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ANCHIP

Laser Dust Digital Sensor

BM25S3221-1

Revision: V1.00 Date: November 21, 2022

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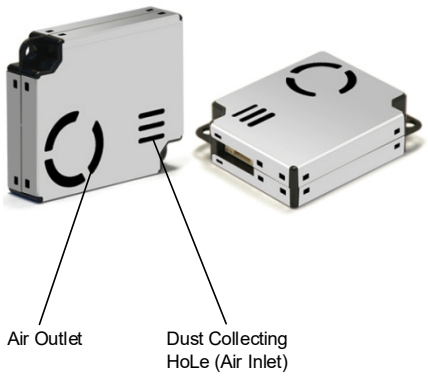
Features

- Operating voltage: 4.8V~5.5V
- Operating current: <120mA @ 5V
- Dormancy current: <25mA @ 5V
- Detectable particle diameter range: 0.3μm~10μm
- Detection range: 0~1000μg/m³
- Interfaces: UART (TX/RX)/PWM
- Communication mode: UART communication
- Communication interface baud rate: 9600bps
- Sensor service life: 3 years
- Interface level: 3.3V
- Warm-up time: 30s
- Response time: T90<30s
- Operating humidity: 0~80%RH – no condensation
- MTTF: continuous>10000h



General Description

The BM25S3221-1 module is a common type and a small size laser dust digital sensor, which is based on the Mie scattering principle to detect the dust particles in air. Professional algorithms and calibration detection technology make the sensor have good consistency and stability. The sensor supports both serial interface output and PWM output modes, which is easy to use and its small size is convenient for integrated applications.

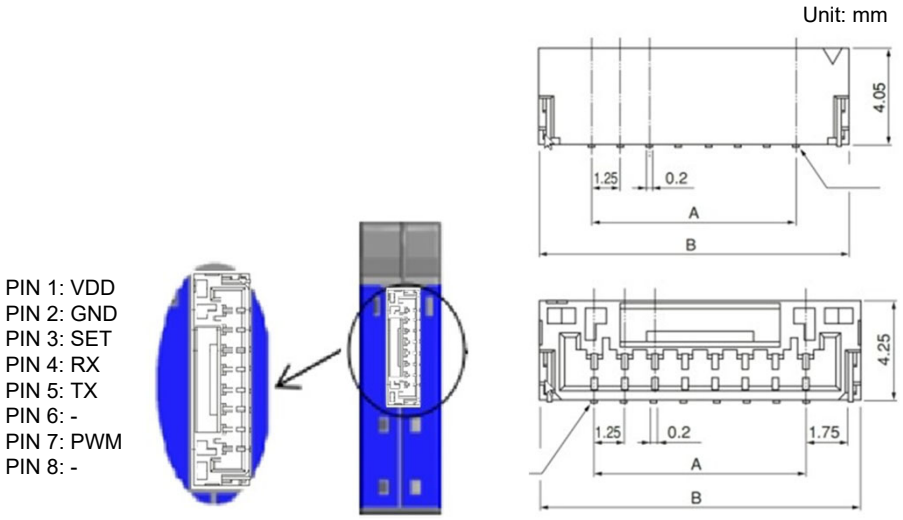
Applications

- Air purifiers
- Ventilation systems
- Portable instruments
- Air quality monitoring equipment
- Air conditioners
- Consumer electronics and other equipment supporting

Selection Table

Detectable Particle Diameter Range	Detection Range	Resolution	Detection Accuracy
0.3μm~10μm	0~1000μg/m³	1μg/m³	0~100μg/m³: ±15μg/m³; 101μg/m³~1000μg/m³: ±15% reading

Pin Assignment



Terminal Description: JST-SM08B-GHS-TB-8P connector, pin spacing is 1.25mm, and pin number is 8.

Pin Description

Pin Number	Pin Name	Type	Description
1	VDD	PWR	Module power input
2	GND	PWR	Ground
3	SET	ST	Power-saving mode configuration, active-low; Floating or normally operates at 3.3V high level
4	RX	ST	UART serial data input - baud rate of 9600bps
5	TX	CMOS	UART serial data output - baud rate of 9600bps
6	—	—	Reserved
7	PWM	O	PWM output
8	—	—	NC

Legend: O: Digital output; ST: Schmitt Trigger input;
PWR: Power; CMOS: CMOS output.

Absolute Maximum Ratings

Supply Voltage ..... V_{SS}-0.1V~V_{SS}+5.5V

Input Voltage ..... V_{SS}-0.1V~V_{DD}+0.1V

Storage Temperature..... -30°C~70°C

Operating Temperature..... -10°C~60°C

Total Power Dissipation 660mW

Note: These are stress ratings only. Stresses exceeding the range specified under “Absolute Maximum Ratings” may cause substantial damage to the sensor. Functional operation of the sensor at other conditions beyond those listed in the specification is not implied and prolonged exposure to extreme conditions may affect sensor reliability.

D.C. Electrical Characteristics

Symbol	Parameter	Test Conditions		Min.	Typ.	Max.	Unit
		V_{DD}	Conditions				
V_{DD}	Operating Voltage	—	—	4.8	5.0	5.5	V
I_{DD}	Operating Current	5.0V	—	—	60	120	mA

Functional Description

Solution Introduction

The BM25S3221-1 laser dust digital sensor is based on an integrated MCU. By using a high-accuracy linear optical sensor to sample the number of particles entering the light scattering measurement cavity in a unit time, it can calculate the total particle mass and concentration and then transmits data to an external MCU. The sensor module contains two output modes. The first output mode is the PWM output mode. In this mode, the sensor can directly convert a concentration signal into the PWM signal to output using the professional algorithms and calibration detection technology. The second output mode is the serial interface mode, which is subdivided into a serial interface automatic output mode and a serial interface communication mode. In the serial interface automatically output mode, when the sensor operates normally, it will output the current sensor state during a sampling period of about 1s using the TX pin with a baud rate of 9600bps. The serial interface communication mode is implemented using the TX/RX pins using the UART communication commands. In this way, the current detection concentration of the sensor module can be read using the TX pin. The sensor communication upload mode and sleep mode parameters can be modified using the RX pin. These two modes have their own special characteristics and can be chosen flexibly according to users' requirements. Refer to the related interface sections for details about how to use the above two output modes.

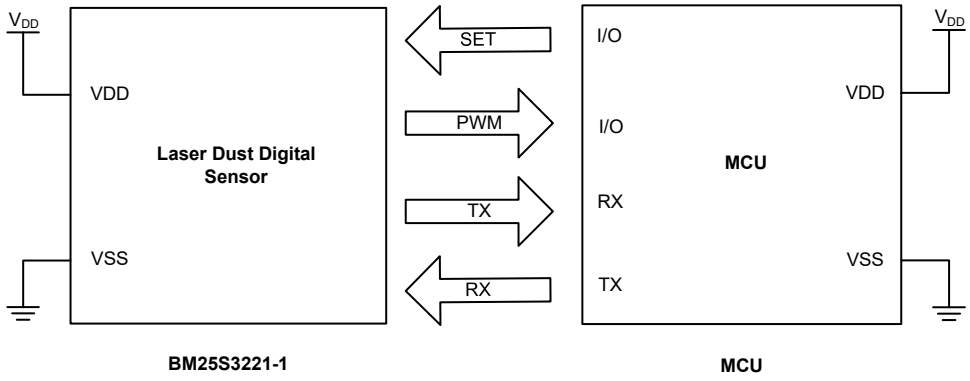
Operating Process

After the system is powered on, the BM25S3221-1 is initialised and warmed up. The default warm-up time is 30s. When the warm-up operation has completed, the sensor will enter the normal operating mode to execute sensor output sampling. In every sensor output sampling period, which is about every 1s, the dust particle diameter and concentration will be detected once, which will be automatically output using the serial interface. When the UART receives a falling edge on the RX pin, the sensor is woken up and will enter the UART receive interrupt routine and execute UART command transmit and receive operations.

Operating Principle

The laser dust sensor operates according to the laser principle. When the laser source and the detected dust particles enters the light scattering measurement cavity, the sensor will use the professional algorithms to sample, the obtained dust particle diameter and concentration data is converted into a voltage output. Using this characteristic, the output can be converted by an A/D converter and data can be converted into concentration data to output after being processed by the calibration concentration conversion reference point and professional algorithm of internal MCU.

Application Circuit



Interface Description

PWM Output Interface

The pin 7 PWM pin is the PWM signal output interface for the sensor to output the concentration. The dust particle concentration is calculated by the ratio of the high level output time in the PWM period to the whole output period. Refer to the calculation formula in the relevant sections for the detailed concentration calculation.

UART Serial Communication Interface

TX pin automatic output data: Under normal conditions, every sampling period the TX pin will automatically output the sensor current detected data such as particle diameter, concentration and other data.

TX/RX pin serial interface communication: The external MCU can configure the sensor or obtain sensor data using the UART serial communication port TX/RX. This could be obtaining the current concentration or modifying the communication upload mode and sleep mode parameters, etc.

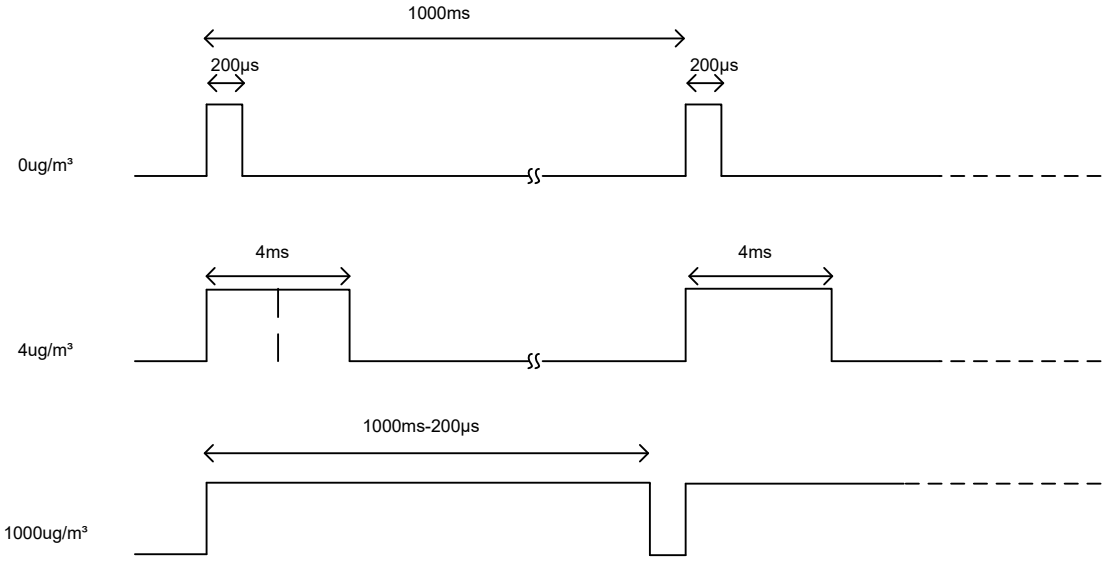
PWM Output

PWM Output Description

Detection range	0~1000μg/m³
PWM signal voltage	3.3V level (default)
PM2.5 concentration output range	0~1000μg/m³
Period	1000ms±5%
High level output at the period start	200μs (theoretical value)
Middle of the period	1000μs±5%
Low level output at the period end	200μs (theoretical value)

Note: The PWM signal can output PM2.5 data only.

PWM Output Concentration Calculation



To calculate the current PM2.5 concentration using PWM:

$$P(\mu g/m^3)=1000\times\frac{T_H}{T_H+T_L}$$

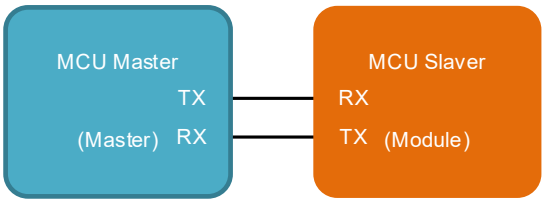
In the above formula, P is calculated value of PM2.5 concentration and its unit is μg/m³;

T_H is the high level time during one period.

T_L is the low level time during one period.

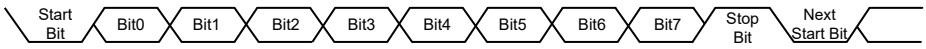
UART Serial Communication

The sensor RX pin will be at a high level under normal conditions. The external MCU transmits data using the UART transmit and receive data format using the TX pin. The start bit of the data is low. A falling edge on the RX pin will wake up the MCU for UART communication processing.



UART Transmit and Receive Data Format

The UART transmit and receive data format is composed of a start bit, data bits and a stop bit. The sensor uses a baud rate of 9600bps for data transmission. The following diagram shows the waveform for UART data transmission and reception.



TX Pin Serial Interface Automatic Output Data Format

When the module operates normally, for every sampling period of about 1s, a frame of data will be output at a baud rate of 9600bps. Each data frame contains 32 bytes as shown in the following table.

Data Number	Data Content	Description	Data Number	Data Content	Description
1	0x42	Fixed data	17	XX	Reserved
2	0x4D	Fixed data	18	XX	Reserved
3	0x00	Fixed data	19	XX	Reserved
4	0x1C	Fixed data	20	XX	Reserved
5	XX	Reserved	21	XX	Reserved
6	XX	Reserved	22	XX	Reserved
7	XX	Reserved	23	XX	Reserved
8	XX	Reserved	24	XX	Reserved
9	XX	Reserved	25	XX	Reserved
10	XX	Reserved	26	XX	Reserved
11	XX	PM1.0 concentration high byte (1)	27	XX	Reserved
12	XX	PM1.0 concentration low byte (1)	28	XX	Reserved
13	XX	PM2.5 concentration high byte (2)	29	XX	Reserved
14	XX	PM2.5 concentration low byte (2)	30	XX	Reserved
15	XX	PM10 concentration high byte (3)	31	XX	Check code high byte (4)
16	XX	PM10 concentration low byte (3)	32	XX	Check code low byte (4)

Note: 1. The current ambient PM1.0 concentration acceptable value is 0~1000μg/m³.
2. The current ambient PM2.5 concentration acceptable value is 0~1000μg/m³.
3. The current ambient PM10 concentration acceptable value is 0~1000μg/m³.
4. Check code calculation method in the initiative upload mode: Take the sum of the first 30 bytes as the check code. Its highest 8 bits will be stored in the 31st byte of the data frame. Its lower 8 bits will be stored in the 32nd byte of the data frame.

Example: If a frame of data received by the master using the serial interface is 42 4D 00 1C 00 54 00 6E 00 7C 00 04 00 0E 00 0C 00 00 00 00 00 00 00 00 00 00 00 00 00 00 02 07, it indicates that the current ambient PM1.0 concentration is 04H, the current PM1.0 concentration 0x04=4μg/m³ can be obtained.

If the current ambient PM2.5 concentration is 0EH, the current PM2.5 concentration 0x0E=15μg/m³ can be obtained.

If the current ambient PM10 concentration is 0CH, the current PM10 concentration 0x0C=12μg/m³ can be obtained.

UART Data Transmission Format

Master transmitted data format: The data frame transmitted by the master device consists of 9 bytes, which are command header, command, Data 0 to Data 5 and check code respectively. Each device has its own UART data command definitions, the details of which can be found in the relevant protocol.

Check code: Take the lower 8 bits of the sum of the 2nd byte to the 8th byte of the data frame, complement and increment by one.

Command Header	Data 0	Command	Data 1	…	Data 5	Check Code
8-bit	8-bit	8-bit	8-bit	…	8-bit	8-bit

Slave responsed data format: The slave responsed data consists of 9 bytes, which are mainly composed of command header, command, Data 0 to Data 5 and check code. The command header is fixed at 0xFF. The check code calculation method is the same as the master.

Command Header	Command	Data 0	…	Data 5	Check Code
8-bit	8-bit	8-bit	…	8-bit	8-bit

UART Communication Command Set Summary

Command type: The BM25S3221-1 laser dust digital sensor UART communication protocol contains two command types, query command and special modification command. There are 3 commands in total, including a query command and 2 special modification commands. For their detailed contents and definitions, refer to the corresponding command description sections.

The query command number and function are as follows:

Command Type	Command Number	Command	Command Function
Query Command	R01	86	Read the sensor concentration

The special modification command number and function are as follows:

Command Type	Command Number	Command	Command Function
Special Modification Command	W01	78	Modify the upload mode - initiative upload mode and Q&A upload mode
	W02	A7	Modify the sleep mode - enter/exit the sleep mode

Query Command Description (R01)

Command R01										
	Master	Header	Data 0	Command	Data 1	Data 2	Data 3	Data 4	Data 5	Check Code
		FF	01	86	00	00	00	00	00	79
	Slave	Header	Command	PM2.5 Concentration		PM10 Concentration		PM1.0 Concentration		Check Code
				Higher 8-bit	Lower 8-bit	Higher 8-bit	Lower 8-bit	Higher 8-bit	Lower 8-bit	
		FF	86	00	85	00	96	00	65	FA
	Description: Read the sensor concentration. **Example**: A frame of data send by the master is FF 01 86 00 00 00 00 00 79, the slave device responses FF 86 00 85 00 96 00 65 FA, this indicates that the current sensor PM2.5 concentration is 0085H, the PM10 concentration is 0096H, and the PM1.0 concentration is 0065H. The current PM2.5 concentration can be obtained which is 0x0085=133μg/m³. The current PM10 concentration can be obtained which is 0x0096=150μg/m³. The current PM1.0 concentration can be obtained which is 0x0065=101μg/m³.									

Special Modification Command Description (W01~W02)

Command W01	Master	Header	Data 0	Command	Data 1	Data 2	Data 3	Data 4	Data 5	Check Code
		FF	01	78	XX	00	00	00	00	XX
	Description: Modify the communication upload mode. When the Data 1 is 40H, the sensor will enter the initiative upload mode, in which the serial interface automatically outputs data during every sensor detect period. When Data 1 is 41H, the sensor will enter the Q&A upload mode. The serial interface outputs data only when there is a query command. **Example**: 1. A frame of data send by the master FF 01 78 40 00 00 00 00 47, this indicates that the communication is set to the initiative upload mode. 2. A frame of data send by the master FF 01 78 41 00 00 00 00 46, this indicates that the communication is set to the Q&A upload mode.									

Command W02	Master	Header	Data 0	Command	Data 1	Data 2	Data 3	Data 4	Data 5	Check Code
		FF	01	A7	XX	00	00	00	00	XX
	Slave	Header	Command	Data 0	Data 1	Data 2	Data 3	Data 4	Data 5	Check Code
		FF	A7	XX	00	00	00	00	00	XX
	Description: Modify the sleep mode. The master Data 1 is set to 01H to enter the sleep mode and is set to 00H to exit the sleep mode. The slave Data 0 responses 01H to indicate that the sleep mode is configured successful and it responses 00H indicates that the module failed to configure the sleep mode. **Example**: 1. A frame of data send by the master FF 01 A7 01 00 00 00 00 57, the slave responses FF A7 01 00 00 00 00 00 58, this indicates that it successfully enters into the sleep mode. 2. A frame of data send by the master FF 01 A7 01 00 00 00 00 57, the slave responses FF A7 00 00 00 00 00 00 59, this indicates that it failed to enter the sleep mode. 3. A frame of data send by the master FF 01 A7 00 00 00 00 00 58, the slave responses FF A7 01 00 00 00 00 00 58, this indicates that the sleep mode is successfully exited. 4. A frame of data send by the master FF 01 A7 00 00 00 00 00 58, the slave responses FF A7 00 00 00 00 00 00 59, this indicates that it failed to exit the sleep mode.									

Considerations

1. It is forbidden to remove the shield cover of the sensor and the internal fixing screw of the sensor, because the shield cover of the sensor is connected with the internal power supply of the sensor through the internal spring. If the shield cover of the sensor is removed, the anti-interference ability of the sensor will be poor, the output value of the sensor will change, and the performance of the sensor will be poor. In addition, and please pay attention to the metal shield of the sensor, avoid contact with other external circuits or conductive parts, so as to reduce the impact of external interference on the sensor.
2. Excessive impact or vibration will affect the accuracy and life of the sensor detection value, so the sensor should avoid falling or vibration when installing and using.
3. This sensor is suitable for the detection of dust particles in the ordinary indoor environment. The actual operating environment should try to avoid oil&smoke environment, too large dust particles, high humidity environment, such as: kitchen, bathroom, smoking room, outdoor environment, etc. If it is used in such environments, corresponding protective measures shall be added to the user's equipment to prevent viscous particles or large particles from entering the interior of the sensor and forming accumulation in the interior of the sensor which will affect the performance of the sensor. (For example, in the operating environment with floccules or fibers, the corresponding coarse filter net should be added ahead the air inlet of the sensor to avoid floccules or large sundries from entering the sensor and blocking the light path of the sensor, thus affecting the detection accuracy of the sensor.)
4. The fan is the air outlet, and the dust collection hole is the air inlet. When the sensor is installed and used, the sensor should avoid strong air flow interference. If it cannot be avoided, try to keep the direction of the external airflow perpendicular to the direction of the sensor internal airflow. During the using of the sensor, the sensor should not be directly placed inside the air duct of the purifier. If it cannot be avoided, an independent space structure should be set up for the installation position of the sensor. The air flow direction is as shown in 'Installation Method'. The sensor should not be impacted by the air flow in the direction of the red arrow. There should

be no obstructions within 2cm around the outlet of the fan. In this independent space, it should be avoided that the air flow from the outlet directly flows back to the inlet, which will affect the accuracy of detection.

5. Under normal operating condition of normal temperature and pressure, the key component of the laser sensor, can work continuously for more than 10000 hours, and the life of the sensor can be greatly prolonged by setting the sensor's sleep mode and interval operating time. The maximum cumulative life of the sensor can be more than 3 years. Refer to the user interface commands for detailed operation methods, or you can contact our technical service staff by telephone or email.
6. The sensor data mentioned in this manual is about to ensure the consistency of the sensors we produced, the comparison standard will not refer to any third-party testing instruments or data. If the user wants the final detection results to be consistent with the third-party testing instrument, the user can do data fitting correction according to the actual detection results.

Dimensions

Unit: mm