

# Bipolar Hall Switch

High Precision Automotive Hall Effect Switch

TLE4968-1K

SP000847992

## TLE4968-1K

## Data Sheet

Revision 1.2, 2019-12-20

Sense & Control

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## Product description

### 1 Product description



RoHS



#### 1.1 Overview

| Characteristic             | Supply Voltage | Supply Current | Sensitivity                                 | Interface         | Temperature    |
|----------------------------|----------------|----------------|---------------------------------------------|-------------------|----------------|
| Bipolar Hall Effect Switch | 3.0 V ~ 32 V   | 1.6 mA         | High<br>$B_{OP}$ : 1 mT<br>$B_{RP}$ : -1 mT | Open Drain Output | -40°C to 170°C |



**Figure 1** TLE4968-1K in the PG-SC59-3-5 package

#### 1.2 Features

- 3.0 V to 32 V operating supply voltage
- Operation from unregulated power supply
- Reverse polarity protection (-18 V)
- Overvoltage capability up to 42 V without external resistor
- Output overcurrent and overtemperature protection
- Active error compensation
- High stability of magnetic thresholds
- Low jitter (typ. 0.35  $\mu$ s)
- High ESD performance
- SOT23 like SMD package PG-SC59-3-5

**Table 1** Ordering information

| Product name | Product type        | Ordering code | Package     |
|--------------|---------------------|---------------|-------------|
| TLE4968-1K   | Bipolar Hall Switch | SP000847992   | PG-SC59-3-5 |

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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. Its superior supply voltage range from 3.0 V to 32 V with overvoltage capability (e.g. load-dump) up to 42 V without external resistor makes it ideally suited for automotive and industrial applications.

The TLE4968-1K has very low magnetic thresholds and a bipolar switching behavior. It is therefore especially suited for applications which require a high sensitivity device and an output switching close to zero magnetic field values. Possible applications are BLDC rotor position measurement or speed and position measurements in camshaft or transmission applications.

**1.4 Product validation**

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

## Functional description

## 2 Functional description

### 2.1 General

The TLE4968-1K is an integrated Hall effect switch designed specifically for highly accurate applications with superior supply voltage capability, operating temperature range and temperature stability of the magnetic thresholds.

### 2.2 Pin configuration (top view)

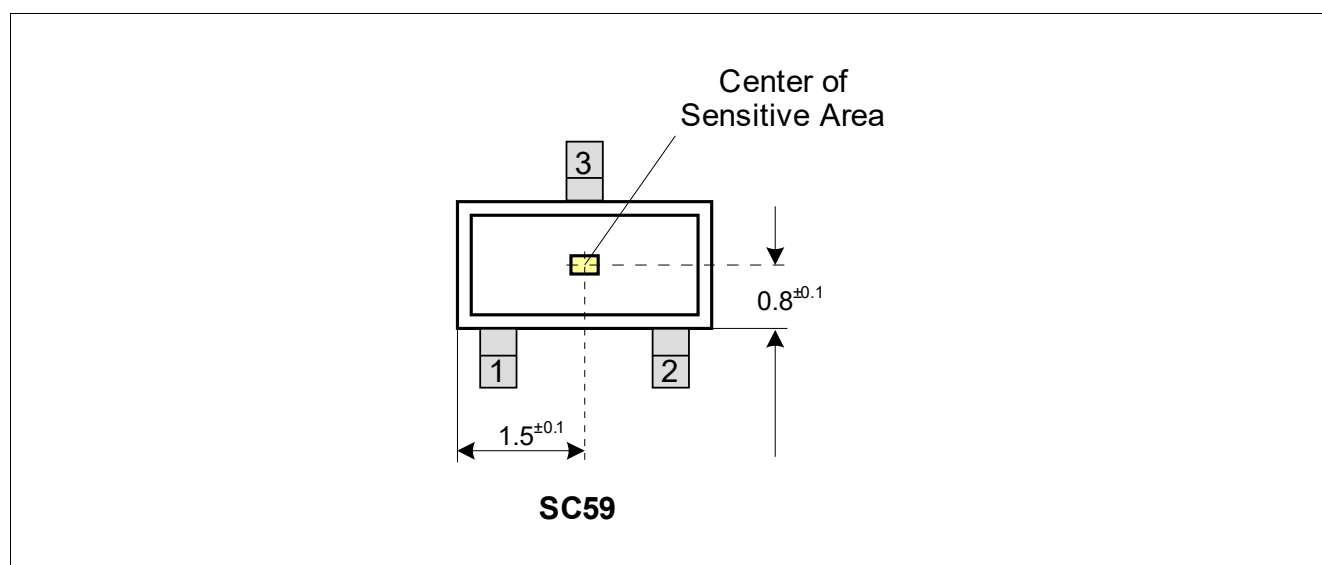


Figure 2 Pin configuration and center of sensitive area

### 2.3 Pin description

Table 2 Pin description PG-SC59-3-5

| 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 TLE4968-1K

## Functional description

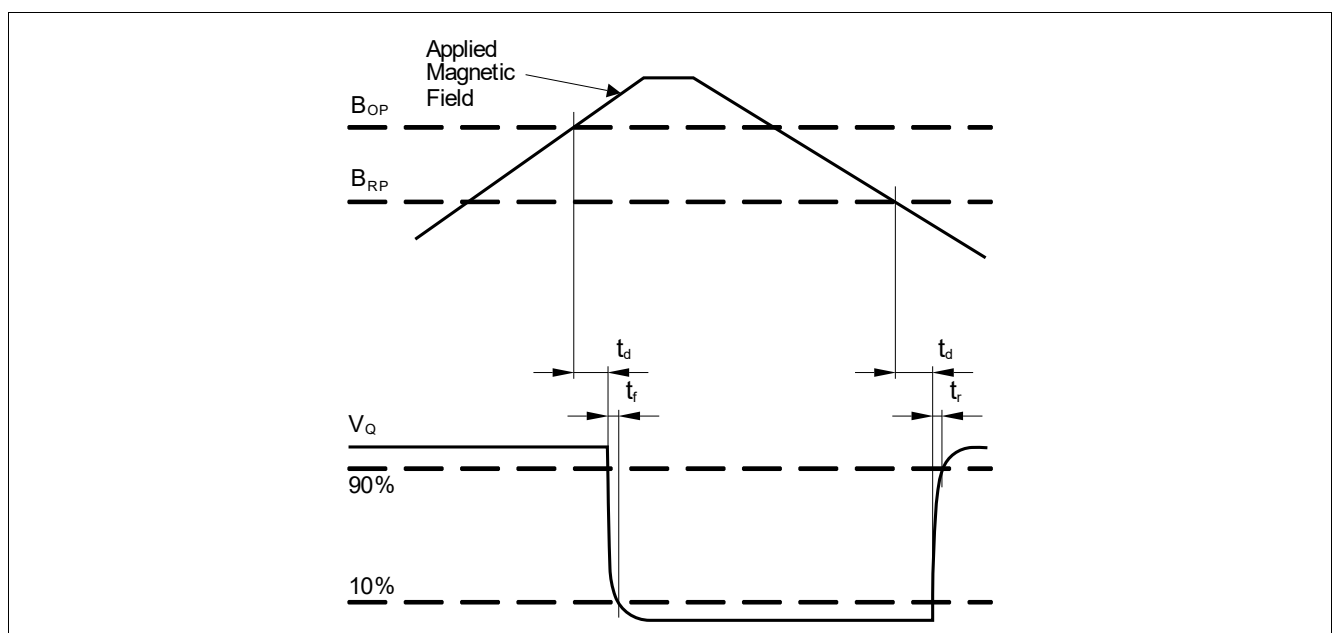
### 2.5 Functional block description

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.

The output transistor has an integrated overcurrent and overtemperature protection.



**Figure 4** Timing diagram TLE4968-1K



**Figure 5** Output signal TLE4968-1K

## 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 TLE4968-1K**

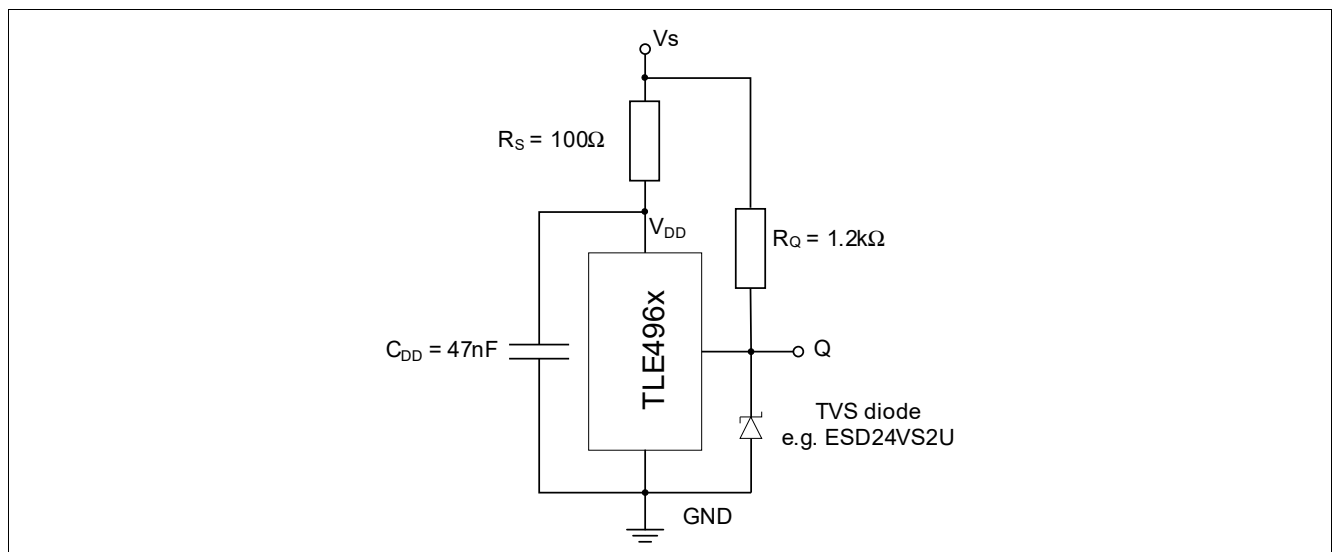
## Specification

### 3 Specification

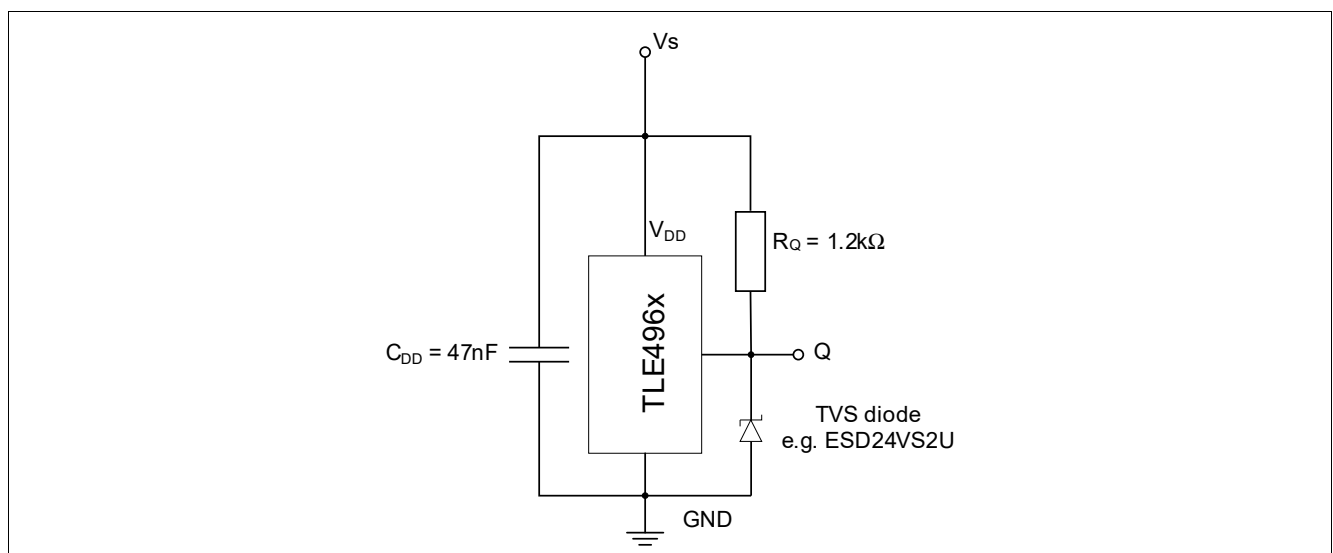
#### 3.1 Application circuit

The following **Figure 7** shows one option of an application circuit. As explained above the resistor  $R_S$  can be left out (see **Figure 8**). The resistor  $R_Q$  has to be in a dimension to match the applied  $V_S$  to keep  $I_Q$  limited to the operating range of maximum 25 mA.

e.g.:  $V_S = 12\text{ V}$ ;  $I_Q = 12\text{ V}/1200\ \Omega = 10\text{ mA}$



**Figure 7** Application circuit 1: with external resistor



**Figure 8** Application circuit 2: without external resistor

## 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>           | $V_{DD}$   | -18    | –    | 32<br>42                 | V    | –<br>10h, no external resistor required                                                                  |
| Output voltage                         | $V_Q$      | -0.5   | –    | 32                       | V    | –                                                                                                        |
| Reverse output current                 | $I_Q$      | -70    | –    | –                        | mA   | –                                                                                                        |
| Junction temperature <sup>1)</sup>     | $T_J$      | -40    | –    | 155<br>165<br>175<br>195 | °C   | for 2000h (not additive)<br>for 1000h (not additive)<br>for 168h (not additive)<br>for 3 x 1h (additive) |
| Storage temperature                    | $T_S$      | -40    | –    | 150                      | °C   | –                                                                                                        |
| Thermal resistance<br>Junction ambient | $R_{thJA}$ | –      | –    | 300                      | K/W  | for PG-SC59-3-5 (2s2p)                                                                                   |
| Thermal resistance<br>Junction lead    | $R_{thJL}$ | –      | –    | 100                      | K/W  | for PG-SC59-3-5                                                                                          |

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 (SC59 example):

e.g. for:  $V_{DD} = 12\text{ V}$ ,  $I_S = 2.5\text{ mA}$ ,  $V_{QSAT} = 0.5\text{ V}$ ,  $I_Q = 20\text{ mA}$

Power dissipation:  $P_{DIS} = 12\text{ V} \times 2.5\text{ mA} + 0.5\text{ V} \times 20\text{ mA} = 30\text{ mW} + 10\text{ mW} = 40\text{ mW}$

Temperature  $\Delta T = R_{thJA} \times P_{DIS} = 300\text{ K/W} \times 40\text{ mW} = 12\text{ K}$

For  $T_A = 150^\circ\text{C}$ :  $T_J = T_A + \Delta T = 150^\circ\text{C} + 12\text{ K} = 162^\circ\text{C}$

## 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>          | $V_{\text{ESD}}$ | -7     | –    | 7    | kV   | $R = 1.5 \text{ k}\Omega$ , $C = 100 \text{ pF}$          |
| ESD voltage (CDM) <sup>3)</sup>          | $V_{\text{ESD}}$ | -1     | –    | 1    | kV   | –                                                         |
| ESD voltage (system level) <sup>4)</sup> | $V_{\text{ESD}}$ | -15    | –    | 15   | kV   | with circuit shown in <b>Figure 7</b> and <b>Figure 8</b> |

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.

4) Gun test (2 k $\Omega$  / 330 pF or 330  $\Omega$  / 150 pF) according to ISO 10605-2008.

### 3.3 Operating range

The following operating conditions must not be exceeded in order to ensure correct operation of the TLE4968-1K.

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    | –    | 32 <sup>1)</sup> | V                | –                      |
| Output voltage                                | $V_{\text{Q}}$  | -0.3   | –    | 32               | V                | –                      |
| Junction temperature                          | $T_{\text{J}}$  | -40    | –    | 170              | $^\circ\text{C}$ | –                      |
| Output current                                | $I_{\text{Q}}$  | 0      | –    | 25               | mA               | –                      |
| Magnetic signal input frequency <sup>2)</sup> | $f_{\text{SW}}$ | 0      | –    | 10               | kHz              | –                      |

1) Latch-up test with factor 1.5 is not covered. Please see max ratings also.

2) 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  $V_{DD} = 12\text{ V}$  and  $T_A = 25^\circ\text{C}$ . The below listed specification is valid in combination with the application circuit shown in [Figure 7](#) and [Figure 8](#).

**Table 6 General electrical characteristics**

| Parameter                       | Symbol       | Values |      |      | Unit          | Note or Test Condition                                                                     |
|---------------------------------|--------------|--------|------|------|---------------|--------------------------------------------------------------------------------------------|
|                                 |              | Min.   | Typ. | Max. |               |                                                                                            |
| Supply current                  | $I_S$        | 1.1    | 1.6  | 2.5  | mA            | –                                                                                          |
| Reverse current                 | $I_{SR}$     | –      | 0.05 | 1    | mA            | for $V_{DD} = -18\text{ V}$                                                                |
| Output saturation voltage       | $V_{QSAT}$   | –      | 0.2  | 0.5  | V             | $I_Q = 20\text{ mA}$                                                                       |
|                                 |              | –      | 0.24 | 0.6  | V             | $I_Q = 25\text{ mA}$                                                                       |
| Output leakage current          | $I_{QLEAK}$  | –      | –    | 10   | $\mu\text{A}$ | –                                                                                          |
| Output current limitation       | $I_{QLIMIT}$ | 30     | 56   | 70   | mA            | internally limited and thermal shutdown                                                    |
| Output fall time <sup>1)</sup>  | $t_f$        | 0.17   | 0.4  | 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>   | $t_{QJ}$     | –      | 0.35 | 1    | $\mu\text{s}$ | for square wave signal with 1 kHz                                                          |
| Delay time <sup>1)3)</sup>      | $t_d$        | 12     | 15   | 30   | $\mu\text{s}$ | see <a href="#">Figure 4</a>                                                               |
| Power-on time <sup>1)4)</sup>   | $t_{PON}$    | –      | 80   | 150  | $\mu\text{s}$ | $V_{DD} = 3\text{ V}$ , $B \leq B_{RP} - 0.5\text{ mT}$ 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

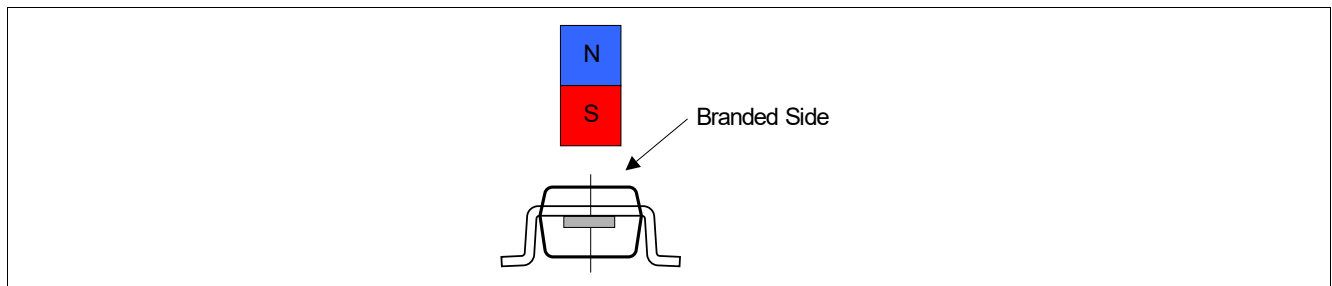
**Table 7 Magnetic characteristics**

| Parameter                                                            | Symbol     | T (°C)    | Values |      |      | Unit  | Note / Test Condition |
|----------------------------------------------------------------------|------------|-----------|--------|------|------|-------|-----------------------|
|                                                                      |            |           | Min.   | Typ. | Max. |       |                       |
| Operating point                                                      | $B_{OP}$   | -40...170 | -0.2   | 1.0  | 2.25 | mT    | –                     |
| Release point                                                        | $B_{RP}$   | -40...170 | -2.25  | -1.0 | 0.2  | mT    | –                     |
| Hysteresis                                                           | $B_{HYS}$  | -40...170 | 1.1    | 2.0  | 2.9  | mT    | –                     |
| Effective noise value of the magnetic switching points <sup>1)</sup> | $B_{Neff}$ | 25        | –      | 62   | –    | μT    | –                     |
| Temperature compensation of magnetic thresholds <sup>2)</sup>        | $T_C$      | –         | –      | 0    | –    | 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 99.7% 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 9 Definition of magnetic field direction PG-SC59-3-5**

## Specification

### 3.5 Electro magnetic compatibility

Characterization of electro magnetic compatibility is carried out on a sample basis from one qualification lot. Not all specification parameters have been monitored during EMC exposure.



**Figure 10** EMC test circuit

Ref: ISO 7637-2 (Version 2004), test circuit [Figure 10](#) (with external resistor,  $R_s = 100\ \Omega$ )

**Table 8** Magnetic compatibility

| Parameter                  | Symbol    | Level / Type                                  | Status |
|----------------------------|-----------|-----------------------------------------------|--------|
| Testpulse 1                | $V_{EMC}$ | -100 V                                        | C      |
| Testpulse 2a <sup>1)</sup> |           | 60 V/110 V                                    | A/C    |
| Testpulse 2b               |           | 10 V                                          | C      |
| Testpulse 3a               |           | -150 V                                        | A      |
| Testpulse 3b               |           | 100 V                                         | A      |
| Testpulse 4 <sup>2)</sup>  |           | -7 V / -5.5 V                                 | A      |
| Testpulse 5b <sup>3)</sup> |           | $U_s = 86.5\text{ V} / U_s^* = 28.5\text{ V}$ | A      |

1) ISO 7637-2 (2004) describes internal resistance = 2  $\Omega$  (former 10  $\Omega$ ).

2) According to 7637-2 for test pulse 4 the test voltage shall be 12 V  $\pm$  0.2 V.

3) A central load dump protection of 42 V is used.  $U_s^* = 42\text{ V} - 13.5\text{ V}$ .

## Specification

Ref: ISO 7637-2 (Version 2004), test circuit [Figure 10](#) (without external resistor,  $R_s = 0 \Omega$ )

**Table 9 Electro magnetic compatibility**

| Parameter                  | Symbol    | Level / Type                                    | Status |
|----------------------------|-----------|-------------------------------------------------|--------|
| Testpulse 1                | $V_{EMC}$ | -50 V                                           | C      |
| Testpulse 2a <sup>1)</sup> |           | 50 V                                            | A      |
| Testpulse 2b               |           | 10 V                                            | C      |
| Testpulse 3a               |           | -150 V                                          | A      |
| Testpulse 3b               |           | 100 V                                           | A      |
| Testpulse 4 <sup>2)</sup>  |           | -7 V / 5.5 V                                    | A      |
| Testpulse 5b <sup>3)</sup> |           | $U_s = 86.5 \text{ V} / U_s^* = 28.5 \text{ V}$ | A      |

1) ISO 7637-2 (2004) describes internal resistance = 2  $\Omega$  (former 10  $\Omega$ ).

2) According to 7637-2 for test pulse 4 the test voltage shall be 12 V  $\pm$  0.2 V.

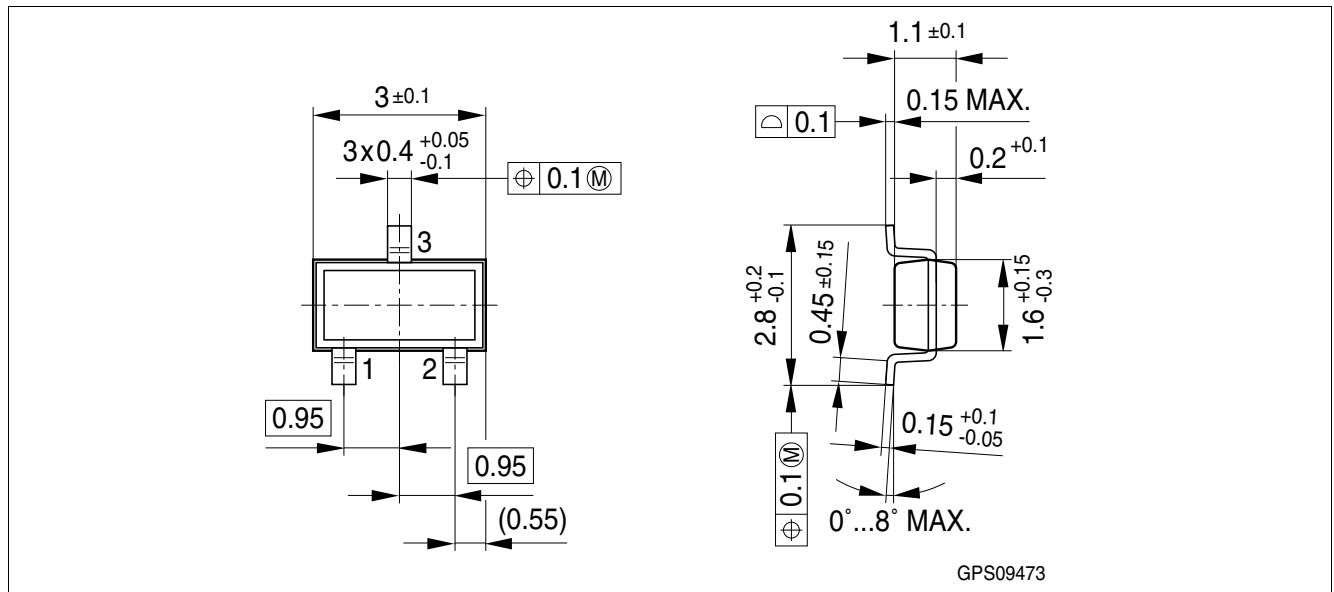
3) A central load dump protection of 42 V is used.  $U_s^* = 42 \text{ V} - 13.5 \text{ V}$ .

## Package information

### 4 Package information

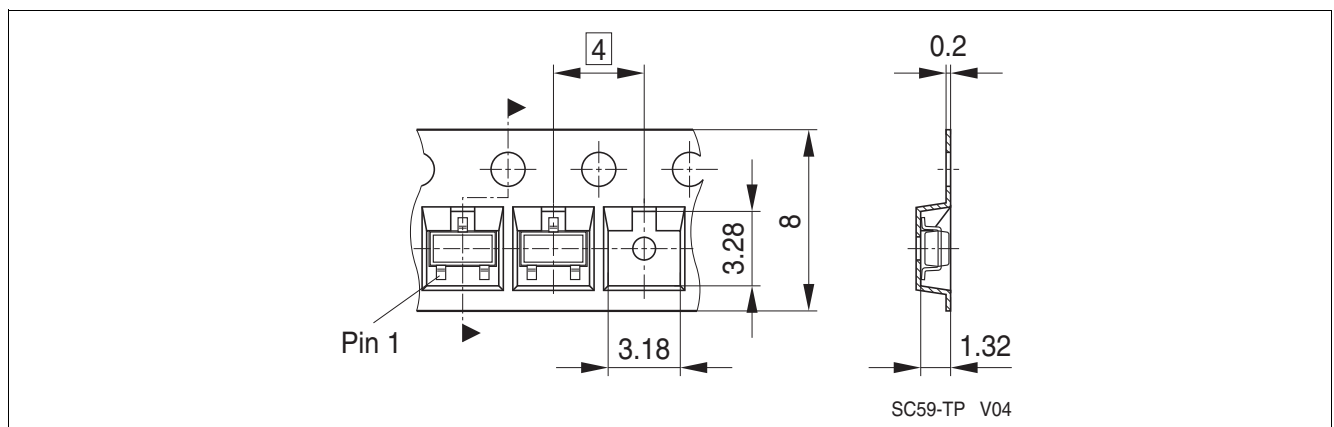
The TLE4968-1K is available in the halogen-free SMD package PG-SC59-3-5 with a SOT23 like pinout and footprint.

#### 4.1 Package outline PG-SC59-3-5



**Figure 11** PG-SC59-3-5 package outline (all dimensions in mm)

#### 4.2 Packing information PG-SC59-3-5



**Figure 12** Packing of the PG-SC59-3-5 in a tape

## Package information

### 4.3 Footprint PG-SC59-3-5



Figure 13 Footprint PG-SC59-3-5

### 4.4 PG-SC59-3-5 distance between chip and package

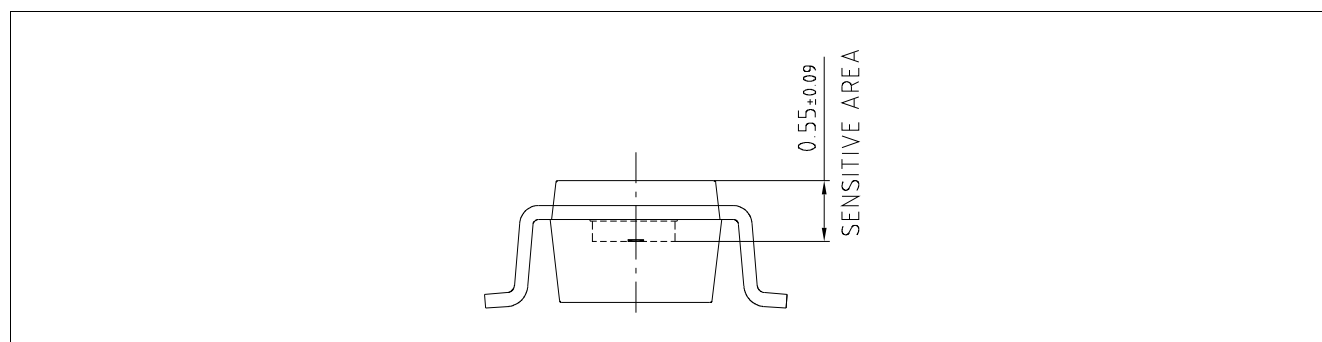


Figure 14 Distance between chip and package

### 4.5 Package marking

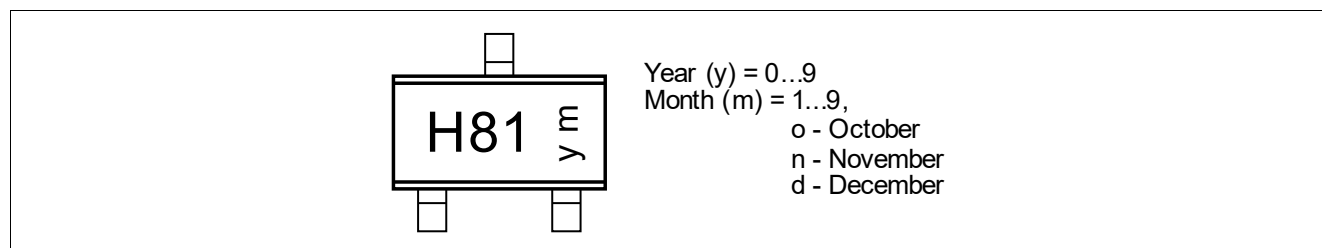


Figure 15 Marking of TLE4968-1K

## Graphs of the magnetic parameters

### 5 Graphs of the magnetic parameters

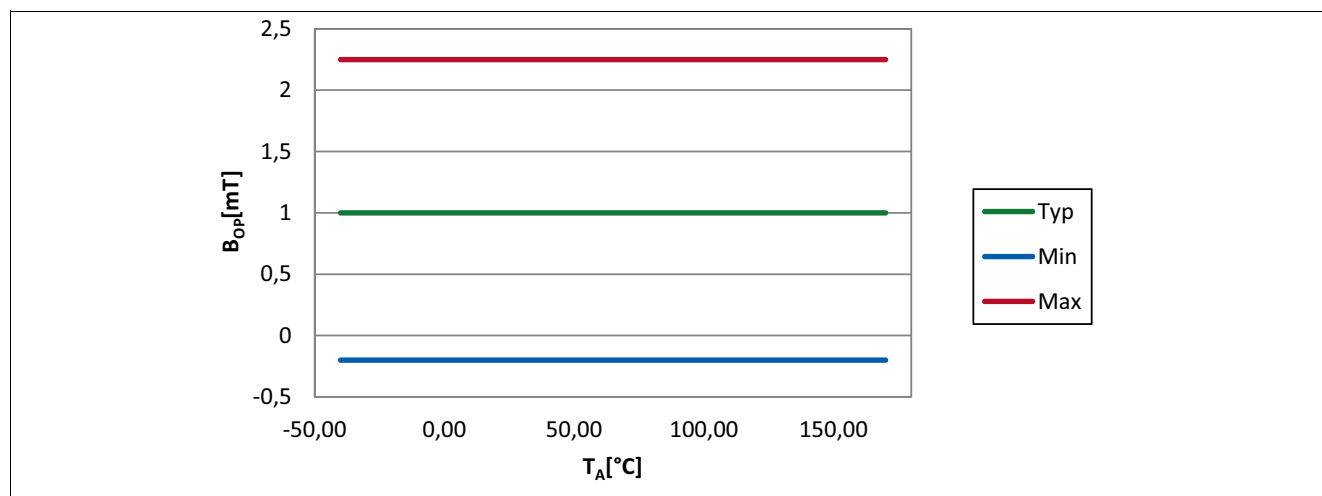


Figure 16 Operating point ( $B_{OP}$ ) of the TLE4968-1K over temperature

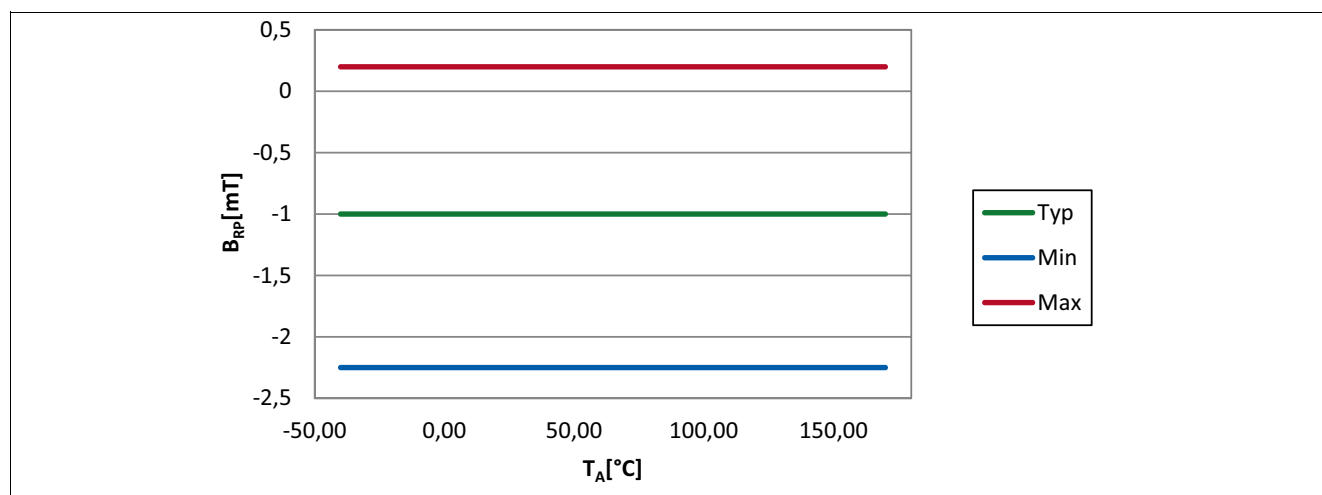


Figure 17 Release point ( $B_{RP}$ ) of the TLE4968-1K over temperature

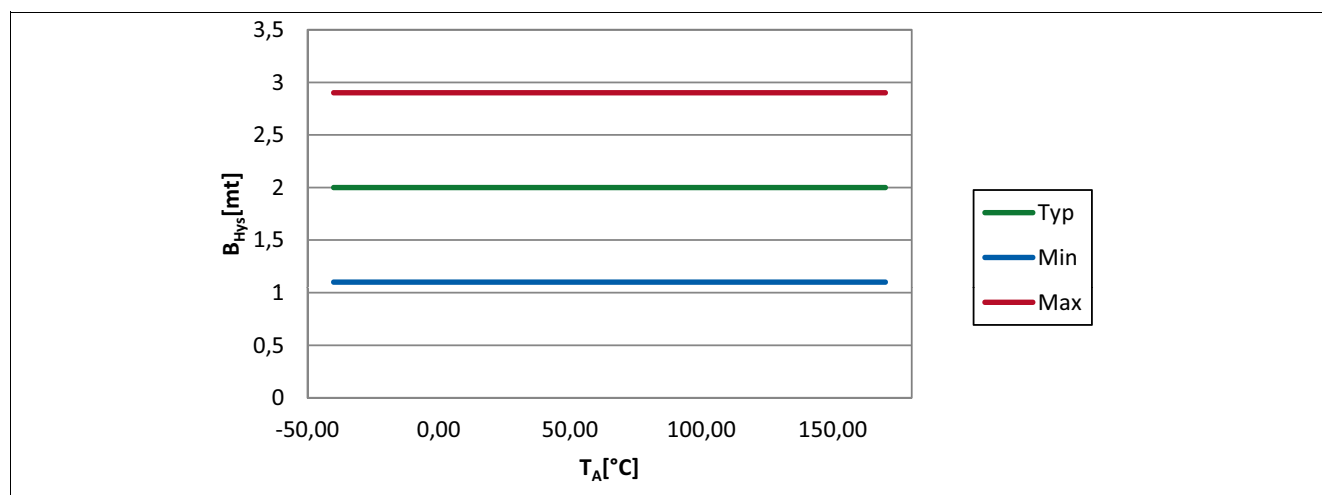


Figure 18 Hysteresis ( $B_{Hys}$ ) of the TLE4968-1K over temperature

Graphs of the electrical parameters

6      Graphs of the electrical parameters

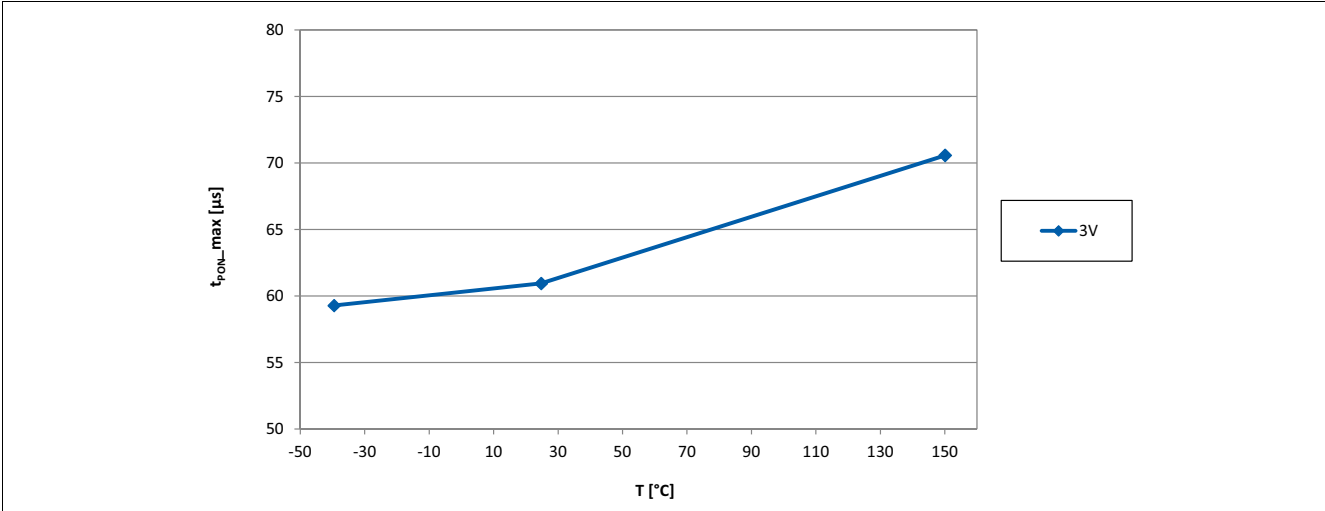


Figure 19    Power on time  $t_{PON}$  of the TLE4968-1K over temperature

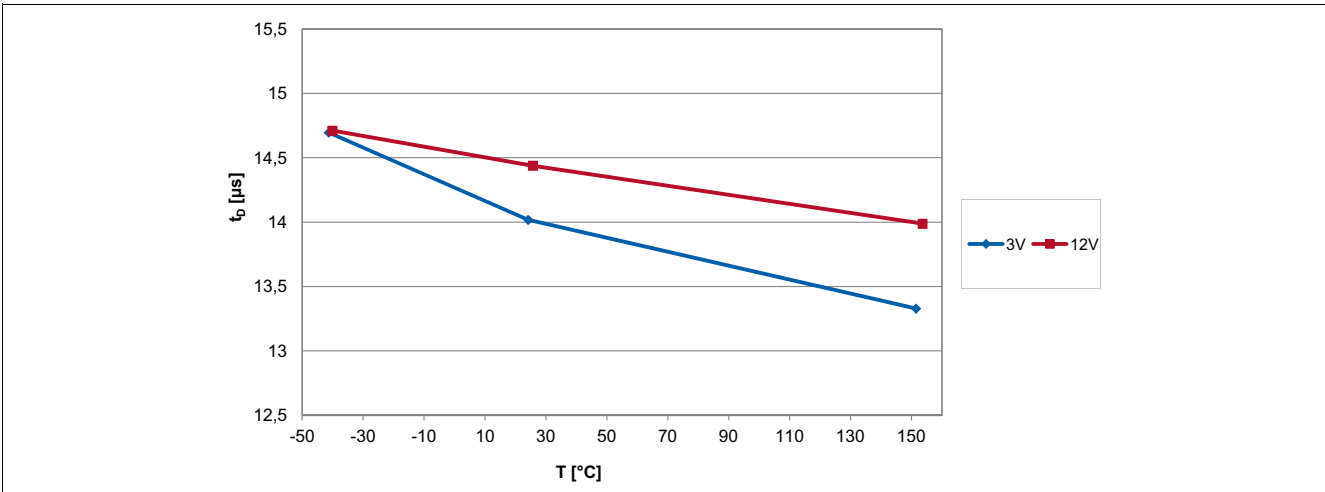


Figure 20    Signal delay time of the TLE4968-1K over temperature

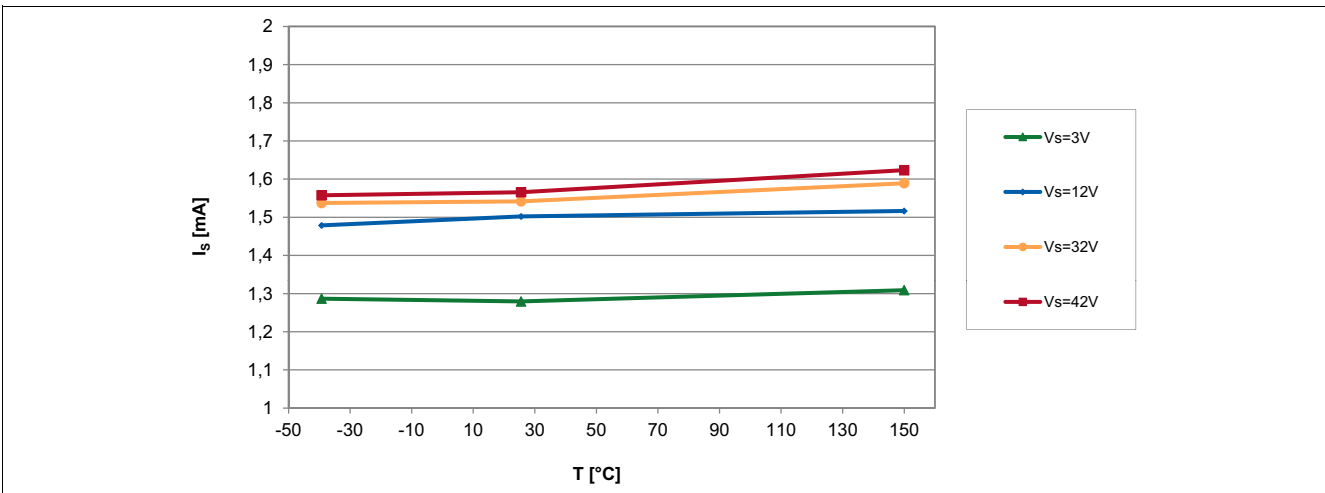


Figure 21    Supply current of the TLE4968-1K over temperature

Graphs of the electrical parameters



Figure 22 Supply current of the TLE4968-1K over supply voltage



Figure 23 Output current limit of the TLE4968-1K over temperature



Figure 24 Output current limit of the TLE4968-1K over applied pull-up voltage

Graphs of the electrical parameters



Figure 25 Output fall time of the TLE4968-1K over temperature



Figure 26 Output fall time of the TLE4968-1K over applied pull-up voltage



Figure 27 Output rise time of the TLE4968-1K over temperature

Graphs of the electrical parameters



Figure 28 Output rise time of the TLE4968-1K over applied pull-up voltage

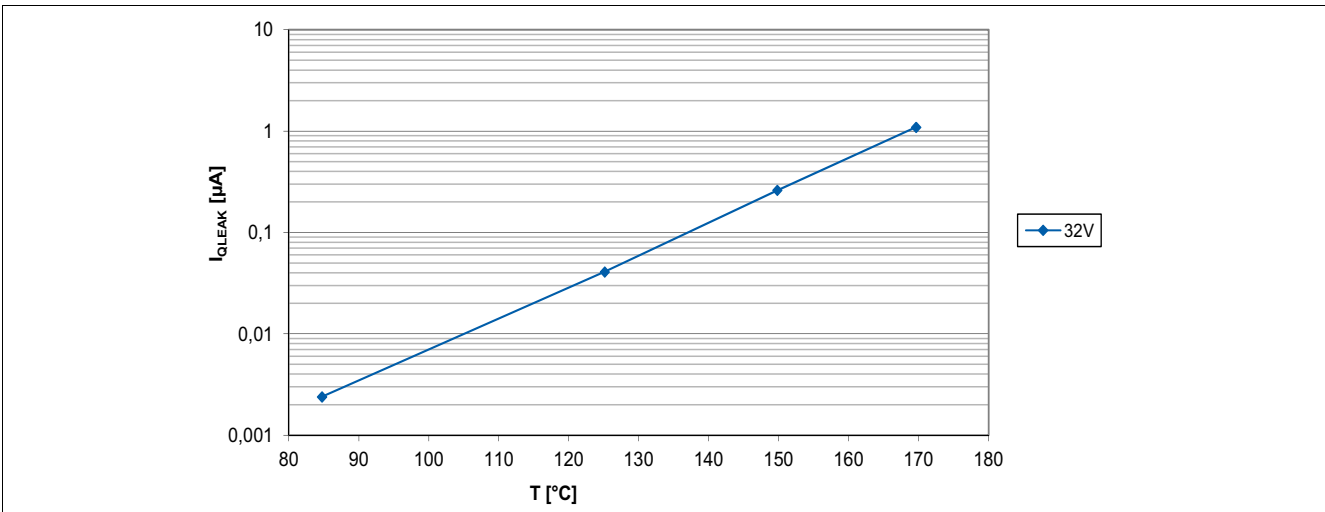


Figure 29 Output leakage current of the TLE4968-1K over temperature

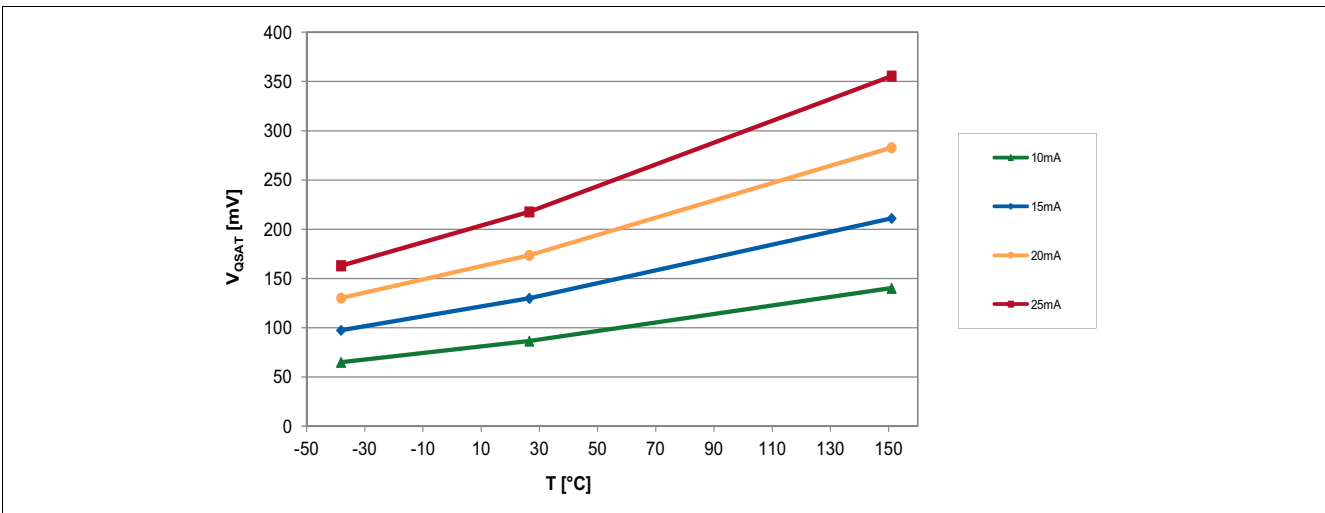


Figure 30 Saturation voltage of the TLE4968-1K over temperature

Graphs of the electrical parameters



Figure 31 Saturation voltage of the TLE4968-1K over output current

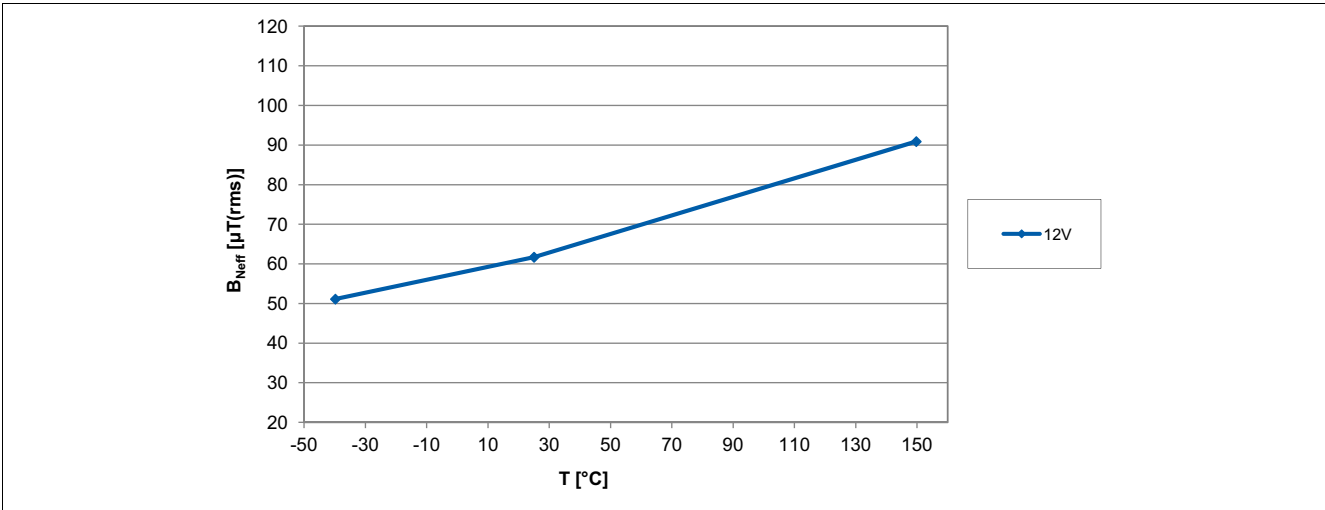


Figure 32 Effective noise of the TLE4968-1K thresholds over temperature

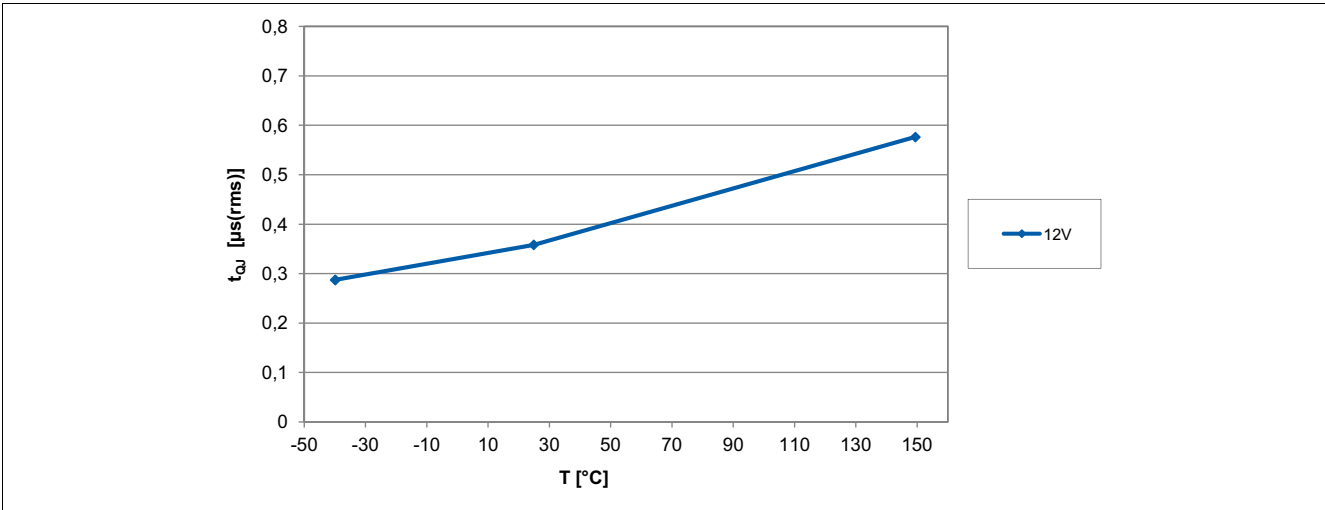


Figure 33 Output signal jitter of the TLE4968-1K over temperature

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**Revision history****7 Revision history**

| Revision     | Date       | Changes                                                                                                                                                                                            |
|--------------|------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Revision 1.2 | 2019-12-20 | Updated text and figure in <b>Chapter 2.6</b><br>Updated standards in <b>Table 4</b><br>Added maximum tested magnetic field in <b>Chapter 3.3</b><br>Updated <b>Figure 14</b><br>Editorial changes |
| Revision 1.0 | 2012-07-10 | Initial release                                                                                                                                                                                    |

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