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ANCHIP

Smoke Detector Digital Sensor

BM22S2021-1

Revision: V1.00 Date: June 29, 2022

Table of Contents

Features

- Operating voltage: 3.0V~5.0V
- Detection range: 0.1~0.8dB/m
- Temperature compensation and drift compensation function
- Adjustable alarm sensitivity
- Interfaces: UART (TX/RX)/STATUS
- Communication mode: UART communication
- Communication interface baud rate: 9600bps
- Standby current: < 15μA @ 3V
- Alarm current: < 20mA @ 3V

General Description

The BM22S2021-1 is a smoke detector digital sensor which includes an integrated MCU as the master device with a serial communication interface which offers widespread, flexible and convenient use. The sensor integrates dual-channel ISINK driver circuit and smoke detection AFE circuit. The sensor's small size advantage offers easy integration into product applications. Additional advantages include long service life, easy operation, no external drive circuit, low cost, etc. In summarising, this is a low-cost digital sensor especially designed for smoke detection applications and suitable for use in smoke alarms, smart homes, etc.

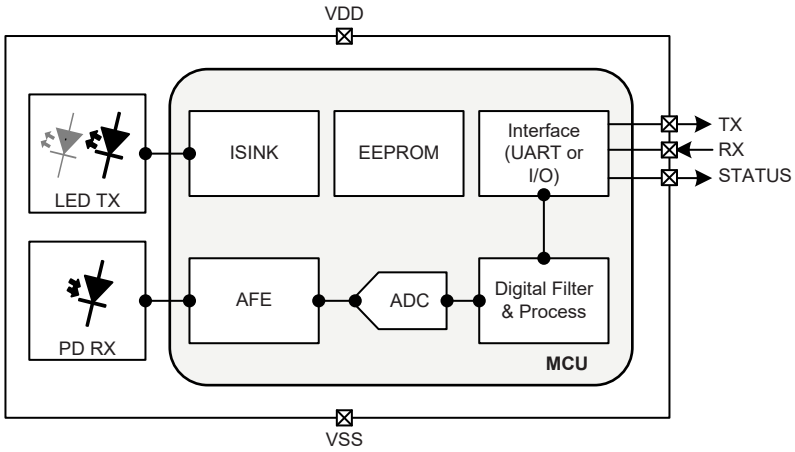
Applications

- Smoke alarms
- Smart homes
- IoT devices

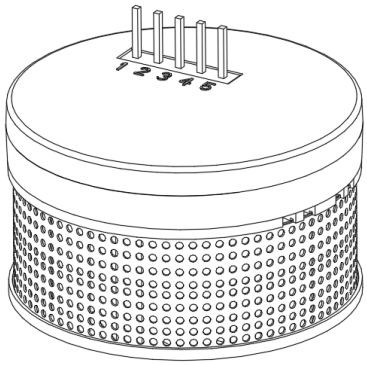
Selection Table

Part Number	Detection Type	Detection Range	Interface
BM22S2021-1	Smoke	0.1~0.8dB/m	UART (TX/RX)/STATUS

Block Diagram



Pin Assignment



Pin Description

Pin Number	Pin Name	Type	Description
1	VDD	PWR	Sensor module power input
2	VSS	PWR	Ground
3	RX	ST	UART RX serial data input – baud rate 9600bps
4	TX	CMOS	UART TX serial data output – baud rate 9600bps
5	STATUS	O	Level output – default output low

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

Absolute Maximum Ratings

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

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

Storage Temperature..... -15°C to 60°C

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

Total Power Dissipation 110mW

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_{DD}	Conditions				
V_{DD}	Operating Voltage	—	—	3.0	3.0	5.0	V
I_{DD}	Operating Current	3V	—	—	3	20	mA
I_{STB}	Standby Current	3V	Operating period: 8s	—	10	15	μA

Functional Description

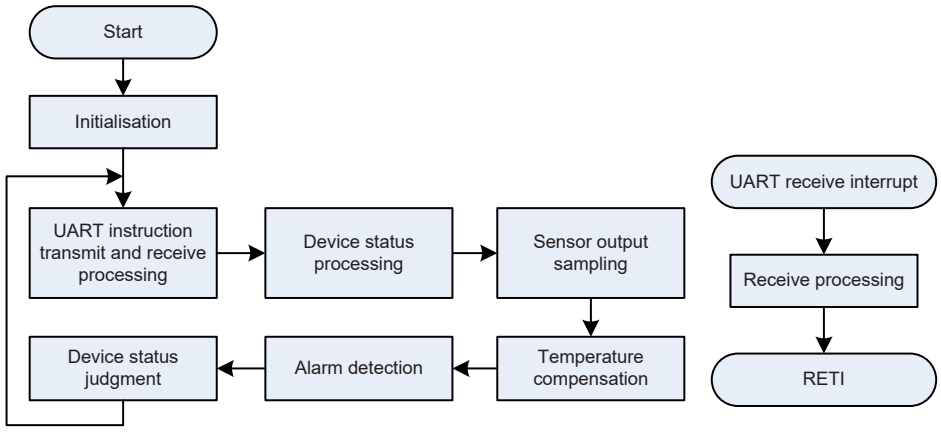
Introduction

The BM22S2021-1 smoke detector digital sensor includes an integrated MCU as the master device. The sensor uses the photoelectric smoke detection principle and integrates a dual-channel ISINK driver circuit and smoke detection AFE circuit. When there is a certain concentration of smoke in the environment where the sensor is located, the sensor will detect this using an infrared emitting diode and photodiode, and then transmit the processed data to an external MCU. 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 serial interface mode, which is subdivided into a serial interface automatic output mode and a serial interface communication mode. In the serial interface automatic output mode, when the sensor operates normally, it will output the current sensor status every sampling period (about 8s) using the TX pin (baud rate 9600bps). The serial interface communication mode is implemented using the TX/RX pins via UART communication instructions. In this way, the detailed sensor module status can be read using the TX pin and the sensor parameters such as the alarm value can be modified using the RX pin. 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

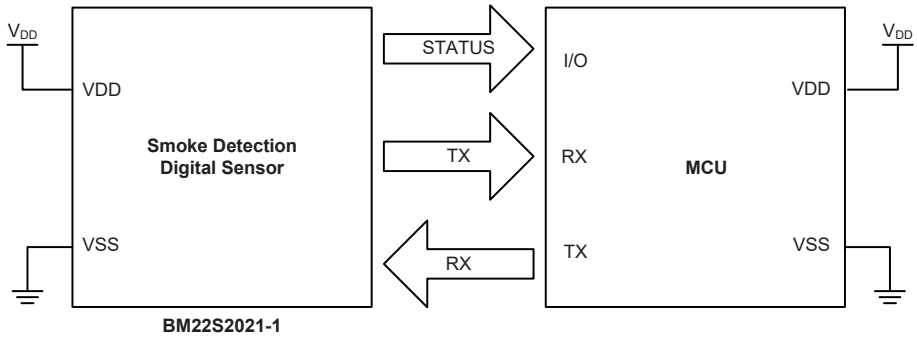
After the system is powered on, the BM22S2021-1 will be initialised. If there are no other problems after initialisation, the sensor enters its normal operation mode. In the normal operation mode, the sensor implements smoke detection, fault detection and device status processing in turn. Every sensor output sampling period, which has a default of 8s, the A/D value of the smoke sensor can be

obtained, which will be automatically output using the serial interface along with the data such as device status. 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 instruction transmit and receive operations.



Operation Flowchart

Application Circuits



Interface Description

Level Output Interface: STATUS

Under normal conditions, the pin 5 STATUS pin, defaults to a low value. 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 the alarm status, the pin will reset back to low. This pin can be modified to be high under normal conditions using instructions.

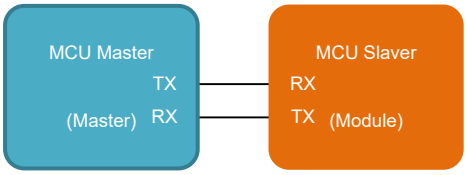
UART Serial Communication Interface: TX/RX

TX pin automatic output data: Under normal conditions, the TX pin will automatically output the sensor current operating status, the real-time smoke concentration A/D value and other data every sampling period, which has a default of 8s.

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 or setting the current smoke detection period, obtaining or modifying the sensor smoke detection parameter values, etc.

UART Serial Communication

The sensor RX pin will be at a high level under normal conditions. The external MCU sends 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

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 with a default of 8s, a frame of data will be output at a baud rate of 9600bps. This function can be set through a register and the output data is the same as the data returned from the slave in the instruction U3, which is query device status and data. Refer to the corresponding instruction description sections.

UART Data Transmission Format

Master sent data format: The data frame sent by the master device consists of a fixed length of 4 bytes, which are instruction, address, data and check code. The related instruction definitions are different depending upon the slave device. Each device has its own UART data instruction definitions, 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: This is calculated by taking the lower 8 bits of the sum of all the data, complementing them and incrementing by one. The calculated result will then be known as the check code. For example if the instruction is 0xE0 0x1A 0x15, its check code will be 0xF1.

Slave returned data format: The data returned from the slave device has a variable length and is 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, which is 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 for different instructions, the check code calculation method is the same as for 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 smoke detector sensor BM22S2021-1 UART communication protocol contains eight instruction types. For their detailed contents and definitions, refer to the corresponding instruction description sections.

The instruction number and function are as follows:

Instruction Number	Instruction Header	Address	Function
U0	AF	00	Sensor module reset
U1	AD	00	Query the production date and software version
U2	AB	00	Trigger the air calibration function
U3	AC	00	Query all current device status and data
U4	E0	XX	Modify the register at the specified address
U5	D0	XX	Read the register at the specified address
U6	D2	XX	Read the run variable at the specified address
U7	A0	00	Factory reset

Note: Do not randomly change any unspecified register addresses which may cause the sensor to operate abnormally.

Instruction Format

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
		AA	08	11	01	AF	00	00	8D

Description: Reset the device.
Example: When a data frame sent by the master is AF 00 00 51, the slave device returns AA 08 11 01 AF 00 00 8D.

Instruction U1								
	Master	Instruction Header	Address	Data				Check Code
		AD	00	00				53
	Slave	Instruction Header	Data Length	Device Type	Protocol Version	Return Instruction	Return Address	Software Version
		AA	0C	11	01	AD	00	XX XX
		Production Date			Check Code			
		XX	XX	XX	XX			

Description: Query the software version and production date. The software version number and production date are 8421 in BCD format.
Example: When a data frame sent by the master is AD 00 00 53, the slave device returns AA 0C 11 01 AD 00 01 20 21 01 12 36.
This indicates that the software version is: V1.20, production date: January 12, 2021.

Instruction U2	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
		AA	08	11	01	AB	D0	XX	XX

Description: Trigger the air calibration function, the calibration time is 8s. During the calibration process, the data bit will return to the current calibration timing in real time. After the calibration has completed, the data bits will return to 0xA0 and if it fails, it will return to 0xF0.

Examples: When a data frame sent by the master is AB 00 00 55, the slave device returns (once per second)

AA 08 11 01 AB D0 00 C1;
AA 08 11 01 AB D0 01 C0;
AA 08 11 01 AB D0 02 BF;
AA 08 11 01 AB D0 03 BE;
.....
AA 08 11 01 AB D0 A0 21; - calibration successful
or
AA 08 11 01 AB D0 F0 D1; - calibration failure

If the calibration is successful, the device will automatically enter the standby mode. The detection period will be determined by the set parameters. If the calibration fails, it will remain in the fast detection mode.

Instruction U3	Master	Instruction Header	Address	Data					Check Code
		AC	00	00					54
	Slave	Instruction Header	Data Length	Device Type	Protocol Version	Return Instruction	Device status	V_{BG} Voltage A/D Value	
		AA	29	11	01	AC	[7:0]	[7:0]	[15:8]
		Reference Value		T0A Status	T0B Status	Reserved		Reserved	
		[7:0]	[15:8]	[7:0]	[7:0]	[7:0]	[15:8]	[7:0]	[15:8]
		T0A Smoke Detection Value		T0B Smoke Detection Value		T0A Calibration Zero		T0B Calibration Zero	
		[7:0]	[15:8]	[7:0]	[15:8]	[7:0]	[15:8]	[7:0]	[15:8]
		T0A Alarm Threshold		T0B Alarm Threshold		A, B Channel Variation Ratio		Reserved	
		[7:0]	[15:8]	[7:0]	[15:8]	[7:0]		[7:0]	[15:8]
			Alarm Count	Temperature A/D Value		Reserved		Fault Count	Smoke Count
			[7:0]	[7:0]	[15:8]	[7:0]	[15:8]	[7:0]	[7:0]
		V_{DD} Voltage		Check Code					
		[7:0]	[15:8]	XX					

Description: Query the current device status and data.

Note: The serial interface automatically output data is also the instruction data. When register is set to 0x80 (detailed data), the serial interface automatically outputs complete data periodically. When the register is set to 0x81 (simple data), the serial interface automatically outputs data 0~19.

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: Reserved.
Bit 5: Initialisation flag.

Bit 6: Reserved.
Bit 7: Reserved.

Byte 6 ~ Byte 7: V_{BG} Voltage A/D Value: The MCU internal V_{BG} voltage A/D value.
Byte 8 ~ Byte 9: Reference Value: Smoke reference value.
Byte 10: T0A Status: The channel A status.
Bit 0: Bit 0 will be set to 1 if the channel is calibrated. Otherwise, bit 0 is zero.
Bit 1: Bit 1 will be set to 1 if the channel is in a pre-alarm status. Otherwise, bit 1 is zero.
Bit 2: Bit 2 will be set to 1 if the channel is in an alarm status. Otherwise, bit 2 is zero.
Bit 3: Bit 3 will be set to 1 if the channel is in a fault condition. Otherwise, bit 3 is zero.
Bit 4: Reserved.
Bit 5: Reserved.
Bit 6: Reserved.
Bit 7: Reserved.
Byte 11: T0B Status: The channel B status can refer to T0A status.
Byte 12 ~ Byte 13: Reserved.
Byte 14 ~ Byte 15: Reserved.
Byte 16 ~ Byte 17: T0A Smoke Detection Value: The channel A sampled data.
Byte 18 ~ Byte 19: T0B Smoke Detection Value (After filtering): The channel B sampled data.
Byte 20 ~ Byte 21: T0A Calibration Zero: The channel A calibration zero points.
Byte 22 ~ Byte 23: T0B Calibration Zero: The channel B calibration zero points.
Byte 24 ~ Byte 25: T0A Alarm Threshold: The channel A alarm threshold.
Byte 26 ~ Byte 27: T0B Alarm Threshold: The channel B alarm threshold.
Byte 28: A, B Channel Variation Ratio: The A, B channel variation ratio is 128 times the actual value, which is used as the main judgment basis for smoke recognition.
Byte 29 ~ Byte 30: Reserved.
Byte 31: Alarm Count: The device alarm count is a signed value. The count range: -12 ~ 3. When the device experiences interference from signals such as water vapor, it will be negative, otherwise it is positive.
Byte 32 ~ Byte 33: Temperature A/D Value: External thermistor A/D sample value.
Byte 34 ~ Byte 35: Reserved.
Byte 36: Fault Count: The count when the sensor fails.
Byte 37: Smoke Count: When smoke is detected, the count is 16, and decrements to 0 when there is no smoke.
Byte 38 ~ Byte 39: V_{DD} Voltage: The V_{DD} voltage is 1024 times the actual voltage of V_{DD}.

Instruction U4									
	Master	Instruction Header	Address	Data					Check Code
		E0	XX	XX					XX
	Slave	Instruction Header	Data Length	Device Type	Protocol Version	Return Instruction	Return Address	Data	Check Code
		AA	08	11	01	E0	XX	XX	XX

Description: Modify the register at the specified address
Example: The master sends E0 05 1F FC and the slave returns AA 08 11 01 E0 05 1F 38.
This indicates that the data 01FH is written to the register at address 05H.

Instruction U5									
	Master	Instruction Header	Address	Data					Check Code
		D0	XX	00					XX
	Slave	Instruction Header	Data Length	Device Type	Protocol Version	Return Instruction	Return Address	Data	Check Code
		AA	08	11	01	D0	XX	XX	XX

Description: Read the register at the specified address
Example: The master sends D0 05 00 2B and the slave returns AA 08 11 01 D0 05 1F 48.
This indicates that the data 01FH is read from the register at address 05H.

Instruction U6	Master	Instruction Header	Address	Data					Check Code
		D2	XX	00					XX
	Slave	Instruction Header	Data Length	Device Type	Protocol Version	Return Instruction	Return Address	Data	Check Code
		AA	08	11	01	D2	XX	XX	XX
Description: Read the run variable at the specified address **Example**: The master sends D2 51 00 DD and the slave returns AA 08 11 01 D2 51 27 F2. This indicates that the data read from the run variable at address 51H is 27H.									

Instruction U7	Master	Instruction Header	Address	Data					Check Code
		A0	00	00					60
	Slave	Instruction Header	Data Length	Device Type	Protocol Version	Return Instruction	Return Address	Data	Check Code
		AA	08	11	01	A0	00	00	9C
Description: Factory reset. After this instruction is sent, reset all parameter configurations to their factory settings.									

Note: 1. In this document, all slave devices refer to smoke detector digital sensors, unless otherwise specified.
2. The last byte of the 4-byte instruction sent by the master is the check code. Ensure that the check code is correct otherwise the slave will consider that 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.

Run Variable List

The following variables can be queried through the instruction U6:

Run Variable		Address	Type	Initial Value	Description
Device Status		0x90	Read Only	0x01	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: Reserved. Bit 5: Initialisation flag. Bit 6: Reserved. Bit 7: Reserved.
V_{BG} Voltage A/D Value	[7:0]	0x91	Read Only	—	The MCU internal V_{BG} voltage A/D value.
	[15:8]	0x92	Read Only	—	
Reference Value	[7:0]	0x93	Read Only	—	Smoke reference value.
	[15:8]	0x94	Read Only	—	

Run Variable		Address	Type	Initial Value	Description
T0A Status (channel A)		0x95	Read Only	0x11	Bit 0: Bit 0 will be set to 1 if the channel is calibrated. Otherwise, bit 0 is zero. Bit 1: Bit 1 will be set to 1 if the channel is in a pre-alarm status. Otherwise, bit 1 is zero. Bit 2: Bit 2 will be set to 1 if the channel is in an alarm status. Otherwise, bit 2 is zero. Bit 3: Bit 3 will be set to 1 if the channel is in a fault condition. Otherwise, bit 3 is zero. Bit 4: Reserved. Bit 5: Reserved. Bit 6: Reserved. Bit 7: Reserved.
T0B Status (channel B)		0x96	Read Only	0x11	The channel B status can refer to T0A status.
Reserved	[7:0]	0x97	Read Only	—	Reserved
	[15:8]	0x98	Read Only	—	
Reserved	[7:0]	0x99	Read Only	—	Reserved
	[15:8]	0x9A	Read Only	—	
T0A Smoke Detection Value	[7:0]	0x9B	Read Only	—	The channel A sampled data.
	[15:8]	0x9C	Read Only	—	
T0B Smoke Detection Value	[7:0]	0x9D	Read Only	—	The channel B sampled data.
	[15:8]	0x9E	Read Only	—	
T0A Calibration Zero	[7:0]	0x9F	Read Only	—	The channel A calibration zero points.
	[15:8]	0xA0	Read Only	—	
T0B Calibration Zero	[7:0]	0xA1	Read Only	—	The channel B calibration zero points.
	[15:8]	0xA2	Read Only	—	
T0A Alarm Threshold	[7:0]	0xA3	Read Only	—	The channel A alarm threshold.
	[15:8]	0xA4	Read Only	—	
T0B Alarm Threshold	[7:0]	0xA5	Read Only	—	The channel B alarm threshold.
	[15:8]	0xA6	Read Only	—	
A, B Channel Variation Ratio		0xA7	Read Only	—	The A, B channel variation ratio is 128 times the actual value, which is used as the main judgment basis for smoke recognition.
Reserved	[7:0]	0xA8	Read Only	—	Reserved.
	[15:8]	0xA9	Read Only	—	

Run Variable		Address	Type	Initial Value	Description
Alarm Count		0xAA	Read Only	—	The device alarm count is a signed value. The count range: -12 ~ 3. When the device experiences interference from signals such as from water vapor, it will be negative, otherwise it is positive.
Temperature A/D Value	[7:0]	0xAB	Read Only	—	External thermistor A/D sample value.
	[15:8]	0xAC	Read Only	—	
Reserved	[7:0]	0xAD	Read Only	—	Reserved
	[15:8]	0xAE	Read Only	—	
Fault Count		0xAF	Read Only	—	The count when the sensor fails.
Smoke Count		0xB0	Read Only	—	When smoke is detected, the count is 16 and decrements to 0 when there is no smoke.
V_{DD} Voltage	[7:0]	0xB1	Read Only	—	The V_{DD} voltage is 1024 times the actual voltage of V_{DD}.
	[15:8]	0xB2	Read Only	—	

Note: The variation ratio is calculated only after pre-alarm.

Register List

The following registers can be read and written using instructions U4 and U5.

Register			Address	Type	Default Value	Description
T0A	Calibration Upper Limit		0x08	R/W	0xC8	Channel A calibration upper/lower limit. 1/16 of the actual smoke detection value.
	Calibration Lower Limit		0x09	R/W	0x19	
T0B	Calibration Upper Limit		0x0A	R/W	0xC8	Channel A calibration upper/lower limit. 1/16 of the actual smoke detection value.
	Calibration Lower Limit		0x0B	R/W	0x19	
T0A Alarm Threshold		[7:0]	0x10	R/W	0x26	Channel A alarm judgment threshold, white smoke alarm threshold. Select 12-bit valid data.
		[15:8]	0x11	R/W	0x02	
T0B Alarm Threshold		[7:0]	0x12	R/W	0x64	Channel B alarm judgment threshold, black smoke (such as n-heptane fire) alarm threshold, select 12-bit valid data.
		[15:8]	0x13	R/W	0x00	
Standby Smoke Detection Period			0x2D	R/W	0x08	Detection period when the device is in standby in a smoke-free environment, the units are s. The device operates rapidly when there is smoke, and the detection period is fixed at 1s.
Serial Interface Automatic Output			0x2E	R/W	0x80	0x80: automatically outputs detailed data for each smoke detection. 0x81: only outputs simple data. 0x00: does not automatically output data.
Alarm Output Level			0x2F	R/W	0x80	0x80: Active high. 0x00: Active low.

Considerations

1. Only supply power to the sensor strictly according to its supply voltage.
2. The sensor should avoid being operated in high temperature and high humidity environments for long periods of time.
3. During storage or during sensor use, excessive vibration, heavy impacts or being dropped should be avoided.
4. Extreme environmental temperature changes will have a certain effect on the sensor.
5. It is recommended to clean the dust from the sensor regularly.

Dimensions