

# Datasheet STSC1

## High Accuracy Digital Temperature Sensor IC

- Accurate:  $\pm 0.3^{\circ}\text{C}$  typ. accuracy
- Small: DFN package,  $2 \times 2 \times 0.7 \text{ mm}^3$
- Easy-to-use: fully calibrated, linearized I<sup>2</sup>C output
- Low-power: 8.6  $\mu\text{W}$  average power consumption
- Fast: Power-up and measurement within 1 ms



### Product Summary

The STSC1 is a digital temperature sensor designed especially for applications requiring a highly accurate temperature measurement. Sensirion's CMOSens<sup>®</sup> technology offers a complete sensor system on a single chip, consisting of a bandgap temperature sensor, analog and digital signal processing, A/D converter, calibration data memory, and a digital communication interface supporting I<sup>2</sup>C fast mode.

The ultra-small,  $2 \times 2 \times 0.7 \text{ mm}^3$  DFN package enables applications in even the most limited of spaces. The sensor covers a temperature measurement range of  $-40$  to  $125^{\circ}\text{C}$ . The typical accuracy of the temperature sensor is  $\pm 0.3^{\circ}\text{C}$ . The operation voltage of 1.8 V and an average power consumption below  $8.6\mu\text{W}$  make the STSC1 suitable for mobile or wireless applications running on the tightest power budgets.

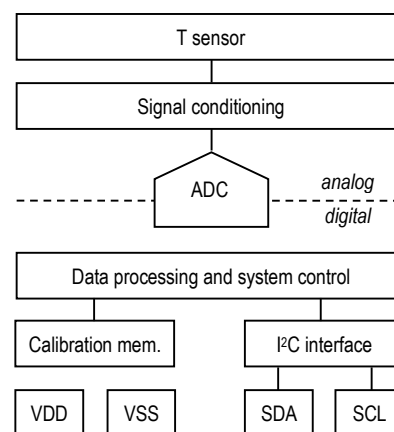
### Benefits of Sensirion's CMOSens<sup>®</sup> Technology

- High reliability and long-term stability
- Sensor system on a single chip
- Designed for mass production
- Optimized for lowest cost
- Low signal noise

### Contents of this Data Sheet

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### Block Diagram

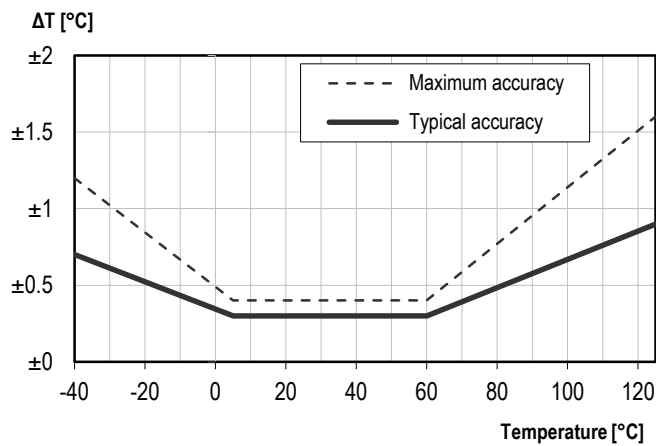


**Figure 1** Functional block diagram of the STSC1.

# 1 Temperature Sensor Specifications

| Parameter                       | Conditions | Value        | Units |
|---------------------------------|------------|--------------|-------|
| Accuracy tolerance <sup>1</sup> | Typ.       | ±0.3         | °C    |
|                                 | Max.       | see Figure 2 | °C    |
| Repeatability <sup>2</sup>      | -          | 0.1          | °C    |
| Resolution <sup>3</sup>         | -          | 0.01         | °C    |
| Specified range <sup>4</sup>    | -          | -40 to +125  | °C    |
| Response time <sup>5</sup>      | τ 63%      | <5 to 30     | s     |
| Long-term drift <sup>6</sup>    | Typ.       | < 0.02       | °C/y  |

**Table 1** Temperature sensor specifications.



**Figure 2** Typical and maximal accuracy for temperature sensor in °C.

<sup>1</sup> For definition of typ. and max. accuracy tolerance, please refer to the document "Sensirion Humidity Sensor Specification Statement".

<sup>2</sup> The stated repeatability is 3 times the standard deviation (3σ) of multiple consecutive measurement values at constant conditions and is a measure for the noise on the physical sensor output.

<sup>3</sup> Resolution of A/D converter.

<sup>4</sup> Specified range refers to the range for which the temperature sensor specification is guaranteed.

<sup>5</sup> Temperature response time depends on heat conductivity of sensor substrate and design-in of sensor in application.

<sup>6</sup> Max. value is < 0.04°C/y.

## 2 Electrical Specifications

### 2.1 Electrical Characteristics

Default conditions of 25 °C and 1.8 V supply voltage apply to values in the table below, unless otherwise stated.

| Parameter                 | Symbol           | Conditions          | Min                 | Typ. | Max                        | Units | Comments  |
|---------------------------|------------------|---------------------|---------------------|------|----------------------------|-------|---|
| Supply voltage            | V <sub>DD</sub>  | -                   | 1.62                | 1.8  | 1.98                       | V     | -   |
| Power-up/down level       | V <sub>POR</sub> | Static power supply | 1.05                | 1.2  | 1.35                       | V     | -   |
| Supply current            | I <sub>DD</sub>  | Idle state          | -                   | 0.7  | 1.5                        | μA    | -   |
|                           |                  | Measurement         | -                   | 385  | 465                        | μA    | Average current consumption while sensor is measuring <sup>7</sup>                              |
|                           |                  | Average             | -                   | 4.8  | -                          | μA    | Average current consumption (continuous operation with one measurement per second) <sup>7</sup> |
| Average power consumption | -                | Average             | -                   | 8.6  | -                          | μW    | Average power consumption (continuous operation with one measurement per second) <sup>7</sup>   |
| Low level input voltage   | V <sub>IL</sub>  |                     | -0.5                | -    | 0.3 V <sub>DD</sub>        | V     | -   |
| High level input voltage  | V <sub>IH</sub>  |                     | 0.7 V <sub>DD</sub> | -    | V <sub>DD(max)</sub> + 0.5 | V     | -   |
| Low level output voltage  | V <sub>OL</sub>  | 3 mA sink current   | -                   | -    | 0.2 V <sub>DD</sub>        | -     | -   |

**Table 2** Electrical specifications.

### 2.2 Absolute Maximum Ratings

Stress levels beyond those listed in Table 3 may cause permanent damage to the device. These are stress ratings only and functional operation of the device at these conditions cannot be guaranteed. Exposure to the absolute maximum rating conditions for extended periods may affect the reliability of the device.

| Parameter                        | Rating          |
|----------------------------------|-----------------|
| Supply voltage, V <sub>DD</sub>  | -0.3 to +2.16 V |
| Operating temperature range      | -40 to +125 °C  |
| Storage temperature range        | -40 to +125 °C  |
| ESD HBM                          | 2 kV            |
| ESD MM                           | 200 V           |
| ESD CDM                          | 500 V           |
| Latch up, JESD78 Class II, 125°C | 100mA           |

**Table 3** Absolute maximum ratings.

<sup>7</sup> These values can be reduced by using the low power measurement mode, see separate application note.

## 4 Timing Specifications

### 4.1 Sensor System Timings

Default conditions of 25 °C and 1.8 V supply voltage apply to values the table below, unless otherwise stated. Max. values are measured at -30°C and 1.98V supply voltage.

| Parameter            | Symbol            | Conditions   | Min. | Typ. | Max. | Units | Comments   |
|----------------------|-------------------|--|------|------|------|-------|--|
| Power-up time        | t <sub>PU</sub>   | After hard reset, V <sub>DD</sub> ≥ V <sub>POR</sub> | -    | 182  | 239  | μs    | Time between V <sub>DD</sub> reaching V <sub>PU</sub> and sensor entering idle state |
| Soft reset time      | t <sub>SR</sub>   | After soft reset.                                    | -    | 173  | 230  | μs    | Time between ACK of soft reset command and sensor entering idle state                |
| Measurement duration | t <sub>MEAS</sub> | -  | -    | 10.8 | 14.4 | ms    | Duration for a temperature measurement <sup>8</sup>                                  |

**Table 4** System timing specifications.

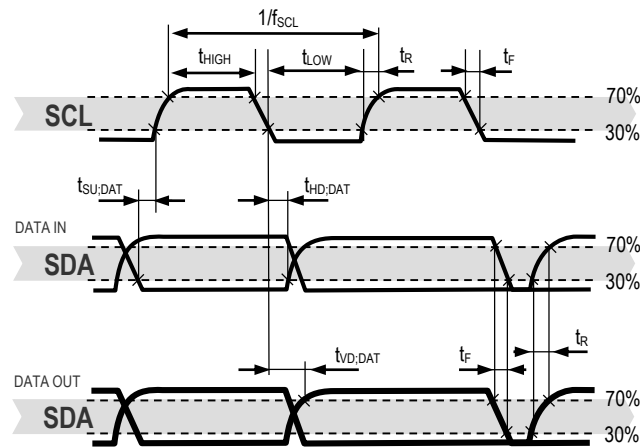
### 4.2 Communication Timings

Default conditions of 25 °C and 1.8 V supply voltage apply to values in the table below, unless otherwise stated.

| Parameter                                  | Symbol              | Conditions  | Min.                           | Typ. | Max. | Units | Comments |
|--|---------------------|---|--------------------------------|------|------|-------|----------|
| SCL clock frequency                        | f <sub>SCL</sub>    | -   | 0                              | -    | 400  | kHz   | -        |
| Hold time (repeated) START condition       | t <sub>HD,STA</sub> | After this period, the first clock pulse is generated | 0.6                            | -    | -    | μs    | -        |
| LOW period of the SCL clock                | t <sub>LOW</sub>    | -   | 1.3                            | -    | -    | μs    | -        |
| HIGH period of the SCL clock               | t <sub>HIGH</sub>   | -   | 0.6                            | -    | -    | μs    | -        |
| Set-up time for a repeated START condition | t <sub>SU,STA</sub> | -   | 0.6                            | -    | -    | μs    | -        |
| SDA hold time                              | t <sub>HD,DAT</sub> | -   | 0                              | -    | -    | -     | -        |
| SDA set-up time                            | t <sub>SU,DAT</sub> | -   | 100                            | -    | -    | ns    | -        |
| SCL/SDA rise time                          | t <sub>R</sub>      | -   | 20                             | -    | 300  | ns    | -        |
| SCL/SDA fall time                          | t <sub>F</sub>      | -   | 20 *<br>(V <sub>DD</sub> /5.5) | -    | 300  | ns    | -        |
| SDA valid time                             | t <sub>VD,DAT</sub> | -   | -                              | -    | 0.9  | μs    | -        |
| Set-up time for STOP condition             | t <sub>SU,STO</sub> | -   | 0.6                            | -    | -    | μs    | -        |
| Capacitive load on bus line                | C <sub>B</sub>      | -   | -                              | -    | 400  | pF    | -        |

**Table 5** Communication timing specifications. The numbers above are values according to the I<sup>2</sup>C specification.

<sup>8</sup> These values can be reduced by using the low power measurement mode, see separate application note.



**Figure 3** Timing diagram for digital input/output pads. SDA directions are seen from the sensor. Bold SDA lines are controlled by the sensor, plain SDA lines are controlled by the micro-controller. Note that SDA valid read time is triggered by falling edge of preceding toggle.

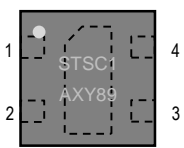
## 5 Interface Specifications

The STSC1 supports I<sup>2</sup>C fast mode (SCL clock frequency from 0 to 400 kHz) with clock stretching. For detailed information on the I<sup>2</sup>C protocol, refer to NXP I<sup>2</sup>C-bus specification and user manual UM10204, Rev. 4, February 13, 2012:

[http://ics.nxp.com/support/documents/interface/pdf/I2C\\_bu\\_s.specification.pdf](http://ics.nxp.com/support/documents/interface/pdf/I2C_bu_s.specification.pdf)

The STSC1 comes in a 4-pin package – see Table 6.

| Pin | Name | Comments                    |
|-----|------|-----------------------------|
| 1   | VDD  | Supply voltage              |
| 2   | SCL  | Serial clock, bidirectional |
| 3   | SDA  | Serial data, bidirectional  |
| 4   | VSS  | Ground                      |



**Table 6** STSC1 pin assignment (top view). The center pad is internally connected to VSS.

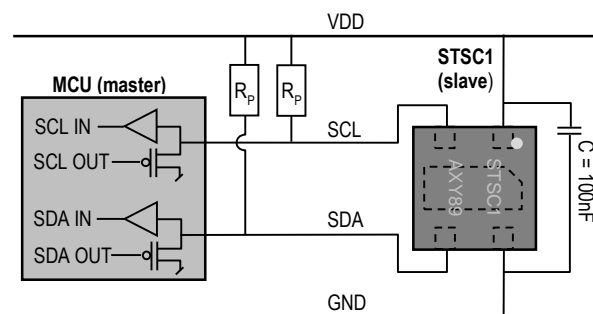
Power-supply pins supply voltage (VDD) and ground (VSS) must be decoupled with a 100 nF capacitor that shall be placed as close to the sensor as possible – see Figure 4.

SCL is used to synchronize the communication between microcontroller and the sensor. The master must keep the clock frequency within 0 to 400 kHz as specified in Table 5. The STSC1 may pull down the SCL line when clock stretching is enabled.

The SDA pin is used to transfer data in and out of the sensor. For safe communication, the timing specifications defined in the I<sup>2</sup>C manual must be met.

To avoid signal contention, the microcontroller must only drive SDA and SCL low. External pull-up resistors (e.g. 10 kΩ) are required to pull the signal high. For dimensioning resistor sizes please take bus capacity

requirements into account. It should be noted that pull-up resistors may be included in I/O circuits of microcontrollers.



**Figure 4** Typical application circuit, including pull-up resistors  $R_p$  and decoupling of VDD and VSS by a capacitor.

For good performance of the STSC1 in the application, it is important to know that the center pad of the STSC1 offers the best thermal contact to the temperature sensor. For more information on design-in, please refer to the document “SHTxx Design Guide”.

For mechanical reasons the center pad should be soldered. Electrically, the center pad is internally connected to GND and may be connected to the GND net on the PCB or left floating.

## 6 Operation and Communication

All commands and memory locations of the STSC1 are mapped to a 16-bit address space which can be accessed via the I<sup>2</sup>C protocol.

| STSC1                    | Bin.     | Dec. | Hex. |
|--------------------------|----------|------|------|
| I <sup>2</sup> C address | 100'1010 | 74   | 0x4A |

**Table 7** STSC1 I<sup>2</sup>C device address.

## 6.1 Power-Up and Communication Start

Upon VDD reaching the power-up voltage level  $V_{POR}$ , the STSC1 enters idle state after a duration of  $t_{PU}$ . In idle state, the STSC1 is ready to receive commands from the master (microcontroller).

Each transmission sequence begins with START condition (S) and ends with an (optional) STOP condition (P) as described in the I<sup>2</sup>C-bus specification. Whenever the sensor is powered up, but not performing a measurement or communicating, it automatically enters idle state for energy saving.

Please note that in case VDD is set to 0 V (GND), e.g. in case of a power off of the STSC1, the SCL and SDA pads are also pulled to GND. Consequently, the I<sup>2</sup>C bus is blocked while VDD of the STSC1 is set to 0 V.

## 6.2 Measurement Commands

The STSC1 provides the possibility to define the sensor behavior during measurement (see Table 8).

| Clock Stretching Enabled | Clock Stretching Disabled |
|--------------------------|---------------------------|
| 0x7CA2                   | 0x7866                    |

**Table 8** Measurement commands.

## 6.3 Starting a Measurement

A measurement communication sequence consists of a START condition followed by the I<sup>2</sup>C header with the 7-bit I<sup>2</sup>C device address and a write bit (write W: '0'). The sensor indicates the proper reception of a byte by pulling the SDA pin low (ACK bit) after the falling edge of the 8th SCL clock. Then the sensor is ready to receive a 16-bit measurement command. Again, the STSC1 acknowledges the proper reception of each byte with ACK condition. A complete measurement cycle is presented in Figure 5.

With the acknowledgement of the measurement command, the STSC1 starts measuring temperature.

## 6.4 Sensor Behavior during Measurement and Clock Stretching

In general, the sensor does not respond to any I<sup>2</sup>C activity during measurement, i.e. I<sup>2</sup>C read and write headers are not acknowledged (NACK). However, when clock stretching has been enabled by using a corresponding measurement command, the sensor responds to a read header with an ACK and subsequently pulls down the SCL line until the measurement is complete. As soon as the measurement is complete, the sensor starts sending the measurement results.

During measurement, the sensor has a current consumption according to Table 2.

For best possible repeatability of temperature measurements, it is recommended to avoid any communication on the I<sup>2</sup>C bus while the STSC1 is

measuring. For more information, see application note "SHTC1 Optimization of Repeatability".

## 6.5 Readout of Measurement Results

After a measurement command has been issued and the sensor has completed the measurement, the master can read the measurement results by sending a START condition followed by an I<sup>2</sup>C read header. The sensor will acknowledge the reception of the read header and send two bytes of temperature data followed by one byte CRC checksum. Each byte must be acknowledged by the microcontroller with an ACK condition for the sensor to continue sending data. If the STSC1 does not receive an ACK from the master after any byte of data, it will not continue sending data.

The I<sup>2</sup>C master can abort the read transfer with a NACK condition after any data byte if it is not interested in subsequent data, e.g. the CRC byte, in order to save time.

## 6.6 Soft Reset

The STSC1 provides a soft reset mechanism that forces the system into a well-defined state without removing the power supply. If the system is in idle state (i.e. if no measurement is in progress) the soft reset command can be sent to STSC1 according to Figure 6. This triggers the sensor to reset all internal state machines and reload calibration data from the memory.

| Command        | Hex. Code | Bin. Code           |
|----------------|-----------|---------------------|
| Software reset | 0x805D    | 1000'0000'0101'1101 |

**Table 9** Soft reset command.

## 6.7 Read-out of ID Register

The STSC1 has an ID register which contains an STSC1-specific product code. The read-out of the ID register can be used to verify the presence of the sensor and proper communication. The command to read the ID register is shown in Table 10.

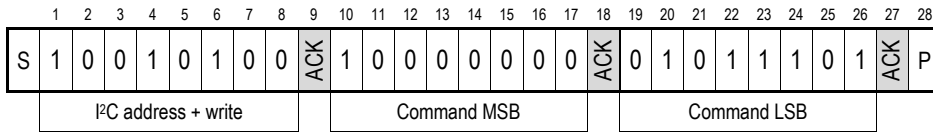
| Command          | Hex. Code | Bin. Code           |
|------------------|-----------|---------------------|
| Read ID register | 0xEFC8    | 1110'1111'1100'1000 |

**Table 10** Read-out command of ID register.

It needs to be sent to the STSC1 after an I<sup>2</sup>C write header. After the STSC1 has acknowledged the proper reception of the command, the master can send an I<sup>2</sup>C read header and the STSC1 will submit the 16-bit ID followed by 8 bits of CRC. The structure of the ID is described in Table 11.



**Figure 5** Communication sequence for starting a measurement and reading measurement results displaying both clock stretching options. The numerical example corresponds to a measurement command with clock stretching enabled. The physical values of the transmitted measurement result is 23.7 °C. Clear blocks are controlled by the microcontroller, grey blocks by the STSC1.



**Figure 6** Command access communication sequence. The example shows a soft reset command. Clear blocks are controlled by the microcontroller, grey blocks by the STSC1.

## 7 Quality

### 7.1 Environmental Stability

Qualification of the STSC1 is performed based on the JEDEC JESD47 qualification test method.

### 7.2 Material Contents

The device is fully RoHS and WEEE compliant, e.g. free of Pb, Cd, and Hg.

## 8 Packaging and Traceability

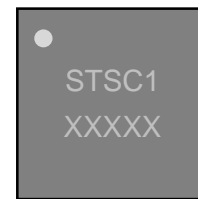
STSC1 sensors are provided in a DFN package with an outline of  $2 \times 2 \times 0.7 \text{ mm}^3$  and a terminal pitch of 1 mm. DFN stands for dual flat no leads.

The sensor chip is made of silicon and is mounted to a lead frame. The latter is made of Cu plated with Ni/Pd/Au. Chip and lead frame are overmolded by a green epoxy-based mold compound. Please note that the side walls of sensor are diced and therefore these diced lead frame surfaces are not covered with the respective plating.

The Moisture Sensitivity Level classification of the STSC1 is MSL1, according to IPC/JEDEC J-STD-020.

All STSC1 sensors are laser marked for easy identification and traceability. The marking on the sensor consists of two lines and a pin-1 indicator. The top line contains the sensor type (STSC1), the bottom line contains a 5-digit,

alphanumeric tracking code. The pin-1 indicator is located in the top left corner. See Figure 7 for illustration.



**Figure 7** Laser marking on STSC1, the top line with the pin-1 indicator and the sensor type, the bottom line with the 5-digit alphanumeric tracking code.

Reels are also labeled and provide additional traceability information.

## 9 Ordering Information

The STSC1 can be ordered in tape and reel packaging with different sizes. The reels are sealed into antistatic ESD bags. A drawing of the packaging tape with sensor orientation is shown in Figure 10.

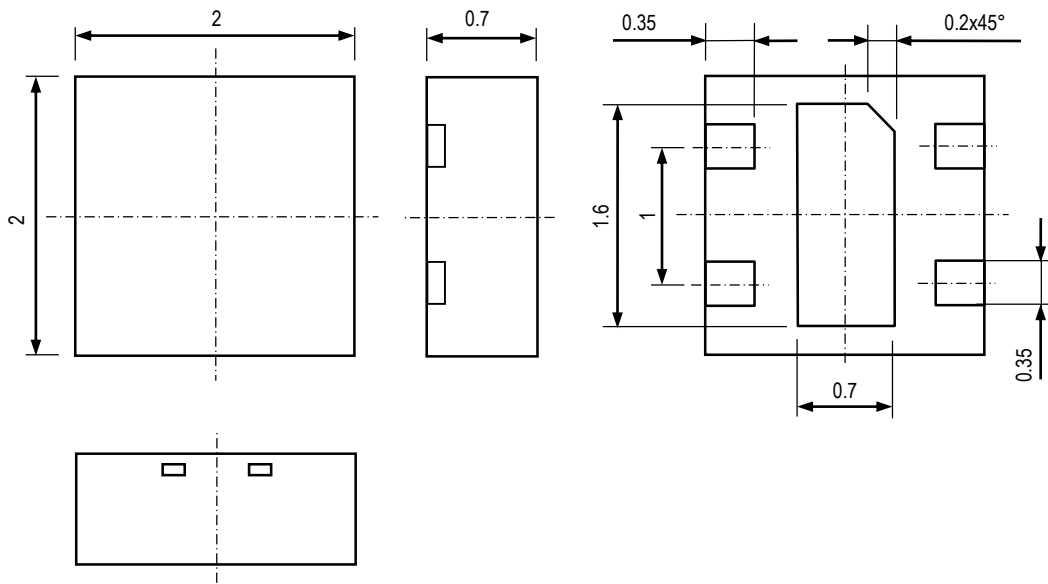
| Quantity | Packaging   | Reel Diameter    | Order Number |
|----------|-------------|------------------|--------------|
| 1'000    | Tape & Reel | 180 mm (7 inch)  | 1-101118-01  |
| 10'000   | Tape & Reel | 330 mm (13 inch) | 1-101085-01  |

**Table 13** STSC1 ordering options.



## 10 Technical Drawings

### 10.1 Package Outline



**Figure 8** Package outline drawing of the STSC1. Dimensions are given in millimeters.



## 11 Further Information

For more in-depth information on the STSC1 and its application please consult the following documents:

| Document Name                        | Description   | Source   |
|--------------------------------------|---|--|
| SHTxx/STSxx Assembly of SMD Packages | Instructions on soldering and processing of Sensirion SMD devices.                      | <a href="http://www.sensirion.com">www.sensirion.com</a> |
| SHTC1 Optimization of Repeatability  | Measures for optimization of repeatability of sensor output (also applicable to STSC1). | <a href="http://www.sensirion.com">www.sensirion.com</a> |
| SHTC1 Low Power Measurement Mode     | Description of SHTC1 low power measurement mode (also applicable to STSC1).             | <a href="http://www.sensirion.com">www.sensirion.com</a> |

**Table 14** Documents containing further information relevant for the STSC1.

## Revision History

| Date              | Version | Page(s) | Changes                    |
|-------------------|---------|---------|----------------------------|
| 23. May 2014      | 1       | all     | Initial released version   |
| 1. September 2015 | 2       | 3       | Improved max. idle current |

## Important Notices

### Warning, Personal Injury

**Do not use this product as safety or emergency stop devices or in any other application where failure of the product could result in personal injury. Do not use this product for applications other than its intended and authorized use. Before installing, handling, using or servicing this product, please consult the data sheet and application notes. Failure to comply with these instructions could result in death or serious injury.**

If the Buyer shall purchase or use SENSIRION products for any unintended or unauthorized application, Buyer shall defend, indemnify and hold harmless SENSIRION and its officers, employees, subsidiaries, affiliates and distributors against all claims, costs, damages and expenses, and reasonable attorney fees arising out of, directly or indirectly, any claim of personal injury or death associated with such unintended or unauthorized use, even if SENSIRION shall be allegedly negligent with respect to the design or the manufacture of the product.

### ESD Precautions

The inherent design of this component causes it to be sensitive to electrostatic discharge (ESD). To prevent ESD-induced damage and/or degradation, take customary and statutory ESD precautions when handling this product.

See application note "ESD, Latchup and EMC" for more information.

### Warranty

SENSIRION warrants solely to the original purchaser of this product for a period of 12 months (one year) from the date of delivery that this product shall be of the quality, material and workmanship defined in SENSIRION's published specifications of the product. Within such period, if proven to be defective, SENSIRION shall repair and/or replace this product, in SENSIRION's discretion, free of charge to the Buyer, provided that:

- notice in writing describing the defects shall be given to SENSIRION within fourteen (14) days after their appearance;

- such defects shall be found, to SENSIRION's reasonable satisfaction, to have arisen from SENSIRION's faulty design, material, or workmanship;
- the defective product shall be returned to SENSIRION's factory at the Buyer's expense; and
- the warranty period for any repaired or replaced product shall be limited to the unexpired portion of the original period.

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