

# SPECIFICATION

Product Name: Dual Beam NDIR CO<sub>2</sub> Sensor Module

Item No.: CM1107N

Version: V0.4

Date: Jan 06, 2020

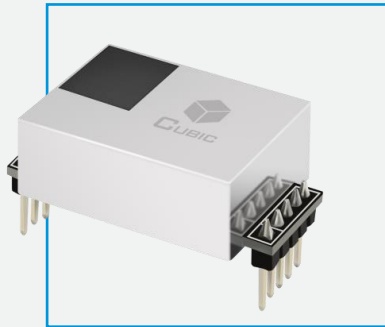
Writer	Audit	Approved
Mei Yang		

# Revision

No.	Version	Content	Date
1	V0.2	UART protocol “check sum”, the correct content is “Cumulative sum of data = 256 - (HEAD+LEN+CMD+DATA)%256”	2017.12.17
2	V0.2	UART protocol “4.2 Note”, Modifying the description as Auto calibration is default closed, if you want to open, then the default calibration cycle is 7 days.	2017.12.17
3	V0.2	Modifying the font to be Arial, updating the company name to be Cubic Sensor and Instrument Co.,Ltd	2018.09.19
4	V0.3	UART Communication Protocol “4.1 Note”, modifying the description of status bit I2C Communication Protocol “2.2 Note”, modifying the description of status bit	2019.07.11
5	V0.4	Add the 4.2.4 check the ABC status and ABC cycle	2020.01.06

# Dual Beam NDIR CO<sub>2</sub> Sensor Module

CM1107



## Applications

- HVAC industry
- IAQ monitor
- Air purifier
- Automotive
- IoT devices
- Intelligent agriculture
- Cold-chain

## Description

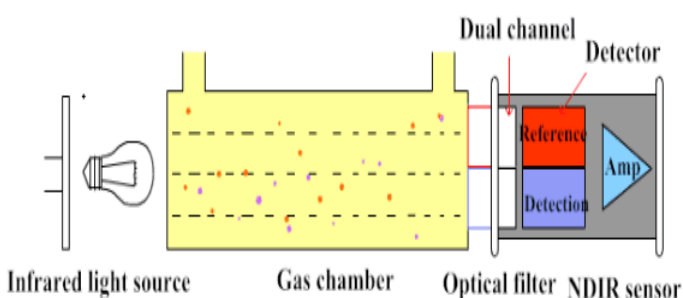
CM1107 is a dual beam (single light source, dual channel) NDIR CO<sub>2</sub> sensor, based on non-dispersive infrared (NDIR) technology, which can detect CO<sub>2</sub> concentration of indoor air. With higher accuracy, superior long term stability, it is widely used for ventilation system, air purifier, air conditioner, intelligent agriculture, storage and cold-chain, etc.

## Features

- NDIR technology with independent intellectual property
- Dual beam detection for superior stability and better accuracy
- High accuracy, long term stability, long life (>10years)
- Temperature calibration within whole measurement range
- Signal output PWM / UART / I<sup>2</sup>C
- Small size and compact structure, easy to install

## Working Principle

The main components of an NDIR CO<sub>2</sub> sensor are an infrared source, a sample chamber, a filter and two detectors. The infrared light is directed by the infrared source passing through the gas chamber towards the detector.



CO<sub>2</sub> molecules inside the gas chamber will only absorb a specific wavelength of the light. The filter allows only the specific wavelength corresponded to pass through it. One detector measures the intensity of infrared light that is related to the intensity of CO<sub>2</sub> and can be described through the Lambert-Beer's Law. The other detector is for reference. The change in sensor signal reflects the change in gas concentration.

## Specifications

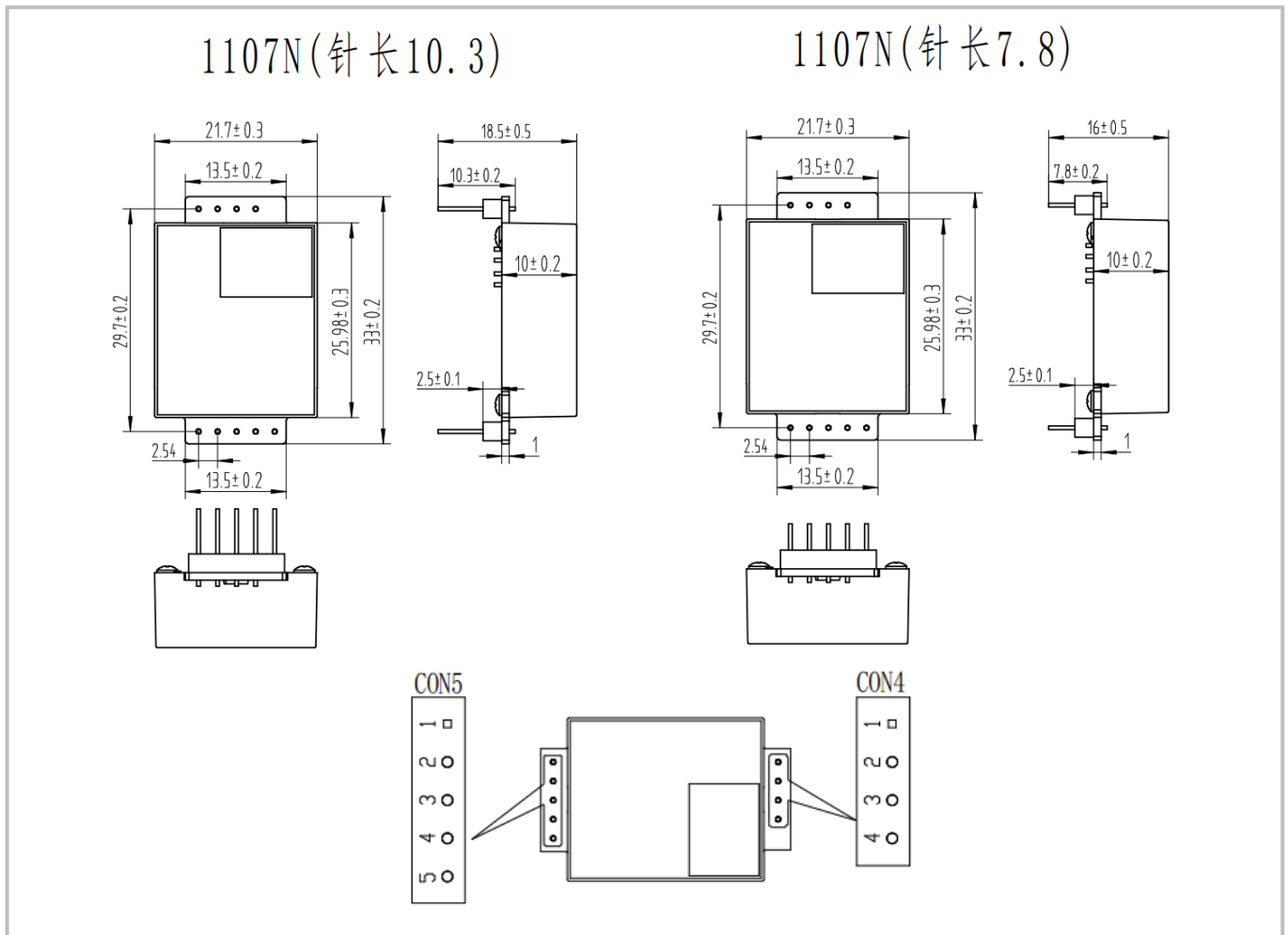
Dual Beam NDIR CO <sub>2</sub> Sensor Specification	
Target gas	Carbon Dioxide (CO <sub>2</sub> )
Operating principle	Non-dispersive infrared (NDIR)
Measurement range	0 ~ 5,000ppm
Working temperature	-10°C ~ 50°C
Working humidity	0 ~ 95%RH (Non-condensing)
Storage temperature	-30°C ~ 70°C
Storage humidity	0 ~ 95%RH (Non-condensing)
Accuracy	± (50ppm+3% of reading) @ 0°C ~ 50°C, 0 ~ 85%RH, 0 ~ 5,000ppm
Data refresh frequency	1 sec
Time to first reading	≤30 sec
Power supply	DC 5V ±0.1V
Ripple wave	<50mV
Working current	<50mA @ 1 sec
Dimensions	w33mm X h21.7mm X d18.5mm or w33mm X h21.7mm X d16.0mm
Weight	6.3g (Error range: ±0.2g)
Signal output	UART: TTL (3.3V/5V electrical level) PWM: Open-collector output I <sup>2</sup> C (3.3V electrical level)
PWM output	Output high level minimum duration: 2ms (0 ppm)
	Output high level maximum duration: 1,004ms (5,000 ppm)
Alarm output	Reserved
Life span	≥10 years

## Reliability test

Test item	Test condition	Judgment standard	Sample qty: N Defective q'ty: C
Thermal shock	100 cycles(every 30 minute) 30 minutes on -40°C, 30 minutes on 60°C. Sensors without power on.	1. $\pm$ (50ppm+3% of reading) after auto / manual calibration. 2. Inspection concentration point: 500ppm, 1,600ppm Note: Test Condition: 25 $\pm$ 2°C, 50 $\pm$ 10%RH	N= 22 C= 0
High temperature high humidity	Under 60°C, 95%RH, continuous working for 1,000 hours. Sensors with power on	1. $\pm$ (50ppm+3% of reading) after auto / manual calibration. 2. Inspection concentration point: 500ppm, 1,600ppm Note: Test Condition: 25 $\pm$ 2°C, 50 $\pm$ 10%RH	N= 22 C= 0

## Dimensions and Connector

### 1. Dimensions (Unit mm, tolerance $\pm 0.2$ mm)

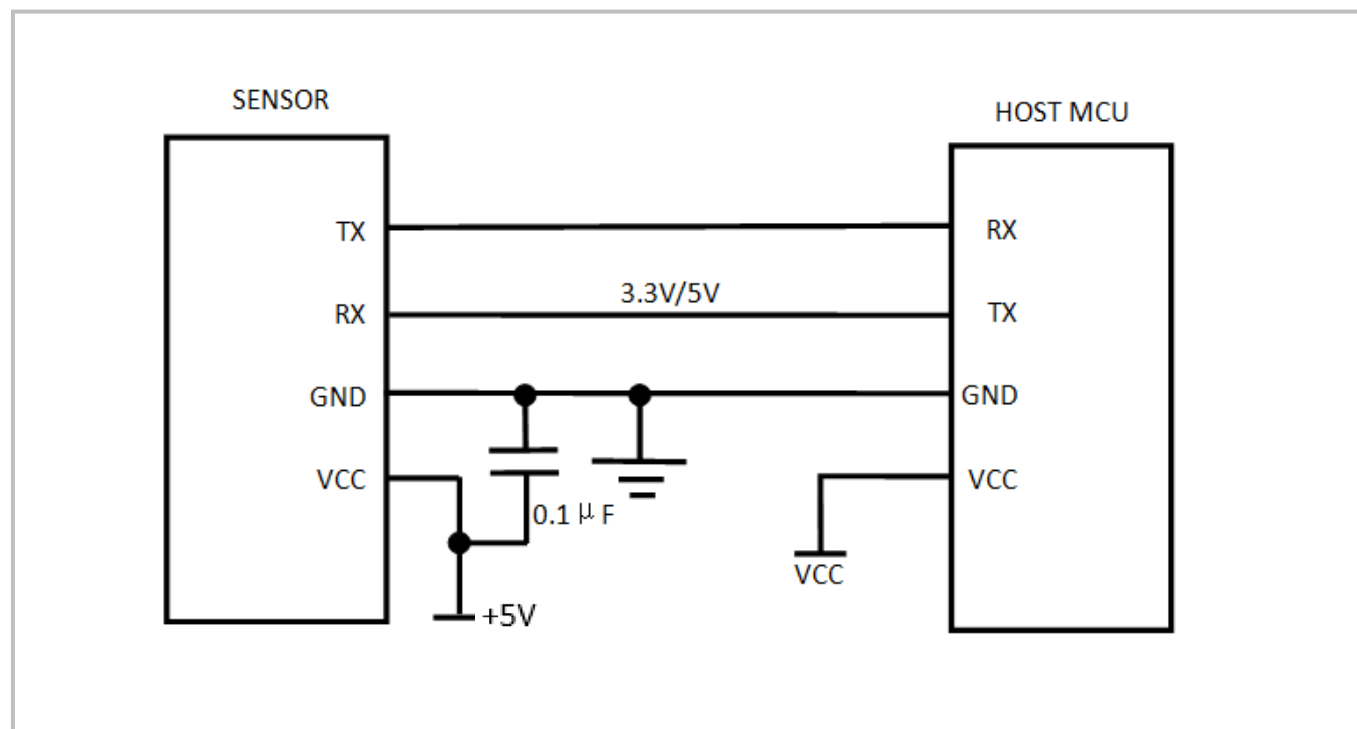


### 2. I/O Connector Pinout

CON5			CON4		
Pin	Name	Description	Pin	Name	Description
1	+3.3V	Power supply output (+3.3V/100mA)	1	+5V	Power supply input voltage,
2	RX/SDA	UART-RX (Receiving) / I <sup>2</sup> C data, compatible with 3.3V and 5V communication	2	GND	Power supply input (GND)
3	TX/SCL	UART-TX (Sending) / I <sup>2</sup> C Clock, 3.3V communication	3	A	Alarming
4	R/T	UART/ I <sup>2</sup> C Switch (Output mode exchange TTL level @3.3V High level or floating is UART communication mode, low level is I <sup>2</sup> C communication mode)	4	PWM	PWM output
5	CA	Manual calibration			

## Typical Application Circuit

Application scene: UART TTL serial port output



## Description of Calibration

### 1. Auto calibration (Closed by default, if open please refer to the protocol)

Rough installing and influence of transportation might result in reducing of sensor measuring accuracy and baseline drift, sensor will correct the drift by the built-in self-correcting logic. Powering on the sensor for 7 days continuously, it will record the lowest CO<sub>2</sub> concentration measurement value during the 7 days, which will be regarded as baseline (400ppm) when sensor do auto calibration after the 7 days working. In order to ensure correct auto calibration, please make sure working environment of the sensor can reach to outdoor fresh air level (400ppm) during the 24 hours and regular 7 days auto baseline correction cycle.

Note: For more detailed information on sensor auto-calibration, please contact Cubic

### 2. Manual calibration:

Rough installing and influence of transportation might result in a reducing of sensor reading accuracy and baseline drift. If need to recover accuracy quickly after installing, users can do manual calibration. Please place the sensor in an environment where outdoor atmospheric CO<sub>2</sub> levels can reach 400 ppm and ensure the CO<sub>2</sub> concentration in this environment is stable before calibration. The CA pin of sensor should be well connected at least 2 seconds when doing the manual calibration. Sensor will activate the calibration program after 6 seconds. In addition, sensor also can-do manual calibration by sending command, please refer to the communication protocol for more details.

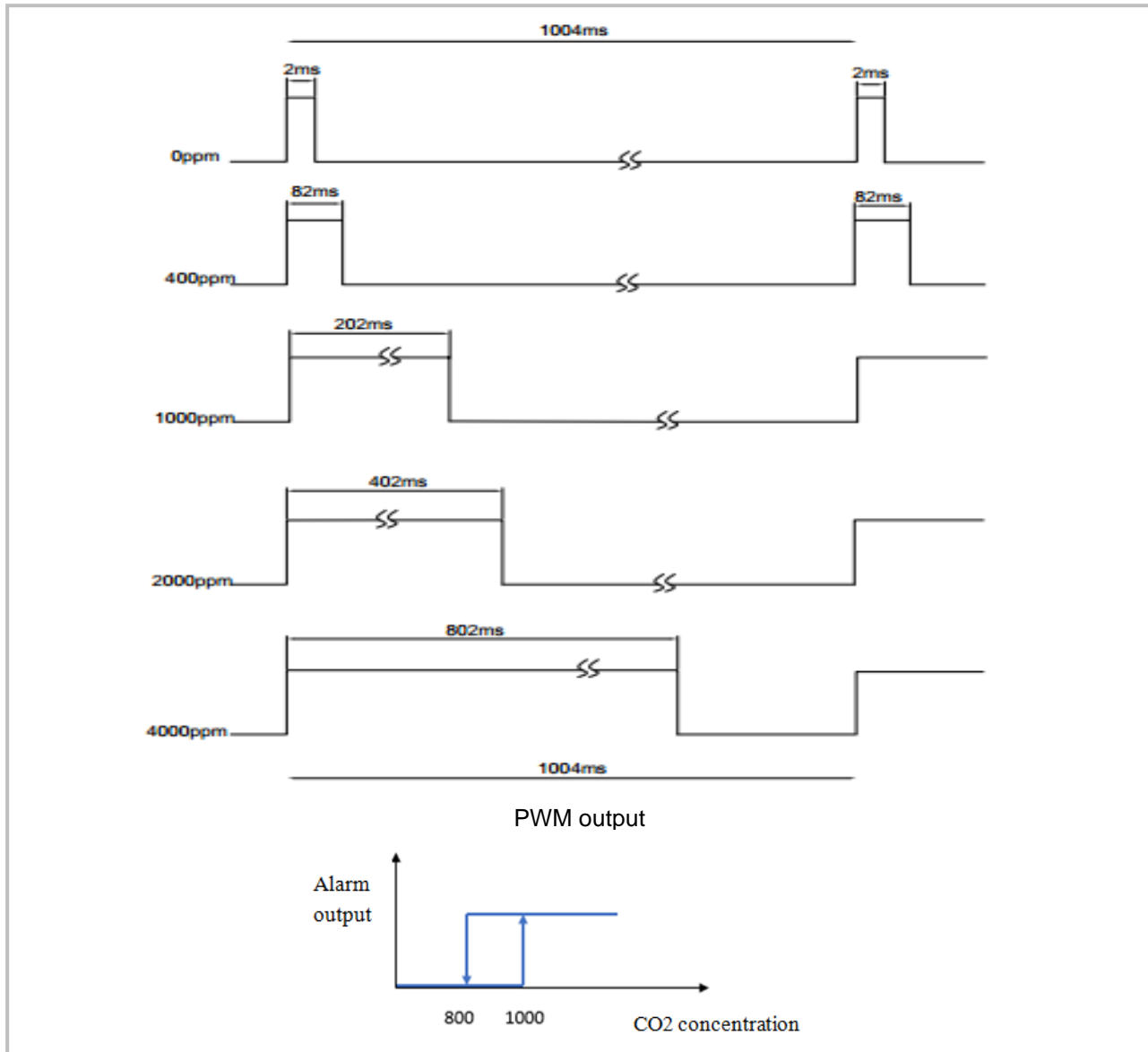
## PWM and Alarm Output

PWM cycle: 1,004ms

Positive pulse width: 0 ~ 5,000:  $(PPM / 5) + 2ms$

CO<sub>2</sub> concentration detection value: 500ppm range:  $(PWM \text{ Positive pulse width} - 2) * 5$

PWM output schema:



### Alarm Output

If the CO<sub>2</sub> concentration rises up to more than 1,000ppm, the alarming will be triggered and output high level. When the CO<sub>2</sub> concentration goes down to below 800ppm, the alarming will stop and output low level.

### Note

Connect the pin of PWM to the oscilloscope.

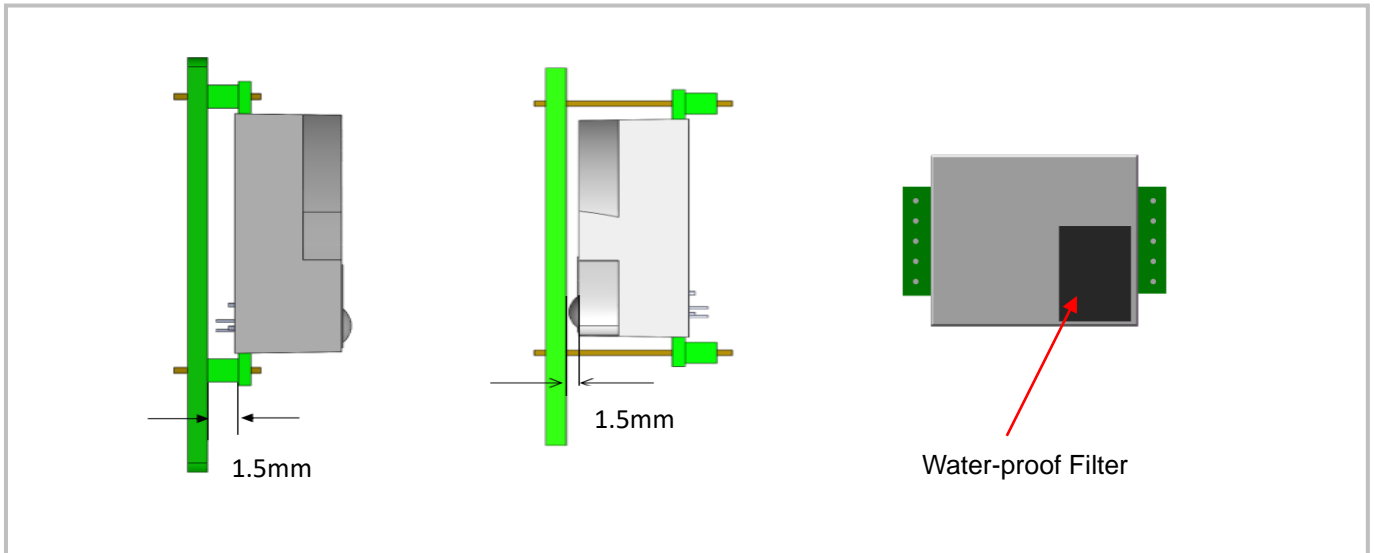
**Add a pull-up resistor around 5K ~ 10K between the pin of PWM and power supply.**



## Product Installation

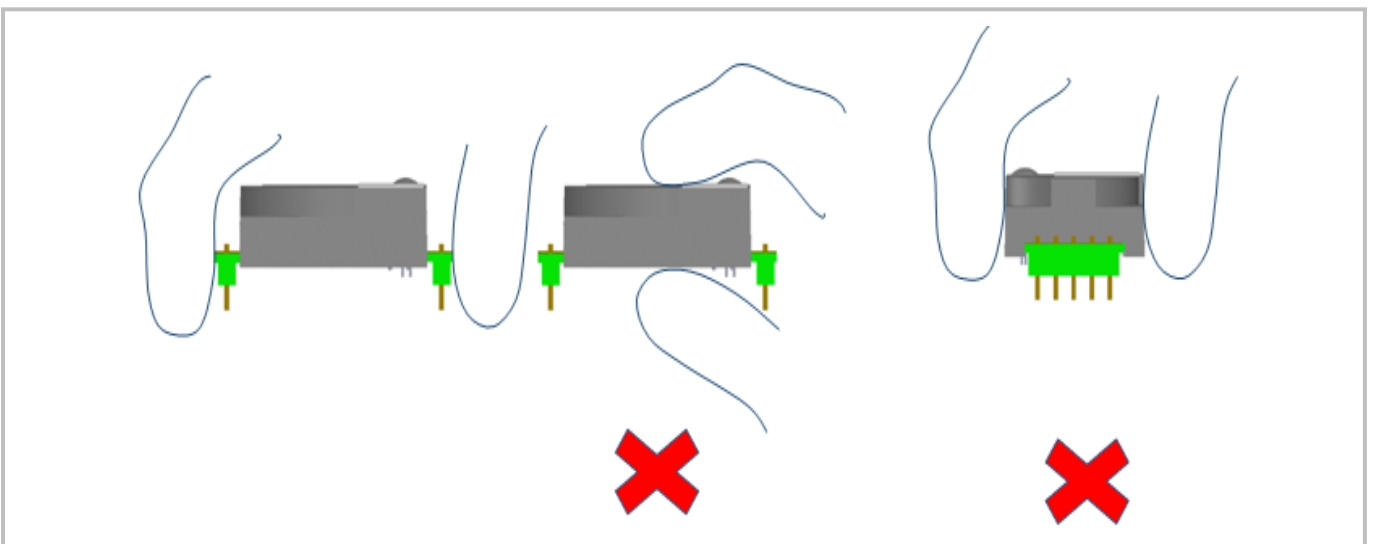
1. In order to ensure airflow diffusion into the sensor inner, make sure the minimum distance between the area of waterproof filter and the other components is 1.5 mm, otherwise, quick response time of the sensor will be affected.

Reference as below:



2. To avoid the influence of stress on sensor, please soldering by hand as much as possible when mounting the sensor to the PCB.

Reference as below:



## UART Communication Protocol

### 1. General Statement

- 1). The data in this protocol is all hexadecimal data. For example, "46" for decimal [70].
- 2). Baud rate: 9,600, Data Bits: 8, Stop Bits: 1, Parity: No, Flow control: No.
- 3). [xx] is for single-byte data (unsigned, 0 ~ 255); for double data, high byte is in front of low byte.

### 2. Format of Serial Communication Protocol

Sending format of upper computer:

Start Symbol	Length	Command	Data1	...	Data n.	Check Sum
HEAD	LEN	CMD	DATA1	...	DATAn	CS
11H	XXH	XXH	XXH	...	XXH	XXH

Detail description on protocol format:

Protocol Format	Description
Start Symbol	Sending by upper computer is fixed as [11H], module respond is fixed as [16H]
Length	Length of frame bytes= data length +1 (including CMD+DATA)
Command	Command
Data	Data of writing or reading, length is not fixed
Check Sum	Cumulative sum of data= 256 - (HEAD+LEN+CMD+DATA)%256

### 3. Command Table of Serial Protocol

Item No.	Function Name	Command
1	Read measured result of CO <sub>2</sub>	0x01
2	Open / Close ABC and set ABC parameter	0x10
3	Calibrate concentration value of CO <sub>2</sub>	0x03
4	Read the serial number of the sensor	0x1F
5	Read software version	0x1E

### 4. Detail Description of UART Protocol

#### 4.1 Read Measured Result of CO<sub>2</sub>

**Send:** 11 01 01 ED

**Response:** 16 05 01 DF1 ~ DF4 [CS]

**Function:** Read measured result of CO<sub>2</sub> (Unit: ppm)

**Note:**

CO<sub>2</sub> measured result= DF1 \* 256 + DF2;

DF3: status bit

Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
Reserved	1: Drift 0: Normal	1: Light Aging 0: Normal	1: Non- calibrated 0: Calibrated	1: Less than Measurement Range 0: Normal	1: Over Measurement Range 0: Normal	1: Sensor Error 0: Operating normal	1: Preheating 0: Preheat complete

DF4 is reserved

**Example:**

Response: 16 05 01 02 58 00 00 8A

**Explanation:**

Hex is converted to decimal: 02 is 02; 58 is 88

CO<sub>2</sub> concentration= 02 \* 256 + 88= 600ppm

**4.2 Open / Close ABC and Set ABC Parameter**

**Send:** 11 07 10 DF1 DF2 DF3 DF4 DF5 DF6 [CS]

**Response:** 16 01 10 D9

**Explanation:**

DF1: Reserved, default 100 (0x64)

DF2: Open / close auto calibration (0: open; 2: close, default close)

DF3: Calibration cycle (1 ~ 255 days optional, default is 7 days)

DF4: High base value (2 bytes)

DF5: Low base value (2 bytes)

DF6: Reserved, default is 100 (0x64)

**Note:**

The auto calibration function is open with 7 days calibration cycle by default.

The default value of DF4 and DF5 is 400, that is DF4: 01; DF5: 90

**4.2.1 Open ABC and Set Calibration Cycle**

When ABC function is closed and you want to re-open ABC function, you should set the DF2= 0.

**Example:** You could send below command to open ABC function and set the calibration cycle 7 days.

**Send:** 11 07 10 64 00 07 01 90 64 78

**Response:** 16 01 10 D9

**4.2.2 Close ABC**

The ABC function is default closed. If you want to close the ABC function after opening it, you should set the DF2= 2.

**Send:** 11 07 10 64 02 07 01 90 64 76

**Response:** 16 01 10 D9

**4.2.3 Change the Calibration Cycle**

If you want to change the calibration cycle to 10 days, you should set the DF3= 10.

**Send:** 11 07 10 64 00 0A 01 90 64 75

**Response:** 16 01 10 D9

#### 4.2.4 Check ABC Status and ABC Cycle

If you want to check the ABC status, you can check the DF2, 0 means open; 2 means close

If you want to check the ABC cycle, you can check the DF3 (DF3 range can be 1-255 days, default is 7 days)

**Send:** 11 01 0F DF

**Response:** [ACK] 07 0F [DF1][DF2][DF3][DF4][DF5][DF6][CS]

#### 4.3 Calibration of CO<sub>2</sub> Concentration

**Send:** 11 03 03 DF1 DF2 [CS]

**Response:** 16 01 03 E6

**Function:** Calibration of CO<sub>2</sub> concentration

**Note:**

1. Calibration target value= DF1 \* 256 + DF2 Unit: PPM, range (400 ~ 1,500ppm)
2. Before calibration, please make sure CO<sub>2</sub> concentration in current ambient is calibration target value. Keeping this CO<sub>2</sub> concentration for two 2 minutes, then began calibration.

**Example:**

When you need to calibrate CO<sub>2</sub> concentration of the sensor to 600ppm, send command:

**Send:** 11 03 03 02 58 8F

Hex is converted to decimal: 02 is 02; 58 is 88

CO<sub>2</sub> concentration= 02 \* 256 + 88= 600ppm

#### 4.4 Read the Serial Number of the Sensor

**Send:** 11 01 1F CF

**Response:** 16 0B 1F (SN1) (SN2) (SN3) (SN4) (SN5) [CS]

**Function:** Read the serial number of the sensor

**Note:** Read the serial number of the sensor. SNn: 0 ~ 9,999, 5 integer form 20-digit number.

#### 4.5 Read Software Version

**Send:** 11 01 1E D0

**Response:** 16 0C 1E DF1 ~ DF11 [CS]

**Function:** Read software version

**Note:**

DF1 ~ DF10: stand for ASCII code of software version, DF11 is reserved.

**Example:**

When the sensor version is CM V0.0.20, respond data as follows:

Hexadecimal converted to ASCII code:

Note: when 20 converted to ASCII code, it equals to blank space.

16 0C 1E 43 4D 20 56 30 2E 30 2E

↓  
CM V0.0.20

# I<sup>2</sup>C Communication Protocol

## 1. Timing Diagram Introduction

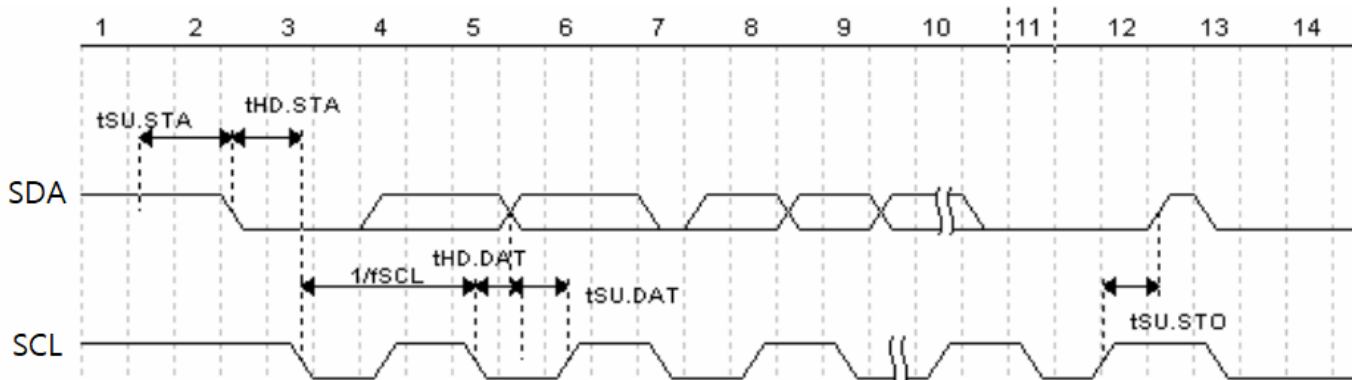
### 1.1 Common Description

- a. This protocol is based on standard I<sup>2</sup>C timing sequence, the clock frequency is 10kHz ~ 400kHz.
- b. Use big-endian format, the most significant bit to be sent first.

### 1.2 I<sup>2</sup>C Sequence Diagram Introduction

Item	Parameter			Unit
	Min	Type	Max	
fSCL (SCL clock frequency)	10		400	KHz
tHD.STA (hold time of the starting bit)		0.6		us
tSU.STA (setup time of the starting bit)		0.6		us
tHD.DAT (hold time of the data)		0		ns
tSU.DAT (setup time of the data)		250		ns
tSU.STO (setup time of the stop bit)		4		us

**Note:** SCL clock frequency is generated by the master device with the range 10kHz~400kHz.

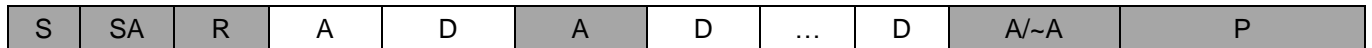


Picture 1: I<sup>2</sup>C clock introduction

### 1.3 Basic Data Transmission Formats



Picture 2: The general data format sends from the master device to the slave

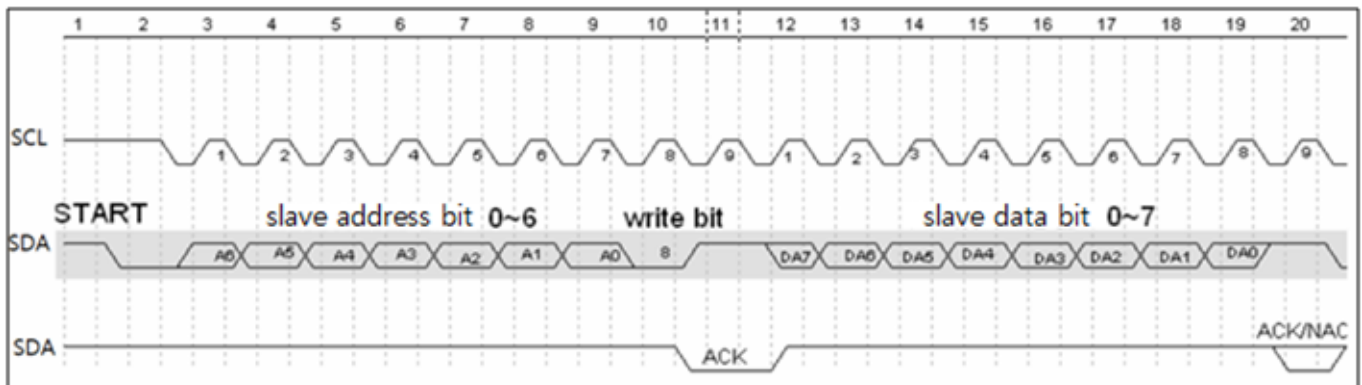


Picture 3: The general data format received from the slave device to the master device

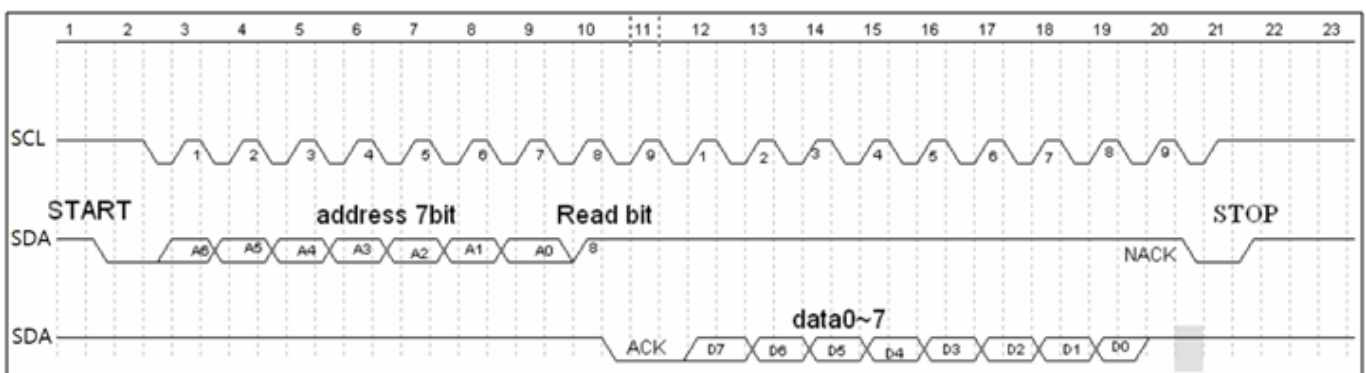
#### The meaning of the symbol in picture 1.2 and picture 1.3:

- S: start condition
- SA: slave address
- W: write bit
- R: read bit
- A: acknowledge bit
- ~A: not acknowledge bit
- D: data, each data is 8bit
- P: stop condition
- Shadow: The signal generated from the master device
- No Shadow: The signal generated from the slave device

### 1.4 Timing Diagram



Picture 4: The address byte send from the master device



Picture 5: The master device read a byte from the slave device

## 1.5 Notes

The performance of the MCU which is used in the sensor is not very high. If you use I/O port to simulate IIC master device, it is suggested to reserve a period before and after ACK signal (such as 100 us), after sending every byte (8 bit) to leave enough time for the SCM to process the data. Within requirements of speed, it is recommended to lower the reading speed as much as possible.

## 2. Measuring Function

### Format of Command

**Format of Sending:** [CMD][DF0].....[DFn]

[CMD] Command number, for distinguishing different command.

[DF0] ... [DFn] The command with parameter item and optional items

**Format of Response:** [CMD][DF0].....[DFn] [CS]

[CMD] Command number

[DF0]... [DFn] Effective data

[CS] Data check bit = ([CMD]+ [DF0]+.....[DFn]) Only use the lowest bit

### 2.1 Statement of Measuring Command

The slave address is 0x31, the data command of the slave device is as below:

No.	Function Name	CMD	Function Description
1	Measure result	0x01	Read measuring result
2	Auto calibration specification setting	0x10	Set auto calibration specification (Open or not, calibration period)
3	Calibration	0x03	Zero setting of CO <sub>2</sub>
4	Read the serial number of the sensor	0x1F	Read the serial number of the sensor
5	Check software version	0x1E	Read software version

### 2.2 Measuring Result

The master device should send command of measuring result.

**Send:** 0x01

**Response:** [0x01][DF0][DF1] [DF2][CS]

#### Note:

1. Sensor starts measuring result status once receiving the command 0x01. After this, all the data which I<sup>2</sup>C read will be such status format data, until the sensor receives new command or re-powering on.
2. Data format, master device receives DF<sub>0</sub> first, and then receives CS at last.

Remark	Status Bite	Decimal Effective Reading Value Range	Relative Value	Multiple
CO <sub>2</sub> measuring result	[DF0] [DF1]	0 ~ 5,000 ppm	0 ~ 5,000 ppm	1
Status bit	[DF2]			1

CO<sub>2</sub> measuring result: DF0\*256+DF1, Fixed output is 550ppm during preheating period.

Status bit: 0: Preheating; 1: Normal operation; 2: Operating trouble; 3: Out of FS, 5: Non-calibrated

### Example:

The master device reads some data: Read 3 bit.

0x01 0x03 0x20 0x01 0xDB

CO<sub>2</sub> measuring result = (0x03 0x20)<sub>hexadecimal</sub> = (800)<sub>decimal</sub> = 800 ppm

Status bit: 0x01 means working normally

[CS]= -(0x01+0x03+0x20+0x01) Only keep the lowest bite.

### 2.3 Auto Zero Specification Setting

**Send:** 0x10 [DF0] [DF1] [DF2] [DF3] [DF4] [DF5]

**Response:** [0x10] [DF0] [DF1] [DF2] [DF3] [DF4] [DF5] [CS]

#### Format description:

1. Sensor will be auto calibration specification setting status after receiving command 0x10. After this, all the data which I<sup>2</sup>C read are the data in this status format, until sensor receives new command or repowering on.
2. Data format, the master will receive [DF0] firstly, and receive [CS] at last.

The result is calculated by high bit in front

Remark	Data Bite	Decimal Effective Reading Value Range	Relative Value	Multiple
Wrong code accelerate value	[DF0]	By default: 100	100	1
Zero setting switch	[DF1]	0 or 2	0: Open, 2: Close	1
Calibration period	[DF2]	1 ~ 15	1 ~ 15	1
Calibration concentration value	[DF3] [DF4]	400 ~ 1,499	Suggest 400 ~ 1,499	1
Reserved byte	[DF5]	By default: 100	100	1

### 2.4 Calibration

1. The master device should send command of zero setting.

**Send:** 0x03 [DF0] [DF1]

**Response:** [0x03] [DF0] [DF1] [CS]

**Note:** 1. Sensor starts zero setting status once receiving command 0x03. After this, all the data which I<sup>2</sup>C read will be such status format data, until the sensor receives new command or re-powering on.

2. Data format, master device receives DF0 first, and then receives CS at last. The result is calculated by high bit in front: [DF0] \* 256 + [DF1].

Remark	Data Bite	Decimal Effective Reading Value Range	Relative value	Multiple
Adjust value	[DF0] [DF1]	400 ~ 1,500	400 ~ 1,500 ppm	1



## 2.5 Read the Serial Number of the Sensor

**Send:** 0x1F

**Response:** [0x1F] [DF0] [DF1] [DF2] [DF3] [DF4] [DF5] [DF6] [DF7] [DF8] [DF9] [CS]

**Note:**

1. Sensor starts device code output status once receiving the command 0x1F. After this, all the data which I<sup>2</sup>C read will be such status format data, until the sensor receives new command or re-powering on.
2. Data format, the master device receives [DF0] first, and then receives [CS] at last. The result is calculated by high bit in front.

Remark	Data Bit	Decimal Effective Reading Value Range	Relative Value	Multiple
Integer type 1	[DF0] [DF1]	0 ~ 9,999	0 ~ 9,999	1
Integer type 2	[DF2] [DF3]	0 ~ 9,999	0 ~ 9,999	1
Integer type 3	[DF4] [DF5]	0 ~ 9,999	0 ~ 9,999	1
Integer type 4	[DF6] [DF7]	0 ~ 9,999	0 ~ 9,999	1
Integer type 5	[DF8] [DF9]	0 ~ 9,999	0 ~ 9,999	1

3. The five-integer type makes 20 codes.

## 2.6 Read Software Version

**Send:** 0x1E

**Response:** [0x1E] [DF0] [DF1] [DF2] [DF3] [DF4] [DF5] [DF6] [DF7] [DF8] [DF9] [CS]

- Note:**
1. Sensor starts software version output status once receiving the command 0x1E. After this, all the data which I<sup>2</sup>C read will be such status format data, until the sensor receives new command or re-powering on.
  2. Data format, the master device receives DF<sub>0</sub> first, and then receives CS at last. [DF<sub>0</sub>] ..... [DF<sub>9</sub>] is ASCII.

## 3. Communication Diagram

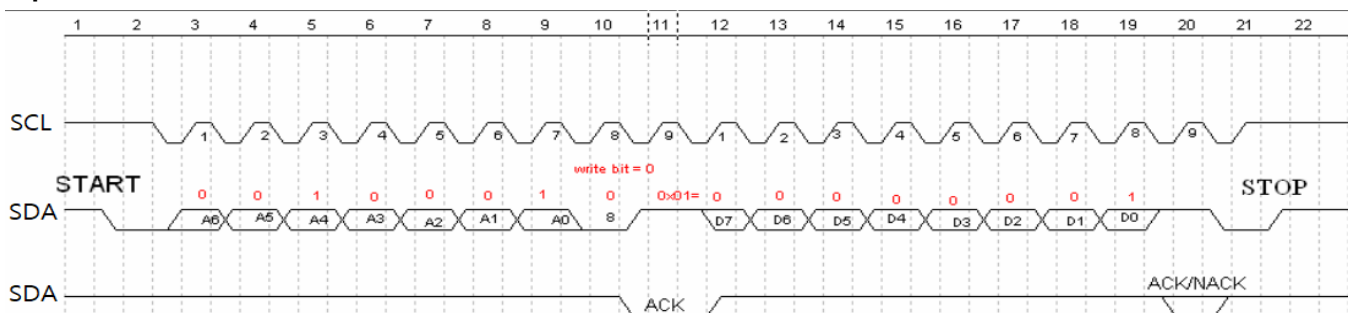
**Diagram 1:** The master device read two bytes continuously from the slave device.

The slave machine address: 0x31= 0110001 (the machine address is 7 bit) + read/write bit (1bit)

The slave data address: 0x01= 00000001

**Step 1:** The master device sends the address of the slave device+ write bit: 0110001+0 → 01100010 (0x62); at this time, the master device is in sending status.

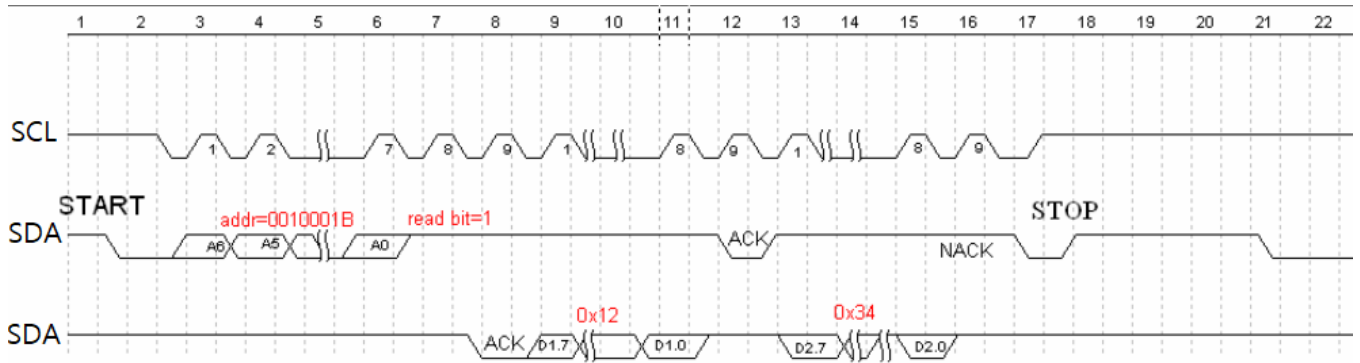
**Step 2:** The master device sends the slave data address: 0x01



Picture 6: The timing diagram send from the master device

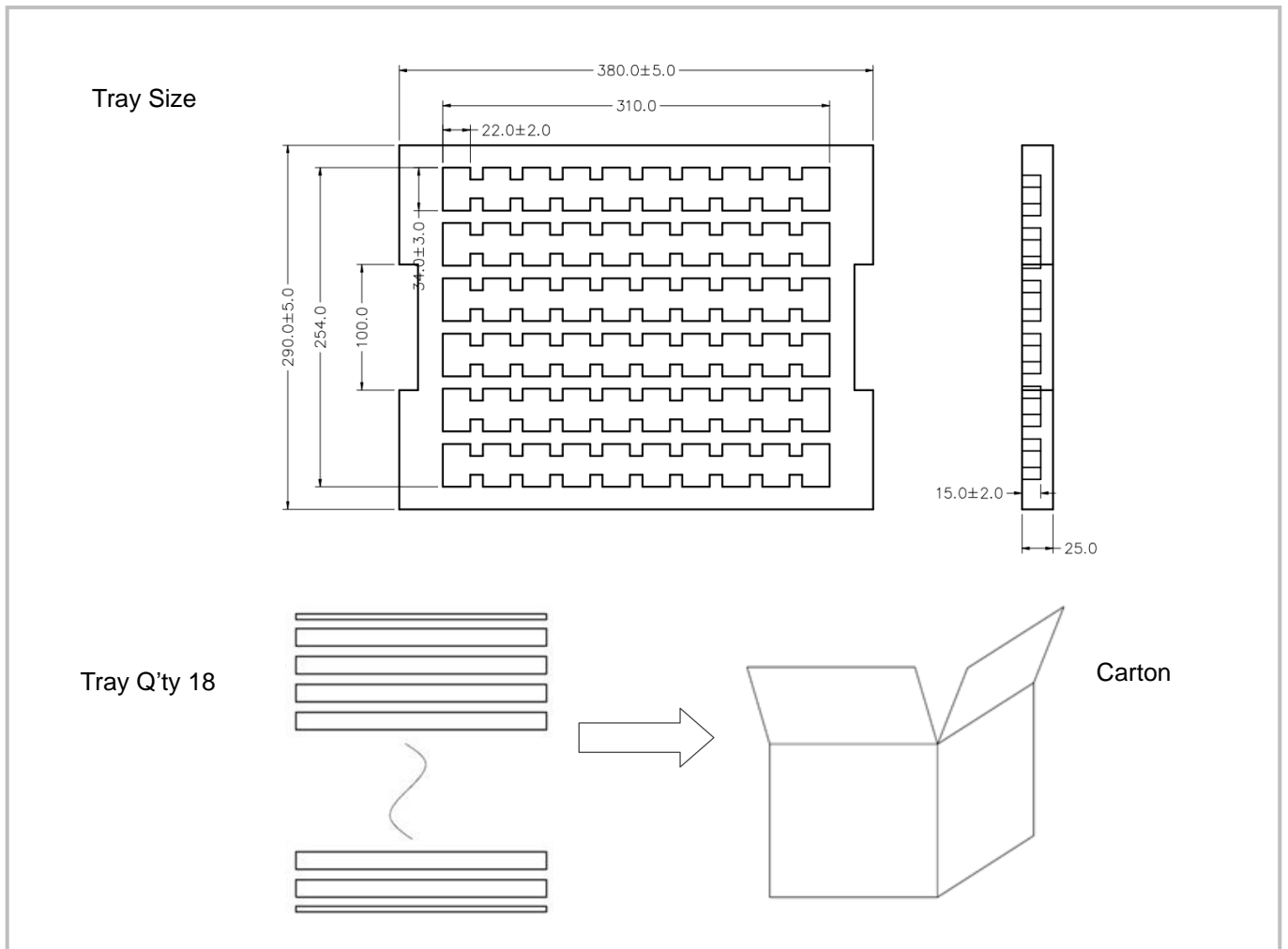
**Step 3:** The master device send the slave machine address+ read bit : 0110001+1 → 01100011 (0x63); at this time, the master device is in receiving status.

**Step 4:** The master device sends the answer bit after receiving a one-bit data and the slave continuously sends the next data. If the master device sends the no-answer bit after receiving a one-bit data, then the communication will stop.



Picture 7: The master device receives the data from the slave device

## Packing Information



Sensor per Tray	Tray Q'ty	Sensor per Carton	Carton Dimensions	Packing Material
60 pcs	18 layers	1,080 pcs	395 x 310 x 480 mm	Red anti-static EPE

## After-Sales Services and Consultancy

**Cubic Sensor and Instrument Co., Ltd**

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Web: [www.gassensor.com.cn](http://www.gassensor.com.cn) / E-mail: [info@gassensor.com.cn](mailto:info@gassensor.com.cn) / South Korea Contact [malbonair@naver.com](mailto:malbonair@naver.com)