Preliminary Datasheet SHT21

Humidity and Temperature Sensor

- Fully calibrated
- Digital output, I²C interface
- Low power consumption
- Excellent long term stability
- DFN type package – reflow solderable

Product Summary

SHT21, 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 digital, true I²C 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.

Every sensor is individually calibrated and tested. Lot identification is printed on the sensor and an electronic identification code is stored on the chip – which may be read out by command. Furthermore, the resolution of SHT21 can be changed by command (8/12bit up to 12/14bit for RH/T), low battery can be detected and a checksum helps to improve communication reliability.

With made improvements and the miniaturization of the sensor the performance-to-price ratio has been improved – and eventually, any device should benefit from the cutting edge energy saving operation mode. For testing SHT21 a new evaluation Kit EK-H4 is available.

Dimensions

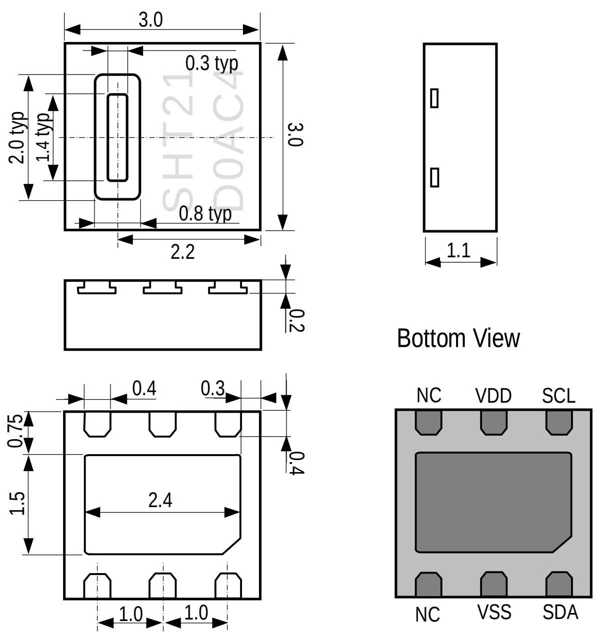

Figure 1: Drawing of SHT21 sensor package, dimensions are given in mm (1mm = 0.039inch), tolerances are ±0.1mm. Die pad (center pad) is internally connected to VSS. NC are floating. VSS = GND, SDA = DATA.

Sensor Chip

SHT21 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

SHT21 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 [1]	12 bit		0.03		%RH
	8 bit		0.5		%RH
Accuracy tolerance [2]	typ		±1.5		%RH
	max	see Figure 2			%RH
Repeatability			±0.1		%RH
Hysteresis			±1		%RH
Nonlinearity			<0.1		%RH
Response time [3]	τ 63%		8		s
Operating Range	extended [4]	0		100	%RH
Long Term Drift [5]	normal		< 0.5		%RH/yr

Temperature

Parameter	Condition	min	typ	max	Units
Resolution [1]	14 bit		0.01		°C
	12 bit		0.04		°C
Accuracy tolerance [2]	typ		±0.3		°C
	max	see Figure 3			°C
Repeatability			±0.1		°C
Operating Range	extended [4]	-40		125	°C
		-40		257	°F
Response Time [7]	τ 63%	5		30	s
Long Term Drift			< 0.04		°C/yr

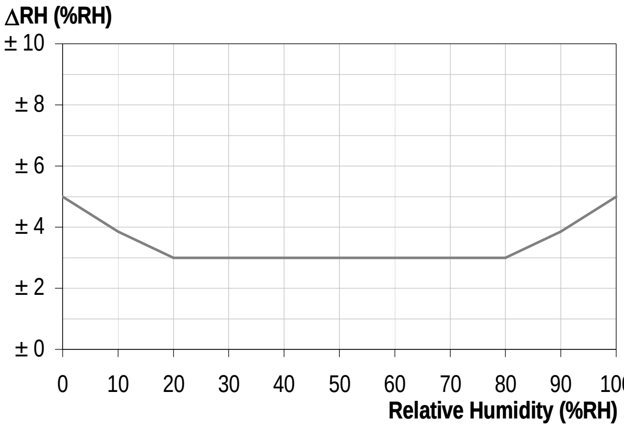

Figure 2 Maximal tolerance at 25°C for relative humidity

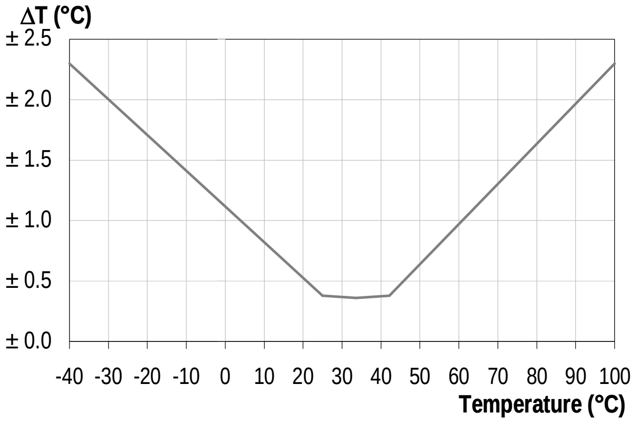

Figure 3 Maximal temperature tolerance

Electrical Specification

Parameter	Conditions	min	typ	max	Units
Supply Voltage, VDD		2.1	3.0	3.6	V
Supply Current, IDD [6]	sleep mode	-	0.15	0.4	µA
	measuring	270	300	330	µA
Power Dissipation [6]	sleep mode	-	0.5	1.2	µW
	measuring	0.8	0.9	1.0	mW
	average 8bit	-	1.5	-	µW
Heater	VDD = 3.0 V	5.5 mW, ΔT = + 0.5-1.5 °C			
Communication	digital 2-wire interface, true I²C protocol				

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

Packaging Information

Sensor Type	Packaging	Quantity	Order Number
SHT21	Tape & Reel	400	Not defined yet
	Tape & Reel	1500	Not defined yet
	Tape & Reel	5000	Not defined yet

[1] Default measurement resolution is 14bit (temp.) / 12bit (humidity). It can be reduced to 12/8bit, 11/11bit or 13/10bit by command to user register.

[2] 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.

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

[4] 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.

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

[6] Min and max values of Supply Current and Power Dissipation are based on fixed VDD = 3.0V and T<60°C. The average value is based on one 8bit measurement per second.

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

Users Guide SHT2x

1 Application Information

1.1 Operating Conditions

The 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.

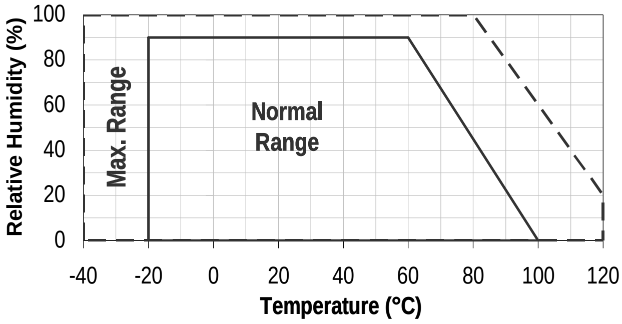

Figure 4 Operating Conditions

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.

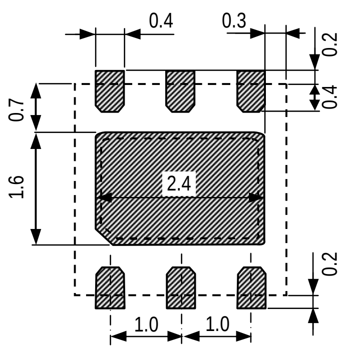

Figure 5 Recommended land pattern for SHT2x. Values in mm. Die pad (centre pad) is internally connected to VSS. NC Pads may be left floating. The outer dotted line represents the outer dimension of the DFN package.

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.

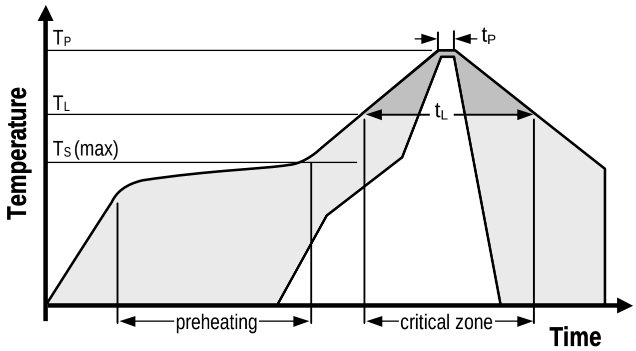

Figure 6 Soldering profile according to JEDEC standard. T_P <= 260°C and t_P < 40sec for Pb-free assembly. T_L < 220°C and t_L < 150sec. Ramp-up/down speeds shall be < 5°C/sec.

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[8].

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[9].

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 [10].

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).

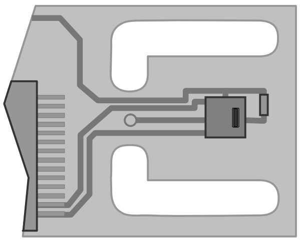

Figure 7 Top view of example of mounted SHT2x with slits milled into PCB to minimize heat transfer.

Furthermore, there are self-heating effects in case the measurement frequency is too high. To keep self heating below 0.1°C, SHT2x should not be active for more than 10% of the time – e.g. maximum two measurements per second at 12bit accuracy shall be made.

1.6 Light

The SHT2x 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

[8] 233°C = 451°F, 260°C = 500°F, 350°C = 662°F

[9] For example, 3M antistatic bag, product "1910" with zipper.

[10] 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

(Delrin), PTFE (Teflon), 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 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. Furthermore, slowing down SCL frequency will possibly improve signal integrity. Power supply pins (VDD, VSS) must be decoupled with a 100nF capacitor – see next Section.

2 Interface Specifications

Pin	Name	Comment
2	VSS	Ground
1	SDA	Serial Data, bidirectional
6	SCL	Serial Clock, bidirectional
5	VDD	Supply Voltage
3,4	NC	Must be left unconnected or connected to VSS

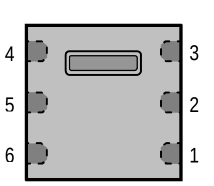

Table 2 SHT2x pin assignment, NC remain floating

2.1 Power Pins (VDD, VSS)

The supply voltage of SHT2x 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 Serial clock (SCL)

SCL is used to synchronize the communication between microcontroller (MCU) and the sensor. Since the interface consists of fully static logic there is no minimum SCL frequency.

2.3 Serial SDA (SDA)

The SDA pin is used to transfer data in and out of the sensor. For sending a command to the sensor, SDA is valid on the rising edge of the serial clock (SCL) and must remain stable while SCL is high. After the falling edge of SCL the SDA value may be changed. For safe communication SDA shall be valid t_{SU} and t_{HO} before the rising and after the falling edge of SCL, respectively – see Figure 9. For reading SDA from the sensor, SDA is valid t_V after SCL has gone low and remains valid until the next falling edge of SCL.

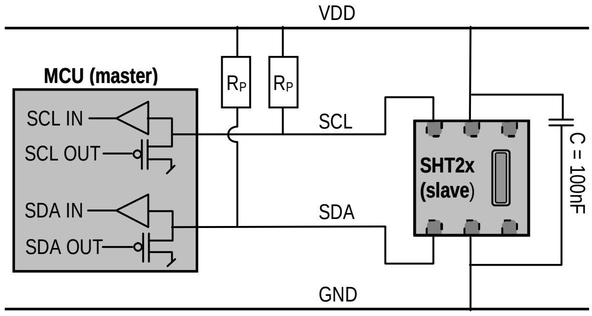

Figure 8 Typical application circuit, including pull-up resistors R_P and decoupling of VDD and VSS by a capacitor.

To avoid signal contention the microcontroller (MCU) must only drive SDA and SCL low. External pull-up resistors (e.g. 10kΩ), are required to pull the signal high – for the choice of resistor size please take bus capacity requirements into account (compare Table 5). It should be noted that pull-up resistors may be included in I/O circuits of MCUs. See Table 4 and Table 5 for detailed I/O characteristic of the sensor.

3 Electrical Characteristics

3.1 Absolute Maximum Ratings

The electrical characteristics of SHT2x 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 ±2 kV). Latch-up immunity is provided at a force current of ±100mA with T_{amb} = 80°C according to JEDEC78A. For exposure beyond named limits the sensor needs additional protection circuit.

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 & 5 and Figure 9.

Parameter	Conditions	min	typ	max	Units
Output Low Voltage, VOL	VDD = 3.0 V, -4 mA < IOL < 0mA	0	-	0.4	V
Output High Voltage, VOH		70% VDD	-	VDD	V
Output Sink Current, IOL		-	-	-4	mA
Input Low Voltage, VIL		0	-	30% VDD	V
Input High Voltage, VIH		70% VDD	-	VDD	V
Input Current	VDD = 3.6 V, VIN = 0 V to 3.6 V	-	-	±1	uA

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

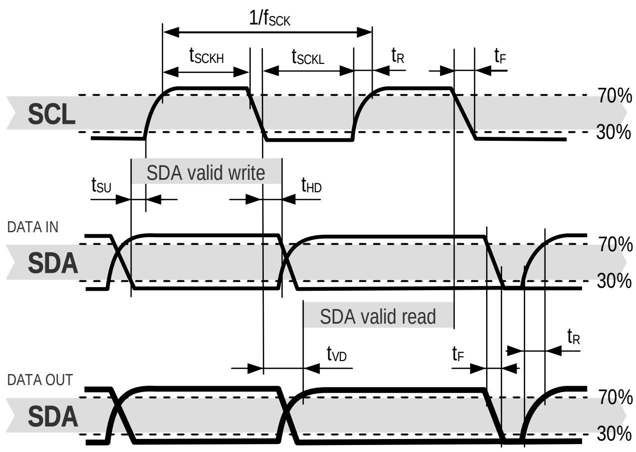

Figure 9 Timing Diagram for Digital Input/Output Pads, abbreviations are explained in Table 5. DATA directions are seen from the sensor. Bold SDA line is controlled by the sensor, plain SDA line is controlled by the micro-controller. Both valid times (SDA read and SDA write) refer to the left SCL toggle.

Parameter	min	typ	max	Units
SCL frequency, f_{SCL}	0	-	0.4	MHz
SCL High Time, t_{SCLH}	0.6	-	-	µs
SCL Low Time, t_{SCLL}	1.3	-	-	µs
SDA Set-Up Time, t_{SU}	100	-	-	ns
SDA Hold Time, t_{HD}	0	-	900	ns
SDA Valid Time, t_{VD}	0	-	400	ns
SCL/SDA Fall Time, t_F	0	-	100	ns
SCL/SDA Rise Time, t_R	0	-	300	ns
Capacitive Load on Bus Line, C_B	0	-	400	pF

Table 5 Timing specifications of digital input/output pads for I²C fast mode. Entities are displayed in Figure 9. VDD = 2.1V to 3.6V, T = -40°C to 125°C, unless otherwise noted.

4 Communication with Sensor

SHT21 communicates with true I²C protocol. For information on I²C beyond the information in the following Chapters please refer to the following website: http://www.standardics.nxp.com/support/i2c/.

Please note that all sensors are set to the same I²C address, as defined in Section 4.4.

Furthermore, please note, that Sensirion provides a sample code on its home page – compare www.sensirion.com/sht21.

4.1 Start up Sensor

As a first step, the sensor is powered up to the chosen supply voltage VDD (between 2.1 V and 3.6 V). After power-up, the sensor needs at most 15 ms, while SCL is high, for reaching idle state, i.e. to be ready accepting commands from the master (MCU).

4.2 Start / Stop Sequence

Each transmission sequence begins with Start condition and ends with Stop condition as displayed in Figure 10 and Figure 11.

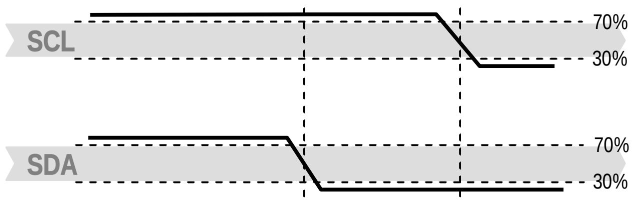

Figure 10 Transmission Start Condition (S) - a high to low transition on the SDA line while SCL is high. The Start condition is a unique state on the bus created by the master, indicating to the slaves the beginning of a transmission sequence (bus is considered busy after a Start).

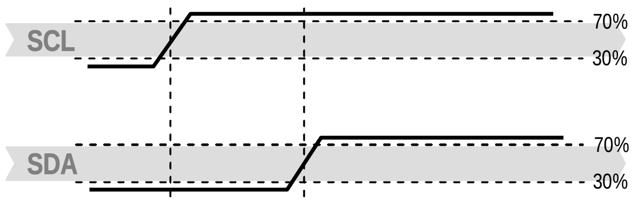

Figure 11 Transmission Stop Condition (P) - a low to high transition on the SDA line while SCL is high. The Stop condition is a unique state on the bus created by the master, indicating to the slaves the end of a transmission sequence (bus is considered free after a Stop).

4.3 Sending a Command

After sending the Start condition, the subsequent I²C header consists of the 7-bit I²C device address '1000'000' and an SDA direction bit (Read R: '1', 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. After the issue of a measurement command

('1110'0011' for temperature, '1110'0101' for relative humidity'), the MCU must wait for the measurement to complete. The basic commands are summarized in Table 6. There are two different modes available, *hold master* or *no hold master*.

Command	Comment	Code
Trigger T measurement	hold master	1110'0011
Trigger RH measurement	hold master	1110'0101
Trigger T measurement	no hold master	1111'0011
Trigger RH measurement	no hold master	1111'0101
Write user register		1110'0110
Read user register		1110'0111
Soft reset		1111'1110

Table 6 Basic command set, RH stands for relative humidity, and T stands for temperature

4.4 Hold / No Hold Master Mode

There are two different operation modes to communicate with the sensor: *Hold Master* mode or *No Hold Master* mode. In the first case the SCL line is blocked (controlled by sensor) during measurement process while in the latter case the SCL line remains open for other communication while the sensor is processing the measurement. No hold master mode allows for processing other I²C communication tasks on a BUS while the sensor is measuring. The communication sequence of the two modes is displayed in Figure 12 and Figure 13, respectively.

In the hold master mode, the SHT2x while measuring pulls down the SCL line to force the master into a wait state. By releasing the SCL line the sensor indicates that internal processing is terminated and that the transmission may be continued.

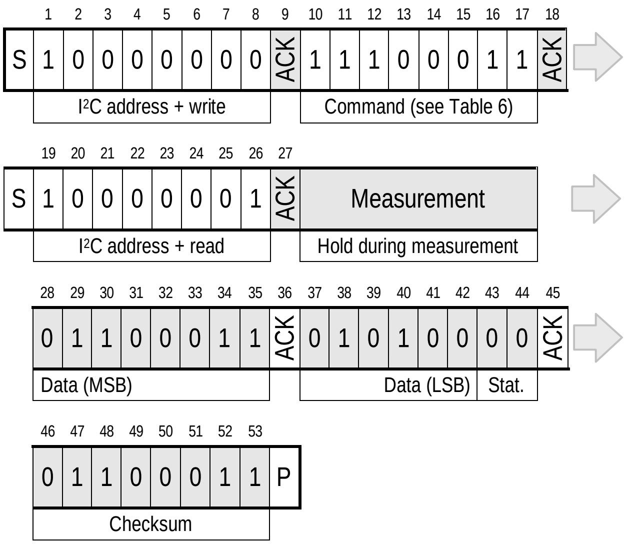

Figure 12 *Hold master* communication sequence – grey blocks are controlled by SHT2x. Bit 45 may be changed to a transmission Stop condition (P) to omit checksum transmission.

In no hold master mode, the MCU has to poll for the termination of the internal processing of the sensor. This is done by sending a Start condition followed by the I²C header (1000'0001) as shown in Figure 13. If the internal processing is finished, the sensor acknowledges the poll of the MCU and data can be read by the MCU. If the measurement processing is not finished the sensor answers no ACK bit and the Start condition must be issued once more.

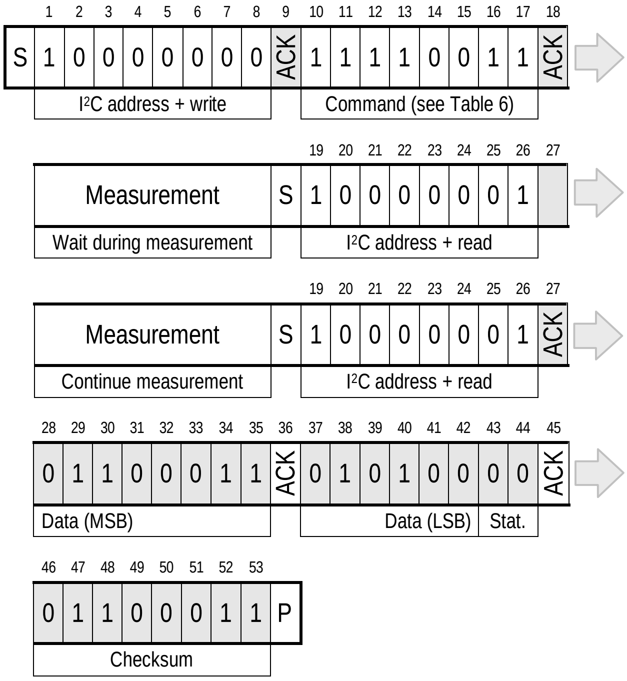

Figure 13 *No Hold master* communication sequence – grey blocks are controlled by SHT2x. If measurement is not completed upon "read" command, sensor does not provide ACK on bit 27 (more of these iterations are possible). If bit 45 is changed to Stop condition (P) checksum transmission is omitted.

Since the maximum resolution of a measurement is 14 bit, the two LSBs on the second measurement SDA bytes are used to transmit status information. Bit 1 of the two LSBs indicated the measurement type ('0': temperature, '1' humidity). Bit 0 is currently not assigned.

Parameter	Resolution	typ	max	Units
Measurement time (max values for -40°C – 125°C.)	14 bit	66	85	ms
	13 bit	33	43	ms
	12 Bit	17	22	ms
	11 bit	8	11	ms
	10 bit	4	6	ms
	8 bit	1	3	ms

Table 7 Measurement times for different resolutions. While the sensor is measuring, other tasks may be executed on the I²C-bus if *no hold master mode* is applied (see section 4.4).

The maximum durations for measurements depend on the resolution chosen and are displayed in Table 7. Maximum values shall be chosen for the communication planning of the MCU. For calculating energy consumption a typical or average value shall be chosen that is about 25% lower than the maximum value.

4.5 Soft Reset

This command (see Table 6) is used to reboot the sensor system without switching the power off and on again. Upon reception of this command, the sensor system reinitializes and starts operation according to the default settings. The soft reset takes less than 15 ms.

4.6 User Register

The content of user register is described in Table 8. Please note that reserved bits must not be changed.

Bit	# Bits	Description / Coding	Default
7, 0	2	Measurement resolution (RH / T): '00': 12 bit / 14 bit; '01': 8 bit / 12 bit; '10': 10 bit / 13 bit; '11': 11 bit / 11 bit	'00'
6	1	Status: End of battery[11] '0': VDD > 2.25 V '1': VDD < 2.15 V	'0'
3, 4, 5	3	Reserved	
2	1	Enable on-chip heater	'0'
1	1	Disable OTP reload	'1'

	RH	T
'00'	12 bit	14 bit
'01'	8 bit	12 bit
'10'	10 bit	13 bit
'11'	11 bit	11 bit

Table 8 User Register. Cut-off value for End of Battery signal may vary by ±0.05V. Reserved bits must not be changed. "OTP reload" = '0' loads default settings after each time a measurement command is issued.

The heater is intended to be used for functionality diagnosis – relative humidity drops upon rising temperature. The heater consumes about 5.5mW and provides a temperature increase of about 0.5 – 1.5°C.

4.7 CRC Checksum

For implementing CRC8 checksum please refer either to Wikipedia (http://en.wikipedia.org/wiki/crc8) or to the Application Note SHT2x CRC Checksum" – to be provided soon.

4.8 Serial Number

SHT21 provides an electronic identification code. For instructions on how to read the identification code please refer to the Application Note "Electronic Identification Code" – to be provided to a soon.

[11] This status bit is updated after each measurement

5 Conversion of Signal Output

Default resolution is set to 12 bit relative humidity and 14 bit temperature reading. Measured data are transferred in two byte packages, i.e. in frames of 8 bit length where the most significant bit (MSB) is transferred first (left aligned). Each byte is followed by an acknowledge bit. In the example of Figure 12 and Figure 13, the transferred 14 bit temperature SDA is '01100011010100' = 6356 = 18D4 (Hex).

5.1 Relative Humidity Conversion

With the relative humidity signal output S_{RH} and temperature signal output S_T the relative humidity RH is obtained by the following formula (result in %RH):

$$RH = c_{00} + c_{10}S_{RH} + c_{01}S_T + c_{20}S_{RH}^2 + c_{11}S_{RH}S_T$$

For relative humidity conversion with S_{RH} at 12bit and S_T at 14bit the coefficients are given in Table 9. If other resolutions R_{RH}/R_T are selected (compare Users Register on Table 8) the coefficients must be multiplied by correction factors given in the third column of the Table:

Coefficient	Value	Correction Factor
c_{00}	-7.7239	1
c_{10}	3.8219 E-2	* 2^(12 – R_{RH})
c_{01}	2.5329 E-4	* 2^(14 – R_T)
c_{20}	-3.6634 E-6	* 2^2*(12 – R_{RH})
c_{11}	8.6345 E-7	* 2^(12 – R_{RH} + 14 – R_T)

Table 9 Preliminary humidity conversion coefficients (final values by 15 Dec 2009). For non-default resolutions the correction factors apply, R_{RH} = humidity resolution, R_T = temperature resolution, or open LSB values are filled with "0" and coefficients without correction are applied.

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 RH_i the values need to be transformed as from relative humidity above water RH_w at a certain temperature t follows – compare also Application Note "Introduction to Humidity":

$$RH_i = RH_w \cdot \exp\left(\frac{\beta_w \cdot t}{\lambda_w + t}\right) \Big/ \exp\left(\frac{\beta_i \cdot t}{\lambda_i + t}\right)$$

Units are %RH for relative humidity and °C for temperature. The corresponding coefficients are defined as follows: β_w = 17.62, λ_w = 243.12°C, β_i = 22.46, λ_i = 272.62°C.

5.2 Temperature Conversion

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

$$T = c_0 + c_1 S_T + c_2 S_T^2$$

For S_T the coefficients given in Table 10 – for resolution R_T other than 14bits the correction factor in third column must be applied.

Coefficient	Value	Correction Factor
c_0	-46.8375	1
c_1	1.1072 E-2	* 2^(14 – R_T)
c_2	-2.1233 E-8	* 2^2*(14 – R_T)

Table 10 Preliminary temperature conversion coefficients (final values by 15 Dec 2009). For non-default resolutions the correction factors apply, R_T = temperature resolution, or open LSB values are filled with "0" and coefficients without correction are applied.

The temperature measurement in Figure 12 and Figure 13 (S_T = 6356) yields a temperature of 22.68°C.

6 Environmental Stability

The sensors are planned to be qualified according to AEC-Q100 standard, grade 1 which corresponds to the operating 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 plated 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 diced and hence lead frame at diced edge is not covered with respective protective coating.

7.2 Traceability Information

All SHT21 are laser marked with an alphanumeric, five-digit code on the sensor – see Figure 14.

Figure 14 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 15 and 16, and give additional traceability information.

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

Lot No.
```

Figure 15: 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 16: 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 17. The reels are provided in sealed antistatic bags.

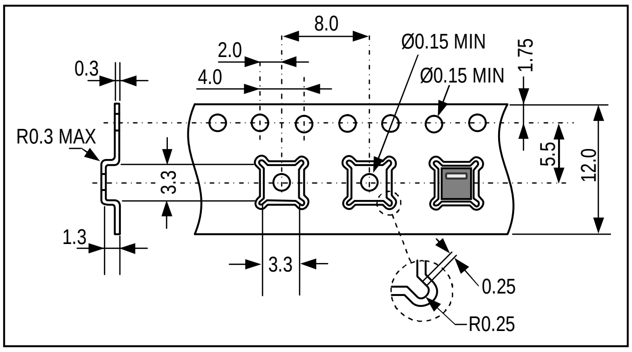

Figure 17 Sketch of packaging tape and sensor orientation.

8 Compatibility to SHT1x / 7x protocol

SHT2x sensors may be run by communicating with the Sensirion specific communication protocol used with SHT1x and SHT7x. In case such protocol is applied please refer to the communication chapter of datasheet SHT1x or SHT7x. Please note that reserved status bits of user register must not be changed.

Please understand that with the SHT1x/7x communication protocol only functions described in respective datasheets can be used with the exception of the OTP reload function that is not implemented on SHT2x. As an alternative to OTP reload the soft reset may be used. Please note that even if SHT1x/7x protocol is applied the timing values of Table 5 in this SHT2x datasheet apply.

Revision History

Date	Version	Page(s)	Changes
6 May 2009	0.3	1 – 9	Initial preliminary release
12 May 2009	0.4	1	Dimensions of sensor opening corrected
7 Sept 2009	0.5	1,3,6,8-9	Revise Section 1.2, Figs. 1, 5 and 9, Table 5. Add Chapter 7

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.
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Headquarter and Sales Offices

Headquarter
SENSIRION AG
Laubisruetistr. 50
CH-8712 Staefa ZH
Switzerland

Phone: +41 44 306 40 00
Fax: +41 44 306 40 30
info@sensirion.com
http://www.sensirion.com/

Sales Office USA:
SENSIRION Inc.
2801 Townsgate Rd., Suite 204
Westlake Village, CA 91361
USA

Phone: +1 805 409 4900
Fax: +1 805 435 0467
michael.karst@sensirion.com
http://www.sensirion.com/

Sales Office Japan:
SENSIRION JAPAN Co. Ltd.
Postal Code: 108-0074
Shinagawa Station Bldg. 7F,
4-23-5, Takanawa, Minato-ku
Tokyo, Japan

Phone: +81 3 3444 4940
Fax: +81 3 3444 4939
info@sensirion.co.jp
http://www.sensirion.co.jp

Sales Office Korea:
SENSIRION KOREA Co. Ltd.
#1414, Anyang Construction Tower B/D,
1112-1, Bisan-dong, Anyang-city
Gyeonggi-Province
South Korea

Phone: +82 31 440 9925~27
Fax: +82 31 440 9927
info@sensirion.co.kr
http://www.sensirion.co.kr

Sales Office China:
Sensirion China Co. Ltd.
Room 2411, Main Tower
Jin Zhong Huan Business Building,
Futian District, Shenzhen,
Postal Code 518048
PR China

phone: +86 755 8252 1501
fax: +86 755 8252 1580
info@sensirion.com.cn
www.sensirion.com.cn

Find your local representative at: http://www.sensirion.com/reps