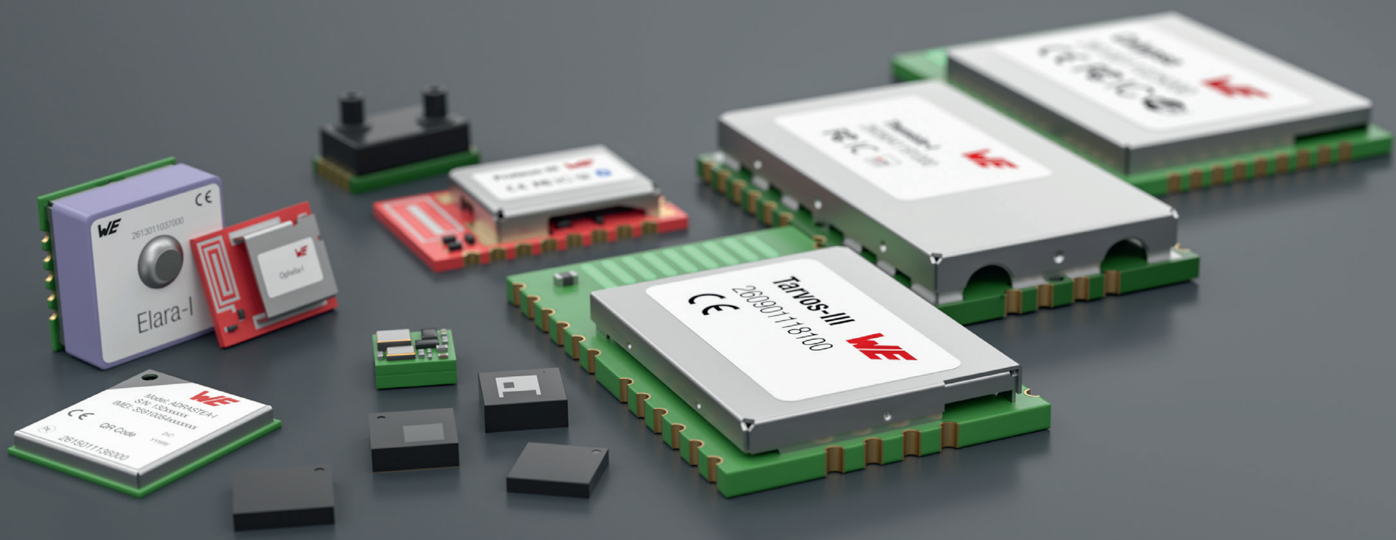


USER MANUAL

WSEN-PDMS

25131308XXX05

VERSION 1.0

NOVEMBER 27, 2025

WÜRTH ELEKTRONIK MORE THAN YOU EXPECT

Revision history

Manual version	Notes	Date
1.0	• Initial release of the manual	November 2025

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
MISO	Master In Slave Out
MOSI	Master Out Slave In
MSB	Most Significant Bit
PCB	Printed Circuit Board
SPI	Serial Peripheral Interface

Contents

Overview of helpful application notes and software resources 5

1 Introduction 6
1.1 Applications . . . 6
1.2 Key features . . . 6
1.3 Ordering information . . . 7
1.4 Block diagram . . . 8

2 Sensor specifications 9
2.1 General information . . . 9
2.2 Media compatibility . . . 9
2.3 Absolute maximum ratings . . . 10
2.4 Pressure sensor specifications . . . 11
2.4.1 Common paramters . . . 11
2.4.2 Part number specific parameters . . . 12
2.5 Temperature sensor specifications . . . 15
2.6 Electrical specifications . . . 15

3 Pinning information 16
3.1 Pin configuration . . . 16
3.2 Pin description . . . 17

4 Digital interface: I²C 18
4.1 General characteristics . . . 18
4.2 *SDA* and *SCL* logic levels . . . 19
4.3 Communication phase . . . 19
4.3.1 Idle state . . . 19
4.3.2 START (S) and STOP (P) condition . . . 19
4.3.3 Data validity . . . 20
4.3.4 Byte format . . . 20
4.3.5 Acknowledge (ACK) and No-Acknowledge (NACK) . . . 20
4.3.6 Slave address for the sensor . . . 21
4.3.7 Read/Write operation . . . 22
4.4 I²C timing parameters . . . 25

5 Digital interface: Serial Peripheral Interface (SPI) 26
5.1 Communcation modes . . . 27
5.2 Data transfer . . . 27
5.3 Sensor SPI Communication . . . 27

6 Application circuit 31

7 Register description 34
7.1 Command register . . . 34
7.2 Temperature register . . . 34
7.3 Pressure register . . . 35
7.4 Status register- synchronized . . . 35

7.5 Status register . . . 37

8 Reading digital output data **38**
8.1 Writing data via I^2C . . . 38
8.2 Reading data via I^2C . . . 38
8.3 Pressure output: digital . . . 40
8.4 Temperature output: digital . . . 41
8.5 Interpreting digital pressure values . . . 42
8.6 Interpreting digital temperature values . . . 43

9 Reading analog pressure data **44**
9.1 Analog pressure output . . . 44

10 Look-up Table **46**

11 Physical specifications **47**
11.1 Sensor drawing: Vertical Nozzles . . . 47
11.2 Sensor drawing: Horizontal-Barbed Nozzles . . . 48
11.3 Footprint . . . 49
11.4 Marking information . . . 50

12 Manufacturing information **51**
12.1 Moisture sensitivity level . . . 51
12.2 Reflow soldering . . . 51
12.3 Cleaning and washing . . . 53
12.4 Potting and coating . . . 53
12.5 Storage conditions . . . 53
12.6 Handling . . . 53

13 Important notes **55**

14 Legal notice **55**

15 License terms for Würth Elektronik eiSos GmbH & Co. KG sensor product software and source code **56**

Overview of helpful application notes and software resources

Application notes

Application note ANM001 - MEMS Sensor PCB design and soldering guideline

http://www.we-online.com/ANM001
This technical document provides necessary information and general guidelines for soldering and PCB design for the Würth Elektronik eiSos MEMS sensor products with an LGA surface-mount package.

Application note ANR034 - How to use Zephyr sensor drivers

http://www.we-online.com/ANR034
The application note shows how to integrate the Zephyr drivers of Würth Elektronik eiSos sensors into the user's application source code to use Würth Elektronik eiSos sensors in the user's end device.

Software resources

https://github.com/WurthElektronik/Sensors-SDK_STM32
The Sensor Software Development Kit (SDK) is a set of software tools that enable rapid software integration of Würth Elektronik eiSos sensors into the application software on the host MCU.

Zephyr sensor driver

https://github.com/zephyrproject-rtos/zephyr/tree/main/drivers/sensor/wsen/
The Zephyr sensor driver provides native support for integrating Würth Elektronik eiSos sensors into applications running on the Zephyr RTOS.

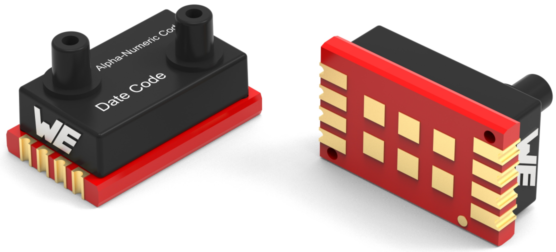
1 Introduction

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 I^2C 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 mm reflow solderable surface mount package with two pressure ports on top, allowing manifold mounting or two barbed ports on the side for direct tube connections.

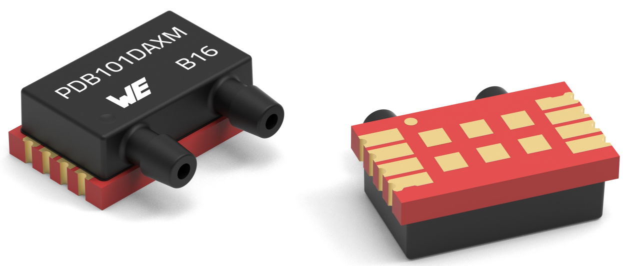
1.1 Applications

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



1.2 Key features

- Available in different pressure ranges
  - $\pm$ 1 kPa
  - $\pm$ 10 kPa
  - $\pm$ 350 kPa
  - 0 to 100 kPa
  - -100 kPa to 1000 kPa
- Supply voltage: 3 V to 5.5 V
- Analog and digital output for pressure
- Communication interface: I^2C, SPI
- Temperature range: -25 °C to 85 °C
- Typical current consumption: 4.6 mA



1.3 Ordering information

WE order code	Pressure range [kPa]	Marking	Dimensions [mm]	Description
2513130810105	± 1	PDB101DAXM	13.3x11.6 x4.5	Horizontal barbed ports
2513130810205	± 10	PDB102DAXM		
2513130835205	± 35	PDB352DAXM		
2513130810305	0 to 100	PDU103DAXM	13.3 x 8.0 x 7.5	Vertical straight ports
2513130810405	-100 to 1000	PDU104DAXM		

Table 1: Ordering information

1.4 Block diagram

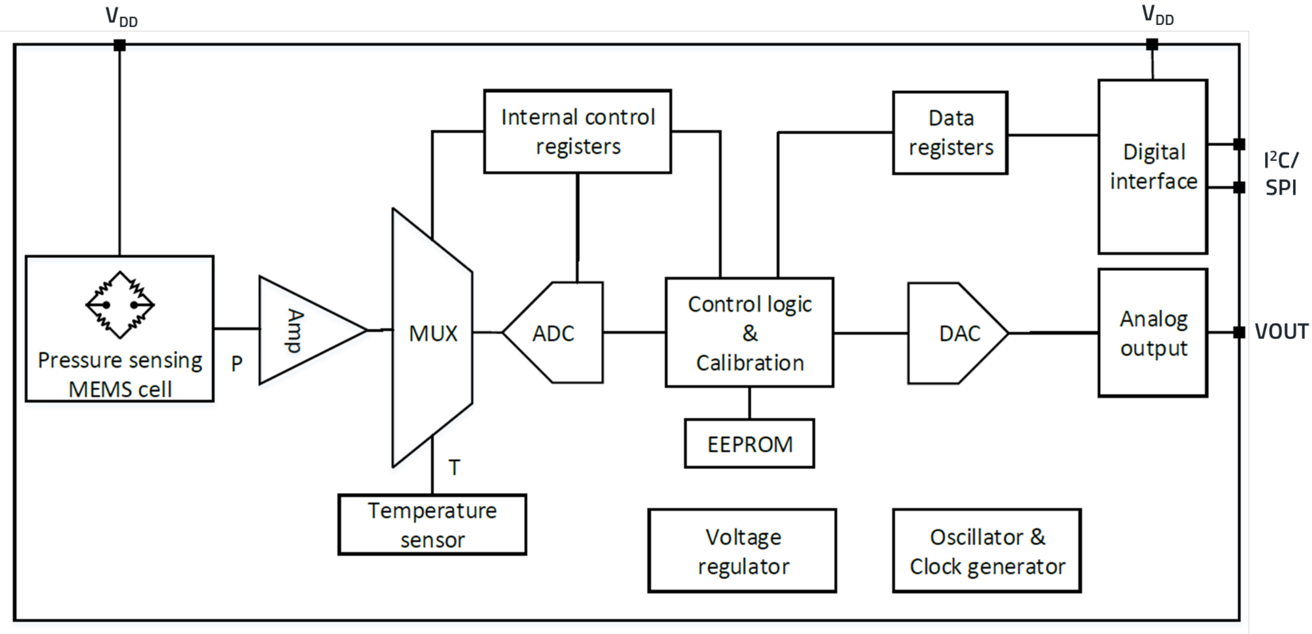


Figure 1: Block diagram

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 I²C or SPI interface.

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

Pressure values are also available as an analog voltage output. 16-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 °C up to +85 °C
Compensated temperature range[1]	0 °C to 70 °C
Storage conditions (in original packaging)	up to 125 °C; < 75% RH
Communication interface	I^2C, SPI and Analog
Moisture sensitivity level (MSL)	1
Electrostatic discharge protection (HBM)	2 kV

Table 2: General information

2.2 Media compatibility

Port	Information
High pressure port[2]	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.
[2] Refer to figure 22 and figure 23 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}	25131308xxx05	-0.3	6	V
Input voltage control pins	V_{IN_MAX} [3]	25131308xxx05	-0.3	V_{DD} + 0.3	V
Differential over pressure[4]	P_{OVER}	2513130810105		10	kPa
		2513130810205		100	
		2513130835205		100	
		2513130810305		300	
		2513130810405		2500	
Differential burst pressure[5]	P_{BURST}	2513130810105		10	kPa
		2513130810205		150	
		2513130835205		170	
		2513130810305		500	
		2513130810405		2500	

Table 4: Absolute maximum ratings

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.

[3] SCL, SDA/MISO, SAO/CS and MOSI are control pins. The maximum allowed voltage on these pins must be always < 6 V.
[4] 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.
[5] This is the pressure that may be applied to the sensor without causing leakage and permanent damage to the sensing element.

2.4 Pressure sensor specifications

Unless otherwise stated, all the specified values were measured under the following condition: V_{DD} = 3.3 V ; T = 25 °C

2.4.1 Common paramters

Following pressure sensor parameters are applicable to part number: 25131308xxx05

Parameter	Symbol	Test conditions	Value			Unit
			Min	Typ	Max	
Nonlinearity [6]	ACC_{P_NL}		-0.3	±0.1	0.3	%FSS
Resolution (ADC)	RES_P			16		bit
Resolution (DAC)	RES_{P_DAC}			16		bit
Response time	t_{RESP}			2.5		ms

Table 5: Pressure sensor specifications (part nr.: 25131308xxx05)

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

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

2.4.2 Part number specific parameters

Unless otherwise stated, all the specified values were measured under the following condition: V_{DD} = 3.3 V ; T = 25 °C

Part number: 2513130810105

Parameter	Symbol	Test conditions	Value			Unit
			Min	Typ	Max	
Measurement range	P_{RANGE}		-1		1	kPa
Absolute accuracy [7]	ACC_{P_ABS}	T = 25 °C	-1	±0.5	1	%FSS
Total accuracy [8]	ACC_{P_TOT}	T = 0 to 70 °C	-1.5	±0.75	1.5	%FSS
Sensitivity (digital)	SEN_P			7.63×10^{-5}		kPa/digit
Repeatability [9]	ACC_{P_REP}			±0.05		%FSS
Long term drift	ACC_{P_DRIFT}			±0.1		%FSS

Table 6: Pressure sensor specifications (part nr.: 2513130810105)

Part number: 2513130810205

Parameter	Symbol	Test conditions	Value			Unit
			Min	Typ	Max	
Measurement range	P_{RANGE}		-10		10	kPa
Absolute accuracy [7]	ACC_{P_ABS}	T = 25 °C	-1	±0.5	1	%FSS
Total accuracy [8]	ACC_{P_TOT}	T = 0 to 70 °C	-1.5	±0.75	1.5	%FSS
Sensitivity (digital)	SEN_P			7.63×10^{-4}		kPa/digit
Repeatability [9]	ACC_{P_REP}			±0.05		%FSS
Long term drift	ACC_{P_DRIFT}			±0.1		%FSS

Table 7: Pressure sensor specifications (part nr.: 2513130810205)

[7] Absolute accuracy includes effects of non-linearity, pressure hysteresis, offset, span and repeatability at room temperature.
[8] Total accuracy includes all effects of offset, non-linearity, pressure hysteresis, span, repeatability and thermal effects between the compensated temperature range 0 °C and 70 °C.
[9] Repeatability is the typical deviation of the sensor output after 10 pressure cycles.

Part number: 2513130835205

Parameter	Symbol	Test conditions	Value			Unit
			Min	Typ	Max	
Measurement range	P_{RANGE}		-35		35	kPa
Absolute accuracy [7]	ACC_{P_ABS}	T = 25 ℃	-1	±0.5	1	%FSS
Total accuracy [8]	ACC_{P_TOT}	T = 0 to 70 ℃	-0.75	±0.25	0.75	%FSS
Sensitivity (digital)	SEN_P			2.67×10^{-3}		kPa/digit
Repeatability [9]	ACC_{P_REP}			±0.05		%FSS
Long term drift	ACC_{P_DRIFT}			±0.1		%FSS

Table 8: Pressure sensor specifications (part nr.: 2513130835205)

Part number: 2513130810305

Parameter	Symbol	Test conditions	Value			Unit
			Min	Typ	Max	
Measurement range	P_{RANGE}		0		100	kPa
Absolute accuracy [7]	ACC_{P_ABS}	T = 25 ℃	-0.3	±0.1	0.3	%FSS
Total accuracy [8]	ACC_{P_TOT}	T = 0 to 70 ℃	-0.75	±0.25	0.75	%FSS
Sensitivity (digital)	SEN_P			3.815×10^{-3}		kPa/digit
Repeatability [9]	ACC_{P_REP}			±0.01		%FSS
Long term drift	ACC_{P_DRIFT}			±0.05		%FSS

Table 9: Pressure sensor specifications (part nr.: 2513130810305)

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

Part number: 2513130810405

Parameter	Symbol	Test conditions	Value			Unit
			Min	Typ	Max	
Measurement range	P_{RANGE}		-100		1000	kPa
Absolute accuracy [7]	ACC_{P_ABS}	T = 25 ℃	-0.3	±0.1	0.3	%FSS
Total accuracy [8]	ACC_{P_TOT}	T = 0 to 70 ℃	-0.75	±0.25	0.75	%FSS
Sensitivity (digital)	SEN_P			4.196×10^{-2}		kPa/digit
Repeatability [9]	ACC_{P_REP}			±0.01		%FSS
Long term drift	ACC_{P_DRIFT}			±0.05		%FSS

Table 10: Pressure sensor specifications (Part nr.: 2513130810405)

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

2.5 Temperature sensor specifications

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 ℃.

Parameter	Symbol	Test conditions	Value			Unit
			Min	Typ	Max	
Operating supply voltage	V_{DD}		3.0		5.5	V
Current consumption	I_{DD}	V_{DD} = 5.0 V		4.6		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}		0.85 * V_{DD}			V
Digital output voltage-low-level	V_{IL}				0.1 * V_{DD}	V

Table 12: Electrical specifications

For a stable current consumption when only "Analog output" is used it is recommended to connect SCL and SDA pins to ground.

3 Pinning information

3.1 Pin configuration

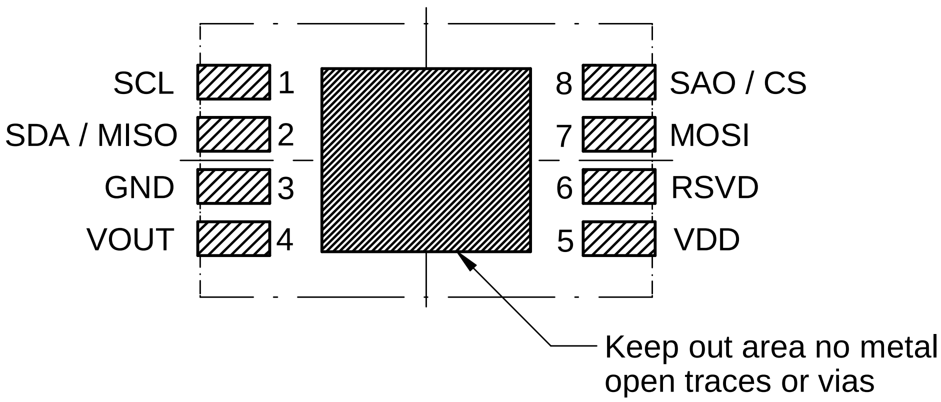


Figure 2: Pin specifications - vertical nozzles (top view)

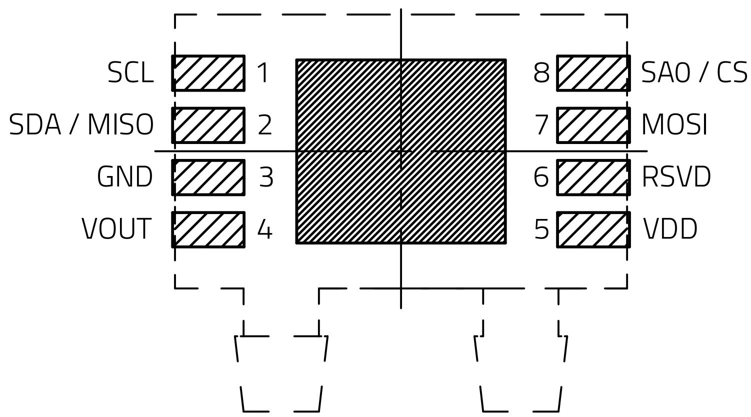


Figure 3: Pin specifications- horizontal nozzles (top view)

3.2 Pin description

Pin No.	Name	Function	Input/output	Comments
1	*SCL*	I^2C /SPI serial clock	Input	
2	*SDA* / *MISO*	I^2C serial data /SPI data out	Input/Output	
3	*GND*	Negative supply voltage	Supply	
4	*VOUT*	Analog output	Output	
5	*VDD*	Positive supply voltage	Supply	
6	*RSVD*	Reserved		Do not connect
7	*MOSI*	SPI data in	Input	
8	*SA0* / *CS*	I^2C address select / SPI chip select	Input	

Table 13: Pin description

4 Digital interface: I²C

The sensor supports standard I²C (Inter Integrated Circuit) bus protocol. I²C is a serial 8-bit protocol with two-wire interface that supports communication between different ICs, for example, between microcontrollers and other peripheral devices[1].

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 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. Therefore, 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. A master device generates the clock pulse, a start condition and a stop condition 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 functions like a slave device on the I²C bus.

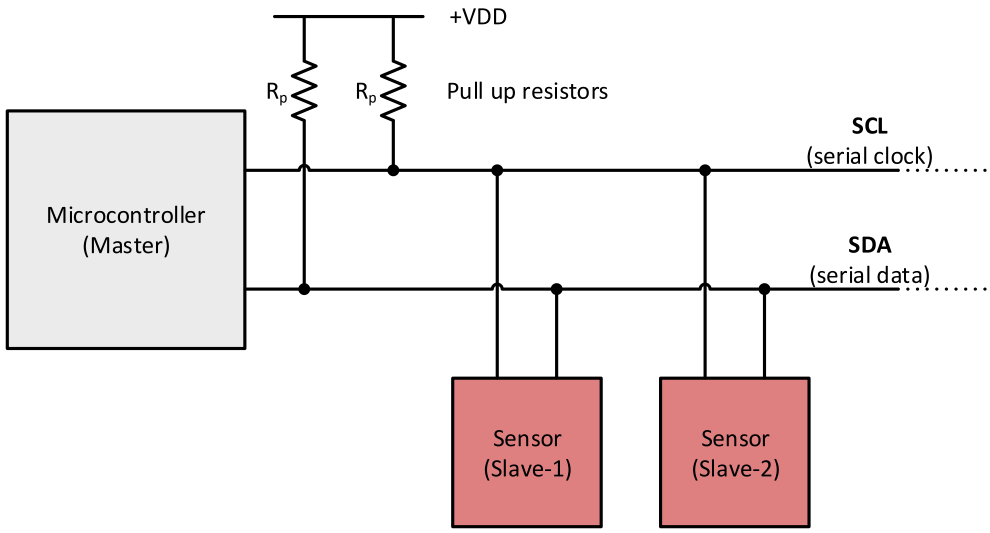


Figure 4: Master-slave concept

[1] Further information about the I²C interface can be found at *https://www.nxp.com/docs/en/user-guide/UM10204.pdf*.

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 5.

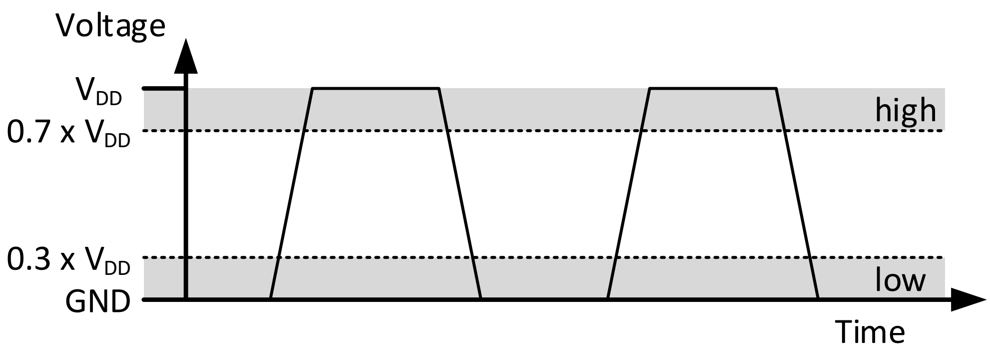


Figure 5: *SDA* and *SCL* logic levels

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 6 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.

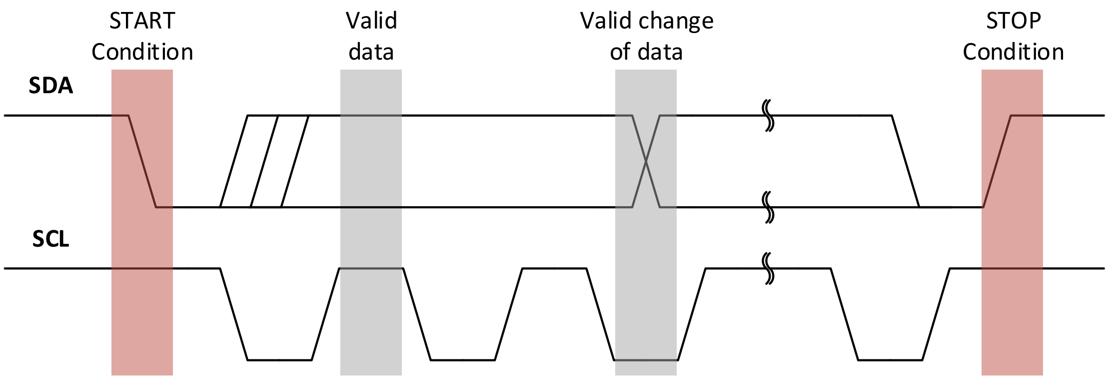


Figure 6: Data validity, START and STOP condition

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.

MSB ... LSB

SA[7]	SA[6]	SA[5]	SA[4]	SA[3]	SA[2]	SA[1]	SA[0]
1	1	0	1	1	0/1	0/1	0=Write 1=Read

7 – bit slave address (SA[7] to SA[1])

Figure 7: Slave address format

In I^2C mode, slave address bit SA[2] is defined by the pin SA0/CS. SA[1] bit selects - either CRC protected or unprotected the I^2C communication mode. Thus, each device can be configured with two separate I^2C addresses. The CRC protected and unprotected communication can be interleaved.

7-bit Slave address (Hex)	
0x6C	SA0/CS pin connected to GND via Pull-down ; data read with CRC
0x6D	SA0/CS pin connected to GND via Pull-down ; data read without CRC
0x6E	SA0/CS pin connected to VDD via Pull-up; data read with CRC
0x6F	SA0/CS pin connected to VDD via Pull-up; data read without CRC

Figure 8: Slave address configuration

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

4.3.7 Read/Write 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.

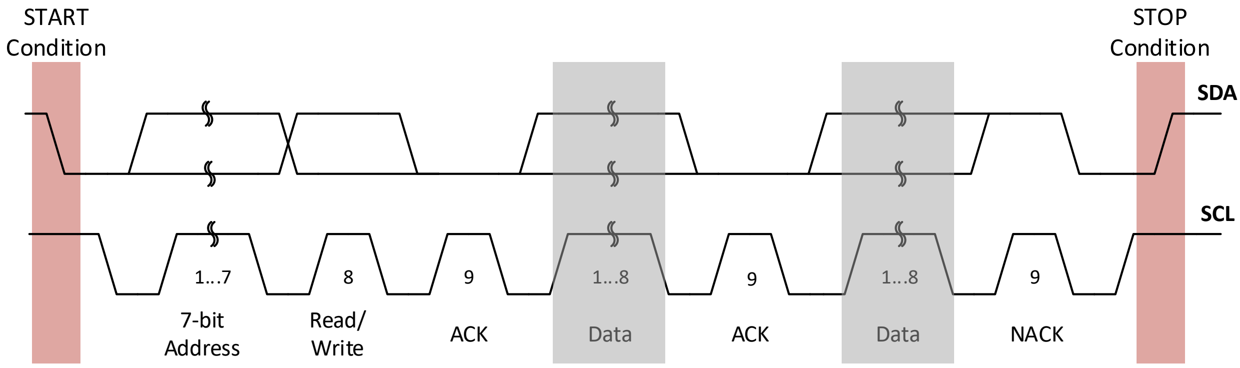


Figure 9: Complete data transfer

The host controller (master) can read from and write to the memory addresses (registers) of the slave using following comands.

Random write

Sets a starting register address and writes data sequentially to the device beginning from that register.

Random read

Sets a starting register address and reads sequential data from the device starting at that register.

Read last

Reads data from the device beginning at the last register address set by the master, allowing repeated reads without resending the register address.

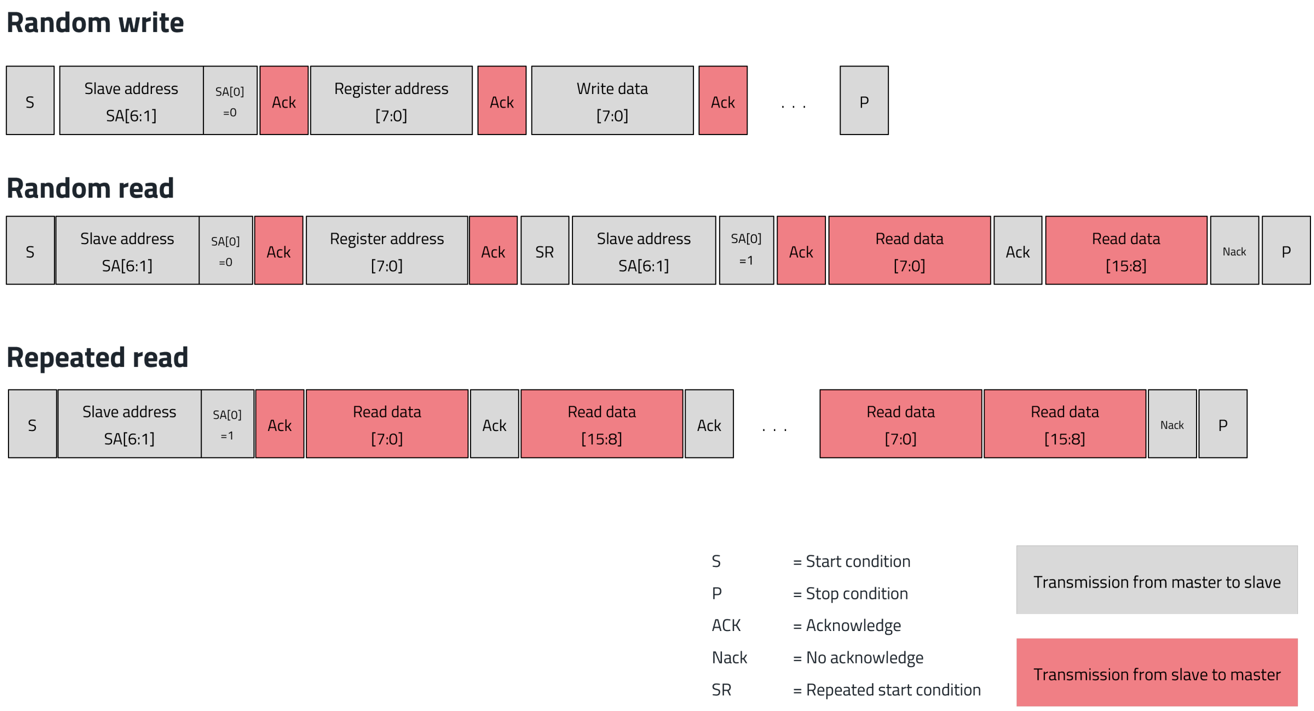


Figure 10: I²C Read and Write command format (No CRC)

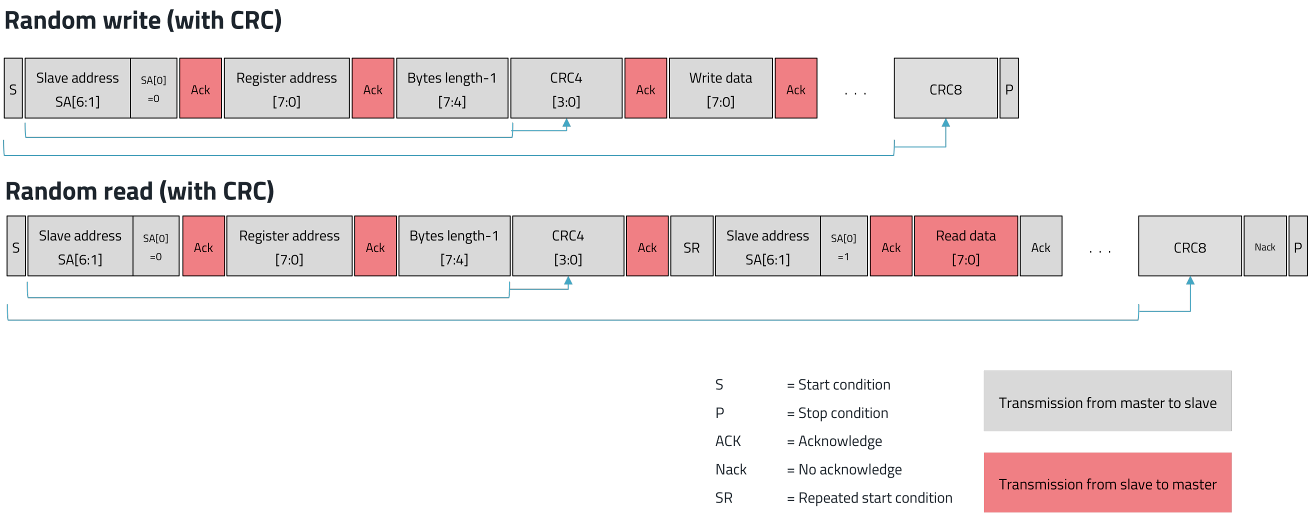


Figure 11: I²C Read and Write command format (with CRC)

The R/W bit SA[0] follows the 7-bit slave address and defines the direction of data transfer. A R/W bit = '0' indicates a write operation (data is written to slave), and R/W = 1 indicates a read operation (data is read from slave).

This is followed by the register address which specifies the location of the register to be written to or read from.

The read/write data is transferred MSB first - low byte before the high byte.

In case of the CRC read/write operation it is also necessary to indicate the number of bytes to be transferred. The length field (bits [7:4]) indicates the number of data bytes to transfer, minus one. For example, a value of '0001' means two bytes will be transferred. All frames must transfer an even number of bytes.

The maximum length for CRC-protected read/write frames is 4 bytes each. For unprotected frames, the length is unlimited.

CRC4 and CRC8 are computed in the same bit and byte order as they are transmitted over the bus. The CRC polynomials are defined as below to compute the CRC.

	Polynomial	Initialization value
CRC4	0x03 ($x^4 + x^1 + x^0$)	0x0F
CRC8	0xD5 ($x^8 + x^7 + x^6 + x^4 + x^2 + x^0$)	0xFF

Table 14: CRC Polynomial

To detect communication errors, it is generally recommended that the master checks the ACK/NACK bits from the slave. If CRC is used, the master should also verify the CRC8 checksums sent by the slave.

if a random read/write command is aborted by a CRC4 error, no read last command may follow.

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}	0.8		µs
Hold time for START condition	t_{HD_S}	0.6		µs
Setup time for (repeated) START condition	f_{SCL}	600		ns
SDA setup time	t_{SU_SDA}	100		ns
SDA data hold time	t_{HD_SDA}	0		ns
Setup time for STOP condition	t_{SU_P}	600		ns
Bus free time between STOP and START condition	t_{BUF}	600		ns

Table 15: I²C timing parameters

5 Digital interface: Serial Peripheral Interface (SPI)

Serial Peripheral Interface (SPI) is a synchronous serial communication bus system for the communication between host microcontroller and other peripheral ICs such as ADCs, EEPROMs, sensors, etc. SPI is a full-duplex master-slave based interface allowing the communication to happen in both directions simultaneously. The data from the master or the slave is synchronized either on the rising or falling edge of clock pulse. 4-wire interface consists of two signal lines and two data lines.

1. Clock (SCL)
2. Chip select (CS)
3. Master out, slave in (MOSI)
4. Master in, slave out (MISO)

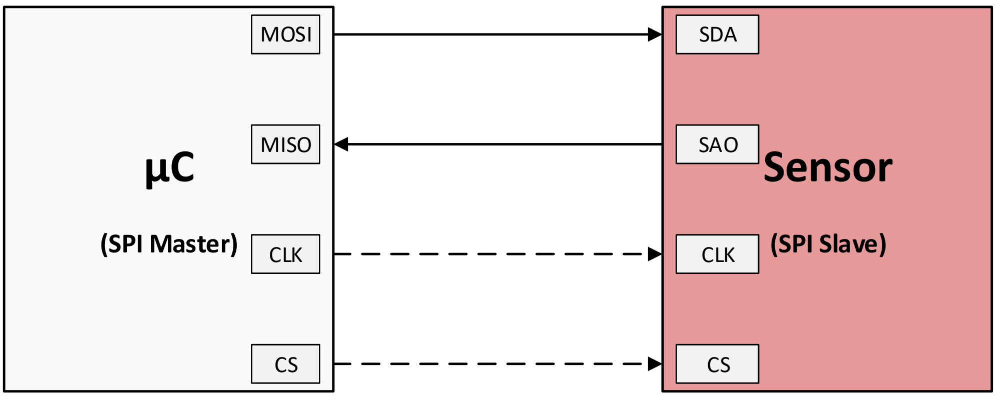


Figure 12: SPI Interface

Master generates the clock signal and is connected to all slave devices. Data transmission between the master and slaves is synchronized to the clock signal generated by the master.

One master can be connected to one or more slave devices. Each slave device is addressed and controlled by the master via individual chip select (CS) signals. CS is controlled by the master and is normally an active low signal.

MOSI and MISO are data lines. MOSI transmits data from the master to the slave. MISO transmits data from the slave to the master.

> ! This sensor supports 4-Wire SPI interface

5.1 Communcation modes

In SPI, the master can select the clock polarity (CPOL) and clock phase (CPHA). The CPOL bit sets the polarity of the clock signal during the idle state. The CPHA bit selects the clock phase. Depending on the CPHA bit, the rising or falling clock edge is used to sample and shift the data. Depending on the CPOL and CPHA bit selection in the SPI control registers, four SPI modes are available as per table 16. In order to ensure proper communication, master and the slave must be set to same communication modes.

CPOL	CPHA	Desription
0	**0**	**Clock polarity LOW in idle state; Data sampled on the rising clock edge**
0	1	Clock polarity LOW in idle state; Data sampled on the falling clock edge
1	1	Clock polarity HIGH in idle state; Data sampled on the falling clock edge
1	0	Clock polarity HIGH in idle state; Data sampled on the rising clock edge

Table 16: SPI communication modes

The sensor operates by default in Mode 0, meaning CPOL and CPHA bits are '0'

5.2 Data transfer

Communication begins when the master selects a slave device by pulling the CS line to LOW. The clock and data lines (MOSI/MISO) are available for the selected slave device. Data stored in the specific shift registers are exchanged synchronously between master and the slave through MISO and MOSI lines. The data transmission is over when the CS line is pulled up to the HIGH state. 4-wire SPI uses both data lines for the synchronous data exchange in both the direction.

5.3 Sensor SPI Communication

4-Wire SPI of this sensor uses following lines: MOSI, MISO, SCL (serial clock) and CS (chip select). For more information, please refer to pin description in the section 3.2

The sensor supports following read and write commands:
Random write:
Sets a starting register address and writes data sequentially to the device beginning from that register.
Random read:
Sets a starting register address and reads sequential data from the device starting at that register.

SPI data transfer begins when CS is pulled LOW by the master. The communication ends when the CS is pulled high.

Register Address							R/$\overline{W}$	0 = Write 1= Read
A[7]	A[6]	A[5]	A[4]	A[3]	A[2]	A[1]	A[0]	

Figure 13: SPI register address

The register address field specifies the byte address of the first register to be read from or written to. Only word-aligned (16-bit) read/write operations are supported and the least significant bit (LSB) of the register address is not considered in the frame. Instead, the LSB of the first byte (register address) sent is used to indicate whether the operation is a read or a write. When R/W is '0', the data is written on to the sensor. When '1', the data is read from the sensor.

> **!** All read and write operations begin at word-aligned addresses and one word represents 16 bits (2 bytes), meaning the least significant bit (LSB) of the register address must be 0 and only even number of bytes transfer is allowed.

The next byte of data, specifies whether the SPI read/write operation is carried out with CRC or without CRC. Communication is CRC protected if the most significant bit (MSB) B[7] of the second byte sent by the master is '1'. Next three bits B[6:4] specifies the number of words (16 bit data) to be transferred minus one. For example, a value of '001' means two 16 bit words (4 bytes) will be transferred. If CRC protected transfer is used, bits B[3:0] are used to send the CRC4 value other wise these bits are always '0000'.

2nd Byte (sent by master)							
B[7]	B[6]	B[5]	B[4]	B[3]	B[2]	B[1]	B[1]
CRC bit	(Number of words to transfer) - 1			CRC4 / 0000			

Figure 14: SPI CRC byte

CRC4 and CRC8 are computed in the same bit and byte order as they are transmitted over the bus. The CRC polynomials are calculated as below

	Polynomial	Initialization value
CRC4	0x03 ($x^4 + x^1 + x^0$)	0x0F
CRC8	0x07 ($x^8 + x^7 + x^6 + x^4 + x^2 + x^0$)	0xF3

Table 17: CRC Polynomial

Complete SPI read and write sequence is showed in the figure 15 and figure 16

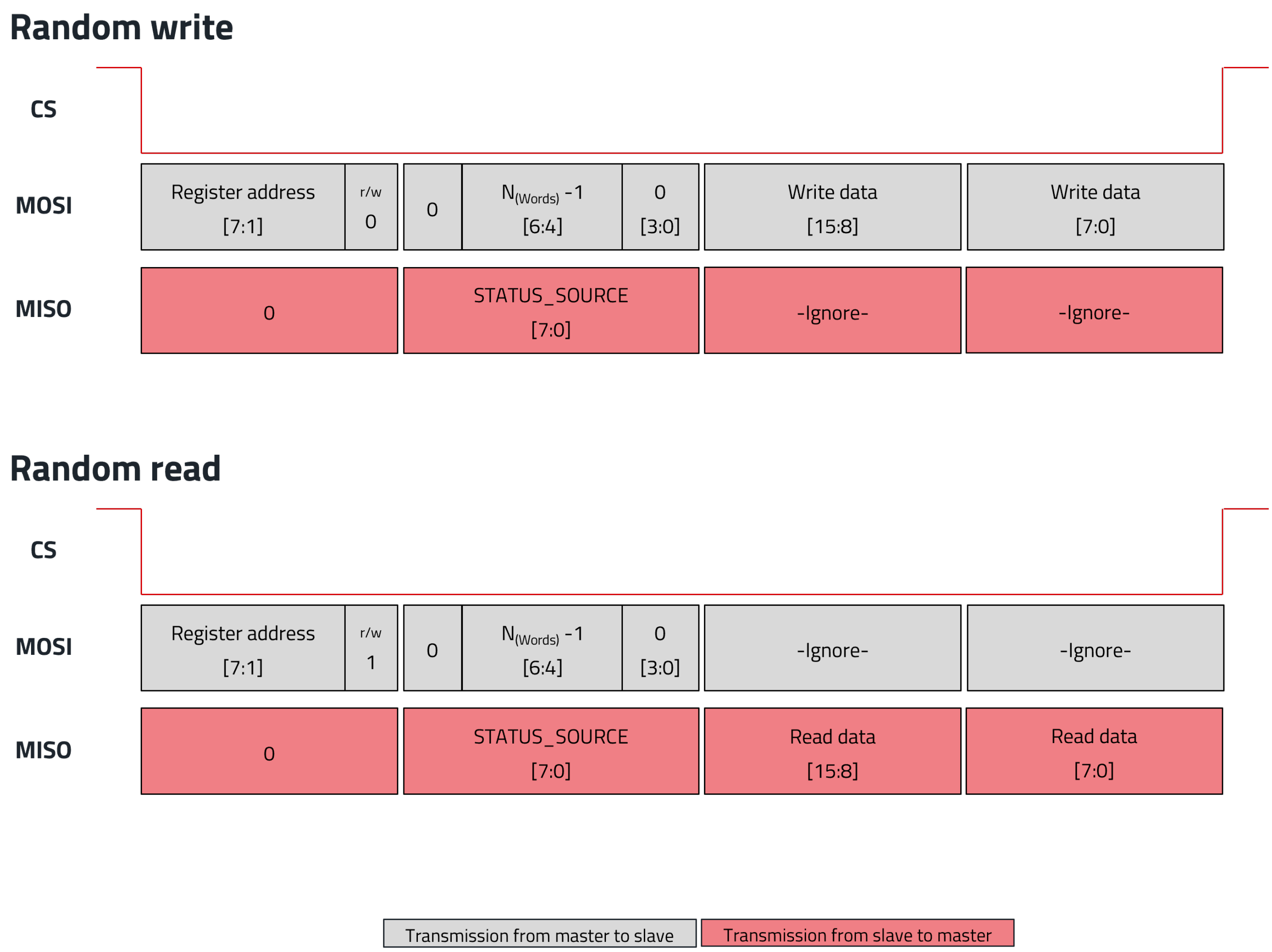


Figure 15: SPI Read and Write command format (No CRC)

For CRC-protected transfer, the maximum data length is 16 bytes for read operations and 4 bytes for write operations. For normal data transfer, the maximum read/write data length is 16 bytes.

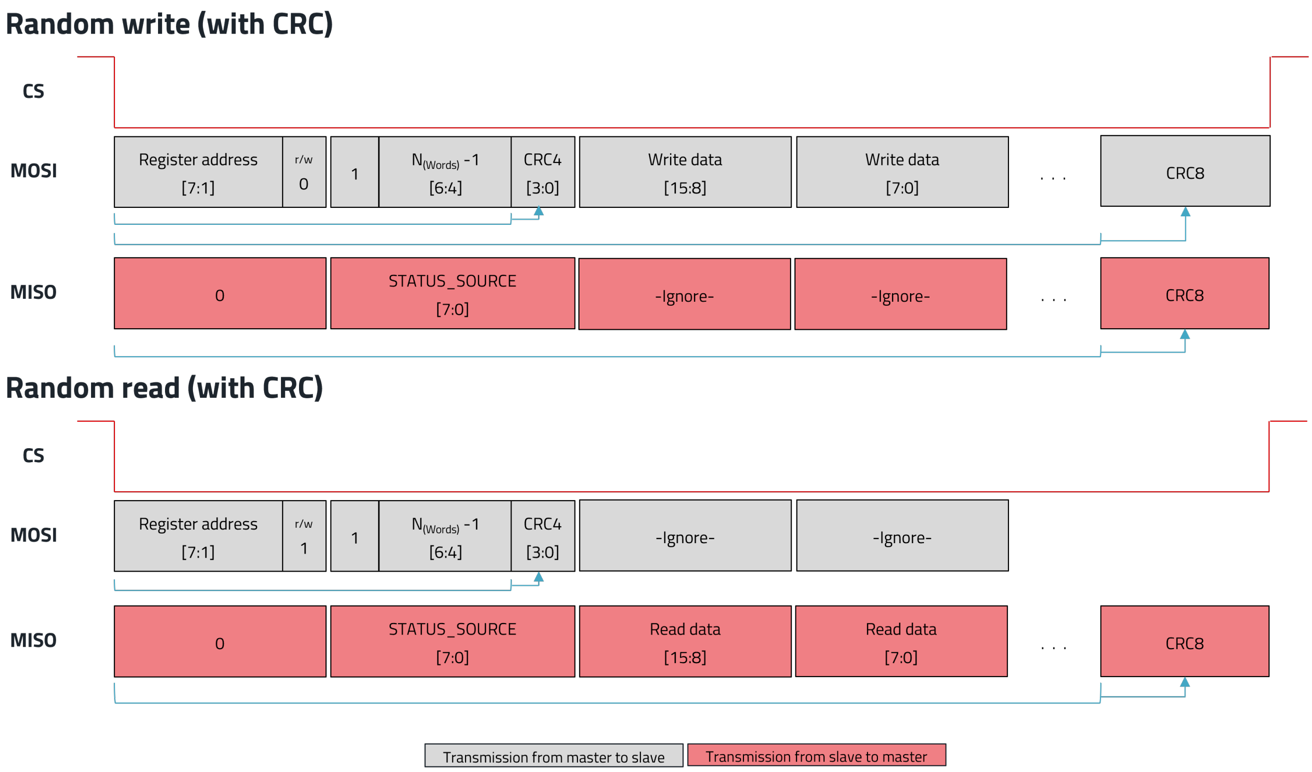


Figure 16: SPI Read and Write command format (with CRC)

6 Application circuit

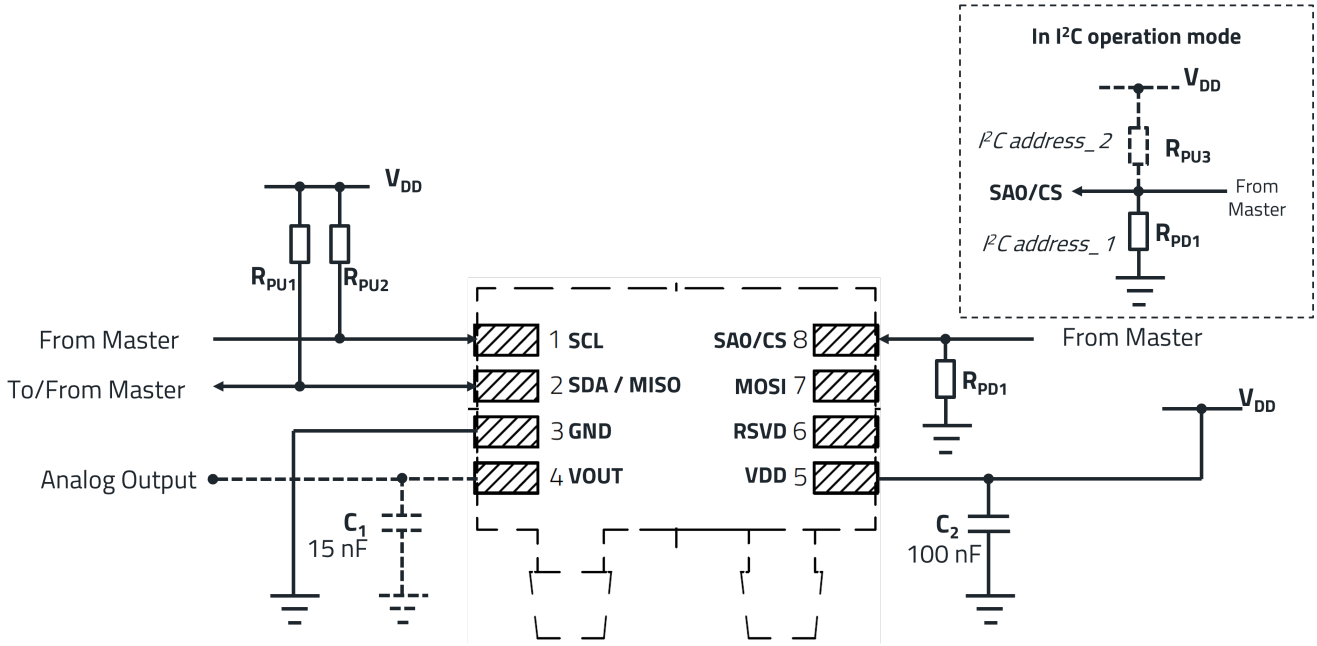


Figure 17: Application circuit with I^{2}C interface (top view)

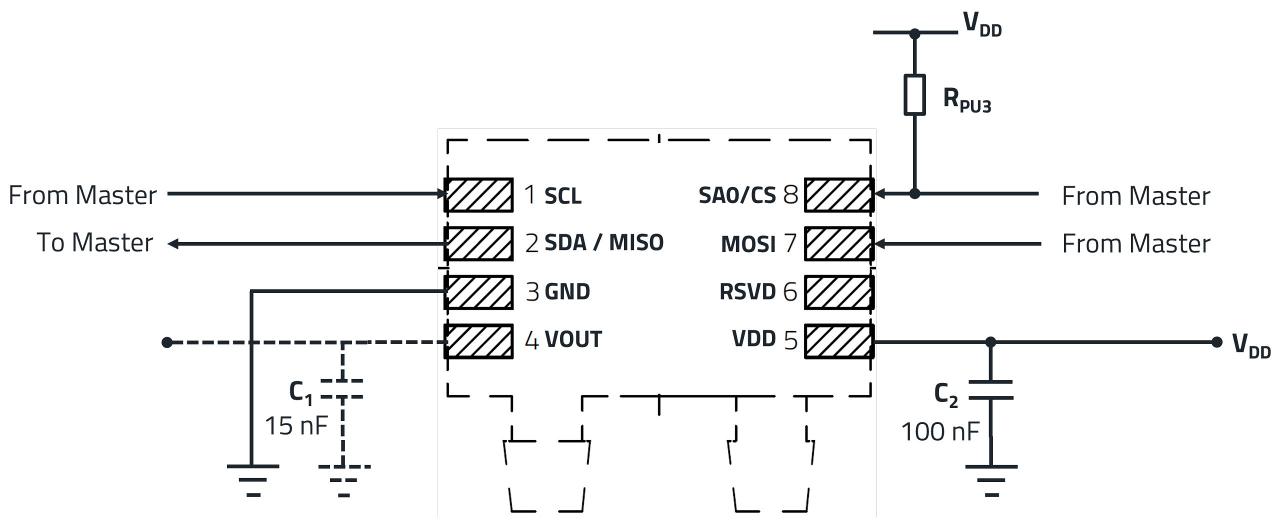


Figure 18: Application circuit with SPI interface (top view)

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 100 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.
Pin *SA0* / *CS* has dual functionality based on how it is connected.

***SA0* / *CS* at power on:**

- Connected to *GND* via external pull-down resistors enables I^2C communication
- Connected to *VDD* via external pull-up resistors enables SPI communication

***SA0* / *CS* in operation:**

- In I^2C communication mode *SA0* / *CS* defines the I^2C slave address.
  SA0 / *CS* connected to *GND* defines the I^2C slave address 0x6C
  SA0 / *CS* connected to *VDD* defines the I^2C slave address 0x6E
- In SPI mode, the master (host microcontroller) pulls down the *SA0* / *CS* pin indicating start of data transfer.

When using I^2C interface, *SCL* and *SDA* must be connected to *VDD* through the pull-up resistors R_{PU1} and R_{PU2}. Proper value of the pull-up resistors must be chosen depending on the I^2C bus speed and load. The sensor does not have internal pull-up resistors.

Pull-up resistors R_{PU1} and R_{PU2} on *SCL* and *SDA* must be >2.2 k Ω

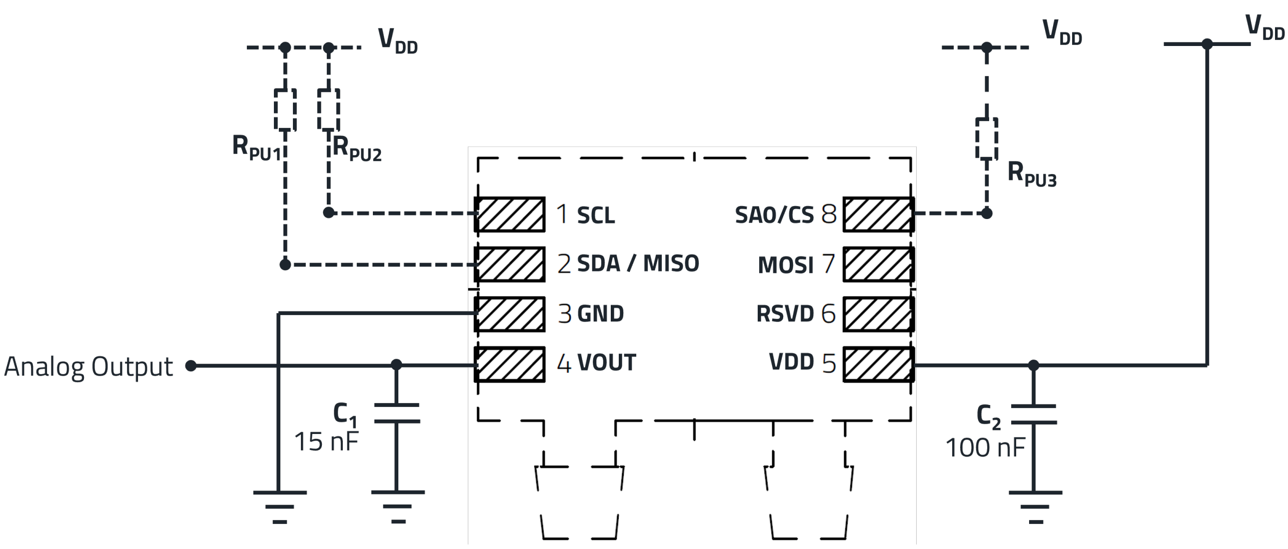


Figure 19: Application circuit with analog interface (top view)

For a stable operation of sensor in analog only mode, it is recommended to connect SCL, SDA/MISO and SA0/CS pins either to VDD via pull-up resistors or to ground via pull-down resistors.

If both digital I^2C and analog interfaces are used simultaneously, it is recommended to route these lines as far from each other as possible.

Avoid routing of the *VDD*, *SDA*/*MISO*, *MOSI* and *SA0* / *CS* lines underneath the sensor (see section 11.3 for further information).

7 Register description

Register read and write operations are performed via the digital communication interface (I^2C or SPI). After power-up, all registers are write-protected by default, except for the STATUS_SOURCE and CMD registers.

All registers represent word-aligned (16-bit) data.

7.1 Command register

CMD (0x22)

Address: 0x22
Type (r/w): R/W
Default Value [15:0]: 0x00

This register controls the state of the sensor and can be used to put the sensor either to SLEEP mode or RESET mode.

Write bytes	Description
0x6C32	SLEEP mode Puts sensor in sleep mode. Internal IC is powered down and all I/O pins are in High-Impedence state. The sensor wakes up on the rising edge signal on SCL pin
0xB169	RESET Software reset is performed and power-up sequence is executed. Configuration parametersfrom the internal memory are copied to the registers and a CRC check is performed

Table 18: Command register

7.2 Temperature register

DSP_T (0x2E)

Address: 0x2E
Type (r/w): R
Default Value [15:0]: 0x00

This register stores the calibrated temperature data in 16-bit signed format (two's complement)

7.3 Pressure register

DSP_P (0x30)

Address: 0x30
Type (r/w): R
Default Value [15:0]: 0x00

This register stores the calibrated pressure data in 16-bit signed format (two's complement)

7.4 Status register- synchronized

STATUS_SYNC (0x32)

Address: 0x32
Type (r/w): R/W
Default Value [15:0]: 0x00

Bit	Name	R/W	Type	Description
0	idle	R	status	Identical to bit idle in STATUS_SOURCE
1	reserved	-	-	-
2	reserved	-	-	-
3	dsp_p_up	R/W	event	Copy of STATUS_SOURCE register bit dsp_p_up when register DSP_P is read
4	dsp_t_up	R/W	event	Copy of STATUS_SOURCE register bit dsp_t_up when register DSP_T is read
5	reserved	-	-	-
6	reserved	-	-	-
7	reserved	-	-	-
8	reserved	-	-	-
9	reserved	-	-	-
10	reserved	-	-	-
11	crc_error	R	event	Identical to bit crc_error in STATUS_SOURCE
12	reserved	-	-	-
13	reserved	-	-	-
14	dsp_p_miss	R	event	Identical to bit dsp_p_miss in STATUS_SOURCE
15	dsp_t_miss	R	event	Identical to bit dsp_t_miss in STATUS_SOURCE

Table 19: STATUS_SYNC register

STATUS_SYNC (0x32) register bits [0, 11] and [15:14] are identical to the corresponding bits of register STATUS_SOURCE (0x36) and are updated synchronously with STATUS_SOURCE (0x36).

Bits [4:3] in the STATUS_SYNC (0x32) register are copied from the respective bits of STATUS_SOURCE (0x36) register only when the corresponding DSP_x register is read.

Bits dsp_t_up and dsp_p_up are used to indicate whether the temperature (DSP_T) and pressure (DSP_P) values were freshly updated at the time of reading.

When a DSP_T or DSP_P register is read - the corresponding event bit (dsp_t_up or dsp_t_up) from the STATUS_SOURCE register is first copied into the STATUS_SYNC register. Immediately after this copy, the original bit in the STATUS_SOURCE register is automatically cleared.

This ensures that the STATUS_SYNC register accurately reflects the freshness of data at the moment it was read, enabling reliable synchronized polling of sensor values.

Performing a single read operation of three consecutive 16-bit words starting from address 0x2E (beginning with DSP_T) ensures that the most recent temperature and pressure values are retrieved in a synchronized and efficient manner.

Event type bits remain set until cleared by writing '1' to the respective bit position in STATUS_SOURCE (0x36).

STOP

Do not write to STATUS_SYNC (0x32) register to clear the event flags.

7.5 Status register

STATUS_SOURCE (0x36)

Address: 0x36
Type (r/w): R/W
Default Value [15:0]: 0x00

Writing 0xFFFF to STATUS_SOURCE register will clear all event bits

Bit	Name	R/W	Type	Description
0	idle	R/W	status	0: sensor in busy state; 1: Sensor in idle state
1	reserved	-	-	-
2	reserved	-	-	-
3	dsp_p_up	R/W	event	Set to ’1’ when DSP_P register is updated; This bit is either self cleared by reading DSP_P register or manually cleared by writing ’1’ to this bit
4	dsp_t_up	R/W	event	Set to ’1’ when DSP_T register is updated; This bit is either self cleared by reading DSP_T register or manually cleared by writing ’1’ to this bit
5	reserved	-	-	-
6	reserved	-	-	-
7	reserved	-	-	-
8	reserved	-	-	-
9	reserved	-	-	-
10	reserved	-	-	-
11	crc_error	R/W	event	Set to ’1’ when CRC error occurs during communication (this bit is not set if CRC4 error occurs during SPI mode)
12	reserved	-	-	-
13	reserved	-	-	-
14	dsp_p_miss	R/W	event	Set to ’1’ when bit dsp_p_up in STATUS_SOURCE was ’1’ and DSP_P register is updated again
15	dsp_t_miss	R/W	event	Set to ’1’ when bit dsp_t_up in STATUS_SOURCE was ’1’ and DSP_T register is updated again

Table 20: STATUS_SORUCE register

The event-type bits [4:3] in the STATUS_SOURCE (0x36) register are first copied into the corresponding bits of the STATUS_SYNC (0x32) register when the associated DSP_x register is read. After this, the bits in STATUS_SOURCE are self cleared.

8 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 I^2C or SPI interface.

8.1 Writing data via I^2C

Figure 20 shows the sequence to put the sensor to SLEEP mode. 16-bits of data (0x6C32) needs to be written to the CMD (0x22) register. For the example, the 7-bit slave address is 0x6C.

In Sleep mode, the sensor is fully powered down and monitors only for a wake-up event. The device is awakened by the next rising edge on the SCL pin.

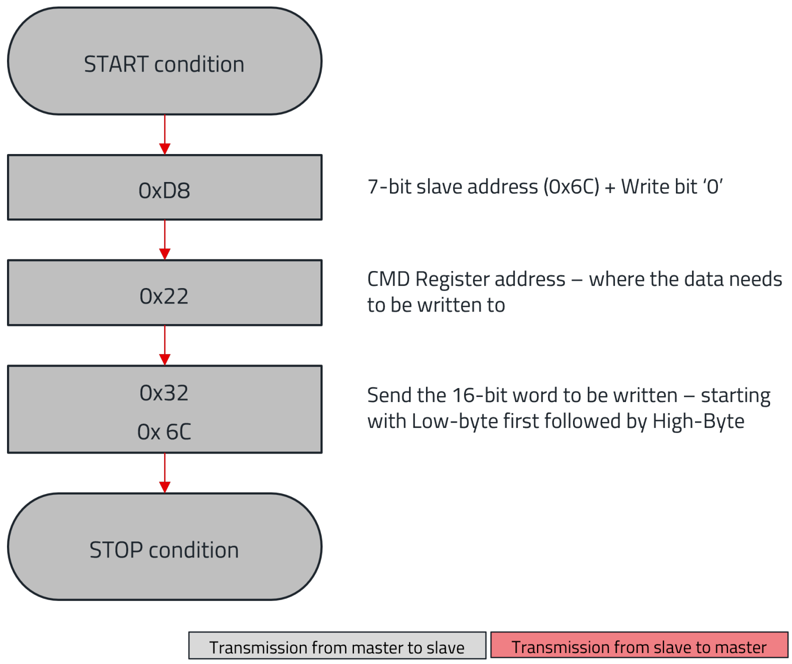


Figure 20: Write data with I^2C interface

8.2 Reading data via I^2C

Following example explains how to read the pressure and temperature data with I^2C. For the example, the 7-bit slave address is 0x6C.
Once the host controller (master) sends the start condition and data direction bit as READ (R/W=1), the master must send the first address byte of the register address (0x2E). Sensor starts transmitting the temperature (2 bytes) and pressure (2 bytes) data. Data from the

STATUS_SYNC register is then transmitted in the following two bytes (5th and 6th). New temperature and pressure data is generated every 2.4 ms.

Figure 21 shows a random read and repeated read operation without the CRC.

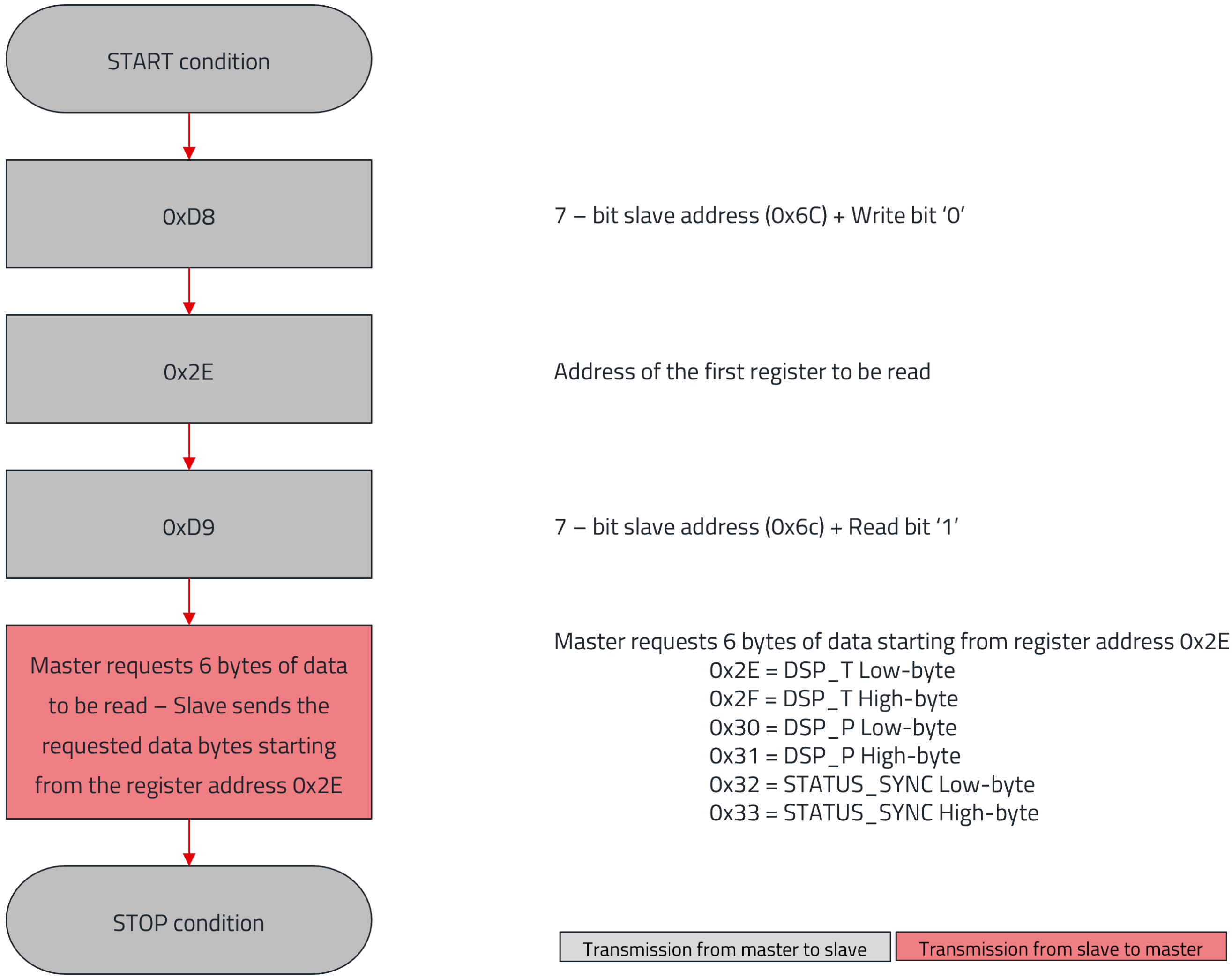


Figure 21: Reading output data with I²C interface

> **!** The sensor response time is about 2.4 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.

> **!** If it is not necessary to monitor every new pressure and temperature update, the STATUS_SYNC flags can be ignored. In such cases, reading only two consecutive 16-bit words starting from address 0x2E (i.e., DSP_T and DSP_P) is sufficient.

8.3 Pressure output: digital

Part numbers: 2513130810105, 2513130810205, 2513130835205

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 21: Digital pressure output: bidirectional

Part numbers: 2513130810305

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 22: Digital pressure output: unidirectional

Part numbers: 2513130810405

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 23: Digital pressure output

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

8.4 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 24: Digital temperature output: all devices

8.5 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 16-bits 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 16-bit pressure value

$$P_{16bits} = P_H \ \& \ P_L$$

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

$$\text{Pressure [kPa]} = [(P_{16bits} - OUT_{P\_MIN}) \times SEN_P)] + P_{MIN}$$

Where,

P_{16bits}	=	Digital pressure value obtained in step 2. (in 2's complement signed 16-bit)
OUT_{P_MIN}	=	Digital output at minimum pressure for the specific part number (see section: 8.3)
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 2513130810305 (pressure range: 0 to 100 kPa) are:

P_H = 0x16
P_L= 0x1C

Concatenating these 2 bytes (0x161C) to obtain 16-bit decimal value

$$P_{16bits}[\text{digit}] = 5660$$

For part number 2513130810305, OUT_{P_MIN} = 3277 digits, $SEN_P = 3.815 \times 10^{-3}$ kPa/digits and P_{MIN} = 0 kPa.

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

8.6 Interpreting digital temperature values

Following the pressure data, temperature data is transmitted as a 3rd and 4th byte. The complete 16-bits 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 (°C) 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 16-bit temperature value

$$T_{16bits} = T_H \ \& \ T_L$$

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

$$\text{Temperature [°C]} = (T_{16bits} - OUT_{T\_MIN}) \times SEN_T$$

Where,

T_{16bits}	=	Digital temperature value obtained in step 2 (in 2's complement signed 16-bit)
OUT_{T_MIN}	=	Digital output at minimum temperature = 8192 [digit] (see table: 24)
SEN_T	=	4.272×10^{-3} [°C/digit] (see table: 11)

Example:

Temperature data obtained from sensor are:

T_H = 0x36
T_L= 0xC5

Concatenating these 2 bytes (0x36C5)to obtain 16-bit decimal value

$$T_{16bits}[digit] = 14021$$

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

9 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.

Analog output voltage is ratiometric[1] to the positive supply voltage *VDD*.

9.1 Analog pressure output

Part number: 2513130810105, 2513130810205, 2513130835205

Parameter	Symbol	Value			Unit
		Min	Typ	Max	
Zero pressure offset	OUT_{OFF}		50		$\%V_{DD}$
Full scale span	FSS		80		
Output at minimum pressure	OUT_{P_MIN}		10		
Output at maximum pressure	OUT_{P_MAX}		90		

Table 25: Analog pressure output

Part number: 2513130810305

Parameter	Symbol	Value			Unit
		Min	Typ	Max	
Zero pressure offset	OUT_{OFF}		10		$\%V_{DD}$
Full scale span	FSS		80		
Output at minimum pressure	OUT_{P_MIN}		10		
Output at maximum pressure	OUT_{P_MAX}		90		

Table 26: Analog pressure output

[1] Ratiometric: Output signal changes in proportion to the change in supply voltage.

Part number: 2513130810405

Parameter	Symbol	Value			Unit
		Min	Typ	Max	
Zero pressure offset	OUT_{OFF}		17.4		$\%V_{DD}$
Full scale span	FSS		80		
Output at minimum pressure	OUT_{P_MIN}		10		
Output at maximum pressure	OUT_{P_MAX}		90		

Table 27: Analog pressure output

10 Look-up Table

Partnumber	Operating Voltage (V_{DD})	OUT_{P_MIN} (digits)	SEN_P (kPa/digit)	P_{MIN} (kPa)
2513130810105	3 to 5 V	3277	7.63×10^{-5}	-1
2513130810205	3 to 5 V	3277	7.63×10^{-4}	-10
2513130835205	3 to 5 V	3277	2.67×10^{-3}	-35
2513130810305	3 to 5 V	3277	3.815×10^{-3}	0
2513130810405	3 to 5 V	3277	4.196×10^{-2}	-100

Table 28: look up table: Digital output

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

Partnumber	Operating Voltage (V_{DD})	OUT_{P_MIN} (V)	SEN_P (kPa/V)	P_{MIN} (kPa)
2513130810105	3 to 5 V	10 $\%V_{DD}$	$(P_{MAX}-P_{MIN})/$ 80 $\%V_{DD}$	-1
2513130810205	3 to 5 V	10 $\%V_{DD}$	$(P_{MAX}-P_{MIN})/$ 80 $\%V_{DD}$	-10
2513130835205	3 to 5 V	10 $\%V_{DD}$	$(P_{MAX}-P_{MIN})/$ 80 $\%V_{DD}$	-35
2513130810305	3 to 5 V	10 $\%V_{DD}$	$(P_{MAX}-P_{MIN})/$ 80 $\%V_{DD}$	0
2513130810405	3 to 5 V	10 $\%V_{DD}$	$(P_{MAX}-P_{MIN})/$ 80 $\%V_{DD}$	-100

Table 29: look up table: Analog output

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

11 Physical specifications

11.1 Sensor drawing: Vertical Nozzles

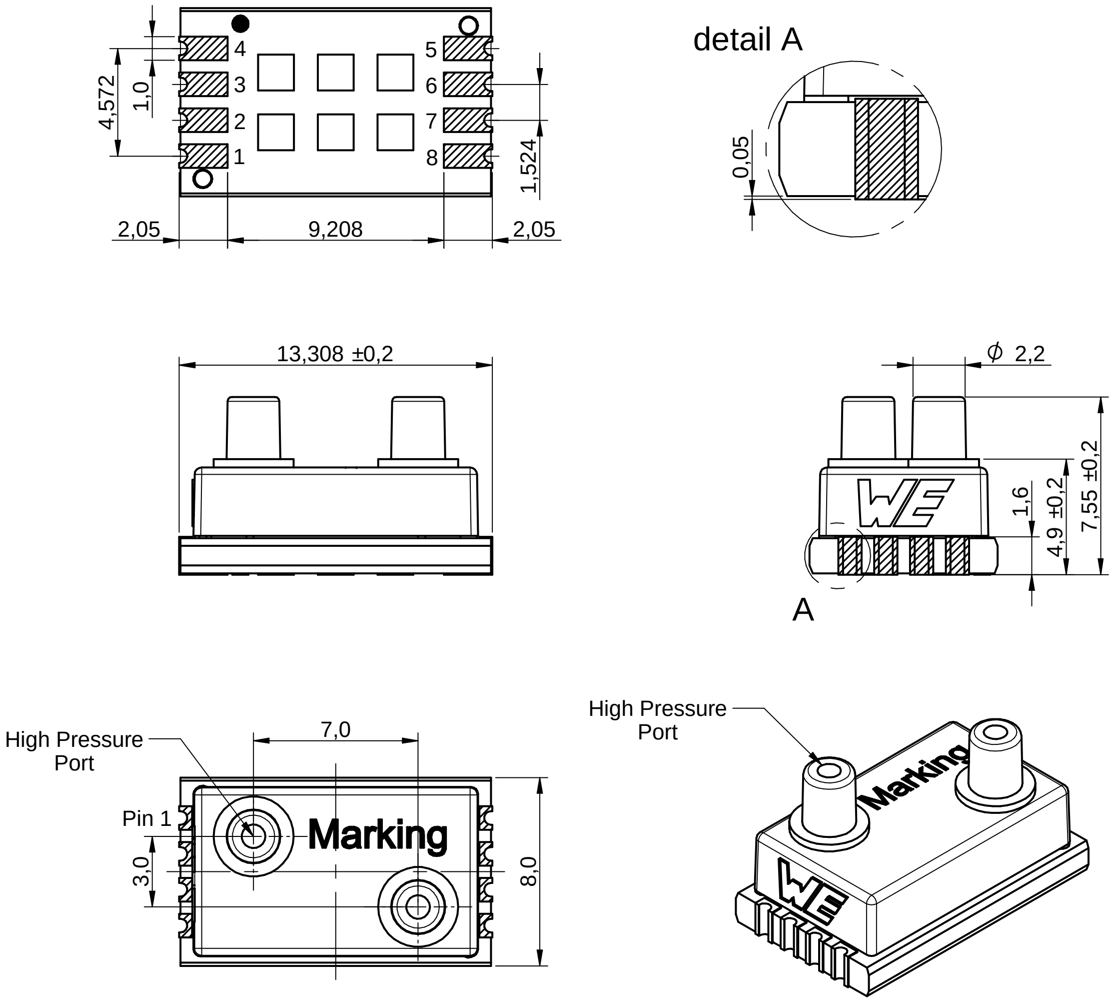


Figure 22: Sensor dimensions: Vertical nozzles [mm]

11.2 Sensor drawing: Horizontal-Barbed Nozzles

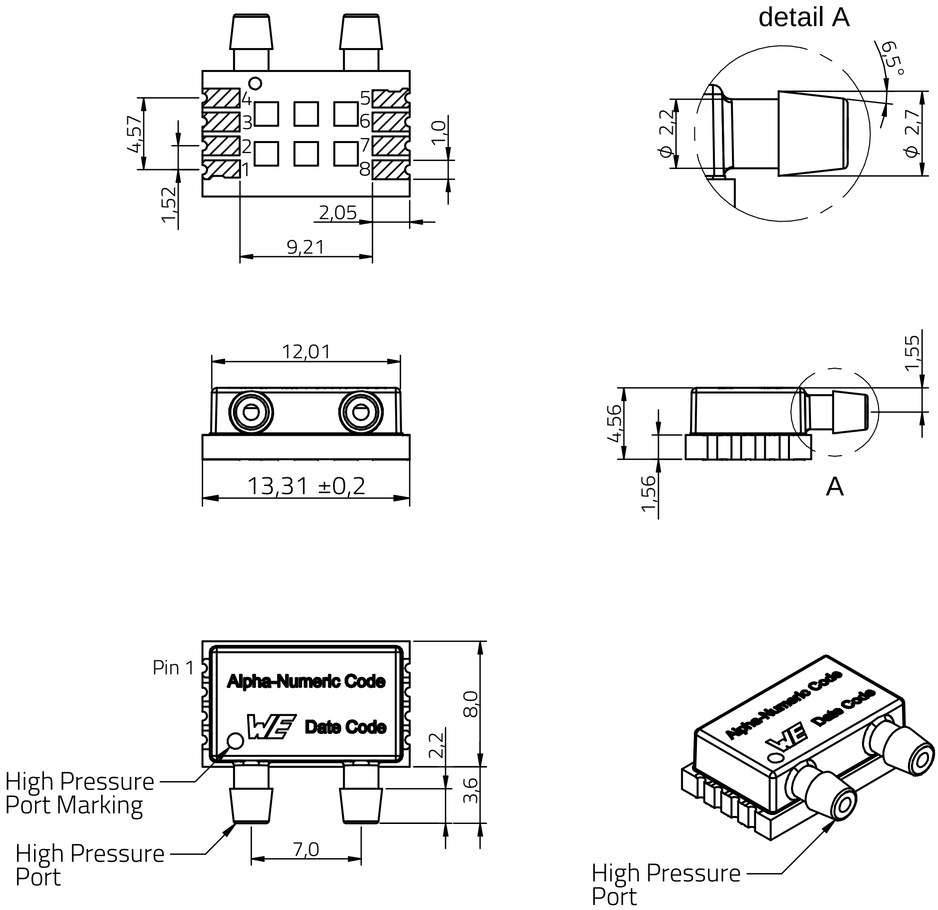


Figure 23: Sensor dimensions: Horizontal-barbed nozzles [mm]

11.3 Footprint

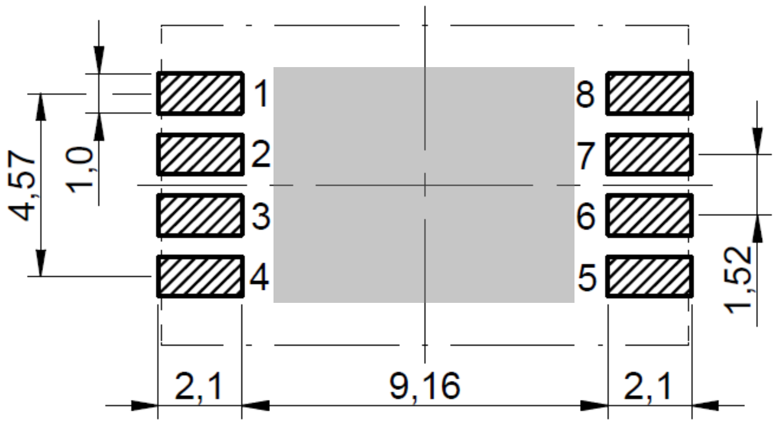


Figure 24: Recommended land pattern [mm] (top view)

STOP Open traces, open wires or vias are not allowed in the centre area of the sensor (marked in grey in the figure 24)

11.4 Marking information

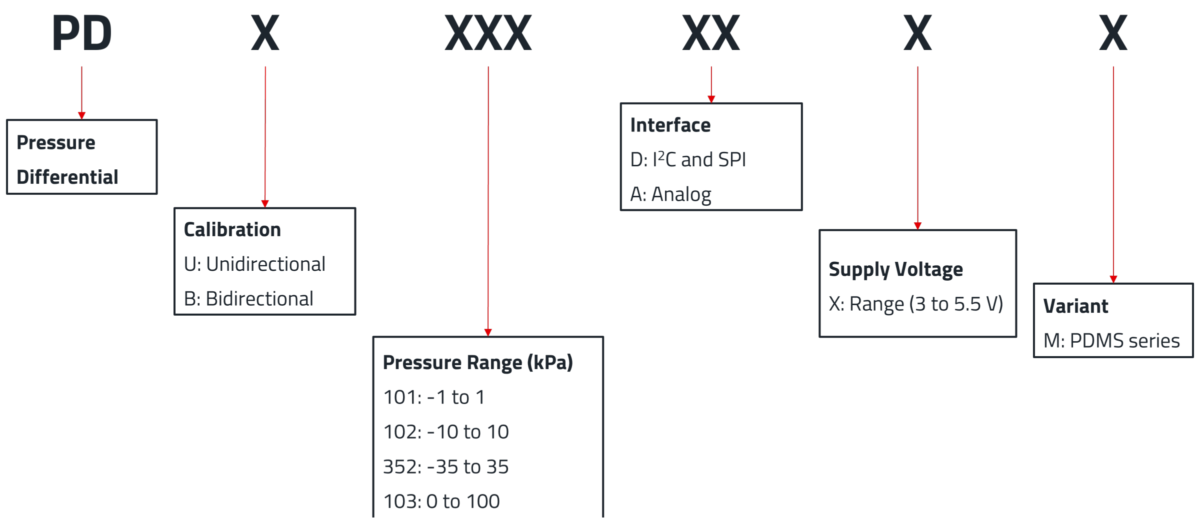


Figure 25: Marking information

> Marking PDB101DAXM indicates a differential pressure sensor with measurement range from -1 to 1 kPa. The corresponding WE part number is 2513130810101.

12 Manufacturing information

12.1 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*.

12.2 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 s
Ramp-up rate (T_L to T_P)		3 °C/s max.
Liquidous temperature	T_L	217 °C
Time t_L maintained above T_L	t_L	60 - 150 s
Peak package body temperature	T_P	see table below
Time within 5 °C of actual peak temperature	t_P	20 - 30 s
Ramp-down rate (T_P to T_L)		6 °C/s max.
Time 20 °C to T_P		8 min max.

Table 30: 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 °C/s.

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

Table 31: 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 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.

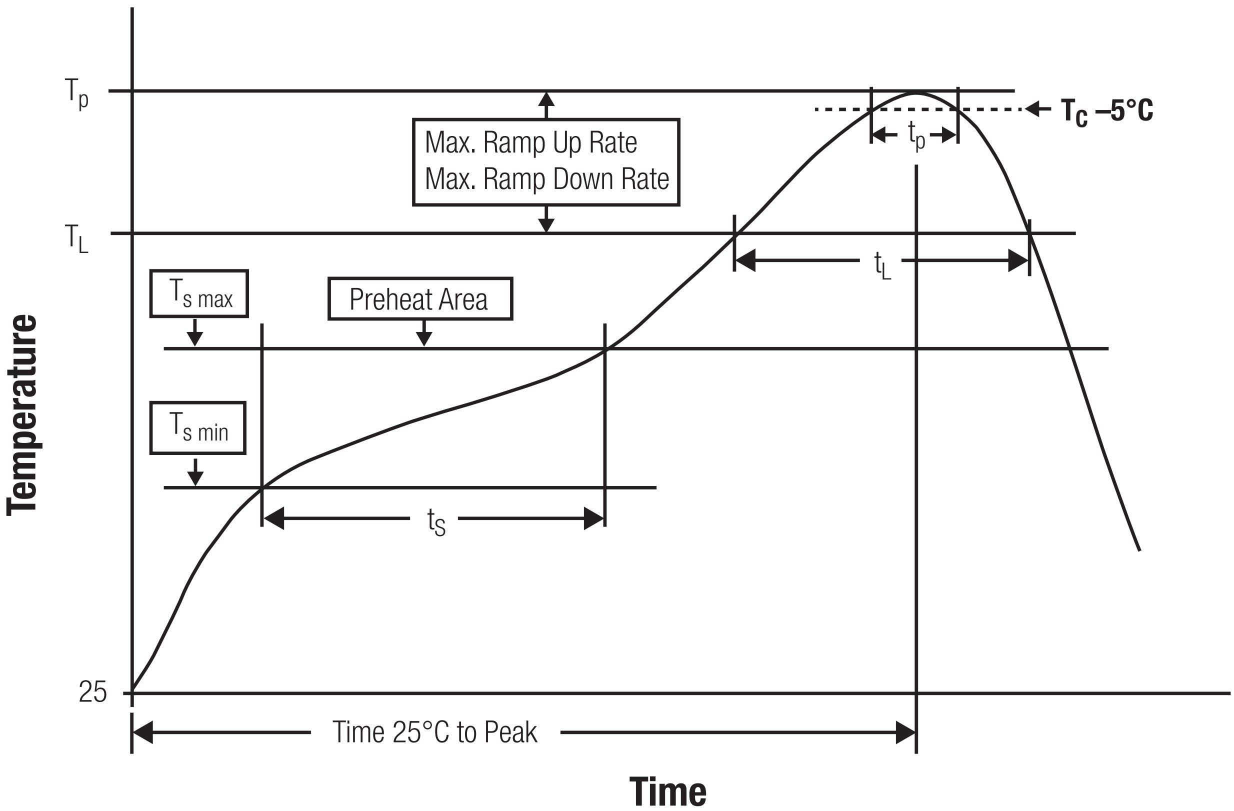


Figure 26: Reflow soldering profile

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

12.3 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

12.4 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.

12.5 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.

12.6 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.

13 Important notes

The following conditions apply to all goods within the wireless connectivity and sensors product range of Würth Elektronik eiSos GmbH & Co. KG:

General customer responsibility
Some goods within the product range of Würth Elektronik eiSos GmbH & Co. KG contain statements regarding general suitability for certain application areas. These statements about suitability are based on our knowledge and experience of typical requirements concerning the areas, serve as general guidance and cannot be estimated as binding statements about the suitability for a customer application. The responsibility for the applicability and use in a particular customer design is always solely within the authority of the customer. Due to this fact, it is up to the customer to evaluate, where appropriate to investigate and to decide whether the device with the specific product characteristics described in the product specification is valid and suitable for the respective customer application or not. Accordingly, the customer is cautioned to verify that the documentation is current before placing orders.

Customer responsibility related to specific, in particular safety-relevant applications
It has to be clearly pointed out that the possibility of a malfunction of electronic components or failure before the end of the usual lifetime cannot be completely eliminated in the current state of the art, even if the products are operated within the range of the specifications. The same statement is valid for all software source code and firmware parts contained in or used with or for products in the wireless connectivity and sensor product range of Würth Elektronik eiSos GmbH & Co. KG. In certain customer applications requiring a high level of safety and especially in customer applications in which the malfunction or failure of an electronic component could endanger human life or health, it must be ensured by most advanced technological aid of suitable design of the customer application that no injury or damage is caused to third parties in the event of malfunction or failure of an electronic component.

Best care and attention
Any product-specific data sheets, manuals, application notes, PCNs, warnings and cautions must be strictly observed in the most recent versions and matching to the products revisions. These documents can be downloaded from the product specific sections on the wireless connectivity and sensors homepage.

Customer support for product specifications
Some products within the product range may contain substances, which are subject to restrictions in certain jurisdictions in order to serve specific technical requirements. Necessary information is available on request. In this case, the Business Development Engineer (BDM) or the internal sales person in charge should be contacted who will be happy to support in this matter.

Product improvements
Due to constant product improvement, product specifications may change from time to time. As a standard reporting procedure of the Product Change Notification (PCN) according to the JEDEC-Standard, we inform about major changes. In case of further queries regarding the PCN, the Business Development Engineer (BDM), the internal sales person or the technical support team in charge should be contacted. The basic responsibility of the customer as per section 13 and 13 remains unaffected.
All software like ¨wireless connectivity SDK¨, ¨Sensor SDK¨ or other source codes as well as all PC software tools are not subject to the Product Change Notification information process.

Product life cycle
Due to technical progress and economical evaluation, we also reserve the right to discontinue production and delivery of products. As a standard reporting procedure of the Product Termination Notification (PTN) according to the JEDEC-Standard we will inform at an early stage about inevitable product discontinuance. According to this, we cannot ensure that all products within our product range will always be available. Therefore, it needs to be verified with the Business Development Engineer (BDM) or the internal sales person in charge about the current product availability expectancy before or when the product for application design-in disposal is considered. The approach named above does not apply in the case of individual agreements deviating from the foregoing for customer-specific products.

Property rights
All the rights for contractual products produced by Würth Elektronik eiSos GmbH & Co. KG on the basis of ideas, development contracts as well as models or templates that are subject to copyright, patent or commercial protection supplied to the customer will remain with Würth Elektronik eiSos GmbH & Co. KG. Würth Elektronik eiSos GmbH & Co. KG does not warrant or represent that any license, either expressed or implied, is granted under any patent right, copyright, mask work right, or other intellectual property right relating to any combination, application, or process in which Würth Elektronik eiSos GmbH & Co. KG components or services are used.

General terms and conditions
Unless otherwise agreed in individual contracts, all orders are subject to the current version of the "General Terms and Conditions of Würth Elektronik eiSos Group", last version available at *www.we-online.com*.

14 Legal notice

Exclusion of liability
Würth Elektronik eiSos GmbH & Co. KG considers the information in this document to be correct at the time of publication. However, Würth Elektronik eiSos GmbH & Co. KG reserves the right to modify the information such as technical specifications or functions of its products or discontinue the production of these products or the support of one of these products without any written announcement or notification to customers. The customer must make sure that the information used corresponds to the latest published information. Würth Elektronik eiSos GmbH & Co. KG does not assume any liability for the use of its products. Würth Elektronik eiSos GmbH & Co. KG does not grant licenses for its patent rights or for any other of its intellectual property rights or third-party rights.
Notwithstanding anything above, Würth Elektronik eiSos GmbH & Co. KG makes no representations and/or warranties of any kind for the

provided information related to their accuracy, correctness, completeness, usage of the products and/or usability for customer applications. Information published by Würth Elektronik eiSos GmbH & Co. KG regarding third-party products or services does not constitute a license to use such products or services or a warranty or endorsement thereof.

Suitability in customer applications
The customer bears the responsibility for compliance of systems or units, in which Würth Elektronik eiSos GmbH & Co. KG products are integrated, with applicable legal regulations. Customer acknowledges and agrees that it is solely responsible for compliance with all legal, regulatory and safety-related requirements concerning its products, and any use of Würth Elektronik eiSos GmbH & Co. KG components in its applications, notwithstanding any applications-related information or support that may be provided by Würth Elektronik eiSos GmbH & Co. KG. Customer represents and agrees that it has all the necessary expertise to create and implement safeguards which anticipate dangerous consequences of failures, monitor failures and their consequences lessen the likelihood of failures that might cause harm and take appropriate remedial actions. The customer will fully indemnify Würth Elektronik eiSos GmbH & Co. KG and its representatives against any damages arising out of the use of any Würth Elektronik eiSos GmbH & Co. KG components in safety-critical applications.

Trademarks
AMBER wireless is a registered trademark of Würth Elektronik eiSos GmbH & Co. KG. All other trademarks, registered trademarks, and product names are the exclusive property of the respective owners.

Usage restriction
Würth Elektronik eiSos GmbH & Co. KG products have been designed and developed for usage in general electronic equipment only. This product is not authorized for use in equipment where a higher safety standard and reliability standard is especially required or where a failure of the product is reasonably expected to cause severe personal injury or death, unless the parties have executed an agreement specifically governing such use. Moreover, Würth Elektronik eiSos GmbH & Co. KG products are neither designed nor intended for use in areas such as military, aerospace, aviation, nuclear control, submarine, transportation (automotive control, train control, ship control), transportation signal, disaster prevention, medical, public information network etc. Würth Elektronik eiSos GmbH & Co. KG must be informed about the intent of such usage before the design-in stage. In addition, sufficient reliability evaluation checks for safety must be performed on every electronic component, which is used in electrical circuits that require high safety and reliability function or performance. By using Würth Elektronik eiSos GmbH & Co. KG products, the customer agrees to these terms and conditions.

15 License terms for Würth Elektronik eiSos GmbH & Co. KG sensor product software and source code

These license terms will take effect upon the purchase and usage of the Würth Elektronik eiSos GmbH & Co. KG sensor products. You hereby agree that these license terms are applicable to the product and the incorporated software, firmware and source codes (collectively, "Software") made available by Würth Elektronik eiSos in any form, including but not limited to binary, executable or source code form.
The software included in any Würth Elektronik eiSos sensor product is purchased to you on the condition that you accept the terms and conditions of these license terms. You agree to comply with all provisions under these license terms.

Limited license
Würth Elektronik eiSos hereby grants you a limited, non-exclusive, non-transferable and royalty-free license to use the software and under the conditions that will be set forth in these license terms. You are free to use the provided software only in connection with one of the products from Würth Elektronik eiSos to the extent described in these license terms.
You are entitled to change or alter the source code for the sole purpose of creating an application embedding the Würth Elektronik eiSos sensor product. The transfer of the source code to third parties is allowed to the sole extent that the source code is used by such third parties in connection with our product or another hardware provided by Würth Elektronik eiSos under strict adherence of these license terms. Würth Elektronik eiSos will not assume any liability for the usage of the incorporated software and the source code.
You are not entitled to transfer the source code in any form to third parties without prior written consent of Würth Elektronik eiSos.
You are not allowed to reproduce, translate, reverse engineer, decompile, disassemble or create derivative works of the incorporated software and the source code in whole or in part.
No more extensive rights to use and exploit the products are granted to you.

Usage and obligations
The responsibility for the applicability and use of the Würth Elektronik eiSos sensor product with the incorporated software in a particular customer design is always solely within the authority of the customer. Due to this fact, it is up to you to evaluate and investigate, where appropriate, and to decide whether the device with the specific product characteristics described in the product specification is valid and suitable for your respective application or not.
You are responsible for using the Würth Elektronik eiSos sensor product with the incorporated software in compliance with all applicable product liability and product safety laws. You acknowledge to minimize the risk of loss and harm to individuals and bear the risk for failure leading to personal injury or death due to your usage of the product.
Würth Elektronik eiSos' products are not authorized for use in safety-critical applications, or where a failure of the product is reasonably expected to cause severe personal injury or death. Moreover, Würth Elektronik eiSos' products are neither designed nor intended for use in areas such as military, aerospace, aviation, nuclear control, submarine, transportation (automotive control, train control, ship control), transportation signal, disaster prevention, medical, public information network etc. You shall inform Würth Elektronik eiSos about the intent of such usage before design-in stage. In certain customer applications requiring a very high level of safety and in which the malfunction or failure of an electronic component could endanger human life or health, you must ensure to have all necessary expertise in the safety and regulatory ramifications of your applications. You acknowledge and agree that you are solely responsible for all legal, regulatory and safety-related requirements concerning your products and any use of Würth Elektronik eiSos' products in such safety-critical applications, notwithstanding any applications-related

information or support that may be provided by Würth Elektronik eiSos. YOU SHALL INDEMNIFY WÜRTH ELEKTRONIK EISOS AGAINST ANY DAMAGES ARISING OUT OF THE USE OF WÜRTH ELEKTRONIK EISOS' PRODUCTS IN SUCH SAFETY-CRITICAL APPLICATIONS.

Ownership
The incorporated software created by Würth Elektronik eiSos is and will remain the exclusive property of Würth Elektronik eiSos.

Disclaimer of warranty
THE SOFTWARE AND IT'S SOURCE CODE IS PROVIDED "AS IS". YOU ACKNOWLEDGE THAT WÜRTH ELEKTRONIK EISOS MAKES NO REPRESENTATIONS AND WARRANTIES OF ANY KIND RELATED TO, BUT NOT LIMITED TO THE NON-INFRINGEMENT OF THIRD PARTIES' INTELLECTUAL PROPERTY RIGHTS OR THE MERCHANTABILITY OR FITNESS FOR YOUR INTENDED PURPOSE OR USAGE. WÜRTH ELEKTRONIK EISOS DOES NOT WARRANT OR REPRESENT THAT ANY LICENSE, EITHER EXPRESS OR IMPLIED, IS GRANTED UNDER ANY PATENT RIGHT, COPYRIGHT, MASK WORK RIGHT, OR OTHER INTELLECTUAL PROPERTY RIGHT RELATING TO ANY COMBINATION, MACHINE, OR PROCESS IN WHICH THE WÜRTH ELEKTRONIK EISOS' PRODUCT WITH THE INCORPORATED SOFTWARE IS USED. INFORMATION PUBLISHED BY WÜRTH ELEKTRONIK EISOS REGARDING THIRD-PARTY PRODUCTS OR SERVICES DOES NOT CONSTITUTE A LICENSE FROM WÜRTH ELEKTRONIK EISOS TO USE SUCH PRODUCTS OR SERVICES OR A WARRANTY OR ENDORSEMENT THEREOF.

Limitation of liability
Any liability not expressly provided by Würth Elektronik eiSos shall be disclaimed.
You agree to hold us harmless from any third-party claims related to your usage of the Würth Elektronik eiSos' products with the incorporated software and source code. Würth Elektronik eiSos disclaims any liability for any alteration, development created by you or your customers as well as for any combination with other products.

Applicable law and jurisdiction
Applicable law to these license terms shall be the laws of the Federal Republic of Germany. Any dispute, claim or controversy arising out of or relating to these license terms shall be resolved and finally settled by the court competent for the location of Würth Elektronik eiSos registered office.

Severability clause
If a provision of these license terms is or becomes invalid, unenforceable or null and void, this shall not affect the remaining provisions of the terms. The parties shall replace any such provisions with new valid provisions that most closely approximate the purpose of the terms.

Miscellaneous
Würth Elektronik eiSos reserves the right at any time to change this terms at its own discretion. It is your responsibility to check at Würth Elektronik eiSos homepage for any updates. Your continued usage of the products will be deemed as the acceptance of the change.
We recommend you to be updated about the status of new software, which is available on our website or in our data sheet, and to implement new software in your device where appropriate.
By ordering a product, you accept these license terms in all terms.

List of Figures

1 Block diagram . . . 8
2 Pin specifications - vertical nozzles (top view) . . . 16
3 Pin specifications- horizontal nozzles (top view) . . . 16
4 Master-slave concept . . . 18
5 *SDA* and *SCL* logic levels . . . 19
6 Data validity, START and STOP condition . . . 20
7 Slave address format . . . 21
8 Slave address configuration . . . 21
9 Complete data transfer . . . 22
10 I^2C Read and Write command format (No CRC) . . . 23
11 I^2C Read and Write command format (with CRC) . . . 23
12 SPI Interface . . . 26
13 SPI register address . . . 28
14 SPI CRC byte . . . 28
15 SPI Read and Write command format (No CRC) . . . 29
16 SPI Read and Write command format (with CRC) . . . 30
17 Application circuit with I^2C interface (top view) . . . 31
18 Application circuit with SPI interface (top view) . . . 31
19 Application circuit with analog interface (top view) . . . 32
20 Write data with I^2C interface . . . 38
21 Reading output data with I^2C interface . . . 39
22 Sensor dimensions: Vertical nozzles [mm] . . . 47
23 Sensor dimensions: Horizontal-barbed nozzles [mm] . . . 48
24 Recommended land pattern [mm] (top view) . . . 49
25 Marking information . . . 50
26 Reflow soldering profile . . . 52

List of Tables

1 Ordering information . . . 7
2 General information . . . 9
3 Media compatibility . . . 9
4 Absolute maximum ratings . . . 10
5 Pressure sensor specifications (part nr.: 25131308xxx05) . . . 11
6 Pressure sensor specifications (part nr.: 2513130810105) . . . 12
7 Pressure sensor specifications (part nr.: 2513130810205) . . . 12
8 Pressure sensor specifications (part nr.: 2513130835205) . . . 13
9 Pressure sensor specifications (part nr.: 2513130810305) . . . 13
10 Pressure sensor specifications (Part nr.: 2513130810405) . . . 14
11 Temperature sensor specifications . . . 15
12 Electrical specifications . . . 15
13 Pin description . . . 17
14 CRC Polynomial . . . 24
15 I^2C timing parameters . . . 25
16 SPI communication modes . . . 27

17 CRC Polynomial . . . 29
18 Command register . . . 34
19 STATUS_SYNC register . . . 35
20 STATUS_SORUCE register . . . 37
21 Digital pressure output: bidirectional . . . 40
22 Digital pressure output: unidirectional . . . 40
23 Digital pressure output . . . 40
24 Digital temperature output: all devices . . . 41
25 Analog pressure output . . . 44
26 Analog pressure output . . . 44
27 Analog pressure output . . . 45
28 look up table: Digital output . . . 46
29 look up table: Analog output . . . 46
30 Classification reflow soldering profile, Note: refer to IPC/JEDEC J-STD-020E . . 51
31 Package classification reflow temperature, PB-free assembly, Note: refer to IPC/-JEDEC J-STD-020E . . . 52

Contact
Würth Elektronik eiSos GmbH & Co. KG
Division Wireless Connectivity & Sensors

Max-Eyth-Straße 1
74638 Waldenburg
Germany

Tel.: +49 651 99355-0
Fax.: +49 651 99355-69
www.we-online.com/wireless-connectivity