SHTxx
Humidity & Temperature
Sensmitter

Application Note
Introduction to Relative Humidity

1 What is relative humidity?

Air, in our normal environment, always holds humidity. The number of water molecules in the air can vary substantially, e.g. it can be as dry as in a desert or as humid as in the tropics. There is an upper limit for the amount of humidity which air can hold at a given temperature. Beyond this limit saturation occurs. If for some reason the humidity level is pushed up to this limit, condensation occurs and fog or water droplets form. Relative humidity tells you what percentage of this maximum amount of humidity is present in the air. In contrast to relative humidity, absolute humidity denotes the absolute amount of humidity in the air regardless of the saturation level expressed as the total mass of water molecules per air volume.
The maximum possible amount of humidity as well as the actual present amount of humidity in the air are defined by so called water vapor pressures. According to Dalton's law, total air pressure is the sum of the partial vapor pressures of its components and water vapor pressure is one of them:

$$P_{total} = p_{water\ vapor} + p_{oxygen} + p_{nitrogen} + p_{others}$$
$$P_{total} = Total\ air\ pressure$$
$$p_{water\ vapour} = partial\ water\ vapor\ pressure$$

The maximum amount of humidity, which air can hold, is defined by the so-called saturation water vapor pressure. This is a function of temperature. See: Figure 1 Saturation water vapor pressure.

If the partial water vapor pressure is equal to the saturation water vapor pressure, condensation occurs. Mathematically, relative humidity is expressed as the ratio of the partial water vapor pressure divided by the saturation water vapor pressure as a percentage.

$$RH\,(\%) = \frac{p_{water\ vapor}}{p_{saturation}} \bullet 100$$

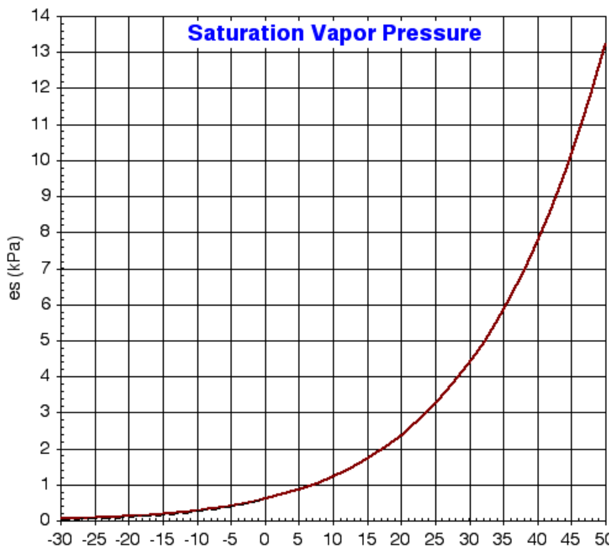

Figure 1 Saturation water vapor pressure

If temperature rises or falls in a closed system, the saturation vapor pressure will increase or decrease. As a consequence, the relative humidity will drop or rise.
Saturation water vapor pressure is not a function of total air pressure, but partial water vapor pressure is. If for example the total air pressure in a closed system is increased, relative humidity will increase as well, because the partial water vapor pressure increases proportionally to the overall pressure increase according to Dalton's law and saturation vapor pressure stays the same.

2 What is the dew point?

Another very important figure in conjunction with relative humidity is the dew point. The dew point is defined as the temperature at which the present amount of humidity in the air starts to condensate. E.g. if air has a temperature of 40°C (104°F) and a relative humidity of 50%, condensation will occur when the air is cooled down to 27.6°C (81.7°F). At the dew point, RH is 100%.
The dew point can be taken from the graph in Figure 1: the partial water vapor pressure at 50% and 40°C is half the saturation water vapor pressure at 40°C. Now, the dew point is where the 50% at 40°C (104°F) blue line crosses the saturation water vapor pressure curve, i.e. at 27.6°C, see Figure 2 .
There are sensors that directly measure dew point. However it can also be calculated by using relative humidity and temperature as inputs (see also application note: “dew point calculation” on Sensirion’s web page). The dew point is a measure for absolute humidity. Consequently, the dew point of air will remain constant in a closed system (unventilated room) even if the air is heated or cooled locally.

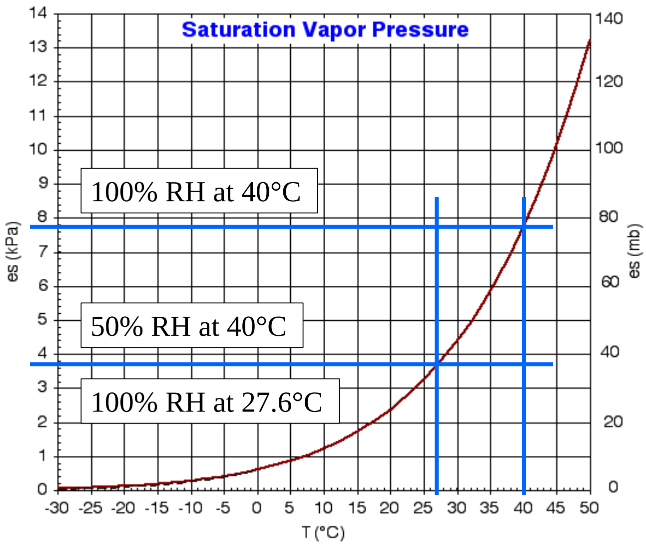

Figure 2 Graphical determination of dew point

3 What to take into account when measuring relative humidity

A very important factor in humidity measurement is always temperature. Temperature defines the saturation vapor pressure. A slight change in temperature especially at high humidity has a significant effect on RH, since saturation pressure changes too. E.g. a change of + 1°C (1.8°F) at 50°C (122°F) and 80% RH means a change of almost -4%RH.
Therefore it is important to know the exact temperature, when comparing relative humidity measurement values. E.g. in a closed system two sensors that are kept at different temperatures will show different RH values, but the same dew point can be calculated.
Another issue is location and stabilization. When comparing measurement values, the reference and the sensor to be tested, should be placed as close to each other as possible, because even at short distances apart there can be considerable differences in levels of humidity and temperature. Related to this is stabilizing time. Before taking a measurement, you always need to wait long enough for the conditions to stabilize. Not only RH levels need to stabilize but also temperature.
These issues make clear, why it is not possible to make extremely accurate relative humidity measurements. Calibration of humidity sensors also has to cope with these effects. The most accurate humidity measurement instruments available on the market are chilled mirror hygrometers. A mirror is chilled down slowly until fog forms on it. The temperature of the mirror at which fog forms is the dew point. With the dew point and actual temperature, you can calculate back to relative humidity. These hygrometers are extremely expensive and are usually used as a reference for the calibration of high precision sensor components.
The best accuracy in the market, based on sensor components, comes with calibrated sensor probes based on capacitive type sensors and is around +/- 1.5% RH. These high precision probes need frequent recalibration. Most calibrated capacitive humidity sensors have an accuracy of between +/- 2% and +/-3.5 % RH. Calibrated resistive type humidity sensors have a lower accuracy of between +/- 5% and +/- 10% RH.

4 Why use Sensirion humidity sensors?

Sensirion humidity sensors are capacitive type sensors and therefore have specific advantages compared to resistive type sensors. Resistive type sensors can only be used in non-condensing environments, don't work at relative humidity levels below 20% and don't show the same good long-term stability as capacitive ones.

The humidity sensors of the SHTxx family are the perfect choice to measure relative humidity for several reasons. These sensors are calibrated and therefore allow you to save costs in your production process. They are of high quality capacitive type, very small, cover the full measurement range of 0-100% RH and are fully immersible. In addition, the integrated temperature sensor allows for accurate dew point calculation. Furthermore, the sensor has a digital interface, which makes it very easy to integrate. And, being a low cost device, it is well suited for high volume products. In short, it's a unique combination of price and quality.
For further information please contact us.

5 Revision history

Date	Revision	Changes
3-Dec-03	0.1	Genesis
12-May-04	1.0	Released
25-May-05	1.1	Changed company address
Oct 3, 2006	1.2	Sensirion Inc. address added

All datasheets and application notes can be found at:
www.sensirion.com/humidity

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