SPECIFICATION

Product Name: Laser Particle Sensor Module

Item No.: PM2105-S

Version: V0.2

Date: December 29, 2018

Writer	Audit	Approved
Mei Yang		

Revision

No.	Version	Content	Reviser	Date
1	V0.2	The PM2.5 particle measurement accuracy is updated	Mei Yang	12.29
2	V0.2	UART protocol “Detail description on protocol format” is modified	Mei Yang	12.29
3	V0.2	In UART Protocol “General Statement”, deleting the previous content No. (4) and modifying content No. (5), the working mode is continuous mode by default	Mei Yang	12.29
4	V0.2	The information of the Mating Female Connector and the Connection cable is updated.	Mei Yang	12.29

Laser Particle Sensor Module

PM2105-S

Applications

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

Description

PM2105-S is a laser particle sensor module for indoor use based on laser scattering technology. This sensor can measure particle concentration size exactly and output particle mass concentration PM2.5 in μg/m³ directly via mathematical algorithm and scientific calibration.

Features

- The smallest size of available measurement: 0.3μm
- Real-time output PM2.5 only in μg/m^3
- High accuracy, high sensitive and quick response (≤8s)
- Signal output optional: UART, I²C, PWM
- Four types of measuring mode for option: single/continuous/timing/dynamic
- RoHS and Reach compliant
- Air inlet and outlet on different side

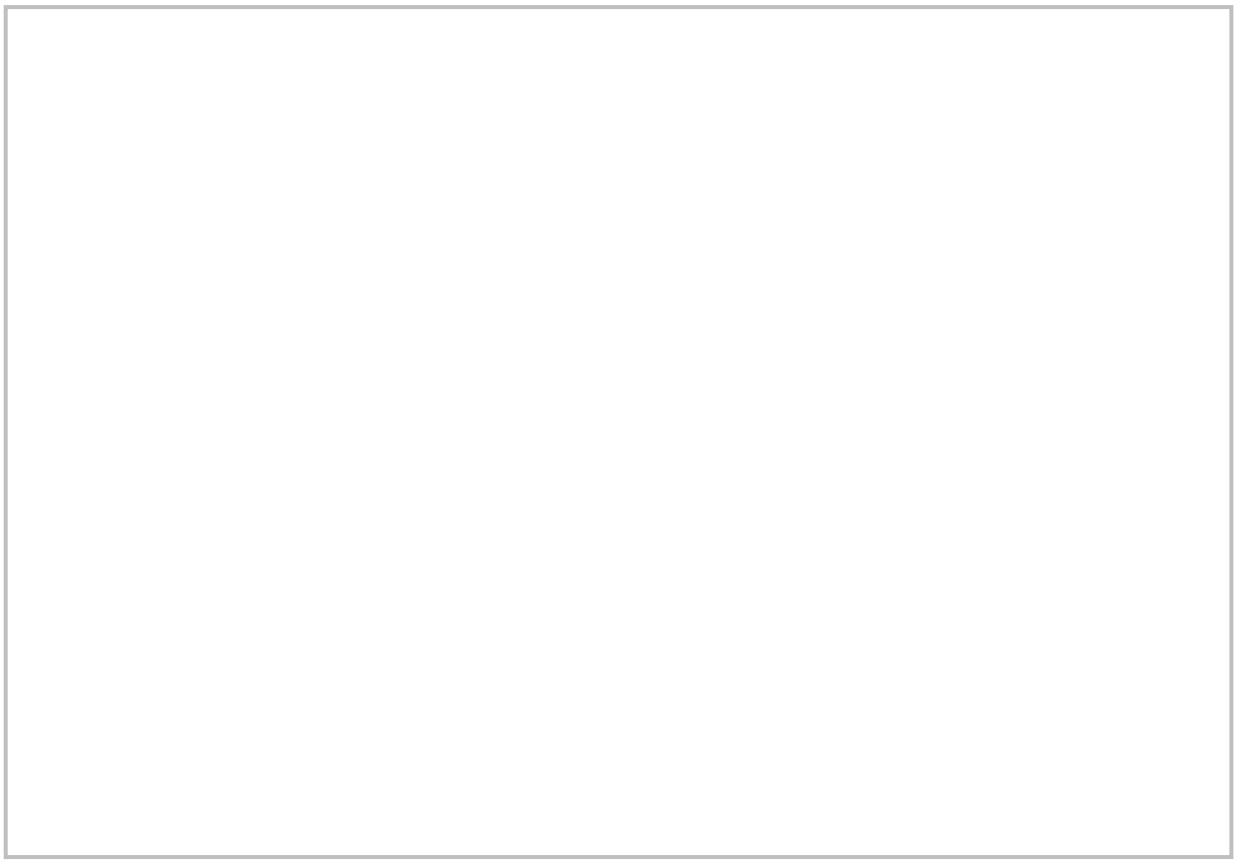
Working Principle

Sampling by the internal pressure which occurs by fan, when sampling particles pass through light beam (laser), there will be light scattering phenomenon. Scattered light will be converted into electrical signal (pulse) via photoelectric transformer. The bigger particles will obtain stronger pulse signal (peak value). Through peak value and pulse value quantity concentration of particles in each size can be calculated. Thus, real-time measured data is obtained through measuring quantity and strength of scattered light.

Specifications

Laser Particle Sensor Specification	
Operating principle	Laser scattering
Measured particle range	0.3μm ~ 10μm
Measurement range	0~1000 μg/m³
Resolution	1μg/m³
Working condition	-10°C ~ 50°C, 0-95%RH (non-condensing)
Storage condition	-30°C ~ 70°C, 0-95%RH (non-condensing)
PM2.5 Measurement accuracy	0 ~35μg/m³, ±5μg/m³ >35μg/m³, ±15% of reading Condition: 25±2℃, 50±10%RH Reference instrument: TSI8530 Dust source: Cigarette
Response time	1sec
Time to first reading	≤ 8 seconds
Power supply	DC 5V±0.1V Ripple wave＜50 mV
Working current	<100 mA
Standby current	<20 mA
Dimensions	42×35×23.7 mm
Digital output 1 (default)	UART_TTL_3.3V (default); I^2C_3.3V/5V (default)
Digital output 2	PWM (customized)
Output method	Default by active output after powering on, sampling time interval should be over 1,000 ms
MTTF	37,297 hrs (continuous turn on)

Internal Architecture Description



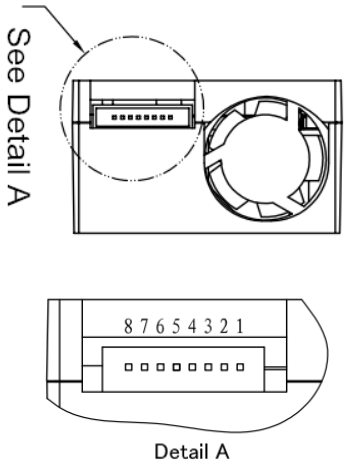
When the fan works, it will generate airflow. When the particles in the sampled gas pass through the beam of the light source (laser), a light scattering phenomenon occurs, and the scattered light is converted into an electrical signal (ie, a pulse) by the photoelectric transformer. The larger the particle size, the larger the amplitude of the pulse signal outputs.

The number of particles of different sizes is calculated by comparing the peak value with the predetermined threshold value, and the mass concentration value is obtained by a professional algorithm. By testing the intensity of the scattered light, real-time test data is obtained.

Dimensions and Connector

1. Dimensions (Unit mm, tolerance ±0.2 mm)

2. I/O Connector Pin Map



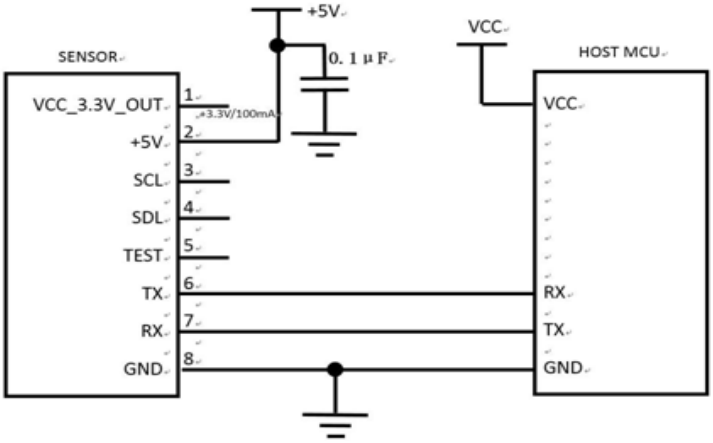
No.	Pin	Description
1	+3.3V	Power output (+3.3V/100mA)
2	5V	Power input (+5V)
3	SCL	I²C clock
4	SDA	I²C data
5	TEST	Suspend this pin without connecting
6	TX	UART-TX output (TTL Level@3.3V)
7	RX	UART-RX input (TTL Level@3.3V)
8	GND	Power input (ground terminal)

The interface connector is located at the side of the sensor. Corresponding female plug part number is A1251WR-S-8P from CJT. The pitch is 1.25mm.

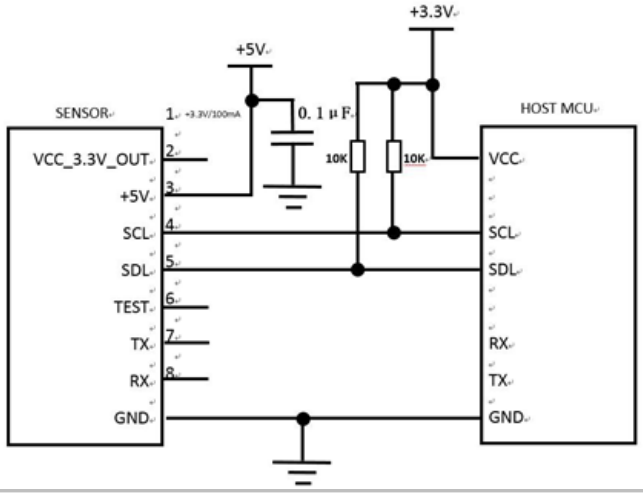
The connection cable with female connector at both ends can also be customized.

Typical Application Circuit

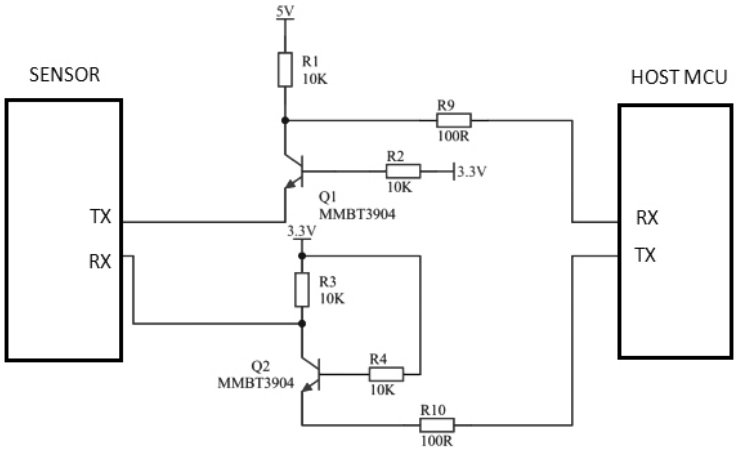
Case 1. UART Application



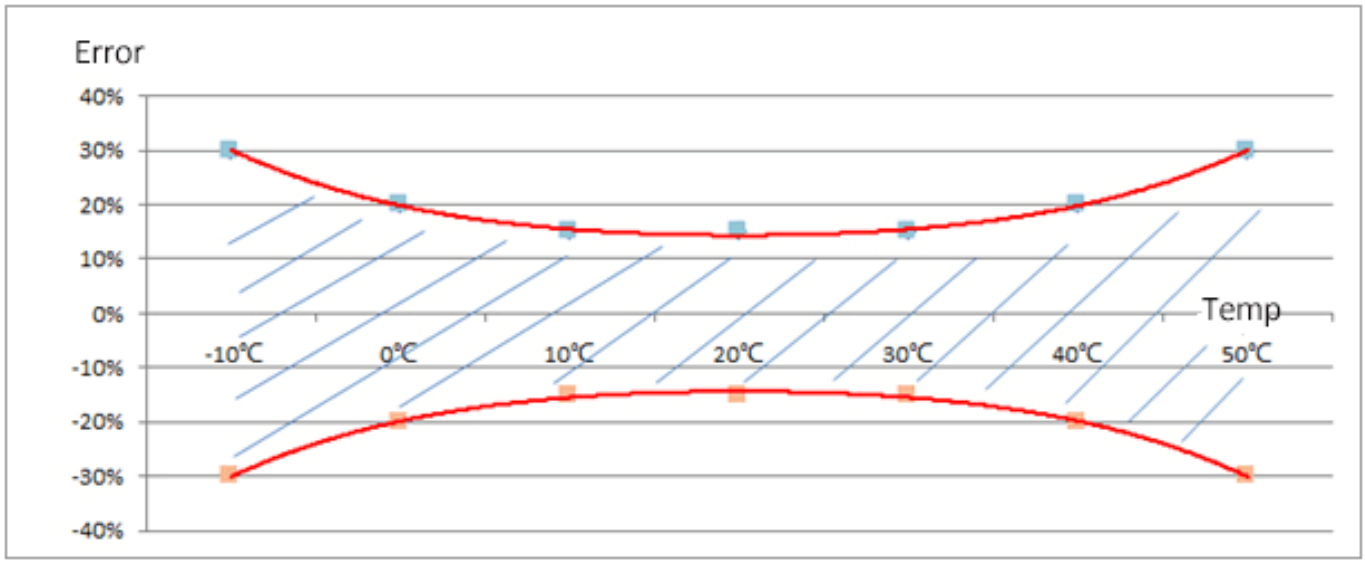
Case 2. I²C Application



Case 3. 3.3V- 5V Level Shift



Temperature Influence Curve

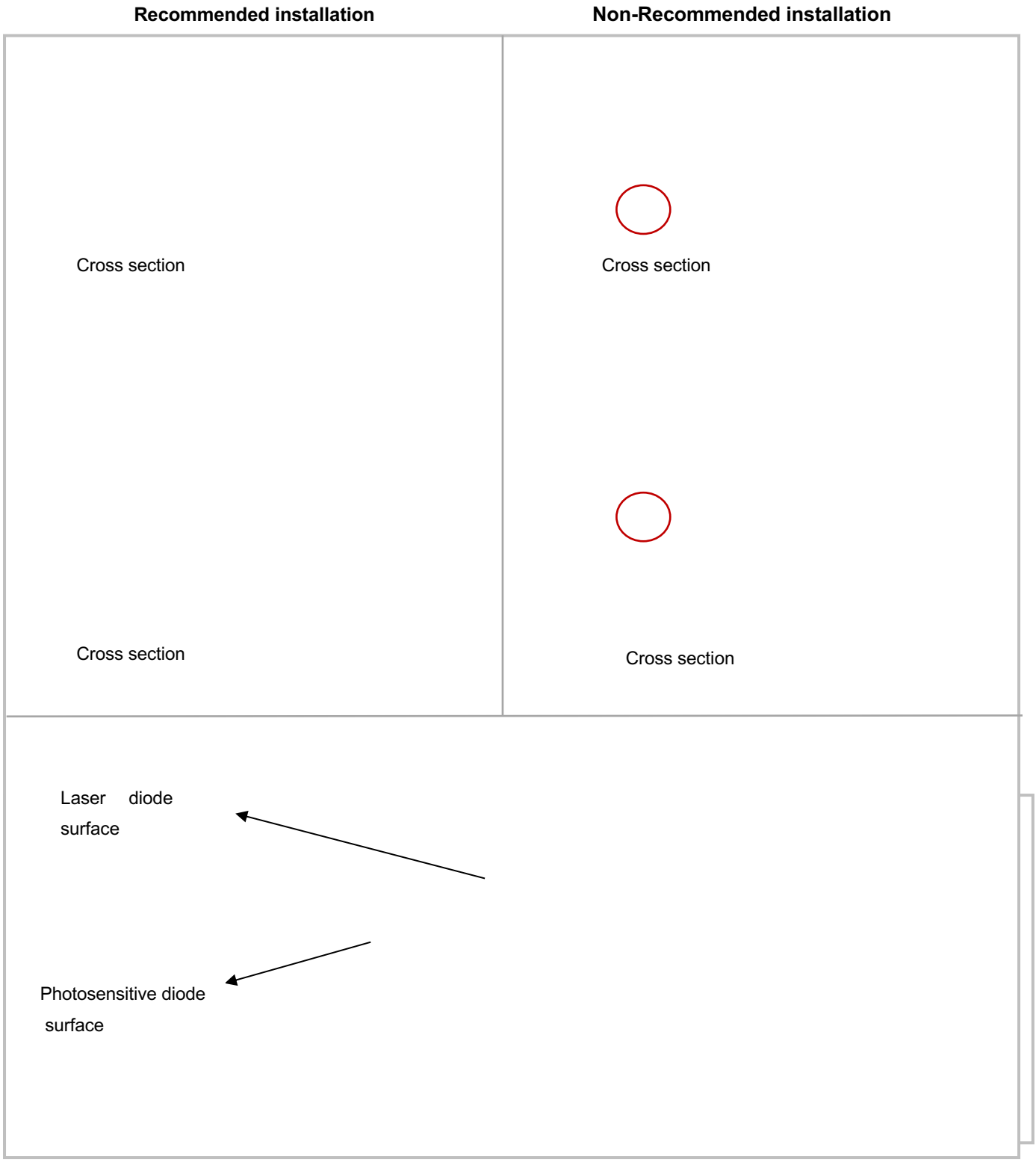


Particle measured error: under 25±2℃, 0~1,000μg/m³, consistency and accuracy of PM2.5 is either ±15% reading or ±15μg/m³, the bigger one is considered.

Temperature influence coefficient: 0.5%/℃ ~ 1%/℃ or 0.5μg/m³/℃ ~ 1μg/m³/℃, the bigger one is considered.

Product Installation

- When install PM2105-S sensor module in your system or equipment, please make sure that the air inlet and air outlet are unobstructed. And there is no huge airflow face to air inlet and air outlet.
- In order to avoid dust deposition on the surface of sensitive component (laser diode and photosensitive diode), which may affect the measurement accuracy of the sensor, the appropriate installation ways are recommended as below.



User Attention

▪The best installation way is to make the surface of air inlet and outlet of the sensor clings to the air vent in the inner wall of the user device that communicates with the outside. If it's not possible, then an air isolation structure between air inlet and air outlet is necessary to avoid the air back flow in the user's device.

▪Air vent size on the internal wall of user's device for airflow should be bigger than the size of air inlet of the sensor.

▪For purification products, sensor cannot be installed in the purifying air duct. If it's not possible, it's necessary to design a separate structure for sensor installation to isolate the sensor from air purifier duct.

▪For purifier and detector device, sensor should be installed above 20cm higher than floor to avoid contamination of large dust particles or even flocs near the ground entering the sensor, which will influence the measurement.

▪Sensor should be prohibited from using for outdoor inspection equipment. Dust storms, rain, snow, and willow flocs can have a significant impact on unprotected sensors.

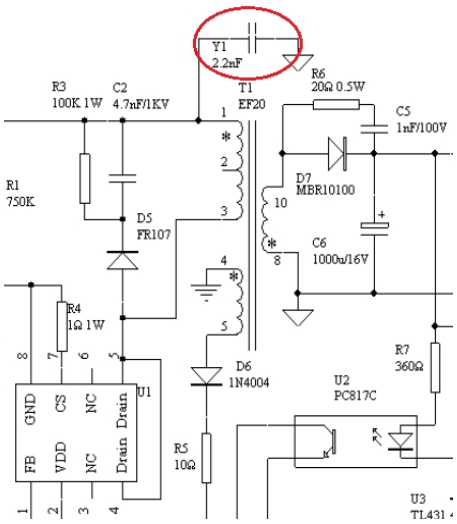
▪It is for household electronics products. For application of medical, mining, disaster preparedness, which needs high security and high dependence, this sensor is not suitable.

▪Avoid using the sensor under the condition with strong magnetic, such as situation close to stereo speaker, microwave oven, induction cooking.

▪There is no high pressure transient protection circuit of the sensor. The power supply of the sensor should be stable and low noise. Please refer to the working voltage in specification table.

▪The sensor needs 5V power supply because the fan needs a 5V power to drive. But all other data communication and control pins require 3.3V as a high level. Therefore, the main board MCU communication with the sensor should be the 3.3V communication level. If the main board MCU is 5V communication level, then it needs to connect 5V to 3.3V level conversion chips or circuits outside the communication port (RX, TX) and control port (RET, RESET).

▪If isolated switch power supply is adopted to obtain DC power, please control the capacitance between the DC ground and the AC ground below 2.2nF and withstand voltage reaches to 3KV.



▪This product is defined as 3R laser product according to 《GB7247.1-2012 laser product safety》 with laser radiation inside. Please avoid direct exposure to your eyes. Warning sign is as shown above.

UART 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 continuous 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 particle measurement result	0x0B
2	Open/close particle measurement	0x0C
3	Set up and read particle measurement time	0x0D
4	Set up and read timing measurement mode	0x05
5	Set up and read dynamic working mode	0x06
6	Read software version number	0x1E
7	Read serial number	0x1F

4. Detail Description of RS232 Protocol

4.1 Read Particle Measurement Result

Send: 11 02 0B 01 E1

Response: 16 11 0B DF1- DF4 DF5- DF8 DF9- DF12 DF13 DF14 DF15 DF16 [CS]

Function: Read particle concentration

Note:

PM2.5 measurement data= = DF1*256^3 + DF2*256^2 + DF3*256^1 + DF4

Data bit: 16 11 0B 00 00 00 C9 00 00 00 00 00 00 00 00 00 00 00 00 05

PM2.5 Reserved Reserved Reserved

Bit	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Alarm definition					1: low working temperature	1: high working temperature	1: Fan at low revolving speed	1: Fan at high revolving speed

DF13: Alarm of sensor module working condition:

DF14: Reserved

DF15: Alarm of sensor module calibrated status

Bit	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Alarm definition						1: Non-calibrated	1: Non-calibrated	1:Non-calibrated

DF16: Reserved

Note: Part of reserved bit is used for our internal testing. The data changeable of reserved bit is nothing related to function.

4.2 Open/Close Particle Measurement

Send: 11 03 0C DF1 1E CS

Response: 16 02 0C DF1 CS

Function: Open/ close particle measurement

Note:

1. When sensor is power-on, it starts continuous measuring.
2. When sending command, DF1=02 means opening measurement, DF1=01 means closing measurement;
3. When receiving response, DF1=02 means measuring opened, DF1=01 means measuring closed;
4. When the sensor receives the command of opening measurement, it will be in default continuous testing mode.

Example:

Send: 11 03 0C 02 1E C0 //open particle measurement

Response: 16 02 0C 02 DA//module is under particle measurement open status

Send: 11 03 0C 01 1E C1 //close particle measurement

Response: 16 02 0C 01 DB// module is under particle measurement closed status

4.3 Set up and Read Particle Measuring Time

Send: 11 03 0D DF1 DF2 [CS] // set up particle measuring time
Send: 11 01 0D E1 // read particle measuring time
Response: 16 03 0D DF1 DF2 [CS]
Function: Read particle measuring time

Note:
1. Particle measuring time = DF1*256+DF2, unit is second. Minimum measuring time is 36 seconds. Time range is 36-65530 seconds. After setting up xx seconds particle measuring time, the sensor will stop working first, then you can send “Open” command to start single xx seconds measuring.
2. When measuring time is ≥ 65531, it means module will be in continuous measuring mode once powered on. It will not stop until stop command is sent.

Example:
Send: 11 03 0D 00 24 BB // set up single measuring mode; measuring time is 36s
Response: 16 03 0D 00 24 B6 // measuring time is set up successfully

Send: 11 03 0D FF FF E1 // set up continuous measuring mode (Repowering on means to start measuring status)
Response: 16 03 0D FF FF DC //continuous measuring mode is set up successfully

Send: 11 01 0D E1 // read particle measuring time
Response: 16 03 0D FF FF DC // read measuring time successfully

4.4 Set up Timing Measuring Mode

Send: 11 03 05 DF1 DF2 [CS] // set up particle measuring mode

Send: 11 01 05 E9 // read particle measuring mode

Response: 16 03 05 DF1 DF2 [CS]

Function: Read particle measuring time

Note:
1. Particle measuring mode value X = DF1*256+DF2, unit is second;
2. When X >=60, it means module is under timing measuring mode. Measurement timing cycle is X seconds. The sensor module will start measurement every X seconds. Default measuring time is 36 seconds.
3. The shortest timing cycle is 1 minute.

Example:
Send: 11 03 05 02 05 E0 // Set up as timing measuring mode, and timing cycle is 517 seconds.
Response: 16 03 05 02 05 DB // Set up successfully

4.5 Set up Dynamic Measuring Mode

Send: 11 02 06 DF1 [CS] // Set up dynamic particle measuring mode

Send: 11 01 06 E8 // Read dynamic particle measuring mode

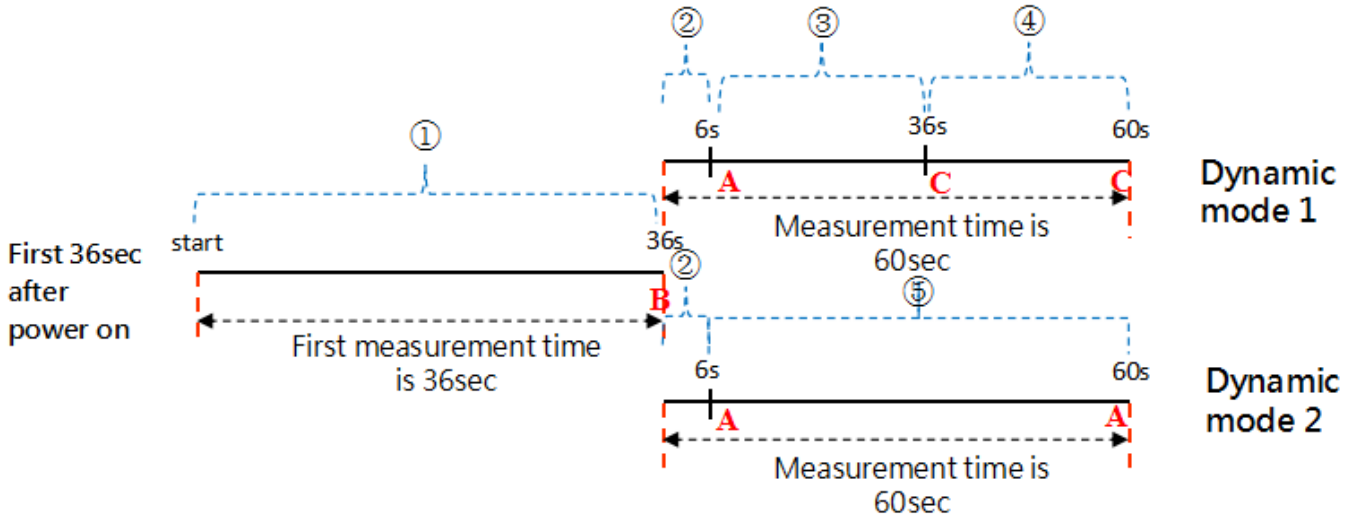
Response: 16 02 06 DF1 [CS]

Function: Read/set up particle dynamic measuring mode

Note:

1. Particle dynamic measuring mode result DF1
2. When DF1=00, close dynamic measuring mode. When DF1=01, start dynamic measuring mode.

Dynamic working mode description:



After sensors are in dynamic working mode, start measuring every 60 seconds.The sensor starts the measurement for the first 36 seconds and output B value.Then it start first 6 seconds of measurement and output A value

① If | A-B |> 10 μg / m³ or | A-B | / B> 10%, the sensor selects Dynamic mode 1. The sensor measures continuously for 30 seconds and outputs the C value. Then the laser diode turns off for 24 seconds, enters the standby state, and outputs the C value.

② If | A-B | <10 μg / m³ or | A-B | / B <10%, the sensor selects Dynamic mode 2 and stores A value, then enters standby state for 54 seconds and outputs A value.

Example:

Send: 11 02 06 01 E6 // Set up opening dynamic particle measuring mode

Response: 16 02 06 01 E1 // Set up successfully

Send: 11 02 06 00 E7 // Set up closing dynamic particle measuring mode

Response: 16 02 06 00 E2 // Set up successfully

Remark:

The module can support 4 kinds of working mode (Single+Continuous+Timing+Dynamic). It can be switched between these 4 kinds of working mode. It is continuous working mode by default after leaving factory. These 4 kinds of working mode can be switched by sending commands, as following:

1. **Send:** 11 03 0D 00 24 BB // Single measuring mode, time is 36s. After setting up successfully, the sensor will stop

working first, then you can send “Open” command to start single 36s measuring.
2. **Send:** 11 03 0D FF FF E1 // Continuously measuring mode
3**. Send:** 11 03 05 02 05 E0 // Timing measuring mode, interval time is 517 seconds
4. **Send:** 11 02 06 01 E6 // Dynamic measuring mode

4.6 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

4.7 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*256+DF2), (DF3*256+DF4), (DF5*256+DF6), (DF7*256+DF8), (DF9*256+DF10)

Example:
Response: 16 0B 1F 00 00 00 7E 09 07 07 0E 0D 72 9E
Serial number: 126 2311 1806 3442

I²C Communication Protocol

1. Brief Introduction

a. This is an I²C protocol for PM2105-S. 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

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 single measurement: 2 Set up continuously measurement : 3 (default measuring time 36s) Set up timing measurement: 4 Set up dynamic measurement: 5 Others: invalid
P4	Data 2, high byte	Measuring time: (range: 36~65530) unit: second. Timing measuring cycle: (range: 300-64800) Unit: second
P5	Data 2, low byte	
P6	Reserved	
P7	Data check code	Check code= (P1^P2^……^P6)

3.2 Read Command Data

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 (P1 to P22, 22 bytes total)
P3	Sensor status	Close: 1 Alarm: 2 Testing: 3 Testing finished: 0x80 Other data is invalid.
P4	Data 1, high byte	Reserved
P5	Data 1, low byte	
P6	Data 2, high byte	PM2.5 concentration , unit ug/m3
P7	Data 2, low byte	
P8	Data 3, high byte	Reserved
P9	Data 3, low byte	
P10	Data 4, high byte	The measuring mode of sensor as: Single measuring mode: 2 Continuous measuring mode: 3 Dynamic measuring mode: 5 Timing measuring mode: >= 300 (means measuring time)
P11	Data 4, low byte	
P12	Data 5, high byte	Reserved, default value is 0.
P13	Data 5, low byte	
P14	Data 6, high byte	Reserved, default value is 0.
P15	Data 6, low byte	
P16	Data 7, high byte	Reserved, default value is 0.
P17	Data 7, low byte	
P18	Data 8, high byte	Reserved, default value is 0.
P19	Data 8, low byte	
P20	Data 9, high byte	Reserved, default value is 0.
P21	Data 9, low byte	
P22	Data check code	Check code = (P1^P2^……^P21)

3.3 Description of Four Kinds of Work Mode

1. Single Measuring Mode

The sensor will start measuring particles after receiving command of opening measuring, sensor status is 3. After preheating for 6 seconds, measured value of last measurement will be output automatically. Measurement will finish in 36s, and sensors situation change to 0x80, it means data is stable, and measurement will be closed automatically.

2. Continuous Measuring

Continuous measuring mode, sensor situation is always 3 after powering on or turning to continuous measuring mode.

3. Dynamic Measuring Mode

After sensors are in dynamic measuring mode, measuring cycle is 1 minute.

The sensor starts the measurement for the first 6 seconds. If measuring result within 6 seconds compared with the last time measured result meets situation ① the sensor will go on testing for another 30s, then measurement is closed for 24s (laser diode and fan both off) until next new 60s measuring cycle.

① Change range is >±10 μg/m³ or >±10%

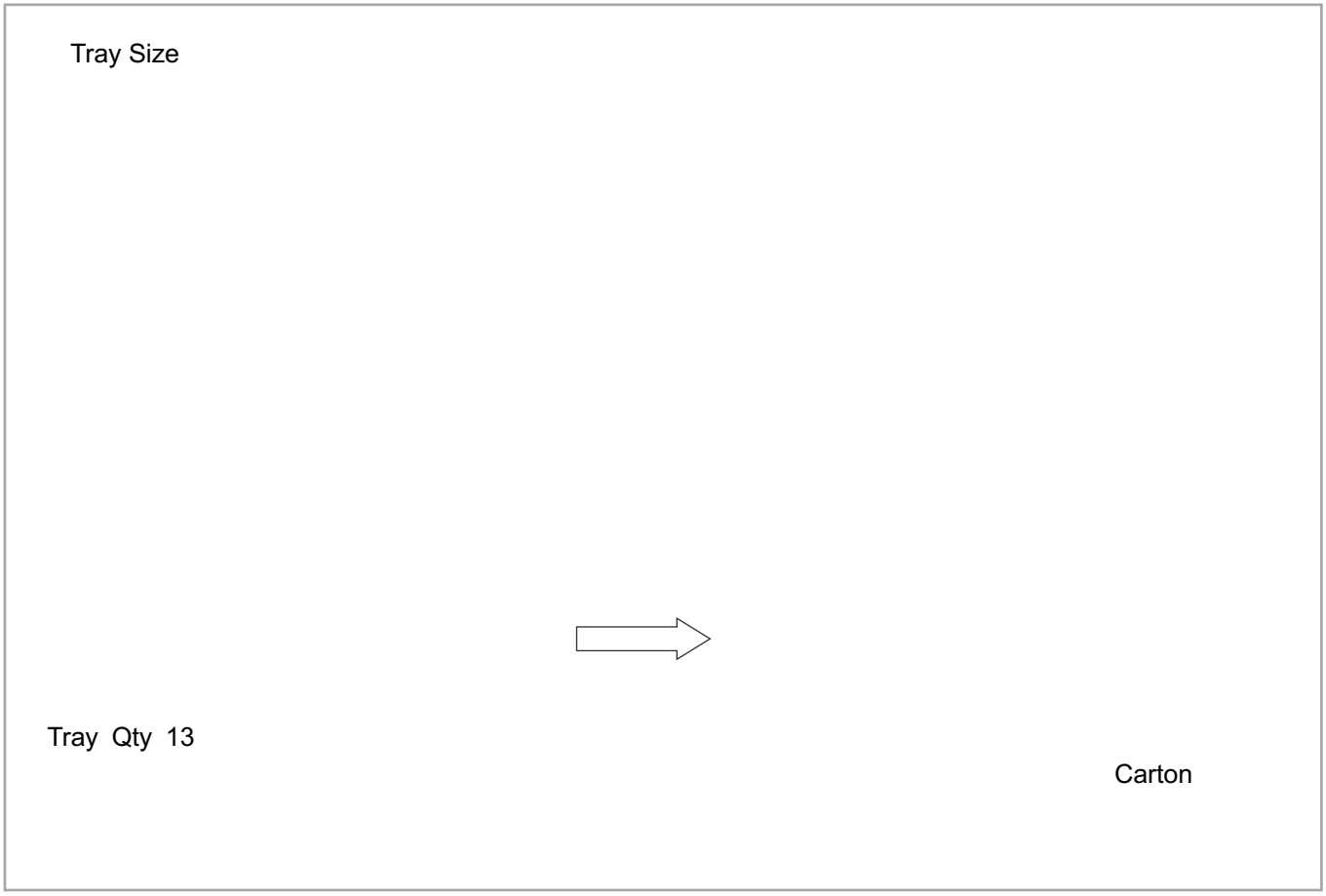
If measuring result within 6 seconds compared with the last time measured result meets situation ②, the measurement is closed for 54s until next new 60s measurement cycle starts.

② Change range is <±10 μg/m³ or <±10%

4. Timing Measuring Mode

After timing measuring mode is set, starting a completed 36s measuring every XX second. Situation is 3 during the measuring. And situation will change to 0x80 after finishing 36s measuring.

Packing Information



Sensor per tray	Tray Qty	Sensor per Carton	Carton Dimensions	Packing Material
30 pcs	13 layers	390 pcs	395*310*480 mm	Red pearl cotton (ESD)

After-Sales Services and Consultancy

Wuhan Cubic Optoelectronics Co., Ltd.
Tel: +86 (0)27 81628827 Fax: +86 (0)27 81628821
Add: Fenghuang No.3 Road, Fenghuang Industrial Park, Eastlake Hi-tech Development Zone, Wuhan 430205, China
E-mail: info@gassensor.com.cn