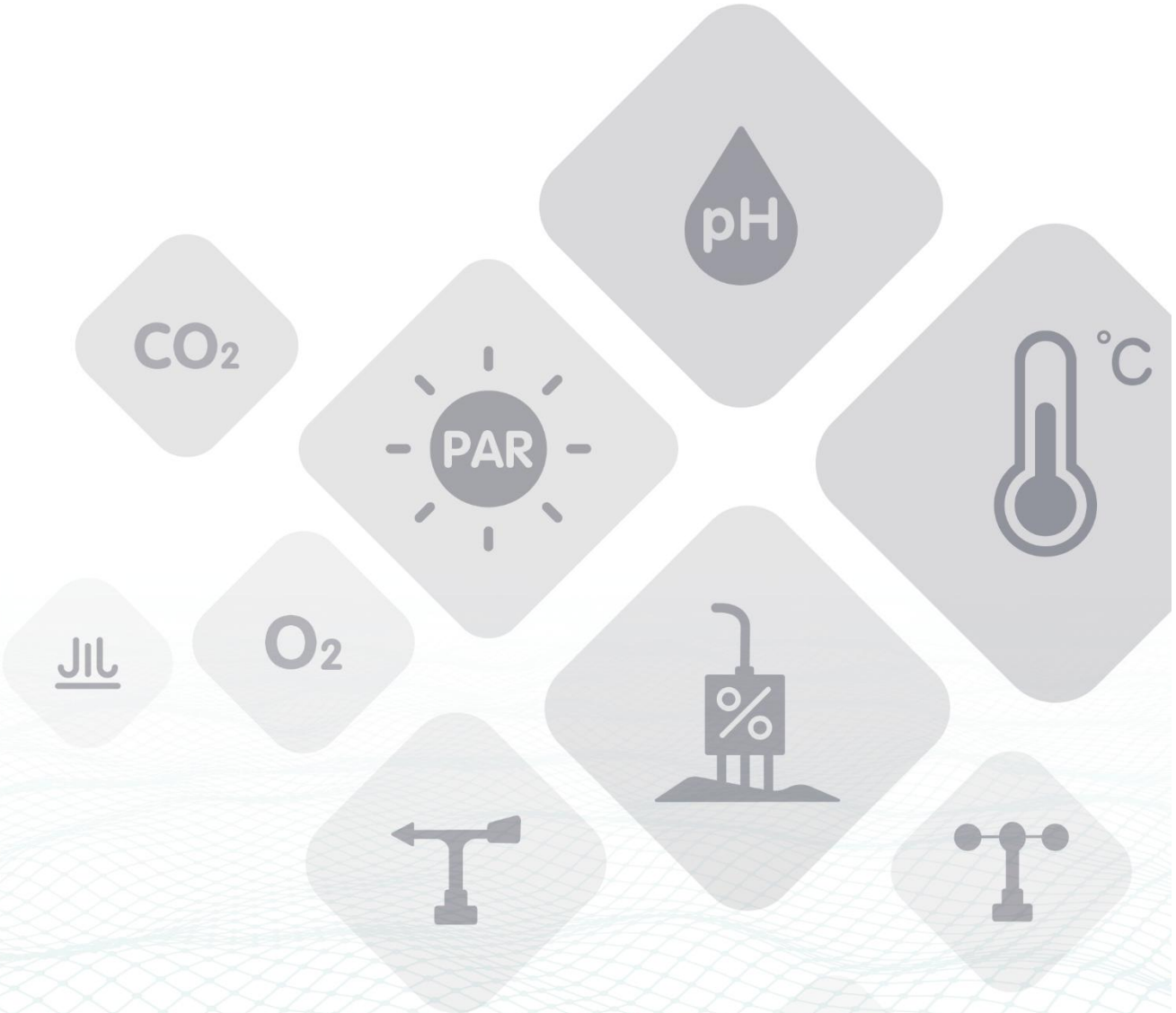
SENSECAP

Soil Moisture & Temperature & EC Sensor User Manual

Product Model: S-Temp&VWC&EC-02

Version: V1.1



Contents

1 Introduction

This S-Temp&VWC&EC-02 soil moisture & EC & temperature sensor is provided with high accurate and high sensitive. It is an important tool to observe and study the occurrence, evolution, improvement and the dynamics water of saline soil. By measuring the dielectric constant of the reaction of soil, soil direct stable real moisture content. This S-Temp&VWC&EC-02 sensor can measure the volume of soil moisture. The soil moisture measurement method is in line with international standards at present. Apply to the soil moisture monitoring, scientific experiment, water-saving irrigation, greenhouse vegetables, flowers, grass, soil, plant cultivation, measured speed of sewage treatment, grain storage, greenhouse control, precision agriculture.

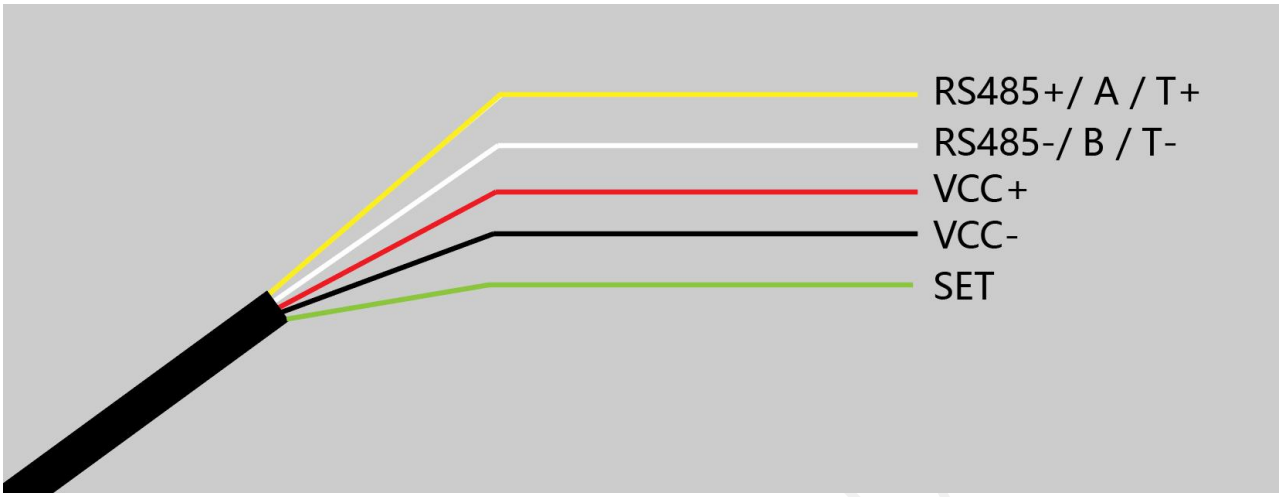
Features:

- Soil moisture content, electrical conductivity and temperature all in one
- One solution can also be used for fertilizer, and other nutrient solution conductivity matrix
- Electrode using special treatment of the alloy material, can withstand a strong external impact, not easy to damage
- Completely sealed, acid and alkali corrosion, can be buried in the soil or directly into the water for long-term dynamic testing
- High precision, fast response, good compatibility, the probe insert design to ensure accurate measurement, reliable performance
- Perfect protection circuit

2 Specifications

Soil Temperature	
Range	-40 ℃~ 80 ℃
Accuracy	± 0.5℃
Resolution	0.1 ℃
Soil Moisture	
Range	From completely dry to fully saturated (0% - 100%)
Accuracy	± 3% (0~50%); ± 5% (50~100%)
Resolution	0.03% (0~50%); 1% (50~100%)
Electrical Conductivity	
Range	0 ~ 10000 μs/cm
Accuracy	± 3%
Resolution	10 μs/cm
Temperature Compensation	Built in temperature compensation sensor, range 0-50℃
General Parameters	
Product Model	S-Temp&VWC&EC-02
Interface	RS-485
Protocol	MODBUS-RTU RS485
Power Supply	3.6 ~ 30V DC
Current Consumption	6mA@24V DC (quiescent dissipation)
IP Rating	IP68
Cable Length	5 meters
Operating Temperature	-40 ~ 85℃
The material of the probe	Anti-corrosion special electrode
Sealing material	The black flame retardant epoxy resin
Installation	All embedded or probe inserted into the measured medium
Device Weight	210g

3 Wiring



Yellow	RS485+/A/T+
White	RS485-/B/T-
Red	VCC+, power supply
Black	VCC-, power ground
Green(SET)	SETTING mode. When sensor power-up with the SET wire connected to Power Supply +, then sensor using setting mode communication parameters for RS485.When sensor power-up with the SET wire connected to Power Supply – or unconnected , the sensor using communication parameters in register for RS485. Please refer to the usage below. All RS485 communication parameters (Mosbus Slave Address, baudrate, parity, databits, stopbits) are set in internal register and can be saved when power down, the factory setting is ADDRESS=1, BAUDRATE=9600bps,PARITY=NONE, DATABITS=8bits, STOPBITS=1bit; Sometimes you may FORGET the communication settings, In this case, you can connect the GREEN & RED wire together to PowerSupply+, black wire to PowerSupply-, then re-power up the sensor, then the sensor start-up with a fixed communication settings(we call it setting mode) ADDRESS=0, BAUDRATE=9600bps,PARITY=NONE, DATABITS=8bits, STOPBITS=1bit; Communicate with the sensor using this parameters and then set your desired communication parameters, then disconnect the green wire from PowerSupply+, then re-power up the sensor, and the sensor will communicate with your settings.

4 Installation

Surface installation

- Clear away any stones. Pre-form holes in very hard soils before insertion.
- Push the sensor into the soil until the rods are fully inserted. Ensure good soil contact.
- If you feel strong resistance when inserting the sensor, you have probably hit a stone. Stop, and re-insert at a new location.

Note: The sensor is suitable for soil surface temperature measurements.

Installing at depth

- Make a 45mm diameter hole, preferably at about 10° to the vertical using a auger.
- Push the sensor into the soil until rods are fully inserted. Ensure good soil contact.
- Fill and repack the hole with soil.

Alternatively

- Dig a trench, and install horizontally.

Because of the direct determination of the soluble salt ions in the soil, the water content of the soil can be higher than about 20%, and the soluble ions in the soil can correctly reflect the electrical conductivity of the soil. In the long-term observation, after irrigation or rainfall measured values are close to the true level. If the velocity measurement, first in the tested soil watering, to be full of water permeability were measured.

(1) Rapid measurement method: selected measurement locations, avoid the rocks, to ensure that the needle will not touch the stones like hard object, according to the required depth of cut open the surface soil, maintain the tightness degree of the original soil below the sensor body, clenched vertically inserted into the soil, can not be inserted before and after shaking, ensure the close contact with the soil. A measuring point within a small range test should repeatedly averaging.

(2) Buried in the underground measurement method: vertical drilling diameter greater than 20 cm depth of pit, according to the measurement needs, then the sensor wire inserted into the pit wall in a given level of depth, the pit landfill compaction, ensure the close contact with the soil. Stable after a period of time, can be last for days, months or even longer to measure and record.

If the surface measurement is hard, should first hole (diameter should be less than the diameter of the probe), and then inserted into the soil and the soil compaction and measurement; sensor should prevent violent vibration and impact, but not with a hard object percussion. Because the sensor for black package, in the strong sunlight will make the sensor to make sharp warming (up to over 50 ℃), in order to prevent the temperature measurement of high temperature impact sensor, please pay attention to sun protection in the field or fields.

5 RS485 Modbus Protocol

5.1 Modbus Protocol

Modbus Protocol is widely used to establish master-slave communication between intelligent devices or sensors. A MODBUS message sent from a master to a slave contains the address of the slave, the function code (e.g. 'read register' or 'write register'), the data, and a check sum (LRC or CRC).

S-Temp&VWC&EC-02 sensor with RS485 interface, support Modbus protocol. The communication parameters to factory default values for: baud rate 9600 bps, one start bit, 8 data bits, no parity, one stop bit. Communication protocol is Modbus RTU protocol. Communication parameters can be changed by the setup program or MODBUS command, after the communication parameters are changed, the sensor is required to re - enter the sensor to be effective.

Following modbus function code are supported by sensor.

Modbus Function Code 0x03 : used for reading holding register.

Modbus Function Code 0x04 : used for reading input register.

Modbus Function Code 0x06 : used for writing single holding register.

Modbus Function Code 0x10: used for writing multiple holding register.

5.2 Modbus Register

Parameter name	Register address (HEX / DEC)	Parameter type	Modbus function number	Parameter range and description
TEMPRATURE	0x0000 /0	INT16, read	3/4	-4000-8000 corresponds to -40.00 ~ 80.00℃.
VWC-Volumetric Water Content	0x0001 /1	UINT16, read	3/4	0-10000 corresponds to 0-100%
EC-Electrical Conductivity	0x0002 /2	UINT16, read	3/4	0-20000 corresponds to 0-20000us/cm
SALINITY	0x0003 /3	UINT16, read	3/4	0-20000 corresponds to 0-20000mg/L
TDS	0x0004 /4	UINT16, read	3/4	0-20000 corresponds to 0-20000mg/L
EPSILON	0x0005 /5	UINT16, read	3/4	0-8200 corresponds to 0.00~82.00
SOIL TYPE	0x0020 /32	UINT16, read-write	3/6/16	0-3 0: Mineral soil 1: Sandy soil 2: Clay 3: Organic soil
TEMP UNIT	0x0021 /33	UINT16, read-write	3/6/16	0:℃ 1:℉
EC&TEMP COFF	0x0022 /34	UINT16, read-write	3/6/16	0-100 corresponds to 0.0%-10.0%
SALINITY COFF	0x0023 /35	UINT16, read-write	3/6/16	0-100 corresponds to 0.00-1.00
TDS COFF	0x0024 /36	UINT16, read-write	3/6/16	0-100 corresponds to 0.00-1.00
Slave ADDRESS	0x0200 /512	UINT16, read-write	3/6/16	0-255
BAUDRATE	0x0201 /513	UINT16, read-write	3/6/16	0-6 0:1200bps 1:2400bps 2:4800bps

				3:9600bps 4:19200bps 5:38400bps
PROTOCOL	0x0202 /514	UINT16, read-write	3/6/16	0~1 0: Modbus RTU 1: Modbus ASCII
PARITY	0x0203 /515	UINT16, read-write	3/6/16	0-2 0: No parity bit 1: even parity check 2: Odd Parity bit
DATABITS	0x0204 /516	UINT16, read-write	3/6/16	1 1:8 data bits
STOPBITS	0x0205 /517	UINT16, read-write	3/6/16	0-1 0:1 Stop bit 1:2 Stop bit
RESPONSE DELAY	0x0206 /518	UINT16, read-write	3/6/16	0-255 corresponds to the 0-2550 milliseconds sensor to receive the host request for a period of time and then the delay response. The time delay for setting the value of *10 milliseconds. Set to 0 when no delay.
ACTIVE OUTPUT INTERVAL	0x0207 /519	UINT16, read-write	3/6/16	0-255 corresponds to 0-255 seconds does not require the host to request, the sensor to send data at a fixed time interval. The time interval is set value * 1 second. Set to 0 when the active output function is prohibited.

5.3 Detail of Modbus Register

TEMPERATURE		
Parameter range	-4000-8000 corresponds to -40.00~80.00℃	Default: none
Parameter storage	none	
Meaning: the measured value of the temperature, negative for complement representation. For example: if the return value is 0702H (Hexadecimal, source code), the first byte is 07H, the second byte and the low byte is 02H, then the temperature for the measured value (07H*256+02H) /100=17.94℃. If the return value is FF05H (Hex, the complement), the first byte is FFH, low second byte is 05H, then temperature measurement value ((FFH*256+05H) -FFFFH-1H) / 100 = (FF05H-FFFFH-1H) Celsius /100=-2.51℃.		

VWC --- volumetric water content		
Parameter range	0-10000 corresponds to 0-100%	Default: none
Parameter storage	None	
Significance: volumetric water content measurements. For example: if the return value is 071DH (Hexadecimal), the first byte of the high byte is 07H, second bytes of low byte is 1DH, then the measured value is (07H*256+1DH) /100= (7*256+29)/100 =18.21. representative volume water content is 18.21%.		

EC --- electrical conductivity		
Parameter range	0-20000 corresponds to 0-20000us/cm	Default: none
Parameter storage	None	
Significance: electrical conductivity measurement. For example: if the return value is 071DH (Hexadecimal), the first byte is 07H, the second byte and the low byte is 1DH, then conductivity measurement value (07H*256+1DH) = (7*256+29) =1821. representative soil conductivity is 1821us/cm		

SALINITY		
Parameter range	0-20000 corresponds to 0-20000mg/L	Default: none

Parameter storage	None	
Significance: Salinity Measurement. For example: if the value returned is 071DH (Hexadecimal), the first byte of the high byte is 07H, the second byte low byte is 1DH, then the salinity measurement value (07H*256+1DH) = (7*256+29) =1821. representative the soil salinity is 1821mg/L		

TDS--- total dissolved solids		
Parameter range	0-20000 corresponds to 0-20000mg/L	Default: none
Parameter storage	None	
Significance: TDS measurement value. For example: if the value returned is 071DH (Hexadecimal), the first byte of the high byte is 07H, second bytes of low byte is 1DH, then the TDS measurement value (1DH+07H*256)= (7*256+29) =1821. representative TDS is 1821mg/L.		

EPSILON--- dielectric constant		
Parameter range	0-8200 corresponds to 0.00-82.00	Default: none
Parameter storage	None	
Meaning: dielectric constant. For e xample: if the value returned is 071DH (Hexadecimal), the first byte is 07H, the second byte low byte is 1DH, then the measured value is (1DH+07H*256) /100= (7*256+29)/100 =18.21. to represent the dielectric constant of 18.21.		

TEMP UNIT--- degree unit		
Parameter range	0：℃ 1：℉	Default: 0
Parameter storage	Immediate storage	
Significance: unit of temperature.		
EC TEMP COFF		
Parameter range	0-100 corresponds to 0.0%-10.0%	Default: 20（2%）
Parameter storage	Immediate storage	
Significance: the temperature compensation coefficient of electrical conductivity		

SALINITY COFF		
Parameter range	0-100 corresponds to 0.00-1.00	Default: 55（0.55）
Parameter storage	Immediate storage	
Significance: Salinity / conductivity compensation coefficient		

TDS COFF		
Parameter range	0-100 corresponds to 0.00-1.00	Default: 50（0.50）
Parameter storage	Immediate storage	
Significance: TDS/ conductivity compensation coefficient		

MEASMUREMETHOD---Measure Method		
Data Range	0: Continuous 1: Request	Default: 1
Power Down Save	Immediate storage	
Note:In Continious mode, the sensor always convert the VWC,EC and Temperature and update the internal data and ready for reading. In Request mode, the sensor convert the VWC,EC and Temperature data by receiving the data request command from master device.		

SLAVE ADDR --- Modbus address		
Parameter range	0-255	Default:1 or 18
Parameter storage	Immediate storage	
Note: Please re-power on the sensor to take effective after set. The default slave address for sensors with a waterproof aviation connector is 18. The default slave address for sensors with hookup wires is 1.		

BAUDRATE		
Parameter range	0-5 0:1200bps 1:2400bps 2:4800bps	Default:3

	3:9600bps 4:19200bps 5:38400bps	
Parameter storage	Immediate storage	

PROTOCOL --- Serial communication Protocol		
Parameter range	0~1 0:Modbus RTU 1:Modbus ASCII	Default:0
Parameter storage	Immediate storage	

PARITY --- Serial communication Check bit		
Parameter range	0-2 0:none 1: even parity check 2: Odd parity check	Default:0
Parameter storage	Immediate storage	

DATA BITS		
Parameter range	1 1:8 data bits	Default:1,Only supports 8 data bits, the other is invalid
Parameter storage	Immediate storage	

STOP BITS		
Parameter range	0-1 0:1 stop bit 1:2 stop bits	Default:0
Parameter storage	Immediate storage	

RESPONSE DELAY		
Parameter range	0-255	Default:0
Parameter storage	Immediate storage	
Serial communication delay response used in the following circumstances: when the host sends a request command, delay module (RESPONSEDELAY*10 milliseconds), then the response data is returned to the host. For example, to set up RESPONSEDELAY=5, so delay module 5*10=50 millisecond response requesting host. Set to 0 for no delay an immediate response. This command is mainly used to host from RS485 transmission switch state to the receiving state relatively slow speed of occasions.		

ACTIVE OUTPUT INTERVAL		
Parameter range	0-255	Default:0
Parameter storage	Immediate storage	
Serial communication active output time interval used in the following circumstances: hosts that do not need to send a request command module active output response data and output interval for ACTIVEOUTPUTINTERVAL second, such as setting ACTIVEOUTPUTINTERVAL=5. So module every 5 seconds according to set up the communication protocol of a debate output data. Set to 0 when the active output is invalid, the main request before response. This command is mainly used in GPRS wireless transmission, terminal active node data transmission occasions. Note: when the active output data is set, only one module can be connected on the RS485 bus.		

5.4 Communication Sample

In the following instructions, the data at the beginning of the 0x or the ending of the H is a 16 - band data. Modbus protocol with two common types of registers:
(1) To maintain the register, storage data is not lost, it is read and write. Usually with function number 3 (0x03) read, use function number 6 (0x06) or 16 (0x10) write.
(2) The input registers are used to store a number of read - only physical variables, such as temperature values, that are read - only and usually read with a function number 4 (0x04).

5.4.1 Function number 3 communication sample

Common request format：AA 03 RRRR NNNN CCCC

AA	1 byte	Address, 0-255
03	1byte	Function number 3
RRRR	2byte	Start register address, high byte in front
NNNN	2byte	read the number of registers N, high byte in the front
CCCC	2byte	CRC CHECK

Common request format：AA 03 MM VV0 VV1 VV2 VV3… CCCC

AA	1byte	Address, 0-255
03	1byte	Function number 3
MM	1byte	Returns the number of data byte in the register value
VV0,VV1	2byte	Returns the first register value
VV2,VV3	2byte	Returns the second register value
…	…	Returns the “N” register value (N=MM/2)
CCCC	2byte	CRC CHECK

For example: to read register 0x0200-0x0201, namely from the machine address and baud rate for example

Ask：01 03 0200 0002 C5B3

Address	1byte	0x01
Function number	1byte	0x03

Start register address	2byte	0x0200
Register number	2byte	0x0002
Check	2byte	0xC5B3

Respond：01 03 04 00 01 00 03 EB F2

Address	1byte	0x01
Function number	1byte	0x03
Effective byte number	1byte	0x04
Slave address register value	2byte	0x00 (From machine address high byte)
		0x01 (From machine address low byte)
The baud rate register value	2byte	0x00 (High baud rate byte)
		0x03 (low baud rate byte)
Check	2byte	0xEBF2

5.4.2 Function number 4 communication sample

Common request format：AA 04 RRRR NNNN CCCC

AA	1byte	Address, 0-255
04	1byte	Function number4
RRRR	2byte	Start register address, High byte in front
NNNN	2byte	o read the number N Register, high byte in the front
CCCC	2byte	CRC CHECK

Common request format：AA 04 MM VV0 VV1 VV2 VV3… CCCC

AA	1byte	Address, 0-255
04	1byte	Function number4
MM	1byte	Returns the number of data byte in the register value
VV0,VV1	2byte	Returns the first register value
VV2,VV3	2byte	Returns the second register value
…	…	Returns the “N” register value (N=MM/2)

CCCC	2byte	CRC CHECK

For example: to read the register 0x0000-0x0003, that reads the temperature, water content, electrical conductivity value

Ask：01 04 0000 0003 B00B

Address	1byte	0x01
Function number	1byte	0x04
Start register address	2byte	0x0000
Register number	2byte	0x0003
Check	2byte	0xB00B

Respond：01 04 06 08 90 0E 93 02 4E D2 57

Address	1byte	0x01
Function number	1byte	0x04
Effective byte number	1byte	0x06
Temperature register value	2byte	0x08
		0x90
Volume water content register value	2byte	0x0E
		0x93
Conductivity register value	2byte	0x02
		0x4E
Check	2byte	0xD257

5.4.3 Function number 6 communication sample

Common request format：AA 06 RRRR VVVV CCCC

AA	1byte	Address, 0-255
06	1byte	Function number6
RRRR	2byte	Register address, high byte in front

VVVV	2byte	To write the value of the register, the high byte is in the front
CCCC	2byte	CRC CHECK

Common request format：AA 06 RRRR VVVV CCCC

AA	1byte	Address, 0-255
06	1byte	Function number6
RRRR	2byte	Register address, high byte in front
VVVV	2byte	To write the value of the register, the high byte is in the front
CCCC	2byte	CRC CHECK

For example: to write register 0x0021, namely the temperature unit for Fahrenheit cases

Ask：01 06 0021 0001 1800

Address	1byte	0x01
Function number	1byte	0x06
Start register address	2byte	0x0021
Register number	2byte	0x0001
Check	2byte	0x1800

Respond：01 06 0021 0001 1800

Address	1byte	0x01
Function number	1byte	0x06
Start register address	2byte	0x0021
Register number	2byte	0x0001
Check	2byte	0x1800

5.4.4 Function number 16 communication sample

Common request format：AA 10 RRRR NNNN MM VVVV1 VVVV2 …CCCC

AA	1byte	Address, 0-255
10 (HEX)	1byte	Function number16 (10 binary system)
RRRR	2byte	Start register address, High byte in front
NNNN	2byte	To read the number N Register, high byte in the front
MM	1byte	The number of byte to write the value of the register
VVVV1	2byte	To write the value of the first register, the high byte is in the front.
VVVV2	2byte	To write the value of the second register, the high byte is in the front.
…	…	To write the value of the “N” register, the high byte is in the front. N=MM/2
CCCC	2byte	CRC CHECK

Common request format：AA 10 RRRR NNNN CCCC

AA	1byte	Address, 0-255
10(HEX)	1byte	Function number16 (10 binary system)
RRRR	2byte	Start register address, High byte in front
NNNN	2byte	To read the number N Register, high byte in the front
CCCC	2byte	CRC CHECK

For example: to write register 0x0200-0x0201 is set from the machine address is 1, the baud rate is 19200bps as an example

Ask：01 10 0200 0002 04 0001 0004 BACC

0x01	1byte	Address
0x10 (HEX)	1byte	Function number 16 (DEC)
0x0200	2byte	Start register address, High byte in front
0x0002	2byte	To read the number N Register, high byte in the front
0x04	1byte	The number of byte to write the value of the register
0x0001	2byte	To write such as from the station address register

		value is 1
0x0004	2byte	To write such as from the station address register value is 4
0xBACC	2byte	CRC CHECK

Respond：01 10 0200 0002 4070

0x01	1byte	Address
0x10 (HEX)	1byte	Function number16 (DEC)
0x0200	2byte	Start register address, high byte in the front
0x0002	2byte	To read the number N Register, high byte in the front
0x4070	2byte	CRC CHECK

5.5 CRC16 Check Algorithm

```
//-----------------------------------------------------------------------------
// CRC calculation of C51 language function is as follows
// Enter the parameter 1:snd, to be the name of the byte Check array
// Input parameters 2:num, the total number of Check to be byte
// Function return value: Check and
//-----------------------------------------------------------------------------
unsigned int calc_crc16 (unsigned char *snd, unsigned char num)
{
unsigned char i, j;
unsigned int c,crc=0xFFFF;
for(i = 0; i < num; i ++)
{
c = snd[i] & 0x00FF;
crc ^= c;
for(j = 0;j < 8; j ++)
{
if (crc & 0x0001)
{
crc>>=1;
crc^=0xA001;
}
else
{
crc>>=1;
        }
}
}
return(crc);
```

For example: to read the register 0x0000-0x0002, that reads the temperature, water content, electrical conductivity value

Host Ask:01 0400000003 B00B (8 byte)

Address	1byte	0x01
Function number	1byte	0x04
Start register address	2byte	0x0000
Register number	2byte	0x0003
Check	2byte	0xB00B

When the host needs to send data to the sensor, it will need to send Check data stored in the snd array. (01 04 00 00 00 03 A total of 6 byte), Among them num=6

Pseudo code as follows:

```
unsigned char request[8]={01,04,00,00,00,03,00,00};// The last two 00,00 are CHECK CRC
unsigned char num=6;// Calculate the array of the first 6 CRC CHECK byte
unsigned int crc16=0;
crc16= calc_crc16 (request, num);
request[6]= crc16%256;// Store check CRC in an array to be sent
request[7]= crc16/256;
CommPort.Send(request, 8);// Send data through serial port
```

Sensor Respond:01 04 06 08 90 0E 93 02 4E D2 57 (11 byte)

Address	1byte	0x01
Function number	1byte	0x04
Effective byte number	1byte	0x06
Temperature register value	2byte	0x08
		0x90
Volume water content register value	2byte	0x0E
		0x93
Conductivity register value	2byte	0x02
		0x4E
Check	2byte	0xD257

When the host receives the 11 byte data returned by the sensor, the following CRC calculation is performed, where num=11

Pseudo code as follows：

```
unsigned char response[11]={ 01 04 06 08 90 0E 93 02 4E D2 57};// The last two byte are the CHECK CRC that the sensor returns
unsigned char num=11;// Calculate the entire return of the 11 CRC CHECK byte
unsigned int crc16=0;
crc16= calc_crc16 (response, num);
if(crc16==0)
{
// Check CRC correctly, you can use the returned data
}
else
{
// Check CRC error, can not be used to return the data
}
```

To get results back to 0 so the success of Check, if Check fails to return to a nonzero value.If the Check does not succeed, it shows that the transmission process is wrong, should give up the collected data, re collection.

The success of the Check, use the following formula to calculate the temperature (negative to complement representation) and conductivity of H at the end of the 16 hexadecimal data：

temperature=（08H*256+90H）/100=2192/100=21.92 ℃

volumetric water content =（0EH*256+93H）/100=3731/100=37.31%

conductivity =02H*256+4EH=2*256+78 =590 μs/cm

6 Document version

Version	Date	Description	Editor
V1.0		First Version	
V1.1	04/28/23	Modify entire document	Yvonne.Meng

