HTU21D - digital humidity and temperature sensor – application examples

Using miniaturized sensors and modern microprocessors building powerful measurement systems becomes very easy. The construction of a measurement system for humidity and temperature is shown for the demonstration board D1HTU21D.

D1HTU21D (*Figure* 1) is based on the combined sensor HTU21D [1] (see *Figure 2*), which is able to measure humidity and temperature with a high precision. This OEM sensor is mounted on a small PCB board (PHTU21D) [2], which can be connected to the D1HTU21D using a plug connection.

The demonstration board is powered using a battery and its LCD displays the relative humidity in percent and the temperature in °C with one digit precision.

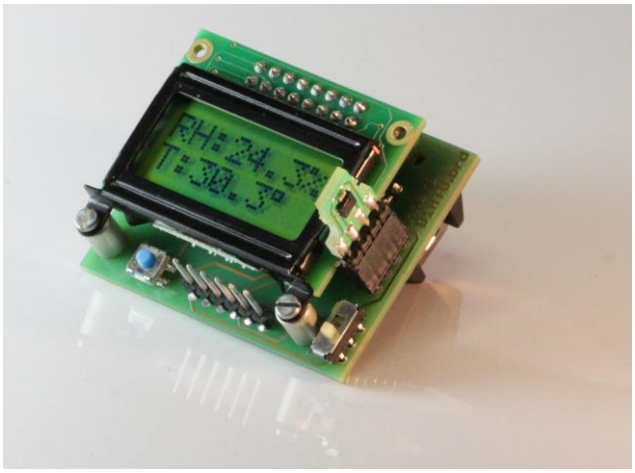

Figure 1: *D1HTU21D with connected PHTU21D on its right side*

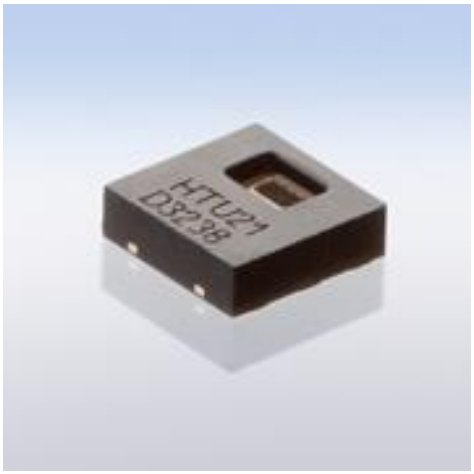

Figure 2: *HTU21D*

The OEM sensor HTU21D (*Figure 2*) is an integrated sensor combining a capacitive humidity measurement cell and a temperature sensor.

In principle capacitive sensors are based on the two electrodes (parallel metal plates) forming an electrical capacitor, whose capacitance changes reproducible with the humidity absorpted and desorpted in a porous polymer contained between the capacitor's plates. This capacitance change is amplified and converted to a digital signal by the ASIC connected to the electrodes. After an electronic calibration in the integrated arithmetric unit digital data words for humidity and temperature can be read from HTU21D's I^2C output.

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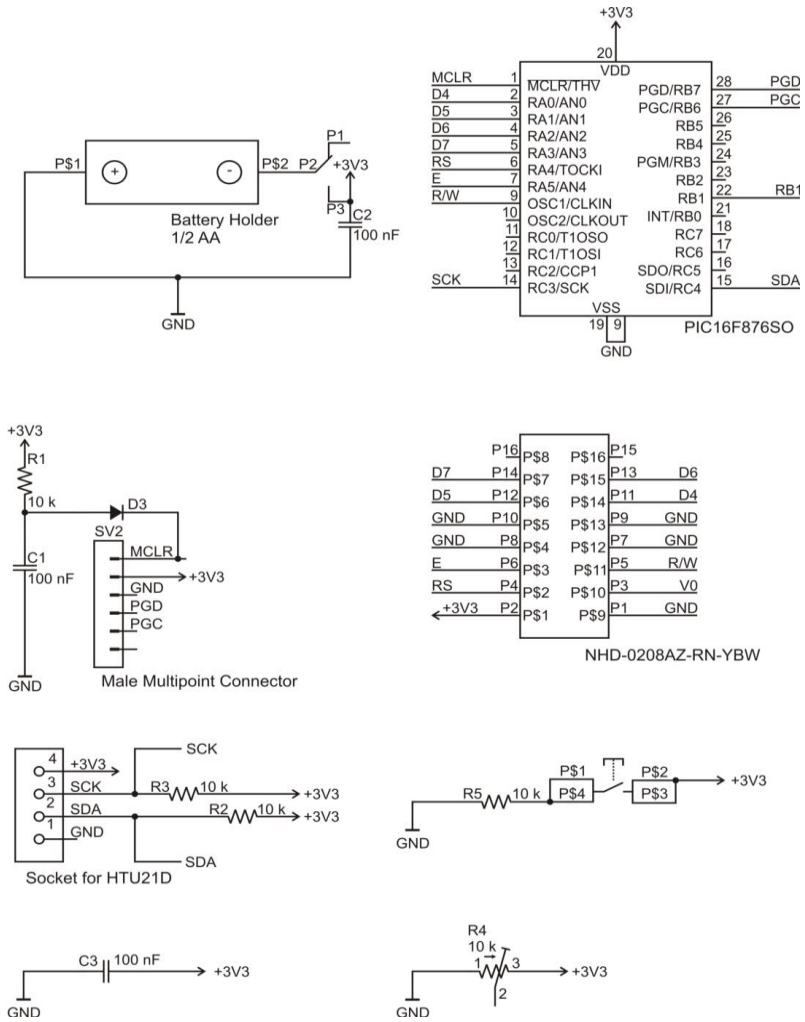

Figure 3: *D1HTU21D's circuit diagram*

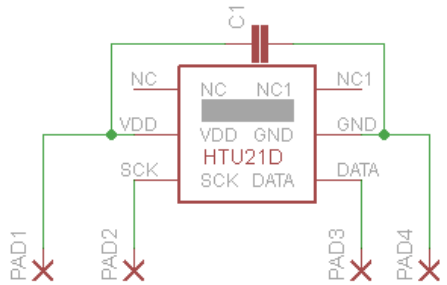

Figure 4: *PHTU21D's pinout*

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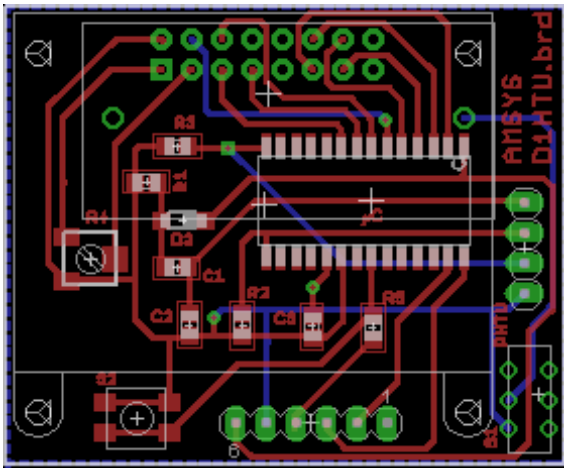

Figure 5: *D1HTU21D's layout*

Dimensions: 45.70mm x 38.40mm

Nr.	Bezeichnung	Anzahl
R1,R2,R3	Widerstand 10 k SMD 0805, ±1 %	3
R4	Trimmer 10 k SMD, ±20 %, 300 V	1
C1,C2,C3	Keramik 0,1 µF 0805, ±10 %,X7R	3
D3	DIODE 1N5711W Schottky,SOD123	1
IC1	µC Pic16LF1518 SMD SOIC28	1
LCD	LC-Display NHD-0208	1
S1	Schiebeschalter DPDT, 24 V	1
K1	4x1 Buchse 2,54RM	1
K2	6x1 Stiftleiste 2,54RM	1
Batterie	1/2AA Lithium 3.6 V	1

Table 1: *D1HTU21D's part list*

General Description

D1HTU21D is used for the visual output of the relative humidity and temperature. It consists of the humidity and temperature sensor PHTU21D, a microcontroller, an LC display, a battery and a PCB. Using the microcontroller PIC16LF1518 [3] the measurements are evaluated and the results are displayed on an 8x2 LC-display [4]. D1HTU21D is powered using an 1/2AA lithium battery. After the sensor was powered up the relative humidity and temperature are measured every minute. The programming was done using C with MPLAB X IDE [5] and the XC8 compiler [6]. The microcontroller was flashed using ICSP (In Circuit Serial Programming).

The D1HTU21D recognizes if the battery voltage drops below 2.25 V and shows „Low Batt" on its display then.

According to HTU21D's specifications the humidity sensor's precision is ±3 %RH at RT = 25 °C in the range from 20 %RH to 80 %RH. The temperature can be measure with a precision of up to ±0,3 °C at room temperature. (see HTU21D's data sheet [1].)

Initial Operation

To put the system into operation PHTU21D [2] has to be inserted into the 4-pin socket and the battery has to inserted into the socket on the system's backside. Using the slide switch S1 the system is turned on or off. D1HTU21D was constructed for a humidity range from 20 %RH up to 80 %RH and a temperature range from 10 to 60 °C.

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Battery Power

The digital humidity and temperature sensor HTU21D is very energy efficient. It only consumes a current of ca. 450 µA (without using the internal heater), making it suitable for battery powered applications.

A standard 1/2AA lithium battery's capacity is ca. 1200 mAh and its output voltage is ca. 3.6 V. At approximately 2 V output voltage the battery is discharged. The following equation can be used to calculate the battery's lifespan.

$$\text{Milliampere hours (mAh)} = \text{measurements per year} \times \text{A/D-conversion time per measurement (ms)} \times \frac{\text{current consumption}}{(1000\,\text{ms/s} \times 3600\,\text{s/h})}$$

HTU21D is ideal for battery powered devices. But for the calculation of the battery's lifetime the additional electrical components' power consumption has to be taken into account as well. The additional components' current consumption can be taken from the following tables.

Parameter		Symbol	Min.	Typ.	Max.	Unit
Voltage Supply		*VDD*	1.5	3.0	3.6	V
Current Consumption [1]	*Sleep Mode*	*Idd*		0.02	0.14	µA
	Measuring		300	450	500	µA
Power Dissipation	*Sleep mode*			0.06	0.5	µW
	Average 8 bit [2]			2.7		µW
Communication		Digital 2-wire interface, I²C protocol				
Heater	*VDD = 3 V*	5.5 mW / ΔT = + 0.5 – 1.5 °C				
Storage		-40 °C .. 125 °C				

Table 2: *Excerpt from HTU21D's data sheet*

1) Conditions: V_{dd} = 3 V, SCK = 400 kHz at 25 °C
2) Conditions: V_{dd} = 3 V, SCK = 400 kHz, Temp < 60 °C, duty cycle < 10 %

Parameter	Symbol	Condition	Min.	Typ.	Max.	Unit
Operating Temperature Range	*Top*	Absolute Max	-20		70	°C
Storage Temperature Range	*Tst*	Absolute Max	-30		80	°C
Supply Voltage	*VDD*			3.3	5.5	V
Supply Current	*IDD*	Ta = 25 °C, VDD = 3.3 V		1.0	1.5	mA
Supply for LCD (contrast)	*VDD – V0*	Ta = 25 °C		3.2		V
"H" Level Input	*Vih*		0.7*VDD		VDD	V
"L" Level Input	*Vil*		0		0.6	V
"H" Level Output	*Voh*		0.75*VDD			V
"l" Level Output	*Vol*				0.2*VDD	V
Backlight Supply Voltage	*Vled*					V
Backlight Supply Current	*Iled*					mA

Table 3: *Excerpt from the display's (NHD-0208AZ-RN-YBW-33V) data sheet*

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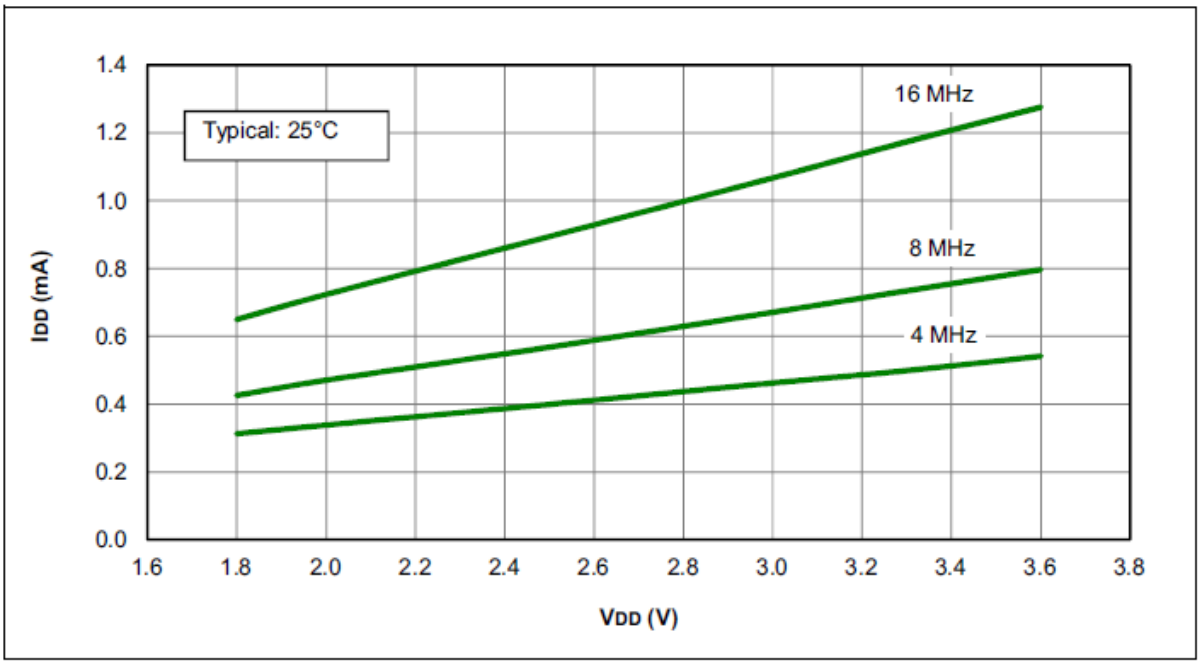

Figure 7: *PIC16LF1518's typical current consumption in HFINTOSC mode*

Operating time example calculation for measurements each second

If the temperature and relative humidity are measured every second, 31.5×10^6 measurements will be done per year. A resolution of 12 bit for the relative humidity and 14 bit for the temperature lead to a conversion time of approximately 58 ms (see page 4 and 6 of HTU21D's data sheet). The OEM sensor requires 0.45 mA, the microcontroller has a current consumption of 0.5 mA and the LCD requires 1 mA. This leads to an overall current consumption for the D1HTU21D of 1.95 mA.

The sensor's quiescent current is approximately 100 nA. This leads to the following power consumption:

a) During measurements:

Milliampere hours (mAh) = $31.5x10^6$ x 58ms x $\frac{1.95\text{mA}}{(1000\text{ms/s} \times 3600\text{s/h})}$ = 989.63mAh

b) In sleep mode:

Milliampere hours (mAh) = 100nA x $\frac{8760(\text{Stunden/Jahr})}{(10^6\ \text{nA/mA})}$ = 0.876 mAh

This leads to a power consumption of approximately 990,5 mAh per year and operating time of more than a year if a 1/2AA battery is used.

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Extra Features

D1HTU21D can be programmed in such a way, that the dew point and the absolute humidity can be displayed.

These values can be calculated using the equations in references and the measured relative humidity and temperature.

The output will alternate between the dew point and absolute humidity and the relative humidity and temperature each three seconds.

The measurement frequency and the digital data word's resolution can be adjusted using the before mentioned software. It is possible to choose between 8 or 12 bit resolution for relative humidity data words and 12 or 14 bit for temperature words.

The demonstrator can be programmed individually using the ICSP programming port and a six-wire cable attached to a programmer/debugger (e.g. the PICkit 3 [7]). The C code can be requested from AMSYS.

Further information

General information at www.amsys-sensor.com

[1] HTU21D pressure sensor: https://www.amsys-sensor.com/products/humidity-sensor/htu21d-digital-humidity-temperature-sensor/

[2] PHTU21D pressure sensor on PCB: https://www.amsys-sensor.com/products/humidity-sensor/phtu21d-digital-humidity-and-temperature-sensor-on-pcb/

[3] Microcontroller PIC16LF1518: http://www.mouser.de/ProductDetail/Microchip/PIC16LF1518-I-SO/?qs=Ot24P6tC%2fQ6lHBE1CUvGjA%3d%3d&gclid=CLyrgq-2kccCFbLJtAodIxEOWQ

[4] 8x2 LC-display: http://www.newhavendisplay.com/nhd0208azrnybw33v-p-5156.html

[5] MPLAB X IDE: http://www.microchip.com/pagehandler/en-us/family/mplabx/

[6] XC8 compiler: http://www.microchip.com/pagehandler/en-us/devtools/mplabxc/home.html

[7] PICkit 3: http://de.rs-online.com/web/p/entwicklungskits-prozessor-mikrocontroller/6872750/

The demonstator D1HTU21D can be obtained from AMSYS on request.

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