DHT22

The DHT22 sensor is composed of two parts, the temperature and the humidity as shown in Figure #. The connection to the MCU is done using the Digital pins, because the sensor's circuit converts analog signals to digital, and with the integration of the DHT.h library, found here[1)] it allows the microcontroller to read the signal, giving the user the values for Temperature and Humidity directly without any extra calculations or interpretations.

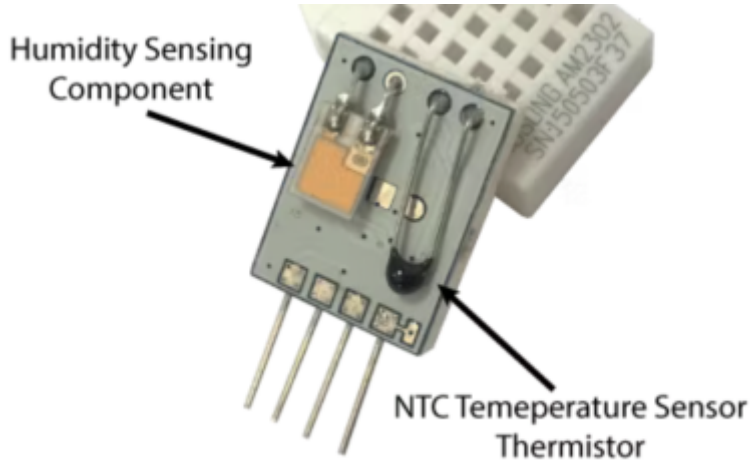


Figure # DHT22 Humidity sensing component. Source: https://howtomechatronics.com

Temperature

A thermistor is a semiconductor device that changes its resistance when the ambient temperature changes. The term is a conjunction of thermal and resistor, and while most resistors are subject to slight changes due to temperature variations, these devices are purposely engineered so that they are very susceptible to minimal temperature fluctuations. There are 1 type of thermistors, Negative Temperature Coefficient (NTC) and Positive Temperature Coefficient (PTC). The type used by the DHT22 sensor is Negative Temperature Coefficient. The change in resistance is non linear but as a curve, as represented in the example of Figure #. The design and performance of the thermistor is selected by the manufacturer, but for all NTC thermistors as the temperature increases, the resistance decreases. Therefore the coefficient B which defines the behavior of the Thermistor is represented by a curve in which we can see the material resistive change over temperature and can be calculated using the following equation[2)]:

$$ Beta_{T1\over T2} = {T2 \cdot T1\over T2-T1} \cdot ln {R1 \over R2 }$$

B = Material resistive value between two predetermined temperatures
T1 = Base point temperature, usually 25oC but calculate in Kelvin, therefore 25o C + 273.15 = 298.15K
T2 = Second temperature point, for example 100o C, and in Kelvin 100o C + 273.15 = 373.15K
R1 = Thermistors resistance at temperature T1 in Ohms
R1 = Thermistors resistance at temperature T2 in Ohms

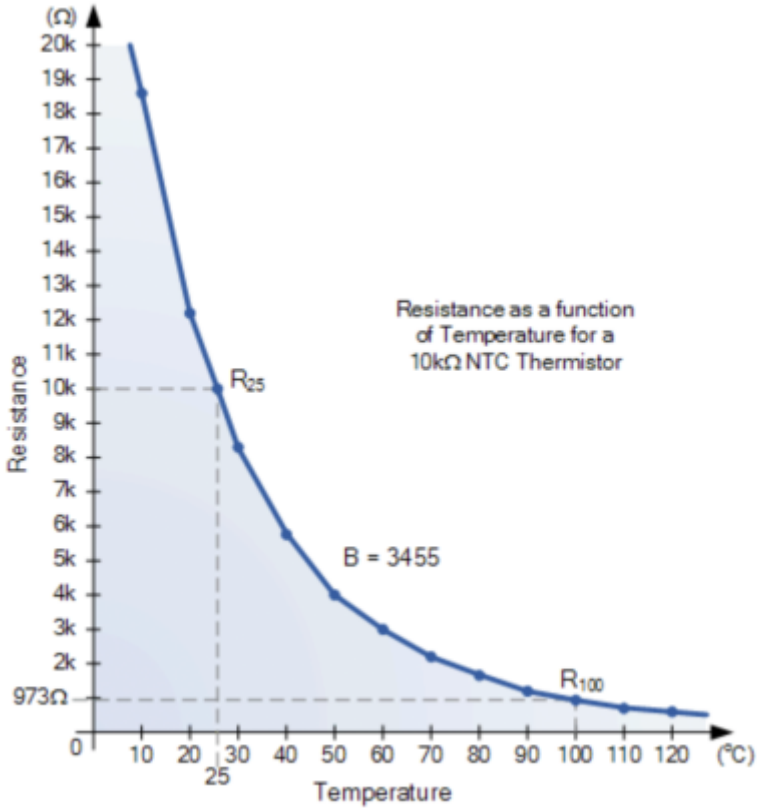


Figure # Graph showing the Relationship between resistance and temperature. Source : https://www.thomasnet.com/articles/automation-electronics/what-is-a-thermistor-and-how-does-it-work/

Humidity

Humidity determines the amount of moisture or water content in the air. Humidity can affect the health of an individual because the density of the air combined with the temperature can make breathing more difficult, also lung infection rates can be higher where relative humidity is higher, and people with respiratory afflictions such as COPD and asthma are more vulnerable to flare-ups and complications [3] therefore maintaining good levels of humidity indoors is beneficial for the overall health of the people living there.

Humidity can be understood through the following terms: Absolute humidity, Relative humidity and Dew point. **Absolute humidity** defines the amount of moisture in air independent of temperature. Higher absolute humidity establishes that there is more water vapor in the air per unit volume, while in lower absolute humidity the air is holding less water vapor per unit volume. **Relative humidity** is a percentage representing the ratio between the absolute humidity content relative to the maximum moisture content possible at a predetermined temperature and atmospheric pressure. **Dew point** declares the temperature at which air has to be cooled in order to achieve 100% relative humidity.[4]

Amongst the various types of humidity sensors, the DHT22 module relies on the principle of **Capacitive humidity**, in it the design is built around measuring relative humidity. This design involves the use of an electrical conductivity sensor in the form of a layering of two electrodes separated by a moisture holding substrate material, as shown in Fig #. the dielectric material is specifically hygroscopic. With the absorption of moisture from the air, the dialectric constant increases, increasing the capacitance of the sensor. Since the change in the dialectric constant is directly proportional to the value of the relative humidity, a measurement of the change in

capacitance will yield the relative humidity level. **Resistive humidity** will employ the same design with two electrodes separated by the gygroscopic conductive layer. The resistivity of the conductive material will vary inversely with the amount of moisture that is absorbed, higher absorption of water vapor will result in higher conductivity or lower resistivity. [5)]

The module converts the data into digital output for the micro controller which with the predetermined values established by the library DHT.h decodes the data and gives out the Relative humidity.

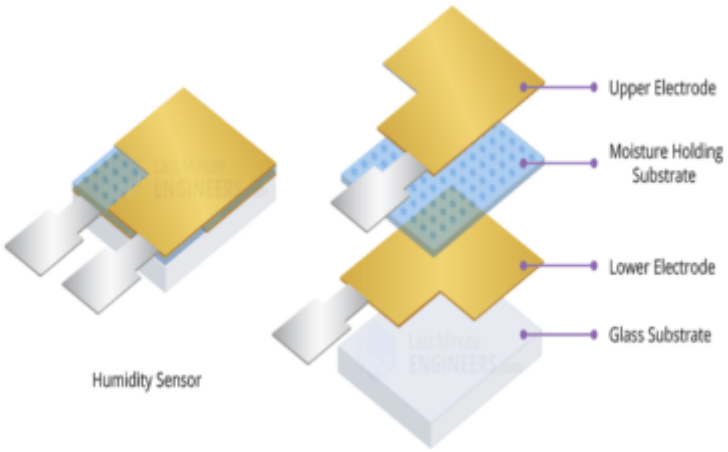


Figure # DHT22 sensing components. Source: https://create.arduino.cc/projecthub/MinukaThesathYapa/dht11-dht22-sensors-temperature-using-arduino-b7a8d6//

Specifications

Table 2 **Table describing DHT-22 Specifications**	
Description	**Value**
Operating Voltage	3.5 to 5.5V
Data Protocol	Serial Transmission
Operating Temperature	-40 to 80 C
Temperature Accuracy	±0.5°C
Humidity Range	0 to 100 %
Humidity Accuracy	±1%
Sampling Rate	0.5 Hz - Once every 2 sec
Humidity Accuracy	±1%
Output Signal	Digital Signal via 1 wire bus

Table 2 Source: https://cdn-shop.adafruit.com/datasheets/Digital+humidity+and+temperature+sensor+AM2302.pdf

Schematics

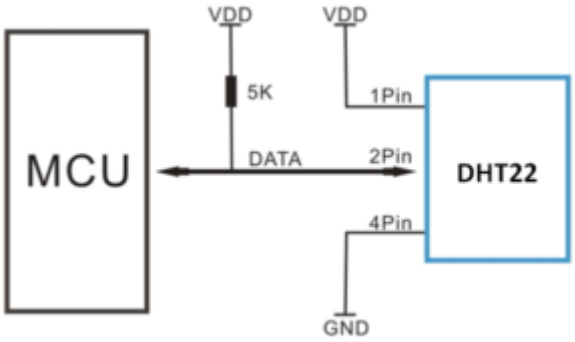


Figure # DHT22 Schematics. Source: https://components101.com/sensors/dht22-pinout-specs-datasheet//

Signal

To read the data obtained by the module a protocol has to be observed. This protocol will function as an activation key that initiative the module, to send the information back to MCU and finalize the process.

1. The micro controller sends a start signal for 500 microseconds
2. The micro controller sends a HIGH logic 1 Signal
3. DHT22 responds by pulling the bus low for 80 microseconds
4. DHT22 pulls the bus HIGH for 80 microseconds.
5. DHT22 pulls the bus LOW again.

Once the right sequence of the signal has been completed then DHT22 will start sending the information regarding both Temperature and Humidity. Transmission of information is done through two set-ups called Logics.

1. Logic 1 is a 48 to 55 microsecond LOW pulse followed by a 68 to 75 microsecond HIGH pulse.
2. Logic 0 is a 48 to 55 microsecond LOW pulse followed by a 22 to 30 microsecond HIGH pulse. [6)]

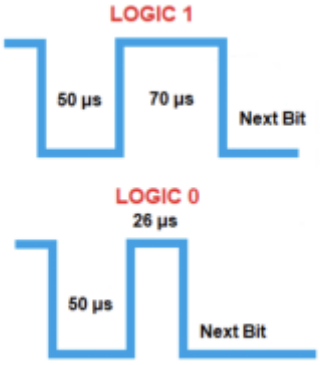


Figure # DHT22 Logic Signal formation. Source: https://www.teachmemicro.com/how-dht22-sensor-works///

Data

Example of how data transmission and the binary system provides information on both Temperature and Humidity.

ESP-32 receives 40 bits from the sensor as follows:

16 bits for	RHumidity	0000 0010 1000 1100
+		
16 bits for	Temperature	0000 0001 0101 1111
=		
8 bits	Check-sum	1110 1110[7)]

——

The conversion from the humidity data is:

Binary system	**>**	**Decimal System**
0000 0010 1000 1100	**>**	652

$$RH = \frac{\mathrm{652}}{\mathrm{10}} = \mathrm{65.2\;\%}$$
The conversion from the Temperatures data is:

Binary system	**>**	**Decimal System**
0000 0001 0101 1111	>	351

1. $$T = \frac{\mathrm{351}}{\mathrm{10}} = \mathrm{35.1°C}$$

If the highest bit of temperature is 1 as in: **_1_**000 0000 0110 0101, this means that the temperature is negative, therefore T = -10.1 °C[8)].

In Figure # down below, we can see the whole siganling process between ESP32 and DHT22.

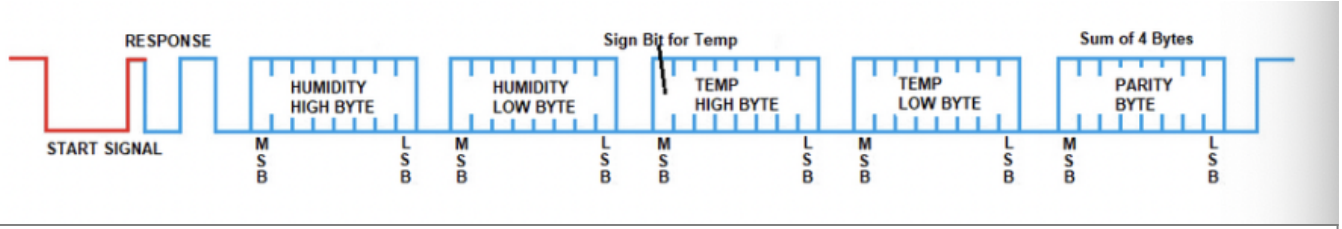


Figure # DHT22 bus transmission. Source: https://www.teachmemicro.com/how-dht22-sensor-works///

Code

Results

1)
https://github.com/adafruit/DHT-sensor-library
2)
https://www.electronics-tutorials.ws/io/thermistors.html
3)
Arundel, A V et al. “Indirect health effects of relative humidity in indoor environments.” Environmental health perspectives vol. 65 (1986): 351-61. doi:10.1289/ehp.8665351
4), 5)
https://www.thomasnet.com/articles/instruments-controls/all-about-humidity-sensors/

6)
https://www.teachmemicro.com/how-dht22-sensor-works/
7)
https://cdn-shop.adafruit.com/datasheets/Digital+humidity+and+temperature+sensor+AM2302.pdf
8)
https://www.researchgate.net/publication/312403569_How_to_Use_the_DHT22_Sensor_for_Measuring_Temperature_and_Humidity_with_the_Arduino_Board

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