Soil Temp. Moisture EC Sensor

JW-S3S(Z2)

(SDI-12 Output, Compatible with 5TE)

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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

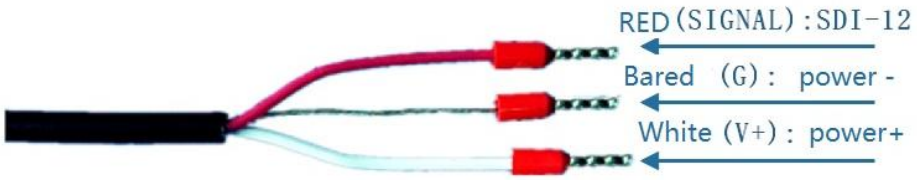
3. Technical Parameters

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:±2%,40.00-81.00:±5% Soil Moisture(VWC): Range:0%-100% (air - water) Resolution:derived by the conversion function from epsilon to VWC Accuracy:derived by the conversion function from epsilon to VWC
EC Measurement	Range: 0-23ds/m Resolution: 0-7ds/m, 0.01ds/m; 7-23ds/m, 0.05ds/m Accuracy: 0-7ds/m, 5%; 7-23ds/m,15% EC temperature compensation: 0-50°C
Temperature Measurement	Range: -40~80°C, Resolution:0.1°C, Accuracy:±0.5°C
Measurement Technique	Moisture by FDR and EC by AC excitation
IP Ratings	IP68
Operating Temperature	-40~85°C
Sensor Rod	Stainless steel
Sensor Sealed	Epoxy resin

Installation	Surface or buried installation
Cable Length	5 meters or Customize
Dimension	88*71*26mm

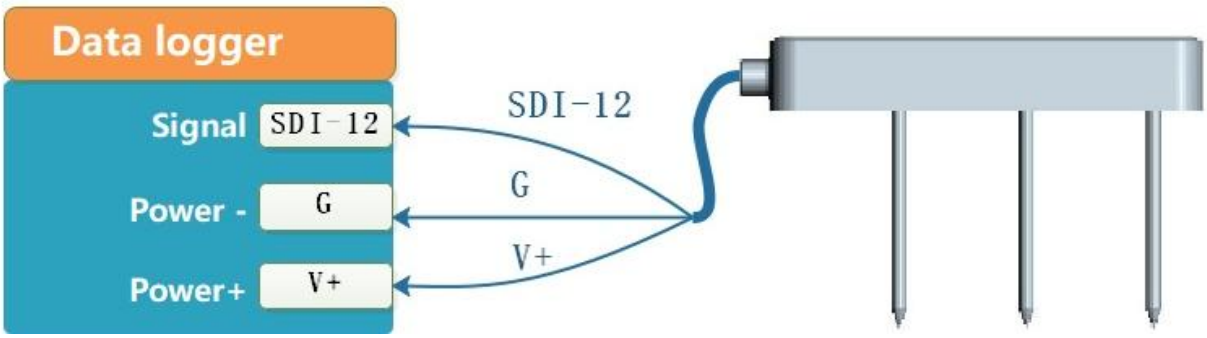
4. Wiring Diagrams

Cold pressed terminal and tinned lead wires

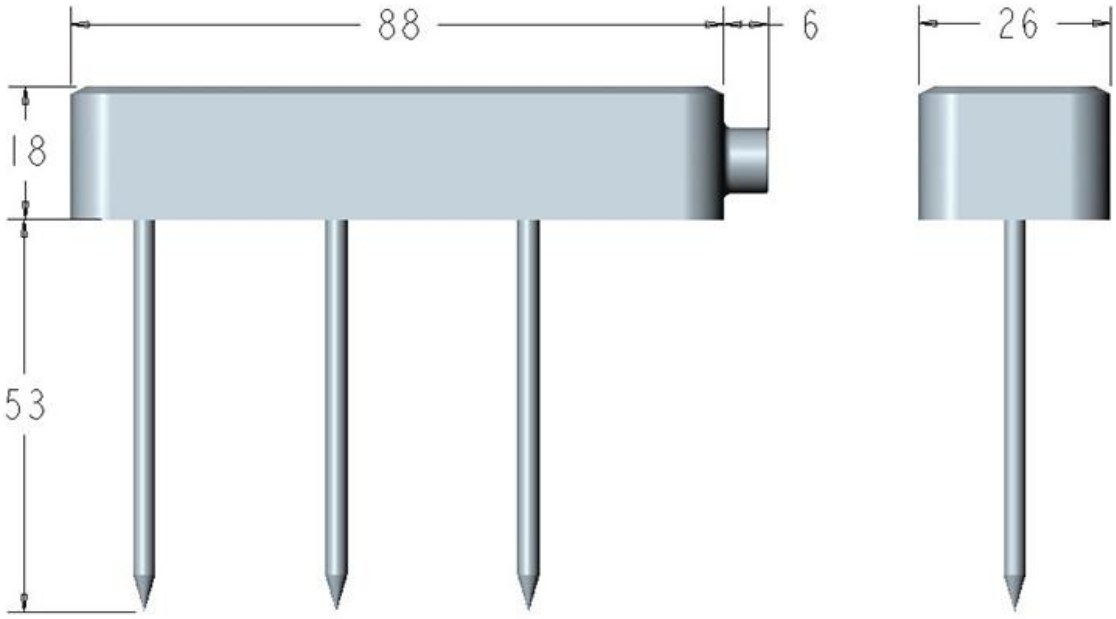


3.5mm stereo plug

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
SDI-12	Apparent dielectric permittivity ξ_a :0.88-81.88	Character string 0.88-81.88
	Temperature:-40.00-80.00°C	Character string -40.00-80.00
	EC:0-20.00ds/m	Character string 0-20.00

Note: VWC can be calculated by ξ_a using formula below.

Note: VWC is volumetric water Content ranges from 0-100%, ξ_a is Apparent dielectric permittivity measured by sensor.

7.1 Water Content Conversion for Soil

Using following conversion formula for VWC calculation.

$VWC = 4.3 * 10^{-6} * \xi_a^3 - 5.5 * 10^{-4} * \xi_a^2 + 2.92 * 10^{-2} * \xi_a - 5.3 * 10^{-2}$

7.2 Water Content Conversion for Non-soil substrate

Using following conversion formula for VWC calculation.

- Potting Soil

$VWC = 2.25 * 10^{-5} * \xi_a^3 - 2.06 * 10^{-3} * \xi_a^2 + 7.24 * 10^{-2} * \xi_a - 0.247$

- Rockwool

$VWC = -1.68 * 10^{-3} * \xi_a^2 + 6.56 * 10^{-2} * \xi_a + 0.0266$

- Perlite

$VWC = -1.07 * 10^{-3} * \xi_a^2 + 5.25 * 10^{-2} * \xi_a - 0.0685$

8. Communication interface and Protocol

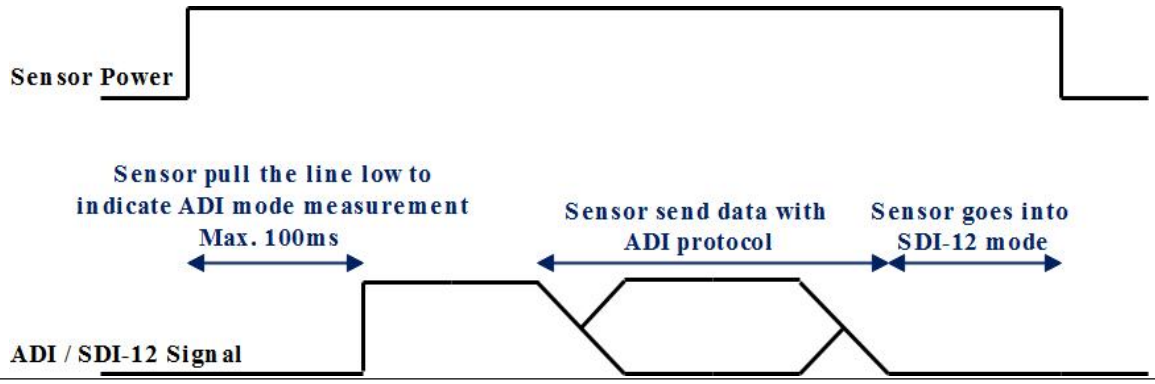
The sensor has two type of serial interface and protocol, ADI protocol(Active Digital Interface)and SDI-12 Protocol.

8.1 ADI Interface and Protocol

8.1.1 ADI Interface

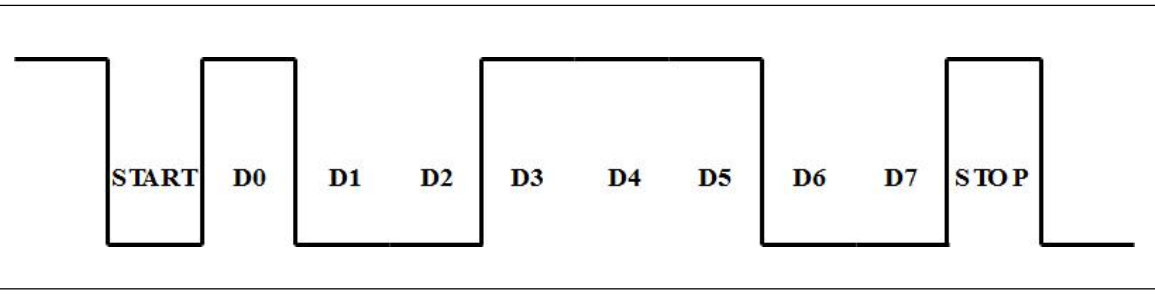
ADI interface protocol(TTL signal),ADI is short for Active Digital Interface. Each time when sensor power

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

The data stream protocol including 3 raw measurement data with space delimited, and terminated by the carriage return.

The first data is Epsilon raw value. The second data is EC raw value(will be always 0 for those sensors without EC measurement),The third data is Temperature raw value. Those raw data can be converted to the measurement values by following formulas:

- Epsilon ξ_a

Epsilon raw value ranges from 0~4094 (and 4095 to indicate the error),and can be converted to epsilon value ξ_a 0.00~81.88 :

ξ_a = (Epsilon raw value)/50.00

- $EC_{(bulk)}$

EC raw value ranges from 0~1022(and 1023 to indicate the error),and can be converted to $EC_{(bulk)}$ 0.00~23.10ds/m :

When $EC_{raw} \leqslant 700$, then $EC_{(bulk)} = EC_{raw}/100$

When EC_{raw}>700, then $EC_{(bulk)}$ = [700 + 5 (EC_{raw} - 700)]/100

The unit of EC is:ds/m

■ Temperature

Temperature raw value ranges from 0~1022(and 1023 to indicate the error),when temperature in -40.0~50.0°C, resolution is 0.1°C;when temperature in 50.5~111.0°C, resolution is 0.5°C:

When $T_{raw} \leqslant 900$, then $T_{Raw2} = T_{Raw}$

When $T_{Raw} > 900$, then $T_{Raw2} = 900 + 5 (T_{Raw} - 900)$

Temperature T(°C)=(T_{Raw2} - 400)/10

Example: Data stream sent by sensor,"56 432 645<0D>zG<0D><0A>"

Parameters	Comment
56	ξ_a =EPSILON$_{raw}$/50.00 = 56/50=1.12,and then using proper formula to convert ξ_a to VWC
Space	data delimiter
432	EC_{raw}=432≤700, then $EC_{(bulk)}$ = EC_{raw}/100 = 432/100=4.32ds/m
Space	data delimiter
645	T_{raw}=645≤900, then $T_{Raw2} = T_{Raw}$ = 645 And then temperature T(°C)= (T_{Raw2} - 400)/10 = (645 - 400)/10 =24.5°C
<0D>	Carriage return
z	Sensor type indicator. 'z'is MT20A 'x'is MT20B
G	Checksum of string "56 432 645<0D>z" for transmission validation.
<0D><0A>	Carriage return,is the data stream terminator

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"56 432 645<0D>z"as function parameters "char * Response" and you will get a checksum 'G'

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!	allccccccccmmmmmmvvvxxxxxxxxx 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 **MT20A Example:** Request: 0I! Response: 013INFWIN MT20A 1.01909250001000<CR><LF> **MT20B Example:** Request: 0I! Response: 013INFWIN MT20B 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	**MT20A Example:** Start Measurement Command. 3 data will be ready in 001 seconds. Request: 0M! Response: 00013<CR><LF> Response: 0<CR><LF> Request: 0D0!

	<CR><LF>:terminates the response	Response: 0+23.53+2.60+17.6<CR><LF> Epsilon=23.53 EC=2.60ds/m Temperature=17.6°C MT20B 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+18.96+18.0<CR><LF> Epsilon=18.96 Temperature =18.0°C
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	MT20A 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+23.53+2.60+17.6Bou<CR><LF> MT20B 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+18.96+18.0Mtu<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	MT20A Example: Start Concurrent Measurement.3 data will be ready in 001 seconds. Request: 0C! Response: 00013<CR><LF> Request: 0D0! Response: 0+23.53+2.60+17.6<CR><LF> MT20B Example: Start Concurrent Measurement.2 data will be ready in 001 seconds. Request: 0C! Response: 00012<CR><LF> Request: 0D0! Response: 0+18.96+18.0<CR><LF>
aCC!	atttn<CR><LF>	MT20A Example: Start Concurrent Measurement and Request CRC.3 data will be

	a:Sensor address ttt: Measurement data will be ready in ttt seconds n:Number of measurement data <CR><LF>:terminates the response	ready in 001 seconds. Request: 0CC! Response: 00013<CR><LF> Request: 0D0! Response: 0+23.53+2.60+17.6Bou<CR><LF> MT20B 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+18.96+18.0Mtu<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 MT20A: a<saaaa><sbbbb><scccc><CR><LF> <saaaa>:Epsilon <sbbbb>:EC <scccc>:Temperature For MT20B: a<saaaa><sbbbb><CR><LF> <saaaa>:Epsilon <sbbbb>:Temperature	MT20A Example: Continuous Measurements, and return data Request: 0R0! Response: 0+23.53+2.60+17.6<CR><LF> MT20B Example: Continuous Measurements, and return data Request: 0R0! Response: 0+18.96+18.0<CR><LF>
aRC0!	For MT20A: a<saaaa><sbbbb><scccc><CRC><CR><LF> <saaaa>:Epsilon <sbbbb>:EC <scccc>:Temperature <CRC>:CRC checksum For MT20B: a<saaaa><sbbbb><CRC><CR><LF> <saaaa>:Epsilon <sbbbb>:EC <CRC>:CRC checksum	MT20AExample: Continuous Measurements and Request CRC, and return data. Request: 0RC0! Response: 0+23.53+2.60+17.6Bou<CR><LF> MT20BExample: Continuous Measurements and Request CRC, and return data. Request: 0RC0! Response: 0+18.96+18.0Mtu<CR><LF>

Appendix

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Version Control

Date	Version	Comment	Updated by
2015-04-23	V6.01	Initial Creation	fg49597