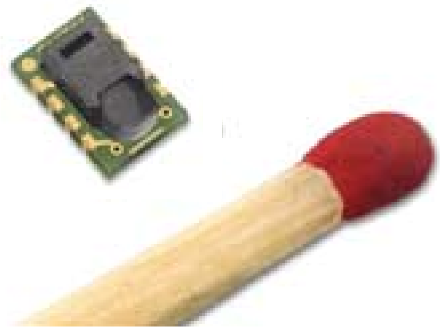
SHT1x

Humidity & Temperature
Sensmitter

_ Relative humidity and temperature sensors
_ Dew point
_ Fully calibrated, digital output
_ No external components required
_ Ultra low power consumption
_ Surface mountable package
_ Excellent long-term stability
_ Small size
_ Automatic power down

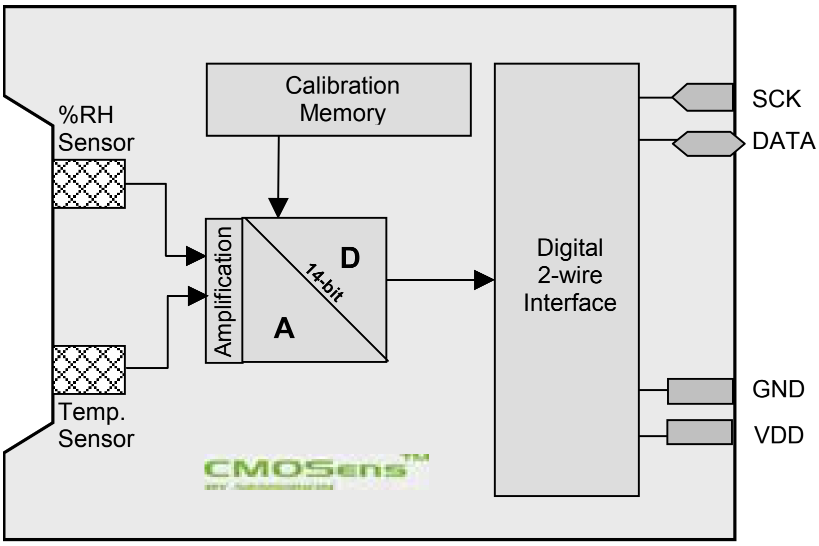


Preliminary Information February 2002

SHT1x Product Summary

The SHT1x is a single chip relative humidity and temperature multi sensor module comprising a calibrated digital output. Application of industrial CMOS processes with customized post processing (CMOSens™ technology) ensures highest reliability and excellent long term stability. The device includes two calibrated microsensors for relative humidity and temperature which are seamlessly coupled to a 14bit analog to digital converter and a serial interface circuit on the same chip. This results in superior signal quality, a fast response time and insensitivity to external disturbances (EMC) at a very competitive price.
Each sensor is calibrated in a precision humidity chamber and the calibration coefficients are programmed into the OTP memory. These coefficients are used internally during measurements to calibrate the signals from the sensors.
The 2-wire serial interface allows easy and fast system integration. Its tiny (7x5x3mm) size and low power consumption makes it the ultimate choice for even the most demanding applications including automotive, instrumentation, medical equipment, heating, ventilation and air conditioning systems (HVAC), portable consumer electronics and battery-operated controllers.
The device is supplied in a surface-mountable LCC type package. Other packaging options are available on request.

SHT1x Single Chip Relative Humidity and Temperature Sensor Module



1 Sensor Performance Specifications(1)

Parameter	Conditions	Min.	Typ.	Max.	Units
Humidity					
Resolution		0.5	0.03	0.03	% RH
		8	12	12	bit
Repeatability			±0.1		% RH
Accuracy(2) & Interchangeability			see figure 1		% RH
Nonlinearity	10 - 90 %RH		±3		% RH
Range		0		100	% RH
Response time	1/e (63%) slowly moving air		4		s
Hysteresis			±1		% RH
Long term stability	Typical		< 1		% RH/yr
Temperature					
Resolution		0.04	0.01	0.01	°C
		12	14	14	bit
Repeatability			±0.1		°C
Accuracy			see figure 1		°C
Range		-40		123.8	°C
Response Time			20		s

Table 1 Sensor Performance Specifications

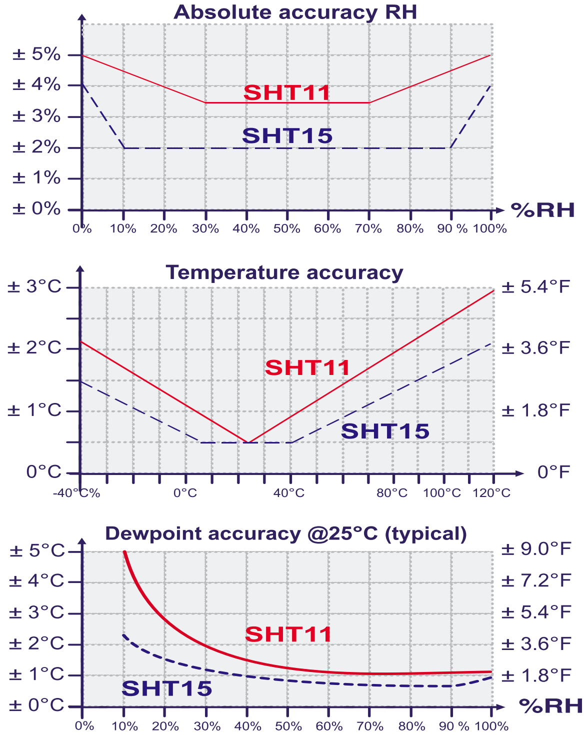


Figure 1 RH, T, and Dewpoint accuracies

1.1 Converting the digital output to physical values

1.1.1 Humidity

To compensate for the non-linearity of the humidity sensor and to obtain the full accuracy it is recommended to convert the readout with the following formula:

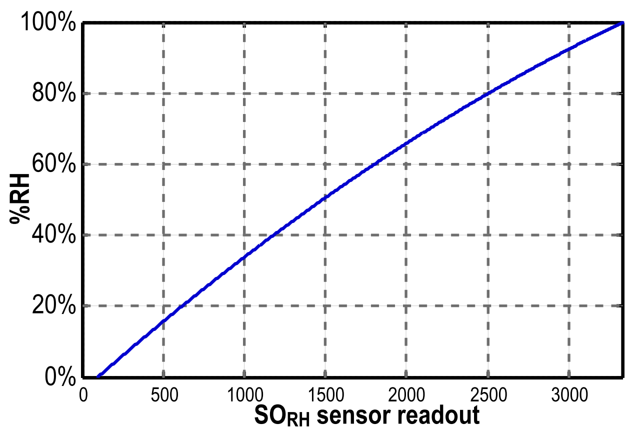
$$RH_{linear} = c_1 + c_2 \bullet SO_{RH} + c_3 \bullet SO_{RH}^{\ 2}$$

where SO_{RH} is the sensor readout for RH and with

$c_1 = -4$ $c_2 = 0.0405$ $c_3 = -2.8 * 10^{-6}$ for 12bit SO_{RH}

$c_1 = -4$ $c_2 = 0.648$ $c_3 = -7.2 * 10^{-4}$ for 8bit SO_{RH}

For simplified, less computation intense conversion formulas see application note “RH Non-Linearity Compensation”.



For temperatures significantly different from 25°C (~77°F) the temperature coefficient of the RH sensor should be considered:

$$RH_{true} = (T_{°C} - 25) \bullet (t_1 + t_2 \bullet SO_{RH}) + RH_{linear}$$

with $t_1 = 0.01$; $t_2 = 0.00008$, $t_2 = 0.00128$ for 8bit SO_{RH}

This equals ~1.2% per 10°C at 50%RH

1.1.2 Temperature

The temperature sensor is very linear by design. Use the following formulas or table to convert from digital 14bit readout to temperature:

$T_{°C} = SO_T * 0.01 - 40$

$T_{°F} = SO_T * 0.018 - 40$

where SO_T is the 14bit sensor readout for Temperature. Multiply coefficient by 4 for 12 bit measurements.

Digital Readout		Temperature	
12 bit	14 bit		
000	0000	-40°C	-40°F
FFF	3FFF	123.83°C	254.89°F

1.1.3 Dewpoint

See application note “Dewpoint calculation” for more information.

(1) For operation within normal operation range as described in Chapter 3

(2) Not including non-linearity

2 Serial Interface

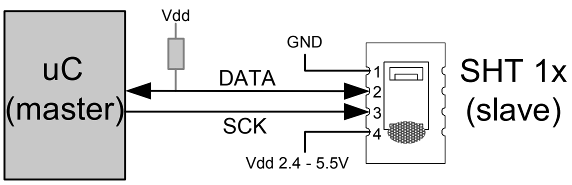


Figure 2 Typical application circuit

Pin	Name	Comment
1	GND	Ground
2	DATA	Serial data bidirectional
3	SCK	Serial clock input
4	VDD	Supply 2.4 – 5.5V

Table 2 SHT1x Pin Description

2.1 Power Pins

The SHT1x requires a voltage supply between 2.4V and 5.5V. After powerup the device requires 11ms to reach its "sleep" state. No commands should be sent before that time. Power supply pins (VDD, GND) may be decoupled with a 100 nF capacitor.

2.2 **I/O Pins** (Bidirectional 2-wire Interface)

See Table 5 for a detailed IO characteristics.

2.2.1 Serial clock input (SCK)

The SCK is used to synchronize the communication between a master and the SHT1x.

2.2.2 Serial data (DATA)

The DATA tristate pin is used to transfer data in and out of the device. Data must be updated on this pin after the falling edge and is valid on the rising edge of the serial clock SCK. An external pull-up resistor is required to pull the signal high. (See Figure 2). Pull-up resistors are often included in I/O circuits of microcontrollers

2.2.3 Command sequence

To initiate a transmission a "Transmission Start" sequence has to be issued. It consists of a lowering of the DATA line while SCK is high, followed by a low pulse on SCK and raising DATA again while SCK is still high.

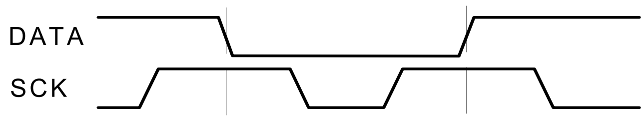


Figure 3 "Transmission Start" sequence

The subsequent command sequence consists of three address bits (only "000" is currently supported) and five command bits. The proper reception of a command by the SHT1x is indicated by pulling the ack bit low on the DATA pin.
See 2.2.5 "Measurement Sequence" for an application of the command sequence

2.2.4 Connection reset sequence

If communication with the SHT1x is lost the following signal sequence will reset its serial interface:
While leaving DATA high toggle SCK 9 or more times. This must be followed by a "Transmission Start" sequence preceding the next command.

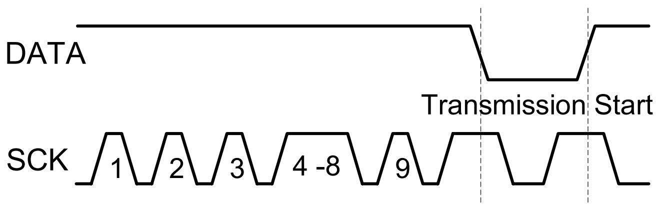
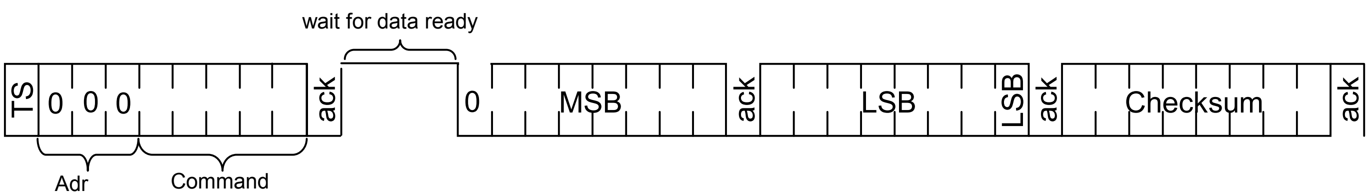


Figure 4 Connection reset sequence

Command	Code	Description
Reserved	0000x	Reserved
Measure Temperature	**00011**	**Temperature measurement**
Measure Humidity	**00101**	**Humidity measurement**
Status Register Read	00111	Read access to the status register (see application note)
Status Register Write	00110	Write access to the status register (see application note)
Reserved	0101x-1110x	Reserved
Soft reset	**11110**	**resets the chip, clears the status register to default values** wait 11ms before next command

Table 3 SHT1x list of commands



2.2.5 *Measurement sequence (T and RH)*

After issuing a measurement command ('00000101' for RH, '00000011' for Temperature) the controller has to wait for the measurement to complete. This takes approximately 11/55/210ms for a 8/12/14bit measurement. The exact time varies by up to ±15% with the speed of the internal oscillator. To signal the completion of a measurement, the SHT1x pulls down the data line (2) and the controller must restart SCK. Two bytes of measurement data and one byte of CRC checksum will then be transmitted. The uC must acknowledge each byte by pulling the DATA line low. All values are MSB first, right justified. (e.g. the 5th SCK is MSB for a 12bit value).

Communication terminates after the acknowledge bit of the CRC data. If CRC-8 Checksum is not used the controller may terminate the communication after the measurement data LSB by keeping ack high.

The SHT 11 automatically returns to sleep mode after the measurement and communication have finished.

Warning: To keep heat up of the SHT1x below 0.1°C it should not be active for more than 15% of the time (e.g. max. 3 measurements / second for 12bit accuracy).

2.2.6 *CRC-8 Checksum Calculation*

Please consult application note "CRC-8 Checksum Calculation" for information on how to calculate the CRC.

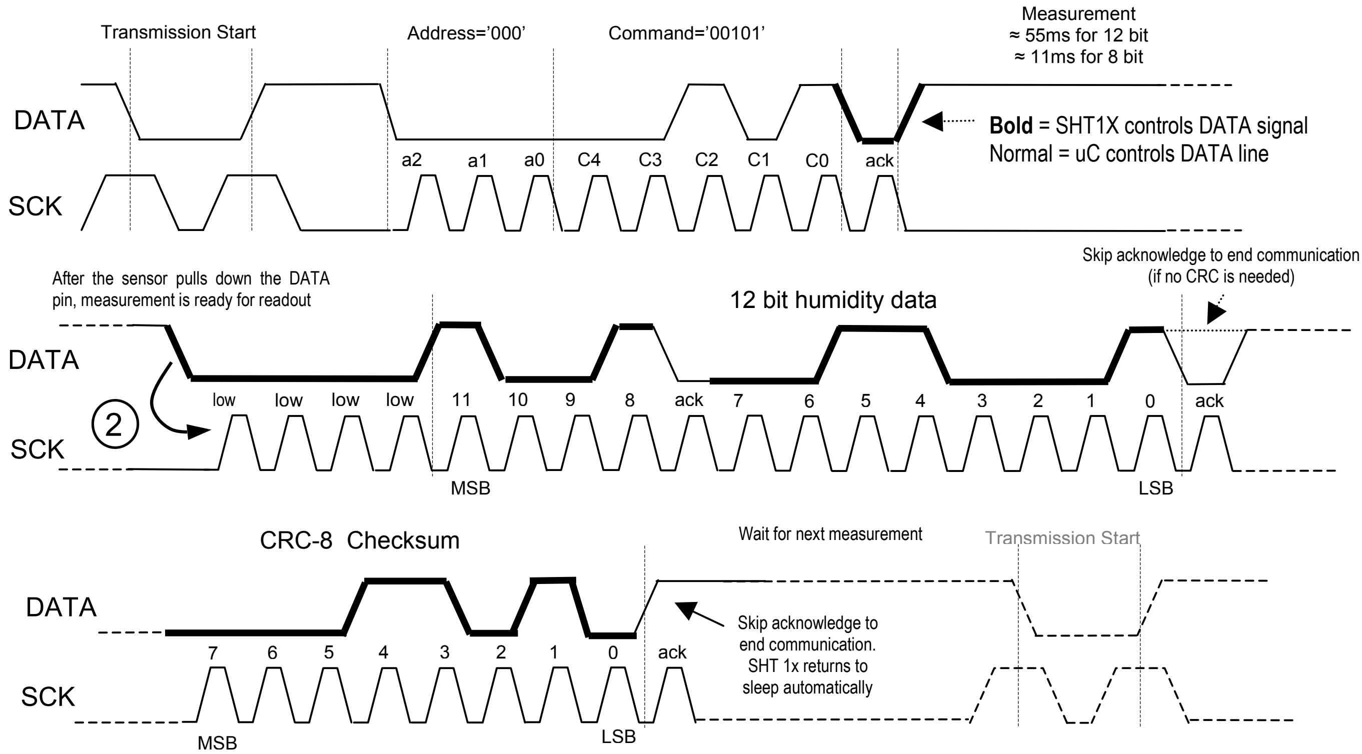


Figure 5 Example RH measurement sequence for value "0000'1001 ' 0011'0001"= 2353 = 75.79%RH

2.3 Status Register

Some of the advanced functions of the SHT1x are available through the status register. The following section gives a brief overview of these features. Please consult application note "Status Register" for more information.

2.3.1 *Heater*

An on chip heating element can be switched on. It will increase the temperature of the sensor by approximately 5°C. Power consumption will increase by 8mA @ 5V.

Applications:

- By comparing temperature and humidity values before and after switching on the heater, proper functionality of both sensors can be verified.
- In high RH environments heating the sensor element will avoid condensation.

Warning: The built-in calibration is not correct while the SHT1x is heated!

2.3.2 *End Of Life (EOL)*

The SHT1x End of Life (EOL) function detects VDD voltages below 2.5V. Accuracy is ±0.05V

2.3.3 *Measurement resolution*

The default measurement resolution of 14bit (temperature) and 12bit (humidity) can be reduced to 12 and 8 bit. This is especially useful in high speed or extreme low power applications.

Please consult application note "Status Register" for more information on how to access and use these features.

3 Specifications SHT1x

3.1 Absolute Maximum Ratings

Ambient Storage Temperature: -40°C to 120°C

3.2 Operating Conditions

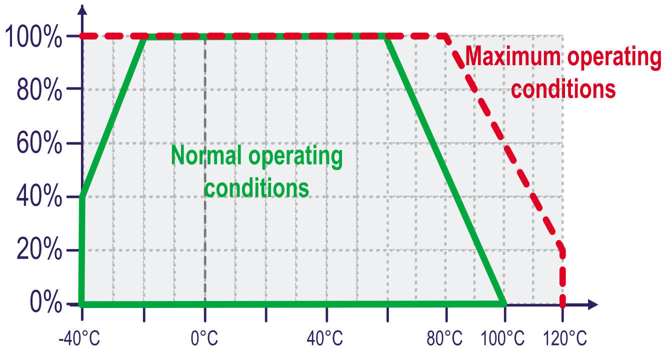


Figure 6 Recommended operating conditions

Temperatures outside the recommended range may temporarily offset the RH signal by up to +3%RH. The sensor will slowly return to calibration conditions but heating the device up to 90°C at <5%RH for 24h will reverse the effect of high RH, high temperature environments promptly. Prolonged exposure to extreme conditions may accelerate ageing of the sensor.

3.3 Special Conditions

Extensive tests were performed in various environments. Please contact us for complete qualification results.

3.4 Electrical Specifications[1]

3.4.1 ESD (Electrostatic Discharge)

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 ±100 mA with T_{amb}=80°C according to JEDEC 17.

3.4.2 DC Characteristics

VDD=5V, Temperature= 25°C unless otherwise noted

Parameter	Conditions	Min.	Typ.	Max.	Units
Power supply DC		2.4	5	5.5	V
Supply current	measuring		550		µA
	average	2[2]	28[3]		µA
	sleep		0.3	1	µA
Low level output voltage		0		20%	Vdd
High level output voltage		75%		100%	Vdd
Low level input voltage	Negative going	0		20%	Vdd
High level input voltage	Positive going	80%		100%	Vdd
Input current on pads				1	µA
Output peak current	on			4	mA
	Tristated (off)		10		µA

Table 4 SHT1x DC Characteristics

3.4.3 I/O Characteristics

	Parameter	Conditions	Min	Typ.	Max.	Unit
F_{SCK}	SCK frequency	VDD > 4.5 V			10	MHz
		VDD < 4.5 V			1	MHz
T_{RFO}	DATA fall time	Output load 5 pF	3.5	10	20	ns
		Output load 100 pF	30	40	200	ns
T_{CLH}	SCK high time		100			ns
T_{CLL}	SCK low time		100			ns
T_V	DATA valid from			50		ns
T_{HO}	Output hold time		0	10		ns
T_R/T_F	SCK rise/fall time				200	ns

Table 5 SHT1x I/O Signals Characteristics

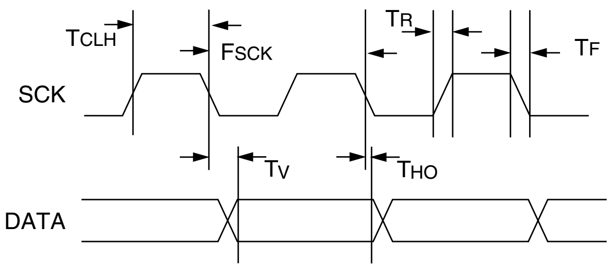


Figure 7 Timing Diagram

(1) Parameters are periodically sampled and not 100% tested
(2) With one measurement of 8 bit accuracy without OTP reload per second
(3) With one measurement of 12bit accuracy per second

4 Physical Dimensions and Mounting Information

4.1 Package type

The device is supplied in a surface-mountable LCC type package. The sensors housing consists of a Liquid Crystal Polymer (LCP) cap with epoxy glob top on a standard 0.8mm FR4 substrate.
Device size is 7.62 x 5.08 x 2.5 mm. Weight 100mg
Other packaging options are available on request.

4.2 Mounting Recommendations

The relative humidity of a gas strongly depends on its temperature. It is therefore essential to keep the sensor at the same temperature as the air of which the humidity is to be measured.
If the SHT1x shares a PCB with heating electronic components it should be mounted below the heat source and the housing must remain well ventilated. To reduce heat conduction copper layers between the SHT1x and the rest of the PCB should be minimized and a slit may be milled in between.

Prolonged direct exposure of the SHT1x to strong light or UV radiation should be avoided.

4.3 Wiring considerations and signal integrity

Carrying the SCK and DATA signal parallel an in close proximity (e.g. in wires) for more than 10cm may result in crosstalk and loss of communication. This may be resolved by routing VDD and/or GND between the two signals.

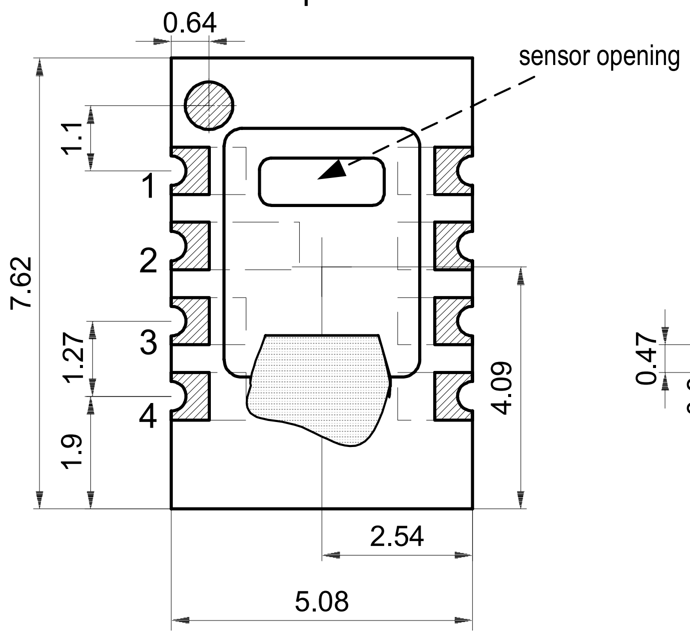
4.4 Soldering Information

The SHT1x can be soldered using standard reflow ovens at maximum 225°C for 20 seconds. For manual soldering contact time must be limited to 5 seconds at up to 350°C
Please consult the application note “Soldering procedure” for detailed instructions.

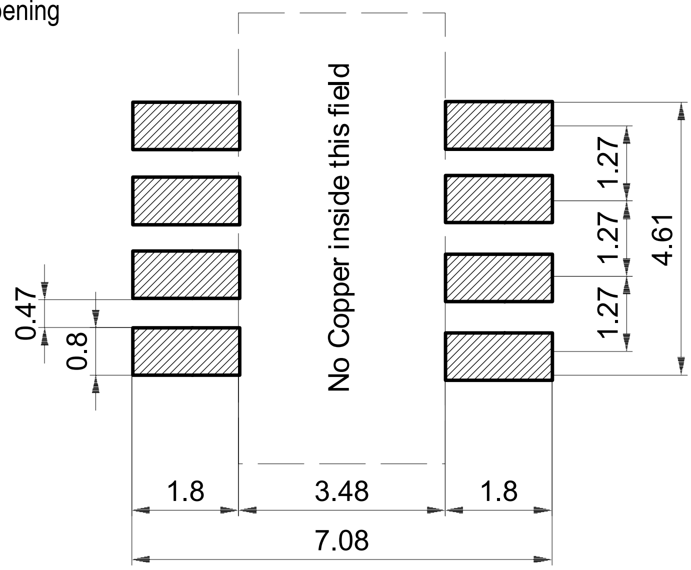
4.5 Delivery Conditions

The SHT1x will be delivered in standard IC tubes by max. 80 pieces per tube. Other delivery options may be available on request.

Top View

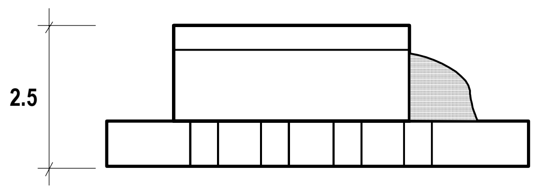


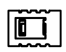
Recommended PCB Footprint



all measurements in mm

Side View





actual size

5 IMPORTANT NOTICES

The warranty for each SENSIRION AG product comes in the form of a written warranty which governs sale and use of such product. Such warranty is contained in the printed terms and conditions under which such product is sold, or in a separate written warranty supplied with the product. Please refer to such written warranty with respect to its applicability to certain applications of such product.

These products may be subject to restrictions on use. Please contact SENSIRION AG for a list of the current additional restrictions on these products. By purchasing these products, the purchaser of these products agrees to comply with such restrictions. Please contact SENSIRION AG for clarification of any restrictions described herein.
SENSIRION AG reserves the right, without further notice, to change the SENSIRION SHT1x Relative Humidity and Temperature Sensor product specifications and/or information in this document and to improve reliability, functions and design.

SENSIRION AG assumes no responsibility or liability for any use of SENSIRION SHT1x product. Application examples and alternative uses of the SENSIRION SHT1x are for illustration purposes only and SENSIRION AG makes no representation or warranty that such applications shall be suitable for the use specified.

6 Caution

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

Headquarters and Sales Office

SENSIRION AG
Eggbühlstr. 14
P.O. Box
CH-8052 Zürich
Switzerland

Phone: + 41 (0)1 306 40 00
Fax: + 41 (0)1 306 40 30
e-mail: info@sensirion.com
http://www.sensirion.com/