

Soil Multi-parameter Sensor Manual V2.2

Soil Temperature, Moisture, Electrical Conductivity, NPK, pH Sensor

1. Working Principle

- **Soil Temperature:** Collected by NTC thermistor, converted by 12-bit ADC.
- **Soil Moisture:** Based on FDR (Frequency Domain Reflectometry) principle. It measures the soil dielectric constant to directly and stably reflect the actual moisture content of various soils, and can measure the volume percentage of soil moisture.
- **Soil Electrical Conductivity:** Uses complementary PWM output as the signal excitation source and collects resistance via a bridge circuit. The EC signal is compensated to 25°C with temperature correction and output as a salt content signal.
- **Soil pH:** Measured by positive and negative voltages generated on zinc and aluminum electrodes by soil acidity and alkalinity.

2. Features

1. Compact design, high measurement accuracy, good consistency, low power consumption with multi-level peripheral management.
2. Excellent sealing, can be directly buried in soil and resist corrosion.
3. Real-time monitoring of temperature, moisture and salt content; supports measurement at different soil depths.
4. Less affected by soil texture, widely applicable in various regions.
5. High resolution; complementary PWM excitation source cancels temperature and common-mode interference.
6. Ultra-low power consumption version: current as low as 70μA.
7. Ultra-wide power supply range: DC 3.3V~24V.
8. Temperature sensing element inside the steel probe; hollow steel probe with 1mm inner diameter and 50% thicker wall than similar products, providing higher sensitivity and longer service life.

3. Application Scope

Applicable to water-saving agricultural irrigation, meteorological monitoring, environmental monitoring, greenhouses, flower and vegetable planting, grasslands and pastures, rapid soil testing, plant cultivation, scientific experiments and other fields requiring soil temperature, moisture and salt content measurement.

4. Product Specifications

Item	Parameters
Power Supply Voltage	DC 3.3V~24V
Power	RS485: Static current <12V: 3mA; Measuring current: 25mA;

Item	Parameters
Consumption @3.3V~24V	Max current: 35mA RS485 (Ultra-low Power): Static current: 0.07mA; Measuring current: 25mA; Max current: 35mA Current Type: Static current: 10mA; Measuring current: 25mA; Max current: 50mA
Operating Temperature	RS485: -40° C~80° C; Analog: -40° C~60° C
Soil Temperature	Range: -40° C~80° C; Resolution: 0.1° C; Accuracy: $\pm 0.5^{\circ}\text{C}$ @25° C
Soil Moisture	Range: 0~100%; Resolution: 0.1%; Accuracy: $\pm 3\%$ (10%~40%)@25° C loam
Electrical Conductivity	Range: 0~20000 $\mu\text{S/cm}$; Resolution: 1 $\mu\text{S/cm}$; Accuracy: $\pm 3\%$ FS (0~10000 $\mu\text{S/cm}$); $\pm 5\%$ FS (10000~20000 $\mu\text{S/cm}$) @loam 60%RH 25° C
Soil pH	Range: 3~9 pH; Resolution: 0.1 pH
Protection Grade	IP68
Sealing Material	Epoxy Resin
Cable Length	Default 2 meters
Dimensions	140mm $\times$ 45mm $\times$ 15mm
Electrode Length	60mm
Measuring Principle	Moisture: FDR; Temperature: NTC; EC: Complementary PWM voltage division; pH: Zinc-aluminum galvanic cell method
Stabilization Time	Temperature <5s, Moisture <5s, EC <5s, First pH measurement >5 minutes

Physical Parameters

- Probe Length: 60mm, $\phi 3\text{mm}$
- Probe Material: 316L Stainless Steel
- Sealing Material: ABS engineering plastic, epoxy resin; Protection grade IP68
- Cable Specification: Standard 2 meters (customizable up to 1200 meters)

5. Outline Dimensions

(No specific content)

6. Usage Method

Power Supply Voltage 9V 12V 20V 24V

Maximum Impedance 125 Ω 250 Ω 500 Ω >500 Ω

7. Data Conversion Method

RS485 Signal (Default Address: 02) Standard Modbus-RTU protocol; Baud rate: 9600; Parity: None; Data bits: 8; Stop bits: 1

7.1 Register Address

Register Address	Content	R/W	Description
0080H	Address	R/W	Device address
0081H	Baud Rate	R/W	1200, 2400, 4800, 9600, 19200, 38400 (max)
0082H	Parity	R/W	2=Even parity, 1=Odd parity
0083H	Data Bits	R/W	8, 9
0084H	Stop Bits	R/W	1, 2
00BFH	Analog 1 Min Range	R/W	Min temperature: -20.0° C
00C0H	Analog 1 Max Range	R/W	Max temperature: 80.0° C
00C1H	Analog 2 Min Range	R/W	Min moisture: 0.0%
00C2H	Analog 2 Max Range	R/W	Max moisture: 100.0%

1. Modify Address

Example: Change transmitter address from 2 to 1 (Master → Slave) Hex: 00 10 00 80 00 01 02 00 01 75 C0

If the transmitter receives correctly, it returns (Slave → Master):
表格

Original Address	Function Code	Register	Count	Length	Data	CRC
0X02	0X10	0X00 0X80	0X00 0X01	0X02	0X00 0X01 6C A0	

Note: If the original sensor address is unknown, use broadcast address 0X00. Only one slave can be connected to the master when using 0X00, which can be used for address query.

2. Modify Baud Rate

Example: Change baud rate from 9600 to 19200 (Master → Slave)

Original Address	Function Code	Register	Count	Length	Data	CRC
0X00	0X10	0X00 0X81	0X00 0X01	0X02	0X19 0X20 BF 99	

In the example, write data 1920 to register 0081 for 19200 baud rate.

Note: If the original sensor address is unknown, use broadcast address 0X00. Only one slave can be connected to the master.

3. Modify Analog Range

Example: Set analog channel 0 range to $-40.0^{\circ}\text{C} \sim 60.0^{\circ}\text{C}$ Hex: 00 10 00 BF 00 02 04 FE 70 34 22

If the transmitter receives correctly, it returns (Slave $\rightarrow$ Master):
表格

Original Address	Function Code	Register	Count	Length	Data	Data	CRC
0X00	0X10	0X00	0XBF	0X00	0X02	0X04	FE 70 02 58 8C CE

Note: If the original sensor address is unknown, use broadcast address 0X00. Only one slave can be connected to the master.

7.2 Query Data

1. Query Real-time Data (Fixed Register Positions)

Query data of transmitter (address 1) (Master $\rightarrow$ Slave):

Address	Function Code	Start Register (High)	Start Register (Low)	Register Length (High)	Register Length (Low)	CRC16 (Low)	CRC16 (High)
0X00	0X03	0x00	0x00	0X00	0X08	45	DD

If the transmitter receives correctly, it returns (Slave $\rightarrow$ Master, example):

This manual is universal. For devices that are not 7-in-1 or 8-in-1, read only the corresponding registers as listed below.

Example for single pH sensor: 00 03 00 07 00 01 + CRC16

Address	0X01
Function Code	0X03
Data Length	0X10
Register 00 (Temperature)	0XFF 0XDD $\rightarrow$ Soil Temperature: -3.5°C
Register 01 (Moisture)	0X01 0X64 $\rightarrow$ Soil Moisture: 35.6%
Register 02 (EC)	0X03 0X20 $\rightarrow$ Soil EC: 800 $\mu\text{S/cm}$
Register 03 (Salt)	0x01 0x90 $\rightarrow$ Salt: 400
Register 04 (Nitrogen)	0x01 0x64 $\rightarrow$ N: 356 mg/kg
Register 05 (Phosphorus)	0x01 0x64 $\rightarrow$ P: 356 mg/kg
Register 06 (Potassium)	0x01 0x64 $\rightarrow$ K: 356 mg/kg
Register 07 (pH)	0x00 0x46 $\rightarrow$ pH: 7.0
CRC16	0XA7 0XB5

Data Representation

A. Soil Temperature: Convert returned data to decimal, then $\div 10$. For negative values, use two's complement: subtract the value from 0XFFFF, add 1, convert to decimal, $\div 10$, then reverse the sign.
B. Soil Moisture:

Convert data to decimal, then $\div 10$. C. Electrical Conductivity: Convert data to decimal directly. D. pH: Convert data to decimal, then $\div 10$.

2. Query Analog Range

Master $\rightarrow$ Slave:

Address	Function Code	Start Register (High)	Start Register (Low)	Register Length (High)	Register Length (Low)	CRC16 (Low)	CRC16 (High)
0X00	0X03	0x00	0xBF	0X00	0X04	0X74	0X3C

If the transmitter receives correctly, it returns (Slave $\rightarrow$ Master):

Address 0X01

Function Code 0X03

Data Length 0X04

Register 0 0XFE 0X70 $\rightarrow$ Min temperature: -40.0°C

Register 1 0X02 0X58 $\rightarrow$ Max temperature: 60.0°C

Register 2 0X00 0X00 $\rightarrow$ Min moisture: 0.0%

Register 3 0x03 0x8E $\rightarrow$ Max moisture: 100.0%

CRC16 0XE6 0X4C

7.3 Analog Conversion

S: Soil temperature ($^{\circ}\text{C}$) A: Current value collected by the collector (mA)

$$S = (A - 4) \div 16 \times (\text{Range Max} - \text{Range Min}) + \text{Range Min}$$

Example: Range $-20^{\circ}\text{C} \sim 80^{\circ}\text{C}$, $A = 12\text{mA}$

$$S = (12 - 4) \div 16 \times (80 - (-20)) + (-20)$$

$$S = 8 \div 16 \times 100 - 20$$

$$S = 0.5 \times 100 - 20$$

$$S = 30^{\circ}\text{C}$$

8. Usage Precautions

- Please read this manual completely before use.
- Do not insert the probe into stones or hard clods to avoid probe damage.
- Do not pull the cable directly when removing the sensor from soil.
- Insert the sensor probe fully into soil / medium to reduce errors and improve accuracy.

9. Product Warranty

This product has a **1-year warranty**. From the date of delivery, failures caused by sensor quality problems (non-human damage) within 12 months will be repaired or replaced free of charge. After the warranty period, only cost price will be charged.