安禧普
ANCHIP

VOC Digital Sensor

# BM25S3421-1

Revision: V1.00 Date: October 16, 2023

# Table of Contents

**Features** ..... 3
**General Description** ..... 3
**Applications** ..... 3
**Selection Table** ..... 3
**Block Diagram** ..... 4
**Pin Assignment** ..... 4
**Pin Description** ..... 4
**Absolute Maximum Ratings** ..... 5
**D.C. Electrical Characteristics** ..... 5
**Functional Description** ..... 5
Solution Introduction ..... 5
Operation Flow ..... 5
Gas Sensor Characteristics ..... 6
Application Circuits ..... 6
**Interface Description** ..... 7
Alarm Status Level Output Interface ..... 7
UART Serial Communication Interface ..... 7
**UART Serial Communication** ..... 7
UART Transmit and Receive Data Format ..... 7
TX Pin Serial Interface Automatic Output Data Format ..... 7
UART Data Transmission Format ..... 8
UART Communication Instruction Set Summary ..... 9
**Considerations** ..... 15
Usage Description ..... 15
Situations that Must Be Avoided ..... 15
Situations that Should Be Avoided ..... 16
**Dimensions** ..... 17

## Features

- Operating voltage: 3~5V
- Operating current: 18mA @ 3.3V (Typical)
- Output level: Level 1~Level 4
  (The corresponding concentration is from low to high)
  Detection range: 0~10PPM
- Interfaces: UART (TX/RX)/STATUS
- Communication mode: UART communication
- Communication interface baud rate: 9600bps
- Default alarm threshold: Level 3
- Factory calibration, default warm-up time: 180s

## General Description

The BM25S3421-1 is a MEMS VOC digital sensor, which includes an integrated MCU as the master device with a serial communication mode, which can offer widespread and convenient use.

The sensor has the advantages of small size, convenience of integration into product applications, long service life, easy operation, no external drive circuit, low cost, etc. To summarise, it is a low-cost digital sensor specially designed for air quality monitoring applications and suitable for use in air cleaner, fresh air ventilation system, intelligent integrated ceiling, air quality monitor, ventilator, air conditioner, etc.

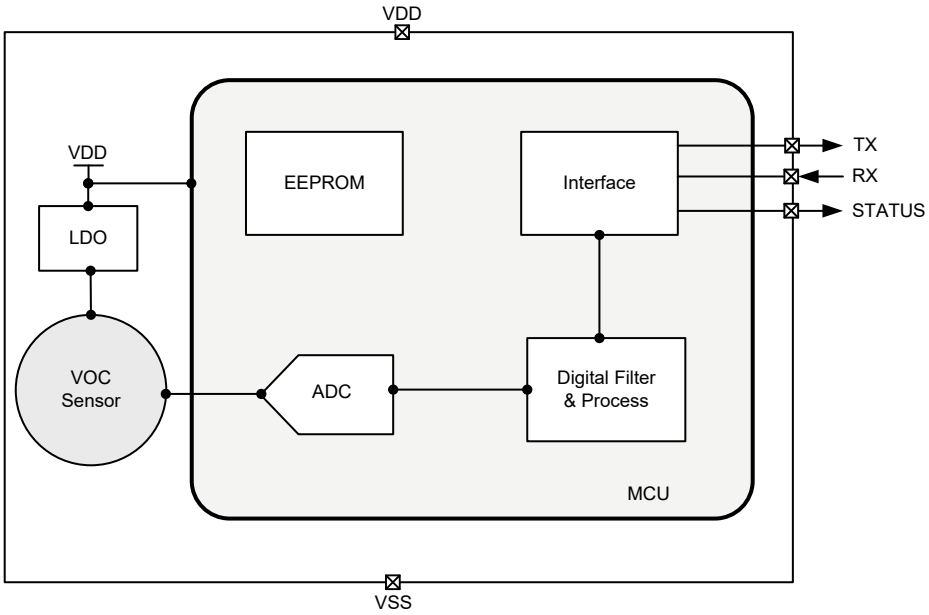
## Applications

- Air cleaner
- Fresh air ventilation system
- Intelligent integrated ceiling
- Air quality monitor
- Ventilator
- Air conditioner

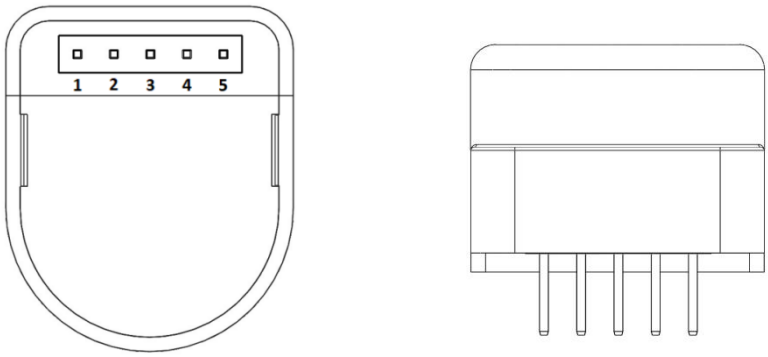
## Selection Table

| Part No. | Gas Type | Output level | Interface |
|---|---|---|---|
| BM25S3421-1 | VOC gases<br>(Ethanol, formaldehyde, toluene) | Level 1 ~ Level 4<br>(The corresponding concentration is from low to high) | UART (TX/RX)/STATUS |

## Block Diagram




## Pin Assignment




## Pin Description

| Pin Number | Pin Name | Type | Description |
|---|---|---|---|
| 1 | VDD | PWR | Sensor module power input (3~5V) |
| 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 | Alarm level output – default output low in non-alarm status |

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

## Absolute Maximum Ratings

Supply Voltage ..... $V_{SS}$-0.1V to $V_{SS}$+5.1V

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

Storage Temperature..... -40℃ to 85℃

Operating Temperature..... -10℃ to 50℃

Total Power Dissipation ..... 100mW

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 | 3.3 | 5.0 | V |
| $I_{DD}$ | Operating Current | 3.3V | — | — | 18.0 | — | mA |

## Functional Description

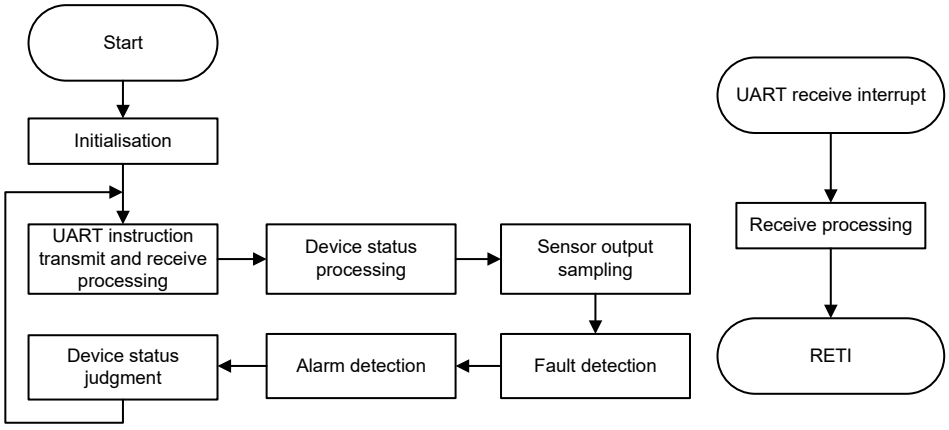
### Solution Introduction

The BM25S3421-1 VOC digital sensor includes an integrated MCU as the master device. As it uses a high accuracy gas sensor, when there is a certain concentration in the environment where the sensor is located, the sensor will process the gas concentration signal and then transmit the processed data to an external MCU. The sensor module has two output modes. The first is the level output mode. Under normal conditions, the STATUS pin defaults to output low. When the gas concentration is detected to have reached the alarm point, the pin will change to a high level. The second is the serial interface mode, which is subdivided into serial interface automatic output mode and 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 1s) using the TX pin (baud rate 9600bps). The serial interface communication mode is implemented using the TX/RX pins using the UART communication instructions. In this way, the detailed sensor module status can be read using the TX pin and the sensor parameters such as warm-up time and alarm value can be modified using the RX pin. These two modes have their own special characteristics and can be chosen flexibly according to users' requirements, the detailed usage of which can be obtained from the relevant interface section.

### Operation Flow

After the system is powered on, the BM25S3421-1 is initialised and warmed-up. The default warm-up time is 180s. After the warming-up is complete, the sensor enters the normal operation mode. In the normal operation mode, the sensor performs device status processing, sensor output sampling, fault detection and alarm detection in turn. Every sensor output sampling period (about 1s) the A/D value of the combustible gas sensor can be obtained, which will be converted to the VOC concentration level and automatically output using the serial interface along with the data such as device status and real-time gas concentration levels. When the UART receives a falling edge on the

RX pin, the sensor is woken up to enter the UART receive interrupt and perform UART instruction transmit and receive processing.

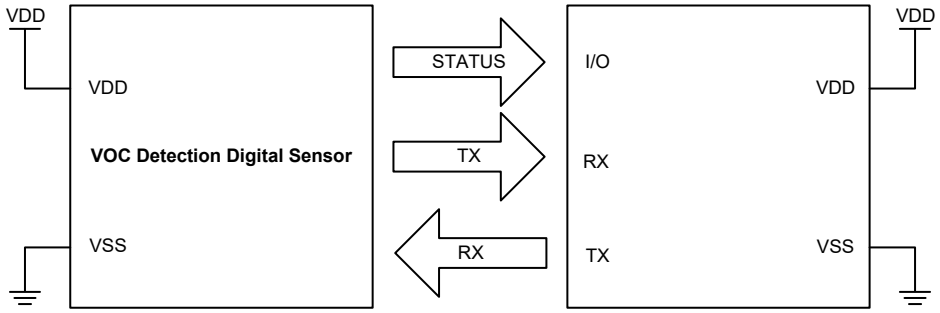



**BM25S3421-1 Operation Flowchart**

## Gas Sensor Characteristics

The MEMS VOC gas sensors makes microthermal plates on Si-based substrates through the MEMS process. The used gas-sensitive material is a metal oxide semiconductor material which has lower conductivity in clean air. When an alcohol gas exists in the air, the sensor conductivity will increase according to the gas concentration increment. With this characteristic, a simple circuit is required to convert the conductivity change into output signals corresponding to the gas concentration through an A/D converter and a filter circuit.

## Application Circuits




**BM25S3421-1** **External MCU**

# Interface Description

## Alarm Status Level Output Interface

Under normal conditions, Pin 5, STATUS, defaults to low. When the sensor detects that the VOC gas concentration in the environment has exceeded the preset alarm concentration level (default Level 3) and remains there for at least 3s, the sensor will enter the alarm status and the pin will change from low to high. When the VOC gas concentration reduces to preset exit alarm concentration level (default Level 1) and remains there for 3s, the pin will reset back to low.

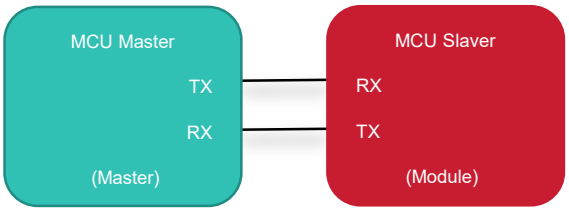
## UART Serial Communication Interface

TX pin automatic output data: Under normal conditions, the TX pin will automatically output the sensor current operating status, real-time VOC gas concentration A/D value, VOC gas concentration level and other data every sampling period (about 1s).

TX/RX pin serial interface communication: The external MCU can configure or obtain sensor data using the UART serial communication port TX/RX, such as obtaining or setting the current alarm concentration level, obtaining or modifying the calibration time and warm-up time, etc.

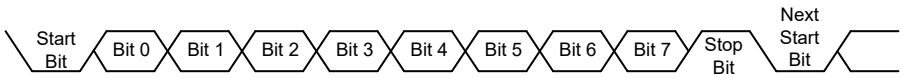
# UART Serial Communication

The sensor RX pin will be at a high level under normal conditions. The external MCU sends data in the following format (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 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, every sampling period (about 1s) a frame of data will be output at a baud rate of 9600bps. Each data frame contains 14 bytes as shown in the following table. The data content is the same as the U01 instruction returned during UART communication.

| Data Number | Data Content | Description | Data Number | Data Content | Description |
|---|---|---|---|---|---|
| 0 | 0xAA | Fixed data | 7 | XX | VOC concentration level (2) |
| 1 | 0x12 | Fixed data | 8 | XX | VOC status (3) |
| 2 | 0x02 | Fixed data | 9 | XX | Calibrate timing (4) |
| 3 | 0x01 | Fixed data | 10 | XX | Warm-up timing (5) |
| 4 | 0xAC | Fixed data | 11 | XX | Software version number high byte (6) |
| 5 | XX | VOC real-time AD value high byte (1) | 12 | XX | Software version number low byte (6) |
| 6 | XX | VOC real-time AD value low byte (1) | 13 | XX | Check code (7) |

Note: 1. Real-time AD value: The VOC gas real-time AD value is sampled by a 12-bit resolution A/D converter.

2. VOC concentration level. The valid values are 1~4, which correspond to Level 1, Level 2, Level 3 and Level 4. It is 0 if the device is warmed up and not calibrated. The sensor accuracy is affected by factors such as reference resistance difference, sensitivity difference, temperature, humidity, interfering gas, aging time and other factors. The sensor input-output has nonlinear, hysteresis and non-repeatable operating characteristics. Therefore, the VOC concentration level is for reference only.

3. VOC sensor status:

   Bit_0: If this bit is 1, it indicates that the sensor is calibrating.

   Bit_1 is reserved.

   Bit_2 is reserved.

   Bit_3 is reserved.

   Bit_4 is reserved.

   Bit_5: If this bit is 1, it indicates that the sensor calibration is complete.

   Bit_6: If this bit is 1, it indicates that the sensor in a fault condition.

   Bit_7: If this bit is 1, it indicates that the sensor in an alarm status.

4. Calibrated countdown, unit s. The default calibration time is 60s. A value of 0 indicates the sensor calibration is complete.

5. Warm-up countdown, unit s. The default warm-up time is 180s. A value of 0 indicates that the warm-up operating is complete.

6. The software version number is in 8421 BCD format.

7. Check code calculation method: Take the lower 8 bits of the sum of the first 13 bytes, complement and increment by one.

Example: If a frame of data received by the master using the serial interface is AA 0E 41 01 AC 0B 65 04 B0 00 00 11 01 24. It indicates that the device is warmed-up and has been calibrated. The current real-time A/D value is 2917, the VOC concentration level is 4 and the software version number is V1.1.1.

## 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 but fall into three categories, general instruction, special query instruction and special modification instruction. The general instructions are supported by all slave devices and mainly used to implement functions such as MCU reset, software version query, production date query, overall device status query. The special query and modification instructions are customised according to different device types. Each device has its own UART data instruction definitions, the details of which can be found in the relevant protocol.

**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 0xE0 0x1A 0x15, its check code is 0xF1.

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

**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 VOC sensor BM25S3421-1 UART communication protocol contains three instruction types, general instruction, special query instruction and special modification instruction. There are 20 instructions in total, including 4 general instructions, 10 special query instructions and 6 special modification instructions. For their detailed contents and definitions, refer to the corresponding instruction description sections.

The general instruction number and function are as follows:

| Instruction Type | Instruction Number | Instruction | Address | Instruction Function |
|---|---|---|---|---|
| General Instruction | U00 | AF | 00 | Device reset |
| | U01 | AC | 00 | Query all current device status and data |
| | U02 | A0 | 00 | Factory reset |
| | U03 | AB | XX | Trigger the user calibration function |

The special query instruction number and function are as follows:

| Instruction Type | Instruction Number | Instruction | Address | Instruction Function |
|---|---|---|---|---|
| Special Query Instruction | R00 | D0 | 1E | Query whether the current device serial interface data is automatically output |
| | R01 | D0 | 1F | Query the current device alarm output level |
| | R02 | D2 | 4F | Query the device status |
| | R03 | D2 | 40 | Query the VOC AD value high byte |
| | R04 | D2 | 41 | Query the VOC AD value low byte |
| | R05 | D2 | 42 | Query the concentration level |
| | R06 | D0 | 1A | Query the alarm level |
| | R07 | D0 | 1C | Query the alarm exit level |
| | R08 | D0 | 1D | Query the warm-up time |
| | R09 | D0 | 00 | Query the calibration setting time |

The special modification instruction number and function are as follows:

| Instruction Type | Instruction Number | Instruction | Address | Instruction Function |
|---|---|---|---|---|
| Special Modification Instruction | W00 | E0 | 1E | Modify the serial port automatic output status |
| | W01 | E0 | 1F | Modify the alarm signal output level |
| | W02 | E0 | 1A | Modify the alarm level |
| | W03 | E0 | 1C | Modify the alarm exit level |
| | W04 | E0 | 1D | Modify the warm-up time |
| | W05 | E0 | 00 | Modify the calibration time |

### General Instruction Description (U00~U03)

| Instruction U00 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Master | Instruction | 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 | 41 | 01 | AF | 00 | 00 | 5D |
| **Description**: Reset the device.<br>The master sends AF 00 00 51 and the slave returns AA 08 01 41 AF 00 00 5D. | | | | | | | | | |

| Instruction U01 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Master | Instruction | Address | Data | | | | | Check Code |
| | | AC | 00 | 00 | | | | | 54 |
| | Slave | Instruction Header | Data Length | Device Type | Protocol Version | Return Instruction | Return Address | | Data |
| | | AA | 0E | 41 | 01 | AC | XXXX | | XXXX |
| | | VOC Status | Calibration Time | Warm-up Time | Software Version Number | | Check Code | | |
| | | XX | XX | XX | XXXX | | XX | | |

**Description**: Query all current device status and data.
0~4) Fixed data header
5~6) Real-time AD value: The VOC real-time AD value is sampled by a 12-bit resolution A/D converter.
7) VOC level. The valid values are 1~4, which correspond to Level 1, Level 2, Level 3 and Level 4. It is 0 if the device is warmed up and not calibrated.
8) VOC sensor status:
Bit_0: If this bit is 1, it indicates that the sensor is calibrating.
Bit_1 is reserved.
Bit_2 is reserved.
Bit_3 is reserved.
Bit_4 is reserved.
Bit_5: If this bit is 1, it indicates that the sensor calibration is complete.
Bit_6: If this bit is 1, it indicates that the sensor in a fault condition.
Bit_7: If this bit is 1, it indicates that the sensor in an alarm status.
9) Calibration countdown: Calibration countdown, unit s. The default calibration time is 60s. A value of 0 indicates that the calibration is complete.
10) Warm-up countdown: Power-on warm-up countdown, unit s. The default warm-up time is 180s. A value of 0 indicates that the warm-up operating is complete.
11~12) Software version
The master sends AC 00 00 54.

| **Instruction U02** | 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 |
| | | AA | 08 | 41 | 01 | A0 | 00 | 00 | 6C |

**Description**: Factory reset. After this instruction is sent, reset all parameter configurations to their factory settings.
Alarm level: 3
Alarm exit level: 1
Warm-up time: 180s

**Example**: If the master sends A0 00 00 60 and slave returns AA 08 41 01 A0 00 00 6C.
This indicates performing the factory reset operation and reloading the factory calibration data inside the sensor.

| **Instruction U03** | Master | Instruction | Address | Data | | | | | Check Code |
|---|---|---|---|---|---|---|---|---|---|
| | | AB | XX | 00 | | | | | XX |
| | Slave | Instruction Header | Data Length | Device Type | Protocol Version | Return Instruction | Return Address | Data | Check Code |
| | | AA | 08 | 41 | 01 | AB | XX | 00 | XX |

**Description**: Trigger the calibration function to determine which calibration mode to use according to the address sent by the master.

**Standard point 1**: Address 01 indicates that the calibration trigger point 1 (Level 1/2 judgment threshold)
The master sends AB 01 00 54 and the slave returns AA 08 41 01 AB 01 00 60.

**Standard point 2**: Address 02 indicates that the calibration trigger point 2 (Level 2/3 judgment threshold)
The master sends AB 02 00 53 and the slave returns AA 08 41 01 AB 02 00 5F.

**Standard point 3**: Address 03 indicates that the calibration trigger point 3 (Level 3/4 judgment threshold)
The master sends AB 03 00 52 and the slave returns AA 08 41 01 AB 03 00 5E.

**Calibration check**: Address 06 will trigger the calibration check and update the calibration point 1~3 check value.
The master sends AB 06 00 4F and the slave returns AA 08 41 01 AB 06 00 5B.

Note: 1. There is no fixed order for calibration points 1~3, it can be calibrated in any order and 1~3 number. After the point calibration is completed, the calibration check instruction needs to be used, the device will enter the calibration completion state.

2. The calibration point must be set at calibration point 1 < calibration point 2 < calibration point 3, otherwise the output VOC concentration level will have unpredictable errors.

### Special Query Instruction Description (R00~R09)

| **Instruction R00** | Master | Instruction | Address | Data | | | | | Check Code |
|---|---|---|---|---|---|---|---|---|---|
| | | D0 | 1E | 00 | | | | | 12 |
| | Slave | Instruction Header | Data Length | Device Type | Protocol Version | Return Instruction | Return Address | Data | Check Code |
| | | AA | 08 | 41 | 01 | D0 | 1E | XX | XX |

**Description**: Query whether the current device serial interface data output is enabled. If the data is 08H, this indicates that the serial interface output has been enabled and the serial interface will automatically output data once every detection period. If the data is 00H, it indicates that the sensor has no data output.

**Example**: If the master sends D0 1E 00 12 and the slave returns AA 08 41 01 D0 1E 00 1E.
This indicates that the device serial port output is not enabled and the sensor has no serial port data output.

| Instruction R01 | Master | Instruction | Address | Data | | | | | Check Code |
|---|---|---|---|---|---|---|---|---|---|
| | | D0 | 1F | 00 | | | | | 11 |
| | Slave | Instruction Header | Data Length | Device Type | Protocol Version | Return Instruction | Return Address | Data | Check Code |
| | | AA | 08 | 41 | 01 | D0 | 1F | XX | XX |

**Description**: Query the current device alarm output level. If the data is 08H, the STATUS port outputs high when alarming and low under normal conditions. 00H is the opposite.
**Example**: If the master sends D0 1F 00 11 and the slave returns AA 08 41 01 D0 1F 08 15.
This indicates that the STATUS port output is high when the device alarming and low under normal conditions.

| Instruction R02 | Master | Instruction | Address | Data | | | | | Check Code |
|---|---|---|---|---|---|---|---|---|---|
| | | D2 | 4F | 00 | | | | | DF |
| | Slave | Instruction Header | Data Length | Device Type | Protocol Version | Return Instruction | Return Address | Data | Check Code |
| | | AA | 08 | 41 | 01 | D2 | 4F | XX | XX |

**Description**: Query the current device status.
**Device status**:
Bit_0: If this bit is 1, it indicates that the sensor is calibrating.
Bit_1 is reserved.
Bit_2 is reserved.
Bit_3 is reserved.
Bit_4 is reserved.
Bit_5: If this bit is 1, it indicates that the sensor calibration is complete.
Bit_6: If this bit is 1, it indicates that the sensor calibration is in a fault state.
Bit_7: If this bit is 1, it indicates that the sensor in an alarm status.
**Example**: If the master sends D2 4F 00 DF and the slave returns AA 08 41 01 D2 4F 32 B9.
This indicates that the device is under normal conditions.

| Instruction R03 | Master | Instruction | Address | Data | | | | | Check Code |
|---|---|---|---|---|---|---|---|---|---|
| | | D2 | 40 | 00 | | | | | EE |
| | Slave | Instruction Header | Data Length | Device Type | Protocol Version | Return Instruction | Return Address | Data | Check Code |
| | | AA | 08 | 41 | 01 | D2 | 40 | XX | XX |

**Description**: Query the high byte of the VOC AD value.
**Example**: If the master sends D2 40 00 EE and the slave returns AA 08 41 01 D2 40 05 F5.
This indicates that the current VOC A/D value high byte is 05H.

| Instruction R04 | Master | Instruction | Address | Data | | | | | Check Code |
|---|---|---|---|---|---|---|---|---|---|
| | | D2 | 41 | 00 | | | | | ED |
| | Slave | Instruction Header | Data Length | Device Type | Protocol Version | Return Instruction | Return Address | Data | Check Code |
| | | AA | 08 | 41 | 01 | D2 | 41 | XX | XX |

**Description**: Query the low byte of the VOC AD value.
**Example**: If the master sends D2 41 00 ED EE and the slave returns AA 08 41 01 D2 41 E5 14.
This indicates that the current VOC AD value low byte is E5H.
Combined with the VOC AD value high byte read by the R03 instruction, the current VOC AD value is 0x05E5 (1509).

| **Instruction R05** | Master | Instruction | Address | Data | | | | | Check Code |
|---|---|---|---|---|---|---|---|---|---|
| | | D2 | 42 | 00 | | | | | EC |
| | Slave | Instruction Header | Data Length | Device Type | Protocol Version | Return Instruction | Return Address | Data | Check Code |
| | | AA | 08 | 41 | 01 | D2 | 42 | XX | XX |

**Description**: Query the concentration level.
**Example**: If the master sends D2 42 00 EC and the slave returns AA 08 41 01 D2 42 01 F7.
This indicates that the current concentration level is Level 1.
Note: The valid values are 1~4, which correspond to Level 1, Level 2, Level 3 and Level 4.

| **Instruction R06** | Master | Instruction | Address | Data | | | | | Check Code |
|---|---|---|---|---|---|---|---|---|---|
| | | D0 | 1A | 00 | | | | | 16 |
| | Slave | Instruction Header | Data Length | Device Type | Protocol Version | Return Instruction | Return Address | Data | Check Code |
| | | AA | 08 | 41 | 01 | D0 | 1A | XX | XX |

**Description**: Query alarm level. The alarm level defaults to Level 3.
**Example**: If the master sends D0 1A 00 16 and the slave returns AA 08 41 01 D0 1A 03 1F.
This indicates that the current alarm level is Level 3.
Note: The valid values are 1~4, which correspond to Level 1, Level 2, Level 3 and Level 4.

| **Instruction R07** | Master | Instruction | Address | Data | | | | | Check Code |
|---|---|---|---|---|---|---|---|---|---|
| | | D0 | 1C | 00 | | | | | 14 |
| | Slave | Instruction Header | Data Length | Device Type | Protocol Version | Return Instruction | Return Address | Data | Check Code |
| | | AA | 08 | 41 | 01 | D0 | 1C | XX | XX |

**Description**: Query alarm exit level. The alarm level defaults to level 1.
**Example**: If the master sends D0 1C 00 14 and the slave returns AA 08 41 01 D0 1C 01 1F.
This indicates that the alarm exit level is level 1.
Note: The valid values are 1~4, which correspond to Level 1, Level 2, Level 3 and Level 4.

| **Instruction R08** | Master | Instruction | Address | Data | | | | | Check Code |
|---|---|---|---|---|---|---|---|---|---|
| | | D0 | 1D | 00 | | | | | 13 |
| | Slave | Instruction Header | Data Length | Device Type | Protocol Version | Return Instruction | Return Address | Data | Check Code |
| | | AA | 08 | 41 | 01 | D0 | 1D | XX | XX |

**Description**: Query the warm-up time, N×1s, default 180s.
**Example**: If the master sends D0 1D 00 13 and the slave returns AA 08 41 01 D0 1D B4 6B.
This indicates that the warm-up time is 0xB4 (180 s).

| **Instruction R09** | Master | Instruction | Address | Data | | | | | Check Code |
|---|---|---|---|---|---|---|---|---|---|
| | | D0 | 00 | 00 | | | | | 30 |
| | Slave | Instruction Header | Data Length | Device Type | Protocol Version | Return Instruction | Return Address | Data | Check Code |
| | | AA | 08 | 41 | 01 | D0 | 00 | XX | XX |

**Description**: Query the calibration setting time, (N+8)×1s, default 60s.
**Example**: If the master sends D0 00 00 30 and the slave returns AA 08 41 01 D0 00 34 08.
This indicates that the calibration time is 0x34(52)+8=60s.

### Special Modification Instruction Description (W00~W05)

| Instruction W00 | Master | Instruction | Address | Data | | | | | Check Code |
|---|---|---|---|---|---|---|---|---|---|
| | | E0 | 1E | XX | | | | | XX |
| | Slave | Instruction Header | Data Length | Device Type | Protocol Version | Return Instruction | Return Address | Data | Check Code |
| | | AA | 08 | 41 | 01 | E0 | 1E | XX | XX |

**Description**: Modify the device serial interface data output enable control. If the data is 08H, this indicates that the serial interface output has been enabled and the serial interface will automatically output data once every period. If the data is 00H, the serial interface will not output data.
**Example**: If the master sends E0 1E 00 02 and the slave returns AA 08 41 01 E0 1E 00 0E.
This indicates that the serial interface output is not enabled, the serial port will have no data output.
If the master sends E0 1E 08 FA and the slave returns AA 08 41 01 E0 1E 08 06.
This indicates that the serial interface output is enabled and the serial interface will automatically output data once every detection period.

| Instruction W01 | Master | Instruction | Address | Data | | | | | Check Code |
|---|---|---|---|---|---|---|---|---|---|
| | | E0 | 1F | XX | | | | | XX |
| | Slave | Instruction Header | Data Length | Device Type | Protocol Version | Return Instruction | Return Address | Data | Check Code |
| | | AA | 08 | 41 | 01 | E0 | 1F | XX | XX |

**Description**: Modify the device alarm output level. If the data is 08H, the STATUS port outputs high when alarming and low under normal conditions. 00H is the opposite.
**Example**: If the master sends E0 1F 08 F9 and the slave returns AA 08 41 01 E0 1F 08 05.
This indicates that the STATUS port outputs high when alarming and low under normal conditions.
If the master sends E0 1F 00 01 and the slave returns AA 08 41 01 E0 1F 00 0D.
This indicates that the STATUS port outputs low when alarming and high under normal conditions.

| Instruction W02 | Master | Instruction | Address | Data | | | | | Check Code |
|---|---|---|---|---|---|---|---|---|---|
| | | E0 | 1A | XX | | | | | XX |
| | Slave | Instruction Header | Data Length | Device Type | Protocol Version | Return Instruction | Return Address | Data | Check Code |
| | | AA | 08 | 41 | 01 | E0 | 1A | XX | XX |

**Description**: Modify the alarm level, effective immediately.
**Example**: Modify the alarm level to Level 3.
If the master sends E0 1A 03 03 and the slave returns AA 08 41 01 E0 1A 03 0F.
This indicates that the alarm level has been modified to Level 3.
Note: The valid values are 1~4, which correspond to Level 1, Level 2, Level 3 and Level 4.

| Instruction W03 | Master | Instruction | Address | Data | | | | | Check Code |
|---|---|---|---|---|---|---|---|---|---|
| | | E0 | 1C | XX | | | | | XX |
| | Slave | Instruction Header | Data Length | Device Type | Protocol Version | Return Instruction | Return Address | Data | Check Code |
| | | AA | 08 | 41 | 01 | E0 | 1C | XX | XX |

**Description**: Modify the exit alarm level, effective immediately, the exit alarm value cannot be greater than or equal to the alarm value.
**Example**: Modify the alarm level to Level 1.
If the master sends E0 1C 01 03 and the slave returns AA 08 41 01 E0 1C 01 0F.
This indicates that the alarm exit level was successfully changed to 1.
Note: The valid values are 1~4, which correspond to Level 1, Level 2, Level 3 and Level 4.

| Instruction W04 | Master | Instruction | Address | Data | | | | | Check Code |
|---|---|---|---|---|---|---|---|---|---|
| | | E0 | 1D | XX | | | | | XX |
| | Slave | Instruction Header | Data Length | Device Type | Protocol Version | Return Instruction | Return Address | Data | Check Code |
| | | AA | 08 | 41 | 01 | E0 | 1D | XX | XX |

**Description**: Modify the warm-up time, N×1s. It will not take effect until the next warm-up.
**Example**: If the master sends E0 1D B4 4F and the slave returns AA 08 41 01 E0 1D B4 5B.
This indicates that the warm-up time has been successfully modified to B4H (180 seconds).
Note: The recommended modification range is 30≤x<255.

| Instruction W05 | Master | Instruction | Address | Data | | | | | Check Code |
|---|---|---|---|---|---|---|---|---|---|
| | | E0 | 00 | XX | | | | | XX |
| | Slave | Instruction Header | Data Length | Device Type | Protocol Version | Return Instruction | Return Address | Data | Check Code |
| | | AA | 08 | 41 | 01 | E0 | 00 | XX | XX |

**Description**: Modify the calibration time, (N+8)×1s, which will take effect in the next calibration.
**Example**: If the master sends E0 00 34 EC and the slave returns AA 08 41 01 E0 00 34 F8.
This indicates that the calibration time has been successfully modified to 0x34(52)+8=60s.
Note: The recommended modification range is 30≤x<255.

Note: 1. In this document, all slave devices refer to VOC digital sensors, unless otherwise specified.

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. If any illegal instruction other than those aforementioned is used, the slave will return the original data sent by the master.
4. Data transmission and reception is in hexadecimal format unless otherwise specified.
5. When the sensor is in the warming-up or calibrating status, do not execute other instructions otherwise the sensor operating status will not be guaranteed.

## Considerations

### Usage Description

When storing the sensor for longer periods, a certain period of warm-up time is required after power on to achieve internal chemical equilibrium before use. If the sensor is stored for a long time after power off, the longer the aging time. If the VOC module is powered off and stored for more than six months, it needs to be powered on and aged for more than three days before use. Care should be paid to heat dissipation during aging.

### Situations that Must Be Avoided

1. Exposure to volatile silicon compound gases

   The sensor should avoid exposure to silicon adhesives, hair gels, silicone rubber, putty or other volatile silicon compounds. If the sensor surface absorbs volatile silicon compounds, the sensor sensitive material will be covered in silicon dioxide formed by the decomposition of silicon compounds. This will inhibit the sensor sensitivity and cannot be reversed.

2. Highly corrosive environment

   If the sensor is exposed to high concentrations of corrosive gases (such as $H_2S$, $SO_X$, $Cl_2$, HCl, etc.), it will not only cause corrosion or damage to heating materials and sensor leads but also cause irreversible deterioration of the sensitive material performance.

3. Pollution of alkali, alkali metal salts and halogens

   If the sensor is contaminated with alkali metals, especially brine sprays or exposed to halogens such as Freon, it will also cause performance deterioration.

4. Contact with water

   Being splashed or immersed in water can cause the sensor sensitivity to decrease.

5. Freezing

   If water freezes on the sensor sensitive material surface, the sensitive layer will break and will lose its sensitivity.

6. Apply power

   Voltage overload may cause heating power to exceed 120mW, which can cause irreversible damage to the sensor. At the same time, the static electricity generated can also damage the sensor, so anti-static measures should be taken when contacting the sensor.

## Situations that Should Be Avoided

1. Condensation water

   Under indoor conditions, slight condensation will have a slight impact on sensor performance. However, if water condenses on the sensitive layer surface and remains for a period of time, the sensor characteristics will decrease.

2. High gas concentrations

   No matter whether the sensor is powered on or not, prolonged placement in high gas concentration situations will affect the sensor characteristics. If the sensor is sprayed directly with lighter gas, it will cause serious damage to the sensor.

3. Prolonged exposure to extreme environments

   No matter whether the sensor is powered on or not, prolonged exposure to extreme environments, such as high humidity, high temperature or high pollution, will seriously affect the sensor performance.

4. Vibrations

   Frequent and excessive vibrations, which may occur in transit or when using tools or ultrasonic welders on assembly line, may cause the internal sensor leads to resonate and break.

5. Impact

   If the sensor is subjected to a strong impact or drop, its leads can break.

## Dimensions