

Indoor CO₂ Monitoring Solution

USER MANUAL

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1 Overview

1.1 Description

Maintaining indoor air quality has become increasingly important in recent years, with a particular emphasis on monitoring carbon dioxide (CO₂) levels. High indoor CO₂ levels are frequently an indicator of poor ventilation, which can lead to the accumulation of other air pollutants such as volatile organic compounds (VOCs). Poor ventilation can also increase the risk of viral infection through airborne contact. To mitigate these risks, indoor CO₂ monitoring has become a critical aspect of environmental protection and health management.

The RAK indoor CO₂ air monitoring solution utilizes a LoRaWAN[®] CO₂ sensor, providing real-time monitoring of CO₂, temperature, and humidity levels. This solution is suitable for a wide range of settings, including homes, schools, office buildings, hospitals, restaurants, shopping malls, factories, hotels, laboratories, and more.

1.2 Features

- **Precision:** Provides high-precision carbon dioxide (CO₂), temperature, and RH readings.
- **Wireless connectivity:** Enables seamless wireless data transmission.
- **Remote monitoring:** Supports remote monitoring, which improves convenience.
- **Configurable reporting:** Allows flexible reporting and notification strategies and can be configured remotely.
- **Supported frequency bands:** EU433, EU868, RU864, CN470, KR920, IN865, AU915, US915, AS923-1/2/3/4 frequencies, with EU868 as the default setting.
- **Network join mode:** OTAA/ABP
- **Device work mode:** Class A

2 Specifications

2.1 Overview



Figure 1: The sensor and the power cable

Device List	Description
Sensor	CO ₂ , Temperature, and RH Sensor
Power Cable	USC Cable
Color	White
Weight	129 g
Screen size	61 × 49 mm

2.2 Hardware Specifications

The following sections cover the parameters and measurements of the sensor. It also includes the sensor overview and dimensions.

2.2.1 Mechanical Dimension

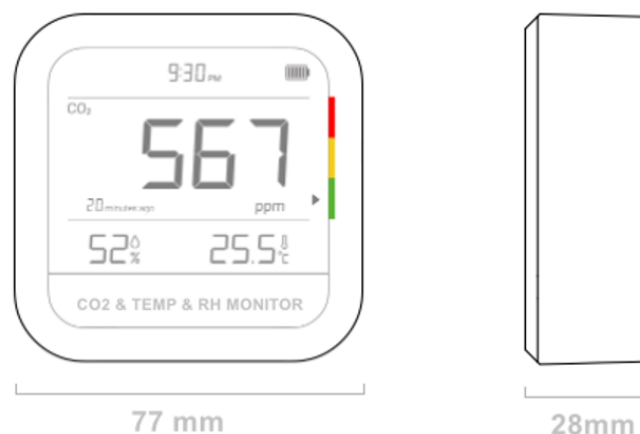


Figure 2: Qingping dimensions

Device	Dimension
Qingping	77 x 28 mm
Screen Display	61 x 49 mm

2.2.2 Parameters Measurement

The following tables show the temperature and humidity measurements of the device.

Carbon Dioxide (CO₂)

Parameter	Value
Range	400~9999 ppm
Precision	±15% of m.v.
Level	<ul style="list-style-type: none"> ● Normal: 400 ~ 1000 ppm ● Slightly High: 1000 ~ 1400 ppm ● High: 1400 + ppm

Temperature

Parameter	Value
Range	-20°C ~ 50°C
Precision	±0.5°C (in the range of 0°C ~ 50°C)
Resolution Ratio	0.1°C

Humidity

Parameter	Value
Range	0 ~ 99.9% RH (no condensation)
Precision	±2% (in the range of 10 ~ 90%)
Resolution Ratio	0.1%

2.2.3 Technical Specifications

Parameter	Description
Wireless Network	LoRa

Bluetooth	Bluetooth 5.0
Battery Type	Lithium battery
Battery Capacity	2600 mAh
Charging Port	USB-C
Rated Input	5V = 1A

3 Installation

The CO₂ sensor is a complete node device, so users do not need to assemble it after unpacking. Refer to the following sections for mounting the sensor in the appropriate location and performing relevant sensor operations:

3.1 Wall Mounting

Included in the product package is a wall sticker with double-sided adhesive tape on the back. To install the sensor, peel off the protective film of the tape and stick the wall sticker to the desired location on the wall or any other object surface. Then, you can easily hang the sensor on the wall sticker.



Figure 3: Wall Mount Installation

3.2 Other Operations

Other operations introduce relevant operations on how to use the sensor. Users may refer to the corresponding sections according to their needs.

3.2.1 Power Options

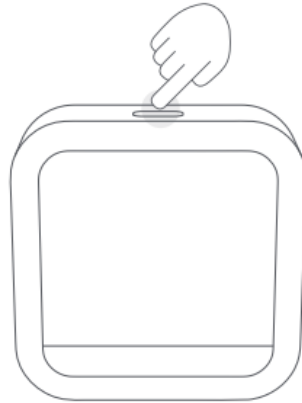


Figure 4: Sensor Power Options

A. Power ON

Long-press the button on the top of the device, as shown in Figure 4. If it doesn't turn on, charge the device first, then try again.

B. Power OFF

Press and hold the button on the top of the device for 6 seconds.

 **NOTE**

Press and hold the top button for 2 seconds, then release. The sensor will enter Bluetooth pairing mode to connect to the mobile app.

3.2.2 Charging

Use a USB-C charging cable and a power adapter with a 5V output voltage and a current output of at least 1A. While charging, the battery icon in the upper right corner of the screen will flash to indicate the charging progress. When fully charged, the battery icon will stop flashing.

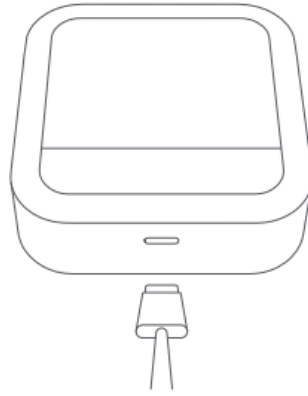


Figure 5: USB-C Charging Cable

 **NOTE**

The device's body temperature rises during the charging process. The temperature reading cannot accurately reflect the ambient temperature at this time. It will take about 30 minutes to fully charge the device and then accurately read the temperature.

3.2.3 Check the Network Signal

To check the signal status of the LoRa network, short-press the button on the top of the device.

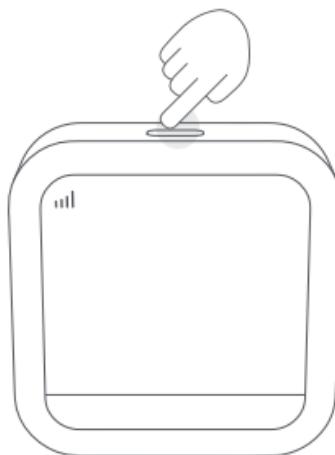


Figure 6: Check the LoRa Network Signal

To extend the battery life, the sensor will not remain continuously connected to the network. Instead, it will connect to the network at set intervals. If you are not connected to the internet, the network signal status will not be displayed on the screen.

You can adjust the timing of the sensor connecting to the network by using the QingPing IoT application. For more information, refer to the **Connect the Device** section in the user manual.

3.2.4 Factory Reset

1. Turn off the sensor to restore factory settings. Press and hold the button on the top of the device for 6 seconds to turn it off.
2. Press and hold the top button while the device is off. Continue holding it even after the device turns on until it turns off again to complete a factory reset.

4 Device Configuration

4.1 Connect the Device

The CO₂ sensor is configurable with a mobile application. Before proceeding, download the Qingping IoT application, available on Android and iOS.

- After downloading, sign up for and log in to the mobile application.
- Open the app and click **More** in the lower-right corner of your screen.
- Select **Advanced Options**, then **Configure LoRa Product**.
- Choose **CO₂ & Temp & RH Monitor**. Press and hold the device's button for 2 seconds, or until the Bluetooth icon begins to flash.

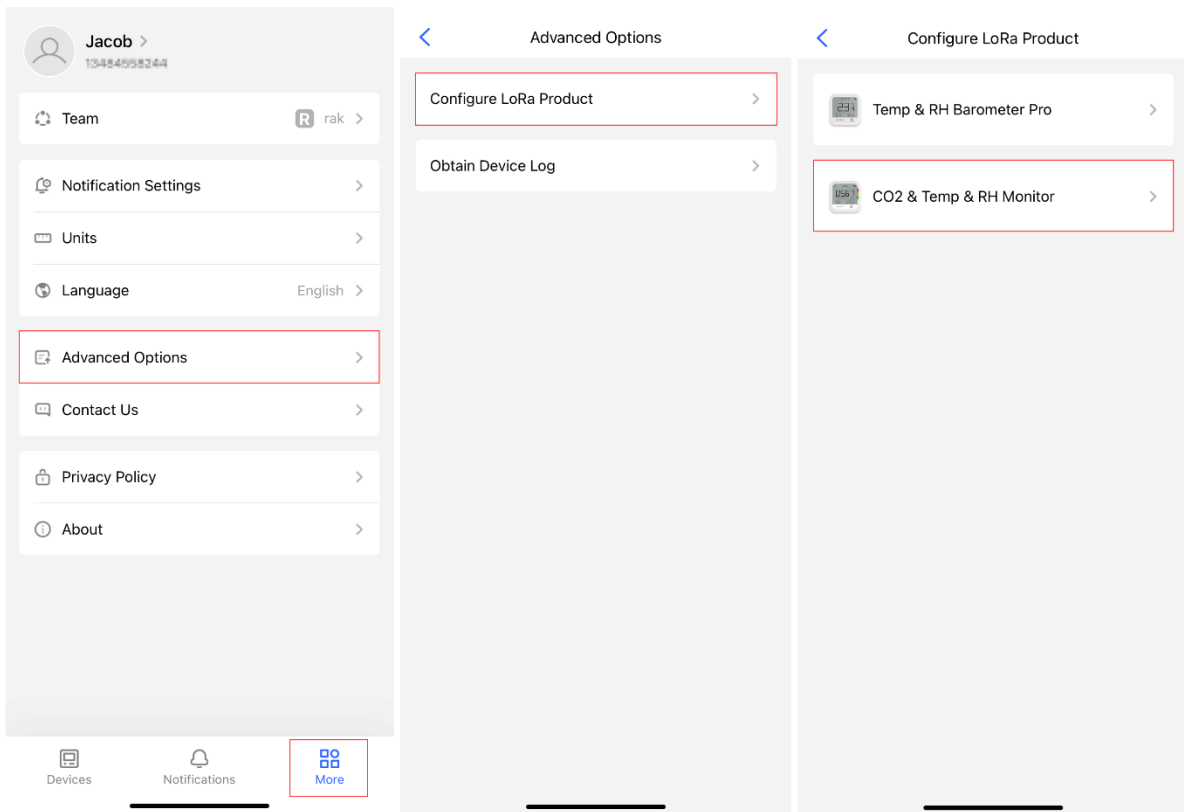


Figure 7: Device Configuration

- Place the mobile device near the sensor.
- Enter the device settings page once the Bluetooth connection is successful.

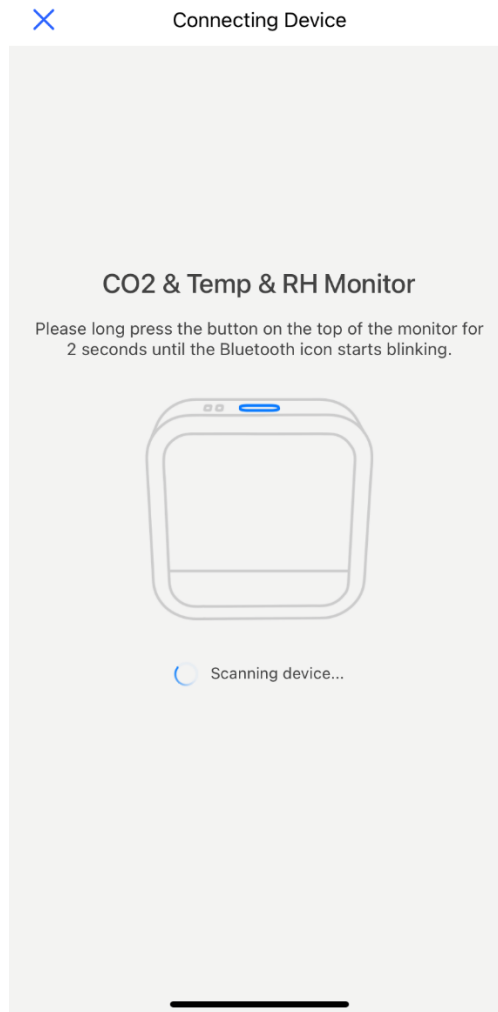


Figure 8: Connect to Temp & RH Barometer Pro

- Place the mobile device near the sensor.
- Enter the device settings page once the Bluetooth connection is successful.

4.2 Basic Settings

Basic settings include the recording and uploading interval, temperature unit, CO₂ detection interval, and other CO₂ configurations. You can configure the settings according to your preference. Other device information is available, but not configurable.

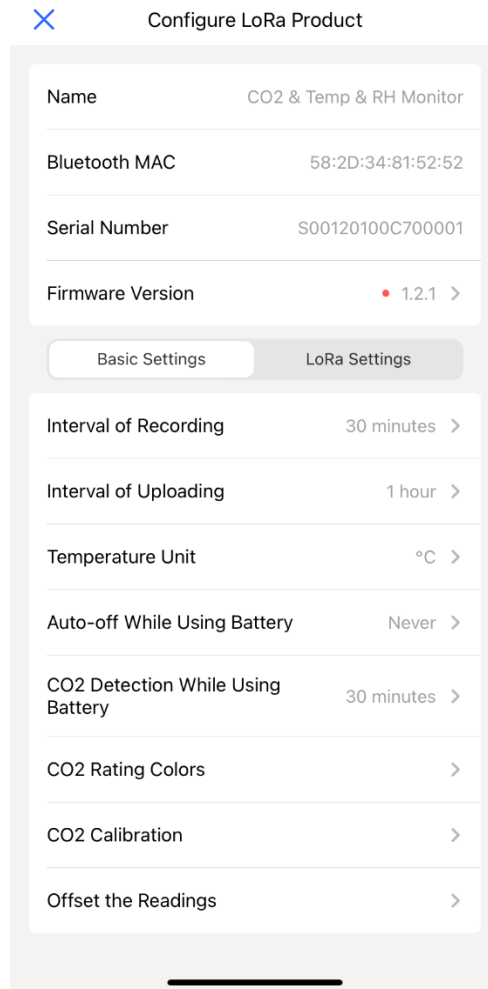


Figure 9: Basic Settings Configuration

4.3 LoRa Network Configuration

In the **LoRa Settings** menu, you can choose the network join mode you prefer—either OTAA or ABP. Additionally, you can adjust other settings, such as the ternary group and frequency band, to suit your needs.

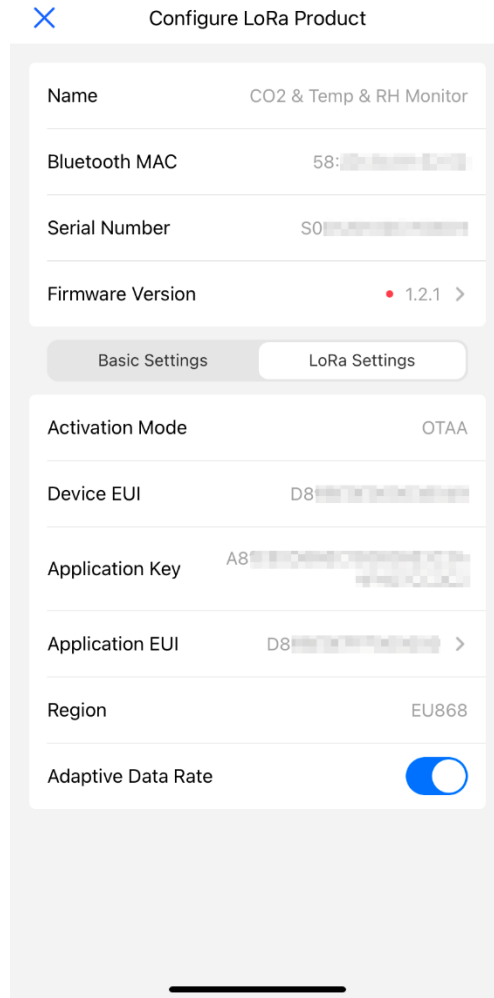


Figure 10: Settings Configuration

After you have completed configuring the settings, click the **X** button located at the upper right corner of the screen. It will exit the connection interface and automatically join the network.

4.4 Data Description

4.4.1 Protocol Communication

The protocol used follows a data format like Modbus-RTU. It enables devices to actively report or request data.

4.4.2 Protocol Command Format

All contents are arranged with high bytes first, followed by low bytes. Listed in the table is the protocol format.

Protocol Format	ADDR	CMD	LEN	DATA	CRC
	Address	Function Code	Data Length	Data Content	Cyclic Redundancy Check
Number of bytes	1	1	1	N	2

Where:

- **ADDR** – Address
- **CMD** – Function code
- **LEN** – Data length
- **DATA** – Data content
- **CRC** – Cyclic redundancy check

CRC Code:

```

unsigned short modbus_crc16(unsigned char *data, unsigned short data_len )
{
    unsigned int i,j ,CRC_Reg1,Check1;
    CRC_Reg1 = 0xFFFF;
    for( i = 0;i < data_len;i ++)
    {
        CRC_Reg1 = CRC_Reg1 ^ (unsigned int)* (data + i );
        for(j= 0;j <8;j++)
        {
            Check1 = CRC_Reg1 & 0x0001;
            CRC_Reg1 >>= 1;
            if( Check1==0x0001)
            {
                CRC_Reg1 ^= 0xA001;
            }
        }
    }
    return ((CRC_Reg1>>8) | (CRC_Reg1<<8));
}
    
```

4.4.2.1 Command Details

The tables display command definitions and sensor data reports, including both real-time and historical data formats.

A. CMD Definitions

CMD	Description
0x41	Device reports data
0x42	Device reports event configuration
0x43	Device retrieves event/server sends event
0x44	Device reports event
0x47	Device reports configuration/server sends configuration
0x48	Set AES128 ECB key

B. Sensor Data Report

Type	ADDR	CMD	LEN	DATA	CRC
Send	0x01	0x41	0x06 - 0x24	0x00 0x01	-

Under **Data**, there are two data types:

- Historical data
- Real-time data

Data Type	Description
0x00	Historical data
0x01	Timestamp: 4-byte
	Real-time data: 6-byte
	Version number: 5-byte

Historical Data Format Description

The following is an example of a complete historical data reporting format for sensor data:

**01 41 25 00 5C 77 88 B6 00 05 2F C2 9A 01 AA 4E 2F C2 9A 01 AA 4E 2F C2 9A
01 AA 4E 2F C2 9A 01 AA 4E 2F C2 9A 01 AA 4E 46 FE**

The table below shows the historical data analysis:

Byte Number	Description	Value
1	Device address	0x01
2	Data reporting function code	0x41
3	Data length	0x25
4	Data type (historical data)	0x00
5 – 8	Timestamp	0x5C7788B6
9 – 10	Data storage interval (in seconds)	0x0005
11 – 16	First set of sensor data	Bytes 1–3: 0x2FC29A <ul style="list-style-type: none"> • Represent temperature and humidity • Temperature: 0x02FC (high 12 bits)¹ • Humidity: 0x29A (low 12 bits)² Bytes 4–5: 0x01AA <ul style="list-style-type: none"> • Represent CO₂ Byte 6: 0x4E <ul style="list-style-type: none"> • Represents the battery level
17 – 22	Second set of sensor data	The same format as the first set.
Every 6 bytes is a set of sensor data.	LoRa: One frame of historical data has up to 5 sets of sensor data.	The same format as the first set.
41 – 42	Check code	0x46FE

¹ The temperature value is forward offset by 500. To get the actual temperature value, subtract 500 from the byte value of 0x02FC, equating to 264. However, the reading is expanded ten times, implying that the actual temperature of 264 is divided by ten.

$$\text{actual temperature value } ^\circ\text{C} = \frac{\text{temp value} - 500}{10}$$

² The humidity value is expanded ten times to get the actual value.

$$\text{actual humidity value } \%RH = \frac{\text{humidity value}}{10}$$

The timestamp of each set of sensor data must be calculated based on the starting timestamp and data acquisition interval. In the previous reference data, the acquisition time for the set of sensor data is as follows:

- First set: **0x5C7788B6**
- Second set: **0x5C7788B6 + 0x0005** (data acquisition interval)
- Third set: **0x5C7788B6 + 0x0005 + 0x0005**

Real-Time Data Format Description

The following is an example of a complete real-time data reporting format for sensor data:

01 41 15 01 5C 77 88 B6 2F C2 9A 01 AA 4E 31 2E 30 2E 30 43 FE

The table below shows the real-time data analysis:

Byte Number	Description	Value
1	Device address	0x01
2	Data reporting function code	0x41
3	Data length	0x15
4	Data type (real-time data)	0x01
5 – 8	Timestamp	0x5C7788B6
9 – 14	Sensor data	Bytes 1–3: 0x2FC29A <ul style="list-style-type: none"> • Represent temperature and humidity • Temperature: 0x02FC (high 12 bits)¹ • Humidity: 0x29A (low 12 bits) Bytes 4–5: 0x01AA <ul style="list-style-type: none"> • Represent CO₂ Byte 6: 0x4E <ul style="list-style-type: none"> • Represents the battery level
15 – 19	Version number	Corresponding to ASCII: 1.0.0
20-21	Check code	0x43FE

¹ For actual temperature and humidity value calculation, refer to **Historical Data Format Description** section.

C. Event Reporting

The returned parameter format is shown in the following table:

Type	ADDR	CMD	LEN	DATA			
				Event type	Timestamp	Sensor data	Event setting value
Send	0x01	0x44	0x0B	1 byte	4 bytes	6 bytes	2 bytes

Sensor Data Format

Refer to the **Sensor Data Format** table in the **Real-Time Data Format Description** section for more information.

Event Type

The event type in hex corresponds to temperature and humidity-specific conditions. It indicates when a report should be triggered based on the conditions.

Event Type	Description
0x07	Temperature is above a certain value.
0x08	Temperature is below a certain value.
0x0A	Humidity is above a certain value.
0x0B	Humidity is below a certain value.
0x39	CO2 level is above a certain value.
0x3A	CO2 level is below a certain value.

D. Event Sending

The description of setting the sensor reporting policy is as follows:

Type	ADDR	CMD	LEN	DATA					
				Event type	Repeat times	Start time	End time	Settings	Ring duration
Send	0x01	0x42	0x0C	1 byte	1 byte	4 bytes	4 bytes	2 bytes	2 bytes

Event Type

Refer to the **Event Types** table in the **Event Reporting** section for more information.

Repeat Times

Repeat Times	Value	Description
1 time in total	0x01	The default setting.
1 time a day	0xFE	

Start and End Time

The start and end times are offset in minutes, with 0:00 as the base point. For example, a time of 7:00 to 10:00 corresponds to 420 to 600 minutes.

If the period is a full day, set the start and end times to the same value of 0. The predefined values indicate that the entire day has been covered.

Value Setting

To convert the temperature value to its actual reading, offset the value forward (subtract) by 500, then expand (multiply) by 10. However, for humidity, multiply the given value by 10.

Unit description:

- Temperature: °C
- Humidity: %RH
- CO₂: ppm

Ring Duration

The buzzer ringing duration is in seconds. For example, if the temperature remains above 26 degrees Celsius for the entire period and the buzzer rings for 5 seconds, the hexadecimal value would be:

01 42 0C 07 01 00 00 00 00 00 00 00 02 F8 00 05 D9 78

E. Configuration Settings

To configure the interval settings, set the values as follows:

- Data reporting interval: 1 hour
- Data acquisition interval: 15 minutes
- CO₂ acquisition interval: 5 minutes
- CO₂ superior level: 1000
- CO₂ inferior level: 1400
- CO₂ automatic calibration: 1 (on by default)
- Shutdown time: 0 (no active shutdown)
- Fill in the unused items with 0 and send:

01 47 09 00 3C 03 84 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 05 03 E8 05 78 00 00 01 01 00 C3 2C

Refer to the following tables for the data interval and calibration.

Type	ADDR	CMD	LEN	DATA
Send	0x01	0x47	0x06	Refer to the table below.

DATA								
Data reporting interval	Data acquisition interval	Bluetooth broadcast interval	Notification repeating interval	Temperature unit	Temperature offset calibration	Humidity offset calibration	CO ₂ offset calibration	Temperature percentage calibration

2 bytes (minutes)	2 bytes (seconds)	2 bytes (seconds, reserved unused)	2 bytes (reserved, unused)	1 byte	2 bytes	2 bytes	2 bytes	2 bytes
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DATA								
Humidity percentage calibration	CO ₂ percentage calibration	CO ₂ acquisition interval	CO ₂ superior level	CO ₂ inferior level	Shutdown time	12-hour format	CO ₂ automatic calibration switch	CO ₂ starting calibrating
2 bytes	2 bytes	2 bytes (minutes)	2 bytes	2 bytes	2 bytes (minutes)	1 byte	1 byte	1 byte

E. Data Encryption Settings

Set the communication data encryption key to AES128 ECB.

- When the length is 16, use the key for encrypted communication.
- When the length is 0, communication is in plaintext.

Type	ADDR	CMD	LEN	DATA				
Send	0x01	0x47	0x06	Data Reporting Interval	Data Acquisition Interval	Bluetooth Broadcast interval	Notification Repeating Interval	Temperature unit
				2 bytes (minutes)	2 bytes (seconds)	2 bytes (seconds, reserved unused)	2 bytes (reserved unused)	1 byte (reserved unused)