

Compensating Temperature and Relative Humidity for a PCB

This application note presents equations and associated examples to compensate for temperature and relative humidity readings from the HS sensor.

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1. Introduction

In some applications, components on an end-user’s PCB will create heat that affects both the temperature and relative humidity readings from the HS sensor. This can generally be mitigated by using the layout techniques specified in the HS datasheet, but if the heat generated is too high, or if there is not enough ventilation in the end product enclosure, some of the heat may still reach the sensor.

This document presents equations that can be used to compensate for this effect, followed by examples to show how the equations are used. These equations and examples work for all HS sensor types.

2. Temperature Sensor Compensation

Compensating for the temperature sensor is straightforward – the user can simply measure the temperature of the HS sensor and the temperature of the environment (using an accurate and calibrated external temperature sensor), and then subtract the difference from the output of the HS temperature sensor.

The equation for this procedure is:

$$T_{Corrected} = T_{HS} - T_{Diff} \tag{Eq. 1}$$

where  $T_{HS}$  is the temperature measured by the HS sensor,  $T_{Diff}$  is the level of heating generated from the PCB that reaches the sensor, and  $T_{Corrected}$  is the temperature that should be output from the MCU after the correction is applied.

$T_{Diff}$  is the difference between the temperature reading from the HS sensor and the reading of an **accurate** temperature sensor measuring the environmental temperature outside of the user’s enclosure.

The measurement of the temperature outside of the enclosure must be done carefully to ensure the correction of the HS sensor is valid – it is important to ensure this measurement is not affected by factors such as the presence of direct sunlight, strong air flow from fans, etc.

### 3. Humidity Sensor Compensation

Relative humidity is strongly dependent on temperature so, if the temperature at the HS sensor is different than the environmental temperature due to heating from the PCB, the relative humidity output also needs to be compensated.

The basic definition for relative humidity is:

$$RH = \frac{P_W}{P_{WS}} \cdot 100 \quad \text{Eq. 2}$$

where  $P_W$  is the water vapor pressure, and  $P_{WS}$  is the saturation vapor pressure.

The saturation vapor pressure  $P_{WS}$  depends on temperature, and can be calculated (in hPa) using the following equation:

$$P_{WS} = A \cdot 10^{\frac{mT}{T+T_n}} \quad \text{Eq. 3}$$

where  $T$  is the temperature in °C

$A$ ,  $m$ , and  $T_n$  are constants that vary by temperature range (see table below)

Temperature Range (°C)	A	m	T <sub>n</sub>
-20 to 50	6.1162	7.5892	240.71
50 to 100	5.9987	7.3313	229.1

Use the following steps to compensate for the relative humidity output from the HS sensor in the presence of heating from the user's PCB.

1. Calculate the saturation vapor pressure at the temperature being output by the HS sensor by using the equation:

$$P_{WS\_T_{HS}} = A \cdot 10^{\frac{mT_{HS}}{T_{HS}+T_n}} \quad \text{Eq. 4}$$

2. Calculate the saturation vapor pressure at the corrected temperature by using the equation:

$$P_{WS\_T_{Corrected}} = A \cdot 10^{\frac{mT_{Corrected}}{T_{Corrected}+T_n}} \quad \text{Eq. 5}$$

3. Calculate the water vapor pressure based on the Relative Humidity reading from the HS Sensor by using the equation:

$$P_W = \frac{RH_{HS} * P_{WS\_T_{HS}}}{100} \quad \text{Eq. 6}$$

4. Calculate the corrected relative humidity by using the equation:

$$RH_{Corrected} = \frac{P_W}{P_{WS\_T_{corrected}}} \cdot 100 \quad \text{Eq. 7}$$

## 4. Examples of Compensation

**Example 1:** Assuming the temperature and relative humidity output of the HS sensor in the presence of heat coming from inside the product enclosure is 25.2°C, and 54% RH, and the temperature of the environment is measured to be 23°C.

The values to use in Equation 1 to compensate for temperature are:

$$T_{HS} = 25.2^{\circ}\text{C}$$

$$T_{Diff} = 2.2^{\circ}\text{C}$$

$$T_{Corrected} = 23^{\circ}\text{C}$$

Next, follow the steps below using Equations 4 – 7 to calculate the corrected relative humidity value.

**Example 2:** The product would output the corrected temperature of 23°C (based on the external temperature sensor that is not affected by any undesired heat sources) and the corrected relative humidity of 61.62% RH.

These equations can be combined to optimize the firmware code as necessary.

$$1. P_{WS\_T_{HS}} = A \cdot 10^{\frac{mT_{HS}}{T_{HS}+T_n}} = 6.1162 \cdot 10^{\frac{7.589 \cdot 25.2}{25.2+240.71}} = 32.041 \text{ hPa}$$

$$2. P_{WS\_T_{Corrected}} = A \cdot 10^{\frac{mT_{Corrected}}{T_{Corrected}+T_n}} = 6.1162 \cdot 10^{\frac{7.5892 \cdot 23}{23+240.71}} = 28.080 \text{ hPa}$$

$$3. P_W = \frac{RH_{HS} \cdot P_{WS\_T_{HS}}}{100} = \frac{54 \cdot 32.041}{100} = 17.302 \text{ hPa}$$

$$4. RH_{Corrected} = \frac{P_W}{P_{WS\_T_{Corrected}}} \cdot 100 = \frac{17.302}{28.080} \cdot 100 = 61.62 \%RH$$

$$RH_{Corrected} = 61.62\% \text{ RH}$$

## 5. Revision History

Revision	Date	Description
1.00	Nov 17, 2023	Initial release.

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