Application Note
Interfacing HUMIREL humidity Sensor with MCU

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Objective

Interfacing Humirel sensors HS1101 LF / HTS20XX with low cost MCU to perform %RH measurement.

Introduction

HUMIREL humidity sensors are designed for cost sensitive applications such as automotive cabin air control, home appliance and industrial process control systems.
Devices such as HS1101 LF and HTS20XX are capacitive sensors with rugged characteristics and excellent metrology behavior.

HUMIREL suggests to include these sensors in very simple circuitries such as 555 timer or astable oscillator using a NAND or a comparator. The output signal (frequency or voltage) is then fed into a comparator / counter for threshold detection or MCU for more accurate calculation.

In order to reduce the overall cost of the customer system, direct interfacing with MCU is feasible by directly connecting the sensor to the input or output of micro controller. This application note shows different circuit configurations using various resources available on small micros such as Microchip, ST, Motorola, Atmel…

Features

- Cost effective solution.
- Automatic calibration.
- Accurate measurement of humidity.
- No external active component required.

1. MCU overview

Micro controller are more and more used in the consumer market, very low cost solutions are available to make devices and applications more “intelligent”.
8-bits micro controllers are manufactured by several companies, these micros are widely used in home automation and many other fixtures.

HC05XX from Motorola, PIC16FXX micro controller from Microchip and many others are low-cost, low-power and easy of use (see Figure1).

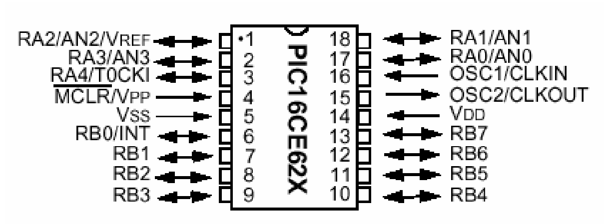


Figure1

Different resources are available on each micro most common ones are:

Time measurement

Micro controller usually run at frequencies between 4Mhz and 20Mhz, these frequencies are divided internally to reach a resolution of measurement between 1us and 250ns. An 8-bit or 16-bit internal time counter is available and will be used to measure periods and elapsed time.(see Table 1)

Internal frequency	Timer resolution	8-bit length	16-bit length
1MHz	1us	256us	65536us
2MHz	500ns	128us	32768us
4Mhz	250ns	64us	16384us

Table1

Input & output

I/O pins are available with threshold detection of about 2.5 volts with an hysteresis of 100mV. These pins depending on their sink current capability will be used to drive LED, relays, sensors … (see Table 2)

I/O ports	Min	Max.	Unit
Input Low voltage	Vss	0.15Vdd	V
Input high voltage	2	Vdd	V

Table 2

Smith trigger input

These inputs are very useful as they offer the possibility to detect two different thresholds. (see Table 3)

I/O ports Schmitt Trigger	Min	Max.	Unit
Input Low voltage	Vss	0.2Vdd	V
Input high voltage	0.8Vdd	Vdd	V

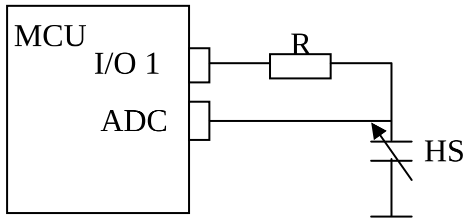
Table 3

Voltage measurement

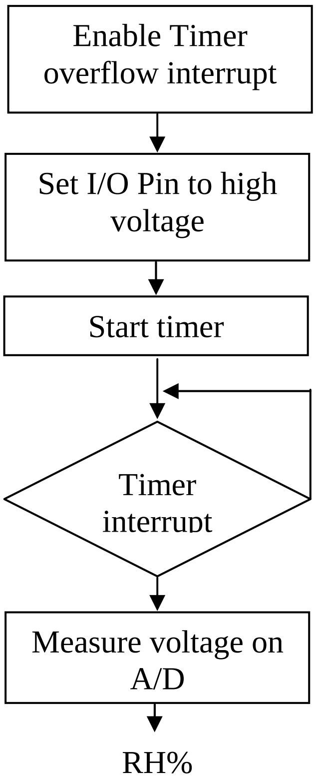
A/D converters are available with different resolutions some of them have an 8-bit resolution (steps of 20mV) and some others have a 10-bit resolution (steps of 5mV).

2. Voltage measurement

MCU required resources:	internal TIMER A/D converter I/O Pin



I/O1 initiates the charge of the sensor through R. When an internal reference time is reached, the MCU converts the voltage at the sensor pads in its internal ADC.



This circuit shows a small dynamic range (some hundreds of millivolts) due to the nominal value of the sensor. The resolution is correlated to the ADC resolution and bias. As an example, with a 400mV of dynamic, a standard internal 8-bits ADC of 0-5V, the maximum resolution which can be expected is 5%RH.

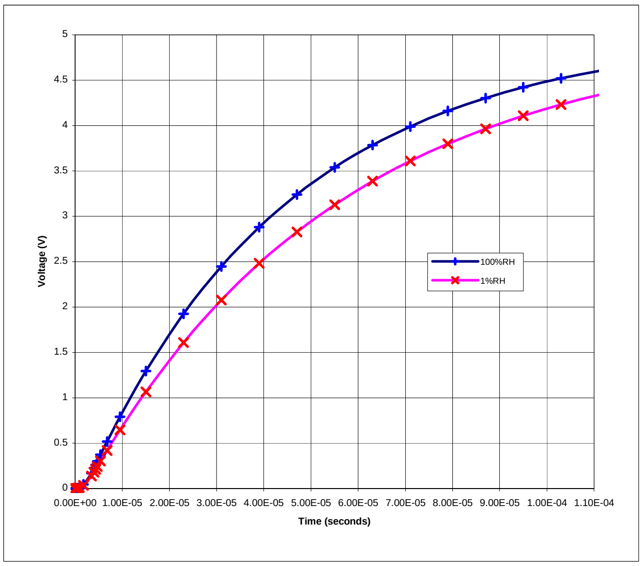


Figure 2
(R=270K)

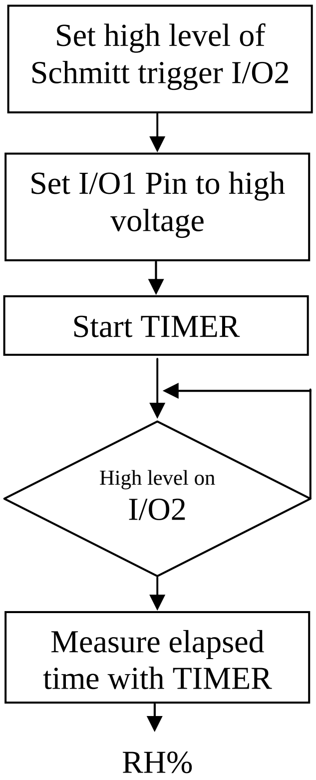
Looking to the Figure 2 the best dynamic range is around 50 to 60 us.

This kind of method should be used when detecting a threshold or a humidity variation .

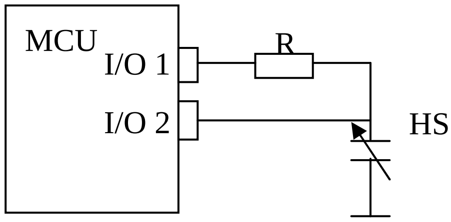
3. Time measurement

MCU required resources:	internal TIMER I/O2 Schmitt trigger I/O1 Pin

The principle is very close from the voltage measurement (see previous paragraph). I/O1 initiates the charge of the sensor through R. The timer input usually has a NAND gate input or a Schmitt trigger input. The “0” to “1” threshold voltage is used as a comparison voltage. When the threshold voltage is reached the timer stops running. The counted time is directly proportional to humidity. (see Figure 3)



This circuit typically exhibits a dynamic range of approximately 0.45us/%RH. This requires a fast clocked MCU in order to achieve a good resolution.



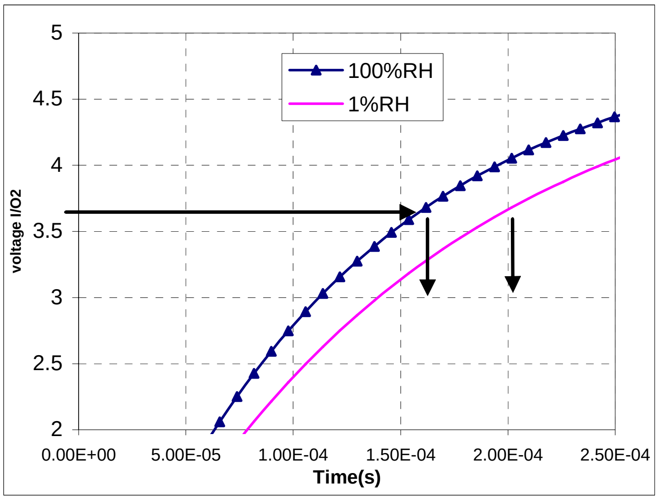


Figure 3

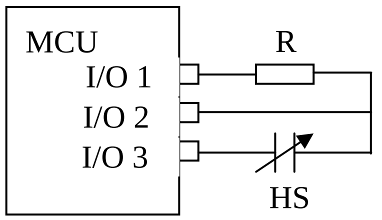
As an example, for 1%RH resolution, the internal MCU clock should run at 2 MHz. This may triggers the choice of the MCU, since internal clock frequency may run up to 1/4th of the external quartz oscillator (typically 4 or 8MHz).

This design provides a simple interface and accuracy can be improved with a trimming resistor. This option may be preferred when the MCU has a 16 bits timer available.

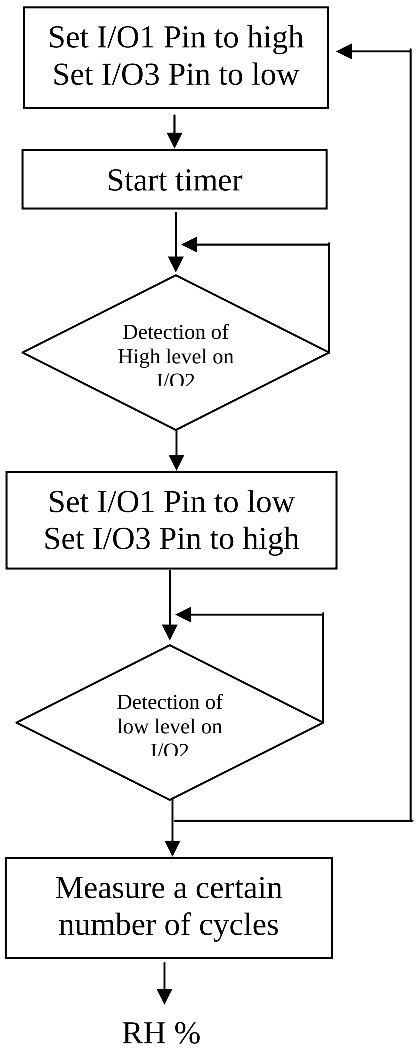
4. Frequency Interface

4.1 frequency interface using I/O pins

MCU required resources:	internal TIMER I/O1 and I/O3 I/O2

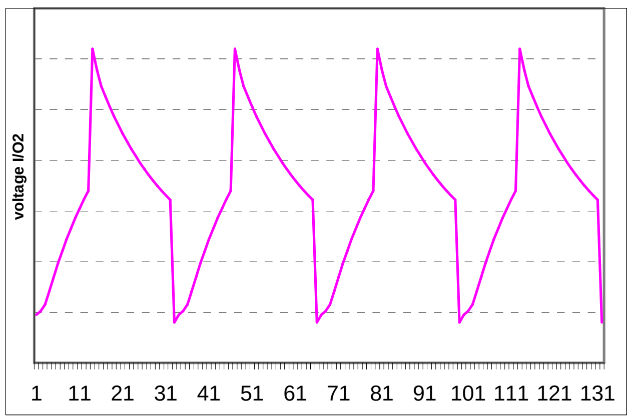


The principle is to charge and discharge the sensor through R. In order to achieve a free oscillating circuit, I/O1 and I/O3 should be logically inverted and toggled each time I/O2 logic value changes. As in the voltage interface circuit, the “0” to “1” threshold voltage is used as a comparison voltage but also the “1” to “0” threshold. In standard CMOS chip, it is usually Vcc/2.



I/O1 and I/O3 are standard input-output pads and should be configured as outputs. I/O2 should be a Schmitt trigger pad. The period (image of the humidity) or frequency is measured by a MCU timer through I/O2. Therefore, the resolution depends directly on the MCU frequency.

Figure 4 shows the signal at I/O2 pin when the sensor is charged and discharged.

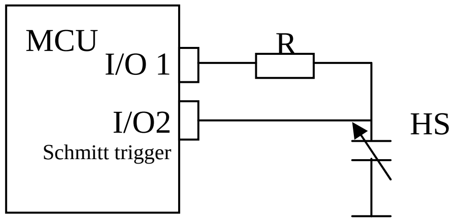


This design provides a very good resolution (better than 1%) when using a 20 MHz MCU with 16 bits timer.

Please refer to appendix 1 for example and preliminary results obtained with a PIC16F627.

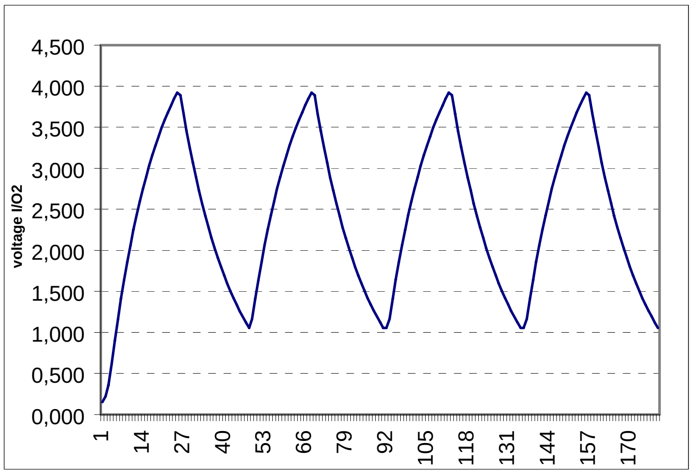
4.2 SCHMITT Trigger input

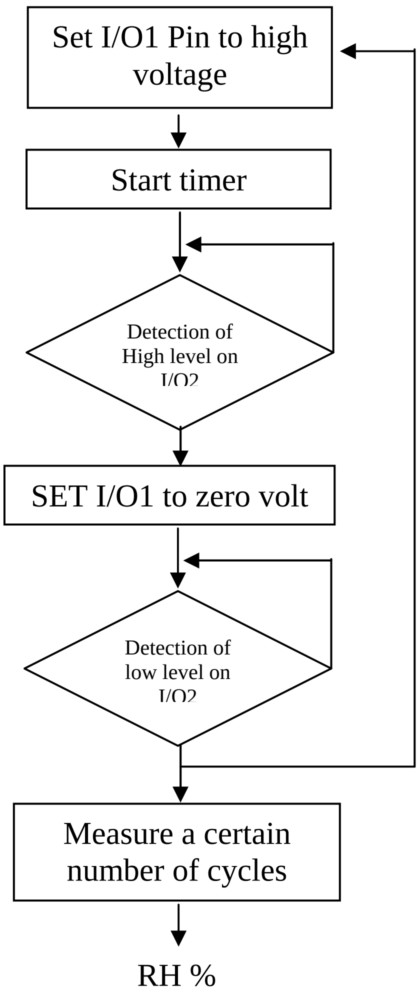
MCU required resources:	internal TIMER I/O 1 I/O 2 Schmitt trigger



NB: The Schmitt trigger input has two threshold levels as described in paragraph 1.

The I/O 1 is set to logical “1”, the sensor is charged through R. When the first threshold voltage is reached, I/O 1 should be set to a logical “0”. The sensor is then discharged through R, down to the second threshold voltage at which I/O 1 should be set to “1” again .





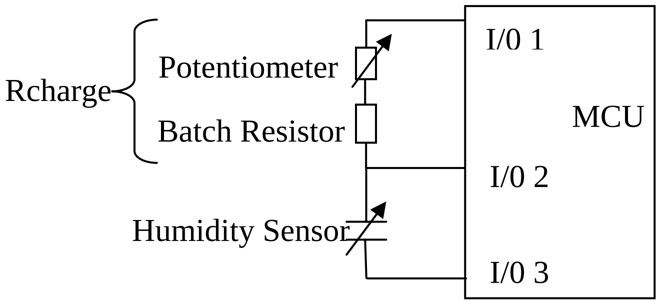
5. Calibration process

The calibration of this system should be done using internal EEPROM of MCU, of course a hardware calibration could be done by trimming the R_{charge}. Only one point calibration is required to get ±5%RH accuracy in the range of 10%RH to 90%RH.

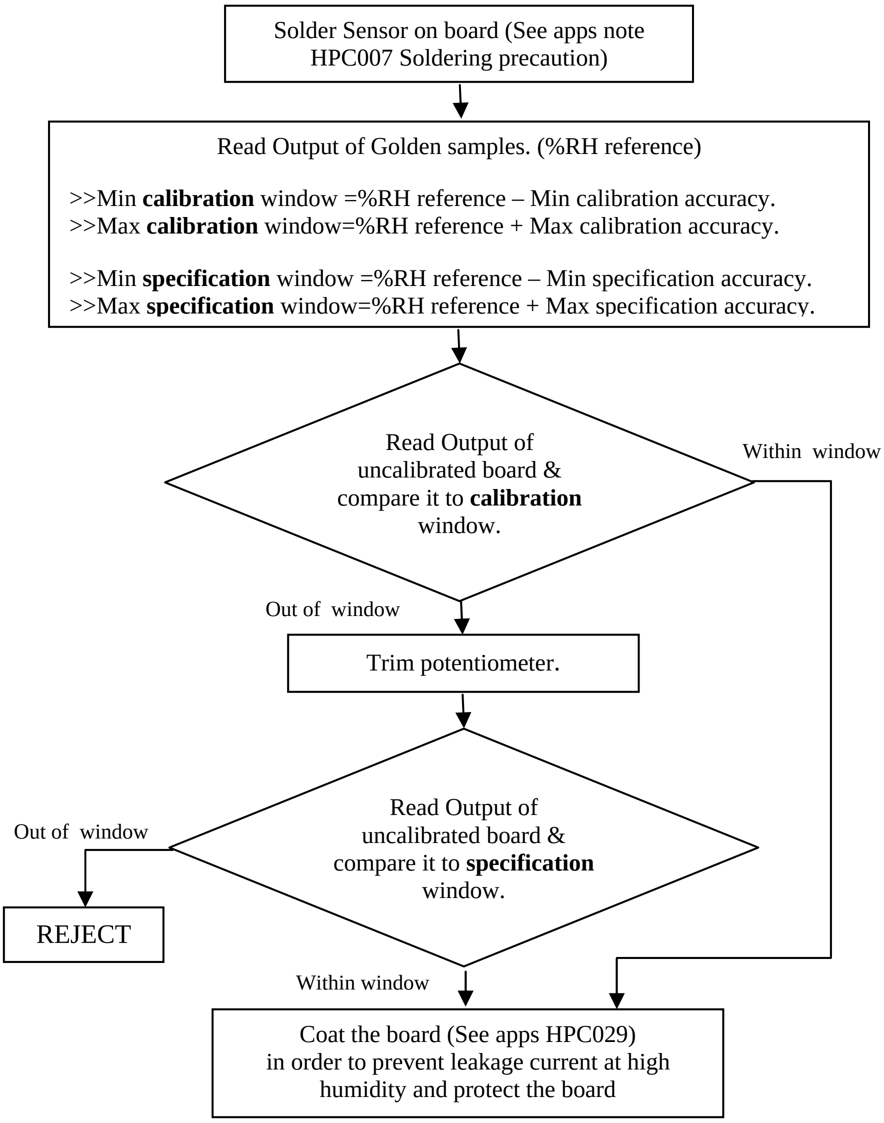
Before starting calibration, a humidity reference is required. Usually, a certain number of boards are calibrated under a well monitored humidity and temperature environment. Those boards are used as reference, their frequency output is the target to reach for boards to be calibrated. Golden samples can be calibrated at HUMIREL facility.

Hardware calibration:

In this case, Rcharge is constituted by a batch resistor in series with potentiometer.
Potentiometer should be adjusted, to get microcontroller %RH output values in agreement with humidity reference.

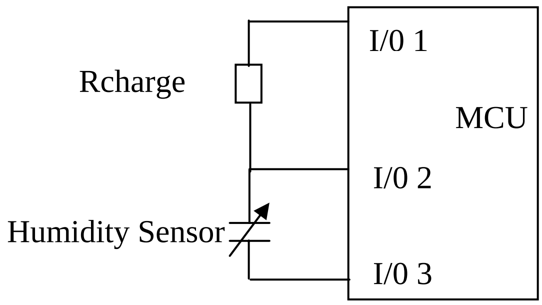


Calibration of boards at production area:

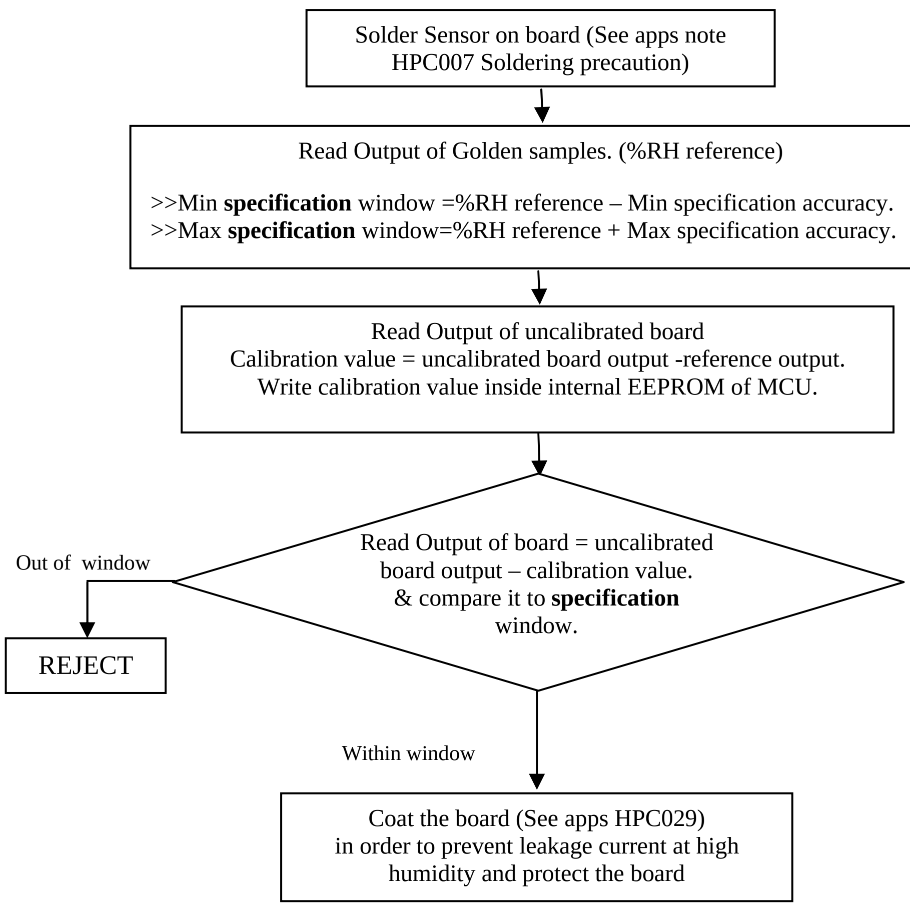


Software calibration:

In this case, Rcharge is constituted by a resistor. Calibration value implemented inside EEPROM of MCU is used to get microcontroller %RH output values in agreement with humidity reference



Calibration of boards at production area:



Conclusion

Using HS1101LF or HTS20XX and an appropriate simple MCU this direct interface method provides a single point calibration procedure to reach ±5%RH accuracy.

Please fell free to contact us if you should need any assistance.

REFERENCES

- HPC052 : Relative humidity sensor HS1100LF / HS1101LF.
- HPC055 : Temperature and Relative humidity sensor HTS2030.