Build a digital thermo-hygrograph (Part I)

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Temperature and humidity are two of the most commonly measured environmental data. Browsing the internet for "temperature and humidity sensor", I was directed to Parallax Inc. (www.parallax.com). There are several excellent articles on Parallax's web site plus all necessary information for interfacing a Sensirion's SHT11 temperature & humidity sensor with a BASIC STAMP microcontroller. SHT11 temperature and humidity sensor from Sensirion AG (www.sensirion.com) is like the skin of a microcontroller. It senses the environment of temperature and relative humidity and outputs the measurement results in form of calibrated digital data.

Figure 1

With my old "STAMP in CLASS" educational board, what I need is nothing but a few samples of SHT11 sensor (Figure 1). Though I could have bought the Sensirion SHT11 sensor in a DIP8 pre-mounted configuration at US$29 from USA to Hong Kong, I have chosen a less accurate model SHT10 for testing purpose.

	Humidity accuracy (%RH)	**Temperature accuracy (K) @ 25°C**
SHT10	±4.5 %RH	±0.5K
SHT11	±3.0 %RH	±0.4K

Table 1

Indeed, the SHT11 is more accurate than SHT10, but SHT10 is much cheaper and good enough for testing. Nevertheless, SHT11 and SHT10 share the same hardware/software interface and PCB footprint. If there is a more serious application in the future that requires the accuracy of SHT11, I can always replace the SHT10 with a SHT11 with no modification on the same PCB pads.

There are only four wires required to connect the sensor with BS2 board as below (Figure 2). Extra care must be taken to the temperature of the solder tip and the time of tip contact. From SHT1x data sheet, it is stated that

"Standard wave SHT7x soldering ovens may be used at maximum 235 °C for 20 seconds.
For manual soldering contact time must be limited to 5 seconds at up to 350 °C.
After wave soldering the devices should be stored at >74 %RH for at least 24 h to allow the polymer to rehydrate. Please consult the application note "Soldering procedure" for more information."

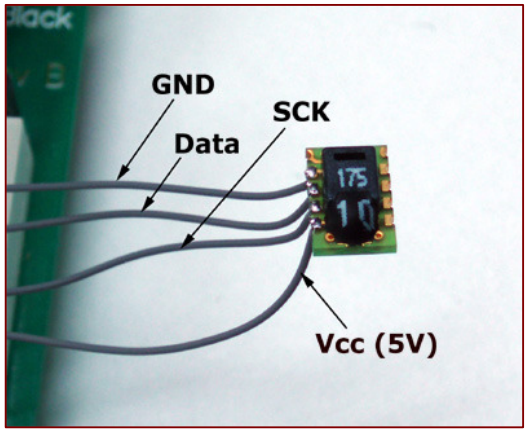

Figure 2

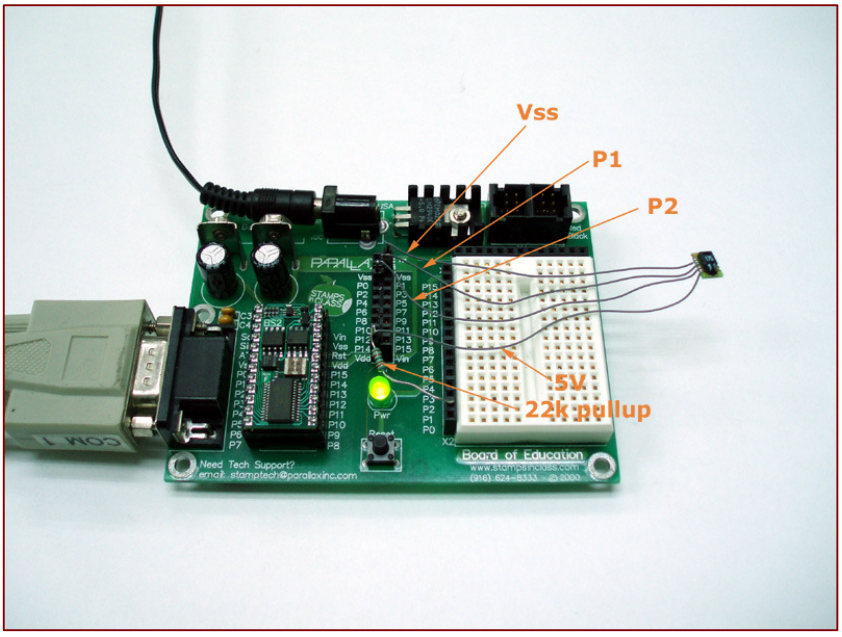

Figure 3

Parallax is excellent in supporting her customers. Just download a file SHT11 Advanced.BS2 from www.parallax.com and have it run on the BS2 education board, the following result (Figure 4) flashed on my PC.

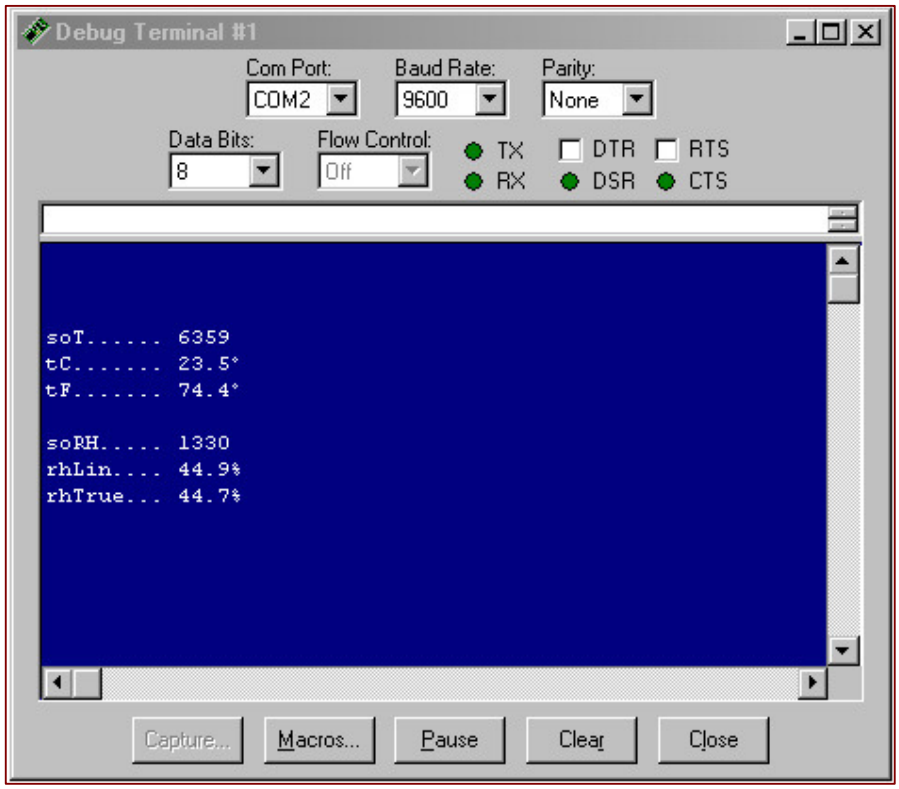

Figure 4

Almost no programming required except that I need to modify the source file about pins P1 and P2 as follows.

```
ShtData         CON     1               ' bi-directional data for Pin 1
Clock           CON     2               ' CLK for PIN 2
```

An interesting part of this experiment is to compare the SHT10 result with a low-cost digital temperature and humidity meter as show below (Figure 5). I bought the meter (model CTH-608) with HK$60 (US$7.7). At the time of measurement, it showed 22.5°C, RH @ 56%; whereas, the parallax debug windows showed 23.5°C, RH @ 44.7% from STH10 sensor!

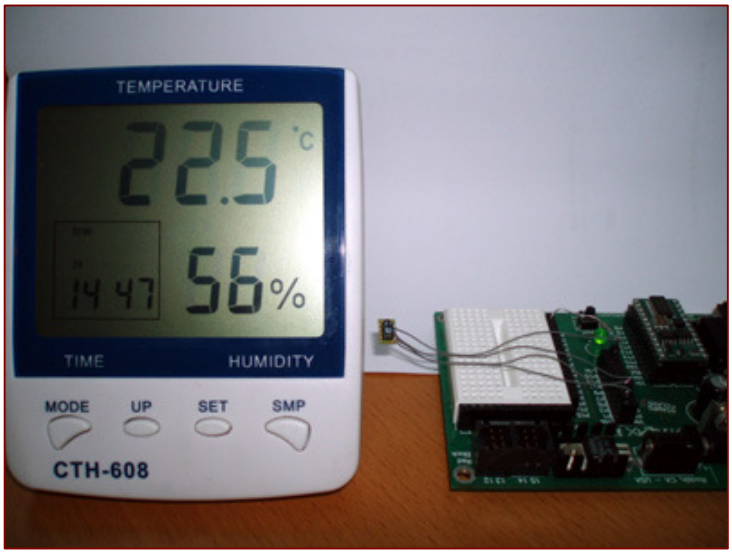

Figure 5

The problem is, which one to trust? Honestly, I won't trust CTH-608 simply because there is no data on accuracy. I don't expect an instrument-graded thermal-hydrograph out of US$7.7! However, it doesn't mean my home-made Basic Stamp experiment is something any better than the CTH-608 at this moment. From an application note obtained from Sensirion, I have learned the following fact:

"*The most accurate humidity measurement instruments are chilled mirror hygrometers. A mirror is chilled down slowly until fog forms on it. The temperature of the mirror at which fog forms is the dew point. With the dew point and actual temperature, you can calculate back to relative humidity.*"

The next logical question is, why bother making a temperature and humidity measurement device as long as there is something in the market at US$7.7?

Surely, accuracy is one thing; the other important factor is the response time of measurement. From SHT10 data sheet, it is stated that the sensor response time is 5-30 seconds. I don't know why there is such a range at this time, but I have got a good feeling on how fast SHT10 sensor responses to a change on humidity. Simply breathed out a warm, moist air from my mouth and put the SHT10 sensor nearby, I have recorded the following data (Figure 6) in 5 seconds! Yes, the sensor recorded a sudden increase from 44.7% to 83.3% RH in 5 seconds from my mouth.

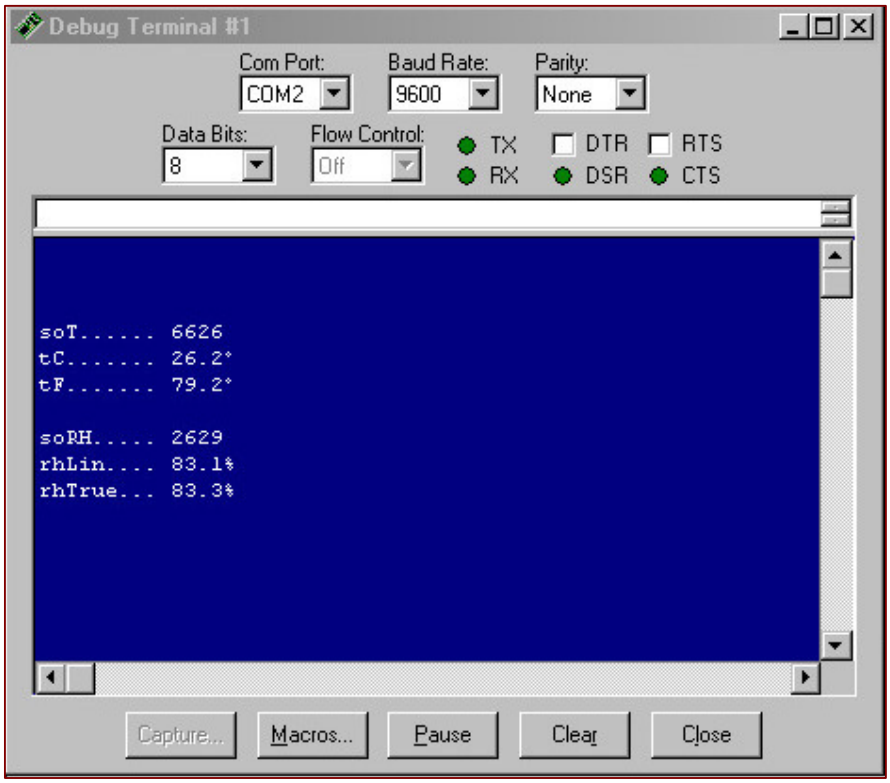

Figure 6

I have repeated the experiment with CTH-608, the following result obtained:

52% at 0 s
54% at 36 s
55% at 96 s

The RH reading on CTH-608 did not change right after I have breathed out a warm air on the sensor window. Instead, the reading made a discrete jump from 52% to 54% after 36s, then another discrete jump to 55% after 96s. During such period of time, I was not sure if the change in RH is from the environment or my mouth. Repeating experiments with SHT10 sensor and CTH-608 gave the same result. CTH-608 is not sensitive for measuring a sudden change in RH, while the SHT10 gives a very fast response within a few seconds. This properties is critical for a data logger.

As a salesman in the past, I have sold a couple of digital thermo-hygrograph (Figure 7) at more than US$300 each. This is a self-

contained recorder that makes simultaneous records on temperature and humidity for every 1 day, 8 days, or 32 days. It has bi-metal temperature sensor and nylon film humidity sensor built-in. The accuracy is ±2°C (-10°C ~ 40°C or 10°F ~ 110°F) and ±5% RH between 30% and 90%. The funny feature of this recorder is that, you need to replace paper disc and disposable pen cartridges every 1 day, 8 days, or 32 days. It depends on your choice of recorder precision. If it is in 1 day precision, you have got a good resolution in readings since the paper disc will revolve a whole circle (360°) while the red and blue pens draw temperature and humidity readings on the paper disc. At the expense of precision, you need to replace paper disc every 1 day or 8 days.

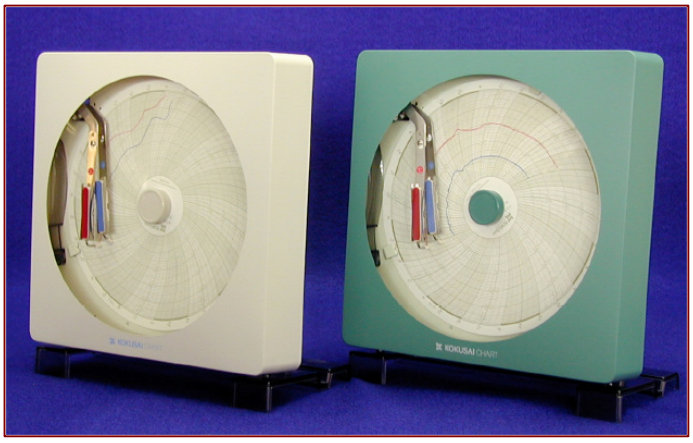

Figure 7

Conclusion:

The accuracy of SHT10 sensor is not bad comparing to a commercial thermo-hygrograph. With today's microprocessor, it is possible to build a digital thermo-hygrograph that contains a SHT1x sensor, graphical LCD display, mcu, and an mmc card. Readings on temperature and relative humidity will be recorded on the mmc card for data retrieval and analysis on a PC. This future device can potentially improve current paper-based digital thermo-hygrograph in the market.

Resources:

www.parallax.com
www.sensirion.com
www.emesystems.com/OL2sht1x.htm

To be continued.