Developer's Guide

HC109

Miniature SMD Capacitive Humidity Sensor

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1 Driving circuitry for HC109

HC109 is a capacitive, thin-film sensing element for relative humidity (RH) in SMD architecture, designed for mass production assembly lines. Typical applications are automotive, consumer electronic and home appliances.

Key features for easy design-in and high measurement performance:

- Outstanding linearity over the entire humidity range 0 – 100%.
- High reproducibility of the sensor data. This is valid also for the temperature dependence, which allows for efficient software temperature compensation, and consequently for high accuracy over a wide temperature range.

HC109 is a passive, not adjusted sensing element, and requires humidity adjustment/calibration for each individual measuring device built with it. The accuracy of the measuring device depends primarily on the overall uncertainty of its adjustment process.

A recommended driving circuitry for HC109 is described in §2 “Schematic circuit diagram”. This is a highly cost efficient solution because it makes use of the microcontroller already available on board.

Features of the circuitry based on existing microcontroller:

Very low material cost of approx. 0,05 €
Electronics accuracy of ±1 % RH with reference adjustment
Customer specific digital output depending on the microcontroller

2 Schematic circuit diagram

A detailed description of the circuitry is available in the E+E patent EP 1 574 847 B1 // US 7,084,644 B2.

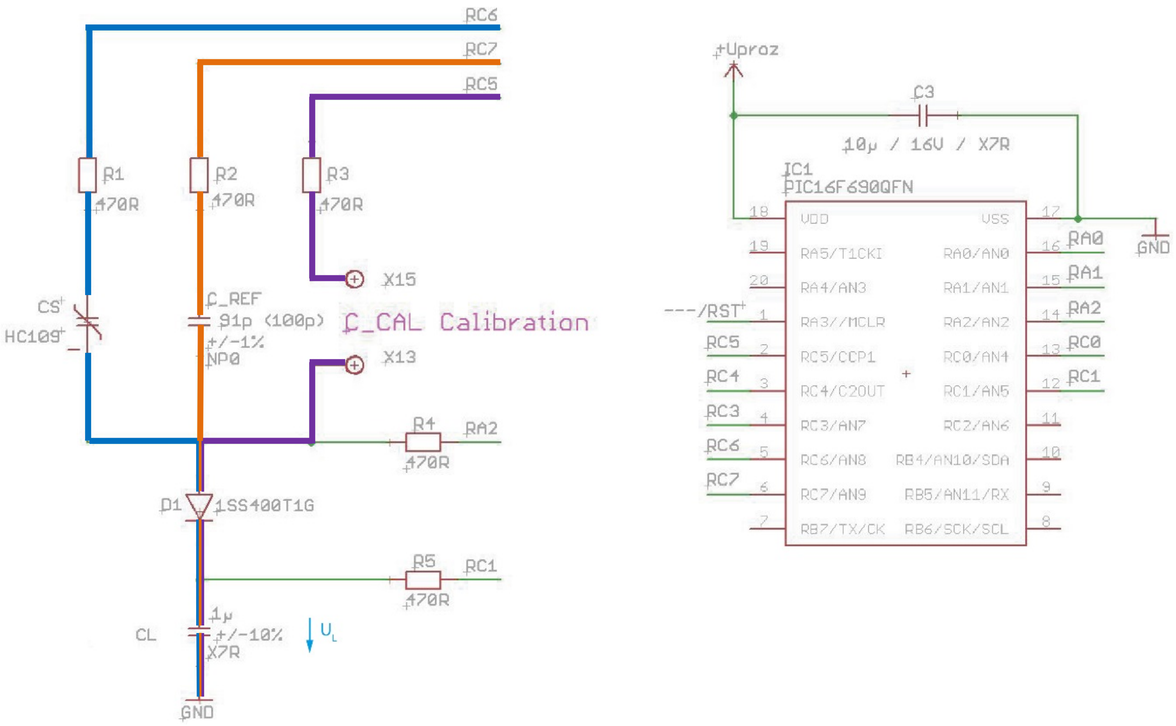


Figure 1: Schematic circuit design[1]

For best performance, the driving circuitry should include three measurement paths:

1.) **Measurement** path used for humidity measurement in normal operation
R1 + HC109 + D1 + C_L

2.) **Reference** path used also during humidity measurement in normal operation for exact evaluation of the HC109 capacity. R2 + C_REF + D1 + C_L

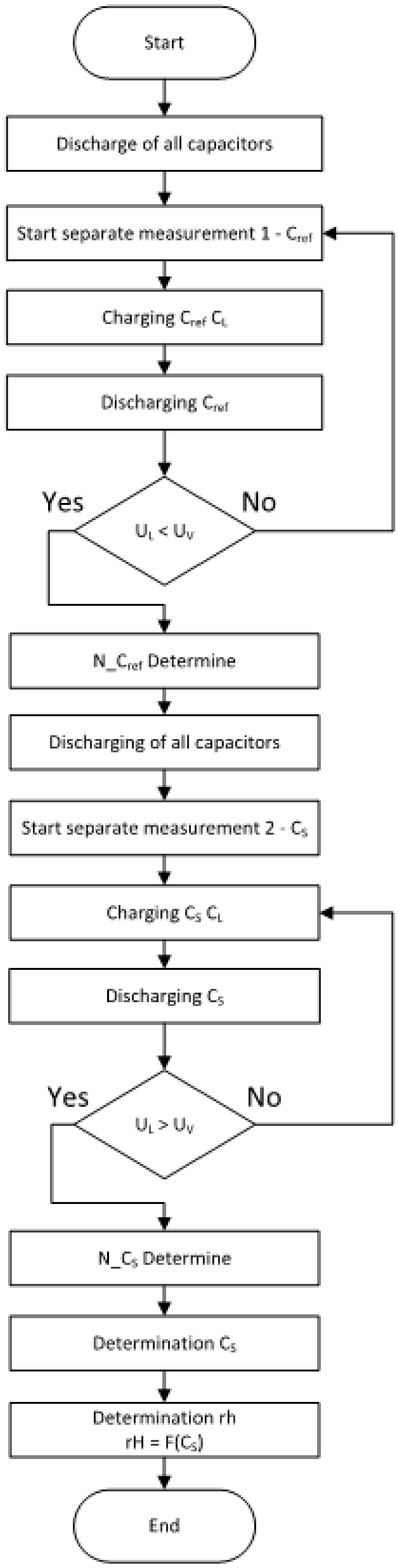
3.) **Calibration** path used during the manufacturing for testing the electronics with a reference capacitance R3 + C_CAL + D1 + C_L

U_L = voltage at C_L

U_V = Voltage at the µC internal voltage divider (reference voltage)

C_Cal= Capacitance which is used for calibration end testing [no soldering necessary]

All three measurement paths measurement, reference and calibration use the same algorithm.



Example: reference path

1.) Discharge all capacitors
(I/O pins RC1, RC5, RC6, RC7 and RA2 = output LOW)

2.) Charge reference capacitor and C_L (RC6, RC5, RA2 = input, RC1 = switched to comparator input, RC7 = output HIGH).

The charge of the reference capacitor is also transferred to the capacitor C_L and the voltage in C_L rises a little bit. CL is approx. 10.000 times higher than C_REF.

3.) Discharge reference capacitor (RC6, RC5 = input, RC1 = switched to comparator input, RA2, RC7 = output LOW).

4.) Increment the number of charge/discharge events (in this case N_C_{Ref}).

5.) Check if the voltage U_L at the pin RC1 (comparator) equals the reference voltage U_V at the µC internal voltage divider.

no ➔ repeat point 2.) and recharge the reference.

yes ➔ end of loop and save the numbers of charge/discharge events.

6.) Each cycle measures the reference path and the sensor path and calculates the sensor capacitance C_s from these measurements.

$$C_s = C_{Ref} * \frac{N\_C_{ref}}{N\_C_s}$$

3 Bill of Materials

Quantity	Symbol	Device	Dimension	Supplier
1 pc	HC109	Humidity sensor	HC109	E+E Elektronik
1 pc	D1	Fast Si-Diode	1SS400TiG	
1 pc	CL	Resistor	1 µF, ceramic / X7R	
1 pc		Existing microcontroller	PIC16F690	Microchip
1 pc	C_REF	Capacitor	91 pF (100 pF*), ceramic / NP0 / CG0	
5 pcs	R1-R5	Resistor	470 Ω	

(*) For use at continuous high humidity (> 85% RH) the recommended C_REF = 100 pF

Requirements for the microcontroller

1.) 3 to 4 digital I/O pins, switchable between output and (analog) input
2.) Integrated comparator switchable to digital I/O output (external component also possible)
3.) Integrated voltage divider used as reference voltage at comparator (external component also possible)

4 Hints for the development engineer

For accurate measurement, it is of utmost importance to reduce as far as possible any stray capacitance (and by this its variation with temperature and humidity) related to the printed circuit board. This might require several test and layout optimizing loops. These imply tests for assessing the impact of the stay capacitance and its variations on the output signal of the device, as follows:

1. Test a sample of relevant size at defined environmental conditions (various combinations of humidity and temperature) for determining the spread of the characteristic of the device including HC109 sensor.

2. Test a batch of printed circuit boards with a known, accurate capacitor instead of the humidity sensor at defined environmental conditions (various combinations of humidity and temperature) for determining the impact of the electronics board on the output signal.

The electronics design shall be optimized for narrow spread of the characteristic of the entire device and for minimum impact of the electronics layout on the output signal.

5 Contact information

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6 Revision history

Date	Revision number	Changes
October 2016	V_1.0	Initial release