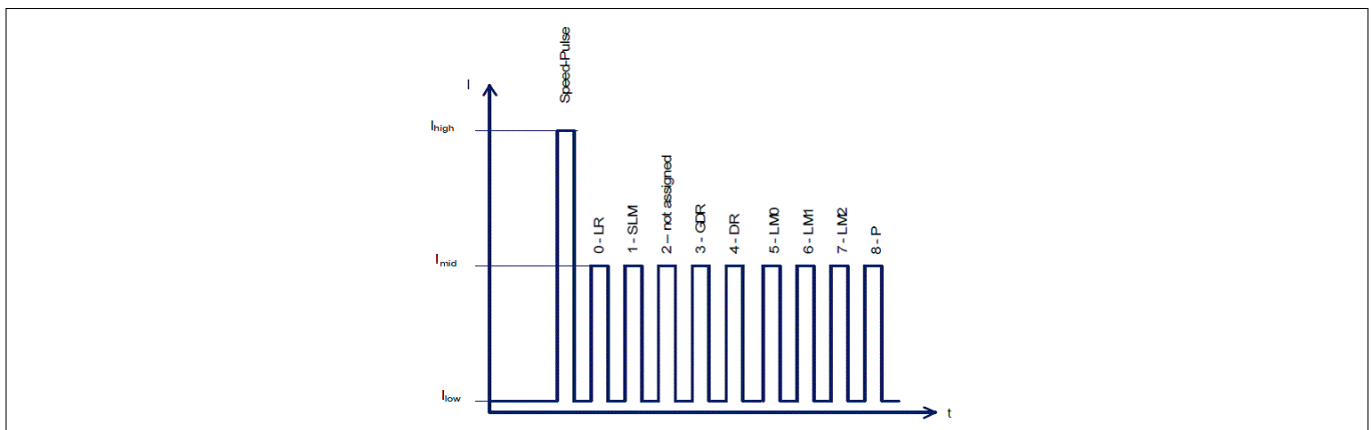
**4 AK Protocol**

**4 AK Protocol**

TLE5046iC-AK-LR and TLE5046iC-AK-ERR devices are compliant with: “Requirement Specifications for Standardized Interface for Wheel Speed Sensors with Additional Information ‘AK-Protocol’ Version: 4.0” dated 13.02.2008 of Daimler AG, unless otherwise stated in this document or in the valid Technical Datasheets.

The 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 additional information to the speed pulse.

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 (ERR). The two different variants TLE5046iC-AK-LR and TLE5046iC-AK-ERR, respectively, perform accordingly.



**Figure 4 Data protocol**

**5 Safety Mechanisms**

The TLE5046iC 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 notify the Control System in case of an internal error by setting the output current level to a constant failure indication level  $I_{Error}$ .

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:

- 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 air gap, ADC clipping and temperature monitoring: This safety mechanisms verifies critical states inside the ASIC itself.



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## 6 ESD and EMC Characteristics

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.

The entirety of 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. Also, the speed algorithm is designed for fast start-up and optimization of duty cycle. The extremely low jitter of the sensor contributes to high time accuracy of the speed signal.

TLE5046iC 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.

## 6 ESD and EMC Characteristics

The TLE5046iC is characterized according to the IC level EMC requirements described in the “Generic IC EMC Test Specification” Version 2.0 from 2014. EMC testreport 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.

## 7 ESD HBM Model

**Table 6**

| Parameter   | Symbol    | Min. | Typ. | Max. | Unit | Note / Test Condition                  |
|-------------|-----------|------|------|------|------|--|
| ESD Voltage | $V_{HBM}$ | -    | -    | ±12  | kV   | Method AEC-Q100 Rev H (1.5 kΩ, 100 pF) |

## 8 Product Qualification

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

9 Pin Configuration

9 Pin Configuration

Table 7

| Pin No. | Symbol | Function       |
|---------|--------|----------------|
| 1       | VDD    | Supply voltage |
| 2       | GND    | Ground         |

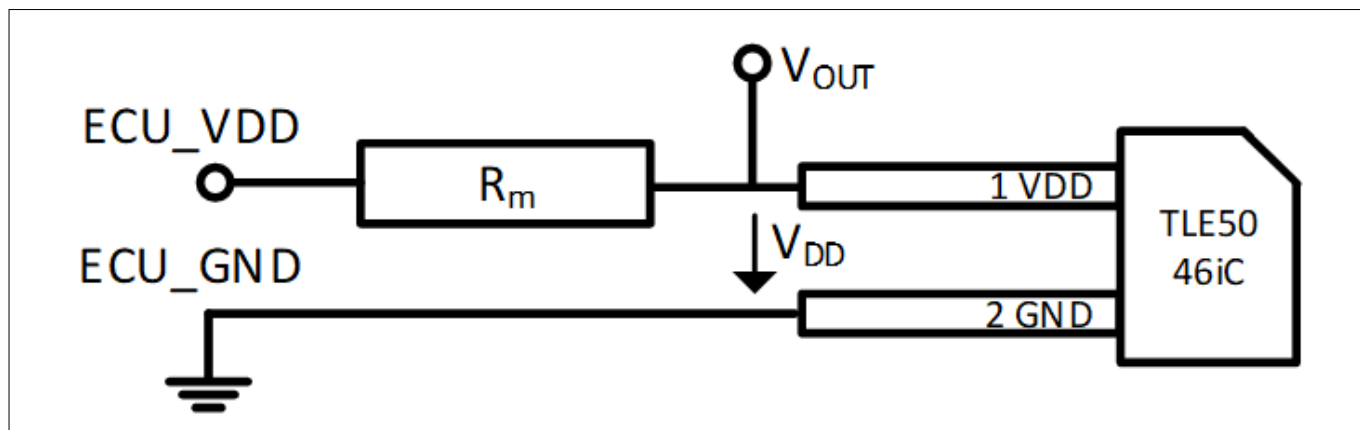


Figure 5 Pin configuration

10 Package Outline

10 Package Outline

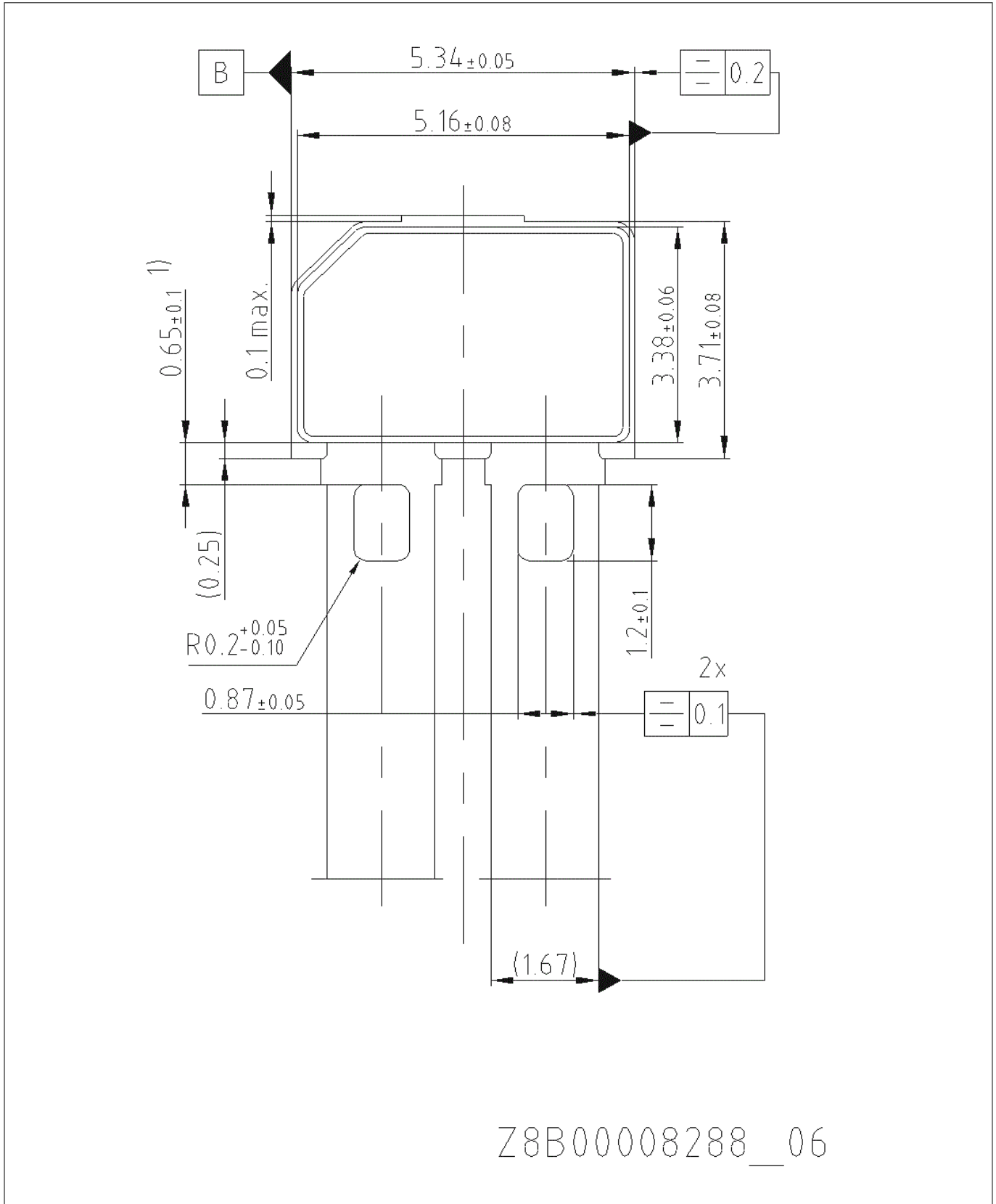


Figure 6 Package Outline

**11 Terminology**

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**Table 8**

|       |   |
|-------|---|
| μs    | microsecond   |
| μT    | micro-Tesla   |
| A     | Ampere  |
| AEC   | Automotive Electronics Council                                  |
| AK    | Arbeitskreis  |
| ASIC  | application specific integrated circuit                         |
| ASIL  | automotive safety integrity Level                               |
| C     | Celsius   |
| CISP  | Comité international spécial des perturbations radioélectriques |
| EMC   | electromagnetic compatibility                                   |
| ESD   | electrostatic discharge   |
| GMR   | giant magneto resistance  |
| GND   | ground  |
| h     | hour  |
| HBM   | human body model  |
| Hz    | Hertz   |
| IC    | integrated circuit  |
| iGMR  | integrated giant magneto resistance                             |
| ISO   | International Organization for Standardization                  |
| iTPMS | integrated tire pressure monitoring system                      |
| kΩ    | kilo-Ohm  |
| kV    | kilo-Volt   |
| mA    | milli-Ampere  |
| min   | minute  |
| mm    | millimeter  |
| ms    | millisecond   |
| mT    | milli-Tesla   |
| Ω     | Ohm   |
| pF    | picofarad   |
| PWM   | pulse width modulation  |
| V     | Volt  |
| VDD   | supply voltage  |

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**Revision history**

**Revision history**

| <b>Document version</b> | <b>Date of release</b> | <b>Description of changes</b>  |
|-------------------------|------------------------|--|
| 1.0                     | 2018-11-06             | <ul style="list-style-type: none"><li>Initial version</li></ul>              |
| 2.0                     | 2020-06-30             | <ul style="list-style-type: none"><li>PWM protocol changed to PWM2</li></ul> |

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