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Ultra-compact Smoke Detector Digital Sensor

BM22S2301-1

Revision: V1.10 Date: November 03, 2025

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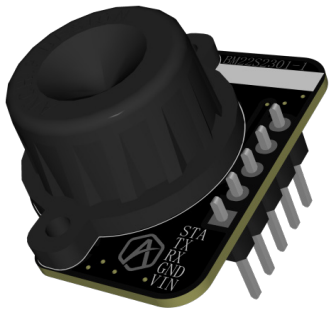
Features

- Operating voltage: 6.0V ~ 28.0V
- Operating current: 2.0mA @ 12V(Typ.)
- Sleep current: 5.0μA @ 12V(Typ.)
- Detection range: 0.1 ~ 1.0dB/m
- Temperature compensation and drift compensation functions
- Adjustable alarm sensitivity
- Communication interfaces: UART / STATUS
- Communication mode: UART communication
- Communication baud rate: 9600bps



General Description

The BM22S3021-1 is an ultra-compact smoke detector digital sensor which includes an integrated MCU as the master device. The sensor uses the principle of photoelectric operation, using infrared and blue light receiving SMD integrated sensor combined with an ultra-small labyrinth. With the MCU unique software algorithm, it can effectively identify various types of smoke. The sensor has the advantages of high integration, small size, long service life, easy operation, no external drive circuit, low cost, etc. In summarising, this is a digital sensor especially designed for smoke detection applications and suitable for use in energy storage cabinet smoke alarms, new energy fire detection, IoT devices, etc.

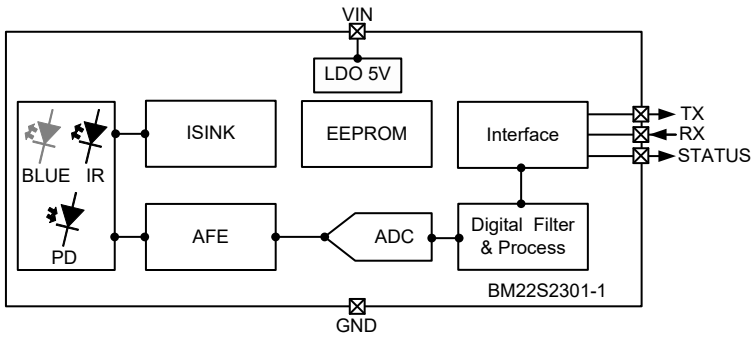
Applications

- Energy storage cabinet smoke alarms
- New energy fire detection
- PACK level fire detector
- IoT devices

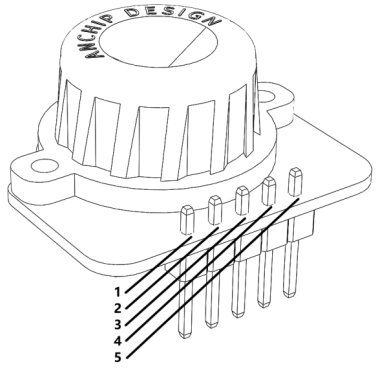
Selection Table

Part Number	Detection Type	Detection Range	Interface
BM22S2301-1	Smoke	0.1 ~ 1.0dB/m	UART / STATUS

Block Diagram



Pin Assignment



Pin Description

Pin Number	Pin Name	Type	Description
1	VIN	PWR	Power supply voltage input
2	GND	PWR	Ground
3	RX	I	UART RX serial data input – TTL voltage level 5.0V
4	TX	O	UART TX serial data output –TTL voltage level 5.0V
5	STATUS	O	Alarm level output –high voltage level of 5.0V, default output low in non-alarm status

Legend: PWR: Power; I: Digital input; O: Digital output;

Absolute Maximum Ratings

Supply Voltage ..... V_{SS}-0.1V to V_{SS}+30V

Port Input Voltage..... V_{SS}-0.1V to V_{SS}+5.1V

Storage Temperature.....-15°C to 60°C

Operating Temperature.....-10°C to 55°C

Total Power Dissipation 300mW

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

Ta=25°C

Symbol	Parameter	Test Conditions		Min.	Typ.	Max.	Unit
		V_{IN}	Conditions				
V_{IN}	Power Supply Voltage	—	—	6.0	12.0	28.0	V
I_{DD}	Operating Current (1)	12V	—	—	2.0	6.0	mA
I_{STB}	Sleep Current (1)	12V	Enter shutdown mode	—	5.0	17.0	μA
V_{IO}	Port Voltage (2)	12V	—	4.9	5.0	5.1	V

Note: (1) Current test method: without peripheral load and take the average value after testing for a period of time.
(2) The port include RX, TX and STATUS.

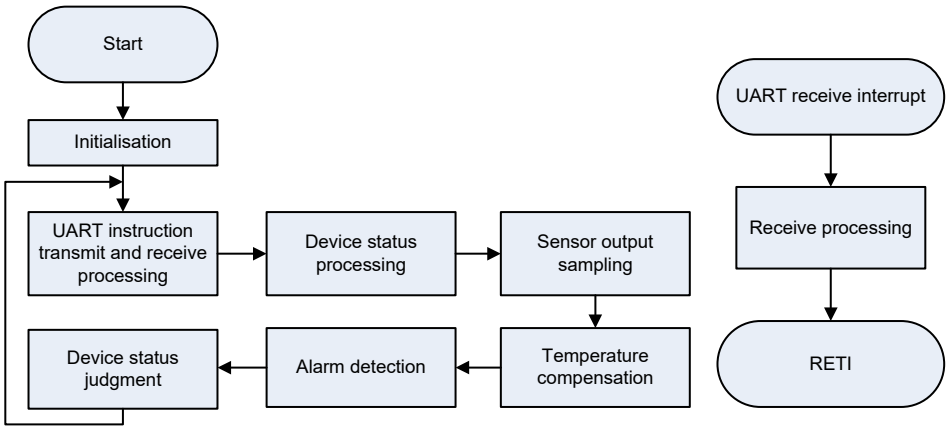
Functional Description

Solution Introduction

The BM22S2301-1 ultra-compact smoke detector digital sensor uses the photoelectric smoke detection principle and consists of infrared and blue lights receiving SMD integrated sensor combined with an ultra-small labyrinth. The sensor includes an integrated MCU as the master device, and the MCU integrates smoke detection AFE circuit and a dual-channel ISINK driver circuit, of which channel A is the blue light (BLUE) channel and channel B is the infrared (IR) channel. When there is a certain concentration of smoke in the environment where the sensor is located, the PD output signal will change. The sensor will process this signal internally, and then transmit the processed data to external through the UART interface. The sensor module has two output modes. The first output mode is the level output mode. Under normal conditions, the STATUS pin defaults to output low. When the smoke concentration is detected to have reached the alarm threshold, the pin will change to a high level. The second output mode is the UART mode, which is subdivided into UART automatic output mode and UART communication mode. In the UART automatic output mode, when the sensor operates normally, it will output the current sensor status every sampling period (about 1s) using the TX pin. The UART communication mode is implemented using the TX/RX pins via UART communication instructions. In this way, the detailed sensor module status can be read and the sensor parameters such as the alarm value can be modified. These two modes have their own special characteristics and can be chosen according to the users' requirements, the detailed usage of which can be obtained from the relevant interface section.

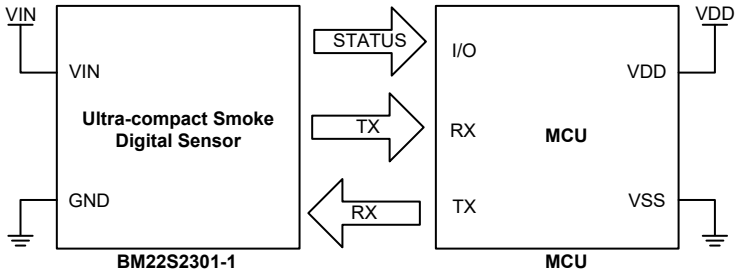
Operation Flow

After the system is powered on, the BM22S2301-1 is initialized within 5s. If there are no other problems after the initialization is complete, the sensor enters the normal operation mode. In the normal operation mode, the sensor performs smoke detection, fault detection, device status processing, etc. Every sensor output sampling period (about 1s) the sampling value of the current smoke sensor can be obtained, this data will be automatically output using the UART interface along with the data such as the device status. The sensor can also receive data through the RX pin to enter the UART receive interrupt and perform UART instruction transmit and receive processing.



BM22S2301-1 Operation Flowchart

Application Circuits



Note: When application, attention should be paid to avoid voltage backflow caused by pin voltage level mismatch. If the communication pin voltage of the BM22S2301-1 sensor and the external MCU is different, it is recommended to add a level matching circuit.

Interface Description

Level Output Interface: STATUS

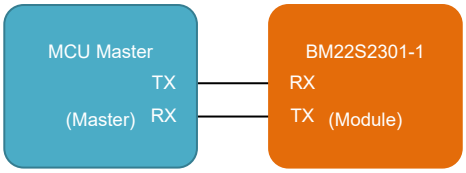
Under normal conditions, Pin 5, STATUS, defaults to low. When the sensor detects that the smoke concentration in the environment has exceeded the preset alarm value, the sensor will enter the alarm status and the pin will change from low to high. When the sensor exits alarm status, the pin will reset back to low. If necessary, the pin can be changed to output high under normal operations by modifying the instructions.

UART Serial Communication Interface: TX/RX

TX pin automatic output data: Under normal conditions, every sampling period the TX pin will automatically output the data such as the current sensor status, real-time smoke sampling value, etc.

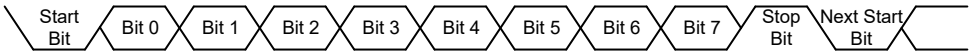
TX/RX pin serial interface communication: The external MCU can configure the sensor registers or obtain sensor data using the UART serial communication port, such as obtaining the current smoke sampling value, obtaining or modifying the sensor smoke alarm threshold, etc.

UART Serial Communication



UART Transmit and Receive Data Format

The UART transmit and receive data format is composed of a start bit, 8 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

When the module operates normally, every sampling period will output a frame of data, which can be set by the registers. The output data is the same as the returned data of the slave in instruction U2 (query the current status and data). For the details, refer to the corresponding instruction description.

UART Data Transmission Format

Master sent data format: The data frame sent by the master device consists of 4 bytes (fixed length), which are instruction, address, data and check code respectively. The related instruction definitions are different depending upon the slave device, the details of which can be found in the relevant protocol.

Instruction	Address	Data	Check Code
8-bit	8-bit	8-bit	8-bit

Check code: Take the lower 8 bits of the sum of all data, complement and increment by one, the calculated result will then be known as the check code. For example if the instruction is 0xAF 0x00 0x00, its check code is 0x51.

Slave returned data format: The data returned from the slave device has variable length and mainly composed of instruction header, data length, device type, protocol version, return instruction, data 0 ~ data N and check code. The instruction header is fixed at 0xAA, the data length is the length from the instruction header to the check code (i.e., the length of all data). The device type is used to indicate what the current slave type is, the protocol version refers to the version of the UART communication protocol used by the current slave and the return instruction corresponds to the instruction sent by the master. Data 0 ~ Data N is the returned data under different instructions, the check code calculation method is the same as the master.

Instruction Header	Data Length	Device Type	Protocol Version	Return Instruction	Data 0	…	Data N	Check Code
8-bit	8-bit	8-bit	8-bit	8-bit	8-bit	…	8-bit	8-bit

UART Communication Instruction Set Summary

Instruction type: The ultra-compact smoke detector digital sensor BM22S2301-1 UART communication protocol contains 6 instructions in total.

The general instruction number and function are as follows:

Instruction Number	Instruction Header	Address	Instruction Function
U0	AF	00	Device reset
U1	AB	00	Trigger zero point calibration(calibration zero)
U2	AC	XX	Query current device status and data
U3	E8	XX	Modify the registers at specified address
U4	D8	XX	Read the registers at specified address
U5	A0	00	Factory reset

Instruction Description

Instruction U0									
	Master	Instruction Header	Address	Data					Check Code
		AF	00	00					51
	Slave	Instruction Header	Data Length	Device Type	Protocol Version	Return Instruction	Return Address	Data	Check Code
		0	1	2	3	4	5	6	7
		AA	08	12	01	AF	00	00	8C
Description: Reset the sensor module. **Example**: If a frame of data send by the master is AF 00 00 51 and the slave device returns AA 08 12 01 AF 00 00 8C.									

Instruction U1	Master	**Instruction Header**	**Address**	**Data**					**Check Code**
		AB	00	00					55
	Slave	**Instruction Header**	**Data Length**	**Device Type**	**Protocol Version**	**Return Instruction**	**Return Address**	**Data**	**Check Code**
		0	1	2	3	4	5	6	7
		AA	08	12	01	AB	D0	XX	XX

Description: trigger zero point calibration (calibration zero), and the calibration time is 8s. During calibration, the data bit returns the current calibration timing in real time. If calibration is successful, it returns 0xA0. If failed, it returns 0xF0.

Example: The master sends AB 00 00 55.
and the slave device returns (once per second)
AA 08 12 01 AB D0 00 C0
AA 08 12 01 AB D0 01 BF
AA 08 12 01 AB D0 02 BE
AA 08 12 01 AB D0 03 BD
.....
AA 08 12 01 AB D0 A0 20 (successful)
or
AA 08 12 01 AB D0 F0 D0 (failed)
If calibration is successful, the sensor will enter normal detection mode. If failed, the sensor will enter an un-calibrated state and erase the original records.

Instruction U2	Master	**Instruction Header**	**Address**	**Data**					**Check Code**
		AC	XX	00					XX
	Slave	**Instruction Header**	**Data Length**	**Device Type**	**Protocol Version**	**Return Instruction**	**Device State**	**Reserved**	
		0	1	2	3	4	5	6~15	
		AA	XX	12	01	AC	[7:0]		
		Channel A Smoke Sampling Value		**Channel B Smoke Sampling Value**		**Channel A Calibration Zero**		**Channel B Calibration Zero**	
		16	17	18	19	20	21	22	23
		[7:0]	[15:8]	[7:0]	[15:8]	[7:0]	[15:8]	[7:0]	[15:8]
		Channel A Alarm Threshold Value		**Channel B Alarm Threshold Value**		**Reserved**			
		24	25	26	27	28~31			
		[7:0]	[15:8]	[7:0]	[15:8]				
		NTC Temperature		**Reserved**					**Check Code**
		32	33	34~39					40
		[7:0]	[15:8]						XX

Description: Query the current device status and data.
When the address is set to 0x80, the serial interface automatically outputs data 0~39 and check code.
When the address is set to 0x81, the serial interface automatically outputs data 0~19 and check code.

Note: The serial interface automatically output data is also the instruction data, and the serial interface automatically output register can control the output data type. For example, when set to simple data output, the serial interface automatically outputs data 0~19 and check code.

Byte 5: Device status:
Bit 0: Bit 0 will be set to 1 if the device is calibrated. Otherwise, bit 0 is zero.
Bit 1: Bit 1 will be set to 1 if the device is in a pre-alarm status. Otherwise, bit 1 is zero.
Bit 2: Bit 2 will be set to 1 if the device is in an alarm status. Otherwise, bit 2 is zero.
Bit 3: Bit 3 will be set to 1 if the device is in a fault condition. Otherwise, bit 3 is zero.
Bit 4: Bit 4 will be set to 1 if non-smoke interference is detected. Otherwise, bit 4 is zero.
Bit 5: Reserved.
Bit 6: High concentration signal flag, it will be set to 1 if there is a high concentration signal.
Bit 7: Reserved.

Byte 06~Byte15: Reserved

Byte 16~Byte17: Channel A smoke sampling value: Channel A sampling data (16-bit signed data).

Byte 18~Byte19: Channel B smoke sampling value: Channel B sampling data (16-bit signed data).

Byte 20~Byte21: Channel A calibration zero: Channel A calibration zero (16-bit signed data).
Byte 22~Byte23: Channel B calibration zero: Channel B calibration zero (16-bit signed data).
Byte 24~Byte25: Channel A alarm threshold value: Channel A alarm threshold value (16-bit unsigned data).
Byte 26~Byte27: Channel B alarm threshold value: Channel B alarm threshold value (16-bit unsigned data).
Byte 28~Byte31: Reserved
Byte 32~Byte33: NTC temperature: It is a 16-bit signed data, which is the actual temperature °C ×10. (Note: It is only used for internal smoke sampling temperature compensation.)
Byte 34~Byte39: Reserved

Instruction U3									
	Master	**Instruction**	**Address**	**Data Length**	**Data 0**	**Data 1**	**…**	**Data N**	**Check Code**
		E8	XX	XX	XX	XX	XX	XX	XX
	Slave	**Instruction Header**	**Data Length**	**Device Type**	**Protocol Version**	**Return Instruction**	**Return Address**	**Return Data Length**	
		AA	XX	12	01	E8	XX	XX	
		Data 0	**Data 1**	**…**	**Data N**	**Check Code**			
		XX	XX	XX	XX	XX			

Description: Modify the register at the specified address
Example: The master sends E8 02 04 10 04 80 80 FE and the slave returns AA 0C 12 01 E8 02 04 10 04 80 80 35. This indicates that the data 0x10, 0x04, 0x80 and 0x80 are written to the register at the address of 0x02, 0x03, 0x04 and 0x05 respectively.

Instruction U4								
	Master	**Instruction**	**Start Address**			**Data Length**		**Check Code**
		D8	XX			XX		XX
	Slave	**Instruction Header**	**Data Length**	**Device Type**	**Protocol Version**	**Return Instruction**	**Return Address**	**Return Data Length**
		AA	XX	12	01	D8	XX	XX
		Data 0	**Data 1**	**…**	**Data N**	**Check Code**		
		XX	XX	XX	XX	XX		

Description: Read the register at the specified address
Example: The master sends D8 02 04 22 and the slave returns AA 0C 12 01 D8 02 04 10 04 80 80 45. This indicates that the data 0x10, 0x04, 0x80 and 0x80 are written to the register at the address of 0x02, 0x03, 0x04 and 0x05 respectively.

Instruction U5									
	Master	**Instruction**	**Address**	**Data**					**Check Code**
		A0	00	00					60
	Slave	**Instruction Header**	**Data Length**	**Device Type**	**Protocol Version**	**Return Instruction**	**Return Address**	**Data**	**Check Code**
		0	1	2	3	4	5	6	7
		AA	08	12	01	A0	00	00	9B

Description: Factory reset. After this instruction is sent, reset all register configurations to their factory default settings and reset to the factory calibration data.

Note: 1. In this document, all slaves/devices refer to ultra-compact smoke detector digital sensors, unless otherwise specified. Master refers to external MCU or master computer that communicates with slave
2. The last byte of the 4-byte instruction sent by the master is the check code. Ensure the check code is correct otherwise the slave will consider the received data is incorrect and ignore it. Refer to the UART data format description section for the check code calculation method.
3. Data transmission and reception is in hexadecimal format unless otherwise specified.
4. When the sensor is in the calibrating status, do not execute other instructions.
5. It is recommended to execute zero calibration (zero adjustment) under any of the following situations:
   (1) When the sensor is powered on for the first time
   (2) After a long period of power-off
   (3) After switching from shutdown mode to normal operation mode
   (4) When the operating environment changes

Register List

The following registers can be read and write through the read and write instruction.

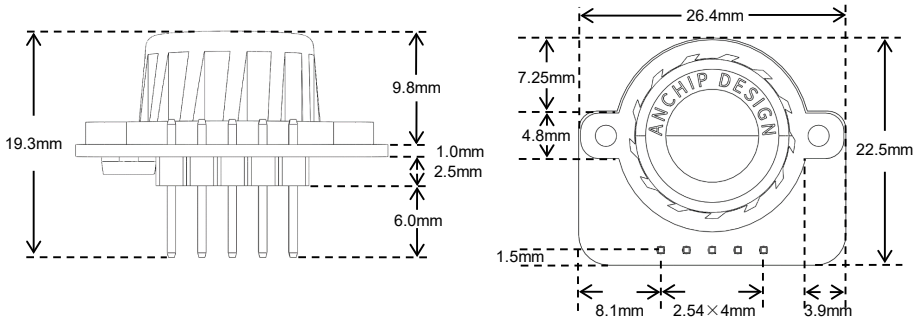
Register		Address	Type	Default	Description
Channel A Alarm Threshold value	[7:0]	0x00	Read/Write	0x9A	Channel A alarm judgment threshold value, which is the slow fire alarm threshold value. Setting range: 500~10000.
	[15:8]	0x01	Read/Write	0x07	
Channel B Alarm Threshold value	[7:0]	0x02	Read/Write	0xA0	Channel B alarm judgment threshold value, which is the rapid fire alarm threshold value. Setting range: 500~10000.
	[15:8]	0x03	Read/Write	0x03	
Serial Interface Automatically Output		0x04	Read/Write	0x80	0x80: automatically output 41 bytes data 0x81: only output 21 bytes data 0x00: not automatically output data.
Alarm output level		0x05	Read/Write	0x80	0x80 means high level is active, and other values mean low level is active.
Shutdown mode		0x06	Read/Write	0x00	Set 0xCE to enter the shutdown mode, which will not perform any detection and the serial interface data will not be automatically output. Set any value except 0xCE will exit the mode.
Fault status		0x07	Read	0x00	Bit 0~Bit 2: If any bit is set to 1, it indicates that optical sensor is in a fault status. Bit 3: If the bit is set to 1, it indicates that NTC thermistor is in a fault status. Bit 4: If the bit is set to 1, it indicates that other peripheral components is in a fault status.
Device status		0x08	Read	0x81	Bit 0: this bit will be set to 1 if the device is calibrated. Otherwise, this bit is zero. Bit 1: this bit will be set to 1 if the device is in a pre-alarm status. Otherwise, this bit is zero. Bit 2: this bit will be set to 1 if the device is in an alarm status. Otherwise, this bit is zero. Bit 3: this bit will be set to 1 if the device is in a fault status. Otherwise, this bit is zero. Bit 4: this bit will be set to 1 if non-smoke interference is detected. Otherwise, this bit is zero. Bit 5: Reserved Bit 6: High concentration signal flag, it will be set to 1 if there is a high concentration signal Bit 7: Reserved

Note: 1. Do not randomly change any unspecified register addresses which may cause the sensor to operate abnormally.
2. The default values of registers may vary with version updates.
3. The default alarm thresholds for channel A and channel B of different sensors may be different.

Considerations

1. Supply power to the sensor strictly according to its supply voltage, and it is recommended to use a power supply with better quality and less ripple.
2. Avoid making the sensor operating in a high temperature and high humidity environment for a long time, and note that drastic change in environmental temperature will has a certain impact on sensor output.
3. Pay attention to electrostatic protection and avoid directly touching the sensor components or pins with hands.
4. The sensor is sensitive to electromagnetic interference. Strong electromagnetic interference in the operating environment may affect the sensor output.
5. Violent vibration, strong impact or drop should be avoided during sensor storage or use.
6. Keep the sensor clean during storage and use to avoid contact with corrosive chemical reagents.
7. Do not disassemble the sensor without permission.

Dimensions



*Note: Dimension tolerance: 0.2mm