

## XENSIV™ TCI Integrated Thermal Conductivity Gas Sensor

### Features

- Thermal Conductivity Sensing Principle
  - Insensitive to Sensor Poisoning
  - Low Lifetime Offset Drift of maximal  $\pm 0.1 \text{ vol\%H}_2$
  - Fully factory calibrated sensor, no need for further recalibration in the field
  - Firmware compensates Temperature, Humidity and Pressure Effects\*
  - Hydrogen Measurement Range 0 to 16 vol%
  - Fast Response Time  $< 100 \text{ ms}$
  - Measurement Accuracy up to  $\pm 0.12 \text{ vol\%H}_2$
  - Ultra-low Power Consumption: typ.  $112 \mu\text{A}$  @1 meas./sec
  - 1Mbit/s I2C Interface and 3.3 V Supply Voltage
  - 15 Years Lifetime
  - UL Recognition (FTAM2/FTAM8) according to UL 2075 and ULC 588
- (\*External humidity and pressure information required)



### Potential applications

- Automotive Fuel Cell Hydrogen Leakage Measurement
- Automotive Battery Monitoring Systems (Thermal Runaway Detection)
- General Industrial Hydrogen Leakage Measurement

### Product validation

- Qualified for automotive applications according to AEC-Q100, grade 2
- Qualified for industrial applications according to the relevant tests of JEDEC JESD47L, JESD22, and J-STD-020

### Description

The product is designed for measuring the thermal conductivity of gases e.g., hydrogen in air. It comprises a resistive full sensor bridge and an ASIC which provides a calibrated and temperature compensated digital output signal.

**Table 1**                      **Ordering Information**

| Product Name | Marking | Ordering Code | Package        |
|--------------|---------|---------------|----------------|
| TCI          | "TCI"   | SP006004240   | PG-DSOSP-14-84 |

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## 1 Absolute maximum rating

Table 2 Maximum ratings

| Parameter                       | Symbol        | Values     |      |         | Unit | Note or condition                                                                                                                                                                                        |
|---------------------------------|---------------|------------|------|---------|------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                 |               | Min.       | Typ. | Max.    |      |                                                                                                                                                                                                          |
| DC current                      | $I_{DC}$      | -10        |      | 10      | mA   | Maximum Input/Output Current at any Pin                                                                                                                                                                  |
| Transient latch-up current      | $I_{LU}$      | $\pm 100$  |      |         | mA   | Maximum transient current at any pin according JEDEC78 class II level A                                                                                                                                  |
| ESD robustness HBM              | $V_{HBM}$     | $\pm 2000$ |      |         | V    | All pins tested according to AEC-Q100-002                                                                                                                                                                |
| ESD robustness CDM, corner pins | $V_{CDM\ C}$  | $\pm 750$  |      |         | V    | Corner pins tested according to AEC-Q100-011                                                                                                                                                             |
| ESD robustness CDM              | $V_{CDM}$     | $\pm 500$  |      |         | V    | Non-corner pins tested according to AEC-Q100-011                                                                                                                                                         |
| Storage temperature             | $T_{STORAGE}$ | -50        |      | 150     | °C   | Maximal 1000 hours accumulated over lifetime between 125°C and 150°C.<br>Maximum 1000 hours between -40°C and -50°C.<br>Device not powered.<br>Temperature cycling only allowed between -40°C and 125°C. |
| Maximum pressure                | $p_{MAX}$     |            |      | 600     | kPa  | Static                                                                                                                                                                                                   |
| Max. supply voltage             | $V_{DD\_MAX}$ | -0.3       |      | 3.8     | V    | Voltage at VDDBAT pin                                                                                                                                                                                    |
| Input voltage at PPx            | $V_{IN\_PPx}$ | -0.3       |      | VDD+0.3 | V    |                                                                                                                                                                                                          |
| Mechanical shock                | $a_{SHOCK}$   |            |      | 6000    | g    | 0.3 ms half sine pulses. 5 shocks in $\pm x$ , $\pm y$ , and $\pm z$ direction (30 shocks in total) Device unpowered.                                                                                    |

## 2 Operating range

**Table 3** Operating range

| Parameter                           | Symbol         | Values   |      |          | Unit | Note or condition                                                     |
|-------------------------------------|----------------|----------|------|----------|------|-----------------------------------------------------------------------|
|                                     |                | Min.     | Typ. | Max.     |      |                                                                       |
| Operating ambient temperature       | $T_{amb}$      | -40      |      | 105      | °C   |                                                                       |
| Flash programming temperature range | $T_{FLASH}$    | -20      |      | 90       | °C   | Temperature range for flash erasing/programming.                      |
| Analysis gas pressure               | $p_{GAS}$      | 50       |      | 130      | kPa  | Absolute pressure                                                     |
| Supply voltage range                | $V_{DD}$       | 3.3 - 5% | 3.3  | 3.3 + 5% | V    | Target supply voltage is 3.3 V                                        |
| External capacitor at VDDREG        | $C_{VDD\_REG}$ | 7        | 10   | 13       | nF   |                                                                       |
| Relative humidity                   | $RH$           | 0        |      | 100      | %    | no condensation                                                       |
| Hydrogen measurement range          | $C_{H2}$       | 0        |      | 4        | vol% | Without external ignition protection                                  |
| Extended hydrogen measurement range | $C_{extH2}$    | 4        |      | 16       | vol% | External ignition protection in place                                 |
| Operating hours                     | $t_{op}$       |          |      | 15       | y    | Valid for the specified <a href="#">temperature mission profile</a> . |

### 3 TC sensor characteristics

#### 3.1 General TC sensor characteristics

**Table 4** TC sensor characteristics

| Parameter                                                    | Symbol             | Values |       |      | Unit       | Note or condition                                                 |
|--------------------------------------------------------------|--------------------|--------|-------|------|------------|-------------------------------------------------------------------|
|                                                              |                    | Min.   | Typ.  | Max. |            |                                                                   |
| Response/ recovery time (t <sub>90</sub> , t <sub>10</sub> ) | t <sub>90,10</sub> |        |       | 100  | ms         | Analysis-gas present at device gas-inlet at start of measurement. |
| Digital resolution                                           | Sens <sub>H2</sub> |        | 0.01  |      | vol%H2/LSB |                                                                   |
| RMS noise level                                              | σ <sub>H2</sub>    |        | 0.015 | 0.02 | vol%H2     |                                                                   |

#### 3.2 Total measurement error

Notes:

1. The following accuracy values are valid if the external humidity sensor used for compensation does not exceed a tolerance of  $\pm 1.5\%RH$  and  $\pm 1^\circ C$ . For the accuracy values with pressure compensation, the external pressure sensor must not exceed a tolerance of  $\pm 2$  kPa.
2. %RD stands for percent of concentration reading.
3. Note that for fulfilling the total measurement error specification at  $c_{H2} > 5\%$  the following output signal correction is required:

$$c_{H2\_corrected} = 1.15 * c_{H2\_uncorrected} - 0.75 \text{ vol}\%H2$$

This correction must be done on system level, it is not performed in the TCI.

##### 3.2.1 Total measurement error with pressure compensation

**Table 5** Total thermal conductivity measurement error with pressure compensation

| Parameter               | Symbol | Values |      |      | Unit   | Note or condition                                                                                                                                                                   |
|-------------------------|--------|--------|------|------|--------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                         |        | Min.   | Typ. | Max. |        |                                                                                                                                                                                     |
| Total measurement error | TME    | -0.12  |      | 0.12 | vol%H2 | $0 \text{ vol.\%} \leq c_{H2} \leq 1 \text{ vol.\%}$<br>$80 \text{ kPa} \leq p_{GAS} \leq 120 \text{ kPa}$<br>$0\% \leq RH \leq 100\%$<br>$-5^\circ C \leq T_{amb} \leq 35^\circ C$ |

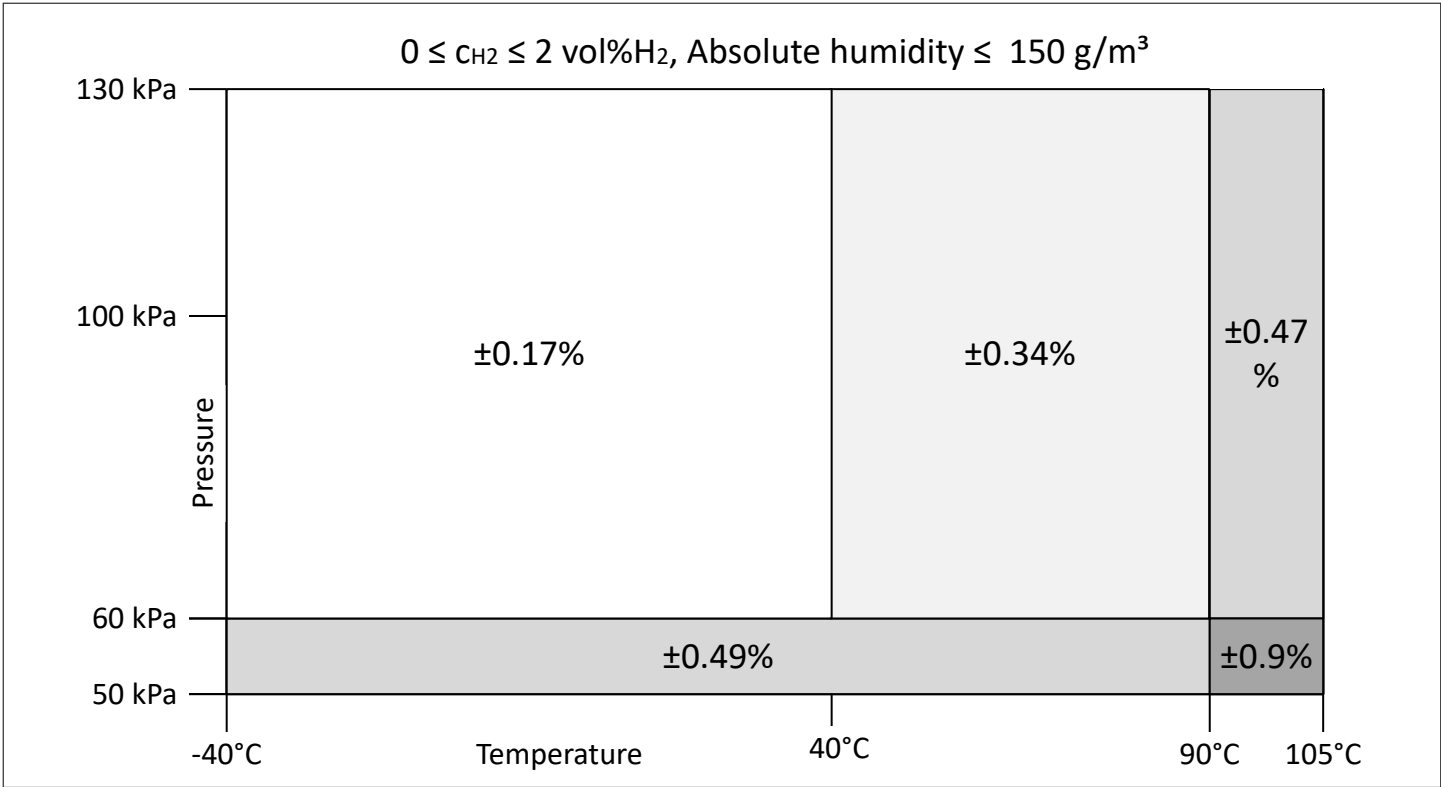


Figure 1 Total measurement error with p-compensation, low concentration range

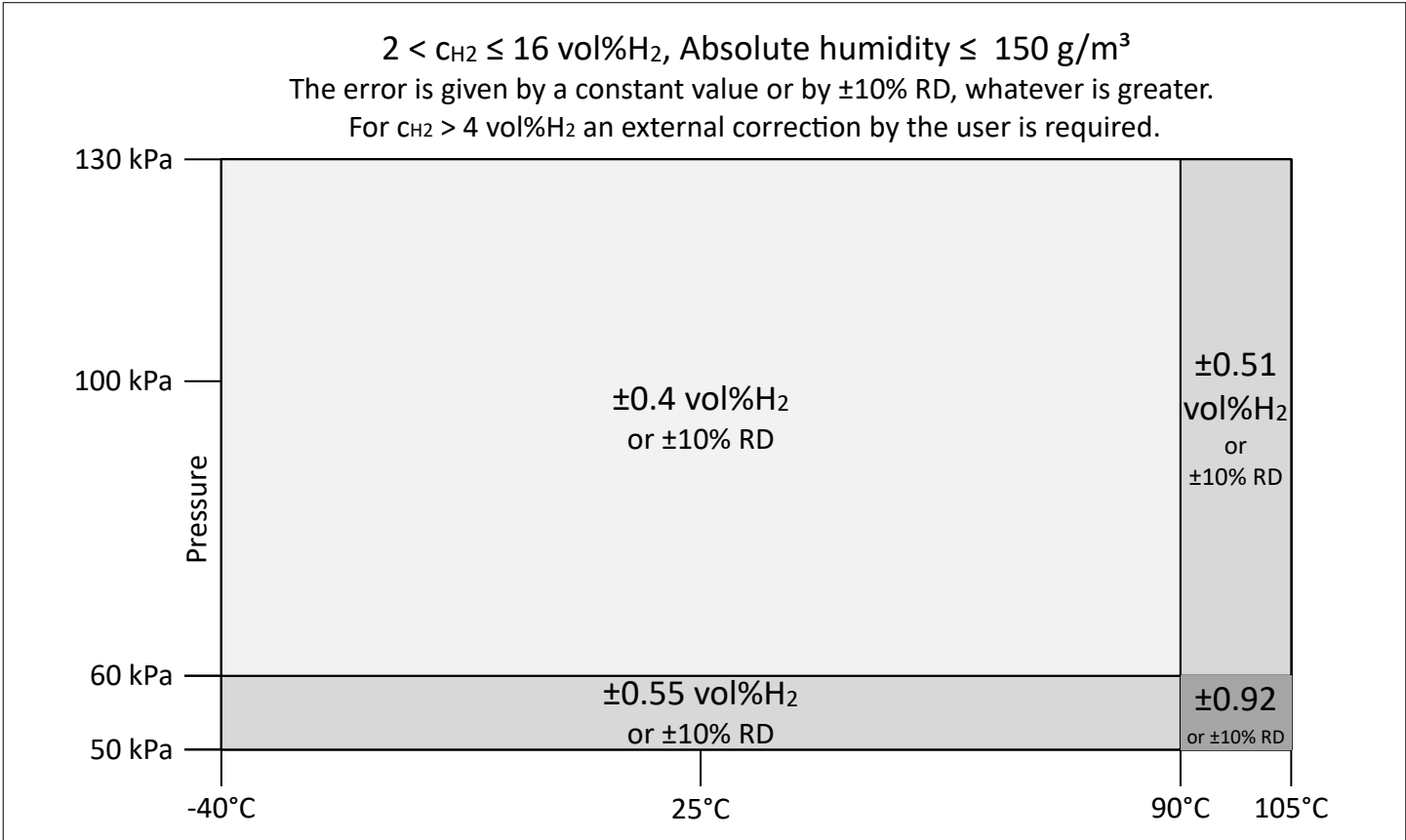


Figure 2 Total measurement error with p-compensation, high concentration range

### 3.2.2 Total measurement error w/o pressure compensation

**Table 6** Total thermal conductivity measurement error without pressure compensation

| Parameter                                  | Symbol              | Values |      |      | Unit               | Note or condition                                                                                                                                                                                |
|--------------------------------------------|---------------------|--------|------|------|--------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                            |                     | Min.   | Typ. | Max. |                    |                                                                                                                                                                                                  |
| Total measurement error w/o p-compensation | $TME_{no\_p\_comp}$ | -0.2   |      | 0.2  | vol%H <sub>2</sub> | $0 \text{ vol.}\% \leq c_{H_2} \leq 1 \text{ vol.}\%$<br>$80 \text{ kPa} \leq p_{GAS} \leq 120 \text{ kPa}$<br>$0\% \leq RH \leq 100\%$<br>$-5^\circ\text{C} \leq T_{amb} \leq 35^\circ\text{C}$ |

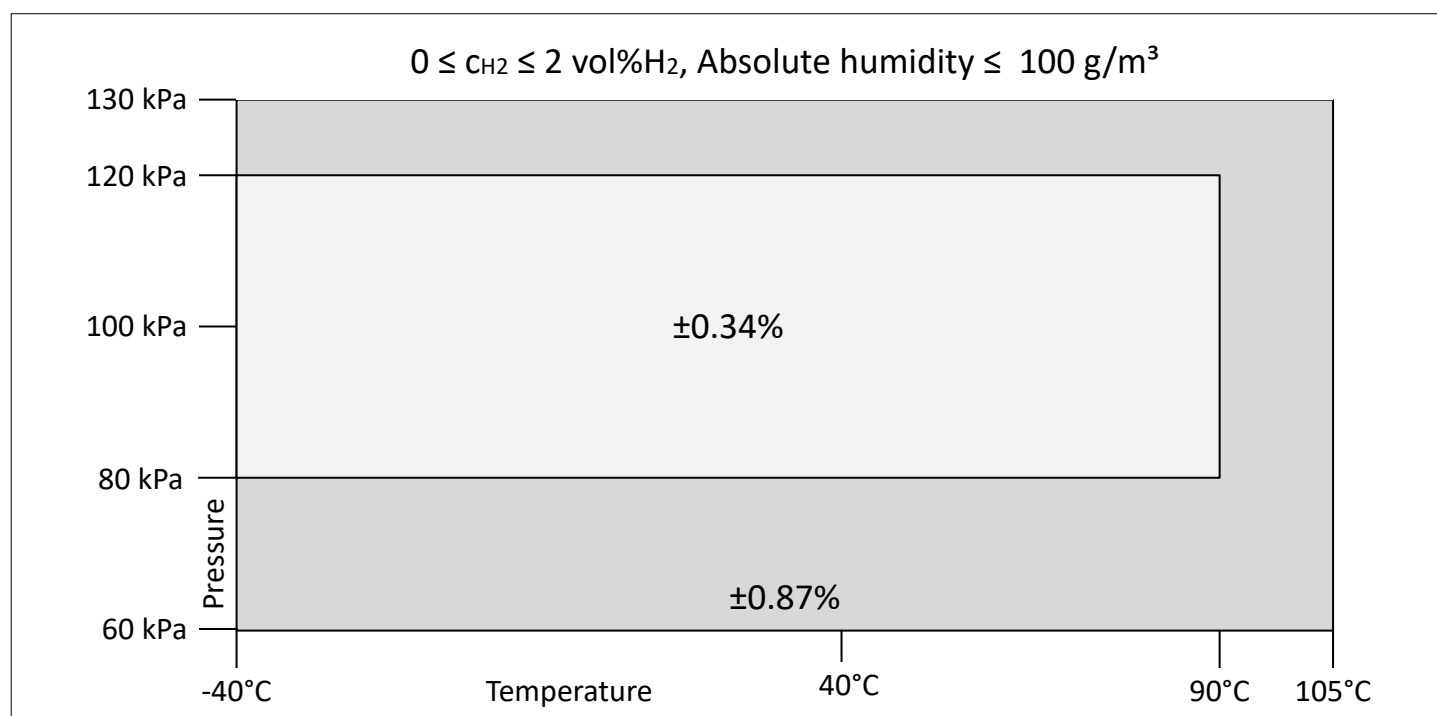


**Figure 3** Total measurement error w/o p-compensation, low concentration range

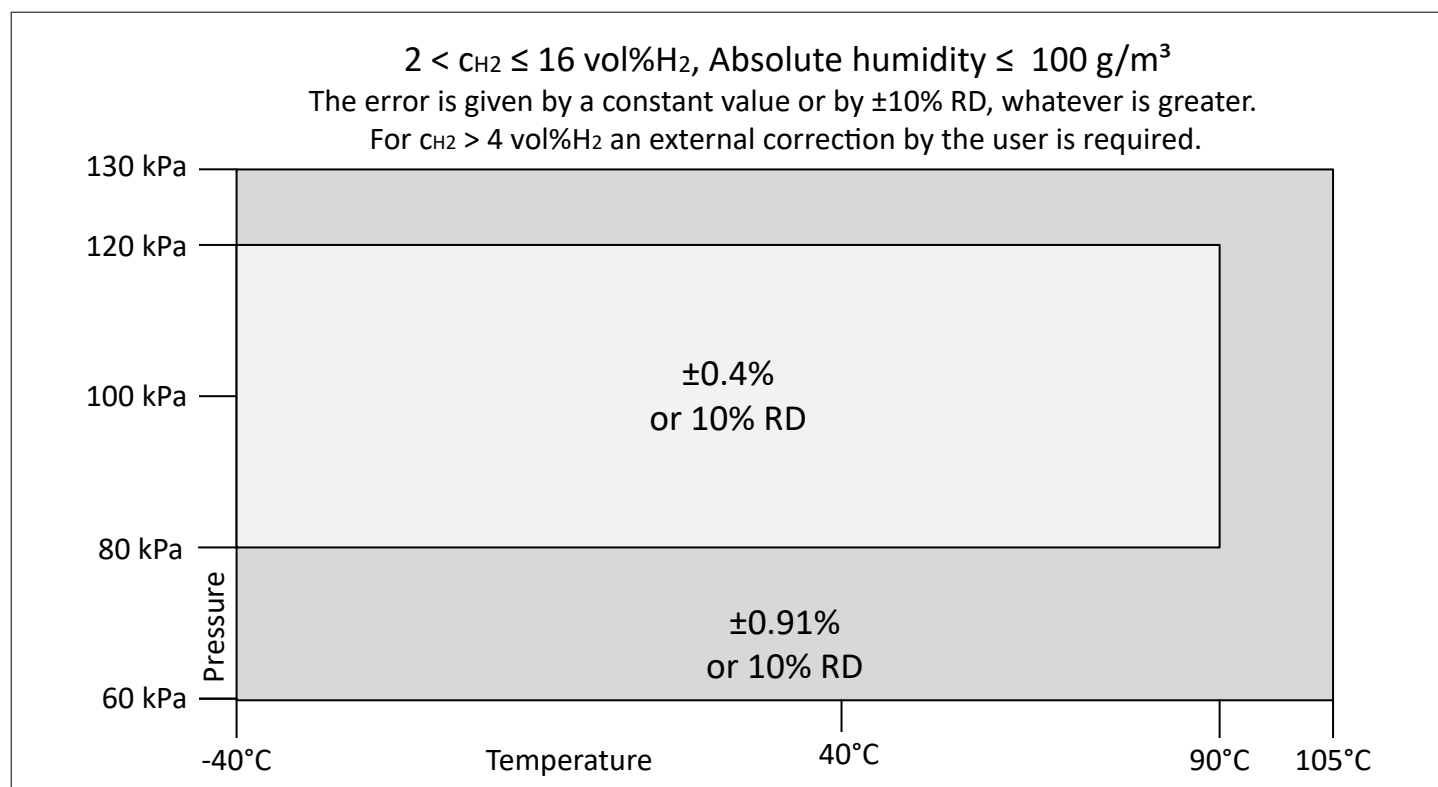


**Figure 4** Total measurement error w/o p-compensation, high concentration range

## 4 Temperature sensor

**Table 7** Temperature sensor characteristics

| Parameter                              | Symbol                   | Values |      |      | Unit | Note or condition                                                                  |
|----------------------------------------|--------------------------|--------|------|------|------|------------------------------------------------------------------------------------|
|                                        |                          | Min.   | Typ. | Max. |      |                                                                                    |
| Temperature measurement range          | $T_{\text{MEAS\_RANGE}}$ | -40    |      | 125  | °C   |                                                                                    |
| Temperature sensor physical resolution | $T_{\text{RES}}$         |        | 0.2  | 1    | °C   |                                                                                    |
| Temperature sensor total error         | $T_{\text{ERR}}$         | -5     |      | 5    | °C   | The measurement error is understood as total error, including random error (noise) |
| Temperature sensor total error, RT     | $T_{\text{ERR\_RT}}$     | -3     |      | 3    | °C   | $T_{\text{OP}} = -20^{\circ}\text{C}$ to $+90^{\circ}\text{C}$                     |

## 5 General purpose I/O pins

**Table 8** General purpose I/O pins

| Parameter                              | Symbol              | Values         |      |             | Unit   | Note or condition                                                                                                                   |
|----------------------------------------|---------------------|----------------|------|-------------|--------|-------------------------------------------------------------------------------------------------------------------------------------|
|                                        |                     | Min.           | Typ. | Max.        |        |                                                                                                                                     |
| Output high voltage                    | $V_{OH}$            | $V_{DD} - 0.3$ |      |             | V      | $I_{load} = 1 \text{ mA}$                                                                                                           |
| Output low voltage                     | $V_{OL}$            |                |      | 0.3         | V      | $I_{load} = -1 \text{ mA}$                                                                                                          |
| I <sup>2</sup> C low datarate          | $DR_{I2C\_low}$     |                | 100  |             | kbit/s |                                                                                                                                     |
| I <sup>2</sup> C medium datarate       | $DR_{I2C\_med}$     |                | 400  |             | kbit/s |                                                                                                                                     |
| I <sup>2</sup> C high datarate         | $DR_{I2C\_HIGH}$    |                |      | 1000        | kbit/s | maximal load capacitance at either pins is 80pF                                                                                     |
| PPx pin input capacitance              | $C_{IN}$            |                |      | 10          | pF     |                                                                                                                                     |
| Input high voltage                     | $V_{IH}$            | $0.8V_{DD}$    |      |             | V      |                                                                                                                                     |
| Input low voltage                      | $V_{IL}$            |                |      | $0.2V_{DD}$ | V      |                                                                                                                                     |
| PPx leakage current                    | $I_{IN\_PPX}$       | -2             |      | 2           | μA     |                                                                                                                                     |
| Equivalent pull resistor               | $R_{PULL}$          | 10             |      | 70          | kΩ     | $V_{IN\_PPX} = 1.5 \text{ V}$ , $V_{DD} = 3.3 \text{ V}$ ; Valid for pull-down at PP0, PP1, PP2, PP3. Valid for pull-up at PP2, PP3 |
| Equivalent pull-up resistor at PP0/PP1 | $R_{PULL\_up\_pp0}$ | 5.9            | 8.4  | 11          | kΩ     | $V_{IN\_PPX} = 1.5 \text{ V}$ , $V_{DD} = 3 \text{ V}$ ; Valid for pull-up at PP0, PP1                                              |

## 6 Supply currents

**Table 9** Supply currents

| Parameter                 | Symbol                 | Values |      |      | Unit          | Note or condition                    |
|---------------------------|------------------------|--------|------|------|---------------|--------------------------------------|
|                           |                        | Min.   | Typ. | Max. |               |                                      |
| Stand-by current, RT      | $I_{\text{STDBY\_RT}}$ |        | 2.3  | 6    | $\mu\text{A}$ | $T_{\text{OP}} = 25^{\circ}\text{C}$ |
| Sensor peak current at RT | $I_{\text{Peak\_RT}}$  |        | 5    | 7    | $\text{mA}$   |                                      |

## 7 Timing

**Table 10** Timing

| Parameter                          | Symbol                 | Values |      |      | Unit          | Note or condition                                                                        |
|------------------------------------|------------------------|--------|------|------|---------------|------------------------------------------------------------------------------------------|
|                                    |                        | Min.   | Typ. | Max. |               |                                                                                          |
| Stand-by resume time               | $t_{\text{RES\_STBY}}$ |        |      | 500  | $\mu\text{s}$ | 1)                                                                                       |
| Concentration measurement time     | $t_{\text{conc}}$      |        |      | 30   | ms            |                                                                                          |
| Concentration measurement interval | $t_{\text{conc\_int}}$ | 50     |      |      | ms            | Time between two consecutive concentration measurement commands.                         |
| Temperature measurement time       | $t_{\text{T}}$         |        |      | 1    | ms            |                                                                                          |
| Read ID time                       | $t_{\text{read\_ID}}$  |        |      | 100  | $\mu\text{s}$ |                                                                                          |
| Configuration command time         | $t_{\text{cfg}}$       |        |      | 100  | $\mu\text{s}$ |                                                                                          |
| Power on time                      | $t_{\text{INI}}$       |        |      | 20   | ms            | Time from $V_{\text{DD}}$ exceeding $V_{\text{THR}}$ until serial interface ready.<br>2) |
| VDD rise time                      | $t_{\text{RISE\_VDD}}$ |        |      | 1    | s             | Linear rise to $V_{\text{DD}} = 2.2 \text{ V}$                                           |

1) Time from change of level at wake-up pin until device ready for receiving a new I2C command.

2) The power on time is only valid if at least one of the 2 GPIO pins PP0 and PP1 is either not connected or connected to high level. If both GPIOs are actively connected to ground the power on time will prolong to approx. 3 seconds.

## 8 Block diagram

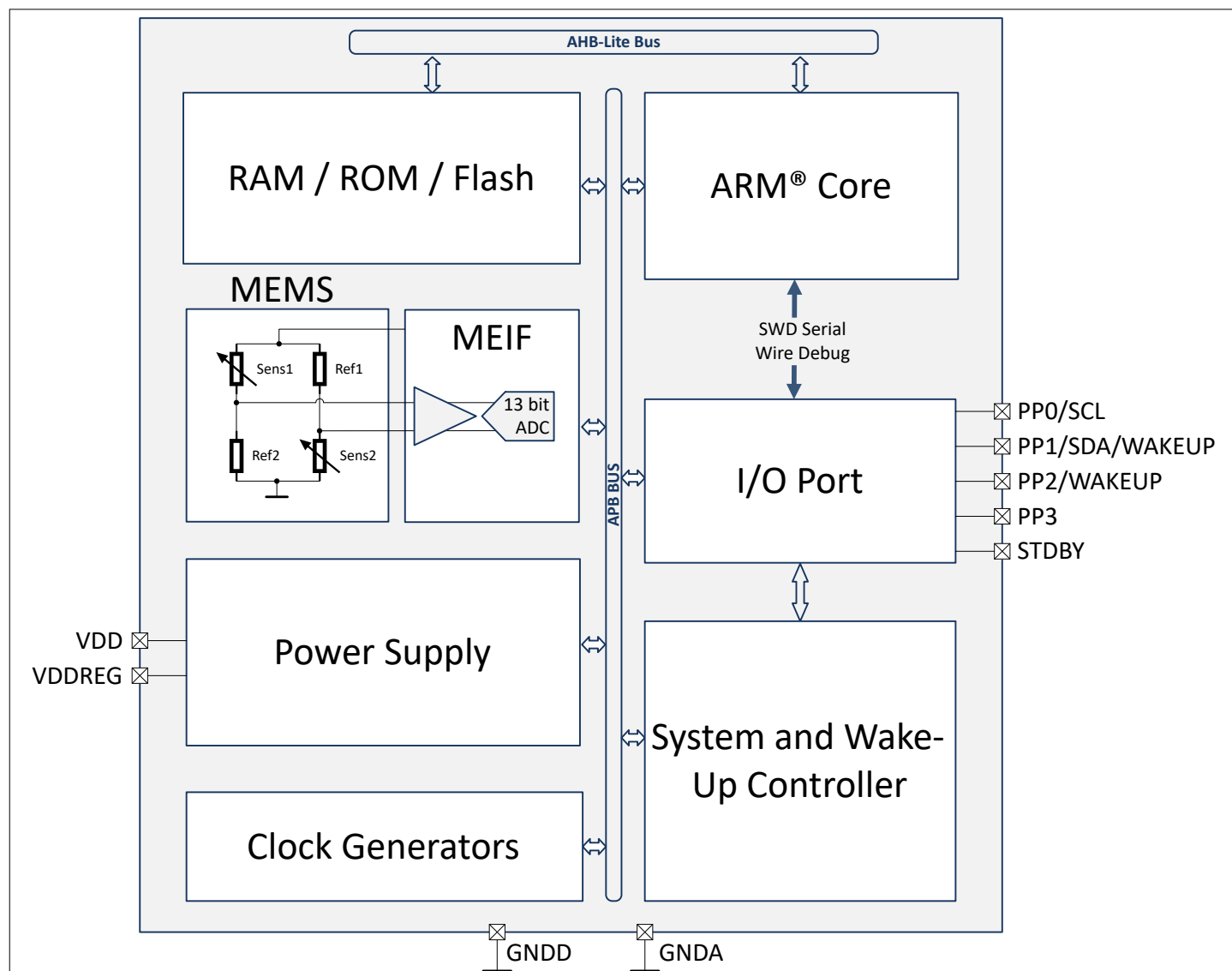


**Figure 5** Block diagram

## 9 Pin description

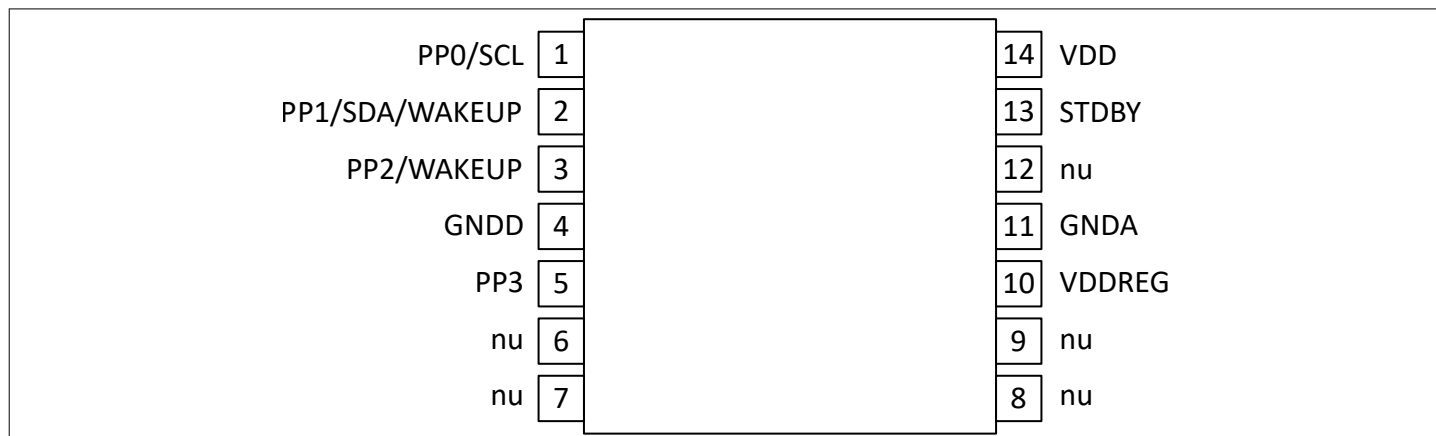


**Figure 6** TCI pinout

**Table 11** Pin Description

| Pin | Name              | Description                                                                                         |
|-----|-------------------|-----------------------------------------------------------------------------------------------------|
| 1   | PPO/SCL           | General Purpose IO / I2C-SCL                                                                        |
| 2   | PP1/SDA/WAKEUP    | General Purpose IO / I2C-SDA / External Wakeup <sup>1)</sup>                                        |
| 3   | PP2/SWDCLK/WAKEUP | General Purpose IO / Serial Wire Debug Interface Clock/ External Wakeup <sup>1)</sup> / device busy |
| 4   | GNDD              | Digital Ground                                                                                      |
| 5   | PP3 / SWDIO       | General Purpose IO / Serial Wire Debug Interface Input Output                                       |
| 6   | nu                | not used, do not connect                                                                            |
| 7   | nu                | not used, do not connect                                                                            |
| 8   | nu                | not used, do not connect                                                                            |
| 9   | nu                | not used, do not connect                                                                            |
| 10  | VDDREG            | Internal power supply stabilization, connect via 10 nF±10% capacitor to ground.                     |
| 11  | GNDA              | Analog and Power amplifier Ground                                                                   |
| 12  | nu                | not used, do not connect                                                                            |
| 13  | STDBY             | Output pin for indicating Stand-by or "device busy" condition.                                      |
| 14  | VDD               | Power Supply                                                                                        |

<sup>1)</sup> only one PP can be configured as external wake-up source at a time.

## 10 Firmware

### 10.1 Sensor operating concept

#### 10.1.1 I<sup>2</sup>C operation

I<sup>2</sup>C operating concept

- The device is implemented as I<sup>2</sup>C slave. The 7-bit slave address is 0x36.
- The device also acknowledges the address byte with the reserved I<sup>2</sup>C address 0x2E. However, full I<sup>2</sup>C commands sent to this address are not acknowledged and not executed.
- The master triggers a measurement by I<sup>2</sup>C command, then waits for a defined processing time and finally reads the measurement result from the slave.
- The device provides an output pin that indicates that the processing is ongoing.
- The I<sup>2</sup>C commands as well as the I<sup>2</sup>C reply are secured by a 16-bit CRC value. The CRC is calculated according to CRC-16/CCITT-FALSE standard with initialization value = 0xFFFF.
- Commands are not executed in case of an erroneous CRC value.
- In the I<sup>2</sup>C protocol all values (including the CRC) are transmitted with highest byte first.
- The specified processing times in section "Timing" do not include the I<sup>2</sup>C command execution times.

#### 10.1.2 Stand-by control

- The device may be configured such that it goes automatically into Stand-by after the measurement result has been read. The automatic stand-by functionality is disabled by default.
- Alternatively the device may be put into stand-by via a dedicated I<sup>2</sup>C command.
- The device provides an output pin that indicates the device is in Stand-by.
- If the device is in stand-by and before sending the actual measurement triggering command, the master needs to wake-up the slave.
- Wake-up can be either accomplished via a separate pin or by pulling SDA low for  $t_{pull}$ . The time between the wake-up and the following I<sup>2</sup>C command must be greater than the stand-by resume time  $t_{RES\_STBY}$ .
- The wake-up method (via dedicated pin or via SDA line) is configurable by the user.

**Note:** If the device is not periodically resumed from stand-by by the host-controller, it will resume automatically after typically 15.9 min. (This time has a tolerance, the minimum is 12.2 min, the maximum is 22.7 min.) In this situation the pin configured for stand-by indication (STDBY, PP2, or PP3) can be used to wake-up the host-controller.

#### 10.1.3 Invalid I<sup>2</sup>C commands

- If the device receives a command from the master during Stand-by, the command is not executed. In this case the status 0x20 is transmitted, followed by the CRC bytes 0xC5 and 0x92.
- If the device receives a command with invalid CRC it will reply with status 0x40, followed by the CRC bytes 0xA9 and 0x34.
- In case of an invalid command the status 0x80 is transmitted, followed by the CRC bytes 0x70 and 0x78

### 10.2 Trigger concentration measurement command

This command triggers a concentration measurement. For humidity compensation an external humidity and external temperature value may be provided via this command. This temperature is the temperature from the external humidity sensor and is only used for calculating the absolute humidity. For the actual temperature compensation an internal temperature sensor is used. Therefore, if the sensor is configured to perform only the temperature compensation this value is ignored. Further an external pressure value may be provided if pressure compensation is required. The command contains following fields:

|         |      |        |    |   |   |      |      |
|---------|------|--------|----|---|---|------|------|
| Address | 0xA8 | Config | RH | T | p | CRCH | CRCL |
|---------|------|--------|----|---|---|------|------|

Definition of the fields:

|            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
|------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Address    | Bit <7...1>=7-bit slave address<br>Bit <0> = 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| 0xA8       | Command identifier                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| Config     | Bit <7...6>: RH resolution enhancement. 1LSB=0.25%, see note 1.<br>Bit <5> =1: Field contamination check enabled, see note 2<br>Bit <5> =0: Field contamination check disabled<br>Bit <4> =1: EoL contamination check enabled, see note 2<br>Bit <4> =0: EoL contamination check disabled<br>Bit <3> =1: MEMS voltage regulator bypassed, see note 3<br>Bit <3> =0: MEMS voltage regulator not bypassed (recommended)<br>Bit <2> =1 : R32 calibration selected<br>Bit <2> =0 : H2 calibration selected<br>Bit <1...0> =11 <sub>b</sub> : The raw value is provided, no compensation<br>Bit <1...0> =10 <sub>b</sub> : Only temperature and humidity compensation<br>Bit <1...0> =01 <sub>b</sub> : Only temperature compensation<br>Bit <1...0> =00 <sub>b</sub> : The fully compensated concentration is provided |
| RH         | RH (relative humidity): 1%/LSB, range: 0% to 100%, see note 3.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| T          | T (temperature at RH sensor): 1°C / LSB, range: -40 °C to 105 °C (signed), see note 3.<br>This value is used to calculate the absolute humidity. If this value is set to 0x7F the value is not used, but the on-chip temperature value instead.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| p          | Ambient pressure used for compensation. 1 kPa / LSB, range: 50 kPa to 130 kPa. If no pressure value is available p=100 kPa is recommended.<br>See also note 3.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| CRCH, CRCL | 16-bit CRC value calculated from 5 bytes, 0xA8 to p                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |

**Note 1:** This bit field may be used to increase the resolution of the input parameter RH by two bits to achieve a more accurate humidity compensation. If the external humidity sensor does not provide this accuracy the bitfield should be set to zero. Config<7> represents 0.5%RH and Config<6> 0.25%RH.

**Note 2:** The End of Line (EoL) contamination check is more sensitive than the field contamination check and should not be used in the field. If the EoL contamination check is enabled then Config<5> will be ignored, i.e. for Config<4>=Config<5> = 1 only the EoL check will be executed.

**Note 3:** Depending on the supply voltage, bypassing the MEMS regulator can increase the concentration measurement sensitivity. However, the concentration value will no longer be correctly calibrated and it is the user's responsibility to do the calibration based on the raw value. Furthermore, bypassing the MEMS regulator requires a well regulated supply voltage.

**Note 4:** If the parameter is out of range the concentration measurement command is still executed and the corresponding status bit is set in the response.

This read command is used to fetch the reply from the device after a processing time of  $t_{conc\_meas}$ :

|         |        |        |        |      |      |
|---------|--------|--------|--------|------|------|
| Address | Status | Conc_H | Conc_L | CRCH | CRCL |
|---------|--------|--------|--------|------|------|

Definition of the fields:

|                             |                                                                                                                                                                                                                                                                                                                                                                                                |
|-----------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Address                     | Bit <7...1>=7-bit slave address<br>Bit <0>=1                                                                                                                                                                                                                                                                                                                                                   |
| Status                      | Status =0: measurement valid.<br>Bit<7...6> unused, always 0<br>Bit<5> previous command not executed due to stand-by<br>Bit<4> VDD out of range, concentration not in spec.<br>Bit<3> indicated a MEMS error or contamination check fail<br>Bit<2> indicates an "input parameter out of range" condition.<br>Bit<1> indicates an ADC overflow error<br>Bit<0> indicates an ADC underflow error |
| Conc_H, Conc_L (see note 1) | Depending on "Config" a fully compensated, a partially compensated, or the ADC raw value is provided.                                                                                                                                                                                                                                                                                          |
| CRCH, CRCL                  | 16-bit CRC value calculated from 3 bytes, Status to Conc_L                                                                                                                                                                                                                                                                                                                                     |

*Note 1:* The fully and partially compensated concentration values are 16-bit signed integer values with unit 0.01%H<sub>2</sub> / LSB if H<sub>2</sub> calibration is selected. If R<sub>32</sub> calibration is selected the resolution is 0.01%R<sub>32</sub>/LSB. The sensitivity of the uncompensated concentration raw value is individual for each device.

### 10.3 Trigger temperature measurement command

This command triggers a temperature measurement. The command contains following fields:

|         |      |      |      |
|---------|------|------|------|
| Address | 0xA9 | CRCH | CRCL |
|---------|------|------|------|

Definition of the fields:

|            |                                                |
|------------|------------------------------------------------|
| Address    | Bit <7...1>=7-bit slave address<br>Bit <0> = 0 |
| 0xA9       | Command identifier                             |
| CRCH, CRCL | 16-bit CRC value calculated from 1 byte, 0xA9  |

This read command is used to fetch the reply from the device after a processing time of  $t_{T\_meas}$ :

|         |        |   |      |      |
|---------|--------|---|------|------|
| Address | Status | T | CRCH | CRCL |
|---------|--------|---|------|------|

Definition of the fields:

|            |                                                                                                                                                                                                                                  |
|------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Address    | Bit <7...1>=7-bit slave address<br>Bit <0>=1                                                                                                                                                                                     |
| Status     | Status =0: measurement valid.<br>Bit<7...6> unused, always 0<br>Bit<5> previous command not executed due to stand-by<br>Bit<4...2> always 0<br>Bit<1> indicates an ADC overflow error<br>Bit<0> indicates an ADC underflow error |
| T          | Signed 8-bit on-chip temperature 1°C / LSB                                                                                                                                                                                       |
| CRCH, CRCL | 16-bit CRC value calculated from 2 bytes, Status and T                                                                                                                                                                           |

## 10.4 Configuration command

This command has several purposes:

1. disable/enable the Stand-by after reading the measurement result.
2. select the wake-up pin.
3. configure the "Busy" pin
4. configure the "Stand-by" pin

|         |      |       |       |       |      |      |
|---------|------|-------|-------|-------|------|------|
| Address | 0xC4 | Cfg_1 | Cfg_2 | Cfg_3 | CRCH | CRCL |
|---------|------|-------|-------|-------|------|------|

Definition of the fields:

|            |                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
|------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Address    | Bit <7...1>=7-bit slave address<br>Bit <0> = 0                                                                                                                                                                                                                                                                                                                                                                                                           |
| 0xC4       | Command identifier                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| Cfg_1      | Bit <7...4> don't care, should be 0<br>Bit <3> =1: Spike filter enabled, see <i>note 1</i><br>Bit <3> =0: Spike filter disabled<br>Bit <2> =1: PP2 wake-up on high level<br>Bit <2> =0: PP2 wake-up on low level<br>Bit <1> =1: PP2 is used as wake-up pin<br>Bit <1> =0: PP1(SDA) is used as wake-up pin, see <i>note 2</i><br>Bit <0> =1: Automatic Stand-By after reading result from command 0xA8 or 0xA9<br>Bit <0> =0: Automatic Stand-By disabled |
| Cfg_2      | Cfg_2=0: no "Busy" signal, see <i>notes 3, 4, 5</i><br>Cfg_2=1: "Busy" signal on PP2<br>Cfg_2=2: "Busy" signal on PP3<br>Cfg_2=3: "Busy" signal on STDBY                                                                                                                                                                                                                                                                                                 |
| Cfg_3      | Cfg_3=0: no "Stand-by" signal, see <i>notes 3, 4, 5</i><br>Cfg_3=1: "Stand-by" signal on PP2<br>Cfg_3=2: "Stand-by" signal on PP3<br>Cfg_3=3: "Stand-by" signal on STDBY                                                                                                                                                                                                                                                                                 |
| CRCH, CRCL | 16-bit CRC value calculated from 4 bytes, 0xC4 to Cfg_3                                                                                                                                                                                                                                                                                                                                                                                                  |

Notes:

1. The spike filter is disabled by default after power on. It can be enabled if spikes on the I<sup>2</sup>C lines are expected. If the filter is enabled the I<sup>2</sup>C communication speed is limited to 800 kbit/s.
2. For PP1 the wake-up is always triggered on low level.
3. Busy and Stand-by signals are active high
4. It is allowed to put Busy and Stand-by on the same pin
5. The default setting after power on is PP2 = "Busy", STDBY= "Stand-by"

This read command is used to fetch the reply from the device after a processing time of  $t_{STWU\_cfg}$ :

|         |        |      |      |
|---------|--------|------|------|
| Address | Status | CRCH | CRCL |
|---------|--------|------|------|

Definition of the fields:

|            |                                                                                                                                              |
|------------|----------------------------------------------------------------------------------------------------------------------------------------------|
| Address    | Bit <7...1>=7-bit slave address<br>Bit <0>=1                                                                                                 |
| Status     | Status =0: measurement valid.<br>Bit<7...6> unused, always 0<br>Bit<5> previous command not executed due to stand-by<br>Bit<4...0>: always 0 |
| CRCH, CRCL | 16-bit CRC value calculated from 1 byte, Status                                                                                              |

## 10.5 Stand-by command

This command puts the sensor into Stand-by:

|         |      |      |      |
|---------|------|------|------|
| Address | 0xC3 | CRCH | CRCL |
|---------|------|------|------|

Definition of the fields:

|            |                                                |
|------------|------------------------------------------------|
| Address    | Bit <7...1>=7-bit slave address<br>Bit <0> = 0 |
| 0xC3       | Command identifier                             |
| CRCH, CRCL | 16-bit CRC value calculated from byte 0xC3     |

*Note 1:* This command must not be followed by a read command if the SDA line is configured as wake-up line. Otherwise the device would immediately resume from Stand-by.

*Note 2:* The device will resume from Stand-by if any I<sup>2</sup>C read or write command is sent including the command 0xC3 itself. The command used for resuming the device will not be executed and not acknowledged.

## 10.6 Read ID command

This command allows to read the following parameter from the sensor:

- Unique sensor ID.
- Product code
- FW revision number
- Manufacturer identifier

The command contains following fields:

|         |      |      |      |
|---------|------|------|------|
| Address | 0xC2 | CRCH | CRCL |
|---------|------|------|------|

Definition of the fields:

|            |                                                |
|------------|------------------------------------------------|
| Address    | Bit <7...1>=7-bit slave address<br>Bit <0> = 0 |
| 0xC2       | Command identifier                             |
| CRCH, CRCL | 16-bit CRC value calculated from byte 0xC2     |

This read command is used to fetch the reply from the device after a processing time of  $t_{\text{read\_ID}}$ :

| Address | Status | ID3 | ID2 | ID1 | ID0 | PC_H | PC_L | FW_H | FW_L | MANU | CRCH | CRCL |
|---------|--------|-----|-----|-----|-----|------|------|------|------|------|------|------|
|---------|--------|-----|-----|-----|-----|------|------|------|------|------|------|------|

Definition of the fields:

|                    |                                                                                                                                                      |
|--------------------|------------------------------------------------------------------------------------------------------------------------------------------------------|
| Address            | Bit <7...1>=7-bit slave address<br>Bit <0>=1                                                                                                         |
| Status             | Status =0: measurement valid.<br>Bit<7...6> unused, always 0<br>Bit<5> previous command not executed due to Stand-by<br>Bit<4...0>: unused, always 0 |
| ID3, ID2, ID1, ID0 | 32-bit Sensor ID                                                                                                                                     |
| PC_H, PC_L         | 16-bit Product Code                                                                                                                                  |
| FW_H, FW_L         | 16-bit Firmware revision number                                                                                                                      |
| MANU               | 8-bit Manufacturer Code                                                                                                                              |
| CRCH, CRCL         | 16-bit CRC value calculated from 10 bytes, Status to MANU                                                                                            |

## 11 Temperature mission profile

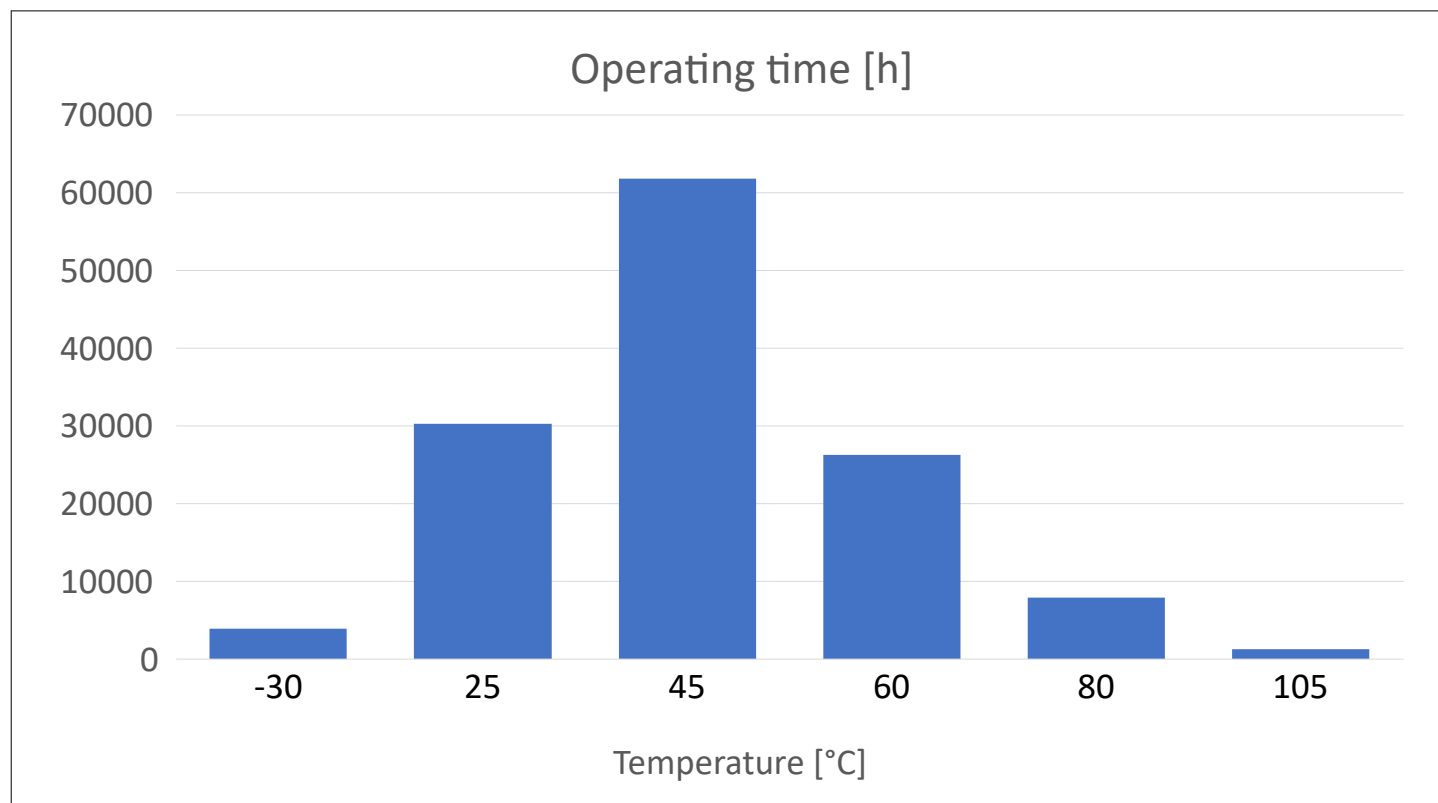


**Figure 7** Temperature mission profile

*Note:* This is a typical temperature mission profile for which the lifetime of 15 years is valid

12 Package dimensions and footprint

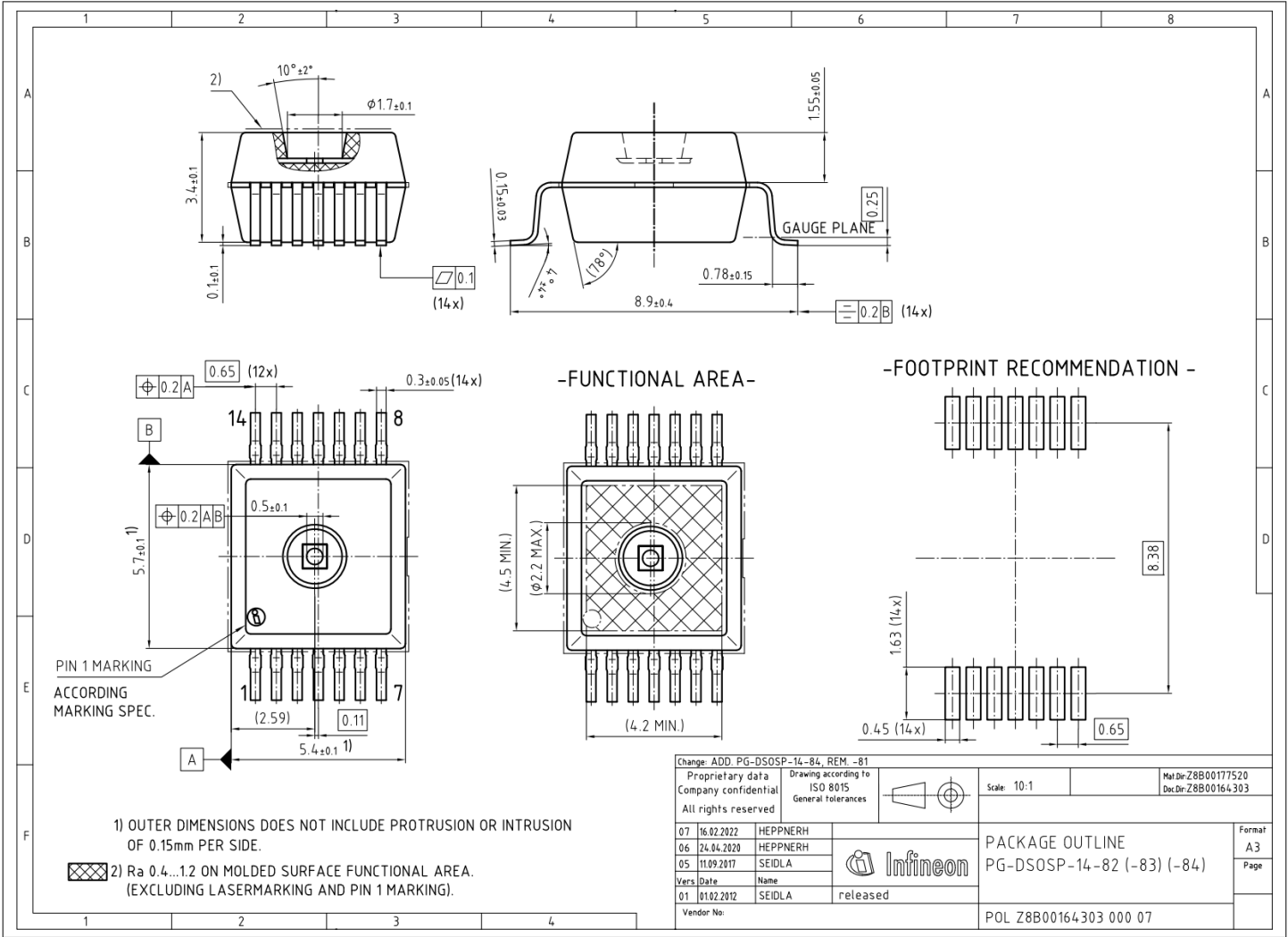


Figure 8 Package outline

## 13 Package marking

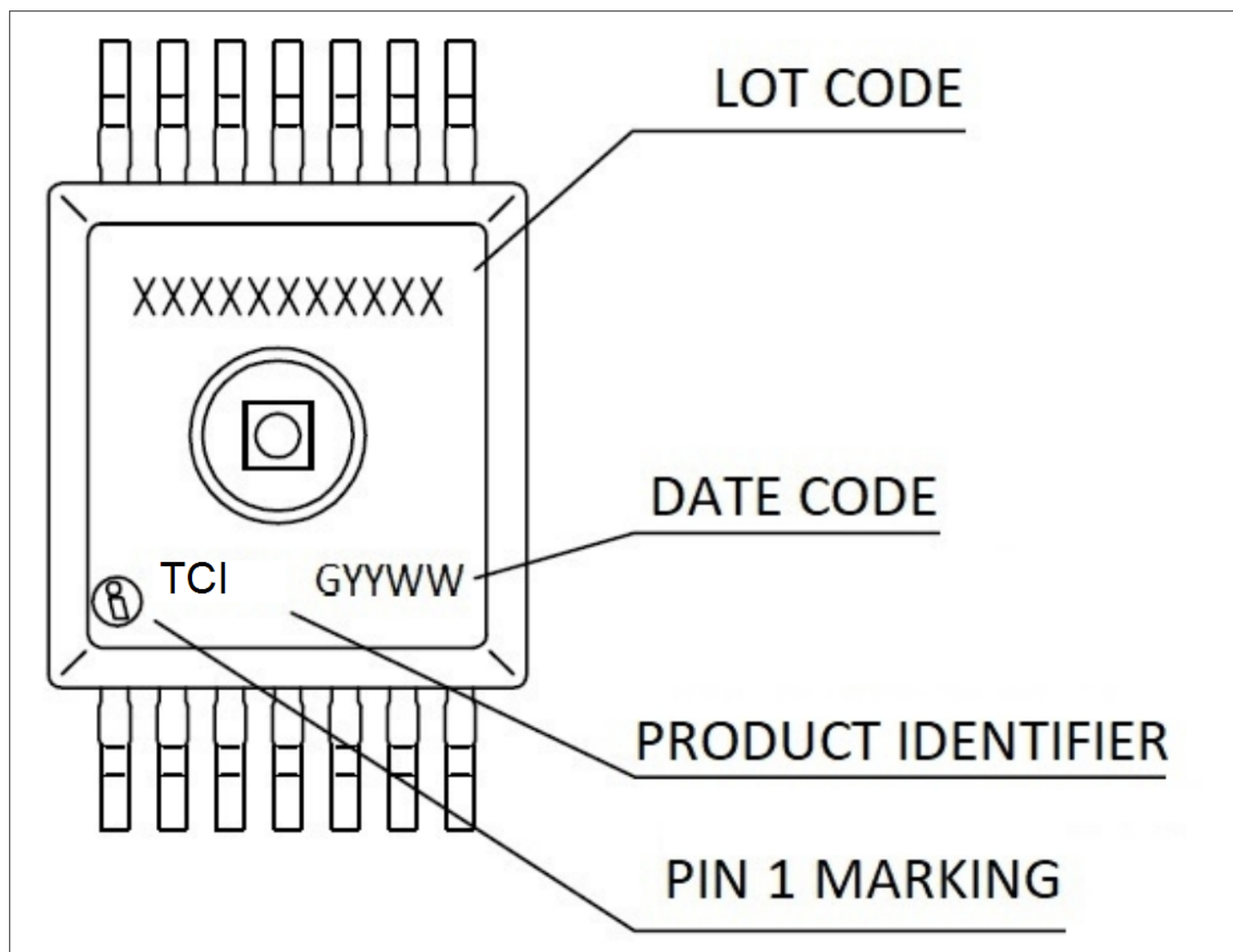


Figure 9 Package marking

## **14 User instructions**

### **14.1 Device contamination**

The very fine gas-sensitive structures are nested inside the component and are therefore protected from direct contact. However, contaminants in the form of small particles can still reach these structures and alter the sensor properties. Therefore, depending on the environmental conditions, the sensor must be installed in a way that protects it from such particles.

### **14.2 Device communication**

There are certain restrictions when communicating with the TCI:

- During the busy phase the I<sup>2</sup>C interface is disabled. Commands will be ignored and will not be acknowledged.
- If the busy signal is not monitored then the minimum command execution time must be waited between write and read command.
- Commands cannot be executed in parallel. The sequence write - wait - read must be completed before the next command is sent.
- The minimal concentration measurement interval ( $t_{\text{conc\_int}}$ ) must be considered.

Figure 10 shows examples how to communicate with the TCI. The flow on the left side is the most straight forward method where simply the specified command execution times are considered between each write and read command.

The flow in the middle waits for the busy signal between each write and read command rather than a fixed waiting time.

The flow on the right is a proposed flow to wait for the busy signal. However this flow if necessary must be modified depending on the speed of the host controller. For instance if the host controller is slow and the command execution time is short ( $< 100 \mu\text{s}$ ) there is some risk that the code is trapped in the "Busy pin active" loop.

In this case the better solution would be to implement the fixed wait time like in the flow on the left side.

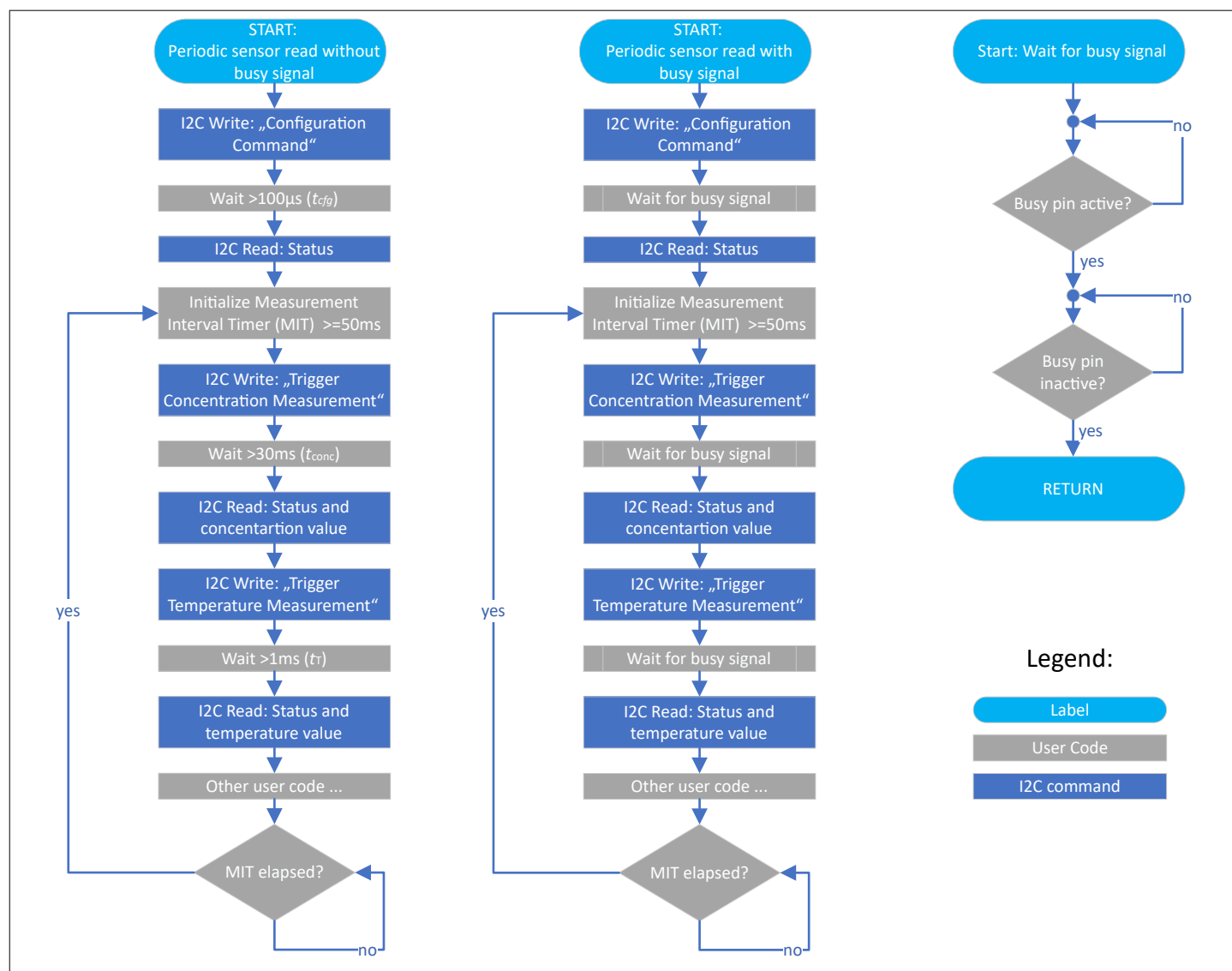


Figure 10 User instruction flow diagram

## 15 Revision history

**Table 12**                      **Revision History**

| <b>Document version</b> | <b>Date of release</b> | <b>Description of changes</b>                                                                                                                                                                                                  |
|-------------------------|------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1.00                    | 2025-03-25             | Initial release                                                                                                                                                                                                                |
| 1.10                    | 2025-05-06             | Added Chapter "Block Diagram"<br>Changed chapter "User Instructions"                                                                                                                                                           |
| 1.20                    | 2025-08-13             | Removed error bits Status<6> and Status<7> from the I <sup>2</sup> C read commands because there are dedicated I <sup>2</sup> C messages for these errors.<br>Updated the Configuration Command with the spike filter feature. |
| 1.21                    | 2025-09-16             | Changed the representation of the Total Measurement Error                                                                                                                                                                      |
| 1.30                    | 2026-05-28             | Added UL2075 recognition                                                                                                                                                                                                       |

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