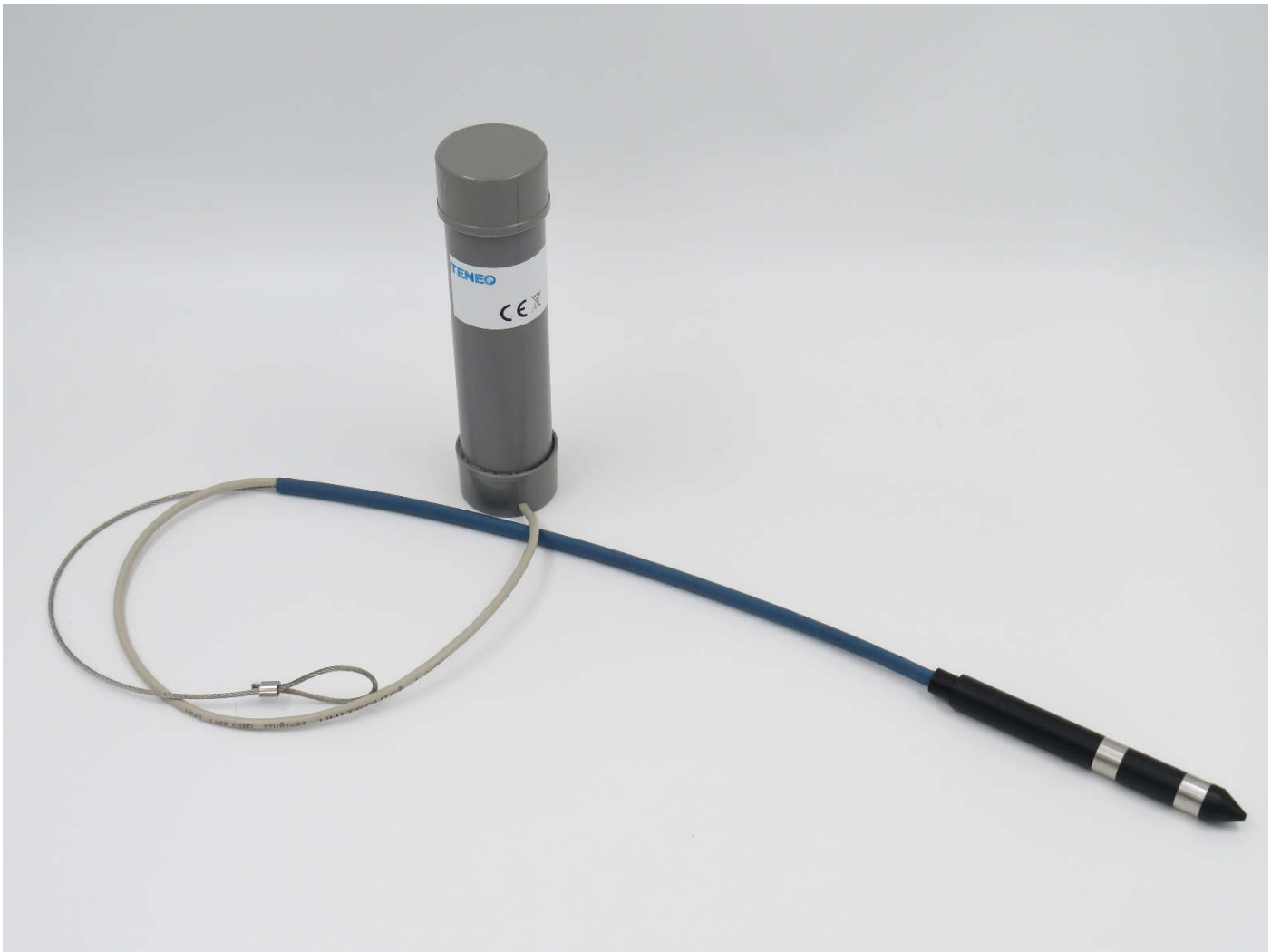
User Manual

LoRaWAN Soil Moisture Sensor



Version: 2.0

Version control

Version:	Date:	Description:	Author:
1.0	21 April 2020	Publication of the first version	I. Heideman
1.1	6 July 2020	Addition of technical specifications	I. Heideman
1.2	November 22, 2022	Updating	I. Heideman
2.0	November 11, 2024	Addition of new hardware variant and update/clarification.	I. Heideman

support@teneo-iot.nl
+31 (0)543 535 535

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Register

Term:	Definition:
LoRaWAN	Abbreviation for: Long Range Wide Area Network. A Low Power, Wide Area (LPWA) network protocol specifically designed to wirelessly connect battery-powered 'things' to the internet in regional, national or global networks. (For more information, see: www.lora-alliance-org/about-lorawan).
Node	A node is a device equipped with a radio module. This radio module uses LoRaWAN modulation, which gives the device the ability to communicate via the LoRaWAN network (i.e. sending messages and receiving messages)
Gateway	A device that takes care of the translation and therefore the connection of two incompatible networks to each other. In this case, the gateway provides the connection between the LoRaWAN network in question and the internet.
Backend	A backend is a program or part of a program that is invisible to the user. It can be addressed via a command-line interface. The interaction with users does not take place directly with the backend but via the graphical user interface or frontend of the program.
OTAA	Abbreviation for Over the Air Activation. With OTAA, a join procedure is used to activate a node on a network.
Uplink	A LoRaWAN message sent by the node ("sensor") to the gateway ("receiver"/"user").
Downlink	A LoRaWAN message sent from the gateway ("receiver"/"user") to the node ("sensor").
Hexadecimal	Sixteen digit system with digits 0 to F, is indicated by 0x before the number. Example: 0xFF is a hexadecimal notation of the decimal number 255.

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1. Foreword

This document is intended as a user manual for the LoRaWAN Soil Moisture Sensor from Teneo Sales B.V. This document aims to provide a clear overview of how the LoRaWAN Soil Moisture Sensor can be installed, used and maintained.
In addition, any dangers and/or risks are pointed out in order to inform the user as well as possible about the LoRaWAN Soil Moisture Sensor.

Figure 1: Photo LoRaWAN Soil Moisture Sensor with measuring pins.

Figure 2: Photo LoRaWAN Soil Moisture Sensor with measuring probe.

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2. Introduction

2.1. Product description

The LoRaWAN Soil Moisture Sensor is intended to be used in the soil, to determine the moisture level of the soil. The sensor measures the moisture percentage in the soil by means of the measuring pins or the measuring probe (depending on which variant you use), after which the measured data is transmitted via LoRaWAN.

It depends on the type of soil which moisture percentage leads to certain actions; such as watering.

When choosing a suitable measuring principle, a trade-off was made between price and (absolute) accuracy, so the LoRaWAN Soil Moisture Sensor can only give an indication of the moisture percentage of the soil. No rights and/or guarantees can be derived from the values of the sensors in relation to the health of the soil, tree and/or plants.

Users of the sensors also remain responsible at all times for the actions they take on the basis of the measurements of the sensors.

In the photo below, a legend indicates the construction/components of the Soil Moisture Sensor with measuring pins.
On the following page a legend follows of the soil moisture sensor which is equipped with a measurement probe.

Legend:

1) Measuring pins;
2) Measuring end (incl. electronics);
3) Cable;
4) Housing (incl. electronics);
5) Top (end of antenna);
6) Bottom, wireless charging part;

Figure 3: Overview photo of the LoRaWAN Soil Moisture Sensor with measuring pins.

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Legend:

1) Measuring rings;
2) Measuring end (incl. electronics);
3) Cable;
4) Housing (incl. electronics);
5) Top (end of antenna);
6) Bottom, wireless charging part;
7) Stainless steel (pulling) eye;

Figure 4: Overview photo of the LoRaWAN Soil Moisture Sensor with measuring probe.

2.2. Product specifications

Category:	Part:	Specification:
Physical	Dimensions	L: 17 cm, Ø: 5 cm (housing)
	Material	PVC & PETG
	Weight	± 400 grams
	Weatherproofing	IP67
	Cable length measuring pins	± 90 centimeters
	Cable length measuring probe	± 125 centimeters
Operating Conditions	Temperature	- 20 ºC to 55 ºC
Soil Moisture Sensor	Measuring	Volumetric Water Content (VWC)
	Unit	Percentage (%)
	Measuring range	3% - 50%
LoRaWAN	Transmission power	14 dBm
	Class	A (baseline)
	Activation method	OTAA
	Frequency	EU 868 MHz (863 – 870 MHz)
	Encryption	AES128
Power Supply	Battery	LiFePO4, rechargeable
	Voltage	3.2V
	Battery life	5 years with measurement and uplink frequency 1x per 24 hours.
Wireless charging	Qi Wireless Charging	1.1.
	Frequency	100 – 300 kHz
	Temperature	0 ºC to 30 ºC
Temperature sensor	Unit	Celsius
	Accuracy	Type. ± 0.3 ºC

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3. Operation

3.1. Installation/Assembly

	Warning!
	In the event of extreme heat (temperature > 85 ºC), the node and the battery may be damaged. Therefore, do not use gas burner(s) near (< 1.5 meters) of the node.

Before installing/mounting the sensors, it is advisable to check whether the sensors at the relevant location have LoRaWAN coverage via the relevant LoRaWAN network.
In addition, it is recommended to also test the connection with the backend to be used with at least one sensor.

The sensor is supplied with a protection around the test probes, as displayed in image 5 below.

Figure 5: Soil Moisture Sensor with protection around measuring end.

Leave this protection on for as long as possible and only remove it when you place the test pins in the ground.

When installing/placing the sensor, it is possible to bury the sensor a bit (± 5 centimeters) below ground level, so that it cannot be seen from the top of the ground.
This can come in handy in public spaces, where it is desirable that the sensors are as inconspicuous as possible. However, burying in the ground does affect the signal strength of the sensors.

In addition, it is important for good measurements that the measuring end/measuring pins are well pressed with sand/surrounding soil after placing them in the ground. If this is not done in this way, an air bubble may form around the test probes, causing the measurements not to be carried out properly and incorrect measurement data to be obtained.

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The Soil Moisture Sensor with the measuring pins must be placed in the soil by hand.
For the speed of (re)installing the Soil Moisture Sensor, Teneo launched a new design in early 2024 (with the measurement probe) which can be placed in the ground with an installation tool without having to dig to get deeper into the soil.

Please note: this tool is not included as standard with the new Soil Moisture Sensors, but must be ordered separately from Teneo in case user want to use this tool.
It is also still possible to place the Soil Moisture Sensors with the measuring probe in the same way as the Soil Moisture Sensors with the measuring pins (by digging by hand).

Below an explanation follows for how to use the installation tool for the Soil Moisture Sensors with measuring probe.

1) Preparation:

For placing the Soil Moisture Sensors with a new measuring probe (from April 2024 onwards), we have a special installation set (consisting of two tools) that are used to easily place the sensors in the ground.

This set consists of one long pin (with pointed tip) with which the hole will "pre-punctured", before we actually push the sensor into the ground. This pin has an SDS coupling, so this can easily be done with a combi-hammer.

This "pre-puncturing" tool is pointed out with number 1 in the image below.

The second tool is the hand tool with which we actually push the sensor into the ground after we have made the hole where we want to place the sensor, this tool is pointed out in the image below with number 2.

Figure 6: Soil Moisture Sensor installation tools.

Both placement tools are 1 meter long, which is more than adequate for most common clods and soil types.

In addition, a combi hammer is required for placement, this can be any possible combi hammer, but it is important that this combi hammer has a position for only knocking (so no turning).
We are going to use that mode when "pre-puncturing" (step 2).

2) "Pre-puncture" hole:

To pre-puncture the hole, we look for the place in the ground where we want to place the sensor.

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For this, we recommend that you first try pre-drilling with an SDS+ hammer drill of diameter 22 mm.

Then we put the tool with the pointed tip with SDS coupling in the combi hammer and knock the hole in the ground to the depth where we want to measure.

Figure 7: Example of pre-puncturing a hole for the Soil Moisture Sensor.

When the hole has been pre-punctured to the right depth, the tool with pointed tip can be removed from the ground again.

It is highly recommended to push the tool into the ground by hand immediately after removing it from the ground close to (± 10 – 20 cm) the hole made with the same slope/slope as with which the hole was pierced.

This prevents you from accidentally pressing the sensor in the wrong way when pressing the probe into the ground, which can damage the sensor (by encountering stones or other unwanted material).

3) Insert sensor:

For transport and to prevent the cables of different sensors from getting tangled in each other, the cable has a tie-wrap ("pull strap" around the cables.

Before placing it, you have to cut it loose, otherwise you cannot use the full cable length of the sensor.

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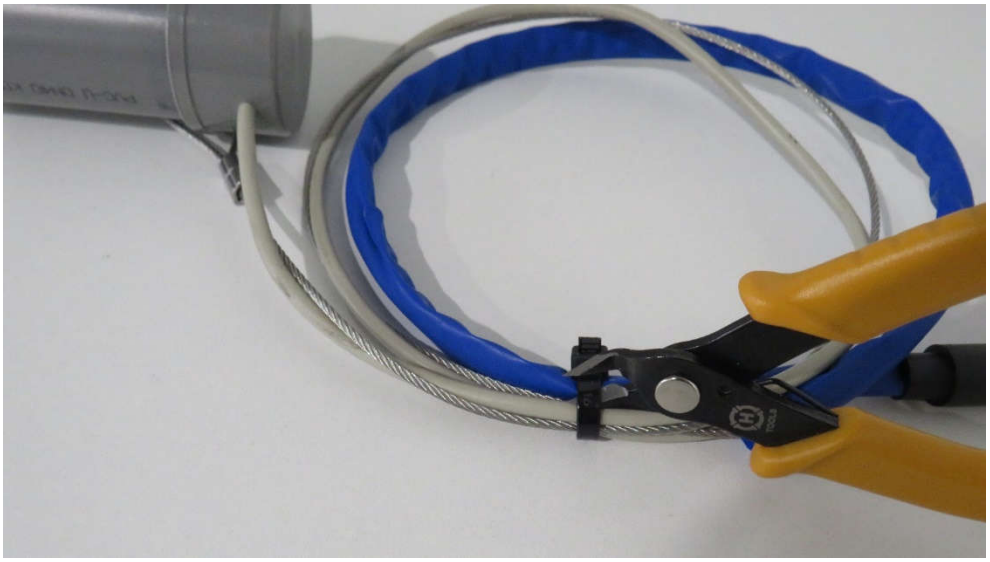

Figure 8: Example of cutting off the tie-wrap.

Use a pointed tip to cut it loose and be careful not to accidentally damage the sensor cable itself!

After this, you are ready to push the sensor into the ground by hand, for this you can use the hand tool (with the handgrip).

The hand tool has a recess where the sensor's probe fits exactly.

Figure 9: Example of a probe in a hand tool.

Pull the wire rope a little so that it runs in one straight parallel line with the rod of the hand tool.

Make sure that when pushing into the ground, the probe goes into the ground in one straight line with the rod of the hand tool, and follows the same slope

After this, you can push the sensor into the ground through the pre-punched hole with the hand tool.

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As mentioned earlier, it is important that the sensor goes into **the ground in one straight line with the pre-punched hole** and the hand tool (take into account the slope/inclination of the hole).

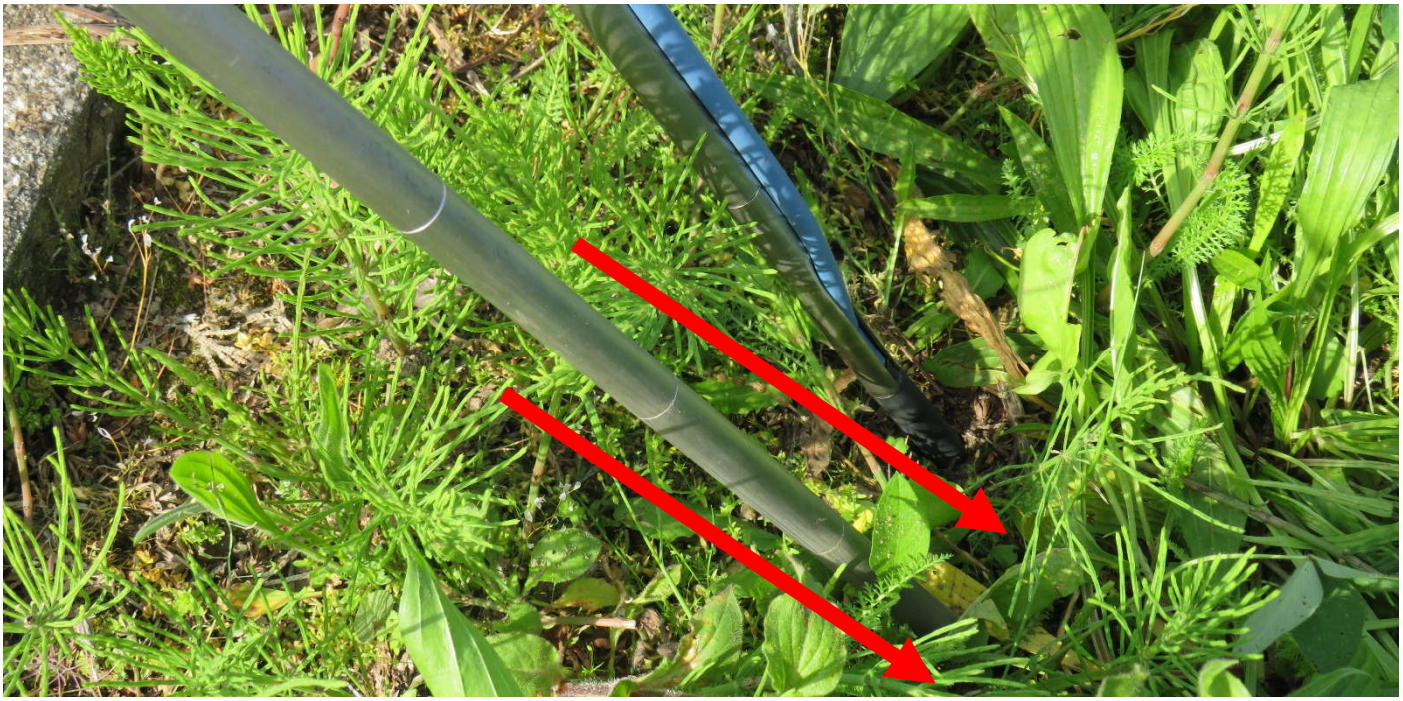

Figure 10: Insert the probe into the prepared hole.

When that is successful and the sensor is at the right depth, pull the hand tool out of the ground.

Then the measuring probe is well in the ground and you can possibly hide the housing of the sensor and the steel cable nicely (in the ground or on the watering edge/tree pole).

4) Bury sensor housing:

As a final step, you can choose (if you don't use a tree stake or something similar) to bury the sensor housing in the ground.

You can lay the housing horizontally in the ground, but this can also be done vertically.
When placing vertically in the ground, it is best for the wireless range of the sensor if the side where the cable comes out of the housing is at the bottom of the ground.
You can also see this if the sticker on the housing of the sensor points upwards.

3.2. Use

When the sensors are delivered, they are already switched on, so no actions need to be taken to turn on the node.

3.3. Error messages

The Soil Moisture Sensor is equipped with the functionality to indicate status messages. The node does this by sending a status message on Port 223; For more information, see also chapter 5.1 of this manual.

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3.4. Maintenance

3.4.1. Battery Charging

When a node's battery is low, the node repeatedly alerts the user by means of a LoRaWAN uplink message on Port 223; See also chapter 5.1.

To be able to charge the battery of a node, the nodes have a wireless charging option.

The node can be charged by means of wireless charging pads. It is recommended to purchase a suitable charging pad from Teneo IoT if desired.

To be able to charge the node, it must be placed with the bottom, which is near the measurement cable, in the middle on the charger.
To clarify, a photo of proper placement of the node on the charger has been added below.

Figure 11: Soil Moisture Sensor on a charging pad (GOOD).

Figure 12: Soil Moisture Sensor on a charging pad (GOOD).

For comparison, Figure 6 and Figure 7 show two more examples of incorrect node placement on the charger below.

In figure 13, the node is not properly centered on the charging pad and in figure 14, the wrong side of the Soil Moisture Sensor is placed on the charging pad.

Figure 13: Node faulty placed on a charger.

Figure 14: Node faulty placed on charging pad.

Many charging pads also have an LED that indicates the status (charging/not charging). In many cases, a (solid) red LED means that the node is not charging and a (flashing) green LED that the node is charging.

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In addition, the node also sends a LoRaWAN uplink with the confirmation that the battery is being charged. Such a charging message is sent on Port 3, for more explanation see 5.1. Uplinks.

When the sensors have sent uplinks with "battery empty" messages, we recommend putting the sensor on a charging pad for around 36 hours.
Basically, the sensor itself indicates when the 36-hour period has expired, with a charging pad purchased through Teneo, the LED of the charging pad then turns permanently red.

3.5. Decommissioning

When the soil moisture node is replaced or removed, for example because the battery needs to be charged or because the sensor no longer functions, it must be removed from the ground.

When you have the Soil Moisture Sensor with the measuring probe (for sale from 2024 onwards), this can be done by pulling the probe out again with the stainless steel wire.
Do not remove this mechanically but do this by hand, because of the risk that the towing eye of the stainless steel cable will break.

The battery of the node cannot be replaced, only charged. If the node no longer functions, the entire node must be replaced.

For other information, see also section 7.1.2. WEEE 2012/19/EU.

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4. LoRaWAN

4.1. Sensor Login to LoRaWAN Network Server (LNS)

The Soil Moisture Sensor is equipped with LoRaWAN for the communication of the sensor data to the user. The sensor is configured to the band EU 863-870 MHz.

With LoRaWAN, the node has a so-called 'join procedure' in which the node registers on the relevant LoRaWAN network. There are two ways in which a node can join the network; by means of Over the Air Activation (abbreviated: OTAA) or Activation by Personalization (ABP). Teneo nodes only and exclusively support the OTAA process. OTAA is generally seen within the LoRaWAN protocol as the most solid and secure way of joining on the network.

For the purpose of setting up the sensors in a LoRaWAN backend and for the unique identification of each sensor on the LoRaWAN network, a set of unique 'keys' is used: namely the DevEUI, AppKey and AppEUI.

The DevEUI and AppKey differ for each device separately, while the AppEUI can be the same per set of sensors (this is the case with Teneo and allows different types of sensors to be distinguished from each other).

These different keys are structured and recognizable as follows:
- DevEUI, for example: 70B3D5CDD0000001 (EU-64);
- AppKey, for example: 2B4D6251655468576D5A713474377721;
- AppEUI, for example: 70B3D5CDD000000187 (EU-64);

Nodes manufactured and supplied by Teneo can be identified by the prefix 70B3D5CDD, which is issued to Teneo by the IEEE SA. This makes all DevEUIs unique and traceable back to Teneo.
A DevEUI is assigned by Teneo only once to a node and is provided to the buyer upon delivery of the sensors.

These three keys are all pre-configured by Teneo and cannot be changed by the user. These keys are made available to the user to link the sensors to a specific back-end.

The DevEUI of each sensor is also mentioned on each sticker, as shown below.

Legend sticker:

1) DevEUI;
2) Model number;
3) Certification logos (CE and WEEE);
4) Firmware version (for internal reference only);

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4.2. Join Procedure

Sensors supplied by Teneo are already switched on when they are delivered.

If the sensors are not yet linked to a LoRaWAN network server (LNS for short), users still need to do so before placing the sensors in the field.

To do this, the keys can be added to the LNS and then the sensor, provided it is in range of a gateway of the network server in question, will execute a join request within 24 hours.
The node then sends a join request every 15 minutes and repeats this 5 times (so in total it performs 6 join requests per day), until it has joined a network.

In case you have purchased a dedicated charging pad at Teneo, you can “overrule” the 24 hours period between each joining procedure by placing the sensor shortly (± 5 – 10 seconds) on the wireless charging pad. The node will then almost immediately start sending its first join request of the join procedure to the LNS.

If the node is joined by a network, it will send an "alive" message (see chapter 5.1 "Uplinks") and then send the first regular uplink.

The sensor only executes a join request when it is not joined with an LNS, in addition, the node checks every few messages whether it is still connected to an LNS. To do this, the node must receive a confirmed message from the LNS.
If the node has not received it after a number of times, the node will also perform the join procedure as described above.
The advantage of this setting is that nodes can be transferred remotely from one LNS to another, without the need to actually go to the node (in the field).

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5. Payload

5.1. Uplinks

Uplinks consist of 3 components: Port, Header and the message.

5.1.1. Ports

The port is a number in the range of 1 through 223. The value of the port indicates the type of the message.

5.1.2. Header

Our firmware provides a header for each message as the first byte of the payload. The header consists of a type and parameters:

Bit	Description
7..6	Header Type
5..0	Parameters

Header Type:

Value (bit)	Name	Description
00	Default	If a standard message is sent, this header type is used. This header type has no parameters.
01	MultiMessage	LoRa messages have a limited length. With MultiMessage, an entire message is divided over multiple uplinks because it does not fit into 1 uplink. The current version of the program will not exceed that. MultiMessage does not occur.
10	Status	Status messages are given when the node starts up or something has gone wrong. These messages always go to port 223.
11	Power	When battery protection is used, these messages indicate what condition it is in. These messages always go to port 223

Default message:

Bit number	Name	Description
3..0	Battery voltage	Indicates the voltage of the node. Calculation: Voltage = 2 + Battery voltage / 10.

The most commonly used header is a standard header with a battery voltage. This header will be used by default, unless otherwise described. For example, the default header looks like this: binary: 0x0C or binary 0000 1100.

The first two bits (**00**00 1100) mean that it is a default message. The second two bits (00**00** 1100) have no meaning. The last four bits (0000 **1100**) represent the battery voltage. The last four bits represent the number 12. This means that the voltage is: 2 + 12/10 = 3.2 Volts.

Other header types

The MultiMessage is not explained because no large messages are sent.
The status and power header are described in the chapter "port 223: Status" because they only occur there.

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5.1.3. Message

A Soil Moisture Sensor can send the following uplink messages:

Port	Message type	Description
1	Soil moisture	This message contains the soil moisture measurement and additional information about the battery voltage of the sensor and the measured temperature. This is sent at an adjustable time.
3	Charging	This message indicates that the node is charging.
223	Status	Status messages are sent on port 223. These can be alive or power status messages. *For further explanation, see the heading "Port 223: Status".*

Port 1: Soil moisture

Byte	Length	Description
0	1	Header
1	1	Soil moisture percentage
2-3	2	Temperature
4-5	2	Default value: 0xFFFF.

A soil moisture message is the most common message. This indicates the measured percentage of soil moisture. This message will be sent if the measured value differs enough from the previous sent values. More information about this can be found at 5.2.2. "FPort 4: Bandwidth and maximum number of measurements".

If a soil moisture message also gives the optional temperature, a payload will look like this:
For example: 0C28FFFCFFFF.

This number is divided into the following pieces: |0C|28|FFFC|FFFF|. The meaning of these pieces is:
0x0C = Battery voltage: 3.2V
0x28 = decimal 40; The soil moisture value is then: 40%
0xFFFC (signed) = decimal -4; the temperature is then -4 / 100 = -0.04°C

If a soil moisture message does not provide an optional temperature, a payload will look like this.
For example: 0B27.
This number is divided into the following parts: |0B|27|. The meaning of these pieces is:
0x0B = Battery voltage: 3.1V
0x27 = decimal 39; The soil moisture value is then: 39%

Header:

Bit number	Description
3..0	Battery voltage

The battery voltage is calculated as: 2 + (hex payload / 10). So, if the hexadecimal payload is 12 (0x0C), the calculation becomes: 2 + (12/10) = 3.2 V.

Because Teneo uses batteries that do not have a linear discharge curve, it is difficult to present a graph or percentage of how full the battery is based on the battery voltage.
However, the battery can be assumed to be low if the node is transmitting a battery voltage of 3.0V or lower.

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Port 1 - Soil Moisture Percentage:

The Soil Moisture Percentage is the percentage of soil moisture measured by the node.
This value will be between 0 and 50% (between 0x00 and 0x32).
A value lower than 3% will indicate the node as 0%.
This value is unsigned, and can therefore only be positive.

Byte:	Length:	Name:
1	1 byte	Soil moisture percentage

Optionally, the temperature measured by the node (in the housing) can also be measured and controlled with the Soil Moisture Sensor.

When this is sent by the sensor, the data can be found in the following bytes:

Byte:	Length:	Name:
2-3	2 bytes	Temperature

This value is signed, and can therefore be negative as well as positive. To calculate the temperature from the payload, the value must be divided by 100.

If the temperature is negative, the MSB (Most Significant Bit) must be looked at to convert it.
Regardless of whether the temperature is positive or negative, it must then always be divided by 100 divided.
If this MSB is 1 then the temperature is: - (65536 – temperature value) / 100.
If this MSB is 0 then the temperature is: temperature value / 100.

For example, for value 0x0753: is binary: 0001 0001 0100 1101, last bit is 0 so:
0x0753 = decimal 1875: the temperature = 1875/100 = 18.75 degrees Celsius.

For example, for value 0xFCE0: is binary: 1111 1100 1110 0000, last bit is 1 so:
0xFCE0 = decimal 64736: the temperature = - (65536 - 64736) / 100 = -8.00 degrees Celsius.

When the temperature sensor sends 0x7FFF (+327.67 °C), the sensor has not been able to measure the temperature.

Port 2 – Soil moisture measurement out of Measuring Range:

If a Soil Moisture Sensor takes a soil moisture measurement higher than 50%, it is sent to Fport 2 instead of Fport 1.

The payload of an uplink where the measured soil moisture is higher than 50% will be sent by the node as 0xFF (i.e. 255%). This was deliberately chosen to immediately make it clear that the measurement is higher than 50% (or higher than the maximum set percentage, see downlinks Fport 5).

For almost all soil types that occur in (Western) Europe, it is no problem at all that the Soil Moisture Sensor does not exceed 50%

If the temperature is set at the sensor, the temperature measurement will still be forwarded with this Fport 2 message.
This temperature measurement can be read in exactly the same way as with a regular Fport 1 message (when the soil moisture measurement is within the set range).

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Port 3 – Charging:

Byte	Length	Description
0	1	Header

When the node's battery is charging, a message is sent on port 3. Only the battery voltage is given.

Bit number	Description
3..0	Battery Voltage

A Charging message can look hexadecimal like this: 0B. 0x0B = 11. The voltage is 3.1V (2 + 11/10)

Port 233: Status

A Status message is used to provide information about the node's 'Alive' or power status.

Byte	Length	Description
0	1	Header

A status message only has a header. The header can be divided into two pieces

Bit number	Name
7..6	Status type
5..0	Parameters

The following chapters are divided into status types. Then the parameters of the corresponding status type are explained.

Status type:

There are two status types that can be expected.

Value (bit)	Name	Description
10	Alive	Indicates the status of the node.
11	Power	Indicates the status of the battery voltage.

For example, an Alive status would look like this: 10001010 or 0x8A. If you then look at the first two bits (**10**001010) then it is clear that it is an Alive status.

Alive:

The following parameters can be found in an alive message.

Bit	Name	Description
3..0	Status code	Indicates the status of the node.

The status code indicates what is going on with the node. A status message is sent when the node starts up and when an error occurs.

Status code:

A Soil Moisture Sensor can send the following status codes:

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Value (bit)	Name	Description
0001	Timeout	In the event of a timeout, the node takes too long to collect data, which resets the node.
1010	Alive	Sent to let you know that the node has joined.

A status message is always sent when the node starts up or if something has gone wrong within the node. An alive message looks binary like this: 1000 1010 or hexadecimal 8A.

Power:

The following parameters can be found in a power message

Bit	Name	Description
5..4	Power status	Indicates the status of the node.
3..0	Battery voltage	Indicates the voltage of the battery. Calculation: Battery voltage = 2 + (hex payload / 10).

Power status:

Value (bit)	Name	Description
10	Standby	This message is sent when the battery voltage has dropped below 2.9 volts, and is greater than or equal to 2.8 Volts (0xE8). This message is sent again after a time interval of several hours to let you know that the battery needs to be charged.
11	Shutdown	This message will be sent as the very last message if the battery voltage falls below 2.7 Volts (0xF7). After this, the node will no longer send messages and will only join when the node is put back on a charging path.

Standby:

A standby message is sent if the battery voltage of the node is less than 2.9V or is greater than/equal to 2.7V. After sending this message, the node goes into sleep mode for a time based on the voltage of the battery. After that, the node wakes up and checks the battery voltage. If the battery voltage is less than 2.9V and greater than or equal to 2.7V, the message is sent again and the node goes back to sleep.

For example, this message looks like this: 1110 1000 or 0xE8. The first two bits (**11**10 1000) indicate that it is a power message. The second two bits (11**10** 1000) indicate that it is a standby message. The last four bits (1110 **1000**) indicate that the battery voltage is 2.8 volts.

Shutdown:

A shutdown message is sent as the very last message when the node has too low a battery voltage to function properly (lower than 2.8V). The node will then go into a deep sleep until the battery is recharged. When this is done, the node will reboot and join.

For example, this message looks like this: 1111 0101 or 0xF5. The first two bits (**11**11 0101) mean that it is a power message. The second two bits (11**11** 0101) indicate that it is a shutdown message. The last four bits (1111 **0101**) mean that the battery voltage of the node is 2.5 volts.

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5.2. Downlinks

In order to be able to control the node remotely, for example to be able to adjust settings, downlinks can be sent to the node.
The port, as with the uplinks, indicates what type of message it is, but no header needs to be sent.

The following types of messages can be sent as a downlink.

FPort	Message Type	Description
1	Period time	Change the cycle time (period time) when the node starts measuring.
4	Setting Bandwidth and Maximum Number of Readings	Change the bandwidth and maximum number of readings the node uses to determine whether to send a message.
5	Maximum soil moisture in %	Change the maximum percentage that is controlled (maximum 50%).

5.2.1. FPort 1: Period Time

Default: 0x00015180 (86,400 seconds, or: 1 measurement per day).

A period time message is used to indicate how much time should be between node's measurements.
The measurement frequency/time must be controlled hexadecimally in seconds.

For example, if the cycle time is to be set to 6 hours (= 21,600 seconds), the following message is sent on FPort 1: 0x00005460.

Byte	Length	Description
3..0	4	Time value in seconds

Some examples of settings that can be sent to the nodes are:
- 4 hours: 14,400 seconds = 0x00003840;
- 6 hours: 21,600 seconds = 0x00005460;
- 8 hours: 28,800 seconds = 0x00007080;
- 12 hours: 43,200 seconds = 0x0000A8C0;
- 24 hours: 86,400 seconds = 0x00015180.

Note: with the Soil Moisture Sensor, the fastest ("minimum period time") is 1 measurement per every 4 hours (i.e. 14,400 seconds). It therefore makes no sense to send downlinks with period times that are faster than 1 measurement per 4 hours.

5.2.2. FPort 4: Bandwidth and maximum number of measurements

Default: 0x0000 (bandwidth: 0 [off] and maximum number of measurements: 1).

With this downlink you can set the minimum difference in percentage compared to the previous sent measurement to send the new measurement.

This function also sets the maximum number of measurements that do not give a new LoRa message if the measurement falls within a set bandwidth.
If this number is exceeded, a soil moisture message (uplink) will always be sent.

Some examples of this message:
Bandwidth: 10% Max number of measurements: 5 → Payload downlink: 0x0A05
Bandwidth: 30% Max number of measurements: 18 → Payload downlink: 0x1E12

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Byte	Length	Description
0	1	Bandwidth
1	1	Maximum number of measurements

The advantage of applying this setting is that in those cases the sensor does measure, but that it is only sent if it has really changed substantially. This can also slightly extend the battery life of the sensor.

Bandwidth:

The bandwidth indicates how large the bandwidth of the filter is that determines whether a new value is sent or not. If the bandwidth is 10% and the last message sent is 27%, a message will only be sent if a new measurement is less than 22% or greater than 32% or if more than the maximum number of measurements have already been taken that were not outside the bandwidth.

Example: The maximum number of measurements is set to 4 and the bandwidth is 10%. The previous percentage sent is 30%. The new measurement is 33%. This is between 25 and 35%. Now the number of measurements is 1. Then a percentage of 40% is measured. This percentage is outside the bandwidth, so the measurement is sent. Now the number of measurements is 0 again and the next measurement must be outside 35% and 45%.

Maximum number of measurements:

If a maximum number of times has already been measured without a value being sent (because the measured value has always been within the bandwidth), then the new value is always sent regardless of the bandwidth.

This number can be set to 4, for example. If the soil moisture meter then measures a value that falls within the bandwidth 4 times, the percentage will always be sent at the 5th measurement. If a soil moisture message is sent, the node will start counting again, even if a soil moisture message is sent if the maximum number of measurements has not yet been reached.

5.2.3. FPort 5: Maximum humidity

Default: 50% (0x32).

Byte	Length	Description
0	1	Maximum percentage of humidity

The maximum humidity is the maximum measured percentage that will be sent.
For example, this downlink message might look like this: 0x23. This hexadecimal value 0x23 is decimal 35. Then the maximum percentage may be 35%.

If the measured percentage is 40%, this value will not be sent until the maximum number of measurements is reached (see the downlink on Fport 4).
If the maximum number of measurements is reached, this value will still be sent, even if it is above the maximum set humidity.

Note: the maximum percentage of soil moisture that can be measured by the sensor is 50%, it is not the case that if it is set higher than 50% (e.g. at 60%) that the Soil Moisture Sensor can measure up to 60%.

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6. Frequently Asked Questions (FAQ)

Q: *I have sent my Soil Moisture Sensor a downlink where it has to measure 1x per hour (for example), but the sensor keeps sending a measurement 1x every 4 hours, how is this possible?*

A: Teneo's Soil Moisture Sensors have a minimum period time of 1 message per 4 hours, this is hardcoded in the firmware and has to do with the reproducibility of the measurement. All downlinks sent to the nodes that are faster than 1x per 4 hours are set to 1x every 4 hours by the sensor itself.

Q: *My sensor never gives readings lower than 3%, how is this possible?*

A: All measurements lower than 3% will be sent by the sensor as 0%. As a result, measurements with 1% or 2% will never be presented.

Q: *My Soil Moisture Sensor only gives soil moisture readings from 0xFF on Port 2, is my sensor working properly?*

A: Yes, definitely, in that case it means that the measuring end of the sensor is in a place that is more humid than 50% (the maximum that can be measured by the sensor). It may be that the probe is deeper in the ground than you ideally want it to be, if so, you could place the sensor again and a little higher in the soil.

Q: *I have a Soil Moisture Sensor that continuously shows 0% as a measurement while I think there is moisture in the soil/soil. What can I do to see if the sensor is working properly or not?*

A: In that case, we recommend that you place the measuring end of the sensor back in the soil, because it is possible that due to shrinkage and expansion of the soil, the measuring end does not (or no longer) make good contact with the soil. If the Soil Moisture Sensor still shows 0% after relocation, it means that the soil is really dry. In that case, it may be advisable to take a soil sample with a gouge.

Q: *The Soil Moisture Sensor gives a different moisture percentage than how I would estimate the soil myself or gives a different value than a hand meter, can you explain why?*

A: All Soil Moisture Sensors are delivered calibrated "from the factory", the formula used for this calibration is based on a number of most common soil moisture types in the Netherlands. Because this formula is sensor-specific, it may therefore differ from other meters or your own interpretations. It is therefore also important to get a feeling for "too dry" or "too wet" by comparing measurements from the Soil Moisture Sensor with a visual observation at the beginning (e.g. by means of a soil sample with a gouge), so that you get a sense of the meaning of the percentages sent.

Q: *The Soil Moisture Sensor never gives moisture percentages higher than 50% while I would estimate the soil to have a higher moisture percentage, how is this possible?*

A: It may well be that this type of soil, in which the Soil Moisture Sensor is placed, has a saturation point that is lower than 50% (NB: this is the case with several common soil types). In that case, the Soil Moisture Sensor will not indicate higher than the saturation point of the soil.

Q: *I have the Soil Moisture Sensor hanging in a container of water and I would expect a reading of 100% but the sensor indicates a lower soil moisture reading. Is the sensor working properly?*

A: The Soil Moisture Sensor always needs solids to be able to take a measurement. If you hang the sensor in only water, it will therefore not be able to measure properly.

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Q: *What is the most ideal place to place the probe/measuring end of the Soil Moisture Sensor?*

A: Different people look at this differently and are therefore opinion-dependent. With young trees we often see that they are placed about halfway in the root ball, but because they root further in the first few years, it may be advisable to reposition the sensor further from the root ball or deeper in the soil later.

Q: *How long do I need to charge the battery if the node has sent a message that the battery is completely empty?*

A: If the sensor has indicated through messages on Fport 223 that the battery is really empty, we recommend that you put the sensor on the charger for the full period of 36 hours. Depending on the period time of the sensor, this will have to be carried out once every 3 (with a measurement 1x per 4 hours) to 5 years (with a measurement of 1x per 24 hours).
If the sensor is removed from the ground after each growing season (e.g. in winter), the battery will not be completely empty and it will be sufficient to put the sensor on the charging pad for 24 hours, for example.

Q: *Can I use a wireless charging pad from you in combination with a power bank?*

A: Yes, the wireless charging pads that we optionally sell with the sensor work in combination with a power bank. However, the capacity of the power bank does determine whether it is able to charge a sensor, for example, for the full 36 hours.

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7. Regulations

7.1. CE Certification

7.1.1. EU Declaration of Conformity

Manufacturer:	Teneo Sales B.V.
Product:	LoRaWAN Soil Moisture Sensor
Designation:	02SMS
Batch/Serial Number:	TBV-02SMS-01LR

Teneo Sales B.V. hereby declares that the "LoRaWAN Soil Moisture Sensor 02SMS" is in compliance with the Radio Equipment Directive (2014/53/EU).

The full text of the Declaration of Conformity can be requested via our e-mail address support@teneo-iot.nl

7.1.2. WEEE 2012/19/EU

The node, including all components, must not be disposed of with household and/or industrial waste. Users are obliged to dispose of the node at the end of its life in accordance with the requirements of the WEEE (Waste Electronic and Electrical Equipment) Regulation in order to contribute to the protection of the environment and the reduction of waste (recycling).
For further information on how this can be done, please contact a certified collection party.

The node contains a Lithium battery, which must be recycled separately.

In order to comply with its obligations as a producer, as a result of the WEEE Regulation, Teneo Sales B.V. is affiliated with Wecycle (Dutch party).

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+31 (0)543 535 535