Innovative Sensor Technology
physical. chemical. biological.

Application Note
Humidity Modules
HYT

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Content

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1. General benefits of the HYT-module family

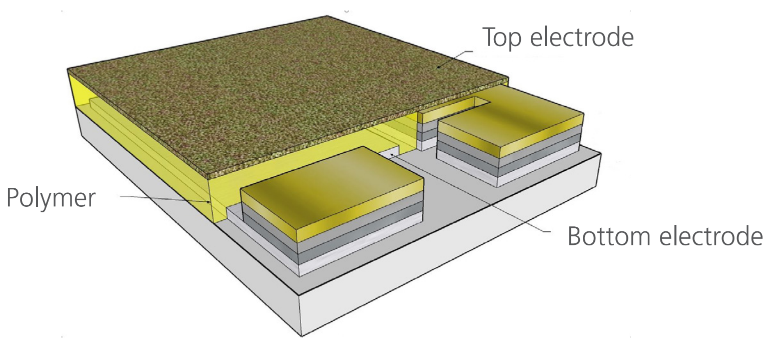
- Fast response time (HYT 271)
- Stable at high humidity
- I²C protocol
- Low drift
- Low hysteresis
- Humidity and temperature sensor with excellent accuracy
- Easy integration, interchangeable without adjustments
- Different calibrations available with up to > 0.5 %RH accuracy
- Customer specific versions
- Fully calibrated and temperature-compensated

IST AG's fully calibrated and temperature-compensated humidity modules are the best solution for the most demanding humidity applications.

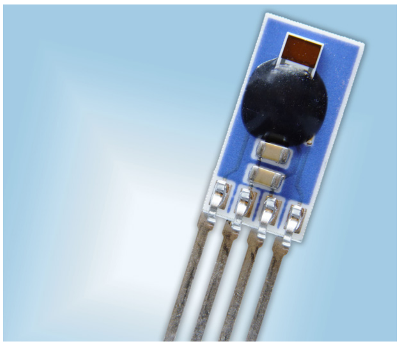
The heart of any type of module is its capacitive polymer-based sensor element, which is fabricated with IST AG's cutting-edge thin film techniques. Its proprietary polymer and porous humidity-permeable cover layer enables excellent stability while maintaining the advantages of fast response times. The use of only first-class materials and the robust sensor design make the elements very stable in harsh conditions, such as high humidity and dew formation. With the SIL or pin-contacts, the modules can easily be integrated into various assemblies.

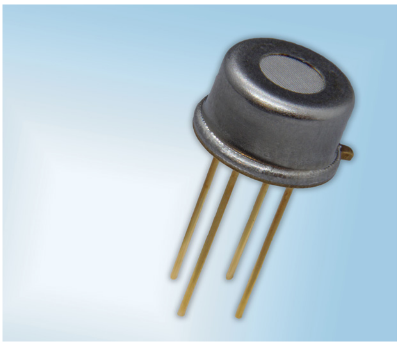
The signal processing integrated in the sensor completely processes the measured data and directly delivers the physical parameters of relative humidity and temperature over the I²C compatible interface as digital values. The precise calibration of every module against dewpoint ensures the outstanding accuracy of our humidity modules.

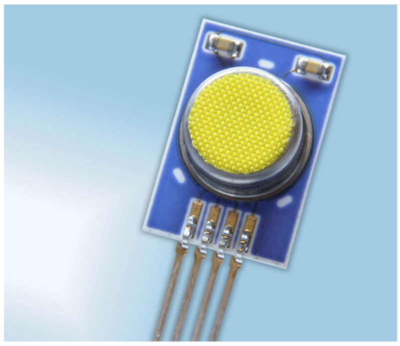
Sensor construction



2. Models


HYT 271


HYT 939


HYT 221

Due to the very precise calibration of HYT as well as the pin contacts, the modules can easily be integrated and replaced in the assembly.

Accuracy/Calibration

IST AG's off-the-shelf modules are available with standard and low humidity calibration. Both configurations are appliccable to HYT 271, 939 and 221 models.

Standard calibration:	Accuracy humidity:	±1.8 %RH (0-90 %RH)
	Accuracy temperature:	±0.2 °C
Low humidity calibration:	Accuracy humidity:	±0.5 %RH (0-5 %RH) ±1 %RH (5-10 %RH)
	Accuracy temperature:	±0.2 °C

For details see product data sheets.

Custom specific versions

If a higher accuracy or different sensor design is needed, the modular design of HYT allows for high flexibility – the sensor, its calibration and assembly can easily be adapted to develop tailor-made modules fulfilling individual demands.

Customized IST AG humidity modules feature extraordinary response times, high accuracies in condensing environments or low humidity conditions. Please contact us for custom specific versions.

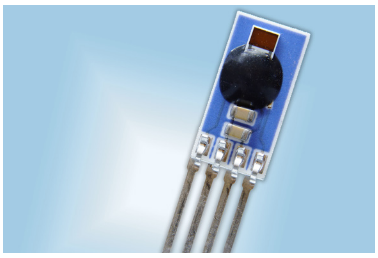
3. HYT 271

The fastest and smallest of the HYT family is the HYT 271. The digital module with only 10.2 mm x 5.1 mm x 1.8 mm size offers a wide application window and an optimal price-performance-ratio. It is the best solution for fast measurements or sophisticated mass applications. With its SIL-contacts, it can easily be integrated into various assemblies. Like all representatives of the HYT family, the module is precisely calibrated and temperature-compensated and directly delivers the relative humidity and temperature parameters.

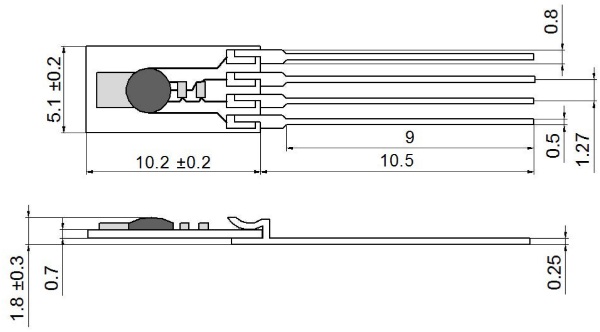
HYT 271 is available in standard, low humidity and custom specific calibrations

3.1 Typical Areas of Application

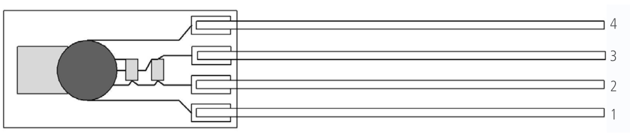
- Handheld measurement instruments
- Humidity transmitters
- Industrial applications
- Measuring technology
- HVAC
- Outside air humidity measurement (weather monitoring, weather stations, etc.)



3.2 Mechanical Dimensions



3.3 Pin Assignment



1	2	3	4
SDA	GND	VDD	SCL

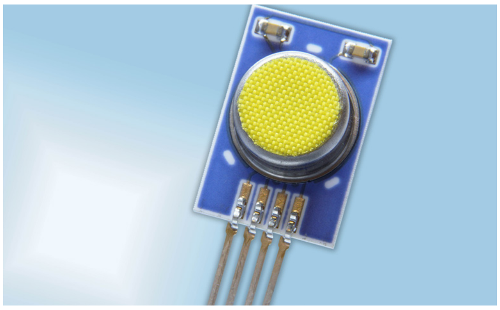
4. HYT 221

The round stainless steel casing can be easily fitted into housing openings and sealed against a wall with the use of an O-Ring. The hydrophobic/oleophobic PTFE membrane filter protects the sensor from dust and liquids while providing a high dynamic responsiveness. It is therefore the best solution for harsh environments. The HYT 221 is easy to handle and can be integrated into various assemblies.

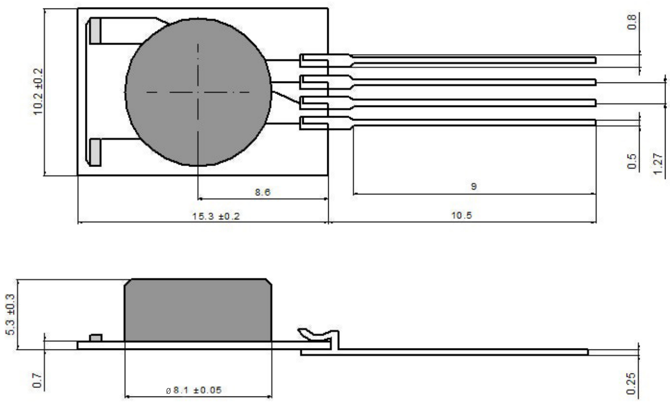
HYT 221 is available in standard, low humidity and custom specific calibrations

4.1 Areas of Application

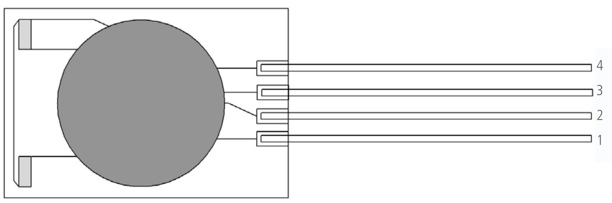
- Agriculture
- HVAC
- Industrial applications
- Outside air humidity measurement (weather monitoring, weather stations etc.)



4.2 Mechanical Dimensions



4.3 Pin Assignment



1	2	3	4
SDA	GND	VCC	SCL

5. HYT 939 and HYT 939p

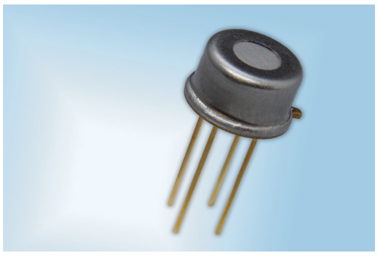
The strongest of the HYT modules in TO39 packaging particularly features mechanical robustness. Through glass to metal seals and welding of the stainless-steel cap onto the metal header, it is pressure tight up to 16 bar in the 939p version.

The round stainless-steel cap can easily be fitted into housing openings and sealed against a wall with the use of an O-Ring. The metallic mesh filter protects the sensor from dust while providing a high dynamic responsiveness. This special model is therefore ideal for sophisticated industrial applications.

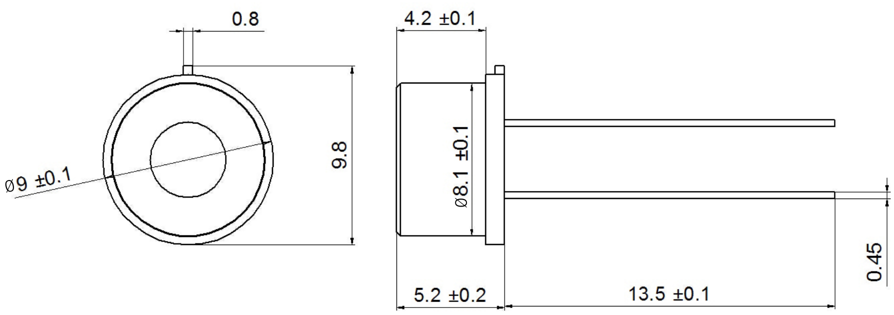
HYT 939 is available in standard, low humidity and custom specific calibrations

5.1 Areas of Application

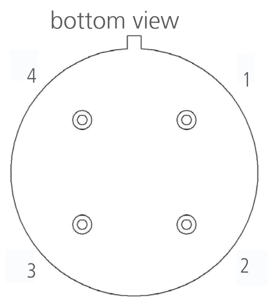
- Pressure dew point measurement (pressure tight sensor packaging HYT939p required and low humidity calibration is beneficial)
- Industrial applications
- Drying systems (low humidity calibration is beneficial)
- Semiconductor Equipment
- Compressed air
- Process control
- Autoclaves



5.2 Mechanical Dimensions



5.3 Pin Assignment



1	2	3	4
SCL	VCC	GND	SDA

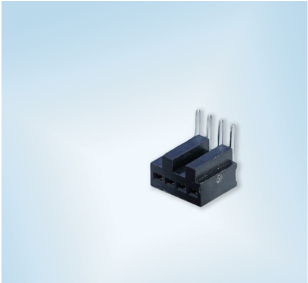
6. Design Recommendations

6.1 Connector

For easy replacement of HYT 271 and 221 in the application, there is a connector available: Con.HYT.1.27.B, part number 105443.

front view of connector 105443

rear view of connector 105443



6.2 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 constructed so 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 a flat surface.

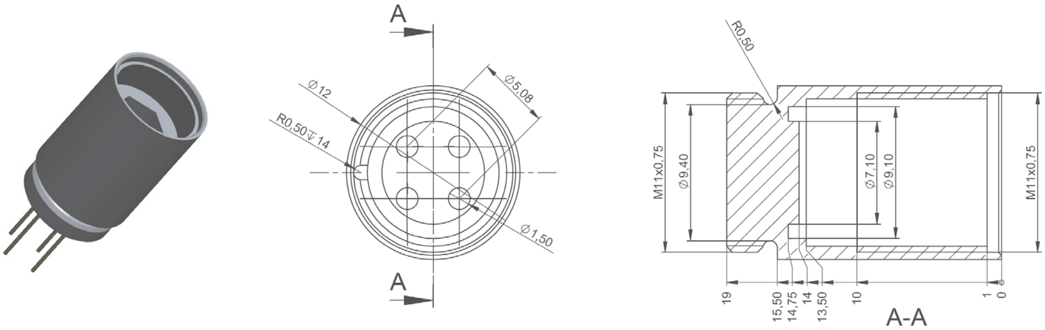
6.3 Sealing Rings

The most frequent error in a pressure-resistant assembly is the loss of sealing and therefore needs high attention. Standard sealing rings in the form of O-rings are available in the market, which are offered by various manufacturers. A typical dimension is, for example, 7 x 1 mm. The material is dependent on the application. To ensure best quality, high grade options of VITON or FPM are recommended, which are also resistant to ageing and temperature exposure.

6.4 Construction Recommendations

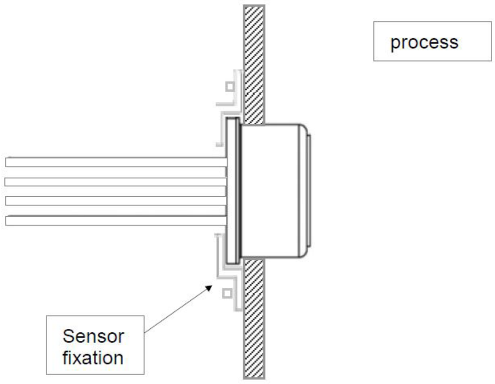
These recommendations for construction are to be understood only as assistance for your own construction. The dimensioning of the components in each case is to be decided suiting the application and needs to be checked. Please also consider the fitting and application guidelines of the O-ring manufacturer.

Version 1



Version 2

Legal Notice: The recommendations for construction are not binding; alterations are possible in the recommendations at any time without prior notice. Any liability on our part for damages of any kind is excluded.



6.5 Coupling to environmental conditions

In the assembly, the module should measure as close as possible to the real humidity and temperature value of the application. When designing an assembly/probe, please consider the following:

Heat sources: e.g. electronic components in the vicinity of the module can influence the temperature as well as the humidity measurement via heat conduction. Therefore, do not place possible heat sources near the module or make sure to thermally decouple critical components.

H_2O microclimate: Materials with large water absorption capacity in the vicinity of the humidity sensor element can cause a H_2O microclimate. In this case the relative humidity in the surrounding atmosphere of the element is not the same as in the conditions to be tested. This often results in wrong %RH readings. The exact value of maximal water absorption capacity of a material used in an assembly is extremely application dependent. To avoid false readings only use tested materials.

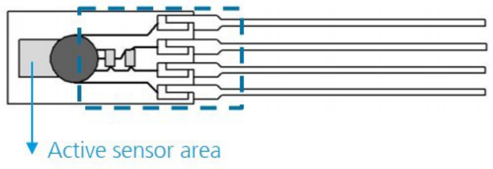
Filters/dead volume: Additional filters as well as dead volume in the assembly can decrease the response time of the humidity measurement system.

UV-VIS radiation Protect the module in the assembly as good as possible from radiation, especially UV-VIS and heat radiation. Penetration of UV-VIS radiation damages the chemical structure of the humidity sensitive polymer and has therefore a large influence on the sensor performance.

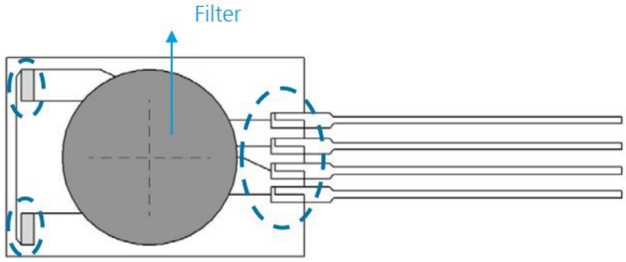
Heat radiation Increasing the temperature in the materials around the temperature sensor, heat radiation can have an influence on the temperature measurement. Protect the module in the assembly as good as possible from radiation.

Thermal coupling to environmental conditions: A large thermal mass in direct contact with the module decreases the thermal response time of the assembly. If a fast temperature response time is important, decouple the module from the mass of the assembly.

7. Application in condensing environment



Area to be covered on the HYT 271 in the assembly for the application in condensing environment

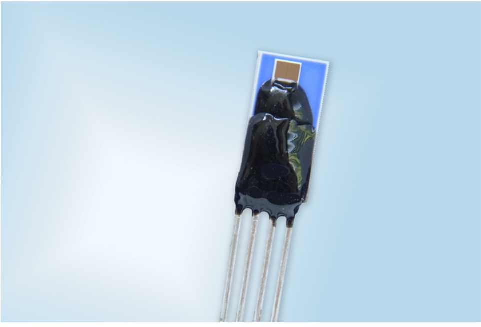


Area to be covered on the HYT 221 in the assembly for the application in condensing environment

For the application in condensing environment, the electronics must be protected by a suitable coating material which does not release polluting chemicals or produces a H_2O microclimate. The capacitors and SIL contacts on both sides should be covered (see blue box/circle in the figure above). Be careful not to touch or cover the active sensor area or filter during dispensing. Solvents or other compounds of epoxies, glob tops etc. can damage the sensitive layers. Even small dots of impurities on the cover electrode must be avoided.

Covered versions of 221 and 271 are available

HYT 271 covered: part No 103957



HYT221 covered: part No 152508

Contact us for versions with high humidity calibration for very high accuracy in the high humidity range.

8. Handling guidelines

8.1 Sensor pollution

Gaseous chemicals such as volatile organic compounds (VOCs) are known to pollute the sensitive layer of the humidity sensor element. If such pollutants are present in the surrounding atmosphere of the sensor, they diffuse into the polymer where they occupy spaces reserved for water molecules. This process often results in lower humidity readings.

Sources of pollution can be materials that release chemicals such as:

- Plastics or other packaging materials, such as ESD Bags, cardboard boxes, foams etc.
- Potting compounds
- Adhesives
- Coatings
- Glues etc.

High concentrations of pollutants are known to occur in storage rooms and manufacturing floors especially where castings, gules, epoxies etc. are cured.

To avoid false readings please:

- Store the modules in the original sealed packaging material
- Only use tested or recommended packaging material
- The ESD bag must be hermetically sealed
- Eliminate VOCs during storage and manufacturing
- Ensure a clean surrounding atmosphere by fresh air supply and good ventilation. Keep the sensor in the recommended/tested packaging materials during longer storage times
- Use only tested materials in the sensor assembly

8.2 Reconditioning procedure

Once the modules already read wrong humidity signals, the pollutants can be removed by evaporation in many cases. For reconditioning

- bake the sensors for 2-24 hours at 120°C.

It is possible that the modules read slightly too high values after reconditioning, then

- store the modules for 4-8 weeks in eurostat ESD bags (without desiccant) at 55 °C

8.3 Packaging

Due to the polluting effect of many plastics (see 8.1), only use tested or recommended packaging materials.

Recommendations:

ESD Bag

- ESD bag (eurostat 20-87x-xxxx, 20-771-xxxx) or
- W-Tech France MBB Aluminium bag: Total thickness 150µm ±10% Structure: ESD+PET (12µm) / PA (15µm) / AL (7µm) / ESD+LDPE (110µm)

Desiccant bag

- Desiccant bag DESI PAK (Clariant 25085627656

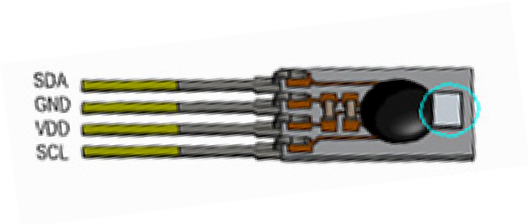
Never use the ESD bags without desiccant bag (except reconditioning procedure)!

The bag with the desiccant and the modules must be sealed. For HYT 271: Fix the modules in the packaging to avoid damages on the active sensor area or on the black glob top.

8.4 Handling

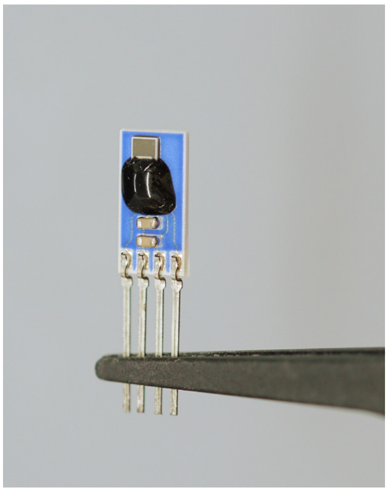
- Do not use metal tweezers to handle the modules
- Never handle the modules by hand without gloves
- Avoid mechanical stress, e.g. bending or touching the module with sharp objects
- Hold the module with plastic tweezers on the wires and side edges only
- HYT271: Do not touch the active sensor area or the black glob top on the module. Scratches and contaminations can damage the sensitive layers and therefore degrade the sensor performance (see pictures below). Mechanical stress on the black glob top can damage the electronics.

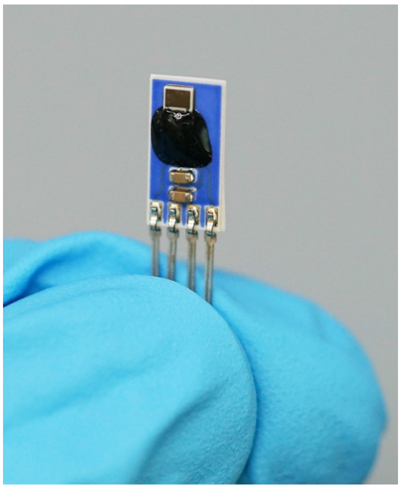
8.6 Active sensor area



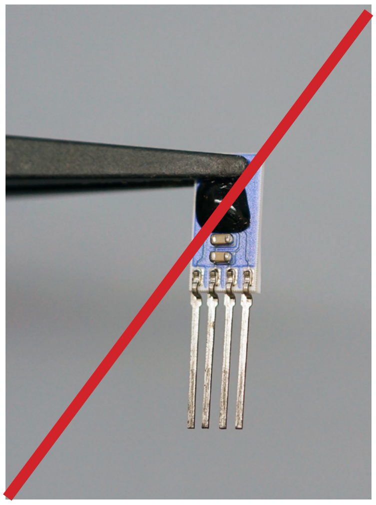
8.7 Sensor handling

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

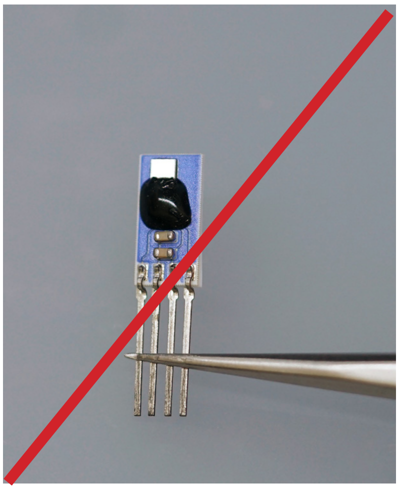

Sensor held with plastic tweezers on the wires only


Sensor held with gloves on the wires only

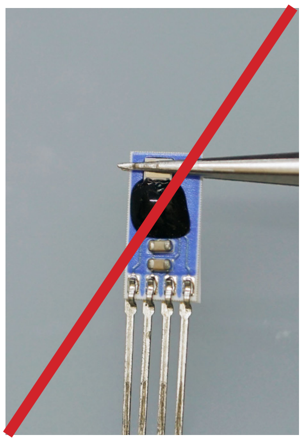
Examples of prohibited handling:



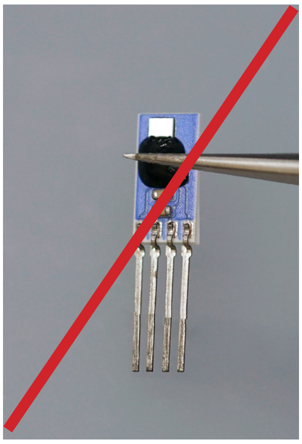
Sensor picked on the active area



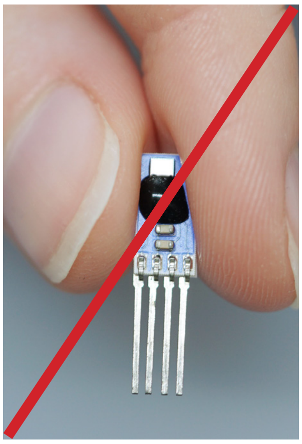
Sensor picked on the wires with metal tweezers



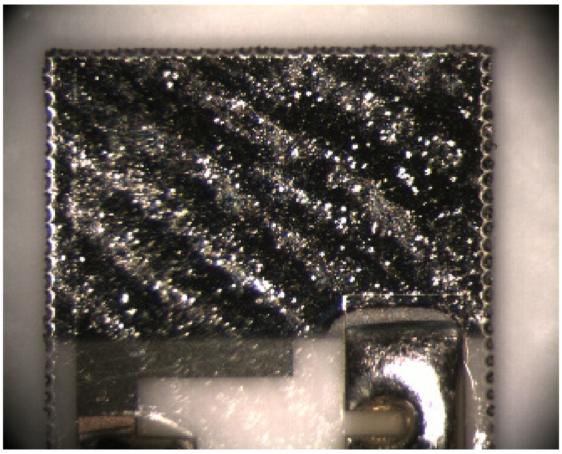
Sensor picked on the active area with metal tweezers



Sensor picked on the glob top area



Sensor held with fingers without gloves



Sensor with contaminations

Sensor with a scratch

8.8 Soldering of the sensor

During the soldering process it is recommended not to exceed temperatures of 200°C at the active sensor area. This can be achieved by hand soldering within 10 s at the end of the wires with a maximum temperature of 320 °C at the soldering iron. Avoid soldering flux residues caused by the soldering process or any other contaminants on the active sensor area.

8.9 Cleaning of the sensor

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.

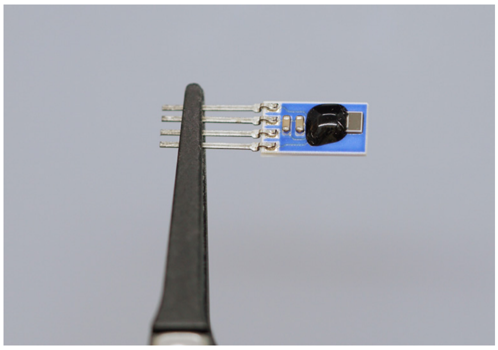
8.10 Handling of the original blisters

To avoid damages handle as follows:

1. Digital humidity sensors delivered in plastic blister

2. Open the plastic blister carefully

3. Remove the modules from the blister using plastic tweezers

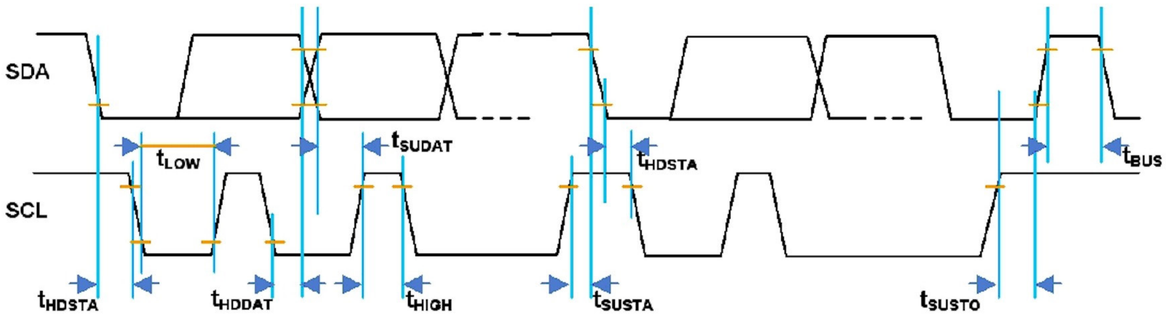


4. Use plastic tweezers only to handle the module

9. I²C Protocol description

9.1 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.

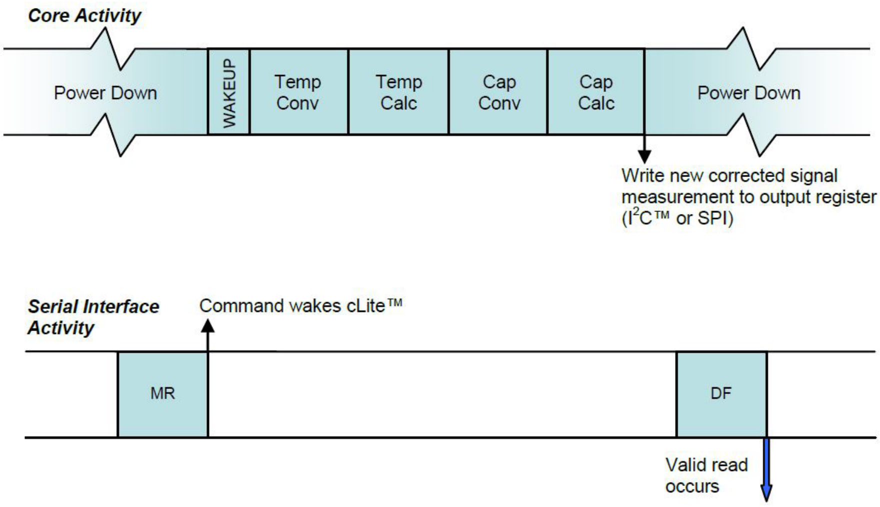


Parameter	Symbol	Min	Max	Unit
SCL clock frequency	fSCL	100	400	kHz
Start condition hold time relative to SCL edge	tHDSTA	0.1		µs
Minimum SCL clock low width 1	tLOW	0.6		µs
Minimum SCL clock high width 1	tHIGH	0.6		µs
Start condition setup time relative to SCL edge	tSUSTA	0.1		µs
Data hold time on SDA 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 I²C 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 (DF) command. Valid data can be fetched only when a measurement cycle (ASIC conversion) is complete. User must wait for the measurement to complete before performing the DF. The status bit of the DF can be used to tell whether the data is valid or stale, but polling for the result must not be done before the time required for conversion has elapsed. The conversion time is between 60 and 100 milliseconds.



9.2 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

SA	6	5	4	3	2	1	0	W	A	SP
	Device Slave Address [6:0]									

Master		SA	Start condition	A	Acknowledge
		W	Write bit	N	Not acknowledge
Slave (HYT)		R	Read bit	SP	Stop condition

9.3 DF (Data Fetch)

The data fetch command serves to read 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 in case of correct addressing. The humidity and temperature value are encoded in two bytes each. If only the humidity value shall be read, the master can issue a stop condition after two bytes. The illustration below *PC DF - 2 Bytes: Slave returns only capacitance data to the master in 2 bytes* illustrates the transfer. The first two bits contain two status bit [31:30], which must be masked for the humidity value. The last two bit [1:0] are not used and must also be masked off.

In case of a failure, the slave issues not acknowledgement.

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

SA	6	5	4	3	2	1	0	R	A	31	30	29	28	27	26	25	24	A	23	22	21	20	19	18	17	16
	Device Address									humidity msb [29:24]									humidity lsb [23:16]							

A	15	14	13	12	11	10	9	8	A	7	6	5	4	3	2	1	0	N	SP
	temperatur msb [15:8]									temperatur lsb [7:2]									

Master		SA	Start condition	A	Acknowledge
		W	Write bit	N	Not acknowledge
Slave (HYT)		R	Read bit	SP	Stop condition

9.4 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:

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

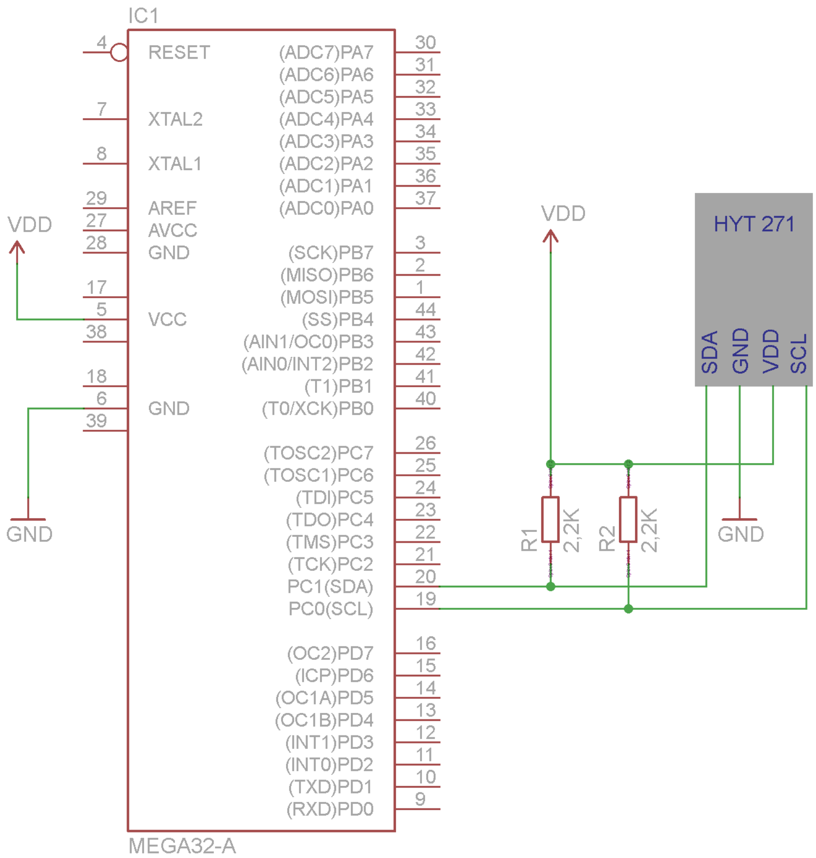
0x0 complies with -40 °C
0x3FFF complies with +125 °C
T_{raw} = 0x0000 to 0x3FFF (Hex) or 0 to 16383 (Dec)

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	

9.5 I²C pull up resistor



10. I²C Address change

Code Examples can be found on our website, sort by „Software" on: https://www.ist-ag.com/en/downloads

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

Slave Address:	0x28	default value
Command-Byte:	0xA0	start command-mode
	0x1C	read configurations parameter that includes the I²C-address
	0x5C	write configurations parameter 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:	10b	command-mode
	01b	stale
Diagnostic:	xxx1b	corrected EEPROM-error
	xx1xb	uncorrectable EEPROM-error
	x1xxb	RAM Parity error
	1xxxb	configuration error
Response:	00b	busy
	01b	positive acknowledge
	10b	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

10.1 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. If the sensor can be read out correctly, but entering command mode failed, please try to reduce your clock frequency to below 100kHz, and then repeat step 1) and 2).

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

11. Additional documents

	Document name:	
Data sheets:	DHHYT271_E	DHHYT271_D
	DHHYT221_E	DHHYT221_D
	DHHYT939_E	DHHYT939_D
Software code examples:	https://www.ist-ag.com/en/downloads => Software	

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