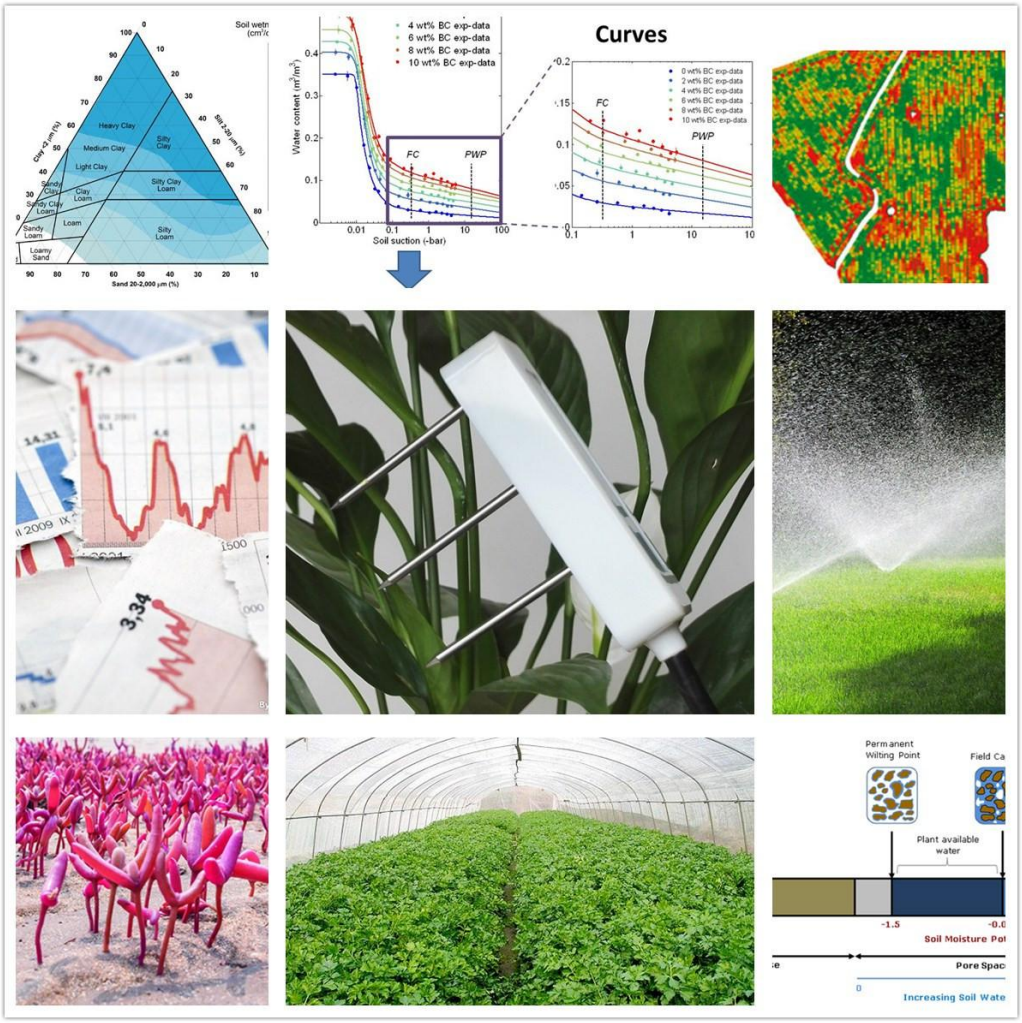
TR02 (SDI-12 Interface)

Soil Moisture, EC and Temperature Sensor (TR02A)

Soil Moisture, Temperature Sensor (TR02B)

User Manual



SIBO.X INDUSTRIAL CO.,LTD.
Add: No. Building 1, No. 1, Jingshi Road, Cicheng Town Industrial Park, Jiangbei District, Ningbo City, Zhejiang, China
https://www.sbxsun.com
Email: info@sbxsun.com
Tel: +86-15958288207

Index

1 Customer Support

Thank you very much for your order. Our success comes from the continuous faith in the excellence of our products and services, something we are committed to and would never sacrifice. Our customer service, especially in the after sales phase, guarantees the satisfaction of our clients. In line with this strategy, we appreciate that you can share with us your feedback at any time for our improvement, be it positive or negative, so if we can serve you better in anyway, please do inform us.

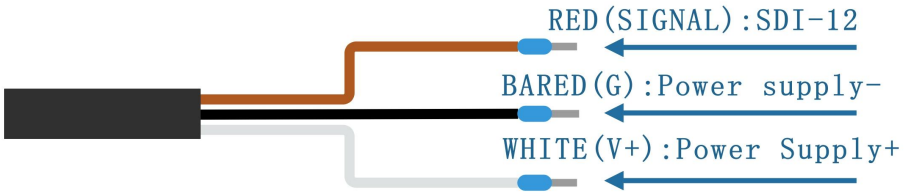
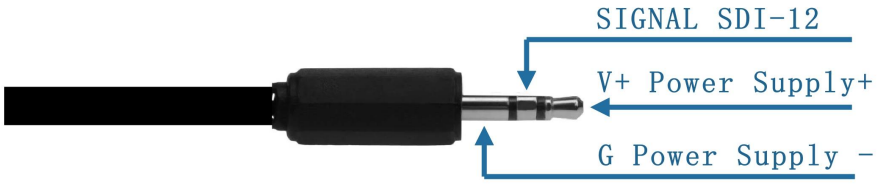
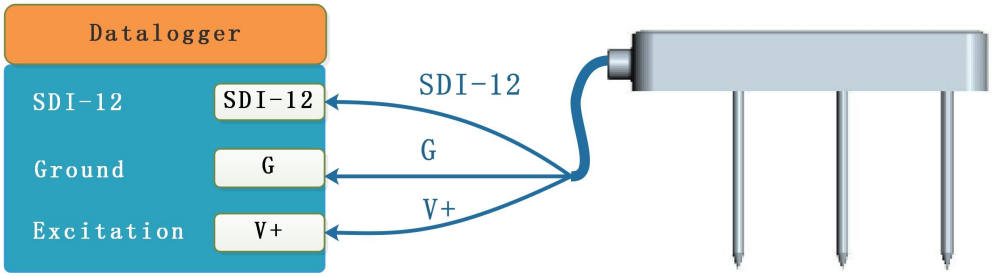
2 Introduction

TR02 is a sensor with SDI-12 interface, measuring soil moisture content, temperature and EC, or soil moisture content and temperature regarding the order information. It sealed with resin packaged plastic body with sensing rods which can be insert directly into the soil with long time stability. The sensor is applicable for science research, irrigation, greenhouse, smart agriculture etc.

- Integrated with Soil Moisture, temperature or with EC measurement
- Output Interface SDI-12
- Low salinity sensitivity
- Minimal soil disturbance
- Water proof to IP68 ratings and can be directly buried into soil
- High accuracy with excellent stability
- Reverse power protection and Built-in TVS/ESD protection
- ODM/OEM Service

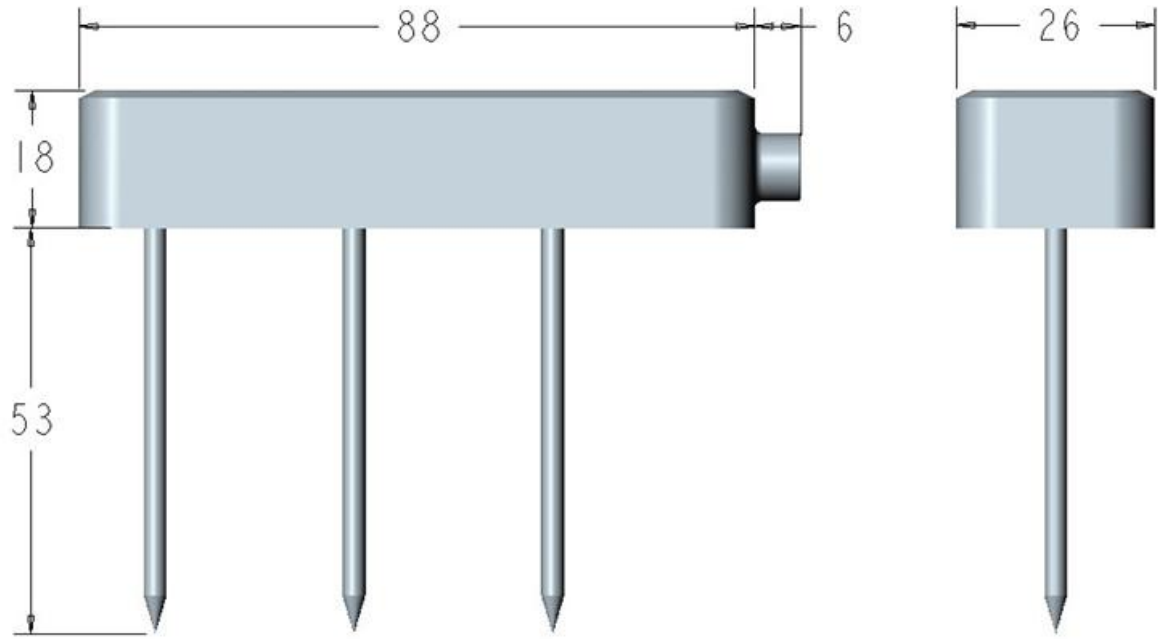
Specifications	
Output Interface	SDI-12, V1.3
Power Supply	3.6-16V/DC
Power Consumption	Quiescent Current : 30uA Measuring Current : 10mA during 150ms measurement
Soil Moisture Measurement	Apparent dielectric permittivity (ξ_a): Range:1-81 (air - water) Resolution: 0.88-40.00:+/-0.1，40.00-81.88:+/-0.5 Accuracy:1.00-40.00:+/-1 ξ_a ,40.00-81.00:+/-10% of Readings
EC Measurement	Range: 0-23ds/m Resolution: 0.001ds/m Accuracy: 0-7ds/m, 5%; 7-23ds/m,8% EC temperature compensation: 0-50°C
Temperature Measurement	Range: -40-80°C, Resolution:0.1°C, Accuracy:+/-0.5°C
IP Ratings	IP68
Operating Temperature	-40-85°C
Sensor Sealed	Epoxy resin
Installation	Surface or buried installation
Cable Length	5 meters or Customize
Dimension	88*26*71mm

3 Wiring diagrams

Type	Wiring diagram
SDI-12 Interface	Cold pressed terminal and tinned lead wires  3.5 mm stereo plug  Wiring Diagram 

4 Dimension and Ordering Infomation

4.1 Dimension



Unit: mm

4.2 Ordering Information

Ordering Information		
Parameters	**Code**	**Comments**
Code 1: Product Series	TR02	TR02 SDI-12 interface sensor
Code 2: Measuring Parameters	A B	Soil Moisture & Temperature & EC Soil Moisture & Temperature
Code 3: Soil Moisture Range	B	0-100%
Code 4: EC Range	C X	0-23ds/m No EC measurement when measuring parameters is Soil Moisture & Temperature
Code 5: Power Supply	B	3.6-16V DC
Code 6: Connector	A B C	3.5 mm stereo plug Cold pressed terminal Stripped & tinned lead wires
Code 7: Cable Length	005 XXX	5 meters Customize, XXX is required cable length(Unit: meter)
Ordering Code Example: TR02 – A B C B A 005 Product Series: TR02 SDI-12 interface sensor; Measuring Parameters: Soil Moisture & Temperature & EC; Moisture Rang: 0-100%; EC range: 0-23ds/m; Power supply 3.6-16V DC; Connector: 3.5 mm stereo plug; Cable length: 5 meters;		

5 Safty ,Care and Installation

5.1 Care and Safty

■ The rods of the Sensor are sharp for ease insertion. Care must be taken and handling precautions followed.
■ Avoid touching the rods or exposing them to other sources of static damage, particularly when powered up.

■ Do not pull the sensor out of the soil by its cable.

■ If you feel any resistance when inserting the sensor into soil, it is likely you have encountered a stone. Stop pushing and re-insert at a new location.

5.2 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.

6 Output Signal Conversion

Output Interface	Parameters	Range
ADI Interface or SDI-12 Interface	<calibratedCountsVWC> or <RAW> , Calibrated ADC for volumetric water content	+0.0 - +4095.0
	<temperature>, temperature	-40.00 - +80.00℃
	<electricalConductivity>, Bulk electrical conductivity normalized to 25 °C	+0 - +23000 us/cm
Customize	Please contact us for more info	

Note: VWC can be calculated by <calibratedCountsVWC> using formula below.

6.1 Water Content Conversion for Mineral Soil

Linear equation below can be used for soil from 0% to statured%. And VWC reaches a maximum at approximately 70% in pure water:

$$VWC = 3.879 * 10^{-4} * RAW - 0.6956$$

Using equation below can reaches a maximum at approximately 100% in pure water:
When RAW<3200

$$VWC = 1.1033765 * 10^{-10} * RAW^{3} - 7.7895464 * 10^{-7} * RAW^{2} + 2.1949004 * 10^{-3} * RAW - 2.0970717$$

When RAW>=3200:

$$VWC = 4.0263182 * 10^{-8} * RAW^{3} - 3.8868517 * 10^{-4} * RAW^{2} + 1.2516687 * RAW - 1343.9820$$

VWC:Volumetric Water Content 0-100%，RAW:Calibrated ADC for volumetric water content.

6.2 Water Content Conversion for Non-soil substrate

The calibration for several potting soils, perlite, and peat moss is shown

$$VWC = 6.771 * 10^{-10} * RAW^{3} - 5.105 * 10^{-6} * RAW^{2} + 1.302 * 10^{-2} * RAW - 10.848$$ ， Where:

VWC:Volumetric Water Content 0-100%，RAW:Calibrated ADC for volumetric water content.

6.3 Epsilon Calculation

Dielectric permittivity (ξ_a) can be used to determine VWC using equations such as the Topp equation.

$\xi_a = (2.887*10^{-9}*RAW^3 - 2.080*10^{-5}*RAW^2 + 5.276*10^{-2}*RAW - 43.39)^2$， Where:

ξ_a :Epsilon， RAW:Calibrated ADC for volumetric water content.

7 Communication interface and Protocol

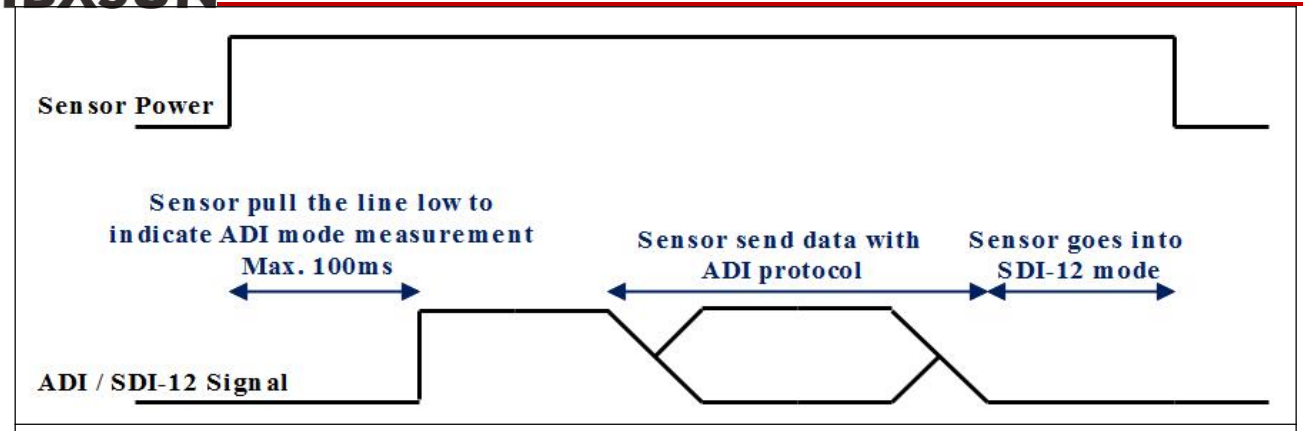
The sensor has two type of serial interface and protocol, ADI protocol(Active Digital Interface)and SDI-12 Protocol. The description and terms used within this chapter are listed in table below:

Parameters	Unit	Description
+/-	-	Sign of the value
a	-	SDI-12 address
n	-	Number of measurements (fixed width of 1)
nn	-	Number of measurements with leading zero if necessary (fixed width of 2)
ttt	s	Maximum measurement time (fixed width of 3)
<TAB>	-	Tab character
<SPACE>	-	Space character
<CR>	-	Carriage return character
<LF>	-	Line feed character
<calibratedCountsVWC>	-	Calibrated ADC for volumetric water content
<temperature>	° C	Temperature
<electricalConductivity>	us/cm	Bulk electrical conductivity normalized to 25 °C
<sensorType>	-	ASCII character denoting the sensor type For TR02A, the character is ‘g’ For TR02B, the character is ‘h’
<Checksum>	-	SUM Checksum
<CRC_ADI>		ADI protocol CRC Checksum
<CRC>	-	SDI-12 protocol CRC Checksum

7.1 ADI Interface and Protocol

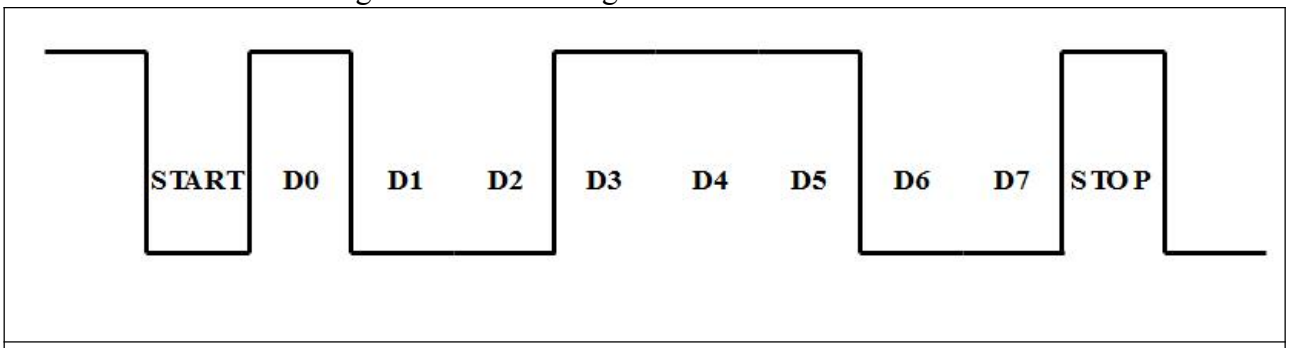
7.1.1 ADI Interface

ADI interface protocol(TTL signal),ADI is short for Active Digital Interface. Each time when sensor power up with SDI-12 address 0,the sensor firstly enter into the ADI mode and pull down the SDI-12 signal line for 100ms to indicating the measurement in processing,then release the SDI-12 signal line and output the ADI protocol data, and then enter into the SDI-12 interface mode.



ADI protocol logic

ADI interface is TTL compatiable standard(0-3.6V),protocol data stream is encoded in ASCII,Baudrate 1200bps,None parity,8 data bits,1 stop bit.The sensor enter into SDI-12 standby mode after the ADI output.You'll need to re power up the sensor again for another ADI output.ADI interface transmission bit diagram is as following.



Transmission bit diagram of the ASCII character'9'(0x39)

7.1.2 Protocol

ADI protocol format:

<TAB><calibratedCountsVWC><SPACE><temperature><SPACE><electricalConductivity><CR><sensorType><Checksum><CRC_ADI>

Parameters	Description
<TAB>	Tab Character
<calibratedCountsVWC>	Calibrated ADC for volumetric water content
<SPACE>	Space Character
<temperature>	Temperature
<SPACE>	Space Character (Not applicable for TR02B)
<electricalConductivity>	Bulk electrical conductivity normalized to 25 °C (Not applicable for TR02B)
<CR>	Carriage return character
<sensorType>	ASCII character denoting the sensor type For TR02A, the character is 'g' For TR02B, the character is 'h'
<Checksum>	SUM Check from <TAB> to <sensorType>
< CRC_ADI >	ADI protocol CRC Check from <TAB>to < Checksum>

Example: “<TAB>2749.0<SPACE>23.8<SPACE>660<CR>g8o”

Parameters	Description
<TAB>	Tab Character
2749.0	Calibrated ADC for volumetric water content 2749.0
<SPACE>	Space Character
23.8	Temperature 23.8°C
<SPACE>	Space Character
660	conductivity 660us/cm
<CR>	Carriage return character
g	sensor type
8	SUM Check
o	ADI protocol CRC Check

ADI Interface checksum calculation:

```
char CalcADIChecksum(char * Response)
{
    int length, sum = 0, i, crc;
    // stream data length
    length = strlen(Response);
    // checksum calculation
    for( i = 0; i < length; i++ )
        sum += Response[i];
    // convert to printable character
    crc = sum % 64 + 32;
    return crc;
}
```

Using “**<TAB>2749.0<SPACE>23.8<SPACE>660<CR>g**” as function parameters “char * Response” and you will get a checksum ‘8’

7.2 SDI-12 Interface and Protocol

7.2.1 SDI-12 Interface

Please refer to SDI-12 standard user manual V1.3.

7.2.2 Protocol

Request	Response	Comment
a!	a<CR><LF>	Acknowledge Active a: Sensor address **Example:** Request: 0! Response: 0<CR><LF>

aI!	allccccccccmmmmmmvvvxxxxxxxxxxxxx<CR><LF>	Send Identification a: Sensor address ll:SDI-12 Version Number cccccccc: 8 characters vendor identification mmmmmm: 6 characters specifying the sensor model number vvv: 3 characters specifying the sensor version xxxxxxxxxxxxx: 13 characters serial number <CR><LF>: terminates the response **TR02A Example:** Request: 0I! Response: 013INFWIN TR02A 1.01909250001000<CR><LF> **TR02B Example:** Request: 0I! Response: 013INFWIN TR02B 1.01909250001000<CR><LF>
?!	a<CR><LF>	Sensor Address Query a:Sensor address **Example:** Request: ?! Response: 0<CR><LF>
aAb!	b<CR><LF>	Change Sensor address a:Current Sensor address b:New Sensor address **Example:** Request: 0A1! Response: 1<CR><LF>
aM!	atttn<CR><LF> a:Sensor address ttt: Measurement data will be ready in ttt seconds n:Number of measurement data <CR><LF>:terminates the response	**TR02A Example:** Start Measurement Command. 3 data will be ready in 001 seconds. Request: 0M! Response: 00013<CR><LF> Response: 0<CR><LF> Request: 0D0! Response: 0+2749.0+23.8+660<CR><LF> <calibratedCountsVWC>=+2749 <temperature>=+23.8 <electricalConductivity>=+660 **TR02B Example:** Start Measurement Command. 2 data will be ready in 001 seconds. Request: 0M! Response: 00012<CR><LF>

		Response: 0<CR><LF> Request: 0D0! Response: 0+2749.0+23.8<CR><LF> <calibratedCountsVWC>=+2749.0 <temperature>=+23.8
aMC!	atttn<CR><LF> a:Sensor address ttt: Measurement data will be ready in ttt seconds n:Number of measurement data <CR><LF>:terminates the response	**TR02A Example:** Start Measurement and Request CRC. 3 data will be ready in 001 seconds. Request: 0MC! Response: 00013<CR><LF> Response: 0<CR><LF> Request: 0D0! Response: 0+2749.0+23.8+660A]p<CR><LF> **TR02B Example:** Start Measurement and Request CRC. 2 data will be ready in 001 seconds. Request: 0MC! Response: 00012<CR><LF> Response: 0<CR><LF> Request: 0D0! Response: 0+2749.0+23.8H_H<CR><LF>
aC!	atttn<CR><LF> a:Sensor address ttt: Measurement data will be ready in ttt seconds n:Number of measurement data <CR><LF>:terminates the response	**TR02A Example:** Start Concurrent Measurement.3 data will be ready in 001 seconds. Request: 0C! Response: 00013<CR><LF> Request: 0D0! Response: 0+2749.0+23.8+660<CR><LF> **TR02B Example:** Start Concurrent Measurement.2 data will be ready in 001 seconds. Request: 0C! Response: 00012<CR><LF> Request: 0D0! Response: 0+2749.0+23.8<CR><LF>
aCC!	atttn<CR><LF> a:Sensor address ttt: Measurement data will be ready in ttt seconds n:Number of measurement data <CR><LF>:terminates the response	**TR02A Example:** Start Concurrent Measurement and Request CRC.3 data will be ready in 001 seconds. Request: 0CC! Response: 00013<CR><LF> Request: 0D0! Response: 0+2749.0+23.8+660A]p<CR><LF>

		TR02B Example: Start Concurrent Measurement and Request CRC.2 data will be ready in 001 seconds. Request: 0CC! Response: 00012<CR><LF> Request: 0D0! Response: 0+2749.0+23.8H_H<CR><LF>
aD0!	a[<saaaa>][<sbbbb>][<scccc>][<CRC>]<CR><LF>	Send Data Command, The sensor responds by sending the data The data returned depends on the command you send most recently. [<saaaa>]: data 1 [<sbbbb>]: data 2 [<scccc>]: data 3 [<CRC>]: Optional 3 characters CRC checksum, <CR><LF>:terminates the response
aR0!	**For TR02A:** a<saaaa><sbbbb><scccc><CR><LF> <saaaa>:+<calibratedCountsVWC> <sbbbb>:±<temperature> <scccc>:+<electricalConductivity> **For TR02B:** a<saaaa><sbbbb><CR><LF> <saaaa>:+<calibratedCountsVWC> <sbbbb>:±<temperature>	**TR02A Example:** Continuous Measurements, and return data Request: 0R0! Response: 0+2749.0+23.8+660<CR><LF> **TR02B Example:** Continuous Measurements, and return data Request: 0R0! Response: 0+2749.0+23.8<CR><LF>
aRC0!	**For TR02A:** a<saaaa><sbbbb><scccc><CRC><CR><LF> <saaaa>:+<calibratedCountsVWC> <sbbbb>:±<temperature> <scccc>:+<electricalConductivity> <CRC>:CRC checksum **For TR02B:** a<saaaa><sbbbb><CRC><CR><LF> <saaaa>:+<calibratedCountsVWC> <sbbbb>:±<temperature> <CRC>:CRC checksum	**TR02AExample:** Continuous Measurements and Request CRC, and return data. Request: 0RC0! Response: 0+2749.0+23.8+660A]p<CR><LF> **TR02BExample:** Continuous Measurements and Request CRC, and return data. Request: 0RC0! Response: 0+2749.0+23.8H_H<CR><LF>
aR3!	**For TR02A:** a<TAB><saaaa><SPACE><sbbbb><SPACE><scccc><CR><sensorType><Checksum><CRC_ADI><CR><LF> <saaaa>：<calibratedCountsVWC> <sbbbb>：<temperature>	TR02A Example: Continuous Measurements, and return data Request: 0R3! Response: 0<TAB>2749.0<SPACE>23.8<SPACE>660<CR>g8o<CR><LF>

	<scccc>：<electricalConductivity> **For TR02B:** a<TAB><saaaa><SPACE><sbbbb><CR><sensorType><Checksum><CRC_ADI><CR><LF> <saaaa>：<calibratedCountsVWC> <sbbbb>：<temperature>	TR02B Example: Continuous Measurements, and return data Request: 0R3! Response: 0<TAB>2749.0<SPACE>23.8<CR>h=U<CR><LF>
aRC3!	**For TR02A:** a<TAB><saaaa><SPACE><sbbbb><SPACE><scccc><CR><sensorType><Checksum><CRC_ADI><CRC><CR><LF> <saaaa>：<calibratedCountsVWC> <sbbbb>：<temperature> <scccc>：<electricalConductivity> <CRC>:CRC checksum **For TR02B:** a<TAB><saaaa><SPACE><sbbbb><CR><sensorType><Checksum><CRC_ADI><CRC><CR><LF> <saaaa>：<calibratedCountsVWC> <sbbbb>：<temperature> <CRC>:CRC checksum	**TR02AExample:** Continuous Measurements and Request CRC, and return data. Request: 0RC3! Response: 0<TAB>2749.0<SPACE>23.8<SPACE>660<CR>g8oN[o<CR><LF> **TR02BExample:** Continuous Measurements and Request CRC, and return data. Request: 0RC3! Response: 0<TAB>2749.0<SPACE>23.8<CR>h=UA|v<CR><LF>
aR4!	**For TR02A:** a<TAB><saaaa><SPACE><sbbbb><SPACE><scccc><CR><sensorType><Checksum><CRC_ADI><CR><LF> <saaaa>：<calibratedCountsVWC> <sbbbb>：<temperature> <scccc>：<electricalConductivity> **For TR02B:** a<TAB><saaaa><SPACE><sbbbb><CR><sensorType><Checksum><CRC_ADI><CR><LF> <saaaa>：<calibratedCountsVWC> <sbbbb>：<temperature>	TR02A Example: Continuous Measurements, and return data Request: 0R4! Response: 0<TAB>2749.0<SPACE>23.8<SPACE>660<CR>g8o<CR><LF> TR02B Example: Continuous Measurements, and return data Request: 0R4! Response: 0<TAB>2749.0<SPACE>23.8<CR>h=U<CR><LF>
aRC4!	**For TR02A:** a<TAB><saaaa><SPACE><sbbbb><SPACE><scccc><CR><sensorType><Checksum><CRC_ADI><CRC><CR><LF> <saaaa>：<calibratedCountsVWC> <sbbbb>：<temperature> <scccc>：<electricalConductivity> <CRC>:CRC checksum	**TR02AExample:** Continuous Measurements and Request CRC, and return data. Request: 0RC4! Response: 0<TAB>2749.0<SPACE>23.8<SPACE>660<CR>g8oN[o<CR><LF> TR02BExample:

	For TR02B: a<TAB><saaaa><SPACE><sbbbb><CR><sensorType><Checksum><CRC_ADI><CRC><CR><LF> <saaaa>：<calibratedCountsVWC> <sbbbb>：<temperature> <CRC>:CRC checksum	Continuous Measurements and Request CRC, and return data. Request: 0RC4! Response: 0<TAB>2749.0<SPACE>23.8<CR>h=UA|v<CR><LF>

Appendix

Version Control

Date	Version	Comment	Updated by
2021-02-07	V6.01	Initial Creation	sl51930