Soil Moisture Sensor

Featuring LoRaWAN®

EM500-SMT

User Guide

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Safety Precautions

Milesight will not shoulder responsibility for any loss or damage resulting from not following the instructions of this operating guide.

- The device must not be disassembled or remodeled in any way.
- In order to protect the security of the device, please change device password when first configuration. The default password is 123456.
- The device is not intended to be used as a reference sensor, and Milesight will not should responsibility for any damage which may result from inaccurate readings.
- Do not place the device close to objects with naked flames.
- Do not place the device where the temperature is below/above the operating range.
- Make sure electronic components do not drop out of the enclosure while opening.
- When installing the battery, please install it accurately, and do not install the reverse or wrong model.
- The device must never be subjected to shocks or impacts.

Declaration of Conformity

EM500 series is in conformity with the essential requirements and other relevant provisions of the CE, FCC, and RoHS.

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Revision History

Date	Doc Version	Description
Nov. 23, 2020	V 1.0	Initial version
Dec. 7, 2021	V 1.1	Content update
Apr. 11, 2022	V 2.0	Update based on hardware v2.x: 1. Supports soil type selection; 2. Support RX2 datarate and frequency settings
May 31, 2023	V 2.1	1. Add data storage, data transmission and data retrievability feature; 2. Add single-channel mode; 3. Add frequency AS923-2&3&4; 4. Add downlink commands: reboot, time settings; 5. Add sensor installation guide.

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1. Product Introduction

1.1 Overview

EM500-SMT is designed for measuring soil moisture in harsh environments and transmitting data using LoRaWAN® technology. With this low power consumption technology, EM500-SMT can work up to 10 years with 19000 mAh battery. Combining with Milesight LoRaWAN® gateway and Milesight IoT Cloud solution, users can manage all sensor data remotely and visually.

EM500-SMT is widely used for outdoor applications like smart agriculture, smart horticulture, etc.

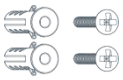
1.2 Features

- High precision for multiple kinds of soil
- Ultra-wide-distance transmission up to line of sight of 10km
- IP67 waterproof enclosure for harsh environment applications
- Built-in 19000 mAh replaceable battery and work for 10 years without replacement
- Equipped with NFC for easy configuration
- Compliant with standard LoRaWAN® gateways and network servers
- Quick and easy management with Milesight IoT Cloud solution

2. Hardware Introduction

2.1 Packing List

1 × EM500 Device (Include Mounting Bracket)

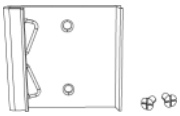


2 × Wall Mounting Kits

2 × Fixing Screws

4 × Rubber Screw Caps

1 × Hose Clamp



1 × DIN Rail Kit (Optional)

1 × Warranty Card

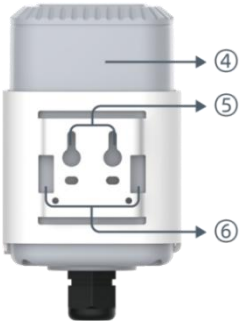
1 × Quick Guide

If any of the above items is missing or damaged, please contact your sales representative.

2.2 Hardware Overview

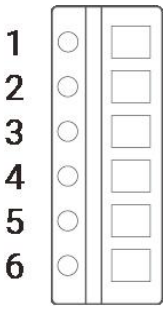
EM500 series sensors is made up of a LoRaWAN® transceiver and a sensor. Among them, ultrasonic sensors and gas sensors are combined with LoRaWAN® transceiver.

Front View of EM500:
①LoRaWAN® Antenna (Internal)
②NFC Area
③Water-proof Connector



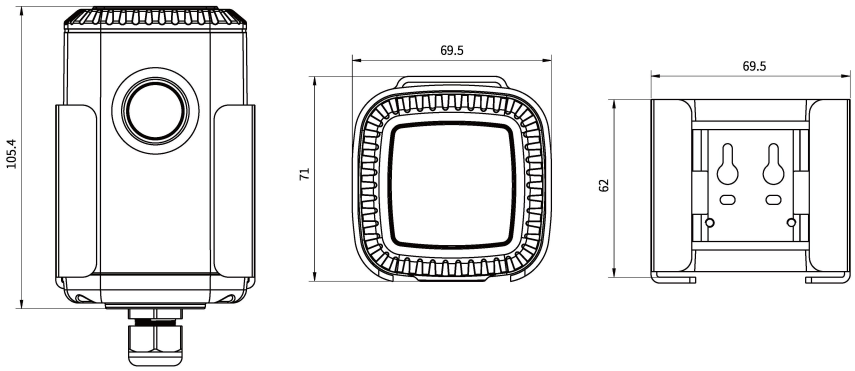
Back View:
④Battery (Internal)
⑤Wall Mounting Holes
⑥Pole Mounting Holes

Sensor Terminal Block:



PIN	Description
1	Black/GND
2	Yellow/AIN
3	---
4	---
5	---
6	Brown/VOUT=2.5V

2.3 Dimensions(mm)



2.4 Power Button

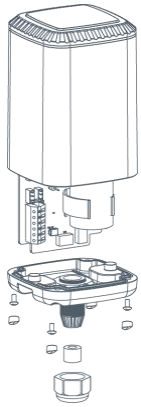
Note: The LED indicator and power button are inside the device. Switch on/off and reset can also be configured via NFC.

Function	Action	LED Indication
Turn On	Press and hold the button for more than 3 seconds.	Off → On
Turn Off	Press and hold the button for more than 3 seconds.	On → Off
Reset	Press and hold the button for more than 10 seconds.	Blink 3 times.
Check On/Off Status	Quickly press the power button.	Light On: Device is on.
		Light Off: Device is off.

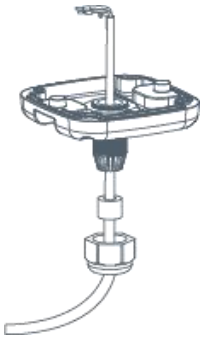
3. Sensor Assembly

It is necessary to connect sensor to the EM500 transceiver to make the whole device work.

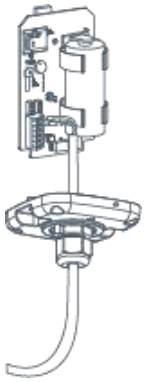
1. Take off the mounting bracket on the transceiver, remove the screws and then bottom cover with the waterproof connector.



2. Pass all sensor wires through the waterproof connector and leave sufficient length for connecting to the EM500 transceiver, then tighten the waterproof connector to the bottom cover.

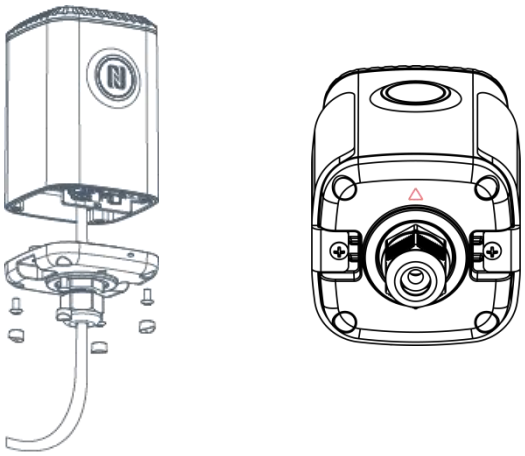


3. Screw the sensor wires to the terminal block of the EM500 transceiver tightly referring to the label. After wiring, gently pull the wires to ensure they are securely fastened to the transceiver.



4. Put the motherboard back and restore everything to its due position. When restoring the cover, ensure the arrow faces the front of the transceiver.

Note: Rubber seal and rubber screw caps should be installed accordingly, or the water will come into the device.



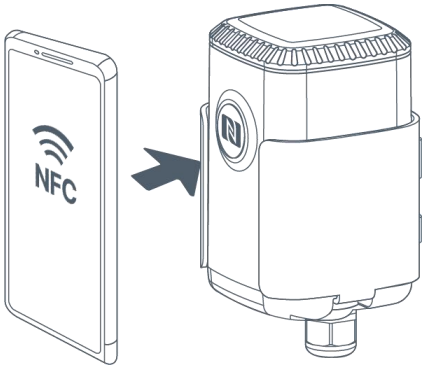
4. Operation Guide

4.1 Log in the ToolBox

EM500 series can be monitored and configured via ToolBox App or ToolBox software.

4.1.1 NFC Configuration

1. Download and install **Milesight ToolBox** App from Google Play or Apple App Store.
2. Enable NFC on the smartphone and launch Milesight ToolBox.
3. Attach the smartphone with NFC area, click **NFC Read** button to read device information. You can read and configure the device by tapping the Read/Write device on the App. In order to protect the security of the device, please change password when first configuration. The default password is **123456**.



Note:

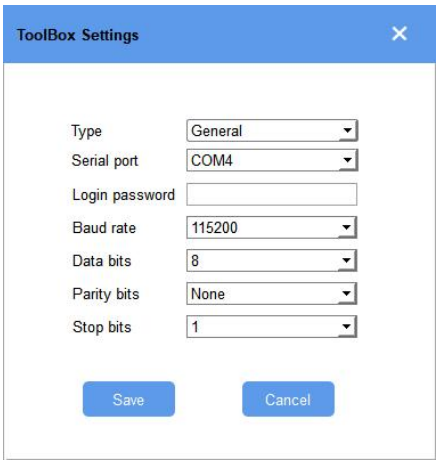
1) Ensure the location of smartphone NFC area and it's recommended to take off phone case.

2) If the smartphone fails to read/write configurations via NFC, keep the phone away and back to try again.

4.1.2 USB Configuration

1. Download ToolBox software from Milesight official website.
2. Release the enclosure of the EM500 transceiver, then connect the device to a computer via Type-C port.

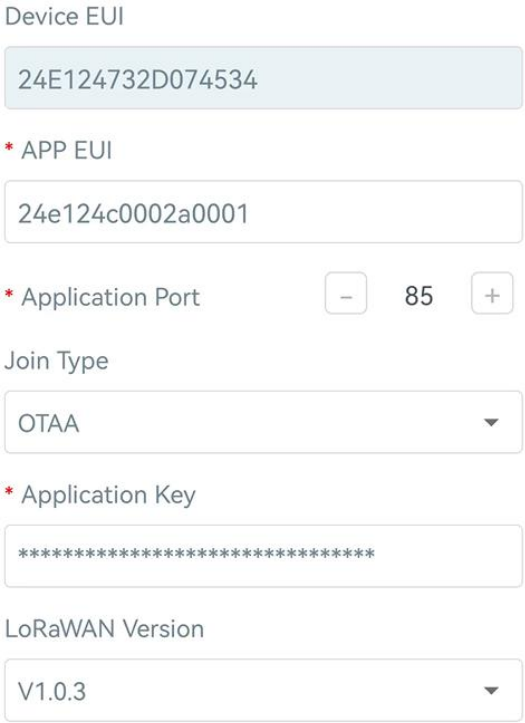
3. Open the ToolBox and select type as **General**, then click password to log in ToolBox. (Default password: **123456**)



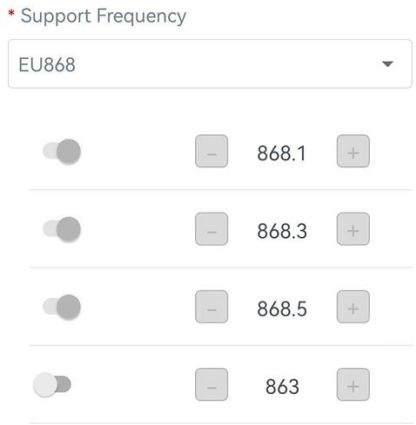
4. After logging in the ToolBox, you can turn on/off devices and change other settings.

4.2 LoRaWAN Settings

LoRaWAN settings is used for configuring the transmission parameters in LoRaWAN® network.



Parameters	Description
Device EUI	Unique ID of the device which can also be found on the label.
App EUI	Default App EUI is 24E124C0002A0001.
Application Port	The port used for sending and receiving data, default port is 85.
Join Type	OTAA and ABP mode are available.

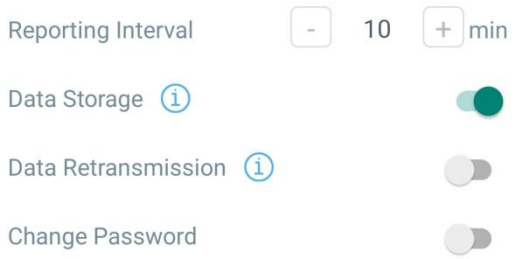
LoRaWAN Version	V1.0.2 and V1.0.3 are available.
Work Mode	It's fixed as Class A.
Application Key	Appkey for OTAA mode, default is 5572404C696E6B4C6F52613230313823.
Device Address	DevAddr for ABP mode, default is the 5th to 12th digits of SN.
Network Session Key	Nwkskey for ABP mode, default is 5572404C696E6B4C6F52613230313823.
Application Session Key	Appskey for ABP mode, default is 5572404C696E6B4C6F52613230313823.
RX2 Data Rate	RX2 data rate to receive downlinks.
RX2 Frequency	RX2 frequency to receive downlinks. Unit: Hz
Channel Mode	Select Standard-Channel mode or Single-Channel mode. When Single-Channel mode is enabled, only one channel can be selected to send uplinks. Please enable Single-Channel mode if you connect device to DS7610.
Channel	Enable or disable the frequency to send uplinks.  If frequency is one of CN470/AU915/US915, enter the index of the channel that you want to enable and make them separated by commas. **Examples:** 1, 40: Enabling Channel 1and Channel 40 1-40: Enabling Channel 1 to Channel 40 1-40, 60: Enabling Channel 1 to Channel 40 and Channel 60 All: Enabling all channels Null: Indicates that all channels are disabled

Spread Factor	If ADR is disabled, the device will send data via this spread factor.
Confirmed Mode	If the device does not receive ACK packet from network server, it will resend data once.
Rejoin Mode	Reporting interval ≤ 35 mins: the device will send a specific number of LinkCheckReq MAC packets to the network server every reporting interval or 2*reporting interval to validate connectivity; If there is no response, the device will re-join the network. Reporting interval > 35 mins: the device will send a specific number of LinkCheckReq MAC packets to the network server every reporting interval to validate connectivity; If there is no response, the device will re-join the network.
Set the number of packets sent	When rejoin mode is enabled, set the number of LinkCheckReq packets sent. Note: the actual sending number is **Set the number of packets sent** + 1.
ADR Mode	Allow network server to adjust datarate of the device.
Tx Power	Transmit power of device.

Note:

1) Please contact sales for device EUI list if there are many units.
2) Please contact sales if you need random App keys before purchase.
3) Select OTAA mode if you use Milesight IoT cloud to manage devices.
4) Only OTAA mode supports rejoin mode.

4.3 Basic Settings

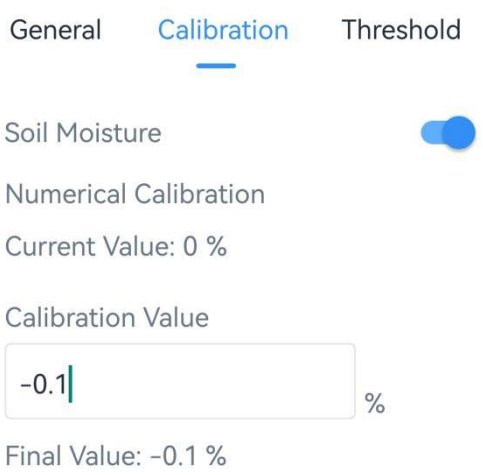


Parameters	Description
Reporting Interval	Reporting interval of transmitting data to network server. Default: 10 mins, Range: 1-1080 mins.
Data Storage	Disable or enable data storage locally.
Data Retransmission	Disable or enable data retransmission.
Change Password	Change the password for ToolBox App to write this device or ToolBox software to log in this device.

4.4 Advanced Settings

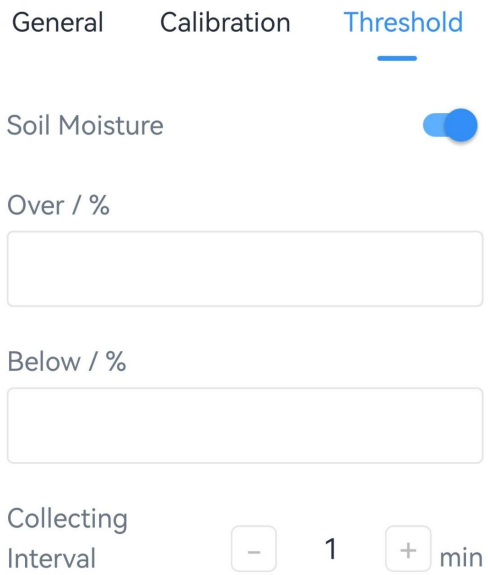
4.4.1 Calibration Settings

Type the calibration value and save, the device will add the calibration value to raw value, then display and report the final value.



4.4.2 Threshold Settings

The device will upload the threshold alarm packet when the collected value is over or below the threshold. Only when the alarm is dismissed and re-triggered, the device will send the alarm again.

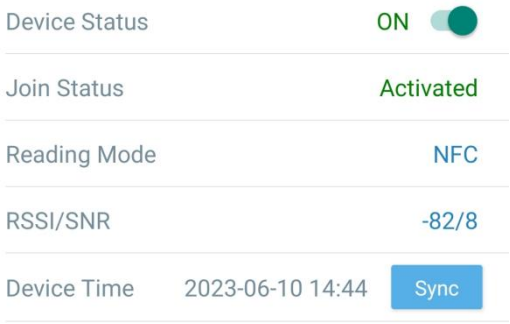


Parameters	Description
Collect Interval	The interval to collect sensor data after threshold alarm triggers. This interval should be less than reporting interval.

4.4.3 Data Storage

The device supports storing 1000 data records locally and exports data via ToolBox. The device will record the data according to reporting interval even not joining network.

1. Go to **Status** of ToolBox software or **Device > Status** of ToolBox App to sync the device time;

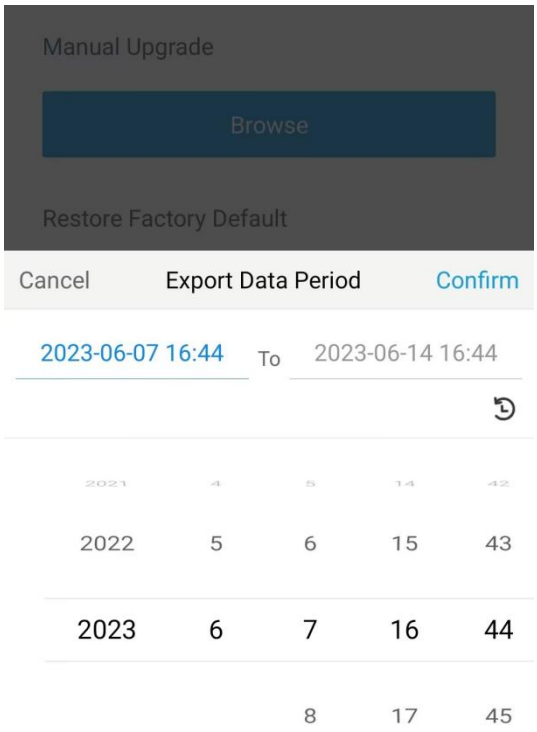


Besides, when device LoRaWAN® version is set as 1.0.3, the device will send MAC commands to ask the network server for the time every time it joins the network.

2. Enable data storage feature.

3. Go to **Maintenance > Backup and Reset** of ToolBox software or **Device > Maintenance** of ToolBox App, click **Export**, then select the data time range and click **Save** to export data.

Note: ToolBox App can only export 14 days' data at most. If you need to export more data, please use ToolBox software.



4. Click **Data Cleaning** to clear all stored data inside the device if necessary.

4.4.4 Data Retransmission

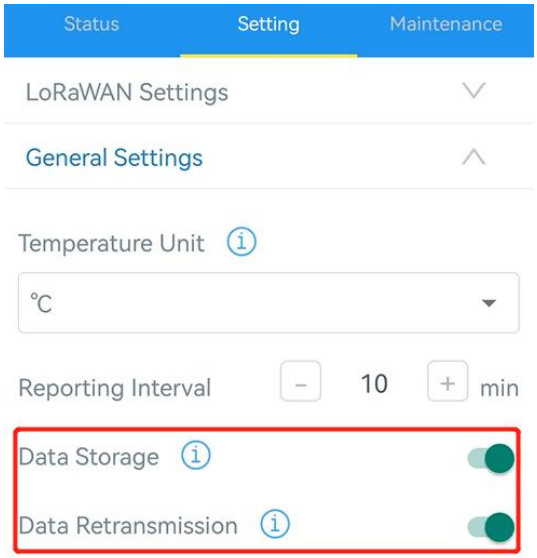
The device supports data retransmission to ensure network server can get all data even if network is down for some times. There are two ways to get the lost data:

- Network server sends downlink commands to enquire the historical data for specifying time range;
- When network is down if no response from LinkCheckReq MAC packets for a period of time, the device will record the network disconnected time and re-transmit the lost data after

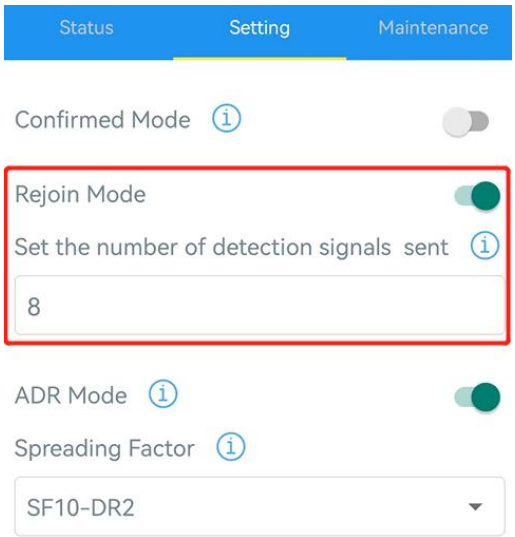
device re-connects the network.

Here are the steps for data retransmission:

1. Enable data storage feature and data retransmission feature;



2. Enable rejoin mode feature and set the number of packets sent. Take below as example, the device will send LinkCheckReq MAC packets to the network server regularly to check if the network is disconnected; if there is no response for 8+1 times, the join status will change to de-active and the device will record a data lost time point(the time to join the network).



3. After the network connected back, the device will send the lost data from the point in time when the data was lost according to the reporting interval.

Note:

1) If the device is rebooted or re-powered when data retransmission is not completed, the device will re-send all retransmission data again after device is reconnected to the network;

2) If the network is disconnected again during data retransmission, it will only send the latest disconnection data;

3) The default report data retransmission interval is 600s, this can be changed via downlink command.

4) The reported format of retransmission data will include timestamps and is different from periodic report data.

5) Data retransmission will increase the uplinks and shorten the battery life.

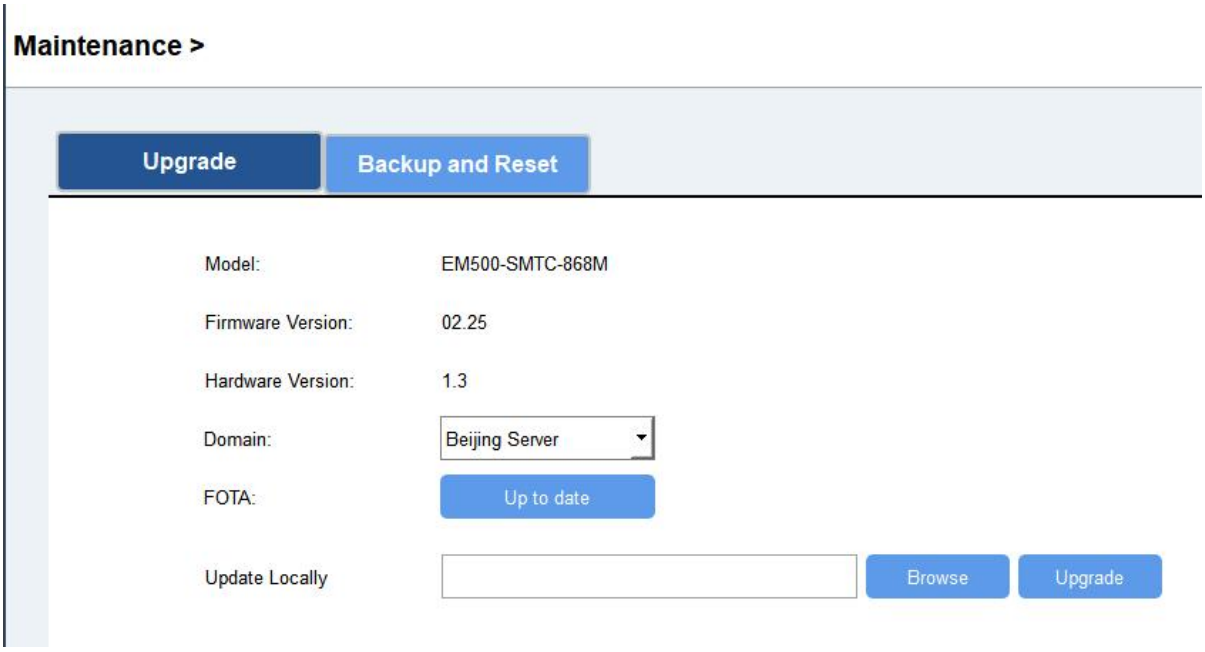
4.5 Maintenance

4.5.1 Upgrade

ToolBox Software:

1. Download firmware from Milesight official website to your PC.

2. Go to **Maintenance > Upgrade**, click **Browse** to import firmware and upgrade the device.



ToolBox App:

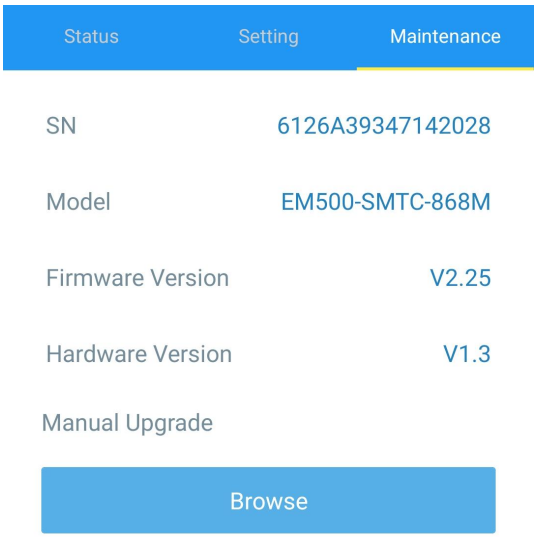
1. Download firmware from Milesight official website to your smartphone.

2. Open ToolBox App and click **Browse** to import firmware and upgrade the device.

Note:

1) Operation on ToolBox is not supported during the upgrade.

2) Only Android version ToolBox supports the upgrade feature.

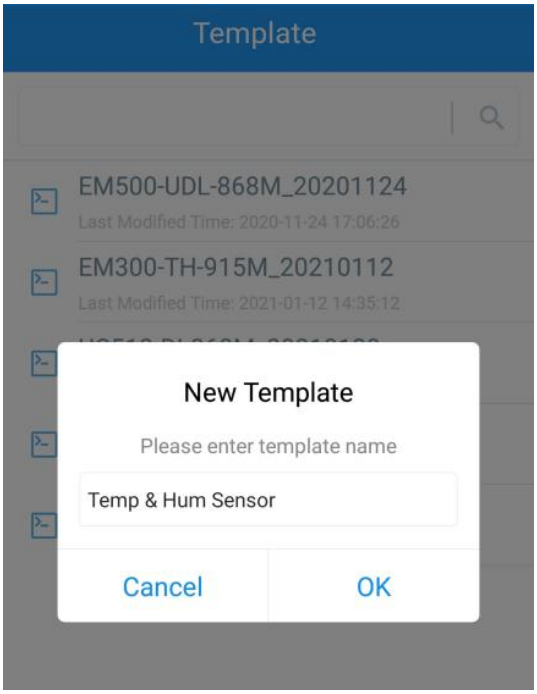


4.5.2 Backup

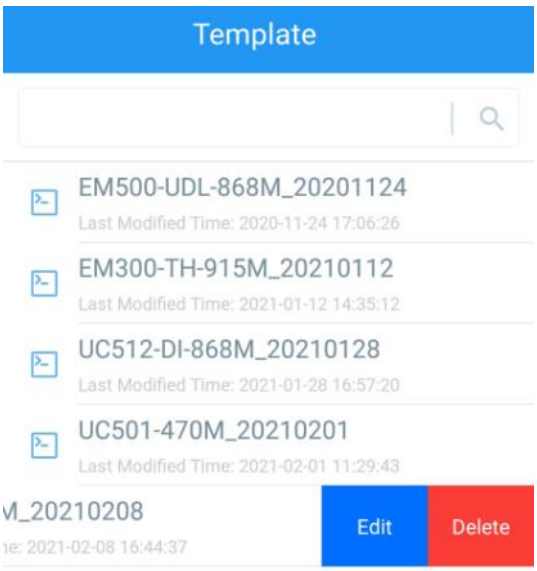
EM500 devices support configuration backup for easy and quick device configuration in bulk. Backup is allowed only for devices with the same model and LoRaWAN® frequency band.

1. Go to **Template** page on the App and save current settings as a template. You can also edit the template file.

2. Select one template file which saved in the smartphone and click **Write**, then attach to another device to write configuration.



Note: Slide the template item left to edit or delete the template. Click the template to edit the configurations.

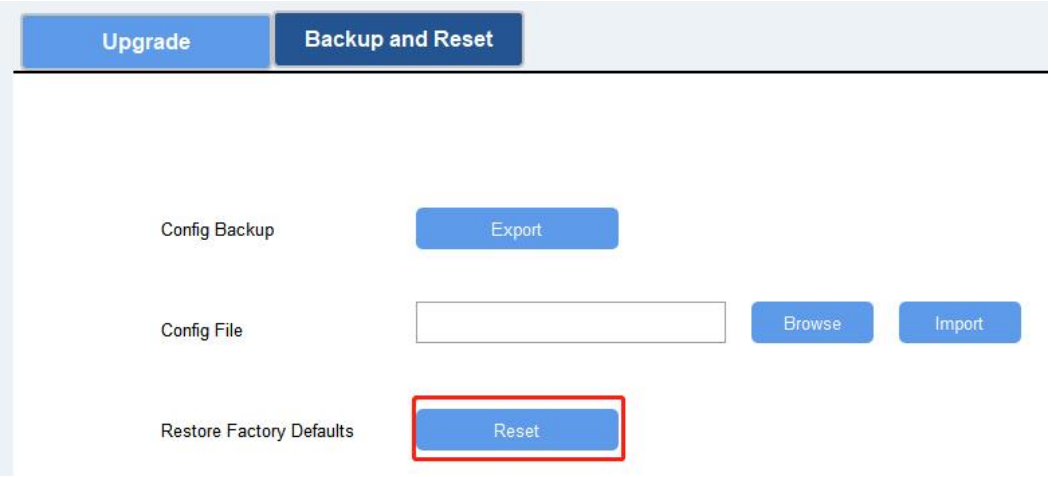


4.5.3 Reset to Factory Default

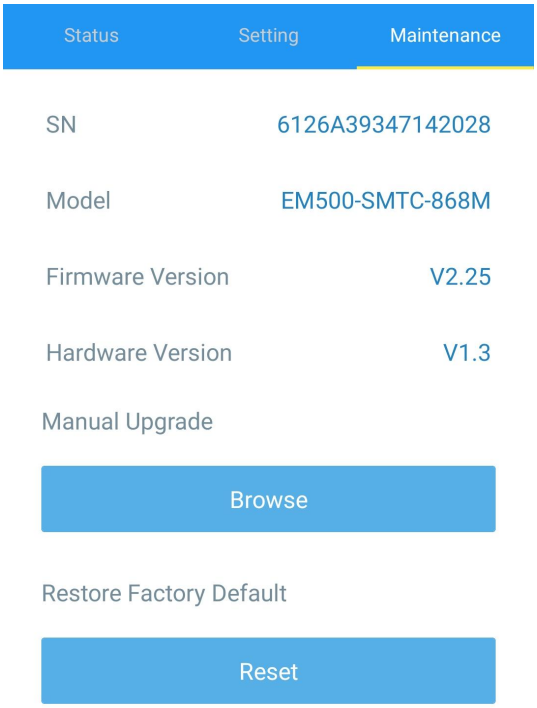
Please select one of following methods to reset device:

Via Hardware: Hold on power button (internal) for more than 10s.

Via ToolBox Software: Go to **Maintenance > Backup and Reset** to click **Reset**.



Via ToolBox App: Go to **Device > Maintenance** to click **Reset**, then attach smart phone with NFC area to device to complete reset.



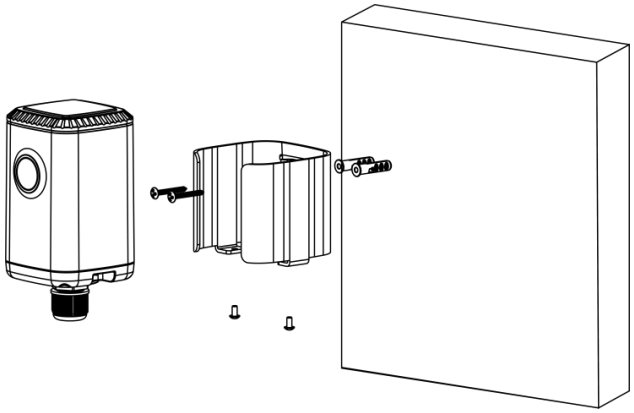
5. Installation

5.1 EM500 Transceiver Installation

EM500 transceiver support wall, pole and DIN rail mounting. Before installation, ensure the mounting bracket has fixed to the device via screws.

Wall Mounting:

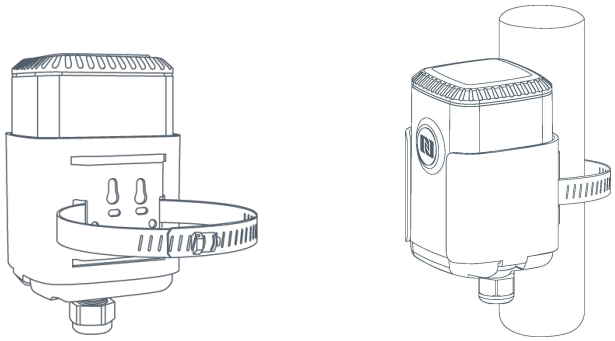
1. Drill 2 holes on the wall according to the mounting bracket, then fix the wall plugs into the wall.
2. Fix the mounting bracket to the wall via screws.
3. Put the device onto the mounting bracket, then fix the device to the bracket with 2 fixing screws.



Pole Mounting:

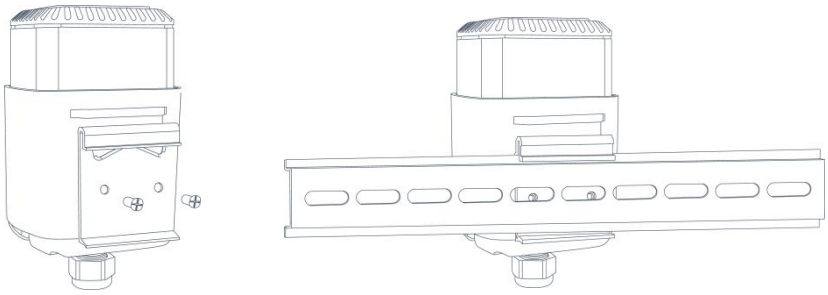
Straighten out the hose clamp and slide it through the rectangular holes in the mounting bracket, wrap the hose clamp around the pole. After that use a screwdriver to tighten the locking

mechanism by turning it clockwise.



DIN Rail Mounting:

Use 2 pcs of M3 × 6 flat head Phillips screws to fix the mount clip to the bracket, and then hang the device to the DIN rail. The width of DIN rail is 3.5 cm.



5.2 Soil Sensor Installation

The soil sensor should be considered following notes to insure proper installation:

- Abnormal data may show up if sensor prongs are exposed in the air.
- It is suggested to put the prongs totally to the soil to ensure accurate measurement.
- It is possible to get sticks, bark, roots or other material stuck between the sensor prongs, which will severely affect the sensor data readings. Any air gaps or excessive soil compaction around the sensor can also influence the readings.
- Do not install the sensor adjacent to large metal objects.
- Be careful when inserting the sensor into dense soil, as the prongs will break if excessive sideways force is used.
- When installing the sensor in a lightning prone area, please check your lightning protection.
- When removing the sensor from the soil, do not pull it out of the soil by the cable. Doing so may break internal connections and make the sensor unusable.

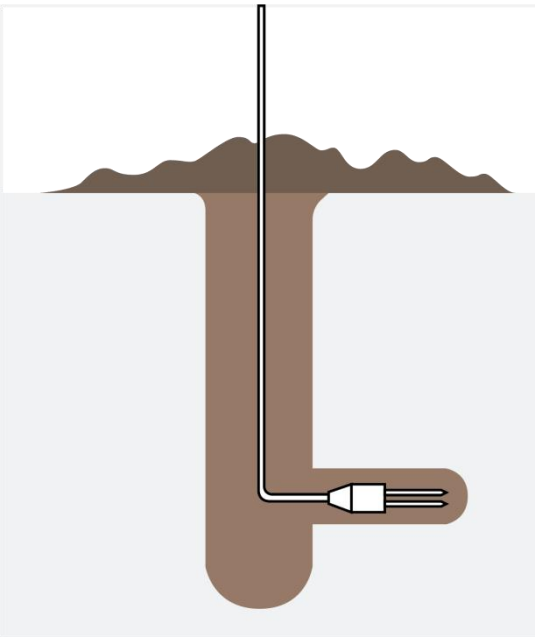
5.2.1 Horizontal Installation

1. Excavate a hole or trench a few centimeters deeper than the depth at which the sensor is to be installed.
2. At the installation depth, shave off some soil from the vertical soil surface exposing undisturbed soil.

3. Insert the sensor into the undisturbed soil surface until the entire sensor is inserted. The tip of each prong has been sharpened to make it easier to push the sensor into the soil. Be careful with the sharp tips!

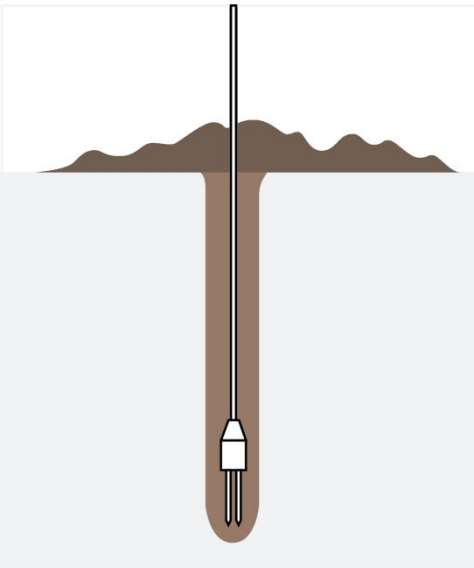
Note: If there is difficulty inserting the sensor, loosen or wet the soil.

4. Backfill the trench taking care to pack the soil back to natural bulk density around the sensor body.



5.2.2 Vertical Installation

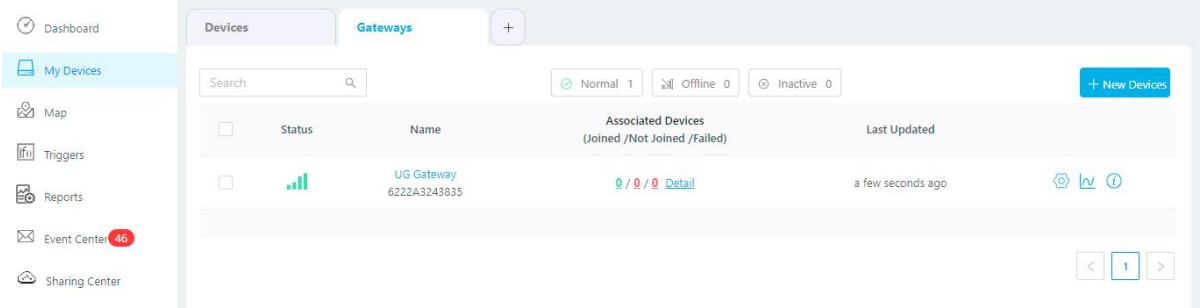
1. Drill a hole to the depth at which the sensor is to be installed.
2. Insert the sensor into the undisturbed soil at the bottom of the drilled hole using a hand or any other implement that will guide the sensor into the soil at the bottom of the hole.
3. After inserting the sensor, backfill the hole, and take care to pack the soil back to natural bulk density while not damaging the over molding of the sensor and the sensor cable in the process.



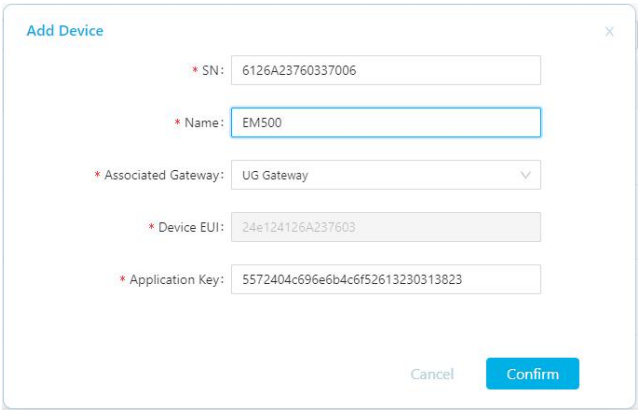
6. Milesight IoT Cloud Management

The device can be managed by Milesight IoT Cloud platform. Milesight IoT cloud is a comprehensive platform that provides multiple services including device remote management and data visualization with the easiest operation procedures. Please register a Milesight IoT Cloud account before operating following steps.

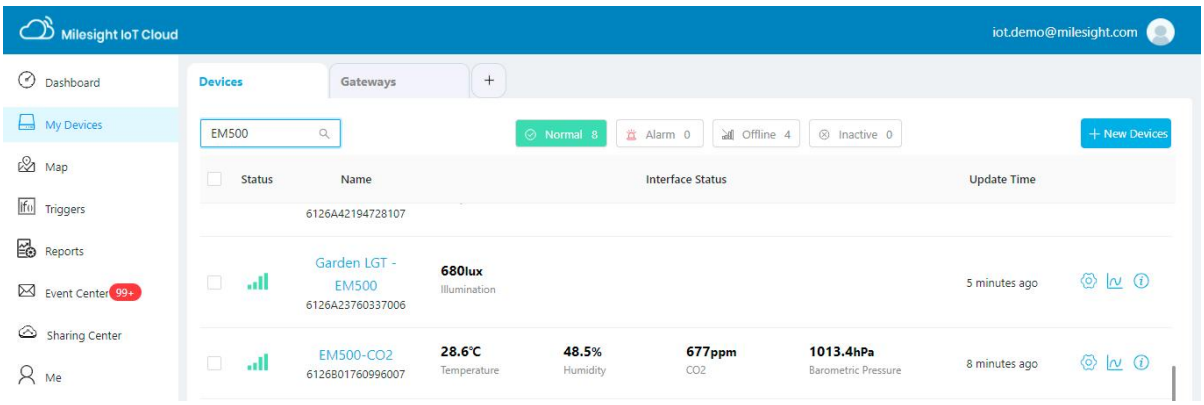
1. Ensure Milesight LoRaWAN® gateway is online in Milesight IoT Cloud. For more info about connecting gateway to cloud please refer to gateway's user guide.



2. Go to "My Devices" page and click "+New Devices". Fill in the SN of device and select an associated gateway.



3. After the device is online in Milesight IoT Cloud, you can check the data via webpage or mobile App and create dashboard for it.



7. Communication Protocol

All data are based on following format (HEX), the Data field should follow little-endian:

Channel1	Type1	Data1	Channel2	Type2	Data2	Channel 3	...
1 Byte	1 Byte	N Bytes	1 Byte	1 Byte	M Bytes	1 Byte	...

For decoder examples please find files on https://github.com/Milesight-IoT/SensorDecoders.

7.1 Basic Information

The device reports basic information of sensor whenever joining the network.

Item	Channel	Type	Description
Power On	ff	0b	ff, this means the device is on
Protocol Version		01	01=>V1
Hardware Version		09	01 40 => V1.4
Software Version		0a	01 14 => V1.14
Device Type		0f	00: Class A, 01: Class B, 02: Class C
Device SN		16	16 digits

Example:

ff0bff ff0101 ff166136c40091605408 ff090300 ff0a0101 ff0f00					
Channel	**Type**	**Value**	**Channel**	**Type**	**Value**
ff	0b (Power On)	ff	ff	01 (Protocol Version)	01 (V1)
Channel	**Type**	**Value**	**Channel**	**Type**	**Value**
ff	16 (Device SN)	6136c40091605408	ff	09 (Hardware Version)	0300 (V3.0)
Channel	**Type**	**Value**	**Channel**	**Type**	**Value**
ff	0a (Software Version)	0101 (V1.1)	ff	0f (Device Type)	00 (Class A)

7.2 Sensor Data

Item	Channel	Type	Description
Battery Level	01	75	UINT8, Unit: %
Soil Moisture	04	68	UINT8/2, Unit: % **Note:** This will works with the device hardware version is 1.x and the firmware version is below 2.34.

Soil Moisture	04	ca	UINT16/100, Unit: %

Examples:

1. Periodic packet or alarm packet.

04cad804		
Channel	**Type**	**Value**
04	ca (Soil Moisture)	d8 04=>04 d8=1240/100=12.4%

2. Battery level periodic packet: reports when the device joins the network or every 24 hours.

017564		
Channel	**Type**	**Value**
01	75	64 => 100%

3. Low battery level alarm packet: reports when battery level is below to 1%.

017501		
Channel	**Type**	**Value**
01	75	Battery level: 01 => 1%

7.3 Downlink Commands

The device supports downlink commands to configure the device. The application port is 85 by default.

Item	Channel	Type	Description
Collecting Interval	ff	02	2 Bytes, unit: s
Reporting Interval		03	2 Bytes, unit: s
Re-collect Setting		1c	Byte 1: re-collect times Byte 2-3: re-collect interval
Reboot		10	ff
UTC Time Zone		17	INT16/10
Device		11	Unix timestamp, Unit: s
Data Storage		68	00: disable, 01: enable
Data Retransmission		69	00: disable, 01: enable
Data Retransmission Interval		6a	Byte 1: 00 Byte 2-3: interval time, unit:s, range: 30~1200s (600s by default)
Calibration		f1	Byte 1: 01 Byte 2: 00=disable, 01=enable Byte 3-4: calibration value, INT16/100,

			Unit: %

Examples:

1. Set Reporting Interval as 20 mins

ff 03 b0 04		
Channel	**Type**	**Data**
ff	03(Reporting Interval)	b0 04 => 04 b0 = 1200s=20 mins

2. Reboot the device.

ff10ff		
Channel	**Type**	**Value**
ff	10 (Reboot)	ff

3. Set the time zone as UTC-2.

ff17ecff		
Channel	**Type**	**Value**
ff	17	ec ff => ff ec = -20/10=-2 the time zone is UTC-2

4. Enable calibration and set the calibration value.

ff1f0101fdff		
Channel	**Type**	**Value**
ff	f1	01=Enable Fdff=>fffd=-3/100=-0.03%

7.4 Historical Data Enquiry

The device supports sending downlink commands to enquire historical data for specified time point or time range. Before that, ensure the device time is correct and data storage feature was enabled to store the data.

Command format:

Channel	Type	Description
fd	6b (Enquire data in time point)	4 Bytes, unix timestamp
fd	6c (Enquire data in time range)	Start time (4 bytes) + End time (4 bytes), Unix timestamp
fd	6d (Stop query data report)	ff
ff	6a (Report Interval)	3 Bytes Byte 1: 01

		Byte 2-3: interval time, unit:s range: 30~1200s (60s by default)

Reply format:

Channel	Type	Description
fc	6b/6c	00: data enquiry success 01: time point or time range invalid 02: no data in this time or time range
20	ce (Historical Data)	Data time stamp (4 B) + Moisture (2B)

Note:

1. The device only uploads no more than 300 data records per range enquiry.
2. When enquiring the data in time point, it will upload the data which is closest to the search point within the reporting interval range. For example, if the device reporting interval is 10 minutes and users send command to search for 17:00's data, if the device find there is data stored in 17:00, it will upload this data; if not, it will search for data between 16:50 to 17:10 and upload the data which is closest to 17:00.

Example:

1. Enquire historical data between 2023/03/09 17:00:00 to 2023/03/09 17:10:40.

fd6c 2cc26164 84c46164		
Channel	**Type**	**Value**
fd	6c (Enquire data in time range)	Start time: 2cc26164 => 6461c22c = 1684128300 =2023/05/15 13:25:00 End time: 84c46164 => 6461c484 = 1684128900 =2023/05/15 13:35:00

Reply:

fc6c00		
Channel	**Type**	**Value**
fc	6c (Enquire data in time range)	00: data enquiry success

20ce b1c36164 d804			
Channel	**Type**	**Time Stamp**	**Value**
20	ce (Historical Data)	b1c36164 => 6461c3b1=2023/05/15 13:31:00	d8 04=>04 d8=1240/100=12.4%

-END-