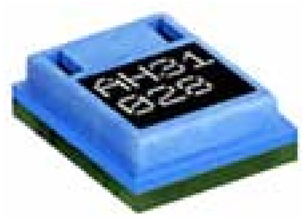
SENSIRION
THE SENSOR COMPANY

AH31
Humidity & Temperature Sensmitter

_ 2% Accuracy
_ Fully calibrated, digital serial output (SPI)
_ No external components required
_ Ultra low power consumption when pulsed readout
_ Fast RH response time (4 sec. typical 1/e)
_ Small size
_ Fully interchangeable
_ Immersible



10,2 mm / 8 mm / 3,5 mm
0,4 in. / 0,31 in. / 0,14 in.

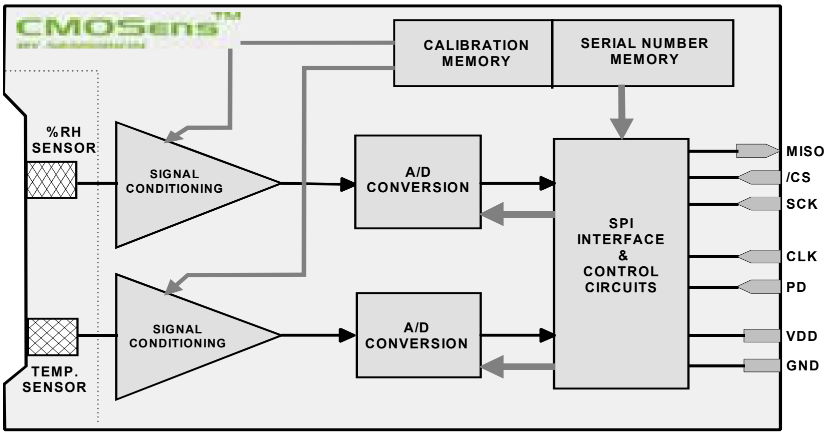
Preliminary Information as of September 2001

AH31 Product Summary

The AH31 is a Relative Humidity and Temperature Multi Sensor Module comprising a calibrated digital output. Application of industrial CMOS processes with customized post processing (CMOSens™ technology) ensures highest reliability and excellent long term stability. The device includes two calibrated microsensors for relative humidity and temperature which are seamlessly coupled to an amplification, analog to digital conversion and serial interface circuit on the same chip. This results in superior signal quality, a fast response time and absolute insensitivity to external disturbances even immersing the sensmitter into chemically non-reactive liquids e.g. water, does not result in any problems.
Each sensmitter is then 2*2 point calibrated in a precision humidity chamber and the calibration coefficients are burnt into the OTP memory.

These coefficients are used internally during measurement to calibrate the signals from the sensors. This leads to a full interchangeability of the device by keeping the accuracy given in the specifications.
The unidirectional SPI compliant 3-wire serial interface allows easy and fast system integration. Its small (11x8x3.5mm) size and low power consumption makes it the ultimate choice for even the most demanding applications including instrumentation, medical equipment, heating, ventilation and air conditioning systems (HVAC), portable consumer electronics, automotive and battery-operated controllers.
The device is supplied in a surface-mountable ball grid array (BGA) package.

AH31 Single Chip Relative Humidity and Temperature Sensor Module (CMOSens™ technology)



1 Sensor Performance Specifications

Temperature=25°C, measurement frequency=32kHz, VDD=5V unless otherwise noted

Sensor	Parameter	Conditions	Min.	Typ.	Max.	Units
Humidity	Resolution	with enhanced resolution[1]		0.1		% RH
	Reproducibility	with enhanced resolution[1]		±0.1		% RH
	Accuracy[2]	10 .. 90 % RH		±2		% RH
	& Interchangeability	<10, >90 % RH		±4		% RH
	Nonlinearity	10 .. 90 % RH uncompensated		±3		% RH
		0 .. 100 % RH compensated		±0.2		% RH
	Range		0		100	% RH
	Response time	1/ e (63 %) in slowly moving air			4	s
	Hysteresis			±1		% RH
	Long term stability	Typical			< 1	% RH/yr
Temperature	Resolution	with enhanced resolution[1]		0.1		°C
	Reproducibility	with enhanced resolution[1]		±0.1		°C
	Accuracy	0°C - 60°C		±0.9		°C
		<0°C, >60°C		±1.5		°C
	Range		-20		80	°C
	Response Time			30		s

Table 1 Relative Humidity and Temperature Sensor Performance Specifications

1.1 Converting the readout to physical values

1.1.1 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[3]:

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

with c_1 = -12.84; c_2 = 0.68; c_3 = -0.0007981

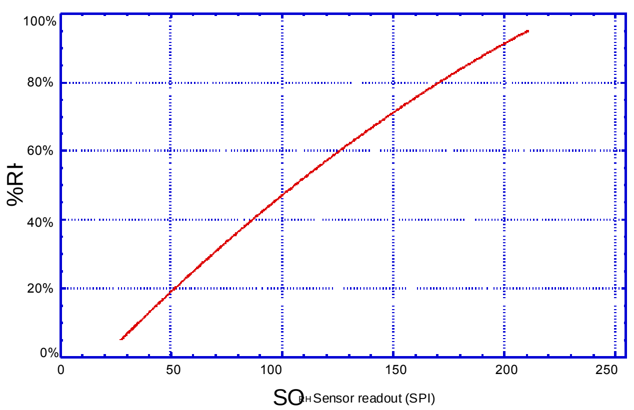


Figure 1 Sensor readout vs. real RH before linearization

For temperatures significantly different from 25°C (~77°F) the temperature coefficient of the RH sensor should be considered:

$$RH_{true} = (T_{°C} - 25) \bullet (t_1 + t_2 \bullet SO_{RH}) + RH_{linear}$$

with t_1 = 0.01; t_2 = 0.00075

1.1.2 Temperature

The temperature sensor is very linear by design.
Use the following formulas or table to convert from digital readout to temperature:

$T_{°C} = SO_T / 2.55 - 20$
$T_{°F} = SO_T / 1.416 – 4$

SPI Readout (Hex, 8bit)	Temperature	
00	-20 °C	-4 °F
FF	80 °C	176 °F

[1] See Application Note "Resolution Enhancement" for information on how to achieve resolutions of up to 12bit / 0.1%RH / 0.1°C
[2] Not including non-linearity
[3] For a simplified conversion formula see application note "RH_Non-Linearity_Compensation"

2 Serial Interface

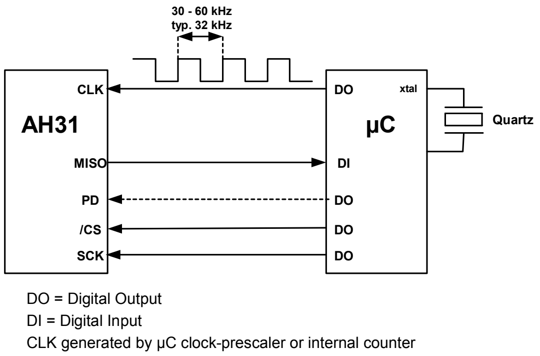


Figure 2 Typical application circuit

Pin	Name	Comment
1	CLK	Sensor clock
2	/CS	SPI chip select input
3	SCK	SPI serial clock input
4	MISO	SPI serial data output
5	VDD	SUPPLY
6	GND	Ground
7	PD	Power down
8	CKS	NOT USED, MUST BE TIED TO VDD LOCALLY

Table 2 AH31 Pin Description

Unused inputs must always be tied to an appropriate voltage level (e.g. either VDD or GND)

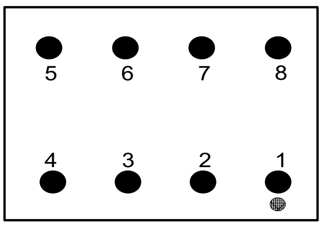


Figure 3 AH31 Pin out (bottom view)

2.1 Power Pins

The AH31 requires a voltage supply between 3.2V and 5.5V. The sensors are calibrated at 5V. In unstable supply environments, power supply pins (VDD, GND) can be decoupled with 100 nF capacitor to achieve highest accuracy.

2.2 SPI Pins

The unidirectional serial peripheral interface (SPI) provides an updated 8 bit relative humidity and an 8 bit temperature output every 512 cycles of CLK.(2)

2.2.1 Clock (CLK)

This pin provides the clock for the internal sensor circuitry. See “Figure 2 Typical application circuit” for a sample circuit. The recommended CLK frequency is 30 to 60 kHz.

2.2.2 Chip Select (/CS)

A low level on this pin selects the device and initiates a readout operation. /CS has to return to a high level in between two accesses.
As soon as the device is deselected (/CS high level), MISO changes to the high impedance state, allowing multiple parts to share the same SPI bus.

2.2.3 Serial Output (MISO)

The MISO tristate pin is used to transfer data out of the device. During a read cycle, data is updated on this pin after the falling edge and is valid on the rising edge of the serial clock SCK.

2.2.4 Serial Clock (SCK)

The SCK is used to synchronize the communication between a master and the AH31. SCK must remain low for at least two clock cycles after the falling edge of /CS. Data on the MISO pin is updated after the falling edge of the serial clock input.

2.2.5 Readout sequence[(3)]

After /CS is low for more than 2 clock cycles the MSB (most significant bit) of the 8 bit humidity data is available on the MISO pin. SCK should stay low during this time(1).
After that SCK can run at any speed (< 10 MHz) to shift out the data.
8 bits of humidity data are followed by 8 bits of temperature data(2). Transmission is MSB first in both cases. The data is valid on the rising edge of SCK.

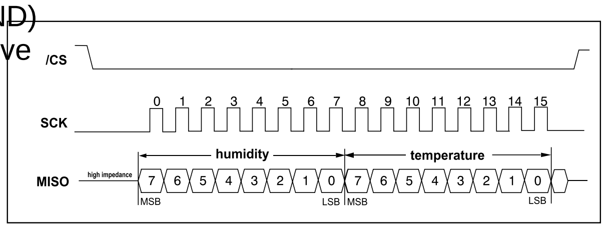


Figure 4 AH31 SPI readout sequence

(1) SPI mode 0,0 as defined in Motorola microcontroller datasheets
(2) See Application Note “Resolution Enhancement” for information on how to achieve resolutions of up to 12bit / 0.1%RH / 0.1°C.
(3) For best accuracy wait 60sec after powerup before the first measurement to allow the device to reach its operating temperature. If this is not suitable for your application consult the Application Note "Low Power Measurements" for an alternative solution.

2.3 Other Pins

2.3.1 Powerdown (PD)

While PD is high the device is powered down.
The powerdown sequence described below must be observed.
If not used this pin must be tied to GND

2.3.2 Powerdown Sequence

Clock CLK has to continue for at least 16 cycles after the rising edge of PD. It can then be shut off to achieve lowest powerdown consumption.
After the falling edge of PD the device will initialize itself for 1350 cycles (43ms @ 32kHz)(1) of the main clock and should not be accessed during that time.

See the application note “Low Power Measurements” for information on how to achieve average power consumptions of below 1.5µA with the use of the power down mode.

2.3.3 Reset Sequence

The powerdown sequence described above will also cause a reset to the device.

Clock Serial Number (CKS)

CKS is not used in normal operation and must be tied to VDD locally. Voltage spikes relative to VDD on this pin may cause a temporary loss of the calibration data.

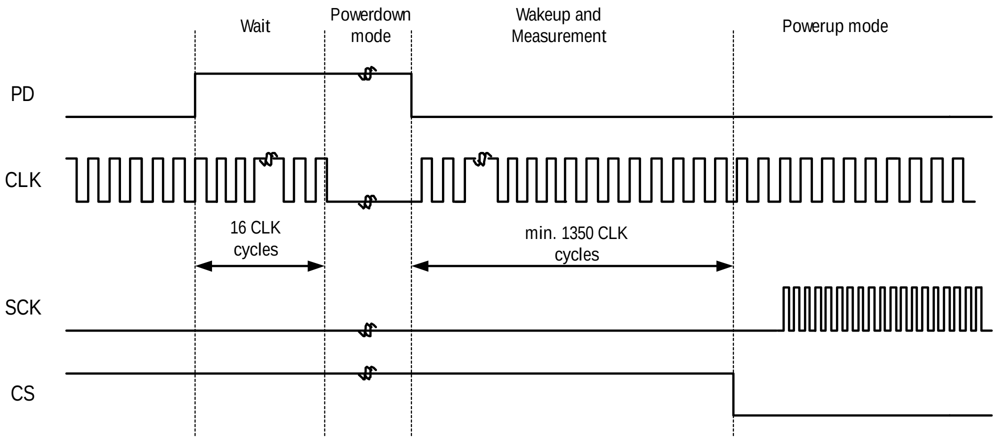


Figure 5 Powerdown and Reset Sequence

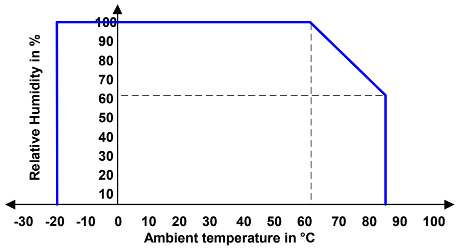
(1) For best accuracy wait 60sec after powerup before the first measurement to allow the device to reach its operating temperature. If this is not suitable for your application consult the application note "Low Power Measurements" for an alternative solution.

3 Specifications AH31

3.1 Absolute Maximum Ratings

Ambient Storage Temperature: -40°C to 90°C (1)
Reflow soldering as described in "Soldering Information" is allowed.

3.2 Operating Conditions(1)



3.3 ESD (Electrostatic Discharge)

ESD immunity is qualified according to MIL STD 883E, method 3015 (Human Body Model ±2kV).
Latch-up immunity is provided at a force current of ±100 mA with Tamb=80°C according to JEDEC 17.

3.4 Reliability Tests

Extensive test were performed in various environments.

Test	Standard
Temperature Cycles	JESD22-A104-A
PRESSURE COOKER	JESD22-A110-B
Salt Spray	DIN-50021ss
Elevated Atmosphere	JESD22-A101-B
Top of Swiss mountain	-
Cellular Phone	-
Tab Water	-
Ethanol	-

Table 3 Qualification data (extract)

Please check www.sensirion.com for results and additional information.

3.5 Electrical Specifications(2)

VDD=5V, Temperature=25°C unless otherwise noted

DC Characteristics(2)

Parameter	Conditions	Min.	Typ.	Max.	Units
Power supply DC(3)		3.3	5	5.5	V
Operating current	PD=0 CLK=32kHz			600	µA 800
Powerdown current	PD=1 CLK=32kHz			50	µA
	PD=1 CLK=0kHz		0.3		1 µA
Low level output voltage			0	0.2	0.4 V
High level output voltage			4.0	4.9	5 V
Low level input voltage	Negative going		0		1.1 V
High level input voltage	Positive going		3.9		5 V
Input current				1	µA
Output peak current(4)	active			4000	µA
	Tristated (floating)			10	µA

Table 4 AH31 DC Characteristics

AC Characteristics(2)

Parameter	Conditions	Min.	Typ.	Max.	Units
CLK frequency(5)		30	32	60	kHz
CLK duty cycle			40	50	60 %
PD high time			16		CLK cycles
First SPI access after reset or PD falling edge		1350			CLK cycles

Table 5 AH31 AC Characteristics (without SPI signals)

(1) Temperatures above 60°C with RH>60% will temporarily offset the RH signal by up to +3%RH. The sensor will slowly return to initial calibration conditions but heating the device up to 90°C at <5%RH for 24h will repeal the effect of high RH, high temperature environments
(2) Parameters are periodically sampled and not 100% tested.
(3) VDD below 4.5V may affect the offset of the humidity / temperature signal by up to +/-1%RH, +/-0.5C.
(4) Continuous current drain on the output pin will heat up the device and may affect the temperature and humidity measurement.
(5) The temperature sensor will have an offset of –0.5°C / 10kHz at CLK frequencies above 32kHz.

SPI I/O Characteristics

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Units
F_{SCK}	SCK frequency				10	MHz
T_{RFO}	MISO rise/fall time	Output load 5 pF	3.5	10	20	ns
		Output load 100 pF	30	40	200	ns
T_{CLH}	SCK high time		100			ns
T_{CLL}	SCK low time		100			ns
T_{CSS}	/CS setup time		2			CLK cycles
T_C	MISO valid from SCK low				50	ns
T_{HO}	Output hold time		0	10		ns
T_R/T_F	SCK rise/fall time				200	ns
T_{CSD}	CS disable time	Between two accesses to the same device	3	512		CLK cycles

Table 6 AH31 SPI Signals Characteristics

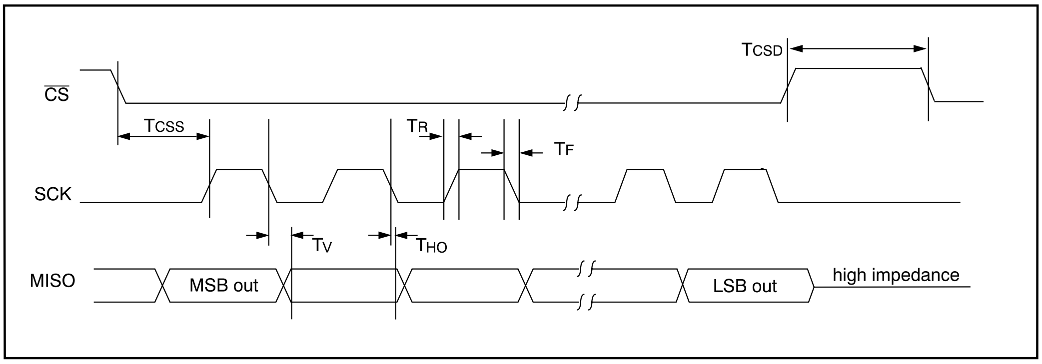


Figure 6 AH31 SPI Timing Diagram

4 Physical Dimensions and Mounting Information

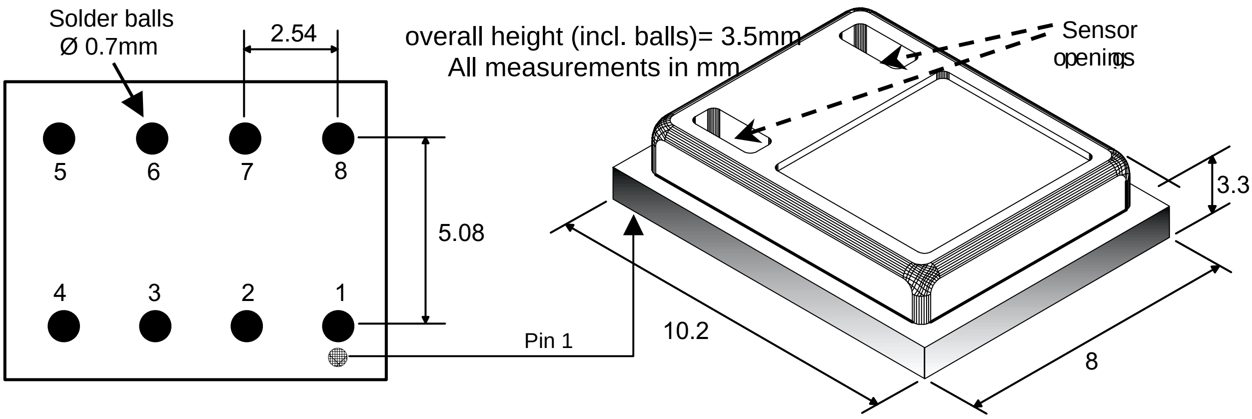


Figure 7 AH31 Mounting Information, bottom and side view.

The AH31 sensmitter housing consists of a Liquid Crystal Polymer (LCP) cap on a standard FR4 substrate.

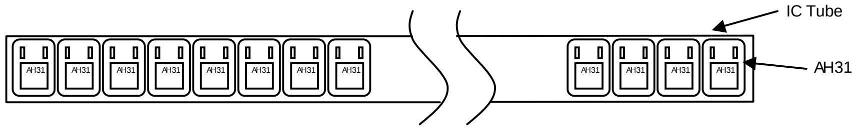
4.1 Mounting Recommendations

Relative humidity measurements are very sensitive to temperature variations. It is essential to keep the sensmitter at the same temperature as the air of which the humidity is to be measured.

The mounting location should be carefully chosen to avoid warm up of the sensmitter due to heat conduction (e.g. through the PCB) or radiation (Sunlight, hot electronic components).

4.2 Delivery Conditions

The AH31 will be delivered in standard IC tubes by max. 60 pieces per tube.



5 Soldering Information

The AH 31 can be soldered using standard reflow soldering procedure. For information see application note “
Procedure”

6 IMPORTANT NOTICES

The warranty for each SENSIRION AG product comes in the form of a written warranty which governs sale and use of such product. Such warranty is contained in the printed terms and conditions under which such product is sold, or in a separate written warranty supplied with the product. Please refer to such written warranty with respect to its applicability to certain applications of such product.

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7 Caution

The inherent design of this component causes it to be sensitive to electrostatic discharge (ESD). To prevent ESD-induced damage and/or degradation, take normal ESD precautions when handling this product.

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