MICRONAS

Hardware
Documentation

Data Sheet

HAL® 1 4xy

Hall-Effect Switches for Industrial and Consumer Applications

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Contents

Hall-Effect Switches for Industrial and Consumer Applications

1. Introduction

The HAL 14xy Hall-switch family members produced in CMOS technology as 3-wire device with open-drain output transistor include a temperature-compensated Hall plate with active offset compensation, a comparator, and an output stage.

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.

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.

HAL 14xy is available in a JEDEC TO236-compliant SMD-package 3-lead SOT23.

1.1. Features of HAL 14xy

– SOT23-3L JEDEC TO236-compliant package
– Short-circuit protected open-drain output and thermal shutdown
– Low current consumption of typ. 1.6 mA
– Operates with supply voltages from 2.7 V to 24 V
– Reverse-voltage protected VSUP-pin (–18 V)
– Operates with static and dynamic magnetic fields up to 12 kHz
– High resistance to mechanical stress by active offset compensation
– Junction temperature range from –20 °C to 125 °C
– Built-in temperature coefficient

2. Ordering Information

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

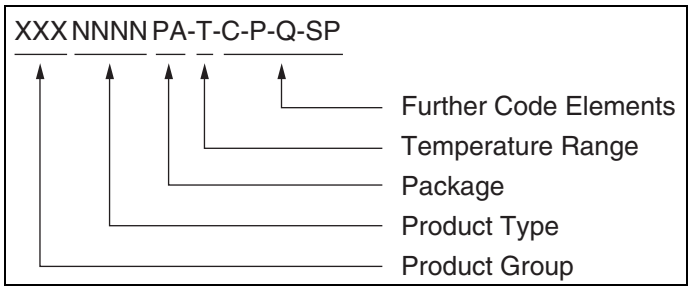


Fig. 2–1: Ordering Code Principle

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

2.1. Device-Specific Ordering Codes

is available in the following package and temperature range.

Table 2–1: Available packages

Package Code (PA)	Package Type
SU	SOT23

Table 2–2: Available temperature ranges

Temperature Code (T)	Temperature Range
I	T_J = –20 °C to 125 °C

The relationship between ambient temperature (T_A) and junction temperature (T_J) is explained in **Section 5.2. on page 36**.

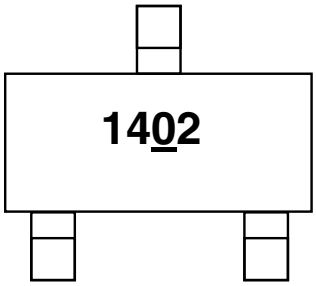
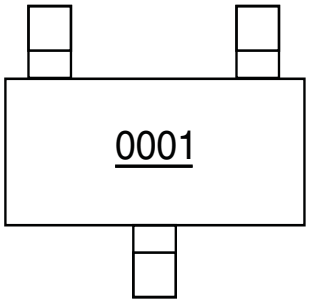
For available variants for Configuration (C), Packaging (P), Quantity (Q) and Special Procedure (SP) please contact TDK-Micronas.

Table 2–3: Available ordering codes

Available Ordering Codes
HAL1401SU-I-[C-P-Q-SP]
HAL1402SU-I-[C-P-Q-SP]
HAL1403SU-I-[C-P-Q-SP]
HAL1404SU-I-[C-P-Q-SP]
HAL1405SU-I-[C-P-Q-SP]
HAL1406SU-I-[C-P-Q-SP]
HAL1407SU-I-[C-P-Q-SP]
HAL1408SU-I-[C-P-Q-SP]
HAL1409SU-I-[C-P-Q-SP]
HAL1410SU-I-[C-P-Q-SP]

This data sheet is valid for HAL 14xy derivatives with an underlined trace code, as shown in the example below.

Table 2–4: Example for Product Marking

Package Top Surface Marking	Package Bottom Surface Marking
	
1402 = Product Type	0001 = Trace Code

3. Functional Description of HAL 14xy

The HAL 14xy sensors are monolithic integrated circuits which switch in response to magnetic fields. If a magnetic field with flux lines perpendicular to the sensitive area is applied to the sensor, the biased Hall plate forces a Hall voltage proportional to this field. The Hall voltage is compared with the actual threshold level in the comparator. If the magnetic field exceeds the threshold levels, the output stage is switched to the appropriate state.

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

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

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

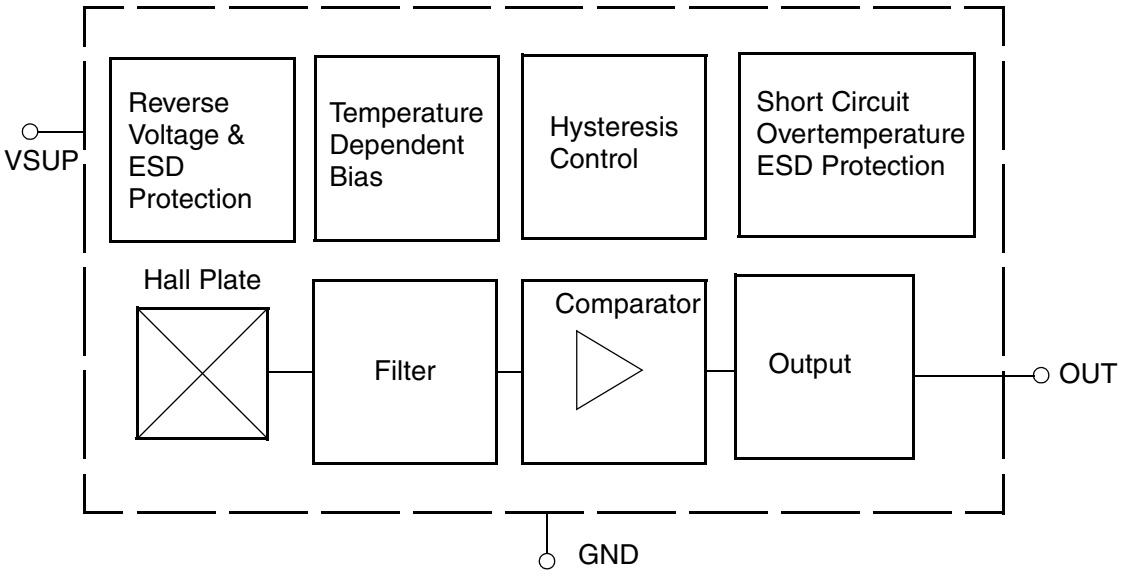
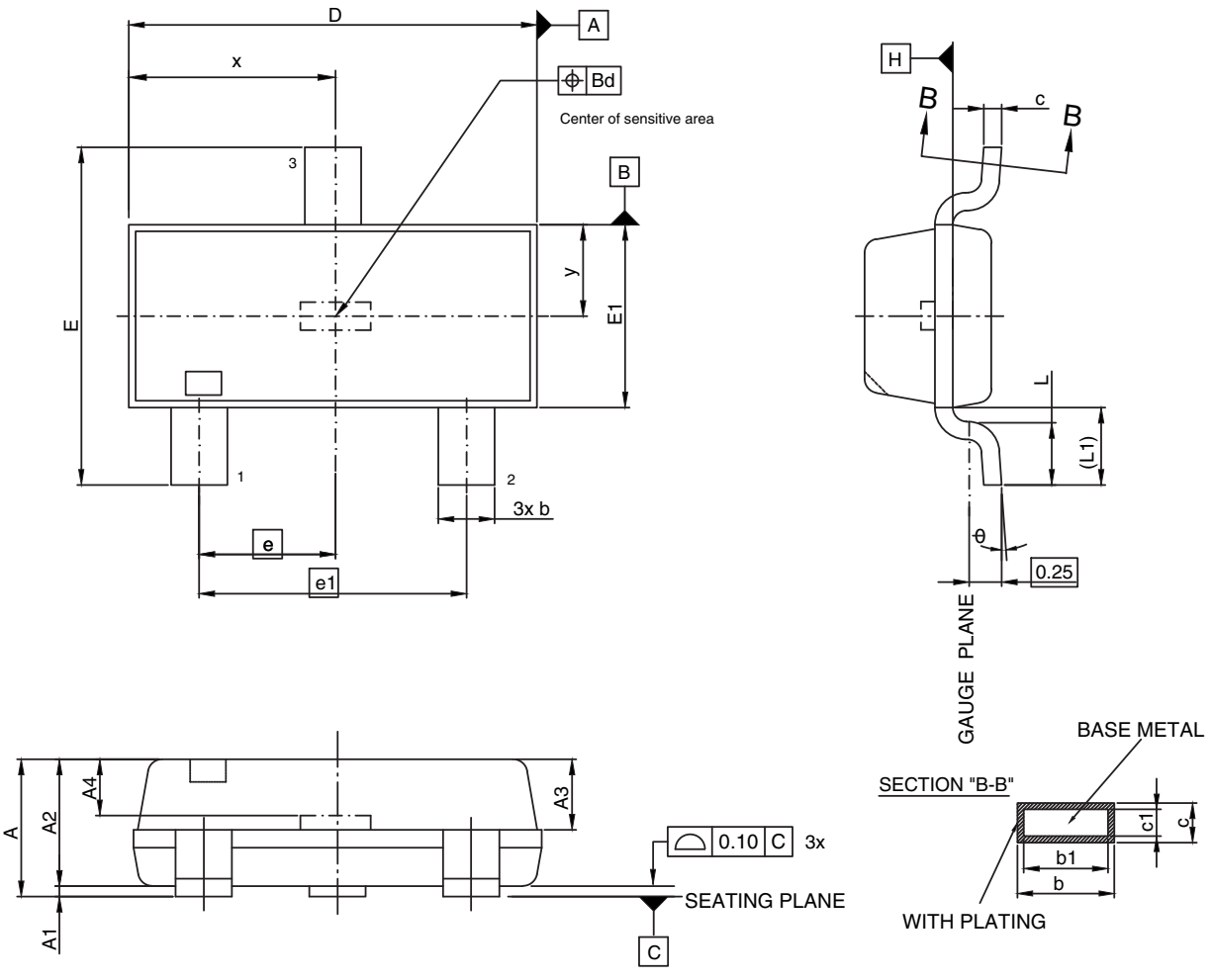


Fig. 3–1: HAL 14xy block diagram

4. Specifications

4.1. Outline Dimensions



physical dimensions do not include moldflash.

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

UNIT	A	A1	A2	A3	b	b1	c	c1	D	E	E1	e	e1	L	L1	θ
mm	1.10 max.	0.05 0.10	0.88 1.02	0.5	0.3 0.48	0.3 0.45	0.1 0.18	0.1 0.15	2.8 3.0	2.1 2.5	1.2 1.4	0.95	1.9	0.4 0.6	0.55	0° 8°

JEDEC STANDARD		ANSI	ISSUE DATE YY-MM-DD	DRAWING-NO.	ZG-NO.
ISSUE	ITEM NO.				
-	TO-236		13-05-10	06902.0001.4	ZG001101_Ver.01

Fig. 4–1:
SOT23: Plastic **S**mall **O**utline **T**ransistor package, 3 leads
Ordering code: SU
Weight approximately 0.01094 g

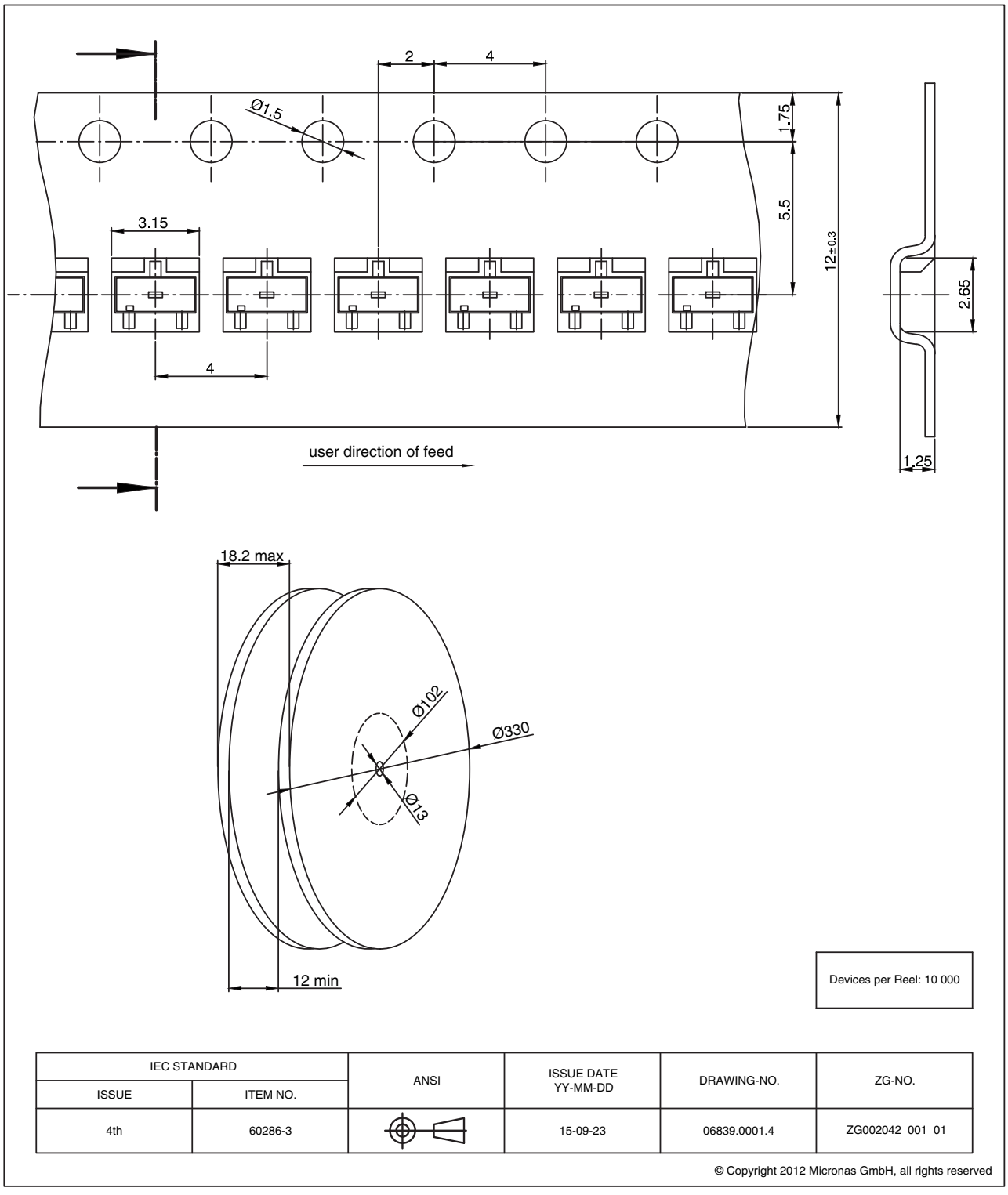


Fig. 4–2:
SOT23: Tape & Reel Finishing

4.2. Soldering, Welding and Assembly

Information related to solderability, welding, assembly, and second-level packaging is included in the document “Guidelines for the Assembly of Micronas Packages”.
It is available on the TDK-Micronas website (http://www.micronas.com/en/service-center/downloads) or on the service portal (http://service.micronas.com).

4.2.1. SOT23 Footprint for Reflow and Wave Soldering

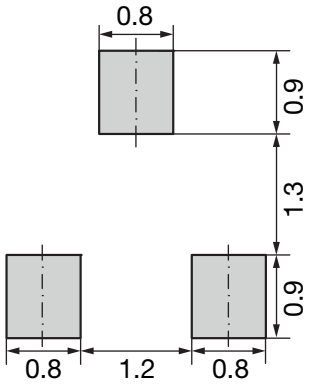


Fig. 4–3: SOT23 footprint for reflow soldering

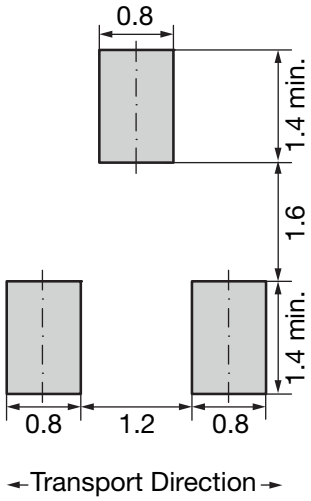


Fig. 4–4: SOT23 footprint for wave soldering

All dimensions in mm.

4.3. Pin Connections (from Top Side, Example HAL 1402) and Short Descriptions

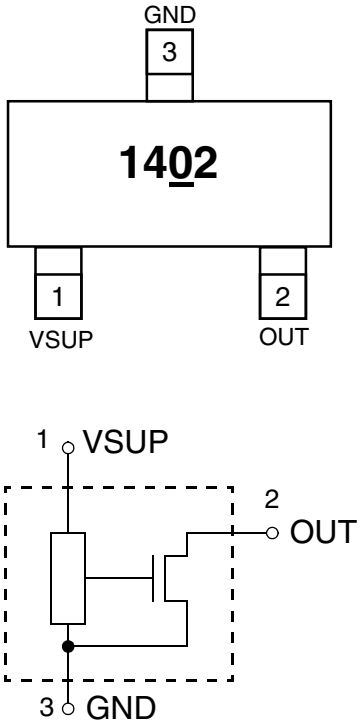


Fig. 4–5: Pin configuration

Table 4–1: Pin assignment.

Pin number	Name	Function
1	VSUP	Supply voltage
2	OUT	Output
3	GND	Ground

4.4. Dimension and Position of Sensitive Area

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

4.5. Absolute Maximum Ratings

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

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

All voltages listed are referenced to ground (GND).

Symbol	Parameter	Pin No	Min.	Max.	Unit	Conditions
T_J	Junction temperature range A	–	–40	140	°C	t < 96 h[1)]
$T_{storage}$	Transportation/ Short-Term Storage Temperature	–	–50	155	°C	Device only without packing material
V_{SUP}	Supply voltage	1	–18	28	V	t < 96 h[1)]
V_{OUT}	Output voltage	2	–0.5	28	V	t < 96 h[1)]
I_O	Output current	2	–	65	mA	
I_{OR}	Reverse output current	2	–50	–	mA	
[1)] No cumulative stress						

4.6. Storage and Shelf Life

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

4.7. Recommended Operating Conditions

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

All voltages listed are referenced to ground (GND).

Symbol	Parameter	Pin No.	Min.	Typ.	Max.	Unit
V_{SUP}	Supply voltage	1	2.7	–	24	V
T_J	Junction temperature range A[1)]	–	–20	–	125	°C
V_{OUT}	Output voltage	2	–	–	24	V
I_{OUT}	Output current	2	–	–	25	mA

[1)] Depends on the temperature profile of the application. Please contact TDK-Micronas for life time calculations.

4.8. Characteristics

at T_J = –20 °C to 125 °C, V_{SUP} = 2.7 V to 24.0 V,
at Recommended Operating Conditions if not otherwise specified in the column “Conditions”.
Typical Characteristics for T_J = 25 °C and V_{SUP} = 12.0 V

Symbol	Parameter	Pin No.	Min.	Typ.	Max.	Unit	Conditions
Supply							
V_{UV}	Undervoltage threshold	1	2.0	–	2.7	V	
I_{SUP}	Supply current	1	1.1	1.6	2.4	mA	
Port Output							
V_{ol}	Port low output voltage	2	–	0.13	0.4	V	I_O = 20 mA
			–	–	0.5	V	I_O = 25 mA
I_{oleak}	Output leakage current	2	–	0.1	10	µA	
t_f	Output fall time[1)]	2	–	–	1	µs	V_{SUP} = 12 V; R_L = 820 Ω; C_L = 20 pF
t_r	Output rise time[1)]	2	–	–	1	µs	
t_{en}	Enable time of output after exceeding of V_{UV}	2	20	50	60	µs	V_{SUP} = 12 V B > B_{on} + 2 mT or B < B_{off} – 2 mT
Package							
R_{thja}	Thermal Resistance junction to air	–	–	–	300	K/W	Determined with a 1s0p board
		–	–	–	250	K/W	Determined with a 1s1p board
		–	–	–	210	K/W	Determined with a 2s2p board
R_{thjc}	Thermal Resistance junction to case	–	–	–	30	K/W	Determined with a 1s0p board
		–	–	–	50	K/W	Determined with a 1s1p board
		–	–	–	40	K/W	Determined with a 2s2p board

[1)] Characterized on small sample size, not tested

4.9. HAL 1401 Magnetic Characteristics

The HAL 1401 bipolar Hall-switch provides highest sensitivity (see Fig. 4–6 on page 15).

The output turns to Low-Z with the magnetic south pole on the top side of the package and turns to High-Z with the magnetic north pole on the top side. The output state is not defined if the magnetic field is removed again.

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

Magnetic Features:

– switching type: bipolar

– very high sensitivity

– typical B_{ON}: 0.4 mT at room temperature

– typical B_{OFF}: –0.4 mT at room temperature

– operates with static magnetic fields and dynamic magnetic fields up to 12 kHz

– typical temperature coefficient of magnetic switching points is 0 ppm/K at room temperature

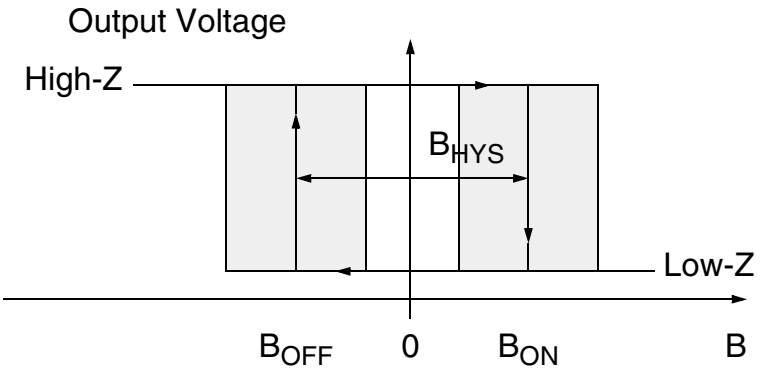


Fig. 4–6: Definition of magnetic switching points for the HAL 1401

Magnetic Characteristics

at T_J = –20 °C to 125 °C, V_{SUP} = 2.7 V to 24.0 V,
Typical Characteristics for V_{SUP} = 12.0 V

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

Parameter	On point B_{ON}			Off point B_{OFF}			Hysteresis B_{HYS}			Unit
T_J	Min.	Typ.	Max.	Min.	Typ.	Max.	Min.	Typ.	Max.	
–20 °C	–1.2	0.5	2.2	–2.2	–0.5	1.2	–	1.0	–	mT
25 °C	–1.0	0.4	2.1	–2.1	–0.4	1.0	–	0.8	–	mT
125 °C	–1.7	0.4	2.9	–2.9	–0.4	1.7	–	0.8	–	mT

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

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

4.10. HAL 1402 Magnetic Characteristics

The HAL 1402 Hall-latch provides highest sensitivity (see Fig. 4–7 on page 17).

The output turns to Low-Z with the magnetic south pole on the top side of the package and turns to High-Z with the magnetic north pole on the top side. The output does not change if the magnetic field is removed. For changing the output state, the opposite magnetic field polarity must be applied.

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

Magnetic Features:

– switching type: latching

– high sensitivity

– typical B_{ON}: 2.5 mT at room temperature

– typical B_{OFF}: −2.5 mT at room temperature

– operates with static magnetic fields and dynamic magnetic fields up to 12 kHz

– typical temperature coefficient of magnetic switching points is −1000 ppm/K at room temperature

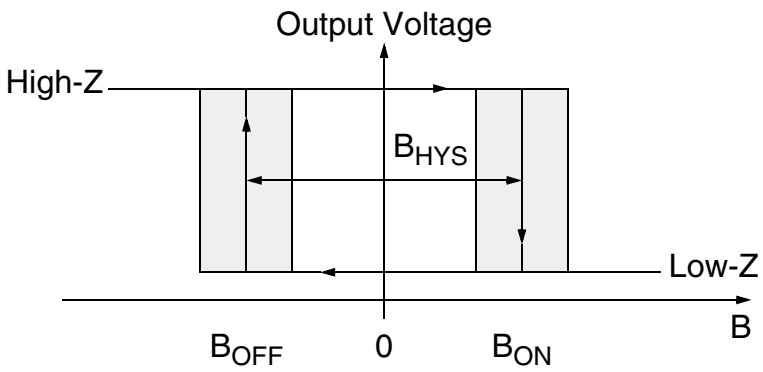


Fig. 4–7: Definition of magnetic switching points for the HAL 1402

Magnetic Characteristics

at T_J = –20 °C to 125 °C, V_{SUP} = 2.7 V to 24.0 V,
Typical Characteristics for V_{SUP} = 12.0 V

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

Parameter	On point B_{ON}			Off point B_{OFF}			Hysteresis B_{HYS}			Unit
T_J	Min.	Typ.	Max.	Min.	Typ.	Max.	Min.	Typ.	Max.	
–20 °C	0.4	2.7	5.0	–5.0	–2.7	–0.4	–	5.4	–	mT
25 °C	0.2	2.5	4.8	–4.8	–2.5	–0.2	–	5.0	–	mT
125 °C	0.1	2.4	4.7	–4.7	–2.4	–0.1	–	4.8	–	mT

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

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

4.11. HAL 1403 Magnetic Characteristics

The HAL 1403 unipolar Hall-switch provides high sensitivity (see Fig. 4–8 on page 19).

The output turns to Low-Z with the magnetic south pole on the top side of the package and turns to High-Z if the magnetic field is removed. The sensor does not respond to the magnetic north pole on the top side of the package.

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

Magnetic Features:

– switching type: unipolar
– high sensitivity
– typical B_{ON}: 5.5 mT at room temperature
– typical B_{OFF}: 3.7 mT at room temperature
– operates with static magnetic fields and dynamic magnetic fields up to 12 kHz
– typical temperature coefficient of magnetic switching points is –1000 ppm/K at room temperature

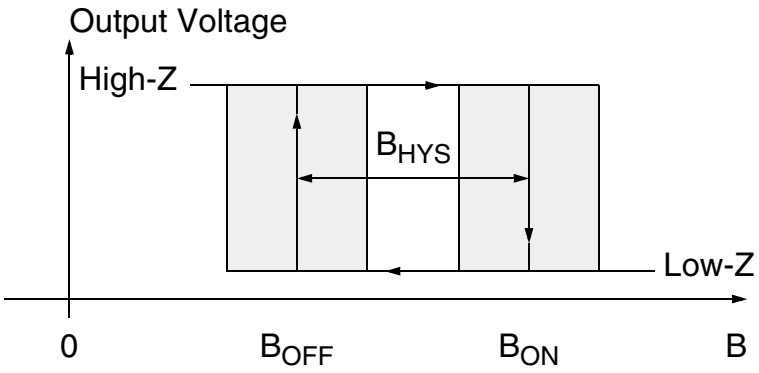


Fig. 4–8: Definition of magnetic switching points for the HAL 1403

Magnetic Characteristics

at T_J = –20 °C to 125 °C, V_{SUP} = 2.7 V to 24.0 V,
Typical Characteristics for V_{SUP} = 12.0 V

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

Parameter	On point B_{ON}			Off point B_{OFF}			Hysteresis B_{HYS}			Unit
T_J	Min.	Typ.	Max.	Min.	Typ.	Max.	Min.	Typ.	Max.	
–20 °C	3.3	5.9	8.2	1.5	3.9	6.5	–	2.0	–	mT
25 °C	2.9	5.5	8.0	1.3	3.7	6.5	–	1.8	–	mT
125 °C	2.1	5.2	7.8	0.9	3.6	6.5	–	1.5	–	mT

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

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

4.12. HAL 1404 Magnetic Characteristics

The HAL 1404 Hall latch provides high sensitivity (see Fig. 4–9 on page 21).

The output turns to Low-Z with the magnetic south pole on the top side of the package and turns to High-Z with the magnetic north pole on the top side. The output does not change if the magnetic field is removed. For changing the output state, the opposite magnetic field polarity must be applied.

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

Magnetic Features:

– switching type: latching

– high sensitivity

– typical BON: 7.6 mT at room temperature

– typical BOFF: -7.6 mT at room temperature

– operates with static magnetic fields and dynamic magnetic fields up to 12 kHz

– typical temperature coefficient of magnetic switching points is –1200 ppm/K at room temperature

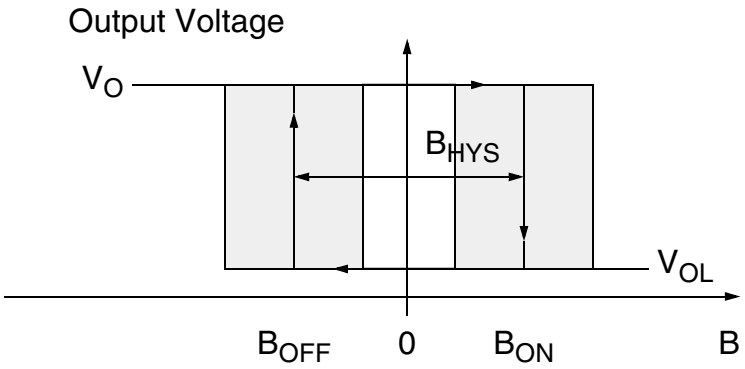


Fig. 4–9: Definition of magnetic switching points for the HAL 1404

Magnetic Characteristics

at T_J = –20 °C to 125 °C, V_{SUP} = 2.7 V to 24.0 V,
Typical Characteristics for V_{SUP} = 12.0 V

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

Parameter	On point B_{ON}			Off point B_{OFF}			Hysteresis B_{HYS}			Unit
T_J	Min.	Typ.	Max.	Min.	Typ.	Max.	Min.	Typ.	Max.	
–20 °C	5.0	8.2	11.8	–11.8	–8.2	–5.0	–	16.4	–	mT
25 °C	5.2	7.6	11.3	–11.3	–7.6	–5.2	–	15.2	–	mT
125 °C	3.1	6.8	10.6	–10.6	–6.8	–3.1	–	13.6	–	mT

The hysteresis is the difference between the switching points BHYS = | BON - BOFF |

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

4.13. HAL 1405 Magnetic Characteristics

The HAL 1405 Hall-latch provides medium sensitivity (see Fig. 4–10 on page 23).

The output turns to Low-Z with the magnetic south pole on the top side of the package and turns to High-Z with the magnetic north pole on the top side. The output does not change if the magnetic field is removed. For changing the output state, the opposite magnetic field polarity must be applied.

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

Magnetic Features:

– switching type: latching

– medium sensitivity

– typical BON: 13.5 mT at room temperature

– typical BOFF: –13.5 mT at room temperature

– operates with static magnetic fields and dynamic magnetic fields up to 12 kHz

– typical temperature coefficient of magnetic switching points is –1200 ppm/K at room temperature

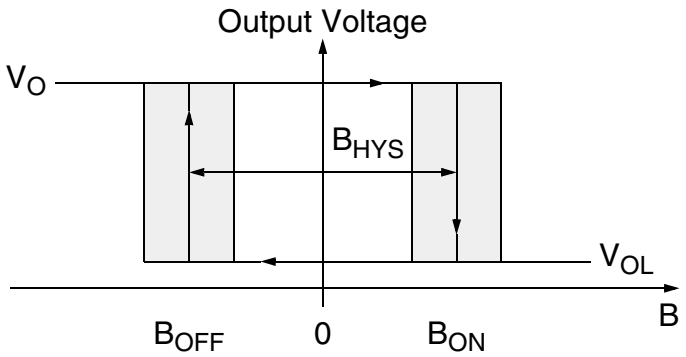


Fig. 4–10: Definition of magnetic switching points for the HAL 1405

Magnetic Characteristics

at T_J = –20 °C to 125 °C, V_{SUP} = 2.7 V to 24.0 V,
Typical Characteristics for V_{SUP} = 12.0 V

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

Parameter	On point B_{ON}			Off point B_{OFF}			Hysteresis B_{HYS}			Unit
T_J	Min.	Typ.	Max.	Min.	Typ.	Max.	Min.	Typ.	Max.	
–20 °C	9.7	14.6	19.6	–19.6	–14.6	–9.7	–	29.2	–	mT
25 °C	9.7	13.5	18.8	–18.8	–13.5	–9.7	–	27.0	–	mT
125 °C	8.7	12.2	18.9	–18.9	–12.2	–8.7	–	24.4	–	mT

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

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

4.14. HAL 1406 Magnetic Characteristics

The HAL 1406 unipolar Hall-switch provides medium sensitivity (see Fig. 4–11 on page 25).

The output turns to Low-Z with the magnetic south pole on the top side of the package and turns to High-Z if the magnetic field is removed. The sensor does not respond to the magnetic north pole on the top side of the package.

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

Magnetic Features:

– switching type: unipolar
– medium sensitivity
– typical B_{ON}: 18.9 mT at room temperature
– typical B_{OFF}: 17.3 mT at room temperature
– operates with static magnetic fields and dynamic magnetic fields up to 12 kHz
– typical temperature coefficient of magnetic switching points is –1200 ppm/K at room temperature

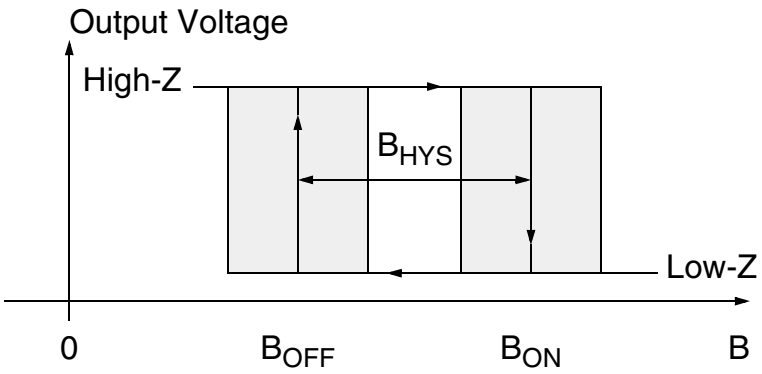


Fig. 4–11: Definition of magnetic switching points for the HAL 1406

Magnetic Characteristics

at T_J = –20 °C to 125 °C, V_{SUP} = 2.7 V to 24.0 V,
Typical Characteristics for V_{SUP} = 12.0 V

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

Parameter	On point B_{ON}			Off point B_{OFF}			Hysteresis B_{HYS}			Unit
T_J	Min.	Typ.	Max.	Min.	Typ.	Max.	Min.	Typ.	Max.	
–20 °C	13.7	20.2	26.3	11.0	18.4	23.9	–	1.8	–	mT
25 °C	13.6	18.9	24.5	12.0	17.3	22.9	–	1.6	–	mT
125 °C	11.5	17.6	21.4	10.2	16.3	19.9	–	1.3	–	mT

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

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

4.15. HAL 1407 Magnetic Characteristics

The HAL 1407 unipolar Hall-switch provides low sensitivity (see Fig. 4–12 on page 27).

The output turns to Low-Z with the magnetic south pole on the top side of the package and turns to High-Z if the magnetic field is removed. The sensor does not respond to the magnetic north pole on the top side of the package.

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

Magnetic Features:

– switching type: unipolar
– low sensitivity
– typical B_{ON}: 28.2 mT at room temperature
– typical B_{OFF}: 23.9 mT at room temperature
– operates with static magnetic fields and dynamic magnetic fields up to 12 kHz
– typical temperature coefficient of magnetic switching points is –300 ppm/K at room temperature

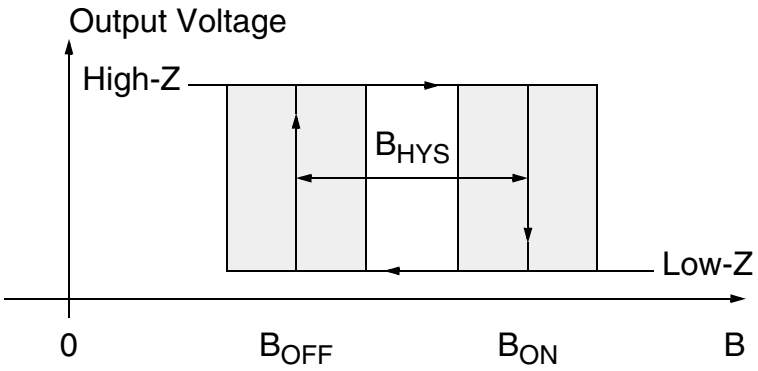


Fig. 4–12: Definition of magnetic switching points for the HAL 1407

Magnetic Characteristics

at T_J = –20 °C to 125 °C, V_{SUP} = 2.7 V to 24.0 V,
Typical Characteristics for V_{SUP} = 12.0 V

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

Parameter	On point B_{ON}			Off point B_{OFF}			Hysteresis B_{HYS}			Unit
T_J	Min.	Typ.	Max.	Min.	Typ.	Max.	Min.	Typ.	Max.	
–20 °C	20.8	29.1	37.4	15.4	24.5	33.5	–	4.6	–	mT
25 °C	21.4	28.2	35.0	16.5	23.9	31.3	–	4.3	–	mT
125 °C	20.0	27.9	35.7	15.9	23.9	31.9	–	4.0	–	mT

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

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

4.16. HAL 1408 Magnetic Characteristics

The HAL 1408 unipolar Hall-switch provides high sensitivity (see Fig. 4–13 on page 29).

The output turns to Low-Z with the magnetic north pole on the top side of the package and turns to High-Z 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 top side of the package.

Magnetic Features:

– switching type: unipolar
– high sensitivity
– typical B_{ON}: –5.5 mT at room temperature
– typical B_{OFF}: –3.7 mT at room temperature
– operates with static magnetic fields and dynamic magnetic fields up to 12 kHz
– typical temperature coefficient of magnetic switching points is –1000 ppm/K at room temperature

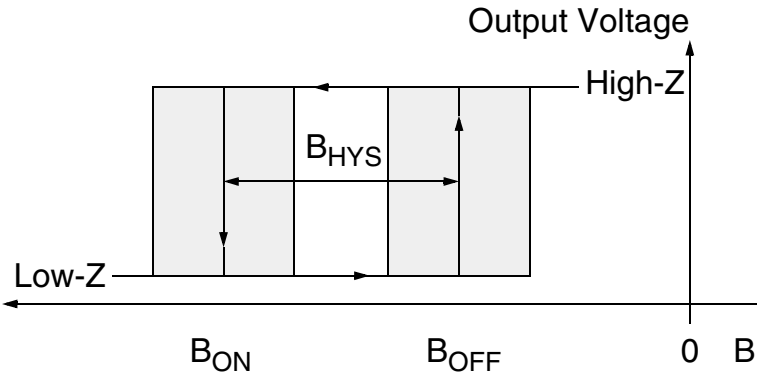


Fig. 4–13: Definition of magnetic switching points for the HAL 1408

Magnetic Characteristics

at T_J = –20 °C to 125 °C, V_{SUP} = 2.7 V to 24.0 V,
Typical Characteristics for V_{SUP} = 12.0 V

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

Parameter	On point B_{ON}			Off point B_{OFF}			Hysteresis B_{HYS}			Unit
T_J	Min.	Typ.	Max.	Min.	Typ.	Max.	Min.	Typ.	Max.	
–20 °C	–8.2	–5.9	–3.3	–6.5	–3.9	–1.5	–	2.0	–	mT
25 °C	–8.0	–5.5	–2.9	–6.5	–3.7	–1.3	–	1.8	–	mT
125 °C	–7.8	–5.2	–2.1	–6.5	–3.6	–0.9	–	1.6	–	mT

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

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

4.17. HAL 1409 Magnetic Characteristics

The HAL 1409 unipolar inverted Hall-switch provides high sensitivity (see Fig. 4–14 on page 31).

The output turns to High-Z with the magnetic south pole on the top side of the package and turns to Low-Z if the magnetic field is removed. The sensor does not respond to the magnetic north pole on the top side of the package.

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

Magnetic Features:

– switching type: unipolar inverted

– high sensitivity

– typical B_{ON}: 3.7 mT at room temperature

– typical B_{OFF}: 5.5 mT at room temperature

– operates with static magnetic fields and dynamic magnetic fields up to 12 kHz

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

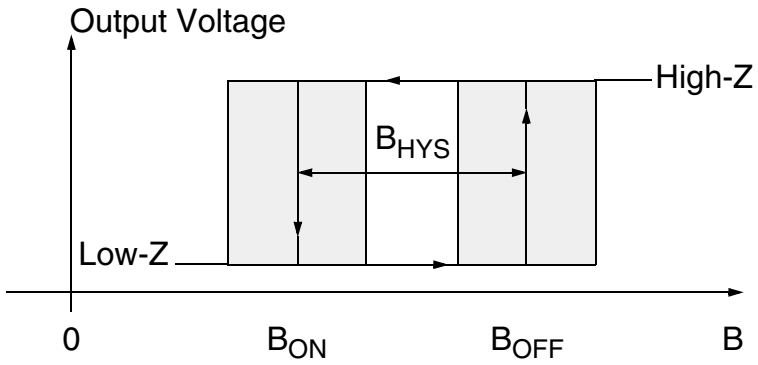


Fig. 4–14: Definition of magnetic switching points for the HAL 1409

Magnetic Characteristics

at T_J = –20 °C to 125 °C, V_{SUP} = 2.7 V to 24.0 V,
Typical Characteristics for V_{SUP} = 12.0 V

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

Parameter	On point B_{ON}			Off point B_{OFF}			Hysteresis B_{HYS}			Unit
T_J	Min.	Typ.	Max.	Min.	Typ.	Max.	Min.	Typ.	Max.	
–20 °C	1.5	3.9	6.5	3.3	5.9	8.2	–	2.0	–	mT
25 °C	1.3	3.7	6.5	2.9	5.5	8.0	–	1.8	–	mT
125 °C	0.9	3.6	6.5	2.1	5.2	7.8	–	1.6	–	mT

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

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

4.18. HAL 1410 Magnetic Characteristics

The HAL 1410 unipolar Hall switch provides medium sensitivity (see Fig. 4–15 on page 33).

The output turns to Low-Z with the magnetic south pole on the top side of the package and turns to High-Z if the magnetic field is removed. The sensor does not respond to the magnetic north pole on the top side of the package.

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

Magnetic Features:

– switching type: unipolar

– medium sensitivity

– typical B_{ON}: 12.0 mT at room temperature

– typical B_{OFF}: 7.0 mT at room temperature

– operates with static magnetic fields and dynamic magnetic fields up to 12 kHz

– typical temperature coefficient of magnetic switching points is –1200 ppm/K at room temperature

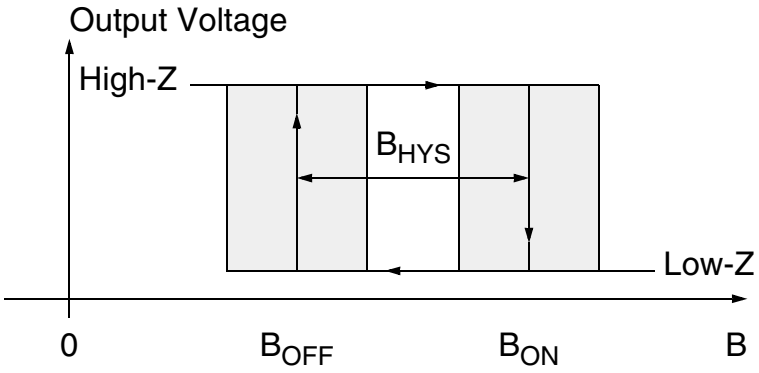


Fig. 4–15: Definition of magnetic switching points for the HAL 1410

Magnetic Characteristics

at T_J = –20 °C to 125 °C, V_{SUP} = 2.7 V to 24.0 V,
Typical Characteristics for V_{SUP} = 12.0 V

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

Parameter	On point B_{ON}			Off point B_{OFF}			Hysteresis B_{HYS}			Unit
T_J	Min.	Typ.	Max.	Min.	Typ.	Max.	Min.	Typ.	Max.	
–20 °C	8.6	12.7	17.3	4.0	7.4	11.2	–	5.3	–	mT
25 °C	8.2	12.0	15.8	4.0	7.0	10.1	–	5.0	–	mT
125 °C	8.1	10.7	16.0	3.6	6.2	10.2	–	4.5	–	mT

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

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

5. Application Notes

5.1. Application Circuits

For applications with disturbances on the supply line or radiated disturbances, two capacitors (for example: C_P=10 nF and C_L=4.7 nF) all placed close to the sensor are recommended (see Fig. 5–1).

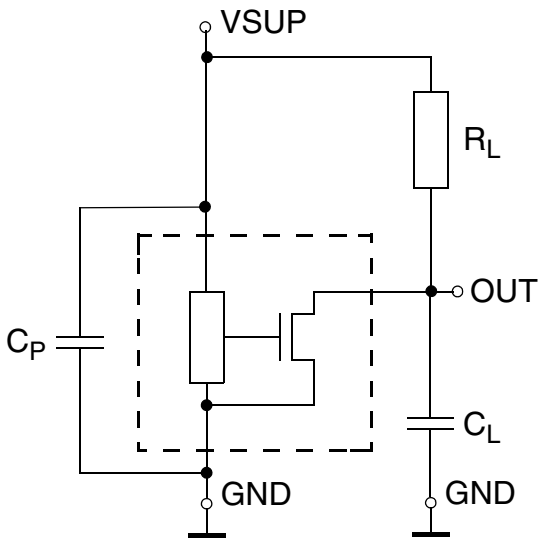


Fig. 5–1: Example for a recommended application circuit

R_L is the open-drain pull-up resistor and has to be placed close to the input of the host controller to enable wire-break detection.

5.2. Ambient Temperature

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

$$T_J = T_A + \Delta T$$

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

$$\Delta T = (I_{SUP} \times V_{SUP} \times R_{thja}) + (I_{OUT} \times V_{OUT} \times R_{thja})$$

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

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

For typical values, use the typical parameters. For worst case calculation, use the max. parameters for I_{SUP} , I_{OUT} , and R_{thja}, and the max. value for V_{OUT} and V_{SUP} from the application.

5.3. Start-Up Behavior

For supply voltages below the undervoltage threshold V_{UV}, the output is undefined. After exceeding V_{UV}, the sensor has an enable time (t_{en}). During the enable time, the output state is defined as High-Z.

After t_{en}, the output will be Low-Z if the applied magnetic field B is above B_{ON}. The output will be High-Z if B is below B_{OFF}. In case of sensors with an inverted switching behavior, the output state will be High-Z if $B > B_{OFF}$ and Low-Z if $B < B_{ON}$.

After t_{en} and magnetic fields between B_{OFF} and B_{ON}, the output state of the HAL 14xy sensor will be either High-Z or Low-Z. Any transition of magnetic switching points above B_{ON}, respectively, below B_{OFF} will switch to the corresponding output state.

6. Document History

1. Data Sheet: “HAL 14xy, Hall-Effect Switches for Industrial and Consumer Applications”, June 25, 2019; DSH000206_001EN. First release of the data sheet.
2. Data Sheet: “HAL 14xy, Hall-Effect Switches for Industrial and Consumer Applications”, April 6, 2020; DSH000206_002EN. Second release of the data sheet.

   Change: Disclaimer updated

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