CLIMATE SENSOR – Realization with EnOcean Technology

Climate Sensor (Temperature / Humidity / Air Quality) based on EnOcean Modules

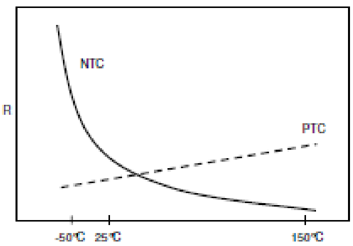
Wireless climate sensors are essential to set up intelligent automation in green buildings. EnOcean's wireless modules like the STM-family are optimized for self-powered sensor applications. You can find an overview of available STM sensor modules on the EnOcean website: http://www.enocean.com/products-technology/

The following note provides some examples of ambient sensors and their applications in a combined room sensor based on STM devices. Please note however that EnOcean already offer "complete" modules therefore like the STM 3xy-family, e.g. already calibrated sensor STM 330(C) with sensor, storage element, learn button, antenna and solar panel on board.

For more details please always consult carefully the correspondently actual user manuals and the "Standardization EnOcean communication profiles" document. Please note that the following examples are rough concepts only.

1. TEMPERATURE SENSOR

Sensors for temperature measurement are suitable for a large variety of applications in heating and air conditioning: for room temperature monitoring, as outdoor temperature sensors, etc. Selection criteria for temperature sensors are: type, temperature range, resistance range, measuring accuracy, environment, response time, power requirements, dimensional requirements and cost. One common application circuit for temperature measurement is the Wheatstone bridge with a thermistor used as one bridge leg. The most used temperature sensors therefore are NTC and PTC devices.



The high sensitivity of the low cost NTC makes them an ideal candidate for low cost temperature sensing applications.
NTC's are made from certain metal oxides whose resistance decreases with increasing temperature. Because the resistance characteristic falls off with increasing temperature they are called Negative Temperature Coefficient (NTC) sensors. Their pronounced non linearity is a disadvantage of NTC's and limits their application field.
In opposite, PTC's employ the property that the electrical resistance of metals increases with temperature, means they are Positive Temperature Coefficient (PTC) sensors. The main metals in use are platinum (Pt) and nickel (Ni). The most widely used sensor is the 100 ohm or 1000 ohm Pt resistance thermometer (Pt100 / Pt1000). These are the most accurate sensors and also offer the best linearity and long-term stability over a very large range of temperature. Their temperature dependence is international standardized and they need no extra calibration.

The following wireless sensor concept allows measurement of temperature using a Pt1000 element with 3.85Ω/ °C temperature coefficient in a Wheatstone bridge. The bridge is used in a ratiometeric configuration, with the system reference driving both the sensor and the ADC voltage reference. By using the same reference for both the sensor excitation and

ADC, the variation in the reference can be cancelled out. The temperature range of the circuit example is approx. −20 to +45 °C (Pt1000 = 921 Ω @-20 °C to 1175 Ω @+45 °C). The temperature offset is controlled by R2. For highest resolution V_{OUT} range must be 0 to V_{REF}. The used OPs are supplied by the STM device and therefore must be low power single supply, rail to rail input/output, operate at voltages as low as 1.8 V, and have a quiescent current significantly lower than 1 mA. Meantime there are many such standard devices on the market, e.g. from NS, LT, TI, Maxim, AD and Micrel. The application concept below uses an AD8607 (dual, rail to rail, precision, micro power). The slope (temperature dependent Vout) is determined by the relation R5/R4. Note: V_{OUT} must be limited to maximum STM AD Input (V_{REF})

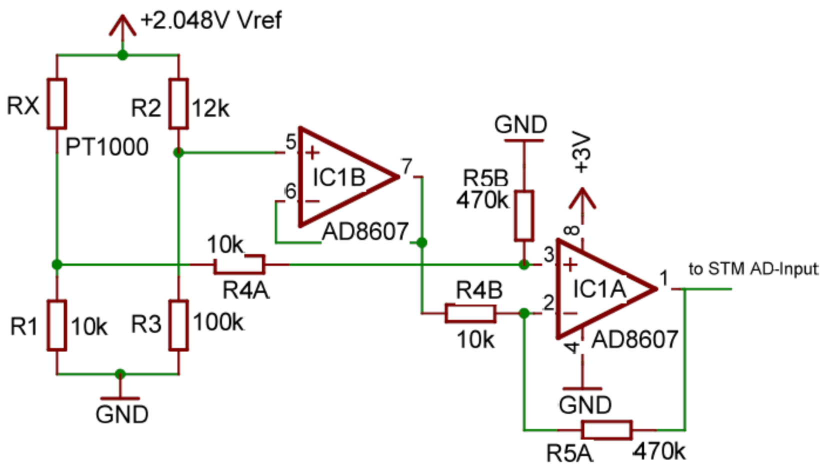


Fig. 1: Example of temperature sensor and signal conditioning circuit

The relation between Rx (Pt1000 temperature dependent value) and V_{OUT} is given by the following equation:

$$Rx = \frac{R1||(R4+R5)}{\frac{V_{OUT}\ R4}{V_{REF}\ R5} + \frac{R3}{R2+R3}} - R1||(R4+R5)$$

With these values, V_{OUT} varies between about 0 V @+45 °C to about V_{REF} @-20 °C, meaning that the resolution here is about V_{REF}/65 °C.

°C	Ω	°C	Ω
-20	921.6	+20	1077.9
-10	960.9	+30	1116.7
0	1000.0	+40	1155.4
+10	1039.0	+50	1194.0

Tab. 1: Pt1000 resistance vs. temperature table (dependence about +3.9 Ω / °C):

2. RELATIVE HUMIDITY SENSOR

Suitable passive relative humidity (RH) sensors are based on the change of their capacitance. Such a humidity sensor is nothing other than a two-terminal capacitor that increases in value as water molecules are absorbed into its active polymer dielectric. The capacitance can be measured analog or digital. Usually low-cost solutions deliver a frequency dependent output signal. Typical Requirements:

- Measurement range 0%-100% r.h.
- Accuracy typ. ±5% r.h. between 30%-70% r.h. and 0-40°C
- Result ready time after Voltage on < 2 ms
- Supply voltage 1,8 V

The circuit diagram below (Fig. 2) shows a rough concept based on capacitive humidity sensors. Basic components can be modified for the specific sensor and application.

The circuit generates an oscillating signal with a humidity dependent frequency and converts this into a PWM signal proportional to the relative humidity. This output can be directly applied to the STM AD input and its width measured by appropiate FW.

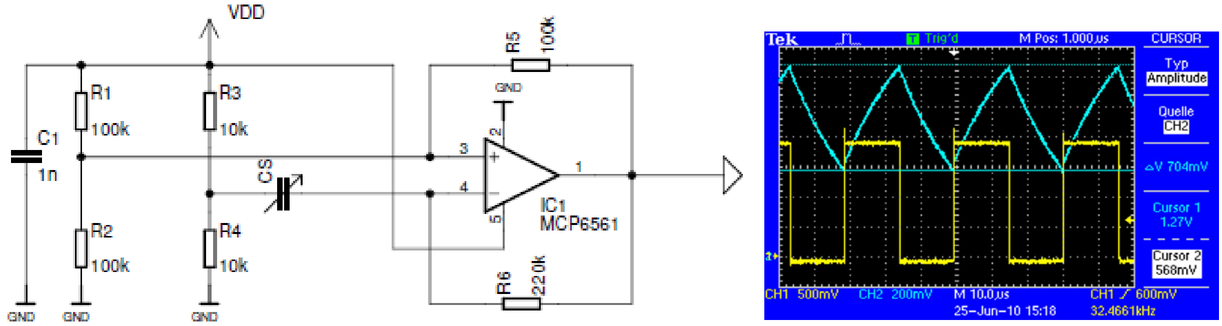


Fig. 2: Example of humidity sensor and signal conditioning circuit

The example circuit shown above is based on the comparator MCP6561 and generates a rectangular signal with variable period T of about 30 µs, where the humidity sensor CS is used as a variable capacitor. This period could be measured and interpreted by a STM 3xy module with appropiate FW.

Background: calibration of humidity sensors

Digital humidity sensors are most already calibrated but they need higher supply voltage (>2.7 V) and deliver the humidity value digital via UART, which needs more time. Therefore they are not suitable for this application. Unfortunately the calibration of analog humidity sensors takes some effort. Special saturated salt solutions always have the same humidity in the area above. Humidity depends only on temperature. Below (Tab. 2) you can find an overview of the common standard salt solutions that can be used.

Salt (saturated in water)	RH(%)@25°C	RH(%)@20°C
Magnesium chloride MgCl	32.8 (±0.3)	33.1 (±0.2)
Magnesium nitrate Mg(NO3)	53.0 (±0.1)	55
Sodium chloride NACl	75.3 (±0.1)	75.5 (±0.1)

Tab. 2: Humidity of some saturated salt solutions. Source: extract from Handbook of Chemistry and Physics

3. PERSPECTIVE: CARBON DIOXIDE SENSOR

Standard CO2 sensors were till now not suitable for self powered wireless sensors because they are very power hungry (hundreds of mW, required by NDIR, heater).

An interesting alternative offers a new NDIR CO2 sensor technology, COZIR http://www.cozir.com/index.php from GSS (Gas Sensing Solutions UK), which needs considerable less power vs. existing solutions. Optional integrated temperature, humidity and light sensing are available. First internal evaluations regarding its suitability and energy balance are already successful started at EnOcean.