XENSIV™ TCI Integrated Thermal Conductivity Gas Sensor

Features

- Thermal Conductivity Sensing Principle
- Insensitive to Sensor Poisoning
- Low Lifetime Offset Drift of maximal ±0.1vol%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 < 100ms
- Measurement Accuracy up to ±0.34vol%H_2
- Ultra-low Power Consumption: typ. 112µA @1 meas./sec
- 1Mbit/s I2C Interface and 3.3V Supply Voltage
- AEC-Q100 Automotive Qualified for 105°C and 15 Years Lifetime
- Qualified according to JEDEC JESD47L

(*External humidity and pressure information required)

RoHS

AEC Qualified

Potential Applications

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

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	see chapter "Package Marking"	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}	±100			mA	Maximum transient current at any pin according JEDEC78 class II level A
ESD robustness HBM	V_{HBM}	±2000			V	All pins tested according to AEC-Q100-002
ESD robustness CDM, Corner Pins	$V_{CDM\ C}$	±750			V	Corner pins tested according to AEC-Q100-011
ESD robustness CDM	V_{CDM}	±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. Maximum 1000 hours between -40°C and -50°C. Device not powered. 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 ±x, ±y, and ±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 3.3V
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_ext_{H2}	4		16	vol%	External ignition protection in place
Operating Hours	t_{op}			15	y	Valid for the specified temperature mission profile.

3 TC Sensor Characteristics

Note that for fulfilling the total measurement error specification at c_{H2} > 5% the following output signal correction is required:

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

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

Table 4 TC Sensor Characteristics

Parameter	Symbol	Values			Unit	Note or condition
		Min.	Typ.	Max.		
Response/ Recovery Time (t90, t10)	$t_{90,10}$			100	ms	Analysis-gas present at device gas-inlet at start of measurement.
Digital Resolution	$Sens_{H2}$		0.01		vol%H2/ LSB	
RMS Noise Level	σ_{H2}		0.015	0.02	vol%H2	

Table 5 Total Thermal Conductivity Measurement Error Without Pressure Compensation

Parameter	Symbol	Values			Unit	Note or condition
		Min.	Typ.	Max.		
Total Measurement Error 1.1	$TME_{1.1}$	-0.34		+0.34	vol%H2	0 vol.% ≤ c_{H2} ≤ 2 vol.% 80kPa ≤ p_{GAS} ≤ 120kPa Abs. Humidity <100 g/m³ T_{amb} ≤ 90°C
Total Measurement Error 1.2	$TME_{1.2}$	-0.4		+0.4	vol%H2	2 vol.% < c_{H2} ≤ 4 vol.% 80kPa ≤ p_{GAS} ≤ 120kPa Abs. Humidity <100 g/m³ T_{amb} ≤ 90°C
Total Measurement Error 1.3	$TME_{1.3}$	-10		+10	%RD	4 vol.% < c_{H2} ≤ 16 vol.% 80kPa ≤ p_{GAS} ≤ 120kPa Abs. Humidity <100 g/m³ T_{amb} ≤ 90°C External correction required
Total Measurement Error 2.1	$TME_{2.1}$	-0.87		+0.87	vol%H2	0 vol.% ≤ c_{H2} ≤ 2 vol.% 60kPa ≤ p_{GAS} ≤ 130kPa Abs. Humidity <100 g/m³ T_{amb} ≤ 105°C
Total Measurement Error 2.2	$TME_{2.2}$	-0.91		+0.91	vol%H2	2 vol.% < c_{H2} ≤ 4 vol.% 60kPa ≤ p_{GAS} ≤ 130kPa Abs. Humidity <100 g/m³ T_{amb} ≤ 105°C

(table continues...)

Table 5 **(continued) Total Thermal Conductivity Measurement Error Without Pressure Compensation**

Parameter	Symbol	Values			Unit	Note or condition
		Min.	Typ.	Max.		
Total Measurement Error 2.3	$TME_{2.3}$	-0.91		+0.91	vol%H2	4 vol.% < c_{H2} ≤ 9.1 vol.% 60kPa ≤ p_{GAS} ≤ 130kPa Abs. Humidity <100 g/m^3 90°C < T_{amb} ≤ 105°C External correction required
Total Measurement Error 2.4	$TME_{2.4}$	-10		+10	%RD	9.1 vol.% < c_{H2} ≤ 16 vol.% 60kPa ≤ p_{GAS} ≤ 130kPa Abs. Humidity <100 g/m^3 90°C < T_{amb} ≤ 105°C External correction required

Notes:
1. *This table is valid if the external humidity sensor used for compensation does not exceed a tolerance of ±1.5%RH and ±1 °C.*
2. *%RD stands for percent of concentration reading.*

Table 6 **Total Thermal Conductivity Measurement Error With Pressure Compensation**

Parameter	Symbol	Values			Unit	Note or condition
		Min.	Typ.	Max.		
Total Measurement Error 3.1	$TME_{3.1}$	-0.34		+0.34	vol%H2	0 vol.% ≤ c_{H2} ≤ 2 vol.% 60kPa ≤ p_{GAS} ≤ 130kPa Abs. Humidity <150 g/m^3 T_{amb} ≤ 90°C
Total Measurement Error 3.2	$TME_{3.2}$	-0.4		+0.4	vol%H2	2 vol.% < c_{H2} ≤ 4 vol.% 60kPa ≤ p_{GAS} ≤ 130kPa Abs. Humidity <150 g/m^3 T_{amb} ≤ 90°C
Total Measurement Error 3.3	$TME_{3.3}$	-10		+10	%RD	4 vol.% < c_{H2} ≤ 16 vol.% 60kPa ≤ p_{GAS} ≤ 130kPa Abs. Humidity <150 g/m^3 T_{amb} ≤ 90°C External correction required
Total Measurement Error 4.1	$TME_{4.1}$	-0.49		+0.49	vol%H2	0 vol.% ≤ c_{H2} ≤ 2 vol.% 50kPa ≤ p_{GAS} ≤ 60kPa Abs. Humidity <150 g/m^3 T_{amb} ≤ 90°C

(table continues...)

Table 6 (continued) Total Thermal Conductivity Measurement Error With Pressure Compensation

Parameter	Symbol	Values			Unit	Note or condition
		Min.	Typ.	Max.		
Total Measurement Error 4.2	$TME_{4.2}$	-0.55		+0.55	vol%H2	2 vol.% < c_{H2} ≤ 4 vol.% 50kPa ≤ p_{GAS} ≤ 60kPa Abs. Humidity <150 g/m^3 T_{amb} ≤ 90°C
Total Measurement Error 4.3	$TME_{4.3}$	-0.55		+0.55	vol%H2	4 vol.% < c_{H2} ≤ 5.5 vol.% 50kPa ≤ p_{GAS} ≤ 60kPa Abs. Humidity <150 g/m^3 T_{amb} ≤ 90°C External correction required
Total Measurement Error 4.4	$TME_{4.4}$	-10		+10	%RD	5.5 vol.% < c_{H2} ≤ 16 vol.% 50kPa ≤ p_{GAS} ≤ 60kPa Abs. Humidity <150 g/m^3 T_{amb} ≤ 90°C External correction required
Total Measurement Error 5.1	$TME_{5.1}$	-0.47		+0.47	vol%H2	0 vol.% ≤ c_{H2} ≤ 2 vol.% 60kPa ≤ p_{GAS} ≤ 130kPa Abs. Humidity <150 g/m^3 +90°C<T_{amb} ≤ 105°C
Total Measurement Error 5.2	$TME_{5.2}$	-0.51		+0.51	vol%H2	2 vol.% < c_{H2} ≤ 4 vol.% 60kPa ≤ p_{GAS} ≤ 130kPa Abs. Humidity <150 g/m^3 +90°C<T_{amb} ≤ 105°C
Total Measurement Error 5.3	$TME_{5.3}$	-0.51		+0.51	vol%H2	4 vol.% < c_{H2} ≤ 5.1vol.% 60kPa ≤ p_{GAS} ≤ 130kPa Abs. Humidity <150 g/m^3 90°C < T_{amb} ≤ 105°C External correction required
Total Measurement Error 5.4	$TME_{5.4}$	-10		+10	%RD	5.1 vol.% < c_{H2} ≤ 16 vol.% 60kPa ≤ p_{GAS} ≤ 130kPa Abs. Humidity <150 g/m^3 90°C < T_{amb} ≤ 105°C External correction required
Total Measurement Error 6.1	$TME_{6.1}$	-0.9		+0.9	vol%H2	0 vol.% ≤ c_{H2} ≤ 2 vol.% 50kPa ≤ p_{GAS} ≤ 60kPa Abs. Humidity <150 g/m^3 +90°C<T_{amb} ≤ 105°C

(table continues...)

Table 6 (continued) Total Thermal Conductivity Measurement Error With Pressure Compensation

Parameter	Symbol	Values			Unit	Note or condition
		Min.	Typ.	Max.		
Total Measurement Error 6.2	$TME_{6.2}$	-0.92		+0.92	vol%H2	2 vol.% < c_{H2} ≤ 4 vol.% 50kPa ≤ p_{GAS} ≤ 60kPa Abs. Humidity <150 g/m^3 +90°C<T_{amb} ≤ 105°C
Total Measurement Error 6.3	$TME_{6.3}$	-0.92		+0.92	vol%H2	4 vol.% < c_{H2} ≤ 9.2 vol.% 50kPa ≤ p_{GAS} ≤ 60kPa Abs. Humidity <150 g/m^3 90°C < T_{amb} ≤ 105°C External correction required
Total Measurement Error 6.4	$TME_{6.4}$	-10		+10	%RD	9.2 vol.% < c_{H2} ≤ 16 vol.% 50kPa ≤ p_{GAS} ≤ 60kPa Abs. Humidity <150 g/m^3 90°C < T_{amb} ≤ 105°C External correction required

Notes:

1. *This table is valid if the external humidity sensor used for compensation does not exceed a tolerance of ±1.5%RH and ±1 °C. The external pressure sensor used for compensation must not exceed a tolerance of ±2 kPa.*
2. *%RD stands for percent of concentration reading.*

4 Temperature Sensor

Table 7 Temperature Sensor

Parameter	Symbol	Values			Unit	Note or condition
		Min.	Typ.	Max.		
Temperature Measurement Range	T_{MEAS_RANGE}	-40	--	125	°C	
Temperature Sensor Physical Resolution	T_{RES}		0.2	1	°C	
Temperature Sensor Total Error	T_{ERR}	-5		5	°C	The measurement error is understood as total error, including random error (noise)
Temperature Sensor Total Error, RT	T_{ERR_RT}	-3		3	°C	T_{OP} = -20°C to +90°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} = 1mA
Output Low Voltage	V_{OL}			0.3	V	I_{load} = -1mA
I2C Low Datarate	DR_{I2C_low}		100		kbit/s	
I2C Medium Datarate	DR_{I2C_med}		400		kbit/s	
I2C 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} = 1.5V, VDD=3.3V; 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} = 1.5V, VDD=3V; 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_{STDBY_RT}		2.3	6	µA	T_{OP} = 25°C
Sensor Peak Current at RT	I_{Peak_RT}		5	7	mA	

7 Timing

Table 10 Timing

Parameter	Symbol	Values			Unit	Note or condition
		Min.	Typ.	Max.		
Stand-By Resume Time	t_{RES_STBY}			500	µs	1)
Concentration Measurement Time	t_{conc}			30	ms	
Concentration Measurement Interval	t_{conc_int}	50			ms	Time between two consecutive concentration measurement commands.
Temperature Measurement Time	t_T			1	ms	
Read ID Time	t_{read_ID}			100	µs	
Configuration Command Time	t_{CFG_CMG}			100	µs	
Power on time	t_{INI}			20	ms	Time from V_{DD} exceeding V_{THR} until serial interface ready. 2)
VDD rise time	t_{RISE_VDD}	-		1	s	Linear rise to V_{DD} = 2.2V

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

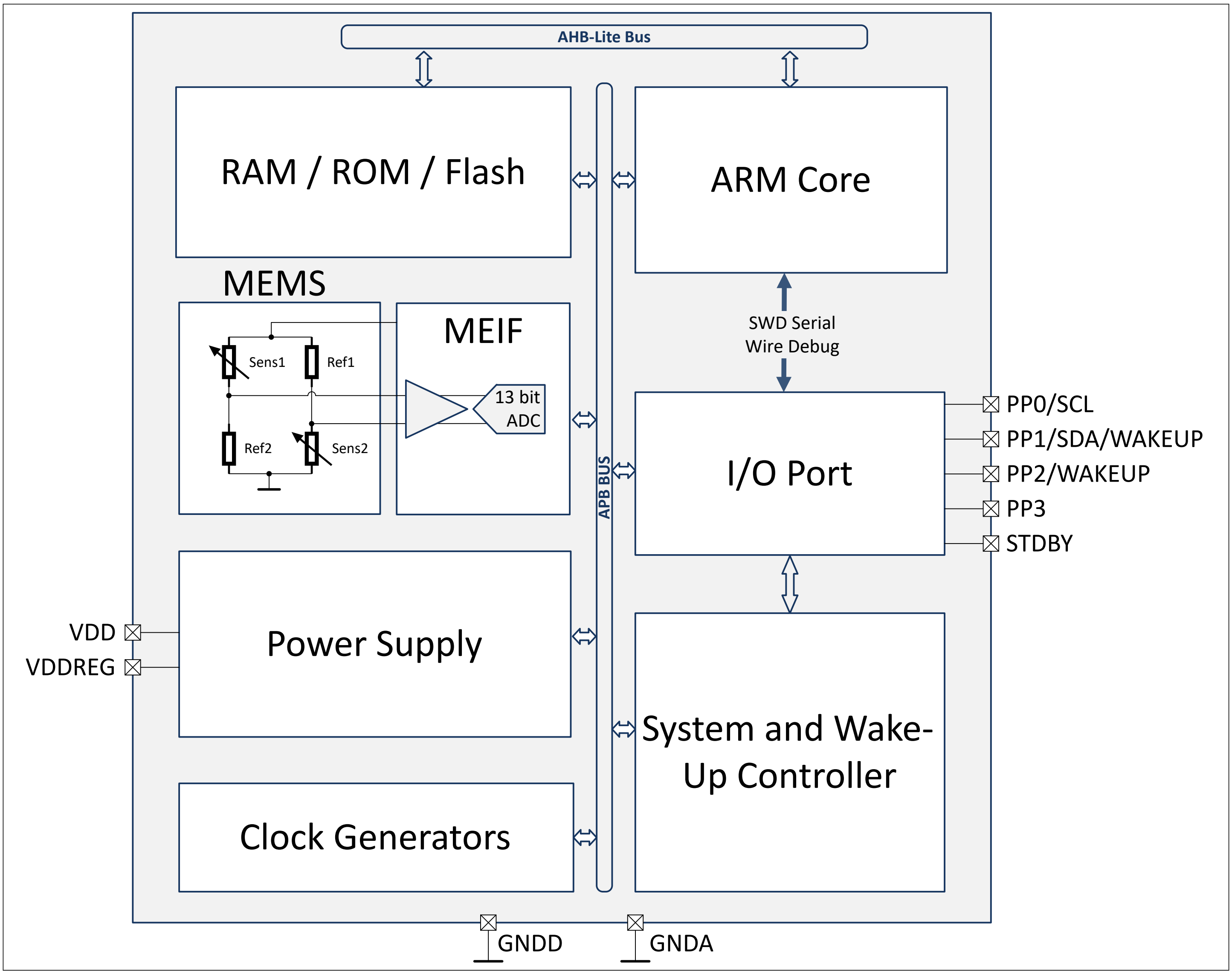

Figure 1 Block Diagram

9 Pin Description

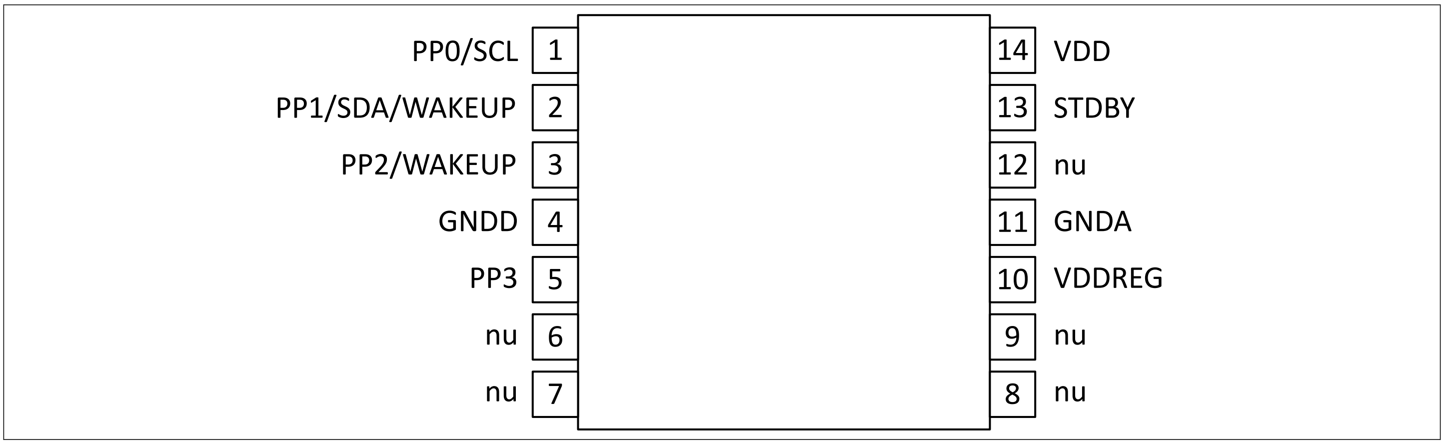

Figure 2 **TCI Pinout**

Table 11 **Pin Description**

Pin	Name	Description
1	PP0/SCL	General Purpose IO / I2C-SCL
2	PP1/SDA/WAKEUP	General Purpose IO / I2C-SDA / External Wakeup[1)]
3	PP2/SWDCLK/WAKEUP	General Purpose IO / Serial Wire Debug Interface Clock/ External Wakeup[1)]/ 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 10nF±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

[1)] only one PP can be configured as external wake-up source at a time.

10 Firmware

10.1 Sensor Operating Concept

10.1.1 I2C Operation

I2C operating concept

- The device is implemented as I2C slave. The 7 bit slave address is 0x36.
- The device also acknowledges the address byte with the reserved I2C address 0x2E. However, full I2C commands send to this address are not acknowledged and not executed.
- The master triggers a measurement by I2C 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 I2C commands as well as the I2C 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 I2C protocol all values (including the CRC) are transmitted with highest byte first.
- The specified processing times in section "Timing" do not include the I2C 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 I2C 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 I2C 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 I2C 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 Bit <0> = 0
0xA8	Command identifier
Config	Bit <7...6>: RH resolution enhancement. 1LSB=0.25%, see note 1. Bit <5> =1: Field contamination check enabled, see note 2 Bit <5> =0: Field contamination check disabled Bit <4> =1: EoL contamination check enabled, see note 2 Bit <4> =0: EoL contamination check disabled Bit <3> =1: MEMS voltage regulator bypassed, see note 3 Bit <3> =0: MEMS voltage regulator not bypassed (recommended) Bit <2> =1 : R32 calibration selected Bit <2> =0 : H2 calibration selected Bit <1...0> =11_b: The raw value is provided, no compensation Bit <1...0> =10_b: Only temperature and humidity compensation Bit <1...0> =01_b: Only temperature compensation Bit <1...0> =00_b: 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 to 105 (signed), see note 3. 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. 1kPa / LSB, range: 50 to 130. If no pressure value is available p=100 is recommended. 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 sensitiv 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 users 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 Bit <0>=1
Status	Status =0: measurement valid. Bit<7> indicates an invalid command Bit<6> indicates an I2C-CRC error Bit<5> previous command not executed due to stand-by Bit<4> VDD out of range, concentration not in spec. Bit<3> indicated a MEMS error or contamination check fail Bit<2> indicates an "input parameter out of range" condition. Bit<1> indicates an ADC overflow error 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%H2 / LSB if H2 calibration is selected. If R32 calibration is selected the resolution is 0.01%R32/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 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 Bit <0>=1
Status	Status =0: measurement valid. Bit<7> indicates an invalid command Bit<6> indicates an I2C-CRC error Bit<5> previous command not executed due to stand-by Bit<4...2> always 0 Bit<1> indicates an ADC overflow error 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 Bit <0> = 0
0xC4	Command identifier
Cfg_1	Bit <7...3> don't care, should be 0 Bit <2> =1: PP2 wake-up on high level Bit <2> =0: PP2 wake-up on low level Bit <1> =1: PP2 is used as wake-up pin Bit <1> =0: PP1(SDA) is used as wake-up pin (see note) Bit <0> =1: Automatic Stand-By after reading result from command 0xA8 or 0xA9 Bit <0> =0: Automatic Stand-By disabled
Cfg_2	Cfg_2=0: no "Busy" signal Cfg_2=1: "Busy" signal on PP2 Cfg_2=2: "Busy" signal on PP3 Cfg_2=3: "Busy" signal on STDBY
Cfg_3	Cfg_3=0: no "Stand-by" signal Cfg_3=1: "Stand-by" signal on PP2 Cfg_3=2: "Stand-by" signal on PP3 Cfg_3=3: "Stand-by" signal on STDBY
CRCH, CRCL	16 bit CRC value calculated from 4 bytes, 0xC4 to Cfg_3

Notes:

1. *For PP1 the wake-up is always triggered on low level.*
2. *Busy and Stand-by signals are active high*
3. *It is allowed to put Busy and Stand-by on the same pin*
4. *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	CRCL

Definition of the fields:

Address	Bit <7...1>=7 bit slave address Bit <0>=1
Status	Status =0: ok Bit<7> indicates an invalid command Bit<6> indicates an I2C-CRC error Bit<5> previous command not executed due to stand-by Bit<4...0>: always 0
CRCH, CRCL	16 bit CRC value calculated from1 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 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 I2C 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 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_{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 Bit <0>=1
Status	Status =0: ok Bit<7> indicates an invalid command Bit<6> indicates an I2C-CRC error Bit<5> previous command not executed due to stand-by 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

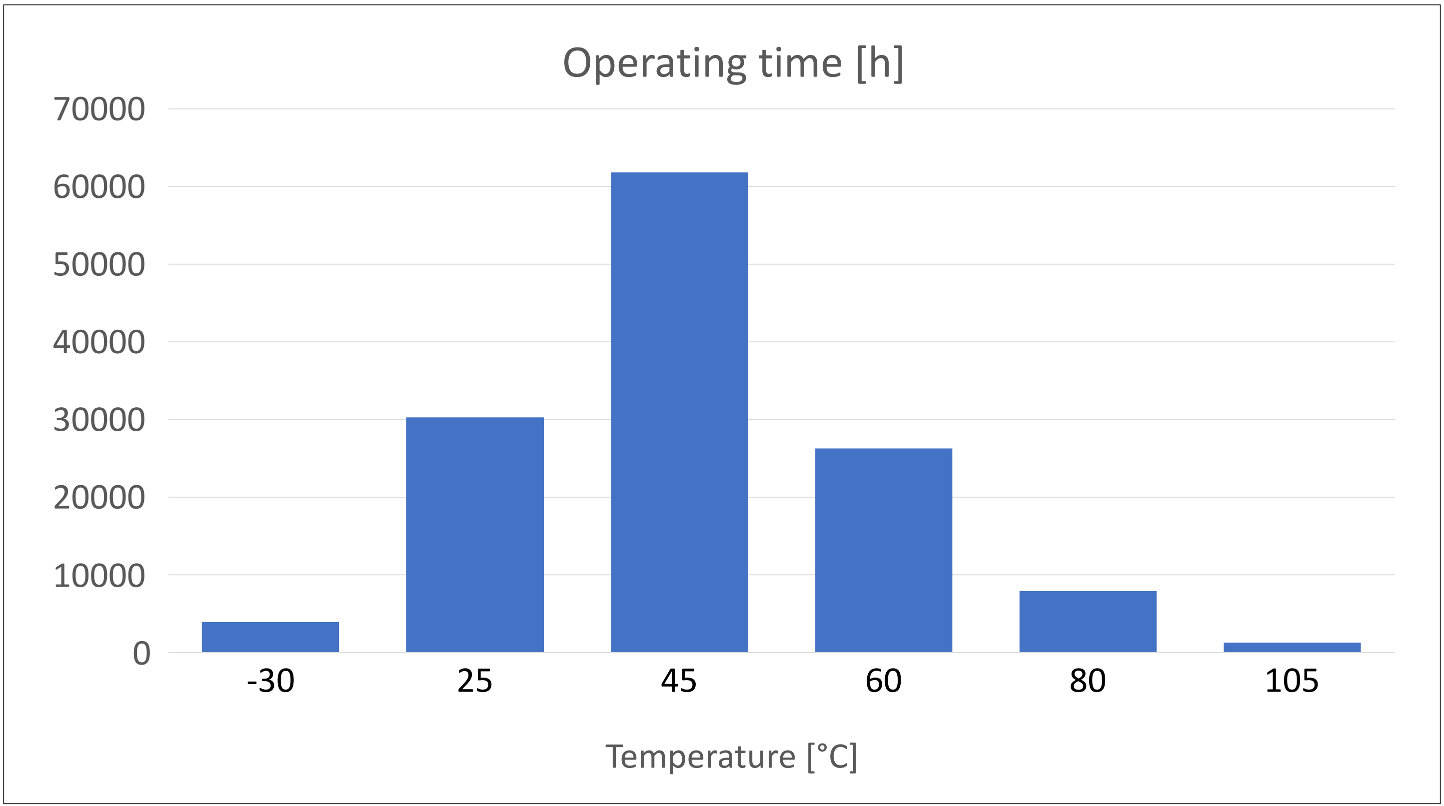

Figure 3 **Temperature Mission Profile**

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

12 Package Outline

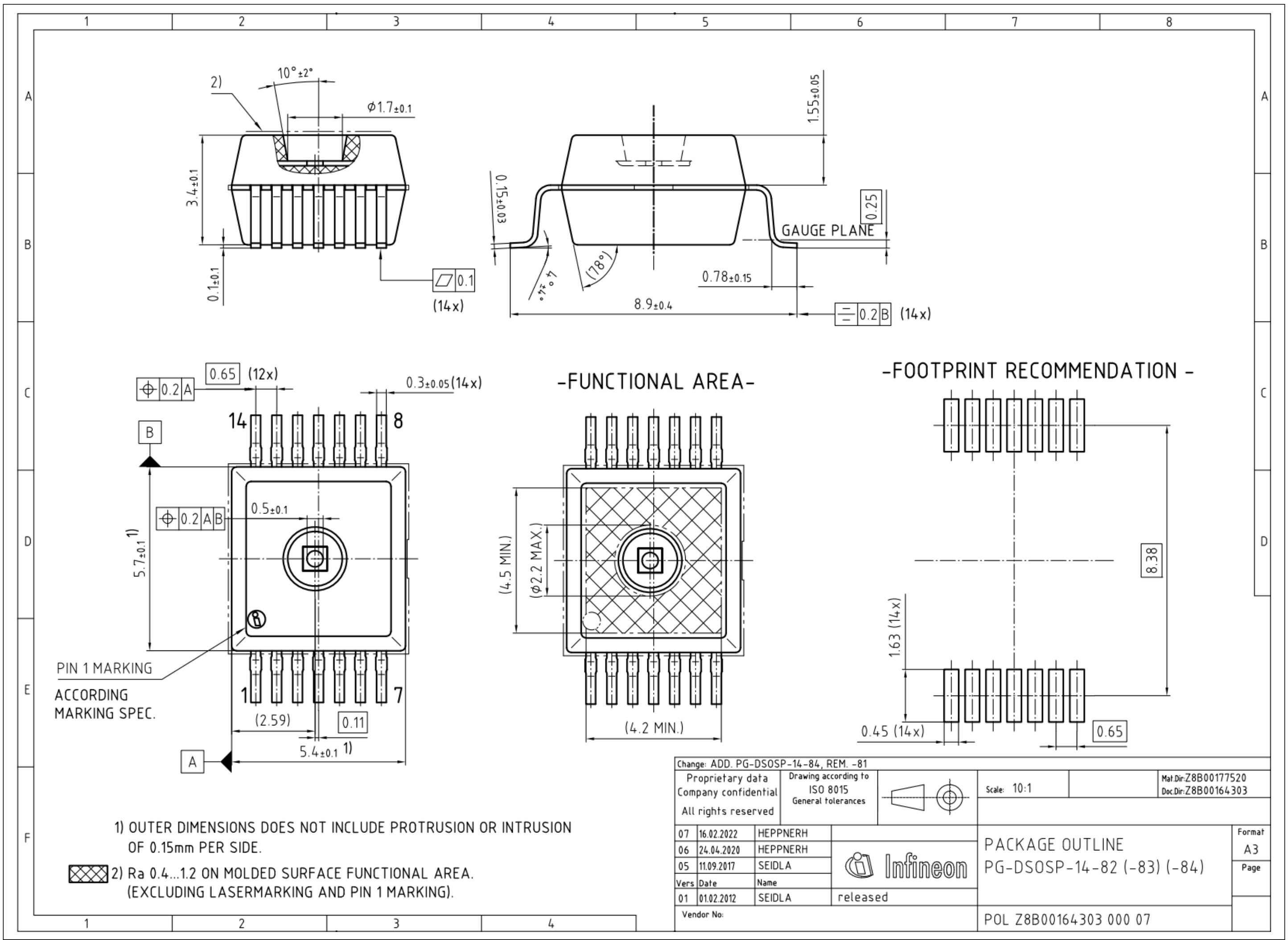

Figure 4 **Package Outline**

13 Package Marking

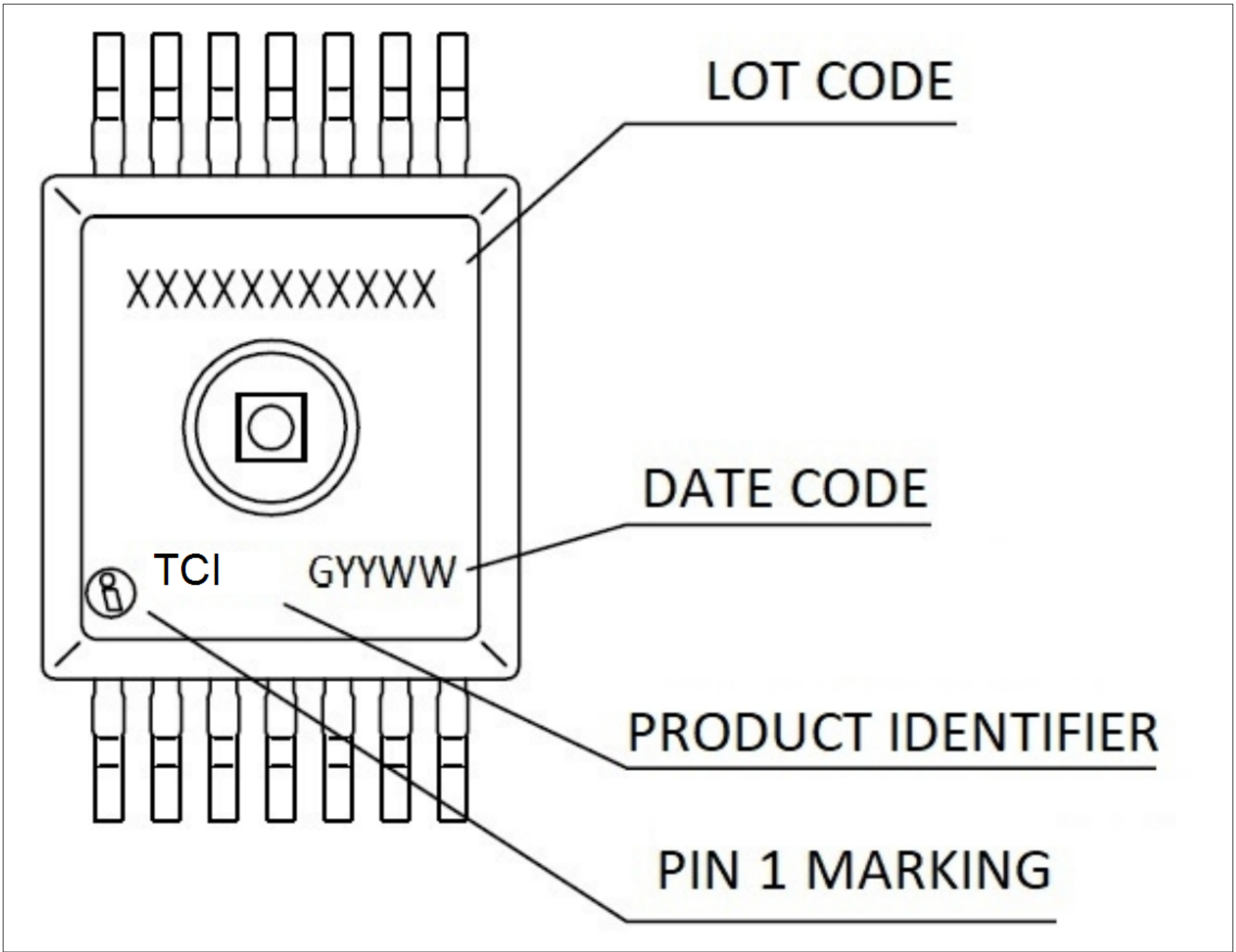

Figure 5 **Package Marking**

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.

See the app note “Appnote_TCIx_Assembly&Testing” for more information.

14.2 Device Communication

There are certain restrictions when communicating with the TCI:

- During the busy phase the I2C 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_{conc_int}) must be considered.

Figure 6 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 (< 100µs) 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.

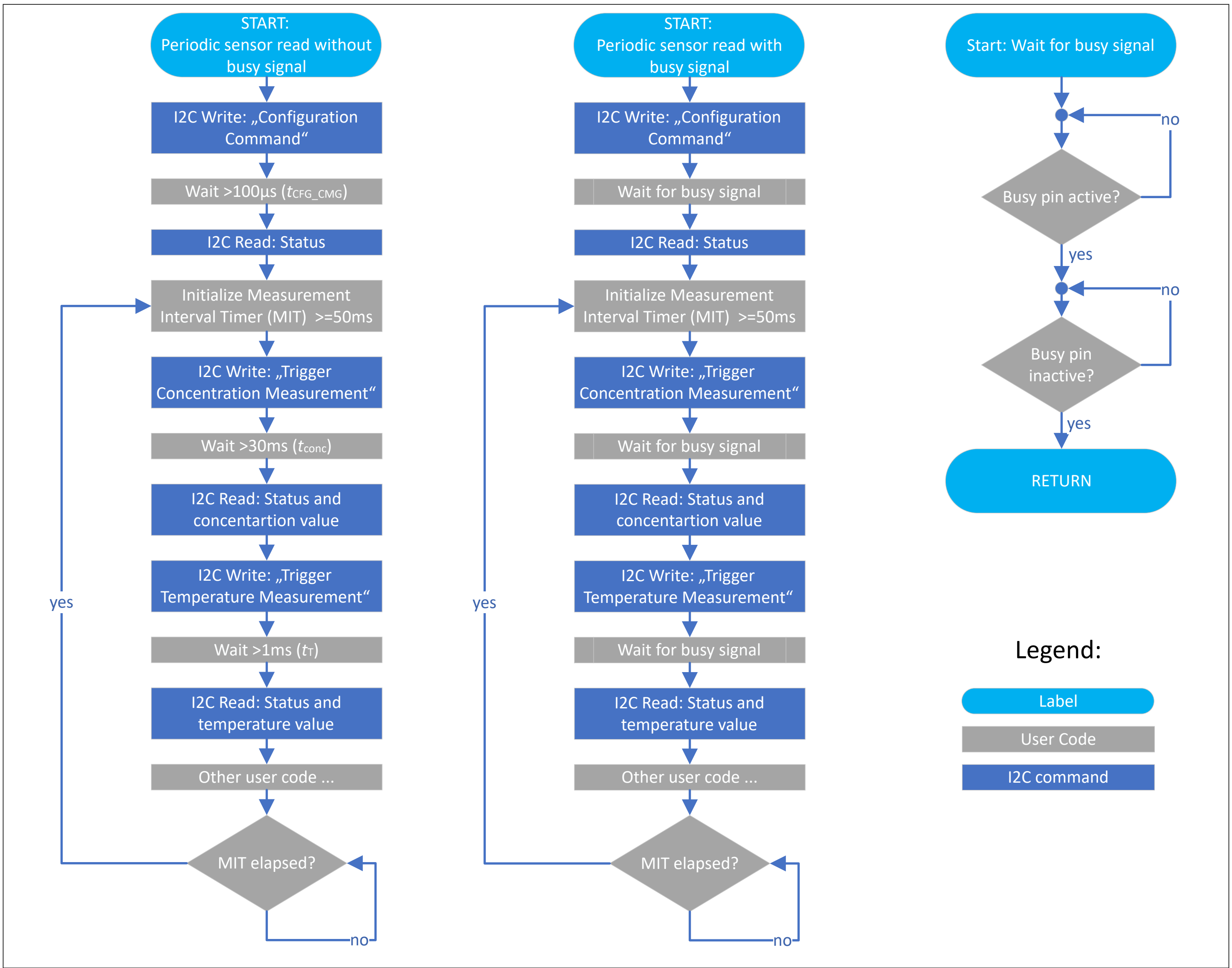

Figure 6 **User Instruction Flow Diagram**

15 Revision History

Table 12 Revision History

Document version	Date of release	Description of changes
1.0	2025-03-25	Initial version
1.1	2025-05-06	Added Chapter "Block Diagram" Changed chapter "User Instructions"

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