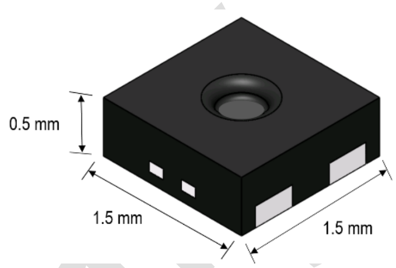
Datasheet SHT4x

4th Generation Digital Humidity and Temperature Sensor

- Relative humidity accuracy up to 1.8 %RH
- Temperature accuracy up to 0.1 °C
- Supply voltage 1.08 V … 3.6 V
- Average current: 0.6 µA (at meas. rate 1 Hz)
- Idle current 80 nA
- I2C fast mode plus
- Operating range: 0 … 100 %RH, -40…125 °C
- Fully calibrated and linearized digital output
- Operational in condensing environment
- Variable power heater
- Mature technology from the market & technology leader



Abstract

4th generation digital relative humidity and temperature sensor with lowest current consumption, highest accuracy and robust design.

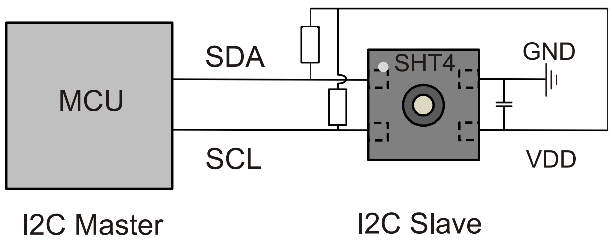
Device Overview / Ordering Information

Name	RH accuracy [%RH]	T accuracy [°C]
SHT40	±1.8	±0.2
SHT41	tbd	tbd
SHT45	tbd	tbd

Contents

1 Quick Start – Hello World

Once the sensor is electrically connected to its four pins (see pin description in **Figure 6**), it can be powered up applying supply voltage. After the power-up time of 1ms, the sensor is ready for I2C communication on address 0x44. The quickest way to measure humidity and temperature is shown in **Figure 1**. Together with the conversion formulae given in equations (1), (2), and (3) the digital signals can be translated into relative humidity and temperature readings.



Pseudo code for measuring and reading RH&T

```
i2c_write(i2c_addr=0x44, tx_bytes=[0xFD])
wait_seconds(0.02)
rx_bytes = i2c_read(i2c_addr=0x44,
number_of_bytes=6)
t_ticks = rx_bytes[0] * 256 + rx_bytes[1]
rh_ticks = rx_bytes[3] * 256 + rx_bytes[4]
t_degC = -45 + 175 * t_ticks/65535
rh_pRH = -6 + 125 * rh_ticks/65535
```

Figure 1: Typical application circuit and pseudo code for easy starting.

Detailed code and further information can be downloaded from this github location (link tbd)

2 Humidity and Temperature Sensor Specifications

2.1 Relative Humidity

Parameter	Conditions	Value	Units
SHT40 RH accuracy[1]	Typ.	$\pm$1.8	%RH
	Max.	to be provided in **Figure 2**	%RH
High repeatability[2]	-	0.1	%RH
Resolution[3]	-	0.01	%RH
Hysteresis	-	$\pm$1	%RH
Specified range[4]	extended[5]	0 to 100	%RH
Response time[6]	τ 63%	8	s
Long-term drift[7]	Typ.	<0.25	%RH/y

Table 1: Humidity sensor specifications

[1] For definition of typ. and max. accuracy, 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. Different repeatability commands are listed in Table 7.

[3] Resolution of A/D converter.

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

[5] For details about recommended humidity and temperature operating range, please refer to section 2.3.

[6] Time for achieving 63% of a humidity step function, valid at 25°C and 1 m/s airflow. Humidity response time in the application depends on the design-in of the sensor.

[7] Typical value for operation in normal RH/T operating range. Max. value is < 0.5 %RH/y. Value may be higher in environments with vaporized solvents, out-gassing tapes, adhesives, packaging materials, etc. For more details please refer to Handling Instructions.

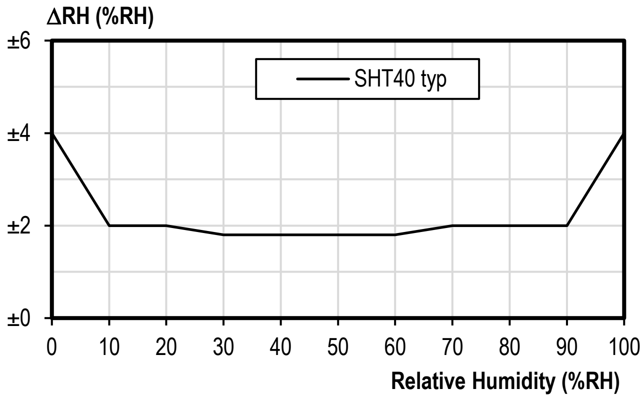


Figure 2: Typical accuracy for relative humidity in %RH at 25 °C.

RH Accuracy at Various Temperatures

Typical RH accuracy map at 25°C will be described here.

2.2 Temperature

Parameter	Conditions	Value	Units
SHT40 T Accuracy[1]	Typ.	±0.2	°C
	Max.	To be provided in **Figure 3**	°C
High repeatability[2]	-	0.04	°C
Resolution[3]	-	0.01	°C
Specified range[4]	-	–40 to +125	°C
Response time[8]	τ 63%	2	s
Long-term drift[9]	Typ.	<0.03	°C/y

Table 2: Temperature sensor specifications

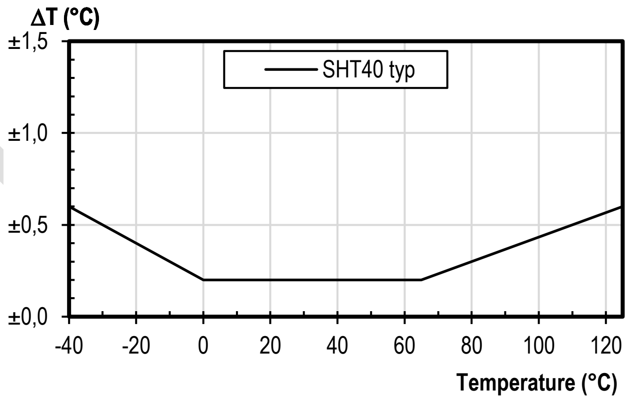


Figure 3: Typical accuracy for temperature in °C.

[8] Temperature response time depends on heat conductivity of sensor substrate and design-in of sensor in application.
[9] Max. value is < 0.04°C/y.

2.3 Recommended Operating Conditions

The sensor shows best performance when operated within the recommended normal temperature and humidity range of 5 °C … 60 °C and 20 %RH … 80 %RH, respectively. Long term exposure to conditions outside recommended normal range, especially at high relative humidity, may temporarily offset the RH signal (e.g. +3 %RH after 60 h at > 80 %RH). After returning into the recommended normal temperature and humidity range the sensor will recover to within specifications by itself. Prolonged exposure to extreme conditions may accelerate ageing.

To ensure stable operation of the humidity sensor, the conditions described in the document "SHTxx Assembly of SMD Packages", section "Storage and Handling Instructions" regarding exposure to volatile organic compounds have to be met. Please note as well that this does apply not only to transportation and manufacturing, but also to operation of the SHT4x.

3 Electrical Specifications

Valid for all electrical specifications: Typical values correspond to V_{DD} = 3.3 V and T = 25 °C. Min. and max. values are valid in the full temperature range -40 °C … 125 °C and at declared V_{DD} levels.

3.1 Electrical Characteristics

Parameter	Symbol	Conditions	Min	Typ.	Max	Units	Comments
Supply voltage	V_{DD}		1.08	3.3	3.6	V	-
Power-up/down level	V_{POR}	Static power supply	0.6		1.08	V	-
Supply current (heater not activated)	I_{DD}	Idle state		0.08		µA	-
		Measurement		350		µA	Average current consumption while sensor is measuring
		Average, high repeat. Average, med. repeat. Average, low repeat.		2.6 1.5 0.55		µA	Average current consumpt. (contin. operation with one meas. per second)
Power consumption at VDD=1.2V (heater not activated)	-	Average, high repeat. Average, med. repeat. Average, low repeat.		3.1 1.8 0.7		µW	Average power consumpt. (contin. operation with one meas. per second)
Low level input voltage	V_{IL}	-	0		0.3 * V_{DD}	V	-
High level input voltage	V_{IH}	-	0.7 * V_{DD}		V_{DD}	V	-
Pull up resistors	R_p	V_{DD} < 1.62 V	820			Ω	
		V_{DD} ≥ 1.62 V	390			Ω	
Low level output voltage	V_{OL}	V_{DD} < 1.62V, R_{pullup} > 820 Ω			0.2 * V_{DD}	V	-
		V_{DD} = 1.62V … 2.0V, R_{pullup} > 390 Ω			0.2 * V_{DD}	V	
		V_{DD} > 2.0V, R_{pullup} > 390 Ω			0.4	V	
Cap bus load	C_b	R_P ≤ 820 Ω: fast mode			400	pF	Capacitive bus load can be determined from $C_b < t_{rise}/(0.8473*R_{pullup})$. Rise times are t_{rise} =300ns for fast mode and t_{rise} = 120ns for fast mode plus
		R_p = 390 Ω; fast mode plus			340	pF	

Table 3: Electrical specifications.

3.2 Timings

Max. values are measured at -40°C and 1.08 V supply voltage (based on characterization).

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Units	Comments
Power-up time	t_{PU}	After hard reset, $V_{DD} \geq V_{POR}$			1	ms	Time between V_{DD} reaching V_{POR} and sensor entering idle state
Soft reset time	t_{SR}	After soft reset			1	ms	Time between ACK of soft reset command and sensor entering idle state. Also valid for I2C general call reset.
Measurement duration	$t_{MEAS,l}$	low repeatability		1.3	2.5	ms	The three repeatability modes differ with respect to measurement duration, noise level and energy consumption
	$t_{MEAS,m}$	Medium repeatability		3.7	5.5	ms	
	$t_{MEAS,h}$	high repeatability		6.9	10	ms	
Heater-on duration	t_{Heater}	-	0.8	1	1.2	s	After that time the heater is automatically switched off

Table 4 System timing specifications.

3.3 Absolute Maximum Ratings

Stress levels beyond those listed in Table 5 may cause permanent damage or affect the reliability of the device. These are stress ratings only and functional operation of the device at these conditions is not guaranteed. Ratings are only tested each at a time.

Parameter	Rating
Max. voltage on any pin	V_{SS} - 0.3 V … V_{DD} + 0.3 V
Operating temperature range	-40 °C … 125 °C
Storage temperature range[10]	-40 °C …150 °C
ESD HBM	2 kV
ESD CDM	500 V
Latch up, JESD78 Class II, 125°C	+-100 mA

Table 5: Absolute maximum ratings.

4 Sensor Operation

4.1 I2C communication

I2C communication is based on NXP's I2C-bus specification and user manual UM10204, Rev.6, 4 April 2014. Supported I2C modes are standard, fast mode, and fast mode plus. Data is transferred in multiples of 16-bit words and 8-bit check sum (cyclic redundancy check = CRC). All transfers must begin with a start condition (S) and terminate with a stop condition (P). To finish a read transfer, send not acknowledge (NACK) and stop condition (P). Addressing a specific slave device is done by sending its 7-bit I2C address followed by an eighth bit, denoting the communication direction: "Zero" indicates transmission to the slave, i.e. "write", a "one" indicates a "read" request.

[10] The recommended storage temperature range is 10-50°C. Please consult the document "SHTxx Handling Instructions" for more information.

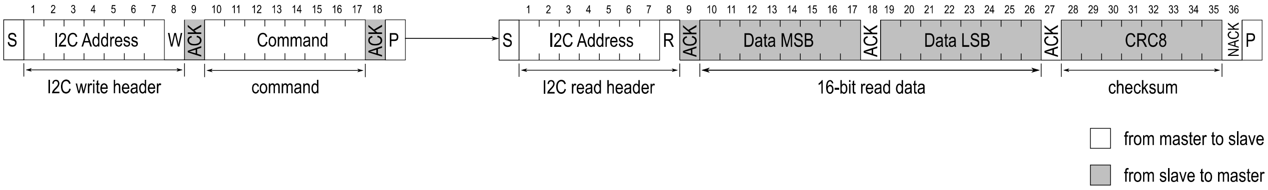


Figure 4: I2C transfer types: First a write header is sent to the I2C slave, followed by a command, for example "measure RH&T with highest precision". After the measurement is finished the read request directed to this I2C slave will be acknowledged and transmission of data will be started by the slave.

4.2 Data type & length

I2C bus operates with 8-bit data packages. Information from the sensor to the master has a checksum after every second 8-bit data package.

Humidity and temperature data will always be transmitted the following way: First temperature signal (2 * 8-bit data + 8-bit CRC), second humidity signal (2 * 8-bit data + 8-bit CRC). The serial number is transmitted as two 16-bit words.

4.3 Checksum Calculation

For read transfers each 16-bit data is followed by a checksum with the following properties

Property	Value
Name	CRC-8
Message Length	16-bit
Polynomial	0x31 ($x^8 + x^5 + x^4 + 1$)
Initialization	0xFF
Reflect Input/Output	false/false
Final XOR	0x00
Examples	CRC(0xBEEF) = 0x92

Table 6 Data check sum properties.

The master may abort a read transfer after the 16-bit data, if it does not require a checksum.

4.4 Command Overview

Command		Description
BIN	HEX	
1111 1101	FD	Measure T & RH with highest precision (high repeatability)
1111 0110	F6	Measure T & RH with medium precision (medium repeatability)
1110 0000	E0	Measure T & RH with lowest precision (low repeatability)
1000 1001	89	Read serial
1001 0100	94	Soft Reset
0011 1001	39	Activate highest heater power for 1s

Table 7 Overview of I2C commands.

4.5 Conversion of Signal Output

The digital sensor signals correspond to following humidity and temperature values:

$$RH = \left(-6 + 125 \cdot \frac{S_{RH}}{2^{16} - 1}\right) \%\mathrm{RH} \qquad (1)$$

$$T = \left(-45 + 175 \cdot \frac{S_T}{2^{16} - 1}\right) {}^\circ\mathrm{C} \qquad (2)$$

$$T = \left(-49 + 315 \cdot \frac{S_T}{2^{16} - 1}\right) {}^\circ\mathrm{F} \qquad (3)$$

4.6 Reset

A reset of the sensor can be achieved on three ways:

- Soft reset: send the reset command described in **Table 7**.
- I2C general call: all devices on I2C bus are reset by sending the command 0x06 to the I2C address 0x00.
- Power down (incl. pulling SCL and SDA low)

4.7 Heater Operation

The sensor incorporates an on-chip heater which can be switched on by the command given in **Table 7**. After sending the heater activation command, the heater will run for 1 second. After 1 second, a temperature and humidity measurement is started and the heater will be automatically turned off after the measurement is finished. This is a safety feature to prevent permanent turn-on of the heater. The measurement data are stored in the internal register. Thus, these measurement values correspond to the state of the sensor right before the heater is turned off.

There is no dedicated command to turn off the heater since it has an internal timer set to 1s after which it is turned off automatically.

If higher heating temperatures are desired, consecutive heating commands have to be sent to the sensor.

5 Physical Specification

5.1 Package Description

SHT4x is provided in an open-cavity dual flat no lead (DFN) package. The humidity sensor opening is centered on the top side of the package. The sensor chip is made of silicon, hosted on a copper lead frame and overmolded by an epoxy-based mold compound. Exposed bottom side of the leadframe with the metallic contacts is Ni/Pd/Au coated, side walls are bare copper.
Moisture sensitivity level (MSL) of 1 according to IPC/JEDEC J-STD-020 is achieved. It is recommended to process the sensors within one year after date of delivery.

5.2 Package Outline

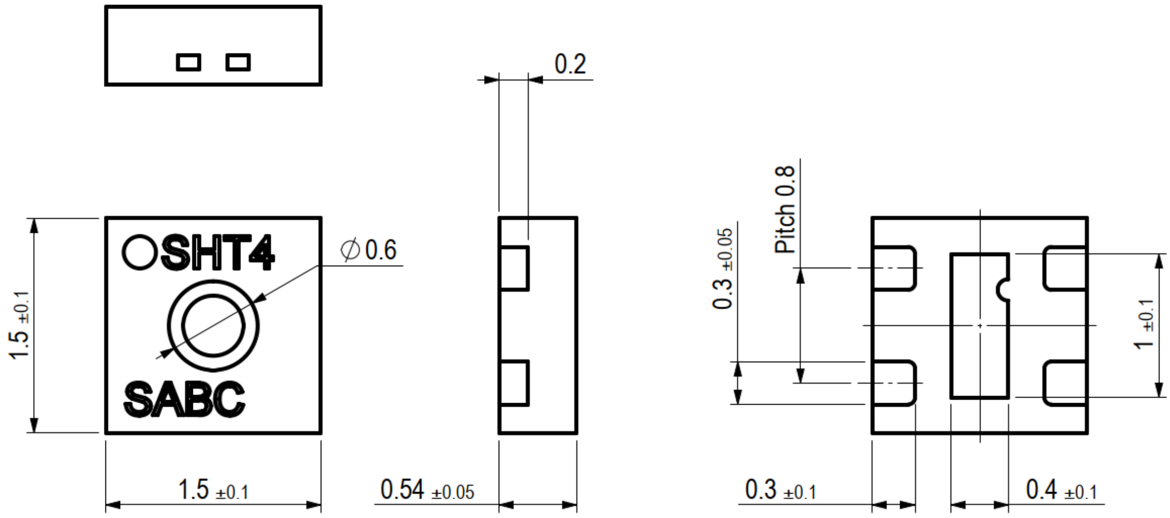


Figure 5 Dimensional drawing of SHT4x including package tolerances (units mm).

5.3 Land Pattern

The land pattern is recommended to be designed according to the used PCB and soldering process together with the physical outer dimensions of the sensor.

5.4 Pin Assignment

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

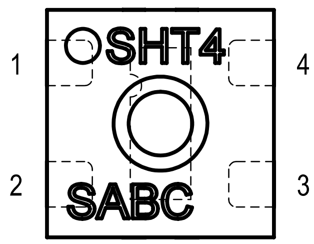


Figure 6 Pin assignment (transparent top view). Dashed lines are only visible if sensor is viewed from below. The die pad is not directly connected to any pin.

5.5 Thermal Information

tbd

6 Quality and Material Contents

Qualification of SHT4x is performed based on the JEDEC JESD47 qualification test method. The device is fully RoHS and WEEE compliant, e.g. free of Pb, Cd, and Hg.
For general remarks of best practice in processing humidity sensor please refer to the (Handling Guide).

7 Ordering Information

Name	Quantity	Order Number
SHT40-B2.5k	2500	tbd
SHT40-B10k	10000	tbd
SHT41-B2.5k	2500	tbd
SHT41-B10k	10000	tbd
SHT45-B2.5k	2500	tbd
SHT45-B10k	10000	tbd

Table 8: SHT4x ordering options.

8 References

(n.d.). *Handling Guide.*

9 Revision History

Date	Version	Page(s)	Changes
January 2020	0.1	all	First preliminary version

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.

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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:

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

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