RRH62000

All-in-one Air Quality Module

The RRH62000 series is an integrated sensor module for measuring critical air quality parameters. Sensors for particulate matter (PM), total volatile organic compounds (TVOC), Indoor Air Quality Index (IAQ), estimation of carbon dioxide (eCO2), temperature (T) and relative humidity (RH) are combined in a single package.

The RRH62000 provides digital outputs for each sensor, which can be measured simultaneously. Output correction algorithms use the correlation between sensors to improve the accuracy of each measurement and identify detectable substances. In addition, control and arithmetic processing is done within the module, freeing resources on the host MCU and simplifying the implementation on the customer's side.

The RRH62000 is configurable with selectable I²C or UART interface, and operating mode depending on response time and accuracy needed.

The sensors are placed within the module housing, which protects against malfunctions from dust accumulation. The air flow channel has a high-speed fan self-cleaning mechanism. A six-pin connector provides an easy plug and play interface.

Features

- Simultaneous multi-sensor measurements of all relevant air quality parameters
- Sensor outputs feature:
  - Detection of particle sizes from 0.3µm to 10.0µm
  - Output mass concentration bins for PM1, PM2.5, and PM10
  - Temperature (T) and Relative Humidity (RH)
  - Measurement of Total Volatile Organic Compounds (TVOC) concentrations and indoor air quality (IAQ) index according to UBA [1]
  - Estimates carbon dioxide level (eCO2)
- Operating temperature range from -10°C to 60°C
- Operating humidity range up to 90%RH
- Siloxane resistant
- I²C and UART interfaces
- Outline dimensions 46.6 mm × 34.8 mm × 12 mm
- Qualified according to JEITA ED-4701

Applications

- Home appliances / air purifiers
- Air quality monitors
- HVAC / industrial automation
- IoT devices

Figure 1. RRH62000 Module

1. UBA = Umweltbundesamt, German Federal Environmental Agency

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1. Overview

1.1 Block Diagram

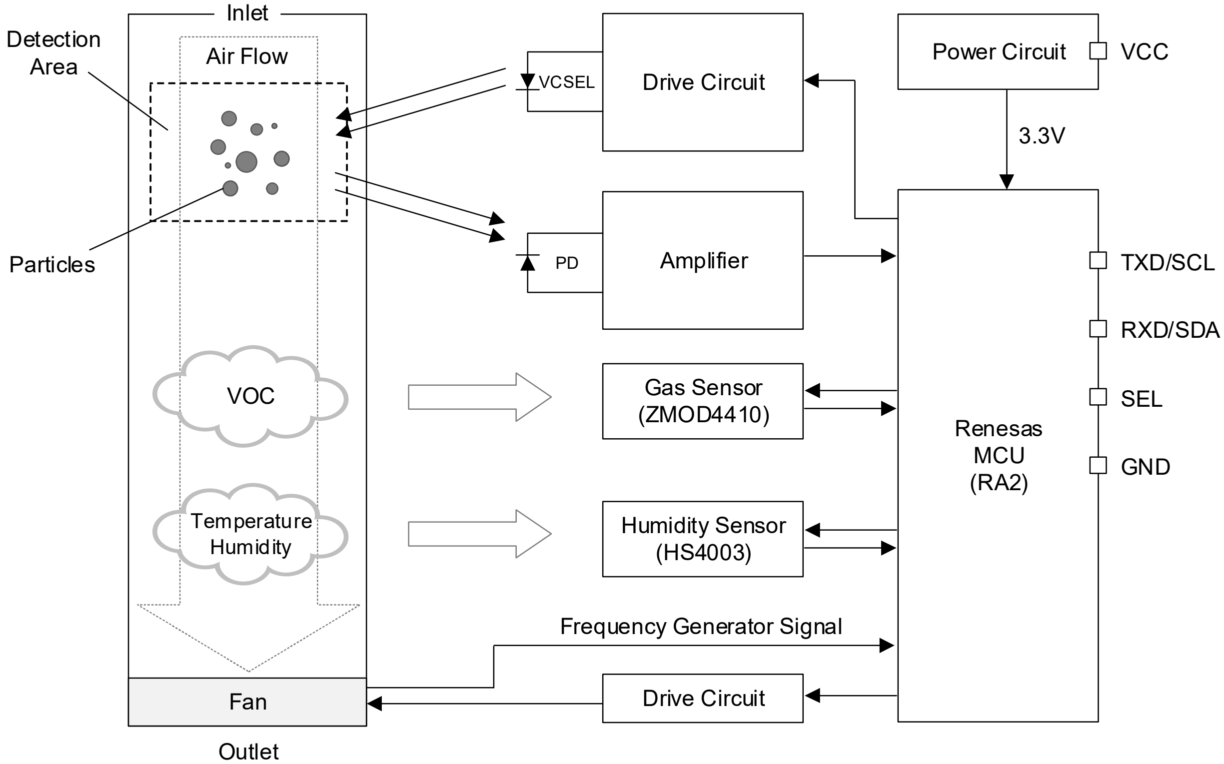


Figure 2. RRH62000 Block Diagram

Note: For an overview of the product family, see "Ordering Information".

2. Pin Information

2.1 Pin Assignments

The RRH62000-A1V uses the ACES 51468-0064N-001 connector for its interface.

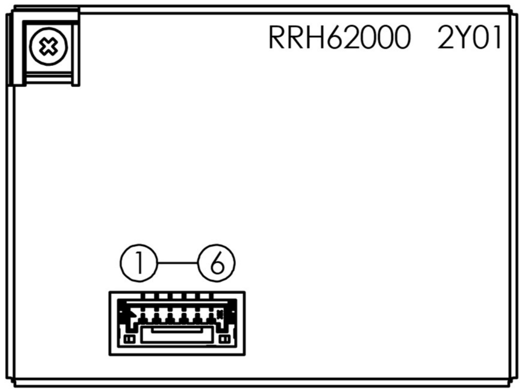


Figure 3. Pin Assignments [1]

2.2 Pin Descriptions

Table 1. Pin Descriptions

<table>
<tr><th>Pin Number</th><th>Pin Name</th><th colspan="2">Description</th><th colspan="2">Remarks</th></tr>
<tr><td>1</td><td>NC</td><td colspan="2">Do not connect</td><td colspan="2">-</td></tr>
<tr><td rowspan="2">2</td><td rowspan="2">SEL</td><td colspan="2" rowspan="2">Interface select</td><td>UART</td><td>Floating or 3.3V</td></tr>
<tr><td>I2C</td><td>Low level (GND)</td></tr>
<tr><td rowspan="2">3</td><td>TxD</td><td>UART</td><td>Transmitting pin</td><td colspan="2" rowspan="2">3.3V Logic</td></tr>
<tr><td>SCL</td><td>I2C</td><td>Serial clock</td></tr>
<tr><td rowspan="2">2</td><td>RxD</td><td>UART</td><td>Receiving pin</td><td colspan="2" rowspan="2">3.3V Logic</td></tr>
<tr><td>SDA</td><td>I2C</td><td>Serial data</td></tr>
<tr><td>5</td><td>GND</td><td colspan="2">Ground</td><td colspan="2">-</td></tr>
<tr><td>6</td><td>VCC</td><td colspan="2">Supply Voltage</td><td colspan="2">5V ±10%</td></tr>
</table>

[1] RRH62000-B1V version includes an adapter cable to provide compatibility with the specified pinout configuration.

3. Specifications

3.1 Absolute Maximum Ratings

Caution: Do not operate at or near the maximum ratings listed for extended periods of time. Exposure to such conditions can adversely impact product reliability and result in failures not covered by warranty.

Table 2. Absolute Maximum Ratings

Parameter	Minimum	Maximum	Unit
Supply voltage (V_{CC})	-0.3	6.0	V
Interface select (SEL)	-0.3	3.6	V
I/O pins (RxD/SCL, TxD/SDA)	-0.3	3.6	V
Maximum current on any I/O pin	-	±25	mA
Operating temperature	-10	60	°C
Storage temperature	-40	75	°C
Humidity range (non-condensing)	0	90	%RH

3.2 Electrical Characteristics

Table 3. Electrical Characteristics

Parameter	Symbol	Conditions		Min.	Typ.	Max.	Unit
Supply Voltage	V_{CC}	-		4.5	5.0	5.5	V
Power Supply Ripple Voltage	$V_{p\text{-}p}$	-		-	-	0.1	V
Power Consumption	P_{CC}	During measurement		-	200	-	mW
Active Current [1]	I_{CC}	During measurement		-	40	60	mA
Cleaning Current [2]	I_{clean}	Only at the very first start		-	50	70	mA
Sleep Current	I_{sleep}	Sleep mode		-	30	50	µA
Input High Level Voltage	V_{IH}	UART		2.64	-	-	V
		I²C		2.31	-	-	V
Input Low Level Voltage	V_{IL}	UART		-	-	0.66	V
		I²C		-	-	0.99	V
Output High Level Voltage	V_{OH}	UART	I_{OH} = 2mA	3.00	3.30	3.6	V
		I²C	I_{OH} = 4mA	3.00	3.30	3.6	V
Output Low Level Voltage	V_{OL}	UART	I_{OL} = 2mA	-	-	0.80	V
		I²C	I_{OL} = 3mA	-	-	0.40	V

1. Current consumption on average during operation. In-rush current can be maximum of 250mA over a period of 300µs after power-on.
2. During the first start-up, the sensor may initiate a cleaning cycle for one minute.

3.3 Sensor Specifications

3.3.1 General Specifications

Table 4. General Specifications

Parameter	Conditions	Value	Unit
Lifetime [1]	$T_{Ambient}$ = 25°C, 15-65%RH	64,500	h
Acoustic noise [2]	-	28	dB(A)
Response time [3]	Moving average = 10	24	s
Start-up time [4]	-	3.3	s
Sample interval	-	3	s

1. Lifetime may vary depending on different operating conditions.
2. Acoustic measurement with microphone set at a distance of 0.3m from sensor.
3. Response time depends on number of moving averages selected.
4. Data readout is valid after start up time. Samples read before start up time is complete will have all data bytes set to 0xFF, and have failing checksum.

3.3.2 Particulate Matter Specifications

Table 5. Particulate Matter Module Specifications during Operation

Parameter	Conditions	Value	Unit
Technology	-	Laser scattering	-
Particle size range	-	0.3 to 10.0	µm
Mass concentration consistency PMX_1 [1][2] (KCl [3] particles)	0 - 100 µg/m³	±30	µg/m³
	100 - 500 µg/m³	±30	%
Mass concentration consistency (PMX_2) [2][4] (Cigarette smoke)	0 - 100 µg/m³	±10	µg/m³
	100 - 500 µg/m³	±10	%
Mass concentration range	-	0 to 1,000	µg/m³
Mass concentration resolution	-	1	µg/m³
Mass concentration size range	PM1	0.3 to 1.0	µm
	PM2.5	0.3 to 2.5	µm
	PM10	0.3 to 10.0	µm
Number concentration range	-	0 to 3,000	1/cm³
Number concentration size range (Particles)	NC_0.3	0.3 to 10.0	µm
	NC_0.5	0.5 to 10.0	µm
	NC_1	1.0 to 10.0	µm
	NC_2.5	2.5 to 10.0	µm
	NC_4	4.0 to 10.0	µm

1. PMX_1 represents the mass concentration of particle size 0.3µm - Xµm. Reference with standard particles (KCl particles). As reference measuring instrument, TSI DustTrak™ II Model 8530 is used.
2. The fan speed setting value is 86% (default setting).
3. KCl = chemical symbol for the reference dust potassium chloride (Kalium Chloride)
4. PMX_2 represents the mass concentration of particle size 0.3µm - Xµm. Reference with cigarette smoke.

3.3.3 Humidity and Temperature Sensor Specifications

Important: The HS40xx series sensors are optimized to perform best in the more common temperature and humidity ranges of 10°C to 50°C and 20% RH to 80% RH, respectively. If operated outside of these conditions for extended periods, especially at high humidity levels, the sensors may exhibit an offset. In most cases, this offset is temporary and will gradually disappear when the sensor is returned to normal temperature and humidity conditions. The amount of the shift and the duration of the offset vary depending on the duration of exposure and the severity of the relative humidity and temperature conditions. The time needed for the offset to disappear can also be decreased by using the procedures described in “Conditioning”.

Table 6. Humidity and Temperature Sensor Specifications, $T_{Ambient}$ = +25°C, VDD = 1.71V to 3.6V

Parameter	Condition	Minimum	Typical	Maximum	Unit
Humidity Sensor					
Range	-	0	-	100	%RH
Accuracy [1]	20% to 80% RH	-	± 5	± 7	%RH
Resolution	14-bit	-	0.04	-	%RH
Hysteresis	-	-	-	±1.0	%RH
Non-linearity from Response Curve	20% to 80% RH	-	± 0.15	-	%RH
Long-Term Stability	-	-	± 0.1	-	%RH/Yr
Response Time Constant [2] (T_H)	20% to 80% RH Still Air	3.0	4.0	6.0	s
Temperature Sensor					
Range	-	-40	-	125	°C
Accuracy	-10°C to 80°C	-	±0.4	±0.55	°C
Resolution	14-bit	-	0.01	-	°C
Response Time Constant [3] (T_T)	-	-	>2.0	-	s
Long-Term Stability	-	-	-	0.03	°C/Yr
Supply Voltage Dependency	-	-	0.03	0.1	°C/V

1. Monotonic increases from 20 to 80% RH after sensor has been stabilized at 50%RH.
2. Initial value to 63% of total variation. Response time depends on the system airflow.
3. Initial value to 63% of total variation. Response time depends on system thermal mass and air flow.

3.3.4 Gas Sensor Specifications

Table 7. Gas Sensor Module Specifications during Operation

Parameter	Conditions	Minimum	Typical	Maximum	Unit
TVOC Specified Measurement Range	Ethanol in air	160	-	10000	ppb
IAQ Specified Measurement Range [1]	Ethanol in air	1	-	5	IAQ
Accuracy for IAQ	Full UBA range	-	1	-	IAQ
eCO_2 Range	Estimated CO_2	400	-	5000	ppm

1. Source: Umweltbundesamt, Beurteilung von Innenraumluftkontaminationen mittels Referenz- und Richtwerten, (Bundesgesundheitsblatt - Gesundheitsforschung - Gesundheitsschutz, 2007).

4. Typical Performance Graphs

4.1 Temperature Effect on Particulate Measurement

Typical performance of the particulate sensor as a function of temperature.

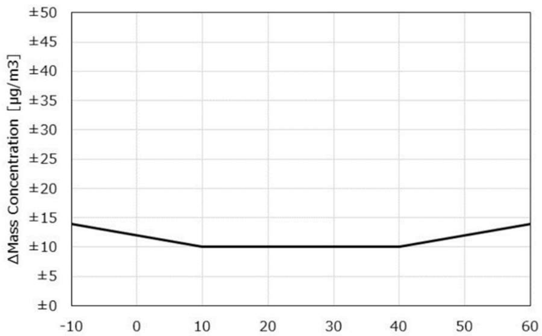


Figure 4. Consistency vs. Temperature (PM1_2: 0 - 100 µg/m³)

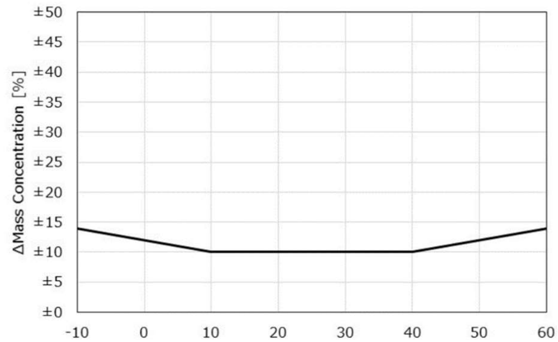


Figure 5. Consistency vs. Temperature (PM1_2: 100 - 500 µg/m³)

4.2 Performance on TVOC

4.2.1 Air Quality – IAQ Levels According to UBA

Renesas has adopted the definition of TVOCs and their impact on user health and comfort proposed by the UBA (see Table 8). The RRH62000 can detect the presence of elevated TVOC levels as described in the UBA study.

There are many sources of poor indoor air quality that can elevate TVOC levels in the typical home or office environments, and the types of TVOC that might be present can vary widely. Additional information on this topic is available in Renesas' *ZMOD4410 White Paper – Overview of TVOC and Indoor Air Quality*.

The RRH62000 can respond reliably to all types of organic compounds that are typically found in indoor environments. To assess the response of the gas sensor module to the levels described in the UBA study, the module has been tested using several TO-15/17 multi-component TVOC standards defined by the EPA. The RRH62000 response to the EPA standard with the TVOC levels from UBA is shown in Table 8. A third-party report and certification from an independent research lab are available on the Renesas website that confirms the good conformity for IAQ measurements with respect to the UBA study and EPA standard.

Table 8. Level of Indoor Air Quality Based on TVOC Levels Described by UBA

Renesas IAQ Rating	Reference Level [1]	Air Information	TVOC (mg/m^3) [1]	Air Quality
≤ 1.9	Level 1	Clean Hygienic Air (target value)	< 0.3	Very Good
2.0 to 2.9	Level 2	Good Air Quality (if no threshold value is exceeded)	0.3 to 1.0	Good
3.0 to 3.9	Level 3	Noticeable Comfort Concerns (not recommended for exposure > 12 months)	1.0 to 3.0	Medium
4.0 to 4.9	Level 4	Significant Comfort Issues (not recommended for exposure > 1 month)	3.0 to 10.0	Poor
≥ 5.0	Level 5	Unacceptable Conditions (not recommended)	> 10.0	Bad

1. Conversion from mg/m3 to ppm for many common TVOC is by the factor approximately 0.5 (e.g., 10mg/m^3 equals approximately 5ppm). Conversion from ppm to ppb is by the factor 1000 (e.g., 0.1ppm equals 100ppb).

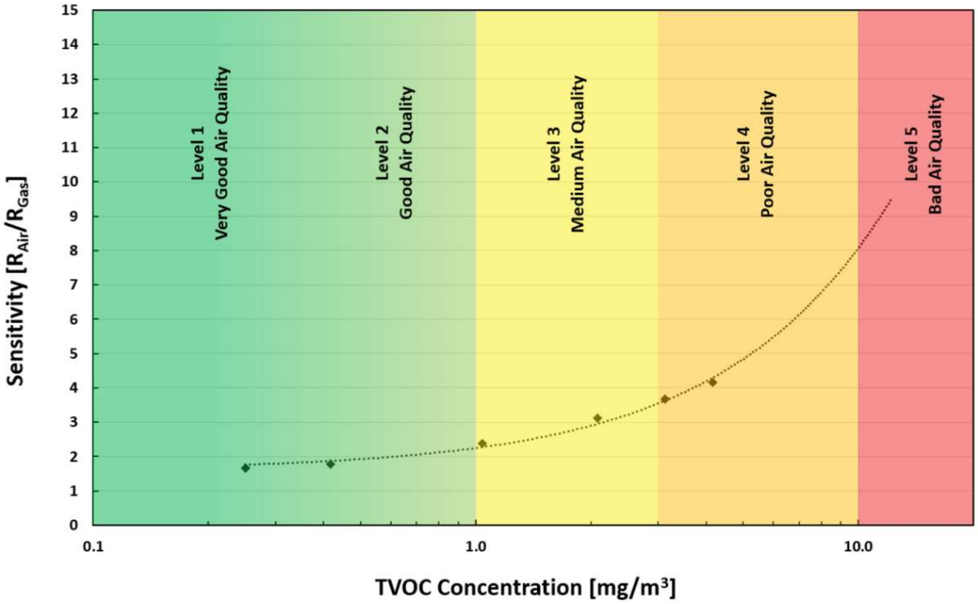


Figure 6. Typical ZMOD4410 Response to Levels of TVOC Described by UBA Using EPA Standard Mixture

Note: TVOC is a subset comprising 25 of the EPA's TO-15/17 certified mixtures.

4.2.2 Air Quality – Estimated Carbon Dioxide Correlation (eCO2)

A reliable correlation can be made based on TVOC levels for situations where an elevated carbon dioxide (CO_2) concentration is caused by human occupancy, although the sensor module is not directly responsive to CO_2. Renesas has developed a robust, patent pending, correlation algorithm between elevated TVOCs and CO_2 attributable to human occupancy in a wide variety of living spaces, including homes and offices. The measurement range for the eCO2 has its minimum at the atmospheric background level at 400ppm and ranges up to 5000ppm. The correlation can predict the CO_2 level as shown in Figure 7.

Additional details about Renesas' CO_2 correlation algorithm are available in the *RRH62000 Application Note – Estimating Carbon Dioxide.*

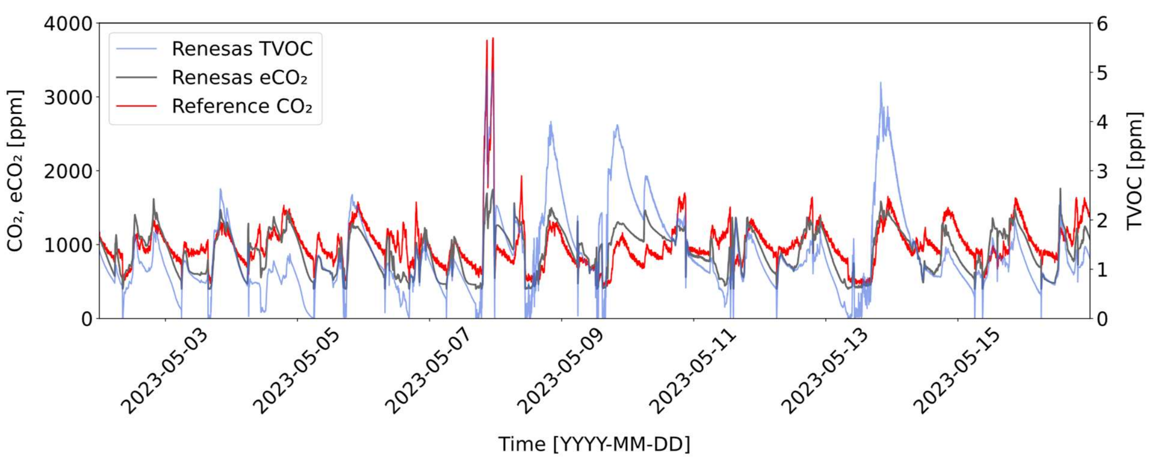


Figure 7. Typical Graph of CO_2 Estimation in an Application

4.2.3 Accuracy and Consistency

All Renesas gas sensor modules come with electrical and chemical factory calibration with data stored in the module's non-volatile memory (NVM). Using the algorithms provided by Renesas and the calibration coefficients in the NVM will lead to stable measurement of the IAQ levels according to UBA with a maximum deviation of ±1 category over the module's lifetime.

The RRH62000 can respond reliably to all types of organic compounds that are typically found in indoor environments. To assess the response of the gas sensor module to the levels described in the UBA study[2], the module has been tested using several TO-15/17 multi-component TVOC standards defined by the EPA[3]. The RRH62000 response to the EPA standard with the TVOC levels from UBA is shown in Figure 6. A third-party report and certification from an independent research lab are available on the Renesas website that confirms the good conformity for IAQ measurements with respect to the UBA study.

Typical IAQ accuracy and consistency in an appropriate system implementation are displayed in Figure 8 and in Table 9. The accuracy for Renesas eCO_2 algorithm was proved on more than 20000 measurements and is shown in Figure 9.

Table 9. Typical TVOC Sensor Module Performances

Parameter	Conditions	Minimum	Typical	Maximum	Unit
Accuracy for IAQ	Full UBA range [1]	-	± 1	-	IAQ
Accuracy for IAQ Ultra-Low Power	Full UBA range [2]	-	± 1	-	IAQ
Consistency for IAQ	Part-to-Part Variation [3]	-	± 10	-	%

1. With 95% confidence based on more than 26500 measurements with 280 sensor modules.
2. With 82% confidence based on more than 3500 measurements with 104 sensor modules.
3. Based on more than 30000 measurements with 380 sensor modules.

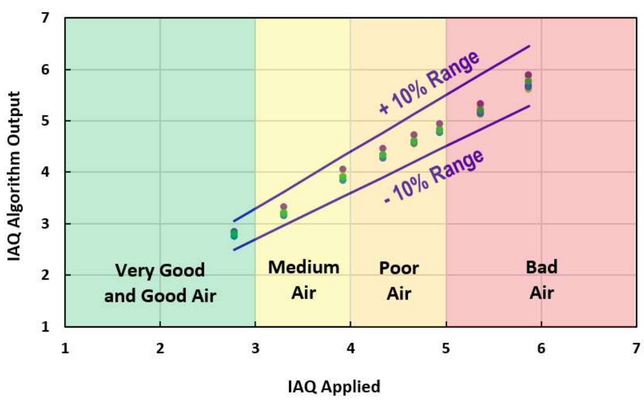


Figure 8. IAQ Accuracy and Consistency

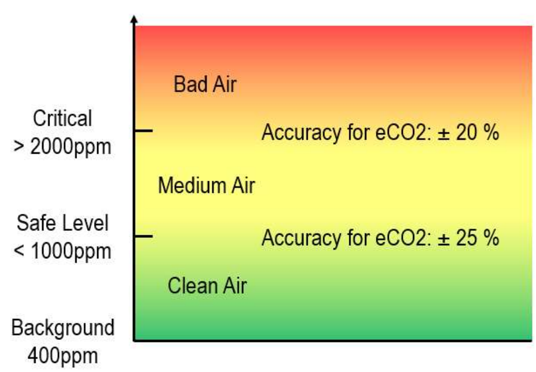


Figure 9. Concentration Dependent Accuracy for eCO2

1. Umweltbundesamt, Beurteilung von Innenraumluftkontaminationen mittels Referenz- und Richtwerten, (Bundesgesundheitsblatt - Gesundheitsforschung - Gesundheitsschutz, 2007).
2. EPA = Environmental Protection Agency (of the United States of America)

5. Functional Description

5.1 UART Interface

5.1.1 Typical Application Circuit for UART Interface

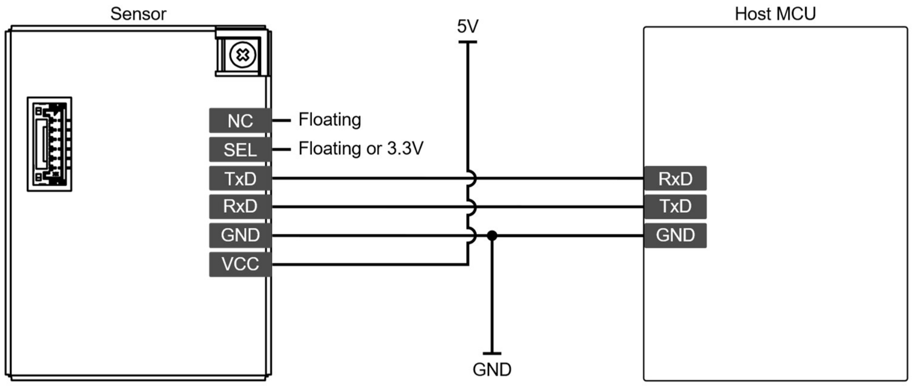


Figure 10. UART Application Circuit

To select the UART interface, set the SEL terminal (pin 2) to either floating or 3.3V. If the RxD terminal (pin 4) of the sensor is not needed, leave it floating.

5.1.2 UART Transmission Characteristics

Each data frame consists of a start bit, data, and stop bit. Data is sent asynchronously within each data frame.

Table 10. UART Data Frame Setting

Parameter	Value
Data Bit Size	8-bit
Parity	None
Stop Bit Size	1-bit
Baud Rate	9600 bps

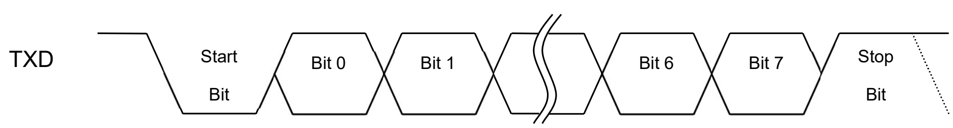


Figure 11. UART Transmission Data Packet

5.1.3 UART Measurement Data Format

5.1.3.1 Byte Descriptions

The measurement data format for UART is shown in the following table. Except for status and checksum, all UART output data is in 16-bit big-endian unsigned integer format.

Table 11. UART Byte Descriptions

Byte	Symbol	Size (Byte)	Format	Description	Unit
0 - 1	Start Frame	2	0xFF, 0xFA	Start of output data	-
2 - 3	Status	2	Unsigned int (16bit) big-endian	Information about the internal state of the dust sensor module, see Section **5.1.3.2**	-
4 - 5	NC_0.3	2	Unsigned int (16-bit) big-endian	Number concentration of particle size X µm - 10 µm	0.1 /cm^3
6 - 7	NC_0.5	2			
8 - 9	NC_1	2			
10 - 11	NC_2.5	2			
12 - 13	NC_4	2			
14 - 15	PM1_1	2	Unsigned int (16-bit) big-endian	Mass concentration of particle size 0.3 µm - X µm with reference to **KCl particle**	0.1 µg/m^3
16 – 17	PM2.5_1	2			
18 – 19	PM10_1	2			
20 – 21	PM1_2	2	Unsigned int (16-bit) big-endian	Mass concentration of particle size 0.3 µm – X µm with reference to **cigarette smoke**	0.1 µg/m^3
22 - 23	PM2.5_2	2			
24 - 25	PM10_2	2			
26 - 27	Temperature	2	Signed int (16-bit) big-endian	Temperature	0.01 ℃
28 - 29	Humidity	2	Unsigned int (16-bit) big-endian	Humidity	0.01 %RH
30 - 31	TVOC	2		Total volatile organic compounds (TVOC) concentrationsg	0.01 mg/m^3
32 - 33	eCO2	2		Estimated carbon dioxide (eCO_2) level	0.01 ppm
34 - 35	IAQ	2		Indoor Air Quality level according to UBA	0.01
36 - 37	Relative IAQ	2		Reserved	-
38	Checksum	1	Unsigned int (8-bit)	Check sum (8-bit) = $(\sum_{i=0}^{37} byte[i])\ \%\ 256$	-

5.1.3.2 Status Byte Details

	15	14	13	12	11	10	9	8
Byte 2	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved
	7	6	5	4	3	2	1	0
Byte 3	Reserved	Reserved	Reserved	Reserved	Fan	Fan Speed	Dust Accumulation	High Concentration

Figure 12. UART Status Bits (Bytes 12 and 13)

Bit 0: High Concentration

0 = Particle concentration is within the measurable range.
1 = Particle concentration is extremely high (not measurable).

Bit 1: Dust Accumulation

0 = Normal.
1 = Dust accumulated inside the sensor (not measurable).

Bit 2: Fan Speed

0 = Fan speed is normal.
1 = Fan speed is out of the set range.

Bit 3: Fan

0 = Fan is working normally.
1 = Fan malfunctioned or broke down.

Bit 4-15: Reserved

These "Reserved" bits are reserved for future expansion. These bits can be both 0 and 1.

5.1.4 UART Commands

By sending the protocol data in the following table from the Host to the sensor, it is possible to change the operation mode, read the measurement data at any timing, execute each command, and change the setting of each parameter.

Table 12. UART Command Packet

START byte1	START byte2	Command	Data1	Data2	Check Sum1	Check Sum2
0xA1	0x4D	CMD	DATAH	DATAL	CSH	CSL

Checksum = 0xA1 + 0x4D + CMD + DATAH + DATAL

Note: Set sensor in passive mode (0xE1 0x00) before reading any data in order to prevent overlapping of auto reporting with data.

Table 13. UART Command Definitions

CMD	DATAH	DATAL	Symbol	Function
0xE2	X [1]	X	READ	Read data in passive mode
0xE1	X	0x00	MODE	Set sensor in passive mode
		0x01		Set sensor in active mode (default)
0xE4	X	0x00	SLEEP	Sleep
		0x01		Wake up
0x01	X	X	CLEAN	Start fan cleaning of module
0x02	0x81	X	RESET	Software reset
0x03	0x00	DATA	MAVE	Set the number of moving averages 1-60 [times] <default = 10>
0x06	DATA	DATA	TINTC	Set interval time for dust auto-cleaning 0-60480 [10s] <default = 20160>
0x07	0x00	DATA	TCLEAN	Set fan auto-cleaning time 0-255 [s] <default = 10>
0x08	0x00	DATA	SPEEDFAN	Fan speed control 60-100 [%] <default = 86>
0x11	X	X	READ RMOX	READ MOX Resistance (4 Bytes)
0x12	X	X	READ ID	Read Unique ID (6 Bytes)
0x13	X	X	ARGVER	Read algorithm version (3 Bytes) [0] = Major [1] = Minor [2] = Patch
0x14	X	X	CSTATUS	Read TVOC sensor cleaning status (1 Byte): 0x00 = Cleaning not completed 0x01 = Cleaning completed
0x15	X	X	FWVER	Read Firmware Version (2 Bytes) [0] = Major [1] = Minor

1. "X" means "don't care" byte.

5.2 I²C Interface

5.2.1 Typical Application Circuit for I²C Interface

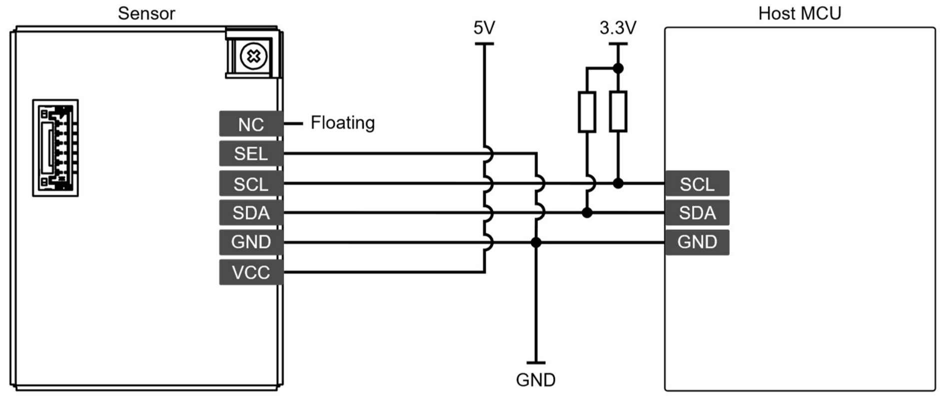


Figure 13. I²C Application Circuit

To select I²C interface, set the SEL terminal (pin 2) to GND. SCL and SDA terminals should be connected to external pull-up resistors (e.g., 4.7kΩ).

5.2.2 I²C Transmission Characteristics

Table 14. I²C Communication Specifications

Slave Address	0x69 (7-bit)
Clock Frequency	Typical 100kHz
General Call Address	Unsupported

5.2.3 I²C Measurement Data Format

5.2.3.1 Byte Descriptions

The measurement data format for I²C is shown in the following table. Except for status and CRC, all I²C output data is in 16-bit big-endian unsigned integer format.

Table 15. I²C Byte Descriptions

Byte	Symbol	Size (Byte)	Format	Description	Unit
0 - 1	Status	2	-	Information about the internal state of the dust sensor module, see Section 5.2.3.2	-
2 - 3	NC_0.3	2	Unsigned int (16-bit), Big-endian	Number concentration of particle size 0.3µm-10µm	0.1 /cm³
4 - 5	NC_0.5	2		Number concentration of particle size 0.5µm-10µm	
6 - 7	NC_1	2		Number concentration of particle size 1µm-10µm	
8 - 9	NC_2.5	2		Number concentration of particle size 2.5µm-10µm	
10 - 11	NC_4	2		Number concentration of particle size 4µm-10µm	

Byte	Symbol	Size (Byte)	Format	Description	Unit
12 - 13	PM1_1	2	Unsigned int (16-bit), Big-endian	Mass concentration of particle size 0.3 µm - 1 µm with reference to **KCl particle**	0.1 µg/m^3
14 - 15	PM2.5_1	2		Mass concentration of particle size 0.3 µm - 2.5 µm with reference to **KCl particle**	
16 - 17	PM10_1	2		Mass concentration of particle size 0.3 µm - 10 µm with reference to **KCl particle**	
18 - 19	PM1_2	2	Unsigned int (16-bit), Big-endian	Mass concentration of particle size 0.3 µm - 1 µm with reference to **cigarette smoke**	0.1 µg/m^3
20 - 21	PM2.5_2	2		Mass concentration of particle size 0.3 µm - 2.5 µm with reference to **cigarette smoke**	
22 - 23	PM10_2	2		Mass concentration of particle size 0.3 µm - 10 µm with reference to **cigarette smoke**	
24 - 25	Temperature	2	Unsigned int (16-bit), Big-endian	Temperature	0.01 ℃
26 - 27	Humidity	2		Humidity	0.01 %
28 - 29	TVOC	2	Unsigned int (16-bit), Big-endian	Total volatile organic compounds (TVOC) concentrations	0.01 mg/m^3
30 - 31	eCO2	2	Unsigned int (16-bit), Big-endian	Estimated carbon dioxide (eCO_2) level	1 ppm
32 - 33	IAQ	2	Unsigned int (16-bit), Big-endian	Indoor Air Quality level according to UBA	0.01
34 - 35	Relative IAQ	2	Unsigned int (16-bit), Big-endian	Reserved, Output = 0	-
36	CRC8	1	CRC-8 for Bytes 0-35	-	-

5.2.3.2 Status Byte Details

	15	14	13	12	11	10	9	8
Byte 1	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved

	7	6	5	4	3	2	1	0
Byte 0	Reserved	Reserved	Reserved	Reserved	Fan	Fan Speed	Dust Accumulation	High Concentration

Figure 14. I^{2}C Status Byte Details

Bit 0: High Concentration

0 = Dust concentration is within the measurable range.
1 = Dust concentration is extremely high (not measurable).

Bit 1: Dust Accumulation

0 = Normal.
1 = Dust accumulated inside the sensor (not measurable).

Bit 2: Fan Speed

0 = Fan speed is normal.
1 = Fan speed is out of the set range.

Bit 3: Fan

0 = Fan is working normally.
1 = Fan malfunctioned or broken down.

Bit 4-15: Reserved

These reserved bits are reserved for future expansion. These bits can be both 0 and 1.

5.2.4 Checksum

CRC-8 is used as check sum in I2C output. Calculate CRC-8 for 36 bytes of data. The specifications of CRC-8 used in this sensor are shown in the following table.

Table 16. CRC-8 Specifications

Name	CRC-8
Protected Data	Read Data
Width	8-bit
Polynomial	0x31
Initialization	0xFF
Reflect Output	None
Final XOR	None
Example	CRC (0xBEEF) = 0x92 CRC (0x0000) = 0x81

Note: Received data is valid when the received data and the checksum are matched.

5.2.5 I²C Commands

Table 17. Available I²C Commands

Command (Hex)	R/W	Symbol	Function
0x00	R	READ	Read Measured value (see Table 14) (37 Bytes)
0x40	R	DATA	0x01 = New data arrived, 0x00 = New data did not arrive
0x50	R/W	SLEEP	0x80 = Wake-up 0x00 = Sleep
0x51	W	CLEAN	0x01 = Start fan dust-cleaning of module
0x52	W	RESET	0x81 = RESET (Same as power-on reset)

Command (Hex)	R/W	Symbol	Function
0x53	R/W	MAVE	[7:0] Number of moving average : 1-60 (times) <default = 10>
0x5A	R/W	TINTC_H	[7:0] Cleaning interval time_H: 0-60480 (30s) <default = 20160>
0x5B	R/W	TINTC_L	[7:0] Cleaning interval time_L: 0-60480 (30s) <default = 20160>
0x5C	R/W	TCLEAN	[7:0] Fan cleaning time : 0-60 (s) <default = 10>
0x63	R/W	SPEEDFAN	[7:0] Fan speed control : 60-100 (%) <default = 86>
0x71	R	RMOX	Read MOX [6] resistance (4 Bytes) Unsigned long (Ohms)
0x72	R	UID	Read unique ID in Hex (6 Bytes)
0x73	R	ARGVER	Read algorithm version (3 Bytes) [0] = Major, [1] = Minor, [2] = Patch
0x74	R	CSTATUS	Read cleaning status (1 Byte) 0x00 = ZMOD Cleaning not completed 0x01 = ZMOD Cleaning completed
0x75	R	FWVER	Read Firmware version (2 Bytes) [0] = Major, [1] = Minor

5.2.6 I^{2}C Electrical Characteristics

5.2.6.1 I^{2}C AC Specifications

Table 18. I^{2}C AC Characteristics

Parameter	Symbol	Conditions [1]	Minimum	Typical	Maximum	Unit
SCL clock frequency	f_{SCL}	(*1)	80	100	400	kHz
Hold time START condition	$t_{HD:STA}$	(*1)(*2)	0.6	-	-	µs
Low period of the SCL clock	t_{LOW}	(*1)	1.3	-	-	µs
High period of the SCL clock	t_{HIGH}	(*1)	0.6	-	-	µs
Data setup time	$t_{SU:DAT}$	(*1)	100	-	-	ns
Data hold time	$t_{HD:DAT}$	(*1)(*3)	0	-	0.9	µs
Setup time for STOP condition	$t_{SU:STO}$	(*1)	0.6	-	-	µs
Bus free time between START and STOP condition	t_{BUF}	(*1)	1.3	-	-	µs
Startup time for I^{2}C	t_{ST}	(*4)	-	-	1	S
Wait time for clock stretch	t_{CSW}	(*5)	-	-	10	µs
Period of the data access	t_{RD}	(*6)	1	-	-	s

1. For I^{2}C conditions details, see section 5.2.6.2.

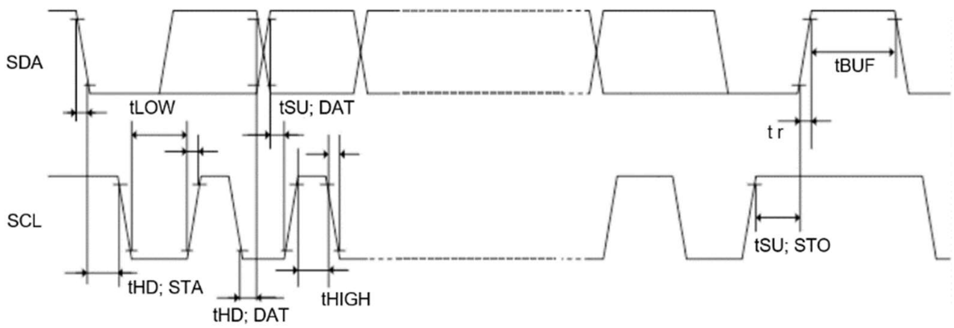


Figure 15. I²C Timing Diagram

5.2.6.2 I²C Timing Conditions

The following numbered items correspond to the conditions listed in Table 18.

1. The maximum value of C_b (capacitive load for each bus line) and maximum value of R_b (pull-up resistor for each bus line) is the following: $C_b = 200pF$, $R_b = 6k\Omega$.
2. After this period, the first clock pulse is generated.
3. $t_{HD;DAT}$ is the data hold time that is measured from the falling edge of SCL. It applies to data in transmission and acknowledge.
4. Time before I²C access becoming effective after Vcc is applied.

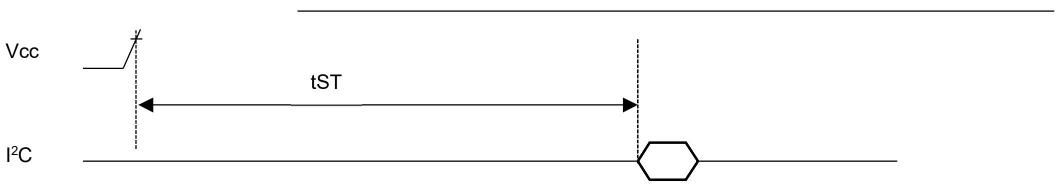


Figure 16. I²C Start Time Diagram

5. I²C-master device needs to wait for t_{CSW} if it does not have the clock-stretch function.

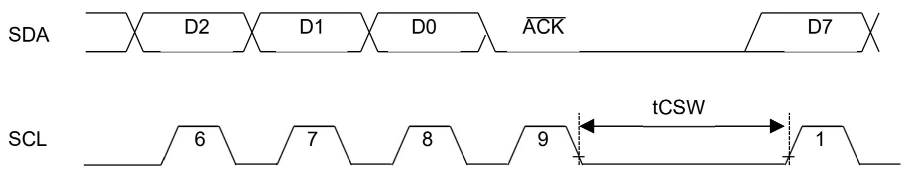


Figure 17. I²C Clock Stretch Wait Time Diagram

6. I²C-master access interval for these products must be longer than t_{RD}.

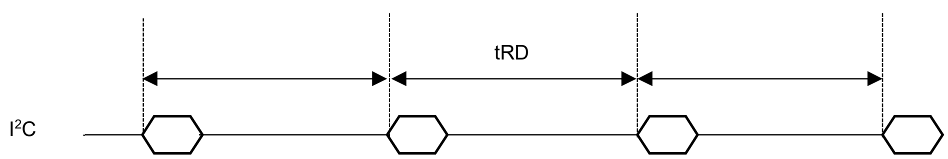


Figure 18. I²C Data Access Period

6. Packaging and Storage

6.1 Packing Method

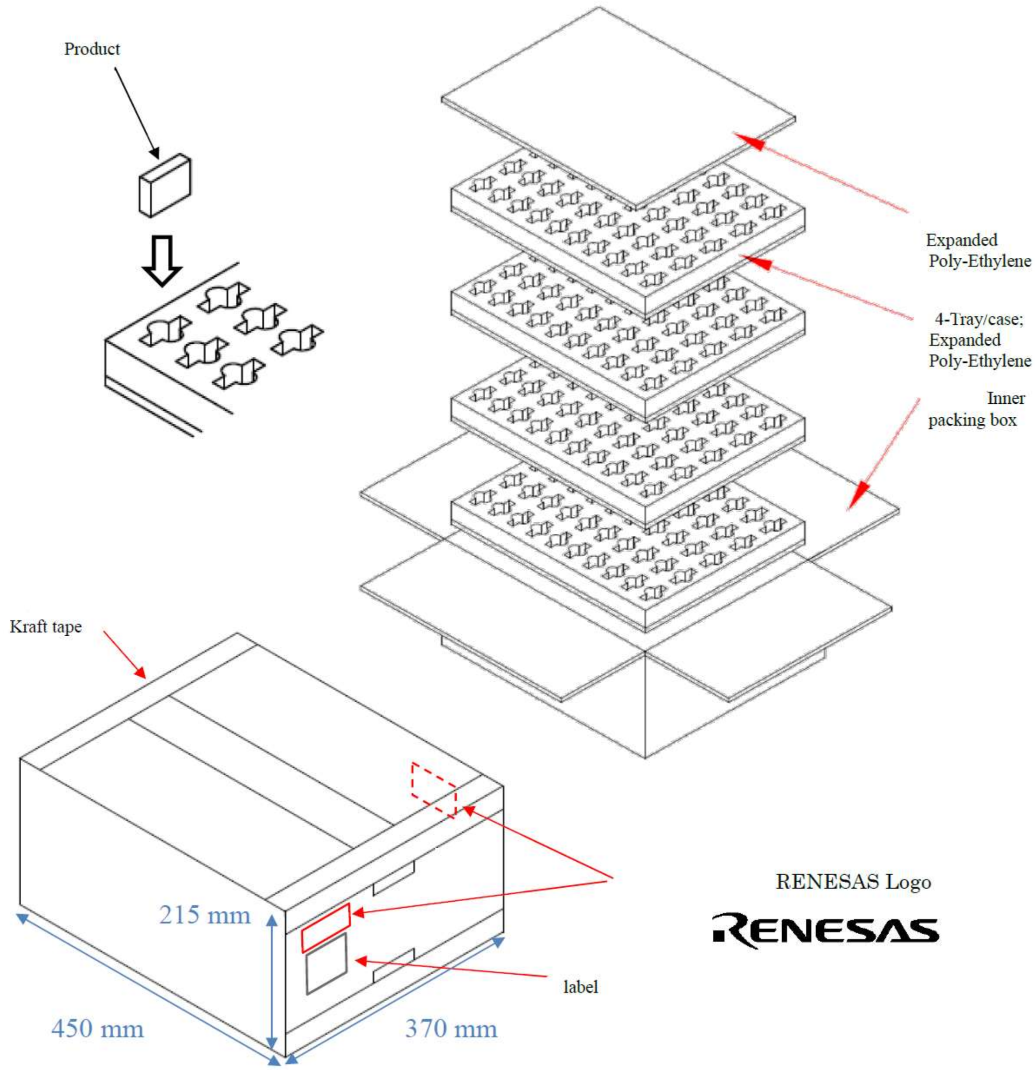


Figure 19. Packing Method

1. Each tray contains up to 50 units.
2. Trays are stacked in four rows. Padding (EPE) is only put on top of tray. The four trays are put in the inner packing box.
3. Inner packing box is sealed with kraft tape. The label contains product name, quantity, lot number, and packing date.
4. The weight of package is approximately 5.7kg.

6.2 Storage and Handling

Avoid direct sunlight and keep the temperature between 10°C and 30°C, and the humidity between 20%RH and 60%RH.

When using the sensor for the first time, allow up to 48 hours for re-hydration of the humidity sensor in ambient air and for TVOC sensor conditioning. This will allow the module to take optimal readings. **After turning on the**

module for the first time, the sensor will automatically start in TVOC sensor cleaning mode for 1 minute. Do not cut power to the sensor during this period.

If the sensor flow channel becomes filled with dust or debris, the user can activate dust cleaning mode manually by sending a command through UART (see Table 13) or I²C (see Table 17).

If the sensor is not used for a prolonged period and is restarted, allow up to 24 hours for humidity sensor rehydration and TVOC conditioning. Actual time needed to reach optimal readings could be much shorter, depending on environment conditions.

6.3 Conditioning

Nominal storage conditions are 10°C to 30°C and humidity between 20% and 60% RH. The humidity sensor readings may be offset if stored outside of these conditions for extended periods of time. To ensure maximum performance of the relative humidity sensor, it is recommended that the conditioning routine be performed prior to initial use of the sensor. The sensor can be reconditioned and returned to its calibration condition by completing the following procedure:

1. Bake at 100°C with humidity < 10% RH for 10 to 12 hours.
2. Rehydrate the sensor at a humidity of 75% RH and a temperature between 20°C and 30°C for 12 to 14 hours.

7. Ordering Information

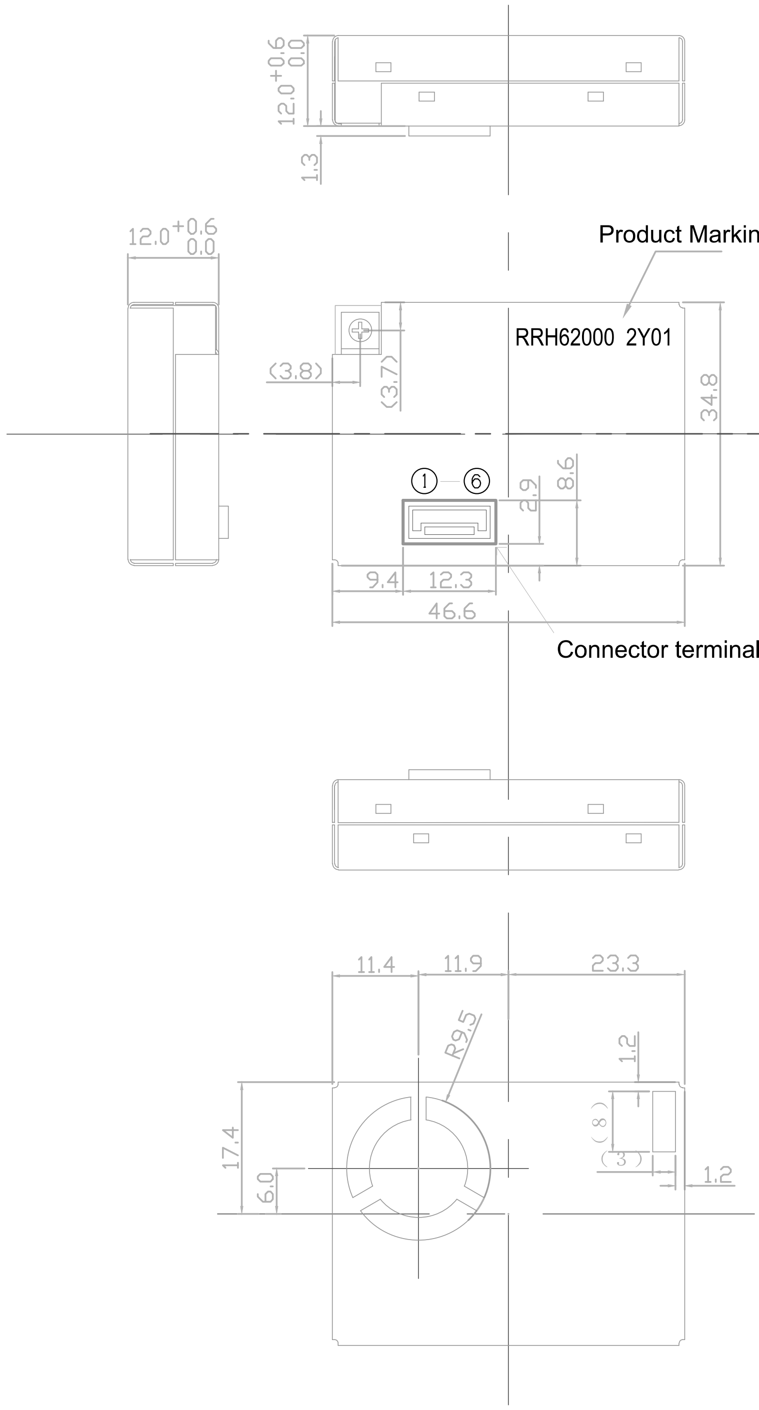
Part Number	Package Description	Description	MOQ (pcs)
RRH62000-A1V	6-MOD, 46.6 × 34.8 × 12.0 mm	Sensor module with connector ACES 51468-0064N-001	400
RRH62000-B1V	6-MOD, 46.6 × 34.8 × 12.0 mm	Sensor module with connector JCTC 50801W00-6P-S-HF, adapter cable included	400
RRH62000-EVK	-	Evaluation Kit, containing: Sensor module, Environmental Sensor Communications Board, USB-C cable	1

8. Revision History

Revision	Date	Description
1.00	Jul 24, 2024	Initial release.

Package Outline Drawing

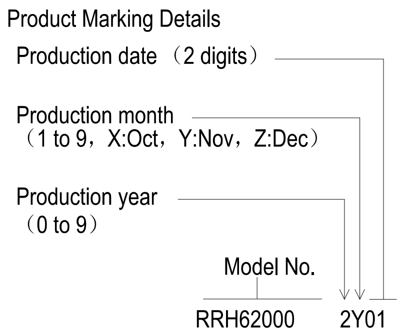
Package Code: MN0006AA
6-MOD 46.6 x 34.8 x 12.0 mm Body, 0,0mm Pitch
PSC-5006-01, Revision: 01, Date Created:June 10, 2024



Connector Terminal Pinout

Pin #	Pin Name
1	N.C.(*)
2	SEL
3	TxD/SCL
4	RxD/SDA
5	GND
6	Vcc(5V)

(＊N.C. - Don't connect)

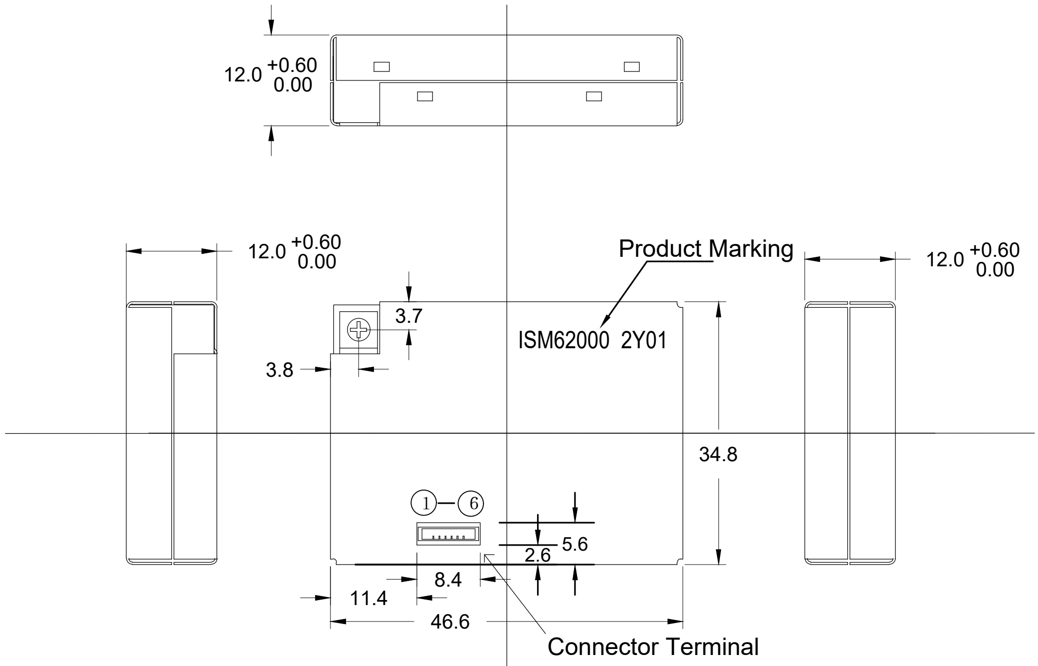


RRH62000 Outline Dimensions

Connector: ACES 51468-0064N-001 Unit: mm

NOTES:

1. All dimension are in mm. angles in degrees.
2. Top down view, as viewed on PCB.
3. NSMD land pattern assumed.
4. Land pattern recommendation as per IPC-7351B
   generic requirement for surface mount design and land pattern.



Connector Terminal Pinout

Pin #	Pin Name
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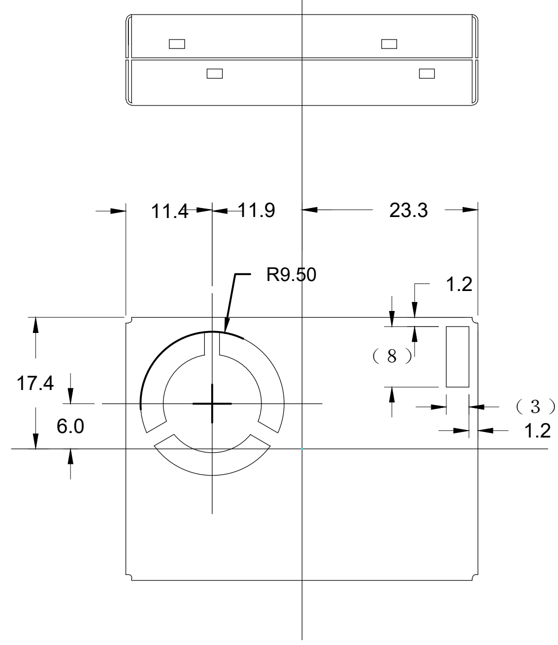
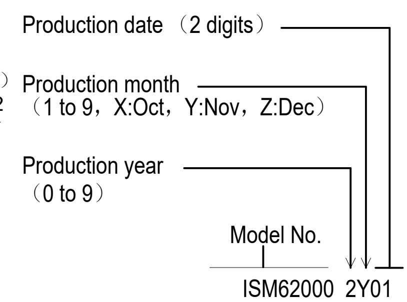
(＊N.C. - Don't connect)



Product Marking Details



RRH62000 Outline Dimensions

NOTES:

1. All dimension are in mm. angles in degrees.
2. Top down view, as viewed on PCB.
3. NSMD land pattern assumed.
4. Land pattern recommendation as per IPC-7351B
   generic requirement for surface mount design and land pattern.

Connector: Shenglan Technology.CO.,LTD.(JCTC)
50801W00-6P-S-HF

Unit：ｍｍ

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