DATA SHEET

# HAL54x
# Hall Effect Sensor Family

Edition Sept. 13, 2004
6251-605-2DS

MICRONAS

## Contents

**Hall Effect Sensor Family**

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

## 1. Introduction

The HAL54x family consists of different Hall switches produced in CMOS technology. All sensors include a temperature-compensated Hall plate with active offset compensation, a comparator, and an open-drain output transistor. The comparator compares the actual magnetic flux through the Hall plate (Hall voltage) with the fixed reference values (switching points). Accordingly, the output transistor is switched on or off.

In addition to the HAL50x/51x family, the HAL54x features a power-on and undervoltage reset.

The sensors of this family differ in the switching behavior and the switching points.

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 4.3 V to 24 V in the ambient temperature range from –40°C up to 150°C.

All sensors are available in the SMD-package SOT89B-1 and in the leaded versions TO92UA-1 and TO92UA-2.

### 1.1. Features

– switching offset compensation at typically 62 kHz

– operates from 4.3 V to 24 V supply voltage

– overvoltage protection at all pins

– reverse-voltage protection at $V_{DD}$-pin

– magnetic characteristics are robust against mechanical stress effects

– short-circuit protected open-drain output by thermal shut down

– operates with static magnetic fields and dynamic magnetic fields up to 10 kHz

– constant switching points over a wide supply voltage range

– the decrease of magnetic flux density caused by rising temperature in the sensor system is compensated by a built-in negative temperature coefficient of the magnetic characteristics

– ideal sensor for applications in extreme automotive and industrial environments

– EMC corresponding to ISO 7637

### 1.2. Family Overview

The types differ according to the magnetic flux density values for the magnetic switching points and the temperature behavior of the magnetic switching points.

| Type | Switching Behavior | Sensitivity | see Page |
|---|---|---|---|
| 542 | latching | high | 18 |
| 543 | unipolar | low | 20 |
| 546 | unipolar | high | 22 |
| 548 | unipolar | medium | 24 |

**Latching Sensors:**

The output turns low with the magnetic south pole on the branded side of the package and turns high with the magnetic north pole on the branded 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.

**Unipolar Sensors:**

The output turns low with the magnetic south pole on the branded side of the package and turns high if the magnetic field is removed. The sensor does not respond to the magnetic north pole on the branded side.

### 1.3. Marking Code

All Hall sensors have a marking on the package surface (branded side). This marking includes the name of the sensor and the temperature range.

| Type | Temperature Range | |
|---|---|---|
| | K | E |
| HAL542 | 542K | 542E |
| HAL543 | 543K | 543E |
| HAL546 | 546K | 546E |
| HAL548 | 548K | 548E |

#### 1.3.1. Special Marking of Prototype Parts

Prototype parts are coded with an underscore beneath the temperature range letter on each IC. They may be used for lab experiments and design-ins but are not intended to be used for qualification tests or as production parts.

### 1.4. Operating Junction Temperature Range

The Hall sensors from Micronas are specified to the chip temperature (junction temperature $T_J$).

**K:** $T_J$ = –40 °C to +140 °C

**E:** $T_J$ = –40 °C to +100 °C

**Note:** Due to power dissipation, there is a difference between the ambient temperature ($T_A$) and junction temperature. Please refer to section 5.1. on page 26 for details.

### 1.5. Hall Sensor Package Codes

HALXXXPA-T

Temperature Range: K or E

Package: SF for SOT89B-1
UA for TO92UA

Type: 54x

Example: **HAL542UA-K**

→ Type: 542
→ Package: TO92UA
→ Temperature Range: $T_J$ = –40 °C to +140 °C

Hall sensors are available in a wide variety of packaging versions and quantities. For more detailed information, please refer to the brochure: "Hall Sensors: Ordering Codes, Packaging, Handling".

### 1.6. Solderability

all packages: according to IEC68-2-58

During soldering reflow processing and manual reworking, a component body temperature of 260 °C should not be exceeded.

### 1.7. Pin Connections

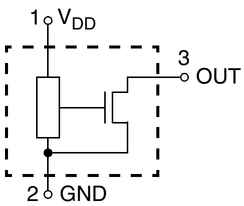



**Fig. 1–1:** Pin configuration

## 2. Functional Description

The Hall effect sensor is a monolithic integrated circuit that switches 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. The temperature-dependent bias increases the supply voltage of the Hall plates and adjusts the switching points to the decreasing induction of magnets at higher temperatures. If the magnetic field exceeds the threshold levels, the open drain output switches to the appropriate state. The built-in hysteresis eliminates oscillation and provides switching behavior of output without bouncing.

Magnetic offset caused by mechanical stress is compensated for by using the “switching offset compensation technique”. Therefore, an internal oscillator provides a two phase clock. The Hall voltage is sampled at the end of the first phase. At the end of the second phase, both sampled and actual Hall voltages are averaged and compared with the actual switching point. Subsequently, the open drain output switches to the appropriate state. The time from crossing the magnetic switching level to switching of output can vary between zero and $1/f_{osc}$.

Shunt protection devices clamp voltage peaks at the Output-pin and $V_{DD}$-pin together with external series resistors. Reverse current is limited at the $V_{DD}$-pin by an internal series resistor up to –15 V. No external reverse protection diode is needed at the $V_{DD}$-pin for reverse voltages ranging from 0 V to –15 V.

A built-in reset-circuit clamps the output to the “high” state (reset state) during power-on or when the supply voltage drops below a reset voltage of $V_{reset}$ < 4.3 V.

For supply voltages between $V_{reset}$ and 4.3 V, the output state of the device responds to the magnetic field. For supply voltages above 4.3 V, the device works according to the specified characteristics.

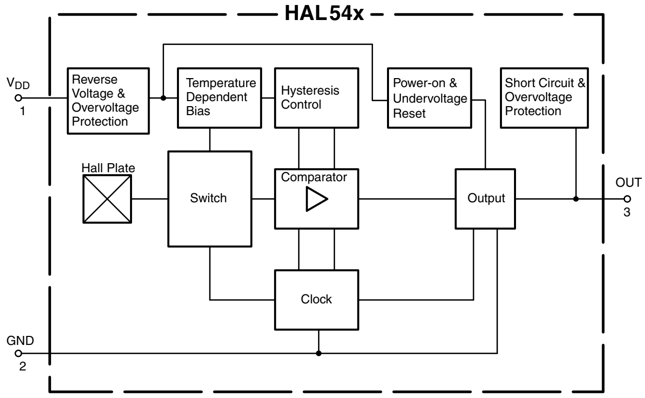



**Fig. 2–1:** HAL54x block diagram

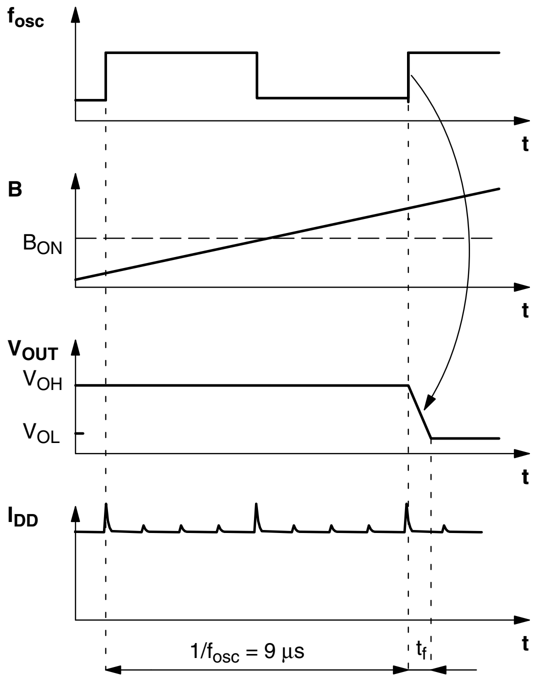
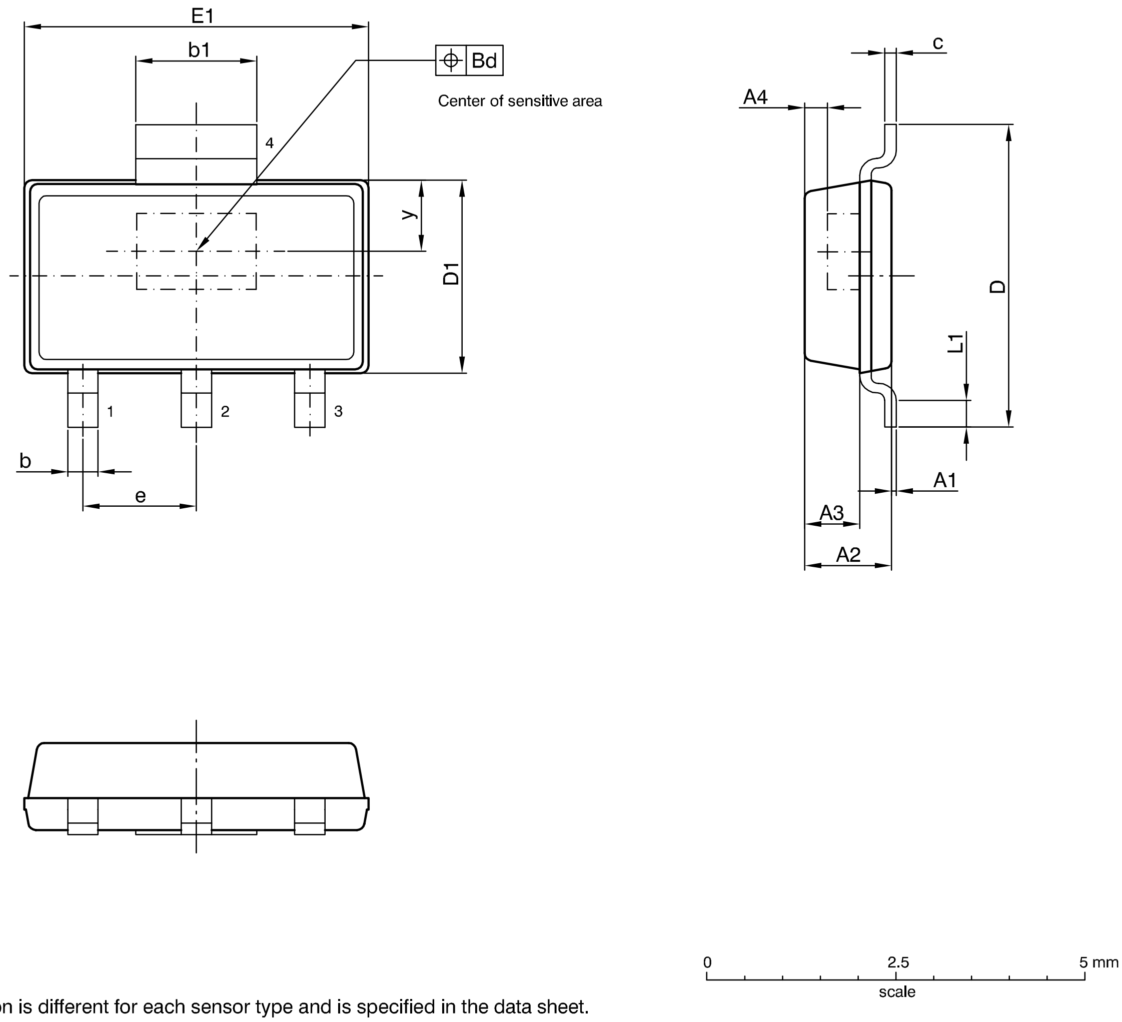



**Fig. 2–2:** Timing diagram

## 3. Specifications

### 3.1. Outline Dimensions




y= this dimension is different for each sensor type and is specified in the data sheet.

| UNIT | A1 | A2 | A3 | A4 | b | b1 | Bd | c | D | D1 | e | E1 | L1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| mm | 0.10<br>0.02 | 1.20<br>1.10 | 0.755<br>0.705 | 0.3 | 0.4 | 1.7 | 0.2 | 0.15 | 4.0 | 2.6<br>2.5 | 1.5 | 4.6<br>4.5 | 0.25<br>min. |

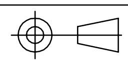
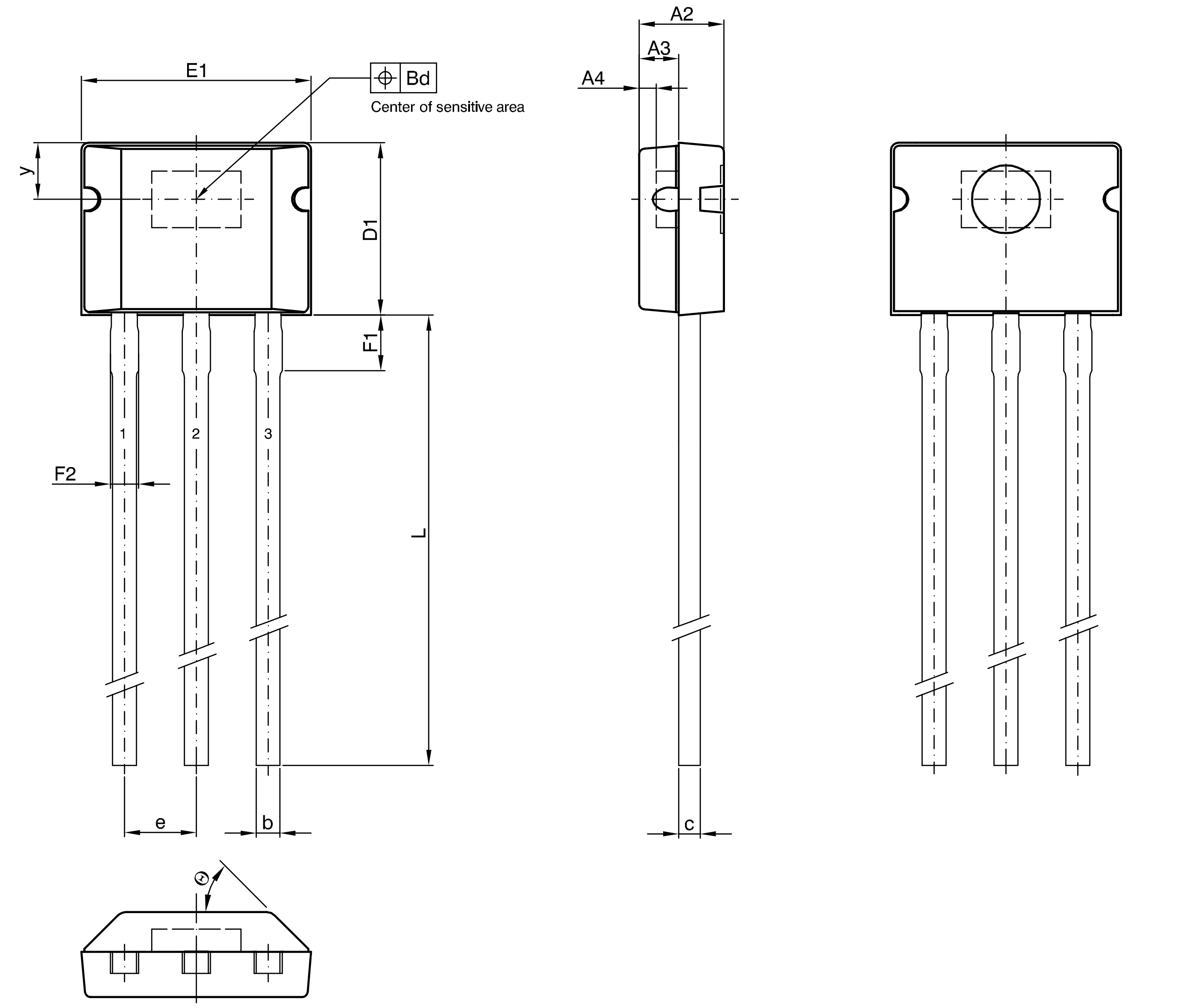
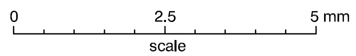
| JEDEC STANDARD | | ANSI | ISSUE DATE YY-MM-DD | DRAWING-NO. | SPZG-NO. |
|---|---|---|---|---|---|
| ISSUE | ITEM NO. | | | | |
| - | - |  | 03-03-10 | 06610.0001.4 | SPZG001010_001_01 |

**Fig. 3–1:**
**SOT89B-1**: Plastic **S**mall **O**utline **T**ransistor package, 4 leads
Weight approximately 0.039 g



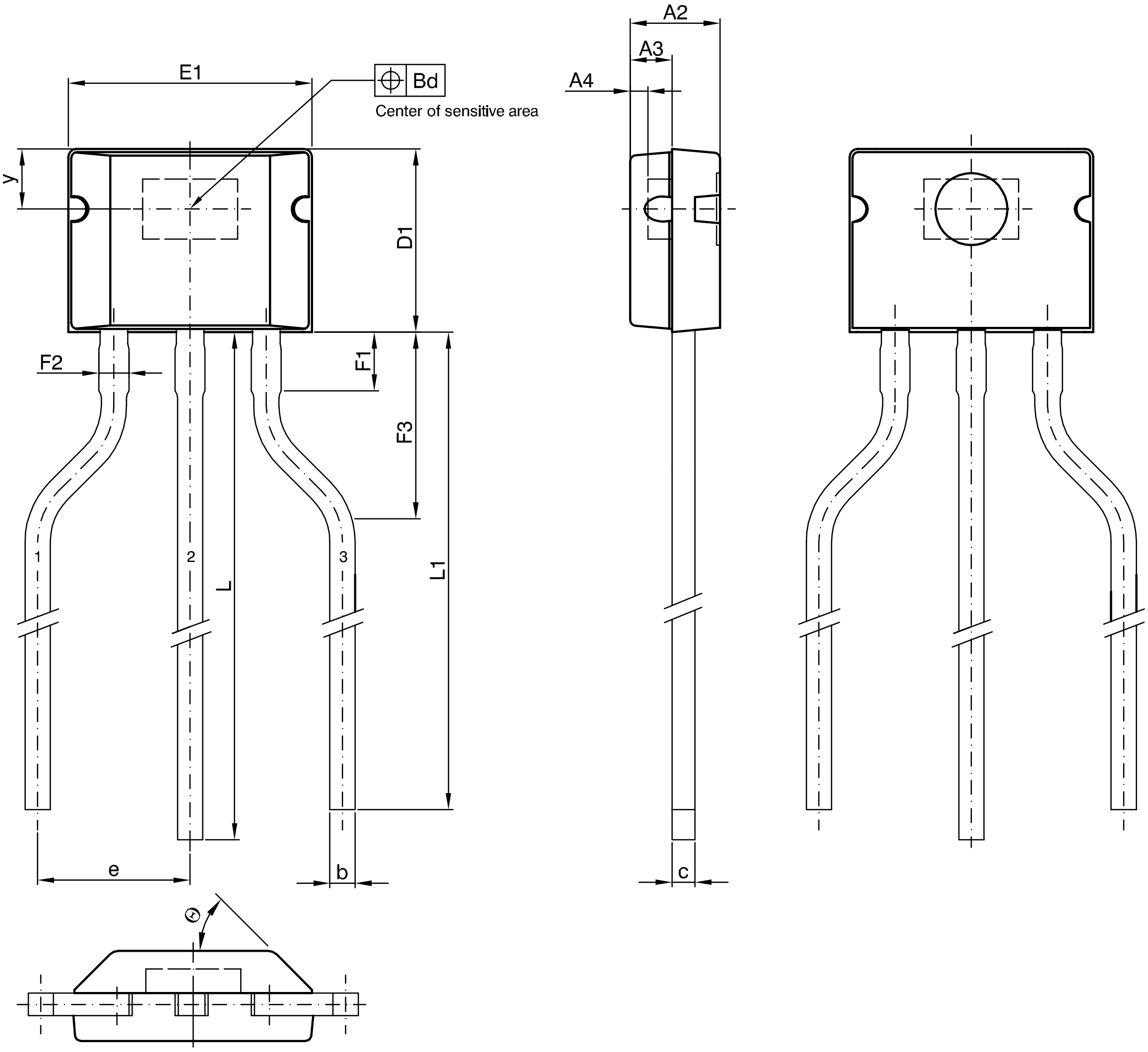

solderability is guaranteed between end of pin and distance F1.

y= this dimension is different for each sensor type and is specified in the data sheet.

| UNIT | A2 | A3 | A4 | b | Bd | c | D1 | e | E1 | F1 | F2 | L | Θ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| mm | 1.55<br>1.45 | 0.7 | 0.3 | 0.42 | 0.2 | 0.36 | 3.1<br>3.0 | 1.27 | 4.11<br>4.01 | 1.2<br>0.8 | 0.60<br>0.42 | 15.5<br>min | 45° |

| JEDEC STANDARD | | ANSI | ISSUE DATE YY-MM-DD | DRAWING-NO. | SPZG-NO. |
|---|---|---|---|---|---|
| ISSUE | ITEM NO. | | | | |
| - | - | | 03-11-18 | 06612.0001.4 | SPZG001012_001_03 |

**Fig. 3–2:**
**TO92UA-2**: Plastic Transistor Standard UA package, 3 leads, not spread
Weight approximately 0.105 g




0 2.5 5 mm
scale

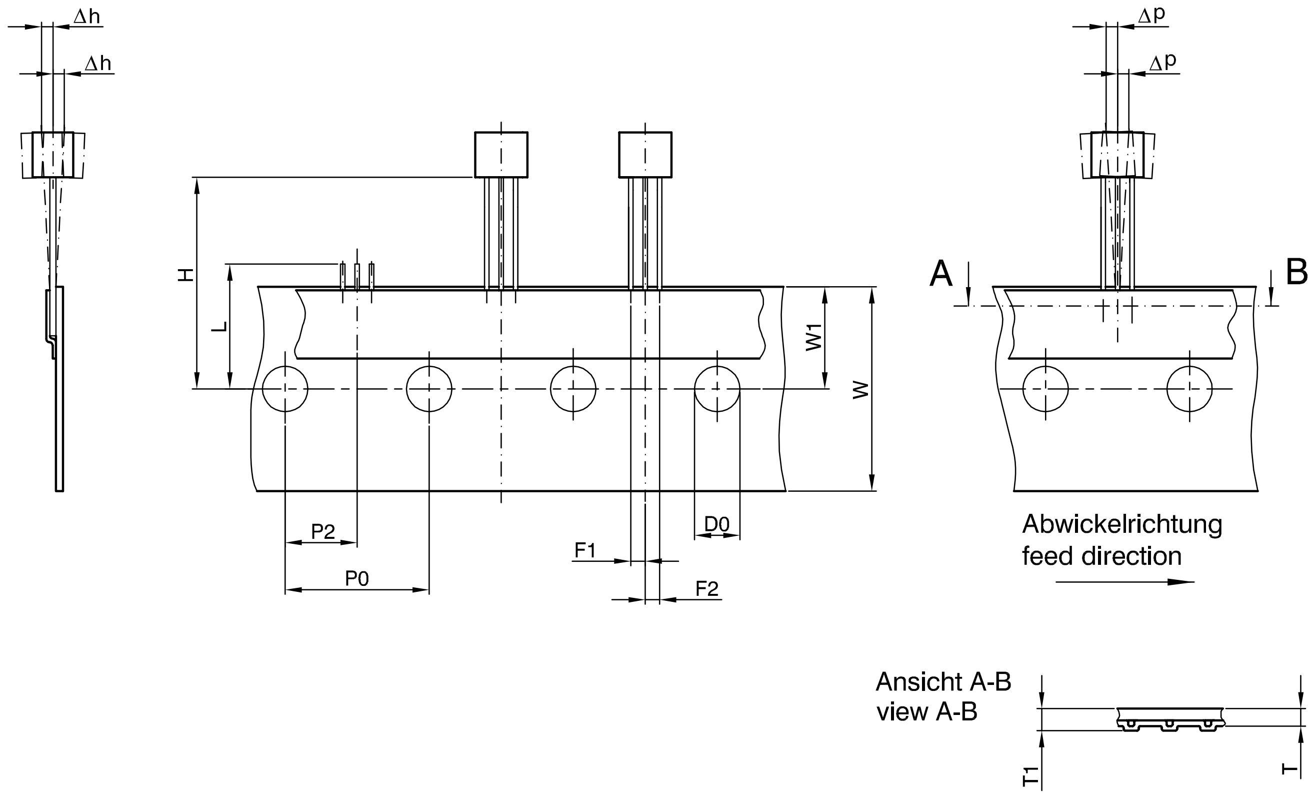
solderability is guaranteed between end of pin and distance F1.

y= this dimension is different for each sensor type and is specified in the data sheet.

| UNIT | A2 | A3 | A4 | b | Bd | c | D1 | e | E1 | F1 | F2 | F3 | L | L1 | Θ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| mm | 1.55<br>1.45 | 0.7 | 0.3 | 0.42 | 0.2 | 0.36 | 3.1<br>3.0 | 2.54 | 4.11<br>4.01 | 1.2<br>0.8 | 0.60<br>0.42 | 4.0<br>2.0 | 15.5<br>min | 14.5<br>min | 45° |

| JEDEC STANDARD | | ANSI | ISSUE DATE<br>YY-MM-DD | DRAWING-NO. | SPZG-NO. |
|---|---|---|---|---|---|
| ISSUE | ITEM NO. | | | | |
| - | - | | 03-11-18 | 06616.0001.4 | SPZG001016_001_02 |

**Fig. 3–3:**
**TO92UA-1**: Plastic Transistor Standard UA package, 3 leads, spread
Weight approximately 0.105 g



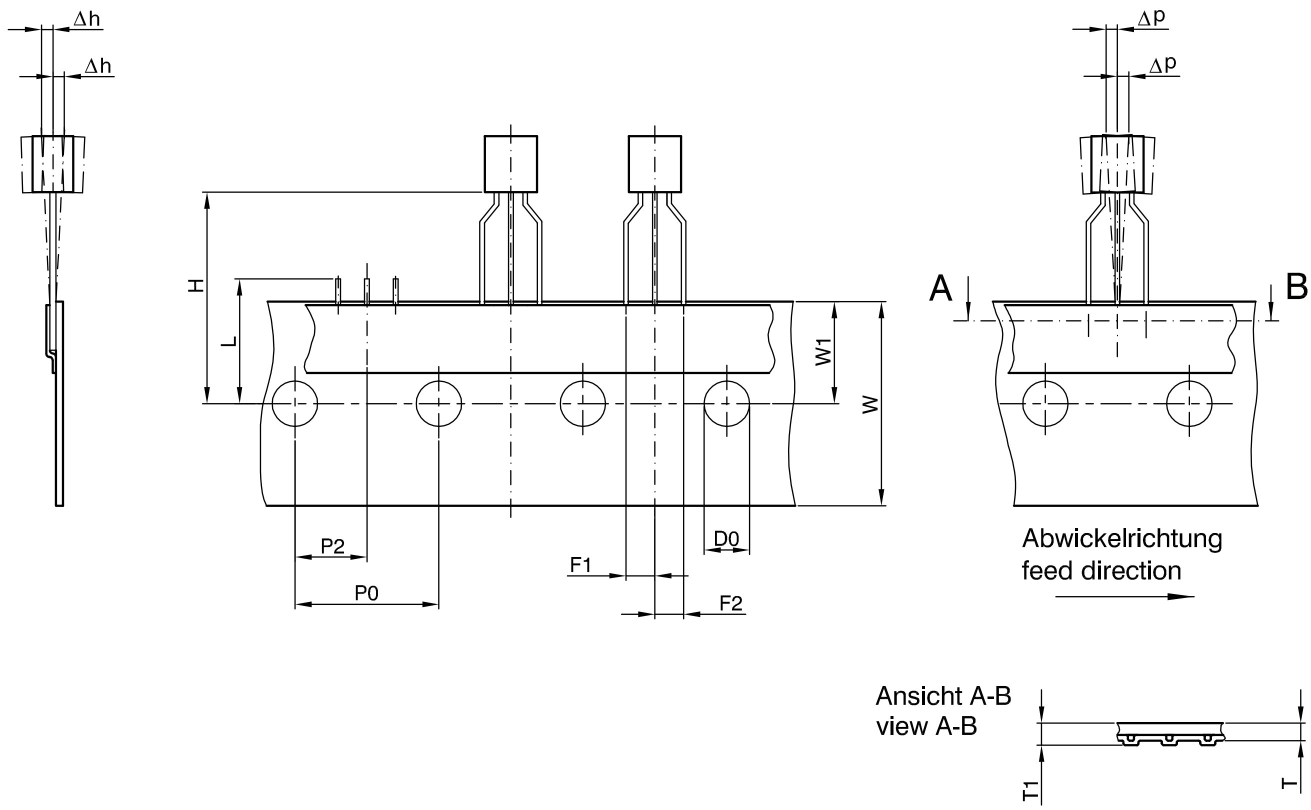

alle Maße in mm / all dimensions in mm

max. zul. Abweichung über 20 Lochabstände ±1.0 / max. allowed tolerance over 20 hole spacings ±1.0

| UNIT | D0 | F1 | F2 | H | Δh | L | P0 | P2 | Δp | T | T1 | W | W1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| mm | 4.0 | 1.47<br>1.07 | 1.47<br>1.07 | 20.0<br>18.0 | ±1.0 | 11.0<br>max | 13.2<br>12.2 | 7.05<br>5.65 | ±1.0 | 0.5 | 0.9 | 18.0 | 9.0 |

| JEDEC STANDARD | | ANSI | ISSUE DATE<br>YY-MM-DD | DRAWING-NO. | SPZG-NO. |
|---|---|---|---|---|---|
| ISSUE | ITEM NO. | | | | |
| - | ICE 60286-2 | | 03-09-12 | 06631.0001.4 | SPZG001031_001_02 |

**Fig. 3–4:**
**TO92UA-2**: Dimensions ammopack inline, not spread




alle Maße in mm / all dimensions in mm

max. zul. Abweichung über 20 Lochabstände ±1.0 / max. allowed tolerance over 20 hole spacings ±1.0

| UNIT | D0 | F1 | F2 | H | Δh | L | P0 | P2 | Δp | T | T1 | W | W1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| mm | 4.0 | 2.74<br>2.34 | 2.74<br>2.34 | 20.0<br>18.0 | ±1.0 | 11.0<br>max | 13.2<br>12.2 | 7.05<br>5.65 | ±1.0 | 0.5 | 0.9 | 18.0 | 9.0 |

| JEDEC STANDARD | | ANSI | ISSUE DATE YY-MM-DD | DRAWING-NO. | SPZG-NO. |
|---|---|---|---|---|---|
| ISSUE | ITEM NO. | | | | |
| - | ICE 60286-2 | | 03-09-12 | 06632.0001.4 | SPZG001032_001_02 |

**Fig. 3–5:**
**TO92UA-1**: Dimensions ammopack inline, spread

### 3.2. Dimensions of Sensitive Area

0.25 mm × 0.12 mm

### 3.3. Positions of Sensitive Areas

| | SOT89B-1 | TO92UA-1/-2 |
|---|---|---|
| y | 0.95 mm nominal | 1.0 mm nominal |

### 3.4. 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 be taken to avoid application of any voltage higher than absolute maximum-rated voltages to this high-impedance circuit.

All voltages listed are referenced to ground (GND).

| Symbol | Parameter | Pin No. | Min. | Max. | Unit |
|---|---|---|---|---|---|
| $V_{DD}$ | Supply Voltage | 1 | –15 | 28[1] | V |
| $V_O$ | Output Voltage | 3 | –0.3 | 28[1] | V |
| $I_O$ | Continuous Output On Current | 3 | – | 50[1] | mA |
| $T_J$ | Junction Temperature Range | | –40 | 170 | °C |
| [1] as long as $T_J$max is not exceeded | | | | | |

#### 3.4.1. Storage and Shelf Life

The permissible storage time (shelf life) of the sensors is unlimited, provided the sensors are stored at a maximum of 30 °C and a maximum of 85% relative humidity. At these conditions, no Dry Pack is required.

Solderability is guaranteed for one year from the date code on the package. Solderability has been tested after storing the devices for 16 hours at 155 °C. The wettability was more than 95%.

## 3.5. 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. | Max. | Unit |
|---|---|---|---|---|---|
| $V_{DD}$ | Supply Voltage | 1 | 4.3 | 24 | V |
| $I_O$ | Continuous Output On Current | 3 | 0 | 20 | mA |
| $V_O$ | Output Voltage (output switched off) | 3 | 0 | 24 | V |

### 3.6. Characteristics

at $T_J$ = –40 °C to +140 °C, $V_{DD}$ = 4.3 V to 24 V, GND = 0 V,
at Recommended Operation Conditions if not otherwise specified in the column “Conditions”.
Typical Characteristics for $T_J$ = 25 °C and $V_{DD}$ = 12 V.

| Symbol | Parameter | Pin No. | Min. | Typ. | Max. | Unit | Conditions |
|---|---|---|---|---|---|---|---|
| $I_{DD}$ | Supply Current | 1 | 2.3 | 3 | 4.2 | mA | $T_J$ = 25 °C |
| $I_{DD}$ | Supply Current over Temperature Range | 1 | 1.6 | 3 | 5.2 | mA | |
| $V_{DDZ}$ | Overvoltage Protection at Supply | 1 | – | 28.5 | 32 | V | $I_{DD}$ = 25 mA, $T_J$ = 25 °C, t = 20 ms |
| $V_{OZ}$ | Overvoltage Protection at Output | 3 | – | 28 | 32 | V | $I_{OH}$ = 25 mA, $T_J$ = 25 °C, t = 20 ms |
| $V_{OL}$ | Output Voltage | 3 | – | 130 | 280 | mV | $I_{OL}$ = 20 mA, $T_J$ = 25 °C |
| $V_{OL}$ | Output Voltage over Temperature Range | 3 | – | 130 | 400 | mV | $I_{OL}$ = 20 mA |
| $I_{OH}$ | Output Leakage Current | 3 | – | 0.06 | 0.1 | µA | Output switched off, $T_J$ = 25 °C, $V_{OH}$ = 4.3 to 24 V |
| $I_{OH}$ | Output Leakage Current over Temperature Range | 3 | – | – | 10 | µA | Output switched off, $T_J$ ≤150 °C, $V_{OH}$ = 4.3 to 24 V |
| $f_{osc}$ | Internal Oscillator Chopper Frequency | – | – | 62 | – | kHz | $T_J$ = 25 °C, $V_{DD}$ = 4.5 to 24 V |
| $V_{reset}$ | Reset Voltage | 1 | – | 3.8 | – | V | |
| $t_{en(O)}$ | Enable Time of Output after Setting of $V_{DD}$ | 1 | – | 70 | – | µs | $V_{DD}$ = 12 V [1)] |
| $t_r$ | Output Rise Time | 3 | – | 75 | 400 | ns | $V_{DD}$ = 12 V, $R_L$ = 820 Ohm, $C_L$ = 20 pF |
| $t_f$ | Output Fall Time | 3 | – | 50 | 400 | ns | |
| $R_{thJSB}$ case SOT89B-1 | Thermal Resistance Junction to Substrate Backside | – | – | 150 | 200 | K/W | Fiberglass Substrate 30 mm x 10 mm x 1.5 mm, pad size |
| $R_{thJA}$ case TO92UA-1, TO92UA-2 | Thermal Resistance Junction to Soldering Point | – | – | 150 | 200 | K/W | |

[1)] B > $B_{ON}$ + 2 mT or B < $B_{OFF}$ - 2 mT

### 3.7. Magnetic Characteristics Overview at $T_J$ = –40 °C to +140 °C, $V_{DD}$ = 4.3 V to 24 V, Typical Characteristics for $V_{DD}$ = 12 V

Magnetic flux density values of switching points.
Positive flux density values refer to the magnetic south pole at the branded side of the package.

| Sensor | Parameter | On point $B_{ON}$ | | | Off point $B_{OFF}$ | | | Hysteresis $B_{HYS}$ | | | Unit |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Switching Type | $T_J$ | Min. | Typ. | Max. | Min. | Typ. | Max. | Min. | Typ. | Max. | |
| **HAL542** | –40 °C | 1 | 2.8 | 5 | –5 | –2.8 | –1 | 4.5 | 5.85 | 7.2 | mT |
| latching | 25 °C | 1 | 2.6 | 4.5 | –4.5 | –2.6 | –1 | 4.5 | 5.5 | 6.5 | mT |
| | 140 °C | 0.5 | 2.3 | 4.8 | –4.8 | –2.3 | –0.5 | 3.0 | 4.0 | 6.0 | mT |
| **HAL543** | –40 °C | 21 | 27 | 33 | 15 | 21 | 27 | 4 | 6 | 8 | mT |
| unipolar | 25 °C | 21 | 27 | 33 | 15 | 21 | 27 | 4 | 6 | 8 | mT |
| | 140 °C | 21 | 26 | 33 | 15 | 20 | 27 | 4 | 5.5 | 8 | mT |
| **HAL546** | –40 °C | 4.3 | 5.9 | 7.7 | 2.1 | 3.8 | 5.5 | 1.5 | 2.1 | 2.9 | mT |
| unipolar | 25 °C | 3.8 | 5.5 | 7.2 | 2 | 3.5 | 5 | 1.4 | 2 | 2.8 | mT |
| | 140 °C | 3.2 | 4.8 | 6.9 | 1.8 | 3.1 | 5.5 | 1 | 1.7 | 2.6 | mT |
| **HAL548** | –40 °C | 12 | 19 | 24 | 6 | 13 | 18 | 4 | 6.2 | 8 | mT |
| unipolar | 25 °C | 12 | 18 | 24 | 6 | 12 | 18 | 4 | 5.6 | 8 | mT |
| | 140 °C | 12 | 16 | 24 | 6 | 11 | 18 | 4 | 5 | 8 | mT |

**Note:** For detailed descriptions of the individual types, see pages 18 and following.

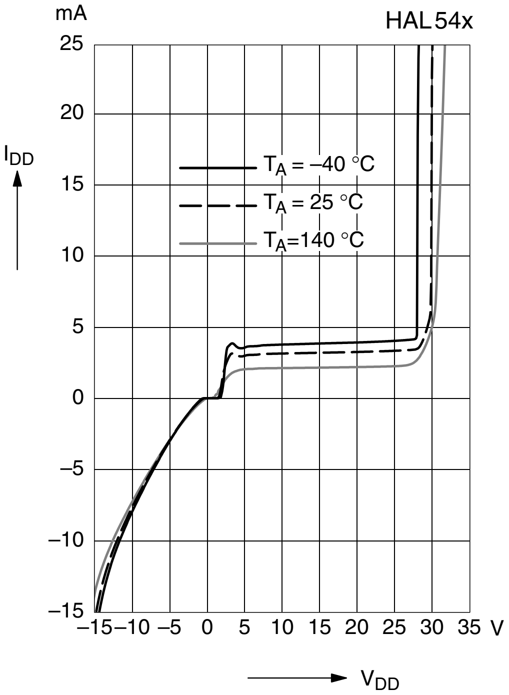



**Fig. 3–6:** Typical supply current versus supply voltage

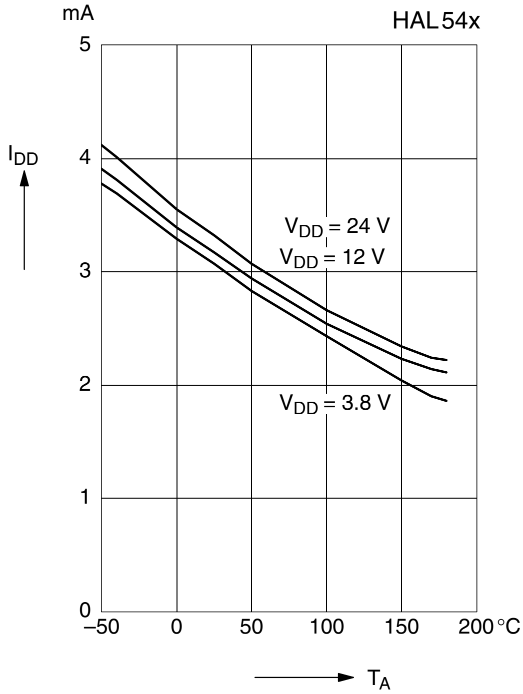



**Fig. 3–8:** Typical supply current versus ambient temperature

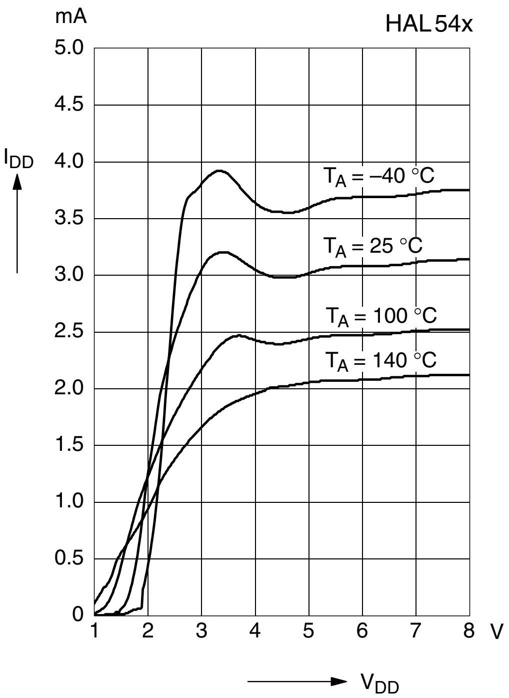



**Fig. 3–7:** Typical supply current versus supply voltage

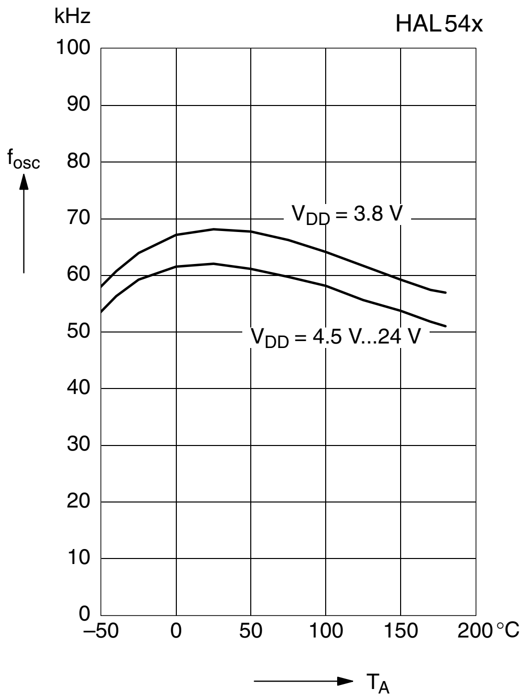



**Fig. 3–9:** Typ. internal chopper frequency versus ambient temperature

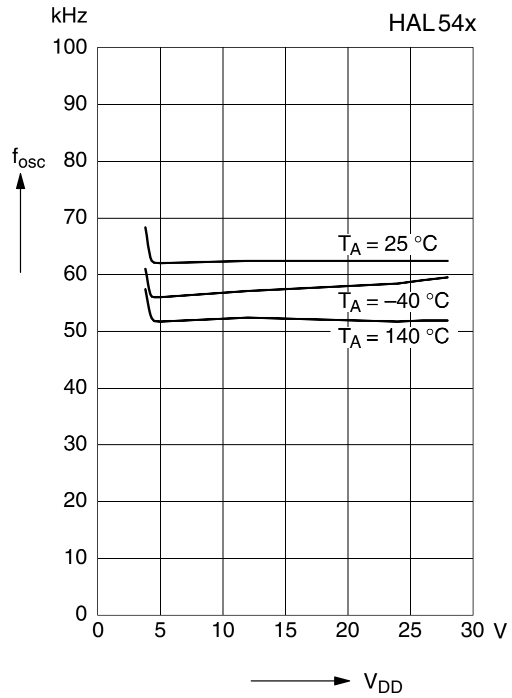



**Fig. 3–10:** Typ. internal chopper frequency versus supply voltage

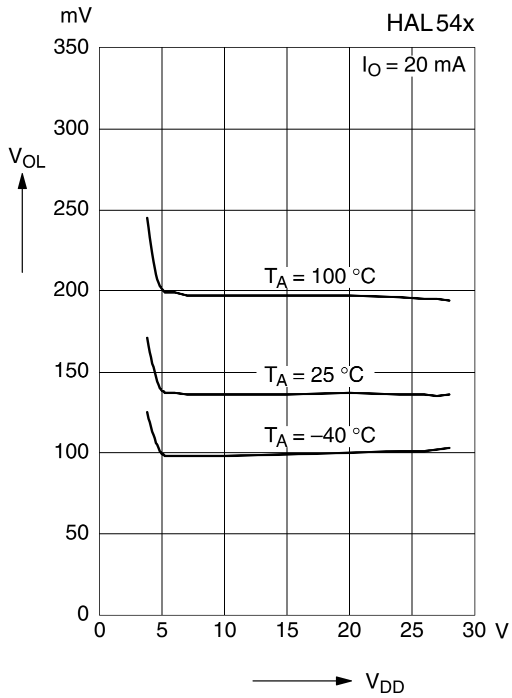



**Fig. 3–12:** Typical output low voltage versus supply voltage

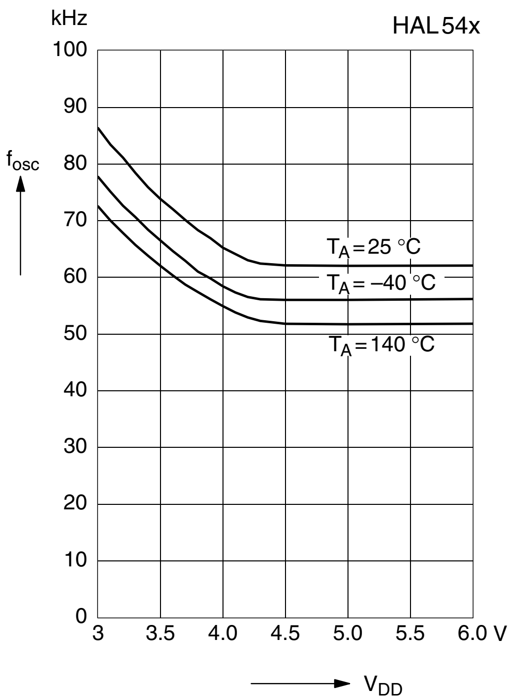



**Fig. 3–11:** Typ. internal chopper frequency versus supply voltage

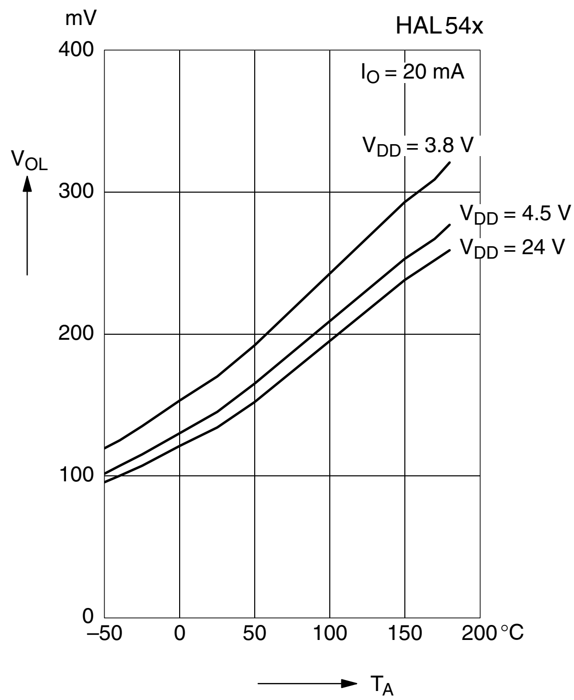



**Fig. 3–13:** Typical output low voltage versus ambient temperature

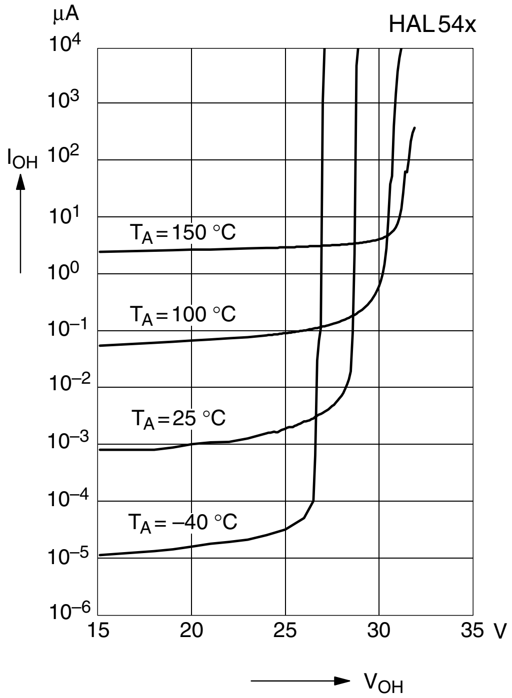



**Fig. 3–14:** Typ. output high current versus output voltage

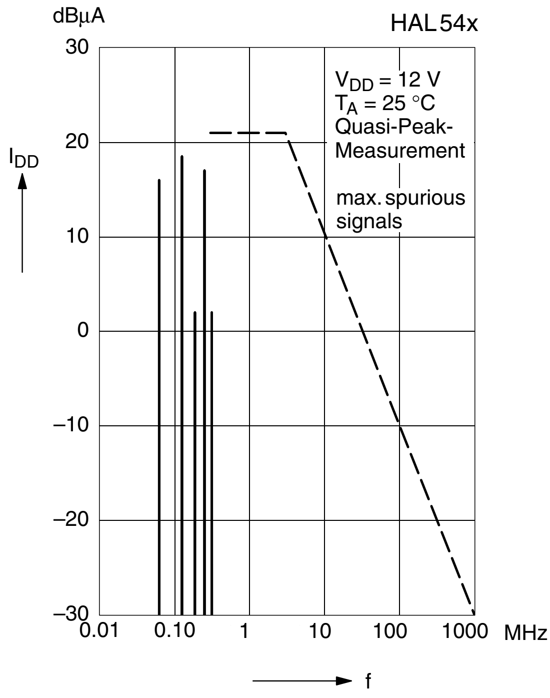



**Fig. 3–16:** Typ. spectrum of supply current

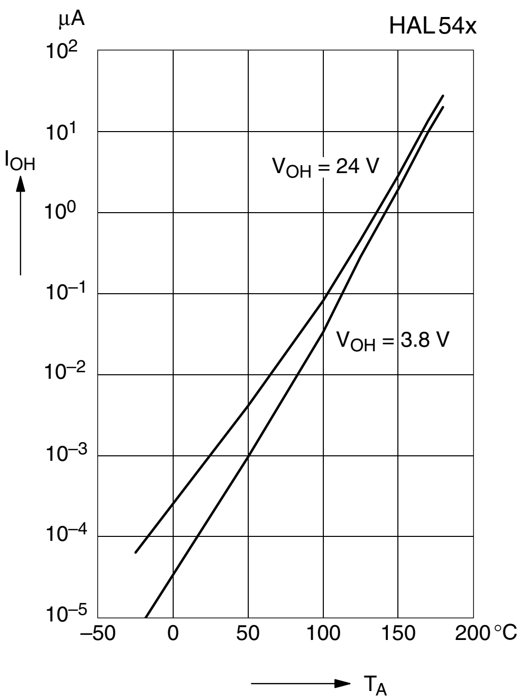



**Fig. 3–15:** Typical output leakage current versus ambient temperature

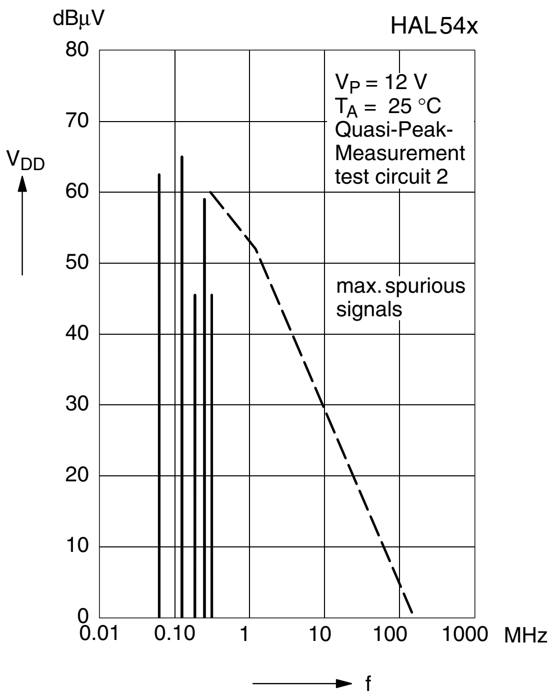



**Fig. 3–17:** Typ. spectrum of supply voltage

## 4. Type Description

### 4.1. HAL 542

The HAL 542 is the most sensitive latching sensor of this family (see Fig. 4–1).

The output turns low with the magnetic south pole on the branded side of the package and turns high with the magnetic north pole on the branded 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 branded side of the package.

**Magnetic Features:**

- switching type: latching
- high sensitivity
- typical $B_{ON}$: 2.6 mT at room temperature
- typical $B_{OFF}$: –2.6 mT at room temperature
- operates with static magnetic fields and dynamic magnetic fields up to 10 kHz
- typical temperature coefficient of magnetic switching points is –1000 ppm/K

**Applications**

The HAL 542 is the optimal sensor for applications with alternating magnetic signals and weak magnetic amplitude at the sensor position such as:

- applications with large airgap or weak magnets,
- rotating speed measurement,
- commutation of brushless DC motors, and
- CAM shaft sensors, and
- magnetic encoders.

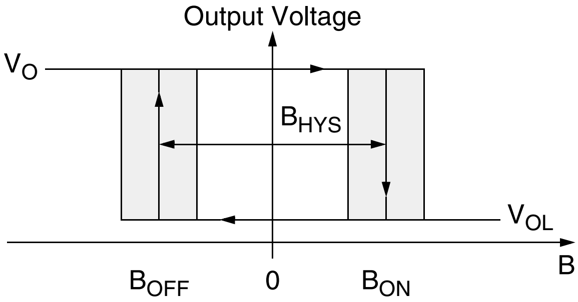



**Fig. 4–1:** Definition of magnetic switching points for the HAL 542

**Magnetic Characteristics** at $T_J$ = –40 °C to +140 °C, $V_{DD}$ = 4.3 V to 24 V,
Typical Characteristics for $V_{DD}$ = 12 V

Magnetic flux density values of switching points.
Positive flux density values refer to the magnetic south pole at the branded side of the package.

| Parameter | On point $B_{ON}$ | | | Off point $B_{OFF}$ | | | Hysteresis $B_{HYS}$ | | | Magnetic Offset | | | Unit |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $T_J$ | Min. | Typ. | Max. | Min. | Typ. | Max. | Min. | Typ. | Max. | Min. | Typ. | Max. | |
| –40 °C | 1 | 2.8 | 5 | –5 | –2.8 | –1 | 4.5 | 5.85 | 7.2 | | 0 | | mT |
| 25 °C | 1 | 2.6 | 4.5 | –4.5 | –2.6 | –1 | 4.5 | 5.5 | 6.5 | –1.5 | 0 | 1.5 | mT |
| 100 °C | 0.95 | 2.5 | 4.4 | –4.4 | –2.5 | –0.95 | 3.7 | 5.0 | 6.3 | | 0 | | mT |
| 140 °C | 0.6 | 2.4 | 4.6 | –4.6 | –2.4 | –0.6 | 3.3 | 4.8 | 6.2 | | 0 | | mT |

The hysteresis is the difference between the switching points $B_{HYS} = B_{ON} – B_{OFF}$
The magnetic offset is the mean value of the switching points $B_{OFFSET} = (B_{ON} + B_{OFF}) / 2$

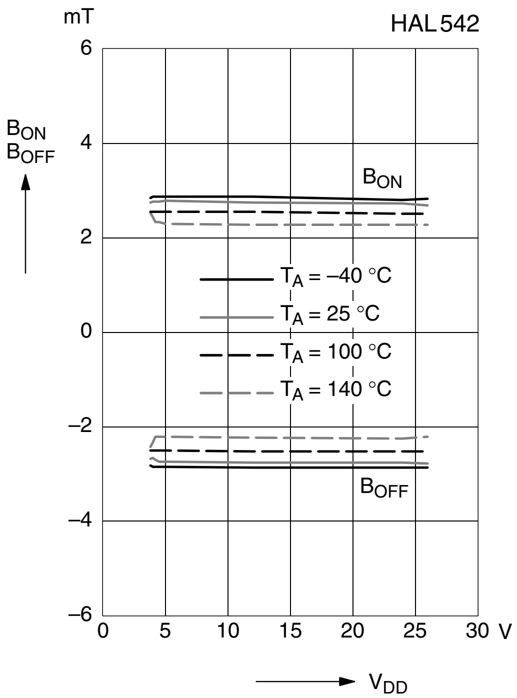



**Fig. 4–2:** Typ. magnetic switching points versus supply voltage

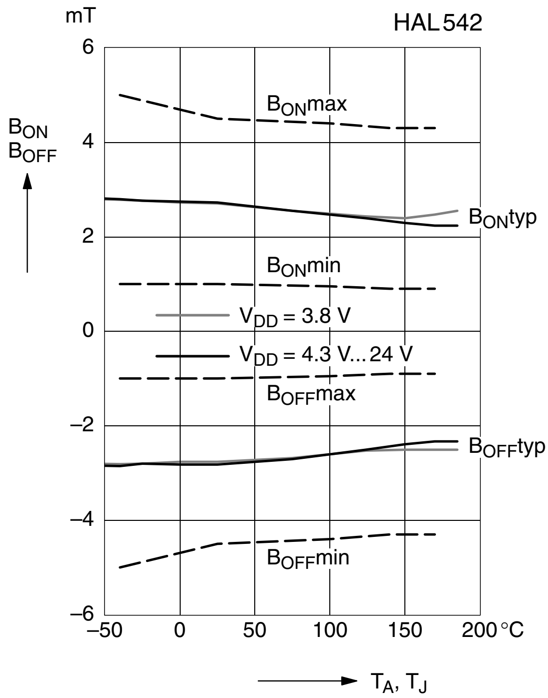



**Fig. 4–3:** Magnetic switching points versus temperature

**Note:** In the diagram "Magnetic switching points versus ambient temperature", the curves for $B_{ON}$min, $B_{ON}$max, $B_{OFF}$min, and $B_{OFF}$max refer to junction temperature, whereas typical curves refer to ambient temperature.

## 4.2. HAL 543

The HAL 543 is the most insensitive unipolar sensor of this family (see Fig. 4–4).

The output turns low with the magnetic south pole on the branded side of the package and turns high if the magnetic field is removed. The sensor does not respond to the magnetic north pole on the branded side.

### Magnetic Features:

– switching type: unipolar
– low sensitivity
– typical $B_{ON}$: 27 mT at room temperature
– typical $B_{OFF}$: 21 mT at room temperature
– operates with static magnetic fields and dynamic magnetic fields up to 10 kHz
– points is –1000 ppm/K

### Applications

The HAL 543 is the optimal sensor for applications with unipolar magnetic signals and large magnetic amplitude at the sensor position such as:

– position and end point detection,
– contactless solution to replace micro switches,
– rotating speed measurement.

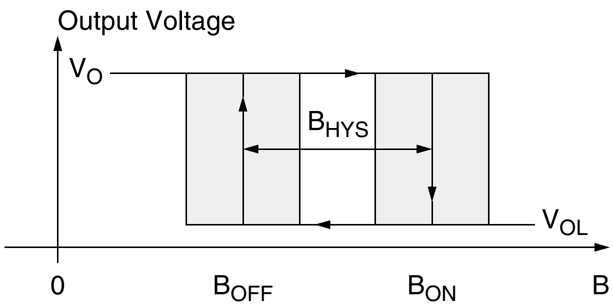



**Fig. 4–4:** Definition of magnetic switching points for the HAL 543

**Magnetic Characteristics** at $T_J$ = –40 °C to +140 °C, $V_{DD}$ = 4.3V to 24 V,
Typical Characteristics for $V_{DD}$ = 12 V

Magnetic flux density values of switching points.
Positive flux density values refer to the magnetic south pole at the branded side of the package.

| Parameter | On point $B_{ON}$ | | | Off point $B_{OFF}$ | | | Hysteresis $B_{HYS}$ | | | Magnetic Offset | | | Unit |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $T_J$ | Min. | Typ. | Max. | Min. | Typ. | Max. | Min. | Typ. | Max. | Min. | Typ. | Max. | |
| –40 °C | 21 | 27 | 33 | 15 | 21 | 27 | 4 | 6 | 8 | – | 24 | – | mT |
| 25 °C | 21 | 27 | 33 | 15 | 21 | 27 | 4 | 6 | 8 | 18 | 24 | 30 | mT |
| 100 °C | 21 | 27 | 33 | 15 | 21 | 27 | 4 | 6 | 8 | – | 24 | – | mT |
| 140 °C | 21 | 27 | 33 | 15 | 21 | 27 | 4 | 5.5 | 8 | – | 24 | – | mT |

The hysteresis is the difference between the switching points $B_{HYS} = B_{ON} - B_{OFF}$
The magnetic offset is the mean value of the switching points $B_{OFFSET} = (B_{ON} + B_{OFF}) / 2$

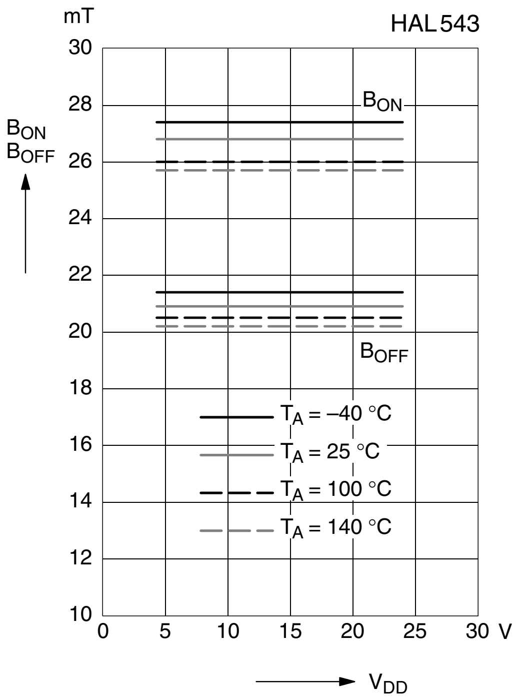



**Fig. 4–5:** Typ. magnetic switching points versus supply voltage

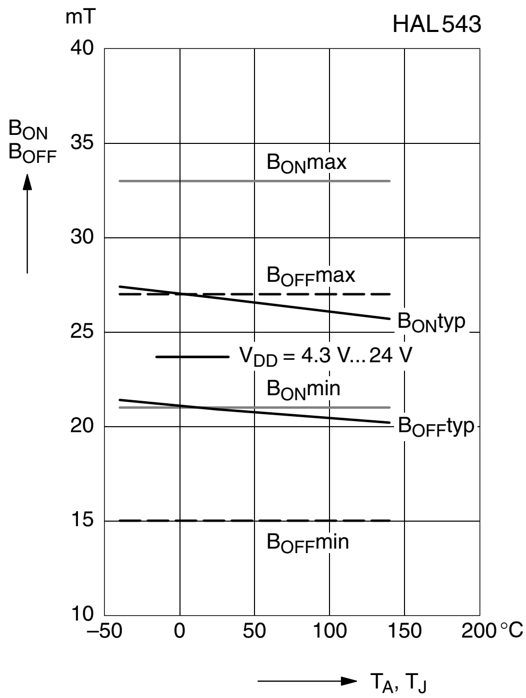



**Fig. 4–6:** Magnetic switching points versus temperature

**Note:** In the diagram “Magnetic switching points versus ambient temperature”, the curves for $B_{ON}$min, $B_{ON}$max, $B_{OFF}$min, and $B_{OFF}$max refer to junction temperature, whereas typical curves refer to ambient temperature.

### 4.3. HAL 546

The HAL 546 is a quite sensitive unipolar sensor (see Fig. 4–7).

The output turns low with the magnetic south pole on the branded side of the package and turns high if the magnetic field is removed. The sensor does not respond to the magnetic north pole on the branded side.

**Magnetic Features:**

– switching type: unipolar

– high sensitivity

– typical $B_{ON}$: 5.5 mT at room temperature

– typical $B_{OFF}$: 3.5 mT at room temperature

– operates with static magnetic fields and dynamic magnetic fields up to 10 kHz

– typical temperature coefficient of magnetic switching points is –1000 ppm/K.

**Applications**

The HAL 546 is the optimal sensor for applications with one magnetic polarity such as:

– solid state switches,

– contactless solution to replace micro-switches, and

– rotating speed measurement.

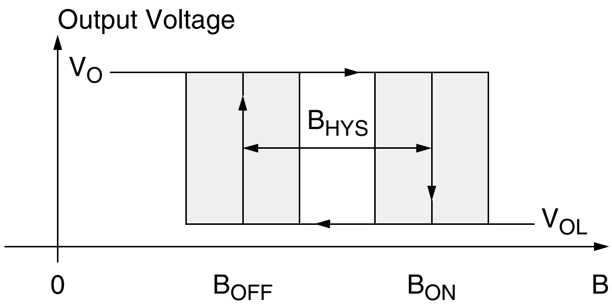



**Fig. 4–7:** Definition of magnetic switching points for the HAL 546

**Magnetic Characteristics** at $T_J$ = –40 °C to +140 °C, $V_{DD}$ = 4.3 V to 24 V,
Typical Characteristics for $V_{DD}$ = 12 V

Magnetic flux density values of switching points.
Positive flux density values refer to the magnetic south pole at the branded side of the package.

| Parameter | On point $B_{ON}$ | | | Off point $B_{OFF}$ | | | Hysteresis $B_{HYS}$ | | | Magnetic Offset | | | Unit |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $T_J$ | Min. | Typ. | Max. | Min. | Typ. | Max. | Min. | Typ. | Max. | Min. | Typ. | Max. | |
| –40 °C | 4.3 | 5.9 | 7.7 | 2.1 | 3.8 | 5.5 | 1.5 | 2.1 | 2.9 | – | 4.9 | – | mT |
| 25 °C | 3.8 | 5.5 | 7.2 | 2 | 3.5 | 5 | 1.4 | 2 | 2.8 | 2.9 | 4.5 | 6.1 | mT |
| 100 °C | 3.5 | 5.3 | 7 | 1.9 | 3.3 | 5.4 | 1.1 | 1.9 | 2.6 | – | 4.3 | – | mT |
| 140 °C | 3.2 | 4.8 | 6.9 | 1.8 | 3.1 | 5.5 | 1 | 1.7 | 2.6 | – | 4 | – | mT |

The hysteresis is the difference between the switching points $B_{HYS} = B_{ON} - B_{OFF}$
The magnetic offset is the mean value of the switching points $B_{OFFSET} = (B_{ON} + B_{OFF}) / 2$

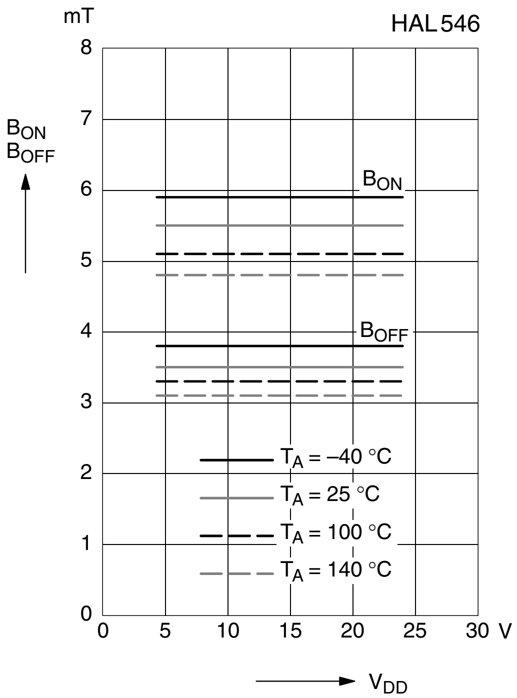



**Fig. 4–8:** Typ. magnetic switching points versus supply voltage

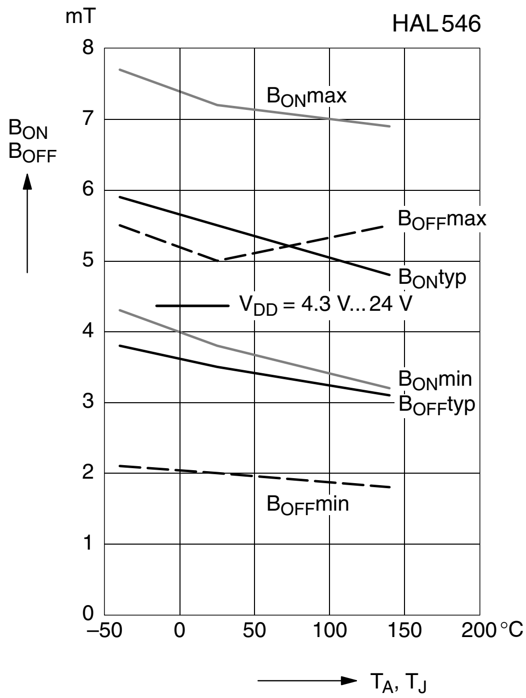



**Fig. 4–9:** Magnetic switching points versus temperature

**Note:** In the diagram “Magnetic switching points versus ambient temperature”, the curves for $B_{ON}$min, $B_{ON}$max, $B_{OFF}$min, and $B_{OFF}$max refer to junction temperature, whereas typical curves refer to ambient temperature.

## 4.4. HAL 548

The HAL 548 is a unipolar switching sensor (see Fig. 4–10).

The output turns low with the magnetic south pole on the branded side of the package and turns high if the magnetic field is removed. The sensor does not respond to the magnetic north pole on the branded side.

**Magnetic Features:**

– switching type: unipolar,

– medium sensitivity

– typical $B_{ON}$: 18 mT at room temperature

– typical $B_{OFF}$: 12 mT at room temperature

– operates with static magnetic fields and dynamic magnetic fields up to 10 kHz

**Applications**

The HAL 548 is the ideal sensor for all applications with one magnetic polarity and weak magnetic amplitude at the sensor position such as:

– solid state switches,

– contactless solution to replace micro switches,

– position and end point detection, and

– rotating speed measurement.

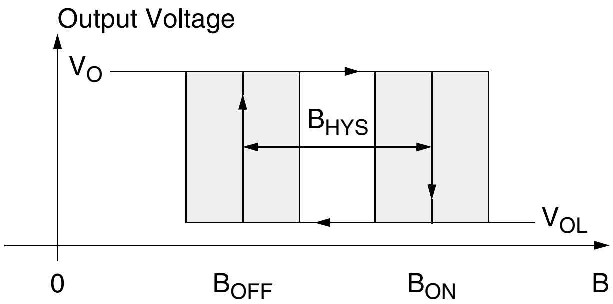



**Fig. 4–10:** Definition of magnetic switching points for the HAL 548

**Magnetic Characteristics** at $T_J$ = –40 °C to +140 °C, $V_{DD}$ = 4.3 V to 24 V,
Typical Characteristics for $V_{DD}$ = 12 V

Magnetic flux density values of switching points.
Positive flux density values refer to the magnetic south pole at the branded side of the package.

| Parameter | On point $B_{ON}$ | | | Off point $B_{OFF}$ | | | Hysteresis $B_{HYS}$ | | | Magnetic Offset | | | Unit |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $T_J$ | Min. | Typ. | Max. | Min. | Typ. | Max. | Min. | Typ. | Max. | Min. | Typ. | Max. | |
| –40 °C | 12 | 19 | 24 | 6 | 13 | 18 | 4 | 6 | 8 | – | 16 | – | mT |
| 25 °C | 12 | 18 | 24 | 6 | 12 | 18 | 4 | 6 | 8 | 9 | 15 | 21 | mT |
| 100 °C | 12 | 18 | 24 | 6 | 12 | 18 | 4 | 6 | 8 | – | 15 | – | mT |
| 140 °C | 12 | 17 | 24 | 6 | 11 | 18 | 4 | 6 | 8 | – | 14 | – | mT |

The hysteresis is the difference between the switching points $B_{HYS} = B_{ON} - B_{OFF}$
The magnetic offset is the mean value of the switching points $B_{OFFSET} = (B_{ON} + B_{OFF}) / 2$

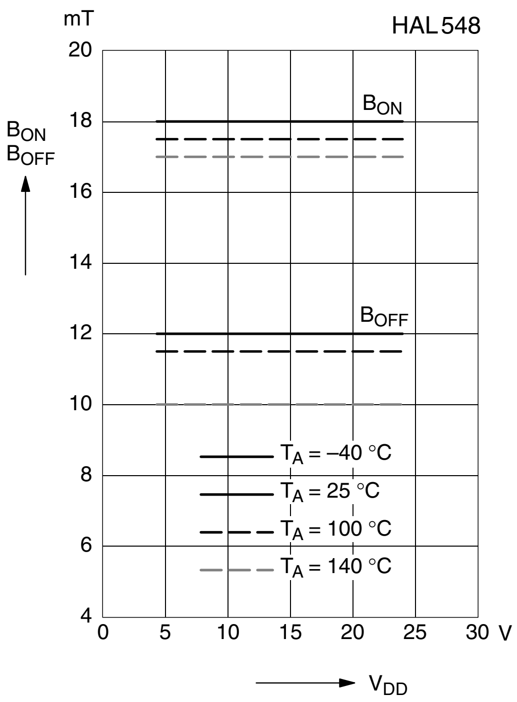



**Fig. 4–11:** Typ. magnetic switching points versus supply voltage

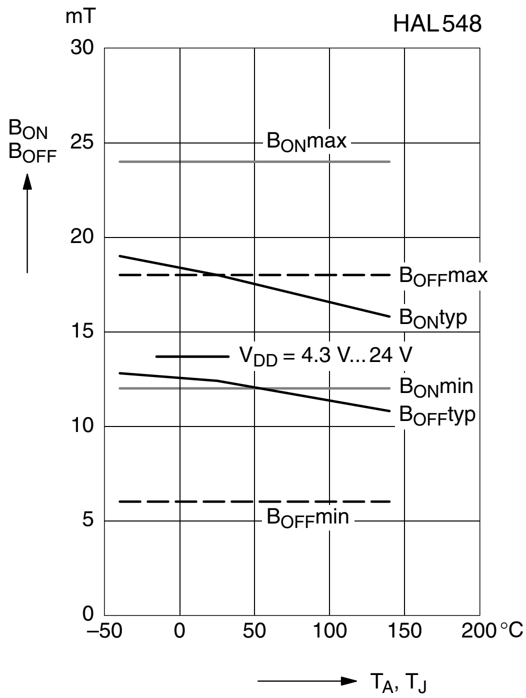



**Fig. 4–12:** Magnetic switching points versus temperature

**Note:** In the diagram “Magnetic switching points versus ambient temperature”, the curves for $B_{ON}$min, $B_{ON}$max, $B_{OFF}$min, and $B_{OFF}$max refer to junction temperature, whereas typical curves refer to ambient temperature.

## 5. Application Notes

### 5.1. 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 $T_A$).

$T_J = T_A + \Delta T$

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

$\Delta T = I_{DD} * V_{DD} * R_{th}$

For typical values, use the typical parameters. For worst case calculation, use the max. parameters for $I_{DD}$ and $R_{th}$, and the max. value for $V_{DD}$ from the application.

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

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

### 5.2. Extended Operating Conditions

All sensors fulfill the electrical and magnetic characteristics when operated within the Recommended Operating Conditions (see page 12).

**Supply Voltage Below 4.3 V**

The devices contain a Power-on Reset (POR) and a undervoltage reset. For $V_{DD} < V_{reset}$ the output state is high. For $V_{reset} < V_{DD} < 4.3$ V the device responds to the magnetic field according to the specified magnetic characteristics.

**Note:** The functionality of the sensor below 4.3 V is not tested. For special test conditions, please contact Micronas.

### 5.3. Start-up Behavior

Due to the active offset compensation, the sensors have an initialization time (enable time $t_{en(O)}$) after applying the supply voltage. The parameter $t_{en(O)}$ is specified in the Characteristics (see page 13).

During the initialization time, the output state for the HAL 54x is 'Off-state' (i.e. Output High). After $t_{en(O)}$, the output will be high. The output will be switched to low if the applied magnetic field B is above $B_{ON}$.

### 5.4. EMC and ESD

For applications with disturbances on the supply line or radiated disturbances, a series resistor and a capacitor are recommended (see Fig. 5–1). The series resistor and the capacitor should be placed as closely as possible to the Hall sensor.

Please contact Micronas for the detailed investigation reports with the EMC and ESD results.

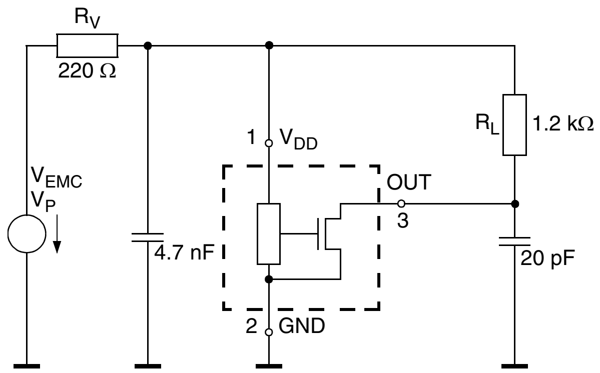



**Fig. 5–1:** Test circuit for EMC investigations

**WARNING:**
DO NOT USE THESE SENSORS IN LIFE-SUPPORTING SYSTEMS, AVIATION, AND AEROSPACE APPLICATIONS.

## 6. Data Sheet History

1. Data sheet: “HAL 54x Hall Effect Sensor Family”, Nov. 27, 2002, 6251-605-1DS. First release of the data sheet.

2. Data Sheet: “HAL 54x Hall Effect Sensor Family”, Sept. 13, 2004, 6251-605-2DS. Second release of the data sheet. Major changes:

– new package diagrams for SOT89B-1 and TO92UA-1

– package diagram for TO92UA-2 added

– ammopack diagrams for TO92UA-1/-2 added

Micronas GmbH
Hans-Bunte-Strasse 19
D-79108 Freiburg (Germany)
P.O. Box 840
D-79008 Freiburg (Germany)
Tel. +49-761-517-0
Fax +49-761-517-2174
E-mail: docservice@micronas.com
Internet: www.micronas.com

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