

## HAL<sup>®</sup> 156y

Hall-Effect Switches  
with Current Interface (2-wire)  
in SOT23 Package

**ASIL**|ready

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## Hall-Effect Switches with Current Interface (2-wire) in SOT23 Package

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**Release Note: Revision bars indicate significant changes to the previous edition.**

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### 1. Introduction

The HAL 156y Hall-switch family members produced in CMOS technology as 2-wire devices with current interface include a temperature-compensated Hall plate with active offset compensation, a comparator, and a current source.

The comparator compares the actual magnetic flux through the Hall plate (Hall voltage) with the fixed reference values (switching points). Accordingly the current source is switched on or off.

The active offset compensation leads to constant magnetic characteristics over supply voltage and temperature range. In addition, the magnetic parameters are robust against mechanical stress effects.

The sensors are designed for industrial and automotive applications and operate with supply voltages from 3 V to 24 V in the junction temperature range from  $-40\text{ }^{\circ}\text{C}$  up to  $170\text{ }^{\circ}\text{C}$ .

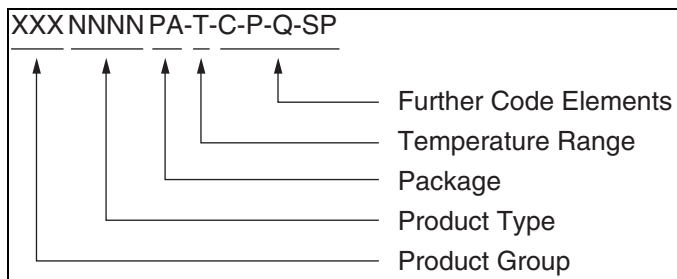
HAL 156y is available in a JEDEC TO236-compliant SMD-package 3-lead SOT23.

## 1.1. Features of HAL 156y

- SOT23-3L JEDEC TO236-compliant package
- ISO 26262 compliant as ASIL A ready device
- Current interface
- Operates from 3 V to 24 V supply voltage
- Overvoltage protection capability up to 40 V
- Reverse-voltage protected VSUP-pin (–18 V)
- High ESD performance up to  $\pm 8$  kV (HBM)
- Thermal shutdown
- Sample frequency of 500 kHz, 2  $\mu$ s output refresh time
- Operates with static and dynamic magnetic fields up to 12 kHz
- High resistance to mechanical stress by active offset compensation
- Constant switching points over a wide supply voltage and temperature range
- Wide junction temperature range from  $-40$  °C to 170 °C
- Built-in temperature coefficient
- Optimized for applications in extreme automotive and industrial environments
- Qualified according to AEC-Q100 test standard for automotive electronics industry to provide high-quality performance
- Robust EMC performance, corresponding to different standards, such as ISO 7637, ISO 16750, IEC 61967, ISO 11452, and ISO 62132

## 2. Ordering Information

A Micronas device is available in a variety of delivery forms. They are distinguished by a specific ordering code:



**Fig. 2–1:** Ordering Code Principle

For a detailed information, please refer to the brochure: “Sensors and Controllers: Ordering Codes, Packaging, Handling”.

### 2.1. Device-Specific Ordering Codes

HAL 156y is available in the following package and temperature range.

**Table 2–1:** Available packages

| Package Code (PA) | Package Type |
|-------------------|--------------|
| SU                | SOT23        |

**Table 2–2:** Available temperature ranges

| Temperature Code (T) | Temperature Range                      |
|----------------------|--|
| A                    | $T_J = -40\text{ °C to }170\text{ °C}$ |

The relationship between ambient temperature ( $T_A$ ) and junction temperature ( $T_J$ ) is explained in **Section 5.2. on page 32.**

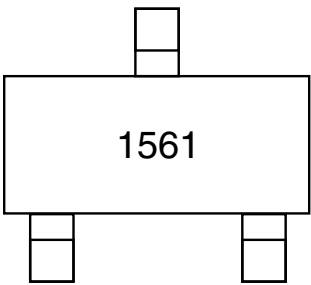
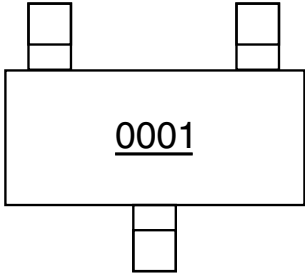
For available variants for Configuration (C), Packaging (P), Quantity (Q) and Special Procedure (SP) please contact TDK-Micronas.

**Table 2–3:** Available ordering codes

| Available Ordering Codes |
|--------------------------|
| HAL1561SU-A-[C-P-Q-SP]   |
| HAL1562SU-A-[C-P-Q-SP]   |
| HAL1563SU-A-[C-P-Q-SP]   |
| HAL1564SU-A-[C-P-Q-SP]   |
| HAL1565SU-A-[C-P-Q-SP]   |
| HAL1566SU-A-[C-P-Q-SP]   |

This data sheet is valid for HAL 156y derivatives with an underlined trace code, as shown in the example below.

**Table 2–4:** Example for Product Marking

| Package Top Surface Marking   | Package Bottom Surface Marking   |
|---|--|
|  |  |
| 1561 = Product Type   | <u>0001</u> = Trace Code   |

### 3. Functional Description of HAL 156y

The HAL 156y sensors are monolithic integrated circuits which switch in response to magnetic fields. If a magnetic field with flux lines perpendicular to the sensitive area is applied to the sensor, the biased Hall plate forces a Hall voltage proportional to this field. The Hall voltage is compared with the actual threshold level in the comparator. If the magnetic field exceeds the threshold levels, the current source is switched to the appropriate state.

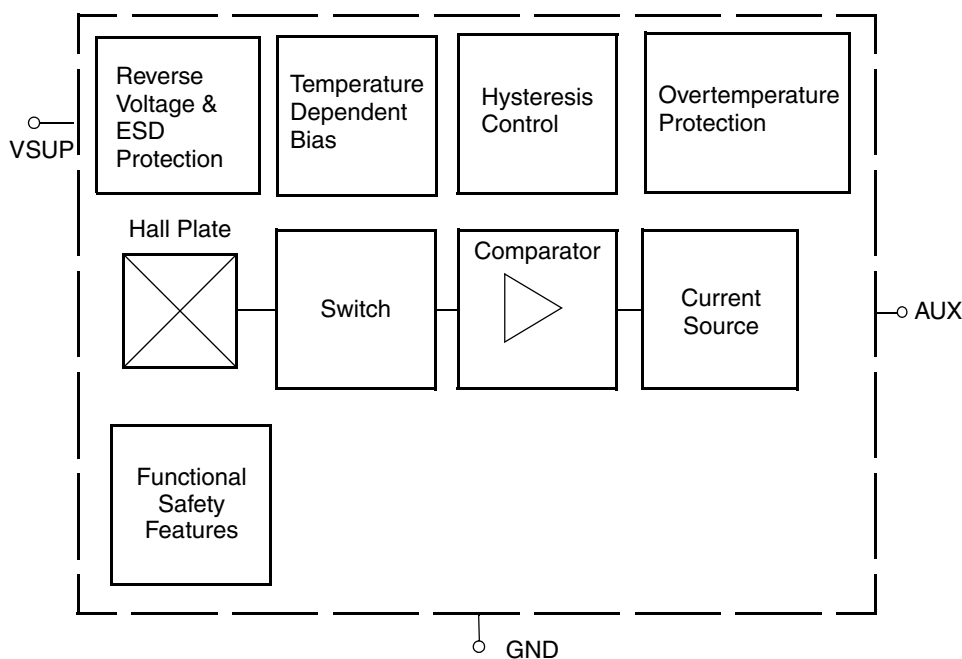
The built-in hysteresis eliminates oscillation and provides switching behavior without bouncing.

Offsets caused by mechanical stress are compensated by using the “switching offset compensation technique”.

A diode on the supply line is not required thanks to the built-in reverse voltage protection.

The current source is forced to a safe, error current level ( $I_{SUP}$ ), in any of the following fault conditions: overtemperature and functional safety related diagnoses (see Section 3.1.).

The device is able to withstand a maximum supply voltage of 24 V over lifetime and features overvoltage capability (40 V load dump).



**Fig. 3–1:** HAL 156y block diagram



### 3.1. Functional Safety According to ISO 26262

The HAL 156y is ISO 26262 compliant as an ASIL A ready device.

Magnetic and switching performance is defined as hardware safety requirement.

The safe state is defined as error current level and is specified in Section 4.9. on page 16.

#### 3.1.1. Diagnostic Features

Internal states are monitored and in an error condition flagged as error current:

- Internal voltage regulator: overvoltage detection
- Monitoring of internal bias and current levels
- Monitoring of the internal reference voltage
- Monitoring of the Hall plate voltage

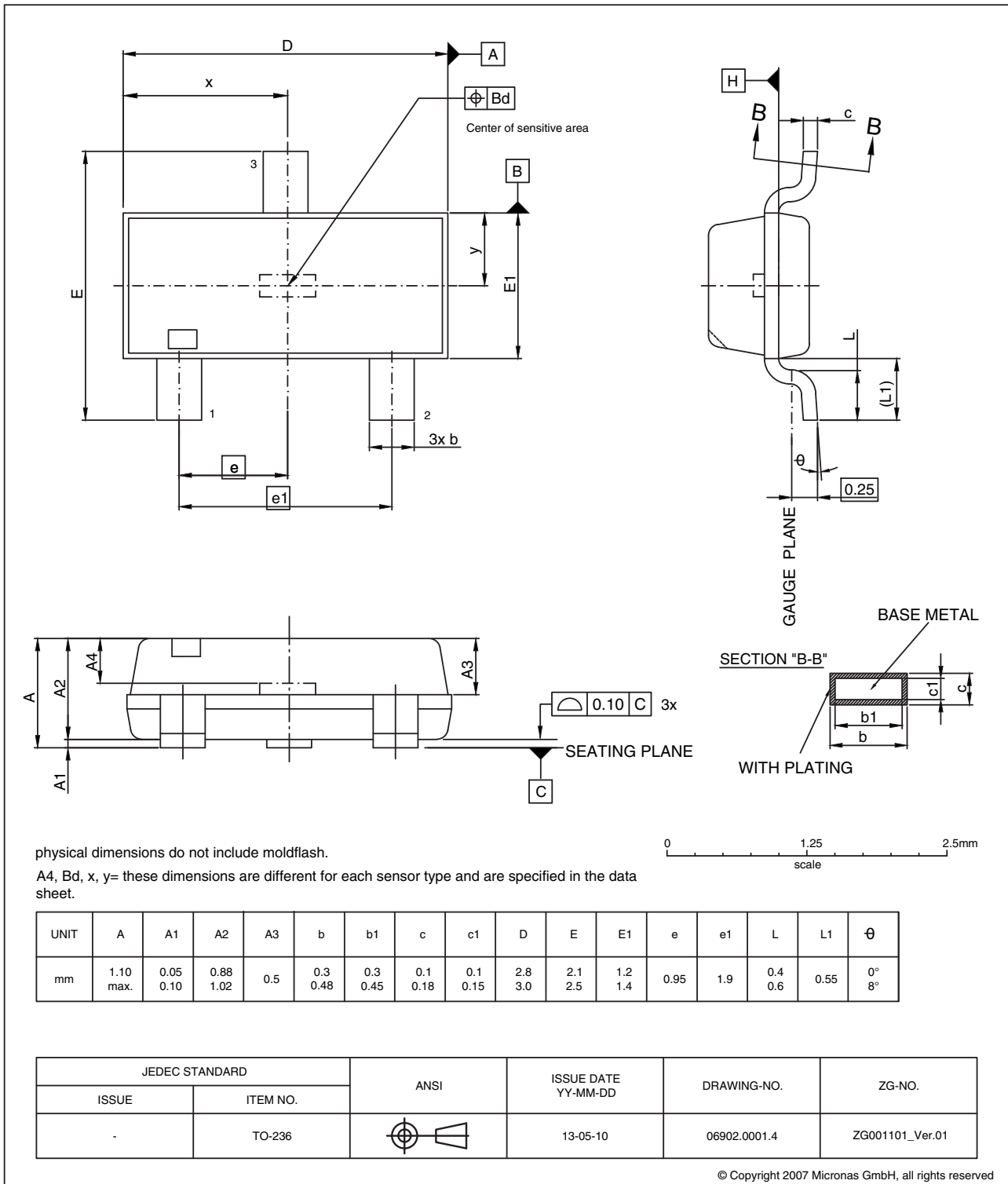
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**Note** For further documentation regarding functional safety please contact TDK-Micronas.

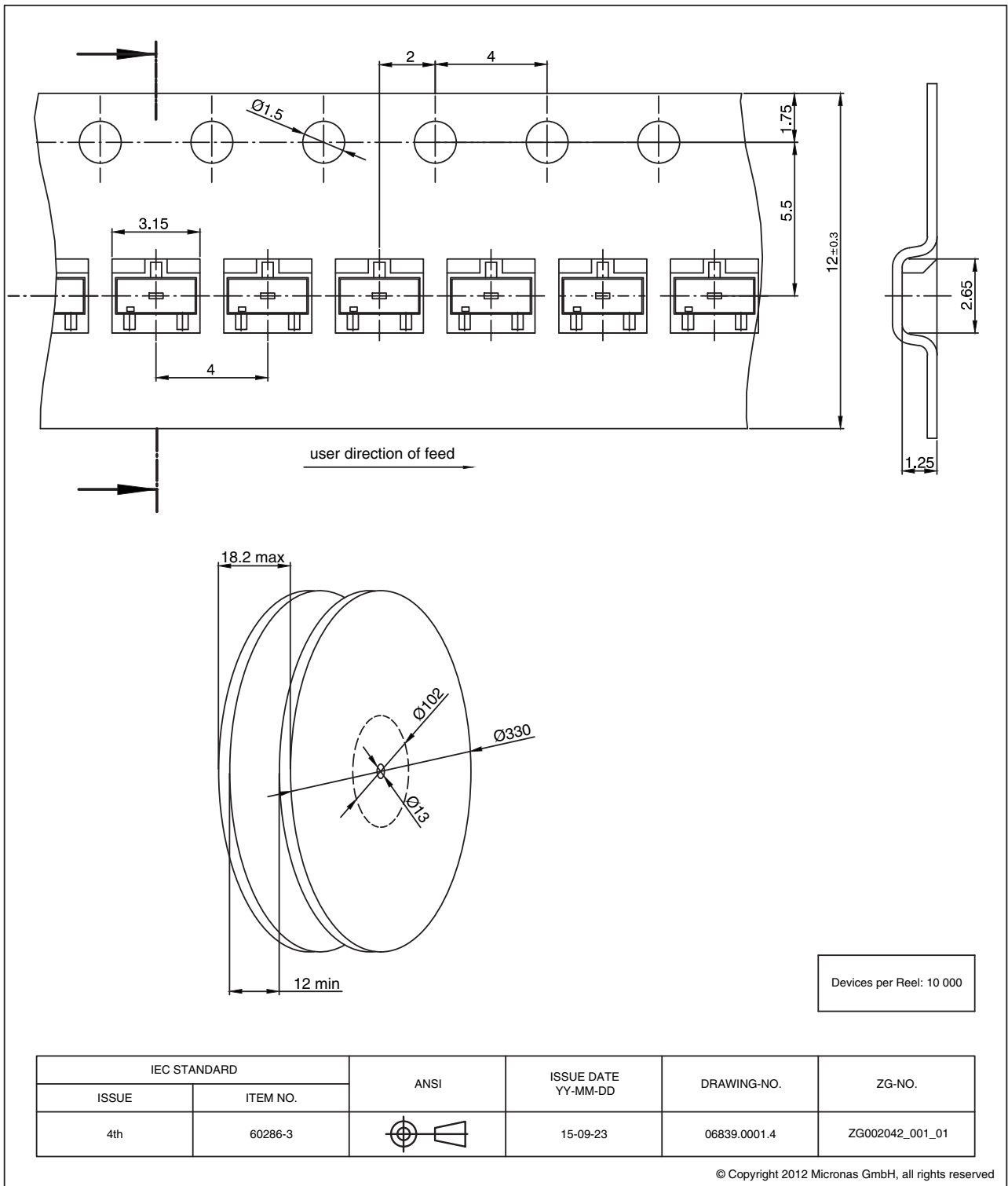
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## 4. Specifications

### 4.1. Outline Dimensions



**Fig. 4-1:**  
**SOT23: Plastic Small Outline Transistor package, 3 leads**  
 Ordering code: SU  
 Weight approximately is 0.01094 g



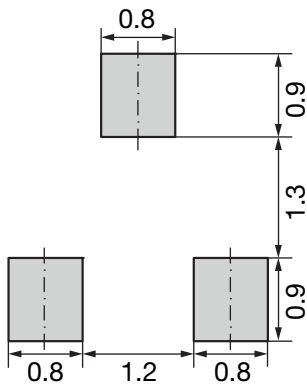
**Fig. 4-2:**  
**SOT23: Tape & Reel Finishing**

## 4.2. Soldering, Welding and Assembly

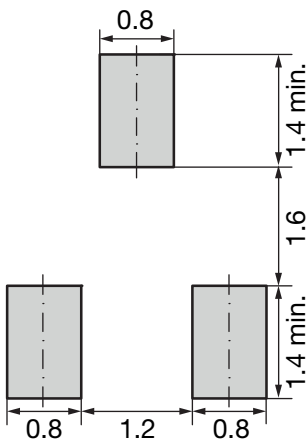
Information related to solderability, welding, assembly, and second-level packaging is included in the document “Guidelines for the Assembly of Micronas Packages”.

It is available on the TDK-Micronas website (<http://www.micronas.com/en/service-center/downloads>) or on the service portal (<http://service.micronas.com>).

### 4.2.1. SOT23 Footprint for Reflow and Wave Soldering



**Fig. 4–3:** SOT23 footprint for reflow soldering



← Transport Direction →

**Fig. 4–4:** SOT23 footprint for wave soldering

All dimensions in mm.

### 4.3. Pin Connections (from Top Side, example HAL 1564) and Short Descriptions

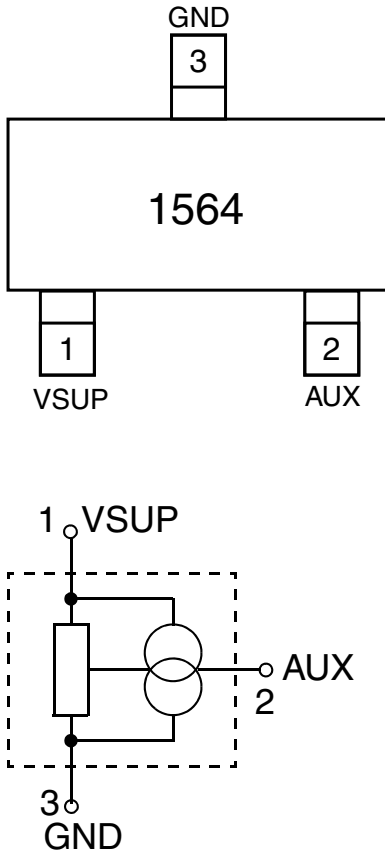


Fig. 4–5: Pin configuration

Table 4–1: Pin assignment.

| Pin number  | Name              | Function            |
|---|-------------------|---------------------|
| 1   | VSUP              | Supply and output   |
| 2   | AUX <sup>1)</sup> | Functional test pin |
| 3   | GND               | Ground              |
| <sup>1)</sup> connection to ground is recommended |                   |                     |

#### 4.4. Dimension and Position of Sensitive Area

| Parameter  | Min. | Typ.      | Max. | Unit            |
|--|------|-----------|------|-----------------|
| Dimension of sensitive area  | –    | 100 x 100 | –    | μm <sup>2</sup> |
| A4 (denotes the distance of die to top package surface in Z-direction)                               | 0.24 | 0.27      | 0.37 | mm              |
| x (denotes the nominal distance of the center of the Bd circle to the package border in x-direction) | 1.45 |           |      | mm              |
| y (denotes the nominal distance of the center of the Bd circle to the package border in y-direction) | 0.65 |           |      | mm              |
| Bd (denotes the diameter of the circuit in which the center of the sensitive area is located)        | –    | –         | 0.23 | mm              |

#### 4.5. Absolute Maximum Ratings

Stresses beyond those listed in the “Absolute Maximum Ratings” may cause permanent damage to the device. This is a stress rating only. Functional operation of the device at these conditions is not implied. Exposure to absolute maximum rating conditions for extended periods will affect device reliability.

This device contains circuitry to protect the inputs and outputs against damage due to high static voltages or electric fields; however, it is advised that normal precautions must be taken to avoid application of any voltage higher than absolute maximum-rated voltages to this circuit.

All voltages listed are referenced to ground (GND).

| Symbol                             | Parameter                                      | Pin No | Min. | Max. | Unit | Conditions  |
|------------------------------------|--|--------|------|------|------|---|
| T <sub>J</sub>                     | Junction temperature range A                   | –      | –40  | 190  | °C   | t < 96 h <sup>1)</sup>  |
| T <sub>storage</sub>               | Transportation/ Short-Term Storage Temperature | –      | –55  | 150  | °C   | Device only without packing material.   |
| V <sub>SUP</sub>                   | Supply voltage                                 | 1      | –18  | 28   | V    | t < 96 h <sup>1)</sup>  |
|                                    |  |        | –    | 32   | V    | t < 5 min <sup>1)</sup>   |
|                                    |  |        | –    | 40   | V    | t < 10 x 400 ms “Load-Dump” <sup>1)</sup> with series resistor R <sub>V</sub> > 100 Ω |
| <sup>1)</sup> No cumulative stress |  |        |      |      |      |   |

## 4.6. ESD and Latch-up

| Symbol   | Parameter  | Min. | Max. | Unit |
|--|--|------|------|------|
| $I_{\text{latch}}$   | Maximum latch-up free current at any pin (measurement according to AEC Q100-004), class 1                      | -100 | 100  | mA   |
| $V_{\text{HBM}}^{1)}$  | Human body model (according to AEC Q100-002)   | -8   | 8    | kV   |
| $V_{\text{HBM}}^{2)}$  | Human body model (according to AEC Q100-002)   | -6   | 6    | kV   |
| $V_{\text{CDM}}$   | Charged device model (according to AEC Q100-011)   | -1   | 1    | kV   |
| $V_{\text{SYSTEM\_LEVEL}}$   | Unpowered Gun Test (150 pF/330 $\Omega$ or 330 pF/2 k $\Omega$ ) according to ISO 10605-2008 <sup>1)3)4)</sup> | -15  | 15   | kV   |
| <sup>1)</sup> VSUP-pin and GND-pin<br><sup>2)</sup> AUX-pin<br><sup>3)</sup> Only valid with ESD System Level Application Circuit (see Fig. 5–2 on page 31)<br><sup>4)</sup> Based on 3-wire HAL 15xy test results |  |      |      |      |

## 4.7. Storage and Shelf Life

Information related to storage conditions of Micronas sensors is included in the document “Guidelines for the Assembly of Micronas Packages”. It gives recommendations linked to moisture sensitivity level and long-term storage. It is available on the TDK-Micronas website (<http://www.micronas.com/en/service-center/downloads>) or on the service portal (<http://service.micronas.com>).

## 4.8. Recommended Operating Conditions

Functional operation of the device beyond those indicated in the “Recommended Operating Conditions” of this specification is not implied, may result in unpredictable behavior of the device, and may reduce reliability and lifetime.

All voltages listed are referenced to ground (GND).

| Symbol   | Parameter                                  | Pin No. | Min. | Typ. | Max.              | Unit | Conditions  |
|--|--|---------|------|------|-------------------|------|---|
| $V_{\text{SUP}}$   | Supply voltage                             | 1       | 3    | –    | 24                | V    |   |
| $T_{\text{J}}$   | Junction temperature range A <sup>1)</sup> | –       | -40  | –    | 170<br>150<br>125 | °C   | $t < 1000 \text{ h}^2)$<br>$t < 2500 \text{ h}^2)$<br>$t < 8000 \text{ h}^2)$ |
| <sup>1)</sup> Depends on the temperature profile of the application. Please contact TDK-Micronas for life time calculations.<br><sup>2)</sup> No cumulative stress |  |         |      |      |                   |      |   |

## 4.9. Characteristics

at  $T_J = -40\text{ °C}$  to  $170\text{ °C}$ ,  $V_{SUP} = 3.0\text{ V}$  to  $24.0\text{ V}$ ,

at Recommended Operating Conditions if not otherwise specified in the column "Conditions".

Typical Characteristics for  $T_J = 25\text{ °C}$  and  $V_{SUP} = 12.0\text{ V}$

| Symbol   | Parameter  | Pin No. | Min. | Typ.       | Max.       | Unit          | Conditions  |
|--|--|---------|------|------------|------------|---------------|---|
| <b>Supply</b>  |  |         |      |            |            |               |   |
| $V_{UV}$   | Undervoltage threshold   | 1       | 2.0  | –          | 3.0        | V             |   |
| $I_{SUPlo}$  | Low supply current 1   | 1       | 2.5  | –          | 5          | mA            | valid for:<br>HAL 1564 and HAL 1565   |
| $I_{SUPlo}$  | Low supply current 2   | 1       | 5    | –          | 7          | mA            | valid for:<br>HAL 1561, HAL 1562,<br>HAL 1563, and HAL 1566   |
| $I_{SUP}$  | Error current  | 1       | 0.8  | –          | 2.2        | mA            |   |
| $I_{SUPhi}$  | High supply current  | 1       | 12   | –          | 17         | mA            |   |
| $I_{SUPR}$   | Reverse current  | 1       | –    | –          | 0.6        | mA            | for $V_{SUP} = -18\text{ V}$  |
| <b>Port Output</b>   |  |         |      |            |            |               |   |
| $B_{noise}$  | Effective noise of magnetic switching points (RMS) <sup>2)</sup> | –       | –    | 72         | –          | $\mu\text{T}$ | For square wave signal with 12 kHz  |
| $t_j$  | Output jitter (RMS) <sup>1)</sup>                                | –       | –    | $\pm 0.58$ | $\pm 0.72$ | $\mu\text{s}$ | For square wave signal with 1 kHz. Jitter is evenly distributed between $-1\text{ }\mu\text{s}$ and $+1\text{ }\mu\text{s}$ |
| $t_d$  | Delay time <sup>2)3)</sup>                                       | –       | –    | 16         | 21         | $\mu\text{s}$ |   |
| $t_{samp}$   | Output refresh period <sup>2)</sup>                              | –       | 1.6  | 2.2        | 3.0        | $\mu\text{s}$ |   |
| $t_{en}$   | Enable time of output after exceeding of $V_{UV}$                | –       | 20   | 50         | 60         | $\mu\text{s}$ | $V_{SUP} = 12\text{ V}$<br>$B > B_{on} + 2\text{ mT}$ or<br>$B < B_{off} - 2\text{ mT}$                                     |
| <sup>1)</sup> Characterized on small sample size, not tested<br><sup>2)</sup> Guaranteed by design<br><sup>3)</sup> Systematic delay between magnetic threshold reached and output switching |  |         |      |            |            |               |   |



| Symbol            | Parameter                           | Pin No. | Min. | Typ. | Max. | Unit | Conditions                   |
|-------------------|-------------------------------------|---------|------|------|------|------|------------------------------|
| <b>Package</b>    |                                     |         |      |      |      |      |                              |
| R <sub>thja</sub> | Thermal Resistance junction to air  | –       | –    | –    | 300  | K/W  | Determined with a 1s0p board |
|                   |                                     | –       | –    | –    | 250  | K/W  | Determined with a 1s1p board |
|                   |                                     | –       | –    | –    | 210  | K/W  | Determined with a 2s2p board |
| R <sub>thjc</sub> | Thermal Resistance junction to case | –       | –    | –    | 30   | K/W  | Determined with a 1s0p board |
|                   |                                     | –       | –    | –    | 50   | K/W  | Determined with a 1s1p board |
|                   |                                     | –       | –    | –    | 40   | K/W  | Determined with a 2s2p board |

## 4.10. HAL 1561 Magnetic Characteristics

The HAL 1561 Hall-latch provides high sensitivity (see Fig. 4–6 on page 18).

The output turns to low current consumption ( $I_{SUPlo}$ ) with the magnetic north pole on the top side of the package and turns to high current consumption ( $I_{SUPhi}$ ) with the magnetic south pole on the top side. The output does not change if the magnetic field is removed. For changing the output state, the opposite magnetic field polarity must be applied.

For correct functioning in the application, the sensor requires both magnetic polarities (north and south) on the top side of the package.

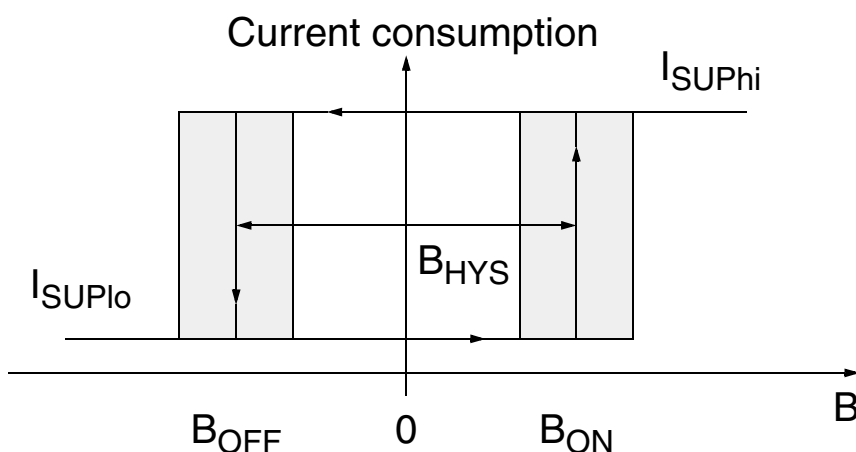
### Magnetic Features:

- switching type: latching
- high sensitivity
- typical  $B_{ON}$ : 4.0 mT at room temperature
- typical  $B_{OFF}$ : –4.0 mT at room temperature
- operates with static magnetic fields and dynamic magnetic fields up to 12 kHz
- typical temperature coefficient of magnetic switching points is 0 ppm/K

### Applications

The HAL 1561 is the optimal sensor for applications with alternating magnetic fields, such as:

- seat position detection
- break-by-wire
- electric sunroof
- window lifter
- motor commutation



**Fig. 4–6:** Definition of magnetic switching points for the HAL 1561

### Magnetic Characteristics

at  $T_J = -40\text{ °C}$  to  $170\text{ °C}$ ,  $V_{SUP} = 3.0\text{ V}$  to  $24.0\text{ V}$ ,  
 Typical Characteristics for  $V_{SUP} = 12.0\text{ V}$

Magnetic flux density values of switching points:

Positive flux density values refer to the magnetic south pole at the top side of the package.

| Parameter<br>$T_J$ | On point $B_{ON}$ |      |      | Off point $B_{OFF}$ |      |      | Hysteresis $B_{HYS}$ |      |      | Unit |
|--------------------|-------------------|------|------|---------------------|------|------|----------------------|------|------|------|
|                    | Min.              | Typ. | Max. | Min.                | Typ. | Max. | Min.                 | Typ. | Max. |      |
| $-40\text{ °C}$    | 2.0               | 4.0  | 7.0  | -7.0                | -4.0 | -2.0 | -                    | 8.0  | -    | mT   |
| $25\text{ °C}$     | 2.0               | 4.0  | 7.0  | -7.0                | -4.0 | -2.0 | -                    | 8.0  | -    | mT   |
| $170\text{ °C}$    | 2.0               | 4.0  | 7.0  | -7.0                | -4.0 | -2.0 | -                    | 8.0  | -    | mT   |

The hysteresis is the difference between the switching points  $B_{HYS} = |B_{ON} - B_{OFF}|$

#### Note

Regarding switching points, temperature coefficients and B-field switching frequency, customized derivatives via mask option are possible. For more information contact TDK-Micronas.

## 4.11. HAL 1562 Magnetic Characteristics

The HAL 1562 Hall-latch provides medium sensitivity (see Fig. 4–7 on page 20).

The output turns to low current consumption ( $I_{\text{SUPlo}}$ ) with the magnetic north pole on the top side of the package and turns to high current consumption ( $I_{\text{SUPhi}}$ ) with the magnetic south pole on the top side. The output does not change if the magnetic field is removed. For changing the output state, the opposite magnetic field polarity must be applied.

For correct functioning in the application, the sensor requires both magnetic polarities (north and south) on the top side of the package.

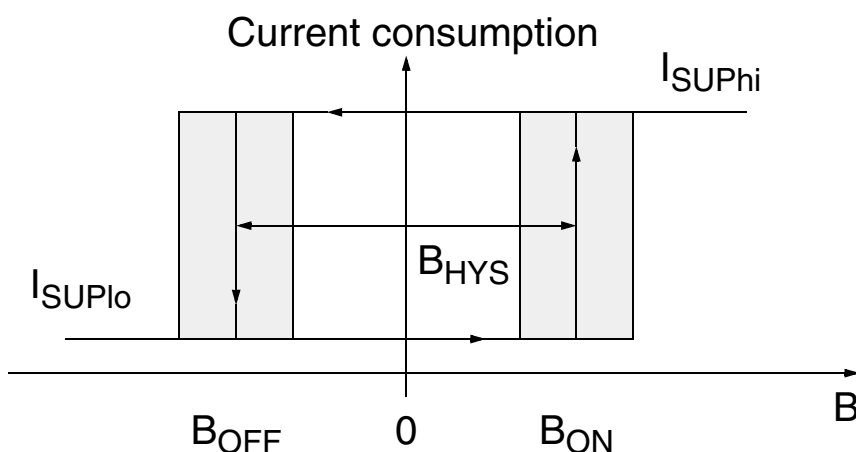
### Magnetic Features:

- switching type: latching
- medium sensitivity
- typical  $B_{\text{ON}}$ : 12.0 mT at room temperature
- typical  $B_{\text{OFF}}$ : –12.0 mT at room temperature
- operates with static magnetic fields and dynamic magnetic fields up to 12 kHz
- typical temperature coefficient of magnetic switching points is 0 ppm/K

### Applications

The HAL 1562 is the optimal sensor for applications with alternating magnetic fields, such as:

- seat position detection
- break-by-wire
- electric sunroof
- window lifter



**Fig. 4–7:** Definition of magnetic switching points for the HAL 1562

### Magnetic Characteristics

at  $T_J = -40\text{ °C}$  to  $170\text{ °C}$ ,  $V_{SUP} = 3.0\text{ V}$  to  $24.0\text{ V}$ ,  
 Typical Characteristics for  $V_{SUP} = 12.0\text{ V}$

Magnetic flux density values of switching points:

Positive flux density values refer to the magnetic south pole at the top side of the package.

| Parameter<br>$T_J$ | On point $B_{ON}$ |      |      | Off point $B_{OFF}$ |         |        | Hysteresis $B_{HYS}$ |      |      | Unit |
|--------------------|-------------------|------|------|---------------------|---------|--------|----------------------|------|------|------|
|                    | Min.              | Typ. | Max. | Min.                | Typ.    | Max.   | Min.                 | Typ. | Max. |      |
| $-40\text{ °C}$    | 7.0               | 12.0 | 17.0 | $-17.0$             | $-12.0$ | $-7.0$ | –                    | 24.0 | –    | mT   |
| $25\text{ °C}$     | 7.0               | 12.0 | 17.0 | $-17.0$             | $-12.0$ | $-7.0$ | –                    | 24.0 | –    | mT   |
| $170\text{ °C}$    | 7.0               | 12.0 | 17.0 | $-17.0$             | $-12.0$ | $-7.0$ | –                    | 24.0 | –    | mT   |

The hysteresis is the difference between the switching points  $B_{HYS} = |B_{ON} - B_{OFF}|$

#### Note

Regarding switching points, temperature coefficients and B-field switching frequency, customized derivatives via mask option are possible. For more information contact TDK-Micronas.

## 4.12. HAL 1563 Magnetic Characteristics

The unipolar inverted HAL 1563 Hall-switch provides high sensitivity (see Fig. 4–8 on page 22).

The sensor turns to low current consumption ( $I_{SUPlo}$ ) with the magnetic south pole on the top side of the package and turns to high current consumption ( $I_{SUPhi}$ ) if the magnetic field is removed. It does not respond to the magnetic north pole on the top side of the package.

For correct functioning in the application, the sensor requires only the magnetic south pole on the top side of the package.

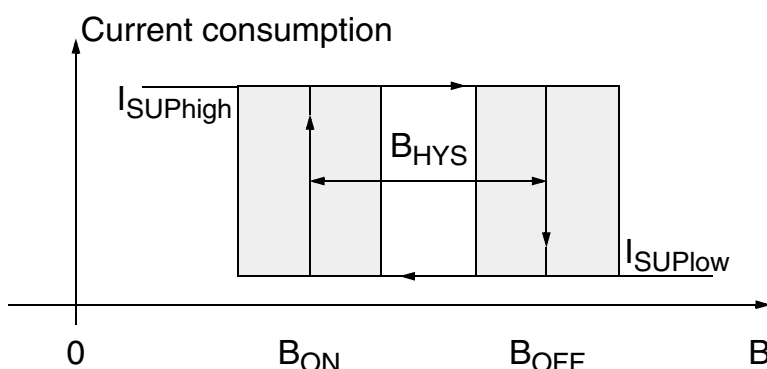
### Magnetic Features:

- switching type: unipolar inverted
- high sensitivity
- typical  $B_{ON}$ : 7.6 mT at room temperature
- typical  $B_{OFF}$ : 9.4 mT at room temperature
- operates with static magnetic fields and dynamic magnetic fields up to 12 kHz
- typical temperature coefficient of magnetic switching points is 0 ppm/K

### Applications

The HAL 1563 is the optimal sensor for all applications with one magnetic polarity and weak magnetic amplitude at the sensor position where an inverted output signal is required, such as:

- applications with large air gap or weak magnets
- brake pedal position detection (brake light switch)
- seat belt presence detection
- seat position detection,
- break fluid level switch



**Fig. 4–8:** Definition of magnetic switching points for the HAL 1563

### Magnetic Characteristics

at  $T_J = -40\text{ °C}$  to  $170\text{ °C}$ ,  $V_{SUP} = 3.0\text{ V}$  to  $24.0\text{ V}$ ,  
 Typical Characteristics for  $V_{SUP} = 12.0\text{ V}$

Magnetic flux density values of switching points:

Positive flux density values refer to the magnetic south pole at the top side of the package.

| Parameter<br>$T_J$ | On point $B_{ON}$ |      |      | Off point $B_{OFF}$ |      |      | Hysteresis $B_{HYS}$ |      |      | Unit |
|--------------------|-------------------|------|------|---------------------|------|------|----------------------|------|------|------|
|                    | Min.              | Typ. | Max. | Min.                | Typ. | Max. | Min.                 | Typ. | Max. |      |
| $-40\text{ °C}$    | 5.5               | 7.6  | 10.5 | 7.0                 | 9.4  | 12.0 | –                    | 1.8  | –    | mT   |
| $25\text{ °C}$     | 5.8               | 7.6  | 10.0 | 7.0                 | 9.4  | 11.5 | –                    | 1.8  | –    | mT   |
| $170\text{ °C}$    | 5.5               | 7.6  | 10.5 | 7.0                 | 9.4  | 12.0 | –                    | 1.8  | –    | mT   |

The hysteresis is the difference between the switching points  $B_{HYS} = |B_{ON} - B_{OFF}|$

### Note

Regarding switching points, temperature coefficients and B-field switching frequency, customized derivatives via mask option are possible. For more information contact TDK-Micronas.

### 4.13. HAL 1564 Magnetic Characteristics

The unipolar inverted HAL 1564 Hall-switch provides high sensitivity (see Fig. 4–9 on page 24).

The sensor turns to low current consumption ( $I_{SUPlo}$ ) with the magnetic south pole on the top side of the package and turns to high current consumption ( $I_{SUPhi}$ ) if the magnetic field is removed. It does not respond to the magnetic north pole on the top side of the package.

For correct functioning in the application, the sensor requires only the magnetic south pole on the top side of the package.

#### Magnetic Features:

- switching type: unipolar inverted
- high sensitivity
- typical  $B_{ON}$ : 4.1 mT at room temperature
- typical  $B_{OFF}$ : 6.0 mT at room temperature
- operates with static magnetic fields and dynamic magnetic fields up to 12 kHz
- typical temperature coefficient of magnetic switching points is  $-1000$  ppm/K

#### Applications

The HAL 1564 is the optimal sensor for all applications with one magnetic polarity and weak magnetic amplitude at the sensor position where an inverted output signal is required, such as:

- applications with large air gap or weak magnets
- brake pedal position detection (brake light switch)
- seat belt presence detection
- seat position detection
- break fluid level switch

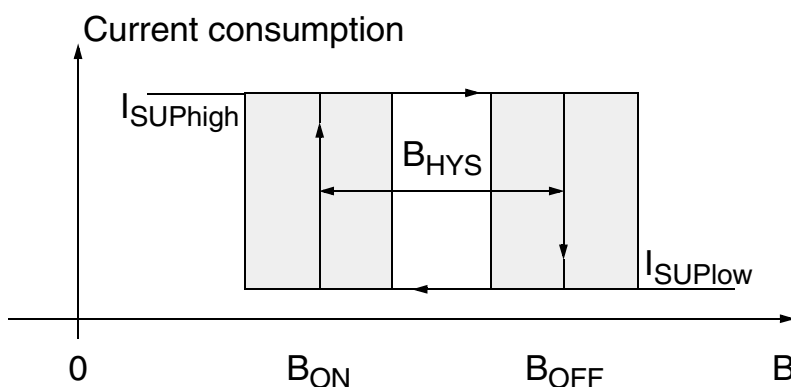


Fig. 4–9: Definition of magnetic switching points for the HAL 1564



### Magnetic Characteristics

at  $T_J = -40\text{ °C}$  to  $170\text{ °C}$ ,  $V_{SUP} = 3.0\text{ V}$  to  $24\text{ V}$ ,  
 Typical Characteristics for  $V_{SUP} = 12.0\text{ V}$

Magnetic flux density values of switching points:

Positive flux density values refer to the magnetic south pole at the top side of the package.

| Parameter<br>$T_J$ | On point $B_{ON}$ |      |      | Off point $B_{OFF}$ |      |      | Hysteresis $B_{HYS}$ |      |      | Unit |
|--------------------|-------------------|------|------|---------------------|------|------|----------------------|------|------|------|
|                    | Min.              | Typ. | Max. | Min.                | Typ. | Max. | Min.                 | Typ. | Max. |      |
| $-40\text{ °C}$    | 3.2               | 4.5  | 6.7  | 5.0                 | 6.4  | 8.5  | –                    | 1.9  | –    | mT   |
| $25\text{ °C}$     | 2.9               | 4.1  | 6.1  | 4.3                 | 6.0  | 7.7  | –                    | 1.9  | –    | mT   |
| $170\text{ °C}$    | 2.4               | 4.0  | 6.4  | 3.7                 | 5.6  | 7.7  | –                    | 1.6  | –    | mT   |

The hysteresis is the difference between the switching points  $B_{HYS} = |B_{ON} - B_{OFF}|$

### Note

Regarding switching points, temperature coefficients and B-field switching frequency, customized derivatives via mask option are possible. For more information contact TDK-Micronas.

#### 4.14. HAL 1565 Magnetic Characteristics

The unipolar HAL 1565 is a high-sensitive unipolar switching sensor (see Fig. 4–10 on page 26).

The sensor turns to high current consumption ( $I_{\text{SUPhi}}$ ) with the magnetic south pole on the top side of the package and turns to low current consumption ( $I_{\text{SUPlo}}$ ) if the magnetic field is removed. It does not respond to the magnetic north pole on the top side of the package.

For correct functioning in the application, the sensor requires only the magnetic south pole on the top side of the package.

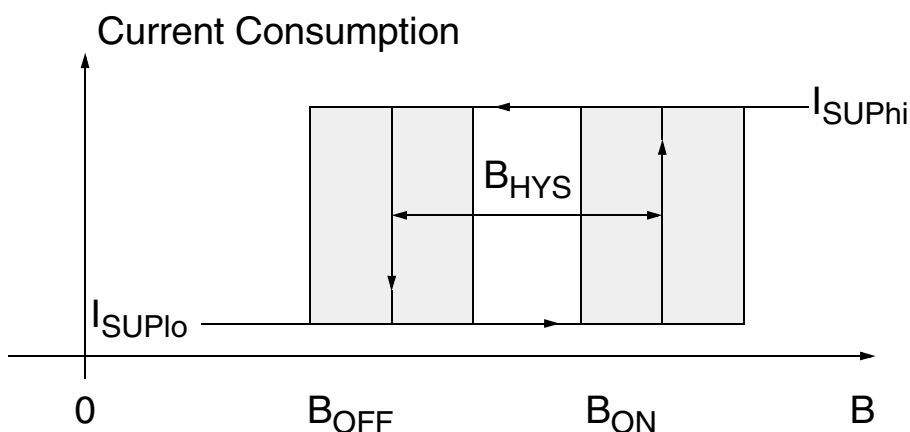
##### Magnetic Features:

- switching type: unipolar
- high sensitivity
- typical  $B_{\text{ON}}$ : 6.0 mT at room temperature
- typical  $B_{\text{OFF}}$ : 4.1 mT at room temperature
- operates with static magnetic fields and dynamic magnetic fields up to 12 kHz
- typical temperature coefficient of magnetic switching points is  $-1000$  ppm/K

##### Applications

The HAL 1565 is the optimal sensor for all applications with one magnetic polarity and weak magnetic amplitude at the sensor position, such as:

- seat belt presence detection
- flow measurement
- door lock
- roof top open/close



**Fig. 4–10:** Definition of magnetic switching points for the HAL 1565

### Magnetic Characteristics

at  $T_J = -40\text{ °C}$  to  $170\text{ °C}$ ,  $V_{SUP} = 3.0\text{ V}$  to  $24.0\text{ V}$ ,  
 Typical Characteristics for  $V_{SUP} = 12.0\text{ V}$

Magnetic flux density values of switching points:

Positive flux density values refer to the magnetic south pole at the top side of the package.

| Parameter<br>$T_J$ | On point $B_{ON}$ |      |      | Off point $B_{OFF}$ |      |      | Hysteresis $B_{HYS}$ |      |      | Unit |
|--------------------|-------------------|------|------|---------------------|------|------|----------------------|------|------|------|
|                    | Min.              | Typ. | Max. | Min.                | Typ. | Max. | Min.                 | Typ. | Max. |      |
| $-40\text{ °C}$    | 5.0               | 6.4  | 8.5  | 3.2                 | 4.5  | 6.7  | –                    | 1.9  | –    | mT   |
| $25\text{ °C}$     | 4.3               | 6.0  | 7.7  | 2.9                 | 4.1  | 6.1  | –                    | 1.9  | –    | mT   |
| $170\text{ °C}$    | 3.7               | 5.6  | 7.7  | 2.4                 | 4.0  | 6.4  | –                    | 1.9  | –    | mT   |

The hysteresis is the difference between the switching points  $B_{HYS} = |B_{ON} - B_{OFF}|$

### Note

Regarding switching points, temperature coefficients and B-field switching frequency, customized derivatives via mask option are possible. For more information contact TDK-Micronas.

## 4.15. HAL 1566 Magnetic Characteristics

The unipolar HAL 1566 is a high-sensitive unipolar switching sensor (see Fig. 4–11 on page 28).

The sensor turns to high current consumption ( $I_{\text{SUPhi}}$ ) with the magnetic south pole on the top side of the package and turns to low current consumption ( $I_{\text{SUPlo}}$ ) if the magnetic field is removed. It does not respond to the magnetic north pole on the top side of the package.

For correct functioning in the application, the sensor requires only the magnetic south pole on the top side of the package.

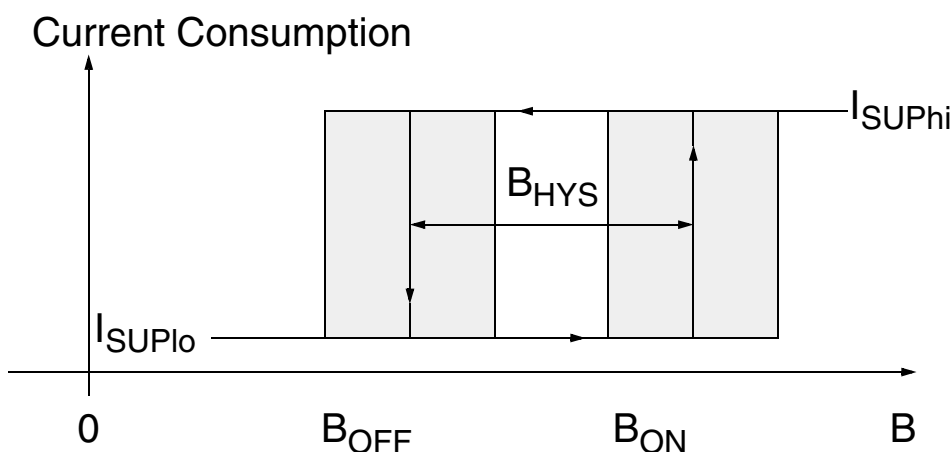
### Magnetic Features:

- switching type: unipolar
- high sensitivity
- typical  $B_{\text{ON}}$ : 9.4 mT at room temperature
- typical  $B_{\text{OFF}}$ : 7.6 mT at room temperature
- operates with static magnetic fields and dynamic magnetic fields up to 12 kHz
- typical temperature coefficient of magnetic switching points is 0 ppm/K

### Applications

The HAL 1566 is the optimal sensor for all applications with one magnetic polarity and weak magnetic amplitude at the sensor position, such as:

- seat belt presence detection
- seat position
- electric sun roof
- gear shift lever



**Fig. 4–11:** Definition of magnetic switching points for the HAL 1566

### Magnetic Characteristics

at  $T_J = -40\text{ °C}$  to  $170\text{ °C}$ ,  $V_{SUP} = 3.0\text{ V}$  to  $24.0\text{ V}$ ,  
 Typical Characteristics for  $V_{SUP} = 12.0\text{ V}$

Magnetic flux density values of switching points:

Positive flux density values refer to the magnetic south pole at the top side of the package.

| Parameter<br>$T_J$ | On point $B_{ON}$ |      |      | Off point $B_{OFF}$ |      |      | Hysteresis $B_{HYS}$ |      |      | Unit |
|--------------------|-------------------|------|------|---------------------|------|------|----------------------|------|------|------|
|                    | Min.              | Typ. | Max. | Min.                | Typ. | Max. | Min.                 | Typ. | Max. |      |
| $-40\text{ °C}$    | 7.0               | 9.4  | 12.0 | 5.5                 | 7.6  | 10.5 | –                    | 1.8  | –    | mT   |
| $25\text{ °C}$     | 7.3               | 9.4  | 11.5 | 5.8                 | 7.6  | 10.0 | –                    | 1.8  | –    | mT   |
| $170\text{ °C}$    | 7.0               | 9.4  | 12.0 | 5.5                 | 7.6  | 10.5 | –                    | 1.8  | –    | mT   |

The hysteresis is the difference between the switching points  $B_{HYS} = |B_{ON} - B_{OFF}|$

### Note

Regarding switching points, temperature coefficients and B-field switching frequency, customized derivatives via mask option are possible. For more information contact TDK-Micronas.

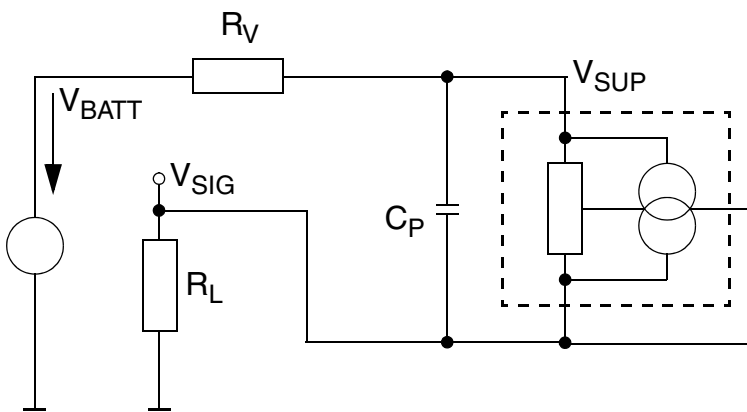
## 5. Application Notes

### 5.1. Application Circuits

For applications with disturbances on the supply line or radiated disturbances, a series resistor  $R_V$  and a capacitor  $C_P$  both placed close to the sensor are recommended (see Fig. 5–1). In this case, the maximum  $R_L$  can be calculated as:

$$R_{Lmax} = \frac{V_{BATTmin} - V_{SUPmin}}{I_{SUPhimax}} - R_V$$

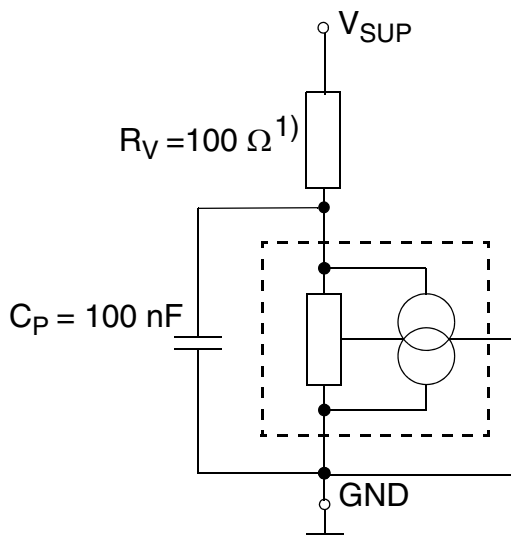
For example:  $R_V = 100 \Omega$  and  $C_P = 47 \text{ nF}$



**Fig. 5–1:** Example application circuit

### 5.1.1. ESD System Level Application Circuit (ISO10605-2008)

For an ESD system level application circuit according to ISO10605-2008 a 100 nF capacitor at VSUP is necessary.



<sup>1)</sup> required for 40 V load dump capability

**Fig. 5–2:** Application circuit with external resistor

## 5.2. Ambient Temperature

Due to the internal power dissipation, the temperature on the silicon chip (junction temperature  $T_J$ ) is higher than the temperature outside the package (ambient temperature  $T_A$ ).

$$T_J = T_A + \Delta T$$

Under static conditions and continuous operation, the following equation applies:

$$\Delta T = \left[ \left( I_{SUPhi} \times \frac{t_{high}}{t_{period}} \right) + \left( I_{SUPlo} \times \frac{t_{low}}{t_{period}} \right) \right] \times V_{SUP} \times R_{thja}$$

For all sensors, the junction temperature range  $T_J$  is specified. The maximum ambient temperature  $T_{Amax}$  can be calculated as:

$$T_{Amax} = T_{Jmax} - \Delta T$$

For typical values, use the typical parameters. For worst case calculation, use the max. parameters according to the application conditions.

Example calculation for  $\Delta T$  with  $I_{SUPhi}=17$  mA ( $t_{high}=20\%$ ),  $I_{SUPlo}=7$  mA ( $t_{low}=80\%$ ),  $V_{SUP}=5$  V,  $R_{th}=300$  K/W

$$\Delta T = [(0.017 \text{ A} \times 0.2) + (0.007 \text{ A} \times 0.8)] \times 5 \text{ V} \times 300 \text{ K/W} = 13.5 \text{ K}$$

$$T_{Amax} = 170 \text{ °C} - 13.5 \text{ °C} = 156.5 \text{ °C}$$

For 2-wire devices self-heating can be critical due to the range of  $I_{SUPhi}$ . The junction temperature can be reduced with pulsed supply voltage. For supply times ( $t_{on}$ ) of e.g. 120  $\mu$ s, the following equation can be used:

$$\Delta T = I_{SUPhi} \times V_{SUP} \times R_{thja} \times \frac{t_{on}}{t_{off} + t_{on}}$$



### 5.3. Start-Up Behavior

For supply voltages below the undervoltage threshold  $V_{UV}$ , the current consumption is undefined. After exceeding  $V_{UV}$ , the sensor has an enable time ( $t_{en}$ ). During the enable time, the current consumption is defined as error current ( $I_{SUP}$ ).

After  $t_{en}$ , the current consumption will be  $I_{SUPhi}$  if the applied magnetic field  $B$  is above  $B_{ON}$ . The current consumption will be  $I_{SUPlo}$  if  $B$  is below  $B_{OFF}$ . In case of sensors with an inverted switching behavior, the current consumption will be  $I_{SUPlow}$  if  $B > B_{OFF}$  and  $I_{SUPhi}$  if  $B < B_{ON}$ .

After  $t_{en}$  and magnetic fields between  $B_{OFF}$  and  $B_{ON}$ , the current consumption of the HAL 156y sensor will be either  $I_{SUPhi}$  or  $I_{SUPlo}$ . Any transition of magnetic switching points above  $B_{ON}$ , respectively, below  $B_{OFF}$  will change the corresponding current consumption.

### 5.4. EMC and ESD

For applications with disturbances on the supply line or radiated disturbances, a series resistor and a capacitor are recommended. The series resistor and the capacitor should be placed as closely as possible to the HAL sensor.

Special application arrangements were evaluated to pass EMC tests according to different standards, such as ISO 7637, ISO 16750, IEC 61967, ISO 11452 and ISO 62132.

## 6. Document History

1. Data Sheet: "HAL 156y, Hall-Effect Switches with Current Interface (2-wire) in SOT23 Package, Feb. 27, 2018; DSH000194\_001EN. First release of the Data Sheet.
2. Data Sheet: "HAL 156y, Hall-Effect Switches with Current Interface (2-wire) in SOT23 Package", Sept. 6, 2018; DSH000194\_002EN. Second release of the Data Sheet.  
Major change:
  - Table 2–4 on page 7: 'Example for Product Marking' updated