MICRONAS

Hardware Documentation

Data Sheet

HAL® 1821...HAL1823

Linear Hall Effect Sensors Family

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DSH000157_001EN

Contents

Linear Hall Effect Sensors Family

1. Introduction

The HAL 182x is a new family of linear Hall-effect sensors. It is a universal magnetic field sensor with a ratiometric, linear analog output. This sensor family can be used for magnetic field measurements, current measurements and detection of mechanical movements. Very accurate angle measurements or distance measurements can also be done. The sensors are very robust and can be used in harsh environments.

The output voltage is proportional to the magnetic flux density through the hall plate. The choppered offset compensation leads to stable magnetic characteristics over supply voltage and temperature.

The different family members vary by sensitivity (25 mV/mT, 31.25 mV/mT and 50 mV/mT). The quiescent output voltage (offset) is for all family members 50% of supply voltage.

The sensor is designed for industrial and automotive applications and operates in the junction temperature range from –40 °C up to 170 °C. The HAL 182x is available in the very small leaded packages TO92UA-1 and TO92UA-2 and in the SMD-package SOT89B-1.

1.1. Major Applications

Due to the sensor's robust characteristics, the HAL 182x is the optimal system solution for applications such as:

– linear position measurements,
– angle sensors,
– distance measurements,
– magnetic field and current measurement.

1.2. Features

– ratiometric linear output proportional to the magnetic field
– temperature and stress stable quiescent output voltage
– very accurate sensitivity and offset
– customized versions possible
– on-chip temperature compensation
– active offset compensation
– operates from –40 °C up to 170 °C junction temperature
– operates from 4.5 V up to 5.5 V supply voltage in specification operates with static magnetic fields and dynamic magnetic fields up to 2.25 kHz
– overvoltage and reverse-voltage protection at V_{SUP} pin
– magnetic characteristics extremely robust against mechanical stress
– short-circuit protected push-pull output
– EMC and ESD optimized design

1.3. Family Overview

Type	Offset	Sensitivity	see Page
1821	50% of V_{SUP}	50 mV/mT	15
1822	50% of V_{SUP}	31.25 mV/mT	15
1823	50% of V_{SUP}	25 mV/mT	15

1.4. Marking Code

The HAL 182x has a marking on the package surface (branded side). This marking includes the name of the sensor and the temperature range.

Type	Temperature Range	
	A	K
HAL 1821	1821A	1821K
HAL 1822	1822A	1822K
HAL 1823	1823A	1823K

1.5. Operating Junction Temperature Range (T_J)

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

A: T_J = –40 °C to +170 °C

K: T_J = –40 °C to +140 °C

The relationship between ambient temperature (T_A) and junction temperature is explained in Section 4.1. on page 18.

1.6. Hall Sensor Package Codes

HALXXXPA-T

Temperature Range: A or K

Package: SF for SOT89B-1
UA for TO92UA-1/2

Type: 182x

Example: **HAL1821UA-K**

→ Type: 1821
→ Package: TO92UA-1/2
→ 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”.

1.7. Solderability and Welding

Soldering

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.

1.8. Pin Connections and Short Descriptions

Pin No.	Pin Name	Type	Short Description
1	V_{SUP}	IN	Supply Voltage Pin
2	GND		Ground
3	OUT	OUT	Push-Pull Output

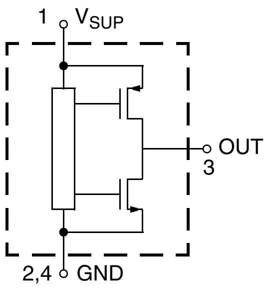


Fig. 1–1: Pin configuration

2. Functional Description

2.1. General Function

The HAL 182x is a monolithic integrated circuit which provides an output voltage proportional to the magnetic flux through the Hall plate and proportional to the supply voltage (ratiometric behavior).

The external magnetic field component perpendicular to the branded side of the package generates a Hall voltage. The Hall IC is sensitive to magnetic north and south polarity. This voltage is amplified and stabilized by a push-pull output transistor stage.

Internal temperature compensation circuitry and the choppered offset compensation enables operation over the full temperature range with minimal degradation in accuracy and offset. The circuitry also rejects offset shifts due to mechanical stress from the package. In addition, the sensor IC is equipped with devices for overvoltage and reverse-voltage protection at supply pin.

Output/Magnetic Field Polarity

Applying a south-pole magnetic field perpendicular to the branded side of the package will increase the output voltage from the quiescent (offset) voltage towards the supply voltage. A negative magnetic field will decrease the output voltage.

In addition HAL 182x features an internal error detection. The following error modes can be detected:

– Over-/underflow in adder or multiplier

– Over-/underflow in A/D converter

– Overtemperature detection

In case of an error the sensors output will be forced to the lower error band. The error band is defined by

V_{DIAG} (see Section 3.6. on page 14).

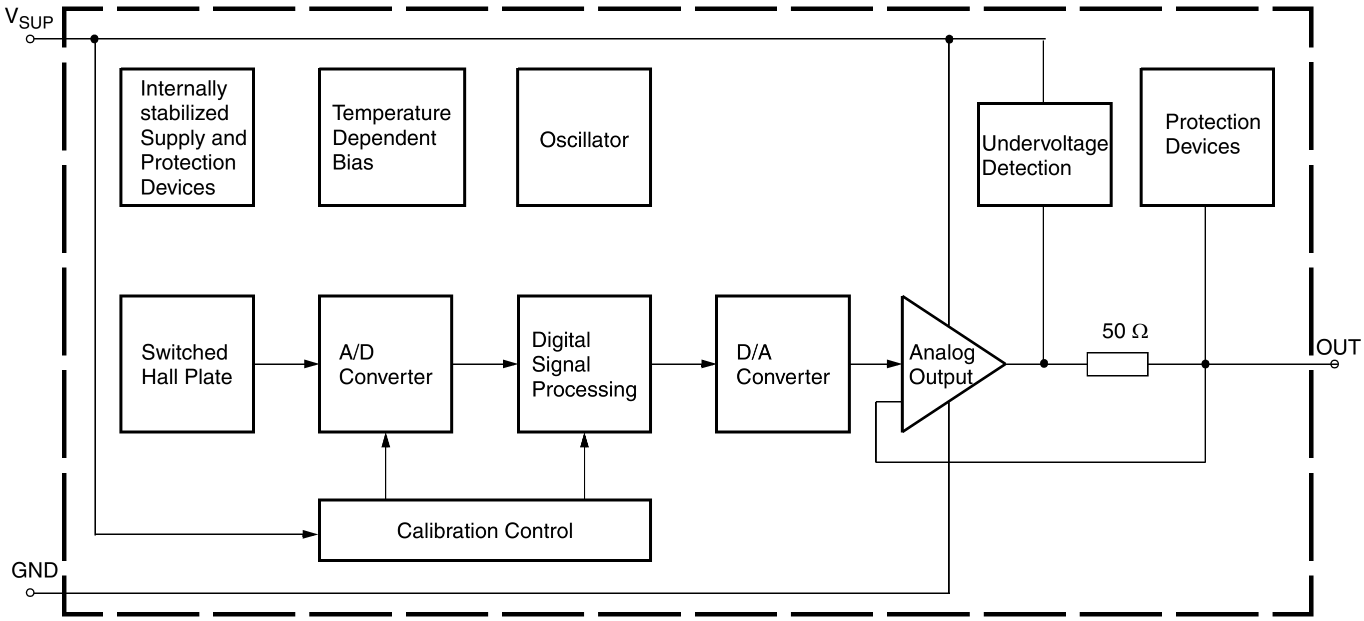
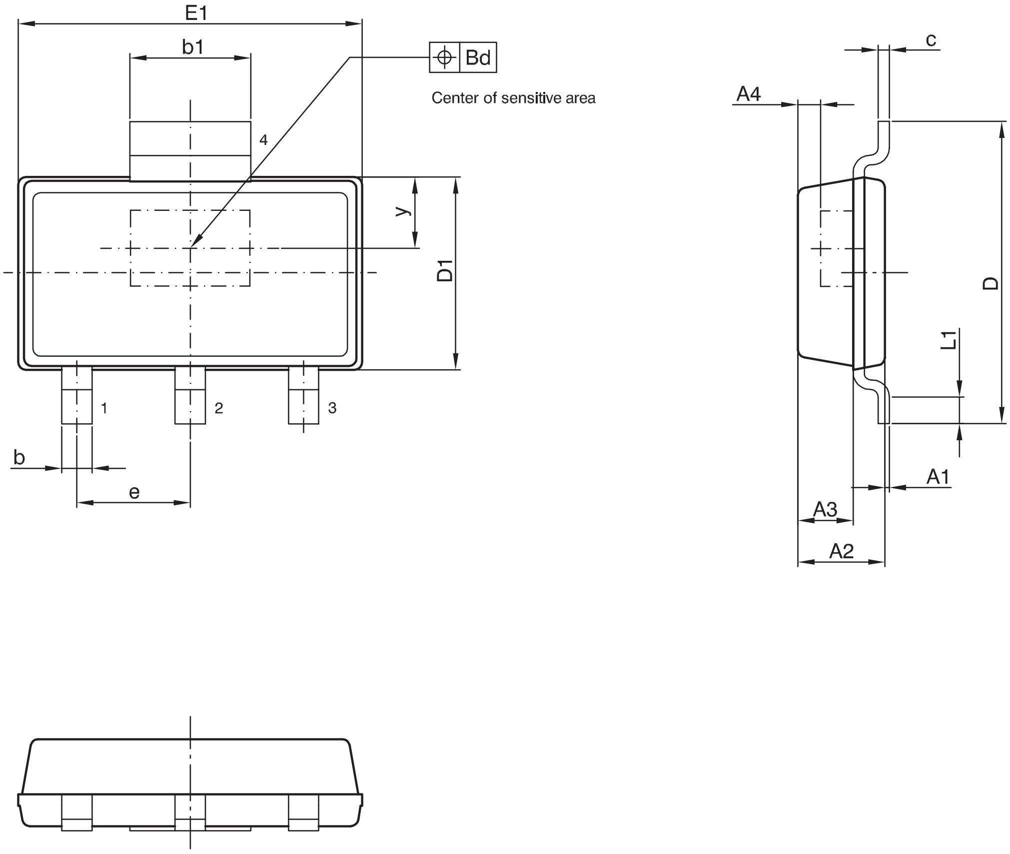


Fig. 2–1: HAL182x block diagram

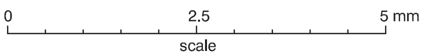
3. Specifications

3.1. Outline Dimensions



physical dimensions do not include moldflash.

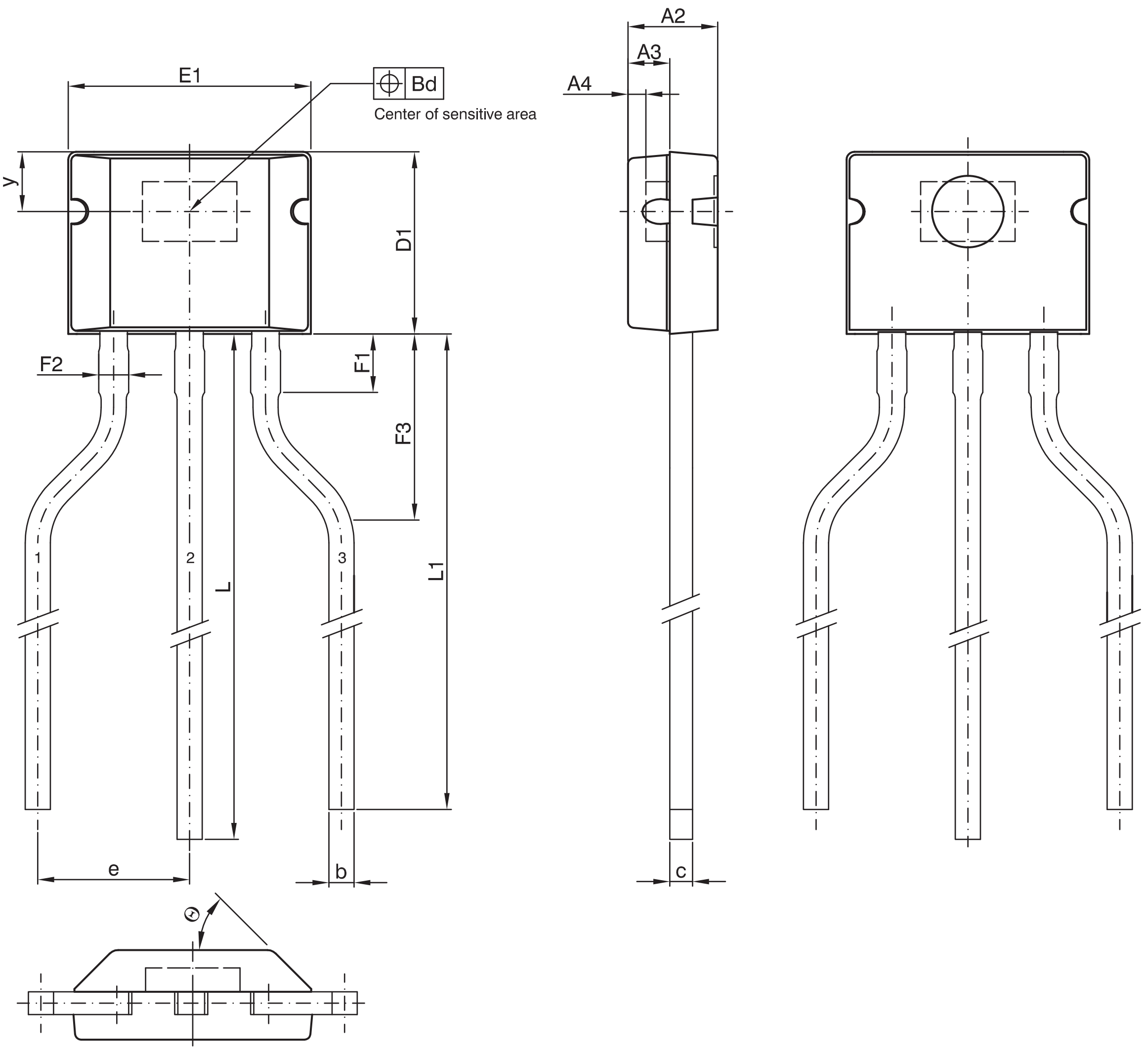
A4, y= these dimensions are different for each sensor type and are specified in the data sheet.



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

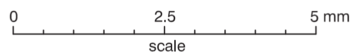


physical dimensions do not include moldflash.

solderability is guaranteed between end of pin and distance F1.

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

min/max of D1 are specified in the datasheet.



UNIT	A2	A3	b	Bd	c	D1	e	E1	F1	F2	F3	L	L1	Θ
mm	1.55 1.45	0.7	0.42	0.2	0.36	3.05	2.54	4.11 4.01	1.2 0.8	0.60 0.42	4.0 2.0	15.5 min	15.0 min	45°

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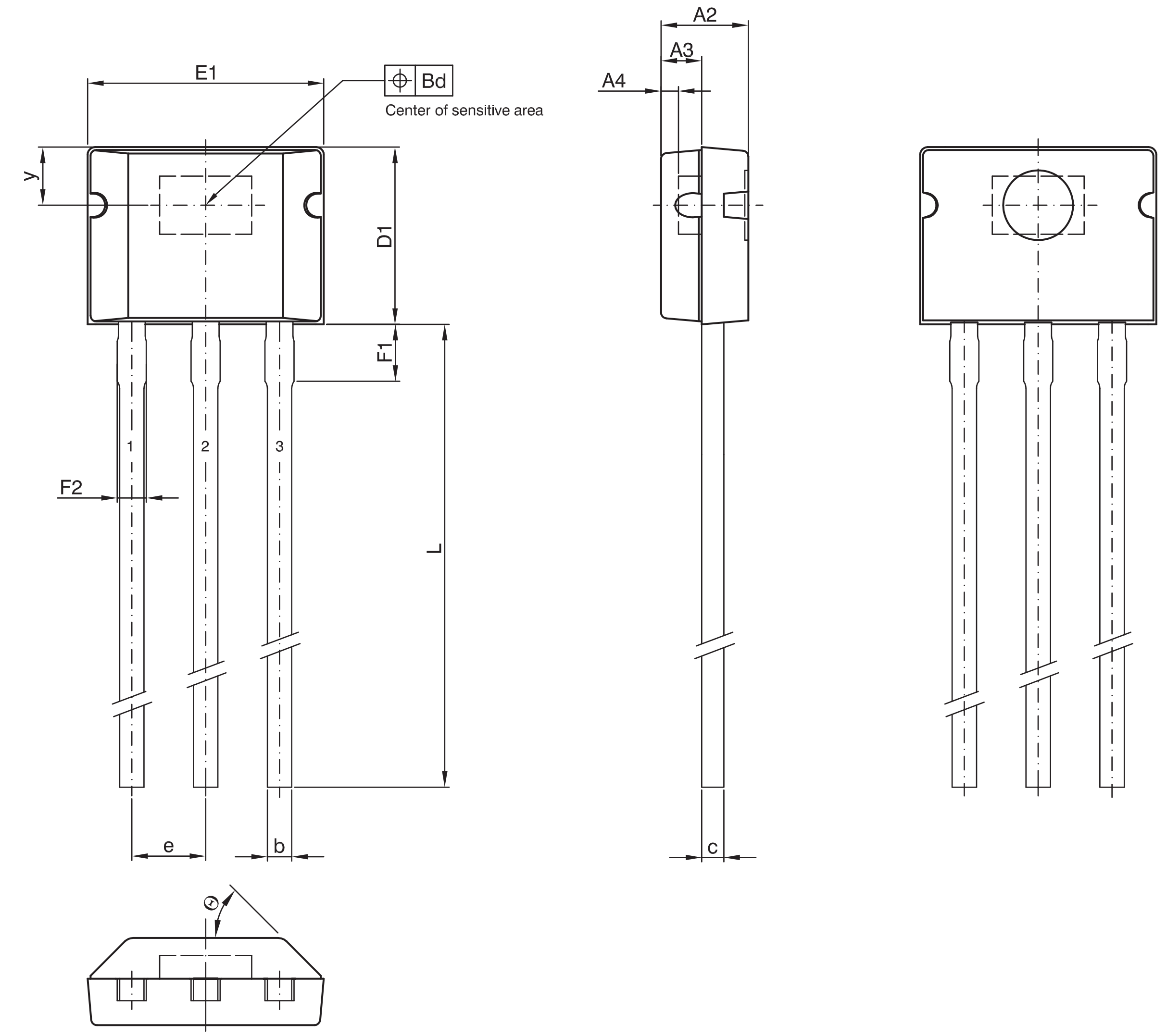
ISSUE	ITEM NO.				
-	-		09-06-09	06616.0001.4	ZG001016_Ver.05

Fig. 3–2:
TO92UA-1: Plastic Transistor Standard UA package, 3 leads, spread
Weight approximately 0.106 g

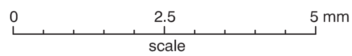


physical dimensions do not include moldflash.

solderability is guaranteed between end of pin and distance F1.

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

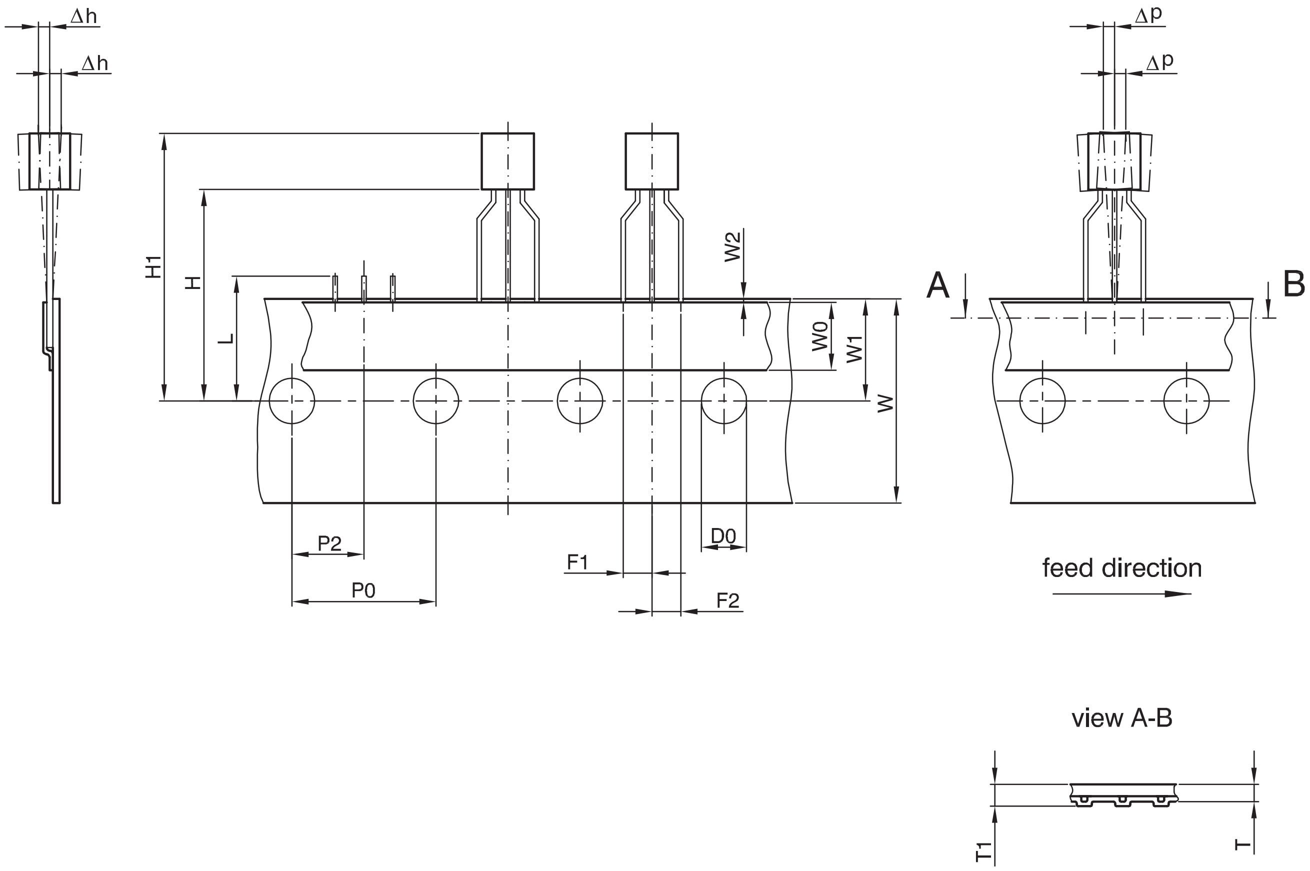
min/max of D1 are specified in the datasheet.



UNIT	A2	A3	b	Bd	c	D1	e	E1	F1	F2	L	Θ
mm	1.55 1.45	0.7	0.42	0.2	0.36	3.05	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.				
-	-		09-06-05	06612.0001.4	ZG001012_Ver.06

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

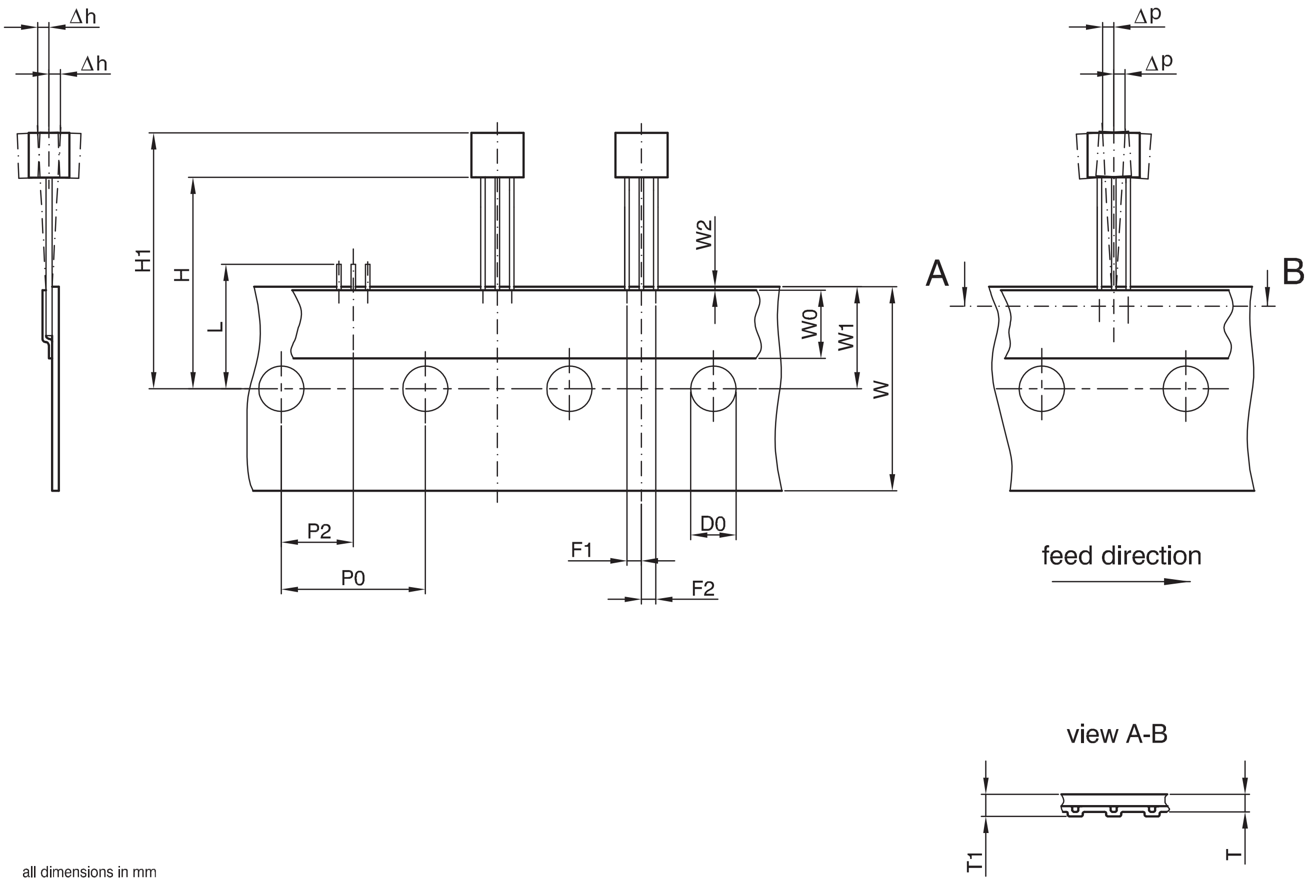


all dimensions in mm
other dimensions see drawing of bulk
max. allowed tolerance over 20 hole spacings ±1.0
H1= this dimension is different for each sensor type and is specified in the data sheet

UNIT	D0	F1	F2	H	Δh	L	P0	P2	Δp	T	T1	W	W0	W1	W2
mm	4.0	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. 3–4:
TO92UA/UT-1: Dimensions ammopack inline, 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	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. 3–5:
TO92UA/UT-2: Dimensions ammopack inline, not spread

3.2. Dimensions of Sensitive Area

0.2 mm x 0.1 mm

3.3. Position of Sensitive Areas

	TO92UA-1/-2	SOT89B-1
y	1.0 mm nominal	0.95 mm nominal
A4	0.4 mm nominal	0.4 mm nominal
D1	3.05 ±0.05 mm	2.55 ±0.05 mm
H1	min. 21 mm max. 23.1 mm	not applicable

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	Condition
V_{SUP}	Supply Voltage	1	–8.5	8.5	V	t < 96 h, not additive
			–14.4 –15	14.4 16	V	t < 10 min. 1) t < 1 min. 1) not additive
V_{OUT}	Output Voltage 1)	3	–0.5 2) –0.5 2) –0.5 2)	8.5 14.4 16	V	t < 96 h t < 10 min. t < 1 min. not additive
$V_{OUT}-V_{SUP}$	Excess of Output Voltage over Supply Voltage	1,3	–	0.5	V	
I_{OUT}	Continuous Output Current	3	–5	5	mA	
t_{Sh}	Output Short Circuit Duration	3	–	10	min	
T_J	Junction Temperature Range		–40	190 3)	°C	not additive
V_{ESD}	ESD Protection 4)	1,2,3	–4.0	4.0	kV	

1) as long as T_{Jmax} is not exceeded
2) internal protection resistor = 50 Ω
3) for 96h - Please contact Micronas for other temperature requirements
4) AEC-Q100-002 (100 pF and 1.5 kΩ)

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/Characteristics” is not implied and 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	Remarks
V_{SUP}	Supply Voltage	1	4.5	5	5.5	V	
I_{OUT}	Continuous Output Current	3	–1.0	–	1.0	mA	
R_L	Load Resistor	3	5.5	10	–	kΩ	
C_L	Load Capacitance	3	0.33	10	47	nF	
T_J	Junction Operating Temperature [1]	–	–40 –40 –40	– – –	125 150 170	°C °C °C	for 8000 h (not additive) for 2000 h (not additive) < 1000 h (not additive)

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

3.6. Characteristics

at T_J = –40 °C to +170 °C (for temperature type A), V_{SUP} = 4.5 V to 5.5 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_{SUP} = 5 V.
For all other temperature ranges this table is also valid, but only in the junction temperature range defined by the temperature grade (Example: For K-Type this table is limited to T_J = –40°C to +140°C).

Symbol	Parameter	Pin No.	Min.	Typ.	Max.	Unit	Conditions
I_{SUP}	Supply Current over Temperature Range	1	–	7	10	mA	
	Resolution	3	–	10	–	Bit	
INL	Non-Linearity of Output Voltage over Temperature	3	–1.0	0	1.0	%	% of supply voltage[1)]
E_R	Ratiometric Error of Output over Temperature (Error in V_{OUT} / V_{SUP})	3	–1.0	0	1.0	%	
V_{OQ}	Output Quiescent Voltage	3	2.425	2.5	2.575	V	B = 0 mT, T_J = 25 °C, I_{OUT} = ±1 mA
V_{OUTH}	Output High Voltage	3	4.7	4.9	–	V	V_{SUP} = 5 V, I_{OUT} = ±1 mA[2)]
V_{OUTL}	Output Low Voltage	3	–	0.1	0.3	V	V_{SUP}= 5 V, I_{OUT} = ±1 mA[2)]
$t_{r(O)}$	Response Time of Output[3)]	3	–	0.5	1	ms	C_L = 10 nF, time from 10% to 90% of final output voltage for a step like signal B_{step} from 0 mT to B_{max}
t_{POD}	Power-Up Time (Time to reach stabilized Output Voltage)[3)]	–	–	1	1.5	ms	C_L = 10 nF, 90% of V_{OUT}
BW	Small Signal Bandwidth (–3 dB)[3)]	3	2.25	2.5	–	kHz	B_{AC} < 10 mT
V_{OUTn}	Output RMS Noise[3)]	3	–	2.6	5	mV	B = 5 to 95% of B_{max}
R_{OUT}	Output Resistance over Recommended Operating Range[3)]	3	–	60	–	Ω	$V_{OUTLmax} \leq V_{OUT} \leq V_{OUTHmin}$
V_{PORLH}	Power-On Reset Level from V_{SUPLow} to $V_{SUPHigh}$	1	3.9	4.35	4.5	V	
V_{PORHL}	Power-On Reset Level from $V_{SUPHigh}$ to V_{SUPLow}	1	3.8	4.2	4.4	V	
V_{PORHYS}	Power-On Hysteresis	1	0.1	0.175	0.2	V	
V_{DIAG}	Output Voltage in case of Error Detection	3	0	–	300	mV	
TO92UA Package							
	Thermal Resistance						Measured with a 1s0p board
R_{thja}	junction to air	–	–	–	250	K/W	
R_{thjc}	junction to case	–	–	–	70	K/W	
SOT89B Package							
	Thermal Resistance						Measured with a 1s0p board 30 mm x 10 mm x 1.5 mm, pad size (see Fig. 3–6)
R_{thja}	junction to air	–	–	–	210	K/W	
R_{thjc}	junction to case	–	–	–	60	K/W	

1) if more than 50% of the selected magnetic field range are used and V_{OUT} is between 0.3 V and 4.7 V
2) Linear output range
3) Guaranteed by design

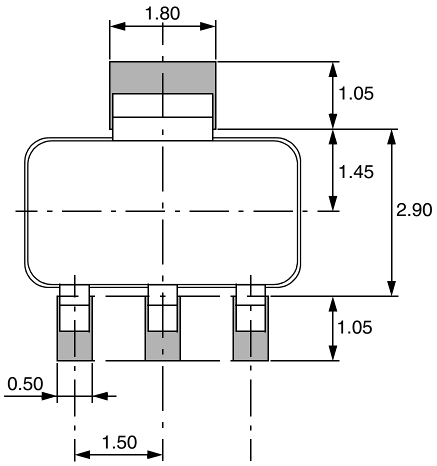


Fig. 3–6: Recommended footprint SOT89B-1, Dimensions in mm.
All dimensions are for reference only. The pad size may vary depending on the requirements of the soldering process.

3.7. Magnetic Characteristics

at Recommended Operating Conditions if not otherwise specified in the column 'Test Conditions',
T_J =–40 °C to +170 °C (for temperature type A), V_{SUP} = 4.5 V to 5.5 V.
Typical Characteristics for T_A = 25 °C and V_{SUP} = 5 V.
For all other temperature ranges this table is also valid, but only in the junction temperature range defined by the temperature grade (Example: For K-type this table is limited to T_J = –40 °C to +140 °C)

Symbol	Parameter	Pin No.	Values			Unit	Test Conditions
			Min.	Typ.	Max.		
Sens	Sensitivity	3	47.5 30.0 24.0	50.0 31.25 25.0	52.5 32.5 26.0	mV/mT	HAL1821; T_J = 25°C HAL1822; T_J = 25°C HAL1823; T_J = 25°C
ES	Sensitivity Error over Temperature Range	3	–6	0	6	%	Part-to-part variation
ΔSens	Sensitivity Drift (beside temperature drift)[1]		–	±2	–	%	T_J = 25°C; after temperature cycling and over life time
B_{OFFSET}	Magnetic offset	3	–1.4 –2.3 –2.8	0 0 0	1.4 2.3 2.8	mT	HAL1821 HAL1822 HAL1823 B = 0 mT, T_A = 25 °C
ΔB_{OFFSET}	Magnetic offset drift over Temperature Range $B_{OFFSET}(T) - B_{OFFSET}$ (25 °C)	3	–950 –950 –1015	0 0 0	950 950 1015	µT	HAL1821 HAL1822 HAL1823 B = 0 mT
$B_{Hysteresis}$	Magnetic Hysteresis[1]	3	–20	0	20	µT	Range = 40 mT

[1] Guaranteed by design

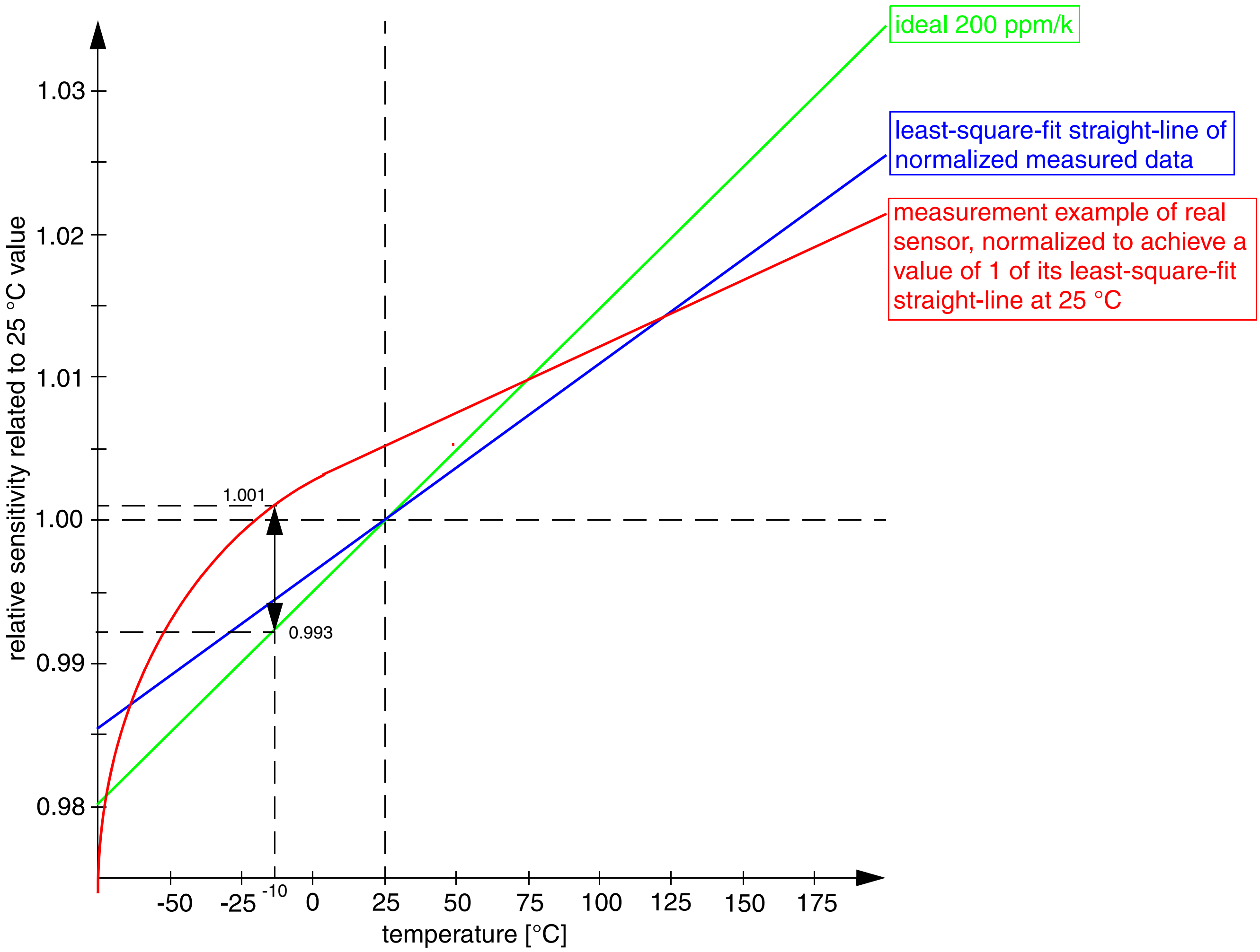


Fig. 3–7: Definition of Sensitivity Error ES.

3.7.1. Definition of Sensitivity Error ES

ES is the maximum of the absolute value of 1 minus the quotient of the normalized measured value[1)] over the normalized ideal linear[2)] value:

$$ES = \max\left(\mathrm{abs}\left(\frac{meas}{ideal} - 1\right)\right)\Big|_{[Tmin,\ Tmax]}$$

In the example shown in Fig. 3–7 the maximum error occurs at −10 °C:

$$ES = \frac{1.001}{0.993} - 1 = 0.8\%$$

1) normalized to achieve a least-square-fit straight-line that has a value of 1 at 25 °C

2) normalized to achieve a value of 1 at 25 °C

4. Application Notes

4.1. 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:

$\Delta T = I_{SUP} * V_{SUP} * R_{thjX}$

The X represents junction to air or to case.

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

The following example shows the result for junction to air conditions. V_{SUP} = 5.5 V, R_{thja} = 250 K/W and I_{DD} = 10 mA the temperature difference ΔT = 13.75 K.

The junction temperature T_J is specified. The maximum ambient temperature T_{Amax} can be calculated as:

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

4.2. EMC and ESD

The HAL 182x is designed for a stabilized 5 V supply. Interferences and disturbances conducted along the 12 V onboard system (product standard ISO 7637 part 1) are not relevant for these applications.

For applications with disturbances by capacitive or inductive coupling on the supply line or radiated disturbances, the application circuit shown in Fig. 4–1 is recommended. Applications with this arrangement should pass the EMC tests according to the product standards ISO 7637 part 3 (Electrical transient transmission by capacitive or inductive coupling) and part 4 (Radiated disturbances).

4.3. Application Circuit

For EMC protection, it is recommended to connect one ceramic 47 nF capacitor between ground and output voltage pin as well as 100 nF between supply and ground.

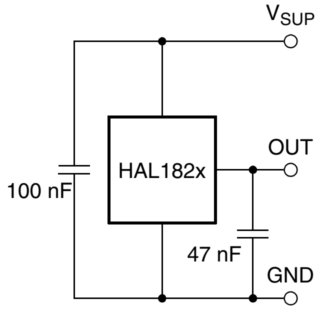


Fig. 4–1: Recommended application circuit

5. Data Sheet History

1. Advance Information: “HAL1821...HAL1823, Linear Hall Effect Sensors Family”, July 1, 2009, 000148_001EN. First release of the advance information.
2. Advance Information: “HAL1821...HAL1823, Linear Hall Effect Sensors Family”, April 28, 2010, 000148_002EN. Second release of the advance information.
   Major changes: Electrical characteristics
3. Data Sheet: “HAL1821...HAL1823, Linear Hall Effect Sensors Family”, May 6, 2011, 000157_001EN. First release of the data sheet.

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