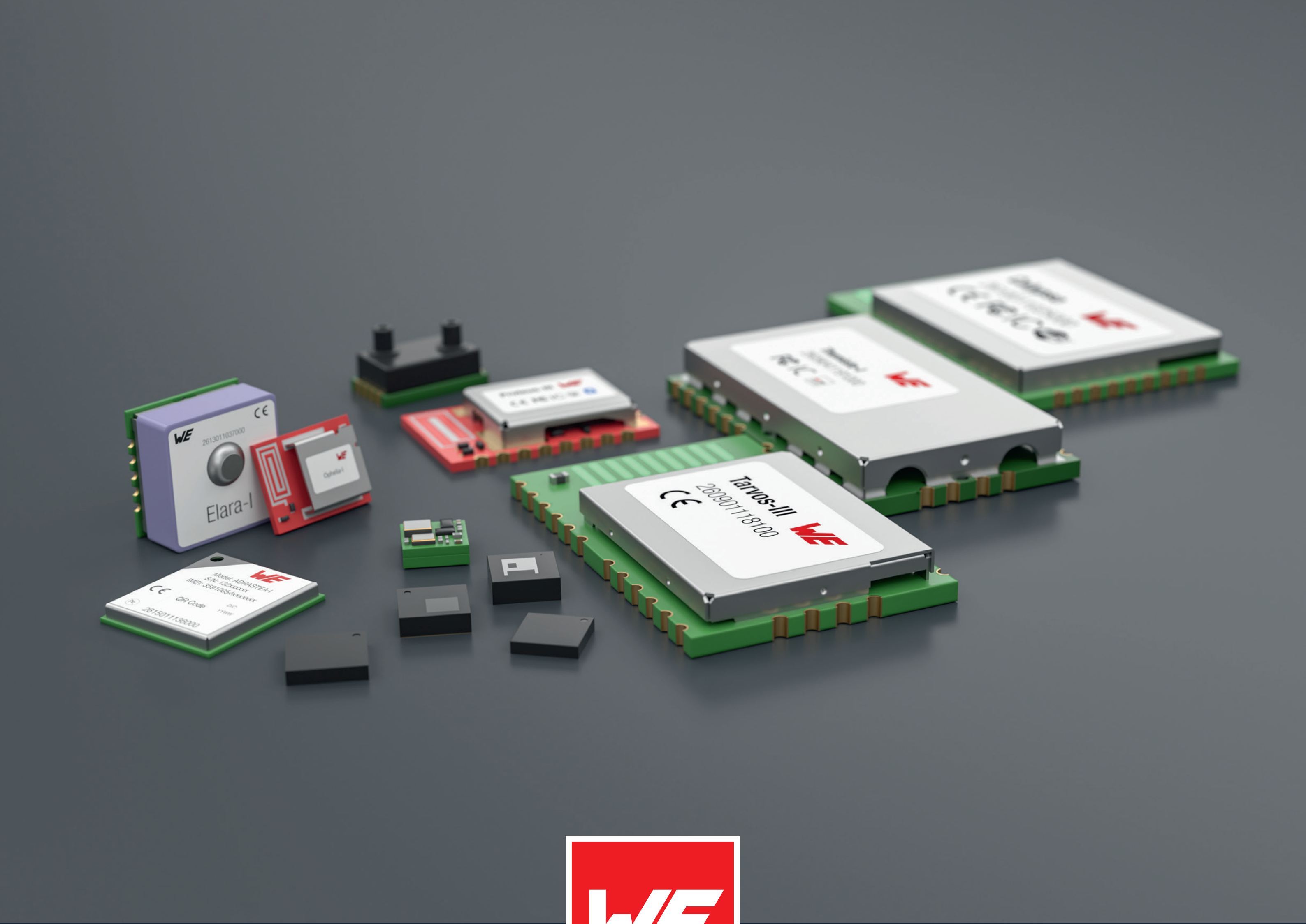

User manual

WSEN-HIDS

2525020210002

Version 1.2

October 18, 2024

WÜRTH ELEKTRONIK MORE THAN YOU EXPECT

Revision history

Manual version	Product version	Notes	Date
1.0	1.0	• Initial release of the manual	June 2023
1.1	1.0	• Updated chapter 3: Sensor and electrical specifications • Updated Figure 6: Slave address format	August 2023
1.2	1.0	• Updated chapter `Important notes` • Updated chapter `Legal notice`	October 2024

Abbreviations

Abbreviation	Description
ESD	Electrostatic discharge
I^2C	Inter integrated circuit
LGA	Land grid array
LSB	Least significant bit
MEMS	Micro-Electro Mechanical system
MSB	Most significant bit
ODR	Output data rate
PCB	Printed circuit board

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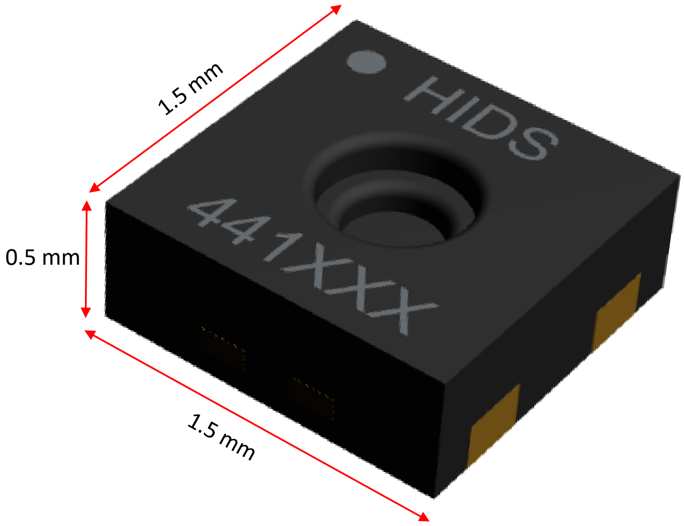
1 Product description

1.1 Introduction

The humidity sensor is a 16-bit digital ultra-low-power and high-performance sensor with digital output interface. It measures relative humidity from 0 to 100% rH in one shot mode or continuous mode operation with an output data rate of 1 Hz. It is also embedded with a temperature sensor for ambient temperature measurement. The sensor is fully calibrated and no further calibration is required. The dimension of the sensor is 1.5 mm ×1.5 mm ×0.5 mm. It is available in Dual Flat No-Lead (DFN).

1.2 Applications

- HVAC systems
- Home and building automation
- Goods and asset tracking
- Air conditioners
- Refrigerators



1.3 Sensor features

- Humidity measurement range : 0 to 100% rH
- Humidity accuracy : 1.8 to 3%
- Temperature measurement range : -40 to +125 ℃
- Temperature accuracy : 0.2 to 0.6 ℃
- Output data rate : 1 Hz
- Operating modes : Continuous mode and one-shot mode
- Current consumption : 8.9µA @ODR 1Hz
- Communication interface : I^2C

1.4 Block diagram

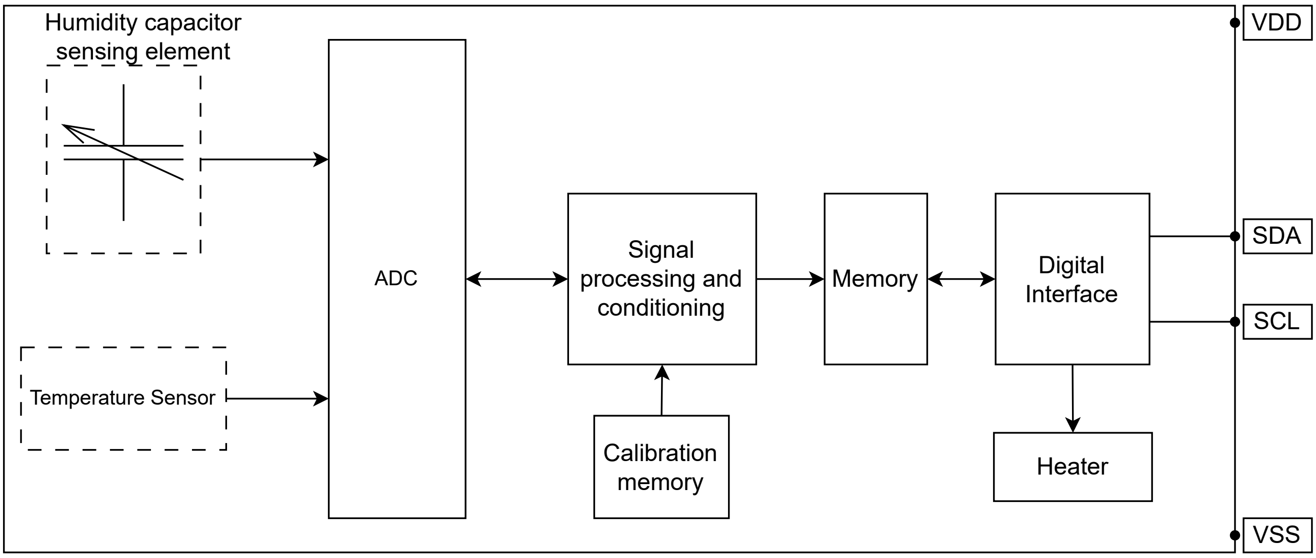


Figure 1: Block diagram

The sensor is a MEMS based capacitive humidity sensor with an integrated ASIC. MEMS sensing element is a capacitor with a dielectric polymer which absorbs or desorbs water with proportional to the relative humidity in the environment. A silicon based temperature sensor is integrated in the same package. ASIC comprises of analog-to-digital converter, signal processing and conditioning and memory. ASIC converts the analog signal from the both humidity and temperature sensing element into a 16-bit digital humidity and temperature values. The sensor is factory calibrated for both humidity and temperature measurements. The calibration parameters are stored in calibration memory. When the sensor is powered on, these calibration parameters are loaded from the calibration memory to the registers. Hence, no further calibration is required for humidity and temperature values.

1.5 Ordering information

WE order code	Measurement Range	Description
2525020210002	0 to 100% rH, -40 ℃ to +125 ℃	Tape & reel packaging (2500 pcs/reel)

Table 1: Ordering information

2 Handling humidity sensor

- It is important to understand that a humidity sensor is not a normal electronic component. It must be handled with care.
- Chemical vapours at high concentration in combination with long exposure time may offset the sensor reading.
- It is recommended to store the sensors within a temperature range of 10 °C to 50 °C and humidity with a range of 20% rH to 60% rH.
- Long-term exposure to conditions outside normal humidity and temperature range, especially at higher humidity range may temporarily offset the output value of humidity sensor.
- After returning to the normal exposure conditions, the humidity output value will usually slowly return to the calibration state by itself.
- To recover the sensor accuracy to the normal state after exposing to outside normal humidity and temperature range, it has to be reconditioned with the following procedure:

    1. Baking: 100 °C to 110 °C at 5% rH for 24h
    2. Re-hydration: 20 °C to 30 °C at 80% rH for 48h

WSEN_HIDS humidity sensor is not a normal electronic component. The sensing element of the humidity sensor is made of polymer. Long-term exposure above normal humidity (20% rH to 60% rH) and temperature (10 °C and 50 °C) range may offset the sensor value.

3 Sensor and electrical specifications

T = 25 ℃, supply voltage VDD = 3.3V, unless otherwise stated. Sensor parameter values are verified after soldering the sensor on a PCB. The PCB is designed by following the MEMS Sensor PCB design guidelines described in chapter 9.

3.1 Humidity sensor specifications

Parameters	Symbol	Test conditions	Min	Typ.	Max.	Unit
Measurement range	H_{RANGE}		0		100	% rH
Resolution	RES_H			0.01		% rH
Accuracy	H_{ACC}	20% rH to 80% rH		±1.8		% rH
		0% rH to 100% rH			±3	% rH
Humidity Repeatability (high)[1]	$REP_{H,high}$	High repeatability		±0.08		% rH
Humidity Repeatability (medium) [1]	$REP_{H,med}$	Medium repeatability		±0.15		% rH
Humidity Repeatability (low)[1]	$REP_{H,low}$	Low repeatability		±0.25		% rH
Hysteresis	HYS_H	At 25 ℃		±0.8		% rH
Long-term drift	H_{DRIFT}	20% rH to 80% rH		0.2		% rH/Year
Response time	$t_{RESP,H}$	Step response time of 63%		4		s

Table 2: Humidity sensor specification

[1] *The stated repeatability is 3 times the standard deviation (3σ) of consecutive measurements taken under constant conditions at 25 ℃ and 50% rH (indicating the sensor's output noise)*

3.2 Temperature sensor specifications

Parameters	Symbol	Test conditions	Min.	Typ.	Max.	Unit
Measurement range	T_{RANGE}		-40		+125	°C
Resolution	RES_T			0.01		°C
Absolute accuracy	T_{ACC_ABS}	0°C to 60°C		±0.2		°C
		-40°C to 125°C			±0.6	°C
Temperature Repeatability (high)[1]	$REP_{T,high}$	High repeatability		±0.04		°C
Temperature Repeatability (medium)[1]	$REP_{T,med}$	Medium repeatability		±0.07		°C
Temperature Repeatability (low)[1]	$REP_{T,low}$	Low repeatability		±0.1		°C
Long-term drift	T_{DRIFT}			0.03		°C/Year
Response time	$t_{RESP,T}$	Step response time of 63%		2		s

Table 3: Temperature sensor specification

[1] *The stated repeatability is 3 times the standard deviation (3σ) of consecutive measurements taken under constant conditions at 25°C and 50% rH (indicating the sensor's output noise)*

3.3 Electrical specifications

Parameters	Symbol	Conditions	Min.	Typ.	Max.	Unit
Operating supply voltage	V_{DD}		1.08	3.3	3.6	V
Current consumption in power down mode	I_{DD_PD}	Idle state (no heater) at V_{DD} = 3.3V		0.08		uA
Current consumption in power up mode	I_{DD_PO}	Power up (no heater) at V_{DD} = 3.3V		50		uA
Current consumption	I_{DD}	Measurement (no heater) at V_{DD} = 3.3V		320	500	uA
Current consumption in high repeatability mode[1]	I_{DD_high}	High repeatability (no heater) at V_{DD} = 3.3 V		2.2		uA
Current consumption in medium repeatability mode[1]	I_{DD_med}	Medium repeatability (no heater) at V_{DD} = 3.3 V		1.2		uA
Current consumption in in low repeatability mode[1]	I_{DD_low}	Low repeatability (no heater) at V_{DD} = 3.3 V		0.4		uA
Power consumption in high repeatability mode[1]	$P_{DD,high}$	At V_{DD} = 1.2 V (no heater)		2.6		uW
Power consumption in medium repeatability mode[1]	$P_{DD,med}$	At V_{DD} = 1.2 V (no heater)		1.4		uW
Power consumption in in low repeatability mode[1]	$P_{DD,low}$	At V_{DD} = 1.2 V (no heater)		0.5		uW

Table 4: Electrical specification

[1] *The average current/power consumption of a device during continuous operation, with one measurement taken per second.*

3.4 Timings

Parameters	Symbol	Conditions	Min.	Max.	Unit
Measurement duration	-	High repeatability	-	8.4	ms
		Medium repeatability	-	4.6	ms
		Low repeatability	-	1.6	ms

Table 5: Timing information

3.5 Absolute maximum rating

Parameter	Min.	Max.	Unit
Max. voltage on any pin	-0.3	3.9	V
Operating temperature range	-40	125	℃

Table 6: Absolute maximum rating

3.6 General information

Parameters	Values
Operating temperature	-40 ℃ to +125 ℃
Storage temperature	-40 ℃ to +150 ℃
Communication interface	I^2C
Moisture sensitivity level (MSL)	1
Electrostatic discharge protection(HBM)	2 kV
Electrostatic discharge protection(CDM)	500 V

Table 7: General information

The device is susceptible to damage by electrostatic discharge (ESD). Always use proper ESD precautions when handling. Improper handling of the device can cause performance degradation or permanent damage to the part

For better performance, the recommended storage condition for the humidity sensor is 10 ℃ to 50 ℃ with 20% rH to 60% rH

4 Pinning description

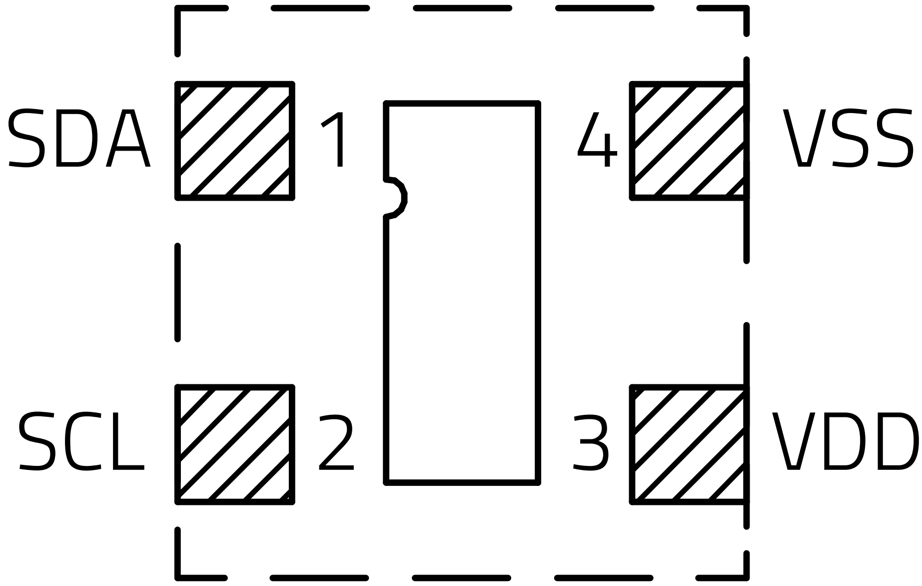


Figure 2: Pinout (top view)

No	Function	Description	Input/Output
1	*SDA*	Serial data	Input/Output
2	*SCL*	Serial clock	Input
3	*VDD*	Positive supply voltage	Supply
4	*VSS*	Ground	Supply

Table 8: Pin description

The central die pad helps to dissipate the heat which will prevent temperature variations. It is not recommended to solder the central die pad because the sensor can reach higher temperature during the heater activation.

5 Application circuit

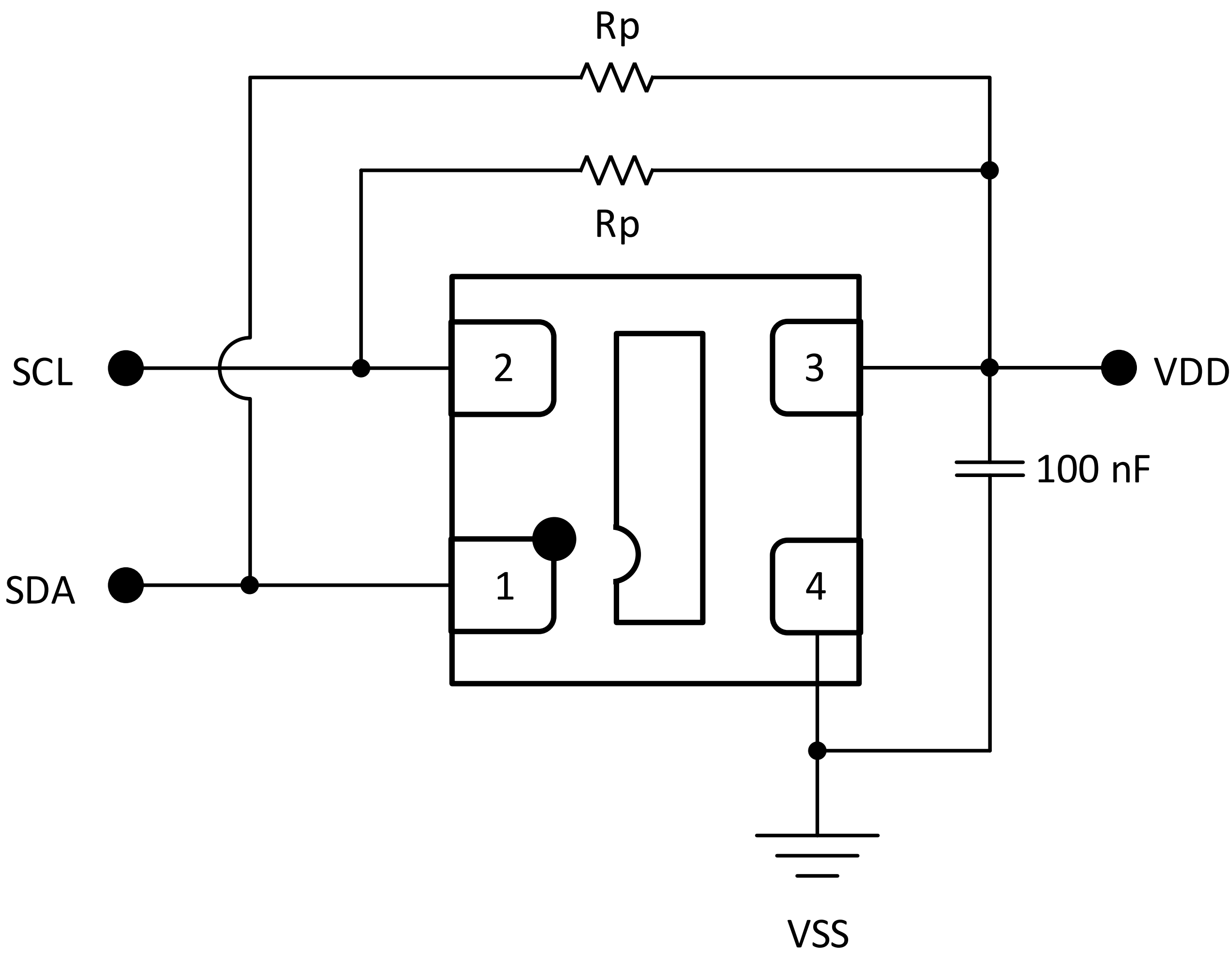


Figure 3: Electrical connection

A positive supply voltage is applied to the sensor through *VDD* pin and negative voltage to *GND*. The decoupling capacitor of 100 nF in parallel is highly recommended to prevent the voltage ripples on the *VDD* line. It should be placed as close as possible to the *VDD* pin. The pull up resistors R_p for I^2C communication interface should be connected parallel between supply voltage *VDD* and *SCL* and *SDA* pins.

Depending on the internal resistance of I^2C pins at the master side, the pull up resistors R_p can be selected for proper rise and fall time of the digital signals.

6 Digital interface

The humidity sensor supports standard I²C (Inter-IC) bus protocol. Further information of the I²C interface can be found at *https://www.nxp.com/docs/en/user-guide/UM10204.pdf*. I²C is a serial 8-bit protocol with two-wire interface, which supports communication between different ICs. For example, between the microcontroller and other peripheral devices.

6.1 General characteristics

A serial data line (*SDA*) and a serial clock line (*SCL*) are required for the communication between the devices connected via I²C bus. Both *SDA* and *SCL* lines are bidirectional. The output stages of devices connected to the bus must have an open-drain or open-collector. Hence, the *SDA* and *SCL* lines are connected to a positive supply voltage via pull-up resistors. In I²C protocol, the communication is realized through master-slave principle. The master device generates the clock pulse, a start command and a stop command for the data transfer. Each connected device on the bus is addressable via a unique address. Master and slave can act as a transmitter or a receiver depending upon whether the data needs to be transmitted or received.

> **!** The sensor implements the I²C role "slave"

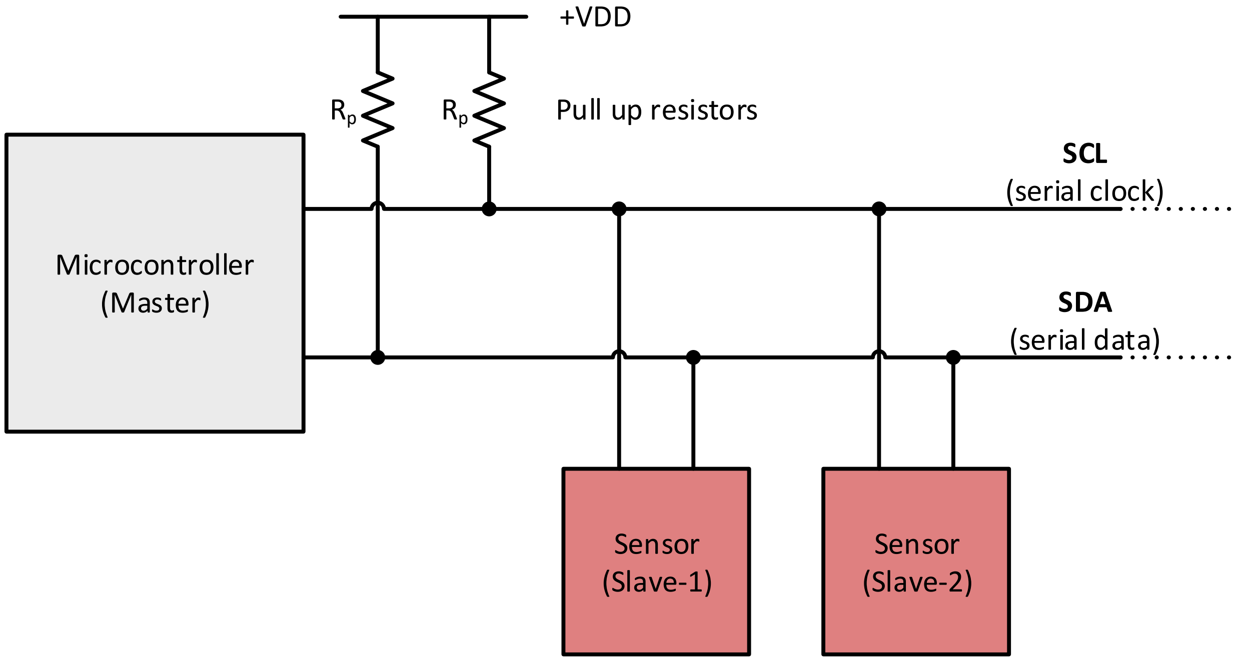


Figure 4: Master-slave concept

6.2 *SDA* and *SCL* logic levels

The positive supply voltage to which *SDA* and *SCL* lines are pulled up (through pull-up resistors), in turn determines the high level input for the slave devices. The sensor has separate supply voltage *VDD_IO* for the *SDA* and *SCL* lines. The logic high '1' and logic low '0' levels for the *SDA* and *SCL* lines then depend on the *VDD*.

6.3 Communication phase

6.3.1 Idle state

During the idle state, the bus is free and both *SDA* and *SCL* lines are in logic high '1' state.

6.3.2 START(S) and STOP(P) condition

Data transfer on the bus starts with a START command, which is generated by the master. A start condition is defined as a high-to-low transition on the *SDA* line while the *SCL* line is held high. The bus is considered busy after the start condition.

Data transfer on the bus is terminated with a STOP command, which is also generated by the master. A low-to-high transition on the *SDA* line, while the *SCL* line being high is defined as a STOP condition. After the stop condition, the bus is again considered free and is in idle state. Figure 5 shows the I^2C bus START and STOP conditions.

Master can also send a REPEATED START (SR) command instead of STOP command. REPEATED START condition is same as the START condition.

6.3.3 Data validity

After the start condition, one data bit is transmitted with each clock pulse. The transmitted data is only valid when the *SDA* line data is stable (high or low) during the high period of the clock pulse. High or low state of the data line can only change when the clock pulse is in low state.

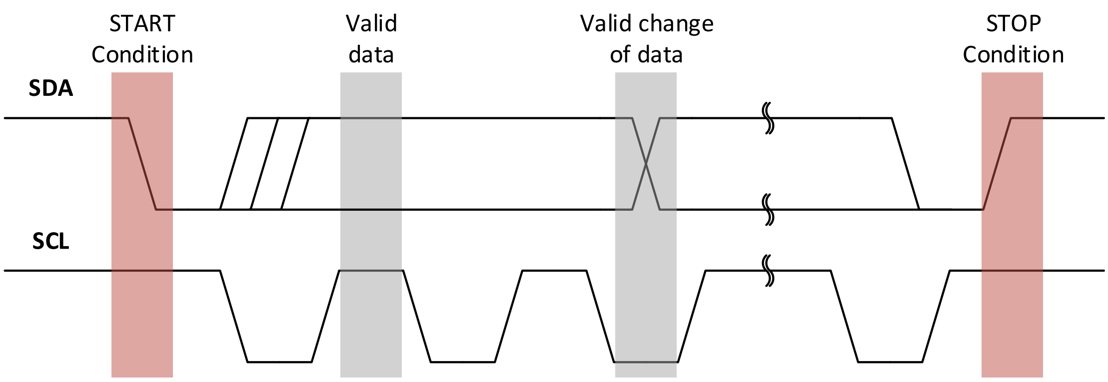


Figure 5: Data validity, START and STOP condition

6.3.4 Byte format

Data transmission on the *SDA* line is always done in bytes, with each byte being 8-bits long. Data is transmitted with the most significant bit (MSB) followed by other bits.

If the slave cannot receive or transmit another complete byte of data, it can force the master into a wait state by holding *SCL* LOW. Data transfer continues when the slave is ready which is indicated by releasing the *SCL* pin.

6.3.5 Acknowledge (ACK) and No-Acknowledge (NACK)

Each byte transmitted on the data line must follow an Acknowledge bit. The receiver (master or slave) generates an Acknowledge signal to indicate that the data byte was received successfully and ready to receive next data byte.

After one byte is transmitted, the master generates an additional Acknowledge clock pulse to continue the data transfer. The transmitter releases the *SDA* line during this clock pulse so that the receiver can pull the *SDA* line to low state in such a way that the *SDA* line remains stable low during the entire high period of the clock pulse. It is considered as an Acknowledge signal.

If the receiver does not want to receive any further byte, it will not pull down the *SDA* line and it remains in stable high state during the entire clock pulse. It is considered as a No-Acknowledge signal and the master can generate either a stop condition to terminate the data transfer or a repeated start condition to initiate a new data transfer.

6.3.6 I²C address for the sensor

The I²C address is transmitted after sending the start condition. Master selects the slave by sending corresponding I²C address after the start condition. A I²C address is a 7 bits long followed by a Read/Write bit.

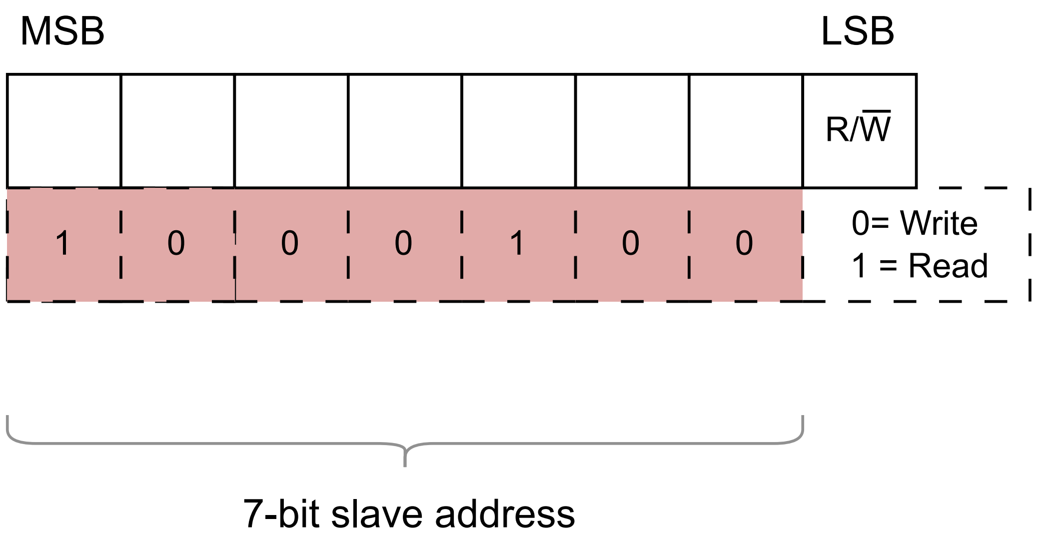


Figure 6: Slave address format

The 7-bit I^2C address of the humidity sensor is 1000100b ("0x44"). The R/W bit determines the data direction. ’0’ indicates a write operation (transmission from master to slave) and a ’1’ indicates a read operation (data request from slave).

7-bit slave address of the humidity sensor is 1000100b ("0x44"). Depending on the used micro-controller, left shifting this 7 bits by 1 may be required. Check host micro-controller of the user manual for device specific information

6.3.7 Read/Write operation

Figure 7: Write and read operations of the sensor

All communication on the I^2C bus begins with a start condition (S) and ends with a stop condition (P). The start condition initializes the communication, while the stop condition indicates the completion of a transfer. To interact with the sensor, the user must send its 7-bit I^2C address followed by an eighth bit that specifies the communication direction and 8-bit command (please refer chapter 7). Setting the eighth bit to "0" denotes a write operation, while setting it to "1" indicates a read operation. For write transfers, a write header is sent to the sensor following its I^2C address. The write header is followed by a command or instruction, which specifies the desired operation.

After the sensor completes the requested measurement, a read request can be issued. Upon receiving the read request, the sensor acknowledges it and prepares to transmit data. Upon acknowledgement of the read request, the sensor starts transmitting data over the I^2C bus. The user can receive this data. It is important to note that the sensor allows the data to be received only once. The sensor transmits humidity and temperature data in a consistent format. Each data transmission includes two values. The first value represents the temperature signal and consists of two sets of 8-bit data, followed by an 8-bit CRC (Cyclic Redundancy Check) for error detection. The second value represents the humidity signal and follows the same format, including two sets of 8-bit data and an 8-bit CRC.

Once the first acknowledged I^2C read header is sent, the measurement data is deleted from the sensor's register. The sensor does not support clock stretching. If the sensor is busy performing tasks such as measurement or heating when it receives a read header, it will return a not acknowledge (NACK) response. This indicates that the sensor is not ready to transmit data at that time.

6.4 Checksum Calculation

In read operation each 16-bit data is followed by a checksum with following properties. The master may abort a read transfer after the 16-bit data if it does not require a checksum.

Property	Value
Name	CRC-8
Message Length	16-bit
Polynomial	0x31 (x + x5 + x4 +1)
Initialization	0xFF
Reflect Input/Output	false/false
Final XOR	0x00
Examples	CRC(0xBEEF) = 0x92

Table 9: Data checksum properties

6.5 I²C timing parameters

Parameter	Symbol	Standard mode		Fast mode		Fast mode plus		Unit
		Min	Max	Min	Max	Min	Max	
SCL clock frequency	f_{SCL}	0	100	0	400	0	1000	kHz
LOW period for *SCL* clock	t_{LOW_SCL}	4.7	-	1.3		0.5	-	µs
HIGH period for *SCL* clock	t_{HIGH_SCL}	4.0	-	0.6	-	0.26	-	µs
Hold time for START condition	t_{HD_S}	4	-	0.6	-	0.26	-	µs
Setup time for (repeated) START condition	f_{SCL}	4.7	-	0.6	400	0.26	-	µs
SDA setup time	t_{SU_SDA}	250	-	100	-	50	-	ns
SDA data hold time	t_{HD_SDA}	0	3.45	0	0.9	0	-	µs
Setup time for STOP condition	t_{SU_P}	4	-	0.6	-	0.26	-	µs
Bus free time between STOP and START condition	t_{BUF}	4.7	-	1.3	-	0.5	-	µs

Table 10: I²C timing parameters

7 Command description

7.1 Measure temperature and relative humidity

The commands listed in Table 11 can be utilized to obtain readings of relative humidity and temperature from the sensors.

Command (hex)	Description
0xFD	High precise measurements of temperature and relative humidity (high repeatability).It maintains an average current consumption of 2.2 µA during continuous operation, with one measurement per second. The data format consists of 2 bytes for temperature, followed by an 8-bit CRC, and then 2 bytes for relative humidity with another 8-bit CRC.
0xF6	Medium precise measurements of temperature and relative humidity (medium repeatability). It maintains an average current consumption of 1.2 µA during continuous operation, with one measurement per second. The data format consists of 2 bytes for temperature, followed by an 8-bit CRC, and then 2 bytes for relative humidity with another 8-bit CRC.
0xE0	Low precise measurements of temperature and relative humidity (low repeatability). It maintains an average current consumption of 0.4 µA during continuous operation, with one measurement per second. The data format consists of 2 bytes for temperature, followed by an 8-bit CRC, and then 2 bytes for relative humidity with another 8-bit CRC.

Table 11: Command overview to measure temperature and relative humidity

7.1.1 Conversion of sensor signals

The digital sensor signals correspond to the following humidity and temperature values:

$$RH = (-6 + \frac{125 * SRH}{2^{16} - 1})\%RH \tag{1}$$

$$T = (-45 + \frac{175 * ST}{2^{16} - 1})^{\circ}C \tag{2}$$

$$T = (-49 + \frac{315 * ST}{2^{16} - 1})^{\circ}F \tag{3}$$

Note: Equation (1) allows reporting of RH values outside the range of 0%RH to 100%RH. However, these values may be non-physical and it is advised to crop the RH signal to the range of 0%RH to 100%RH, unless specific boundary measurements or other purposes require the full range.

7.2 Operating heater

The sensor features an integrated on-package heater that can be activated using a series of commands specified in Table 12 . The heater can eliminate condensed water on the sensor surface, preventing it from interfering with the sensor's ability to detect and respond to changes in relative humidity in the surrounding air.

Command (hex)	Description
0x39	Activate the heater at 200mW for 1 second and perform a high precision measurement before turning it off.The data format consists of 2 bytes for temperature, followed by an 8-bit CRC, and then 2 bytes for relative humidity with another 8-bit CRC.
0x32	Activate the heater at 200mW for 0.1 second and perform a high precision measurement before turning it off. The data format consists of 2 bytes for temperature, followed by an 8-bit CRC, and then 2 bytes for relative humidity with another 8-bit CRC.
0x2F	Activate the heater at 110mW for 1 second and perform a high precision measurement before turning it off. The data format consists of 2 bytes for temperature, followed by an 8-bit CRC, and then 2 bytes for relative humidity with another 8-bit CRC.
0x24	Activate the heater at 110mW for 0.1 second and perform a high precision measurement before turning it off.The data format consists of 2 bytes for temperature, followed by an 8-bit CRC, and then 2 bytes for relative humidity with another 8-bit CRC.
0x1E	Activate the heater at 20mW for 1 second and perform a high precision measurement before turning it off. The data format consists of 2 bytes for temperature, followed by an 8-bit CRC, and then 2 bytes for relative humidity with another 8-bit CRC.
0x15	Activate the heater at 20mW for 0.1 second and perform a high precision measurement before turning it off. The data format consists of 2 bytes for temperature, followed by an 8-bit CRC, and then 2 bytes for relative humidity with another 8-bit CRC.

Table 12: Command overview of different heater operations

7.2.1 Important considerations for operating the heater

- The heater's duty cycle should not exceed 10 % of the sensor's lifetime.
- During heater operation, the sensor's specifications are not valid.
- Thermal stress may affect the temperature sensor, causing offset in temperature readings.
- The sensor's temperature (including heater contribution) must not exceed maximum operating temperature (T_{RANGE_MAX} = 125℃) for proper electrical functionality.

- The heater draws high current (up to ∼75mA), so ensure a strong power supply to avoid voltage drops and sensor resets.
- For higher heating temperatures, send consecutive heating commands. However, the sensor's temperature (including the heater contribution) must stay within in the sensor's maximum operating temperature to avoid sensor offset drifts.

7.3 Serial number of the sensor

Every sensor is assigned a unique serial number during manufacturing, which is stored in non-modifiable memory. To retrieve the serial number, use the I^2C command 0x89. The serial number is transmitted as two 16-bit words, with each word accompanied by an 8-bit cyclic redundancy check (CRC).

Command (hex)	Description
0x89	Read the serial number.The data format consists of 2 bytes for data, followed by an 8-bit CRC, and then 2 bytes for data with another 8-bit CRC.

Table 13: Command overview to read the serial number

7.4 Reset of the sensor

Command (hex)	Description
0x94	Perform a soft reset. Upon successful execution, an acknowledgement ([ACK]) response is expected.

Table 14: Command overview for reset of the sensor

8 Physical specifications

8.1 Module drawing

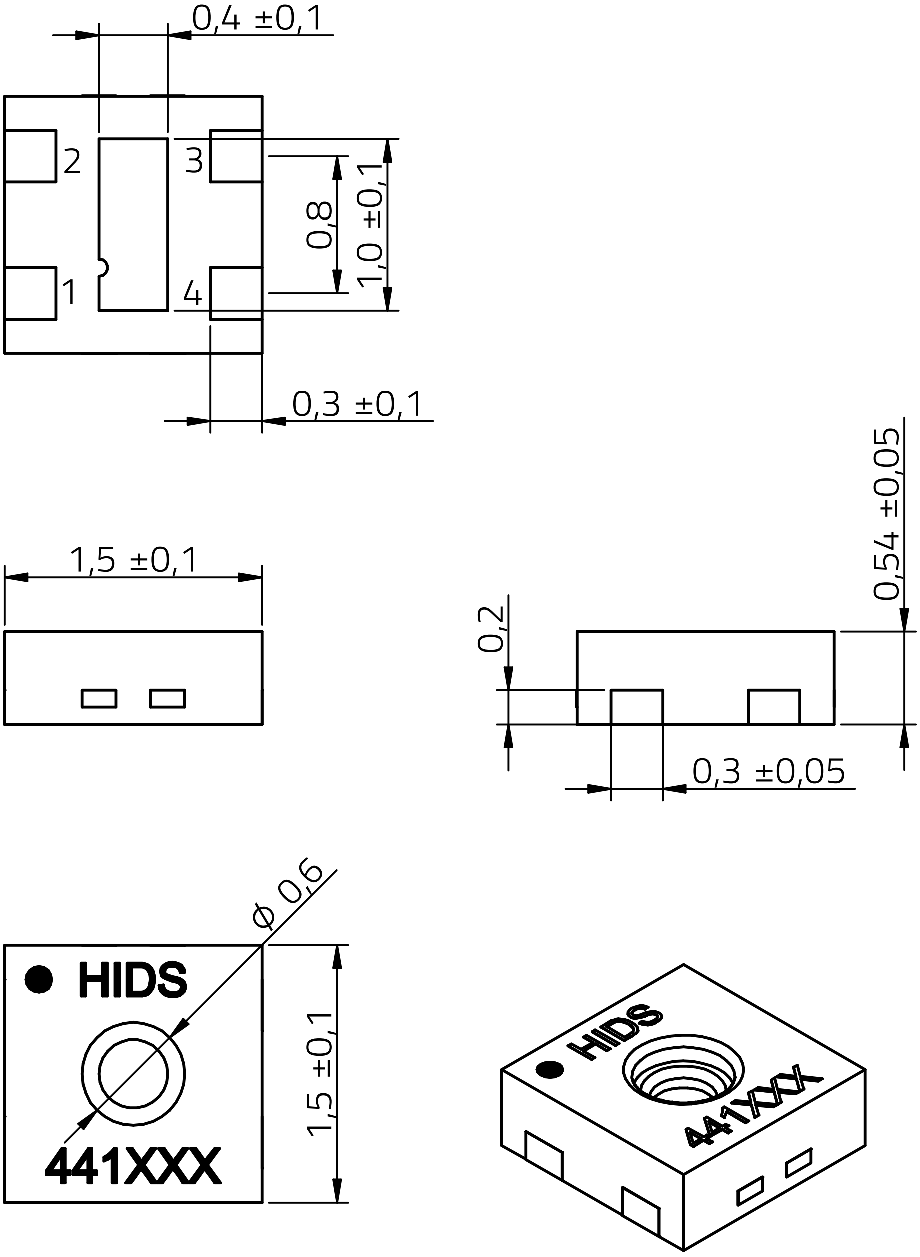


Figure 8: Sensor dimension [mm]

8.2 Footprint

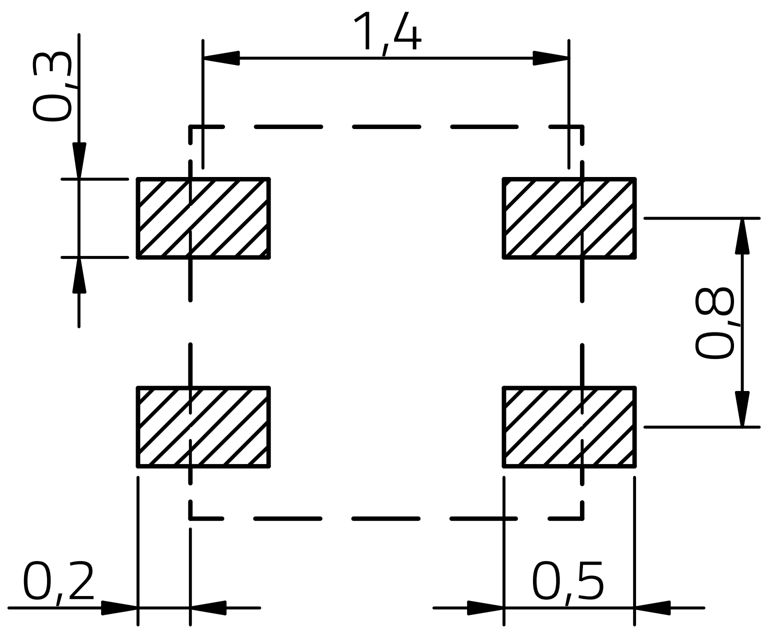


Figure 9: Recommended land pattern [mm] (top view)

In order to enhance heat dissipation during heater operations, it is recommended not to solder the central die pad.

9 MEMS Sensor PCB Design Guidelines

The following design guidelines for PCB, soldering, solder paste, stencil and re-flow process must be considered as a good hardware design practice for Würth Elektronik eiSos MEMS sensor products. Not following these guidelines will result in poor performance from the Würth Elektronik eiSos MEMS Sensors. e.g. offset, offset vs temperature, accuracy and accuracy vs temperature.

9.1 PCB Design rules

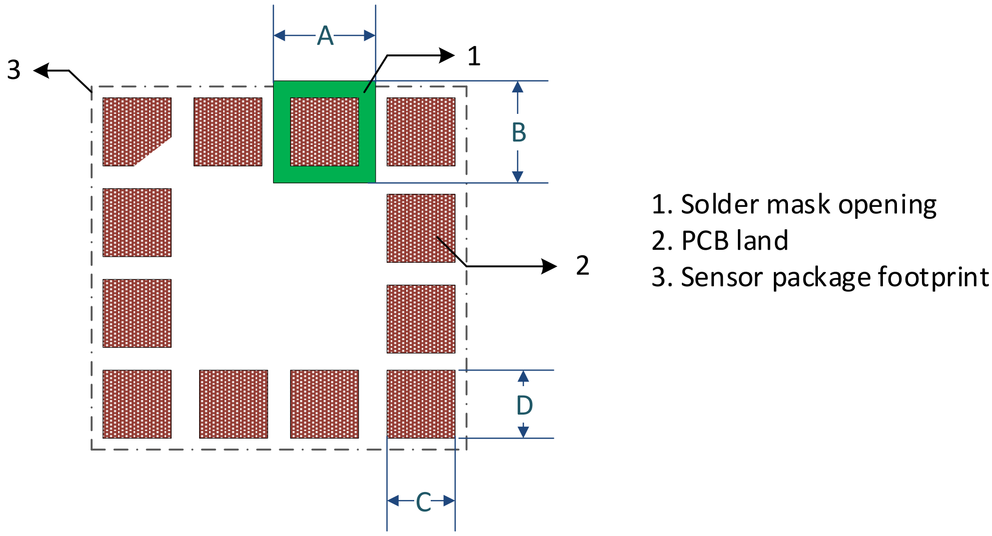


Figure 10: PCB land and solder mask recommendations for sensors with LGA package

Dimension	LGA pad spacing > 200 µm	LGA pad spacing ≤ 200 µm
PCB land width: C	LGA solder pad width + 0.1 mm	LGA solder pad width
PCB land length: D	LGA solder pad length + 0.1 mm	LGA solder pad length

Table 15: PCB land design dimensions

Dimension	Description
Solder mask opening width: A	PCB land length + 0.1 mm
Solder mask opening length: B (when applicable)	PCB land length + 0.1 mm

Table 16: Solder mask opening dimensions

Any structure underneath the sensor should be avoided

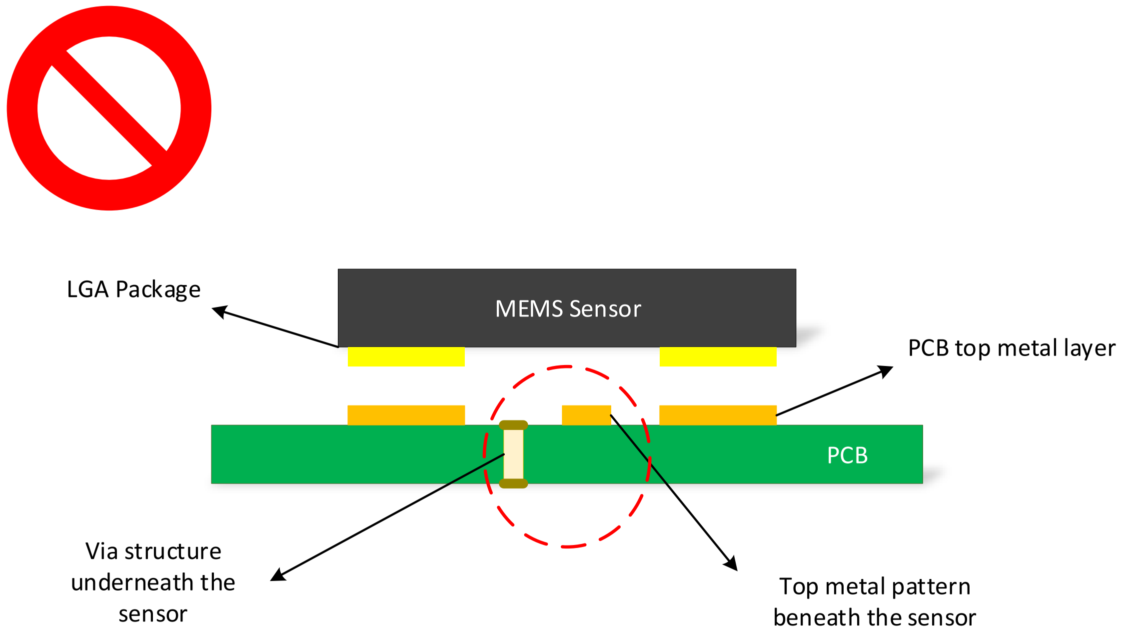


Figure 11: Incorrect PCB design

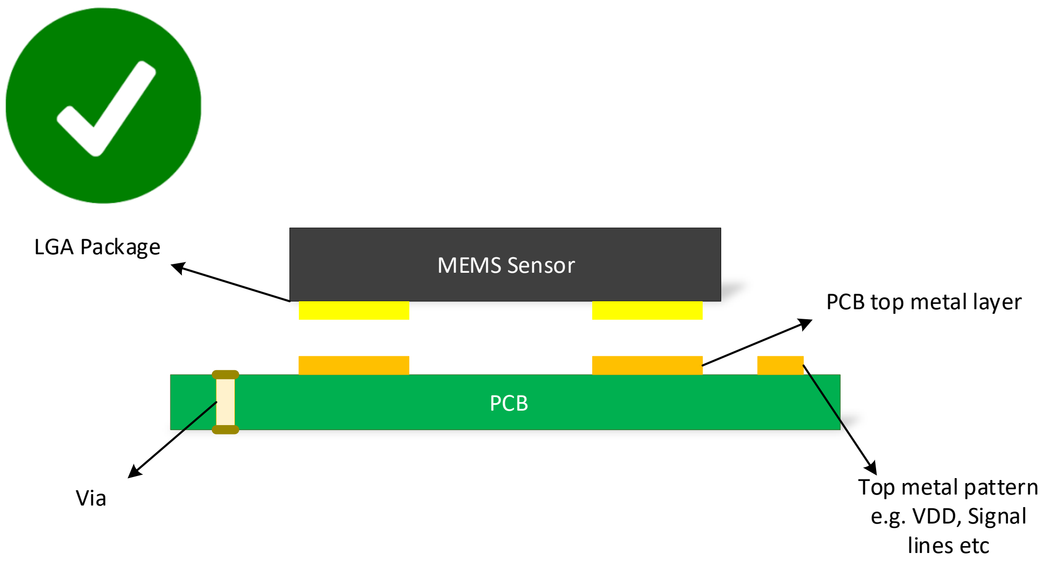


Figure 12: Correct PCB design

Placing any Screw mounting holes, vias and components at a distance greater than 1.5mm away from the sensor is highly recommended to get optimal performance of the sensor.

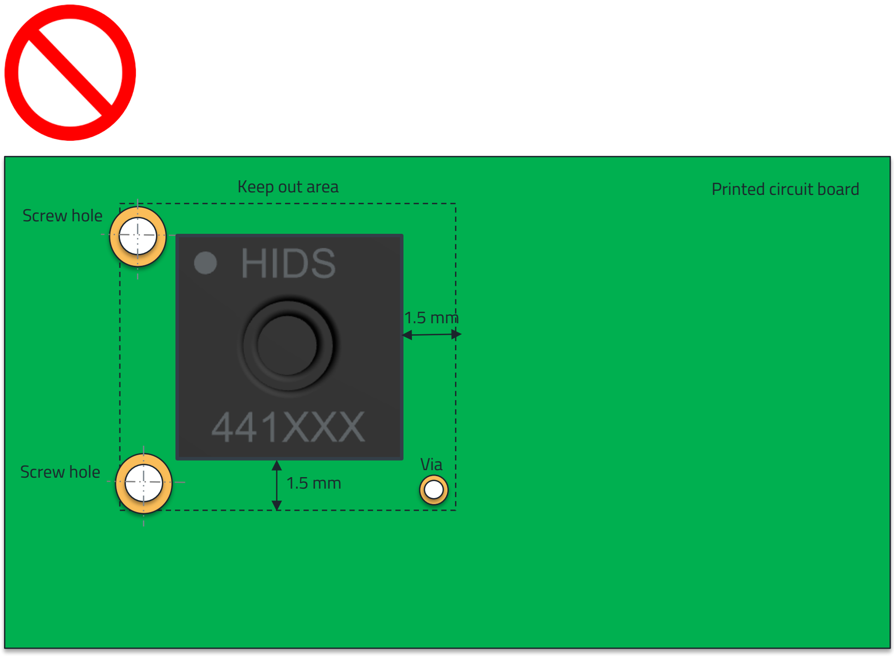


Figure 13: Components inside sensor keep out area

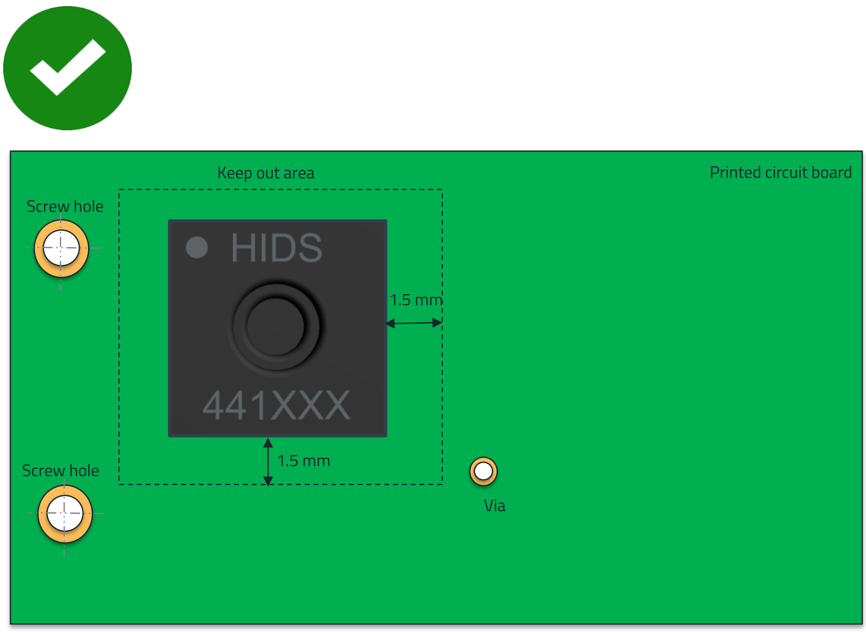


Figure 14: Components outside sensor keep out area

In order to improve the sensor thermal decoupling from the system/PCB, it is recommended to have thermal cut around the sensor which removes all unnecessary metal from the PCB around the sensor.

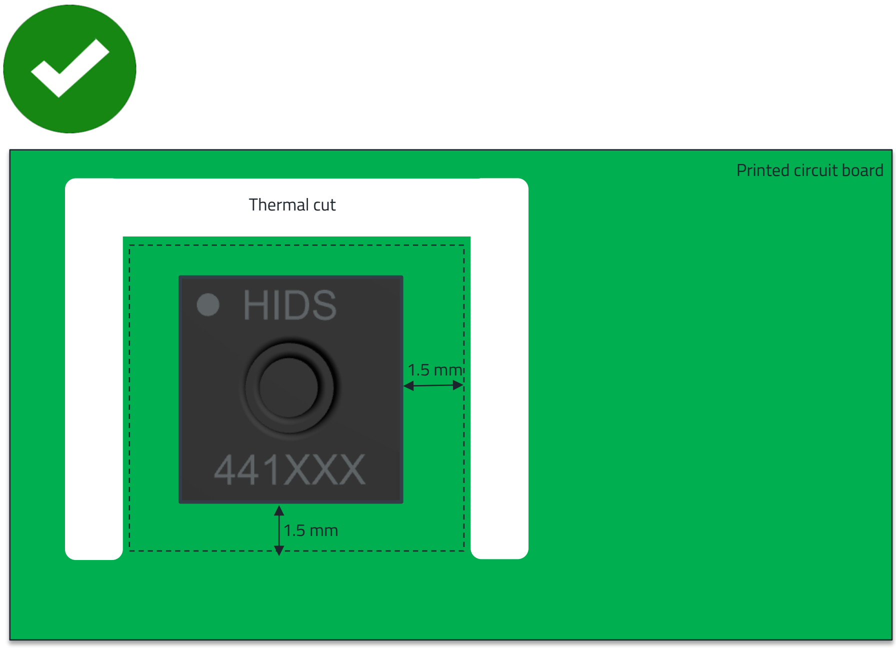


Figure 15: Thermal cut around the sensor

9.2 Guidelines for PCB Design

- The solder mask opening external to the PCB land is highly recommended. Please refer to figure 10.
- It is recommended to define a keep-out area for the sensor. Any structure underneath the sensor should be avoided.
- The traces connected to the pads should be as symmetrical as possible. Symmetry and balance to the pad connections will help the sensor self-align which leads to better control of solder paste reduction after reflow.
- Screw mounting holes at a distance greater than 2mm from the sensor is highly recommended to get optimal performance of the sensor.
- We recommend to separate digital ground from analog ground in the PCB, if enough space or layer is available. The relatively large, sharp pulses of digital current transitions might affect the precise analog signals if the two signals are not separated.
- Copper planes/traces underneath the sensor shall be avoided to improve thermal isolation. Although ground planes are normally advisable for a good EMC performance, placing them underneath the sensor deteriorates the thermal isolation.

It is generally recommended to reduce the PCB thickness (e.g. $\leq$ 1.6 mm). Intrinsic stress during PCB bending is less in thin PCBs

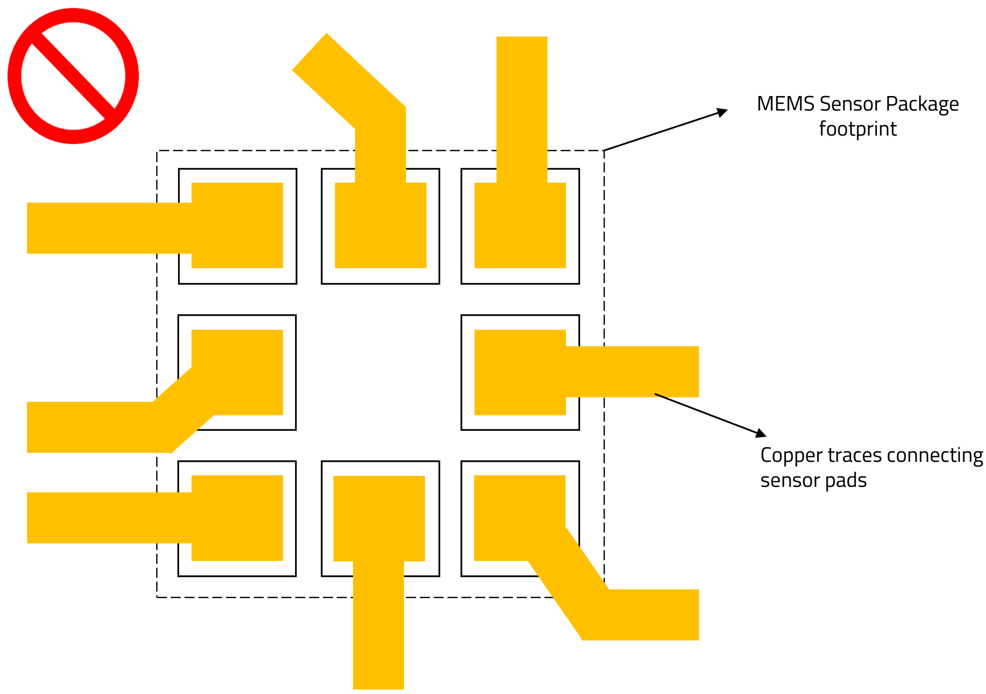


Figure 16: Asymmetrical trace and sensor pad connections

Information of the PCB design and soldering processes provided in this document is considered for use as a reference.

PCB land design and connecting traces should be designed symmetrically

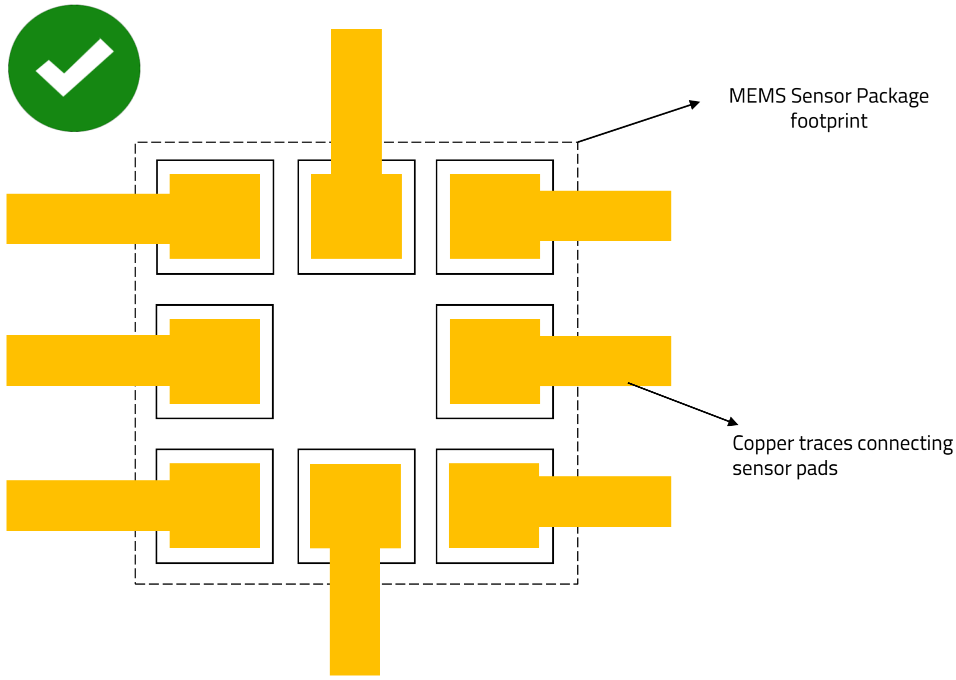


Figure 17: Symmetrical trace and sensor pad connections

9.3 Guidelines for soldering

The following soldering guidelines should be taken into consideration for a common PCB design and industrial practices.

9.3.1 Before soldering

- Routing traces and vias below the sensor should be avoided. The active signals that are routed under may interfere with the MEMS sensor, which will affect the sensor performance.
- It is not necessary to have large traces on VDD/GND line, as the power consumption of the MEMS sensors are very low.
- The placement of the MEMS sensor on the PCB should avoid locations in close proximity to heat sources e.g. microprocessors, batteries, graphic controllers etc.
- Push-buttons, screws and PCB anchor points can produce mechanical stress onto the PCB, hence the sensor placement close to these components should be avoided.
- PCB bending will induce mechanical stress to the sensor therewith influence the sensor performance.

9.3.2 After soldering

- In general, high-amplitude resonant vibrations of the PCB should be avoided. It could possibly damage the MEMS structure.
- The thickness of solder paster must be uniform to reduce the inconsistent stress on the sensor.
- Solder paste must be as thick as possible to reduce the decoupling stress and to avoid the PCB solder mask touching the device package.

9.4 Guidelines for stencil design and solder paste

For proper mounting process of the MEMS sensor, thickness and soldering paste pattern are very important.

- Stencil thickness of 90 - 150 µm (3.5 - 6 mils) is recommended for screen printing.
- Stainless steel stencils are recommended for solder paste application.
- The signal pad openings of the stencil should be between 70% and 90% of the PCB pad area.
- It is recommended that for better solder paste release, the aperture walls should be trapezoidal and the corners rounded.
- The stencil and printed circuit assembly should be aligned to within 25 µm (1 mil) before applying the solder paste.

9.5 Guidelines for process considerations

- To reduce the residual stress on the components, the recommended ramp-down temperature slope should not exceed -3 ℃/s.
- LGA packages show metal traces on the side of the package, hence no solder material reflow on the side of the package is allowed.
- The final volume of the solder paste applied to a single PCB land should be less than 20% of the volume of the solder paste of all pads of one device.
- It is not possible to define a specific soldering profile only for the sensors. The soldering profile depends on the number, size and placement of the components in the application board.
- Customer should use a time and temperature reflow profile based on PCB design and manufacturing knowledge.
- No-clean solder paste is recommended for assembly of the MEMS sensor to prevent further cleaning steps.
- Sensor with opening surface on top should be handled carefully. Do not pick the component with vacuum tools which make direct contact with the opening of the sensor.

It is recommended to use a standard pick and place process and equipment. Do not use the hand soldering process.

10 Manufacturing information

10.1 Moisture sensitivity level

The sensor product is categorized as JEDEC Moisture Sensitivity Level 1 (MSL1), which requires special handling.

More information regarding the MSL requirements can be found in the IPC/JEDEC J-STD-020 standard on *www.jedec.org*. More information about the handling, picking, shipping and the usage of moisture/re-flow and/or process sensitive products can be found in the IPC/JEDEC J-STD-033 standard on *www.jedec.org*.

10.2 Soldering

10.2.1 Reflow soldering

Attention must be paid on the thickness of the solder resist between the host PCB top side and the modules bottom side. Only lead-free assembly is recommended according to JEDEC J-STD020.

Profile feature		Value
Preheat temperature Min	$T_{S\ Min}$	150 °C
Preheat temperature Max	$T_{S\ Max}$	200 °C
Preheat time from $T_{S\ Min}$ to $T_{S\ Max}$	t_S	60 - 120 seconds
Ramp-up rate (T_L to T_P)		3 °C / second max.
Liquidous temperature	T_L	217 °C
Time t_L maintained above T_L	t_L	60 - 150 seconds
Peak package body temperature	T_P	<= 260 °C
Time within 5 °C of actual peak temperature	t_P	20 - 30 seconds
Ramp-down Rate (T_P to T_L)		6 °C / second max.
Time 20 °C to T_P		8 minutes max.

Table 17: Classification reflow soldering profile, Note: refer to IPC/JEDEC J-STD-020E

It is recommended to solder the sensor on the last re-flow cycle of the PCB. For solder paste use a LFM-48W or Indium based SAC 305 alloy (Sn 96.5 / Ag 3.0 / Cu 0.5 / Indium 8.9HF / Type 3 / 89%) type 3 or higher.

The reflow profile must be adjusted based on the thermal mass of the entire populated PCB, heat transfer efficiency of the reflow oven and the specific type of solder paste used. Based on the specific process and PCB layout the optimal soldering profile must be adjusted and verified. Other soldering methods (e.g. vapor phase) have not been verified and have to be validated by the customer at their own risk. Rework is not recommended.

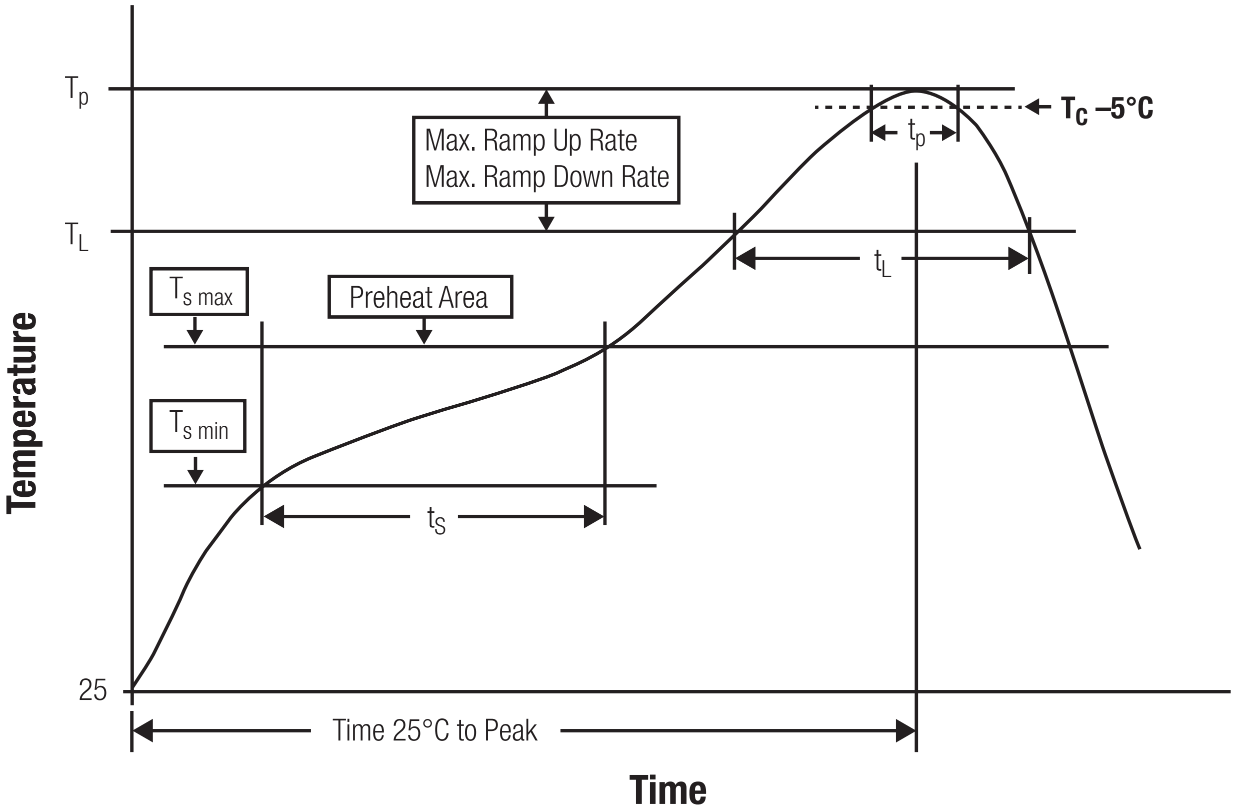


Figure 18: Reflow soldering profile

After reflow soldering, visually inspect the board to confirm proper alignment

10.2.2 Cleaning and washing

Do not clean the product. Any residue cannot be easily removed by washing. Use a "no clean" soldering paste and do not clean the board after soldering.

- Washing agents used during the production to clean the customer application might damage or change the characteristics of the component. Washing agents may have a negative effect on the long-term functionality of the product.
- Using a brush during the cleaning process may damage the component. Therefore, we do not recommend using a brush during the PCB cleaning process

10.2.3 Potting and coating

- Potting material might shrink or expand during and after hardening. This might apply mechanical stress on the components, which can influence the characteristics of the transfer function. In addition, potting material can close existing openings in the housing. This can lead to a malfunction of the component. Thus, potting is not recommended.

- Conformal coating may affect the product performance. We do not recommend coating the components.

10.2.4 Storage conditions

- A storage of Würth Elektronik eiSos products for longer than 12 months is not recommended. Within other effects, the terminals may suffer degradation, resulting in bad solderability. Therefore, all products shall be used within the period of 12 months based on the day of shipment.
- Do not expose the components to direct sunlight.
- The storage conditions in the original packaging are defined according to DIN EN 61760 - 2.
- For a moisture sensitive component, the storage condition in the original packaging is defined according to IPC/JEDEC-J-STD-033. It is also recommended to return the component to the original moisture proof bag and reseal the moisture proof bag again.

10.2.5 Handling

- Violation of the technical product specifications such as exceeding the nominal rated supply voltage, will void the warranty.
- Violation of the technical product specifications such as but not limited to exceeding the absolute maximum ratings will void the conformance to regulatory requirements.
- ESD prevention methods need to be followed for manual handling and processing by machinery.
- The edge castellation is designed and made for prototyping, i.e. hand soldering purposes only.
- The applicable country regulations and specific environmental regulations must be observed.
- Do not disassemble the product. Evidence of tampering will void the warranty.

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