# HTU21D - humidity and temperature sensor - assembly and applications

***Humidity is something we more or less used to live with. You opened or shut windows, drained pipes, wiped panes with a cloth or set up a dryer.***

***However, the advance of automation technology in all areas of our lives means that humidity is becoming ever more important as a measurable variable. Thanks to the advent of high-tech sensors, which can be mass produced at little cost, it can now be quickly and accurately measured. The following shall describe these miniaturized humidity sensors and their typical applications, taking the HTU21X series as an example.***

## Description

The OEM sensors in the HTU21X series are an integrated combination of capacitive humidity sensing element and temperature sensor.

Capacitive sensors are based on the principle of two electrodes (parallel metal plates) forming an electrical capacitor, the capacitance of which can be measured according to the following equation (Figure 1).

The following applies to the capacitor with an insulating material between the plates:

$C = \varepsilon_O \varepsilon_r A/d$

where $\varepsilon_O$ is the electric constant, $\varepsilon_r$ the relative permittivity, A the capacitor area and d the distance between the plates.

Permittivity ε = εo εr denotes the permeability of a material for electric fields. The higher the permittivity, the more energy can be stored in the electric field between the plates of the capacitor. Relative permittivity εr of a material between the capacitor plates thus indicates by which magnitude the capacitance of a capacitor increases with an insulator as opposed to a capacitor in a vacuum (or air).

Permittivity is not a constant (it used to be incorrectly named a "dielectric constant") and can be dependent on both frequency and humidity. If, for example, a hygroscopic, insulating material (polymer) is inserted between the two plates of the capacitor (*Figure 1*), $\varepsilon_r$ changes depending on the amount of absorbed/desorbed humidity, resulting in a change in capacitance which can be measured.

In most cases the sensing elements are assembled in a bridge circuit and the signal recorded by an instrumentation amplifier. Following A/D conversion the signal is individually linearized, calibrated and temperature compensated. It is then present in a standard format at the output (*Figure 2*).

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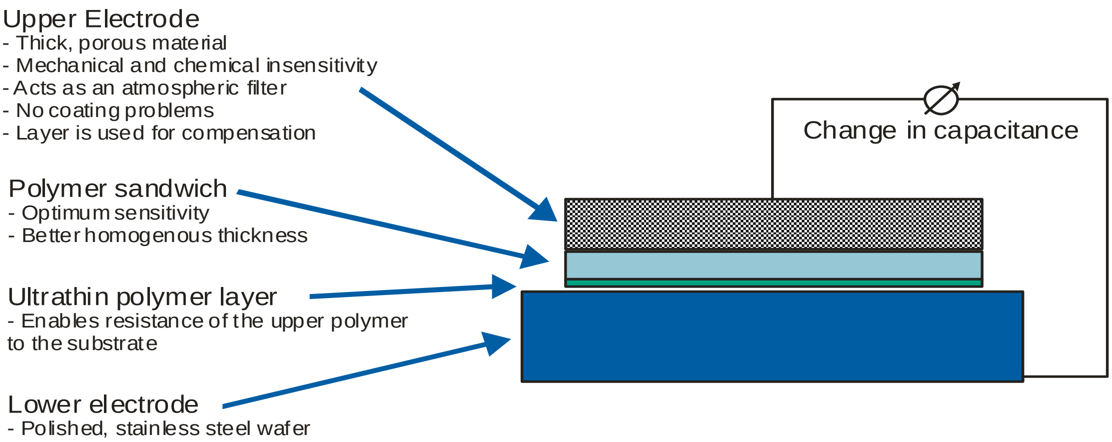


***Figure 1:*** *assembly of a capacitive humidity sensing element*

In addition to its capacitive sensing element HTU21X has a temperature sensor which is implemented by an integrated bandgap circuit. Information on the temperature is required in order to electronically compensate for the temperature in the sensor, allowing users to profit from the added benefit of an independent temperature sensor.

All of the aforementioned electronic functions of the signal conditioning system are integrated in a CMOS ASIC or application-specific integrated circuit (Figure 2).

The digital output values for humidity and temperature are suitable for transfer with the I²C protocol.

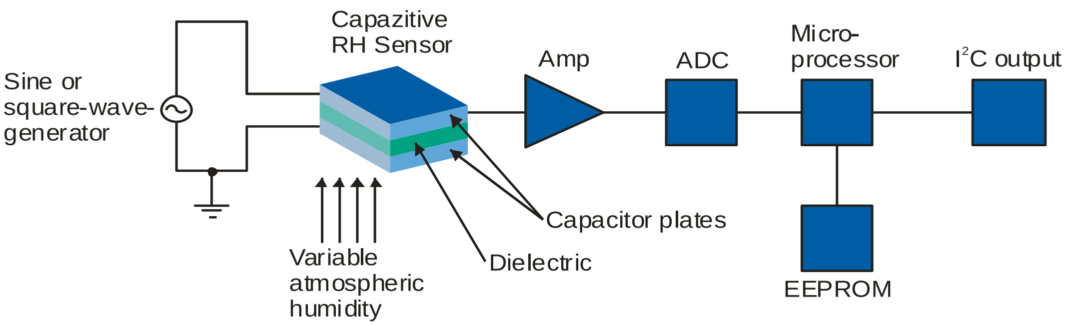


**Figure 2:** circuit diagram of the HTU21X humidity sensor

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Integrating the humidity sensing element and temperature sensor in the same sensor ensures that both values can be measured close together, guaranteeing a high measurement accuracy and good matching. The long-term measurement drift of HTU21X caused by aging is less than 0.5% of the relative atmospheric humidity and just 0.04°C of the temperature per year.

Its high long-term stability, low hysteresis of ±1% RH and practically linear characteristic make HTU21X ideally suited to use in industry and medicine.

The integrated heater in HTU21X enables the drift to be reduced in environments with a relatively high atmospheric humidity and the important sensor elements to be protected from condensation.

The sensor has a wide supply voltage range of 1.5 to 3.6 V and a low power consumption of typically 450 µA which is beneficial to mobile, battery-operated devices in particular.

Each sensor is individually calibrated and compensated for, enabling an accuracy of ±3% RH maximum within a range of 20 to 85% RH to be achieved. An accuracy of ±5% RH is given for measurements in the extended 5 to 90% RH range (for the HTU21A: ±3% RH maximum in a range of 15 to 90% RH). In principle, the sensors can be applied across the entire range of 0 to 100% RH.


***Figure 3:*** *humidity and temperature sensor HTU21D*

The sensors in the HTU21X series have been designed for the extended temperature range which can be measured by the temperature sensor with an accuracy of ±0.3°C.

The HTU21D sensor outputs the digitized values for humidity and temperature independently of one another in I²C format.

HTU21A is a version of HTU21D which provides more accurate values in an extended humidity range.

Sensor HTU21P (PWM output) can be combined with a suitable circuit to produce an industrial analog signal for humidity.

The sensors in the HTU21X series are mounted in a (reflow) soldered 3x3-mm DFN (dual flat no-lead) chip package 0.9 mm high and are supplied with or without a filter cover.

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## Applications

Humidity in hermetically sealed high-rise buildings and insulated homes and offices (self-sufficient houses) has become a modern phenomenon which has a significant influence on our health, work efficiency and sense of well-being. Together with the room temperature, as shown in the RH/T diagram (*Figure 4*) humidity produces various seasonal zones (e.g. for summer and winter) which, according to ASHRAE or the American Society of Heating, Refrigeration and Air-Conditioning Engineers, are described as "comfort zones" and seen to create optimum ambient conditions.

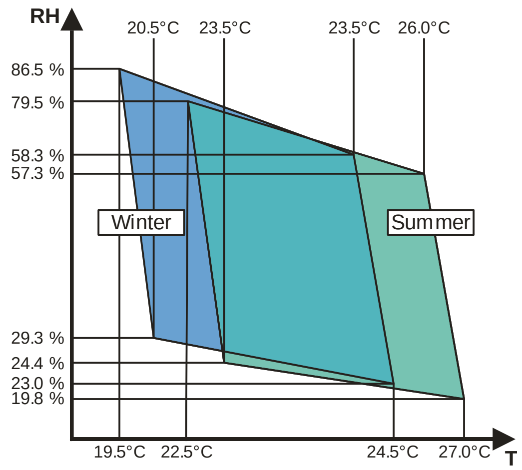


***Figure 4:*** *RH/T comfort zones*

An individual's perception of temperature does not just depend on the ambient temperature but also on the humidity. The greater the humidity, the warmer the environment feels. Physiologically speaking, this is due to the fact that our bodies then vaporize less water (i.e. we perspire less) and our cooling system thus functions less efficiently.

Ideally, both parameters must be able to be configured and optimized in areas occupied by people. Plans for smart homes already include this option. Comfort zones in future buildings will be individually settable using an iPad or tablet.

Furthermore, information on both parameters could prove to be an advantage where saving energy is concerned. If the humidity in a room is too low, for example, a higher temperature is required for people to feel comfortable. The heating is then regulated to a higher temperature. As the humidity in dry rooms can be increased using less energy, the temperature could then be retained or lowered to yield a positive energy balance.

For humidity and temperature to be set to optimum values, they must be able to be measured with suitable accuracy. The digital HTU21X humidity sensor, which determines both humidity and temperature, has been developed for this purpose. A sensor such as this therefore provides both of the parameters which are needed to regulate heating/cooling systems and humidifiers/dehydrators for the comfort zone.

Both measurements (with a connected processor) can also be used to calculate the dew point temperature (Td = f(RH)) which is necessary where measures preventing the formation of condensation and thus possibly mold in homes and offices are to be introduced.

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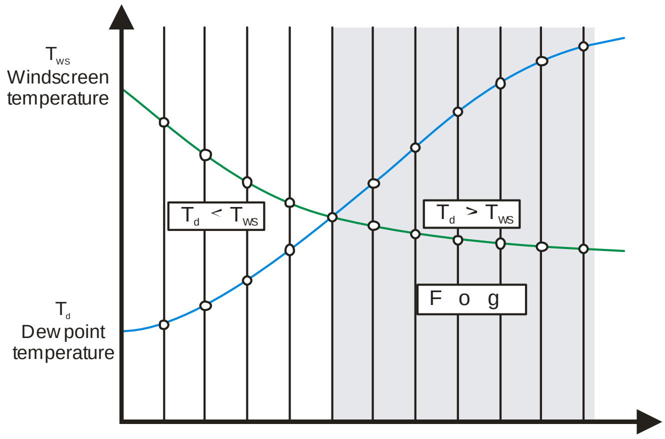
In automotive engineering HTU21X can be utilized to monitor humidity in electronic systems and in the vehicle interior to prevent windows from fogging over. There is an HTU21A automobile version for this particular application.

Once car windows have steamed up, for instance, it is too late to clear them quickly with the fan. In most cases the driver has to wipe them with his or her hand which considerably limits his or her concentration on the traffic.

In such cases help is provided by a fan controller which is based on the computation of the dew point temperature and reacts before car windows mist up *(Figure 6).*




If the window temperature of the vehicle $T_{WS}$ falls below dew point temperature $T_d$ in the windscreen area, (*Figure 5*), the windscreen fogs over. The greater the difference in temperature, the faster the windows mist up – a situation any car driver is familiar with. Typical transition points are when you drive your car into a warm parking block or somebody with damp clothes gets into the car; the windows immediately fog.

***Abbildung 5:*** *fog conditions*

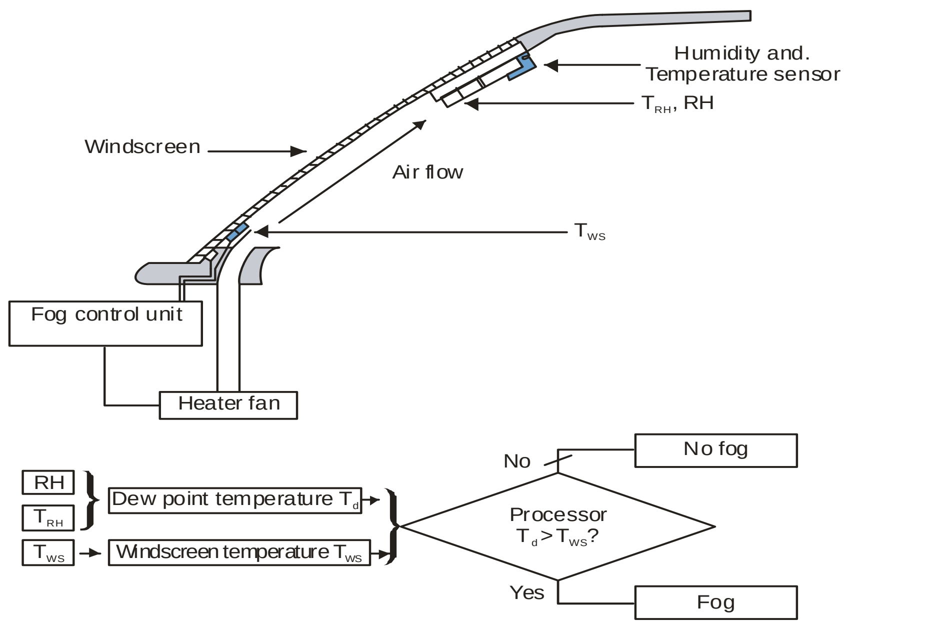



***Figure 6:*** *principle of operation for a vehicle anti-fog system*

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Optimized washing and drying processes are now taken for granted in state-of-the-art household appliances. Here, HTU21X measures the humidity of the washing and of the machine interior and uses this data to determine the drying level, which today is adjusted to suit the items to be washed and dried to produce optimum results. The dew point can also be defined, thus helping to prevent condensation forming in the appliances.

In our new smartphones humidity and temperature sensors establish the atmospheric humidity and ambient temperature from the user's current location. An app then shows the user to which degree the current values deviate from health-relevant recommendations.

Another important area where humidity and temperature sensors are used is medical technology. Devices featuring these sensors include incubators, sleep apnea equipment and anesthesia apparatus. All of the above contain humidifiers which ensure that the breathing conditions are ideal. Inspiration gases (e.g. anesthetic gases) must be moistened and tempered for all artificially respirated patients as the tube and tracheal cannula prevent the upper respiratory tract from conditioning air. In order to compensate for this, the relevant parameters in the supply of air to the patient are constantly measured. In certain anesthesia equipment these variables include humidity and temperature in particular.

The miniaturized OEM sensors in the HTU21X series enable humidity and temperature to be measured with high accuracy, providing solutions which are also cost efficient for high-quantity applications.

The area of application for humidity and temperature sensors in the HTU21X series is not limited to individual fields. These sensors can be used in all instances where knowledge of the level of humidity in conjunction with temperature is important, enabling appropriate action to be taken.

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