SPECIFICATION

Product Name: Laser Particle Sensor Module

Item No.: PM2012SE-A

Version: V0.2

Date: June 24, 2020

Writer	Audit	Approved
Mei Yang		

Revision

No.	Version	Content	Reviser	Date
1	V0.1	The first version	Mei Yang	2019.03.01
2	V0.2	Update description of IIC protocol	Yang Wei	2020.06.24

Laser Particle Sensor Module

PM2012SE-A

Applications

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

Description

PM2012SE-A is a laser particle sensor module which uses light scattering principle. It measures and calculates the suspending particle number which is within unit volume on the air exactly and output particle mass concentration µg/m^3 directly via mathematical algorithm and scientific calibration.

Features

- The smallest size of available measurement: 0.3µm
- Real-time output particle mass concentration in µg/m^3 available
- High accuracy, high sensitive and quick response (≤8s)
- Small size, compact structure, easy to install

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 calculate. 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	0~5,000μg/m³
Resolution	1μg/m³
Working condition	-10°C ~ 60°C, 0-95%RH (non-condensing)
Storage condition	-40°C ~ 80°C, 0-95%RH (non-condensing)
Accuracy PM1.0 PM2.5 PM10	PM2.5/PM1.0: 0~100μg/m³, ±10μg/m³ 101~500μg/m³, ±10% reading PM10: 0~100μg/m³, ±25μg/m³ 101~500μg/m³, ±25% reading (GRIMM, 25±2℃, 50 ±10%RH）
Response time	1sec
Time to first reading	≤ 8 seconds
Power supply	DC 5V±0.1V, ripple wave＜50mV
Working current	≤100mA
Standby current	≤200μA
Dimensions	W38*H35*D12 mm
Digital output 1 (default)	UART/IIC: 3.3V/5V(Level)
MTTF	110,000 hrs (continuous turn on)

# Internal Architecture Description
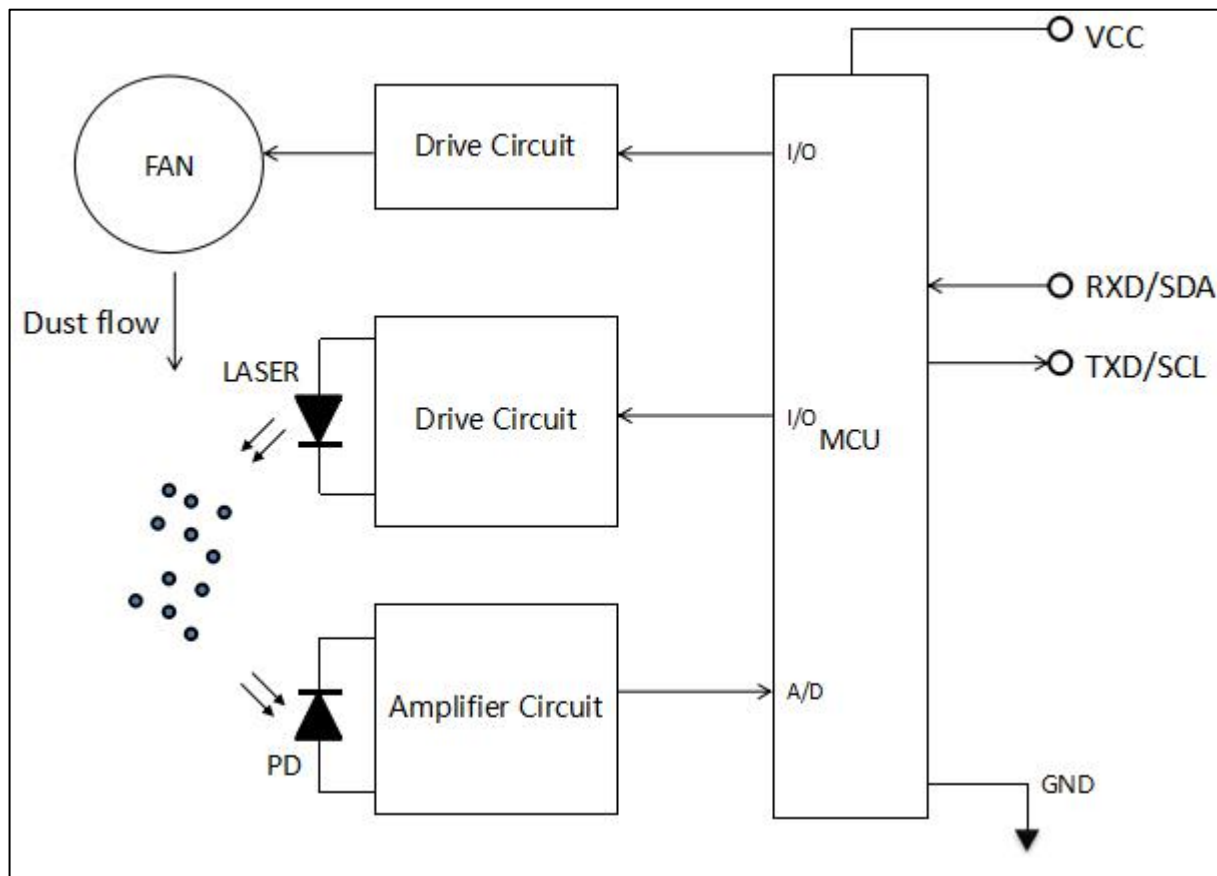
According to the above figure, The light source part of PM2012SE-A is composed of a laser tube and a driving circuit. The detection part of the sensor is composed of light sensitive part which receives reflected light and amplifying circuit. Data processing and communication output are completed by microprocessor.

The gas flows into the module through the fan, when sampling particles pass through light beam (laser), there will be light scattering phenomenon, 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.

Dimensions and Connector

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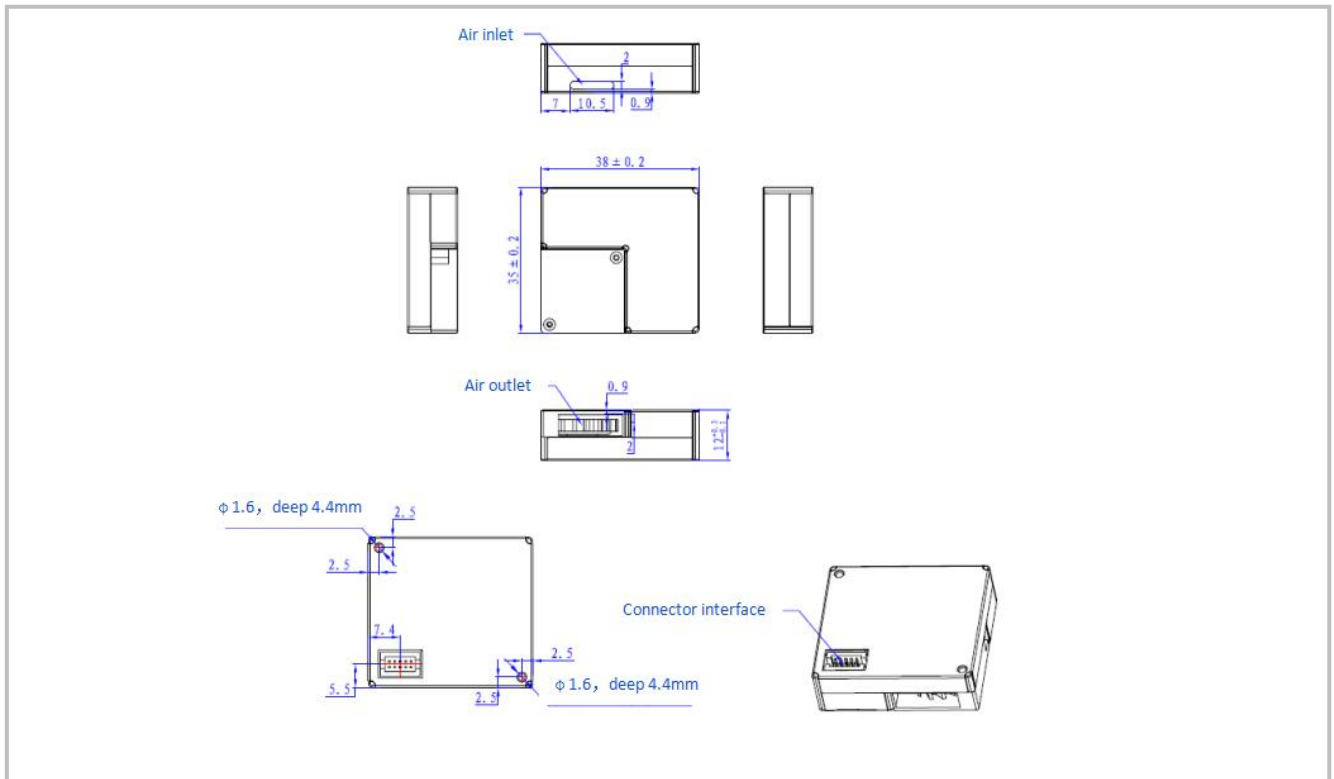

2. I/O Connector Pin out
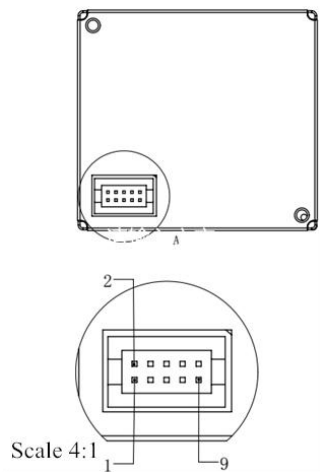
| No.	Pin	Description
1	VCC	Power input (+5V)
2	VCC	Power input (+5V)
3	GND	Power input (ground terminal)
4	GND	Power input (ground terminal)
5	Reset	Reset(Low level is reset, floating is default)
6	NC	NC
7	RXD/SDA	UART receiving/I²C data
8	P	Output mode exchange TTL level @3.3V High level or floating is UART communication mode, low level is I²C communication mode
9	TXD/SCL	UART sending/I²C clock
10	Set	Set (TTL level @3.3V, high level or floating is normal working status, while low level is sleeping mode）

Item	Part Number	Pitch
Connector	JSD-BH-312-002	1.27 mm

Typical Application Circuit

Case 1. UART Application
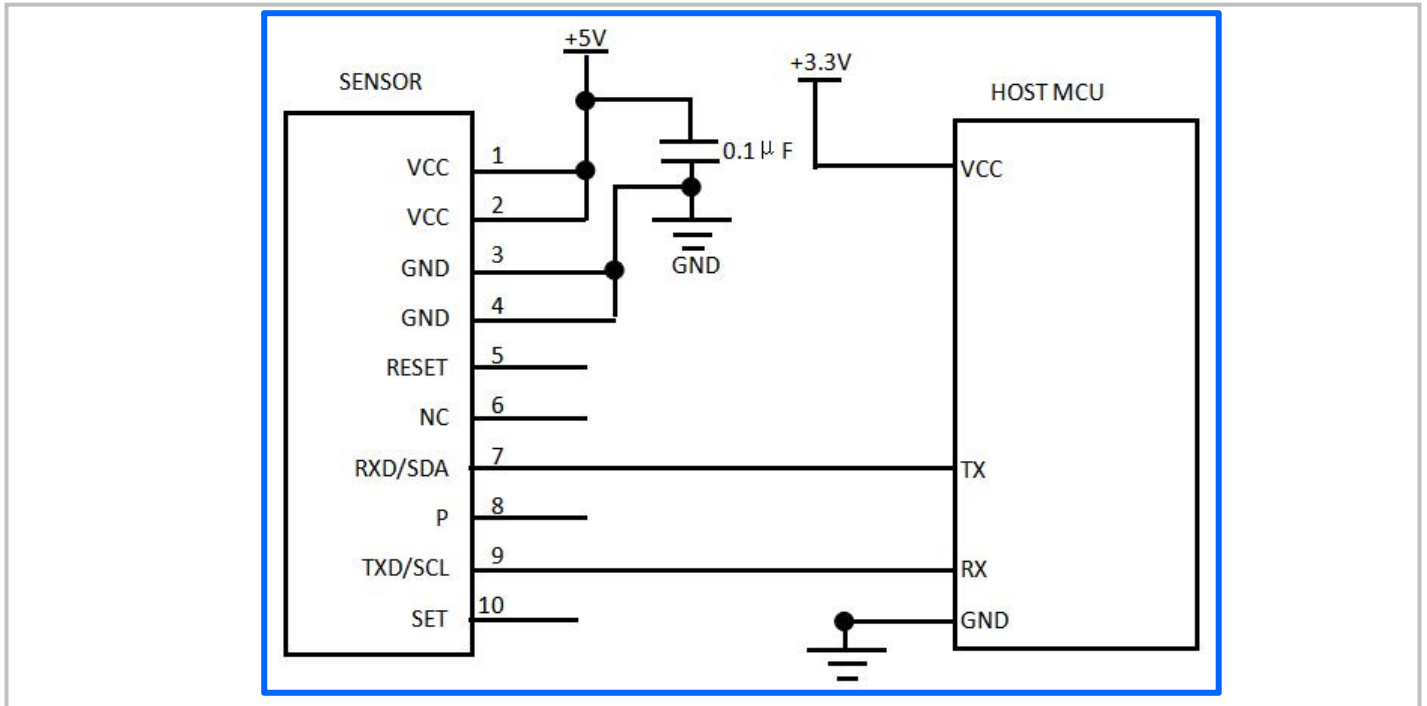
Case 2. I²C Application
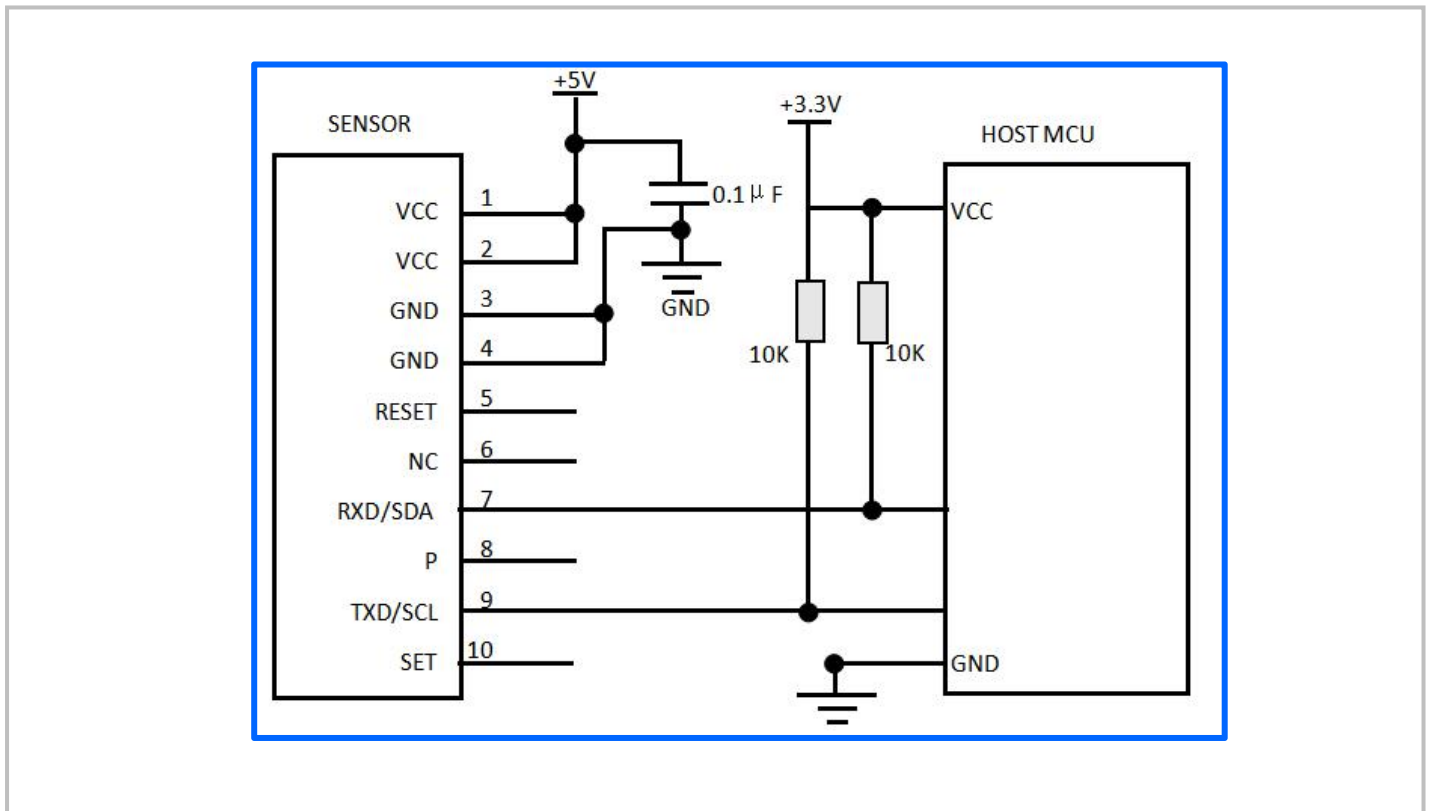
Temperature Influence
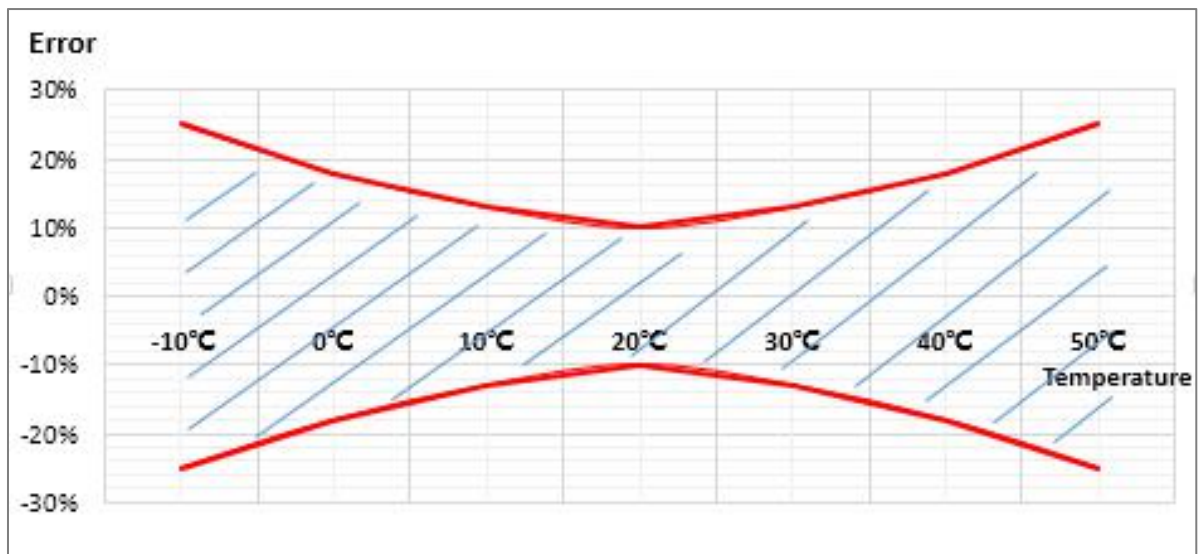
Particle measured error: under 25±2℃, 50±10%RH, 0~1000μg/m³, consistency and accuracy of PM1.0/PM2.5 is ±10% reading or ±10μg/m³, use the biggest one(TSI-8530, Cigarette)

Temperature influence coefficient: 0.5%/℃~1%/℃or 0.5μg/m³/℃~ 1μg/m³/℃, use the biggest one.

User Attention

▪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.

▪ 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 installing to system, make sure the inlet and outlet is unobstructed, and cannot be touched against by 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.

Inner crossing section drawn   Recommend installation
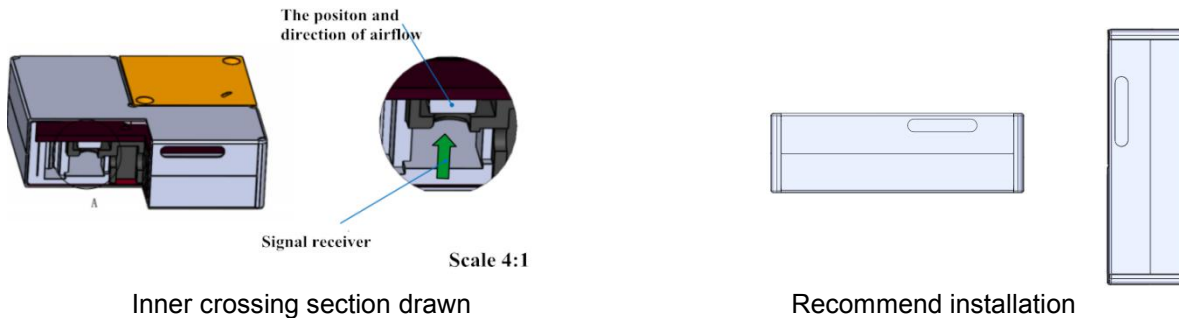
▪The metal case of sensor connects with the DC ground of inner circuit directly, which will cause safety problem if touching with DC ground. To avoid this problem, Sensor should be internally installed and no permit for touching sensor before power off.

▪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 using RC decrease voltage, metal case will contact with fringe line or null line of 220VAC, special protection is needed.
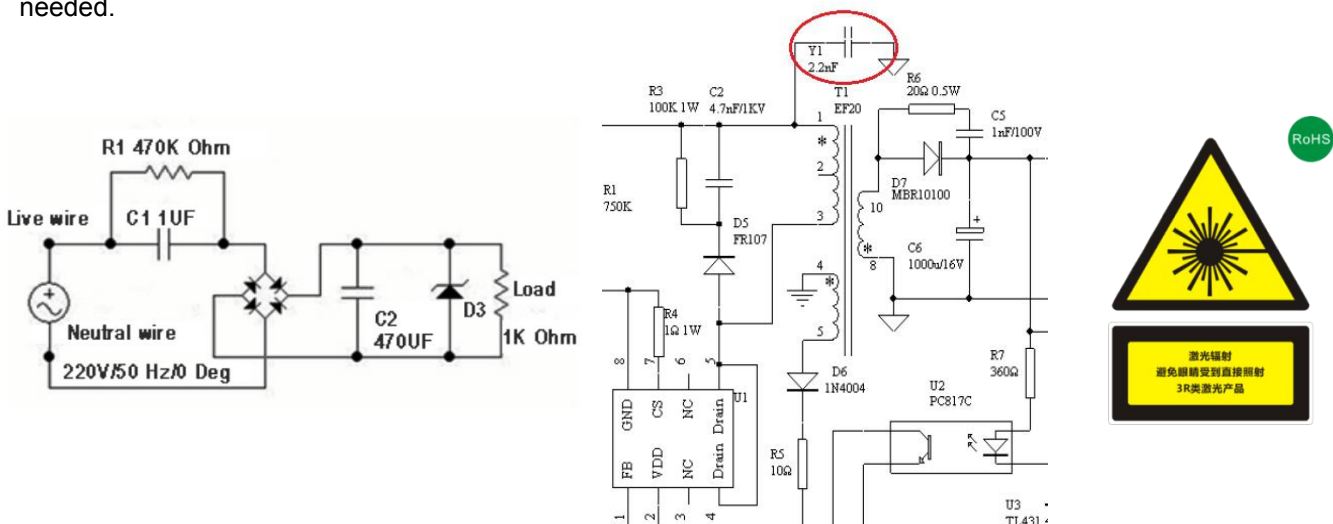
▪If isolated switch power supply is adopted to obtain DC power, please control the capacitance between the DC ground and the AC ground below 2.2nF and withstand voltage reaches to 3KV.

▪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. The warning label is as 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 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 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	Set up and read particle calibrated coefficient	0x07
7	Close/open laser diode	0x08
8	Read software version number	0x1E
9	Read serial number	0x1F

4. Detail Description of RS232 Protocol

4.1 Read Particle Measurement Result

Send: 11 02 0B 07 DB

Response: 16 35 0B DF1- DF52 [CS]

Function: Read concentration of particle and particles number.

Note: Read particle concentration (ug/m3) and particles number (pcs/0.1L)

PM1.0 GRIMM mass concentration = DF1*256^3 + DF2*256^2 + DF3*256^1 + DF4

PM2.5 GRIMM mass concentration = DF5*256^3 + DF6*256^2 + DF7*256^1 + DF8

PM10 GRIMM mass concentration = DF9*256^3 + DF10*256^2 + DF11*256^1 + DF12

PM1.0 TSI mass concentration = DF13*256^3 + DF14*256^2 + DF15*256^1 + DF16

PM2.5 TSI mass concentration = DF17*256^3 + DF18*256^2 + DF19*256^1 + DF20

PM10 TSI mass concentration = DF21*256^3 + DF22*256^2 + DF23*256^1 + DF24

Particles number >0.3um = DF25*256^3 + DF26*256^2 + DF27*256^1 + DF28

Particles number >0.5um = DF29*256^3 + DF30*256^2 + DF31*256^1 + DF32

Particles number >1.0um = DF33*256^3 + DF34*256^2 + DF35*256^1 + DF36

Particles number >2.5um = DF37*256^3 + DF38*256^2 + DF39*256^1 + DF40

Particles number >5.0um = DF41*256^3 + DF42*256^2 + DF43*256^1 + DF44

Particles number >10um = DF45*256^3 + DF46*256^2 + DF47*256^1 + DF48

DF49: Alarm of sensor module working condition:

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

DF50, DF51, DF52: 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.

Continuously working mode:

When continuously measuring mode is set, sensor situation is 2 . When PM1.0 is less than 5 $\mu g/m^3$, then measuring is close (situation changes to 0x80, only the laser diode turns off for 5 seconds) and outputs the last value in standby mode. After 5 seconds, the PM sensor resumes the measurement for 4 seconds , If PM1.0 measuring data within the 4s is less than 5 $\mu g/m^3$, then measuring is close (situation changes to 0x80, only the laser diode turns off for 5 seconds). Otherwise, the sensor will go ahead testing until the PM1.0 measuring data is less than 5 $\mu g/m^3$.

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 successfully, 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 mode

Response: 16 03 0D 00 24 B6   // read single measuring mode 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. Range for X is 60-3600*18, minimum timing period is 3 minutes, maximum timing period is 18 hours.

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

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

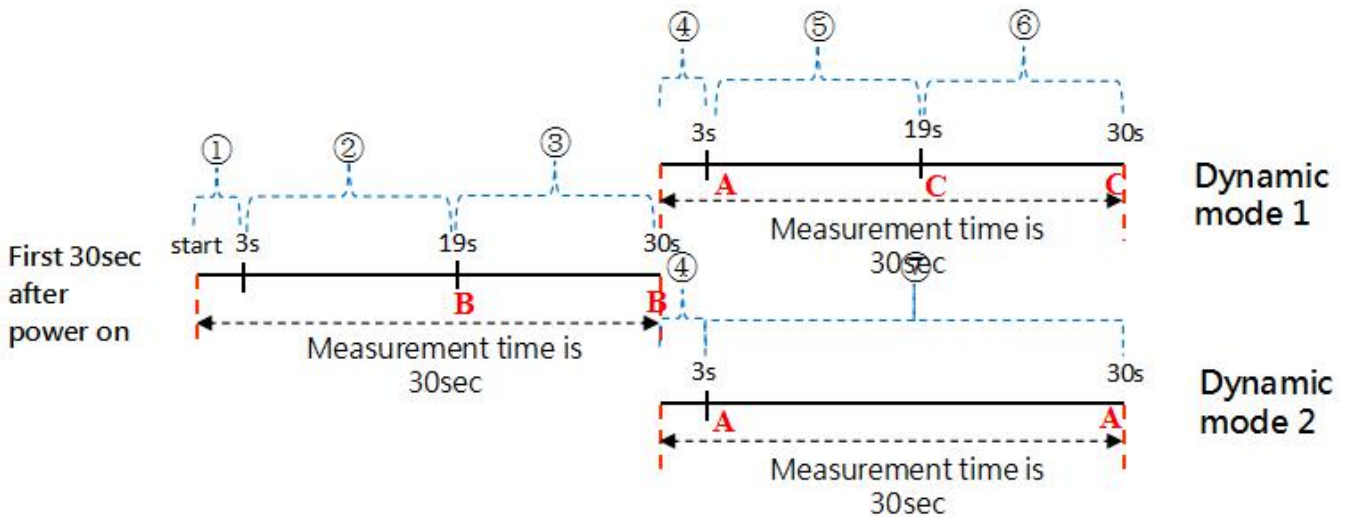**Send:** 11 01 06 E8 // Read dynamic particle measuring mode

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 30s. The sensor starts the measurement for the first 3 seconds.

After 3 seconds of measurement, the sensor starts measuring again continuously for 16 seconds and outputs the B value.

The laser diode turns off for 11 seconds, enters the standby state, and outputs the B value.

After the first 30 second period, the sensor starts a new 3 second measurement and outputs the 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 16 seconds and outputs the C value.

    The laser diode turns off for 11 seconds, enters the standby state, and outputs the C value.

②If | 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 27 seconds and outputs A value.

Remark: A, B, C value is related to PM1.0 Grimm mass concentration

Regardless of the dynamic mode A or B, the sensor starts a new 30 second measurement cycle by starting the initial 3 second measurement. Compare the measured value with the previously stored value for the initial 3 seconds and select Dynamic mode 1 or 2 again.

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 Set up and Read Particle Calibrated Coefficient
Send: 11 02 07 DF1 [CS] // Set up particle calibrated coefficient
Send: 11 01 07 E7 // Read particle calibrated coefficient
Response: 16 02 06 DF1 [CS]
Function: Read/set up particle calibrated coefficient

Note:
1. Range 70~150　Corresponding coefficient: 0.7~1.5

Description:
1. When there is difference between standard device, calibrated coefficient can be set to correct the final value.
2. When calibrated coefficient is set, the value of PM1.0, PM2.5, and PM10 will be all corrected by this coefficient.

4.7 Close/Open Laser Diode
Send: 11 02 08 04 E1// Close laser diode
Send: 11 01 08 E6 // Read status
Response: 16 02 08 04 DC

Note:
When laser diode is closed, the sensor will stop measuring but the FAN will stay working. The measuring data will keep the same with the last time measured data. If to open the laser diode again, you can use "Open/ close particle measurement' command.

4.8 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

4.9 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 PM2012SE-A. 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 Set up particle measurement time : 3 Set up timing measurement: 4 Set up dynamic measurement: 5 Set up calibration coefficient:6
P4	Data 2, high byte	Measuring time: range: 36~65530 second (for single and timing measurement mode)
P5	Data 2, low byte	Measuring period:range:60~64800 second(for timing measurement mode) It should be 0xFF 0xFF when setting up continuously measurement here. (default mode) Calibration coefficient:(Range: 70~150, Corresponding: 0.7~1.5）
P6	Data 3	Reserved
P7	Data check code	Check code= (P1^P2^……^P6)

3.2 Read Data Command

Send by main controlled board:
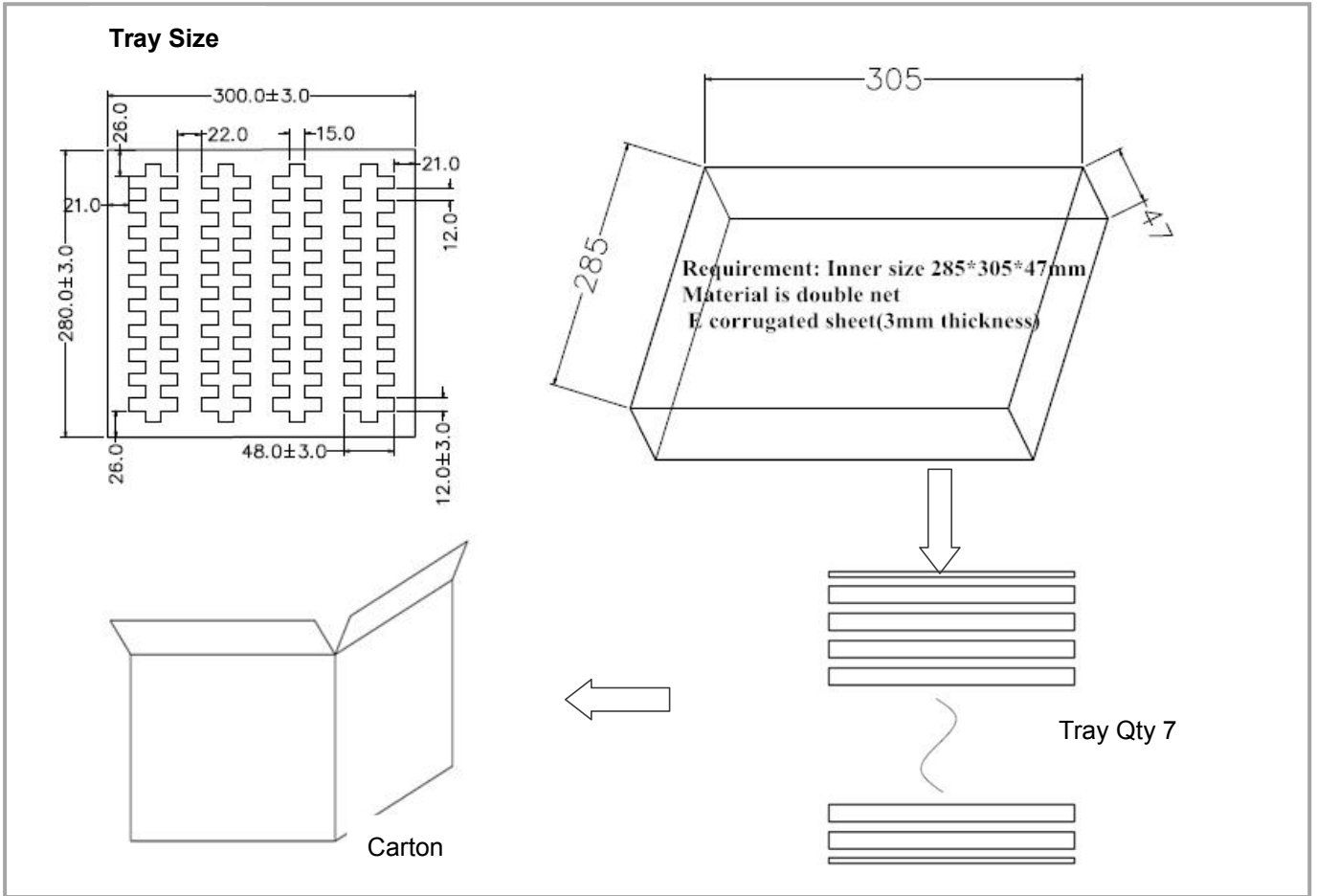
START+READ+ACK+P1+ACK+P2+ACK+……+P32+NACK+STOP

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 P32, 32 bytes in total)
P3	Sensor status	Close: 1;　Alarm: 7; Testing: 2; Data stable: 0x80　Other data is invalid.(Check 3.3 detailed introduction for every kinds of sensor status)
P4	Data 1, high byte	The measuring mode of sensor as:
P5	Data 1, low byte	Single measuring mode: 2;　Continuous measuring mode: 3 Dynamic measuring mode: 5;　Timing measuring mode: >= 60 (means measuring period)
P6	Data 2, high byte	Calibration coefficient: (Range: 70~150, Corresponding: 0.7~1.5）
P7	Data 2, low byte	
P8	Data 3, high byte	PM1.0 concentration , unit: µg/m³, GRIMM
P9	Data 3, low byte	
P10	Data 4, high byte	PM2.5 concentration , unit: µg/m³, GRIMM
P11	Data 4, low byte	
P12	Data 5, high byte	PM10 concentration , unit: µg/m³, GRIMM
P13	Data 5, low byte	
P14	Data 6, high byte	PM1.0 concentration , unit: µg/m³, TSI
P15	Data 6, low byte	
P16	Data 7, high byte	PM2.5 concentration , unit: µg/m³, TSI
P17	Data 7, low byte	
P18	Data 8, high byte	PM10 concentration , unit: µg/m³ , TSI
P19	Data 8, low byte	
P20	Data 9, high byte	Number of PM0.3, unit: pcs/0.1L
P21	Data 9, low byte	
P22	Data 10, high byte	Number of PM0.5, unit: pcs/0.1L
P23	Data 10, low byte	
P24	Data 11, high byte	Number of PM1.0, unit: pcs/0.1L
P25	Data 11, low byte	
P26	Data 12, high byte	Number of PM2.5, unit: pcs/0.1L
P27	Data 12, low byte	
P28	Data 13, high byte	Number of PM5.0, unit: pcs/0.1L
P29	Data 13, low byte	
P30	Data 14, high byte	Number of PM10, unit: pcs/0.1L

P31	Data 14, low byte	
P32	Data check code	Check code = (P1^P2^……^P31)

3.3 Description of sensor status

1. Status "1"

   Means sensor is closing.

2. Status "2"

   Means sensor is under measuring.

3. Status "7"

   Means the temperature is too high or too low, or fan speed is too high or too low.

4. Status "0x80"

   Means measuring data is stable.

Package Information

Tray Size

Requirement: Inner size 285*305*47mm
Material is double net
E corrugated sheet(3mm thickness)

Tray Qty 7

Carton

Sensor per Tray	Tray Qty	Sensor per Carton	Carton Dimensions	Packing Material
40 pcs	7 layers	280 pcs	395*310*330 mm	Red anti-static EPE

After-Sales Services and Consultancy

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