Application Note
Humidity Module
HYT

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1. HYT 271

Mechanically robust, chemical resistant and dew formation resistant, the digital humidity sensor with only 10.2 mm x 5.1 mm x 1.8 mm size offers the widest application window and an optimal price performance ratio. Precisely calibrated, the HYT 271 delivers an accuracy of ±1.8 % RH and ±0.2 °C - ideal for sophisticated mass applications, industrial handheld devices and precise humidity transmitters. Like all representatives of the HYT family, the sensor combines the advantages of a precise, capacitive polymer humidity sensor with the high integration density and functionality of an ASIC. The signal processing integrated in the sensor completely processes the measured data and directly delivers the physical parameters of relative humidity and temperature over the I²C compatible interface as digital values.

The module is precisely calibrated by the manufacturer and is therefore fully interchangeable without adjustment. Both the linearity error as well as temperature drift are corrected "OnChip" through computation resulting in an outstanding accuracy over a wide range of applications. The high chemical resistance, dew formation resistant design and an excellent long-term stability speaks for itself.

Typical Areas of Application:
- Handheld measurement instruments
- Humidity transmitters
- Industrial applications
- Measuring technology
- HVAC

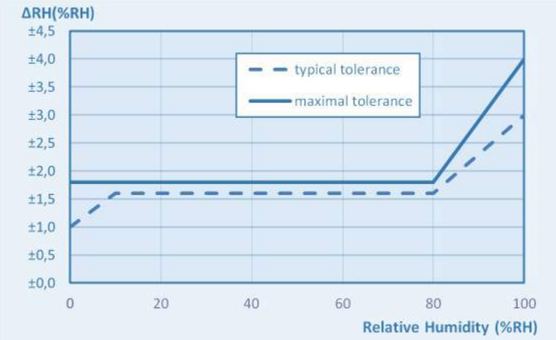


Figure 1 Typical and maximal tolerance at 23°C for relative humidity

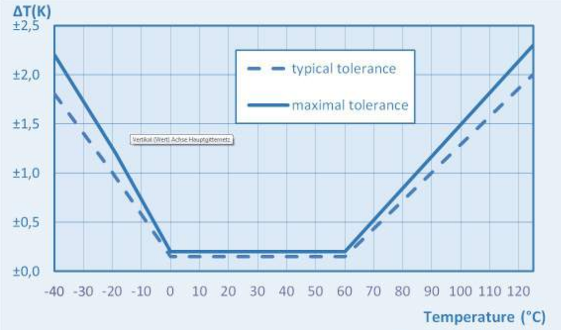


Figure 2 Typical and maximal tolerance for temperature sensor

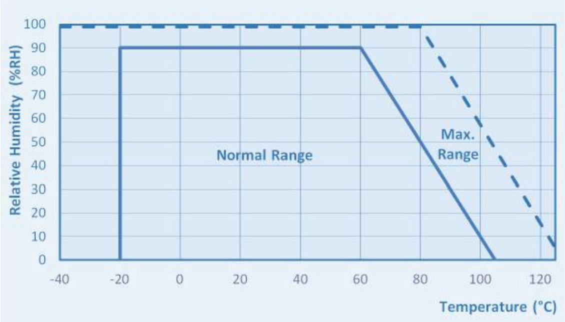
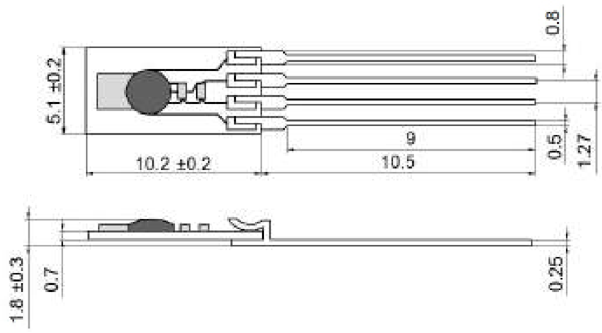
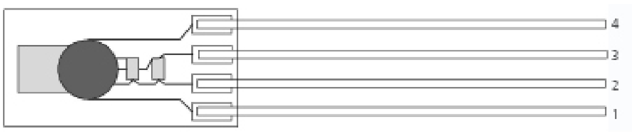


Figure 3 Operating Conditions

Mechanical Dimensions



Pin Assignment



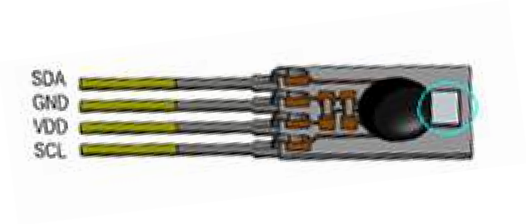
1	2	3	4
SDA	GND	VDD	SCL

1.2 Storage Temperature

The digital humidity sensor HYT 271 has to be stored in the original plastic blister only.

Storage temperature (limited by the plastic tube): -20 °C to +50 °C

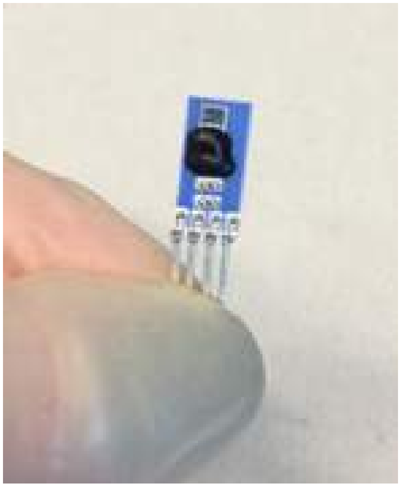
1.3 Active Sensor Area



1.4 Sensor Handling

Hold the sensor with plastic tweezers or with gloves on the wires only

Sensor held with plastic tweezers on the wires only

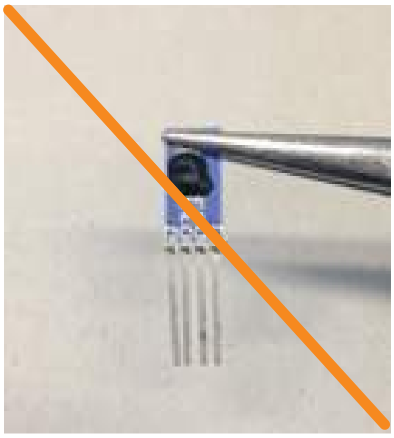


Sensor held with gloves on the wires only

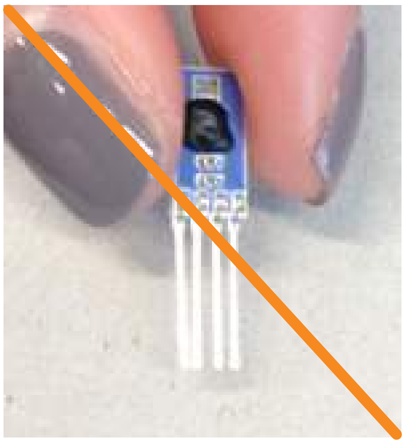
Examples of prohibited handling:

Sensor picked on the active area

Sensor picked on the wires with metal tweezers

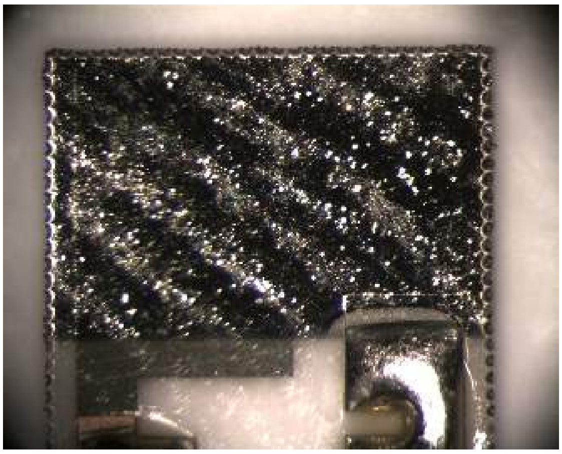


Sensor picked on the active area with metal tweezers



Sensor held with fingers without gloves

- Do not touch the active area of the sensor
- Do not use metal tweezers to handle the sensors
- Never handle the sensor by hand without gloves
- Avoid mechanical stress to the sensor, e.g. bending or touching the sensor with sharp objects
- Hold the sensor with plastic tweezers on the wires and side edges only
- Do not touch or scratch the active area of the sensors. Scratches and contaminations can degrade the sensor characteristic (see bad examples below)



Sensor with contaminations

Sensor with a scratch

1.5 Soldering of the Sensor

The 320 °C maximum temperature of the soldering iron may not be exceeded. Maximum heat applyed to the iron or solder wave cannot exceed 10 s and only at the very end of the connecting wires.
Avoid soldering flux residues caused by the soldering process or any other contaminations inside the active area of the sensor.
Soldering flux residues on the outside of the active sensor area are not critical.
If the sensor is mounted with glue, baking the sensor at 60 °C for 1 h after the gluing process is recommended.

1.6 Cleaning of the Sensor

Residues can be removed with isopropanol at room temperature. Applying low ultrasonic energy could improve the cleaning process. The sensor must be dried after the cleaning process.
The sensor cannot be cleaned mechanically with cotton swabs.
It is possible to clean the sensor with oil free and filtered clean air, e.g. to remove dust particles.

2. HYT 221

The round stainless steel casing can easily be fitted into housing openings and can be sealed against the wall with the use of an O-ring. Combined with the waterproof metal filter, it results into an assembly that is splash water proof and enables a sealed housing construction while providing a high dynamic responsiveness. Precisely calibrated, the HYT 221 delivers an accuracy of ±1.8 % RH and ±0.2 °C. Like all representatives of the HYT family, the sensor combines the advantages of a precise, capacitive polymer humidity sensor with the high integration density and functionality of an ASIC. The signal processing integrated in the sensor completely processes the measured data and directly delivers the physical parameters of relative humidity and temperature over the I²C compatible interface as digital values. The module is precisely calibrated by the manufacturer and is therefore fully interchangeable without adjustment.

Both the linearity error as well as the temperature drift are corrected “OnChip” through computation resulting in an outstanding accuracy over a wide range of applications. Due to mechanical robustness, high chemical stability, dew formation resistance as well as excellent long term stability, the typical areas of application are humidity measurement in saunas, applications in outdoor areas or industrial applications in the field of drying systems.

Typical Areas of Application:

- Meteorology
- Industrial drying systems
- Medical devices
- Agriculture

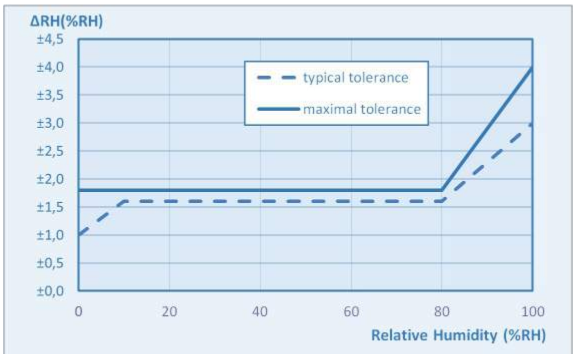


Figure 1 Typical and maximal tolerance at 23°C for relative humidity

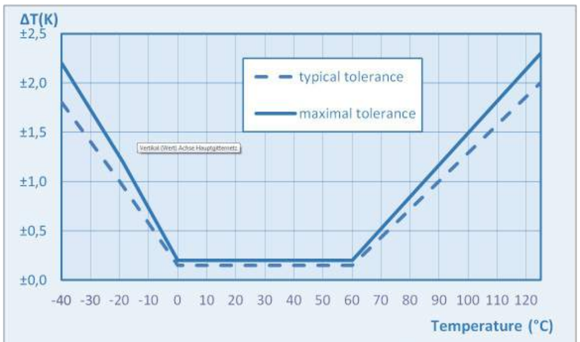


Figure 2 Typical and maximal tolerance for temperature sensor

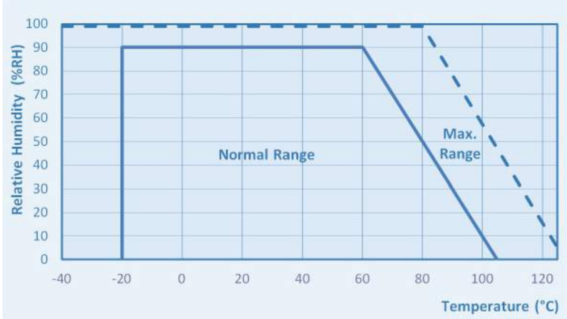


Figure 3 Operating Conditions

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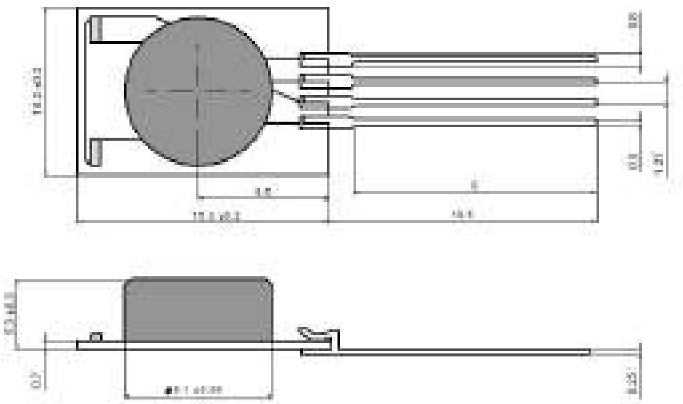
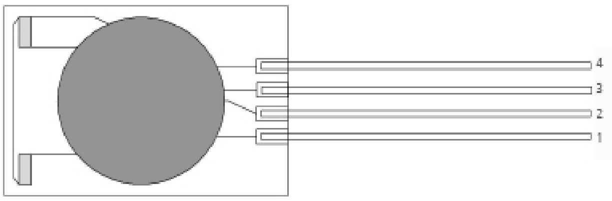
Mechanical Dimensions



Pin Assignment



1	2	3	4
SDA	GND	VCC	SCL

3. HYT 939

Precisely calibrated, the HYT 939 delivers an accuracy of ±1.8 % RH and ±0.2 °C. Further features are the integrated signal processing for measuring the physical parameters of relative humidity and temperature, the I²C compatible interface, easy interchangeability without adjustment as well as mechanical robustness, chemical resistance, dew formation resistance and long-term stability.
Both the linearity error and temperature drift are corrected "OnChip" through computation. Because of the special robust construction, the sensor also withstands peak loading at high temperatures. Therefore, this special model is also ideal for extremely sophisticated industrial applications in drying systems and suitable for medical systems.

For a pressure tight sensor packaging consult IST AG.

Typical Areas of Application:

- Medical systems
- Autoclaves
- Pressure dew point measurement (pressure tight sensor packaging required)
- Drying systems
- Laboratories

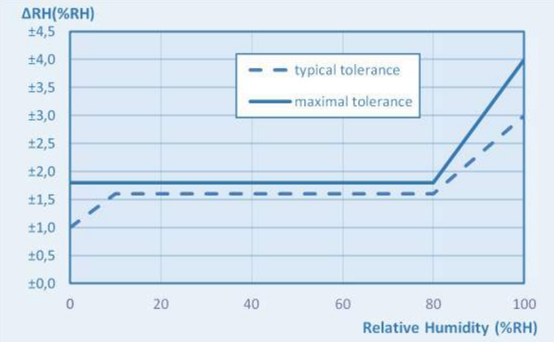


Figure 1 Typical and maximal tolerance at 23°C for relative humidity

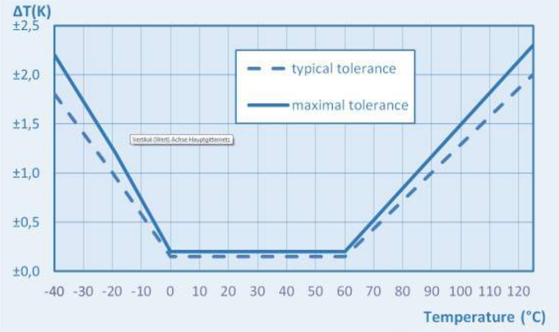


Figure 2 Typical and maximal tolerance for temperature sensor

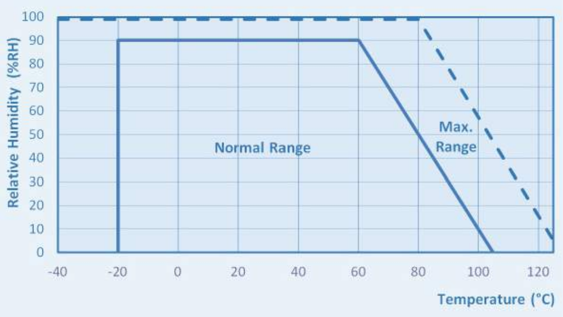


Figure 3 Operating Conditions

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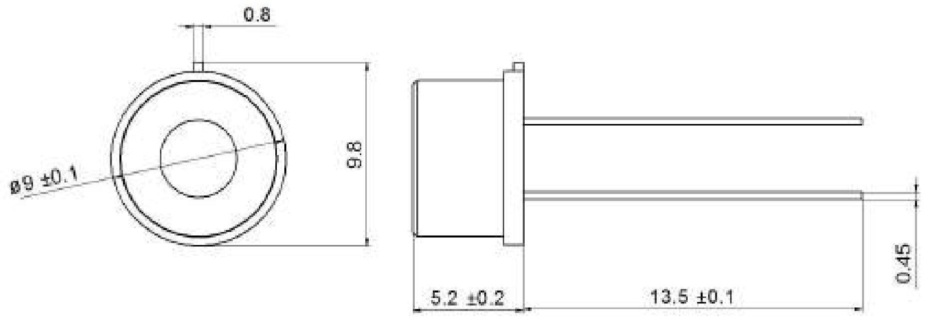
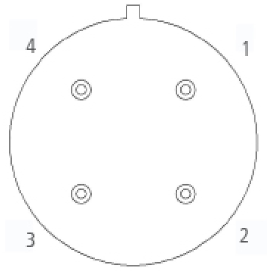
Mechanical Dimensions



Pin Assignment



1	2	3	4
SCL	VCC	GND	SDA

3.1 Mounting Instructions

The media compatibility of the sensor, housing and sealing materials are to be checked and kept suitable as per the application. The housing and the assembly must be so constructed that it can withstand the application pressure multiplied by the factor of safety. In case of dynamic applications in the upper pressure range, an additional extra factor is to be taken into account for the material fatigue. The assembly must be done stress free. This should remain valid for the entire temperature range, considering the different coefficients of expansion between the sensor housing and the opening. The support from top may be provided only in the boundary area. The upper mounting ring must rest upon flat.

3.2 Sealing Rings

The most frequent error in case of a pressure resistant assembly is the loss of sealing. Therefore, this is the point where high attention is to be given. Standard sealing rings in the form of O-rings are available in the market, which are offered by different manufacturers. A typical dimension is, for example, 7 x 1 mm. The material is dependant on the application, hence due to qualitative reasons, high grade options of VITON or FPM are recommended, which are also resistant to ageing and temperature exposure.

3.3 Construction Recommendations

These recommendations for construction are to be understood only as an assistance for your own construction. The dimensioning of the components in each case is to be decided suiting to the application and checked. Please also consider the fitment and application guidelines of the O-ring manufacturer.

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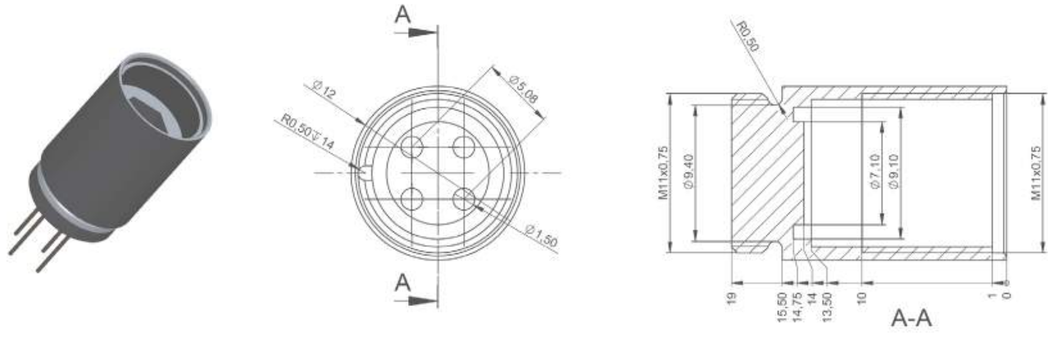
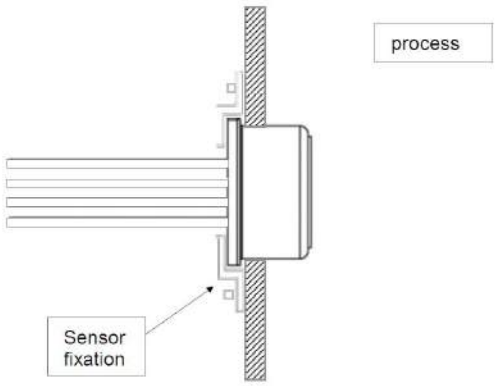
Version 1



Version 2

Legal Notice: The recommendations for construction are unbinding; alterations are possible in the recommendations at any time without prior notice. Any liability on our part for damages of any kind is excluded.



4. HYT131

Relative humidity accuracy

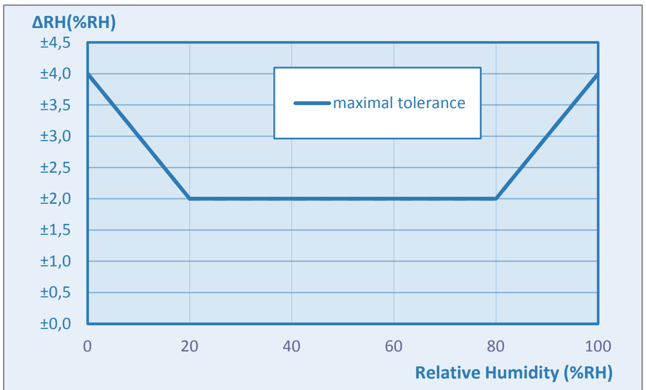
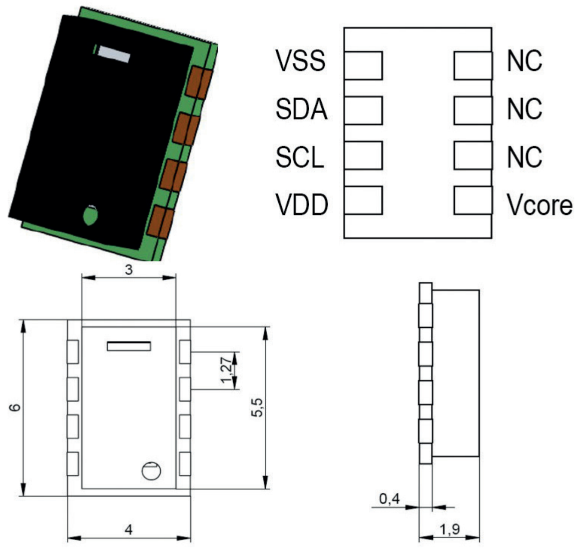


Figure 1 Maximal tolerance at 23°C for relative humidity

[1] The accuracy is tested at 23 °C and 3.3 V operating voltage in the direction of rising humidity. The accuracy does not include Tk-Residual error, residual linearity error or Hysteresis effect.
[2] The maximum dew point is brought down to 80 °C.

Mechanical dimensions



Temperature measurement accuracy

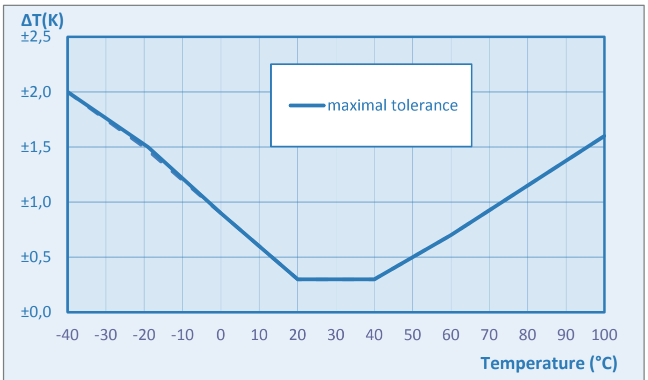
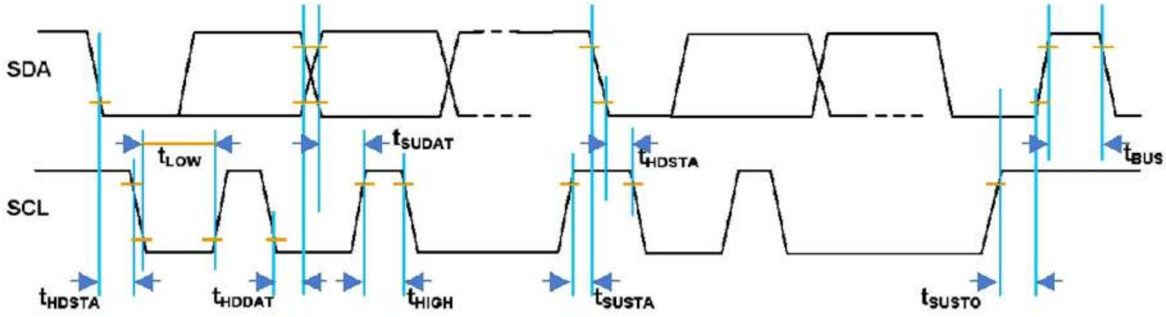


Figure 2 Maximal tolerance for temperature sensor

5. I²C Protocol Description

5.1 I²C Interface and Timing

For integration with a micro-controller, the humidity module has an I²C-compatible interface which supports both 100 kHz and 400 kHz bit rates. The I²C slave address is programmed by default on 0x28 and can be adjusted in the entire address range (0x00 to 0x7F). Hence, up to 126 humidity modules can be operated on a single I²C-Bus.

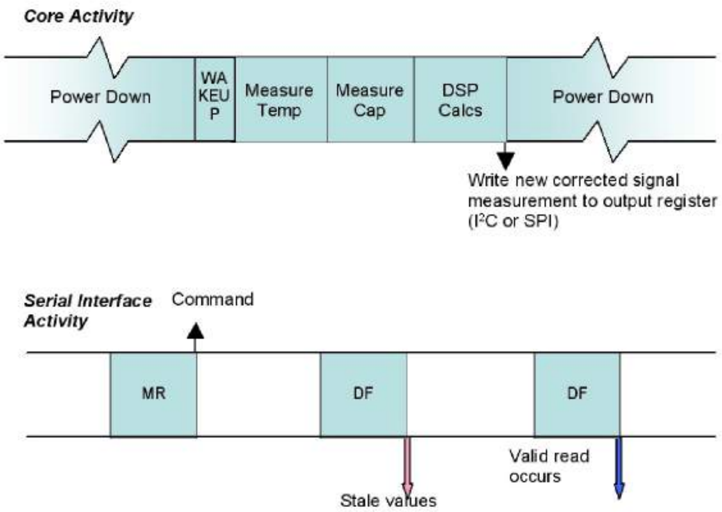


Parameter	Symbol	Min	Max	Unit
SCL clock frequency	fSCL	100	400	kHz
Start condition hold time relative to SCL edge	tHDSTA	0.1		µs
Minimum SCL clock low width 1	tLOW	0.6		µs
Minimum SCL clock high width 1	tHIGH	0.6		µs
Start condition setup time relative to SCL edge	tSUSTA	0.1		µs
Data hold time on SDA relative to SCL edge	tHDDAT	0		µs
Data setup time on SDA relative to SCL edge	tSUDAT	0.1		µs
Stop condition setup time on SCL	tSUSTO	0.1		µs
Bus free time between stop condition and start condition	tBUS	1		µs

There are two I^2C commands for the user to access the humidity module:

Command	Description
‚Data Fetch' (DF)	Fetch the last measured value of Humidity / Temperature
‚Measuring Request' (MR)	Start a measuring cycle

In the initial condition, the humidity module is in sleep mode to minimize the current consumption. A new measurement is carried out only after the command measuring request (MR) is received. Access to the status bits and measured values is made by the data fetch command. After the measuring cycle has been completely processed, the ready status bit is set and the current measured values are available. To determine if the measuring cycle has been already finished, the output registers may be cyclically polled. If the access to the measured values takes place too early, the measured values of the previous measuring cycle are transferred and the stale status bit is set.



5.2 MR (Measurement Requests)

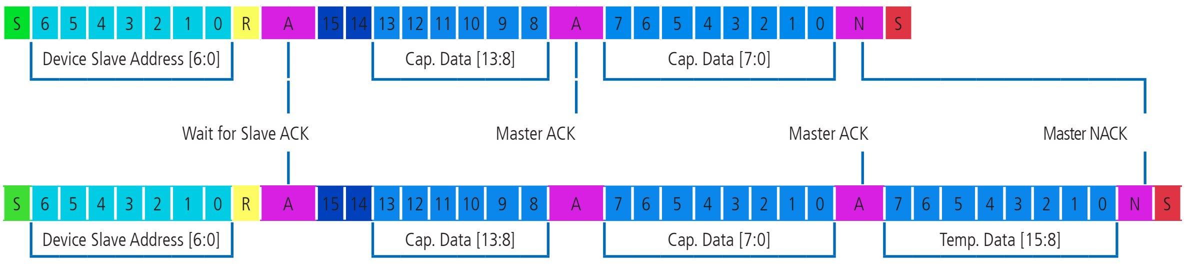
By a measurement request command, the sleep mode is terminated and the humidity module executes a measurement cycle. The measuring cycle begins with the temperature measurement, followed by humidity measurement, digital signal processing (linearizing, temperature compensation) and finally writes the processed measured values into the output register.

I²C MR - Measurement Request: Slave starts a measurement cycle

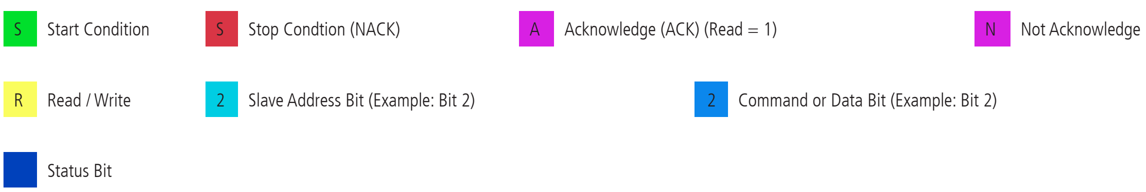
5.3 DF (Data Fetch)

The data fetch command serves to finish reading the output register. The DF command is sent by the master to the humidity module (slave) and begins with the 7 Bit slave address. The 8th bit is 1 (= read). The humidity module sends back an acknowledgement (ACK = 0) in case of correct addressing. The number of bits, that the humidity module sends back, is completed when the master sends a NACK (ACK = 1) and launches stop condition. The first two bytes of measurement data contain the two status bits as MSB, followed by the humidity value with 14 bits. The MR command consists of the address of the humidity module, with which the R/W bit is transferred as 0 (= write). After the humidity module is answered with ACK (= measurement started), the master finalized the transfer with NACK (ACK = 1) and launches stop condition. If temperature data is needed, these can be read after the humidity value. The most significant 8 bits of the temperature value will be transferred as third byte. Then the least significant 6 bits of the temperature value can be read as the fourth byte. The last two bits are not used and should be masked away. The master has the possibility to terminate the reading after each read byte through a NACK. Hence, it is possible to finish reading even after the first byte and evaluate only the status/stale bit and the master can terminate the transfer without completing the whole cycle. If only the upper 8 bits of the temperature value are to be transferred (8 bit resolution), the transfer can be aborted after the third byte by a NACK.

PC DF - 2 Bytes: Slave returns only capacitnce data to the master in 2 bytes



PC DF - 3 Bytes: Slave returns 2 capacitance data bytes & temperature high byte (T [15:8]) to master



5.4 Scaling of Measurement Values

T_{raw} and RH_{raw} are the digital 16 bit values submitted by the sensor.

Humidity signal (2 bytes):

The first top bits are status bits with following relevance:

Bit 15: CMode Bit, if 1 – element is in command mode
Bit 14: Stale bit, if 1 – no new value has been created since the last reading.

To mask the 2 top status bits in a 16 bit value, it will be linked logically with 3FFF and AND. The remaining 14 bit represents the measured value. The masked value data now have to be scaled into physical measurement units:

Humidity values will be calculated as follows:

$$RH\ [\%] = (100\ /\ (2^{14} - 1)) * RH_{raw}$$

0x0 complies with 0 % RH
0x3FFF complies with 100 % RH
RH_{raw} = 0x0000 to 0x3FFF (Hex) or 0 to 16383 (Dec)

Temperature signal (2 bytes):
The bits 15 to 2 represent the 14 bit measured value. Bit 1 and 0 are not used. The value data now have to be scaled into physical measurement units:

Temperature values will be calculated as follows:

$$T\ [°C] = (165\ /\ (2^{14} - 1)) * T_{raw} - 40$$

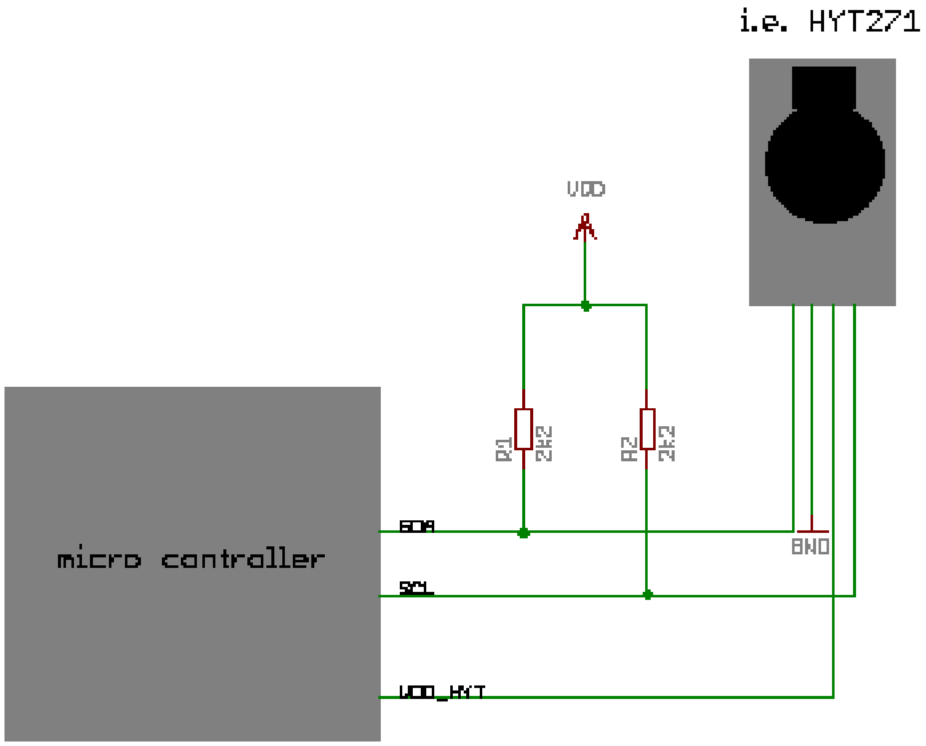
0x0 complies with -40 °C
0x3FFF complies with +125 °C
T_{raw} = 0x0000 to 0x3FFF (Hex) or 0 to 16383 (Dec)

C-Code examples are available upon request.

Example:

	Byte 1	Byte 2	Byte 3	Byte 4
	31 dec	109 dec	96 dec	72 dec
bin	~~00~~01.1111	0110.1101	0110.0000	0100.10~~00~~
	Humidity 14 bit right-adjusted		Temperature 14 bit left-adjusted	
hex	1F6D		1812	
dec	8045 x 100/16383 =		6162 x 165/16383 - 40 =	
	49.1 % RH		22.06 % °C	

5.5 I2C pull up resistor



6. I²C Address Change

To change the I²C-address of the sensor module, the module must be switched into the Command-Mode. The switching is performed by sending the start-command-mode message over I²C-bus no later than 10 ms after Power-On reset. Each command-mode message is 4 byte long, like shown in table 1.

S	6	5	4	3	2	1	0	W	A	7	6	5	4	3	2	1	0	A	7	6	5	4	3	2	1	0	A	7	6	5	4	3	2	1	0	A	P
S	0	1	0	1	0	0	0	0	A	C	C	C	C	C	C	C	C	A	D	D	D	D	D	D	D	D	A	D	D	D	D	D	D	D	D	A	P
	Slave Address									Command Byte									Command Data [15:8]									Command Data [7:0]									

Table 1

SlaveAddress:	0x28	default value
Command-Byte:	0xA0	start command-mode
	0x1C	read configurationsparameter that includes the I²C-address
	0x5C	write configurationsparameter that includes the I²C-address
	0x80	end of command-mode, start normal-mode

At writing access both command data bytes contains the data, at reading access both data bytes must be set to 0x00. The response to the command-mode message can be read out by a Data-Fetch. The response time of the command-mode messages are 100 µs.

Table 2 shows the response to the start of the command-mode.

S	6	5	4	3	2	1	0	R	A	7	6	5	4	3	2	1	0	N	P
S	0	1	0	1	0	0	0	0	A	S	S	D	D	D	D	R	R	N	P
	Slave Address									Status		Diagnostics				Response			

Table 2

Status:	10_b	command-Mode
	01_b	stale
Diagnostic:	$xxx1_b$	corrected EEPROM-error
	$xx1x_b$	uncorrectable EEPROM-error
	$x1xx_b$	RAM Parity error
	$1xxx_b$	configuration error
Response:	00_b	busy
	01_b	positive acknowledge
	10_b	negative acknowledge

Table 3 shows the response to the read out of the I²C-address.

S	6	5	4	3	2	1	0	R	A	7	6	5	4	3	2	1	0	A	7	6	5	4	3	2	1	0	A	7	6	5	4	3	2	1	0	A	P
S	0	1	0	1	0	0	0	0	A	S	S	D	D	D	D	R	R	A	E	E	E	E	E	E	E	E	A	E	E	E	E	E	E	E	E	A	P
	Slave Address									Status		Diagnostics				Response			EEPROM Data (15:8)									EEPROM Data (7:0)									

Table 3

Status:	see table 2 on page 16
Diagnostic:	see table 2 on page 16
Response:	see table 2 on page 16
EEPROM-Data:	content of the memory

The response to the command byte 0x1C contains the I²C-address in bitposition 6:0, default value is 0101000b. The old I²C-address is valid until the module is in command mode.

The following table shows a complete process of reading and writing back of the I²C-address.

Power – On Reset

S	0x50	A	0xA0	A	0x00	A	0x00	N	P	Start Command – Mode
S	0x51	A	0x81	N	P					Response (ACK)
S	0x50	A	0x1C	A	0x00	A	0x00	N	P	Read out Data Bytes with I²C-address
S	0x51	A	0x81	A	Highbyte	A	Lowbyte	N	P	Response
Write the new address into the bits 6:0 of the lowbyte.										
S	0x50	A	0x5C	A	Highbyte	A	Lowbyte	N	P	Write back Data Bytes with I²C-address
S	0x51	A	0x81	N	P					Reponse (ACK)

S	0x50	A	0x80	A	0x00	A	0x00	N	P	Start normaler mode

or alternatively Power – Off

The following table shows the I²C timing.

Command Byte 8 Command Bits	Third and Fourth Bytes 16 Data Bits (Hex)	Description	Response Time §§
00_H to $1F_H$	0000_H	EEPROM Read of addresses 00_H to $1F_H$ After this command has been sent and executed, a data fetch must be performed	100 µs
40_H to $5F_H$	$YYYY_H$ (Y = data)	Write to EEPROM addresses 00_H to $1F_H$ The 2 bytes of data will be written to the address specified in the 6 LSBs of the command byte	12 ms
80_H	0000_H	Start_NOM Ends Command Mode and transitions to Normal Operation Mode	Length of initial conversions depends on temperature and capacitance resolution settings and the capacitance „mult" setting
$A0_H$	0000_H	Start_CM Start Command Mode: used to enter the command interpreting mode. Start_CM is only valid during the power-on command window	100 µs
$B0_H$	0000_H	Get revision Get the revision of the part. After this command has been sent and executed, a data fetch must be performed	100 µs

6.1 Step by Step - I²C Address Change

1. Power-on-reset
2. Within 10 ms, send command 0XA0 (start command mode) through I²C bus. The default 7 bit I²C address is 0x28. In I²C write mode, the bit "W" shall be 0

0x50	0xA0	0x00	0x00	Send Start-Command-Mode
0x51				Response fetch, the bit "R" is 1

   If the response is not 0x81, then you did not enter the command mode successfully

3. First try to read the configuration parameters stored inside EEPROM. If entering command-mode is successful, the content can be read out successfully, otherwise start from step 1)

0x50	0X1C	0X00	0X00	Send read register 1C command. Register (1C) includes the I²C address
0x51				Read out data bytes with I²C address

4. If the response is not 0x81 0x00 0x28, then you did not read successfully
   Change I²C address by sending the following command:

0x50	0x5C	0x00	0x31	Change I²C address into 0x31

   Repeat 3) to confirm whether the I²C address is successfully changed. If successful, the response is 0x81 0x00 and 0x31

5. Power-off, if 1), 2), 3) and 4) failed