

Humidity Sensor

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ABSTRACT

This application note will explain the basics of humidity sensing and some important design considerations. The application note begins with a brief description of humidity and how it is quantified. Next, some design guides to implement good system measurement are presented. Finally, different designs with HDC1000 are reviewed.

Humidity affects many properties of air, and of materials in contact with air. Water vapor is a key agent in both weather and climate, and it is an important atmospheric greenhouse gas. Humidity measurements are used wherever there is a need to prevent condensation, corrosion, mold, warping or other spoilage of products. This is highly relevant for foods, pharmaceuticals, chemicals, fuels, wood, paper, and many other products. Air-conditioning systems in buildings often control humidity, and significant energy goes into cooling the air to remove water vapor. Humidity measurements are necessary to maintain comfortable environmental conditions. An accurate humidity sensor can work in synergy with heating and cooling systems to reduce a building energy footprint.

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1 Humidity

Humidity is the presence of water vapor in air (or any other gas). In ambient air there is typically about 1 % water vapor, but this can vary to a large extent. Dry environments can cause irritation of the respiratory tract, skin and eyes. It also increases the chances of an electrostatic discharge from the body to a conductive surface. Humidity is expressed in several different ways :

Relative humidity – is the amount of moisture in the air compared to what the air can "hold" at that temperature. This is the most common used measure of humidity. Usually expressed as a percentage, with the symbol "%rh", for example "The humidity is 51 %rh". The term "relative humidity" is commonly abbreviated to RH (note this is different from the unit symbol: %rh).

$$RH \% = \frac{P_{\text{water vapor}}}{P_{\text{saturation water vapor}}} \times 100 \tag{1}$$

where $P_{\text{water vapor}}$ is the pressure of the water vapor in the air at given temperature $P_{\text{saturation water vapor}}$ represents the max quantity of water vapor that the air can hold at given temperature.

Dew point (or dew-point temperature) - the temperature at which condensation (dew) would occur if a gas was cooled at constant pressure. Dew point is a useful measure for two reasons:

- The dew point tells us what temperature to keep a gas at, to prevent condensation
- Dew point is an absolute measure of the gas humidity (at any temperature) and relates directly to the amount of water vapor present (partial pressure of water vapor).

Dew point is expressed in temperature units.

The dew point can be calculated by using the relative humidity and temperature as inputs.

$$Dp = \frac{\lambda \times \left(\ln \left(\frac{RH}{100} \right) + \frac{\beta \times T}{\lambda + T} \right)}{\beta - \left(\ln \left(\frac{RH}{100} \right) + \frac{\beta \times T}{\lambda + T} \right)} \tag{2}$$

For the range from -45°C to 60°C, Magnus parameters are given by $\beta = 17.62$ and $\lambda = 243.12 \text{ } ^\circ\text{C}$

2 Design Guide

The accuracy of a RH and temperature measurement depends on the sensor accuracy and the set up of the sensing system. The HDC10x0 sensors sample relative humidity and temperature of their direct environment. It is thus important that the local conditions at the sensor correspond to the conditions under test.

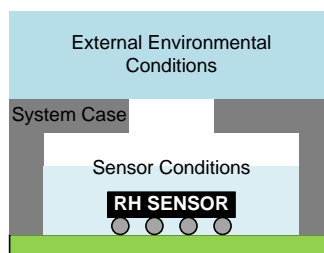


Figure 1. Same Sensor Conditions and External Environmental Conditions Guarantee Good RH Measurements

More generally, correct sampling is about making sure the measurement is representative of the condition you want to measure. Avoid temperature and relative humidity (RH) deviations between the sensor and the environment. A usual root cause for temperature deviations are heat sources, while RH deviations are mostly caused by temperature deviations as well as slow response times.

For any temperature or humidity change of the environment, the sensor requires a certain amount of time to equilibrate with the new environmental conditions. To get precise data it is recommended to improve the response time of the sensor system.

In order to optimize the measurement of the relative humidity consider the following design constraints:

- Heating
 - Conducted
 - Self-heating
- Air flow

3 Heat Conduction

The most common root cause for local heating of the sensor is due to thermal conduction from a nearby heat source (power electronics, microprocessors, displays, etc). Temperature change causes relative humidity change. Isolating the sensor from heat source is very important. To isolate the sensor from the heat source, special attention needs to be paid to circuit board design.

As thermal conduction mostly occurs through the metal in the PCB, thin metal lines and sufficient distances between the sensor and potential heat sources are recommended. Further, heat conduction can be decreased by milling slots in, and removing (etching) all unnecessary metal from the PCB around the sensor

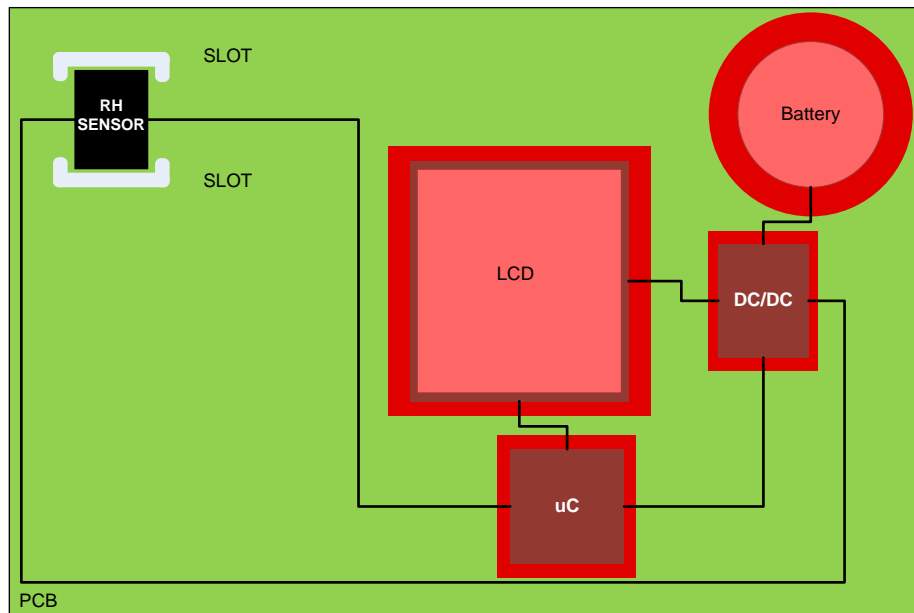


Figure 2. Example of Heating Sources in a Mobile Application

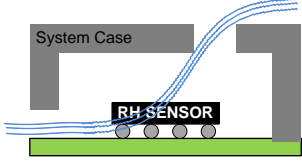
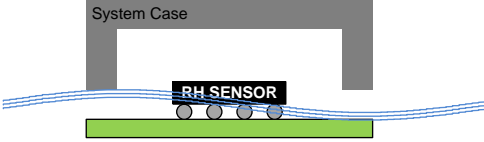
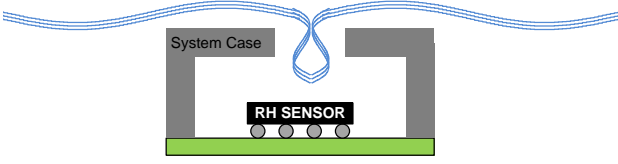
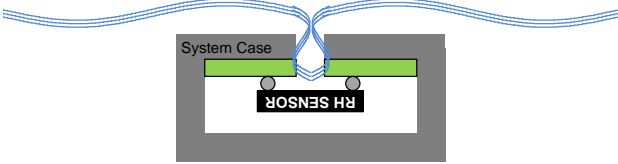
4 Self-Heating

The HDC10x0 humidity sensors have very low power consumption in sleep mode so their self-heating is very limited. The power consumption during the measurement increases and it might cause self-heating. In order to mitigate this effect it is suggested to not exceed more than 2 measurements per second at high resolution (1 measurement of temperature and 1 measurement of relative humidity). The length of the active state depends on the acquisition time: higher the resolution, longer is the active state.

5 Air Flow

In order to monitor outside humidity by using the sensor mounted in the device a design with air flow around the sensor is favorable in terms of response times. Even if there is no defined flow (such as static air condition in a room) a design with multiple openings and a possible flow is preferred. Placing the sensor close to the window and making the cavity around the sensor small helps improve the sensor's response time.

In the following table are some possible designs which optimize the air flow to measure the outside humidity.

| | |
|---|---|
|  | <p>Case 1) Multi windows (openings not aligned)</p> |
|  | <p>Case 2) Multi windows (openings aligned)</p> |
|  | <p>Case 3) Single window</p> |
|  | <p>Case 4) Single window (flipped device)</p> |

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