Humidity Sensors

Humidity Overview

Humidity Sensors can be found in many products, ranging from smart home assistants to wireless base stations. The function of these sensors allow careful monitoring of environmental conditions ranging from in-home use—alerting the user of any alarming conditions that may impact air quality—to monitoring expensive wireless equipment during events in weather that can impact communication and equipment performance. Aside from the applications listed above, humidity sensors are also found in:

- Refrigeration monitoring in cold-chain transports (ensuring shipped perishables arrive fresh)
- Clothing manufacturing processes
- Smart thermostats
- Inkjet printers
- HVAC systems
- Surveillance cameras

Traditional methods in recording humidity include the use of large mechanical Hygrometers, which largely rely on measurements of temperature, pressure, thermal conductivity, or mass change during moisture absorption. While these traditional devices provide highly detailed data after calibration, advances in technology have paved the path towards the use of a significantly smaller alternative of incorporating a humidity-sensing device in an integrated circuit. As Moore’s Law has predicted the scaling of transistors in semiconductor technologies, it has also enabled the microminiaturization of sensing elements, which are now fairly commonplace in ICs.

Largely due to their chemical and physical properties over a wide range of characteristics, polymer thin film technologies are the primary sensing components in most humidity-sensing integrated circuits. This thin material reports and encapsulates humidity information in the form of capacitive, resistive, or thermal change.

The primary type of humidity information reported by these sensing ICs is Relative Humidity (RH). Relative Humidity can be described as the ratio of the amount of water vapor present in the air versus the amount of vapor the atmosphere can hold at a given temperature. The equation for relative humidity is shown in Equation 1. The different Saturated Vapor densities (SVD) of water for a given temperature is shown in Figure 1.

$$\text{Relative Humidty (\%)} = \frac{\text{actual vapor density}}{\text{saturation vapor density}} \times 100 \quad (1)$$

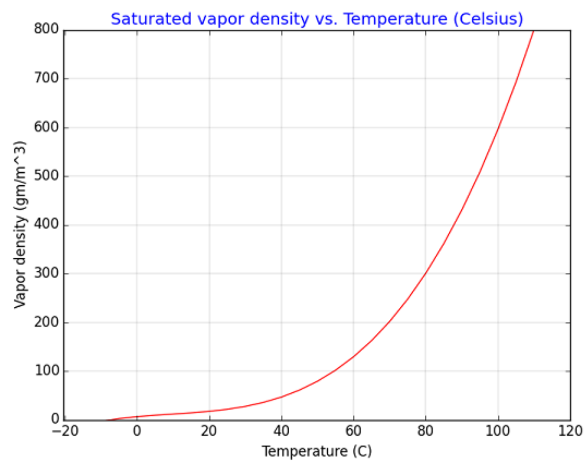

Figure 1. Saturated Vapor Density vs Temperature Graph [1]

Due to the limited moisture content the air can hold at a given temperature, it is apparent that RH will gradually increase to 100% if the air is cooled while maintaining constant moisture content. The point where the environment becomes completely saturated is often described as dew point, as any temperature below this saturation point will result in condensation.

Humidity Sensing

One primary method in capturing Relative Humidity information is through capacitive sensing. These sensors consist of two conductive electrodes that sandwich a thin film polymer dielectric. As humidity increases, the polymer begins to absorb water molecules from the surrounding (air) environment, which alters the dielectric constant of the capacitor sensor. Depending on the technology and integration, this capacitance can be as low as <1 pF (low RH) to >800 pF (high RH). Response times can additionally range from a few seconds to minutes.

(1) The empirical fit equation of saturated vapor density vs temperature used to graph Figure 1 was obtained from http://hyperphysics.phy-astr.gsu.edu

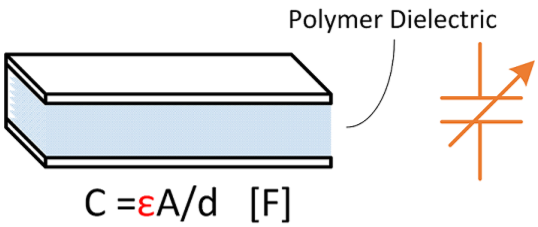

Figure 2. Capacitor With Polymer Dielectric

To measure the developed potential across the capacitor, an integrated signal-conditioning circuit amplifies the voltage produced across the sampling capacitor and multiplexes this value to an analog-to-digital converter (ADC). The ADC translates this voltage into a digital code, which is then passed through a digital block for linearization. If the sensor is digital, it typically incorporates an I2C or SPI interface that enables communication to a host controller. Figure 3 shows the block diagram of the humidity and temperature sensor.

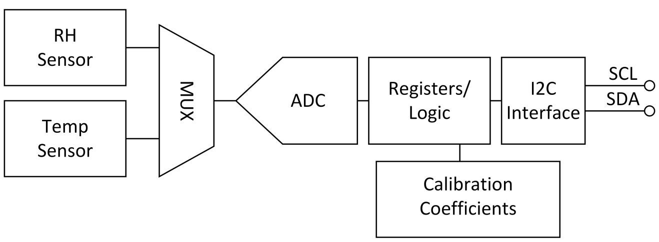

Figure 3. Relative Humidity and Temperature Sensor Block Diagram

Texas Instruments Humidity Sensors

Texas Instruments provides a wide variety of environmental sensing solutions to capture humidity and temperature information. Two of TI's latest humidity sensor solutions are the HDC2010 and HDC2080 devices. Both devices include integrated humidity and temperature sensors that provide high accuracy measurements (±2%RH typical) with very low power consumption (550 µA typical at 1.8 V). The HDC2010 features an ultra-compact 1.5-mm × 1.55-mm WLCSP (Wafer Level Chip Scale Package), while the HDC2080 features a 3-mm × 3-mm WSON package. The programmable sampling intervals, low inherent power consumption, and support for 1.8-V supply voltage, make the HDC20X0 devices well suited for battery-operated systems or applications with strict power-budget requirements.

As with all humidity sensors, the HDC devices must follow special guidelines regarding handling and storage that are not common with standard semiconductor devices. To ensure optimal performance and device longevity, the collateral in Table 1 is recommended for review.

Table 1. Recommended Collateral

COLLATERAL	DESCRIPTION
Application Report	*Humidity Sensor: Storage and Handling Guidelines*
Application Report	*Optimizing Placement and Routing for Humidity Sensors*

Table 2. External References

Website Name	DESCRIPTION
Georgia State University Hyperphysics website	http://hyperphysics.phy-astr.gsu.edu

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