Preliminary Datasheet SHT21S

Humidity and Temperature Sensor

- Fully calibrated
- SDM interface convertible to analog output
- Low power consumption
- Excellent long term stability
- DFN type package – reflow solderable

Product Summary

SHT21S, the new humidity and temperature sensor of Sensirion is about to set new standards in terms of size and intelligence: Embedded in a reflow solderable Dual Flat No leads (DFN) package of 3 x 3mm foot print and 1.1mm height it provides calibrated, linearized signals in analog Sigma Delta Modulated (SDM) format.

With a completely new designed CMOSens® chip, a reworked capacitive type humidity sensor and a standard band gap temperature sensor the performance level has been lifted even beyond the outstanding reliability level of the previous sensor generation (SHT1x and SHT7x). For example, measures have been taken to stabilize the behavior at high humidity levels.

SDM signal is a pulse sequence that with a low pass filter may be converted into analog voltage output. The data signal is provided on SDA line. Pulling SCL high or low allows for switching between humidity and temperature, respectively. The sensor measures the physical values once per second.

Every sensor is individually calibrated and tested. Lot identification is printed on the sensor.

With made improvements and the miniaturization of the sensor the performance-to-price ratio has been improved. SHT21 is also available with digital I²C or PWM interface.

Dimensions

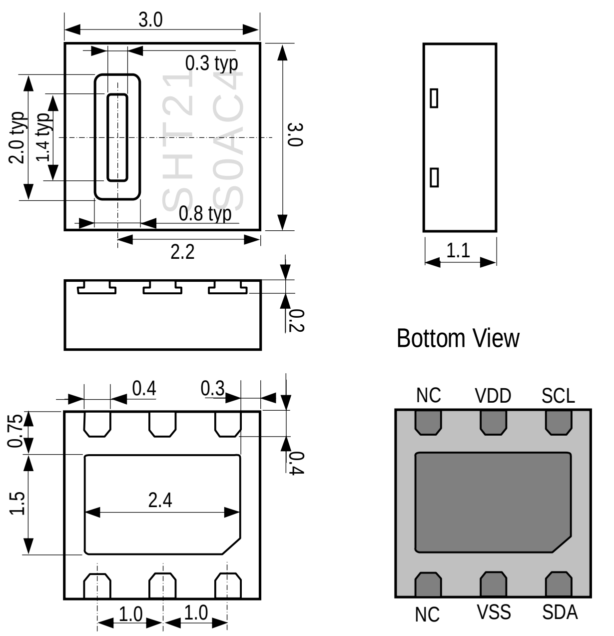

Figure 1: Drawing of SHT21S sensor package, dimensions are given in mm (1mm = 0.039inch), tolerances are ±0.1mm. NC and die pad (center pad) are internally connected to VSS. They may be left floating. VSS = GND, SDA = DATA.

Sensor Chip

SHT21S feature a generation 4C CMOSens® chip. Besides the capacitive relative humidity sensor and the band gap temperature sensor, the chip contains an amplifier, A/D converter, OTP memory and a digital processing unit.

Material Contents

While the sensor itself is made of Silicon the sensors' housing consists of a plated Cu lead-frame and green epoxy-based mold compound. The device is free of Pb, Cd and Hg – hence it is fully RoHS and WEEE compliant.

Roadmap of Product Launch

SHT21S samples at design freeze status are available – please check www.sensirion.com/sht21. Volume supply will be started in May 2010. For more information please contact Sensirion at info@sensirion.com.

Please note that this is a preliminary Datasheet – all details are subject to change.

Sensor Performance

Relative Humidity

Parameter	Condition	min	typ	max	Units
Resolution	10 bit		0.12		%RH
Accuracy tolerance [1]	typ		±2.0		%RH
	max	see Figure 2			%RH
Repeatability			±0.1		%RH
Hysteresis			±1		%RH
Nonlinearity			<0.1		%RH
Response time [2]	τ 63%		8		s
Operating Range	extended [3]	0		100	%RH
Long Term Drift [4]	normal		< 0.5		%RH/yr

Temperature

Parameter	Condition	min	typ	max	Units
Resolution	12 bit		0.04		°C
Accuracy tolerance [1]	typ		±0.3		°C
	max	see Figure 3			°C
Repeatability			±0.1		°C
Operating Range	extended [3]	-40		125	°C
		-40		257	°F
Response Time [6]	τ 63%	5		30	s
Long Term Drift			< 0.04		°C/yr

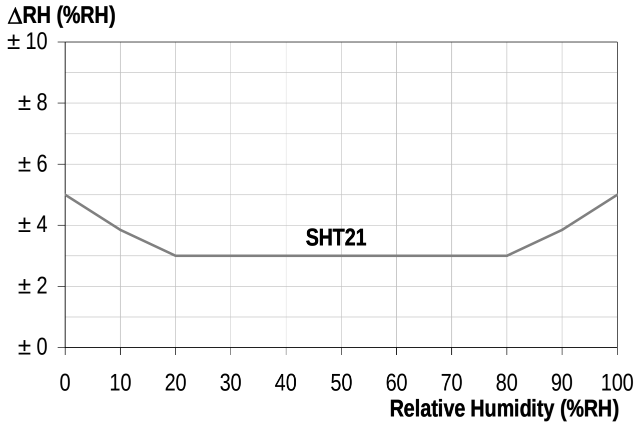

Figure 2 Maximal accuracy at 25°C for relative humidity

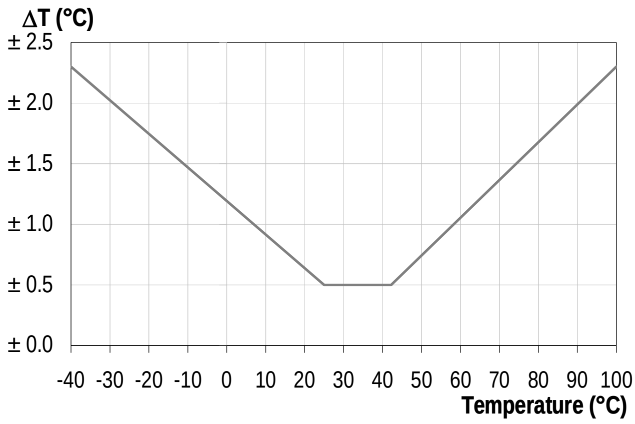

Figure 3 Maximal temperature accuracy

Electrical Specification

Parameter	Condition	min	typ	max	Units
Supply Voltage, VDD		2.1	3.0	3.6	V
Supply Current, IDD [5]			160		μA
Power Dissipation [5]			0.48		mW
Measurement Frequency			1		Hz
Switch RH/T on SDA	SCL up → RH; SCL down → T				

Table 1 Electrical specification. For absolute maximum values see Chapter 3 of Users Guide.

Packaging Information

Sensor Type	Packaging	Quantity	Order Number
SHT21S	Tape & Reel	400	Not defined yet
	Tape & Reel	1500	Not defined yet

[1] Accuracies are tested at Outgoing Quality Control at 25°C (77°F) and 3.0V. Values exclude hysteresis and non-linearity and are applicable to non-condensing environments only.

[2] Time for achieving 63% of a step function, valid at 25°C and 1 m/s airflow.

[3] Normal operating range: 0-80%RH, beyond this limit sensor may read a reversible offset with slow kinetics (<3%RH after 200hours at 90%RH). Operating range is further restricted to values with dew point at -40 – 80°C.

[4] Value may be higher in environments with vaporized solvents, out-gassing tapes, adhesives, packaging materials, etc. For more details please refer to Handling Instructions.

[5] Min and max values of Supply Current and Power Dissipation are based upon fixed VDD = 3.0V and T<60°C (average value at one 10bit measurement per two seconds) and with the load equivalent to a cable of 1cm length.

[6] Response time depends on heat conductivity of sensor substrate.

Users Guide SHT21S

1 Application Information

1.1 Operating Conditions

Sensor works stable within recommended normal range – see Figure 4. Long term exposures to conditions outside normal range, especially at humidity >80%RH, may temporarily offset the RH signal (+3 %RH after 60h). After return to normal range it will slowly return towards calibration state by itself. See Section 1.4 "Reconditioning Procedure" to accelerate eliminating the offset. Prolonged exposure to extreme conditions may accelerate ageing.

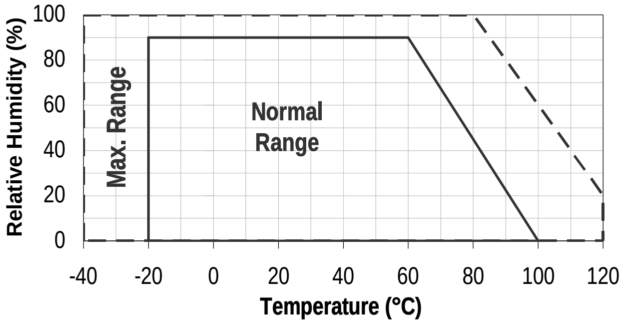

Figure 4 Operating Conditions

1.2 Soldering instructions

The DFN's die pad (centre pad) and perimeter I/O pads are fabricated from a planar copper lead-frame by over-molding leaving the die pad and I/O pads exposed for mechanical and electrical connection. Both the I/O pads and die pad should be soldered to the PCB.

The I/O lands should be 0.2mm longer than the package I/O pads. Inward corners may be rounded to match the I/O pad shape. The I/O land width should match the package I/O pads width 1:1 and the thermal land for the die pad should match 1:1 with the package - see Figure 5.

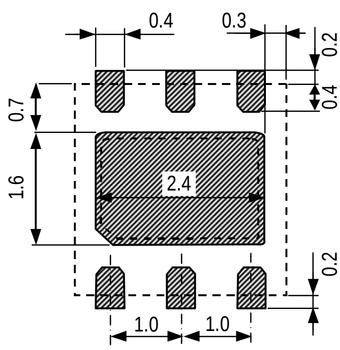

Figure 5 Recommended land pattern for SHT2x. Values in mm. Die pad (centre pad) is internally connected to VSS. NC Pads may be left floating. The outer dotted line represents the outer dimension of the DFN package.

For land pattern and solder mask design Non-Solder Mask Defined (NSMD) with solder mask openings larger than metal pads is recommended: It allows for better control of the copper etching process, it reduces stress concentrations near the solder mask overlap region and it improves the reliability of solder joints as solder is allowed to "wrap around" the sides of the metal pads on the board.

For NSMD pads, the solder mask opening should be about 120µm to 150µm larger than the pad size, providing a 60µm to 75µm design clearance between the copper pad and solder mask. Rounded portions of package pads should have a matching rounded solder mask-opening shape, especially at corner leads to allow for enough solder mask web to prevent solder bridging. For the actual pad dimensions, each pad on the PCB should have its own solder mask opening with a web of solder mask between adjacent pads.

A laser-cut, stainless steel stencil with electro-polished trapezoidal walls is recommended. Electro-polishing "smoothes" aperture walls, resulting in reduced surface friction, good paste release and void reduction. A 0.125mm stencil thickness is recommended.

For the I/O pads the stencil aperture is 0.1mm longer than PCB pads with 0.1 mm offset away from the centre of the package. The die pad aperture should cover about 70-90% of the pad area – say up to 1.4mm x 2.3mm centered on the thermal land area. It could also be split in two openings.

Due to the low mounted height of the QFN, "no clean" type 3 paste is recommended as well as Nitrogen purge during reflow.

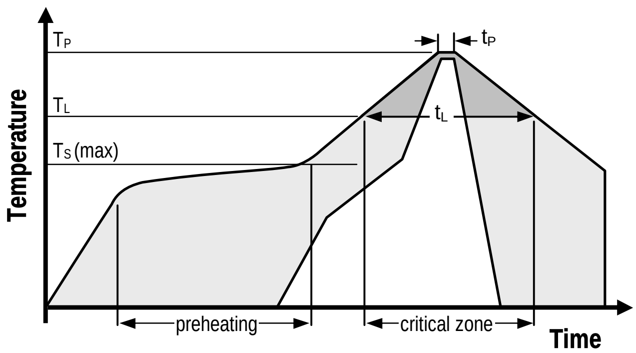

Figure 6 Soldering profile according to JEDEC standard. T_P <= 260°C and t_P < 40sec for Pb-free assembly. T_L < 220°C and t_L < 150sec. Ramp-up/down speeds shall be < 5°C/sec.

It is important to note that the diced edge or side faces of the I/O pads may oxidise over time, therefore a solder fillet may or may not form. Hence there is no guarantee for solder joint fillet heights of any kind.

For soldering SHT2x standard reflow soldering ovens may be used. The sensor is qualified to withstand soldering profile according to IPC/JEDEC J-STD-020C with peak temperatures at 260°C during up to 40sec including Pb-free assembly in IR/Convection reflow ovens.

For soldering in Vapor Phase Reflow (VPR) ovens the peak conditions are limited to T_P < 233°C during t_P < 60sec and ramp-up/down speeds shall be limited to 10°C/sec. For manual soldering contact time must be limited to 5 seconds at up to 350°C[7].

IMPORTANT: After soldering the devices should be stored at >75%RH for at least 12h to allow the polymer to re-hydrate. Otherwise the sensor may read an offset that slowly disappears if exposed to ambient conditions.

In no case, neither after manual nor reflow soldering, a board wash shall be applied. Therefore, and as mentioned above, it is strongly recommended to use "no-clean" solder paste. In case of application with exposure of the sensor to corrosive gases the soldering pads shall be sealed to prevent loose contacts or short cuts.

For the design of the SHT2x footprint it is recommended to use dimensions according to Figure 5. In order to prevent oxidation and to optimize soldering, sensor pads are plated with Ni/Pd/Au. Please note that this protective coating is not present at side walls – hence fillets may or may not form depending on oxidation at diced edge.

1.3 Storage Conditions and Handling Instructions

Moisture Sensitivity Level (MSL) is 2, hence storage time is limited to one year.

It is of great importance to understand that a humidity sensor is not a normal electronic component and needs to be handled with care. Chemical vapors at high concentration in combination with long exposure times may offset the sensor reading.

For these reasons it is recommended to store the sensors in original packaging including the sealed ESD bag at following conditions: Temperature shall be in the range of 10°C – 50°C and humidity at 20 – 60%RH (sensors that are not stored in ESD bags). For sensors that have been removed from the original packaging we recommend to store them in ESD bags made of PE-HD[8].

In manufacturing and transport the sensors shall be prevented of high concentration of chemical solvents and long exposure times. Out-gassing of glues, adhesive tapes and stickers or out-gassing packaging material such as bubble foils, foams, etc. shall be avoided. Manufacturing area shall be well ventilated.

For more detailed information please consult the document *"Handling Instructions"* or contact Sensirion.

1.4 Reconditioning Procedure

As stated above extreme conditions or exposure to solvent vapors may offset the sensor. The following reconditioning procedure may bring the sensor back to calibration state:

Baking: 100 – 105°C at < 5%RH for 10h
Re-Hydration: 20 – 30°C at ~ 75%RH for 12h [9].

1.5 Temperature Effects

Relative humidity reading strongly depends on temperature. Therefore, it is essential to keep humidity sensors at the same temperature as the air of which the relative humidity is to be measured. In case of testing or qualification the reference sensor and test sensor must show equal temperature to allow for comparing humidity readings.

If the sensor shares a PCB with electronic components that produce heat it should be mounted in a way that prevents heat transfer or keeps it as low as possible. Measures to reduce heat transfer can be ventilation, reduction of copper layers between the sensor and the rest of the PCB or milling a slit into the PCB around the sensor (see Figure 7).

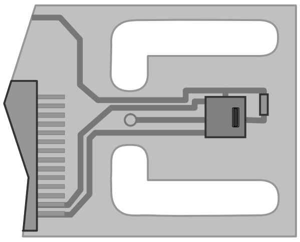

Figure 7 Top view of example of mounted SHT21S with slits milled into PCB to minimize heat transfer.

1.6 Light

The SHT21S is not light sensitive. Prolonged direct exposure to sunshine or strong UV radiation may age the housing.

1.7 Materials Used for Sealing / Mounting

Many materials absorb humidity and will act as a buffer increasing response times and hysteresis. Materials in the vicinity of the sensor must therefore be carefully chosen. Recommended materials are: Any metals, LCP, POM (Delrin), PTFE (Teflon), PE, PEEK, PP, PB, PPS, PSU, PVDF, PVF.

For sealing and gluing (use sparingly): Use high filled epoxy for electronic packaging (e.g. glob top, underfill), and Silicone. Out-gassing of these materials may also

7 233°C = 451°F, 260°C = 500°F, 350°C = 662°F

8 For example, 3M antistatic bag, product "1910" with zipper.

9 75%RH can conveniently be generated with saturated NaCl solution. 100 – 105°C correspond to 212 – 221°F, 20 – 30°C correspond to 68 – 86°F

contaminate the sensor (see Section 1.3). Therefore try to add the sensor as a last manufacturing step to the assembly, store the assembly well ventilated after manufacturing or bake at >50°C for 24h to outgas contaminants before packing.

1.8 Wiring Considerations and Signal Integrity

Carrying the SCL and SDA signal parallel and in close proximity (e.g. in wires) for more than 10cm may result in cross talk and loss of communication. This may be resolved by routing VDD and/or VSS between the two SDA signals and/or using shielded cables. Power supply pins (VDD, VSS) must be decoupled with a 100nF capacitor, see next Chapter.

2 Interface Specifications

Pin	Name	Comment
5	VSS	Ground
6	SDA	Data bit-stream
3	SCL	Selector for RH or T
2	VDD	Supply Voltage
1,4	NC	Not connected

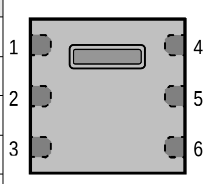

Table 2 SHT21S pin assignment, NC remain floating

2.1 Power Pins (VDD, VSS)

The supply voltage of SHT21S must be in the range of 2.1 – 3.6V, recommended supply voltage is 3.0V. Power supply pins Supply Voltage (VDD) and Ground (VSS) must be decoupled with a 100nF capacitor, that shall be placed as close to the sensor as possible – see Figure 8.

2.2 SCL – Output Selector Pad

SCL is used to select humidity or temperature output. SCL high yields humidity output, SCL low yields temperature output.

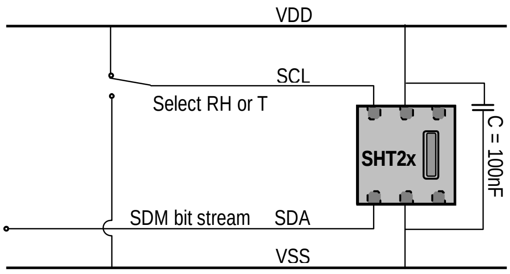

Figure 8 Typical application circuit, including decoupling of VDD and VSS by a capacitor.

2.3 SDA – Bit Stream Pad

On SDA the sensor is providing SDM output. The signal is carrying humidity or temperature data depending on SCL being high or low, respectively. See Table 4 for detailed I/O characteristic of the sensor.

3 Electrical Characteristics

3.1 Absolute Maximum Ratings

The electrical characteristics of SHT21S are defined in Table 1. The absolute maximum ratings as given in Table 3 are stress ratings only and give additional information. Functional operation of the device at these conditions is not implied. Exposure to absolute maximum rating conditions for extended periods may affect the sensor reliability (e.g. hot carrier degradation, oxide breakdown).

Parameter	min	max	Units
VDD to VSS	-0.3	5	V
Digital IO Pins (SDA, SCL) to VSS	-0.3	VDD + 0.3	V
Input Current on any Pin	-100	100	mA

Table 3 Electrical absolute maximum ratings

ESD immunity is qualified according to MIL STD 883E, method 3015 (Human Body Model at ±2kV). Latch-up immunity is provided at a force current of ±100mA with T_{amb} = 80°C according to JEDEC78A.

3.2 Input / Output Characteristics

The electrical characteristics such as power consumption, low and high level input and output voltages depend on the supply voltage. For proper communication with the sensor it is essential to make sure that signal design is strictly within the limits given in Table 4.

Parameter	min	typ	max	Units
Output Low Voltage, VOL		0		V
Output High Voltage, VOH		VDD		V
Output Sink Current, IOL			40	µA

Table 4 DC characteristics of input / output pad. VDD = 2.1 V to 3.6 V, T = -40 °C to 125 °C, unless otherwise noted.

4 Communication with Sensor

4.1 Start up Sensor

As a first step, the sensor is powered up to the chosen supply voltage VDD (between 2.1V and 3.6V). After power-up, the sensor needs at most 90ms for reaching idle state. Then the sensor starts measuring and providing data on SDM bit-stream.

4.2 SDM Output Principal

Sigma Delta Modulation is a bit-stream of pulses; the more high pulses the higher the value in the full measurement range – see Figure 9. Such information is humidity for SCL pulled high and temperature for SCL pulled low. The fundamental frequency of SDM is in the range of roughly 4 kHz and 65 kHz.

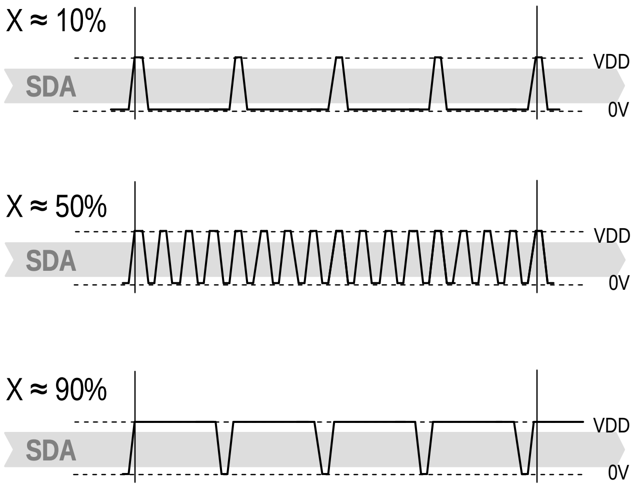

Figure 9 Schematic principle of SDM signal. X represents either RH or T at different levels of sensor output.

4.3 Converting SDM to Analog Signal

An SDM signal normally is converted to an analog voltage signal by the addition of a low-pass filter. Figure 10 displays a typical circuit where a simple RC-filter is used. For conversion into physical values please read the following Chapter.

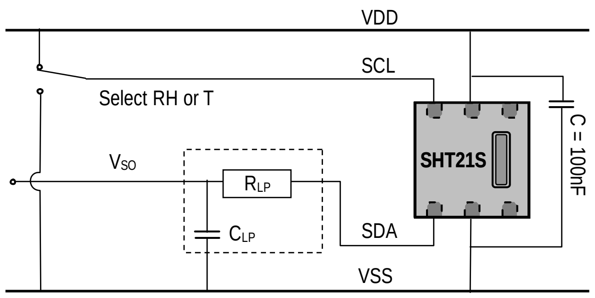

Figure 10 Typical circuit with low pass filter (surrounded by hatched line) for analog output. Recommended component size: R_{LP} = 100kΩ and C_{LP} = 220nF. By pulling SCL low or high, the output value is switched to temperature or humidity, respectively.

For an acceptable small ripple of the analog voltage signal, a cut-off frequency of at least 5.8Hz is recommended. Typical values for the low pass filter components are R = 100kΩ and C = 220nF – that result in a cut-off frequency of 7Hz. The corresponding ripple of the signal is limited to maximal amplitude of ±0.2%RH. If larger deviations are acceptable the capacitor size can be reduced.

Important: The maximum current from SDA should not exceed 40µA. Therefore, there are restrictions on the size of the resistance R_{LP}. Furthermore, the current should be kept as low as possible and therefore the input impedance of the reading buffer shall be larger than 50MΩ (60nA input biased current).

5 Conversion of Signal Output

After the low pass filter the sensor provides an output Voltage V_{SO} which as a portion of VDD then is converted into a physical value.

Resolution is set to 10 bit for relative humidity and 12 bit for temperature and cannot be changed. The sensor reading is linearized and hence it can be converted to a physical value by an easy linear equation.

5.1 Relative Humidity Conversion

With the relative humidity signal output the relative humidity *RH* is obtained by the following formula (result in %RH):

$$RH = c_0 + c_1 \frac{V_{SO}}{VDD}$$

The corresponding coefficients are given in Table 5:

Coefficient	Value
c_0	-5
c_1	125

Table 5 Preliminary humidity conversion coefficients (final values by 15 Dec 2009).

The physical value *RH* given above corresponds to the relative humidity above liquid water according to World Meteorological Organization (WMO). For relative humidity values above ice a different set of coefficients needs to be applied that will be given in a separate application note.

5.2 Temperature Conversion

The temperature *T* is calculated by inserting temperature signal output S_T into the following formula (result in °C):

$$T = c_2 + c_3 \frac{V_{SO}}{VDD}$$

The corresponding coefficients given in Table 6:

Coefficient	Value
c_2	-46.83
c_3	175.72

Table 6 Preliminary temperature conversion coefficients (final values by 15 Dec 2009).

6 Environmental Stability

The sensors are planned to be qualified according to AEC-Q100 standard, grade 1 which corresponds to the temperature range of -40 – 125°C. Details will be given when qualification results are available.

7 Packaging

7.1 Packaging type

SHT21 sensors are provided in DFN packaging (in analogy with QFN packaging). DFN stands for Dual Flat No leads.

The sensor chip is mounted to a lead frame made of Cu and coated with Ni/Pd/Au. Chip and lead frame are over molded by green epoxy-based mold compound. Please note that side walls of sensors are sawed and hence lead frame is not covered with respective protective coating. Side fences hence may corrode slightly and therefore the wetability at soldering may degrade over time.

7.2 Traceability Information

All SHT21 are laser marked with an alphanumeric, five-digit code on the sensor – see Figure 11.

Figure 11 Laser marking on sensor. For details see text.

The marking on the sensor consists of two lines with five digits each. The first line denotes the sensor type (SHT21). The first digit of the second line defines the output mode (D = digital, Sensibus and I2C, P = PWM, S = SDM). The second digit defines the manufacturing year (0 = 2010, 1 = 2011, etc.). The last three digits eventually represent an alphanumeric tracking code. That code can be decoded by Sensirion only and allows for tracking on batch level through production, calibration and testing – and will be provided upon justified request.

Reels are also labeled, as displayed in Figures 19 and 20, and give additional traceability information.

Lot No.:	XXO-NN-YRRRRTTTT
Quantity:	RRRR
RoHS:	Compliant

Lot No.

Figure 12: First label on reel: XX = Sensor Type (21 for SHT21), O = Output mode (D = Digital, P = PWM, S = SDM), NN = Chip Version, Y = last digit of year, RRRR = number of sensors on reel, TTTT = Traceability Code.

SENSIRION
THE SENSOR COMPANY

Device Type:	1-100PPP-NN
Description:	Humidity & Temperature Sensor SHTxx
Part Order No.	1-100PPP-NN or Customer Number
Date of Delivery:	DD.MM.YYYY
Order Code:	45CCCC / 0

Figure 13: Second label on reel: For Device Type and Part Order Number is not defined yet, Delivery Date (also Date Code) is date of packaging of sensors (DD = day, MM = month, YYYY = year), CCCC = Sensirion order number.

7.3 Shipping Package

SHT2x are provided in tape & reel shipment packaging, sealed into antistatic ESD bags. Standard packaging sizes are 400, 1500 and 5000 units per reel. The drawing of the packaging tapes with sensor orientation is shown in Figure 14. The reels are provided in sealed antistatic bags.

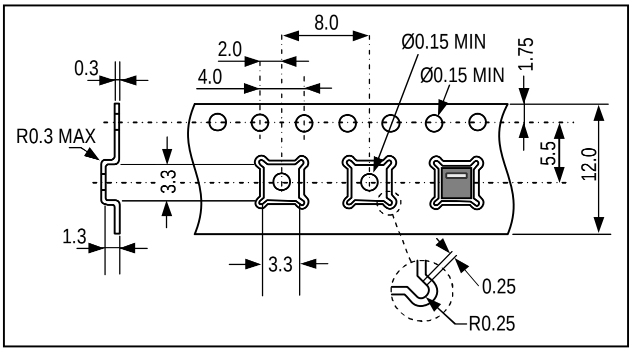

Figure 14 Sketch of packaging tape and sensor orientation.

Revision History

Date	Version	Page(s)	Changes
6 May 2009	0.3	1 – 9	Initial preliminary release
3 June 2009	0.5	1 – 7	Adaptation to SDM communication
19 Aug 2009	0.6	1, 7	Figure 1, add details to Chapter 7, add coefficients to Tables 5, 6.

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.

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