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Datasheet STSC1

High Accuracy Digital Temperature Sensor IC

- Accurate: ±0.3°C typ. accuracy
- Small: DFN package, 2 × 2 × 0.7 mm^3
- Easy-to-use: fully calibrated, linearized I^{2}C output
- Low-power: 8.6 µW average power consumption
- Fast: Power-up and measurement within 1 ms
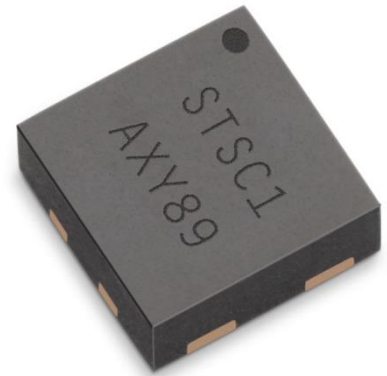
Product Summary

The STSC1 is a digital temperature sensor designed especially for applications requiring a highly accurate temperature measurement. Sensirion's CMOSens® 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^{2}C fast mode.

The ultra-small, 2 × 2 × 0.7 mm^3 DFN package enables applications in even the most limited of spaces. The sensor covers a temperature measurement range of –40 to 125 °C. The typical accuracy of the temperature sensor is ±0.3°C. The operation voltage of 1.8 V and an average power consumption below 8.6µW make the STSC1 suitable for mobile or wireless applications running on the tightest power budgets.

Benefits of Sensirion's CMOSens® 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

Block Diagram

Figure 1 Functional block diagram of the STSC1.

1   Temperature Sensor Specifications

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

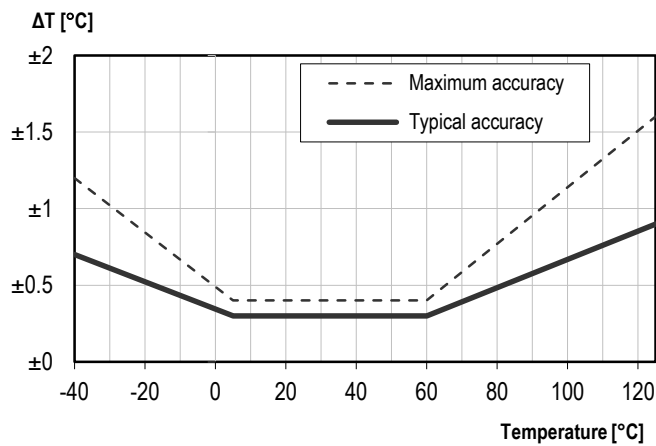**Table 1** Temperature sensor specifications.

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

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[1] For definition of typ. and max. accuracy tolerance, please refer to the document "Sensirion Humidity Sensor Specification Statement".

[2] 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.

[3] Resolution of A/D converter.

[4] Specified range refers to the range for which the temperature sensor specification is guaranteed.

[5] Temperature response time depends on heat conductivity of sensor substrate and design-in of sensor in application.

[6] 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_{DD}	-	1.62	1.8	1.98	V	-
Power-up/down level	V_{POR}	Static power supply	1.05	1.2	1.35	V	-
Supply current	I_{DD}	Idle state	-	0.7	1.5	µA	-
		Measurement	-	385	465	µA	Average current consumption while sensor is measuring[7]
		Average	-	4.8	-	µA	Average current consumption (continuous operation with one measurement per second)[7]
Average power consumption	-	Average	-	8.6	-	µW	Average power consumption (continuous operation with one measurement per second)[7]
Low level input voltage	V_{IL}		-0.5	-	0.3 V_{DD}	V	-
High level input voltage	V_{IH}		0.7 V_{DD}	-	V_{DD}(max) + 0.5	V	-
Low level output voltage	V_{OL}	3 mA sink current	-	-	0.2 V_{DD}	-	-

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_{DD}	-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.

[7] These values can be reduced by using the low power measurement mode, see separate application note.

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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_{PU}	After hard reset, $V_{DD} \geq V_{POR}$	-	182	239	µs	Time between V_{DD} reaching V_{PU} and sensor entering idle state
Soft reset time	t_{SR}	After soft reset.	-	173	230	µs	Time between ACK of soft reset command and sensor entering idle state
Measurement duration	t_{MEAS}	-	-	10.8	14.4	ms	Duration for a temperature measurement[8]

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_{SCL}	-	0	-	400	kHz	-
Hold time (repeated) START condition	$t_{HD;STA}$	After this period, the first clock pulse is generated	0.6	-	-	µs	-
LOW period of the SCL clock	t_{LOW}	-	1.3	-	-	µs	-
HIGH period of the SCL clock	t_{HIGH}	-	0.6	-	-	µs	-
Set-up time for a repeated START condition	$t_{SU;STA}$	-	0.6	-	-	µs	-
SDA hold time	$t_{HD;DAT}$	-	0	-	-	-	-
SDA set-up time	$t_{SU;DAT}$	-	100	-	-	ns	-
SCL/SDA rise time	t_R	-	20	-	300	ns	-
SCL/SDA fall time	t_F	-	20 * (V_{DD}/5.5)	-	300	ns	-
SDA valid time	$t_{VD;DAT}$	-	-	-	0.9	µs	-
Set-up time for STOP condition	$t_{SU;STO}$	-	0.6	-	-	µs	-
Capacitive load on bus line	C_B	-	-	-	400	pF	-

Table 5 Communication timing specifications. The numbers above are values according to the I2C specification.

[8] These values can be reduced by using the low power measurement mode, see separate application note.
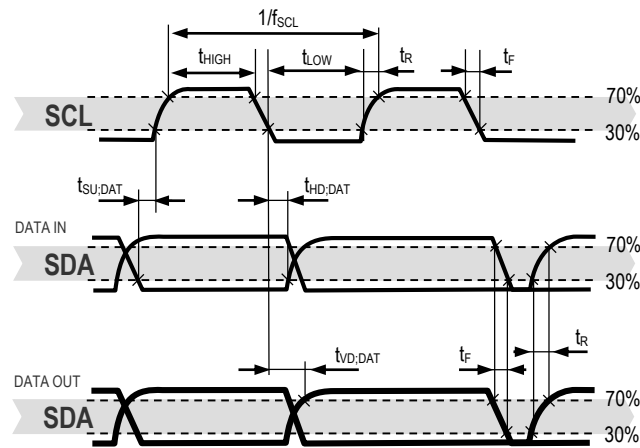
Figure 3 Timing diagram for digital input/output pads. SDA directions are seen from the sensor. Bold SDA lines are controlled by the sensor, plain SDA lines are controlled by the micro-controller. Note that SDA valid read time is triggered by falling edge of preceding toggle.

5 Interface Specifications

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

http://ics.nxp.com/support/documents/interface/pdf/I2C.bus.specification.pdf

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

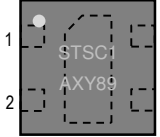| Pin	Name	Comments
1	VDD	Supply voltage
2	SCL	Serial clock, bidirectional
3	SDA	Serial data, bidirectional
4	VSS	Ground

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^{2}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.
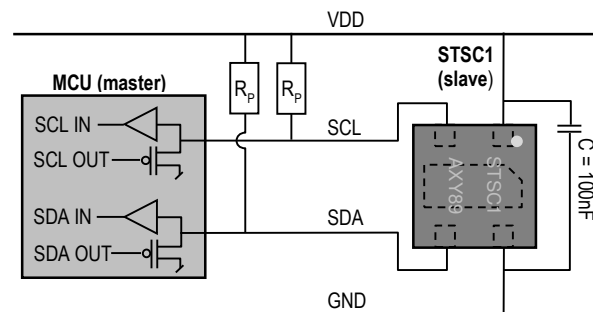

Figure 4 Typical application circuit, including pull-up resistors R$_P$ and decoupling of VDD and VSS by a capacitor.

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^{2}C protocol.

STSC1	Bin.	Dec.	Hex.
I^{2}C address	100'1010	74	0x4A

Table 7 STSC1 I^{2}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 I2C-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 I2C 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 I2C header with the 7-bit I2C 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 I2C activity during measurement, i.e. I2C 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 I2C bus while the STSC1 is measuring. For more information, see application note "SHTC1 Optimization of Repeatibility".

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 I2C 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 I2C 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 I2C write header. After the STSC1 has acknowledged the proper reception of the command, the master can send an I2C 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.
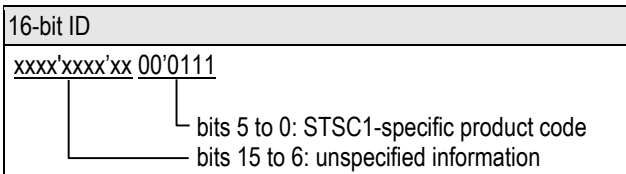
16-bit ID
xxxx'xxxx'xx 00'0111

bits 5 to 0: STSC1-specific product code
bits 15 to 6: unspecified information

Table 11 Structure of the 16-bit ID. Bits 15:6 of the ID contain unspecified information (marked as "x"), which may vary from sensor to sensor, while bits 5:0 contain the STSC1-specific product code.

6.8 Checksum Calculation

The 8-bit CRC checksum transmitted after each data word is generated by a CRC algorithm with the properties displayed in Table 12. The CRC covers the contents of the two previously transmitted data bytes.

Property	Value
Name	CRC-8
Width	8 bits
Polynomial	$0x31$ ($x^8 + x^5 + x^4 + 1$)
Initialization	0xFF
Reflect input	False
Reflect output	False
Final XOR	0x00
Examples	CRC (0x00) = 0xAC CRC (0xBEEF) = 0x92

Table 12 STSC1 I^{2}C CRC properties.

6.9 Conversion of Signal Output

Measurement data is always transferred as 16-bit values. These values are already linearized by the STSC1. Temperature values can be calculated with the formula given below.

Temperature conversion formula (result in °C):

$$T = -45 + 175 \cdot \frac{S_T}{2^{16}}$$

S_T denotes the raw sensor output (as decimal value) for temperature.
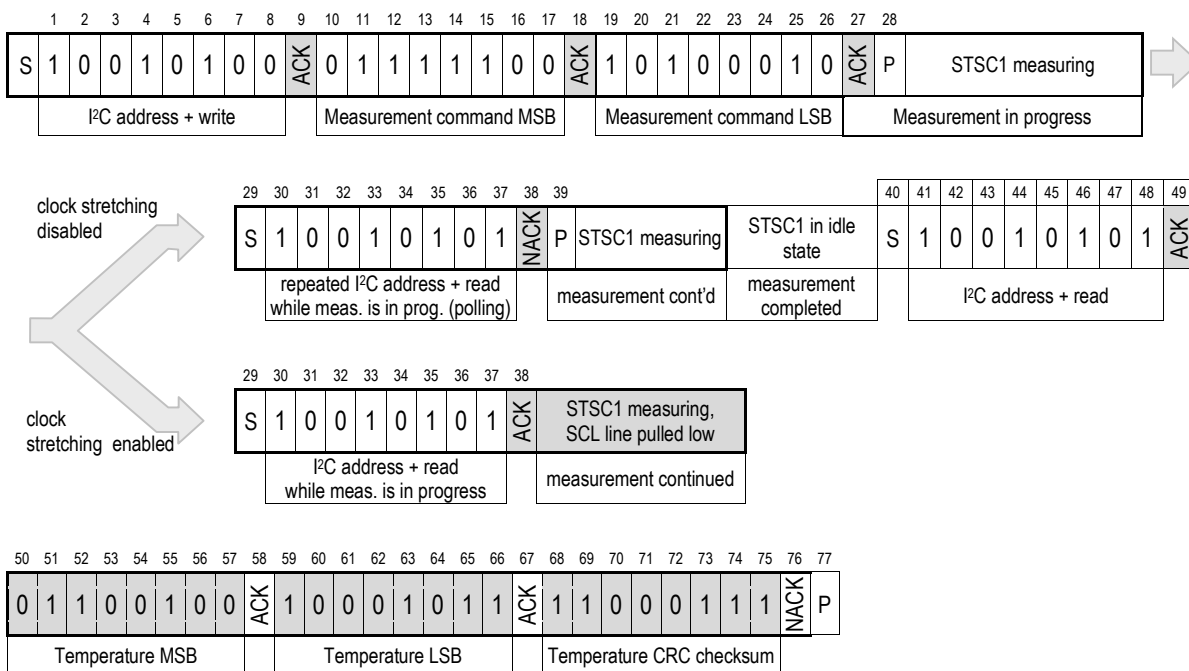
6.10 Communication Data Sequences

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.
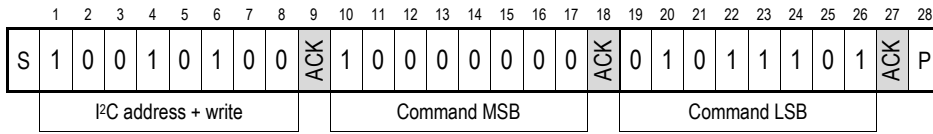
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
S	1	0	0	1	0	1	0	0	ACK	1	0	0	0	0	0	0	0	ACK	0	1	0	1	1	1	0	1	ACK	P

| I²C address + write | Command MSB | Command LSB |

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 × 2 × 0.7 mm³ 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.
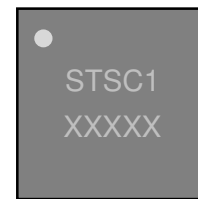

Figure 7 Laser marking on STSC1, the top line with the pin-1 indicator and the sensor type, the bottom line with the 5-digit alphanumeric tracking code.

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.
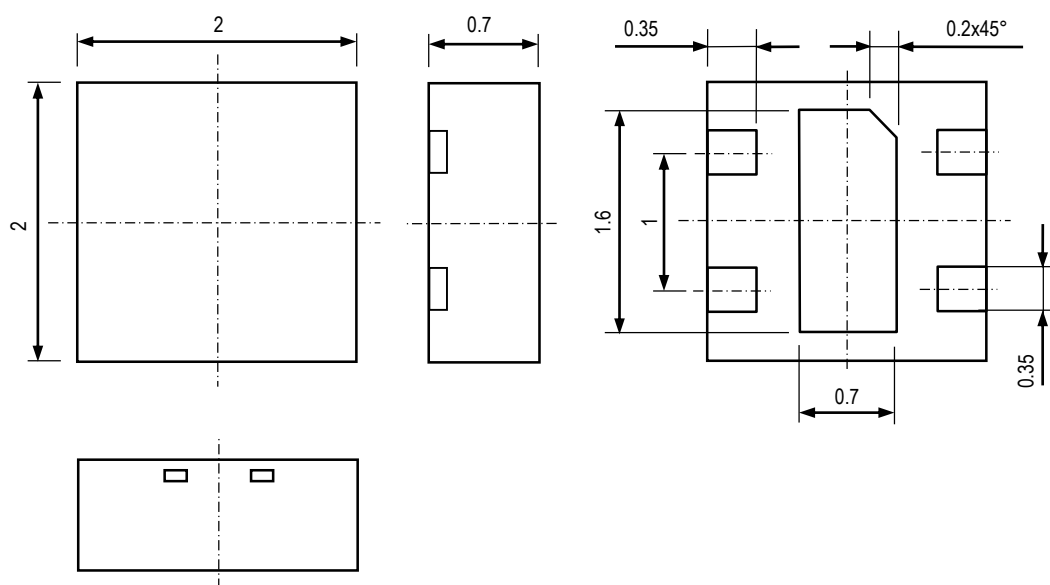
10 Technical Drawings

10.1 Package Outline

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

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10.2 Metal Land Pattern

NOTE:
SOLDER PAD DIMENSIONS (COPPER)
SOLDER PASTE DIMENSIONS (STENCIL OPENING)
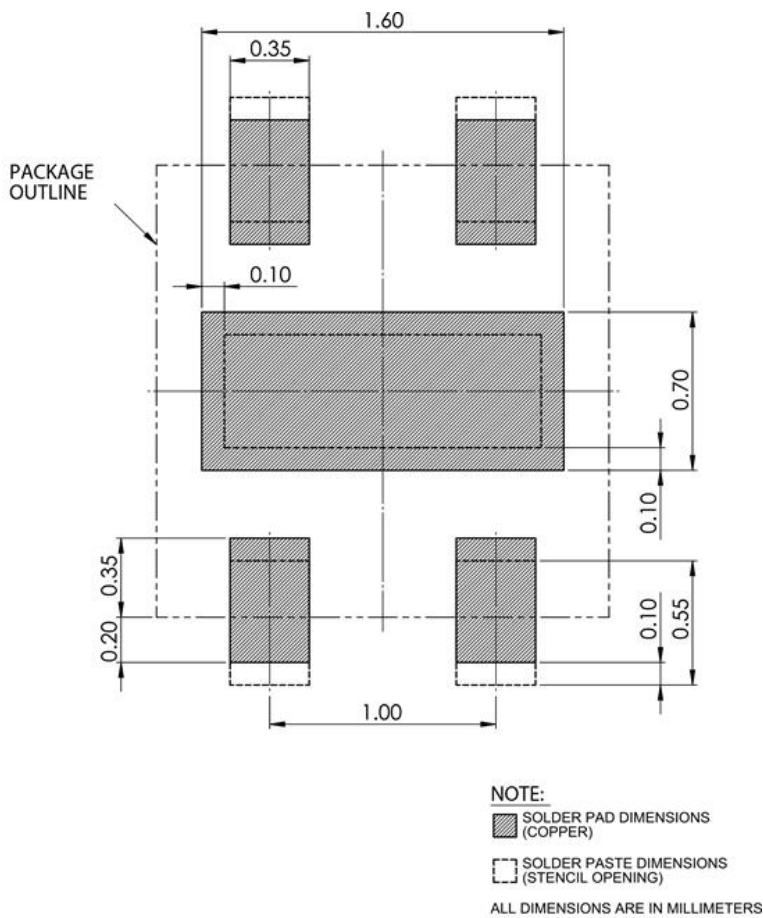ALL DIMENSIONS ARE IN MILLIMETERS

Figure 9 Recommended metal land pattern for STSC1 (all dimensions are in mm). Recommended solder paste stencil thickness is 100μm, pads on PCB are recommended to be non solder mask defined (NSMD).

10.3 Tape and Reel Package

Ao = 2.25
Bo = 2.25
Ko = 1.15

TOLERANCES - UNLESS NOTED 1PL ±.2 2PL ±.10

NOTES:
1. 10 SPROCKET HOLE PITCH CUMULATIVE TOLERANCE ±0.2
2. CAMBER IN COMPLIANCE WITH EIA 481
3. POCKET POSITION RELATIVE TO SPROCKET HOLE MEASURED AS TRUE POSITION OF POCKET, NOT POCKET HOLE
4. Ao AND Bo ARE CALCULATED ON A PLANE AT A DISTANCE "R" ABOVE THE BOTTOM OF THE POCKET.
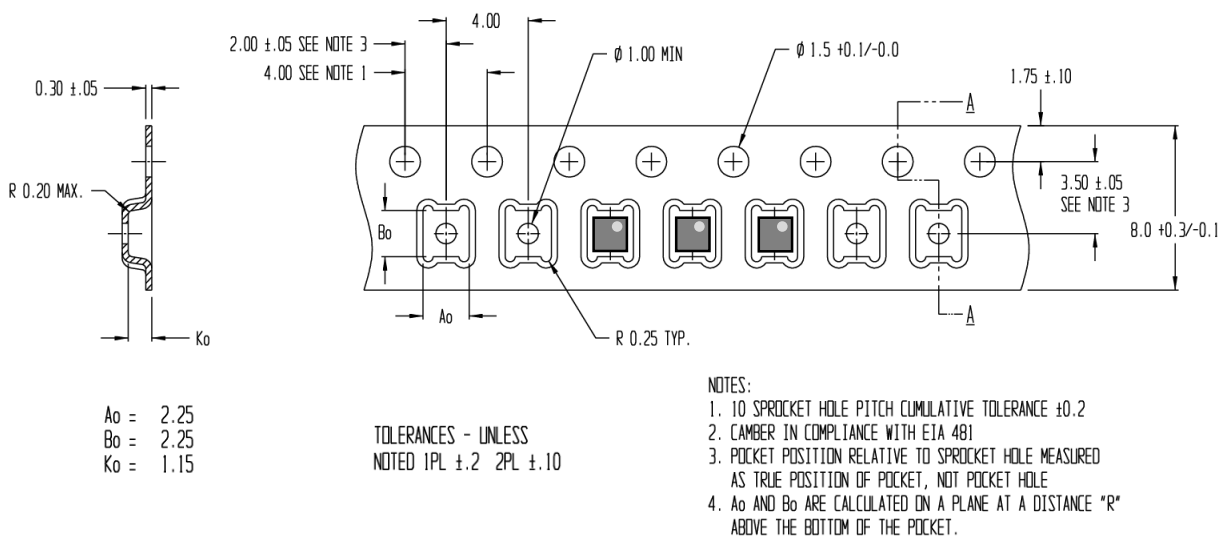
Figure 10 Technical drawing of the packaging tape with sensor orientation in tape. Header tape is to the right and trailer tape to the left on this drawing. Dimensions are given in millimeters.

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.	www.sensirion.com
SHTC1 Optimization of Repeatibility	Measures for optimization of repeatability of sensor output (also applicable to STSC1).	www.sensirion.com
SHTC1 Low Power Measurement Mode	Description of SHTC1 low power measurement mode (also applicable to STSC1).	www.sensirion.com

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.

This warranty does not apply to any equipment which has not been installed and used within the specifications recommended by SENSIRION for the intended and proper use of the equipment. EXCEPT FOR THE WARRANTIES EXPRESSLY SET FORTH HEREIN, SENSIRION MAKES NO WARRANTIES, EITHER EXPRESS OR IMPLIED, WITH RESPECT TO THE PRODUCT. ANY AND ALL WARRANTIES, INCLUDING WITHOUT LIMITATION, WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE, ARE EXPRESSLY EXCLUDED AND DECLINED.

SENSIRION is only liable for defects of this product arising under the conditions of operation provided for in the data sheet and proper use of the goods. SENSIRION explicitly disclaims all warranties, express or implied, for any period during which the goods are operated or stored not in accordance with the technical specifications.

SENSIRION does not assume any liability arising out of any application or use of any product or circuit and specifically disclaims any and all liability, including without limitation consequential or incidental damages. All operating parameters, including without limitation recommended parameters, must be validated for each customer's applications by customer's technical experts. Recommended parameters can and do vary in different applications.

SENSIRION reserves the right, without further notice, (i) to change the product specifications and/or the information in this document and (ii) to improve reliability, functions and design of this product.

Headquarters and Subsidiaries

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Phone: +41 44 306 40 00 Fax: +41 44 306 40 30 info@sensirion.com www.sensirion.com	Sensirion Japan Co. Ltd. Phone: +81 3 3444 4940 info@sensirion.co.jp www.sensirion.co.jp	Sensirion China Co. Ltd. Phone: +86 755 8252 1501 info@sensirion.com.cn www.sensirion.com.cn
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