Proposed Integrated Temperature and Humidity Digital Sensor for the RICH Detector

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In this note, a new, integrated temperature and humidity digital sensor, the Sensirion SHT85, is proposed for the RICH detector, for which accurate measurement of temperature and humidity is critical.

The Sensirion SHT85, released for sample testing in November 2018, is a low-cost, complete sensor system on a *single chip*. SHT85 consists of a capacitive humidity sensor, a bandgap temperature sensor, analog to digital converter, calibration data memory, measurement data processing, and a digital communication interface. Figure 1 shows the internal block diagram of SHT85.

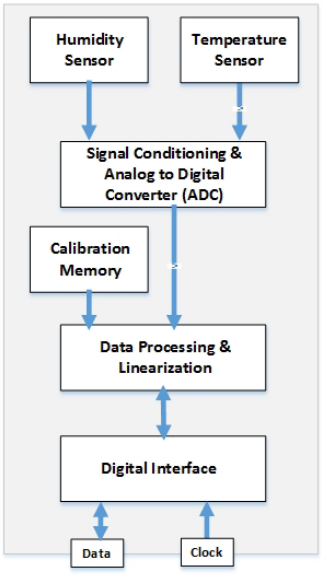

FIG. 1. Sensirion SHT85 block diagram.

For humidity measurements, SHT85 covers the range 0% to 100% RH and for temperature measurements, the range is -40°C to 105°C with an accuracy of ±1.5% RH and ±0.1°C, respectively. Table I summarizes the SHT85 specifications.

Each SHT85 sensor is individually calibrated at the factory. During factory calibration, the internal memory is programmed with the linearization and temperature compensation calibration data for that specific sensor. All linearization and temperature compensation corrections occur within the sensor's internal circuity prior to the transmission of the measurements. Additionally, each sensor has a unique serial number that can be read out via the status register.

Data and commands are received and transmitted by SHT85's digital I²C communication interface, which consists of a two-wire communication bus that supports bidirectional data transfer between a master and slave, Fig. 2.

With each temperature or humidity data word sent by the sensor (slave), a cyclic redundancy check byte is calculated and transmitted. Upon reception, the calculation is repeated by the master to verify data integrity. In the event the values do not match, data is flushed.

Incorporating all supporting circuitry and calibration corrections internal to the sensor reduces system complexly. Since an external ADC for humidity and RTD module for the temperature measurement is not needed, system reliability is increased and readout costs reduced.

	Parameter	Specification
Humidity	accuracy	± 1.5% RH
	long-term drift	< 0.25% RH/yr
	operating range	0–100% RH
	resolution	0.01% RH
	repeatability	0.08[1] % RH
Temperature	accuracy	±0.1°C
	long-term drift	< 0.03°C/yr
	operating range	–40–105°C
	resolution	0.01°C
	repeatability	0.04[1]°C
Communication interface	I²C	
Supply voltage range	2.15–5.5 V	
Measurement duration	13 ms	
Avg. current consumption	1.7 µA	

1 The stated repeatability is three times the standard deviation (3σ) of multiple consecutive measurement values at constant operating conditions.

TABLE I: Sensirion SHT85 specifications.

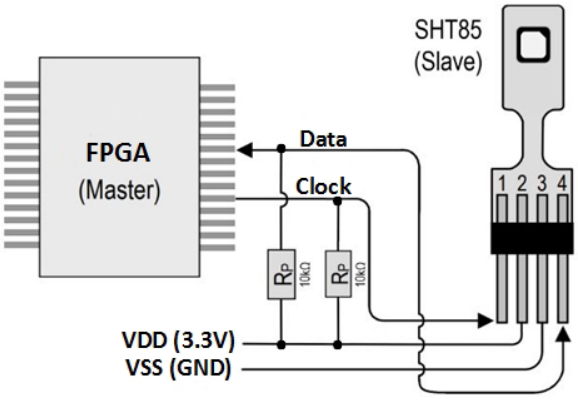

FIG. 2. SHT85 application diagram.

In detector systems, the space available for sensors, cabling, and connectors is often at a premium. The integration of the temperature and humidity sensors, along with the serial digital interface, significantly decreases sensor size and the number of required cables and connectors.

The SVT, RICH, and Forward Tracker use a dual sensor board consisting of two Honeywell HIH 4030-003 humidity sensors and two Omega RTD-3-F3105-36-T. Figure 3 illustrates the size difference between the new SHT85 board and the currently used dual sensor board. Table II compares the features of the sensors.

In conclusion, the Sensirion SHT85 integrated temperature and humidity digital sensor has many advantages over the existing analog measurement system and for this reason is proposed for the new RICH detector.

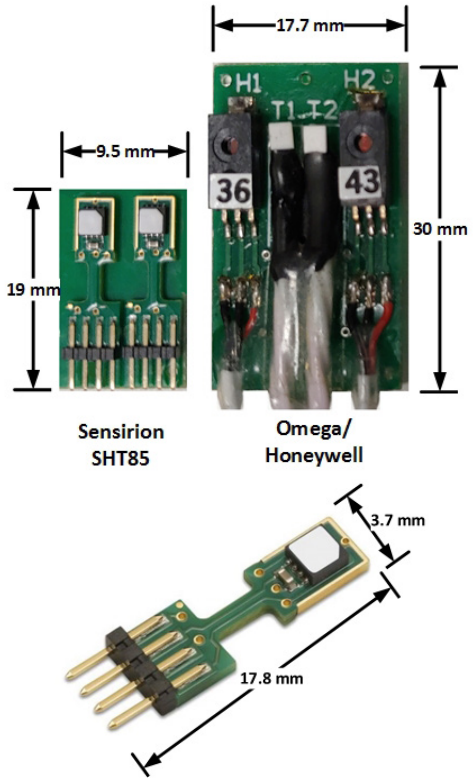

FIG. 3. Dual sensor board size comparison.

Parameter	Omega/Honeywell	Sensirion SHT85
Accuracy	humidity: ±3.5% RH, temperature: ±0.15°C	humidity: ±1.5% RH, temperature: ±0.1°C
Sensor configuration	separate temperature and humidity sensors	integrated temperature and humidity sensor
Interface signal	humidity: analog V, temperature: RTD resistance	digital serial interface using two-wire I^2C communication protocol
Data error-detecting	none	cyclic redundancy check on each measurement (temperature and humidity)
Calibration of output	user must externally linearize and calculate temperature compensation on analog output	linearization and temperature compensation calculations are done internally by sensor
Size of PCB	17.7 mm x 30 mm	9.5 mm x 19 mm (66% reduction in size)
# of Conductors	14 conductors, 4 wires	8 conductors, 2 wires (2x wire reduction)
Connector	none; wires soldered directly to sensor and PCB	integrated 4-pin connector (easy replacement)
Sensor protection	none	sensor opening is covered by PTFE membrane to protect sensor from dust and contaminants
Readout electronics	requires 2 ADC channels for humidity and 2 RTD readout channels for temperature	2 digital, serial data channels
Supply voltage	Honeywell humidity sensor: +5 V, humidity measurement is dependent on supply voltage	2.15 V to 5.5 V; humidity measurement not dependent on supply voltage
Cost/PCB (sensors)	$140 total for 4 sensors (2 temp, 2 humidity)	$50 total for 2 integrated sensors

TABLE II. Comparison of dual sensor boards Sensirion SHT85 and Omega/Honeywell.