

# TLE4976-1K / TLE4976L

High Precision Hall Effect Switch with Current Interface

Data Sheet

Rev. 2.0

Sense & Control



Never stop thinking

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**Revision History: 2009-02-12, Rev. 2.0**

Previous Version: V1.1

| Page | Subjects (major changes since last revision) |
|------|----------------------------------------------|
|      | H" version substituted by "K" version        |
| 6, 7 | timing and output switching diagram inserted |
|      |                                              |
|      |                                              |
|      |                                              |
|      |                                              |
|      |                                              |
|      |                                              |

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## 1 Product Description

### 1.1 Overview

The TLE4976-1K and TLE4976L are high precision unipolar Hall switches with a two wire, 6mA/14mA current interface in a SMD or leaded package. A chopped measurement principle provides high stability switching thresholds for operating temperatures between -40°C and 150°C.

### 1.2 Features

- 3.0V to 24V supply voltage operation
- High sensitivity and high stability of the magnetic switching points
- High resistance to mechanical stress by Active Error Compensation
- Reverse battery protection (-18V)
- Superior temperature stability
- Peak temperatures up to 195°C without damage
- Low jitter (typ. 1µs)
- High ESD performance (± 8kV HBM)
- Digital output signal with current modulation 6mA / 14mA
- Unipolar version
- SMD package SC59 (SOT23 compatible): TLE4976-1K
- Leaded package PG-SSO-3-2: TLE4976L



### 1.3 Target Applications

The sensor targets all applications where a high precision unipolar magnetic switch is required (e.g. position sensing). Due to the current interface the number of wires required in the application is minimized thus saving costs and increasing reliability. This is specially helpful in all applications where the microcontroller is not on the same PCB as the Hall switch but in some distance.

| Product Name | Product Type       | Ordering Code | Package    |
|--------------|--------------------|---------------|------------|
| TLE4976-1K   | Hall Effect Switch | SP000475038   | SC59       |
| TLE4976L     | Hall Effect Switch | SP000012951   | PG-SSO-3-2 |

## 2 Functional Description

### 2.1 General

The TLE4976-1K and the TLE4976L are integrated circuit Hall-effect sensors designed specifically for highly accurate applications. Precise magnetic switching thresholds and high temperature stability are achieved by active error compensation circuits and chopper techniques on the chip. The IC has a current interface with a 6mA / 14mA output.

### 2.2 Pin Configuration (top view)

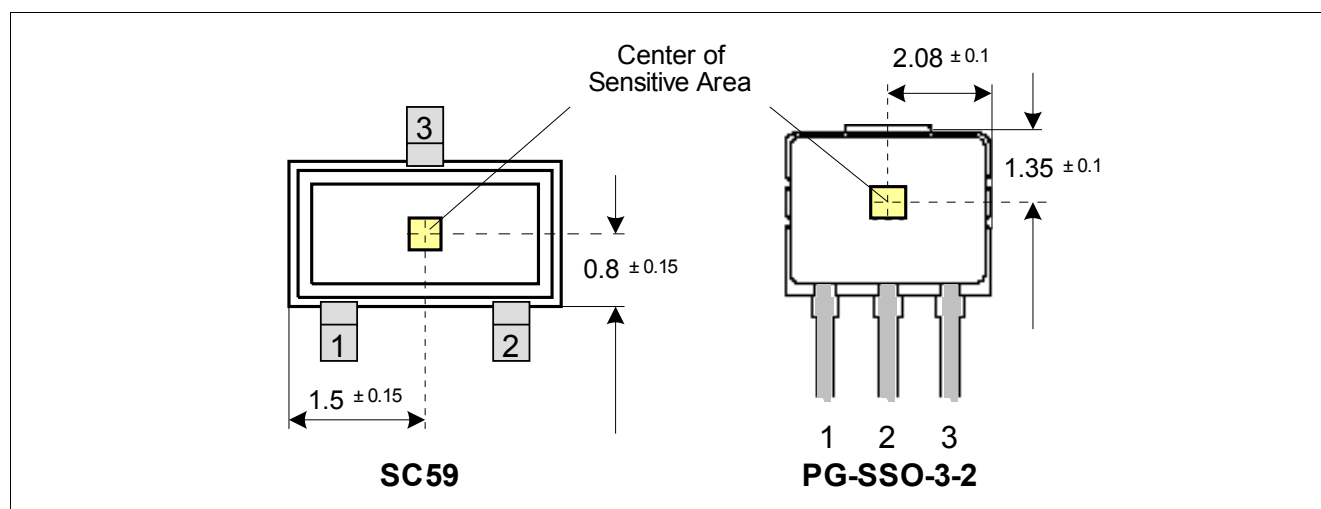


Figure 1 Pin Configuration and Center of Sensitive Area

### 2.3 Pin Description

Table 1 Pin Description for TLE4976-1K (SC59)

| Pin No. | Symbol | Function               | Comment |
|---------|--------|------------------------|---------|
| 1       | $V_S$  | Supply voltage         |         |
| 2       | N.C.   | No internal connection |         |
| 3       | GND    | Ground                 |         |

Table 2 Pin Description for TLE4976L (PG-SSO-3-2)

| Pin No. | Symbol | Function               | Comment |
|---------|--------|------------------------|---------|
| 1       | $V_S$  | Supply voltage         |         |
| 2       | GND    | Ground                 |         |
| 3       | N.C.   | No internal connection |         |

## 2.4 Block Diagram

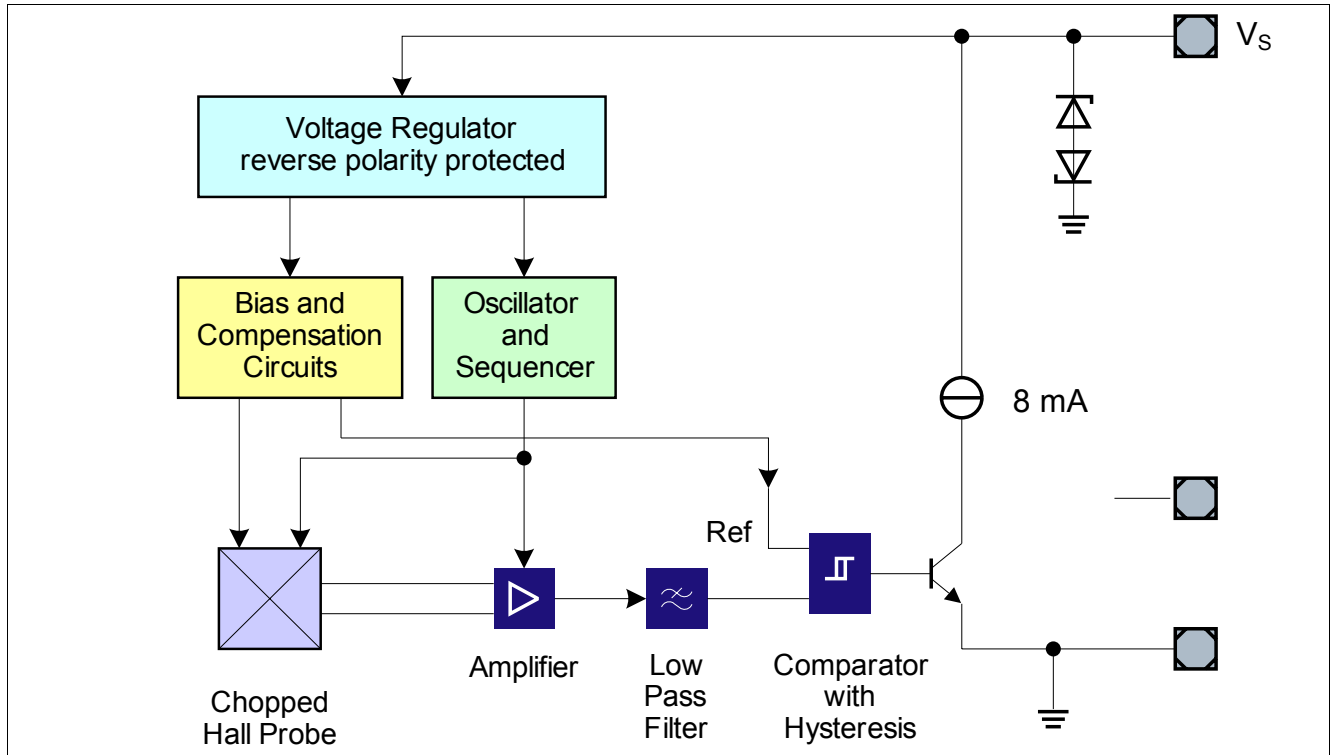


Figure 2 Functional Block Diagram

## 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 technology variations.

The Active Error Compensation rejects offsets in signal stages and the influence of mechanical stress to the Hall probe caused by molding and soldering processes and other thermal stresses in the package.

This chopper technique together with the threshold generator and the comparator ensure high accurate magnetic switching points.

The current consumption depends on the switching status.



## 2.6 Timing Diagram and Output Switching

The output switching is different for the TLE4976-1K and TLE4976L. It is explained in the following section.

### TLE4976-1K:

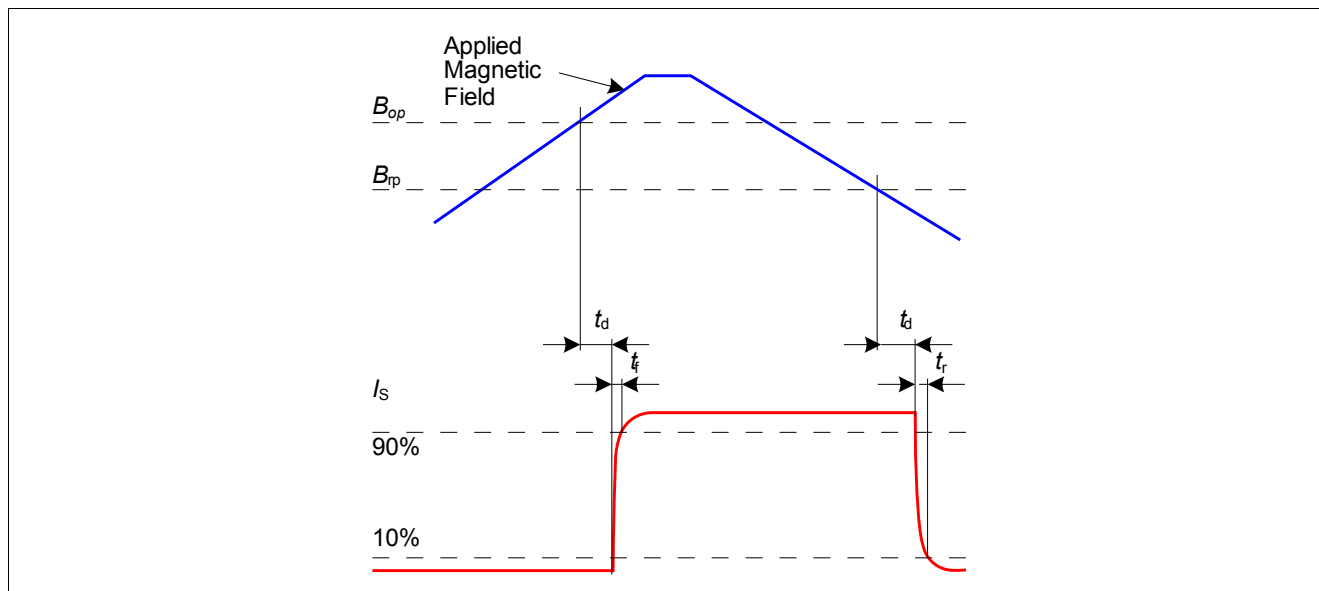


Figure 3 Timing Diagram of TLE4976-1K

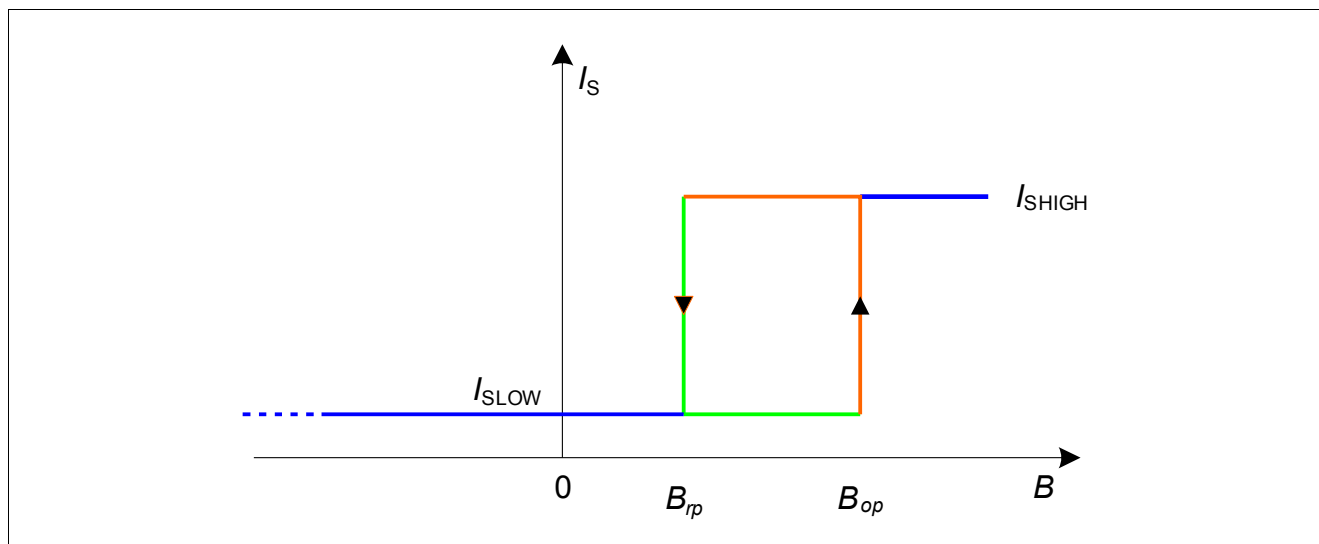


Figure 4 Output Switching of TLE4976-1K



TLE4976L:

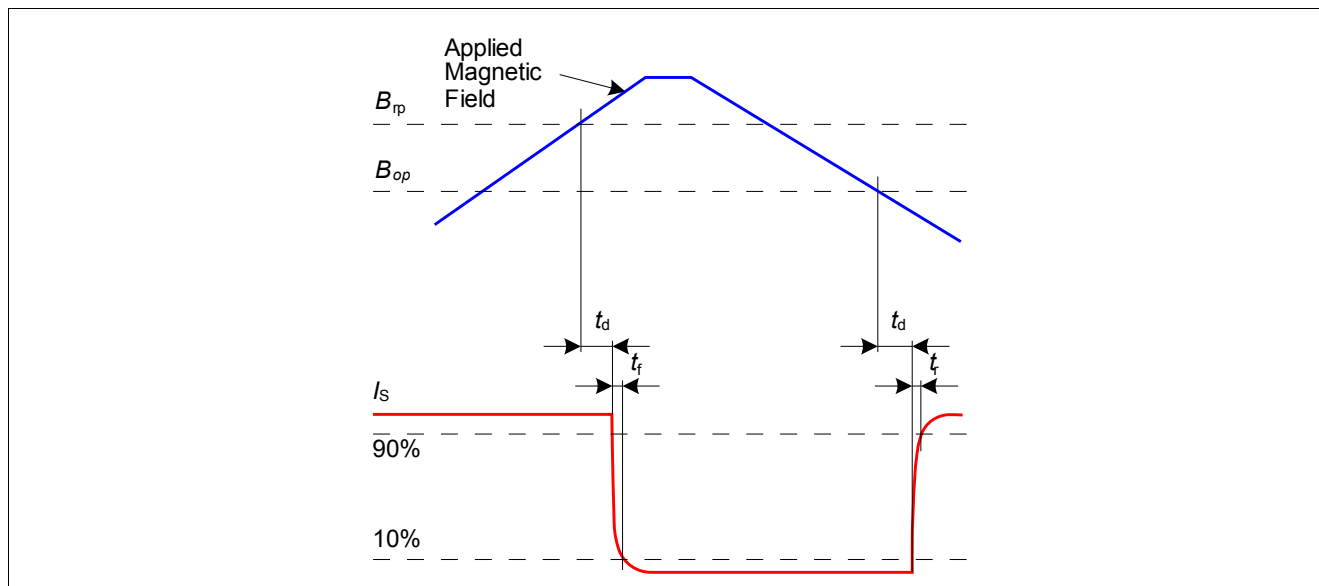


Figure 5 Timing Diagram of TLE4976L

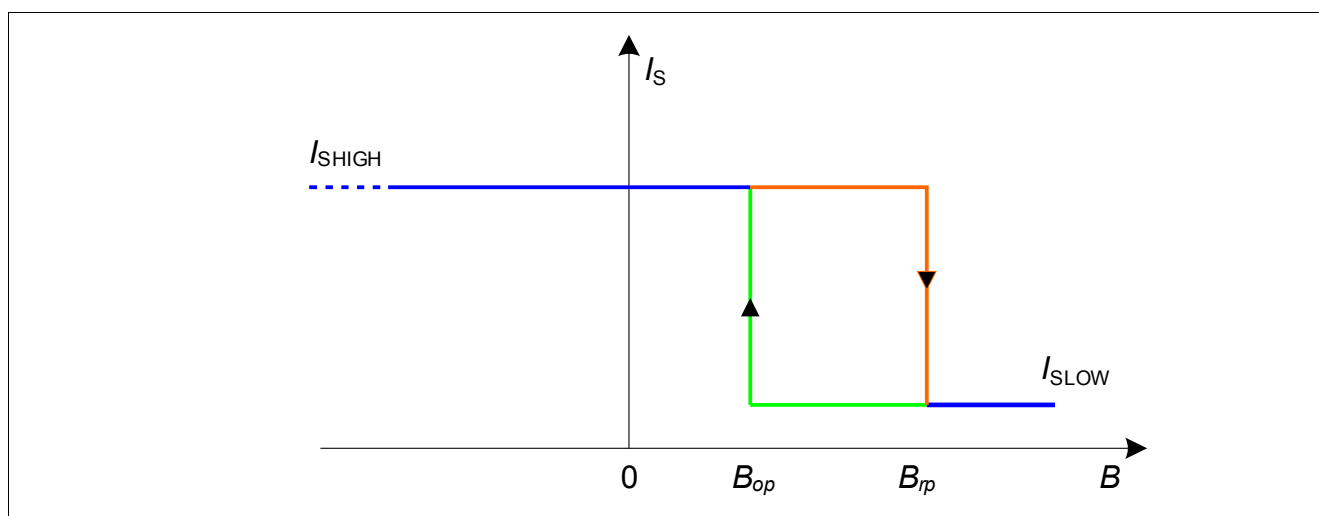


Figure 6 Output Switching of TLE4976L

### 3 Specification

#### 3.1 Application Circuit

The advantage of the current interface is, that only two wires are necessary to connect the sensor.

At least one series resistor is required to convert the two output states of the Hall sensor from current consumption to a voltage information.

A typical value for  $R_L$  is 100Ω. This gives a typical signal voltage level  $V_{SIG} = 0.8V$  in the *Off* state and 1.4V in the *On* state.

If the sensor is operated in an application environment with disturbances on the supply line, an additional series resistor  $R_S$  is recommended. The maximum value for the series resistor  $R_S$  can be calculated using the following formula:

$$R_{Smax} = \frac{V_{Supplymin} - V_{Smin}}{I_{Shighmax}} - R_L$$

$V_{Smin}$  is the minimal supply voltage which might occur due to disturbances on the supply line  $V_S$ .

Example:  $V_{Supplymin} = 6V$ ;  $V_{Smin} = 3V$ ;  $R_L = 100\Omega$ ;  $I_{Shighmax} = 17mA$  :  $R_{Smax} = 76.5\Omega$

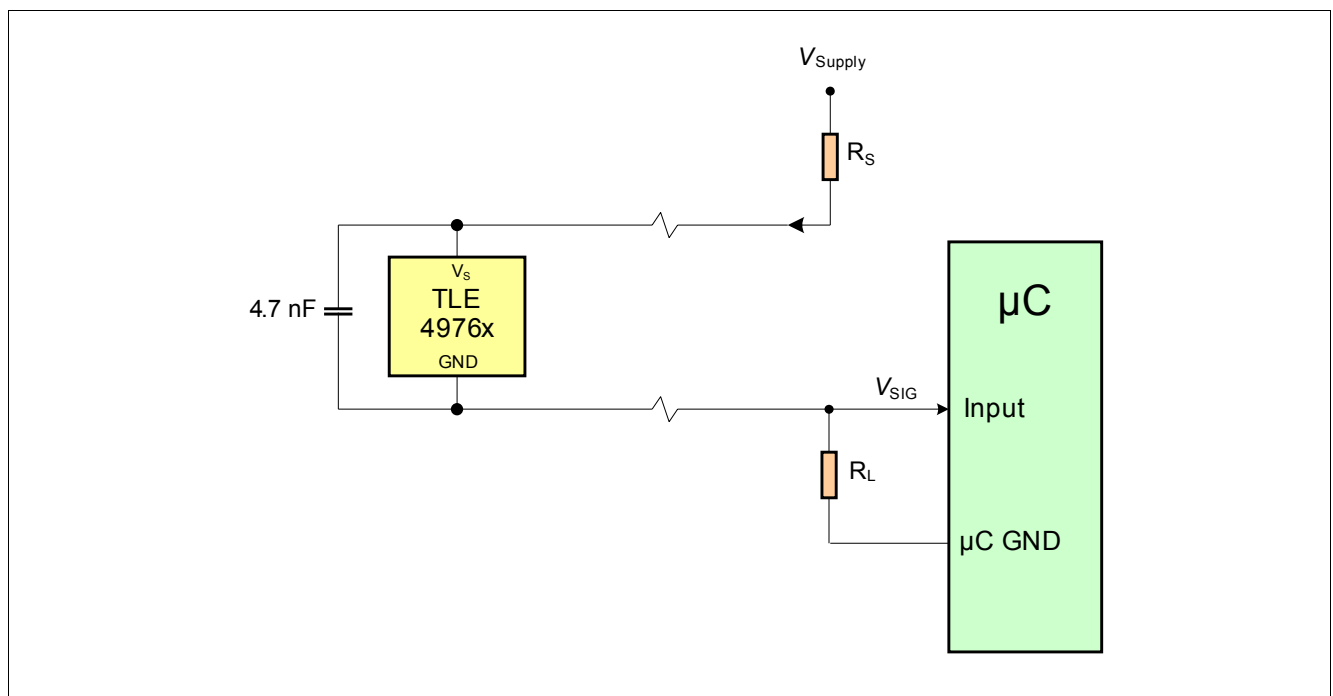


Figure 7 Application Circuit

## 3.2 Absolute Maximum Ratings

**Table 3 Absolute Maximum Rating Parameters**

| Parameter                                | Symbol | Limit Values         |                          | Unit | Note / Test Condition                                                                                    |
|------------------------------------------|--------|----------------------|--------------------------|------|----------------------------------------------------------------------------------------------------------|
|                                          |        | Min.                 | Max.                     |      |                                                                                                          |
| Supply voltage                           | $V_S$  | – 18<br>– 18<br>– 18 | 18<br>24<br>26           | V    | for 1h, $R_S+R_L > 75\Omega$<br>for 5min, $R_S+R_L > 75\Omega$                                           |
| Supply current through protection device | $I_S$  | – 50                 | +50                      | mA   |                                                                                                          |
| Junction temperature                     | $T_j$  | –<br>–<br>–<br>–     | 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   |                                                                                                          |
| Magnetic flux density                    | B      | –                    | unlimited                | mT   |                                                                                                          |

**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.**

**Table 4 ESD Protection<sup>1)</sup>**

| Parameter   | Symbol    | Limit Values |      | Unit | Note / Test Condition                                        |
|-------------|-----------|--------------|------|------|--------------------------------------------------------------|
|             |           | Min.         | Max. |      |                                                              |
| ESD Voltage | $V_{ESD}$ | ±8           |      | kV   | HBM, $R = 1.5k\Omega$ ,<br>$C = 100pF$<br>$T_A = 25^\circ C$ |

1) Human Body Model (HBM) tests according to: EOS/ESD Association Standard S5.1-1993 and Mil. Std. 883D method 3015.7

## 3.3 Operating Range

The following operating conditions must not be exceeded in order to ensure correct operation of the Hall Effect Switch.

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

**Table 5 Operating Conditions Parameters**

| Parameter            | Symbol | Values |      |      | Unit | Note / Test Condition            |
|----------------------|--------|--------|------|------|------|----------------------------------|
|                      |        | Min.   | Typ. | Max. |      |                                  |
| Supply voltage       | $V_S$  | 3      |      | 18   | V    |                                  |
|                      |        | 3      |      | 24   |      | for 5 min, $R_S+R_L > 100\Omega$ |
| Junction temperature | $T_j$  | – 40   |      | 150  | °C   |                                  |
|                      |        |        |      | 175  |      | for 168h                         |

### 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.

**Table 6 General Electrical Characteristics<sup>1)</sup>**

| Parameter                        | Symbol      | Values |      |                  | Unit          | Note / Test Condition                                                      |
|----------------------------------|-------------|--------|------|------------------|---------------|----------------------------------------------------------------------------|
|                                  |             | Min.   | Typ. | Max.             |               |                                                                            |
| Supply current low               | $I_{SLOW}$  | 5      | 6    | 7                | mA            | TLE4976-1K: $B < B_{RP}$<br>TLE4976L: $B > B_{RP}$<br>$V_S = 3V \dots 18V$ |
| Supply current high              | $I_{SHIGH}$ | 12     | 14   | 17               | mA            | TLE4976-1K: $B > B_{OP}$<br>TLE4976L: $B < B_{OP}$<br>$V_S = 3V \dots 18V$ |
| Reverse current                  | $I_{SR}$    | 0      | –    | 0.2              | mA            | $V_S = -18V$                                                               |
| Output fall time                 | $t_f$       | –      | 0.4  | 1.6              | $\mu s$       | $R_S = 100\Omega$                                                          |
| Output rise time                 | $t_r$       | –      | 0.4  | 1.6              | $\mu s$       |                                                                            |
| Chopper frequency                | $f_{OSC}$   | –      | 320  | –                | kHz           |                                                                            |
| Switching freq.                  | $f_{SW}$    | 0      | –    | 15 <sup>2)</sup> | kHz           |                                                                            |
| Delay time <sup>3)</sup>         | $t_d$       | –      | 13   | –                | $\mu s$       |                                                                            |
| Output jitter <sup>4)</sup>      | $t_{QJ}$    | –      | 1    | –                | $\mu s_{RMS}$ | Typical value for square wave signal 1kHz                                  |
| Power-on time <sup>5)</sup>      | $t_{PON}$   | –      | 13   | –                | $\mu s$       | $V_S \geq 3.0V$                                                            |
| Thermal resistance <sup>6)</sup> | $R_{thJA}$  |        | 100  |                  | K/W           | SC59                                                                       |
|                                  |             |        |      | 190              |               | PG-SSO-3-2                                                                 |

1) over operating range, unless otherwise specified. Typical values correspond to  $V_S = 12V$  and  $T_A = 25^\circ C$

2) To operate the sensor at the max. switching frequency, the value of the magnetic signal amplitude must be 1.4 times higher than for static fields. This is due to the - 3dB corner frequency of the low pass filter in the signal path

3) Systematic delay between magnetic threshold reached and output switching

4) Jitter is the unpredictable deviation of the output switching delay

5) Time from applying  $V_S \geq 3.0V$  to the sensor until the output state is valid

6) Thermal resistance from junction to ambient

#### Calculation of the ambient temperature:

e.g. for  $V_S = 12.0V$ ,  $R_S = 100\Omega$ ,  $I_{SHIGHtyp} = 14mA$  :

Power Dissipation:  $P_{DIS} = 148.4mW$ .

In  $T_A = T_j - (R_{thJA} \times P_{DIS}) = 175^\circ C - (100K/W \times 0.15W)$

Resulting max. ambient temperature:  $T_A = 160^\circ C$

**Table 7**     **Magnetic Characteristics<sup>1)</sup>**

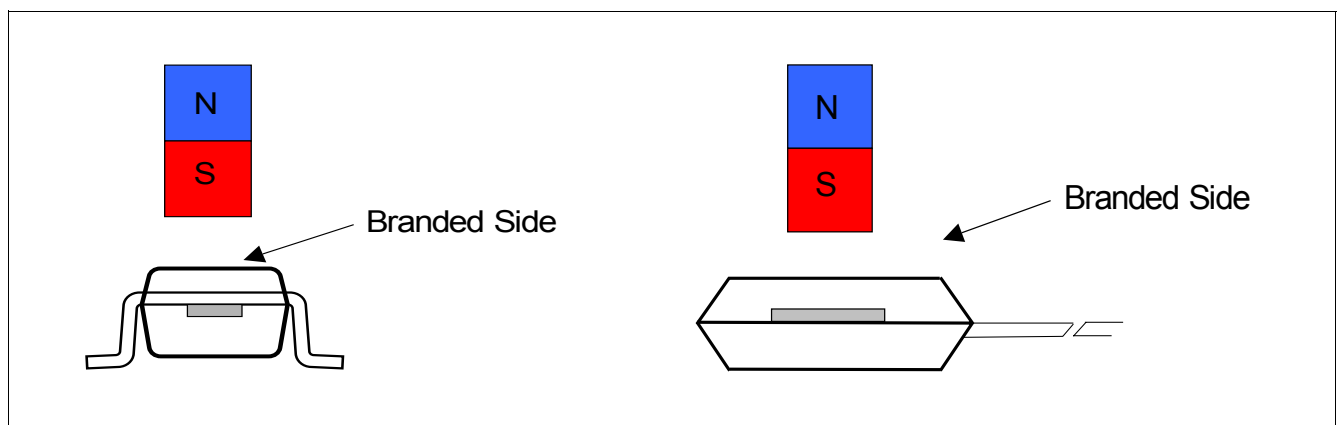
| Parameter                                          | Symbol           | T <sub>j</sub> [°C] | Values |      |      | Unit              | Note / Test Condition             |
|----------------------------------------------------|------------------|---------------------|--------|------|------|-------------------|-----------------------------------|
|                                                    |                  |                     | Min.   | Typ. | Max. |                   |                                   |
| Operating point                                    | B <sub>OP</sub>  | -40 ... 150         | 5.5    | 9.25 | 11.0 | mT                | TLE4976-1K                        |
|                                                    |                  | -40                 | 1.1    | 4.1  | 6.1  |                   | TLE4976L                          |
|                                                    |                  | 25                  | 1.0    | 4.0  | 6.0  |                   |                                   |
|                                                    |                  | 150                 | 0.9    | 3.8  | 5.8  |                   |                                   |
| Release point                                      | B <sub>RP</sub>  | -40 ... 150         | 5.0    | 7.25 | 10.5 | mT                | TLE4976-1K                        |
|                                                    |                  | -40                 | 3.1    | 6.1  | 8.2  |                   | TLE4976L                          |
|                                                    |                  | 25                  | 3.0    | 6.0  | 8.0  |                   |                                   |
|                                                    |                  | 150                 | 2.9    | 5.8  | 7.7  |                   |                                   |
| Hysteresis                                         | B <sub>HYS</sub> | -40 ... 150         | 0.5    | 2.0  | 3.0  | mT                | TLE4976-1K                        |
|                                                    |                  | -40                 | -      | -    | -    |                   | TLE4976L                          |
|                                                    |                  | 25                  | 0.5    | 2.0  | 3.5  |                   |                                   |
|                                                    |                  | 150                 | -      | -    | -    |                   |                                   |
| Temperature compensation of magnetic thresholds    | T <sub>C</sub>   |                     | -      | 0    | -    | ppm/°C            | TLE4976-1K                        |
|                                                    |                  |                     | -      | -200 | -    |                   | TLE4976L                          |
| Repeatability of magnetic thresholds <sup>2)</sup> | B <sub>REP</sub> |                     | -      | 40   | -    | μT <sub>RMS</sub> | Typ. value for ΔB / Δt > 12 mT/ms |

1) over operating range, unless otherwise specified. Typical values correspond to V<sub>S</sub> = 12 V.

2) B<sub>REP</sub> is equivalent to the noise constant

### 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**

## 4 Package Information

### 4.1 Package Outline

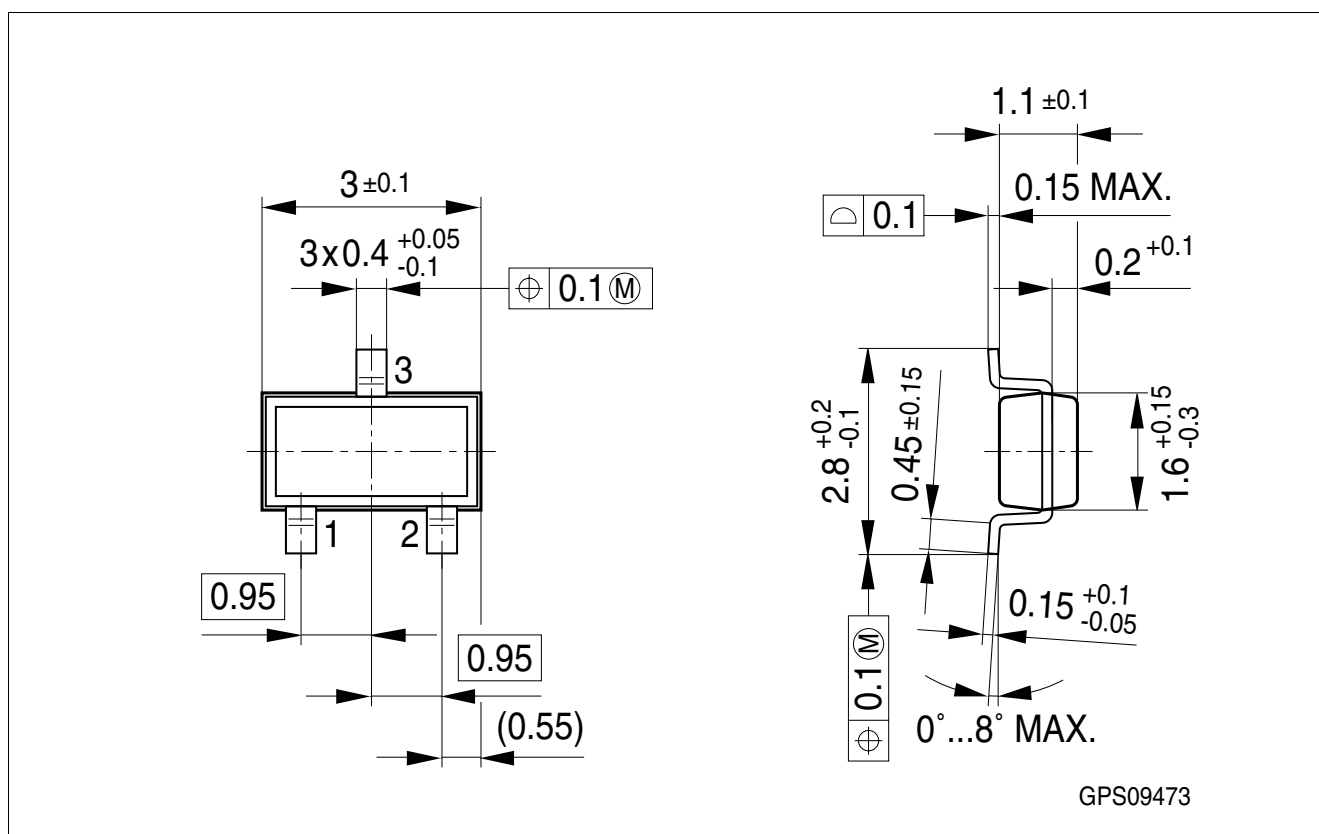


Figure 9 SC59 Package Outline (All dimensions in mm)

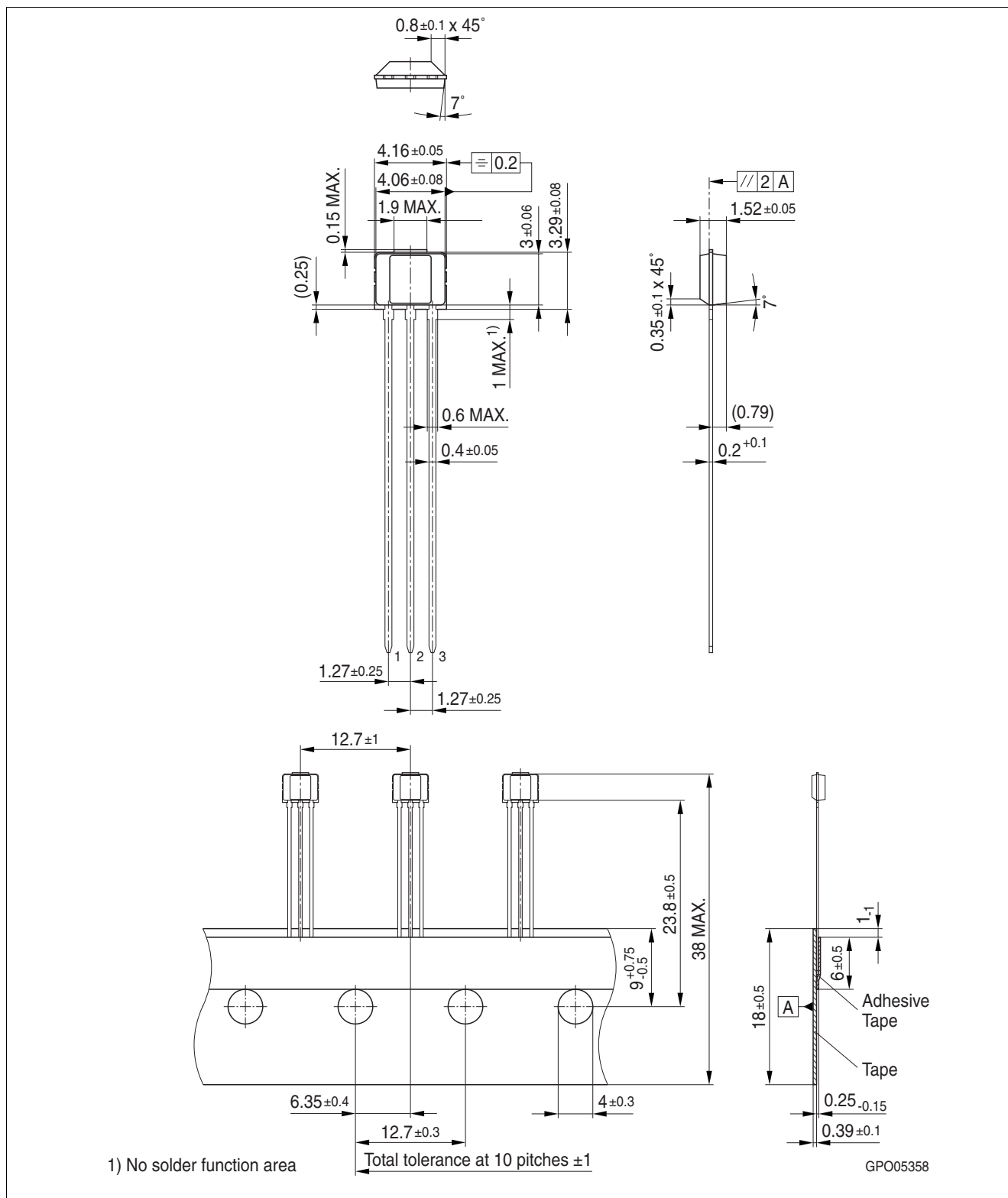


Figure 10 PG-SSO-3-2 Package Outline (All dimensions in mm)



## 4.2 Footprint

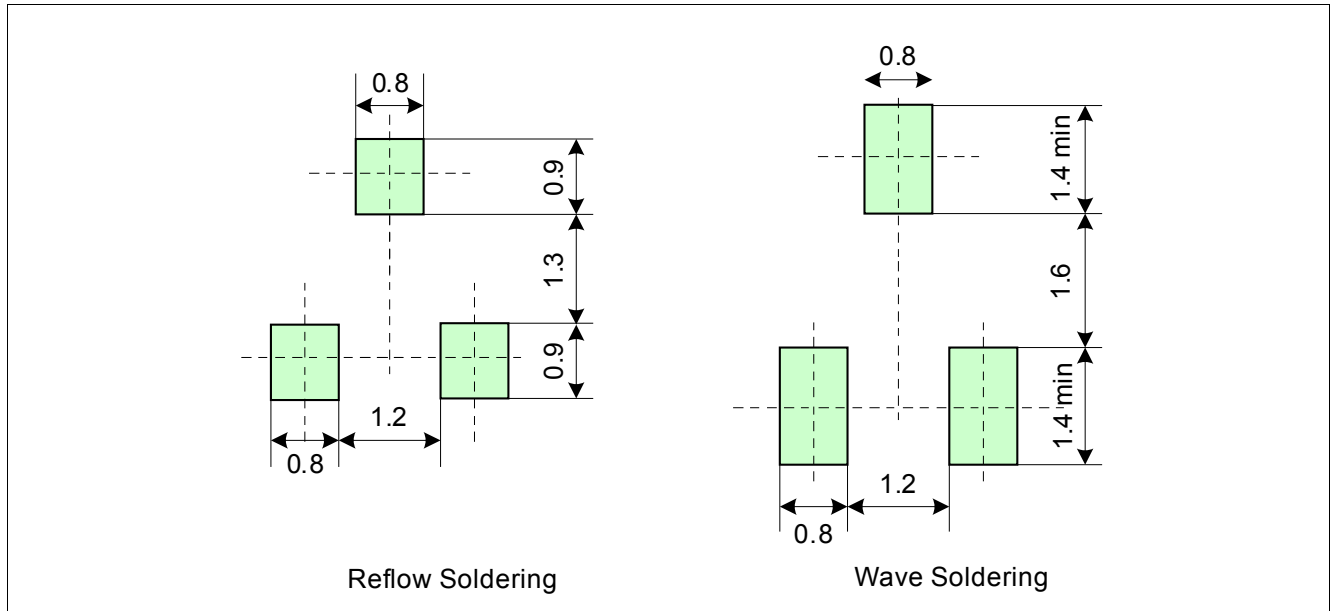
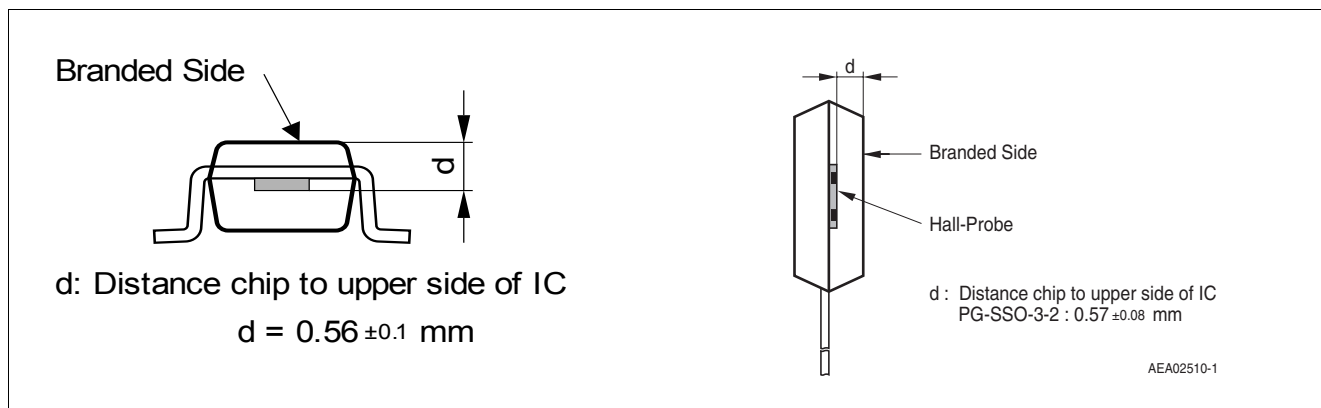


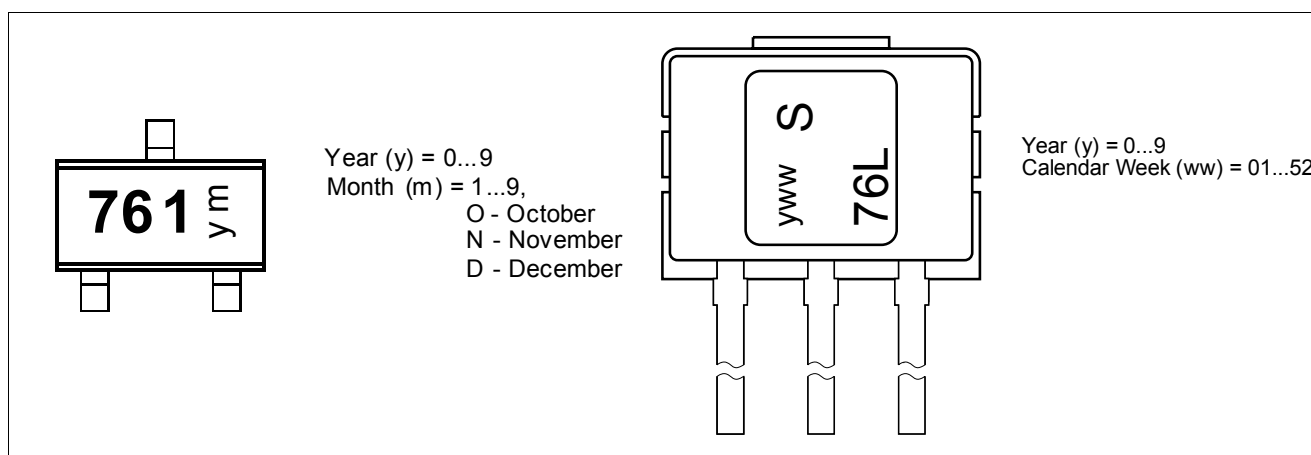
Figure 11 Footprint SC59

### 4.3 Distance between Chip and Package



**Figure 12** Distance between chip and package: left: TLE4976-1K, right: TLE4976L

### 4.4 Package Marking



**Figure 13** Marking of TLE4976-1K and TLE4976L

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