Temtop

# PMS 16

## Specifications of

## External Pump Laser PM Sensor

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# 1. Product Overview

The PMS 16 series, which is an external pump laser sensor, is specially designed to provide solutions for the online monitoring industry of atmospheric environment, which can be widely used in micro air monitoring stations, dust monitoring, oil-smoke monitoring and other air monitoring systems.

# 2. Produce Features

- Benchmarking β-ray method adopted, enjoying higher accuracy and correlation;
- Users can install an external pump whose flow is 1.1L/min, flow also can be customized.
- All-metal precise optical-mechanical structure, stable operation in multiple scenes;
- Small size, convenient for integrated use of multiple devices;
- Laser can work more than 20000 hours;

# 3. Working Principle

This sensor relies on the MIE scattering principle to monitor the concentration of particles. When the outside air passes through the light collection chamber uniformly, the particles in the sampled gas will scatter through the light beam. The photoelectric collection unit converts the scattered light signal into a voltage pulse signal, which is converted into a digital signal after pre-amplification and AD conversion. The number of voltage pulses measured is the number of particles, and the amplitude of voltage pulses reflects the size of optical equivalent size of particle. The standard substance is used to calibrate the senor after particle conversion, so as to determine the concentration of particles in the testing environment.

## 3.1 MIE scattering principle

Mie scattering theory is the exact solution of Maxwell's equation for a single medium sphere with homogeneous homogeneity in homogeneous medium under irradiation of monochromatic parallel light. A scattering occurs when the diameter of particles in the atmosphere is equal to the wavelength of radiation is called the MIE scattering. Unlike Rayleigh scattering enjoying a symmetrical distribution, MIE scattering has stronger scattering in the forward direction than in the backward direction, with a more obvious directivity. When the particle diameter is large, Mie scattering can be approximated as Fraunhofer diffraction.

## 3.2 Optical-mechanical structure and principle

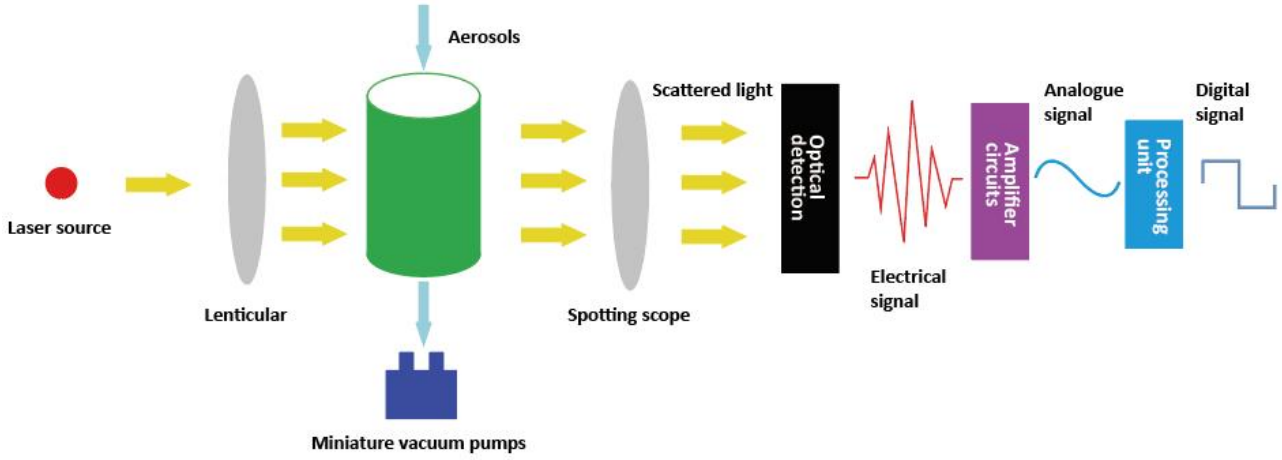


Fig. 1 principle of sensor

## 4. Sensor's Specifications

| Parameters | | Values | Unit | Remarks |
|---|---|---|---|---|
| Particle size | | PM1.0, PM2.5, PM10, TSP | ----- | ----- |
| Measurement range | | 0-50000 | μg/m³ | 0-50mg/m³ |
| Resolving power | | 1 | μg/m³ | ----- |
| Accuracy* | PM1.0 | ±10（0-100μg/ m³） | μg/m³ | ----- |
| | | ±10%（100-10000μg/m³） | | |
| | PM2.5 | ±10（0-100μg/ m³） | μg/m³ | ----- |
| | | ±10%（100-10000μg/m³） | | |
| | PM10 | ±15（0-100μg/m³） | μg/m³ | ----- |
| | | ±15%（100-10000μg/m³） | | |
| | TSP | ±20（0-100μg/m³） | μg/m³ | ----- |
| | | ±20%（100-10000μg/m³） | | |
| Life of laser | | 20000+ | hr | ----- |
| Counting efficiency | | 50% for 0.3μm | ----- | ----- |
| | | 100% for more than 0.5μm | | |
| Flow | | 1.1 | L/min | External, flow can be customed |
| Weight | | 170 | g | ----- |
| Maximum size | | 35*88*38 | mm | Excluding the size of air inlet and outlet, terminal |

**Table 1 Specifications of Particle Monitor**

*This is the data measured under the general atmospheric environment, with the Temtop instrument as a reference, the ambient temperature is 25±1℃, and the humidity is 50±3%RH. The actual use time depends on the environment in which it is used.

## 5. Electrical Specifications

### 5.1 Electrical Properties

The electrical properties under standard output (temperature 25℃, humidity 50%RH and 5V power supply voltage) are shown in Table 2.

| Parameters | Values | Unit |
|---|---|---|
| Rated voltage | DC 5.0 | V |
| Standby current | 30 | mA |
| Average current | 100 | mA |
| Maximum current | 200 | mA |
| Rated power | 1 | W |

**Table 2 Electrical Properties**

### 5.2 Absolute Limit Values

The reliability of the device may be affected under the limited conditions for a long time. Exceeding the following parameters range (Table **3**) may cause permanent damage to the device.

| Parameters | Range |
|---|---|
| Power supply voltage | DC 5.0±0.2V |
| Voltage at I/O pin | 0~3.3 V |
| Working temperature range | -10~ 50 °C |
| Storage temperature range | -20 ~ 70 °C |
| Working humidity range | 0-95%RH（non-condensation） |
| Static electricity | 1KV for terminal test 8KV for test voltage of other surfaces |
| Power ripple | 50mV |

**Table 3 Absolute Limit Values**

## 6. Hardware Interface

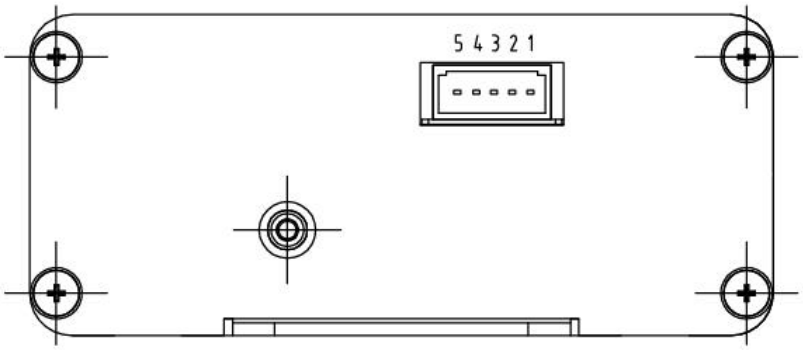


**Fig.2 Hardware Interface**

| Pin | Name | Description | Note |
|---|---|---|---|
| 1 | VCC | Device power supply (positive) | DC 5.0±0.2 |
| 2 | GND | Device grounding | —— |
| 3 | TX | Communication sending pin | (TTL) serial sending |
| 4 | RX | Communication receiving pin | (TTL) serial receiving |
| 5 | NC | —— | For factory testing |

**Table 4 Definition of Hardware Interface**

## 7. Communication Protocol

**UART parameters:**

- Baud rate: 9600
- Data bit: 8
- Check bit: None
- Stop bit: 1

**Communication mode:**

- TTL(Modbus RTU)

**Command mode:**

- The slave (sensor) is in the receiving state, only responding to the command of the host, not actively sending the command; The sensor needs 3 seconds to start, so it will not respond to command within 3 seconds when just powering on;

**Checksum:**

- CRC-16(Modbus), with low bytes before high bytes.

### 7.1 Register

Restrictions：

1. Input register and holding register are not allowed to overlap.
2. Bit addressing (coil and discrete input) cannot be realized.
3. The total number of registers is limited; it currently supports 32 input registers and 32 holding registers.
4. The current version does not support file transfer with a large amount of data.
5. See table 5 and table 6 for register details. All registers are 16-bit words and the register address is register number – 1.

See Table 5 for description of input Register.

| Register number | Address | Definition |
|---|---|---|
| IR1 | 0 | For later extended use |
| IR2 | 1 | For later extended use |
| IR3 | 2 | For later extended use |
| IR4 | 3 | PM1.0 mass concentration |
| IR5 | 4 | PM2.5 mass concentration |
| IR6 | 5 | PM10 mass concentration |
| IR7 | 6 | TSP mass concentration |
| IR8 | 7 | For later extended use |
| … | … | … |
| IR32 | 31 | For later extended use |

**Table 5 input register**

See Table 6 for description of holding register

| Register number | Address | Definition | Meaning |
|---|---|---|---|
| IR1 | 0 | For later extended use | For later extended use |
| IR2 | 1 | Special command register | 0x0000 Stop Measurement |
| | | | 0x0001 Start Measurement |
| IR3 | 2 | Address setting register | Slave Address（1-247） |
| IR4 | 3 | For later extended use | For later extended use |
| IR5 | 4 | For later extended use | For later extended use |
| IR6 | 5 | For later extended use | For later extended use |

| | | | |
|---|---|---|---|
| IR7 | 6 | Zero calibration register (1) | 0x0001 Start zero point calibration<br>Others : no response |
| IR8 | 7 | PM1.0 correction factor register (2) | Value range: 1000-65535, expanded by 10000 times |
| IR9 | 8 | PM2.5 correction factor register (2) | Value range: 1000-65535, expanded by 10000 times |
| IR10 | 9 | PM10 correction factor register (2) | Value range: 1000-65535, expanded by 10000 times |
| IR11 | 10 | TSP correction factor register (2) | Value range: 1000-65535, expanded by 10000 times |
| IR12 | 11 | For later extended use | For later extended use |
| … | … | … | … |
| IR32 | 31 | For later extended use | For later extended use |

**Table 6 holding register**

(1) After starting, the user needs to wait for 3s, and the register value will automatically return to 0 after completion;

(2) The factory has been corrected, it is not recommended that users modify; if there is a demand, please be careful to modify; if you need to modify, you need to read the original coefficients, then calculate the coefficient of the current need to be corrected (i.e., the multiplier between the trend of the demand data and the product data), the original coefficients multiplied by the coefficients of the current need to be corrected, and then write to the K register;

## 7.2 Protocol

### 7.2.1 Protocol Description

The MODBUS protocol consists of 4 parts: additional address, function code, data and error check. The additional address is used to indicate the address of the sensor which should receive this data; the function code is used to instruct the sensor to perform a certain operation; the data has different data structures according to different function code.

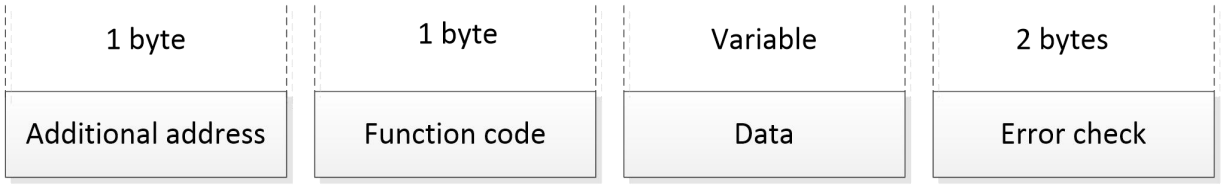


**Fig.3 general MODBUS frame**

### 7.2.2 Additional Address Description

| Address | MODBUS | PMS 16 |
|---|---|---|
| 0 | broadcast | Broadcast is not support temporarily |
| 1-247 | Slave device address | Slave device address |
| 248-253 | For later extended use | Nothing |
| 254 | For later extended use | Any Sensor |
| 255 | For later extended use | Nothing |

**Table 7 Address description**

### 7.2.3 Function Code Description

The sensor supports 4 function codes, see Table 8 for details.

| Function code | Function description | Corresponding operation |
|---|---|---|
| 0x03 | Read holding registers | Used to read sensor configuration parameters, including:<br>✓ Get address of sensors;<br>✓ Get correction factors; |
| 0x04 | Read input registers | Get mass concentration |
| 0x06 | Write single register | Used for setting separately, including:<br>✓ Set address of sensors;<br>✓ Start or Stop sensors;<br>✓ Set correction factors;<br>✓ Start zero calibration; |
| 0x10 | Write multiple registers | Used for setting continuously |

**Table 8 Function code description**

### 7.2.4 Data Description

For different function codes, the corresponding format of the data items is different. The protocol uses a 'big-endian' representation. The specific format is shown in Fig.4.


**Fig.4 format of data item**

### 7.3 Examples

Application Conditions:

1. Assume as a single sensor, with address 254(any sensor);
2. Display with hexadecimal data;

#### 7.3.1 Get Mass Concentration

(1) Get mass concentration of PM1.0

The mass concentration of PM1.0 is 0x0016 (actual value is 22μg/m$^3$).

| | |
|---|---|
| host | 0xFE 0x04 0x00 0x03 0x00 0x01 0xD5 0xC5 |
| slave | 0xFE 0x04 0x02 0x00 0x16 0x2C 0xEA |

(2) Get mass concentration of PM2.5

The mass concentration of PM2.5 is 0x002D (actual value is 45μg/m$^3$).

| | |
|---|---|
| host | 0xFE 0x04 0x00 0x04 0x00 0x01 0x64 0x04 |
| slave | 0xFE 0x04 0x02 0x00 0x2D 0x6D 0x39 |

(3) Get mass concentration of PM10

The mass concentration of PM10 is 0x0043 (actual value is 67μg/m$^3$).

| | |
|---|---|
| host | 0xFE 0x04 0x00 0x05 0x00 0x01 0x35 0xC4 |
| slave | 0xFE 0x04 0x02 0x00 0x43 0xEC 0xD5 |

(4) Get mass concentration of TSP

The mass concentration of TSP is 0x0053 (actual value is 83μg/m$^3$).

| | |
|---|---|
| host | 0xFE 0x04 0x00 0x05 0x00 0x01 0x35 0xC4 |
| slave | 0xFE 0x04 0x02 0x00 0x53 0xED 0x19 |

(5) Get mass concentrations of PM1.0, PM2.5, PM10, TSP continuously;

The mass concentration of PM1.0 is 0x0016 (actual value is 22μg/m$^3$);

The mass concentration of PM2.5 is 0x002D (actual value is 45μg/m$^3$);

The mass concentration of PM10 is 0x0043 (actual value is 67μg/m$^3$)

The mass concentration of TSP is 0x0053 (actual value is 83μg/m$^3$);

| | |
|---|---|
| host | 0xFE 0x04 0x00 0x03 0x00 0x04 0x15 0xC6 |
| slave | 0xFE 0x04 0x08 0x00 0x16 0x00 0x2D 0x00 0x43 0x00 0x53 0x7D 0x34 |

#### 7.3.2 Start/Stop Sensors

(1) Start sensors

Write the holding register IR2 with value 0x0001;

| | |
|---|---|
| host | 0xFE 0x06 0x00 0x01 0x00 0x01 0x0D 0xC5 |
| slave | 0xFE 0x06 0x00 0x01 0x00 0x01 0x0D 0xC5 |

(2) Stop sensors

Write the holding register IR2 with value 0x0000;

| | |
|---|---|
| host | 0xFE 0x06 0x00 0x01 0x00 0x00 0xCC 0x05 |
| slave | 0xFE 0x06 0x00 0x01 0x00 0x00 0xCC 0x05 |

### 7.3.3 Setting Address

Set address to 03: write the holding register IR3 with value 0x0003;

| | |
|---|---|
| host | 0xFE 0x06 0x00 0x02 0x00 0x03 0x7C 0x04 |
| slave | 0xFE 0x06 0x00 0x02 0x00 0x03 0x7C 0x04 |

### 7.3.4 Zero calibration

Perform a zero calibration of the sensor, write the holding register IR7 to 0x0001 and wait 3s for the sensor to complete the zero calibration (it is recommended to have an external cartridge in the air intake or a zero calibrator, etc.);

| | |
|---|---|
| host | 0xFE 0x06 0x00 0x06 0x00 0x01 0xBC 0x04 |
| slave | 0xFE 0x06 0x00 0x06 0x00 0x01 0xBC 0x04 |

### 7.3.5 Setting the correction factor

Note: The factory has been corrected, it is not recommended that the user modify; if there is a need, please be careful to modify; if you need to modify, you need to read the original coefficient (with the read coefficient instruction, see 7.3.7 for details), and then calculate the coefficient of the current need for correction (i.e., the multiplier between the trend of the demand data and the product data), the original coefficient multiplied by the coefficient of the current need to be corrected, and then written into the corresponding register; the correction coefficient of 1.1 below is the value of coefficient that need to be written into the hold register. The following correction factor 1.1 is the coefficient value to be written into the holding register, where the correction factor registers for the four channels PM1.0, PM2.5, PM10 and TSP are independent of each other and can be set to different values.

（1）Individual setting of PM1.0 correction factor

Set the correction factor of PM1.0 to 1.1: Write the holding register IR8 to 0x2AF8 (actual value 1.1);

Note: Correction factor 1.1 is the actual value that needs to be corrected, the actual write register needs to be expanded 10,000 times that is 11,000 (only retain the expanded integer write register, range of values: 1000 - 65535); then for example, correction factor 0.5 is the actual value that needs to be corrected, the actual write register needs to be expanded 10,000 times that is 5000 (only retain the expanded integer write register, take the value of the range: 1000 - 65535), that is, hold register IR8 write 0x1388 (the actual value of 0.5); the following is the same reason.

| | |
|---|---|
| host | 0xFE 0x06 0x00 0x07 0x2A 0XF8 0x32 0xE6 |
| slave | 0xFE 0x06 0x00 0x07 0x2A 0XF8 0x32 0xE6 |

（2）Individual setting of PM2.5 correction factor

Set the correction factor of PM2.5 to 1.1: Write the holding register IR9 to 0x2AF8 (actual value 1.1);

| | |
|---|---|
| host | 0xFE 0x06 0x00 0x08 0x2A 0XF8 0x02 0xE5 |
| slave | 0xFE 0x06 0x00 0x08 0x2A 0XF8 0x02 0xE5 |

（3）Individual setting of PM10 correction factor

Set the correction factor of PM10 to 1.1: Write the holding register IR10 to 0x2AF8 (actual value 1.1);

| | |
|---|---|
| host | 0xFE 0x06 0x00 0x09 0x2A 0XF8 0x53 0x25 |
| slave | 0xFE 0x06 0x00 0x09 0x2A 0XF8 0x53 0x25 |

（4）Individual setting of TSP correction factor

Set the correction factor of TSP to 1.1: Write the holding register IR11 to 0x2AF8 (actual value 1.1);

| | |
|---|---|
| host | 0xFE 0x06 0x00 0x0A 0x2A 0XF8 0xA3 0x25 |
| slave | 0xFE 0x06 0x00 0x0A 0x2A 0XF8 0xA3 0x25 |

（5）Continuously set PM1.0, PM2.5, PM10, TSP correction factor

Set the correction factor for PM1.0, PM2.5, PM10, TSP to 1.1: Write the holding registers IR8, IR9, IR10, IR11 to 0x2AF8 (actual value 1.1);

| | |
|---|---|
| host | 0xFE 0x10 0x00 0x07 0x00 0x04 0x08 0x2A 0xF8 0x2A 0xF8 0x2A 0xF8 0x2A 0xF8 0x36 0x4C |
| slave | 0xFE 0x10 0x00 0x07 0x00 0x04 0x64 0x04 |

### 7.3.6 Setting Address

Set address to 03: write the holding register IR3 with value 0x0003;

| | |
|---|---|
| host | 0xFE 0x03 0x00 0x02 0x00 0x01 0x31 0xC5 |
| slave | 0xFE 0x03 0x02 0x00 0x03 0xEC 0x51 |

### 7.3.7 Setting Correlation Factors

（1） Individual setting of PM1.0 correction factor

Read the corresponding value of hold register IR8: 0x2AF8 (the value of register IR8 is the value after expanding 10000 times, the actual value is 1.1);

| | |
|---|---|
| host | 0xFE 0x03 0x00 0x07 0x00 0x01 0x21 0xC4 |
| slave | 0xFE 0x03 0x02 0x2A 0XF8 0xB2 0xB2 |

（2）Individual setting of PM2.5 correction factor

Read the corresponding value of hold register IR9: 0x2AF8 (the value of register IR9 is the value after expanding 10000 times, the actual value is 1.1);

| | |
|---|---|
| host | 0xFE 0x03 0x00 0x08 0x00 0x01 0x11 0xC7 |
| slave | 0xFE 0x03 0x02 0x2A 0XF8 0xB2 0xB2 |

（3）Individual setting of PM10 correction factor

Read the corresponding value of hold register IR10: 0x2AF8 (the value of register IR10 is the value after expanding 10000 times, the actual value is 1.1);

| | |
|---|---|
| host | 0xFE 0x03 0x00 0x09 0x00 0x01 0x40 0x07 |
| slave | 0xFE 0x03 0x02 0x2A 0XF8 0xB2 0xB2 |

（4）Individual setting of TSP correction factor

Read the corresponding value of hold register IR11: 0x2AF8 (the value of register IR11 is the value after expanding 10000 times, the actual value is 1.1);

| | |
|---|---|
| host | 0xFE 0x03 0x00 0x0A 0x00 0x01 0xB0 0x07 |
| slave | 0xFE 0x03 0x02 0x2A 0XF8 0xB2 0xB2 |

（5）Continuous reading of PM1.0, PM2.5, PM10, TSP correction factor.

Read the corresponding value of holding register IR8: 0x2AF8 (the value of register IR8 is the value after expanding 10000 times, the actual value is 1.1; the same as the following);

Read the corresponding value of holding register IR9: 0x2AF8 (actual value 1.1);

Read the corresponding value of holding register IR10: 0x2AF8 (actual value 1.1);

Read the corresponding value of holding register IR11: 0x2AF8 (actual value 1.1);

| | |
|---|---|
| host | 0xFE 0x03 0x00 0x07 0x00 0x04 0xE1 0xC7 |
| slave | 0xFE 0x03 0x08 0x2A 0xF8 0x2A 0xF8 0x2A 0xF8 0x2A 0xF8 0x6C 0x7D |

### 7.3.8 Get Settings Continuously

Read the corresponding values of 2 consecutive registers starting from the holding register IR2. The device is currently in the startup state and the sensor address is 1;

| | |
|---|---|
| host | 0xFE 0x03 0x00 0x01 0x00 0x02 0x81 0xC4 |
| slave | 0xFE 0x03 0x04 0x00 0x01 0x00 0x01 0x65 0x3C |

### 7.3.9 Setting Continuously

Set the sensor address to 03 to start the device;

| | |
|---|---|
| host | 0xFE 0x10 0x00 0x01 0x00 0x02 0x04 0x00 0x01 0x00 0x03 0x10 0xB5 |
| slave | 0xFE 0x10 0x00 0x01 0x00 0x02 0x04 0x07 |

## 8. Dimension Drawing

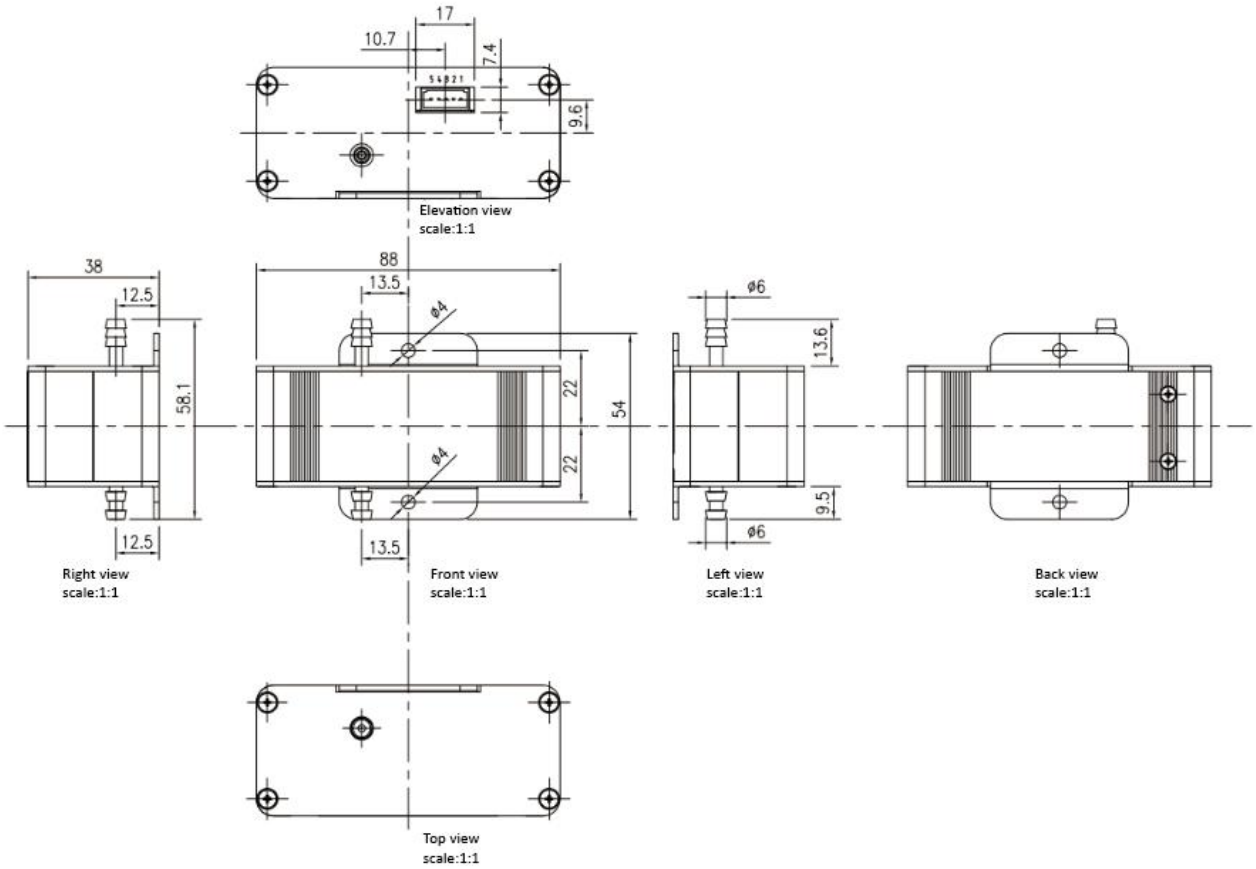


**Fig.5 Dimension Drawing of PMS 16**

## 9. Precautions

- Make sure that the ground wire in the power cord is well grounded when installing;
- When installing, the outer shell is recommended to be grounded or insulated, and the outer shell is not allowed to be charged;
- It is forbidden to knock, shake, or drop the product to avoid damage to the circuit board and optical structure;
- When the sensor is used for outdoor fixed equipment, the protection of sandstorms, rain, snow and other weather and fluffy catkins should be completed by the outdoor equipment provider;
- Without permission, please do not disassemble the sensor, and it is forbidden to repair it privately, so as to avoid accidents or aggravate the damage of the sensor. The sensor should be repaired by the manufacturer's special personnel;
- The sensor will heat up when it is working, so it is necessary to maintain good ventilation in the working environment to avoid damage to the machine due to excessive temperature;
- When this product is installed in the system, ensure that the inlet and outlet are unobstructed, and there should be no large airflow directly facing the inlet and outlet;
- The size of the ventilation on the inner wall of the user machine for the air inlet should not be smaller than the size of the sensor's air inlet;
- The sensor is not in direct contact with the monitoring environment (for example, installed in the equipment enclosures). In order to measure the results accurately, please connect the sensor's air inlet to the external probe of the enclosure, and the length of the connecting hose between them should be

controlled within 30cm;

- The external probe of the enclosure shall have the ability of wind proof, coarse filtration and water proof;
- l When the humidity increases, the data of the sensor and the Beta attenuation mass monitor may have a positive deviation, so the users need to provide a dynamic heating system to ensure the data correlation with the Beta attenuation mass monitor;

## 10. Maintenance

- This product is a particle sensor based on the principle of laser scattering, which is a precision optoelectronic instrument. A good use environment is conducive to the maintenance of the instrument and its service life. Keep it dry and clean, excessive humidity and dust will corrode the circuit board and optical structure and shorten service life;
- If the sensor does not work normally, please send it back to the manufacturer for repair, and professionals will provide you with help services, and it is forbidden to disassemble the machine privately;
- In order to ensure the safe and reliable use of the product, it is recommended that the user send back the sensor to the manufacture for calibration once a year. We only charge a small maintenance fee.

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