Compact Weather Sensor

Version: V1.1

Dates: 2024-9-5

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Version	Description	Date	The modifier
V1.0	Initial version	04-07-2023	Jenkin Lu
V1.1	Add new product Introduction	04-25-2023	Xinan Rao

1 Product Introduction

SenseCAP ONE is a series of all-in-one compact weather sensors, including S1000 10-in-1, S800 8-in-1, S700 7-in-1, S500 5-in-1, S200 weather sensors. These weather sensors integrate multiple sensors into this compact device, monitoring up to10 weather parameters: air temperature, air humidity, atmospheric pressure, light intensity, wind speed, wind direction, precipitation, PM 2.5, PM 10,noise and CO2. The sensors use ultrasonic to measure wind speed and wind direction, to achieve high-precision data collection, which is easy maintenance. The equipment is designed with industry standards and can work stably in harsh outdoor environments from -40°C to 85°C. The product supports the Modbus-RTU (RS485) and SDI-12 protocols.

Basic parameters	
Product Model	SenseCAP ONE Series (S200/S500/S700/S800/S1000)
Power Supply	12V~ 24V（0.42W）
Heating Power Supply	24V（21W）
Support Protocols	RS485 (MODBUS-RTU) / SDI-12
IP Rating	IP66
Working Temperature	-40 ℃ ~ + 85℃
Working Humidity	0 to 100%RH (non-condensing)

Product Model: S200 (2-in-1)			
Measurement Parameter	Measurement Range	Measurement Accuracy	Resolution
Wind speed	0~60 m/s standard range 0~75m/s extended range Up to 80m/s withstand range	±0.3m/s(≤10m/s); ±3%（10m/s ~ 50m/s) ±5% (>50m/s)	0.1m/s
Direction of the wind	0~360°（@-40℃~60℃）	±3.0°	0.1°
Product Model: S500 (5-in-1)			
Measurement Parameter	Measurement Range	Measurement Accuracy	Resolution
Air temperature	-40~85°C	±0.1℃	0.01°C
Air humidity	0~100%RH	±1.5%RH	0.01%RH
Barometric pressure	300~1250hPa	±50Pa	10 Pa
Wind speed	0~60 m/s standard range 0~75m/s extended range Up to 80m/s withstand range	±0.3m/s(≤10m/s); ±3%（10m/s ~ 50m/s) ±5% (>50m/s)	0.1m/s

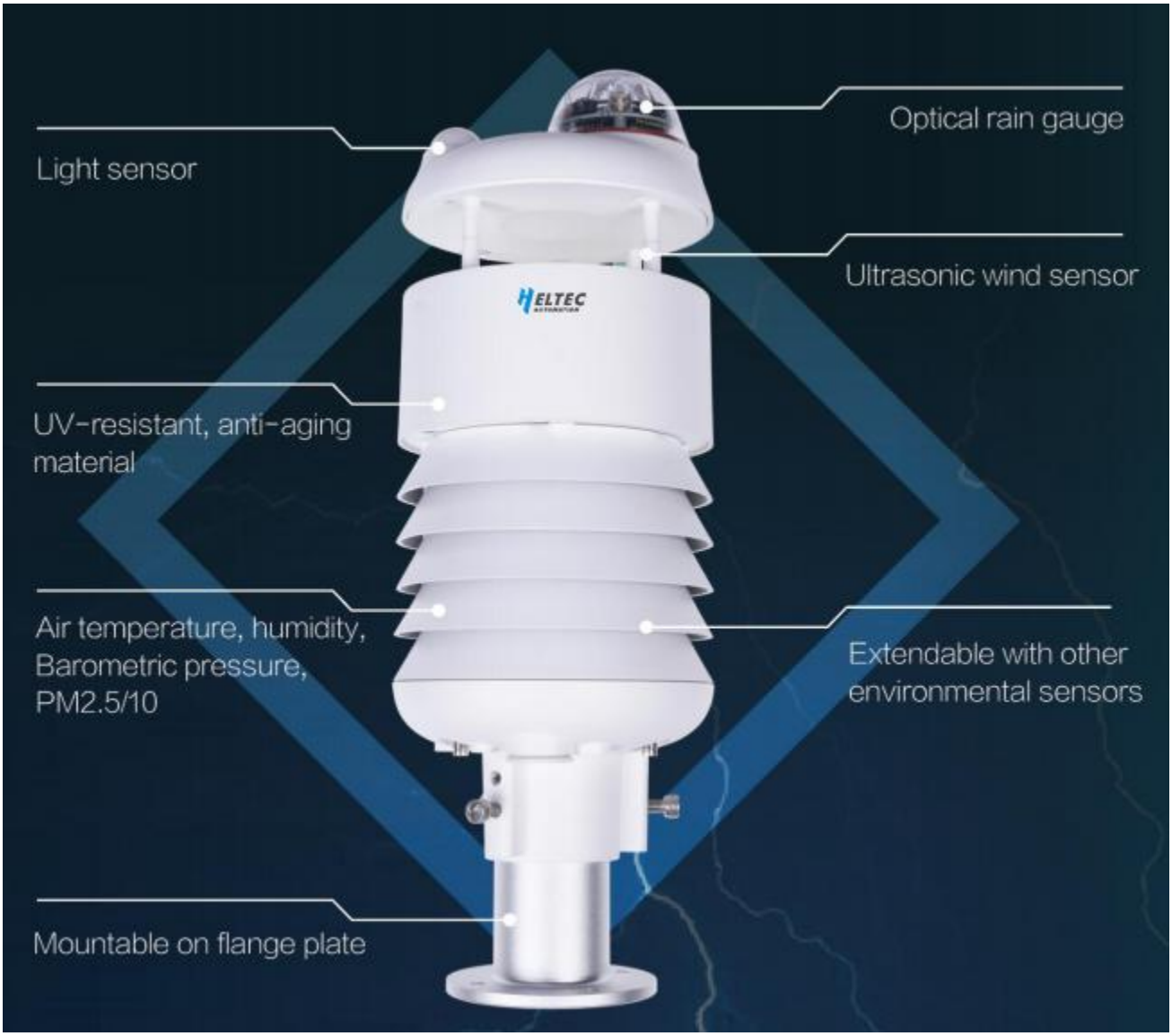
Direction of the wind	0~360° (@-40~60℃)	±3.0°	0.1°
Product Model: S700 (7-in-1)			
Measurement Parameter	Measurement Range	Measurement Accuracy	Resolution
Air temperature	-40~85°C	±0.1℃	0.01°C
Air humidity	0~100%RH	±1.5%RH	0.01%RH
Barometric pressure	300~1250hPa	±50Pa	10 Pa
Wind speed	0~60 m/s standard range 0~75m/s extended range Up to 80m/s withstand range	±0.3m/s(≤10m/s); ±3% (10m/s ~ 50m/s) ±5% (>50m/s)	0.1m/s
Direction of the wind	0~360° (@-40℃~60℃)	±3.0°	0.1°
Light intensity	0~188000 Lux	5% * reading	5Lux
Rain intensity	0~200mm/h	±10%	0.2mm/0.02mm
Product Model: S800 8-in-1)			
Measurement Parameter	Measurement Range	Measurement Accuracy	Resolution
Air temperature	-40~85°C	±0.1℃	0.01°C
Air humidity	0~100%RH	±1.5%RH	0.01%RH
Barometric pressure	300~1250hPa	±50Pa	10 Pa
Wind speed	0~60 m/s standard range 0~75m/s extended range Up to 80m/s withstand range	±0.3m/s(≤10m/s); ±3% (10m/s ~ 50m/s) ±5% (>50m/s)	0.1m/s
Direction of the wind	0~360° (@-40℃~60℃)	±3.0°	0.1°
Noise intensity	35~100dB	±1.5dB	0.1dB
PM2.5	0~1000μg/m3	±10%@100~1000μg/m3 ±10μg/m3@0~100μg/m3	1μg/m3
PM10	0~1000μg/m3	±15%@100~1000μg/m3 ±15μg/m3@0~100μg/m3	1μg/m3
Product Model: S1000 (10-in-1,CO2 series)			
Measurement Parameter	Measurement Range	Measurement Accuracy	Resolution
Air temperature	-40~85°C	±0.1℃	0.01°C

Air humidity	0~100%RH	±1.5%RH	0.01%RH
Barometric pressure	300~1250hPa	±50Pa	10 Pa
Wind speed	0~60 m/s (@-40℃~60℃)	±0.3m/s, (≤10m/s) ±3% of the measured value (>10m/s)	0.1m/s
Direction of the wind	0~360° (@-40℃~60℃)	±3.0°	0.1°
Light intensity	0~188000 Lux	5% * reading	5Lux
Rain intensity	0~200mm/h	±10%	0.2mm/0.02mm
PM2.5	0~1000μg/m3	±10%@100~ 1000μg/m3 ±10μg/m3@0~ 100μg/m3	1μg/m3
PM10	0~1000μg/m3	±15%@100~ 1000μg/m3 ±15μg/m3@0~ 100μg/m3	1μg/m3
CO2	400- 5000ppm;extended range up to 10000 ppm	土(30 ppm +3% of reading) (extended range ±10% of reading)	1ppm

Note: Multi-in-one meteorological environment sensors with other monitoring elements can be customized. For specific requirements, please contact relevant personnel of the company.

2 Installation

Before the installation, check the packing list and make sure there are no missing parts.



2.1 Packing List

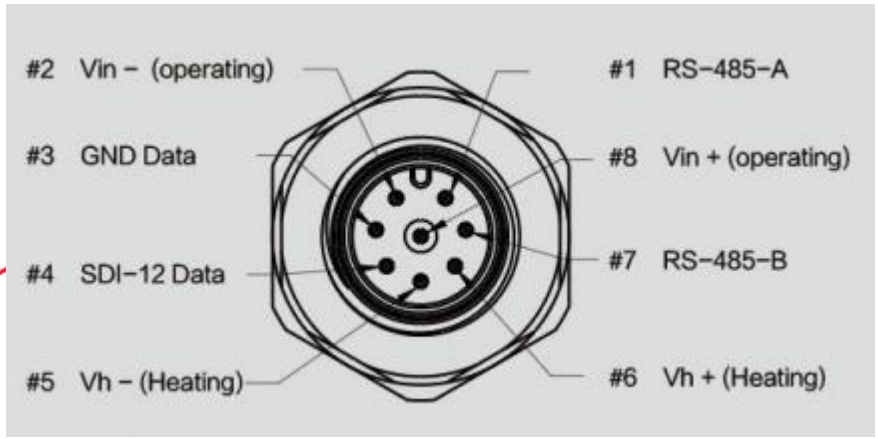
Number	Parts	Number
1	S700 V2 7-in-1 compact weather sensor	1
2	M12 8-pin communication cable (default length 3-meter hook-up wire, and there is a waterproof aviation connector type to choose when working with SenseCAP SensorHub datalogger. If the aviation connector is not needed, cut it off by yourself)	1
3	USB Type-C cable, for configuring devices	1
4	Flange plate (purchased separately)	1
5	Pole adapter sleeve base (purchased separately)	1
6	Pole adapter cross bar (purchased separately)	1

2.2 Installation

2.2.1 Device Interface Introduction

There are two connectors at the bottom of the device.

- USB Type-C interface allows you to connect your computer with a normal USB Type-C cable to the device for configuration.
- The main data interface can be connected to the M12 8-pin cable, supporting multiple bus protocols

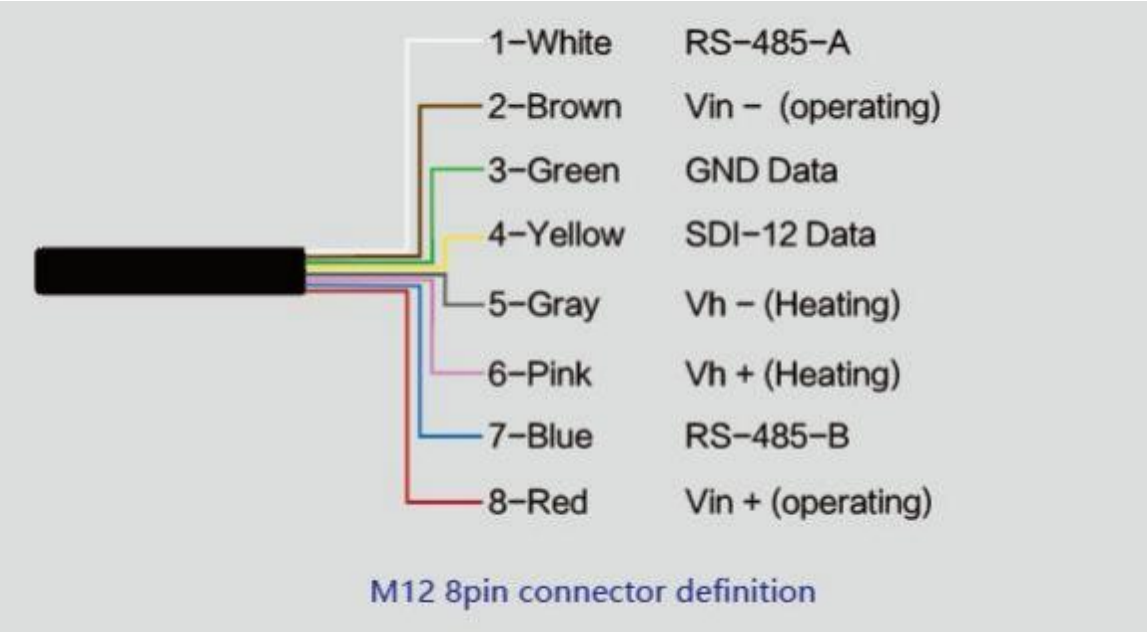


Bottom of the device

2.2.2 Connect with USB Cable

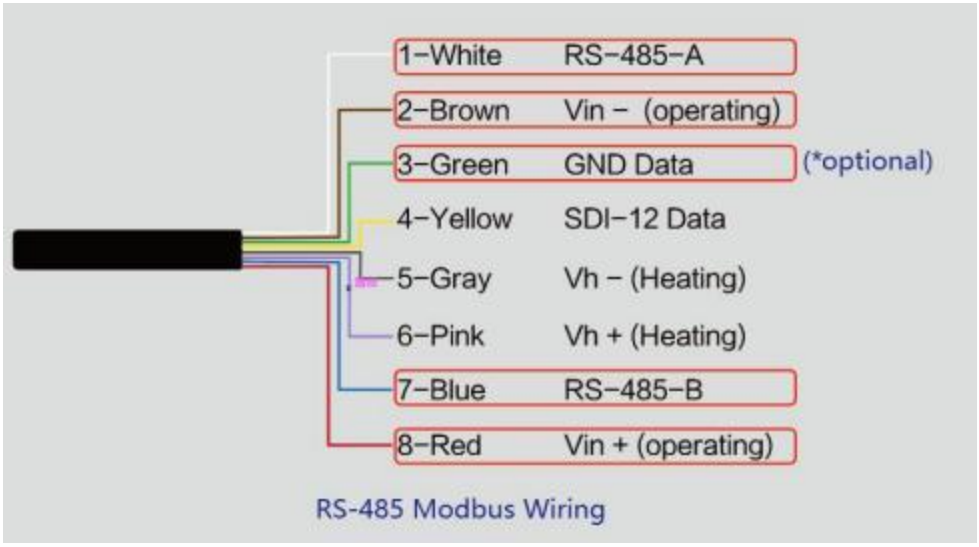
Note: The white cover (on the side near the label) should be tightened after debugging to prevent water from entering the device!

2.2.3 M12 Cable



The device adopts an M12 8-pin connector, the different colored pins provide power and data communication (as shown in the above diagram).

When working with the RS-485, you can connect only 4 wires (not using a heating function), and the rest can be individually wrapped with tape to prevent short circuit

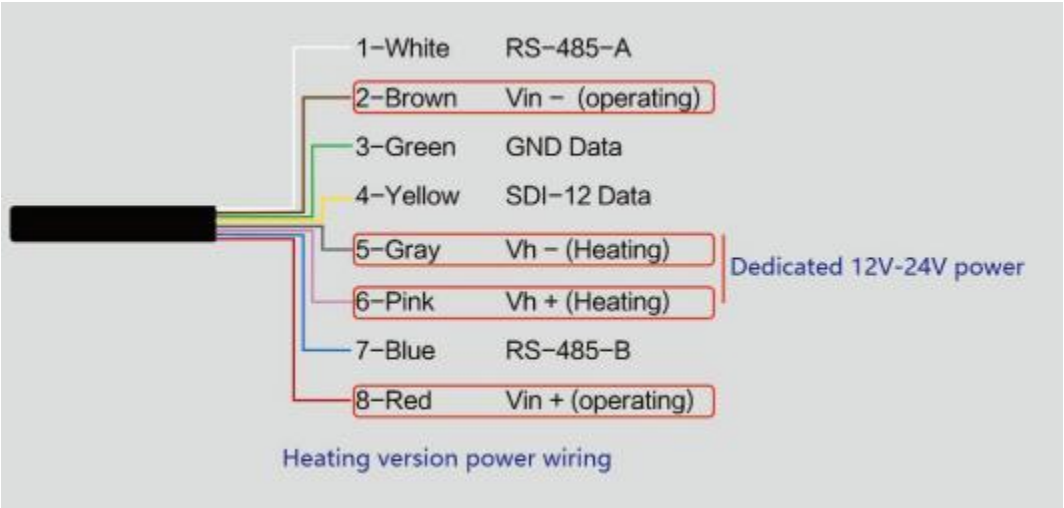


The holes of the cable and the pins of the device connector must be aligned when the cable is plugged in.

Plugin the cable and tighten it clockwise

Note: the cable is aimed at with the bottom before inserting it into the bottom. Otherwise,the pins are skewed may cause the communication is abnormal .

When using the device with a heating function, a separate 24V (24V@ 1A is recommended) power supply is required. Gray wire #5 is connected to the negative of the power supply, and pink wire #6 is connected to the positive pole of the power supply.



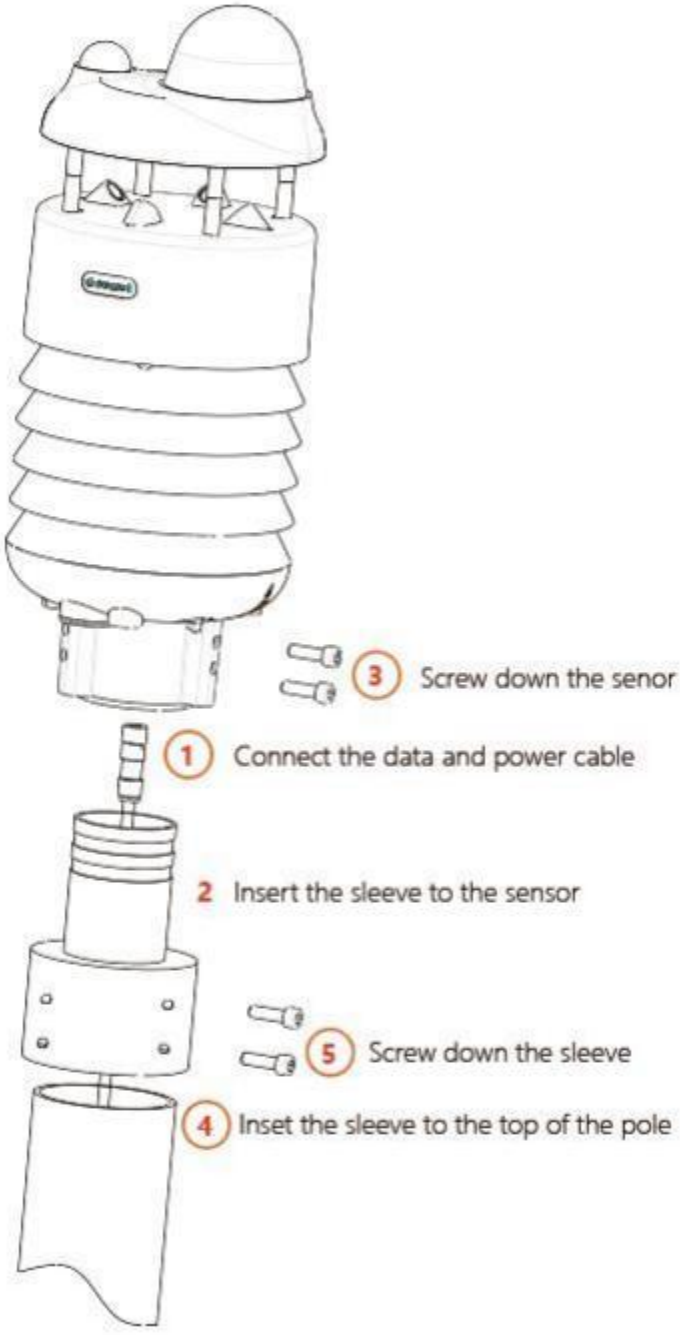
Reminding:

1. When the device needs to add power extension cable, if its length is more than 100 meters, it needs to use 24V/2A for power supply (without heating function);

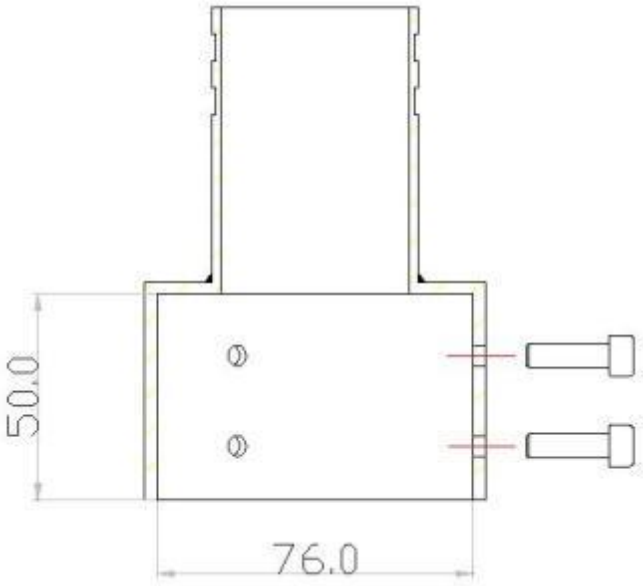
2. When the heating function is enabled, the power supply of the heating module should be within 3 meters of the SenseCAP ONE.The distance between the power supply of the heating module and the device is not more than 5m. Please use the 3m / 5m conversion cables sold by our company.

2.2.4 Install the device.

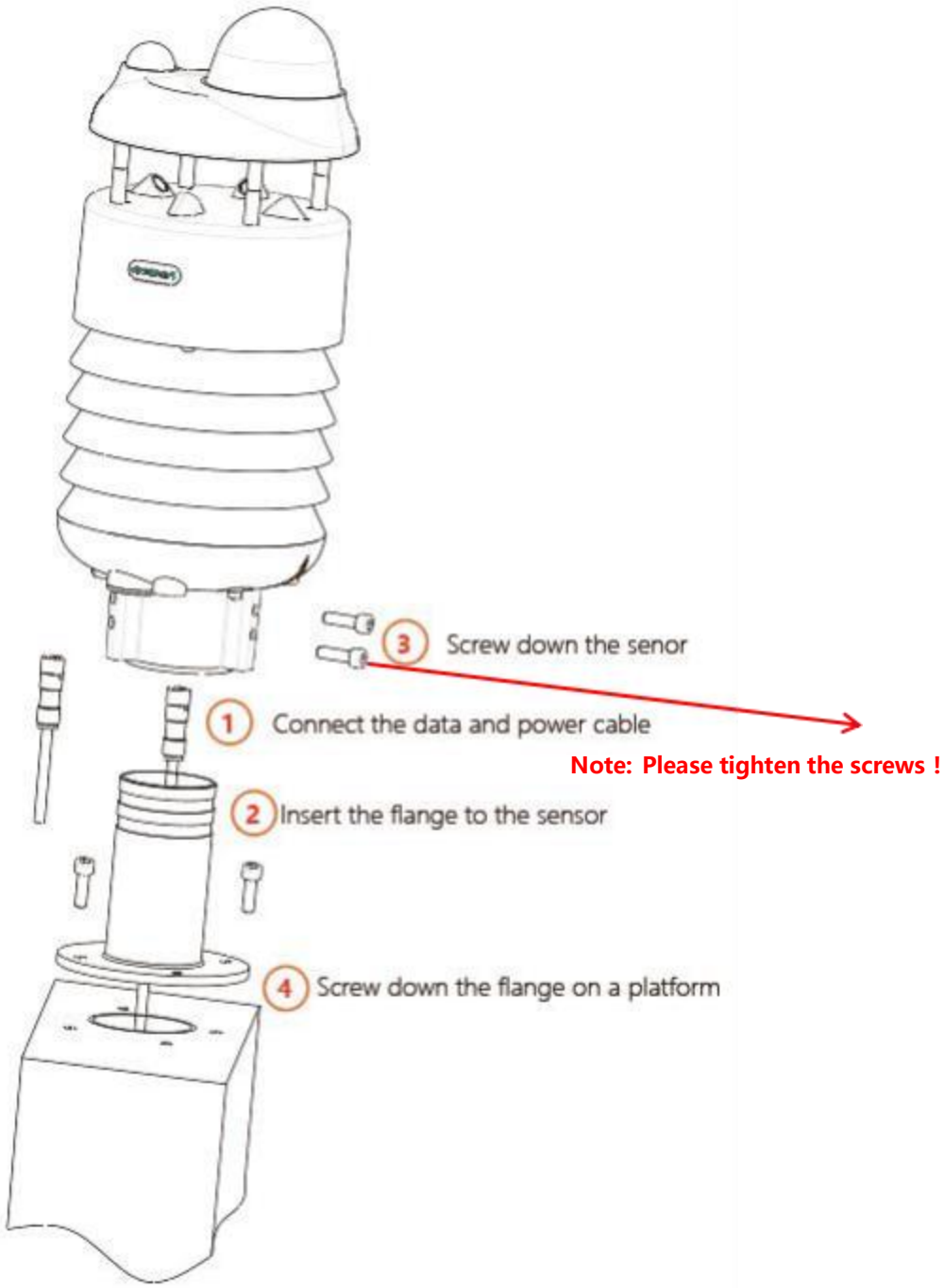
There are two major installation methods, either mount on a pole with a sleeve or a platform with a flange plate



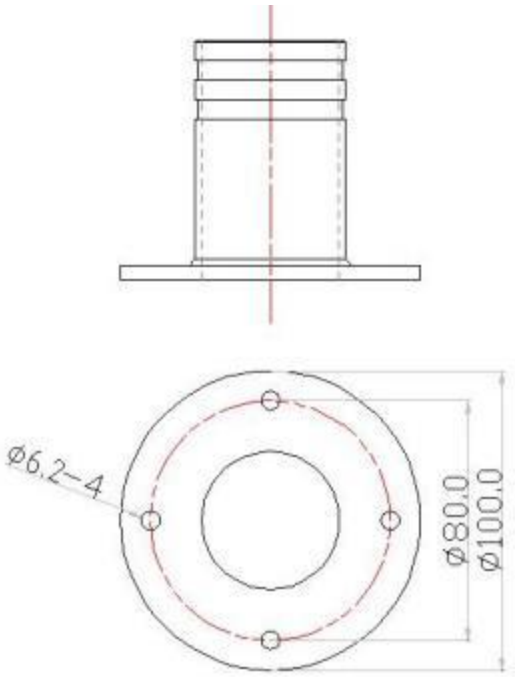
The size of the sleeve is shown below.



It is recommended that the diameter of the pole should be less than or equal to 75cm.



The dimension of the flange plate is shown below.


ø6.2-4
ø80.0
ø100.0

3 Device's Operating Mode

After installation, you can power on the device, configure it and collect data from the device. The device has two operating modes, **configuration mode, and working mode.**

Configuration Mode	With a USB cable, you can check or configure the device's parameters, such as device name, version number, and communication protocol configuration. Product firmware can be upgraded in this mode.
Working Mode	Connect the devices and data logger with an M12 data and power cable, and then the data collected by the device will be sent to the host via different communication protocols.

3.1 Configure the device via USB port

There is a waterproof round cover at the bottom of the device. Turn it counterclockwise to remove this cover, and you can see a USB Type-C connector and a configuration button.

Connect the device to your computer with a USB Type-C cable. The computer will automatically install the device driver. After the driver is successfully installed, you can see a serial port in the device's manager.

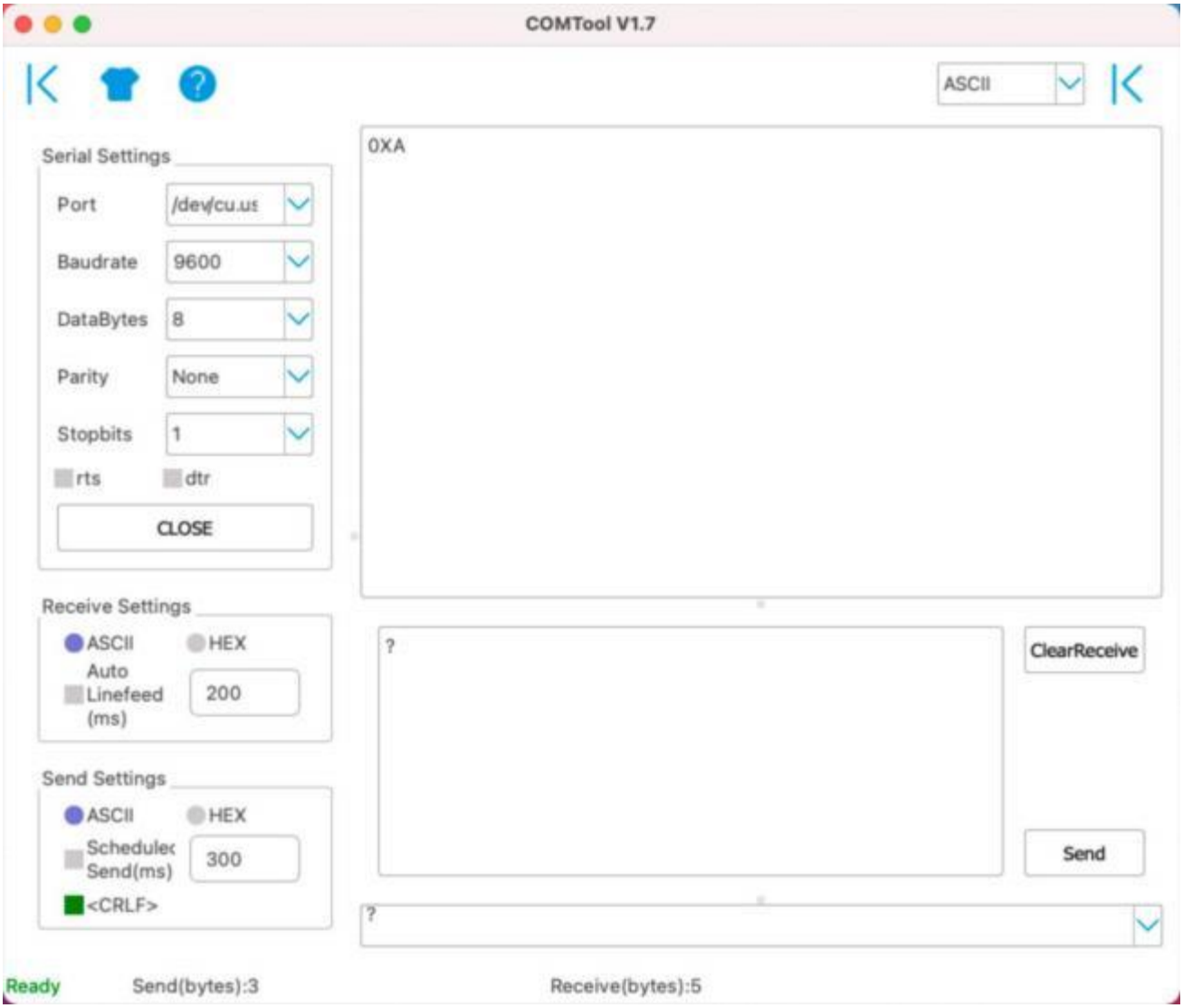
If the driver is not installed automatically, click this link to manually download and install the driver. (

The version is CP210x Windows Drivers)

3.2 Serial debug tool

The communication settings are as follows:

Select the serial port	You can find port information in your computer's device manager
Baud rate	9600bps, 8 data bits, 1 stop bits, none parity, none flow control.



- In the Serial Debug Assistant, select the corresponding COM port.
- Check the "click Enter to start a new line" check box.
- Set the baud rate to 9,600.
- Send ? in the send area.
- If you receive the corresponding 0XA message in the serial receive window, the configuration is successful. If not, please check the COM port and the baud rate.

Please check the detailed ASIIC command in the next chapter.

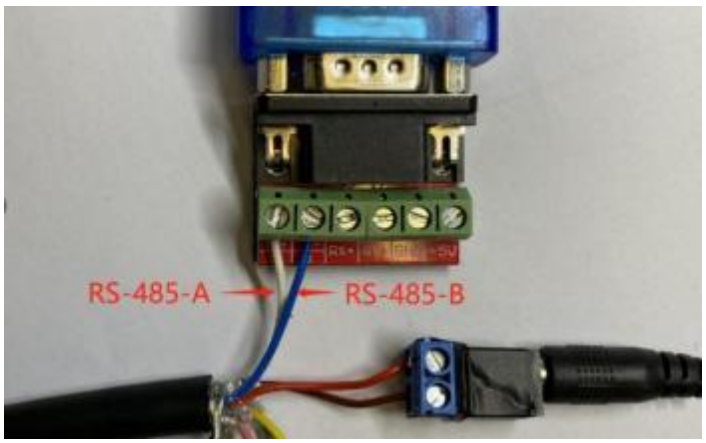
4 Communication Protocols

The device supports the following communication protocols:

Modbus-RTU	The Modbus protocol is a common language applied to electronic devices. With this protocol, devices can communicate within their network. It has become a universal industry standard, widely used in data loggers, sensor equipment, and so on. Based on this protocol, devices produced by different vendors can communicate with each other for system integration. The Modbus protocol is a master-slave protocol. One node is the host, and the other nodes that use the Modbus protocol to join the communication are the slave. Each slave has a unique address.
ASCII	The ASCII protocol is a query-response or a question-and-answer communication protocol in which a host PC uses ASCII characters to send commands to a device and then receives responses from that device.
SDI-12	Single-bus-based data communication protocol , is an asynchronous serial communications protocol for intelligent sensors that monitor environment data.

4.1 Modbus-RTU Protocol

To start Modbus-RTU communication, the M12 data cable of the device needs to be connected to the RS-485 port of one Data Logger, which powers up the device at a voltage of 12V-24V. The following image is a diagram of the wiring:



Protocol communication parameters

Data Format	One start bit, 8 Data bits, None parity, one Stop bits.		
Baud Rate	9600bps (default), which can be modified by configuration.		
Default Device Address (Decimal)	S1000	43(CO2 series)	
	S800	46	
	S700	20	
	S500	10	
	S200	44	

4.1.1 Modbus-RTU Protocol Message Format

Sensor data is stored in the Input Register and is read-only

The device address and the communication baud rate of RS-485 are stored in the Holding Register and can be modified.

Each register is 16bits and takes up 2 bytes.

Read the message from the input register.

The message format from by the host				
Slave address	**Function code**	**Register address**	**Number of registers**	**CRC check**
1 byte	1 byte	2 bytes (big-endian).	2 Byte (big-endian).	2 bytes
AA	0x04	RRRR	NNNN	CCCC
Address 0-247	0x04	big endian	big endian	little endian

The message response from the slave						
Slave address	**Function code**	**Number of registers**	**First Register data**	**Second register data**	**...**	**CRC check**
1 byte	1 byte	1 byte	2 bytes	2 bytes	...	2 bytes
AA	0x04	MM	VV0	VV1	...	CCCC
Address 0-247	0x04	big endian	big endian	big endian	...	little-endian

Read and write the holding register.

The message format from by the host				
Slave address	**Function code**	**Register address**	**Number of registers**	**CRC check**
1 byte	1 byte	2 bytes (big-endian).	2 Byte big-endian).	2 bytes
AA	0x03/0x06	RRRR	NNNN	CCCC
Address 0-247	0x03/06	big endian	big endian	little endian

The message response from the slave						
Slave address	**Function code**	**Number of registers**	**First Register data**	**Second register data**	**...**	**CRC check**
1 byte	1 byte	1 byte	2 bytes	2 bytes	...	2 bytes
AA	0x03/0x06	MM	VV0	VV1	...	CCCC
Address 0-247	0x03/0x06	big endian	big endian	big endian	...	little-endian

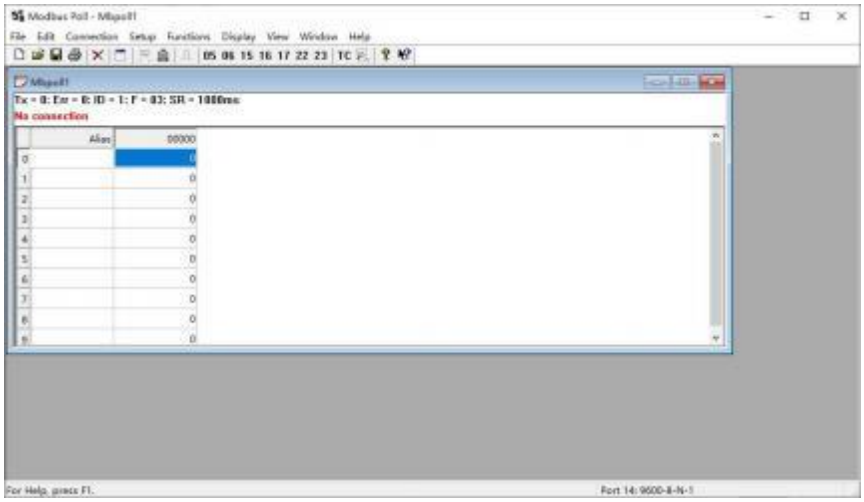
4.1.2 Register Address Definition

Register type	Address	Name	values range	Number of registers	Register status	Note
Input register	0x0000	Air temperature	-40000~85000	2	R	big endian Data format int32 Divide the data value by 1000 to get the true measurements
	0x0002	Air humidity	0~100000	2	R	
	0x0004	barometric pressure	30000000~125000000	2	R	
	0x0006	Light intensity	0~188000000	2	R	
	0x0008	Minimum wind direction	0~360000	2	R	
	0x000A	Maximum wind direction	0~360000	2	R	
	0x000C	Average wind direction	0~360000	2	R	
	0x000E	Minimum wind speed	0~60000	2	R	
	0x0010	Maximum wind speed	0~60000	2	R	
	0x0012	Average wind speed	0~60000	2	R	
	0x0014	Accumulated rainfall	0~80000000	2	R	
	0x0016	Accumulated rainfall duration	0~2000000000	2	R	
	0x0018	Rain intensity	0-200000	2	R	
	0x001A	Maximum rainfall	0-60000	2	R	

		intensity				
	0x001C	Heating Temperature	-40000~85000	2	R	
	0x001E	The dumping of state	0 or 1000((The dumping of state is 1000, the vertical of state is 0)	2	R	
	0x0030	PM2.5	0~1000000	2	R	
	0x0032	PM10	0~1000000	2	R	
	0x0040	CO2	0-10000	2	R	
	0x0048	Noise intensity	35000~100000	2	R	
Holding register	0x1000	Device address		1	R/W	The default address is 1 Can be set to 1 - 247
	0x1001	Baud rate		1	R/W	The default is 96, which means 9600. It can be set to: 12=1200 24=2400 48=4800 96=9600 192=19200 384=38400 576=57600 1152=115200
	0x2000	Set the accumulated rainfall to 0		1	R/W	Write 1 to set accumulated rainfall to 0. Read back 1 to confirm that the setting is finished. Read back 0 indicates that the setting failed
	0x2001	Set the accumulated rainfall duration to 0		1	R/W	Write 1 to set accumulated rainfall duration to 0. Read back 1 to confirm that the setting is finished. Read back 0 indicates that the setting failed

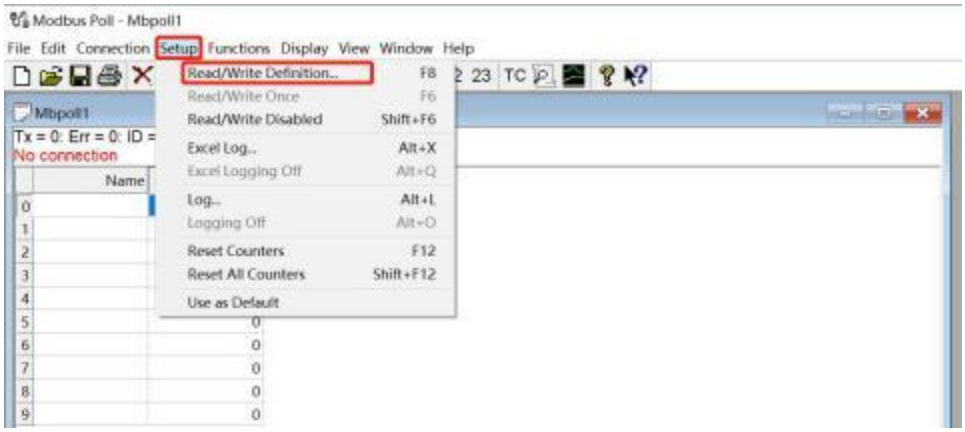
4.1.3 Modbus-RTU Read

Here is an example of the **Modbus Poll tool**
(download from https://www.modbustools.com/download.html).



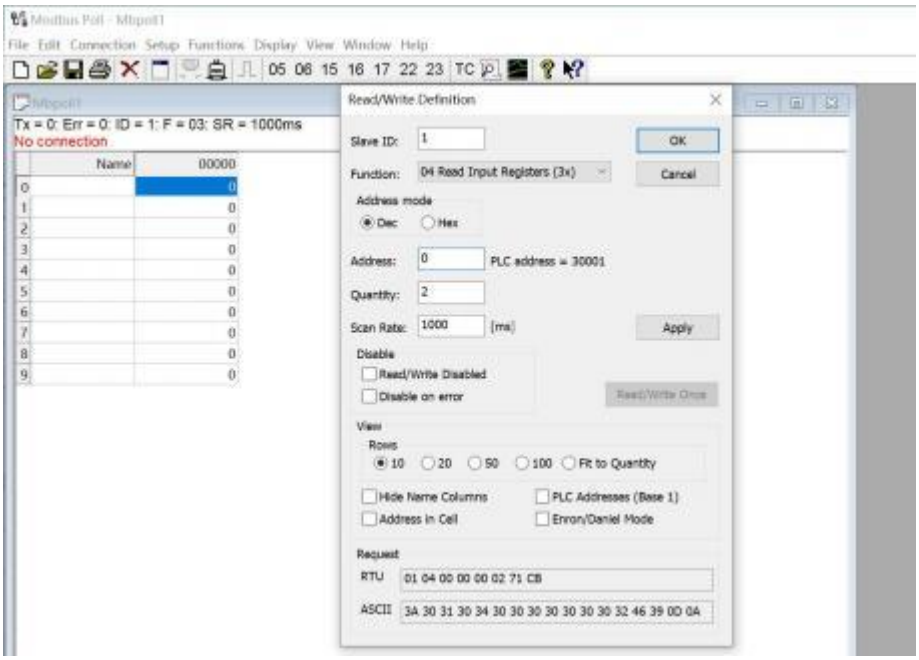
Configuration connection parameters: Baud rate 9600bps, 8 Data bits, None Parity, 1 Stop bits.

Read the air temperature register 0x0000 to 0x0001, click Setup, and select Read/Write Definition

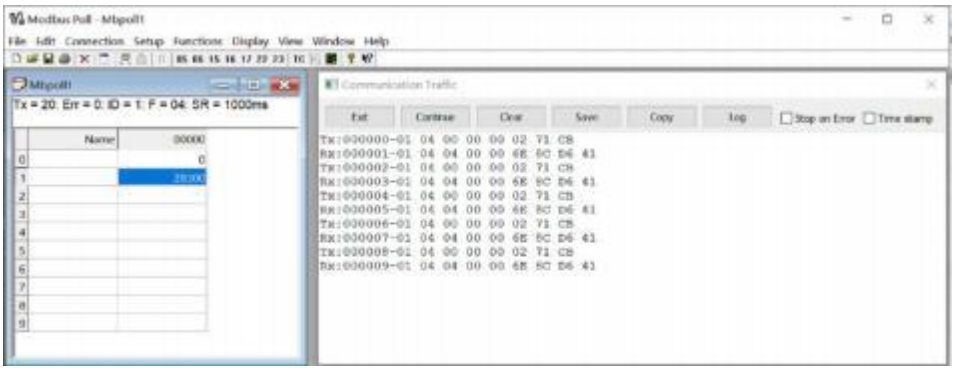


Set the default slave ID(2-in-1 is 44,5-in-1 is 10 , 7-in-1 is 20), function code 04, starting address

0, quantity (2-in-1 is 12 , 5-in-1 is 6 , 7-in-1 is 28);



Now the computer reads the sensor data every 1 second, and the measurement (line 0 and line 1) is shown in below picture, after dividing the measurement by 1000, it is the true temperature value, 28300/1000 = 28.3 °C



On the right, you can check the raw sent and received data packages. When the temperature is positive:

1. Host sends 01 04 00 00 00 02 71 CB
2. Slave responses 01 04 04 00 00 6E 8C D6 41
3. Return temperature data 0x00006E8C (Hex), converted to decimal = 28300, get the corresponding air temperature by dividing through 1000, air temperature = 28300/1000 = 28.3 °C

When the temperature is negative:

The temperature needs to be obtained through a complement calculation.

1. Host sends 01 04 00 00 00 02 71 CB
2. Slave responses 01 04 04 FF FF FC 18 D6 41
3. Returned temperature data FFFFFC18H (Hex complement).
4. The original code is - (FF FF FC 18-1 = FF FF FC 17) = 80 00 03 E8(Hex) = -1000 (Decimal).
5. Then the temperature measurement is -1000/1000 = -1°

S500 decode:

Read register 0x0000~0x0005.

Send command： 0A 04 00 00 00 06 71 73 （Check code）；

Return： 26 04 40 00 00 70 80 （Temperature） 00 00 95 10 （Humidity） 06 07 94 40 （Air pressure） 99 09 （Check code）；

Read register 0x0008~0x0013.

Send commond： 0A 04 00 08 00 0C 70 B6 （Check code）；

Return: 0A 04 0C 00 00 00 00 （Min wind direction） 00 03 6E 84 （Max wind direction） 00 03 C8 C0 （Avg wind direction） 00 00 00 00 （Min wind speed） 00 00 04 BC （Max wind speed） 00 00 02 10 （Avg wind speed） BC 78 （Check code）

S700 decode:

Read register 0x0000~0x001F and 0x0030~0x0033. Send command: 14 04 00 00 00 20 F3 06

Return: 14 04 40 00 00 70 80 （Temperature） 00 00 95 10 （Humidity） 06 07 94 40 （Air pressure） 00 00 00 00 （Light） 00 00 00 00 （Min wind direction） 00 00 00 00 （Max wind direction） 00 00 00 00 （Avg wind direction） 00 00 00 00 （Min wind speed） 00 00 00 00 （Max wind speed） 00 00 00 00 （Avg wind speed） 00 00 00 00 （Accumulated rainfall） 00 00 00 00 （Accumulated rainfall duration） 00 00 00 00 （Rain intensity） 00 00 00 00 （Maximum rainfall intensity） 00 00 6A 7C （Heating Temperature） 00 00 00 00 （The dumping of state） 99 09 （Check code）

S1000 decode:

Read register 0x0000~0x001F and 0x0030~0x0033. Send command: 2B 04 00 00 00 20 F6 18

Return: 2B 04 40 00 00 70 80 (Temperature) 00 00 95 10(Humidity) 06 07 94 40(Air pressure) 00 00 00 00(Light) 00 00 00 00(Min wind direction) 00 00 00 00(Max wind direction) 00 00 00 00(Avg wind direction) 00 00 00 00 (Min wind speed) 00 00 00 00(Max wind speed) 00 00 00 00(Avg wind speed) 00 00 00

00(Accumulated rainfall) 00 _00 _00 00(Accumulated rainfall duration) 00 _00 _00 00(Rain intensity) 00 _00 _00 _ 00(Maximum rainfall intensity)00 00 6A 7C(Heating Temperature) 00 00 _00 00(The dumping of state) 99 09(Check code)

PM2.5,PM10 and CO2 need to be read separately: Send command: 2B 04 00 30 00 04 F6 0C

Return: 2B 04 08 00 00 90 88(PM2.5) 00 00 A4 10(PM10) 13 FA(Check code) Read register 0x0040~0x0041.

Send command:2B 04 00 40 00 02 77 D5

Return:2B 04 04 00 0C EC 98 _ (CO2) FD 2F (Check code) ;

4.2 ASCII Protocol

4.2.1 Command definition

A	Device address, 0 by default
XA	Starter, fixed value
;	The separator used to distinguish multiple commands
...	A command, represented by different strings
?	A query term used to query values
=	Assignment, which is used to set the value
v	The argument, the specific value of the parameter is set
m	Sensor measurement
&	Sensor measurements combine character for getting or setting multiple measurement parameters
<CR><LF>	Response terminator

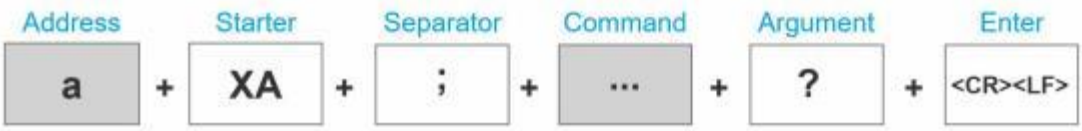
Terms Explanation

Command	Represented by different strings, such as BD for Baud rate and CP for communication protocol
Data List	A Data List contains multiple sensor measurement types, represented by an abbreviation of G0. For example, G0 contains several test types: AT;AH;AP;LX;DN;DM;DA;SN;SM;SA;RA;RD;RI;RP;HT;TILT

4.2.2 Query Command Format

Commands come in two formats:

1. A command without = refers to the basic query method.



Example: ?<CR><LF> indicates query the device's address

2. A command **with = refers to a query with an argument**

Example: 0XA;BD=?<CR><LF> indicates query the device's baud rate

4.2.3 Setting Command Format

Set a specified parameter, such as setting a baud rate.

Example: 0XA;BD=96<CR><LF> indicates query the device's baud rate

4.2.4 Command List

Device info queries and related commands settings

Query Device address		**?**
Query	Send	?<CR><LF>
	Response	0XA<CR><LF>
	Description	The default response address is 0
Query baud rate		**BD**
Query	Send	0XA; BD=?<CR><LF>
	Response	0XA; BD=96<CR><LF>
	Description	The baud rate for device 0 is 9,600
Setting	Send	0XA; BD=[bd]<CR><LF>
	Response	0XA; BD=[bd]<CR><LF>
	Description	Return the Baud rate of device 0 is [bd], it could be 96 for 9600; 192 for 19200, 384 for 38400; 576 for 57600; and 1152 for 115200. For example, the return value 0XA;BD=96 represents the successful setting of a Baud rate of 9,600
Communication protocol		**CP**
Query	Send	0XA; CP=?<CR><LF>
	Response	0XA; CP=[cp]<CR><LF>
	Description	[cp] Represents the code of the communication protocol, the device supports multiple communication protocols. **1** SDI-12 **2** RS-485 Modbus-RTU **3** RS-485 ASCII Response 0XA;CP=3<CR><LF> means that the data communication protocol of device 0 is Modbus-RTU protocol based on the RS-485 bus
Setting	Send	0XA; CP=[cp] <CR><LF>
	Response	0XA; CP=[cp] <CR><LF>
	Description	Set the communication protocol of device 0 to [cp], if [cp] is 6, the communication protocol is set to ASCII text protocol based on the RS-485 bus
RS-485 address		**MBAD**

Query	Send	0XA; MBAD=?<CR><LF>
	Response	0XA; MBAD= 1<CR><LF>
	Description	The RS-485 address of device 0 is 1 (decimal)
Setting	Send	0XA; MBAD=2<CR><LF>
	Response	0XA; MBAD=2 <CR><LF>
	Description	Set the address of device 0 to 2 (decimal)
RS-485 baud rate		**MBBD**
Query	Send	0XA; MBBD=?<CR><LF>
	Response	0XA; MBBD=96<CR><LF>
	Description	The RS-485 communication baud rate for device 0 is 9,600
Setting	Send	0XA; MBBD=[bd]<CR><LF>
	Response	0XA; MBBD=[bd]<CR><LF>
	Description	Return device 0's RS-485 communication baud rate is [bd]: it can be 96 for 9600, 192 for 19200, 384 for 38400, 576 for 57600, and 1152 for 115200. For example, the return value is 0XA;MBBD=96 represents the successful setting of the baud rate of 9,600
Device Name		**NA**
Query	Send	0XA; NA=?<CR><LF>
	Response	0XA; NA=SenseCAP ONE S700<CR><LF>
	Description	Device name is: SenseCAP ONE S700
Setting	Send	0XA; NA=[na]<CR><LF>
	Response	0XA; NA=[na] <CR><LF>
	Description	Set the new device name to [na], and the character length limitation is 64 bytes
Device model		**TP**
Query	Send	0XA; TP=?<CR><LF>
	Response	0XA; TP=SenseCAP ONE S700<CR><LF>
	Description	The device model is SenseCAP ONE S700
Device version		**VE**
Query	Send	0XA; VE=?<CR><LF>
	Response	0XA; VE=HW-1.0&SW-2.0&S1-2.2<CR><LF>
	Description	Device hardware(HW) is v1.0, the software firmware(SW) is v2.0, and the #1 driver board firmware is v2.2
Device serial number		**S/N**
Query	Send	0XA; S/N=?<CR><LF>
	Response	0XA; S/N= 1019906922012011<CR><LF>
	Description	S/N represents the serial number of the device
Production date		**MD**
Query	Send	0XA; MD=?<CR><LF>
	Response	0XA; MD=20201027<CR><LF>
	Description	The production date of the return device is October 27, 2020, 20201027
Restore configuration		**RESTORE**
Setting	Send	0XA; RESTORE= 1<CR><LF>
	Response	0XA; RESTORE= 1<CR><LF>
	Description	Return 0XA; RESTORE= 1 means the setting is successful and return 0XA means the setting fails.

Electronic Compass		CC
Query	Send	0XA;CC=?<CR><LF>
	Response	0XA;CC=[cc]<CR><LF>
	Description	[cc] Electronic Compass offset state Y Enable Electronic Compass N Disable Electronic Compass C Enable Geomagnetic compensation
Setting	Send	0XA;CC=Y<CR><LF>
	Response	0XA;CC=Y<CR><LF>
	Description	Enable Electronic Compass
	Send	0XA;CC=N<CR><LF>
	Response	0XA;CC=N<CR><LF>
	Description	Disable Electronic Compass
	Send	0XA;CC=C<CR><LF>
	Response	0XA;CC=C<CR><LF>
	Description	Enable Geomagnetic compensation , it will start the 30s compensation process, during this time, the device should be placed horizontally, and rotate evenly along the Z-axis for 1-2 rounds.
Tilt Detect		**TD**
Query	Send	0XA;TD=?<CR><LF>
	Response	0XA;TD=Y/N<CR><LF>
	Description	Y: Enable tilt detection function N: Disable tile detection function
Setting	Send	0XA;TD=Y<CR><LF>
	Response	0XA;TD=Y<CR><LF>
	Description	Set to enable tilt detection function： TILT=0 means the device is placed vertically, TILT=1 means the device is placed not placed upright.
	Send	0XA;TD=N<CR><LF>
	Response	0XA;TD=N<CR><LF>
	Description	Disable tile detection function： the TILT always equals 0 when the device is placed at any position.
Heating		**HC**
Query	Send	0XA; HC =?<CR><LF>
	Response	0XA; HC =Y/N<CR><LF>
	Description	Y: enable heating function N: disable heating function
Setting	Send	0XA;HC=Y<CR><LF>
	Response	0XA;HC=Y<CR><LF>
	Description	Turn on the heating function of the device; When the air temperature is between [5℃ and -25℃], the device begins to heat, and the temperature of the heating plate is the highest, up to 40℃ When the air temperature is higher than 5 ° C, the device stops to heat; (Note: If the temperature is lower than -25 ° C ,the heating module cannot raise the temperature of the device above 0 ° C, it may freeze, which will affect the detection of wind speed and direction)
	Send	0XA;HC=N<CR><LF>
	Response	0XA;HC=N<CR><LF>
	Description	Set to enable heating function.

Command to read sensor data.

For quick reading of all measurements, G0 is the command.

Read all measurements		G0
Query	Send	0XA; G0?<CR><LF>
	Response	0XA;AT=23.6;AH=56.4;AP= 100819. 1;LX=93.0;DN=0.0;DM=0.0;DA=0.0;SN=0.0;SM=0.0;SA=0.0;RA=1.4 ;RD=60.0;RI=0.0;RP=0.0;HT=-38.4;TILT=0.0<CR><LF>
	Description	Returns the value of all measurement parameters

Group Name	Measurement	Name	Unit
G0	Contains all combinations of measurement parameters		
	AT	Air temperature	℃ (default), T
	AH	Air humidity	%RH
	AP	Barometric pressure	Pa (default), hPa, bar, mmHg, inHg
	LX	Light intensity	Lux
	DN	Minimum wind direction	deg
	Dm	Maximum wind direction	deg
	DA	Average wind direction	deg
	SN	Minimum wind speed	m/s (default), km/h, mph, knots
	SM	Maximum wind speed	m/s (default), km/h, mph, knots
	SA	Average wind speed	m/s (default), km/h, mph, knots
	RA	Accumulated rainfall	mm (default), in
	RD	Duration of rainfall	s
	RI	Rainfall intensity	mm/h (default), in/h
	Rp	Maximum rainfall intensity	mm/h (default), in/h
	HT	Heating temperature	℃
	TILT	Fall detection	

Modify the Properties of Measurement Parameters

Properties represent some characteristics of the measured data, such as the unit of output temperature and the interval between data updates.

Temperature and Humidity Data Update Interval		IB
Query	Send	0XA;IB=? <CR><LF>
	Response	0XA;IB= 1<CR><LF>
	Description	The default data updates every 1 second
Setting	Send	0XA;IB=2<CR><LF>
	Response	0XA;IB=2<CR><LF>
	Description	Set the data update interval to 2 seconds, you can choose a value between 1 to 3600 seconds.
Air Temperature Unit		**UT**
Query	Send	0XA; UT=? <CR><LF>

	Return	0XA; UT=C<CR><LF>
	Description	The temperature unit is Celsius
Set up	Send	0XA; UT=F<CR><LF>
	Response	0XA; UT=F<CR><LF>
	Description	Set the air temperature unit to Fahrenheit. C=°C, F=°F
Barometric Pressure Unit		**UP**
Query	Send	0XA; UP=? <CR><LF>
	Response	0XA; UP=P<CR><LF>
	Description	The unit is Pa.
Set up	Send	0XA; UP=H<CR><LF>
	Response	0XA; UP=H<CR><LF>
	Description	Set the unit to hPa. P = Pa, H = hPa, B = bar, M = mmHg, I=inHg
Wind Speed & Direction Data Update Interval		**IW**
Query	Send	0XA; IW=? <CR><LF>
	Response	0XA; IW=1<CR><LF>
	Description	The default data updates every 1 second.
Set up	Send	0XA; IW=2<CR><LF>
	Response	0XA; IW=2<CR><LF>
	Description	Set the data update interval to 2 seconds, you can choose a value between 1 to 3600 seconds.
Wind speed & direction average time window		**AW**
Query	Send	0XA; AW=? <CR><LF>
	Response	0XA; AW=5<CR><LF>
	Description	The default average update interval for wind speed & direction data is 5 seconds. The device collects wind speed & direction in 5s intervals and then averages the value.
Setting	Send	0XA; AW=10<CR><LF>
	Response	0XA; AW=10<CR><LF>
	Description	Set the data update interval to 10 seconds, you can choose a value between 1 to 3600 seconds
Wind Speed Unit		**US**
Query	Send	0XA; US=? <CR><LF>
	Response	0XA; US=M<CR><LF>
	Description	The default wind speed unit is m/s
Setting	Send	0XA; US=K<CR><LF>
	Response	0XA; US=K<CR><LF>
	Description	Set unit to km/h M = m/s, K = km/h, S = mph, N = knots
The wind direction offset correction value		**DO**
Query	Send	0XA;DO=? <CR><LF>
	Response	0XA; DO=0<CR><LF>

	Description	The default correction angle for the wind direction is 0.
Setting	Send	0XA; DO=1<CR><LF>
	Response	0XA; DO=1<CR><LF>
	Description	Set the wind direction offset to +10°, if the current wind direction is 280°, the corrected wind direction is 290 degrees. The wind correction range is -180° to 180°
Rainfall Data Update Interval		**IR**
Query	Send	0XA;IR=? <CR><LF>
	Response	0XA;IR=10<CR><LF>
	Description	The default rain data update interval is 10 seconds.
Setting	Send	0XA;IR=60<CR><LF>
	Response	0XA;IR=60<CR><LF>
	Description	Set the data update interval to 60seconds. The interval range is 10 to 3600 seconds.
Rainfall Unit		**UR**
Query	Send	0XA; UR=? <CR><LF>
	Response	0XA; UR=M<CR><LF>
	Description	The default rainfall unit is mm
Setting	Send	0XA; UR=I<CR><LF>
	Response	0XA; UR=I<CR><LF>
	Description	Set the units of rainfall to inches M = mm, I = inch.
Rainfall Counter Reset Mode		**CR**
Query	Send	0XA; CR=? <CR><LF>
	Response	0XA; CR=M<CR><LF>
	Description	Rain counter reset mode is by manual M
Setting	Send	0XA; CR=L<CR><LF>
	Response	0XA; CR=L<CR><LF>
	Description	Set the counter reset mode to overflow reset, and you can select the modes as: **M:** Manual reset, reset immediately after sending the reset command (the reset command is available under all three communication protocols, as detailed in the different protocol sections). **A:** Post-read reset (accumulated rainfall and accumulated rainfall time are performed separately after reading reset) **L:** Overflow reset
Accumulated rainfall overflow value		**AL**
Query	Send	0XA; AL=? <CR><LF>
	Response	0XA; AL=80000<CR><LF>
	Description	The default accumulated rainfall overflow value is 80000, which is measured in the current rainfall unit. This overflow value takes effect only if the CR rainfall counter reset mode is set to **L** overflow reset.
Setting	Send	0XA; AL=1000<CR><LF>
	Response	0XA; AL=1000<CR><LF>
	Description	When the rainfall is set to 1000 (current unit), the accumulated rainfall will be reset to 0.

		The overflow value range is 10-80000 (current unit).
Accumulated rainfall duration overflow value		**DL**
Query	Send	0XA; DL=? <CR><LF>
	Response	0XA; DL=2000000<CR><LF>
	Description	The default rainfall duration overflow value is 2,000,000, the unit is second. This overflow value will only take effect when the CR rainfall counter reset mode is **L** overflow reset.
Setting	Send	0XA; DL=3600<CR><LF>
	Response	0XA; DL=3600<CR><LF>
	Description	Set the rainfall duration overflow value to 3600 seconds. It ranges between 100 – 2000000 seconds.
Clear the accumulated rainfall		**CRA**
Setting	Send	0XA; CRA= 1<CR><LF>
	Response	0XA; CRA= 1<CR><LF>
	Description	Clear the accumulated rainfall.
Clear accumulated rainfall Duration		**CRD**
Setting	Send	0XA; CRD= 1<CR><LF>
	Response	0XA; CRD= 1<CR><LF>
	Description	Clear the accumulated rainfall duration.
Interpretation	Accumulated rainfal	Once the device is powered ,the accumulated value will be calculated and saved. When the accumulated value reaches 80,000 mm, it will be automatically cleared and enter the recalculation stage (it will still be saved after power off).
	Accumulated rainfall duration	Once the device is powered ,the accumulated value will be calculated and saved. When the accumulated value reaches 2000000s, it will be automatically cleared and enter the recalculation stage (it will still be saved after power off).
	Rainfall intensity (hourly rainfall)	The accumulated rainfall in the past hour, during which the accumulated value is updated every 10s until the accumulated time reaches 1 hour
	Maximum rainfall intensity	Maximum rainfall per minute in the past hour *60 minutes

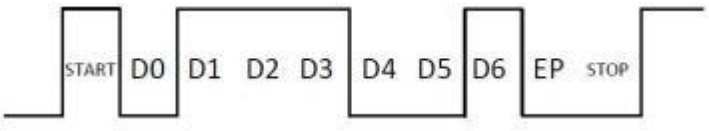
4.3 SDI-12

SDI-12 communication adopts three wires, two of which are sensor power supply wires and the other is SDI-12 signal wire.

Each sensor on the SDI-12 bus has a unique address, which can be set to '0', '1' ~ '9', 'A' ~ 'Z', 'A' ~ 'Z'. The SDI-12 address of the SenseCAP ONE defaults to '0'. The instructions supported by this sensor are shown in the next chapter, where each instruction conforms to the SDI-12 v1.4.

The sensor is powered by a DC power supply of 3.6~16V. After the sensor is powered on, it will go into sleep mode immediately and wait for the data acquisition equipment to give instructions. SDI-12 uses baud rate 9600bps, 1 start bit (high level), 7 data bits (high 0 and low 1, anti-logic), 1 even parity bit, and 1 stop bit.

The sequence of each byte sent is shown in the following figure:



4.3.1 SDI-12 command and response

Command format

- Start with device address 'a', it is '0'in the following sample.
- End with '!'as a terminator
- The response command end with the <CR><LF>

Query the device address	**?!**
Send	?!
Response	0<CR><LF>
Description	The sensor at address '0' responded to the query
Query the device status	**0!**
Send	0!
Response	0<CR><LF>
Description	Address '0' of device online
Query the device information	**0I!**
Send	0I!
Response	014SenseCAPONE3.01019906922104001<CR><LF>
Description	Response the device information

<table>
<tr><td></td><td>accccccccmmmvvvxxxxxxxxxxxxxxxx<CR><LF>
<table>
<tr><td>a</td><td>Device address: 0</td></tr>
<tr><td>14</td><td>SDI-12 protocol version :v1.4</td></tr>
<tr><td>cccccccc</td><td>Product: SenseCAP</td></tr>
<tr><td>mmm</td><td>Device series : ONE</td></tr>
<tr><td>vvv</td><td>Software version : 3.0</td></tr>
<tr><td>xxxxxxxxxxxxxxxx</td><td>Device serial number: 1019906922104001</td></tr>
</table></td></tr>
<tr><td>Modify device address</td><td>0Ab!</td></tr>
<tr><td>Send</td><td>0A1!</td></tr>
<tr><td>Response</td><td>1<CR><LF></td></tr>
<tr><td>Description</td><td>Device address 0 is changed to 1. The address range is 0-9、A-Z、a-z.</td></tr>
<tr><td>Start Measurement</td><td>0M!</td></tr>
<tr><td>Send</td><td>0M!</td></tr>
<tr><td>Response</td><td>Immediately response : 00024<CR><LF>
After 2s, the response device’s address, means finishing the measurement. : 0<CR><LF></td></tr>
<tr><td>Description</td><td>This command is to start THPL measurement, in order: air temperature, air humidity, atmospheric pressure, illuminance, but the sensor will not reply to the measurement data immediately after receiving this command, but the time required to reply the measurement data and the number of measurements. To obtain measurement data, you must wait until the measurement is completed, and then use the send data command “0D0!” to obtain it.
After using this command, the sensor will enter a sleep mode after the measurement to save power consumption. After using "continuous measurement command 0R0!...0R9!", it will exit the low power consumption state.
The response format is defined as follows: atttn<CR><LF>
<table>
<tr><td>a</td><td>Device address:0</td></tr>
<tr><td>ttt</td><td>The time expense to measure data, the unit is seconds.</td></tr>
<tr><td>n</td><td>The number of measurements</td></tr>
</table></td></tr>
<tr><td>Extended Measurement</td><td>0M1!...0M9!</td></tr>
<tr><td>Send</td><td>0Mn! (n ranges 0~9)</td></tr>
<tr><td>Response</td><td>Immediately response : 00024<CR><LF>
After 2s, the response device’s address, means finishing the measurement. : 0<CR><LF></td></tr>
<tr><td>Description</td><td>0M1!: Start Wind measurement: minimum wind direction, maximum wind direction, average wind direction, minimum wind speed, maximum wind speed, average wind speed.

0M2!: Start Rain measurement: accumulated rainfall, accumulated rainfall time, rainfall intensity, maximum rainfall intensity.

0M3!: Start Dust measurement: PM2.5, PM10.</td></tr>
</table>

<table>
<tr><td></td><td>0M9!: Start other measurements: heating temperature, tilt status.

0M4!...0M8!: reserved.

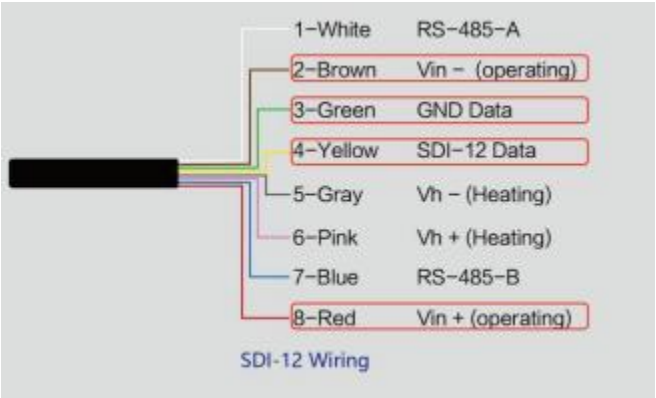
After using this command, the sensor will enter a sleep mode after the measurement to save power consumption. After using "continuous measurement command 0R0!...0R9!", it will exit the low power consumption state.

For the definition of reply, please refer to "Start measurement command 0M!"</td></tr>
<tr><td>Read measurement value</td><td>0D0!...0D9!</td></tr>
<tr><td>Send</td><td>0D0!</td></tr>
<tr><td>Response</td><td>0+27.65+65.81+100000+5000<CR><LF></td></tr>
<tr><td>Description</td><td>This command is used to obtain a set of measurement data in the sensor. The sensor responds with the measurement data. If all the desired measurement data is not returned in 0D0!, you can continue to
send 0D1!, 0D2!, etc., until all the measurement data is
received. The response format is defined as follows:
a<values><CR><LF>
<table><tr><td>a</td><td>Device address:0</td></tr><tr><td><values></td><td>This the real measurement value.
pd.d
p is the polarity symbol.
the first d is the number before the decimal
point. the second d is the data after the
decimal point. Note that the decimal point is
not necessary.
In this example, "+27.65" is the first measurement data, "+65.81" is the second measurement data, "+100000" is the third measurement data, and "+5000" is the fourth measurement data.</td></tr></table></td></tr>
<tr><td>Continuous measurement command</td><td>0R0!..0R9!</td></tr>
<tr><td>Send</td><td>0R0!</td></tr>
<tr><td>Response</td><td>0+27.65+65.81+100000+5000<CR><LF></td></tr>
<tr><td>Description</td><td>This is different from "start measurement command 0M!", the measurement value can be returned directly. Each "continuous measurement command" is an independent measurement process, for example, 0R0! and 0R1! are not required before 0R2!.
0R0!: Start continuous THPL measurement: air temperature, air humidity, atmospheric pressure, light intensity.
0R1!: Start Wind continuous measurement: minimum wind direction, maximum wind direction, average wind direction, minimum wind speed, maximum wind speed, average wind speed.
0R2!: Start Rain measurement: accumulated rainfall, accumulated rainfall time, rainfall intensity,</td></tr>
</table>

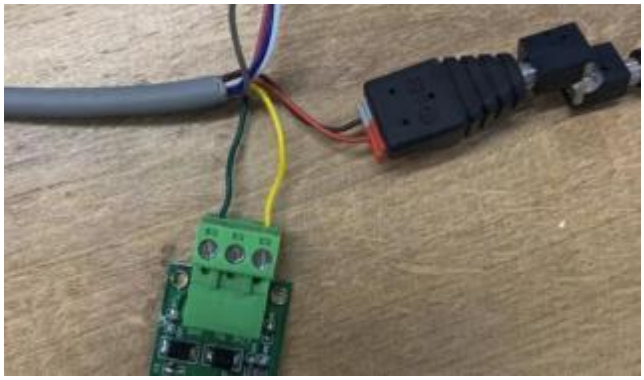
<table>
<tr><td></td><td>maximum rainfall intensity.
0R3!: Start Dust continuous measurement: PM2.5, PM10.
0R9!: Start another Continuous measurement: heating temperature, dumping status. 0R4!...0R8!: reserved.
If the sensor was in a low-power working state before, after using this command, the sensor will exit the low-power working state.</td></tr>
<tr><td>Start Measurement with CRC</td><td>aMC!,aMC1!...aMC9!,aRC0!...aRC9!</td></tr>
<tr><td>Send</td><td>0RC0!</td></tr>
<tr><td>Response</td><td>0+26.52+67.73+100280+35JKy</td></tr>
<tr><td>Description</td><td>To enhance the error detection capability of the SDI-12 protocol, "start measurement command 0M!", "extended measurement command 0M1!..0M9!" and "continuous measurement command 0R0!...0R9!" can add 16-bit cyclic redundancy check. Add the character C after the command character M or R of these commands to form a new command: aMC!,aMC1!...aMC9!,aRC0!...aRC9!.
For the calculation of CRC-16, please refer to the SDI-12 protocol v1.4 document.</td></tr>
<tr><td>Clear accumulated rainfall command</td><td>0XCRA!</td></tr>
<tr><td>Send</td><td>0XCRA!</td></tr>
<tr><td>Response</td><td>01<CR><LF></td></tr>
<tr><td>Description</td><td>aN<CR><LF>
a: Device address:0
N: Clear success: 1
Clear failed: 0</td></tr>
<tr><td>Clear accumulated rainfall duration</td><td>0XCRD!</td></tr>
<tr><td>Send</td><td>0XCRD!</td></tr>
<tr><td>Response</td><td>01<CR><LF></td></tr>
<tr><td>Description</td><td>aN<CR><LF>
a: Device address:0
N: Clear success: 1
Clear failed: 0</td></tr>
</table>

4.3.2 SDI-12 Read

Wiring the SDI-12



Use USB to SDI-12 debugger to communicate with the device



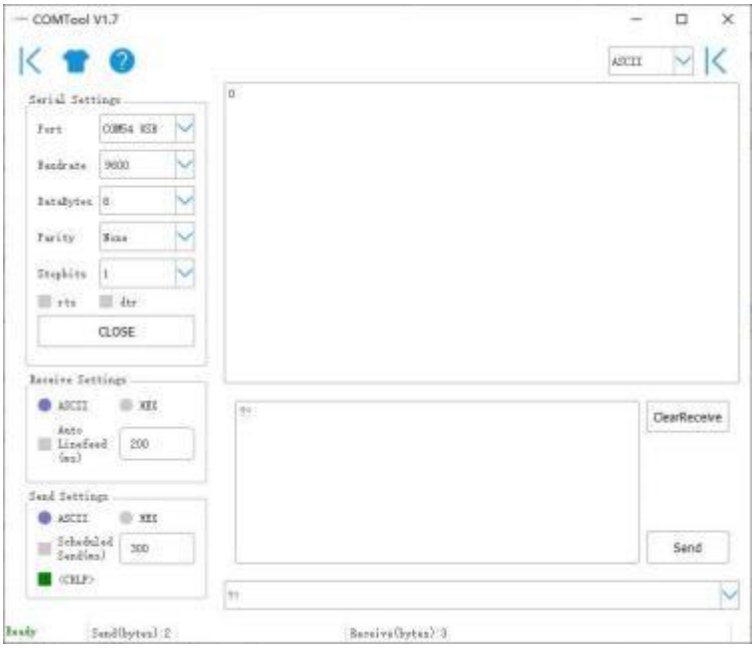
The communication settings:

Format	1 start bits, 7 data bits, Even parity, 1 stop bits
Baud rate	1200bps
Device address	0x00

Connect the green wire (GND Data) and yellow wire (SDI-12 Data) to the **USB to SDI-12** debugger. And connect the red wire (Vin+ power positive) and brown wire (Vin- power ground) to the 12V power supply.

Download the serial port debugging assistant: https://github.com/Neutree/COMTool , and then open the serial port debugging tool.

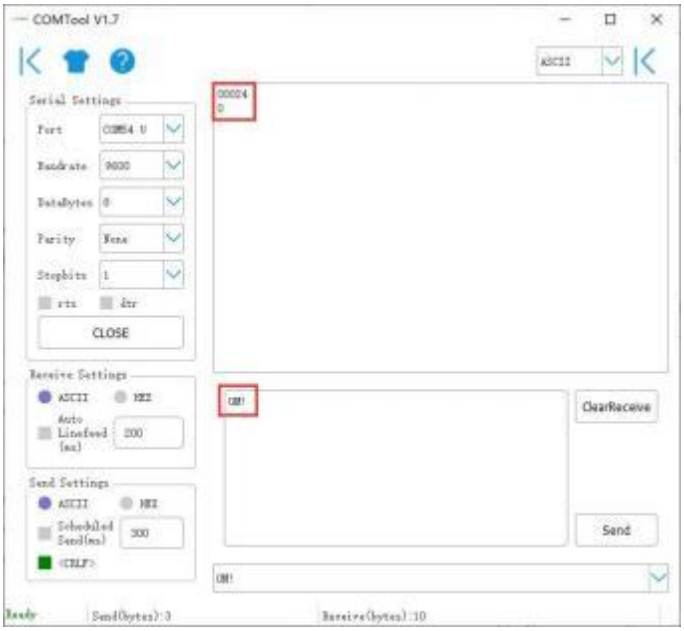
- Choose the correct port number
- Set the baud rate to the baud rate of the USB to SDI-12 debugger (note that it is not the baud rate of the SDI-12 protocol)
- Check the "CRLF"
- Click to open the serial port.
- Send the query device address command "?!", if you can see the response "0", it means the connection is OK.



Start Measurement

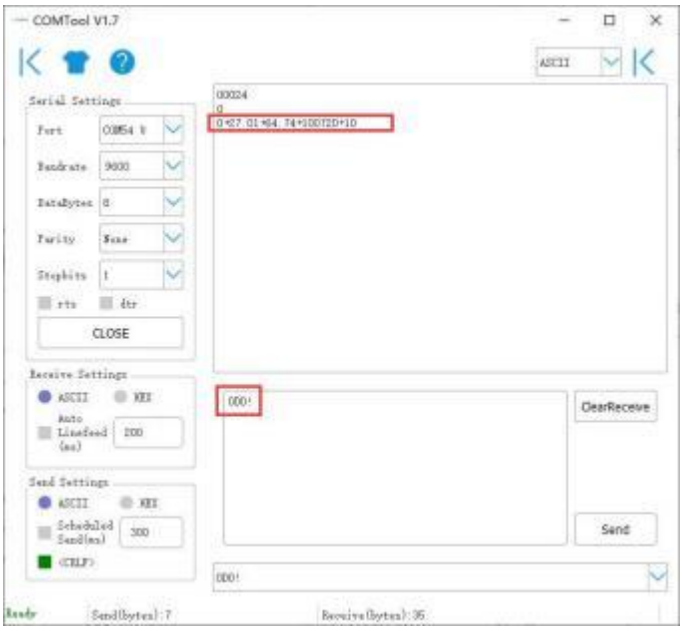
Read air temperature, air humidity, barometric pressure, light intensity

Send the "start measurement command 0M!", the sensor first responds with "00024", which means that the "0M!" command takes 2 seconds to measure and returns 4 measured values. After 2 seconds, the sensor responds with its own address "0", indicating that the measurement has been completed.

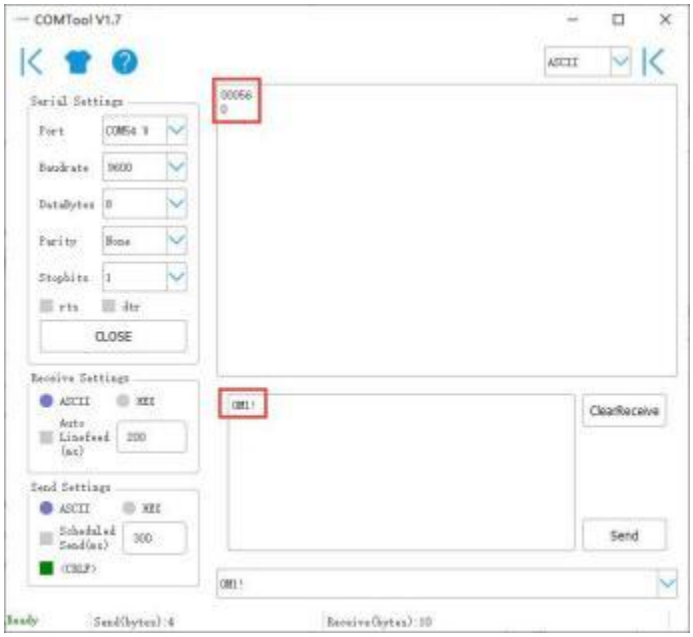


Then send " Read measurement value command 0D0!" to get the 4 measured values of this

measurement, which are air temperature +27.01℃, air humidity 64.74%, barometric pressure 100720Pa, and light intensity 10Lux.



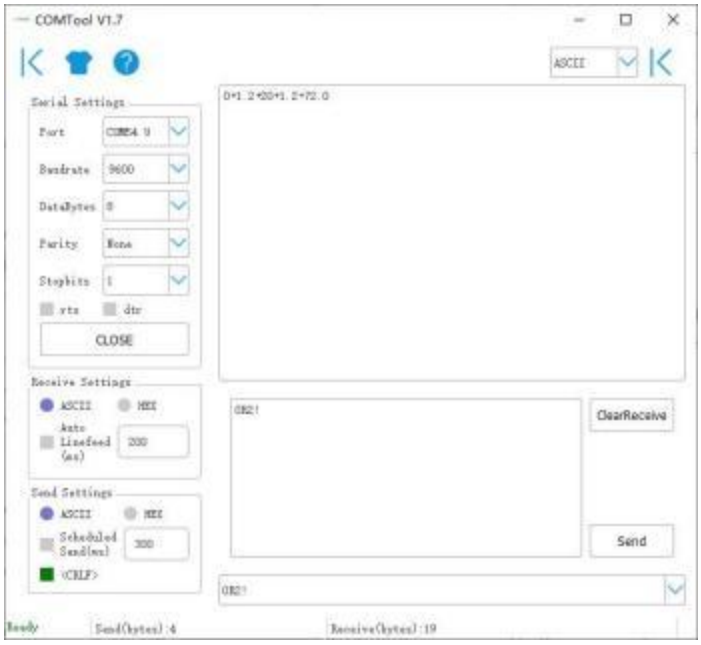
Use extended measurement command 0M1! to read minimum wind direction, maximum wind direction, average wind direction, minimum wind speed, maximum wind speed, average wind speed. The device responds with "00056", which means that the "0M1!" command takes 5 seconds to measure and returns 6 measured values. After 5 seconds, the device responds with its own address "0", indicating that the measurement has been completed.



Then send " Read measurement value command 0D0!" to get the 6 measured values of this measurement, which are minimum wind direction 345.9 degrees, maximum wind direction 347.5 degrees, average wind direction 346.3 degrees, minimum wind speed 2.8m/s, and maximum wind speed 2.8m. /s, average wind speed 2.8m/s.

Then send “continuous measurement command 0R2!, the device returns 4 measured values: cumulative rainfall 1.2mm, cumulative rainfall duration 20 seconds, rainfall intensity 1.2mm/h, maximum rainfall

intensity 72.0mm/h.



5 Error code

5.1 Modbus error code

Error code	Description	Response instance
0x01	Device do not response	01 84 01 82 C0
0x04	Sensor probe exception	01 84 04 42 C3

5.2ASCII error code

Error code	Description	Response instance
0	Command do not exist	0XA;...=#0
1	Device do not response	0XA;AT=#1
3	The command length exceeds the limit, it needs to be reduced	0XA; …=#3
4	Sensor probe exception	0XA;AT=#4

5.3 SDI-12 error code

Error code	Description	Response instance
2001001	Device do not response	0+2001001+2001001+2001001+2001001<CR><LF>
2001004	Sensor probe exception	0+2001004+2001004+2001004+2001004<CR><LF>