

TECHNICAL DATA

MQ-7 GAS SENSOR

FEATURES

- * High sensitivity to carbon monoxide
- * Stable and long life

APPLICATION

They are used in gas detecting equipment for carbon monoxide(CO) in family and industry or car.

SPECIFICATIONS

A. Standard work condition

Symbol	Parameter name	Technical condition	Remark
Vc	circuit voltage	$5V \pm 0.1$	Ac or Dc
V _H (H)	Heating voltage (high)	$5V \pm 0.1$	Ac or Dc
V _H (L)	Heating voltage (low)	$1.4V \pm 0.1$	Ac or Dc
R _L	Load resistance	Can adjust	
R _H	Heating resistance	$33 \Omega \pm 5\%$	Room temperature
T _H (H)	Heating time (high)	60 ± 1 seconds	
T _H (L)	Heating time (low)	90 ± 1 seconds	
PH	Heating consumption	About 350mW	

b. Environment conditions

Symbol	Parameters	Technical conditions	Remark
Tao	Using temperature	-20℃-50℃	
Tas	Storage temperature	-20℃-50℃	Advice using scope
RH	Relative humidity	Less than 95%RH	
O ₂	Oxygen concentration	21%(stand condition) the oxygen concentration can affect the sensitivity characteristic	Minimum value is over 2%

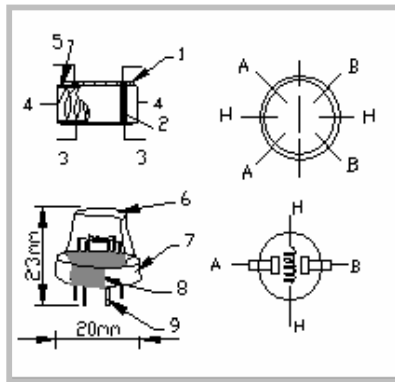
c. Sensitivity characteristic

symbol	Parameters	Technical parameters	Remark
R _s	Surface resistance Of sensitive body	2-20k	In 100ppm Carbon Monoxide
a (300/100ppm)	Concentration slope rate	Less than 0.5	R _s (300ppm)/R _s (100ppm)
Standard working condition	Temperature -20℃ ± 2℃	relative humidity 65% ± 5%	RL:10K Ω ± 5%
	Vc:5V ± 0.1V	VH:5V ± 0.1V	VH:1.4V ± 0.1V
Preheat time	No less than 48 hours	Detecting range: 20ppm-2000ppm carbon monoxide	

D. Structure and configuration, basic measuring circuit

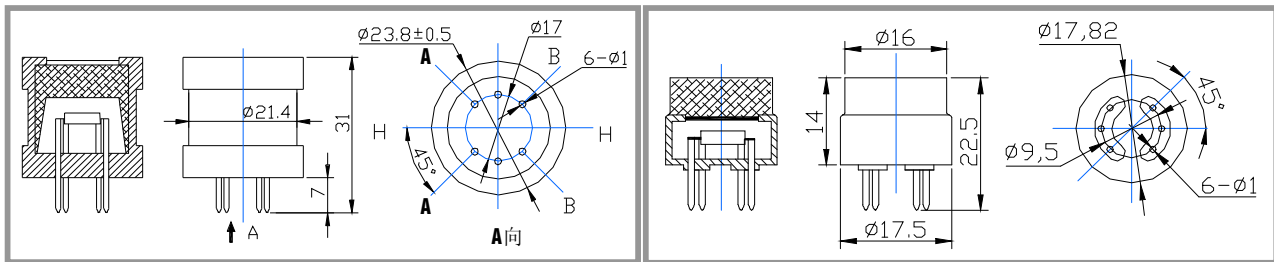
Structure and configuration of MQ-7 gas sensor is shown as Fig. 1 (Configuration A or B), sensor composed by micro AL₂O₃ ceramic tube, Tin Dioxide (SnO₂) sensitive layer, measuring electrode and heater are fixed into a crust made by plastic and stainless steel net. The heater provides necessary work conditions for work of sensitive components. The enveloped MQ-7 have

6 pin, 4 of them are used to fetch signals, and other 2 are used for providing heating current.



Parts	Materials
1 Gas sensing layer	SnO ₂
2 Electrode	Au
3 Electrode line	Pt
4 Heater coil	Ni-Cr alloy
5 Tubular ceramic	Al ₂ O ₃
6 Anti-explosion network	Stainless steel gauze (SUS316 100-mesh)
7 Clamp ring	Copper plating Ni
8 Resin base	Bakelite
9 Tube Pin	Copper plating Ni

Fig.1



Standard circuit:

As shown in Fig 2, standard measuring circuit of MQ-7 sensitive components consists of 2 parts. one is heating circuit having time control function (the high voltage and the low voltage work circularly). The second is the signal output circuit, it can accurately respond changes of surface resistance of the sensor.

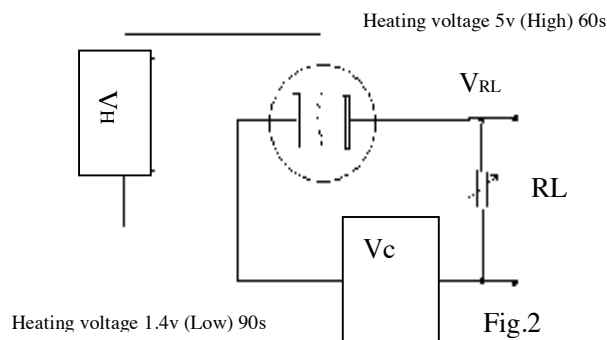


Fig.2

Electric parameter measurement circuit is shown as Fig.2

E. Sensitivity characteristic curve

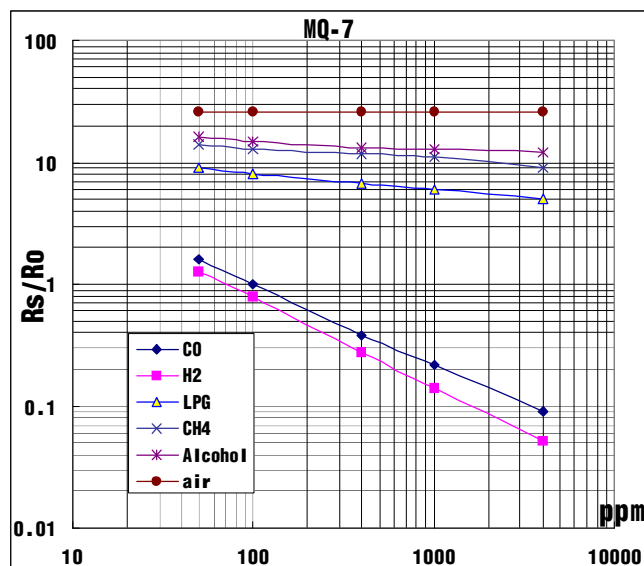


Fig.3 sensitivity characteristics of the MQ-7

Fig.3 is shows the typical sensitivity characteristics of the MQ-7 for several gases.

in their: Temp: 20°C、

Humidity: 65%、

O₂ concentration 21%

RL=10k Ω

Ro: sensor resistance at 100ppm

CO in the clean air.

Rs: sensor resistance at various concentrations of gases.

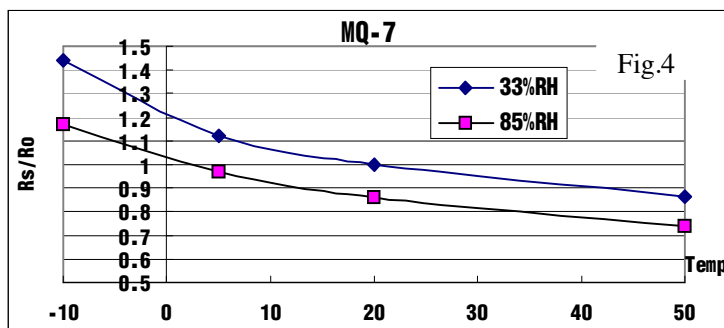


Fig.4 is shows the typical dependence of the MQ-7 on temperature and humidity.

Ro: sensor resistance at 100ppm CO in air at 33%RH and 20degree.

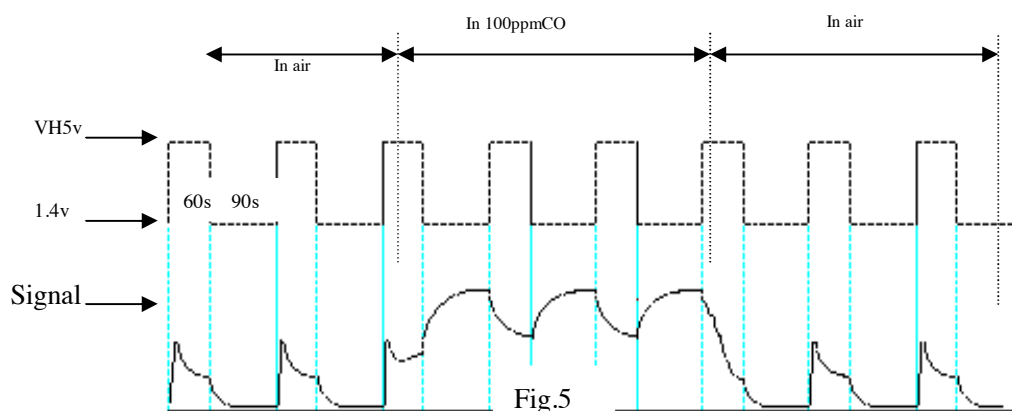
Rs: sensor resistance at 100ppm CO at different temperatures and humidities.

OPERATION PRINCIPLE

. The surface resistance of the sensor R_s is obtained through effected voltage signal output of the load resistance R_L which series-wound. The relationship between them is described:

$$R_s \backslash R_L = (V_c - V_{RL}) / V_{RL}$$

Fig. 5 shows alterable situation of R_L signal output measured by using Fig. 2 circuit output



signal when the sensor is shifted from clean air to carbon monoxide (CO), output signal measurement is made within one or two complete heating period (2.5 minute from high voltage to low voltage).

Sensitive layer of MQ-7 gas sensitive components is made of SnO_2 with stability, So, it has excellent long term stability. Its service life can reach 5 years under using condition.

SENSITIVITY ADJUSTMENT

Resistance value of MQ-7 is difference to various kinds and various concentration gases. So, When using this components, sensitivity adjustment is very necessary. we recommend that you calibrate the detector for 200ppm CO in air and use value of Load resistance that(R_L) about 10 K Ω (5K Ω to 47 K Ω).

When accurately measuring, the proper alarm point for the gas detector should be determined after considering the temperature and humidity influence. The sensitivity adjusting program:

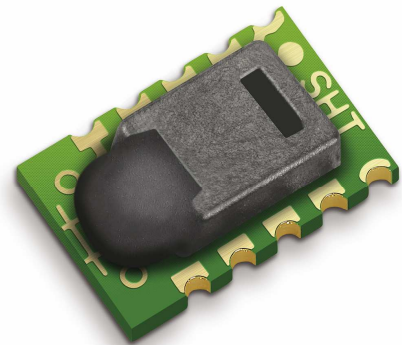
- Connect the sensor to the application circuit.
- Turn on the power, keep preheating through electricity over 48 hours.
- Adjust the load resistance R_L until you get a signal value which is respond to a certain carbon monoxide concentration at the end point of 90 seconds.
- Adjust the another load resistance R_L until you get a signal value which is respond to a CO concentration at the end point of 60 seconds .

[Supplying special IC solutions, More detailed technical information, please contact us.](#)

Datasheet SHT1x (SHT10, SHT11, SHT15)

Humidity and Temperature Sensor

- Fully calibrated
- Digital output
- Low power consumption
- Excellent long term stability
- SMD type package – reflow solderable



Product Summary

SHT1x (including SHT10, SHT11 and SHT15) is Sensirion's family of surface mountable relative humidity and temperature sensors. The sensors integrate sensor elements plus signal processing on a tiny foot print and provide a fully calibrated digital output. A unique capacitive sensor element is used for measuring relative humidity while temperature is measured by a band-gap sensor. The applied CMOSens® technology guarantees excellent reliability and long term stability. Both sensors are seamlessly coupled to a 14bit analog to digital converter and a serial interface circuit. This results in superior signal quality, a fast response time and insensitivity to external disturbances (EMC).

Each SHT1x is individually calibrated in a precision humidity chamber. The calibration coefficients are programmed into an OTP memory on the chip. These coefficients are used to internally calibrate the signals from the sensors. The 2-wire serial interface and internal voltage regulation allows for easy and fast system integration. The tiny size and low power consumption makes SHT1x the ultimate choice for even the most demanding applications.

SHT1x is supplied in a surface-mountable LCC (Leadless Chip Carrier) which is approved for standard reflow soldering processes. The same sensor is also available with pins (SHT7x) or on flex print (SHTA1).

Dimensions

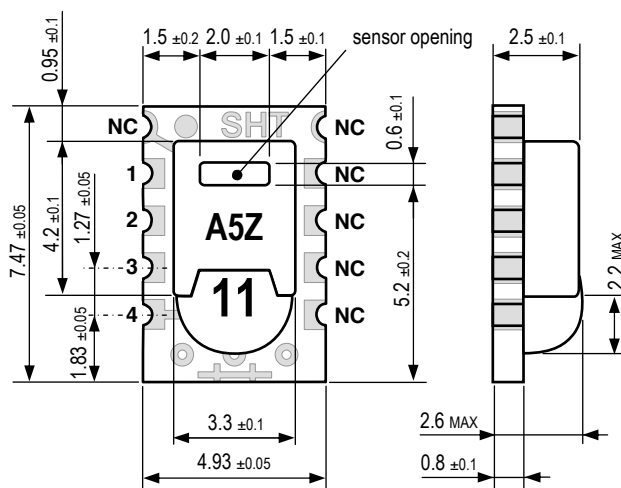


Figure 1: Drawing of SHT1x sensor packaging, dimensions in mm (1mm = 0.039inch). Sensor label gives "11" for SHT11 as an example. Contacts are assigned as follows: 1:GND, 2:DATA, 3:SCK, 4:VDD.

Sensor Chip

SHT1x V4 – for which this datasheet applies – features a version 4 Silicon sensor chip. Besides a humidity and a temperature sensor the chip contains an amplifier, A/D converter, OTP memory and a digital interface. V4 sensors can be identified by the alpha-numeric traceability code on the sensor cap – see example "A5Z" code on Figure 1.

Material Contents

While the sensor is made of a CMOS chip the sensor housing consists of an LCP cap with epoxy glob top on an FR4 substrate. The device is fully RoHS and WEEE compliant, thus it is free of Pb, Cd, Hg, Cr(6+), PBB and PBDE.

Evaluation Kits

For sensor trial measurements, for qualification of the sensor or even experimental application of the sensor there is an evaluation kit *EK-H2* available including sensor, hard and software to interface with a computer.

For more sophisticated and demanding measurements a multi port evaluation kit *EK-H3* is available which allows for parallel application of up to 20 sensors.

Sensor Performance

Relative Humidity

Parameter	Condition	min	typ	max	Units
Resolution ¹		0.4	0.05	0.05	%RH
		8	12	12	bit
Accuracy ² SHT10	typical		±4.5		%RH
	maximal	see Figure 2			
Accuracy ² SHT11	typical		±3.0		%RH
	maximal	see Figure 2			
Accuracy ² SHT15	typical		±2.0		%RH
	maximal	see Figure 2			
Repeatability			±0.1		%RH
Replacement		fully interchangeable			
Hysteresis			±1		%RH
Nonlinearity	raw data		±3		%RH
	linearized		<<1		%RH
Response time ³	τ (63%)		8		s
Operating Range		0		100	%RH
Long term drift ⁴	normal		< 0.5		%RH/yr

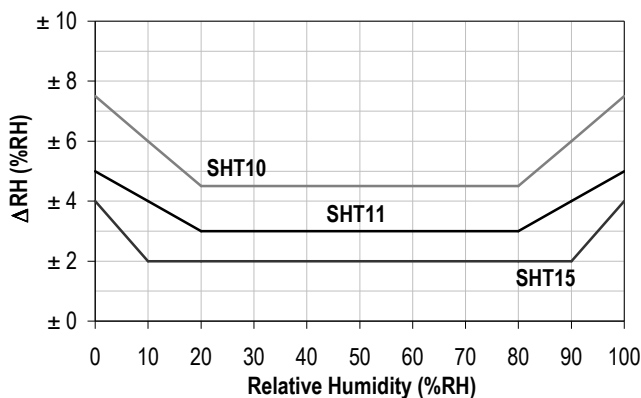


Figure 2: Maximal RH-accuracy at 25°C per sensor type.

Temperature

Parameter	Condition	min	typ	max	Units
Resolution ¹		0.04	0.01	0.01	°C
		12	14	14	bit
Accuracy ² SHT10	typical		±0.5		°C
	maximal	see Figure 3			
Accuracy ² SHT11	typical		±0.4		°C
	maximal	see Figure 3			
Accuracy ² SHT15	typical		±0.3		°C
	maximal	see Figure 3			
Repeatability			±0.1		°C
Replacement		fully interchangeable			
Operating Range		-40		123.8	°C
		-40		254.9	°F
Response Time ⁶	τ (63%)	5		30	s
Long term drift			< 0.04		°C/yr

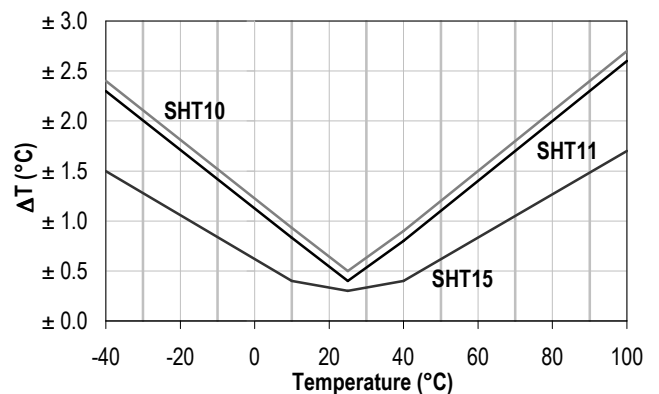


Figure 3: Maximal T-accuracy per sensor type.

Electrical and General Items

Parameter	Condition	min	typ	max	Units
Source Voltage		2.4	3.3	5.5	V
Power Consumption ⁵	sleep		2	5	μW
	measuring		3		mW
	average		150		μW
Communication	digital 2-wire interface, see Communication				
Storage	10 – 50°C (0 – 125°C peak), 20 – 60%RH				

Packaging Information

Sensor Type	Packaging	Quantity	Order Number
SHT10	Tape & Reel	2000	1-100218-04
SHT11	Tape & Reel	100	1-100051-04
	Tape & Reel	400	1-100098-04
	Tape & Reel	2000	1-100524-04
SHT15	Tape & Reel	100	1-100085-04
	Tape & Reel	400	1-100093-04

¹ The default measurement resolution of is 14bit for temperature and 12bit for humidity. It can be reduced to 12/8bit by command to status register.

² Accuracies are tested at Outgoing Quality Control at 25°C (77°F) and 3.3V. Values exclude hysteresis and non-linearity.

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

⁴ Value may be higher in environments with high contents of volatile organic compounds. See Section 1.3 of Users Guide.

⁵ Values for VDD=5.5V at 25°C, average value at one 12bit measurement per second.

⁶ Response time depends on heat capacity of and thermal resistance to sensor substrate.

Users Guide SHT1x

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 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.

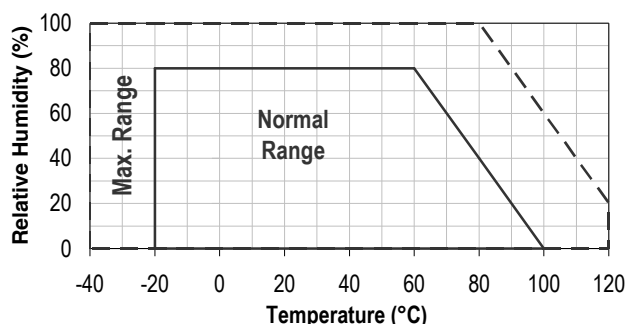


Figure 4: Operating Conditions

1.2 Soldering instructions

For soldering SHT1x 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.

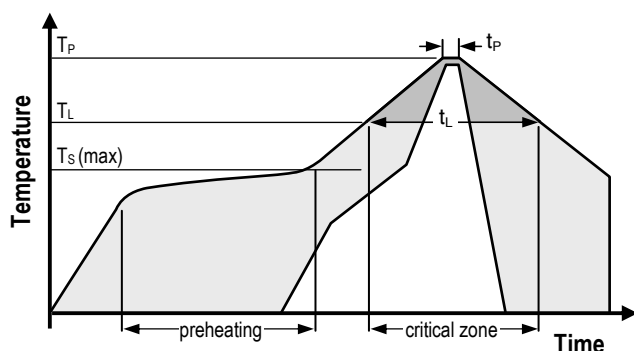


Figure 5: Soldering profile according to JEDEC standard. $T_P \leq 260^\circ\text{C}$ and $t_P < 40\text{sec}$ for Pb-free assembly. $T_L < 220^\circ\text{C}$ and $t_L < 150\text{sec}$. Ramp-up/down speeds shall be $< 5^\circ\text{C/sec}$.

For soldering in Vapor Phase Reflow (VPR) ovens the peak conditions are limited to $T_P < 233^\circ\text{C}$ during $t_P < 60\text{sec}$ 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.

⁷ $233^\circ\text{C} = 451^\circ\text{F}$, $260^\circ\text{C} = 500^\circ\text{F}$, $350^\circ\text{C} = 662^\circ\text{F}$

IMPORTANT: After soldering the devices should be stored at $>75\%\text{RH}$ 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 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 SHT1x footprint it is recommended to use dimensions according to Figure 7. Sensor pads are coated with $35\mu\text{m Cu}$, $5\mu\text{m Ni}$ and $0.1\mu\text{m Au}$.

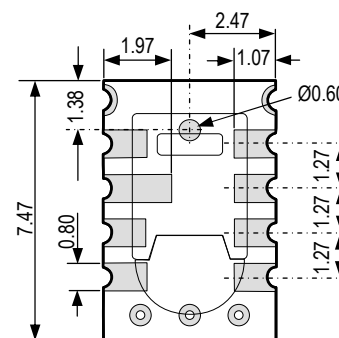


Figure 6: Rear side electrodes of sensor, view from top side.

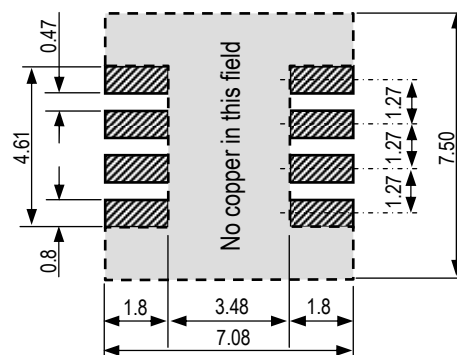


Figure 7: Recommended footprint for SHT1x. Values in mm.

1.3 Storage Conditions and Handling Instructions

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 $10^\circ\text{C} - 50^\circ\text{C}$ ($0 - 125^\circ\text{C}$ for limited time) and humidity at $20 - 60\%\text{RH}$ (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-HD⁸.

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 12h⁹.

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 SHT1x 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 SHT1x and the rest of the PCB or milling a slit into the PCB around the sensor (see Figure 8).

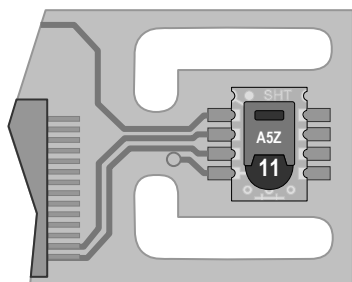


Figure 8: Top view of example of mounted SHT1x with slits milled into PCB to minimize heat transfer.

Furthermore, there are self-heating effects in case the measurement frequency is too high. Please refer to Section 3.3 for detailed information.

1.6 Light

The SHT1x is not light sensitive. Prolonged direct exposure to sunshine or strong UV radiation may age the housing.

1.7 Membranes

SHT1x does not contain a membrane at the sensor opening. However, a membrane may be added to prevent dirt and droplets from entering the housing and to protect the sensor. It will also reduce peak concentrations of chemical vapors. For optimal response times the air volume behind the membrane must be kept minimal. Sensirion recommends and supplies the SF1 filter cap for optimal IP54 protection (for higher protection – i.e. IP67 - SF1 must be sealed to the PCB with epoxy). Please compare Figure 9.

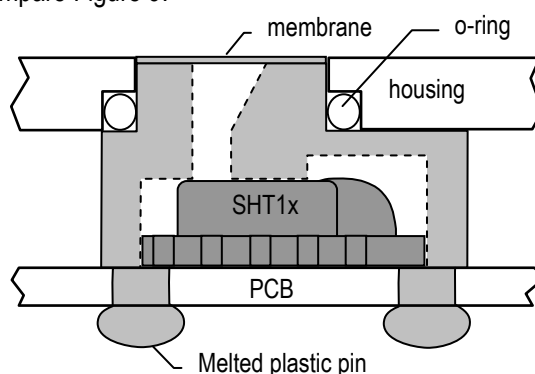


Figure 9: Side view of SF1 filter cap mounted between PCB and housing wall. Volume below membrane is kept minimal.

1.8 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): High filled epoxy for electronic packaging (e.g. glob top, underfill), and Silicone. Out-gassing of these materials may also contaminate the SHT1x (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.

1.9 Wiring Considerations and Signal Integrity

Carrying the SCK and DATA 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 GND between the two data signals and/or using shielded cables. Furthermore, slowing down SCK frequency will possibly improve signal integrity. Power supply pins (VDD, GND) must be decoupled with a 100nF capacitor if wires are used.

⁸ For example, please check www.sirel.ch

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

Capacitor should be placed as close to the sensor as possible. Please see the Application Note “ESD, Latchup and EMC” for more information.

1.10 ESD (Electrostatic Discharge)

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 ± 100 mA with $T_{amb} = 80^\circ\text{C}$ according to JEDEC78A. See Application Note “ESD, Latchup and EMC” for more information.

2 Interface Specifications

Pin	Name	Comment
1	GND	Ground
2	DATA	Serial Data, bidirectional
3	SCK	Serial Clock, input only
4	VDD	Source Voltage
NC	NC	Must be left unconnected

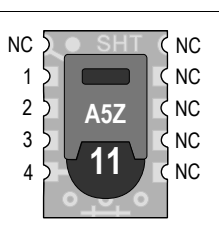


Table 1: SHT1x pin assignment, NC remain floating.

2.1 Power Pins (VDD, GND)

The supply voltage of SHT1x must be in the range of 2.4 – 5.5V, recommended supply voltage is 3.3V. Power supply pins Supply Voltage (VDD) and Ground (GND) must be decoupled with a 100 nF capacitor – see Figure 10.

The serial interface of the SHT1x is optimized for sensor readout and effective power consumption. The sensor cannot be addressed by I²C protocol, however, the sensor can be connected to an I²C bus without interference with other devices connected to the bus. The controller must switch between the protocols.

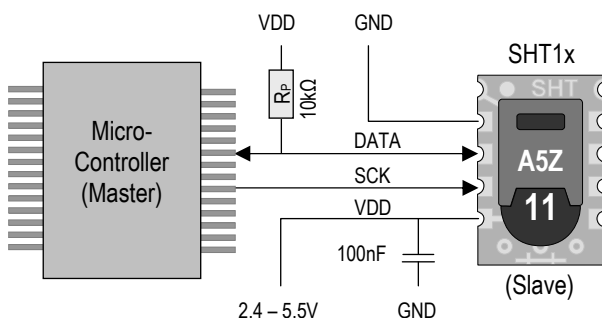


Figure 10: Typical application circuit, including pull up resistor R_P and decoupling of VDD and GND by a capacitor.

2.2 Serial clock input (SCK)

SCK is used to synchronize the communication between microcontroller and SHT1x. Since the interface consists of fully static logic there is no minimum SCK frequency.

2.3 Serial data (DATA)

The DATA tri-state pin is used to transfer data in and out of the sensor. For sending a command to the sensor, DATA is valid on the rising edge of the serial clock (SCK) and must remain stable while SCK is high. After the falling edge of SCK DATA may be changed. For safe communication DATA valid shall be extended T_{SU} and T_{HO} before the rising and after the falling edge of SCK, respectively – see Figure 11. For reading data from the sensor, DATA is valid T_V after SCK has gone low and remains valid until the next falling edge of SCK.

To avoid signal contention the microcontroller must only drive DATA low. An external pull-up resistor (e.g. 10kΩ) is required to pull the signal high – it should be noted that pull-up resistors may be included in I/O circuits of microcontrollers. See Table 2 for detailed I/O characteristic of the sensor.

2.4 Electrical Characteristics

The electrical characteristics such as power consumption, low and high level, input and output voltages depend on the supply voltage. Table 2 gives electrical characteristics of SHT1x with the assumption of 5V supply voltage if not stated otherwise. For proper communication with the sensor it is essential to make sure that signal design is strictly within the limits given in Table 3 and Figure 11.

Parameter	Conditions	min	typ	max	Units
Power supply DC ¹⁰		2.4	3.3	5.5	V
Supply current	measuring		0.55	1	mA
	average ¹¹	2	28		μA
	sleep		0.3	1.5	μA
Low level output voltage	$I_{OL} < 4$ mA	0		250	mV
High level output voltage	$R_P < 25$ kΩ	90%		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 current	on			4	mA
	Tri-stated (off)		10	20	μA

Table 2: SHT1x DC characteristics. R_P stands for pull up resistor, while I_{OL} is low level output current.

¹⁰ Recommended voltage supply for highest accuracy is 3.3V, due to sensor calibration.

¹¹ Minimum value with one measurement of 8 bit accuracy without OTP reload per second, typical value with one measurement of 12bit accuracy per second.

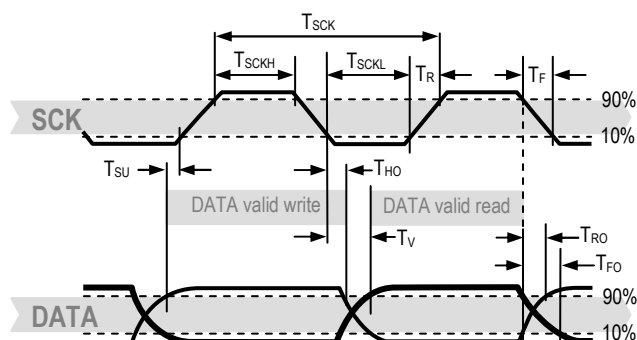


Figure 11: Timing Diagram, abbreviations are explained in Table 3. Bold DATA line is controlled by the sensor, plain DATA line is controlled by the micro-controller. Both valid times refer to the left SCK toggle.

	Parameter	Conditions	min	typ	max	Units
F _{SCK}	SCK Frequency	VDD > 4.5V	0	0.1	5	MHz
		VDD < 4.5V	0	0.1	1	MHz
T _{SCKx}	SCK hi/low time		100			ns
T _R /T _F	SCK rise/fall time		1	200	*	ns
T _{FO}	DATA fall time	OL = 5pF	3.5	10	20	ns
		OL = 100pF	30	40	200	ns
T _{RO}	DATA rise time		**	**	**	ns
T _V	DATA valid time		200	250	***	ns
T _{SU}	DATA setup time		100	150	***	ns
T _{HO}	DATA hold time		10	15	****	ns

* $T_{R_max} + T_{F_max} = (F_{SCK})^{-1} - T_{SCKH} - T_{SCKL}$

** T_{RO} is determined by the $R_P \cdot C_{bus}$ time-constant at DATA line

*** T_{V_max} and T_{SU_max} depend on external pull-up resistor (R_P) and total bus line capacitance (C_{bus}) at DATA line

**** $T_{HO_max} < T_V - \max(T_{RO}, T_{FO})$

Table 3: SHT1x I/O signal characteristics, OL stands for Output Load, entities are displayed in Figure 11.

3 Communication with Sensor

3.1 Start up Sensor

As a first step the sensor is powered up to chosen supply voltage VDD. The slew rate during power up shall not fall below 1V/ms. After power-up the sensor needs 11ms to get to Sleep State. No commands must be sent before that time.

3.2 Sending a Command

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 – see Figure 12.

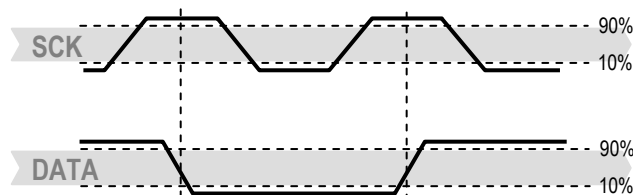


Figure 12: "Transmission Start" sequence

The subsequent command consists of three address bits (only '000' is supported) and five command bits. The SHT1x indicates the proper reception of a command by pulling the DATA pin low (ACK bit) after the falling edge of the 8th SCK clock. The DATA line is released (and goes high) after the falling edge of the 9th SCK clock.

Command	Code
Reserved	0000x
Measure Temperature	00011
Measure Relative Humidity	00101
Read Status Register	00111
Write Status Register	00110
Reserved	0101x-1110x
Soft reset , resets the interface, clears the status register to default values. Wait minimum 11 ms before next command	11110

Table 4: SHT1x list of commands

3.3 Measurement of RH and T

After issuing a measurement command ('00000101' for relative humidity, '00000011' for temperature) the controller has to wait for the measurement to complete. This takes a maximum of 20/80/320 ms for a 8/12/14bit measurement. The time varies with the speed of the internal oscillator and can be lower by up to 30%. To signal the completion of a measurement, the SHT1x pulls data line low and enters Idle Mode. The controller must wait for this Data Ready signal before restarting SCK to readout the data. Measurement data is stored until readout, therefore the controller can continue with other tasks and readout at its convenience.

Two bytes of measurement data and one byte of CRC checksum (optional) will then be transmitted. The micro controller 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, for a 8bit result the first byte is not used).

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 device automatically returns to Sleep Mode after measurement and communication are completed.

Important: To keep self heating below 0.1°C, SHT1x should not be active for more than 10% of the time – e.g. maximum one measurement per second at 12bit accuracy shall be made.

3.4 Connection reset sequence

If communication with the device is lost the following signal sequence will reset the serial interface: While leaving DATA high, toggle SCK nine or more times – see Figure 13. This must be followed by a Transmission Start sequence preceding the next command. This sequence resets the interface only. The status register preserves its content.

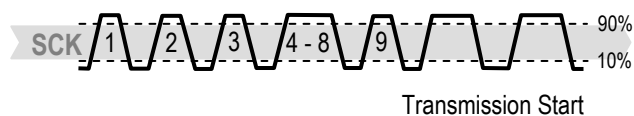


Figure 13: Connection Reset Sequence

3.5 CRC-8 Checksum calculation

The whole digital transmission is secured by an 8bit checksum. It ensures that any wrong data can be detected and eliminated. As described above this is an additional feature of which may be used or abandoned.

Please consult Application Note “CRC-8 Checksum Calculation” for information on how to calculate the CRC.

Status Register

Some of the advanced functions of the SHT1x such as selecting measurement resolution, end of battery notice or using the heater may be activated by sending a command to the status register. The following section gives a brief overview of these features. A more detailed description is available in the Application Note “Status Register”.

After the command Status Register Read or Status Register Write – see Table 4 – the content of 8 bits of the status register may be read out or written. For the communication compare Figures 16 and 17 – the assignation of the bits is displayed in Table 5.

TS	0	0	0	0	0	1	1	0	ACK	Bit 7	Status Register	ACK
----	---	---	---	---	---	---	---	---	-----	-------	-----------------	-----

Figure 14: Status Register Write

TS	0	0	0	0	0	1	1	1	ACK	Bit 7	Status Register	ACK	Bit 7	Checksum	ACK
----	---	---	---	---	---	---	---	---	-----	-------	-----------------	-----	-------	----------	-----

Figure 15: Status Register Read

Examples of full communication cycle are displayed in Figures 15 and 16.

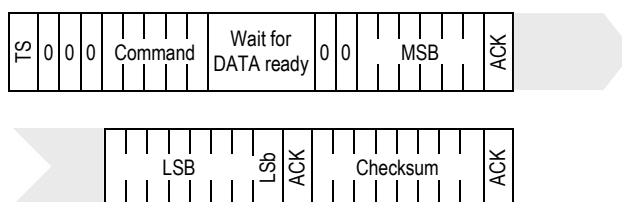


Figure 16: Overview of Measurement Sequence. TS = Transmission Start, MSB = Most Significant Byte, LSB = Last Significant Byte, LSb = Last Significant Bit.

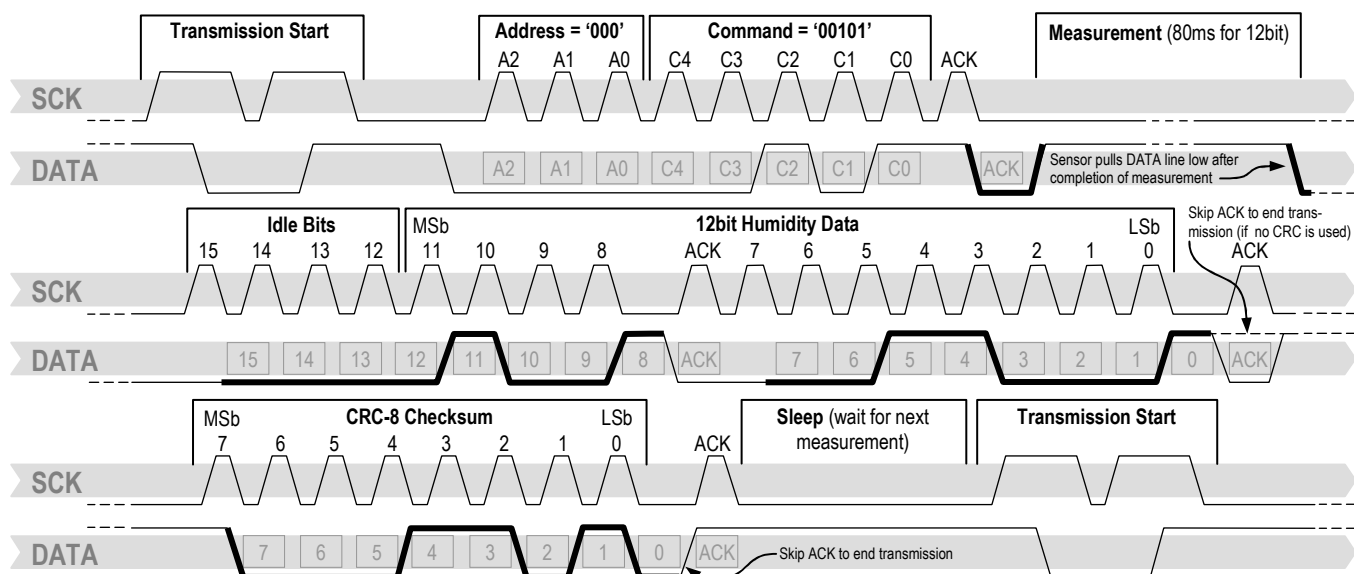


Figure 17: Example RH measurement sequence for value “0000’1001’0011’0001” = 2353 = 75.79 %RH (without temperature compensation). DATA valid times are given and referenced in boxes on DATA line. Bold DATA lines are controlled by sensor while plain lines are controlled by the micro-controller.

Bit	Type	Description	Default
7		reserved	0
6	R	End of Battery (low voltage detection) '0' for VDD > 2.47 '1' for VDD < 2.47	X No default value, bit is only updated after a measurement
5		reserved	0
4		reserved	0
3		For Testing only, do not use	0
2	R/W	Heater	0 off
1	R/W	no reload from OTP	0 reload
0	R/W	'1' = 8bit RH / 12bit Temp. resolution '0' = 12bit RH / 14bit Temp. resolution	0 12bit RH 14bit Temp.

Table 5: Status Register Bits

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

End of Battery function detects and notifies VDD voltages below 2.47 V. Accuracy is ± 0.05 V.

Heater: An on chip heating element can be addressed by writing a command into status register. The heater may increase the temperature of the sensor by 5 – 10°C¹² beyond ambient temperature. The heater draws roughly 8mA @ 5V supply voltage.

For example the heater can be helpful for functionality analysis: Humidity and temperature readings before and after applying the heater are compared. Temperature shall increase while relative humidity decreases at the same time. Dew point shall remain the same.

Please note: The temperature reading will display the temperature of the heated sensor element and not ambient temperature. Furthermore, the sensor is not qualified for continuous application of the heater.

4 Conversion of Signal Output

4.1 Relative Humidity

For compensating non-linearity of the humidity sensor – see Figure 18 – and for obtaining the full accuracy of the sensor it is recommended to convert the humidity readout (SO_{RH}) with the following formula with coefficients given in Table 6:

$$RH_{linear} = c_1 + c_2 \cdot SO_{RH} + c_3 \cdot SO_{RH}^2 \quad (\%RH)$$

¹² Corresponds to 9 – 18°F

SO_{RH}	c_1	c_2	c_3
12 bit	-2.0468	0.0367	-1.5955E-6
8 bit	-2.0468	0.5872	-4.0845E-4

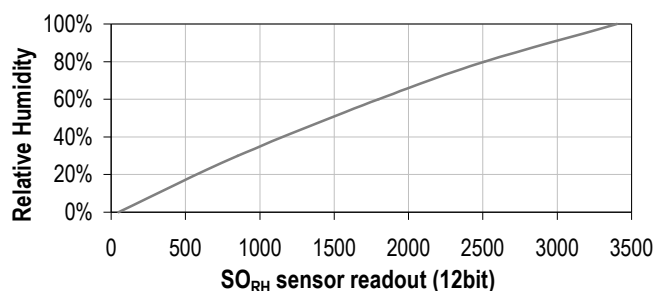
Table 6: Optimized V4 humidity conversion coefficients

The values given in Table 6 are newly introduced and provide optimized accuracy for V4 sensors along the full measurement range. The parameter set c_x^* , which has been proposed in earlier datasheets, which was optimized for V3 sensors, still applies to V4 sensors and is given in Table 7 for reference.

SO_{RH}	c_1^*	c_2^*	c_3^*
12 bit	-4.0000	0.0405	-2.8000E-6
8 bit	-4.0000	0.6480	-7.2000E-4

Table 7: V3 humidity conversion coefficients, which also apply to V4.

For simplified, less computation intense conversion formulas see Application Note “RH and Temperature Non-Linearity Compensation”. Values higher than 99% RH indicate fully saturated air and must be processed and displayed as 100%RH¹³. Please note that the humidity sensor has no significant voltage dependency.

**Figure 18:** Conversion from SO_{RH} to relative humidity

4.2 Temperature compensation of Humidity Signal

For temperatures significantly different from 25°C (~77°F) the humidity signal requires a temperature compensation. The temperature correction corresponds roughly to 0.12%RH/°C @ 50%RH. Coefficients for the temperature compensation are given in Table 8.

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

SO_{RH}	t_1	t_2
12 bit	0.01	0.00008
8 bit	0.01	0.00128

Table 8: Temperature compensation coefficients¹⁴

¹³ If wetted excessively (strong condensation of water on sensor surface), sensor output signal can drop below 100%RH (even below 0%RH in some cases), but the sensor will recover completely when water droplets evaporate. The sensor is not damaged by water immersion or condensation.

¹⁴ Coefficients apply both to V3 as well as to V4 sensors.

4.3 Temperature

The band-gap PTAT (Proportional To Absolute Temperature) temperature sensor is very linear by design. Use the following formula to convert digital readout (SO_T) to temperature value, with coefficients given in Table 9:

$$T = d_1 + d_2 \cdot SO_T$$

VDD	d_1 (°C)	d_1 (°F)	SO_T	d_2 (°C)	d_2 (°F)
5V	-40.1	-40.2	14bit	0.01	0.018
4V	-39.8	-39.6	12bit	0.04	0.072
3.5V	-39.7	-39.5			
3V	-39.6	-39.3			
2.5V	-39.4	-38.9			

Table 9: Temperature conversion coefficients¹⁵.

4.4 Dew Point

SHT1x is not measuring dew point directly, however dew point can be derived from humidity and temperature readings. Since humidity and temperature are both measured on the same monolithic chip, the SHT1x allows superb dew point measurements.

For dew point (T_d) calculations there are various formulas to be applied, most of them quite complicated. For the temperature range of -40 – 50°C the following approximation provides good accuracy with parameters given in Table 10:

$$T_d(RH, T) = T_n \cdot \frac{\ln\left(\frac{RH}{100\%}\right) + \frac{m \cdot T}{T_n + T}}{m - \ln\left(\frac{RH}{100\%}\right) - \frac{m \cdot T}{T_n + T}}$$

Temperature Range	T_n (°C)	m
Above water, 0 – 50°C	243.12	17.62
Above ice, -40 – 0°C	272.62	22.46

Table 10: Parameters for dew point (T_d) calculation.

Please note that “ln(...)” denotes the natural logarithm. For RH and T the linearized and compensated values for relative humidity and temperature shall be applied.

For more information on dew point calculation see Application Note “Dew point calculation”.

5 Environmental Stability

If sensors are qualified for assemblies or devices, please make sure that they experience same conditions as the reference sensor. It should be taken into account that response times in assemblies may be longer, hence enough dwell time for the measurement shall be granted. For detailed information please consult Application Note “Qualification Guide”.

The SHT1x sensor series were tested according to AEC-Q100 Rev. F qualification test method. Sensor specifications are tested to prevail under the AEC-Q100 temperature grade 2 test conditions listed in Table 11¹⁶. Sensor performance under other test conditions cannot be guaranteed and is not part of the sensor specifications. Especially, no guarantee can be given for sensor performance in the field or for customer’s specific application.

Please contact Sensirion for detailed information.

Environment	Standard	Results ¹⁷
HTSL	125°C, 1000 hours	Within specifications
TC	-50°C - 125°C, 1000 cycles Acc. JESD22-A104-C	Within specifications
UHST	130°C / 85%RH, 96h	Within specifications
THU	85°C / 85%RH, 1000h	Within specifications
ESD immunity	MIL STD 883E, method 3015 (Human Body Model at ±2kV)	Qualified
Latch-up	force current of ±100mA with $T_{amb} = 80^\circ\text{C}$, acc. JEDEC 17	Qualified

Table 11: Qualification tests: HTSL = High Temperature Storage Lifetime, TC = Temperature Cycles, UHST = Unbiased Highly accelerated temperature and humidity Test, THU = Temperature humidity unbiased

6 Packaging

6.1 Packaging type

SHT1x are supplied in a surface mountable LCC (Leadless Chip Carrier) type package. The sensor housing consists of a Liquid Crystal Polymer (LCP) cap with epoxy glob top on a standard 0.8mm FR4 substrate. The device is fully RoHS and WEEE compliant – it is free of Pb, Cd, Hg, Cr(6+), PBB and PBDE.

¹⁵ Temperature coefficients have slightly been adjusted compared to datasheet SHTxx version 3.01. Coefficients apply to V3 as well as V4 sensors.

¹⁶ Sensor operation temperature range is -40 to 105°C according to AEC-Q100 temperature grade 2.

¹⁷ According to accuracy and long term drift specification given on Page 2.

Device size is 7.47 x 4.93 x 2.5 mm (0.29 x 0.19 x 0.1 inch), see Figure 1, weight is 100 mg.

6.2 Traceability Information

All SHT1x are marked with an alphanumeric, three digit code on the chip cap (for reference: V3 sensors were labeled with numeric codes) – see “A5Z” on Figure 1. The lot numbers allow full traceability through production, calibration and testing. No information can be derived from the code directly, respective data is stored at Sensirion and is provided upon request.

Labels on the reels are displayed in Figures 19 and 20, they both give traceability information.

Lot No.:	XX0-04-YRRRRTTTT
Quantity:	RRRR
RoHS:	Compliant
Lot No.	
	

Figure 19: First label on reel: XX = Sensor Type (11 for SHT11), 04 = Chip Version (V4), Y = last digit of year, RRRR = number of sensors on reel, TTTT = Traceability Code.

SENSIRION THE SENSOR COMPANY	
Device Type:	1-100PPP-04
Description:	Humidity & Temperature Sensor SHTxx
Part Order No.	1-100PPP-04 or Customer Number
Date of Delivery:	DD.MM.YYYY
Order Code:	45CCCC / 0

Figure 20: Second label on reel: For Device Type and Part Order Number please refer to Table 12, Delivery Date (also Date Code) is date of packaging of sensors (DD = day, MM = month, YYYY = year), CCCC = Sensirion order number.

6.3 Shipping Package

SHT1x are shipped in 12mm tape at 100pcs, 400pcs and 2000pcs – for details see Figure 21 and Table 12. Reels are individually labeled with barcode and human readable labels.

Sensor Type	Packaging	Quantity	Order Number
SHT10	Tape & Reel	2000	1-100218-04
SHT11	Tape & Reel	100	1-100051-04
	Tape & Reel	400	1-100098-04
	Tape & Reel	2000	1-100524-04
SHT15	Tape & Reel	100	1-100085-04
	Tape & Reel	400	1-100093-04

Table 12: Packaging types per sensor type.

Dimensions of packaging tape is given in Figure 21. All tapes have a minimum of 480mm empty leader tape (first pockets of the tape) and a minimum of 300mm empty trailer tape (last pockets of the tape).

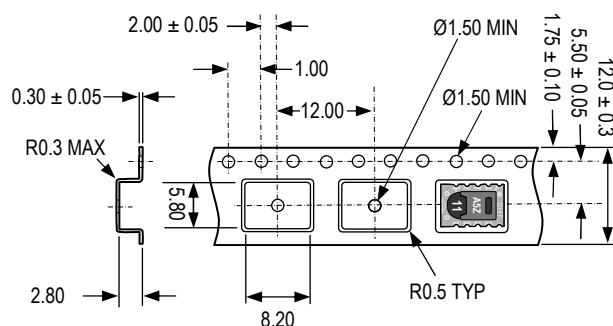


Figure 21: Tape configuration and unit orientation within tape, dimensions in mm (1mm = 0.039inch). The leader tape is at the right side of the figure while the trailer tape is to the left (direction of unreeling).

Revision History

Date	Version	Page(s)	Changes
March 2007	3.0	1 – 10	Data sheet valid for SHTxx-V4 and SHTxx-V3
August 2007	3.01	1 – 10	Electrical characteristics added, measurement time corrected
July 2008	4.0	1 – 10	New release, rework of datasheet

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.

Copyright© 2007, SENSIRION.

CMOSens® is a trademark of Sensirion

All rights reserved

Headquarter and Sales Offices

Headquarter

SENSIRION AG
 Laubisruetistr. 50
 CH-8712 Staefa ZH
 Switzerland

Phone: + 41 (0)44 306 40 00
 Fax: + 41 (0)44 306 40 30
info@sensirion.com
<http://www.sensirion.com/>

Sales Office USA:

SENSIRION Inc.
 2801 Townsgate Rd., Suite 240
 Westlake Village, CA 91361
 USA

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

Sales Office Korea:

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

Phone: 031 440 9925-27
 Fax: 031 440 9927
info@sensirion.co.kr
<http://www.sensirion.co.kr>

Sales Office Japan:

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

Phone: 03 3444 4940
 Fax: 03 3444 4939
info@sensirion.co.jp
<http://www.sensirion.co.jp>

Find your local representative at: <http://www.sensirion.com/rep>s

Particle Sensor

Model PPD42NS

This sensor is to create Digital (Lo Pulse) output to Particulate Matters(PM). Lo Pulse Occupancy time (LPO time) is in proportion to PM concentration. The output from "P1" is for PM whose size is around 1 micro meter or larger. "P1" Output characteristics is shown in the attached drawing Fig2.,when tested in standard condition stipulated below.

Specification

Model	PPD42NS
Detectable particle size	approx. 1 μ m (minimum.)
Detectable range of concentration	0~28,000 pcs/liter (0~8,000pcs/0.01 CF=283ml)
Supply Voltage	DC5V +/- 10% (CN1:Pin1=GND, Pin3=+5V)
	Ripple Voltage within 30mV
Operating Temperature Range	0~45°C
Operating Humidity Range	95%rh or less (without dew condensation)
Power consumption	90mA
Storage temperature	-30~60°C
Time for stabilization	1 minute after power turned on
Dimensions	59(W) × 45(H) × 22(D) [mm]
Weight	24g(approx.)
Output Method	Negative Logic, Digital output, Hi : over 4.0V(Rev.2) Lo : under 0.7V (As Input impedance : 200k Ω) OP-Amp output, Pull-up resistor : 10k Ω

Configuration and connector pin assignment

The configuration and connector pin allocation are shown in the attached drawing Fig1.

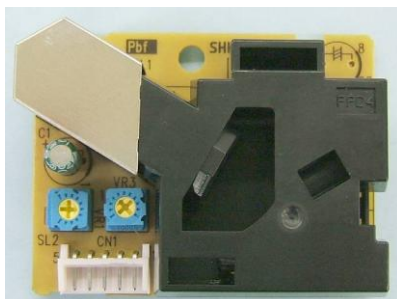
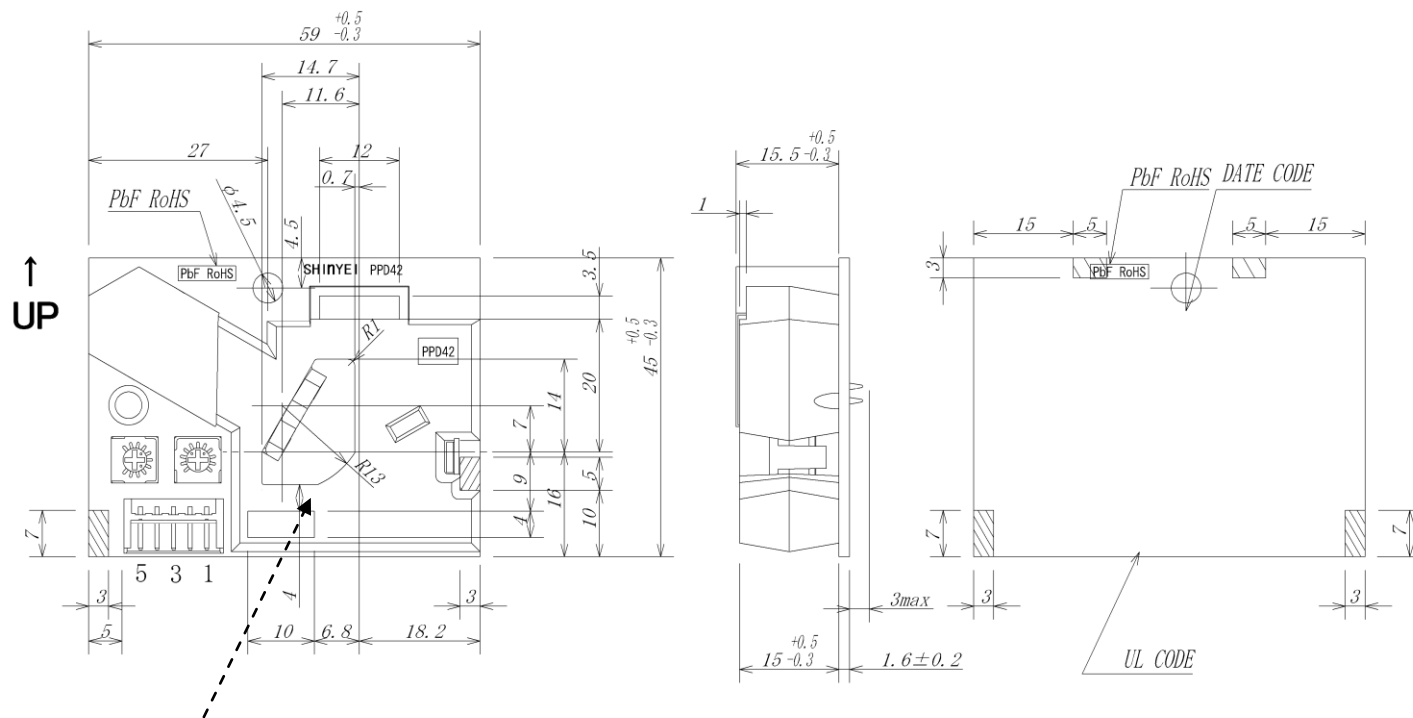


Fig. 1



Rib (inside of housing)

An additional rib structured to inside of housing to hide RH1 lead wire from view. Following components replaced with equivalent ones; OP-Amp, Volume and Al Electrolytic Cap.

Connector

- CN : S5B-EH(JST)
 1 : COMMON(GND)
 2 : OUTPUT(P2)
 3 : INPUT(5VDC 90mA)
 4 : OUTPUT(P1)
 5 : INPUT(T1) ··· FOR THRESHOLD FOR [P2]

Fig. 2

