SHTxx
Humidity & Temperature
Sensmitter

Application Note
Non-Linearity compensation

1 Introduction

The SHTxx devices show a small non-linearity of the humidity and temperature sensors.
This application note describes various ways to compensate it in the attached microcontroller.

2 Relative Humidity Non Linearity

If the formula on page 5 of the SHT1x / SHT7x datasheet is too complex and therefore too computation intense, the follow calculations may provide simplified alternatives.

The examples are based on a 8 bit humidity readout. 12 bit readouts can be converted with similar formulas but with a slightly more complex calculation.

Type of calculation	Inaccuracy due to non-linearity (10-90%RH)	Complexity of calculation
linear	± 2.2% RH	Simple (8bit subtract, right shift)
2 * linear	± 0.8% RH	Quite simple (8bit multi, 16bit add/subtract)
Polynomial 2nd order	± 0.1% RH	Floating point multiplications

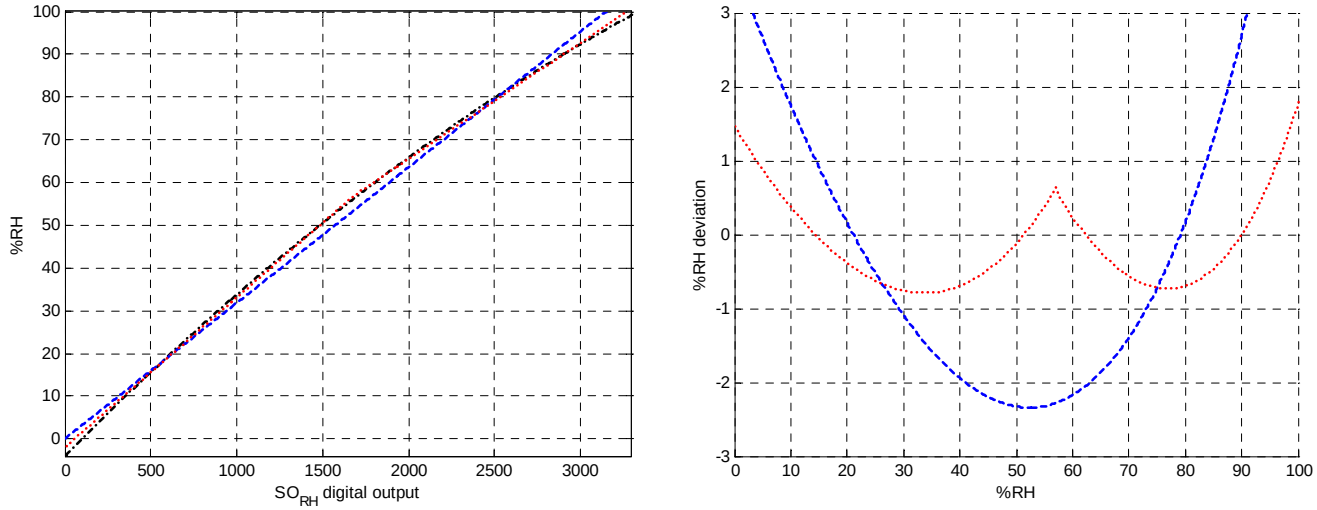

Figure 1 Inaccuracy due to non-linearity, original(from datasheet, black, dash-dotted), linear (blue, dashed) , 2* linear (red, dotted)

2.1 Linear

The most basic conversion formula from sensor output to %RH is:

$$RH_{simple} = c_1 + c_2 \bullet SO_{RH}$$

with $c_1 = 0.5$; $c_2 = 0.5$

2.2 2* linear

For improved accuracy with minimal calculation complexity the following calculation is recommended:
$RH_{real} = (a*SO + b) / 256$
Where SO denotes the 8 bit humidity sensor output signal.

Validity	a	b
$0 \leq SO \leq 107$	143	-512
$108 \leq SO \leq 255$	111	2893

With the above values the calculation can be done with a single 8 bit multiplication followed by a 16bit addition / subtraction.

For a 16 bit SO, $RH_{real} = (a'*SO' + b') / 4096$, where SO' denotes the 12bit sensor output signal and a' = a, b'= b*16. The validity limits also have to be multiplied by 16.

Sample Code 8 bit SO:

```
u16 result;          // 16Bit unsigned for the result
u08 sensor_out;      // 8Bit unsigned for the sensoroutput

sensor_out = readSensor8(); // read 8 bit humidity value from SHTxx

If ( sensor_out <= 107 )
{
   result = mult8Bit( 143, sensor_out );      // result = a * sensor_out
   result < 512 ? result = 512;               // check for underflow
   result = result – 512                      // result = result + b
}
else
{
   result = mult8Bit( 111, sensor_out );      // result = a * sensor_out
   result = result + 2893                     // result = result + b
   result > 25600 ? result = 25600;           // check for overflow (optional)
}

//8 MSB’s are 0-100%RH integers, 8 LSB’s are remainder

result = result >> 8  // result = result / 256
```

2.3 Polynomial 2nd order

Please consult the SHT1x/ SHT7x datasheet for formula and coefficients.

3 Temperature Non Linearity

Due to the inherent properties of the bandgap PTAT (Proportional To Absolute Temperature) temperature sensor, the temperature output signal is not fully linear.
For improved accuracies in extreme temperatures please use the following formula:

$$\text{Temperature} = d_1 + d_2 \bullet SO_T + d_3 \bullet (SO_T - f)^2$$

with d_1 and d_2 as specified in the SHTxx datasheet page 5.

SO_T	d_3 [°C]	f
14bit	-2e-8	7000
12bit	-3.2e-7	1750

This results in a correction of about -1°C at –40°C or 100°C compared to the linear formula.

4 Revision History

Date	Revision	Changes
October 20, 2001	0.9 (Preliminary)	
February 10, 2002	1.0	modified to final coefficients
February 15, 2003	1.1	added Temperature information
Oct. 17, 2003	1.2	Changed download link
May 10, 2004	1.3	Added Temperature non linearity information
October 19, 2004	1.31	Added 16 bit information in chapter 2.2
May 25, 2005	1.32	Changed company address
Oct 3, 2006	1.4	Sensirion Inc. address added

The latest version of this document and all application notes can be found at:
www.sensirion.com/humidity

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