DIFFERENTIAL PRESSURE SENSOR
WSEN-PDUS
USER MANUAL

25131308XXX01

VERSION 1.0

AUGUST 14, 2019

Revision history

Manual version	Notes	Date
1.0	• Initial release of the manual	August 2019

Abbreviations

Abbreviation	Description
ASIC	Application Specific Integrated Circuit
BFSL	Best Fit Straight Line
ESD	Electrostatic Discharge
EEPROM	Electrically erasable programmable read-only memory
FSS	Full Scale Span
HBM	Human Body Model
HVAC	Heating, ventilation and air conditioning
I^2C	Inter Integrated Circuit
LCP	Liquid-crystal polymers
LSB	Least Significant Bit
MEMS	Micro-electro-mechanical system
MSB	Most Significant Bit
PCB	Printed Circuit Board

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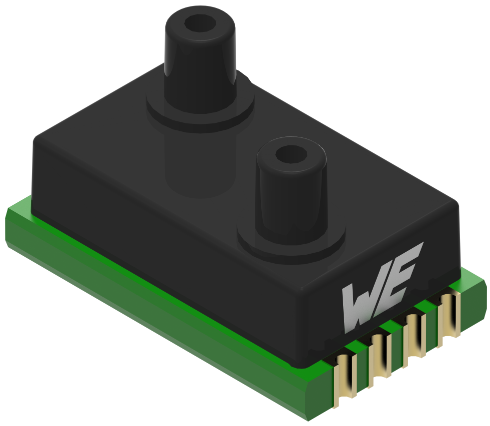
1 Introduction

The differential pressure sensors from Würth Elektronik eiSos allow measurement of pressure difference between two vertical pressure ports. The sensors consist of a MEMS based piezo-resistive sensing element and an ASIC integrated on a ceramic substrate. On-chip calibration, temperature compensation and signal conditioning provide highly accurate pressure in both digital and analog forms. Digital pressure data can be accessed by interfacing the sensor to the host controller via digital I²C interface. Simple communication protocol enables easy integration of the software, without the need of programming internal registers.

The sensors, available in various pressure ranges can measure differential pressure up to 10 bar. They are intended to be used for non-corrosive gases such as air and other dry gases (See section 2.2 for further information). The sensors come in 13 x 8 x 7.5 mm reflow solderable surface mount package with two pressure ports on top, allowing flexible mounting.

1.1 Applications

- HVAC
- Filter monitoring
- Gas leak detection
- Inhalers
- Fume hood



1.2 Key features

- Available in different pressure ranges
  - ± 0.1 KPa
  - ± 1 KPa
  - ± 10 KPa
  - 0 to 100 KPa
  - -100 KPa to 1000 KPa
- Supply voltage: 5V
- Digital output for pressure and temperature
- Communication interface: I²C
- Analog voltage output for pressure
- Temperature range: -25 ℃ to 85 ℃
- Typical current consumption: 4 mA

1.3 Ordering information

WE order code	Pressure range [kPa]	Marking	Dimensions [mm]	Description
2513130810001	± 0.1	PDB100IA0N	13.3 x 8.0 x 7.5	Tape & reel packaging
2513130810101	± 1	PDB101IA0N		
2513130810201	± 10	PDB102IA0N		
2513130810301	0 to 100	PDU103IA0N		
2513130810401	-100 to 1000	PDU104IA0N		

Table 1: Ordering information

1.4 Block diagram

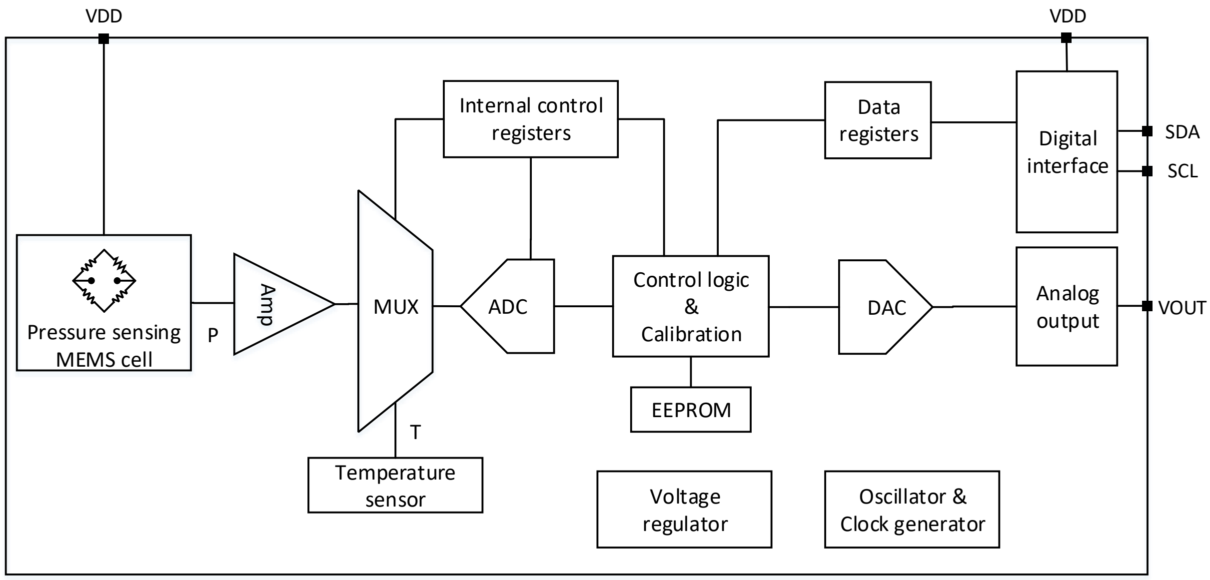


Figure 1: Block diagram

MEMS based piezo-resistors embedded on a suspended silicon membrane is the primary sensing element of the device. The piezo-resistors, connected in a Wheatstone bridge configuration produce analog output voltage proportional to the applied pressure.

Analog output is converted to the digital values through delta-sigma analog-to-digital converter (ADC).The ASIC embeds a high-resolution temperature sensor which is used for internal compensation of the pressure signal.

Each sensor is calibrated at three temperature and three pressure points. The trimming parameters and calibration coefficients (stored in the on-chip EEPROM) are used for the digital signal correction. The digital pressure values are available for the user to read via digital I^2C interface.

Additionally, the sensors also provide optional digital temperature values for the temperature measurements via embedded temperatue sensor.

Pressure values are also available as an analog voltage output. 11-bit digital to analog converter (DAC) embedded in the ASIC provides a calibrated analog voltage output through the *VOUT* pin.

2 Sensor specifications

2.1 General information

Parameter	Value
Operating temperature	-25 ℃ up to +85℃
Compensated temperature range [1]	0 ℃ to 70 ℃
Storage conditions	< 40 ℃; < 90% RH
Communication interface	I^2C, analog
Moisture sensitivity level (MSL)	1
Electrostatic discharge protection (HBM)	2 kV

Table 2: General information

2.2 Media compatibility

High pressure port*	Dry and non-corrosive gases compatible with silicon, RTV, ceramics Al_2O_3, Pyrex and LCP plastics
Low pressure port	Dry and non-corrosive gases compatible with silicon, RTV, ceramics Al_2O_3, Pyrex, epoxy and FR4

Table 3: Media compatibility

1. *The sensor output will be within the specified performance limits in this temperature range.*

* *Refer to figure 10 for port identification.*

2.3 Absolute maximum ratings

Absolute maximum ratings are the limits, the device will withstand without permanent damage.

Parameter	Symbol	Part number	Value		Unit
			Min	Max	
Input voltage *VDD* pin	V_{DD_MAX}	25131308xxx01	-0.3	6.5	V
Input voltage *SDA*, *SCL* pins	V_{IN_MAX}	25131308xxx01	-0.3	5.5	V
Differential over pressure [2]	P_{MAX}	2513130810001		10	kPa
		2513130810101			
		2513130810201		100	
		2513130810301		300	
		2513130810401		2500	
Differential burst pressure [3]	P_{BURST}	2513130810001		10	kPa
		2513130810101			
		2513130810201		150	
		2513130810301		500	
		2513130810401		2500	

Table 4: Absolute maximum ratings

2. *This is the pressure that may be applied to the sensor without causing damage to the sensing element. However, exposure to higher pressure may cause permanent damage to the sensor.*
3. *This is the pressure that may be applied to the sensor without causing leakage and permanent damage to the sensing element.*

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

2.4 Pressure sensor specifications

Unless otherwise stated, all the specified values were measured under the following conditions: T=25 °C, V_{DD}=5 V.

2.4.1 Common paramters

Following pressure sensor parameters are applicable to part number.: 25131308xxx01

Parameter	Symbol	Test conditions	Value			Unit
			Min	Typ	Max	
Nonlinearity [4]	ACC_{P_NL}		-0.3	±0.1	0.3	%FSS
Resolution (ADC)	RES_{P}			15		bit
Resolution (DAC)	RES_{P_DAC}			11		bit
Response time	t_{RESP}			2.2		ms

Table 5: Pressure sensor specifications (part nr.: 25131308xxx01)

2.4.2 Part number specific parameters

Part number: 2513130810001

Parameter	Symbol	Test conditions	Value			Unit
			Min	Typ	Max	
Measurement range	P_{RANGE}		-0.1		0.1	kPa
Absolute accuracy [5]	ACC_{P_ABS}	T = 25 °C	-4	±2	4	%FSS
Total accuracy [6]	ACC_{P_TOT}	T = 0 to 70 °C	-5	±2.5	5	%FSS
Sensitivity (digital)	SEN_{P}			7.63×10^{-6}		kPa/digit
Sensitivity (analog)	SEN_{P_AN}			0.05		kPa/ V
Repeatability [7]	ACC_{P_REP}			±0.1		%FSS
Long term drift	ACC_{P_DRIFT}			±0.5		%FSS

Table 6: Pressure sensor specifications (part nr.: 2513130810001)

Full Scale Span (FSS) is the algebraic difference between the sensor output at the maximum and minimum pressure of the measurement range (P_{RANGE}).

4. *Nonlinearity is the maximum deviation of the sensor output from the straight line fit (BFSL) across the entire pressure measurement*

Part number: 2513130810101

Parameter	Symbol	Test conditions	Value			Unit
			Min	Typ	Max	
Measurement range	P_{RANGE}		-1		1	kPa
Absolute accuracy [5]	ACC_{P_ABS}	T = 25 ℃	-1	±0.5	1	%FSS
Total accuracy [6]	ACC_{P_TOT}	T = 0 to 70 ℃	-1.25	±0.75	1.25	%FSS
Sensitivity (digital)	SEN_P			7.63×10^{-5}		kPa/digit
Sensitivity (analog)	SEN_{P_AN}			0.5		kPa/ V
Repeatability [7]	ACC_{P_REP}			±0.05		%FSS
Long term drift	ACC_{P_DRIFT}			±0.1		%FSS

Table 7: Pressure sensor specifications (part nr.: 2513130810101)

Part number: 2513130810201

Parameter	Symbol	Test conditions	Value			Unit
			Min	Typ	Max	
Measurement range	P_{RANGE}		-10		10	kPa
Absolute accuracy [5]	ACC_{P_ABS}	T = 25 ℃	-1	±0.5	1	%FSS
Total accuracy [6]	ACC_{P_TOT}	T = 0 to 70 ℃	-1.25	±0.75	1.25	%FSS
Sensitivity (digital)	SEN_P			7.63×10^{-4}		kPa/digit
Sensitivity (analog)	SEN_{P_AN}			5		kPa/ V
Repeatability [7]	ACC_{P_REP}			±0.05		%FSS
Long term drift	ACC_{P_DRIFT}			±0.1		%FSS

Table 8: Pressure sensor specifications (part nr.: 2513130810201)

5. *Absolute accuracy includes effects of non-linearity, pressure hysteresis, offset, span and repeatability at room temperature.*
6. *Total accuracy includes all effects of offset, non-linearity, pressure hysteresis, span, repeatability and thermal effects between the compensated temperature range 0 ℃ and 70 ℃.*
7. *Repeatability is the typical deviation of the sensor output after 10 pressure cycles.*

Part number: 2513130810301

Parameter	Symbol	Test conditions	Value			Unit
			Min	Typ	Max	
Measurement range	P_{RANGE}		0		100	kPa
Absolute accuracy [5]	ACC_{P_ABS}	T = 25 ℃	-0.3	±0.1	0.3	%FSS
Total accuracy [6]	ACC_{P_TOT}	T = 0 to 70 ℃	-0.5	±0.25	0.5	%FSS
Sensitivity (digital)	SEN_P			3.815×10^{-3}		kPa/digit
Sensitivity (analog)	SEN_{P_AN}			25		kPa/ V
Repeatability [7]	ACC_{P_REP}			±0.01		%FSS
Long term drift	ACC_{P_DRIFT}			±0.05		%FSS

Table 9: Pressure sensor specifications (part nr.: 2513130810301)

Part number: 2513130810401

Parameter	Symbol	Test conditions	Value			Unit
			Min	Typ	Max	
Measurement range	P_{RANGE}		-100		1000	kPa
Absolute accuracy [5]	ACC_{P_ABS}	T = 25 ℃	-0.3	±0.1	0.3	%FSS
Total accuracy [6]	ACC_{P_TOT}	T = 0 to 70 ℃	-0.5	±0.25	0.5	%FSS
Sensitivity (digital)	SEN_P			4.196×10^{-2}		kPa/digit
Sensitivity (analog)	SEN_{P_AN}			275		kPa/ V
Repeatability [7]	ACC_{P_REP}			±0.01		%FSS
Long term drift	ACC_{P_DRIFT}			±0.05		%FSS

Table 10: Pressure sensor specifications (Part nr.: 2513130810401)

5. *Absolute accuracy includes effects of non-linearity, pressure hysteresis, offset, span and repeatability at room temperature.*
6. *Total accuracy includes all effects of offset, non-linearity, pressure hysteresis, span, repeatability and thermal effects between the compensated temperature range 0 ℃ and 70 ℃.*
7. *Repeatability is the typical deviation of the sensor output after 10 pressure cycles.*

2.5 Temperature sensor specifications

Unless otherwise stated, all the specified values were measured under the following conditions: T=25℃, V_{DD}=5 V.

Parameter	Symbol	Test conditions	Value			Unit
			Min	Typ	Max	
Measurement range	T_{RANGE}		0		70	℃
Resolution	T_{RES}			15		bits
Sensitivity	SEN_T			4.272×10^{-3}		℃/digit

Table 11: Temperature sensor specifications

2.6 Electrical specifications

Unless otherwise stated, all the specified values were measured under the following conditions: T=25℃, V_{DD}= 5V.

Parameter	Symbol	Test conditions	Value			Unit
			Min	Typ	Max	
Operating supply voltage	V_{DD}		4.75	5	5.25	V
Current consumption	I_{DD}			4	6.5	mA
Output current analog pin	I_{OUT_A}				1	mA
Digital input voltage-high-level	V_{IH}		0.7 * V_{DD}			V
Digital input voltage-low-level	V_{IL}				0.3 * V_{DD}	V
Digital output voltage-high-level	V_{IH}		0.9 * V_{DD}			V
Digital output voltage-low-level	V_{IL}				0.1 * V_{DD}	V

Table 12: Electrical specifications

3 Pinning information

3.1 Pin configuration

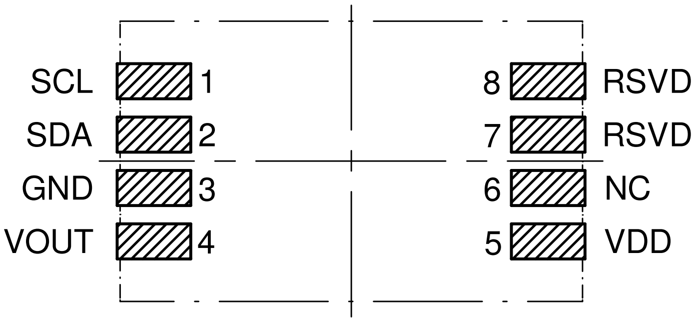


Figure 2: Pin specifications (top view)

3.2 Pin description

Pin No.	Name	Function	Input/output	Comments
1	*SCL*	I^2C serial clock	Input	
2	*SDA*	I^2C serial data	Input/Output	
3	*GND*	Negative supply voltage	Supply	
4	*VOUT*	Analog output	Output	
5	*VDD*	Positive supply voltage	Supply	
6	*NC*	No connection		
7	*RSVD*	Reserved		Do not connect
8	*RSVD*	Reserved		Do not connect

Table 13: Pin description

4 Digital interface

The sensor supports standard I^{2}C (Inter-IC) bus protocol. I^{2}C is a serial 8-bit protocol with two-wire interface that supports communication between different ICs, for example, between microcontrollers and other peripheral devices. Further information about the I^{2}C interface can be found at *https://www.nxp.com/docs/en/user-guide/UM10204.pdf*.

4.1 General characteristics

A serial data line (*SDA*) and a serial clock line (*SCL*) are required for the communication between the devices connected via I^{2}C 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 I^{2}C protocol, the communication is realized through master-slave principle. A 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 (master-transmitter or slave transmitter) or a receiver (master receiver or slave receiver) depending upon whether the data needs to be sent or received.

This sensor behaves like a slave device on the I^{2}C bus

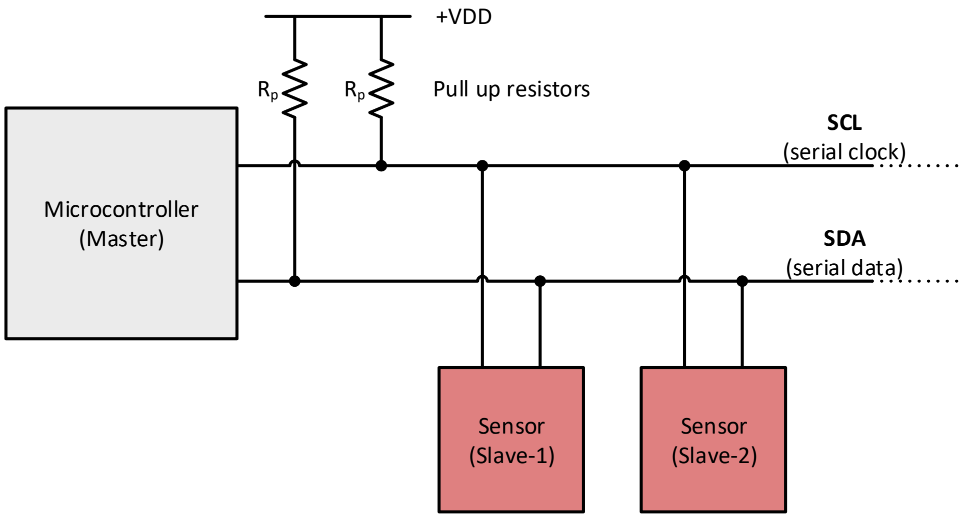


Figure 3: Master-slave concept

4.2 *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. Input reference levels for this sensor are set as 0.7 * *VDD* (for logic high) and 0.3 * *VDD* (for logic low). See figure 4.

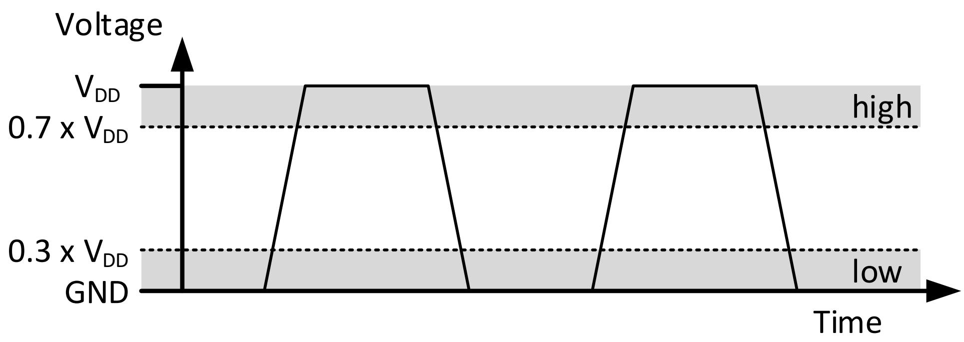


Figure 4: *SDA* and *SCL* logic levels

4.3 Communication phase

4.3.1 Idle state

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

4.3.2 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 considered free again 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 the same as the START condition.

4.3.3 Data validity

After the start condition, one data bit is transferred 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 clock pulse is in low state.

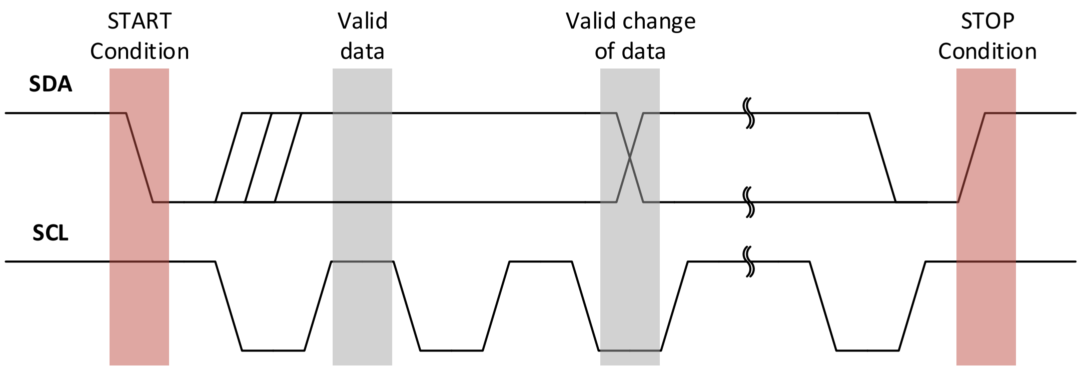


Figure 5: Data validity, START and STOP condition

4.3.4 Byte format

Data transmission on the *SDA* line is always done in bytes, with each byte being 8-bits long. Data is transferred 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* line.

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

Each byte sent on the data line must be followed by an Acknowledge bit. The receiver (master or slave) generates an Acknowledge signal to indicate that the data byte was received successfully and another data byte could be sent.

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. This is considered as an Acknowledge signal.

In case the receiver does not want to receive any further byte, it does not pull down the *SDA* line and it remains in stable high state during the entire clock pulse. This 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.

4.3.6 Slave address for the sensor

The slave address is transmitted after the start condition. Each device on the I^2C bus has a unique address. Master selects the slave by sending corresponding address after the start condition. A slave address is 7 bits long followed by a Read/Write bit.

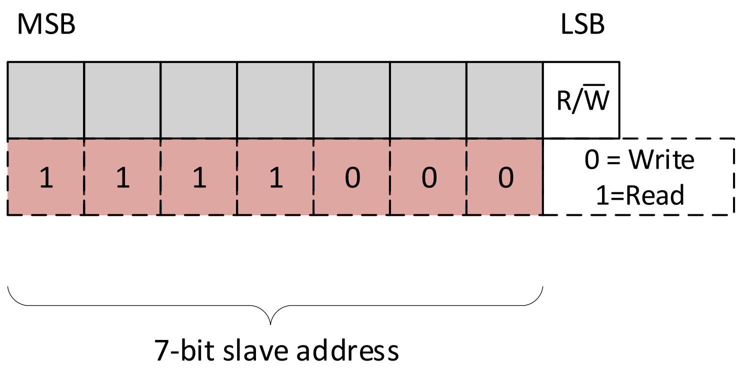


Figure 6: Slave address format

7-bit slave address of this device is 1111000b (0x78).

The R/W bit determines the data direction. A ’0’ indicates a write operation (transmission from master to slave) and a ’1’ indicates a read operation (request data from slave).

This device is configured to work as a slave-transmitter, meaning it can only respond to the data request made by master (R/W bit = 1).

4.3.7 Read operation

Once the slave-address and data direction bit is sent, the slave acknowledges the master. The slave can then transmit multiple number of data bytes. Each transmitted data byte is followed by an Acknowledgement from the master. If the master no longer wants to receive further data from the slave, it would send No-Acknowledge (NACK). Afterwards, Master can send a STOP condition to terminate the data transfer.

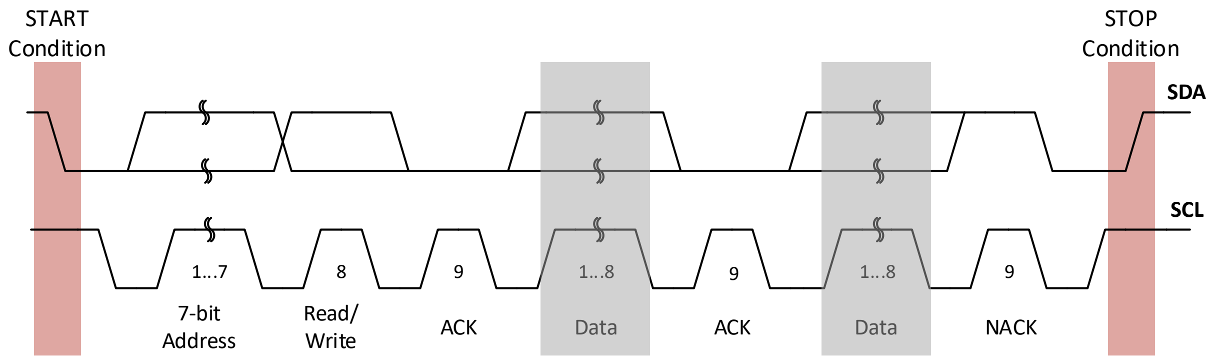


Figure 7: Complete data transfer

4.4 I²C timing parameters

Parameter	Symbol	Min	Max	Unit
SCL clock frequency	f_{SCL}	100	400	kHz
LOW period for *SCL* clock	t_{LOW_SCL}	1.3		µs
HIGH period for *SCL* clock	t_{HIGH_SCL}	0.6		µs
Hold time for START condition	t_{HD_S}	0.8		µs
Setup time for (repeated) START condition	f_{SCL}	1		µs
SDA setup time	t_{SU_SDA}	0.2		µs
SDA data hold time	t_{HD_SDA}	0		µs
Setup time for STOP condition	t_{SU_P}	0.6		µs
Bus free time between STOP and START condition	t_{BUF}	1.3		µs

Table 14: I²C timing parameters

5 Application circuit

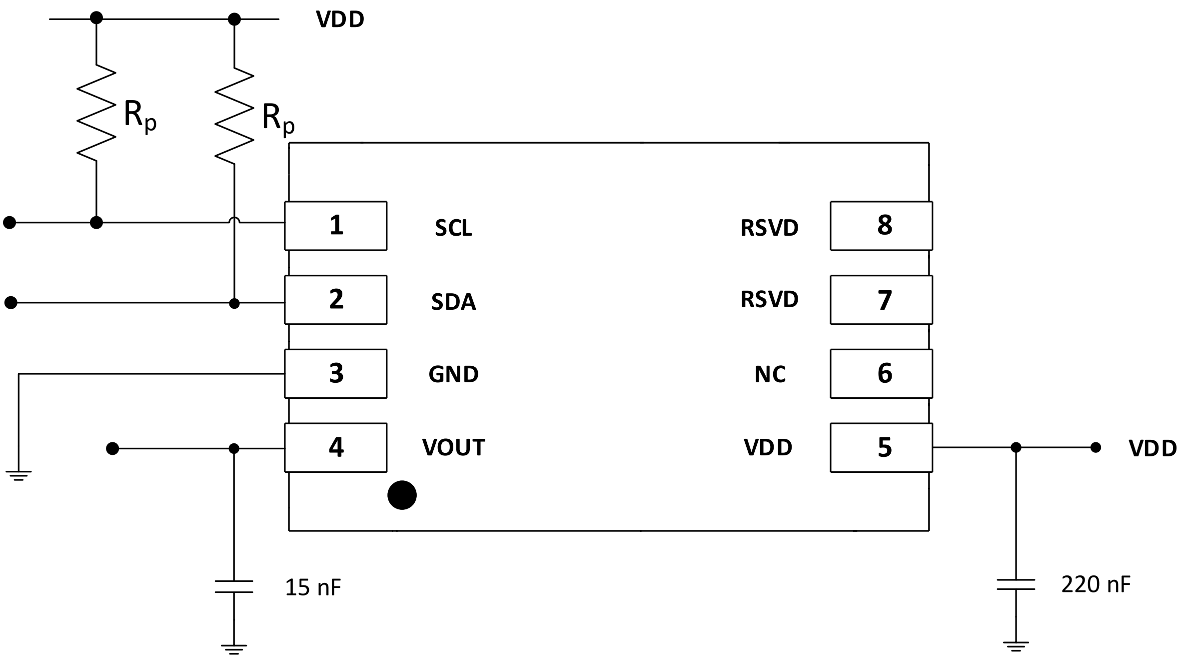


Figure 8: Application circuit with I²C interface (top view)

VDD pin is the central supply pin for the MEMS cell and internal circuits. In order to prevent ripple from the power supply, a decoupling capacitor of 220 nF must be placed as close to the *VDD* pad of the sensor as possible. Further, a decoupling capacitor of 15 nF should be placed between *VOUT* and ground.

If both digital I²C and analog interfaces are used simultaneously, it is recommended to route these lines as far from each other as possible.

SCL and *SDA* must be connected to *VDD* through the pull-up resistors. Proper value of the pull-up resistors must be chosen depending on the I²C bus speed and load. The sensor does not have internal pull-up resistors.

Avoid routing of the *VDD*, *SDA*/*SCL* and *GND* lines underneath the sensor (See section 8.2 for further information).

6 Reading digital output data

The sensor generates fully calibrated and temperature compensated digital pressure values which is available for the user to read through host controller. Sensor must be interfaced to the host controller via I²C interface. For details about I²C interface, refer to chapter 4. Once the host controller (master) sends the start condition and data direction bit as READ (R/W=1), the sensor starts transmitting the pressure (2 bytes) and temperature (2 bytes) data. Pressure data is transmitted in 1st and 2nd bytes as a 15 bit information. Temperature data is then transmitted in the following two bytes (3rd and 4th) as a 15 bit information. New Pressure and temperature data is generated every 2.2 ms. The sensor will continue to send the alternating pressure and temperature values as 15-bit information until it is deactivated by a STOP condition from the host controller.

Figure 9 shows the reading operation the master and the slave device (sensor).

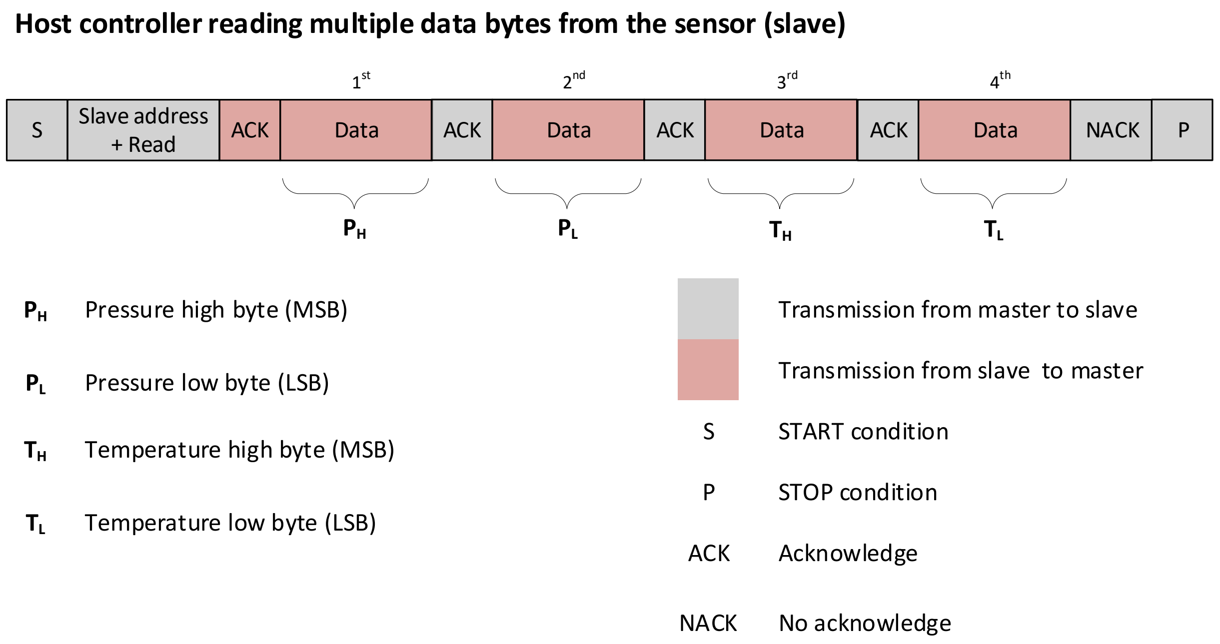


Figure 9: Reading output data with I²C interface

> The sensor response time is about 2.2 ms, meaning it sends a new set of pressure (2 bytes) and temperature (2 bytes) data every 2.2 ms. With the I²C clock frequency of 400 kHz, the exchange of the 4 data bytes containing the current pressure and temperature values takes about 80 µs.

6.1 Pressure output: digital

Part number: 2513130810001, 2513130810101, 2513130810201

Parameter	Symbol	Value			Unit
		Min	Typ	Max	
Zero pressure offset	OUT_{OFF}		16384		digits
Full scale span	FSS		26214		
Output at minimum pressure	OUT_{P_MIN}		3277		
Output at maximum pressure	OUT_{P_MAX}		29491		

Table 15: Digital pressure output

Part number: 2513130810301

Parameter	Symbol	Value			Unit
		Min	Typ	Max	
Zero pressure offset	OUT_{OFF}		3277		digits
Full scale span	FSS		26214		
Output at minimum pressure	OUT_{P_MIN}		3277		
Output at maximum pressure	OUT_{P_MAX}		29491		

Table 16: Digital pressure output (part nr.: 2513130810301)

Part number: 2513130810401

Parameter	Symbol	Value			Unit
		Min	Typ	Max	
Zero pressure offset	OUT_{OFF}		5660		digits
Full scale span	FSS		26214		
Output at minimum pressure	OUT_{P_MIN}		3277		
Output at maximum pressure	OUT_{P_MAX}		29491		

Table 17: Digital pressure output (part nr.: 2513130810401)

Digital output is not ratiometric to the positive supply voltage *VDD*

6.2 Temperature output: digital

Parameter	Symbol	Value			Unit
		Min	Typ	Max	
Output at minimum temperature	OUT_{T_MIN}		8192		digits
Output at maximum temperature	OUT_{T_MAX}		24576		

Table 18: Digital temperature output: all devices

6.3 Interpreting digital pressure values

First two bytes transmitted from the sensor consists of pressure data where the first byte being most significant byte (MSB) and the second byte being least significant byte (LSB). The complete 15-bit pressure value can be obtained by concatenating the two bytes of pressure data. Corresponding pressure in SI unit (Pa) can be obtained from the digital pressure values with the help of sensitivity parameter SEN_P (see section 2.4.2).

Step 1: Get two bytes of pressure data

1. P_H
2. P_L

Step 2: Concatenate two pressure data bytes to obtain complete 15-bit pressure value

$$P_{15bit} = P_H \ \& \ P_L$$

Step 3: Obtain pressure value in SI unit (Pa) with following formula

$$\text{Pressure [kPa]} = [(P_{15bit} - OUT_{P\_MIN}) \times SEN_P)] + P_{MIN}$$

Where,

P_{15bit}	=	Digital pressure value obtained in step 2.
OUT_{P_MIN}	=	Digital output at minimum pressure for the specific part number (See section: 6.1)
SEN_P	=	Sensitivity (digital) for specific part number (See section: 2.4.2)
P_{MIN}	=	Minimum pressure measurement range for specific part number (see section: 2.4.2)

Example:

Pressure data obtained from sensor 2513130810301 (pressure range: 0 to 100 kPa) are:

P_H = 0x16
P_L= 0x1C

Concatenating these 2 bytes (0x161C) to obtain 15-bit decimal value

$$P_{15bit}[\text{digit}] = 5660$$

For part number 25131308103, OUT_{P_MIN} = 3277 digits (See table:16), SEN_P = 3.815 $\times 10^{-3}$ kPa/digits and P_{MIN} = 0 kPa (See table:9).

$$P[\text{kPa}] = (5660\text{-}3277)\ [\text{digit}] \times 3.815 \times 10^{-3} [\text{kPa/digits}] = 9.09\ \text{kPa}$$

6.4 Interpreting digital temperature values

Following the pressure data, temperature data is transmitted as a 3rd and 4th byte. The complete 15-bit temperature value can be obtained by concatenating the two bytes of temperature data, where the 3rd byte being most significant byte (MSB) and the 4th byte being least significant byte (LSB) of the temperature value. Corresponding temperature in SI unit (℃) can be obtained from the digital temperature values with the help of sensitivity parameter SEN_T (see table 11).

Step 1: Get two bytes of temperature data

1. T_H
2. T_L

Step 2: Concatenate the two bytes to obtain complete 15-bit temperature value

$$T_{15bit} = T_H \ \& \ T_L$$

Step 3: Obtain temperature value in SI unit [℃] with following formula

$$\text{Temperature [℃]} = (T_{15bit} - OUT_{T\_MIN}) \times SEN_T$$

Where,

T_{15bit}	=	Digital temperature value obtained in step 2.
OUT_{T_MIN}	=	Digital output at minimum temperature = 8192 [digit] (See table: 18)
SEN_T	=	4.272×10^{-3} [℃/digit] (See table: 11)

Example:

Temperature data obtained from sensor are:

T_H = 0x36
T_L= 0xC5

Concatenating these 2 bytes (0x36C5)to obtain 15-bit decimal value

$$T_{15bit}\text{[digit]} = 14021$$

$$T\text{[℃]} = (14021\text{-}8192)\text{[digit]} \times 4.272 \times 10^{-3} \text{ [digit/℃]} = 24.90 \text{ ℃}$$

7 Reading analog pressure data

The sensors also produce fully calibrated pressure values as a ratiometric analog voltage output, which can be read through *VOUT* pin of the sensor. Following section shows the typical analog voltage values for the sensors at V_{DD} = 5 V.

7.1 Pressure output: analog

Part number: 2513130810001, 2513130810101, 2513130810201

Parameter	Symbol	Value			Unit
		Min	Typ	Max	
Zero pressure offset	OUT_{OFF}		2.5		V
Full scale span	FSS		4		
Output at minimum pressure	OUT_{P_MIN}		0.5		
Output at maximum pressure	OUT_{P_MAX}		4.5		

Table 19: Analog pressure output

Part number: 2513130810301

Parameter	Symbol	Value			Unit
		Min	Typ	Max	
Zero pressure offset	OUT_{OFF}		0.5		V
Full scale span	FSS		4		
Output at minimum pressure	OUT_{P_MIN}		0.5		
Output at maximum pressure	OUT_{P_MAX}		4.5		

Table 20: Analog pressure output (part nr.: 2513130810301)

Part number: 2513130810401

Parameter	Symbol	Value			Unit
		Min	Typ	Max	
Zero pressure offset	OUT_{OFF}		0.87		digits
Full scale span	FSS		4		
Output at minimum pressure	OUT_{P_MIN}		0.5		
Output at maximum pressure	OUT_{P_MAX}		4.5		

Table 21: Analog pressure output (part nr.: 2513130810401)

Analog output voltage is ratiometric* to the positive supply voltage *VDD*.

* *Ratiometric: Output signal changes in proportion to the change in supply voltage.*

8 Physical dimensions

8.1 Sensor drawing

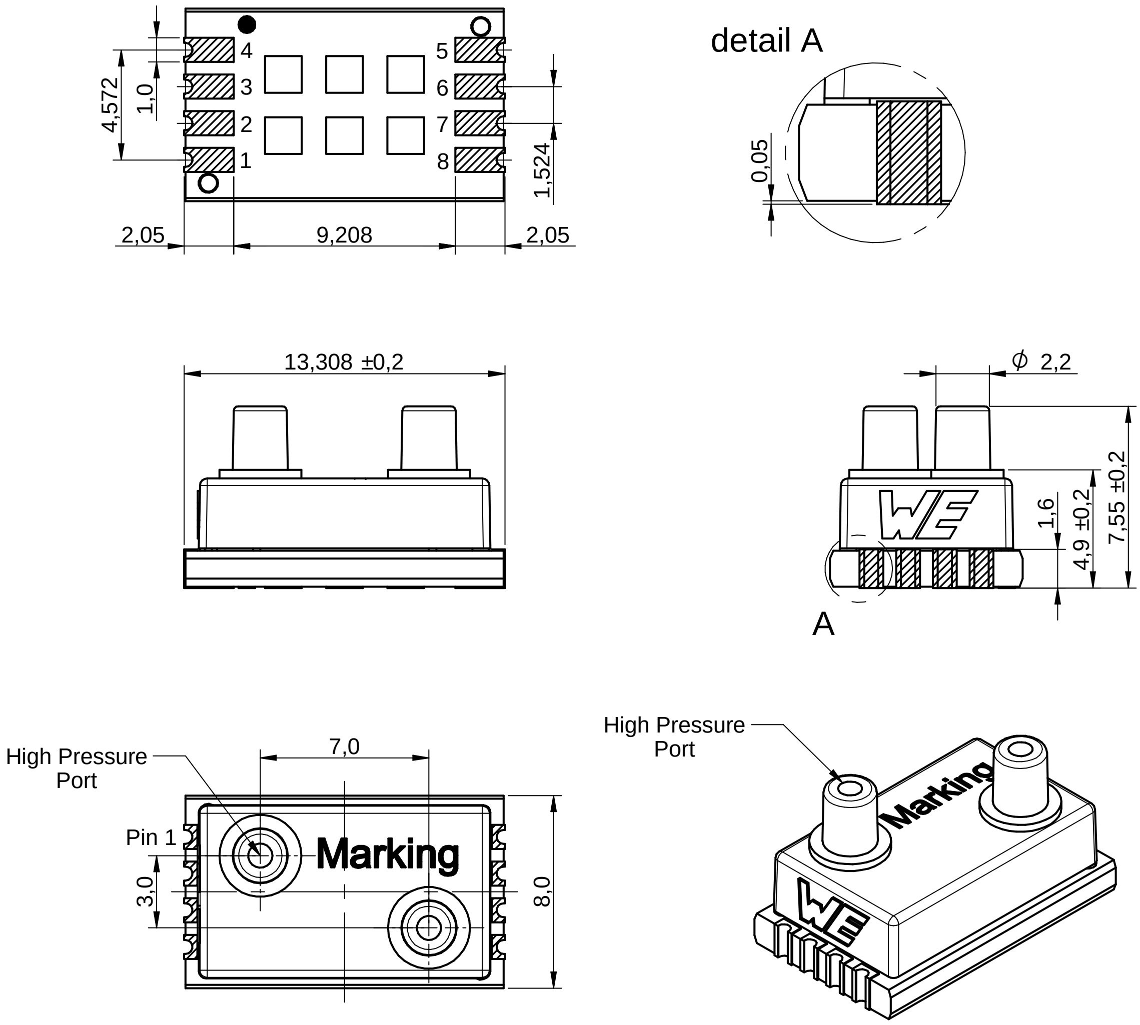


Figure 10: Sensor dimensions [mm]

8.2 Footprint

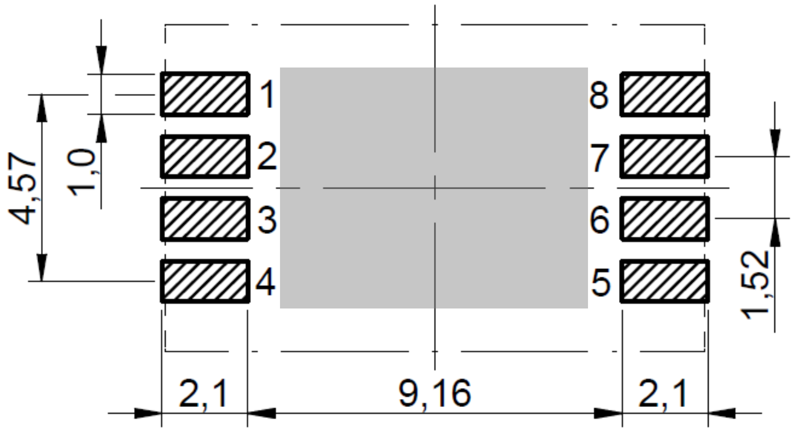


Figure 11: Recommended land pattern [mm] (top view)

Open traces, open wires or vias are not allowed in the centre area of the sensor (marked in grey in the figure 11)

8.3 Marking information

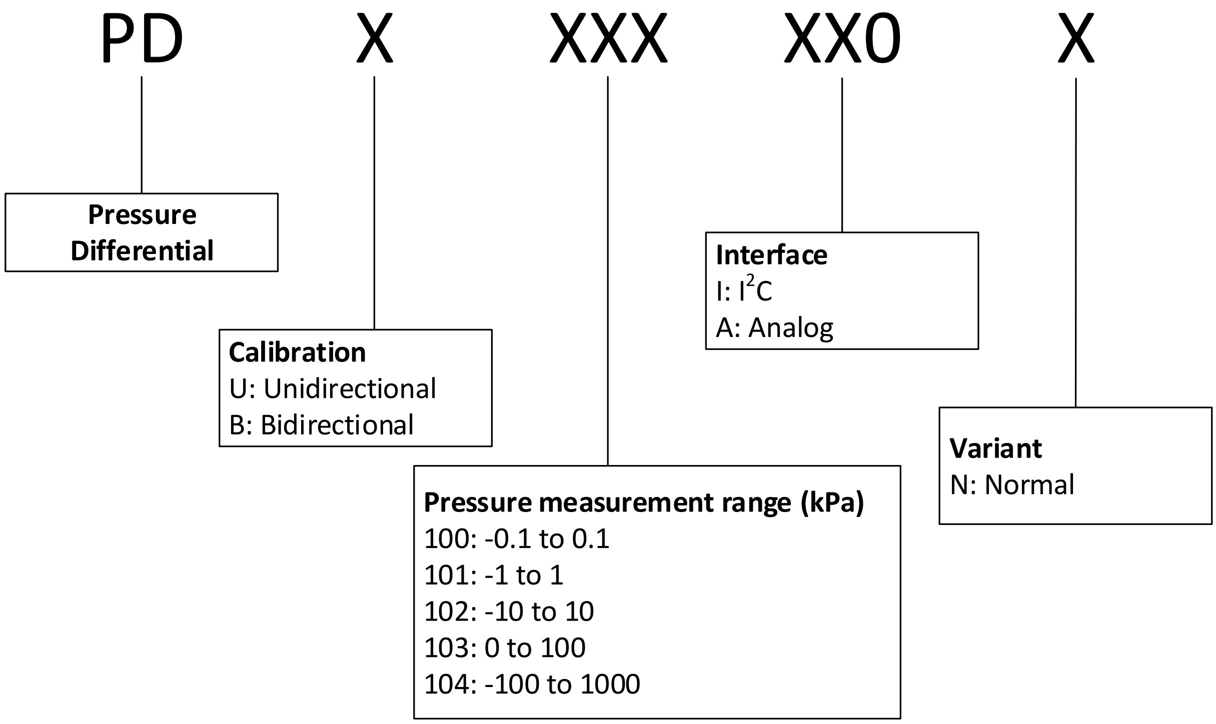


Figure 12: Marking information

Marking PDB101IA0N indicates a differential pressure sensor with measurement range from -1 to 1 kPa. The corresponding WE part number is 2513130810101.

9 Manufacturing information

9.1 Moisture sensitivity level

The sensor product is categorized as JEDEC Moisture Sensitivity Level 3 (MSL3), 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.

9.2 Soldering

9.2.1 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℃
Preheat temperature Max	$T_{S\,Max}$	200℃
Preheat time from $T_{S\,Min}$ to $T_{S\,Max}$	t_S	60 - 120 seconds
Ramp-up rate (T_L to T_P)		3℃ / second max.
Liquidous temperature	T_L	217℃
Time t_L maintained above T_L	t_L	60 - 150 seconds
Peak package body temperature	T_P	see table below
Time within 5℃ of actual preak temperature	t_P	20 - 30 seconds
Ramp-down Rate (T_P to T_L)*		6℃ / second max.
Time 20℃ to T_P		8 minutes max.

Table 22: Classification reflow soldering profile, Note: refer to IPC/JEDEC J-STD-020E

*** In order to reduce residual stress on the sensor component, the recommended ramp-down temperature slope should be lower than 3℃ /s.**

Package thickness	Volume mm³ <350	Volume mm³ 350-2000	Volume mm³ >2000
< 1.6mm	260℃	260℃	260℃
1.6mm - 2.5mm	260℃	250℃	245℃
> 2.5mm	250℃	245℃	245℃

Table 23: Package classification reflow temperature, PB-free assembly, 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 re-flow 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.

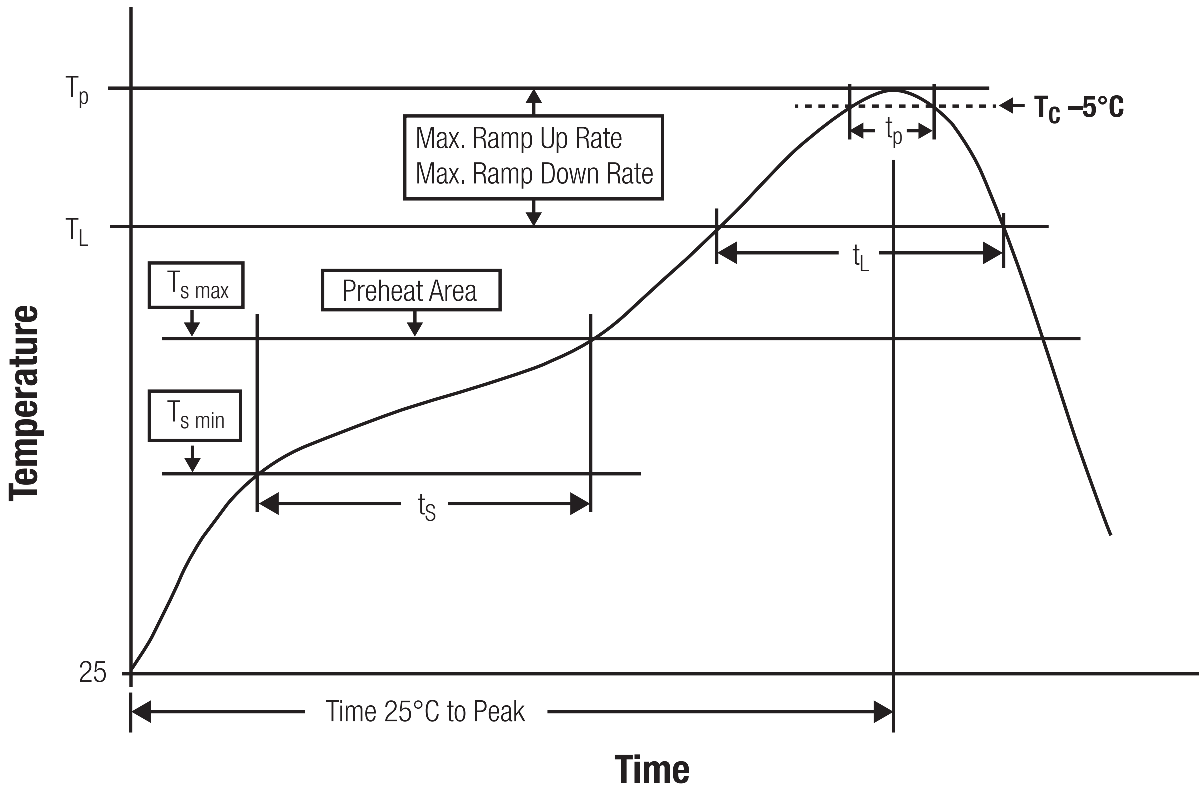


Figure 13: Reflow soldering profile

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

9.2.2 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

9.2.3 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.

9.2.4 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.

9.2.5 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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