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MICRONAS

Hardware
Documentation

Data Sheet

HAL® 1860

Programmable Linear Hall-Effect Sensor in TO92 Package

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Contents

Programmable Linear Hall-Effect Sensor in TO92 Package

1. Introduction

The HAL 1860 is a universal programmable Hall-Effect sensor with a ratiometric, linear analog output proportional to the magnetic flux density applied to the sensor surface. The sensor can be used for magnetic field measurements, current measurements, and detection of mechanical movement, like for small-angle or distance measurements. The sensor is robust and can be used in harsh electrical and mechanical environments.

Major characteristics like magnetic field range, sensitivity, offset (output voltage at zero magnetic field) and the temperature coefficients are programmable in a non-volatile memory. Several output signal clamping levels can be programmed. Diagnostic features are implemented to indicate various fault conditions like under/overvoltage, under/overflow or thermal supervision.

The HAL 1860 is programmable by modulating the supply voltage with a serial telegram on the sensor’s output pin or supply pin. No additional programming pin is needed. Several sensors on the same supply line can be programmed individually (communication through OUT pins). The easy programmability allows a 2-point calibration by adjusting the output signal directly to the input signal (like mechanical angle, distance, or current).

Individual adjustment of each sensor during the customer’s manufacturing process is possible. With this calibration procedure, the tolerance of the sensor, the magnet and the mechanical positioning can be compensated in the final assembly.

The spinning-current offset compensation leads to stable magnetic characteristics over supply voltage and temperature. In addition, the temperature compensation of the Hall IC can be fit to all common magnetic materials by programming first and second order temperature coefficients of the Hall sensor sensitivity. This enables operation over the full temperature range with high accuracy.

The calculation of the individual sensor characteristics and the programming of the EEPROM memory can easily be done with a PC and the application kit from TDK-Micronas.

The sensor is designed for industrial and automotive applications, is AEC-Q100 qualified, and operates in the junction temperature range from –40 °C up to 170 °C. The HAL 1860 is available in the very small leaded package TO92UA-2.

1.1. Major Applications

Thanks to the sensors' robust and cost-effective design, the HAL 1860 is the optimal system solution for applications such as:

- Small-angle or linear position measurements
- Gear position detection
- Current sensing for battery management
- Rotary selector

1.2. Features

- Ratiometric linear output proportional to the magnetic field
- Digital signal processing
- Continuous measurement ranges from ±40 mT to ±160 mT (±20 mT available for test purpose only)
- Selectable clamping levels with selectable diagnosis
- Comprehensive diagnostic feature set
- Lock function and built-in redundancy for EEPROM memory
- Programmable temperature characteristics for matching all common magnetic materials
- Programming via output pin or supply voltage modulation
- 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 and dynamic magnetic fields up to 5 kHz
- Selectable sampling rate (8 kHz or 16 kHz)
- Overvoltage and reverse-voltage protection at VSUP pin
- Magnetic characteristics extremely robust against mechanical stress
- Short-circuit protected push-pull output
- EMC and ESD optimized design
- AEC-Q100 qualified

2. Ordering Information

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

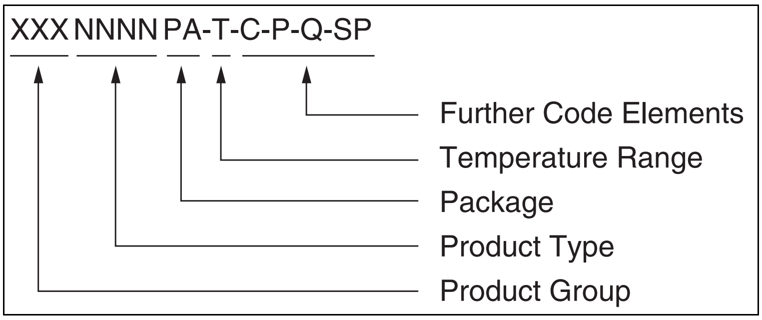


Fig. 2–1: Ordering code principle

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

2.1. Device-Specific Ordering Codes

HAL 1860 is available in the following package and temperature variants.

Table 2–1: Available packages

Package Code (PA)	Package Type
UA	TO92UA-2

Table 2–2: Available temperature ranges

Temperature Code (T)	Temperature Range
A	T_J = –40 °C to +170 °C

The relationship between ambient temperature (T_A) and junction temperature (T_J) is explained in Section 5.1. on page 25.

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

Table 2–3: Available ordering codes and corresponding package marking

Available Ordering Codes	Package Marking
HAL 1860UA-A-[C-P-Q-SP]	1860A

3. Functional Description

3.1. General Function

The HAL 1860 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 Hall IC is sensitive to magnetic north and south polarity. This Hall voltage is converted to a digital value, processed in the Digital Signal Processing unit (DSP) according to the settings of the EEPROM registers, converted back to an analog voltage by a D/A converter and buffered by a push-pull output transistor stage. Selectable clamping levels for the output voltage as well as diagnostic features are available. The function and the parameter for the DSP are explained in Section 3.2. on page 9. Internal temperature compensation circuitry and the spinning-current 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.

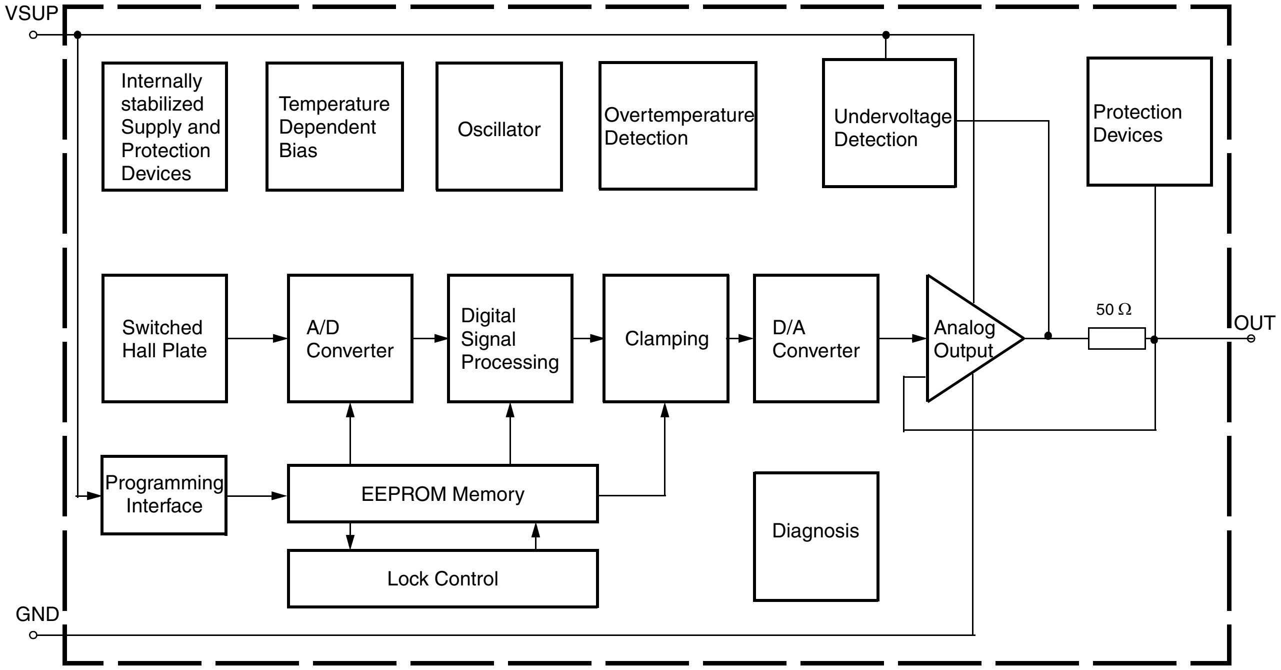


Fig. 3–1: HAL 1860 block diagram

The IC can be programmed via supply or output pin voltage modulation. After detecting a command, the sensor reads or writes the memory and answers with a digital signal on the output pin. As long as the LOCK register is not set, the output characteristic can be adjusted by programming the EEPROM registers. The LOCK register disables the programming of the EEPROM memory. The register cannot be reset by the customer.

In addition HAL 1860 features an internal error detection. The following error modes can be detected: over-/underflow in adder or multiplier, over-/underflow in A/D converter and overtemperature

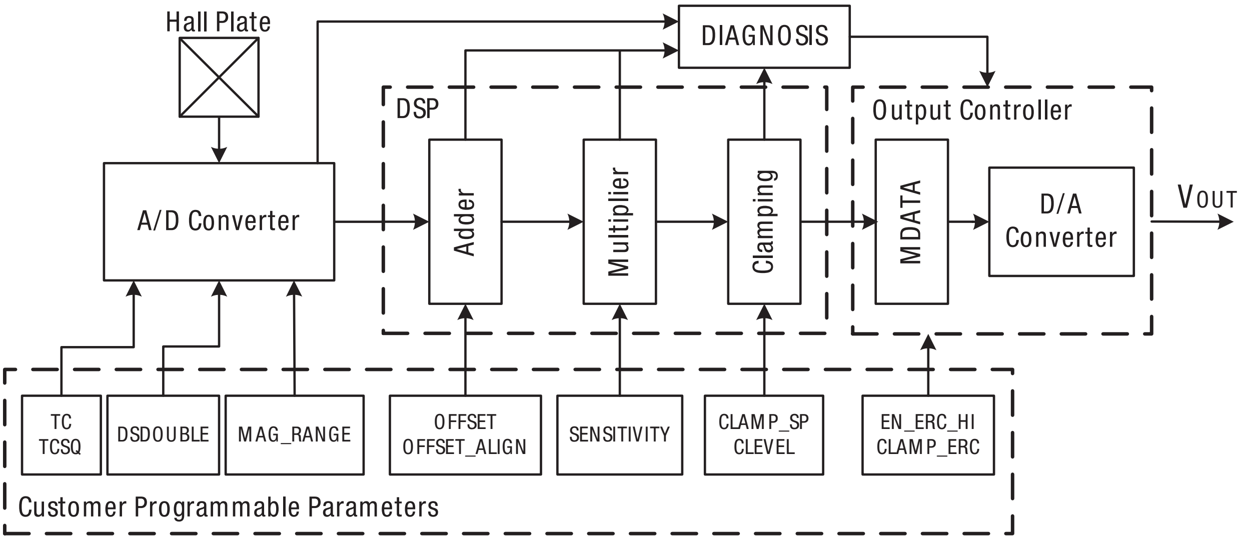


Fig. 3–2: Details of Programming Parameter and Digital Signal Processing

Table 3–1: Cross reference table for EEPROM register and sensor parameter

EEPROM-Register	Parameter	Data Bits	Function
Customer Setup 1	DSDOUBLE	1	Sampling frequency
	CLEVEL	2	Output clamping values selection
	EN_ERC_HI	1	Enables High and Low error band
Customer Setup 2	LOCK	1	Customer Lock
	CLAMP_SP	14	Activates unbalanced clamping levels
	OFFSET_ ALIGN	1	Magnetic Offset Alignment Bit (MSB or LSB aligned)
	TCSQ	5	Quadratic temperature coefficient
	TC	5	Linear temperature coefficient
	MAG_RANGE	3	Available magnetic ranges
Output Scaling	SENSITIVITY	8	Magnetic sensitivity
	OFFSET	8	Magnetic offset
Micronas ID1	MIC_ID_1	16	Micronas production information (read only)
Micronas ID2	MIC_ID_2	16	Micronas production information (read only)
Micronas ID3	MIC_ID_3	16	Micronas production information (read only)

Note For more Information on the registers and the memory map of the HAL1860, please refer to the application note “HAL1860 User Manual”.

3.2. Digital Signal Processing and EEPROM

The DSP is a key function of this sensor and performs the signal conditioning. The parameters for the DSP are stored in the EEPROM registers. Details are shown in Fig. 3–2 on page 8.

The measurement data can be readout from the digital output register MDATA.

MDATA register

This 16-bit register delivers the actual digital value of the applied magnetic field after the signal processing. This register can only be read out, and it is the basis for the calibration procedure of the sensor in the customer application. Only 10 bits of the register contain valid data. The MDATA range is from –512 to 511.

For SENSITIVITY = 1 the MDATA value will increase for negative magnetic fields (north pole) on the branded side of the package (positive MDATA values).

Note During application design, it shall be taken into consideration that the MDATA value should not saturate in the full operational range of the specific application.

The area in the EEPROM accessible to the customer consists of registers with a size of 16 bit each.

3.2.1. Output Scaling Register

The Output Scaling register contains the bits for magnetic sensitivity (SENSITIVITY) and magnetic offset (OFFSET).

SENSITIVITY

The SENSITIVITY bits define the parameter for the multiplier in the DSP and is programmable between [–2...2] in steps of 0.0156. SENSITIVITY = 1 (@ Offset = 0) corresponds to full-scale of the output signal if the A/D-converter value has reached the full-scale value. The SENSITIVITY register has a resolution of 8 bits.

OFFSET

The OFFSET bits define the parameter for the adder in the DSP.

The customer can decide if the offset is MSB aligned or LSB aligned. The MSB or LSB alignment is enabled by an additional offset alignment bit (OFFSET_ALIGN). In case this bit is set to 1, the offset is programmable from –25% up to 25% of V_{SUP}. If the OFFSET_ALIGN bit is set to zero, then the offset covers only 1/8 of the full-scale (–6.25% up to 6.25% of V_{SUP}) but with higher resolution. The customer can adjust the offset symmetrically around 50% of V_{SUP}. The OFFSET register can be set with 8-bit resolution.

3.2.2. Customer Setup 2 Register

Customer Setup 2 register contains the bits for magnetic range (MAG_RANGE), linear and quadratic temperature coefficients (TC and TCSQ), magnetic offset alignment (OFFSET_ALIGN), unbalanced clamping levels (CLAMP_SP) and the customer lock bit.

MAG_RANGE

The MAG_RANGE bits define the magnetic field range of the A/D converter. The following eight magnetic ranges are available.

Table 3–2: MAG_RANGE bit definition

Magnetic Field Range	Bit Setting	Comment
−20 mT...20 mT	0	For test purpose only
−40 mT...40 mT	1	
−60 mT...60 mT	2	
−80 mT...80 mT	3	
−100 mT...100 mT	4	
−120 mT...120 mT	5	
−140 mT...140 mT	6	
−160 mT...160 mT	7	

TC and TCSQ

The temperature dependence of the magnetic sensitivity can be adapted to different magnetic materials in order to compensate for the change of the magnetic strength with temperature. The adaption is done by programming the TC (Linear Temperature Coefficient) and the TCSQ registers (Quadratic Temperature Coefficient). Thereby, the slope and the curvature of the temperature dependence of the magnetic sensitivity can be matched to the magnet and the sensor assembly. As a result, the output signal characteristic can be fixed over the full temperature range. The sensor can compensate for linear temperature coefficients ranging from about –3100 ppm/K up to 2550 ppm/K and quadratic coefficients from about –7 ppm/K^2 to 15 ppm/K^2 (typical range). Min. and max. values for the quadratic temperature coefficient depend on the linear temperature coefficient. Please refer to Section 5.4. on page 27 for the recommended settings for different linear temperature coefficients.

Magnetic Offset Alignment Bit (OFFSET_ALIGN)

Please refer to Section 3.2.1. on page 9 (OFFSET).

LOCK

By setting this 1-bit register, all registers will be locked, and the EEPROM content can not be changed anymore. The LOCK bit is active after the first power-off and power-on sequence after setting the LOCK bit.

Warning **This register cannot be reset!**

3.2.3. Micronas ID Number Registers

Micronas ID Number registers contain 16 bits each. These three registers can be read by the customer and TDK-Micronas will use the registers to store production information like wafer position, wafer number and production lot number.

3.2.4. Customer Setup Registers

The Customer Setup 1 register contains the bits to select the sampling frequency, to enable/disable the overriding of the output signal clamping in case of faults, to define the output signal clamping levels and to enable the reading of the sensor's memory after lock.

DSDOUBLE

The bit DSDOUBLE allows to double the sampling frequency and the permitted values are 8 kHz and 16 kHz, corresponding to a 3 dB filter cutoff frequency of 2.5 kHz and 5 kHz.

CLEVEL

The 2-bit CLEVEL together with CLAMP_SP select the clamping levels, i.e. the maximum and minimum output voltage levels of the analog output. The following choices are available {CLAMP_SP:CLEVEL}:

Table 3–3: Clamping Level definition

CLAMP_SP	CLEVEL	Clamping Level (%FS)	
		low	**high**
0	00	0 (OFF = supply voltage)	100 (OFF = supply voltage)
0	01	5	95
0	10	10	90
0	11	15	85
1	00	5	90
1	01	10	95
1	10	20	90
1	11	10	80

Clamping is normally not considered as an error. However, the user is able to activate the Clamping Error Code by setting the CLAMP_ERC bit of the Customer Setup 1 register. In that case the output will be forced to the Low Error Band (GND) or High Error Band (VSUP), as soon as the output signal reaches the programmed clamping levels. The upper error band is realized by setting the MDATA register to maximum value. The resulting clamping behavior therefore depends on the selection of the Clamping Levels, the setting of the CLAMP_ERC bit, and the setting of the EN_ERC_HI bit (Error Code Selection). All possible clamping variations are shown in Fig. 3–3.

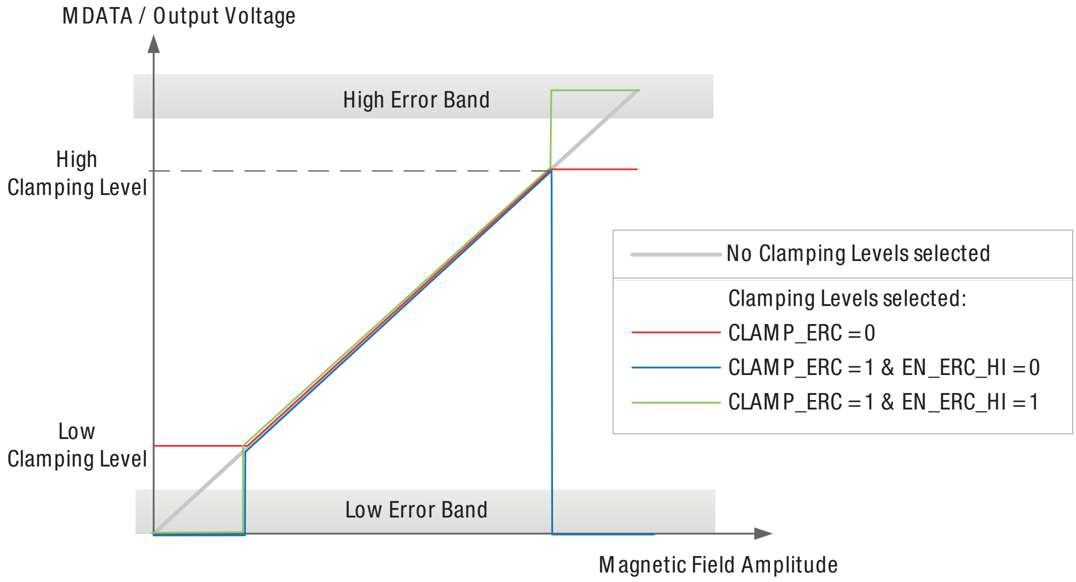


Fig. 3–3: Clamping levels HAL 1860

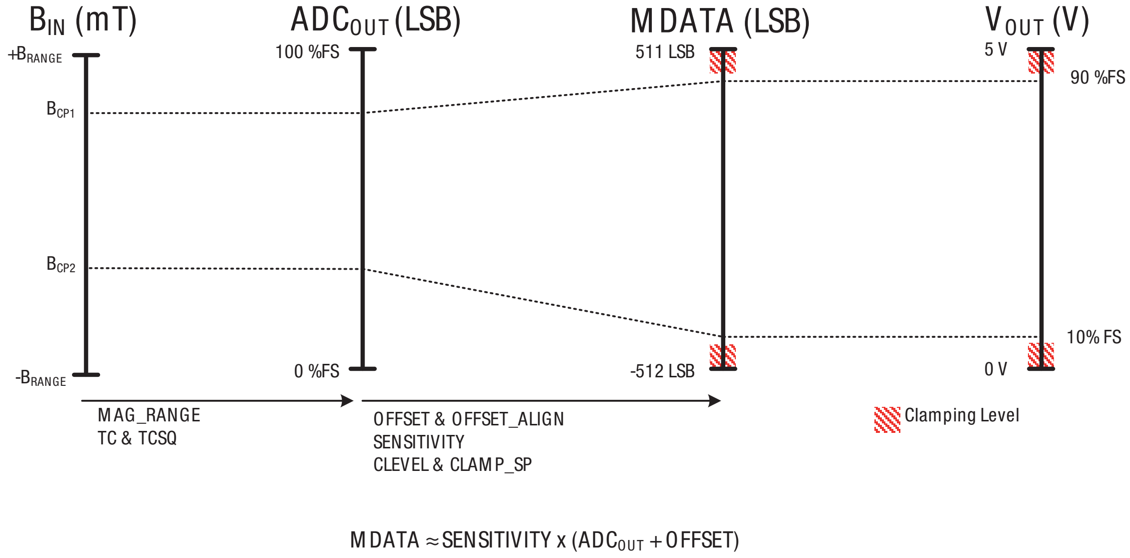


Fig. 3–4: Signal path HAL 1860

3.2.5. Signal Path

Fig. 3–4 on page 12 shows the signal path and signal processing of HAL 1860. The measurement output value MDATA is calculated with the output value of the ADC by the following equation.

$$MDATA = SENSITIVITY \times (ADC_{OUT} + OFFSET)$$

The parameters OFFSET and SENSITIVITY are two’s complement encoded 8-bit values (see Section 3.2.5. on page 13).

3.3. On-board Diagnostic Features

The HAL 1860 features following diagnostic functions:

– **Thermal supervision of the output stage (overcurrent, short circuit, etc.)**
The sensor switches the output to tristate if an over temperature is detected by the thermal supervision.

– **Undervoltage detection with internal reset**
The occurrence of an undervoltage is indicated immediately by switching the output to VDIAG_L. The output will be kept at VDIAG_L after the end of an undervoltage detection event until a correct measurement value is available. This delay time depends on the selected sampling frequency.

– **Magnetic signal amplitude out of range (overflow or underflow in ADC)**

– **Over-/underflow in adder or multiplier**

These faults are visible at the output as long as present. The occurrence of these faults forces the output to the Low Error Band or High Error Band (see VDIAG_L and VDIAG_H in Section 4.11. on page 22), depending on the source of the error, and the customer parameter settings, such as the sign of the sensitivity and the Error Code Selection bit (see Table 3–4).

Table 3–4: Error Code source and settings combinations

Settings		**Source**					
Sign of Sensitivity	EN_ERC_HI	A/D-Converter		Adder		Multiplier	
		under	over	under	over	under	over
+	1	Low	High	Low	High	Low	High
–		High	Low	High	Low		
±	0	Low		Low		Low	

3.4. Sensor Calibration

3.4.1. General Procedure for Development or Evaluation Purposes

For calibration of the sensor in the customer application, the development tool kit from TDK-Micronas is recommended. It contains the hardware for the generation of the serial telegram for programming and the corresponding software for the programming of register values.

For the individual calibration of each sensor in the final customer application, a two-point adjustment is recommended. Please refer to "HAL1860 User Manual" for further details on calibration procedure.

Locking the Sensor

For qualification and production purpose the device has to be locked.

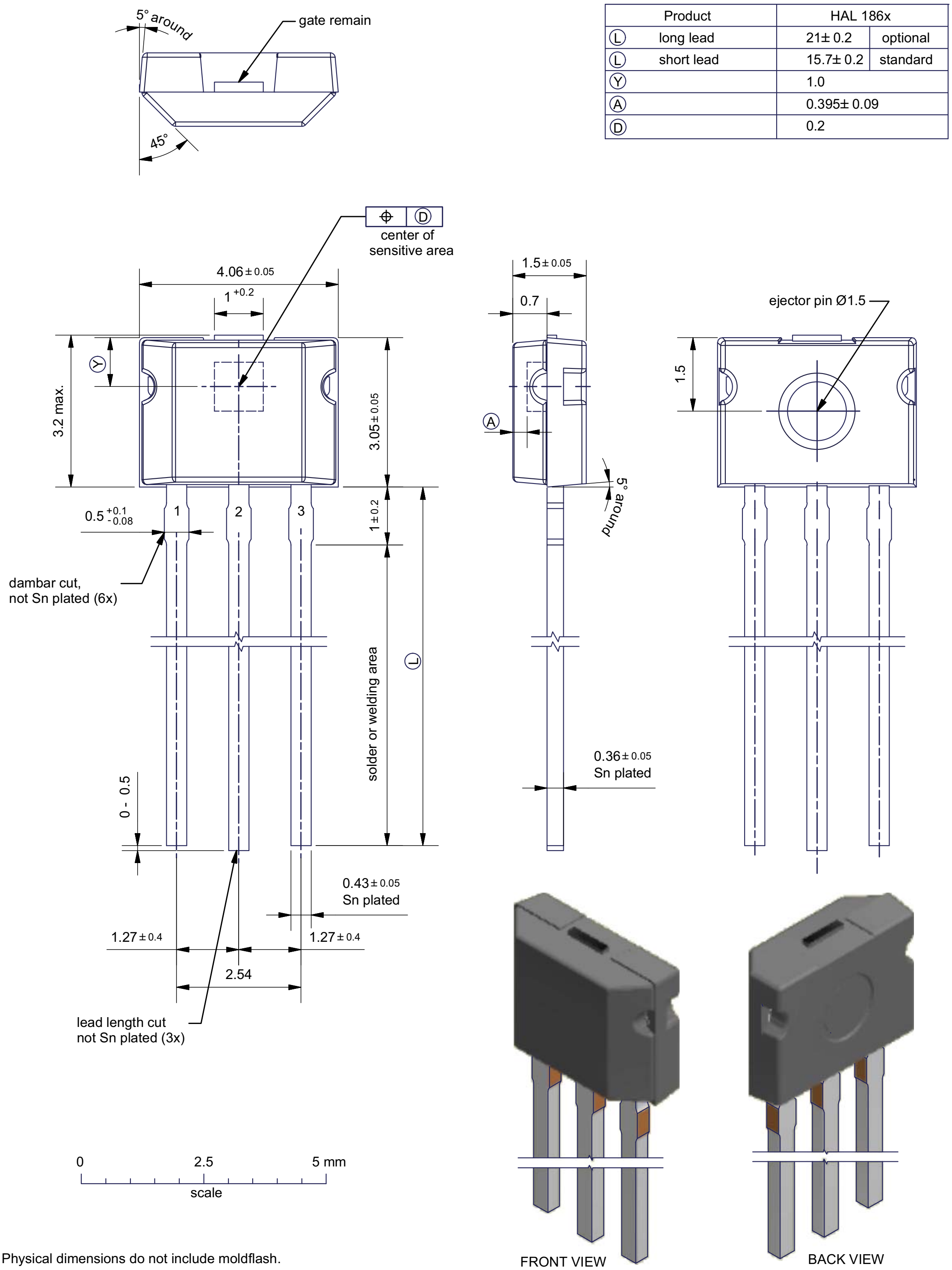
The last programming step activates the memory lock function by setting the LOCK bit. Please note that the memory lock function becomes effective after power-down and power-up of the Hall IC. The sensors EEPROM is then locked and its content can not be changed nor read anymore.

Warning **This register cannot be reset!**

4. Specifications

4.1. Outline Dimensions

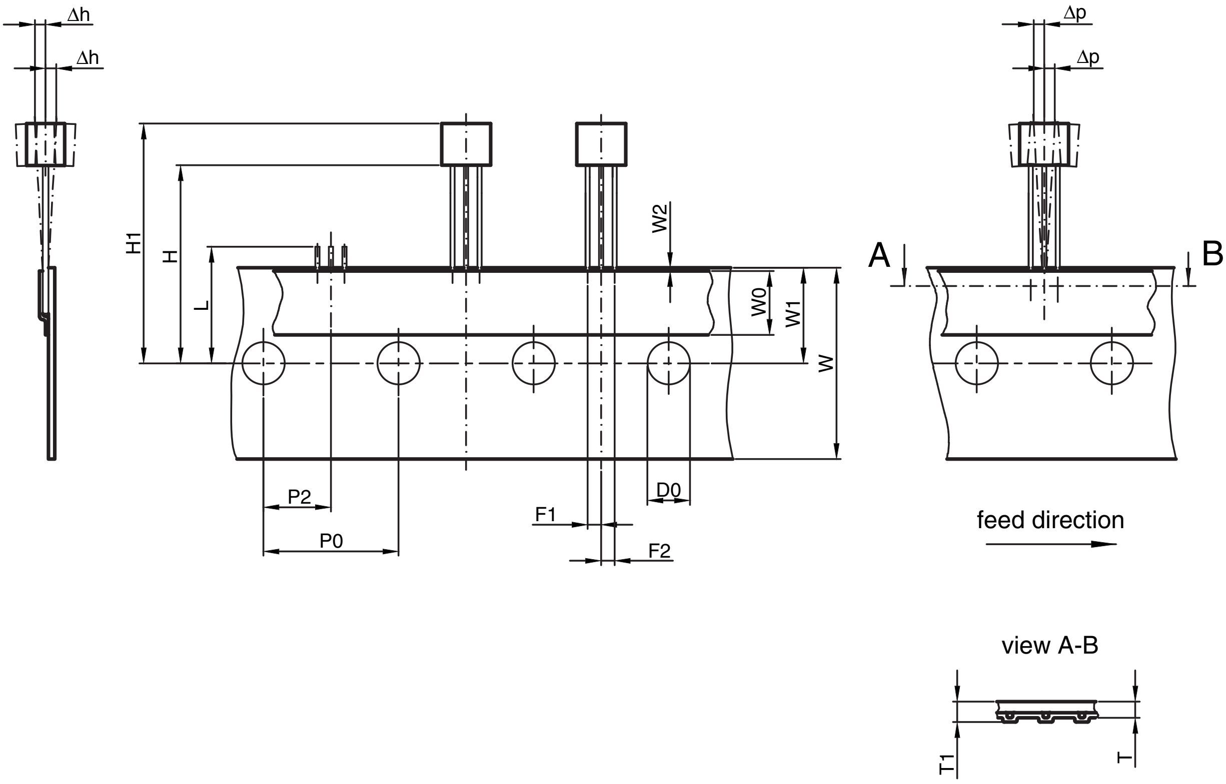
Product		HAL 186x	
Ⓛ	long lead	21± 0.2	optional
Ⓛ	short lead	15.7± 0.2	standard
Ⓨ		1.0	
Ⓐ		0.395± 0.09	
Ⓓ		0.2	



Physical dimensions do not include moldflash.
Sn-thickness might be reduced by mechanical handling.

PACKAGE	ISSUE DATE (YY-MM-DD)	JEDEC STANDARD		ANSI	REVISION DATE (YY-MM-DD)	REV.NO.	DRAWING-NO.	SPECIFICATION	
		ITEM NO.	ISSUE					TYPE	NO.
TO92UA-2	16-06-28				16-06-28	1	CUAI00031005.1	ZG	2047_Ver.01

Fig. 4–1: TO92UA-2: Plastic Transistor Standard UA package, 3 leads, non-spread, standard lead length
Weight approximately 0.106 g



all dimensions in mm
other dimensions see drawing of bulk
max. allowed tolerance over 20 hole spacings ±1.0

	H	H1	
		TO92UA	TO92UT
Short leads	18 - 20	21 - 23.1	22 - 24.1
Long leads	24 - 26	27 - 29.1	28 - 30.1

UNIT	D0	F1	F2	Δh	L	P0	P2	Δp	T	T1	W	W0	W1	W2
mm	4.0	1.47 1.07	1.47 1.07	±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

STANDARD		ANSI	ISSUE DATE YY-MM-DD	DRAWING-NO.	ZG-NO.
ISSUE	ITEM NO.				
-	IEC 60286-2		16-07-18	06631.0001.4	ZG001031_Ver.05

Fig. 4–2: TO92UA/UT: Dimensions ammopack inline, not spread, standard lead length

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).

4.3. Pin Connections and Short Descriptions

Pin No.	Pin Name	Short Description
1	VSUP	Supply Voltage Pin
2	GND	Ground
3	OUT	Push-Pull Output

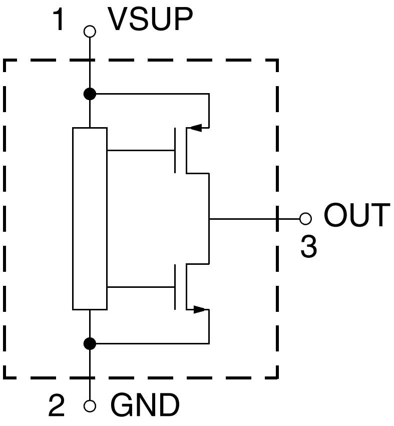


Fig. 4–3: Pin configuration

4.4. Dimensions of Sensitive Area

Hall plate area = 0.2 mm × 0.1 mm

See Fig. 4–1 on page 15 for more information on the Hall plate position.

4.5. Output/Magnetic Field Polarity

Applying a south-pole magnetic field perpendicular to the branded side of the package will increase the output voltage (for Sensitivity <0) from the quiescent (offset) voltage towards the supply voltage. A north-pole magnetic field will decrease the output voltage. The output logic will be inverted for a Sensitivity setting >0.

4.6. 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	Notes
V_{SUP}	Supply Voltage	1	–8.5 –14.4 –15	8.5 14.4 16	V	t < 96 h[4] t < 10 min[4] t < 1 min[4]
V_{OUT}	Output Voltage	3	–0.5[1] –0.5[1] –0.5[1]	8.5 14.4 16	V	t < 96 h[4] t < 10 min[4] t < 1 min[4]
$V_{OUT}-V_{SUP}$	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 under Bias		–40	190	°C	[2]
$T_{STORAGE}$	Transportation/Short-Term Storage Temperature		–55	150	°C	
V_{ESD}	ESD Protection[3]	1,2,3	–8.0	8.0	kV	

[1] Internal protection resistor = 50 Ω
[2] For 96h - Please contact TDK-Micronas for other temperature requirements
[3] AEC-Q100-002 (100 pF and 1.5 kΩ)
[4] No cumulated stress

4.7. 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).

4.8. 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	Notes
V_{SUP}	Supply Voltage	1	4.5 5.7	5 6	5.5 8.0	V	Normal operation During programming
I_{OUT}	Continuous Output Current	3	–1	–	1	mA	
R_L	Load Resistor	3	5.5	10	–	kΩ	
C_L	Load Capacitance	3	0.33	–	47	nF	
N_{PRG}	Number of EEPROM Programming Cycles	–	–	–	100	–	0 °C < T_{amb} < 55 °C
T_J	Junction Operating Temperature[1]	–	–40 –40 –40	– – –	125 150 170	°C °C °C	for 8000 hrs[2] for 2000 hrs[2] for 1000 hrs[2]

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

[2] Time values are not cumulative.

4.9. Characteristics

At T_J = –40 °C to +170 °C, V_{SUP} = 4.5 V to 5.5 V, GND = 0 V, after programming the sensor and locking the EEPROM, at Recommended Operation Conditions if not otherwise specified in the column “Notes”. Typical characteristics for T_J = 25 °C and V_{SUP} = 5 V.

Symbol	Parameter	Pin No.	Min.	Typ.	Max.	Unit	Notes	
I_{SUP}	Supply Current over Temperature Range	1	5	6.75	8.5	mA		
V_{PORLH}	Power-On Reset Level (rising supply)	1	3.9	4.35	4.5	V		
V_{PORHYS}	Power-On Reset Hysteresis[4]	1	0.1	0.175	0.3	V		
Signal								
–	Resolution	3	–	10	–	Bit		
f_s	Sampling Rate	–	–	8	–	kHz		
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_{OUTH}	Analog Output High Voltage	3	4.7	4.9	–	V	V_{SUP} = 5 V, I_{OUT} =±1 mA[2]	
V_{OUTL}	Analog Output Low Voltage	3	–	0.1	0.3	V	V_{SUP} = 5 V, I_{OUT} = ±1 mA[2]	
BW	Small Signal Bandwidth (–3 dB)[3]	3	2.25	2.5	–	kHz	B_{AC}<10 mT	
$CLAMP_L$	Clamp low[3]					%V_{SUP}	CLAMP_SP	CLEVEL
		3	–	0	–		0	00
			–	5	–		0	01
			–	10	–		0	10
			–	15	–		0	10
			–	5	–		1	00
			–	10	–		1	01
			–	20	–		1	10
			–	10	–		1	11

Symbol	Parameter	Pin No.	Min.	Typ.	Max.	Unit	Notes	
$CLAMP_H$	Clamp High[3]					$\%V_{SUP}$	CLAMP_SP	CLEVEL
		3	–	100	–		0	00
			–	95	–		0	01
			–	90	–		0	10
			–	85	–		0	10
			–	90	–		1	00
			–	95	–		1	01
			–	90	–		1	10
			–	80	–		1	11
Output Pin								
$t_{r(O)}$	Response Time of Output[4]	3	–	68	300	µs	With DSDOUBLE=1 (16 kHz sampling rate) C_L = 10 nF, time from 10% to 90% of final output voltage for a magnetic input signal	
$t_{r(O)}$	Response Time of Output[4]	3	–	125	375	µs	With DSDOUBLE=0 (8 kHz sampling rate) C_L = 10 nF, time from 10% to 90% of final output voltage for a magnetic input signal	
t_{POD}	Power-Up Time (Time to reach stabilized Output Voltage)	–	–	1	1.5	ms	C_L = 10 nF, 90% of V_{OUT} with DSDOUBLE=1 (16 kHz sampling rate)	
t_{POD}	Power-Up Time (Time to reach stabilized Output Voltage)	–	–	750[4]	1000	µs	C_L = 10 nF, 90% of V_{OUT} with DSDOUBLE= 0 (8 kHz sampling rate)	
V_{OUTn}	Output RMS Noise[4]	3	–	2.6	5	mV	B = 5% to 95% of B_{max}	
R_{OUT}	Output Resistance over Recommended Operating Range[3]	3	–	60	–	Ω	$V_{OUTLmax} \leq V_{OUT} \leq V_{OUTHmin}$	
[1] Linear regression [2] Linear output range [3] Guaranteed by design [4] Characterized on sample basis								
TO92UA Package								
	Thermal Resistance						Determined with a 1s0p board	
R_{thja}	junction to air	–	–	–	250	K/W		
R_{thjc}	junction to case	–	–	–	70	K/W		

4.10. Undervoltage Detection

At T_J = –40 °C to +170 °C, GND=0 V, typical characteristics for T_J = 25 °C, after programming and locking.

Symbol	Parameter	Pin	Min.	Typ.	Max.	Unit	Notes
$V_{SUP,UV}$	Undervoltage Detection Level (Power-On Reset)	1	3.9	4.35	4.5	V	
$V_{SUP,UVhyst}$	Undervoltage Detection Level Hysteresis$^{1)}$	1	150	225	300	mV	
$^{1)}$ Characterized on sample basis							

4.11. Output Voltage in Case of Error Detection

At T_J = –40 °C to +170 °C, typical characteristics for T_J = 25 °C, after programming and locking.

Symbol	Parameter	Pin	Min.	Typ.	Max.	Unit	Notes
V_{DIAG_L}	Output Voltage in case of Error Detection	3	0	0.02	0.1	V	V_{SUP} = 5 V R_L = 5 kΩ pull-up
V_{DIAG_H}	Output Voltage in case of Error Detection	3	4.7	4.9	-	V	V_{SUP} = 5 V R_L = 5 kΩ pull-down

4.12. Magnetic Characteristics

At Recommended Operating Conditions if not otherwise specified in the column ’Notes’, T_J =–40 °C to +170 °C, V_{SUP} = 4.5 V to 5.5 V, after programming the sensor and locking the EEPROM. Typical Characteristics for T_A = 25 °C and V_{SUP} = 5 V.

Symbol	Parameter	Pin No.	Values			Unit	Notes
			Min.	Typ.	Max.		
$\text{RANGE}_{\text{ABS}}$	Absolute Magnetic Range of A/D Converter over temperature	–	80	100	120	%	% of nominal RANGE Nominal RANGE programmable from 40 mT[3] up to 160 mT
RANGE	Magnetic field range	–	±40[3]	±80	± 60	mT	TO92UA-1/-2
Sensitivity	Trim range for absolute sensitivity[1]	3	±10		±55[4]	mV/mT	Depending on magnetic field range [1] and SENS register content
$\Delta\text{Sens}_{\text{trim}}$	Trim step for absolute sensitivity[1]	3	0.3		 1	mV/mT	At min. sensitivity At max. sensitivity
$\Delta\text{Offset}_{\text{trim}}$	Offset trim[1]	3	±2.5 ±10		±312 ±1250	mV	OALN=0 OALN=1
ES	Sensitivity Error over Temperature Range	3	–6	0	6	%	Part to part variation for certain combinations of TC and TCSQ (see Section 4.12.1.)
$\Delta\text{Sens}_{\text{Life}}$	Sensitivity Drift (beside temperature drift)[2]		-4.5	0	5.5	%	T_J = 25 °C; after temperature cycling and over life time
B_{OFFSET}	Magnetic offset	3	–2	0	2	mT	B = 0 mT, T_A = 25 °C
ΔB_{OFFSET}	Magnetic offset drift over Temperature Range $B_{\text{OFFSET}}(T) - B_{\text{OFFSET}}$ (25 °C)	3	–600	0	600	μT	B = 0 mT, RANGE = 40 mT[3], Sens = 100 mV/mT
$B_{\text{Hysteresis}}$	Magnetic Hysteresis[1]	3	–20	0	20	μT	Range = ±40 mT

[1] Characterized on sample basis

[2] After 1000 temperature cycles –50 °C to +170 °C (liquid-liquid) 1000 shocks. Characterized on small sample size. Limits are 6-sigma limits based on the measurement of 15 devices out of 3 production lots.

[3] ±20 mT range available for test purpose only

[4] ±110 mV/mT for test purpose

4.12.1. Definition of Sensitivity Error ES

ES is the maximum of the absolute value of the quotient of the normalized measured value1) over the normalized ideal linear value2) minus 1:

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

In the example shown in Fig. 4–4 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

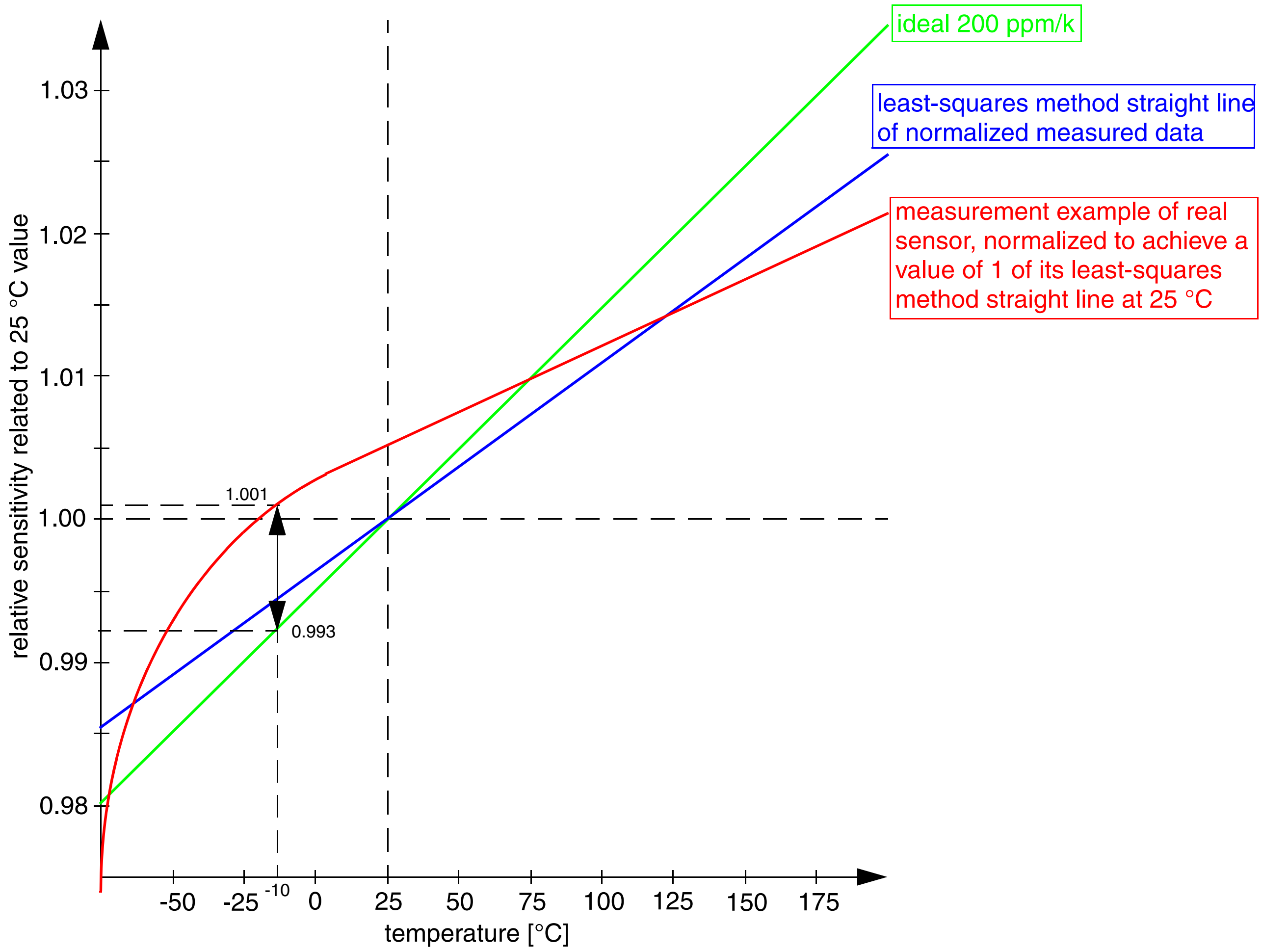


Fig. 4–4: Definition of Sensitivity Error ES

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:

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

The X represents junction to air or to case.

In order to estimate the temperature difference ΔT between the junction and the respective reference (e.g. air, case, or solder point) use the max. parameters for I_{SUP}, R_{thX}, 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 $I_{SUP} = 10$ mA the temperature difference $\Delta T = 13.75$ K.

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

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

5.2. EMC and ESD

HAL 1860 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. 5–1 on page 26 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).