

## Data Sheet

# HAL<sup>®</sup> 556, HAL<sup>®</sup> 560, HAL<sup>®</sup> 566

Two-Wire Hall Effect  
Sensor Family

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## Two-Wire Hall Effect Sensor Family in CMOS technology

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

### 1. Introduction

This sensor family consists of different two-wire Hall switches produced in CMOS technology. All sensors change the current consumption depending on the external magnetic field and require only two wires between sensor and evaluation circuit. The sensors of this family differ in the magnetic switching behavior and switching points.

The sensors 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 (high current consumption) or off (low current consumption).

The active offset compensation leads to constant magnetic characteristics in the full 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 V to 24 V in the junction temperature range from  $-40\text{ }^{\circ}\text{C}$  up to  $140\text{ }^{\circ}\text{C}$ . All sensors are available in the SMD-package SOT89B-1 and in the leaded versions TO92UA-1 and TO92UA-2.

#### 1.1. Features:

- current output for two-wire applications
- junction temperature range from  $-40\text{ }^{\circ}\text{C}$  up to  $140\text{ }^{\circ}\text{C}$ .
- operates from 4 V to 24 V supply voltage
- operates with static magnetic fields and dynamic magnetic fields up to 10 kHz
- switching offset compensation at typically 145 kHz
- overvoltage and reverse-voltage protection
- magnetic characteristics are robust against mechanical stress effects
- constant magnetic 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 mode of switching and the magnetic switching points.

Type	Switching Behavior	Sensitivity	see Page
556	unipolar	very high	18
560	unipolar inverted	low	20
566	unipolar inverted	very high	22

#### Unipolar Switching Sensors:

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

#### Unipolar Inverted Switching Sensors:

The sensor turns to low current consumption with the magnetic south pole on the branded side of the package and turns to high consumption 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
HAL556	556K	556E
HAL560	560K	560E
HAL566	566K	566E

#### 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

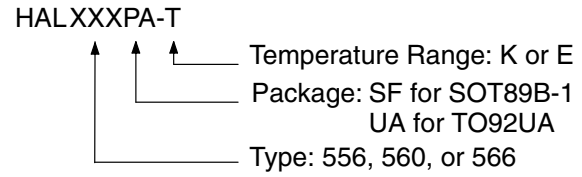
The Hall sensors from Micronas are specified to the chip temperature (junction temperature  $T_J$ ).

**K:**  $T_J = -40\text{ °C to }+140\text{ °C}$

**E:**  $T_J = -40\text{ °C to }+100\text{ °C}$

**Note:** Due to the high power dissipation at high current consumption, there is a difference between the ambient temperature ( $T_A$ ) and junction temperature. Please refer to section 5.4. on page 25 for details.

### 1.5. Hall Sensor Package Codes



Example: **HAL556UA-E**

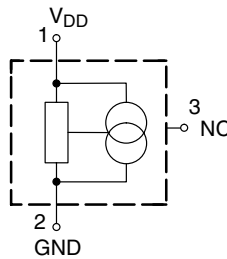
- Type: 556
- Package: TO92UA
- Temperature Range:  $T_J = -40\text{ °C to }+100\text{ °C}$

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.



**Fig. 1-1:** Pin configuration

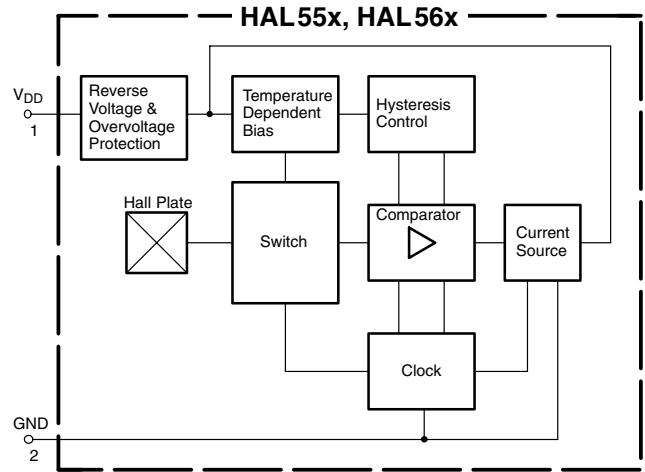
**2. Functional Description**

The HAL55x, HAL56x two-wire 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. 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.

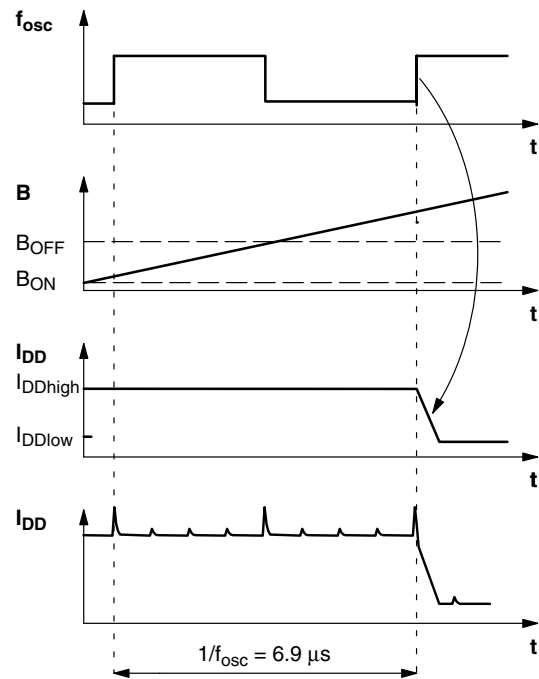
If the magnetic field exceeds the threshold levels, the current source switches to the corresponding state. In the low current consumption state, the current source is switched off and the current consumption is caused only by the current through the Hall sensor. In the high current consumption state, the current source is switched on and the current consumption is caused by the current through the Hall sensor and the current source. The built-in hysteresis eliminates oscillation and provides switching behavior of the output signal without bouncing.

Magnetic offset caused by mechanical stress is compensated for by using the “switching offset compensation technique”. An internal oscillator provides a two-phase clock. In each phase, the current is forced through the Hall plate in a different direction, and the Hall voltage is measured. At the end of the two phases, the Hall voltages are averaged and thereby the offset voltages are eliminated. The average value is compared with the fixed switching points. Subsequently, the current consumption switches to the corresponding state. The amount of time elapsed from crossing the magnetic switching level to switching of the current level can vary between zero and  $1/f_{osc}$ .

Shunt protection devices clamp voltage peaks at the  $V_{DD}$ -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 protection diode is needed for reverse voltages ranging from 0 V to  $-15$  V.



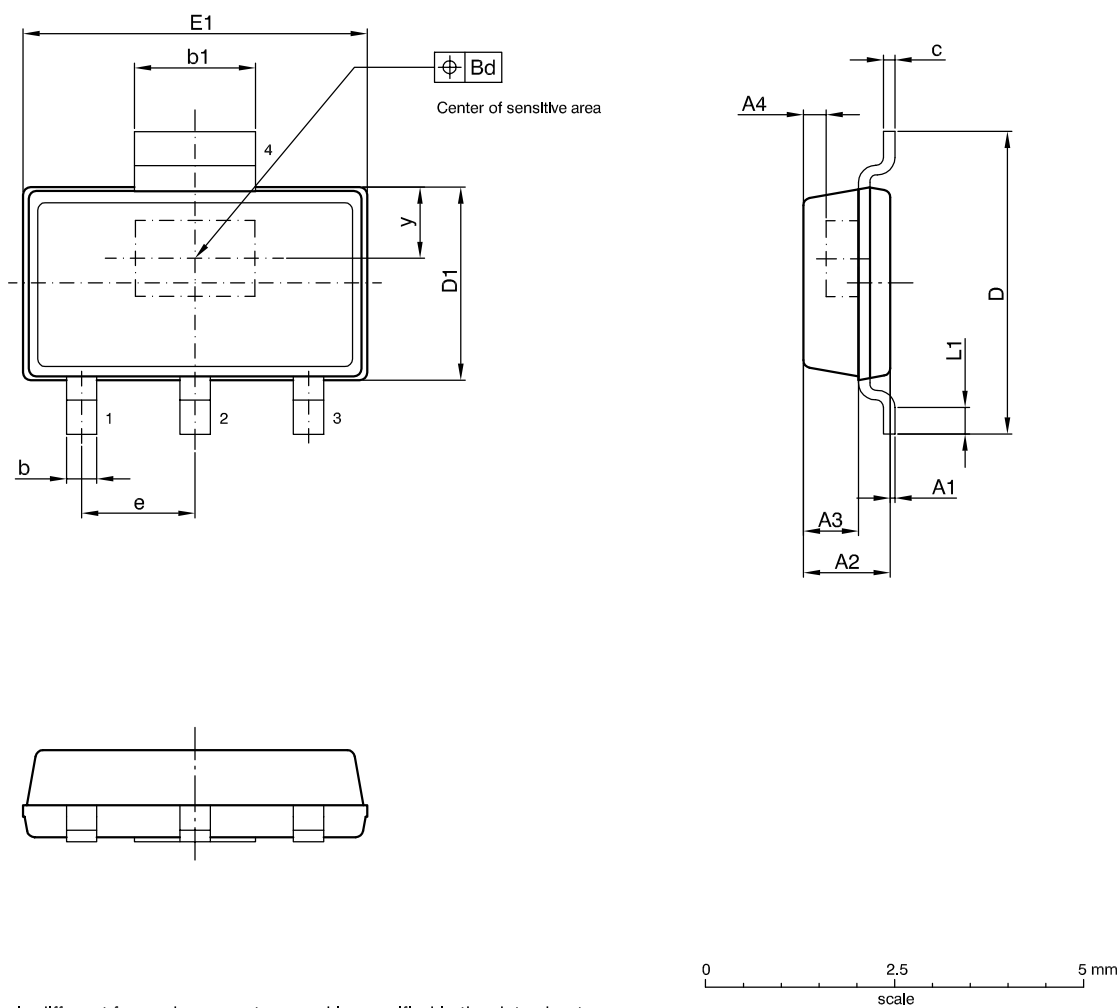
**Fig. 2-1:** HAL55x, HAL56x block diagram



**Fig. 2-2:** Timing diagram (example: HAL56x)

## 3. Specifications

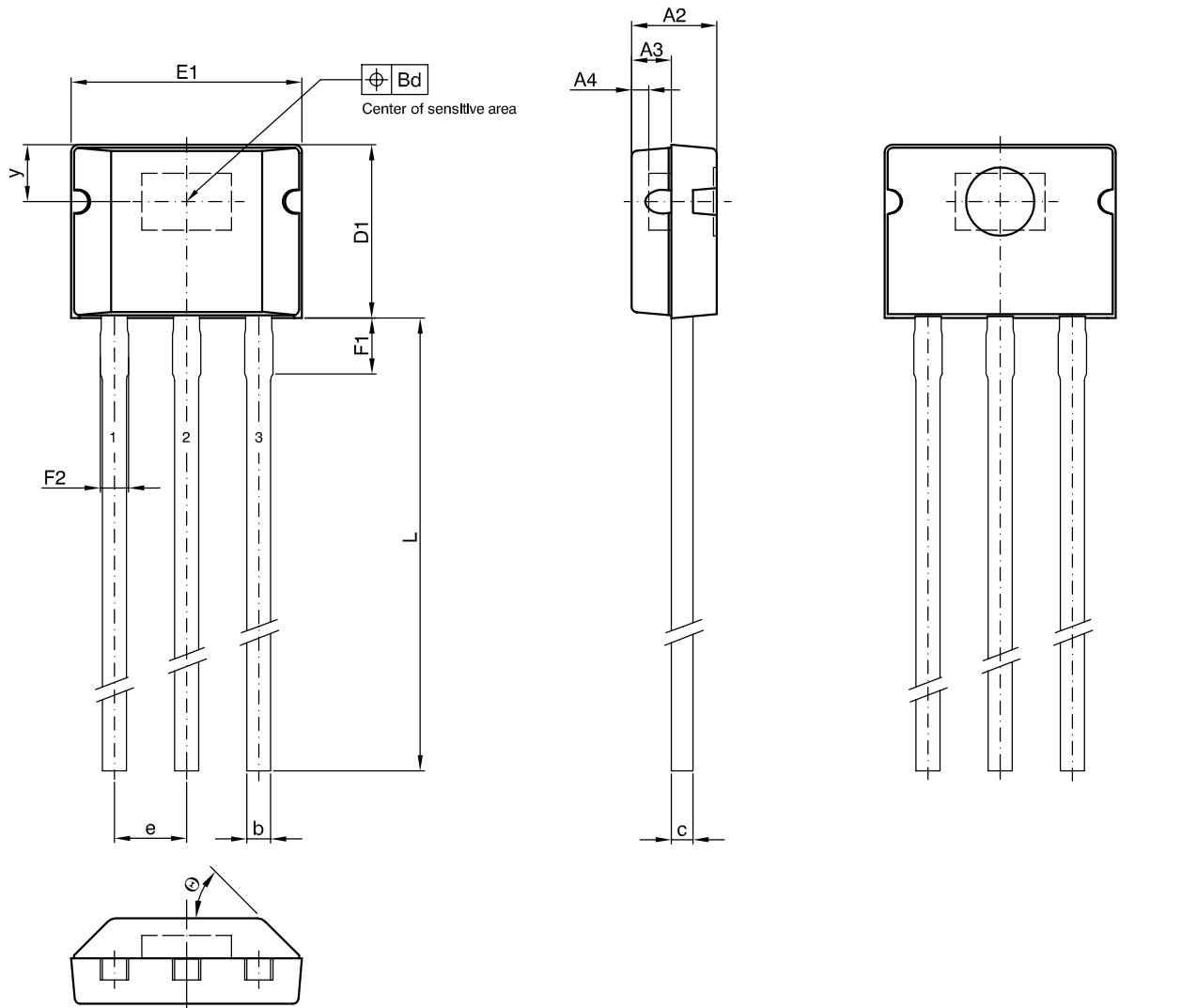
### 3.1. Outline Dimensions



UNIT	A1	A2	A3	A4	b	b1	Bd	c	D	D1	e	E1	L1
mm	0.10 0.02	1.20 1.10	0.755 0.705	0.3	0.4	1.7	0.2	0.15	4.0	2.6 2.5	1.5	4.6 4.5	0.25 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 Small Outline Transistor package, 4 leads  
 Weight approximately 0.039 g

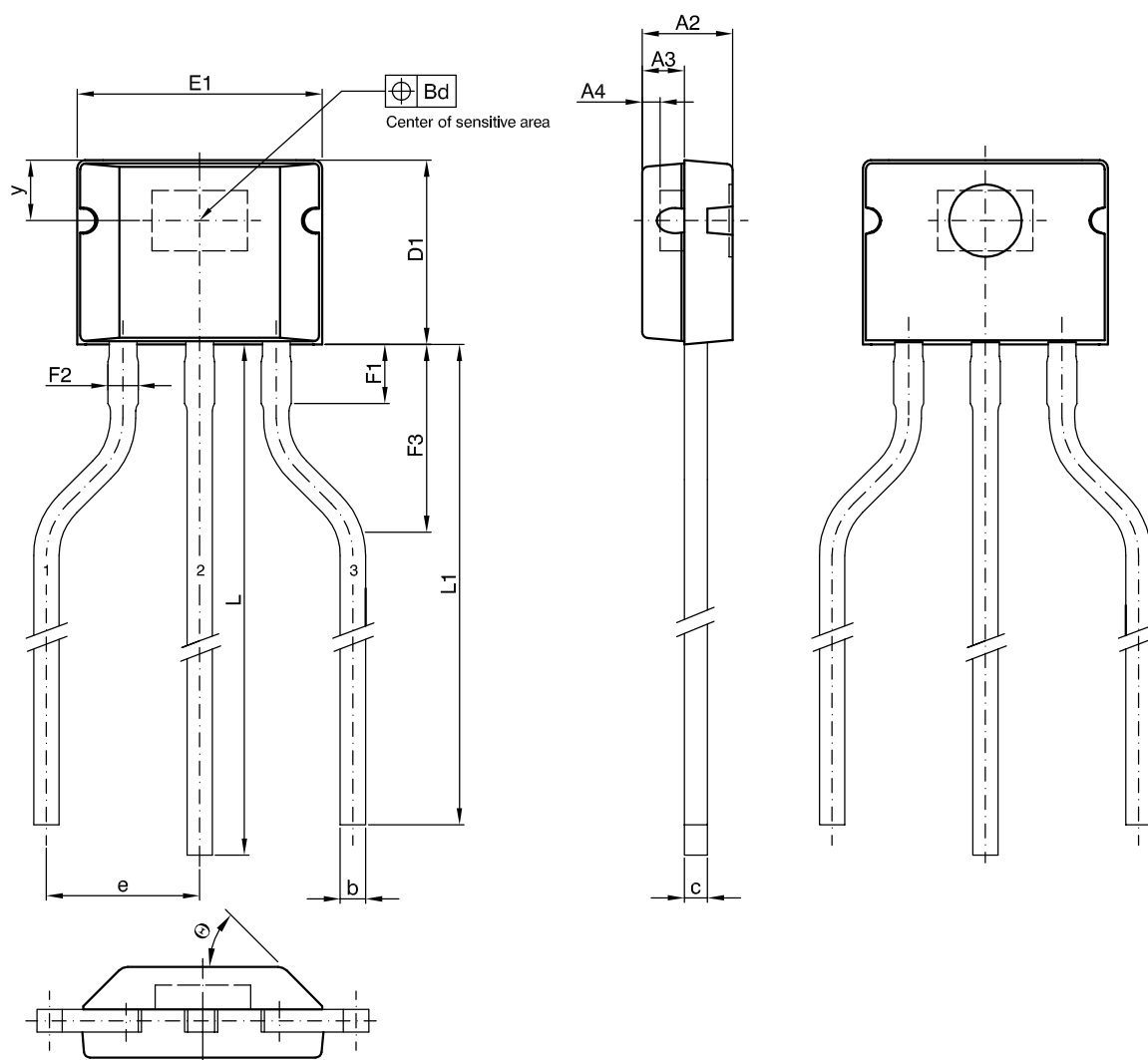


solderability is guaranteed between end of pin and distance F1.  
 y= this dimension is different for each sensor type and is specified in the data sheet.

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

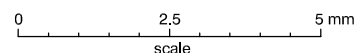
JEDEC STANDARD		ANSI	ISSUE DATE YY-MM-DD	DRAWING-NO.	SPZG-NO.
ISSUE	ITEM NO.				
-	-		03-11-18	06612.0001.4	SPZG001012_001_03

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



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.

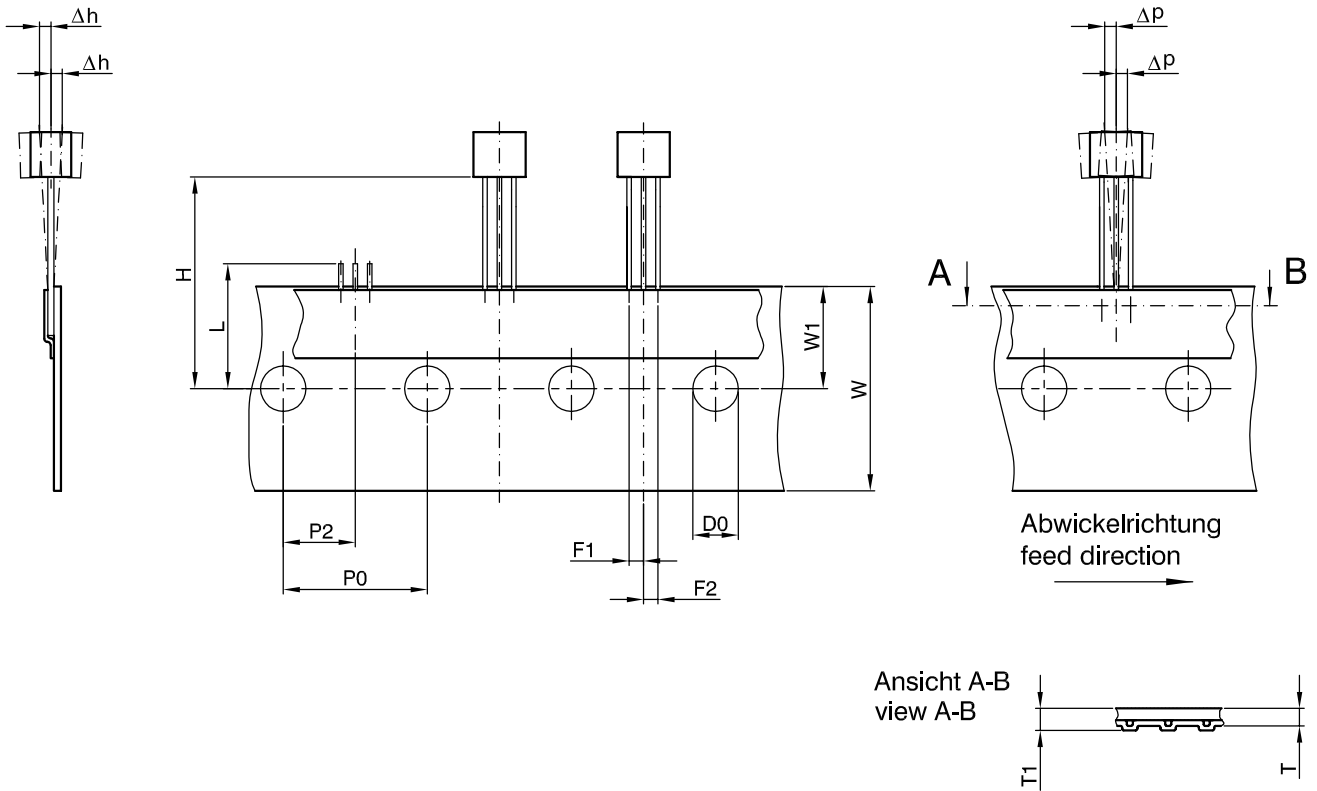


UNIT	A2	A3	A4	b	Bd	c	D1	e	E1	F1	F2	F3	L	L1	θ
mm	1.55 1.45	0.7	0.3	0.42	0.2	0.36	3.1 3.0	2.54	4.11 4.01	1.2 0.8	0.60 0.42	4.0 2.0	15.5 mln	14.5 mln	45°

JEDEC STANDARD		ANSI	ISSUE DATE 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



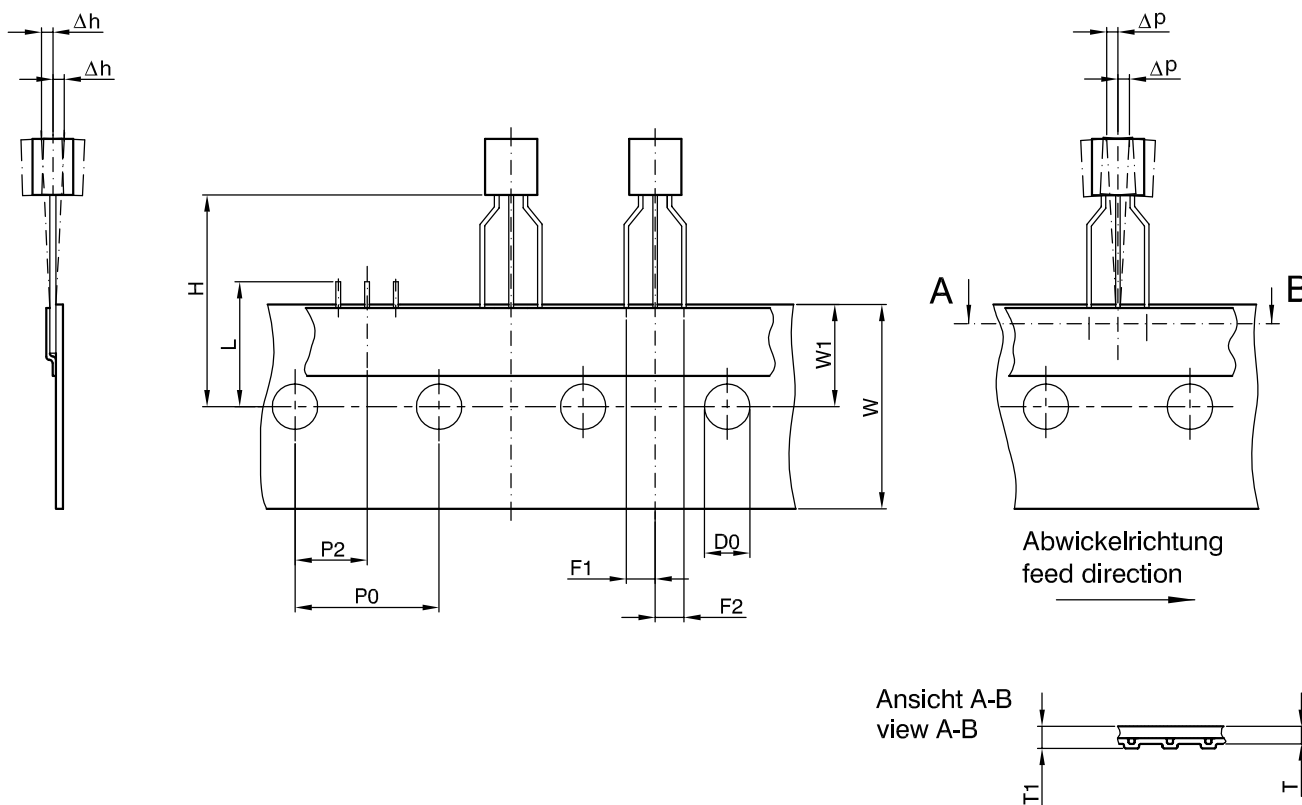


alle Maße in mm / all dimensions in mm  
 max. zul. Abweichung über 20 Lochabstände ±1.0 / max. allowed tolerance over 20 hole spacings ±1.0

UNIT	D0	F1	F2	H	Δh	L	P0	P2	Δp	T	T1	W	W1
mm	4.0	1.47 1.07	1.47 1.07	20.0 18.0	±1.0	11.0 max	13.2 12.2	7.05 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	06631.0001.4	SPZG001031_001_02

**Fig. 3-4:**  
**TO92UA-2: Dimensions ammpack 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 2.34	2.74 2.34	20.0 18.0	±1.0	11.0 max	13.2 12.2	7.05 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 ammpack inline, spread**

### 3.2. Dimensions of Sensitive Area

0.25 mm x 0.12 mm

### 3.3. Positions of Sensitive Areas

	SOT89B-1	TO92UA-1/-2
x	center of the package	center of the package
y	0.85 mm nominal	0.9 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 circuit.

All voltages listed are referenced to ground (GND).

Symbol	Parameter	Pin No.	Min.	Max.	Unit
$V_{DD}$	Supply Voltage	1	-15 <sup>1)</sup> 2)	28 <sup>2)</sup>	V
$T_J$	Junction Temperature Range		-40	170	°C

1) -18 V with a 100  $\Omega$  series resistor at pin 1 (-16 V with a 30  $\Omega$  series resistor)  
 2) as long as  $T_{Jmax}$  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).

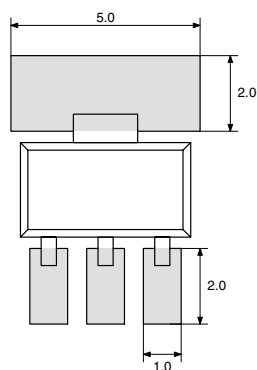
Symbol	Parameter	Pin No.	Min.	Max.	Unit
$V_{DD}$	Supply Voltage	1	4	24	V
$T_A$	Ambient Temperature for Continuous Operation		-40	85 <sup>1)</sup>	°C
<sup>1)</sup> when using the “K” type and $V_{DD} \leq 16$ V					

**Note:** Due to the high power dissipation at high current consumption, there is a difference between the ambient temperature ( $T_A$ ) and junction temperature. The power dissipation can be reduced by repeatedly switching the supply voltage on and off (pulse mode). Please refer to section 5.4. on page 25 for details.

**3.6. Characteristics** at  $T_J = -40\text{ }^\circ\text{C}$  to  $+140\text{ }^\circ\text{C}$ ,  $V_{DD} = 4\text{ V}$  to  $24\text{ V}$   
 at Recommended Operation Conditions if not otherwise specified in the column "Conditions".  
 Typical Characteristics for  $T_J = 25\text{ }^\circ\text{C}$  and  $V_{DD} = 12\text{ V}$

Symbol	Parameter	Pin No.	Min.	Typ.	Max.	Unit	Conditions
$I_{DDlow}$	Low Current Consumption over Temperature Range	1	2	3.3	5	mA	
$I_{DDhigh}$	High Current Consumption over Temperature Range	1	12	14.3	17	mA	
$V_{DDZ}$	Overvoltage Protection at Supply	1	–	28.5	32	V	$I_{DD} = 25\text{ mA}$ , $T_J = 25\text{ }^\circ\text{C}$ , $t = 20\text{ ms}$
$f_{osc}$	Internal Oscillator Chopper Frequency	–	–	145	–	kHz	
$t_{en(O)}$	Enable Time of Output after Setting of $V_{DD}$	1	–	30	–	$\mu\text{s}$	1)
$t_r$	Output Rise Time	1	–	0.4	1.6	$\mu\text{s}$	$V_{DD} = 12\text{ V}$ , $R_S = 30\ \Omega$
$t_f$	Output Fall Time	1	–	0.4	1.6	$\mu\text{s}$	$V_{DD} = 12\text{ V}$ , $R_S = 30\ \Omega$
$R_{thJSB}$ case SOT89B-1	Thermal Resistance Junction to Substrate Backside	–	–	150	200	K/W	Fiberglass Substrate 30 mm x 10 mm x 1.5mm, pad size see Fig. 3–6
$R_{thJA}$ case TO92UA-1, TO92UA-2	Thermal Resistance Junction to Soldering Point	–	–	150	200	K/W	

1)  $B > B_{ON} + 2\text{ mT}$  or  $B < B_{OFF} - 2\text{ mT}$  for HAL55x,  $B > B_{OFF} + 2\text{ mT}$  or  $B < B_{ON} - 2\text{ mT}$  for HAL56x



**Fig. 3–6:** Recommended pad size SOT89B-1  
 Dimensions in mm

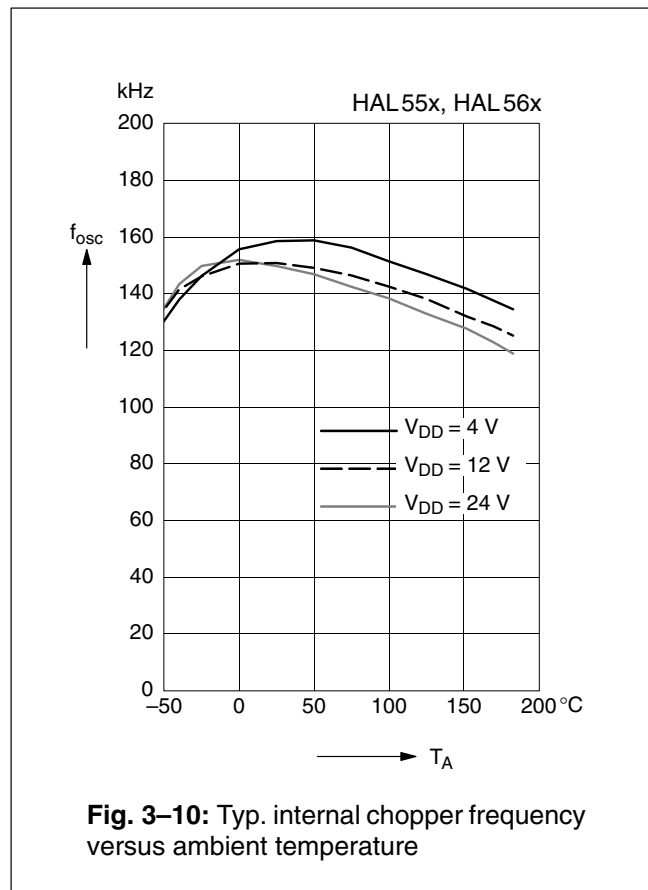
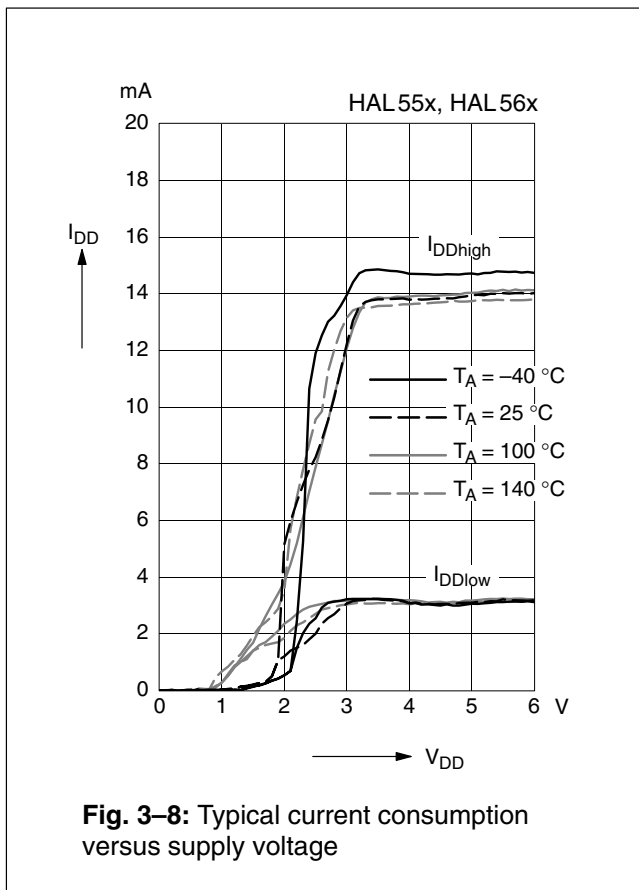
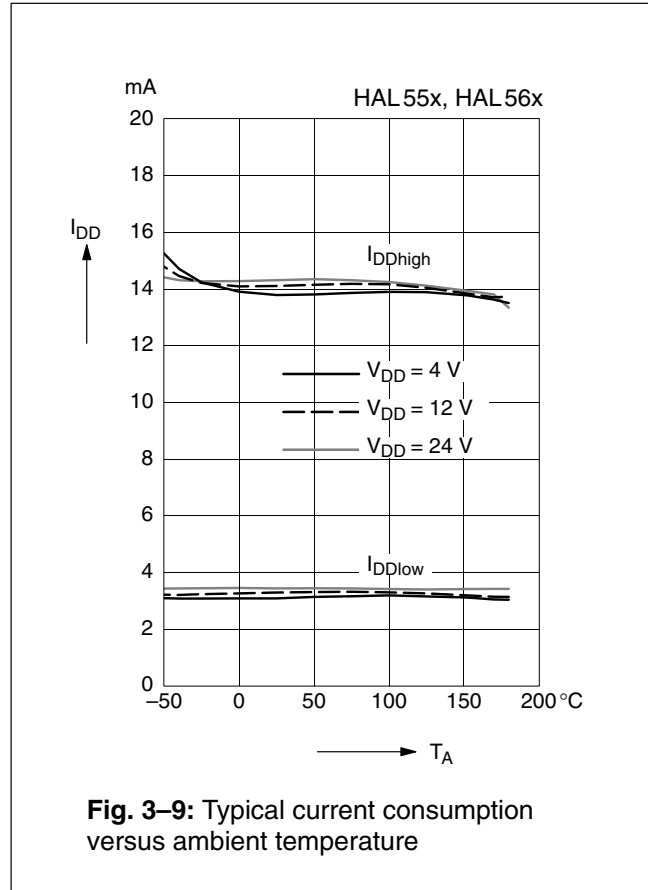
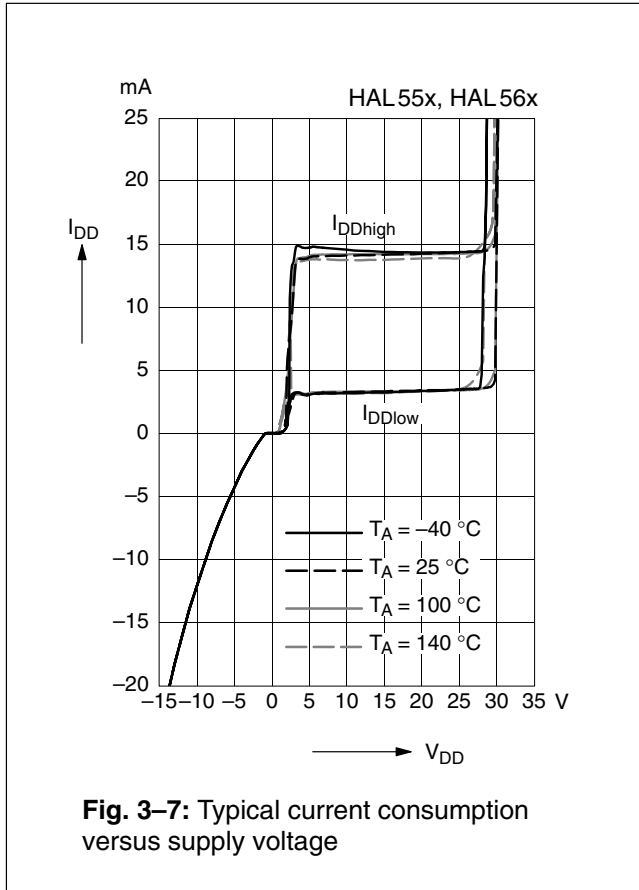
**3.7. Magnetic Characteristics Overview** at  $T_J = -40\text{ °C}$  to  $+140\text{ °C}$ ,  $V_{DD} = 4\text{ V}$  to  $24\text{ V}$ ,  
 Typical Characteristics for  $V_{DD} = 12\text{ V}$

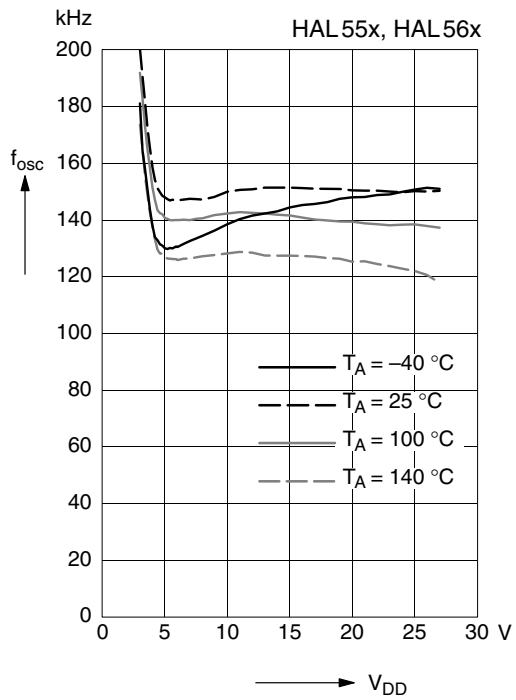
Magnetic flux density values of switching points.

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

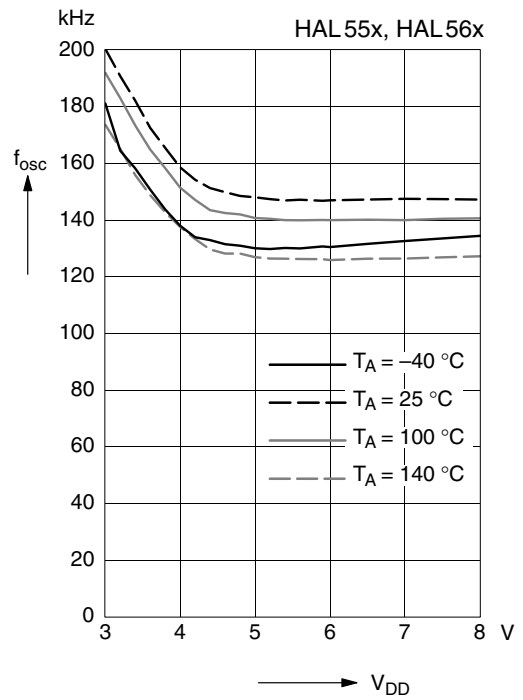
Sensor Switching Type	Parameter $T_J$	On point $B_{ON}$			Off point $B_{OFF}$			Hysteresis $B_{HYS}$			Unit
		Min.	Typ.	Max.	Min.	Typ.	Max.	Min.	Typ.	Max.	
HAL 556 unipolar	-40 °C	3.4	6.3	7.7	2.1	4.2	5.9	0.8	2.1	3	mT
	25 °C	3.4	6	7.4	2	3.8	5.7	0.5	1.8	2.8	mT
	100 °C	3.2	5.5	7.2	1.9	3.7	5.7	0.3	1.8	2.8	mT
	140 °C	3	5.2	7.4	1.2	3.6	6	0.2	1.6	3	mT
HAL 560 unipolar inverted	-40 °C	41	46.5	52	47	53	59	4	6.5	10	mT
	25 °C	41	46.6	52	46	52.5	58.5	3	6	9	mT
	100 °C	41	45.7	52	45	41.1	57.5	2	5.4	8	mT
	140 °C	39	44.8	51	43.5	49.8	56.5	2	5	8	mT
HAL 566 unipolar inverted	-40 °C	2.1	4	5.9	3.4	6	7.7	0.8	2	2.8	mT
	25 °C	2	3.9	5.7	3.4	5.9	7.2	0.5	2	2.7	mT
	100 °C	1.85	3.8	5.7	3.25	5.6	7	0.3	1.8	2.6	mT
	140 °C	1.3	3.6	6	2.6	5.2	7.3	0.2	1.6	3	mT

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





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



**Fig. 3-12:** Typ. internal chopper frequency versus supply voltage



**intentionally left vacant**

**4. Type Description**

**4.1. HAL556**

The HAL556 is a very sensitive unipolar switching sensor (see Fig. 4–1).

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

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

In the HAL55x, HAL56x two-wire sensor family, the HAL566 is a sensor with the same magnetic characteristics but with an inverted output characteristic.

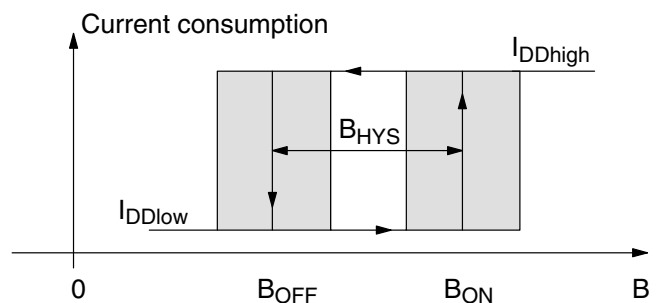
**Magnetic Features:**

- switching type: unipolar
- very high sensitivity
- typical  $B_{ON}$ : 6 mT at room temperature
- typical  $B_{OFF}$ : 4 mT at room temperature
- operates with static magnetic fields and dynamic magnetic fields up to 10 kHz

**Applications**

The HAL556 is designed for applications with one magnetic polarity and weak magnetic amplitudes at the sensor position such as:

- applications with large airgap or weak magnets,
- solid state switches,
- contactless solutions to replace micro switches,
- position and end point detection, and
- rotating speed measurement.



**Fig. 4–1:** Definition of magnetic switching points for the HAL556

**Magnetic Characteristics** at  $T_J = -40\text{ °C}$  to  $+140\text{ °C}$ ,  $V_{DD} = 4\text{ V}$  to  $24\text{ V}$ , Typical Characteristics for  $V_{DD} = 12\text{ V}$

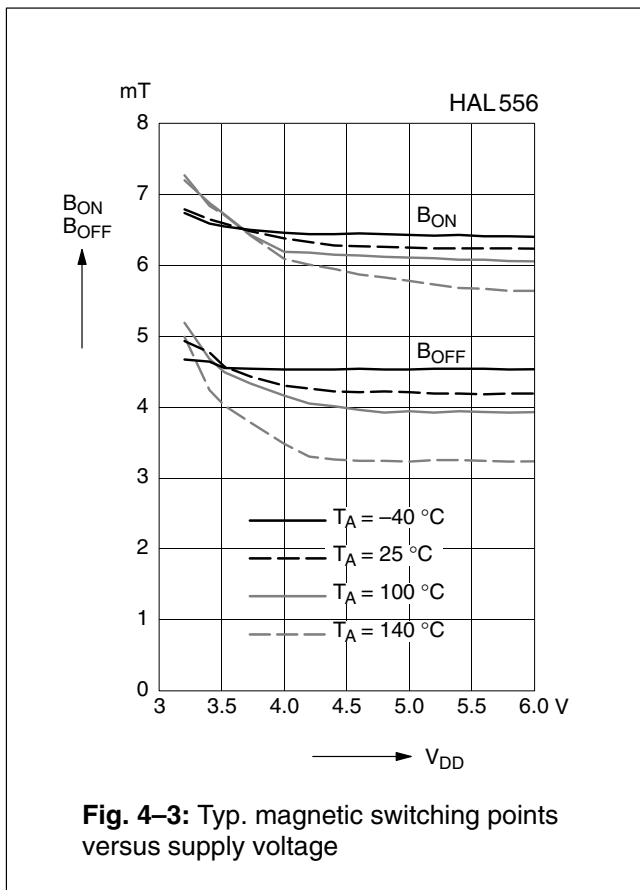
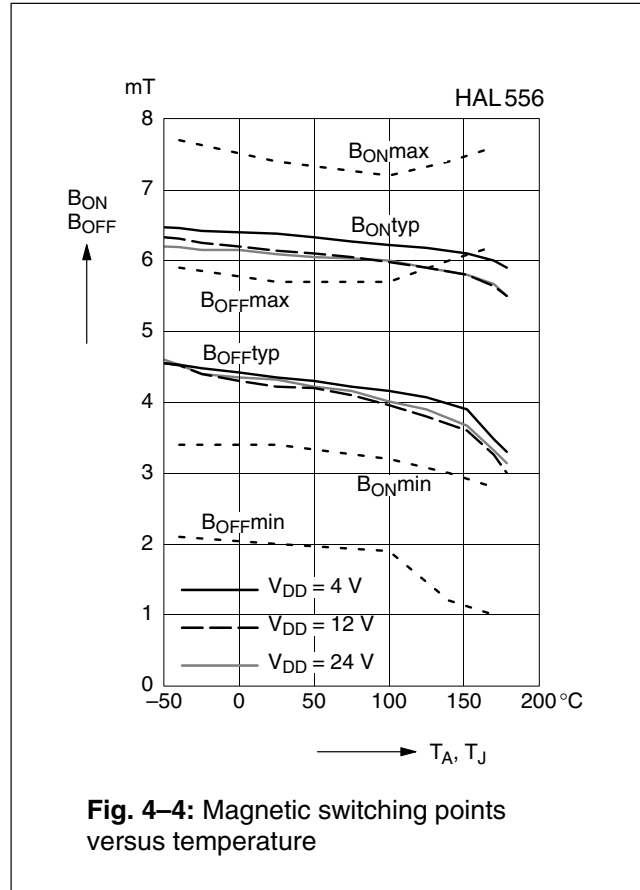
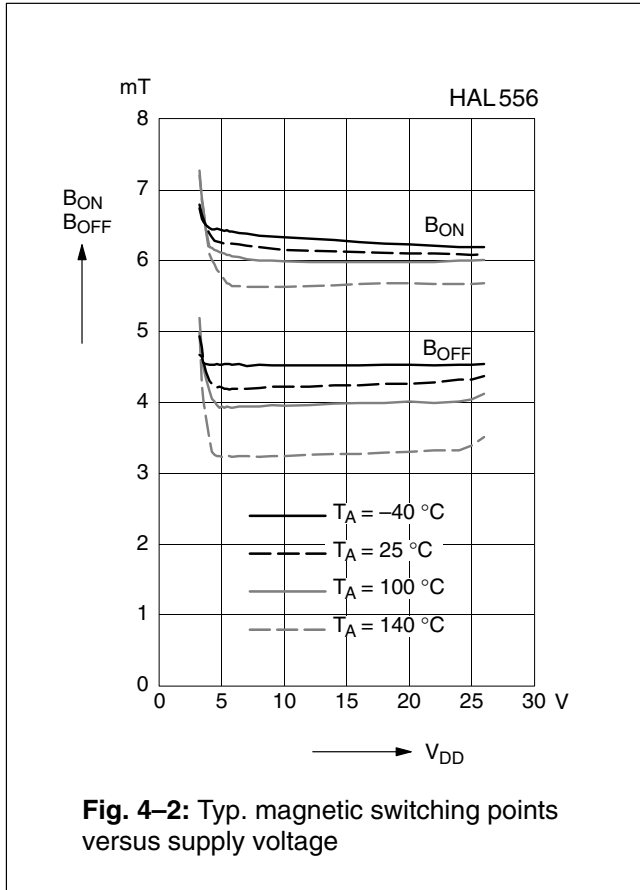
Magnetic flux density values of switching points.

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

Parameter $T_J$	On point $B_{ON}$			Off point $B_{OFF}$			Hysteresis $B_{HYS}$			Magnetic Offset			Unit
	Min.	Typ.	Max.	Min.	Typ.	Max.	Min.	Typ.	Max.	Min.	Typ.	Max.	
-40 °C	3.4	6.3	7.7	2.1	4.2	5.9	0.8	2.1	3		5.2		mT
25 °C	3.4	6	7.4	2	3.8	5.7	0.5	1.8	2.8	2.7	4.9	6.5	mT
100 °C	3.2	5.5	7.2	1.9	3.7	5.7	0.3	1.8	2.8		4.6		mT
140 °C	3	5.2	7.4	1.2	3.6	6	0.2	1.6	3		4.4		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  $B_{OFFSET} = (B_{ON} + B_{OFF}) / 2$



**Note:** In the diagram “Magnetic switching points versus temperature” the curves for  $B_{ONmin}$ ,  $B_{ONmax}$ ,  $B_{OFFmin}$ , and  $B_{OFFmax}$  refer to junction temperature, whereas typical curves refer to ambient temperature.

**4.2. HAL560**

The HAL 560 is a low sensitive unipolar switching sensor with an inverted output (see Fig. 4–5).

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

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

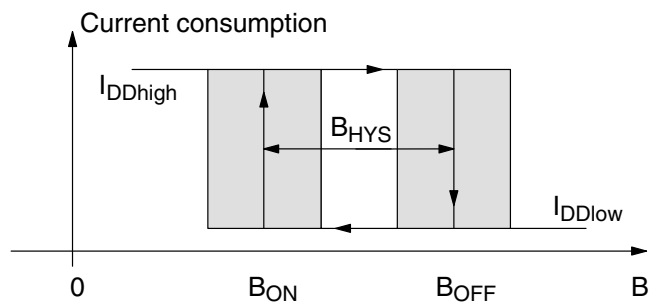
**Magnetic Features:**

- switching type: unipolar inverted
- low sensitivity
- typical  $B_{ON}$ : 45.6 mT at room temperature
- typical  $B_{OFF}$ : 51.7 mT at room temperature
- operates with static magnetic fields and dynamic magnetic fields up to 10 kHz

**Applications**

The HAL 560 is designed for applications with one magnetic polarity and strong magnetic amplitudes at the sensor position where an inverted output signal is required such as:

- applications with strong magnets,
- solid state switches,
- contactless solutions to replace micro switches,
- position and end point detection, and
- rotating speed measurement.



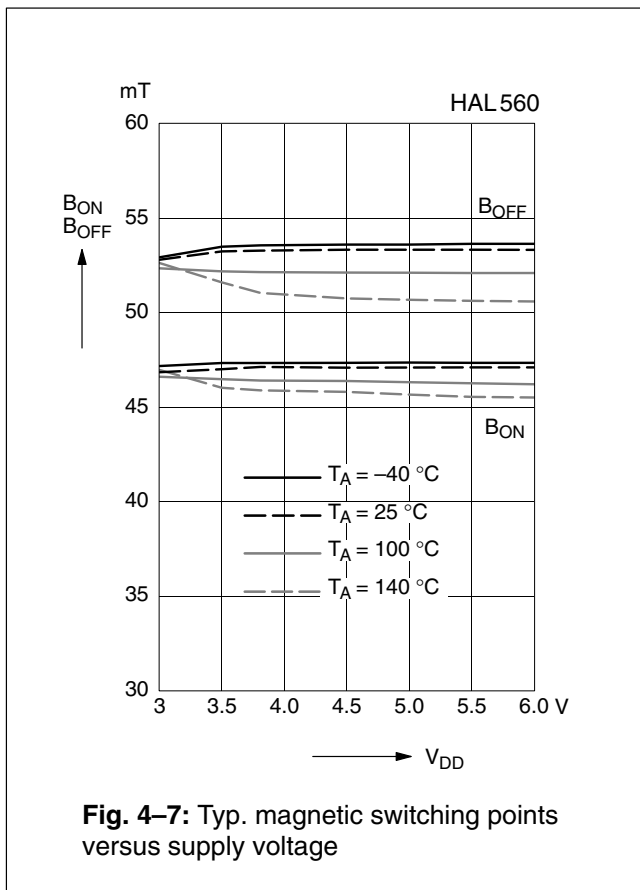
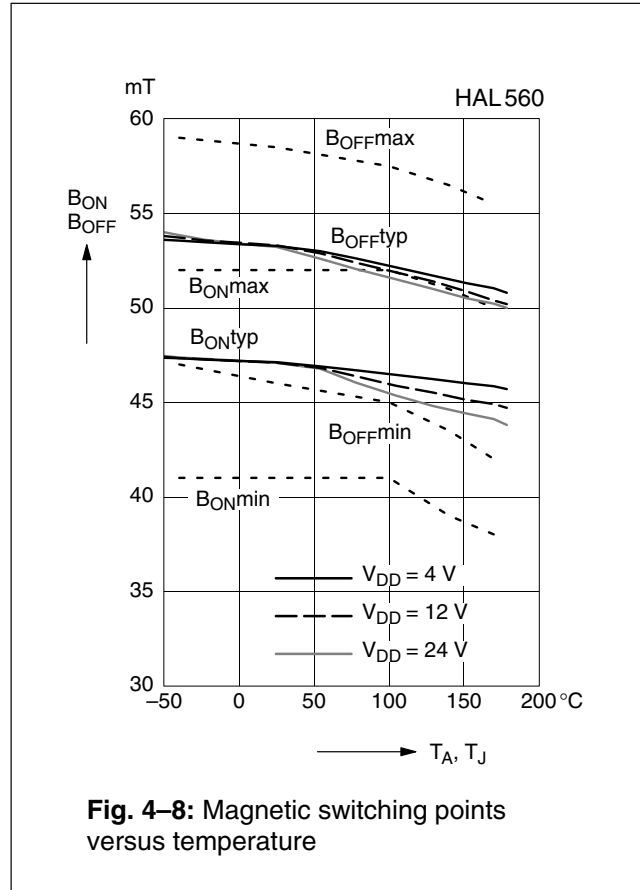
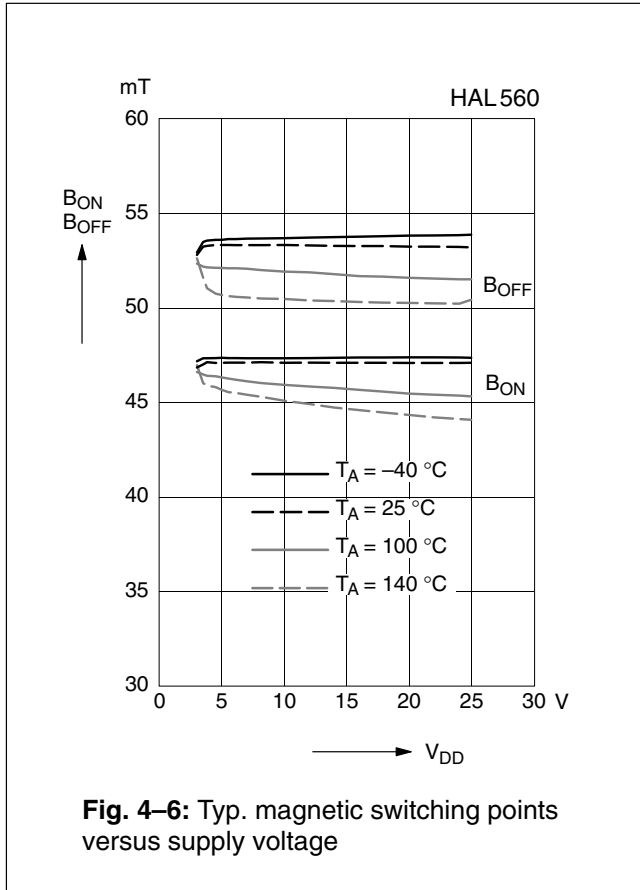
**Fig. 4–5:** Definition of magnetic switching points for the HAL560

**Magnetic Characteristics** at  $T_J = -40\text{ °C}$  to  $+140\text{ °C}$ ,  $V_{DD} = 4\text{ V}$  to  $24\text{ V}$ , Typical Characteristics for  $V_{DD} = 12\text{ V}$

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 $T_J$	On point $B_{ON}$			Off point $B_{OFF}$			Hysteresis $B_{HYS}$			Magnetic Offset			Unit
	Min.	Typ.	Max.	Min.	Typ.	Max.	Min.	Typ.	Max.	Min.	Typ.	Max.	
-40 °C	41	46.5	52	47	53	59	4	6.5	10		49.8		mT
25 °C	41	46.5	52	46	52.5	58.5	3	6	9		49.5		mT
100 °C	41	45.7	52	45	51.1	57.5	2	5.4	8		48.4		mT
140 °C	39	44.8	51	43.5	49.8	56.5	2	5	8		47.3		mT

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



**Note:** In the diagram “Magnetic switching points versus temperature” the curves for  $B_{ONmin}$ ,  $B_{ONmax}$ ,  $B_{OFFmin}$ , and  $B_{OFFmax}$  refer to junction temperature, whereas typical curves refer to ambient temperature.

**4.3. HAL566**

The HAL566 is a very sensitive unipolar switching sensor with an inverted output (see Fig. 4–9).

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

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

In the HAL55x, HAL56x two-wire sensor family, the HAL556 is a sensor with the same magnetic characteristics but with a normal output characteristic.

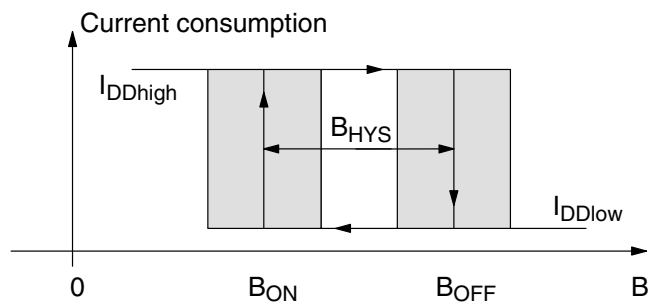
**Magnetic Features:**

- switching type: unipolar inverted
- high sensitivity
- typical  $B_{ON}$ : 4 mT at room temperature
- typical  $B_{OFF}$ : 5.9 mT at room temperature
- operates with static magnetic fields and dynamic magnetic fields up to 10 kHz

**Applications**

The HAL566 is designed for applications with one magnetic polarity and weak magnetic amplitudes at the sensor position where an inverted output signal is required such as:

- applications with large airgap or weak magnets,
- solid state switches,
- contactless solutions to replace micro switches,
- position and end point detection, and
- rotating speed measurement.



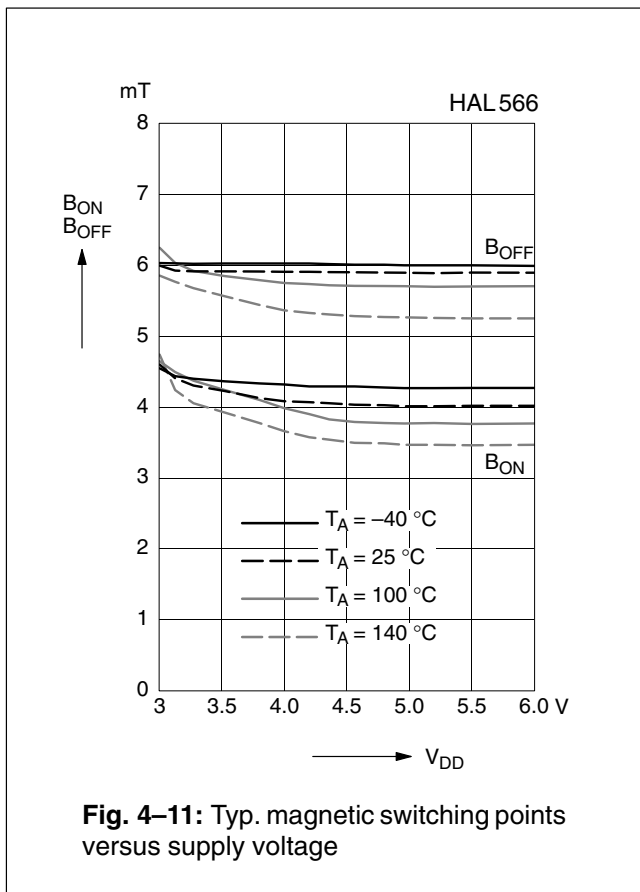
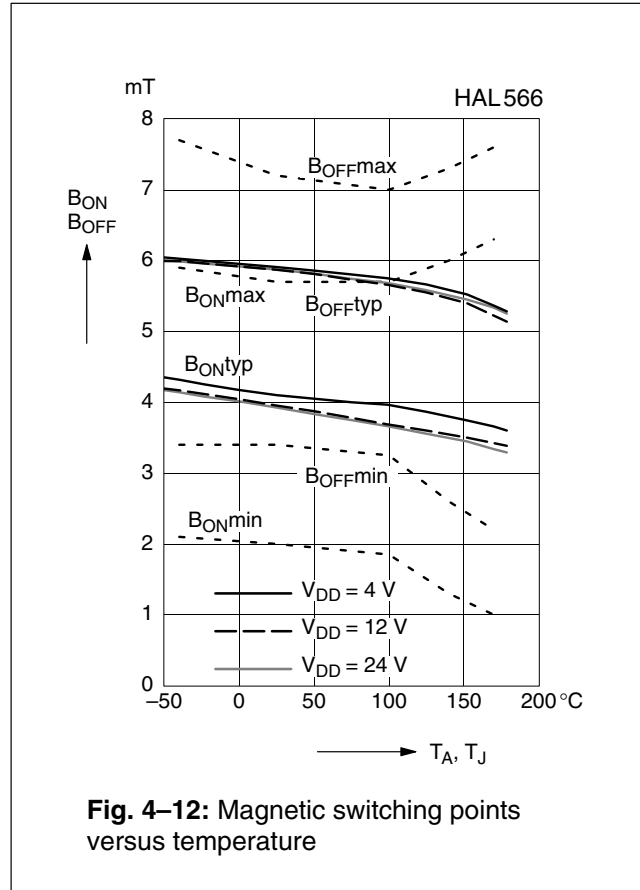
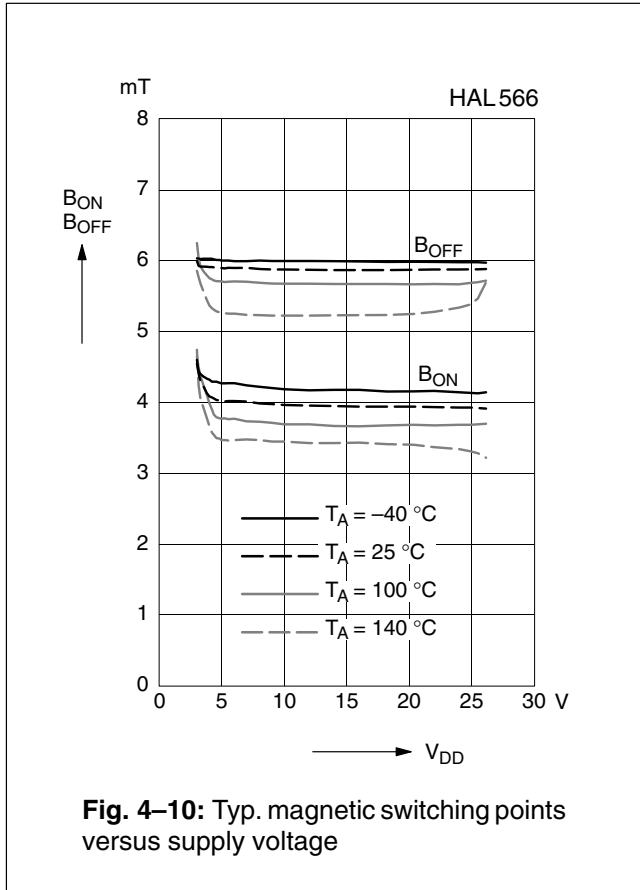
**Fig. 4–9:** Definition of magnetic switching points for the HAL566

**Magnetic Characteristics** at  $T_J = -40\text{ °C}$  to  $+140\text{ °C}$ ,  $V_{DD} = 4\text{ V}$  to  $24\text{ V}$ , Typical Characteristics for  $V_{DD} = 12\text{ V}$

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 $T_J$	On point $B_{ON}$			Off point $B_{OFF}$			Hysteresis $B_{HYS}$			Magnetic Offset			Unit
	Min.	Typ.	Max.	Min.	Typ.	Max.	Min.	Typ.	Max.	Min.	Typ.	Max.	
-40 °C	2.1	4	5.9	3.4	6	7.7	0.8	2	2.8		5		mT
25 °C	2	3.9	5.7	3.4	5.9	7.2	0.5	2	2.7	3	4.9	6.2	mT
100 °C	1.85	3.8	5.7	3.25	5.6	7	0.3	1.8	2.6		4.7		mT
140 °C	1.3	3.6	6	2.6	5.2	7.3	0.2	1.6	3		4.4		mT

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



**Note:** In the diagram “Magnetic switching points versus temperature” the curves for  $B_{ONmin}$ ,  $B_{ONmax}$ ,  $B_{OFFmin}$ , and  $B_{OFFmax}$  refer to junction temperature, whereas typical curves refer to ambient temperature.

5. Application Notes

5.1. Application Circuit

Figure 5–1 shows a simple application with a two-wire sensor. The current consumption can be detected by measuring the voltage over  $R_L$ . For correct functioning of the sensor, the voltage between pin 1 and 2 ( $V_{DD}$ ) must be a minimum of 4 V. With the maximum current consumption of 17 mA, the maximum  $R_L$  can be calculated as:

$$R_{Lmax} = \frac{V_{SUPmin} - 4V}{17 \text{ mA}}$$

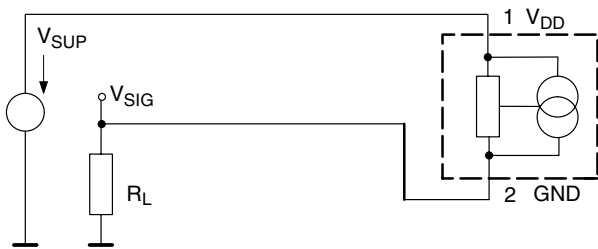


Fig. 5–1: Application Circuit 1

For applications with disturbances on the supply line or radiated disturbances, a series resistor  $R_V$  (ranging from 10  $\Omega$  to 30  $\Omega$ ) and a capacitor both placed close to the sensor are recommended (see figure 5–2). In this case, the maximum  $R_L$  can be calculated as:

$$R_{Lmax} = \frac{V_{SUPmin} - 4V}{17 \text{ mA}} - R_V$$

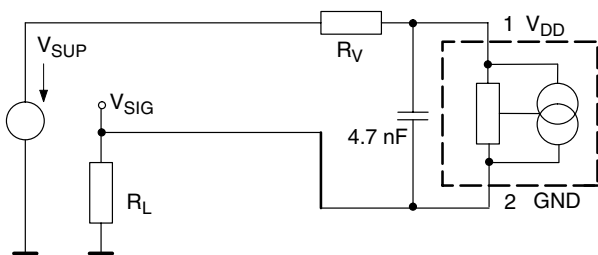


Fig. 5–2: Application Circuit 2

5.2. Extended Operating Conditions

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

Typically, the sensors operate with supply voltages above 3 V. However, below 4 V, the current consumption and the magnetic characteristics may be outside the specification.

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**Note:** The functionality of the sensor below 4 V is not tested on a regular base. For special test conditions, please contact Micronas.

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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 Electrical Characteristics (see page 13). During the initialization time, the current consumption is not defined and can toggle between low and high.

**HAL 556:**

After  $t_{en(O)}$ , the current consumption will be high if the applied magnetic field  $B$  is above  $B_{ON}$ . The current consumption will be low if  $B$  is below  $B_{OFF}$ .

**HAL 560, HAL 566:**

In case of sensors with an inverted switching behavior, the current consumption will be low if  $B > B_{OFF}$  and high if  $B < B_{ON}$ .

---

**Note:** For magnetic fields between  $B_{OFF}$  and  $B_{ON}$ , the current consumption of the HAL sensor will be either low or high after applying  $V_{DD}$ . In order to achieve a defined current consumption, the applied magnetic field must be above  $B_{ON}$ , respectively, below  $B_{OFF}$ .

---



**5.4. Ambient Temperature**

Due to 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:

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

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 for  $I_{DD}$  and  $R_{th}$ , and the max. value for  $V_{DD}$  from the application.

Due to the range of  $I_{DDhigh}$ , self-heating can be critical. The junction temperature can be reduced with pulsed supply voltage. For supply times ( $t_{on}$ ) ranging from 30  $\mu s$  to 1 ms, the following equation can be used:

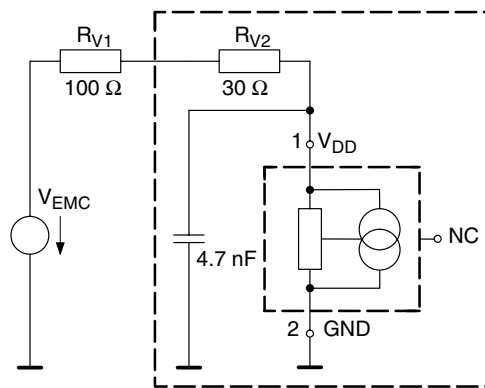
$$\Delta T = I_{DD} * V_{DD} * R_{th} * \frac{t_{on}}{t_{off} + t_{on}}$$

**5.5. EMC and ESD**

For applications with disturbances on the supply line or radiated disturbances, a series resistor and a capacitor are recommended (see Fig. 5–2). The series resistor and the capacitor should be placed as closely as possible to the HAL sensor.

Applications with this arrangement passed the EMC tests according to the product standard ISO 7637.

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



**Fig. 5–3:** Recommended EMC test circuit

**WARNING:**

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

## 6. Data Sheet History

1. Final data sheet: "HAL 556, HAL 560, HAL 566, Two-Wire Hall Effect Sensor Family, April 6, 1999, 6251-425-1DS. First release of the final data sheet.
2. Final data sheet: "HAL 556, HAL 560, HAL 566, Two-Wire Hall Effect Sensor Family, Aug. 3, 2000, 6251-425-2DS. Second release of the final data sheet. Major changes:
  - magnetic characteristics for HAL556 and HAL560 changed. Please refer to pages 12 and 14 for details.
  - new temperature ranges "K" and "A" added
  - temperature range "C" removed
  - outline dimensions for SOT-89B: reduced tolerances
  - SMD package SOT-89A removed
3. Final data sheet: "HAL 556, HAL 560, HAL 566, Two-Wire Hall Effect Sensor Family, Jan. 28, 2003, 6251-425-3DS. Third release of the final data sheet. Major changes:
  - temperature range "A" removed
  - outline dimensions for TO-92UA changed
4. Final data sheet: "HAL 556, HAL 560, HAL 566, Two-Wire Hall Effect Sensor Family, May 14, 2004, 6251-425-4DS. Fourth release of the final data sheet. Major changes:
  - new package diagrams for SOT89-1 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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