Soil Temp. Moisture EC Sensor

JW-S2S(Z1)

(SDI-12 Output, Compatible with Teros 12)

Beijing Jingelway Sci-Tech Co.,Ltd.

Add:3-201,Zhenguan International Park,No.7 Jinghai Road,Beijing,102600,China

Tel:86-13520127780 Website:www.jw-iot.com Email:info@jingelway.com

1. Product Introduction

It 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.

2. Features

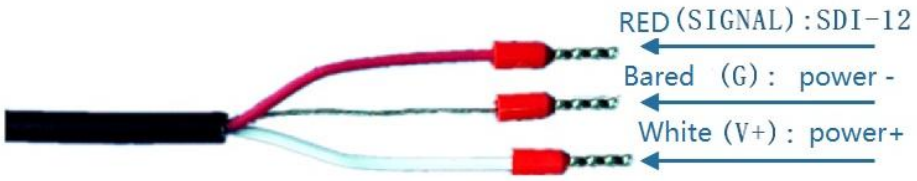
- Integrated with Soil Moisture, EC, Temperature measurement
- Output Interface SDI-12
- Low salinity sensitivity
- Minimal soil disturbance
- Water proof to IP68 ratings and can be directly buried into soil
- High accuracy with excellent stability
- Reverse power protection and Built-in TVS/ESD protection

3. Technical Parameters

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:1.00-40.00:±0.1,40.00-81.00:±0.5 Accuracy:1.00-40.00:±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*71*26mm

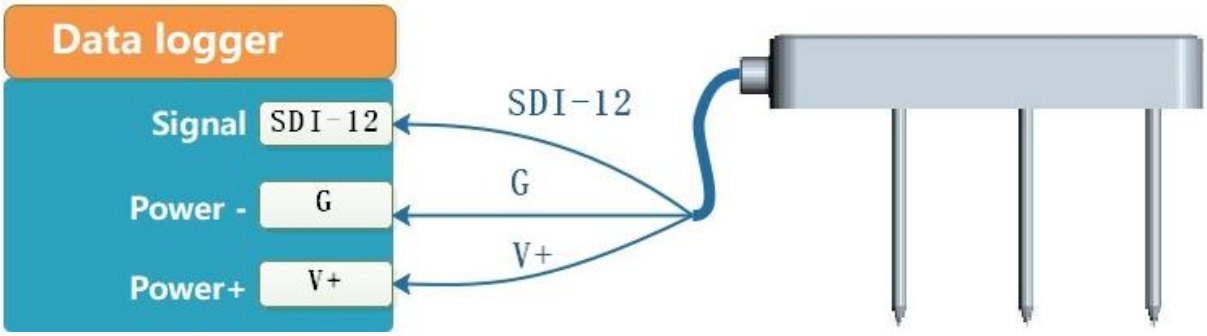
4. Wiring Diagrams

Cold pressed terminal and tinned lead wires

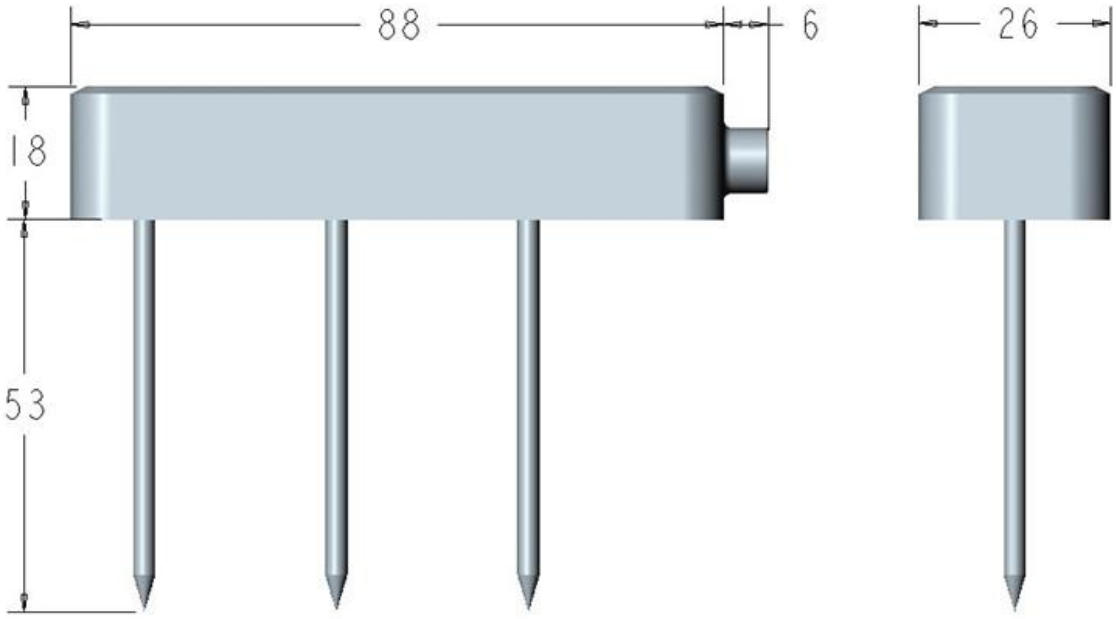


3.5mm stereo plug

Wiring Diagram



5. Dimension



6. Safety, Care and Installation

6.1 Safety and Care

- 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.

6.2 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.

7. Output Signal Conversion

Output Interface	Parameters Range	Conversion Formula
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.

7.1 Water Content Conversion for 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.

7.2 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.

7.3 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.

8. Communication interface and Protocol

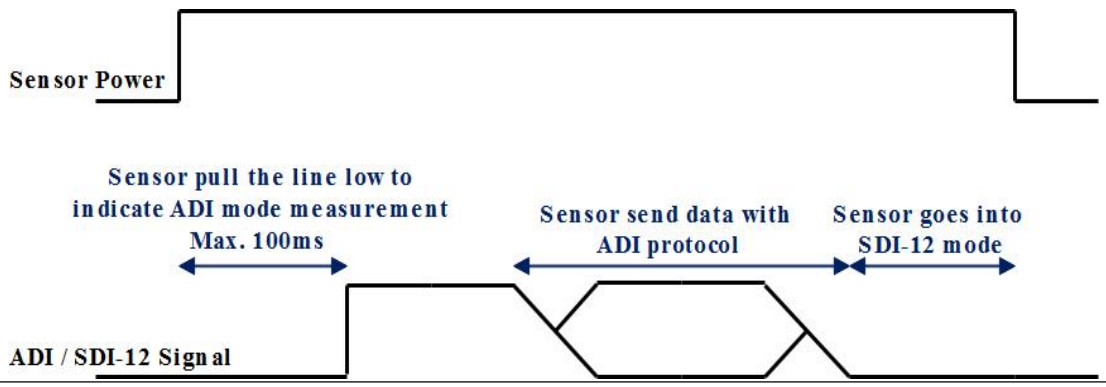
The sensor has two type of serial interface and protocol, ADI protocol(Active Digital Interface)and SDI-12 Protocol. The description and terms used within this chapter are listed in table below:

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 MT22A, the character is 'g' For MT22B, the character is 'h'
<Checksum>	-	SUM Checksum
<CRC_ADI>		ADI protocol CRC Checksum
<CRC>	-	SDI-12 protocol CRC Checksum

8.1 ADI Interface and Protocol

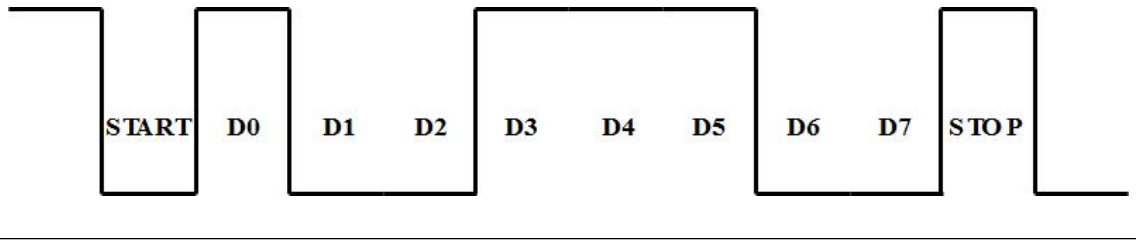
8.1.1 ADI Interface

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)

8.1.2 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 MT22B)
<electricalConductivity>	Bulk electrical conductivity normalized to 25 °C (Not applicable for MT22B)
<CR>	Carriage return character
<sensorType>	ASCII character denoting the sensor type For MT22A, the character is 'g' For MT22B, 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'

8.2 SDI-12 Interface and Protocol

8.2.1 SDI-12 Interface

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

8.2.2 Protocol

Request	Response	Comment
a!	a<CR><LF>	Acknowledge Active a: Sensor address Example: Request: 0! Response: 0<CR><LF>
aI!	allccccccccmmmmmmvvvxxxxxxxxxx xxxx<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 MT22A Example: Request: 0I! Response: 013INFWIN MT22A

		1.01909250001000<CR><LF> MT22B Example: Request: 0I! Response: 013INFWIN MT22B 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	MT22A 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 MT22B 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	MT22A Example: Start Measurement and Request CRC. 3 data will be ready in 001 seconds. Request: 0MC! Response: 00013<CR><LF> Response: 0<CR><LF>

	<CR><LF>:terminates the response	Request: 0D0! Response: 0+2749.0+23.8+660A]p<CR><LF> MT22B 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	MT22A 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> MT22B 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	MT22A 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> MT22B 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 MT22A: a<saaaa><sbbbb><scccc><CR><LF> <saaaa>:+<calibratedCountsVWC> <sbbbb>:±<temperature> <scccc>:+<electricalConductivity> For MT22B: a<saaaa><sbbbb><CR><LF> <saaaa>:+<calibratedCountsVWC> <sbbbb>:±<temperature>	MT22A Example: Continuous Measurements, and return data Request: 0R0! Response: 0+2749.0+23.8+660<CR><LF> MT22B Example: Continuous Measurements, and return data Request: 0R0! Response: 0+2749.0+23.8<CR><LF>
aRC0!	For MT22A: a<saaaa><sbbbb><scccc><CRC><CR><LF> <saaaa>:+<calibratedCountsVWC> <sbbbb>:±<temperature> <scccc>:+<electricalConductivity> <CRC>:CRC checksum For MT22B: a<saaaa><sbbbb><CRC><CR><LF> <saaaa>:+<calibratedCountsVWC> <sbbbb>:±<temperature> <CRC>:CRC checksum	MT22AExample: Continuous Measurements and Request CRC, and return data. Request: 0RC0! Response: 0+2749.0+23.8+660A]p<CR><LF> MT22BExample: Continuous Measurements and Request CRC, and return data. Request: 0RC0! Response: 0+2749.0+23.8H_H<CR><LF>
aR3!	For MT22A: a<TAB><saaaa><SPACE><sbbbb> SPACE><scccc><CR><sensorType> <Checksum><CRC_ADI><CR><LF> <saaaa> : <calibratedCountsVWC><sbbbb> : <temperature> <scccc> : <electricalConductivity> For MT22B: a<TAB><saaaa><SPACE><sbbbb> CR><sensorType><Checksum><CRC _ADI><CR><LF> <saaaa> : <calibratedCountsVWC> <sbbbb> : <temperature>	MT22A Example: Continuous Measurements, and return data Request: 0R3! Response: 0<TAB>2749.0<SPACE>23.8<SPACE>660<CR>g8o<CR><LF> MT22B Example: Continuous Measurements, and return data Request: 0R3! Response: 0<TAB>2749.0<SPACE>23.8<CR>h=U<CR><LF>
aRC3!	For MT22A: a<TAB><saaaa><SPACE><sbbbb> <SPACE><scccc><CR><sensorType ><Checksum><CRC_ADI><CRC><	MT22AExample: Continuous Measurements and Request CRC, and return data. Request: 0RC3! Response:

	CR><LF> <saaaa> : <calibratedCountsVWC> <sbbbb> : <temperature> <scccc> : <electricalConductivity> <CRC>:CRC checksum For MT22B: a<TAB><saaaa><SPACE><sbbbb> CR><sensorType><Checksum><CRC _ADI><CRC><CR><LF> <saaaa> : <calibratedCountsVWC> <sbbbb> : <temperature> <CRC>:CRC checksum	0<TAB>2749.0<SPACE>23.8<SPACE>660<CR>g8o N[o<CR><LF> MT22BExample: 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 MT22A: a<TAB><saaaa><SPACE><sbbbb> SPACE><scccc><CR><sensorType> <Checksum><CRC_ADI><CR><LF> <saaaa> : <calibratedCountsVWC> <sbbbb> : <temperature> <scccc> : <electricalConductivity> For MT22B: a<TAB><saaaa><SPACE><sbbbb> CR><sensorType><Checksum><CRC _ADI><CR><LF> <saaaa> : <calibratedCountsVWC> <sbbbb> : <temperature>	MT22A Example: Continuous Measurements, and return data Request: 0R4! Response: 0<TAB>2749.0<SPACE>23.8<SPACE>660<CR>g8o <CR><LF> MT22B Example: Continuous Measurements, and return data Request: 0R4! Response: 0<TAB>2749.0<SPACE>23.8<CR>h=U<CR><LF>
aRC4!	For MT22A: 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 MT22B: a<TAB><saaaa><SPACE><sbbbb>< CR><sensorType><Checksum><CRC _ADI><CRC><CR><LF> <saaaa> : <calibratedCountsVWC> <sbbbb> : <temperature> <CRC>:CRC checksum	MT22AExample: Continuous Measurements and Request CRC, and return data. Request: 0RC4! Response: 0<TAB>2749.0<SPACE>23.8<SPACE>660<CR>g8o N[o<CR><LF> MT22BExample: 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

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Version Control

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