

# SPECIFICATION

Preliminary Version

Product Name: Integrated Air Quality Sensor Module

Item No.: AM1009

Version: V0.1

Date: September 17, 2020

# Revision

No.	Version	Content	Date
	V0.1	The first version	2020-09-17

# Integrated Air Quality Sensor Module

AM1009



## Applications

- Air purifier
- Air quality monitor
- Air conditioner
- Ventilation system
- Consumer electronic products
- Environmental monitoring

## Description

AM1009 is an integrated air quality sensor module with function of particle concentration, VOC and NO<sub>2</sub> concentration, temperature and relative humidity measurement. Particle concentration is measured by laser particle sensor which uses light scattering principle. It measures and calculates the suspended particle number exactly, and output particle mass concentration  $\mu\text{g}/\text{m}^3$  directly via mathematical algorithm and scientific calibration. VOC&NO<sub>2</sub> concentration are measured by a combined MOX sensor, which can detect VOC and NO<sub>2</sub> simultaneously. It has extremely high sensitivity to various kinds of organic volatile gases such as formaldehyde, benzene, ethanol, formic acid, nicotine and some inorganic gases like carbon monoxide, ammonia and hydrogen.

## Features

- Super highly integrated, with function of particle, VOC, NO<sub>2</sub>, temperature and humidity measurement
- The smallest particle size of available measurement: 0.3 $\mu\text{m}$
- Real-time output particle mass concentration in  $\mu\text{g}/\text{m}^3$  available
- High accuracy, high sensitive and quick response
- Temperature compensation algorithm
- Matrix calibration technology and optimized algorithm, for high accuracy and consistency
- Siloxane resistance of VOC sensor, for long lifespan and high stability
- Intelligent VOC auto-calibration strategy on site, maintenance-free

## Working Principle

- The PM sensor integrated adopts laser scattering technology to detect particle mass concentration
- The VOC&NO<sub>2</sub> sensor is based on MOX technology
- The RH&T sensor integrated adopts capacitance resistance materials to detect indoor RH&T

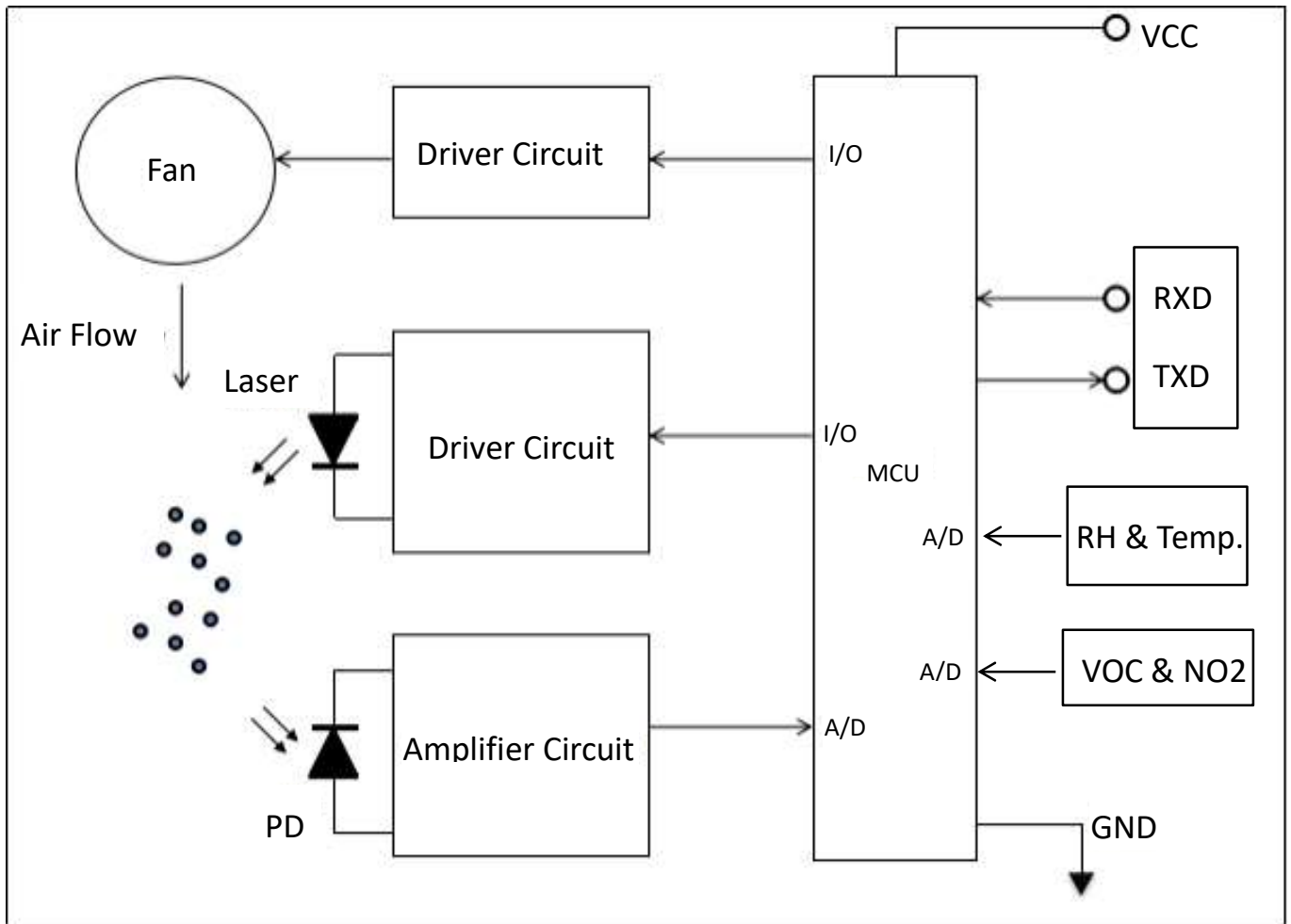
## Specifications

Integrated Indoor Air Quality Sensor Specification	
Operating principle	Laser scattering/MOX
Measurement range	Particle: 0~5,000 $\mu\text{g}/\text{m}^3$ VOC: 0~10ppm, NO <sub>2</sub> : 0~1,000ppb Temperature: -20-70 $^{\circ}\text{C}$ , Humidity: 0-99%RH
Measured particle range	0.3 $\mu\text{m}$ ~10 $\mu\text{m}$
Output resolution	Particle: 1 $\mu\text{g}/\text{m}^3$ , VOC: 1ppb, NO <sub>2</sub> : 1ppb Temperature: 0.1 $^{\circ}\text{C}$ , Humidity: 0.1%RH
Working condition	-20 $^{\circ}\text{C}$ ~ 60 $^{\circ}\text{C}$ , 0-95%RH (non-condensing)
Storage condition	-40 $^{\circ}\text{C}$ ~ 80 $^{\circ}\text{C}$ , 0-95%RH (non-condensing)
Particle accuracy	PM1.0/PM2.5: 0~100 $\mu\text{g}/\text{m}^3$ : $\pm 10\mu\text{g}/\text{m}^3$ 101~500 $\mu\text{g}/\text{m}^3$ : $\pm 10\%$ reading  PM10: 0~100 $\mu\text{g}/\text{m}^3$ : $\pm 20\mu\text{g}/\text{m}^3$ 101~500 $\mu\text{g}/\text{m}^3$ : $\pm 20\%$ reading  (GRIMM, 0-50 $^{\circ}\text{C}$ , 50 $\pm 10\%$ RH)
Particle Count Efficiency	>50% for particles above 0.3 $\mu\text{m}$
Temperature accuracy <sup>1</sup>	$\pm 1^{\circ}\text{C}$ (0-50 $^{\circ}\text{C}$ )
Humidity accuracy <sup>1</sup>	Typical/Max: $\pm 5\%/\pm 8\%$ @5%-95%RH <sup>2</sup>
VOC Accuracy	160ppb or $\pm 40\%$ of reading, whichever is larger (0-40 $^{\circ}\text{C}$ , 50 $\pm 10\%$ RH)
NO <sub>2</sub> Accuracy	40ppb or $\pm 40\%$ of reading, whichever is larger (0-40 $^{\circ}\text{C}$ , 50 $\pm 10\%$ RH)
Sampling interval	1s (particle) / 10.5s (VOC, NO <sub>2</sub> , Temperature & Humidity)
Response time	$\leq 180$ seconds (VOC&NO <sub>2</sub> ); $\leq 8$ seconds (Particle); $\leq 8$ seconds (RH&T)
Power supply	DC 5V $\pm 0.1\text{V}$ , ripple wave <50mV
Average working current	$\leq 105\text{mA}$ (at continuous working mode)
Standby current	$\leq 200\mu\text{A}$
Dimensions	W50*H38*D21 mm
Digital output	UART_TTL / IIC ( Reserved)
Life time	$\geq 10$ years

Note 1: Temperature and humidity accuracy in the table are defined at stable environment

Note 2: Humidity accuracy is defined at temperature of  $25 \pm 2^{\circ}\text{C}$

## Internal Architecture Description



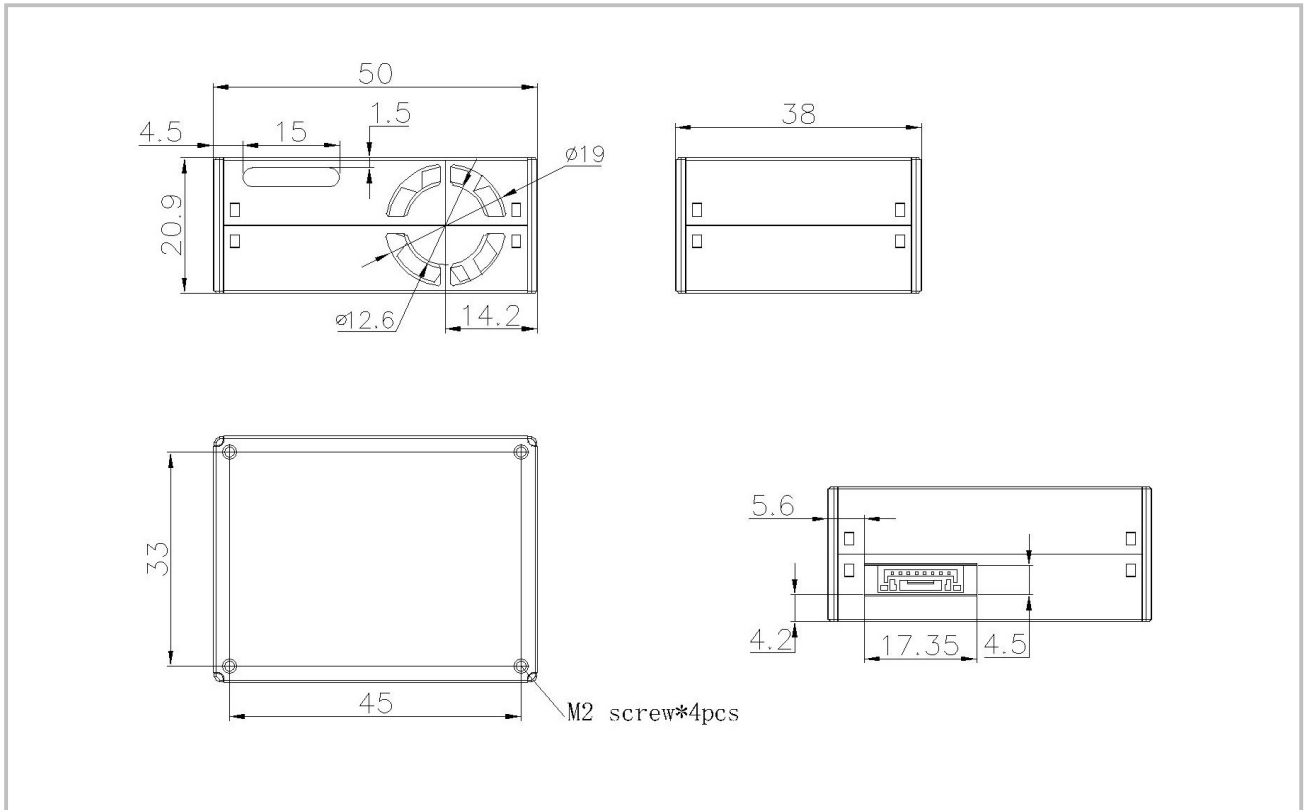
According to the above figure, the light source part of AM1009 is composed of a laser tube and a driving circuit. The detection part of the sensor is composed of light sensitive part which receives reflected light and amplifying circuit. Data processing and communication output are completed by microprocessor.

The gas flows into the module through the fan, when sampling particles pass through light beam (laser), there will be light scattering phenomenon, and scattered light will be converted into electrical signal (pulse) via light sensitive part. Electrical signal will be transformed into digital signals after amplifying circuit, smoothing and MCU processed.

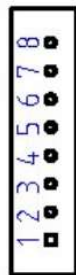
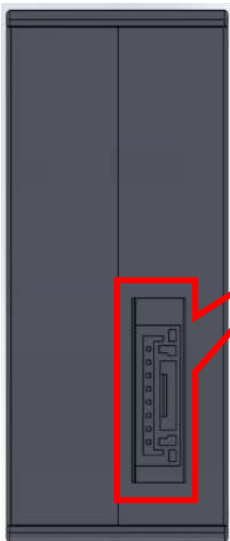
Temperature and relative humidity is measured by sensor directly and data is transferred to MCU. MOX type VOC&NO2 sensor is integrated, which has extremely high sensitivity to NO2 gas and various kinds of organic volatile gases such as formaldehyde, benzene, ethanol, formic acid, nicotine and some inorganic gases like carbon monoxide, ammonia and hydrogen.

## Dimensions and Connector

### 1. Dimensions (Unit mm, tolerance $\pm 0.2$ mm)



### 2. I/O Connector Pin out

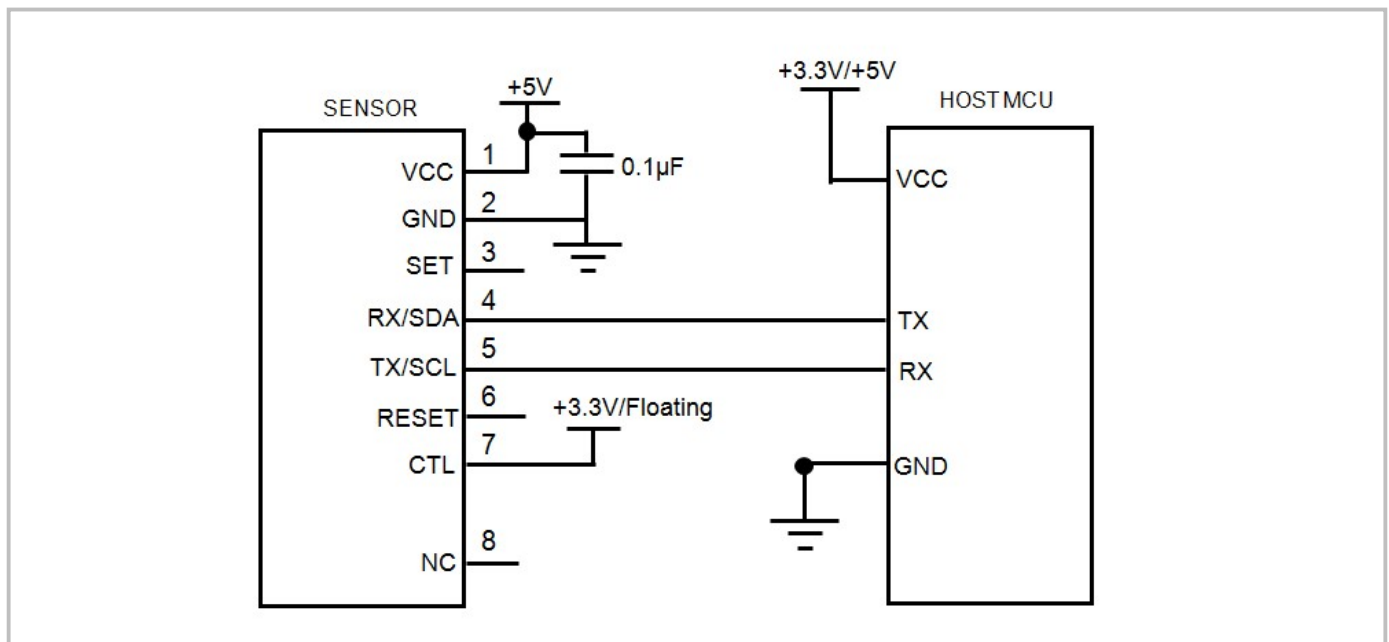


No.	Pin	Description
1	VCC	Power input(+5V)
2	GND	Power input (ground terminal)
3	SET	Set (TTL level @3.3V, high level or floating is normal working status, while low level is sleeping mode)
4	RX/SDA	UART-RX / I <sup>2</sup> C data
5	TX/SCL	UART-TX / I <sup>2</sup> C clock
6	RESET	Reset/ (Floating is normal working, ground connect is reset)
7	CTL	Output mode exchange TTL level @3.3V High level or floating is UART communication mode, low level is I <sup>2</sup> C communication mode
8	NC	NC

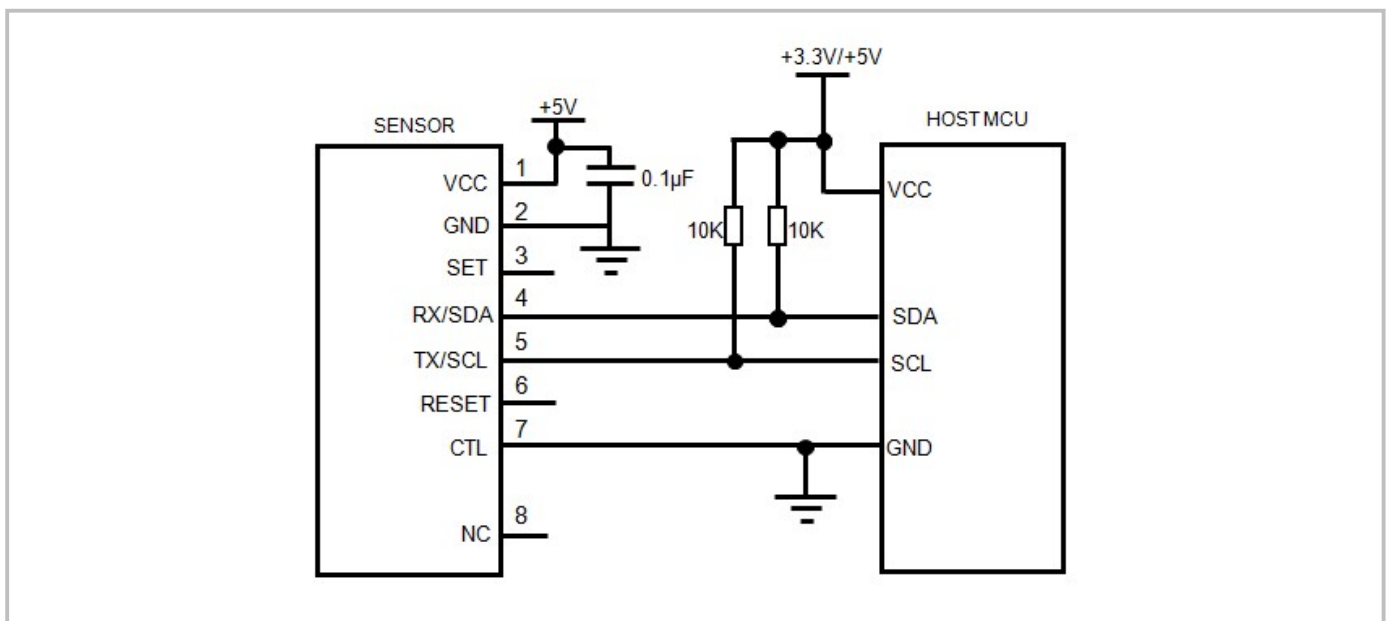
Item	Part Number	Pitch
Connector	CJT-A1251WR-8P	1.25 mm

## Typical Application Circuit

### UART Application



### IIC circuit connect diagram



### Note of Circuit Design

- I<sup>2</sup>C communication is 3.3V level, UART communication is 5V compatible.
- PIN3, PIN6, PIN7 should be floating.
- The power supply of sensor should be 5V, please refer to specification for more details.

# Communication Protocol

## 1. General Statement

- 1) The data in this protocol is all hexadecimal data. For example, "46" for decimal [70].
- 2) [xx] is for single-byte data (unsigned, 0-255); for double data, high byte is in front of low byte.
- 3) Baud rate: 9600; Data Bits: 8; Stop Bits: 1; Parity: No
- 4) It is default by continuously mode after powering on. Working mode will not be saved after powering off.

## 2. Format of Serial Communication Protocol

Sending format of software:

Start Symbol	Length	Command	Data 1	.....	Data n.	Check Sum
HEAD	LEN	CMD	DATA1	.....	DATAn	CS
11H	XXH	XXH	XXH	.....	XXH	XXH

Detail description on protocol format:

Protocol Format	Description
Start symbol	Sending by software is fixed as [11H], module respond is fixed as [16H]
Length	Length of frame bytes= data length + 1 (including CMD+DATA)
Command	Command
Data	Data of writing or reading, length is not fixed
Check sum	Cumulative sum of data = 256- (HEAD+LEN+CMD+DATA)

## 3. Command Table of Serial Protocol

Item No.	Function Description	Command
1	Read measurement result	0x16
2	Read software version number	0x1E
3	Read serial number	0x1F

## 4. Detail Description of Protocol

### 4.1 Read Measurement Result

Send: 11 01 16 D8

Response: 16 13 16 DF1~DF18 [CS]

Response description:

1. DF1-DF2: TVOC concentration = DF1\*256<sup>1</sup> + DF2, unit: ppb
2. DF3-DF4: NO2 concentration = DF3\*256<sup>1</sup> + DF4, unit: ppb
3. DF5-DF6: PM1.0=DF5\*256<sup>1</sup> + DF6, unit: µg/m<sup>3</sup>
4. DF7-DF8: PM2.5= DF7\*256<sup>1</sup> + DF8, unit: µg/m<sup>3</sup>



5. DF9-DF10: PM10+  $DF9 \times 256 + DF10$ , unit:  $\mu\text{g}/\text{m}^3$
6. DF11-DF12: Temperature=  $DF11 \times 256 + DF12$ , unit:  $^{\circ}\text{C}$  (real temperature  $= ((DF11 \times 256 + DF12) - 500) / 10$ )
7. DF13-DF14: humidity= $DF13 \times 256 + DF14$ , unit:1% (real relative humidity  $= ((DF13 \times 256 + DF14) / 10)$ )
8. DF15-DF16: reserved
9. DF17-DF18: reserved

#### 4.2 Read Software Version Number

**Send:** 11 01 1E D0

**Response:** 16 0E 1E DF1~DF13 [CS]

**Function:** Read software version

**Note:**

Software version="DF1~DF13"

Should change the HEX code to ASCII code.

**Example:**

HEX code: 16 0E 1E 50 4D 20 56 31 2E 32 36 2E 35 2E 32 38 E9

ASCII code: PM V1.26.5.28

#### 4.3 Read Serial Number

**Send:** 11 01 1F CF

**Response:** 16 0B 1F DF1 DF2 DF3 DF4 DF5 DF6 DF7 DF8 DF9 DF10 CS

**Function:** Read serial number

**Note:**

Serial number =  $(DF1 \times 256 + DF2)$ ,  $(DF3 \times 256 + DF4)$ ,  $(DF5 \times 256 + DF6)$ ,  $(DF7 \times 256 + DF8)$ ,  $(DF9 \times 256 + DF10)$

**Example:**

Response: 16 0B 1F 00 00 00 7E 09 07 07 0E 0D 72 9E

Serial number: 126 2311 1806 3442

# I<sup>2</sup>C Communication Protocol

## 1. Brief Introduction

- a. This is an I<sup>2</sup>C protocol for PM2009. The sensor module is lower computer, which is not able to initiate communication automatically. Communication is initiated via main controlled board, which reads data and sends control commands.
- b. Communication clock frequency <=100Khz

## 2. Communication Common Command

START: start signal, send by main controlled board;

STOP: stop signal, send by main controlled board;

ACK: acknowledge signal, send by the sensor module if in bold; otherwise, send by main controlled board;

NACK: non-acknowledge signal, send by the sensor module if in bold; otherwise, send by main controlled board;

Px: receive and send data; send by the sensor module if in bold; otherwise, send by main controlled board.

## 3. Protocol Detailed Description

### 3.1 Send Command Data

Send by main controlled board:

START+WRITE+ACK+P1+ACK+P2+ACK+..... +P7+ACK+STOP

Data	Byte content	Description
Device address	Sensor address and read/write command	This byte is 0x50 when write data
P1	0x16	Frame header
P2	Frame length	Number of byte, not including length of device address (From P1 to P7, 7 bytes in total)
P3	Data 1	Control command of the sensor as: Close measurement: 1    Open measurement: 2 Others: invalid
P4	Reserved	Reserved
P5		
P6		
P7	Data check code	Check code= (P1^P2^.....^P6)

### 3.2 Read Data Command

Send by main controlled board:

START+READ+ACK+P1+ACK+P2+ACK+.....+P32+NACK+STOP

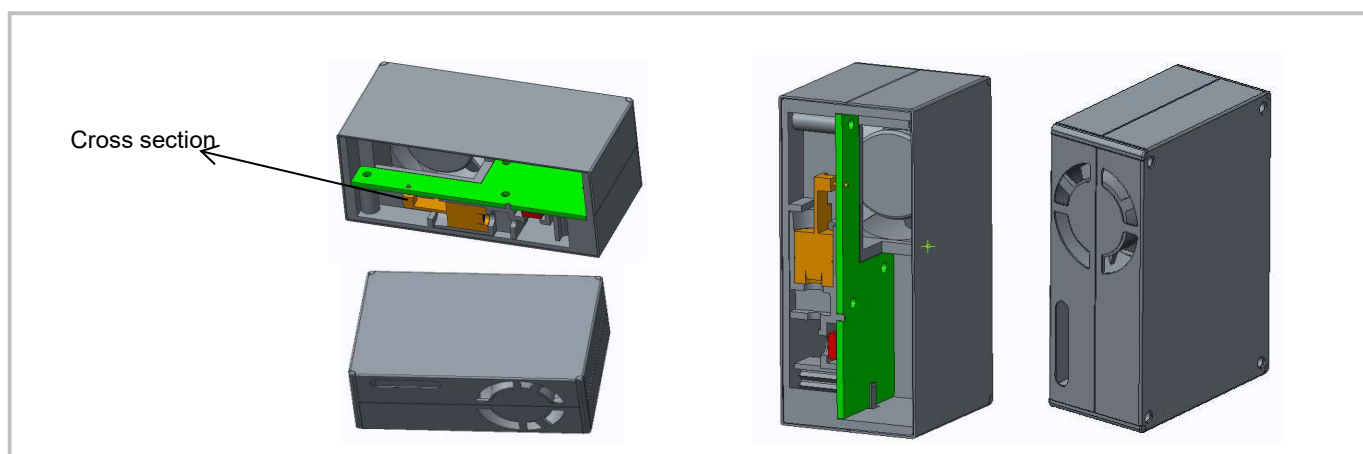
Data	Byte content	Description
Device address	Sensor address and read/write command	This byte is 0x51 when read data
P1	0x16	Frame header
P2	Frame length	Number of byte, not including length of device address (from P1 to P21, 21 bytes in total)
P3	Data 1, high byte	VOC concentration, unit: ppb
P4	Data 1, low byte	

P5	Data 2, high byte	NO2 concentration, unit: ppb
P6	Data 2, low byte	
P7	Data 3, high byte	PM1.0 concentration , unit: $\mu\text{g}/\text{m}^3$ , GRIMM
P8	Data 3, low byte	
P9	Data 4, high byte	PM2.5 concentration , unit: $\mu\text{g}/\text{m}^3$ , GRIMM
P10	Data 4, low byte	
P11	Data 5, high byte	PM10 concentration , unit: $\mu\text{g}/\text{m}^3$ , GRIMM
P12	Data 5, low byte	
P13	Data 6, high byte	Temperature, unit:°C
P14	Data 6, low byte	
P15	Data 7, high byte	Relative humidity, unit: %RH
P16	Data 7, low byte	
P17	Data 8, high byte	Reserved
P18	Data 8, low byte	
P19	Data 9, high byte	Reserved
P20	Data 9, low byte	
P21	Data 10, high byte	Check code = $(P1^P2^{\dots}P31)$

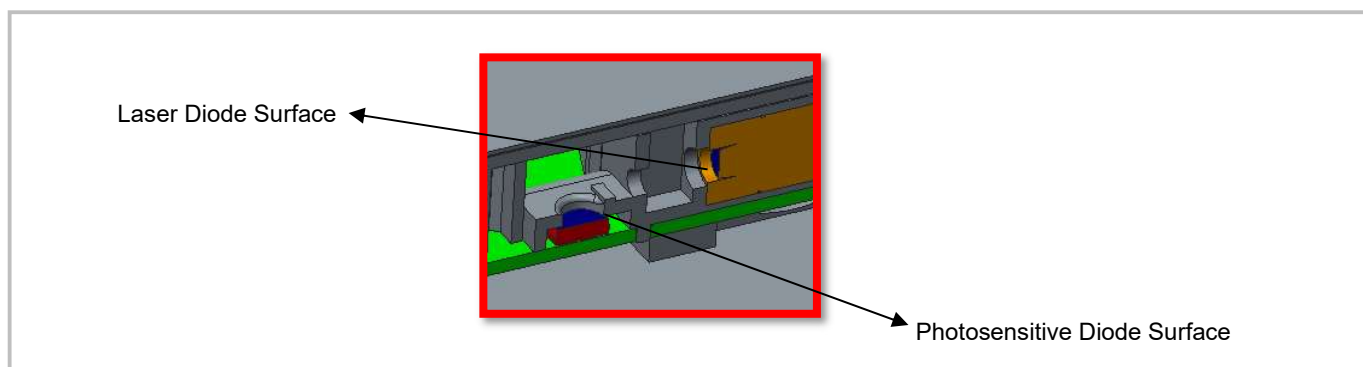
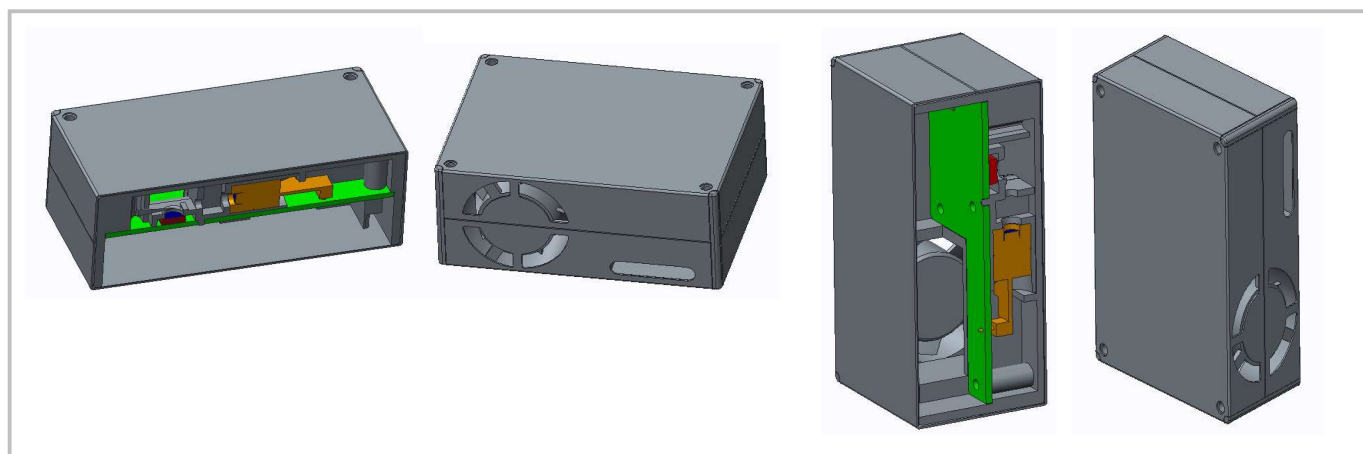
## User Attention

- The sensor is for household electronics products. For application of medical, mining, disaster preparedness, which needs high security and high dependence, this sensor is not suitable.
- Please do not use it in bad dusty environment and close sampling port.
- Avoid using the sensor under situation with strong magnetic, such as situation close to stereo speaker, microwave oven, induction cooking.
- When install the sensor, make sure the inlet and outlet is unobstructed, and cannot be fronted onto large air stream. There are two sides cannot be put downwards (As below pictures), In case of dust deposition on the surface of sensitive device, dust deposition will affect accuracy of sensor.

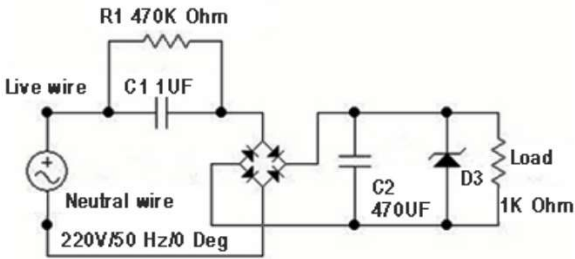
### Recommended installation



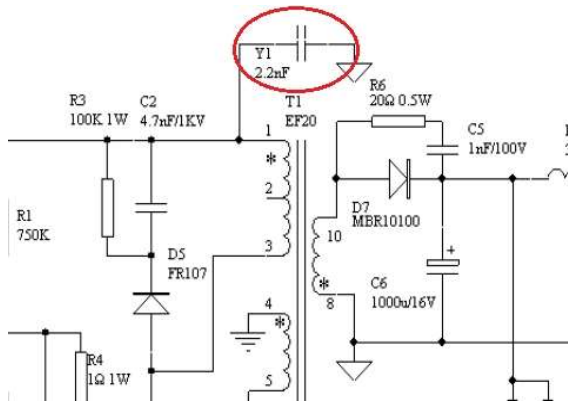
### Non-Recommended installation



- The metal case of sensor connects with the DC ground of inner circuit directly, which will cause safety problem if touching with DC ground. To avoid this problem, Sensor should be internally installed and no permit for touching sensor before power off.
- There is no high pressure transient protection circuit of the sensor. The power supply of the sensor should be stable 5V and low noise. Please refer to the working current in specification table.
- If use RC to decrease voltage, metal case will contact with 220V phase line or null line, special protection is needed.

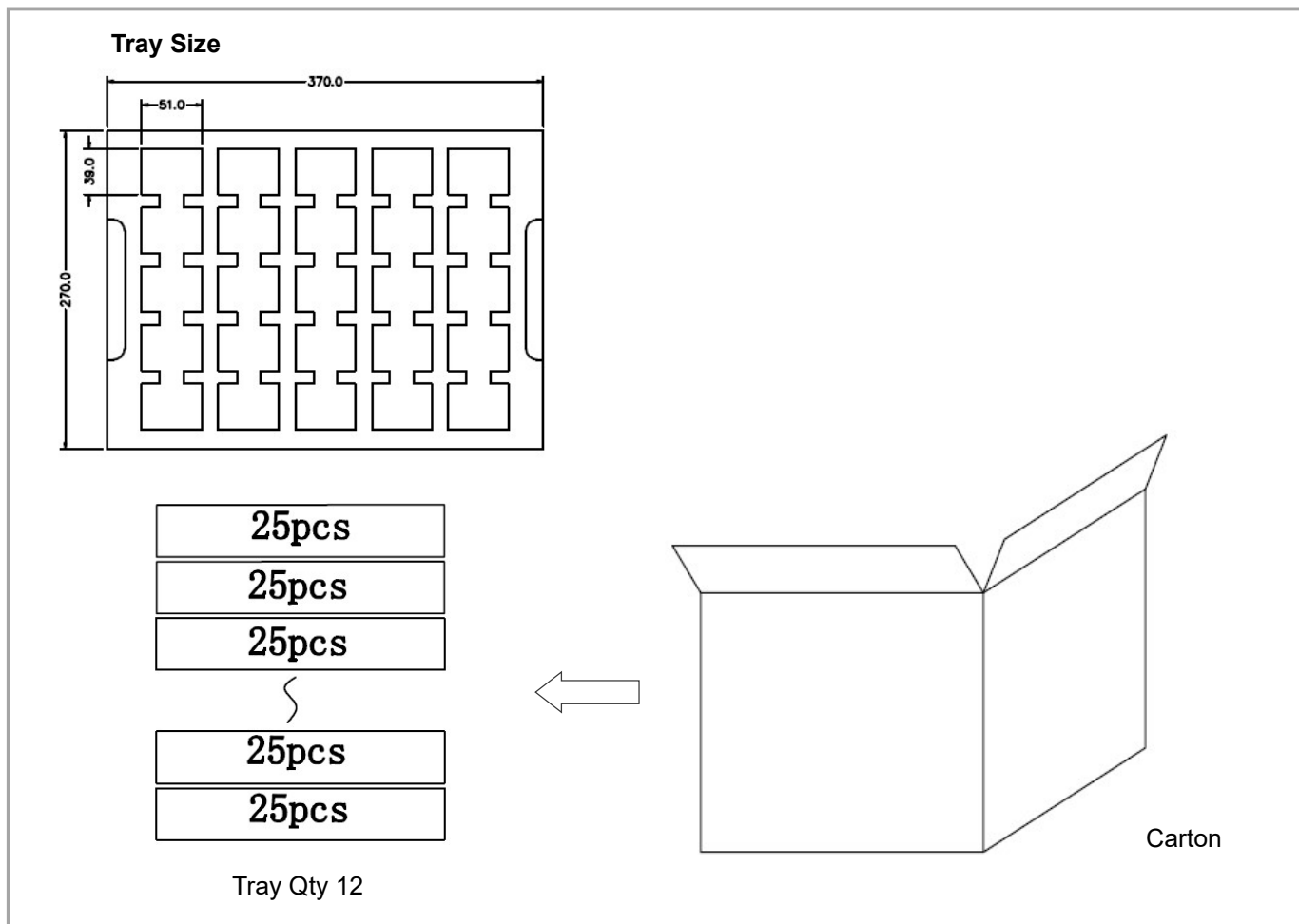


- If isolated switch power supply is adopted to obtain DC power, then capacitance between the DC ground and the AC ground shall be  $\leq 2.2\text{nF}$  and voltage withstand  $\geq 3\text{kV}$ .



- The sensor itself is safe to use. What you should be cautious is the safety of power supply and structure design on the sensor.
- This product is defined as 3R laser product according to 《GB7247.1-2012 laser product safety》 with laser radiation inside. Please avoid direct illumination on the eye.

## Package Information



Sensor per Tray	Tray Qty	Sensor per	Carton Dimensions	Packing Material
25 pcs	12 layers	300 pcs	395*310*330 mm	Red anti-static EPE

## After-Sales Services and Consultancy

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