

ISEN-H1D

Humidity & Temperature

Sensor Module

User's Manual

1. Features

- On-chip humidity & temperature sensors
- Fully calibrated, various output (I²C, Voltage)
- Excellent long-term stability
- Low power consumption
- Serial interface control (I²C)
- Small size



ISEN-H1D Product Summary

The ISEN-H1D is a humidity & temperature sensor. The device includes a relative capacitive humidity sensor elements and a band-gap temperature sensor with capacitive-to-voltage converter (C-V Converter). This results in superior signal quality, a fast response time and insensitivity to external disturbances at a very competitive price. Each ISEN-H1D is individually calibrated in a precision chamber. The calibration coefficients are programmed into the memory. These coefficients are used internally during measurements to calibrate the signals from the sensors. The serial interface and internal voltage regulation allows easy and fast system integration. Its small size and low power consumption makes it the ultimate choice for even the most demanding applications. The device is supplied in single-in-line type devices. Customer specific packaging options may be available on request.

<u>ISEN</u>	-	<u>H1</u>	<u>(D)</u>
①		②	③

①	InnerSensor Enviromental
②	Humidity
③	Pin Type (D)

Application

- | | |
|---|--|
| <ul style="list-style-type: none"> - HVAC - Automotive - Consumer Goods - Weather Stations - Humidifiers | <ul style="list-style-type: none"> - Test & Measurement - Data Logging - Automation - White Goods - Medical |
|---|--|

2. Specification

Table.1 Specification for humidity sensor

Parameter	Condition	Min	Typ	Max	units
Resolution			14		bit
Operating Range		0		100	%RH
Accuracy	Typical		±2.5		%RH
	Maximal	See figure 1,3			
Hysteresis			< ± 1.5		
Response time				10	sec

Table.2 Specification for temperature sensor

Parameter	Condition	min	Typ	max	Units
Resolution			14		bit
Operating Range		-40		120	°C
Accuracy	Typical		±0.5		°C
	Maximal	See figure 2			
Response time		15		25	sec

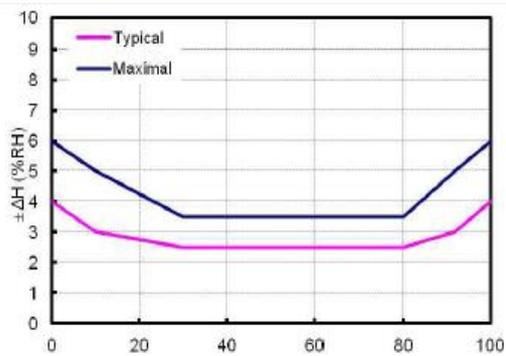


Fig.1 Humidity-accuracy at 25°C

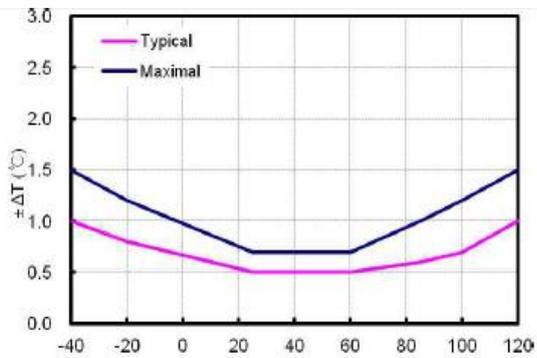


Fig.2 Temperature-accuracy

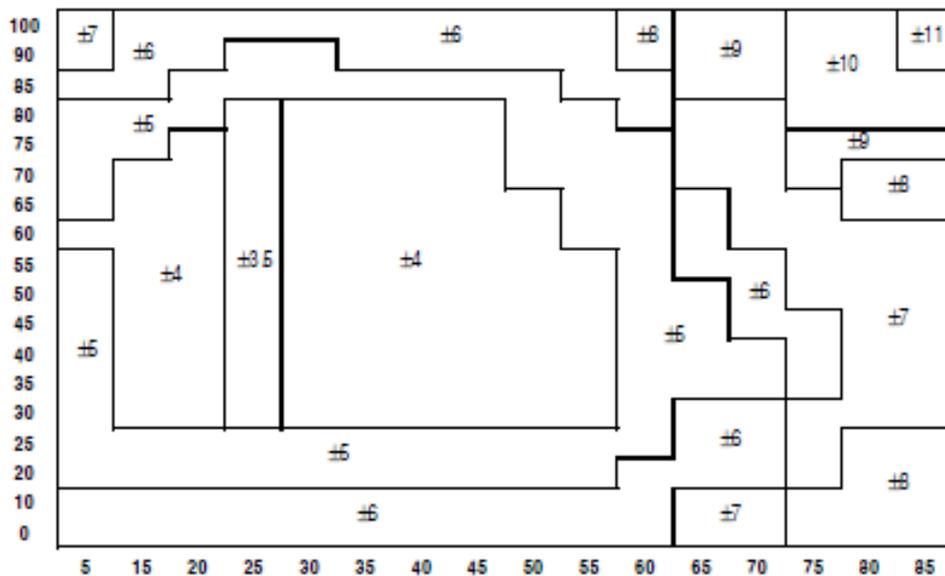


Fig.3 Temperature (°C)

3. Reliability of Humidity Sensor

1) Normal operating Range

The sensor works stable within recommended normal range(see Figure.3). Long term exposures to conditions outside normal range, especially at humidity >80%RH, may temporarily offset the RH signal. After return to normal range it will slowly return towards calibration state by itself.

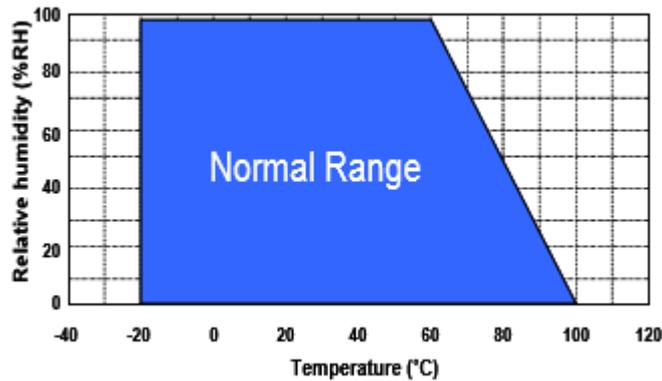


Fig.4 Normal operating range.

2) Hysteresis of Characteristics

The graph shows the hysteresis curve of ISEN-H1D sensor. Considering the relative humidity of the sensor, the hysteresis formula is give by

$$\text{Hysteresis Value} = H(10\%RH \rightarrow 90\%RH) - H(90\%RH \rightarrow 10\%RH)$$

The hysteresis variety of samples indicate $\Delta H < \pm 1.5\%RH$ at each humidity point. This result shows that the sensor satisfies our specification. The meter is set to measure humidity value at $V_{DD} = 5V$. For the precise measurement, we used the hygrometer and compared with the humidity of temperature-humidity chamber.

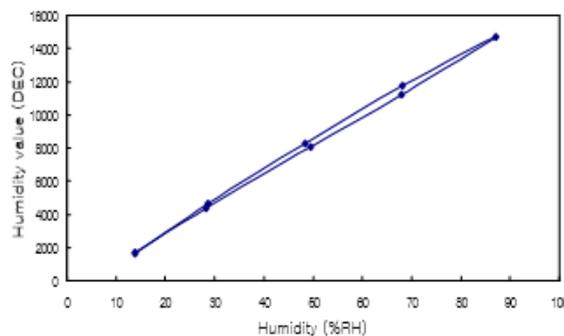
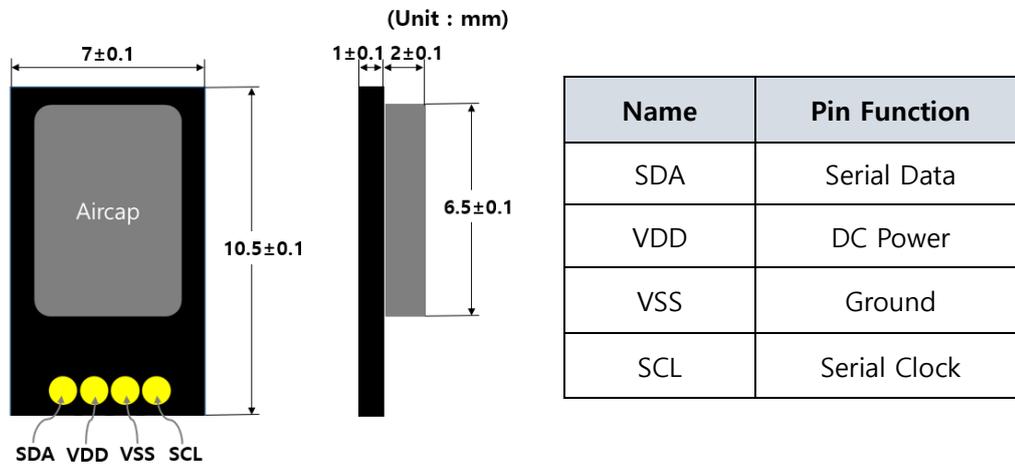


Fig.5 Hysteresis of Humidity Sensor

4. Dimension

1) ISEN-H1D



5. Reconditioning Procedure

The sensor exposed to extreme conditions or chemical solvents may have offset. The following reconditioning procedure may bring back to the calibrated state of device.

- **BAKING : 80 °C FOR 30 MIN**
- **RE-HYDRATION : 25°C, >80%RH FOR 12 HOURS**

6. Shipping details

ISEN-H1D was packaged in plastic trays. Please be careful opening from side of the tray cover to avoid damage of sensors.

7. Storage instructions

The storage instructions must be followed precisely in order to guarantee specification. Guarantees are one-year storage of the sensor package. Chemical vapors at high concentration in combination with long exposure times may offset the sensor reading.

8. Block Diagram

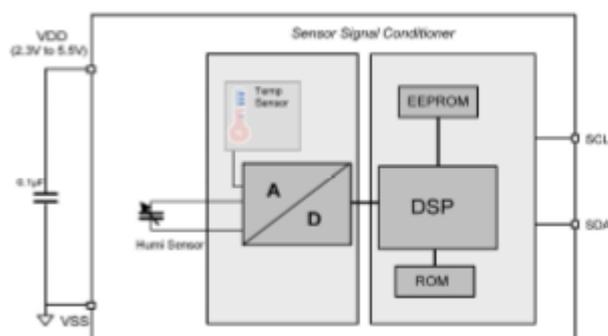


Fig.6 ISEN-H1D Block diagram

9. Operating Condition

1) Absolute Maximum Ratings

Parameter	Symbol	Min	Typ	Max	Units
Analog Supply Voltage	V_{DD}	-0.3		6.0	V
Voltages at Analog I/O In Pin	V_{INA}	-0.3		$V_{DD}+0.3$	V
Voltages at Analog I/O Out Pin	V_{OUTA}	-0.3		$V_{DD}+0.3$	V
Storage Temperature Range	T_{STOR}	-55		150	°C

2) Operating Conditions

Parameter	Symbol	Min	Typ	Max	Units
Supply Voltage to GND	V_{SUPPLY}	2.3	5	5.5	V
Ambient Temperature Range	T_{AMP}	-40		125	°C
External Capacitance between V_{DD} pin and GND	$C_{VSUPPLY}$	100	220	470	nF
External Capacitance between V_{CORE} pin and GND	C_{VCORE}	10		110	nF
I ² C Pull-up Resistor	R_{PU}	1	2.2	10	kΩ
SDA Load Capacitance	C_{SDA}			0.2	nF
Current	Digital output	I_{sleep}	1	3	µA

10. Circuit Interface

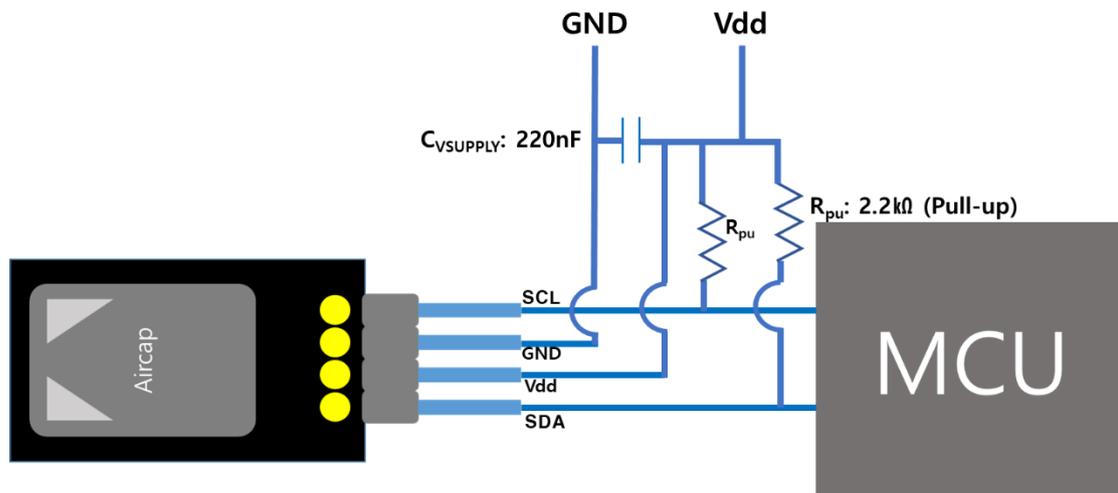


Fig.7 ISEN-H1D I2C Interface

1) Power

The ISEN-H1D requires a voltage supply between 2.3 and 5.5V. After power on, the device needs 10ms to reach measurement state. No commands should be sent. If you send command at that time, you cannot receive correct data from sensors.

2) Serial Clock(SCL)

The SCLK is used to synchronize the communication between a microcontroller and the ISEN-H1D. Since the interface consists of fully static logic there is no minimum SCL frequency.

3) Serial Data(SDA)

The SDA 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 the serial clock SCL. During transmission the SDAT line must remain stable while SCL is high. An external pull-up resistor is required to pull the signal high.

11. I²C Interface

For integration with the micro-controller, the ISEN-H1D has a I²C-compatible interface which supports both 100 kHz and 400 kHz bit rate. The I²C slave address is programmed by default on 28_H and can be adjusted in the entire address range of (00_H to 7F_H).

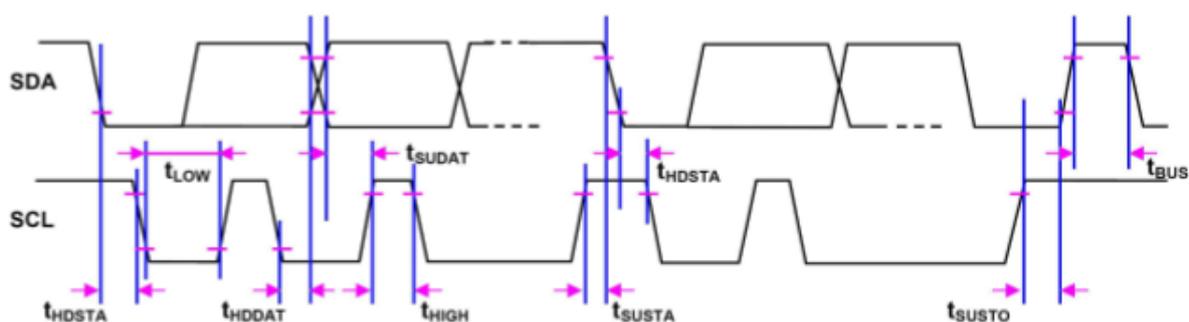


Fig.8 I²C Timing Diagram

1) I²C Parameters

Parameter	Symbol	Min	Max	Units
SCL clock frequency	f_{SCL}	100	400	kHz
Start condition hold time relative to SCL edge	t_{HDSTA}	0.1		μ s
Minimum SCL clock low width	t_{LOW}	0.6		μ s
Minimum SCL clock high width	t_{HIGH}	0.6		μ s
Start condition setup time relative to SCL edge	t_{SUSTA}	0.1		μ s
Data hold time on SDA relative to SCL edge	t_{HDDAT}	0		μ s
Data setup time on SDA relative to SCL edge	t_{SUDAT}	0.1		μ s
Stop condition setup time on SCL	t_{SUSTO}	0.1		μ s
Bus free time between stop condition and start condition	t_{BUS}	1		μ s

12. I²C commands

As detailed in below table, there are two types of commands for user operating a ISEN-H1D. The Measurement Request (MR) is wake up command sent by the master for a new measurement cycle.

The Data Fetch (DF) command is used to fetch data in I2C communication. With the start of communication the entire output packet will be loaded in a serial output register. The register will be updated after the communication is finished. The output is always scaled to 14-bits programmed resolution.

I²C command types

Type	Descriptions
Measurement Request(MR)	Start measuring cycle
Data Fetch(DF)	Used to fetch data in any digital mode

Humidity modules do not carry out internal arithmetic operation to minimize on the current consumption. A measurement process is carried out only after the command measuring request (MR) is received.

1) Measurement Requests (MR)

By a measurement request command, the ISEN-H1D is woke up and it executes a measuring cycle. The measuring cycle begins with the temperature measurement, followed by humidity measurement, digital signal processing and finally writing the measured values into the output register.

The MR command consists of the address of the ISEN-H1D, with which the R/W bit is transferred as 0(= write). The real signal of MR is 0x50 adding write bit(0) to address(0x28). After the humidity module is answered with ACK (= measurement started), the master finalized the transfer with NACK (=stop condition).



Fig.9 Measurement Request Command

2) Data Fetch(DF)

The DF command is began by the micro-controller (master) as sending address(7bit : 0x28) and read bit (1bit : 1). The real signal is 0x51. The ISEN-H1D sends back an acknowledgement (ACK) to indicate success. The others data are two status bit and measurement data with humidity and temperature to sending a NACK (= stop condition) by the master. The first two bytes of measurement data contain the two status bits as MSB, and then followed by the humidity value with 14 bits.

If the temperature data is also needed, then these can be read after the humidity value. The most significant 8 bits of the temperature value will be transferred as third byte. Then the least significant 6 bits of the temperature value can be read as the fourth byte. The last two bits are not used and should be masked away. But if the temperature data is not needed, the master can send a NACK signal. If it doesn't appear "state bit 00", does not communicate.

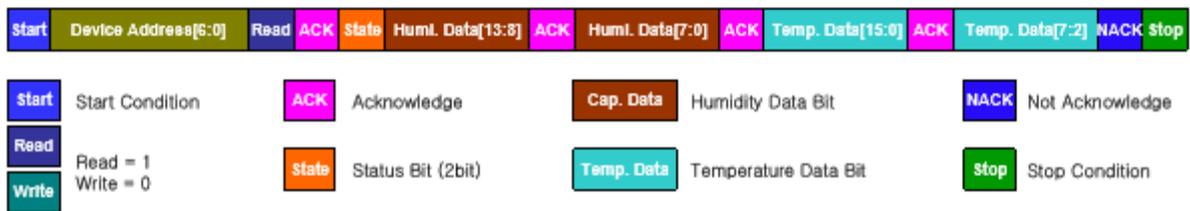


Fig.10 Measurement Packet Reads

Status Bit Table

Status Bits	Output	Definition
00B	Clipped normal output	Data that has not been fetched since the last measurement cycle.
01B	Not applicable	Data that has already been fetched since the last measurement cycle.
10B	Not used	Not used
11B	Not used	Not used

3) Relative Humidity and Temperature Raw Data Collection

Raw data are collected for the ISEN-H1D. The Raw data should also be the average of several samples to minimize noise effects. To collect relative humidity and temperature raw data in measurement, the expression as follows;

The Humidity_High and Humidity_Low bytes can be read in %.

$$\text{Humidity}[\%RH] = \{ (\text{Humidity_High}[5:0] \times 256 + \text{Humidity_Low}[7:0]) / 16383 \} * 100$$

The Temp_High and the Temp_Low bytes can be read as temperature output in °C.

$$\text{Temp output}[C] = (\text{Temp_High}[7:0] \times 64 + \text{Temp_Low}[7:2] / 4) / 2^{14} \times 165 - 40$$

4) I2C Source Code

```
#include<Wire.h>
void ISEN-H1D_convert(unsigned char dat[4]) {
  // Convert Humidity
  long value = (unsigned char)(dat[0] & 0x3F);
  value <<= 8;
  value += (unsigned char)dat[1];
  value = (int)((value/16383)*100);
  Serial.print("Humi:"); Serial.print(value); Serial.print(" ");
  // Convert Temperature
  value = (unsigned char)dat[2]; value *= 64;
  value += (dat[3] >> 2);
  value *= 165; value /= 16383; value -= 40;
  Serial.print("Temp:"); Serial.println(value);
}

void setup() {
  Wire.begin();           // join i2c bus (address optional for master)
  Serial.begin(9600);     // start serial communication at 9600bps
}

int reading = 0;
void loop() {
  unsigned char dat[4];
  // step 1: instruct sensor to read echoes
  Wire.beginTransmission(0x28);
  Wire.write(byte(0x50)); // sets register pointer to the command register (0x00)
  Wire.endTransmission(); // stop transmitting

  // step 2: wait for readings to happen
  delay(70); // datasheet suggests at least 65 milliseconds

  // step 3: instruct sensor to return a particular echo reading
  Wire.beginTransmission(0x28); // transmit to device #112
  Wire.write(byte(0x51)); // sets register pointer to echo #1 register (0x02)
  Wire.endTransmission(); // stop transmitting
  delay(70);
  // step 4: request reading from sensor
  Wire.requestFrom(0x28, 4); // request 2 bytes from slave device #112

  // step 5: receive reading from sensor
  if (4 <= Wire.available()) { // if two bytes were received
    dat[0] = Wire.read(); // receive high byte (overwrites previous reading)
    dat[1] = Wire.read(); // receive high byte (overwrites previous reading)
    dat[2] = Wire.read(); // receive high byte (overwrites previous reading)
    dat[3] = Wire.read(); // receive high byte (overwrites previous reading)
```

```
ISEN-H1D_convert (dat);  
}  
  
delay(500);           // wait a bit since people have to read the output :)  
}
```

13. Document Revision History

Revision	Date	Description
1	July. 5, 2018	1 st Release
2	Sept. 4, 2018	Modification of the humidity conversion function
3	Nov. 4, 2020	■ Modification of the humidity, Temperature conversion function ■ Revision to Fig. 6