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MICRONAS

Hardware
Documentation

Data Sheet

HAL® 880

Programmable Linear Hall-Effect Sensor

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DSH000152_004EN

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Contents

Programmable Linear Hall-Effect Sensor

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

1. Introduction

The HAL880 is a member of the Micronas family of programmable linear Hall sensors. The HAL880 complements the existing Hall-effect sensor family HAL8xy to the lower end. It is designed to fulfill the requirements of today's state-of-the-art applications for linear and angular measurements that require programmability to compensate system tolerances.

The HAL880 is an universal magnetic field sensor with a linear output based on the Hall effect. The IC can be used for angle or distance measurements if combined with a rotating or moving magnet. The major characteristics like magnetic field range, sensitivity, output quiescent voltage (output voltage at B = 0 mT), and output voltage range are programmable in a non-volatile memory. The sensor has a ratiometric output characteristic, which means that the output voltage is proportional to the magnetic flux and the supply voltage.

The HAL880 features a temperature-compensated Hall plate with choppered offset compensation, an A/D converter, digital signal processing, a D/A converter with output driver, an EEPROM memory with redundancy and lock function for the calibration data, an EEPROM for customer serial number, a serial interface for programming the EEPROM, and protection devices at all pins. The internal digital signal processing is of great benefit because analog offsets, temperature shifts, and mechanical stress do not degrade the sensor accuracy.

The HAL880 is programmable by modulating the supply voltage. No additional programming pin is needed. The easy programmability allows a 2-point calibration by adjusting the output voltage 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 tolerances of the sensor, the magnet, and the mechanical positioning can be compensated in the final assembly. This offers a low-cost alternative for all applications that presently need mechanical adjustment or laser trimming for calibrating the system.

In addition, the temperature compensation of the Hall IC can be fit to common magnetic materials by programming first and second order temperature coefficients of the Hall sensor sensitivity.

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 Micronas.

The sensor is designed for hostile industrial and automotive applications and operates with typically 5 V supply voltage in the ambient temperature range from –40 °C up to 125 °C. The HAL880 is available in the very small leaded packages TO92UT-1, TO92UT-2 and in the eight-pin SOIC8 SMD package.

1.1. Major Applications

Due to the sensor's versatile programming characteristics and low temperature drifts, the HAL880 is the optimal system solution for applications such as:

- contactless potentiometer,
- rotary position measurement,
- linear movement,
- current measurements.

1.2. Features

- programmable linear Hall effect sensor with ratiometric output and digital signal processing
- 12-bit analog output
- multiple programmable magnetic characteristics in a non-volatile memory (EEPROM) with redundancy and lock function
- open-circuit (ground and supply line break detection) with 10 kΩ pull-up and pull-down resistor, overvoltage and undervoltage detection
- for programming an individual sensor within several sensors in parallel to the same supply voltage, a selection can be done via the output pin
- temperature characteristics are programmable for matching common magnetic materials
- programmable clamping function
- programming through a modulation of the supply voltage
- operates from –40 °C up to 140 °C junction temperature
- operates from 4.5 V up to 5.5 V supply voltage in specification and functions up to 8.5 V
- operates with static magnetic fields and dynamic magnetic fields up to 1 kHz
- overvoltage and reverse-voltage protection at all pins
- magnetic characteristics extremely robust against mechanical stress
- short-circuit protected push-pull output
- EMC and ESD optimized design

2. Ordering Information

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

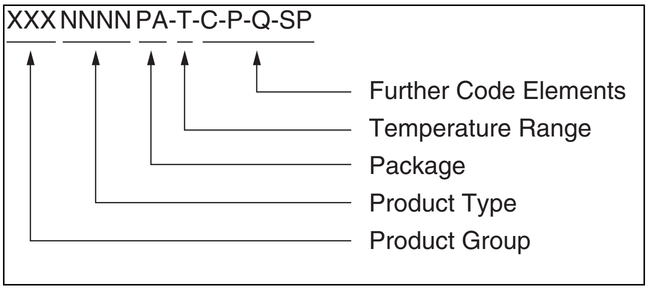


Fig. 2–1: Ordering Code Principle

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

2.1. Device-Specific Ordering Codes

HAL880 is available in the following package and temperature variants.

Table 2–1: Available packages

Package Code (PA)	Package Type
UT	TO92UT-1/-2
DJ	SOIC8

Table 2–2: Available temperature range

Temperature Code (T)	Temperature Range
K	T_J = –40 °C to +140 °C

The relationship between ambient temperature (T_A) and junction temperature (T_J) is explained in Section 5.4. on page 29.

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

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

Available Ordering Codes	Package Marking
HAL880UT-K-[C-P-Q-SP]	880K
HAL880DJ-K-[C-P-Q-SP]	880K

3. Functional Description

3.1. General Function

The HAL880 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 converted to a digital value, processed in the Digital Signal processing Unit (DSP) according to the settings of the EEPROM registers, converted to an analog voltage with ratiometric behavior, and stabilized by a push-pull output transistor stage. The function and the parameters for the DSP are explained in Section 3.2. on page 8.

The setting of the LOCK register disables the programming of the EEPROM memory for all time. This register cannot be reset.

As long as the LOCK register is not set, the output characteristic can be adjusted by programming the EEPROM registers. The IC is addressed by modulating the supply voltage (see Fig. 3–1). In the supply voltage range from 4.5 V up to 5.5 V, the sensor generates an analog output voltage. After detecting a command, the sensor reads or writes the memory and answers with a digital signal on the output pin.

The analog output is switched off during the communication. Several sensors in parallel to the same supply and ground line can be programmed individually. The selection of each sensor is done via its output pin.

The open-circuit detection provides a defined output voltage if the V_{SUP} or GND line is broken. Internal temperature compensation circuitry and the choppered offset compensation enables operation over the full temperature range with minimal changes in accuracy and high offset stability. The circuitry also rejects offset shifts due to mechanical stress from the package. The non-volatile memory consists of redundant and non-redundant EEPROM cells. The non-redundant EEPROM cells are only used to store production information inside the sensor. In addition, the sensor IC is equipped with devices for overvoltage and reverse-voltage protection at all pins.

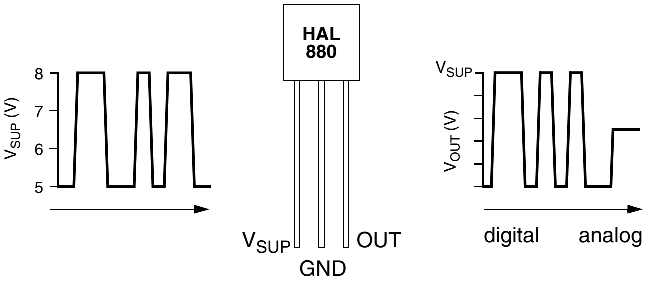


Fig. 3–1: Programming with V_{SUP} modulation

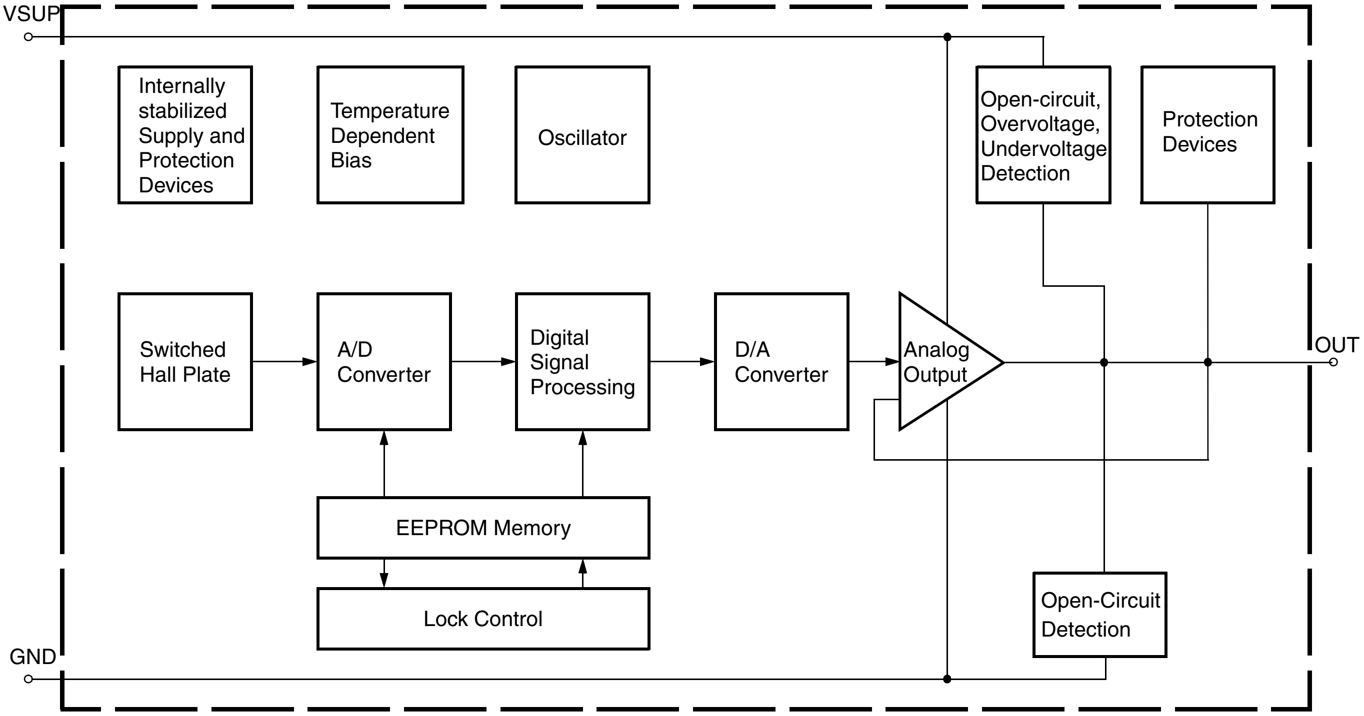


Fig. 3–2: HAL880 block diagram

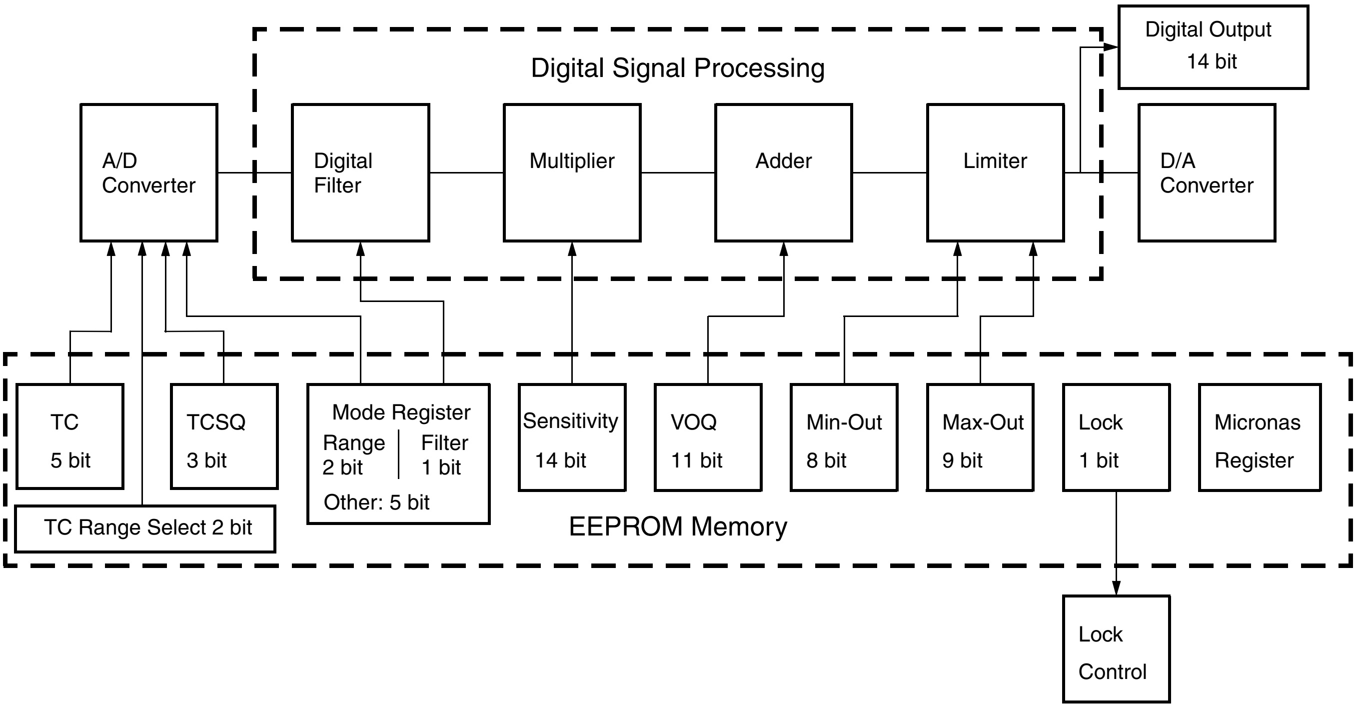


Fig. 3–3: Details of EEPROM and digital signal processing

3.2. Digital Signal Processing and EEPROM

The DSP is the main part of this sensor and performs the signal conditioning. The parameters for the DSP are stored in the EEPROM registers. The details are shown in Fig. 3–3 on page 7.

Terminology:

SENSITIVITY:	name of the register or register value
Sensitivity:	name of the parameter

The EEPROM registers consist of four groups:

Group 1 contains the registers for the adaption of the sensor to the magnetic system: MODE for selecting the magnetic field range and filter frequency, TC, TCSQ and TC-range for the temperature characteristics of the magnetic sensitivity.

Group 2 contains the registers for defining the output characteristics: SENSITIVITY, VOQ, CLAMP-LOW, and CLAMP-HIGH. The output characteristic of the sensor is defined by these 4 parameters.

- The parameter V_{OQ} (Output Quiescent Voltage) corresponds to the output voltage at B = 0 mT.
- The parameter Sensitivity defines the magnetic sensitivity:

$$Sensitivity = \frac{\Delta V_{OUT}}{\Delta B}$$

- The output voltage can be calculated as:

$$V_{OUT} \sim Sensitivity \times B + V_{OQ}$$

The output voltage range can be clamped by setting the registers CLAMP-LOW and CLAMP-HIGH in order to enable failure detection (such as short-circuits to V_{SUP} or GND and open connections).

Group 3 contains the general purpose register GP. The GP register can be used to store customer information, like a serial number after manufacturing. Micronas will use this GP REGISTER to store information such as lot number, wafer number, x and y position of the die on the wafer, etc. This information can be readout by the customer and stored in its own data base or it can stay in the sensor as it is.

Group 4 contains the Micronas registers and LOCK for the locking of all registers. The Micronas registers are programmed and locked during production. These registers are used for oscillator frequency trimming, A/D converter offset compensation, and several other special settings.

An external magnetic field generates a Hall voltage on the Hall plate. The ADC converts the amplified positive or negative Hall voltage (operates with magnetic north and south poles at the branded side of the package) to a digital value. The digital signal is filtered in the internal low-pass filter and manipulated according to the settings stored in the EEPROM. The digital value after signal processing is readable in the D/A-READOUT register. Depending on the programmable magnetic range of the Hall IC, the operating range of the A/D converter is from –30 mT … +30 mT up to –100 mT … +100 mT.

During further processing, the digital signal is multiplied with the sensitivity factor, added to the quiescent output voltage and limited according to the clamping voltage. The result is converted to an analog signal and stabilized by a push-pull output transistor stage.

The D/A-READOUT at any given magnetic field depends on the programmed magnetic field range, the low-pass filter, TC values, CLAMP-LOW and CLAMP-HIGH. The D/A-READOUT range is min. 0 and max. 16383.

Note: During application design, it should be taken into consideration that the maximum and minimum D/A-READOUT should not saturate in the operational range of the specific application.

Range

The RANGE bits are bit 2 and 3 of the MODE register; they define the magnetic field range of the A/D converter.

Magnetic Field Range	RANGE
–30mT...30 mT	0
–60 mT...60 mT	1
–80 mT...80 mT	2
–100 mT...100 mT	3

Filter

The FILTER bit is bit number 4 of the MODE register; it defines the –3 dB frequency of the digital low pass filter.

–3 dB Frequency	FILTER
500 Hz	0
1 kHz	1

Bit Time

The BITTIME bit is bit number 5 of the MODE register; It defines the protocol bit time for the communication between the sensor and the programmer board.

Bit Time	BITTIME
1:64 (Typ. 1.75 ms)	0
1:128 (Typ. 3.5 ms)	1

Output Format

The OUTPUTMODE bits are the bits numbers 6 to 7 of the MODE register.

Output Format	OUTPUTMODE
Analog Output (12 bit)	0

TC Register

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 (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 voltage 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 1000 ppm/K and quadratic coefficients from about –7 ppm/K² to 2 ppm/K². The full TC range is separated in the following four ranges:

TC-Range [ppm/k]	GROUP
–3100 to –1800	0
–1750 to –550	2
–500 to +450 (default value)	1
+450 to +1000	3

TC (5 bit) and TCSQ (3 bit) have to be selected individually within each of the four ranges. For example: 0 ppm/k requires TC-Range = 1, TC = 15 and TCSQ = 1.

Sensitivity

The SENSITIVITY register contains the parameter for the multiplier in the DSP. The Sensitivity is programmable between –4 and 4. For V_{SUP} = 5 V, the register can be changed in steps of 0.00049.

For all calculations, the digital value from the magnetic field of the D/A converter is used. This digital information is readable from the D/A-READOUT register.

$$SENSITIVITY = \frac{\Delta V_{out} \times 16384}{2 \times \Delta DA\text{-}Readout \times V_{SUP}}$$

VOQ

The VOQ register contains the parameter for the adder in the DSP. V_{OQ} is the output voltage without external magnetic field (B = 0 mT) and programmable from $-V_{SUP}$ up to V_{SUP}. For V_{SUP} = 5 V, the register can be changed in steps of 4.9 mV.

Note: If V_{OQ} is programmed to a negative voltage, the maximum output voltage is limited to:

$$V_{OUTmax} = V_{OQ} + V_{SUP}$$

Clamping Voltage

The output voltage range can be clamped in order to detect failures like short circuits to V_{SUP} or GND or an open circuit.

The CLAMP-LOW register contains the parameter for the lower limit. The lower clamping voltage is programmable between 0 V and $V_{SUP}/2$. For V_{SUP} = 5 V, the register can be changed in steps of 9.77 mV.

The CLAMP-HIGH register contains the parameter for the upper limit. The upper clamping voltage is programmable between 0 V and V_{SUP}. For V_{SUP} = 5 V, in steps of 9.77 mV.

GP Register

This register can be used to store some information, such as production date or customer serial number. Micronas will store production lot number, wafer number, and x, y coordinates in three blocks of this registers. The total register contains of four blocks with a length of 13 bit each. The customer can read out this information and store it in his production data base for reference or he can store own production information.

Note: To enable programming of the GP register, bit 0 of the MODE register has to be set to 1. This register is not a guarantee for traceability.

LOCKR

By setting the first bit of this 2-bit register, all registers will be locked and the sensor will no longer respond to any supply voltage modulation. This bit is active after the first power-off and power-on sequence after setting the LOCK bit.

Warning: This register cannot be reset!

D/A-Readout

The 14-bit D/A-READOUT register delivers the actual digital value of the applied magnetic field after the signal processing. This register can be read out and is the basis for the calibration procedure of the sensor in the system environment.

Note: The MSB and LSB are reversed compared with all the other registers. Please reverse this register after readout.

3.3. Calibration Procedure

3.3.1. General Procedure

For calibration in the system environment, the application kit from Micronas is recommended. It contains the hardware for the generation of the serial telegram for programming (Programmer Board Version 5.1) and the corresponding software (PC880) for the input of the register values.

For the individual calibration of each sensor in the customer application, a two-point adjustment is recommended. The calibration has be done as follows:

Step 1: Input of the registers which need not be adjusted individually

The magnetic circuit, the magnetic material with its temperature characteristics, the filter frequency, the output mode and the GP register value are given for this application. Therefore, the values of the following registers should be identical for all sensors of the customer application.

- FILTER
  (according to the maximum signal frequency)
- RANGE
  (according to the maximum magnetic field at the sensor position)
- OUTPUTMODE
- TC, TCSQ, and TC-RANGE
  (depends on the material of the magnet and the other temperature dependencies of the application)
- GP
  (if the customer wants to store own production information, it is not necessary to change this register)

The clamping voltages should be set after the adjustment process. This avoids clamping of the D/A-Readout value during calibration, because the D/A-Readout value is needed for the Sensitivity and Voq calculations during calibration.

Write the appropriate settings into the HAL880 registers.

Step 2: Initialize DSP

As the D/A-READOUT register value depends on the settings of SENSITIVITY, VOQ, and CLAMP-LOW/HIGH, these registers have first to be initialized with defined values:

- $VOQ_{INITIAL}$ = 2.5 V
- $Sensitivity_{INITIAL}$ = 0.5
- Clamp-Low = 0 V
- Clamp-High = 4.999 V

Step 3: Define Calibration Points

The calibration points 1 and 2 can be set inside the specified range. The corresponding values for V_{OUT1} and V_{OUT2} result from the application requirements.

$$Lowclampingvoltage \le V_{OUT1,2} \le Highclampingvoltage$$

For highest accuracy of the sensor, calibration points near the minimum and maximum input signal are recommended. The difference of the output voltage between calibration point 1 and calibration point 2 should be more than 3.5 V.

Step 4: Calculation of V_{OQ} and Sensitivity

Set the system to calibration point 1 and read the register D/A-READOUT. The result is the value D/A-READOUT1.

Now, set the system to calibration point 2, read the register D/A-READOUT again, and get the value D/A-READOUT2.

With these values, and the target values V_{OUT1} and V_{OUT2}, for the calibration points 1 and 2, respectively, the values for Sensitivity and V_{OQ} are calculated as:

$$Sensitivity = \frac{1}{2} \times \frac{(Vout2 - Vout1)}{D/A\text{-}Readout2 - D/A\text{-}Readout1} \times \frac{16384}{5}$$

$$V_{OQ} = \frac{1}{16} \times \left[\frac{Vout2 \times 16384}{5} - [(D/A\text{-}Readout2 - 8192) \times Sensitivity \times 2] \right] \times \frac{5}{1024}$$

This calculation has to be done individually for each sensor.

Next, write the calculated values for Sensitivity and V_{OQ} into the IC for adjusting the sensor. At that time, it is also possible to store the application specific values for Clamp-Low and Clamp-High into the sensors EEPROM.

The sensor is now calibrated for the customer application. However, the programming can be changed again and again if necessary.

Note: For a recalibration, the calibration procedure has to be started at the beginning (step 1). A new initialization is necessary, as the initial values from step 1 are overwritten in step 4.

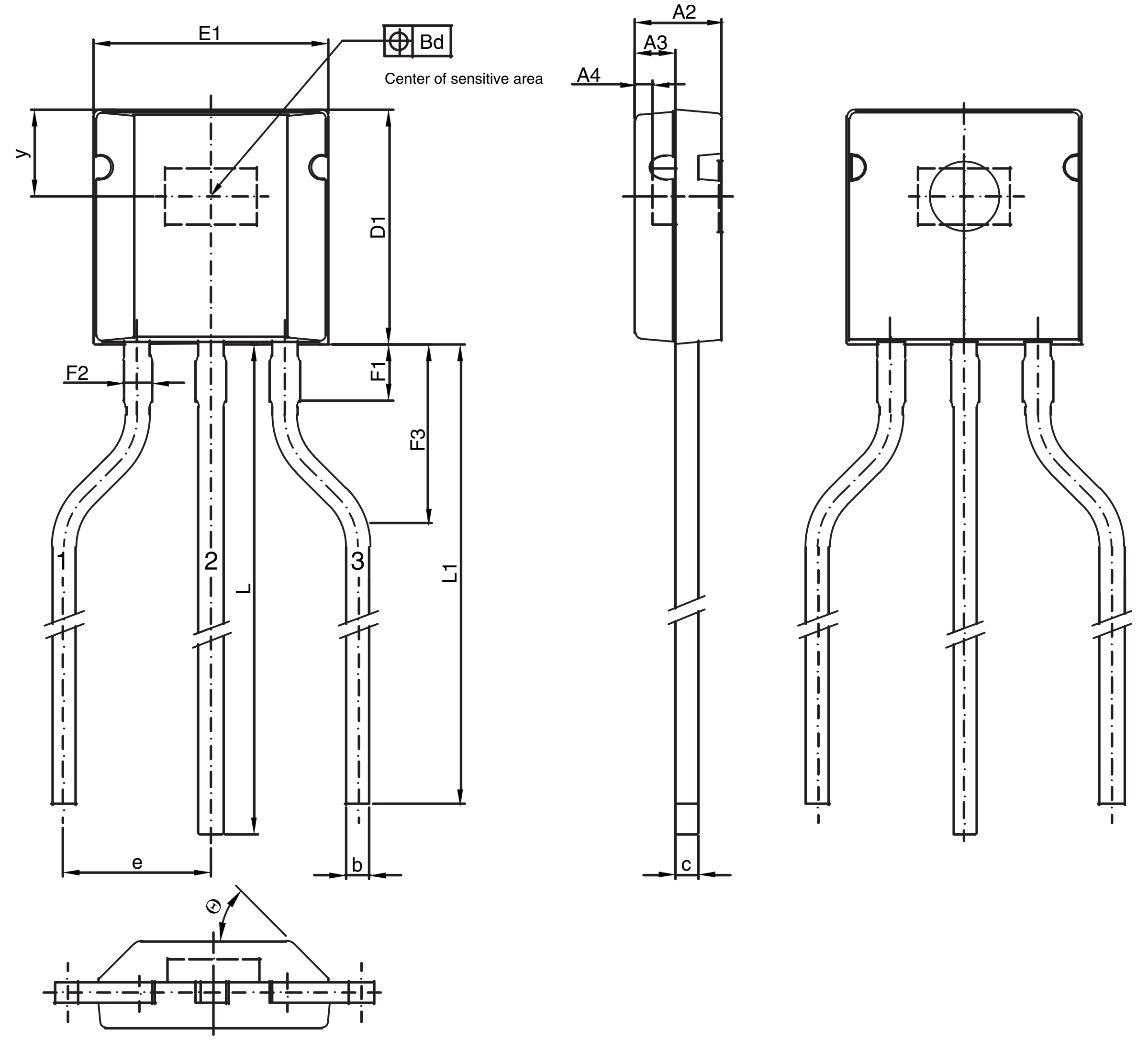
Step 5: Locking the Sensor

The last step is activating the LOCK function by programming the LOCK bit. Please note that the LOCK function becomes effective after power-down and power-up of the Hall IC. The sensor is now locked and does not respond to any programming or reading commands.

Warning: This register can not be reset!

4. Specifications

4.1. Outline Dimensions



physical dimensions do not include moldflash.

solderability is guaranteed between end of pin and distance F1.

Sn-thickness might be reduced by mechanical handling.

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

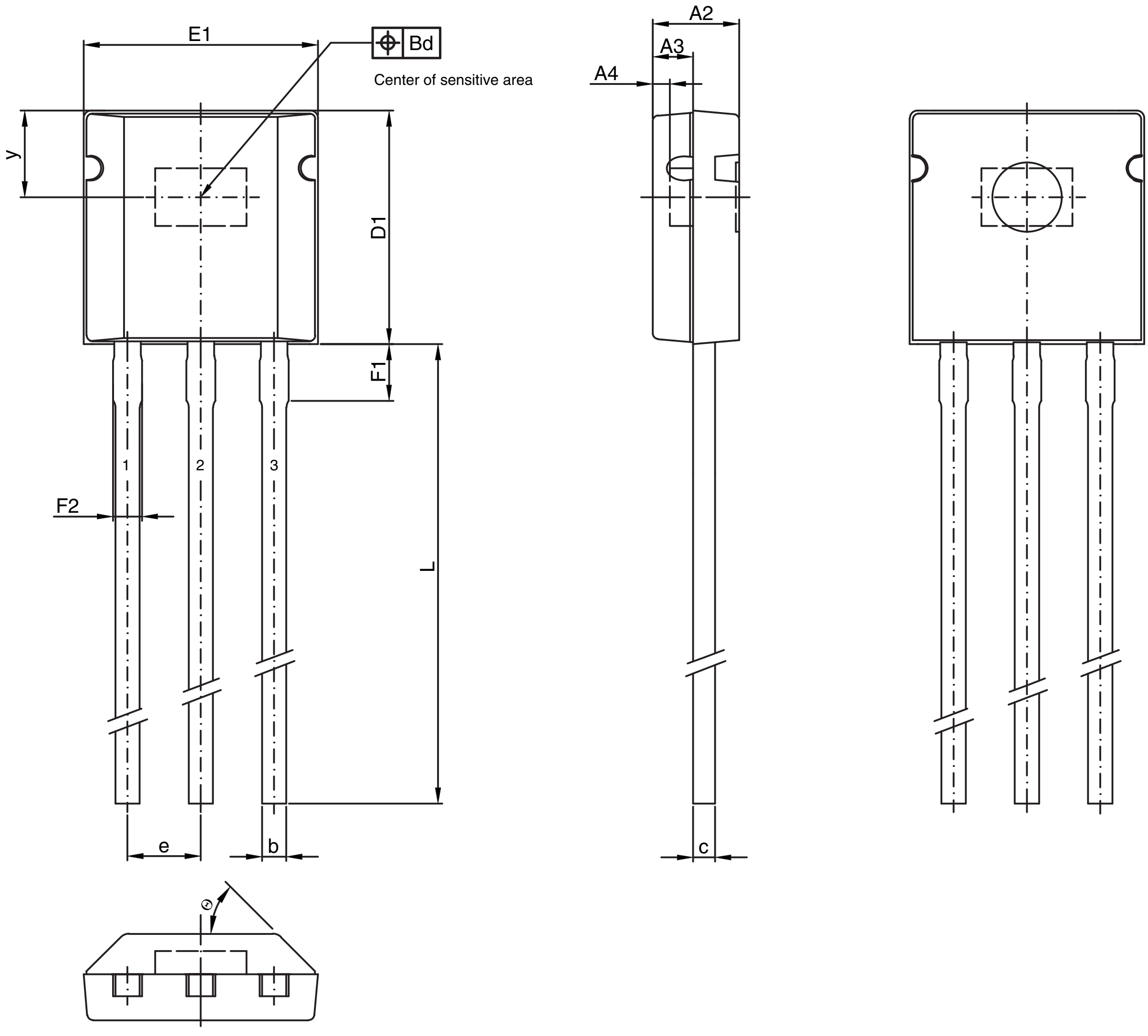
min/max of D1 are specified in the datasheet.

0 2.5 5 mm
scale

UNIT	A2	A3	b	c	D1	e	E1	F1	F2	F3	L	L1	Θ
mm	1.55 1.45	0.7	0.42	0.36	4.05	2.54	4.11 4.01	1.2 0.8	0.60 0.42	4.0 2.0	14.5 min	14.0 min	45°

JEDEC STANDARD		ANSI	ISSUE DATE YY-MM-DD	DRAWING-NO.	ZG-NO.
ISSUE	ITEM NO.				
-	-		10-04-29	06609.0001.4	ZG001009_Ver.07

Fig. 4–1:
TO92UT-1 Plastic Transistor Standard UT package, 3 leads, spread
Weight approximately 0.12 g



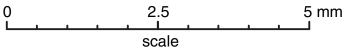
physical dimensions do not include moldflash.

solderability is guaranteed between end of pin and distance F1.

Sn-thickness might be reduced by mechanical handling.

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

min/max of D1 are specified in the datasheet.



UNIT	A2	A3	b	c	D1	e	E1	F1	F2	L	Θ
mm	1.55 1.45	0.7	0.42	0.36	4.05	1.27	4.11 4.01	1.2 0.8	0.60 0.42	14.5 min	45°

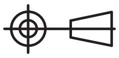
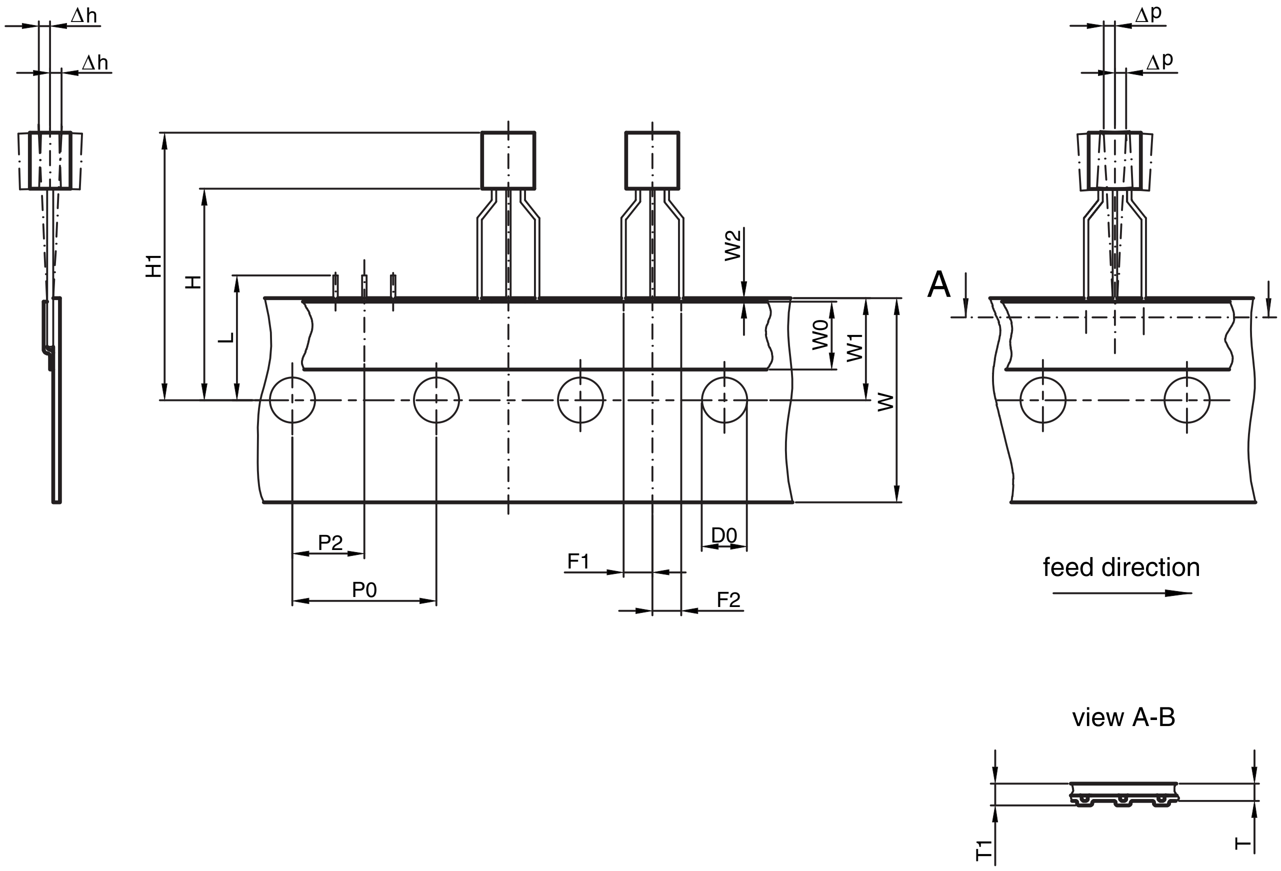
JEDEC STANDARD		ANSI	ISSUE DATE YY-MM-DD	DRAWING-NO.	ZG-NO.
ISSUE	ITEM NO.				
-	-		15-01-09	06615.0001.4 Bl. 1	ZG001015_Ver.08

Fig. 4–2:
TO92UT-2 Plastic Transistor Standard UT package, 3 pins
Weight approximately 0.12 g

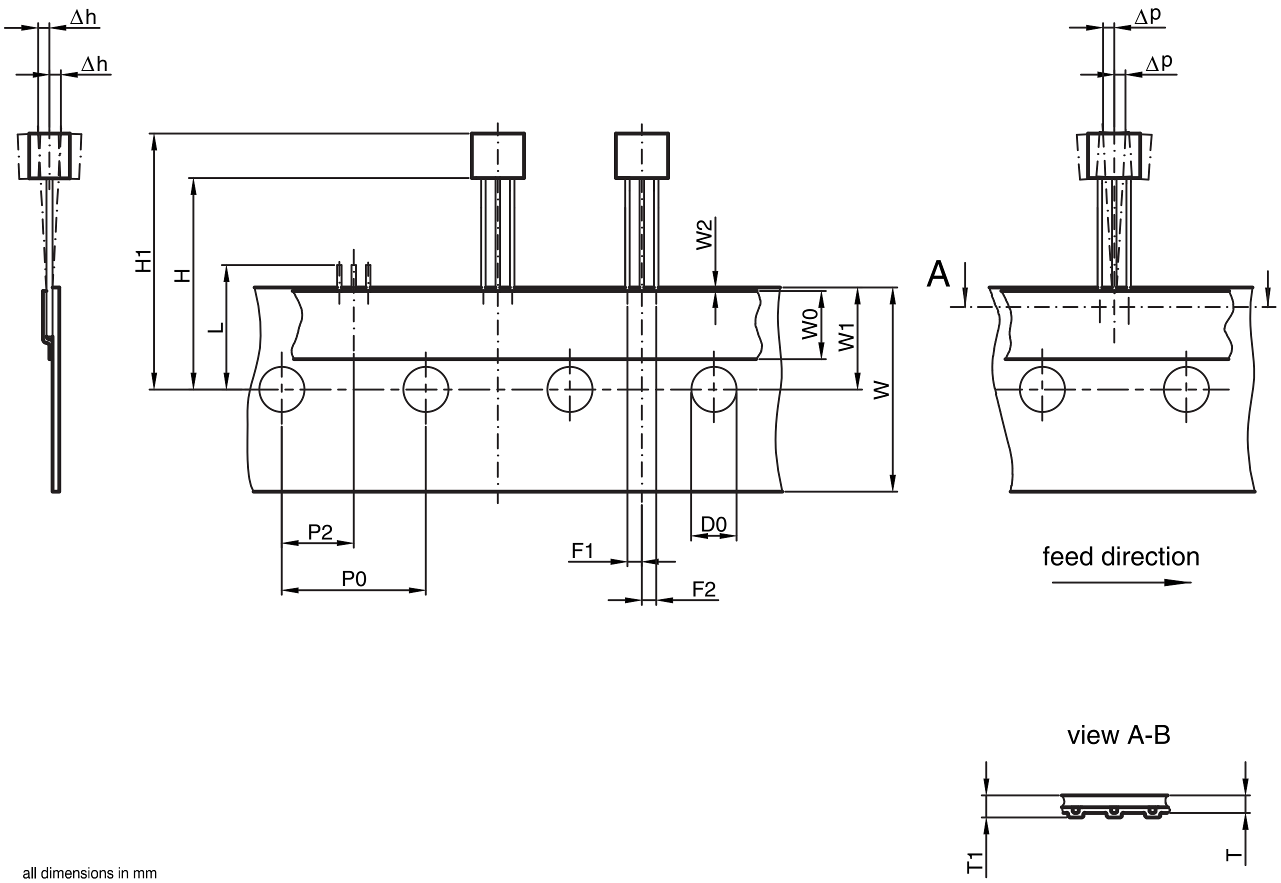


all dimensions in mm
other dimensions see drawing of bulk
max. allowed tolerance over 20 hole spacings ±1.0
H1= this dimension is different for each sensor type and is specified in the data sheet

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		15-01-09	06632.0001.4 Bl. 1	ZG001032_Ver.05

Fig. 4–3:
TO92UA/UT: Dimensions ammopack inline, spread, standard lead length

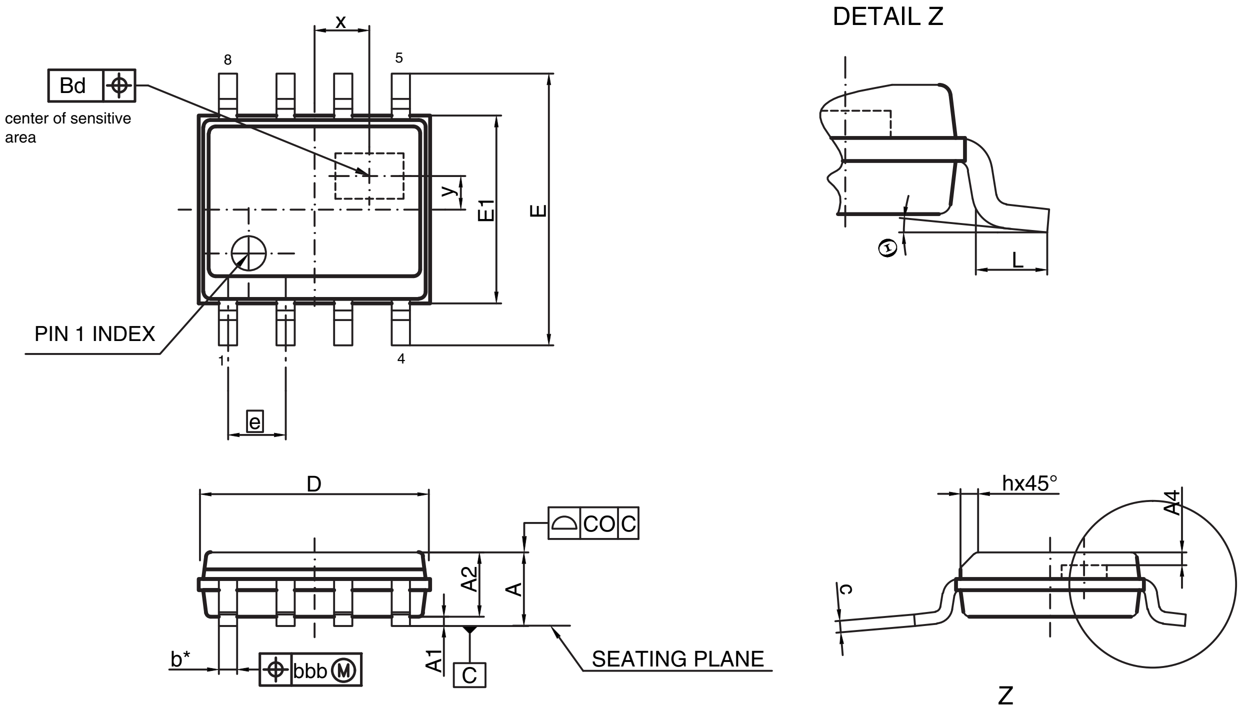


all dimensions in mm
other dimensions see drawing of bulk
max. allowed tolerance over 20 hole spacings ±1.0
H1= this dimension is different for each sensor type and is specified in the data sheet

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

STANDARD		ANSI	ISSUE DATE YY-MM-DD	DRAWING-NO.	ZG-NO.
ISSUE	ITEM NO.				
-	IEC 60286-2		15-01-09	06631.0001.4 Bl. 1	ZG001031_Ver.04

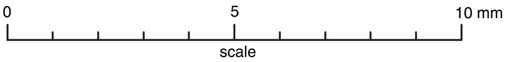
Fig. 4–4:
TO92UA/UT: Dimensions ammopack inline, not spread, standard lead length



"D" and "E1" are reference data and do not include mold flash or protrusion.
Mold flash or protrusion shall not exceed 150 µm per side.

* does not include dambar protrusion of 0.1 max. per side

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



UNIT	A	A1	A2	b	bbb	c	CO	D	E	E1	e	h	L	Θ
mm	1.65	0.25 0.1	1.45	0.4	0.25	0.22	0.1	5.0 4.8	6.0	4.0 3.8	1.27	0.3	0.41 min.	8° max.

JEDEC STANDARD			ISSUE DATE YY-MM-DD	DRAWING-NO.	ZG-NO.
ISSUE	ITEM NO.				
F	MS-012		09-07-21	06690.0001.4 Bl. 1	ZG001090_Ver.05

Fig. 4–5:
SOIC8-1: Plastic **S**mall **O**utline **IC** package, 8 leads, gullwing bent, 150 mil
Ordering code: DJ
Weight approximately 0.076 g

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 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

4.3.1. TO92UT Package

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

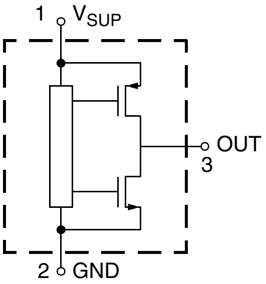


Fig. 4–6: Pin configuration TO92UT

4.3.2. SOIC8 Package

Pin No.	Pin Name	Type	Short Description
1	V_{SUP}	In	Supply Voltage and Programming Pin
2,5,6,7,8	Gnd		Ground
3	NC		Not Connected
4	OUT	OUT	Push-Pull Output and Selection Pin

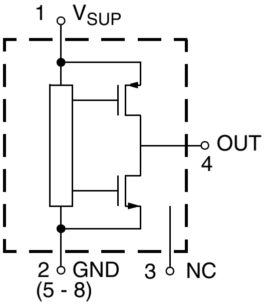


Fig. 4–7: Pin configuration SOIC8

Note: Pins number 2, 5, 6, 7, and 8 must be connected to GND.

4.4. Dimensions of Sensitive Area

0.25 mm x 0.25 mm

4.5. Package Parameters and Positions of Sensitive Areas

	TO92UT-1/-2	SOIC8
x	–	0 mm nominal
y	1.5 mm nominal	0.13 mm nominal
A4	0.3 mm nominal	0.38 mm nominal
Bd	0.3 mm	0.3 mm
D1	4.05 mm ± 0.05 mm	–
H1	min. 22.0 mm max. 24.1 mm	–

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	Comment
V_{SUP}	Supply Voltage	1	–8.5	8.5	V	t < 96 h[1]
V_{SUP}	Supply Voltage	1	–16	16	V	t < 1 h[1]
$-I_{DD}$	Reverse Supply Current	1	–	50	mA	[1]
V_{OUT}	Output Voltage	3 or 4	–5[2]	8.5	V	[1]
			–5[2]	16	V	< 1 hr[1]
$V_{OUT} - V_{SUP}$	Excess of Output Voltage over Supply Voltage	3 or 4,1	–	2	V	
T_J	Junction Temperature	–	–40	140	°C	[1]
I_{OUT}	Continuous Output Current	3 or 4	–10	10	mA	
t_{Sh}	Output Short Circuit Duration	3 or 4	–	10	min	

[1] No cumulated stress
[2] internal protection resistor = 50 Ω

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 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, reduce reliability and lifetime of the device.

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 or 4	–1.2	–	1.2	mA	
R_L	Load Resistor	3 or 4	5.0	10	–	kΩ	Can be pull-up or pull-down resistor
C_L	Load Capacitance	3 or 4	0.33	100	1000	nF	
N_{PRG}	Number of EEPROM Programming Cycles	–	–	–	100	cycles	0°C < T_{amb} < 55°C
T_J	Junction Temperature Range (1)	–	–40 –40	–	125 150	°C	for 8000 h(2) for 2000 h(2)

(1) Depends on the temperature profile of the application. Please contact Micronas for life time calculations.
(2) Time values are not cumulative

4.9. Characteristics

at T_J = –40 °C to 140 °C, V_{SUP} = 4.5 V to 5.5 V, GND = 0 V after programming and locking,
at Recommended Operating Conditions if not otherwise specified in the column “Conditions”.
Typical Characteristics for T_J = 25 °C and V_{SUP} = 5 V.

Symbol	Parameter	Pin No.	Min.	Typ.	Max.	Unit	Conditions
I_{DD}	Supply Current over Temperature Range	1	–	7	10	mA	
	Resolution	3 or 4	–	12	–	bit	ratiometric to V_{SUP} [1]
INL	Non-Linearity of Output Voltage over Temperature	3 or 4	–1	0	1	%	% of supply voltage[2] For V_{out} = 0.35 V ... 4.65 V; V_{SUP} = 5 V, Sensitivity ≤ 0.95
E_R	Ratiometric Error of Output over Temperature (Error in V_{OUT} / V_{SUP})	3 or 4	–1.0	0	1.0	%	$\lvert V_{OUT1} - V_{OUT2} \rvert > 2\ V$ during calibration procedure
ES	Error in Magnetic Sensitivity over Temperature Range	3 or 4	–6	0	6	%	(see Section 4.9.1. on page 23)
ΔV_{OUTCL}	Accuracy of Output Voltage at Clamping Low Voltage over Temperature Range	3 or 4	–30	0	30	mV	R_L = 5 kΩ, V_{SUP} = 5 V
ΔV_{OUTCH}	Accuracy of Output Voltage at Clamping High Voltage over Temperature Range	3 or 4	–30	0	30	mV	R_L = 5 kΩ, V_{SUP} = 5 V
V_{OUTH}	Upper Limit of Signal Band[3]	3 or 4	4.65	4.8	–	V	V_{SUP} = 5 V, –1 mA ≤ I_{OUT} ≤ 1mA
V_{OUTL}	Lower Limit of Signal Band[3]	3 or 4	–	0.2	0.35	V	V_{SUP} = 5 V, –1 mA ≤ I_{OUT} ≤ 1mA
f_{ADC}	Internal ADC Frequency over Temperature Range	–	–	128	–	kHz	
$t_{r(O)}$	Step Response Time of Output	3 or 4	–	1 0.5	2 1	ms ms	3 dB Filter frequency = 500 Hz 3 dB Filter frequency = 1 kHz 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} (se.....)
$t_{d(O)}$	Delay Time of Output	3 or 4	–	0.1	0.5	ms	C_L = 10 nF
t_{POD}	Power-Up Time (Time to Reach Stabilized Output Voltage)	–	1.5	1.7	1.9	ms	C_L = 10 nF, 90% of V_{OUT}
BW	Small Signal Bandwidth (–3 dB)	3 or 4	–	1	–	kHz	B_{AC} < 10 mT; 3 dB Filter frequency = 1 kHz
V_{OUTn}	RMS Noise of Output Voltage	3 or 4	–	6	15	mV	magnetic range = 60 mT[4] 3 dB Filter frequency = 500 Hz Sensitivity ≤ 0.7; C = 100 nF (V_{SUP} & V_{OUT} to GND)
DAC_{GE}	D/A-Converter Glitch Energy	3 or 4	–	400	–	nVs	[4]
R_{OUT}	Output Resistance over Recommended Operating Range	3 or 4	–	1	10	Ω	$V_{OUTLmax}$ ≤ V_{OUT} ≤ $V_{OUTHmin}$

[1] Output DAC full scale = 5 V ratiometric, Output DAC offset = 0 V, Output DAC LSB = V_{SUP}/4096

[2] if more than 50% of the selected magnetic field range is used (=> Sensitivity ≤ 0.95) and the temperature compensation is suitable. INL = V_{OUT} - V_{OUTLSF} with V_{OUTLSF} = Least Square Fit Line voltage based on V_{OUT} measurements at a fixed temperature

[3] Signal Band Area with full accuracy is located between V_{OUTL} and V_{OUTH}. The sensor accuracy is reduced below V_{OUTL} and above V_{OUTH}

[4] The energy of the impulse injected into the analog output when the code in the D/A-Converter register changes state. This energy is normally specified as the area of the glitch in nVs.

TO92UT Packages

Symbol	Parameter	Pin No.	Min.	Typ.	Max.	Unit	Conditions
	Thermal Resistance						
R_{thja}	Junction to Air	–	–	–	235	K/W	Measured with a 1s0p board
R_{thjc}	Junction to Case	–	–	–	61	K/W	Measured with a 1s0p board
R_{thjs}	Junction to Solder Point	–	–	–	128	K/W	Measured with a 1s1p board
SOIC8 Package							
	Thermal Resistance						
R_{thja}	Junction to Air	–	–	–	142	K/W	Measured with a 1s0p board
		–	–	–	88	K/W	Measured with a 1s1p board
R_{thjc}	Junction to Case	–	–	–	33	K/W	Measured with a 1s0p board
		–	–	–	22	K/W	Measured with a 1s1p board

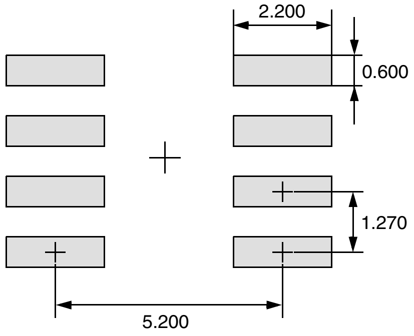


Fig. 4–8: Recommended pad size in mm for SOIC8 package

4.9.1. Definition of Sensitivity Error ES

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

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

In the example below, the maximum error occurs at −10 °C:

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

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[1] normalized to achieve a least-squares method straight line that has a value of 1 at 25 °C

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

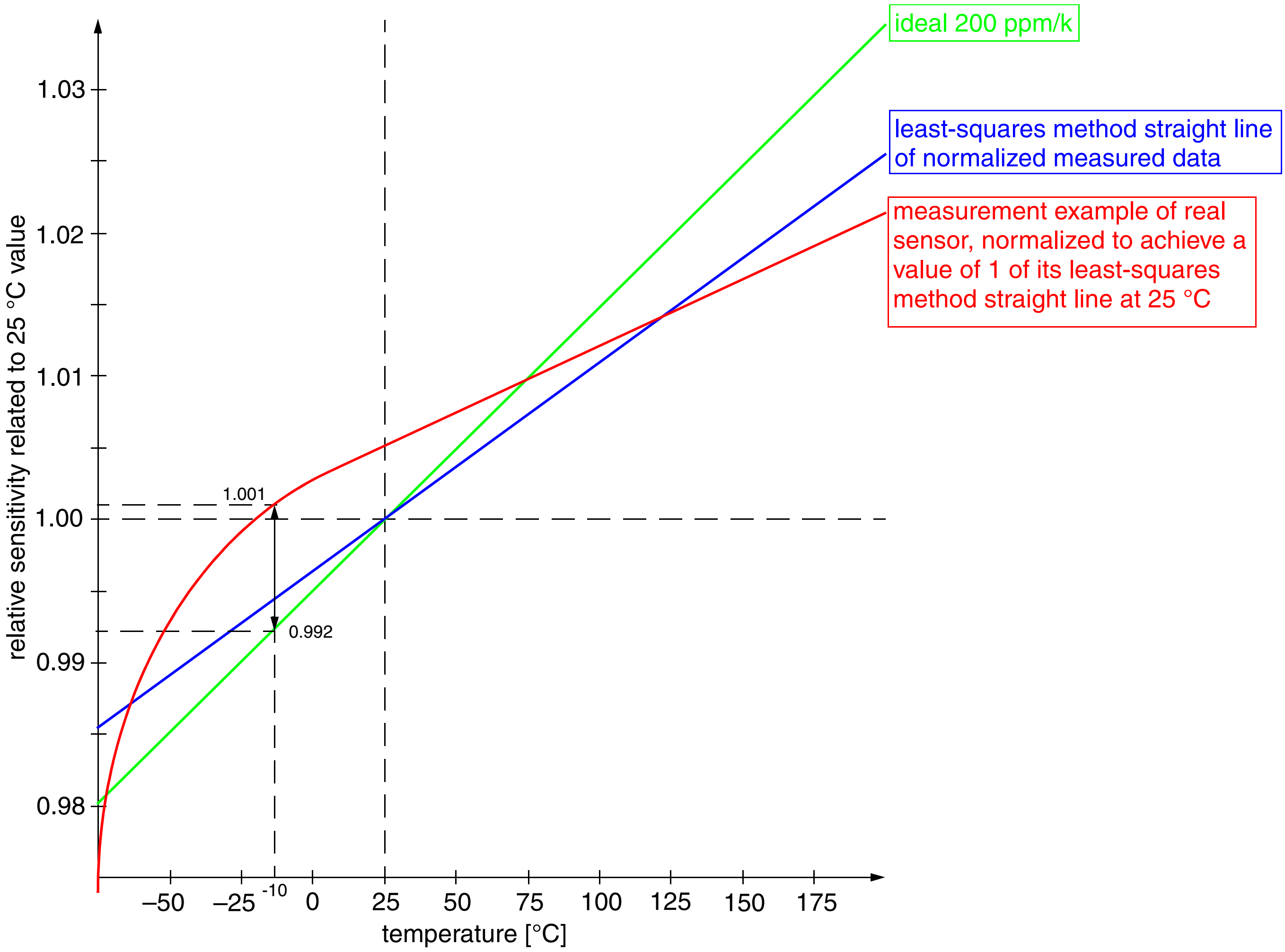

Fig. 4–9: ES definition example

4.10. Open-Circuit Detection

at T_J = –40 °C to +140 °C. Typical Characteristics for T_J = 25 °C, after locking the sensor

Symbol	Parameter	Pin No.	Min.	Typ.	Max.	Unit	Comment
V_{OUT}	Output Voltage at Open V_{SUP} Line	3 or 4	0	0	0.15	V	V_{SUP} = 5 V R_L = 10 kΩ to 200 kΩ
V_{OUT}	Output Voltage at Open GND Line	3 or 4	4.85	4.9	5.0	V	V_{SUP} = 5 V R_L = 10 kΩ to 200 kΩ
R_L: can be pull-up or pull-down resistor							

4.11. Power-On Operation

at T_J = –40 °C to +140 °C, after programming and locking. Typical Characteristics for T_J = 25 °C.

Symbol	Parameter	Min.	Typ.	Max.	Unit
POR_{UP}	Power-On Reset Voltage (UP)	–	3.4	–	V
POR_{DOWN}	Power-On Reset Voltage (DOWN)	–	3.0	–	V

4.12. Overvoltage and Undervoltage Detection

at T_J = –40 °C to +140 °C. Typical Characteristics for T_J = 25 °C, after programming and locking

Symbol	Parameter	Pin No.	Min.	Typ.	Max.	Unit	Conditions
$V_{SUP,UV}$	Undervoltage Detection Level	1	–	4.2	4.3	V	1)
$V_{SUP,OV}$	Overvoltage Detection Level	1	8.5	8.9	10.0	V	1)
1) If the supply voltage drops below $V_{SUP,UV}$ or rises above $V_{SUP,OV}$, the output voltage is switched to V_{SUP} (≥97% of V_{SUP} at R_L = 10 kΩ to GND). The CLAMP-LOW register has to be set to a voltage ≥ 200 mV.							

Note: The over- and undervoltage detection is activated only **after** locking the sensor!

5. Application Notes

5.1. Application Circuit

For EMC protection, it is recommended to connect one ceramic 100 nF capacitor each between ground and the supply voltage, respectively the output voltage pin. In addition, the input of the controller unit should be pulled-down with a 10 kΩ resistor and a ceramic 100 nF capacitor.

Please note that during programming, the sensor will be supplied repeatedly with the programming voltage of 12.5 V for 100 ms. All components connected to the V_{SUP} line at this time must be able to resist this voltage.

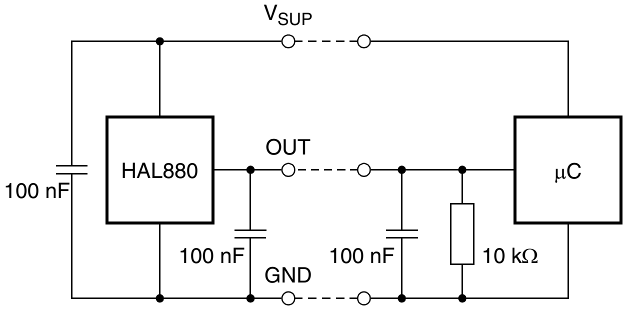

Fig. 5–1: Recommended application circuit

5.2. Use of two HAL880 in Parallel

Two different HAL880 sensors which are operated in parallel to the same supply and ground line can be programmed individually. In order to select the IC which should be programmed, both Hall ICs are inactivated by the “Deactivate” command on the common supply line. Then, the appropriate IC is activated by an “Activate” pulse on its output. Only the activated sensor will react to all following read, write, and program commands. If the second IC has to be programmed, the “Deactivate” command is sent again and the second IC can be selected.

Note: The multi-programming of two sensors works only if the outputs of the two sensors are pulled to GND with a 10 kΩ pull-down resistor.

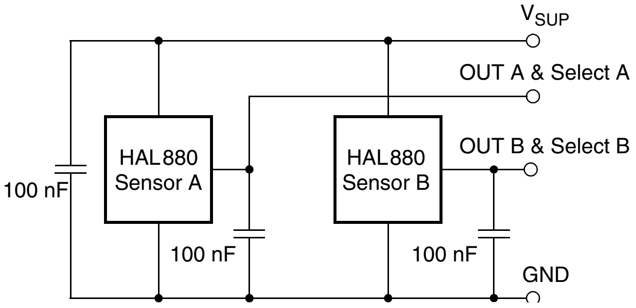

Fig. 5–2: Parallel operation of two HAL880