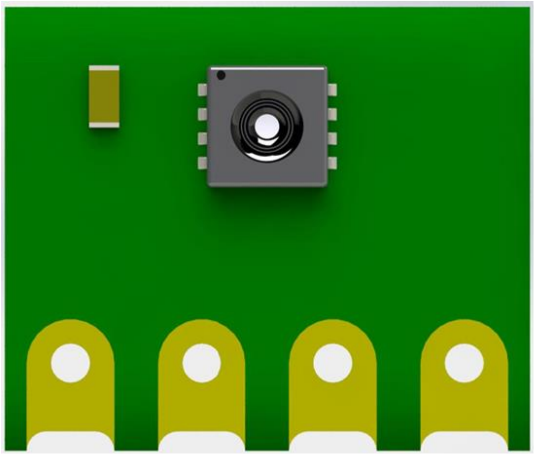
Features



- Fully calibrated, linearized, and temperature compensated digital output
- Wide supply voltage range, from 2.4 V to 5.5 V
- I2C Interface with communication speeds up to 1MHz and two user selectable addresses
- Typical accuracy of 1.5 % RH and 0.1 °C for TH10
- High reliability and long-term stability
- High signal-to-noise ratio
- Industry-proven technology with a track record of more than 15 years

Applications

- HVAC/R
- Thermostats/humidistats
- Respiratory therapy
- White goods
- Indoor weather stations
- Micro-environments/data centers
- Automotive climate control and defogging
- Asset and goods tracking
- Mobile phones and tablets

Description

The TH10 has increased intelligence, reliability and improved accuracy specifications compared to its predecessor. Its functionality includes enhanced signal processing, two distinctive and user selectable I2C addresses and communication speeds of up to 1 MHz. This allows for integration of the TH10 into a great variety of applications. Additionally, the wide supply voltage range of 2.4 V to 5.5 V guarantees compatibility with diverse assembly situations. All in all, the TH10 incorporates 15 years of knowledge of HOPERF, the leader in the humidity sensor industry.

1. Specifications

1.1 Electrical Specifications

Table 1 Electrical specifications, valid at 25°C.

Parameter	Symbol	Condition	Min.	Typ.	Max.	Units	Comments
Supply voltage	V_{DD}		2.4	3.3	5.5	V	
Power-up/down level	V_{POR}		2.1	2.3	2.4	V	
Slew rate change of the supply voltage	VDD_{slew}		-	-	20	V/ms	Voltage changes on the VDD line between VDD_{min} and VDD_{max} should be slower than the maximum slew rate.faster slew rates may lead to reset;
Supply current	I_{DD}	idle state (single shot mode)	-	0.2	2.0	uA	Current when sensor is not performing a measurement during single shot mode
		idle state (periodic data acquisition mode)	-	45	70	uA	Current when sensor is not performing a measurement during periodic data acquisition mode
		Measuring	-	800	1500	uA	Current consumption while sensor is measuring
		Average	-	2	-	uA	Current consumption (operation with one measurement per second at lowest repeatability , single shot mode)
Alert Output driving strength	IOH		0.8x Vdd	1.5x Vdd	2.1x Vdd	mA	See also section 3.5
Heater power	P_{heater}	Heater running	4.5	-	33	mW	Depending on the supply voltage

1.2 Timing Specification for the Sensor System

Table 2 System timing specification, valid from -40 °C to 125 °C and 2.4 V to 5.5 V.

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Units	Comments
Power-up time	tPU	After hard reset, VDD ⩾ VPOR	-	0.5	1	ms	Time between VDD reaching VPOR and sensor entering idle state
Soft reset time	tSR	After soft reset.	-	0.5	1	ms	Time between ACK of soft reset command and sensor entering idle state
Duration of reset pulse	tRESETN		1	-	-	µs	See section 3.6
Measurement duration	tMEAS,l	Low repeatability	-	2.5	4	ms	The three repeatability modes differ with respect to measurement duration, noise level and energy consumption.
	tMEAS,m	Medium repeatability	-	4.5	6	ms	
	tMEAS,h	High repeatability	-	12.5	15	ms	

1.3 Absolute Minimum and Maximum Ratings

Table 3 Minimum and maximum ratings; voltage values may only be applied for short time periods.

Parameter	Rating	Units
Supply voltage VDD	-0.3 to 6	V
Max Voltage on pins (pin 1 (SDA); pin 2 (ADDR); pin 3 (ALERT); pin 4 (SCL); pin 6 (nRESET))	-0.3 to VDD+0.3	V
Input current on any pin	±100	mA
Operating temperature range	-40 to 125	°C
Storage temperature range	-40 to 150	°C
ESD HBM (human body model)	4	kV
ESD CDM (charge device model)	750	V

Table 4 Humidity sensor specification

Parameter	Condition	Value	Units
Accuracy tolerance	Typ.	±1.5	% RH
	Max.	**Figure 1**	-
Repeatability	Low	0.25	% RH
	Medium	0.15	% RH
	High	0.1	% RH
Resolution	Typ.	0.01	% RH
Hysteresis	at 25°C	±0.8	% RH
Specified range	extended4	0 to 100	% RH
Response time	t63%	86	s
Long-term drift	Typ.	<0.25	% RH/y r

Humidity Sensor Performance Graphs

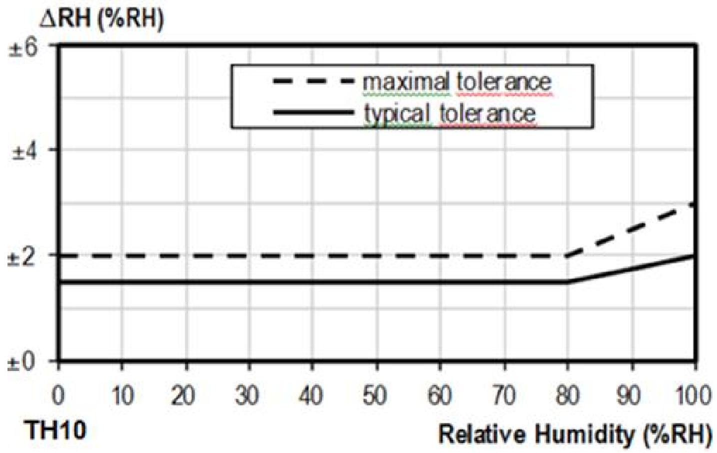


Figure 1 Tolerance of RH as 25℃ for TH10

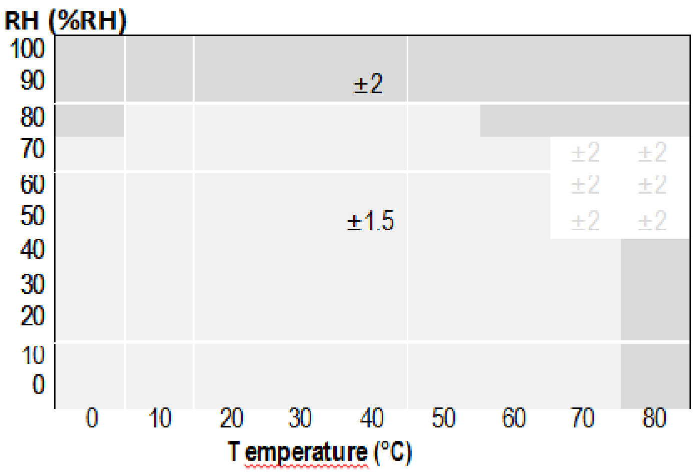


Figure 2 Typical of RH over T for TH10

Table 5 Temperature sensor specification

Parameter	Condition	Value	Units
Accuracy tolerance	-40°C to 90°C	±0.2	°C
Repeatability	Low	0.24	°C
	Medium	0.12	°C
	High	0.06	°C
Resolution	Typ.	0.015	°C
Specified Range	-	-40 to 125	°C
Response time	t63%	>2	s
Long Term Drift	max	<0.03	°C/yr

Temperature Sensor Performance Graphs

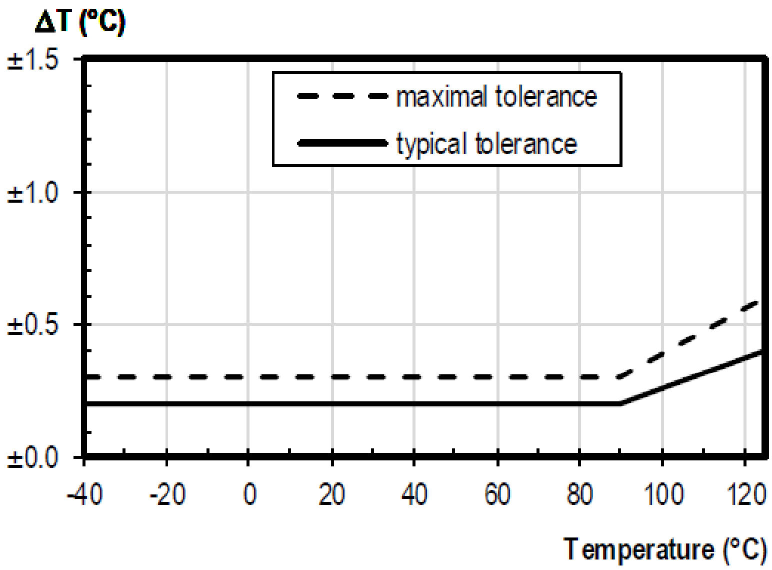


Figure 10 Temperature accuracy of the TH10 sensor.

A. The stated repeatability is 3 times the standard deviation (3σ) of multiple consecutive measurements at the stated repeatability and at constant ambient conditions. It is a measure for the noise on the phy sical sensor output. Different measurement modes allow for high/medium/low repeatability.

B. Specified range refers to the range for w hich the humidity or temperature sensor specification is guaranteed.

C. For details about recommended humidity and temperature operating range, please refer to section 1.4

D. Time for achiev ing 63% of a humidity step function, valid at 25°C and 1m/s airflow. Humidity response time in the application depends on the design-in of the sensor.

E. With activ ated ART function (see section 3.7) the response time can be improved by a factor of 2.

F. Typical value for operation in normal RH/T operating range, see section 1.4. Maximum value is < 0.5 %RH/yr. Higher drift values might occur due to contaminant env ironments with vaporized solvents, out-gassing tapes, adhesives, packaging materials, etc. For more details please refer to Handling Instructions.

G. Temperature response times strongly depend on the ty pe of heat ex change, the av ailable sensor surface and the design environment of the sensor in the final application.

1.4 Recommended Operating Condition

The sensor shows best performance when operated within recommended normal temperature and humidity range of 5 °C – 60 °C and 20 %RH – 80 %RH, respectively. Long-term exposure to conditions outside normal range, especially at high humidity, may temporarily offset the RH signal (e.g. +3%RH after 60h kept at >80%RH). After returning into the normal temperature and humidity range the sensor will slowly come back to calibration state by itself. Prolonged exposure to extreme conditions may accelerate ageing. To ensure stable operation of the humidity sensor, section “Storage and Handling Instructions” regarding exposure to volatile organic compounds have to be met. Please note as well that this does apply not only to transportation andmanufacturing, but also to operation of the TH10.

2. Pin Assignment and Typical Application

Table 6 TH10 pin assignment

Pin Name	Pin #	Pin Description
VDD	1	Supply voltage
SDA	2	I2C data
SCL	3	I2C clock
GND	4	Ground

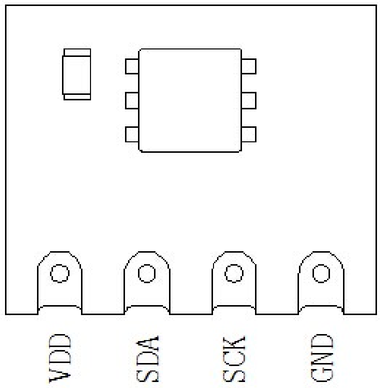


Figure 4.

Typical Application Circuits

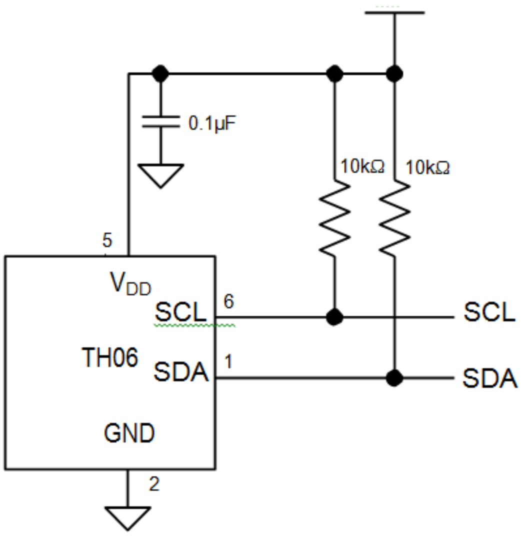


Figure 5. Typical Application Circuit for Relative Humidity and Temperature Measurement

3. Operation and Communication

The TH10 supports I2C fast mode (and frequenc ies up to 1000 kHz). Cloc k stretc hing c an be enabled and disabled through the appropriate user command. For detailed information on the I2C protocol.

TH10 commands and data are mapped to a 16- bit address space. Additionally, data and commands are protected with a CRC checksum. This increases communication reliability. The 16 bits commands to the sensor already include a 3 bit CRC checksum. Data sent from and received by the sensor is always succeeded by an 8 bit CRC.In write direction it is mandatory to transmit the checksum, since the TH10 only accepts data if it is followed by the correct checksum. In read direction it is left to the master to read and process the checksum.

3.1 Power-Up and Communication Start

The sensor starts powering-up after reac hing the power- up threshold voltage VPOR specified in Table 1. After reaching this threshold voltage the sensor needs the time tPU to enter idle state. Once the idle state is entered it is ready to receive commands from the master (mic rocontroller).

Each transmission sequence begins with a START condition (S) and ends with a STOP condition (P) as described in the I2C-bus specification. The stop condition is optional. Whenever the sensor is powered up, but not performing a measurement or communicating, it automatic ally enters idle state for energy saving. This idle state cannot be controlled by the user.

3.2 Starting a Measurement

A measurement communication sequence consists of a START condition, the I2C write header (7-bit I2C device address plus 0 as the write bit) and a 16-bit measurement command. The proper reception of each byte is indicated by the sensor. It pulls the SDA pin low (ACK bit) after the falling edge of the 8th SCL clock to indicate the reception. A complete measurement cycle is depicted in Table 8.

With the acknowledgement of the measurement command, the TH10 starts measuring humidity and temperature.

3.3 Measurement Commands for Single Shot Data Acquisition Mode

In this mode one issued measurement command triggers the acquisition of one data pair. Each data pair consists of one 16 bit temperature and one 16 bit humidity value (in this order). During transmission each data value is always followed by a CRC checksum, see section 3.4.

In single shot mode different measurement commands can be selec ted. The 16 bit commands are shown in T able 8. They differ with respect to repeatability (low, medium and high) and clock stretching (enabled or disabled).

The repeatability setting influenc es the measurement duration and thus the overall energy c onsumption of the sensor. This is explained in section 2.

3.4 Readout of Measurement Results for Single Shot Mode

After the sensor has completed the measurement, the master can read the measurement results (pair of RH& T) by sending a START condition followed by an I2C read header. The sensor will acknowledge the reception of the read header and send two bytes of data (temperature) followed by one byte CRC checksum and another two bytes of data (relative humidity) followed by one byte CRC checksum. Each byte must be acknowledged by the microcontroller with an ACK condition for the sensor to continue sending data. If the sensor does not receive an ACK from the master after any byte of data, it will not continue sending data.

The sensor will send the temperature value first and then the relative humidity value. After having received the checksum for the humidity value a NACK and stop condition should be sent (see Table 8).

The I2C master can abort the read transfer with a NACK condition after any data byte if it is not interested in subsequent data, eg. the CRC byte or the sec ond measurement result, in order to save time.

In case the user needs humidity and temperature data but does not want to process CRC data, it is recommended to read the two temperature bytes of data with the CRC byte (without proc essing the CRC data); after having read the two humidity bytes, the read transfer can be aborted with a with a NACK.

No Clock Stretching

When a command without clock stretching has been issued, the sensor responds to a read header with a not acknowledge (NACK), if no data is present.

Clock Stretching

When a command with clock stretching has been issued, the sensor responds to a read header with an ACK and subsequently pulls down the SCL line. The SCL line is pulled down until the measurement is complete. As soon as the measurement is complete, the sensor releases the SCL line and sends the measurement results.

Table 8

Condition		Hex. code	
Repeatability	Clock stretching	MSB	LSB
High	enabled	0x2C	06
Medium			0D
Low			10
High	disabled	0x24	00
Medium			0B
Low			16

e.g. 0x2C06: high repeatability measurement with clock stretching enabled

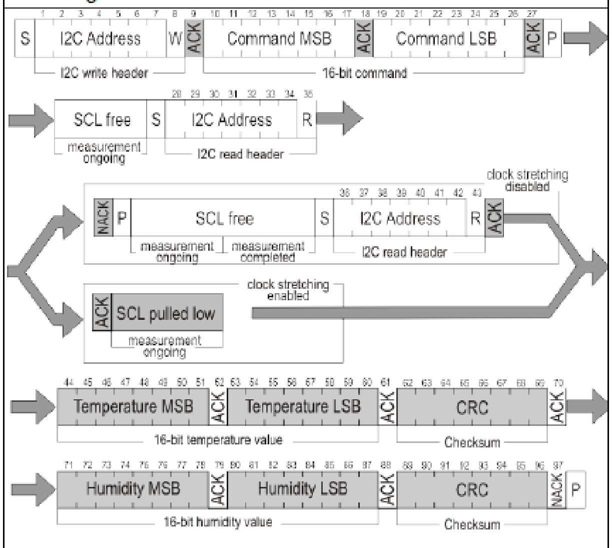
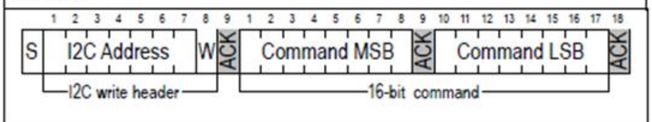


Table 9

Condition		Hex. code	
Repeatability	mps	MSB	LSB
High	0.5	0x20	32
Medium			24
Low			2F
High	1	0x21	30
Medium			26
Low			2D
High	2	0x22	36
Medium			20
Low			2B
High	4	0x23	34
Medium			22
Low			29
High	10	0x27	37
Medium			21
Low			2A

e.g. 0x2130: 1 high repeatability mps - measurement per second



3.5 Measurement Commands for Periodic Data Acquisition Mode

In this mode one issued measurement command yields a stream of data pairs. Each data pair consists of one 16 bit temperature and one 16 bit humidity value (in this order).

In periodic mode different measurement commands can be selected. The corresponding 16 bit commands are shown in Table 9. They differ with respect to repeatability (low, medium and high) and data acquisition frequency (0.5, 1, 2, 4 & 10 measurements per second, mps). Clock stretching cannot be selected in this mode.

The data acquisition frequency and the repeatability setting influences the measurement duration and the current consumption of the sensor. This is explained in section 2 of this datasheet.

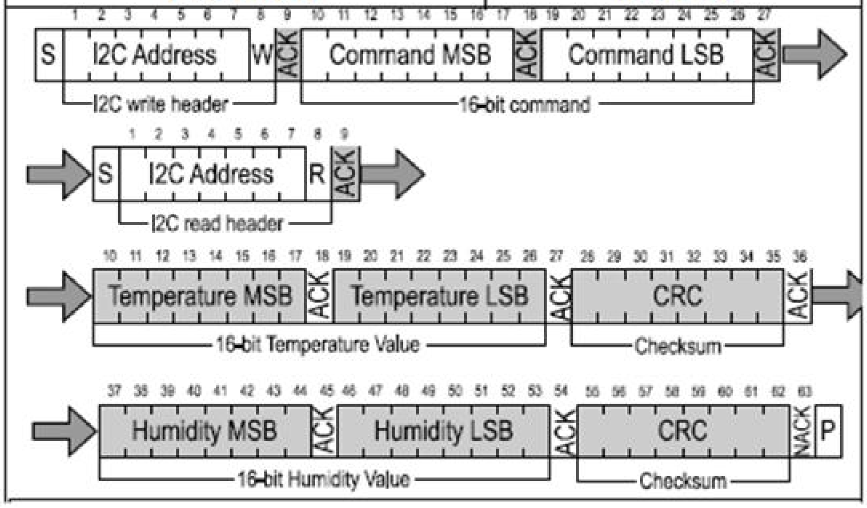
If a measurement command is issued, while the sensor is busy with a measurement (measurement durations see Table 2), it is recommended to issue a break command first (see section 3.8). Upon reception of the break command the sensor will finish the ongoing measurement and enter the single shot mode.

3.6 Readout of Measurement Results for Periodic Mode

Transmission of the measurement data c an be initiated through the fetch data command shown in Table 10. If no measurement data is present the I2C read header is responded with a NACK (Bit 9 in Table10) and the communication stops. After the read out command fetch data has been issued, the data memory is cleared, i.e. no measurement data is present

Table 10

Command	Hex code
Fetch Data	0x E0 00



3.7 ART Command

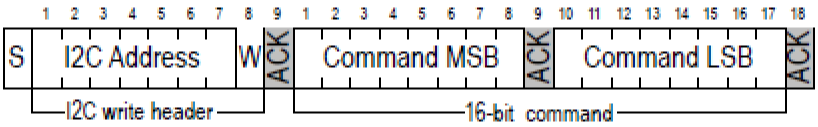
The ART (accelerated response time) feature c an be activated by issuing the command in Table 11. After issuing the ART command the sensor will start acquiring data with a frequenc y of 4Hz.

The ART command is structurally similar to any other command in Table 9. Henc e section 3.5 applies for starting a measurement, section 3.6 for reading out data and section 3.8 for stopping the periodic data acquisition.

The ART feature can also be evaluated using the Evaluation Kit from HOPERF

Table 11

Command	Hex Code
Periodic Measurement with ART	0x2B32

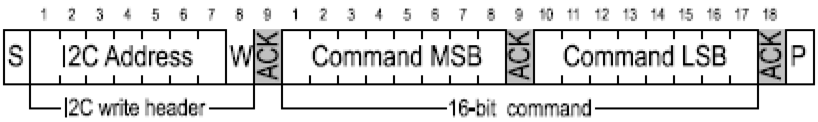


3.8 Break command / Stop Periodic Data Acquisition Mode

The periodic data acquisition mode can be stopped using the break command shown in Table 12. It is recommended to stop the periodic data acquisition prior to sending another command (except Fetch Data command) using the break command. Upon reception of the break command the sensor enters the single shot mode, after finishing the ongoing measurement. This can take up to 15 ms, depending on the selec ted repeatability.

Table 12

Command	Hex Code
Break	0x3093



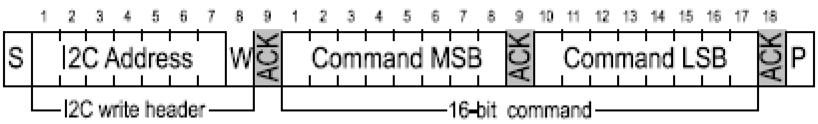
3.9 Reset

The TH10 provides a soft reset mechanism that forces the system into a well-defined state without removing the power supply. When the system is in idle state the soft reset command can be sent to the TH10. This triggers the sensor to reset its system controller and reloads calibration data from the memory.In order to start the soft reset procedure the command as shown in Table 13 should be sent.

It is worth noting that the sensor reloads calibration data prior to every measurement by default.

Table 13

Command	Hex Code
Soft Reset	0x30A2

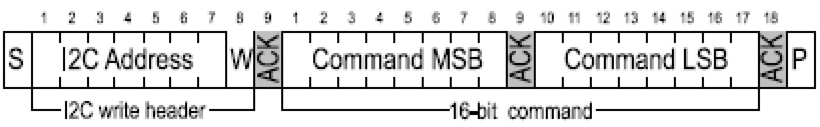


3.10 Heater

The heater can be switched on and off by command, see table below. The status is listed in the status register. After a reset the heater is disabled (default condition).

Table 14

Command	Hex Code	
	MSB	LSB
Heater Enable	0x30	6D
Heater Disabled		66



3.11 Status Register

The status register contains information on the operational status of the heater, the alert mode and on the execution status of the last command and the last write sequence. The command to read out the status register is shown in Table 15 whereas a description of the content can be found in Table 16.

Table 15

Command	Hex code
Read Out of status register	0xF32D

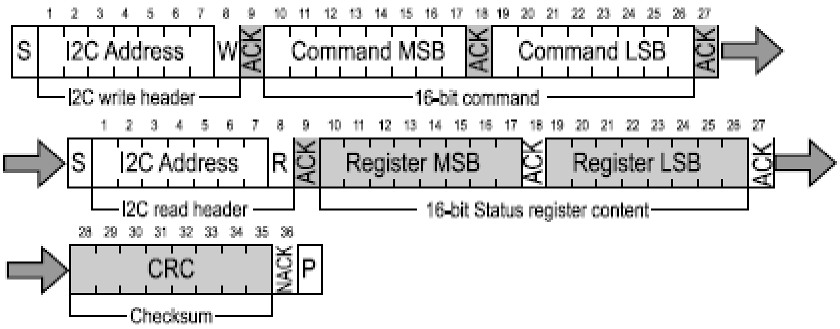


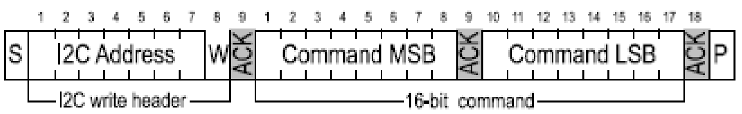
Table 16

Bit	Field description	Default value
15	Alert pending status '0': no pending alerts '1': at least one pending alert	‘1’
14	Reserved	‘0’
13	Heater status ‘0’ : Heater OFF ‘1’ : Heater ON	‘0’
12	Reserved	‘0’
11	RH tracking alert ‘0’ : no alert ‘1’ . alert	‘0
10	T tracking alert ‘0’ : no alert ‘1’ . alert	‘0’
9:5	Reserved	‘xxxxx’
4	System reset detected '0': no reset detected since last ‘clear status register’ command '1': reset detected (hard reset, soft reset command or supply fail)	‘1’
3:2	Reserved	‘00’
1	Command status '0': last command executed successfully '1': last command not processed. It was either invalid, failed the integrated command checksum	‘0’
0	Write data checksum status '0': checksum of last write transfer was correct '1': checksum of last write transfer failed	‘0’

Clear Status Register

All flags (Bit 15, 11, 10, 4) in the status register can be cleared (set to zero) by sending the command shown in **Table 17.**

Command	Hex Code
Clear status register	0x 30 41



3.12 Checksum Calculation

The 8-bit CRC checksum transmitted after each data word is generated by a CRC algorithm. Its properties are displayed in Table 18. The CRC covers the contents of the two previously transmitted data bytes. To calculate the checksum only these two previously transmitted data bytes are used.

Table 18

Property	Value
Name	CRC-8
Width	8 bit
Protected data	read and/or write data
Polynomial	0x31 ($x^8 + x^5 + x^4 + 1$)
Initialization	0xFF
Reflect input	False
Reflect output	False
Final XOR	0x00
Examples	CRC (0xBEEF) = 0x92

3.13 Conversion of Signal Output

Measurement data is always transferred as 16-bit values (unsigned integer). These values are already linearized and compensated for temperature and supply voltage effects. Converting those raw values into a physical scale can be achieved using the following formulas.

Relative humidity conversion formula (result in %RH)：

$$RH = 100 \cdot \frac{S_{RH}}{2^{16} - 1}$$

Temperature conversion formula (result in °C)：

$$T[°C] = -45 + 175 \cdot \frac{S_T}{2^{16} - 1}$$

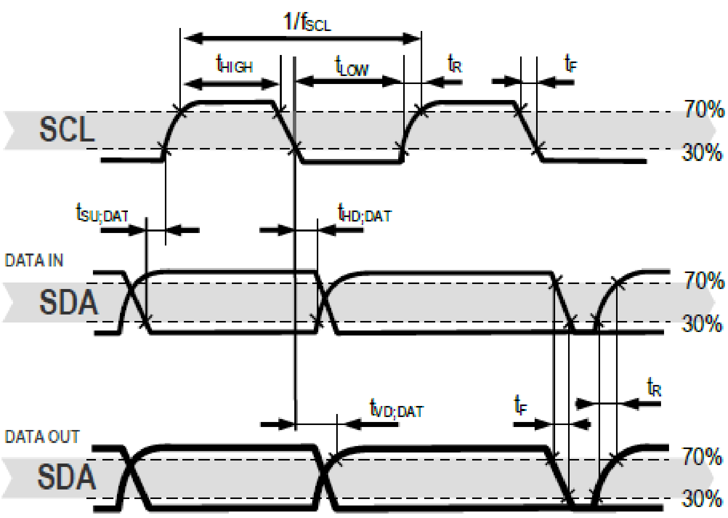
SRH and ST denote the raw sensor output for humidity and temperature, respectively. The formulas work only correctly when SRH and ST are used in decimal representation.

3.14 Communication Timing

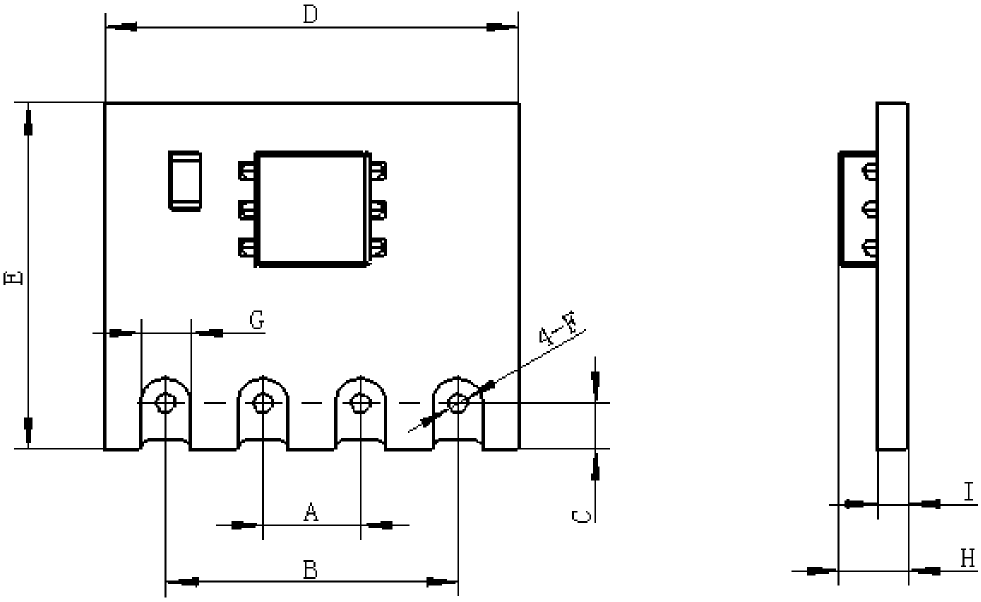
Table 20 Communication timing specifications for I2C fm (fast mode), specifications are at 25°C

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Units	Comments
SCL clock frequency	f_{SCL}		0	-	1000	kHz	
Hold time (repeated) START condition	$t_{HD;STA}$	After this period, the first clock pulse is generated	0.24	-	-	µs	
LOW period of the SCL clock	t_{LOW}		0.65	-	-	µs	
HIGH period of the SCL clock	t_{HIGH}		0.26	-	-	µs	
SDA hold time	$t_{HD;DAT}$		0	-	250	ns	Transmitting data
			0	-	-	ns	Receiving data
SDA set-up time	$t_{SU;DAT}$		100	-	-	ns	
SCL/SDA rise time	t_R		-	-	300	ns	
SCL/SDA fall time	t_F		-	-	300	ns	
SDA valid time	$t_{VD;DAT}$		-	-	0.9	µs	
Set-up time for a repeated START condition	$t_{SU;STA}$		0.6	-	-	µs	
Set-up time for STOP condition	$t_{SU;STO}$		0.6	-	-	µs	
Capacitive load on bus line	CB		-	-	400	pF	
Low level input voltage	V_{IL}		-0.5	-	0.3x V_{DD}	V	
High level input voltage	V_{IH}		0.7xV_{DD}	-	1xV_{DD}	V	
Low level output voltage	V_{OL}	3 mA sink current	-	-	0.66	V	

Timing diagram for digital input/output pads.



4. Package Outline



Dimension	Min	Nom	Max
A	2.6	2.7	2.8
B	8.0	8.1	8.2
C	1.7	1.8	1.9
D	10.8		
E	9.1		
F	∮0.7	∮0..8	∮0.9
G	1.6	1.8	2.0
H	1.7	1.8	1.9
I	0.7	0.8	0.9
Notes: All dimensions are shown in millimeters (mm).			

HOPE MICROELECTRONICS CO.,LTD
Add: 2/F, Building 3, Pingshan Private Enterprise Science and Technology Park, Lishan Road, XiLi Town, Nanshan District, Shenzhen, Guangdong, China
Tel: 86-755-82973805
Fax: 86-755-82973550
Email: sales@hoperf.com
Website: http://www.hoperf.com
http://www.hoperf.cn