DTH-14

High Accuracy Digital Temperature / Humidity Sensor

- Temperature & humidity sensor
- Dewpoint
- Digital output
- Excellent long term stability
- 2-wire interface
- 4 conductor 3.5mm plug
- High accuracy
- Conformal coated & environmentally filtered

Summary

The DTH-14 is a digital temperature and humidity sensor with superb accuracy and long term stability. The device includes a capacitive polymer sensing element for relative humidity and a bandgap temperature sensor. Both sensors are coupled to a 14-bit analog to digital converter and a serial interface circuit on the same chip. This results in superior signal quality, a fast response time and insensitivity to external disturbances. The 2-wire serial interface and internal voltage regulation allows for rapid integration. Its dual capability and low power consumption makes the DTH-14 an ideal choice for demanding applications.

Applications

- Information Technology
- HVAC
- Refrigeration
- Temperature protection and control
- Automation
- Test and Measurement
- Process control
- Automotive
- Weather stations
- Data logging

REVISION HISTORY

12/28—Revision 1: Initial Version

1.0 Performance Specifications

1.1 Temperature

Parameter	Condition	Min	Typ	Max	Units
Resolution		0.04 0.07 12	0.01 0.02 14	0.01 0.02 14	°C °F bit
Repeatability			±0.1 ±0.2		°C °F
Accuracy		See Figure 1			
Range		-40 -40		80 176	°C °F
Response Time		5		30	sec

Table 1 – Temperature specifications

1.11 Temperature Accuracy

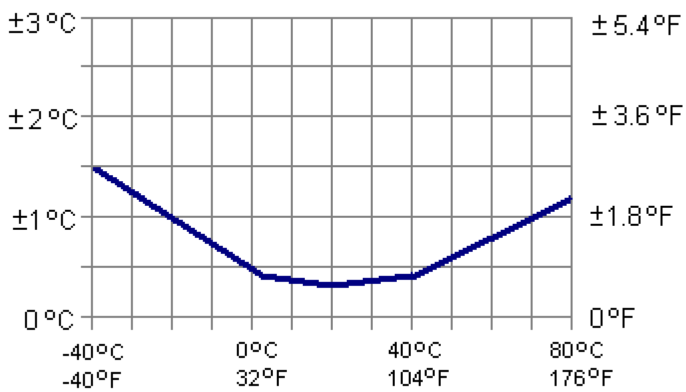


Figure 1 – Temperature accuracy

1.2 Humidity

Parameter	Condition	Min	Typ	Max	Units
Resolution		0.5 8	0.03 12	0.03 12	%RH bit
Repeatability			±0.1		%RH
Accuracy	linearized	See Figure 2			
Nonlinearity	raw data		±3		%RH
	linearized		<<1		%RH
Range		0		100	%RH
Response Time	@25°C 1m/sec air	6	8	10	sec

Table 2 – Humidity specifications

1.21 Humidity Accuracy

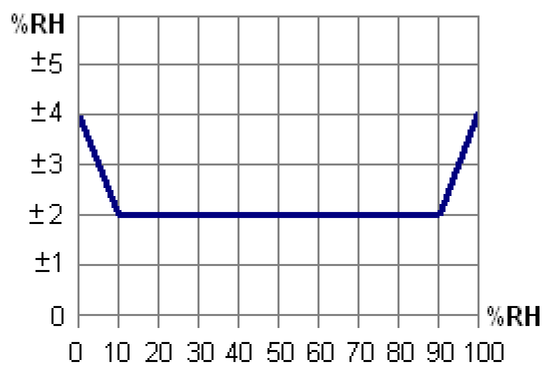
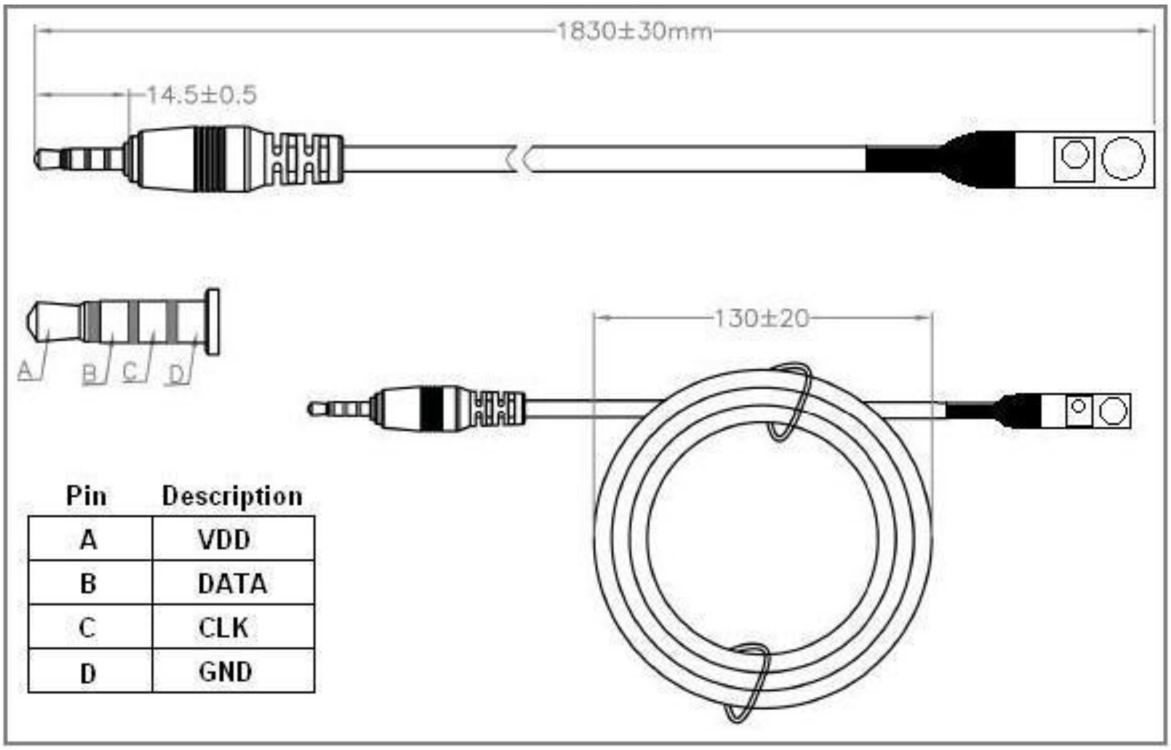


Figure 2 – Humidity accuracy

2.0 Mechanical Specifications

- Cable gauge: 4 conductor #26AWG
- Cable outer diameter: 3.7mm
- Receptacle overmold: Black PVC
- Cable shield: Aluminum foil
- Receptacle: 3.5mm 4 conductor
- RoHS status: Lead Free / RoHS compliant



Pin	Description
A	VDD
B	DATA
C	CLK
D	GND

Figure 3 – Mechanical specifications

3.0 Interface Specifications

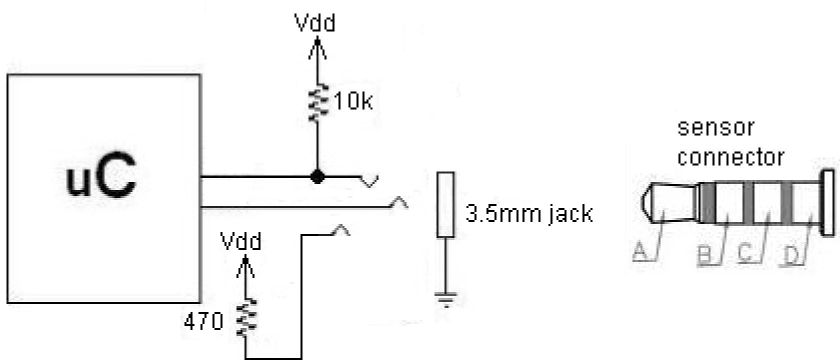


Figure 4 – Typical Application

Note: VDD to the sensor should be current limited via a 470 ohm resistor in the event of cable damage.

Pin A: Power (Vdd)

The sensor requires a voltage supply between 2.5 and 5.5 V. After power-up the device needs 11ms to reach it's "sleep" state. No commands should be sent before that time.

Pin B: Serial Data (DATA)

The DATA tristate pin is used to transfer data in and out of the device. DATA changes after the falling edge and is valid on the rising edge of serial clock SCK. To avoid signal contention the microcontroller should only drive DATA low. An external pull-up resistor (e.g. 10 kΩ) is required to pull the signal high.

Pin C: Serial Clock (SCK)

The SCK is used to synchronize the communication between a microcontroller and the sensor. Since the interface consists of fully static logic, there is no minimum SCK frequency.

Pin D: GROUND (Gnd)

Ground reference for the device.

3.1 Electrical Characteristics

Parameter	Conditions	min	typ	max	Units
Power Supply VDD		2.4	3.3	5.2	VDC
Supply current	measuring		0.55	1	mA
	average	2	28		uA
	sleep		0.3	1.5	uA
Low level output voltage	I_{OL} < 4mA	0		250	mV
High level output voltage	R_p < 25 kΩ	90%		100%	VDD
Low level input voltage	Negative going	0%		20%	VDD
High level input voltage	Positive going	80%		100%	VDD
Input current on pads				1	uA
Output current	on			4	mA
	Tri-stated (off)		10	20	uA

Table 3 – Electrical characteristics

3.2 Sending a command

To initiate a transmission, a “Transmission Start” sequence has to be issued. It consists of a lowering of the DATA line while SCK is high, followed by a low pulse on SCK and raising DATA again while SCK is still high.

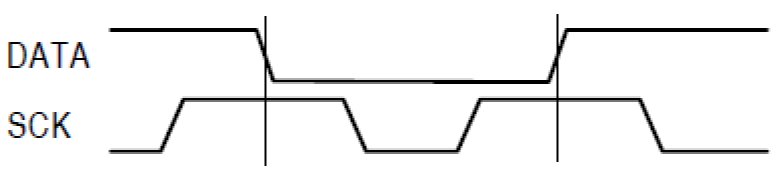


Figure 5 – Transmission start sequence

The subsequent command consists of three address bits (only “000” is currently supported) and five command bits. The SHTxx indicates the proper reception of a command by pulling the DATA pin low (ACK bit) after the falling edge of the 8th SCK clock. The DATA line is released (and goes high) after the falling edge of the 9th SCK clock.

Command	Code
Reserved	0000x
Measure Temperature	00011
Measure Humidity	00101
Read Status Register	00111
Write Status Register	00110
Reserved	0101x-1110x
Soft Reset (resets the interface, clears the status register to default values. Must wait 11mSec prior to next command)	11110

Table 4 – List of commands

3.3 Measurement Sequence (Temperature and Relative Humidity)

After issuing a measurement command (‘00000101’ for RH, ‘00000011’ for Temperature) the controller must wait for the measurement to complete. This takes approximately 11/55/210 ms for a 8/12/14bit measurement. The exact time varies by up to ±15% with the speed of the internal oscillator. To signal the completion of a measurement, the sensor pulls down the data line and enters idle mode. The controller must wait for this “data ready” signal before restarting SCK to readout the data. Measurement data is stored until readout, therefore the controller can continue with other tasks and readout as convenient.

Two bytes of measurement data and one byte of CRC checksum will then be transmitted. The controller must acknowledge each byte by pulling the DATA line low. All values are MSB first, right justified. (e.g. the 5th SCK is MSB for a 12bit value, for a 8bit result the first byte is not used). Communication terminates after the acknowledge bit of the CRC data. If CRC-8 checksum is not used the controller may terminate the communication after the measurement data LSB by keeping ack high. The device automatically returns to sleep mode after the measurement and communication have ended.

Note: *To keep self heating below 0.1 °C the sensor should not be active for more than 10% of the time (e.g. max. 2 measurements / second for 12bit accuracy).*

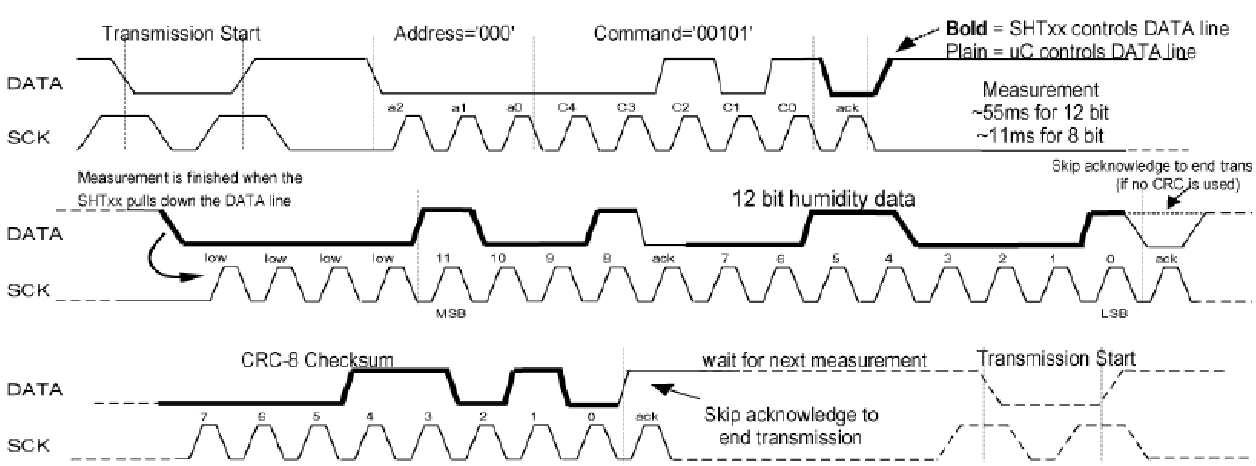


Figure 6 – Example RH measurement sequence for value “0000’1001 ’ 0011’0001”= 2353 = 75.79 %RH (without temperature compensation)

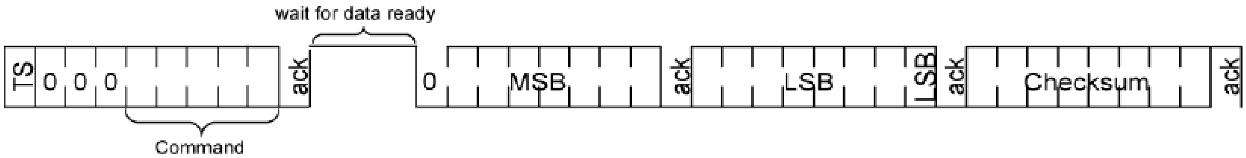


Figure 7 – Overview of Measurement Sequence (TS = Transmission Start)

3.4 Connection Reset Sequence

If communication with the device is lost the following signal sequence will reset its serial interface: While leaving DATA high, toggle SCK 9 or more times. This must be followed by a “Transmission Start” sequence preceding the next command. This sequence resets the interface only. The status register preserves its content.

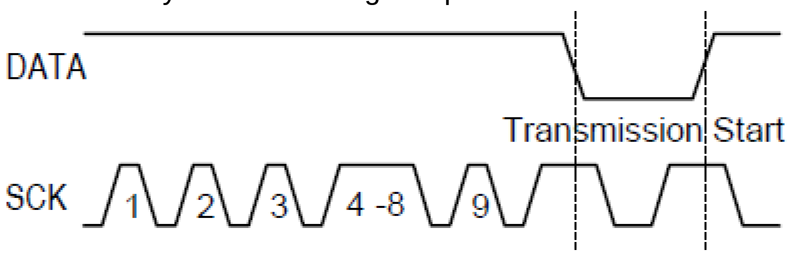


Figure 8 – Connection reset sequence

3.5 CRC-8 Checksum calculation

The entire digital transmission is secured by a 8 bit checksum. It ensures that any wrong data can be detected and eliminated.

3.6 Status Register

Some of the advanced functions of the probe such as selecting measurement resolution, end of battery notice or using the heater may be activated by sending a command to the status register. The following section gives a brief overview of these features. After the command Status Register Read or Status Register Write – see Table 4 – the content of 8 bits of the status register may be read out or written. For the communication compare Figures 7 and 8 – the assignation of the bits is displayed in Table 4.

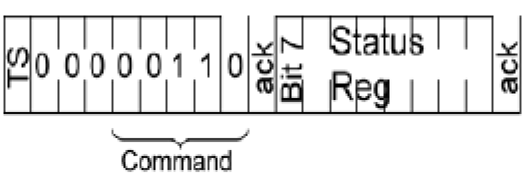


Figure 9 – Status register write

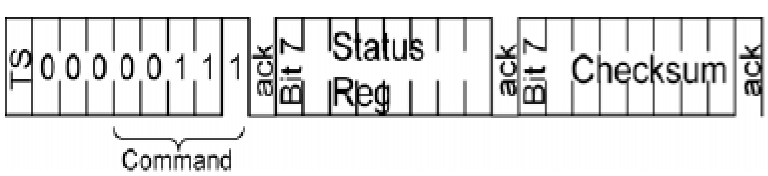


Figure 10 – Status register read

Bit	Type	Description	Default	
7		Reserved	0	
6	R	End of battery (low voltage detection) '0' for VDD > 2.47 '1' for VDD < 2.47	X	No default bit is updated after each measurement
5		Reserved	0	
4		Reserved	0	
3		Reserved	0	
2	R/W	Heater	0	off
1	R/W	no reload from OTP	0	reload
0	R/W	1' = 8 bit RH / 12 bit Temp resolution '0' = 12 bit RH/ 14 bit Temp resolution	0	12 bit RH 14 bit Temp

Table 5 – Status register bits

Measurement resolution: The default measurement resolution of 14bit (temperature) and 12bit (humidity) can be reduced to 12 and 8bit. This is especially useful in high speed or extreme low power applications.
End of Battery function detects and notifies VDD voltages below 2.47 V. Accuracy is ±0.05 V.

Heater: An on chip heating element can be addressed by writing a command into status register. The heater may increase the temperature of the sensor by 5 – 10°C beyond ambient temperature. The heater draws roughly 8mA @ 5V supply voltage. For example the heater can be helpful for functionality analysis: Humidity and temperature readings before and after applying the heater are compared. Temperature shall increase while relative humidity decreases at the same time. Dew point shall remain the same.
Note: The temperature reading will display the temperature of the heated sensor element and not ambient temperature. Furthermore, the sensor is not qualified for continuous application of the heater.

4.0 Converting Output to Physical Values

4.1 Relative Humidity

To compensate for the non-linearity of the humidity sensor and to obtain the full accuracy it is recommended to convert the readout with the following formula:

$$RH_{linear} = c_1 + c_2 \bullet SO_{RH} + c_3 \bullet SO_{RH}^{\;2}$$

SOrh	C1	C2	C3
12 bit	-2.0468	0.0367	-1.5955E-6
8 bit	-2.0468	0.5872	-4.0845E-4

Table 6 – Humidity conversion coefficients

Values higher than 99% RH indicate fully saturated air and must be processed and displayed as 100%RH. Please note that the humidity sensor has no significant voltage dependency.

4.2 Temperature Compensation of Humidity Signal

For temperatures significantly different from 25°C (~77°F) the humidity signal requires a temperature compensation. The temperature correction corresponds roughly to 0.12%RH/°C @ 50%RH. Coefficients for the temperature compensation are given in Table 6.

$$RH_{true} = (T_{^\circ C} - 25) \cdot (t_1 + t_2 \cdot SO_{RH}) + RH_{linear}$$

SORH	T1	T2
12 bit	0.01	0.00008
8 bit	0.01	0.00128

Table 7 – Temperature compensation coefficients

4.3 Temperature

The band-gap PTAT (Proportional To Absolute Temperature) temperature sensor is very linear by design. Use the following formula to convert digital readout (SOT) to temperature value, with coefficients given in Table 7:

$$T = d_1 + d_2 \cdot SO_T$$

VDD	d1 (degrees C)	d1 (degrees F)
5V	-40.1	-40.2
4V	-39.8	-39.6
3.5V	-39.7	-39.5
3V	-39.6	39.3
2.5V	-39.4	-38.9

SOT	d2 (degrees C)	d2 (degrees F)
14 bit	0.01	0.018
12 bit	0.04	0.072

Table 8 – Temperature conversion coefficients

4.4 Dewpoint

Dew point can be derived from humidity and temperature readings. Since humidity and temperature are both measured on the same chip, the probe allows for superb dew point measurements. For dew point (Td) calculations there are various formulas to be applied, most of them quite complicated. For the temperature range of -40 – 50°C the following approximation provides good accuracy with parameters given in Table 7:

$$T_d(RH,T) = T_n \cdot \frac{\ln\left(\frac{RH}{100\%}\right) + \frac{m \cdot T}{T_n + T}}{m - \ln\left(\frac{RH}{100\%}\right) - \frac{m \cdot T}{T_n + T}}$$

Temperature Range	T_n °C	m
Above water, 0 - 50°C	243.12	17.62
Above ice, -40 - 0°C	272.62	22.46

Table 9 – Parameters for dew point calculation

Please note that "ln(…)" denotes the natural logarithm. For RH and T the linearized and compensated values for relative humidity and temperature shall be applied.

4.5 Environmental Stability

The internal sensor element was tested according to AECQ100 Rev. F qualification test method. Sensor specifications are tested to prevail under the AEC-Q100 temperature grade 2 test conditions listed in Table 7. Performance under other test conditions cannot be guaranteed and is not part of the sensor specifications. Especially, no guarantee can be given for sensor performance in the field or for specific applications.

Environment	Standard	Result
HTSL	125°C, 1000 hours	Within specifications
TC	-50°C - 125°C, 1000 cycles Acc. JESD22-A104-C	Within specifications
UHST	130°C / 85%RH, 96h	Within specifications
THU	85°C / 85%RH, 1000h	Within specifications
ESD immunity	MIL STD 883E, method 3015 (Human Body Model @ ±2kV	Qualified
Latch-up	force current of ±100mA with Tamb = 80°C, acc. JEDEC 17	Qualified

Table 10 – Qualification tests

4.0 Integration

4.1 Industrial hardening

For rugged applications, typical considerations include opto-isolation of the SCK and CLK signals on the interface board used with the sensor. Transient protection may also be considered using series resistors inline between the microcontroller and connection jack. TVS diodes can be used on the data, clk and VDD signals.

4.2 Firmware code

Rapid integration is possible using the code supplied on the Microteknix website. Refer to the code sample document on our website.

Additional Information:

Questions & Comments: info@microteknix.com