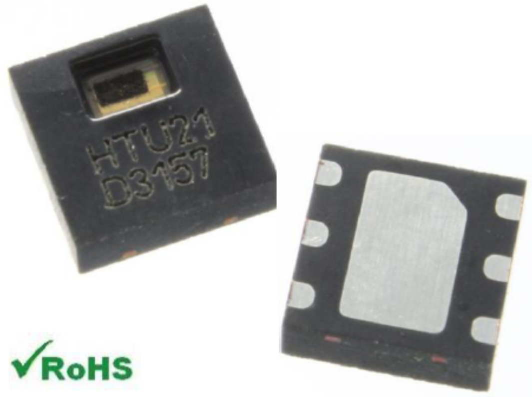
HTU21D--Micro Temperature and Relative Humidity Sensor



- **DFN packaging is adopted**
- **Temperature and humidity value digital output, I2C interface**
- **Full range calibration**
- **Lead-free material, suitable for reflow soldering**
- **Low power products**
- **Fast response time and very low temperature coefficient**

1． Sensor Brief Description

Humirel's new-generation HTU21D temperature and humidity sensor sets a new benchmark in compact design and smart functionality. Featuring a dual-column flat pinless (DFN) package optimized for reflow soldering, it measures 3x3 mm at the base with a 1.1mm height. The sensor delivers calibrated digital signals in standard I2C format, delivering reliable performance through its precision engineering.

The HTU21D temperature and humidity sensor delivers accurate and reliable measurement data for OEM applications. Through a microcontroller interface and module connectivity, it provides digital outputs for temperature and humidity monitoring. Designed with compact size and low power consumption, the HTU21D is specifically engineered to meet the demands of space-constrained environments and applications requiring product integrity.

Every sensor undergoes rigorous calibration and testing. The product features batch numbers printed on its surface, while embedded chips store electronic identification codes that can be retrieved through command input. Additionally, the HTU21D's resolution can be adjusted via commands (from 8/12-bit to 12/14-bit RH/T), with sensors detecting low battery status and generating checksums to enhance communication reliability. Through optimized miniaturization and performance enhancements, the sensor achieves greater cost-effectiveness－ultimately enabling all devices to benefit from advanced energy-efficient operation modes.

2. Characteristics of sensors

- Complete interchangeability, no calibration required in standard environment
- Long-term humidity saturation can be quickly restored
- Produced by automatic assembly process, made of lead-free material, suitable for reflow soldering
- Each sensor has a separate tag and can be traced back to the source of production

Application examples

- household application
- The medical field
- printer
- humidifier

3. Performance Requirement

parameter	symbol	parameter values	unit
Storage temperature	Tstg	-40 to +125	℃
Power supply voltage (peak)	Vcc	3.8	Vdc
Humidity measurement range	RH	0 to 100	%RH
Temperature measurement range	Ta	-40 to +125	℃
VDD to GND		-0.3 to 3.6V	Vdc
Digital I/O port pins (DATA/SCK) to VDD		-0.3 to VDD+0.3	Vdc
Each pin inputs current		-10 to +10	mA

4. Electrical characteristics and basic performance(in T=25℃,Vdd=3.3V below)

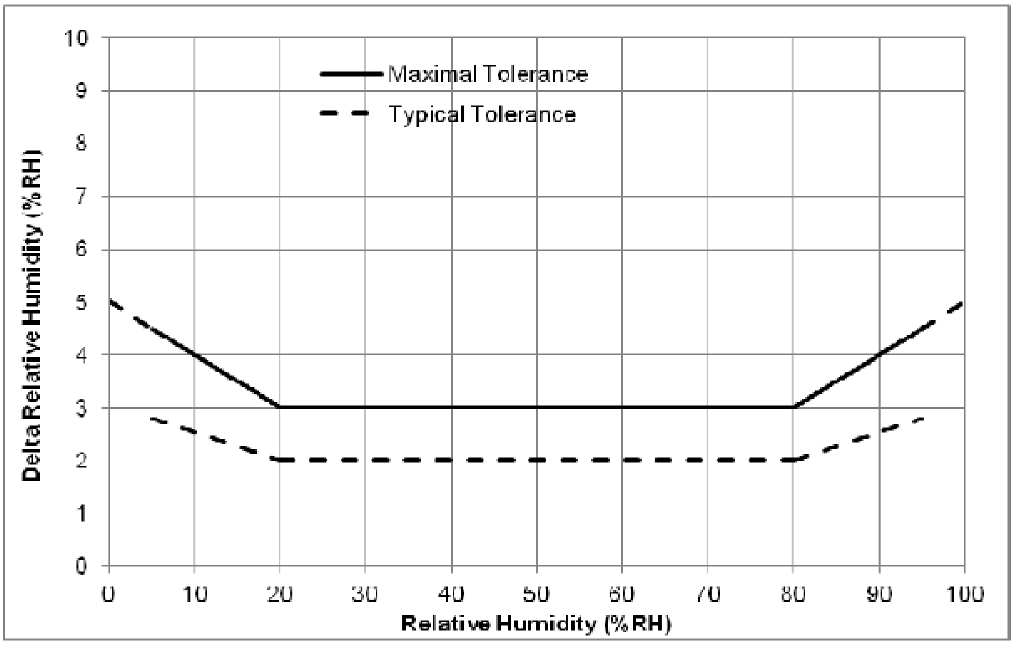
characteristic		symbol	least value	representative value	crest value	unit
service voltage		VDD	1.8	3	3.6	V
current consumption	Sleep mode	idd		0.08	0.3	uA
	Measuring in		300	450	500	uA
power dissipation	Sleep mode			0.25	1.1	uW
	8 bit pattern			2.7		uW
communication		Digital (dual-wire interface)				
Storage environment		-40—125℃				

5.Humidity Performance

(In T=25℃,Vdd=3.3V)

characteristic		symbol	least value	representative value	crest value	unit
resolution ratio	12 Position			0.04		%RH
	8 Position			0.7		%RH
Humidity measurement range		RH	0		100	%RH
Humidity measurement accuracy (10% --95%RH)	representative value			±2		%RH
	crest value			±3	±5	%RH
Humidity hysteresis					±1	%RH
MT	12 Position			14	18	ms
	11 Position			7	9	ms
	10 Position			4	5	ms
	8 Position			2	3	ms
Recovery time after 150 hours of condensation		t		10		s
long term drift				0.5		%RH/yr
response time		TRH		5	10	s

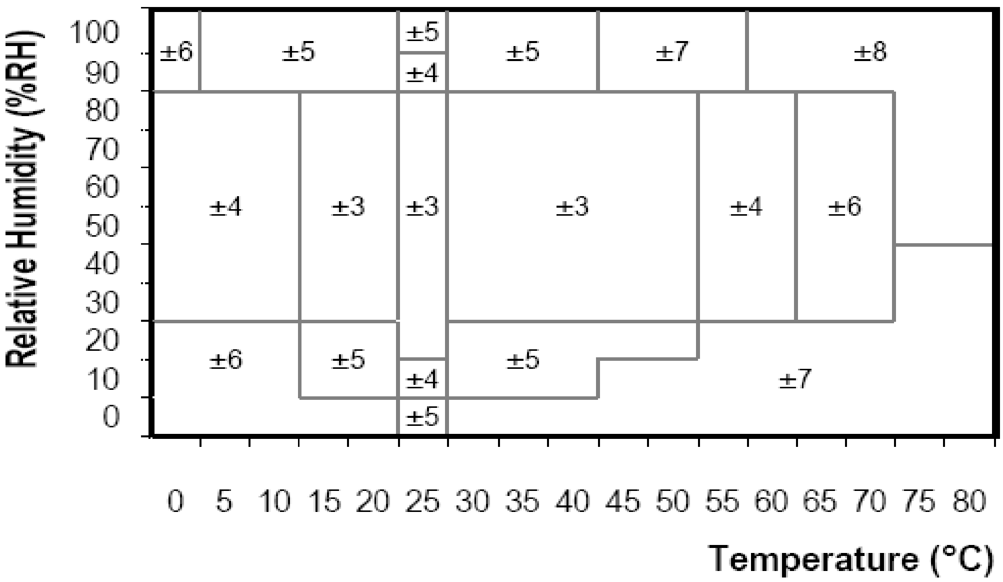
6. Relative Humidity Error Estimation at 25°C



- The optimal measurement range specified by the HTU21D sensor module is 5%RH-95%RH
- In other humidity ranges (<5%RH or> 95% RH, or condensation state), the stability and reliability of HTU21D will not be affected.

7.Humidity Accuracy at Different Temperatures

The RH accuracy at 25°C is defined in the figure, and the maximum humidity error for other temperature ranges is shown:

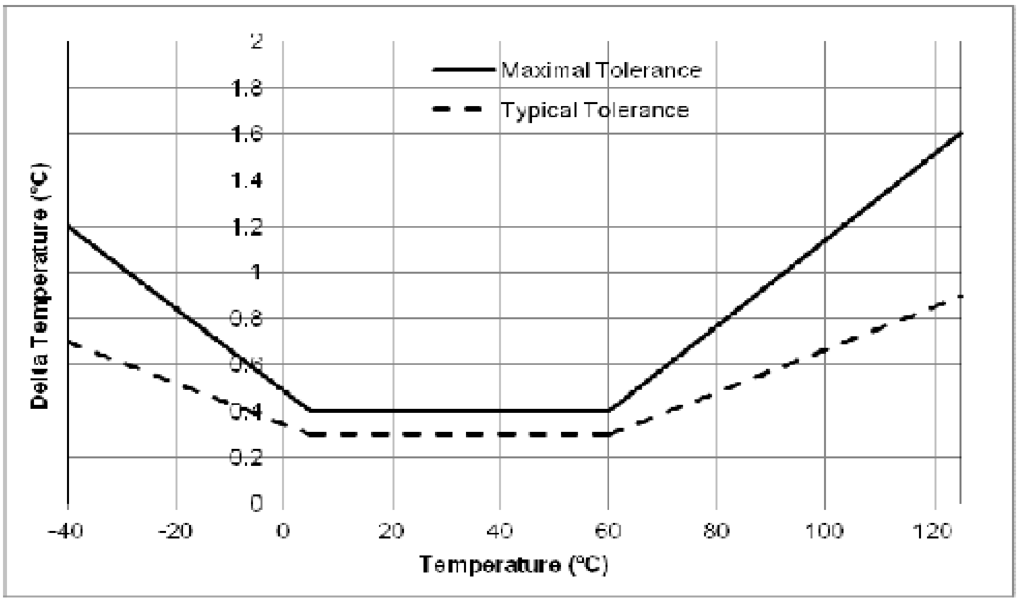


8.Thermal Performance

(In Vdd=3.3V)

characteristic		symbol	least value	representative value	crest value	unit
resolution ratio	14 Position			0.01		℃
	12 Position			0.04		℃
Temperature measurement range		T	-40		+125	℃
Temperature measurement accuracy (25℃)	representative value			±0.3		℃
	crest value			±0.4		℃
operating temperature range			-40		125	℃
			-40		221	° F
Measurement time (14 bits)	14 Position			44	58	ms
	13 Position			22	29	ms
	12 Position			11	15	ms
	11 Position			6	8	ms
Response time (15℃-45℃)		Tt		10		s

9. Temperature Error Estimates

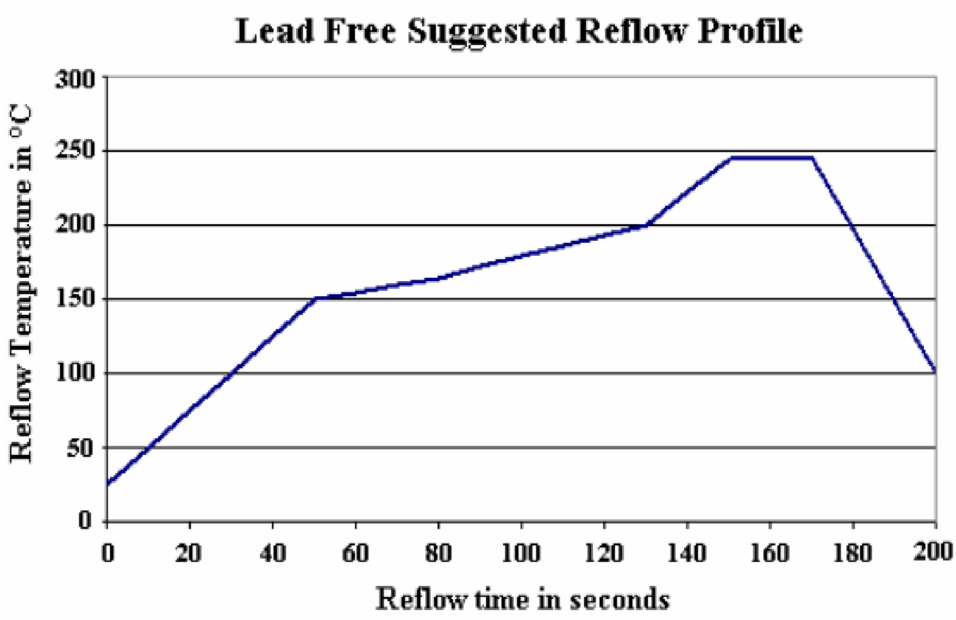


10. Welding Notes

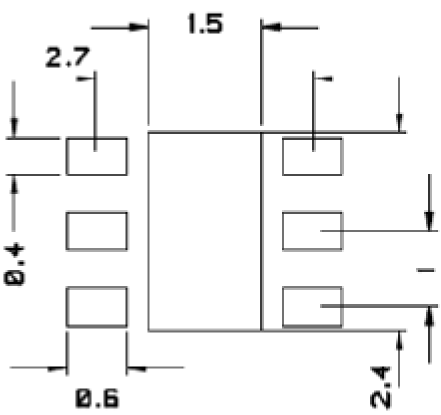
The HTU21 can be welded using a standard reflow soldering furnace. The sensor fully complies with the IPC/JEDEC J-STD-020D welding standard, with a contact time of less than 30 seconds at a maximum temperature of 240℃.

In the steam reflow soldering furnace, the conditions are TP<233℃ and tp<60 seconds. During welding, the temperature rise and fall should be less than 10℃/second. For manual welding, the contact time must be less than 5 seconds under the highest temperature of 350℃.

Standard reflow solder pattern:



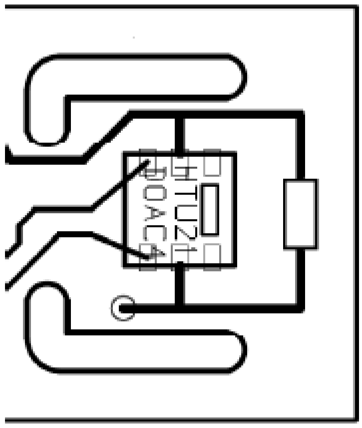
11. Sensors and Electrodes Behind and Size Diagram



Recommended HTU21 footprint, unit: mm

12.Temperature Effect

The relative humidity of gases is largely dependent on temperature. Therefore, when measuring humidity, it's crucial to ensure all sensors measuring the same humidity operate under identical temperature conditions. During testing, the sensor under test and reference sensor should be kept at the same temperature before comparing their humidity readings. When mounting HTU21 sensors with heat-sensitive components on the same PCB, design considerations should minimize thermal conduction effects. Measures include: maintaining proper ventilation for the enclosure, minimizing copper plating between the HTU21 and other PCB components, or leaving a gap between them, as shown in the diagram.



13. Cabling Rules and Signal Integrity

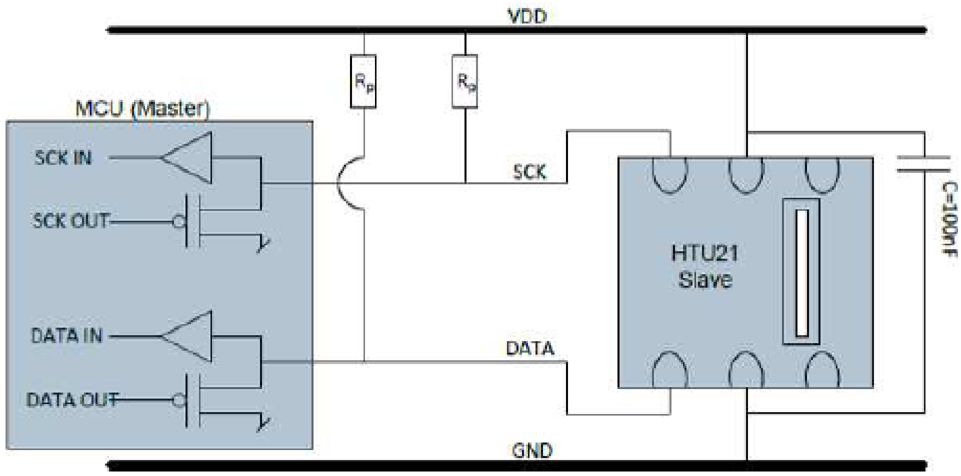
If SCL and SDA signal lines are placed parallel and too close to each other, this may cause signal crosstalk and communication failures. The solution involves placing a VDD or GND component between the two signal lines to isolate them, or using shielded cables. Additionally, reducing the SCL frequency can improve signal transmission integrity. A 100nF decoupling capacitor should be added between the power pins (VDD, GND) for filtering purposes. This capacitor should be positioned as close as possible to the sensor.

14.Light

HTU21 is not affected by light. However, prolonged exposure to sunlight or intense ultraviolet radiation can cause the shell to age.

15. Typical Sensor Application Circuit and Pin Specifications

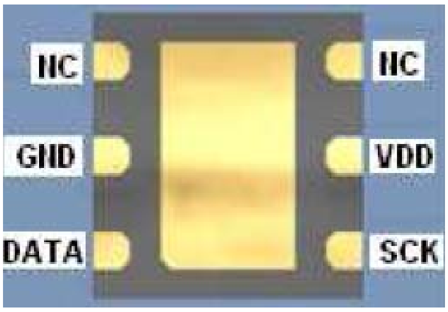
Typical circuit :



Typical application circuit, including pull-up resistor RP and decoupling capacitor between VDD and GND.

Pin definitions :

order number	function	description
1	DATA	Serial data port (bidirectional)
2	GND	Powering up
3	NC	throw out of gear
4	NC	throw out of gear
5	VDD	power input
6	SCK	Serial clock (bidirectional)



· <Power pins (VDD, GND)

The HTU21 has a power supply range of 1.8VDC-3.6VDC and a recommended voltage of 3.0V. A 100nF decoupling capacitor must be connected between the power supply (VDD) and ground (VSS), and the capacitor should be located as close as possible to the sensor.

· Serial Clock Input (SCK)

The SCK is used to synchronize communication between the microprocessor and HTU21. Since the interface contains completely static logic, there is no minimum SCK frequency.

· Serial data (DATA)

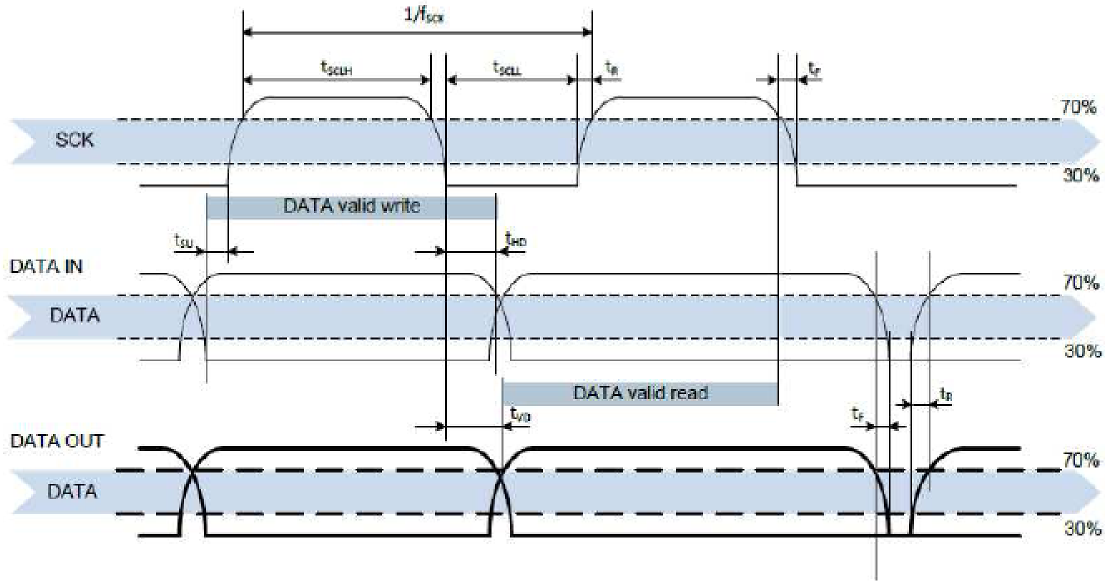
The DATA pin operates in a tri-state configuration for sensor data transmission. When sending commands to the sensor, DATA becomes active on the rising edge of SCK and must remain stable during the high phase of SCK. It transitions after the SCK's falling edge. During data reception from the sensor, DATA activates after the SCK's low phase and persists until the next SCK's falling edge. To prevent signal conflicts, the microcontroller should drive DATA to a low level. An external pull-up resistor (e.g., 10kΩ) is required to elevate the signal to a high level. Such resistors are typically integrated into the microcontroller's I/O circuitry.

16. Electrical Character

Characteristics		Symbol	Min	Typ	Max	Unit
Low level output voltage	VDD=3V -4mA<IOL<0mA	VOL	0	-	0.4	V
High level output voltage		VOH	70%	-	VDD	V
Low level input voltage		VIL	0%	-	30%VDD	V
High level input voltage		VIH	70%VDD	-	VDD	V
Leakage current	VDD=3.6V VIN=0V to 3.6V	IL	-	-	TBD	μA

DC characteristic

Characteristics	Symbol	Min	Typ	Max	Unit
SCK frequency	f_{SCK}	0	-	0.4	MHz
SCK high time	t_{SCKLH}	0.6	-	-	μs
SCK low time	t_{SCLL}	1.3	-	-	μs
DATA set-up time	t_{SU}	100	-	-	ns
DATA hold-time	t_{HD}	0	-	900	ns
DATA valid-tile	t_{VD}	0	-	400	ns
SCK/DATA fall time	t_F	0	-	100	ns
SCK/DATA rise time	t_R	0	-	300	ns
Capacitive load on bus line	C_B	0	-	500	pF



17.Communication Protocol With Sensor

· start sensor

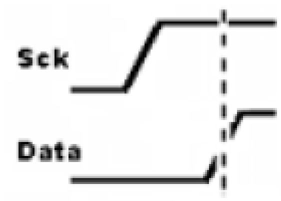
Power the sensor to the selected VDD power supply voltage (ranging between 1.8V and 3.6V). After powering on, the sensor reaches an idle state within 15 milliseconds (when SCL is at a high level), ready to receive commands from the host MCU.

· activating signal

To initiate a transfer, sending a bit of data involves a DATA line transition to a low level during the high level of the SCK line.

· break alarm

Terminate transmission, stop sending data, including a high level jump of the DATA line to a high level during the SCK line high level.



18. List of Commands for HTU21 Sensor

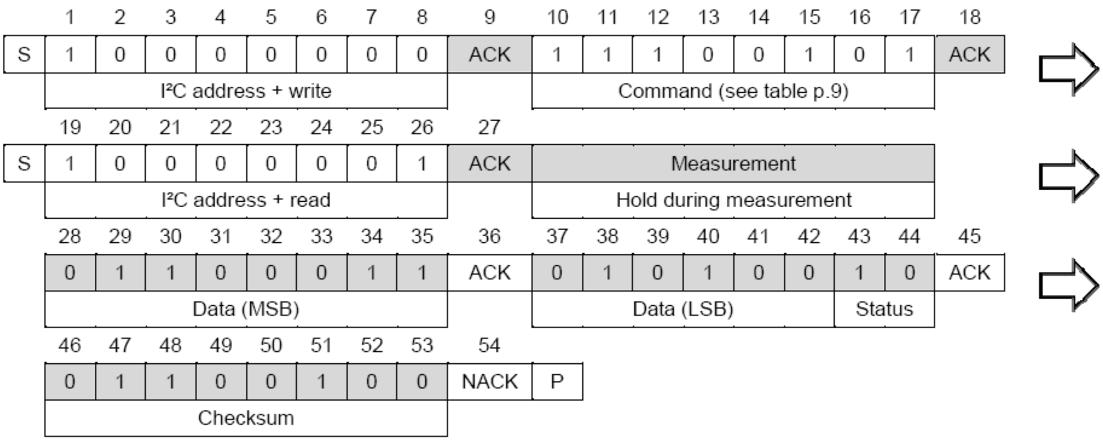
命令	释义	代码
触发 T 测量	保持主机	1110’0011
触发 RH 测量	保持主机	1110’0101
触发 T 测量	非保持主机	1111’0011
触发 RH 测量	非保持主机	1111’0101
写用户寄存器		1110’0110
读用户寄存器		1110’0111
软复位		1111’1110

表 6 基本命令集、RH 代表相对湿度、T 代表温度

· Host/non-host mode

The communication between the MCU and sensors operates in two distinct modes: host mode and non-host mode. In host mode, the SCL line remains locked during measurement operations (controlled by the sensor). In non-host mode, the SCL line stays open during sensor measurements while maintaining communication capabilities. This configuration enables sensors to handle additional I2C bus tasks on the same line during measurement processes. The corresponding communication timing for both modes is illustrated in the diagram below.

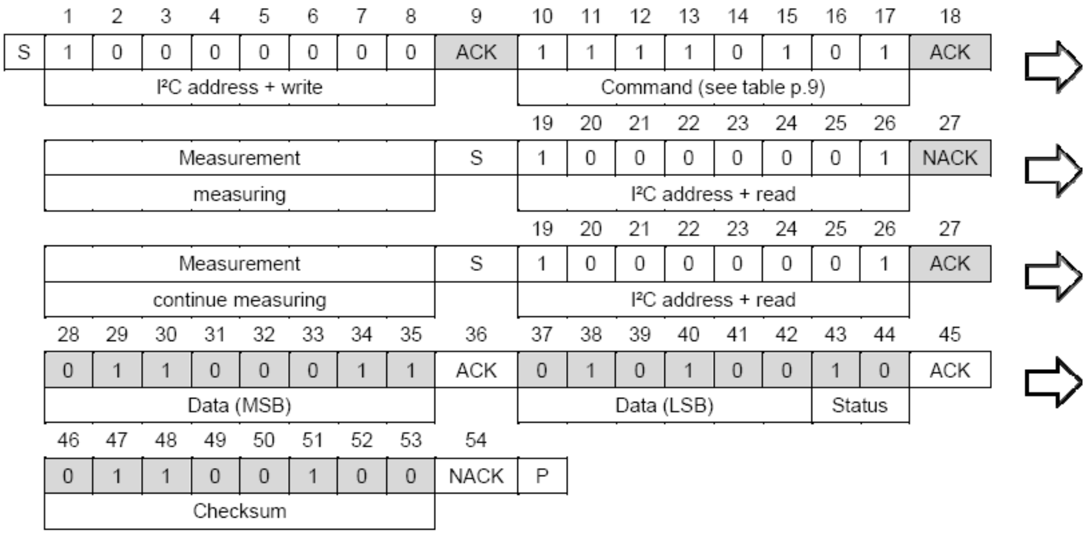
When measured in host mode, HTU21 lowers SCL to force the host into a waiting state. By releasing SCL line, it indicates that the internal processing of the sensor is finished, and then the data transmission can continue.



As shown in the figure, the host communication mode timing-the gray part is controlled by HTU21. If you want to omit the CRC transmission, you can change the 45th bit to NACK, followed by a transmission stop timing (P).

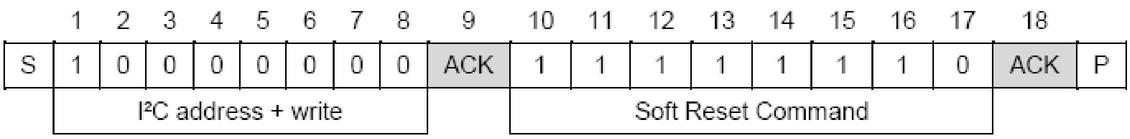
In non-host mode, the MCU must initiate sensor status queries. This process is executed by first sending a start transmission sequence, followed immediately by the I2C first byte (1000 '0001) as shown in Figure 16. Once internal processing is complete and the MCU receives the sensor's acknowledgment signal, relevant data can be retrieved via the MCU. If measurement processing remains incomplete and the sensor outputs no ACK bit, the start transmission sequence must be resent.

Regardless of the transmission mode, since the maximum measurement resolution is 14 bits, the last two least significant bits (LSBs) on the second byte SDA are used to transmit relevant status information. Bit 1 in these LSBs indicates the measurement type ('0' for temperature; '1' for humidity). Bit 0 remains unassigned.



19. Soft repositioning

This command (see Table 6) enables the sensor system to be restarted without requiring power shutdown and reboot. Upon receiving this command, the system initiates initialization and restores default settings, except for the heater bit in the user register. The soft reset process takes no more than 15 milliseconds.



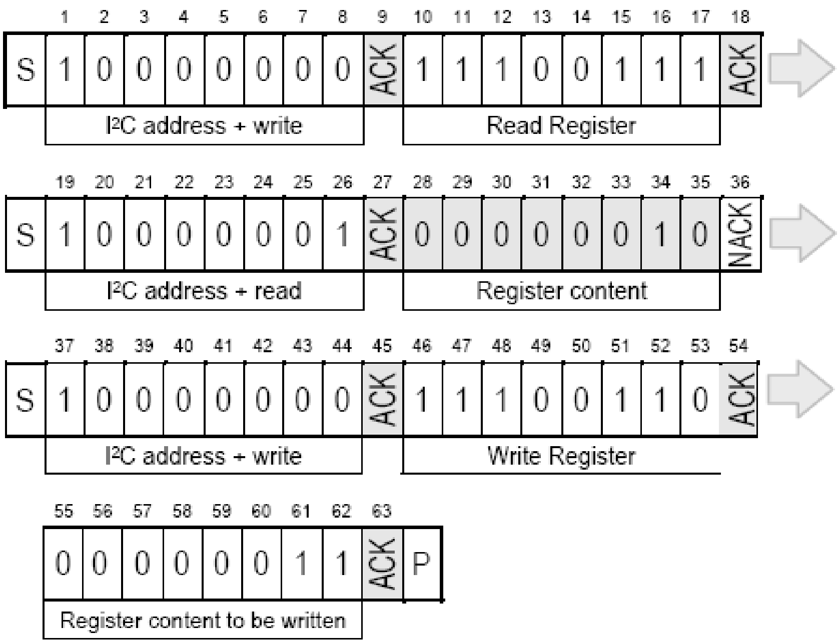
User registers

The contents of the user register are described in the table below. Please note that reserved bits must not be altered, as their default values may change without prior notice. Therefore, before performing any write operation on the register, the default value of the reserved bits must be read first. Subsequently, each user register byte consists of the default value of the corresponding reserved bits combined with the default values of other remaining bits or the write value.

二进制位	#位	描述/代码	默认
7, 0	2	测量分辨率 RH / T '00': 12 bit / 14 bit '01': 8 bit / 12 bit '10': 10 bit / 13 bit '11': 11 bit / 11 bit	'00'
6	1	电池状态 End of battery[15] '0': VDD > 2.25 V '1': VDD < 2.15 V	'0'
3, 4, 5	3	预留	
2	1	启动片上加热器	'0'
1	1	不能启动 OTP 加载	'1'

The low battery level alarm activates when the power supply voltage drops below 2.25V. The internal heater is used for sensor functionality diagnosis – when temperature rises, relative humidity decreases. With a power consumption of approximately 5.5mW, it can increase temperature by 0.5-1.5°C. OTP reloaded serves as a safety feature that loads the entire OTP configuration into registers before each measurement, excluding the heater bit. This function in HTU21 is disabled by default and not recommended for user use. Instead, a soft reset should be employed – which includes OTP reloaded functionality.

The I2C communication between read and write user registers is shown in the figure:



The timing diagram for read and write registers – the gray sections are controlled by HTU21. In this example, the resolution is set to 8 bits per channel.

12bit。

21、 CRC-8 checksum calculation

When the HTU21 sensor communicates through the I2C protocol, the 8-bit CRC check can be used to detect transmission errors. CRC check covers all the read data transmitted by the sensor. The CRC check properties of the I2C protocol are shown in the following table:

CRC with I²C protocol	
Generator polynomial	$X^8 + X^5 + X^4 + 1$
Initialization	0x00
Protected data	Read data
Final Operation	none

22.signal conversion

The sensor's default resolution is set to 12-bit relative humidity and 14-bit temperature. The SDA output data is converted into two-byte packets with the MSB (most significant bit) positioned first (left-aligned). Each byte is followed by a response bit. Two status bits – specifically the last two bits of the least significant bit (LSB) – must be set to 0 before performing physical calculations. In this example, the transmitted 16-bit relative humidity data is represented as 0110 0011 0101 0000 =25424.

· Relative humidity conversion

Regardless of which resolution is used, the relative humidity RH can be calculated based on the relative humidity signal S_{RH} output by SDA as follows (the result is expressed as%RH):

$$RH = -6 + 125 \cdot \frac{S_{RH}}{2^{16}}$$

For example, the 16-bit humidity data is 0x6350:25424, and the calculated relative humidity is 42.5%RH.

· Temperature conversion

Regardless of which resolution is used, the temperature T can be calculated by substituting the temperature output signal S_T into the following formula (the result is expressed in °C):

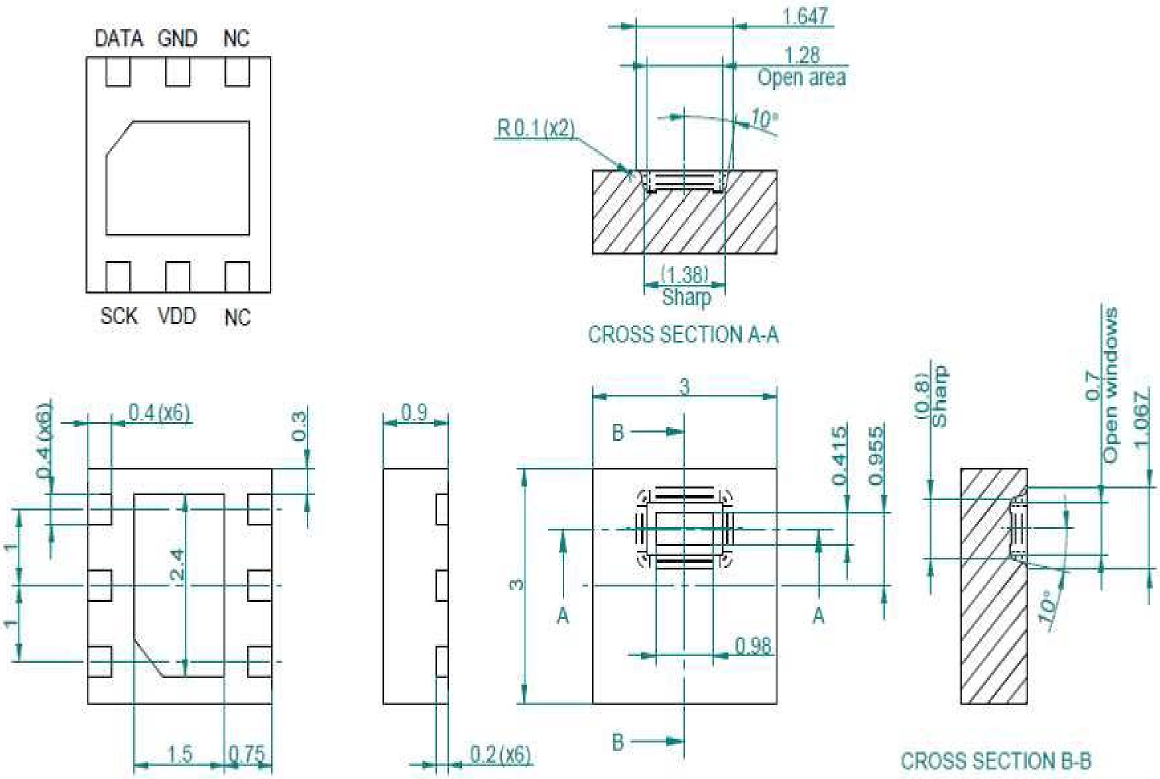
$$T = -46.85 + 175.72 \cdot \frac{S_T}{2^{16}}$$

23.HTU21 Sensor Size and Packaging Information

:: Packaging information

The HTU21D features a DFN package (similar to QFN), where DFN stands for Double-Faced Non-Pin Flat Package. The sensor chip is constructed with a Ni/Pd/Au-coated copper lead frame, with both the chip and lead frame encapsulated in green epoxy resin. Notably, since the sensor's side is cut to a square shape, the corresponding lead frame section lacks protective coating. The total weight of the sensor is 25mg.

• Sensor size

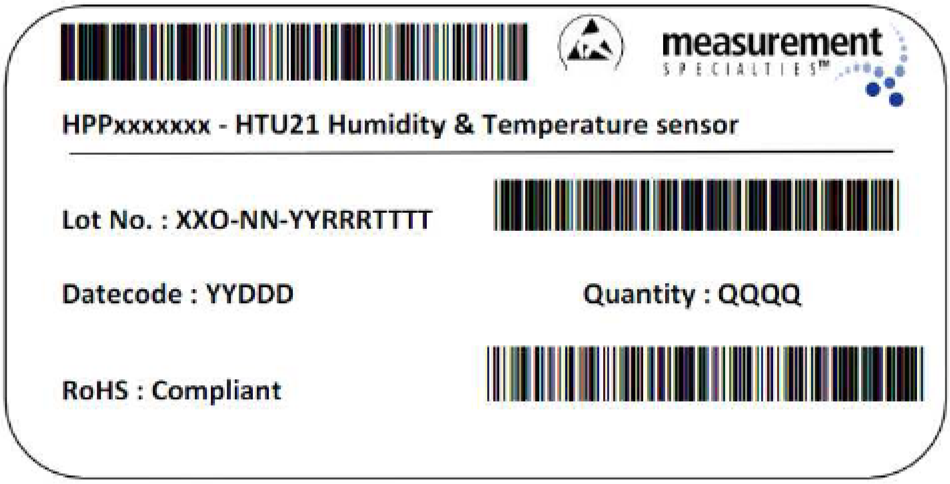


Note: The unit of size is mm, the tolerance is ±0.1mm, and the bottom of the sensor has been grounded.

· Laser identification

Laser identification on the sensor

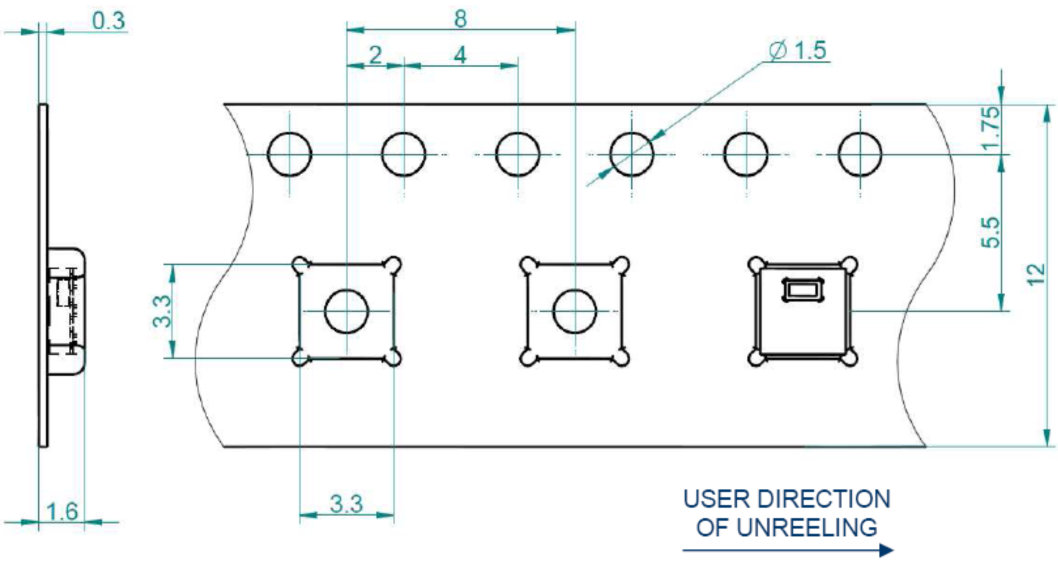
The scroll is also labeled and provides additional tracking information, as shown below:



XX = Sensor model (21 for HTU21D)
O = Output mode (D = Digital, P = PWM, S = SDM)
NN = Chip version
YY = The last two digits of the year
RRR = Number of sensors on the roll divided by 10 (usually 200 or 2000)
TT = Meas tracking code
DDD= date code
QQ= actual quantity (400,1500 or 5000 units)

· packing for transport

The HTU21 is packaged in roll-type sealed units within anti-static ESD bags. Standard packaging sizes include 400,1500, and 5000 units per roll. For HTU21 packaging, the first 200mm (containing 25 sensors) and last 440mm (containing 55 sensors) sections of each roll are filled with air. The packaging diagram with sensor positioning is shown below. The rolls are stored in anti-static pockets.



statement：

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深圳市杰晟兴电子有限公司 JM Components Limited

地址：深圳市福田区中航路7号鼎诚国际大厦南座2007室 **邮编：518031**
手机：13662266995 马少良 电话：0755-83951311 **传真：0755-83952401**
官网：cn-sensor.com **电邮：jackson@jmcomponents.com**