MICRONAS

Hardware Documentation

Data Sheet

HAL® 549

Hall-Effect Sensor with Undervoltage Reset

Edition Jan. 30, 2009
DSH000022_003EN

Contents

Hall-Effect Sensor with Undervoltage Reset
in CMOS Technology

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

1. Introduction

The HAL549 is a Hall Effect switch produced in CMOS technology. The sensor includes 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 HAL549 features a power-on and undervoltage reset.

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 sensor is designed for industrial and automotive applications and operates with supply voltages from 4.3 V to 24 V in the ambient temperature range from –40 °C up to 140 °C.

The HAL549 sensor is 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
- power-on and undervoltage reset
- 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

1.2. 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
HAL549	549K	549E

1.3. Operating Junction Temperature Range (T_J)

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 21 for details.

1.4. Hall Sensor Package Codes

HALXXXPA-T

Temperature Range: K or E
Package: SF for SOT89B-1
UA for TO92UA
Type: 549

Example: **HAL549UA-K**

→ Type: 549
→ 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”.

1.5. Solderability and Welding

All packages: according to IEC68-2-58.

Solderability

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

Welding

Device terminals should be compatible with laser and resistance welding. Please note that the success of the welding process is subject to different welding parameters which will vary according to the welding technique used. A very close control of the welding parameters is absolutely necessary in order to reach satisfying results. Micronas, therefore, does not give any implied or express warranty as to the ability to weld the component.

1.6. Pin Connections

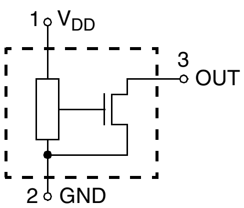


Fig. 1–1: Pin configuration

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 "low" 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. The output state is not defined for V_{DD} < 3 V.

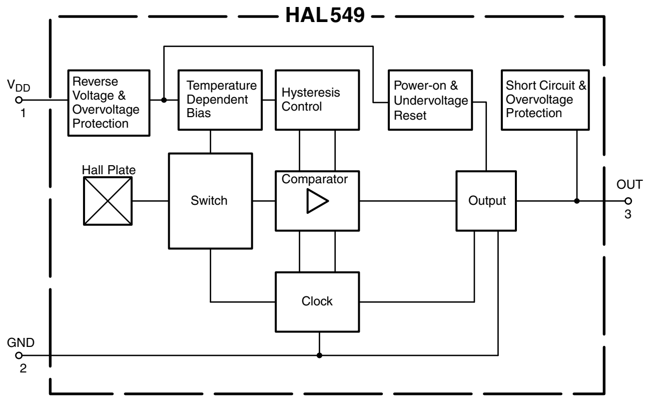


Fig. 2–1: HAL549 block diagram

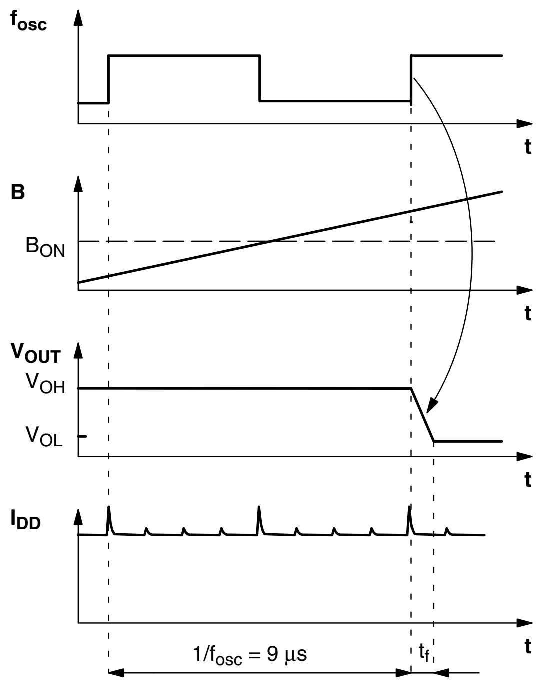
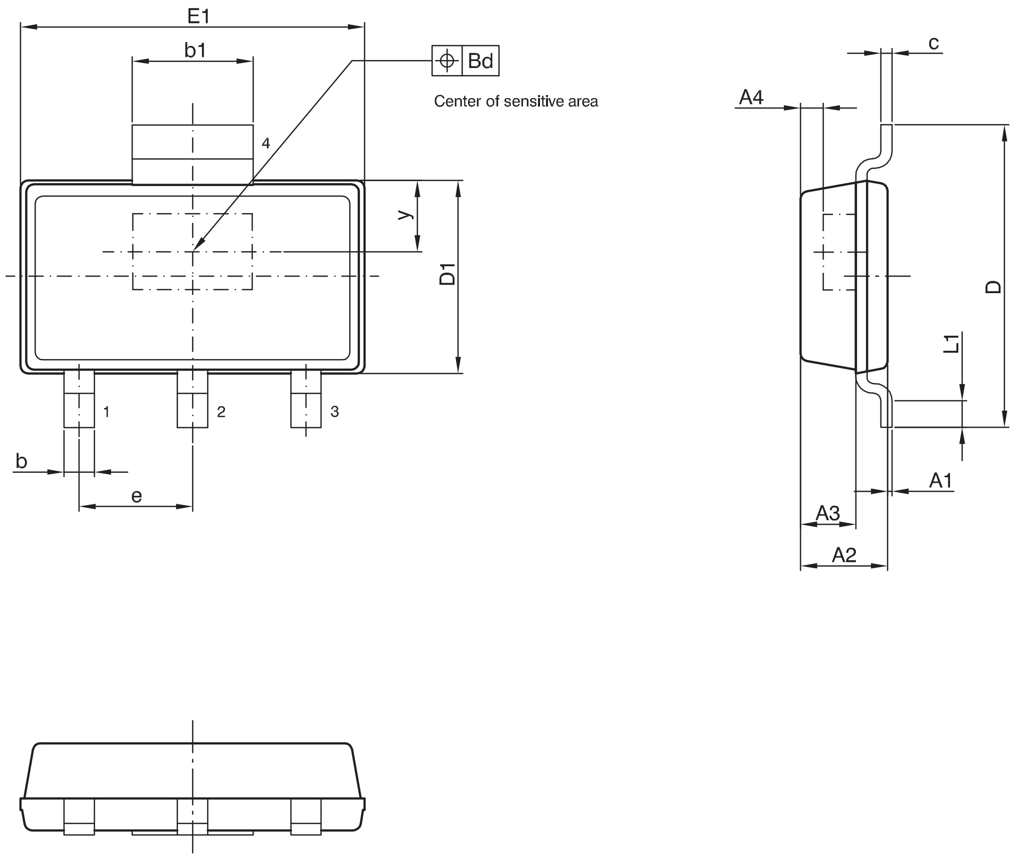


Fig. 2–2: Timing diagram

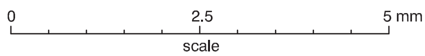
3. Specifications

3.1. Outline Dimensions



physical dimensions do not include moldflash.

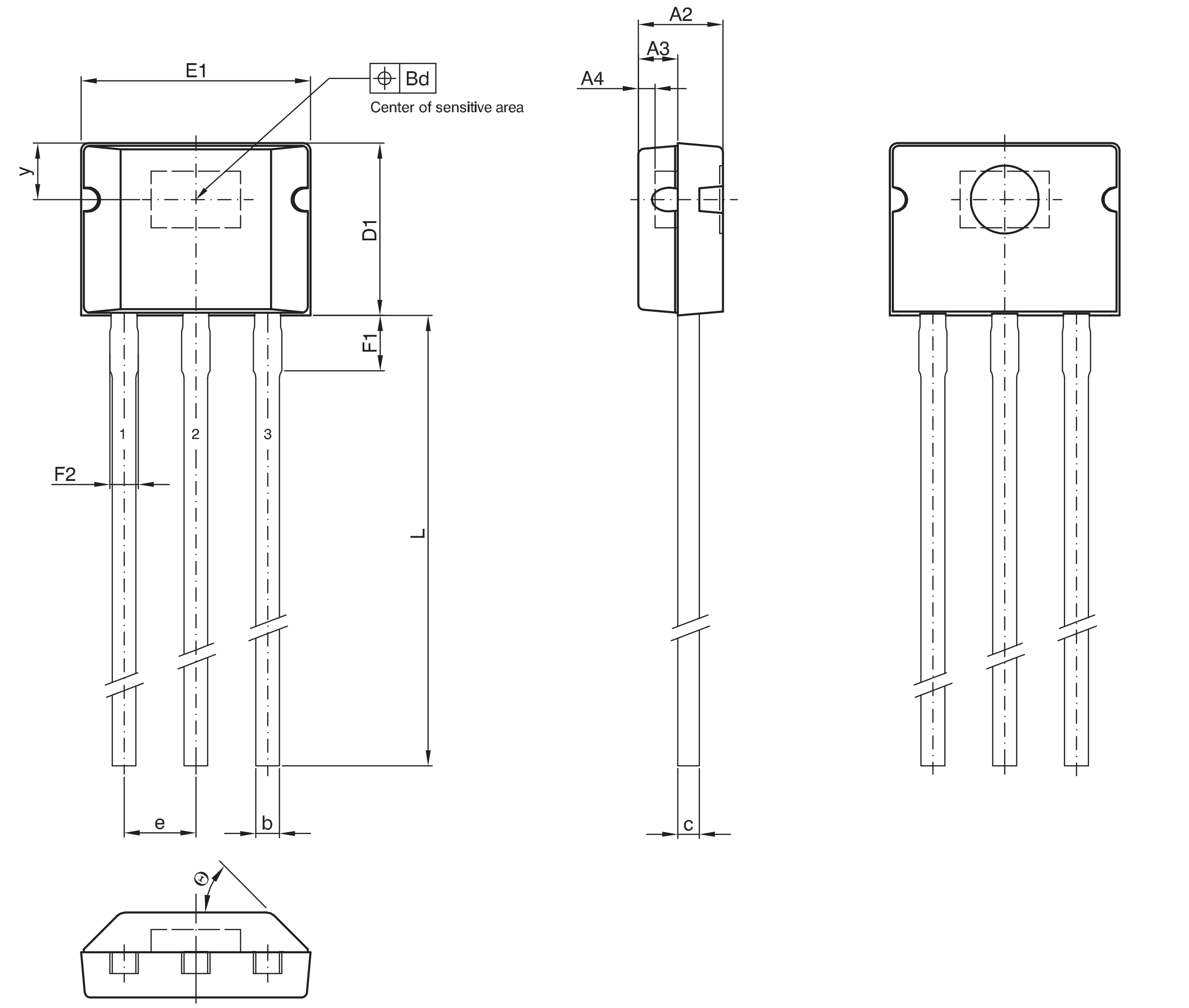
A4, y= these dimensions are different for each sensor type and are specified in the data sheet.



UNIT	A1	A2	A3	b	b1	Bd	c	D	D1	e	E1	L1
mm	0.10 0.02	1.20 1.10	0.73	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.	ZG-NO.
ISSUE	ITEM NO.				
-	-		07-07-02	06610.0001.4	ZG001010_Ver.03

Fig. 3–1:
SOT89B-1: Plastic **S**mall **O**utline **T**ransistor package, 4 leads
Ordering code: SF
Weight approximately 0.034 g



physical dimensions do not include moldflash.

solderability is guaranteed between end of pin and distance F1.

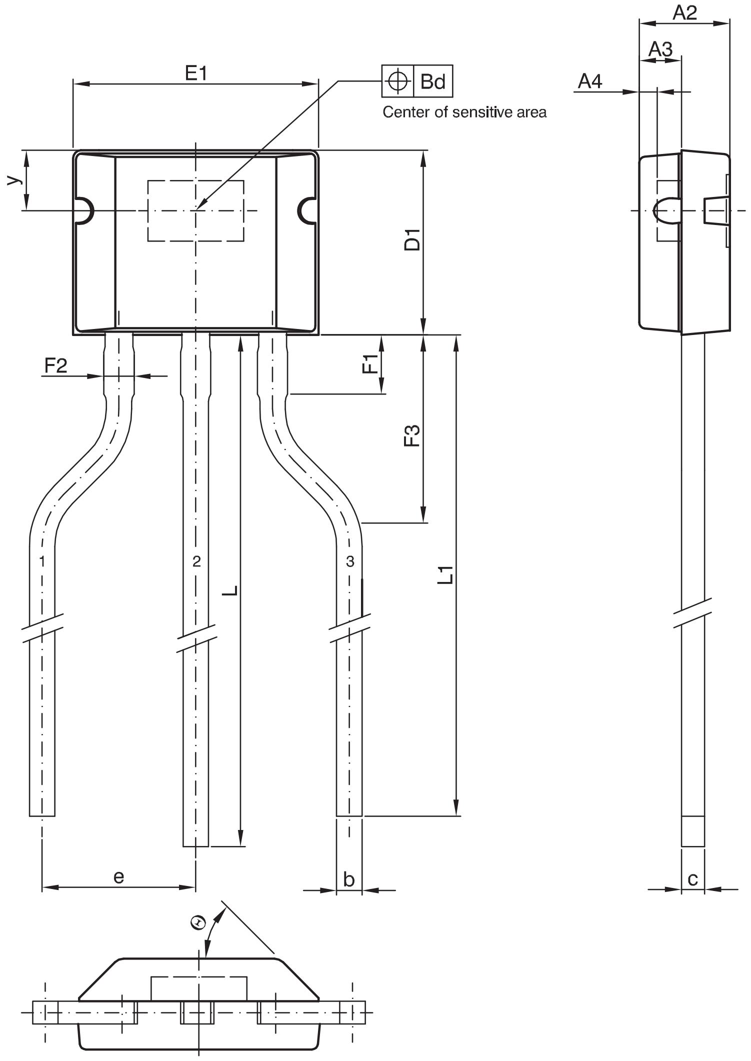
y= this dimension is different for each sensor type and is specified in the data sheet.

0 2.5 5 mm
scale

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.	ZG-NO.
ISSUE	ITEM NO.				
-	-		07-07-03	06612.0001.4	ZG001012_Ver.04

Fig. 3–2:
TO92UA-2: Plastic Transistor Standard UA package, 3 leads, not spread
Weight approximately 0.106 g



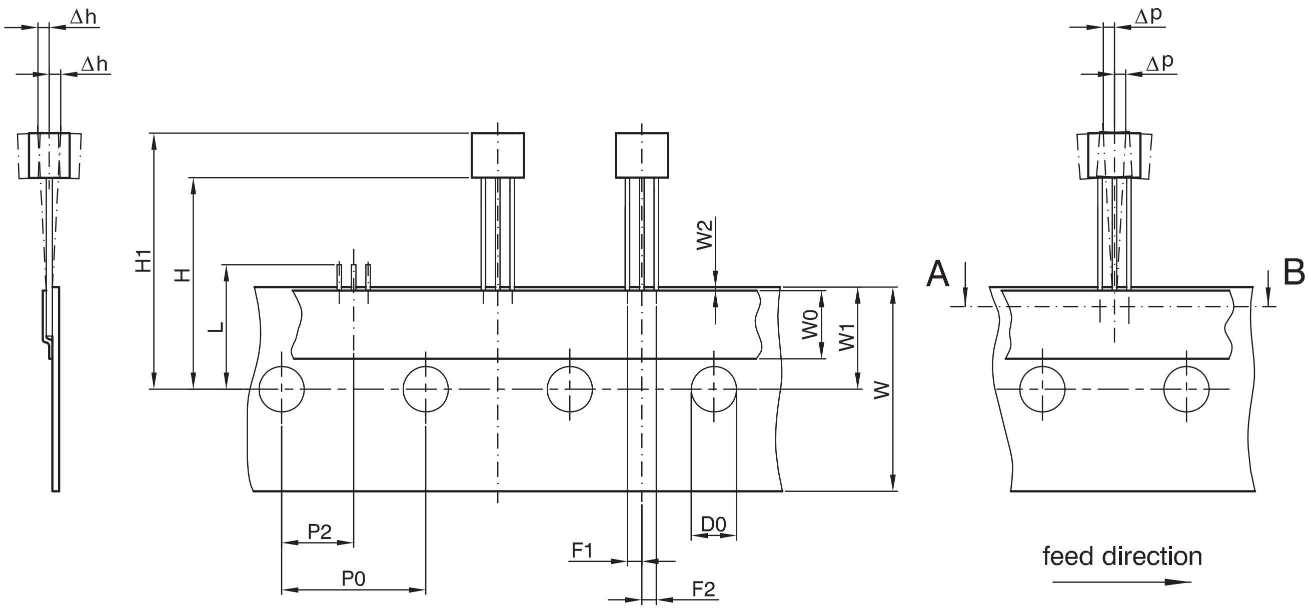
physical dimensions do not include moldflash.
solderability is guaranteed between end of pin and distance F1.
y= this dimension is different for each sensor type and is specified in the data sheet.

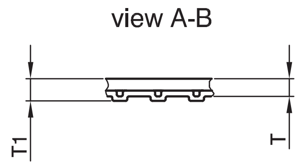
0 2.5 5 mm
scale

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 min	14.5 min	45°

JEDEC STANDARD		ANSI	ISSUE DATE YY-MM-DD	DRAWING-NO.	ZG-NO.
ISSUE	ITEM NO.				
-	-		07-07-03	06616.0001.4	ZG001016_Ver.03

Fig. 3–3:
TO92UA-1: Plastic Transistor Standard UA package, 3 leads, spread
Weight approximately 0.106 g



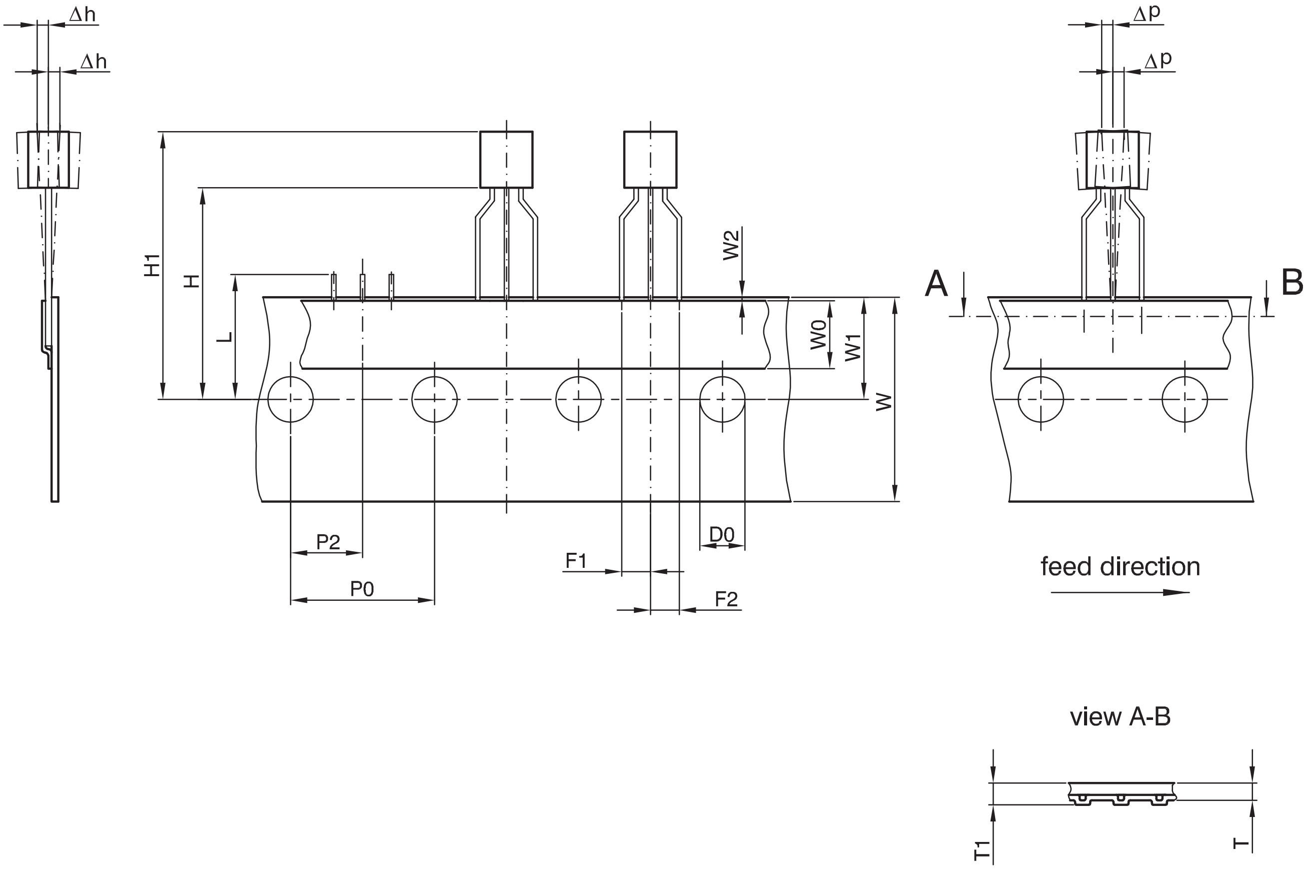


all dimensions in mm
other dimensions see drawing of bulk
max. allowed tolerance over 20 hole spacings ±1.0
H1 = this dimension is different for each sensor type and is specified in the data sheet

UNIT	D0	F1	F2	H	Δh	L	P0	P2	Δp	T	T1	W	W0	W1	W2
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	6.0	9.0	0.3

JEDEC STANDARD		ANSI	ISSUE DATE YY-MM-DD	DRAWING-NO.	ZG-NO.
ISSUE	ITEM NO.				
-	ICE 60286-2		07-01-18	06631.0001.4	ZG001031_Ver.03

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



all dimensions in mm
other dimensions see drawing of bulk
max. allowed tolerance over 20 hole spacings ±1.0
H1 = this dimension is different for each sensor type and is specified in the data sheet

UNIT	D0	F1	F2	H	Δh	L	P0	P2	Δp	T	T1	W	W0	W1	W2
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	6.0	9.0	0.3

JEDEC STANDARD		ANSI	ISSUE DATE YY-MM-DD	DRAWING-NO.	ZG-NO.
ISSUE	ITEM NO.				
-	ICE 60286-2		07-01-18	06632.0001.4	ZG001032_Ver.04

Fig. 3–5:
TO92UA/UT: 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
x	center of the package	center of the package
y	0.95 mm nominal	1.0 mm nominal
A4	0.3 mm nominal	–
Bd	0.2 mm	–

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 –40	150 170[2)]	°C

1) as long as $T_J$max is not exceeded
2) t < 1000h

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.

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 over Temperature Range	3	–	130	400[1)]	mV	I_{OL} = 20 mA
I_{OH}	Output Leakage Current over Temperature Range	3	–	–	10	µA	Output switched off, T_J ≤140 °C, V_{OH} = 4.3 to 24 V
f_{osc}	Internal Oscillator Chopper Frequency over Temperature Range	–	–	62	–	kHz	
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[2)]
t_r	Output Rise Time	3	–	75	400	ns	V_{DD} = 12 V, R_L = 820 Ω, C_L = 20 pF
t_f	Output Fall Time	3	–	50	400	ns	
SOT89B Package							
	Thermal Resistance						30 mm x 10 mm x 1.5 mm, pad size (see Fig. 3–6)
R_{thja}	Junction to Ambient	–	–	–	209[3)]	K/W	
R_{thjc}	Junction to Case	–	–	–	56[3)]	K/W	
R_{thjs}	Junction to Solder Point	–	–	–	82[4)]	K/W	
TO92UA Package							
	Thermal Resistance						
R_{thja}	Junction to Ambient	–	–	–	246[3)]	K/W	
R_{thjc}	Junction to Case	–	–	–	70[3)]	K/W	
R_{thjs}	Junction to Solder Point	–	–	–	127[4)]	K/W	

1) For supply voltage below 4.3 V, the output low voltage will increase and will be higher than 400 mV
2) B > B_{ON} + 2 mT or B < B_{OFF} – 2 mT
3) Measured with a 1s0p board
4) Measured with a 1s1p board

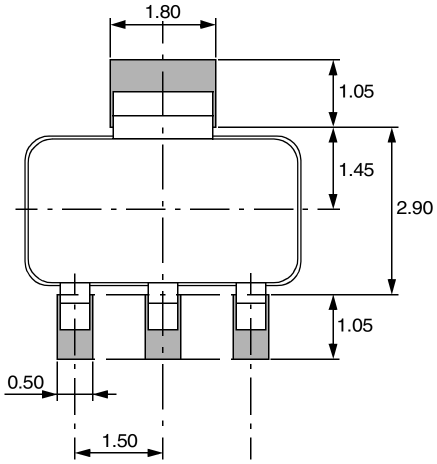


Fig. 3–6: Recommended pad size SOT89B-1
Dimensions in mm

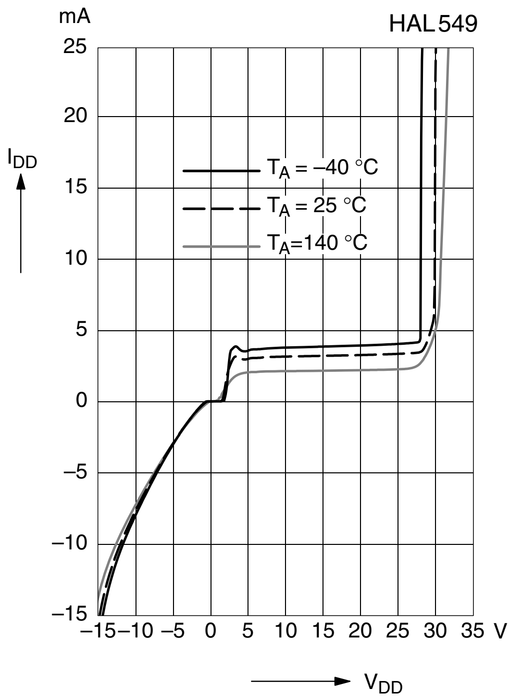


Fig. 3–7: Typical supply current versus supply voltage

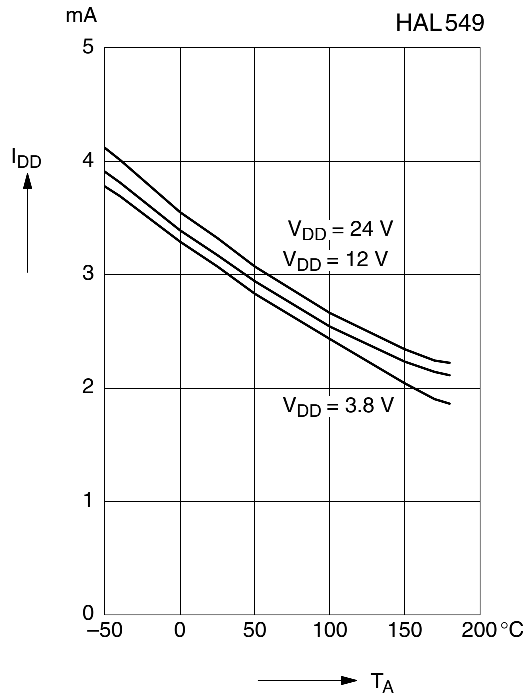


Fig. 3–9: Typical supply current versus ambient temperature

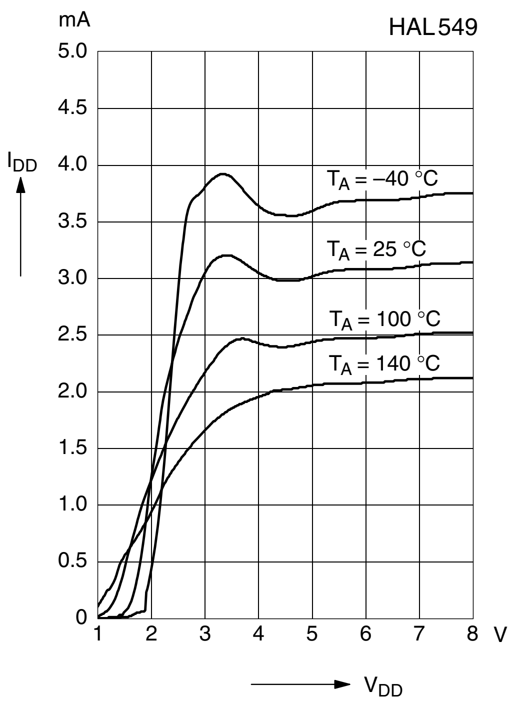


Fig. 3–8: Typical supply current versus supply voltage

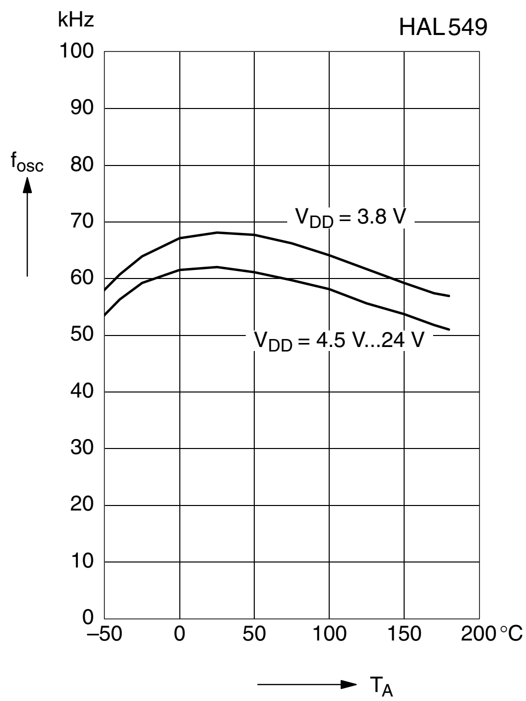


Fig. 3–10: Typ. internal chopper frequency versus ambient temperature

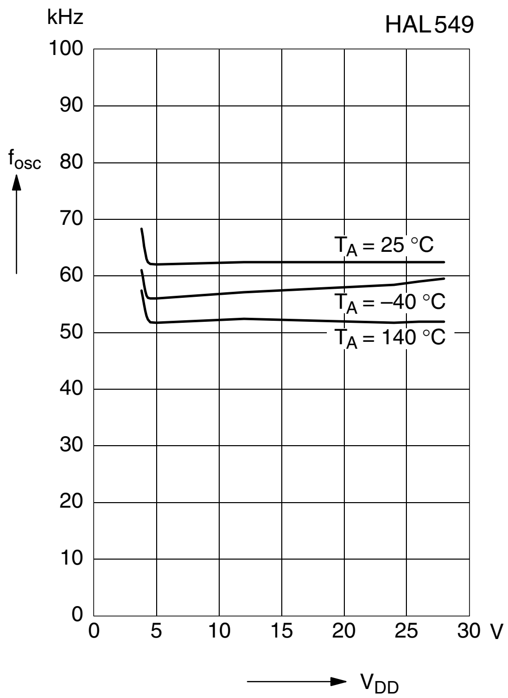


Fig. 3–11: Typ. internal chopper frequency versus supply voltage

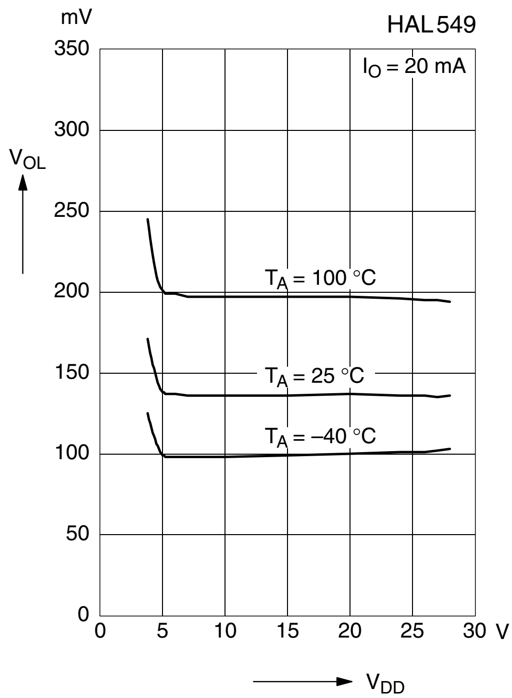


Fig. 3–13: Typical output low voltage versus supply voltage

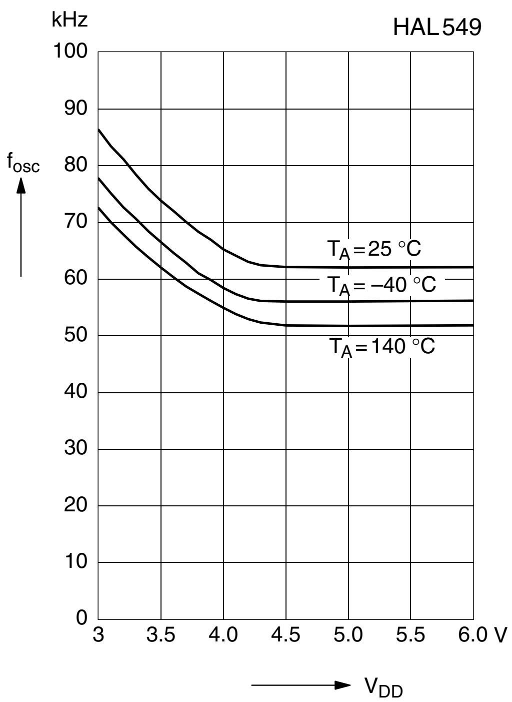


Fig. 3–12: Typ. internal chopper frequency versus supply voltage

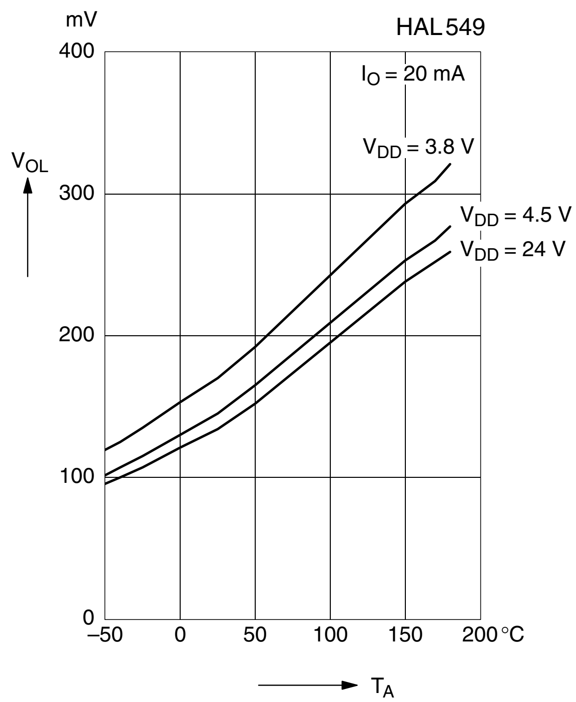


Fig. 3–14: Typical output low voltage versus ambient temperature

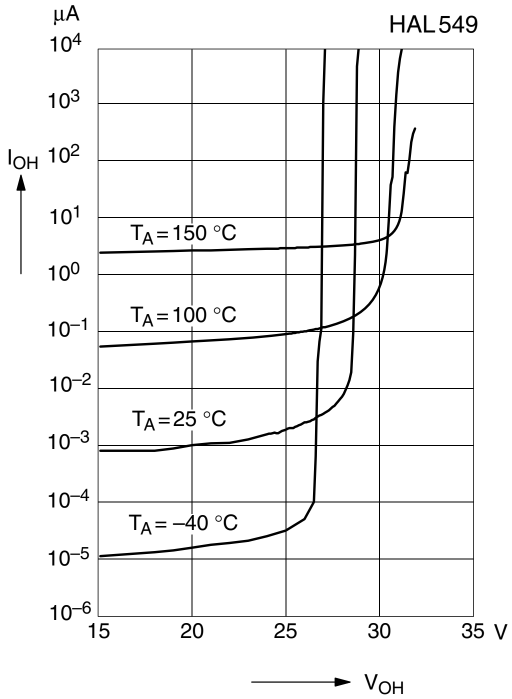


Fig. 3–15: Typ. output high current versus output voltage

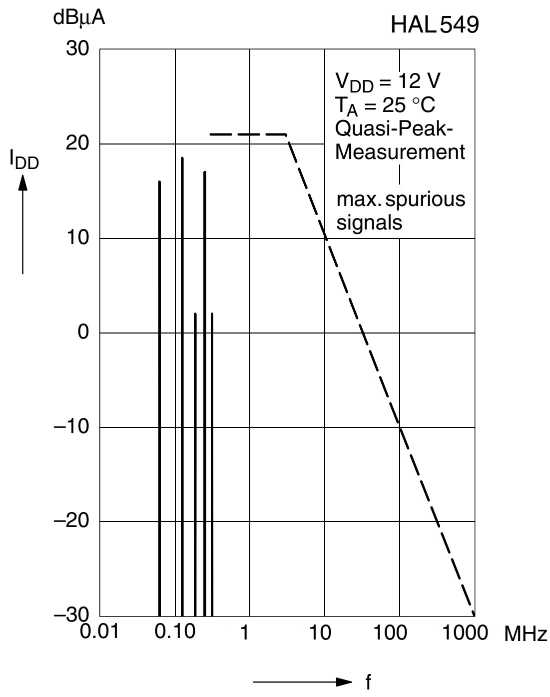


Fig. 3–17: Typ. spectrum of supply current

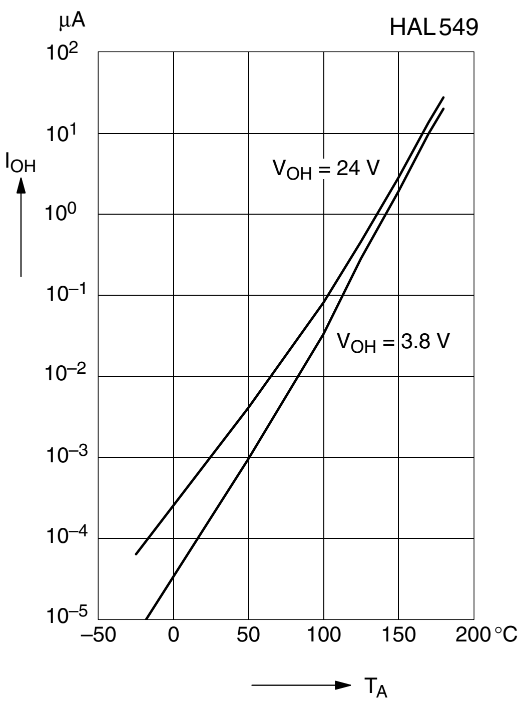


Fig. 3–16: Typical output leakage current versus ambient temperature

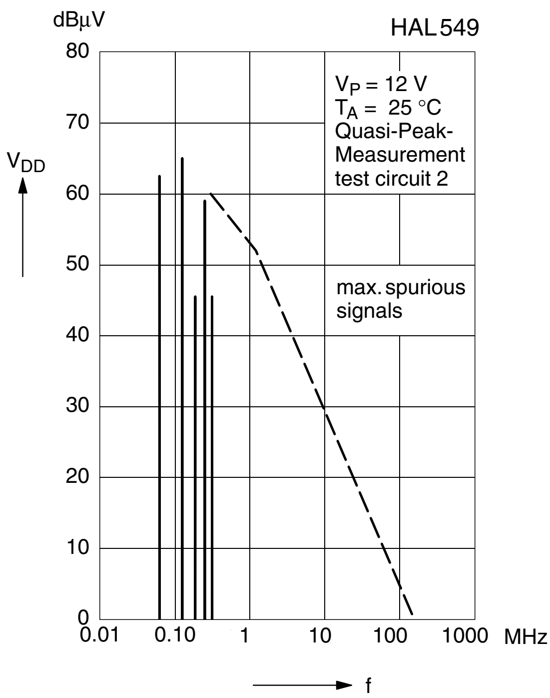


Fig. 3–18: Typ. spectrum of supply voltage

4. Type Description

4.1. HAL549

The HAL549 is a very sensitive unipolar switching sensor only sensitive to the magnetic north polarity (see Fig. 4–1).

The output turns low with the magnetic north 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 south pole.

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

Magnetic Features:

– switching type: unipolar
– high sensitivity
– typical B_{ON}: –5.5 mT at room temperature
– typical B_{OFF}: –3.6 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 HAL549 is the optimal 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.

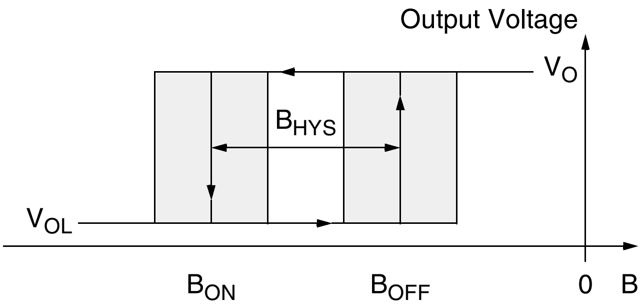


Fig. 4–1: Definition of magnetic switching points for the HAL549

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	–7.7	–5.9	–4.3	–5.4	–3.8	–2.1	1.6	2.1	2.8	–	–4.8	–	mT
25 °C	–7.2	–5.5	–3.8	–5	–3.6	–2	1.5	1.9	2.7	–	–4.5	–	mT
100 °C	–6.7	–5	–3.4	–4.9	–3.3	–1.9	1.2	1.7	2.6	–	–4.2	–	mT
140 °C	–7	–4.8	–3.0	–5.3	–3.1	–1.7	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 $B_{OFFSET} = (B_{ON} + B_{OFF}) / 2$

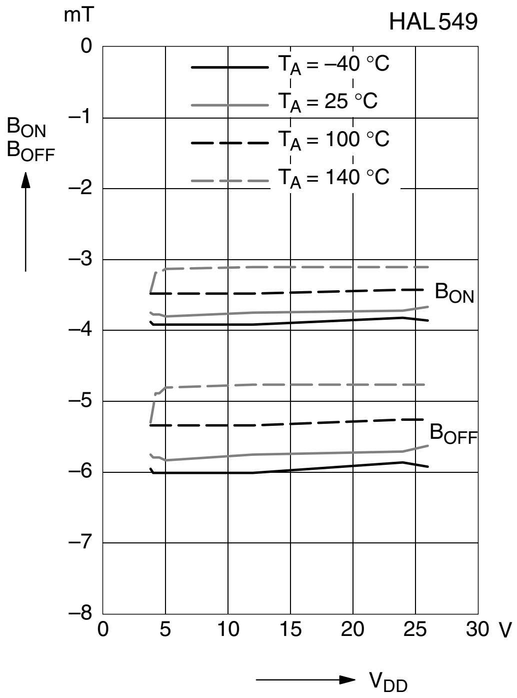


Fig. 4–2: Typ. magnetic switching points versus supply voltage

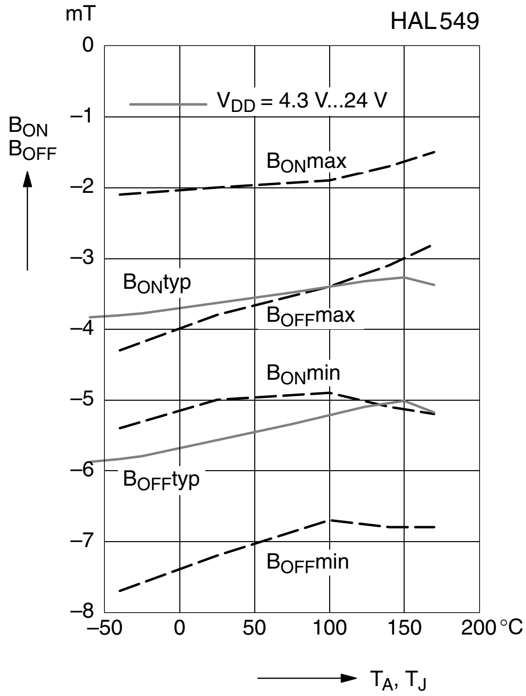


Fig. 4–3: Magnetic switching points versus temperature

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.

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:

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

If $I_{OUT} > I_{DD}$, please contact Micronas application support for detailed instructions on calculating ambient-temperature.

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 Section 3.5. on page 13).

Supply Voltage Below 4.3 V

The devices contain a Power-on Reset (POR) and an undervoltage reset. For 3 V < V_{DD} < V_{reset} < 4.3 V, the output state is "low" (reset state). For V_{DD} < 3 V, the output state is not defined.

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 Section 3.5. on page 13).

The initialization time consists of two parts: internal power-up time and internal initialization time. During the internal power-up time (some µsec.), the output state may change. After the internal power-up time and with a supply voltage higher than 3 V, the output state for HAL 549 is "On-state". After $t_{en(O)}$, the output will be high. The output will be switched to low if the applied magnetic field "B" is below 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.

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

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

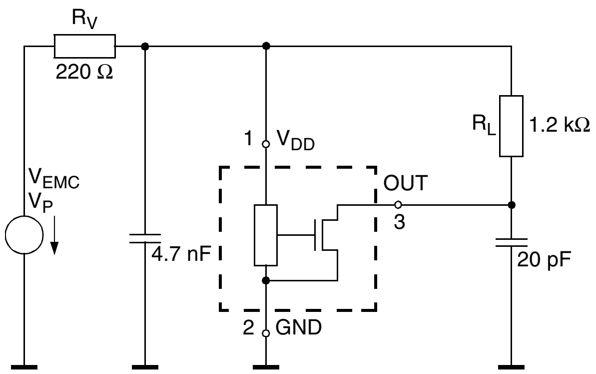


Fig. 5–1: Test circuit for EMC investigations

6. Data Sheet History

1. Data Sheet "HAL 549 Hall Effect Sensor with Undervoltage Reset", May 27, 2004, 6251-611-1DS. First release of the data sheet.

2. Data Sheet: "HAL 549 Hall Effect Sensor with Undervoltage Reset", Dec. 10, 2007, DSH000022_002EN. Second release of the data sheet. Major changes:

– Outline dimensions for SOT89B and TO92UA updated

– Position parameters for sensitive areas in SOT89B package added

– Pad size dimensions SOT89B updated

– Section "Ambient Temperature" updated

3. Data Sheet: "HAL 549 Hall-Effect Sensor with Undervoltage Reset", Jan. 30, 2009, DSH000022_003EN. Third release of the data sheet. Major changes:

– Section 1.5. "Solderability and Welding" updated

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