SHTxx
Humidity & Temperature
Sensmitter

Trouble Shooting Guide
SHTxx

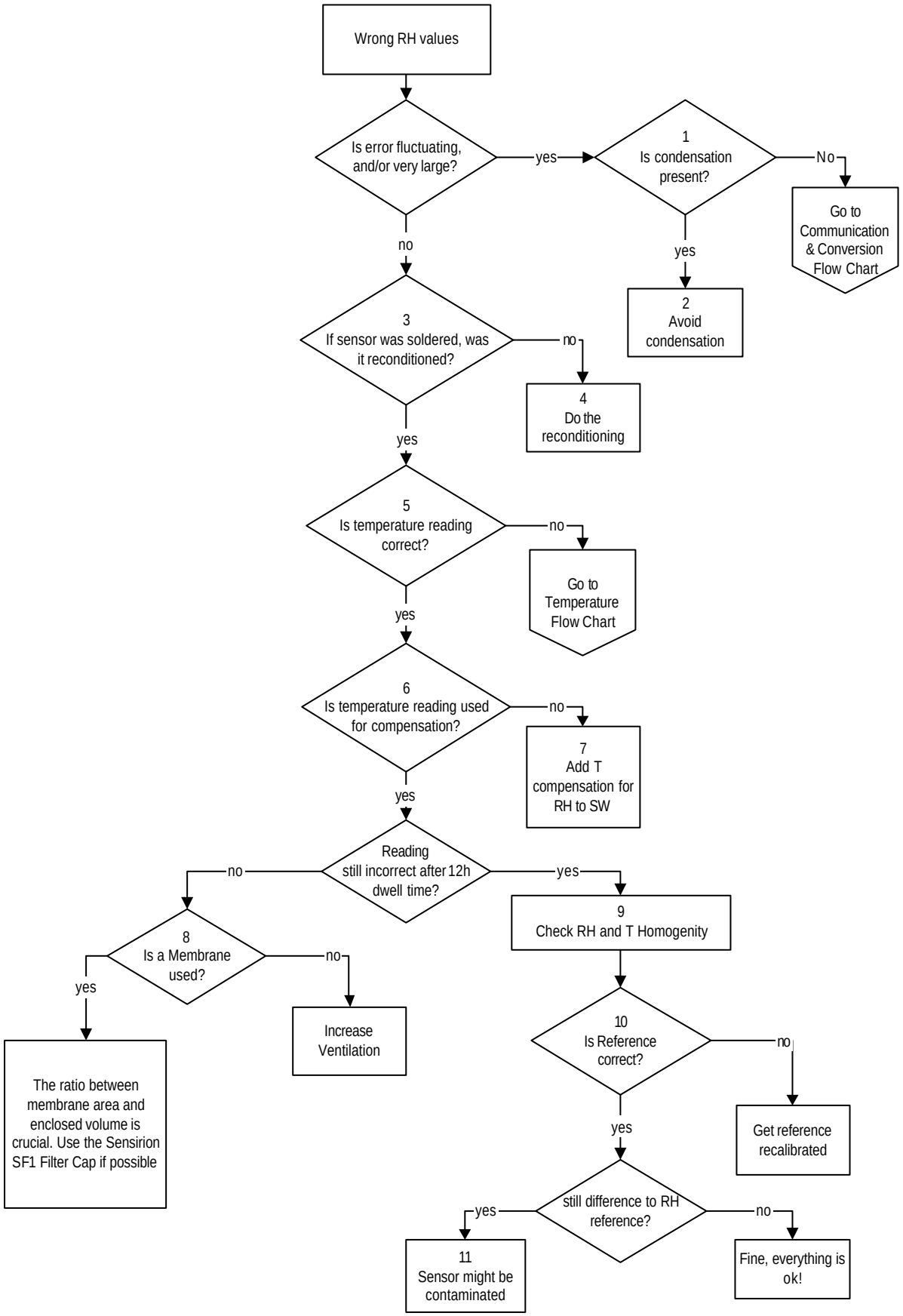
1 Introduction

This guide shall help the engineer to easily find the root cause of any problem regarding interfacing and getting correct measurements from the combined humidity and temperature sensor SHTxx. There are three different areas of problems that can occur:

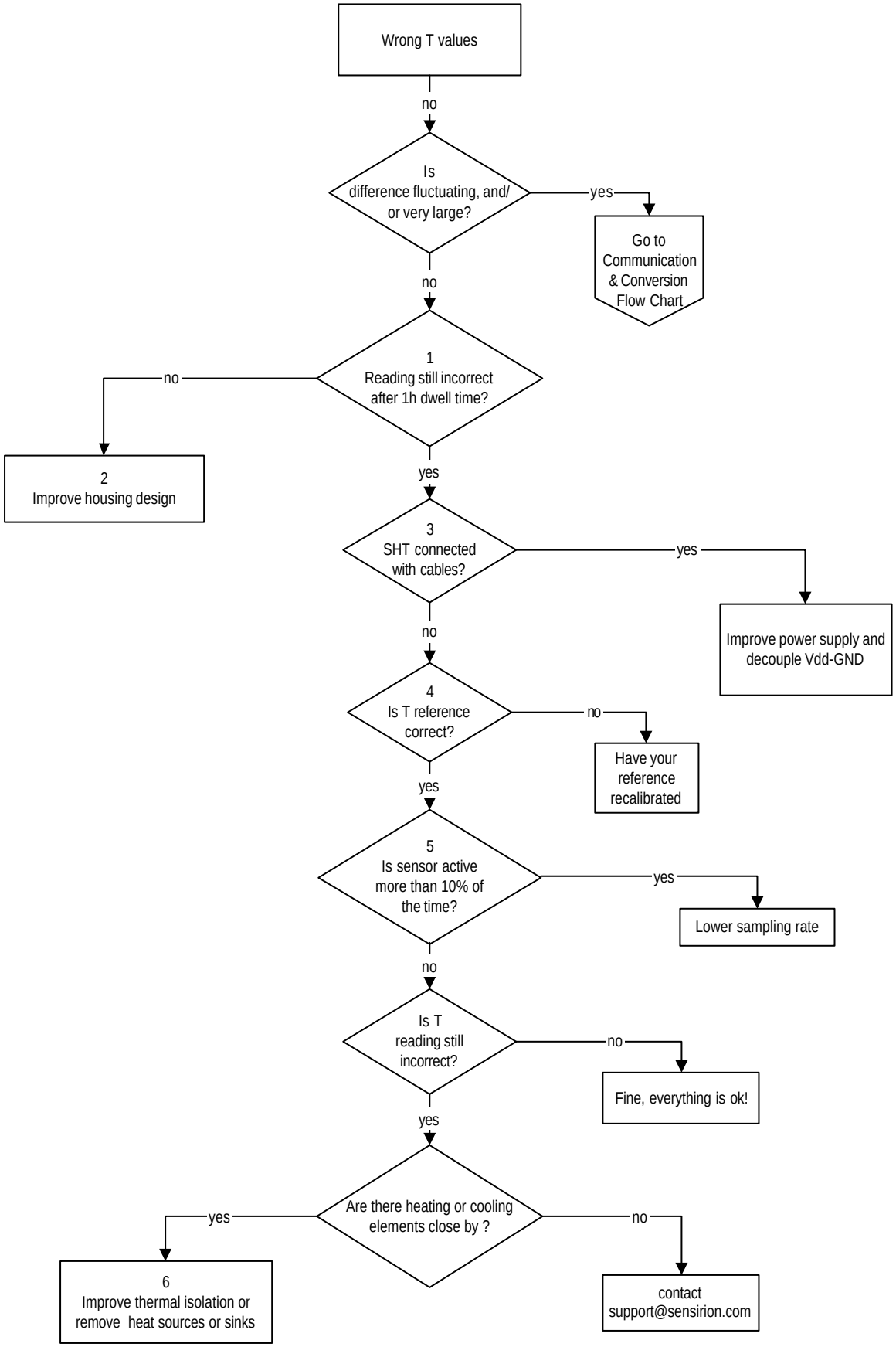
1. Humidity measurement
2. Temperature measurement
3. Communication & Conversion

In three flow charts corresponding to these areas, the engineer is walked through an easy to understand path to finally find the root cause of the problem.
For every box or shape in the flow chart, which has a number to it, you'll find a detailed explanation of what to do to answer the question or information about the involved physical, chemical or electrical/electronical effects.

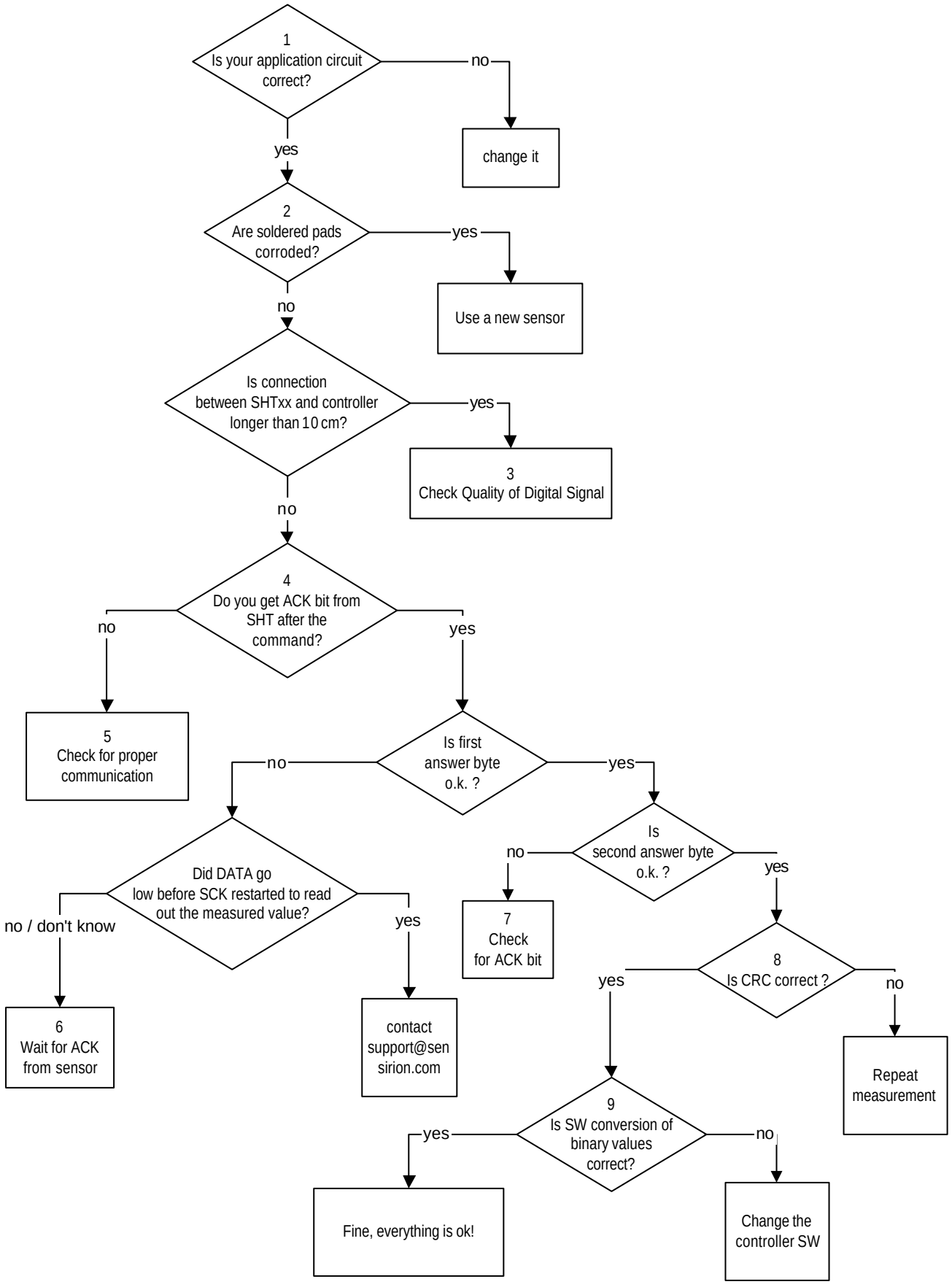
2 Flow Chart Humidity



3 Flow Chart Temperature



4 Flow Chart Communication & Conversion



5 Details Humidity

1. Is condensation present?
   Condensation can occur when the sensor temperature is below the actual dewpoint temperature. The sensor is fully immersible, i.e. condensation is allowed to form on the sensing element and will not have any damaging effect on the sensor. However, the readings will become unreliable, if droplets are present on the sensing element. The RH readings can show anything between 0 and 100% RH. As soon as condensation has evaporated, readings will be back to normal.
2. Avoid condensation
   Condensation can be avoided by either heating up the sensor to bring its temperature above dewpoint, using it's internal heater or ensuring that it never is used in 100% RH environments.
3. If sensor was soldered, was it reconditioned?
   When you solder the SHTxx sensors manually or using a reflow oven, the sensing element will completely dry out and readings will be too low in the range of 5-7%RH. The sensor needs rehydration in order to get back into its correct calibration.
4. Do the reconditioning
   The application note “Soldering procedure” available on Sensirion's webpage (document: soldering procedure SHT11/SHT15 (January 2004)) will explain in detail how to recondition the sensor after soldering.
5. Is temperature reading correct?
   The very definition of RH shows a strong temperature dependency. RH is defined as the proportion of partial water vapour pressure to saturation water vapour pressure. The latter is strongly depending on temperature. See also application note available on Sensirion's wepage (document: Introduction to relative humidity). Therefore it is essential, that the temperature measurement is correct.
6. Is temperature reading used for compensation?
   The RH readings have to be compensated for temperature due to the T -sensitivity of the RH sensor element.
7. Add T compensation for RH to SW
   See datasheet section: Humidity Sensor RH/T compensation (document: Data sheet humidity sensors SHT1x/SHT7x)
8. Is a membrane used?
   Depending on how the sensor is mounted, e.g. if there is dead volume (non-ventilated space) inside the product housing or probe or if a special filter membrane is used, response time can vary very much. The sensing element itself has a response time of 4s for 63% of a change in RH. This response time can be negatively influenced by bad mounting. See also app note: SHTxx_housing_design
9. Check homogenity
   Humidity testing must be done in special climate chambers, which can provide stable and homogeneous RH and T conditions. To further improve measurement results, the sensor and the reference instrument must placed close to each other. The air in the test chamber must be stirred. E.g. temperature inhomogenity of +-0.3°C will result in an error of about 1.6% RH @ 90 % RH.
10. Is reference correct?
    A good reference instrument needs to be periodically recalibrated (about once a year) by a laboratory that uses traceable standards such as NPL or NIST to ensure correct calibration. Even if a reference is precisely calibrated it still has an error, which is usually defined by a band of plus or minus a certain value (e.g. +/-1.5%RH). The sensor itself has an accuracy of e.g. +/-3%RH. In the worst case, the reference is at one of its accuracy limits and the sensor exactly at the opposite, e.g. you have to add the two accuracy limits to get the allowable tolerance band. In this example the measurement of the reference and the sensor are allowed to show a difference of +/-4.5%RH.
11. Sensor might be contaminated
    There are various chemicals which can generate a drift in the RH sensor signal. Depending on the type of chemical this drift is reversible by a reconditioning process or not. The reconditioning process is described in the datasheet, section 4.3. reconditioning procedure. For details, pls. contact Sensirion AG.

6 Details Temperature

1. Reading still incorrect after 1h dwell time?
   Temperature testing must take place in a special climate chamber, which can provide homogeneous and stable temperature distribution. To further improve results, the sensor and the reference instrument should be placed close to each other. The response time of the T sensor on the SHTxx is about 20s provided that the thermal mass (heat capacitance and resistance) connected to the sensor is minimal. I.e. temperature response time depends a lot on how the sensor is mounted and enclosed in the product housing. Good ventilation will also improve response time.
2. Improve housing design
   The following application note give you tips and hints on how to improve the temperature response time of your measurement system: SHTxx_housing_design.
3. SHT connected with cables?
   Using cables to connect the sensor with the microcontroller can affect the quality of the supply voltage. The temperature sensor is sensitive to supply voltage changes. See also datasheet, section 3.2 Temperature. You can either shorten the cables to minimize the effect and/or use a decoupling capacitor between Vdd and GND pins of the sensor or improve the power supply itself.
4. Is T reference correct?
   A good reference instrument needs to be periodically recalibrated (about once a year) by a laboratory that uses traceable standards such as NPL or NIST to ensure correct calibration. Even if a reference is precisely calibrated it still has an error, which is usually defined by a band of plus or minus a certain value (e.g. +/-0.2°C). The sensor itself has an accuracy of e.g. +/-0.5°C. In the worst case, the reference is at one of its accuracy limits and the sensor exactly at the opposite, e.g. you have to add the two accuracy limits to get the allowable tolerance band. In this example the measurement of the reference and the sensor are allowed to show a difference of +/-0.7°C.
5. Is sensor active more than 10% of the time?
   During measurement the sensor draws a supply current of 550 microA @ 5V Vdd. When the sensor is not measuring, it is in sleep state and consumes only 0.3 microA. To avoid self heating and therefore wrong temperature measurements, the sample rate mustn't be too high. The sensor should not be active more than 10% of time. A 8/12/14 bit measurement takes 11/55/210 ms. To see whether self heating is a problem, you can also check whether temperature increases after starting to make measurements in a temperature stabilized climate chamber.
6. Improve thermal isolation or remove heat sources or sinks
   Make sure that thermal conductance is minimal between the sensor and its environment on the PCB and that no heating or cooling elements are close by. Pls. also refer to application note: SHTxx_housing_design.

7 Details Communication and Conversion

1. Is your application circuit correct?
   Pls. verify that your application circuit looks as indicated in the datasheet , section 2, Interface specifications. The pull-up resistor should be around 10k Ohm. It is important, that the power supply is absolutely clean and free of spikes. Therefore a capacitor of at least 100nF must be connected as close as possible to the sensors power pins (Vdd and GND). Because of the bidirectional data line, make sure that the DATA pin of the micro controller only drives low, but not high. For that the micro controller needs an “open collector” or “open drain” output.
2. Are soldered pads corroded?
   If the soldered and unprotected pads are exposed to high humidity (around condensation or 100%RH), sooner or later they will corrode. T herefore if the sensor is used in such environments, the electrical contacts of the sensor must be protected by isolation material. Sensirion recommends to use: SMA10SL from Electrolube: http://www.electrolube.co.uk/docs/tds/SMA.pdf
3. Check Quality of Digital Signal
   If connection between sensor and microcontroller is longer than 10cm, the quality of the digital signal might become bad. There are number of precautions you should take in this case to avoid crosstalk between DATA and SCK lines and to improve EMC:
   - use low transmission frequencies, e.g. 10kHz
   - avoid running DATA and SCK next to each other, e.g. run them at the edges of a flat ribbon cable
   - reduce slopes by introducing a low pass filter, see also app.note EMC, section 4.
   - use the CRC check feature, see also app. note CRC check
   Use an oscilloscope to verify the quality of the digital signals.
4. Do you get ACK bit from SHT after the command?
   A communication sequence starts always with the microcontroller sending a transmission start, address and command to the sensor. For details see also datasheet, section 2.2.4 measurement sequence. After that the microcontroller must relase (float) the DATA line, such that the sensor can pull down the DATA line to send the ACK bit. If the sensor is not sending the ACK bit, something very fundamental is wrong
5. Check for proper communication
   Make sure that the microcontroller waits at least 11ms, after having applied power supply to the Vdd and GND pins of the sensor before a communication sequence is started. The sensor needs this time to get into sleep state in order to get ready for receiving a command. Check with an oscilloscope for correctness of the transmission start, address (always '000') and command sequences. Also check for correct signal levels and slopes.
6. Wait for ACK from sensor
   The controller must wait for the sensor to send the ACK bit (pulling DATA low) to signal that it has completed the measurement internally and is ready to send the measurement value. Only then can the controller start to toggle SCK to actually read out the value. Measurement cycle times for a 8/12/14 bit resolution measurement are about 11/55/210ms. Actual values can differ by +/-15%.
7. Check for ACK bit
   The controller must send an ACK bit after the first data byte. It is important to observe the correct timing. DATA is only allowed to change after the falling SCK edge and it must be valid during the rising SCK edge.
8. Is CRC correct?
   If the controller sends an ACK bit after having received the second byte from the sensor, the sensor will send the CRC checksum. The SW on the controller can calculate the CRC checksum and compare it with the one received from the sensor. Are both the same, then the transmission was entirely successful. If there's a difference, there must be a faulty transmission due to EMC problems. For more details, pls. consult the application note CRC calculation.
9. Is SW conversion of binary values correct?
   The binary values received from the sensor must be converted into RH and T values using the formulas given in the datasheet under section 3, "converting output to physical values". To check if the conversion was done correctly you can get the binary values with an oscilloscope and convert them "by hand" and compare them to what the SW on the controller calculates.

8 Tools

A very cheap way to debug digital communication is a digital storage oscilloscope. Price is around 600$.
http://www.linkinstruments.com/oscilloscope.htm

9 Revision History

Date	Revision	Changes
¨10.2.05	0.1	Draft
6.5.05	0.1	Review by MST
May 25, 2005	0.2	Changed company address
19.8.05	1.0	Last changes before first release

Headquarters and Sales Office

SENSIRION AG
Laubisrütistr. 50
CH-8712 Stäfa ZH
Switzerland

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