

# Unipolar Hall Switch

High Precision Automotive Hall Effect Switch

TLE4965-5M

SP000978610

**TLE4965-5M**

**Data Sheet**

Revision 1.2, 2019-12-20

Sense & Control

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## Product description

### 1 Product description



#### 1.1 Overview

The TLE4965-5M is a high precision Hall effect unipolar switch with highly accurate switching thresholds for operating temperatures up to 170°C.

Characteristic	Supply Voltage	Supply Current	Sensitivity	Interface	Temperature
Unipolar Hall Effect Switch	3.0 V ~ 5.5 V	1.5 mA	High $B_{OP}$ : 7.5 mT $B_{RP}$ : 5 mT	Open Drain Output	-40°C to 170°C



**Figure 1** TLE4965-5M in the PG-SOT23-3-15 package

#### 1.2 Features

- 3.0 V to 5.5 V operating supply voltage
- Operation from regulated power supply
- Active error compensation
- High stability of magnetic thresholds
- Low jitter (typ. 0.28  $\mu$ s)
- 4 kV ESD (HBM) performance
- Small SMD package PG-SOT23-3-15

**Table 1** Ordering information

Product name	Product type	Ordering code	Package
TLE4965-5M	Unipolar Hall Switch	SP000978610	PG-SOT23-3-15

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**Product description****1.3 Target applications**

Target applications for the TLE496x Hall Switch family are all applications which require a high precision Hall Switch with an operating temperature range from -40°C to 170°C.

The TLE4965-5M is a unipolar switch with a typical operating point  $B_{OP} = 7.5$  mT and a hysteresis of  $B_{HYS} = 2.5$  mT. It is ideally suited for various position detection applications, e.g. gear stick, steering lock or brake light.

**1.4 Product validation**

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

## Functional description

## 2 Functional description

### 2.1 General

The TLE4965-5M is an integrated Hall effect switch designed specifically for highly accurate applications where the sensor is connected to a regulated power supply voltage in the range of 3.0 V to 5.5 V. It provides a large operating temperature range and temperature stability of the magnetic thresholds.

### 2.2 Pin configuration (top view)

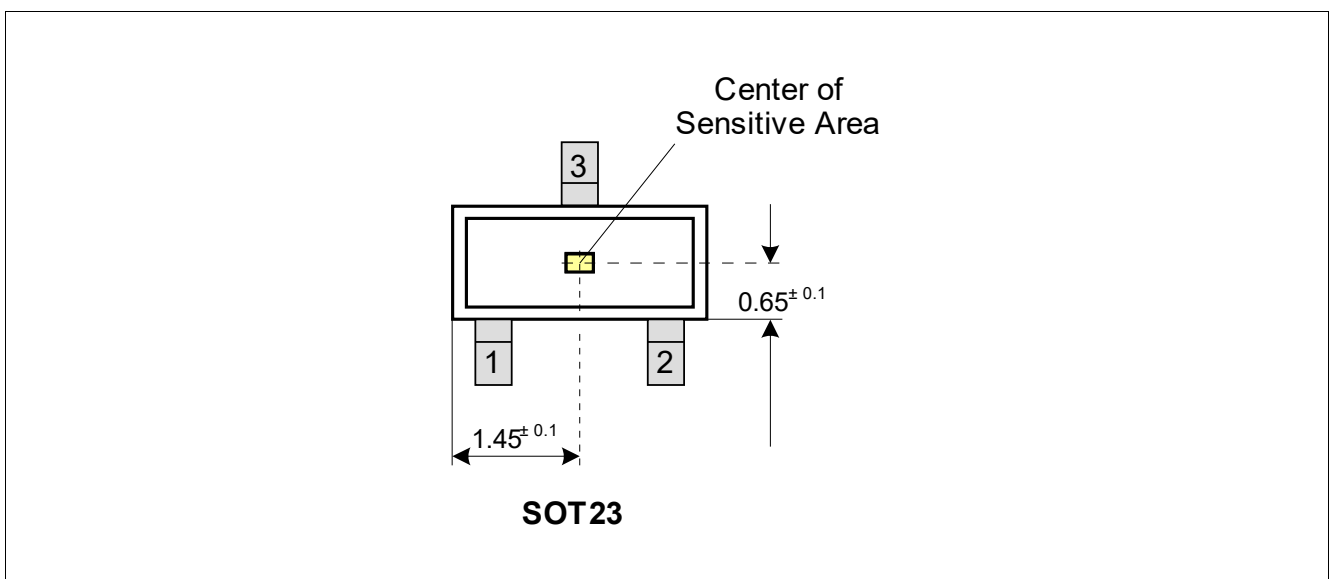


Figure 2 Pin configuration and center of sensitive area

### 2.3 Pin description

Table 2 Pin description PG-SOT23-3-15

Pin no.	Symbol	Function
1	VDD	Supply voltage
2	Q	Output
3	GND	Ground

Functional description

2.4 Block diagram

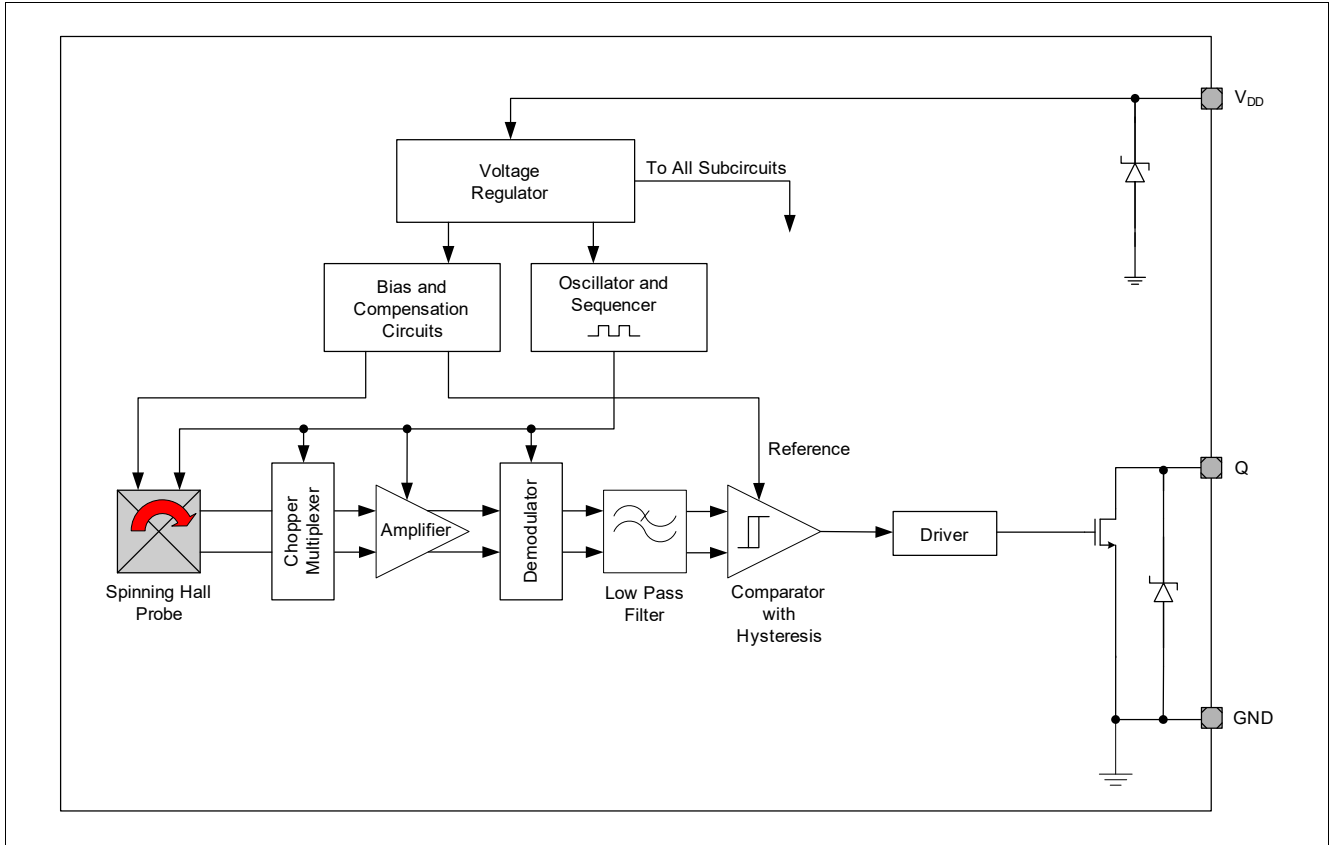


Figure 3 Functional block diagram TLE4965-5M



Functional description

2.5 Functional block description

The chopped Hall IC switch comprises a Hall probe, bias generator, compensation circuits, oscillator and output transistor.

The bias generator provides currents for the Hall probe and the active circuits. Compensation circuits stabilize the temperature behavior and reduce influence of technology variations.

The active error compensation (chopping technique) rejects offsets in the signal path and the influence of mechanical stress to the Hall probe caused by molding and soldering processes and other thermal stress in the package. The chopped measurement principle together with the threshold generator and the comparator ensures highly accurate and temperature stable magnetic thresholds.

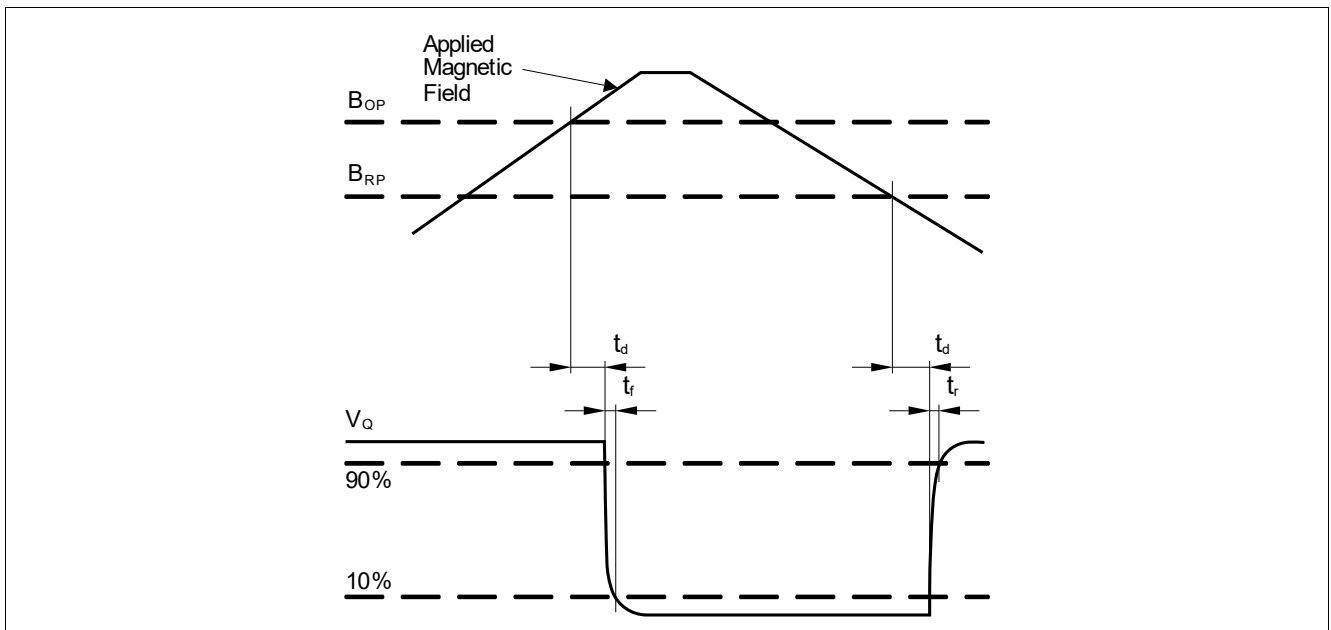


Figure 4 Timing diagram TLE4965-5M

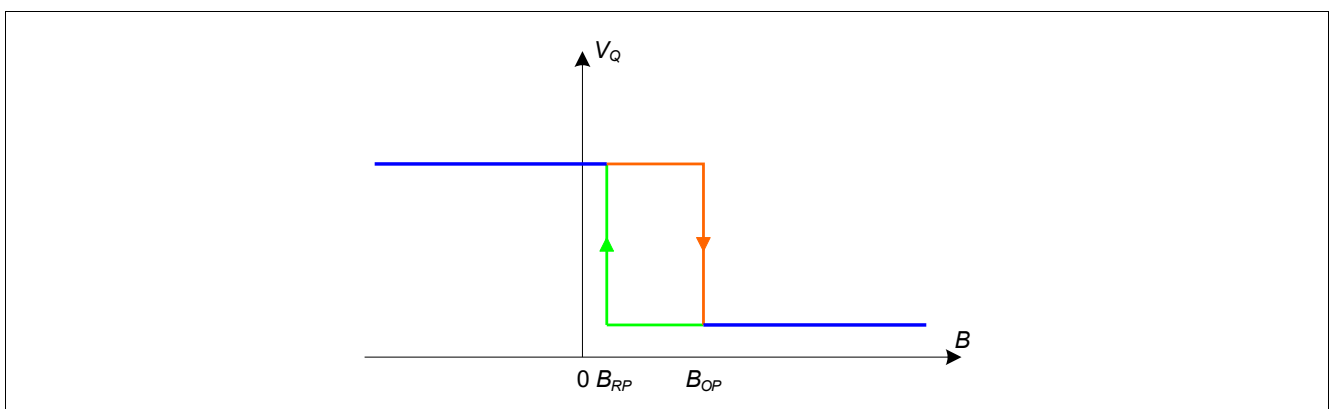


Figure 5 Output signal TLE4965-5M

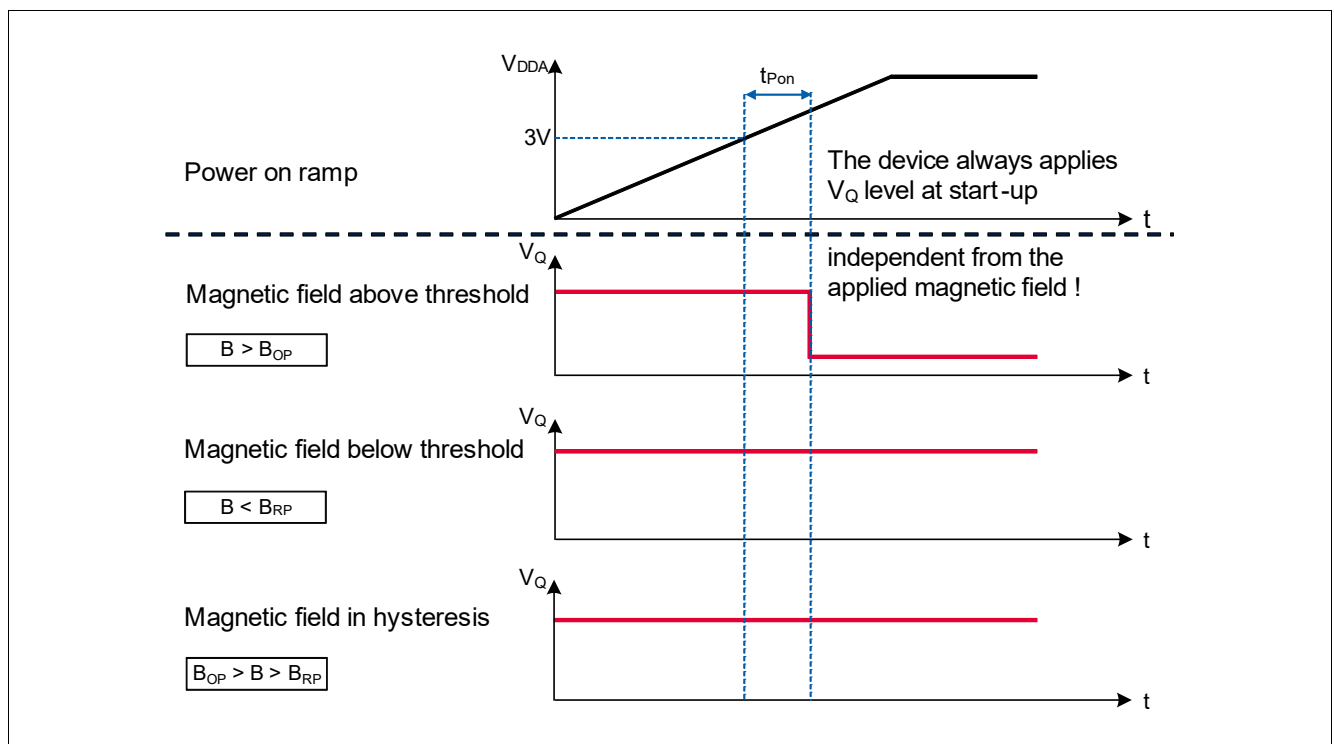
**Functional description**

**2.6 Default start-up behavior**

The magnetic thresholds exhibit a hysteresis  $B_{HYS} = B_{OP} - B_{RP}$ . In case of a power-on with a magnetic field  $B$  within hysteresis ( $B_{OP} > B > B_{RP}$ ) the output of the sensor is set to the pull up voltage level ( $V_Q$ ) per default. After the first crossing of  $B_{OP}$  or  $B_{RP}$  of the magnetic field the internal decision logic is set to the corresponding magnetic input value.

$V_{DDA}$  is the internal supply voltage which is following the external supply voltage  $V_{DD}$ .

This means for  $B > B_{OP}$  the output is switching, for  $B < B_{RP}$  and  $B_{OP} > B > B_{RP}$  the output stays at  $V_Q$ .

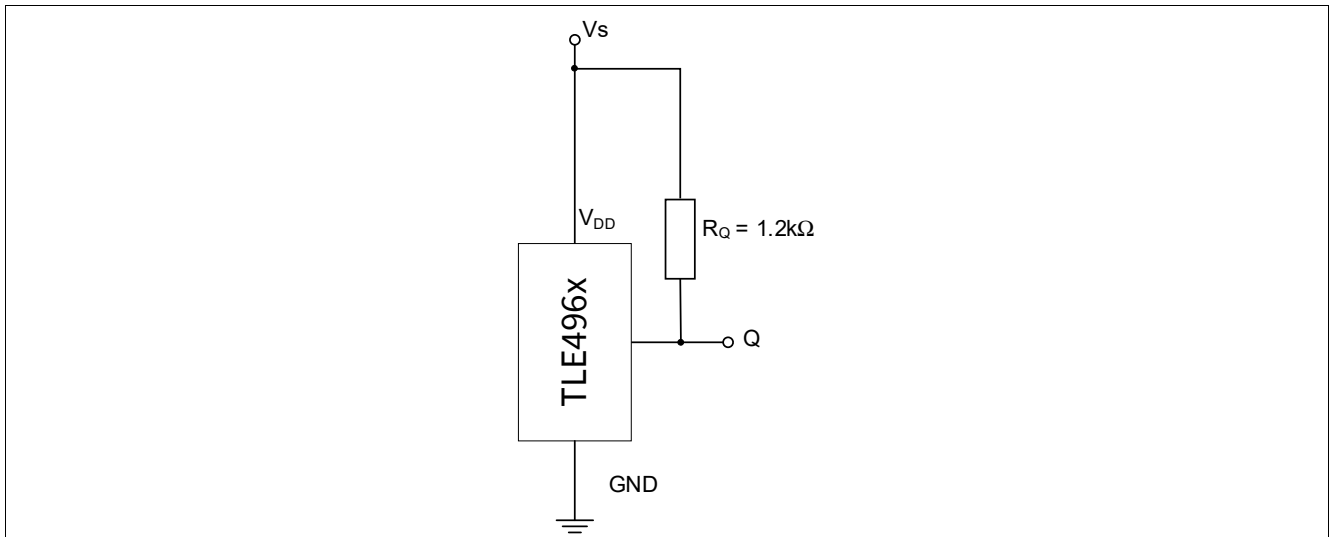


**Figure 6 Start-up behavior of the TLE4965-5M**

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**Specification****3 Specification****3.1 Application circuit**

The following **Figure 7** shows one option of an application circuit.



**Figure 7 Application circuit**

## Specification

### 3.2 Absolute maximum ratings

**Table 3 Absolute maximum rating parameters**

Parameter	Symbol	Values			Unit	Note or Test Condition
		Min.	Typ.	Max.		
Supply voltage <sup>1)</sup>	$V_{DD}$	-0.3	–	6	V	–
Output voltage	$V_Q$	-0.5	–	6	V	–
Junction temperature <sup>1)</sup>	$T_J$	-40	–	155 165 175 195	°C	for 2000h (not additive) for 1000h (not additive) for 168h (not additive) for 3 x 1h (additive)
Thermal resistance Junction ambient	$R_{thJA}$	–	–	300	K/W	for PG-SOT23-3-15 (2s2p)
Thermal resistance Junction lead	$R_{thJL}$	–	–	100	K/W	for PG-SOT23-3-15

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

**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 integrated circuit.**

Calculation of the dissipated power  $P_{DIS}$  and junction temperature  $T_J$  of the chip (SOT23 example):

e.g. for:  $V_{DD} = 5\text{ V}$ ,  $I_S = 2\text{ mA}$ ,  $V_{QSAT} = 0.5\text{ V}$ ,  $I_Q = 1\text{ mA}$

Power dissipation:  $P_{DIS} = 5\text{ V} \times 2\text{ mA} + 0.5\text{ V} \times 1\text{ mA} = 10\text{ mW} + 0.5\text{ mW} = 10.5\text{ mW}$

Temperature  $\Delta T = R_{thJA} \times P_{DIS} = 300\text{ K/W} \times 10.5\text{ mW} = 3.15\text{ K}$

For  $T_A = 150^\circ\text{C}$ :  $T_J = T_A + \Delta T = 150^\circ\text{C} + 3.15\text{ K} = 153.15^\circ\text{C}$

## Specification

**Table 4 ESD protection<sup>1)</sup> ( $T_A = 25^\circ\text{C}$ )**

Parameter	Symbol	Values			Unit	Note or Test Condition
		Min.	Typ.	Max.		
ESD voltage (HBM) <sup>2)</sup>	$V_{\text{ESD}}$	-4	-	4	kV	$R = 1.5 \text{ k}\Omega$ , $C = 100 \text{ pF}$
ESD voltage (CDM) <sup>3)</sup>	$V_{\text{ESD}}$	-1	-	1	kV	-

- 1) Characterization of ESD is carried out on a sample basis, not subject to production test.
- 2) Human Body Model (HBM) tests according to ANSI/ESDA/JEDEC JS-001.
- 3) Charge device model (CDM) tests according to JESD22-C101.

### 3.3 Operating range

The following operating conditions must not be exceeded in order to ensure correct operation of the TLE4965-5M.

All parameters specified in the following sections refer to these operating conditions unless otherwise mentioned.

The maximum tested magnetic field is 600 mT.

**Table 5 Operating conditions parameters**

Parameter	Symbol	Values			Unit	Note or Test Condition
		Min.	Typ.	Max.		
Supply voltage	$V_{\text{DD}}$	3.0	-	5.5	V	-
Output voltage	$V_{\text{Q}}$	-0.3	-	5.5	V	-
Junction temperature	$T_{\text{J}}$	-40	-	170	$^\circ\text{C}$	-
Output current	$I_{\text{Q}}$	0	-	5	mA	-
Magnetic signal input frequency <sup>1)</sup>	$f_{\text{SW}}$	0	-	10	kHz	-

- 1) For operation at the maximum switching frequency the magnetic input signal must be 1.4 times higher than for static fields. This is due to the -3 dB corner frequency of the internal low-pass filter in the signal path.

## Specification

### 3.4 Electrical and magnetic characteristics

Product characteristics involve the spread of values guaranteed within the specified voltage and ambient temperature range. Typical characteristics are the median of the production and correspond to  $V_{DD} = 5\text{ V}$  and  $T_A = 25^\circ\text{C}$ . The below listed specification is valid in combination with the application circuit shown in [Figure 7](#).

**Table 6** General electrical characteristics

Parameter	Symbol	Values			Unit	Note or Test Condition
		Min.	Typ.	Max.		
Supply current	$I_S$	1.1	1.5	2.5	mA	–
Reverse current <sup>1)</sup>	$I_{SR}$	–	–	2.5	mA	for $V_{DD} = -0.3\text{ V}$ and $170^\circ\text{C}$
Output saturation voltage	$V_{QSAT}$	–	0.2	0.5	V	$I_Q = 5\text{ mA}$
Output leakage current	$I_{QLEAK}$	–	–	10	$\mu\text{A}$	–
Output fall time <sup>1)</sup>	$t_f$	0.17	0.24	1	$\mu\text{s}$	1.2 k $\Omega$ / 50 pF, see <a href="#">Figure 4</a>
Output rise time <sup>1)</sup>	$t_r$	0.4	0.5	1	$\mu\text{s}$	1.2 k $\Omega$ / 50 pF, see <a href="#">Figure 4</a>
Output jitter <sup>1)2)</sup>	$t_{QJ}$	–	0.28	1	$\mu\text{s}$	for square wave signal with 1 kHz
Delay time <sup>1)3)</sup>	$t_d$	11.5	15	30	$\mu\text{s}$	see <a href="#">Figure 4</a>
Power-on time <sup>1)4)</sup>	$t_{PON}$	–	50	100	$\mu\text{s}$	$V_{DD} = 3\text{ V}$ , $B \leq B_{RP} - 0.5\text{ mT}$ or $B \geq B_{OP} + 0.5\text{ mT}$
Chopper frequency <sup>1)</sup>	$f_{OSC}$	–	350		kHz	–

- 1) Not subject to production test, verified by design/characterization.
- 2) Output jitter is the  $1\sigma$  value of the output switching distribution.
- 3) Systematic delay between magnetic threshold reached and output switching.
- 4) Time from applying  $V_{DD} = 3.0\text{ V}$  to the sensor until the output is valid.

## Specification

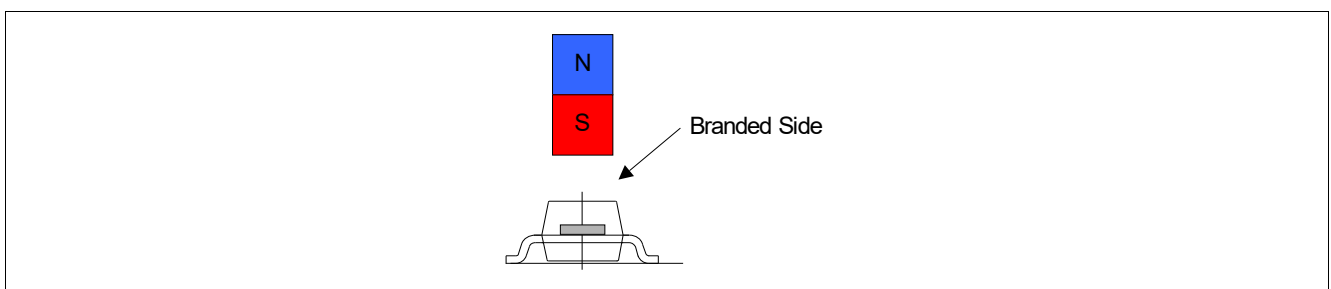
**Table 7 Magnetic characteristics**

Parameter	Symbol	T (°C)	Values			Unit	Note / Test Condition
			Min.	Typ.	Max.		
Operating point	$B_{OP}$	-40	5.4	8.5	11.6	mT	-
		25	4.6	7.5	10.4		
		170	3.0	5.3	7.7		
Release point	$B_{RP}$	-40	3.2	5.7	8.1	mT	-
		25	2.8	5.0	7.3		
		170	1.6	3.6	5.5		
Hysteresis	$B_{HYS}$	-40	1.5	2.8	4.1	mT	-
		25	1.3	2.5	3.7		
		170	0.8	1.8	2.7		
Effective noise value of the magnetic switching points <sup>1)2)</sup>	$B_{Neff}$	25	-	39	-	$\mu$ T	-
Temperature compensation of magnetic thresholds <sup>2)</sup>	$T_C$	-	-	-2000	-	ppm/K	-

- 1) The magnetic noise is normal distributed and can be assumed as nearly independent to frequency without sampling noise or digital noise effects. The typical value represents the rms-value and corresponds therefore to a  $1\sigma$  probability of normal distribution. Consequently a  $3\sigma$  value corresponds to 0.3% probability of appearance.
- 2) Not subject to production test, verified by design/characterization.

### Field direction definition

Positive magnetic fields are defined with the south pole of the magnet to the branded side of package.


**Figure 8 Definition of magnetic field direction PG-SOT23-3-15**

Package information

### 4 Package information

The TLE4965-5M is available in the small halogen-free SMD package PG-SOT23-3-15.

#### 4.1 Package outline PG-SOT23-3-15

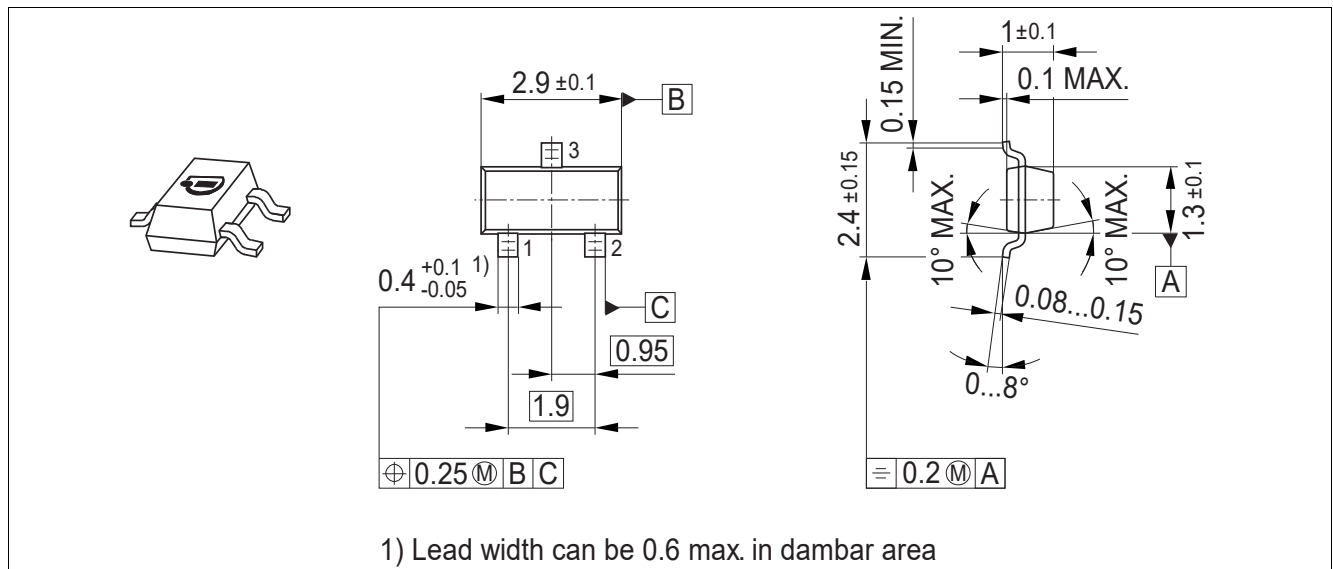


Figure 9 PG-SOT23-3-15 package outline (all dimensions in mm)

#### 4.2 Packing information PG-SOT23-3-15

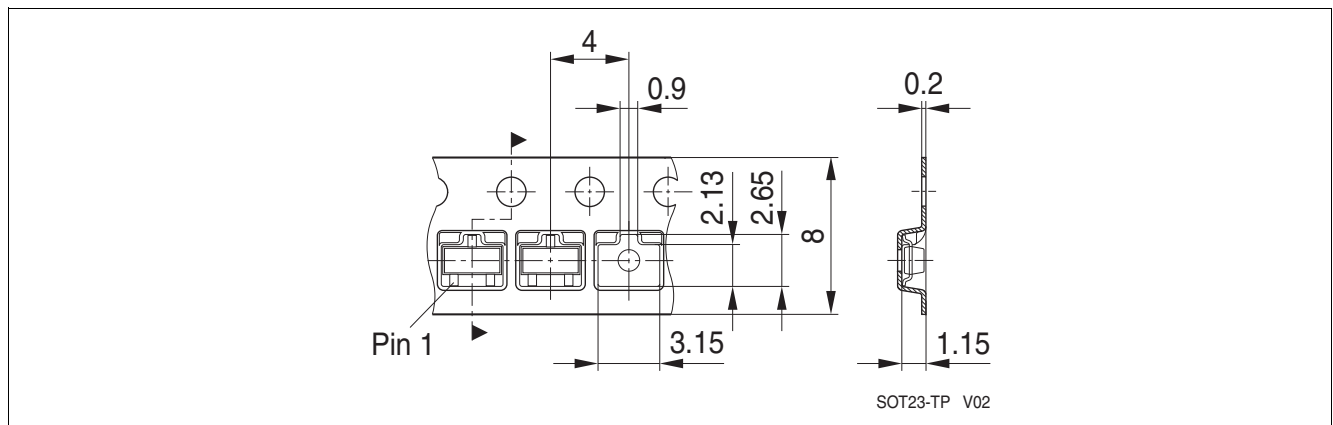


Figure 10 Packing of the PG-SOT23-3-15 in a tape



Package information

4.3 Footprint PG-SOT23-3-15

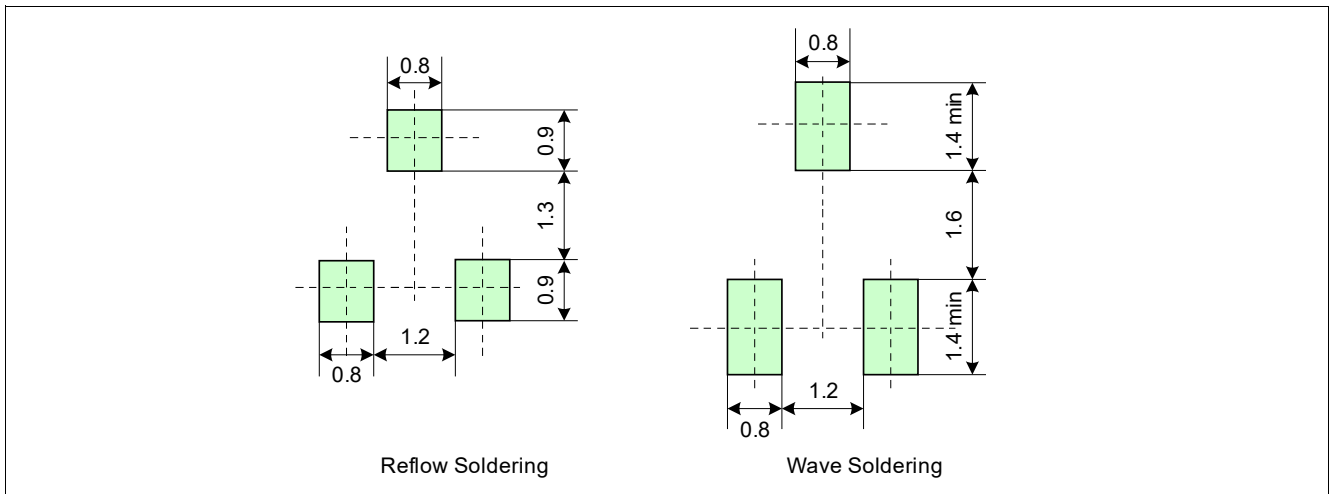


Figure 11 Footprint PG-SOT23-3-15

4.4 PG-SOT23-3-15 distance between chip and package

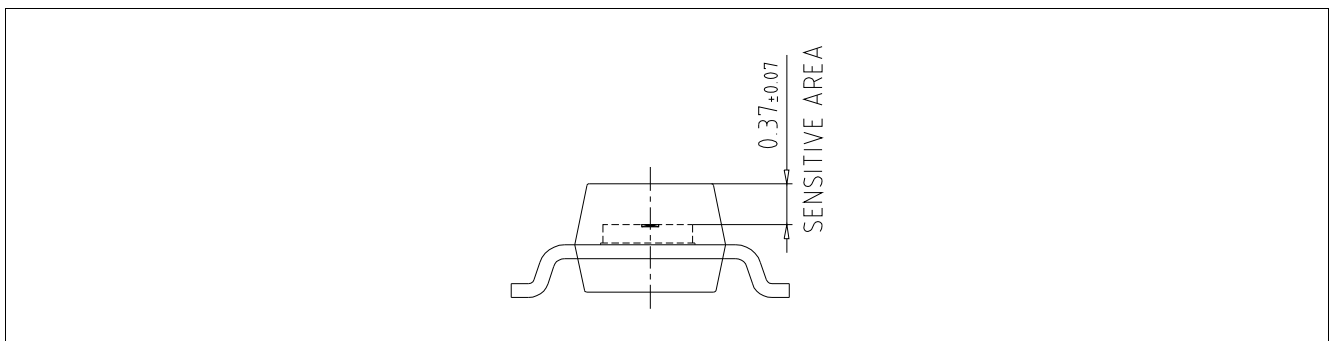


Figure 12 Distance between chip and package

4.5 Package marking

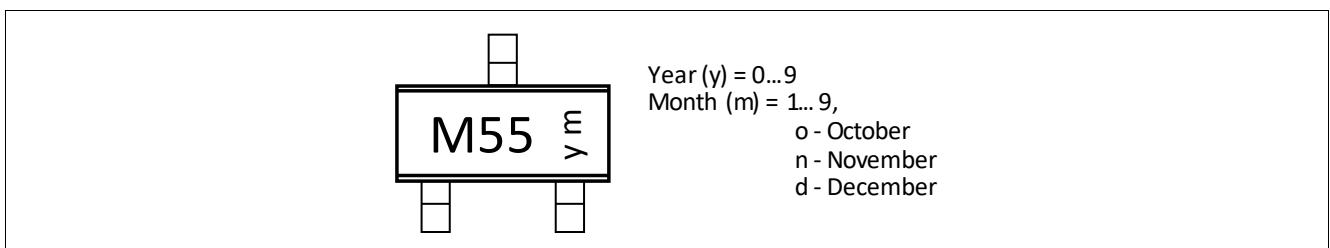


Figure 13 Marking of TLE4965-5M

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**Revision history****5 Revision history**

<b>Revision</b>	<b>Date</b>	<b>Changes</b>
Revision 1.2	2019-12-20	Updated text and figure in <b>Chapter 2.6</b> Updated standards in <b>Table 4</b> Added maximum tested magnetic field in <b>Chapter 3.3</b> Editorial changes
Revision 1.0	2016-01-12	Initial release

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